Bay and High Intersection Redesign

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Problem

- Over the next few years, P3 will bring 3,000 more students to UCSC. UCSC's transportation infrastructure must be able to accommodate these additional students.
    - With busses and on campus parking already at capacity, we must explore cycling as a solution to make transportation the least of student and faculty worries.
- UCSC is experiencing
    - Bus congestion
    - Lack of ADA compliance at Bay and High intersection
        - The sidewalk is too narrow for a person in a wheelchair cannot get to the northbound Bay and High bus stop.
- https://youtu.be/Fr9iKn1ACXU

Bus Congestion

- Two (or more) buses at the northbound Bay and High bus stop is a common occurrence.
- When a queue of buses forms, the second and third buses block the bike lane, forcing cyclists into the merge lane of traffic.

Problem (continued)

- With 10% of all non-vehicular UCSC commuters traveling by bike, the current intersection’s infrastructure fails to meet this demand.
- Current design overlooks an opportunity to alleviate pressure from current transportation infrastructure.
  - If we design infrastructure to incentivize cycling, in response to current and future congestion, we provide an alternative for UCSC commuters to utilize.

Four Way Intersection Design

We suggest that the current infrastructure be *updated* to facilitate transportation needs without incurring unnecessarily high costs.

- Bike boxes on both north & south-bound Bay
- Northbound shared transit/right turn only lane on northbound Bay
- Bus island at northbound Bay stop

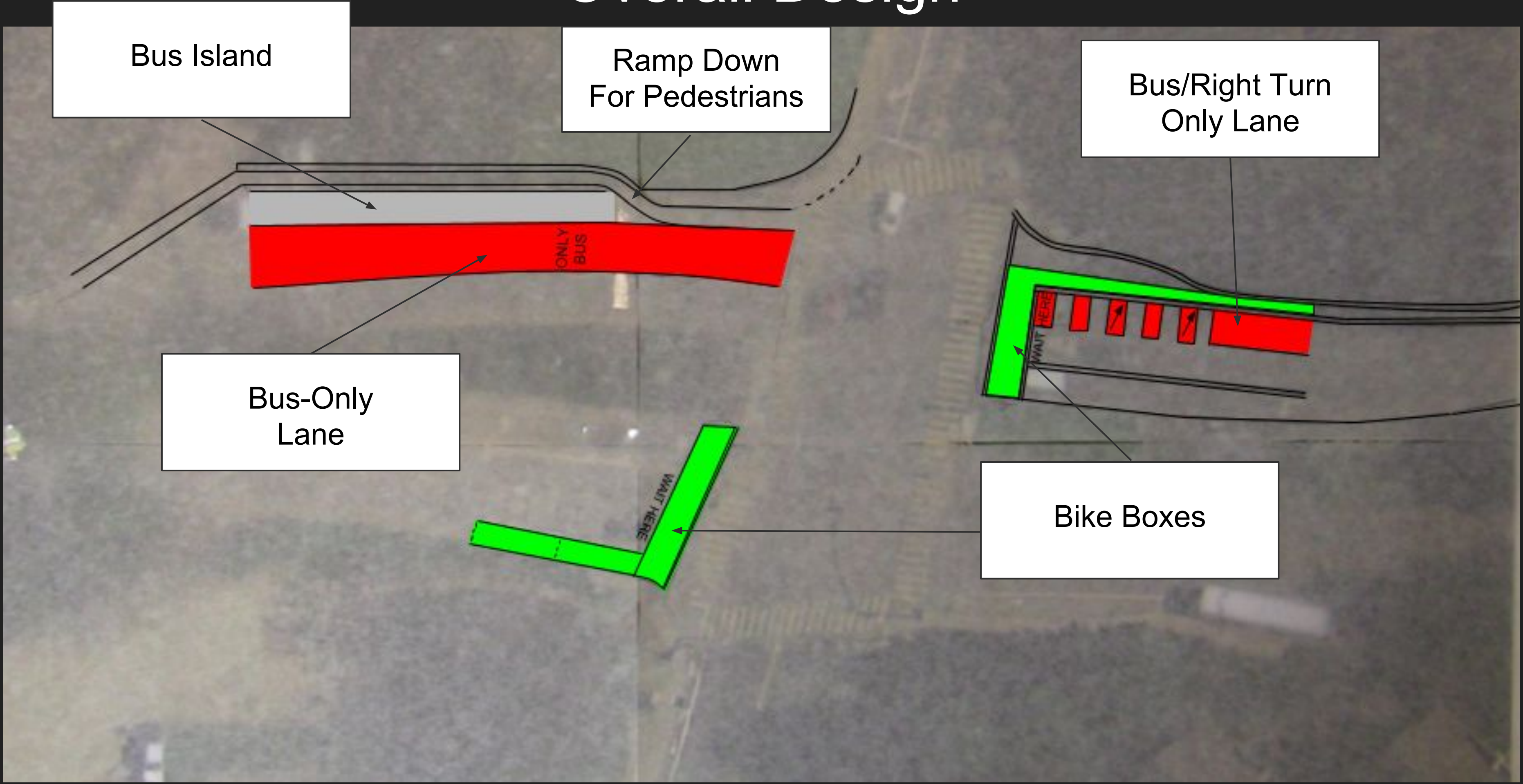
In the event that the roundabout is ultimately installed, the bus island could easily be incorporated into the design, given that the bus stops are not dramatically changed by the roundabout design. If the stops are pushed further away from the intersection to accommodate the roundabout itself, it would make sense to use this opportunity to install a bus island.

We based our implementations of the above treatments on the National Association of City Transportation Officials (NACTO) guidelines.

Considerations

The Granary, located on High Street, will see increased traffic volume in the future due it potentially becoming the new site of Admissions.

Overall Design



Treatment 1: Bike Boxes

Bike boxes are defined as a “designated area at the head of a traffic lane at a signalized intersection that provides bicyclists with a safe and visible way to get ahead of queuing traffic during the red signal phase” (NACTO).

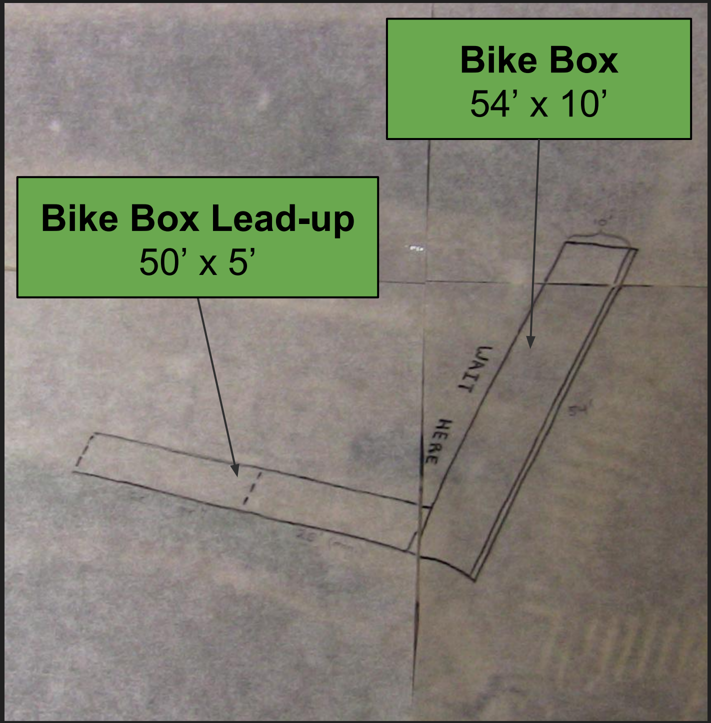
They are particularly useful in accommodating bicycle left-turns and eliminating conflict between right-turning vehicles and bicyclists (NACTO). These applications are relevant to BH as we have bicyclists a) turning left from Bay in both directions and b) competing with right-turning vehicles in both directions on Bay. Bike boxes would ensure that bicyclists could queue ahead of cars and thus reduce potential conflict.

Bike boxes have been adopted in San Francisco and San Luis Obispo, to name a few.

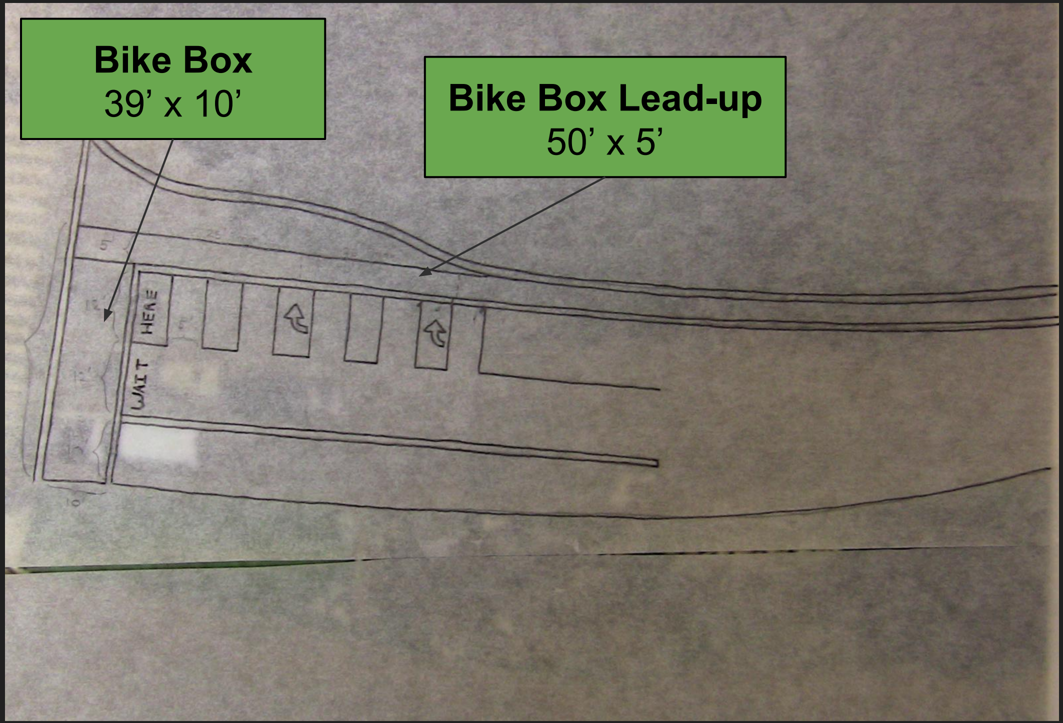
Our design would require the following:

- 1,180 - 1,430 ft^2 of green paint (10 ft wide boxes)
- 2 “No Turn on Red” signs
- 2 bike stencils
- 2 “Wait Here” stencils

Treatment 1b: Sketch



Southbound Coolidge

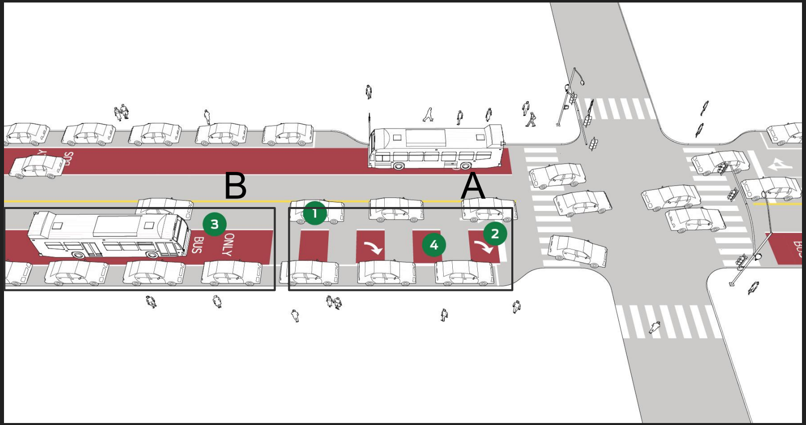


Northbound
Bay

Treatment 2: Shared Transit/Right Turn Lane

“On streets with a right-side dedicated transit lane that accommodates a moderate volume of right-turn movements, the **transit lane** can permit right turns approaching an intersection” (NACTO).

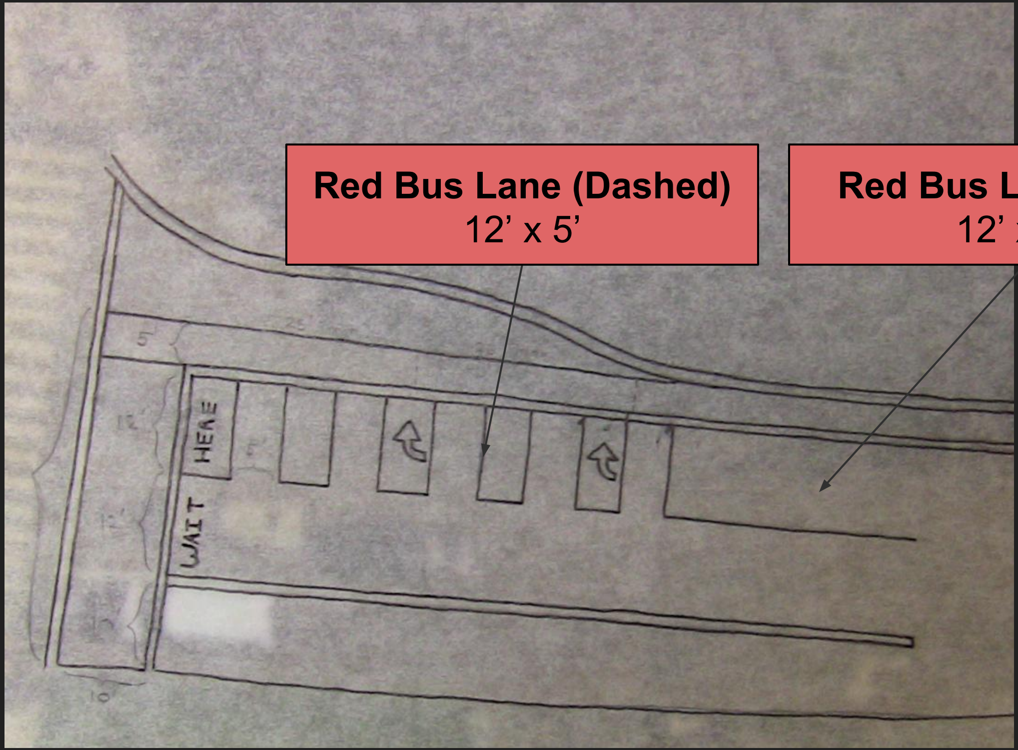
Our vision is to force northbound-thru Bay traffic to take the left thru-lane in order to accommodate a bus island on the opposite side of the intersection. Given that vehicles often turn right from northbound Bay onto eastbound High, a shared transit/right turn lane is necessary to a) force thru-traffic into the left thru-lane, b) allot a lane for transit, and c) allow for vehicles to turn right onto Bay.



Our design would require the following:

- 600 ft^2 of solid red paint/surfacing (50 ft long) - “B”
- 300 ft^2 of dashed red paint/surfacing (50 ft before intersection) - “A”
- “Right Lane Must Turn Right” and “Except Buses” signs (MUTCD R3-7R & R3-1B)
- 1 “Bus Only” stencil
- 2 right-arrow stencils - within “A”

Treatment 2b: Sketch



Red Bus Lane (Dashed)
12' x 5'

Red Bus Lane (Solid)
12' x 50'

Northbound
Bay

Treatment 3: Side Boarding Island Stop

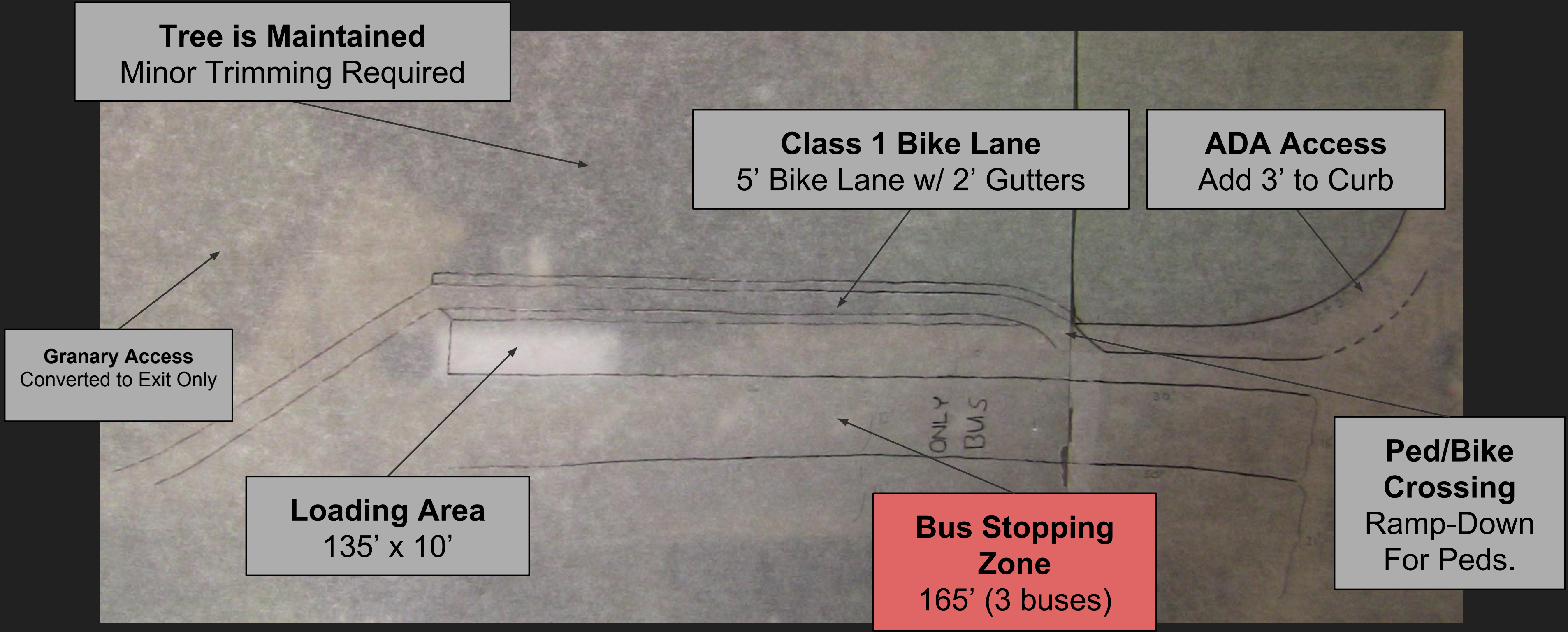
A Side Boarding Island Stop is a “dedicated waiting and boarding area for passengers that streamlines transit service and improves accessibility by enabling in-lane stops… side boarding islands are separated… by a bike channel, eliminating conflicts between transit vehicles and bikes at stops.” (NACTO)

Currently, Bay has 2-lanes on the northbound side, and we envision provisioning the right-lane as being bus-only in order to allow for a bus island. A bus island would permit for a wider boarding area and allow for us to bring the bike lane around the right-side of the island, thus separating bicyclists from vehicle traffic. Buses often get backed up here, getting in the way of bicyclists. Link

Our design would require the following:

- 1,350 ft^2 of concrete boarding area
- 1,000 ft^2 of additional bike lane + 540 ft^2 of gutter
- 2,640 ft^2 of solid red paint/surfacing
- 3 ft curb extension
- 1 bus only stencil
- “Bikes Yield to Pedestrians” sign (MUTCD R9-6)
- A sign on High that mandates cars use the far lane when making a right
- Granary access road would need to be exit only on Bay to ensure no line-of-sight issues with cyclists.

Treatment 3b: Sketch

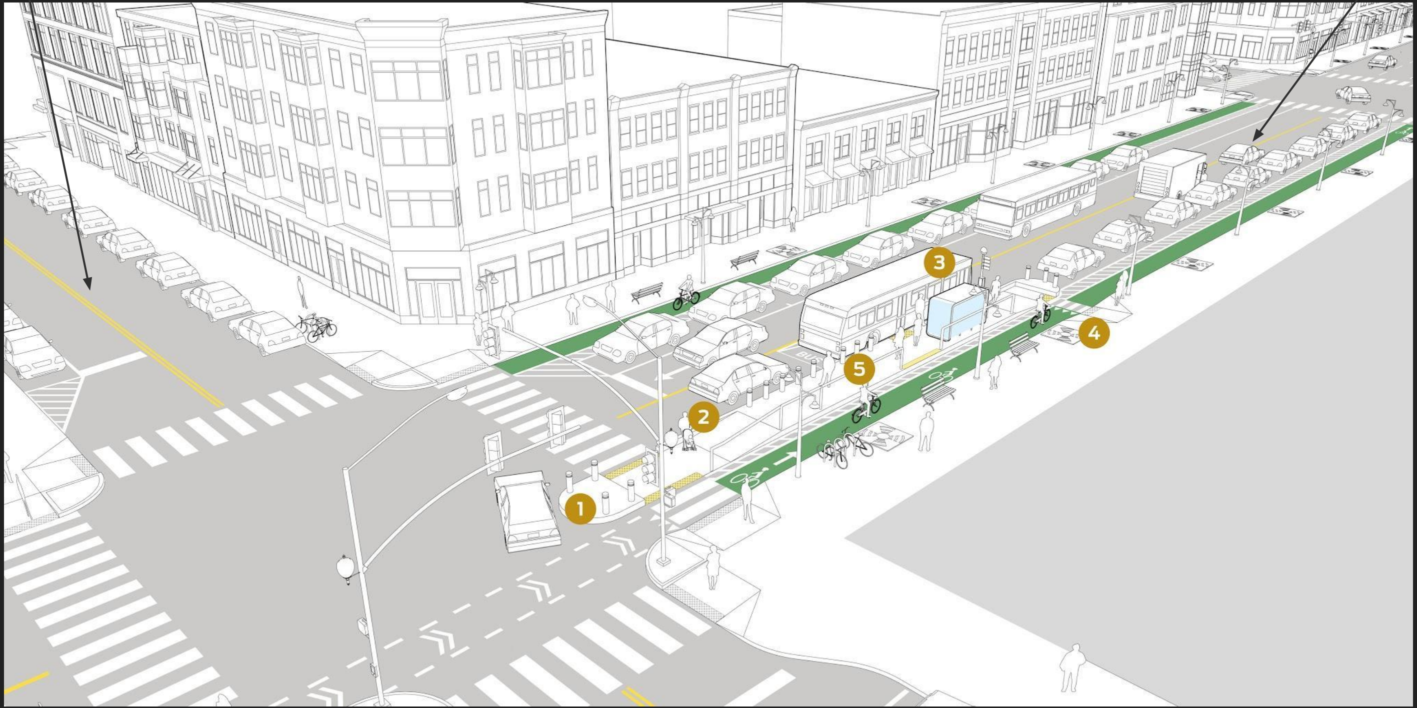


Northbound Coolidge

High Street

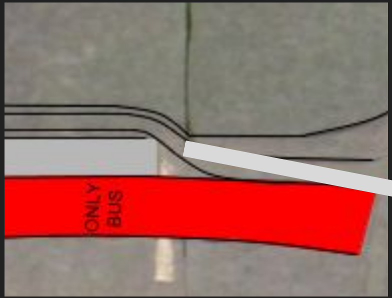
Treatment 3c: NACTO

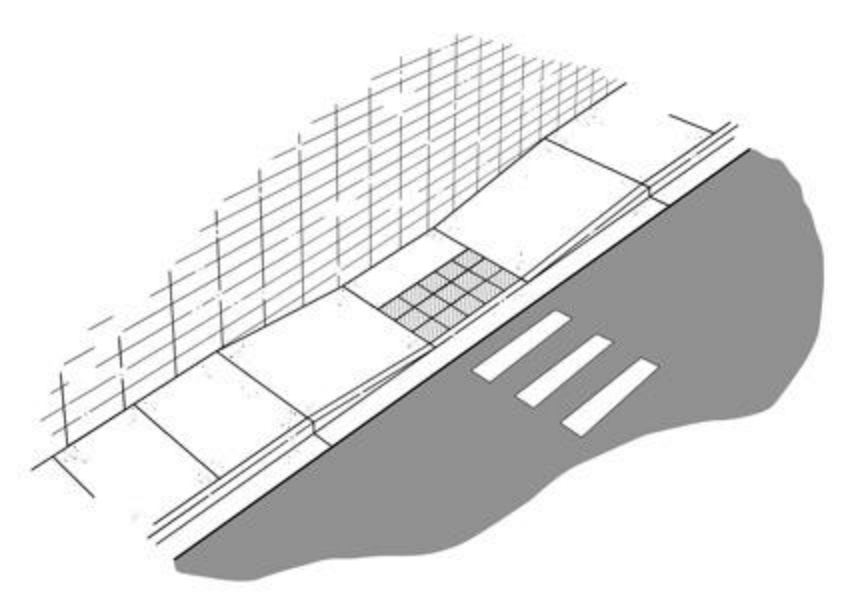
Bay Street



NACTO provides this in-depth concept art for a side boarding bus stop. Conveniently, their included intersection is similar to Bay/High.

Ramp Down Reference





- Promotes yielding to bicyclists.

“But why should bicyclists the have right of way?”

- They don’t have to slow down and/or queue in the street, a potential danger.
- Essentially, it is less costly for pedestrians to yield than for bicyclists to yield.

Important Note: The Granary

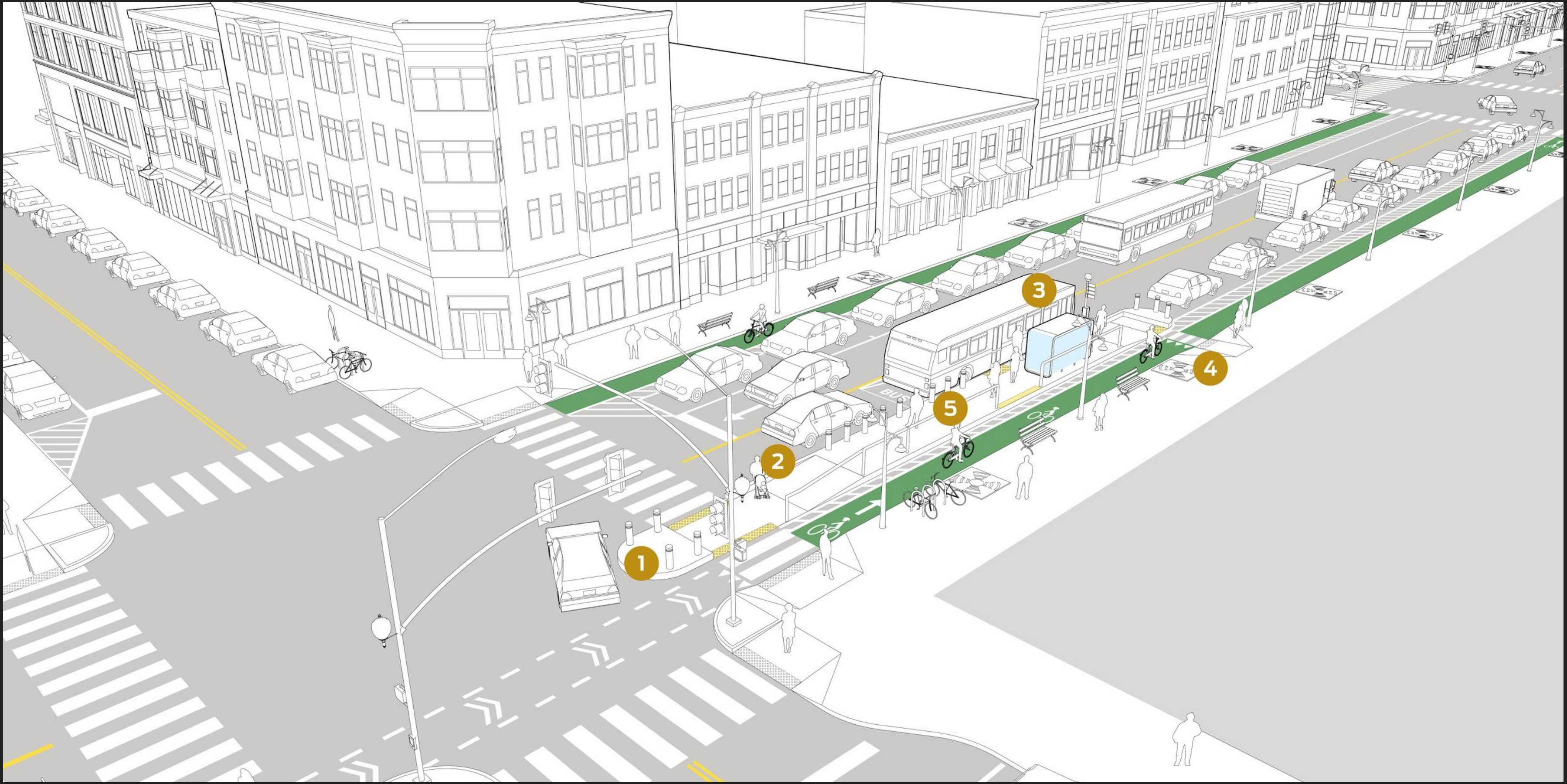
Currently: there is only one entrance/exit, and it is on Bay. This is not compatible with our design. Entering vehicles would be blind to bicyclists.

Clockwise (entrance Bay, exit High): same issue.

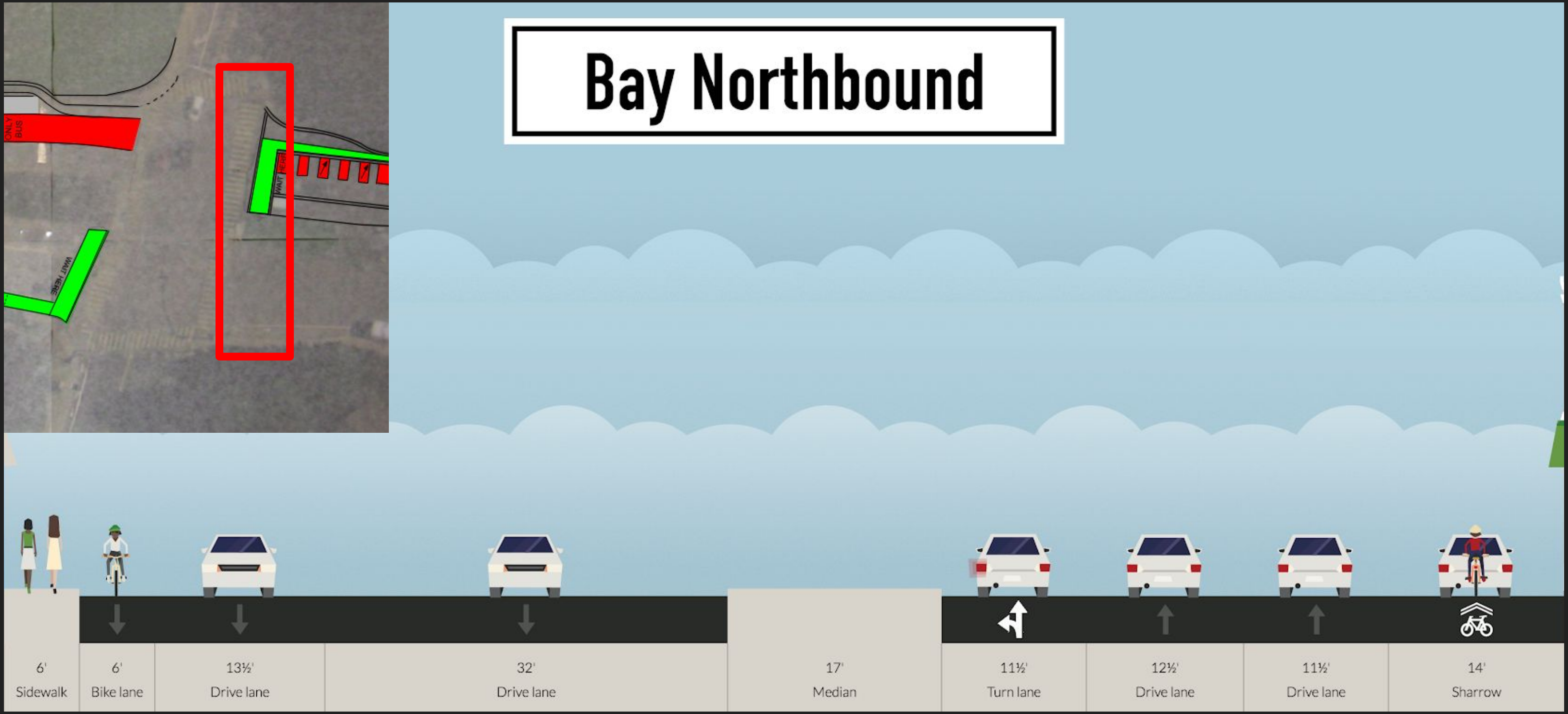
Counterclockwise (entrance High, exit Bay): compatible with our design, though requiring cars to cross traffic.

High entrance/exit: compatible with our design, streamlines Bay traffic.

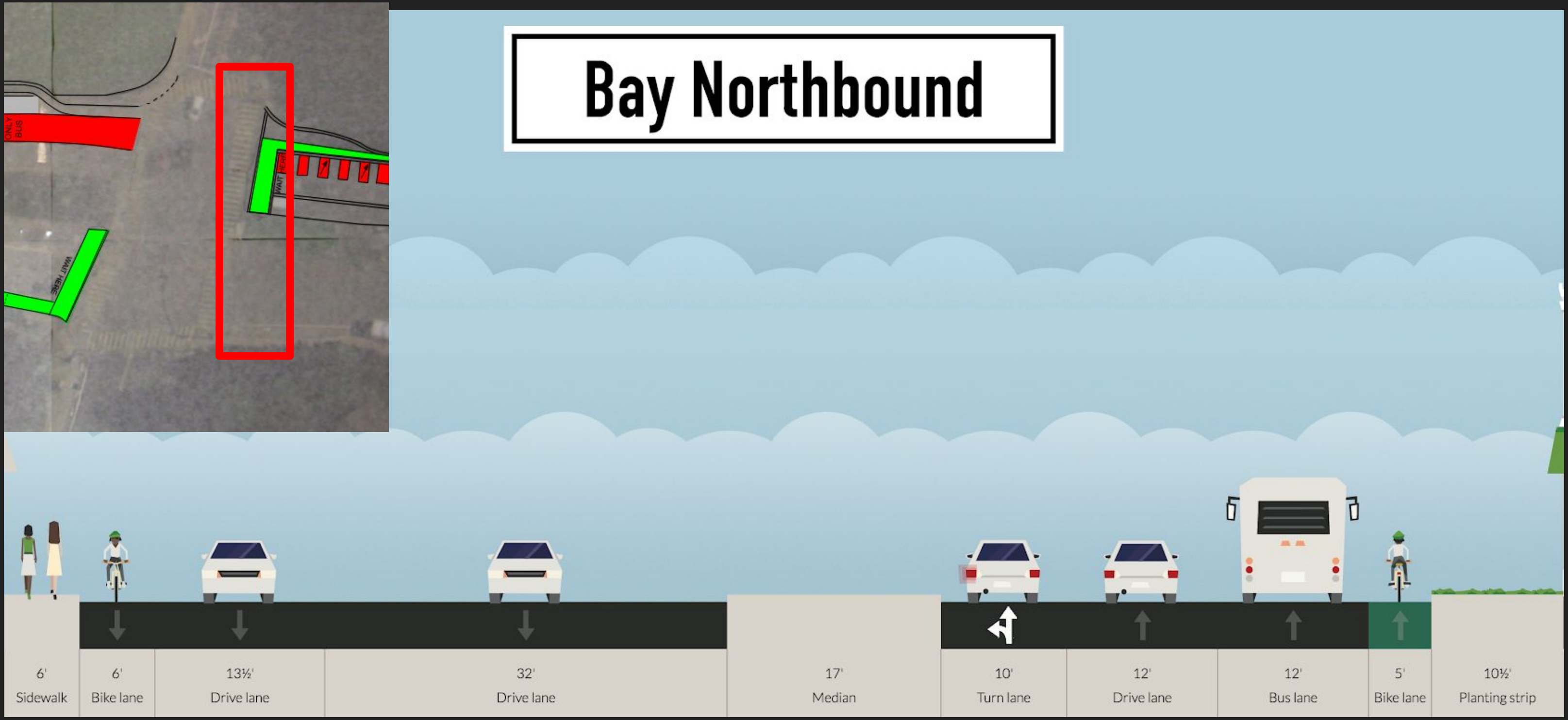
NACTO Side Boarding Island Stop Design



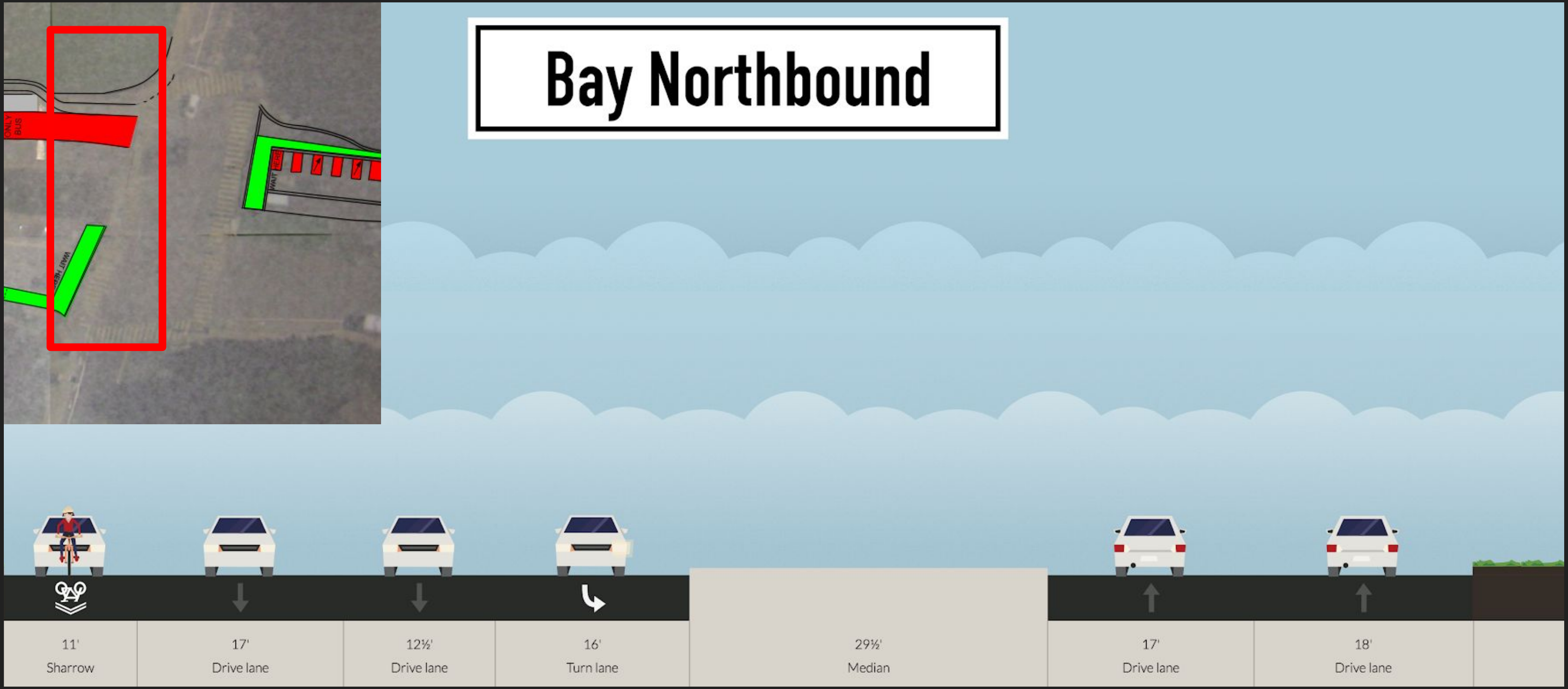
South Side - Right of Way Allocation (Current)



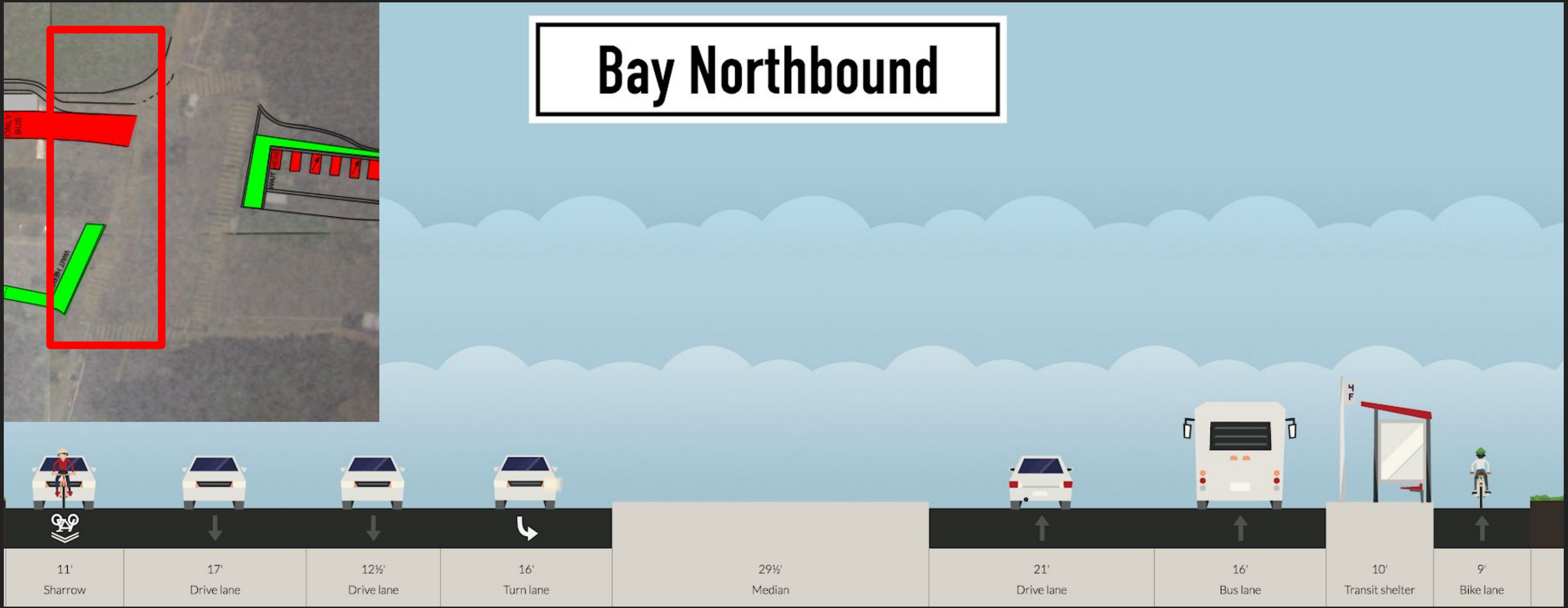
South Side - Right of Way Allocation (Proposed)



North Side - Right of Way Allocation (Current)



North Side - Right of Way Allocation (Proposed)



Costs

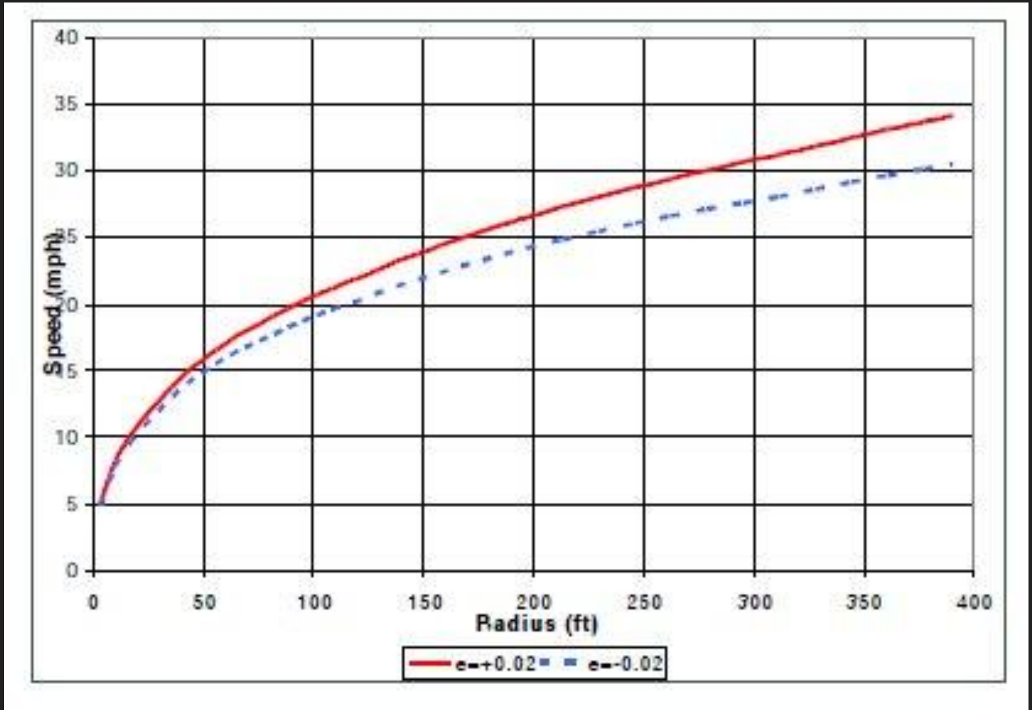
- Paint — colored paint indicating bus and bike lanes around the intersection
  - Green: 1180 - 1430 ft^2 x $1.20 - $1.60 per ft^2 = $ 1416 - 2288
  - Red: 3540 ft^2 x $1.20 - $1.60 per ft^2 = $4248 - 5664
  - Stencils: 30ft^2 x 2 (“wait here” stencils) x $7 = $420
  - Total: $6048 - 8372
- Signage
  - “Bikes Yield to Pedestrians” sign (MUTCD R9-6)
  - “Right Lane Must Turn Right” and “Except Buses” signs (MUTCD R3-7R & R3-1B)
  - “No Turn on Red” sign x2
  - (4 signs x $15 - 18) + (40ft of posts x $15 - $20) + (4 foundations x $150 - 200) = $1260 to $1672
- Concrete
  - At around $24 per ft^2, concrete installation will cost in the range of $200,000. We estimate an area of nearly 10,000, accounting for bike lane construction.

Revised Roundabout Design:

Intersection redesign is compatible with a roundabout, but existing proposed roundabout should be scaled down

- According to the 2010 National Cooperative Highway Research Program (NCHRP), informational guide to roundabouts by Rodegerdts, Bansen, Tiesler, Knudsen, and Myers:
    - A roundabout need only be two lanes if the intersection experiences a volume of over 1,300 vehicles per hour, per leg of the roundabout
    - According to TAPS intersection counts from Spring 2016 provided by Larry Pageler, Bay and High experiences a maximum of around 1000 vehicles per hour in the busiest direction (northbound)
        - Bay and High does not experience the flow demand requiring a two lane roundabout
        - Therefore, one lane is sufficient
- Cyclists who share the lane with cars will need to be going roughly the same speed, or will need to be separated
    - NCHRP estimates cyclists to travel at 12-20mph; northbound Bay and High sees cyclists traveling substantially slower since they are traveling uphill.
    - In order to be compatible with bike traffic, a roundabout at Bay and High needs to have either a smaller radius to control traffic speeds, or bike infrastructure to make the roundabout usable to bikes, if vehicle speeds are higher.
- We need not design an intersection built to serve traffic demand that shouldn't exist in the future

Radius Considerations



Example:

- In order to control traffic to 20mph* (the maximum NCHRP estimate for bike speed), a roundabout must have a radius of **~90 ft.**
- In order to control traffic to 12mph* (the minimum NCHRP estimated bike speed), a roundabout must have a radius of **~25 ft.**

*Speed, radius data, and graph from the NCHRP report.

Redesign Will Have No Effect on LOS for Automobiles

- We used simplified level of service analysis from the 2016 Highway Capacity Manual (HCM), supplemented with alternate volume-to-capacity ratio explanations from *Traffic Engineering*, Roger P. Roess and Elena S. Prassas.
  - Calculations followed those outlined in the HCM, and Garber
  - Input and calculated using Google Sheets
  - LOS Spreadsheet
- Procedure simplifications
  - Northbound delay was the only direction calculated, since this is the direction where the bulk of our changes would take place
  - HCM adjustment factors very close to 0 or 1, or unaffected by our design changes, omitted from analysis
  - Data acquired from city required interpretation, and variables were assumed based on standard HCM values
- Data required for analysis
  - Intersection dimensions (estimated by Google Earth, measured and confirmed by me and Miles)
  - Intersection vehicle counts (provided by TAPS from Spring 2016, and from our own lane-specific counts)
  - Signal timing data (provided by the city, and standard values provided by the HCM)

Key Values and Variables

- Key values*
  - Cycle length (city signal timing data): 175 seconds
  - Saturation (field data): 540 vehicles per hour (veh/h)
  - Effective green time (city signal timing data): 55 seconds
- Key variables
  - Number of northbound lanes: 1 left + 1 through + 1 through/right = 3
    - Changes to 1 left + 1 through = 2 lanes of vehicle traffic
  - Bus blockage factor: 0.988
    - Changes to 0.976 after bus lane design change

*Values only calculated for northbound Bay, since other lanes are unaffected in our design.

Level of Service Analysis: Results

- Level of Service rating B, with a delay of 19.7 seconds per vehicle (s/veh)
  - This is the middle of the delay range for LOS rating B.
- Intersection design changes add less than five seconds of delay, from 19.7 s/veh 24.2 s/veh, still within LOS rating B
  - Design changes include reducing the northbound through lanes from two to one, and altering the bus-blockage factor to account for a bus-only and right turn lane
- Even with our changes, we remain above the city's standard of LOS rating C.
  - At or below rating C, the city would have to undergo expensive and time-consuming environmental review
- Additional delay to vehicles will be offset by intersection treatments
  - Omission of northbound lane maintains LOS B at peak hour
  - Marginal delay increase will be offset by higher bus speeds and greater cyclist safety and accessibility
- Sources
  - Observation and measurement, Google Earth, Santa Cruz Public Works department, TAPS, HCM
- Note: LOS and delay values only calculated for northbound Bay, since other lanes are unaffected in our design.

Conclusions

- Our approach to this project is focused on cyclists
    - Cycling infrastructure is in the most dire need of investment from the city and the university, because of the potential impacts of P3.
        - Three thousand extra students will be housed on campus; this means that three thousand more students will need transportation--already, the campus' loop bus system, the metro buses that serve campus, and campus parking are all at capacity.
- A growing student population should be able to rely on cycling to alleviate stress on existing modes of transportation.
- In redesigning the Bay and High intersections we allow expansion of alternate modes of transportation while precluding more vehicle traffic, thereby putting infrastructure in place around which a strong cycling culture can form.
    - Therefore, Santa Cruz's population can increase without contributing to congestion or pollution.
- Having proved that our intersection treatments will not impact level of service, we urge the city of Santa Cruz and TAPS to adopt our cycling infrastructure treatments.

Works Cited

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