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Transit First: Culver City Washington Boulevard Transit Lane Feasibility Study

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TRANSIT FIRST

Culver City Washington Boulevard Transit Lane Feasibility Study

UCLA Luskin School of Public Affairs
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16. Abstract

The goal of the Culver City Transportation Department (Culver CityBus) is to "create a great community for all to live and work by developing connected, autonomous, and shared-use transportation services and infrastructure." In line with this goal, the City is developing a set of plans and programs to enhance multi-modal travel. These include support for transit-oriented development, a microtransit pilot program, and efforts to improve traffic safety.

Additionally, the Culver City Transportation Department sponsored the Washington Boulevard transit lane feasibility study. The agency designated the section of Washington Boulevard, bounded by National Boulevard to the east and Ince Boulevard to the west, as a pilot design corridor for implementing a bus lane. The purpose of the Transit First: Culver City Washington Boulevard Transit Lane Feasibility Study is to explore and showcase transit lane design concepts to improve the efficiency and convenience of transit as a mobility option. The recommendations are intended to be consistent with existing conditions in the City as well as current policies and programs.

Transit service in Culver City can be improved; it suffers from slow bus speeds, poor on-time performance, and—perhaps as a consequence—declining ridership. These indicators are exacerbated by congested traffic conditions as well as an under-investment in multi-modal infrastructure.

To improve transit service in and through Culver City, this report presents four different design concepts. The first concept is the narrowest in scope and, perhaps, could be implemented most easily. It is a Westbound Only Bus Lane that could fill the pressing need for reliable morning peak period, peak directional trips. The other three concepts require larger efforts; however, they would contribute more substantially to broader visions that the city has for Washington Boulevard. The three mid-term and long-term interventions propose transit lanes in conjunction with bike infrastructure. They include a Westbound Only Bus Lane with Elevated Bike Lanes, Two-Way Bus Lanes with Elevated Bike Lanes, and Two-Way Bus Lanes with Elevated Bike Lanes and A Reversible Traffic Lane.

Each of the four design concepts has different benefits and costs, including diverse effects on use of the street and on the larger community. The Westbound Only Bus Lane would improve transit service at the lowest cost relative to the other three options. The mid-term and long-term concepts require substantial budgets to fund roadway surface construction and sign/signal installation. The Two-Way Bus Lanes would greatly improve travel times and, therefore, likely increase ridership by approximately 40%, but they also would have effects on auto throughput due to the reduction in the number of general traffic lanes.

This report closes with a set of recommendations for the implementation of successful bus lanes. This process should be

inter-departmental with continuous efforts to involve diverse stakeholders and members of the community. The study will serve as an editable and adaptable document for future project development and implementation in the City.

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TRANSIT FIRST

Culver City Washington Boulevard Transit Lane Feasibility Study

University of California,
Los Angeles

TRANSIT FIRST: CULVER CITY WASHINGTON BLVD TRANSIT LANE FEASIBILITY STUDY

A comprehensive project submitted in partial satisfaction of the requirements for the degree Master of Urban and Regional Planning.

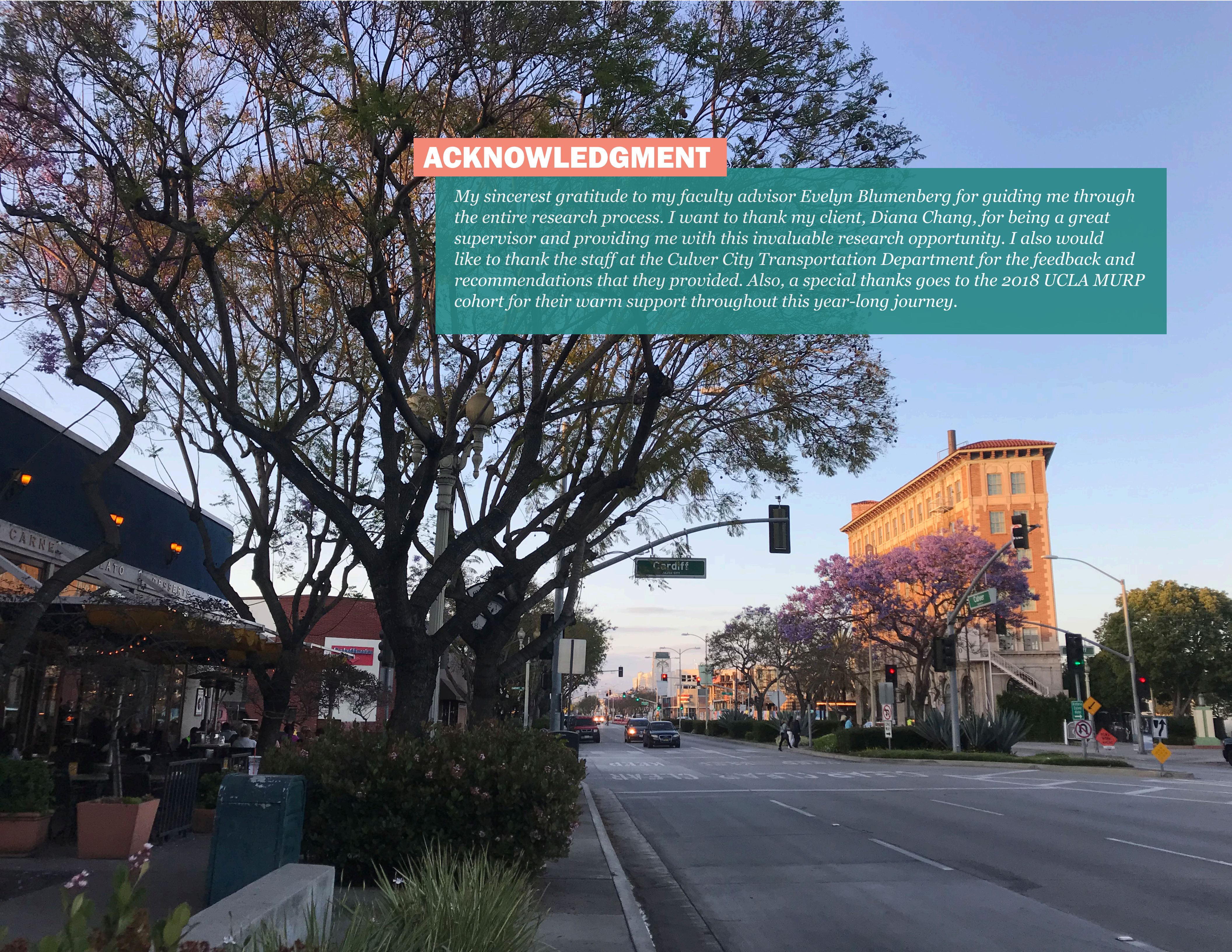
by

Weicheng Lu (Jeffery)

Client: Diana Chang, Culver City Transportation Department
Faculty Chair of Committee: Evelyn Blumenberg

June 2018

Disclaimer: *This report was prepared in partial fulfillment of the requirements for the Master in Urban and Regional Planning degree in the Department of Urban Planning at the University of California, Los Angeles. It was prepared at the direction of the Department and of Culver City Transportation Department as a planning client. The views expressed herein are those of the authors and not necessarily those of the Department, the UCLA Luskin School of Public Affairs, UCLA as a whole, or the client.*



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EXECUTIVE SUMMARY

The goal of the Culver City Transportation Department (Culver CityBus) is to “create a great community for all to live and work by developing connected, autonomous, and shared-use transportation services and infrastructure.” In line with this goal, the City is developing a set of plans and programs to enhance multimodal travel. These include support for transit-oriented development, a microtransit pilot program, and efforts to improve traffic safety.

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TABLE OF CONTENTS

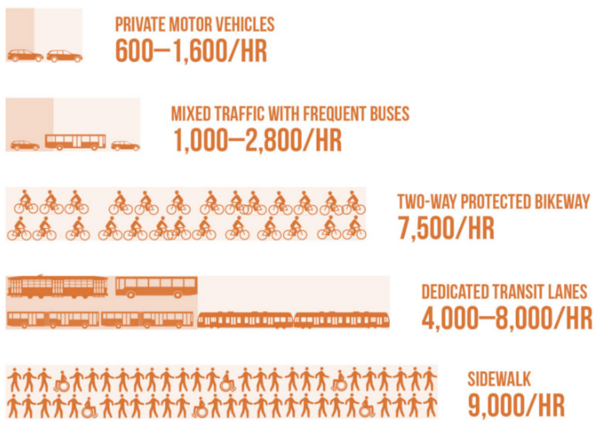
LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Figure 1. The Person Throughput Capacity of a 10' Lane by Mode at Peak Conditions



Source: NACTO - Designing to Move People

Los Angeles County has an expansive roadway system and the streets in the county play an important role in moving around people and goods. Nowadays, automobiles—particularly single-occupant vehicles--are the dominant transportation mode on most streets. However, private motor vehicles are the least spatially efficient mode on the street and have difficulty satisfying the existing travel demand, causing congestion (NACTO, 2018). Cars also have serious negative environmental consequences, contributing to poor air quality and climate change (US EPA, 2015). Local governments can potentially reduce some of these negative externalities by providing more convenient and efficient public transit service. If transit service begins to rival that of the automobiles, some drivers may shift their travel modes, increasing the performance of limited street space. Currently, one of the principal disadvantages to using transit is travel time (Maciag, 2017). On average transit trips tend to be 1.9 times longer than auto trips (Maciag, 2017).

Street spaces should be designed to move people instead of cars. As transit is one of the most spatially efficient modes (Figure 1), this project explores the use of bus lanes to help move people more efficiently. Bus lanes usually are reserved for the exclusive use of buses (FTA, 2017). Bus lanes also can play many roles in different circumstances. They can be a type of managed lane (FHWA, 2015), a transit improvement technique, one element of a complete street (Kittleson & Associates, 2013), and/or a feature of bus rapid transit (BRT) (Li, Song, Li, & Zhang, 2009). Many cities such as New York, San Francisco, Paris, and Sydney have implemented bus lanes as one strategy to improve transit service quality and reduce bus travel times (Agrawal, 2012; Agrawal, Goldman, & Hannaford, 2013).

With a population of approximately 40,000, Culver City is the 207 largest city in California (League of California Cities, 2017). It is located on the Westside of Los Angeles County and surrounded by neighborhoods in the City of Los Angeles. One of the goals of the Culver City Transportation Department (Culver CityBus) is to "create a great community for all to live and work by developing connected, autonomous, and shared-use transportation services and infrastructure." One potential strategy is to implement transit lanes on Washington Boulevard, a major corridor through the city. The Culver City Transportation Department designated the section of Washington Boulevard, bounded by National Boulevard to the east and Ince Boulevard to the west, as the pilot design corridor for bus lane implementation.

Therefore, the purpose of this report, Transit First: Culver City Washington Boulevard Transit Lane Feasibility Study, is to explore and showcase potential design concepts and make recommendations in line with the City's existing conditions and current policies and programs. The study is organized into seven chapters: introduction, literature review, research design, existing conditions, design concepts, evaluation, and other recommendations.

CHAPTER 2

LITERATURE REVIEW

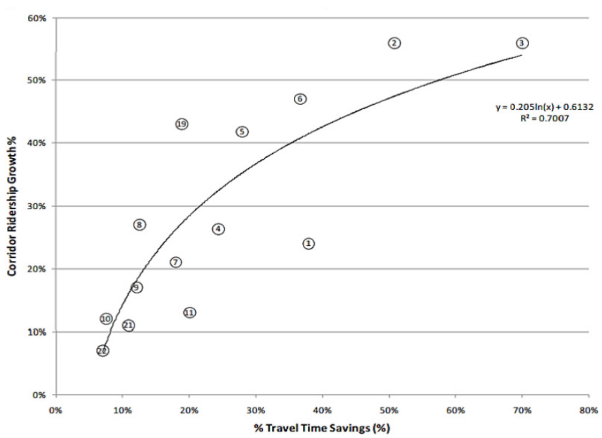
In this chapter, I draw on existing studies to examine how best to design a bus lane. In the first section, I draw on research to provide a rationale for the implementation of bus lanes. In the subsequent section I address the potential impacts of bus lanes. I then explore current bus lane types and practices, including the use of space, operation hours, and transit lane access policies. Finally, I present potential design tools to enhance bus lane reliability.

Source: Vogue.com

01 WHY BUS LANES

Public transit can help increase number of travelers passing through the city and improve urban mobility. Since the benefits of bus lanes are highly localized, studies highlight different but related benefits depending on the site and project characteristics. I organize these benefits into the following six categories: (1) improved transit service quality, (2) increased transit ridership, (3) reductions in vehicle miles of travel (VMT), (4) energy conservation and improved environmental sustainability, (5) greater public health and street safety, and (6) social equity.

Figure 2. Transit Ridership Gains from Transit Travel Time Savings



Source: Litman 2016

A. Improved transit service quality

Bus lanes can enhance transit service quality by increasing bus travel speeds, reducing total travel time and improving service reliability. Numerous studies highlight the relationship between bus lanes and service quality improvements (Shalaby, 1999; Currie and Sarvi, 2012; Boyle, 2013). Bus lanes provide dedicated roadway space for buses to travel without sharing the road with automobile users, thus minimize congestion and delay. Bus travel speed and reliability increase greatly after the implementation of bus lanes (National Academies of Sciences, 2013).

B. Increased transit ridership

Bus lanes can contribute to increased transit ridership through enhancing transit service quality. Every ten percent reduction in total travel time is associated with an approximately five percent increase in transit ridership (Paulley et al., 2006). Figure 2 also shows that ridership growth is positively correlated with travel time savings (Litman, 2016). Another benefit is the increase in fare revenues that are associated with additional boardings.

C. Reductions in vehicle miles of travel (VMT)

Reductions in vehicle miles of travel are associated with better transit facilities, such as bus lanes (Bailey, 2008). Studies show that congestion eases when drivers shift to buses, and cars do not compete for the roadway with buses (Basso, Guevara, Gschwendher, & Fuster, 2011). However, congestion is a rather complicated problem to solve since as soon as space becomes available on the roads and highways some travelers make the choice to drive and congestion resumes (Downs, 1992).

D. Foster energy conservation and environmental sustainability

Transportation is the source of 27 percent of greenhouse gas (GHG) emissions. Shifting from cars to transit could help reduce GHG emissions (US EPA, 2015). A reduction in auto travel also can help to decrease fuel consumption (Shaheen & Lipman, 2007).

E. Improve public health and street safety

In California, 3,680 people died on the road in 2016, an increase of 13 percent over the previous year (Lavender, 2017). Bus lanes are associated with fewer collisions, reported collisions, and fatal crashes (Goh, Currie, Sarvi, & Logan, 2013). Bus lanes also appear to reduce excessive speeding, aggressive acceleration, and hard braking by more than 20 percent (Zendrive, 2016). Finally, bus lanes encourage more walking and the use of active modes of travel that enhance public health (Lee & Buchner, 2008).

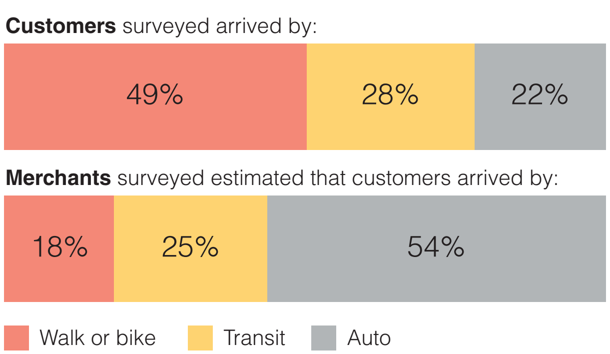
F. Address social equity

In Los Angeles County, about three fourths of transit riders live in households with household incomes of less than $25,000 (LA Metro, 2016). By reallocating street space, bus lanes would provide riders with a more equal shares of the roadway relative to automobile drivers. Bus lanes also can reinforce the opportunities and transit options for physically, economically and socially disadvantaged people (Darshini, Joshi and Datey 2013; Litman, 2016).

02 IMPACT OF BUS LANES

Bus lanes provide many benefits, but they also impose costs on other users of the street. These impacts often are used in arguments against bus lane projects. Although we still do not have good transportation models to predict these impacts (Brown and Paling, 2014), it is still worthwhile to address them. There are three major negative impacts of bus lanes; they include:

Figure 3. How Customers Travel to Business Corridor: Customer and Merchant Responses



Source: SFMTA - Geary Corridor Bus Rapid Transit, 2013

A. Reduced vehicular-traffic capacity and potentially more traffic congestion

Many bus lane projects reconfigure existing travel lanes as bus lanes. In doing so, these projects reduce overall lane capacity for automobiles (Agrawal, 2012; Agrawal, Goldman, & Hannaford, 2013). This approach can lead to increased roadway congestion.

However, as I discussed previously, congestion is used to maintain self-limiting equilibrium (Litman, 2016). One important factor in predicting congestion in the quality of the transportation is the presence of alternatives, such as bikeways, buses, and alternative routes. If the alternatives are relatively fast and convenient, the effect of bus lanes on congestion would be less severe than otherwise (Currie and Sarvis, 2012; Litman, 2014). As moving people is the main goal of a transit street, using person throughput to measure street performance instead of traditional volume measures broadens mode shift goals.

B. Reduced parking supply

The curbside bus lane is one of the most common bus lane types. It typically displaces on-street parking (Levinson and Krizek, 2015). Some of these parking spaces are critical, especially for drivers and passengers with special needs. One way to address this issue is to analyze the supply and demand of on-street parking and provide alternative parking solutions on side streets and in parking lots (Iteris, 2015).

C. Reduced car-dependent business activity

The vitality of street-front businesses in urban arterials can depend on the access that car drivers have to them (Woodin, 2017). Dedicated bus lanes on curbsides and the removal of parking spaces concern business owners (Iteris, 2015). However, as Figure 3 shows, studies find that businesses tend to exaggerate the assumptions associated with auto-mobility and commerce (SFMTA, 2013). As there are not as many auto customers as businesses might think, projects that improve the quality of sidewalks and bike/bus facilities also attract customers who arrive by modes other than a car (Roth, 2009). Therefore, the multi-modal quality of streets can contribute to the vitalization of businesses along urban arterials.

Soliciting stakeholders' input early and addressing the needs of local businesses are critical to building public support for bus lanes (LA Metro, 2016). For example, the city of Santa Monica's Lincoln Neighborhood Corridor Plan (LiNC) underscores the importance of business input for the success of implementation (Iteris, 2015).

03 BUS LANE TYPES AND PRACTICES

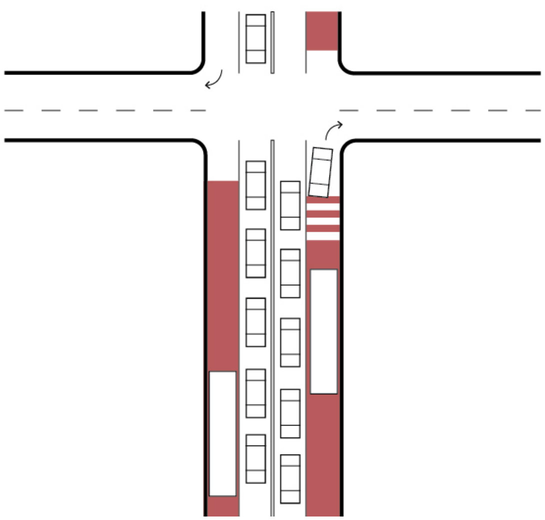
1. BUS LANE TYPES

There are numerous bus lane designs in terms of the use of space on the roadway. Different designs need different considerations and have varying impacts. The following sections and schematics present five common design types and some of their features.

A. Curbside Bus Lane

- Location: installed right next to the curb and replaces the rightmost traffic lane or street parking
- Benefit: permits right-turn vehicles to travel on the bus lane
- Minimum width: 11 feet (NACTO, 2017)

Figure 4. Typical Curbside Bus Lanes Configuration

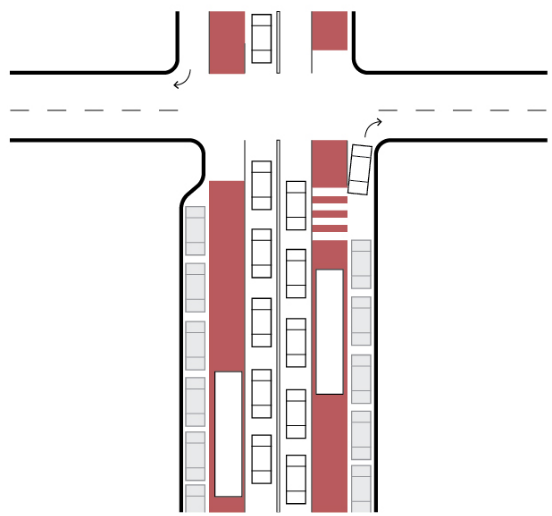


Source: NACTO - Curbside Bus Lane

B. Offset Bus Lane

- Location: located in an offset configuration
- Design: can be installed so buses do not need to pull into the curb for boarding and alighting
- Minimum width: 10 feet (NACTO, 2017)

Figure 5. Typical Offset Bus Lanes Configuration



Source: NACTO - Offset Bus Lane

C. Median Bus Lane

- Location: placed along the centerline of the street
- Benefit: omits potential conflicts with other vehicles
- Design: requires wide road space to accommodate two medians as buses stop on both sides.
- Minimum width: 11 feet in each direction
- Median bus stop: long enough to accommodate the expected number of buses; median bus stop should be at least 8 feet for boarding/landing areas, and additional space when accommodating stop furniture such as shelters and leaning rails (NACTO, 2017)

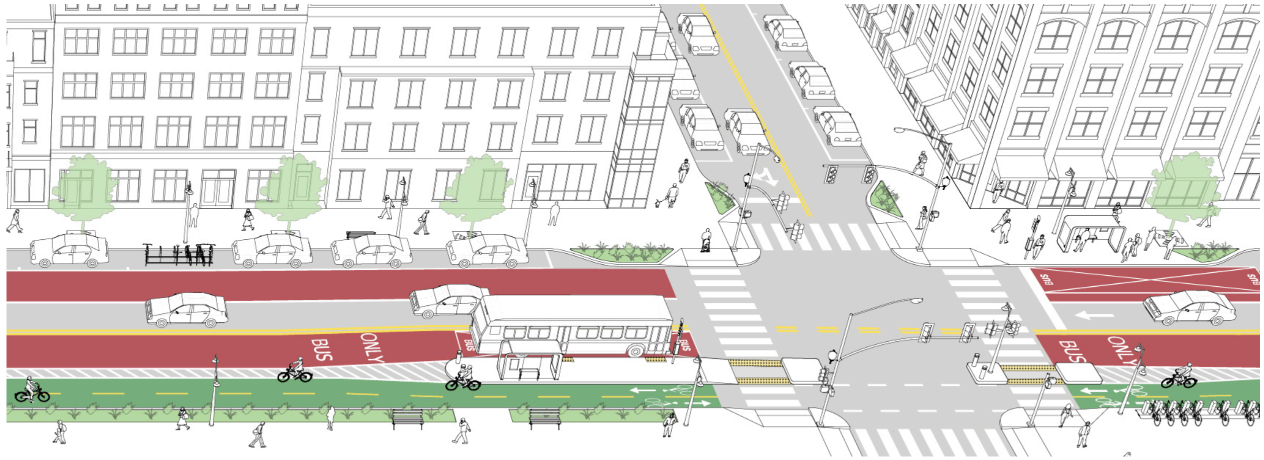
Figure 6. Typical Median Bus Lanes Configuration

Source: NACTO - Dedicated Median Bus Lanes

D. Contraflow Bus Lane

- Design: runs against the traffic flow, allowing a more flexible use of street space for transit service
- Potential concern: ineffective when there is unauthorized encroachment by non-transit vehicles
- Minimum width: 11 feet (NACTO, 2017)

Figure 7. Contraflow Bus Lanes Configuration

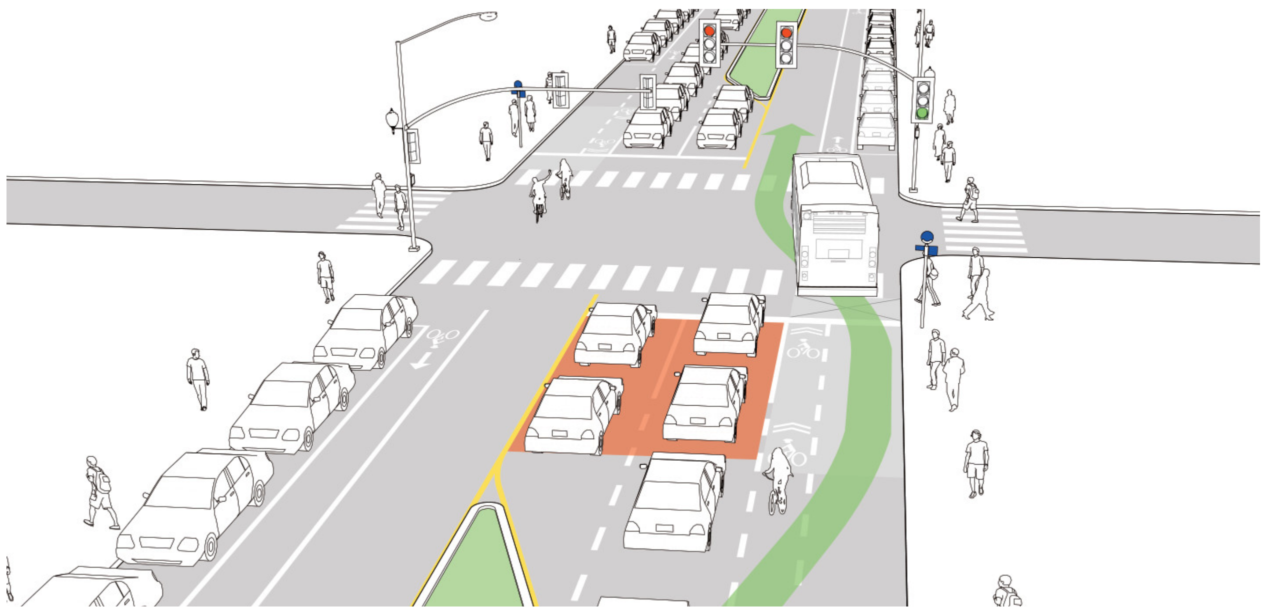


Source: NACTO - Contraflow Transit Lane

E. Queue Jump Lane

- Location: designed for intersections
- Design: links the bus stop to travel lane for buses to enter traffic flow more easily
- Technology: use of Transit Signal Priority to indicate when other general vehicles need to yield to buses, so buses can cross the intersection at the beginning of the signal cycle without being delay (NACTO, 2017)

Figure 8. Queue Jump Lanes Configuration



Source: NACTO - Queue Jump Lanes

2. OPERATION PERIOD

Bus lanes can be operated all-day full-time, while there are also some examples of peak-hour bus lanes, daytime bus lanes, and weekday bus lanes (Agrawal, 2012; Agrawal, Goldman, & Hannaford, 2013).

To provide adequate transit service to commuters, buses usually run more frequently during peak hours and on weekdays. Therefore, enforcing dedicated bus lanes for 4-6 hours a day during weekday peak hours is a common strategy (Agrawal, 2012; Agrawal, Goldman, & Hannaford, 2013). When the peak hour bus lane is not enforced during off peaks, the lane would shift back to a general traffic or parking lane. Peak-hour operations are popular in many cities, such as on Wilshire Boulevard in Los Angeles (Figure 9) and New York (Figure 10) (Agrawal, 2012; Agrawal, Goldman, & Hannaford, 2013). Having an all-day full-time bus lane or standardized operation period would help drivers better understand when they can or cannot access the bus lane (Agrawal, 2012). As seen in Table 1, Agrawal et al clearly outline the operation periods favored and used by six different cities.

Tailoring specific bus lane operation periods to different segments of streets would give transit agencies greater flexibility to coordinate bus volumes and traffic flow. However, having a standard operation period would help drivers better understand when they can or cannot enter the lanes.

Table 1. Bus Lane Operation Hours by cities (% of total lane miles)

Operation Period	London	LA	NYC	Paris	SF	Seoul	Sydney
All-day full time	29%		<2%	100%	66%	44%	12%
Daytime hours (typically weekdays)	25%		40%		11%	32%	18%
Peak Periods Only	46%	100%	58%		23%	24%	70%

Source: Agrawal et al 2013 - Shared-Use Bus Priority Lanes on City Streets: Approaches to Access and Enforcement

Figure 9. LA Wilshire Boulevard Peak-Only Bus Lane

Source: NACTO - Peak-Only Bus Lane

Figure 10. New York Day-Time Bus Lane

Source: RTW Travels

3. VEHICLE TYPE ACCESS POLICY

Instead of taking away traffic lanes and dedicating them to the exclusive use of buses, some cities provide relatively flexible access policies allowing other types of vehicles to use the bus lanes. Common vehicles permitted in bus lanes include turning vehicles, governmental vehicles, and taxis (Agrawal, 2013). Allowing turning vehicles to drive into bus lanes places less of a burden on the general traffic lanes since drivers do not need to wait for turning vehicles before proceeding. There are also examples of cities that allow bicycles, high occupancy vehicles, and electric vehicles to use bus lanes (Agrawal, 2013; Vaughan, 2016). Allowing these vehicles to use the bus lanes incentivizes the use of green and low-emission transportation modes.

A. Right-Turn vehicles

Generally, curbside bus lanes allow right-turn vehicles to drive into the bus lane to make turns (Agrawal, 2013). This approach can smooth the traffic pressure in the general traffic lane. It also reduces the conflicts between vehicles that are turning right and buses that are proceeding ahead.

B. Governmental vehicles

Fire trucks and ambulances are the most common vehicle types that are permitted to use bus lanes (Agrawal, Goldman, & Hannaford, 2013). Sometimes transit agencies also allow mail trucks, school buses, or other government vehicles to operate on the bus lanes (Agrawal, Goldman, & Hannaford, 2013).

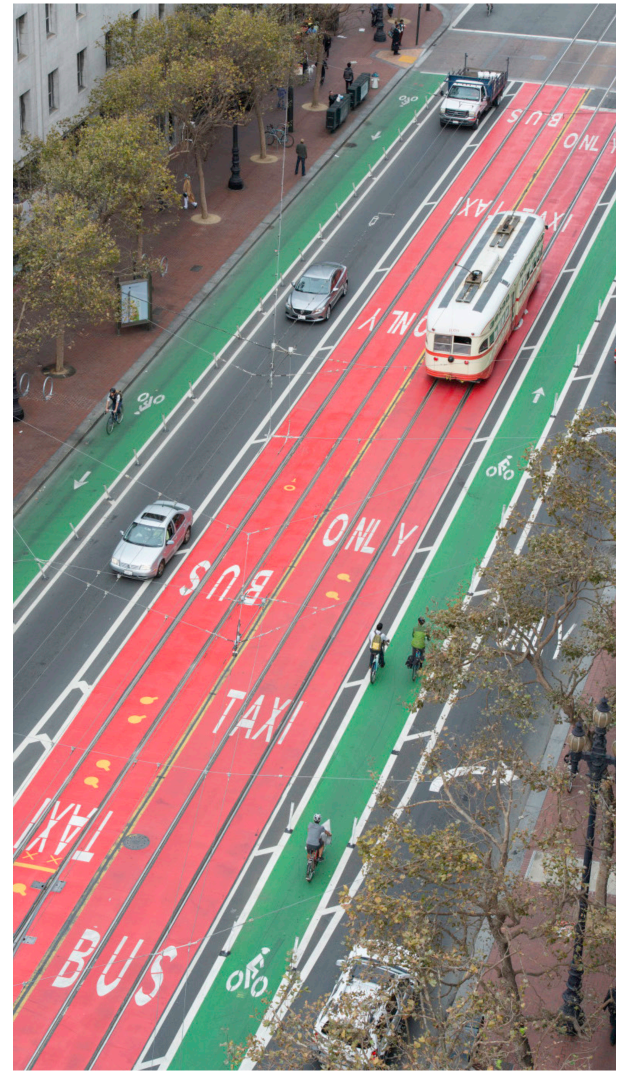
C. Bicycles and motorcycles

Shared bicycle/bus lanes (SBBL) are intended to promote multi-modal urban streets. As of 2012, cities installed 27 SBBLs across the United States (Florida Department of Transportation, 2012). In Shizuoka City, Japan, there are also examples of bus lanes that permit motorcycles (Sakamoto, 2007).

D. High occupancy vehicles

One reason for implementing bus lanes is to encourage shared-use of the street. High occupancy vehicles, carpools, and taxi/rideshare services may follow this principle (Litman, 2016). Electric vehicles also address the issue of air pollution and energy consumption (Litman, 2016). Allowing these vehicles to use bus lanes incentivizes a greener and more efficient use of street space by motorists (Litman, 2016).

Figure 11. San Francisco Bus/Taxi Share Lane



Taxis is authorized to use bus lane in San Francisco.
Source: San Francisco Municipal Transportation Agency

04 DESIGN TOOLS AND ELEMENTS

This section presents a selection of transportation-focused design tools to transform the proposed transit corridor into a safer and more vibrant downtown street. An understanding of potential design tools allows for bus transit lane recommendations that result in the fewest disruptions and the greatest benefits to street users.

A. Color and Markings

Cities typically use paint to designate a bus lane and alert roadway users of the modified driving environment. Cities like San Francisco, New York, Washington DC paint their bus lanes red (Figure 12). According to SFMTA, the red carpet treatment has reduced the number of vehicle violation by up to 55 percent, and the police-reported collisions have also decreased (SFMTA, 2017). The study finds that red painted bus lanes are effective in preventing risky driving behavior and the use of the bus lane by unauthorized vehicles.

Markings also can play an important role in informing drivers; however the design should avoid wordy descriptions that only confuse or distract drivers. "Bus only" and "bus lane" are two common markings in most of the cities (Agrawal, 2012). The frequency of the markings also affects the awareness of drivers; short distances between markings can help prevent drivers from encroaching on the lane (Snyder, 2017).

B. Signs

Signage also is an effective tool to inform road users. Bus stop signage will usually indicate the operation period and vehicle type access policy. However, sometimes the signs can be misleading particularly when transit agencies try to deliver too much information at the same time. Good signage will allow road users and law enforcement personnel to understand the context quickly without confusing them (Linton, 2016).

C. Lane Width

Different lane uses require different lane widths (Figure 14). Eleven-foot-wide transit lanes and eight-foot-wide parking lanes are adequate (NACTO, 2017). The existing street striping provides motorists with an excessively wide traffic lane (about 12 feet). In so doing, it creates opportunities for speeding and risky driving. As seen in Figure 15, reducing the general traffic lane to 10 – 10.5 feet wide will reduce crash rates and, at the same time, effectively move high volumes of traffic (Jaffe, 2015).

It oftentimes is challenging to implement transit lanes while minimizing the negative impacts on general traffic lane capacity. Lane width modification is an efficient strategy to calm traffic while providing adequate space for different sized vehicles.

D. Curb Extension

Curb extensions at transit stops, or so-called bus bulbs, would make it safer and easier for buses to board and alight riders without changing lanes. Moreover, curb extensions can reduce stop delay by up to 20 seconds since buses would not have to continually exit and re-enter the flow of traffic (NACTO 2018). Since curb extensions visually and physically narrow the roadway, they would create shorter and safer crossings (NACTO 2018).

Bus bulbs oftentimes come with other amenities such as wayfinding maps, lighting, and shade structure to improve bus riders' experience while waiting for the bus (NACTO, 2017).

E. Transit Signal Priority

Transit signal priority (TSP) can further improve bus speeds by reducing bus delays due to traffic signals. TSP allows transit vehicles to communicate with traffic signals. When a bus is running behind schedule, the bus will talk to the signal automatically, and the traffic signal will hold the green light to ensure that transit vehicles can pass through the intersection instead of waiting for the light to turn green. NACTO (2018) states that TSP could reduce bus travel time by around ten percent and up to 50 percent at target intersections.

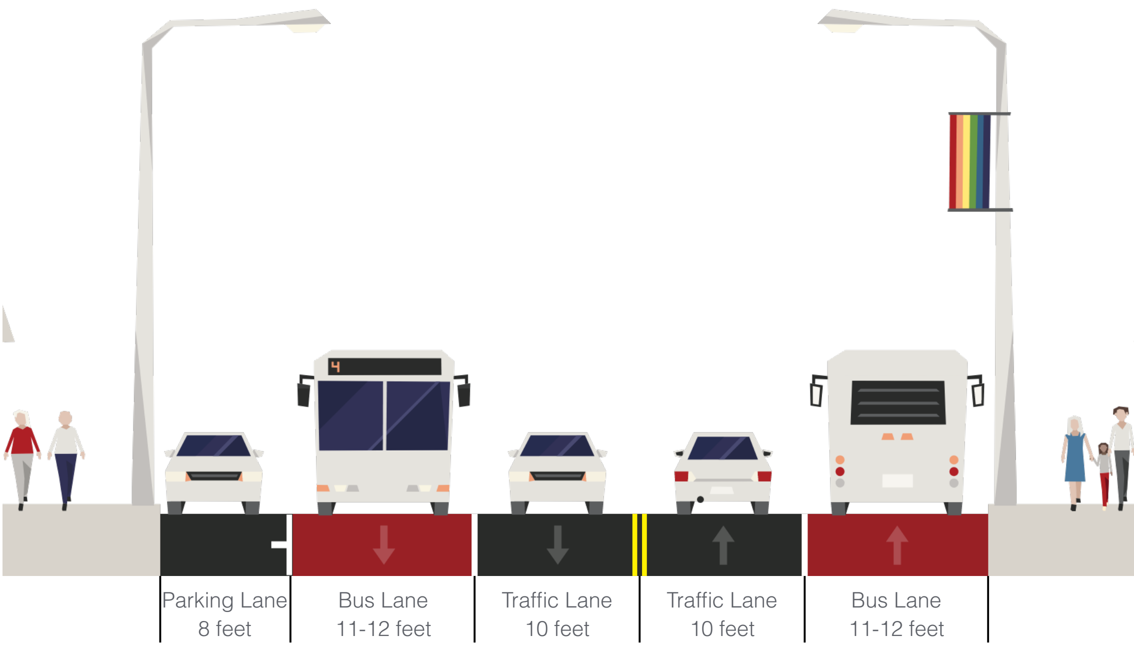
Figure 12. Red Carpet Bus Lane with “Bus Only” Marking (MUTCD 3D-01)

Source: Greater Washington

Figure 13. Bus Bulb / Sidewalk Extension Rendering

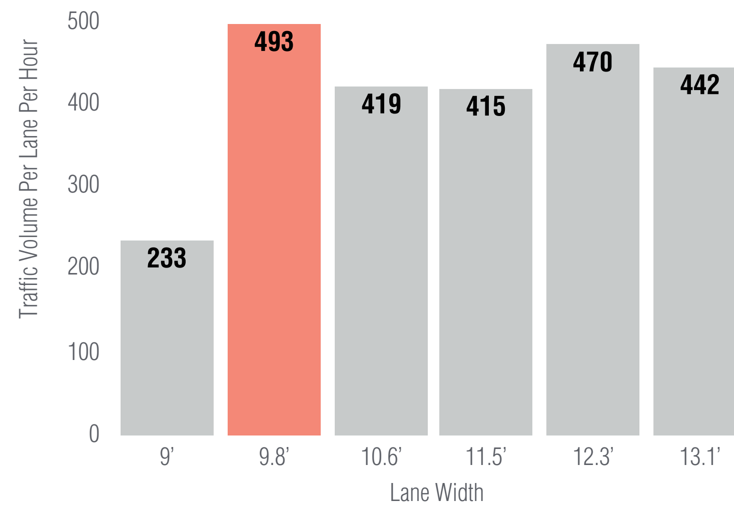
Source: SFMTA

Figure 14. Recommended Widths for Different Lanes



Source: Streetmix.com

Figure 15. Distribution of Traffic Capacity (Per Lane Per Hour) Demand and Lane Width



Traffic capacity is the highest for 10-feet wide general traffic lane (Source: Jaffe, 2015)

05 SUMMARY

The purpose of bus lanes extends beyond moving riders faster. Bus lanes also can contribute to increased ridership, improve street safety, and revitalization of street-front business. Studies highlight the many advantages and disadvantages of bus lanes. However, it is not always clear why some bus lanes are more successful than others; the reasons for the varied findings are complicated and difficult to measure. However, bus lane design recommendations for Culver City ought to be informed by studies of the strengths and weaknesses of bus lane designs. Moreover, bus lane design varies in different situations and under different conditions. The opportunity to design bus lanes in a way that satisfies the needs of multiple stakeholders and to develop a multi-modal urban transit corridor is exciting and challenging. It involves analyzing the street from both local and regional perspectives, understanding community preferences, and ensuring that the recommendations meet the needs of the city.

CHAPTER 3

RESEARCH DESIGN

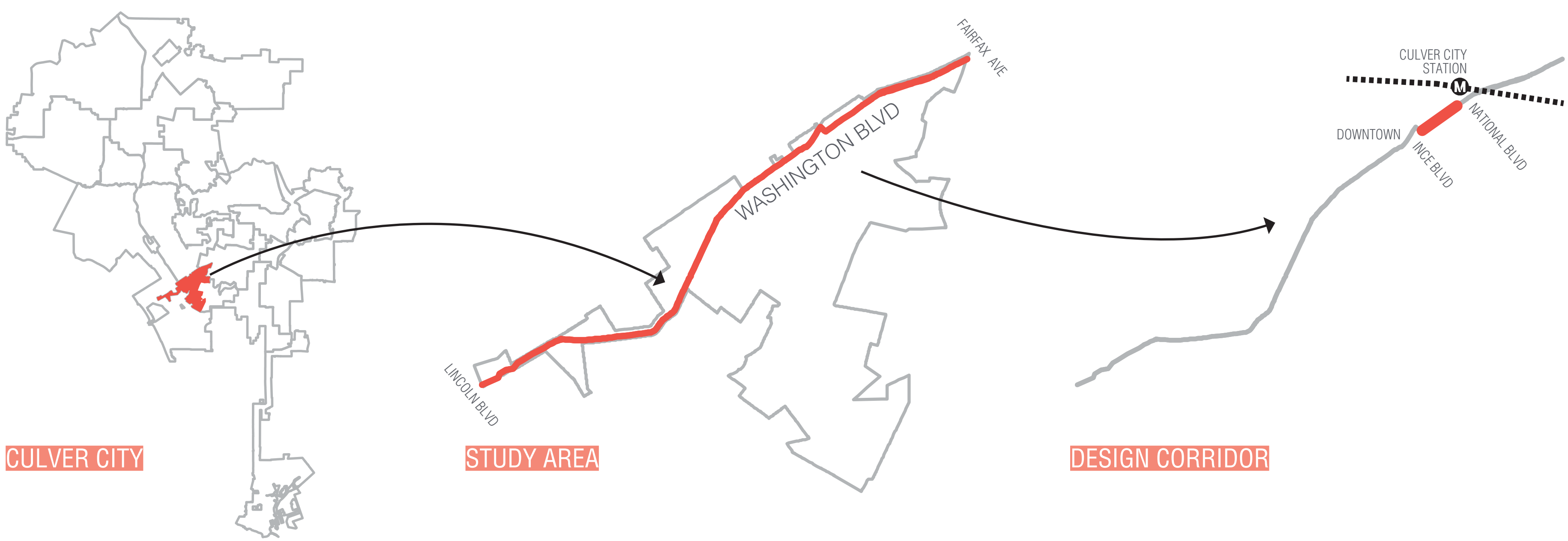
01 RESEARCH QUESTION

Transit ridership has declined over time in Southern California (Manville et al., 2018). To encourage greater transit use, the Culver City drafted a TOD Visioning Study to advance the use of first/last mile connections and to link various transportation modes into a coherent concept on Washington Boulevard. To achieve this goal and address transit service issues, the study recommends the implementation of dedicated transit lanes on Washington Boulevard.

My research builds on this report. Working with Diana Chang from the Culver City Department of Transportation as my client and advised by UCLA Luskin School Urban Planning Professor Evelyn Blumenberg, I examine the following question: "How should the city design effective transit lanes on Washington Boulevard?" As shown in Figure 16, the project includes the entire stretch of Washington Boulevard in Culver City from Fairfax Avenue to Lincoln Boulevard, while only focusing on the design elements from the Expo Station to Downtown Culver City (National Boulevard to Ince Boulevard).

> ***"How should the city design effective transit lanes on Washington Boulevard?"***
>
> Research Question

Figure 16. Study Area and Design Corridor Location



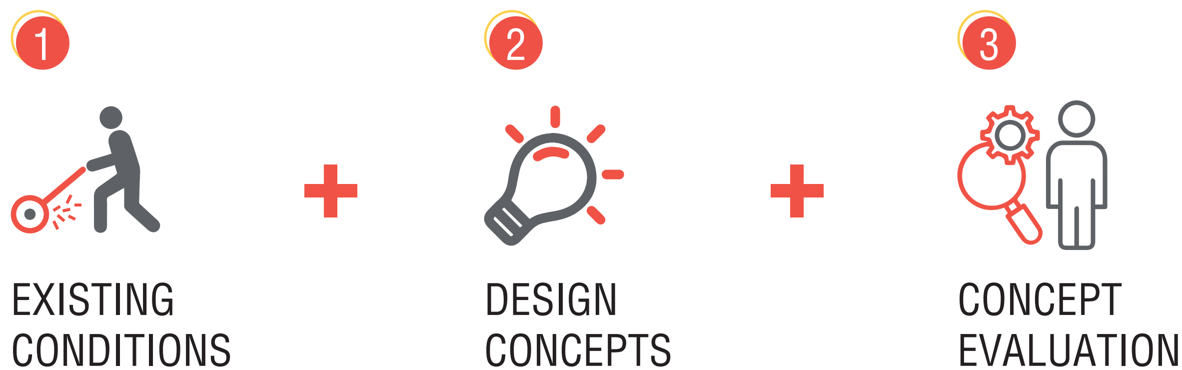
02 METHODOLOGY

The study includes the following three components: the assembly of baseline existing conditions and the development and evaluation of design concepts. The report concludes with a set of recommendations based on this analysis.

(1) The analysis of ***existing conditions*** provides the conceptual basis for developing a successful transit lane. I assemble baseline existing conditions using both secondary data and through a field audit.

(2) The ***design concepts*** center on a preliminary streetscape design from National Boulevard to Ince Boulevard, including the corresponding signal phasing, transportation management, and other implementation prerequisites.

(3) The ***concept evaluation*** explores and evaluates the potential benefits and impacts of the design concepts.

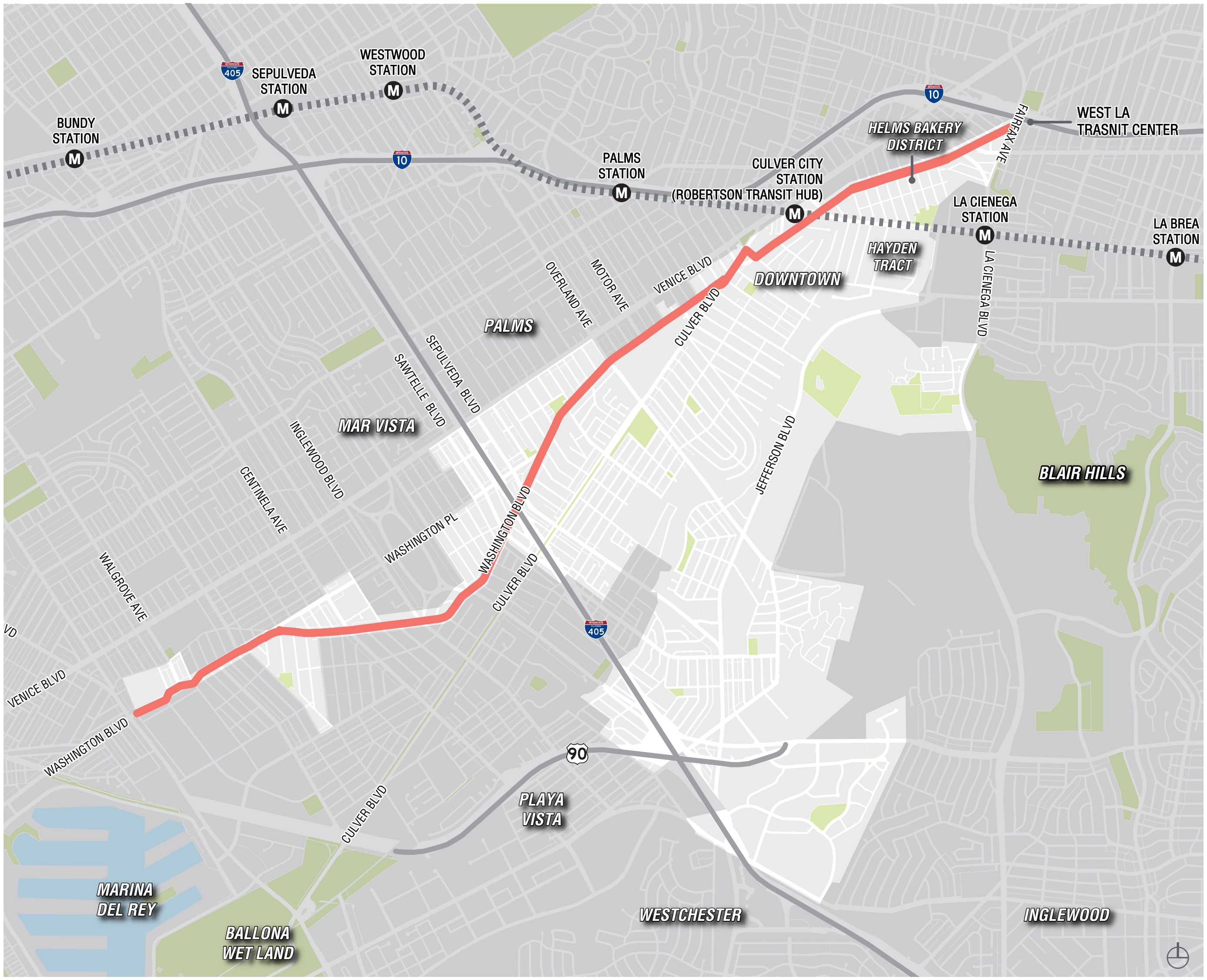


03 STUDY AREA & DESIGN CORRIDOR

STUDY AREA

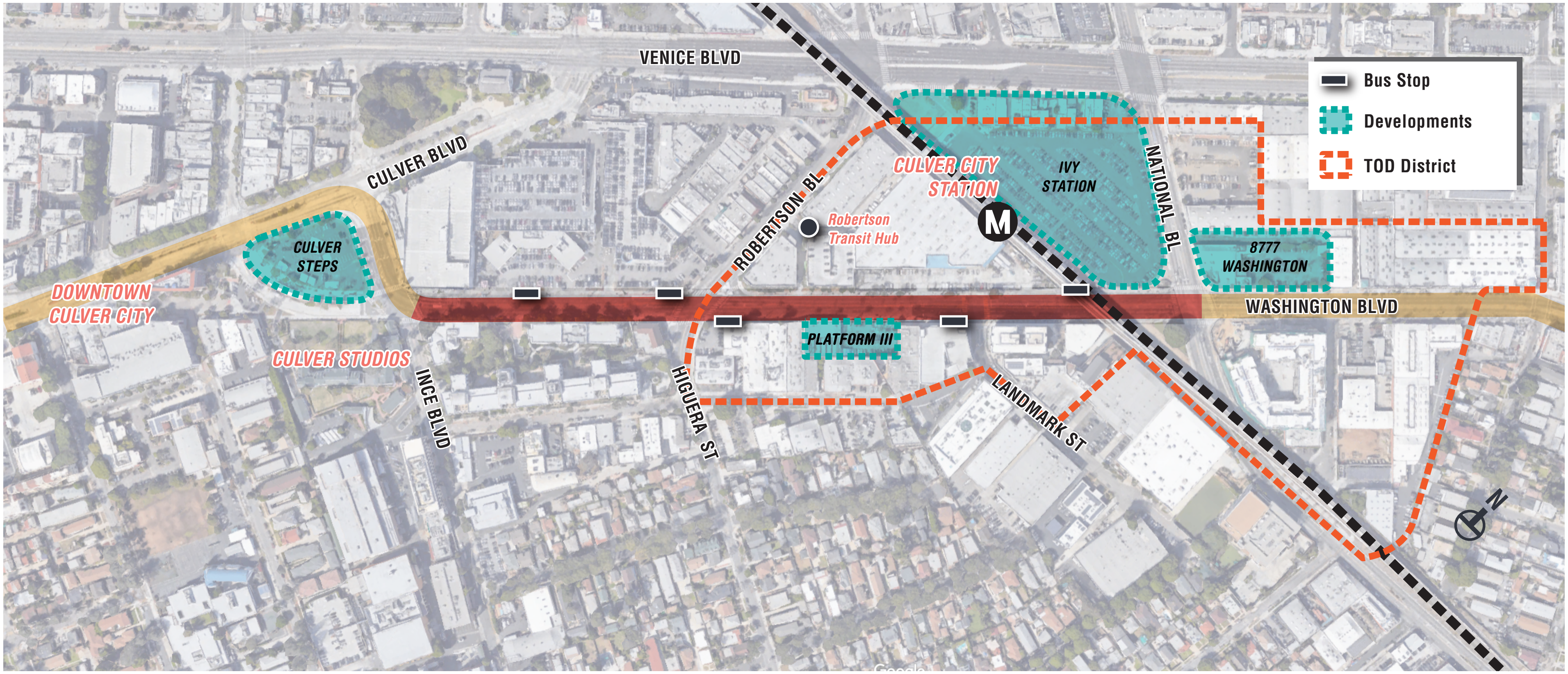
The study area covers Washington Boulevard from Fairfax Avenue to Lincoln Boulevard and is the main arterial through Culver City (Figure 17). The 6.2-mile-long corridor links the community with a light rail station, major roads, and landmarks such as the Helms Bakery District (a historic commercial development), and the Hayden Tract Business District, a neighborhood with technology companies and studios. The study area also crosses two main transit hubs – the Robertson Transit Hub and the West LA Transit Center.

Figure 17. Study Area Map



DESIGN CORRIDOR

Figure 18. Design Corridor Map



The design corridor lies between National Boulevard and Ince Boulevard (Figure 18). It is a 0.4-mile-long corridor connecting Expo Line Culver City Station on the east with the Downtown area on the west. There are two intersections in the design corridor: one is a cross intersection at Washington and Robertson/Higuera, and the other is a T intersection at Washington and Landmark.

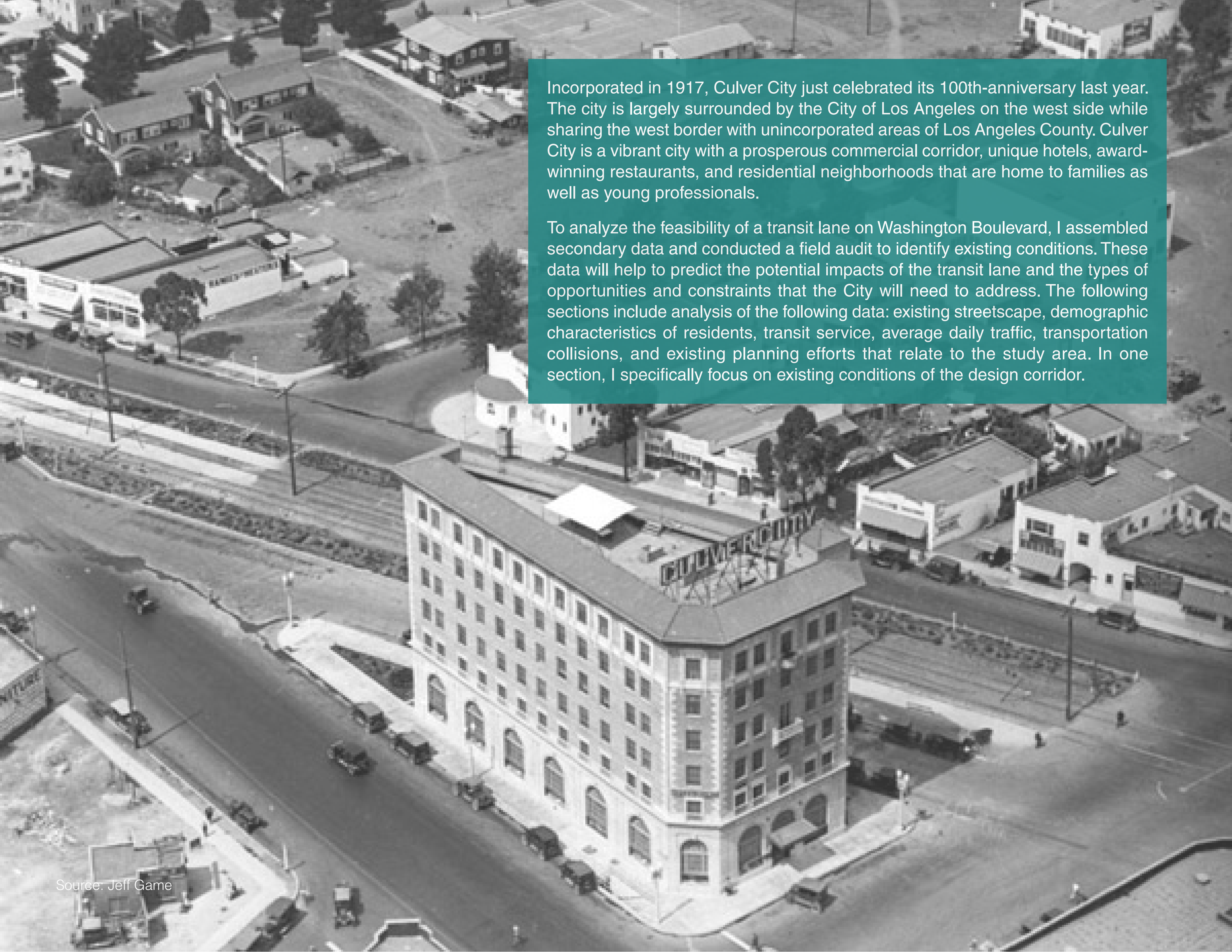
The design corridor is one of the most important sections along the proposed transit corridor. It not only connects numerous bus lines and light rail service, but also it serves as an important arterial linking key destinations and landmarks in the broader community.

CHAPTER 4

EXISTING CONDITIONS

Incorporated in 1917, Culver City just celebrated its 100th-anniversary last year. The city is largely surrounded by the City of Los Angeles on the west side while sharing the west border with unincorporated areas of Los Angeles County. Culver City is a vibrant city with a prosperous commercial corridor, unique hotels, award-winning restaurants, and residential neighborhoods that are home to families as well as young professionals.

To analyze the feasibility of a transit lane on Washington Boulevard, I assembled secondary data and conducted a field audit to identify existing conditions. These data will help to predict the potential impacts of the transit lane and the types of opportunities and constraints that the City will need to address. The following sections include analysis of the following data: existing streetscape, demographic characteristics of residents, transit service, average daily traffic, transportation collisions, and existing planning efforts that relate to the study area. In one section, I specifically focus on existing conditions of the design corridor.



Source: Jeff Game

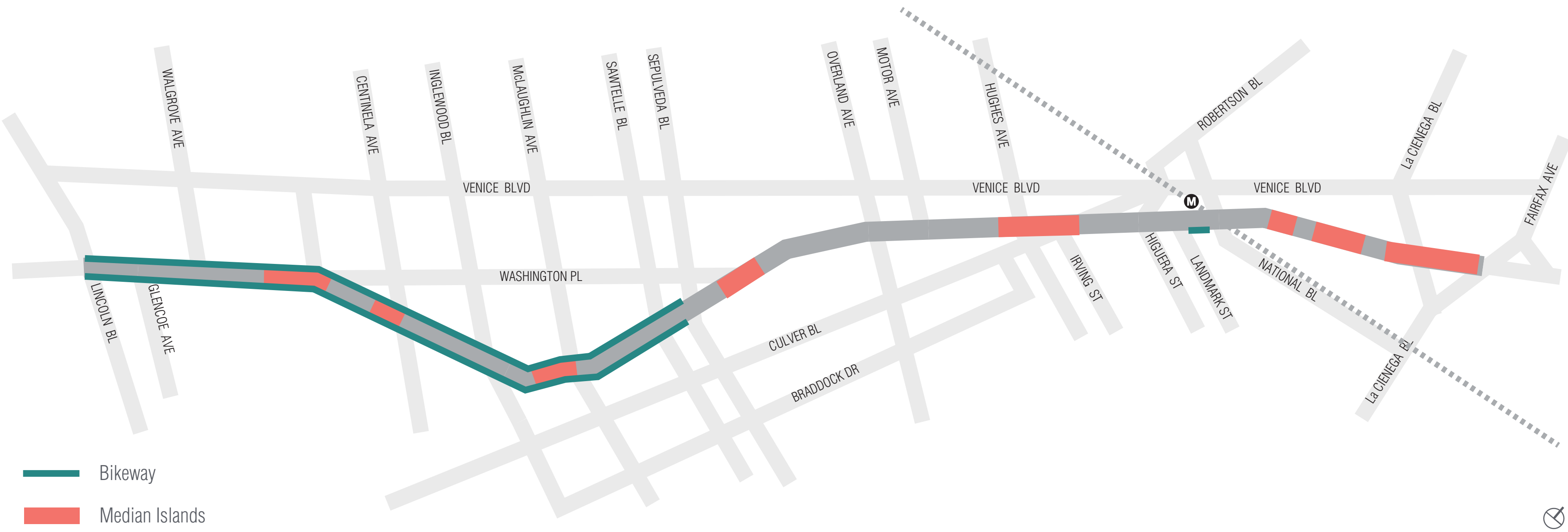
01 EXISTING STREETSCAPE

Understanding the existing streetscape will help planners better redesign the street with transit supportive infrastructure. As I show in Table 2, the street width of Washington Boulevard varies from approximately 55 feet to 85 feet with two general traffic lanes in each direction and one center turn lane. The eastbound direction expands to three traffic lanes at the section of Washington Boulevard that merges with Culver Boulevard in Downtown Culver City. The existing study area provides parking on both sides of the street. As Figure 19, there is an existing Class II bike lane and a Class III bike route (bike sharrow) along Washington Boulevard from west of Sepulveda Boulevard. There is also a short stretch of Washington Boulevard in the eastbound direction that includes a Class II bike lane from Landmark Street to National Boulevard. There are several median islands throughout the corridor, one-mile-long in total (Figure 19).

Table 2. Study Area Existing Streetscape

Street Width (curb to curb)	55' to 85'	
Median Islands	Approximately 1 mile in total	
Number of lanes	**EB**	**WB**
General Traffic Lanes (GTL)	2 - 3	2
Bike Lane	0 - 1	0 - 1
Center Turn Lane	1	

Figure 19. Study Area Median Islands and Bikeways Distribution



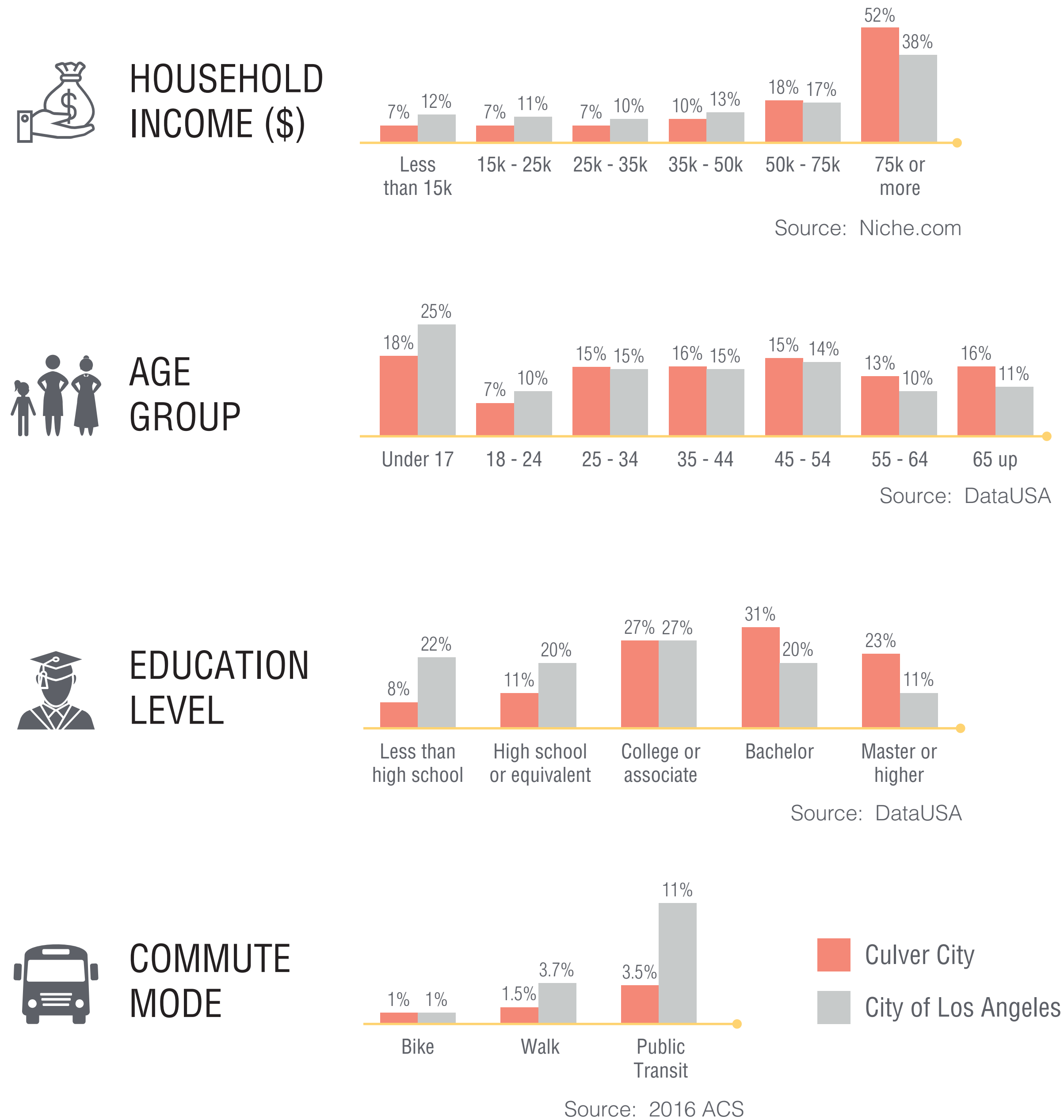

Washington Blvd at Downtown Culver City
Source: Google Map Street View
Median Islands
Center Turn Lane
Street parkings
DOWNTOWN Culver CITY
DELMAS
S & W COUNTRY DINER
Washington Blvd

02 DEMOGRAPHIC

An understanding of the characteristics of Culver City residents will help in implementing a transit corridor that best caters to the needs of residents. In this section, I use data from DataUSA, Niche, and the 2016 American Community Survey to compare the characteristics of the Culver City population to the characteristics of the population in the City of Los Angeles. Culver City has a population of approximately 40,000 people with a median household income of $81,189. Fifty-five percent of neighborhood residents are home-owners and 45 percent are renters. Culver City also has a higher percentage of seniors compared to the City of Los Angeles. Approximately 57 percent of the population has a bachelor's degree or higher. These figures suggest that Culver City is largely home to middle-class families.

In terms of commute mode share, about 3.5 percent of workers use public transit, 1.5 percent walk, and just under one percent bike. These percentages are lower than those for the City of Los Angeles, with the biggest gap associated with the use of public transit. The data show that workers in Culver City are highly dependent on the automobile for their commutes. At the same time, the city should and is trying to improve non-automobile modes as competitive alternative options.

Figure 20. Culver City Demographic (Household Income, Age, Education Level, Commute Mode)



03 TRANSIT SERVICE

1. BACKGROUND OF CULVER CITYBUS

Founded in 1928, Culver CityBus is the second oldest municipal transit agency in California. Culver CityBus includes seven local lines and one bus express transit line that operate in Culver City and the Los Angeles communities of Century City, Marina del Rey, Mar Vista, Palms, Rancho Park, Venice, West Los Angeles, Westchester and Westwood (Culver CityBus Short Range Transit Plan, 2016). Figure 21 shows the Culver CityBus Service Schedule and system map.

In terms of bus service time period, the Culver CityBus morning (AM) peak is from 6 am to 9 am and the afternoon (PM) peak is from 4 pm to 6 pm (Figure 22).

Figure 22. Culver CityBus Time Period Definition

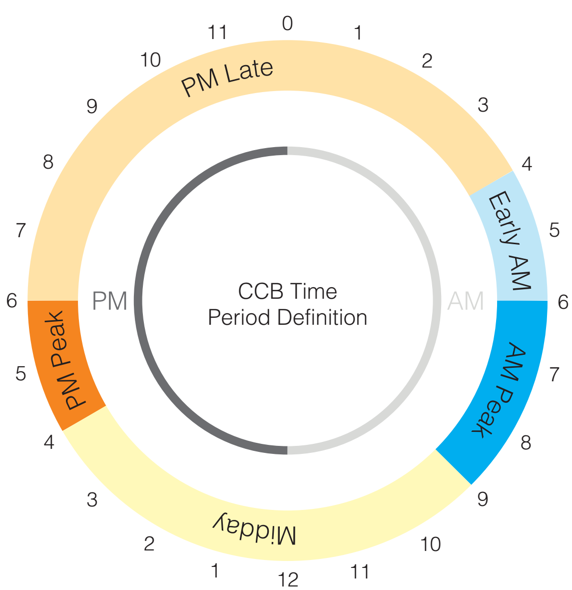


Figure 21. Culver City System Map

Source: Jane Chan Client Project

2. WASHINGTON BLVD TRANSIT SERVICE

In this section, I discuss the state of public transit within and beyond Washington Boulevard. This information coupled with an understanding of future transportation investments in the area is necessary to develop recommendations for a proposed bus lane.

Table 3. Bus Services along the Study Area

Bus Route	Section	Length (ml)	Direction	Days of Service
Line 1	Fairfax - Lincoln	6.19	EB - West LA Transit Center WB - Venice	Weekday, Saturday, Sunday
Line 2	Inglewood - Centinela	0.4	EB - Westfield Culver City WB - Venice High School	Weekday
Line 3	Motor - Overland	0.2	EB - Century City WB - Westfield Culver City	Weekday, Saturday, Sunday
Line 5	Higuera - Irving	0.4	EB - Rodeo/La Cienega WB - Culver City Schools	Weekday
Line 7	National - Irving	0.7	EB - Expo Culver City WB - Marinal del Rey	Weekday
BBB 16	Wade - Glencoe	0.7	EB - Wilshire/Bundy WB - Marinal del Rey	Weekday
BBB 17	National - Robertson	0.4	WB - Culver City Station (at Robertson Transit Hub)	Weekday, Saturday, Sunday
BBB R12	Motor - Overland	0.2	WB - UCLA	Weekday, Saturday, Sunday
Metro 17	National - Robertson	0.4	WB - Downtown LA	Weekday
LADOT CE437	Fairfax - Irving	1.7	EB - Downtown LA WB - Marinal del Rey	Weekday

Source: Compiling from transit agencies' website

A. Bus Services

The proposed transit corridor is a popular bus service route for regional transportation services. Four transit agencies operate bus service along parts of the corridor in Culver City, including Culver CityBus, Metro Bus, Santa Monica's Big Blue Bus, and Los Angeles Department of Transportation (LADOT) Commuter Express (Table 3 ; Figure 23).

Washington Boulevard is the most frequented corridor for Culver CityBus, underscoring the importance of the proposed transit corridor. Five out of seven local Culver CityBus lines run service on, at least parts of, the proposed transit corridor, particularly Line 1, which runs the entire corridor and provides service to the adjacent Los Angeles communities of Mar Vista and Venice.

Other than Culver CityBus, the Metro Bus Line 17 runs on Washington Boulevard from National to Robertson. Santa Monica's Big Blue Bus also runs three routes along portions of the corridor. LADOT's Commuter Express route CE437 uses Washington Boulevard as the connection line for Downtown Los Angeles and Venice.

In all, the proposed transit corridor accommodates nine bus routes operated by four different transit agencies. Service is highest (5 lines) along Washington Boulevard from National to Robertson (Figure 24).

Figure 23. Bus Services along Study Area

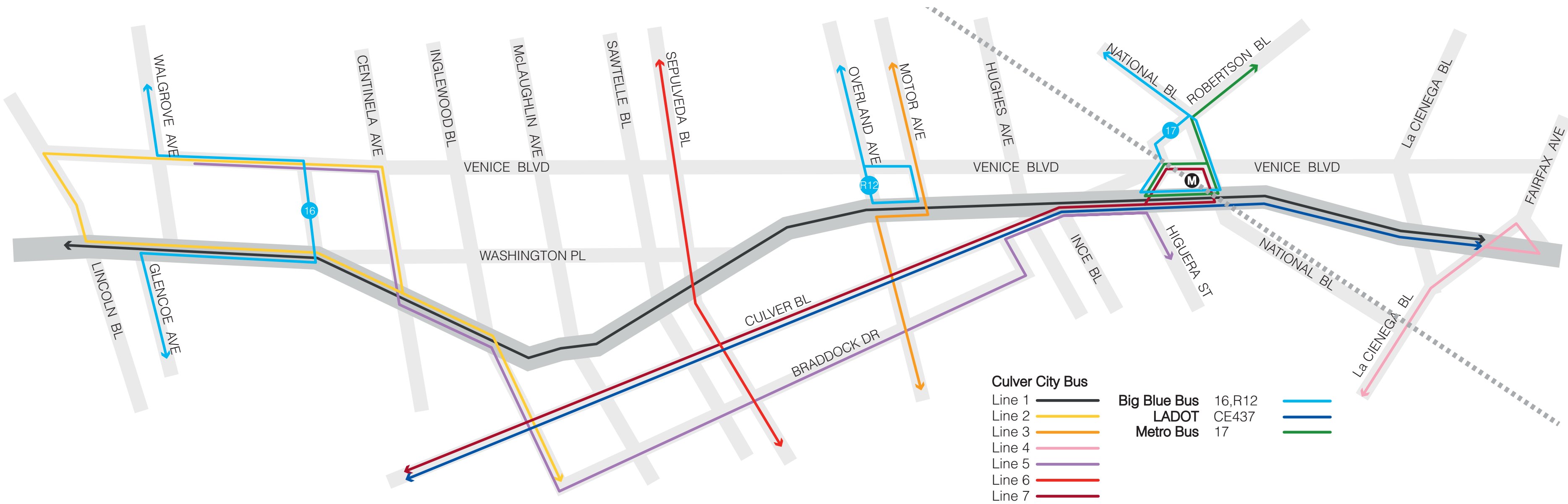


Figure 24. Bus Line Intensity along Study Area

Table 4. Expo Culver City Station Connected Services

Entrance	Connected Bus Services
Washington Blvd	Culver CityBus - Line1, Line7 LADOT - CE437
Venice Blvd	Metro - Local 17, Local 33, Rapid 733 Big Blue Bus - Line 17

Source: Compiling from transit agencies' website

Figure 25. Expo Station - Washington Blvd Entrance

Source: Google Map Streetview

B. Light Rail Service: The Expo Line

Operated by the Los Angeles Metropolitan Transportation Authority (Metro), the Exposition Light Rail Line is a 15.2-mile rail system that connects Downtown Los Angeles to Downtown Santa Monica (Figure 26). The Expo Culver City Station opened in 2012 as the last stop of Expo Line Phase 1, and the phase 2 construction to Santa Monica was completed in 2016.

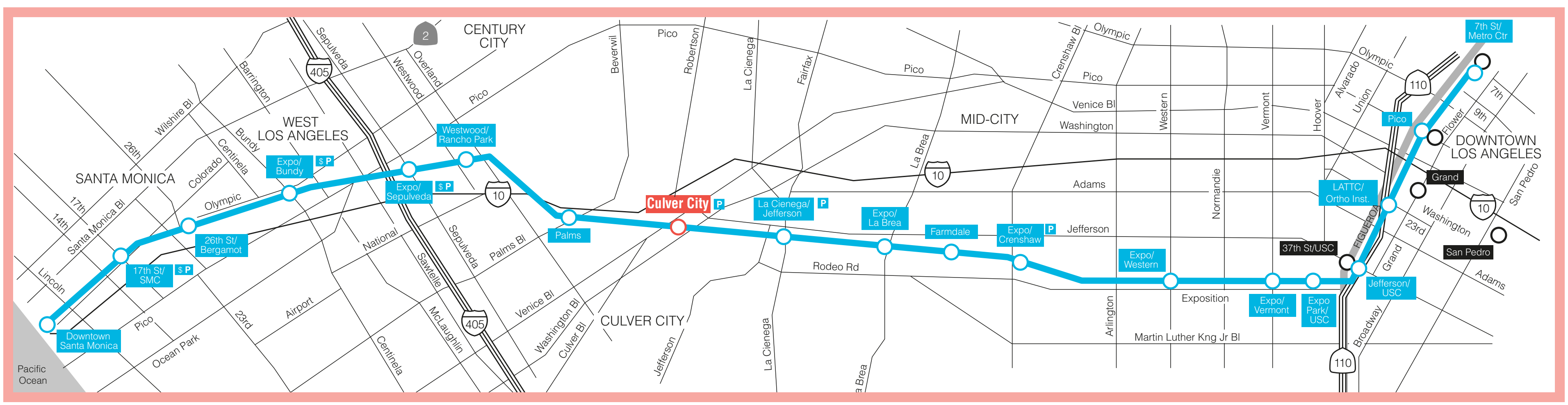
There are two entrances to the Culver City Station (Table 4). One entrance fronts Washington Boulevard and connects to the Culver CityBus and LADOT Commuter Express. The second entrance fronts Venice Boulevard and connects to Metro buses and the Big Blue Bus.

C. Potential Future Transit Projects

Culver City seeks to provide convenient and innovative mobility options for the residents and commuters. To do so, it is exploring the feasibility of a number of new services including a microtransit pilot service along Washington Boulevard.

With the operation of the Exposition Light Rail and the booming of the Hayden Tract Business District, the Culver City Transportation Department seeks to develop a Microtransit Pilot project for first/last-mile travel for Culver City employees. Main boulevards like National and Washington face serious congestion during rush hour. A transit lane on Washington Boulevard for both buses and microtransit vehicles could reduce commute times and might also ensure that bus and microtransit are competitive options relative to driving.

Figure 26. Metro Expo Line Map



Source: LA Metro

The Culver City Transportation Department is facing decreasing bus ridership, low on-time performance, stagnant bus speed, and, perhaps related, delays in bus services due to traffic congestion, especially during rush hours (Basso, 2008).

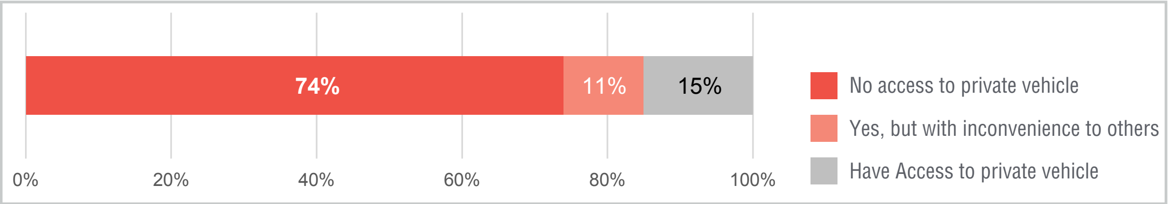
As the Culver CityBus Line 1 is the main line that runs along Washington Boulevard within the City, this section focuses on this Line 1 and examines (1) the characteristics of riders, (2) ridership, (3) on-time performance, and (4) bus speeds along the proposed transit corridor.

A. Ridership Profile

The Culver City Transportation Department conducted The 2015 Culver CityBus on-Board Passenger Survey on all routes to better understand the experience of customers. The agency collected a total of 589 surveys on Line 1. The survey included rider demographics including sex, race, income, disability, language, etc.

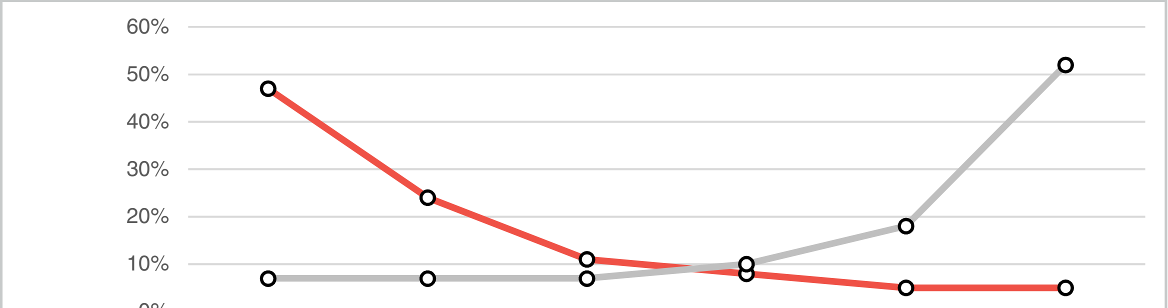
What does the survey show? Only 15 percent of respondents have unimpeded access to private vehicles should they need one, underscoring the importance of transit to the majority of riders (Figure 27). In terms of household income, while only seven percent of Culver City residents have household income less than $15,000 a year, almost half of Line 1 riders fall into this income group (Figure 28). The survey showcases the importance of transit, especially for people who do not have cars and for low-income households. As discussed in the literature review, repurposing lanes for transit use could ensure a more equitable distribution of street space between transit riders and motorists.

Figure 27. Respondent Access to Private Vehicle



Source: 2015 Culver CityBus on-Board Passenger Survey

Figure 28. Respondent Household Income Comparing with Culver City Demographic



	Less than $15,000	$15,000 to $24,999	$25,000 to $34,999	$35,000 to $49,999	$50,000 to $74,999	$75,000 or more
Line 1	47%	24%	11%	8%	5%	5%
Culver City	7%	7%	7%	10%	18%	52%

Source: Niche.com ; 2015 Culver CityBus on-Board Passenger Survey

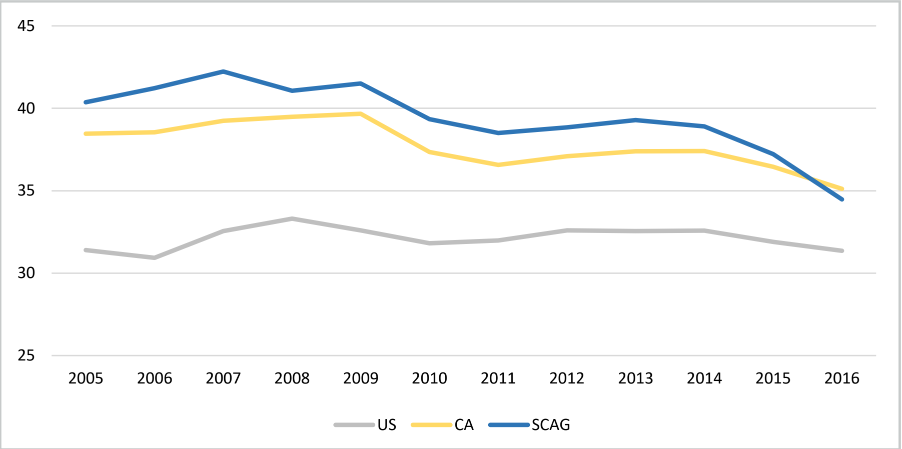
B. Decreasing Ridership

Figure 31 shows the boarding and alighting ridership along Washington Boulevard within the Culver City boundary (2017 September schedule data). Bus stops with higher ridership tend to concentrate at transit hubs (West LA Transit Center, Expo Culver City Station and Robertson Hub) and major thoroughfares (Sepulveda Boulevard and Inglewood Boulevard). The boarding and alighting activities around Downtown are relatively flat while there are more frequent riders on the west side of Sepulveda Boulevard. Boarding and alighting tend to be distributed disproportionately at the two ends of Washington Boulevard, suggesting that riders tend to travel from one side of the city to the other side instead of short distances.

Average weekday ridership on all Culver CityBus Line 1 route decreased by approximately 20 percent from fiscal year 2015 to fiscal year 2017 (Figure 29).

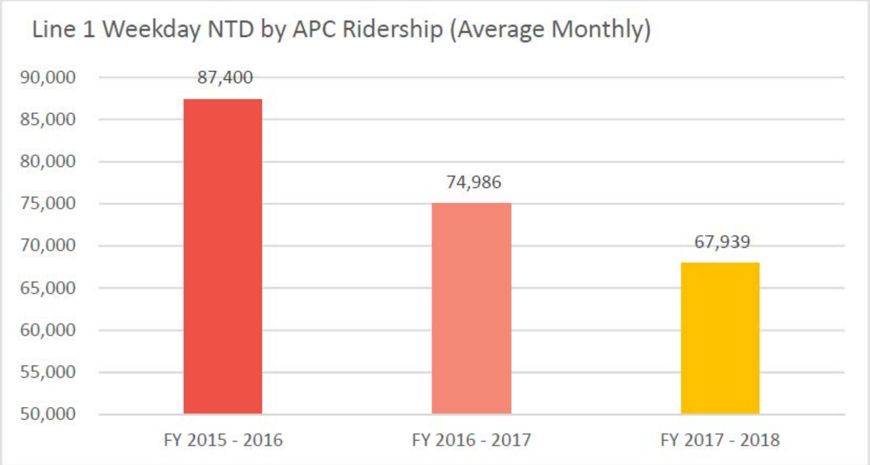
As shown in Figure 30, transit ridership in the Southern California Association of Government (SCAG) region also declined since 2012 (Manville et al, 2018). However, ridership outside of the SCAG region actually increased by approximately 20 percent over the same period.

Figure 30. Transit Trips per Capita from 2000 to 2016



Source: Manville et al, 2018 - Falling Transit Ridership

Figure 29. Line 1 APC Weekday Ridership (Average Monthly)



Source: Culver CityBus APC Data

Figure 31. Line 1 Total Activities by Stop (Total Boarding and Alighting)

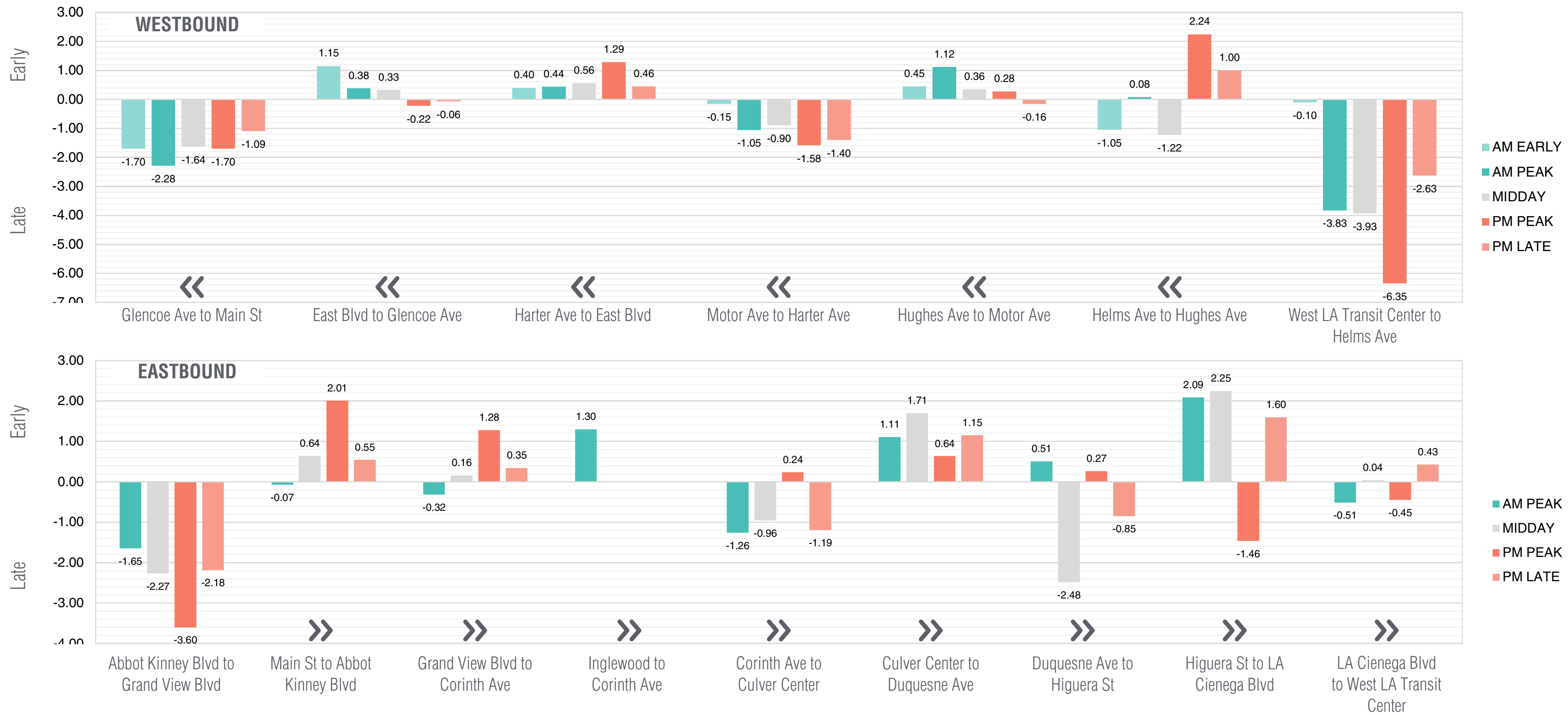
C. On-Time Performance

One of the main goals of this project is to enhance on-time performance through the implementation of bus lanes. Poor on-time performance not only includes delay but also early bus service. When a bus leaves the bus stop early, it sometimes inconveniences riders who did not catch the bus and have to wait for the next bus to arrive.

I collected the weekday average on-time performance data from September 2017 to January 2018. The overall bus on-time rate is 40%, with 49% on-time rate for eastbound direction and 32% on-time rate for westbound direction. The dataset divides the study area into different street sections for the performance observation (Figure 32). In the westbound direction, it seems that the bus on-time performance is lower during PM peak hours. Street sections between Motor Ave and Harter Ave, and Glendon Ave and Main Ave have an obvious bus-delay while other street sections have bus early or unclear performance. Eastbound on-time performance shows a similar pattern. The first segment in both directions has higher delay rates, but these data are skewed since they count layover time.

It is also critical to adjust the trip schedule if performance is consistently unreliable at certain sections. Even though the on-time performance for the entire corridor is less than one minute in both directions, the poor on-time performance at each segment still will reduce bus service reliability at the stop level.

Figure 32. Line 1 On Time Performance Analysis



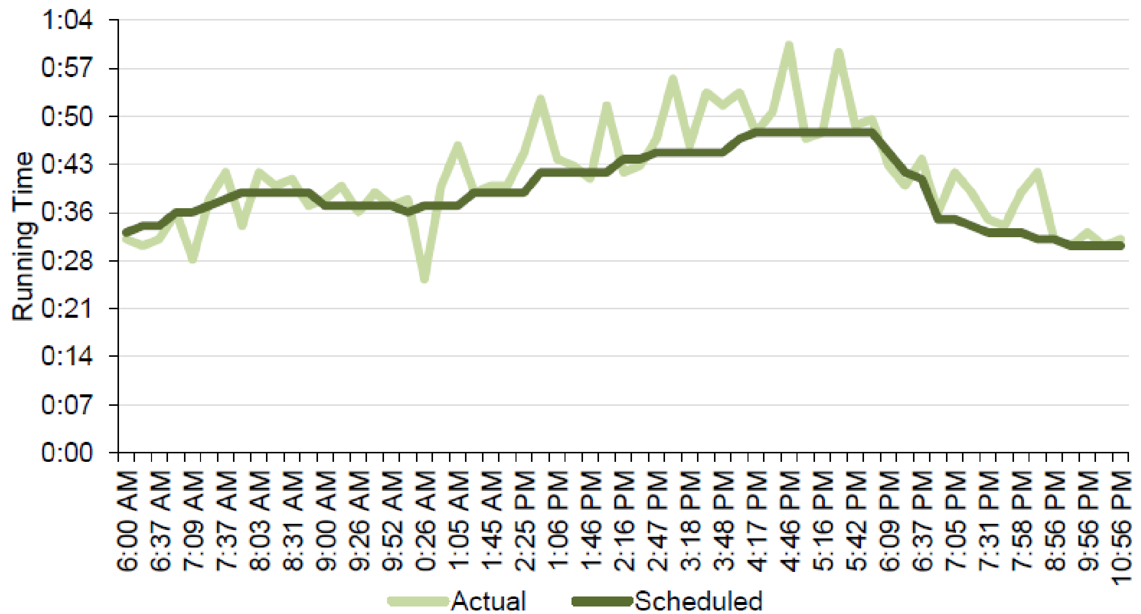
Source: Ridecheck Plus Report

D. Stagnant Bus Speed

The run time on Line 1 fluctuates throughout the day. In the Culver CityBus Line-by-Line and Comprehensive Analysis, the Line 1 westbound weekday run time ranges from 28 minutes to 50 minutes (Figure 33). The run time increases to 36 minutes and higher from 7:00 am to 6:30 pm, with no obvious pattern during peak hours. Perhaps the trip delay segments are compensated with the segments that have lower traffic volume. For eastbound weekday trips, the run time ranges from 28 minutes to 60 minutes, with peak-hour service from 2:00 pm to 6:00 pm (Figure 34).

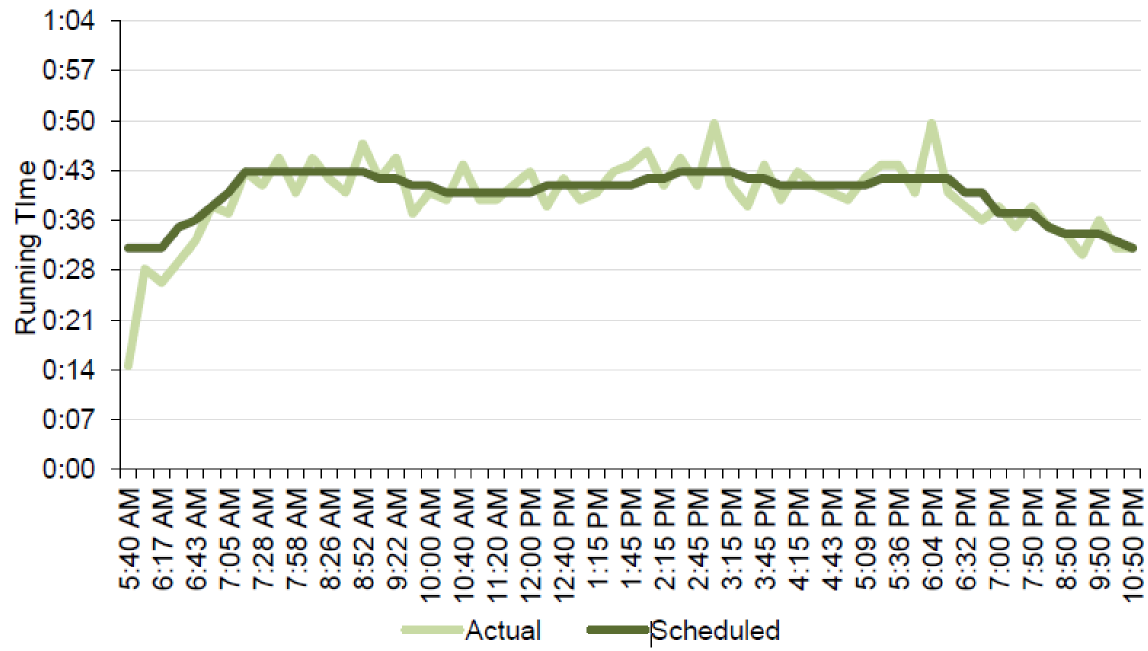
Given the 8-mile-long directional trip distance for Line 1, the bus can run as fast as 21 miles per hour during off-peak, and as slow as 4.6 miles per hour in mixed traffic during weekdays peak periods (Runtime summary of Sept. 2017 average weekday schedule). For eastbound direction, the most congested segment is Washington Boulevard from Duquense Avenue to Higuera Street in Downtown Culver City (Figure 35). Therefore, the data suggest that bus speeds are negatively affected by traffic conditions throughout the day for both directions, and the Downtown area is affected the most. The pro-posed transit lanes potentially can help alleviate the impact of traffic conditions on bus service and further improve bus speeds and on-time performance.

Figure 33. Line 1 Westbound Weekday Running Time by Trip



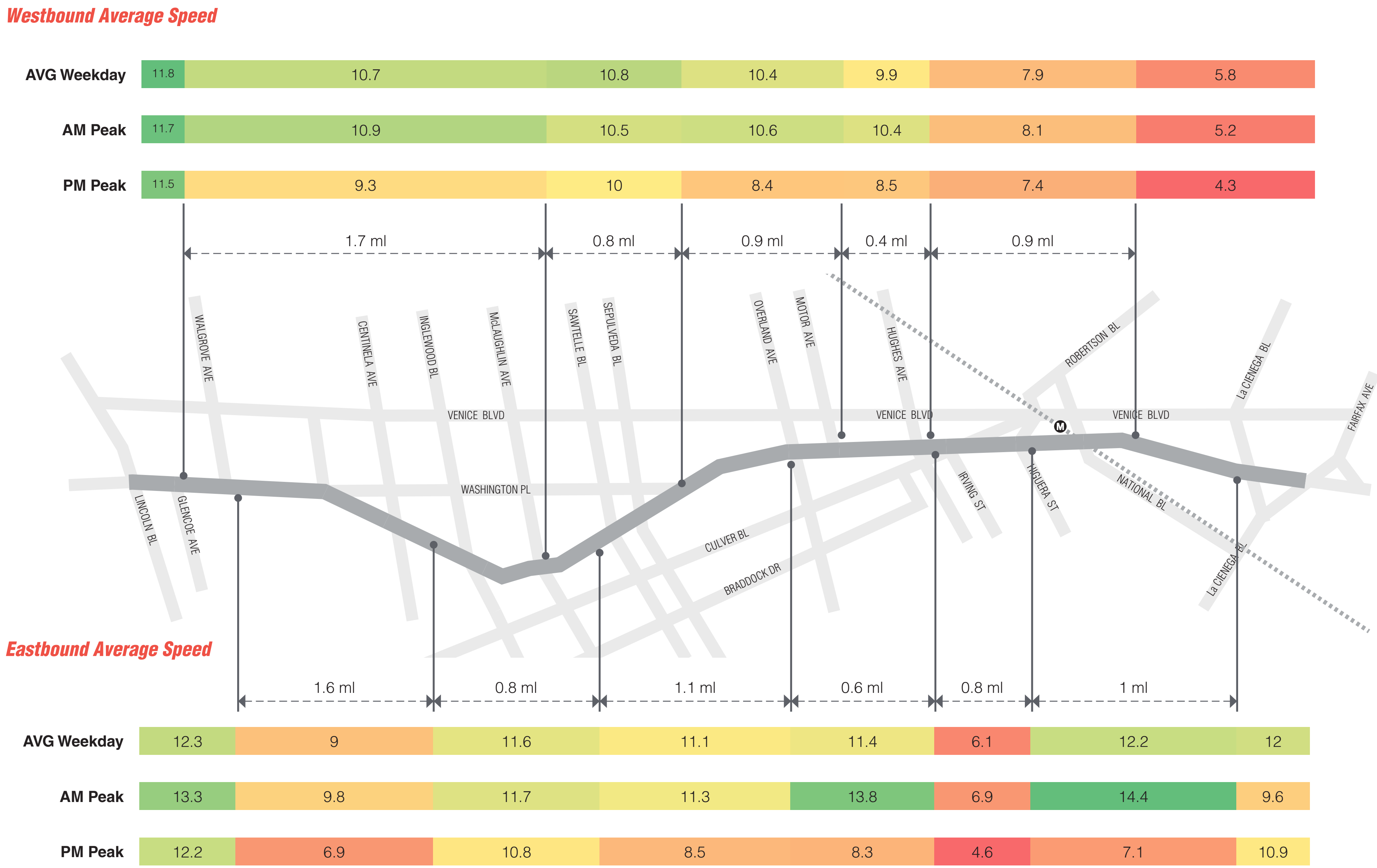
Source: Culver CityBus Line-by-Line Analysis

Figure 34. Line 1 Eastbound Weekday Running Time by Trip



Source: Culver CityBus Line-by-Line Analysis

Figure 35. Line 1 Weekday Average Speed by Segment



Source: Culver CityBus Ridecheck Plus System (Sept 2017 Booking Data)

04 AVERAGE DAILY TRAFFIC

Average Daily Traffic (ADT) counts serve as a standard measurement for automobile traffic on the street. They are essential information for transit infrastructure planning and street improvements. Culver City publishes the Average Daily Traffic (ADT) and traffic volume data in the *2013 Citywide Engineering and Traffic Survey (E&TS) Report.*

The proposed transit corridor consists of four to five lanes and a turn lane with an ADT that ranges from 22,000 to 34,000 (Figure 36). The sections of the proposed transit corridor that connect to Washington Place have a higher ADT, reaching 34,001 ADT. The National Association of City Transportation Officials (NACTO) *Urban Street Design Guide 2016* states that the most comfortable limit for a road diet on a four-lane street is under 20,000 and recommends that cities do not implement road diets when ADT is greater than 25,000 (NACTO, 2016). Federal Highway Administration suggests that agencies to complete a feasibility study for road diets when the ADT is greater than 20,000 (Federal Highway Administration, 2016).

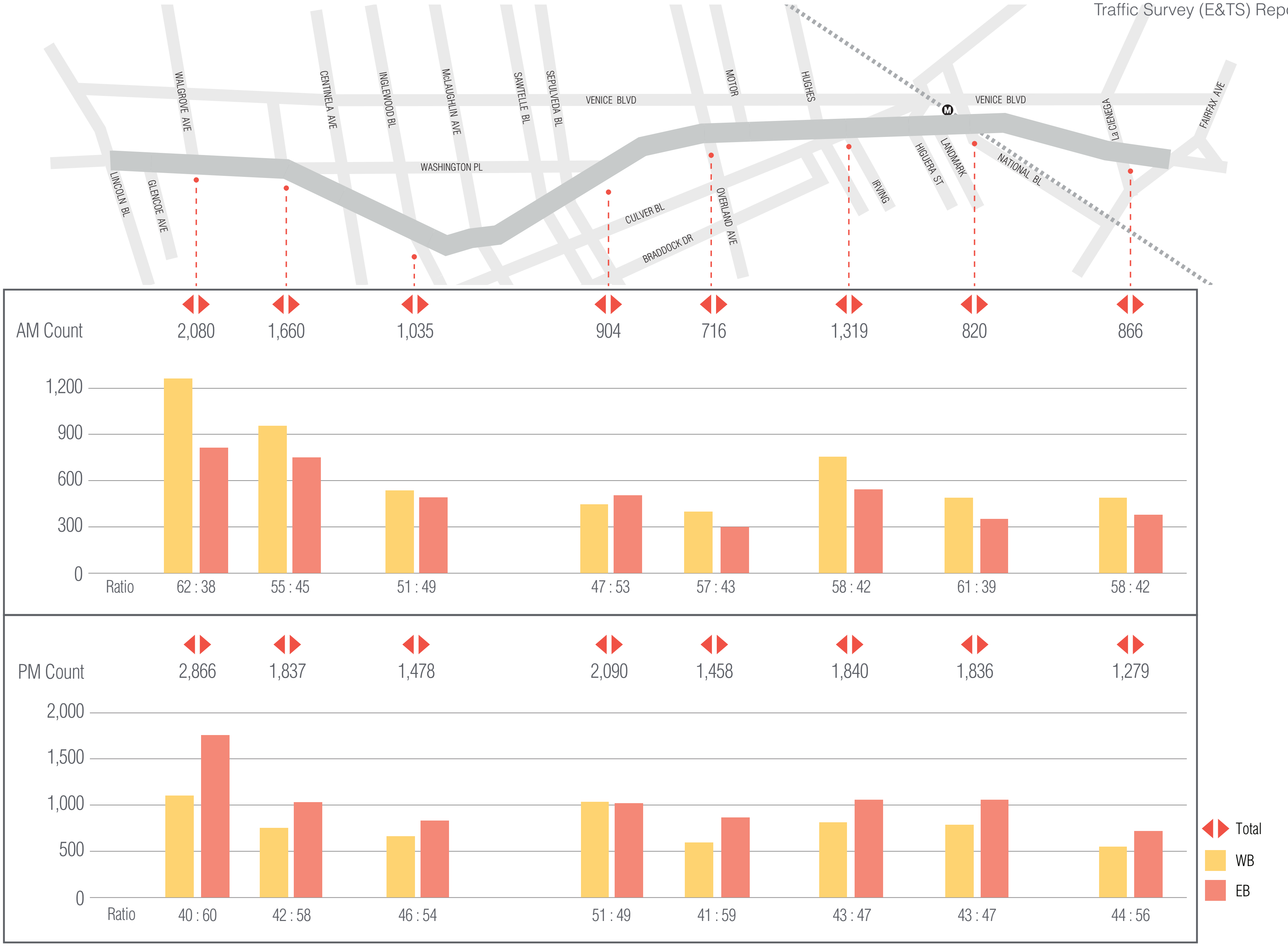
The directional flow of average hourly traffic varies between the morning (AM) peak period and afternoon (PM) peak period (Figure 37). During the AM peak period, the westbound traffic is generally 33 percent higher than the eastbound traffic, with more traffic flow on the westside of Washington Boulevard. During the PM peak period, the eastbound traffic generally is 27 percent higher than the westbound traffic.

Figure 36. Average Daily Traffic Volume

Source: 2013 Culver City Citywide Engineering and Traffic Survey (E&TS) Report

Figure 37. Average Daily Traffic Volume

Source: 2013 Culver City Citywide Engineering and Traffic Survey (E&TS) Report



Source: 2013 Culver City Citywide Engineering and Traffic Survey (E&TS) Report

05 TRANSPORTATION COLLISIONS

Washington Boulevard accommodates a maximum posted speed limit of 35 MPH

Data on transportation collisions highlight the transportation safety issues on the proposed transit corridor and reveal that the corridor is one of the most dangerous streets in Culver City. This report analyzes transportation-related injury data collected from the Transportation Injury Mapping Systems (TIMS) from 2006 to 2016. Over the 11-year period, on average Culver City experienced 226 collisions, of which 57 occurred on the proposed transit corridor (Table 5).In other words, 25 percent of all collisions in Culver City occur along the proposed corridor. Moreover, the proposed transit corridor tends to have approximately 6 times more accidents per mile than all the other streets in Culver City combined.

Figure 40 maps all Culver City transportation collisions over the time period, and includes a kernel density analysis. Collisions are clustered along Washington Boulevard, Sepulveda Boulevard, and Jefferson Boulevard, three major thoroughfares in Culver City. The study corridor is ranked second in terms of collisions per mile even though it has the greatest number of total collision. On the proposed transit corridor, the data show that collisions occurred throughout the corridor, with hot spots in downtown Culver City and on other major intersections including Overland Avenue, Sepulveda Boulevard, and Lincoln Boulevard.

In terms of modes involved in the collision, as Figure 38 shows, more than 60 percent of the collisions are between two cars. Bicycles and pedestrians are involved in more than 25 percent of all the collisions, underscoring the need to better accommodate diverse modes of travel.

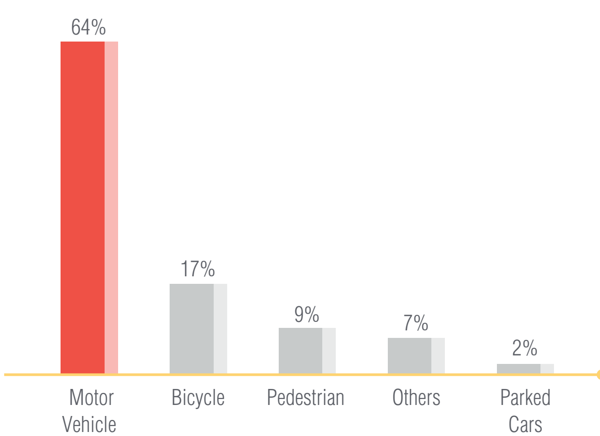
Vehicular speed limits can serve as a proxy of safety for motorists, transit riders, cyclists, and pedestrians (Jaffe, 2015). Washington Boulevard accommodates a maximum posted speed limit of 35 miles per hour (mph). Nevertheless, unsafe speed contributed to 13 percent of collisions along the proposed transit corridor (Figure 39). To decrease the risk of collisions, the proposed transit corridor should be designed to reduce vehicle speeds and increase the safety and comfort of other mobility options.

Table 5. Collisions in Study Area

	Washington Blvd	Culver City	Washington Blvd / Culver City
Street Length (mile)	6.2	149.8	4%
Ave. Annual Collisions	57	226	25%
Ave. Annual Collisions Per Mile	9.22	1.51	611%

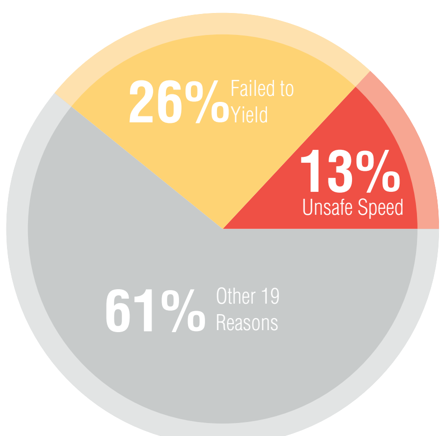
Source: TIMS

Figure 38. Different Modes involved in the collisions



Source: TIMS

Figure 39. Primary Collision Factors



Source: TIMS

Figure 40. Culver City Collision Hot Spots

Source: TIMS

06 RELEVANT PLANS & PROGRAMS

The Transit First: Culver City Washington Boulevard Transit Lane Feasibility Study relates to multiple existing policies and regulatory documents in Culver City. The recommendations try to recognize and align with the long-term planning and visions included in the following documents:

- *General Plan: Circulation*
- *Culver City TOD Visioning Study*
- *Washington National TOD District Streetscape Plan*
- *Pedestrian and Bicycle Master Plan*
- *Expo-Downtown Bicycle Connector Feasibility Study*

1. GENERAL PLAN: CIRCULATION

Last revised in 2004, the *Culver City General Plan* consists of nine elements to guide the direction of future growth and development in the city. In particular, the Circulation Element emphasizes the goal of increased mobility and congestion management at two scales – the local and regional levels. It also promotes the enhancement of regional transportation systems and efficient city infrastructure. Related measures include roadway system improvements and the support of shared off-street parking.

The *General Plan* classifies Washington Boulevard as the primary artery of the city, serving as a major cross-town thoroughfare. It also characterizes the traffic flow as high volume and fast moving. However, subsequent plans and programs demonstrate that Culver City has reimagined Washington Boulevard as a multi-modal transit corridor and in recent years has tried to incentivize transit and active modes of transportation.

2. CULVER CITY TOD VISIONING STUDY

Published in 2017, the *Culver City TOD Visioning Study* focuses on mobility planning near the Expo Culver City Station and Downtown area and proposes efforts to increase active transportation modes, such as walking, biking, and public transit use. The plan also recommends the implementation of bike paths and pilot programs to test the effectiveness of dedicated transit lanes for both bus and micro-transit on Washington Boulevard.

To foster first/last mile connections and local circulation in the transit-oriented development (TOD) area, the plan includes strategies to advance the use of transit and to create pedestrian-first and cyclist-friendly environments. The study also suggests implementing automobile disincentives on Washington Boulevard, which would include reductions in auto capacity and parking, and the use of congestion pricing.

Source: Culver City Website

3. WASHINGTON NATIONAL TOD DISTRICT STREETSCAPE PLAN

Published in 2016, the *Washington National TOD District Master Plan* focuses on enhancing the area's multi-mobility, connectivity, and sustainability through creating principles to guide streetscape design in the vicinity of the Expo Culver City Station. The principles cover tree species, paving patterns, signage, directories, and other elements that promote revitalization. The proposed transit corridor recommendations comport with the *Washington National TOD District Master Plan* and strive to provide a complete multi-modal experience for citizens.

Source: Culver City Website

4. PEDESTRIAN AND BICYCLE MASTER PLAN

Adopted in 2016, the *Culver City Bicycle & Pedestrian Master Plan* includes policies, recommendations, and guidelines for increasing the viability of cycling and walking in Culver City. Washington Boulevard is designated as one of the main routes for the bicycle network, with proposed bike lanes, bike routes, and sharrows along the street.

The *Washington Boulevard Transit Lane Feasibility Study* aims to be complementary with the existing Bicycle & Pedestrian Master Plan while creating transit lanes along the proposed transit corridor. The corridor will not only be a pleasant and safe environment for riders, but also for cyclists, pedestrians, and motorists.

Source: Culver City Website

5. EXPO-DOWNTOWN BICYCLE CONNECTOR FEASIBILITY STUDY

Published in 2016 by the Public Works Department, the *Expo-Downtown Bicycle Connector Feasibility Study* evaluates the feasibility of connecting the Expo Station to Downtown Culver City with a high-quality bike facility. The study recommends the installation of a two-way protected bike lane on Washington Boulevard from Wesley to Ince Boulevard, and on Robertson Boulevard from Washington to Venice Boulevard. However, the project failed to consider the associated transit operation issues, such as the need for riders to cross the bike path for bus boardings and alightings.

It is important to note that Culver City staff suggests retaining the center turn lane on Washington Boulevard for the entire length of the block between Ince and Robertson Boulevard to allow access to the principal driveway for Sony's Imageworks campus.

Source: Culver City Website

07 DESIGN CORRIDOR

1. CONSTRUCTION PROJECTS

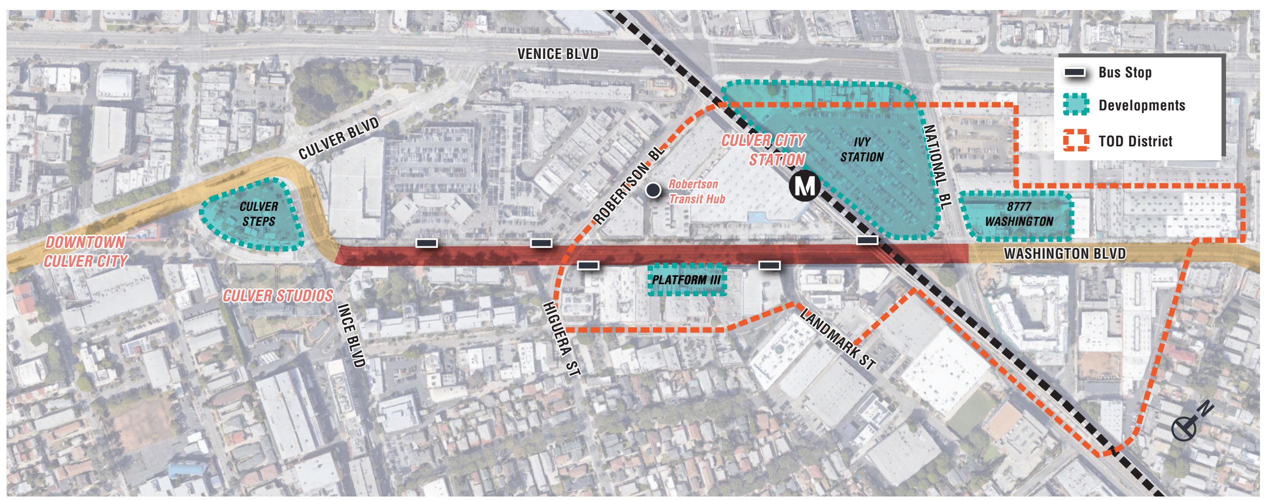
As the main corridor connecting Downtown and light rail station, the design corridor serve as hot spots for transit-oriented developments in the City. There are currently four TOD construction projects on the corridor, including Parcel B, Platform Hayden Tract III, Ivy Station, and 8777 Washington Boulevard. These developments no doubt will create transportation challenges for the region, including new vehicular traffic and increased parking demand. However, they also present an opportunity for the City to advance mobility choices and promote healthier and more active lifestyles. The four projects are the following:

- Culver Steps: A four-story complex that will house offices above ground-floor shops and restaurants. Located between Trader Joe's and Culver Hotel, the project is set to complete in 2019 (Chandler, 2017).
- Platform Hayden Tract III: A four-story office building with ground floor retail and restaurants (Sharp, 2016). The proposed development will include a structure with three subgrade levels of parking that will provide an additional 231 parking spaces.
- Ivy Station: Consisting of multiple five- and six-story buildings with spaces for retail, restaurants, offices, 200 apartments, and a 148-room hotel (Vincent, 2017). The anticipated completion is in 2019.
- 8777 Washington Blvd: Sits directly across the street from Ivy Station, the project site will become a four-story structure providing mixed-use offices and retail space. The demolition of existing buildings started in February 2018 with no further details on completion time yet (Sharp, 2018).

Figure 41. Culver Steps Rendering

Source: Culver City Website

Figure 42. Design Corridor Construction Projects



2. EXISTING STREETSCAPE

Many of these conditions are present in the design corridor – Washington Boulevard between Ince Boulevard and National Boulevard. This part of Washington Boulevard has parking on both sides of the street and two general traffic lanes in each direction, with one center turn lane (Table 6, Figure 44). The curb-to-curb street width ranges from 60 feet to 76 feet. There are several segments with lane widths greater than 11 feet, suggesting that the city considers a lane width reduction for street safety purposes as I discuss in the literature review.

In my renderings, I divide the design corridor into three segments. The drawings represent the current streetscapes with lane widths, striping, bus stops, markings, and sidewalks. The three segments are:

- *A – Ince & Robertson/Higuera*
- *B - Robertson/Higuera & Landmark*
- *C – Landmark & National*

Table 6. Design Corridor Existing Streetscape

Street Width (curb to curb)	60' to 76'	
Lane Width	10' to 14'	
Street Parking	20	
Number of lanes	**EB**	**WB**
General Traffic Lanes (GTL)	2	2
Bus Lanes	0	0
Bike Lane	1(240')	0
Center Turn Lane	1	

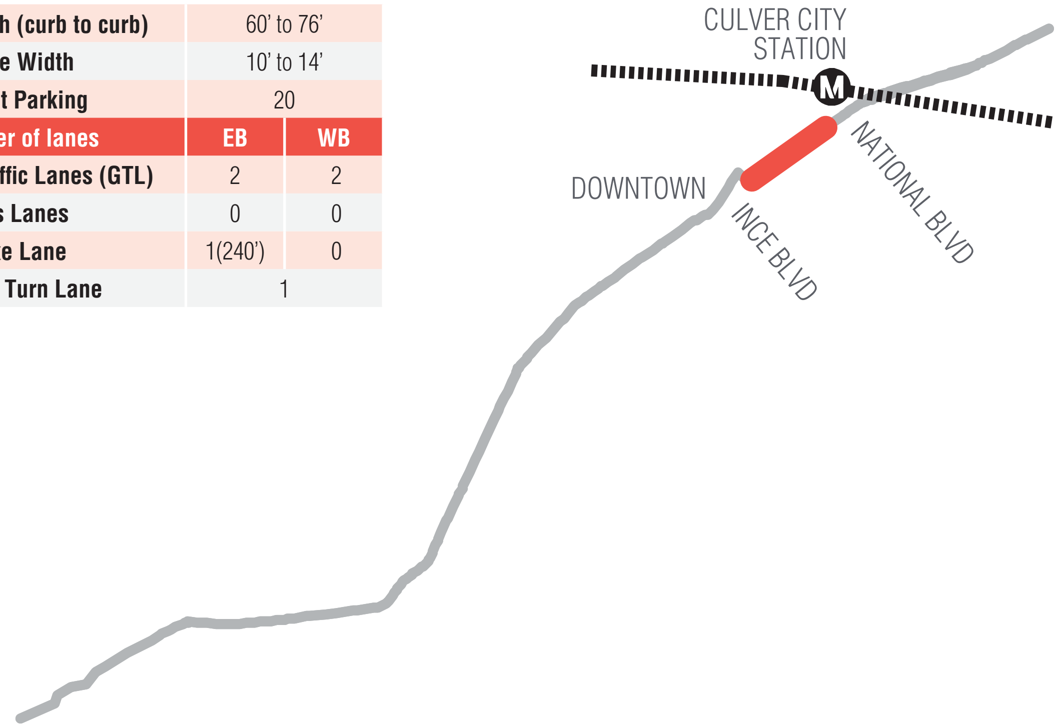
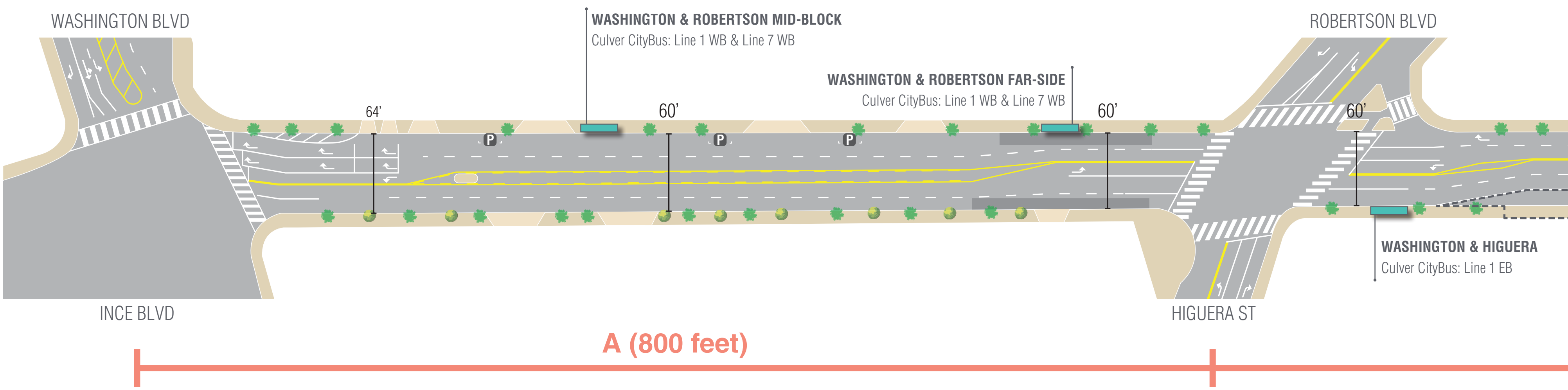


Figure 43. Design Corridor Plan View - Existing



A. A - Ince & Robertson/Higuera

The curb-to-curb street width of this segment ranges from 60 to 64 feet. In this 800 feet segment, there are four drive-ways that connect to Washington Boulevard on the north side, and three drive-ways on the south sides. There are three metered parking spaces on the north side of the street. Finally, in terms of transit service, there are two bus stops located on the north side for westbound travel.

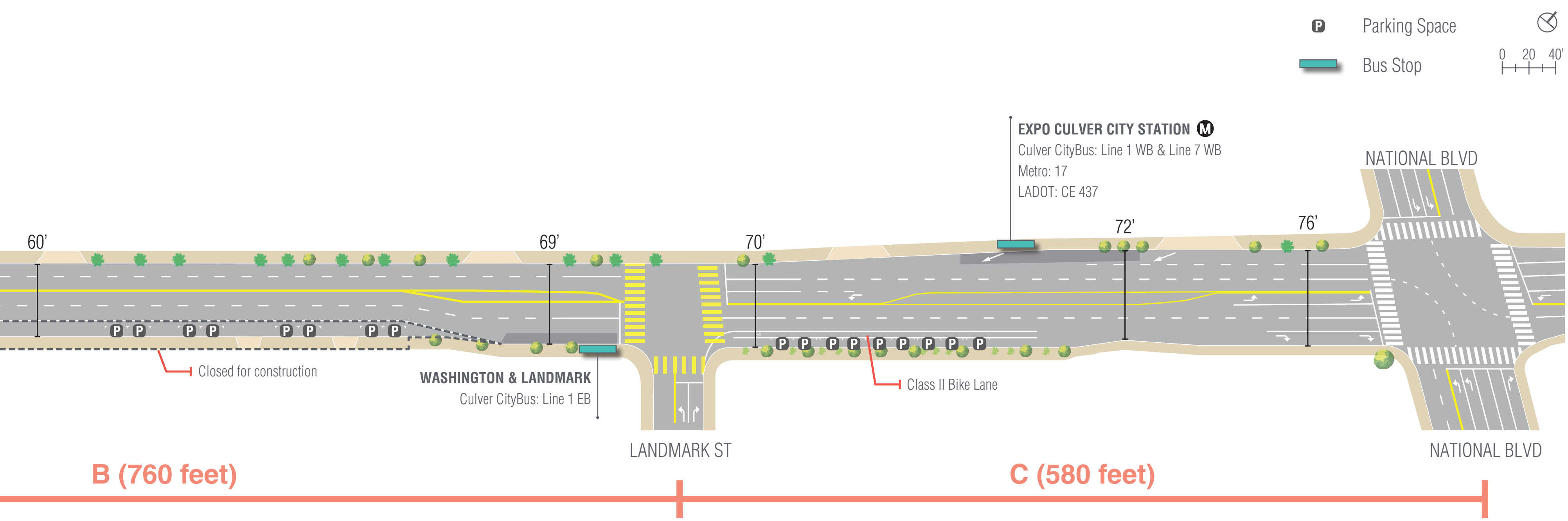
B. B - Robertson/Higuera & Landmark

The curb-to-curb width of this street segment is approximately 60 feet; it widens to 69 feet when approaching Landmark Street. There are two drive-ways on the north side and two drive-ways on the south side of this 760-feet long segment.

In terms of parking spaces, there are eight metered parking spaces on the south side of the street. The current parking lane has been closed as a staging area for the Platform Hayden Tract III construction. The City anticipates the completion of the construction in summer 2019. Finally, in terms of transit service, there is one bus stop at the nearside of Washington/Robertson for westbound bus service and one bus stop at the nearside of Washington/Landmark for eastbound bus service.

C. C - Landmark & National

The curb-to-curb width of this segment ranges from 70 to 76 feet. There are two drive-ways on the north side of this 580-feet long segment. There are nine metered parking spaces on the south side with a five foot eastbound bike lane. In terms of transit service, there is one bus stop in front of the Expo Culver City Station for westbound bus service and layover.



3. BUS SERVICE

To design and recommend transit lanes that can best accommodate and enhance existing transit demand, I analyze the bus service in the design corridor.

There are four transit agencies with five bus lines that run through the design corridor. Culver City Bus operates a heavily-used regular bus route, Line 1, and one lightly-used route, Line 7, along the design corridor. The following is a brief description of both transit lines:

Line 1

- Connects to Mar Vista and Venice (two communities to the west of Culver City);
- Includes four bus stops within the design corridor;
- Has a daily ridership of approximately 3,500 on a regular weekday; and
- Provides services on weekdays with peak-periods headways of 10-15 minutes and 15-20 minute headways on weekends.

Line 7

- Connects to Marina Del Rey;
- Includes two bus stops within the design corridor;
- Had a daily ridership of approximately 400 on a regular weekday; and
- Provides weekday service approximately every 30 minutes during peak periods.

A. Bus Routes and Trips

As Figure 44 shows, each of the transit agencies differs with respect to the service they offer along Washington Boulevard. Culver CityBus Line 1 and LADOT Community Express 437 use both eastbound and westbound directions throughout the whole corridor. There are nearly twice as many westbound trips than eastbound trips (Table 7). Moreover, since both the Westbound Metro 17 and the Big Blue Bus 17 make a right turn at Robertson, the number of westbound bus trips is highly concentrated on the street segment between National and Robertson. In terms of transit use, implementing a westbound bus lane from National to Robertson would potentially be the most efficient and cost-effective.

In terms of time period, only two bus routes operate on Saturday and Sunday, since most of the trips occur on weekdays. Therefore, it is critical to operate the bus lane on weekdays.

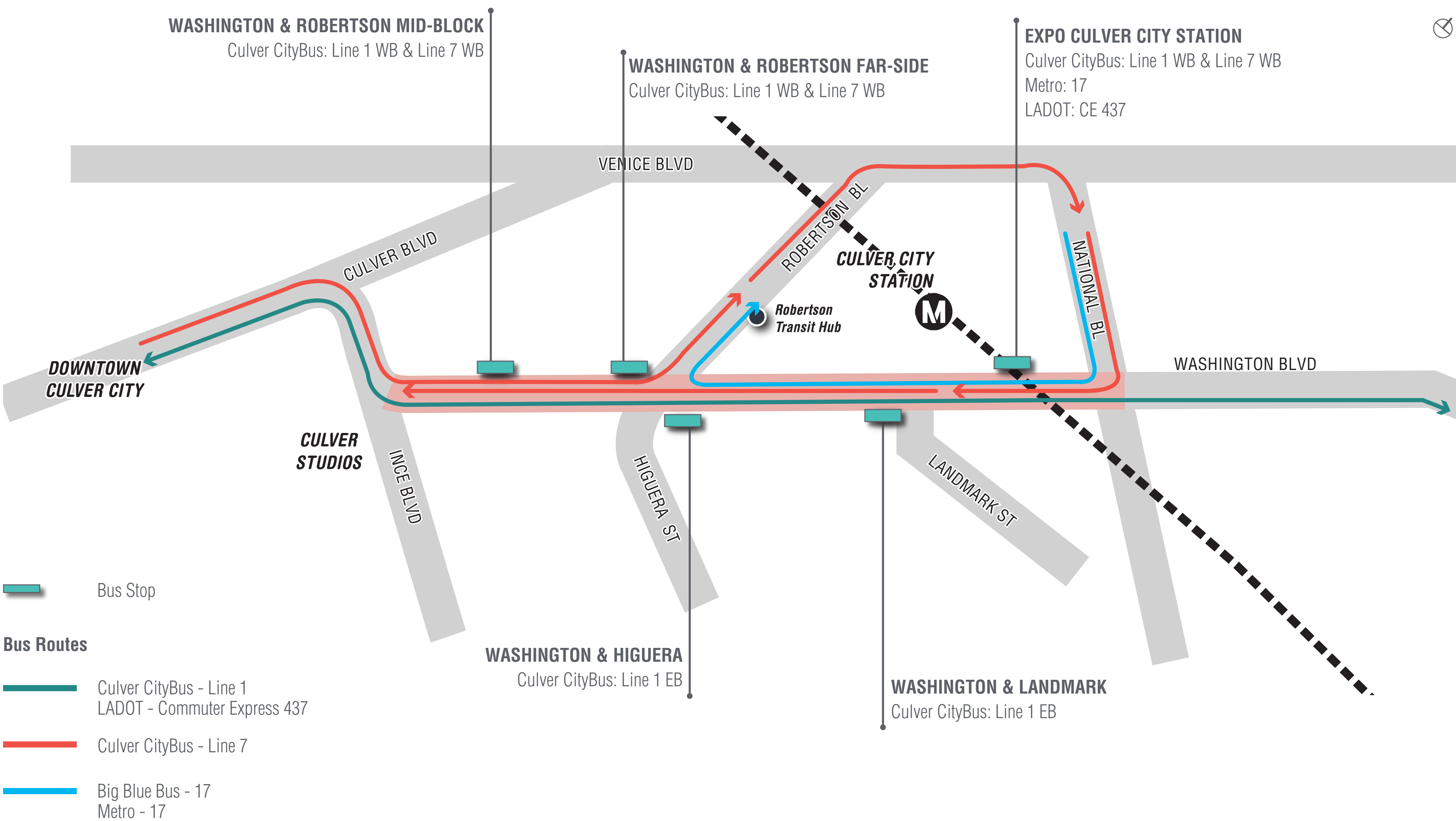
Table 7. Design Corridor Bus Routes and Number of Trips

<table>
<tr><th colspan="2"></th><th colspan="3">Both Eastbound and Westbound</th><th colspan="2">Westbound Only</th></tr>
<tr><th colspan="2">Transit Agency</th><th>LADOT</th><th>Culver City Bus</th><th>Culver City Bus</th><th>Big Blue Bus</th><th>Metro</th></tr>
<tr><th colspan="2">Route</th><td>437</td><td>Line 1</td><td>Line 7</td><td>17</td><td>17</td></tr>
<tr><th colspan="2">Connection</th><td>Downtown LA</td><td>West LA Transit Center, Venice, and Mar Vista</td><td>Marina Del Rey</td><td>VA Medical Center, UCLA</td><td>Beverly Hills, West Hollywood, Downtown LA</td></tr>
<tr><th rowspan="2">Trips per Day</th><th>Weekday</th><td>6</td><td>57</td><td>25</td><td>46</td><td>22</td></tr>
<tr><th>Weekend</th><td></td><td>45</td><td></td><td>21</td><td></td></tr>
</table>

B. Bus Stops

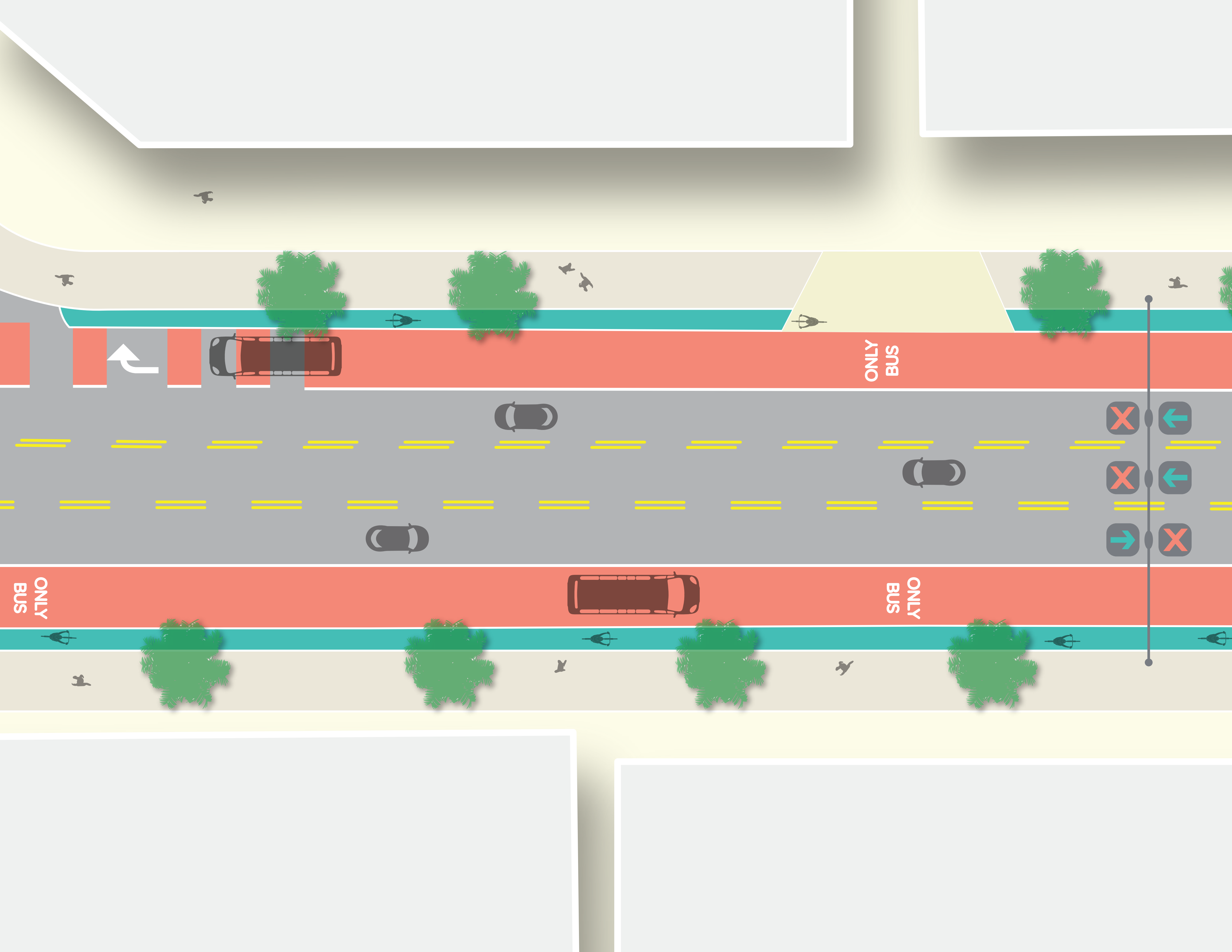
The design corridor has five bus stops that accommodate four different bus routes, including the Culver CityBus 1 and 7, Metro 17, and LADOT Commuter Express 437 (Figure 44). The Expo Culver City Station is the major transit station for bus services, accommodating all four bus routes. Eastbound bus stops only serve Line 1.

Figure 44. Bus Services on Design Corridor



CHAPTER 5

DESIGN CONCEPTS


ONLY
BUS
ONLY
BUS
ONLY
BUS

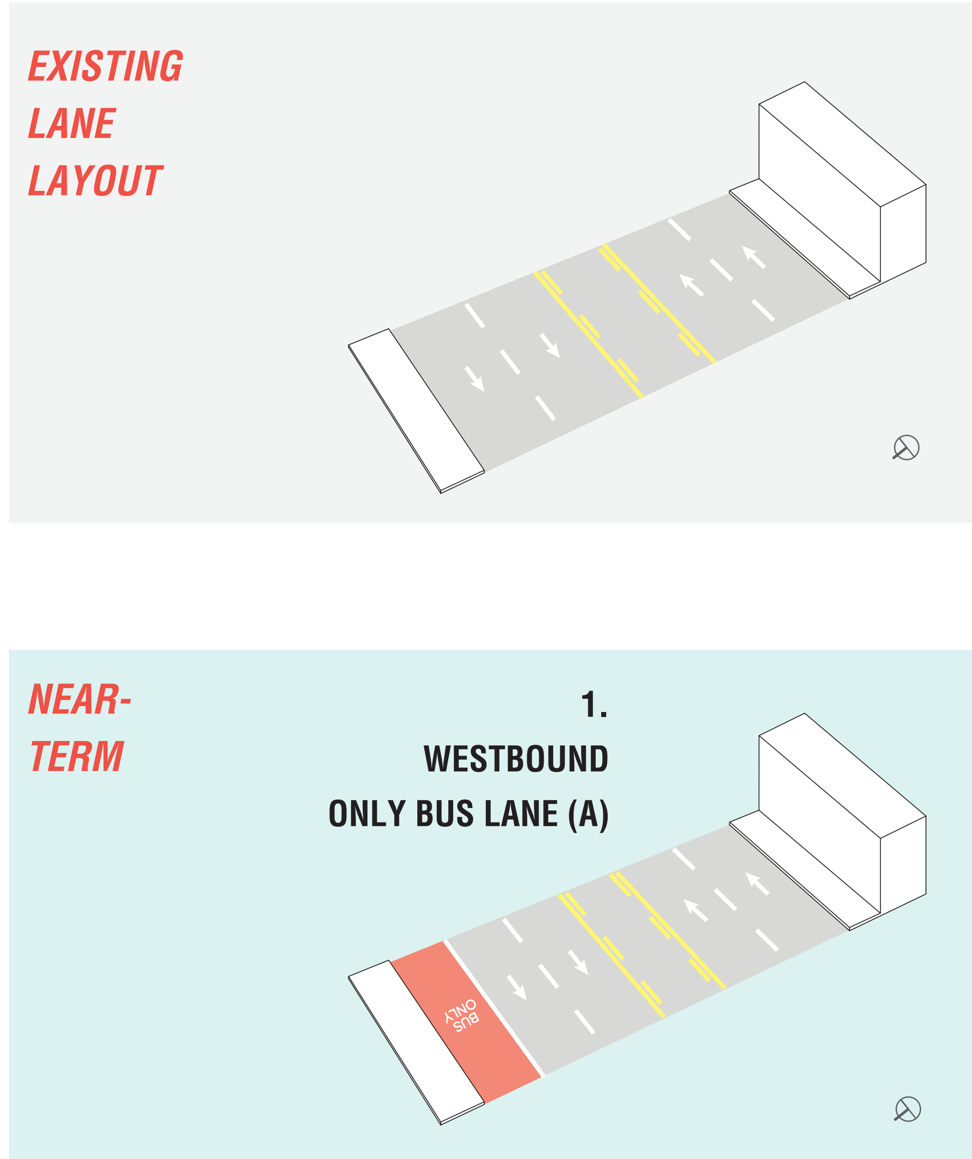
01 INTRODUCTION

Historically, urban arterials conveyed social connection and civic pride (Jacobs, 1961). However, over time street designs started to focus on accommodating automobiles and facilitating vehicular traffic flow as their highest priority (Arieff, 2018). Washington Boulevard serves as the main arterial in Culver City, providing access to destinations within the city as well as serving as a connector to neighborhoods in the City of Los Angeles. In this section, I propose a set of design concepts for the corridor, reorienting the street to focus on transit and, in so doing, enhancing the multimodal experience and expanding the public realm (Figure 45).

The following sections include four main design concepts for the half-mile-long design corridor that could be implemented in the near-term, mid-term, and long-term. The proposed plans emphasize one core concept: accommodating multiple and diverse users of the street including pedestrians, cyclists, transit riders, motorists, and other street users. While the design concepts focus on the section between Ince Boulevard and National Boulevard, ultimately the hope is to expand these design elements to include the full length of Washington Boulevard.

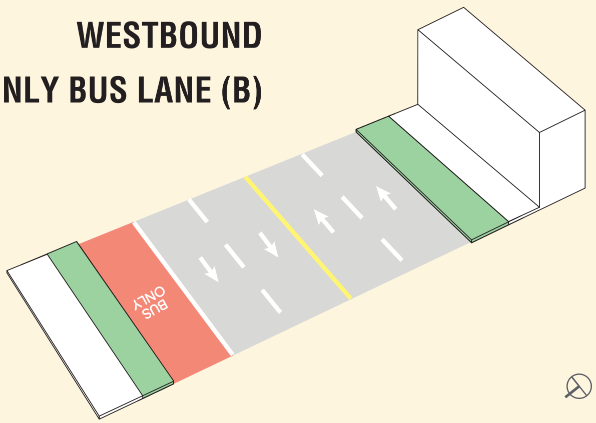
Washington Boulevard serves as a bike route for cyclists. The City has proposed to establish a Washington/Culver corridor as the principal east-west bike spine through the city. A class IV separated bikeway would not only help to increase street safety and reduce traffic conflicts, but also to increase the volume of cyclists (Alta, 2017). The mid-term and long-term concepts propose elevated bike lanes in both directions with the intention to create a friendlier downtown street environment not only for transit riders, but also for pedestrians and cyclists.

Figure 45. Bus Lane Design Concept Diagrams



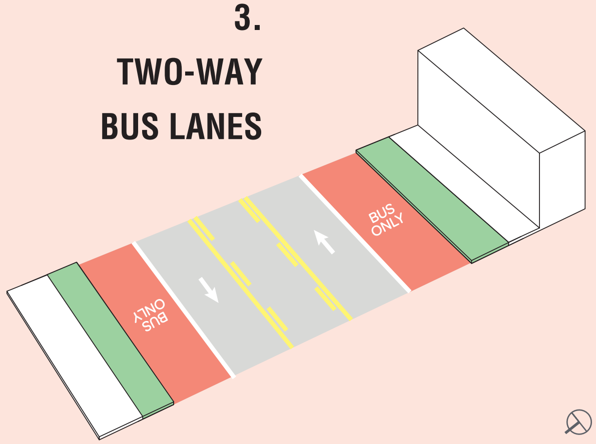
MID-
TERM
+
ELEVATED
BIKE LANES

2.
WESTBOUND
ONLY BUS LANE (B)

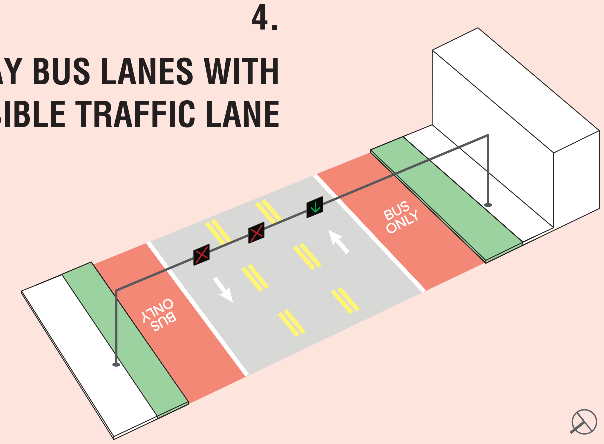


LONG-
TERM
+
ELEVATED
BIKE LANES

3.
TWO-WAY
BUS LANES



4.
TWO-WAY BUS LANES WITH
A REVERSIBLE TRAFFIC LANE

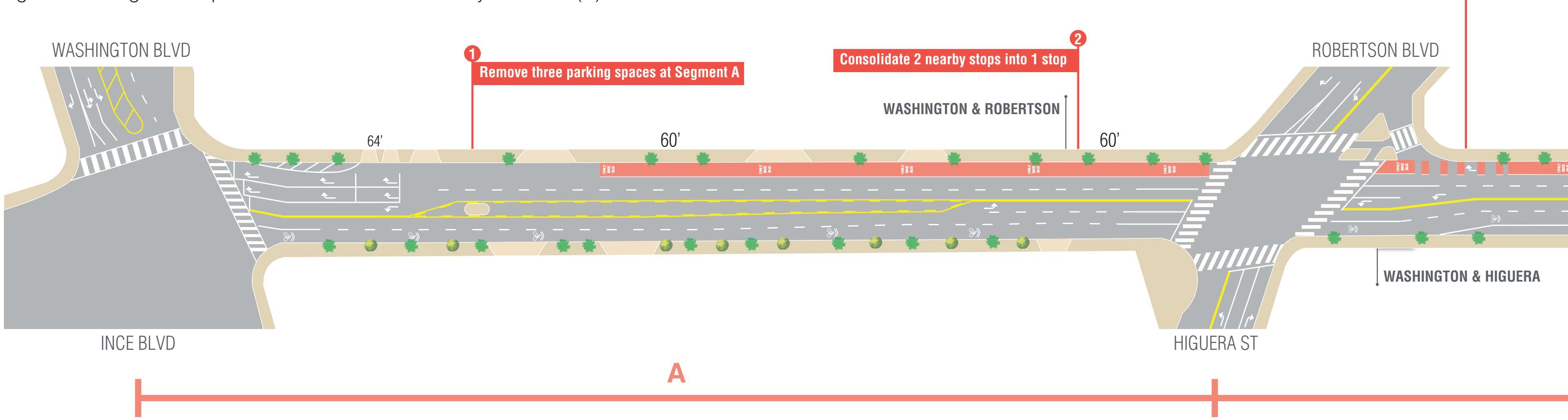


1. WESTBOUND ONLY BUS LANE (A)

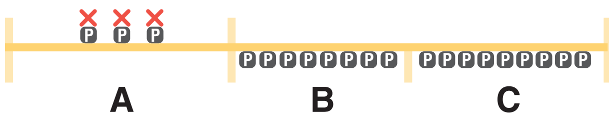
This design concept reflects two important existing conditions. First, data show that the number of transit trips and transit ridership on all bus service is significantly higher in the westbound direction than the eastbound direction. Second, morning peak-period traffic flows are highest in the westbound direction, reducing speeds for morning bus commuters. Culver City anticipates implementing this design concept in 2018–2019 as a pilot transit lane; the transit lane will be aligned with the implementation of a Microtransit Pilot Project. The city-run microtransit vehicles will use the transit lane.

As Figure 46 shows, this design concept requires several changes to the existing roadway, including a reconfiguration of the design corridor to accommodate two lanes each way for vehicular traffic and one westbound bus lane along the curbside. The bus lane should be clearly and distinctly marked and considered as a transit space with clear policies specifying the types of vehicles that can access the lane. The concept keeps the center turn lanes and the current signal operation phase (Figure 47; Figure 48). The proposed plan does not remove any existing traffic lanes; therefore, the westbound bus-only lane would have minimal impact on general traffic.

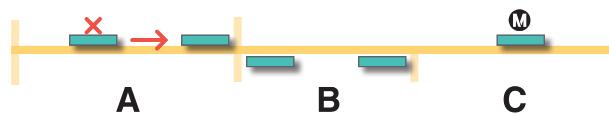
Figure 46. Design Concept 1 Plan View - Westbound Only Bus Lane (A)



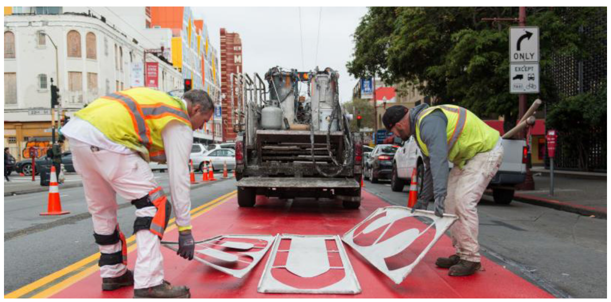
1 Remove three parking spaces at Segment A



2 Consolidate two westbound stops at Segment A



3 Painted Pavement and Markings



Source: SFTMA

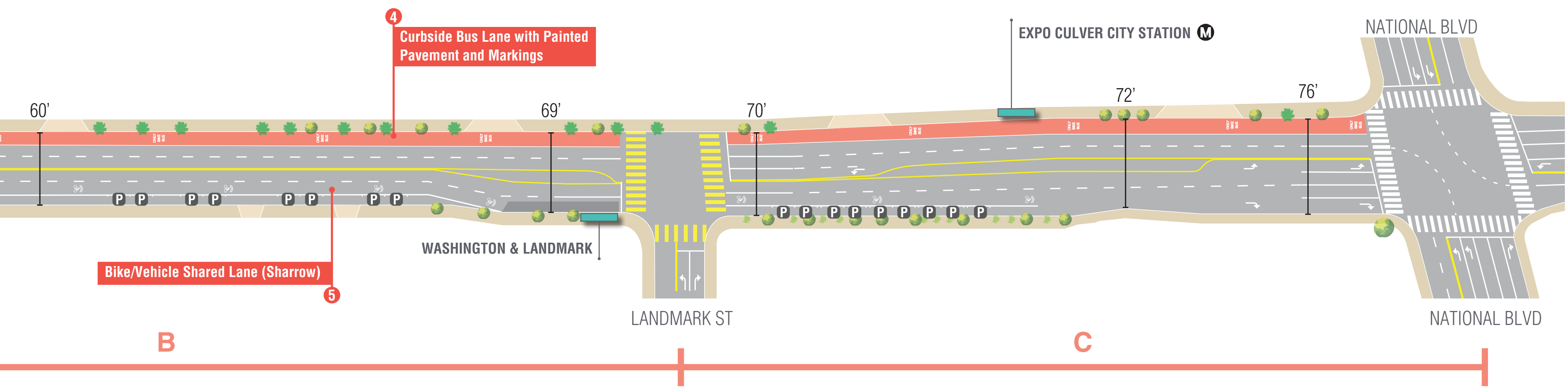
4 Potential Bike/Vehicle Shared Lane (Sharrow)

Source: Caltrans

Parking Space

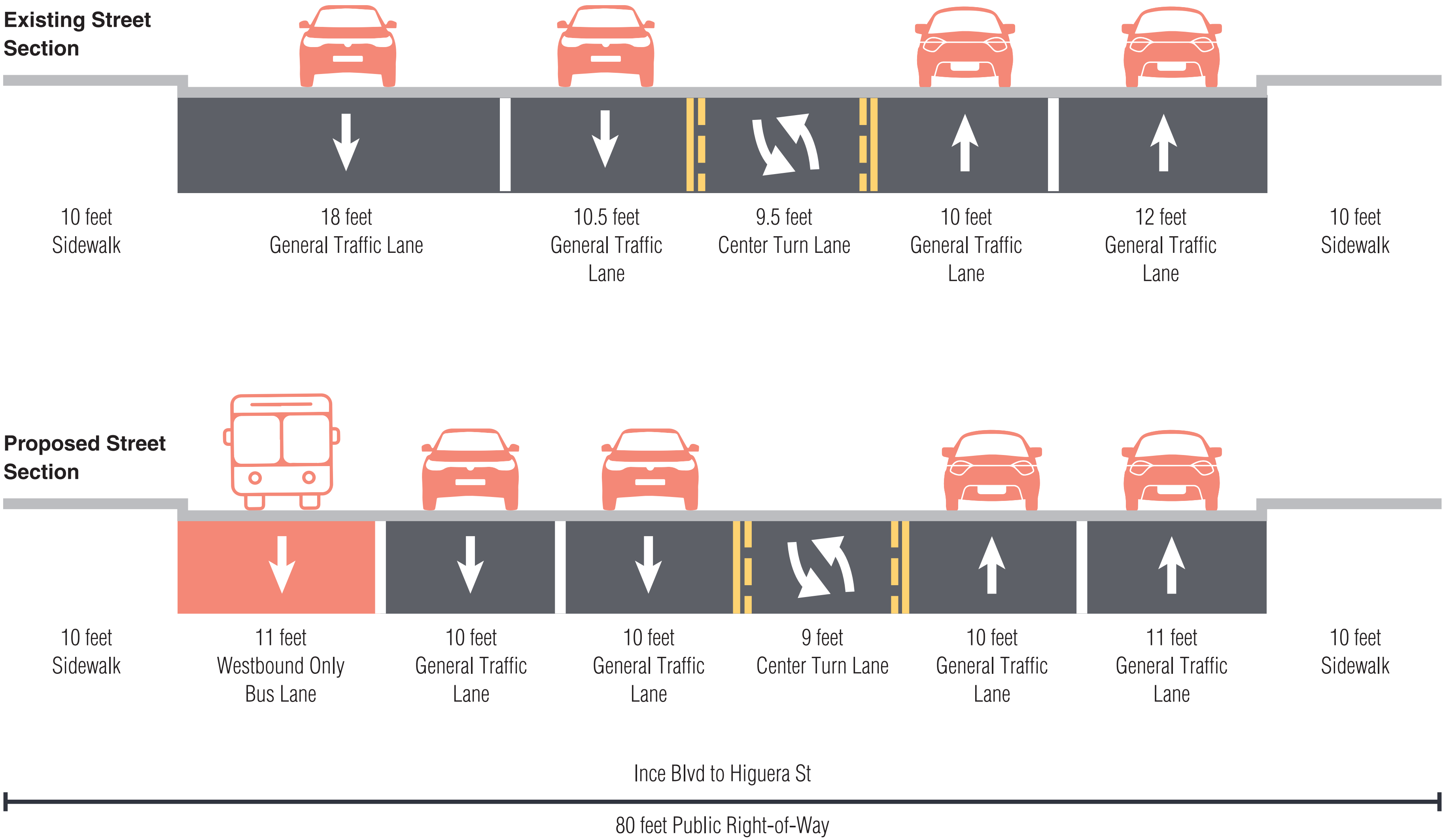
Bus Stop

0 20 40'



A. Proposed Street Section

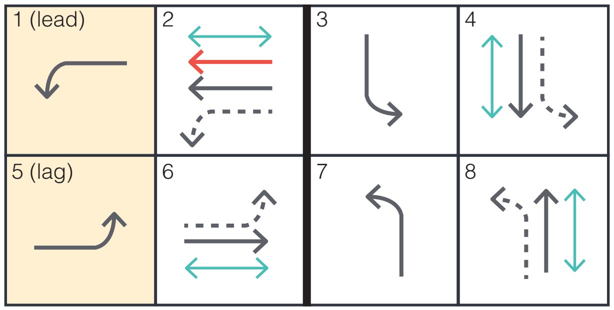
Figure 47. Design Concept 1 Section View - Westbound Only Bus Lane (A)

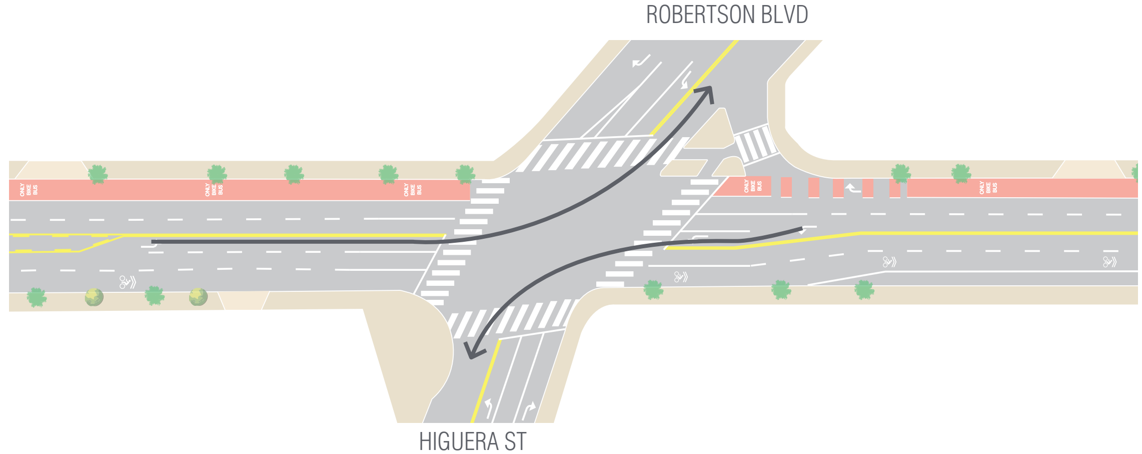


B. Proposed Signal Operation at Intersection

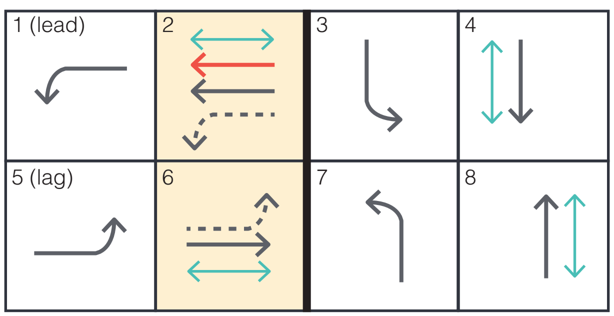
Figure 48. Design Concept 1 Signal Operation - Westbound Only Bus Lane (A)

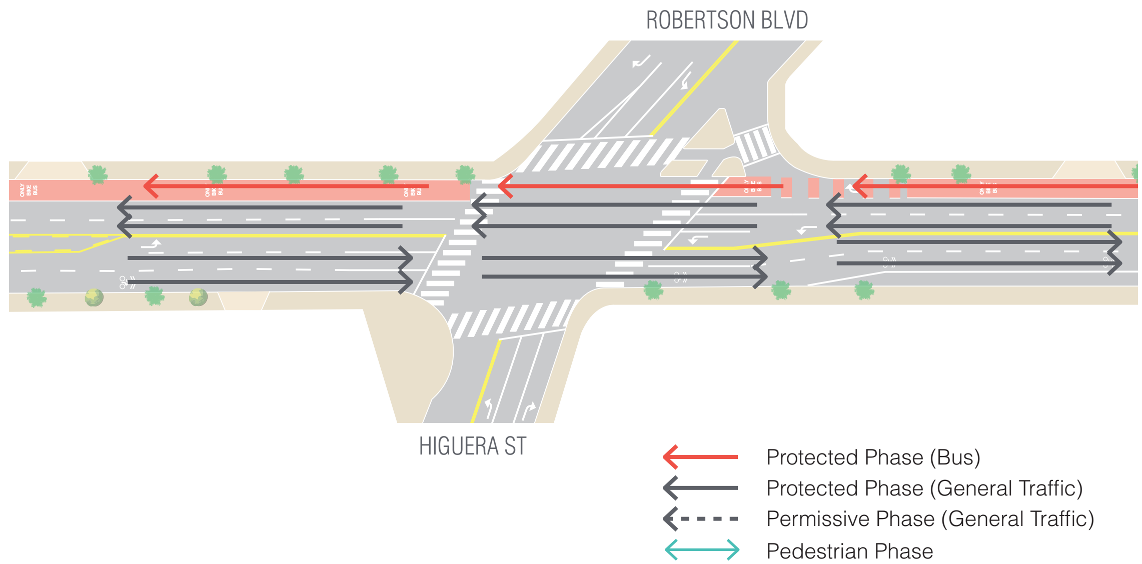
Phase 1 & 5: Left Turns Only





Phase 2 & 6: Bus + Through Traffic + Permissive Left Turns





2. WESTBOUND ONLY BUS LANE (B)

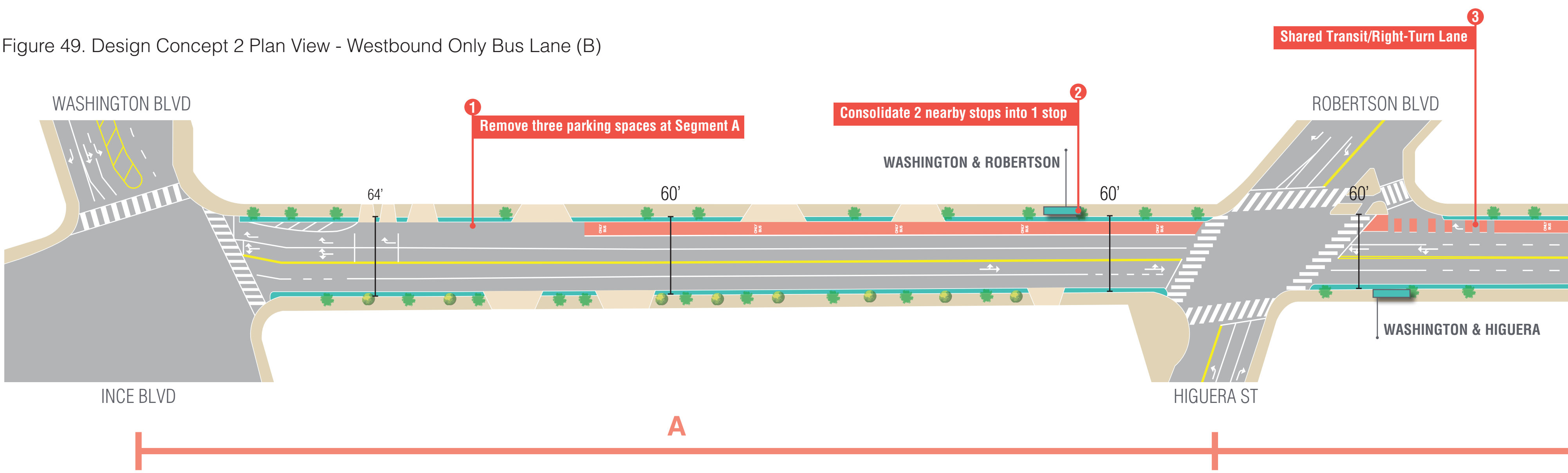
The mid-term design concept combines the westbound only bus lane with elevated bike lanes, a proposal that aligns with the Culver City TOD Visioning Plan for proposed bike facilities (Figure 49). The recommended minimum width for a separated one-way bike lane is five feet (FHWA, 2015), while a minimum four-feet-wide bike lane is suggested when the bike facility is designed exclusively for cyclists (AASHTO, 1999). With the existing limited right-of-way, I propose four-feet-wide elevated bike lanes adjacent to sidewalk spaces in both directions.

The elevated bike lanes would be completely separated from vehicular traffic; therefore, the concept would result in at least an eight-foot reduction in the curb to curb street width. Similar to the near-term design concept, the westbound-only bus lane will sit right next to the new extended north-side curb.

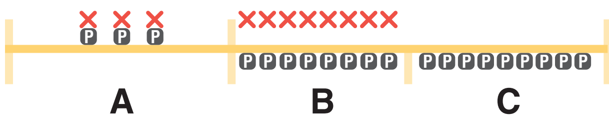
The mid-term design concept requires reconfiguring the design corridor to two lanes each way for vehicular traffic, and the removal of the center turn lane (Figure 50). In terms of signal operation, left-turning vehicles would still have a protected signal phase that is shared with general traffic (Figure 51). The plan also affects the number of on-street parking spaces. In this plan, three north-side parking spaces between Ince and Robertson/Higuera and eight south-side parking spaces between Robertson/Higuera and Landmark would be removed.

The Culver City Public Works Department is currently developing a detailed plan for an elevated bike lane to connect Downtown Culver City and the Expo Station. The cooperation of the Departments of Public Works and Transportation is pivotal for the implementation of this concept.

Figure 49. Design Concept 2 Plan View - Westbound Only Bus Lane (B)



1 Remove 11 parking spaces

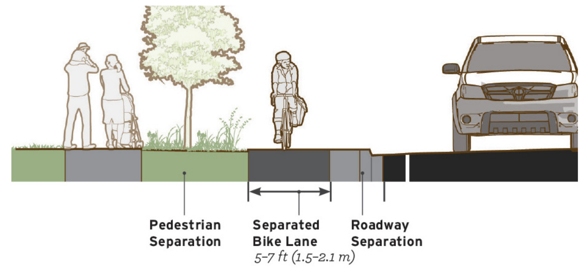


3 Shared Transit/Right-Turn Lane

As discussed in the literature review section of the report, a curbside bus lane could typically accommodate moderate volumes of right-turning traffic. The lane should be dashed for at least 50 feet in advance of the intersection (NACTO, 2018). The pavement should be marked with right turn arrows with signs indicating the use of the lane (MUTCD R3-7R & R3-1B).

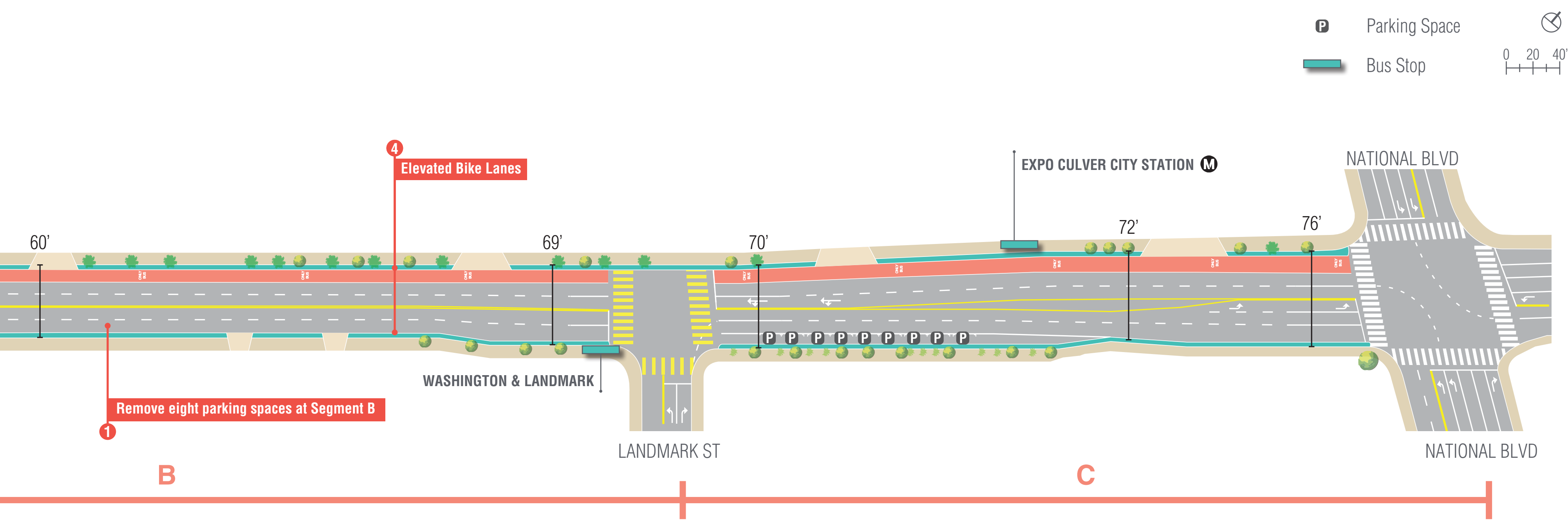
Source: MUTCD

2 Elevated Bike Lanes with Curb Extensions



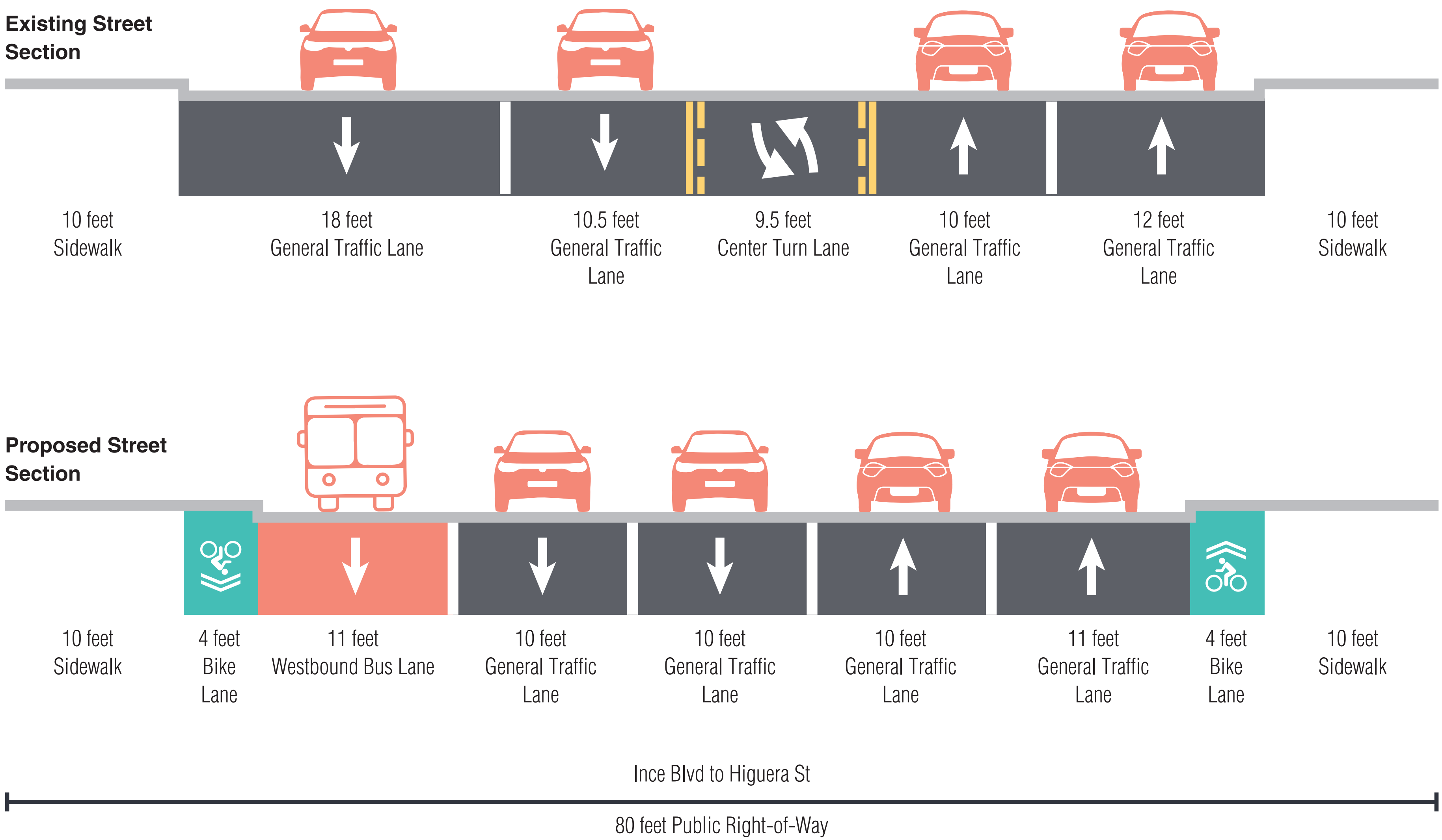
Recommended Width Characteristics and
Source: Small Town and Rural Design Guide

Wyoming Pathways in Jackson Hole, WY
Source: Small Town and Rural Design Guide



A. Proposed Street Section

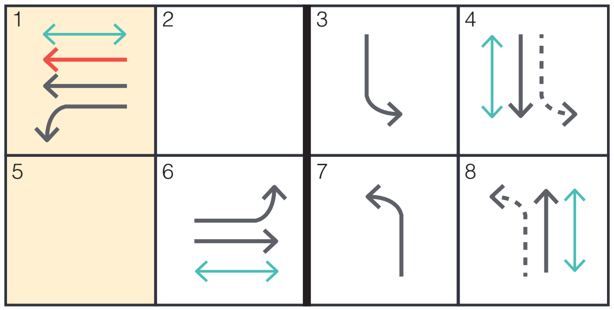
Figure 50. Design Concept 2 Section View - Westbound Only Bus Lane (B)

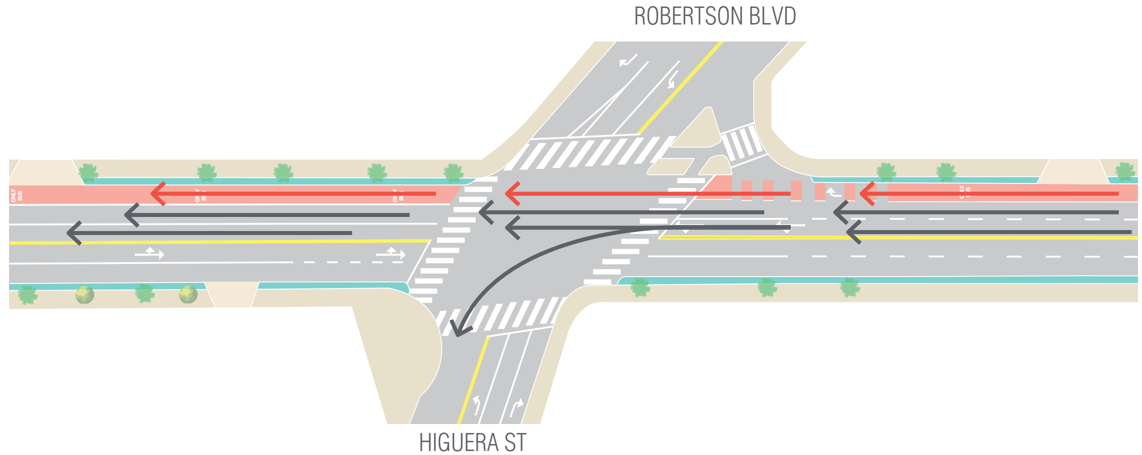


B. Proposed Signal Operation at an Intersection

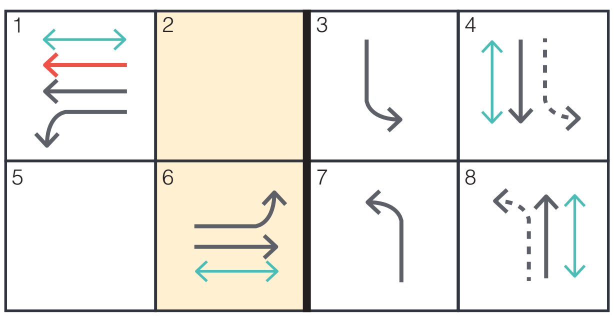
Figure 51. Design Concept 2 Signal Operation - Westbound Only Bus Lane (B)

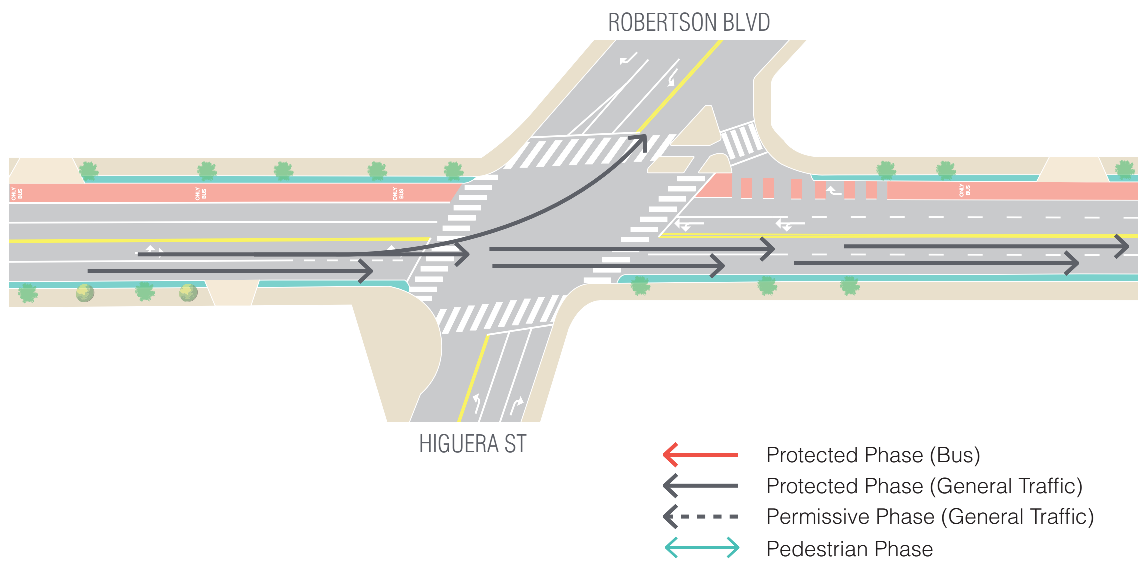
Phase 1 & 5: Bus + Westbound Through Traffic & Protected Left Turns





Phase 2 & 6: Eastbound Through Traffic & Protected Left Turns





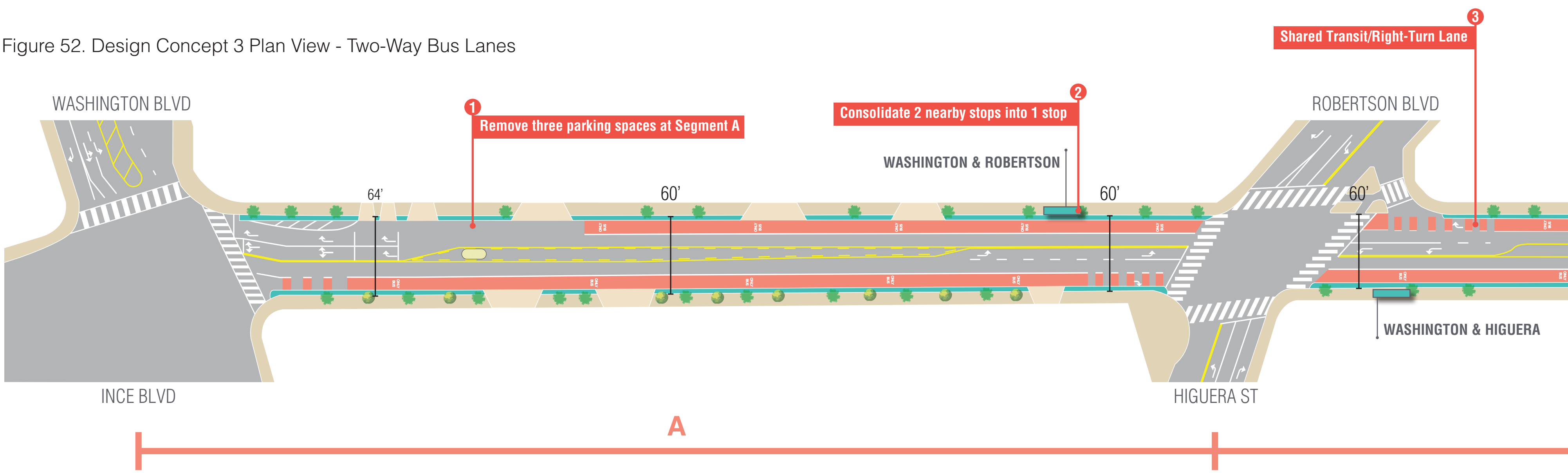
3. TWO-WAY BUS LANES

To fully re-vision street life in Downtown Culver City, the City should prioritize transit riders, cyclists, and pedestrians. A greener, safer, and friendlier Washington Boulevard would move and engage people, but not cars. The long-term goal of the project, therefore, is to implement two-way bus lanes and elevated bike lanes.

Should the city implement this concept, general traffic lanes in the narrowest segments (60 feet) of the corridor would be affected. The concept would require a road diet with 30 feet left for general traffic lanes after the installation of both the bus lanes and the elevated bike lanes (Figure 53). There would be two general traffic lanes with the middle lane reserved for left-turn vehicles (Figure 52). This concept would greatly decrease the vehicle throughput on Washington Boulevard, especially during peak hours.

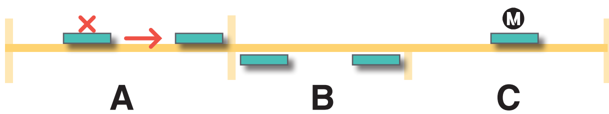
This design concept also requires the removal of parking on segments A and B of the design corridor, contributing to the loss of 11 parking spaces in total. In terms of signal operation, the study proposes to maintain a protected phase for left-turn movements at intersections (Figure 54). Buses would share the same signal phase with through traffic.

Figure 52. Design Concept 3 Plan View - Two-Way Bus Lanes



1 Remove 11 parking spaces

2 Consolidate two westbound stops at Segment A



3 Two-Way Bus Lanes

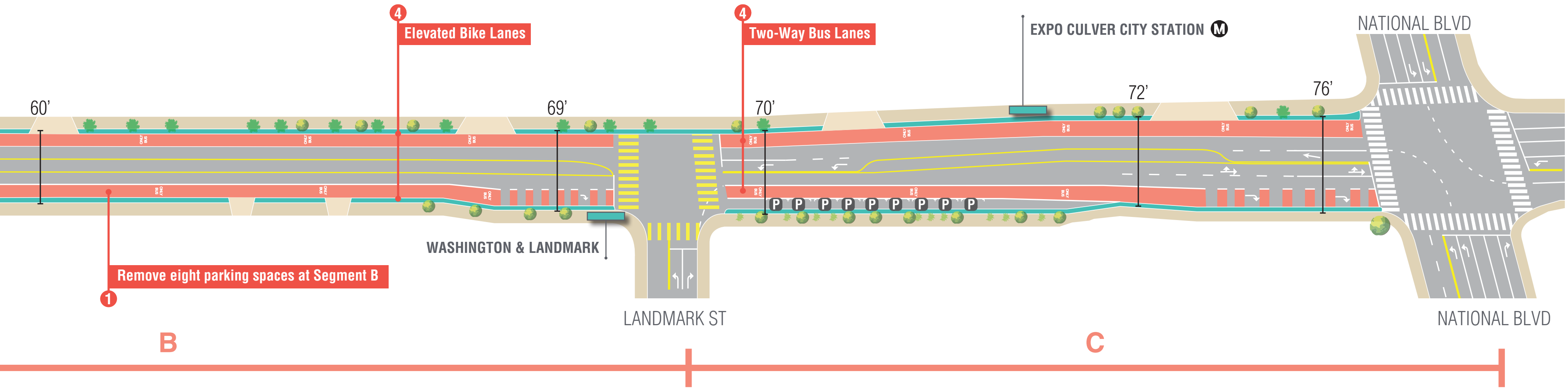
New York City - Queens Two-Way Bus Lanes speed up transit service in congested roads

Source: StreetblogNYC

Parking Space

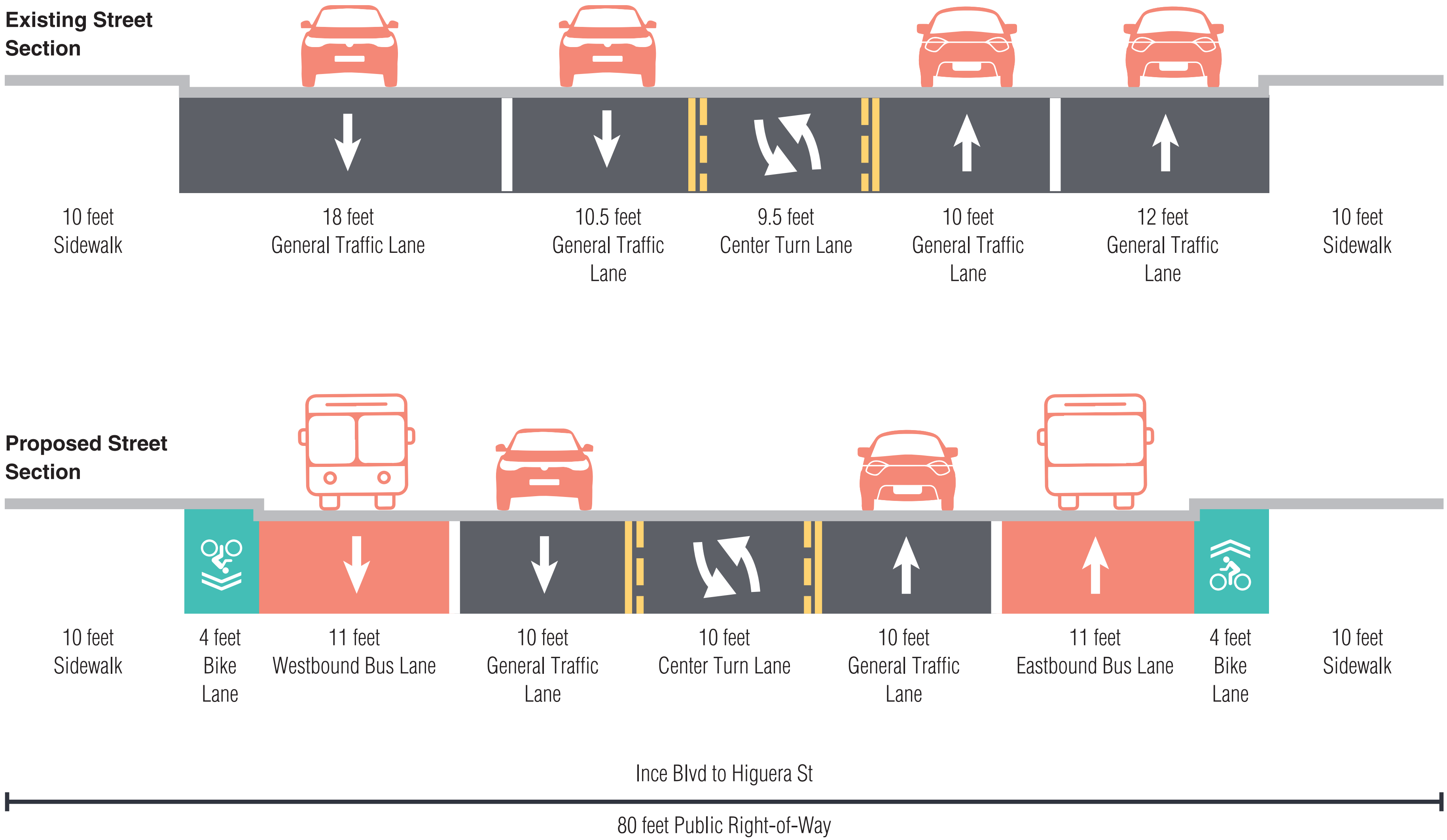
Bus Stop

0 20 40'



A. Proposed Street Section

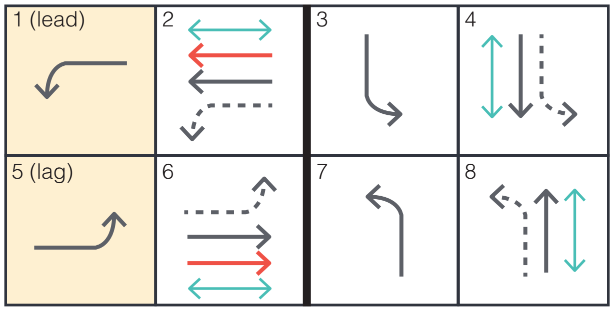
Figure 53. Design Concept 3 Section View - Two-Way Bus Lanes

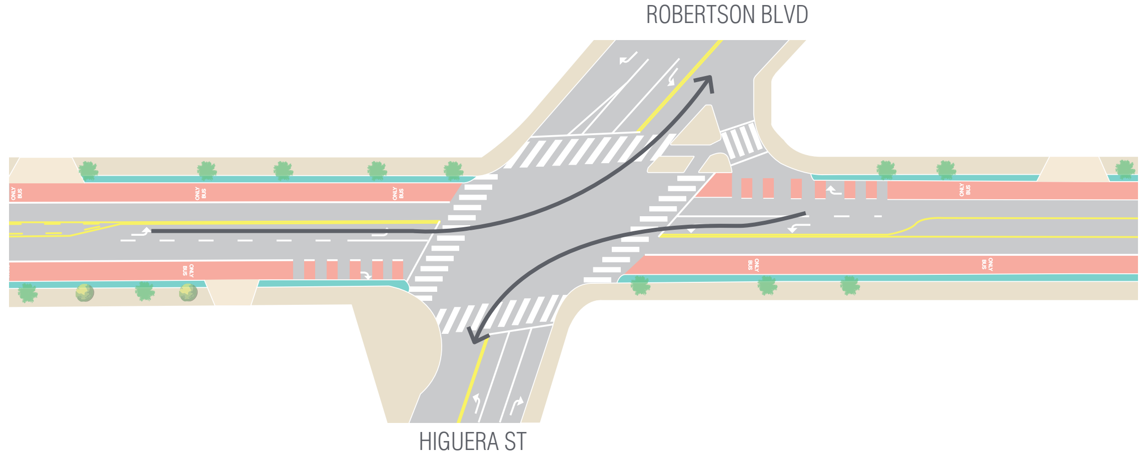


B. Proposed Signal Operation at an Intersection

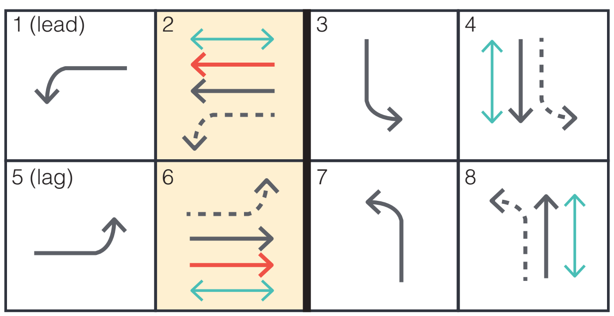
Figure 54. Design Concept 3 Signal Operation - Two-Way Bus Lanes

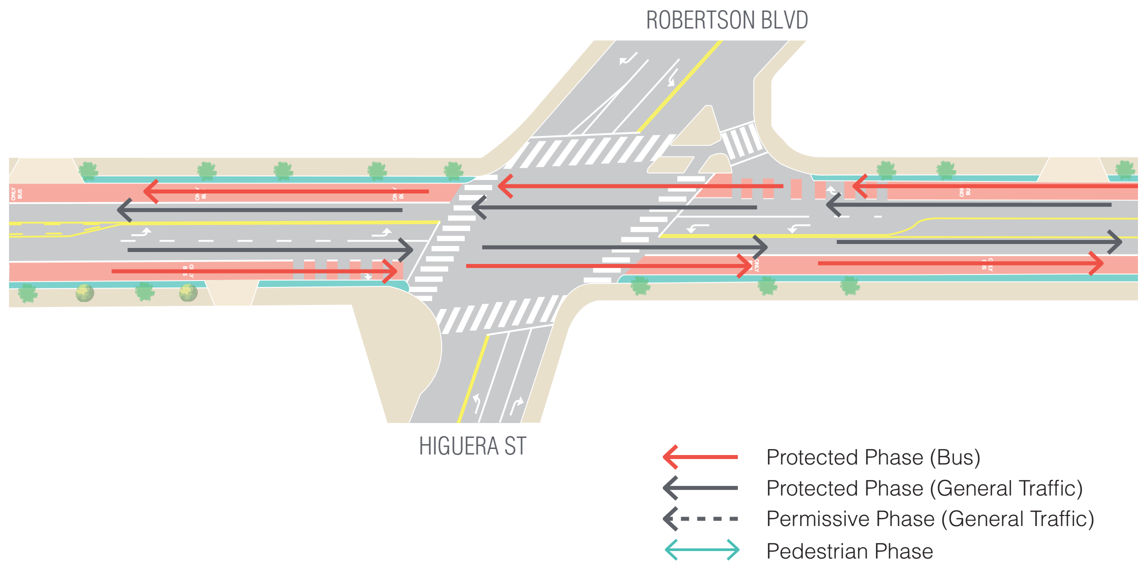
Phase 1 & 5: Left Turns Only





Phase 2 & 6: Bus + Through Traffic + Permissive Left Turns





4. TWO-WAY BUS LANES WITH A REVERSIBLE TRAFFIC LANE

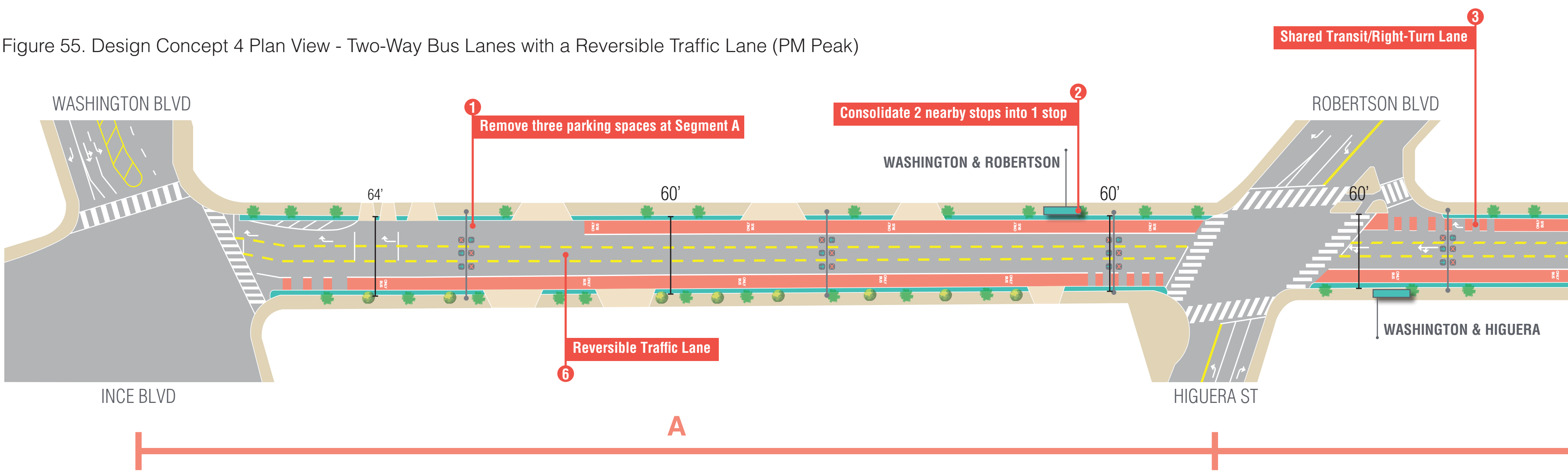
As I discuss previously, Washington Boulevard has clear directional congestion based on time of day. According to the 2013 Citywide Engineering and Traffic Survey (E&TS) Report (2013), directional imbalance reaches approximately 63/37[1] for westbound/eastbound direction during the morning peak period, and the ratio reaches approximately 65/35[2] for eastbound/westbound direction during the evening peak period. Having more dynamic lane use could expand the roadway capacity without requiring additional right-of-way.

1 The ratio of westbound : eastbound traffic volume on Washington Boulevard during 6:00 am to 10:00 am is 63:37 based on the 2013 Citywide Engineering and Traffic Survey (E&TS) Report
2 The ratio of eastbound : westbound traffic volume on Washington Boulevard during 3:00 pm to 7:00 pm is 65:35 based on the 2013 City-wide Engineering and Traffic Survey (E&TS) Report

A second long-term option is to have one middle lane, one westbound traffic lane, and one eastbound traffic lane as in the previous proposal. In this option, the middle lane would function as a reversible traffic lane (Figure 55; Figure 56). The reversible lane would serve westbound traffic during the morning peak period, and eastbound traffic during the evening peak period (Figure 57). The reversible lane can also function as a protective turn lane during the off-peak period (Figure 58). The merit of this design concept is that it offers the City flexibility in efficiently managing traffic capacity given limited road conditions.

According to the Manual on Uniform Traffic Control Devices (MUTCD), Culver City will need to provide yellow broken markings and striping (MUTCD 3B.03;4M.01), and either reversible lane control signs or signals to indicate which directional vehicles can drive on the reversible lane in a given time period (MUTCD 2B.26). Additional analysis is needed to determine whether the reversible traffic flow could be controlled with pavement markings and signs without the use of signals (MUTCD 2B. 25). Given the complexity of multiple lane types, and intersections along the design corridor, there are “chances of drivers getting confused and leading into a dangerous traffic scenario (Arvind and Parentela, 15).” I propose the use of control signals with the support of signs and markings. Drivers also might benefit from driver education programs that inform drivers on how to drive safely and alertly on the reversible traffic lane.

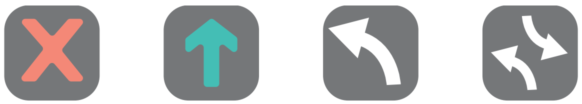
Figure 55. Design Concept 4 Plan View - Two-Way Bus Lanes with a Reversible Traffic Lane (PM Peak)



5 Lane Control Signs/Signals

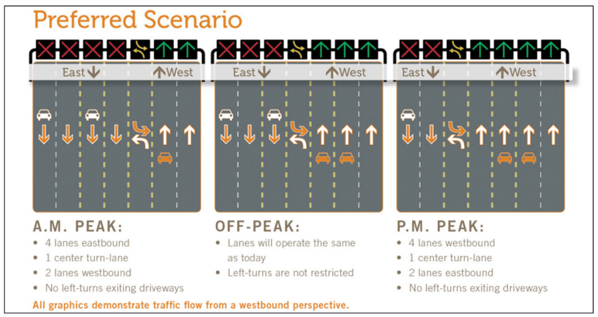
Reversible lane control signs

Source: MUTCD R3-9d, R3-9f through R3-9i



Reversible lane control signals (selected)

Source: MUTCD Section SJ.04



Source: MUTCD Section SJ.04

6 Reversible Traffic Lane

A reversible traffic lane (so called reversible lane or flex lane) improves traffic operation by borrowing the lane capacity from the off-peak direction. It relieves congestion during peak hours without widening the right-of-way. Computational research shows the merits of reversible bus lanes. One study concludes that an optimum lane reversal configuration could increase lane use efficiency by 72 percent (Arvind and Parentela, 2013). However, researchers note the lack of specific design standards for reversible lanes which has resulted in municipal transportation agencies developing their own guidelines (Texas A&M Transportation Institute, 2018). Successful reversible lane implementation cases include West Alabama Street in Downtown Houston and 5400 South Flex Lanes Corridor in Utah.

West Alabama Street, Houston

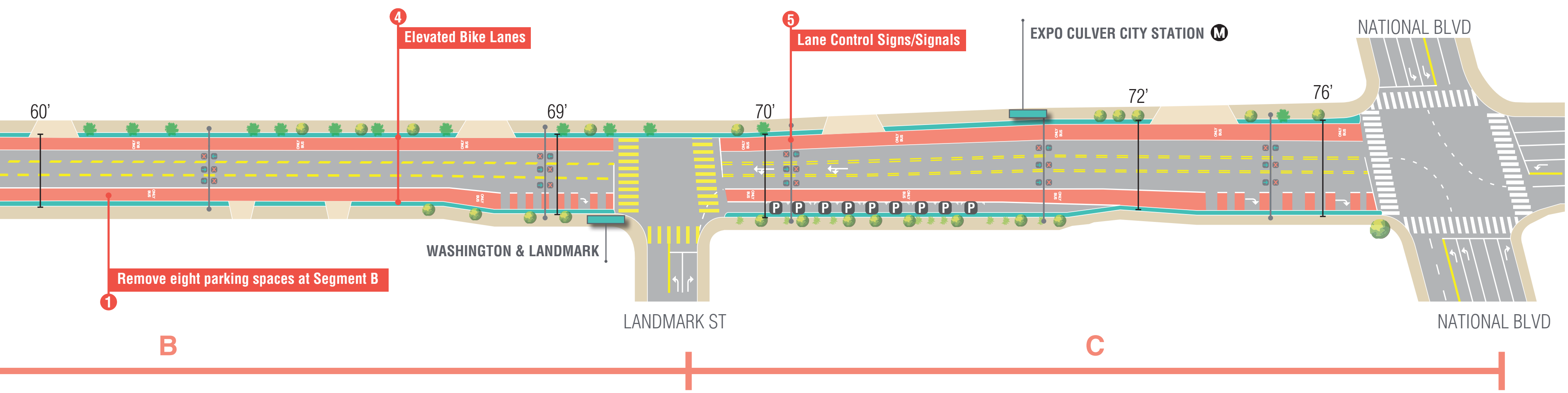
A case study of downtown Houston on West Alabama Street shows how a three-lane roadway could be configured to two traffic lanes with one reversible lane. The reversible lane serves peak-direction traffic during peak periods and become center turn lanes during off-peak hours.

5400 South Flex Lanes Corridor, Utah

In 2012, the Utah Department of Transportation (UDOT) transformed a two-mile-long seven-lane corridor into flex lanes with three reversible lanes set in the middle of the street and successfully reduced the travel time in the peak-period direction by approximately seven percent (Lee, 2012; Davidson, 2013).

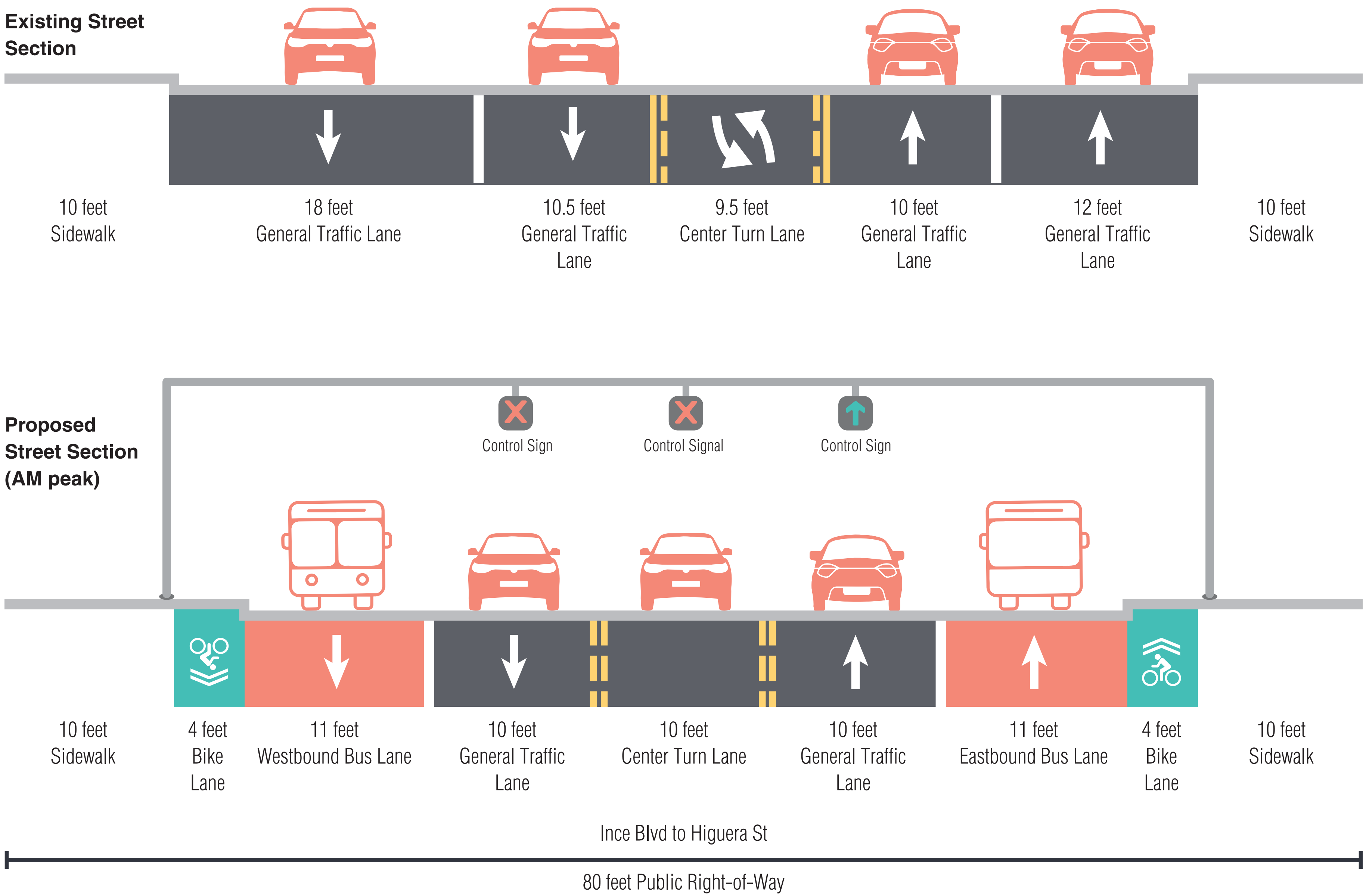
The system has provided a “warming” clearance interval (yellow “X”) for one minute before transitioning the lane configuration. The overhead signs/signals (gantries) are also spaced frequently along the corridor to ensure that motorists can see at least two signal gantries at a time. These approaches provide a safe street environment, reducing crash rates by approximately 35 percent according to UDOT.

The spacing between each overhead sign (gantry) is about 700 feet ensuring that drivers could see the two overhead signs at any time. The flex lane is monitored and operated by the UDOT Traffic Operation Center Control Room. The graphic on the left demonstrates three scenarios based on time of day (Boal, 2009).



A. Proposed Street Section

Figure 56. Design Concept 4 Section View - Two-Way Bus Lanes with a Reversible Traffic Lane



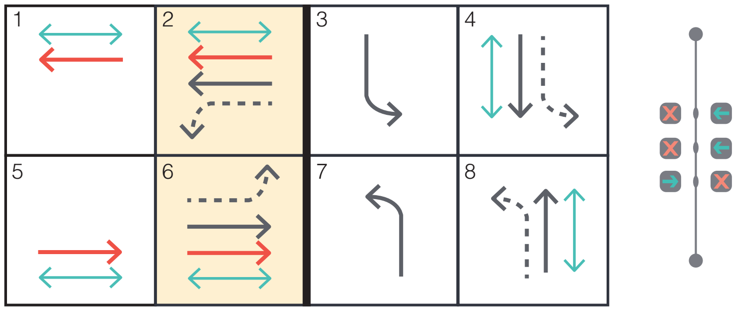
B. Proposed Signal Operation at an Intersection

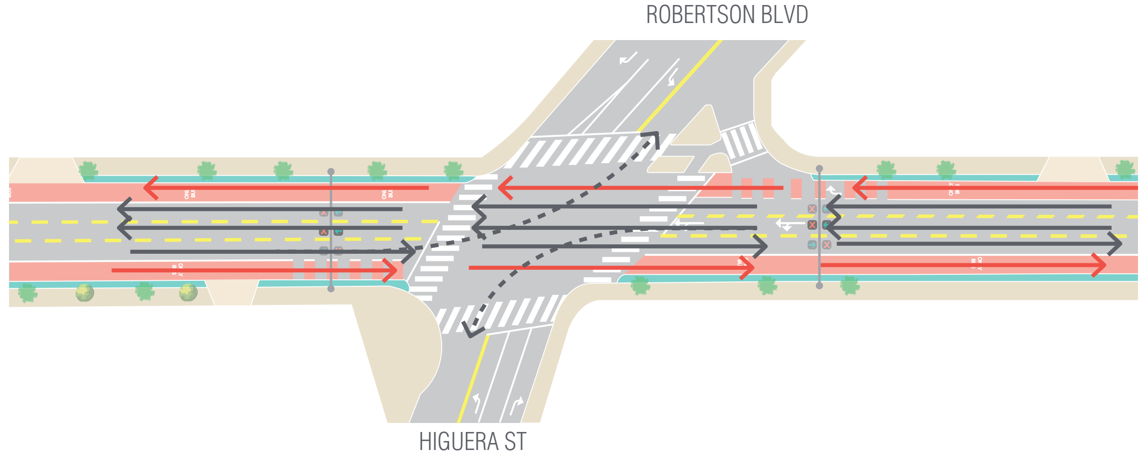
Figure 57. Design Concept 4 Signal Operation - Two-Way Bus Lanes with a Reversible Traffic Lane (Peak Period)

AM peak period

***Phase 1 & 5 is only activated when there is bus waiting at the intersection.**

Phase 2 & 6: Bus +Through Traffic + Permissive Left Turns

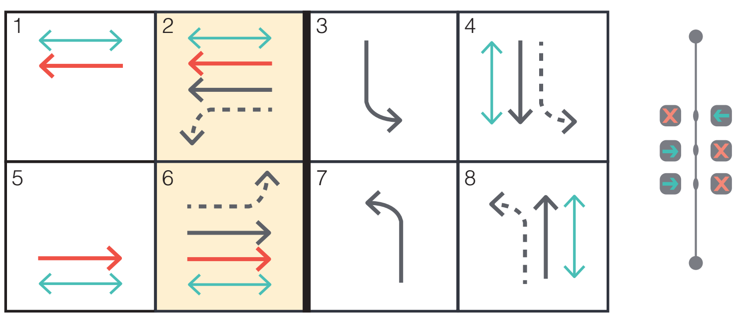


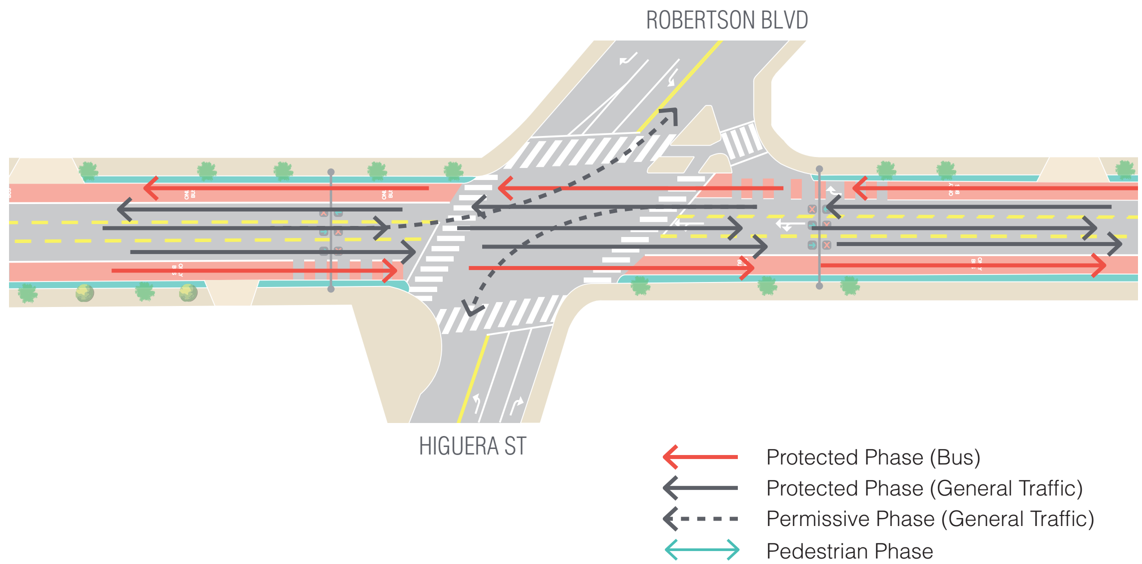


PM peak period

***Phase 1 & 5 is only activated when there is bus waiting at the intersection.**

Phase 2 & 6: Bus +Through Traffic + Permissive Left Turns

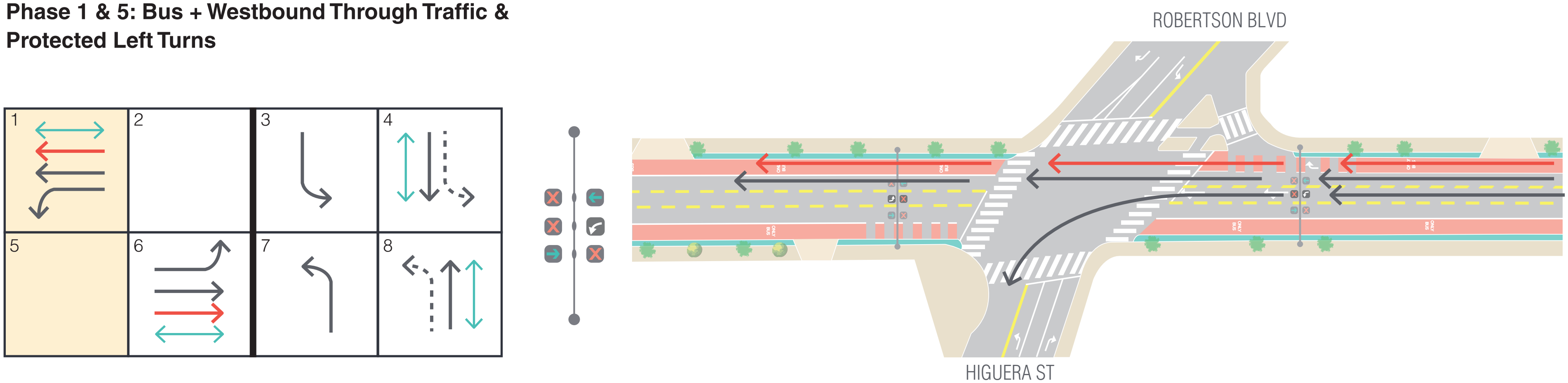




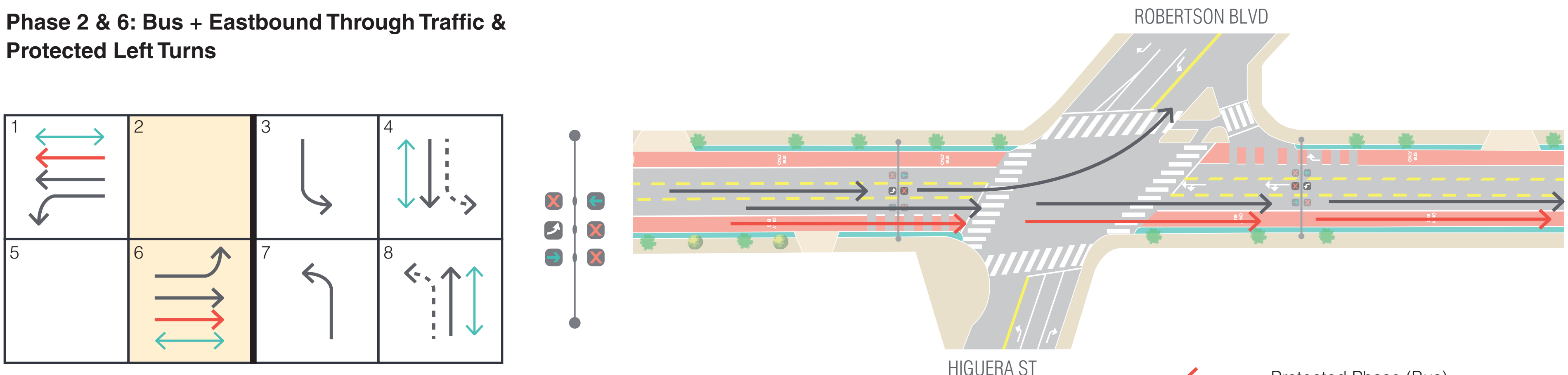
Off-peak period

Figure 58. Design Concept 4 Signal Operation - Two-Way Bus Lanes with a Reversible Traffic Lane (Off-Peak Period)

Phase 1 & 5: Bus + Westbound Through Traffic & Protected Left Turns



Phase 2 & 6: Bus + Eastbound Through Traffic & Protected Left Turns



Protected Phase (Bus)
Protected Phase (General Traffic)
Permissive Phase (General Traffic)
Pedestrian Phase

It is important to note that there are some potential traffic conflicts and other issues that need to be resolved to ensure safety and efficient operations, especially in applying the design concept to the entire Washington Boulevard. Some of the conflicts include:

- Continuity of reversible traffic lane: there are segments where Washington Boulevard merges with other streets (Culver Boulevard and Washington Place) and segments with median islands. These segments deserve extra attentions when designing the reversible traffic lane configuration.
- Left-turn movements on driveways: there are 13 driveways along the design corridor many more on the rest part of Washington Boulevard. Planners need to know how to manage driveway in and out movements during different time periods.
- Transition to conventional street configuration: Planners need to design a smooth transition from the reversible lane back to regular street configuration and vice versa.

Figure 59. Design Concept 4 - Rendering

CHAPTER 6

EVALUATION

This section includes estimates of the costs and benefits of the four different design concepts in the half-mile-long design corridor. With respect to benefits, I analyze potential transit travel time savings, ridership growth, and transit operating & maintenance cost savings. I also discuss potential construction costs and lane capacity impacts. Due to limited access to data from other agencies, I focus on one Culver CityBus line: Line 1.

Source: Westsidetoday.com

01 TRANSIT TRAVEL TIME SAVINGS

1. CURRENT BUS TRAVEL TIME

Bus speed is generally worse during the evening peak period than the morning peak period. During the morning peak period, the average westbound bus speed is 8.1 mph and the average eastbound speed is 6.9 mph (Table 8). During the evening peak period, the average westbound bus speed is 7.4 mph and eastbound is 4.6 mph (Table 8). The travel time is calculated by dividing the length of the design corridor (0.4 miles from National Boulevard to Ince Boulevard) by the existing bus speed.

Table 8. Design Corridor Existing Bus Speed and Travel Time

		Bus Speed (mph)	Travel Time (mins)
Westbound	AM Peak	8.1	3.0
	PM Peak	7.4	3.2
	Average	**7.9**	**3.0**
Eastbound	AM Peak	6.9	3.5
	PM Peak	4.6	5.2
	Average	**6.1**	**3.9**

Source: Culver CityBus Ridecheck Plus (Sept 2017 Schedule)

2. TRAVEL TIME SAVINGS PER TRIP

As seen in Figure 60, bus speed efficiency vary by 35% to 100% depending on the type of roadway facilities (Kittleson, 2013). All four recommendations include curb bus lanes that increase the average bus speed by 75 percent compare to a mixed traffic scenario. Bus travel time savings could be used to increase service frequency and, therefore, reduce headways. Bus travel time savings are calculated based on the following three scenarios: without a bus lane, a westbound only bus lane, and a two-way bus lane. The summary is organized in Table 9 and Figure 61.

Westbound Only Bus Lane (Concept 1 & 2): 1.3 minutes travel time savings per trip

Two-Way Bus Lane (Concept 3 & 4): 2.9 total minutes travel time savings per trip (1.3 minutes/trip for westbound direction and 1.6 minutes/trip for eastbound direction)

Figure 60. Bus Speed Relative to Full Operation Speed by Facility Type

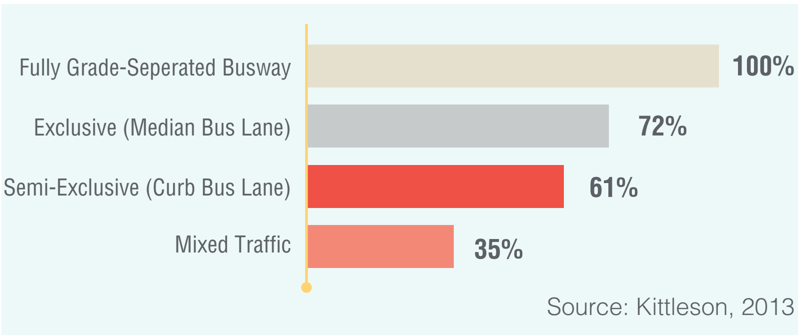
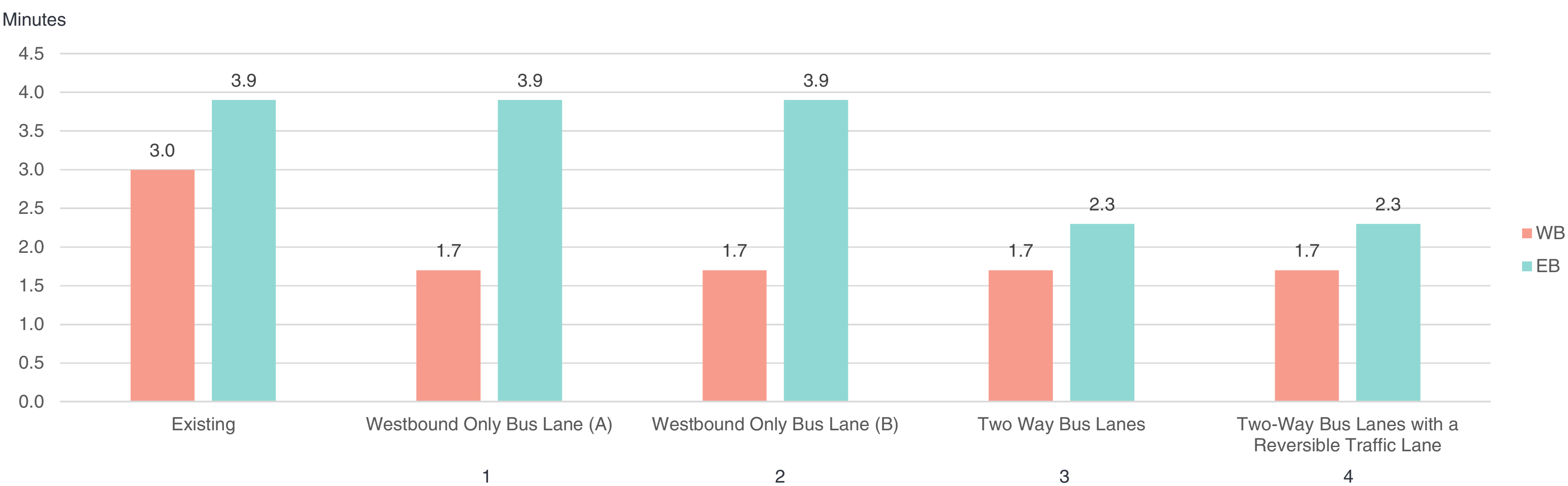


Table 9. Bus Speed (mph) and Travel Time Per Trip (mins) by Scenarios

		Speed (mph)		Travel Time per Trip (mins)		
		Current	Semi-Exclusive Bus Lane	Current	Westbound Only Bus Lane (1&2)	Two-Way Bus Lanes (3&4)
Westbound	AM Peak	8.1	14.1	3.0	1.7	1.7
	PM Peak	7.4	12.9	3.2	1.9	1.9
	Average	**7.9**	**13.8**	**3.0**	**1.7**	**1.7**
Eastbound	AM Peak	6.9	12.0	3.5	3.5	2.0
	PM Peak	4.6	8.0	5.2	5.2	3.0
	Average	**6.1**	**10.6**	**3.9**	**3.9**	**2.3**

Source: Kittleson, 2013; Culver CityBus Ridecheck Plus (Sept 2017 Schedule)

Figure 61. Travel Time per Trip by Design Concepts



Source: Kittleson, 2013; Culver CityBus Ridecheck Plus (Sept 2017 Schedule)

3. TRAVEL TIME SAVINGS PER DAY

To understand the relationship between the bus lane scenarios and overall travel time savings, I calculate the average weekday daily travel time savings for each design concept. Assuming the transit travel time savings presented above, I then multiplied by the number of trips to get the total travel time savings per day. I summarize these findings in Table 10.

Westbound Only Bus Lane (Concept 1 & 2): 73.8 minutes travel time savings per day.

Two-Way Bus Lane (Concept 3 & 4): 169.4 minutes travel time savings per day.

Table 10. Travel Time Savings Per Day by Design Concepts

		Weekday Trips		Time Savings Per Trip (mins)		Time Savings Per Day (mins)		
		WB	EB	WB	EB	WB	EB	Total
1	Westbound Only Bus Lane (A)	57	57	1.3	0.0	73.8	0.0	**73.8**
2	Westbound Only Bus Lane (B)			1.3	0.0	73.8	0.0	**73.8**
3	Two Way Bus Lanes			1.3	1.7	73.8	95.6	**169.4**
4	Two-Way Bus Lanes with a Reversible Traffic Lane			1.3	1.7	73.8	95.6	**169.4**

Source: Culver CityBus Ridecheck Plus (Sept 2017 Schedule)

4. TOTAL PERSON HOURS OF TRAVEL TIME SAVINGS

Travel time savings can benefit passengers by providing them with additional time that they can then use for other purposes such as work, recreation, or socializing. They also may reduce tension and fatigue caused by commuting (Brody, 2013). Therefore, reduced travel times through the design corridor can benefit transit passengers and provide yet another rationale for implementing the bus lanes. Therefore, I analyze the potential total person travel time savings by multiplying the travel time savings with the current on-board ridership (data from the September 2017 schedule). Table 11 represents the total person travel time savings for all Line 1 bus services during a normal weekday.

Design concepts 1 & 2 (Westbound Only Bus Lane) will contribute to 15 hours total person travel time savings per day; design concepts 3 & 4 (Two-Way Bus Lanes) result in nearly double the travel time savings compared to the first two concepts.

Table 11. Total Person Hours of Travel Time Savings by Design Concepts

		Weekday Trips		Time Savings Per Trip (mins)		On-board Passengers Per Trip		Total Person Hours of Travel Time Saving (hrs)				
		WB	EB	WB	EB	WB	EB	WB	EB	Daily	Weekdays per Week	Total Annual Working Days
1	Westbound Only Bus Lane (A)	57	57	1.3	0.0	12	8	15	0	**15**	**74**	**3853**
2	Westbound Only Bus Lane (B)			1.3	0.0			15	0	**15**	**74**	**3853**
3	Two Way Bus Lanes			1.3	1.7			15	13	**28**	**138**	**7179**
4	Two-Way Bus Lanes with a Reversible Traffic Lane			1.3	1.7			15	13	**28**	**138**	**7179**

Source: Culver CityBus Ridecheck Plus (Sept 2017 Schedule)

02 RIDERSHIP GROWTH

Research shows a positive relationship between improved transit service and ridership. More specifically, several studies find a positive correlation between transit travel time savings and ridership growth (Litman, 2016; Currie and Sarvi, 2012; Anlezark et al. 1994; McCollom and Pratt, 2004). Increasing ridership is mainly associated with mode shifts away from car use as both drivers and passengers and an increase in trips that were previously not made (Currie and Sarvi, 2012). Therefore, bus lanes should also increase transit ridership, boosting transit revenues that could be invested in improving bus services or other transit infrastructure.

The Line 1 average weekday trip run time for the entire corridor is 46 minutes on eastbound direction with average bus speed of 9.16 mph and 54.2 minutes on westbound direction with average bus speed of 8.87 mph (2017 September schedule data). As seen in Figure 2 on page 16, Litman (2016) find that a bus lane would result in time savings of at least 40 percent and contribute to nearly a 40 percent increase in ridership (Litman, 2012).

I draw on the assumptions from Litman (2016); the calculations and the explanations are listed in Table 12, Table 13. Design concepts 1 & 2 (Westbound Only Bus Lane) will attract approximately 718 new boarding passengers on a normal weekday if the concepts expand to the entire Washington Boulevard, design concepts 3 & 4 (Two-Way Bus Lanes) will attract 1400 new boarding riders in the same condition.

Table 12. Line 1 Percent of Travel Time Savings and Ridership Growth by Design Concepts (Entire Route)

		Travel Time per Trip (mins)		Pct of Time Savings		Pct of Ridership Growth	
		WB	EB	WB	EB	WB	EB
	Existing	54.2	46.0	0%	0%		
1	Westbound Only Bus Lane (A)	31.1	46.0	43%	0%	42%	
2	Westbound Only Bus Lane (B)	31.1	46.0	43%	0%	42%	
3	Two Way Bus Lanes	31.1	26.4	43%	41%	42%	40%
4	Two-Way Bus Lanes with a Reversible Traffic Lane	31.1	26.4	43%	41%	42%	40%

Source: Culver CityBus Ridecheck Plus (Sept 2017 Schedule); Litman, 2016

Table 13. Ridership Growth by Design Concepts

		Boarding Passengers Per Trip		Pct of Ridership Growth		Ridership Growth		
		WB	EB	WB	EB	WB	EB	Total
1	Westbound Only Bus Lane (A)	1709	1705	42%		718		718
2	Westbound Only Bus Lane (B)			42%		718		718
3	Two Way Bus Lanes			42%	40%	718	682	1400
4	Two-Way Bus Lanes with a Reversible Traffic Lane			42%	40%	718	682	1400

Source: Culver CityBus Ridecheck Plus (Sept 2017 Schedule); Litman, 2016

03 TRANSIT OPERATING AND MAINTENANCE SAVINGS

The potential transit travel time savings could be financially beneficial for Culver CityBus, since the reduction in operating and maintenance costs could be used to maintain or enhance transit frequency and, therefore, reduce headways. Based on the numbers provided by Culver City Transportation Department staff, the operating and maintenance costs of the Culver CityBus Line 1 service is $130 per hour. I analyze the potential reduction in the annual cost by multiplying daily travel time savings with the hourly operating and maintenance cost (OM cost). The results represent the total daily, weekly, and annual cost savings to the Culver City Transportation Department (Table 14).

With the implementation of bus lanes on this 0.4-mile-long design corridor, the OM cost savings could be up to approximately $95,800 annually, and the savings would be even higher if the City decides to extend the transit lanes to the entire Washington Boulevard corridor.

Table 14. Transit Operating and Maintenance Savings by Design Concepts

		OM Cost ($)	Travel Time Savings (hrs)			OM Cost Savings ($)		
			Daily	Weekly	Annual	Daily	Weekly	Annual
1	Westbound Only Bus Lane (A)	$130.0	1.23	6.15	321.06	$160	$800	**$41,738**
2	Westbound Only Bus Lane (B)	$130.0	1.23	6.15	321.06	$160	$800	**$41,738**
3	Two Way Bus Lanes	$130.0	2.82	14.12	736.87	$367	$1,835	**$95,793**
4	Two-Way Bus Lanes with a Reversible Traffic Lane	$130.0	2.82	14.12	736.87	$367	$1,835	**$95,793**

04 CONSTRUCTION COST LEVEL

It is crucial to understand the costs associated with implementing each of the design options. Due to the difficulty of calculating the exact costs of each concept, a task that is outside the scope of this project, I examine relative construction costs and categorize them into three levels based on the elements that need to be in place before implementing the four design concepts:

- Level 1: Restriping, loop detectors relocation, new signage, and etc.
- Level 2: Level 1 + roadway surface construction
- Level 3: Level 2 + signal modification

As described in Table 15, among the four proposals the westbound curb bus lane is the simplest project. It does not require excavation of the roadway surface or other big investments. In contrast, design concepts that include elevated bike lanes or reversible traffic lanes are expensive. Beyond construction costs, there are also additional costs associated with the mid-term and long-term design concepts, including planning, staffing, public outreach, etc.

Table 15. Construction Cost Level by Design Concepts

Bus Lane Design Concepts		Level	Descriptions
1	Westbound Only Bus Lane (A)	●○○	1. Restriping/Lane Reconfiguration 2. Loop detectors relocation 3. New signage
2	Westbound Only Bus Lane (B)	●●○	1. Restriping/Lane Reconfiguration 2. Loop detectors relocation 3. New signage 4. Road surface construction for new bike lanes 5. Utility reconstruction including drainage, lighting, and others
3	Two Way Bus Lanes	●●○	1. Restriping/Lane Reconfiguration 2. Loop detectors relocation 3. New signage 4. Road surface construction for new bike lanes 5. Utility reconstruction including drainage, lighting, and others
4	Two-Way Bus Lanes with a Reversible Traffic Lane	●●●	1. Restriping/Lane Reconfiguration 2. Loop detectors relocation 3. New signage 4. Road surface construction for new bike lanes 5. Utility reconstruction including drainage, lighting, and others 6. New overhead dynamic lane control signals

05 TRAFFIC CAPACITY IMPACT LEVEL

Washington Boulevard has long served as a thoroughfare for automobile drivers, and the modification of lane uses can affect the existing car travel. Understanding the traffic capacity impact is a pivotal component of the project. Traffic Capacity Impact Level is based on the potential traffic impact due to the various the lane changes in each of the concepts. Potential effects on traffic lanes include:

Level 1: no primary and direct impact on traffic capacity

Level 2: a reduction in the center turn lane, but no reduction of general traffic lanes or reversible traffic lane

Level 3: a reduction in general traffic lanes

As shown in Table 16, the westbound curb bus lane falls into level 1 since there is no direct traffic impact; however design concepts that include elevated bike lanes will have greater traffic impacts associated with the reduction of lanes. A reversible traffic lane could alleviate the potential impact on traffic assuming dynamic signaling that facilitates traffic flow during peak periods and direction.

With the increase in multi-modal infrastructure, accessing traffic capacity should be more dynamic and take into account capacity changes of other modes, including transit, bike, and walking, but not only focusing on cars.

Table 16. Traffic Capacity Impact Level by Design Concepts

Bus Lane Design Concepts		Level	Descriptions
1	**Westbound Only Bus Lane (A)**	● ○ ○	1. The bus lane would be implemented through reducing widths of other traffic lanes, but direct reduction of any lanes
2	**Westbound Only Bus Lane (B)**	● ● ○	1. Reduce the dedicated middle lanes and left turn lanes 2. Left turners at intersections will share the lane with number one lane traffic
3	**Two Way Bus Lanes**	● ● ●	1. Reduce one general traffic lane for both directions 2. Keep the center turn lane
4	**Two-Way Bus Lanes with a Reversible Traffic Lane**	● ● ◐	1. Keep one dedicated general traffic lane for both directions 2. The middle lane serve as reversible traffic lane, allowing peak directional vehicles to move through the corridor 3. Reduce the directional traffic impact during the peak hours

06 SUMMARY

Table 17 summarizes the characteristics of the four design concepts. The table includes implementation prerequisites, costs, benefits, and overall impact. The table also shows the applicability of the design concepts to the entire design corridor. The evidence suggests that a bus lane on Washington Boulevard would result in significant benefits. However, each design concept has different benefits and costs, including diverse effects on the use of the street and on the larger community:

- Near-Term - Westbound Only Bus Lane: this option is the narrowest in scope and, therefore, could be implemented most easily. The near-term concept could fill the pressing need for reliable morning peak period, peak directional trips without significant effects on roadway capacity.
- Mid-Term - Westbound Only Bus Lane: This option is different from the near-term concept because it includes dedicated bike infrastructure. The mid-term concept removes the center turn lane and potentially impedes roadway capacity through a shared left-and-through lane.
- Long-Term - Two-Way Bus Lanes: The concept could greatly enhance person throughput on Washington Boulevard by having buses run in both directions on dedicated transit lanes. It also includes the installation of elevated bike lanes. This concept requires a reduction in general traffic lanes in each direction; however, the center turn lane remains. Through-traffic on the design corridor likely will decrease, with motorists experiencing longer travel times through the corridor, especially during peak periods.

- Long-Term – Two Way Bus Lanes with a Reversible Traffic Lane: To address the traffic impacts of design concept 3, one alternative is to implement a reversible traffic lane to alleviate peak period, peak directional traffic. However, there are many uncertainties in the design and operation of reversible traffic lanes and, therefore, it requires further study.

The Westbound Only Bus Lane (Design Concept 1) would improve transit service at the lowest cost relative to the other three options. The mid-term and long-term concepts (Design Concepts 2-4) require substantial budgets since they include roadway surface construction and sign/signal installation. The Two-Way Bus Lanes would greatly improve travel times and, therefore, likely improve ridership by 40 percent, but this option would affect auto throughput due to the reduction in the number of general traffic lanes.

This report is an initial investigation into the feasibility of establishing a bus lane on Washington Boulevard. The City should commission additional studies, public outreach, and stakeholder solicitation to ensure that the bus lane plan and implementation is operational, safe, and implemented such that it benefits the community.

Table 17. Summary of Four Design Concepts

General Traffic Lane – GTL
Bus Lane – BuL
Bike Lane - BiL

	Concept Number	1	2	3	4
	Transit Lane Design Concepts	**Westbound Only Bus Lane (A)**	**Westbound Only Bus Lane (B)**	**Two Way Bus Lanes**	**Two-Way Bus Lanes with a Reversible Traffic Lane**
	Implementation Horizon	**Near-term**	**Mid-term**	**Long-term**	**Long-term**
Implementation Prerequisites	Restriping, loop detectors relocation, new signage, etc.	●○○	●●○	●●○	●●○
	Signal Modification	●○○	●○○	●○○	●●●
	Roadway Surface Construction	○○○	●●○	●●○	●●○
	Removal of Parking Spaces	3	11	11	11
	ROW Required (Min. Road Width)	60	60	60	60
	Lane Configuration (Minimum)	4 GTLs + 1 BuL + 1 Center Turn Lane	4 GTLs + 1BuL + 2 BiLs	2 GTLs + 2 BuLs + 2 BiLs + 1 Center Turn Lane	2 GTLs + 2 BuLs + 2 BiLs +
	Transit Service Quality Improvement Level	●○○	●○○	●●●	●●●
	Travel Time savings per day (mins)	74	74	169	169
	Total Person Hours of Travel Time Savings (hrs/daily)	15	15	28	28
	Daily Ridership Growth (for entire Line 1 Service)	718	718	1400	1400
	General Purpose Lane Capacity Impact Level	●○○	●●○	●●●	●●○
	Construction Cost Level	●○○	●●○	●●○	●●●
Benefits	Reduce transit travel time	●○○	●○○	●●●	●●●
	Improve transit on-time performance	●○○	●○○	●●●	●●●
	Increase multi-modal capacity	●○○	●●○	●●●	●●●
	Reduce pass through traffic on Washington Blvd	●○○	●●○	●●●	●●○
Impacts	Reduce capacity for single occupancy vehicles	●○○	●◐○	●●○	●●○
	Unprotected/Restricted Left Turns	○○○	●●○	○○○	●○○
	Parking impact	●○○	●●○	●●○	●●○
	Increase signal cycle time	○○○	○○○	○○○	●○○
	Increase signal operation complexity	○○○	○○○	●○○	●●○
	Applicability to the Design Corridor	●●●	●●○	●●○	●◐○

CHAPTER 7

RECOMMENDATIONS

Beyond physical design, there are other components that are critical to the successful implementation and operation of bus lanes. In this section, I recommend that the city explore the followings: data collection and analysis, operation period, access policy, community engagement, and other strategies for creating a more multi-modal environment.

Source: Culver City Website

01 DATA COLLECTION AND ANALYSIS

To better justify the need for a bus lane, the City needs additional data and analysis. This task could follow the framework included in Chapter 3 (Existing Conditions) and include a deeper investigation into the physical and social implications of this project.

First, a more in-depth transit service analysis could help justify the need for a bus lane. This includes a cost-benefit analysis of various bus lane concepts for both the design corridor and the study area. This analysis would better highlight the benefits of the bus lane. It would also allow the city to better budget for these investments. Second, traffic impact and parking studies are also critical to understanding the effect of the bus lanes on adjacent streets and communities and to devising plans to mitigate or adapt to these changes.

These studies require the proper collection and storage of data overtime that allow the city to evaluate the performance of the bus lane after implementation. Quantifying the changes and comparing a set of metrics before and after implementation would help planners adjust and potentially expand the project to the entire corridor in the future.

02 OPERATION PERIOD

Transit lanes can be operated all day and all week. However, there are some examples of peak-hour transit lanes, daytime transit lanes, and weekday transit lanes. Wisely devising the operation period can keep buses and passengers from getting stuck in traffic while also lessening the burden on drivers. The operation period should be determined by closely examining data on hourly on-board and boarding/alighting transit passengers, hourly transit trips, hourly traffic volume, and other criteria for an entire week.

The data suggest that the City implement all-day full-time (24/7) curbside bus lanes for the following two reasons:

- Both traffic volumes and transit ridership remain high during peak hours and low during off-peak hours. Therefore, the benefits of allowing auto access to the bus lanes during off-peak hours are limited.
- The implementation of all-day full-time bus lanes is a clear and consistent policy choice. It would create less confusion for drivers and lessen the chances that drivers would accidentally enter the bus lane.

03 ACCESS POLICY

As discussed in the literature review, instead of dedicating transit lanes to the exclusive use of buses, the City could provide a relative flexible access policy and allow certain types of vehicles to enter the transit lanes. Common vehicles that cities permit in bus lanes include turning vehicles, governmental vehicles, and taxis (Agrawal, 2013). Also, allowing turning vehicles to drive into the bus lane would place less of a burden on the general traffic lanes since drivers do not need to wait for turning vehicles before proceeding. There are also examples of cities that allow bicycles, high occupancy vehicles, and electric vehicles to drive in transit lanes (Agrawal, 2013; Vaughan, 2016). Allowing these vehicles to enter the bus lanes incentivizes the use of green and low-emission transportation modes.

When devising the access policy for transit lanes, Culver City should set the policy to relieve traffic congestion if possible, maintain high-quality public transit service, and to enhance traveler’s multimodal experience.

In Table 18, I summarize the types of vehicles that ought to be able to use the transit lanes; these include vehicles making right turns, government and emergency vehicles, pick up/drop off vehicles, and bicycles.

Table 18. Potential Authorized Vehicle Types

Types	Description
Right Turn Vehicle	Smoothen the traffic pressure on general traffic lane
Governmental/ Emergency Vehicle	Reduce the conflicts of right turners and buses that are going straight.
Pick up/Drop off vehicle	Allowing governmental vehicles will help the delivery of public services, allowing police cars and fire trucks to bypass traffic during emergency events.
Bicycles	Promote multi-modal urban streets and protect cyclists who compete for use of the roadway with general vehicles (For the near-term concept only)

Figure 62. Broadway Bus Lane Pilot, MassDOT

The City and MassDOT state the pilot to be "successful"
Source: Universal Hub

04 COMMUNITY ENGAGEMENT

Taking street spaces from drivers and businesses can be challenging (New Mexico Department of Transportation, 2016). Therefore, the City will have to engage with community members and other stakeholders to build a strong consensus in support of the project. There are various approaches the City can take including (but not limited to): education programs, public workshops, social media campaigns, business engagement and so on (Community Places, 2013).

Planners also can use creative approaches to involving the community. For example, in early 2017, MassDOT transformed a parking lane into pop-up bus lane in Downtown Everett to test the feasibility of implementing permanent transit lanes (Miller, 2017). During this process, the public was able to evaluate the benefits of the transit lane and the impact of reduce parking spaces. The pilot was success, providing the city with the evidence they needed to implement the transit lane permanently (Transit Center, 2018). This project also highlights the benefits of limited implementation as an approach rather than ongoing deliberations.

I recommend that the City, first, identify interested stakeholders including local residents; second, use diverse strategies to engage different groups; and third, make use of stakeholder feedback to devise a plan that benefits the general public.

05 MULTI-MODAL ENVIRONMENT

This research largely focuses on the feasibility of transforming Washington Boulevard from a driving-oriented street into a transit priority corridor, hopefully enhancing the use of transit for first/last mile connections and local/regional circulation. The proposal fits into the city's goal of creating multi-modal, safe, efficient, convenient, and social environments that prioritize the use of transit, biking, walking, and other innovative modes of travel. To do this, the proposed plans must be aligned with the City's broader vision that includes housing, safety, public health, climate change, etc.

CONCLUSION

The project presents a set of bus lane design concepts based on a three-part analysis of (a) existing research on transit lanes (b) existing conditions, and (c) a field audit. I propose four different design concepts including a Westbound Only Bus Lane, Westbound Only Bus Lane with Elevated Bike Lanes, Two-Way Bus Lanes with Elevated Bike Lanes, and Two-Way Bus Lanes with Elevated Bike Lanes and a Reversible Traffic Lane. After evaluating these four concepts, I recommend that Culver City implement the Westbound Only Bus Lane as a near-term plan, and work toward implementing Two-Way Bus Lanes in the long-term and as part of broader planning efforts for Washington Boulevard. The effectiveness of all four design concepts would be enhanced by transit signal priority, curb extensions, lane width modifications, and color and markings to clearly designate the lane(s).

In order to bring the project closer to implementation, I also recommend several issues for further study. These elements include additional data collection and analysis of:

- The physical and social implications of the proposed design concept(s);
- The operation period and access policy;
- How best to engage diverse stakeholders and community members; and
- Other enhancements to encourage greater multi-modal travel and to ensure the efficiency and safety of all travelers.

This report is an initial examination of the feasibility of implementing a bus lane on Washington Boulevard. The further development of these design concepts will require input by the public and various stakeholders to ensure the project moves forward in a unified, cohesive manner.

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TRANSIT FIRST

Culver City Washington Boulevard Transit Lane Feasibility Study

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