Clearing the air: Barriers to improving air quality and reducing environmental inequity along the Clark-Knight corridor

by

Nancy Chan

B.A. (Communication), Simon Fraser University, 2011

Project Submitted in Partial Fulfillment of the
Requirements for the Degree of
Master of Urban Studies

in the
Urban Studies Program
Faculty of Arts and Social Sciences

SIMON FRASER UNIVERSITY
Fall 2022

Declaration of Committee

Name:	**Nancy Chan**
Degree:	**Master of Urban Studies**
Title:	**Clearing the air: Barriers to improving air quality and reducing environmental inequity along the Clark-Knight corridor**
Committee:	**Chair: Karen Ferguson** Professor, Urban Studies and History
	Meg Holden Supervisor Professor, Urban Studies and Resource and Environmental Management
	Meghan Winters Committee Member Professor, Health Sciences
	Jonathan Cote Examiner Mayor City of New Westminster

Ethics Statement

The author, whose name appears on the title page of this work, has obtained, for the research described in this work, either:

a. human research ethics approval from the Simon Fraser University Office of Research Ethics

or

b. advance approval of the animal care protocol from the University Animal Care Committee of Simon Fraser University

or has conducted the research

c. as a co-investigator, collaborator, or research assistant in a research project approved in advance.

A copy of the approval letter has been filed with the Theses Office of the University Library at the time of submission of this thesis or project.

The original application for approval and letter of approval are filed with the relevant offices. Inquiries may be directed to those authorities.

Simon Fraser University Library
Burnaby, British Columbia, Canada

Update Spring 2016

Abstract

Air pollution has become a silent killer, and in Canada, claims more lives than do motor vehicle accidents annually with mortality rates being higher in metropolitan cities. Of concern for Canada's densely populated regions is traffic-related air pollution (TRAP). This study focuses on the Clark-Knight corridor, home to a six-lane arterial road and one of the busiest, most polluted truck routes in the Metro Vancouver region. Exposure to harmful TRAP along this corridor is inequitable and is exposing disadvantaged and vulnerable populations to increased health hazards. Despite known health risks, planning practices and policies continue to allow residential densification along busy truck routes. Past attempts by the Province of B.C. and Metro Vancouver to put in place a mandatory emissions testing program to address air pollutant emissions from heavy-duty diesel trucks that are older, poorly maintained or have illegally tampered with emission control systems have also stalled.

This thesis investigates the barriers to implementing policies and programs to improve air quality and reduce environmental inequity related to TRAP exposure along the Clark-Knight corridor. The research uses a qualitative, mixed-methods case study approach, featuring a primary case study on the Clark-Knight corridor and secondary contrast case on the Province of Ontario's DriveON Emissions and Safety Inspection Program.

Findings reveal the impacts of planning decisions that have increased truck traffic volumes and residential density along the Clark-Knight corridor, and that the trucking industry's lobby efforts and Province of B.C.'s prioritization of greenhouse house gas emissions reductions have inhibited policy innovation and the ratification of stricter environmental policies to manage air pollutant emissions from heavy-duty diesel trucks in British Columbia. Recommendations to support a shift towards more sustainable planning and policymaking practices are also offered.

Keywords: built environment; environmental inequity; land use planning; public health; sustainable transportation planning; traffic-related air pollution; truck routes; healthy communities

Acknowledgements

I couldn't have completed this work without the support of many people around me who encouraged me, believed in me, and took an interest in my research.

I am extremely grateful to the participants who took time out of their busy schedules to be interviewed, especially during such a disorienting time at the height of the COVID-19 pandemic. Your insight, expertise, and knowledge on this policy issue was invaluable. Although there are indeed barriers that will need to be overcome in your work to improve air quality and reduce environmental inequity along the Clark-Knight corridor, your vision and passion to build healthier, sustainable communities was not unnoticed.

As I wrap up my M.Urb journey, I'd also like to acknowledge the faculty and staff of the Urban Studies Program from whom I've learned so much from and have been inspired by. To my supervisor, Meg Holden, thank you for your mentorship, understanding and support throughout the process. Thank you for helping me see other perspectives and ways of thinking. Anthony Perl, Annika Airas, Karen Ferguson, Meghan Winters, and Tiffany Muller Myrdahl, thank you for your contributions to my learning experience and for converting the pessimist in me to see that change is possible and worth fighting for.

To fellow students and alumni, your words of wisdom, support and encouragement kept me going. When things felt challenging, you made me feel truly understood and helped me find the path forward.

Last but definitely not the least, thank you to my friends and family who have been there for me every step of the way.

Table of Contents

List of Tables

List of Figures

Chapter 1. Introduction

1.1. Research question

It's mostly invisible and is not usually noticeable in our day-to-day lives but it's there. Air pollution in our urban environment has become a silent killer and in Canada, claims more lives than do motor vehicle accidents annually (Brauer et al., 2012). Of specific concern, especially for Canada's densely populated regions, is traffic-related air pollution (TRAP), which is a result of the decisions we make regarding the movement of people and goods. Within Vancouver and other comparable port cities, studies show that unequal exposure to TRAP is putting disadvantaged populations at increased health risks (Cummings, 2019; Kimbrough 2017). Census data reveals that 32% of Canadians reside in TRAP exposure zones; this means they live within 100 m of a major urban road that sees average daily traffic volumes of 15,000+ vehicles or within 500 m range of a highway that sees average daily traffic volumes of 18,000+ vehicles (Brauer et al., 2013). These residents live in areas that regularly expose them to increased risks of negative physical and mental health impacts such as asthma, cancer and stroke, and depression and anxiety (Braithwaite et al., 2019; Brauer et al., 2013; Health Canada, 2019). This percentage drastically increases in cities such as Vancouver, where up to 74% of Vancouverites reside within TRAP exposure zones along major urban roads (Brauer et al., 2012, p. 44). Considering increasing urbanization and that more than 80% of Canadians now live in urban areas, we need to develop policies and plans that protect the physical and mental health of present and future generations (Brauer et al., 2013; Brauer et al., 2012; Doiron et al., 2020).

Of specific interest to this study is the Clark-Knight corridor, home to a six-lane arterial road and one of the busiest, most polluted truck routes in the Metro Vancouver region. Research shows that exposure to TRAP along this corridor, particularly from older heavy-duty diesel trucks and those with illegally tampered with emissions control systems, are exposing disadvantaged and vulnerable populations to increased health risks (Envirotest Canada, 2013; Southern Ontario Centre for Atmospheric Aerosol Research, 2019; Doiron et al., 2020). The corridor is primarily made up of low-density residential areas of single detached and duplex homes, soon to be further densified through municipal rental housing zoning policies such as the City of Vancouver's

Secured Rental Policy. Passed by Vancouver City Council in 2019, the policy aims to increase affordability by "increas[ing] the supply of secure market rental housing that is available to renter households" (City of Vancouver, 2022a, p. 4) and "include provisions for below-market rental housing" (City of Vancouver, 2022b). Under this policy, rental buildings up to six storeys would be allowed on low-density residential zoning along arterial streets, with the stipulation that at least 20% of the residential floor area be dedicated to below-market rental housing (City of Vancouver, 2022a). This densification of rental housing along arterial roads, which includes the Clark-Knight corridor, is particularly concerning because it has the potential to shift more people with low income to live within TRAP exposure zones (Brauer et al., 2013; Creating and Protecting Market Rental Housing | City of Vancouver, n.d.). The impacts from TRAP exposure are an intensifying problem for Canada's densely populated regions as goods movement continues to grow (Southern Ontario Centre for Atmospheric Aerosol Research, 2019; Timmers & Achten, 2016). Faced with a housing affordability crisis, growing population, growing international trade, growing transportation demands, and land constraints, we must find better ways to balance growth with healthy communities to develop in a way that supports the wellbeing of residents and the economy in a sustainable manner.

Despite the known health risks of TRAP, planning practices and policies continue to allow residential densification along busy truck routes. Past attempts by the Province of B.C. and Metro Vancouver to put in place a mandatory emissions testing program to address air pollutant emissions from heavy-duty diesel trucks that are older, poorly maintained or have illegally tampered with emission control systems have also stalled. **This study aims to identify and understand the barriers to implementing policies and programs to improve air quality and reduce environmental inequity related to truck traffic-related air pollution exposure along the Clark-Knight corridor, one of Metro Vancouver's busiest truck routes.** I look at inequity as the motivation for this study. Environmental inequity is the unjust distribution of exposure to environmental harms where the negative impacts of health risks are disproportionately carried by people who face disadvantages, such as visible minority groups, children and lower income populations (BC Centre for Disease Control, 2017; Mitchell and D'Onofrio, 2016). The unacceptability of environmental inequity in exposure to TRAP is the main reason why policymakers must pay attention to air quality along busy truck routes through residential areas. This study is guided by the premise that reducing TRAP along

truck routes, particularly from heavy-duty diesel trucks, will help reduce inequitable exposure to related public health risks.

The Clark-Knight corridor case study brings to light 1) planning decisions and practices that have increased truck traffic volumes and residential density along the Clark-Knight corridor and 2) the political factors that inhibit policy innovation and the ratification of stricter environmental policies in B.C. A contrast case of the Province of Ontario's ratification and implementation of a mandatory emissions testing program for heavy-duty trucks to address poor maintenance and emission control system tampering was also examined to further understand the factors that make such a program possible for Ontario but so far, not possible in B.C. Through a mixed-methods approach, this study achieves the following:

- Establish a narrative of how the Clark-Knight corridor came to be one of the most polluted arterial roads in the Lower Mainland to live along through planning and policy decisions that discounted the impacts of air pollution on local residents
- Identify who has a role to play in policymaking related to the management of air emissions and truck TRAP along with what dependencies and influences exist
- Identify what is and is not being done by levels of government to reduce truck TRAP and concomitant health hazards along the Clark-Knight corridor
- Identify barriers that constrain sustainable urban mobility policymaking and sustainable trucking practices, and how the lack of these has contributed to TRAP-related inequity along the corridor
- Develop an understanding of how the Ontario Trucking Association and Government of Ontario were able to ratify and implement a mandatory emissions testing program for heavy-duty diesel trucks

Recommendations to improve policy and planning to manage TRAP in the Metro Vancouver region are also offered to help enable a sustainable shift and create healthier built environments along truck routes and arterial roads. In the following sections, Chapter 2 grounds this research in relevant literature and identifies a knowledge gap related to how freight transport intersects with wider city planning practices within urban contexts, supporting the need for research at this local contextual level to take place. Chapter 3 provides an overview of the research design methodology chosen that will lead to the data and level of analysis required to answer the research question. Chapter 4 reviews the history and context that led the Clark-Knight corridor to become one of the

busiest and most polluted truck routes in the region, the current air quality management approaches, and provides an overview of the trucking sector. In Chapter 5, I cover the results and findings that directly answer my research question. Chapter 6 concludes this research by discussing key barriers and identifying what's needed to drive effective policy innovation. In closing, a series of recommendations are offered to policymakers to encourage a more active approach to managing air quality issues along busy truck routes and arterial roads.

1.2. Significance of research

While there is extensive research in urban studies related to the use of private automobiles, public transportation, and active transportation, a knowledge gap exists regarding how urban freight transport intersects with "transport planning, land-use and wider urban planning" (Cui, Dodson, & Hall, 2015, p 2). This research will help fill a gap related to the institutional landscape and state of sustainable planning and policy practices related to urban planning and freight movement within a Canadian context. By leveraging the Clark-Knight corridor as a primary example of how planning and policy practices can lead to the intensification of environmental inequity due to exacerbated public health impacts related to TRAP, this work aims to highlight the urgent need for more comprehensive and sustainable approaches to planning and policymaking to support a transition towards more sustainable trucking practices across Canada's port cities and dense metropolitan areas. My research underscores the importance of an approach that prioritizes public health over private interests and the reduction of ground level air pollutants without neglecting the significance of one type of emissions for a focus on another. In the context of the Metro Vancouver region, this work is particularly timely due to container terminal expansion underway and the anticipated growth of trade in shipping containers through the Port of Vancouver, which is expected to significantly increase heavy-duty diesel truck traffic along the Clark-Knight Corridor and other regional roadways. My findings also reveal the impact of the trucking industry's lobby efforts to inhibit the ratification of environmental policies to manage air pollutant emissions from heavy-duty diesel trucks in B.C.

Through an analysis of the journey towards the development and ratification of mandatory emissions testing programs for heavy-duty diesel trucks in B.C. and Ontario, I was able to uncover what made the journey impossible for one province and what made

it possible for another. Currently, no measures are in place in B.C. to ensure high-polluting diesel trucks get taken off the road or are properly maintained to lower pollutant output. In contrast, the Province of Ontario has an integrated mandatory emissions and safety inspection program that came into effect in June 2021 for heavy-duty diesel trucks, which includes anti-emissions control system tampering checks for all trucks and emissions testing for trucks seven years or older (Government of Ontario, 2018; Government of Ontario, 2019).

These cases reveal how the promises of political re-election can steer governments away from environmental policies and highlight the urgency of action needed for better land use planning, transportation planning, and the adoption of policies and programs to transition towards more sustainable trucking practices across Canada's port cities and dense metropolitan areas. The results of this study can be used by policymakers and planners to gain perspective on what is needed to drive change and break through barriers that hinder the development of new policies and programs that effectively address harmful air emissions. Insights from this research are relevant to the entire regional road network and highlight the importance of creating healthier communities through a shift towards a more holistic, sustainable approach to planning and policymaking — one that effectively considers how land use and transportation decisions can perpetuate environmental inequity by placing concentrated burdens on lower income and marginalized populations. This research also highlights the importance of considering the interconnections between public health, sustainability, governance, economic development, goods movement and policy making to ensure that decisions made do not create negative downstream effects.

Chapter 2. Conceptual Framework

To contextualize my research question and guide my data collection, I have developed a conceptual framework based on three bodies of existing literature. The first section focuses on how TRAP exposure is negatively impacting the physical and mental health of those who live in Canada's metropolitan cities. Relatedly, the second section looks at the impact and existence of environmental inequity in Vancouver and other comparable metropolitan cities. To contextualize what is occurring along the Clark-Knight corridor with respect to heavy-duty diesel truck traffic, I highlight how unequal exposure to air pollution is putting vulnerable and disadvantaged populations at increased health risks. The final body of literature will then transition to a discussion on the barriers that inhibit the development of policies and programs to address air emissions and the agenda for a much-needed paradigm shift towards sustainable urban mobility policymaking.

2.1. Public health impacts of traffic-related air pollution exposure

2.1.1. Exposure to traffic-related air pollution

Approximately one third of Canadians (10 million individuals) live in a TRAP exposure zone, meaning that they live within 100 m of a major urban road that sees average daily traffic volumes of greater than 15,000 vehicles or 500 m range of a highway that sees average daily traffic volumes greater than 18,000 vehicles (Brauer et al., 2012). In Canada's large cities, such as Vancouver, proportions of those at risk increase dramatically with up to 74% of Vancouverites residing within TRAP exposure zones (Brauer et al., 2012, p. 44). This puts many Vancouverites at higher risk of negative health effects from being regularly exposed to air pollutants.

In a report to Health Canada, Brauer et al. (2013) conducted a critical analysis of existing literature and concluded that TRAP exposure is a "significant public health issue in Canada" and can cause adverse effects related to "respiratory health, pregnancy outcomes, cardiovascular disease and cancer" (Brauer, et al., 2013, p. 3). This report also concluded that there is a causal link between TRAP and new onset cases of asthma in children (Brauer, et al., 2013, p. 28). While these are the more widely

documented outcomes, the authors also mention that an association between TRAP exposure and diabetes (Brauer, et al., 2013, p. 24-25). As Brauer et al.'s report focuses on a Canadian context and closely examines studies conducted in urban settings such as Vancouver and Toronto, this work helps shine a light on public health impacts in a country often regarded as having good air quality (Brauer, et al., 2013, p. 3).

Health Canada reports in 2019 and 2021 supported claims that exposure to air pollution "increases the risk of premature mortality from heart disease, stroke and lung cancer" (Health Canada, 2019, p. 5) and determined that annual premature deaths attributable to exposure to air pollution in Canada totaled 15,300 people or 42 deaths per 100,000 people (Health Canada, 2021). The "total economic cost of all health impacts attributable to air pollution was also estimated to total $129 billion […] equivalent to approximately 6% of Canada's 2016 real gross domestic product" (Health Canada, 2021, para. 4). In B.C., it is estimated that 1,900 annual premature deaths are attributable to air pollution and costs the economy an estimated $13.9 billion (Health Canada, 2021).

According to Health Canada, "there is no evidence of an exposure threshold: that is, any incremental increase in air pollutant concentration is associated with an increased risk of adverse health outcomes" (Health Canada, 2019, p. 6). Their research also showed that higher mortality outcomes were observed in urban areas with higher population density and traffic volumes, such as those found in Vancouver. Brauer et al.'s (2019) team found "there is at least a five per cent increase in the risk of deaths of Canadians when comparing between high- and low-pollution areas" (Brauer et al., 2019, p. 3).

There has also been growth in the body of research that points to a strong link between TRAP exposure and adverse mental health impacts, including depression, suicide, reduced intelligence, anxiety, and psychiatric disorders (Carey et al., 2018; Ho et al., 2018; Zhang et al., 2018; Braithwaite et al., 2019). In a first-of-its-kind study published in 2018, researchers in Hong Kong found that for those with mental health or behavioural disorders, hazy days caused by air pollution are correlated with a 16% higher chance of death on the first day of exposure, and a 27% higher chance on the second day (Ho et al., 2018). In separate studies done in Taiwan, Ontario (Canada), and London (England), positive correlations were found between TRAP exposure and the

development of dementia and Alzheimer's disease (Jung, Lin & Hwang, 2015; Chen et al., 2017; Carey et al., 2018). Age-specific risk profiles were suggested by a study in China, which found that long-term exposure to air pollution could impact cognitive function in people of all ages with even bigger impacts for children and elderly populations, impeding their ability to learn, conduct daily tasks, and make decisions (Zhang et al., 2018). Finally, research has also shown that noise pollution associated with road traffic sources may contribute to physical and mental health risks for those who live along roads with heavy traffic (Hegewald et al., 2020; Shin et al., 2020).

These are just a few examples of studies relating TRAP exposure to mental health consequences in a growing body of literature. To better understand how air pollution impacts our mental health, researchers are urging for more studies to be conducted. For instance, further research on the impacts of fine particulate matter (PM2.5) on the human blood-brain barrier are needed but related studies in mice point to potential oxidative stress, neuroinflammation, and neurodegeneration in the human brain, which may be the cause of mental health impacts (Young et al., 2019).

Overall, TRAP's adverse impacts on physical and mental health results cannot be denied, presenting concerns around environmental inequities for those living in TRAP exposure zones. Considering that more than 80% of Canadians currently live in urban areas, it is important that we look to ensure the movement of people and goods is done in a sustainable manner that does not negatively impact the physical and mental health of present and future generations (Doiron et al., 2020, p. 1).

2.1.2. Relationship between air pollution, ground-level ozone, and climate change

The additional context of climate change makes matters more concerning. Climate change is expected to increase frequency of weather conditions that can increase air pollution, including heat waves, higher temperatures and air stagnation (Pfister et al., 2014). The Government of Canada's public notice on the interacting effects of air pollution, heat and urban density provides the following:

- People breathe more quickly in hot weather and therefore breathe in more air, that can be polluted.

- Extreme heat also changes the body's ability to handle toxins.
- Large cities may experience higher temperatures due to the built environment (e.g. roads, buildings) which trap the heat, also known as the heat-island effect.

  (*Climate Change, Air Contaminants, and Your Health - Canada.Ca*, n.d., para 10)

These compounding impacts underscore the importance of mitigating climate change through both reducing greenhouse gas emissions and improving air quality. In the Metro Vancouver region, “on-road transportation is estimated to contribute approximately one quarter of smog forming pollutants,” including ground-level ozone (Envirotest Canada, 2013, p. 13). In addition to increasing air pollution in regional airsheds from primary sources such as cars and trucks, weather conditions created by climate change also increase levels of secondary air pollution in the form of ground-level ozone. Ground-level ozone is created when heat and sunlight react with nitrogen oxides and volatile organic compounds, which are forms of TRAP. These compounding conditions are predicted to worsen as climate change intensifies: “Researchers predict that, because ground-level ozone and weather are so closely linked, climate change will cause higher average ozone concentrations, more frequent peak ozone periods and longer summers which can increase summer ozone periods" (*Climate Change, Air Contaminants, and Your Health - Canada.Ca*, n.d., para 5; Pfister et al., 2014; Canadian Association of Physicians for the Environment, 2021)

Ground-level ozone exposure is understood to cause harmful health effects. Within a review of research conducted by Metro Vancouver, they note that exposure to ground-level ozone causes both acute and chronic health effects with "more evidence for acute ozone exposure impacts than chronic exposure impacts” (Metro Vancouver, 2014, p. 14). These health effects include impacts to respiratory, cardiovascular, and central nervous systems, and an “increased number of cardiopulmonary-related deaths” (Metro Vancouver, 2014, p. 14). Based on trends released by Environment and Climate Change Canada, the estimated percentage of deaths attributable to ground-level ozone are on the rise across Canada. Figure 1 offers a visual depiction of the upward trend between 1984 and 2012.

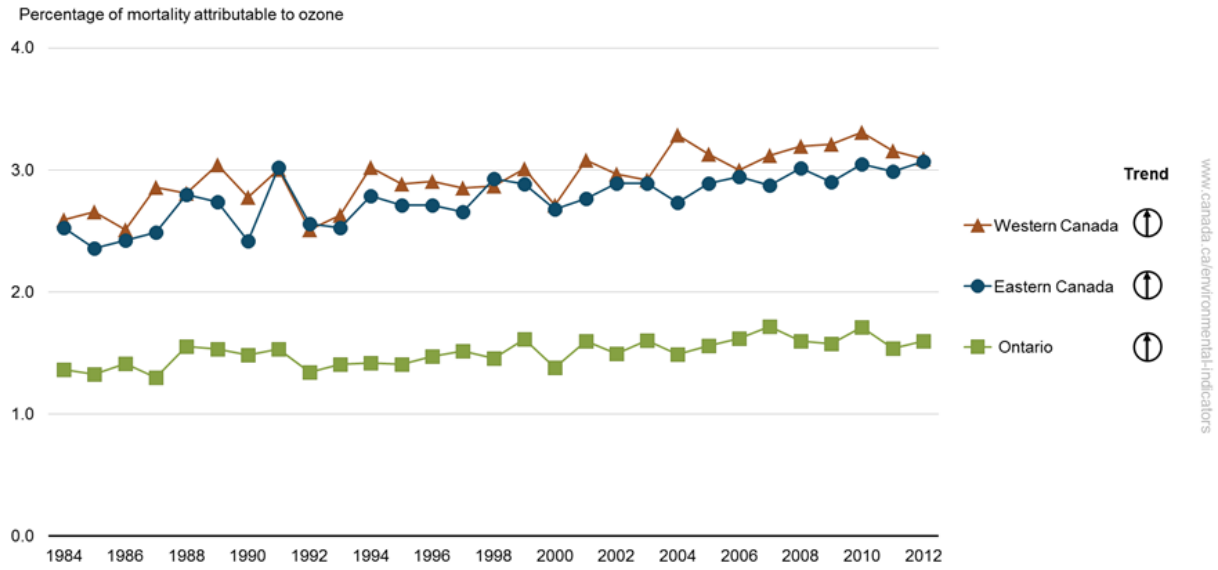

Figure 1. Percentage of mortality attributable to ozone exposure in Canada
(Environment Climate Change Canada, 2018, n.p.)

Considering that concentration levels of ground-level ozone have been on the rise in the Metro Vancouver region, the estimated percentage of deaths attributable to ozone exposure is expected to have continued on its upward trend (Metro Vancouver, 2022b). Occurrences of heat waves, higher temperatures, and air stagnation are expected to increase in frequency due to climate change and create conditions for ground-level ozone to increase.

The Vancouver region caught a glimpse of what climate change brings during the heat wave experienced in the last week of June in 2021, which saw corresponding air quality warnings prompted by high concentrations of ground-level ozone (CBC News, 2021). During the heat wave, B.C. recorded 815 sudden deaths with 610 of those being deemed as heat-related (British Columbia Coroners Service, 2022). This “represented a nearly 300 per cent increase from the average number of deaths recorded over the same week every year since 2016” (CBC News, 2021, para. 2). However, there has not been analysis on how many sudden deaths occurred during the heat wave because of air pollution. However, data on the causes of death during the 2003 European heat wave where temperatures reached up to 47.3 degrees can be used as a guide. One study reported, heat and air pollution caused 35,000 excess deaths, mostly among the elderly (Garcia-Herrera et al., 2010); and that “in the Netherlands more than a third of deaths

were caused by ozone exposure, and in England and Wales, 20-40% of deaths were due to air pollution" (*Climate Change, Air Contaminants, and Your Health - Canada.Ca*, n.d).

Within their 2022 Caring for the Air report, Metro Vancouver reiterated the importance of action to rapidly reduce air pollution in order to mitigate the impacts of climate change on air quality and human health:

> As a result of the heat, ground-level ozone concentrations reached levels not recorded since the late 1980s, despite programs and regulations implemented over the last two decades to reduce air contaminants that form ground-level ozone. This shows how extreme weather can erode emission reductions already realized. High ground-level ozone concentrations also add another health threat during already dangerous heat waves.
>
> Although significant progress has been made over the last few decades to reduce regional air contaminant emissions, more aggressive action is required. The high ozone concentrations experienced in June show how extreme weather associated with climate change can compromise decades of progress, so we must continue to adapt and find innovative solutions as threats emerge (Metro Vancouver, 2022a, p. 3).

As our province and region continue to experience more extreme heat events due to climate change, it is expected that the interacting and compounding effects of air pollution, heat, and urban density will intensify and lead to higher mortality rates.

2.2. Environmental inequity related to traffic-related air pollution exposure in Canadian metropolitan cities

Since the Vancouver region is home to Canada's largest port (Vancouver Fraser Port Authority, 2022a), I relied on literature focused on other port cities because these types of cities have activities taking place within them that are "major traffic generators" with "warehousing and distribution facilities often clustered around terminals, or are located near each other at the urban periphery" (Cui, Dodson, & Hall, 2015, p 1). The movement of trade-related freight in port cities "has been recognized as a major contributor to urban air pollution [with] diesel trucks [being] the most significant contributor of particulate emissions in most cities" (Cui, Dodson, & Hall, 2015, p 5).

Within Vancouver and other comparable port cities, studies show that unequal exposure to TRAP is putting disadvantaged populations at increased health risks. This was found to be true within American port cities, such as Los Angeles, which has seen strong local opposition to TRAP from heavy-duty diesel trucks along truck routes near residential areas. Due to environmental inequity, TRAP disproportionately exposes communities of low socio-economic status and people of colour to air pollution (Cummings, 2019; Kimbrough 2017)

This inequitable exposure to "environmental harms and benefits" is referenced as environmental racism, environmental injustice, or environmental inequality. While these terms are somewhat interchangeable, environmental justice is usually considered the umbrella field of study (Mitchell and D'Onofrio, 2016, p. 307-308). There are analytical as well as activist elements of the field of environmental justice. The analytical side of the field investigates the existence of environmental injustices and traces the drivers, conditions, and impacts of these conditions on particular disadvantaged and racialized groups where they occur. The normative policy and practice activist element of environmental justice "promotes the concept that environmental harms, such as air pollution, and environmental benefits, such as access to public green spaces, should be equality distributed, without discrimination on the basis of socio-economic status, race, ethnic origin, or residence on a First Nations reserve" (Mitchell and D'Onofrio, 2016, p. 308). The understanding and analytical as well as normative framework offered by environmental justice are core rationale for the need for my research, because I aim to both demonstrate the existence of environmental inequity in the Clark-Knight corridor due to TRAP conditions and an absence of policy action to curtail these, and to provide information and analysis aimed at helping practitioners understand the policy barriers that exist to improve air quality and reduce the concentrated burdens placed on disadvantaged populations.

There has been increasing attention to environmental inequities in the U.S., but also now in Canadian cities. Doiron et al. (2020) conducted a spatial analysis of the relationship between material deprivation (composed of education, employment and income) and multiple urban environmental factors (neighbourhood walkability, nitrogen dioxide (NO_2) air pollution and green area) in Canada's largest metropolitan areas: Vancouver, Montreal, and Toronto. Findings show that in all three cities, areas of high material deprivation were more likely to experience high TRAP exposure and to have

less greenery, which when present can help mediate the impacts of TRAP. Specific to the City of Vancouver, Doiron et al. (2020) found that areas of high material deprivation were 23% more likely to experience high TRAP exposure and 57% less likely to have high urban greenery when compared to city-wide prevalence (Doiron et al., 2020, p. 4). These findings were also consistent with another environmental justice study conducted by Su et al. (2010) in Vancouver and Seattle, which found that lower median household income census tracts had higher levels of air pollution (Su et al., 2010).

Studies such as these reveal existing inequity in Vancouver and other Canadian cities related to air pollution. Doiron et al.'s study is particularly relevant to my research question because within their analysis, spatial data revealed clusters of areas along the Clark-Knight corridor as being high in material deprivation, low in greenness, and high in TRAP. These findings align with research focused on air quality along the corridor and draw attention to considerations that urban planners must act on when planning around and designating truck routes.

In a study completed in 2018 by University of Toronto researchers, Wang et al. (2018) found that air pollution levels along the Clark-Knight Corridor in B.C. were similar to levels seen beside Highway 401 in Ontario, despite the road carrying less than one-tenth of the vehicle traffic. They took measurements of TRAP near urban roads in Vancouver and Toronto and showed that "the difference between emission levels across sites was more correlated with the number of large trucks on the road rather than number of cars" (Wang et al., 2018, p. 8). Specifically, they highlighted the volume of older heavy-duty trucks running on diesel engines as a major contributing factor to elevated air pollution, determined through diesel engine exhaust markers of black carbon and nitrous oxides. In a summary report of their research, researchers urged that the density of trucks must be considered in mitigating public health risks, especially along truck routes close to homes, schools and daycares and suggested that more should be done to protect public health by continually measuring and reducing harmful diesel engine emissions such as black carbon (BC), nitrous dioxide (NO_2), nitrous oxide (NO), and fine particulate matter (PM2.5) (Southern Ontario Centre for Atmospheric Aerosol Research, 2019). Findings of their study were consistent with Metro Vancouver Regional District's annual Caring for the Air annual reports, which identifies the Clark-Knight location as having consistently higher levels of air pollutants due to influence from

traffic emissions (Metro Vancouver, 2017; Metro Vancouver, 2018; Metro Vancouver, 2019).

For reasons related to lack of awareness of the dangers and concentrations of TRAP and for reasons of socioeconomic factors that give some households little choice but to live in high TRAP exposure zones, exposure to pollutants is long term and difficult to avoid. And for children who grow up in these neighbourhoods and spend most of their time at home, at school, or at nearby playgrounds, the adverse impacts on their cognitive development, academic performance, and health can impact long term well-being compared to other children who don't live in or spend as much time in TRAP exposure zones. In 2010, Amram et al. analyzed 1,556 public elementary schools in Canada's 10 most populated cities to find out how many urban schools were located close to major roads and highways (Amram et al., 2010, p. 1). Their study found that in Vancouver, nearly 55% of urban schools were "located close to a highway or major road", and schools located in lower-income neighbourhoods were more likely to be located within a TRAP exposure zone (Amram et al., 2010, p. 5). More generally, across studies, results have consistently indicated that residents of urban Canada who have less money and live in areas of higher density and closer proximity to busy truck routes are more likely to be exposed to TRAP, and carry the burden of the consequent physical and mental health impacts.

Shifting focus to the normative, "what should we do?" side of environmental justice research, case studies on TRAP in Los Angeles have shown that community and environmental groups have been able to galvanize movements to push for the transition to the use of cleaner trucks near port infrastructure and truck routes (Cummings, 2019). Activism on such a scale has not happened in Canada. According to Mitchell and D'Onofrio (2016), this may be due to the fact that environmental injustice is less blatant in Canadian cities, or perhaps due to a lack of awareness. The reasons for this relate to social and historic differences stemming from racial segregation in the United States and a lack of research in Canadian contexts that "explore the links between socio-economic status, race, and environmental hazards" (Mitchell & D'Onofrio, 2016, p. 321). Mitchell and D'Onofrio also note that "socially and economically marginalized communities may also be less able to effectively mobilize political, economic, and social resources to effectively participate in decision-making processes and communicate concerns" (Mitchell & D'Onofrio, 2016, p. 309).

More studies on the impacts and state of environmental inequality in Canada are needed to help urban planning practitioners make informed decisions on how best to balance economic, social, and environmental needs. Such research would also generate information, providing communities and organizations with quantifiable evidence that can be leveraged to invoke change. It is important that children, seniors, visible minorities, and socioeconomically disadvantaged populations do not continue to face compounding challenges by bearing the brunt of the negative impacts of goods movement-related truck traffic. This literature confirms that environmental inequity exists in Canada and indeed, that it is occurring along the Clark-Knight corridor. Although many principles on which environmental inequities have been identified point to different approaches to measuring inequity, in this study I focus on steps not taken by levels of government to address them. I present data that identifies that inequity is an issue, but do not seek to establish an equity-based framework through which to assess or analyze the issue.

2.3. Need for a paradigm shift towards sustainable transportation

According to Schiller & Kenworthy (2017) in their book titled, *An introduction to sustainable transportation: policy, planning and implementation,* markers of an unsustainable "business as usual approach" (Schiller & Kenworthy, 2017, p. 3) to transportation planning includes a tendency for transportation planning to occur in silos "disconnected from environmental, social and other planning areas," and a lack of consideration for "environmental and social equity impacts" (Schiller & Kenworthy, 2017, p. 252). This stems from a "lack of integrated planning, flawed policy-making and excluding effective public participation" (Schiller & Kenworthy, 2017, p. 14). Based on these markers, it becomes apparent that that transportation planning decisions along the Clark-Knight corridor takes place according to this business as usual approach and has not been done in a sustainable manner, allowing for the continued endangerment of the health of vulnerable and disadvantaged populations. This thesis research demonstrates how a lack of attention to the specific role of urban freight transportation within mobility planning and policy escalates concerns about the negative consequences of business as usual.

Schiller & Kenworthy argue that business as usual cannot be the way forward and a shift to a new sustainable transportation paradigm is needed. To describe

sustainable transportation, Schiller and Kenworthy rely on a definition developed by the Organisation for Economic Co-operation and Development which states, “an environmentally sustainable transport system is one where transportation does not endanger public health or ecosystems and meets needs for access consistent with use of renewable resources below their rates of regeneration, and use of non-renewable resources below the rates of development of renewable substitutes” (Schiller & Kenworthy, 2017, p. 12). This definition aligns with my research since it highlights what we need to transition towards, which is to move goods through the road network in a way that does not cause harms to human health and the environment, and through modes of transportation that largely use cleaner, renewable energy sources.

The shift towards the new sustainable transportation paradigm to make trucking and transportation practices more sustainable would be done through:

- **Integrated and coordinated policy-making** that successfully manages “cross-cutting issues in policy-making that transcend the boundaries of established policy fields” (Schiller & Kenworthy, 2017, p. 252).
- **Mobility management** that makes current goods movement practices more efficient through strategies such as land-use solutions or increased use of other transportation modes (Schiller & Kenworthy, 2017, p. 252)
- **Regeneration, repair, and renewal** of what has been degraded (Schiller & Kenworthy, 2017, p. 269)

Through this new paradigm, policies could be put in place to eliminate air emissions from heavy-duty diesel trucks, reduce truck traffic, reduce environmental inequity, and create healthier communities along the Clark-Knight corridor.

While there is a large range of research focused within urban studies related to the use of private automobiles, public transportation, and active transportation, a knowledge gap has been noted by researchers related to how urban freight transport intersects with “transport planning, land-use and wider urban planning” (Cui, Dodson, & Hall, 2015, p. 2). According to Cui, Dodson, & Hall (2015) in a review of literature and discussion paper, three key ways to empirically look at urban freight planning in order to incorporate this significant sector within the move towards more sustainable practices includes: 1) consideration of the relationship between urban freight movement and local communities, and how they impact each other 2) recognition of goods movement networks as not self-contained and detached but rather “a dynamic set of

interrelationships between the […] urban places they connect, traverse and are located within" (p. 13) and 3) the development of an understanding of the freight sector and the role of governance. My research is aligned with the aforementioned approaches and helps fill a knowledge gap related to how freight transport intersects with "transport planning, land-use and wider urban planning" (Cui, Dodson, & Hall, 2015, p. 2). Also noted in their article were institutional issues in urban freight planning, which include difficulties in considering a wide range of perspectives and stakeholders as part of meaningful engagement, jurisdictional issues between levels of government, and challenges in balancing private and public sector interests (Cui, Dodson, & Hall, 2015, p. 7, 8).

In the academic literature, there is agreement on the importance of integrated decision making across different areas of expertise and meaningful engagement with a wide range of stakeholders, including people who live along truck routes. This is particularly important since "many groups and interests often [get] left out of participation and policy-making in transportation because they are insufficiently organized, socially marginal or without voice unless championed by an interest group" (Schiller & Kenworthy, 2017, p. 238). According to Grant, Perl, and Knoepfel (1999) in *The Politics of Improving Urban Air Quality*, "what gets done about urban mobility and air quality depends on who participates in the public deliberations over objectives, instruments and institutional arrangements that fall under the definition of policy development" (Knoepfel, Grant, & Perl, 1999, p. 152). In the planning and development of truck routes and regulations in the Metro Vancouver region, there is a lack of representation of interests from residents, property owners, health authorities, and environmental organizations, which frustrates incorporation of these multiple, sometimes competing interests. According to Knoepfel, Grant, & Perl (1999, p. 159): "innovation will only succeed if policy actors have the [ability] to discriminate between competing private interests in pursuit of the public interest" (Knoepfel, Grant, & Perl, 1999, p. 159). The authors suggest that this could imply a need for multi-stakeholder forums that bring in a range of agencies and policy participants focused on achieving a balance between private and public interests. The diversity of perspectives articulated in such a process is a means to achieve the sustainable mobility paradigm transition advocated by Schiller & Kenworthy in that it would be a means to "integrate sustainable urban mobility objectives into

related, but otherwise autonomous, bureaucracies" (Knoepfel, Grant, & Perl, 1999, p. 158).

This body of literature provides me with the lens through which I assess unsustainable business as usual approaches to current practices and identify opportunities to adopt more sustainable transportation policymaking and trucking practices.

Chapter 3.

Research Design and methods

To answer my research question, I chose a qualitative, mixed-methods case study approach, focused on the Clark-Knight corridor. The primary case was studied through a review of government documents, news media coverage, and semi-structured interviews with key informants who have insight and information on air quality concerns and governance related to TRAP along the corridor. A contrast case on the Province of Ontario's DriveON Emissions and Safety Inspection Program, was used to disprove the conclusion reached by some in the case of the Clark-Knight corridor about the intractability of policy barriers to sustainable mobility. Although two cases are featured, the primary case remains focused on the Clark-Knight corridor.

3.1.1. Case study approach and selection

Of interest to me was developing an understanding of how the Clark-Knight corridor came to be one of the most polluted streets to live along in the region and why levels of government have not been successful in implementing programs and policies to improve air quality and in turn, reduce environmental inequity along the corridor. Considering this focus on the how, why, and on building an understanding of this real-world scenario, I determined that a case study approach that compares and analyzes multiple sources of data would be the best fit to answer my research question. By using this mixed methods approach and analysis of data from multiple sources, I felt that I could effectively piece together and validate the narrative and findings through triangulation and comparison to develop a comprehensive and accurate understanding, and add new insight to answering my research question (Yin, 2018).

The intent of this case study is to understand the barriers to sustainable mobility policymaking that exist in B.C. and that perpetuate unhealthy and environmentally unjust neighbourhood conditions along the Clark-Knight corridor. A single case study was considered sufficient to bring to light insights applicable to all arterial roads in the Metro Vancouver region and other urban areas in the Province of B.C. This focus also permits drawing inferences about the importance of considering both private and public interests,

the interconnections between transportation planning, land use planning, public health, sustainability, urban governance, economic development, goods movement, and in urban planning and policymaking.

As I worked through the data collection process for the Clark-Knight corridor, I discovered an opportunity to feature a contrast case, where I could examine approaches to managing air pollutant emissions from heavy-duty diesel trucks in Ontario. The Ontario case highlighted how the development of a mandatory emissions testing program could be possible within a Canadian context, and allowed me to draw further conclusions related to enabling and inhibiting factors. This case was also needed to disprove the conclusion reached by some in the case of the Clark-Knight corridor that policy barriers to sustainable mobility could not be overcome and provided validation of the inhibiting barriers that were identified to exist in B.C. Understanding that I could not conduct a case study on the same scale as I did for the Clark-Knight Corridor, I focused my data collection efforts on answering the question of how the Province of Ontario's DriveON Emissions and Safety Inspection Program was developed and implemented with mandatory emissions system testing requirements between 2018 to 2020. Specifically, I limited my focus to understanding whose idea it was, and how this came to fruition without strong opposition.

3.1.2. Document and content review

For the Clark-Knight corridor case, I reviewed publicly available documents produced between 2003 to 2022 by organizations with a role to play in land use planning, transportation planning, air quality, and the environmental regulation of heavy-duty trucks that were applicable to the Metro Vancouver region and Clark-Knight corridor. These documents further detailed in Table 1 included air quality strategies, plans, media releases, and reports from Metro Vancouver, Province of B.C., and Vancouver Fraser Port Authority; community plans, reports, and other council documents related to the Clark-Knight corridor available through the City of Vancouver; transportation planning strategies and environmental plans from TransLink and the Vancouver Fraser Port Authority; and regional land use plans from Metro Vancouver. For the Ontario contrast case, I relied on media releases issued by the Government of Ontario and Ontario Trucking Association that mentioned work to reduce emissions from heavy-duty diesel trucks along with program information on their website.

Table 1. Documents reviewed

Document	Source
Integrated Air Quality and Greenhouse Gas Management Plan (2011) Caring for the Air annual air quality report (2017-2022) Health Impacts of Diesel Exhaust fact sheet (2022) Media release related to heavy-duty diesel truck emissions (2013) On-Road Heavy-Duty Diesel Vehicle Program – Update and 2013 Work Plan (2013) Integrated Air Quality and Greenhouse Gas Management Plan Progress Report (2014) Short sea shipping in Metro Vancouver (2014) Toxic Air Pollutants Risk Assessment and Emissions Inventory for the Lower Fraser Valley (2015) Metro Vancouver Near-Road Air Quality Monitoring Study (2020)	Metro Vancouver
City of Vancouver Major Streets Plan (1929) Clark-Knight Corridor Whole Route Analysis (2003) Council minutes where the Clark-Knight corridor and truck traffic were mentioned (2003-2020) Secured Rental Policy (2022)	City of Vancouver
Media releases related to AirCare and other emissions-reduction measures for heavy-duty diesel trucks (2012-2019 Clean BC Roadmap to 2030 (2021)	Province of B.C.
Regional Goods Movement Strategy (2017)	TransLink
Media releases related to reducing emissions from heavy-duty diesel trucks (2014-2022) Project communications fact sheets for container terminal expansion projects (2017-2018) Trade statistics reports (2018-2020) Container traffic forecast (2021)	Vancouver Fraser Port Authority
Climate Leadership Plan Submission (2016) Media releases related to reducing emissions from heavy-duty diesel trucks (2012-2019)	BC Trucking Association
Media releases related to emissions testing for heavy-duty diesel trucks (2018-2020)	Government of Ontario
Media releases related to emissions testing for heavy-duty diesel trucks (2018-2020)	Ontario Trucking Association

Analysis of these documents was conducted to achieve the following:

- Establish a narrative of how government decision making through planning and policy decisions between 1929, since the release of the City of Vancouver's Major Streets Plan, to 2022 have led the Clark-Knight corridor to become one of the most polluted arterial roads

- Identify who has a role to play in policymaking related to the management of air emissions and truck TRAP in B.C. along with what interdependencies

exist between levels of government and government agencies through an assessment of the assigned roles and responsibilities within plans and the expectations held by policymakers who I interviewed

- Identify plans and strategies that were set or considered by levels of government between 2011 to 2022 to reduce truck TRAP-related health hazards for those who live along the Clark-Knight corridor
- Develop an understanding of the steps the Ontario Trucking Association and Government of Ontario took to ratify and implement a mandatory emissions testing program for heavy-duty diesel trucks between 2018 to 2020

Insights and information gaps noted from initial phases of document analysis also helped guide questions that I raised during semi-structured interviews.

3.1.3. News media articles

To gather data on community concerns, political dynamics, tension and how politicians and levels of government were working to improve air quality along the corridor, I analyzed news stories that referenced environmental regulation of heavy-duty trucks in B.C. and concerns about air quality and truck traffic along the Clark-Knight corridor. The date range of my search included news coverage from 2005 to 2021. I selected this date range to ensure I captured key developments related to air emissions initiatives related to heavy-duty trucks, which primarily took place between 2008 to 2016. I added extra buffers surrounding the period of intensified activity to capture data on policy dynamics and ongoing community concerns, and the reaction to air quality study data regarding the Clark-Knight corridor released in 2019 (Wang, et al., 2018; Southern Ontario Centre for Atmospheric Aerosol Research, 2019). For the Ontario case, I analyzed news stories that referenced environmental regulation of air emissions from heavy-duty trucks between 2018 and 2021 since that was around the time that the DriveON emissions and safety inspection program began to take shape. Keyword searches within Pressreader, Canadian Newsstream, and Google News were used to identify articles of interest.

3.1.4. In-depth, semi-structured interviews

In-depth, semi-structured interviews were also conducted to collect data that complemented information gathered through document and news media analysis. I chose to conduct interviews instead of surveys or structured interviews as part of my

mixed-methods approach because it allowed me to have more wide-ranging discussions, explore information more deeply, ask questions about information gathered from other sources, and gave interviewees an opportunity to “raise issues that [I had not] anticipated” (Martin & Flowerdew, 2014, p. 111). It also gave me access to undocumented perspectives about the barriers that exist, which would not have been possible if I relied solely on documents and news articles. I used a combination of purposive and snowball sampling. Interviewees with the following backgrounds were of specific interest:

- Elected officials or staff who have worked for or currently work for government/agencies with a role in air quality management
- Members of advocacy groups or individuals who have raised concerns about stricter environmental requirements for heavy-duty diesel trucks
- Members of advocacy groups or individuals who have raised concerns about air quality along the Clark-Knight corridor

Purposive sampling was used to ensure that the data I collected reflected the wide range of perspectives with a role to play in air quality management and environmental regulation of heavy-duty diesel trucks. Snowball sampling was also leveraged because support was needed from key informants to access their networks and contacts. For the Clark-Knight corridor case, interviews began with 9 contacts derived from publicly accessible sources such as LinkedIn and government directories. Snowball sampling occurred thereafter to help fill knowledge gaps and access contacts who I would not have access to if I were to solely rely on publicly accessible databases. Snowball sampling led to the generation of 9 additional contacts. For the Ontario case, I purposely chose to approach the director of policy and industry awareness programs with the Ontario Trucking Association because they would have been able to speak to their work with industry and Government of Ontario.

In the end, a total of 16 semi-structured interviews were conducted: 12 with key informants who have previously worked for or currently work within different levels of government or government agencies in B.C.; one resident who lives within 250 m of the Clark-Knight corridor; one citizen scientist volunteer who is working to actively improve air quality along the corridor; one representative from the trucking industry in B.C.; and one representative from the trucking industry in Ontario. Since the network of decision makers and stakeholders is small and because some preferred to keep their quotes as

anonymous, I have chosen to remove most attributions to quotes derived from interviews in order to protect the identities of those who did not want to have their names released.

Data collected from interviews were integral in my effort to answer the following elements of my research question:

- Identify barriers that constrain sustainable transportation policymaking and trucking practices, and how it has contributed to TRAP-related inequity along the corridor
- Identify enabling factors that allowed the Government of Ontario and Ontario Trucking Association to work together to ratify and implement mandatory emissions testing for heavy-duty diesel trucks
- Inform recommendations to improve policy and planning regarding TRAP in the Metro Vancouver region to help enable a sustainable shift, and help create healthier homes and built environments along truck routes and arterial roads

3.2. Analytical approach

Since my case study relied heavily on reconstructing narratives related to the Clark-Knight corridor and air quality governance, data collection was primarily done by creating a timeline of activities that were categorized and coded within Excel. Both inductive and deductive codes were used in analysis. To make sense of current planning and policy practice, I assessed them against principles derived from literature related to sustainable transportation and urban mobility policymaking to assess opportunities to help make planning and policymaking more sustainable. This informed the creation of deductive codes to determine how planning and policy related to truck TRAP along the Clark-Knight corridor is taking place and what economic, social, and environmental factors were considered or not considered in the process. Through this lens, opportunities to improve were analyzed along with barriers that constrain sustainable transportation policymaking and trucking practices, and how it has contributed to TRAP-related inequity along the corridor.

To better understand the narrative of how planning and policy change progressed, and the political barriers that reinforce a business as usual approach and prevent a sustainable shift in transportation practices, I also use the following approaches and work from the field of policy studies to unpack the dynamics created by industry lobbying efforts to oppose more stringent environmental policies and regulation:

- **Kathryn Harrison (1996)'s assessment of the federal and provincial role in the development of Canadian environmental policy** to understand the role of electoral incentives in a democratic government's decision-making process to pursue or not to pursue developing more stringent environmental policies

- **Gregory C. Unruh (2002)'s Carbon lock-in model** to help deconstruct how policy action to push the trucking industry towards a sustainable shift has been "inhibited by techno-institutional lock-in" (p. 320)

Through this analytical framework, I was not only able to identify the barriers that exist, but also their root cause. It also provided me with an effective means to explain why the ratification and implementation of a mandatory emissions testing program was possible in Ontario but not in B.C.

Chapter 4. Case and context

This chapter situates the Clark-Knight corridor against the urban context that makes this truck route more than merely just a street but also a place of tension between regional economic interests and those of the local resident community. This is done by highlighting the corridor's significance to the cargo economy and supply chain logistics, the local community residents, local concerns about urban freight movement, and the structures that play a role in regulating urban air quality and heavy-duty trucks. The chapter also covers background information on the trucking industry in Metro Vancouver, including their ability to create economic disruption through organized work stoppages. Analysis and detailed discussion of the identified barriers that inhibit the development of stricter environmental regulations to reduce air emissions from heavy-duty diesel trucks will be covered in Chapter 5.

4.1. Metro Vancouver region: a dense and growing metropolitan centre and port city

The Metro Vancouver region is the CMA with the second highest population density in Canada and is home to 2.59 million people, over 50% of all British Columbians (Metro Vancouver, 2021d, p. 91; Statistics Canada, 2016). The region is also home to the City of Vancouver, which is the census subdivision with the highest population density in Canada with 5,493 residents per square kilometre (Statistics Canada, 2016; Daily Hive, 2021; Metro Vancouver, 2021). These numbers are expected to grow as a result of increasing urbanization and immigration. Even with "short term shocks and uncertainties such as the one presented by COVID-19," the region expects to see a population increase of over 1 million residents by 2050, to a projected 3.85 million people – people who will need to move around as part of their daily lives to work, play, and access goods and services (Metro Vancouver, 2021, p.54; TransLink, 2017).

Metro Vancouver is also home to Canada's largest port, which plays a key role in connecting the nation to international markets and supporting the local and national economy. As trade through the Port of Vancouver continues to increase, so too will the volume of goods that get moved by truck and rail. Directly impacting the region's transportation networks are the movement of shipping containers by truck and rail that

hold imported and exported goods. According to 2018 data from the Vancouver Fraser Port Authority, shipping container quantities that moved in and out of the port totalled 3,396,449 TEUs and were made up of 1,014,949 individual import containers and 924,799 individual export containers. Specific to import containers, approximately 63% (639,418) of shipping containers that arrive to the Port of Vancouver (imported) get directly put onto trains headed east and 37% (375,531) get moved by truck through the regional road network destined for local markets or transload facilities (Vancouver Fraser Port Authority, 2021a; TransLink, 2017). Although no data was accessible regarding the percentage of export containers that arrive to local terminals by truck, the import container breakdown gives a sense of magnitude.

To plan for forecasted trade growth, the port authority is actively working on increasing container capacity at the Port of Vancouver to be able to move more containers through the Metro Vancouver region and claims that "Canada's west coast ports will run out of space to handle container traffic by the mid- to late-2020s" (Vancouver Fraser Port Authority, 2021, para. 2). Current plans to increase container capacity at the Port of Vancouver are listed in Table 2.

Table 2. Container terminal expansion projects at the Port of Vancouver

Name of terminal	Location	Type of development	Capacity	Completion
Centerm Container Terminal	Vancouver (South shore)	Expansion	Adds 600,000 TEUs to existing 900,000 TEUs	Approved and underway, to be completed in 2022
Vancouver Container Terminal	Vancouver (South shore)	Terminal efficiency and other upgrades	Adds 215,000 TEUs to existing 835,000 TEUs	Approved and underway
Roberts Bank Terminal 2	Delta	New shipping container terminal	Adds 2.4 million TEUs	Project pending, awaiting completion of federal government environmental review in early 2023

(Daily Hive, 2020; Vancouver Fraser Port Authority, 2017; Vancouver Fraser Port Authority, 2021c; Journal of Commerce, 2019)

Of direct interest to my research question are container capacity projects at Centerm and Vanterm container terminals in Vancouver along the south shore of the Burrard Inlet depicted in Figure 2 below, which will directly increase the amount of container truck movements along the Clark-Knight corridor. Whether Roberts Bank Terminal 2 gets approved will also impact whether more expansion projects will take place on the south shore because it contains “one of the few port locations [in the Metro Vancouver region] that could accommodate more container capacity” (Vancouver Sun, 2021, para 12). The port authority has publicly acknowledged their intentions to repurpose land currently leased to non-container shipping operations on the south shore for the handling of containers to help meet future needs if the Terminal 2 project does not go ahead (Vancouver Fraser Port Authority, 2021; Vancouver Sun, 2021).

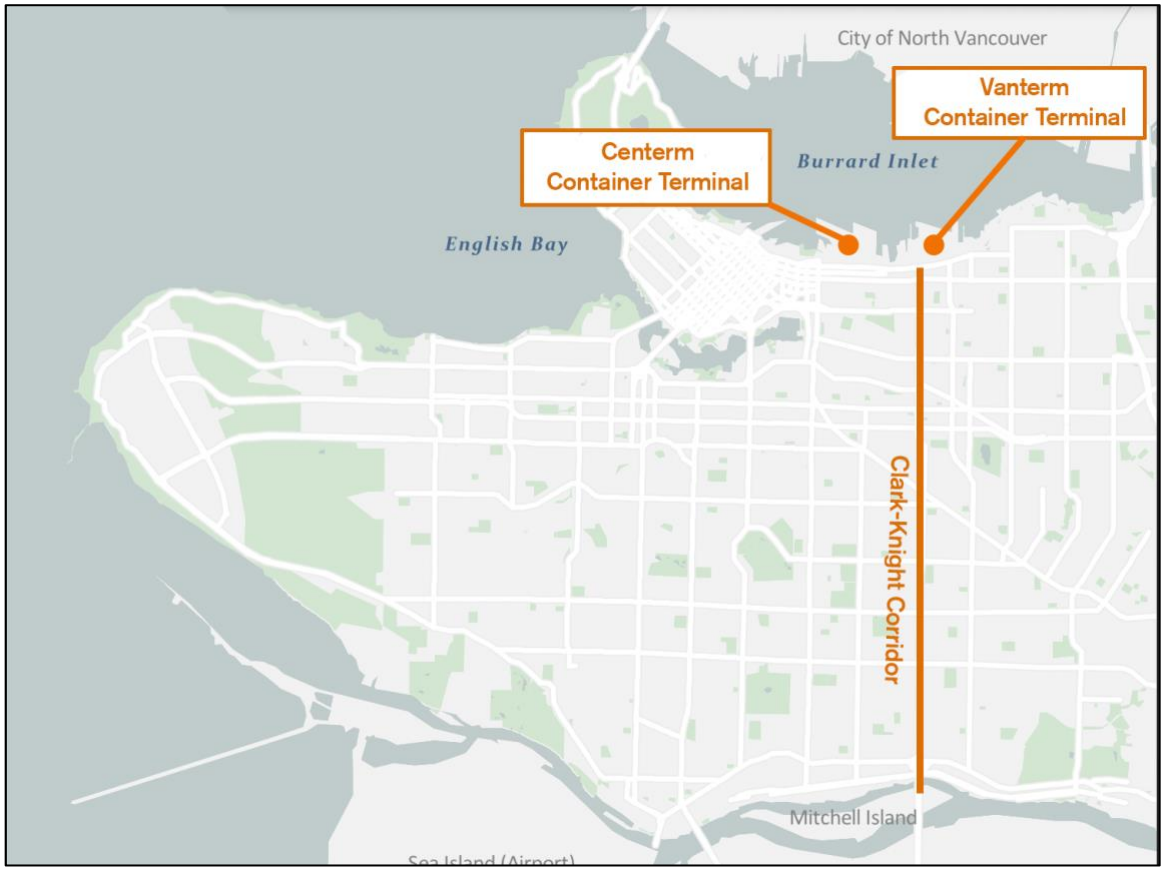

Figure 2. Locations of Centerm and Vanterm Container Terminals
Adapted from "VanMap“ by City of Vancouver, n.d.

Based on a truck traffic impact assessment completed in 2016 for the Centerm Expansion Project, container truck traffic along the Clark-Knight corridor within a 23-hour

period is forecasted to increase by 53%. Non-container truck traffic such as from employee and service vehicles are also forecasted to increase by 121%. In the case of Vanterm Container Terminal, no truck traffic impact assessments or forecasts were found for capacity-building upgrades. Based on these trade projections, container truck movements along the Clark-Knight corridor are expected to dramatically increase by at least 53% with the Port of Vancouver's plans to add capacity and move more containers through the region. As heavy-duty truck traffic volumes increase along the Clark-Knight Corridor, TRAP will also intensify.

4.2. Role of major road corridors for goods movement in and out of ports

Although waterfront port terminals physically begin and end along the water's edge, the freight that moves through the port relies on an intricate supply chain network of major roads, railways and other transportation infrastructure to be moved to the port for export or away from the port towards their final destinations. According to the Canadian federal government, major road corridors such as the Clark-Knight corridor are part of Canada's gateways and trade corridors, comprised of the "roads, marine ports, rail terminals, and airports" that connect "British Columbia and Canada to the United States, Asia, and the world" (Government of Canada, 2020, TransLink, 2017, p. 2). In the context of the Metro Vancouver region, the network is referred to as the Greater Vancouver Gateway, which is a part of the Asia–Pacific Gateway and Trade Corridor that make up the supply chain network across Canada's four western provinces (B.C., Alberta, Saskatchewan and Manitoba) (Transport Canada, 2020, Greater Vancouver Gateway Forum, n.d.). There is consensus amongst government and related agencies that the fluidity, efficiency, reliability, and effectiveness of this network strengthens Canada's competitive position as a trading nation and Metro Vancouver's "role as a trade portal is critical to the viability of our national and provincial economies" (Transport Canada, 2020; Translink, 2017, p. 2).

While some view large trucks barreling down major streets as an eyesore, they play a role in supporting a quality of life that most expect within a large city. From delivering fresh produce to stores to supporting construction to moving local wines bound for export markets, transportation networks involving light and heavy commercial trucks help keep goods, services, and the economy moving. Major road corridors are

integral to both the behind-the-scenes industries that need to move goods to and from the port and a growing urban population that has "spurred increased demand for goods and services" (Translink 2017, Cui, Dodson, & Hall 2015, p. 3). However, Cui, Dodson, & Hall (2015, p.6) iterate that urban freight movement "can often result in conflicts between economic demands on the one hand, and social and environmental goals of communities on the other hand". This conflict is reflected in the lived experience of corridor residents and in the positioning of the region's role in urban freight movement to support the 'greater' economic good to promote a sense of pride and national significance, and justify the negative impacts of trade. This is problematic because the "benefits and costs of [trade and urban freight movement] are unevenly distributed" (Hall, 2018, p. 6). Hall argues that:

> Although the gateway has proven to be a compelling metaphor, it is subject to challenge when it is perceived to focus too much on remote hinterland interests to the exclusion of those who make the (urban) gateway their home. In the greater Vancouver case, local non-transport and non-cargo interests, especially municipal, community and environmental interests have felt excluded… They have complained that the "gateway" makes them a "doormat" (Hall, 2018, p. 11).

4.3. The Clark-Knight corridor

The Clark-Knight corridor is "the most heavily used truck route in the [City of Vancouver]" (City of Vancouver, 2003, p. 3). The corridor is a north-south connection that runs down the middle of the city, "extending eight kilometres from Burrard Inlet to the Knight Street Bridge across the Fraser River" (City of Vancouver, 2003, p. 10). It is a "key regional connection between Vancouver and Richmond, Delta, Surrey, and the United States" (City of Vancouver, 2003, p. 3).

4.3.1. Role in the major road network and as a major truck route since the opening of the Knight Street Bridge in 1974

Within the Metro Vancouver region, there are three types of roads: local roads managed and maintained by municipalities, provincial highways managed and maintained by the Province of B.C., and the Major Road Network (MRN) managed as a partnership between TransLink and local municipalities. Roads within the City of Vancouver that make up the MRN are displayed in blue within Figure 3. The Clark-

Knight corridor highlighted in purple within Figure 3 is one of many designated truck routes within the MRN, which “includes 675 kilometers of major arterial roads that carry commuter, transit, and truck traffic” across the Metro Vancouver region (TransLink, 2021). These roads have regional importance and are key transportation routes, connecting “the provincial highway system with the local road network” and play a key role in the movement of people and goods (TransLink, n.d., para. 7).

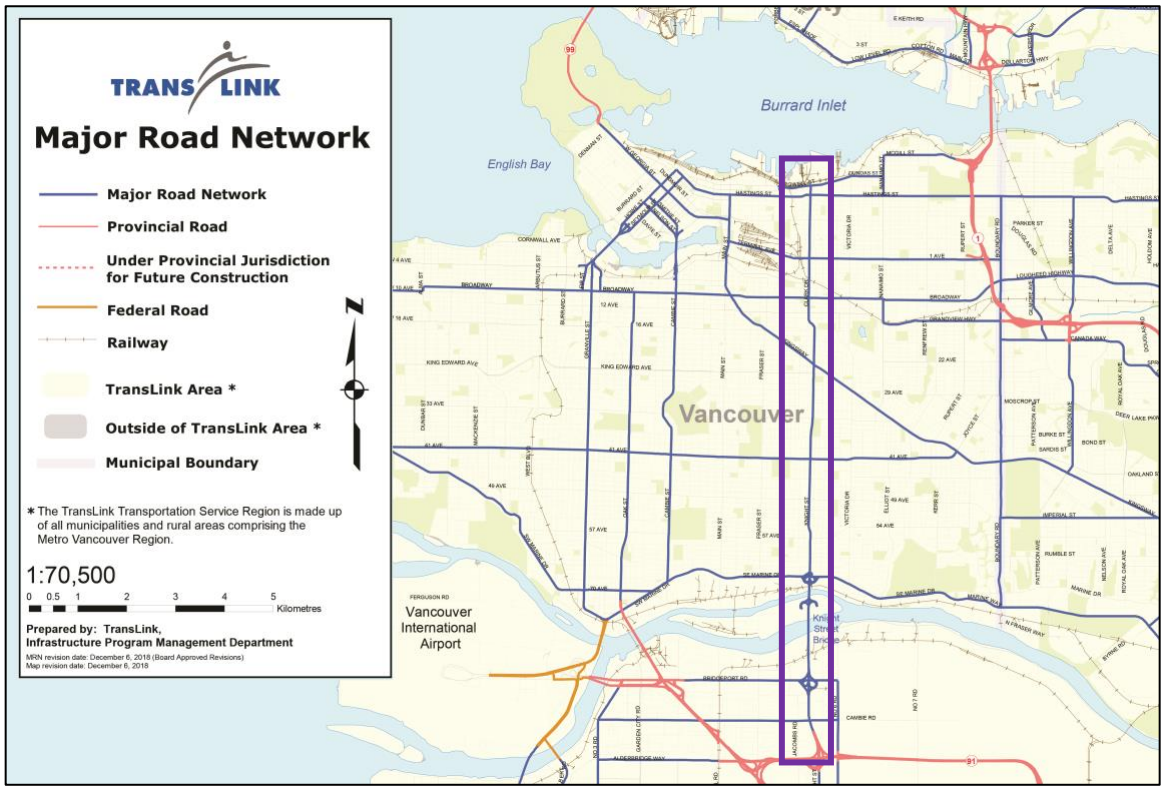

Figure 3. The Major Road Network, Provincial Highways, and Municipal Road Networks (in the City of Vancouver)

(Translink, 2017, p. 14)

TransLink maintains strategic planning oversight and “contributes funding for the on-going operation, maintenance and rehabilitation of the Major Road Network while ownership and operational responsibility remains with the respective municipalities” (TransLink, 2021, para. 8). For example, if a municipality wanted to make a change to an MRN road running through their city that would impact or prohibit the movement of trucks, the request would go through TransLink’s review process and be presented to the TransLink Board of Directors for a final decision (Anonymous informant A, TransLink 2017, p. 24). Although TransLink does not directly operate and maintain the roads, it

“has a broad mandate to provide a regional transportation system that moves people and goods and supports the regional economy” (TransLink, 2017, p. 4)

From a regional perspective, heavy use of the Clark-Knight corridor by heavy-duty trucks is due to its “strategic position linking the port and industrial areas on the north side of the City [of Vancouver] with industrial areas in south Vancouver, Richmond, Delta, Surrey, and beyond via Highways 91 and 99” (City of Vancouver, 2003, p. 11). However, “it was not until the opening of the Knight Street Bridge in 1974 that the corridor became a prominent regional roadway. (City of Vancouver, 2003, p. 13).

The Knight St. Bridge was built to replace the Fraser Ave. Bridge and with its opening, came opportunities for industry to expand and grow during a time when the vacancy of prime industrial land was dwindling. In a study completed by Levesque (1974) titled, *Impact of the Knight St. Bridge on Allocation of Industrial Land*, it was found that industrial land “consumption [in the Metro Vancouver region] is heaviest in areas containing at least two of the following features: proximity to a regional roadway, an industrial park, and an area intermediate between the regional core and the periphery” (Levesque, 1974, p. 4). During the time leading up to the development and opening of the bridge, Levesque observed that industrial land consumption “closely paralleled development with the [regional roadway system] and that industrial development opportunities near existing roadways were almost exhausted (Levesque, 1974, p. 4).

> “The region is on the verge of a new era of industrial land development in the periphery. Within this context the lands around the new bridge have a particular significance. Their industrial potential is displayed in the existence of all three features mentioned above. In addition, the potential for expansion of this industrial area offers the only location for expansion within the intermediate zone. This makes the land all the more valuable for industry.” (Levesque, 1974, p. 4)

This pattern of industrial land development in the City of Richmond is reflected in the map displayed in Figure 4.

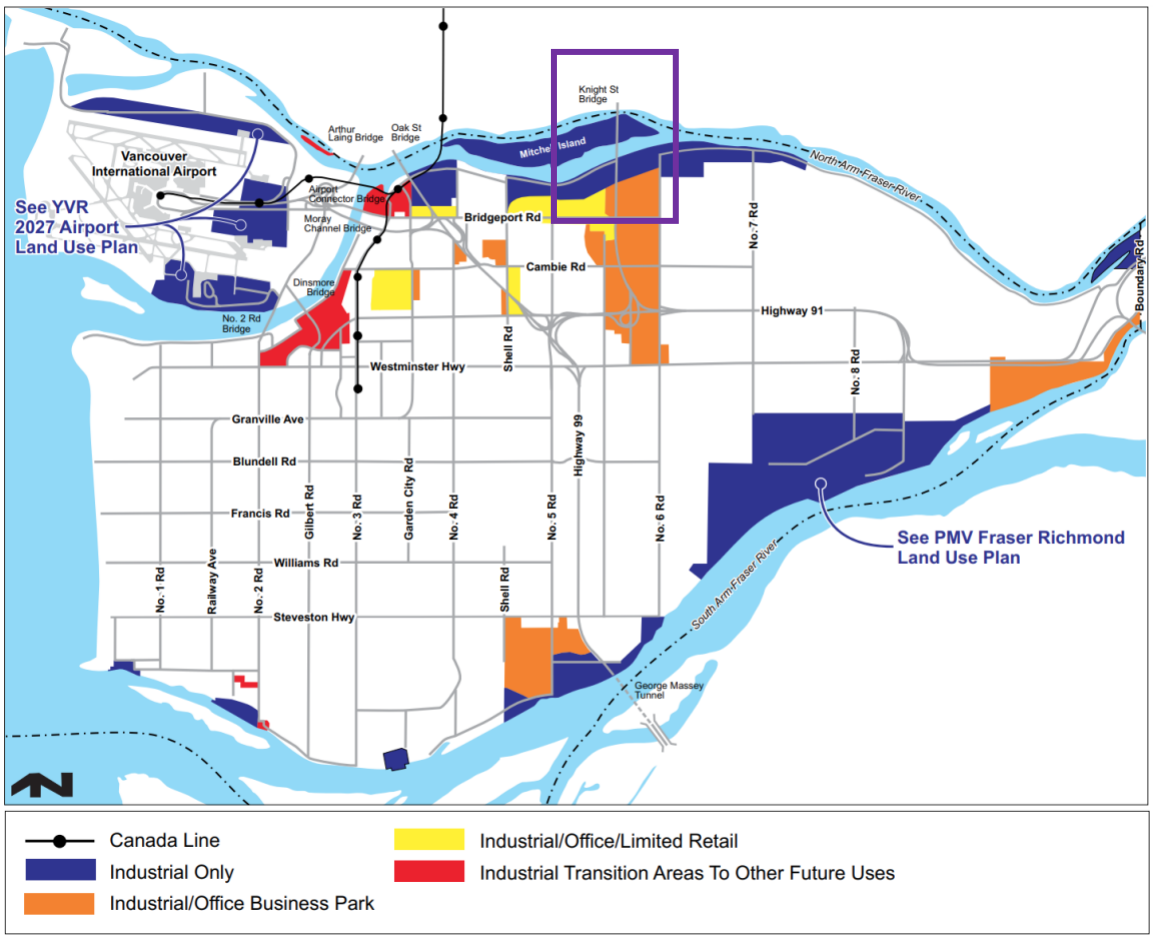

Figure 4. Industrial lands in the City of Richmond

(City of Richmond, 2020, p. 26)

Before the opening of the Knight St. bridge, access to the lands in the immediate area surrounding the bridge and eastwards was less direct and limited due to weight restrictions on the Fraser Ave. Bridge and congestion issues in the area partly caused by the existing bridge span that needed to open to allow vessels to pass through the Fraser River. The new bridge highlighted in purple within Figure 4 above relieved those issues and provided road users with direct and efficient access to and from the City of Vancouver. For truckers, it also meant better connections with south shore container terminals, trade-related businesses in industrial areas south of the Fraser River and other major regional roadways and provincial highways. With the opening, traffic flows shifted from Fraser St. to Knight St. and more trucks began to use the Clark-Knight corridor as a more direct and efficient route (Levesque, 1974; City of Vancouver, 2003). “The subsequent openings of the Alex Fraser Bridge and the Richmond Freeway

(Highway 91) further reinforced Knight's role as a major regional goods movement and traffic arterial" (City of Vancouver, 2003, p. 13)

4.3.2. Significance to the supply chain and local economy

As a port city and home to Canada's largest port, the local and national economy relies on the movement and processing of goods efficiently through the Metro Vancouver region, and these types of truck trips are part of a larger supply chain network that businesses across Canada depend on to bring in the goods that they need or expand their business through international trade. Today, the Clark-Knight corridor sees the highest truck traffic volumes of all roads in the City of Vancouver and continues to play a major role in helping keep people and our regional and national economy moving. Based on present land uses and logistics, these trips along the corridor are a necessary part of business operations. Although light and heavy-duty trucks associated with other industries also use this corridor, heavy-duty container trucks are "the largest generator of truck trips on the corridor" due to its connection with two major container terminals located on the South Shore of the Burrard Inlet, Centerm and Vanterm Container Terminals (City of Vancouver, 2003, p. 16). Many of these truck movements are related to container trade and logistics-related services such as "warehousing and trading operations" (City of Vancouver, 2003, p. 16). These "services [also] include stuffing/destuffing, cleaning/repair and storage" which are usually located away from the port in Richmond, Surrey, Burnaby, and Coquitlam (City of Vancouver, 2003, p. 16). With respect to container storage, "the majority of containers are stored either at Mitchell Island or in Delta due to limited container storage at the port and the proximity of Richmond to three of the most major port container terminals in the region," Vanterm and Centerm Container Terminals, and GCT Deltaport Container Terminal (City of Vancouver, 2003, p. 16).

This reliance on urban freight movement through the region will continue to grow as the port authority works to increase container capacity and both federal and provincial governments look to increase export trade opportunities through trade agreements with other countries, particularly those overseas. The most relevant and recent example of this is through the Comprehensive and Progressive Agreement for Trans-Pacific Partnerships (CPTPP) that came into force in December 2018. These agreements are part of Canada's export diversity strategy, which states an ambitious goal to "achiev[e]

50% more overseas exports by 2025" (Government of Canada, 2020, para. 1). Similarly, the B.C. provincial government and other Western Canadian provinces share this vision to support export growth to build a strong economy and create jobs. Examples of exported Canadian goods that move in shipping containers include craft beer and wine, forestry products, and agri-food products to name a few (Province of B.C., n.d., Vancouver Fraser Port Authority, 2018). According to the port authority, one container that moves through the port represents "over $500 in wages, almost $1,000 in GDP, and almost $2,000 in economic output" (Vancouver Fraser Port Authority, 2018, p. 11). As a sector, the import and export of containerized goods through the Port of Vancouver supports local 26,500 jobs, $1.66 billion in wages, $2.83 billion in GDP, and $5.81 billion in economic output (Vancouver Fraser Port Authority, 2016, p. 34).

4.3.3. Land uses and residents who live along the corridor

Although the north end of the Clark-Knight corridor between the Port of Vancouver and 7th Ave. are zoned and primarily used for industrial purposes, residentially zoned areas for single detached homes and duplexes has historically made up much of the land use along the corridor from 7th Ave to 64th Ave (City of Vancouver, 2003a). "Schools, parks, small-scale commercial areas, and a community centre" can also be found scattered along the route (City of Vancouver, 2003a, p. 3). This is unlike other arterial roads in the City of Vancouver where there is more commercial development and pedestrian foot traffic. According to the City of Vancouver's (2003a) Clark-Knight Corridor Whole Route Analysis:

> The pattern of development on Knight Street is largely a consequence of it never having been a streetcar route, unlike Fraser Street to the west or Victoria Drive to the east. As such, the street was not fully built-up until the 1960s and commercial development was limited and more automobile-oriented.
>
> The opening of the Knight Street Bridge in 1974 redirected traffic from Fraser to Knight and led to the traffic volumes experienced today. While Knight does not have heavy traffic conflicting with heavily used pedestrian-oriented commercial areas, as on Kingsway, the street lacks the activities and appearance that help to make other arterials more characteristic of urban streets. (City of Vancouver, 2003a, p. 6)

This provides historical context regarding the urban street design and further provides insight on the intended use of the corridor for regional transportation needs:

> Since the 1920s, the Clark-Knight corridor has been designated as a major regional transportation corridor. The 1929 Vancouver Major Streets Plan established the current 24 m wide right-of-way to accommodate a six lane road. The regional importance of the corridor was secured in 1974 when the Knight Street Bridge to Richmond was built to replace a 1905 bridge at Fraser Street. This new link provided a direct connection to the Vancouver Port lands and resulted in a major shift of regional traffic from Fraser Street to Knight Street. The [residential] land uses along Knight were already well established by the time the bridge opened. The opening of the Alex Fraser Bridge in 1986, with its link to Knight Street via Highway 91, further reinforced the importance of Clark-Knight in the regional network. (City of Vancouver, 2003a, p. 4)

Figure 5 below showing a map of the 1929 Major Streets Plan identifies the intent to create a new major street connection, connecting Knight St. to the City of Richmond.

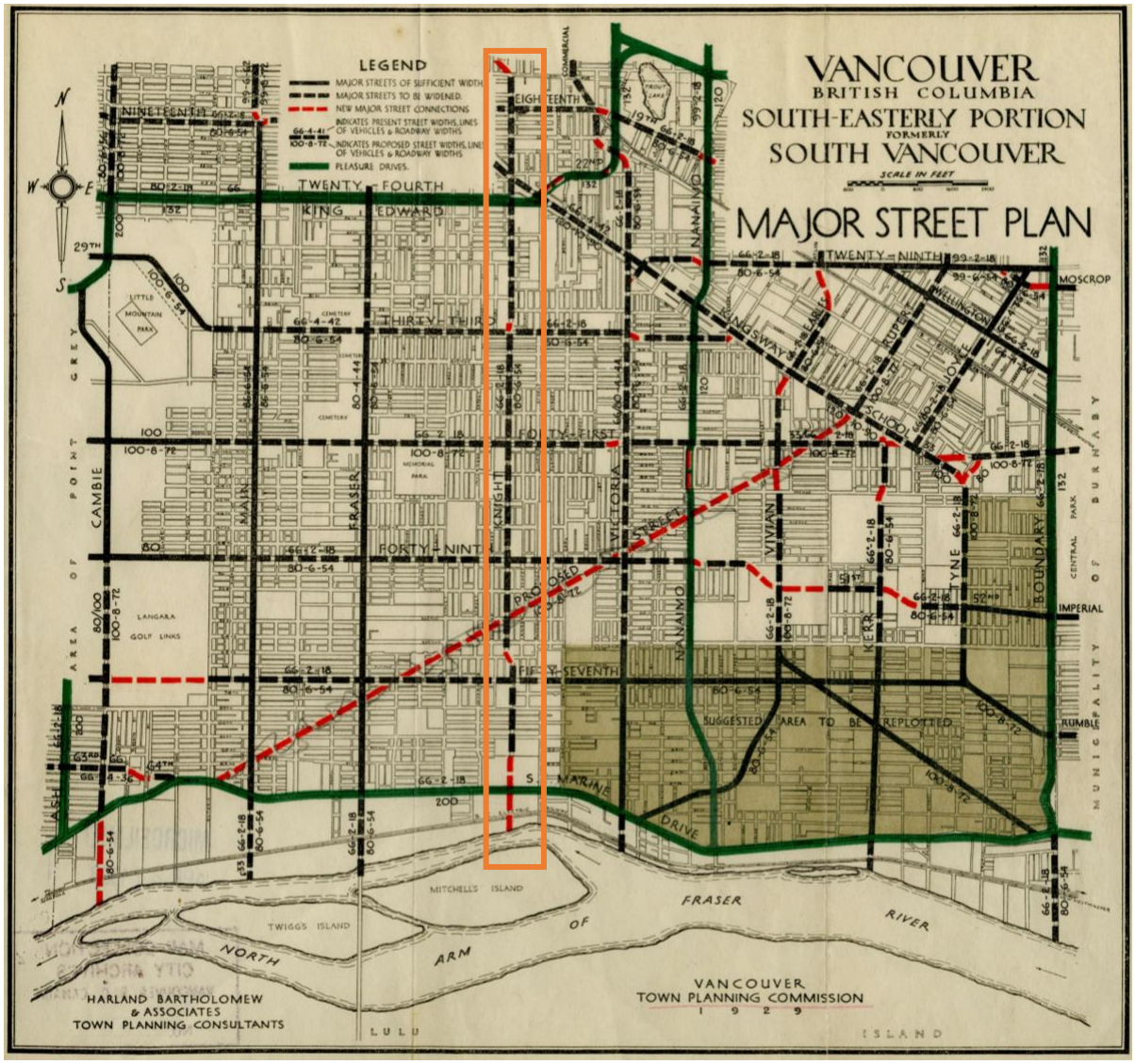

Figure 5. 1929 Vancouver Major Streets Plan

City of Vancouver Archive: AM1594-: MAP 774

Intended as a six-lane arterial road and as a place for residents to live and play, and for families to grow, it is not surprising that reconciliation would be needed between the street's transportation function and neighbourhood liveability (City of Vancouver, 2003a).

As part of the Housing Vancouver Strategy released in 2018 to increase affordable rental housing and a City of Vancouver decision in 2019 to approve rental housing zoning policies that would allow for the streamlining and fast tracking of rental building developments, future land uses along the corridor and other arterial roads will involve further densification of housing. In areas currently zoned as residential directly

along arterial roads, market-rental buildings up to five storeys will be allowed and up to six storeys will be allowed if the composition includes at least 20% below market rentals. For areas 150 metres off arterial roads, rental buildings of up to three to four storeys will be allowed (City of Vancouver, 2022). Figure 6 outlines areas where these policies will apply in blue:

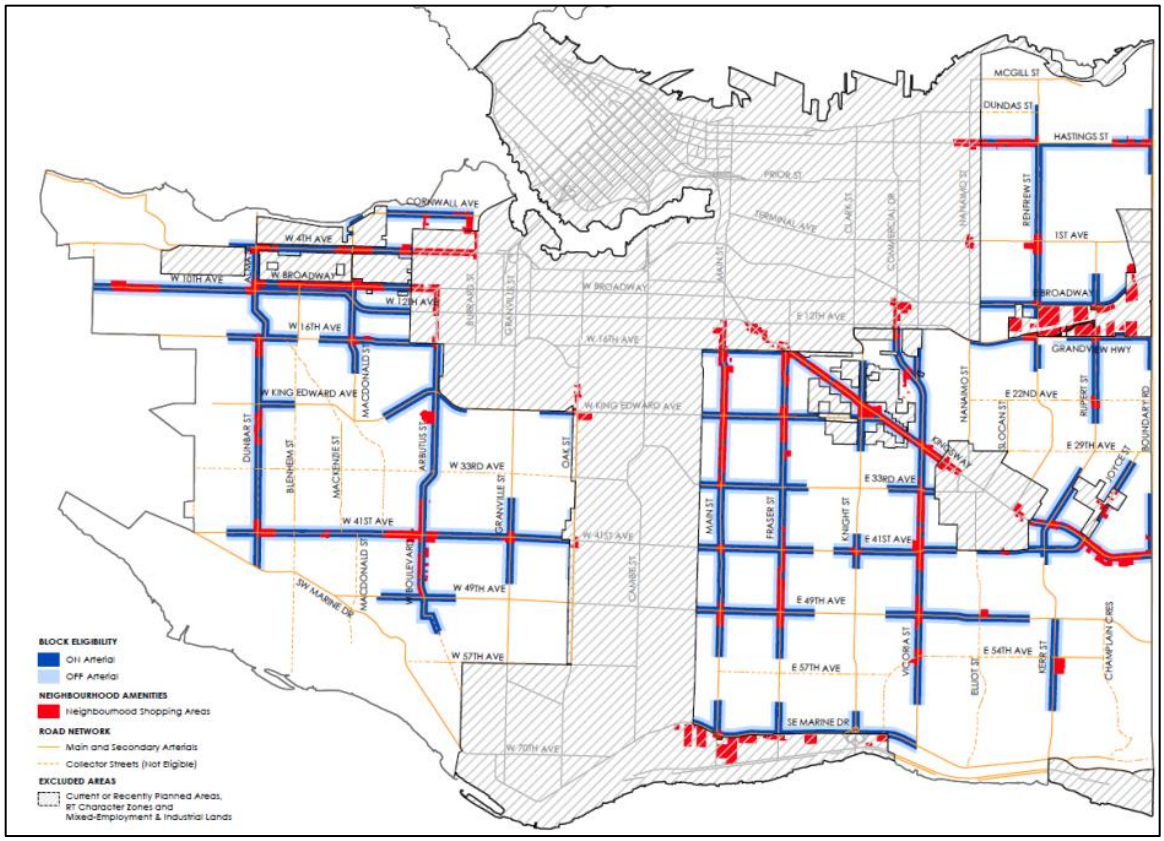

Figure 6. City of Vancouver Eligibility Map for Increased Density On and Off Arterials

(City of Vancouver, 2022a, p. 13)

At the outset of my research, draft eligibility maps released by the City of Vancouver in June 2020 included eligibility areas that included much of the area along the Clark-Knight Corridor (City of Vancouver, 2020b). However, in the final eligibility map released in 2022, the areas were reduced along the corridor. When asked about the reasons for what led to the amendment, city staff answered to explain that this was done in response to “concerns regarding displacement of existing renters from the public and Council” and the fact that these areas “contain much higher proportions of existing rental

homes as well as protected heritage properties and character homes" (M. Espina, personal communication, July 28, 2022). The map featured in Figure 7 depicts the density of purpose-build rental buildings and renter populations within the City of Vancouver and shows the Clark-Knight Corridor as an area with a higher density of renters. The red box within Figure 7 represents the 500 m TRAP exposure zone along the corridor.

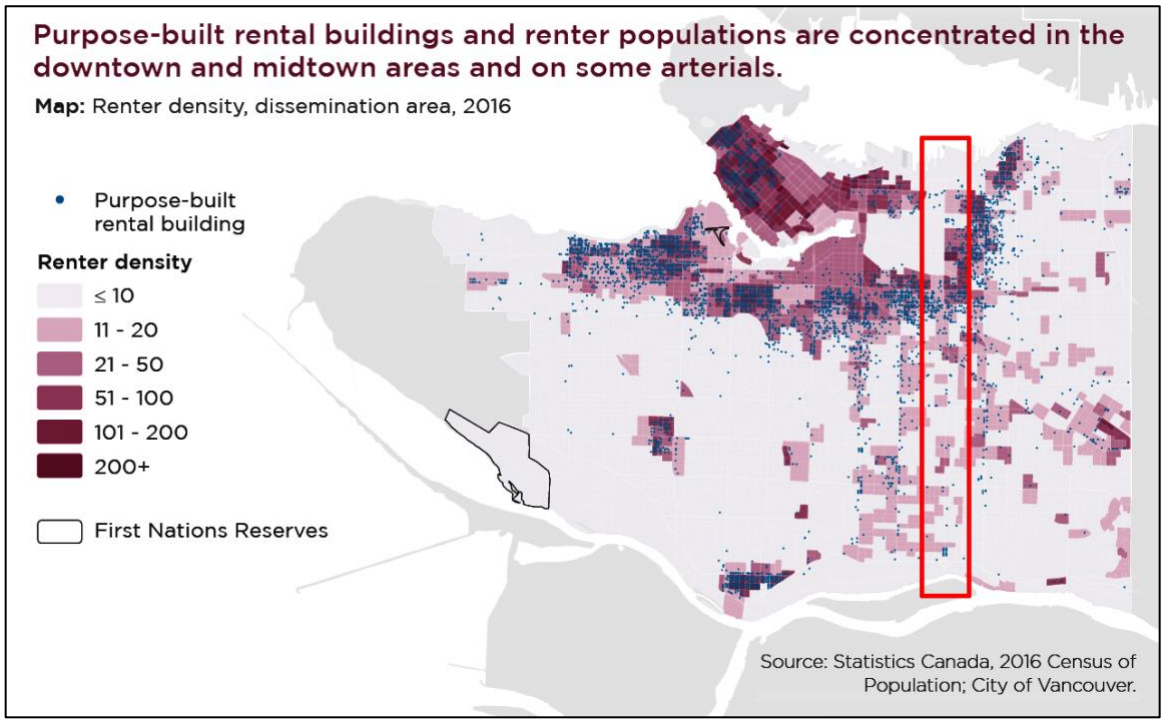

Figure 7. Renter density in the City of Vancouver based on 2016 Statistics Canada census data

(City of Vancouver, 2022c, p. 10)

Despite the amendment, changes brought on through the Secured Rental Policy will still bring more people to live within TRAP exposure zones along arterial roads through densification, particularly a higher proportion of those who rent and those who rely on below-market rental housing (City of Vancouver, 2022b). Renter households in Vancouver also tend to be lower income with a median income of $50,250, which is 23% less than the city-wide median household income of $65,327 (Statistics Canada, 2016). According to data compiled by the Neighbourhood Change Research Partnership within Figure 8, the TRAP exposure zone surrounding the Clark-Knight Corridor is predominantly home to lower income populations.

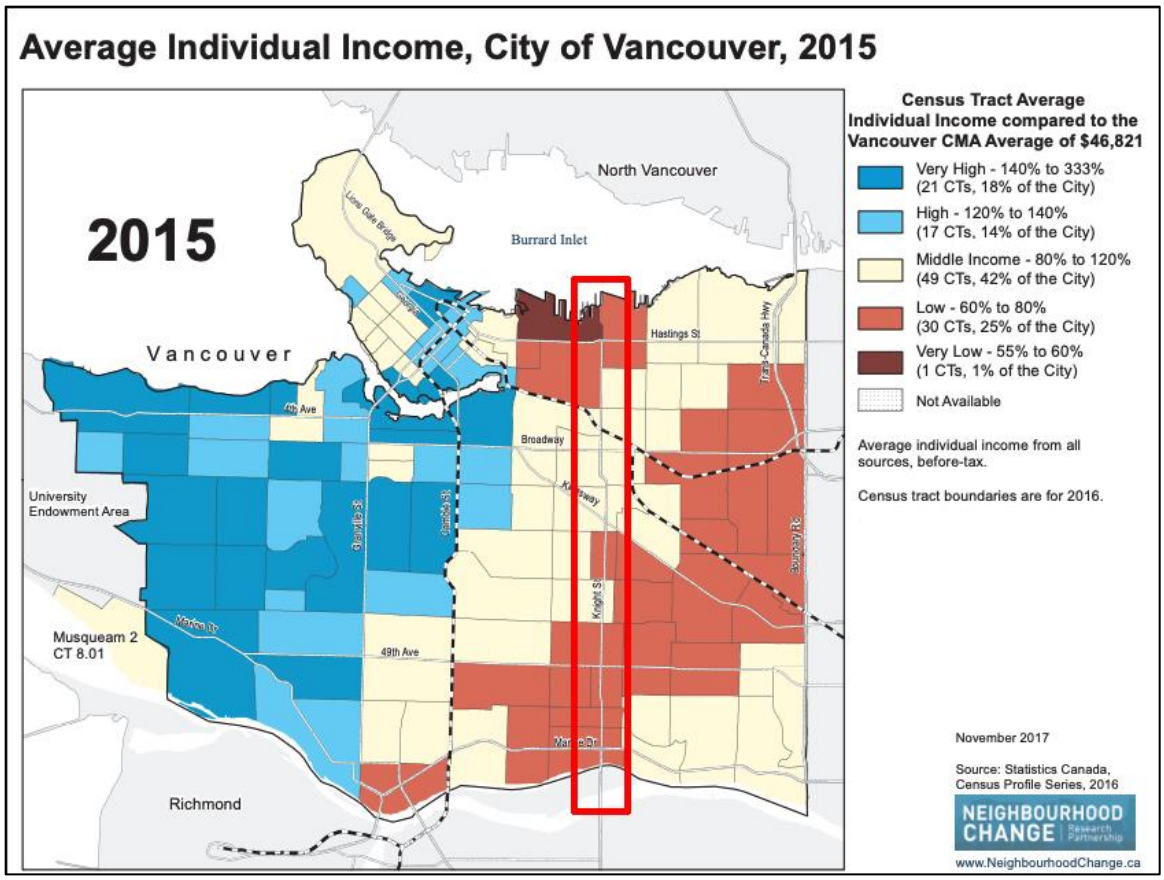

Figure 8. Average individual income in the City of Vancouver based on 2016 Statistics Canada census data

(Neighbourhood Change Research Partnership, 2017)

Not only are residents along the Clark-Knight Corridor more likely to be lower income, but census data also reveals that the TRAP exposure zone surrounding the corridor is home to a higher density of toddlers and visible minority groups. Figure 9 depicts the concentration of visible minority populations in the City of Vancouver and Figure 10 depicts the number of toddlers per km^2, which reveal higher densities of children surrounding the corridor and other arterial roads. Since the Clark-Knight corridor is primarily made up of residences, schools and daycares, this is especially concerning as TRAP and the frequency of truck traffic has been linked to new cases of asthma, asthma exacerbation, and chest congestion in children (Brauer et al., 2012).

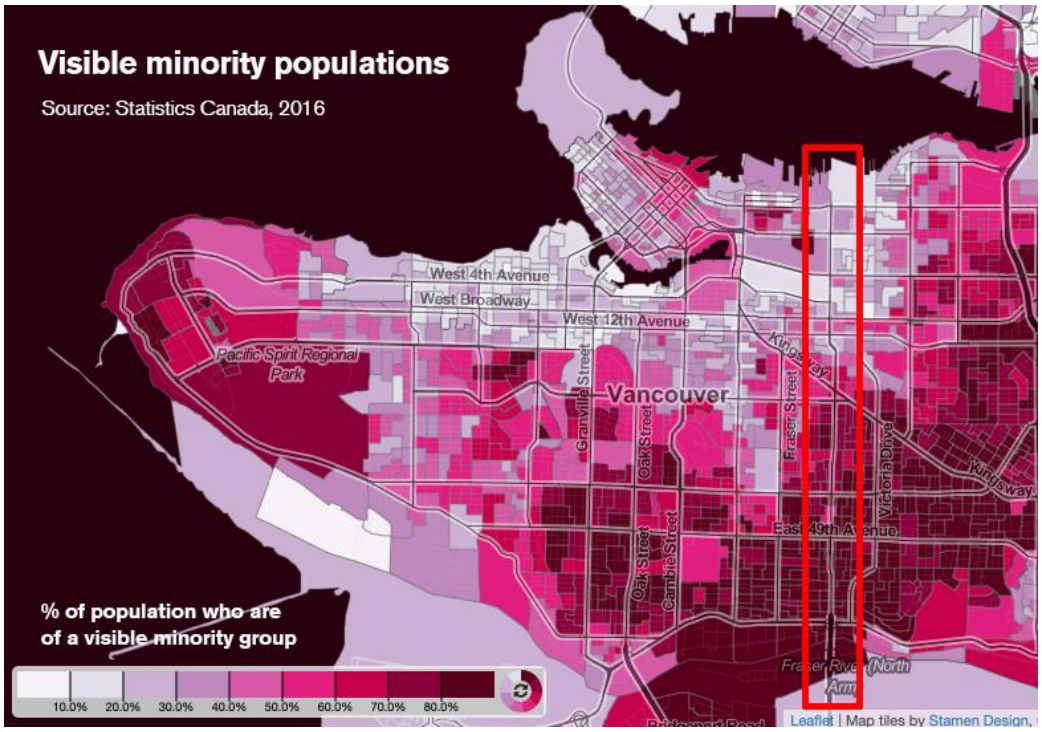

Figure 9. Concentration of visible minority residents in the City of Vancouver
(Statistics Canada, 2016)

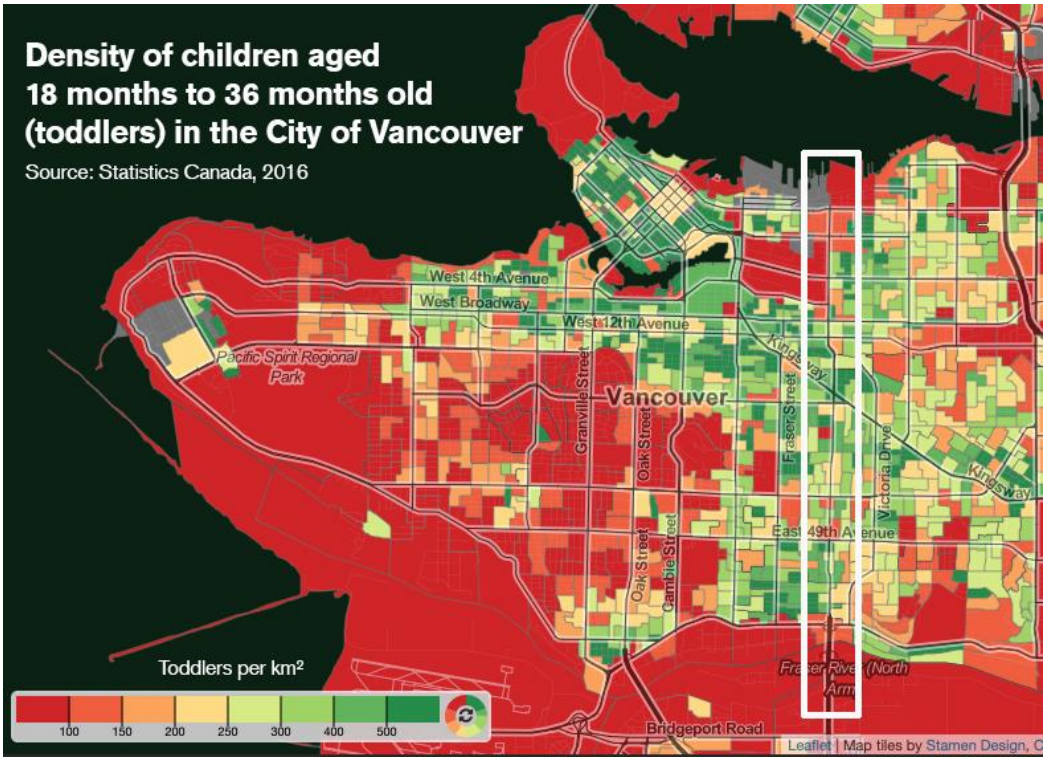

Figure 10. Toddlers per km² in the City of Vancouver

(Statistics Canada, 2016)

This data shows that plans to increase residential density along the Clark-Knight Corridor and other arterial roads, particularly with a higher density of renter populations will increase inequity by exposing more visible minority groups, children, and lower income populations to TRAP.

During the City of Vancouver's consultation process for the Secured Rental Policy, "respondents expressed equity concerns about geographic concentration of purpose built rental housing along busy arterial streets with higher noise and air pollution levels [and] many renters expressed a desire to live in secure rental housing on local streets" (City of Vancouver, 2020a p. 139). While the policy would allow for more density both directly on arterials and one block in from arterials (approximately 150 metres in from the arterial), this would still place rental housing within TRAP exposure zones along the corridor. As one of the most polluted streets to live along in the City of Vancouver and potentially the Metro Vancouver region, census and research data suggests that exposure to harmful TRAP along this corridor from older, heavy-duty trucks is inequitable and is exposing more vulnerable communities to environmental burdens.

4.3.4. Air quality related to heavy-duty diesel trucks

Due to the corridor's proximity to residential land uses that surround this truck route, livability and public health issues are concerns for residents (Anonymous informant B; Anonymous informant D; City of Vancouver, 2003a). As mentioned in Chapter 2, a study led by University of Toronto researchers in 2018 showed that air pollution levels along Clark and Knight St. "were close to levels seen beside Highway 401, despite the road carrying less than one-tenth of the vehicle traffic" (Wang, et al., 2018). In comparison, Highway 401 is known as the busiest highway in North America and measurements for the study were taken at the "busiest stretch of highway in North America with annual average daily traffic reported at 411,600 vehicles" (Southern Ontario Centre for Atmospheric Aerosol Research, 2019, p. 27). Their study concluded that TRAP, particularly from trucks with older diesel engines indicated by measures of black carbon and nitrous oxides, was the cause of poor air quality along the Clark-Knight corridor (Southern Ontario Centre for Atmospheric Aerosol Research, 2019). Figure 11 below shows the measured concentrations of nitrous oxides and compares it against the proposed Canadian standard. Measures were taken from the Clark-Knight corridor truck route, Highway 401 in Ontario, and downtown Toronto.

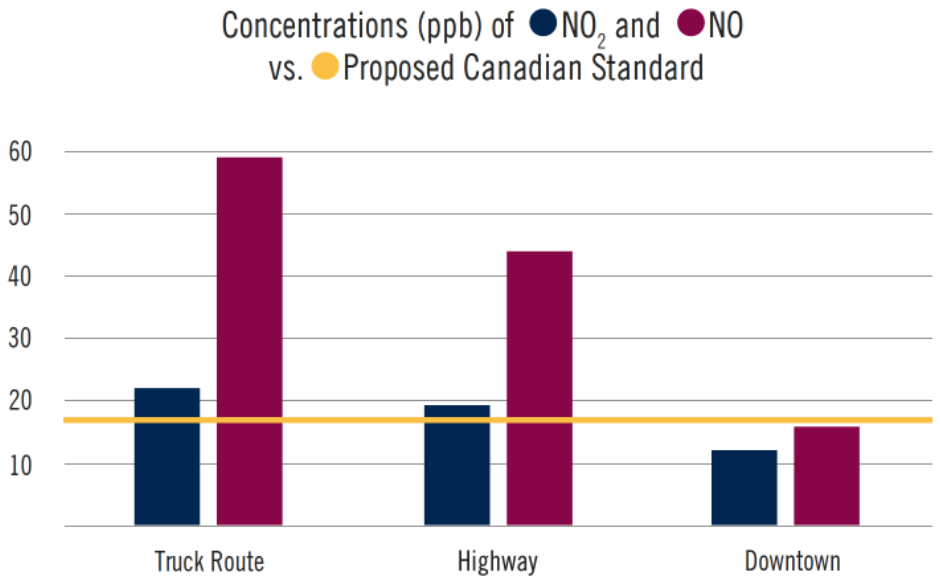

Figure 8. The hourly averaged nitrogen oxide data for 2015–2017 indicates that excessive exposure to diesel exhaust is occurring at some sites. Reductions in emissions will be required to achieve the 2020 Canadian ambient air quality standard for NO_2 of 17 ppb, indicated by the yellow line.

Figure 11. Measured concentrations of nitrous oxides along the Clark-Knight corridor ('Truck Route'), Highway 401 ('Highway'), and downtown Toronto ('Downtown')

(Southern Ontario Centre for Atmospheric Aerosol Research, 2019, p. 9)

The Clark-Knight St. near-road monitoring station used by the study was put in place in 2015 through a collaboration between researchers and the Metro Vancouver Regional District and remains in place today as a long-term monitor. Previously, no air quality data was being collected along the corridor. Beginning in 2017, Metro Vancouver began publishing annual averages in their annual Caring for the Air report. Findings of the study were consistent with Metro Vancouver Regional District's annual Caring for the Air reports, which identifies the location as being one with consistently higher levels of air pollutants due to influence from traffic emissions. The Clark-Knight corridor was one of the only locations to fail annual average air quality objectives set by the regional district in 2017. When compared with Canadian Ambient Air Quality Standards set federally to protect human health and environment, measures of harmful nitrous oxide emissions at the location in 2017, 2018, and 2019 consistently exceeded the 17ppb maximum. 2020 levels were within standards at 16 ppb but it is not clear whether reduced traffic volumes due to the COVID-19 pandemic was a factor that reduced air pollutant emissions. In each of these reports, the source of nitrous oxides was identified as traffic-related sources. Measures of PM 2.5 along the Clark-Knight corridor were only available from 2018 onwards and in 2018, 2019, and 2020, annual daily averages all exceeded Canadian standards. Mentioned reasons for exceedances include impact from traffic sources, wildfires, wood burning, and stagnant air weather conditions (Metro Vancouver, 2017; Metro Vancouver, 2018; Metro Vancouver, 2019; Metro Vancouver, 2020).

NITROGEN DIOXIDE IN 2019

Figure 12. Nitrogen Dioxide in 2019

(Metro Vancouver, 2019)

Note: Circle identifies the location of the air quality monitor along the Clark-Knight corridor.

FINE PARTICULATE MATTER ($PM_{2.5}$) IN 2019

Figure 13. Fine Pariculate Matter (PM2.5) in 2019

(Metro Vancouver, 2019, p. 16)

Note: Circle identifies the location of the air quality monitor along the Clark-Knight corridor.

Measures of black carbon captured in Figure 14 that are directly correlated with the amount of older heavy-duty diesel trucks was particularly troubling:

> There is no [Canadian] standard or guideline to govern exposure of the public to black carbon. The Netherlands has proposed an exposure standard [of 1.4 µg/m-3] for workers. This standard corresponds to a lifetime risk of lung cancer 400 cases in 100,000 people, much higher than the 1 in 100,000 risk-factor often used to establish allowable exposure in industry. Moreover, standards for public exposure are generally much lower than those for workers as some members of the public are more vulnerable. The average concentrations of black carbon at [the Clark-Knight truck route] exceeded this standard [of 1.4 µg/m-3] (Southern Ontario Centre for Atmospheric Aerosol Research , 2019, p. 9).

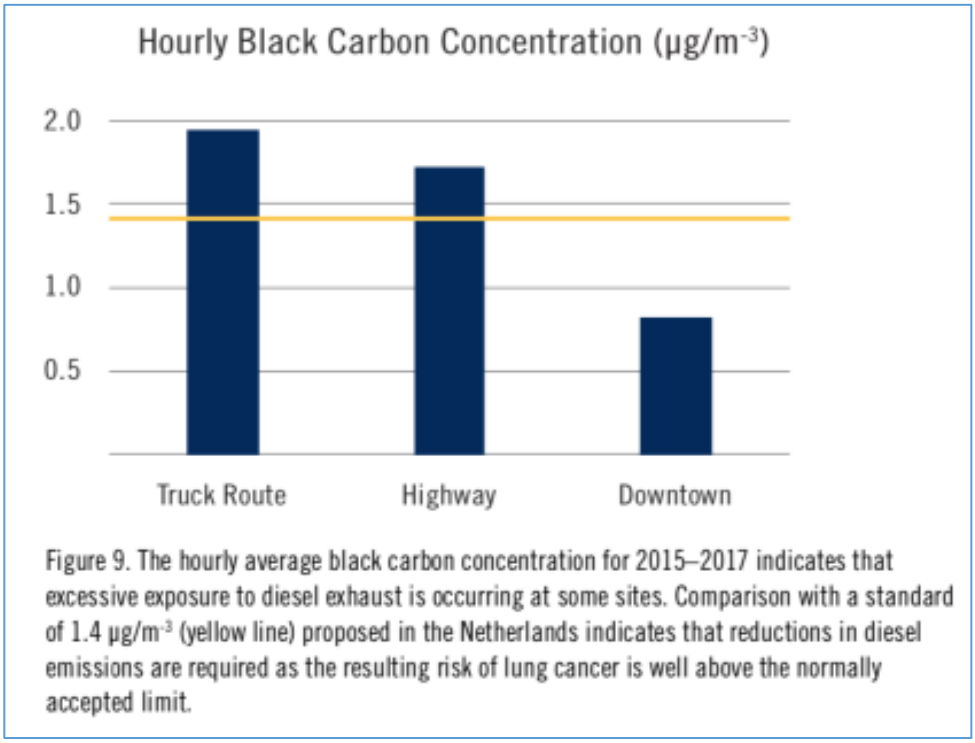

Figure 9. The hourly average black carbon concentration for 2015–2017 indicates that excessive exposure to diesel exhaust is occurring at some sites. Comparison with a standard of 1.4 µg/m-3 (yellow line) proposed in the Netherlands indicates that reductions in diesel emissions are required as the resulting risk of lung cancer is well above the normally accepted limit.

Figure 14. Hourly black carbon concentrations along the Clark-Knight corridor truck route, Highway 401, and downtown Toronto

(Southern Ontario Centre for Atmospheric Aerosol Research, 2019, p. 9)

Currently, Metro Vancouver does not report on levels of black carbon in their annual report. Key informant interviews confirm that there is room for improvement and opportunities to increase transparency in how levels of government report on air quality data.

> You might have come across a report from Health Canada, which focused on the costs of air contaminants. I have an air quality background and I looked at that report and I thought, “They only assessed a couple of air pollutants.” It doesn't take into account, for example, diesel particulate matter. Like that's probably an underestimate of the true impact and it's significant.
>
> There have also been toxic air pollutants risk assessments commissioned by Metro Vancouver. It is kind of in the public realm, but you really have to dig for it. The reason I mention it, and it might sound a little bit out of context is that those are examples of reports that studied not just criteria air contaminants. You've probably been doing lots of reading on nitrogen oxides and sulfur oxides in particulate matter, et cetera. This one looked at, diesel particulate matter such as 1-3 butadiene, benzene, like all sorts of these other air toxics that aren't commonly monitored and measured, but can have very serious health effects. I'm going to really over generalize here because it depends on the pollutant, but a lot of them are carcinogens, versus the criteria air contaminants that are more often attributed to respiratory and cardiovascular symptoms. Anyway, the reason I'm getting into all of these studies is that I believe both the 2007 and then the 2014, [2015, and 2016] updated versions all found that by a large, large margin, the [toxic air pollutants,] out of the hundred or so studied that pose the greatest risk to human health and are quite a bit above what we considered the background acceptable rate was diesel particulate matter (Anonymous informant B).

Their statements reveal that Health Canada’s estimate of 15,300 annual premature deaths attributable to exposure to air pollution in Canada is very likely understated. In addition to regularly monitored PM2.5, NO2 and ozone, there are other toxic air pollutants related to heavy-duty diesel trucks that aren’t commonly monitored and measured that can also have very serious health effects. These include other chemicals such as benzene, formaldehyde, and 1-3 butadiene, which are known carcinogens and associated with incomplete combustion of fossil fuels. These chemicals are also not regularly monitored and reported through Metro Vancouver’s Caring for the Air report (Sonoma Technology, 2015). According to a toxic air pollutants risk assessment conducted by Sonoma Technologies for Metro Vancouver in 2015, diesel particulate matter and chemicals related to incomplete combustion of fossil fuels was found to be a major concern and responsible for 67% of the lifetime cancer risk from air pollution in Metro Vancouver (Metro Vancouver, 2022):

> Diesel particulate matter poses far and away the highest cancer risk associated with toxic air pollutants, with a risk range at ten times higher than the remainder of the pollutants studied and larger than the sum of the cancer risks from all the other toxic air pollutants combined. The remainder

> of the top 10 includes a number of pollutants associated with incomplete combustion of fossil fuels or wood (benzene, formaldehyde, 1-3 butadiene, wood smoke PM, naphthalene), and three metals predominantly from fugitive dust and industrial emissions. (Metro Vancouver, 2015, p. 3)

Canadian Ambient Air Quality Standards for PM2.5, ozone, sulphur dioxide and nitrogren dioxide are determined by a "[federal]minister-led intergovernmental forum for collective action on environmental issues" (Canadian Council of Ministers of the Environment, 2022, para. 1), and are set to become more stringent in 2025 with stricter targets for ozone, sulphur dioxide and nitrogen dioxide (Canadian Council of Ministers of the Environment, 2022). It is not clear how the region will achieve target standards if more is not done to ensure cleaner emissions from heavy-duty trucks. The forecasted growth in truck traffic along the corridor due to container terminal expansions and increased demand for goods and services from a growing urban population will also pose challenges to reducing toxic air pollutants and achieving air quality standards for nitrogen dioxide and fine particulate matter (Vancouver Fraser Port Authority, 2016).

University of Toronto researchers also found that temperatures play a factor in poor air quality. Cold weather during winter months increased amounts of nitrous oxides from heavy trucks emitted near roads by up to 400% in -15 degrees Celsius compared to milder days in Toronto along Highway 401. Based on more realistic temperatures in Metro Vancouver, a change from 10 degrees Celsius to -5 degrees Celsius could mean an approximately 300% increase in nitrous oxides. These findings suggest that "the emission treatment systems on diesel vehicles may not function as effectively under cold winter temperatures" (Southern Ontario Centre for Atmospheric Aerosol Research, 2019, p. 10). It was not mentioned whether this applied to older or newer heavy diesel trucks, or both, but these findings called into question the efficacy of the newer truck models that are often touted as much cleaner combusting. Their findings also align with the *Remote Sensing Device Trial for Monitoring Heavy-Duty Vehicle Emissions* done by Metro Vancouver in 2013 where emissions from heavy-duty vehicles were analyzed. Metro Vancouver concluded that the region faced an issue of "gross emitters" related to emission control system malfunction and tampering.

> These are the dirtiest vehicles contributing a disproportionately high amount of emissions per kilometre compared to a vehicle of the same age and type. The study found that the dirtiest ten per cent of the vehicle fleet emitted four to five times more nitrogen oxides and diesel soot and eleven times more carbon monoxide than a properly operating vehicle of the same

> model year. Many of these “gross emitters” have problems with their emission control systems, which can be repaired to improve emissions performance. (Metro Vancouver, 2013, p. 2)

Aftermarket tampering of emission control systems on heavy-duty trucks have been reported to be a prevalent in issue in both B.C. and Ontario where mechanics claim that benefits of bypassing emission control systems on newer trucks include “promises [of] better fuel mileage, more horsepower and an end to expensive maintenance bills” (Trucking News, 2013, p. 3; Envirotest Canada, 2013). “Roadside inspectors can use a regular opacity test to spot those who bypass a diesel particulate filter. But the latest emission [control]-related changes have focused on reducing invisible and odorless nitrogen oxides. The only way to efficiently and quickly determine if an electronic control module has been reprogrammed to bypass such rules is to use a scan tool” (Today's Trucking, 2018, p. 7). Unfortunately, in B.C. data does not exist to show how widespread the use of tampering and delete kits are on heavy-duty diesel trucks but according to industry experts, it’s rampant across the industry for trucks both new and old.

> Nobody knows how many trucks are deleted but it’s a problem across North America. At some point in time, an owner of a truck will take it to a shop to either have all the emissions controls equipment removed, the engine control module reflashed or reprogrammed, or they’ll just deactivate it all. Why do they do it? It improves their reliability and it increases fuel economy by five to twelve per cent. […] Also, in colder climates once you move past Hope, trucks are deleted because of problems with idling time and reliability. […] Anything running in the north has been deleted because if it’s not, the thing is going to run for five days and be in the shop for two. Like, literally, it’s that bad. In cold weather, the system gets jelled up, gummed up, and it just doesn’t work, so they rip the stuff off. They rip it off when the truck is new when industries use the trucks up north and then where does it go? When the truck doesn’t get used anymore, it comes off the highway fleet [gets sold and resold], and then all of a sudden, it’s a regional truck running around Metro Vancouver. (Anonymous informant C)

With no mandatory checks in place, such aftermarket activities nullify federal government environmental requirements for newer trucks and highlight that checks and balances are key to reducing air pollutant emissions from heavy-duty diesel trucks.

4.3.5. Community concerns and activism related to air quality

Over the span of at least two decades, community concerns regarding the impacts of living along a busy truck route have been well documented in government reports, city council minutes and news coverage. Specifically, there are two key time periods where community concerns and action took place to raise awareness on air quality issues along the corridor. The first period is between 2003 to 2005 when attention was heightened on air quality along with other issues. In response to community concerns and a recommendation within the 1997 City Transportation Plan, the City of Vancouver commissioned a Clark-Knight Corridor Whole Route Analysis in 2003 that assessed “key land use, transportation and environmental issues” in a holistic manner (City of Vancouver, 2003b, para. 3). Highlighted issues focused on truck traffic volumes, air quality, noise, public health impacts and road safety for cyclists, motorists and pedestrians. Based on the report, a Clark-Knight corridor Plan was developed by the City of Vancouver to help address noise and road safety. While the plan mentioned air quality, it deferred those responsibilities to Metro Vancouver and the Province of B.C. who has jurisdiction over air quality (City of Vancouver, 2003; City of Vancouver, 2005).

During the development of the plan, public statements and a petition were presented to the City’s Standing Committee of Council on Transportation and Traffic in 2005 that called for action to address community concerns related to air quality, safety, truck traffic volumes, land use conflicts, and noise. Suggestions from the public included intersection safety improvements, increasing greenery, banning cycling and parking during peak traffic hours, and converting land use along the corridor from residential to light industrial. At the end of a public meeting on March 29, 2005 where these statements were shared, “[city] staff agreed to provide a memo back to Council regarding options for a grade separated trucking route along the corridor and potential funding from the Port and other levels of government, as well as information from the Health Authority’s Environmental Health office on air quality assessment and impact of motor vehicle emissions along Knight Street” (City of Vancouver, 2005).

The second period is between 2019 and 2020, triggered by the release of air quality data regarding the Clark-Knight corridor by University of Toronto researchers. The study’s findings were covered extensively by the media with published news stories

in the Daily Hive, CBC, The Globe and Mail, Vancouver Courier, and The Star. Although it did not trigger a large community outcry or organized community action, it did inspire a city councillor and community resident to take action. It inspired City of Vancouver Councillor Jean Swanson to put forward a motion with follow up actions that focused on working with the health authority, school board, municipal planning staff, Union of BC Municipalities and all other levels of government to investigate potential mitigation measures and advocate for the adoption of more sustainable trucking practices. Potential mitigations mentioned within the motion that are within the city's jurisdiction focus on potential changes made to zoning and planning practices, building codes, and protection from future housing development (Swanson, 2019). However, no mitigations or changes were introduced following Jean Swanson's attempts to raise the profile of air quality concerns.

It also inspired East Vancouver resident Trefor Smith to act. Beginning in 2017, he corralled a group of concerned citizen scientists -- volunteers who contribute scientific data to public research -- who live near the Clark-Knight corridor and port industrial area to begin work in getting involved in the port authority's Centerm Container Terminal Expansion Project public engagement process (Dickinson, 2012). Their key concern was how "the expansion of the Centerm Container Terminal and the resulting increase in truck, train and ship traffic would impact our local air quality" (Strathcona Residents Association, n.d.). They highlighted the fact that there were no air emissions monitoring or mitigation planned despite the project's potential to result in double the amount of air pollutants associated with the movement of goods through the terminal, spoke up on increased air pollutant emissions from truck traffic, and called for a more stringent environmental review process for the project that would also involve a Province of B.C. environmental review -- more than just the port authority's own permitting process.

Although the Province of B.C. ended up exempting the project from its environmental review process, the group was successful in influencing the Province to issue a condition for the Centerm Expansion Project to develop an air quality management plan. The release of the University of Toronto near-road study findings and corresponding Metro Vancouver report at the time helped create a heightened sense of urgency regarding project impacts to air quality and increased truck traffic, which led to media coverage highlighting their concerns (Vancouver is Awesome, 2019). As of 2022, the group of citizen scientists remains active and has completed a community survey

and received a grant from the port authority to develop an air monitoring network within the Strathcona community, located immediately west of Clark Dr. just south of Centerm and Vanterm container terminals (Anonymous informant D).

For the purposes of gaining an insider's perspective on what it's like to live along the Clark-Knight corridor, I spoke with a former resident who had lived within one block of Knight St. and 11th St. for 11 years between 2009 and 2020. With a young family at the time, Mr. C (adjusted for privacy reasons) moved to the area in 2009 and at first, the trucks didn't bother him in a major way but as time went on, concerns about air pollution and noise from heavy-duty trucks intensified.

> I started to really notice or mind the noise and pollution around 2011 or 2012. The vibrations were literally window shattering. Even when the windows were closed, you'd know when the trucks were starting and going. The loudest noise came from the trailers with no containers on them. If the trailers have no container on them, they're very light. Their springs are fully extended and with every little imperfection in the road, it's like steel beams chattering in the same way your teeth do when you're absolutely freezing.
>
> With the pollution, you'd be able to see it and smell it if you went walking, cycling, or had your window open. You would also see it on anything that was outside. Anything that was white would be covered in black pretty quick. It got so bad that we stopped using our vegetable garden and kept our windows closed as much as we could in the summertime even when it was hot. You'd have to make a choice. Do we open the window to get cool air and suffer from the noise and pollution from trucks or do we keep the windows closed but endure the heat? (Mr. C, 2021)

Although Mr. C wasn't aware of any community activities to raise awareness on the issue, he did write to the Province of B.C., his elected member of parliament and member of the legislative assembly outlining his concerns. He did not receive a response. Finally, in 2020 during the COVID-19 pandemic that forced him and his family to spend more time at home, they decided that it was the last straw.

> We now live four blocks [or approximately 550 m] away from the corridor and it's been a big improvement. While working from home at our previous house, there was no rest from it all and I felt constantly abused by it. (Mr. C, 2021)

When asked about why he thinks more residents haven't banded together to push for change over the years, Mr. C says he believes language barriers were a factor but that he remains hopeful for change to take place along the corridor.

> I think there are a lot of folks who are maybe new to Canada who don't feel they have as much of a voice. You've got a very multicultural mix, particularly further south along the corridor. I'm actually quite hopeful that things will change though. I'm seeing more densification as single family homes get assembled into multi-family properties. The number of people being negatively impacted by truck traffic is increasing and it's going to reach a critical mass. I suspect that it just takes one person to provide an outlet for these people because like me, they probably just suffer in silence or complain to politicians, but probably not taking it beyond that. (Mr. C, 2021)

4.4. Air quality governance and management in Metro Vancouver

Air quality governance in the Metro Vancouver region is influenced by multiple parties and is shaped by decisions and policies made by the regional district, provincial and federal governments, and its related agencies. Although Metro Vancouver as a regional district is "responsible for managing and regulating air contaminants in the region under authority delegated by the BC Government in the Environmental Management Act," it relies heavily on other levels of government and agencies to lead actions set out in its Clean Air Plan (Metro Vancouver, 2021, p. 13). Hence, collaboration, coordination, and a shared vision are crucial to achieving air quality objectives. The sections that follow outline roles and responsibilities related to air quality governance and the existing approaches and strategies for managing air emissions from heavy-duty trucks.

4.4.1. Responsibilities related to air quality governance

The following table summarizes responsibilities related to air quality governance broadly and as it relates to air emissions from heavy-duty trucks.

Table 3. Responsibilities related to air quality governance

Governing bodies	Responsibilities related to air quality governance	Responsibilities related to heavy-duty truck traffic-related air emissions

Metro Vancouver	Responsible for managing and regulating air contaminants in the Metro Vancouver region under authority delegated by the BC Government in the Environmental Management Act Develops plans, strategies and regulations; promotes compliance with permits and regulations; monitors air quality; and delivers awareness and incentive programs Coordinates with other governments and regional partners to move the region forward on air quality targets	Possesses the power to develop regulations and programs to target heavy-duty truck emissions but relies heavily on provincial government partnership because many truck movements also move in and out of the region
B.C. government	Sets emission standards for fuels and other emission sources, and manages air quality in BC for areas outside of Metro Vancouver, including adjacent regional districts	Possesses the power to develop regulations and programs to target emissions from heavy-duty trucks Ability to put into place programs that encourage higher rates of fleet renewal Holds responsibility and jurisdiction over all commercial trucking matters in B.C.
Government of Canada	Sets emission standards for on-road vehicles, non-road equipment, rail locomotives, home heating appliances, fuels, and some industrial sources. Coordinates the national Air Quality Management System to improve air quality in Canada, and regulates federal undertakings such as ports and airports.	Sets greenhouse gas and pollutant emission standards for new and future builds of heavy-duty trucks Able to support programs that encourage higher rate of fleet renewal
Municipal government	None, but responsible for land-use policy and enforcing building codes that support clean air and human health	None, but truck routes run through municipalities
TransLink	None, but provides public and active transportation infrastructure and services in the region, which have low emissions	None, but has responsibility for the major road network in the region
Vancouver Fraser Port Authority	Responsible for managing air quality and emissions from activities on federal port lands in Metro Vancouver Conducts environmental reviews of projects on port lands when applicable in scope; issue project permits and conditions	Possesses power to regulate truck emissions on federal port lands

		Establishes “minimum truck age, safety and environmental requirements” for container trucks accessing the port through the truck licensing system
Health authorities	None, but provides research and information on the health impacts of air contaminants to support air quality management	None

4.4.2. Management strategies and approaches

Despite evidence that confirms there is a problem, no province-wide programs or regulations exist within B.C. to ensure that the worst emitting heavy-duty trucks get addressed or taken off the road. These include older heavy-duty trucks built before 2008, heavy-duty trucks that are not maintained properly, and newer trucks with emission control systems that have been tampered with. Approaches to addressing air pollutant emissions focus on incentivizing voluntary retrofits on older heavy-duty trucks through diesel particulate filters and diesel oxidization catalysts that reduce emissions of particulate matter. Incentives have also been put in place to encourage fleet renewal and adoption of low-carbon heavy-duty trucks through rebates (BC Trucking Association, 2021). Although mandatory retrofits and inspection programs have been explored over the years, the provincial government has shied away from such measures.

The boldest attempt to put forward a mandatory emission testing and inspection program for trucks occurred in 2012 when the province of B.C. simultaneously announced AirCare for cars and light trucks would be cancelled as of 2014 but that they would be shifting AirCare’s focus to heavy-duty diesel trucks. AirCare, a vehicle emissions testing program active between 1992 to 2014 in B.C., once regularly tested the tailpipes of cars and light trucks to ensure segments of older and heavier polluting cars remained off the roads. The rationale for cancelling the program in 2014 was that newer cars were much cleaner and the program’s benefits to regional air quality were getting incrementally smaller. As part of that announcement, the provincial government at the time also announced that while the program was to end for cars and light trucks, AirCare would then turn its focus to managing heavy-duty diesel truck emissions.

However, following the announcement and subsequent work by the provincial government and Metro Vancouver to investigate policy options to introduce a mandatory

inspection program, there was opposition from the trucking industry that highlighted reasons why such a program would not be necessary (BC Trucking Association, 2012; BC Trucking Association 2013). The reasons for pushback will be detailed in Chapter 5. In the end, the AirCare ON-ROAD Program for heavy-duty diesel trucks and buses put in place since 1999 remains the same to this day and does not conduct mandatory checks on heavy-duty diesel trucks but instead continues to conduct roadside tests based on an initial visual inspection where they only test if an inspector sees a certain level of reduced exhaust opacity (Province of B.C., n.d.). However, this visual test is not a reliable measure of emissions and cannot detect tampering in newer trucks that do not necessarily produce reduced exhaust opacity but rather, invisible nitrous oxides (Today's Trucking, 2018; Metro Vancouver, 2013). According to Metro Vancouver, “vehicles can be categorized as high-emitters […] without showing a visible smoke plume. This has implications for the effectiveness of programs, such as the current AirCare ON-ROAD (ACOR) Program, that rely on visual inspection as a screening method” (Metro Vancouver, 2013, p. 86).

Concerns about the ACOR Program’s ability to enforce compliance also exist and were expressed by elected local government officials. In 2005, Vancouver City Councillor David Cadman raised his concerns through a motion that “the City of Vancouver urge the Provincial Government to act as quickly as possible to enact appropriate legislation to provide the AirCare On-Road Program (ACOR) with the ability to enforce compliance for heavy duty vehicles that fail to meet appropriate air emission standards” (City of Vancouver, 2005b, p. 1). In addition to the impact of air pollution on public health, the motion listed the following reasons and rationale:

- Published reports indicate many heavy-duty vehicles fail the Air Care On-Road Program
- The current version of the ACOR Program has no means of compelling compliance by way of issuing fines or linking compliance to vehicle registration and/or licence removal for heavy-duty vehicles that fail to meet appropriate emission testing
- In less than twenty years respiratory disease has increased four-fold across the country
- Moving the ACOR program for heavy-duty vehicles from a voluntary to a mandatory compliance phase requires legislative action from the Provincial Government

(City of Vancouver, 2005b, p. 1)

This highlights known weaknesses of the ACOR Program, which further shows how the program in essence, is not stringent, is outdated, and does have clear goals or targets to improve air quality.

The only mandatory program in place is the port authority's Truck Licensing System introduced in 2008, which comes with minimum safety, truck age, and environmental requirements that container trucks must meet before being issued a license to access and provide service to port container terminals. Over the years, these requirements have adjusted and changed to adapt to new standards and technology. Presently, these requirements include retrofits to decrease air pollutant emissions and bring emissions closer to those of trucks newer than 2010. Truck age requirements state, "any new container trucks being added by a Truck Licensing System participant must be 2014 or newer, both in model and engine year" and beginning February 1, 2022, the "program will age out Truck Licensing System truck models older than 10 years from the port authority's Truck Licensing System" (Vancouver Fraser Port Authority, n.d., para. 5; Vancouver Fraser Port Authority, 2020). The port authority's rationale includes the fact that "truck engines built from 2007 onwards produce 90% less particulate matter, a known human carcinogen, than older engines" and those "built from 2010 onwards also produce 20 times less nitrogen oxides, a key component of smog, than older engines" (Vancouver Fraser Port Authority, 2020, para. 10). However, the port authority will still allow case-by-case exceptions for non-compliant trucks and existing trucks within the Truck Licensing System serving the port can be as old as 1994 (Vancouver Fraser Port Authority, n.d). While newer trucks are expected to emit lower amounts of particulate matter and nitrous oxides, the Truck Licensing System does not monitor for emission control system malfunction or tampering. And for trucks that will soon age out of the Truck Licensing System program, they can still operate on regional roads to move goods from point A to point B if it is not on federal port lands. Interestingly, the port authority's latest move to age out truck models older than 10 years in 2022 continues to be met with resistance by the trucking industry and has been put on pause and delayed yet again at the request of the trucking industry (Global News, 2022a).

4.5. Trucking sector in Metro Vancouver

Although the focus thus far has been on heavy-duty diesel container trucks, we cannot lose sight of the fact that heavy-duty diesel trucks move throughout the region and do not only originate from Port of Vancouver terminals. This section provides an overview of the types of heavy-duty truck traffic in the region and the dynamics at play specific to heavy-duty diesel container trucks that serve port terminals, which will provide context for why mandatory environmental requirements exist only for heavy-duty diesel trucks that access the Port of Vancouver.

4.5.1. Truck movements in the region

Heavy-duty truck traffic related to container trade aren't the only types of movement that need to be accounted for. According to a regional truck survey conducted by the Applied Freight Research Initiative (AFRI) in 2012, heavy-duty truck trips in the region can be categorized into four sectors:

- Regional Metro Vancouver (50%) - Truck trips providing local service e.g., deliveries of produce or other goods such as furniture, laundry services etc.
- Intra-BC/Inter-Canada (7%) - Truck trips that travel across other regions e.g., Vancouver Island or to interior B.C. and beyond.
- Cascade Border (6%) - Truck trips in the region that move through Canada-US borders
- Asia-Pacific Gateway (37%) - Truck trips associated with gateway-related goods movement attributed to the Port of Vancouver or YVR airport.

This breakdown highlights the importance of the region's role as part of the wider supply chain and road logistics network, and reflects a reliance on the region as a transport and economic hub. While no available data was found regarding heavy-duty truck traffic projections, a Truck Classification and Dangerous Goods Survey commissioned by Transport Canada, TransLink and the B.C. Ministry of Transportation & Infrastructure in 2014 found that between 2008 and 2014, heavy truck volumes on the region's truck route network increased by 16%, giving us a sense of the rate of growth over time (Acuere Consulting Inc., 2015). The survey also showed that heavy-duty truck traffic volumes were changing across the region with some routes seeing more growth than others, especially eastwards, potentially indicating that sprawl is occurring due to

factors such as rising industrial land values, decreasing land availability, and increased affordability further eastwards outside the region's core (Acuere Consulting Inc., 2015; Vancouver Sun, 2019).

The chart below from this survey highlights in dark blue, the routes taken by heavy trucks across the region. The thicker dark blue lines indicate high volumes defined by more than 51 trucks per hour during peak hours. Highlighted in the red box within Figure 15 is the Clark-Knight corridor.

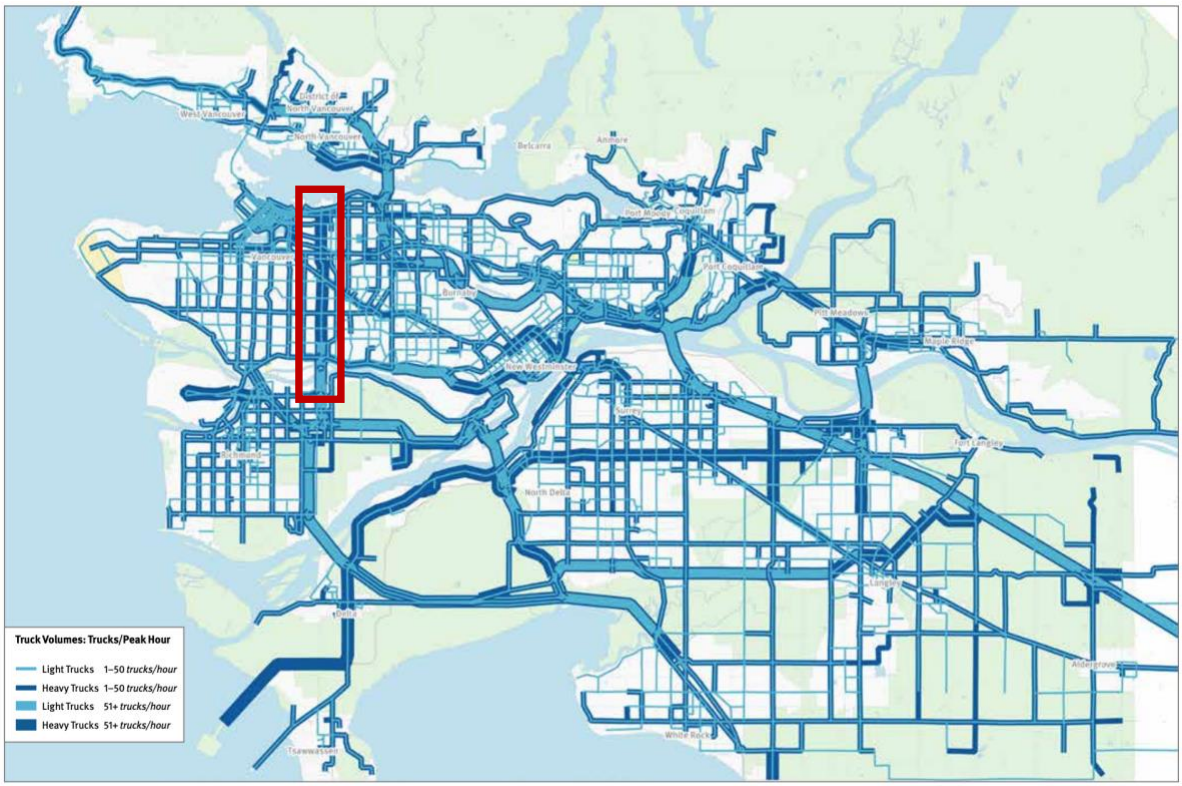

Figure 15. Truck volumes on all roads, including the Clark-Knight corridor in Metro Vancouver

(Translink, 2017, p. 15)

With container terminal expansion projects currently underway along the South Shore of Vancouver, also shown contained in the red box within Figure 15. and a proposed new container terminal planned for Delta, truck trips within these four sectors will only continue to grow along the Clark-Knight corridor and other truck routes as more goods get moved through the region for trade and to serve a growing population.

4.5.2. Role of trucking associations and unions

Representing the interests of truck drivers and trucking companies are various associations and unions. While some have been in existence for many decades, dating back to 1913, some have also been created as a response to tensions within industry and between industry and the port authority and the Province of B.C. These include the following:

Table 4. Trucking associations and unions

Name	Represents	Purpose
B.C. Trucking Association (BCTA)	BCTA includes among its members for-hire and private carriers hauling every conceivable type of freight. Members include large trucking courier and motor coach companies, but the majority are small to medium size, often family-owned enterprises.	BCTA is a member-based, province-wide, non-partisan, non-profit motor carrier association formed solely to advance the interests of B.C. motor carriers. Focus includes advocacy, consultation, and communication to industry, government, and public.
Unifor-Vancouver Container Truckers' Association	A private sector union representing a segment of container truck drivers that serve Port of Vancouver terminals.	Focused on advocacy, collective bargaining and building strength for truckers through a strong union.
United Truckers Association	Represents more than 1,000 non-union truck drivers that serve Port of Vancouver terminals	Focused on advocacy on behalf of over 1,100 Independent Operators in the Metro Vancouver drayage sector.
Port Transportation Association	Drayage trucking company owners	To provide an avenue for information sharing amongst trucking company owners to be able to share their frustrations about dealing with the port authority, B.C. Container Trucking Commissioner's Office or port terminals

These organizations play a role in influencing government policy and decision making through their advocacy work. These dynamics will be detailed in the sections that follow.

4.5.3. Past container trucking work stoppages

Unique to the container trucking sector in the Metro Vancouver region are a series of work stoppages that occurred due to strike action in 1999, 2005, and 2014 by local truck drivers serving Port of Vancouver container terminals. An understanding of the context and dynamics behind these strikes is relevant to this research question

because the work stoppages are what led to the development of environmental regulations within the port authority's truck licensing system. Many of the issues and dynamics at play during these work stoppages persist through to our present day and continue to be played out in the public realm as the trucking industry advocates for a pause on the port authority's plans introduce more stringent truck age requirements. Studying these work stoppages provides insight into the forces and processes that have inhibited and continue to inhibit policy innovation and the development of more stringent criteria and broader-reaching policies to ensure cleaner commercial trucks and the retirement of older, diesel engine trucks that emit higher levels of air pollutants.

Policy change and related activities that took place during this time were punctuated by three major work stoppages by truck drivers in 1999, 2005, and 2014. As a result of ongoing issues that persisted through this period and the ineffectiveness of policies and policy actors to foresee issues and maintain stability, strike action and threats of strike action became the means by which truck drivers demanded and caught the attention of government and industry parties (Ready & Bell, 2014). The first of the three strikes covered took place between July 22, 1999, and August 23, 1999, lasting for 33 days. The strike was initiated by approximately 450 independent owner-operators and company-hired truck drivers, and the cause was found to be the following:

> "It was the consequence of extremely low rates of compensation, and dysfunctional operating practices in the container transportation system limiting driver productivity. The drivers believed that the operating practises were causing delays in the movement of containers at the ports, which subsequently caused downward pressure on driver pay rates rendering it uneconomical for drivers to operate in the ports." (Ready & Bell, 2014, p. 5).

The end of the strike was brought on by the "implementation of a licensing system by the Vancouver Fraser Port Authority, which required trucking companies wishing to access the port terminals to sign a Memorandum of Agreement (MOA) setting out rates of compensation for independent owner-operators" (Ready & Bell, 2014, p. 5). Through collective bargaining, it was agreed that drivers would transition to be paid hourly rates to reflect proper compensation for time spent working versus trip rates. At the time, no environmental requirements were part of the licensing system. Because of a lack of enforcement mechanism and continued undercutting, most companies eventually reverted to the old system of trip-based rates. With an increased understanding of

concerns related to container terminal inefficiencies in connecting truck drivers with their specific containers, the port authority set up working groups and committees with terminal operators and container sector stakeholders in hopes of improving efficiency (Ready & Bell, 2014).

Efforts stemming from the 1999 strike to help bring better driver rates and efficiencies to the sector were not successful. In the summer of 2005, strike action and picket lines involved approximately 1,200 truck drivers and lasted for 47 days, creating major disruption and "costing the economy approximately $400 million" (Vancouver Sun, 2014, p. 16). While concerns from truck drivers were similar to those in 1999, the 2005 strike was further triggered by the increasing cost of fuel, resulting in costs that further chipped away at driver earnings. The strike in 2005 was far more disruptive and caught the attention of the provincial and federal government who jointly appointed veteran mediator Vince Ready to help resolve the dispute. Strike action resulted in updated rates of compensation for independent owner-operators as laid out in the MOA 2005 and a more formal truck licensing system "which established the [issuing] of licenses for a period of two years and required all trucking companies to sign the MOA 2005 in order to have access" to container terminals (Ready & Bell, 2014, p. 6). Further to this, in 2006 the federal government "imposed a legal obligation on the port authority to ensure compliance with a minimum rate floor, as set out in conditions outlined in the truck licensing system" (Ready & Bell, 2014, p. 6). To ensure that the MOA was being adhered to, the Province of B.C. also established a container truck dispute resolution program in 2007. The port authority's truck licensing system over time also became more formalized and empowered "to help manage the number of vehicles and drivers, impose safety and environmental standards, and to provide a mechanism for imposing sanctions on operators whose behaviour does not meet the port's standards or service requirements" (Ready & Bell, 2014, p. 7). In 2008, the Port of Vancouver became the "first port in Canada with stringent environmental requirements for port container drayage trucks to reduce air emissions," which selectively granted access to trucks that met environmental requirements (Vancouver Fraser Port Authority, n.d.). In addition to the protection of the environment and human health, these environmental requirements served double duty to "avoid the truck surplus which previously plagued the drayage sector" (Unifor v. Vancouver Fraser Port Authority, 2017).

In 2005, B.C. Provincial Minister of Labour Mike de Jong stated, “This is the second go around, so the lesson here is that we can’t apply a band-aid and have the same issues reappear” (The Tyee, 2005, p. 15). However, the same issues did reappear and another strike occurred in 2014, involving approximately 1,300 truck drivers and lasted for 28 days, similarly creating major disruptions that rippled throughout the supply chain (CBC News, 2014). Economic pressures felt in 2005 were also intensified due to continued rising costs of fuel and living. Concerns expressed by truck drivers were also essentially the same, focusing on undercutting, an oversupply of trucks, environmental requirements, poor compensation, “lengthy waiting times to pick up or drop off containers at terminals,” and “lack of an industry-wide auditing system, and proper enforcement of audit judgments” (Vancouver Sun, 2014, p. 3; Ready & Bell, 2014, p. 9). Since 2005, the composition of truck drivers had changed where independent owner-operators “dramatically decreased and were replaced by employee drivers” (Ready & Bell, 2014, p. 8). However, the rates cited by Vince Ready in the 2005 MOA “only applied to licensed owner-operators, not employee drivers of companies where drivers are paid by the hour.” While actions taken in 2005 “partly regulated the system”, it “left enough loopholes for companies and drivers to undercut themselves to win business” (Vancouver Sun, 2014, p. 18).

Due to the increased severity of the situation involving the economy, violence amongst striking truckers, and inability of past efforts to stabilize the sector, the federal government appointed Vince Ready and Corinne Bell to conduct an independent review and provide recommendations to both provincial and federal governments. However, this step did not convince drivers to end the strike and “instead, the federal and provincial governments and [port authority] negotiated a Joint Action Plan with the [United Truckers Association] and Unifor on March 26, 2014 that returned the drivers to work” (Ready & Bell, 2014, p. 10). The Joint Action Plan included commitments and tangible steps towards resolving key issues, and the recommendations of Ready and Bell would go on to help inform actions (CBC News, 2014). Since March 26, 2014, drivers threatened to strike again on two occasions, once in July 2014 and another time in January 2015. The basis of these threats was to ensure the terms of the Joint Action Plan and enforcement as needed (Vancouver Sun, 2015; CBC News, 2014).

Through this summarized historical account of the development of policies and regulations related to the container trucking sector, we can see that this period of time

was punctuated by three major strikes and further threats of strike activity. These work stoppages were successful in capturing the attention of the Province of B.C. and federal government, sparking a series of policy changes that took place as parties sought a resolution. Due to their ripple effects throughout the supply chain and the potential for a halt to the national economy, these work stoppages effectively pressured government to quickly ensure that drivers got back to work. These pressures were articulated publicly through media releases, letters, and statements from business groups such as the Retail Council of Canada, Greater Vancouver Board of Trade, and B.C. Chamber of Commerce, as calls for groups to work together toward solutions (Retail Insider, 2014; CBC News, 2005; CBC News, 2005; BC Chamber of Commerce, 2014). As each round of strikes involved more drivers, frustration grew, and subsequent actions taken by government also grew with more regulation and policy adjustments.

Past strike activity in the trucking industry reveals more about the context of the politics of trucking industry work, which is important to keep in mind in the context of attempting to craft stronger and more effective environmental regulation. The trucking industry has raised concerns about the costs and inefficiencies of environmental regulation and threatened strike action in 2014-15, when the port authority attempted to introduce more stringent environmental requirements on container trucks. In a news release issued by the port authority on December 22, 2014, titled Container Truckers Stand to Lose on Major Concessions in the Event of Work Stoppage, it was revealed that the easing of environmental regulations was part of previous deals to get truckers back to work or prevent a strike. The excerpt from a port authority media release that was issued in reaction to threats of strike in 2014 serves as proof that work stoppage could be leveraged to weaken and prevent the implementation of environmental regulations.

> Port Metro Vancouver, with the support of [federal] Minister of Transport Lisa Raitt, is advising container truckers who serve the port that a work stoppage to protest recent reforms will result in the loss of compromises offered to them as part of changes to stabilize port trucking. […] The restriction on truck age, which had been eased at the request of drivers, will be returned to the original proposal which will not allow any truck older than 10 years to serve the port as of 2017 (Vancouver Fraser Port Authority, 2014).

Based on the port authority's current plans to introduce container truck age requirements on February 1, 2022, it appears that strike action was successful in

delaying the introduction of more stringent environmental requirements by five years. The port authority also met with resistance in 2016 when “Unifor sought judicial review of [the port authority’s] 10-year Truck Age Policy, including its environmental requirements” (Vancouver Fraser Port Authority, 2020, p. 3). As the implementation date nears, Unifor and the United Truckers Association continue to express their concerns through the summer and fall of 2021 publicly through media releases, petitions and small-scale protests focused on attracting the attention of provincial and federal governments. In a news release issued July 13, 2021, Unifor states the following position:

> Unifor has resisted the proposed program for years, and even fought it in the courts in 2017. The union is renewing its demands to consult truck drivers about the fairest way to transition to newer trucks that doesn't penalize drivers financially.
>
> Unifor is calling for a two-year pause in the implementation of the truck age program. To encourage better policy-making in the sector, Unifor is seeking the establishment of a joint advisory council involving truckers, employers, the B.C. government and the federal government.
>
> […] "We need Minister Alghabra to step in, press pause, and set up a process with his B.C. counterpart to properly consult those who will be impacted."
>
> […] Sylvester's refusal to engage with truck drivers was a key factor in the job action that shut down Vancouver's ports for two weeks in 2014. (Unifor, 2021)

This news release reveals attempts to gain media attention and pressure the provincial and federal government to help put a pause on the port authority’s attempts to introduce stronger regulation. The last line within the news release appears to serve as a stark reminder of what may happen if their cries for a course change go ignored.

Although strike activity was focused on the container trucks that were authorized to access Port of Vancouver terminals, it shines a light on the potential resistance that government may face across the entire trucking sector when implementing mandatory programs and policies to reduce air pollution. On one hand, environmental regulations would improve air quality and protect human health, but on the other hand, could risk another work stoppage. These politics hold environmental policy improvements hostage to economic non-disruption, time and time again.

Chapter 5. Identifying policy barriers to sustainable transportation in B.C.

By reviewing and analyzing semi-structured interview, documents, and news media articles, I was able to answer my research question: what are the barriers to implementing policies and programs to improve air quality and reduce environmental inequity related to TRAP exposure along the Clark-Knight corridor? In the sections that follow, I categorize findings into two major categories: barriers created by planning decisions that reinforce environmental inequity, and political barriers that slow and prevent the ratification and implementation of stricter environmental regulations.

5.1. Planning decisions and practices that reinforce environmental inequity

Through an analysis of land use and transportation planning decisions and practices surrounding the Clark-Knight corridor, I was able to identify how decisions related to industrial land supply, zoning for residential areas, truck routes, and port growth from various levels of government and government agencies reinforced environmental inequity. The sections that follow summarize my findings, which highlight how pressures on a limited land base can create ripple effects and create barriers to more sustainable approaches to planning.

5.1.1. Constrained land supply and pressures on industrial land

The root challenge driving the intensification of container activity can be considered a challenge to the region's ability to effectively protect all residents from TRAP, in its own right. This challenge is related to land use planning and the region's need to support a growing population, growing economy, and growing port on a limited land base. Specifically, the conversion of industrial land for non-industrial uses to support a growing population is creating pressures on industry and the port authority, tasked with a federal mandate to support growing trade.

> For more than a decade, we've been calling for the protection of our region's industrial land. […] From a port perspective, we need these lands (and in particular, those lands that are close to major roads and railways)

> for port-related distribution and logistics activity, including operations like those relating to Canadian Tire, Ikea, Amazon, Walmart, Staples, Toys"R"Us, Dollar Tree, Winners/Marshalls, The Brick, Lululemon, and many other household names. What we're seeing, though, is that local governments are allowing these lands to be converted and rezoned, often to build condos, at an alarming rate. – (Vancouver Fraser Port Authority, 2020, p. 6)

Conversion of industrial land for housing and commercial use, along with growth in demand from industry has pushed the industrial land vacancy rate down to a record low of 0.6% as recorded in Q3 2021 (Vancouver Fraser Port Authority, n.d.; Business in Vancouver, 2021; CBRE, 2021). According to real estate experts from Coldwell Banker Richard Ellis, "a 4% vacancy rate would be needed to consider the region's industrial real estate market as being balanced" (Business in Vancouver, 2021, para. 16). This lack of 'room to grow' was found to be a reason why container terminal expansion projects have taken place on the south shore and not elsewhere in the region, which in turn leads to further intensification of truck traffic and TRAP exposure along the Clark-Knight corridor.

Outlined within Metro Vancouver's Regional Industrial Lands Strategy, the root cause of issues facing industrial lands in the region can be narrowed to a fractured regulatory landscape, overlapping jurisdictions, competition between municipalities, and a "lack of collaboration and coordination between government agencies" (Metro Vancouver, 2020, p. 25).

> The issues facing industrial lands involve multiple stakeholders and overlapping jurisdictions of government, which may have their own organizational mandates. The result is a fractured regulatory landscape which can occasionally result in redundancies or competing policy objectives that stifle the effective utilization of the region's remaining industrial lands for various purposes.
>
> In other regards, competition between neighbouring municipalities to attract business and grow their respective property tax bases may result in decisions that undermine the resiliency of the broader regional economy. This is best exemplified by the continued conversion of industrial areas to higher value land uses, despite the limited amount of industrial land remaining in the region. (Metro Vancouver, 2020, p. 25)

The port authority's Land Use Plan also reveals that collaboration between various levels of government that are involved in land use and community planning has room for improvement. Specifically, the port authority has advocated for the protection of

industrial land for over a decade and continues to highlight the need for municipal governments to consider the role of the port and work together to find solutions to reduce “conflicts between port-related and non-industrial uses in the community through careful planning and collaboration between the port authority and adjacent municipalities and Indigenous groups” (Vancouver Fraser Port Authority, 2020, p. 63).

Faced with the shortage of waterfront industrial land to accommodate port terminal growth and recognizing the need to protect industrial lands to support logistics and warehousing in the region, the port authority has three strategic foci. First, the port authority seeks to “optimize the use of existing facilities.” Second, it will continue to advocate for the “protection of the remaining supply of industrial land.” Third, it will “acquire suitable industrial land parcels where possible” (Vancouver Fraser Port Authority, 2020, p. 6); clearly, the Roberts Bank Terminal 2 project is key to this and if this does not get built, further intensification of container operations will be necessary. In accordance with their federal mandate, the port authority is tasked with facilitating trade and accommodating growth of throughput at Canada’s largest port. Although Metro Vancouver’s first Regional Industrial Lands Strategy will aim to protect the remaining stock of industrial land, intensify and optimize use of existing land, and improve collaboration and coordination, the challenges created by planning decisions will be difficult to undo.

The current distribution of industrial lands across the region for off-terminal logistics and warehousing was also alleged to be a barrier to improving air quality and reducing truck-traffic related air pollution along the Clark-Knight corridor and other regional roadways. Although the use of industrial lands is intensifying, one research informant explained that industrial lands across the region are not being utilized efficiently, which is contributing to higher greenhouse gas and pollutant emissions, longer distances traveled, more truck trips, and higher costs.

> I think there's some opportunity for the port to do work around organizing how this drayage fleet actually operates. Currently [container trucks] run all over the place throughout the region. Metro Vancouver is a unique port. If you look at the Port of LA, San Diego, and Seattle, the ship comes in and all the port activities are done on one piece of land, right by the water. Here, we have pieces of land for port activity all over the place. So, they've got to move goods in containers, empty containers, all over the region because they have all these separate pieces of land. (Anonymous informant F)

However, the high price and lack of industrial land in the region has triggered industry to look for available land eastwards towards the Fraser Valley, farther away from port terminals, which poses a challenge to reorganizing the stock of industrial land in a way that is efficient and minimizes the number of trips and amount of distance travelled by trucks (Business in Vancouver, 2021).

> When you purchase something from your local store, consider how it got there. It quite likely came from overseas, and it needed not only a ship to get here, but also a port terminal, a distribution centre, a truck or two, perhaps a train, and a warehouse at the very least. The closer those things can be to each other, the more efficient goods movement can be. Forcing distribution centres and warehouses to locate outside the Lower Mainland means more traffic on our roads, increased emissions, higher prices for consumers, and challenges for companies seeking to import and export their goods. (Vancouver Fraser Port Authority, n.d., para. 6)

As municipalities and the regional district tackle problems of urban sprawl through tactics such as densification, mixed use zoning, transit-oriented developments, and other ways of shortening trip lengths for residents in a less auto-dependent city, similar ways of thinking and level of attention need to be applied to how industrial land is zoned and distributed throughout the region to make truck movements and the goods movement network more efficient and sustainable. For instance, “industrial and commercial land uses that have good connectivity to the transportation network and that support the ability to co-locate related uses reduce trip distances, improve load factors, and help manage commercial vehicle volumes on the region’s roads” (TransLink, 2017). As the region grows, more industrial land will be needed to support activities such as warehousing and the growth of local businesses. If industrial activities continue to get pushed further away from the places they need to connect to and serve, trip distances, volumes and emissions will only increase. While some believe that it’s up to the port authority to “do work to [reorganize] how this drayage fleet actually operates,” (Anonymous Informant F) the port authority and Metro Vancouver stress that it will require a collaborative, coordinated and cooperative effort between “all jurisdictions that have authority over land use in the region” to be able to ensure land is being used efficiently and strategically (Vancouver Fraser Port Authority, 2020, p. 25). There is currently no standing body to deliver this.

5.1.2. Intensification and growth of container trade through Vancouver's South Shore

As mentioned in Chapter 4.3.2, container terminal expansion projects along the south shore of the Burrard Inlet at Centerm and Vanterm container terminals will result in at least 53% more container truck traffic along the corridor. If the port authority's proposed Roberts Bank Terminal 2 project in Delta B.C. is not federally approved, the port authority will then look for ways to further increase container capacity to accommodate forecasted trade growth along the south shore of the Burrard Inlet. This will generate even more truck traffic along the Clark-Knight corridor. Sources confirm that the lack of industrial land in the Metro Vancouver region presents a barrier to more evenly distributing port growth and container truck traffic, along with their environmental hazards:

> It seems unrelated but it's not. The lack of industrial land in the region can actually be an exacerbator [sic] for emissions from container trucks along the Clark-Knight corridor] because there's not just land aplenty for the port to expand. The port authority then must make the best use of the existing footprint and that means intensifying operations where they currently are. On the south shore of the Burrard Inlet in Vancouver, you're seeing a lot of projects to help move more goods through that limited land base. That's going to translate into more trucks going to and from [Centerm and Vanterm container terminals]. It ends up concentrating that industrial activity because there's nowhere else for it to spread out to. If there was land elsewhere for terminals to be developed, there would be other options and you wouldn't see the same concentration of [container truck traffic along the corridor]. It wouldn't necessarily be less truck trips in the region, but it would be distributed differently. (Anonymous informant E)

In their 2020 Land Use Plan, the port authority argues that "local governments are allowing [industrial] lands to be converted and rezoned, often to build condos, at an alarming rate" and highlights the tensions that come with port growth and the intensification of operations along the south shore (Vancouver Fraser Port Authority, 2020, p. 24).

> As more and more people live closer to industrial operations, the potential for conflict at the interface between the working waterfront and adjacent land uses will increase. While some of this is inevitable in a growing region with a limited land base, it nevertheless requires all jurisdictions to plan and manage growth, and to design communities in recognition of the critical role the port plays in the region. This will become even more important as port activities on and near the waterfront intensify due to new development and investments that increase the capacity and throughput of existing terminals

> in response to Canada's trade growth. (Vancouver Fraser Port Authority, 2020, p. 25)

The scarcity of industrial land places increased pressure to move more goods through south shore port lands and the Clark-Knight corridor, and creates barriers to reducing and managing the public health burdens placed upon residents along the corridor and Vancouver's East Side.

5.1.3. Concentration of truck traffic down paths of least resistance

In The Social Life of Truck Routes, Peter V. Hall (2015) highlights that the designation and creation of truck routes is more complex than just building and labeling streets that can physically bear the weight and accommodate the movement of heavy-duty trucks. "Behind the technical and rational mask [truck routes] are a result of multiple social and political processes" that work to frame "why and how certain city roads become accepted [and channeled] as routes for truck movement (while others are not)" (Hall, 2015, p. 117). These social and political processes have long been at play along the Clark-Knight corridor.

Through a series of transportation planning decisions influenced by residents of Nanaimo St., who also live along a truck route that runs adjacent to the Clark-Knight corridor, the corridor residents have over the years seen a continued increase and channeling of truck traffic down the corridor. Opposition to heavy-duty truck traffic, particularly container trucks, was triggered in 2010 when the port authority worked to increase efficiencies on port roads by changing access for inbound container trucks looking to access Centerm and Vanterm container terminals. By asking container trucks to access terminals through the McGill St. entrance where there was more space for truck staging, the port authority hoped to reduce queuing and congestion at the Clark Dr. entrance. As truck drivers adjusted their driving patterns to find efficient routes to access the McGill St. entrance, residents along Nanaimo St. soon took notice that container trucks were using Nanaimo St. to access the port. Although Nanaimo St. was technically designated as a truck route, it was not as frequently used by container trucks prior to that point (Vancouver is Awesome, 2011; Vancouver is Awesome, 2012; CBC News, 2011; CTV News, 2011). According to news sources, during a "one-day count in June,

271 trucks were spotted on Nanaimo as a result of the change," representing a "900-per-cent increase" (CTV News, 2011, para. 5).

This sparked outrage in the neighbourhood and led to the creation of a community opposition group called Advocating for Container Traffic Off Residential Streets (ACTORS), which advocated for Nanaimo St. residents. Through organized action involving community meetings, Google Groups, letter writing, media and targeted outreach to elected officials, the group "convinced the City of Vancouver to negotiate a 'pilot project' with the port, to be followed by a more permanent regulatory agreement, to restrict the movement of port-destined container trucks to [truck routes that are part of TransLink's Major Road Network]" (Hall, 2015, p. 126). Although the success of this community campaign meant relief for Nanaimo St. residents, it simultaneously represented a loss of environmental quality for the residents who live along the Clark-Knight corridor. The diversion meant that trucks were spending at least 15 more minutes on Clark-Knight, releasing more greenhouse gases and air pollutants, and generating more truck traffic. Interestingly, the corridor resident interviewed as part of this research noted that he only really started to notice the "noise and pollution around 2011 or 2012." This recollection corresponds with the time of initiation of the pilot project shifting truck traffic back to Clark-Knight (Resident informant).

At the time, city councillor Kerry Jang noted, "the challenge is reducing that traffic without simply moving the problem somewhere else" (CBC News, 2011, para. 11). For planners and politicians, this example highlights the backlash that one may face if we consider balancing and redistributing truck traffic along other truck routes. Despite media attention on the issues and intentions raised by ACTORS to ask that trucks return to using the Clark-Knight corridor, there were no obvious signs of reaction from Clark-Knight Street residents. While it is difficult to pinpoint why the Nanaimo Street opposition group was successful in their efforts, whereas Clark-Knight residents did not mount a defense of their own street, Hall (2015) suggests that contributing factors include the political acumen and knowledge of port operations that the group possessed along with the fact that "2011 was a local government election year, and clearly ACTORS found at city hall a sympathetic political and administrative leadership" (Hall, 2015, p. 127). At the time, Gregor Robertson of Vision Vancouver was mayor of the City of Vancouver and faced an upcoming election against their primary political opponent, the Non-Partisan Association (NPA). In my review of news media coverage on the issue, I found that NPA

candidate Dave Pasin was frequently quoted in related news coverage, lived in the area along Nanaimo St. and was also one of the key organizers of ACTORS (CBC News, 2011; The Georgia Strait, 2011). In a conversation with a reporter present at an organized media event related to the issue, it became apparent that NPA candidates were working hard to amplify community voices and leverage their concerns as an election issue.

> I remember reporting on the issue and attending an event in the community. Media outlets were invited to attend through a media advisory that was issued by the NPA, and not ACTORS. The NPA candidates spoke at that event and their volunteers were holding up campaign signs at that media event. (Media informant 1)

Influenced by the social and political processes at play that ultimately diverted and mandated container truck traffic away from non-MRN truck routes and onto the Clark-Knight corridor, transportation planning decisions made nearly a decade ago still contribute to the continued intensification of environmental inequity along the corridor. Moving truck traffic away from Nanaimo St. made life better for some, but worse for others. Since the Clark-Knight corridor has consistently been known as a busy truck route, these processes also worked to reinforce and legitimize that container trucks belong along the corridor even though residential areas surround it. Considering that the corridor remains the most direct and efficient route for truck drivers who need to access the port and that container truck traffic volumes are projected to increase by at least 53% with the completion of container terminal expansion projects, TRAP exposure from heavy-duty trucks is set to intensify. Is it only a matter of time until corridor residents decry that they've had enough? Or will they stand idly by, accepting that while the truck route is "unwanted," it is an "unchangeable social fact" (Hall, 2015, p. 127).

5.1.4. Densification of housing along arterial roads

Another barrier to reducing inequitable exposure to TRAP is the existence of planning policies that encourage housing densification along arterial roads. Of specific concern is the City of Vancouver's Secure Rental Policy, which allows up to six-storeys of rental housing along areas of arterial roads that are currently zoned for low-density residential uses and up to four-storeys one block in on either side of arterials (City of Vancouver, 2022). While this could increase the stock of rental housing and generate more affordable housing options within the City of Vancouver, these changes will bring

even more people to live within TRAP exposure zones along arterial roads. This inequity is compounded by the fact that this policy will attract a higher proportion of lower income people to live along these arterials, as these are the people who rent their housing and who rely on affordable and below-market housing.

Within an article published by the Sightline Institute, Daniel Oleksiuk (2021) points out that the decision to focus expansion of rental housing opportunities along arterial roads aligns with preferences that can already be found in the 2005 community vision statements for Vancouver's Arbutus Ridge, Kerrisdale, and Shaughnessy neighborhoods. The community vision recommends locating new apartments "on or near arterial roads" so that they can "shield, to some extent, adjacent single family homes from the noise of arterial traffic, …act[ing] as a buffer" (City of Vancouver, 2005c, p. 41). This unabashed reference to using apartment buildings and their residents as shields for the benefit of detaching housing dwellers on quieter, interior streets reveals the blatant inequity of planning decisions that have disproportionately affected those who rent apartments along busy streets, when it comes to TRAP exposure. The City of Vancouver's Secure Rental Policy is destined to intensify these biases and environmental inequities, with particularly troubling consequences for Clark-Knight corridor residents. Decisions such as these underscore the importance of ensuring planning is done in a holistic and coordinated manner that protects the wellbeing and quality of life for all who live in the region.

5.2. Political factors that inhibit the development of stricter environmental policies

As part of this study, I also analyzed policymaking and change over the past decade to understand the forces and processes that have inhibited policy innovation and the development of more stringent and broader-reaching policies in B.C. to ensure cleaner commercial trucks and the retirement of older, diesel engine trucks that emit higher levels of health-harming air pollutants. Currently, the only mandatory program in place remains the port authority's truck licensing system, which applies to container trucks that access the Port of Vancouver.

To make sense of the political dynamics at play and history of failed attempts by various government agencies to ratify policies that address air pollutant emissions from

heavy-duty trucks, I lean on Harrison (1996)'s assessment of the federal and provincial role in the development of Canadian environmental policy featured in her book titled, *Passing the Buck*. Harrison highlights the importance of "considering governments' electoral incentives to extend or defend their jurisdiction over the environment" and concludes that "the absence of electoral incentives, rather than constitutional constraints" are the reason why democratic governments tend to shy away from pursuing environmental policies (Harrison, 1996, p. 5).

Although environmental protection through regulation generates diffuse benefits for the public at large, it typically does so through "concentrated costs […] borne by a smaller number of regulated firms or individuals" (Harrison, 1996, 14). These regulated industries "with a great deal at stake are more likely to overcome the obstacles to collective action in light of the resulting bias in both interest group activity and citizens' levels of awareness" (Harrison, 1996, p. 12). Regulated industries "can [also] offer politicians more than just votes or even campaign contributions -- [by creating] jobs -- and thus offer[ing] extremely valuable indirect benefits" and electoral incentives (Harrison, 1996, p. 14). In contrast, individuals who make up the public at large who receive diffuse benefits of environmental policies "are unlikely to organize to pursue their shared political goals, or even to inform themselves about the nature of the costs and benefits they bear" (Harrison, 1996, p. 12). This combination of limited public attention to environmental issues and strong opposition from potentially regulated industries yields significant political costs and limited political benefits, a recipe for government reluctance to impose environmental regulations (Harrison, 1996).

The sections that follow discuss a series of failed attempts by government agencies to introduce stricter environmental regulations and overcome the barriers created by industry lobby efforts, which contribute to what Harrison describes as an absence of electoral incentives.

5.2.1. A lack of electoral incentives created by industry opposition to environmental regulation

Schiller and Kenworthy (2017) regard business as usual as "the dominant transportation paradigm," which has prioritized auto mobility and "ignores many social and environmental costs" of transportation (Schiller and Kenworthy, 2017, p. 12-13).

Business as usual is also marked by a reluctance to “interrupt and reverse harmful trends” and a willingness to instead “accommodate and accept” them (Schiller and Kenworthy, 2017, p. 13). Despite clear trends and data that emphasize the need to take action to reduce air pollutant emissions from heavy-duty diesel trucks in order to protect the health of local residents and reduce population-wide impacts throughout the region, actions taken by the trucking industry continue to reinforce business as usual and resist change required to shift us towards sustainable transportation practices. The trucking industry’s actions were found to be a clear example of how a combination of limited public attention to air quality issues and strong opposition from potentially regulated industries yielded significant political costs and limited political benefits, which deterred government from moving forward on stricter environmental regulation.

In the case of the port authority’s environmental regulations for container trucks, strike action put a halt on the national economy and as part of a series of concessions, effectively delayed the start of more stringent environmental requirements for port-serving container trucks. The key players involved in strike activity (include the United Truckers Association and Unifor, which represent container truck drivers, the BC Trucking Association, which represents trucking companies) have been instrumental in leading lobby efforts to oppose AirCare for heavy-duty trucks and other forms of mandatory emission testing and inspection programs. These organizations work to maintain business as usual as they lobby against policy changes that go against the interests of the trucking industry. It is important that we look back at these lobby efforts to understand what it will take to accelerate fleet renewal and ensure the heaviest polluters get off local roads.

Looking back at news coverage and media releases issued around the time that AirCare for heavy-duty trucks was announced, the first media mentions occurred on March 20 and 22, 2012 when “[Minister of Environment Terry Lake] revealed that ministry staff, TransLink and Pacific Vehicle Testing Technologies (which administers AirCare) [were] reviewing whether it [was] viable to redevelop the emissions testing program for commercial vehicles” because the existing program for heavy-duty trucks “[wasn’t] able to cover a lot of ground” (BC Trucking Association, 2012; CTV, 2012). Shortly after, BC Trucking Association President & CEO at the time, Louise Yako contacted Minister Lake on March 28, 2012 to oppose the idea based on the argument

that the program “would not necessarily improve air quality” (BC Trucking Association, 2012, para. 3).

> Louise noted that requiring heavy-duty vehicles to participate in AirCare will not necessarily improve air quality (the reason Minister Lake gave to justify the proposal). Improvements to engine standards since 1990 have required progressive emissions reductions, to the point where the 2010 standard results in near zero emissions. Stringent engine emissions standards as well as diesel fuel standards implemented in 2006 have resulted in significant changes to smoke opacity levels and particulate matter emissions (including an impressive 97 percent reduction in the sulphur content of diesel). Louise also pointed out that provincial requirements for diesel oxidation catalyst retrofits for some older trucks are already in place, while indicating the futility of testing older vehicles that do not have compliance options. (BC Trucking Association, 2012, para. 3)

However, the BC Trucking Association’s counter arguments do not address the issue of tampering and despite their arguments, the Province of B.C. with Metro Vancouver officially announced their plans on May 24, 2012 through a media release to “shift gears” and “change the focus of the AirCare program to reduce significant sources of diesel particulates” by managing emissions from heavy-duty trucks (Province of B.C., 2012. Para. 6). In response, the BC Trucking Association issued their own release that very same day to “defend the industry against a potential shift in the AirCare program to heavy trucks” (BC Trucking Association, 2012, para. 1). The dialogue that took place in media stories focused on the following:

- The BC Trucking Association defending the trucking industry by focusing on the cost of time for owners to take trucks for testing and the narrative that newer trucks were emitting less air pollutants

- The Province of B.C. Ministry of Environment clarifying that concerns are not new trucks, but older heavy-duty trucks

- Metro Vancouver stressing the importance of addressing TRAP from heavy-duty trucks, particularly diesel particulate matter by featuring information on human health impacts

(Vancouver Sun, 2012; Vancouver Sun, 2013; Business in Vancouver, 2012; CTV News, 2012)

As Metro Vancouver worked with the Province of B.C. to assess policy options and conduct emissions studies throughout 2013, the BC Trucking Association continued to pay close attention and attempt to counter the narrative through public statements sent through the media (BC Trucking Association, 2012; BC Trucking Association, 2013). On April 11, 2013, results of the Metro Vancouver-commissioned *Remote Sensing Device Trial for Monitoring Heavy-Duty Truck Emissions* were shared with Metro Vancouver's Environment and Parks Committee with the recommendation "that the Board direct staff to forward the [results, recommendations, and next steps] to the Provincial Minister of Environment with the request that the Province work with Metro Vancouver and other agencies in the development and evaluation of policy and program options to address air emissions from on-road heavy-duty diesel vehicles supported by the findings of the 2012 remote sensing device study" (Metro Vancouver, 2013, p. 1). On that same day, the BC Trucking Association issued a media release titled, *Metro Vancouver Diesel Emissions Study Confirms Most Trucks are Clean and Getting Cleaner, says BC Trucking Association*, attempting to shape the narrative of the findings to focus on how newer heavy-duty diesel trucks run cleaner and why AirCare for heavy-duty trucks would not be effective (BC Trucking Association, 2013). While it is generally true that newer heavy-duty diesel trucks run cleaner when operating properly, the media release ignored many other findings. Particularly interesting is how the BC Trucking Association could review the findings and issue a news release the very same day study results were shared with Metro Vancouver's internal committees. This suggests that the BC Trucking Association may have had a level of access to information ahead of the public, in order to offset a potentially negative story by shaping the narrative through media in advance.

Nearly two weeks after the BC Trucking Association's media release, Metro Vancouver issued their own media release on April 26, 2013 titled, *Older Trucks Create the Most Diesel Pollution on Metro Vancouver Roads*, that validated concerns about air emissions from older heavy-duty diesel trucks, and emission control system malfunction and tampering in both newer and older trucks. Metro Vancouver also stated that they would require help from the province to "shape a comprehensive package of programs and policies to effectively target the real issues of aging fleet, gross emitters and tampering" (Metro Vancouver, 2013, para. 7; Vancouver Sun, 2013). These activities in the public realm through attempts to create media attention and reshape the narrative

highlight how the trucking industry worked to maintain business as usual and prevent AirCare for heavy-duty trucks from ever materializing.

Since then, AirCare for heavy-duty trucks or other forms of mandatory emissions testing and inspection programs that focus on health-harming air pollutants have not been seriously considered by the Province. Provincial initiatives announced as part of the Climate Leadership Plan in 2016 and CleanBC Plan in 2018 and 2021 have focused on voluntary programs that aim to first and foremost reduce greenhouse gas emissions and help truck owners save on fuel costs. These incentives come in the form of rebates for those who choose to purchase zero-emission trucks or install fuel-saving engine/body modifications. Currently, these rebates and incentives fall under the CleanBC heavy-duty vehicle efficiency program, which was launched in 2019 as a partnership between the provincial Ministry of Transportation and Infrastructure and BC Trucking Association (BC Trucking Association, 2019; Province of B.C., 2019). No publicly accessible information could be found regarding the effectiveness of this program and no enforcement appears to be in place to ensure modifications are used after receiving rebates and other incentives.

This collaborative partnership is a stark contrast between what appeared to be a combative relationship between the BC Trucking Association, Ministry of Environment and Metro Vancouver when mandatory measures to reduce truck TRAP were being considered. As part of stakeholder engagement leading up to the development of the Climate Leadership Plan in 2016, the BC Trucking Association was invited to submit thoughts on actions that could reduce emissions. Within their submission, they highlighted opportunities to reduce greenhouse gas emissions through initiatives to incentivize fleet renewal and enable the installation of “technologies verified to improve fuel efficiency” (BC Trucking Association, 2016, p. 4). These highlighted opportunities appear to have been considered within the Climate Leadership Plan and CleanBC Plan as they continue to form the foundations of the CleanBC heavy-duty vehicle efficiency program in place today.

Based on information gathered from the BC Trucking Association’s Climate Leadership Plan submission and from key informant interviews, industry’s opposition to a mandatory emission testing and inspection program is related to fuel efficiency and greenhouse gas trade-offs for diesel engines, impacts to profit margins that are already

slim, and lack of clarity on the most reliable and operationally efficient zero-emission engine option. The most frequently mentioned reason was fuel efficiency and greenhouse gas trade-offs along with impacts to profit margins (BC Trucking Association, 2016, Anonymous Informant A, Anonymous Informant C, Anonymous Informant H).

> The irony is that the reduction of smog emissions came at a cost – not only a direct financial cost to industry, but an environmental cost. The technology to meet the emission standards reduced fuel efficiency and, as result, increased GHG emissions. The negative impact was particularly severe for 2007 to 2009 model-year trucks – fuel efficiency dropped by 5 to 10% relative to previous model years. Fortunately, the emission control technology developed to meet the 2010 emission standard also offset some of the fuel efficiency loss associated with the 2007 emission standard. Nevertheless, the net result is that today's modern trucks produce very clean exhaust, but are no more fuel efficient than their predecessors built in the late 1990s. In other words, the cost of achieving a "smog-free" truck was a decade of lost fuel efficiency gains and GHG reduction. (BC Trucking Association, 2016, p. 3)

For these reasons, the BC Trucking Association believes that incentives to accelerate fleet renewal should be a key focus when it comes to reducing truck TRAP and greenhouse gas emissions, and argue that there's no point in looking back at addressing old diesel engine technology.

> Where do we go from here? That's been a lot of our work as an association, particularly over the past year to really try and get a handle on what's the art of the possible, what can we do? Where we've landed is that we can't go back. If we go out and we say, you know what, that's it, leaving aside all the problems and all the issues [related to tampering and emission control systems] and run them through [testing and inspections] and build it into the semi-annual commercial vehicle inspection protocols and programs, what do we end up doing? If we win and say, we're going to make sure that all the equipment out there isn't deleted, what you will do is increase your greenhouse gas profile by 5-10%. So, if I put the [emission control components] back on or reactivate it, our greenhouse gases go up and your NOx and Sox come down. Pick your poison.
>
> It was great except it didn't work -- terrible reliability problems. You had vehicles in the shop consistently losing productivity, serious cost implications. And the fuel burn went up anywhere from five to 12%, a commensurate increase in GHG emissions. It took us to 2017 to get back to the fuel efficiency that we had in the late nineties.
>
> What we've been saying, and this is quite recent – it's insane – is to government is don't waste your time. Don't waste your energy. There is no

> point. It doesn't make any sense to go to an owner and say, I want you to spend $20,000 or $30,000 to un-delete your truck and get it on there and get it rolling. Because what you're going to do is just increase your greenhouse gas emissions. What we need to do is get the old crap off the road and turn the fleet over. We need to turn the fleet over more quickly than we have, and we need to get serious and aggressive about doing it. (Anonymous Informant C)

And according to other stakeholders, there is consensus that the cost associated with addressing tampering would create burdens and unrest within the trucking sector.

> There are issues in the container trucking sector. A lot of it relates to, are they getting paid enough money right now? Then [is government] going to come along and say, well, by the way, you got to retrofit all your trucks. You've got to go put this other device on your trucks to scrub it? It makes it a very difficult and sensitive situation now to compound that with it. (Anonymous informant F)

This creates barriers to fleet renewal and addressing emission control system tampering due to cost concerns. However, some argue that ignoring the issue of tampering and waiting for fleet renewal to take place turns a blind eye on national safety codes and allows illegal activity to continue occurring.

> It’s laid out in the portions of the national safety code. Safety code standard 11 B is incorporated into the vehicle inspection program here in British Columbia. Tampering with emission control systems is illegal as part of that inspection program. Right now, it's a visual inspection, which doesn't necessarily capture what's going on. (Anonymous informant A)

While the BC Trucking Association argues that retiring older trucks through fleet renewal is key to addressing both greenhouse gas and air pollutant emissions, what has happened with the port authority’s minimum truck age requirements shows us that extending the life of trucks is what truck owners and operators would rather do. Getting older trucks off the road will not be an easy task. What was supposed to be a ban on port terminal access for trucks aged 10 years or older starting February 2022 was adjusted to a restriction on trucks aged 12 years or older, starting in September 2022. This requirement continues to meet resistance with threats of strike (Global News, 2022b; Vancouver Fraser Port Authority, 2022b).

Through this look back at activities taken by industry and the BC Trucking Association, it becomes apparent that lobby efforts have maintained business as usual by continuing to create a policy environment where unsustainable practices and trends

are accommodated and accepted. This has worked to protect private interests focused on profit margins. The relationship between the BC Trucking association and Province of B.C., particularly the Ministry of Transportation and Infrastructure, has also shifted towards a collaborative partnership, which may also create a barrier within itself to take a firmer stance that challenges the interests of industry.

These events also highlight the complexity of managing truck traffic related air pollution along the Clark-Knight corridor because simply diverting traffic from one truck route to another reactively in response to community concerns such as in the case of Nanaimo St. is not the answer. This research highlights how land use and transportation planning must be done in a way that considers the health of communities. As trucks continue to move through the corridor, along other regional roadways, and make their way across the province and beyond, it becomes clear that a paradigm shift is needed and an opportunity exists for the province to take leadership and spearhead programs that disrupt the status quo to support a sustainable shift in the trucking industry and address problems with gross emitters throughout the province to help ensure that all trucks are not tampered with and are properly maintained.

5.2.2. Government reluctance towards the ratification and implementation of environmental policies with concentrated costs despite diffuse benefits

Since 2011, Metro Vancouver has recognized the need to introduce a mandatory emission testing and inspection program for heavy-duty diesel trucks running on local roads to target gross emitting heavy-duty diesel trucks, which include trucks that have emission control systems that either malfunction or that have been deliberately tampered with. Such a program was first mentioned in Metro Vancouver's 2011 Integrated Air Quality and Greenhouse Gas Management Plan. Since Metro Vancouver "does not have regulatory authority over all air emission sources in the region," the integrated plan laid out how Metro Vancouver would "work with other air quality, health, climate change and transportation authorities at the regional, provincial, federal and international levels to collaboratively plan and implement initiatives to improve air quality and address climate change" (Metro Vancouver, 2011, p. 5). Specifically, it listed the key roles and responsibilities of the Government of Canada, Province of B.C., TransLink, and local governments, which all had a role to play in the implementation and establishment of

policies and initiatives laid out within the plan. The provincial government possessed the most influence over the development of a B.C.-wide program to manage air pollutant emissions from heavy-duty trucks (Metro Vancouver, 2011).

As mentioned in chapter 4.4.2, the boldest attempt to develop a mandatory emission testing and inspection program for trucks occurred in 2012 when provincial government Environment Minister Terry Lake and Metro Vancouver Chair Greg Moore together announced that AirCare would turn its focus to managing heavy-duty diesel truck emissions. Interestingly, interviews revealed that the announcement caught some government staff by surprise, which suggests that coordination and collaboration between Metro Vancouver and provincial government ministries on emissions testing for heavy-duty vehicles was not already underway despite being referenced in Metro Vancouver's plans in 2011.

> Air care for trucks was an interesting announcement. It was done during the announcement to end AirCare for light duty vehicles. How can I say this politely? Um, it wasn't [originally] in the minister's speech. He said we're going to look at AirCare for heavy-duty vehicles and that caught everybody – everybody -- by surprise. So, that's why we went and said, "Okay, now we've got to look at this. Can we do that? And that's why we did the pilot testing and everything." (Anonymous Informant F)

Despite surprising some government employees, the announcement triggered a period of heightened activity within government between 2012 and 2013 to assess policy options and conduct studies to quantify the largest sources of emissions. One such study was the *Remote Sensing Device Trial for Monitoring Heavy-Duty Truck Emissions* conducted in 2013, which highlighted the importance of managing air pollutant emissions from older heavy-duty diesel trucks and tackling issues related to poorly maintained emissions control systems and tampering. In another report done in 2013 titled *Heavy Duty Diesel Vehicle Policy Options Evaluation Study* led by both Metro Vancouver and BC Ministry of Environment, and reviewed by members of the Diesel Vehicle Subcommittee of the AirCare Steering Committee, "a prioritized list of targeted and focused policies or programs to reduce air emissions from heavy duty diesel vehicles operating in the Canadian Lower Fraser Valley" was developed (Envirotest Canada, 2013; SNC Lavalin, 2013, p. 2). The report recommended the implementation of a mandatory inspection and "maintenance program targeting trucks with engines older than [seven years]" to reduce health-harming diesel particulate matter and nitrous oxide

emissions from heavy duty diesel trucks (SNC Lavalin, 2013, p. 7). Such a program would have “yield[ed] emission reductions from heavy duty vehicles of 83% for [diesel particulate matter] and 76% for [nitrous oxides] by 2020, compared to 2010” (SNC Lavalin, 2013, p. 7). It was noted that a benefit of such a program would “be viewed as fairer by the public and businesses since it targets the worst emitting vehicles” (SNC Lavalin, 2013, p. 7).

In Metro Vancouver’s Integrated Air Quality and Greenhouse Gas Management Plan Progress Report issued in October of 2014, Metro Vancouver continued to mention that they will “work with the provincial government, AirCare and the Fraser Valley Regional District to design and implement more effective and user-friendly emission inspection and maintenance programs for the most polluting light and heavy-duty vehicles” (Metro Vancouver, 2014, p. 41). The progress report also mentions work done in 2013 to assess policy options to address emissions from heavy-duty diesel vehicles and maintains that “one of the top ranked options was an inspection and maintenance program for heavy-duty diesel vehicles” (Metro Vancouver, 2014, p. 41).

However, now, eight years after these reports, such a program has not yet been put in place despite collaborative work across agencies and strong messages from government that support the creation of a mandatory emissions testing and inspection program. Although no news releases or statements were made by government to media publicly to explain why AirCare for heavy-duty trucks lost steam or was put on hold, interviews conducted as part of this research reveal multiple factors were at play.

Despite the time that has passed, Metro Vancouver has not yet lost hope and still holds the view that emissions system tampering and malfunction needs to be addressed. In its draft Clean Air Plan released for public and stakeholder consultation in 2021, Metro Vancouver once again stressed the importance of emissions testing and inspection of heavy-duty trucks along with the need to accelerate fleet renewal towards zero-emission technologies. The following “big moves” were identified in the draft plan as “foundational to achieving the 2030 targets, and should lead to the most significant emission reductions” that will help contribute to a “25% reduction in diesel particulate matter emissions, from 2020 levels [and a] 40% reduction in nitrogen oxides emissions, from 2020 levels (Metro Vancouver, 2021, p. 28, 29):

- **Regulate Existing Medium and Heavy Trucks.** Develop regulatory requirements for existing medium and heavy duty vehicles, to be implemented by the BC Government or Metro Vancouver. Regulatory approaches to reduce emissions could include an inspection and maintenance program that requires repairs on higher emitting trucks, registration requirements targeting older trucks, a regional smoking vehicle hotline, and low or zero emission zones […] Requirements would initially target health-harming air contaminants but should eventually include greenhouse gas emissions. Lead Agencies: Metro Vancouver, BC Government, member jurisdictions; Start Years 2022 – 2023

- **Require Zero Emission Sales Targets for New Medium and Heavy Trucks.** Advocate to the BC Government to set mandatory zero emission vehicle sales targets for new medium and heavy duty vehicles. For medium duty vehicles, the zero emission sales target should reach 100% by 2050. For heavy duty vehicles, the zero emission sales target should reach 100% before 2060. Lead Agency: BC Government; Start Years 2023 – 2024 (Metro Vancouver, 2021, p. 28, 29).

In addition, Metro Vancouver is advocating for a program to address tampering of emissions control systems in both medium and heavy duty trucks:

- **Eliminate Tampering with Vehicle Emission Controls.** Work with the BC Government and the Government of Canada to reduce the air quality impacts from tampering with emission control systems in passenger vehicles, and medium and heavy duty vehicles. This could include banning the sale or import of tampering devices, and improving enforcement of tampering in vehicles and by automotive repair shops. Lead Agencies: BC Government, Government of Canada, Metro Vancouver; Start Years 2022 – 2023 (Metro Vancouver, 2021, p. 28)

Next steps for Metro Vancouver's draft Clean Air Plan include a review of public and stakeholder comments received before a final Clean Air Plan is released.

However, when a key stakeholder was asked about Metro Vancouver's plans to consider a maintenance and inspection program for its 2021 Clean Air Plan as part of this research, they questioned the program's effectiveness if incentives to encourage fleet renewal to adopt zero-emission vehicles will be in place.

> They're good policies but what's the effectiveness of them? What is the lifespan going to be with them with [the province's] new vision for transportation where everything's zero emission vehicles? And how fast can we get there? How much [longer] do we want to test these internal combustion engines for? (Anonymous informant F)

Looking to the Province of B.C.'s CleanBC Roadmap to 2030 released on October 25, 2021, no targets for zero-emission heavy-duty trucks will be in place until sometime in

2023 due to “time required for research and engagement” (Province of B.C., 2021, p. 35). There was also no mention of any plans to manage air pollutant emissions from heavy-duty trucks. According to some sources, we can’t just rely on programs that incentivize fleet renewal while ignoring trucks on the road already because heavy-duty diesel trucks will likely still be around for at least two more decades (Anonymous Informant A, Anonymous Informant C, Anonymous Informant H).

> While you can transition in the long term, hopefully the majority of the fleet to zero emission freight vehicles, you're never going to get to a hundred percent. Certainly, over the next couple of decades, based on the modeling that that I've seen, is that diesel trucks are going to be with us into the foreseeable future. The name of the game here is trying to ensure that there is compliance with the emission standards and address tampering and defeat devices. (Anonymous informant A)

A key question that I asked interviewees focused on what made the management of air pollutant emissions from heavy-duty trucks difficult and what they thought contributed to the stalled ratification and implementation of a mandatory inspection and testing program for heavy-duty trucks. Interviewees revealed that momentum to move forward on the program seemed to stop once it reached the provincial government. Reasons included siloed decision making between provincial government ministries and agencies, along with the provincial government’s assessment of how well it would be compatible with their climate action plans.

> I presume it was in a staff report that pointed out that a change in focus towards heavy-duty trucks was recommended. But then of course, because you're dealing with the trucking industry, all of a sudden you're dealing with Ministry of Transportation and Infrastructure (MOTI) that run the Commercial Vehicle Safety and Enforcement program. With that, it was suddenly out of the hands of the Ministry of Environment and into the hands of the MOTI. There had to be a lot of cross ministry meetings to kind of come up with the recommendation that we focus more on heavy-duty trucks than on cars and light trucks. But once it moved over to MOTI, it became their baby. They're looking after it. And to be honest, I just never heard about what was going on with it after that. (Anonymous Informant G)

> The intention on [the provincial government’s] part, our understanding anyways, was that they were going to take the suggested [policy] proposals for heavy duty vehicles and see how that meshed with their climate planning. And the work essentially kind of started to languish at that point. I'm not sure that it was a high enough priority on the climate change list for the province. (Anonymous Informant I)

Another informant was also vocal about the provincial government's choice to prioritize greenhouse gas emissions reductions over air pollutant emissions when both should have been prioritized:

> Provincially, I think greenhouse gas emissions reductions are prioritized over air pollutant emission reductions. Generally speaking, with tampering and delete kits aside, when you reduce one, you generally reduce both, especially from combustion of fossil fuels. […] Both climate change and air pollution have significant adverse health effects and a whole range of other adverse effects. There's huge value in addressing both. […] I would also say that I think politically, and you see this in media as well, right? Climate change and the reduction of greenhouse gases have definitely become more prominent. (Anonymous Informant B)

In addition, interviews revealed that fragmented governance, opposing interests, and political influence from the trucking community were all contributing factors.

> It is a fragmented regulatory and policy framework. It's an accurate statement to say that no government agency in this region has full authority over everything that pertains to goods movement. In many cases the authority is complementary. There is also a lot of overlap. Similarly, not all the stakeholders are on the same page. They have disparate interests. They do align, but not necessarily to the extent where it makes the policy process smooth and easy. (Anonymous Informant A)

To combat "challenges in planning for freight movement" TransLink convened the Greater Vancouver Urban Freight Council in 2017, a stakeholder group formed to advance the implementation of their Regional Goods Movement Strategy. This was meant to bring together both public and private sector partners in order to increase coordination and collaboration, and address issues related to a "fractured regulatory landscape" (TransLink, 2017, p. 3, 4). While not a core part of the group's mandate, air quality related to TRAP has come up.

> It is a significant enough of an issue in the industry that it warrants taking a closer look at and trying to see whether the policy recommendations that Metro Vancouver made should be moving forward. The issue of [emission control system tampering and delete kits] was actually put in front of the Urban Freight Council all throughout [2020]. We're going to push it and get a better sense of where we can go or what the options are in terms of an inspection and maintenance program by the end of [2021]. It has been brought up at the regional level and it has been brought up by the City of Vancouver directly and also through various council resolutions at the City of Vancouver, specifically in relation to the Clark-Knight corridor. (Anonymous Informant A)

When asked directly about whether the history of container trucking strikes in 1999, 2005, and 2014 had any direct influence over the implementation of a mandatory emissions testing and inspection program, most interviewees either told me that they didn't know, declined to answer or told me that "No one's going to answer your question. No one is going to be willing to actually say that" (Anonymous informant). One answer did however reveal that container trucking strikes and political influence had a role in a shift towards voluntary incentive programs versus mandatory programs.

> The trucking industry has two key powers. One, to stop the economy [through strike action] and two, politically they are all aligned. So, it's difficult…well it's not difficult… you just have to be very sensitive of their needs while you're doing any policy work. That's why the focus has been on voluntary programs through the [CleanBC Heavy-duty Vehicle Efficiency Program]. The program provides training and gives them money to help them purchase new equipment. So again, it's incentives to get [truck owners] to clean up their vehicles completely. The truckers that represent the drayage fleet are organized very well.
>
> Now we've gone onto the softer side, away from legislation to the incentive program where our heavy-duty vehicle efficiency program that focuses on getting these guys burning less fuel. Let's teach them good driving habits and teach them about cleaner vehicles and how cheaper they are to operate. […] Let's teach them to burn less fuel. If they burn less fuel and less greenhouse gases, less NOX, less SO2. So that's where we've shifted now, is into a voluntary policy. (Anonymous informant F)

However, by taking a voluntary approach and by offering subsidies, this "alone cannot eliminate regulated interests' economic incentive to pollute" and is at "best seen as a supplement rather than an alternative to regulation" (Harrison 1996, p. 14). To be effective, Harrison argues that "some form of regulation, possibly supplemented by subsidies or public enterprise, is necessary to overcome economically rational polluting behavior" (Harrison 1996, p. 14).

News releases from the port authority and the Ready-Bell report related to container truck strikes also note that costs related to meeting environmental regulations were part of the set of concerns that ignited the strike in May 2014 and future threats of strike action in July 2014 extending to January 2015 (Vancouver Fraser Port Authority, 2014; Vancouver Fraser Port Authority, 2015; Ready-Bell, 2014). Interestingly, 2014 was the same year that AirCare for passenger vehicles and light-duty trucks ended on December 31. Actions taken by the BC Trucking Association to persuade the public, media and government that a mandatory emission testing and inspection program would

not be necessary also confirm that lobbying and political pressures were being placed on government to shift to voluntary measures.

As Metro Vancouver embarks on another attempt to bring in a testing and inspection program through their revised clean air plan, it is important to reflect on and learn from past attempts and obstacles to move forward and break through the barriers that restrict policy innovation. Findings from this research reveal that the trucking industry has been successful in influencing policymakers to delay the implementation of the port authority's rolling 10-year truck age requirements for container trucks and shift the Province of B.C.'s focus from mandatory to voluntary measures to reduce air emissions from heavy-duty diesel trucks. The data shows that the industry will continue to resort to similar tactics of potential threats of strike action and political pressure through lobbying.

5.3. Contrast case: How the ratification and implementation of a mandatory safety and emission control system testing program for heavy-duty trucks was possible for Ontario

In contrast to the Province of B.C., the Government of Ontario has embarked on a clear path towards ensuring that the biggest polluters are taken off the roads. Ontario once had a program similar to B.C.'s AirCare Program called Drive Clean, which enforced mandatory emission testing on passenger vehicles. The Government of Ontario decided to cancel the program in 2018 to focus on redesigning their program to target heavy-duty trucks, similar to what B.C. had announced it intended to do. While B.C.'s program became much less stringent and did not enforce mandatory emissions testing, Ontario took a different path. Upon cancelling Drive Clean, an announcement was made regarding mandatory emissions testing effective April 1, 2019 for heavy-duty diesel trucks that are seven years and older. Trucks would have to pass minimum emissions requirements before being able to renew their registration (Government of Ontario, 2018; Government of Ontario, 2019). On December 3, 2019, the Government of Ontario took an even firmer step by announcing "the creation of a new integrated emissions and annual safety testing program", which streamlines testing and mandates annual testing in all heavy-duty diesel trucks to ensure emission control systems are not tampered with and that emission levels meet minimum requirements before continuing to operate for trucks seven years or older (Ontario Trucking Association, 2019, p. 1). With

this new program and on-road enforcement in place, the Government of Ontario can continue to incrementally shift trucking towards a more sustainable path whereas B.C. currently has no formal program in place to enforce and create this shift. Through an analysis of how the Government of Ontario was able to ratify and implement a mandatory safety emission control system testing program for heavy-duty trucks, I identify the factors that made it possible for Ontario but so far, impossible for B.C. These factors include industry and provincial support for environmental regulations, pressure from municipalities to address air quality, and effective collaboration between provincial government ministries.

As I gathered information on how Ontario was able to put such a program in place, I was not able to find obvious signs of opposition to the program or lobbying tactics similar to what has been observed in B.C. Through news releases, I discovered that the Ontario Trucking Association was a key partner in helping launch this program together with the Province of Ontario (Ontario Trucking Association, 2019). The role and mandate of the Ontario Trucking Association is similar to the BC Trucking Association and "represents all segments of the industry" and "provides services and public policy advocacy for trucking companies hauling freight into, out of and within the Province of Ontario" (Ontario Trucking Association, 2022, para. 1). B.C. and Ontario also share a similar situation with the rising use of emissions tampering delete kits and related concerns about the impacts of air pollution from tampered and older heavy-duty trucks on human health.

According to Lak Shoan, director of policy and affairs with the Ontario Trucking Association, the organization took action on the issue due to concerns raised by their membership. Their members saw tampering as jeopardizing fair competition for responsible owners and operators who followed the rules. By working with the Province of Ontario to address emissions tampering, the Ontario Trucking Association helped create a more even playing field and curb undercutting.

> We raised the issue to the Provincial Government back in 2017 or 2018. The use of emissions tampering delete kits had steadily been rising here in Ontario and it quickly became a competitive issue for a lot of our member companies. The upkeep and maintenance for a truck can be very expensive. If you have a fleet that's employing the use of delete kits, they can reduce their maintenance costs upwards of 40%. That leads to a distortion in the marketplace and its hurting operators that are following the

> rules, being compliant, and doing everything they can to be responsible from a GHG perspective, and from an environmental perspective. These aren't the companies that are competing and offering, their services at a very reduced rate. While I can't talk about freight rates because of the Competition Act, I can say that it leads to an obvious distortion in the marketplace and a competitive imbalance, along with the environmental impacts and the impacts of air quality that impacts all of Ontario. So, that's where our charge on this issue started. (L. Shoan, personal interview, January 28, 2022)

Although price undercutting was a major factor that led to strike activity and trucking industry unrest in B.C., the use of emissions tampering delete kits was not found to be mentioned as a related concern. Considering that the use of delete kits exists in B.C. and can reduce maintenance costs by up to 40%, emissions tampering could have been an unaccounted-for factor in B.C., which contributed to undercutting. While prices within B.C.'s drayage sector are provincially regulated and set to prevent undercutting, an unfair playing ground remains where companies and drivers can continue to make more profit by using delete kits to decrease their operating costs due to the lack of enforcement measures. The Ontario Trucking Association's members were supportive of the mandatory measures and chose to take action was due to the pride and integrity that they had in being able to uphold environmental standards and do the right thing:

> If you're using delete kits or you're bypassing the way an engine functions, or should be functioning, and creating all that particulate matter and all the harmful things that can lead to smog and illness and airborne diseases, our members are not proponents of that and don't stand for it. I think a part of it as well is that a number of our members are very proud of our environmental record. They're doing a lot to reduce the effects of air quality and GHG emissions through their operations. They're working with their customers to ensure that they're delivering their freight in the most efficient and environmentally friendly way possible. This is all obviously a big factor in leading the charge on this issue as well. (L. Shoan, personal interview, January 28, 2022)

The timing of Ontario Trucking Association's decision to pitch their plans also worked in their favour as it came around the time that the Government of Ontario actively worked to push back on a federal government-imposed carbon tax, which would add additional costs to using fossil fuels. At the time, the Government of Ontario argued that the tax would place too high of a financial burden on Ontarians and called "on the federal government to eliminate the unconstitutional carbon tax and let the provinces decide how best to regulate greenhouse gas emissions" (Government of Ontario, 2018,

para. 3; Government of Canada, 2022b). Although the argument that an imposed tax on burning fossil fuels would create financial ripple effects and turn into a “job-killing tax” is a sign of carbon lock-in, it contributed to a positive scenario for the Ontario Trucking Association (Government of Ontario, 2018, para. 5).

> This coincided with the Government of Ontario looking at creative ways to tackle climate change and air quality. At that point in time, the Province of Ontario, wasn’t a part of the federal carbon tax policy. They were pushing back on it and so I guess our interests and the interests of the provincial government coincided at that point, which led to a natural partnership to look at introducing some other measures that could tackle the issue of air quality, greenhouse gases and the environment in a more creative way. (L. Shoan, personal interview, January 28, 2022)

With the launch of their mandatory testing program, Ontario became “one of the first jurisdictions in North America” to launch such strong measures to combat emission system tampering (L. Shoan, personal interview, January 28, 2022). Though the scope of the inspection program only applies to trucks that are plated and based in Ontario, the Ontario Trucking Association recognizes that out-of-province trucks are part of the problem. As part of an on-road enforcement study by Ministry of Environment, Conservation and Parks (MECP) officers in 2019, the ministry found that out of “over 150 inspections on heavy-duty vehicles with an out-of-province license plate, nearly 60 per cent of these trucks were found to be non-compliant and subject to fines, abatement or other enforcement action” (Ontario Trucking Association, 2020, para. 3). This underscores the importance of an enforcement approach to tackle a nation-wide issue and word is spreading about the program Ontario has in place. With the dual function of federal lobby for the Canadian Trucking Alliance, a federation of provincial trucking associations, the Ontario Trucking Association is taking the opportunity to share what’s been done in Ontario with other provinces and at the federal level to develop a national enforcement strategy:

> Word is definitely spreading and we've been doing our best through the Canadian Trucking Alliance to work on a national enforcement strategy to tackle the issue of delete kits as well. And we got support from [Federal Minister of Environment at the time] Jonathan Wilkinson, I believe it was last year to look at tackling the issue of emissions tampering from a national perspective as well. So, that's probably another reason why a lot of the provinces have looked at this issue a lot more closely over the last year or two. (L. Shoan, personal interview, January 28, 2022)

Considering that heavy-duty diesel trucks have a long lifespan and that older trucks are also a part of the problem, an additional way to reduce air pollutant emissions is to encourage fleet renewal by providing incentives for drivers and owners to scrap old trucks in return for rebates on the purchase of new trucks. While the federal government and the Canadian Trucking Alliance have discussed such measures in addition to efforts to prevent emissions system tampering, the Ontario Trucking Association warns that a scrappage and rebate program may not work as intended without a method of enforcement and compliance:

> We've been talking with some of the officials at the federal government in terms of whether that's introducing a scrappage program or something as an incentive to get some of these older vehicles off the road, but that sort of brings in its own challenges because if we're having operators that are using trucks that have deleted emissions, are they going to take advantage of these scrappage programs to scrap their older vehicles to buy newer trucks at a competitive advantage and then go ahead and delete those emissions on those new vehicles as well? But if we can mitigate people taking advantage of things like a scrappage program and finding loopholes to keep this cycle going, then I think we're definitely open to that. (L. Shoan, personal interview, January 28, 2022)

Despite discussions held between the Ontario Trucking Association, Canadian Trucking Alliance, and federal government in 2021 regarding the need for a national enforcement strategy to address engine tampering and reduce emissions, the Government of Canada has not made commitments to move this forward. In the 2030 Emissions Reduction Plan, which lays out federal commitments to improve air quality and reduce GHG emissions, actions to reduce emissions from heavy duty diesel trucks focused on objectives to "accelerate the switch to zero-emission on-road vehicles" with the goal of "reaching 35% of total [medium and heavy-duty vehicle] sales being ZEVs by 2030" and developing "regulation to require 100% [medium and heavy-duty vehicle] sales to be ZEVs by 2040 for a subset of vehicle types based on feasibility" (Government of Canada, 2022a, p. 61). In support of the objectives, additional investments to incentivize new vehicle purchases, accelerate the uptake of hydrogen-powered heavy-duty trucks, expand Canada's zero emission vehicle recharging infrastructure, and retrofit trucks already on the road were mentioned.

While retrofits for trucks already on the road are mentioned, technology will likely focus on increasing fuel efficiency. This likelihood is inferred from past industry engagements led by Transport Canada in 2020 to "seek industry input about fuel-saving

retrofits for heavy-duty vehicles in Canada" (BC Trucking Association, 2020) and "address questions around barriers to adoption of fuel saving technologies" (Canadian Trucking Association, 2020, para. 3). Currently, commitments laid out in the 2030 Emissions Reduction Plan focus on transitioning to zero-emission vehicles and does not directly address the issue of air pollutant emissions from heavy-duty diesel trucks, nor does it address emissions system tampering.

According to the Ontario Trucking Association, it's imperative that we do not lose focus on addressing air pollutant emissions from trucks currently on the road as levels of government work towards a transition to zero emission vehicles. When asked about the concerns regarding trade-offs raised by the BC Trucking Association between greenhouse gases and fuel efficiency, and air pollutant emissions, the Ontario Trucking Association's perspective is that air pollutants from heavy-duty diesel trucks on roads now can't be ignored and need to be addressed, regardless. Growing concerns raised by academia and local municipalities were also a factor that influenced the Ontario Trucking Association to take proactive action against air pollutant emissions and tampering, specifically targeting trucks already on the road.

> It's a good question and it's a bit of a conundrum. The air quality issues have been raised by a bunch of other folks, including the University of Toronto and a bunch of other sectors. We have a lot of traffic here in Ontario and we have the most truck traffic in the Greater Toronto Area compared to any other place in North America and maybe even in the world with the amount of trucking companies and trucks going down the 401 and certain corridors here. And It's a big issue within a lot of different cities and jurisdictions [in Ontario] such as the City of Hamilton.
>
> [Municipalities] are trying to tackle the issue of air quality and having discussions about making cities more livable, so the issue is not only coming up from a provincial perspective but a lot through municipal perspectives as well. And they're looking at implementing truck routes and limiting access to trucks in certain areas of cities, so it's a multipronged issue.
>
> From our perspective, diesel trucks are going to be here probably for the next 10 to 15 years. We're not going to be looking at potentially hydrogen or electric trucks in the short to medium term because the technology definitely isn't ready for the long-haul trucking sector. We need to continue focusing on diesel trucks and what we can do to not only reduce emissions from that perspective, but also to reduce the use of delete kits to make our air quality better because diesel trucks are going be here for at least the next 10 to 15 years, so we can help eliminate both the [GHG] emissions

> and the air quality issue a lot more effectively. (L. Shoan, personal interview, January 28, 2022)

To address concerns about the public health impacts of diesel particulate matter on local communities, municipalities became increasingly interested in limiting which routes trucks could take through their communities. This began to concern the Ontario Trucking Association due to potential impacts to efficiency and led to increased collaboration between the Ontario Trucking Association and municipalities to work together to address air quality concerns while ensuring adequate access.

> In Hamilton, specifically, and there seems to be a lot of jurisdictions that are looking at implementing truck routes or updating their truck route. They do have the ability to limit where certain trucks can go within the city. We've been trying to work with them and say, “Hey, there's certain routes that trucks need to take. We understand that you want to crack down on the air quality issues and emissions. We think we have, certain things that we can do, whether that's enforcement in certain areas or ensuring that trucks that don't need to cut through certain routes or through the cities that don't need to be there and are just taking a short route or a shortcut for the sake of taking a shortcut and are not making deliveries within the cities are not going to be there. Let’s work with you to try to address these issues, but trying to limit trucks from being there that need to be there to make deliveries to certain customers just don’t make sense. (L. Shoan, personal interview, January 28, 2022)

These power dynamics reveal that the Ontario Trucking Association faced increasing pressure from multiple municipalities that began taking matters into their own hands by limiting truck access in a way that would impact the trucking industry’s ability to deliver goods in an efficient manner. This leverage that municipalities had and were willing to use alarmed the OTA, which resulted in action to increase collaboration with municipalities to help manage truck traffic and emissions.

In the case of the Clark-Knight corridor, the City of Vancouver would not have been empowered in the same way to make changes to major roads since the corridor is part of the TransLink-managed Major Road Network. For any road within the Major Road Network, change requests would need to go through TransLink’s approvals process and get presented to TransLink’s Board of Directors who are responsible for making the final decision on whether it gets approved (Anonymous Informant A).

Another key difference between B.C. and Ontario was the presence of cross-ministry collaboration. In B.C., the momentum to put in place a mandatory emission

testing program for heavy-duty trucks was lost entirely when the lead role shifted from the Ministry of Environment to the Ministry of Transportation and Infrastructure (Anonymous Informant G). In contrast, the informant in Ontario suggested that effective collaboration between the Ministry of Transportation and Ministry of Environment, Conservation and Parks helped lead to the successful launch of their emissions testing program.

> First, we raised it with the Ministry of Environment, Conservation and Parks. And from there it sort of morphed into, “We need to get the Ministry of Transportation involved”. So, that's where they joined forces and led the charge on developing this program. And up until recently, I would say probably within about the last year, the program has shifted more so to the [Ministry of Transportation (MTO)] end of it, after the emissions end of it got finalized. So, we're continuing to work with MTO in terms of how the actual safety [inspections] are going to be done, what the on-road enforcement can look like, what the new emission systems are going to look like for shops and technicians and what they're going to have to do and what oversight is going to be occurring over them as well. So, it's sort of shifted from the environment back to MTO, although environment will still have an oversight role in the process moving forward. (L. Shoan, personal interview, January 28, 2022)

Considering Harrison’s (1996) explanation of why governments and politicians are unlikely to pursue environmental regulation, we see that the conditions aligned for the Province of Ontario — the main condition being the lack of organized opposition to regulation — which meant no electoral disincentives for the government in power. The motivation to act against air pollutant emissions through environmental regulation arose from the trucking industry in Ontario, whereas the situation in B.C. was the opposite where the trucking industry viewed environmental regulations as being unwanted and imposed upon them. By acting in response to suggestions by the Ontario Trucking Association, the provincial government could position themselves as being supportive of industry, the environment, and being responsive to air quality concerns raised by municipalities and Ontario residents — a win-win situation. It also meant being able to generate “diffuse benefits on the public” without the political backlash of organized opposition by industry who would typically act to oppose regulation due to the potential cost of environmental regulation (Harrison, 1996, p. 13).

With mandatory safety and emission testing in place, the Province of Ontario now has an effective means to ensure compliance with national safety codes, which prohibit the removal of or tampering of emissions control systems on heavy-duty trucks. Despite

concerns about how enforcement measures that range from the issuing of fines to not being able to renew insurance may impact local business, the Ontario Trucking Association believes that compliance should apply to all companies and owner-operators.

> From our perspective, it's the rules are the rules, the laws are the law, and if you're compliant, it should be the same for everyone, whether you're a company that has 500 trucks or you're a company that has one truck. Does that mean that the book should be thrown at that one truck operator and they should lose their livelihood? You know, maybe not obviously, but that sort of enforcement lens is being taken enforcement officials at [the Ministry of Transportation] and [the Ministry of the Environment, Conservation and Parks]. They're going to levy the fines and penalties taking it to account all those different considerations. (L. Shoan, personal interview, January 28, 2022)

Meanwhile in B.C., there remains no effective means to combat emission system tampering and ensure the worst polluters are taken off the roads.

Chapter 6. Conclusions and recommendations

6.1. Summary of findings

Through a qualitative, mixed-methods case study approach featuring a primary case focused on the Clark-Knight corridor and a secondary, contrasting case focused on Ontario's DriveOn Emissions and Safety Inspection Program, I was able to identify the barriers to implementing policies and programs to improve air quality and reduce environmental inequity related to TRAP exposure along the Clark-Knight corridor. Data was collected through the completion of semi-structured interviews and reviews of government documents and news media coverage. A total of 16 semi-structured interviews were completed, comprised of 12 informants with experience working within different levels of government or government agencies on related portfolios, one Clark-Knight corridor resident who lived within the TRAP exposure zone, one citizen scientist volunteer, and two representatives from the trucking industry.

To make sense of planning and policy practices, I leveraged principles derived from Schiller & Kenworthy's (2017) work related to sustainable transportation and urban mobility policymaking to assess opportunities to help make planning and policymaking more sustainable (Schiller & Kenworthy, 2017). To better understand barriers to policy innovation, I leaned on Harrison's (1996) work, which explained the role of electoral incentives in a democratic government's decision-making process to pursue or not to pursue more stringent environmental policies (Harrison, 1996). Findings fell within two categories: 1) planning decisions that increased truck traffic volumes and residential density along the Clark-Knight corridor and 2) political factors that inhibited policy innovation and the ratification of stricter environmental policies for heavy-duty diesel trucks in B.C. In this conclusion section, I also leverage Unruh's (2002) carbon lock-in model to help explain the slow adoption and development of zero-emission technologies for trucks and to provide insights on what it might take to break through the barriers that hinder the development of new policies and programs that effectively address harmful air emissions. Unruh uses the term carbon lock-in to describe situations where fossil fuel-dependent systems and technologies become so engrained within societies over time that it creates challenges to public and private efforts to switch to low-carbon alternatives and effectively reduce air emissions (Unruh, 2022).

Through an analysis of planning decisions made by different levels of government and government agencies, I have concluded that existing environmental inequity was reinforced and intensified through transportation and land use planning practices related to heavy-duty truck traffic movements along the Clark-Knight corridor and industrial activities in Metro Vancouver. Specifically, this includes the decision by the City of Vancouver to restrict heavy-duty truck traffic movements to truck routes that belong to the Major Road Network due to community concerns raised by Nanaimo St. residents after port entrance changes, which led drivers to find more efficient routes. When Nanaimo St. residents started noticing an increase in truck traffic through their neighbourhood, they fought back and gained momentum during a municipal election year. Ironically, the decision to restrict truck movements in the City of Vancouver meant that the problem would only be intensified for Clark-Knight corridor residents who were not vocal in their opposition.

The Vancouver Fraser Port Authority's plans to accommodate container trade growth through terminal expansion projects on the south shore of the Burrard Inlet due to the lack of waterfront land elsewhere in the region also contributed to more truck traffic along the corridor. Paired with the City of Vancouver's decision to increase residential density, particularly for rental buildings, along arterial roads through the Secured Rental Policy passed in 2019, these decisions combined will shift even more lower income and vulnerable populations to live within increasingly polluted TRAP exposure zones and intensify environmental inequity.

Challenges to shifting port growth elsewhere and making heavy-duty truck trips shorter and more efficient were identified; namely, inefficient distribution of industry component activities and lack of industrial land. Considering that the region's roadways serve and connect more than just the municipalities that they are located within, it is integral that land use and transportation planning are done in a holistic way that considers the health and wellbeing of communities along with the needs of industry and regional goods movement. Schiller & Kenworthy (2017) note that "many of transportation's deleterious impacts stem from the lack of integrated planning" and findings show that opportunities exist for the Vancouver Fraser Port Authority, Metro Vancouver, TransLink, health authorities, and municipalities to work together to break down silos to facilitate integrated and coordinated land use and transportation planning (Schiller & Kenworthy, 2017, p. 14). Key considerations include a critical look at the

distribution of industrial land, how zoning should be approached along arterial roads, and how to plan regional goods movement in a way that is environmentally and socially responsible. Opportunities also exist for port authorities in B.C., the federal government, and other industry stakeholders to collaborate on facilitating trade and building the infrastructure needed to ensure the burdens of goods movement are not overly concentrated in specific areas.

This study also uncovered political barriers that inhibit policy innovation and the ratification of stricter environmental policies for heavy-duty diesel trucks in B.C. These barriers largely stem from organized industry opposition to environmental regulation, which creates a lack of electoral incentives for the government in power; and carbon lock-in, which "creates persistent market and policy failures that can inhibit the diffusion of carbon-saving technologies despite their apparent environmental and economic advantages" (Unruh, 2000, p. 817). Through my research, I found that the trucking industry's lobby efforts and threats of strike action in B.C. have been successful in achieving the following:

- Shifting the provincial government's focus from mandatory programs to voluntary incentive programs that increase fuel efficiency
- Delaying the implementation of the port authority's truck age requirement by at least 4 years
- Shifting the port authority's requirement for trucks to be no more than 10 years old to being no more than 12 years old

Despite clear evidence that air pollutant emissions from gross emitting heavy-duty diesel trucks are a public health issue, the Province of B.C. currently does not have plans to tackle the issue. Meanwhile, Metro Vancouver has continued to urge the Province of B.C. to collaborate on an inspection and maintenance program to target emissions control system tampering and poor maintenance. Such a program was referenced in Metro Vancouver's 2011 Integrated Air Quality and Greenhouse Gas Management Plan and again in their 2021 Clean Air Plan. The results of this research show that Metro Vancouver faced challenges in implementing key initiatives laid out within its 2011 Integrated Air Quality and Greenhouse Gas Management Plan. As Harrison (1996) pointed out, elected officials tend to shy away from pursuing environmental policies if they feel it could impact their ability to stay in power after the next election. Considering that Metro Vancouver does not have direct control over all

elements laid out within their latest Clean Air Plan and must rely on cooperation from other levels of government and related agencies, more should be done to strengthen or formalize commitments in order that electoral incentives do not have as big of an impact on implementation.

This research also revealed decision-making processes at the Province of B.C., which favoured and placed a higher priority on initiatives that focused on reducing greenhouse gas emissions rather than air pollutant emissions. Key informant interviews and document analysis revealed information on the trucking industry's message to government, which focused on how addressing emission control system tampering to reduce air pollutant emissions would lead to increased greenhouse gas emissions due to a resulting loss in fuel efficiency. Through data collected, I was able to conclude that the Province of B.C.'s priority to reduce greenhouse gasses inhibited the ability of the province to take action on addressing air pollutant emissions from heavy-duty diesel trucks.

In contrast, my findings from the contrast case study on Ontario's DriveOn Emissions and Safety Inspection Program prove that the ratification and implementation of a mandatory safety and emissions testing program is possible within a Canadian context. A key factor that led to the successful implementation was trucking industry support of the program, because there, it was perceived by truckers as a means to help address cost undercutting between companies. Cost undercutting was found to be enabled by the maintenance cost savings amongst fleets with deleted emission control systems. Findings shows that it was a win-win situation for the trucking industry and Ontario government because suggestions from the Ontario Trucking Association to address tampering came at a time when the Ontario government was actively opposing the federal carbon tax and looking to create a made-in-Ontario solution to address air quality and greenhouse gas emissions. By moving forward on the program with the Ontario Trucking Association, the Ontario government could generate "diffuse benefits on the public" without the political backlash of organized opposition by industry who would typically act to oppose regulation due to the potential cost of environmental regulation (Harrison, 1996, p. 13). Data generated from interviews with the Ontario Trucking Association reveals that tampering continues to contribute to an uneven playing ground for B.C.'s trucking industry where some companies are able to charge less or make more profit. Considering the public health and competitive impacts of

overprioritizing the reduction of greenhouse gas emissions over air pollutant emissions, the Province of B.C. must take action to effectively address both air pollutant and greenhouse gas emissions in climate action and climate change mitigation plans.

Other factors that have inhibited the development of more stringent environmental policies in BC include siloed decision making and a fragmented regulatory and policy framework. Considering that the health impacts of air pollution cost the B.C. economy an estimated $13.9 billion, there is an opportunity to factor this cost into programs and initiatives that focus on improving air quality (Health Canada, 2021). Doing this would help break down siloed planning practices and can provide a more holistic view of the costs and benefits across different ministries. This would require a fundamental change in the way budgets and spending are approached.

Data also led me to conclude that carbon lock-in is occurring within B.C. The lack of mandatory zero-emission heavy-duty truck sales, slow fleet renewal rates, and lack of disincentives to continue driving a poorly maintained or tampered heavy-duty diesel truck, highlights how government institutions are continuing to foster the expansion of carbon-based energy systems. Policy actors representing the interests of truckers work to maintain status quo and resist change through the creation of “defense mechanisms and entry barriers” in order to reinforce the existing policy framework and carbon lock-in (National Collaborating Centre for Healthy Public Policy, 2018, p. 2; Unruh, 2002).

6.2. Discussion

To make sense of why transitioning away from fossil fuels has been a slow and challenging process, particularly as it relates to heavy-duty trucks, I rely on Unruh (2000). He argues that “industrial economies have been locked into fossil fuel-based energy systems” through what he calls carbon lock-in, which “creates persistent market and policy failures that can inhibit the diffusion of carbon-saving technologies despite their apparent environmental and economic advantages” (Unruh, 2000, p. 817). Since “industrial countries have become locked into fossil fuel-based energy systems through path dependent processes driven by increasing returns to scale,” Unruh theorizes that change is not expected to be driven within industry or by government. Instead, we should look to external forces such as a major technological breakthrough or societal pressure to bring about change to break the cycle of lock-in (Unruh, 2002, p. 317).

Focusing on the processes of path dependence and the related carbon lock-in model, it is no surprise that policy innovation and the development of more stringent criteria and broader-reaching policies to ensure cleaner commercial trucks and the retirement of older, diesel engine trucks that emit higher levels of health-harming air pollutants has not occurred. According to Unruh (2000), the slow adoption and development of zero-emission technologies for trucks are due to "industrial economies [that] have been locked into fossil fuel-based energy systems through a process of technological and institutional co-evolution driven by path-dependent increasing returns to scale" (Unruh, 2000, p. 817). Once locked-in, these processes can "lock-out alternative technologies for extended periods, even when the alternatives demonstrate improvements" (Unruh, 2000, p. 818). Given these circumstances, the role of government cannot be underestimated as it possesses the power "to override market forces [… and] can create alternative incentive structures, or 'rules of the game', to which firms have to adapt their strategies" (Unruh, 2000, p. 824). To override these forces, we can move towards a shift by creating our "own condition of lock-in" by putting strict policies in place to make it more difficult to continue using fossil fuels and provide incentives to adopt sustainable technologies and practices (Unruh, 2000, p. 824). This would help 'lock-out' fossil fuels, and begin to 'lock-in' and facilitate a transition towards sustainable solutions and systems. However, at the same time, one must also anticipate opposition from policy actors representing the interests of truckers as they work to maintain equilibrium and resist change.

The processes of carbon lock-in are clearly present as we reflect on AirCare for heavy-duty diesel trucks. Such a program has not yet been put in place even though it was based on a continuity approach, one that "seeks to maintain as much similarity as possible between the existing system and the new configuration, and thus, likely easier to implement" (Unruh, 2002, p. 318). What is less discussed is a discontinuous approach in government plans and strategies expressed through measures to completely move away from fossil fuels for heavy duty trucks. Alternatives to fossil fuels may include renewable diesel, electrification, hydrogen and hybrid engines, which also come with fewer health and climate harming emissions. The Province of B.C.'s Go Electric Commercial Vehicle Pilots Program aims to subsidize purchases of zero-emission heavy-duty trucks in exchange for data sharing "used to further the understanding of the operational capabilities of commercial ZEVs" (Province of B.C., n.d., para. 2). What this

program also highlights is that the adoption and development of alternative fuel trucks is lagging as the sector looks to test which technologies work best. While this shows some commitment to a sustainable shift, it reflects a careful approach that will allow the government to make sure it is "bett[ing] on the right horse" due to the potentially high cost of a shifting away from lock-in whether it be provision of renewable energy infrastructure to facilitate the shift or costs of more rapid fleet renewal (Pierson, 2000, p. 254). Due to past resistance and the overall tendency to maintain equilibrium, it appears that government and partners are treading cautiously and carefully to ensure they are steering a shift towards the right energy alternative while protecting the interests of the trucking industry. Although government commitment and policymaking is required to foster a sustainable shift, government institutions are often slow to change and would avoid setting mandates that could generate radical change (Unruh, 2002).

According to Unruh (2002), two interrelated external forces are key to creating enough disruption to escape policy path dependence and carbon lock-in. One force is through a major technological breakthrough that creates a "force so compelling that it drives current users to switch to the new technology" (Unruh, 2002, p. 321). The second is through social pressures where large numbers of the general population and people of influence are able to capture attention and trigger institutional change (Unruh, 2002). This is also in line with Harrison's (1996) view that government will more likely act to "in periods of pronounced public attentiveness, when the level of environmental awareness among the beneficiaries of environmental protection may be high enough to overcome opposition from [regulated industries] who will bear the costs" (Harrison, 1996, p. 24).

While technological alternatives to the use of fossil fuels exist in the container trucking sector, cost is a barrier to fleet renewal and given that it is not yet clear which technology may rise to the top. Technology seems unlikely to trigger change anytime soon. "The problem, of course, is that ''cost effective'' is not an objective criterion, but depends on the incentives and disincentives established by the institutions [, which] currently foster the continued expansion of carbon-based energy systems" (Unruh, 2002, p. 232). Considering the lack of mandatory zero-emission heavy-duty truck sales, slow fleet renewal rates, and lack of disincentives to continue driving an older or tampered heavy-duty diesel truck, government institutions are continuing to foster the expansion of carbon-based energy systems. Thus, unfortunately for B.C., findings do not suggest that

superior technological breakthroughs or social movements are building to attract enough attention to trigger a policy shift.

As the Metro Vancouver region continues grow, it is imperative that we work to ensure growth does not come at the cost of the health and wellbeing of communities. My research highlights the importance of reflecting on past, present and future approaches to planning and policymaking to ensure that we are not heading perpetually in the wrong direction. My findings clearly show how land use and transportation planning practices can reinforce environmental inequity, and how political barriers such as a lack of electoral incentives and industry lobbying can inhibit policy innovation and the ratification of stricter environmental policies for heavy-duty diesel trucks in B.C..

What is needed is a paradigm shift away from conventional transportation planning practices towards a new paradigm grounded in sustainable transportation planning practices. To reiterate Schiller and Kenworthy's (2017) preferred definition of sustainable transportation, they refer to an environmentally sustainable transport system as "one where transportation does not endanger public health or ecosystems and meets needs for access consistent with use of renewable resources below their rates of regeneration, and use of non-renewable resources below the rates of development of renewable substitutes" (Schiller & Kenworthy, 2017, p. 12).

Directly related to the health impacts of TRAP, markers of an unsustainable "business as usual approach" (Schiller & Kenworthy, 2017, p. 3) to transportation planning include a tendency for transportation planning to occur in silos "disconnected from environmental, social and other planning areas," and a lack of consideration for "environmental and social equity impacts" (Schiller & Kenworthy, 2017, p. 252). Based on my research findings, it is clear that transportation planning related to the Clark-Knight corridor and policymaking related to air pollutant emissions from heavy-duty diesel trucks has not been done in a sustainable manner, allowing for the continued endangerment of the health of vulnerable and disadvantaged populations. In contrast, a new paradigm rooted in sustainable transportation practices involves integrated and coordinated policymaking, efficient goods movement practices, consideration of social and environmental equity, effective public participation, and the regeneration, repair and renewal of what has been degraded (Schiller & Kenworthy, 2017).

By reflecting on the intergovernmental division of responsibilities between levels of government that have interconnected roles and jurisdictions, it becomes obvious that collaboration and coordination are key to reducing public health impacts associated with TRAP from heavy-duty trucks. Although this division of responsibility may make it hard to point the finger of blame towards a single party, the policy networks in place in the region could potentially provide opportunities to galvanize disparate parties towards a common vision (Perl, Hargraft, & Muxlow, 1999). Through integrated and coordinated policy-making and land use planning that properly balance public and private interests, we can achieve a truly sustainable transportation system and better public health outcomes.

6.3. Recommendations

My findings underscore the need for action across levels of government and industry to take a bold stance on improving air quality and reducing environmental inequity along not only the Clark-Knight Corridor but other truck routes and major arterial roads in the region that run through residential areas. Although there is a need and widespread political desire to increase housing supply to accommodate more residents and address affordability concerns, work to improve air quality along arterial roads and truck routes must coincide with plans to increase residential density. Strategies to improve indoor quality to reduce TRAP exposure through air filtration requirements should also not be limited in focus on new buildings. Though the City of Vancouver has approved requirements for air filtration systems in new buildings, which come into effect July 2023, this does little to improve conditions for those who already live along arterial roads and cannot afford newer homes (City of Vancouver, 2022d). In addition, a nation-wide approach to addressing TRAP is preferred because heavy-duty truck movements are not confined to just the Clark-Knight Corridor and can span across provinces. Based on the findings and observations within this research study, policy recommendations are proposed within Table 5 to achieve the following:

- Address poor maintenance and emissions system tampering in heavy-duty trucks within B.C. and Canada
- Ensure planning decisions do not disproportionately expose vulnerable or disadvantaged populations to health hazards

Table 5. Policy recommendations

Organization	Recommended actions
Provincial/federal government	• Introduce a mandatory provincial and/or federal emissions testing program to address poor maintenance and tampering in all heavy-duty diesel trucks • Ban and enforce penalties on importing, selling or installing illegal delete kits • Aggressive incentives, subsidies and targets to stimulate technological breakthrough, innovation, and a transition to heavy-duty ZEVs • Invest in trade infrastructure required to enable more balanced growth across Canada's west coast ports
City of Vancouver	• Work with Vancouver Coastal Health and UBC air pollution researchers to amend the Secure Rental Policy and not allow housing to be built in the highest risk TRAP exposure areas alongside arterials (e.g., setbacks) • Build a coalition with other municipalities to advocate for provincial and federal government action to address TRAP • Conduct pilot studies to measure TRAP and noise exposure reductions from planting hedges alongside arterials; acquire and/or zone land for green infrastructure as part of a short-term mitigation strategy if studies yield positive results • Expand on work to implement air filtration requirements in large new buildings, which come into effect in 2023 with work to support air filtration retrofits for already-existing residences along arterials
Metro Vancouver	• Build new strategic partnerships and gain commitment from existing partners to support the Clean Air Plan (e.g., enlist new support from road safety partners)
TransLink	• Widen representation in the Urban Freight Council to include members with equity expertise and provide paid opportunities for residents along truck routes to help shape goods movement strategy
Vancouver Fraser Port Authority	• Build strategic partnerships and gain commitment from the provincial and federal government to support the introduction of truck age and future environmental requirements
Trucking associations and unions	• Follow the Ontario Trucking Association's lead in taking action to address unfair competition by putting a stop to the use of delete kits
BC Centre for Disease Control	• Set up a framework for tracking illnesses and deaths caused by air pollution
All parties above	• Work with health authorities and the BCCDC to adopt a shared understanding and framework of health equity to assess actions and inactions • Develop equity boards and paid opportunities for the public to take part in engagement, so that public and private interests can be better balanced and prioritized

In addition to introducing new policies and strengthening collaboration across levels of government, work should also be undertaken to build public awareness and understanding of the health impacts caused by TRAP. Considering that public attention may tip the scales in favour of government action on environmental policies despite industry opposition, Metro Vancouver, along with other public health agencies and foundations, should increase the number of monitoring stations near arterial roads, conduct further studies, and take action to communicate the public health risks of poor air quality.

Looking back on the influential power of industry to oppose environmental regulation and shape policy, we can see that change needs to happen to properly balance public and private interests. Interviews conducted for this research study revealed frustration amongst residents and citizen scientists, who were left feeling unheard, powerless and drained as they worked to advocate for cleaner air along the Clark-Knight corridor. By building in effective public participation to balance private sector interests through recommendations made in Table 5, we can ensure voices are heard and that the necessary dialogue and consideration takes place. According to the words of one local citizen scientist, communities have a large role to play and should be involved in the governance process to help advocate for change:

> Communities can say things that no one else can, we can say things that Metro Vancouver can't say, we can say things that Vancouver Coastal Health, won't say, we can say things that the port authority won't and can't say. We can say, “Hey, trucking industry, get with it, get with the future, get with what's happening here and your trucks, we understand they're your livelihood. But if there's a million of them driving through our neighborhood every year, we're the ones that are dealing with the health impacts and think about it as children and elders in our community that we should be respecting and taking care of. And this is a real thing that isn’t made up. Cumulative air pollution is a serious problem and here's the data to show it.” I think the value of the community being involved in the air quality monitoring is that if it ends up in the back rooms of the port authority or Metro Vancouver, they may not be in a position to highlight it in the way that we can. (Anonymous informant D)

Although the change will take time, “sustainable transportation is not as an end state or static product, but [is] a dynamic ongoing process. It builds on feedback, reiteration, revisiting of original visions and a long-term perspective. It is constantly adjusting and is informed by new information” (Schiller & Kenworthy, 2017, p. 249). With the courage to take action, our province and region can move towards a more

sustainable future for Clark-Knight corridor residents and all citizens that live along arterial roads through collaboration and by continuing to learn from past mistakes and setting a long-term vision for sustainable goods movement through the region. According to psychologist Herbert Gerjuoy referenced in Alvin Toffler's (1970, p. 414) book, *Future Shock,* "the illiterate of the 21st century will not be those who cannot read and write, but those who cannot learn, unlearn, and relearn," and what it will take to move us forward will be to reflect and learn from policy failures and successes to shape what a sustainable future can look like – one that does not does not perpetuate environmental inequity by continuing to allow concentrated burdens to be placed on disadvantaged, vulnerable racialized populations.

6.4. Opportunities for further research

As I reviewed literature for my conceptual framework, it became apparent that more research needs to be done to broaden and deepen our understanding of environmental inequity in Canada and how urban freight transport intersects with wider urban planning within a Canadian context. Specific topics for future research related to my research question include the feasibility of using waterways for goods movement to reduce truck traffic within a Metro Vancouver context, the true death toll from poor air quality in Canada, updated research on the impacts of emission control system tampering, and the impacts of increasing non-tailpipe emissions created by tire and brake wear due to heavier zero-emissions vehicles.

Considering that heavy-duty truck traffic will increase as containerized trade through the Port of Vancouver continues to grow, one wonders how the region will accommodate more trucks on the road. In a region surrounded by water, an opportunity exists to reduce heavy-duty truck traffic and TRAP exposure along arterials through short-sea shipping, which involves maximizing the use of local waterways to move containers that arrive at port terminals though via tug and barge to other terminals, or local distribution and warehousing areas. Transportation demand management and mobility management approaches such as this "make existing transportation resources function more efficiently, as well as directing users of those resources towards more efficient use of them" (Schiller & Kenworthy, 2017, p. 252). The social and environmental benefits of this modal shift include lower air and noise pollution, reduced road congestion, fewer deaths and accidents attributed to traffic, and lower greenhouse gases

per tonne of cargo moved (Genivar, 2008; Lee et al., 2010; Raza et al., 2020). In comparison to trucks and trains, short-sea shipping via tug and barge is reported to be "nearly four times more [fuel] efficient than the truck mode and nearly 1.5 times more [fuel] efficient than railroads" (Genivar, 2008, p. 4). Based on this and other existing research, there is no doubt that short sea shipping is a more socially and environmentally friendly mode of freight transport compared to trucks. It is recommended that levels of government and industry stakeholders continue to investigate the feasibility of short-sea shipping in the Metro Vancouver region and consider developing policies and programs to increase use of and modal shift towards short sea shipping. Pilot projects and studies should be done in a way that suits the local context and aims to reduce the amount of truck traffic along arterial truck routes as trade continues to grow.

Although a sustainable shift in trucking practices will take time to implement, municipalities and other levels of government can leverage urban design solutions as short-term mitigation to reduce health impacts caused by TRAP exposure. In a study conducted in Guildford, UK, researchers found planting hedges along urban roads to be "effective at reducing pollution exposure, cutting black carbon by up to 63 percent" (Science Daily, 2019, p. 3). Considering these positive results, an opportunity exists for the City of Vancouver and Metro Vancouver Regional District to collaborate on pilot studies to measure possible TRAP and noise exposure reductions due to the presence of hedges along arterial roads. Although acquiring the land to plant hedges alongside arterials may be a barrier, data collected could be used to inform urban design and landscaping guidelines to help build healthier cities.

As our province and region expect to see more extreme heat events due to climate change, more public health data collection, research and reporting is needed to better understand the full extent of how climate change can worsen air quality and in turn, impact mortality. In a review of deaths caused by the heat wave in June 2021, deaths due to air pollution were not analyzed despite the fact that Metro Vancouver had issued an advisory to warn about high concentrations of ground level ozone. Better data and reporting could help raise the profile of the air quality issue and provide stronger rationale for the development of mitigation strategies to prevent unnecessary deaths. To help raise the profile for policy change, updated studies on the impact of emissions system control tampering in Canada should also be done. Spatial health data mapping to track increased occurrences of TRAP-related health issues are also encouraged.

In addition to TRAP, non-tailpipe emissions created by tire and brake wear have also become a growing concern; as a recent report noted, “non-tailpipe emissions of primary particulate matter (PM2.5) have been rising since 2012 and now exceed primary tailpipe emissions” in major Canadian cities (Southern Ontario Centre for Atmospheric Aerosol Research, 2019, p. 12). Although tailpipe-related emissions from traffic sources are generally decreasing due to cleaner burning and more efficient engines, increasing heavy-duty truck traffic volumes and the rising trend in heavier consumer vehicles on urban roads are adding air pollutants in the form of airborne metal dust risks nullifying mitigation efforts and progress made. The impacts from TRAP exposure are an intensifying problem for Canada’s densely populated regions as goods movement continues to grow, and as Canadians continue to purchase heavier vehicles such as SUVs and pick-up trucks, and seek to transition to electric vehicles, which are 24% heavier than conventional cars (Southern Ontario Centre for Atmospheric Aerosol Research, 2019; Timmers & Achten, 2016). To prevent a ‘whack-a-mole’ situation where another problem pops up with every problem’s solution, more research should be done on the impacts of non-tailpipe emissions and how it can be mitigated. This highlights the potential ramifications of a transition to electric heavy-duty trucks and reflects the complexities and iterative process of achieving truly sustainable solutions.

Through more research and data generated within a Canadian context, policymakers and advocates can be armed with the necessary information to clearly highlight issues of public interest and make more informed decisions.

References

Acuere Consulting Inc. (2015, July). *2014 Metro Vancouver Truck Classification and Dangerous Goods Survey.* Retrieved 11 23, 2019 from TransLink: https://www.translink.ca/-/media/Documents/plans_and_projects/urban_showcase/goods_movement/background_research/2014_truck_classification_and_dangerous_goods_survey_report.pdf

Amram, O., Abernethy, R., Brauer, M., Davies, H., & Allen, R. W. (2011). Proximity of public elementary schools to major roads in Canadian urban areas. International Journal of Health Geographics, 10(1), 68. https://doi.org/10.1186/1476-072X-10-68

Braithwaite, I., Zhang, S., Kirkbride, J. B., Osborn, D. P. J., & Hayes, J. F. (2019). Air Pollution (Particulate Matter) Exposure and Associations with Depression, Anxiety, Bipolar, Psychosis and Suicide Risk: A Systematic Review and Meta-Analysis. *Environmental Health Perspectives*, *127*(12), 126002. https://doi.org/10.1289/EHP4595

Brauer, M., Reynolds, C., & Hystad, P. (2012). Traffic-Related Air Pollution and Health: A Canadian Perspective on Scientific Evidence and Potential Exposure-Mitigation Strategies. School of Population and Public Health. Vancouver: The University of British Columbia.

Brauer, M., Reynolds, C., & Hystad, P. (2013). Traffic-related air pollution and health in Canada. *Canadian Medical Association Journal*, *185*(18), 1557–1558. https://doi.org/10.1503/cmaj.121568

Brauer, M, Brook, J R, Christidis, T, Chu, Y, Crouse, D L, Erickson, A, Hystad, P, Li, C, Martin, R V, Meng, J, Pappin, A J, Pinault, L L, Tjepkema, M, van Donkelaar, A, Weichenthal, S, & Burnett, R T. (2019). Mortality-Air Pollution Associations in Low-Exposure Environments (MAPLE): Phase 1. Research Report - Health Effects Institute, 203, 1–87.

BC Centre for Disease Control. (2017). Handbook of health equity in environmental public health practice. Retrieved October 4, 2022, from BC Centre for Disease Control: http://www.bccdc.ca/resource-gallery/Documents/Educational%20Materials/EH/BCCDC_equity-handbook_web.pdf

BC Chamber of Commerce. (2014). 2014 TRUCKING DISRUPTION - PORT METRO VANCOUVER (2014). Retrieved 06 23, 2020, from BC Chamber of Commerce: http://www.bcchamber.org/policies/2014-trucking-disruption-port-metro-vancouver-2014-0

British Columbia Coroners Service. (2022). Extreme Heat and Human Mortality: A Review of Heat-Related Deaths in B.C. in Summer 2021. Retrieved June 20, 2022, from https://www2.gov.bc.ca/assets/gov/birth-adoption-death-marriage-

and-divorce/deaths/coroners-service/death-review-panel/extreme_heat_death_review_panel_report.pdf

BC Trucking Association. (2012). BCTA Opposes Potential AirCare Plan for Heavy Trucks. Retrieved from BC Trucking Association: https://www.bctrucking.com/bulletin/2012/03/29/bcta-opposes-potential-aircare-plan-heavy-trucks

BC Trucking Association. (2012). BCTA Speaks Out against AirCare for Heavy Trucks. Retrieved from BC Trucking Association: https://www.bctrucking.com/bulletin/2012/05/31/bcta-speaks-out-against-aircare-heavy-trucks

BC Trucking Association. (2013). Metro Vancouver Diesel Emissions Study Confirms Most Trucks are Clean and Getting Cleaner, says BCTA. Retrieved from BC Trucking Association: https://www.bctrucking.com/news/metro-vancouver-diesel-emissions-study-confirms-most-trucks-are-clean-and-getting-cleaner-says-

BC Trucking Association. (2016). Climate Leadership Plan Submission. Retrieved from BC Trucking Association: https://www.bctrucking.com/sites/default/files/bcta_2016_02_climate_leadership_plan_final.pdf

BC Trucking Association. (2019). BC Carriers Invited to Reduce Emissions through New CleanBC Heavy-duty Vehicle Efficiency Program. Retrieved from BC Trucking Association: https://www.bctrucking.com/news/bc-carriers-invited-reduce-emissions-through-new-cleanbc-heavy-duty-vehicle-efficiency-program

BC Trucking Association. (2020). Input requested: Transport Canada survey heavy duty vehicle retrofits. Retrieved from BC Trucking Association: https://www.bctrucking.com/bulletin/2020/02/10/input-requested-transport-canada-survey-heavy-duty-vehicle-retrofits

BC Trucking Association. (2021). Program Guide – Year Three: CleanBC Heavy-duty Vehicle Efficiency Program. Retrieved from BC Trucking Association: https://www.bctrucking.com/sites/default/files/pdfs/cleanbc_hdve_program_y3_guide.pdf

Business in Vancouver. (2012). Environment AirCare ending for cars, commercial trucks may be added. Retrieved from Business in Vancouver: https://biv.com/article/2012/05/aircare-ending-for-cars-commercial-trucks-may-be-a

Business in Vancouver. (2021). Industrial space shortage crimps Metro Vancouver economy. Retrieved from Business in Vancouver: https://biv.com/article/2021/11/industrial-space-shortage-crimps-metro-vancouver-economy

Business in Vancouver. (2021). Real Estate Metro Vancouver readies for vote to expand industrial land base. Retrieved from Business in Vancouver: https://biv.com/article/2021/10/metro-vancouver-readies-vote-expand-industrial-

land-base

Canadian Council of Ministers of the Environment. (2022). About. Retrieved from Canadian Council of Ministers of the Environment: https://ccme.ca/en/about

Cairney. (2012). Understanding public policy : theories and issues / Paul Cairney. Palgrave Macmillan.

Canadian Sailings (2012). DP World launches B.C. short-sea-shipping venture with Port of Nanaimo. Retrieved from: https://canadiansailings.ca/dp-world-launches-b-c-short-sea-shipping-venture-with-port-of-nanaimo/

Canadian Trucking Alliance (2020). Transport Canada Survey on Heavy Duty Vehicle Retrofits Extended to March 6. Retrieved from: https://cantruck.ca/transport-canada-survey-on-heavy-duty-vehicle-retrofits-extended-to-march-6/

Carey, I. M., Anderson, H. R., Atkinson, R. W., Beevers, S. D., Cook, D. G., Strachan, D. P., Dajnak, D., Gulliver, J., & Kelly, F. J. (2018). Are noise and air pollution related to the incidence of dementia? A cohort study in London, England. BMJ Open, 8(9), e022404. https://doi.org/10.1136/bmjopen-2018-022404

CBC News, (2005, July 27). *CBC News*. Retrieved June 23, 2020, from B.C. truckers strike may soon end, Ottawa says : https://www.cbc.ca/news/canada/b-c-truckers-strike-may-soon-end-ottawa-says-1.541673

CBC News. (2011). Noisy truck traffic rocking East Van street. Retrieved from: https://www.cbc.ca/news/canada/british-columbia/noisy-truck-traffic-rocking-east-van-street-1.1121306

CBC News. (2014, July 7). *Truckers' strike threatened for Port Metro Vancouver* . Retrieved June 12, 2020, from CBC News: https://www.cbc.ca/news/canada/british-columbia/truckers-strike-threatened-for-port-metro-vancouver-1.2698531

CBC News. (2021). Air quality advisory in effect for parts of B.C.'s Lower Mainland. https://www.cbc.ca/news/canada/british-columbia/air-quality-lower-mainland-1.6081996

CBRE. (2021). Vancouver Industrial Marketview Q2 2021. Retrieved from CBRE: https://www.cbre.ca/en/research-and-reports/Vancouver-Industrial-Marketview-Q2-2021

Chen, H., Kwong, J. C., Copes, R., Tu, K., Villeneuve, P. J., van Donkelaar, A., Hystad, P., Martin, R. V., Murray, B. J., Jessiman, B., Wilton, A. S., Kopp, A., & Burnett, R. T. (2017). Living near major roads and the incidence of dementia, Parkinson's disease, and multiple sclerosis: A population-based cohort study. The Lancet, 389(10070), 718–726. https://doi.org/10.1016/S0140-6736(16)32399-6

City of Vancouver. (n.d.) VanMap. Retrieved October 1, 2022 from City of Vancouver: https://maps.vancouver.ca

City of Vancouver. (2003a). Clark-Knight corridor Whole Route Analysis.

City of Vancouver. (2003b). Administrative Report - Whole Route Analysis: Clark Drive-Knight Street Corridor. Retrieved 03 12 2021 from City of Vancouver: https://council.vancouver.ca/20030410/cs2.htm

City of Vancouver. (2005a). Administrative Report - Clark/Knight Corridor Plan. Retrieved 02 12 2021 from City of Vancouver: https://council.vancouver.ca/20050329/tt5.pdf

City of Vancouver. (2005b). Motion on notice. Retrieved 02 12 2022 from City of Vancouver: https://council.vancouver.ca/20050329/motionb2.htm

City of Vancouver. (2005c). Arbutis Ridge Kerrisdale Shaughnessy Arks Community Vision. Retrieved 02 12 2022 from City of Vancouver: https://vancouver.ca/docs/planning/arbutus-ridge-kerrisdale-shaughnessy-arks-community-vision-full-report.pdf?utm_source=vancouver%20is%20awesome&utm_campaign=vancouver%20is%20awesome&utm_medium=referral

City of Vancouver. (2020a). Referral Report: Amendments to the Zoning and Development By-law to Increase Rental Housing in the C-2, C-2B, C-2C, and C-2C1 Commercial Districts. Retrieved on 02 03 2021 from City of Vancouver: https://council.vancouver.ca/20200623/documents/rr10.pdf?_ga=2.164633207.917603746.1630874945-711568335.1630785906

City of Vancouver. (2020b). Secured Rental Policy for Low-density Transition Areas (Draft eligibility map). Retrieved on July 10, 2020 from City of Vancouver: https://vancouver.ca/files/cov/secured-rental-policy-low-density-transition-areas-eligibility-map.pdf

City of Vancouver. (2022a). Secured Rental Policy. Retrieved 02 12 2022 from City of Vancouver: https://bylaws.vancouver.ca/zoning/policy-rezoning-secured-rental.pdf

City of Vancouver. (2022b). Creating and protecting purpose-built rental housing. Retrieved 02 12 2022 from City of Vancouver: https://vancouver.ca/people-programs/creating-new-market-rental-housing.aspx

City of Vancouver. (2022c). Vancouver Plan Supplementary Document: Data, Maps and Graphics. Retrieved August 19, 2022 from City of Vancouver: https://vancouverplan.ca/wp-content/uploads/Vancouver-Plan-Data-Maps-and-Graphics-2022-06-27.pdf

City of Vancouver. (2022d). City advances climate action with deep emissions reductions. Retrieved December 15, 2022 from City of Vancouver: https://vancouver.ca/news-calendar/city-advances-climate-action-with-deep-emissions-reductions.aspx

City of Richmond. (2020). Report to Committee: Industrial Lands Intensification Initiative – Summary of Findings and Proposed Amendments to Richmond Official Community Plan Bylaw 9000 and Richmond Zoning Bylaw 8500. Retrieved 05 02 2020 from City of Richmond: https://www.richmond.ca/__shared/assets/ILII_GP_01052157450.pdf

Climate change, air contaminants, and your health—Canada.ca. (n.d.). Retrieved November 27, 2021, from https://www.canada.ca/en/public-health/services/health-promotion/environmental-public-health-climate-change/climate-change-public-health-factsheets-air.html

Creating and protecting market rental housing | City of Vancouver. (n.d.). Retrieved November 27, 2021, from https://vancouver.ca/people-programs/creating-new-market-rental-housing.aspx

CTV News. (2011). Vancouver residents say port traffic endangering safety. Retrieved from: https://bc.ctvnews.ca/vancouver-residents-say-port-traffic-endangering-safety-1.669016

CTV News. (2012). Should big trucks be part of B.C.'s AirCare program? Retrieved from CTV News: https://bc.ctvnews.ca/should-big-trucks-be-part-of-b-c-s-aircare-program-1.785815

Cui, J., Dodson, J., & Hall, P. V. (2015). Planning for Urban Freight Transport: An Overview. Transport Reviews, 35(5), 583–598. https://doi.org/10.1080/01441647.2015.1038666

Cummings, S. L. (2019). Blue and green: The drive for justice at America's port. http://dx.doi.org/10.7551/mitpress/9780262036986.001.0001

Daily Hive. (2021). New cranes arrive in Vancouver harbour for container terminal expansion. https://dailyhive.com/vancouver/vanterm-terminal-container-expansion-new-cranes

Daily Hive. (2021). Metro Vancouver's population now projected to reach 3.8 million people by 2050. https://dailyhive.com/vancouver/metro-vancouver-population-forecast-2050-subregions

Dickinson, Louv, R., Bonney, R., & Fitzpatrick , J. W. (2012). Citizen Science. Cornell University Press.

Doiron, Setton, E. M., Shairsingh, K., Brauer, M., Hystad, P., Ross, N. A., & Brook, J. R. (2020). Healthy built environment: Spatial patterns and relationships of multiple exposures and deprivation in Toronto, Montreal and Vancouver. Environment International, 143, 106003. https://doi.org/10.1016/j.envint.2020.106003

Environment Climate Change Canada, & Environnement et Changement climatique Canada. (2018). Air health trends – Mortality attributable to ground-level ozone by region, Canada [Data set]. Open Data Canada.

Pfister, G. G., Walters, S., Lamarque, J.-F., Fast, J., Barth, M. C., Wong, J., Done, J., Holland, G., & Bruyère, C. L. (2014). Projections of future summertime ozone over the U.S.: Projections of Future U.S. Surface Ozone. Journal of Geophysical Research: Atmospheres, 119(9), 5559–5582. https://doi.org/10.1002/2013JD020932

Envirotest Canada (2013). *Greater Vancouver Regional District – Remote Sensing Device Trial for Monitoring Heavy-Duty Vehicle Emissions (Commissioned by Metro Vancouver)*. Retrieved from http://www.metrovancouver.org/services/air-quality/AirQualityPublications/2013_RSD_HDV_Study.pdf.

García-Herrera, R., Díaz, J., Trigo, R. M., Luterbacher, J., & Fischer, E. M. (2010). A Review of the European Summer Heat Wave of 2003. Critical Reviews in Environmental Science and Technology, 40(4), 267–306. https://doi.org/10.1080/10643380802238137

Genivar. (2008). Evaluation of Environmental and Social Impacts and Benefits of Shortsea Shipping in CAnada. Retrieved from Bureau d'audiences publiques sur l'environment: https://archives.bape.gouv.qc.ca/sections/mandats/La%20Romaine_raccordement/documents/DQ17-2.pdf

Global News. (2022a). Port of Vancouver to 'slightly' delay ban on trucks more than 10 years old. Retrieved from CTV News: https://globalnews.ca/news/8512738/vancouver-port-delays-ban-on-older-trucks/

Global News. (2022b). Truckers to vote on work stoppage over Vancouver port's 'penalizing' rolling age program. Retrieved from Global News: https://globalnews.ca/news/8937068/truckers-work-stoppage-rolling-age-program-vancouver/

Government of Canada. (2020). *Gateways and Corridors*. Retrieved 07 12 2021 from Government of Canada: https://tc.canada.ca/en/corporate-services/policies/gateways-corridors

Government of Canada. (2020). Diversifying Canada's trade and investment opportunities. Retrieved 04 03 2021 from Government of Canada: https://www.international.gc.ca/gac-amc/campaign-campagne/trade-diversification-commerce/index.aspx?lang=eng

Government of Canada. (2022a). 2030 Emissions Reduction Plan: Clean Air, Strong Economy. Retrieved 03 029 2022 from Government of Canada: https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview/emissions-reduction-2030.html?utm_campaign=not-applicable&utm_medium=vanity-url&utm_source=canada-ca_emissions-reduction-plan

Government of Ontario. (2018, September 28). *Ontario Cancelling Outdated, Ineffective Drive Clean Program* . Retrieved 11 18, 2019 from Government of Ontario: https://news.ontario.ca/opo/en/2018/09/ontario-cancelling-outdated-ineffective-drive-clean-program.html

Government of Ontario. (2019, May 6). Mandatory emissions testing for older heavy-duty diesel vehicles . Retrieved 11 09, 2019 from Government of Ontario: https://www.ontario.ca/page/mandatory-emissions-testing-for-older-heavy-duty-diesel-vehicles

Government of Ontario. (2018). Ontario Leads Growing Opposition to the Federal Carbon Tax. Retrieved from https://news.ontario.ca/en/release/50840/ontario-leads-growing-opposition-to-the-federal-carbon-tax

Greater Vancouver Gateway Forum. (n.d.). About the Greater Vancouver Gateway Forum. Retrieved 07 01 2021 from Greater Vancouver Gateway Forum: http://vancouvergateway.ca/

Hall. (2015). The Social Life of Truck Routes. In Transport, Mobility, and the Production of Urban Space (1st ed., pp. 117–133). Routledge. https://doi.org/10.4324/9781315709680-8

Hall. (2018). Traffic Planning in Port-Cities: Discussion Paper. Discussion Papers (International Transport Forum), 1–24.

Harrison. (1996). Passing the buck federalism and Canadian environmental policy / Kathryn Harrison. UBC Press.

Health Canada. (2019). *Health Impacts of Air Pollution in Canada.* Ottawa: Government of Canada.

Health Canada. (2021). Health Impacts of Air Pollution in Canada: Estimates of morbidity and premature mortality outcomes – 2021 Report. Ottawa: Government of Canada.

Health Canada. (2022). Exposure to traffic-related air pollution in Canada : an assessment of population proximity to roadways. Health Canada = Santé Canada.

Hegewald, Janice, Schubert, Melanie, Freiberg, Alice, Romero Starke, Karla, Augustin, Franziska, Riedel-Heller, Steffi G, Zeeb, Hajo, & Seidler, Andreas. (2020). Traffic Noise and Mental Health: A Systematic Review and Meta-Analysis. International Journal of Environmental Research and Public Health, 17(17), 6175. https://doi.org/10.3390/ijerph17176175

Ho, H. C., Wong, M. S., Yang, L., Shi, W., Yang, J., Bilal, M., & Chan, T.-C. (2018). Spatiotemporal influence of temperature, air quality, and urban environment on cause-specific mortality during hazy days. Environment International, 112, 10–22. https://doi.org/10.1016/j.envint.2017.12.001

Journal of Commerce. (2019). GCT to expand Vancouver port capacity. https://www.joc.com/port-news/international-ports/port-vancouver/gct-expand-vancouver-port-capacity_20190510.html

Journal of Commerce. (2020). New Canadian short-sea container offerings emerge. Retrieved from Journal of Commerce: https://www.joc.com/port-news/international-ports/port-vancouver/new-canadian-short-sea-container-offerings-emerge_20201109.html

Jung, C.-R., Lin, Y.-T., & Hwang, B.-F. (2015). Ozone, Particulate Matter, and Newly Diagnosed Alzheimer's Disease: A Population-Based Cohort Study in Taiwan. Journal of Alzheimer's Disease, 44(2), 573–584. https://doi.org/10.3233/JAD-140855

Kimbrough, C. J. (2017). Los Angeles' "Clean Up, Green Up" Ordinance: A Victory in the Environmental Justice Fight. National Civic Review, 106(1), 3–8. https://doi.org/10.1002/ncr.21309

Knoepfel, P., Grant, W., & Perl, A. (1999). Conclusion: Institution building for sustainable urban mobility policies . In P. Knoepfel, W. Grant, & A. Perl, The Politics of Improving Urban Air Quality. Cheltenham, UK: Edward Elgar Publishing Limited.

Levesque, E. R. (1974). The impact of the knight street bridge on the allocation of industrial land

Lucas, Martens, K., Ciommo, F. D., & Dupont-Kieffer, A. (2019). *Measuring Transport Equity*. Elsevier.

David M. Martin, & Robin Flowerdew. (2013). *Methods in Human Geography*. Taylor and Francis. https://doi.org/10.4324/9781315837277

Metro Vancouver. (2011). Metro Vancouver Integrated Air Quality and Greenhouse Gas Management Plan. Retrieved June 14, 2020, from Metro Vancouver: http://www.metrovancouver.org/services/air-quality/AirQualityPublications/IntegratedAirQualityGreenhouseGasManagementPlan-October2011.pdf

Metro Vancouver Regional District. (2013). Older Trucks Create the Most Diesel Pollution on Metro Vancouver Roads. http://www.metrovancouver.org/media-room/media-releases/MediaReleases/2013-04-26-OlderTrucksCreateTheMostDieselPollutionOnMetroVancouverRoads.pdf

Metro Vancouver Regional District. (2013). On-Road Heavy-Duty Diesel Vehicle Program – Update and 2013 Work Plan. Retrieved from Metro Vancouver: http://www.bctrucking.com/sites/default/files/on-road_heavy-duty_diesel_vehicle_program_-_update_and_report.pdf

Metro Vancouver Regional District. (2014). Integrated Air Quality and Greenhouse Gas Management Plan Progress Report. Retrieved from Metro Vancouver:

http://www.metrovancouver.org/services/air-quality/AirQualityPublications/2014IAQGGMPProgressReport.pdf

Metro Vancouver. (2014, December). *Short sea shipping in Metro Vancouver.* Retrieved 11 15, 2019 from Planning Publications: http://www.metrovancouver.org/services/regional-planning/PlanningPublications/Short_Sea_Shipping_Facts_in_Focus.pdf

Metro Vancouver Regional District. (2015). Toxic Air Pollutants Risk Assessment and Emissions Inventory for the Lower Fraser Valley. Retrieved on 08 21 2021 from Metro Vancouver: http://www.metrovancouver.org/services/air-quality/AirQualityPublications/ToxicAirPollutantsRiskAssessment.pdf

Metro Vancouver Regional District. (2017). Caring for the Air Reports . Retrieved 11 15, 2019 from Metro Vancouver: http://www.metrovancouver.org/services/air-quality/information-public/caring-for-the-air/Pages/default.aspx

Metro Vancouver Regional District. (2018). Caring for the Air 2018. Burnaby: Metro Vancouver Regional District. Metro Vancouver Regional District. (2018). Caring for the Air Reports . Retrieved 11 15, 2019 from Metro Vancouver: http://www.metrovancouver.org/services/air-quality/information-public/caring-for-the-air/Pages/default.aspx

Metro Vancouver Regional District. (2019). Caring for the Air Reports . Retrieved 11 15, 2019 from Metro Vancouver: http://www.metrovancouver.org/services/air-quality/information-public/caring-for-the-air/Pages/default.aspx

Metro Vancouver Regional District. (2020). Caring for the Air Reports . Retrieved 11 15, 2019 from Metro Vancouver: http://www.metrovancouver.org/services/air-quality/AirQualityPublications/CaringForTheAir2020.pdf

Metro Vancouver Regional District. (2020). Metro Vancouver Regional Industrial Lands Strategy. Retreived from Metro Vancouver: http://www.metrovancouver.org/boards/GVRD/RD_2020-Jul-3_AGE.pdf#page=28

Metro Vancouver Regional District. (2020). Metro Vancouver Near-Road Air Quality Monitoring Study. Retrieved 08 15 2020 from Metro Vancouver: http://www.metrovancouver.org/services/air-quality/AirQualityPublications/MV_Near-Road_Air_Quality_Monitoring_Study-Technical_Report.pdf

Metro Vancouver Regional District. (2021a). Caring for the Air Reports . Retrieved 11 15, 2019 from Metro Vancouver: http://www.metrovancouver.org/services/air-quality/AirQualityPublications/CaringfortheAir2021.pdf

Metro Vancouver Regional District. (2021b). Metro Vancouver Growth Projections Methodology Report. Retrieved 07 12, 2021 from Metro Vancouver: http://www.metrovancouver.org/services/regional-planning/PlanningPublications/Metro_Vancouver_Growth_Projections_Methodology_Report.pdf

Metro Vancouver Regional District. (2021c). Draft – Clean Air Plan 2021. Retrieved from: http://www.metrovancouver.org/services/air-quality/AirQualityPublications/Clean-Air-Plan-2021.pdf

Metro Vancouver Regional District. (2021d). Metro Vancouver Regional District Board of Directors Regular Board Meeting Minutes. Retrieved from: http://www.metrovancouver.org/boards/GVRD/RD_2021-Apr-30_AGE.pdf

Metro Vancouver Regional District. (2022a). Health Impacts of Diesel Exhaust. Retrieved from: http://www.metrovancouver.org/services/Permits-regulations-enforcement/non-road-diesel/compliance-monitoring/Pages/default.aspx

Metro Vancouver Regional District. (2022b). Caring for the Air Reports 2022. Retrieved from: http://www.metrovancouver.org/services/air-quality/AirQualityPublications/CaringForTheAir2022.pdf

Mitchell, K., & D'Onofrio, Z. (2016). Environmental Injustice and Racism in Canada: The First Step is Admitting We Have a Problem. Journal of Environmental Law and Practice, 29, 305–345.

Ontario Trucking Association. (2019, December 3). Ontario Trucking Association. Retrieved December 4, 2019 from Ford Govt Announces Plan to Eliminate Emissions Tampering and Reduce Red Tape for Trucking : http://ontruck.org/ford-govt-announces-plan-to-eliminate-emissions-tampering-and-reduce-red-tape-for-trucking/

Ontario Trucking Association. (2020). Emissions Tampering Enforcement Beginning to Show Results. Retrieved February 4, 2022 from Ontario Trucking Association: https://ontruck.org/enforcement-on-emissions-tampering-beginning-to-show-results/

Ontario Trucking Association. (2022). About the Ontario Trucking Association. Retrieved February 4, 2022 from Ontario Trucking Association: https://ontruck.org/about-the-ota/

National Collaborating Centre for Healthy Public Policy. (2018, January). *An Introduction to Punctuated Equilibrium: A Model for Understanding Stability and Dramatic Change in Public Policies.* Retrieved 06 06, 2020, from National Collaborating Centre for Healthy Public Policy: https://www.ncchpp.ca/docs/2018_ProcessPP_Intro_PunctuatedEquilibrium_EN.pdf

Pierson. (2000). Increasing Returns, Path Dependence, and the Study of Politics. The American Political Science Review, 94(2), 251–267. https://doi.org/10.2307/2586011

Province of British Columbia. (n.d.). Trade Policy & Negotiations. Retrieved 03 29 2020 from Province of British Columbia: https://www2.gov.bc.ca/gov/content/employment-business/international-

investment-and-trade/trade-policy-negotiations

Province of British Columbia. (n.d.). AirCare ON-ROAD Program. Retrieved from Province of British Columbia: https://www.th.gov.bc.ca/acor/

Province of British Columbia. (n.d.). Go Electric Commercial Vehicle Pilots Program. Retrieved from Province of British Columbia: https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/transportation-energies/clean-transportation-policies-programs/clean-energy-vehicle-program/commercial-vehicles/17208-53529

Province of British Columbia. (2012). AirCare to end after 2014, new options explored. Retrieved from Province of British Columbia: https://archive.news.gov.bc.ca/releases/news_releases_2009-2013/2012ENV0032-000734.htm

Province of British Columbia. (2019). Province invests in CleanBC Heavy-duty Vehicle Efficiency Program. Retreived from Province of British Columbia: https://archive.news.gov.bc.ca/releases/news_releases_2017-2021/2019TRAN0194-002086.htm

Province of British Columbia. (2021). CleanBC Roadmap to 2030. Retrieved from Province of British Columbia: https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/cleanbc/cleanbc_roadmap_2030.pdf

Raza, Svanberg, M., & Wiegmans, B. (2020). Modal shift from road haulage to short sea shipping: a systematic literature review and research directions. *Transport Reviews*, *40*(3), 382–406. https://doi.org/10.1080/01441647.2020.1714789

Ready, V., & Bell, C. (2014). Recommendation Report – British Columbia Lower Mainland Ports.

Retail Insider. (2014, March 5). Vancouver Port Strike will hurt Canadian retailing: Retail Council of Canada. Retrieved 06 13, 2020, from Retail Insider: https://www.retail-insider.com/retail-insider/2014/3/retail-council-of-canada-calls-for-end-to-labour-dispute-disrupting-the-movement-of-containers-through-port-metro-vancouver

Shin, Saeha, Bai, Li, Oiamo, Tor H, Burnett, Richard T, Weichenthal, Scott, Jerrett, Michael, Kwong, Jeffrey C, Goldberg, Mark S, Copes, Ray, Kopp, Alexander, & Chen, Hong. (2020). Association Between Road Traffic Noise and Incidence of Diabetes Mellitus and Hypertension in Toronto, Canada: A Population-Based Cohort Study. Journal of the American Heart Association, 9(6), e013021. https://doi.org/10.1161/JAHA.119.013021

Sightline Institute. (2021). Confining rental homes to busy streets is a devil's bargain. Retrieved from Sightline Institute: https://www.sightline.org/2021/10/19/confining-rental-homes-to-busy-streets-is-a-devils-bargain/

Southern Ontario Centre for Atmospheric Aerosol Research. (2019). Near-Road Air Pollution Pilot Study. University of Toronto, Southern Ontario Centre for Atmospheric Aerosol Research. Toronto: University of Toronto.

Sonoma Technology. (2015). Toxic Air Pollutants Risk Assessment. Retrieved from Metro Vancouver: http://www.metrovancouver.org/services/air quality/AirQualityPublications/ToxicAirPollutantsRiskAssessment.pdf

SNC Lavalin. (2013). *Heavy Duty Diesel Vehicle Policy Options Evaluation Study.* Burnaby: Greater Vancouver Regional District (Metro Vancouver).

Strathcona Residents Association. (n.d.). Air Quality Project. https://strathcona-residents.org/issues/air-quality/

Su, J. G., Larson, T., Gould, T., Cohen, M., & Buzzelli, M. (2010). Transboundary air pollution and environmental justice: Vancouver and Seattle compared. GeoJournal, 75(6), 595–608. https://doi.org/10.1007/s10708-009-9269-6

Swanson, C. (2019, May 29). *City of Vancouver*. Retrieved September 30, 2019 from Reducing Truck Pollution in Clark-Knight corridor and Other City Streets: https://council.vancouver.ca/20190528/documents/motionb3.pdf

The Georgia Strait. (2011). Dave Pasin: Park board commissioners should look at the big picture. Retrieved from The Georgia Strait: https://www.straight.com/article-482091/vancouver/dave-pasin-park-board-commissioners-should-look-big-picture

Timmers, V. R. J. H., & Achten, P. A. J. (2016). Corrigendum to “Non-exhaust PM emissions from electric vehicles” [Atmos. Environ. 134 (June 2016) 10–17]. Atmospheric Environment, 147, 492. https://doi.org/10.1016/j.atmosenv.2016.10.047

Today's Trucking. (2018, May 29). *Dirty Secrets: Carriers call for emissions crackdown* . Retrieved 12 1, 2019 from Today's Trucking: https://www.todaystrucking.com/dirty-secrets-carriers-call-for-emissions-crackdown/

Toffler. (1970). *Future shock.* Random House.

Translink. (2017, June). *Translink.* Retrieved September 28, 2020 from Moving the Economy: https://www.translink.ca/-/media/Documents/plans_and_projects/roads_bridges/RGMS_Moving_the_Economy.pdf?la=en&hash=73930C139F490F237975332CB1B52659B1C997E6

Translink. (2021.). Roads, Bridges, and Goods Movement. Retrieved 07 01 2021 from TransLink: https://www.translink.ca/plans-and-projects/projects/roads-bridges-and-goods-movement#major-road-network

Transport Canada. (2019.). Government of Canada invests in transportation infrastructure at the Port of Vancouver to move goods to market. Retrieved 02 01 2022 from Cision: https://www.newswire.ca/news-releases/government-of-

canada-invests-in-transportation-infrastructure-at-the-port-of-vancouver-to-move-goods-to-market-843686084.html

Trucking News. (2013, March 18). *SPECIAL REPORT: Can I get a DPF Delete?* . Retrieved 12 1, 2019 from Trucking News: https://www.trucknews.com/regulations/special-report-can-i-get-a-dpf-delete/1002148784/

The Tyee. (2005). What the Truckers' Fight Is All About. https://thetyee.ca/News/2005/07/30/TruckersFight/

Unifor v. Vancouver Fraser Port Authority. (2017) https://canlii.ca/t/gx65d

Unifor. (2021). Unifor calls for more time to transition container trucks. Retrieved from Cision: https://www.newswire.ca/news-releases/unifor-calls-for-more-time-to-transition-container-trucks-869800799.html

Unruh, G. C. (2000). Escaping carbon lock-in. Energy Policy, 30(4), 317–325. https://doi.org/10.1016/s0301-4215(01)00098-2

Unruh. (2000). Understanding carbon lock-in. Energy Policy, 28(12), 817–830. https://doi.org/10.1016/S0301-4215(00)00070-7

Vancouver Fraser Port Authority. (n.d.). Truck Licensing System. Retrieved from Port of Vancouver: https://www.portvancouver.com/truck-rail/truck/truck-licensing-system/.

Vancouver Fraser Port Authority. (2016). Centerm Expansion Project Traffic Impact Study. Retrieved 07 12 2021 from Port of Vancouver: https://www.portvancouver.com/wp-content/uploads/2016/12/November-2016-Traffic_Impact_Study-CEP.pdf

Vancouver Fraser Port Authority. (n.d.). What land is managed by the port authority and how is it managed?. Retrieved from Port of Vancouver: https://www.portvancouver.com/about-us/faq/land-use-planning/

Vancouver Fraser Port Authority. (n.d.). Short sea shipping. Retrieved from Port of Vancouver: https://www.portvancouver.com/marine-operations/short-sea-shipping/.

Vancouver Fraser Port Authority. (2014). Media release: Container truckers stand to lose on major concessions in the event of work stoppage.

Vancouver Fraser Port Authority. (2015). Statement: Changes to port trucking needed for stability program available to ease transition.

Vancouver Fraser Port Authority. (2016). Port of Vancouver Economic Impact Study. Retrieved 02 01 2019 from Port of Vancouver: https://www.portvancouver.com/wp-content/uploads/2016/05/2016-Port-of-Vancouver-Economic-Impact-Study.pdf

Vancouver Fraser Port Authority. (2017). Centerm Expansion Project Application Review Phase - Round 1 Public Consultation Discussion Guide and Feedback. Retrieved 08 01 2021 from Port of Vancouver https://www.portvancouver.com/wp-content/uploads/2015/05/CEP_Round-2-DG_Feb-20-2017_FINAL.pdf

Vancouver Fraser Port Authority. (2018). Roberts Bank Terminal 2 Project Overview and Rationale. Retrieved 03 28 2020 from Port of Vancouver: https://www.robertsbankterminal2.com/wp-content/uploads/VFPA-RBT2-Project-Rationale-October2018.pdf

Vancouver Fraser Port Authority. (2020). Land Use Plan. Retrieved from Port of Vancouver: https://www.portvancouver.com/wp-content/uploads/2019/11/500_POV-Land-Use-Plan_FINAL-2.pdf

Vancouver Fraser Port Authority. (2020). Reducing container truck emissions.

Vancouver Fraser Port Authority. (2020). Implementation of environmental requirements for container trucks delayed to address driver uncertainty . Retrieved from Port of Vancouver: https://www.portvancouver.com/news-and-media/news/implementation-of-environmental-requirements-for-container-trucks-delayed-to-address-driver-uncertainty/?doing_wp_cron=1593894783.1610350608825683593750

Vancouver Fraser Port Authority. (2021a). Statistics overview – 2018 to 2020. Retrieved 08 01 2021 from Port of Vancouver: https://www.portvancouver.com/wp-content/uploads/2021/02/2020-Stats-Overview.pdf

Vancouver Fraser Port Authority. (2021b). Vancouver Fraser Port Authority view on container forecast volumes 2020-2060 Container forecasts. Retrieved on 08 01 2021 from Port of Vancouver: https://www.robertsbankterminal2.com/wp-content/uploads/2021-01-19-PDF-Vancouver-Fraser-Port-Authority-view-on-container-forecast-volumes.pdf.pdf

Vancouver Fraser Port Authority. (2021c). Container traffic forecast 2020. Retrieved on 07 31 2021 from Port of Vancouver: https://www.robertsbankterminal2.com/news-updates/container-traffic-forecasts/container-traffic-forecast-2020/

Vancouver Fraser Port Authority. (202d1). How does the port authority support the grain and agriculture sectors?. Retrieved on 07 21 2021 from Port of Vancouver: https://www.portvancouver.com/about-us/faq/grain-and-agriculture/

Vancouver Fraser Port Authority. (2022). About us. Retrieved on 03 21 2022 from Port of Vancouver: https://www.portvancouver.com/about-us/

Vancouver Fraser Port Authority. (2022). Rolling truck age program at Port of Vancouver to launch on September 15 following additional stakeholder engagement. Retrieved from Port of Vancouver June 13, 2022: https://www.portvancouver.com/news-and-media/news/rolling-truck-age-program-at-port-of-vancouver-to-launch-on-september-15-2022-following-additional-stakeholder-engagement/

Vancouver is Awesome. (2011). Truckers decry Vancouver route changes. https://www.vancouverisawesome.com/courier-archive/news/truckers-decry-vancouver-route-changes-2927084

Vancouver is Awesome. (2012). New traffic regulations target port-bound trucks. https://www.vancouverisawesome.com/courier-archive/news/new-traffic-regulations-target-port-bound-trucks-2922577

Vancouver is Awesome (2019). As Vancouver port expansion looms, residents fear what more truck traffic will mean for the air they breathe. https://www.thestar.com/vancouver/2019/11/15/as-vancouver-port-expansion-looms-residents-fear-what-more-truck-traffic-will-mean-for-the-air-they-breathe.html

Vancouver Sun. (2012). AirCare unnecessary for new trucks: association. Retrieved from PressReader: https://www.pressreader.com/canada/vancouver-sun/20120528/281629597320052

Vancouver Sun. (2013). Metro wants province to deal with truck emissions. Retrieved from Vancouver Sun: https://vancouversun.com/news/metro/metro-vancouver-wants-province-to-deal-with-truck-emissions

Vancouver Sun. (2014, March 10). Port trucking almost at a halt behind Unifor pickets. Retrieved 06 06, 2020, from Vancouver Sun: http://www.vancouversun.com/business/Port+trucking+almost+halt+behind+Unifor+pickets/9602255/story.html

Vancouver Sun. (2015, January 16). Port Metro Vancouver truckers deliver ultimatum to transportation ministers on deal terms . Retrieved 06 25, 2020, from Vancouver Sun: http://www.vancouversun.com/business/Vancouver+port+threatened+action/10736059/story.html

Vancouver Sun. (2021). Container plans put pressure on Port of Vancouver tenants, neighbours. https://vancouversun.com/news/local-news/container-plans-put-pressure-on-port-of-vancouver-tenants-neighbours

Yin, & Campbell, D. T. (2018). *Case study research and applications : design and methods / Robert K. Yin.* (Sixth edition.). SAGE Publications, Inc.

Young, T. L., Zychowski, K. E., Denson, J. L., & Campen, M. J. (2019). Blood-brain barrier at the interface of air pollution-associated neurotoxicity and neuroinflammation. In Advances in Neurotoxicology (Vol. 3, pp. 295–337). Elsevier. https://doi.org/10.1016/bs.ant.2018.10.010

Wang, Jonathan M, Jeong, Cheol-Heon, Hilker, Nathan, Shairsingh, Kerolyn K, Healy, Robert M, Sofowote, Uwayemi, Debosz, Jerzy, Su, Yushan, McGaughey, Michiyo, Doerksen, Geoff, Munoz, Tony, White, Luc, Herod, Dennis, & Evans, Greg J. (2018). Near-Road Air Pollutant Measurements: Accounting for Inter-Site

Variability Using Emission Factors. Environmental Science & Technology, 52(16), 9495–9504. https://doi.org/10.1021/acs.est.8b01914

Zhang, X., Chen, X., & Zhang, X. (2018). The impact of exposure to air pollution on cognitive performance. Proceedings of the National Academy of Sciences, 115(37), 9193–9197. https://doi.org/10.1073/pnas.1809474115