

Final Report

Biking from UCSC Main Campus to Coastal Science Campus

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ENVS-196

Executive Summary

Due to the expansion of the University of California, Santa Cruz's Coastal Science Campus (CSC), many students and faculty members now make trips from the main campus of the University of California, Santa Cruz (UCSC Main) to classes and operations at CSC. Commuters currently rely on the hourly bus service between the two campuses, their personal motor vehicles, or cycling. Many would prefer to bike this four-mile route than by driving or by bus. Even more commuters would choose to bike it if conditions along the route were better (as shown by the results to our survey). Out of the three possible routes between UCSC Main to CSC, the majority of cyclists – roughly 60% of respondents – currently choose to ride on Western Dr route (i.e., Bay Dr → Meder St → Western Dr → Mission St → Natural Bridges Drive → Delaware).

With this in mind, we decided to focus in on improving the Western Dr route rather than others where habit does not already exist. Overall, the current conditions along this route are not optimal for bikes – in our survey data we discovered that 59.4% of respondents either disagreed or strongly disagreed with the statement “I feel safe biking to and from the two campuses.” In addition, a guided safety audit conducted by the Federal Highway Administration (FHWA) found a diverse range of concerns along the route – from tree limb debris to lighting issues to collision risks – which detracts from bike safety. We conducted an LTS evaluation (level of traffic stress, with a score of 1 denoting the safest and most comfortable riding conditions while a score of 4 denoting the most stressful and dangerous) and discovered stretches of LTS 2 and LTS 3 along the route, both of which can be improved upon to support and increase cycling.

We broke up the route into ten segments, beginning at the entrance of UCSC Main and ending at Delaware Ave & Shaffer Rd. Each segment has specific short and long-term recommendations appropriate for that given segment to account for the huge variations in road width, bike facilities already in place, parking conditions, and so on. Many of our suggestions include traffic calming efforts in addition to enhancing existing or installing bike facilities (e.g., painted sharrows and bike lanes).

Introduction

There is a community of commuters absent from the vision to ease traffic between the University of California, Santa Cruz Main Campus (UCSC Main) and the University of California, Santa Cruz Coastal Science Campus (CSC). Those who frequently cycle between UCSC Main and CSC are currently forced to make do with the sub-par route design and infrastructure that the city provides. We believe that this does not and should not have to be the reality for cyclist commuters.

After surveying almost one-hundred commuters, we discovered three primary routes used to travel between the two University campuses: the Western Dr route, the Bay St route, and the Arroyo Seco path. The primary goal of our project is to recommend improvements to one of the current routes between UCSC Main and CSC. For the purpose of this report, we will be focusing on the Western Dr route. We prioritized Western Dr since it is more direct and roughly sixty percent of our survey respondents bike this particular route. This clear majority guided our research towards identifying the existing conditions of this high-traffic commuting route between UCSC Main and CSC. Through strategic redesigns along the route, our goals are to improve safety, provide an alternative to the hourly bus service, and create an incentive for students to use a more enjoyable and sustainable mode of transit between the campuses.

Although the Western Dr route is currently used by a large majority of respondents, many expressed that they felt unsafe using this route and that they would be more comfortable using the Arroyo Seco path if it was improved. However, redesigning the Arroyo Seco path would create a high volume of issues for the city, such as its lack of accessibility for machinery to make such improvements and a lack of a clearly mapped out route design for the path connections. This route may be a part of longer-term solutions to improve the biking connections between UCSC Main and CSC, but for the sake of feasible short-term solutions, this report will focus solely on the Western Dr route.

Through both survey data from commuters and auditing the route in question, we were able to gather a holistic picture of the Western Dr route's efficacy at allowing students, faculty, and the UCSC community to travel between the UCSC Main and CSC via bicycle with ease, safety, efficiency, and confidence.

Western Dr Route - Quick Facts

- Length of route: 4 miles
- Travel time from UCSC Main to CSC:
 - By regular bike: ~20 min.
 - By electric bike: ~9 min.
 - By bus (hourly): ~24 min.
 - By car ~11 min.
- Travel time from CSC to UCSC Main:
 - By regular bike: ~37 min.
 - By electric bike: ~12 min.
 - By bus (hourly): ~25 min.
 - By car: ~11 min.
- Number of bicycle-involved collisions on route since January 1, 2010: 14

Cyclist Survey Data

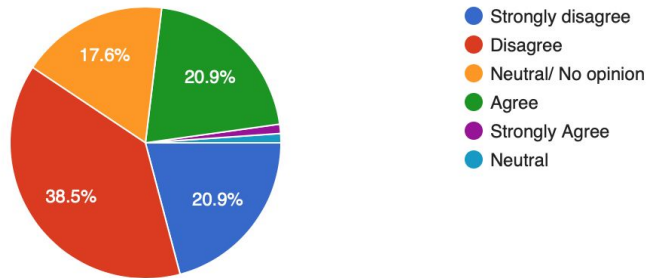
To collect data about the routes that cyclists were taking, we created a survey with Google Forms. This was our means of gathering information directly from cyclist commuters about their preferences and priorities regarding safe and easy biking infrastructure. We traveled to CSC and asked willing cyclists to complete the survey and reached out to professors teaching at CSC to send the survey out to their students and peers. We aimed to gather information about the priorities and preferences of students and faculty who regularly commute between the two locations. The relevant perspectives gained from our survey helped steer our team towards making more informed decisions as to how to best improve the cycling routes from UCSC Main to CSC.

In our survey, we asked questions regarding which route was most frequented by cyclist commuters, how safe cyclists felt on their route, hazards they faced, aspects they enjoyed about their route, and three improvements they would make to their route if they had the ability. We first aimed to create a baseline understanding of whether or not cyclists feel safe and comfortable during their

commutes by providing statements and asking respondents how much they agreed or disagreed with them. The following are charts created with our data:

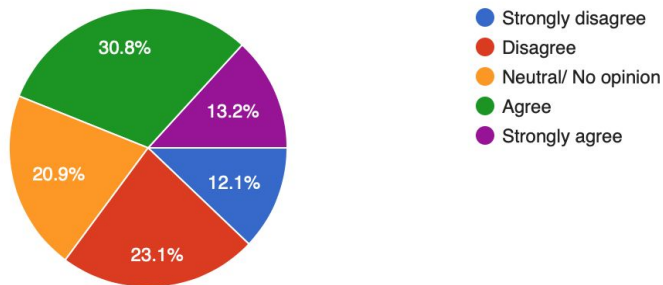
“I feel safe biking to and from the two campuses/facilities.”

91 responses



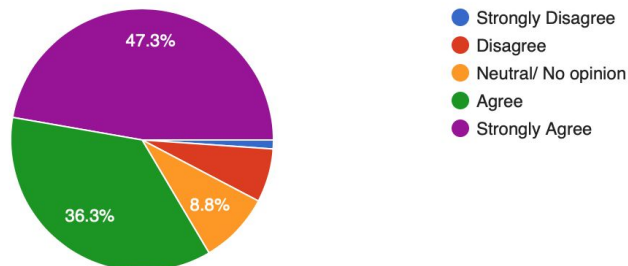
“I am comfortable with riding a bike between the campuses/facilities.”

91 responses



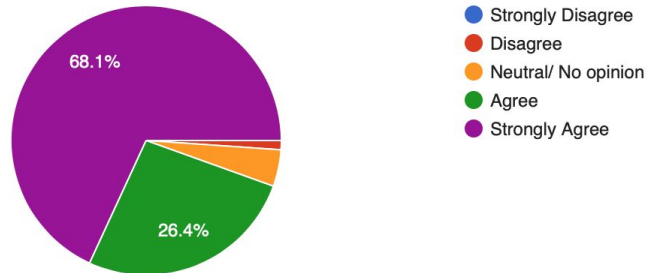
“I feel uneasy biking when there are no bike lanes.”

91 responses



“I would feel more comfortable biking between campuses/facilities if bikes had a route partially protected from car traffic.”

91 responses



A majority of our respondents said that they do not feel safe on their chosen route between UCSC Main and CSC, while less than half of respondents (44%) stated that they were comfortable biking between the two campuses. A vast majority of our respondents stated that they were uneasy riding without bike lanes, which is a hugely important factor for our design process because the bike lanes disappear in multiple sections of the Western Dr route to become sharrows. In addition, a majority of those who took the survey stated that they would feel more comfortable commuting if their route was partially protected from car traffic.

In addition to gaining an understanding of how people feel while cycling between the campuses, we wanted to gather information about aspects of their routes that they have either seen as hazards or as features they enjoy and appreciate. The following is a list of common hazards that cyclists wrote about the current Western Dr route:

- Very steep & narrow; not enough room for bikes and cars, cars speed. Scary when cars pass, fear of being doored when super narrow.
- There is no bike lane for most of Western Dr. Going downhill isn't so much of a problem, because it is possible to go closer to the speed of auto traffic, but uphill is more of a problem.
- Poor quality of roads.
- Western Dr narrows at several places, particularly when there are cars parked along the route. At the same time, there are usually cars trying to pass the cyclists at those points. The road also turns at these points. These factors together make those "crunch spots" difficult to navigate and

potentially dangerous. Also, when going uphill along Western, the bike path is narrow enough and the cycling slow enough that it feels like a contested space between cyclists and motorists.

- Even though Western is a wide street where cars can easily make room to pass a bike, some drivers feel the need to practically brush up against my elbow anyway, or force me against the side of the road, where you have to ride uneasily across eucalyptus nuts and small branches.
- The Western Dr route does not have a continuous bike lane. Additionally, the route has several twists where the bikes/cars are not so visible – it is often dangerous to bike especially during low lighting conditions and high humidity.

Common themes among responses to this question had to do with a fear of dooring due to narrow bike lanes and parked cars along Western Dr. Dooring is a type of traffic collision in which a cyclist either rides into or is hit by a car door. These types of collisions typically occur because of narrow bike lanes that are an inadequate distance between parked cars, and because of inattentive drivers who do not check for cyclists before opening their doors. In addition, a lack of maintenance of the roads and bike lanes were mentioned multiple times, as were a lack of bike lanes altogether, and car traffic speed.

Things that were shared as enjoyable aspects of the routes were as follows: low traffic, exercise, fun, beautiful view, and quick. Meanwhile, other common responses were: “not much,” “direct but not safe,” and “nothing.” Our objective for asking this question was to gather information on the things that people enjoy so that we can improve the quality of the Western Dr route and make the positive aspects of biking more prevalent. We hope to completely eliminate the features of the commute that lead people to respond with “not much” or “nothing.”

The final question on our survey asked people to list in order of importance three improvements they wish to add to the route they frequent between the campuses. The following is a chart of the most common responses listed in order of importance:

#1	#2	#3
Better lighting at night	Good visibility	Wide enough lanes
Separation from cars	Not too steep	Maintenance
Protected bike lanes	Paved, level	More bike culture among drivers
No parking in the bike lane	Green paint, physical barriers	Flexible plastic posts
Smooth, maintained, no debris	No pedestrians	Clearly marked path
A mirror on the corner of Highway 1 and Western so that cars can clearly see cyclists	Marked lanes	An easier way to cross Empire Grade at Western
Wider bike lanes	Maintenance	Scenic
Reasonable grade	Visual reminders of bikes for cars, signs	Extending bike path from campus further
No cars	Fewer cars, slower cars	No debris
-----	More driver awareness	-----

The most common responses regarded road maintenance and the quality of bike lanes. Many respondents requested wider, more clearly marked, and/or protected bike lanes. These were all very essential responses to keep in mind for the next stages of our proposal and helped us as we conceptualized ideas for new infrastructure designs.

Route Safety Audit

In order to gain a better understanding of the problems associated with the cycling route, we also performed a bicycle road safety audit. For this portion of the study, we followed the route by foot and noted down all evident and prominent cycling hazards, as defined by the Federal Highway Administration’s (FHWA) Bicycle Road Safety Audit Guidelines and Prompt List. We broke the route down into ten segments to better organize our findings. This allowed us to focus on smaller, more digestible sections of road to ensure thoroughness and accuracy. Through performing the audit we noticed many clear hazards that currently exist along the route.

The following chart lists and details these findings for each segment, ending at the CSC entrance:

Main Campus to Coastal Science Campus FHWA Route Safety Audit Findings

Street Segment	Safety Audit Findings
Bay Dr (High to Meder)	<ul style="list-style-type: none"> ➤ <u>Obstruction</u>: Bus stop crosses and occupies bike lane ➤ <u>Lighting</u>: Only one streetlamp on the entire block ➤ <u>Transition</u>: Bike lane vanishes right before the right turn onto Meder
Meder (Bay to Western)	<ul style="list-style-type: none"> ➤ <u>Transition/Continuity</u>: Bike lane vanishes upon turning from Bay onto Meder ➤ <u>Presence & Availability</u>: No bike lane, no signage to denote a sharrow ➤ <u>Design & Placement</u>: Car parking available on both sides of the street, dooring risk
Western 1 (Meder to Schiller)	<ul style="list-style-type: none"> ➤ <u>Design & Placement</u>: Bike lane on one side of the street frequently passes in front of driveways ➤ <u>Lighting</u>: Few streetlamps on the street ➤ <u>Design & Placement</u>: Cars occasionally park in the bike lane, collision and dooring risk
Western 2 (Schiller to Yosemite)	<ul style="list-style-type: none"> ➤ <u>Obstruction</u>: Multiple bus stops designated the middle of sharrow lane (i.e., no cutout) ➤ <u>Quality & Conditions</u>: Bike hazards as gutters, large cracks, and woody debris
Western 3 (Yosemite Ave to Mountain Way)	<ul style="list-style-type: none"> ➤ <u>Design & Placement</u>: Frequent street parking along sharrow, high dooring risk ➤ <u>Obstruction</u>: Bus stop in the middle of sharrow lane (i.e., no cutout)
Western 4 (Mountain Way to Highway 1)	<ul style="list-style-type: none"> ➤ <u>Design & Placement</u>: Frequent street parking along sharrow, high dooring risk ➤ <u>Obstruction</u>: Bus stop in the middle of sharrow lane (i.e., no cutout) ➤ <u>Transition/Continuity</u>: Bike lane vanishes in front of a very busy apartment complex driveway

	<ul style="list-style-type: none"> ➤ <u>Design & Placement</u>: Dooring and collision risk when bike lane reappears with parked cars to the right and the driving lane to the left (parking/departing cars cross bike lane) ➤ <u>Quality & Conditions</u>: Woody debris in bike lane ➤ <u>Transition/Continuity</u>: Bike lane vanishes just before the busy, high-speed Highway 1 intersection
Western 5 (Highway 1 to Mission St)	<ul style="list-style-type: none"> ➤ <u>Design & Placement</u>: Parked cars on both sides of street, dooring risk in the sharrows
Mission St (Western to Natural Bridges Dr)	<ul style="list-style-type: none"> ➤ <u>Design & Placement</u>: Parked cars on both sides of street, dooring risk in the sharrows
Natural Bridges Dr (Mission to Delaware)	<ul style="list-style-type: none"> ➤ <u>Design & Placement</u>: Dooring and collision risk in bike lane; parked cars to one side and driving lane to the other (parking/departing cars cross bike lane) ➤ <u>Quality & Conditions</u>: Potential hazard; open railroad track crevices ➤ <u>Obstruction</u>: Bus stop crosses and occupies bike lane
Delaware (Natural Bridges Dr to Coastal Science Campus)	<ul style="list-style-type: none"> ➤ <u>Design & Placement</u>: Parking/departing cars cross bike lane, dooring risk ➤ <u>Obstruction</u>: Bus stop crosses and occupies bike lane

It is clear that certain portions of the route have more hazards than others. The segment of Western Dr between Mountain Way and Highway 1 was especially problematic with six distinct hazards sighted. In addition to ranking segments by the number of hazards present, it is also useful to analyze the audit data by category. Though some hazards could fit into multiple categories, the majority are easily labeled as above. It is interesting to note that the dominant category along the route was design and placement issues with a count of ten noted hazards. This illuminates the fact that many areas along this route are not well built to accommodate safe cycling and can certainly be improved upon at a basic design level.



Bike lane along Western with high collision and dooring risk; Disappearing bike lane before a busy driveway



Bus stop in the middle of a single lane sharrow (i.e., no cutout)

LTS Fitting and Mapping

Level of Traffic Stress (LTS) is a rating assigned to a road segment which denotes the amount of stress imposed upon cyclists. LTS values range from 1-4 where a value of 1 is the most comfortable and accommodating for bikes while a value of 4 is the most stressful and least accommodating. Using the LTS criteria provided by Peter Furth (Northeastern University College of Engineers Professor), we were able to calculate and assign an LTS value to each of our ten segments. LTS is calculated on a case by case basis based on the existing qualities of a roadway. Factors which go into calculating an LTS value include whether a bike lane currently exists, whether the bike lane is segregated from the street, the number of traffic lanes, the speed of traffic, whether or not parking is present, street widths, bike lane widths, parking lane widths, bike lane blockages, etc.



The route from the main UCSC campus to Coastal Science Campus. Colors represent different Levels of Traffic Stress (LTS). LTS 1 denotes the most comfortable and accommodating routes to bike; LTS 4 denotes the most stressful and hardest routes for bicycling.

Street Segment	LTS Rationale
Bay Dr (High St to Meder St)	<u>LTS 2</u> ➤ Speed 30mph, 2 lanes each way ➤ 5ft bike lanes present (no parking)
Meder (Bay to Western)	<u>LTS 2</u> ➤ Speed 25mph, 1 lane each way ➤ Mixed traffic, no sharrow signage
Western 1 (Meder St to Schiller Pl)	<u>LTS 2</u> ➤ Speed 30mph, 1 lane each way ➤ Bike lane 5ft when present
Western 2 (Schiller Pl to Yosemite Ave)	<u>LTS 3</u> ➤ Speed 30mph, 1 lane each way ➤ Mixed traffic sharrow
Western 3 (Yosemite Ave to Mountain Way)	<u>LTS 3</u> ➤ Speed 30mph, 1 lane each way ➤ Mixed traffic sharrow
Western 4 (Mountain Way to Highway 1)	<u>LTS 3</u> ➤ Speed 30mph, 1 lane each way ➤ Sum of bike lane and parking lane less than 13.5ft
Western 5 (Highway 1 to Mission St)	<u>LTS 2</u> ➤ Speed 30mph, 1 lane each way ➤ Mixed traffic sharrow
Mission St. (Western Dr to Natural Bridges Dr)	<u>LTS 2</u> ➤ Speed 30mph, 1 lane each way ➤ Mixed traffic sharrow
Natural Bridges Dr (Mission to Delaware)	<u>LTS 3</u> ➤ Speed 30mph, 1 lane each way ➤ Sum of bike lane and parking lane less than 13.5ft
Delaware (Natural Bridges Dr to Coastal Science Campus)	<u>LTS 2</u> ➤ Speed 30mph, 1 lane each way ➤ Sum of bike lane and parking is 15ft, but prevailing speed is greater than 25mph

In order to accurately calculate LTS values, we walked the route once more and measured the streets by hand, noting down widths of driving lanes, bike lanes, and parking lanes. We also noted the number of lanes and the posted speed limits for each segment. With the necessary data collected, and the safety audit completed (for bike lane blockages, etc.) we then analyzed each segment based on Furth’s LTS criteria tables and assigned the proper value for each segment. To easily visualize the findings we constructed a color-coded map with the LTS data as seen above. We found that the route from the main UCSC campus to Coastal Science Campus exhibited LTS values of 2 and 3 respectively. The LTS 2 grade is dependent upon the road measurements, the presence of a bike lane, width, and prevailing vehicle speed, therefore there are some LTS 2 segments with a mixed traffic sharrow and some with a bike lane. There were no sections of the route which exhibited LTS 1 or 4 values. These ratings are extremely useful for deciding which areas should be improved.

Street Segment	Street Widths
Bay Dr (High St to Meder St)	2 lanes, 12ft driving lanes, 5ft bike lanes
Meder St (Bay Dr to Western Dr)	1 lane, 20ft both sides
Western 1 (Meder St to Schiller Pl)	Southbound: 12ft driving lane, 18ft when parking cutout appears, 21ft @ Schiller Pl with parking cutout. Northbound: 19ft driving lane, 5ft bike lane appears for a short time (11ft driving lane here). 19ft with parking cutout, 20ft sharrow with street parking
Western 2 (Schiller Pl to Yosemite Ave)	14ft sharrow both ways
Western 3 (Yosemite Ave to Mountain Way)	Eastbound: 13ft lane, 20ft when parking present Westbound: 12ft lane, 19ft when parking present No centerline
Western 4 (Mountain Way to Highway 1)	Southbound: 13ft driving lane, 8ft bike lane. On the hill it turns into 24ft total (10ft driving + 6ft bike + 8ft parking) Northbound: 19ft near Flower St. On the hill it turns into 11ft driving lane, 5ft bike lane.

Western 5 (Highway 1 to Mission St)	20ft sharrow both ways
Mission St (Western Dr to Natural Bridges Dr)	20ft sharrow both ways
Natural Bridges Dr (Mission to Delaware)	Southbound: 11ft driving lane, 13ft bike +parking (4ft bike, 9ft parking) Northbound: 10ft driving lane + 4ft bike lane + 9ft parking lane
Delaware (Natural Bridges Dr to Coastal Science Campus)	17ft drive lane + 15ft bike and parking both ways

It is clear from the measurements above that the route between UCSC Main and CSC has intermittent bike lanes of inconsistent widths. The Bay Dr segment has 5ft bike lanes both Northbound and Southbound. The 2014 NACTO *Urban Bikeway Design Guide* states that 6 ft is the desirable width for conventional bike lanes adjacent to a curb. The next segment with a bike lane is Western 1 in the Northbound direction. This bike lane, too, is narrower than recommended by NACTO, at only 5ft wide. The Western 4 segment in the Southbound direction briefly has an 8ft bike lane, which then turns into a 6ft bike lane as one approaches the Highway 1 intersection. This is one of the only segments on the route that meets the NACTO recommendations. Western 4 going Northbound also has a 5ft bike lane. Upon reaching the Natural Bridges Dr segment, the narrowest and more substandard bike lanes are found at 4ft wide. The last segment of the route, along Delaware, has a combined bike and parking lane of 15ft. The NACTO guidelines state that bike lanes next to parking lanes should, from the curb to the edge of the bike lane, reach 14.5ft. Therefore, a 15ft parking and bike lane just exceeds NACTO recommendations. A majority of the route lacks bike lanes and for those segments that do, a majority of them are either substandard or just barely meeting the NACTO minimum standards.

Recommendations Overview

Due to a severe lack of consistent infrastructure that gives bicyclists both space and safety on the route between CSC and Main Campus, we have made the following recommendations. There are both short- and long-term solutions to guide the city in where to focus improvements based on priority and ease of implementation. Short-term solutions require low amounts of funding and are considered to be bare minimum improvements based on design guidelines such from institutions such as NACTO, AASHTO, and FHWA, such as striping for sharrows or green segments of bike lanes in mixing zones. Longer-term solutions are recommended for when the city has the funds required for larger-scale solutions and should be considered as a solution to bypass the short-term solutions whenever possible. These solutions reconfigure the street to efficiently use its entire width to accommodate pedestrians, bicyclists, vehicles, and buses alike. Bike lanes with adequate width and buffers whenever possible are recommended in every segment of the route. Multiple segments of the route that have proposed advisory bike lanes, which have had lots of success in European segments with relatively low traffic.

Bay Dr (High to Meder)

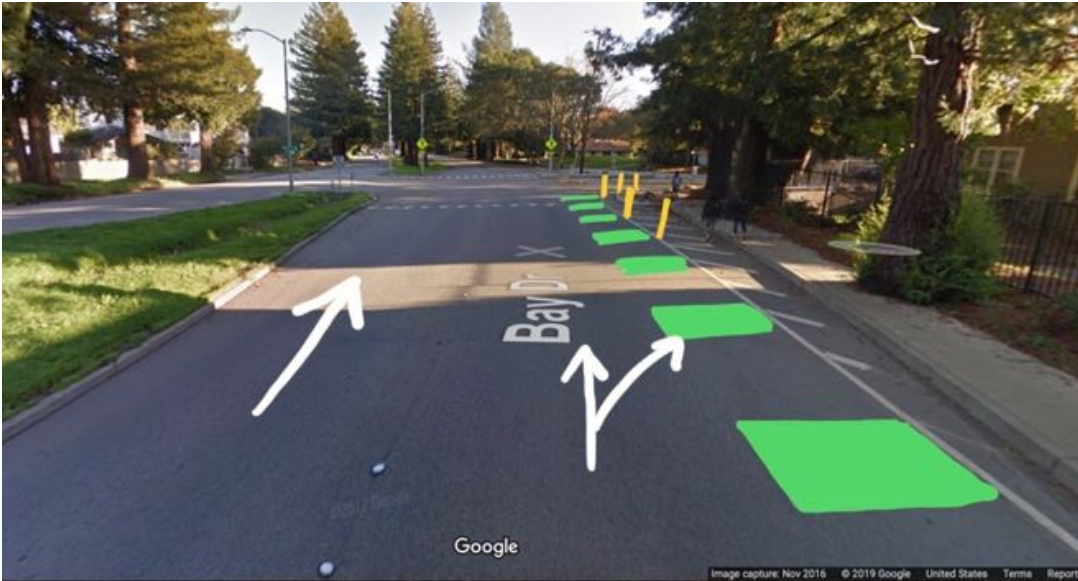
Short-term solutions. Headed Southbound on Bay Dr from the UCSC Main Entrance, green paint is needed to demarcate the bike lane. One of the simple fixes that can be made to help draw vehicle driver attention to cyclists is a green-painted bike lane. In addition, there is a potentially dangerous mixing zone at the corner of Bay Dr and Meder St. Cars turning right onto Meder St. can take advantage of a curb with a wide radius, allowing for a potentially dangerous, high-speed turn. If this mixing zone were more clearly marked with green paint, driver awareness would be drawn to potential cyclists continuing straight prior to making the turn.



Heading Northbound on Bay Dr from Meder St, more clearly marked and painted bike lanes would also help for the same reasons as listed above. In addition, once the corner of Bay Dr and High St is reached, there is a potentially dangerous mixing zone that could be improved. With more paint, the disappearance of the bike lane could be converted into a NACTO-approved mixing zone, with right-turning cars crossing through a striped bike lane for cyclists continuing straight. Cyclists turning right would share the right lane with vehicles.



Long-term solutions. In addition to the short-term solutions, larger more long-term projects should also be considered to redesigning these segments of the bike route. Specifically, on the corner of Bay Dr and Meder St, soft-hit posts or similar physical barriers should be installed to sharpen the turn radius for cars.



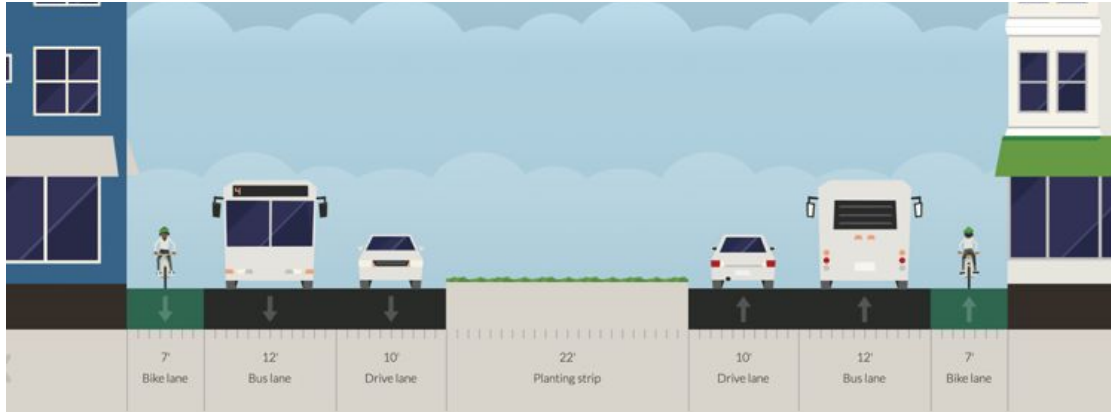
A street view of the corner of Bay St. & Meder St. with flexible bollards.



An aerial view of the corner of Bay Dr & Meder St with flexible bollards.

Sharpening this turn would force vehicle drivers to slow down while turning right, which may lead some to believe that traffic will be more likely to get backed up in the right lane. Fortunately, slowing this turn won't have that large of an impact on traffic speeds continuing down Bay Dr, given that there are two lanes for motor vehicles.

For both the North and Southbound directions on the segment of the route, it would be ideal to widen the bike lanes. Currently, they are 5ft wide in both directions. NACTO guidelines state that a desirable bike lane width adjacent to a curb is 6ft. The left lane of vehicle traffic in both directions should be limited to 10ft, which the NACTO guidelines state is an appropriate width for urban areas and has a positive impact of street's safety without negatively impacting traffic. The right lane should remain 12ft for the buses that frequent this segment of Bay Dr. With these extra 2ft on each side taken from the left driving lane should be added to the bike lanes, leaving 7ft bike lanes on each side.



The widening of the bike lane will allow cyclists to feel more comfortable, safer, further from vehicle traffic, and most importantly, cyclists won't have to ride in the gutters. In the longer-term, protected bicycle lanes should be considered for the entire length of Bay Dr.

Meder St (Bay to Western)

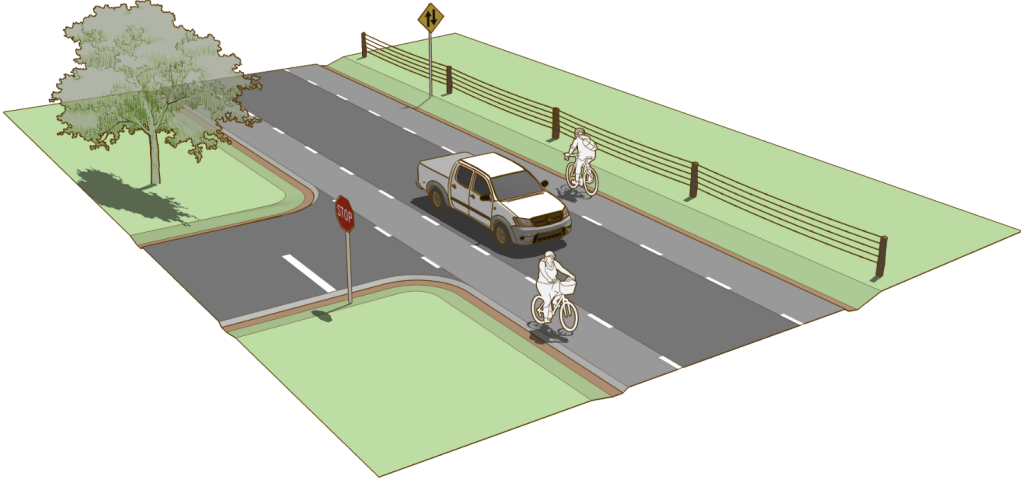
Short-term solutions. With the limited amount of space currently on Meder St, there is little that can be done in terms of short-term fixes. The one promising option would be to add sharrows along the entirety of Meder St, between Bay Dr and Western Dr, in both traffic directions. Currently, there is no bike infrastructure whatsoever on Meder St, so painting sharrows would be a low-cost way to bring vehicle driver awareness to cyclists and remind them to share the road.

Long-term solutions. Ideally, a larger-scale project on Meder St would calm the street enough that protected bike lanes would unnecessary. To accomplish this goal, Meder St should be converted into an advisory bike lane. This design features one shared driving lane for vehicles traveling both directions, bordered by bike lanes on each side. When cars travelling in opposite directions meet, they yield to bicycles in the bike lane to their right and then pass each other when clear. Advisory bike lanes are described by Alta Planning as “a preferred space for bicyclists and motorists to operate on narrow streets that would otherwise be a shared roadway environment. Because of their reduced cross-section requirements, advisory bike lanes have the potential to open up more roadways to more comfortable bicycle travel.”

According to a report from Alta Planning¹, advisory bike lane widths should meet or exceed standard dimensions for conventional bike lanes with a recommended width of 6ft, and a minimum of

¹ https://altaplanning.com/wp-content/uploads/Advisory-Bike-Lanes-In-North-America_Alta-Planning-Design-White-Paper.pdf

4ft. FHWA also recommends that the two-way travel lane width should be 13.5-16ft (though some installations in Cambridge feature two-way travel lanes of 9ft). According to the Alta Planning report, the FHWA also requires the installation of Bike Lane signage and recommends using an unmodified two-way traffic warning sign (W6-3) to indicate two-way operations. A custom graphic sign can indicate desired yield behavior to assist drivers who haven't experienced advisory bike lane systems before. Advisory bike lanes can look like this:



(From Alta Planning) A rendering of an advisory bike lane. The lines for both bike lanes are constantly dashed to facilitate the movement of traffic in and out for passing and turning.



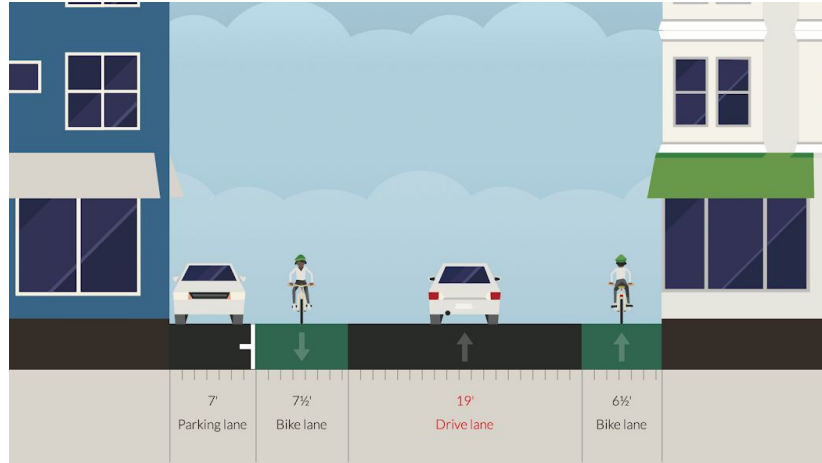
Advisory bike lane in the Netherlands (Greater Auckland). Paint can be used to enhance visibility for cyclists and to keep cars alert.



An advisory bike lane in Minneapolis' Elliot Park. This design need not remove parking.

Having an advisory bike lane would mitigate the effects of speeding vehicles and create an overall safer and more welcoming environment along Meder St for pedestrians and cyclists. This is especially crucial along Meder St because it is located in a highly residential area, and Meder Park is heavily frequented by pedestrians and cyclists. With an advisory bike lane design, bike lanes will be added in each direction bordering a single driving lane, with parking removed from one side of the street. Along the side with parking removed, a 7.5ft wide bike lane should be added next to the curb. When bike lanes are placed adjacent to a parking lane, the NACTO guidelines recommend that the distance from the curb to the edge of the bike lane (including the parking lane, bike lane, and optional buffer between them) is 14.5ft. We thus recommend this bike lane to be 7.5ft.

On the opposite side of the street, parking should be replaced with a 6.5ft bike lane. This leaves 19ft for a driving lane. The FHWA guidelines state that an advisory bike lane with parking on only one side can be as narrow as 13.5-16ft, so 19ft is sufficient for cars to safely yield and pass one another. Although parking must be removed on one side of the street, adjacent streets have plenty of parking and overall impacts of parking removal have shown to be minimal: only seven spaces would be moved, which can be accommodated on the other side of the street.



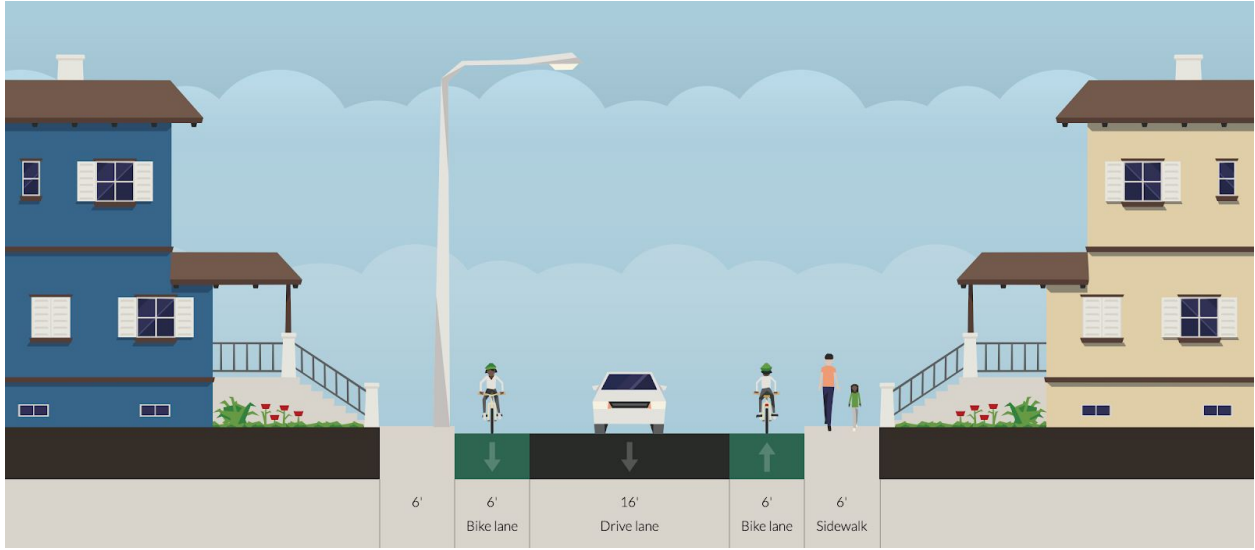
The Meder St segment with advisory bike lanes.

Western 1 (Meder St to Schiller Pl) & Western 2 (Schiller Pl to Yosemite Ave)

For the first two segments of Western Dr we recommend the adoption and construction of advisory bike lanes. Alta Planning and FHWA recommendations note that advisory bike lanes work best in areas with a low-to-moderate traffic volume, i.e., an annual average daily traffic (AADT) of less than or equal to 5,000. In addition, advisory bike lanes are optimal for routes with low-to-moderate motor vehicle speed (i.e., less than or equal to 30mph). According to city traffic monitoring data, the entirety of Western Dr experienced an AADT of about 4,318 ADT in 2013, and the street features a 30mph speed limit making it a perfect place for advisory bike lanes from a traffic volume standpoint. Advisory bike lanes excel in areas where the roadway width is narrow and dedicated bicycle lanes cannot be supported without roadway widening or removal of other street elements. Due to physical constraints and existing property lines, we found that it is not feasible to widen the roadway significantly on this area of Western Dr (segments 1-2) to create enough space for viable bike lanes, nor would the removal of other street elements do much good for cyclists. For these reasons, advisory bike lanes would be an ideal method to improve the state of this route for cyclists while abstaining from costly alterations to the current physical footprint of the segments.

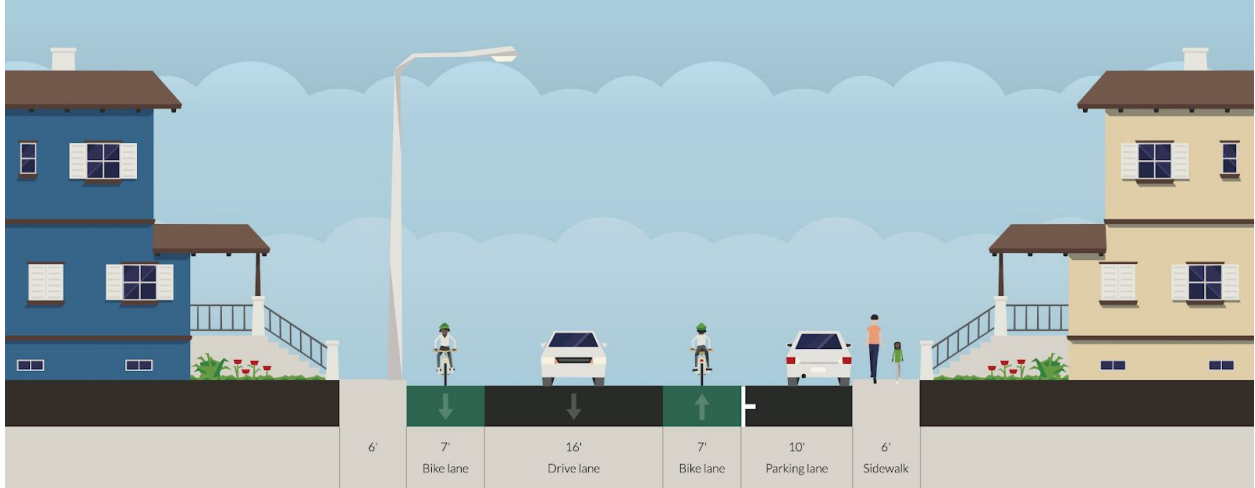
Segment 1 of Western Dr features varying street widths – the street is 28ft at its narrowest and 40ft at its widest (i.e., with parking). Here is what segment 1 would look like with advisory bike lane configuration.

At its narrowest (28ft):



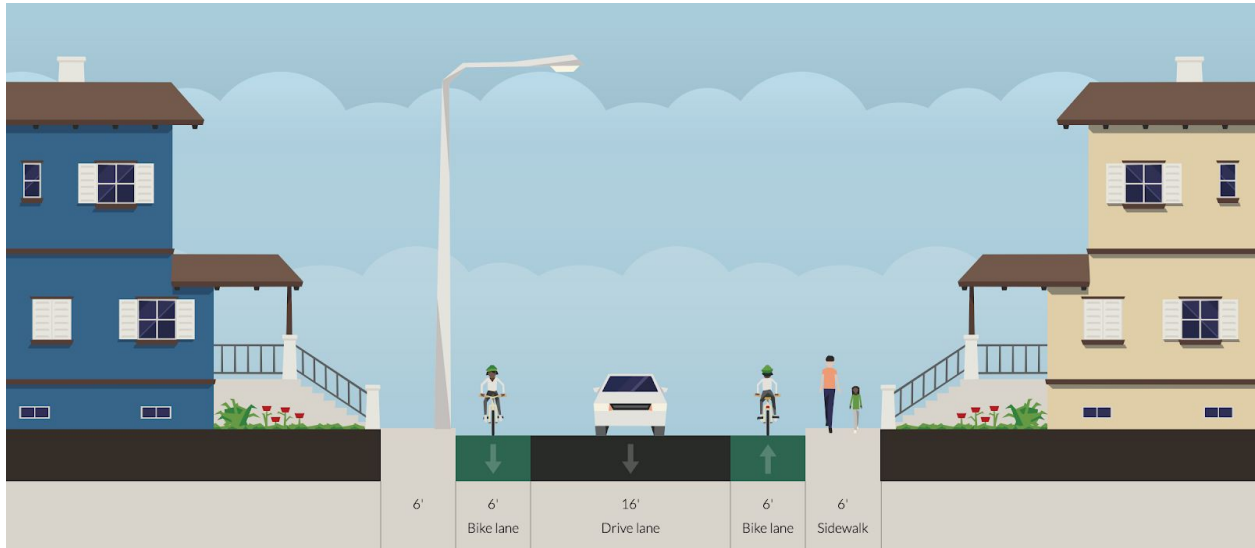
(Note – sidewalks are included for visualization purposes. If sidewalks along the route are not always 6ft they need not be changed to accommodate this design.)

At its widest (40ft with parking):



With this design configuration, there is no need to remove any existing parking on segment 1 since there is plenty of space to leave the parking cutouts be. With areas of newly available road space, bike lanes can be increased to 7ft each.

Western Dr segment 2 currently features 14ft sharrows in both directions (no parking). Here is what Western Dr segment 2 would look like with advisory bike lanes (identical to narrow segment 1).



The utilization of this system suits Western Dr 1 and 2 perfectly, and would not alter any existing residential parking. This system would provide commuting cyclists with safe, comfortable access to the roadway in both directions while providing plenty of space for cars and buses thanks to the large 16ft lane and the low traffic volume (less than 5,000 ADT) of the route. No road widening or road alterations would be necessary to facilitate this project.

Western 3 (Yosemite Ave to Mountain Way)

This segment would appear similar to the previous segments of Western Dr, with both sides of the road in this segment bordered with housing and on-street parking. However, there are two major differences which makes segment 3 troubling to recommend similar solutions: first is that the lanes with sharrows are slightly narrower, with the Eastbound lane being 13ft wide and the Westbound at 12ft (there is no paint delineating the travel lane from the adjacent parking lanes, so these are merely estimates). Second is that where the segment is widest at 39ft, parking is present on both sides simultaneously (cutouts are made for parked cars on the Eastbound side). This leaves just roughly 21ft

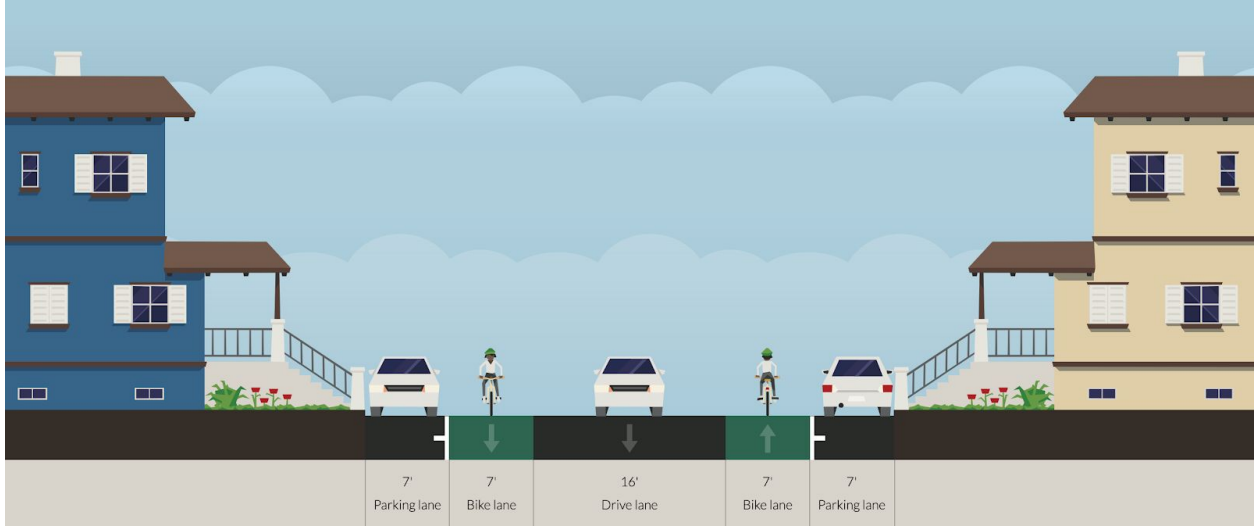
of room for all travelling vehicles – the bottleneck of bottlenecks along the whole route. Physical constraints such as property lines are again a limiting factor in any major redesigns in this segment.

Short-term solutions. Being the narrowest segment for travellers and with little room for expansion, the most feasible recommendation is to keep the current sharrow design with additional signage to make it more apparent to drivers. An additional custom sign could also be a warning that this particular segment is especially narrow, and that traffic should take especial heed to bicyclists. Similar to narrow segments like Meder St, there are few short-term recommendations for Western 3.

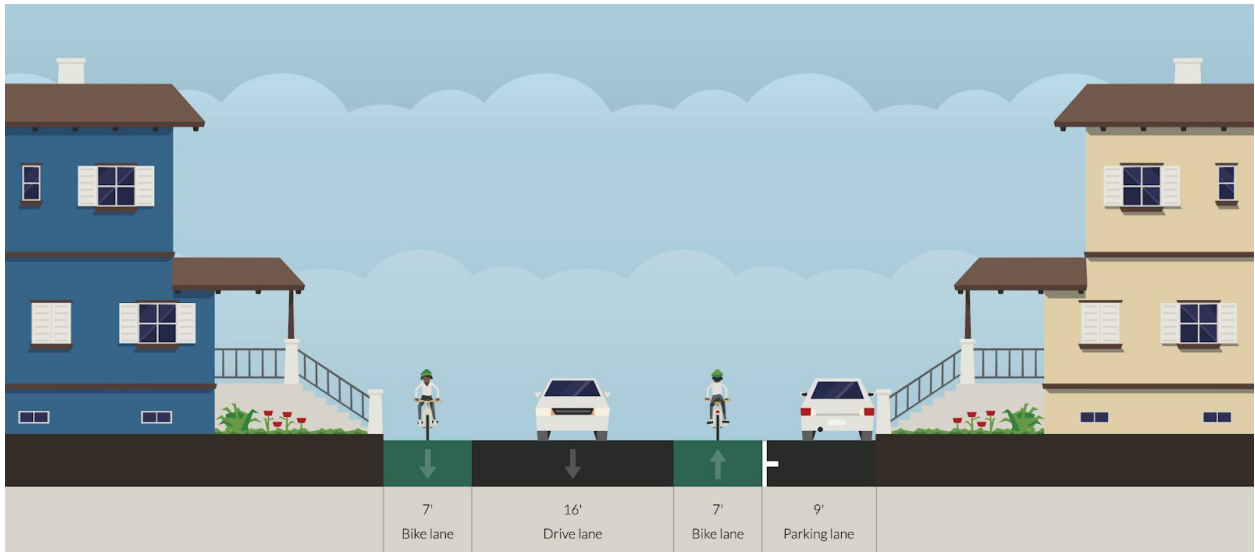


Additional signage to make the sharrow more apparent to drivers.

Long-term solutions. One prospective fix would come from negotiations with property owners. The best-case scenario would be to widen the entire segment by about 5ft (total width would be 44ft) so that an advisory bike lane design could be implemented that would be continuous with segment 2. If widening is not possible, the next best decision would be to remove parking along the east side of the segment to allow the necessary space for the advisory bike lane design. Parking on the West side would be retained, as it is in a cutout that cannot easily be continuously extended along the whole segment. Less than ten spaces would need to be removed, which could very likely be accommodated on the adjacent side streets (e.g., Yosemite Ave, Alamo Ave, Mountain Way, Westview Ct, Cypress Park).



Plan A -A widened segment 3 (44ft) featuring advisory bike lanes continuous with segment 2.



Plan B - Segment 3 with parking solely on the west side.

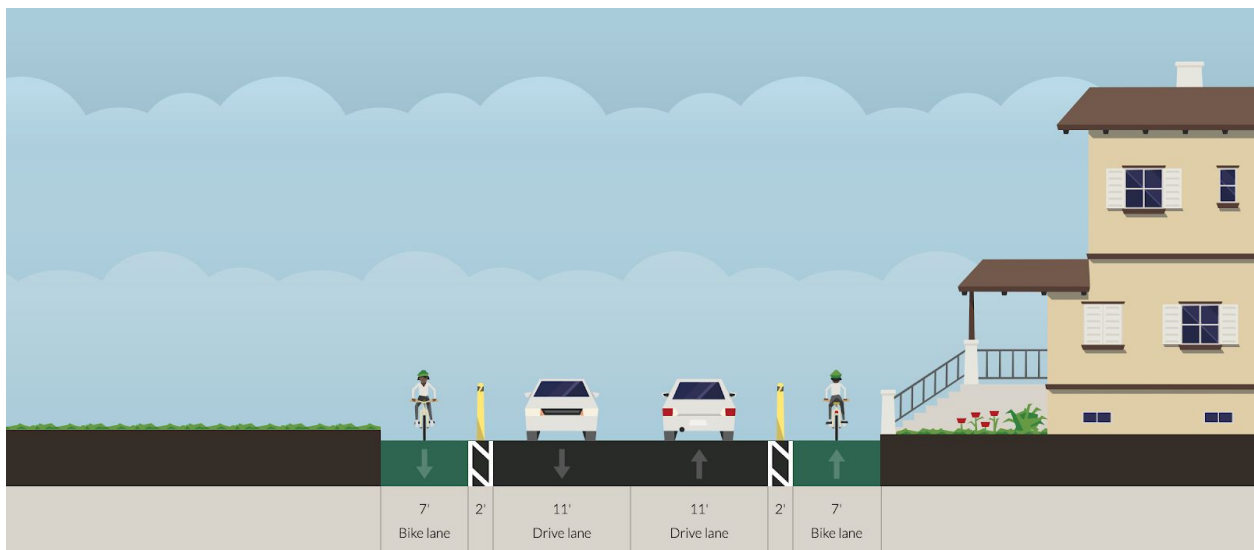
Western 4 (Mountain Way to Highway 1)

The beginning of segment 4 (from Mountain Way to Echo St) measures at 40ft and has virtually the same features as the previous segment, although parking is actually along the East side solely. This makes it easy to recommend Plan B of segment 3 (i.e., a continuous advisory bike lane) to also be utilized here.

After passing Echo St, the segment features one of the route's only painted bike lanes and is

additionally characterized by the steep gradient that descends to the Highway 1 intersection. This hill makes it difficult for northbound bicyclists (and drivers) to accelerate and especially difficult for bicyclists to ascend the hill at a pace drivers behind are comfortable with. Parallel parking is present on the east side, and the risk of dooring associated with it is heightened by the increased speed bicyclists and vehicles typically travel down the hill. Furthermore, the Northbound bike lane is only 5ft, which is not only under NACTO’s recommended standards but is especially problematic considering that bicyclists have less breathing room and often need to slow down and pedal harder to ascend the hill. This is one of the more challenging segments of the Western Dr route because in addition to having six distinct hazards identified, most recommendations need to take the grade of the hill into account.

Short-term solutions. Similar to segment 3, the beginning of segment 4 should feature a heightened emphasis on making the sharrow more obvious with respective signage. Since the hill portion of this particular segment can be strenuous for most bicyclists, we also recommend emphasizing electric bicycles to be utilized. These would allow slightly faster ascension for bicyclists and would partially alleviate the issue with Northbound traffic.



The hill section of the Western 4 segment. There are 4ft to spare with this configuration.

Long-term solutions. In 2017 the city’s Active Transportation Plan called for the widening of the Northbound bike lane “at the next repaving.” They also recommended bikes to use the full lane while going down the hill. Since then, the City has striped bike lanes in both directions. However, there is no physical protection for bicycles, and it remains critical to get high-speed downhill bicyclists

out of the dooring zone. Therefore, parking along this segment (eight to twelve spaces) should be removed and may be accommodated along the adjacent Beachview Ave. Redesigning this segment as such would leave 4ft to spare and could be utilized as buffers with soft-hit posts. The Southbound driving lane could be expanded by a foot.

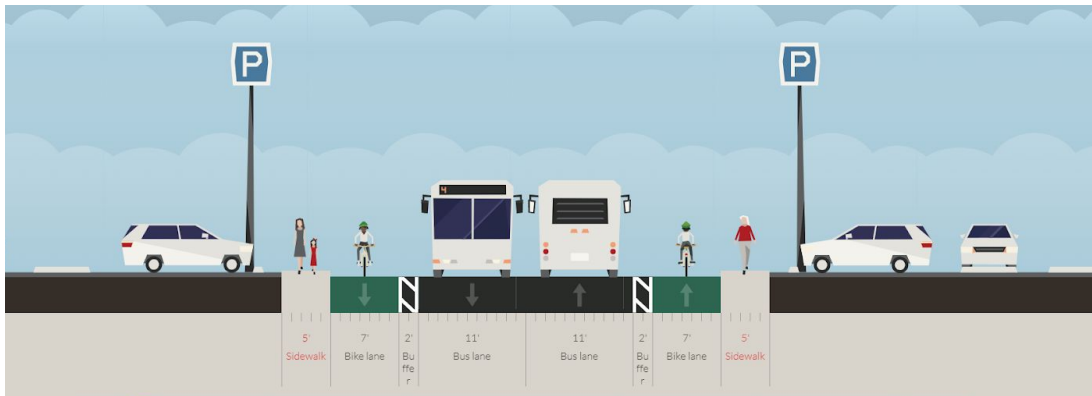
Regarding Northbound bicyclists, Alta Planner recommends uphill bike lanes to be 6-7 feet in width “to facilitate safe passing behavior.” Judging by how if bicycle traffic eventually increases along this route due to our recommended redesigns, this is an especially necessary solution. Expanding the Northbound bike lane to this width would eliminate bikes travelling in the close pass zone with cars.

Western 5 (Highway 1 to Mission St)

Currently, this segment of the route has no protection for bicyclists whatsoever, and requires cyclists to take safety risks in order to bike like a driver would drive their car, or what urban planner John Forester calls “vehicular cycling.” In an attempt to give bicyclists a portion of the road, and thus create the safety measures that many people require to consider cycling as their habitual form of transportation, a reshaping of this segment must start with the removal of parking. This is due to the mere 40’ of street width to work with. This tradeoff is both feasible and better for long-term use of the road. Employees of the businesses on Mission Street Extension who use this segment of Western Dr might voice a lack of support for these changes, however, their parking can be accommodated elsewhere. The removal of approximately 21 spaces on Western Dr, from Highway 1 to Mission St Extension can be accommodated by the 30 available spaces on Natural Bridges Dr. This shifting of parking allows for the space required to give bicyclists some real protection and visibility on the road.

Short-term solutions. In the short term, the removal of parking will make possible a buffered bike lane, which the NACTO design guide recommends in any instance a bike lane is being considered. A buffered bike lane in each direction, 7’ in width, with a 2’ striped buffer will allow for bicyclists to have the spatial separation from cars and buses that utilize the segment. As per NACTO recommendation, the 7’ bicycle travel area is to accommodate the differing bicycle speeds that may come as a result of the changing incline as well as the stop sign and stop light that border either end of the segment. The design also includes a 2’ buffer which exceeds the NACTO recommendation for a minimum width of 18”. The drive lanes (one in each direction) proposed for the segment are 11’, which follow AASHTO’s design guide for bus capable lanes. A significant trade-off to this proposed

design is that the sidewalks will not have any renovations and stay at 5' in width, which saves a lot of time and energy that would otherwise be required to rip out the concrete sidewalks and replace them.



The intersection of Highway 1 and Western Dr.

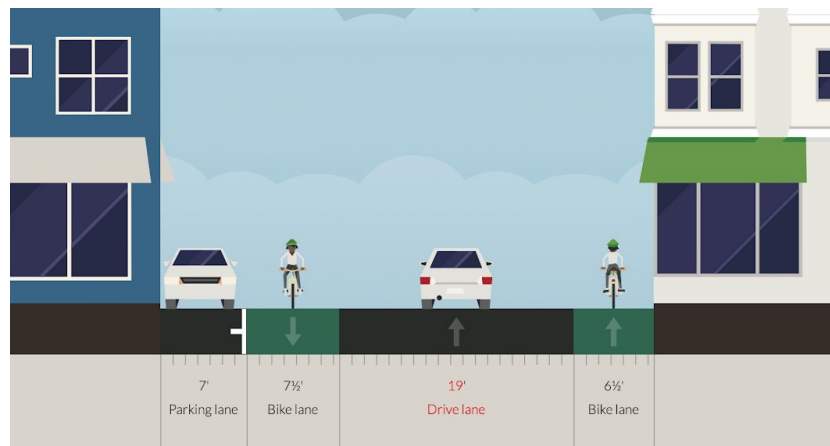
At the intersection of Western Dr and Highway 1, a bike box should be put in place in both directions of Western Dr. This is NACTO recommendation compliant. Additionally, signal detection loops are proposed for the bike boxes so that bikers are not stuck at this busy intersection that prioritizes long green lights for Highway 1 traveling traffic. Lastly, green intersection markings should be put in place in both directions of traffic on Western Drive. This allows for bikers to easily see where they should cross the intersection as well as to force drivers to acknowledge that bikers will be crossing the intersection and reduce safety concerns of cars turning an unprotected left.

Long-term solutions. In the longer term, more signaling geared towards cyclists will help bicyclists' ease of travel through this segment in the route. The green wave signal that is very popular in Copenhagen should be installed on the Northbound side of Western, to help the biker time their crossing of the intersection and beginning the incline. The green wave is a series of lights on the pavement on the side of the road that all light up at the speed required to make the green light in the upcoming intersection, to guide bikers to travel the speed that will benefit them the most.

Mission St.

Short-term solutions. Due to the very limited space on this segment of the route (40ft wide street with parking on either side), feasible, immediate changes are limited. Repainting of sharrows along both Western Dr and Mission St and added signage reminding vehicle drivers to share the road with cyclists can improve cyclist safety and confidence for the time being.

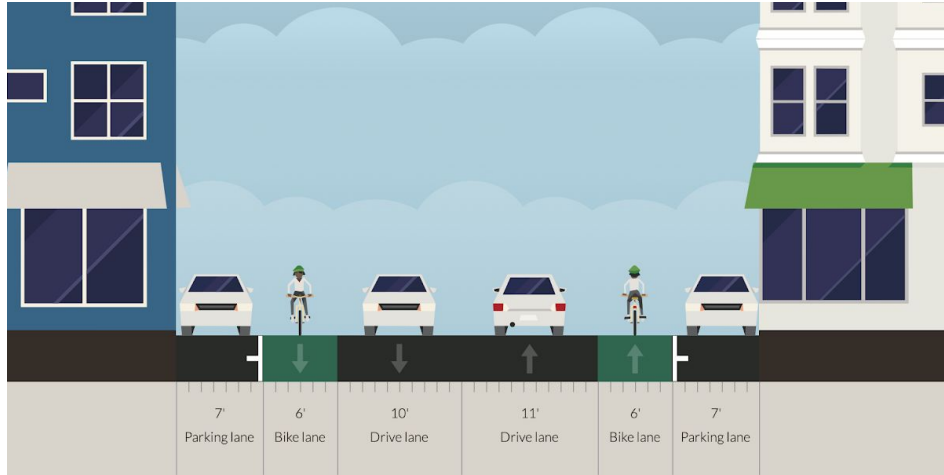
Long-term solutions. Similarly to the suggestions for Meder St and Western Dr segments 1-3, these two blocks of Western Dr. and Mission St. would be greatly improved by implementing an advisory bike lane design. By removing parking on one side of the street, roughly 12 parking spaces, there becomes enough space for a 6.5ft bike lane on one side, a 7ft parking lane on the other, and a 7.5ft bike lane adjacent to the parking lane. Therefore, 19ft remain for a driving lane. Although the removal of parking on one side of the street may sound unfavorable, it should not negatively impact those who frequent the businesses in the surrounding area. Natural Bridges Dr. can accommodate 10 of those parking spaces, and with the added bike infrastructure, those who frequent the area will be more likely to change their habits and cycle instead of drive a car. In addition, there is a lot of space on Mission St Extension one block before our improvements begin.



Mission St as an advisory bike lane.

Natural Bridges Dr (Mission St to Delaware Ave)

Short-term solutions. Currently, this segment of the route includes 9ft parking lanes on either side of Natural Bridges Dr. and 4ft bike lanes, which are below NACTO's recommended width. One short-term change that should be considered is repainting and reallocating the space that is shared between the bike and parking lanes along both sides of the street. If the parking lane were allowed only 7ft and the bike lane was expanded to 6ft, although technically not meeting the NACTO recommendation of 14.5ft total reach from curb to bike lane edge, cyclists would have much more room and therefore feel safer. In addition, while these changes are being made, painting the bike lane with green paint is another simple way to draw vehicle driver attention to and awareness to cyclists and improve cyclist safety.



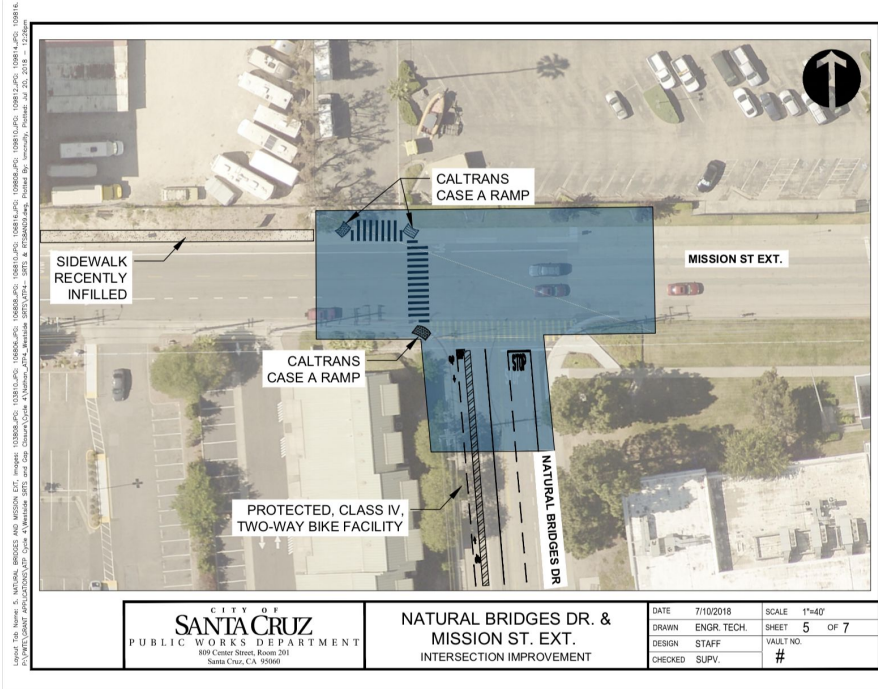
The short-term improvements that could be made to reallocate parking space to bike lanes.

Long-term solutions. The Natural Bridges Dr (Mission St to Delaware Ave) segment of the route are being redesigned as part of the city’s Westside Safe Routes to School and Gap Closure Project. This project is a school and community-based program aiming to improve safety and increase walking and biking. The redesigns incorporated in this project improve sidewalk infrastructure utilized by the most vulnerable pedestrians on these routes, including students traveling to school and elderly and disabled individuals accessing nearby services in addition to improving bike facilities.

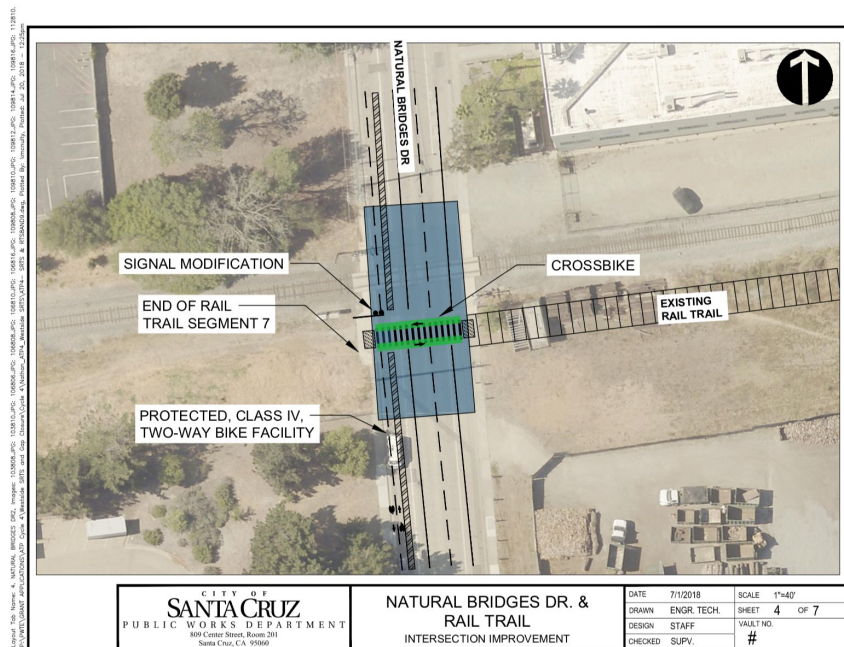


This map shows the overall changes that are going to be completed as part of the Westside Safe Routes to School and Gap Closure Project.

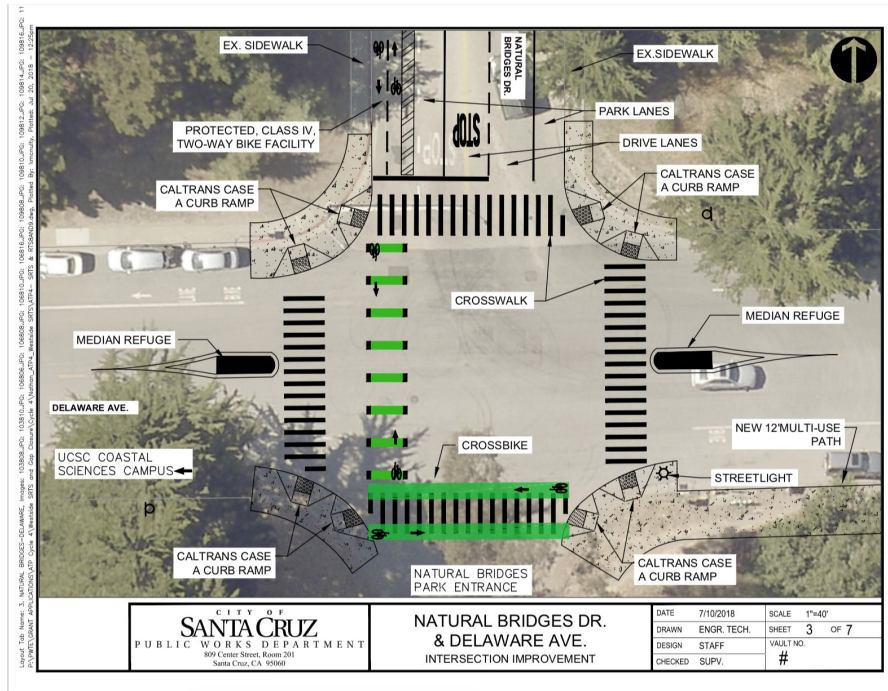
Along Natural Bridges Dr, bike facility improvements will be made and three intersections (Natural Bridges Dr & Mission St Extension, Natural Bridges Dr & Rail Trail, and Natural Bridges Dr & Delaware Ave) have proposed improvements. Following all of Natural Bridges Dr, there will be a protected class IV two-way bike lane. Each individual intersection has specific proposed improvements as well, each shown below.



The proposed changes for Natural Bridges Dr & Mission St Extension.



The proposed changes for Natural Bridges Dr and the Rail Trail.

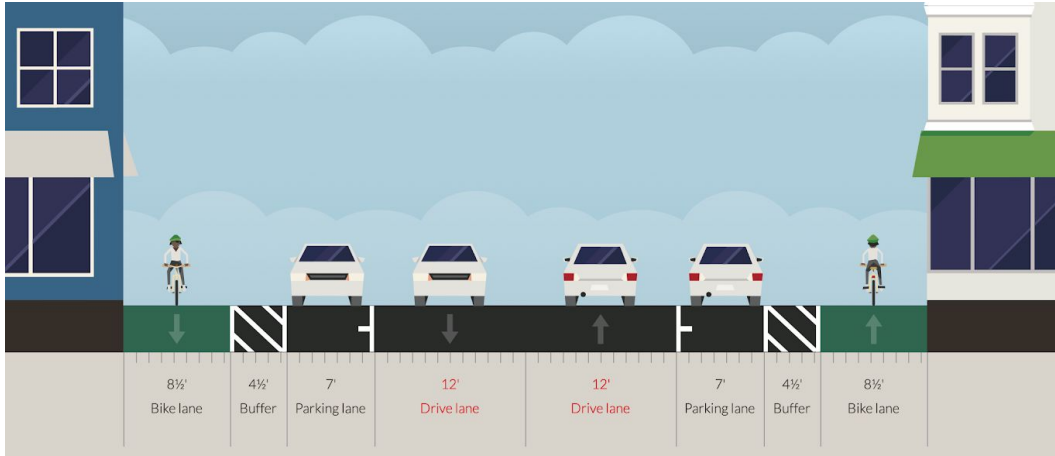


The city's proposed changes for Natural Bridges Dr & Delaware Ave.

Delaware Ave (Natural Bridges Dr to Coastal Science Campus)

Short-term solutions. This last segment of the route is one of the few that has NACTO compliant bike facilities. With a spacious 15ft from the curb to edge of the bike lane, there is little that ought to be done in the short-term to improve this segment aside from repainting the bike lane as a visual reminder for vehicle drivers.

Long-term solutions. If the parking lanes on Delaware Ave were limited to 7ft wide, even leaving the driving lanes with 12ft, the bike lanes on both sides of the street could be widened to 8.5ft. In addition, it is recommended that the bike lanes be moved in between the curb and parking lanes with painted buffers 4.5ft in width added in between. This creates a physical separation between cyclists and moving traffic and provides more than enough room to protect cyclists from the dangers of dooring. Wider, parking-protected bike lanes will lead to safer, more confident cyclists.



The redesigned Delaware Ave segment with added cyclist separation.