

Understanding and Mitigating Freight-Related Impacts from the West Seattle Bridge Closure

Anne Goodchild Giacomo Dalla Chiara Nota Goulianou Şeyma Güneş Urban Freight Lab September 2021 Sponsored by the Seattle Department of Transportation



SUPPLY CHAIN TRANSPORTATION & LOGISTICS CENTER UNIVERSITY of WASHINGTON Urban Freight Lab

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1 Introduction

1 INTRODUCTION

West Seattle (WS) is a part of the city of Seattle, Washington, but is located on a peninsula west of the Duwamish River. The West Seattle High-Rise Bridge serves as the primary connector between West Seattle and the rest of the city, carrying some 84,000 vehicles on average each day. [1] On March 23, 2020, that high bridge was suddenly closed to all vehicle traffic for safety reasons due to greater-than-expected structural deterioration. The high bridge is now being repaired with reopening planned for 2022 [2].

With the closure, vehicles have needed to take alternative routes to and from the peninsula, including the 1st Avenue South Bridge and the South Park Bridge, located some 2.1 and 3.4 miles south of the high bridge (see Figure 1). After the closure, the total number of available vehicle traffic lanes across the river dropped from 21 to 12, with eight lanes on the 1st Avenue South Bridge and four on the South Park Bridge [2]. Before the closure, drivers also used the two-lane Spokane Street Low Bridge under the high bridge to access West Seattle. But after the closure, low bridge use was initially (as of March 2021) restricted from 5:00 am to 9:00 pm to authorized vehicles only, including emergency vehicles, public transit, and 10,000+ pound gross weight freight vehicles [3].

Figure 1: Map of West Seattle bridges.



The unexpected high bridge closure disrupted passenger and freight mobility to and from WS, increasing travel times and creating bottlenecks on the remaining bridges. This has had negative impacts on the peninsula's economy, as well as its livability. Concerns also persist regarding the environmental and health impacts of traffic detours into Duwamish Valley neighborhoods that are already disproportionately impacted by air pollution and asthma [4]. As traffic demand increases with the gradual recovery from the COVID-19 pandemic, the negative impacts could worsen.

Notably, the timing of the high bridge closure coincided with the start of the pandemic and the resulting economic shutdowns and slowdowns that continue as of this writing. As such, it is difficult at times in this report to entirely disentangle the broader effects of the pandemic from the more specific effects of the bridge closure. This challenge surfaces especially in our interviews with study area businesses and with carriers performing deliveries and pick-ups in the study area: They report definite impacts, but it is not always clear how much of the impact stems from the bridge closure alone versus the bridge closure on top of the pandemic's myriad ripple effects.

That said, this study seeks to:

- Document the impacts of the high bridge closure on freight flow, businesses, and carriers.
- Understand current freight movements and quantify freight demand.
- Identify mitigation strategies for freight flow to/from WS, both during the bridge closure and beyond.

This report's study area covers 13 residential and industrial neighborhoods spanning both sides of the Duwamish Waterway (some on the WS peninsula, some to the east) and five port terminals. Within these neighborhoods, we solicited impacts from 19 businesses representing carriers, restaurants and supermarkets, retailers and service providers, and industry through interviews or online surveys, as well as from five neighborhood and local business associations. Overall, small food businesses and restaurant operations stand out as having seen heavy operational impacts by the concurrent bridge closure and pandemic—as well as heavy impacts on both goods supply and demand.

To aid in data-driven decision-making, we estimate the total number of commercial vehicle deliveries and pickups on a typical day in the study area generated by each of three building types: industrial, commercial, and residential. Through our modeling, we estimate that the buildings in the study area generate approximately 30,152 freight deliveries and pick-up trips per day, with the WS peninsula attracting overwhelmingly residential deliveries and pick-ups (representing fully 93% of all trips in the WS peninsula).

We offer a snapshot of the relative differences in bridge closure effects among study area neighborhoods using various measures. Six neighborhoods (North Admiral, Genesee, Alki, Seaview, Gatewood, and Fairmount Park) had both longer re-route time—the extra time needed to reach the neighborhood compared to when the bridge was open—and the largest share of deliveries and pick-ups to residential and commercial buildings. It's precisely these building types that attract deliveries and pick-ups from the vans and smaller commercial vehicles that as of this writing are not allowed to use the lower bridge.

And, finally, we offer possible short- and longer-term mitigation strategies for the freight challenges on the peninsula and the adjacent areas that serve it.

Notably, Seattle Department of Transportation (SDOT) work is already underway to improve access to and mobility around the peninsula, addressing broad traffic, transit, and livability issues in the "Reconnect West Seattle Implementation Plan" [1]. This report complements that work by highlighting freight issues specifically.

The appendix offers detailed statistics describing the study area and the estimation of the number of deliveries and pick-ups by neighborhood.



2

Study area

2 STUDY AREA

Figure 2 shows the study area, which comprised 13 neighborhoods located on the West Seattle peninsula and east of the Duwamish waterway and five port terminals.

The study area was divided into three macro areas: the west area (corresponding to the WS peninsula), the east area, and the port terminals. Table 1 lists the neighborhood names and terminal names in each macro area.

As shown in Table 2, which summarizes the main characteristics of each macro area, the east and west areas have radically different land use patterns. The west is mostly residential (86 percent of building area), while the east is mostly industrial (80 percent of building area). The study area contained 30,221 buildings.

The study area population totaled 101,231 people, of whom 99,072 (98 percent) lived on the WS peninsula. In addition to being the study area's most populated neighborhoods, Delridge and North Admiral were the largest land wise. The neighborhoods with the highest population densities were Fairmount Park, Gatewood, Genesee, and Alki, all located in the center-north of the peninsula. Additional neighborhood-level details are reported in Appendix 1.





Table 1. Study area neighborhoods and port terminals

AREAS	NEIGHBORHOODS AND TERMINALS
West	Alki, Delridge, Fairmount Park, Fauntleroy, Gatewood, Genesee, Industrial District West, North Admiral, Seaview, South Park
East	Georgetown, Harbor Island, Industrial District East
Port terminals	T-5, -18, -30, -46, -115

Table 2. Study area population and land use

STATISTIC		WEST	FAST	τοται
Land area (square miles)		14.5	5.5	19.90
Population		99,072.0	2,159.0	101,231.0
Population density (people per squ	uare mile)	6,857.0	369.0	5,087.0
Number of buildings		28,759.0	1,462.0	30,221.0
Percentage of building area by	Industrial	10.0%	80.2%	35.8%
land-use type	Public buildings	1.2%	11.0%	4.8%
	Residential	86.2%	4.94%	56.3%
	Commercial	2.7%	4.0%	3.1%

While this analysis deals with West Seattle, the selected neighborhoods to the east of the Duwamish Waterway are included both to capture congestion impacts in adjacent areas as drivers must re-route to access to the peninsula and because many warehouses that serve the peninsula are in these areas to the east (such as UPS, Amazon, and a large liquor wholesaler).



3

Bridge closure impacts

BRIDGE CLOSURE IMPACTS

3.1 Methodology

We sought to understand the operations of establishments receiving or delivering freight in the study area and document WS bridge closure impacts on those operations. To do this, we conducted 30-minute face-toface interviews via Zoom and ran an online survey with carriers making deliveries and pick-ups in the study area as well as businesses in the study area.

We structured interviews and surveys around these four areas:

- **Operations**, including freight trip generation and delivery methods.
- Impacts of the bridge closure on operations (comparing operations before/after the closure)
- Actions the business has taken to mitigate bridge closure impacts
- *Strategies* SDOT could take to mitigate bridge closure impacts.

We interviewed five neighborhood and business associations, listed in the box below. These groups helped us establish interview contacts with local businesses and helped distribute the online survey locally.

Business Groups and Associations	WS Junction
	WS Chamber
	Delridge Neighborhood Association
	Morgan Neighborhood Association
	Admiral Neighborhood Association

The 19 establishments interviewed or surveyed are listed in Table 3. These represent four business sectors:

- Carriers (food, beverage, and parcel carriers)
- Food establishments (restaurants and supermarkets)
- Retail and services
- Industry (port and manufacturers).

Table 3. Stakeholders interviewed/surveyed

ESTABLISHMENT TYPE	MET	THOD
	INTERVIEW (SAMPLE SIZE=12)	ONLINE SURVEY (SAMPLE SIZE=7)
Carrier	4 businesses: 1 parcel delivery, 1 beverage delivery and 2 food delivery carriers	2 businesses: 1 parcel delivery and 1 food delivery
Restaurant and super- market	5 businesses: 2 restaurants and 3 supermar- kets	2 businesses: 2 restaurants
Retail and services	1 business: 1 book store	3 businesses: 1 art center, 1 printing store -and 1 school
Industry	2 businesses: 1 port authority and 1 steel manufacturer	

3.2 Findings

3.2.1 BRIDGE CLOSURE IMPACTS ON RESTAURANTS AND SUPERMARKETS

IMPACT SUMMARY:

- While supermarkets did not report major changes, smaller food establishments like restaurants and cafes did report important delivery disruptions: canceled, delayed, and incomplete deliveries.
- To cope with these disruptions, small food establishments reported having to pick up goods themselves from supplier locations, relying on smaller vehicles, such as personal cars or business vans, to do so; having to move their supply delivery destinations to locations off the peninsula; and/or having to buy their supplies from local WS supermarkets.
- Businesses reported difficulties in retaining current employees and hiring new employees due to increased commute times.

Overall, interviewees blamed the pandemic for decreased consumer demand. One restaurant reported a 40 percent reduction in customers; one supermarket reported a notable drop in customers, too. While restaurants said their local WS customer base had held relatively steady during the bridge closure, they reported losing regular commuter customers who live off the peninsula and those who would otherwise visit WS on weekends or for special events due to much longer travel times to/from the peninsula. Interviewees connected bridge closure-related congestion to business impacts as they believe that WS residents who commute for work off the peninsula delayed their return trip home, opting to dine and shop off the peninsula as a result.

Due to lower demand, businesses that were still able to operate ordered lower volumes of goods. A carrier serving food establishments reported that several restaurants no longer served lunch and were open for dinner only.

The interplay of the concurrent pandemic and the bridge closure translated into big impacts on deliveries to small food establishments. The pandemic led to disruptions in some supply chains that resulted in shortened and incomplete deliveries (e.g., smaller delivered volumes than what was promised or missing items altogether). Additionally, decreased demand caused a reduction in shipment volumes.

Food establishments still needed frequent deliveries for things like bread, produce, pizza boxes, etc. But with the bridge closure increasing travel time to access WS, due to both increased access point congestion and commercial vehicle re-routing, carriers reduced delivery frequency and increased consolidation. As a result, food establishments experienced delivery delays (e.g., morning deliveries shifted to the afternoon or after closing times) and cancellations, disrupting their operations and potentially causing economic losses.

While smaller food businesses reported experiencing these delivery disruptions, supermarkets generally did not. One supermarket did report an increase in deliveries outside its normal receiving times (between 6:00 am and 2:00 pm) but with no major disruptions in the supply of goods.

Small businesses reported making several changes stemming from delayed and canceled deliveries. They started using their personal or company vehicles to pick up deliveries at the supplier site, mostly located outside WS. The travel time to pick up supplies off the peninsula was exacerbated by rerouting and increased congestion at access points since most small establishments did not own larger vehicles that could use the lower bridge.

They drove to local WS supermarkets to purchase goods: One restaurant reported that if it was not going to receive bread in time, employees usually drove to buy bread in bulk at a local supermarket.

Both restaurants interviewed reported often changing delivery destinations for some of their supplies from their WS stores to other store locations outside WS and using their vehicles to pick up those supplies.

Restaurants reported that special temporary lower bridge passes for smaller businesses' vehicles were beneficial. The WS Junction Association established a booking system for its six passes and noticed that 70 percent of pass users were restaurants.

3.2.2 BRIDGE CLOSURE IMPACTS ON RETAIL AND SERVICE

IMPACT SUMMARY:

- It was reported that, due to bridge closure-related longer driving times, service vehicles from outside WS and serving WS establishments sometimes refused to serve WS establishments.
- Both smaller and larger retail and service establishments reported difficulties in hiring new employees in the wake of increased commute time after the bridge closure.
- It was also reported that some smaller businesses lost non-WS resident employees.

3.2.3 BRIDGE CLOSURE IMPACTS ON CARRIERS

IMPACT SUMMARY:

- Decreased restaurant demand in the pandemic led to reduced delivery volume to food and beverage businesses on the peninsula, leading in turn to food and beverage carriers both delivering less frequently and consolidating their deliveries by delivering to more customers per route.
- In contrast, increased e-commerce demand in the pandemic meant rising parcel volume, leading parcel carriers to increase the number of routes serving the peninsula while the bridge closure and ineligibility to use the lower bridge led to mounting traffic delays at access points.

Food and beverage carriers reported a decrease in WS demand. One carrier reported restaurants closing, reducing delivery volumes, and limiting operations to one shift per day, usually no longer serving lunch. As such, one heavy goods carrier reported reducing its delivery frequency from five to four days a week.

Unlike the food and beverage carriers, one of the two parcel carriers interviewed reported an increase in demand from WS (because of the pandemic.) Between September 2019 and September 2020, the carrier reported a 50 percent increase in the number of truck routes entering the peninsula on a typical day. While the pandemic-triggered increase in goods delivery demand was the reason behind most of the additional daily vehicle routes, the carrier reported that the additional driving time required by rerouting and congestion in the bridge closure (as well as DOT restrictions on hours/driver per day) was the reason for adding one route per day.

Food and beverage carriers also reported increased congestion in the wake of the bridge closure, both on the lower bridge (with reports that container trucks caused queues around Harbor Island that stretched to I-5) and at the 1st Avenue Bridge. One such carrier reported that because of the increased congestion, drivers who were unauthorized to use the lower bridge or who had to deliver south were instructed not to use the 1st Avenue Bridge but to reroute to southern access points, such as the South Park Bridge. The carrier reported that the company had also considered performing deliveries earlier in the morning, but this strategy was not possible because restaurants were no longer open for the lunch shift.

Food and beverage carriers used a mix of larger trucks that were allowed to use the lower bridge and vans that were not. Parcel carriers used a mix of vans, rental single-axle box trucks, and some personal vehicles. Parcel carriers expressed a preference to be able to request permits or passes that would allow their vehicle drivers to use the lower bridge.

One parcel carrier reported that if volumes and/or travel times continued to increase for WS, it would consider adding vehicle routes to the peninsula by pulling vehicles elsewhere (e.g., downtown) or sending some routes instead to depart from its southern depot, though this would require considerable infrastructure cost to add facility capacity. That carrier said it was not considering cargo bikes for WS due to the area's low density of delivery demand and hilly topography. Nor was it considering opening a satellite distribution center in the area because of infrastructure costs.

3.2.4 BRIDGE CLOSURE IMPACTS ON INDUSTRY

IMPACT SUMMARY:

- Port and industry operations did not seem to experience major disruptions as they were still authorized to use the lower bridge to cross the Duwamish Waterway.
- That said, there were reports of lower bridge congestion from container trucks lining up at the port gates waiting to enter the terminal.

Manufacturers and port operations seemed largely unaffected by the bridge closure, as the heavy goods vehicle freight traffic that had previously used the high bridge to get to the peninsula was now using the low bridge and West Marginal Way to gain access.

The port expects the reopening of the T-5 terminal to add 1,800 vehicle trips per day to the lower bridge. The T-115a and T-18 terminals are also using the lower bridge and West Marginal Way.



4

Estimating Freight Trip Generation (FTG)

ESTIMATING FREIGHT TRIP GENERATION (FTG)

4.1 Introduction

This analysis is intended to generate exploratory baseline freight data to help with data-driven decision making. The data are not intended to illustrate changes in freight trip generation because of the bridge closure and/or the pandemic.

Different establishments have different needs for goods supply, generating different amounts of freight. Freight is transported to an establishment via commercial vehicles, performing one or more vehicle trips, and for each trip, performing a delivery/pick-up. The number of freight vehicle trips generated by an establishment is referred to as the Freight Trip Generation (FTG). We will estimate FTGs using the number of deliveries and pick-ups to establishments.

FTG models are mathematical models that characterize the relationship between the FTG of an establishment and some characteristics of that establishment. Characteristics used as model inputs are the type of establishment (e.g., residential, industrial, or commercial), and the size of the buildings hosting the establishment (measured in acres, for commercial and industrial buildings, or in a number of residential units, for residential buildings). The number of deliveries per establishment is used to quantify its FTG.

The goal is to develop and implement an FTG model for the case study area by using public data sources. The output of the FTG model can be interpreted as the number of deliveries and pick-ups to a given building on a typical day. The FTG estimated for each building in the study area is then aggregated to obtain the total FTG for the whole study area. This, in turn, can be interpreted as the total number of deliveries and pick-ups performed by commercial vehicles in the study area on a typical day.

While the results of the FTG modeling are suggestive of the amount of traffic generated in an area by different building types, the model has several limitations that should be considered when interpreting the results. The model does not:

- Account for any changes due to the COVID-19 pandemic.
- Distinguish between different vehicle types.
- Account for the tendency for vehicles delivering smaller shipment sizes (e.g., parcel delivery vehicles) to aggregate multiple deliveries into a single stop (i.e. a driver might stop the vehicles and perform multiple deliveries on foot) and aggregate multiple stops into tours (i.e. parcel delivery vehicles often perform "milk runs"); as a consequence, the reader should not use FTG results to directly estimate traffic volumes as more modeling is needed to derive volumes from the FTG.
- Include service vehicles (such as plumbing, HVAC, etc.).

All metrics developed here are reported on an interactive map accessible at the following link:

https://sgunes.shinyapps.io/WestSeattle/

4.2 Methodology

In our modeling, we assume that different land uses have different numbers and types of freight trips, but that FTG is homogeneous within the same land-use type. We consider the following land uses:

- Industrial/manufacturing
- Public buildings
- Residential
- Retail/commercial.

Tables 5 and 6 report the trip rates used to compute the total commercial vehicle trips by land use and the data sources used. After these tables, we then explain how we did the study area FTG analysis.

Table 5. Trip rates per land-use type and examples of present uses

LAND-USE TYPE	EXAMPLES OF PRESENT USE1	TRIP RATE
Residential	Apartment, Single Family, Condominium,	Single-unit: 0.5 daily trips/unit ³
		Multi-unit: 0.4 daily trips/unit ³
Industrial/ manufactur- ing	Warehouse, Terminal (Rail)	3.6 daily trips/acre ²
Retail/ commercial	Grocery Store, Retail Store, Shopping Center, Convenience Store, Restaurant	14.3 daily trips/acre ²
Public building	Governmental Service, Office Building, /Assembly Building	0.4 daily trips/acre ²

¹ King County categorization [7]

²Holguin-Veras et al. [5]

³ PSRC dataset [9]

Table 6. Model inputs and data sources

MODEL INPUTS	DATA SOURCE
Number of home deliveries on travel day	Puget Sound Regional Council Household Travel Survey [9]
Trip rate per land-use type	NCHRP 739 database [5]
Building area	King County Department of Assessments [6]
Present use	Parcels for King County with Address, Property and Ownership Information (King County GIS Center) [7]
Parcel/lot area	Parcels for King County with Address, Property and Ownership Information (King County GIS Center) [7]
Daily truck trips generated at Port terminals	2015 Container Terminal Access Study (CTAS) [8]

4.2.1 ESTIMATION OF RESIDENTIAL FREIGHT TRIPS IN THE STUDY AREA

To estimate the number of freight trips for residential parcels, the research team used data from the Puget Sound Regional Council (PSRC) Household Travel Survey [9]. Survey participants were asked about delivery frequency, i.e., the number of times they received a home delivery (food, package, service, or grocery) on a given day. The total number of deliveries received on a given day was calculated as the sum of food, package, service, and grocery deliveries. The *Residence Type* attribute was re-coded into multi-unit residence or singleunit residence categories. Then, grouping by residence type, the average number of daily deliveries (number of freight trips) was computed. By using the *Number of Units* attribute from the King County Department of Assessments data set, the residential parcels were categorized as multi- or single-unit and matched with the computed trip rate. For these parcels, the number of trips was assumed to be the average number of daily deliveries for that residence type multiplied by the number of units.

4.2.2 ESTIMATION OF COMMERCIAL AND INDUSTRIAL FREIGHT TRIPS IN THE STUDY AREA

We calculated the number of commercial freight trips by using an FTG model developed by Holguin-Veras et al. [5]. This model uses as inputs a building footprint area and its land-use category and outputs the total number of commercial vehicle trips that end in a given building during a typical day. The model uses the following formula to compute the daily number of freight trips generated by a building i:

$$TG_i = A_i \sum_j \beta_j \mathbb{1}_{[use_i=j]}$$

In this formula:

- TG_i = number of commercial vehicle trips that end in building during a typical day
- A_i = area of building footprint in acres
- β_j = daily trips per acre of a building of land-use type (see Table 5 for land uses)
- $1_{[use_i=j]}$ = binary variable equal to 1 if the land use of building *i* corresponds to land-use type j, 0 otherwise

Table 6 describes the main data sets used in this analysis. The Parcels for King County with Address (KCA), Property and Ownership Information data set (KCA) provided the geometry and location for individual parcels, as well as address, present use, and lot square footage area information. The KCA data were used to get information about the buildings on each parcel, including the establishment's square footage.

Figure 3 summarizes the data processing method. To find the building area located on each parcel, the parcel data set was merged with the processed KCA data set containing information about apartment buildings, residential buildings, commercial buildings, condo units, and complexes. For parcels a match with the KCA data set and that were not listed as vacant in the present use cell, missing data were imputed by extrapolation. For every present use, the average ratio of the building size over the parcel lot size was calculated. Building areas for missing cells were calculated by multiplying the parcel area by the average ratio by present use.

Once the parcel data set had been processed to include the building area, either matched from the KCA data or estimated via extrapolation, the present use attribute was used to classify the parcels in terms of the land-use categories in the FTG model selected [5]. For the parcel-level FTG estimation, the area of each establishment was multiplied by the trip rates for each land-use type.

The results were visualized on a map by using the geometric locations of the parcels and the calculated number of trips. This visualization was used to identify discrepancies or inconsistencies, such as a very high number of trips at a non-commercial parcel. As a result of this process, we made some modifications to the land-use category corresponding to the *Present Use*.

After estimating the freight trips for each establishment, we aggregated results by neighborhood to identify neighborhoods with higher freight activity.





4.2.3 ESTIMATION OF PORT TERMINAL FREIGHT TRIPS IN THE STUDY AREA

We used real traffic counts from the 2014 Container Terminal Access Study [8] to compute the daily truck trips generated by each terminal.

4.3 How many total freight trips were generated in the study area?

As noted earlier, while the FTG modeling results suggest a preliminary indication of the traffic volume generated in a particular area by different building types, the model has several limitations that make it inadvisable to use the modeling results to directly estimate traffic volume. Applying the FTG model to the study area does, however, let us interpret the total number of deliveries and pick-ups performed by commercial vehicles in the study area on a typical day, which we will generally refer to as freight trips.

Table 7 summarizes the total estimated freight trips generated by the whole study area, which includes the WS peninsula (West) and the neighborhoods of Georgetown and SODO (East). We estimate that the buildings in the study area generate approximately 30,152 freight deliveries and pick-up trips per day, across all types of activities, including deliveries and pick-ups to residential buildings (such as parcel deliveries), to buildings housing commercial activities (such as retail stores and restaurants), and to Port terminals and industrial buildings. Of these, 68 percent of deliveries and pick-ups are generated by the WS peninsula (20,599 trips per day), 20 percent by Port Terminals (6,145 trips per day) and 11 percent by the Georgetown, Harbor Island and SODO (3,408 trips per day).

As Table 7 clearly shows below, while deliveries and pick-ups in the WS peninsula are predominantly generated by residential buildings (93.2 percent), it is the industrial buildings that generate the largest share (74.1 percent) of deliveries and pick-ups in the east of the study district.

LAND TYPE	WEST	EAST	PORT	TOTAL
Industrial	794.2 (3.9%)	2,524.8 (74.1%)	6,145.00 (100%)	9,463.9 (31.4%)
Public buildings	8.6 (0.04%)	40.6 (1.2%)	0	49.2 (0.2%)
Residential	19,188.9 (93.2%)	318.8 (9.4%)	0	19,507.7 (64.7%)
Commercial	607.7 (2.95%)	523.8 (15.4%)	0	1,131.5 (3.8%)
All land types	20,599.3 (100%)	3,407.9 (100%)	6,145.00 (100%)	30,152.2 (100%)

Table 7. FTG estimates

Figure 4(a) shows the geographic distribution of freight trips across the neighborhoods and Port Terminals (see Appendix 2 for details). The Delridge neighborhood generated the largest number of trips, followed by North Admiral and Genesee. Figure 4(b) shows the trip density, computed as the total number of trips divided by the acres covered by buildings in each neighborhood (excluding Port Terminals). The neighborhoods with the largest trip density are Genesee, Fairmount Park and Gatewood. Figure 4(c) shows the total number of trips to residential buildings. The neighborhoods with the largest number of trips to residential buildings are Delridge, North Admiral and Genesee. Figure 4(d) shows the total number of trips to commercial buildings. The neighborhoods with the largest number of trips to commercial buildings. The neighborhoods with the largest number of trips to commercial buildings.

Additional visualizations can be generated interactively by using the following app:

https://sgunes.shinyapps.io/WestSeattle/

Figure 4. Distribution of total freight trips generated by neighborhood. (a) Total number of trips. (b) Trip density measured in trips per acre of building area. (c) Total residential trips. (d) Total commercial trips.











5

Which neighborhoods did the bridge closure affect the most?

5 WHICH NEIGHBORHOODS DID THE BRIDGE CLOSURE AFFECT THE MOST?

To identify the neighborhoods most affected by the bridge closure, we considered the following variables:

- <u>Neighborhood percentage residential/commercial FTG</u>. Percentage of deliveries/pick-ups that were generated by residential and commercial buildings in a neighborhood. According to our interviews, commercial and residential deliveries/pick-ups were more likely than industrial deliveries/pick-ups to be performed by smaller commercial vehicles and personal vehicles, which weigh under 10,000 pounds and therefore were not eligible to use the lower bridge under rules in place at the time of this report, forcing these smaller vehicles to re-route to reach the WS peninsula.
- 2. <u>Neighborhood total number of FTG</u>. Total number of deliveries/pick-ups in a neighborhood.
- 3. <u>Neighborhood re-route time</u>. Worst-case re-route times from eastbound to westbound. This is defined as the difference between the travel time from a fixed point on the east side of the Duwamish River (Spokane St. Viaduct, Seattle, Washington, 98134) to the center of each neighborhood before the bridge closure (assuming use of both the high and lower bridges, no peak hour) and after the bridge closure (assuming no use of either bridge and 4 PM peak hour traffic congestion). Travel times were obtained using the Google Maps Distance Matrix API.

Figure 5 displays all three of the above variables for the 13 neighborhoods. The patterns we see in reroute time and percentage of commercial and residential FTG suggest five different clusters across the 13 neighborhoods, summarized in Table 8. According to those patterns, the most impacted neighborhoods were those in clusters 1 and 2, namely North Admiral, Genesee, Alki, Seaview, Gatewood and Fairmount Park. These neighborhoods are characterized by both largest share of FTG often performed by vehicles prohibited from using the lower bridge and, therefore, notable re-route times.

CLUSTER	NEIGHBORHOODS	WORST-CASE RE-ROUTE TIME	PERCENTAGE OF COMMERCIAL AND RESIDENTIAL NEIGHBORHOOD FTG
Cluster 1	North Admiral	21 minutes	99 %
Cluster 2	Genesee, Alki, Seaview, Gate- wood and Fairmount Park	15 minutes	98 %
Cluster 3	Fauntleroy and Delridge	5 minutes	96 %
Cluster 4	SouthPark, Industrial District East (SODO), and Georgetown	0 minutes	35 %
Cluster 5	Industrial District West	11 minutes	4 %

Table 8. Neighborhood clusters, their re-route time and share of commercial and residential FTG.







6

Conclusion and mitigation strategies

6 CONCLUSION AND MITIGATION STRATEGIES

The research team used multiple measures to document the impact of the West Seattle high bridge closure on freight flow in and out of the West Seattle peninsula—a closure that coincided with shutdowns and slowdowns related to the COVID-19 pandemic and its own economic and traffic follow-on effects. Interviews and surveys with 19 local businesses and carriers performing deliveries and pick-up in the study area including parcel delivery carriers, food and beverage carriers, supermarkets and restaurants, retailers, manufacturers, the Port of Seattle and five neighborhood and local business associations reveal the following key impacts.

On restaurants and supermarkets:

- While supermarkets did not report major changes, smaller food establishments like restaurants and cafes did report important delivery disruptions: cancelled, delayed, and incomplete deliveries.
- To cope with these disruptions, small food establishments reported having to pick up goods themselves from supplier locations, relying on smaller vehicles, such as personal cars or business vans, to do so; having to move their supply delivery destinations to locations off the peninsula; and/or having to buy their supplies from local WS supermarkets.
- Businesses reported difficulties in retaining current employees and hiring new employees due to increased commute times.

On carriers:

- Decreased restaurant demand in the pandemic led to reduced delivery volume to food and beverage businesses on the peninsula, leading in turn to food and beverage carriers both delivering less frequently and consolidating their deliveries by delivering to more customers per route, also reducing the number of routes performed.
- In contrast, increased e-commerce demand in the pandemic meant rising parcel volume, leading parcel carriers to increase the number of routes serving the peninsula due to both the increased pandemic-related demand and the bridge closure impacts, including mounting traffic delays at access points.

On industry:

- Port and industry operations did not seem to experience major disruptions as they were still authorized to use the lower bridge to cross the Duwamish Waterway.
- That said, there were reports of lower bridge congestion from container trucks lining up at the port gates waiting to enter the terminal.

On retail, service and other establishments:

- Service vehicles from outside the peninsula sometimes refused to serve establishments on the peninsula citing longer drive times with the bridge closure.
- Smaller and larger retail and service establishments reported difficulties in hiring new employees in the wake of increased commute times after the bridge closure.
- Some smaller businesses reported losing non-WS resident employees due to increased commute times after the bridge closure.

To help with data-driven decision making, the team developed a Freight Trip Generation (FTG) model that estimated at approximately 27,700 the daily number of freight vehicle trips in the study area across all activity types and to residential, commercial, and industrial buildings. Of those 27,700 daily freight deliveries and pick-ups, 74 percent are generated by the West Seattle peninsula. And of those deliveries and pick-ups generated by the West Seattle peninsula, 94 percent are to residential buildings. Significantly, the FTG data are not intended to illustrate changes in freight trip generation because of the bridge closure and/or the pandemic.

The team then analyzed a host of variables on each of the study area's 13 residential and industrial neighborhoods to determine the relative impact of the bridge closure on each neighborhood. The most impacted neighborhoods were North Admiral, Genesee, Alki, Seaview, Gatewood and Fairmount Park. These neighborhoods have the largest share of FTG often performed by vehicles that are not allowed to use the lower bridge and experienced the longer re-route times.

Given these conclusions, what freight strategies could help mitigate the impacts of the bridge closure?

The short-term mitigation strategies below largely center on expanding lower bridge access while taking steps to ensure the expanded access does not impede the free flow of traffic. These steps could include:

- <u>Granting bridge permits to small businesses</u>. As noted in the key findings, smaller food and service establishments surfaced in surveys and interviews as those most impacted by the bridge closure. These businesses often used smaller freight and personal vehicles to perform pick-ups and deliveries to overcome delivery disruptions. Granting these establishments lower bridge access would support their operations and reduce the negative effects of delivery disruptions.
- *Granting bridge permits to parcel carriers*. The FTG modeling showed that most daily freight trips were home deliveries, including food and parcel deliveries. These deliveries were often performed with vans and personal vehicles. Allowing parcel delivery vehicles to use the lower bridge would reduce vehicle miles traveled by reducing the need for these vehicles to re-route to south access points.
- <u>Making permits time-based</u>, (e.g., morning/afternoon only) to avoid peak traffic congestion and stagger lower bridge use throughout the day.
- <u>Staging container trucks</u>. Container trucks accessing terminals T-5 and T-18 were reported to create frequent back-ups on the lower bridge. To assure free flow on the bridge, container trucks could be staged along Marginal Way, with a system of traffic lights, and allowed lower bridge access only when the trucks ahead have checked through the terminal gates.
- *Promoting zero-emission vehicles.* Lower bridge permits could be given to establishments that use electric vehicles to perform deliveries and pick-ups to mitigate environmental impacts from the bridge closure, such as increased driving times with re-routing etc.

The long-term mitigation strategies below largely center on efforts to support local businesses both the supply and demand side. These steps could include:

• <u>Creating a centralized receiving station</u>. Smaller businesses, especially food establishments, reported experiencing myriad delivery disruptions in the wake of the bridge closure. Giving larger vehicles carrying deliveries for multiple smaller WS establishments a centralized receiving station in a location closer to the businesses on the peninsula would allow carriers to deconsolidate their deliveries and stage goods until the small businesses or third parties (e.g., cargo bike delivery companies) could cover the last mile. This could increase delivery density for carriers, thereby reducing delivery delays

and guaranteeing businesses timely access to their deliveries. It also removes the need for businesses to use smaller vehicles and vans to pick up goods off peninsula and lessens congestion on the lower bridge.

- <u>Creating a shared freight vehicle fleet.</u> Disruptions caused by delivery delays led several establishments to use personal vehicles to perform deliveries and pick-ups, sharing a small number of lower bridge passes given to business associations. To increase vehicle utilization and reduce the total number of vehicles used, a fleet of smaller, zero-emission electric commercial vehicles could be procured and shared across multiple businesses and given a lower bridge pass.
- <u>Taking steps to increase the WS customer base</u>. Businesses reported plummeting consumer demand in the wake of the concurrent COVID-19 pandemic and the bridge closure, particularly those customers coming from off the peninsula, such as tourists and weekend or special events visitors. While businesses report the local customer base grew stronger, they see the need to regain the off-peninsula customers lost. To support smaller businesses several strategies could be pursued to rebuild both the local and off-peninsula customer base:
 - Promote access to WS by bicycle and other micro-mobility modes in partnership with local businesses to attract new customers.
 - Encourage "Stay Local" and "Shop Local" campaigns to support local businesses and keep trips contained within the peninsula.
 - Deploy a parcel locker system at local businesses that receives packages from multiple carriers to increase foot traffic at local commercial areas on the peninsula. This could also increase delivery density and reduce the number of home deliveries.

Any of the above short- and/or long-term strategies could be considered to mitigate the effects of the West Seattle bridge closure on peninsula residents, carriers and businesses.

7 REFERENCES

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Neighborhoods	Land area	Residential	Population	Number of	0 %	f building area	by land use type	
	(square miles)	population	density (people per square mile)	buildings	Industrial / Manufacturing	Public buildings	Residential	Retail / Commercial
Alki	0.88	8,146	9,277.94	2,194	0.02%	0.11%	99.17%	0.69%
Delridge	5.82	34,131	5,860.51	10,106	11.13%	1.79%	83.89%	3.19%
Fairmount Park	0.58	8,465	14,558.8	1,814	4.18%	1.87%	91.02%	2.92%
Fauntleroy	1.22	6,449	5,307.7	2,208	0.10%	0.22%	99.14%	0.54%
Gatewood	0.82	8,159	9,939.05	2,550	0.89%	0.18%	97.31%	1.63%
Genesee	0.76	7,218	9,517.04	2,352	0.31%	0.87%	92.61%	6.21%
Industrial District W.	0.90	1,499	1,665.43	29	83.33%	11.90%	0.00%	4.76%
North Admiral	1.75	14,421	8,246.09	4,412	0.11%	0.68%	96.38%	2.84%
Seaview	0.66	5,588	8,438.48	1,873	%80.0	0.41%	97.37%	2.14%
South Park	1.06	4,996	4,717.54	1,221	69.71%	2.63%	26.39%	1.27%
Total West	14.45	99,072	6,857.23	28,759	9.98%	1.17%	86.17%	2.67%
Georgetown	1.85	1,306	706.21	852	82.54%	7.84%	6.70%	2.91%
Harbor Island	0.65	0	0	17	100.00%	0.00%	0.00%	0.00%
Industrial District E.	2.95	853	289.23	593	80.29%	8.33%	2.08%	9.29%
Total East	5.45	2,159	396.25	1,462	80.21%	10.92%	4.94%	3.92%
Total	19.90	101,231	5,087.92	30,221	35.81%	4.76%	56.29%	3.13%

APPENDIX 1:A STUDY AREA STATISTICS

Neighborhoods	Total daily deliveries	Trip density (trip		Total d	eliveries	
6		ends per acre)	Industrial/	Public Buildings	Residential	Retail/ Commercial
			Manufacturing			
Alki	1,681.9 (5.6%)	7.45	0.10 (0.01%)	0.06 (0.004%)	1,669.33 (99.25%)	12.39 (0.74%)
Delridge	7,004.4 (23.2%)	6.62	212.59 (3.04%)	3.78 (0.05%)	6,547.19 (93.47%)	240.87 (3.44%)
Fairmount Park	1,753.2 (5.8%)	14.08	17.04 (0.97%)	0.84 (0.05%)	1,688.31 (96.30%)	47.02 (2.68%)
Fauntleroy	1,184.8 (3.9%)	6.37	0.44 (0.04%)	0.10 (0.01%)	1,175.33 (99.20%)	8.96 (0.76%)
Gatewood	1,540.7 (5.1%)	12.06	3.87 (0.25%)	0.08 (0.01%)	1,508.77 (97.93%)	27.95 (1.81%)
Genesee	2,244.7 (7.4%)	14.09	1.72 (0.08%)	0.53 (0.02%)	2,106.71 (93.85%)	135.72 (6.05%)
Industrial District W.	229.4 (0.8%)	1.28	220.09 (95.92%)	1.00 (0.44%)	0.00	8.35 (3.64%)
North Admiral	2,895.9 (9.6%)	8.21	0.93 (0.03%)	0.58 (0.02%)	2,819.76 (97.37%)	74.65 (2.58%)
Seaview	1,081.7 (3.6%)	10.6	0.26 (0.02%)	0.14 (0.01%)	1,054.78 (97.51%)	26.52 (2.45%)
South Park	982.5 (3.3%)	4.18	337.14 (34.31%)	1.47 (0.15%)	618.64 (62.96%)	25.29 (2.57%)
Total West	20,599.2 (68.3%)	7.60	794.18 (3.86%)	8.58 (0.04%)	19,188.82 (93.15%)	607.72 (2.95%)
Georgetown	1,307.7 (4.3%)	3.89	863.04 (65.99%)	9.10 (0.70%)	314.98 (24.09%)	120.62 (9.22%)
Harbor Island	193.7 (0.6%)	2.62	193.72 (100.00%)	0 (0%)	0	0 (0%)
Industrial District E.	1,906.5 (6.3%)	2.8	1,468 (77.00%)	31.47 (1.65%)	3.85 (0.20%)	403.13 (21.15%)
Total East	3,407,9 (11.3%)	3.13	2,524.76 (74.09%)	40.57 (1.19%)	318.83 (9.36%)	523.75 (15.37%)
T-5	1,140 (3.8%)	198.66	1,140			
T-18	2,480 (8.2%)	921.66	2,480			
T-30	825 (2.7%)	397.10	825			
T-46	730 (2.4%)	179.02	730			
T-115	970 (3.2%)	47.71	970			
Total Port	6,145.0 (20.4%)	175.99	6,145.00 (100%)			
Total	30,152.1 (100%)	7.88	9,463.94 (31.39 %)	49.15 (0.16 %)	19,507.65 (64.70 %)	1,131.47 (3.75 %)

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SUPPLY CHAIN TRANSPORTATION & LOGISTICS CENTER

UNIVERSITY *of* WASHINGTON Urban Freight Lab

> SCTL CENTER UNIVERSITY OF WASHINGTON BOX 352700 SEATTLE, WA 98195

> > Phone: 206.221.6407 Email: sctl@uw.edu