Next-Generation Bicycle Facilities

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Executive Summary

Purpose

The purpose of this report is to widen the appeal of cycling to a broader group of cyclists by recommending the implementation of protected bike lanes in Santa Cruz. Given our limited time, we focused on a high-priority site where protected bike lanes could be most impactful. Water Street is identified as a high-priority site due to its connectivity and access to schools and businesses. Therefore, in order to welcome more cyclists we recommend implementing protected bike lanes along the segment of Water Street between Ocean Street and N Branciforte Avenue. GIS data is used to support Water Street as a connecting corridor and also shows the need for safer bicycle infrastructure along this route. Santa Cruz can increase the percentage of commuters who bike and improve road safety for all users simply by implementing protected bike lanes. The benefits of protected bike lanes come at low costs and require minimal infrastructure changes.

This Report:

- Assesses the available bicycle facilities in Santa Cruz and identifies key routes based on proximity to destinations (schools, businesses, recreation, etc.) and bicycle safety (collisions, traffic volumes, and travel speeds).
- Identifies a high-priority site by ranking routes based on safety and connectivity.
- Recommends feasible bike facilities that fit existing street dimensions and follows the National Association of City Transportation Officials.

Development

The Next-Generation Bicycle Facilities report was developed as part of a senior seminar group project through the University of California, Santa Cruz. Jesus Contreras and Shirley Chun, both Environmental Studies undergrad students, worked under the supervision of Professor Adam Millard-Ball to develop this report.

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Introduction

Background and Purpose

In Santa Cruz, there is a lack of bicycle facilities that reflects the low percentage of bicycle trips for intra-city travel, especially for trips within the east side, which currently has the lowest bicycle mode share percentage. Small cities like Santa Cruz make cycling easier because commute trips tend to be shorter. However, a big obstacle for cyclists in Santa Cruz is the topography which requires more effort from cyclists who need to travel uphill. Other than distance and topography, safety is the other major factor that could be driving down bicycle ridership. It has been widely researched that perceived safety has a stronger influence than actual safety for commuters deciding between cycling or driving. There is a big opportunity here for protected bike lanes because the safety improvements are visible. Due to the lack of separation between cars and bikes, cyclists are forced to ride next to cars restricting bike use to those who are fearless and confident. The lack of street accommodations for cyclists results in overwhelming traffic volumes which have been shown to be detrimental to cities. In Santa Cruz, there is serious congestion along the major roads and highways during peak hours. Not only does this increase CO_2 levels in the atmosphere, but it also makes the city less accessible, noisier, and brings down the overall health of the community. The City of Santa Cruz has made multiple efforts to combat traffic congestion with its Active Transportation Plan and its extended analysis on the 3 cross-city corridors. This report aims to analyze the reasons for the lack of bicycles on the designated bike routes and identify priority sites for design improvements as a way to streamline the much needed bicycle infrastructure to make Santa Cruz more accessible.

This report identifies a key corridor from a subset of connecting corridors where protected bike lanes could be implemented to increasing bike ridership. We will characterize a subset of corridors based on bicycle safety, connectivity, and need for improvement. Based on this data, the corridor with the lowest level of cycling safety where design improvements could incentivize more cyclists on the road will be chosen to prioritize for improvement. Collision data and safety audits will also be used to identify priority sites on the corridor for improvements.

The segment of Water Street between Ocean and N Branciforte Avenue was identified as a high-priority site. It connects the east side residential neighborhoods to the downtown businesses and there are many storefronts, restaurants, and schools that fall along the street. Water Street has the potential to serve as a high capacity bike route given the many

destinations it serves, but the current lack of bicycle accommodations creates stressful bike experiences, hindering this potential. The current bike lane designs have resulted in fast travel speeds, high traffic volumes and minimal separation of cars and bikes which results in high collision rates along the street. Such street characteristics are unwelcoming to cyclists which increases the perceived risk of cycling on this route, detering commuters away from cycling. Therefore, we recommend reducing the width of car lanes and installing protected bike lanes along this segment in order to accomodate a wider range of cyclists and reduce the perceived risk.

The protected bike lane will effectively improve safety with physical separation of bikes and motor vehicles as well as perceived safety with physical objects. It has been widely researched that perceived safety has a greater influence when deciding travel modes than actual safety and, coincidently, protected bike lanes are visually safer. Additionally, the reduced car space will slow down travel speeds making the street safer for all users. Furthermore, the desirability of driving could be diminished with slower travel speeds, directly reducing traffic volumes which will reduce the level of motorized traffic stressed imposed on cyclists.

The benefits of protected bike lanes on Water Street come at a low cost and with minimal infrastructural changes. Few parking spots on Water Street will be removed (2 spots in front of Dig Gardens) to make room for the protected bike lane and the only infrastructure changes required are re-striping and installing of flexi-posts or bollards. This report is presented to demonstrate the ease of promoting bicycle use with protected bike lanes and the minimal cost and infrastructural changes required to do so. As such, Water Street is an ideal candidate to pilot protected bike lanes in Santa Cruz; if successful, they can be a model for elsewhere in the city.

Existing Conditions

The following section describes the existing conditions of the current bike network in Santa Cruz by identifying a subset of bike routes and ranking them based on characteristics such as travel speeds, traffic volumes, available bicycle facilities, and collisions. From this ranking system, we identify a route to focus on for our design recommendations.

Setting

The City of Santa Cruz is located in Santa Cruz County, California with a total land area of 12.7 square miles. The University of California, Santa Cruz (UCSC), established 1965, is located on the edge of the city, and brings in more students every year. The lack of on-campus student housing and numerous jobs make UCSC a major destination. Other notable destinations are downtown and the Beach Boardwalk. Although these destinations are within close proximity of each other, the city's topography is disadvantageous for cyclists cycling to destinations on higher elevations. The city has made recent efforts under the Active Transportation Plan to accommodate cyclists on busy streets with green bike lanes. Unfortunately, these designs lack the protection necessary for motivating cyclists out of their cars. The following graphics detail the travel patterns and current bicycle infrastructure in Santa Cruz.

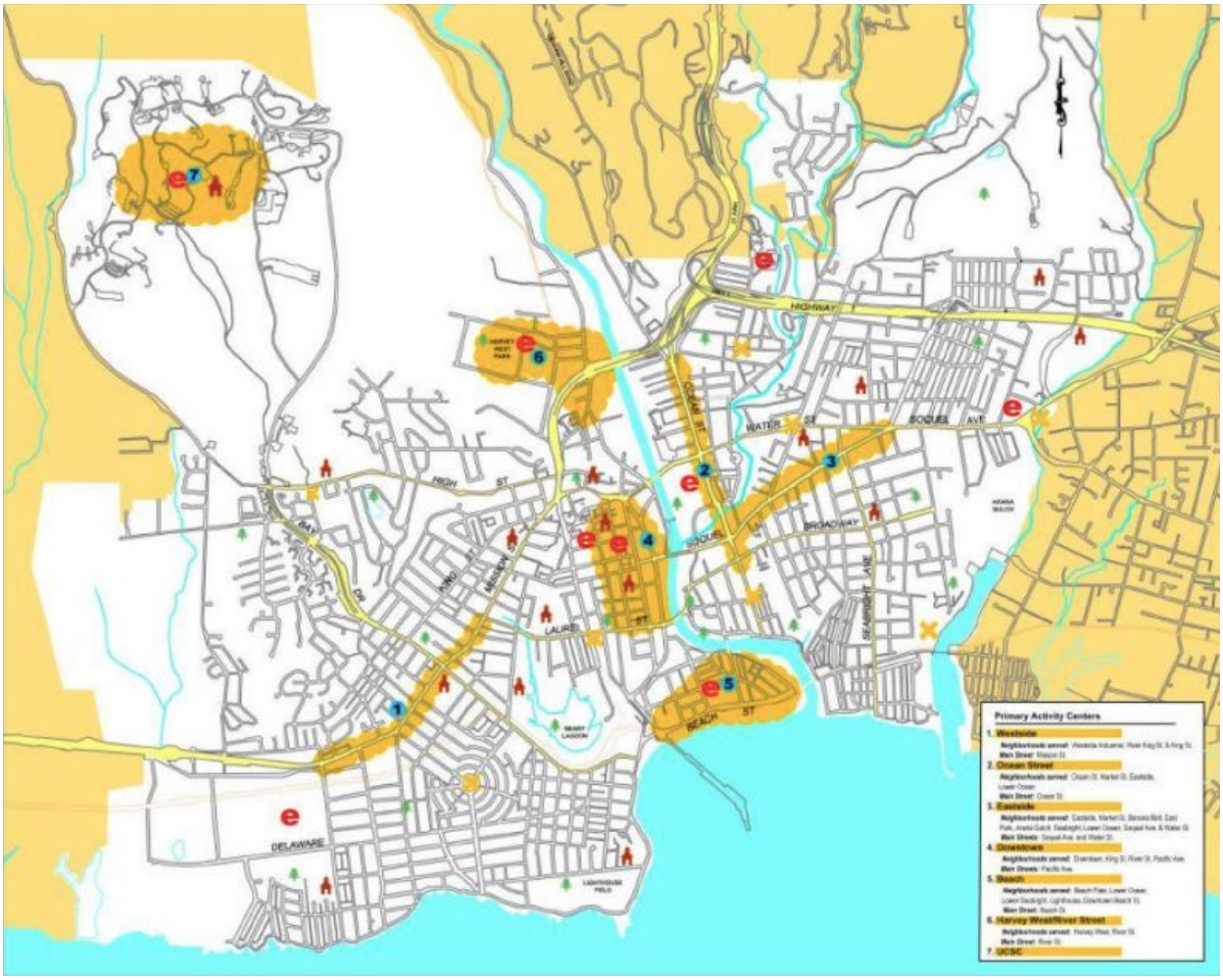

Figure 1. Active Destinations. Map gathered from the Santa Cruz Active Transportation Plan.

Figure 1 Highlights the active destinations in yellow and represents schools with red markings. Most of the destinations are located on the east side, along the river, and are close enough for bike travel to be a feasible choice for many people. The furthest destination is UCSC which accounts for many of the commute trips in Santa Cruz but is also serviced heavily by the public transit system (Metro). With such close destinations and a supporting bus service, we would expect few car trips but according to the travel patterns in Figure 2, car trips dominate the streets.

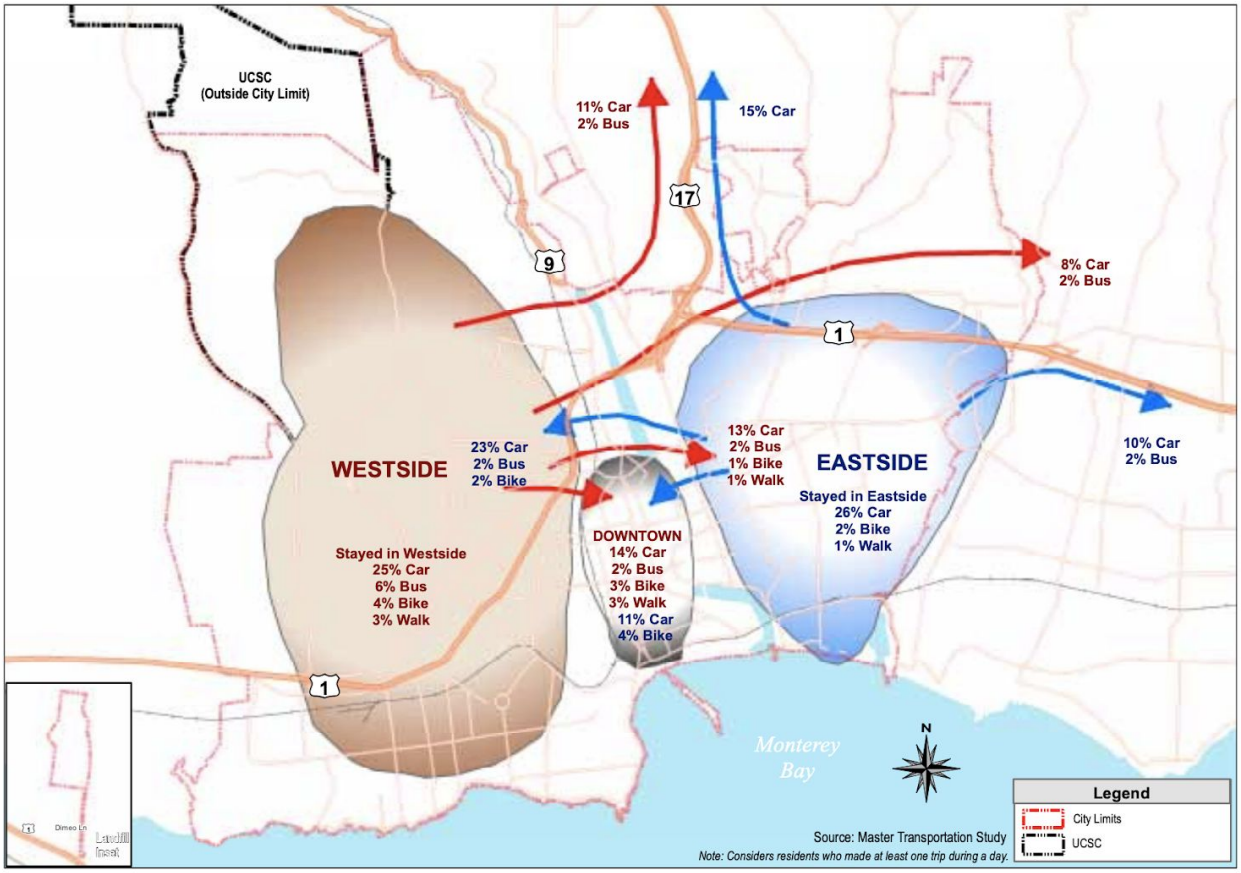

Figure 2. Resident Daily Travel Patterns. Source: Santa Cruz Active Transportation Plan.

Figure 2 shows the low percentage of bicycle trips, even for neighborhood commutes which are less than 5 miles. Here we see the potential bicycles have for alleviating some of the traffic congestion by replacing some of the short commute trips. By comparing this map with the existing bike routes, we can see which routes serve as connecting corridors.

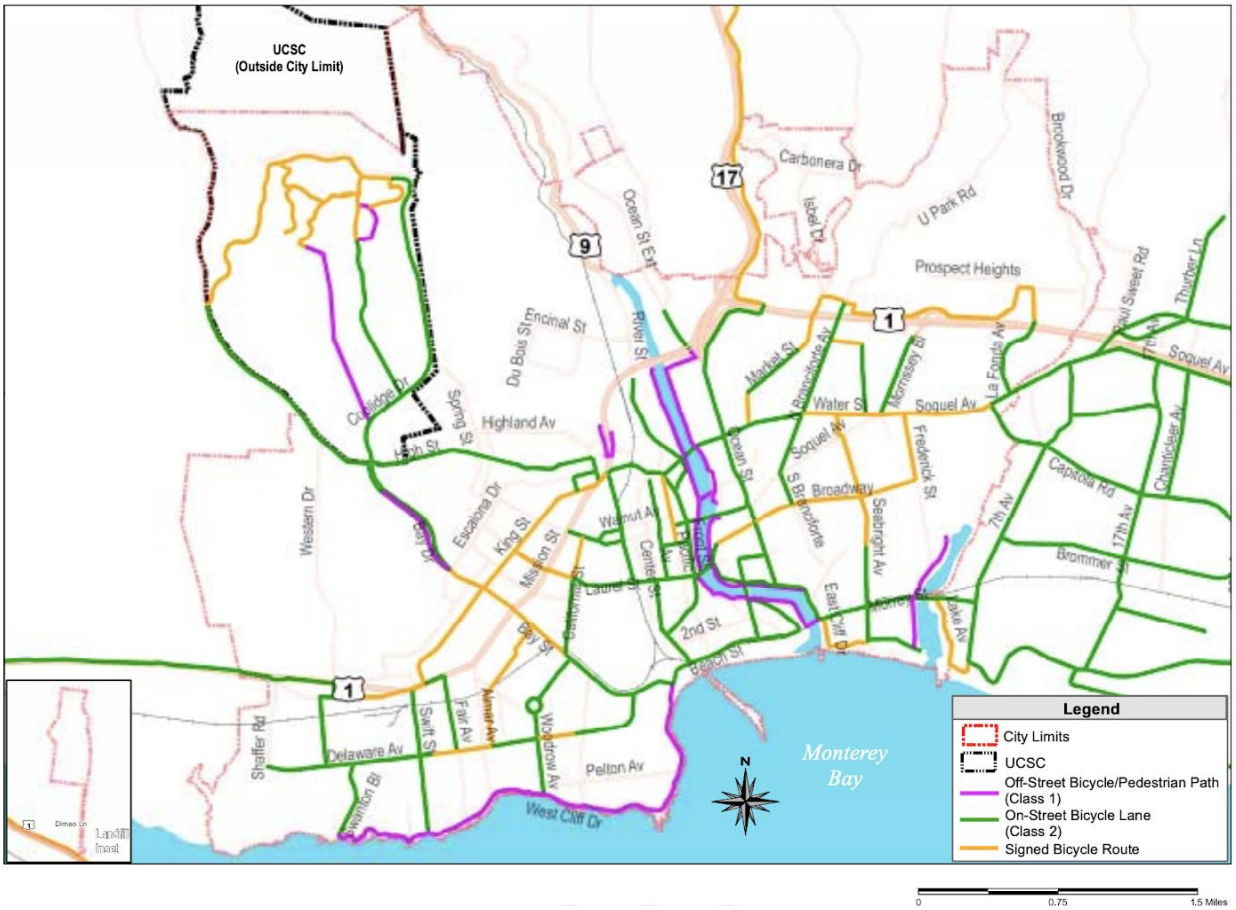

Figure 3. Bike Routes. Map gathered from the Santa Cruz Active Transportation Plan.

Figure 3 shows the designated bike routes in Santa Cruz. This map shows which streets are designated as bike routes. Here, we see the discontinuity along the overall bike network which could be a factor for why people choose not to bike. A closer look at the bicycle accommodations on the identified bike routes exemplified the lack of safety associated with such designs.

Figure 4. Green Bike Lanes on Water Street at Ocean Street intersection. Source: Google Maps

Figure 4 is an example of the green bike lanes recently implemented as part of the Active Transportation Plan. Although these efforts were intended to welcome more cyclists, they do not provide the necessary protection to accommodate the wide range of cyclist needs. With this design, cyclists are still forced to cycle in between car lanes with no added protection that physically separates both users. Furthemore, this design does little to reduce travel speeds and does not facilitate cyclists making left turns or traveling through the intersection. Although the city has made recent infrastructural changes to increase cycling rates, such designs do not cater to the safety needs of less confident cyclists. Therefore, if the city aims to increase cycling rates, officials should consider protected bike lanes.

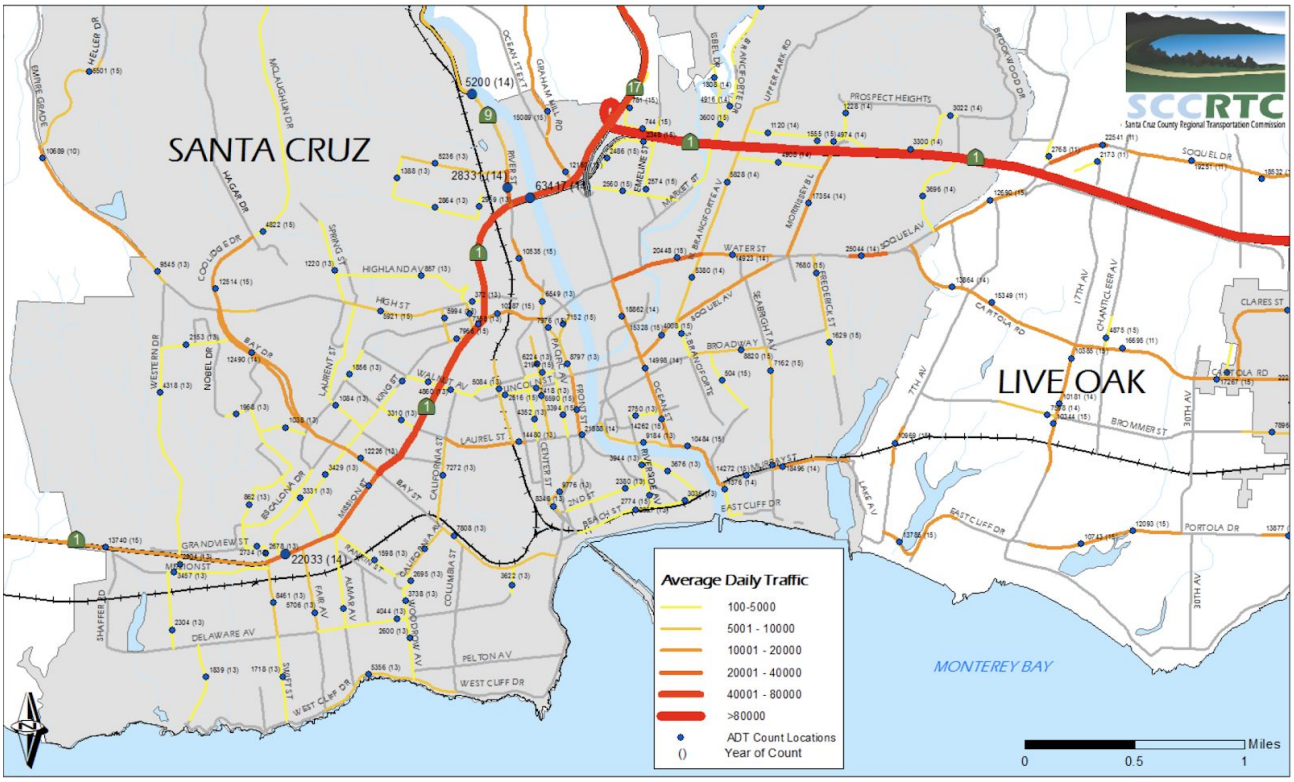

Figure 5. Average Daily Traffic. Source: Santa Cruz Active Transportation Plan

Figure 5 shows the Average Daily Traffic (ADT) on Santa Cruz streets. According to the Dutch guidelines for bicycle infrastructure, referenced in the Level of Traffic Stress[1] criteria, ADT should be less than 5,000 if bikes are to operate with mixed traffic. In Santa Cruz, there are multiple streets that are designated as bike routes where the ADT exceeds 5,000. According to Dutch guidelines, such streets require separated bike facilities which currently do not exist in Santa Cruz. The lack of bicycle protection on busy streets creates dangerous environments for the few brave cyclist on the road.

[1] Level of Traffic Stress is a common rating system that indicates how much stress a given combination of traffic volumes, speeds and (lack of) bicycle infrastructure imposes on cyclists. See the more detailed description below, and http://www.northeastern.edu/peter.furth/research/level-of-traffic-stress/

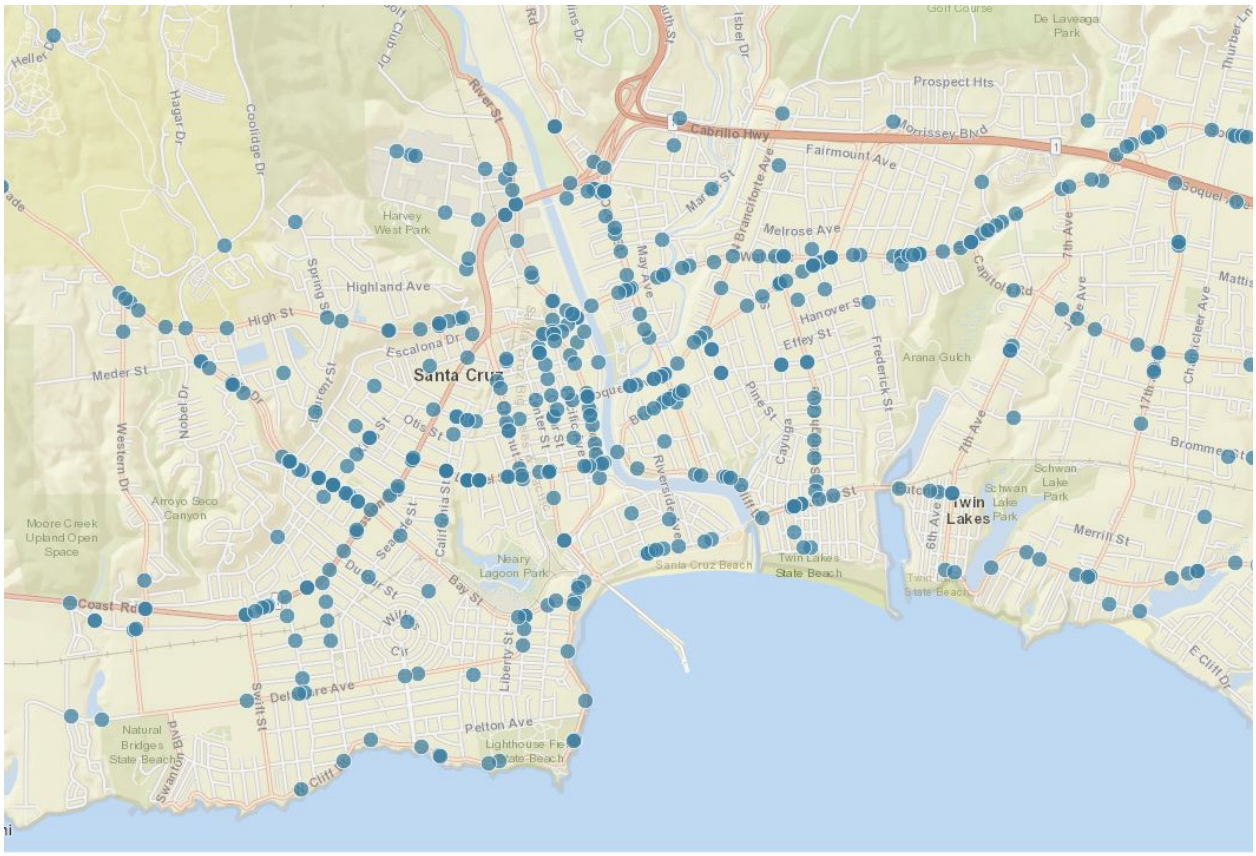

Figure 6. Bicycle Collisions in Santa Cruz from 2013-2017. Source: Transportation Injury Mapping System using SWITRS.

Figure 6 maps out bicycle and car collisions in Santa Cruz. This data, identifies areas that are most dangerous to cyclists. The high traffic volumes and non-existence of protected bike lanes could be a direct cause for high collision rates along busy streets. The current bicycle network in Santa Cruz is unsafe for cyclist making bike use a dangerous option for less confident cyclists and children.

Selection Process and Criteria

The process for selecting a subset of routes for which we recommend design improvements involves multiple stages of analysis. We started by mapping out any existing bike networks in Santa Cruz from which we would then choose a subset of corridors to focus on. Based on this map, we selected a few routes for a more detailed study, then ranked the routes using the following criteria:

- Travel patterns and connectivity — Where and how are people traveling within Santa Cruz? Figure 1 shows the active destinations that attract commuters, such as retail, jobs, schools. Key routes would lead to or run along these locations.
- Average Daily Traffic — Which corridors would benefit from traffic calming designs to make them safer for cyclists, given high traffic volumes? (Figure 4)
- Collisions — Which corridors have a high rate of bicycle collisions? Routes with high collision rates will be prioritized to improve safety.
- Existing bicycle facilities — Which corridors are designated bike routes but lack certain design elements necessary for welcoming new cyclists? (Figure 3)

Based on this criteria, we chose a subset of four bike routes that coincided with the travel patterns and lead to the active destinations for further analysis as to why people were choosing to drive rather than bicycle — Water Street, King Street, Broadway Avenue, and Delaware Street.

Below is a list of the four corridors we decided to focus on and a brief reasoning:

- King Street
    - King Street runs parallel to Mission Street, which has multiple retail shops and restaurants. King is an important alternative route to Mission and is a Safe Route to School for Bay View Elementary, West Lake Elementary, Mission Hill Middle, and Santa Cruz High students. Although the average daily traffic and collision rates are relatively low, traffic speeds are still currently too high to consider it as a safe route for children to get to and from school. This route could benefit from traffic calming street designs to make it safer for kids to bike to school. King Street has been identified as a high priority project in the Active Transportation

Plan, with recommendations to install safe, continuous, and appropriate bike facilities along this street.

- Broadway Avenue
    - Broadway Avenue is a designated bike route that connects to the Arana Gulch trail. It leads to Downtown, runs next to destinations on the East Side, and serves as a connecting route from Downtown to the East Side. However, high traffic speeds could be discouraging to potential cyclists who may be less confident riding alongside high speed traffic.

- Water Street
    - Water Street is a high volume corridor for motorized vehicles that runs through the East Side and into Downtown, connecting multiple activity centers and destinations together. Currently, high collision rates, fast traffic speeds, and high average daily traffic makes it unsafe for less experienced cyclists. This street has been identified as a high priority project in the Active Transportation Plan, with recommendations to focus on intersection improvements and to pursue protected or buffered bike lane treatments.

- Delaware Street
    - Delaware Street is a major connector for the West Side and serves as a connection to the Boardwalk. However, there are discontinuous bike routes and sidewalks along the route, with bike lane gaps between Swift and Surfside and between Woodrow and Columbia, and large distances of missing sidewalks. Delaware has been identified as a high priority project in the Active Transportation plan, with recommendations to fill the remaining sidewalk and bike lane gaps to make this street a continuous active transportation corridor.

Once the subset of four bike routes was identified, we focused our analysis on identifying a single corridor where next-generation facilities can be implemented on priority sites to broaden cycling appeal to a broader group of cyclists. Our analysis includes a comparative view of the data above as well as the Level of Traffic Stress (LTS) measurement. The LTS measurement was developed by researchers at the Minnesota Transportation Institute and provides a data driven approach to evaluate bikeways based on roadway designs, traffic volumes and traffic speeds. LTS ultimately measures the level of traffic stress imposed on cyclists. Levels of traffic stress range from 1 - 4 as follows (provided by Peter G. Furth).

- LTS 1: Strong separation from all except low speed, low volume traffic. Simple crossings. Suitable for children.
- LTS 2: Except in low speed / low volume traffic situations, cyclists have their own place to ride that keeps them from having to interact with traffic except at formal crossings. Physical separation from higher speed and multi-lane traffic. Crossings that are easy for an adult to negotiate. Corresponds to design criteria for Dutch bicycle route facilities. A level of traffic stress that most adults can tolerate, particularly those sometimes classified as “interested but concerned.”
- LTS 3: Involves interaction with moderate speed or multi-lane traffic, or close proximity to higher speed traffic. A level of traffic stress acceptable to those classified as “enthused and confident.”
- LTS 4: Involves interaction with higher speed traffic or close proximity to high speed traffic. A level of stress acceptable only to those classified as “strong and fearless.”

The Level of Traffic Stress for each route — Broadway, King, Delaware, and Water, are measured to get the characteristics of the route and to understand how the route is currently operating. The collected data is used to understand the sites and to understand the importance of having bike routes/bike paths at the site. It can also be a way to see the level of bicycle safety and to identify corridors where next-generation bicycle facilities could be implemented to reduce the Level of Traffic Stress to a manageable level (LTS 1 or 2).

Route	Average Daily Traffic	Bike Collisions 2013-2017	Existing bike facilities	Traffic Speed	Level of Traffic Stress
Broadway	5,000 - 10000	14	Signed bicycle route	29 - 30 mph (River - Frederick) 31mph on Laurel	2
King	1,000 - 5,000	9	Signed bicycle route	26 mph	2
Delaware	1,000 - 5,000 (incomplete data)	8	Signed bicycle route and on-street bicycle lane alternating	32 - 35 mph	2 - 3
Water	1K-2K & 2K-4K (incomplete data, increased traffic could be due to freeway exit)	22	Signed bicycle route w on-street bicycle lane after bancroft	33 mph	2 - 3

Table 1. Comparison of the identified subset of bike routes in Santa Cruz.

Table 1 compares the four bicycle routes according to specified safety characteristics. From this table it is clear that Water Street is the most dangerous and stressful for cyclists. It has the highest rate of collisions and average daily traffic as well as relatively high travel speeds and high traffic stress. As a whole, the Water Street corridor is least welcoming to cyclists according to this data. For this reason, we chose to focus on Water Street for design improvements. Although Delaware Street also has high travel speeds and high levels of traffic stress, it is not as connecting of a route as Water Street. As for Broadway Avenue and King Street, both being effective connector streets, they do not suffer from the same level of traffic stress, traffic volumes and dangerous speeds as Water Street.

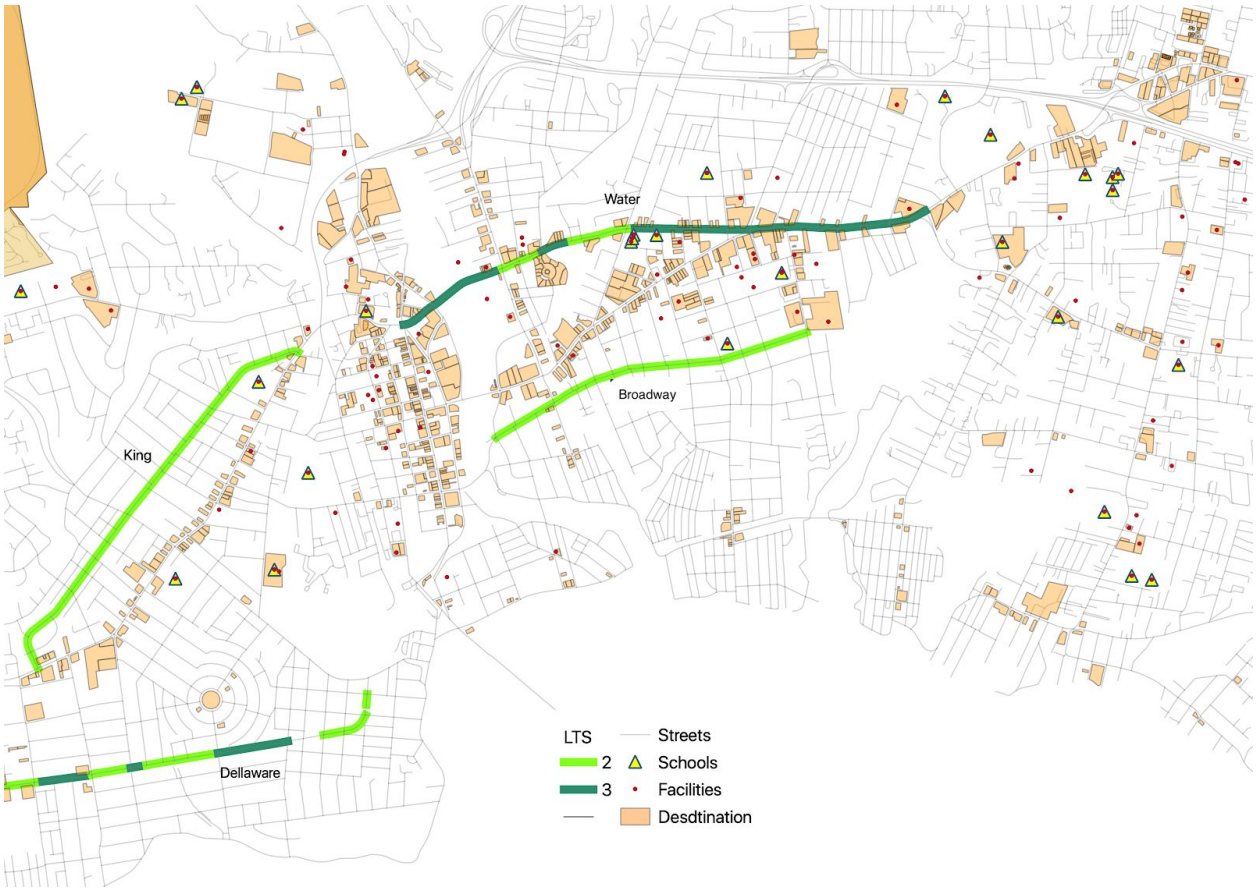

Figure 7. Level of Traffic Stress by segment (data provided by the Santa Cruz County)

Figure 7 maps out the level of traffic stress by segment on each of these corridors and shows their proximity to destinations, facilities and schools. Here, we see the connectivity of Water Street and the high level of traffic stress along that corridor. With next-generation bikeway designs to reduce traffic stress on Water Street, bicycle safety can be improved to effectively increase ridership across different groups.

Out of the four identified routes, Water Street has the highest level of traffic stress, the highest rate of collisions, and the most discontinuous streets. Water Street is a direct route where high levels of traffic stress are discouraging less confident cyclists from getting on their bikes. Currently, only about 1-3% of commuters in Santa Cruz travel by bike. Water Street is a connecting arterial street getting residents through and between Santa Cruz. Therefore, it has the biggest potential to connect multiple bike paths and activity centers to become part of a bigger bike network that connects Santa Cruz east to west and within the two sides. If improved, Water Street could connect the main activity centers on the east side to downtown west side. It could become a route that connects residents to their destinations such as jobs, retail, groceries, schools and the Metro Station.

Water Street by Segments					
	Average Daily Traffic	Bike Collisions 2013-2017	Existing Bike Facilities	Traffic Speed Limit	Level of Traffic Stress
Branciforte — Reed	20,000 - 25,000	2	Bike lanes with 4 lane traffic and raised median	25 mph	2
Reed — Market	20,000 - 25,000	3	Bike lanes with 4 lane traffic	30 mph	3
Market — Ocean	20,000 - 25,000	1	Bike lanes with 4 lane traffic and raised median	30 mph	2
Ocean — River	20,000 - 25,000	9	Bike lanes next to parking with 4 lane traffic and raised median	30 mph	3
River — Pacific	20,000 - 25,000	3	Bike lanes with 4-5 lane traffic and raised median	30 mph	3

Table 2. Segment by segment analysis of Water Street.

To determine which segments to focus our recommendations on, we used Average Daily Traffic, number of collisions, traffic speed limit, and examined the existing bike facilities to determine the level of traffic stress for each segment of Water Street. Based on this criteria and the LTS for each segment, we decided to focus on the segments between Ocean and Branciforte.

Recommendations

Overview

We will start this recommendations section of the report off with an overview of some general design guidelines used by the National Association of City Officials (NACTO). Following, we will break Water Street down into segments and give more detailed design recommendations that follow the NACTO guidelines. In general, we recommend narrowing the driving lanes in order to install protected bike lanes all along Water Street. The NACTO Urban Design Guidelines has shown that narrower driving lanes are appropriate in urban areas and have a positive impact on a street's safety by discouraging speeding without impacting traffic operations. We also recommend moving back stop lines and putting in bike boxes at intersection to minimize conflicts and facilitate a safer and easier left turn for cyclists. Because Water Street is a busy transit corridor, we recommend a wider outside bus lane and floating bus stops (i.e., bus stops that do not block the bicycle lane). We also recommend raised crosswalks at intersections to act as a speed table to slow travel and turning speeds. Furthermore, NACTO also has design guidelines that accommodate driveways and bus stops which are common along Water street. The graphic below from the NACTO Urban Bikeway Design Guidelines goes into more detail about specific design guidelines:

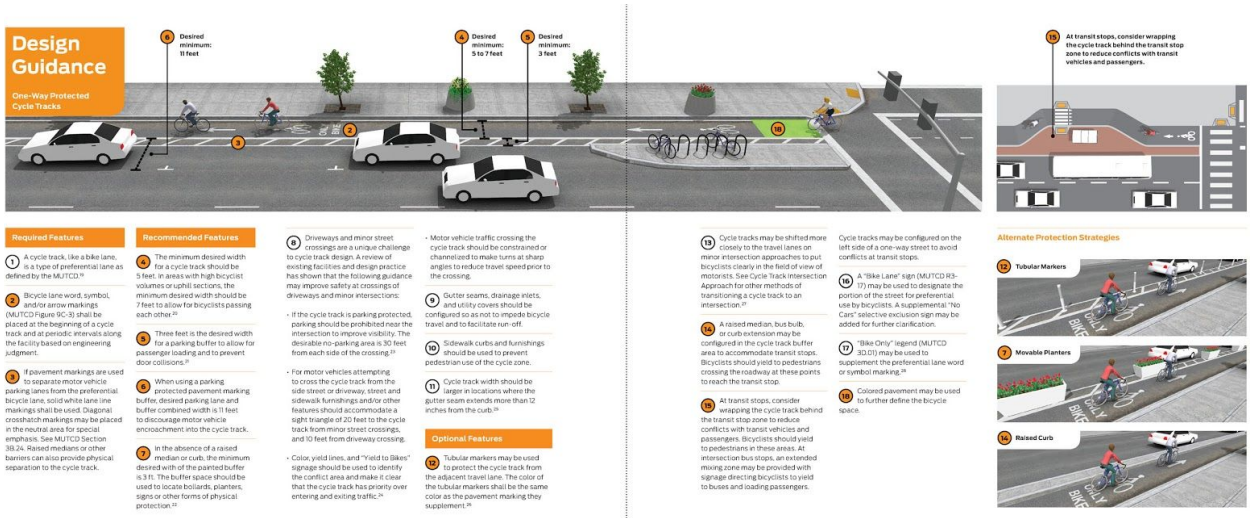

Figure 8: NACTO Design Guidance for one-way protected cycle tracks. Source: https://nacto.org/publication/urban-bikeway-design-guide/

Design Guidelines and Recommendations

- Driving lane widths
    - The NACTO Urban Bikeway Design Guidelines states that driving lane widths of 10 feet are appropriate and provide adequate safety in urban areas and have a positive impact on a street's safety by discouraging speeding without impacting traffic operations. For busy transit routes, a wider outside lane (curbside or next to parking) on each side of the street may be used to accommodate larger transit vehicles.

- Protected bike lanes / One-way protected cycle tracks
    - Narrowing driving lanes leaves space to widen the bike lanes and to add a physical buffer, either with bollards or flexi-posts, between the driving and bike lanes. The NACTO guide requires a minimum width of 5 feet for bike lanes and recommends a width of 6 feet when the lane runs adjacent to a curb face. For uphill sections, a minimum width of 7 feet is recommended to allow for cyclists to pass each other.

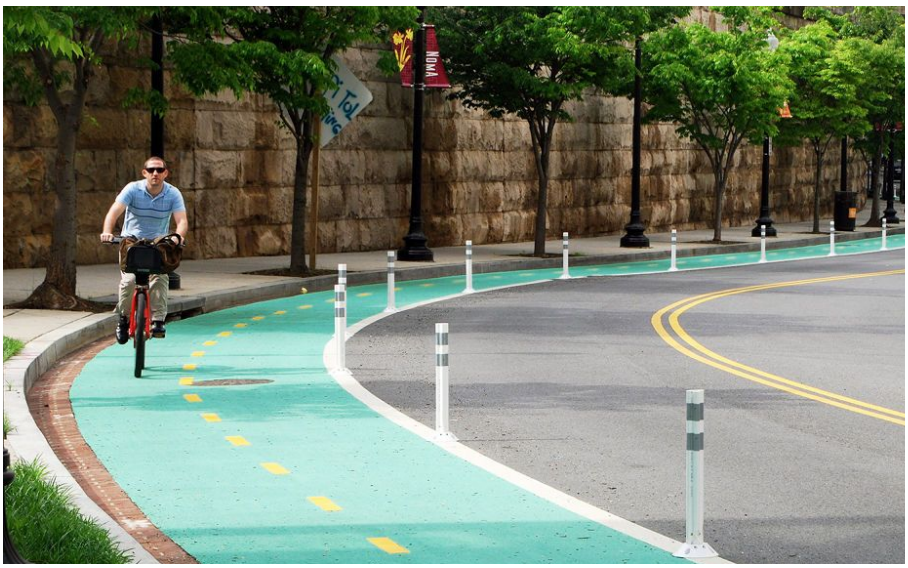

Figure 9: Protected Bike Lane. Source: Charlotte Series.

- Parking protected bike lanes
    - Parked cars can be used as a physical barrier between the bike lane and driving lane. According to the NACTO guide, parking protected bike lanes improves a cyclist's perceived comfort and safety. It also reduces the risk of "dooring" and prevents double-parking. The NACTO guide also recommends that parking should be prohibited 30 feet from each side of the intersection and driveways to improve visibility.

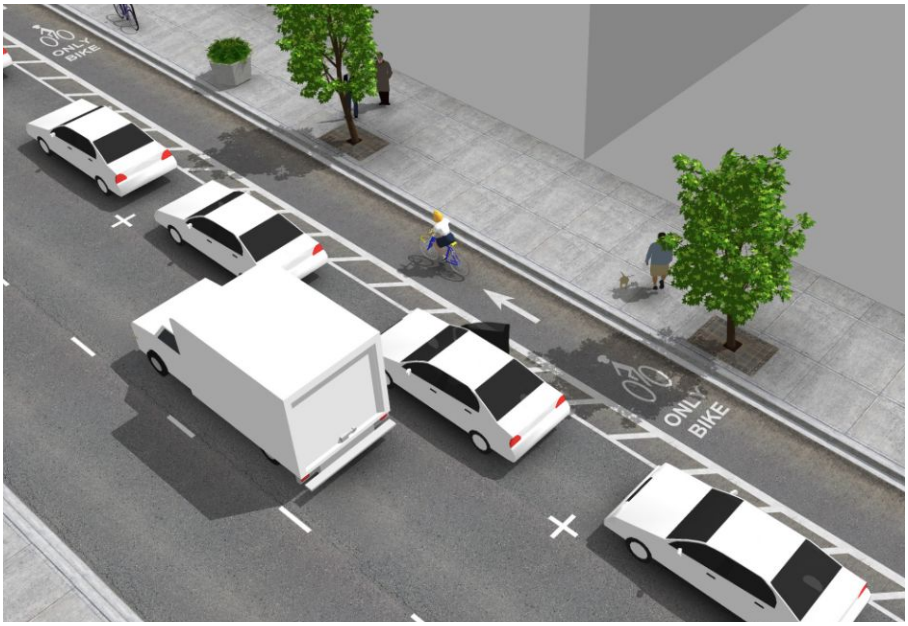

Figure 10: Parking Protected Bike Lane. (1/2)

Figure 11: Parking Protected Bike Lane. (2/2) Source: City of Burlington, VT.

- Floating bus stops
    - Floating bus stops prevent buses from blocking or driving through a bike lane when picking up or dropping off passengers. Our recommendation for floating bus stops allow passengers to wait at the sidewalk and cross through the bike lane to board the bus stopped in the travel lane. Although this creates conflict between pedestrians and cyclist at the bus stop, it prevents the bus from merging into the bike lane which is more dangerous than crossing pedestrians. Furthermore, if the bus can stop in the travel lane, there is no need to reintegrate into the driving lane which could speed up transit times. Where space permits, a waiting platform could be installed between the bike lane and the travel lane.

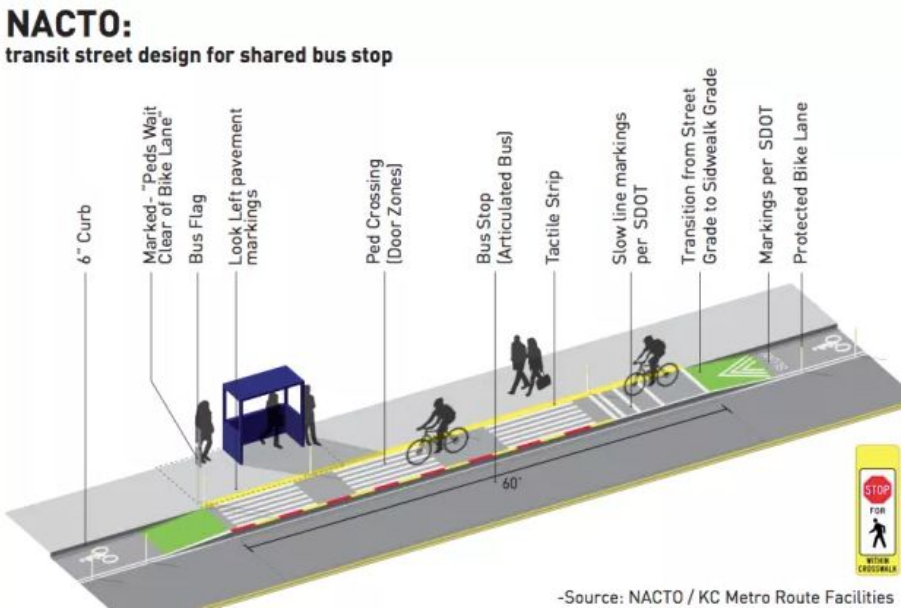

Figure 12: Floating Bus Stop. Source: https://nacto.org/publication/urban-bikeway-design-guide/

- Pedestrian safety islands / Median refuge islands
    - Pedestrian safety islands or median refuge islands are protected spaces in the middle of the street which reduce the crossing distance. Pedestrian safety islands should be at least 6 feet wide (recommended 8-10 feet wide), but where a 6 foot median is not possible, a narrower 4 foot raised median is still preferred over nothing.

Figure 13: Pedestrian Safety Island. Source: https://nacto.org/publication/urban-bikeway-design-guide/

- Speed tables / Raised crosswalk
    - Speed tables are traffic calming devices that raise the entire wheelbase of a vehicle to reduce its speed. Speed tables have a height of 3 - 3.5 inches and a length of 22 feet, and are longer than speed humps. When a speed table coincides with a crosswalk, it should be designed as a raised crosswalk. Speed tables should be accompanied by a sign warning drivers (MUTCD W17-1) and a pedestrian sign (W11-2) at raised crosswalks.

Figure 14: Raised Crosswalk. Source: https://nacto.org/publication/urban-bikeway-design-guide/

- Bike boxes
    - Pushing back the stop line and adding in a bike box between the crosswalk and stop line helps facilitate an easier and safer left turn for cyclists. In addition, bike boxes increase the visibility of cyclists and provides priority for cyclists at signalized intersections. This helps minimize conflict with turning vehicles and allows groups of cyclists to clear the intersection quickly, minimizing impediment to traffic.

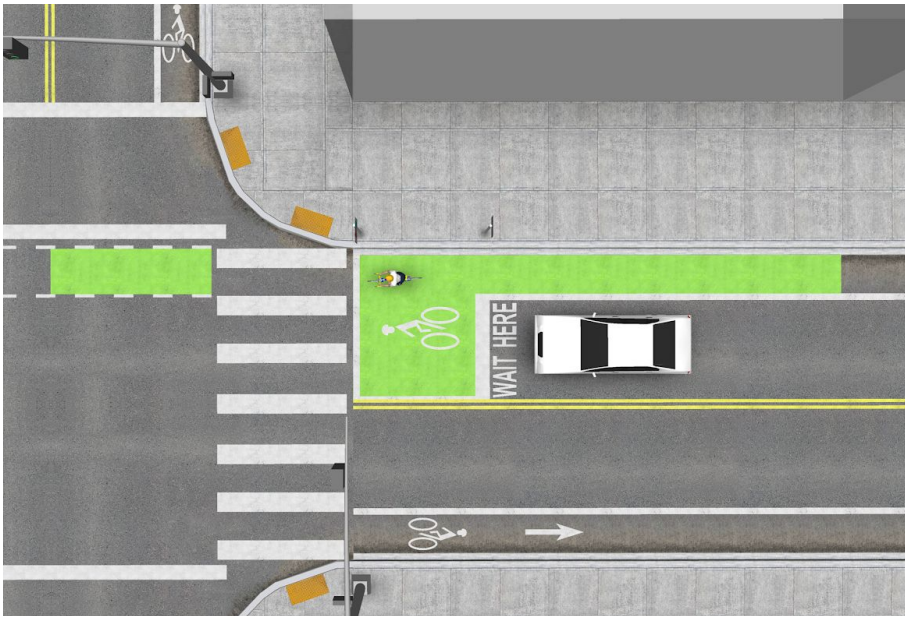

Figure 15: Bike Box. Source: https://nacto.org/publication/urban-bikeway-design-guide/

- Signal priority
    - Signal priority for cyclists at signalized intersections gives cyclists a head start when entering an intersection, giving them the right-of-way over turning vehicles. A leading bicycle interval helps reduce conflicts and collisions by simplifying bicycle movements through intersections, providing priority to bicycle movements, and protecting cyclists in the intersection, which may improve real and perceived safety.

Figure 16: Bicycle Signal Priority. Source: Grist.org

Programmatic Recommendations

Street Segment	Recommendations
Branciforte — Reed Refer to Figure 17 for an aerial image of the segment Refer to Figure 18 for specific street dimensions	● Narrowing driving lanes ○ Narrow driving lanes, but keep a wider outside lane on either side of the street for larger transit vehicles. ● Protected bike lanes / One-way protected cycle tracks ○ Implement a protected bike lane with physical buffers. The NACTO guide recommends bike lanes be a minimum of 7 feet in uphill sections to allow for cyclists to pass each other. ● Bike box ○ Add a bike box to facilitate an easier and safer left turn for cyclists onto Branciforte Avenue. ● Floating bus stop ○ Add floating bus stop to prevent buses from blocking or driving through a bike lane to pick up or drop off passengers and add to the physical separation between the bike lane and driving lane.
Reed — Market Refer to Figure 19 for an aerial image of the segment Refer to Figure 20 for specific street dimensions	● Narrowing driving lanes ○ Narrow driving lanes, but keep a wider outside lane on either side of the street for larger transit vehicles. ○ Keep, but narrow the center turn lane to still allow cars to turn into the driveways of businesses along both sides of the street. ● Protected bike lanes / One-way protected cycle tracks ○ Implement a protected bike lane with physical buffers. The NACTO guide requires a minimum width of 5 feet for bike lanes and recommends a width of 6 feet when the lane runs adjacent to a curb face. ● Parking protected bike lanes ○ On the side of the street with existing parking, keep all the parking spots, but move them to the left of the bike lane to create a physical barrier between the bike lane and driving lane.

Market — May Refer to Figure 21 and Figure 23 for an aerial image of the segment Refer to Figure 22 for specific street dimensions	● Narrowing driving lanes. ○ Narrow driving lanes, but keep a wider outside lane on either side of the street for larger transit vehicles. ● Protected bike lanes / One-way protected cycle tracks ○ Implement a protected bike lane with physical buffers. The NACTO guide requires a minimum width of 5 feet for bike lanes and recommends a width of 6 feet when the lane runs adjacent to a curb face. ● Bike box ○ Add a bike box to facilitate an easier and safer left turn for cyclists. ● Floating bus stop ○ Add floating bus stop to prevent buses from blocking or driving through a bike lane to pick up or drop off passengers and add to the physical separation between the bike lane and driving lane. ● Pedestrian safety islands / median refuge islands ○ Add pedestrian safety islands to facilitate easier and safer pedestrian crossings.
Ocean & Water Intersection Refer to Figure 24 for an aerial image of the segment Refer to Figure 25 for specific street dimensions	● Narrowing driving lanes. ○ Narrow driving lanes, but keep a wider outside lane on either side of the street for larger transit vehicles. ● Protected bike lanes / One-way protected cycle tracks ○ Implement a protected bike lane with physical buffers. The NACTO guide requires a minimum width of 5 feet for bike lanes and recommends a width of 6 feet when the lane runs adjacent to a curb face. ● Bike box ○ Add a bike box to facilitate an easier and safer left turn for cyclists. ● Floating bus stop ○ Add floating bus stop to prevent buses from blocking or driving through a bike lane to pick up or drop off passengers and add to the physical separation between the bike lane and driving lane.

	● Pedestrian safety islands / median refuge islands ○ Add pedestrian safety islands to facilitate easier and safer pedestrian crossings. ● Raised crosswalk ○ Raise existing crosswalks to create traffic calming devices. ● Signal priority ○ Implement a leading bicycle interval at intersection to provide priority to cyclists and reduce conflicts and collisions.

Table 3: Water Street design recommendations by segment.

Figure 17: Aerial view of the new proposed designs for Water Street at the Branciforte to Reed Street segment.

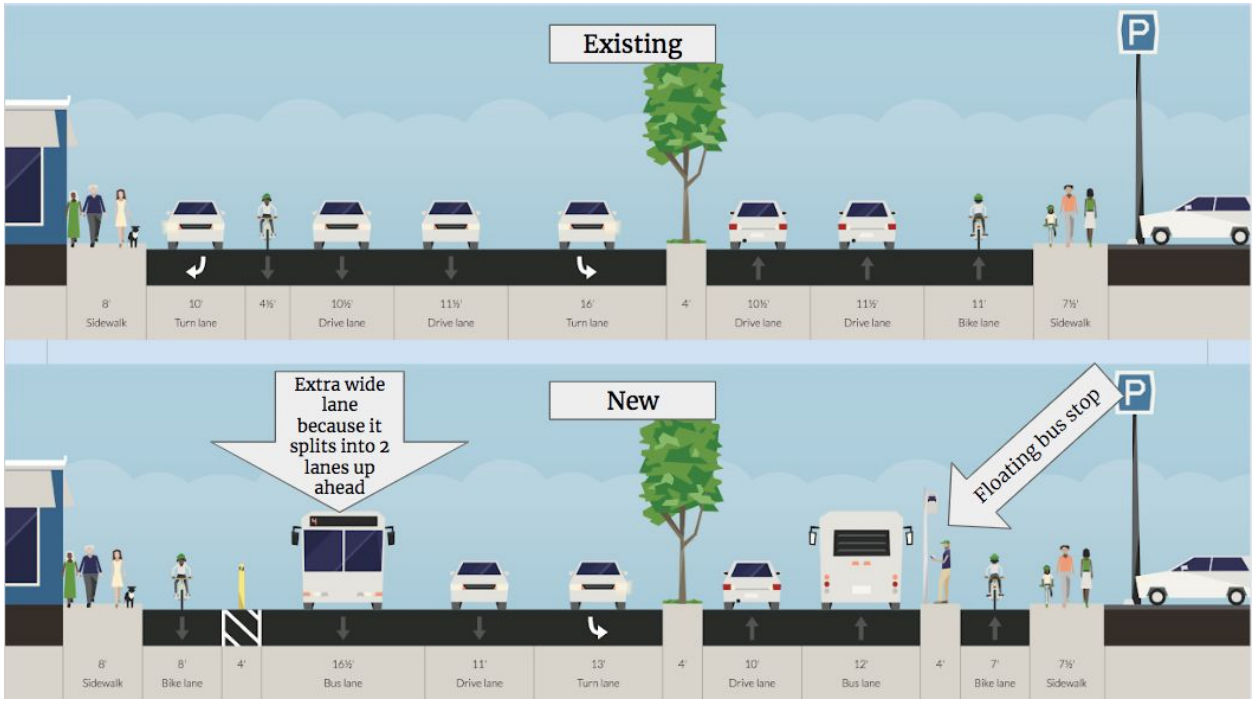

Figure 18: Current existing and new proposed recommended dimensions of Water Street at the Branciforte to Reed segment. Graphics developed using Streetmix.

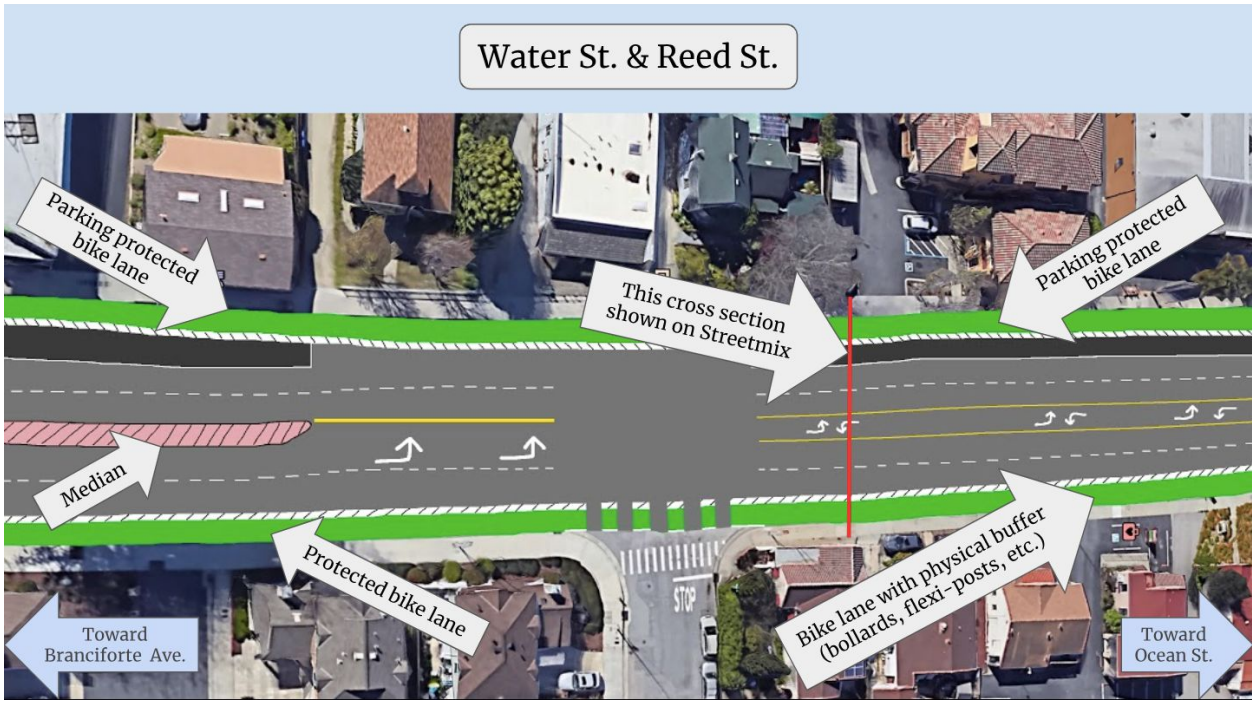

Figure 19: Aerial view of the new proposed designs for Water Street at the Reed to Market segment.

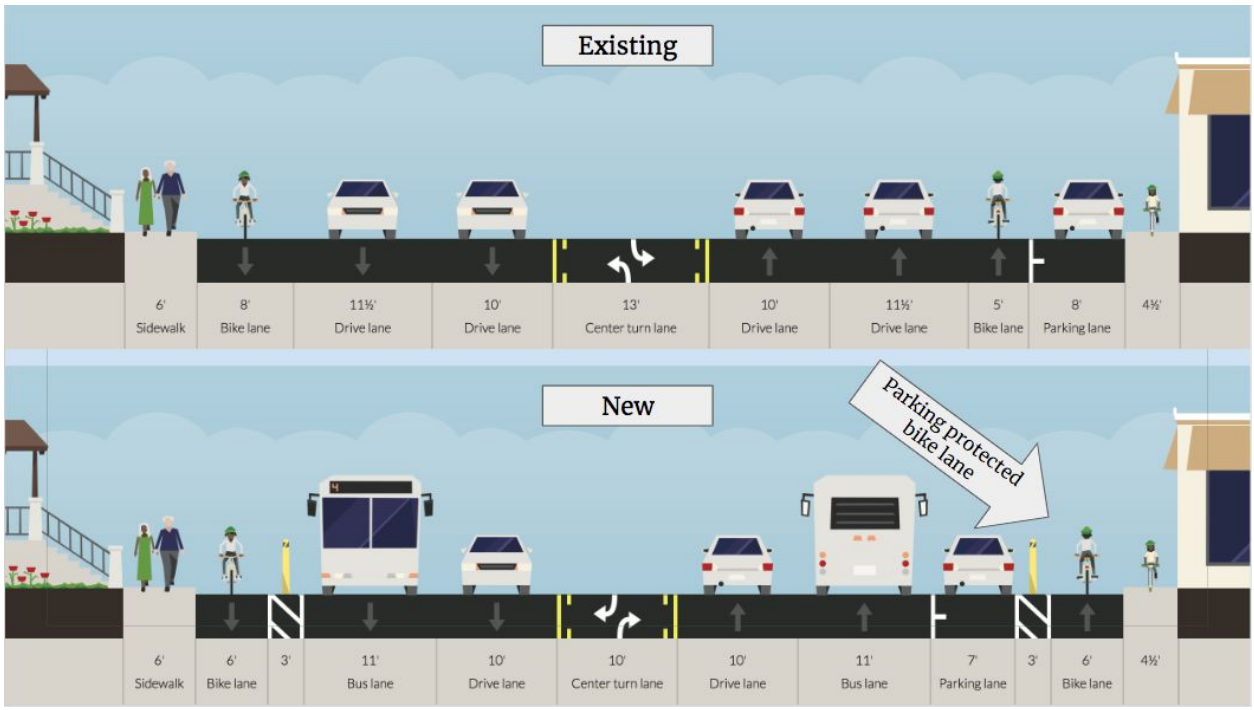

Figure 20: Current existing and new proposed recommended dimensions of Water Street at the Reed to Market segment. Graphics developed using Streetmix.

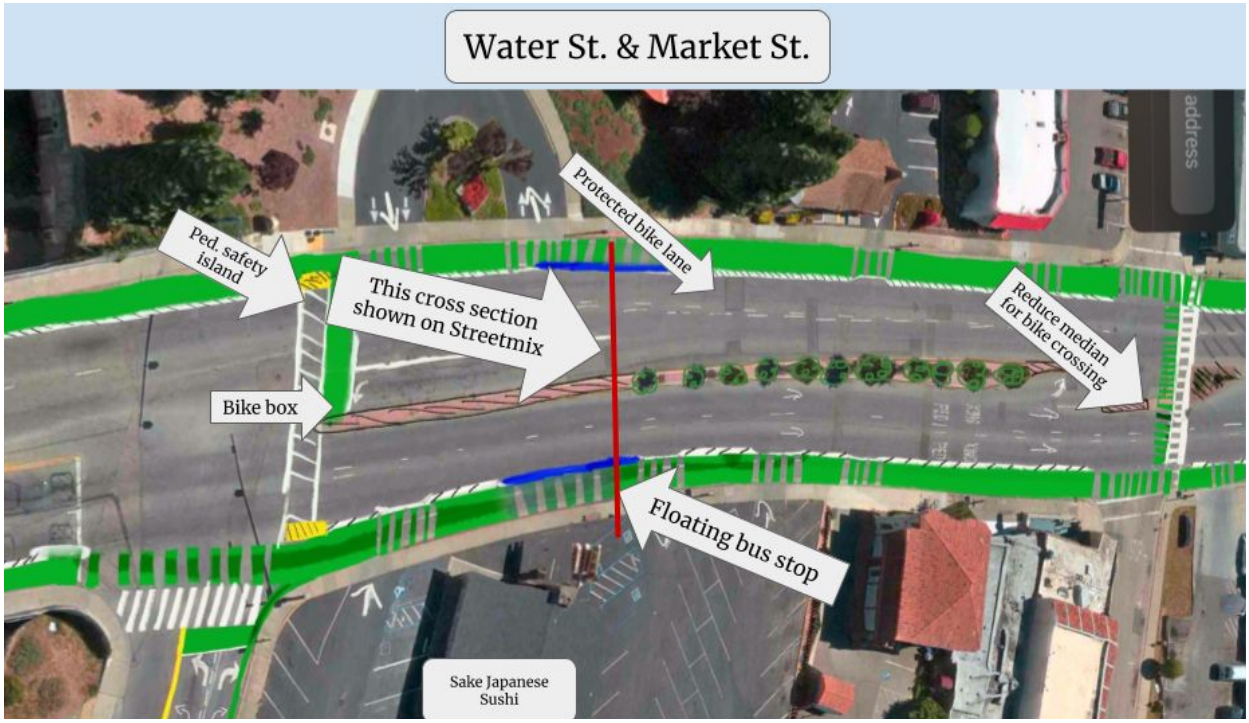

Figure 21: Aerial view of the new proposed designs for Water Street at the Market to May segment.

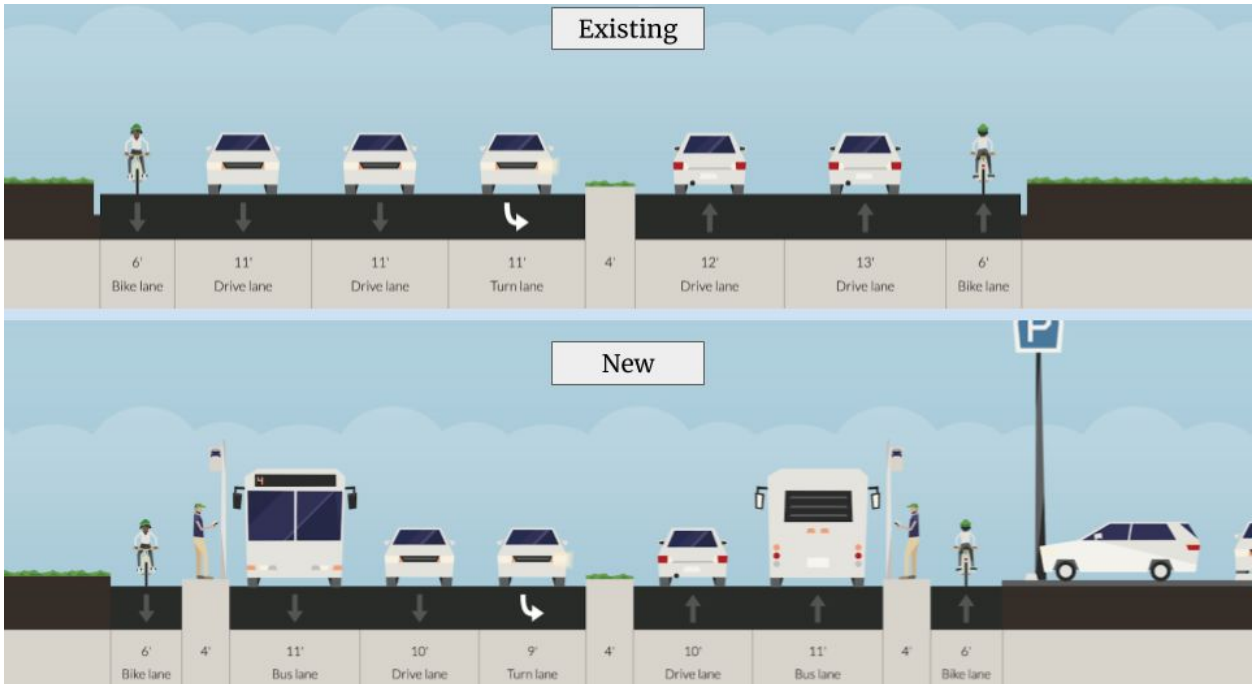

Figure 22: Current existing and new proposed recommended dimensions of Water Street at the Market to May segment. Graphics developed using Streetmix.

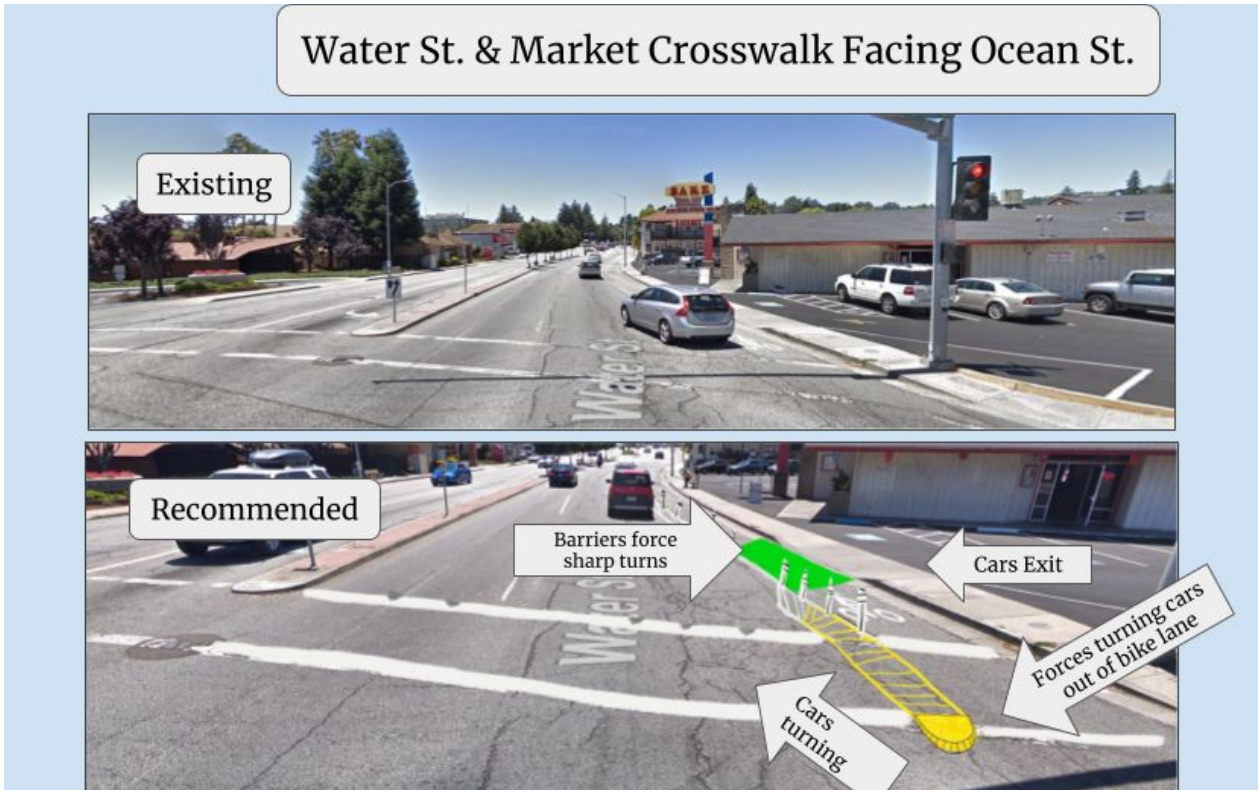

Figure 23: Detailed design for the crosswalk at Water Street and Market Street.

Figure 24: Aerial view of the new proposed designs for the intersection at Water Street and Ocean Street.

Figure 25: Current existing and new proposed recommended dimensions of Water Street at the Water and Ocean intersection. Graphics developed using Streetmix.

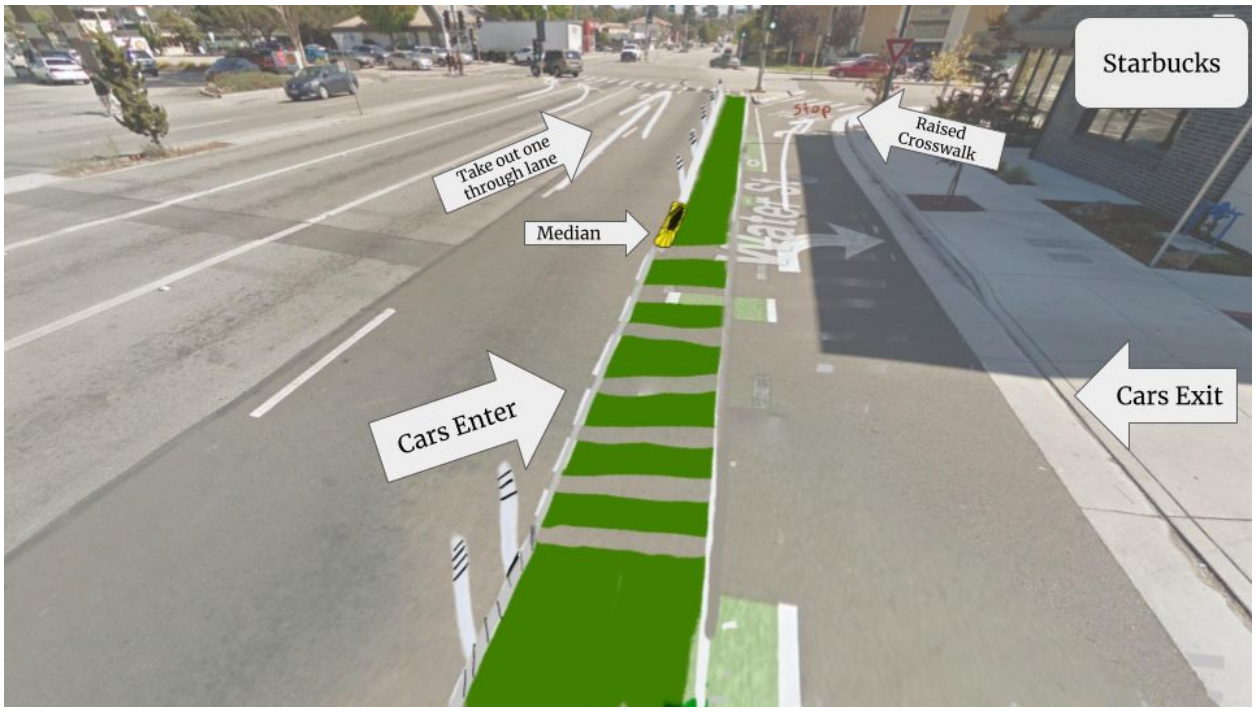

Figure 26: Detailed design for the right turn lane and bike lane mixing zone at the Water Street and Ocean Street intersection.

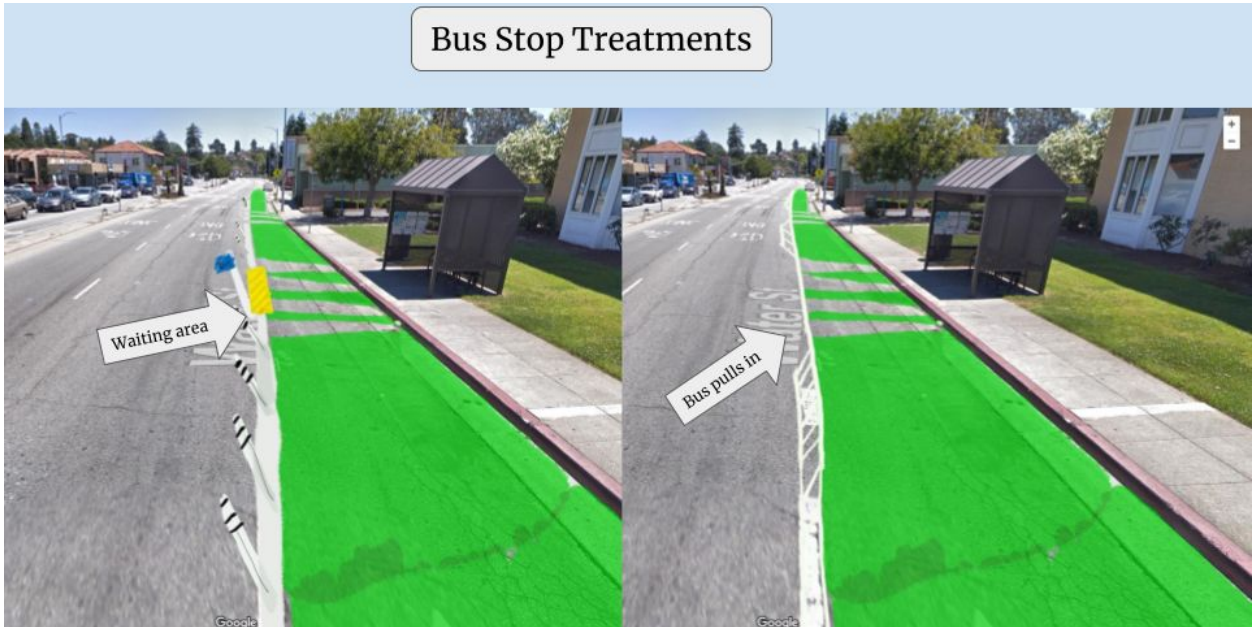

Figure 27: Detailed design for bus stops along Water Street. If there is adequate space, a waiting area/platform could be installed between the bike lane and the travel lane, as shown in the figure on the left. If not, passengers should wait in the shelter on the sidewalk and walk out to board the bus, as shown in the figure on the right.

Figure 28: Detailed design for driveways along Water Street. Source: https://nacto.org/publication/urban-bikeway-design-guide/

Sources

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Furth P. G. (June 2017). Level of Traffic Stress. *Northern University College of Engineering.* Retrieved from: http://www.northeastern.edu/peter.furth/criteria-for-level-of-traffic-stress/