

# Toward Zero-Emissions Last-Mile Deliveries in Denver

## Background Paper

### EXECUTIVE SUMMARY

This background paper provides an overview of current last-mile delivery operations in the City & County of Denver and identifies ways in which deliveries might be accomplished in a more sustainable, safe, and equitable manner. The discussion is informed by input from key stakeholders from both private and public entities, and highlights trends and key impacts on neighborhoods, people, and other transportation activities. Finally, this document identifies best practices emerging or already in place across the country or abroad with the potential to be implemented in the City & County of Denver.

### Acknowledgements

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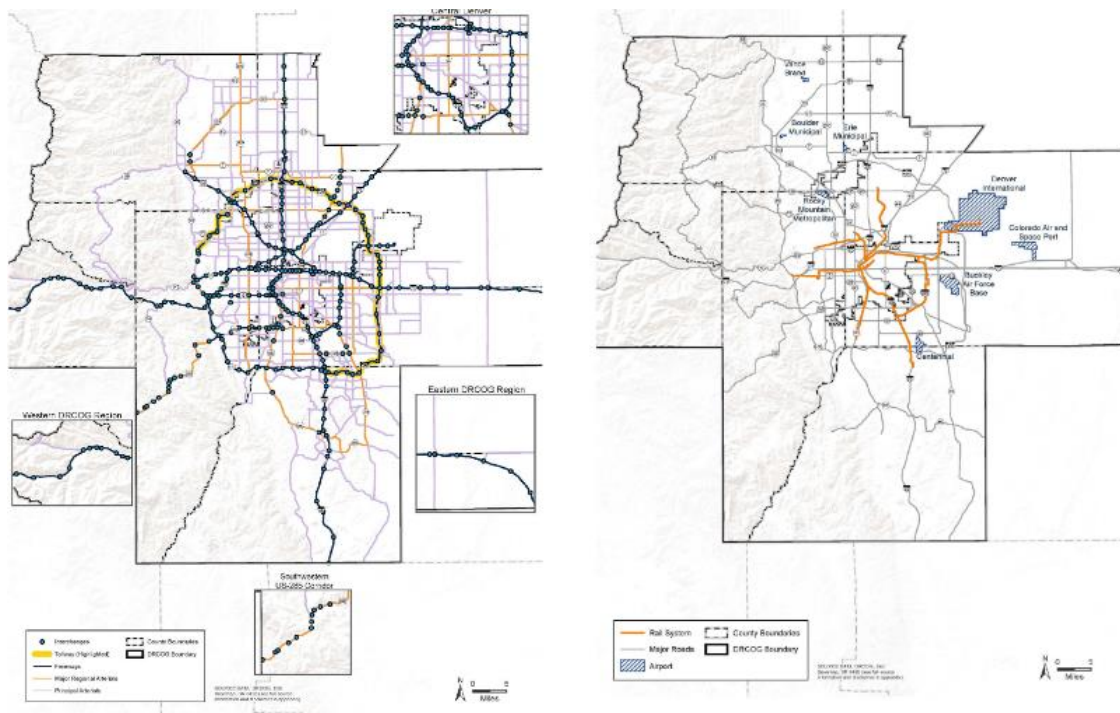
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## OVERVIEW OF LAST-MILE DELIVERY IN DENVER

### Last-Mile Delivery Planning Context

The City & County of Denver (hereafter Denver, or the City) is a key freight linchpin in the state of Colorado and the Mountain West, bringing goods of all types in vehicles of all sizes onto Denver's streets and into Denver neighborhoods. Many of the state's main distribution centers, warehouses, and manufacturing centers make use of the region's rail terminals, highways, and international airport (Figure 1). While much of this freight is not destined to be delivered to and consumed by Denver residents and businesses, the impacts from freight movement through the City create environmental, safety, health, and equity concerns that should be acknowledged and addressed.

Figure 1 Major Roadways and Airports in the Denver Region (source: [2050 RTP](#))



Parcel delivery, food delivery to consumers, and restaurant supply dominate the last-mile delivery market. Independent drivers working as gig laborers comprise a growing share of the labor force for these delivery services. A few of the large delivery companies in the transportation industry in operating in the city of Denver can be found in Figure 2.

**Figure 2 - Transportation Industry in Denver**

Some Major Logistics Companies Operating in the Denver Region			
Amazon	UPS	FedEx	Sysco
United Airlines	BNSF	May Trucking	Shamrock Foodservice Warehouse
Lyft	Uber	Walmart	WasteManagement
MME	Houg	Mile Hi Foods	DPI Specialty Foods

The Colorado Department of Transportation’s Freight Office and its Freight Advisory Council provide guidance on the needs of the commercial transportation industry in the Front Range, having developed Colorado’s first statewide multimodal freight plan in 2019. The main governmental agency conducting freight planning in the Denver region is the Denver Regional Council of Governments (DRCOG). As the designated planning agency for the 9-county Greater Denver area, DRCOG produced the [Regional Multimodal Freight Plan](#) as part of the [2050 Metro Vision Regional Transportation Plan](#), which provides information on regional goods movement. The freight plan notes that the industry must move toward electric or alternative-fuel delivery vehicles, new delivery models, consumer awareness programs to address growing residential delivery demands, more coordination of land use decision-making with cargo logistics, and leveraging big data and new vehicle technology to improve safety, efficiency, and sustainability outcomes across all modes. Key last-mile challenges identified include:

- Conflicts between delivery trucks and cyclists or pedestrians in busy urban and suburban areas
- A lack of delivery zones and parking availability in urban centers
- Curb management balance between transit needs and delivery parking
- The need for alternative delivery options such as off-hours, lockers or store pickup to manage residential delivery demands





The City’s Department of Transportation and Infrastructure (DOTI) is also involved with freight operations, including identification of freight routes, but there is not a division specifically dedicated to freight and delivery management at a citywide or more local scale. The ongoing “[Denver Moves Everyone 2050](#)” transportation planning effort led by DOTI aims to change this pattern: it includes a Freight Working Group made up of delivery providers, driver representatives, Colorado Department of Transportation officials, and local district representatives to provide input on existing conditions, levers of change for future scenarios, and potential plausible strategies and solutions.

DOTI processes commercial vehicle registration applications and collects a [\\$100 annual fee](#) for a commercial vehicle loading permit, providing access to “Truck Loading Only” spaces on-street.





Denver included curb management policies in its 2020 update to the [Complete Streets Guide](#) intended to impact last-mile delivery operations. Freight and goods movement is prioritized after walking, bicycling, and transit, but before vehicle travel and vehicle storage, since “the movement of goods is necessary to keep Denver’s thriving economy strong and growing.” The document describes the preferred design of industrial streets, including adequate provision of sidewalk space and plantings to separate people walking or rolling from truck traffic and reduce pollutants with green infrastructure. In most residential and commercial streets, freight activity is preferred to occur in alleys or on-site, but acknowledgement of on-street loading and unloading is made in downtown and mixed-use street types. The street design details note: “In downtown and other high-activity commercial districts, or when significant, documented demand exists, a ride-hailing loading/unloading area should be provided every 1-2 blocks. Often, it is preferable to have designated ride-hailing loading/unloading areas on side streets.” The guide notes that an entire block’s loading needs should be considered when locating a loading zone, so as to allow multiple businesses along a corridor to use the space effectively.

Despite the many benefits obtained by Denver’s transportation logistical advantages, the City and its residents must contend with the challenges also brought about by the area’s current freight delivery system. Continued population and employment growth in the Denver region may compound these challenges, with an estimated increase of goods movements of [80% between 2015 and 2045](#) (Figure 3 and Figure 4).

**Figure 3 - Value of goods by primary mode, 2015-2045 (source: [2050 RTP](#))**

		2015	2045
	Truck	\$189,741,226,750	\$341,222,927,843
	Air	\$26,544,921,144	\$54,434,069,036
	Pipeline	\$1,789,910,875	\$2,872,651,428
	Rail	\$391,925,539	\$852,084,833

**Figure 4 - Tonnage of goods by primary mode, 2015-2045 (source: [2050 RTP](#))**

		2015	2045
	Truck	204,678,619	311,465,673
	Air	267,171	484,099
	Pipeline	6,346,102	10,186,592
	Rail	503,047	1,037,757



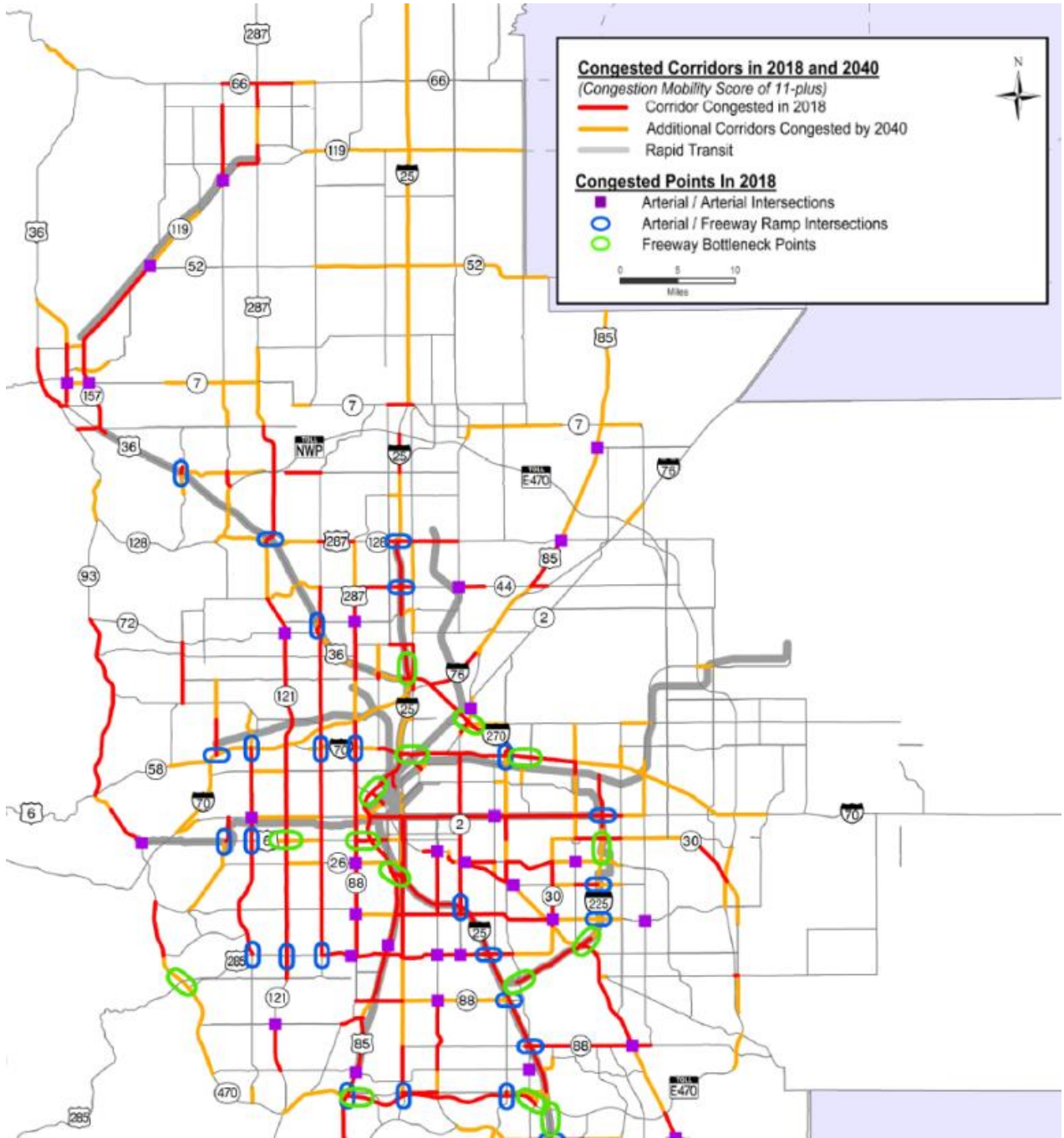
## **Roadway Congestion**

Heavy regional freight activity adds pressure to Denver's already congested streets (Figure 5), increasing pollution and safety concerns. Truck movement, including last-mile delivery routing, contributes to and is affected by congestion between regional or local distribution centers and the final destination.

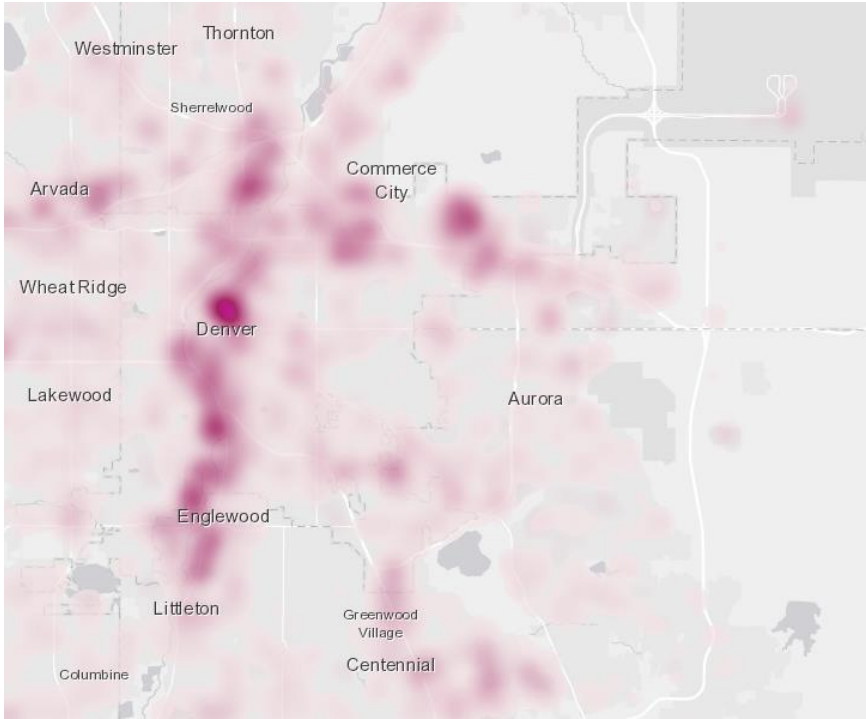
The corridors with the greatest [average truck travel](#) on a daily basis in Denver include I-25 (north of SH 470 to 285), I-270 (southeast of I-76 to I-70), and I-225 (northeast of SH 83 to I-70). Areas with a large presence of warehousing, manufacturing, and transportation firms include Downtown, areas north of the city along I-70, and neighborhoods on the southeast of Denver near Highway 85 (see Figure 6).

Roadway congestion increases emissions by slowing truck travel, increasing freight transportation costs, and reducing fuel efficiency. Where alleys are insufficient to accommodate load demand, limited loading or truck parking zones contribute to double-parking that disrupts travel lanes and impedes safe lines of sight or movement for bicyclists and pedestrians. Alley capacity may be insufficient for a variety of reasons tied to neighborhood design and local context, including driveway entrances in alleys, alleys closed for safety reasons, alleys used for purposes like retail or dining space, and congested alleys from services like waste management. Additionally, in some places alleys may not exist or may be private property, such as some of the alleys in the Little Saigon neighborhood.

Figure 5 Key Congested Locations, 2018 and 2040 (source: [Annual Report on Roadway Traffic Congestion](#))



**Figure 6 Warehousing, Manufacturing, and Transportation Firm Heatmap (source: [City of Denver](#))**



**Emissions, Air Pollution, and the Environment**

Statewide, the transportation sector is a key contributor to greenhouse emissions, as can be observed in Figure 7. While transportation-related carbon emissions are on a downward trend, they still represent the second-highest sector contributing to statewide emissions and the number of annual vehicle miles traveled by higher-pollutant heavy-duty diesel vehicles is increasing (Figure 9). The top contributors to transportation emissions are long and short light duty vehicles, followed by aviation and heavy-duty vehicles (**Error! Reference source not found.**). **Error! Reference source not found.** shows annual vehicle miles traveled by vehicle class, with light-duty gas vehicles traveling the most miles, followed by light-duty gas trucks.

**Figure 7 Colorado Emissions (source: [Colorado Department of Public Health and Environment](#))**

Estimated Colorado GHG Emissions by Sector 2005 - 2019					
Emissions by Sector (MMTCO <sub>2</sub> e)	2005	2010	2015	2019	% of Total in 2019
Electric Power	40.29	39.54	36.28	29.76	23.6%
<b>Transportation</b>	<b>30.43</b>	<b>29.56</b>	<b>28.38</b>	<b>27.44</b>	<b>21.7%</b>
Residential, Commercial & Industrial Fuel Use	24.65	26.31	25.79	27.18	21.5%

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Natural Gas and Oil Systems	19.95	27.85	18.57	20.26	16.1%
Agriculture	11.27	11.75	12.17	10.66	8.4%
Other	12.75	15.19	9.74	10.88	8.6%
<b>Total</b>	<b>139.333</b>	<b>150.195</b>	<b>130.938</b>	<b>126.174</b>	<b>100%</b>

**Figure 8 - Estimated Fuel Emissions from Transportation-Related Fossil Fuel Combustion (source: [Colorado Department of Public Health and Environment](#))**

2019 Emissions by Transportation Type	
	2019
Short Light Duty Vehicles	7.774
Long Light Duty Vehicles	9.419
Medium Duty Vehicles	1.464
Heavy Duty Vehicles	3.853
Buses	0.027
Aviation	4.344
Other	0.555
<b>Total 2019 Emissions Transportation (MMTCO<sub>2</sub>e)</b>	<b>27.436</b>

**Figure 9 - Miles Traveled by Vehicle Class (source: [Colorado Department of Public Health and Environment](#))**

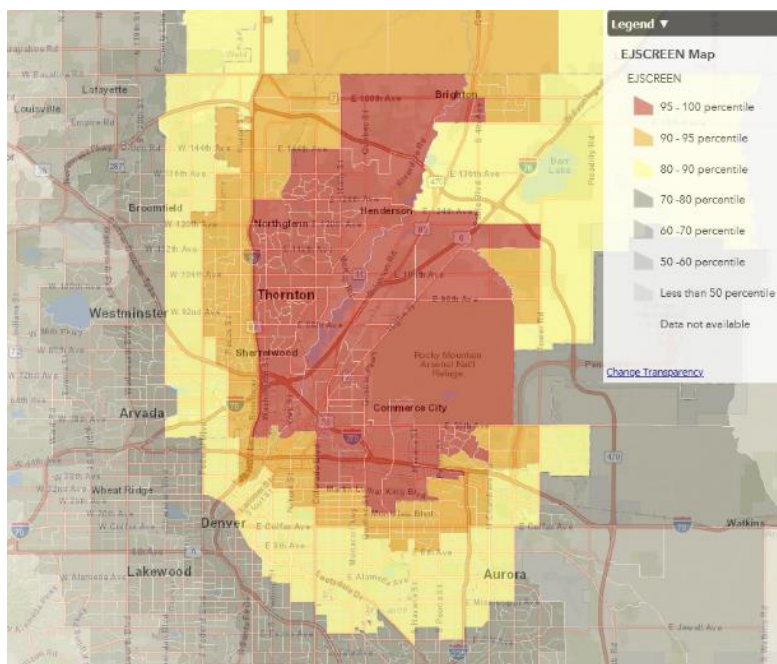
Colorado Annual Vehicle Miles Traveled by Vehicle Class (Annual VMT in Million miles)				
Vehicle Class	2005	2010	2015	2019
Heavy-Duty Diesel Vehicle	3,200	4,517	4,573	NA
Heavy-Duty Gas Vehicle	473	198	207	NA
Light-Duty Diesel Truck	485	397	413	NA
Light-Duty Diesel Vehicle	146	160	175	NA
Light-Duty Gas Truck	16,127	9,454	9,820	NA
Light-Duty Gas Vehicle	27,351	31,899	34,904	NA
Motorcycle	164	293	320	NA
<b>Total</b>	<b>47,946</b>	<b>46,919</b>	<b>50,413</b>	<b>54,634</b>

The transportation sector is also a key contributor to air pollution in Denver, representing [almost 30% of carbon emissions in the city](#). The majority of particles are formed in the

atmosphere due to the complex reactions of chemicals like nitrogen oxides and sulfur dioxide, pollutants that are emitted by automobiles, power plants, and other industries. Particulate matter from engine exhaust, especially diesel exhaust from trucks, is a public health concern, especially for communities bordering expressways. Exposure to ozone and particulate matter can cause health problems, and traffic proximity is associated with an increase in exposures to toxic gases, particulate matter, and ambient noise.

Particulate matter in the Denver region is concentrated in neighborhoods to the north and northeast of downtown, including RiNo, Cole, Clayton, North Capitol, Hill, Five Points, and Park Hill (see Figure 10). All of Denver is subjected to particulate concentrations in the top 30% across the state.

**Figure 10 - Particulate Matter (PM 2.5 in  $\mu\text{g}/\text{m}^3$ ) State Percentiles in the Denver Region (source: [EJSCREEN](#))<sup>1</sup>**



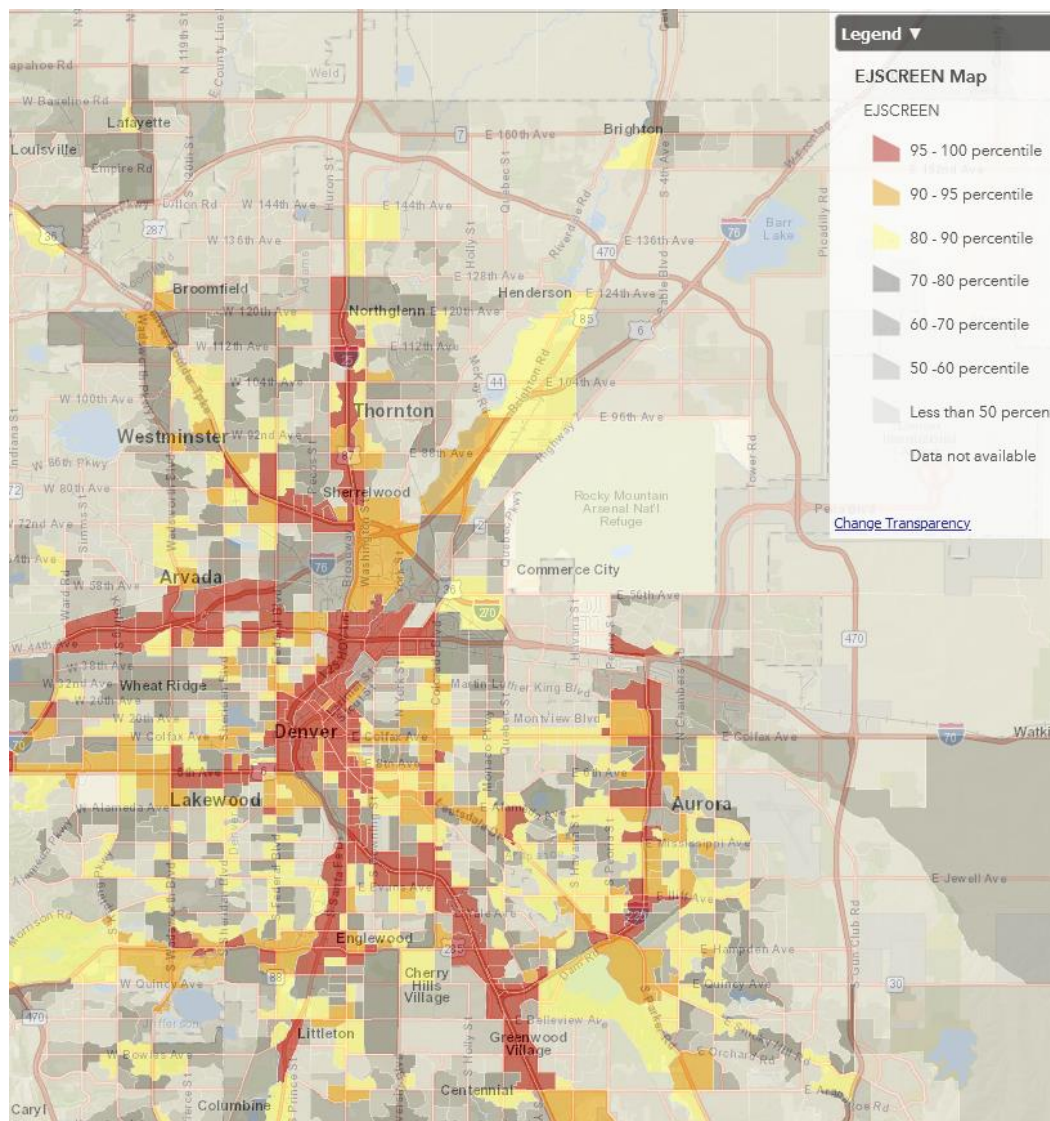
Low income individuals and some ethnic and racial groups often deal with more exposure to pollution, and the burden imposed by air pollution tends to not be shared evenly across communities. Traffic proximity and noise is highest surrounding the region's interstate highways, as well as along Colfax, Leetsdale, Alameda, and 6<sup>th</sup> Ave.

<sup>1</sup> EPA EJScreen is an environmental justice screening and mapping tool from the EPA that provides EPA research and the public with a nationally consistent dataset and approach for combining environmental justice and demographic indicators. EJScreen provides 11 economic indicators (National-Scale Air Toxics Assessment (NATA) air toxics cancer risk; NATA respiratory hazard index; NATA diesel PM; Particulate matter; Ozone; Traffic proximity and volume; Lead paint indicator; Proximity to Risk Management Plan (RMP) sites; Proximity to Hazardous Waste Facilities; Proximity to National Priorities List (NPL) sites; Wastewater Discharge Indicator (Stream Proximity and Toxic Concentration)) and six demographic indicators (percent low-income; percent people of color; less than high school education; linguistic isolation; individuals under 5; individuals over 64). For more information: <https://www.epa.gov/ejscreen>

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Noise, particulate, and air pollution disproportionately hurts sensitive groups and induces respiratory problems, chronic inflammation, and cognitive impairment. For reference, emissions from traffic “typically diminish to near background levels within 150 to 300 meters of the roadway (...); however, the potential exposure zone around roads can vary considerably depending on the pollutant, traffic volume, ambient pollution concentrations, meteorologic conditions, topography, and land use” (CDC). Other research has also shown adverse health effects from traffic pollution further than 300 meters, with the “area most affected (...) roughly the band within 0.2 to 0.3 miles (300 to 500 meters) of the highway” (American Lung Association).

**Figure 11 - Traffic Proximity and Volume (daily traffic count/distance to road) State Percentiles in the Denver Region (source: EJSSCREEN)**

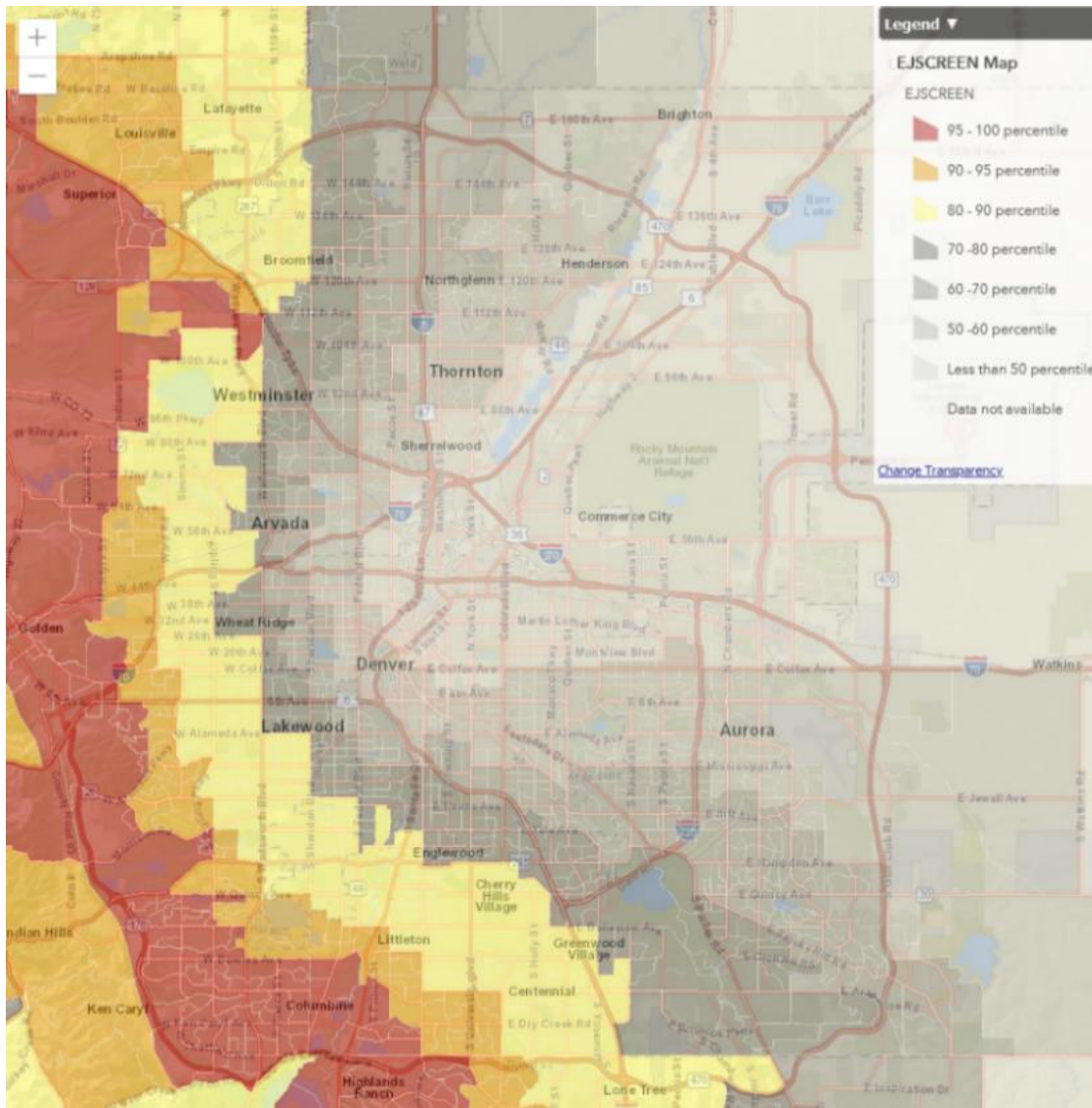


In a city where almost [one in every ten residents is living with asthma](#), reducing air pollution is critical. According to the American Lung’s Association’s 2021 “State of the Air” report, the Denver metro ranked as the [8<sup>th</sup> metropolitan area](#) most polluted by

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ozone, while also experiencing an increase in days with short-term particle spikes (which can be hazardous). Ozone concentrations are higher to the west and south of downtown Denver, although most neighborhoods in the City are exposed to concentration higher than the statewide average (See Figure 12.).

**Figure 12 - Ozone (State Percentiles) in the Denver Region (source: [EJSCREEN](#))**



For particle pollution (PM) and ozone (in addition to other pollutants), the EPA is required to establish [National Ambient Air Quality Standards](#). Primary standards are focused on public health, and secondary ones deal with public welfare protection. The chart below shows standards set for Ozone and PM.

**Figure 13 - NAAQS Table (source [EPA](#))**

Pollutant		Primary/ Secondary	Averaging Time	Level	Form
<a href="#">Ozone (O<sub>3</sub>)</a>		primary and secondary	8 hours	0.070 ppm	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
<a href="#">Particle Pollution (PM)</a>	PM <sub>2.5</sub>	primary	1 year	12.0 µg/m <sup>3</sup>	annual mean, averaged over 3 years
		secondary	1 year	15.0 µg/m <sup>3</sup>	annual mean, averaged over 3 years
		primary and secondary	24 hours	35 µg/m <sup>3</sup>	98th percentile, averaged over 3 years
	PM <sub>10</sub>	primary and secondary	24 hours	150 µg/m <sup>3</sup>	Not to be exceeded more than once per year on average over 3 years

Similarly, the EPA provides information regarding designated nonattainment areas for various pollutants. The County of Denver has the following [designations](#) (as of October 31, 2021):

- 8-Hour Ozone (2015 Standard): Nonattainment
- 8-Hour Ozone (2008 Standard): Nonattainment
- 8-Hour Ozone (1997 Standard): Nonattainment
- 1-Hour Ozone (1979 Standard): Maintenance
- PM-10 (1987 Standard): Maintenance

The City of Denver set various sustainability goals with the aim of implementing a greener form of transportation. For example, the ambitious “[80 x 50 Climate Action Plan](#)” aims to achieve an 80% reduction in greenhouse gas (GHG) emissions citywide by 2050. To accomplish this goal, the decarbonization of transportation is expected to play a key role. Specifically, the document calls for 75% of freight trucks to utilize carbon-neutral fuel, and for all light duty vehicles to be electric by 2050. The Climate Action Plan also calls for an increase in access to healthy transportation choices: whether by increasing the prevalence of electric vehicles, by encouraging transit ridership through better service, or by expanding the city’s walking and biking infrastructure, equity is also taken into account. Strategies and policies arising out of the plan consider equitable access to benefits and prioritize those with universal benefit for vulnerable populations or aim to bring the cost of home ownership, rent, and transportation down. The climate action strategies to switch to cleaner energy sources and reduce air pollution can improve public health and benefit environmental justice communities to delivery equitable health outcomes.

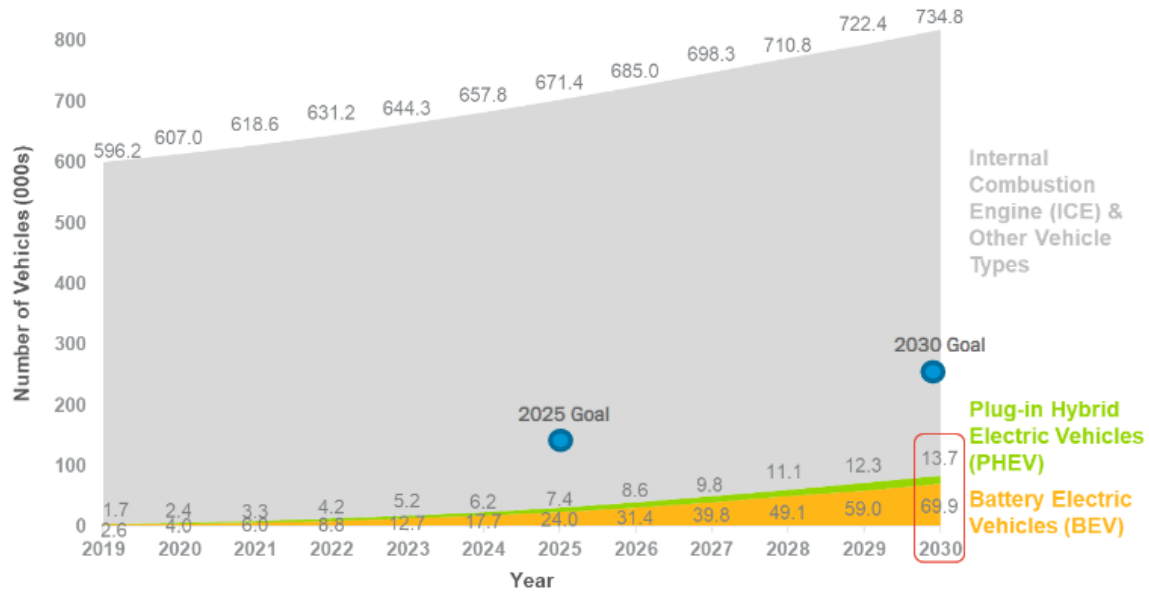


The adoption growth rate of electric vehicles is not on track to meet Denver's goals (see forecast in Figure 14). The City adopted the "[Denver Electric Vehicle \(EV\) Action Plan](#)" in 2020 that calls for the following actions: bolster charging infrastructure availability, drive community awareness, facilitate EV adoption, and supporting EV services and innovation. Tiered EV incentives and rebates to support low-income individuals are aimed to support EV adoption, focusing on removing older vehicles and choosing alternative transportation modes (such as transit passes or electric bikes). The plan further states: "consider options such as financing for lower credit scores, a used EV program, or non-EV options that may be a better fit for different populations" (pg. 21). Additionally, EV mobility hubs are recommended to provide support to EV services and to "incent providers and users of transportation mobility services to choose EVs" (pg. 22). The plan calls for partnerships "to develop mobility hubs leveraging private/public funding", with the expressed equity considerations of targeting "locations near low-income areas" and pairing "with other programs", and co-locating "with existing or new community services and resources like libraries, clinics, recreation centers" (pg. 22)

Specific actions listed by the plan that have the potential to influence delivery operations in Denver include the following:

- Partnerships with businesses, communities, and regional organizations to increase the implementation of charging infrastructure in key areas. The plan envisions that charging areas will be located in a variety of locations, including public areas (such as city property and park-and-rides), multi-family units, and private businesses.
- Fleet owner and workplace campaign to explain the benefits of electric vehicles
- Partnerships with mobility, taxi, car share, ride-hailing, and emerging transportation providers in incentivizing drivers to use electric vehicles in ridesharing apps and providing incentives to customers to choose electric vehicles.

**Figure 14 - Light-Duty Vehicle Population, Denver County: 2019-2030 (Source: [Denver Electric Vehicle \(EV\) Action Plan](#))**



Additionally, e-bike programs have been implemented in the Denver area to help decrease emissions. For example, Denver’s Office of Climate Action, Sustainability and Resiliency (CASR) [has made 70 e-bikes available](#) (free of charge) to essential workers near downtown Denver with assistance from the Climate Protection Fund, which was approved by voters. Similarly, the [Can Do Colorado pilot program](#) is also providing free e-bikes to a limited number of residents throughout the state, with the dual goal of supporting essential workers and decreasing emissions.

Recent developments in the delivery environment have brought many benefits: however, those developments can also negatively impact life quality. For example, an increase in the amount of delivery vehicles [contributes](#) to pollution and traffic congestion. Consequently, tackling the challenges brought about by an increase in last-mile deliveries will be key to decreasing pollution and its adverse effects.

### Safety

The size and weight of trucks pose safety challenges in urban environments, especially when they conflict with pedestrians and cyclists on neighborhood streets supporting commercial and recreation activity. Blind spots in the front, back and sides of trucks make it difficult for drivers to see vulnerable road users while in motion. The size and impermeability of box trucks, and even cargo vans, restrict sight lines for other drivers, pedestrians, and cyclists trying to maneuver around them while parked or idling.

Even within a changing delivery landscape and desire for smaller vehicles, trucks and their drivers will continue to play an important role in delivering goods and services to the doorsteps of Denver residents and businesses. During the transition away from diesel

trucks to emerging modes, providing safe and accessible space for truck drivers to load and unload cargo is a near-term imperative.

Pedestrians and bicyclists involved in a crash with a truck are much more likely to be killed or seriously injured than if they were in a collision with a smaller vehicle. In Denver trucks were involved in 16% of all crashes between 2013 and 2021 and accounted for 12% of all crashes with serious injuries or fatalities. During this period, truck crashes most often occurred in the Central Park, Baker, and Elyria Swansea neighborhoods. The Montbello neighborhood experienced the most pedestrian-involved truck crashes, whereas Capitol Hill, Five Points, Baker, West Colfax, and North Capitol Hill saw the most bicycle-involved truck crashes (all tied with 8 each).

As a result of the dangers posed to public safety by the transportation sector, the City of Denver has adopted a Vision Zero Action Plan, with the goal of achieving zero traffic-related serious injuries and deaths by 2030. The plan identifies Denver's high injury network, which is mainly composed of multi-lane arterials. Specific actions identified in the plan include reducing speeds on the high injury network, reconfiguration of intersections and streets to improve operations and safety, and enacting legislation to improve safety.

## **Equity**

Denver's [2040 comprehensive plan](#) articulates goals that directly center equity and accessibility. Specifically,

We want:

- A city that's equitable, affordable, and inclusive.
- A Denver made up of strong and authentic neighborhoods....
- With connected, safe, and accessible places that are easy to get to, no matter how we want to travel.
- We want a community that is economically diverse and vibrant...
- While being environmentally resilient in the face of climate change.
- And we want a healthy and active city with access to the types of amenities and experiences that make Denver uniquely Denver.

The [80x50 Climate Action Plan](#) also speaks to the intersection of sustainability and equity with a vision to “inspire community action and ensure environmental justice, equity and affordability as Denver transitions to a carbon-free energy system.”

The ongoing “[Denver Moves Everyone 2050](#)” planning effort to set a vision to move “people, goods, and services” explicitly incorporates equity into the process, analysis, and future recommendations. The effort includes both a Racial Equity Working Group and Freight Working Group. The Freight Working Group is taking into account equity, sustainability and other related goals as it works to help guide plan development, providing guidance and strategic direction while helping identify opportunities and key issues. The group includes local and national delivery carriers who operate in Denver, Denver City Council members, City of Denver planning staff, and staff from other local governments, including the City of Aurora and Adams County. However, Denver lacks a

dedicated focus on equity and sustainability in last-mile delivery and urban logistics planning. An increased focus on advancing equity, air quality, and carbon reduction in last mile delivery planning is needed.

Denver does not have staff dedicated to working with industry, residents, and public policymakers on commercial loading and freight planning. The city also has not adopted a dedicated urban logistics or freight plan, but rather relies on DRCOG's Regional Multimodal Freight Plan for its vision, priorities, and action recommendations. The regional plan provides critical vision, data, and strategies. Curb delivery behavior and enforcement in high-demand locations and neighborhoods create local challenges and opportunities, and a local understanding and response is key to address sustainability, improve safety and transit performance, and reduce impacts while maximizing opportunities for priority communities.

Although identifying challenges is key, learning from successful operations currently taking place in Denver is also useful. For example, waste management operations do not seem to cause major concerns at the neighborhood level in Denver—much of the activity occurs during off-peak hours when traffic congestion, bike activity, and pedestrian levels are more limited. A broader analysis of the infrastructure of waste management—including locations of transfer stations and other operations facilities, and their localized impacts—is beyond the scope of this effort. There is a clear opportunity to adopt zero-emissions vehicles for waste management. Recently, the City of Denver [acquired](#) unveiled an electric street sweeper, which was purchased with assistance from a grant, signaling that steps are being taken to limit emissions from core services.

Any City-implemented policy or program would connect to and seek to advance broader city equity goals. When considering the impacts of an overall program and specific project interventions, the experience of vulnerable and often marginalized communities and individuals must be prioritized, in alignment with City values documented in the comprehensive plan and other sources as described above. In the context of last-mile delivery, vulnerable groups include:

- Residents of neighborhoods where deliveries occur
- Delivery drivers, who are often paid lower than average wages, and in many areas are disproportionately people of color;
- Travelers walking, biking, and using transit, who are disproportionately lower-income and disproportionately people of color;
- Business owners, who in the case of some small businesses and in some neighborhoods include people of color and immigrants.
- Residents of areas near distribution and transfer centers and significant freight/delivery routes;

The Evaluation section of this report includes a high-level description of the potential impacts on the first four of these vulnerable groups. Impacts are assessed relative to City values and goals as described above and are generally assessed citywide. Future refinement of the policy and program options must include discussion with the people and businesses likely to be affected, including within specific neighborhoods. Such

engagement was outside the scope of this effort, so the initial assessment reflects professional judgment and general understanding.

The Evaluation section does not address potential impacts on residents of areas near distribution and transfer centers, as the research described here focused on pressures at the delivery end of last-mile trips. Impacts on these residents should be reflected in future work.

## **Delivery Growth and the Impact of Covid-19**

Changes in technology were already accelerating the prevalence of e-commerce before the Covid-19 pandemic. However, the pandemic and the fundamental changes that it has brought have furthered modified supply chains throughout the world. Combined, the dramatic increase in freight volumes, not only between businesses, but to our homes as well, means cities across the nation (including Denver) must now tackle the challenges brought about by an increased proliferation of demand for quick, on-demand last-mile deliveries.

The private shipping industry has already recognized a need to change operations practices, with many beginning to expand a network of smaller urban warehouses and localized fulfillment centers to meet the growing demand for just-in-time deliveries. Denver is no exception to this trend: rents and building values for properties located in constrained “last mile” areas have increased, and developers in the city are exploring the adaptation of distressed properties in dense areas to convert into “last-touch” facilities and fulfillment centers.

This kind of conversion may compete with other uses including residential conversion, potentially contributing to ongoing housing supply constraints which lead to price increases. High-profile new distribution centers in the Denver Area include the transformation of a Macy’s store in Denver’s Southwest Plaza into a fulfillment center-focused operation, additional distribution and warehousing space at the Nexus at DIA Industrial Park near the International Airport (one of the largest in this area of the city), a GE Appliances distribution center in Commerce City, and recent additions to Amazon’s existing operations in the area. Specifically, Amazon’s real estate in the Denver area includes distribution centers in Aurora, Thornton, and Denver, a Prime Now hub (focusing on fast deliveries), and a brand-new Robotics Fulfillment Center near the Colorado Springs Airport.

Newer last-mile ultra-fast delivery startup companies (such as Getir, JOKR, BUYK, Gopuff, and others) have begun leasing or purchasing vacant storefronts within downtown and neighborhood retail areas to serve as hyper-localized fulfillment hubs. These repurposed former storefronts can reduce the ability for new small businesses to find storefront locations and often limit visual interest with papered-over windows that

adds to neighborhood walkability and foot traffic can decline.<sup>2</sup> Further, by encouraging home delivery of convenience goods to residents of neighborhoods with a hyper-local distribution center, they may discourage residents from spending money at other nearby businesses on the main street.

**Figure 15 - The Covid-19 pandemic has brought unprecedented challenges to the transportation system**  
(source: usrisk.com)



### **E-Commerce Delivery and Returns**

Demand for last-mile deliveries, particularly to residential addresses, has increased dramatically, as the pandemic forced many people to stay home and rely on home deliveries for anything from groceries to meals. E-commerce represented approximately 10.5% of all retail sales in the US in the first quarter of 2019. In 2020, business-to-consumer deliveries [rose around 25%](#), and direct-to-consumer and home delivery saw an increased demand for their services. Residential shipping now eclipses deliveries to businesses, and with more services offering same day or less delivery, timeliness is now often measured in hours rather than days. More and more packages are being delivered to more and more addresses through complex local distribution networks that frequently overlap and result in duplication of delivery vehicles on the same streets throughout a neighborhood.

Limitations on the growth of same-day and other rapid delivery may be emerging. Companies buoyed by venture capital investments are absorbing the financial impacts and may revert to higher pricing to preserve profits. As an alternative to higher pricing for fast delivery, companies including Amazon are offering incentives for customers to

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<sup>2</sup> <https://www.bostonglobe.com/2021/12/10/business/downtown-full-delivery-warehouses-dark-stores-are-coming-boston/>

select slower methods. It remains to be seen how (and when) trends will settle out as COVID-era behaviors continue to evolve.

Continued growth in fast delivery will increase delivery and curbside access challenges in residential areas. Outside of changes to the regional freight network, policy reactions within CDOT, CASR, and DOTI to mitigate the current challenges will be essential to counteract the increase in residential package deliveries.

### **Restaurant, Beverage, and Grocery Home Delivery**

In a growing trend accelerated by the Covid-19 pandemic, more and more companies are offering home restaurant and beverage delivery services. For example, the top food-delivery apps in the US (Doordash, Uber Eats, Grubhub and Postmates) experienced a [collective rise in revenues of \\$3 billion](#) simply in the 2<sup>nd</sup> and 3<sup>rd</sup> quarters of 2020, as stay-at-home orders were confining many consumers at home.

Recently, there has also been an increase in the number of companies offering expedited grocery deliveries, which now not only include Amazon, Walmart and Instacart, but a growing list of startups (such as Jokr and GoPuff) with the potential to further change today's last-mile deliveries –highlighting the need for the City of Denver to implement a flexible and responsive strategy to manage its delivery environment.

### **Environmentally Conscious Ordering**

Providing safe and accessible space for truck drivers to deliver these goods is a near-term imperative even as we move away from our reliance on diesel trucks.

At the same time, consumers are becoming more environmentally conscious, with more than [50% of consumers](#) expressing that they are aware of environmental issues affecting e-commerce. In recent years, many companies have started to invest heavily in decarbonization efforts. For example, Amazon has partnered with Rivian to [develop a custom electric delivery vehicle](#), with more than 10,000 of those expected to be on the road by 2022, and 100,000 by the year 2030.<sup>3</sup> In Denver, Amazon started delivering packages with these vans in [April 2021](#).<sup>4</sup> This trend is expected to continue, as the range of electric vehicles improves, their costs become lower, and governments set more ambitious emission standards and goals.

### **Delivery Impacts in Denver Neighborhoods**

There are some delivery impacts that are felt all across Denver, however other impacts are related to land use and ..... In more suburban neighborhoods, there is less competition for curb lane uses. BIDs and Denver Inter Neighborhood Cooperation

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<sup>3</sup> <https://www.ttnews.com/articles/amazon-unveils-prototype-rivian-built-electric-delivery-van#:~:text=Amazon.com%20Inc.%20unveiled%20a%20prototype%20of%20one%20of,up%20to%20the%20full%20100%2C000%20order%20by%202030>. Accessed December 9, 2021.

<sup>4</sup> <https://coloradosun.com/2021/04/27/amazon-electric-vans-denver-rivian/>. Accessed December 9, 2021.

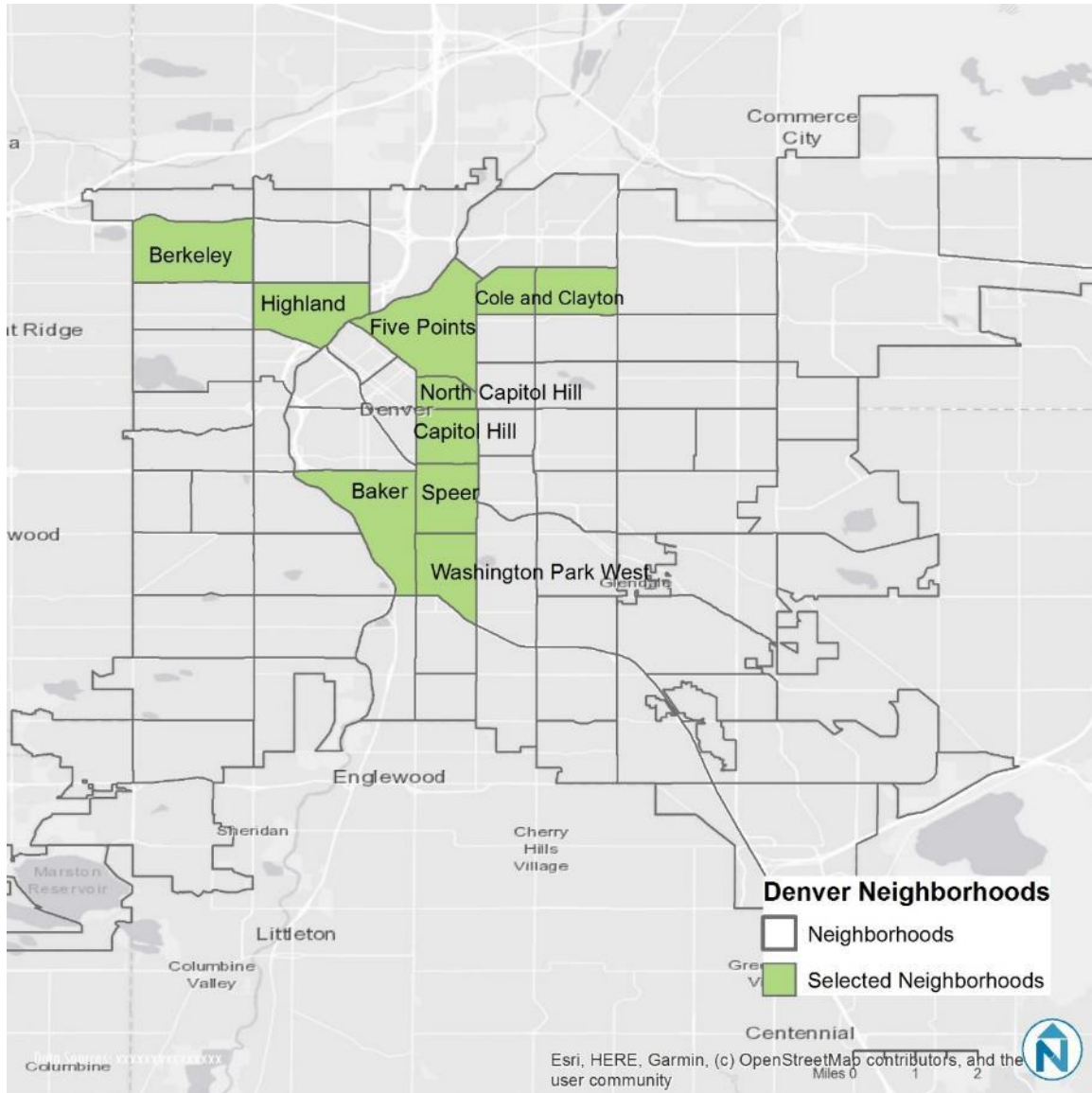
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noticed that delivery vehicles used to follow predictable patterns and truck routes, but designated truck routes seem to no longer be active. There is no policy governing pickups or delivery hours, especially on a block-by-block basis.

This section explores strengths, challenges, opportunities, threats, and the resulting impacts of last-mile deliveries in several Denver neighborhoods which face more challenges from the current freight system than others. These neighborhoods are experiencing high delivery demand based on existing land use mix and density or race and income demographic patterns, are experiencing high development or redevelopment interest, or are disproportionately impacted by neighborhood safety or pollution. Lessons from these neighborhoods may be applicable to additional Denver neighborhoods not spotlighted in this research paper. Information about current conditions is obtained from interviews with local stakeholders, residents, delivery companies, and City partners.



Figure 12: Selected Neighborhoods



### Five Points/Welton

Five Points, to the northeast of Downtown Denver, is one of Denver’s most historic neighborhoods and one of its fastest redeveloping neighborhoods. Historically known as the “Harlem of the West” with a large Black population, Five Points is home to the Black American West Museum and Heritage Center and many Black churches and businesses. With a population over 16,000 residents today, the neighborhood skews younger, with 41% of the population between the ages of 25-34.<sup>5</sup> It is 76% White, 11%

<sup>5</sup> <https://denvermetrodata.org/neighborhood/five-points>

Black, and 18% Latino. These demographics are very similar to the City of Denver demographics, with 76.1% white, 9.2% Black, and 29.9% Latino.<sup>6</sup> Almost 4% of adults speak a language other than English at home. The median household income in Five Points is \$57,301.<sup>7</sup> This is lower than the average median income in the City of Denver, at \$68,592. 20.26% of Five Points residents live in poverty.<sup>8</sup> This is higher than the number of City in Denver residents in poverty, at 12.9%.<sup>9</sup>

Five Points is very walkable and has good transit access, owing to the light rail L Line stops at 25<sup>th</sup> Street, 27<sup>th</sup> Street, and 30<sup>th</sup> Street along Welton and 23 routes that run through Five Points. Most roads in Five Points are local streets or collector streets not designed to carry crosstown traffic at high volumes and high speeds, and instead are meant to facilitate neighborhood commercial activity. N Broadway, N Downing Street, and Park Ave W surround the neighborhood to carry through traffic. The streets with the highest traffic volumes in Five Points are on either side of Larimer and Laurence Streets.

Five Points has a variety of parking regulations, shown in Figure 1, but limited curb space devoted to access for goods delivery. Residential streets are primarily regulated for long-term parking. Surrounding the Denver Language School, where much passenger loading activity happens, loading zones and bus stops make up much of the block. In the central core of the neighborhood, Washington Street is too narrow for on-street parking. On Welton Street, where much of the commercial activity occurs in restaurants and small shops, there are three passenger-only loading zones, one unrestricted loading zone, and one zone with loading allowed from 7am to 6pm. Combined with the light rail tracks and the RTD 27<sup>th</sup> Street/Welton station, the rest of the curbs on Welton are managed with short-term parking or no-parking zones. Trucks, vans, and other delivery vehicles have few opportunities to find available loading zones to make deliveries and must use short-term parking or resort to double-parking. The alley between Welton and California Streets provides an outlet for some businesses.

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<sup>6</sup> <https://www.census.gov/quickfacts/fact/table/denvercitycolorado,US/PST045219>

<sup>7</sup> <https://www.denvergov.org/content/dam/denvergov/Portals/643/documents/Maps/medhhincome.pdf>

<sup>8</sup> <https://denvermetrodata.org/neighborhood/five-points>

<sup>9</sup> <https://www.census.gov/quickfacts/fact/table/denvercitycolorado,US/PST045219>

**Figure 13: Five Points/Welton Parking Regulations**



Five Points and the RiNo Arts District are within the 80-85<sup>th</sup> percentile across the state for exposure to particulate matter. Close to Interstate 25, there are even higher concentrations of particulate matter and traffic volume. People in these areas experience adverse pollution effects and could benefit from innovative solutions to make freight deliveries more environmentally-friendly.

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**Figure 16 - Particulate Matter (PM 2.5 in  $\mu\text{g}/\text{m}^3$ ) -State Percentiles- in the Five Points area (source: [EJSCREEN](#))**

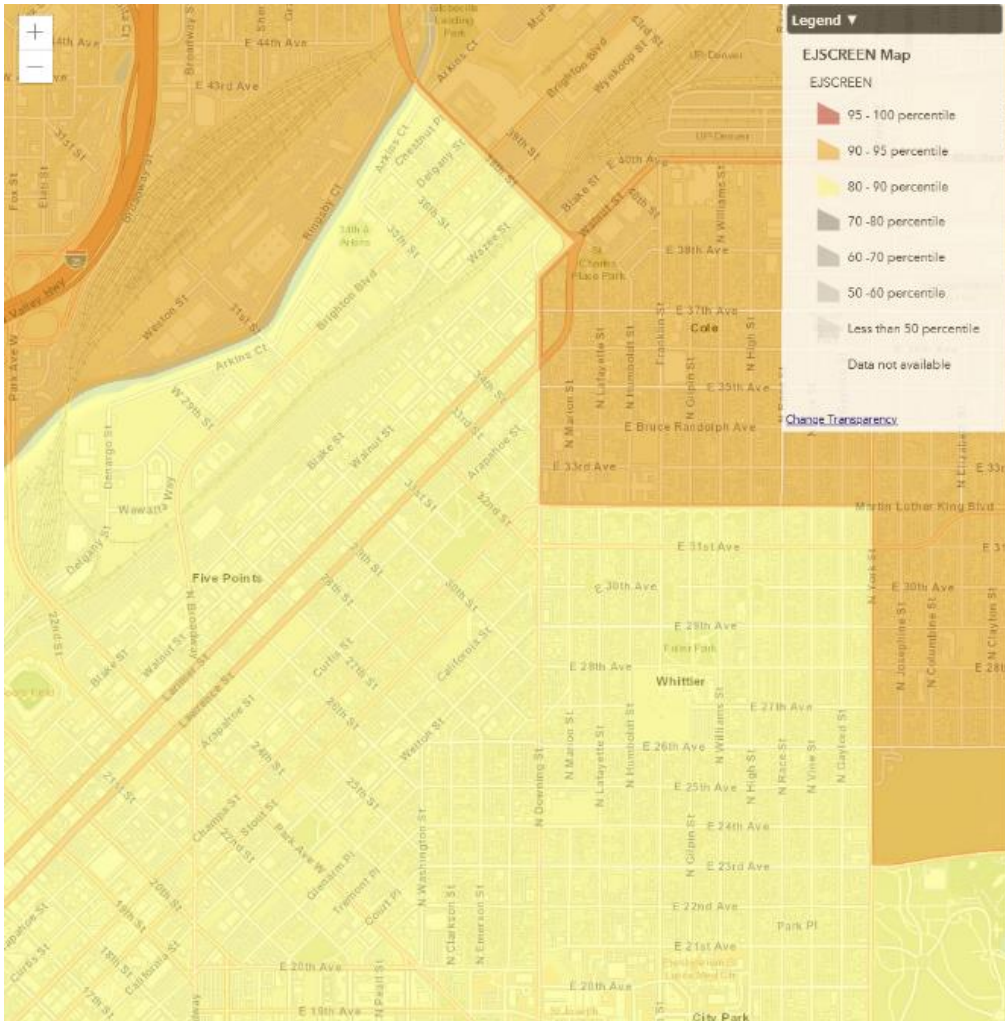
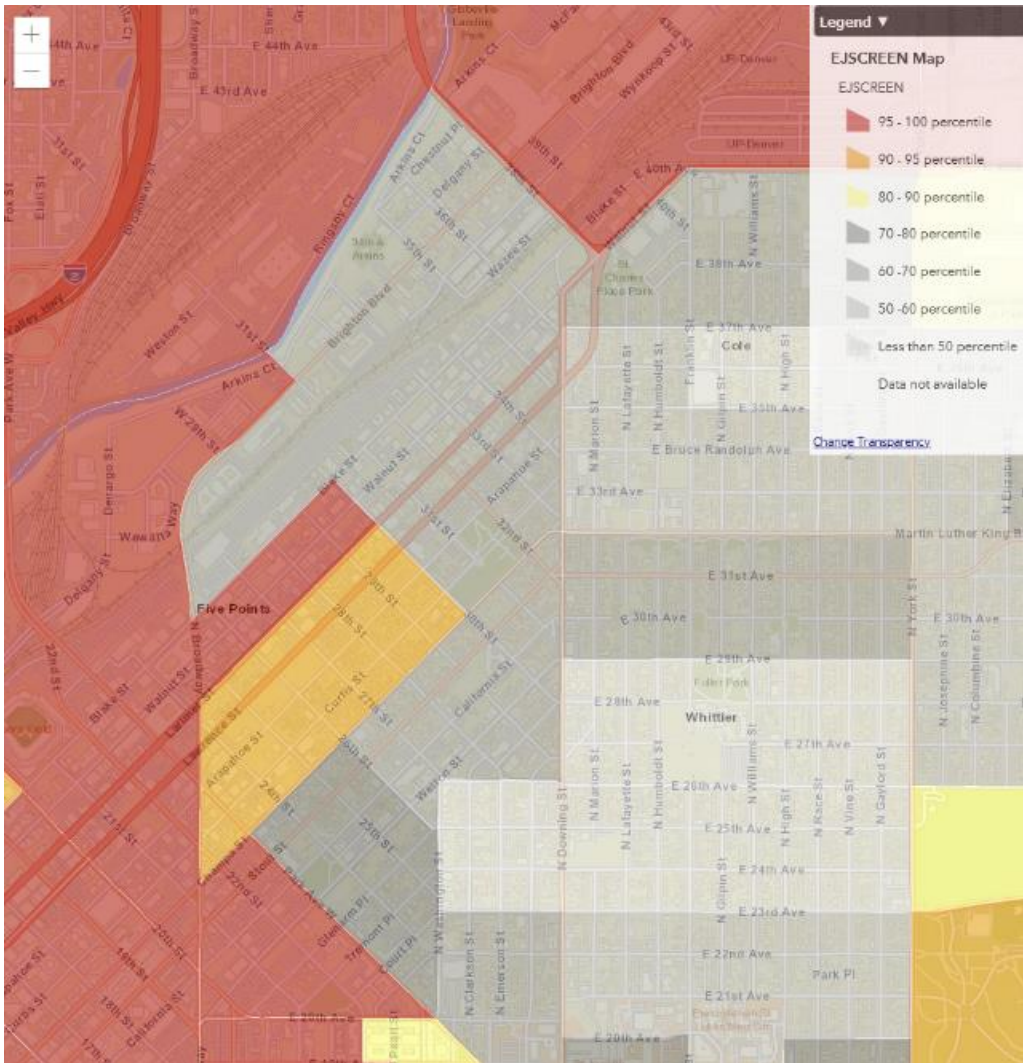


Figure 17 - Traffic Proximity and Volume (daily traffic count/distance to road) -State Percentiles- in the Five Points area (source: [EJSCREEN](#))



### Federal/Little Saigon

Federal Boulevard runs north/south as CO-88 west of the river, I-25, and Denver's central business district. The Federal Boulevard neighborhood centered around Alameda Avenue is surrounded by the larger single-family residential neighborhoods of Westwood to the southwest, Athmar Park to the southeast, Valverde to the northeast, and Barnum to the northwest. Federal Boulevard nestles many low-income communities, including a large Vietnamese population, including many residents with limited English proficiency. The neighborhood's median household income is \$42,292, compared to

\$68,592 for the City of Denver.<sup>10</sup> 23.43% of residents live in poverty, compared to the City of Denver average of 12.9%.<sup>11</sup> The community has advocated for signage in multiple languages, but the City of Denver has not agreed to design and install such signs.

The area is known for the Little Saigon business improvement district, a BID of Asian restaurants in the Federal Boulevard area. This neighborhood is home to a wide range of culturally diverse businesses. Many of these establishments are housed in their rented buildings surrounded by off-street parking or in multistory retail buildings ringed around a parking lot, creating a mix of curb cuts and few established loading and delivery spaces. As a result, many of the businesses in Little Saigon use the same spaces for parking as they do to accommodate supply deliveries. Delivery drivers may block spots for customers in these parking lots or may struggle to find space to unload if the parking lot is full.

While the neighborhood has a high walk score of 85, both South Federal Blvd and West Alameda Street are major arterials of at least five lanes of high-speed traffic that discourage walking to many local destinations. The Federal Boulevard and Alameda intersection is the most dangerous intersection in Denver, with the highest number of fatalities in the city. Neither street allows on-street parking, and medians, recently installed in early 2021, constrict the ability for vehicles to take left turns out of the many driveways.

Many residents and business owners in the area do not speak English as their first language. Many of the property owners in Little Saigon also rent their properties out to business tenants. Additionally, a lot of the Little Saigon area is under easements that cannot be developed. In the past three years, Denver has allocated some alleyways to allow deliveries to be done behind the businesses and off of the busy Federal Boulevard. However, Denver has had to use eminent domain to acquire access to those alleyways. Having to coordinate between tenants, property owners, and easements, often across language and cultural barriers, complicates finding delivery spaces or allowing back-alley deliveries.

BID directors for both the Little Saigon BID and the Federal Boulevard BID have heard complaints from businesses about idling delivery trucks along Federal Boulevard. While there is space for delivery trucks behind buildings and Denver has worked to give those trucks access, many delivery companies would prefer to be directly in front of the building rather than behind in an alley to speed up delivery.

Particulate matter is low in the Little Saigon area, despite what stakeholders noted about delivery trucks idling for deliveries and heavy traffic on Federal Boulevard. Traffic volume

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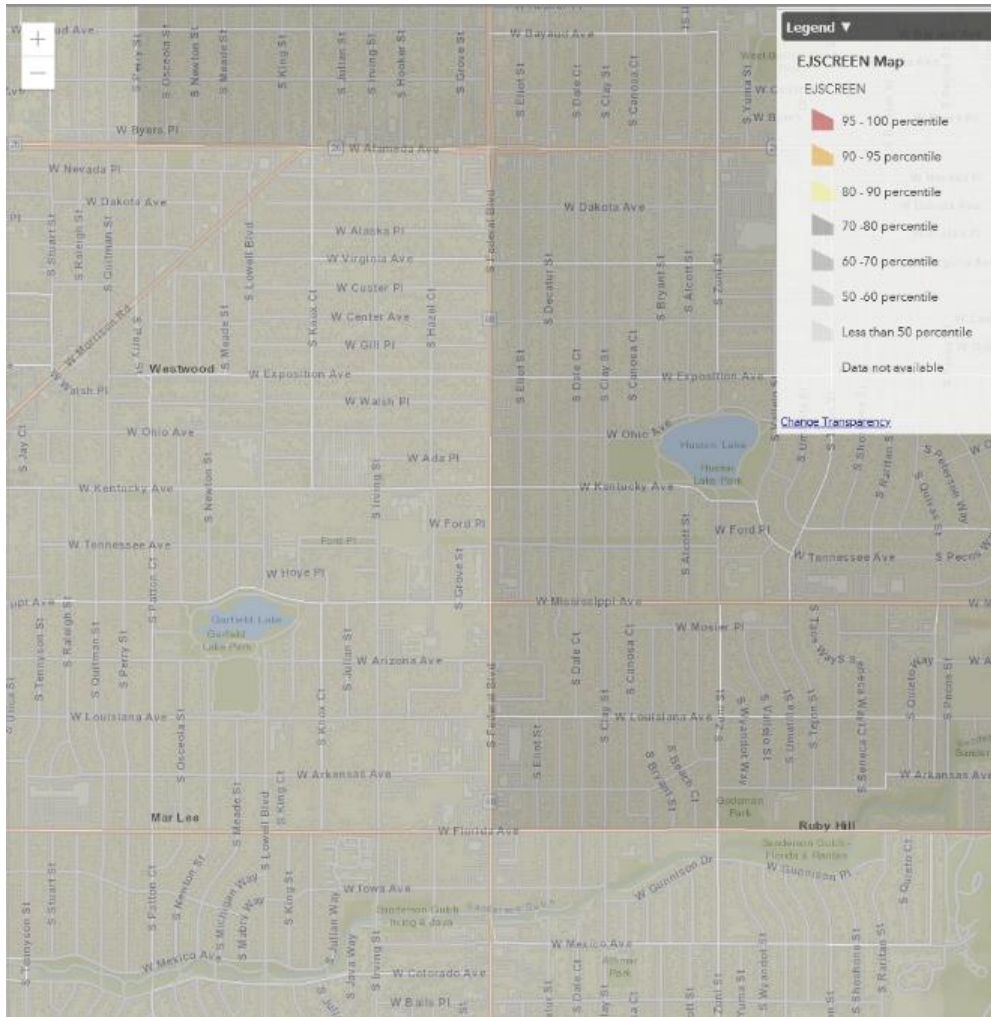
<sup>10</sup> <https://www.denvergov.org/content/dam/denvergov/Portals/643/documents/Maps/medhhincome.pdf>

<sup>11</sup> <https://denvermetrodata.org/neighborhood/jefferson-park>

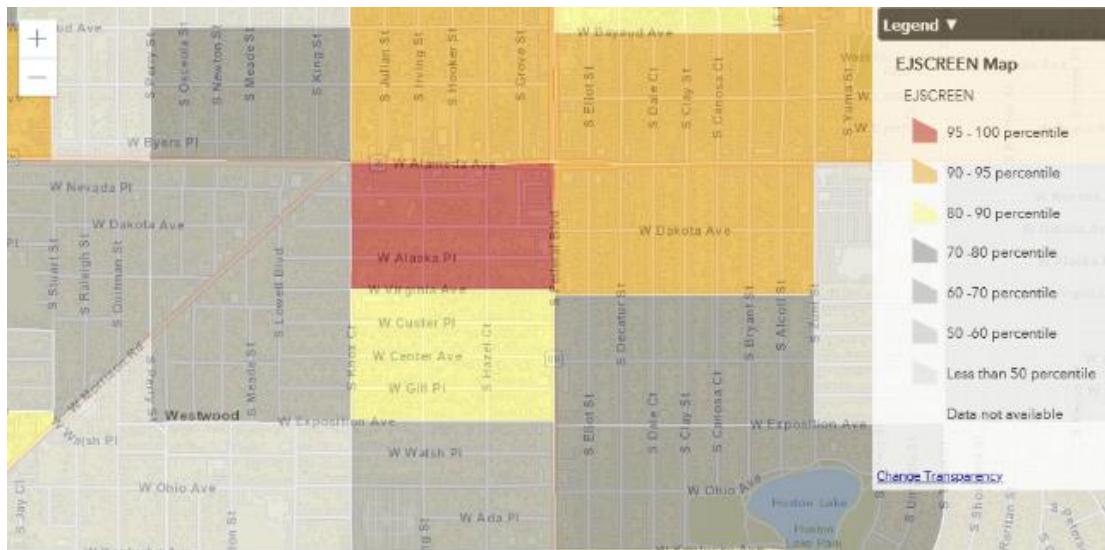
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is highest around the intersection of Federal Boulevard and West Alameda Avenue, where the Little Saigon BID is located.

**Figure 18 - Particulate Matter (PM 2.5 in  $\mu\text{g}/\text{m}^3$ ) -State Percentiles- in the Federal/Little Saigon area (source: [EJSCREEN](#))**



**Figure 19 - Traffic Proximity and Volume (daily traffic count/distance to road) -State Percentiles- in the Federal/Little Saigon area (source: [EJSCREEN](#))**



## Tennyson

The Tennyson Street neighborhood is part of the larger Berkeley neighborhood in northwest Denver. The neighborhood consists of mixed-use commercial and residential buildings. Tennyson Street is the main commercial corridor in the neighborhood between I-70 and W 38<sup>th</sup> Street and one of the main north/south through streets between Sheridan Boulevard and Federal Boulevard. Most roads in the neighborhood are narrower local streets. The Berkeley neighborhood houses more than 9,000 residents, of whom close to 70% of residents are White and 27% are Latino. These demographics are very similar to the overall City of Denver demographics, with 76.1% white and 29.9% Latino. Non-English-speaking adults make up just 4% of the population. The median household income in the Tennyson neighborhood is \$72,288.<sup>12</sup> This is higher than the City of Denver median household income, at \$68,592.<sup>13</sup> 8.01% of residents live in poverty, lower than the City of Denver average of 12.9%.<sup>14</sup>

Famous for its eclectic shops near Cesar Chavez Park, there is little off-street public parking for patrons, forcing restaurant and retail visitors to find space in the limited on-street parking, walk, bike, or take transit. Parking regulations for Tennyson are shown in Figure 2. Most parking in Tennyson is relatively unrestricted. Parking on Utica Street, Tennyson Street, and Stuart Street and cross streets intersecting these streets is restricted to short-term, two-hour parking. Stuart Street, a narrow residential street, has

<sup>12</sup> <https://www.denvergov.org/content/dam/denvergov/Portals/643/documents/Maps/medhincome.pdf>

<sup>13</sup> <https://www.census.gov/quickfacts/fact/table/denvercitycolorado,US/PST045219>

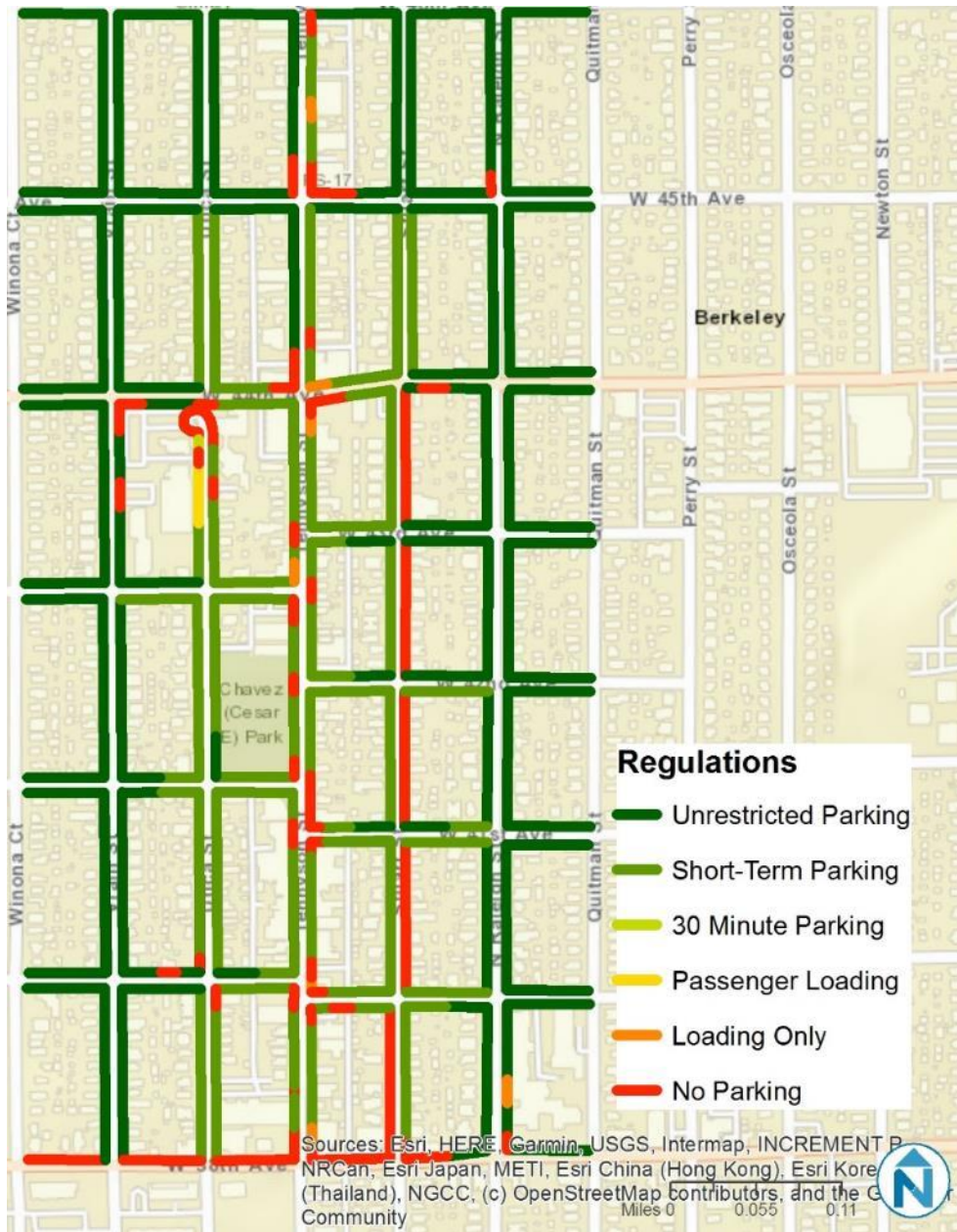
<sup>14</sup> <https://denvermetrodata.org/neighborhood/berkeley>



no-parking restrictions on one side of the street, increasingly the likelihood of temporary obstructions from delivery vehicles.

There are a small number of passenger loading zones along Utica Street, serving the religious assembly and school. Tennyson Street, the main commercial street throughout the neighborhood, has six commercial loading zones, primarily around 44<sup>th</sup> Ave. Most of the commercial businesses are located between 39<sup>th</sup> Ave and 44<sup>th</sup> Ave. More loading zones may be needed between 39<sup>th</sup> Ave and 41<sup>st</sup> Ave. Back alleys are available for delivery to many of these buildings, but a lack of coordination across many independent businesses can create duplication of services and crowding of available spaces. Combined with a limited ability to schedule deliveries from wholesale providers, small business supply deliveries can spill over to disrupt other on-street operations and uses. The northern section of Tennyson Street above West 44<sup>th</sup> Ave is more residential, but there is still a need for loading zones for delivery vehicles to support residential delivery as well as pickup from retail businesses.

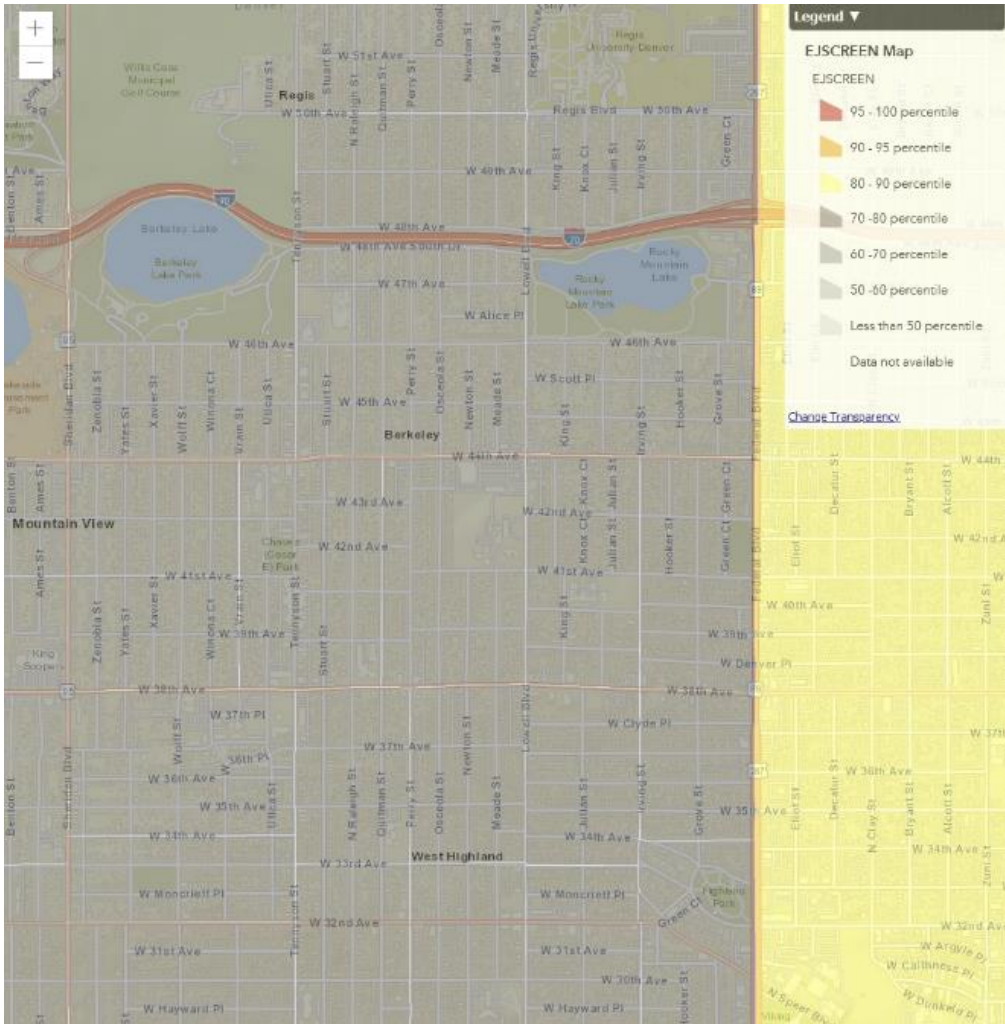
Figure 14: Tennyson Existing Conditions



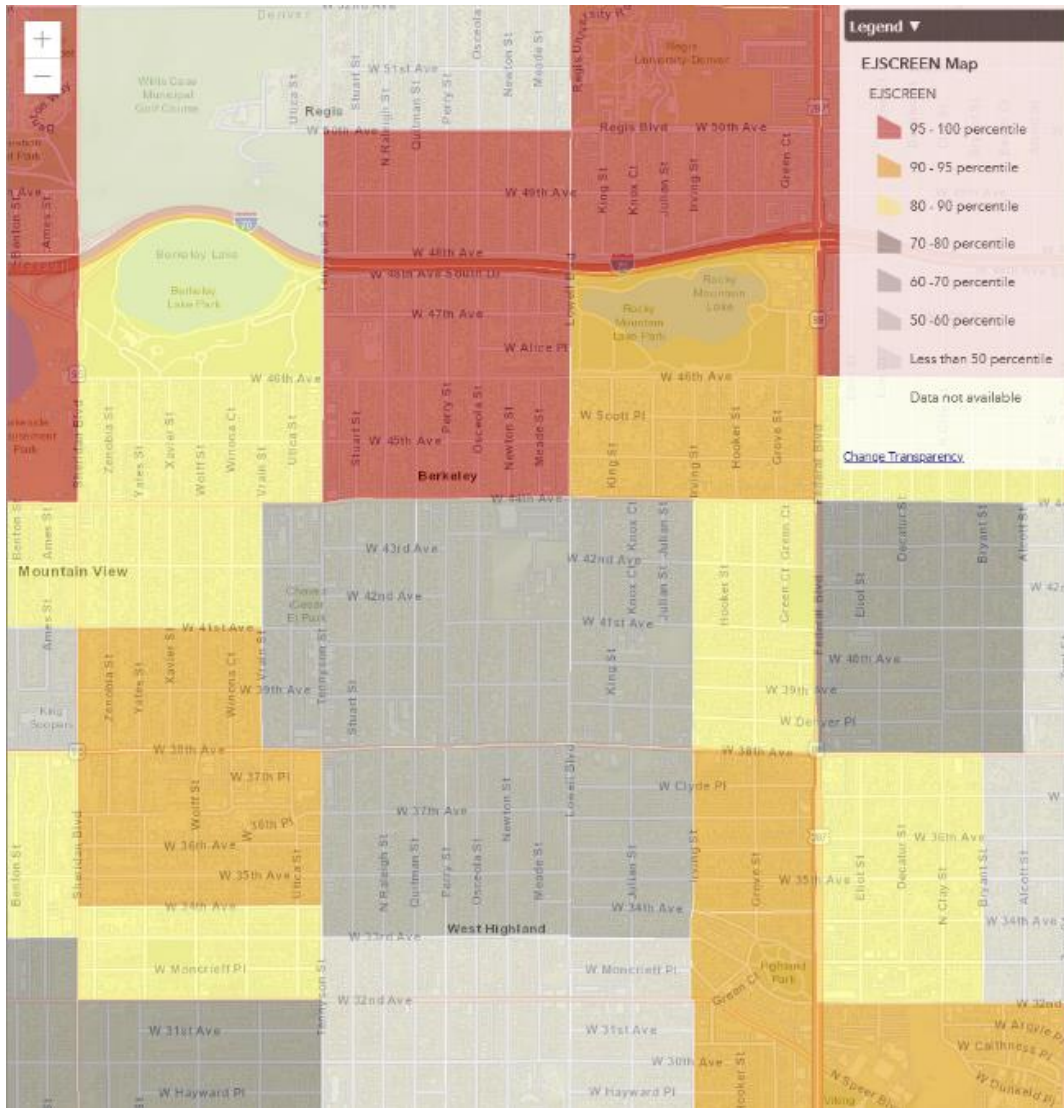
Particulate matter is low in the Berkeley and Tennyson neighborhood, a more residential area with small businesses and fewer large truck deliveries. Traffic volume is varied in the Berkeley neighborhood. Areas near Tennyson Street are in the 60-70<sup>th</sup> percentile for traffic volume, while areas directly north of that are in the 95-100<sup>th</sup> percentile for traffic volume.

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**Figure 20 - Particulate Matter (PM 2.5 in  $\mu\text{g}/\text{m}^3$ ) -State Percentiles- in the Tennyson area (source: [EJSCREEN](#))**



**Figure 21 - Traffic Proximity and Volume (daily traffic count/distance to road) -State Percentiles- in the Tennyson area (source: [EJSCREEN](#))**



## Highland

Denver’s Highland neighborhood, also known as the Lower Highlands or “LoHi” is an upper northwest city-center neighborhood. It is connected to Downtown Denver by the Denver Millennium Bridge, the Platte River Bridge, and the Highland Bridge. Highland has two historic districts, the Potter-Highland Historic District and Stonemans’ Row Historic District. Highland is known for its restaurants and small businesses, as well as

many new residential multifamily buildings.<sup>15</sup> Eight RTD bus routes run through the neighborhood.

Highland's 9,000 residents are 88% White, 1.42% Black, 2.6% Native American, and 21.5% Latino. Highland has a higher percentage of White residents than the City of Denver at 76.1%, and a lower percentage of Black residents, Latino residents, and Native American residents. Non-English-speaking adults are 4.1% of the population. Highland has a median household income of \$73,217, higher than the City of Denver median household income of \$68,592.<sup>16</sup> 8.82% of residents live in poverty, compared to 12.9% of City of Denver residents.<sup>17</sup>

I-25 runs along the southeast border of the neighborhood, with Central Street as a frontage road serving local destinations for visitors and deliveries. Arterial roads like Federal Boulevard and Speer Boulevard border the neighborhood to the west and south.

Parking regulations for Highland are shown in Figure 3. Most of the neighborhood has unrestricted parking along residential streets outside of the commercial core of the neighborhood. Areas along arterial roads with higher traffic volumes, such as areas along Interstate 25 or areas along West 38<sup>th</sup> Avenue, do not allow parking. Highland's commercial core radiates out from West 32<sup>nd</sup> Avenue to Zuni Street. There are 64 loading spaces out of 4,466 total spaces in Highland. Most loading zones are located in areas of commercial activity, as opposed to more residential areas. These loading zones are generally located along corners of the street to aid in parking maneuverability. Unlike other residential neighborhoods further from LoDo and Downtown, alleyways are more constrained and provide few outlets for delivery operations off main streets.

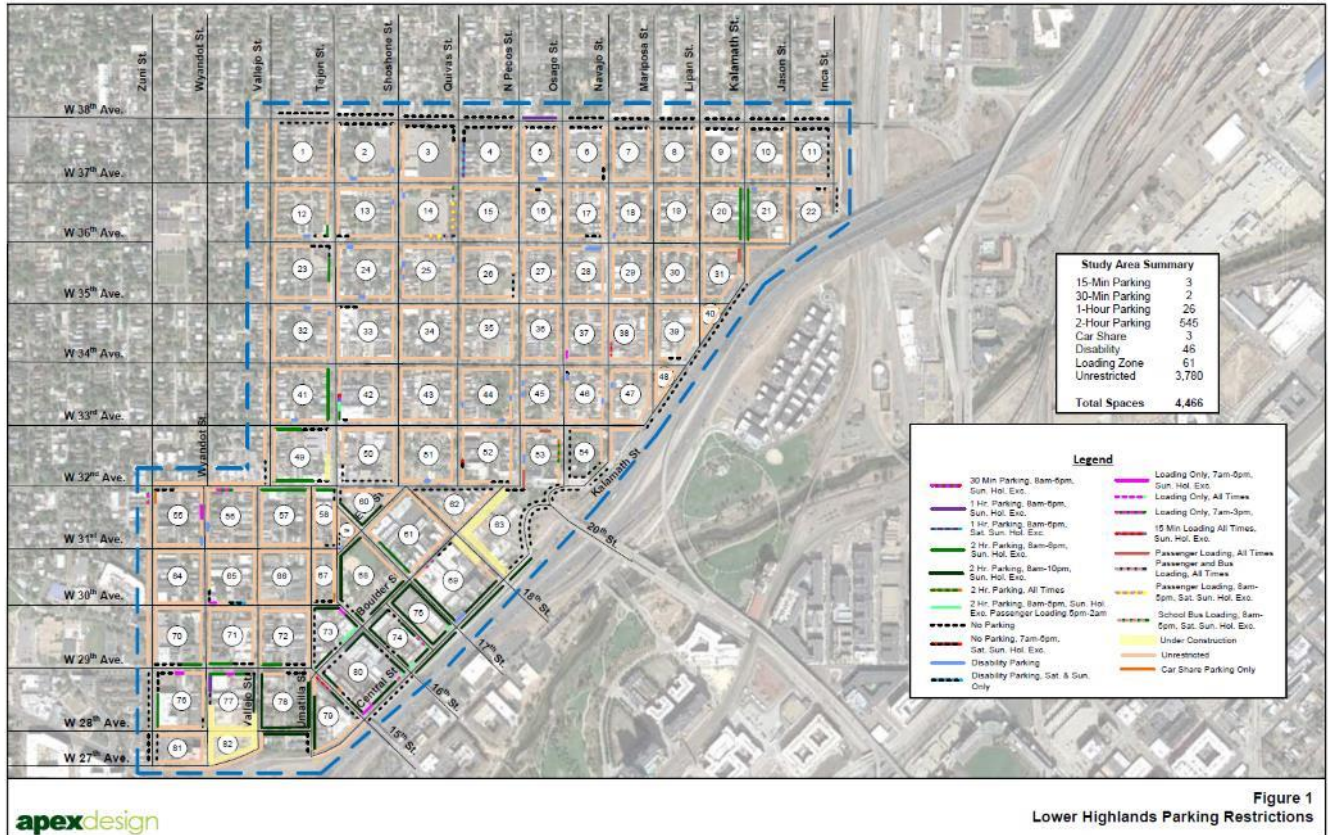
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<sup>15</sup> <https://www.denver.org/about-denver/neighborhood-guides/highlands/>

<sup>16</sup> <https://www.denvergov.org/content/dam/denvergov/Portals/643/documents/Maps/medhhincome.pdf>

<sup>17</sup> <https://denvermetrodata.org/neighborhood/highland>

Figure 15: Highland Parking Regulations<sup>18</sup>



Lastly, the figures below highlight particulate matter and proximity to traffic in the Highland area (by state percentiles), highlighting areas experiencing adverse pollution effects and that could benefit from innovative solutions to make freight deliveries more environmentally-friendly. Areas of Highland north of 20<sup>th</sup> Street see particulate matter levels in the 80-90<sup>th</sup> percentiles, while areas south of 20<sup>th</sup> Street have lower values of particulate matter. Areas of Highland closer to Interstate 25 have traffic volume counts in the 95-100<sup>th</sup> percentiles. Areas farther from interstates and Downtown have lower traffic volumes.

<sup>18</sup> Source: City of Denver

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**Figure 22 - Particulate Matter (PM 2.5 in  $\mu\text{g}/\text{m}^3$ ) -State Percentiles- in the Highland area (source: [EJSCREEN](#))**

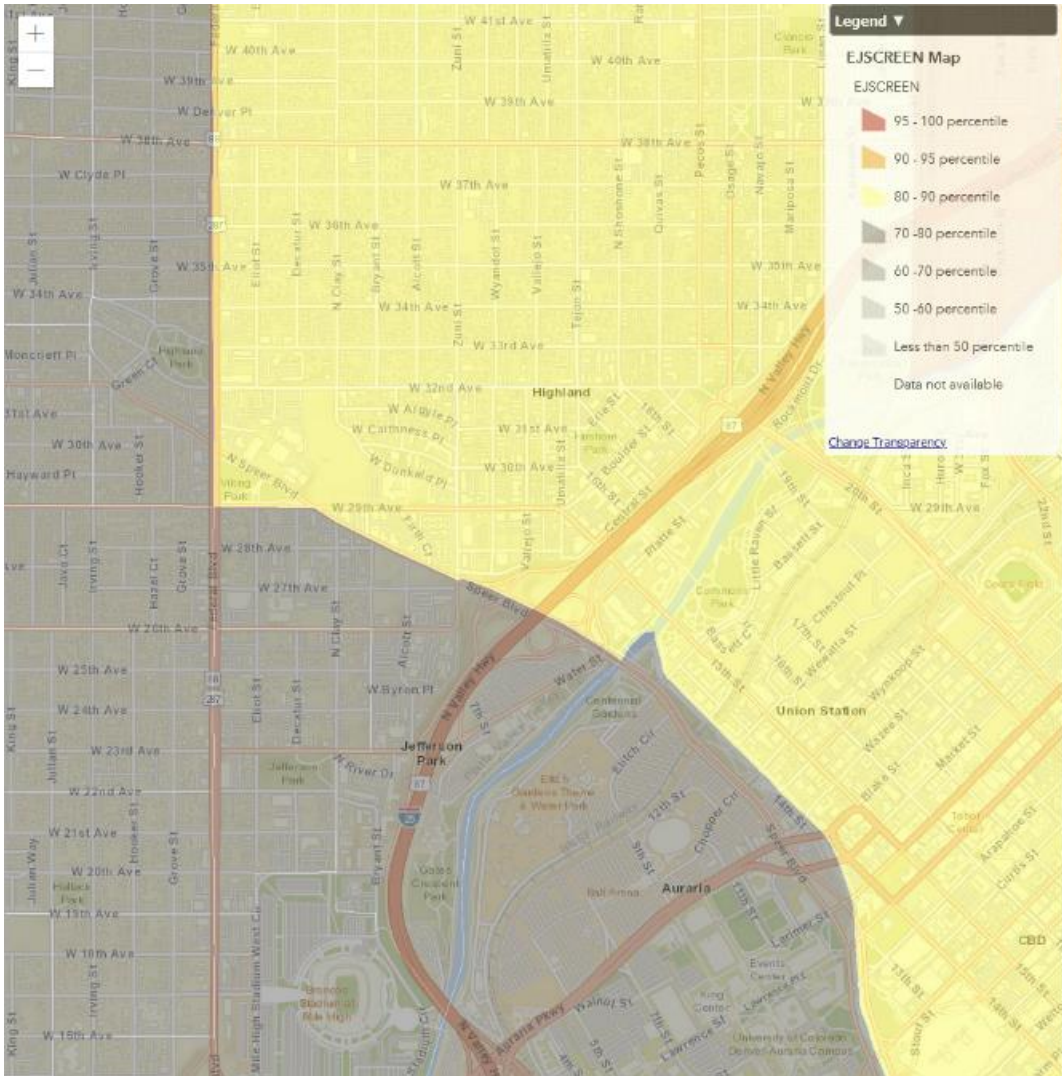
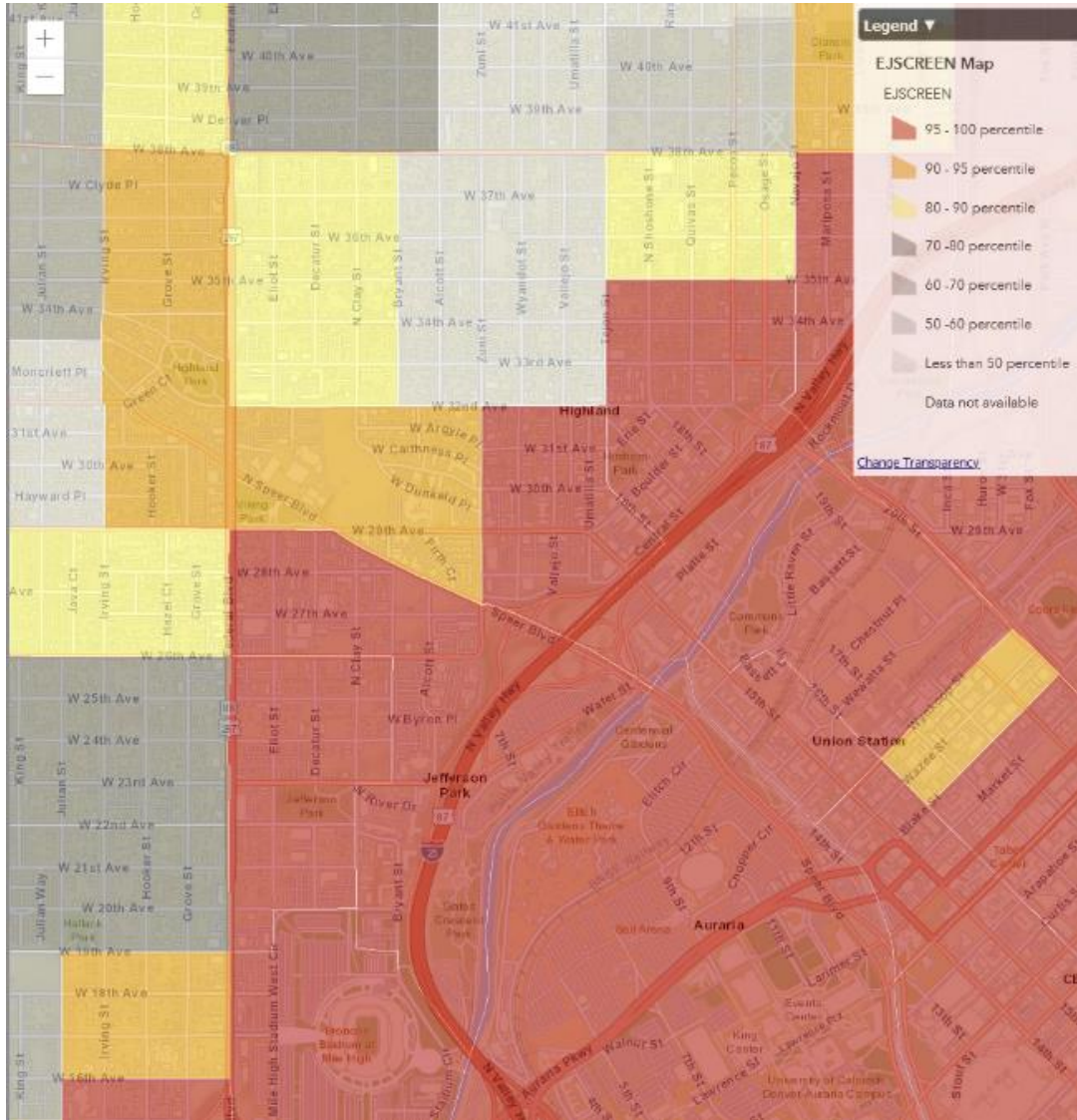


Figure 23 - Traffic Proximity and Volume (daily traffic count/distance to road) -State Percentiles- in the Highland area (source: [EJSCREEN](#))



### Bruce Randolph (Clayton and Cole)

Bruce Randolph Avenue runs through Denver's Clayton and Cole neighborhoods in Northeast Denver. The street, formerly 34<sup>th</sup> Avenue, was named for Bruce Randolph, the "unofficial mayor of Denver" who started the Daddy Bruce Thanksgiving Food



Distribution, in 1985.<sup>19</sup> Bruce Randolph Avenue runs from North Downing Street in the Cole neighborhood through the Clayton neighborhood to Dahlia Street.

The Clayton neighborhood has a total population of 4,253. Clayton is 62% White, 18% Black, and 44% Latino. Non-English-speaking adults comprise 10% of the total population. The Cole neighborhood has a total population of 4,775. Cole is 65% White, 14% Black, and 52% Latino. Clayton and Cole both have significantly higher BIPOC populations than the City of Denver, with 76.1% White, 9.2% Black, and 29.9% Latino. Non-English-speaking adults comprise 15% of the Cole population. The median household income in Clayton is \$44,601 and \$38,542 in Cole.<sup>20</sup> These incomes are significantly lower than the City of Denver median income of \$68,592. 25.18% of residents in Clayton live in poverty, and 25.34% of residents in Cole live in poverty, significantly higher than the City of Denver poverty rate at 12.9%.<sup>21</sup>

The land use along Bruce Randolph Avenue is mixed-use. The 5-lane avenue hosts a mix of restaurants, churches, businesses, and residential dwellings. The Cole and Clayton neighborhoods are near the River North Arts District and the Five Points neighborhoods, two areas with strong commercial activities that bleed onto Bruce Randolph Avenue. The Clayton neighborhood at the eastern portions of Bruce Randolph Avenue have fewer walkable commercial destinations.

Figure 4 shows the current parking and loading regulations for the Cole portion of Bruce Randolph Avenue. Most of the parking is unrestricted, where allowed. There are no loading zones on Bruce Randolph Avenue, and one spot at Franklin Street where there is two-hour time-limited parking. In the Cole neighborhood, loading zones are restricted to passenger loading and school bus loading. The corridor [measured peak parking utilization at noon on a weekday at just 30%](#), meaning delivery vehicles will likely always find a parking space reasonably close to their intended destination.

The City of Denver plans to add bike lanes (N Downing Street to Colorado Boulevard) as part of a Bruce Randolph road diet in the future, after being recommended by Blueprint Denver. The planned design of the corridor would eliminate the northern-side parking lane (as well as a central turning lane) to fit buffered bike lanes. This change creates new pressure on the parking supply. Even eliminating half of the parking supply on the corridor, the low peak utilization indicates there may continue to be limited competition for curb space from delivery vehicles. Special attention should be made to raise awareness of the regulations and safety risks to bicyclists to reduce double parking in the future bike lanes, such as encouraging drivers to pull off onto a side street or residential alley when delivering to a northside business destination.

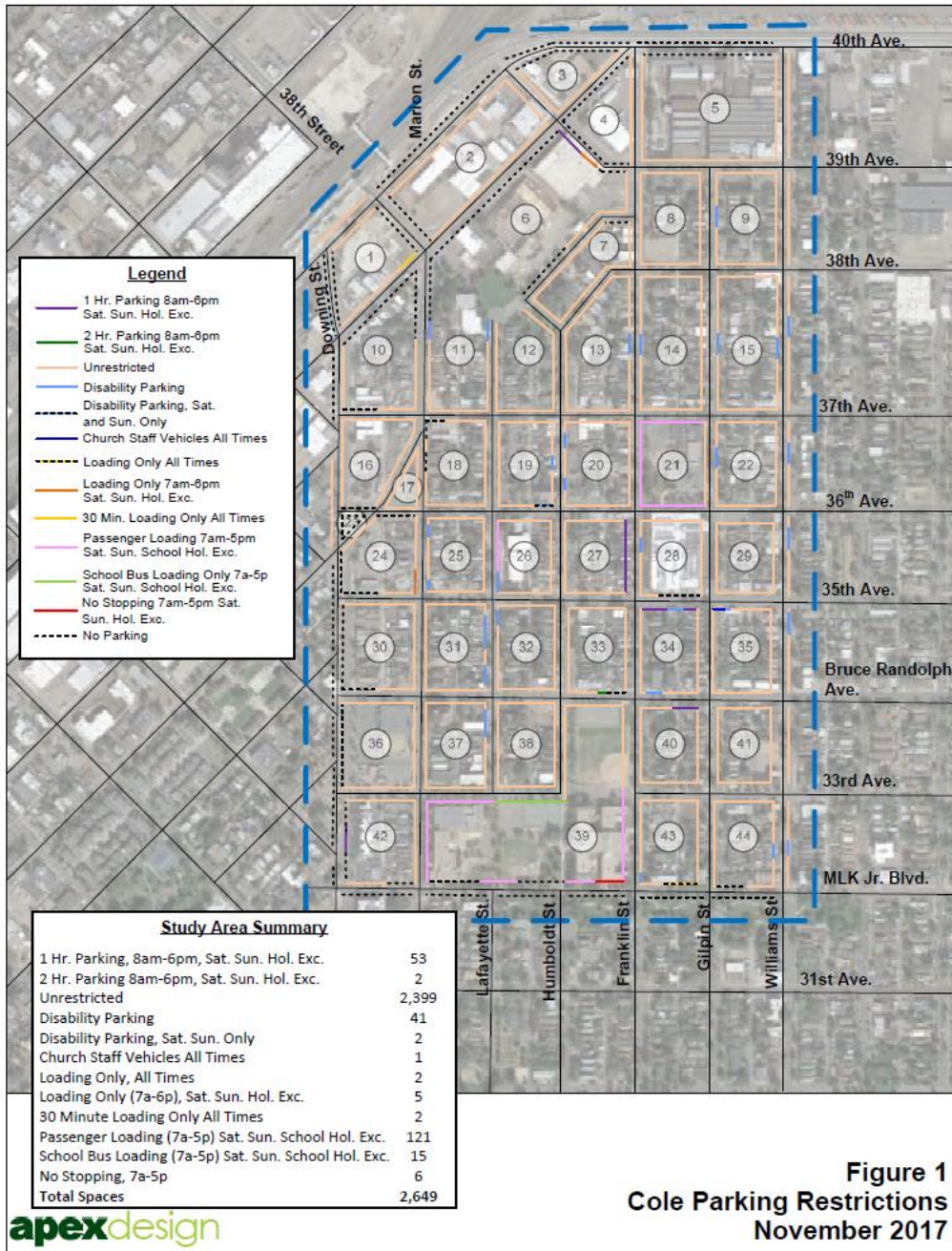
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<sup>19</sup> <https://www.thedenverchannel.com/news/our-colorado/who-was-daddy-bruce-randolph-remembering-denvers-unofficial-mayor>

<sup>20</sup> <https://www.denvergov.org/content/dam/denvergov/Portals/643/documents/Maps/medhhincome.pdf>

<sup>21</sup> <https://denvermetrodata.org/neighborhoods>

Figure 16: Bruce Randolph Avenue Parking Regulations



Lastly, the figures below highlight particulate matter and proximity to traffic in the Clayton and Cole areas (by state percentiles), highlighting areas experiencing adverse pollution effects and that could benefit from innovative solutions to make freight deliveries more environmentally-friendly. Particulate matter in the Clayton and Cole areas is in the 90-95<sup>th</sup> percentiles, higher than surrounding areas. However, traffic volumes surrounding Bruce Randolph Avenue are much lower than areas in Clayton and Cole directly closer to highways.

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**Figure 24 - Particulate Matter (PM 2.5 in  $\mu\text{g}/\text{m}^3$ ) -State Percentiles- in the Clayton and Cole areas (source: [EJSCREEN](#))**

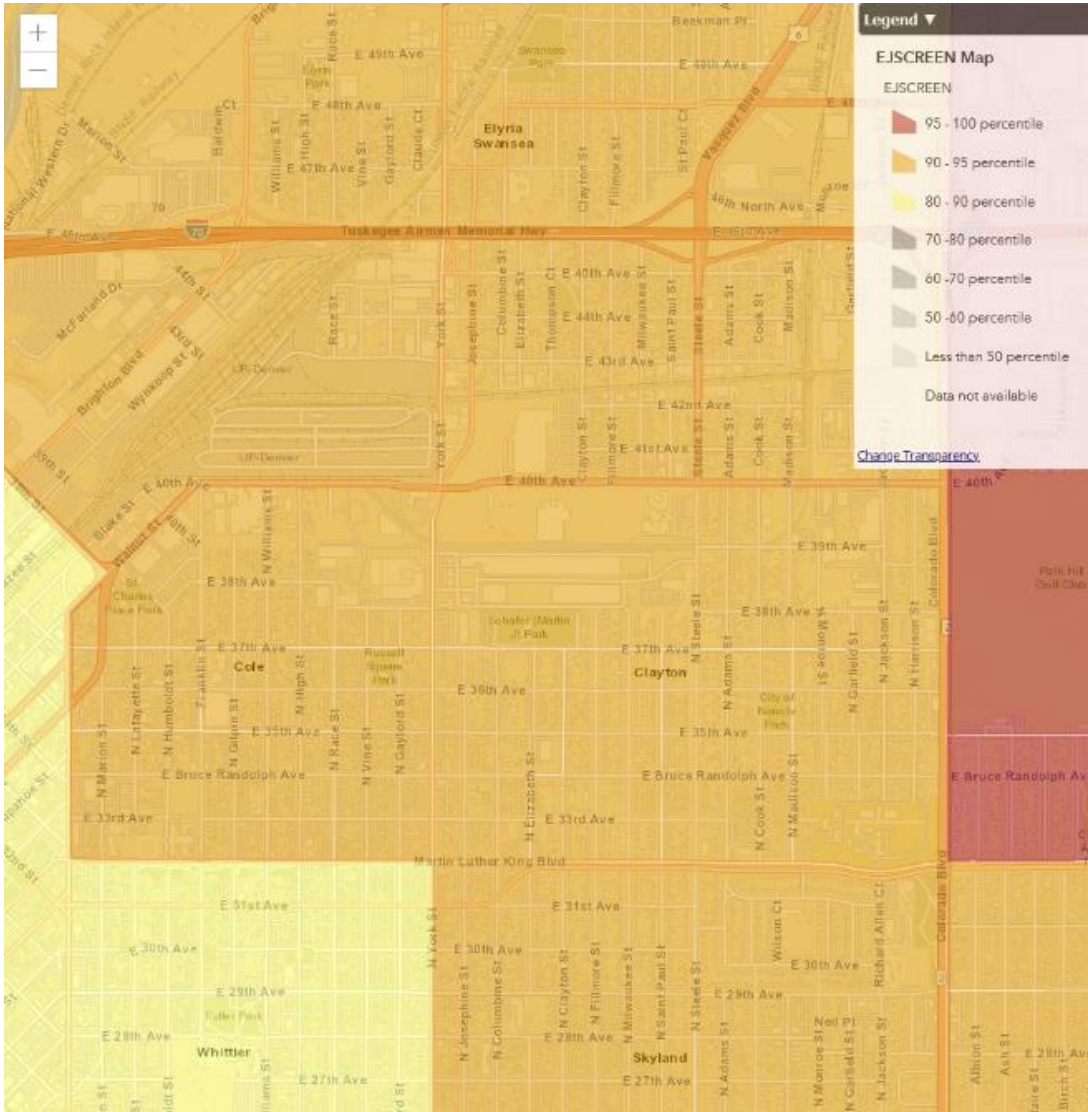
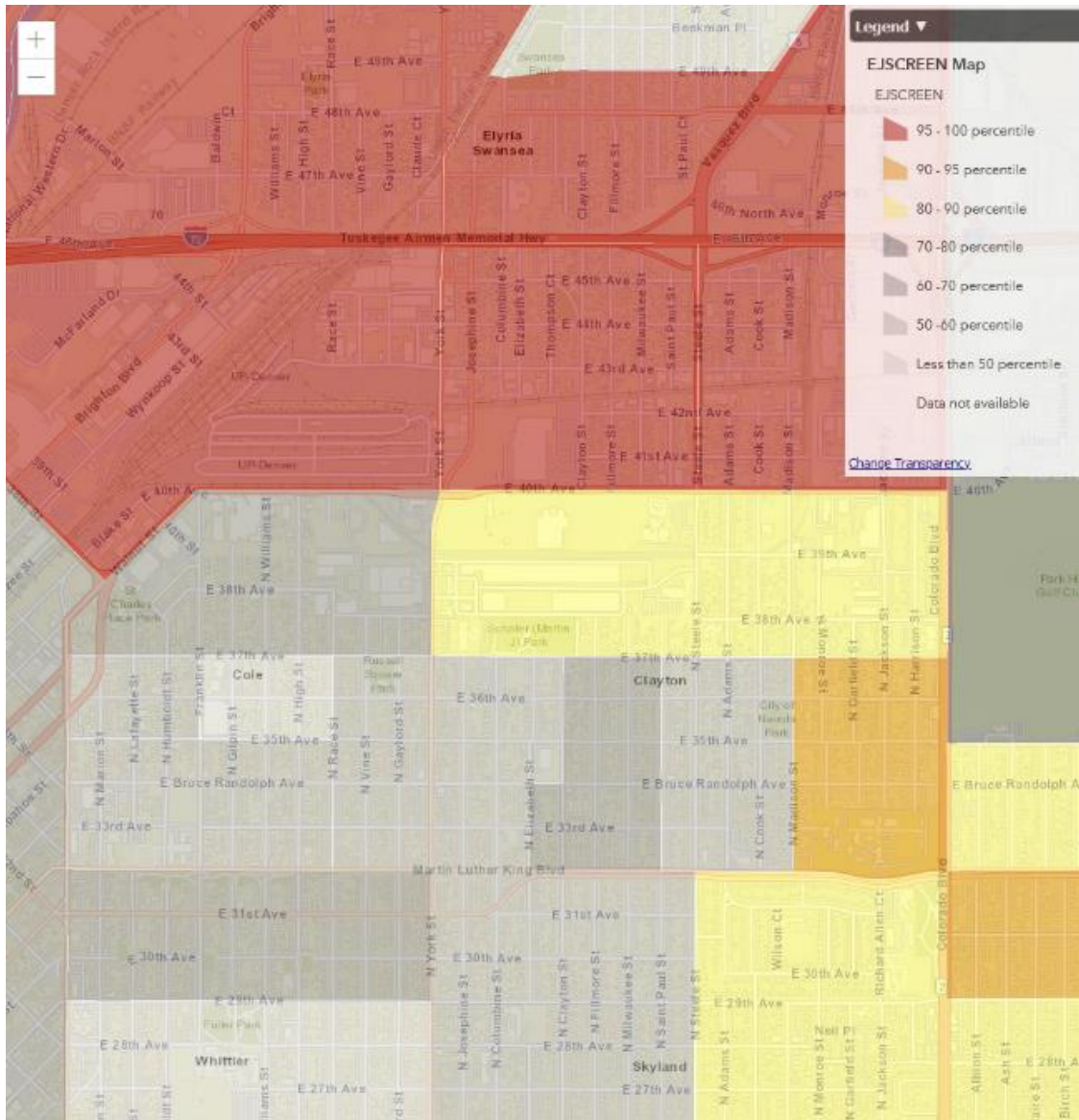


Figure 25 - Traffic Proximity and Volume (daily traffic count/distance to road) -State Percentiles- in the Clayton and Cole areas (source: [EJSCREEN](#))



### East Colfax Avenue (North Capitol Hill)

Colfax Avenue runs east-west through the center of Denver out to Aurora, Colorado, and beyond. The section of East Colfax Avenue that runs through North Capitol Hill from North Washington Street to Franklin Street is a dense commercial core with businesses lining both sides of Colfax. In the North Capitol Hill neighborhood, East Colfax Avenue is a five-lane arterial road, with two lanes of traffic each direction and a center turning lane. Certain portions of the corridor also have on-street parking. A major issue facing delivery

along East Colfax is traffic congestion and high demand driving competition for loading spaces.

The North Capitol Hill neighborhood has a total population of 6,040. The neighborhood is 86% White, 8% Black, and 10% Latino. North Capitol Hill is whiter than most of Denver, at 76.1% White for the City of Denver, 9.2% Black, and 29.9% Latino. Non-English-speaking adults comprise 2% of the North Capitol Hill population. The average household income in North Capitol Hill is \$55,307, lower than the City of Denver median income of \$68,592.<sup>22</sup> 16.18% of residents live in poverty, higher than the City of Denver poverty rate of 12.9%.<sup>23</sup>

East Colfax parking regulations are shown in Figure 17. Most of the spaces directly along East Colfax are metered parking spaces, with a two-hour limit. Alley access for loading is typically perpendicular from East Colfax. East Colfax has three 15-minute loading zones (at Ogden, Marion, and Franklin), where loading is allowed from 7am to 6pm with Sunday and holiday exemptions. Many of the cross streets have loading zones around the corner from East Colfax Avenue. Washington Street has a truck loading zone on the intersection with East Colfax and the rest of the block is unrestricted parking. Emerson Street has a passenger loading space. Marion Street has a loading-only space on the intersection with East Colfax Avenue and a second loading-only space farther up the towards East 16<sup>th</sup> Avenue. Many of the cross streets, including Clarkson Street, Emerson Street, Ogden Street, Marion Street, Lafayette Street, Humboldt Street, and Franklin have short-term or unrestricted parking. Delivery vehicles may be able to use these spaces for deliveries. Many of the businesses also have parking lots behind their buildings. There are likely loading docks or spaces for loading in those lots.

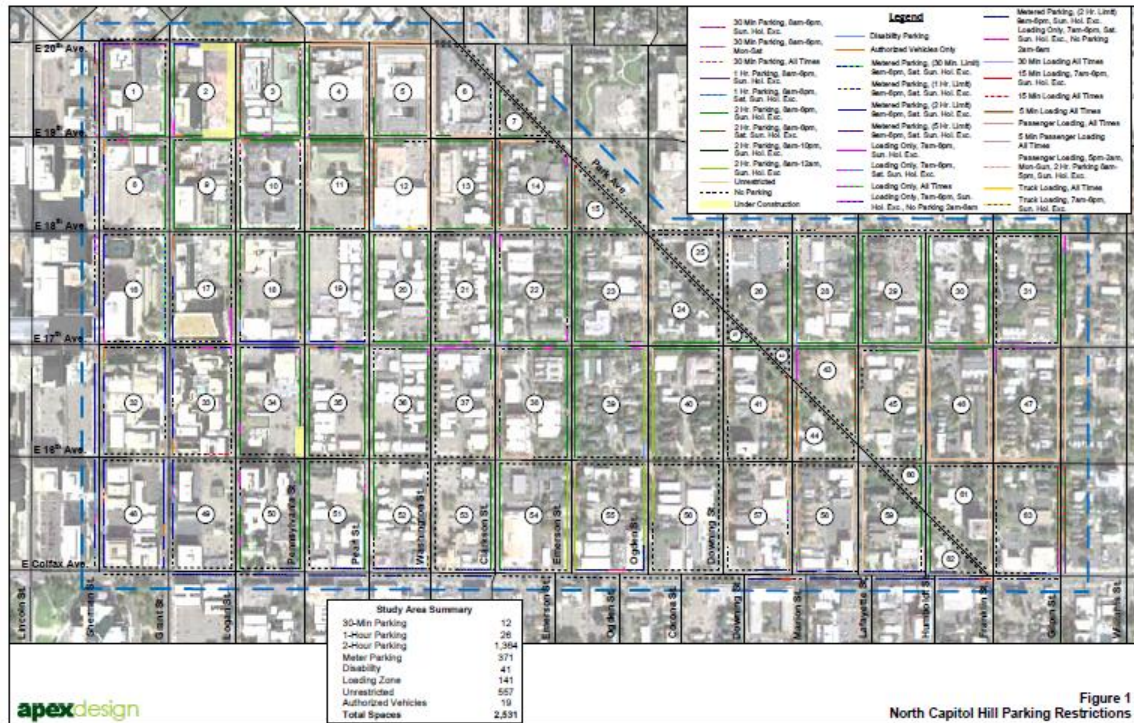
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<sup>22</sup> <https://www.denvergov.org/content/dam/denvergov/Portals/643/documents/Maps/medhnhincome.pdf>

<sup>23</sup> <https://denvermetrodata.org/neighborhood/north-capitol-hill>

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**Figure 17: East Colfax Regulations**



Lastly, the figures below highlight particulate matter and proximity to traffic in the North Capitol Hill area (by state percentiles), highlighting areas experiencing adverse pollution effects and that could benefit from innovative solutions to make freight deliveries more environmentally-friendly. Particulate matter surrounding East Colfax Avenue in the North Capitol Hill area is in the 80-90<sup>th</sup> percentile. Areas further west on East Colfax, closer to the Capitol building, have traffic counts within the 95-100<sup>th</sup> percentile. Areas further east along East Colfax, in the North Capitol Hill neighborhood (north of East Colfax) have traffic volumes in the 80-90<sup>th</sup> percentiles. Areas south of East Colfax in the Capitol Hill neighborhood have traffic volumes within the 90-95<sup>th</sup> percentiles.

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**Figure 26 - Particulate Matter (PM 2.5 in  $\mu\text{g}/\text{m}^3$ ) -State Percentiles- in the North Capitol Hill area (source: [EJSCREEN](#))**

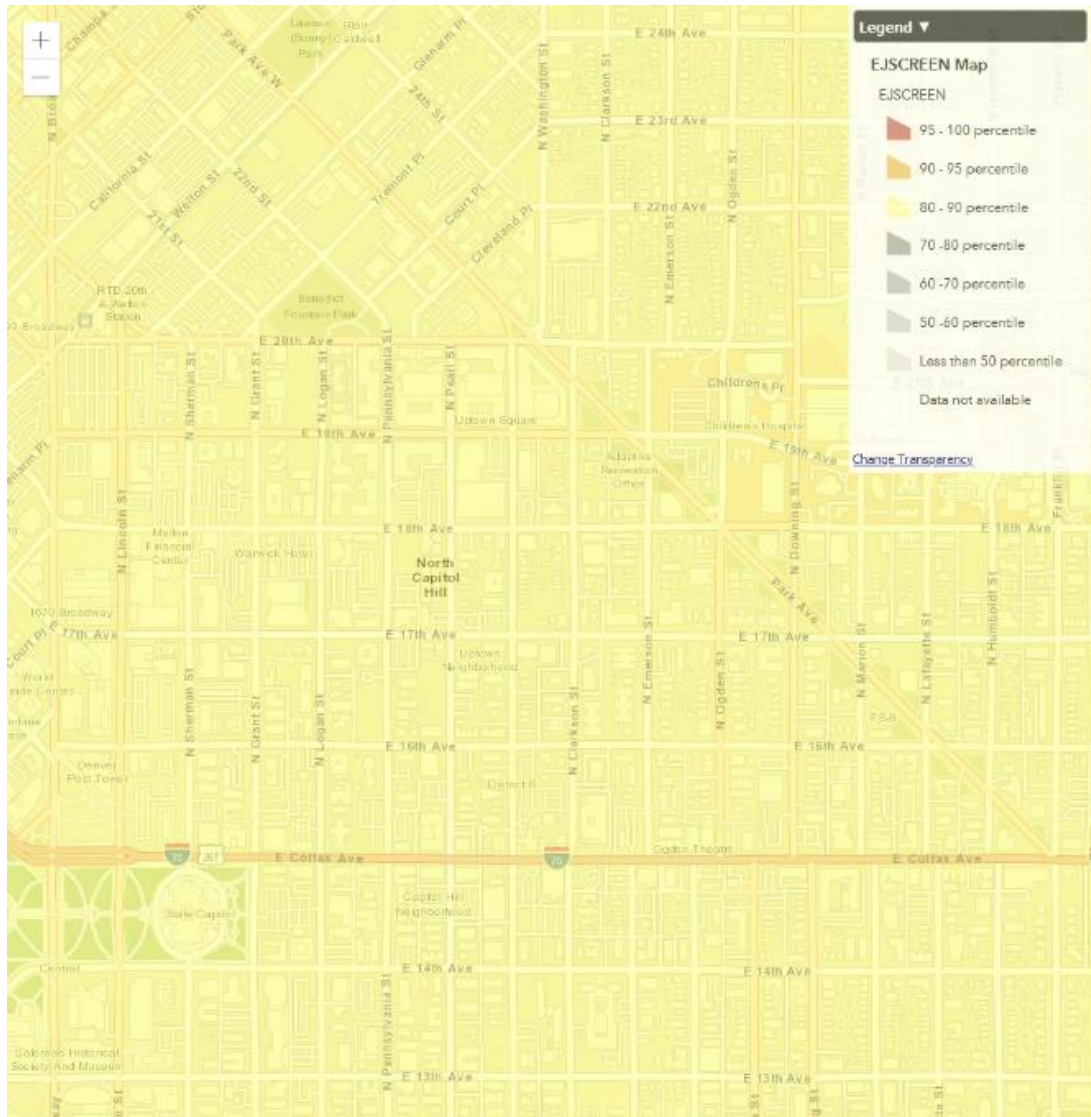
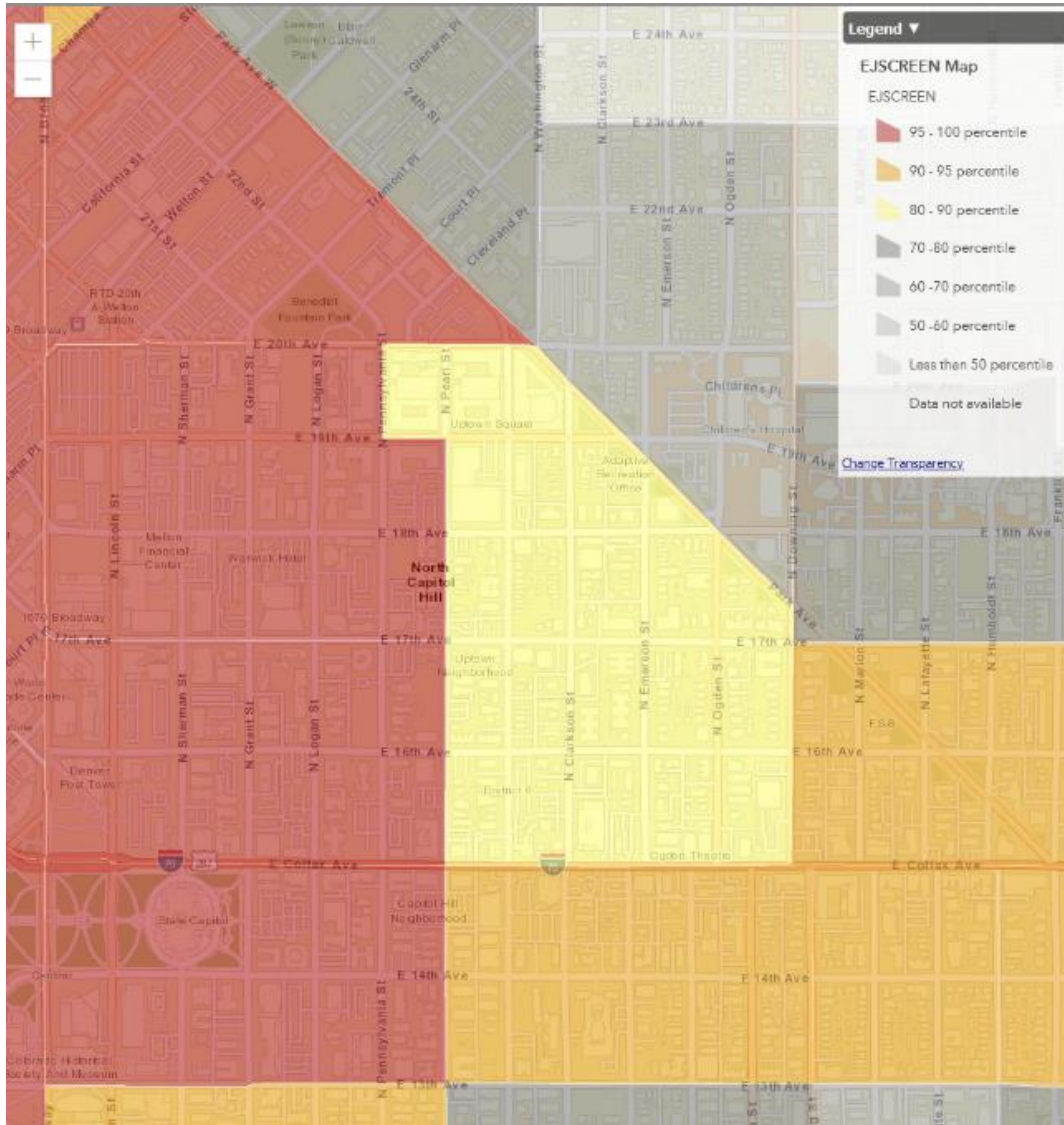


Figure 27 - Traffic Proximity and Volume (daily traffic count/distance to road) -State Percentiles- in the North Capitol Hill area (source: [EJSCREEN](#))



### South Broadway (Alameda Avenue to I-25)

South Broadway is a major transportation corridor in Denver. Historically, used as a major freight route, South Broadway today is a five-lane arterial road, with four lanes of one-way south-bound traffic and a bus lane. RTD's Route 0 and Route 0 Limited run along South Broadway in the bus lane. A protected bike lane also runs along South Broadway. The neighborhoods around South Broadway have an average median household income of \$53,994, lower than the City of Denver median income of



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\$68,592.<sup>24</sup> 11.21% of residents live in poverty, compared to 12.9% for the City of Denver.<sup>25</sup>

South Broadway supports a variety of commercial buildings, with a mixture of restaurants and small retail businesses. There is limited parking along South Broadway. Most spaces are restricted to one-hour parking from 9am to 6pm. Along South Broadway, there are a few Loading-Only zones as well. The limited number of on-street loading zones and parking spaces means that if delivery vehicles need to delivery to destinations on the right side of the street, they may block the bus lane or block a lane of traffic if double-parking. Despite the lack of longer-term parking or larger loading zones, many of the businesses have large off-street parking lots and back alleys for deliveries or delivery pick-ups.

Lastly, the figures below highlight particulate matter and proximity to traffic in the South Broadway area (by state percentiles), highlighting areas experiencing adverse pollution effects and that could benefit from innovative solutions to make freight deliveries more environmentally-friendly. Particulate matter levels along South Broadway are within the 70-80<sup>th</sup> percentile. Areas east of South Broadway have traffic volumes in the 95-100<sup>th</sup> percentiles, while areas west of South Broadway have much lower traffic counts, in the 70-80<sup>th</sup> percentiles.

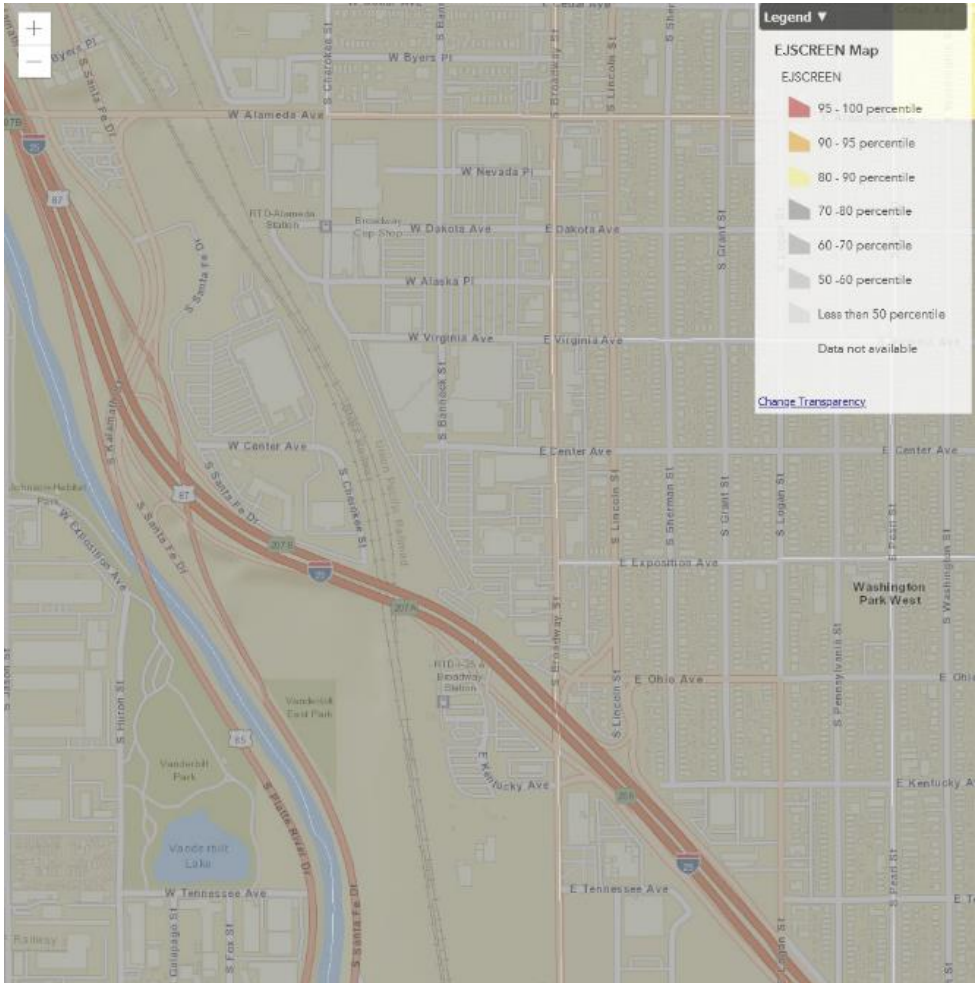
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<sup>24</sup> <https://www.denvergov.org/content/dam/denvergov/Portals/643/documents/Maps/medhhincome.pdf>

<sup>25</sup> <https://denvermetrodata.org/neighborhoods>

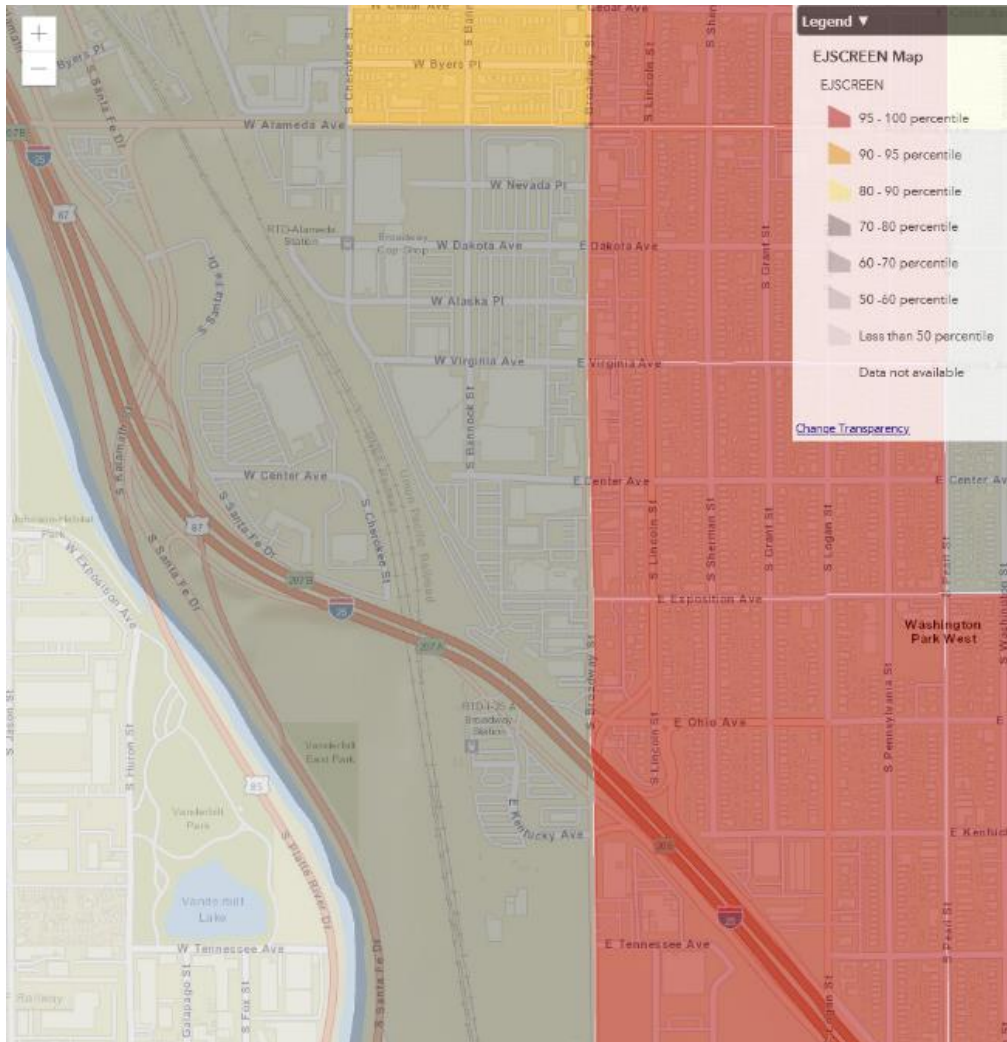
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**Figure 28 - Particulate Matter (PM 2.5 in  $\mu\text{g}/\text{m}^3$ ) -State Percentiles- in the South Broadway area (source: [EJSCREEN](#))**



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**Figure 29 - Traffic Proximity and Volume (daily traffic count/distance to road) -State Percentiles- in the South Broadway area (source: [EJSCREEN](#))**



## BEST PRACTICES

This section explores ways in which cities across the nation and the world are tackling local delivery challenges to improve last-mile delivery by making it more equitable, decreasing environmental impacts, and increasing safety. These examples include efforts with the potential to be modified and implemented in Denver. The following case studies focus on:

- Policies that can be adopted by the City to better organize delivery operations on public rights-of-way;
- Public sector-led programs that have been used to incentivize private sector cooperation and innovation in tackling last-mile delivery challenges; and
- New technological innovations that have the potential to improve last-mile delivery outcomes in Denver.

### City Policies, Regulations, and Programs

The City and County of Denver has the potential to implement various initiatives aimed at bettering the last-mile environment through balancing competing last mile uses, competing needs for the curb and right-of-way, reducing collisions, improving air quality, and reducing greenhouse gas emissions while improving the delivery environment for business needs.

#### C40 Clean and Healthy Streets Initiative

C40 launched the Green and Healthy Streets Declaration in October 2017 with two goals: a) to give a clear signal to the private sector that there is a growing demand for zero-emission products and services, and b) to raise the level of ambition among all cities to transition to zero emissions transit.<sup>26</sup> Cities that join the initiative commit to procure only zero-emission buses beginning in 2025 and ensure that a major area of their city is zero emission by 2030. Signatories so far are:

- US Cities: Austin, Los Angeles, Seattle, Honolulu, Santa Monica, and West Hollywood
- International Cities: Amsterdam, Auckland, Barcelona, Berlin, Bogotá, Cape Town, Copenhagen, Heidelberg, Jakarta, London, Madrid, Medellín, Mexico City, Milan, Moscow, Oslo, Paris, Quito, Rio de Janeiro, Rome, Rotterdam, Santiago, Seoul, Tokyo, Vancouver, Warsaw, Birmingham, Liverpool, Oxford, and Greater Manchester<sup>27</sup>

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<sup>26</sup> <https://www.c40.org/>. Accessed December 13, 2021

<sup>27</sup> <https://www.c40.org/declarations/green-healthy-streets-declaration/>. Accessed December 13, 2021.

## **Commercial Loading Zone Management Program**

The City of Denver could benefit from implementing enhanced commercial zone management programs. Actively managing commercial loading zones in contentious, high-demand areas has the potential to increase roadway safety while promoting the orderly use of the curb, benefiting not only freight operators but the public in general.

In many neighborhoods bustling with commercial activity and high-density residential buildings with on-street parking, commercial vehicles sometimes arrive at their delivery destinations to find no open spaces and block the travel lane by double parking. Double parking is common when drivers, after circling blocks to find an available space or a commercial loading zone or based on time pressure, decide to block a travel lane disrupting traffic flow and creating safety hazards.

In Washington DC, all of the city's curbside loading zones for commercial vehicles are metered and have a two-hour time limit. The policy change reduced violations for double parking and non-trucks parking in loading zones by 50%.<sup>28</sup> Truck routes, local truck routes (prohibiting through trips), and commercial loading zones can be found on an [interactive webmap](#). In order to park, individuals operating commercial vehicles have to purchase a parking permit or make mobile payments for parking. Daily permits costs \$25 and annual permits \$323, while mobile payments cost \$2 per hour.

New York City also implemented metered charges for commercial vehicle spaces to ensure curb space turnover. NYCDOT established an escalating rate structure of \$2.00 for one hour, \$5.00 for two hours and \$9.00 for three hours to encourage shorter dwell times at each loading space: the implementation of this program has resulted in reduced dwelling times. The percentage of occupied curb space dropped to 95% from an average of 140%, with only a quarter of commercial vehicles dwelling in a space for more than an hour. Average occupancy times fell from 160 minutes to 45 minutes.<sup>29</sup> These time limits, however, require increased enforcement to be effective at balancing demand for the loading spaces.

NYCDOT also piloted [Neighborhood Loading Zones](#) (NLZ) starting in 2019 in residential areas to reduce safety risks and travel delays from double parking on narrow streets (less than 35 feet in width) with bus routes or bike lanes by providing space for package delivery and passenger loading. NLZs are usually placed next to a large residential building or on the corner of a one-way block next to a retail store where demand for deliveries is high. While the reallocation of curb space was met by intense opposition in some neighborhoods where residents decried the removal of some parking spaces and resulting difficulty finding on-street spaces for their own vehicles, updated hours for the pilot have eased some of the frustration. The loading zones now ensure that deliveries can be made in daytime hours (7am – 7pm) while allowing cars to park overnight in the

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<sup>28</sup> Institute of Transportation Engineers. Case Study: District Department of Transportation, Study and Pilot Projects, 2018. <https://www.ite.org/pub/?id=C29F4D5E-FE34-2037-3B96-DE312E1DBBFF>.

<sup>29</sup> Diehl, C., Ranjbari, A., & Goodchild, A. (2021). Curbspace Management Challenges and Opportunities from Public and Private Sector Perspectives. Transportation Research Record. <https://doi.org/10.1177/03611981211027156>

more flexible loading zones.<sup>30</sup> While there is still frustration about the loss of parking spaces, New York DOT states that the safety impacts from decreasing double parking far outweigh any frustrations over lost parking. Additionally, the increase in residential deliveries during the pandemic has increased congestion on streets.<sup>31</sup> The program has expanded to all New York City boroughs, and residents have the opportunity to suggest additional locations for NLZs on the New York DOT website.

In Chicago, CDOT has installed parking-protected bike lanes that integrate floating loading zones in commercial areas Downtown. This follows the city's 2006 adoption of a complete streets policy accommodation all transportation users (taking freight into consideration) and the 2013 Complete Streets Design Guidelines to assist in the implementation of that policy. Additionally, CDOT installed a modified protected bike lane (buffered by markings on the pavement) on Elston Avenue, which is an important truck route in the city. As a result of the changes implemented on Elston Ave, safety improvements have been noted and bike ridership has increased in the area and freight operators are supportive of the project.

Curb management and loading programs were issues brought up by BID directors Cindy Ambs, Leslie Twarogowski, and Denver Neighborhood Cooperation's Joel Noble in stakeholder calls. A commercial loading zone management program could be a program implemented across all of the selected neighborhoods or citywide.

Any curb management program has potential equity implications in its design and implementation, including impacts on delivery drivers, business owners including small delivery businesses, and neighbors. As Transportation for America [describes](#), any equitable approach to curb management standards must comport with these principles:

- Local Public Agencies Set the Policy
- Equitable
- Open & Publicly Owned Data
- Easily Transferable
- Clearly Communicated

### **Commercial Delivery Permits**

Annual permits for freight providers can generate revenue while coordinating and managing delivery operations in challenging environments. A city can issue a permit for each calendar year and collect fees associated with that permit. There may be one permit per company or a permit requirement for each driver operating in the right-of-way. Stakeholders brought up a "free-for-all delivery environment" where some businesses do not have control over when delivery trucks come. Commercial delivery permits could

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<sup>30</sup> <https://calstart.org/wp-content/uploads/2021/09/CALSTART-FedEx-Curb-Space-Mgmt-White-Paper-2021.pdf>. Accessed December 9, 2021.

<sup>31</sup> <https://www.brooklynpaper.com/residential-loading-zones-prove-contentious-among-park-slope-motorists/>. Accessed December 9, 2021.

alleviate some of this pressure by restricting deliveries to certain times of the day to support business owners. A permitting system can also lay the groundwork for more sophisticated approaches including curb zone reservations and other differential pricing mechanisms at designated loading zones.

### **Late-night (off-hour) Delivery**

As Denver's business experience increased competition for curbside space for deliveries and pick-ups, off-hour and late-night deliveries could help alleviate congestion and decrease curbside demand during peak hours. In busy areas like Little Saigon, where delivery trucks may unload in the street as opposed to back alleys, late-night or off-hour delivery could alleviate some business concerns.

Pilot projects have shown that night-time deliveries (when truck-drivers avoid typical daytime traffic) have many benefits: "[truck speeds go up, shipment times go down, local traffic gets better, and the air gets cleaner](#)". New York City DOT is actively working with businesses and delivery companies to move deliveries to off-hours, and it is also exploring possible incentives to foster this program. Other cities have also aimed to implement this program. For example, [Washington, D.C.](#), obtained a federal grant to conduct a pilot to implement off-hour deliveries: critical for a city where last-mile deliveries are prevalent.

One potential concern for late-night or off-hour deliveries is noise disrupting nearby residents. However, past pilots have not had noise issues. In an off-peak delivery pilot in the Peel Region, outside of Toronto, Ontario, no noise complaints were submitted throughout the entire pilot.<sup>32</sup> A supermarket chain in Barcelona adopted a Silent Nighttime Unloading Program in 2003 to allow for off-peak deliveries. Trucks were retrofitted with carpeted flooring, a low noise lifting system, and low-noise wheels. This program received zero noise complaints and expanded the program to all stores.<sup>33</sup>

Denver's statute around vehicle noise from deliveries in off-peak hours reads "No person or persons shall make deliveries nor conduct delivery activities between the hours of 10:00 p.m. and 7:00 a.m. that exceeds the sound pressure limits of Table A" (below).<sup>34</sup> Electric trucks are quieter than traditional internal combustion engine trucks and could be used for off-peak deliveries at night since they would be within allowable sound pressure levels.

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<sup>32</sup> Kianoush Mousavi, Sabrina Khan, and Glareh Amirjamshidi (2020). Pilot Off-Peak Delivery Program in the Region of Peel: Final Report. Available at: <https://www.peelregion.ca/pw/transportation/goodsmovement/pdf/Pilot-OffPeak-Delivery-Program-Report.pdf>

<sup>33</sup> James C. LaBelle and Sheena F. Freve. (2016). Exploring the Potential for Off Peak Delivery in Metropolitan Chicago: Research Findings and Conclusions. Available at: [https://ntlrepository.blob.core.windows.net/lib/60000/60200/60283/NURail2015-UIC-R15\\_Final\\_Report\\_Off\\_Peak\\_Delivery.pdf](https://ntlrepository.blob.core.windows.net/lib/60000/60200/60283/NURail2015-UIC-R15_Final_Report_Off_Peak_Delivery.pdf)

<sup>34</sup> <https://www.denvergov.org/content/dam/denvergov/Portals/771/documents/PHI/HFHH/Chapter-36-Noise-Control.pdf>. Accessed December 9, 2021.

*Table A: Allowable Sound Pressure Levels (in dB(A)) with Time of Day Allowance*  
 TABLE INSET:

Source Premises	Receptor Premises							
	Residential		Commercial		Industrial		Public	
	7am--10pm	10pm--7am	7am--10pm	10pm--7am	7am--10pm	10pm--7am	7am--10pm	10pm--7am
Residential	55	50	65	60	80	75	75	70
Commercial	55	50	65	60	80	75	75	70
	[60]	[60]						
Industrial	55	50	65	60	80	75	75	70
	[65]	[65]						
Public	55	50	65	60	80	75	75	70
	[60]	[60]						

**Figure 30 - Late Night Delivery in New York City (source: ohdnyc.com)**



### Freight Villages

This [concept](#) regulates the development of a specific area to provide the necessary infrastructure to ease the movement of goods. Clustering distribution facilities and warehouses has the potential to allow all the shippers and carriers to take advantage of the same improvements. These areas can be identified and appropriate zoning designations can be applied to encourage their development.

Freight villages have the potential to reduce miles traveled by trucks, fostering economic development, and creating an efficient freight movement. They can also help improve livability: for example, brownfield properties can be re-used for these locations, businesses located there can serve the community, and the potential of utilizing [“primarily private funds to achieve local community development goals”](#) is there.



Potentially suitable sites for freight villages must be carefully analyzed by the City of Denver in order to determine the potential benefits and negative side effects associated with their implementation. A freight village will undoubtedly increase the movement of goods in a given area, contributing to truck traffic, noise and air pollution, and added associated safety impacts. Additionally, minority and low-income communities are often locations where freight facilities are already located, raising environmental justice concerns about the equitable distribution of new and additional burdens tied to living near a freight village designed to support the rest of the city. Identifying the ideal location for a freight village (where their positive potential is exalted and their negative impacts avoided) requires an honest and wholistic review, community involvement, and out-of-the-box thinking.

Examples of freight villages in the United States [include](#) Alliance in the Dallas/Fort Worth area in Texas, Raritan Center in New Jersey, and the Greater Columbus Inland Port/Rickenbacker Intermodal Facility.

### **Truck and Truck-Restricted Routes**

Implementing designated truck routes can potentially help [“efficiently meet the needs of all modes of transportation”](#) while creating more livable areas. For example, the City of Orlando aimed to funnel truck traffic onto designated facilities (through its Downtown Orlando Transportation Master Plan) in order [“to better match infrastructure to freight transportation demand”](#). By implementing this change, the city is better prepared to meet the needs of other travel modes in its core area. This effort is potentially compatible with goals established in Denver’s Mobility Action Plan, which calls for the establishment of [“freight efficiency corridors to improve the flow of truck traffic and reduce conflicts with passenger vehicle traffic”](#). Stakeholders advocated for truck routes, and education of business owners and community members about truck routes. Careful consideration is required when designating truck routes to ensure that roads identified do not disproportionately impact BIPOC communities.

### **Low-Emission Zones**

Low-emission or zero-emission zones could be implemented in Denver to decrease greenhouse gas emissions, foster the use of zero emission vehicles, and demonstrate how to combine transportation strategies in specific neighborhoods, which supports many of the goals set by the City of Denver in recent years (in documents such as the 80 x 50 Climate Action Plan and the Denver Electric Vehicle [EV] Action Plan). [Low-emission Zones](#) are areas where the use of certain vehicles is closely regulated, often through financial charges or specific restrictions on types of fuel or engine technology. Low-emission zones have the potential to tackle congestion and other issues in a specific area with the rules set up to manage vehicle activity.

London, England, has implemented a Low Emissions Zone (LEZ) in order to encourage heavily polluting vehicles to become more sustainable. The LEZ is in [operation](#) every day throughout the year, at all times of the day, and covers most of Greater London. Depending on standards met, “vans or specialist diesel vehicles (over 1.205

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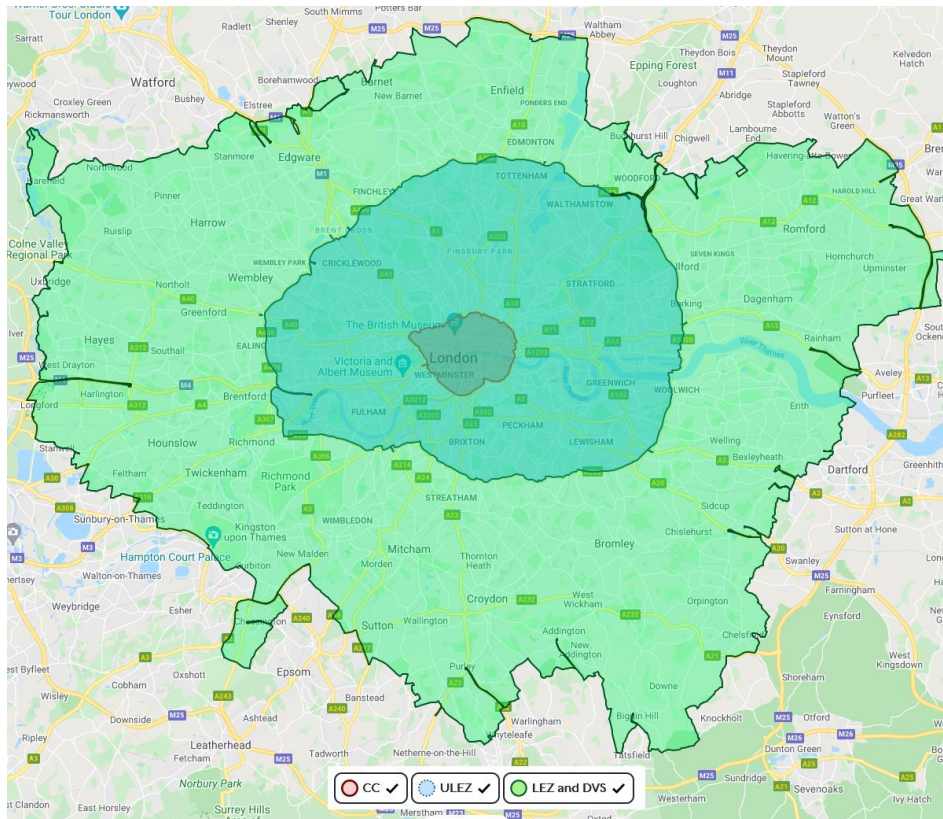
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tonnes unladen weight up to 3.5 tonnes gross vehicle weight) or minibuses (up to 5 tonnes)”, and “HGVs, lorries, vans and specialist heavy vehicles over 3.5 tonnes as well as buses/minibuses and coaches over 5 tonnes” [might have to pay](#) a daily charge ranging from £100 to £300. Similarly, [those operating](#) “lorries over 12 tonnes gross vehicle weight” have “to obtain a safety permit before entering and operating in most of Greater London”, or they might “receive a Penalty Charge Notice (PCN).” This puts a higher price on most large delivery vehicles entering the LEZ and not meeting the set standards.

Additionally, there is an Ultra-Low Emissions Zone (also known as ULEZ) in effect at the central part of the city. The majority of vehicles that do not meet emission standards have to pay a daily charge of £12.50 to drive in the ULEZ, including motorcycles, cars, specialist vehicles, vans, minibuses. However, “lorries, vans or specialist heavy vehicles (over 3.5 tonnes) and buses, minibuses or coaches (over 5 tonnes) do not need to pay the ULEZ charge”, but “they will need to pay” the “LEZ charge if they do not meet the LEZ emissions standard”.

The ULEZ functions all year, except for Christmas day, and it contributed to a 44% [reduction in harmful roadside nitrogen dioxide \(NO<sub>2</sub>\) within the zone](#) before the Covid-19 pandemic. Additional impacts of the ULEZ include the fact that [the number of state primary and secondary schools in areas exceeding legal limits for NO<sub>2</sub> fell from 455 in 2016 to 14 in 2019](#)”, and areas of London were able to meet WHO recommended limits for PM<sub>2.5</sub> for the first time. The boundaries of the ULEZ were expanded in October 2021, now covering 3.8 million individuals in the city. Lastly, to further disincentivize vehicle usage, a [congestion charge](#) of £15 is applied to any vehicle driving within a designated zone in central London from 7:00am to 10:00pm daily, except on Christmas Day. The map of areas where the Congestion Charge, ULEZ, LEZ, and the Direct Vision Standard (DVS) and HGV Safety Permit are required are shown Figure 31.

Figure 31 - Charging Zones (source: [Transport For London](#))



In the US, the [City of Santa Monica and the Los Angeles Cleantech Incubator](#) piloted a voluntary zero-emission zone in downtown Santa Monica to test a variety of delivery and clean transportation technologies. In Santa Monica, zero emissions vehicles have priority access to the curb in select locations via a reservation system, and e-scooters, e-bikes and sidewalk delivery robots are being tested for deliveries. Technology from the firm Autonomous is monitoring and analyzing curb vehicle activity to study impacts on safety, efficiency, emissions, and congestion while also providing real-time data regarding parking to the drivers in the ZE Delivery Zone.<sup>35</sup> The key for this project is the partnership that has developed between community organizations, technology companies, and delivery companies. Participants include Ikea, Shopify, and REEF Technologies, among other local businesses.

<sup>35</sup> <https://www.chargedfleet.com/10137632/santa-monica-launches-zero-emissions-delivery-zone-first-in-u-s>. Accessed December 14, 2021.

Figure 32 - Santa Monica's LEZ Map (source: laincubator.org)



In New York City, NYSDOT and NYSEDA [developed the concept of Green Loading Zones](#) to facilitate low- and zero-emissions vehicle deliveries on curbs designated for exclusive use by green vehicles actively loading and unloading. NYCDOT is actively studying a pilot program, having hosted a [survey](#) for freight managers and conducting focus group interviews to inform pilot design. When combined with the off-hour delivery program, quieter electric fleet vehicles can minimize daytime traffic congestion and nighttime noise disruptions. Installing curbside charging at these locations can incentivize use.

## Innovative Technology Solutions

### Delivery Microhubs and Lockers

Delivery Microhubs are locations that provide a central pick-up and drop-off location for goods and services, often times [located](#) between warehouse facilities and final delivery destinations. Microhubs have the potential to decrease pollution, congestion, competition for curb access, and delivery costs by allowing for the deconsolidation/consolidation of shipments. They can be enhanced by providing other amenities, such as charging infrastructure, and can be operated by more than one business at the same time.

**Figure 33 - Parcel Locker (source: DHL)**



Examples of microhubs include [The Beaugrenelle in Paris, France](#). This microhub processes packages under 66 lbs. in a two-floor facility, which can handle up to 6,500 parcels each day, and gets them ready for delivery (which is done by clean vehicles). As a consequence of this program, driving distances decreased by 52%, emissions were cut by half, and noise from delivery vehicles decreased 8%.

In the US, Urban Freight Lab is currently implementing the [Seattle Neighborhood Delivery Hub](#), a pilot program evaluating logistics strategies in Seattle's Uptown neighborhood. Items being implemented include carrier parcel lockers (where customers can pick up items whenever it is more convenient), a fleet of cargo bikes, and neighborhood kitchens (non-customer facing food preparation centers dedicated to delivery orders). Key findings of the Seattle Neighborhood Delivery Hub Pilot Project included the following:

- "The e-cargo bike can replace a truck mile for mile
- The single neighborhood delivery hub reduced CO<sub>2</sub> by 30% per package delivered
- Networked neighborhood delivery hubs can lead to even greater CO<sub>2</sub> reductions
- The e-cargo bike removed 0.65 truck miles per package delivered
- The e-cargo bike delivered fewer packages per hour than traditional trucks (...) but the researchers urge caution when interpreting this finding (...) the main reason being the small scale and short operating period of the pilot " ([University of Washington](#))

Delivery lockers are smaller [storage units](#) located near the final destination point for a delivery, with the potential to be accessed conveniently by end customers. They are different than traditional post offices in the sense that they are often located in easy to reach locations, such as apartment buildings, grocery retailers, and even gas stations. An example of widespread delivery lockers implementation is the [Amazon Hub Locker](#)

program, which allows Amazon customers to deliver most items (with certain width and height restrictions) to an alternate locker pick-up locations. This provides the end customer with the benefit of a secure location to store their deliveries in cases where direct door delivery might not be done in a safe manner, while also saving Amazon the time and effort to deliver packages to individual addresses. It is important to note that Amazon Hub Lockers are available to other senders, and are not simply limited to Amazon deliveries.

**Figure 34 - Seattle's Neighborhood Hub (source: <https://www.seattleneighborhoodhub.com/>)**



Delivery microhubs and innovative solutions like delivery lockers can help decrease supply chain inefficiencies in the City of Denver, potentially decreasing miles traveled by freight operators and emissions. The likely benefits that could be obtained by these programs warrant further study and support by the City, be it through pilot projects to study their applicability or by legislation promoting their implementation.

### **E-Bikes and other Low and Zero-Emission Vehicles**

The widespread use of zero-emission vehicles is pivotal for sustainable last-mile deliveries. Zero-emission vehicles can come in many types, ranging from electric truck, electric cargo vans, and electric motorized carts, to e-bikes and e-cargo bikes. As previously mentioned, the City of Denver is already working to increase the use of electric vehicles. The City's "[80 x 50 Climate Action Plan](#)" aims to achieve an 80% reduction in GHG emissions by 2050, with the goal of 75% of freight trucks utilizing carbon neutral fuel by that year. The plan also calls for advocacy with State authorities to "adopt Clean Car Standards including the Zero Emission Vehicle (ZEV) standard", acknowledging that the state government plays a key role when it comes to fostering the adoption of lower-emission vehicles. Further, the [Denver Electric Vehicle \(EV\) Action Plan](#) provides more specific actions that the city will take to further increase the use of electric vehicles.

Given the increased competition for parking space, the flexibility provided by e-cargo bikes has the potential to be a game changer. Many cities in the US have implemented pilot programs to incentivize and explore the potential of e-bikes for deliveries. For example, the City of Miami partnered with Reef Technology and DHL to pilot four electric-assist bikes for deliveries in the city. The bikes are expected to “[reduce 101,000 kg of CO<sub>2</sub>e annually](#)”, and are capable of “[pulling up to 400 pounds or 60 cubic feet in volume](#)”. Similarly, New York City recently partnered with DHL, Amazon, and UPS to pilot cargo bikes. The city offered various incentives, including “[free on-street parking, use of commercial parking space, and loading and staging space](#)”, with the aim to “[to reduce congestion, improve air quality and promote pedestrian safety](#)”. As of [early 2021](#), more than 350 bikes are participating in the pilot project: each of those bikes covers approximately 20 service miles each day. 20 bike miles each day result in an approximate CO<sub>2</sub> savings of 7 tons per year per bike, as they replace 20 box truck or van miles. As a result of the success of the program, which has helped deliver essential services during the Covid-19 pandemic, DOT is exploring ways of adapting the program on a permanent basis.

**Figure 35 - DHL's e-Cargo Cycles (source: prnewswire.com)**



### **Electric Delivery Robots**

Looking into the future, new technologies can bring improvements to last-mile deliveries. Established delivery companies, such as FedEx and the US Postal Service, and many startup companies are investing or piloting technology that reduces delivery times. For example, self-driving robots have the potential to provide alternative and sustainable last-mile delivery solutions that remove or eliminate many safety concerns of large vehicles. Sidewalk autonomous delivery robots are small robots that can deliver packages with minimal driver needs. When compared to a traditional delivery van with a

human driver scenario, a 2019 study found that sidewalk autonomous delivery robots provide substantial cost, time, and vehicle mile savings.<sup>36</sup>

Companies with electrified and/or autonomous delivery robots include Starship, Nuro, Udelv, Kiwibot, Eliport, TeleRetail, Postmates Serve, BoxBot, and Amazon Scout. The two most well-known autonomous delivery robots are Starship and Nuro. Starship Technologies' autonomous, electric delivery vehicles are most commonly used on college campuses. Starship operates on 20 college campuses in the US, and carries deliveries from chains like Starbucks and Subway to college dorms. The robots can fit 20 pounds of cargo for deliveries. Besides testing on college campuses, Starship has also tested sidewalk autonomous delivery robots in Greenwich, London and has partnered with Postmates, DoorDash, Mercedes Benz, and Domino's Pizza. Nuro's R2 has also been used in several pilots to transport and deliver goods with contactless delivery. The R2 was the first autonomous vehicle to be granted an exemption by NHTSA for a low-speed autonomous vehicle. The R2 does not have mirrors or a windshield. Nuro has partnered with Domino's for pizza delivery, CVS for prescription delivery, Walmart for grocery delivery, and is currently working with FedEx for last-mile deliveries in Texas. During the COVID-19 pandemic, Nuro used its vehicles to support two medical centers in California with no contact deliveries.<sup>37</sup>

**Figure 36 - Starship Technologies' Self-Driving Delivery Robot (source: NDTV.com)**



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<sup>36</sup> Figliozzi and Jennings, 2020, <https://www.sciencedirect.com/science/article/pii/S2352146520303598>

<sup>37</sup> <https://abc7news.com/nuro-robots-r2-autonomous-vehicles/6133490/>



**Figure 8: Nuro's R2 Delivery Robot (source: The Robot Report)**



Similarly, drones have the potential to be more efficient than other vehicles. In 2017, the University of Washington conducted a study that [determined that](#), although “drones traveled more miles than an equivalent truck route (because drones can carry only one package at a time) (...) drones emit less carbon dioxide than trucks if transporting light packages with fewer stops”. Although drone deliveries can present other challenges (including environmental concerns), municipalities such as the City of Denver can be prepared for the likely advent of widespread drone deliveries (foretold by existing exploratory programs by [Amazon](#) and [Google](#)) by implementing pilots and exploring potential regulations. Most of the urban air mobility solutions like drones are being tested or piloted by large companies like Amazon, Google, and DHL, but there is not a defined or agreed upon timeline for widespread adoption.

**Figure 37 - Amazon PrimeAir Delivery Drone (source: Amazon.com)**



### **Curb and Loading Zone Reservation Systems**

Loading zone reservation systems have the potential to decrease conflicts between modes competing for curb space, reduce incidences of double parking and other

externalities tied to loading activity, and maximize the utilization of available loading space. Reserved curbs ensure loading zones are available to drivers at the time of arrival to their destination, reducing the total amount of time that delivery vehicles spend in an area by removing the need to hunt for space. Digital reservation systems have the potential to regulate curb space in commercial and mixed use areas more efficiently than blanket time limits that may be difficult to enforce and allow drivers to reserve a space for as long as needed, according to the products being delivered.

Registering drivers or fleets into the reservation system can require significant upfront investment of time and attention from city and vendor staff. This outreach is likely to be more successful with smaller-scale delivery companies or on-demand drivers on gig-based online platforms who are more sensitive to costs from tickets and more able to adjust procedures at a limited set of managed curbs. Even so, the relationships gained by this outreach can help with dissemination of new policies and programs unrelated to a managed curb lane system.

Reservation systems often rely on city staff for enforcement, which can be a manpower or financial challenge when scaled across an entire neighborhood or city. Still, enforcement personnel know the length of the reservation, payment status, and length of stay within the system. Pricing (even progressive pricing to encourage turnover) can be incorporated into these systems as well. Enforcement and issuance of fines may also be conducted via camera to eliminate reliance on staffing and field sweeps.

Managed loading zones with the variety of reservation platforms can be good candidate locations for electric vehicle fast charging infrastructure. In practice, pilots have shown short dwell times that may not incentivize the use of such charging access efficiently. Commercial delivery fleets with localized distribution hubs are likely to install chargers on their own property rather than rely on operators to do so during delivery routes.

Various pilot curb reservation programs have taken place across the nation. The [Aspen Smart Zone Pilot Program](#) created specialized loading areas both at the curb and in alleys in the downtown neighborhood, designated as Smart Zones. In all Smart Zones, advance curb space reservation through the Coord Driver app was required. This app allowed drivers to find and pay for a loading space at a specific time in advance and eliminated the need to hunt for a spot. The Smart Zone Pilot program was successful, with most locations observing a reduction in double-parking, decreased pick-up and drop-off times for passengers, and decreased illegal parking in alleys, as well as greater overall utilization of available loading space. Denver has been working on a similar pilot and expects to launch this program in the RiNo neighborhood in 2022.

Similarly, the Washington DC Department of Transportation (DDOT) launched a curbside loading program to improve safety and better manage curb space [in partnership with curbFlow](#). The pilot program removed nine curb parking spaces and replaced them with pre-reserved loading zones (which could be reserved 30-minutes in advance or on-demand). Results of the program included a decrease of more than 60% in double parking and an increase of safety in crosswalks and bike lanes. 85% of drivers

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surveyed rated a 9 out of 10 for their satisfaction with the reservation system.<sup>38</sup> In Columbus, Ohio, a six-month curbFlow pilot replaced existing loading and parking spaces in eight locations with block-wide managed loading zones in strategic locations with high pickup/drop-off activity. Registration into the reservation platform targeted on-demand drivers working for ridehailing, food delivery, and other app platforms, who are more likely swayed by ticketed enforcement, and were less successful with major freight companies. On-demand drivers represented more than 90% of check-ins to the zones over the pilot period; the average dwell time for all zone check-ins was less than five minutes, but freight and parcel delivery drivers had a longer average dwell time than on-demand drivers. Registered drivers legally used the zones for an average of more than 105 visits per day.<sup>39</sup>

The [City of Pittsburgh](#) was awarded a grant by Automotus (a technology company providing curb management solutions) to implement intelligent loading zones in various districts across the City. Users of these parking areas will be charged on a minute-by-minute basis to park in a legal manner in close proximity to businesses, with the aim of improve short-term parking efficiency. These zones are expected to be in operation as early as [November 2021](#).

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<sup>38</sup> Diehl, C., Ranjbari, A., & Goodchild, A. (2021). Curbspace Management Challenges and Opportunities from Public and Private Sector Perspectives. Transportation Research Record. <https://doi.org/10.1177/03611981211027156>

<sup>39</sup> <https://www.columbus.gov/publicservice/parking/curbFlow-Final-Report-June-2020/>

## EVALUATION

This section evaluates the last-mile delivery practices described above across several impact categories, as well as implementation considerations.

The evaluation and subsequent scoring of each delivery practice is based on the depth of research and data available, as well as the intricacies of the implementation of each strategy. Many of the practices here are new and have only been used in a few, albeit promising, pilots across the United States and abroad. As a result, there are still limited systemic research results on costs and benefits for many strategies. Additionally, no pilot implementation can be replicated exactly in a new place because of differences between urban environments, regulation, participating actors, and enthusiasm for trying new things. Intricacies of implementation based on Denver's regulatory environment, built environment, and population dynamics in specific neighborhoods will affect progress and success.

Each delivery practice is evaluated in the appendix chart and described on the following pages based on seven types of impacts:

- **Safety impacts**, as can be measured by pedestrian- or bike-involved crashes and their severity; crashes by census block per capita; near-miss collisions (via video data); impeded traffic flow from double parking; and/or loading vehicle blockages of bike lanes, parking spaces, bus stops, or crosswalks.
- **Environmental impacts**, as can be measured by VMT reduction and/or GHG emissions reduction per trip or per package.
- **Air quality and health impacts**, as can be measured by PM 2.5 in  $\mu\text{g}/\text{m}^3$  and ozone percentiles.
- **Equity impacts on residents of neighborhoods where deliveries occur**, as can be measured by daily traffic counts and distance to the road, truck noise, and community assets for placemaking.
- **Equity impacts on delivery drivers**, as can be measured by fair wages and job creation or loss.
- **Equity impacts on BIPOC business owners**, as can be measured by delivery costs and business opportunities created.
- **Equity impacts on community livability**, as can be measured by daily traffic counts and distance to the road, truck noise, and community assets for placemaking.

These impact categories also align with Denver's goals presented in the city's comprehensive plan. Equity impact categories are designed to show the positive or negative impacts on communities and groups who will be most affected by delivery strategies. Impacts are scored as "negative," "positive," or "unclear" for each strategy. If a strategy is thought to have mostly positive benefits for a specific category, it will get a positive rating. If a strategy is thought to have mostly negative impacts for a specific category, it will get a negative rating. If a strategy has both positive and negative impacts for a specific category, it will receive an unclear rating. Strategy impacts are overall

ratings and not based on particular demographic groups or neighborhoods: specific communities/locations may have additional impacts depending on a variety of factors, and additional analysis and consultation with those affected should be undertaken prior to implementation of those policies.

Each delivery strategy is also assessed based on several implementation considerations, including:

- **Priority**, if the strategy enables another high return strategy, creates synergistic impacts, builds administrative capacity, and/or is an innovation opportunity or opportunity for a demonstration project.
- **Time to implement**, by the necessary partnerships formed and construction required.
- **Cost to implement**, by the amount of funding required.
- **Level of difficulty**, by the legislative or regulatory barriers, necessary partnerships formed, political barriers, and funding sources available.
- **Recommended neighborhoods for implementation.**

Implementation considerations are scored as “low”, “medium”, and “high” for each strategy, indicating the level of effort required to launch a pilot or introduce a new policy. For the priority, the low, medium, and high scoring reflects the degree of urgency to pursue such a strategy. Potential partners for many strategies have been identified as well, including an internal City of Denver lead and internal and external support.

Figure 38 summarizes the evaluation of the policy and technology strategies. The table is also shown in larger format in the Appendix, and provided in its original spreadsheet form as well. After the summary table, the evaluation of each strategy is described in more detail.

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Category	Delivery Strategy	Policies vs. Infrastructure	Potential Impact of Delivery Strategy (Citywide - not specific to particular demographic group or neighborhood)						Implementation Pathway				Potential Partners				
			Safety Impact	Environmental Impact	Air Quality/Health Impact	Equity/Disadvantaged & BIPOC Biz Impact	Equity/Community Disadvantaged & BIPOC Residents Where Deliveries Occur	Equity/Community Livability Impact for Residents Where Deliveries Originate	Equity/Labor & Driver Impact	Priority	Time to Implement	Cost to Implement	Level of Difficulty	Recommended Neighborhood(s) for Implementation	Internal Lead	Internal Support	External Support
City Policy	Commercial Loading Zone Management Program	Policy + New Signage	Positive	Positive	Positive	Positive	Positive	Unclear	Positive	Unclear	High	Medium	Medium	Five Points/Weston Federal/Little Saigon Highland Bruce Randolph East Colfax South Broadway	DOT/ROW Services	Community Planning and Development, Park Smart Denver	Amazon, DHL, LPS, FedEx, Shannock, Moor Carners Association
			Positive	Positive	Positive	Positive	Positive	Positive	Positive	Unclear	Medium	Low	Low	Five Points/Weston Federal/Little Saigon Highland Bruce Randolph East Colfax South Broadway	DOT/ROW Enforcement	Economic Development and Opportunity	
City Policy	Late-night (off-hour) Delivery	Policy + New Signage	Positive	Positive	Positive	Positive	Unclear	Unclear	Positive	Unclear	Medium	Medium	Medium	Five Points/Weston Federal/Little Saigon Highland Bruce Randolph East Colfax South Broadway	DOT		
City Policy	Freight Villages	Policy	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Negative	Positive	Medium	High	High	Highland South Broadway		Community Planning and Development, Economic Opportunity, Performance-Based Infrastructure Office	Amazon, DHL, LPS, FedEx, Shannock, Moor Carners Association
City Policy	Truck and Truck-Restricted Routes	Policy	Unclear	Unclear	Unclear	Positive	Unclear	Unclear	Unclear	Unclear	Medium	Medium	High	Federal/Little Saigon East Colfax South Broadway	DOT		
City Policy	Low or Zero Emissions Zone	Policy + Infrastructure	Unclear	Positive	Unclear	Unclear	Positive	Positive	Positive	Unclear	High	High	High	Five Points/Weston Highland Bruce Randolph East Colfax			
Tech Solutions	Delivery Microbuses and Lockers	Infrastructure	Unclear	Positive	Positive	Positive	Positive	Positive	Positive	Unclear	Low	Medium	Medium	Five Points/Weston Temnyson Highland Bruce Randolph East Colfax South Broadway	DOT Infrastructure Project Mgmt	Community Planning and Development, Economic Opportunity, Performance-Based Infrastructure Office	
			Unclear	Positive	Positive	Positive	Positive	Positive	Positive	Unclear	High	Low	Low	Five Points/Weston Federal/Little Saigon Highland Bruce Randolph East Colfax South Broadway	CASR	DOT Economic Development and Opportunity	
Tech Solutions	Electric Delivery Routes	Policy	Unclear	Positive	Positive	Positive	Positive	Unclear	Unclear	Negative	Low	Low	Low	Temnyson Highland		Motor Vehicle - Title and Registration, Performance-Based Infrastructure Office	
			Positive	Positive	Positive	Positive	Positive	Positive	Positive	Positive	Unclear	High	High	High	Five Points/Weston Federal/Little Saigon Temnyson Highland Bruce Randolph East Colfax South Broadway	DOT Transportation Project Mgmt	Economic Development and Opportunity, Park Smart Denver, Technology Services

Figure 38: Strategy Evaluation Summary

## Strategy Evaluation

### Commercial Loading Zone Management Program

- **Safety Impact:** The Commercial Loading Zone Management Program has the potential to increase safety by reducing double-parking; however, the ultimate overall safety benefit depends on how the policy is implemented and local street context.
- **Environmental Impact:** This program has a positive environmental impact, since it has the potential to increase curb space turnover, which can help reduce time spent circling looking for a loading zone, reducing VMT and greenhouse gas emissions per trip.
- **Air Quality/Health Impact:** The Commercial Loading Zone Management Program has a positive air quality and health impact. It has the potential to increase curb space turnover, which can help reduce time spent circling looking for a loading zone and can reduce particulate matter and ozone percentiles.
- **Equity/Disadvantaged and BIPOC Businesses Impact:** Commercial Loading Zone Management Programs have a positive impact on disadvantaged and BIPOC businesses, since it has the potential to reduce the time needed for deliveries, reducing delivery costs. However, the costs of parking permits might prove too high for some disadvantages/BIPOC businesses, but assistance programs can be implemented to avoid this problem.
- **Equity/Community Livability Impact for Residents Where Deliveries Occur:** Commercial Loading Zone Management Programs have a positive impact on community livability for residents where deliveries occur. This program can reduce the time that trucks circle looking for a delivery spot and can reduce truck noise. Well-implemented and contextualized Commercial Loading Zone Management Programs also have the potential to increase the safety of the neighborhoods where they are implemented.
- **Equity/Community Livability Impact for Residents Where Deliveries Originate:** Commercial Loading Zone Management Programs have an unclear impact on community livability for residents where deliveries originate, since they are focused on the “last mile” where deliveries take place. However, if deliveries are originating in areas where Commercial Loading Zone Management Programs are taking place, they have a positive impact on community livability for residents where deliveries originate. This program can reduce the time that trucks circle looking for a delivery spot and can reduce truck noise. Well-implemented and contextualized Commercial Loading Zone Management Programs also have the potential to increase the safety of the neighborhoods where they are implemented.
- **Equity/Impact on Pedestrians, Bicyclists, and Transit Users:** Well-implemented and contextualized Commercial Loading Zone Management Programs can have a positive impact on pedestrians, bicyclists, and transit riders, since they have the potential to increase safety. However, the specific

level of safety that the program can bring to pedestrians, bicyclists, and transit users depends on local context and program details.

- **Equity/Labor and Driver Impact:** Commercial Loading Zone Management Programs have an unclear impact on labor and drivers, unless they are required to pay any necessary parking fees out of pocket (even if they will be later reimbursed by employer). Additionally, this program can make deliveries smoother for drivers by helping them find a parking space more easily.

### Commercial Delivery Permits

- **Safety Impact:** A Commercial Delivery Permit has the potential to increase safety by helping bring coordination and order to the delivery operations of areas that implement them, although the specific level of safety that the program can bring depends on local context and program details.
- **Environmental Impact:** Commercial Delivery Permits have a positive environmental impact, since restricting deliveries to allowed vehicles can potentially increase curb space turnover: this can help reduce time spent circling looking for parking space, reducing VMT and greenhouse gas emissions per trip.
- **Air Quality/Health Impact:** Commercial Delivery Permits have a positive air quality and health impact, since this program has the potential to increase curb space turnover: this can help reduce time spent circling looking for a parking space and can reduce particulate matter and ozone percentiles.
- **Equity/Disadvantaged and BIPOC Businesses Impact:** Commercial Delivery Permits have a positive impact on disadvantaged and BIPOC businesses, since this program has the potential to reduce the time needed for deliveries, reducing delivery costs. However, the costs of parking permits might prove too high for some disadvantages/BIPOC businesses, but assistance programs can be implemented to avoid this problem
- **Equity/Community Livability Impact for Residents Where Deliveries Occur:** Commercial Delivery Permits have the potential to increase neighborhood safety by helping bring coordination and order to the delivery operations of areas that implement them. Additionally, this program can restrict deliveries to specific times of the day, reducing noise and other nuisances for neighbors.
- **Equity/Community Livability Impact for Residents Where Deliveries Originate:** Commercial Delivery Permits have the potential to increase neighborhood safety by helping bring coordination and order to the delivery and pick-up operations of areas that implement them. Additionally, this program can restrict pick-ups and deliveries to specific times of the day, reducing noise and other nuisances for neighbors.
- **Equity/Impact on Pedestrians, Bicyclists, and Transit Users:** Commercial Delivery Permits have the potential to increase safety for the neighborhoods that implement them by bringing added coordination and order to delivery operations. Additionally, this program can restrict pick-ups and deliveries to specific times of the day, reducing safety issues and other nuisances. However, the specific level



of safety that the program can bring to pedestrians, bicyclists, and transit users depends on local context and program details.

- **Equity/Labor and Driver Impact:** Commercial Delivery Permits have an unclear impact on labor and drivers, unless they are required to pay any necessary parking fees out of pocket (even if they will be later reimbursed by employer). Additionally, this program can make deliveries smoother for drivers by potentially helping them find a parking space more easily.

#### Late-night (off-hour) Delivery

- **Safety Impact:** Off-hour deliveries have the potential to increase safety, since deliveries will not be taking place during peak travel times, and congestion and double parking might be reduced. However, specific safety impacts depend on local context and program details. Additionally, restricting deliveries to late-night hours can raise safety issues due to decreased visibility and potential for increased criminal activity in some areas.
- **Environmental Impact:** By limiting deliveries to off-hours, this policy has a positive environmental impact by potentially decreasing the amount of time that trucks spend on traffic.
- **Air Quality/Health Impact:** By limiting deliveries to off-hours, this policy has a positive air quality and health impact by potentially decreasing the amount of time that trucks spend on traffic.
- **Equity/Disadvantaged and BIPOC Businesses Impact:** Off-hour deliveries can potentially reduce delivery costs by decreasing delivery times and increasing certainty in regards to delivery arrival time. However, businesses receiving those deliveries can incur added costs if those deliveries occur when they would otherwise not operate: however, programs to mitigate or reimburse those costs could be implemented.
- **Equity/Community Livability Impact for Residents Where Deliveries Occur:** As previously mentioned, off-hour deliveries have the potential to increase safety, although specific safety impacts depend on local context and program details. Additionally, off-hour deliveries have positive environmental, air quality, and health impacts by decreasing the time that trucks spend on traffic. However, late night deliveries can raise noise concerns -although measures can be taken to mitigate them. Additionally, restricting deliveries to late-night hours can raise safety issues due to decreased visibility and potential for increased criminal activity in some areas.
- **Equity/Community Livability Impact for Residents Where Deliveries Originate:** Off-hour deliveries have an unclear impact on community livability for residents where deliveries originate: overall impact will depend on the amount of deliveries originating in a given area, the amount of traffic, pollution, and noise they generate, the time of day that they take place, in addition to any safety concerns that might impact the area.

- **Equity/Impact on Pedestrians, Bicyclists, and Transit Users:** Off-hour deliveries have the potential to increase safety, since deliveries are not expected to be taking place during peak transit, bicyclist and pedestrian travel times. However, specific safety impacts depend on local context and program details. Additionally, restricting deliveries to off and night hours can raise safety issues due to decreased visibility and lack of awareness of increased activity after-hours.
- **Equity/Labor and Driver Impact:** Off-hour deliveries have an unclear impact on labor and drivers. Deliveries can potentially become smoother for drivers and decrease the risk of receiving a parking ticket. Additionally, added safety measures might have to be undertaken to mitigate any risks associated with night deliveries -which bring intrinsic safety and crime concerns.

### Freight Villages

- **Safety Impact:** Freight villages undoubtedly raise the level of transportation activity in the area where they are located. Therefore, Freight Villages have major implications for the safety of the area where they are located, and those need to be analyzed further.
- **Environmental Impact:** Freight Villages will raise the level of transportation activity in a given area, including increased environmental impacts and concerns. However, it is also important to keep in mind the potential “[sustainability benefits](#) of freight villages” which might “include reduced truck VMT due to the close geographic proximity of different supply chain components (intermodal terminals, distribution centers, etc.) and associated benefits”. Before a Freight Village project is undertaken, an evaluation of environmental impacts is warranted.
- **Air Quality/Health Impact:** Freight Villages will raise the level of activity in a given area, including increased air quality and health impacts. Before a Freight Village project is undertaken, an evaluation of air quality and health impacts is warranted.
- **Equity/Disadvantaged and BIPOC Businesses Impact:** The costs of locating in a Freight Village can be prohibitive for traditionally disadvantaged businesses, creating a barrier for entry that is difficult to overcome. In order to increase opportunities for all businesses, assistance programs can be implemented.
- **Equity/Community Livability Impact for Residents Where Deliveries Occur:** Freight Villages have an unclear impact on community livability for residents of areas where deliveries originating from a Freight Village are distributed to: overall impact will depend on various factors, including the amount of deliveries, the amount of traffic, pollution, and noise they generate, and the time of day that they take place, in addition to any safety concerns that might impact the area.
- **Equity/Community Livability Impact for Residents Where Deliveries Originate:** Freight Villages undoubtedly raise the level of transportation activity in the area where they are located, which has direct impacts on the safety, environment, and air quality/health of nearby neighborhoods. Therefore, the

feasibility of Freight Villages needs to be analyzed based on local context, their potential benefits, and negative impacts.

- **Equity/Impact on Pedestrians, Bicyclists, and Transit Users:** Freight Villages raise the level of transportation activity in the area where they are located and have a direct impact on the safety and well-being of pedestrians, bicyclists, and transit users. The impact of Freight Villages on pedestrians, bicyclists, and transit users needs to be analyzed further before they are implemented, including considerations that can be taken to avoid any potential negative impacts.
- **Equity/Labor and Driver Impact:** Freight Villages can become important centers of employment and support the local economy: however, it can often be difficult for potential employees to reach them due to gaps on transit service. Additionally, living wage provisions can be applied to ensure that employers located on Freight Villages pay fair wages, especially if the Freight Village received governmental assistance for its development.

#### Truck and Truck-Restricted Routes

- **Safety Impact:** Truck routes undoubtedly raise the level of transportation activity in the area where they are located. Therefore, they have major implications for the safety of the area where they are located, and those need to be analyzed further.
- **Environmental Impact:** Truck routes will raise the level of transportation activity in a given area, including increased environmental impacts and concerns. Truck routes often go through minority and traditionally disadvantaged neighborhoods, fostering environmental inequality. Before a truck route project is undertaken, an evaluation of environmental impacts is warranted to evaluate their feasibility.
- **Air Quality/Health Impact:** Truck routes will raise the level of transportation activity in a given area, including increased air quality and health impacts. Truck routes often go through minority and traditionally disadvantaged neighborhoods, fostering environmental inequality. Before a truck route project is undertaken, an evaluation of air quality and health impacts is warranted to evaluate their feasibility.
- **Equity/Disadvantaged and BIPOC Businesses Impact:** Truck routes are often used to redirect traffic to roadways that can safely handle truck traffic, which can allow deliveries to be conducted in a more efficient manner, benefiting disadvantaged and BIPOC businesses. However, truck routes often go through minority and traditionally disadvantaged neighborhoods, fostering environmental inequality. As previously mentioned, before a truck route project is undertaken, an evaluation of air quality and health impacts is warranted to evaluate their feasibility.
- **Equity/Community Livability Impact for Residents Where Deliveries Occur:** Truck routes have an unclear impact on community livability for residents of areas where deliveries moving through a truck route are distributed to: overall impact will depend on various factors, including the amount of deliveries, the

amount of traffic, pollution, and noise they generate, and the time of day that they take place, in addition to any safety concerns that might impact the area.

- **Equity/Community Livability Impact for Residents Where Deliveries Originate:** Truck routes have an unclear impact on community livability for residents of areas where deliveries moving through a truck route originate: overall impact will depend on various factors, including the amount of deliveries, the amount of traffic, pollution, and noise they generate, and the time of day that they take place, in addition to any safety concerns that might impact the area.
- **Equity/Impact on Pedestrians, Bicyclists, and Transit Users:** Truck routes raise the level of transportation activity in the area where they are located and have a direct impact on the safety and well-being of pedestrians, bicyclists, and transit users. The impact of truck routes on pedestrians, bicyclists, and transit users needs to be analyzed further before they are implemented, including considerations that can be taken to avoid any potential negative impacts.
- **Equity/Labor and Driver Impact:** Truck routes have an unclear impact on labor and drivers. Truck routes are often used to redirect traffic to roadways that can safely handle truck traffic, which can allow deliveries to be conducted in a more efficient manner, ultimately benefiting drivers.

#### Low-Emission Zones

- **Safety Impact:** A delivery truck or vehicle is not inherently safer because it is greener. Low-emissions zones regulate the type of fuel, but not always the type and size of a vehicle. Depending on the exact rules of the pilot or permanent program, the safety impact of low-emissions zones is unclear.
- **Environmental Impact:** Low-emission zones would have a positive environmental impact. Low-emissions zones have been shown to reduce the emissions of vehicles and reduce greenhouse gas emissions per trip.
- **Air Quality/Health Impact:** Low-emission zones would have a positive impact on air quality and health. Low-emission zones reduce air pollution, improving air quality and lowering pollution-related diagnoses like asthma, COPD, and lung cancer.
- **Equity/Disadvantaged and BIPOC Businesses Impact:** Low-emission zones have an unclear impact on disadvantaged and BIPOC businesses. While low-emission zones may create new business opportunities from increased pedestrian activity in a healthier environment or innovation in business models, costs to drive in a low-emission zone or costs from new vehicle types procured to comply with zone regulations may be passed onto the business.
- **Equity/Community Livability Impact for Residents Where Deliveries Occur:** Low-emission zones have a positive impact on residents in neighborhoods where deliveries occur. Low-emission zones can reduce the number of vehicles on the road and reduce truck noise.
- **Equity/Community Livability Impact for Residents Where Deliveries Originate:** Low-emission zones have a positive impact on residents in

neighborhoods where deliveries originate. Low-emission zones can reduce the number of vehicles on the road and reduce truck noise.

- **Equity/Impact on Pedestrians, Bicyclists, and Transit Users:** Low-emission zones have a positive impact on pedestrians, bicyclists, and transit users. Low-emission zones improve air quality and can reduce traffic on the road, making it safer and healthier for pedestrians and bicyclists in the low-emission zone.
- **Equity/Labor and Driver Impact:** Low-emission zones have an unclear impact on labor and drivers. The costs of driving in a low-emission zone may be passed on to drivers.

#### Delivery Microhubs and Lockers

- **Safety Impact:** The safety impact of delivery microhubs and lockers is unclear. Delivery microhubs and lockers do not inherently lead to fewer trucks on the street.
- **Environmental Impact:** The environmental impact of delivery microhubs and lockers is positive. These can potentially decrease the miles traveled by freight operators, decreasing emissions.
- **Air Quality/Health Impact:** The air quality and health of delivery microhubs and lockers is positive. These can potentially decrease the miles traveled by freight operators, decreasing emissions.
- **Equity/Disadvantaged and BIPOC Businesses Impact:** Delivery microhubs and lockers have a positive impact on disadvantaged and BIPOC businesses. Delivery microhubs and lockers can reduce delivery and shipping costs for businesses by allowing for the consolidation of shipments and deliveries.
- **Equity/Community Livability Impact for Residents Where Deliveries Occur:** Delivery microhubs and lockers have a positive impact on residents who live in neighborhoods where deliveries occur. Delivery microhubs and lockers can decrease pollution, congestion, competition for curb access, and delivery costs by allowing for the consolidation of shipments. This reduces truck noise, and can also be used as a community asset for placemaking around the delivery microhub, since residents will be going to pick up packages there.
- **Equity/Community Livability Impact for Residents Where Deliveries Originate:** Delivery microhubs and lockers have a positive impact on residents who live in neighborhoods where deliveries originate. Delivery microhubs and lockers can decrease pollution, congestion, competition for curb access, and delivery costs by allowing for the consolidation of shipments. This reduces the daily traffic count and truck noise.
- **Equity/Impact on Pedestrians, Bicyclists, and Transit Users:** Delivery microhubs and lockers have a positive impact on pedestrians, bicyclists, and transit users. Delivery hubs can reduce the number of trucks on the road, reducing the number of pedestrian and bicyclist crashes.
- **Equity/Labor and Driver Impact:** Delivery microhubs and lockers have an unclear impact on labor and drivers. While delivery microhubs and lockers may

create new jobs to monitor and run the delivery microhubs, the reduction in trips from consolidated shipments may result in job losses.

### *E-Bikes and other Low and Zero-Emission Vehicles*

- **Safety Impact:** The safety impact of e-bikes and other low and zero-emission vehicles is unclear. While e-bikes may remove some trucks from the road, increased e-bike usage may result in increasing bike and pedestrian crashes. Additionally, low- and zero-emission vehicles are not inherently safer than traditional combustion engine vehicles and do not lead to reduce crashes.
- **Environmental Impact:** The environmental impact of e-bikes and other low and zero-emission vehicles is positive. E-bikes can reduce VMT and e-bikes and low and zero-emission vehicles reduce greenhouse gas emissions per trip.
- **Air Quality/Health Impact:** E-bikes and low and zero-emission vehicles have a positive impact on air quality and health. E-bikes and low and zero-emission vehicles reduce air pollution, as measured by reduction in particulate matter and ozone percentiles.
- **Equity/Disadvantaged and BIPOC Businesses Impact:** E-bikes and low and zero emission vehicles have a positive impact on disadvantaged and BIPOC businesses. E-bikes are faster at making deliveries in urban areas than traditional delivery vans, which can reduce delivery costs for BIPOC businesses.<sup>40</sup> E-bikes also cost less than traditional delivery vans or delivery trucks, and can reduce delivery costs.
- **Equity/Community Livability Impact for Residents Where Deliveries Occur:** E-bikes and low and zero-emission vehicles have a positive impact on community livability for residents where deliveries occur. E-bikes and low and zero-emission vehicles can reduce air pollution and truck noise in neighborhoods where deliveries occur. E-bikes can lower daily traffic volumes and reduce the number of vehicles on the road.
- **Equity/Community Livability Impact for Residents Where Deliveries Originate:** E-bikes and low and zero-emission vehicles have a positive impact on community livability for residents where deliveries originate. E-bikes and low and zero-emission vehicles can reduce air pollution and truck noise in neighborhoods where deliveries originate. E-bikes can lower daily traffic volumes and reduce the number of vehicles on the road.
- **Equity/Impact on Pedestrians, Bicyclists, and Transit Users:** E-bikes and low and zero-emission vehicles have a positive impact on pedestrians and bicyclists. E-bikes can replace traditional delivery vans and remove vehicles from the road.

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<sup>40</sup> <https://electrek.co/2021/08/13/electric-cargo-bikes-faster-at-deliveries-than-delivery-vans/>. Accessed on December 13, 2021.

E-bikes and low and zero-emission vehicles can reduce truck noise and reduce air pollution and emissions.

- **Equity/Labor and Driver Impact:** E-bikes have an unclear impact. E-bikes may create new jobs, but they also may replace traditional driver jobs. Low and zero-emission vehicles have a positive impact on labor and drivers. Low and zero-emission vehicles can create new jobs for drivers, with drivers able to transition directly from driving internal-combustion engine trucks to driving low or zero-emission vehicles.

### Electric Delivery Robots

- **Safety Impact:** Electrified delivery impacts have an unclear impact on safety. Electrified delivery robots may reduce vehicles on the street, but may increase traffic and congestion on sidewalks and may increase pedestrian and bicyclist crashes.
- **Environmental Impact:** Electrified delivery robots have a positive environmental impact. They can reduce VMT from delivery trucks or food delivery vehicles, thereby reducing greenhouse gas emissions.
- **Air Quality/Health Impact:** Electrified delivery robots have a positive environmental impact. These vehicles are electric and can reduce particulate matter and ozone percentiles in the neighborhoods where they are piloted, especially if deployed in large numbers.
- **Equity/Disadvantaged and BIPOC Businesses Impact:** Electrified delivery robots have a positive impact on disadvantaged and BIPOC businesses. Electrified delivery robots can create new business opportunities and partnerships for businesses. The cost of electrified delivery robots is not developed enough to comment on.
- **Equity/Community Livability Impact for Residents Where Deliveries Occur:** Electrified delivery robots have a positive impact on community livability for residents where deliveries occur. Electrified delivery robots can reduce the number of delivery trucks making deliveries in the neighborhood, and can reduce air pollution and greenhouse gas emissions.
- **Equity/Community Livability Impact for Residents Where Deliveries Originate:** Electrified delivery robots have an unclear impact on community livability for residents where deliveries originate. Electrified delivery robots are a last mile solution and have little to no impact on the “first mile” where deliveries originate.
- **Equity/Impact on Pedestrians, Bicyclists, and Transit Users:** Electrified delivery robots have an unclear impact on pedestrians, bicyclists, and transit users. Electrified delivery robots can remove vehicles from the road and reduce emissions. However, these robots also operate on the sidewalk and can increase congestion on the sidewalk. There have also been some anecdotal reports of

electrified delivery robots preventing pedestrians and wheelchair users from safely crossing the street.<sup>41</sup>

- **Equity/Labor and Driver Impact:** Electrified delivery robots have a negative impact on labor and drivers. Electrified delivery robots replace delivery vans, resulting in job loss.

### *Curb and Loading Zone Reservation Systems*

- **Safety Impact:** A curb and loading zone reservation system has a positive impact on safety. Reservation systems can reduce impeded traffic flow from double parking and reduce loading vehicle blockages of bike lanes, parking spaces, buses, and crosswalks.
- **Environmental Impact:** Curb and loading zone reservation systems have a positive environmental impact. Reservation systems reduce time spent circling looking for a loading zone or parking space, reducing VMT and greenhouse gas emissions per trip.
- **Air Quality/Health Impact:** Curb and loading zone reservation systems have a positive air quality and health impact. Reservation systems reduce time spent circling looking for a loading space or parking space and can reduce particulate matter and ozone percentiles.
- **Equity/Disadvantaged and BIPOC Businesses Impact:** Curb and loading zone reservation systems have a positive impact on disadvantaged and BIPOC businesses. Reservation systems can reduce the time needed for deliveries, reducing delivery costs, as well as reduce costs from ticketing. Businesses may have to invest in technology and new training to be able to take advantage of reservation system platforms.
- **Equity/Community Livability Impact for Residents Where Deliveries Occur:** Curb and loading zone reservation systems have a positive impact on community livability for residents where deliveries occur. Curb and loading zone reservation systems can reduce the time that trucks circle looking for a delivery spot and can reduce truck noise. Curb and loading zone reservation systems can also increase safety for residents in neighborhoods where they are implemented.
- **Equity/Community Livability Impact for Residents Where Deliveries Originate:** Curb and loading zone reservation systems have an unclear impact on community livability for residents where deliveries originate. Curb and loading zone reservations may not have a large effect on the “first mile” where deliveries originate. Curb and loading zone reservations may not reduce daily truck volumes.

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<sup>41</sup> <https://www.bloomberg.com/news/articles/2019-11-19/why-tech-needs-more-designers-with-disabilities>



- **Equity/Impact on Pedestrians, Bicyclists, and Transit Users:** Curb and loading zone reservation systems have a positive impact on pedestrians, bicyclists, and transit riders. Curb and loading zone reservation systems can reduce double parking and parking in bike lanes or crosswalks, increasing the safety of pedestrians and cyclists.
- **Equity/Labor and Driver Impact:** Curb and loading zone reservation systems have an unclear impact on labor and drivers. A reservation system may not create jobs or cause job loss but can make the act of each delivery smoother for drivers, creating less time-stress or risk of ticketing.

**Toward Zero-Emissions Last-Mile Deliveries in Denver: Background Paper**  
Denver Office of Climate Action, Sustainability, and Resilience

## APPENDIX

Table 38 expanded. Also see the accompanying spreadsheet file.

			Potential Impact of Delivery Strategy (Citywide - not specific to particular demographic group or neighborhood)							
Category	Delivery Strategy	Policy vs. Infrastructure	Safety Impact	Environmental Impact	Air Quality / Health Impact	Equity / Disadvantaged & BIPOC Biz Impact	Equity / Community Livability Impact for Residents Where Deliveries Occur	Equity/ Community Livability Impact for Residents Where Deliveries Originate	Equity / Impact on Pedestrians, Bicyclists, and Transit Users	Equity / Labor & Driver Impact
City Policy	Commercial Loading Zone Management Program	Policy + New Signage	Positive	Positive	Positive	Positive	Positive	Unclear	Positive	Unclear
City Policy	Commercial Delivery Permits	Policy	Positive	Positive	Positive	Positive	Positive	Positive	Positive	Unclear
City Policy	Late-night (off-hour) Delivery	Policy + New Signage	Positive	Positive	Positive	Positive	Unclear	Unclear	Positive	Unclear
City Policy	Freight Villages	Policy	Unclear	Unclear	Unclear	Unclear	Unclear	Negative	Unclear	Positive
City Policy	Truck and Truck-Restricted Routes	Policy	Unclear	Unclear	Unclear	Positive	Unclear	Unclear	Unclear	Unclear
City Policy	Low or Zero Emissions Zone	Policy + Infrastructure	Unclear	Positive	Positive	Unclear	Positive	Positive	Positive	Unclear

			Implementation Pathway				Potential Partners			
Category	Delivery Strategy	Policy vs. Infrastructure	Priority	Time to Implement	Cost to Implement	Level of Difficulty	Recommended Neighborhood(s) for Implementation	Internal Lead	Internal Support	External Support
City Policy	Commercial Loading Zone Management Program	Policy + New Signage	High	Medium	Medium	Medium	Five Points/Welton Federal/Little Saigon Highland Bruce Randolph East Colfax South Broadway	DOTI ROW Services	Community Planning and Development, Park Smart Denver	Amazon, DHL, UPS, FedEx, Shamrock, Motor Carriers Association
City Policy	Commercial Delivery Permits	Policy	Medium	Low	Low	Low	Five Points/Welton Federal/Little Saigon Highland Bruce Randolph East Colfax South Broadway	DOTI ROW Enforcement	Economic Development and Opportunity	
City Policy	Late-night (off-hour) Delivery	Policy + New Signage	Medium	High	Medium	Medium	Five Points/Welton Federal/Little Saigon Highland Bruce Randolph East Colfax South Broadway	DOTI		
City Policy	Freight Villages	Policy	Medium	High	Low	High	Highland South Broadway		Community Planning and Development, Economic Development and Opportunity, Performance-Based Infrastructure Office	Amazon, DHL, UPS, FedEx, Shamrock, Motor Carriers Association
City Policy	Truck and Truck-Restricted Routes	Policy	Medium	Medium	Low	High	Federal/Little Saigon East Colfax South Broadway	DOTI		
City Policy	Low or Zero Emissions Zone	Policy + Infrastructure	High	High	High	High	Five Points/Welton Highland Bruce Randolph East Colfax			

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			Potential Impact of Delivery Strategy (Citywide - not specific to particular demographic group or neighborhood)							
Category	Delivery Strategy	Policy vs. Infrastructure	Safety Impact	Environmental Impact	Air Quality / Health Impact	Equity / Disadvantaged & BIPOC Biz Impact	Equity / Community Livability Impact for Residents Where Deliveries Occur	Equity / Community Livability Impact for Residents Where Deliveries Originate	Equity / Impact on Pedestrians, Bicyclists, and Transit Users	Equity / Labor & Driver Impact
Tech Solutions	Delivery Microhubs and Lockers	Infrastructure	Unclear	Positive	Positive	Positive	Positive	Positive	Positive	Unclear
Tech Solutions	E-Bikes and other Low and Zero-Emission Vehicles	Policy	Unclear	Positive	Positive	Positive	Positive	Positive	Positive	E-Bikes - Unclear Low and Zero-Emission Vehicles - Positive
Tech Solutions	Electric Delivery Robots	Policy	Unclear	Positive	Positive	Positive	Positive	Unclear	Unclear	Negative
Tech Solutions	Curb and Loading Zone Reservation Systems	Policy + Infrastructure	Positive	Positive	Positive	Positive	Positive	Unknown	Positive	Unclear

			Implementation Pathway					Potential Partners		
Category	Delivery Strategy	Policy vs. Infrastructure	Priority	Time to Implement	Cost to Implement	Level of Difficulty	Recommended Neighborhood(s) for Implementation	Internal Lead	Internal Support	External Support
Tech Solutions	Delivery Microhubs and Lockers	Infrastructure	Low	Medium	Medium	Low	Five Points/Welton Tennyson Highland Bruce Randolph East Colfax South Broadway	DOTI Infrastructure Project Mgmt	Community Planning and Development, Economic Development and Opportunity, Performance-Based Infrastructure Office	
Tech Solutions	E-Bikes and other Low and Zero-Emission Vehicles	Policy	High	Low	Low	Low	Five Points/Welton Federal/Little Saigon Tennyson Highland Bruce Randolph East Colfax South Broadway	CASR	DOTI, Economic Development and Opportunity	
Tech Solutions	Electric Delivery Robots	Policy	Low	Low	Low	Low	Tennyson Highland		Motor Vehicle - Title and Registration, Performance-Based Infrastructure Office	
Tech Solutions	Curb and Loading Zone Reservation Systems	Policy + Infrastructure	High	Medium	High	High	Five Points/Welton Federal/Little Saigon Tennyson Highland Bruce Randolph East Colfax South Broadway	DOTI Transportation Project Mgmt	Economic Development and Opportunity, Park Smart Denver, Technology Services	Amazon, DHL, UPS, FedEx, Shamrock, Motor Carriers Association