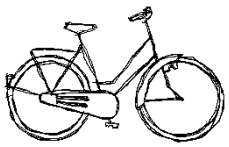

Potential Opportunities and Risks of Protected Bike Lanes on Commercial High Streets in Vancouver – Guidance for the Implementation in Vancouver and Berlin

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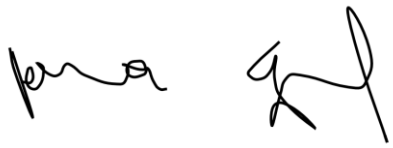

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Vancouver, March 25th 2019

Abstract

Protected bike lanes are an effective and increasingly popular tool to elevate cycling mode shares and road safety in North America and cities worldwide. The positive impacts also include economic, political, socio-economic, socio-cultural and spatial aspects, especially when protected bike lanes are implemented on commercial high streets as destinations and obvious routes. Vancouver (B.C.) is one of the cities in North America that has become well-known for multiplying its cycling mode share over the past decade by investing in protected bike lanes. However, these are not yet present on commercial high streets there, presenting important gaps in the cycling network as well as an opportunity for research. Through qualitative interviews with different stakeholders, the strengths, weaknesses, opportunities and threats of such projects in the City of Vancouver are analyzed in this paper. The information is complemented with findings from a literature analysis. The resulting holistic understanding of the involved potentials and risks serves as a basis to develop approaches for an implementation that is successful on various levels. Building on these results, the applicability to a German context is tested. To date, experiences with protected bike lanes there are limited. The example of Berlin as one of the most progressive German cities in this regard serves as a case study. In a first step, framework conditions in North America and Germany are compared. Differences and similarities between respective determining factors in Vancouver and Berlin then provide further hints on the applicability of previous findings to the Berlin setting. Eventually, this work should promote the successful implementation of protected bike lanes on commercial high streets and foster international knowledge exchange.

Protected Bike Lanes sind ein effektives und beliebtes Mittel zur Erhöhung des Radfahreranteils und der Verkehrssicherheit in Städten weltweit - vor allem in Nordamerika. Die positiven Effekte umfassen unter anderem auch ökonomische, politische, sozioökonomische, soziokulturelle, und räumliche Aspekte, besonders wenn Protected Bike Lanes auf Haupteinkaufsstraßen mit hohem Verkehrsaufkommen eingesetzt werden. Diese eignen sich durch ihre viel besuchten Destinationen und eine offensichtliche Routenwahl besonders für die Radwege. Vancouver (B.C.) ist eine der Städte in Nordamerika, die ihren Radfahreranteil im letzten Jahr durch den Einsatz von Protected Bike Lanes verfielfacht haben. Nichtsdestotrotz sind jene dort noch nicht auf den Hauptgeschäftsstraßen zu finden, was zu bedeutenden Lücken im Radwegenetzwerk führt und eine Forschungsmöglichkeit darstellt.. Durch qualitative Interviews mit veschiedenen Stakeholdern konnten die Stärken, Schwächen, Chancen und Risiken von Protected Bike Lanes auf Hauptgeschäftsstraßen in Vancouver analysiert werden. Die Informationen wurden durch eine Literaturanalyse ergänzt. Das daraus entstehende gesamtheitliche Verständnis der involvierten Potenziale und Risiken dient als Grundlage für die Entwicklung von Lösungsansätzen für eine Umsetzung, die auf vielen Ebenen erfolgreich ist. Aufbauend auf diesen Ergebnissen wird die Übertragbarkeit auf einen deutschen Kontext geprüft. Dort sind Erfahrungen mit Protected Bike Lanes derzeit begrenzt. Die Stadt Berlin soll hierbei als Fallbeispiel fungieren, da sie bezüglich der Protected Bike Lanes führend unter den deutschen Städten ist. In einem ersten Schritt werden Rahmenbedingungen in Deutschland und Nordamerika verglichen. Die Unterschiede und Gemeinsamkeiten der entsprechenden Einflussfaktoren in Vancouver und Berlin sollen daraufhin weitere Hinweise für die Anwendbarkeit der Ergebnisse in Berlin geben. Die Arbeit soll schließlich eine erfolgreiche Umsetzung von Protected Bike Lanes auf Hauptgeschäftsstraßen, sowie den internationalen Wissensaustausch fördern.

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Abbreviations

AAA	All Ages and Abilities
ADFC	Allgemeiner Deutscher Fahrrad-Club e. V. *('German Cyclists' Federation')*
BIA	Business Improvement Association
B.C.	British Columbia
CoV	City of Vancouver
CAD	Canadian Dollar
ERA	Empfehlungen für Radverkehrsanlagen (*'Recommendations for cycling facilities')*
FGSV	Forschungsgesellschaft für Straßen- und Verkehrswesen e.V. *('Road and Transportation Research Association')*
GHG	Greenhouse gas
HOV	High Occupancy Vehicle
KPI	Key performance indicator
n.a.	not available
NACTO	National Association of City Transportation Officials
RASt	Richtlinien für die Anlage von Stadtstraßen (*'Directives for the design of urban roads')*
StVO	Straßenverkehrs-Ordnung *('German road traffic regulations')*
SWOT	Strengths, Weaknesses, Opportunities and Threats
TAC	Transportation Association of Canada
U.S.	United States
UK	United Kingdom
$	Canadian Dollar

Glossary

All Ages and Abilities (AAA)

Tied to the concept of Universal Design, AAA-facilities are accessible, comfortable, and convenient to use for people of all ages and abilities. This includes children, seniors, women, people of colour, low-income riders, people with disabilities. The term is most often used in connection with urban bicycle infrastructure. Providing AAA bike routes has become "[…] an essential strategy for cities seeking to improve traffic safety, reduce congestion, improve air quality and public health, provide better and more equitable access to jobs and opportunities and bolster local economies" (NACTO 2017).

Buffered bike lane

"Buffered and unbuffered bike lanes are exclusive travel lanes for bicycles, typically positioned adjacent to a curb or parking lane, and delineated from adjacent motor vehicle travel lines by a linear pavement marking. […] The buffer pavement marking may be provided on one or both sides of the buffered bike lane. It provides separation from parked and/ or through vehicles" (Transportation Association of Canada 2017c, pp. 13–14).

Business Improvement Association (BIA)

"Business Improvement Areas (BIAs) are specially funded business districts. The districts are managed by non-profit groups of property owners and business tenants whose goal is to promote and improve their business district. Vancouver has 22 BIAs. BIAs are active in their communities, promoting: business, tourism, safety, street beautification" (City of Vancouver).

Commercial high street

A commercial high street is the main commercial and retail street in a city or neighbourhood with a strategic significance for the city (Arfin 2018; Carmona 2015, p. 3). They occur in places of high connection, where existing uses act as multipliers that further add to their attraction (Carmona 2015). A key characteristic is complex interrelations from a broad variety of uses such as commercial destinations, public and community amenities, traffic arteries including public transit, trucking routes, vehicular and bicycle traffic as well as high pedestrian volumes. According to Carmona (2015, p. 7), this wide utilization can also be described as having a role as a place and as a link at the same time. As a result, commercial high streets evince a high social, economic and environmental value (We Made That and LSE Cities 2017, pp. 6, 10; Carmona 2015, pp. 5, 18).

Complete Street

“Complete Streets are streets that are designed to be safe for everyone: people who walk, bicycle, take transit, or drive, and people of all ages and abilities” (Toronto Centre for Active Transportation).

Cycling infrastructure

The term cycling infrastructure generally refers to all facilities in the public realm that are used by cyclists and includes the allocated road space, infrastructure at intersections, and end-of-trip-facilities.

Design Thinking

"Design thinking is a human-centred approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business

success. […] [It] relies on the human ability to be intuitive, to recognize patterns, and to construct ideas that are emotionally meaningful as well as functional. The elements of design thinking combine to form an iterative approach […]" (IDEO U).

High Occupancy Vehicle (HOV) lane

"High Occupancy Vehicle (HOV) lanes were created to move more people in fewer vehicles, reducing congestion and greenhouse gas emissions" (British Columbia). Usage of these lanes is exclusive to High Occupancy Vehicles. These are, for example, passenger vehicles with a specified minimum number of persons, buses, motorcycles, taxis, handy darts or emergency vehicles.

Dooring

"Doorings occur when cyclists are struck by or run into doors of parked motor vehicles, mostly when the driver-side opens the door abruptly and without checking for cyclists in the mirror." (Engel 2018, p. 13)

Modal shift

Modal shift refers to changes in the modal split. Most commonly, including this paper, it is used for describing an increase of more sustainable modes of transport and a decrease of individual motorized transport. Cities all over the world aim for a modal shift in order to respond to global challenges like climate change, fossil fuel dependency, scarcity of resources, environmental pollution, transport accessibility, the finiteness of (urban) land, public health deficiencies through low levels of physical activity, and economic challenges like a limited operating budget and the attraction of business and talent (Neufeld, Richard, Massicotte, Paul j. 2017; Transport Canada 2015; TransLink 2011, 2008, 2008; City of Vancouver 2012a; UNESCAP Transport Division 2015; Breithaupt; McHugh 2014; City of Edmonton 2014).

Modal split

It is widely recognized that different transport modes like walking, biking, driving a car, or using buses or rail transport, differ from each other regarding their costs, land use, energy consumption and CO_2 emissions. In terms of efficiency and environmental sustainability, the ratio of these values is most beneficial for the active modes of transportation - walking and biking, as well as for high-capacity public transport. The modal split is the share of the different transportation modes and is considered one of the most important indicators for the mobility of a region (EPOMM).

Painted bike lane

A painted or unbuffered bike lane is a "[…] travel lane for cyclists defined primarily by white pavement marking line(s) running parallel to the alignment of the roadway" (Transportation Association of Canada 2017c, p. 12). In Germany, there is a differentiation between *advisory lanes*[1] and *cycle lanes*[2]. "Advisory lanes mark an area at the side of the carriageway [with dashed lines] to provide cyclists with a space which generally is not used by cars and used infrequently by trucks and buses when passing by each other […]. Cycle lanes on the carriageway are separated from vehicles visually by a lane edge

[1] German title: *'Schutzstreifen'*
[2] German title: '*Radfahrstreifen'*

marking, […]" (FGSV Translation 2012, p. 81). Cars must not drive on cycle lanes, while it is mandatory for cyclists to use them.

Protected bike lane

If a bike lane is physically separated from motorized traffic, dedicated solely to people on bikes, and runs on or adjacent to a roadway - as opposed to off-street pathways, it is defined as a protected bike lane (Centre Regional Planning Agency; City of Vancouver). The physical separation mostly refers to the application of vertical elements like concrete medians, bollards, planters, raised curbs, or vehicle parking lanes that divide them from vehicle traffic (City of Vancouver; McHugh 2014, p. 30; Centre Regional Planning Agency).

Right-of-way

Besides describing "a precedence in passing accorded to one vehicle over another by custom, decision, or statute" (Merriam-Webster Dictionary), this term also depicts the "area of land acquired for or devoted to the provision of a road" (Transportation Association of Canada 2017c, Glossary). It is often measured from one property line to another (Krahn 2015, p. 29).

Safety in numbers

The concept of *safety in numbers* implies that traffic crash rates decrease as cycling trips increase. (Jacobsen 2003)

Separated bike lane

see protected bike lane

Stakeholders

Stakeholders are groups or individuals that are affected by or have an influence on a project or its external effects either directly or indirectly. The varied interests of stakeholders toward the project can trigger conflict and jeopardize project realization. (Krips, pp. 1,3)

Structural bike path

What is referred to as a *'baulicher Radweg'* in Germany can be translated to *structural bike path* or *cycle path alongside road* (see FGSV Translation 2012, p. 82) in English. According to the *Recommendations for Cycling Facilities, s*tructural bike paths are separated by vehicle traffic and parking by a height differentiation through the curb and by a carriageway safety clearance strip. They are on the same level as sidewalks and separated from pedestrian traffic through visual contrasts and tactile materials (FGSV Translation 2012, p. 82). An example is pictured in *Figure 26*.

Universal Design

The "[…] design and composition of an environment so that it can be accessed, understood and used to the greatest extent possible by all people regardless of their age, size, ability or disability" (Centre for Excellence in Universal Design).

Vancouver

Unless otherwise specified, the term Vancouver in this paper refers to the municipality of the City of Vancouver, not the Metro Vancouver region.

1. Introduction

Cities and regions globally are promoting the bicycle as a means of transport in order to enhance liveability, and address contemporary issues such as traffic congestion, climate change, public health, and socio-economic challenges (Bruntlett and Bruntlett 2018, p. 1; ADFC 2018, pp. 6–7). Protected bike lanes have proven to be an effective measure to increase the cycling mode share in the Netherlands and in North America (ADFC 2018, p. 2; Bruntlett and Bruntlett 2018, p. 2), especially amongst what are considered more vulnerable road users like women, children, seniors, or physically impaired people (City of Vancouver 2012b, p. 7; DuBose 2011, p. 54; TransLink 2011, pp. 18–19).

1.1 Protected bike lanes in North America and Germany

Cities in North America such as Chicago, New York, Seattle, or Portland were able to raise their share of cycling significantly with the implementation of protected bike lanes in the last decade (ADFC 2018, p. 3; League of American Bicyclists 2017, pp. 9–10; Higashide 2018). In the City of Vancouver, an extension of the bicycle network that now features over 80 km of AAA bike routes, has even led to an increase by 3.5 times of cycling within eleven years - from 2% in 2006 to 6.9% in 2017 (McElhanney Consulting Services Ltd., Mustel Group 2018, p. 30; EPOMM; City of Vancouver 2018, p. 24).

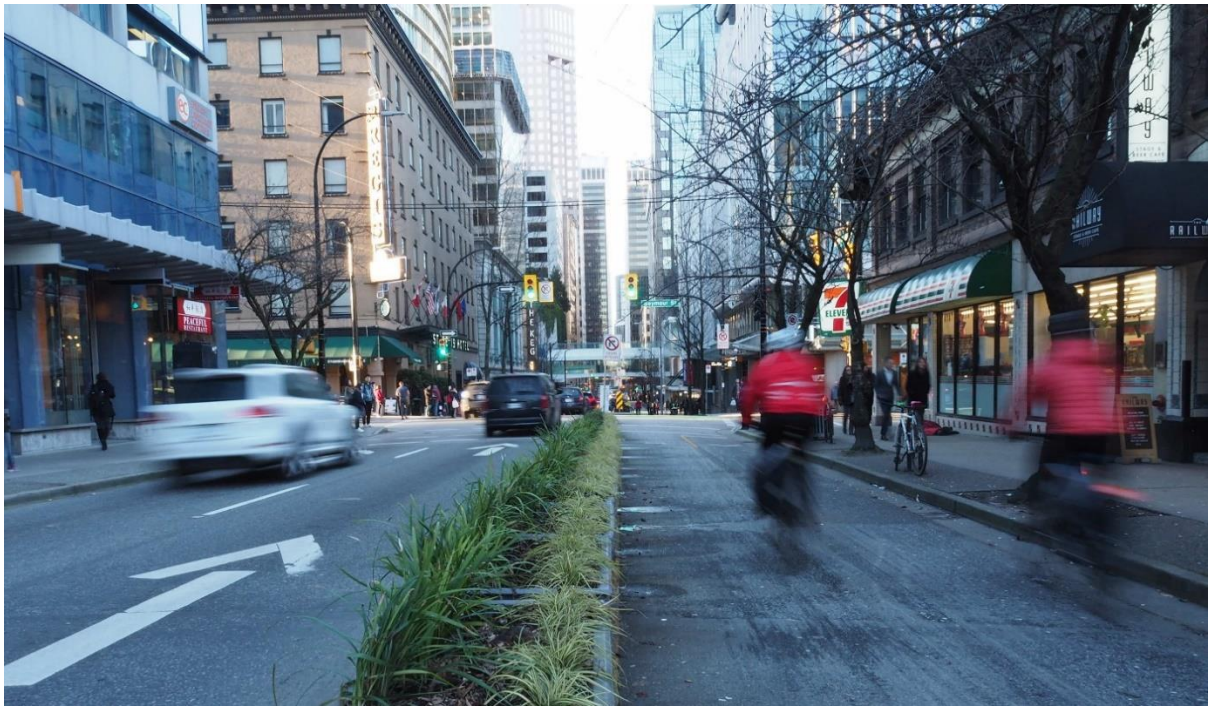

Figure 1 - Protected bike lane in Vancouver (author)

In Germany, too, the implementation of protected bike lanes is aspired to, and highly encouraged by a major German bicycle association, the ADFC (ADFC 2018, p. 2). First projects in cities like Cologne, Berlin, Osnabrück or Frankfurt, are recently being discussed or implemented (Kölner Wochenspiegel 2018; Schlicht 2018; Deutscher Städtetag 2018; Fülling 2018). However, experiences to date are very limited (ADFC 2018, p. 5; Senatsverwaltung für Umwelt, Verkehr und Klimaschutz 2018). Besides, implementation standards have yet to be developed and adopted by German design guidelines such

as the *'Recommendations for cycling facilities'*[3] (FGSV 2010) or the *'Directives for the design of urban roads'*[4] (FGSV 2007).

1.2 The potential of protected bike lanes on commercial high streets

Despite the lack of experiences with protected bike lanes, they are seen as state of the art in Germany due to remarkable international experiences (ADFC 2018, p. 7). Vancouver is often referred to as showcase city for protected bike lanes (see Randelhoff 2016; ROSS 2018) – not only because of its rapid growth of cycling numbers but also considering its political commitment despite a loud opposition (Gutman 2018; Siemiatycki et al. 2014, pp. 226, 234; Bula 2013). Especially on commercial high streets, plans to implement protected bike lanes have spurred political discussions in Vancouver: Business owners fear that taking away parking space to build protected bike lanes will prevent their customers from visiting their shops (Bruntlett and Bruntlett 2018, p. 63; Chan 2017; Pogor 2016). Together with the City's efforts to engage stakeholders in the process, this has been holding back some of the planned projects (City of Vancouver 2017b). On the other hand, an increasing body of research that has been analyzed in a previous work by the author emphasizes the positive effects of protected bike lanes in general and for businesses on commercial high streets (see Engel 2018). The observed or expected potential of protected bike lanes on commercial high streets includes, but is not limited to, improvements of road safety, cycling usage, public health, urban transport efficiency and the environment, as well as an enhanced accessibility for people of all ages and abilities to businesses and services on commercial high streets and hence benefits for their social connectedness.

1.3 Objective of research

The above mentioned expected positive effects of establishing protected bike lanes on commercial high streets make them a popular planning tool for cities worldwide (Monsere et al. 2014, p. ES1). However, through following and engaging in local discussions in Vancouver, the author also observed several challenges and barriers for the matter that had not yet been extensively covered by research (Engel 2018, p. 35). In order to enhance the effectivity and suitability of stated projects for a broad variety of people, a further exploration of the topic is necessary. Attaining a deeper understanding of the involved opportunities and risks shall serve as a basis to elaborate suitable approaches and recommendations for actions thereupon. The developments and political circumstances in Vancouver mentioned earlier make it a great case study that can produce useful insights for other cities and countries. Local circumstances may affect suitable strategies to be deployed. In order to make the results from the study in Vancouver applicable to a German context, a transferability to Berlin as a case study will be examined.

Questions to be answered in this paper are:

- Who are the stakeholders of protected bike lanes on commercial high streets in Vancouver?
- What are the strengths, weaknesses, opportunities and threats of protected bike lanes on commercial high streets in Vancouver?
- What are the characteristics of commercial high streets in North America and Germany?

[3] German title: *'Empfehlungen für Radverkehrsanlagen'*
[4] German title: *'Richtlinien für die Anlage von Stadtstraßen'*

- What standards and guidelines exist for protected bike lanes in North America and Germany?
- What are the differences between projects on protected bike lanes on commercial high streets in Vancouver and Berlin and recommended actions for both cities?

Eventually, the findings should provide suggestions for planners, decision-making entities and bicycle advocacies for a successful implementation of protected bike lanes on commercial high streets in Vancouver and Berlin. Therefore, respective conceptual approaches will be identified by determining underlying opportunities and challenges and simultaneously creating awareness for the dependence of bicycle infrastructure projects on a multitude of economic, political, socio-economic, socio-cultural, and spatial factors. Beyond that, this paper promotes an international knowledge exchange by highlighting relevant differences and similarities between the North American and German context.

2. Methodology

The underlying data for this work was collected using different methods. For one, qualitative interviews were conducted to receive information on existing circumstances, risks, and opportunities of protected bike lanes on commercial high streets. In addition, information from literature and research findings was consulted for the completion and verification of these results.

2.1 Stakeholder interviews

Some of the challenges to building protected bike lanes on commercial high streets in Vancouver originate from the multifunctionality of those streets: They serve as major traffic arteries, mostly including trucking and public transit networks, while they also play an important role as public spaces. This results in opposing interests of the stakeholders of those streets. In his reference guide to stakeholder management for project management purposes, Krips (2017) highlights the importance of stakeholder management to avoid conflicts with stakeholders that can lead to a decline in reputation or the failure of a project (Krips 2017, p. 6). According to Krips (2017, pp. 6, 11), stakeholder management involves obtaining information about stakeholders by identifying them and analyzing their interests and other attributes such as their attitude. The goal is to create acceptance and successfully implement a project. The goal of this paper is not the conduct of stakeholder management practices. On the other hand, identifying stakeholders, their interests and their perceptions can also foster a holistic understanding of the opportunities and risks involved in projects of protected bike lanes on commercial high streets.

The goal of this research is a detailed investigation of possibly unknown issues. Qualitative research, especially in-depth interviews with stakeholders, are considered effective tools to provide more detailed information on a subject (Boyce and Neale 2006, p. 3). In that sense, it is also recommended by the German *Road and Transportation Research Association*[5] (2012, pp. 95–96). Open-ended questions can be used to "[…] explore new issues in depth" (Boyce and Neale, p. 3) by encouraging interviewees to "[…] expand their own experiences" (Appleton 1995, p. 994).

Therefore, qualitative, open-ended, interviews were conducted to assess strengths, weaknesses, opportunities, threats, and suggestions for protected bike lanes on commercial high streets in Vancouver. In total, nine interviews were conducted within the Vancouver context. In order to also get a basic understanding of the situation in Berlin, a similar approach to qualitative interviews was applied in Berlin. However, due to the scope and focus of this paper, only one expert was interviewed in this context. Information from the interview was complemented with literature research, although experiences with protected bike lanes in Berlin are more limited and less discussed in Berlin than in Vancouver. This means that the level of detail and the external validity of the findings for Vancouver is substantially higher than for Berlin. Therefore, the example of Berlin that is described throughout the paper should be considered as an illustrative example to highlight some outstanding differences between Germany and North America and draw conclusions on the possibilities of knowledge exchange.

While open-ended interviews appear to be an appropriate tool for the described purpose (Forschungsgesellschaft für Straßen- und Verkehrswesen 2012, p. 97), they also have limitations. These shall be acknowledged, and strategies deployed to improve the external validity of this research.

[5] German title: '*Forschungsgesellschaft für Straßen- und Verkehrswesen*'

Known study limitations are the bias of selecting interview partners, the participation bias of interview partners, limitations through a small sample size, the subjectivity of opinions and circumstances expressed by interview partners, the dependence on skills and expertise of the interviewer, and analysis bias (Forschungsgesellschaft für Straßen- und Verkehrswesen 2012, p. 97; Boyce and Neale 2006, pp. 3–4; Appleton 1995, p. 994; Smith and Noble 2014, p. 101). Measures taken to improve the validity of this study are described subsequently.

2.1.1 Interview preparation

Stakeholders of projects for protected bike lanes on commercial high streets were interviewed for this research. In a first step, these stakeholders were identified, and depending on their proximity to or relevance for those projects, included in this research (Krips 2017, p. 3). Time and project restraints made for a target sample size of at least one representative per stakeholder group. Due to the heterogeneity of some stakeholder groups and thereto relating amplified risks of selection bias, some interviews with individuals from that group were replaced or complemented by research. The group of commercial high street visitors, for example, is highly heterogeneous and coincides with interests of road users and residents. No individual from this group was interviewed. Nevertheless, their interests are represented by respondents from other stakeholder groups as well as literature findings.

Individual interview partners were identified using the author's knowledge about stakeholders and experts in the field obtained through a previous research project (Engel 2018) and her professional and social network in Vancouver. Since the author herself is part of a community that appreciates cycling and physical activity, this creates a certain selection bias. Additional interviewees were identified during data collection, as suggested by Boyce and Neale (2006, p. 4) and Smith and Noble (2014, p. 100). Doing so, the author explicitly asked some study participants for contacts or references that are knowingly opposed to the concept of protected bike lanes on commercial high streets. The intent was to minimize selection bias as far as possible. However, most of these individuals, of which some were contacted via various means of communication, either did not respond to or neglected the participation request. Examples are taxi companies representing a group that is dependent on vehicle road usage and BIAs. Some individual business owners on commercial high streets that are known to be opposed to the concept were contacted in person but declined participation. A participation bias results from this which is mitigated to an extent by the circumstance that these specific groups have made their positions heard publicly, regardless of this research (SGBIA 2017, p. 6; Ripplinger and Westender 2017; Godsall 2011; Pogor 2016). In addition,

All potential interview partners were contacted stating the purpose of this paper to learn about the opportunities and risks of protected bike lanes on commercial high streets. For positive responses to the participation request, a meeting time and place was arranged. In some cases, the interview was carried out via phone.

2.1.2 Interview conduct

For every interview, the same rough structure was followed: The interviews started with a brief explanation of the research purpose and goals, as well as a brief outline of the interview and editing process. Interviewees were then asked for their verbal agreement to produce an audio record of the interview and for a written agreement to the utilization of contents produced in academic research. In cases where the background, experience, or involvement with the study subject of participants indicated the presence of additional relevant information, the interview was started with an according question. All participants were then asked where they see strengths, weaknesses, opportunities, and

threats of protected bike lanes on commercial high streets. The terms 'protected bike lane' and 'commercial high street' were clarified where necessary. Subsequently, respondents were asked for measures that they think can make specified projects successful. Throughout the interviews, follow-up questions were asked if needed to ensure a mutual understanding or to obtain more detailed information. An open-ended and non-suggestive structure of questions was attempted to maintain where possible and contributions from previous interviews were taken into account at this point. Respondents were then asked if they would like to add anything to the topic. Interviewees were not reimbursed for their participation.

2.1.3 Interview analysis

Considering time constraints and the purpose of the interviews, the author and her supervisor decided that written result logs, confirmed by the participants, would be an adequate means of documenting the interviews. Thus, interview minutes were produced using audio recordings and notes taken during the interview. Information obtained during the interviews was structured and summarized as suggested by Mayring (2015, p. 67). The resulting documents were sent to the respective interviewees for completion, correction, and verification of the depicted insights. Afterwards, the contents from the confirmed minutes were systematically sorted in two steps, with categories and topics evolving during the process. Further integration of filtered and reduced content generated the overall structure of the SWOT analysis used later on.

According to Boyce and Neale (2006, p. 4), the generalization of results from in-depth interviews is only reasonable when "[…] the same stories, themes, issues, and topics are emerging from the interviewees […]". Mayring (2015, p. 123) also states a comparison with results from other sources and existing theories as a criterion for the validity of qualitative research. Therefore, the validity of individual aspects of the SWOT analysis was evaluated with regard to the number of stakeholder groups making references to it and their conformity with literature

2.2 Literature analysis

Considering existing literature on the topic is not only relevant for the validation of the interview content, but it is also necessary for transferring the results of the Vancouver SWOT analysis to a German context. For this purpose, several documents were consulted: city data and documents, legal standards and guidelines, the conclusion of a previous extensive literature analysis around the subject and literature selected thereby (Engel 2018), literature recommended by study participants, relevant newspaper articles, and other research findings.

3. Findings – Stakeholders of commercial high streets in the City of Vancouver

A major part of grasping the complexity of projects for protected bike lanes on commercial high streets in Vancouver is understanding the - sometimes opposing - interests of their stakeholders. An awareness of who these stakeholders are and how they are involved within said projects is also a prerequisite for the selection of interview participants.

3.1 Stakeholder groups

The following chapter provides an overview of the stakeholders of commercial high streets in Vancouver, including their involvement, interests, and perceptions about building protected bike lanes on those streets.

3.1.1 Business owners

Business owners run the numerous shops, cafés, restaurants and service locations that make the streets a destination rather than just a road. Their existence depends on stable revenues through customers and a certain level of intensity and vitality of the street (Carmona 2015, p. 7). Therefore, the street environment including the way that people and goods can get to their businesses but also the public space quality, have an appreciable impact on their activities. Likewise, they are the ones that can profit from street improvements in their surroundings (CABE 2007).

In most cases throughout Vancouver, their voice is reinforced and represented by so-called *Business Improvement Associations*. They are run by a voluntary board of directors comprised of local business and property owners (Mount Pleasant Business Improvement Association; South Granville Business Improvement Association (SGBIA) 2018). Next to being advocates for their members, their goal is to "[…] promote and improve their business district" (City of Vancouver). Funding is provided by the City of Vancouver via a special property tax and used for BIA activities and staff hiring (City of Vancouver; SGBIA 2017).

When it comes to the implementation of bike lanes on commercial high streets, they are amongst the most vocal groups to state their concerns (Zeidler 2018). These are primarily founded in the fear of losing customers due to a lack of on-street parking (Pogor 2016; Ripplinger and Westender 2017). This phenomenon is not just specific to Vancouver and is related to the circumstance that these business owners tend to overestimate the share of their driving customers (Sztabinski 2009, p. 5; Sustrans 2003, p. 2; Tolley, Rodney 2011, p. 2). On Commercial Drive in Vancouver for instance, where there is lots of resistance against existing plans to implement protected bike lanes, only 5.6% of all people that arrive there use the on-street parking on Commercial Drive (City of Vancouver 2016c, pp. 12,13). On the other hand, not all of the businesses in Vancouver believe that bike lanes will have a negative impact on their business, as respondents from resident and business owner groups say. In Toronto, the majority of retailers expect positive changes (Sztabinski 2009, p. 1), and businesses in downtown Vancouver have even changed their attitude: One of the business owners reports that after protected bike lanes were implemented on Hornby and Dunsmuir Streets in 2010, many of the local business owners now acknowledge or actively support the bike lanes (also see Quednau 2016; Klingbeil 2016; Fawcett 2016).

3.1.2 Visitors of commercial high streets

Visitors of commercial high streets sometimes depend on services offered there, including commercial services such as shops, business services, and restaurants; community amenities like parks or public libraries; places to work; and other essential services such as financial, government, and medical services. Having access to commercial high streets is a critical component for residents of all ages, abilities, and socio-economic backgrounds to participate in every day, social, and work activities. Against this backdrop, Meng (2018, pp. 11–12) states that "[t]he accessibility of commercial high streets can be affected by a lack of transport mode choices. Mode choices can be made when various modes of transportation are affordable, safe, and comfortable for a variety of people." Many people are, for instance, not able to drive or cannot afford to acquire, operate and maintain a car, while others are dependent on the usage of a car. Looking at the road space allocation and road space usage on Commercial Drive in Vancouver, current problems of accessibility become more obvious: As can be seen in *Figure 2*, 30% of the road space on the wide sections of Commercial Drive (north of Graveley Street) are dedicated to pedestrians while 70% are built for car drivers (City of Vancouver 2016c, p. 15; VPSN Blog 2017).

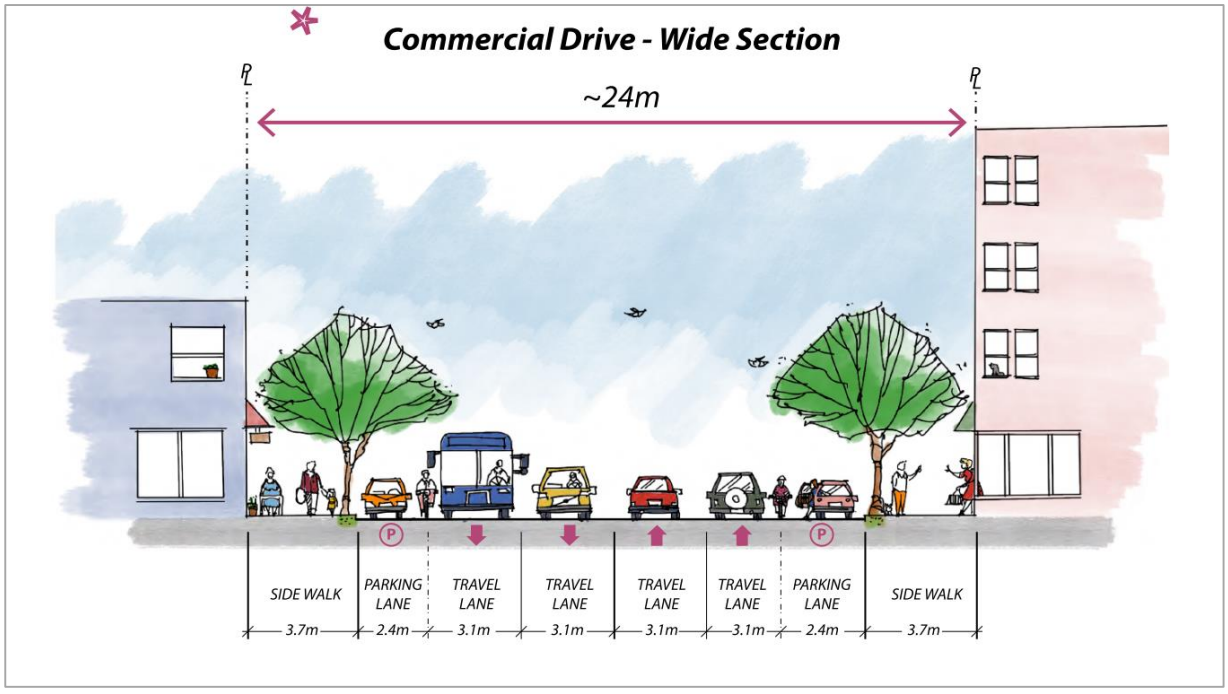

Figure 2 – Commercial Drive cross section (City of Vancouver 2016c, p. 15)

The sidewalks are used by pedestrians and transit users. This space is also used for outdoor seating or merchandise displays of adjacent businesses, as well as cyclists for whom riding on the road is considered unsafe (Monsere et al. 2014, p. 126; McHugh 2014, p. 32). The remaining two-thirds are oriented towards moving and stationary vehicular traffic and also accommodate bikes and transit. No particular space is, however, dedicated to them which leads to less than a quarter of cyclists being comfortable riding there (McElhanney Consulting Services Ltd., Mustel Group 2018, p. 21). This is also criticized by the frequent bike user respondent. Beyond that, this means that transit efficiency is dependent on traffic volumes. However, as shown in *Figure 3*, only 17% of people travelling to Commercial Drive arrive by car, whereas 44% of people walk, 27% take transit, and 11% use a bike (City of Vancouver 2016c, p. 12). Furthermore, 60% of people intercepted on Commercial Drive want to cycle more but deem it unsafe (City of Vancouver 2016c, p. 10). This is not unjustified: Some commercial high streets in Vancouver are some of the most dangerous locations for cycling in the city

(City of Vancouver 2015a, p. 119). A resident observes that even among motorized traffic, there are frequent collisions on commercial high streets. Besides that, the predominantly local catchment area of visitors on commercial high streets (*Figure 4*) implies short travel distances. Building upon that, there is a vast potential for more cycling on commercial high streets if adequate infrastructure is provided (Engel 2018, p. 8).

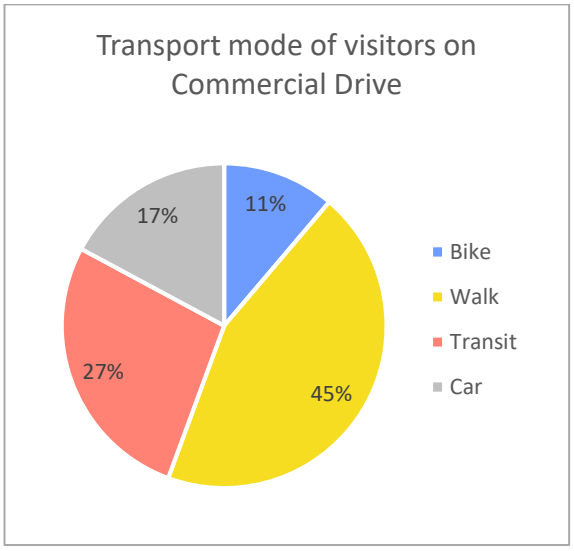

Figure 3 - Transport mode of visitors on Commercial Drive (City of Vancouver 2016c, p. 12)

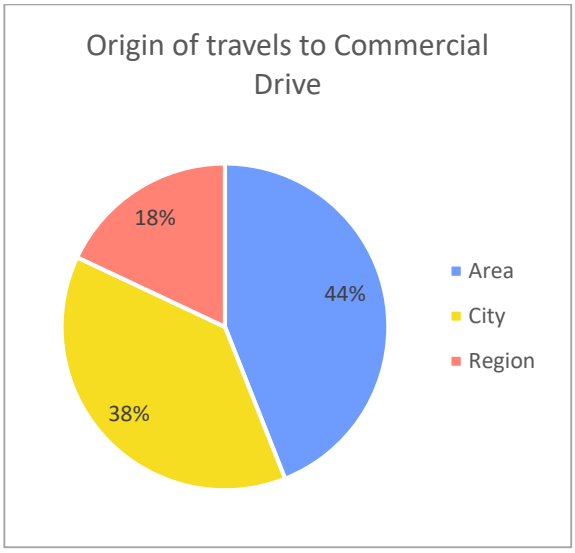

Figure 4 – Origins of travels to Commercial Drive (City of Vancouver 2016c, p. 12)

This demonstrates that there is demand for more and safer cycling infrastructure on commercial high streets in Vancouver. According to Rajé (2018, p. 3), there is a risk that parts of society are excluded if infrastructure is not designed according to the needs of all people (Rajé 2018).

In addition to the need for better accessibility and road safety of commercial high streets, their public space quality has a high impact on the quality of time spent on commercial high streets, including social interactions and wellbeing (Carmona 2015, p. 41).

3.1.3 Road users

As mentioned earlier, one characteristic of commercial high streets is their multitude of functions. Jones and Boujenko (2009, p. 38) describe this as having a 'link' and 'place' function. The accessibility of commercial high streets as traffic arteries is just as important as the accessibility of their destinations that was described above. Similar interests with regard to accessibility and road space allocation apply for road users and visitors of commercial high streets. However, the mode share between road users passing through commercial high streets and those who approach them as destinations may be different. Besides, travel time may become a higher priority in the link function (MAN and Technical University Munich 2013, p. 40). Because of that, the perceived impact of changes in road space allocation is a sensitive topic: People fear increased congestion due to the common perception that taking away travel lanes from motorized traffic reduces the capacity of roads and increases congestion (City Clock 2014; Ripplinger and Westender 2017; Chan 2017; Siemiatycki et al. 2014, p. 225; Monsere et al. 2014, p. 120). As the author concluded in the previous literature analysis, "[…] congestion is a widespread concern when implementing protected bike lanes, but it does generally not materialize in sizable effects (Vijayakumar and Burda 2015)." Nevertheless, it is an important issue to be considered in street design changes (Engel 2018, p. 16).

Figure 5 – Road usage on a winter weekday non-holiday afternoon on Commercial Drive in Vancouver (author)

3.1.4 Residents

Commercial high streets in Vancouver are usually located within 5 km of most of the city's inhabitants. This implies that most people that live in the City of Vancouver live in the catchment area of at least one commercial high street and rely on them as their local destination for running errands. Hence, they could be understood as residents. In this paper, however, the term 'residents' shall be viewed in a narrower perspective - as people whose everyday life is affected by commercial high streets beyond matters of the quality and accessibility of destinations and traffic arteries they offer. Circumstances that are covered by this definition include, but may not be limited to, impacts of traffic noise and air quality at a person's home due to traffic on commercial high streets; residential availability of parking spots and transportation options; as well as the security, liveability and social connectedness within their neighbourhood that can be reflected in housing prices (CABE 2007, pp. 6, 8; Litman 1999, 16-17; Hromádka and Shashko 2015, p. 761). Gentrification and increasing rental and property prices are also a concern of residents when protected bike lanes are implemented (Li and Joh 2016, p. 3495). On the other hand, "[t]his reflects the value consumers attach to walkable neighbourhoods, which tend to be denser, mixed use neighbourhoods with good accessibility, including high quality public transport", as Tolley, Rodney (2011, p. 15) remarks. Following that, the National Complete Streets Coalition notes that "[w]hen residents have the opportunity to walk, bike, or take transit, they have more control over their expenses" than people living in auto-dependent areas. Eventually, this leads to lower total costs for transportation and housing (McElhanney Consulting Services Ltd., Mustel Group 2017, p. 2; Hromádka and Shashko 2015, p. 761). Besides costs for housing and transportation, a major concern for residents is the availability of car parking, even in cases where it is only reduced by a minimum (comment on Montoro 2017; Monsere et al. 2014, p. 142).

3.1.5 Tax payers

As the author learned in several conversations with people during Bike to Work Week, and as also mentioned by Ripplinger and Westender (2017), some people are concerned that the share of cyclists does not justify the size of investments for cycling infrastructure in Vancouver. Tax payers are indeed one of the funding sources of public infrastructure investments. However, "[i]t is an extremely common misconception that motorists pay for the building and maintenance of roads through gas taxes and parking fees. Although this is partially true, for the most part, city roads are funded from general revenue (i.e. property taxes)" (McHugh 2014, p. 110). More than a third of the budget for the City of Vancouver's four-year capital plan, of which 11% is allocated to transportation investments, are sourced from city contributions that include revenues from property taxes (City of Vancouver). Nevertheless, McHugh (2014, p. 10) further elaborates that with roads being a "[…] public commodity […]", the allocated funds for a certain type of infrastructure should reflect the mode share. In this regard, cycling in 2011 was considered to be "[…] currently under-funded […]" in Metro Vancouver with only 1% of regional transportation spending being allocated towards 1.7% of people that cycle (TransLink 2011, p. 22). Both shares have increased in the meantime (City of Vancouver). These changes, as well as the circumstance that some infrastructure, such as street lighting, drainage, or traffic lights, is being shared between motorists and cyclists, induce a more complex investigation to make an accurate case. For this reason, an objective statement about a fair budget allocation cannot be made at this point without further research that would exceed the scope and purpose of this paper. Tax payers are, therefore, and because of the relatively small contribution and relatively low costs for cycling infrastructure, as well as a high expected return on investment (Siemiatycki et al. 2014, p. 225; TransLink 2011, pp. 22–23; Richard 2014), excluded from the stakeholder analysis.

3.1.6 City Council

Besides the previously described stakeholders that can be aggregated as the users of commercial high streets, there are also stakeholders that are involved in the management of the planning, decision-making processes and funding. Since the Canadian government has had a long-time federal policy of non-intervention in urban transportation, the responsibility for the subject is left to provinces and municipalities, hence the majority of transport policies are determined at the municipal and provincial level (Pucher and Buehler 2006, p. 272, 2005, p. 23). The municipalities have the general ownership and operational responsibility for the Major Road Network (TransLink). The City's role in transportation includes building and maintaining City-owned infrastructure; guidance of development through land use and urban design policies and guidelines; management of street use through rules, regulations, and pricing; education and empowerment of citizens "[…] to make sustainable transportation choices […]"; as well as to provide leadership, advocacy and partnership to the outside (City of Vancouver 2012a, p. 6). The City's rationale behind guiding these operations is to ensure a sustainable city development including economic, environmental, social, and public health aspects while responding to issues such as population growth, demographic change, environmental damage, space constraints, and socio-economic inequities (City of Vancouver 2012a, pp. 8,9). Specific challenges arise through budget and time restrictions, as well as the divergence of political interests, as Siemiatycki et al. (2014) demonstrated using the case of the Burrard bridge; and as it becomes apparent during election years (Engel 2018, p. 35).

3.1.7 TransLink

The purpose and responsibilities of TransLink were described in a previous paper by the author: "TransLink is the regional transportation authority that was founded by the province to coordinate transportation between the municipalities of Metro Vancouver. It is mandated to provide a regional transportation system as a whole with a prioritization of walking, cycling, and transit. Funding is required for operations, maintenance, the rehabilitation of the Major Road Network (MRN), and shares in the cost of several capital improvements (TransLink). Broadway, Cambie Street, Granville Street, and 41st Ave are commercial high streets that are part of the MRN (TransLink 2016). In relation to cycling, TransLink has a long-term direct leadership role including the provision of funding for municipal cycling infrastructure such as the Major Bike Network, as well as its coordination, the assurance of an ease of navigation within the bike network and the ease of combining cycling and transit, assistance of school-based training programs regarding cycling skills, bicycle marketing campaigns, and the coordination of a regional bicycle monitoring program (TransLink 2011)" (Engel 2018, p. 28). Consequently, TransLink's interests can be determined as fulfilling their imposed responsibilities to deliver "[…] safe and reliable transportation services" (TransLink 2017, p. 12); securing funding from the City's taxation revenues and their own user fees; meeting stakeholders' expectations (TransLink 2017, p. 7); and managing financial, business, project, labour relations, and environmental risks (TransLink 2017, pp. 41–43).

3.1.8 Advocacies

Bicycle advocacy groups are organizations that acknowledge the benefits of cycling and aim to improve cycling conditions for a variety of people, usually in a specific area. Ways to achieve this are providing physical and knowledge resources for users to make cycling more accessible; creating a community through events, programs, and platforms; advising decision-making entities and businesses; carrying out marketing activities for communication, image, and awareness purposes; and conducting and publishing research (Hub Cycling 2018; Modacity). There are for- and non-profit organizations, however, there seems to be a higher number of non-profit organizations that rely on the engagement of volunteers. One of the biggest advocacy groups in Vancouver is *Hub Cycling*, who, for example, offer bicycle education for all ages, host events like the widely know *Bike to Work Week* or *Bike the Night*, and collaborate on cycling or policy projects with governments, planners, and developers through the work of voluntary local committees (Hub Cycling 2018). Regarding the latter, their individual and organization member base of nearly 3,000, as well as their outreach to more than 30,000 individuals and organizations via newsletters and social media, legitimate their voice. Next to goals of providing people with knowledge and universal bicycle infrastructure, there are also groups that are targeted on providing people with tools, knowledge and support for repairs, as well as affordable bikes. Examples in Vancouver are the volunteer-run community bike shops *Kickstand* or *Our Community Bikes*. Other groups like the *Vancouver Bicycle Club* support a biking community by organizing recreational biking events. Eventually, organizations like *Modacity* focus on marketing biking to citizens and governments by providing education about the benefits of multi-modal transportation and "[…] communicat[ing] a more human image […]" of it (Modacity). The founders Melissa and Chris Bruntlett use writing, photography, film-making, social media, and speaking to advocate for a movement towards "[…] a more inclusive [transportation model] that is accessible to people of all ages, abilities, and economic means" (Modacity). Most of these organizations share the perception that providing universal infrastructure and other bike resources are appropriate means to unleash the social, environmental, public health, and economic potential of cycling.

3.1.9 Construction companies

Construction companies build bicycle infrastructure when they are hired for projects. As Krips (2017, p. 1) mentions, they are considered internal stakeholders of construction projects. Their interest lays in being commissioned for the execution and construction of projects of all types in order to draw profits. In this paper, it is assumed that the type of infrastructure that is being built is not particularly relevant for the named purpose. Therefore, they are not included in the stakeholder analysis.

3.2 Overview of stakeholder groups and their interests

A summary of relevant stakeholder groups in Vancouver and their interests is provided in *Table 1* below.

Table 1 - Overview of stakeholder groups and their interests

Stakeholder group	Interests
Business owners	• Stable revenues • Affordable retail rents • Accessibility for customers • Loading and delivery of goods
Visitors	• Accessibility of services through affordable, safe, and comfortable transportation choices • Public space quality • Social interaction
Road users	• Accessibility of affordable, safe, and comfortable transportation choices • Traffic flow
Residents	• Affordability of housing and transportation • Accessibility of transport options • Liveability of the neighbourhood: limited exposure to traffic noise and air pollution, security • Social connectedness within the neighbourhood
City Council	• Provision of funding, planning, construction, maintenance, education, legislation, regulation, and leadership for urban transportation infrastructure • Meet time, space, and budget constraints • Maintain political stability
TransLink	• Provision of a safe and reliable regional transportation system with prioritization of walking, cycling, and transit • Securing funding through municipalities and transit revenues • Meeting stakeholders' expectations
Advocacies	• Promotion of universal bicycle infrastructure, resources, and education • Increase of cycling safety, participation, and inclusion • Forming a community

3.3 Overview of study participants

In order to obtain a holistic understanding of the potential and the risks involved in projects for protected bike lanes on commercial high streets, individuals of most stakeholder groups were interviewed. *Table 2* provides an overview of these participants along with a brief description of their roles and experiences.

Table 2 - Overview of study participants

Stakeholder group(s)	Group reference	Role description	
Business owners	I-BO	1	Staff person within one of Vancouver's BIAs
		2	Runs a business on a commercial high street in Vancouver, active engagement in public participation processes of complete streets projects
Frequent cyclist	I-FC	3	Bike messenger; self-description as a rather slow and careful cyclist
Residents	I-RE	4	Lives near a commercial high street in Vancouver and runs a business there. Supports the idea of reduced car usage in urban environments.
Municipal advisory council	I-MA	5	Engagement in the City of Vancouver Active Transportation Policy Council, experience with community involvement and planning
Regional transport authority	I-TA	6	Communication specialist working within public transit demand management for a regional transport authority
		7	Transportation engineer at a transit authority, specialized in bike-transit integration
Bicycle advocacy	I-BA	8	Promotion of the public health, environmental, and social benefits of active and multi-modal transportation using writing, photography, film, and social media.
		9	Employee of a community bike shop, promotion of complete street projects on commercial high streets, environmentalist

4. Findings – Strengths, weaknesses, opportunities and threats of protected bike lanes on commercial high streets in the City of Vancouver

Even though investments for protected bike lanes in Vancouver have grown substantially over the past years, to date they are mostly limited to the downtown area, as well as recreational and commuting bike routes. That means that for this specific context pre- and post-implementation data is not yet available. Deduced from related research findings, the effects of protected bike lanes on commercial high streets in Vancouver were therefore assumed in an earlier paper (see Engel 2018). However, in order to reap the benefits and minimize the risks of these projects and produce successful infrastructure, it is necessary to assess both, the positive and negative circumstances and anticipated effects. Due to varying objectives of SWOT-analyses, the classification of strengths, weaknesses, opportunities, and threats may generally differ from other analyses of this type.

4.1 Strengths

Project strengths are existing circumstances that act in favour of an implementation of protected bike lanes on commercial high streets in Vancouver. Those identified within the stakeholder interviews are described below.

4.1.1 Economic

Economic vitality

One of the biggest concerns when it comes to building protected bike lanes on commercial high streets, not just in Vancouver, is a decrease in business revenues (see Pogor 2016; Ripplinger and Westender 2017) (Pogor 2016; Ripplinger and Westender 2017). However, as respondents from the residents and business owner groups say, negative effects of bike lanes on businesses have repeatedly been neglected by research. There are many case studies including Broadway in Salt Lake City (Salt Lake City Division of Transportation 2015, p. 1), 9th Ave in New York City (NYC DOT and Bennet Midland 2013, pp. 38–39), or Columbus Ave in New York City (NYC DOT and Bennet Midland 2013, pp. 32–34) that exhibited increased business sales due to the bike lanes. In all cases, data were collected before and after the intervention, at the project site and a comparable location. A similar methodology was used to evaluate the protected bike lanes installed on Bloor Street in Toronto in 2016. The study by Smith Lea et al. (2017, pp. 4–5) found a growth in customer counts from merchant surveys, increased estimated spending and visit frequency from visitor surveys, and reduced business vacancy counts from a street-level scan. Even though these factors "[…] also showed a similar growth […]" on a comparison street, the results indicate "[…] a positive, or at least neutral, economic impact of the bike lane" (Smith Lea et al. 2017, p. 41).

The only study that is known to the author that found a negative impact on businesses is a study conducted in downtown Vancouver by Stantec (2011). However, no baseline data was conducted prior to the bike lane implementation (Stantec 2011, p. 56) and the study itself highlights the preliminary and short-term character of the results that do not account for an adjustment period (Stantec 2011, p. ii). Besides that, the findings are based on individual responses of best estimates of businesses, and may be affected by a response bias since the businesses that are more affected are said to be more likely to respond (Stantec 2011, p. ii). Additionally, no examination of "[t]he combined impacts of

factors that have influenced downtown businesses including: general economic conditions, stricter impaired driving rules, increased parking taxes, road closures and changes in conjunction with the 2010 Winter Olympics, the opening of the Canada Line rapid transit system, and the re-introduction of buses on Granville St.;" (Stantec 2011, p. 56) has taken place. The study was described as being inconclusive amongst others by Dale Bracewell, Vancouver City's manager for transportation planning (ROSS 2018) and Arancibia (2012, p. 20). Moreover, when it was published in 2011, only shortly after the implementation of the bike lanes, most businesses downtown had a widely negative perception of the bike lanes (Bailey 2015). Since then, however, the "[…] feared loss of businesses […] did not materialize […]" (Vijayakumar and Burda 2015, p. 11). Hence, the support for the bike lanes has grown substantially – towards an active promotion of bike lanes by the downtown business community (ROSS 2018; Bailey 2015; Lovgreen 2017), as also business owner and municipal advisory council representatives remark.

Eventually, as phrased in a meta-study of economic impacts of bike lanes by Quednau (2016), "[…] it would be hard to make the case that bike lanes drastically increase profits for area businesses, but, significantly, what the data does prove is that bike lanes do not have a negative impact on economic viability for businesses. This is crucial because that's one of the key arguments against them." Since most concerns currently revolve around the impact on businesses, the existing broad evidence on anticipated positive, or at least neutral, effects of protected bike lanes on adjacent businesses can be a justification and driver for such projects.

4.1.2 Political and Legal

Transportation strategy

Respondents from the regional transportation authority and the municipal advisory council suggest that another strong foundation for protected bike lanes on commercial high streets in Vancouver is the existing transportation strategy, including the development of an *Active Transportation Promotion and Enabling Strategy* (City of Vancouver 2015a, p. 3), and the formation of the Active Transportation Policy Council. The Active Transportation Policy Council is one of the 23 advisory committees for the City of Vancouver and was formed to advise "[…] on matters that encourage and enhance cycling as a means of transportation, recreation and health" (City of Vancouver 2015a, p. 3). The strategy for the City of Vancouver, *Transportation 2040* (see City of Vancouver 2012a) sets a clear focus on sustainable means of transport – walking, cycling, and transit – that is backed up by the *Regional Growth Strategy* (Greater Vancouver Regional District Board July 2011, p. 7), and the *Greenest City 2020 Action Plan* (City of Vancouver 2015b, pp. 5,21). In the plan, commercial high streets are identified as "critical gaps in the network and connections to key destinations […]" that shall be prioritized within bicycle network development, updates, and improvements (City of Vancouver 2012a, p. 27).

Protected bike lanes are planned as part of the *Grandview-Woodland Community Plan* on Commercial Drive (City of Vancouver 2016b, p. 138). A pedestrian intercept survey (see City of Vancouver 2016c) has already been conducted in order to enable a comparison of the situation before and after an implementation of bike lanes, says the municipal advisory council member. Thus, an overall, specific in parts, strategic and operational base for protected bike lanes on commercial high streets in the City of Vancouver is existent.

Existing demand

Building inclusive bike infrastructure on commercial high streets is not only a strategic means to overcome urban challenges, but also a matter of responding to current demand, as a number of interviewees from different groups state (I-BO; I-FC; I-RE; I-MA; I-TA). As mentioned earlier on, intercept surveys determined that most people use transit or active transportation to get to destinations on commercial high streets. Besides that, the most recent *Vancouver Panel Survey* found that more than half of the city's residents would like to cycle more often (McElhanney Consulting Services Ltd., Mustel Group 2018, p. 19). However, more than a third of all cyclists stated they do not feel comfortable biking on the majority (75%) of the bicycle network (McElhanney Consulting Services Ltd., Mustel Group 2018, p. 21; City of Vancouver 2017a, p. 1, 2018, p. 24; Engel 2018, p. 1). Despite that, there is still "[…] a considerable number of people are willing to cycle with traffic on Commercial Drive without protected cycling infrastructure indicates that there is latent demand potential" as Slow Streets (2015) deduce from street observations and traffic counts in Vancouver. In addition to that, initiatives like the *Commercial Drive Proposal* by Streets For Everyone (2017) demonstrate the public demand for increased bike accessibility and safety of commercial high streets in Vancouver (Engel 2018, p. 3). Eventually, reacting upon existing demand enhances resource allocation to affect social welfare and leads to the anticipation of a reasonably high acceptance and usage of the new transport infrastructure. Cycling infrastructure investments in the past have been "[…] extremely effective […]" in Vancouver (McHugh 2014, p. 103).

Public consent

There has been a general change of attitude towards an increase of public consent in terms of bicycle infrastructure over the past years, note members from the business owners, advisory council, and bicycle advocacy groups. As stated earlier in this chapter, the perception of bike lanes has evolved in recent years, especially downtown. According to a representative of business owners, public consent is improved if negative effects of implemented projects, that were anteriorly feared, do not eventuate. The respondent further explains that people started to realize that creating separated bike lanes does not necessarily come along with disadvantages for drivers. A lot of business owners support the idea of protected bike lanes because they acknowledge that a number of their employees and customers arrive by bike, or because they bike themselves (I-BA). According to McHugh (2014, p. 103), there are broad "[…] positive sentiments towards cycling infrastructure in Vancouver" due to demonstrated thorough planning practices and public engagement. Still, there is resistance left – mostly from street-level retailers (I-BO). However, the past expansion of the separated bicycle network in Vancouver is helping future projects in terms of public consent.

4.1.3 Structural

Planning know-how

Protected bike lanes are a fairly new type of transport infrastructure that, to date, is tried and tested to a lesser extent than more traditional types of infrastructure. Nevertheless, research on best practices and the development of design guides have advanced largely in North America in recent years. Meanwhile, planners in Vancouver can obtain knowledge from internationally adopted guidelines like the *Urban Bikeway Design Guide* (NACTO 2012), national standards like the guidance for *Bicycle Integrated Design* as part of the *Geometric Design Guide for Canadian Roads* (Transportation Association of Canada 2017c), or municipal transportation design guidelines for *All Ages and Abilities Cycling Routes* by the City of Vancouver (2017a). The safe and inclusive design of

protected bike lanes and intersections has also attracted significant attention of science in the past years. Especially in Vancouver, numerous research activities are occupied with the topic - such as the *Cycling in Cities* Research Program at UBC, the *Cities, Health and Active Transportation Research Lab* (CHATR) at Simon Fraser University, research conducted or contracted by the City of Vancouver and TransLink, and a cycling benchmarking project by Hub Cycling and TransLink, to name some of them. In addition to that, a member of the business owner group notes that there is now a diversity of bike lane typologies in downtown Vancouver that consolidates theoretical knowledge with practical experiences. This serves as a good basis for future projects to create safe and functional bicycle infrastructure.

Bicycle network

Despite its hills and frequent rain in the winter months, Vancouver is often described as a cyclable city due to geographical attributes like its size and density that make for relatively short travel distances, as well as its moderate climate - such as by a resident representative and some publications (TransLink 2011, p. 20; Hirschberger 2008, p. 42). Moreover, the bicycle network is somewhat expansive as a result of the creation of a low-cost network along residential streets that was suggested in the *1999 Bicycle Plan* (Pflaum 2011, pp. 2,4; Hirschberger 2008, p. 83; McHugh 2014, p. 42) along with Gregor Robertson's legacy as Vancouver's mayor between 2008 and 2018 (Hirschberger 2008, p. 99; Siemiatycki et al. 2014, p. 233; Proctor 2018; Gutman 2018). However, as identified in the *Transportation 2040* plan (City of Vancouver 2012a, p. 27) and also mentioned by cyclist and municipal advisory council respondents, the Vancouver bicycle network still has critical gaps that keep many potential cyclists from biking (McHugh 2014, pp. 41, 100; O'Melinn 2017). Commercial high streets are amongst the major gaps identified by the City of Vancouver (2012a, p. 27), Hub Cycling's *Priority Gap Map* that is part of their *Ungap the Map* project (Google Maps) and the *Cycling Safety Study* by the City of Vancouver (2015a). Besides being critical gaps in the Vancouver bike network, commercial high streets present multiple qualities that are desirable for high-quality bikeways: A regional transportation authority member and Krahn (2015, p. 2) observe that commercial high streets are amongst the city's most logical and direct routes with access to destinations. According to Sztabinski (2009, p. 6), O'Melinn (2017), and TransLink (2011, p. 3), bike routes are most successful when they are intuitive, direct, and convenient, follow logical paths and provide access to major destinations. Often, the pavement quality and street lighting are also much more favourable for cycling on commercial high streets than on residential bike streets. Moreover, the "[…] streetcar system, […] helped shape both the gridded street layout and the network of arterial, commercial streets that made the city suitable for the bikeway network, […]" (Hirschberger 2008, p. 100). Hence, relatively short travel distances in the City of Vancouver and commercial high streets as identified network gaps as well as obvious and direct connections with gentle slopes are ideal existing circumstances for an expansion of the Vancouver bike network with protected bike lanes on commercial high streets.

End-of-trip facilities

Due to the high rates of bike theft, there is a broad agreement on the importance of end-of-trip facilities for bicycle usage by interviewees from multiple stakeholder groups (I-BO; I-RE; I-TA; I-BA) and publications (see TransLink 2011, pp. 24, 35; NYC DOT and Bennet Midland 2013, p. 8; Parkin et al. 2007, p. 96; Chen et al. 2017, p. 658; Siemiatycki et al. 2014, p. 225). In Vancouver, responsible entities have acknowledged this and channel resources towards creating more appropriate bike facilities. TransLink, for instance, is providing means to increase bicycle parkades based on existing demand. Besides, they raise public awareness about those services that have seen an increased usage recently.

The City of Vancouver has started to realize the potential of end-of-trip facilities by installing more parking facilities and public bike pumps, In addition, awareness for parking facilities is increased through a bike rack design contest. Accordingly, the process of improving end-of-trip facilities in Vancouver is already in progress.

Multimodality

There is just as much consensus between respondents from different groups (I-FC; I-RE; I-TA; I-BA) about the importance of bike-transit integration. Transit and cycling create synergies by solving the first-and-last-mile problem, improving travel times, and catering to people in further catchment areas. The latter is important due to increasing commute and travel distances resulting from population growth and rising property and rental prices in central locations. The effectivity of bike-transit integration regarding the scaling and functioning of both modes is widely supported by existing literature (see Bachand-Marleau et al. 2011, p. 116; TransLink 2011, pp. 29, 36; Siemiatycki et al. 2014, p. 225=. Whether the current state of bike-transit integration in Vancouver is of sufficient scope and quality is left open at this point. However, it can be noted that, by definition of Vijayakumar and Burda (2015, p. 17), Vancouver has a 100% transit integration, measured as the percentage of rapid transit stations that are within 400 m of the nearest bike lane. All major commercial high streets in the City of Vancouver are part of the transit network, with some areas being larger transit hubs (I-RE). Areas around Commercial-Broadway and Broadway-City Hall SkyTrain stations or the express 99 B-Line along Broadway (see TransLink 2018) are a few examples. Beyond that, as mentioned before, the quantity and quality of secure bike parking at transit stations is also being increased by TransLink. Having one agency coordinate bike routes with public transport can be seen as an asset for bike-transit integration (see Pucher and Buehler 2009, p. 89).

Road safety

The traffic infrastructure in Vancouver is lacking more safe options for people to walk and bike. High collision rates appear on commercial high streets and intersections which was mentioned earlier on. This was discovered in the *Cycling Safety Study* (City of Vancouver 2015a). However, a cultural strength with regard to road safety in Vancouver is that there is a good common understanding of who the vulnerable road users are, as a respondent from the transportation authority points out. According to paragraph 179 of the *Motor Vehicle Act* (British Columbia 1996), car drivers are obliged to yield to pedestrians at crosswalks. However, the interviewee has observed that cars are very careful around cyclists and pedestrians even when there is no crosswalk or legal obligation for them to yield which can cause inefficiencies of the traffic flow.

4.1.4 Summary of strengths

Table 3 provides an overview of the previously described project strengths for protected bike lanes on commercial high streets in the City of Vancouver.

Table 3 - Strengths of protected bike lanes on commercial high streets in the City of Vancouver

Economic	
Economic vitality	Anticipated at least neutral, or positive, effects of protected bike lanes on adjacent businesses confirmed by research as a justification for projects
Political and Legal	
Transportation strategy	Existing strategic and operational base for protected bike lanes on commercial high streets in the City of Vancouver
Existing demand	Anticipated effectivity of bicycle infrastructure due to existing demand and past experiences
Public consent	Already implemented bike lane projects in Vancouver benefit public consent on future projects
Structural	
Planning know-how	Good practical and theoretical knowledge base for creating safe and functional bicycle infrastructure due to existing design guidelines and local experiences
Bicycle network	High suitability of commercial high streets as bike routes to fill gaps in the existing bike network
End-of-trip facilities	Acknowledgement of the importance of end-of-trip facilities and translation into action in Vancouver
Multimodality	Commercial high street as transit hubs
Road safety	Good common understanding of who vulnerable road users are

4.2 Weaknesses

Just like strengths, project weaknesses are existing circumstances that impact projects for protected bike lanes on commercial high streets. Obviously, unlike strengths, they complicate these projects rather than supporting them. Additional efforts may be required to overcome the weaknesses.

4.2.1 Political and Legal

Transportation Strategy

Even though there is a transportation strategy present that includes investments in bicycle infrastructure, interviewees from resident and bicycle advocacy groups mention deficiencies of the strategy: Both emphasize the lack of push measures away from motorized traffic. Push-effects discourage car usage by interventions like the elimination of fuel subsidies, charges for automobile ownership and use, parking space restrictions, car limited zones or bans, or speed reductions. They are recommended to be used in combination with pull measures (see PUSH&PULL 2017, p. 25) that emerge from the provision of appealing alternatives, such as improving the accessibility of transit services and cycling (Breithaupt, p. 17; United Nations 2011, p. 10). The latter are incorporated into the Vancouver transportation strategy. The bicycle advocacy member illustrates that there is lots of space in the dense downtown core that is dedicated to cheap street parking which still makes the car a desirable mode of transport.

Existing demand

The existing demand for more accessible cycling infrastructure in Vancouver was depicted earlier. The cycling community shapes and drives investments in new cycling infrastructure in Vancouver by making this demand visible. Demographics of the cycling community in Vancouver to date (see Engel 2018, p. 14) are, however, not necessarily representative of all potential cyclists that shall be addressed with the new infrastructure. A respondent from the regional transportation authority indicates that municipalities and advocacy groups usually end up supporting a certain type of infrastructure that perhaps encourages only certain types of cyclists such as fast and confident riders. Hoffman expresses similar concerns (2016, p. 20) and adds that "[t]here are specific issues that impact people of colour, the working class, and the poor who are largely overlooked by well-intentioned bicycle advocates" (2016, pp. 24–25). Hence, the currently expressed demand for cycling infrastructure in Vancouver may not represent actual needs for cycling infrastructure completely.

Public consent

Respondents from business owners and resident groups agree on the statement that attaining total public consent on urban infrastructure investments seems very unlikely. The resident sees the sharp divide between people being pro and against bike lanes as one of the reasons while adding that upsetting motorists seems inevitable. Hoffman (2016, p. 9) also notes that "[…] the bicycle as a technology has always politicized mobility." This means that irrespective of the nature of street changes and strategies applied, there will likely always be resistance left.

By-laws and policies

Most of the by-laws that concern cycling in Vancouver were introduced under the *Motor Vehicle Act* two or three decades ago (see British Columbia 1996), as transit authority and bicycle advocacy members remark. Hence, some cycling by-laws are considered outdated. Examples named are the

obligation to wear a helmet, set in section 184 of the *Motor Vehicle Act*, or the prohibition to ride side by side that is specified in section 183(2f). Being able to ride next to children is important when cycling with them, says the bicycle advocate. Even though these by-laws are rarely enforced by the police, they keep some people from cycling (I-TA). The helmet law, for instance, creates the perception that cycling is dangerous and, besides, makes cycling less convenient, comfortable, and fashionable for potential cyclists. This has been discussed in several publications (Sieg 2014, pp. 12–13; Pucher and Buehler 2008, pp. 3,15; Ranson 2018, pp. 32,47,70; Randelhoff 2017). Sieg (2014, pp. 12–13) and Randelhoff (2017) have conducted cost-benefit analyses of helmet laws in Germany and Canada. Both conclude that wearing a helmet "[…] does indeed reduce the negative consequences of accidents" (Sieg 2014, pp. 12, 13), but that the negative effects of a reduction of cycling due to helmet laws are much worse "[f]rom an aggregated welfare point of view […]" (Sieg 2014, pp. 12, 13). In addition, another survey respondent from the regional transportation authority comments that wearing a helmet is associated with a certain type of cycling that can be deterrent to potential cyclists. The opportunities and threats that come along with a certain image of cycling will be described later on in this paper. Besides connotations of cycling and its safety, there are a number of people in Vancouver that dislike wearing a helmet or do not regard them as necessary (Zanotto 2014, p. 14).

In addition, a transportation authority respondent also points out that there is a difference between the Netherlands as a country with a strong cycling culture and Canada in terms of the level of regional integration of transportation processes and policies. According to the interviewee, policies and guidelines are quite fragmented in Metro Vancouver. This can cause challenges within planning procedures and further for the integrity of the regional transit and cycling networks that can otherwise have high synergies as described earlier.

Representation

Members from five different stakeholder groups (I-BO; I-RE; I-MA; I-TA; I-BA) stated concerns about misrepresentation in terms of various aspects. All of them share the opinion that some BIAs do not represent their members accurately. It must be noted that most respondents were referring to the same commercial high street in this study. Since "[…] BIAs are highly individualized in their structures as to fit local condition and needs" (Isakov 2009, p. 60), the results may not be generalizable to all BIAs in Vancouver.

There are multiple reasons why business misrepresentation is a problematic issue: Business owners are frustrated that the public perception of businesses is shaped by BIAs while most businesses disagree with their public statements, say some business owners and bicycle advocates. Business owner respondents state that their boards are made up of individuals that strongly disapprove of bike lanes[6], are known to be car-activists, and have a conservative and short-sighted way of thinking. This is even though a lot of businesses support the idea of bike lanes (I-BO; I-BA; see list of supporting businesses in Streets For Everyone 2019, pp. 4–5). Members from four different groups (I-BO; I-RE; I-MA; I-TA) mention a lack of objectivity in their decision-making and surveys conducted, as well as the ignorance of existing studies, data and member's opinions that were brought up to them. Furthermore, businesses on Commercial Drive disclosed democratic deficiencies regarding the organizational structure: An intransparent system of board elections, a lack of information for members on their

[6] The Commercial Drive Business Society states that they generally support cycling infrastructure in Vancouver, but fear a negative impact of protected bike lanes on Commercial Drive itself (Commercial Drive Business Society 2016, p. 2)

status within the BIA, and a non-welcoming community were addressed during the interviews by business owners and BIA members.

While these testimonies reflect subjective perceptions and experiences of individuals, their position is objectified to some extent by the number of stakeholder groups agreeing on the matter. Besides, there are several public statements that comply with this opinion. A *Public Intercept Survey* conducted by the Commercial Drive Business Society (2016) for instance was deemed to be biased by some respondents from the municipal advisory council and cycling advocacies, but also by publicized reports (VPSN Blog 2017). The assertions are reasoned with reference to a skewed selection of participants and the posing of suggestive questions. Additionally, the survey was publicly criticized for a low response rate of only 164 out of 750 businesses (VPSN Blog 2017; Crawford 2016). The *Vancouver Public Space Network* adds that the questionnaire presented "[…] unsubstantiated negative impacts (e.g., “local job loss,” “decreased customer traffic,” “unsafe pedestrian experience”) as de facto outcomes of this process" (VPSN Blog 2017). Hub Cycling (2016) expressed similar concerns.

At this point, no empirically supported statement can be made about the degree to which BIAs represent their members adequately or the substance of their attitude. Nevertheless, there are indications of existing disparities in this context. This is an issue because business advocacies have a relatively high influence regarding planning processes that involve commercial high streets, says a regional transportation authority member and research on *BIAs in B.C*. (Isakov 2009, p. 58). Their stated needs have played a vital role during the process of "[…] consultation with businesses and residents on Commercial Drive [that] has been ongoing for a number of years, […]" (VPSN Blog 2017; also see McArthur 2016). Since 2015, businesses have been involved in planning through the Grandview-Woodland Citizen's Assembly process (see Citizens’ Assembly on the Grandview-Woodland Community 2015), a Business Goods and Movement Survey (see City of Vancouver 2016a), open houses, "[…] including business-specific outreach initiatives" (VPSN Blog 2017), drop-in events, door-to-door outreach to businesses to find out more about individual needs for parking and loading, and meetings with the Commercial Drive Business Society (Sadhu 12/10/2017; City of Vancouver 2019, 2016c). Considering the influence of BIAs and the funding they receive from the City (I-BA), the importance of their proper and representative conduct should be pointed out. With regard to protected bike lanes on commercial high streets, this shall currently be regarded as a weakness due to existing indications of misrepresentation with public representation.

Next to business advocacies, an accurate representation of cyclists and the broad public is equally important in terms of decision-making processes of municipalities and planning agencies. As described earlier (4.2.1), issues arise for instance through a potentially skewed representation of cyclists through municipalities and advocacies that is based on current demand. Another problem elucidated by a bicycle advocacy member is the inaccurate representation of demographics within decision-making entities. These are usually made up of white and wealthy people that only have certain types of people and cycling barriers in mind, as the interviewee states. In the same context, a municipal advisory council member mentions that research showed that the more money people have, the less empathetic they are towards other people. Rajé (2018, p. 7) points out that "Urban transport interventions are overwhelmingly designed to address the problems of urban congestion and the rapid increase in urban car populations. In this case, the main beneficiaries are not the urban poor but are much more likely to be the rich and middle-income sections of the population." According to Hoffman (2016, p. 14), these political power disparities eventually have an impact on the quality of our bicycle infrastructure and the people using them. This means that implementing bicycle infrastructure does

not automatically create a diverse cycling community if demographics are being ignored in the planning and decision-making process.

4.2.2 Socio-cultural

Change perception

A respondent from the business owner group highlights the positive change of attitude that occurred in the downtown area after protected bike lanes had been installed on Hornby and Dunsmuir Streets. This means that the attitude towards the installation of bike lanes downtown differs from the Commercial Drive context. As potential reasons, the interviewee mentions a lower population density and customer base on Commercial Drive that could mean a higher reliance of those businesses on people coming from abroad using their cars. A comparison of the results of the intercept survey on Commercial Drive (City of Vancouver 2016c, p. 12) and a customer exit survey on Dunsmuir and Hornby Streets (Stantec 2011, p. 25), however, shows that this is not necessarily the case (*Figure 6*). Nevertheless, it confirms the respondent's assertion that retailers have been accustomed to the assumption that people shop using their car, even more so in suburban markets than in dense urban markets.

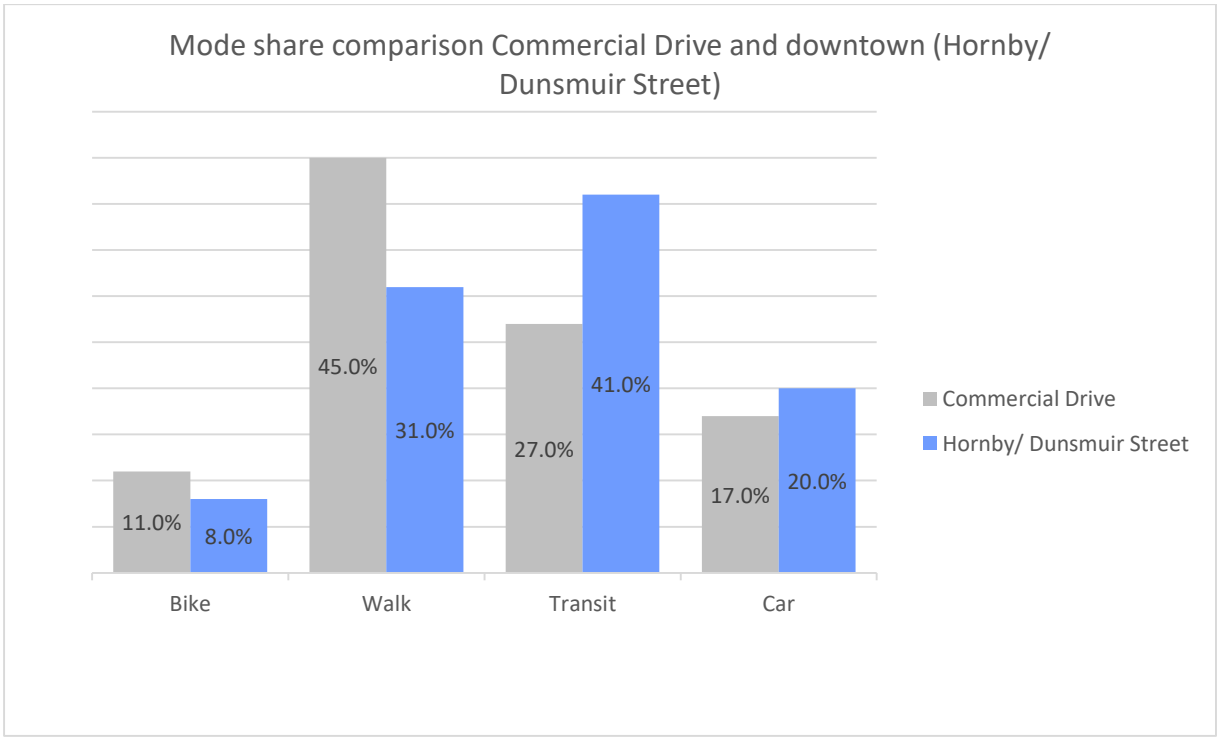

Figure 6 – Mode share comparison Commercial Drive and downtown (City of Vancouver 2016c, p. 12; Stantec 2011, p. 25)

This skewed perception of street usage and mode choice of customers was highlighted as a cause for change aversion in terms of street design by respondents from business owners, municipal advisory council, and advocacy groups, as well as by literature (Stantec 2011, p. 25; TransLink 2011, p. 2). With most of the bike infrastructure being located on side streets instead of streets with a high level of traffic, bicycles are rarely seen by the majority of road users. The resulting invisibility of biking adds to the underestimation of the share and importance of cycling, says the council member. Besides that, a lack of understanding the change motives, trust towards planners and engineers, project benefits and opportunities were mentioned as additional reasons for change reluctance (I-MA; I-BA). Eventually, the fear of change is a widely known phenomenon seen as another, comprehensive and legitimate

factor in this matter by a number of respondents from various stakeholder groups (I-BO; I-MA; I-BA). Thus, the perception of change coming along with projects for protected bike lanes on commercial high streets is negatively affected by these elements.

Image of cycling

As for the previous points, interviewees from different stakeholder groups (I-BO; I-MA; I-TA; I-BA) agree on the problematic nature of the current cycling image in Vancouver. Many people – especially families and seniors (I-BA) - cannot identify with the persisting image of cycling. It is mostly seen as an activity carried out by only physically fit people in Vancouver, as respondents from business owners, transit authority, and advocacy groups observe. This is attributed to a variety of reasons: First, cyclists in Vancouver often wear special clothing which promotes the idea that expensive equipment is required in order to ride a bicycle (I-TA; I-BA). As explicated previously (4.2.1), the existing helmet law in Vancouver creates an image of cycling as a dangerous activity, which prevents several people from biking. Beyond that, the existing infrastructure in terms of the bicycle network and the offer of bicycle types being sold locally are predominantly oriented towards commuters and athletic cyclists (Bruntlett and Bruntlett 2018, pp. 36–40). All this adds to the circumstance that cycling in Vancouver is currently seen as a recreational activity or means to commute, rather than an everyday mode of transport (I-BA). This is further reinforced through media representation (I-TA). Adding to the lack of identification, people often see cyclists as activists – which might be well-founded in the political bicycle activism that notoriously happened throughout past decades in Vancouver. Beyond the aspects of fitness, style and safety, several studies have shown that cultural barriers to cycling are persistent: Bratman and Jadhav's research (2014) shows that "[…] in some places, the people who ride are mostly wealthy and white. […] African Americans were statistically […] less likely to include biking in their ideal mode of transit." Beyond ethnic backgrounds, Jaffe states that "[t]here's strong evidence that poor people don't view cycling as favourable" (2014). This may be due to the circumstance that "[p]oor and working-class riders utilize the bicycle with a different meaning than does the media darling bicycle commuter", as Hoffman says (2016, p. 22). She explains that the bike as "[…] a choice and a marker of pride […]" is only a common perception in some cultural and socio-economic circles. Others understand it as a demonstration of poverty (2016, p. 24). Hence, some people do not want to identify with bicycle culture. Apart from that, people of some ethnicities suffer from racial profiling. The circumstance that people of colour are frequently being unfairly targeted by police, especially when riding their bikes, was mentioned by a bicycle advocacy member and in Hoffman's book, *Bike Lanes are White Lanes* (2016, p. 25). This can discourage non-white people from cycling.

In summary, the present cycling culture, bicycle infrastructure, retail environment, socio-economic and cultural perceptions and prejudices, as well as media representation create an image of cycling as a sport for wealthy white people rather than a means of transport for everyone. This discourages people that cannot identify with that image from cycling.

Figure 7 - Prevalent 'style' of cycling in Vancouver (author)

4.2.3 Socio-economic

Inclusion

Even though cycling is considered one of the most affordable means of transportation and can enhance accessibility as described earlier, an economic barrier still exists for multiple groups of people, as a bicycle advocacy interviewee reports. This includes difficulties of bike access as well as a lack of skills. In London, for example, a study has shown that "57% of ethnic minority groups are excluded from [cycling] participation by poverty. For those on a very low income, the cost of a bike may be a significant barrier to cycling" (Transport for London 2011, p. 3). The concept of bike sharing seeks to increase bicycle ridership and transportation accessibility for low-income users (Gardner et al. 2014). However, there are many studies finding that bike share does not yet reach low-income riders adequately (Goodyear 2015; Jaffe 2014; Gardner et al. 2014, p. 5; Meng 2018, p. 3; Daly 2014, p. 18). One of the reasons that also the bicycle advocate named during the interview is that sometimes access to bike share is dependent on credit card access. In addition to that, there is evidence that socio-economically advantaged people are generally more likely to bike because they are more aware of the health benefits (Chen et al. 2017, p. 658; Transport for London 2011, pp. 1, 3; Parkin et al. 2007, p. 107). Besides having access to a bike, knowledge on how to ride a bike is likewise important but not always available to all people. Skills such as route planning, road safety skills, and the allowance and trust of parents for their children are examples. While cycling as a low-cost means of transportation has the potential to alleviate monetary woes for lower-income households, foster their mobility and therefore enhance social equity, the current physical and institutional infrastructure does not yet grant access to cycling for socio-economically less privileged people and demographic minorities.

Poverty

A detrimental economic situation of parts of the population can not only be a deterrent to cycling for those individuals. High poverty and homelessness levels in Vancouver (Urban Matters CCC and BC Non-Profit Housing Association 2018, i) have amplified bike theft as a serious problem in Vancouver, as regional transportation authority and advocacy interviewees remark. This does keep people in Vancouver from biking (NRG Research Group 2009, p. 7; TransLink 2011, p. 24) and reinforces the issue of prejudiced racial profiling.

4.2.4 Structural

Accessibility

Protected bike lanes effect a cycling uptake amongst many potential riders and hence improve accessibility. On the downside, the bike as a transport mode is not practical for everything and everyone, as a resident says. Reasons why some people need to drive are the transportation of goods, physical limitations of individuals, transportation of children and seniors, or emergency response. The frequent bike user and a bike advocate note that some businesses on commercial high streets are likewise dependent on car accessibility including the provision of parking spots. Types of businesses that are more car-dependent are such that cater to older people, or stores where larger items or items in large quantities (e.g. groceries) are sold.

Planning know-how

Even though there is a vast amount of resources for the design and planning of protected bike lanes in an urban context as listed earlier (3.1.3), there are sometimes compatibility issues. A transportation authority respondent brings up that the design standards of the City of Vancouver on protected bike lanes (see City of Vancouver 2017a) are not completely compatible with the needs of transit operators. Examples are two-way separated bike lanes standards that can conflict with bus stops.

End-of-trip facilities

The importance of end-of-trip facilities was depicted earlier (4.1.3) in this paper. Although their importance has been acknowledged by those providing and improving them, shortfalls of end-of-trip facilities are identified by resident, regional transportation authority, and bicycle advocacy groups. Especially at transit stations, more options for secure bike parking would be needed (I-TA; I-BA). The resident also criticizes the partial funding responsibilities of business owners for bike racks in front of their shops. This could aggravate the existing insufficiencies of secure bike parking mentioned by a transit authority member.

Multimodality

The integration of bike and transit offers great potential to address the first-and-last-mile-problem and people in further catchment areas that want to bike. This will be described in more detail later on (4.3.5). Realizing those benefits, however, requires a good transit provision and sustainable bike share in the first place, say interviewees from the frequent cyclist and regional transportation authority groups. Regarding transit provision, current gaps in most places in North America are seen as key issues for bike-transit integration (I-TA). The frequent bicycle user also states that there is a lack of ease and convenience when taking a bike on buses in Vancouver or some lines of the SkyTrain.

The transportation authority respondent also points out deficiencies in the current bike share system in Vancouver. The interviewee sees difficulties in scaling the current Vancouver bike share program *Mobi* beyond the city core due to the higher costs of docked bike share stations. The same respondent points out the current lack of privately operated bike share programs and the importance of e-bikes to foster regional cycling. Besides, *Mobi* could face competition from Lyft and Uber in the future (I-TA). A study by Hosford et al. (2018) concluded that there is no "[…] association between increased bicycling over time and only living or only working within the service area [of the public bicycle share program in Vancouver], relative to those outside the service area. It may be that the program is either too early in its implementation or was implemented at too small a scale to have a measurable effect over our study period for those exposed to the program at only home or work". This indicates that the public bike share system in Vancouver is not yet sufficient in scale or concept to increase the mode share significantly and have benefits for bike-transit integration.

Multifunctionality of commercial high streets

The multifunctionality of commercial high streets is one of the foundational challenges for implementing protected bike lanes, as previously (2.1) explained. Space limitations and opposing interests of retail, commuting, public transportation, and delivery purposes make such projects more complicated and come along with higher risks. Interview respondents from the municipal advisory council, regional transportation authority, and advocacies agree on that matter. The situation is complicated through the lack of expressways in the city that high traffic volumes could be diverted to (I-BA). Furthermore, the council respondent highlights existing disparities between the Eastern and Western parts of Vancouver: A higher share of industrial lands, trucking and bus routes in the East make the implementation of bike infrastructure there even more difficult, but also more necessary due to the lower income population.

Transport efficiency

Adaptions for road users come along with a changing streetscape. Transforming the street to accommodate protected bike lanes often entails a reduction of parking spaces. The total loss of parking in many planning scenarios is often reduced to a minimum that is expected to be hardly noticeable (I-BO; I-BA; also see Streets For Everyone 2017; Sztabinski 2009, p. 23). Nevertheless, this can create inconveniences for car users, as both group representatives say. The business owner though adds that these are trade-offs that are worth making.

4.2.5 Summary of weaknesses

Weaknesses for protected bike lanes on commercial high streets in Vancouver are summarized below.

Table 4 - Weaknesses of protected bike lanes on commercial high streets in the City of Vancouver

Political and Legal	
Transportation strategy	Existing deficiencies in transportation strategy such as a lack of push measures
Existing demand	Possibly skewed representation of future needs through current demand expressions
Public consent	Unlikelihood of total consent
By-laws and policies	Fragmented and outdated policies can cause challenges for infrastructure investments and their effectivity
Representation	Misrepresentation of demographics and businesses through decision-making entities and advocacies negatively impact social equity and effectivity of infrastructure changes
Socio-cultural	
Change perception	Existing change aversion as a result of skewed street usage perception, lack of opportunity appreciation, and general fear of change
Image of cycling	Lack of identification with prevalent cycling culture in Vancouver discourages people from cycling
Socio-economic	
Inclusion	Effectivity deficiencies of physical infrastructure investments regarding socio-economic inclusion and social equity without the implementation of additional targeted strategies due to existing economic barriers and lack of skills
Poverty	High levels of poverty exacerbate issues of bike theft in Vancouver that discourage people from cycling
Structural	
Accessibility	Existing car dependencies of some businesses and road users
Planning know-how	Compatibility issues of some design standards with stakeholder needs
End-of-trip facilities	Existing lack of end-of-trip facilities
Multimodality	Deficiencies in the transit network and bike sharing system restrict advantages from synergies
Multifunctionality of commercial high streets	Opposing stakeholder interests make projects more difficult and present higher risks
Transport efficiency	Inconveniences for car users

4.3 Opportunities

Opportunities are the expected positive outcomes of a project. In light of protected bike lanes on commercial high streets, they are mostly related to intrinsic characteristics of the research subject or external factors. In order to realize their full potential, additional efforts to minimize existing weaknesses and risks have to be made in some cases.

4.3.1 Economic

Economic vitality

The existing evidence on anticipated non-negative effects of protected bike lanes on business revenues was set out earlier (4.1.1) in this paper. In most cases, positive impacts on businesses can be expected when protected bike lanes are implemented on commercial high streets. This appreciation can be traced back to multiple reasons: Respondents from the transit authority and advocacies mention a more beneficial spending behaviour of cyclists and pedestrians, and interviewees from multiple stakeholder groups (I-BO; I-RE; I-MA; I-TA; I-BA) refer to an increased customer base for various reasons.

Transportation authority and bicycle advocacy respondents state that, compared to car drivers, cyclists do not spend as much per trip but they do make trips more often and stop more often. Existing research indicates that cyclists and pedestrians have an increased awareness of local shops (Krahn 2015, p. 13) because they spend more time on commercial streets than drivers (Tolley, Rodney 2011, p. 14), and stopping for them is easy and inviting (Tolley, Rodney 2011, p. 14; Krahn 2015, p. 13; Sztabinski 2009, p. 6). In addition, cyclists visit more often (City of Vancouver 2016c, p. 12) and hence spend more money in total than car drivers (Sztabinski 2009, pp. 1, 23; Tolley, Rodney 2011, p. 20). Beyond that, protected bike lanes increase the number of cyclists (I-TL; I-BA; see findings from literature analysis in Engel 2018, p. 12). An intensification of these spending patterns after the implementation of protected bike lanes[7] was observed on Union Street in Vancouver (Proulx et al. 2015, p. 19) and in several US cities (Monsere et al. 2014, pp. 142–143).

Furthermore, aspects regarding the street environment have an impact on visitor numbers on commercial high streets. Respective determinants mentioned by interview respondents from the municipal advisory council, the regional transportation authority and advocacies include accessibility, the public space quality, and the efficiency of road space allocation. In a previous section (4.1.3) of this paper, the positive impact of protected bike lanes on the accessibility of destinations on commercial high streets to a broad demographic was presented. Farla et al. (2016, p. 7) associate that "[…] improved cycle access and parking encourages residents to stay local;" which increases footfall in local businesses.

In addition to increased accessibility, the implementation of protected bike lanes often induces an enhancement of the public space quality, as stated in several studies (Stantec 2011, pp. iv, 22, 23, 54, 55; Krahn 2015, p. 15; Hromádka and Shashko 2015, p. 761; NYC DOT and Bennet Midland 2013, p. 8). This can be traced back to the created buffer between sidewalks and motorized traffic, fewer cyclists on sidewalks (Monsere et al. 2014, p. 126), reduced noise levels (NYC DOT and Bennet Midland 2013, p. 8), and a more walkable and cyclable environment (I-RE; I-BA). Eventually the experience created on

[7] The bike lanes on Union Street are protected by a buffer zone and vehicle parking, which, according to the Transportation Association of Canada (2017c, pp. 13–14) is defined as buffered bike lanes rather than protected bike lanes.Transportation Association of Canada 2017c, pp. 13–14

this occasion presents a competitive advantage towards online shopping, and leads to more people visiting and shopping locally, as respondents from multiple stakeholder groups and several researchers state (I-BO; I-RE; I-CC; I-CA; Ledsham and Savan 2017; Tolley, Rodney 2011, p. 26; Monsere et al. 2014, p. 143). Reports by Tali (2016) and Cushman & Wakefield (2015/2016, p. 7) also emphasize the importance of customer experience in physical shops to satisfy the emotional needs of people shopping.

Besides the aforementioned appeal factors of commercial high streets, the physical capacity to absorb a higher visitor turnover depends on the efficiency of road space allocation to some extent. Interviewees from the municipal advisory and transportation authority, as well as advocacies, agree that cycling infrastructure including bike share stations can relatively cater to more people than car infrastructure. This creates a higher turnover of customers. Comparisons between the space efficiency of bike parking and cycling tracks versus car parking were made by researchers like Tolley, Rodney (2011, p. 7), Lee (2008, p. 39), or Sztabinski (2009, p. 23). In her study on the economic contribution of cyclists compared to car drivers in Melbourne, Lee (2008, p. 39) determines that "Public space relocated from car parking to bike parking could produce 3.6 times the retail spend". Sztabinski (2009, p. 9) finds that the increased patronage of cyclists induced by the implementation of protected bike lanes can even offset potentially lost sales from a lower number of car drivers due to reduced parking by a ratio of five to one.

The retail effect of protected bike lanes on commercial high streets becomes more obvious when looking at the reduction of commercial vacancies and retail increases. In some case studies, vacancy declines amounted to 49% around Union Square North in Manhattan (New York City Department of Transportation 2012, p. 6), and the vacancy rate as reported by owners and managers dropped from 12% to 2% after the implementation of the protected bike lanes in Vancouver (Stantec 2011, p. 22). Increases of economic activity were observed on Barracks Row Main Street in Washington where it tripled (Tolley, Rodney 2011, p. 12), and on 8th and 9th Avenues in Manhattan where retail increased by 49% (New York City Department of Transportation 2012, p. 4).

All things considered, there is a high potential of protected bike lanes on commercial high streets to increase retail sales and economic activity, "[…] all while ensuring everyone is safe[…]" (Streets For Everyone 2019, p. 3).

4.3.2 Political and Legal

Existing demand

Demand for more or better infrastructure does not solely exist on the part of (potential) cyclists, but also by other road users. Some sidewalks on commercial high streets, for example, are often considered too narrow. The resident respondent describes that it is sometimes difficult to walk up and down the street because of crowded sidewalks. The interviewee adds that there are current safety issues for cars and that it is a common scheme that transit buses get stuck with motorized individual traffic. A cycling advocacy member states as well that sidewalks are currently not wide enough to accommodate people in wheelchairs, on electric scooters, or with strollers since they are also used for advertisements or outdoor seating. On the other hand, there is still the issue of skewed demand perception of different mode shares as explained earlier (4.2.2). This means that some streets might not be as busy as people think they are (I-BA). Hence, the City can determine how vital commercial high streets are as traffic arteries and investigate options to divert traffic or to provide alternatives for people that need to move through (I-BA). Besides considering traffic volumes, the example of recent

New York City street transformations showed that there is also some leeway when it comes to common design practices: Former transport commissioner Janette Sadik-Khan and her team revisited lane width standards and eventually reduced vehicle lane width to 9 or 10 feet instead of the usual 12. Hence, they were "[…] able to find additional room for wider sidewalks, protected bike lanes, and generous bus stops" (Bruntlett and Bruntlett 2018, p. 18). Altogether, street modifications to install protected bike lanes provide an opportunity to resolve existing shortcomings of the transportation system. Considering the demand of all mode users and adapting roadway structures accordingly can increase the efficiency of the transport system and optimize space utilization.

Public consent

Street enhancements often become more acceptable to the public after changes have been implemented and performance improvements become obvious (NYC DOT and Bennet Midland 2013, p. 9). The example of downtown Vancouver has demonstrated that this connection also holds true for the city. Respondents from businesses and the advisory council suggest that existing good examples of new street infrastructure help the political discussion, foster public consent, and change people's opinion on cycling. Hence, starting to implement protected bike lanes on one commercial high street in Vancouver can have a catalytic effect for other streets of similar typology.

Public engagement

The necessity for public outreach and engagement to further enhance public consent and change readiness was addressed during interviews with business owner, municipal advisory council, transit authority, and bicycle advocacy groups. Beyond that, incorporating input from stakeholders in the design process can be very valuable for creating successful infrastructure that meets many people's needs. Siemiatycki et al. (2014, p. 234) point out that a technical design of projects that is satisfactory for most stakeholders in turn matters for a broad public acceptance as was the case for the Burrard Bridge bike lanes. Public engagement can be especially effective when participants are educated about the developments and motives of city planning (I-MA; I-BA) and the scope and objective of consultations (I-BO; I-MA), say the respondents.

Figure 8 - The formerly controversial protected bike lane on Burrard Bridge in Vancouver (author)

4.3.3 Socio-cultural

Image of cycling

The present cycling environment and media mostly represent cycling in Vancouver as a sport for white, wealthy, and active people, as discussed earlier (4.2.2) in this paper. One of the reasons set out was that the cycling network in Vancouver is mainly targeted towards commuting and long-distance bike rides. Implementing protected bike lanes on commercial high streets can be a significant game-changer in this respect. They enable more people to feel comfortable doing shorter trips to destinations on commercial high streets by bike, as a cycling advocate says. Cycling infrastructure on main streets creates an image of cycling as an easy and accessible everyday transportation mode (I-TA; I-BA). Beyond that, transportation authority and municipal advisory council interviewees add that it rectifies the underappreciating of cycling by making it more visible than on secondary streets. Linking physical infrastructure on commercial high streets with marketing and a public education component can reinforce the idea of cycling as an everyday mode of transport even further (I-TA; I-BA).

Social connectedness

Another effect of making commercial high streets more accessible and pleasant through protected bike lanes is that it promotes a sense of community (I-MA; I-BA). Social interaction in the public realm is encouraged by a high-quality walking and cycling environment and places for enjoyment, which is repeatedly mentioned in literature (Tolley, Rodney 2011, p. 10; McElhanney Consulting Services Ltd., Mustel Group 2017, p. 2; Rissel et al. 2013, pp. 1–2; Litman 1999, p. 16; Carmona 2015, p. 41). An interviewed bike advocate explains that an increased presence of people on sidewalks and bike lanes due to improved accessibility raises the likelihood of accidental meetings. Moreover, people on foot and on bikes are more visible to others and less shielded from their surroundings than cars. The interaction between them has shown to be more present and friendly than amongst car drivers (McElhanney Consulting Services Ltd., Mustel Group 2017, p. 46; Hoffman 2016, p. 38; Jungho 2015, p. 110). Driving as a factor that makes people aggressive and stressed (Legrain et al. 2015, p. 28) can also be reduced amongst citizens by an increased cycling mode share resulting from protected bike lanes, finds a member of the resident group. After all, social connectedness presently becomes more important, according to a bike advocate: Communities become harder to live in because of a population increase that impacts economics, densification, and transportation. This leads to more people losing their sense of community. Fostering vibrant communities through protected bike lanes and more liveable neighbourhoods can be a part of the solution.

4.3.4 Socio-economic

Inclusion

Transportation comes at a cost for individuals and therefore creates mobility barriers for a number of people (Starkey and Hine 2014, p. 46). Using a bike instead of a car as a means of transport is more affordable due to lower costs for acquisition and operation (Hromádka and Shashko 2015, p. 761; DuBose 2011, p. 54; Hoffman 2016, p. 23). Cycling offers a possibility for socio-economically less privileged people to be mobile in their environment, say respondents from the regional transportation authority and bike advocacies. Even when higher prices for more central or liveable home locations are factored into the equation, lower costs for cycling mostly remain (McElhanney Consulting Services Ltd., Mustel Group 2017, p. 2; National Complete Streets Coalition, p. 3). Besides socio-economic inclusion on an individual level, Hoffman (2016, p. 89) states that "[b]icycle lane construction could

potentially be seen as a welcome shift away from injustices in transportation, such as the unequal distribution of resources." The budget allocation for transportation investments was briefly discussed earlier (3.1.5). Eventually, the socio-economically inclusive characteristics of cycling lead to expect an improvement of mobility and social equity through projects for protected bike lanes on commercial high streets.

4.3.5 Structural

Accessibility

A transport system that provides equal opportunities for most of the population is constituted amongst other things by socio-economic access to transportation means and physically accessible transport infrastructure. A bicycle advocate explains that the car-centric design of the environment means that modes that are inaccessible to a variety of people are being centred. In contrast, cycling offers personal mobility (TransLink 2011, p. 2). Interviewees from diverse stakeholder groups (I-BO; I-RE; I-TA; I-BA) agree that investments in bicycle infrastructure have proven to be an effective means to improve the cycling mode share by making it more accessible and safer. According to business owner and transit agents, as well as numerous studies (see Engel 2018, p. 14), protected bike lanes, in particular, have proven to be effective in this regard. People of all ages and abilities, including children (I-BO; National Complete Streets Coalition), are able to make more independent transport choices, are more flexible and can access more places (I-BA). The protected bike lanes in downtown Vancouver, for instance, have effected an increase of women and children biking (I-BO; City of Vancouver 2012b, p. 3). On commercial high streets outside the downtown context, too, they could allow more people to access goods and services safely (I-BO; I-TL; Streets For Everyone 2019, p. 3). Moreover, the implementation of bike infrastructure does not necessarily mean a decreased accessibility for car drivers. As an example, a parking inventory on Commercial Drive conducted by *Slow Streets* found that "[i]mplementing a complete street would have no impact on the total parking both on and off Commercial Drive" (Proulx et al. 2015, p. 20). Therefore, protected bike lanes offer an opportunity to enhance the mobility, transport flexibility, and accessibility of destinations on commercial high streets for a wide range of people. As previously (3.1.3) stated, access to commercial high streets is a critical factor for citizens to participate in every day, social, and work activities.

Planning know-how

Besides the existing base of knowledge and guidelines mentioned earlier (4.1.3), planners and project managers can take advantage of the power of pilot projects. Respondents from regional transportation authority and advocacy groups outline that quick and cheap transformations and small pilot projects offer learning opportunities, have a lower barrier for implementation, and can be adapted easily if necessary. Janette Sadik-Khan and her team within the New York City Department of Transportation became well-known by using this approach to transform Times Square in New York City. She highlighted the potential of fast and cheap city remakes at the *TEDCity2.0* Conference in New York: They can have immediate effects, be very popular, and are easier to implement when people know the changes can be reversed (Sadik-Khan 2013). Accompanied by a measurement strategy, pilot projects provide an opportunity to produce data and insights that can be valuable for future projects (Bruntlett and Bruntlett 2018, p. 19). In Cologne, where pop-up bike lanes appeared for half a day on Hansaring, the temporary intervention was used to stimulate the imaginative power of residents of how streets can look like and also to start a dialogue (Mörchen 2016). Siemiatycki et al. (2014, p. 234) remark that "[b]icycle lanes are also ideal for implementation […] as pilot trial projects, due to their relatively low

cost and ease of delivery, and this can favourably sway skeptical politicians and citizens." Examples in Vancouver are protected bike lanes on Smithe Street that eventually became permanent (I-BA), and the current redesign of the bus exchange outside Nanaimo station (I-TA).

Bicycle network

The high suitability of commercial high streets as bike routes in Vancouver was concluded earlier (4.1.3) in this work. Specified further from the point of view of the image of cycling (4.2.2), protected bike lanes on commercial high streets offer an opportunity for many people to do more frequent trips within their neighbourhood. According to bicycle advocates, this can foster everyday cycling rather than just commuting by bike. As the City of Vancouver (2012a, p. 27) states in their transportation strategy, "[c]ycling routes are most useful when they connect to form a cohesive and legible network providing direct and convenient access to important destinations like schools, community centres, libraries, transit stations, and employment and shopping areas." This means that protected bike lanes on commercial high streets can be expected to be effective in creating a city bike network, fostering the idea of bikes as an everyday means of transport, and offering access to goods and services on commercial high streets.

Multimodality

The potential of bike-transit integration and its current state in Vancouver was discussed as strengths (4.1.3) and weaknesses (4.2.4) in this work. Synergies include increased catchment areas for biking, solving the last-mile-problem of public transit, and optimizing travel times for both modes. These can be achieved or enhanced when both, the transit and bike network, are of sufficient coverage and quality. Protected bike lanes on commercial high streets make the areas around transit hubs more accessible by bike and therefore create benefits for people who combine biking and transit as well as people that bike from point A to B, say transport authority members. Increasing the accessibility of places without a car can reduce car usage and provide relief for urban roads and the environment, say resident and business owner representatives.

Public space quality

Amongst the reasons for an opportunity to increase economic vitality on commercial high streets set out before (4.3.1) was the positive relationship between protected bike lanes and public space quality. Interviewees from multiple stakeholder groups (I-BO; I-RE; I-TA; I-BA) pointed out this connection, too. Some respondents added that commercial high streets are currently no specifically pleasant places due to the impact of motorized traffic (I-RE; I-TA). The positive effects of bike lanes on the public realm are, however, not limited to economic benefits. Interviewees from the groups of residents, transportation authority, and advocacies, as well as multiple researchers (Tolley, Rodney 2011, p. 1; Monsere et al. 2014, p. 142; Crane et al. 2017, p. 392) mention that it also increases the livelihood of an area. Lower noise and air pollutant emissions through motorized vehicles and increased security due to more people being present in the public are some of the reasons for increased livability and also lead to stress reductions. A member from the municipal advisory council adds that even very small changes to public spaces such as car-free plazas can have positive effects. Hence, protected bike lanes can strengthen the 'place' function of commercial high streets and surrounding areas.

Road safety

There is a convincing base of evidence that protected bike lanes increase cycling safety (Lusk et al. 2013, p. 1246; NYC DOT and Bennet Midland 2013, p. 202; TransLink 2011, pp. 23,31; Sadik-Khan 2013;

City of Vancouver 2012b, pp. 5–6; Harris et al. 2013). Respondents from four groups (I-BO; I-FC; I-RE; I-TA) named the improved safety an opportunity for protected bike lanes on commercial high streets. Interviewees from the occupational cyclist and regional transportation authority group share the conception that Vancouver's commercial high streets, in particular, have high safety deficiencies. A *Cycling Safety Study* conducted in Vancouver in 2015 confirms this. It found that parts of Commercial Drive, Main Street, and Broadway are amongst the high collision corridors (City of Vancouver 2015a, pp. 119, 121). Diverting bike riders to main streets can also solve some issues that appear on secondary streets as bike routes: Sightlines at intersections there are limited due to the small buffer zones. Besides, the right-of-way is often unclear (I-TA). Beyond that, the health of cyclists increases if they can ride in a further distance from motorists' exhaust gases. A business owner remarks that the physical separation does not only protect cyclists but makes driving safer, too. An analysis of protected bike lanes in New York reinforces this statement: Total injuries have dropped by 20% three years after the installation of protected bike lanes, measured for twelve projects involving seven miles of protected bike lanes (Trottenberg 2014, p. 2). Sadik-Khan (2013) even observed a 50% drop of injuries after 30 miles of protected bike lanes were built in New York. These safer road circumstances are a result of the physical separation that also induces a higher cycling mode share. Higher shares of biking are associated with increased safety, as the concept of safety in numbers implies (Jacobsen 2003, p. 1; Pucher and Buehler 2008, p. 14; Sadik-Khan 2013).

Transport efficiency

Business owner, resident, and bicycle advocacy respondents referenced a positive effect on urban road congestion and parking availability as an opportunity for protected bike lanes on commercial high streets. Reasons they named are that giving people the option to bike to destinations increases the cycling mode share (I-RE) and reduces the number of cars on arterial streets (I-BA), even when the percentage of cyclists is small (I-BO). Considering literature on the topic, there is "[e]xisting evidence about the advantageousness of cycling for urban decongestion […]" (Engel 2018, p. 22). The League of American Bicyclists and Alliance for Biking & Walking (2009, p. 3) signifies that "[…] a relatively small shift from cars to other modes could have an outsized impact on congestion." On the other hand, there are some indications of slightly increased travel times through protected bike lanes in Vancouver. These, however, cannot explicitly be traced back to the bike lanes as a cause, since interventions also included rerouting of motorized traffic (City of Vancouver 2012b, p. 5) and restricted right turns of cars (Stantec 2011, p. iv). The study by Stantec (2011, p. 35) also takes note of the restricted validity of its results due to limitations in data gathering. In contrast, there are findings from New York City that imply steady or improved travel times after the implementation of protected bike lanes (Trottenberg 2014, p. 2). Altogether, the documented impacts of protected bike lanes on travel times are considered as not yet explicit. Nevertheless, there are proven effects of cycling in general on urban decongestion, and of protected bike lanes to increase cycling and to reduce induced traffic that lowers vehicle volumes on arterials (Engel 2018, p. 15). Besides, there are sufficient indications that cycling is amongst the fastest means of transportation for trips under 5 km in urban areas (League of American Bicyclists and Alliance for Biking & Walking 2009, p. 6; Jungho 2015, p. 110; TransLink 2011, p. 12; MAN and Technical University Munich 2013, p. 5).

Current transport inefficiencies in Vancouver also arise on shared bus and bike lanes, as the occupational cyclist observes. Lanes that are otherwise dedicated to on-street parking become explicit for buses and cyclists during rush hour. However, they are sometimes misused by cars and problems also arise when these lanes become turning lanes at intersections. In Victoria and Montreal, the shared lanes are not popular either (Shingler). They limit bus efficiency because buses can only go as fast as

cyclists (Grossman 2019) and pose a risk to cycling safety. The author's experience also reflects that due to frequent stops of buses at bus stops, people on bikes are left with options to continuously stop and pick up again behind buses, veer around buses and pass them while mixing with fast flowing motorized traffic, or using the sidewalks (Magder 2016; Peacock 2015). This can be an intimidating experience for all types of cyclists, especially for those who are not as confident cycling (Grossman 2019). Outside of rush hours, dooring issues on those streets reduce traffic safety (Magder 2016). According to NACTO (2016), "[the] shared bus-bike lane is not a high-comfort bike facility, nor is it appropriate at very high bus volumes". The available space on commercial high streets offers an opportunity for better road space allocation through protected bike lanes and dedicated bus lanes.

Eventually, making streets more accessible to multiple modes by adding protected bike lanes can provide relief for the problems created by car-centric design like resource intensity and inefficiency. According to business owner and resident respondents, changing the habits of people and how they get around is a future necessity to address the challenges of a growing urban population.

4.3.6 Summary of opportunities

Opportunities of projects for protected bike lanes on commercial high streets in the City of Vancouver are summarized in *Table 5*.

Table 5 – Opportunities for protected bike lanes on commercial high streets in the City of Vancouver

Economic	
Economic vitality	Increase of economic vitality and business revenues due to higher visitor numbers resulting from enhanced accessibility, public space quality, and efficiency of road space allocation, as well as favourable spending behaviour of cyclists
Political and Legal	
Existing demand	Considering specific demands of all modes and adapting roadway structures accordingly can increase the efficiency of the transport system and optimize space utilization
Public consent	Catalytic effects of realized projects to enhance public consent
Public engagement	Creation of successful infrastructure that meets most stakeholders' needs
Socio-cultural	
Image of cycling	Cycling on main streets promotes the idea of cycling as an easy and accessible everyday mode of transport and resolves invisibility issues
Social connectedness	Increased accessibility and public realm quality of commercial high streets through protected bike lanes increases opportunities for social interactions and fosters a sense of community

Socio-economic	
Inclusion	Reinforced affordability of cycling through enhanced accessibility and proportionally representative distribution of resources improve social equity
Structural	
Accessibility	Increase of mobility, transport flexibility, and accessibility of destinations on commercial high streets for a wide range of people
Planning know-how	Pilot projects and quick and cheap transformations offer the potential for learning, public consent, and future adaptions
Bicycle network	Expected effectivity of protected bike lanes on commercial high streets
Multimodality	Realization of synergies from bike-transit-integration through the provision of safe bicycle infrastructure around, from and to transit stations
Public space quality	Enhancement of the public realm quality and liveability of commercial high streets and adjacent areas
Road safety	Increase of road safety for all traffic participants through physical separation and safety in numbers
Transport efficiency	Provision of relief on urban transportation system through better accessibility of more efficient modes of transportation

4.4 Threats

Threats are possible negative consequences of mentioned projects. These can often be mitigated or eliminated by identifying them and taking appropriate actions.

4.4.1 Economic

Economic vitality

While none of the interview respondents mentioned that protected bike lanes on commercial high streets can be a threat to local businesses, this has been overly mentioned in public statements by business representatives (see 3.1.1. Business owners). This can be explained through the previously mentioned participation bias of this study. However, as previously (4.1.1) discussed, there are no significant indications for a negative impact of protected bike lanes on commercial high streets on local business revenues in research.

4.4.2 Political and Legal

Public consent

The cases of the first bike lane pilot on Burrard Street in 1996 and the introduction of the bike lane on Dunsmuir Street in 2010 have demonstrated the importance of public outreach and engagement in Vancouver (I-BO; I-BA; Siemiatycki et al. 2014, p. 228). In both cases, the negative public attention of the newly implemented projects can be partly attributed to the lack of communication to the public. Multiple other articles and reports emphasize the significance of transparency and citizen involvement within public infrastructure projects (MAN and Technical University Munich 2013, pp. 17, 29; Godsall 2011; Stantec 2011, pp. 50–51; Krahn 2015, p. 3; Ledsham and Savan 2017, p. 31). If the public is not informed of or engaged in the process properly, public consent could be negatively impacted. In addition to that, a municipal advisory council member warns that street closures that are part of the construction process of infrastructure projects can stimulate a negative opinion on bike lane projects. An example the same interviewee recites is the rerouting of traffic due to the closure of 1st Avenue for months in the course of *FortisBC* gas line updates in 2018. The political pressure that resulted thereof prevented the implementation of a complete streets project on Commercial Drive that was planned for 2015 to 2018.

Public engagement

The project on Commercial Drive had been postponed in previous years partly due to a loud opposition of local business owners, says a bicycle advocate. While public participation is very important, this highlights one of the involved risks: Interviewees from different groups (I-BO; I-RE; I-BA) indicate that postponements of important infrastructure projects can be the outcome. That is even though a total public consent is very unlikely either way. It means that money invested in public participation can produce unsatisfying results (I-BO). Moreover, it can create feelings of ignorance and disrespect after people have dedicated their time to projects. Causes can be due to unclear expectations of consultation outcomes (I-BO; I-MA) or an involvement of citizens in expert questions they are not qualified to answer (Anderson 2018). Both can lead to disappointment for people if their opinions are eventually not considered the way they imagined. The municipal advisory council member says there is a chance that people complain about not having been consulted enough when they think they could vote for or against a project while the consultation was actually about project details. An example the

respondent refers to are the consultations on the 10th Avenue protected bike lanes: "The City was not consulting whether or not to have protected bike lanes. Yet, 2 years later, many were still advising not to put them in – rather than giving feedback on *how* they went in and *what* they affected." A business owner interviewee, too, underlined that the meetings should not be about having to convince people that bike lanes are a good thing. Anderson (2018) shares similar insights: When questions are asked that the general public is not able to answer because of a lack of expertise they cannot be answered meaningfully and the results will most likely not be considered - "[…] which in this case is the right thing […]", but it makes people feel undervalued and that they wasted their time. He illustrates what the role of citizens in consultation processes can look like: "They are experts in how increasing taxes will stress them out. They are experts in hidden secrets of their streets and alleys. They are experts in the amenities they want for themselves and their family. They are the only experts. […] We should only consult with residents when they are the ones that can best answer the question at hand. But in those moments, they should be treated as the experts they are." (Anderson 2018).

Further reasons for unsatisfying results can be the lack of education, emotional decisions, and uneven representation of participants. The former is reinforced by the circumstance that academic articles and studies are not accessible to the public, as a business owner criticizes. The municipal advisory council respondent explains that people get very emotional about transportation and so their decisions are not necessarily rational and evidence-based. The respondent elaborates that, since everyone participates in transportation daily, people see themselves as experts and rely on their personal anecdotal observances instead of trusting data. The same interviewee also provides insights regarding the representation of citizens in different consultation settings: Because public meetings require time and time availability varies in different population groups, there is an uneven representation of people in these meetings. An example is the consultation process regarding the plans for active transportation on Point Grey Road in 2013: "220 people signed up to (wait hours and) speak to Council against protected bike lanes and traffic calming measures. However, City Council received 4000 emails from people for bike lanes. For those in the room, it looked like everyone agreed with them. And yet Council voted for the changes. It's misleading those present."

All these aspects can lead to a delayed introduction of bike lanes and public mistrust towards planners. This is demonstrated by the example of Commercial Drive, where the majority of people do prefer having bike lanes (I-BO), but the project was not activated or started because of the BIA being very vocal against it (I-BA). Respective issues of potential misrepresentation were also discussed earlier (4.2.1). In addition, the resident interviewee stresses the importance of eventually making decisions and having people adapt to the changes.

While public participation is a crucial tool to create an infrastructure that suits the needs of many and to increase public consent towards the projects, it can also be an investment that leads to project delays and public mistrust if carried out improperly.

4.4.3 Socio-economic

Inclusion

As explained earlier (4.3.1), the instalment of bike lanes and accompanying public space improvements effect an appreciation of a neighbourhood's liveability. This also leads to increasing housing prices and commercial rents (Litman 1999, p. 17; Tolley, Rodney 2011, p. 7; CABE 2007, p. 7; Hoffman 2016, p. 87). A bicycle advocate states that even though bike lanes do not necessarily cause gentrification, they are associated with it and pose a general risk for it. Hoffman (2016, p. 4) similarly remarks that

"[t]he popularity of bicycling can influence the construction of beautiful paths and trails, but it can also be a signifier of gentrification." The advocacy respondent describes that this could affect the development of Vancouver as a city towards biking white, socio-economically well-off people in the centre; and socio-economically less privileged people in the peripheries. Hoffman (2016, p. 86) also describes a critique of gentrification in harming longtime residents through the "[…] potential to displace and erase marginalized communities." However, she adds that "[…] the assumption that gentrification inflicts harm on longtime residents may not be accurate." The fear of social injustice and bike lanes as a politicized issue may impair the perception of vocal residents. Nevertheless, this raises questions of whether newly built infrastructure reflects the needs of longtime residents. She concludes that "[…] bicycling, as taken up by white affluent cyclists, has the potential to gentrify neighbourhoods" (Hoffman 2016, p. 89). In addition, she says, it can impact access to transportation. Often, the needs of middle to upper class are prioritized in transportation funding even though they are less dependent on it (Hoffman 2016, p. 87).

4.4.4 Structural

Accessibility

While protected bike lanes can enhance the accessibility of commercial high streets and their destinations, accessibility can be restricted for individuals if the new street design is inadequate for their needs. Getting rid of all the parking on the street is, according to a resident, certainly an unlikely scenario, but one that could cause a downturn in some businesses. The municipal advisory council interviewee remarks that in regard to the ageing population especially pick up and drop off spots become more important. Another matter that requires attention in planning is curb accessibility. "People with mobility impairments can find the barriers introduced by segregated bike lanes difficult to negotiate (relative to no bike lane at all)" (City Clock 2014). A business owner suggests that the possibly impaired curb accessibility is a solvable planning issue.

Bicycle network

Commercial high streets were identified as important gaps in the bicycle network in Vancouver. However, they are not the only gaps in the network. The occupational cyclist stated that network gaps such as the Granville Bridge need to be addressed in order to make protected bike lanes effective. Chen et al. (2017, p. 658) and McHugh (2014, p. 100) emphasize that a complete cycling network is critical to increase cycling numbers. Another consideration regarding the city's bicycle network is how well it supports a continuous cycling flow. The Transportation Association of Canada (2017c, p. 9) notes that "[f]or bicycles to be an effective means of transportation, cyclists must be able to maintain their momentum without having to slow or stop often. Once slowed or stopped, it takes considerable time and effort to regain the desired operating speed. To the extent reasonable, bicycle routes should be designed for continuous riding and to minimize steep gradients, rough surfaces, sharp corners, intersections, and the need to yield to other users." A respondent from the transit agency points out that the current phasing of traffic signalling prioritizes motorized traffic so that the traffic flow for cyclists is often interrupted by a red light. This means that infrastructure investments at intersections and other locations might be necessary in order to maximize the benefits of protected bike lanes on commercial high streets.

End-of-trip facilities

Interviewees from business owner and advocacy groups agree that creating separated bike lanes without investing in end-of-trip facilities could lower their effectivity in respect of increased ridership. Particularly for people that use expensive bikes or whose only transport option is a bike, the fear of their bike being stolen is enough to keep them from cycling, says the advocate. The role of end-of-trip facilities for an uptake of cycling was described in chapter 4.1.3.

Multifunctionality of commercial high streets

The multifunctionality of commercial high streets creates design challenges for the implementation of protected bike lanes. "If buses, or transit in general, are not prioritized within the street design, there is a potential impact on transit delays due to the limited space shared with vehicles", says a bicycle advocacy representative. The interviewee adds that in addition, bus stops and bike lanes could interfere in a negative way if designed improperly. The municipal advisory council member highlights that due to local disparities, design challenges particularly exist in Vancouver East: "[…] lower income [population], more industrial lands, trucking and bus routes on the east side make the implementation of bicycle infrastructure more difficult but also more necessary."

Road safety

Regarding potential road safety risks on commercial high streets, respondents from various stakeholder groups (I-BO; I-FC; I-TA; I-BA) indicate that the design of protected bike lanes and intersections is crucial to prevent conflicts with pedestrians and cars. A bike advocate and multiple studies (McHugh 2014, p. 78; DuBose 2011, p. 55; City of Vancouver 2015a, pp. iii-iv) imply that the crash risk increases at intersections and driveways, where sightlines are limited and the right-of-way between drivers and cyclists is unclear. Visibility can be limited especially at parking-protected bike lanes, as the frequent cyclist and Montoro (2017) comment. These are, though, by definition of the Transportation Association of Canada (2017c, pp. 14–15), considered as buffered bike lanes as opposed to protected bike lanes due to the lack of vertical separation. Nevertheless, visibility issues could also occur if protected bike lanes are designed improperly. Besides, they should be designed so that their explicit usage by cyclists becomes clear to other road users.

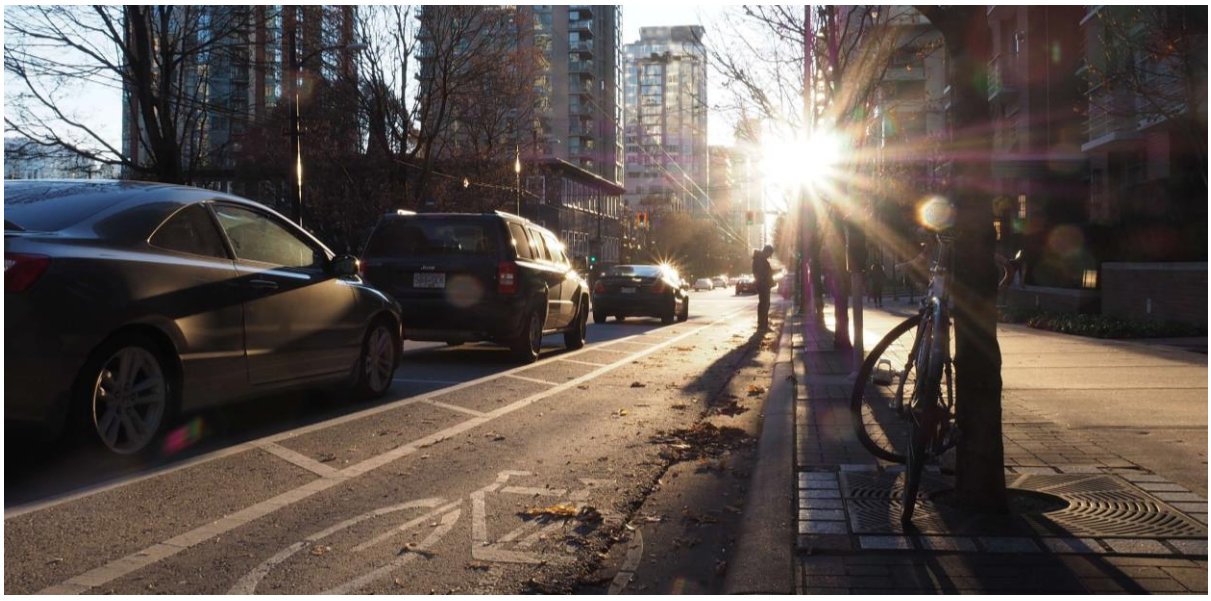

Figure 9 - Parking protected bike lane in Vancouver with disadvantageously facing parking meters (author)

While pilot projects can provide an opportunity to develop and study different types of bicycle infrastructure and intersection designs, a downside is that the emerging city infrastructure is not uniform. A multitude of different intersection designs, right-of-way regulations, and traffic patterns can confuse drivers, pedestrians, and cyclists, and pose a safety risk for them, say transportation agency and frequent cyclist respondents. This type of hazard is repeatedly mentioned in user reports provided by *BikeMaps.org*, a citizen database for bicycle collision, near-miss, hazard, and theft reporting. A misuse of protected bike lanes by pedestrians was also addressed as a risk factor by the frequent cyclist. The regional transportation authority interviewee adds that the current growth of protected bike lanes creates several design challenges. Nevertheless, the respondent is optimistic that the experiments that currently cause confusion can provide valuable input for the development of better standards in the coming years. A literature search has provided no information about the negative impacts of pilot projects. Nevertheless, the author and her social network have experienced confusion themselves or of other traffic participants on Vancouver's streets for that reason, too.

Furthermore, the increased safety for all road users through protected bike lanes can have an offsetting effect so that drivers are being less cautious (I-RU; Litman 1999, p. 8). Cyclists, likewise, might be encouraged to ride faster because of the separated bike lanes (I-TA). The safe and straight infrastructure that municipalities and advocacy groups advocate for could lead to a less desirable situation of fast bikes riding next to slow pedestrian traffic, a transit authority member explains. Municipalities become concerned about conflicts of cyclists with pedestrians, the most vulnerable road users. The respondent anticipates that small meanders and turns, as well as safe obstructions like cycling speed bumps, could counteract the problem.

While protected bike lanes can encourage cyclists to ride faster, infrastructure cannot always engineer human behaviour, suggests the frequent cyclist. The existing aggression of car drivers towards cyclists can be a serious safety hazard for cyclists. Even though these situations happen very rarely, the situation might worsen with the installation of more cycling infrastructure, especially in low usage periods, fears the frequent cyclist.

Hence, safety hazards of protected bike lanes on commercial high streets can arise where there is low visibility, unclear traffic guidance or right-of-way, and where caution of drivers and cyclists is negatively affected by an increased sense of safety. There might be more potential problems that were not covered by the interviews and literature analysis. Nevertheless, it turns out that most safety hazards can be avoided by proper design. The *Transportation Design Guidelines* for protected bike lanes by the City of Vancouver (2017a, p. 6) stress the importance of "[…] heightening visibility, denoting a clear right-of-way, and facilitating eye contact and awareness of different modes" at intersections. Beyond that, protected bike lanes have still proven to be the safest form of infrastructure for drivers, cyclists, and pedestrians, as set out earlier (4.3.5).

Transport efficiency

Bike-transit integration and the realization of its benefits can be accelerated through protected bike lanes on commercial high streets. For this to work, the provision of adequate transit services is essential. A bicycle advocate states that with rising housing prices in the City of Vancouver, an expanding number of people moves to less central areas, leading to increasing commute and travel distances. If no public transportation is provided, people will have to drive into town rather than taking transit. Thus, the transport efficiency of commercial high streets would decrease.

4.4.5 Summary of threats

Table 6 shows a summary of the threats related with protected bike lanes on commercial high streets in Vancouver.

Table 6 - Threats of protected bike lanes on commercial high streets in the City of Vancouver

Political and Legal	
Public consent	Negative project perception or project delay through inappropriate levels of public engagement and expectations of total public consent
Public engagement	Unclear expectations, an involvement of citizens in expert questions they are not qualified to answer, a lack of participant education, emotional decisions by participants, and an uneven representation can produce unsatisfying results, delay projects, and spur public mistrust towards planners and engineers
Socio-economic	
Inclusion	Bike lanes are associated with gentrification that can push socio-economically less privileged people to peripheries
Structural	
Accessibility	Curb access can be impaired for individuals if their needs are not considered in the design
Bicycle network	Impairment of the effectivity of protected bike lanes on commercial high streets through gaps in the cycling network at other locations
End-of-trip facilities	Creating spaces to ride on without considering end-of-trip facilities can reduce effectivity of protected bike lanes
Multifunctionality of commercial high streets	Design challenges for protected bike lanes on commercial high streets as multifunctional streets, especially in East Vancouver
Road safety	Safety hazards can arise where there is low visibility, unclear traffic guidance or right-of-way, or where caution of drivers and cyclists is negatively affected by an increased sense of safety
Transport efficiency	The transport efficiency on commercial high streets can decrease if transit is not sufficiently promoted, especially in non-central areas

5. Findings - Approaches to implement protected bike lanes on commercial high streets in the City of Vancouver

The previous findings of this work presented economic, political and legal, socio-cultural, socio-economic, and structural factors that influence the implementation of protected bike lanes on commercial high streets in Vancouver. As a result, a comprehensive understanding of the status quo, opportunities and risks of undertakings of this kind should be attained. Based upon that, approaches that can promote projects for protected bike lanes on commercial high streets, are identified. This can leverage the opportunities and minimize the risks that come along with them. A brief synopsis of these key opportunities and the approaches they are in connection with is given in this chapter.

5.1 Summary and evaluation of SWOT analysis

The results of the SWOT analysis are briefly summarized below. The strengths and weaknesses, as well as anticipated opportunities and threats that relate to protected bike lanes on commercial high streets, are listed in *Table 8.* The analysis has not taken into account the general health, economic, environmental, social, and urban space benefits that are associated with an increased cycling uptake. However, at this point, it should be acknowledged that protected bike lanes additionally reinforce these positive impacts by making cycling more accessible and raising cycling numbers. In order to increase the informative value of the in-depth interview results, the respondents' statements were compared among each other and with existing research, theories, newspaper articles, City documents, and other records, as suggested by Boyce and Neale (2006, p. 4) and Mayring (2015, p. 123). The resulting evaluation of the individual findings is hence loosely based on the consensus theory described by Legewie (n.d., p. 2). In doing so, each statement is visually filed under one of three categories displayed in *Table 7*.

Table 7 - Conformity evaluation categories and criteria

Minimum consensus	Individual observations, experiences, or opinions by respondents of one or two stakeholder groups and no, or limited, documentation in literature
Basic consensus	Similar statements of respondents from two to three stakeholder groups and limited, or multiple, emergences in literature
Broad consensus	Analogue statements of respondents from at least four stakeholder groups and multiple mentions in literature or broad scientific evidence

First and foremost, this system shall depict the weighting of the results from the interview and literature analysis and increase the significance of the study. Nevertheless, due to other known study limitations, the external validity of the outcome is limited. Study limitations include a selection and participation bias of interview partners, limitations due to the small sample size, the underlying subjectivity of qualitative interviews, and the analysis bias.

Table 8 – Summary of strengths, weaknesses, opportunities and threats of protected bike lanes on commercial high streets in the City of Vancouver

Strengths	Weaknesses	Opportunities	Threats
Economic			
Economic vitality			
Evidence about non-negative effects on businesses		Increased economic vitality and local business revenues	
Political and Legal			
Transportation strategy			
Support by existing transportation strategy	Lack of push-measures in transportation strategy		
Existing demand			
Existing demand for more cycling infrastructure	Possibly skewed demand representation	Road space allocation according to demand for all modes	
Public consent			
Growing public consent in Vancouver	Unlikelihood of total public consent	Enhancement of public consent through realized projects and public engagement	Negative project perception or delays through an inappropriate level of public engagement and unrealistic public consent targets
Public engagement			
		Suitability of infrastructure for all stakeholders through public engagement	Unsatisfying results, project delays and mistrust towards planners and engineers through improper public engagement
By-laws and policies			
	Fragmented and outdated policies and by-laws		
Representation			
	Misrepresentation of demographics and businesses		
Socio-cultural			
Change perception			
	Fear of change and change reluctance		
Image of cycling			
	Low public identification with prevalent cycling image and culture	Promotion of cycling as a safe, easy and accessible everyday mode of transport	
Social connectedness			
		Increased opportunities for social interaction fosters a sense of community	

Strengths	Weaknesses	Opportunities	Threats
Socio-economic			
Inclusion			
	Cycling barriers beyond infrastructure adequacy	Improvement of transportation affordability and social equity	Association with gentrification
Poverty			
	Increased bike theft through high poverty levels		
Structural			
Accessibility			
	Existing car dependencies of some businesses and users	Increased citizen mobility and accessibility of destinations	Curb access as a design challenge
Planning know-how			
Existing practical and theoretical know-how	Compatibility issues of design standards with stakeholder needs	Learning opportunities through pilot projects and quick transformations	
Bicycle network			
Suitability for bicycle network extension		Effectivity regarding cycling uptake	Remaining deficiencies of bicycle network at other locations and intersections
End-of-trip facilities			
Increasing investments in end-of-trip facilities	Lack of end-of-trip facilities		Lack of end-of-trip facilities reduces effectivity
Multimodality			
Commercial high streets as transit hubs	Deficiencies in the transit network and bike sharing system	Realization of bike-transit synergies	
Multifunctionality of commercial high streets			
	Complexity and risks through opposing stakeholder interests		Design challenges through street multifunctionality
Public space quality			
		Enhanced public realm quality and liveability	
Road safety			
Awareness of and respect for vulnerable road users		Increase of road safety for all traffic participants	Safety hazards through improper design
Transport efficiency			
	Inconveniences for car users	Relief on the urban transportation system	decreased transport efficiency through lack of transit promotion

5.2 Key approaches

The interviews that were conducted in the course of this work did not only provide insights about the strengths, weaknesses, opportunities, and threats but also about recommended actions for project execution. The information was complemented with literature findings. On that basis, the approaches were deduced as logical consequences. Actions of planning and design, public engagement, public outreach, citizen empowerment, legal and strategic actions, and additional investments can be distinguished. Following this structure, they are described below.

5.2.1 Planning and design

Approach 1: Capture and center existing transportation needs of all citizens in decision-making, planning, design, and advocacy

Protected bike lanes on commercial high streets can enhance social equity through increased citizen mobility, accessibility of destinations, transportation affordability, and infrastructure suitability, as well as a road space allocation that reflects broad demographic needs. Planning and designing this infrastructure, however, can also result in transportation injustice for minorities, transportation inefficiencies, or political debates. That is if some demographics are being ignored in the decision-making and planning process; if the demand for new bicycle infrastructure is only represented by the current and not the potential cycling community; and if people are feeling left out in the process of road space reallocation as an emotional and politicizing issue.

Therefore, it is important to prioritize existing transportation needs of all citizens, including indigenous communities (I-BA), in the planning an decision-making process. Siemiatycki et al. (2014, p. 234) also emphasize the importance of "[…] developing a design that is acceptable (if not entirely preferred) by as many groups as possible […]" for political support of controversial infrastructure projects. In addition, this can increase the effectivity of the new infrastructure, address shortcomings in the current transportation system, and optimize space utilization. A suggested approach to achieve this is to invest in targeted research and public engagement, ensure that these reach diverse demographics, and eventually plan investments and design infrastructure accordingly, applying methods of Design Thinking. Research in this context could include surveys to determine individuals' motivations for transportation choices including travel patterns, existing restrictions, barriers and dependencies; conduct of precise traffic counts; determining parking demand; large-scale traffic analyses; and modelling different scenarios with variables such as mode share and population growth (I-BO). Questions investigating the motivation to choose a specific mode, and the conditions that could stimulate a mode switch to biking and other sustainable means of transportation, could, for instance, be adopted in the annual transportation panel survey in Vancouver. Appropriate strategies for public engagement will be discussed later on. A solution to reach diverse citizens in research and public engagement could comprise different means of communication such as open houses; online, telephone (cellphones and landlines), and postal surveys; as well as outreach via newspapers, social media, television, radio or billboards to create awareness for the process. Within this process, it is important to distinguish current travel patterns from transportation needs, and consider the desired development for a sustainable urban transportation system. It is also worthwhile noting that protected bike lanes can serve as emergency response routes as the examples of 10th Avenue and Cambie Street Bridge in Vancouver show.

Approach 2: Design safe and accessible bicycle infrastructure with special attention to intersections

Protected bike lanes have repeatedly proven to materially contribute towards increased traffic safety for all road users. This is reinforced through the concept of 'safety in numbers' due to higher cycling mode shares that are associated with protected bike lanes. Nevertheless, design challenges remain: safety at intersections, offsetting behaviour due to increased feelings of safety, accessibility for pedestrians, and confusion caused by non-uniform infrastructure throughout the city. These need to be carefully assessed in the design of protected bike lanes and intersections.

Meanwhile, there are various approaches to address all of the first points, including designs to increase visibility, signage and other visual indications to create awareness for cyclists and pedestrians and assist traffic guidance (I-RU; Stantec 2011, p. 48; Passmore n.d., p. 15); protected phasing through signaling (I-TL; Passmore n.d., p. 15; Stantec 2011, p. 48); speed reduction measures for drivers such as narrower or fewer lanes of traffic (Ledsham and Savan 2017, p. 36); safe obstructions to control cycling speeds; and models for protected intersections and complete streets (I-TL; I-BA; City of Vancouver 2017a, p. 6). Solutions to improve curb accessibility comprise bike lane crosswalks that are on a level with sidewalks and at the same time slow cyclists down, handicap spots, or accessible curbs. Until more detailed guidelines for Vancouver are developed, existing guidelines, local and international research results, international knowledge sharing and exchange (McHugh 2014, p. 113; Bruntlett and Bruntlett 2018, p. 20), as well as pilot projects in Vancouver can provide valuable information on safe and accessible design practices for protected bike lanes and intersections. More detailed technical designs can be continuously tested in Vancouver. However, adjustment periods of all road users to new designs and the importance of a uniform infrastructure throughout the city should be taken into account. There are also indications that the location, scope, and permanence or convertibility of design experiments are decisive for their success. Concurrently, pre- and post-implementation data of protected bike lanes projects of different types shall be collected (Krahn 2015, p. 63) and best practices identified so that more and more infrastructure can be designed in a uniform manner in the future. Alternatively, other strategies to combine the short-term need for safer and more inclusive bicycle infrastructure with the goal to create standardized and understandable infrastructure throughout the city could be explored.

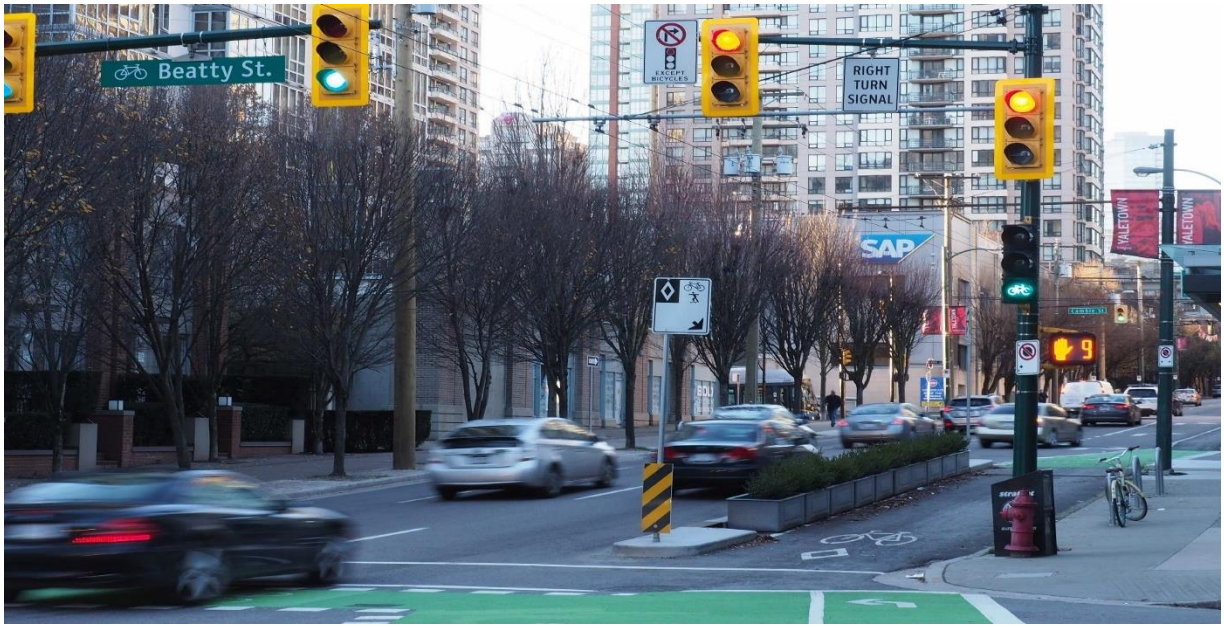

Figure 10 - Phasing protection of cyclists at an intersection in Vancouver

Approach 3: Prioritize transit within the commercial high street design

Fostering cycling on commercial high streets by providing comfortable spaces to ride on can unleash the benefits of cycling in general. Though, when protected bike lanes are built, it must be ensured that other sustainable modes of transport like walking and transit are not negatively impaired. Besides, synergies of bike and transit integration can augment the advantages of both modes. Therefore, transit has to be prioritized within the commercial high street design just as much as pedestrian spaces. Challenges arise through potential impacts on transit punctuality that can be a result of road space limitations if that space is also shared with other vehicles. This is especially with regard to generally increasing travel distances due to gentrification (I-BA). Besides, an efficient design of bus stops that is safe for pedestrians and cyclists, is important. Suggestions to ensure the reliability of transit include: maintaining average bus speeds with fewer bus stoppages and bus priority signals at intersections (Proulx et al. 2015, p. 26); introducing additional limited-stop bus lines (City of Vancouver 2016b, p. 149); or creating dedicated bus lanes (NACTO 2013) that can at times be implemented without losing many parking spaces (I-RE). In order to create safe bus stops, many experts share the view that floating bus stops[8] - where the protected bike lanes run behind the bus stop - are a best practice design solution (I-TL; I-BA; Krahn 2015, p. 63; Better Market Street 2011, p. 77; NACTO 2016).

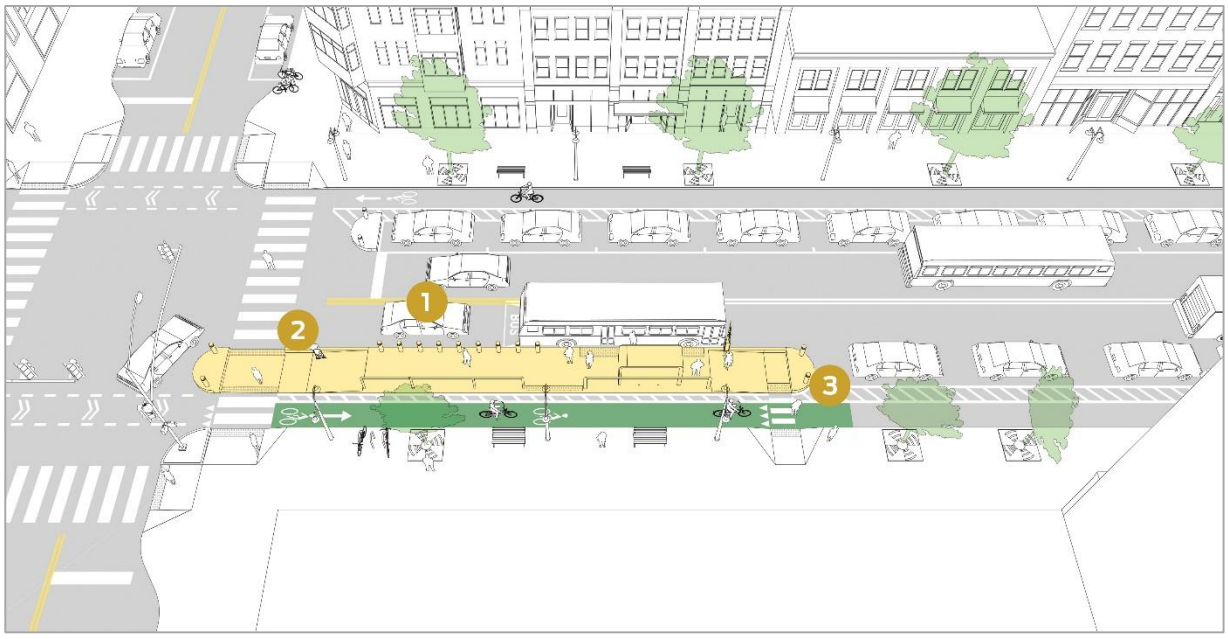

Figure 11 - 'Side Boarding Island Stop' (NACTO 2016)

Approach 4: Utilize the power of quick, cheap, and easy transformations

Pilot projects can be an effective tool to increase public consent. This is due to creating familiarity with different design typologies of protected bike lanes and intersections, and providing insights into their functionality, safety, and effectivity. In doing so, using quick, cheap and easy transformation methods reduces the barriers for implementation and provides a chance for future adaptations in case that other design options turn out to be preferred solutions. Siemiatycki et al. (2014, p. 234) highlight that "[b]icycle lanes are also ideal for implementation first as pilot trial projects, due to their relatively low

[8] Also referred to as 'side boarding island stop' in NACTO 2016

cost and ease of delivery, and this can favourably sway skeptical politicians and citizens." When implementing interim solutions, it is important that these are of high quality. If people do not feel safe and comfortable and the infrastructure is not used, this can be politically discouraging to build more protected bike lanes. Beyond that, a common understanding of the future implications of those test projects is beneficial for future discussions. Popular fast and cheap transitions can, for instance, be enabled by the use of paint and planters. These can transform curbsides into bike lanes, bike parking, parklets, or public plazas (NACTO 2013). A successful example in Vancouver is the transformation of the road section on East 14th Avenue between Main Street and Watson Street into outdoor seating, bike parking, and a bike share station (see *Figure 15*). Internationally renown examples are various street space improvements in New York City (*Figure 12*).

Figure 12 - Road transformation on Broadway, New York City (Andersen 2014)

Approach 5: Research the potential of e-bikes and cargo bikes and consider their requirements in planning

E-bikes and cargo bikes provide an opportunity to reduce car-dependencies further by addressing existing barriers to cycling such as long distances, physically more challenging terrain like hills, physical restrictions of individuals, or moving bigger items (I-TA; I-BA). This can also make commercial high streets quieter and safer. Since both are a fairly new phenomenon, research is required to determine current limitations, requirements for infrastructure, existing standards and best practices, and business models on the supply and demand side. To create lasting solutions for redesigns of commercial high streets, those results should be incorporated in respective road designs. Cargo bikes can also be a solution to ensure loading and deliveries for local businesses during construction phases of street re-designs.

Approach 6: Develop design standards for protected bike lanes and intersections

In the long-term, all resulting knowledge and best practices from all the aforementioned points should be put together to create design standards for protected bike lanes and intersections. This can help to create uniform solutions for protected bike lanes on commercial high streets so that traffic guidance and behaviour become more intuitive, resulting in additional safety.

5.2.2 Public engagement

Approach 7: Apply appropriate public engagement strategies

Public engagement in planning processes for protected bike lanes on commercial high streets can increase public acceptance of the projects and create a successful infrastructure that meets many people's needs as described under *approach 1*. As explained earlier on, the application of inadequate consultation practices, on the contrary, can lead to significant postponements of important infrastructure projects and mistrust in planners and engineers. This can, in turn, result in a reduction of public acceptance, intensified by increased fear of change. Hence, it is important to consider suitable methods for public participation: First of all, planners who lead the process shall be adequately trained in community outreach and public participation (Madrecki 2017). Madrecki (2017) also points out that the language of consultation events and public outreach should not be boring and instead address a broad public. Moreover, an adequate representation of and within stakeholder groups should be ensured. Since this is an issue that goes beyond public participation and was mentioned repeatedly in the interviews for this study, it will be treated as a separate approach hereafter. At the start of the participation process itself, it is recommended to state clear expectations of the consultation outcome to participants, as well as the scope and role of their involvement (I-BO; I-MA). Participants should furthermore be educated about the project motives and objectives (I-MA; I-BA). Building upon this, citizens should only be involved in questions where their local knowledge is valuable and that do not require professional training to produce meaningful results. It is also noteworthy that there appears to be a public interested in the technical design of proposed solutions (Siemiatycki et al. 2014, p. 234). Lastly, respondents from business owner and municipal advisory groups stress the importance of accepting that total public agreement is hardly ever possible.

Approach 8: Ensure accurate representation of and within all stakeholder groups in public participation processes

A conclusive number of interview participants stated concerns about an inaccurate representation of and within all stakeholder groups in public consultation and decision-making. A bicycle advocate mentions that especially indigenous people are frequently left out in these processes. Public outreach should create awareness about, and interest in, options for participation via cross-media distribution channels to reach broad demographics. The opinions of local communities and businesses can also be represented by business improvement associations, resident associations, various community groups, or specific project advisory committees (Ledsham and Savan 2017, p. 31; Krahn 2015, p. 62). In this case, however, decision-making entities and planners should make sure that these represent their members accurately. If there are any doubts about this holding true, individual group members can be surveyed independently.

5.2.3 Public outreach and education

Approach 9: Educate the public about cycling usage, benefits and infrastructure through public outreach and good examples

The natural fear of change, a skewed mode share perception by business owners and tax payers, and a lack of understanding change motives were identified as the main reasons for change reluctance in Vancouver. Yet, a demonstration of the benefits of cycling in general and protected bike lanes on commercial high streets specifically, can assist the political discussion and impact people's perception of biking and investments in cycling infrastructure. Improving public consent and change readiness, this can promote a smooth project progression. Good examples in situ, more tangible research results and strategic public outreach can be key strategies in this regard. The change of attitude towards protected bike lanes in downtown Vancouver after they were built displayed the common collective fear of the unknown and the effectivity of good examples to promote a more positive perception of similar future projects. The same principle applies to pilot projects. Implementing showcase projects might be more effective on streets where the consent for protected bike lanes is relatively high or, at least, not specifically negative. To highlight the positive, non-threatening properties of increased cycling and cycling infrastructure, targeted research to monitor and measure respective tangible benefits can be of significant support. This could encompass economic benefits (Ledsham and Savan 2017, p. 53); societal effects of interventions on social connectivity, people's happiness and a sense of pride in the neighbourhood (I-BA); personal benefits including convenience, low cost, enjoyment, fitness and health benefits (Tolley, Rodney 2003, p. 227), and time savings (I-RE); contributions towards the environment, traffic congestion and accidents (Tolley, Rodney 2003, p. 227); and climate change. Eventually, these benefits should be publicly promoted. Methods can include targeted campaigns in schools, community centers, local amenities and community-based cycling uptake programs (Ledsham and Savan 2017, p. 49), as well as discussions on traditional and social media (I-BO). A regional transportation authority member highlights the Netherlands' success of targeting communications about benefits around parking demand and congestion towards motorists. Another approach besides spreading the word about the positive impacts of cycling and protected bike lanes is to remedy possible disadvantages by providing more accurate circumstantial information and advice on how to deal with detriments (Tolley, Rodney 2003, p. 227).

Approach 10: Display cycling as an easy, affordable, and safe everyday mode of transportation for everyone

Despite knowing about the benefits of cycling, a barrier for many people still exists due to their lack of identification with the concurrent cycling culture and community. While protected bike lanes on commercial high streets foster the image of cycling as an easy, safe, and accessible everyday means of transportation, additional efforts can change the perception of cycling further. Displaying cycling as a mainstream transportation option for all sorts of people through marketing programs plays a vital role hereby (I-TL; Ledsham and Savan 2017, p. 48). An offer of more casual and affordable bike wear and gear in the retail environment can alter the image of cycling in a positive way (Bruntlett and Bruntlett 2018, pp. 36–40). Beyond that, police service and emergency management services using bikes can act as role models and legitimize cycling further (Ledsham and Savan 2017, p. 48). Eventually, the perception of cycling as a dangerous activity can be reduced by adapting by-laws for helmet usage and publicizing investments made to improve the safety for vulnerable road users (Ledsham and Savan 2017, p. 49).

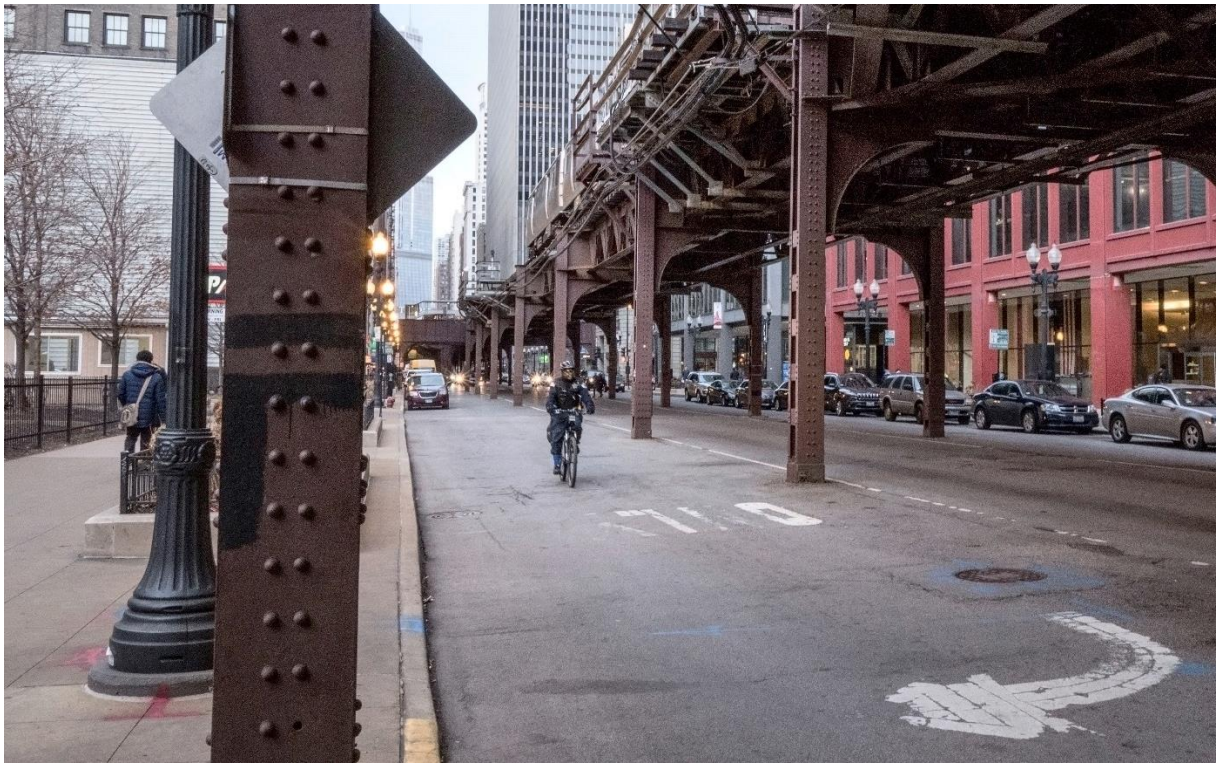

Figure 13 - Policeman on a bike in Chicago (author)

5.2.4 Citizen empowerment

Approach 11: Empower cycling by promoting access to bikes and related skills

Cycling as a low-cost means of transportation can foster social welfare. The equity of resource allocation, citizen mobility, and accessibility of destinations can especially be increased through investments in protected bike lanes on commercial high streets. However, barriers to cycling persist beyond the adequacy of the respective infrastructure. Economic barriers exist for many people that prevents access to bicycles for them. Besides, a lack of skills regarding street riding, route planning, mechanical knowledge, and carrying bigger items or children, can be further obstacles to cycling (Ledsham and Savan 2017, p. 49). Hence, empowering people to take up biking by providing them access to bikes, accessories and necessary skills can reinforce the social equity, mobility, and accessibility benefits of protected bike lanes on commercial high streets. Local bicycle advocacies and non-profit organizations play an important role in this matter: They facilitate access to affordable bikes or loan bikes to people for a limited time; provide maintenance and repair knowledge, tools and support; and offer mentorship, bike to school, and adult training programs. Cycling skill training is deemed particularly effective when it is incorporated into school programs. Options are elementary school curriculums (TransLink 2011, p. 37) or specialist high skill major programs in secondary schools that focus on mechanical training (Ledsham and Savan 2017, p. 50).

Securing funding for these advocacies through the provincial government or the City is essential to support their effective non-profit work (Ledsham and Savan 2017, p. 50). Besides, local decision-makers can work to ensure the accessibility of bike share programs to people with low income and without credit card access (I-BA; Meng 2018, p. 20). Research on awareness and acceptance of bike sharing systems by socio-economically less privileged people and minority groups can provide

indications on how their reach could be improved. Access to bikes can also be improved through for-profit bike shops and retailers by adding more affordable city bikes to their offerings (Bruntlett and Bruntlett 2018, pp. 36–40). Lastly, local governments and community organizations can encourage adults to take up bicycling for transportation through marketing and events. These events can "[…] encourage new cyclists to try cycling in a safe, community-supported fashion. They are fun and highlight the enjoyment that cycling brings to people's lives" (Ledsham and Savan 2017, pp. 49–50).

Approach 12: Provide essential safety training for drivers

New types of infrastructure, especially when they are not uniform across the city, can cause confusion among drivers which poses safety hazards. When drivers encounter cyclists on roads, the author often noticed insecure and hesitant behaviour or a complete lack of awareness. In addition, there is much dissent about codes of behaviour and rights-of-way between drivers and cyclists in Vancouver. While an increased number of cyclists on roads and main streets creates more familiarity and experience with these situations (I-BO), drivers can be additionally educated. Targeted education and awareness campaigns can help to prevent collisions between motorists, cyclists, and pedestrians (Stantec 2011, p. 48). In addition, TransLink (2011, p. 38) suggest to "[w]ork with ICBC to make cycle safety awareness a key component of all driver training courses and examinations in British Columbia, including for commercial licenses." While this can improve the awareness for cyclists of new drivers, people that are already in possession of a driver's license could be incentivized to undergo a voluntary cycle safety awareness training. A cost-benefit-analysis considering enhanced road safety could determine whether additional funding would be required by ICBC if participants received a bonus on their insurance premium or other inducements.

5.2.5 Legal and strategic

Approach 13: Update existing cycling by-laws

Some of the barriers that keep people from cycling are not related solely to infrastructure. The perception of cycling as a dangerous activity, for instance, is intensified by by-laws that require all cyclists to wear a helmet. Other examples of outdated by-laws that pose additional impediments for people to bike include insufficient or unsuitable bike parking that increases the fear and risk of bike theft; or an uneasy feeling because of the prohibition of side-by-side riding. Most of the cycling by-laws in Vancouver were created under the *Motor Vehicle Act* (see British Columbia 1996) a couple of decades ago (I-BA), in a period of car-centred planning and low attention to active and sustainable transportation. Hence, updating those by-laws can reinforce the positive effects of protected bike lanes on commercial high streets, mostly with regard to a cycling uptake by people of all ages and abilities. All of the by-laws should be reviewed against the backdrop of their use for encouraging cycling and making it safer (Sieg 2014, pp. 12–13; Pucher and Buehler 2008, pp. 3, 15; Ranson 2018, pp. 32, 47, 70; Randelhoff 2017). A regional or possibly provincial, integration of those by-laws may also be desirable (I-TA). One of the repeatedly mentioned major pain points of the current law is the existing obligation for cyclists to wear a helmet. There is broad evidence that such legislation has overall negative effects on cycling mode share, safety, and social welfare. For this reason, it is strongly recommended to revoke the helmet law. Similarly, the prohibition of side-by-side riding should be reconsidered since it was identified as a hurdle for cycling with children by interviewees from a transportation authority and cycling advocacies. It is also advisable to revise by-laws for on-site vehicle and bicycle parking requirements (I-BA), and restrictions on advertising and outdoor seating for businesses to enhance the public realm and attract customers (Stantec 2011, pp. 48, 51). Besides,

considerations on regulations relating to vulnerable road users' safety (Ledsham and Savan 2017, p. 37), as well as to right-of-way and bicycle infrastructure usage or misusage can reduce confusion in traffic, foster a common understanding of traffic behaviour and improve road safety further.

Approach 14: Increase push-measures in transportation strategy and legislation

Investments in protected bike lanes on commercial high streets are well supported through respective frameworks relevant to transport infrastructure in Vancouver. These also support the advancement of sustainable and active modes of transport to a high degree. However, there is still a lack of strategies to decrease individual motorized traffic and thus incentivize a shift to sustainable transportation further. Those push-measures can comprise parking management, the introduction or increase of taxation and road fees, or traffic calming measures. Car usage can be discouraged by increased parking pricing (Ledsham and Savan 2017, p. 37) or metered parking spots (I-MA). It can come along with restrictions of parking space or peak hour vehicle parking (Stantec 2011, p. 47). These can be partly replaced by pick up and drop off zones that can accommodate for an ageing society and physically impaired people (I-MA). If parking is reduced, its efficiency should be enhanced (Victoria Transport Policy Institute n.d.) through wayfinding strategies, parking space counting systems (Krahn 2015, p. 63), customer education about the availability of parking (I-BO), or added angled parking on secondary streets if possible (Stantec 2011, p. 47). Beyond measures affecting parking, suggestions are that car usage can be further de-incentivized by eliminating fuel subsidies, increasing charges for car use and ownership as well as road fees (I-RE), whereby congestion pricing can be considered (Integrated Transport Planning Ltd. 2017; Victoria Transport Policy Institute n.d.). In doing so, it must be ensured that comprehensive alternatives are available and that people who are dependent on car usage are not left out so that their current level of mobility can be maintained or improved. In addition to that, speed restrictions and HOV priorities can promote more sustainable mode choices (Victoria Transport Policy Institute n.d.). Eventually, it must be taken into account that the acceptance for push measures is generally low (Malhado et al. 2014, p. 215). Introducing these measures should be carefully evaluated, specifically against an equity and mobility background, and well communicated to the public.

5.2.6 Additional investments

Approach 15: Provide secure bike parking and other end-of-trip facilities at suitable locations

Bike theft is a major issue in Vancouver. The fear of having a bike stolen, or actual bike theft resulting in the unavailability of a bike as a means of transport, were named as major cycling barriers in interviews and literature. Spreading secure bicycle parking facilities at strategic locations (I-TL; Stantec 2011, p. 47) like in front of businesses (I-BO) or at transit stations (I-RE; I-TA; I-BA) can encourage cyclists to use businesses on bike lane routes (Stantec 2011, p. 48), increase business turnover (I-MA), and promote bike-transit integration. These facilities should be designed according to the scale of the street or the area in terms of capacity, and so that they are highly visible (I-BO). It is also recommended that they come along with the provision of storage, change rooms, or bike pumps and tools at destinations (I-BA) to address further cycling barriers. Since the supply of end-of-trip facilities is not the sole responsibility of the City or TransLink, they should be demanded from landlords by employees, customers, or business owners (I-BO; Ledsham and Savan 2017, p. 32).

Approach 16: Enhance bike-transit integration and expand transit services

A successful bike-transit integration has the potential to increase the efficiency of the transport system as a whole and reduce car-dependencies by supporting sustainable modes and optimizing travel times for all modes. This is mainly due to an expansion of catchment areas for biking and solving the last-mile-problem of transit. Commercial high streets as major transit hubs, specifically, can benefit from accessible bicycle infrastructure and good transit services. However, it also means that the transit system must be of high quality and integrate cycling services such as secure parking, bike sharing, and amenities to transport bikes. This makes an enhancement of the existing transit network crucial so that more people are connected to the transit network and less dependent on using a car (I-TA). In order to effectively allocate resources for investments into the transit network, research to determine needs and patterns of multimodal transportation may be necessary (I-BA). Quicker actions are the provision of convenient and secure end-of-trip facilities at transit stops (I-TA), more user-friendly bike racks on buses, an accommodation of bikes on all rail transit vehicles, and a functional public bike share system (Pucher and Buehler 2005, p. 22; McHugh 2014, p. 101; Bratman and Jadhav 2014).

Figure 14 - All buses in Vancouver are equipped with bike racks, however, it takes some practice to operate them (CBC News Vancouver 2014)

Approach 17: Improve public spaces and pedestrian facilities

Protected bike lanes on commercial high streets can enhance the economic vitality of an area by enabling more people to access these destinations, allocating the road space more efficiently to create a higher turnover, and attracting more people to the locality through its appeal. Providing people with a pleasant experience on commercial high streets is even more important in the face of rising competition from online shopping. Recommended design elements to enhance the public environment are widened sidewalks (NYC DOT and Bennet Midland 2013, p. 9); mid-block crossings for pedestrians (Stantec 2011, p. 49); and street furniture like benches, lighting, planters, and parklets (Sztabinski 2009, p. 23; Tolley, Rodney 2011, p. 8; NACTO 2013). Strategies that go beyond design include the allowance of more outdoor café seating, storefront improvement grants, and social events like car-free days (Stantec 2011, p. 49).

Figure 15 - Pedestrian plaza, bike share and bike parking at Main Street and East 14th Avenue in Vancouver

Approach 18: Expand bike sharing services

The opportunities of protected bike lanes on commercial high streets and a bike-transit integration can be substantiated by the provision of a functional and accessible bike share system. It addresses barriers to cycling such as access to bikes or the fear of bike theft and provides a solution for trips where a bike is only practical one-way or part of the way. Realizing all socio-economic and transport efficiency benefits, though, requires access to the bike share for low-income riders and people without credit card access, as well as a sufficient scale of the bike share system. In Vancouver, options to achieve this are to significantly increase the geographic coverage of the current system by locating further bike share stations at strategic locations (Ledsham and Savan 2017, p. 32; Stantec 2011, p. 48), and considering dock-less stations that are cheaper and offer a greater flexibility (I-TA). An admission of private bike share operators under a shared user interface could assist the expansion (I-TA). Besides, it is important to adjust the payment and pricing system to accommodate socio-economically less privileged people as well as additional usages such as sporadic short trips, e.g. by offering pricing models for under half an hour. At this time the only plans available to individuals are daily, 90-day, or annual plans, starting at $10 per day. are Further suggestions for bike share system improvements in Vancouver were determined in a study by Dr. Meghan Winters' Bicycling Research Team at Simon Fraser University (Therrien et al. 2017, pp. 21–24).

Figure 16 - Dock-less private bike share in a residential area in Ballard, Seattle

Approach 19: Map and address other deficiencies in the cycling network

At present, commercial high streets are crucial gaps in the Vancouver cycling network and highly suitable as cycling routes due to enabling access to destinations, an ease of navigation, and the existing street infrastructure like lighting and (mostly) good paving. Implementing accessible and comfortable cycling infrastructure there can have a significant effect on everyday cycling participation. Nevertheless, other gaps or deficiencies in the cycling network should be addressed, too. In doing so, access to commercial high streets (I-RE; Krahn 2015, p. 63) and the overall cycling mode share can be increased further. Current major gaps in Vancouver are the - largely by pedestrians and cyclists avoided - Granville Street Bridge that connects the downtown area and Kitsilano, and cycling infrastructure in the municipalities surrounding the City of Vancouver. Besides the completeness of the bicycle network, its design for continuous riding so that cyclists can maintain their momentum is important "[f]or bicycles to be an effective means of transportation […]" (Transportation Association of Canada 2017c, p. 9). Traffic light phasing can be adapted to average bicycle speeds to minimize stops for cyclists. NACTO (2013) also suggest shortened signal cycles and an adjustment of timing during peak and off-peak hours. Additionally, the ease of navigation within the bicycle network can be enhanced through wayfinding strategies to and from nearby routes (Krahn 2015, p. 63).

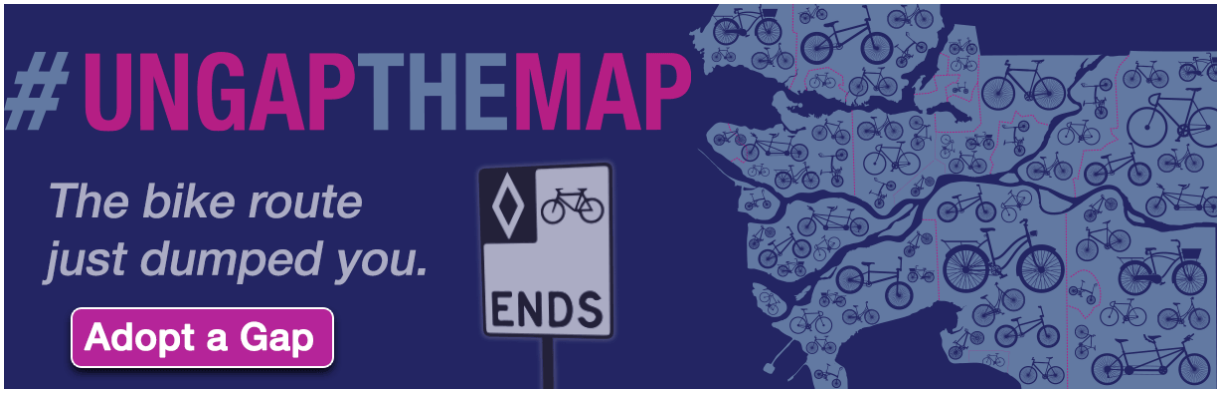

Figure 17 - #UnGapTheMap campaign by Hub Cycling (Hub Cycling 2017)

Approach 20: Implement measures to reduce poverty and homelessness in Vancouver

Bike theft is one of the major barriers to cycling in Vancouver. While some suggest stronger legal enforcement of bike theft, it may be of greater value from a social welfare, equity, and long-term perspective to address the root of the problem instead. Most of the theft activities in Vancouver are survival stealing, which means that bike theft can be combatted by lifting people out of poverty and giving them the resources they need to survive (I-BA). Besides the ethical superiority of this strategy, it also addresses the related issue of racial profiling of cyclists.

5.3 Key opportunities

Many of the approaches explained previously have multiple, overlapping, and similar benefits. Hence, the main opportunities resulting from implementing protected bike lanes on commercial high streets with these approaches are grouped and summarised below:

A. Reduction of barriers to cycling such as bike theft, economic barriers, weather and geography, network gaps, a lack of skills, and cultural barriers

B. Enhancement of social equity in urban transportation through appropriate resource and road space allocation, increased personal mobility, enhanced accessibility of destinations, and suitability of infrastructure for a broad demographics

C. Improvement of the safety, efficiency, sustainability and functionality of newly built infrastructure as well as the urban transportation system as a whole

D. Facilitation of a smooth project progression through effectivity, efficiency, and broad public acceptance

E. Enhancement of the public realm quality to benefit the liveability, economic vitality, and social connectedness of a neighbourhood

These key opportunities summarize the expected potential of protected bike lanes on commercial high streets in Vancouver and provide a link to the key approaches aggregated below.

5.4 Summary of approaches with regard to key opportunities

Table 9 gives an overview of all of the approaches depicted in this chapter and links them to the specific key opportunities they can exploit.

Table 9 - Summary of approaches with regard to key opportunities for Vancouver

Key approaches		Key opportunities				
#	Approach	A	B	C	D	E
Planning and design						
1	Capture and center existing transportation needs of all citizens in decision-making, planning, design, and advocacy		●	●	●	
2	Safe and accessible design of infrastructure			●		●
3	Prioritization of transit within commercial high street design		●	●		
4	Utilize the power of quick and cheap pilot projects			●	●	
5	Research and consider the potential of e-bikes and cargo bikes	●	●	●		●
6	Development of design standards for protected bike lanes and intersections			●	●	
Public engagement						
7	Apply appropriate public engagement strategies		●	●	●	
8	Ensure accurate representation of and within all stakeholder groups		●	●	●	
Public outreach, education, and empowerment						
9	Educate about cycling usage, benefits and infrastructure				●	
10	Display cycling as an easy, affordable, and safe everyday mode of transportation for everyone	●	●			
Citizen empowerment						
11	Empower cycling by promoting access to bikes and related skills	●	●	●		
12	**P**rovide essential safety training for drivers			●		

Key approaches		Key opportunities				
#	Approach	A	B	C	D	E
Legal and strategic frameworks						
13	Update existing cycling by-laws	●		●		●
14	Increase push-measures			●		
Additional investments						
15	Provision of end-of-trip facilities	●				●
16	Enhance bike-transit integration and expand transit services	●	●	●		
17	Improve public spaces and pedestrian facilities			●		●
18	Expand bike sharing services	●	●	●		
19	Map and address other deficiencies in the cycling network	●		●		
20	Reduce poverty and homelessness	●	●			

6. Findings – Implementing protected bike lanes on commercial high streets in Berlin

The antecedent parts of this thesis demonstrated relevant circumstances and proposed solutions to reap the benefits of an increased cycling mode share by investing in protected bike lanes on commercial high streets. The results can provide rough guidance for other cities, too, if additional information is collated. Framework conditions and determining factors in Berlin are therefore considered and compared to the Vancouver context.

6.1 Differences between framework conditions of protected bike lanes on commercial high streets in Vancouver and Berlin

In order to compare the situations in Vancouver and Berlin, it is necessary to clarify the status quo regarding protected bike lanes and identify equivalent research subjects. Some of these framework conditions are not specific to the cities of Vancouver or Berlin but can be derived from national conditions in North America and Germany. In these cases, the wider contexts are described for better accuracy.

6.1.1 Status quo of protected bike lanes

Cycling culture, in general, is historically more present in Germany than in North America. While the cycling mode share in Germany is 11% on average (Bundesministerium für Verkehr und digitale Infrastruktur 2018, p. 47), the national average is about 1% in the USA (Buehler and Pucher 2012, p. 35) and 2% in Canada (TransLink 2011, p. 23). Protected bike lanes, however, are far more widespread in North America. In Germany, protected bike lanes only exist sporadically on very short sections (Senatsverwaltung für Umwelt, Verkehr und Klimaschutz 2018; Blass et al. 2018, p. 1), whereas the number of protected bike lanes in the United States and Canada is constantly rising.

32 cities in the United States had accommodated the new infrastructure type by 2013 (Schmitt 2013), with numbers steadily increasing since. In 2017 alone, more than 115 km of protected bike lanes were built across North America (NACTO 2018). Thus, cities such as Chicago, Seattle, Portland, Washington, and Vancouver significantly increased their cycling mode share in the last decade (Schmitt 2013; Protected Bike Lanes by the Numbers 2013; ADFC 2018, p. 3; League of American Bicyclists 2017, pp. 9–10; Higashide 2018). The NACTO *Urban Bikeway Design Guide* (2012) is seen as one of the drivers for this development, providing the cities with advice, design guidance, and best practices for the implementation of protected bike lanes (Schmitt 2013). The lack of experience with protected bike lanes is one of the barriers for expansion in Germany, which is why transportation planners there now are referring to experiences made in North America (Senatsverwaltung für Umwelt, Verkehr und Klimaschutz 2018).

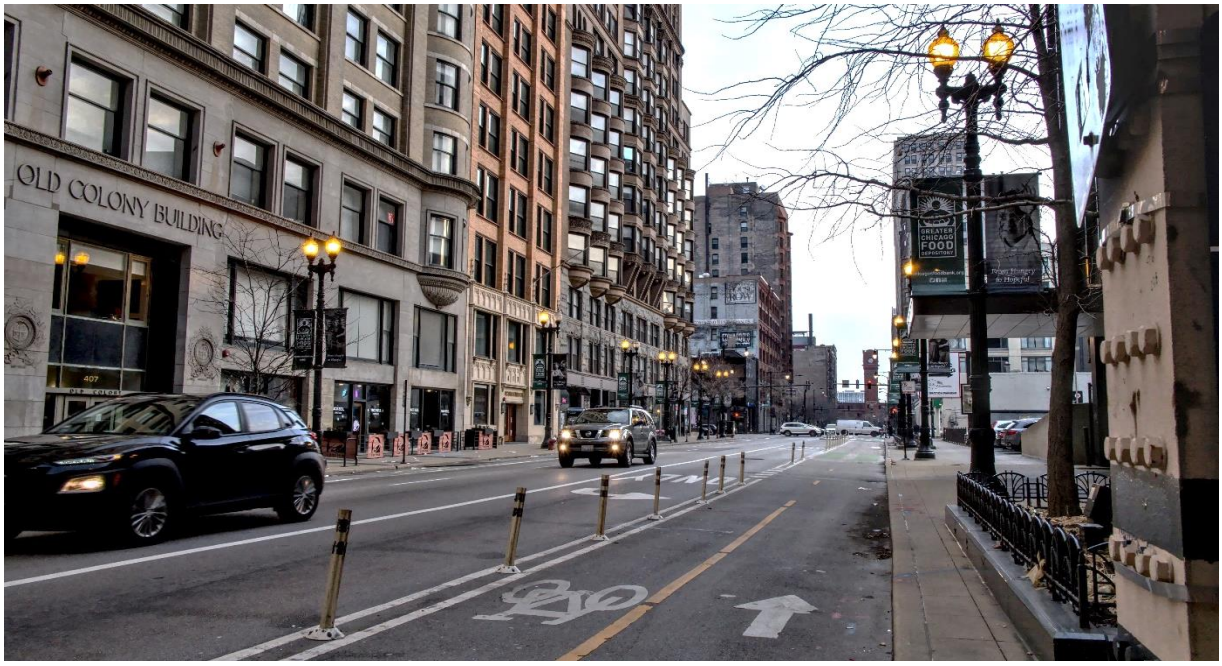

Figure 18 - Protected bike lane in Chicago (author)

First protected bike lane projects are being discussed or implemented in multiple German cities, with Berlin being the most progressive (ADFC 2018, p. 4). The protected bike lane on Holzmarktstraße was not the first of its kind in Germany, but the City is planning many more routes and the subject has a high priority for the responsible *Senate Department for the Environment, Transport and Climate Protection* in Berlin. Another protected bike lane is currently being implemented at Hasenheide (see *Figure 19*), which is supposed to be the showcase projects in Berlin. Additional projects are being planned on Karl-Marx-Straße, a busy street with commercial usage and high traffic volumes, as well as on two streets in the districts Friedrichshain and Kreuzberg (Bicycle infrastructure expert from Berlin 12/21/2018). Berlin can be seen as a role model regarding the development of protected bike lanes in Germany. Therefore, a brief case study of the applicability of approaches will be conducted. The results can give hints on appropriate strategies for implementation in other German cities.

Figure 19 - Rendering of the protected bike lane at Hasenheide, Berlin (Daniel 2017)

6.1.2 Characteristics of commercial high streets

Urban structures in North America differ from those in Germany. In order to apply the approaches worked out for the implementation of protected bike lanes on commercial high streets in the City of Vancouver, a clarification of street typologies is necessary. A suitable description of commercial high streets can be found in the *Urban Street Design Guide* by NACTO (2013). Referred to as a *Neighborhood Main Streets* there, they are described as "[…] a nexus of neighborhood life, with high pedestrian volumes, frequent parking turnover, key transit routes, and bicyclists all vying for limited space." This description contains the diverse usage of commercial high streets as traffic arteries as well as public spaces, which creates somewhat competing interests of their stakeholders. In a city context, they have a high strategic, social, economic, and environmental significance. A schematic visualization of a *Neighborhood Main Street* with a four-lane configuration is shown below.

Figure 20 - Neighborhood Main Street (NACTO 2013)

Throughout North America, there appears to be no consistent name for this specific street type. Within the characterization of urban roads by the Transportation Association of Canada (2017a, p. 54), commercial high streets are best represented by the class *Industrial/ Commercial Collectors*. These are defined by an equal importance of traffic movement and land access, a traffic volume of 1,000 – 12,000 vehicles per day, a design speed of 50 km/h – 80 km/h, average running speeds of 30 km/h – 70 km/h, an accommodation of transit, pedestrians and cyclists, few parking restrictions other than at peak hour, and a right-of-way between 20 m and 24 m. However, these numbers are not prescriptive and the classification of commercial high streets is not necessarily explicit and can vary over different sections of a street. Commercial usage is mostly limited to certain street sections only. In addition, most commercial high streets in the City of Vancouver feature traffic volumes beyond the typical values for Industrial/ Commercial Collectors and approximate the benchmarks for Minor or Major Arterials (Minor: 5,000 – 20,000; Major: 10,000 – 30,000) instead.[9]

[9] Traffic volumes: 8,200 – 13,500 vehicles/ day on Commercial Drive between Napier Street and East 11th Avenue in 2012 and 2013; 17,000 - 25,000 vehicles/ day on Main Street between 6th Avenue and 22nd Avenue in 2011, 2012, and 2013; 9,000 – 12,300 vehicles/ day on West Broadway between Bayswater Street and Burrard Street in 2013; 10,000 – 14,700 vehicles/ day on East 30th Avenue and East 47th Avenue in 2013 Esri

In Germany, streets are classified in the *'Directives for the design of urban roads'* (FGSV 2007). The *Main shopping street* could be considered equivalent to a commercial high street in Vancouver. It is defined as an access road or main arterial road that is located in the centres of large cities and medium-sized towns and has a dense business use with continuous building frontage, and residential use in exceptional cases only. Their length is usually between 300 m and 1,000 m, and traffic volumes under this classification are between 800 and 2,600 vehicles per hour. An extrapolation of this value to a daily vehicle volume is not explicit. Usually, a factorization with 10 is assumed, which yields a traffic volume of roughly 8,000 – 26,000 vehicles per day. This is a very vague number, however, it is in a similar range as traffic volumes for commercial high streets in Vancouver, allowing comparisons between both. Special use requirements of those streets are pedestrians' needs to walk along and across the street and a general presence of people, local public transport, and requirements for parking, delivery, and loading.

Hence, the common properties of commercial high streets in Vancouver and main shopping streets with a high traffic volume in Berlin are their multifunctional usage as places for commercial usage and enjoyment, as well as links for transit, vehicles, trucks, bikes, and pedestrians as road users. The biggest difference is that commercial high streets in Vancouver are located in residential areas, featuring almost exclusively a commercial usage. In Berlin, there is a lot of mixed use in and around main shopping streets with a high traffic volume (Bicycle infrastructure expert from Berlin 12/21/2018).

An example of the main shopping street in Berlin is Karl-Marx-Straße in Berlin. It is the biggest shopping street in the district of Neukölln, however, traffic volumes, street widths, and commercial activity vary over its length. Between Hermannplatz and Weichselstraße, where protected bike lanes are in the planning, traffic volumes amount to 17,500 vehicles per day (Bicycle infrastructure expert from Berlin 12/21/2018), making it comparable to some of the commercial high streets in Vancouver. In addition, the subway line U7 and the night bus line N7 connect multiple destinations on Karl-Marx-Straße and with other districts. All in all, this creates similar challenges through their multifunctional usage like in Vancouver.

Figure 21 - Karl-Marx-Straße in Berlin, from Hermannplatz (Academic)

6.1.3 Protected bike lane standards

In both, the North American, and the German context, protected bike lanes are an emerging type of infrastructure. A lack of experience with protected bike lanes creates design and political challenges for cities and can be a barrier to their implementation. Inversely, the integration or compatibility of protected bike lanes with national design standards promotes protected bike lane projects. The other way around, available design standards can provide information on the feasibility of implementation of protected bike lanes on commercial high streets.

As described within the SWOT analysis, research and development of design guidelines around protected bike lanes are progressing rapidly in North America. The *National Association of City Transportation Officials* (NACTO) initiated a knowledge exchange between cities regarding their experiences with protected bike lanes (Bruntlett and Bruntlett 2018, p. 20). These insights were integrated into design guidelines that are used by cities all over the world and can be useful for German transportation planners as well (ADFC 2018, p. 3). In Vancouver, NACTO's *Urban Bikeway Design Guide*, however, is not the only available design guidance. Standards of different levels of detail that include protected bike lanes are also provided by the *Transportation Association of Canada* and the City of Vancouver. Further guidelines that imply greater compatibility with transit are currently being developed, too.

Figure 22 - Protected bike lane (NACTO 2012)

In Germany, protected bike lanes have not yet been integrated into national design standards. There is, though, a demand to update the *Recommendations for cycling facilities*[10] (FGSV 2010) accordingly (ADFC 2018, p. 19). The *Senate Department for the Environment, Transport and Climate Protection*.in Berlin has already developed execution standards for protected bike lanes in Berlin.

Since the requirements for protected bike lanes are compatible with generally accepted engineering standards and the '*German road traffic regulations*'[11], there are no legal obstacles for it (ADFC 2018, p. 7). The position paper on protected bikes lanes by the *German Cyclists' Federation* points out that

[10] German title: '*Empfehlungen für Radverkehrsanlagen*'
[11] StVO, see Schurig and Frey 2013

installments for a physical separation of bike lanes from vehicular traffic is not explicitly described in the StVO nor is it ruled out: Delineators are no prohibited elements as long as they do not create a condition that jeopardizes or impedes traffic. Keep-out or safety zones that cannot be driven on are not included in these requirements (ADFC 2018, p. 17). The ADFC concludes that, therefore, it is not mandatory to use the installment typologies set out in the StVO catalogue (2018, p. 18).

In addition to legal feasibility and compatibility with existing road standards in Germany, a comparison between North American protected bike lane standards and the German *Recommendations for cycling facilities* (ERA), shows a basic compatibility (see *Appendix A*):

- Physical separation of bike lanes from vehicular traffic is recommended for high traffic volumes and speeds in the NACTO, TAC, CoV, and FGSV guidelines, as well as by TransLink (2011, p. 32) and the ADFC (2018, p. 9).
- Recommended widths for unidirectional bike lanes in all four guidelines range from 1.8 – 2.5 m depending on bicycle volumes, grades, sidewalk usage and maintenance requirements, with legal lower limits set to 1.5 m by TAC and to 1.6 m for bike paths by FGSV.
- Buffers to obstructions are set to 0.2 m by TAC and 0.25 m by FGSV for most cases, while buffers to parking range between 0.6 m in the TAC guidelines to 0.75 m in the FGSV standards and 0.9 m (3 ft) in the NACTO guidelines.
- Recommended delineators in the North American guidelines are flexible bollards, parking stops, planter boxes, concrete barriers, raised medians, depending on the type and speed of the adjacent lane. These could, according to the ADFC (2018, pp. 17–18), also be installed within buffer zones in Germany.
- The North American guidelines also provide solutions for protected intersections that meet the principles for intersection treatment stated by FGSV: Visibility at intersections can be ensured by bending bike lanes closer towards vehicular traffic at intersections and removing or prohibiting parking in those zones (NACTO and TAC). The risk of right hooks can be minimized by creating a protected bicycle signal phase and providing right turn lanes for vehicles (NACTO, TAC and CoV). Adequately sized waiting areas for bikes as required by FGSV can be achieved through two-stage left turns with protected waiting areas as recommended by TAC or advance stopping areas for people on bikes as suggested by the CoV.
- Traffic guidance for bike traffic that is easy to understand for all road users can be accomplished through signage and green paint at conflict zones (NACTO, CoV), which is likewise specified by FGSV.
- Regarding bus stops, all guidelines state a preference for running cycle tracks behind them whilst ensuring visibility between transit users and cyclists and clearly marking the bikeway.
- Lane width requirements are also similar in the TAC guidelines (minimum requirement 2.7 m) and the RASt (minimum requirement 2.75 m), with target widths of 3.0 m – 3.5 m, depending on traffic volumes and bus or truck usage (NACTO, TAC, RASt).

Figure 23 - Major intersection, protected design (NACTO 2013)

This rough comparison shows that the suggestions and guidance for the design of protected bike lanes that were developed in a North American context can complement German bike lane standards. They can provide basic guidance for German cities until protected bike lanes are integrated into the ERA and, moreover, promote the development of the latter.

6.2 Comparison of determining factors of protected bike lanes on commercial high streets in Vancouver and Berlin

The primary goal of building protected bicycle infrastructure on commercial high streets is to make use of the economic, social, and environmental benefits of an increased cycling mode share amongst people of all ages and abilities while improving road safety and efficiency. In order to determine approaches for implementation of protected bike lanes on commercial high streets in Berlin, relevant contrasts between the two cities are highlighted in this chapter.

6.2.1 Motivation to build protected bike lanes on commercial high streets

As mentioned earlier, protected bike lanes on a commercial high street in Berlin are being planned in the district of Neukölln, on Karl-Marx-Straβe between Hermannplatz and Weichselstraße. The section is subject to a major reconstruction that is, however, not due until 2026. Improved accessibility of destinations along the street, a current high bicycle volume despite dangerous conditions, and a lack of cycling infrastructure on adjacent streets are amongst the reasons to test the concept of a protected bike lane on this street (Netzwerk fahrradfreundliches Neukölln 2017). A general motivation to implement protected bike lanes in Berlin originates from current safety and misusage issues of bicycle infrastructure, as well as their spatial, political, and economic potential.

Figure 24 - Rendering of suggestion for a temporary protected bike lane on Karl-Marx-Straße (Netzwerk fahrradfreundliches Neukölln 2017)

Figure 25 - Cross-section of suggestion for a temporary protected bike lane on Karl-Marx-Straße (Netzwerk fahrradfreundliches Neukölln 2017)

Prevalent types of bicycle infrastructure in Berlin are structural bike paths and painted bike lanes. Problems on bike paths arise mostly through conflicts with pedestrians that use the sidewalks aside, as well as limited visibility of cyclists by moving motorized traffic at intersections and driveways. Besides that, the surface is often disrupted by emerging roots of roadside trees which creates additional challenges for the safety and maintenance of those bike paths (Bicycle infrastructure expert from Berlin 12/21/2018; ADFC 2018, p. 9). Painted bike lanes – advisory lanes and cycle lanes - on the other hand, have different deficiencies: Cyclists using them are exposed to doorings of parked vehicles and overtaking with insufficient distances by moving traffic, especially in curves or at critical points. This impedes both, their actual and perceived safety (ADFC 2018, p. 9; Blass et al. 2018, p. 2; Bicycle infrastructure expert from Berlin 12/21/2018). Another issue of painted bike lanes and a major driver to build protected bike lanes is that they are often being abused for vehicle parking (ADFC 2018, p. 8; Blass et al. 2018, p. 2). There is a high demand for parking in Berlin in areas with residential usage and in such that are being densified. This has been intensified since requirements to provide parking spaces for new buildings were abolished after the German reunification, says the Bicycle infrastructure expert from Berlin who was interviewed for this paper (12/21/2018). Meanwhile, controlling the illegal

parking through police and the public order office has been made difficult through the scale of the problem (Bicycle infrastructure expert from Berlin 12/21/2018).

Figure 26 - Structural bike path at Schönhauser Allee in Berlin, photo by Neumann (Scherff 2019)

Beyond solving the aforementioned problems, the implementation of protected bike lanes in Berlin is considered because of their spatial properties of increased road safety, accessibility of commercial and residential destinations on commercial high streets, as well as a high level of functionality and feasibility (Bicycle infrastructure expert from Berlin 12/21/2018; ADFC 2018, pp. 6–7; Blass et al. 2018, p. 2). The latter result from the positioning of protected bike lanes on the curbside of the road. This implies the presence of a high-quality road surface, a fast implementation with low resource costs that can also favour pilot or interim projects, easier maintenance in winter than bike paths, and a high flexibility regarding adaptions to changing demand and a varying center lane usage (Bicycle infrastructure expert from Berlin 12/21/2018; ADFC 2018, pp. 6–9).

In addition to planning considerations regarding different bicycle infrastructure types, there is a high public demand for bike lanes that are separated from motor vehicle traffic. 34% of respondents in a survey by Sinus (2017, p. 140) indicated that they would like to cycle more than they currently do. However, 47% also said they do not feel safe when biking. As one of the main reasons for it, 70% of those feeling unsafe named the lack of protected cycling infrastructure (Sinus 2017, p. 72). Hence, there is a broad public demand for more protected bicycle infrastructure. It is being expressed through multiple organizations, of which one created international attention: The Berlin initiative *Volksentscheid Fahrrad* proposed a bicycle law for Germany and collected more than 100,000 signatures in less than four weeks for it. They explicitly demanded more separated bicycle infrastructure, following the example of the Netherlands, Denmark, and the USA (Birkholz 2016). As a consequence, the *Berlin mobility law*[12] as the first law in Germany to include a section about cycling (see MobG BE section 3) became effective two years later (Volksentscheid Fahrrad n.d.). It was developed by the newly established *mobility council*[13] that is composed of members of advocacies, the senate, and parliamentary representatives (Senatsverwaltung für Umwelt, Verkehr und Klimaschutz

[12] German title: '*Berliner Mobilitätsgesetz'*
[13] German title: *'Mobilitätsbeirat'*

n.d.). The law prioritizes sustainable and active modes of transportation before individual motorized traffic and, amongst other regulations, sets protected bike lanes as the preferred solution for main streets (Neumann 2018). 62% of Berlin citizens and even 50% of car drivers are in favour of the new law (Birkholz 2016). Hence, there is not just a broad public demand for more protected cycling infrastructure, but it is also supported by legislation, the senate in Berlin, and the *German Cyclists' Federation* (ADFC) with its over 175,000 members (Bicycle infrastructure expert from Berlin 12/21/2018).

Besides the public interest in protected bike lanes, they are also an interesting option for planners, project managers, and decision-making entities due to their advantageous cost-benefit ratio. Even though there are no KPIs available yet, they are eventually expected to be the cheapest option for bicycle infrastructure because of low installation costs and effort and the prevention of costs for illegal parking enforcement (ADFC 2018, pp. 6, 9; Bicycle infrastructure expert from Berlin 12/21/2018; Blass et al. 2018, p. 2).

6.2.2 Challenges for protected bike lanes on commercial high streets in Berlin

In order to assess the transferability of approaches to implement protected bike lanes on commercial high streets in Vancouver to the Berlin context, it is important to gain insights into the main challenges for these projects in Berlin. These mainly refer to limitations of road space in Berlin, design challenges, and political challenges on various levels.

Since protected bike lanes require slightly more space than bike lanes adjacent to parking without a physical separation (+ 0.25 m) and about one more meter compared to painted bike lanes, their feasibility is challenged where street widths are insufficient (Senatsverwaltung für Umwelt, Verkehr und Klimaschutz 2018; Blass et al. 2018, p. 2). On commercial high streets, this can be aggravated where parking provision is imperative to accommodate disabled parking spots and business loading and delivery that is sometimes not possible from other streets. Besides that, just like in Vancouver, the removal of parking spots is a highly politicized issue (Bicycle infrastructure expert from Berlin 12/21/2018). In the example of Karl-Marx-Straβe, there is a night bus line that adds additional space requirements. Maintaining or improving the quality of public transit is especially important to reduce car dependencies and volumes (Bicycle infrastructure expert from Berlin 12/21/2018), just like in Vancouver. For 65% of people in Germany the option to take a bike on transit is important (Sinus 2017, p. 137).

Beyond that, additional design challenges include a road accessibility for buses, transit users, pedestrians and fire rescue services; visibility at intersections and driveways; safety in general at intersections; damage to and the aesthetic quality of physical separations; and the novelty of the infrastructure that comes along with a lack of design standards (Bicycle infrastructure expert from Berlin 12/21/2018; Senatsverwaltung für Umwelt, Verkehr und Klimaschutz 2018; Blass et al. 2018, p. 2). A possible solution to space requirements for rescue services is to make protected bike lanes available and suitable for rescue service vehicles in case of an emergency, as exercised in Vancouver. To ensure the safety of cyclists on protected bike lanes, the visibility between cyclists and motorized traffic must be ensured at conflict zones like driveways and intersections. This can be accomplished by keeping them clear of parking which, on the downside, reduces parking spots and interrupts the protected bike lanes, making them somewhat less effective. Therefore, the senate does recommend the introduction of protected bike lanes on street sections with a low number of driveways and interruptions as well as at locations where cyclists are likely to abruptly swerve left, or in curve

situations where car drivers tend to cut corners (Senatsverwaltung für Umwelt, Verkehr und Klimaschutz 2018).

Next to the aforementioned requirements of road safety and accessibility, the design of protected bike lanes, including vertical dividers, should also satisfy needs of durability and aesthetics. Red and white bollards are predominantly planned as separation elements for protected bike lanes in Germany. They are surely amongst the least space intensive partition options. However, some versions are also amongst the least durable. Deliberately or accidentally damaged bollards can be a challenge regarding their maintenance and a safety hazard. Hence, their design and set-up is decisive for the perception of their quality and eventually their service life (Bicycle infrastructure expert from Berlin 12/21/2018). Moreover, the aesthetics of the bollards have been questioned repeatedly (Blass et al. 2018, p. 2; Bicycle infrastructure expert from Berlin 12/21/2018).

Figure 27 - Protected bike lanes with red and white bollards on Holzmarktstraße in Berlin (Prösser 2018)

Other major challenges regarding the implementation of protected bike lanes on commercial high streets in Berlin are of political nature. This includes factors of legislation, public consent and change perception, decision-making, and operation. First of all, while the new mobility law in Berlin prescribes a prioritization of cycling and other sustainable modes of, it is not very specific about a reduced priority for parking. This, and the reliance on federal or provincial legislation, formalized liabilities, and high planning standards, is obstructive for the implementation of protected bike lanes (Bicycle infrastructure expert from Berlin 12/21/2018).

Such is the current lack of experience with the new facilities, which farther lessens the trust towards planners (Bicycle infrastructure expert from Berlin 12/21/2018). In Berlin, too, the negative perception of planned changes and a general change aversion affects these projects. The car is still seen as one of the main means of transport by many people, together with transit and walking (Bicycle infrastructure expert from Berlin 12/21/2018), which fuels debates around road space re-allocations. Showcase projects and KPIs could support the change management, but they are not yet sufficiently available in a Berlin and Germany context. Further on, consent is not just required amongst the broad public, but also within politics. The decision-making and approval process for infrastructure projects involves the central administration, districts, and road authorities, and is therefore quite complex. Variabilities of

political dominance in the different districts complicate the attainment of a political consent additionally (Bicycle infrastructure expert from Berlin 12/21/2018).

6.2.3 Differences and similarities between determining factors in Vancouver and Berlin

This brief depiction of the most prominent motivations and challenges to build protected bike lanes on commercial high streets in Berlin gives hints on some decisive differences between Vancouver and Berlin. For the purpose of assessing the applicability of the approaches determined for Vancouver, some further information is being presented below. Besides that, some of the findings of the SWOT analysis for Vancouver hold true for Berlin, too, because they are generally accepted concepts or sufficiently supported by research. On the other hand, some outcomes are relatively specific to Vancouver without there being equivalent information available for Berlin within the scope of this project. These are labelled as '*n.a.*' in *Table 11*.

To enable better comparability with the previous findings, the same structure of categories and sub-categories as within the SWOT analysis for Vancouver is used. However, it must be taken note of the different degrees of scientific objectivity between the two settings. Due to the scope and focus of this paper, only one expert from Berlin was interviewed and a more superficial literature analysis conducted. This leads to a higher underlying subjectivity of the findings for Berlin. Nevertheless, they promote a basic understanding of the situation there that allows drawing conclusions about appropriate strategies.

As indicated above, some of the named differences between Vancouver and Berlin require a better grasp of respective cycling cultures and related issues: The image of cycling is essentially distinct in both settings. The current perception of cycling in Vancouver as an athletic activity for wealthy, white people, was described earlier. In Berlin, on the contrary, cycling is seen as a more casual everyday mode of transport which manifests in higher usage of the bike for shorter trips in Berlin and a wider distribution of cycling among demographics in Germany. According to a survey by Sinus (2017, p. 42), the majority of people in Berlin use their bike for short trips or running errands (75%), leisurely biking (58%), or trips to leisure activities (54%). 'Only' 32% use it for commuting. In Vancouver on the contrary, the mode share of biking is higher for commuting (6%), than for recreational activities (4%) and shopping (3%, TransLink 2013, p. 43). It is a trend in North America that cycling is first and foremost growing as a means of commuting, but not as much as an everyday means of transport. In the US, the cycling mode share for commuting increased by 51% between 2000 and 2016 (League of American Bicyclists 2017, p. 2), while the overall growth of cycling is usually lower than that. Besides trip purposes and mode share figures, demographic patterns give information on cycling perception and safety. The share of women amongst cyclists, for example, is considered an indicator for the safety and utility of a city's bicycle network (Baker 2009). In North American cities, men's cycling trips "[…] surpass women's by at least 2:1", which also applies for the Metro Vancouver region (TransLink 2011, p. 19). In Germany, the share of people of all ages cycling frequently is only slightly higher amongst men than women (37% vs. 33%), indicating a higher safety perception and familiarity with biking in general (Bundesministerium für Verkehr und digitale Infrastruktur 2018, p. 92).

Even though biking is more widespread in Berlin, safety and network deficiencies are still a barrier for many cycling trips there. The importance of physical separation of bikeways throughout the entire cycling route, however, seems to have a greater significance in Vancouver due to the different perception of cycling. After all, the actual traffic safety is interconnected with the cycling culture. Traffic fatalities are twice as high in Vancouver than in Berlin (City of Vancouver 2018, p. 35). This could

be explained through the phenomenon of *safety in numbers* or the more advanced cycling safety education in Germany, being incorporated into the school system and a prerequisite for obtaining a drivers' license. This also reduces barriers that are non-infrastructure related in Berlin such as the lack of knowledge on how to ride a bike. Furthermore, bike ownership is higher in Berlin than it is in Vancouver, with 75% of people in Berlin owning one or more bikes (Bundesministerium für Verkehr und digitale Infrastruktur 2018, p. 40) and only 56% of people having a bike in their household in Vancouver (Winters et al. 2018, p. 8). Besides bike ownership, access to bikes is also easier in Berlin due to a more developed bike sharing system and a higher circulation of casual and affordable bikes for purchase. Bike theft was repeatedly mentioned as a major barrier to cycling in Vancouver, but has, in this research not appeared to be an issue. Looking at the numbers, though, reveals that bike theft is actually higher in Berlin than in Vancouver. In Germany, Berlin is the city with the highest rate of bike theft. 0.85% of people had a bike stolen there in 2017 (GDV 2018). In comparison, 2,199 bikes were stolen in Vancouver in 2017 (Griffin 2018), which with a population of 632,602 in 2017 (Population of Vancouver 2018 2017), makes for only 0.34% of people that had a bike stolen that year. Nevertheless, a lack of bike parking is a barrier to making trips by bike for 14% of people surveyed in Berlin (Sinus 2017, p. 52), and for 10 % of potential cyclists and 15% of regular cyclists in Vancouver (NRG Research Group 2009, p. 5). Although the latter number for Vancouver might be a bit outdated, bike theft seems to be an issue of similar significance in both cities.

The information previously presented on the differences and similarities regarding the determining factors for the implementation of protected bike lanes on commercial high streets in Vancouver and Berlin is summarized in *Table 10* below.

Table 10 - Major differences and similarities of determining factors between the Vancouver and Berlin context

Category	Vancouver	Berlin
Economic		
Economic vitality	Opportunity for increased economic vitality and local business revenues	
Political		
Transportation strategy	Cycling uptake as major strategic city priority; promotion through a specifically formed advisory council	
	Lack of push measures	n.a.
Existing demand	Existing public demand for protected bike lanes on commercial high streets; potential of road space re-allocation according to demand for all modes	
	Overestimation of parking requirements and underestimation of cycling mode share, possibly skewed demand representation	**High demand for parking**
Public and political consent	Increase of public and political consent through appropriate public engagement and change management	
	Increase of public consent through realized projects, but lack of public consent still disruptive; City Council constellation seems to be no major burden	**Complexity of decision-making processes obstructive for political consent, public majority supportive**
Public engagement	Suitability of infrastructure for all stakeholders through public engagement that is to be applied appropriately to avoid unsatisfying results, project delays, and mistrust in planners and engineers	
By-laws and policies	Fragmented and outdated policies and by-laws	**Higher requirements regarding liabilities and design standards**

Category	Vancouver	Berlin
Representation	Misrepresentation of demographics and businesses in public engagement and decision-making	n.a.
Socio-cultural		
Change perception	Fear of change and change reluctance	
Image of cycling	Promotion of cycling as a safe, easy and accessible everyday mode of transport through protected bike lanes on commercial high streets	
	Lack of public identification with cycling culture that is currently predominantly seen as an activity for male, athletic, white, and wealthy people	**Cycling as a risky everyday mode of transport that is hard to access by some population groups**
Social connectedness	Increased opportunities for social interaction fosters a sense of community	
Socio-economic		
Inclusion	Improvement of transportation affordability and social equity; association with gentrification	
	Economic barriers to bikes and cycling knowledge existent for many people	**Easy access to affordable bikes; most cycling barriers are infrastructure related**
Poverty	Poverty as a large contributor to bike theft	**Bike theft as organized crime**
Structural		
Accessibility	Opportunity to increased citizen mobility and accessibility of destinations, but also existing car dependencies and curb access as a design challenge	
Planning know-how	Challenges through the experimental phase of protected bike lanes as a new type of infrastructure, especially on commercial high streets, however, learning opportunities through pilot projects and interim solutions	
	Development of guidelines specific to Vancouver based on practical experiences and experiments; compatibility issues of current city guidelines	**No significant practical experiences, however, knowledge exchange with North America**
Bicycle network	Commercial high streets as a suitable expansion of bicycle network, however, other gaps in city-wide bicycle network detrimental for general cycling uptake	
	Importance of uninterrupted physically separated bikeways throughout the network to get people started with cycling	**Importance of physically separated bikeways to alleviate critical points and illegal parking, and improve safety so that people cycle more**
End-of-trip facilities	Lack of end-of-trip facilities as cycling barrier	
Multimodality	Realization of bike-transit synergies through protected bike lanes and commercial high streets as transit hubs, limitations for bike transport on public transit vehicles	
	Deficiencies in the transit network and bike sharing system	**Bike transport at an additional cost**
Multifunctionality of commercial high streets	Design challenges and project complexity through a multitude of stakeholders and their interests	
	n.a.	**Additional complexity through residential usage on commercial high streets**
Public space quality	Enhancement of public realm quality and liveability	

Category	Vancouver	Berlin
Road safety	Safety at intersections and conflict zones as a design challenge, but increased road safety through protected bike lanes for all road users	
	Awareness and respect for vulnerable road users	**Cycling safety education part of the school system and a prerequisite for drivers' license**
Transport efficiency	Opportunity to provide relief on urban transportation system; however, effectivity can be impaired by lack of transit promotion; inconveniences for car users possible	

6.3 Approaches for the implementation of protected bike lanes on commercial high streets in Berlin

After characterizing the known differences and commonalities between Vancouver and Berlin, conclusions about the applicability of results from earlier chapters can be drawn. Due to distinct depths of underlying data for both cities, the substance of findings for recommended actions in Berlin is not as high and should be verified through a more thorough analysis of the local strengths, weaknesses, opportunities and threats. Nevertheless, this paper provides an overview of possible actions for the implementation of protected bike lanes on commercial high streets and demonstrates the profundity and diversity of project determinants and potential outcomes.

6.3.1 Major differences and similarities between determinants in Vancouver and Berlin

Table 10 provides a rough overview of relevant differences and similarities between Vancouver and Berlin regarding the implementation of protected bike lanes on commercial high streets. Due to broad research support, some of the statements that were determined in the Vancouver context can be regarded as universally valid and thus concern Berlin, too. Besides, there are other similarities between the two cities. It is notable that the favourable attributes and opportunities in both cities are in greater conformity than the disadvantages and challenges. Inversely, some of the challenges for Vancouver do not appear to have an equal potential for disruption in Berlin and vice versa. The most outstanding differences and similarities of determinants for protected bike lanes on commercial high streets between Vancouver and Berlin are listed below:

Determinants for Berlin with limited relevance for Vancouver

- High political and legal complexity of planning and decision-making
- High actual demand for vehicle parking
- No existence of relevant showcase projects or experiences

Determinants for Vancouver with limited relevance for Berlin

- Lack of public identification with cycling culture
- Economic and educational barriers to cycling for parts of the population
- Deficiencies in the bike sharing system

Relevant determinants for both cities

- Importance of public and political consent, but opposing interests of and between various stakeholder groups

- High demand for protected bike lanes on commercial high streets and expected effectivity regarding an increase in cycling mode share
- Design challenges for the safety of intersections and conflict zones

The differences and similarities between the determining factors in the two cities can inform the transferability of the earlier formulated approaches for Vancouver to Berlin.

6.3.2 Approaches relevant for Berlin

The applicability of the Vancouver approaches to Berlin will be assessed by determining their relevance for Berlin based on the previous findings. Approaches for Vancouver that are linked to those aspects that were found or assumed to be similar between the two cities, for example, could be similarly applied in Berlin. The respective level of relevance for each of the approaches from earlier on is displayed in *Table 11* below. Even though approaches are relevant for both settings, the extent of efforts and investments to put them into practice might vary as a result of different local premises. A more thorough analysis of the strengths, weaknesses, opportunities and threats in Berlin could help to identify these. In other cases, more detailed information on the Berlin context is required to determine the applicability of the respective approach. These are assigned to the '*n.a.*' category.

Table 11 - Relevance of key approaches for Vancouver to the Berlin context

Key approaches for Vancouver		Relevance for Berlin		
Approach		Limited	n.a.	High
Planning and design				
1	Capture and center existing transportation needs of all citizens in decision-making, planning, design, and advocacy			●
2	Safe and accessible design of infrastructure			●
3	Prioritization of transit within commercial high street design		●	
4	Utilize the power of quick and cheap pilot projects			●
5	Research and consider the potential of e-bikes and cargo bikes			●
6	Development of design standards for protected bike lanes and intersections			●
Public engagement				
7	Apply appropriate public engagement strategies		●	
8	Ensure accurate representation of and within all stakeholder groups		●	
Public outreach, education, and empowerment				
9	Educate about cycling usage, benefits and infrastructure		●	

Key approaches for Vancouver		Relevance for Berlin		
Approach		Limited	n.a.	High
10	Display cycling as an easy, affordable, and safe everyday mode of transportation for everyone	●		
Citizen empowerment				
11	Empower cycling by promoting access to bikes and related skills	●		
12	**P**rovide essential safety training for drivers	●		
Legal and strategic frameworks				
13	Update existing cycling by-laws	●		
14	Increase push-measures		●	
Additional investments				
15	Provision of end-of-trip facilities			●
16	Enhance bike-transit integration and expand transit services			●
17	Improve public spaces and pedestrian facilities		●	
18	Expand bike sharing services	●		
19	Map and address other deficiencies in the cycling network			●
20	Reduce poverty and homelessness	●		

6.3.3 Additional approaches

There appear to be challenges in Berlin that were not found to be as relevant for Vancouver. Hence, additional considerations for Berlin should be appraised:

Approach 21: Resolve challenges of high political and legal complexity of planning and decision-making

As described earlier, the political environment in Berlin is somewhat heterogeneous which impedes decisions on bicycle infrastructure in different districts and challenges a unified approach across the city. Especially during election years, the political diversity can have a disruptive impact on transportation projects. Besides that, the decision-making process itself comprises an involvement of various entities, creating additional complexity for transportation projects. To improve this situation in the long-term, a thorough analysis of the current situation could be conducted and methods of resolution deduced thereof. This research should include the dependence of transport planning developments in Berlin on city politics, as well as an evaluation of successful set-ups of decision-making-processes in this regard while taking advantage of the variety of knowledge and abilities of all involved entities due to their roles. In the short-term, however, additional approaches should be

considered. There are parallels to some of the approaches in Vancouver: *Approaches 7* and *9* can be applied to promote a common understanding of the project undertakings and enhance the objectivity of decision-making. The legal complexity of transport planning could be mitigated through the provision of adequate design guidelines, as briefly described in *approach 23*.

Approach 22: Address high demand for vehicle parking

In contrast to Vancouver, where the perception of parking demand differs greatly from the actual demand, there is high pressure for parking spots in Berlin. In the long-term, the principle of induced demand suggests that some of those issues can be resolved by reducing car dependencies through road space re-allocations that enable a provision of sufficient sustainable transport alternatives. However, short-term solutions are vital to avoid major traffic disruptions and preserve political patronage for transportation strategies in place. Some ideas are to focus on parking on side streets and reduce parking on main streets to the necessary minimum. Potential negative effects of curbside parking on traffic arteries for traffic flow could be reduced in this way, too. Parking space that is preserved should be predominantly dedicated to disabled parking, deliveries and loading, and pick-up and drop-off zones (Bicycle infrastructure expert from Berlin 12/21/2018). Alternative parking could also be provided collectively through the establishment of parking garages. In this case, questions of funding and urban space quality arise (Bicycle infrastructure expert from Berlin 12/21/2018). Analyses of parking demands and patterns along with their originating needs could provide insights into suitable quantities and locations for parking supply. This could be supported by incentive models for residential parking provision through developers and property owners.

Approach 23: Promotion of experiences with protected bike lanes and planning guidelines

Even though the status quo of protected bike lanes is different in Vancouver and Berlin, similar approaches can be applied to promote experiences with protected bike lanes and planning guidelines. *Approaches 4* and *6* can be part of the solution to the lack of experiences with protected bike lanes in Berlin. At the moment, there are no significant showcase projects or experiences with protected bike lanes in Berlin or even Germany. Protected bike lanes as a basic design element for German roads have yet to be tested and evaluated (ADFC 2018, p. 7). Therefore, an implementation of first high-quality projects at suitable locations is important to gain momentum. These provide a learning opportunity by collecting pre- and post-implementation data as well as surveying user satisfaction. In Berlin, protected bike lanes on Hasenheide are currently being implemented to demonstrate this type of infrastructure and create a familiarity to help in future discussions. Once implemented, the planned protected bike lanes on Karl-Marx-Straβe could be amongst the first projects for protected bike lanes on commercial high streets in Germany. Subsequently, findings and experiences from these projects can be used when incorporating protected bike lanes into the ERA (ADFC 2018, p. 7). The provision of well-grounded design guidelines that are in accordance with legal and normative prerequisites then could also accelerate future planning processes.

7. Future research recommendation

Throughout the course of this paper, suggestions for future research were mentioned. *Table 12* provides an overview of these recommendations and their relevance for Vancouver and Berlin. Fields marked '*n.a.*' mean that research has already been conducted or is considered not necessary according to the findings of this work.

Table 12 - Recommendations for future research for Vancouver and Berlin

Research recommendation	Vancouver	Berlin
Determination of transportation needs: Motivations for individual mode choice, incentives and barriers to use sustainable means of transportation, car usage and parking patterns and requirements, etc.	●	●
Analysis of patterns, requirements, and potentials of multimodal transportation	●	●
Analysis of the potentials and prerequisites of e-bikes and cargo bikes	●	●
Projections of long-term transportation scenarios resulting from different road space allocations	●	●
Analysis of the strengths, weaknesses, opportunities, and threats of protected bike lanes on commercial high streets	*n.a.*	●
Continuing tests of different technical designs of protected bike lanes and intersections if necessary	●	●
Identification of best practices for the construction of protected bike lanes via project pre- and post-implementation data, if they are built on streets other than commercial high streets	●	●
Collection and comparison of pre- and post-implementation data of protected bike lanes on commercial high streets, including effects on local businesses, cycling usage, and road safety	●	●
Identification of tangible benefits of protected bike lanes on commercial high streets that are accessible to the public; including effects on social connectedness; socio-economic inclusion; urban space quality; personal benefits including convenience, travel times, and transportation costs; individual environmental footprints; and the urban transportation system efficiency	●	●
Options and cost-benefit analysis of incentivizing existing car drivers to undergo a cycling safety awareness training	●	*n.a.*
Cost-benefit analysis of providing free bicycle transport in urban transit	*n.a.*	●
Analysis of the impact of city politics on urban transportation development	*n.a.*	●
Evaluation of successful set-ups of decision-making-processes, considering the variety of knowledge and abilities of all involved entities due to their roles	*n.a.*	●

8. Conclusion

Protected bike lane projects along with evidence for their positive effects are continuously increasing. Especially in North American cities, they are a popular tool to enhance cycling numbers, road safety and public health, as well as environmental, social, and economic aspects. An analysis of qualitative data from Vancouver has shown that an implementation of protected bike lanes on commercial high streets can have additional benefits beyond that: International and local research confirms that local businesses can benefit from greater footfall and sales through a pleasant public realm attracting visitors; higher efficiency of road space allocation; and increased accessibility and mobility for a variety of people and mode users. The latter also enhances social equity which is crucial in rapidly growing cities like Vancouver with a history of racial discrimination and existing socio-economic and urbanization challenges like homelessness, high living costs, a widening gap between rich and poor, and gentrification. As a result, increasing commute distances and other individual transportation needs also raise the importance of a functioning transit network. Synergies between biking and transit can be promoted through protected bike lanes on commercial high streets, which are often transit hubs and can provide a solution to the last-mile-problem and far cycling distances. Thereby reducing car-dependencies further increases the efficiency and sustainability of the urban transportation system, social connectedness, and also reduces stress amongst traffic participants. The existence and promotion of a comprehensive transit network and a provision of easily accessible bike share services are, however, also crucial in this regard. This can pose higher challenges in Vancouver than in Berlin, due to larger existing deficiencies of the transit network, a lower population density, the major city growth during times of mass-production of cars and an absence of private bike share operators.

When planning such projects, it is essential to also be aware of existing project challenges. An example identified in Vancouver is that groups like the indigenous population, minorities, low-income households or business owners appear to be occasionally misrepresented in decision-making processes. Besides, a barrier to cycling is that there are many people that cannot identify with the predominantly recognized cycling culture of white, male, wealthy and athletic cyclists utilizing special clothing and equipment. Even though there is a more casual cycling culture present, too, a large portion of those cyclists uses quieter side streets and stay invisible to the majority of road users.

A comparison between determining factors in Vancouver and Berlin indicated that the aforementioned risks and weaknesses have limited relevance for Berlin. The national cycling culture there is more widespread and self-evident than in North America. Nevertheless, there are safety deficiencies in the cycling network, that, just like in Vancouver, keep many people from cycling and make safer cycling infrastructure a necessity, especially on commercial high streets. A comparable typology in Germany is the so-called *main shopping streets*, combining the place function of local commercial usage, amenities and public spaces with the link function of accommodating high traffic volumes of various mode types. In both locations, there is sufficient demand for protected cycling infrastructure and a high suitability of commercial high streets for this purpose: Lots of people already bike on those streets although they are amongst the most dangerous streets for cyclists, lots of people want to bike more but feel unsafe, and lots of people need to access the destinations on commercial high streets. Besides, they are amongst the most direct and intuitive routes and usually feature good pavement and lighting as well as gentle grades.

When implementing protected bike lanes, road safety usually increases for all road users. The design must be of high quality, though, to avoid safety hazards at intersections and other conflict zones. This poses a challenge for both cities - more so for Berlin, due to limited experiences with this relatively

new type of infrastructure. Pilot projects, interim structures, and eventually the development of design guidelines are generally suggested approaches that are widely supported by a growing research base and international knowledge exchange. Even though most experiences to date are made in a North American context, general compatibility of internationally existing protected bike lane standards with German design standards and legal frameworks was found.

Another similarity between Vancouver and Berlin is the importance of public and political consent. The number of stakeholder groups - including business owners, visitors, road users of different modes, residents, the public sector, transportation authorities, and bicycle advocacies – creates a high complexity of such projects through partially opposing stakeholder interests. Even though achieving sufficient consent seems to be more challenging on a public level in Vancouver, but on a political level in Berlin, similar strategies can be deployed to an extent: The public should be consulted at an adequate level in decision-making processes, and an accurate representation of demographic needs shall be ensured. In addition, education and change management strategies can be effective in this matter, including a clear communication of project goals and backgrounds.

Besides these similarities, there are also issues that are primarily relevant to the Berlin setting. Higher population density, space restrictions, and usage-mixes create more pressure on the demand side than in Vancouver. This manifests in high demand for parking spots that requires additional solution strategies. Particular attention should also be paid to the higher political and legal complexity of planning and decision-making in Berlin.

In a slightly wider context, historic and recent developments of cycling projects in both cities have demonstrated the dependence of urban transportation planning on politics and electoral cycles. Political success is often assessed based on short-term results which can be detrimental to long-term strategies. Acting based on long-term thinking is crucial for sustainable city development, in conjunction with the consideration of existing transportation needs. These are not to be confused with existing transportation patterns. International evolutions, as well as the principle of induced demand, suggest that people eventually adapt to infrastructure changes despite a general aversion to change.

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Appendices

Appendix A - Comparison of North American and German design standards relevant for bike lanes protected from vehicle traffic

Guideline / Properties	NACTO Urban Bikeway Design Guide/ Urban Street Design Guide[14]	TAC Geometric Design Guide for Canadian Roads[15]	City of Vancouver Transportation Design Guidelines for All Ages and Abilities Cycling Routes[16]	FGSV Recommendations for cycling facilities/ RASt[17]
Applicability	• Streets with high parking demand and turnover • High traffic volumes and speeds • Streets with high bicycle volumes	• Traffic speeds from 30 km/h – 80 km/h	• Routes where low motor vehicle volumes are not possible to achieve	• Selection of bicycle facility type according to vehicle volumes, speeds, and road usage
Design bike lane width for comfortable passing (unidirectional)	~ 2.15 m (9 ft)	• Recommended range 1.8 – 2.5 m • Practical lower limit 1.5 m • Depending on bicycle volume and width of maintenance equipment	Preferred minimum of 2.5 m	• 2.0 m recommended for bike paths • 1.6 m for bike paths when limited space or low bicycle volumes • Larger widths for high bicycle volumes sidewalk usage, or grades • Min. 1.85 m for painted bike lanes, recommended 2.0 m (including markings)
Design bike lane width for comfortable passing (bidirectional)	• ~ 3.6 m (12 ft)	• Recommended range 3.0 – 3.6 m • Practical lower limit 2.4 m	• Preferred minimum of 3.0 m	• 3.0 m recommended for bike paths • 2.5 m for bike paths when limited space or low bicycle volumes •
Clearance from vertical obstructions/ buffer width	• ~ 0.9 m (3 ft) buffer from parked cars	• Recommended range for delineator width 0.3 – 1.0 m • Delineator width min. 0.6 m when adjacent to parking • 0.2 m to obstructions between 100 mm and 750 mm high	• required	• 0.25 m from buildings, fences, trees, traffic and other installations • Buffer width to moving vehicle lane 0.5 m • 0.75 m to moving traffic where there are fixed installations or high traffic volumes

[14] NACTO 2012, 2013
[15] Transportation Association of Canada 2017a, 2017b, 2017c
[16] City of Vancouver 2017a
[17] FGSV Translation 2012, 2007

Guideline / Properties	NACTO Urban Bikeway Design Guide/ Urban Street Design Guide[14]	TAC Geometric Design Guide for Canadian Roads[15]	City of Vancouver Transportation Design Guidelines for All Ages and Abilities Cycling Routes[16]	FGSV Recommendations for cycling facilities/ RASt[17]
		• 0.5 m to obstructions greater than 750 mm high		• 0.75 m to parking parallel to roadway
Moving motor vehicle separation	• Parking or vertical separation elements (e.g. delineators, barriers, raised curbs, bollards, planters, signs)	• Delineators: flexible bollards, parking stops, planter boxes, concrete barriers, raised medians, depending on type and speed of adjacent lane • Parking functions as delineator where complementary beyond delineator		• No bike lane type with physical separation from vehicles and pedestrians at the same time • Separation from motorized traffic via bike paths
Pedestrian separation			• The type of separation can vary and could be a landscaped buffer, a bevelled curb, or a painted line depending on context.	• No bike lane type with physical separation from vehicles and pedestrians at the same time • Curb or median strip separate sidewalks from curbside (painted) bike lanes •
Marking	• Bicycle lane word, symbol, and/or arrow markings			• Clear marking of bikeways required on lanes and crossing areas according to ZTV M • Green paint at conflict zones • Red surface paint over the length of the bike lane, should not negatively impair traction • Consistency within city
Intersection design	• Manage intersection and curbside conflicts with transit boarding islands, protected (bend-out or offset) intersection designs, signal phasing, and other turn	• Protected bicycle signal phase • Two-stage left turns, waiting areas more physically protected than bike boxes at protected intersections • When buffered by parking, bike lane	• Right turn lanes for motor vehicles • Separate motor vehicle turn and through bike signal phases at complex intersections or where there are	General principles: • Ensure visibility between bicycle traffic and other road users • Adequately sized waiting areas for bikes • Traffic guidance for bikes easy to

Guideline / Properties	NACTO Urban Bikeway Design Guide/ Urban Street Design Guide[14]	TAC Geometric Design Guide for Canadian Roads[15]	City of Vancouver Transportation Design Guidelines for All Ages and Abilities Cycling Routes[16]	FGSV Recommendations for cycling facilities/ RASt[17]
	management strategies • Prohibit parking near intersections to improve visibility (distance: 9 m)	should bend to be immediately adjacent to general purpose travel lane at intersection	• high turn volumes (>150/hr across unidirectional lanes) • Green coloured treatment and elephants feet at street crossings • Advance stopping areas to increase the visibility of people biking and help accommodate bike turns	understand for all road users • Fast and secure passing of intersections • Prioritize risk minimization of right hooks • Signalling should enhance acceptance by cyclists
Traffic lane width	• ~ 3 m (10 ft) recommended in urban areas • Minimum 2.8 m • Lanes greater than ~3.35 m (11 ft) should be used only for bus or truck lanes (one per direction, the wider lane should be outside lane)	On urban roadways 60 km/h and less: • Practical lower limit 2.7 m • Recommended width 3.0 m – 3.7 m • Practical upper limit 4.0 m	n.a.	• Minimum 2.75 m • Recommended 3.0 – 3.5 m • For bus lanes min. 3.25 m
Parking lane width	• ~ 2.15 - 2.75 0 m (7 – 9 ft)	• Generally 2.4 m, unless used as a travelled lane during a portion of the day	n.a.	• 2.0 m for parallel parking • 2.5 m for angled parking • 2.3 – 2.5 m for delivery and loading
Transit stops	• Cycle track behind transit stop zone, bicycles should yield to pedestrians in these areas	• Routing bikeway behind transit stop (transit island), clearly mark bikeway crossing with pavement treatments and signage and improve sightlines near transit stops		• Cycle track behind bus stops suitable for curbside bike lanes, ensure visibility between transit users and bicycle traffic • For low street width, curbside lanes can be merged with sidewalks, or bike lane reduced to 1.0 m width

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