Comprehensive County Expressway Planning Study

County Expressway
Bicycle Accommodation Guidelines

Roads and Airports Department

Revised August, 2003

County of Santa Clara

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County of Santa Clara

Roads and Airports Department
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San Jose, CA 95110

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Introduction

The Bicycle Accommodation Guidelines (BAG) will be used to develop potential bicycle improvement projects throughout the expressway system. It includes design details and written policies. Policy and technical background, plus resources used to develop the guidelines, are included in the Appendices for reference purposes.

The BAG are consistent with the Caltrans *Highway Design Manual* and will be revised to reflect changes in the *Highway Design Manual* when appropriate. The BAG will be incorporated into the County's Standard Details manual which is formally adopted by the Board of Supervisors.

The following objectives and guidelines have been used to develop the BAG:

Objectives

1. Provide safer accommodation for bicyclists along all expressways.
2. Be consistent along the entire length of each expressway and among the expressways for the benefit of both motorists and cyclists, to the extent possible.

Guidelines

1. Travel width –

   Provide adequate continuous travel width for use by bicyclists on the expressways.

2. Delineation-

   Delineate the bicycle travel width with shoulder stripes and other striping as needed.

3. Entrance and exit ramps-

   On county facility, signalize exiting or merging movements with two or more lanes.

   In Caltrans' jurisdiction, work with Caltrans to improve situations where bicyclists must cross more than one conflicting vehicle lane at a time.

4. Safe passage across intersections –

   Provide intersection design treatments and operations that enhance safer passage for bicyclists.

5. Trail connectivity –

   Wherever feasible, work with trail operators to plan for and provide direct connections between trail over and undercrossings and both directions of expressways.

6. Maintenance –

   Maintain clear and clean shoulder areas on the expressways.

Bike Lane Designation Process

In general, the recommended expressway approach is to delineate bike travel width, but not to designate bike facilities as formal bike lanes. Delineation refers to striping; designation refers to bike lane signs and pavement markings. This approach is based on the concept that children and inexperienced bicyclists should not be encouraged to use the expressways. Another element of designation is the incorporation of routes into various bicycle route maps. Casual recreational or family outing users could misunderstand inclusion on a bike route map to mean an easy route for novices.

However, expressways vary as to existing conditions and community preferences. To allow designation of bike lanes, the following process will be used:

1. Specific criteria for evaluating bike lane designation proposals will be developed. The criteria will consider elements such as: posted speed limit, geometric conditions, type of merge and diverge crossings, consistency along the expressway, consistency with city bike plans, and continuity with other bike facilities, including creek trails. County staff will establish the bike lane designation criteria using a collaborative process involving city staff, the County Roads Commission, and the County BPAC.
2. Where new bike lanes are proposed, cities shall supply a council-approved request.
3. County staff shall than apply the criteria to evaluate the suitability and develop a recommendation about the proposed bike lane. The recommendation will be brought to the County Roads Commission and County BPAC, prior to submittal to the Board of Supervisors for final action.

The existing bike lanes along portions of Oregon-Page Mill and Foothill Expressways will remain in place. Extending these lanes, however, will require Board of Supervisors' approval using the bike lane designation process.

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1. Bicycle Travel Area Widths

- 4' (1.2m) State of California minimum riding zone
- 5' (1.5m) State of California standard shoulder
- 6' (1.8m) Desirable design standard, to enable cyclists to ride to left of debris
- 8' (2.4m) Desirable to enable disabled vehicles to park outside the travel lane

Discussion:

These proposed widths are based on language in *Caltrans Highway Design Manual* (*5th Edition*), Chapter 1000 (Bikeway Planning and Design). The **bold** emphasis appears in the original text.

1003.2 Class II Bikeways

(c) **If no gutter exists, the minimum bike lane width shall be 1.2 m. With a normal 600 mm gutter, the minimum bike lane width shall be 1.5 m.** The intent is to provide a minimum 1.2 m wide bike lane, but with at least 0.9 m between the traffic lane and the longitudinal joint at the concrete gutter, since the gutter reduces the effective width of the bike lane for two reasons. First, the longitudinal joint may not always be smooth, and may be difficult to ride along. Secondly, the gutter does not provide a suitable surface for bicycle travel. Where gutters are wide (say, 1.2 m), an additional 0.9 m must be provided because bicyclists should not be expected to ride in the gutter. Wherever possible, the width of bike lanes should be increased to 1.8 m to 2.4 m to provide for greater safety. 2.4 m bike lanes can also serve as emergency parking areas for disabled vehicles.

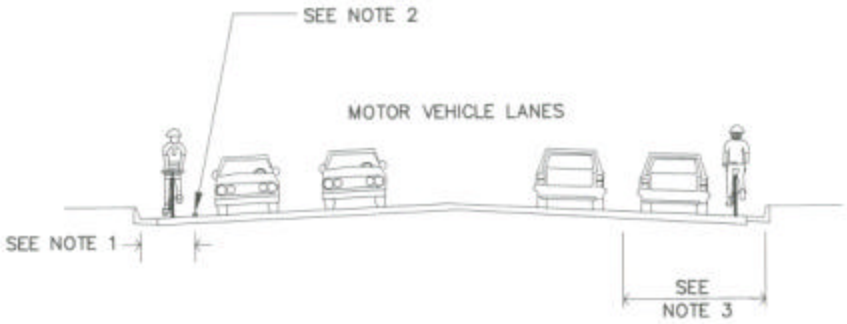
Notes:

The terms "bicycle travel width" and "bike area width" in this document are generic and are not meant to imply a Caltrans Class II bike lane. Bicycle travel width can be provided with shoulders or bike lanes.

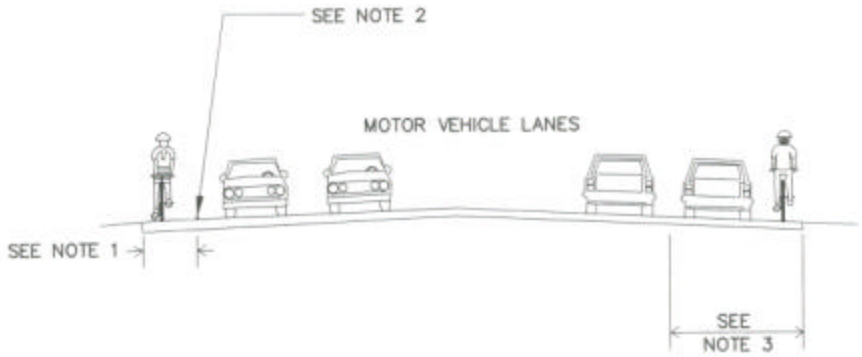
TYPICAL BIKE TRAVEL AREA WIDTHS BETWEEN INTERSECTIONS

NOTES:

1. 2.4m (8') OPTIMUM (TO ALLOW FOR VEHICLE BREAKDOWN FUNCTION)
   1.8m (6') PREFERRED
   1.5m (5') MINIMUM, WHERE GUTTER PAN (MINIMUM 1m(3') ASPHALT SURFACE AREA) EXISTS.
   1.2m (4') MINIMUM WHERE NO GUTTER PAN EXISTS.
2. 150 mm (6") WHITE STRIPE PER DETAIL 39 CALTRANS TRAFFIC MANUAL.
3. WHERE NO BIKE TRAVEL AREA CAN BE DELINEATED THE FOLLOWING APPLY:
   4.8m (16') MINIMUM SHARED WIDTH (NO STRIPE AND WHERE GUTTER PAN EXISTS).
   4.5m (15') MINIMUM SHARED WIDTH (NO STRIPE AND WHERE NO GUTTER PAN EXISTS).



WITH CURB AND GUTTER



WITHOUT CURB AND GUTTER

Figure 1

2. Bicycle Detection Locations and Markings

Bicycle sensitive detection will be provided in the following lanes:

Movement	Lane Used By Experienced Bicyclist	Expressway	Cross Street
Through	Rightmost through lane, or bike lane or shoulder area along the right turn channelization island ("pork chop")	No detection or legend needed - recalls to green	Detection and marking
Left turn	Rightmost left turn lane.	Detection in center of lane. No marking (Note 1)	Detection and marking in center of lane
U-turn	U-turn lane (Lane 1).	Detection in center of lane. No marking (Note 2)	Detection in center of lane. No marking (Note 1)

Notes:

1: The department's policy is not to mark expressway left turn lanes. However, the department's standard detectors and detection sensitivity settings used in left turn and U-turn positions are adequate to detect bicycles. The preferred turning movement is to use the cross street.

2: The current state standard loop detector bicycle pavement legend (Caltrans Standard Plan A24C, shown below) does not indicate the appropriate turning movement(s) for a bicycle positioned on the legend. In dual left turn configurations there is concern that marking the U-turn (Lane 1) as well as the left turn (Lane 2) could lead less-experienced cyclists to incorrectly choose Lane 1 for left turns, exposing them to conflicts with faster left-turning motor traffic to their right. One proposed solution is to combine a small arrow marking with the detection legend. Until that is approved at the state level the U-turn position will not be separately marked.

Discussion:

The following Caltrans inductive loops have been used to detect bicycles reliably:

- Type E modified per City of Palo Alto detail (with added slash) detects bicycles reliably and is the County's preferred loop.
- Type B
- Type C
- Type D (also preferred by the County)
- Type Q

Types A and E (unmodified) are not bike-sensitive in their center, and, therefore, should not be used on the expressway system.

Loops used in left turn lanes should be bike-sensitive in their center to enable a bicycle to wait further from adjacent moving (through) traffic then will be the case if the left turn loop is only sensitive along its sides.

BICYCLE DETECTION LOCATIONS AND MARKINGS

NOTES:

1. BIKE SENSITIVE DETECTOR SHALL BE TYPE D OR MODIFIED TYPE E LOOP.
2. REFER TO CALTRANS STANDARD PLANS A24C FOR BIKE PAVEMENT MARKING.
3. EXACT LOCATION OF BIKE SENSITIVE DETECTOR SHALL BE DETERMINED BY ENGINEER.
4. LOCATION OF BIKE PAVEMENT MARKING SHALL BE CENTERED LATERALLY IN LOOP.

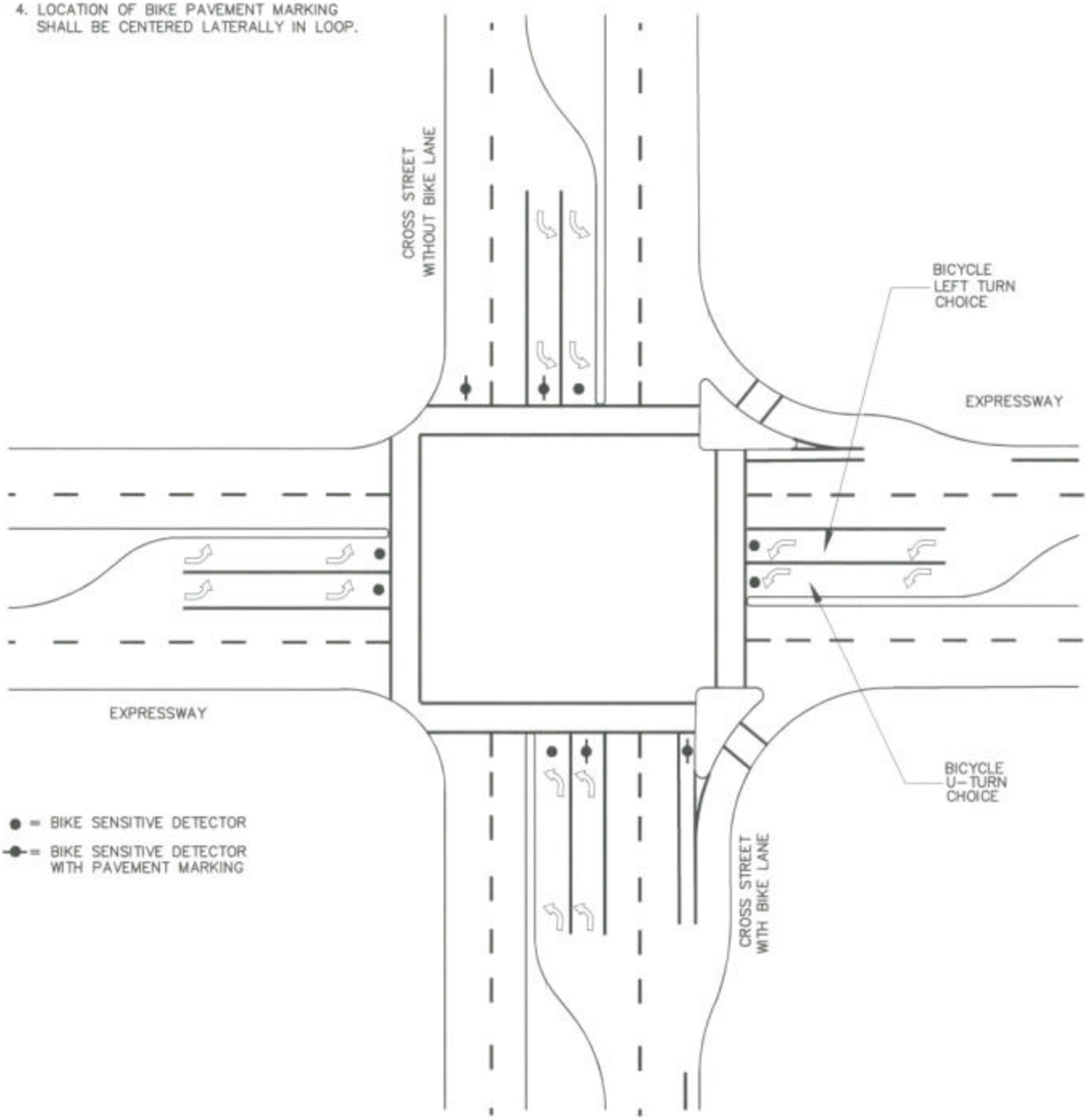
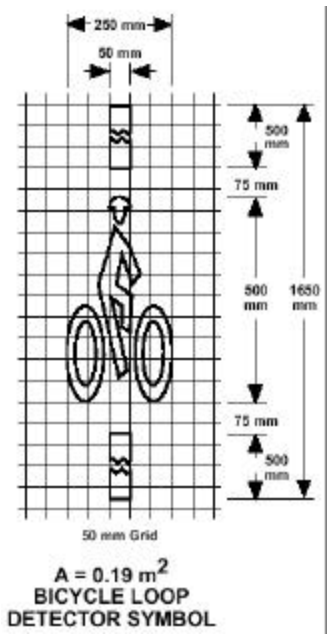


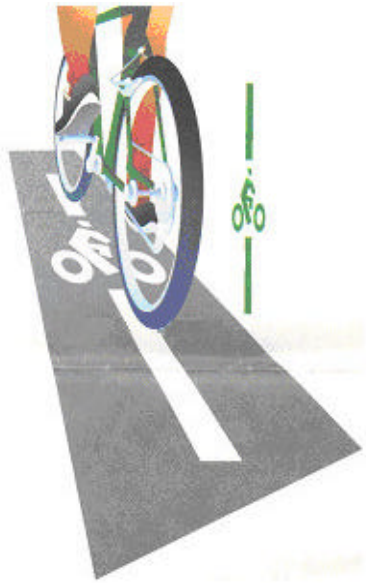
Figure 2

Video zone detection should sense bicycles in all approach lanes and also on the left side of a right-turn channelization island. Bicycle waiting positions listed in the above table should still be marked if video is used because markings indicate where to wait to be detected and the safest position for a given movement. If feasible, create advance detection zones in lanes where cyclists are expected, and have detection software estimate approach speed to identify bicycles and extend green time as needed.

The department's existing practice for locating the position to be marked is to use a bicycle.



Caltrans Standard Plan A24C loop detector bicycle marking



Cyclist use of detector marking

The line segments before and after the Standard Plan A24C bike icon are to be 500 mm long.

References:

Caltrans Standard Plan A24C (markings)

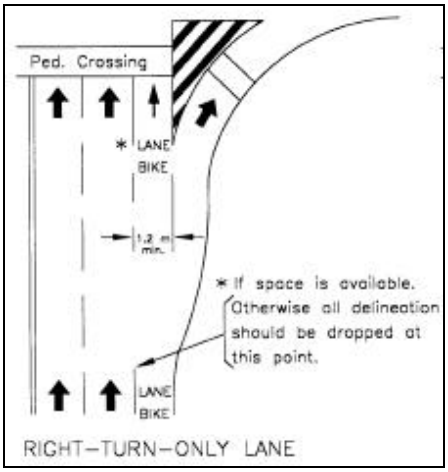
Caltrans Standard Plan ES-5B (loop detector shapes and winding patterns)

City of Palo Alto detail for slashed Type E (circular) loop

3. Signal With Right Turn Channelization

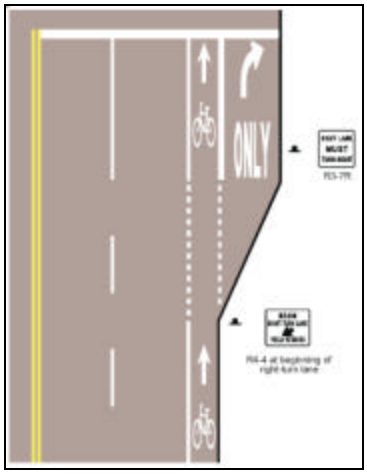
Discussion:

Through bicycle "slot" lanes will be used at signalized intersections. Caltrans' *Highway Design Manual* 5th Edition (HDM) shows no delineation through the transition area. AASHTO (1999) permits optional dashed lines delineating the bicycle travel width through the transition area. MUTCD (2000) Figure 9C-3 is identical to AASHTO Figure 11a except that the dashed lines through the transition area are not described as optional. Caltrans has stated its intention to adopt the MUTCD in the future, replacing several state-specific manuals. At the time Caltrans adopts MUTCD, consideration will be given to use of dashed lines.



Caltrans HDM (5th Edition)
Figure 1003.2C

AASHTO Guide (1999)
Figure 9



AASHTO Guide (1999)
Figure 11a

Figures:

- Figure 3A shows right turn channelization with no turn pocket;
- Figure 3B shows a turn pocket.

In both cases an exit bike area may be delineated if the exit is at least 20' wide.

SIGNAL WITH RIGHT TURN CHANNELIZATION ISLAND AND NO TURN POCKET

NOTES:

1. IF EXIT WIDTH IS GREATER THAN OR EQUAL TO 6m (20') A BIKE AREA MAY BE DELINEATED ALONG THE EXIT LANE AS DEPICTED AND AS DETERMINED BY THE ENGINEER.
2. DETAIL 38 TERMINATES AT TANGENT WITH DETAIL 38 ADJACENT TO THE CHANNELIZATION ISLAND.
3. EXACT LENGTH AND LOCATION OF TRANSITION TO BE DETERMINED BY BY ENGINEER.
4. REFER TO FIGURE 2 FOR BIKE DETECTOR AND SYMBOL LOCATIONS.
5. RIGHT TURN CURB RADIUS TO BE DESIGNED SPECIFIC TO THE INTERSECTION CONDITIONS AND WILL CONSIDER A VARIETY OF FACTORS INCLUDING PEDESTRIAN NEEDS (I.E., A TIGHT RADIUS) AND TRUCK TURNING ENVELOPE NEEDS.

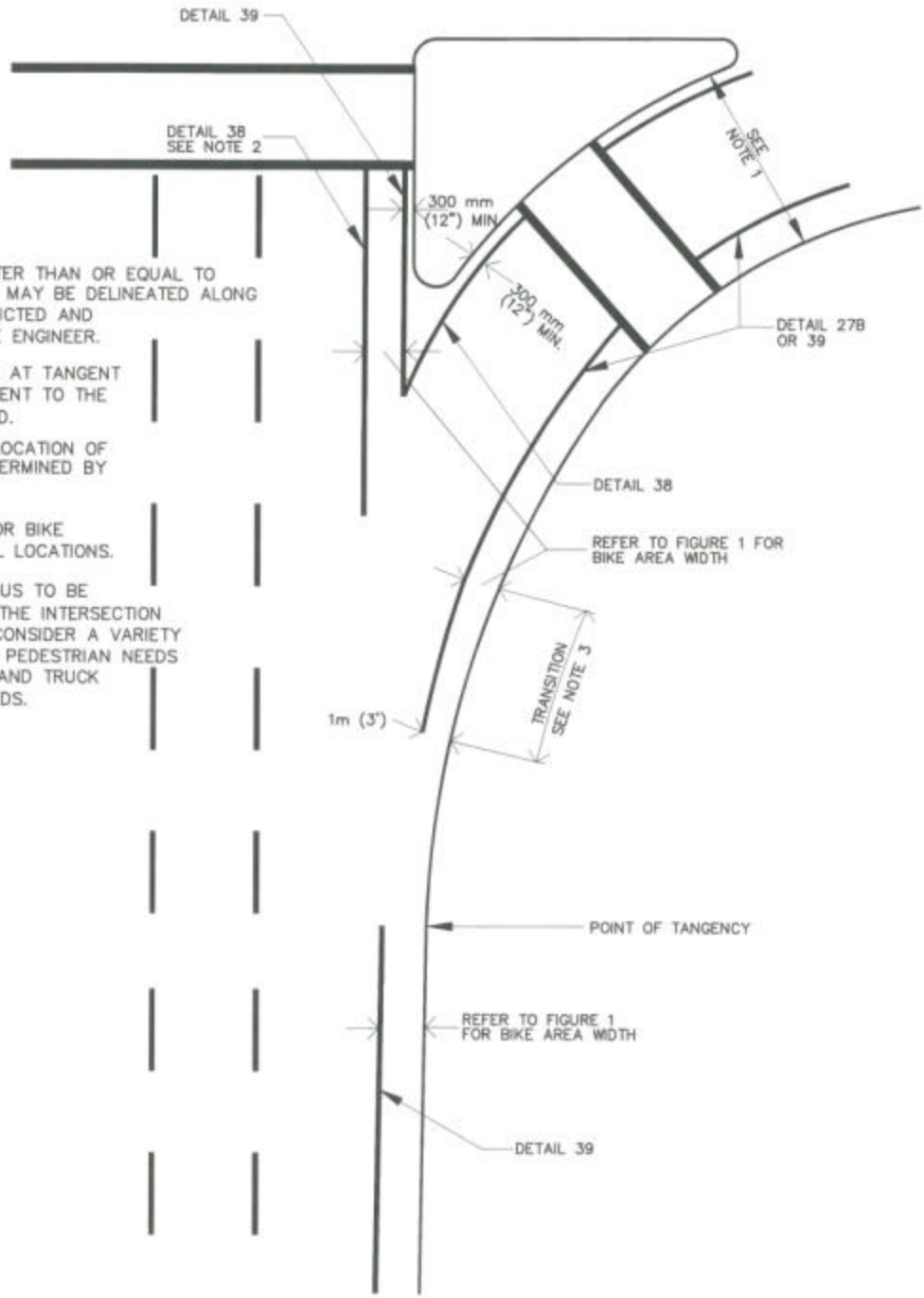


Figure 3A

SIGNAL WITH RIGHT TURN CHANNELIZATION ISLAND AND TURN POCKET

NOTES:

1. IF EXIT WIDTH IS GREATER THAN OR EQUAL TO 6m (20') A BIKE AREA MAY BE DELINEATED ALONG THE EXIT LANE AS DEPICTED AND AS DETERMINED BY THE ENGINEER.
2. DETAIL 38 TERMINATES AT TANGENT WITH DETAIL 38 ADJACENT TO THE CHANNELIZATION ISLAND.
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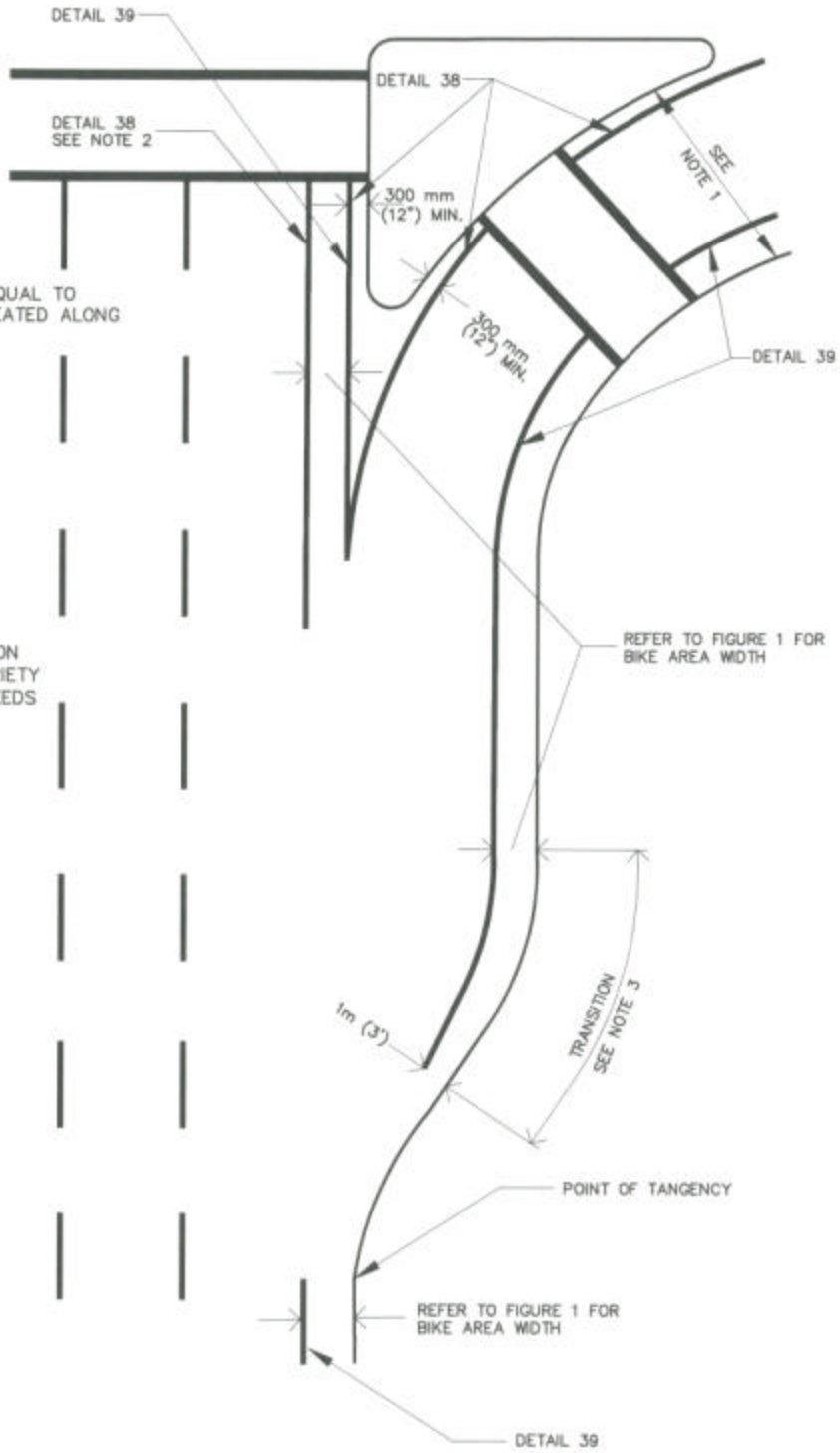


Figure 3B

4. Interchanges

Discussion:

Exit lanes

At short exit lanes most through cyclists will "hold their line" (i.e. continue straight across the short transition area), because to move right and then immediately left is more complex and error-prone. To accommodate through bicyclists, bicycle travel width should be provided to the left of a short exit lane.

At long exit lanes, most through cyclists adopt a different strategy to minimize exposure time: they stay to the right of exiting traffic until near the end of the pocket, then move leftward before the diverge at a position that depends on traffic conditions. To accommodate through bicyclists, bicycle travel width should be provided to the right of a long exit lane until near its end, then to left of the exit lane to receive them as they transition across the exiting flow. The exit from eastbound Central Expressway to northbound San Tomas Expressway is an example of a long exit lane.

Depending on exit width, grade and geometry, exiting cyclists will either stay to the right of exiting motor traffic or will "single up" (get in line) as they continue into the exit. If there is sufficient width, a right-side exit bicycle area should be delineated into the exit toward the cross street. Approaching an exit, available bicycle travel width should be prioritized for the through (left-side) movement over the exiting (right-side) movement.

Trap lanes (lane drops)

A trap lane is similar to an exit lane except that there is no lane-add before the lane-drop. As with a long exit lane, a through cyclist will transition left across a trap lane at a point that depends on traffic conditions. Accommodations for through and exiting cyclists are the same as for right turn pockets.

Merge lanes

Through cyclists generally minimize their exposure to merging traffic by moving to the right edge of the roadway soon after the merge point, unless there is no merging traffic or the merge length is fairly short. For this reason it is not desirable to extend a dashed line across the merge area.

A delineated bicycle travel area should resume on the right side of a merge lane starting at or before the end of the merge gore, to enable cyclists to transition to the right as early as possible if they decide not to continue on a straight line of travel. Bicycle delineation should be resumed when there is 3' (0.9m) of asphalt to the right of the stream of merging vehicles.

If sufficient width is available along the full length of the merge lane starting at the diverge from the cross street, it is useful to delineate a bicycle travel area along its entire length, enabling cyclists to enter the expressway independently of motorists.

Figures:

Figure 4 shows bicycle accommodations at an interchange.

BICYCLE ACCOMODATION AT INTERCHANGES

NOTES

1. IF OVER/UNDERPASSING ARTERIAL PERMITS BICYCLE TRAFFIC AND IF THE EXIT/MERGE AREA WIDTH ≥6m(20') THEN BIKE AREA MAY BE DELINEATED AS DEPICTED AND AS DETERMINED BY THE ENGINEER.
2. WHERE A RIGHT TURN POCKET EXISTS, DELINEATE EXIT SHOULDER PER FIGURE 3B.
3. DETAIL 38B IS OPTIONAL. USAGE OF STRIPING TO BE DETERMINED BY ENGINEER.

LEGEND

CHANGE IN STRIPING

SIGN LOCATION

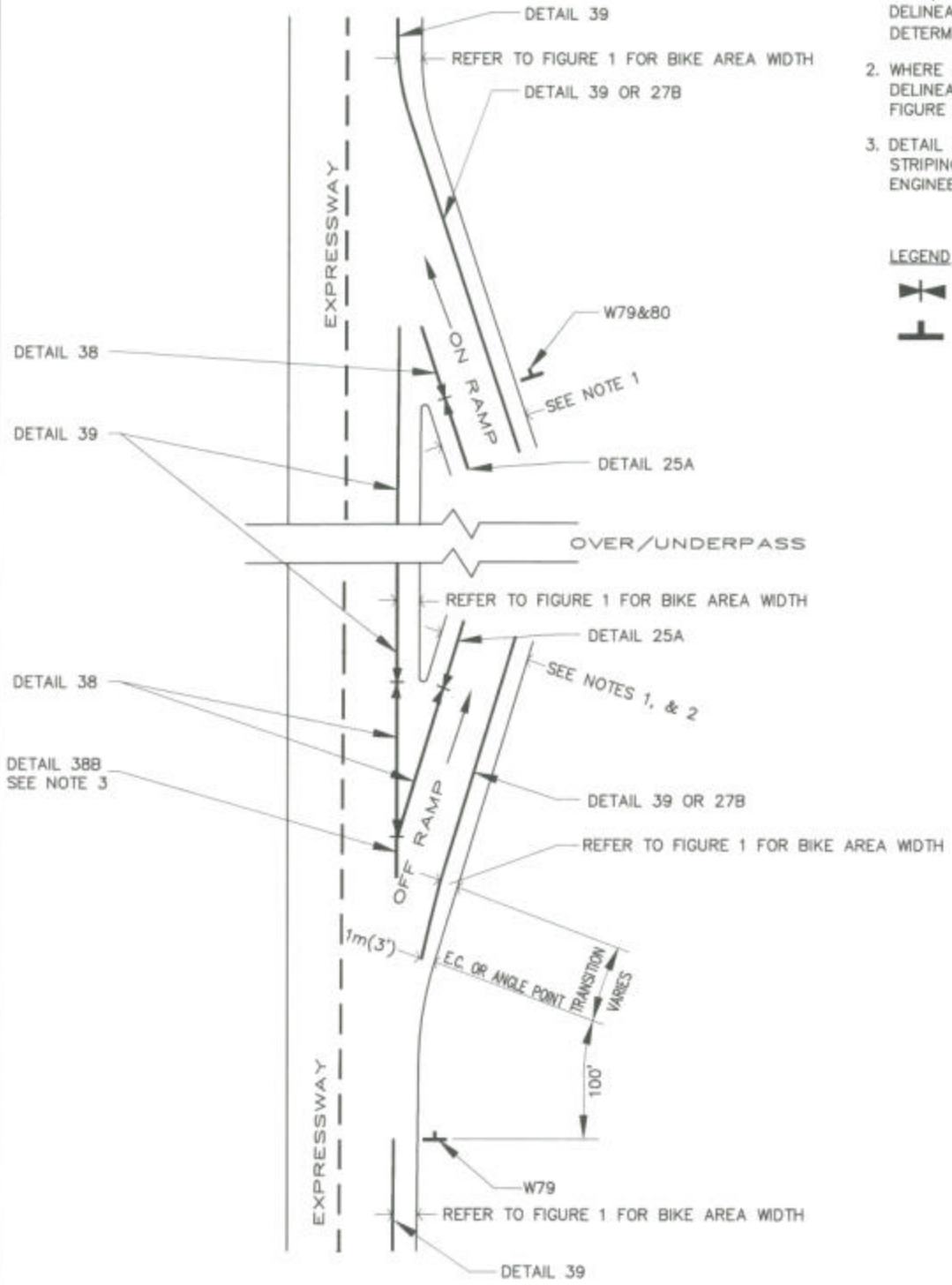


Figure 4

5. Right Turn In/Outs

Discussion:

Through bicyclists will proceed straight across the “top” of a raised or painted right turn in/out island. Depending on the length of the merge area beyond the island, they will either hold a straight line across it, or cross to the right side. The situation is similar to a right turn pocket followed by a merge, each of which is discussed with earlier Figures.

Sufficient bike travel area width should be provided and delineated across the top of a right-turn in/out triangle island. Where there is sufficient width to do so, this width will be delineated as a through bicycle "slot" lane and carried across the island to discourage motorists from continuing straight across the island. The slot should be 5' (1.5m) minimum and 6' (1.8m) maximum.

If the distance between the outer slot line across the island and the island face is wide enough that it might encourage through movements by motorists, that space should be slashed.

RIGHT TURN IN/OUT

NOTES

1. EXACT LENGTH AND LOCATION OF TRANSITION TO BE DETERMINED BY ENGINEER.
2. RIGHT TURN CURB RADIUS TO BE DESIGNED SPECIFIC TO THE INTERSECTION CONDITIONS AND WILL CONSIDER A VARIETY OF FACTORS INCLUDING PEDESTRIAN NEEDS (I.E., A TIGHT RADIUS) AND TRUCK TURNING ENVELOPE NEEDS.

LEGEND

CHANGE IN STRIPING

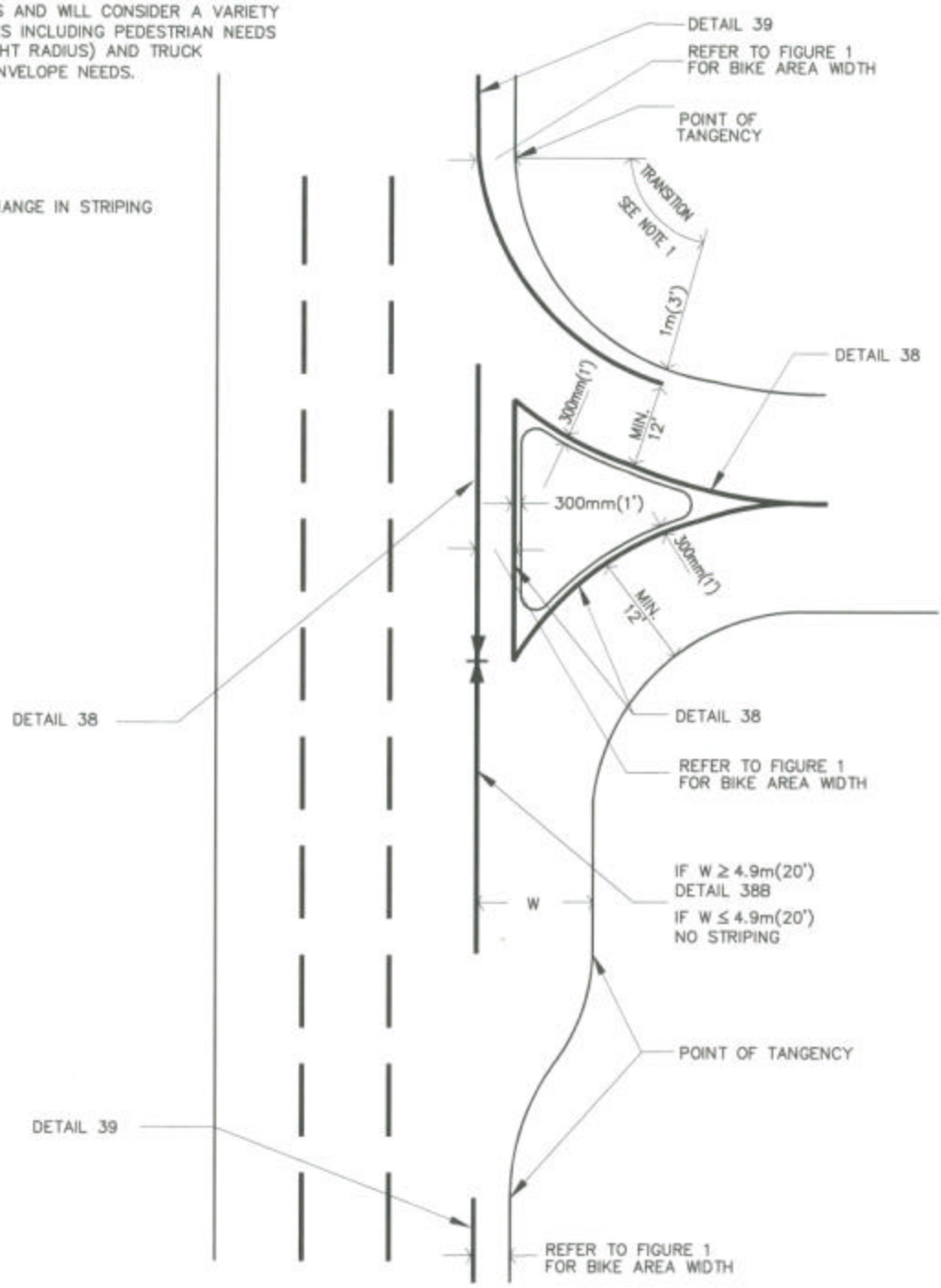


Figure 5

6. Auxiliary Lanes

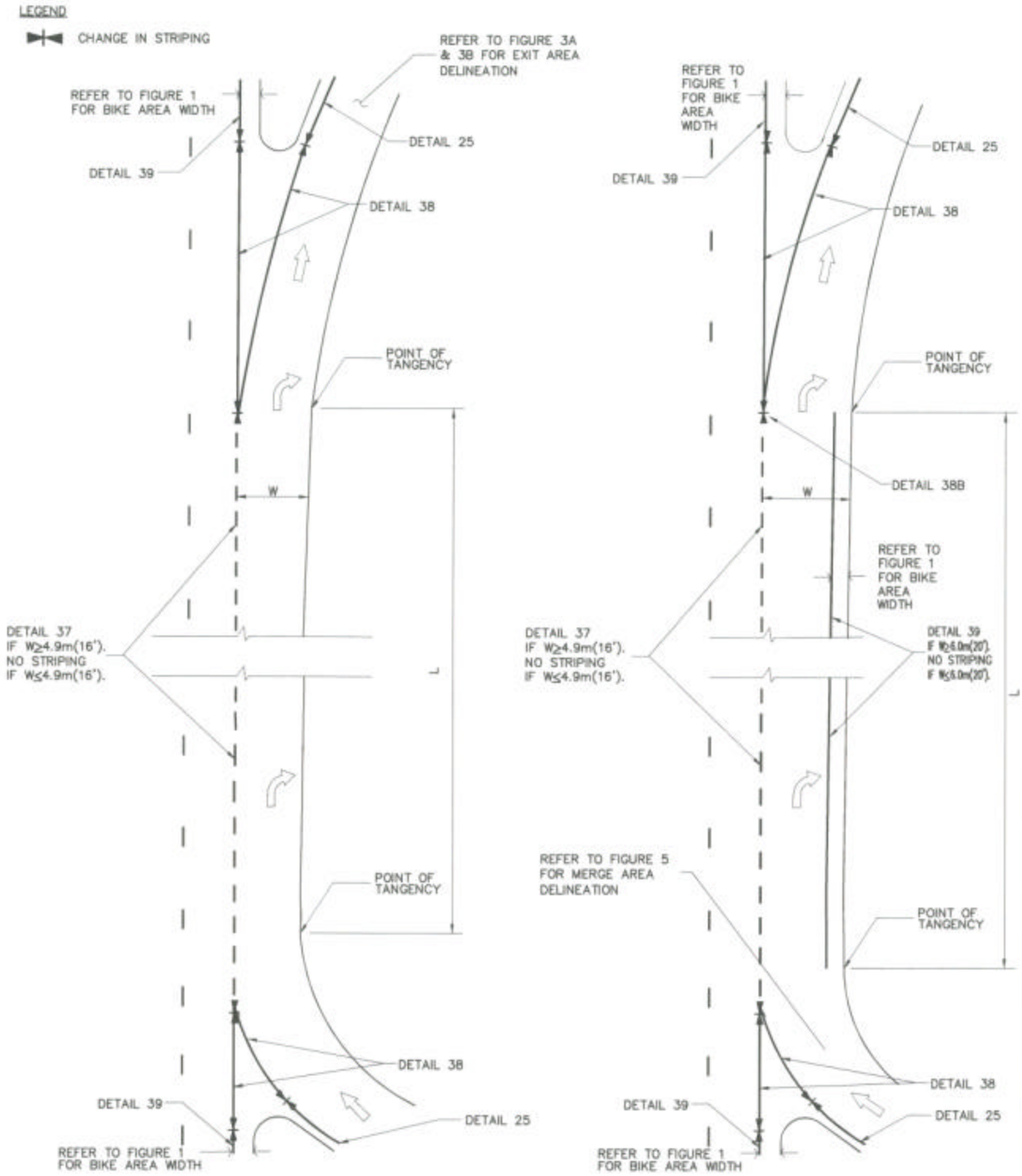
Discussion:

Most cyclists treat auxiliary lanes like exit lanes. If an auxiliary lane is short, through cyclists typically hold a straight line to the left of it. If it is long, they cross to the right side at the start and back across at the end, as shown in Case I and Case II of Figure 6.

Central Expressway eastbound between the Mary Avenue merge and the Pajaro Avenue right turn in/out is an example of a short auxiliary lane.

Sand Hill Road westbound across the I-280 cloverleaf (type L-10) interchange in Menlo Park is an example of a long auxiliary lane. However, at this site Caltrans District 4 Traffic Operations striped a dashed bike lane instead of a single dashed line. This change has been well received by area cyclists.

AUXILIARY LANE



CASE I WHERE L<200m

CASE II WHERE L>200m

Figure 6

7. Alternatives to Two-Lane Free Flow Exits

Discussion:

Multilane crossings of free-flow movements require difficult gap acceptance decisions by cyclists and pedestrians.

On Caltrans intersections and interchanges, designers should utilize the most current Caltrans resources on county facilities, signalize exiting or merging movements with two or more lanes, and, where possible, consider use of innovative designs to improve situations where cyclists (and pedestrians, where applicable) must cross more than one conflicting free-flow lane at a time.

Several Caltrans-proposed study alternatives to 2-lane free-flow exits are shown in Figure 7. These employ 3 principles to reduce the level of conflict at the local street ends of the ramps. (In the context of this document, "local street" is the expressway.)

- If an exit has 2 or more lanes, consider adding the additional lanes after the diverge
- For HOV ramp bypass, consider having HOV's exit separately after mixed-flow
- Consider reducing corner radii of exiting and merging movements at the local street (expressway) end of the ramps, to reduce the speed of those movements.

ALTERNATIVE TWO-LANE FREE FLOW CONCEPTS

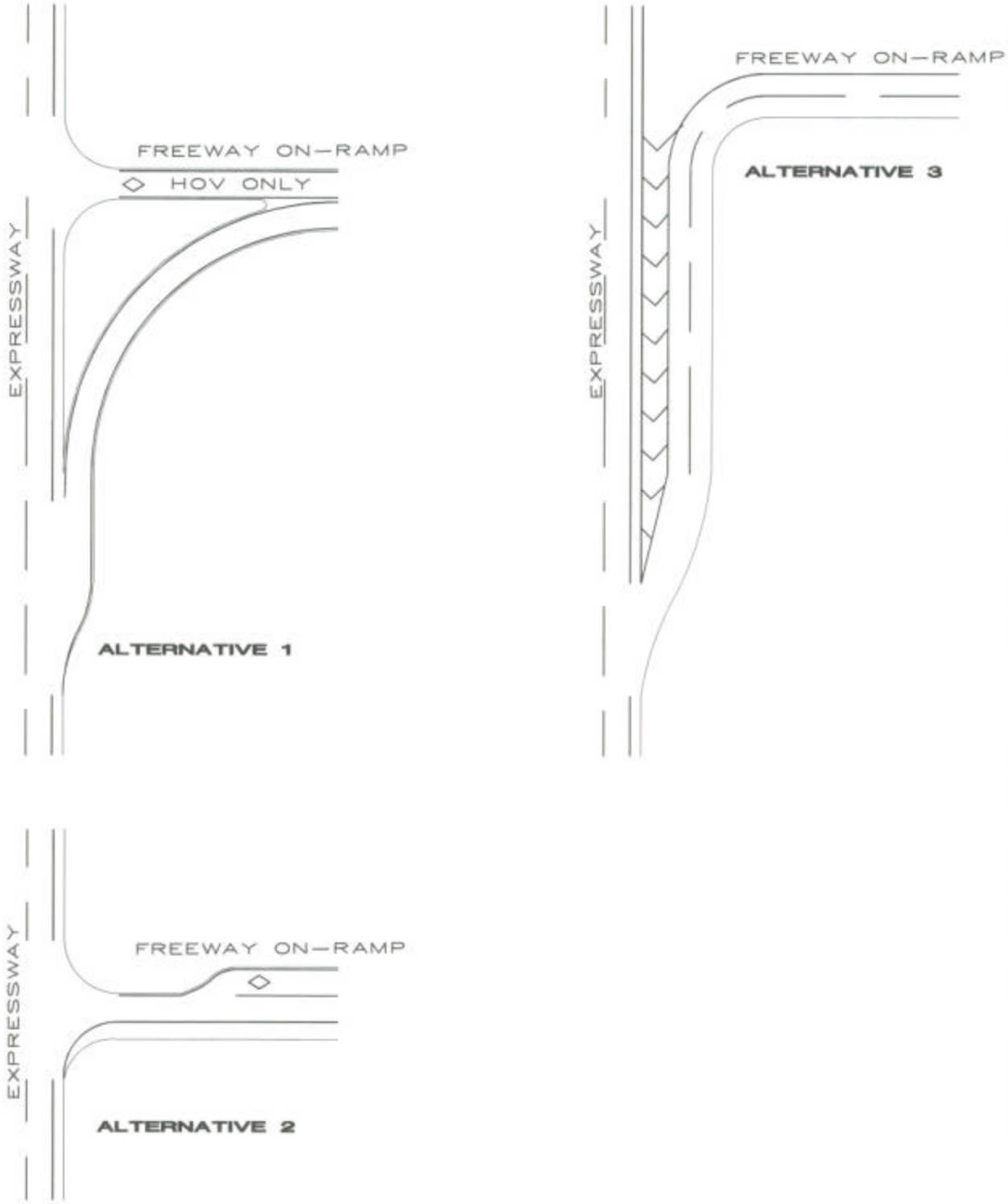


Figure 7

8. Bicycle Travelway Through Construction Zone

Discussion:

It is desirable to accommodate bicycle travel through construction zones during infrastructure improvement projects, as is done for motor vehicles.

a) Preferred accommodation where sufficient width exists for a delineated bicycle area:

- A striped bicycle area to the right of the rightmost mixed flow lane: 4' minimum, 5' desirable, 6' if available. Add 1' extra width for horizontal shy-away along K-rail, if present.

- Optional flexible delineator posts between rightmost mixed flow lane and the bicycle area, but only if 6' is available in the bike area due to the need for shy-away clearance to the posts. The post spacing should be wide enough to enable a cyclist to move laterally from the bike area into the mixed flow lane if necessary to avoid obstacles.

b) Alternate accommodation where construction requirements do not allow delineation of a bicycle area:

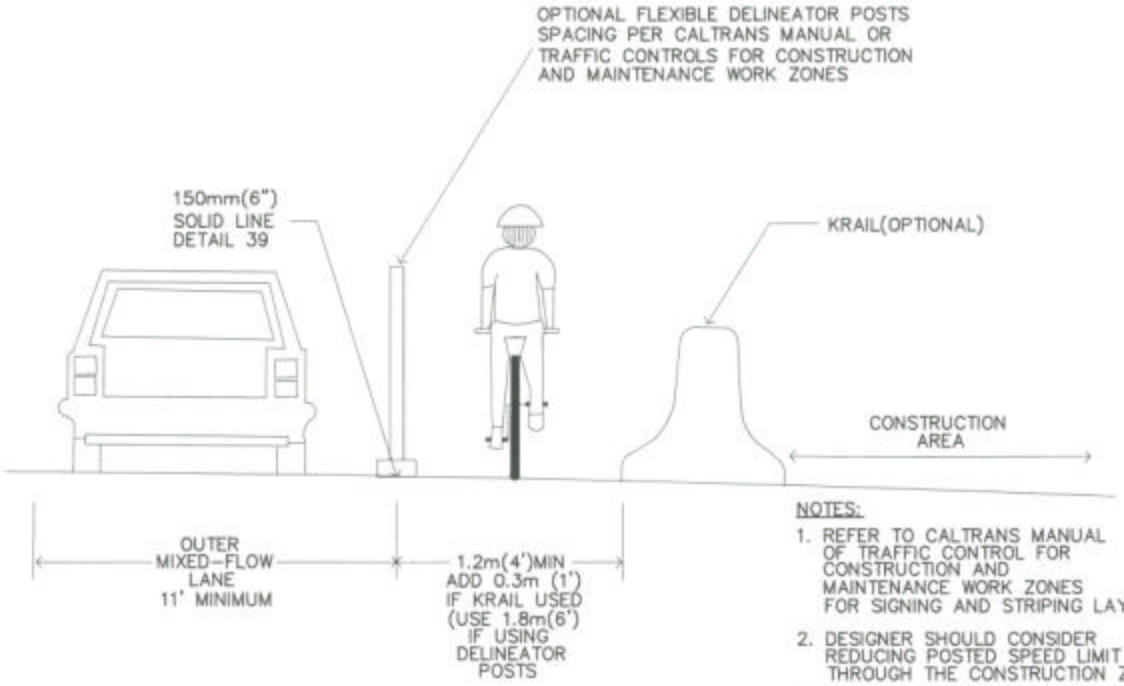
- Minimum 16' outer shared-use lane. Narrow the other vehicle lanes or drop a vehicle lane if feasible.

- Post a reduced construction speed limit based on type and location of work and potential impact on bicyclists.

- Post "Bicycles sharing lane" signs (W79, MUTCD W16-1)

Construction situations will occur where it will not be possible to provide either accommodation (a) or (b). Based on details of specific situation, a determination can be made if a detour or bicycles sharing automobile lane is necessary.

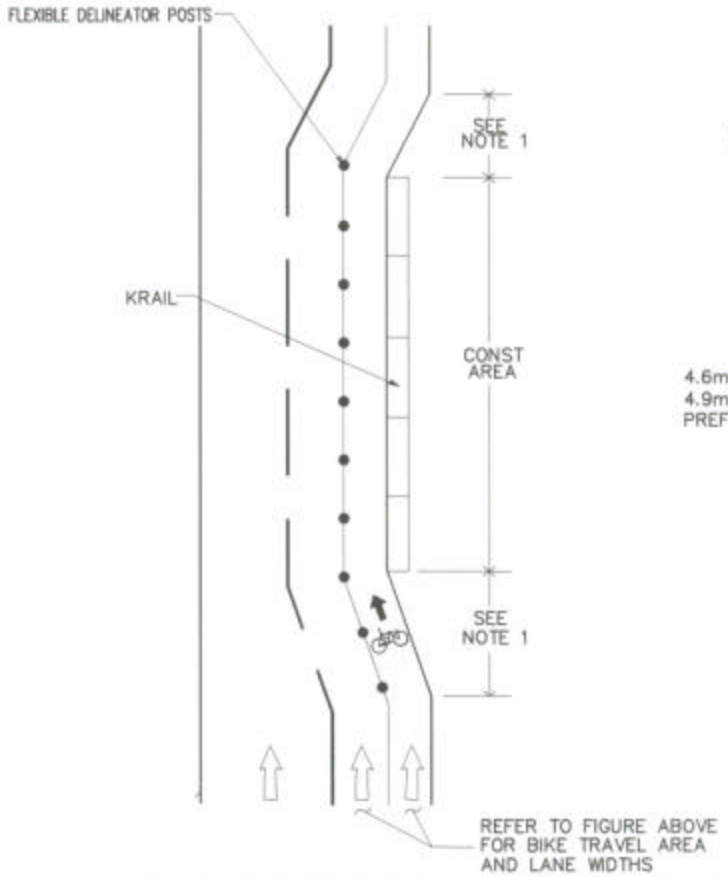
BICYCLE TRAVELWAY THROUGH CONSTRUCTION ZONE



NOTES:

1. REFER TO CALTRANS MANUAL OF TRAFFIC CONTROL FOR CONSTRUCTION AND MAINTENANCE WORK ZONES FOR SIGNING AND STRIPING LAYOUT.
2. DESIGNER SHOULD CONSIDER REDUCING POSTED SPEED LIMIT THROUGH THE CONSTRUCTION ZONE.
3. WHERE BIKE DETOUR IS REQUIRED, REFER TO CALTRANS MANUAL OF TRAFFIC CONTROL FOR CONSTRUCTION AND MAINTENANCE WORK ZONES FOR DETOUR SIGNAGE.

CASE I
SEPARATE BIKE AREA



CASE II
SHARED USE LANE

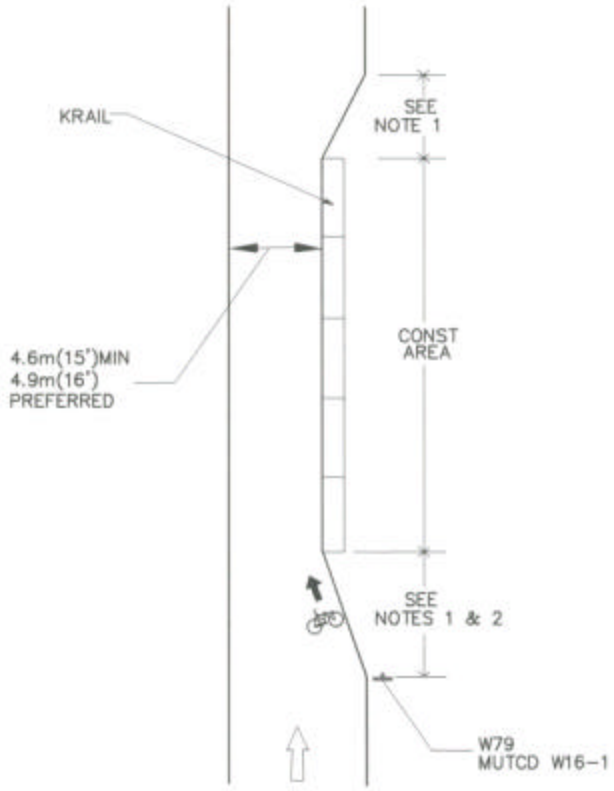


Figure 8

9. Trail Undercrossing and Overcrossing Connections

Discussion:

Typically, trail development and signage is pursued by other agencies. The County Roads and Airports Department is only responsible for the portions of the trail connection within expressway rights-of-way. The following details are provided to encourage trail connections that maximize safety while accommodating a wide range of bicycle configurations including tandems and trailers.

The proposed detail provides full connectivity between trail undercrossings or overcrossings and both directions of the expressway, so cyclists need not cross the expressway or detour via sidewalks to the nearest cross street signal in order to begin legal-direction travel. Although a trail undercrossing is illustrated, the same connections apply to an overcrossing.

Because trail connections are provided to both directions of the expressway, an expressway median fence is recommended at trail junctions to defer crossing of the expressway travel lanes.

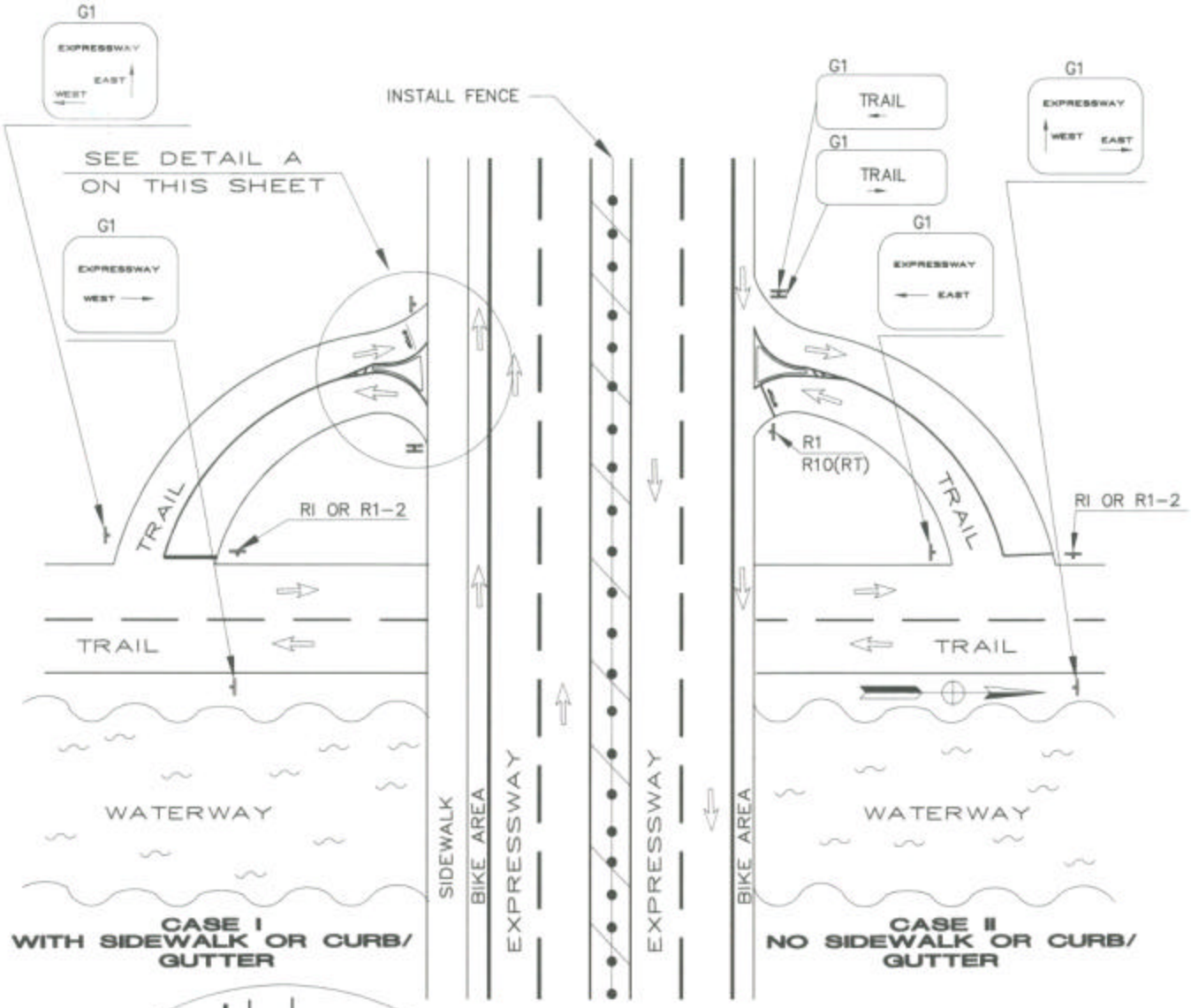
Note that if a street runs parallel to the trail and intersects the expressway, the trail to street connections can be provided to that street instead of the expressway, at the trail sponsor's option.

Regardless of whether the trail linkage is direct to the expressway or to a side street, guide signage should be provided on both directions of the expressway to direct cyclists to the trail. At the trail spur intersections, guide signage should indicate to which direction of the expressway the spur leads, and should indicate the presence of the trail spur intersection serving the other direction of the expressway.

Detail A on Figure 9 provides the following advantages compared with a simple perpendicular ("T") junction:

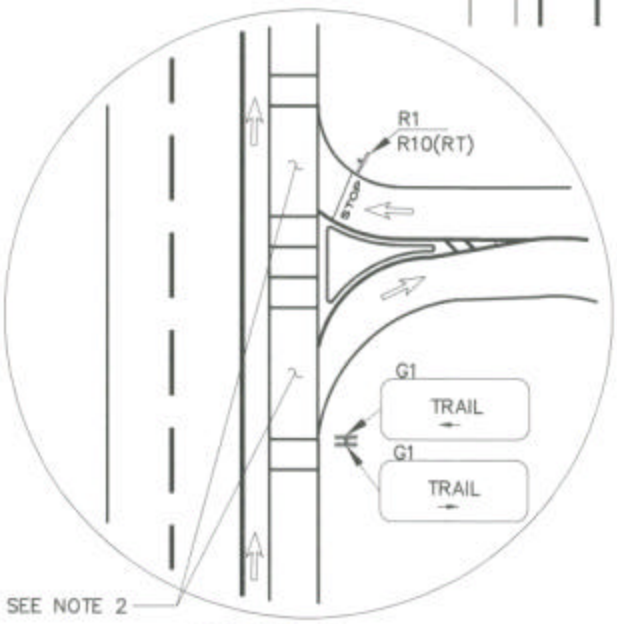
- Raised island between inbound and outbound directions deters nonstop ride-outs onto the expressway and eliminates the need for a center bollard on the trail.
- Directional arrows on one-way branches of the trail spur deter wrong-way travel on the expressway bikeway.
- Providing two curb cuts instead of one enables angled entry and exit movements to/from the expressway bikeway, which accommodates long bicycles and bicycles with trailers. Using one curb cut would force a perpendicular entry or exit movement, and long bicycles or bicycles with trailers might encroach into the outer travel lane. If there is a sidewalk along the expressway, the trail spur is brought to the sidewalk and the curb cuts (1 upstream, 1 downstream) are incorporated into the sidewalk using "parallel" ramps (not angled "driveway aprons").
- Reduced-size versions of Caltrans signs indicate that bicycle operators are subject to the same rules of the road as motorists.

TRAIL UNDER/OVER CROSSING CONNECTIONS



CASE I
WITH SIDEWALK OR CURB/ GUTTER

CASE II
NO SIDEWALK OR CURB/ GUTTER



DETAIL A

NOTES:

1. SIGNAGE WITHIN THE EXPRESSWAY RIGHT OF WAY ARE THE RESPONSIBILITY OF DEPARTMENT OF ROADS AND AIRPORTS. ALL OTHER SIGNAGE IS THE RESPONSIBILITY OF OTHERS.
2. REFER TO FHWA TRAIL BEST PRACTICES GUIDELINES FOR PARALLEL RAMP DESIGN.
3. REFER TO POLICY UD 4.12 OF SANTA CLARA COUNTY 1999 UNIFORM INTERJURISDICTIONAL TRAIL DESIGN, USE, AND MANAGEMENT GUIDELINES FOR ADDITIONAL GUIDANCE.

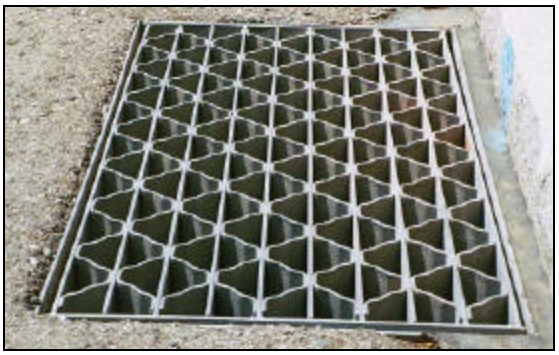
FIGURE 9

10. Drainage Inlets

Discussion:

The County Standard Details Type 1C Drop Inlet Grate is shown at right.

When a grate must be crossed by bicycles, the Type 1C's honeycomb pattern is superior to parallel-bar or rectangle-pattern designs because it has a minimal effect on bicycle steering.



County Type 1C ("honeycomb") grate

Where hydraulic safety is not compromised, a flush (curb-face) inlet is preferable to the Type 1C provided that its inlet slope is not steep enough to affect bicycle handling.

Another option is to put a surface inlet in an off-shoulder pocket as shown at right. This eliminates the need for bicycles to cross the grate.

Recessed grate
(WB Capitol Expwy near Seven Trees)

Parallel-bar grates in bicycle travel areas should be replaced, not retrofitted with welded cross straps, because the straps are eventually knocked off by vehicle impacts, thus re-introducing a crash hazard.

In the photo at right, one cross strap has been damaged. If other straps are dislodged the grate could begin to trap narrow bike tires.

Retrofitted parallel bar grate, San Tomas Expwy

Maintenance and Construction Elements

These elements have no corresponding figures but are important for safe bicycle accommodation. Caltrans *Highway Design Manual* (5th Edition) topic 1003.6: Miscellaneous Bikeway Criteria, in particular subsection (2) Surface Quality, offers more discussion and detail.

Surface quality

a) When repaving, minimize cycling interruptions due to shoulder grinding

Grinding of shoulders interrupts bicycle travel. Cyclists cannot maintain control on ground-off areas and may attempt to share vehicle lanes unless safe passage is provided. Paving contracts should minimize the time between grinding and repaving of shoulders.

b) Bridge decks - asphalt bulges

Transverse asphalt bulges develop at the junction between bridge decks and asphalt shoulders. These can cause bicycle crashes and are difficult to see at night. Maintenance should include periodic inspection and removal of such bulges.

Asphalt bulge at end of bridge deck

c) Pavement finish

For heavily used bicycle routes, pavement finish (for example, dense-graded asphalt) should be considered in selection of paving material for the shoulder area.

d) Utility repair standards

After utility trenching in the bike area, the surface should be restored to high quality. It is essential to avoid longitudinal steps, which can "divert" a bicycle's front tire.

Sweeping

Sweep shoulders frequently enough to keep glass, thorns and other debris from accumulating. During active construction activities, sweeping should be done daily.

Landscape Trimming

Hedges should be trimmed at regular intervals to avoid encroaching on the bike area and obstructing other shoulder uses. Trimming frequency will depend on the species of hedge but should ensure that the following bicycle travel envelope remains clear between trimmings:

- Width: 6' (includes 1' vertical shy-away from hedge)
- Height: 8' (bicycle plus tall standing rider)

See Figure in Appendix B1, page B-1, for further details regarding minimum operational envelopes for bicycles.

Puncture-Vine Abatement/Eradication

A major cause of flat tires for bicyclists throughout Santa Clara County is the "Goat's Head Thorn" plant, also known as "Puncture Vine". Continue and expand the effort to abate or eradicate this plant along all county roads including the expressway system.

APPENDIX

Appendix A - Policy Background

This section lays the foundation for an updated bicycle accommodation policy and accompanying engineering guidelines by explaining what the law requires of cyclists using the expressways and by summarizing the history of county and agency policy on bicycle accommodation.

The County's standard procedures are to be consistent with Caltrans Highway Design Manual. The Expressway BAG are also consistent with VTA's Bicycle Technical Guidelines provisions that apply to expressways and are supported in the Highway Design Manual.

LEGALITY OF BICYCLING ON EXPRESSWAYS

Legal Definition of Bicycle

The California Vehicle Code (CVC) defines "bicycle" as follows:

> 231. A bicycle is a device upon which any person may ride, propelled exclusively by human power through a belt, chain, or gears, and having one or more wheels.

Most bicycles in use today, and most bicycles seen on the expressways, are "upright" single-rider types just under 6' long with two equal-size wheels from 60cm to 70cm (24" to 27.5") in diameter. The "upright" category includes "road", "mountain", and "hybrid" bicycles. However, many other types of human-powered vehicles (HPVs) including "feet-first" or "recumbent" bicycles fit the CVC definition. Although "bi" implies 2 wheels, the CVC definition includes unicycles, tricycles, quadracycles, and configurations with 1 or more trailers that may add another 1 to 4 wheels. "Pedalcycle" is a more general term.

These Guidelines are intended to accommodate not only mainstream single-rider bicycle types but all other configurations that are legal in California.

Figure A-1 shows some of the "bicycle" configurations covered by the CVC definition.

Figure A-1: Examples of Bicycles

Bicycles May Use All Public Streets, with a Few Exceptions

As noted above, California Vehicle Code (CVC) Section 231 defines "bicycle" as a device, not a class of vehicle. CVC 21101 permits local agencies to regulate the on-street operation of *vehicles* by class, for example to prohibit trucks on certain streets:

> 21101. Local authorities, for those highways under their jurisdiction, may adopt rules and regulations by ordinance or resolution on the following matters:
>
> (c) Prohibiting the use of particular highways by certain vehicles, except as otherwise provided by the Public Utilities Commission pursuant to Article 2 (commencing with Section 1031) of Chapter 5 of Part 1 of Division 1 of the Public Utilities Code.

However, no CVC section permits similar local regulation of *devices*, so bicycle travel is legal on all public roads unless prohibited elsewhere in the CVC. There are a few such prohibitions, but only one is relevant to the expressway system. CVC 23330 prohibits bicycle travel on "vehicular" (toll) crossings unless specially permitted, but there are no toll crossings on the expressways.

CVC 21960 allows local authorities to prohibit bicycle travel on freeways or freeway segments "to which all rights of access have been acquired":

> 21960. (a) The Department of Transportation and local authorities may... [on] freeways or designated portions... to which all rights of access have been acquired, prohibit or restrict the use of... bicycles or other nonmotorized traffic or by any person operating a motor-driven cycle, motorized bicycle, or motorized scooter.

Most segments of the expressway system are not freeways with respect to agency acquisition of rights of access, so bicycles cannot be prohibited from them. However, rather than seeking to prohibit or restrict bicycle access on the freeway-like expressway segments, the County of Santa Clara has instead adopted a policy of allowing bicycle access to all segments of all expressways.

Legal Bicycle Movements

Bicyclists are drivers under the law. Even though bicycles are not equated to vehicles, CVC section 21200 gives cyclists the same rights and responsibilities as drivers of vehicles:

> 21200. (a) Every person riding a bicycle upon a highway has all the rights and is subject to all the provisions applicable to the driver of a vehicle by this division....

All CVC sections apply to cyclists except those that are inapplicable by definition. CVC 21650 requires that vehicles be driven on the right half of the roadway, and CVC 21650(g) explicitly permits bicycle operation on shoulders where not otherwise prohibited by CVC or local ordinance. CVC 21650.1 requires that bicycles on shoulders travel in the same direction as vehicles on the roadway.

Two particular CVC sections govern the cyclist's lateral position on the roadway or shoulder. CVC 21202 applies where there is no bike lane, and CVC 21208 applies where there is one. Using similar language, both sections list four situations when cyclists may move to the left of their normal position, into or across adjacent lanes. These situations are shown in Table A-1.

Table A-1: When Cyclists May Leave the Right Edge or Bike Lane

	CVC 21202 (No bike lane)	CVC 21208 (Bike lane)
When traveling "at a speed less than the normal speed of traffic", a cyclist must ride as close as practicable to the right-hand curb or edge in the bicycle lane,		
EXCEPT	(Subsection)	(Subsection)
To pass slower traffic	21202.(a)(1)	21208.(a)(1)
To prepare for a left turn	21202.(a)(2)	21208.(a)(2)
To avoid debris or other hazards	21202.(a)(3) NOTE	21208.(a)(3)
To avoid a right turn area	21202.(a)(4)	21208.(a)(4)

Notes:

- In CVC 21202.(a)(3), "other hazards" specifically includes "substandard width lanes" that are too narrow for a bicycle and vehicle to travel safely side-by-side within.
- Vehicle-style left turns (from left turn lanes) are implicitly permitted by 21202(a)(2) and 21208(a)(2). The same sections implicitly permit vehicle-style U-turns. Other than to prepare for left and U-turns and to avoid right-turn, exit, and auxiliary lane areas, expressway cyclists will generally avoid the through vehicle travel lanes.
- U-turn movements are not explicitly covered in the California Vehicle Code, either for motor vehicles or bicycles. For vehicles, Section 21650 (driving on right side of roadway) and Section 21654 (slow-moving vehicles) have exceptions for left turns, but not explicitly for U-turns. As U-turns are permitted in these circumstances (if otherwise legal), the bicycle-specific sections 21202(a) and 21208(a) could be interpreted the same way.

POLICY HISTORY OF BICYCLING ON EXPRESSWAYS

1991: Board and Agency Policy to Accommodate Bicycles

On August 13, 1991 the Santa Clara County Board of Supervisors adopted a "Policy for Bicycle and Pedestrian Usage of the Expressways", encouraging removal of bicycle prohibitions and restriping of expressway shoulders to accommodate bicycles.

1993: Modified Exit/Entrance Striping and Enhanced Signage

In 1992 the Countywide Bicycle Advisory Committee (BAC) was formed to advise VTA and County Roads. In 1993 County Roads worked with the BAC to create a modified striping and signage treatment with four key elements:

- At exits, terminate the shoulder stripe at the angle break, where a conventional shoulder stripe starts to "taper" into the exit. Use a dashed line for 50 feet or more before this point. (This is similar to bike lane delineation and gives better right of way guidance to through cyclists and exiting motorists.)
- At entrances, begin the shoulder stripe at the point where there is 3' available outside the merging lane
- Post W-79 signs before certain exits
- Post W-79 signs with W-80 ("XING") plates at entrances to inform motorists to expect bicycles crossing their path

W-79 sign and W-80 plate

1996-1998: Lawrence Expressway HOV+Bike Shoulder Lane

In Fall 1996 a commuter (HOV) lane was added to Lawrence Expressway by narrowing the inside travel lanes and combining the outside travel lane with the shoulder area to form a nominally 16' wide "shoulder HOV lane" shared with bicycle traffic. This configuration conformed to the wording of the 1991 policy.

Although shared outside through lanes of 14' or wider are an accepted bicycle accommodation practice on some streets (reference: AASHTO 1999 *Guide for the Development of Bicycle Facilities*), expressway bicyclists were intimidated by attempting to share the shoulder lane with 55 mph motor traffic - especially wider vehicles such as motorhomes and trucks. In addition, Lawrence Expressway has frequent cross streets and right-turn in/out access compared to most other county expressways, so much of the shoulder HOV lane mileage functioned as an exit/entrance (acceleration/deceleration) lane.

The Countywide BAC requested that the nominally 16' shared lane be restriped to 11', creating a nominally 5' wide bicycle shoulder; this was done in early 1998. Some pinch points of lesser width remained and are being addressed as opportunities arise.

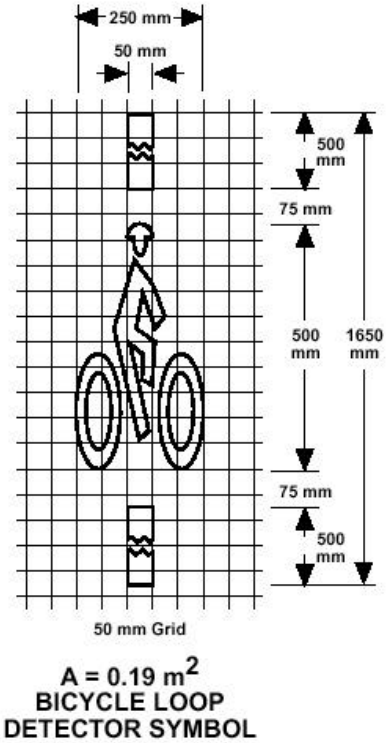
1999-Present: Measure B Pavement Management Program

In 1996 voters passed the Measure B sales tax and the Measure A list of transportation capital and maintenance projects. The Measure B Pavement Management Program funded resurfacing and restriping of the full length of all county expressways over its 9-year term. In 1999 a consultant was retained by Roads and Airports to conduct plan and field reviews of each expressway segment slated scheduled for repaving and propose striping and signage improvements for bicyclist safety. To date these reviews have been completed for all or parts of Almaden, Capitol, Central, Foothill, Oregon/Page Mill, and San Tomas Expressways.

Accepted recommendations have mainly stayed within the parameters of the modified standards defined in 1993: deleting "exit tapers", dashing approaching exits, and adding W-79 signs. At a few locations County Roads has continued the dotted line across exits, connecting with the downstream gore. Several exits and entrances have been restriped to define a bicycle travel area for entering and exiting cyclists. Shoulder stripes were added to Oregon Expressway between West Bayshore Road and Cowper Street.

Bicycle detection has also been improved at expressway signals reviewed under this program. The consultant's recommendations include bicycle sensitive lead loops at all "bicycle waiting positions" - the rightmost lane or space that serves the through, left-turn, and U-turn movements except for those that automatically recall to green. In addition, the agency now applies the state standard loop detector bicycle marking shown in Figure A-2, to indicate the "sweet spot" of a buried or obscured loop.

Figure A-2: Example of Loop Detector Bicycle Marking



Caltrans Standard Plan A24C
Loop detector bicycle marking

Use of detector legend
(VTA)

1999-Present: Page Mill Expressway/I-280 Interchange Modifications

Caltrans, which owns and operates state and interstate highways throughout California, initiated a striping change at the Page Mill Expressway interchange with Interstate 280 in Los Altos Hills. The connection from the westbound expressway to the southbound freeway was formerly an exit-only outer lane and a through/right option lane; it is now 2 exit-only lanes. Concerns raised by cyclists throughout the county and Peninsula that 2-lane gaps had become harder to obtain led to videotaping of westbound PM peak traffic and cyclists crossing it to continue on Page Mill Road. Although Caltrans has not agreed to reconfigure the 2-lane on-ramp and this interchange remains a serious concern to cyclists, several significant outcomes resulted that may be applicable elsewhere in the expressway system:

a) For the first time, Caltrans District 4 (Bay Area) staff agreed to a signed and striped bike lane through the interchange. Previously this agency had not agreed to such designation unless the intersecting local roadway had bike lanes. Page Mill Expressway has striped shoulders which function like bike lanes but are not designated as such.

b) District 4 also agreed to post bicycle-specific signage (W-79 signs plus large advance lane assignment guide signs depicting the through bike lane). Such signage was also previously tied to the designation on the intersecting roadway.

c) Jerry Champa, a design chief at Caltrans headquarters in Sacramento, subsequently visited this interchange and other expressway/freeway junctions with 2-lane free-flow exits and entrances, and has prepared draft revisions to the Caltrans *Highway Design Manual* and *Ramp Meter Design Manual*. As of Summer 2002 these are being discussed by a newly convened Intersection/Interchange Safety Task Force chaired by Maggie O'Mara, one of four Caltrans Bicycle Coordinators, also based at headquarters in Sacramento. Jerry Champa's draft diagrams appear in the Working Paper text under the Figure 7 discussion.

Implications of Policy History for the BAG

County Roads now has 10 years of experience with bicycle travel being legal on all expressways, and several years more experience with bicycles on some expressways. Several dimensions and principles developed during this time are relevant to these Bicycle Accommodation Guidelines:

Width	The shoulder widths listed in the 1991 policy are still useful:
	8' to 10' preferred, to enable emergency (auto and/or pedestrian) use; 5' where economically feasible [these Guidelines will recommend 6']; 4' absolute minimum
Delineation	"Bike lane like" striping at exits, in the through position at signals, and possibly through interchanges.
	Consider standardizing the use of a dashed line across exits.
2-lane exits and entrances	Discouraged. Track progress of Caltrans Interchange Task Force and possible future changes to Highway Design Manual and Ramp Meter Design Manual.
Signage	Continue use of W-79 (bicycle warning) and W-80 ("XING") plate

Appendix B - Technical Background

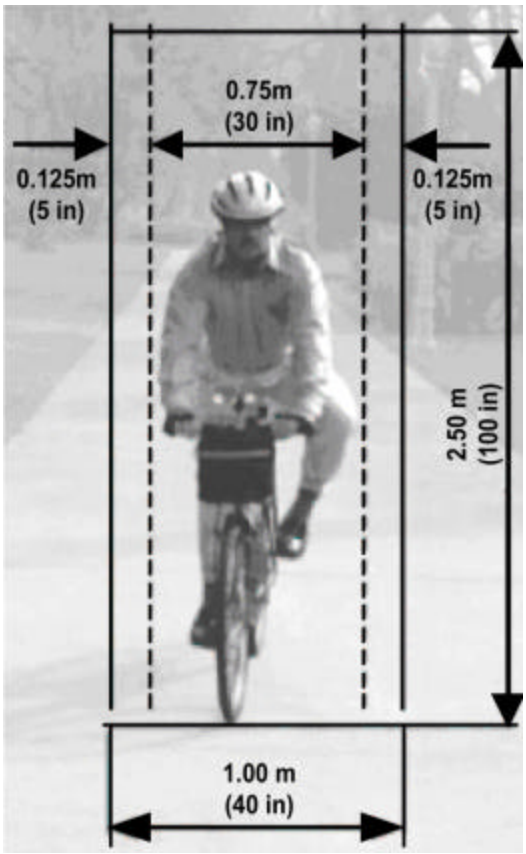
The "Design Bicycle" and Its Operating Envelope

Table B-1: Attributes of Bicycles, shows the considerable range in widths, lengths and operating characteristics of California Vehicle Code (CVC) legal bicycles. The most important attribute for expressway accommodation is *operating width* – the sum of bicycle + rider width plus the larger of the shy-away and wind-blast clearances on both sides.

Because the *turning radius* of even long bicycle + trailer configurations is no greater than that of cars, it is not a limiting factor for on-street accommodation. However, it is a key factor at street/path intersections where bicycle + trailer combinations and long single-unit bicycles cannot make sharp turns. The design of street/path intersections should accommodate long wheel base bicycles and bicycles with trailers.

The abruptness of grade change is another issue at path entrances. A sharply inclined apron can cause trailers with long rear overhangs to drag their tail.

REF: AASHTO guide; Santa Clara County Trail Guidelines



Bicyclist operating envelope (AASHTO 1999)

Table B-1: Attributes of Bicycles

	Attribute	Values (approximate)	Design impact *(Notes)*
1	**Operating width** including rider Does not include shy-away or wind-blast clearances	Standard: 1.0m Most child and cargo trailers are also 1.0m or narrower 3- and 4-wheel "workbikes" designed for bulk cargo transport may exceed 1.2m	Through travel width (at right edge, to left of right turn areas and islands) Horizontal cutback of vegetation along right edge *Primary accommodation factor*
2	**Horizontal shy–away** distance	1' along vertical barrier or surface Add 2' or more to high speed trucks	Width in subways along K-rail or guardrail, and along hedges
3	**Length**	Uprights: single: 6', tandem 9' Recumbent single: 5' to 8' Upright single + child trailer: 10' Recumbent tandem: to 10' Tandem + child trailer: 13' Upright single + 8' cargo trailer: 15'	Turning movements at path intersections and median cuts
4	**Operating height** (standing rider)	2.50m (8.2') [AASHTO]	Vertical cutback of vegetation Headroom in path subways
5	**Speed** under human power on expressway system	Level, no headwind or tailwind: "Commuter" 12-18 mph "Recreational" 10-25 mph Streamlined ("faired") 25-35 mph Ascending overpasses: 5-10 mph Descending overpasses: to 30 mph Headwind/tailwind: -10 to +10 mph	*None of the county expressways are hilly, but interchange approaches have short but considerable grades.* *Summer afternoon headwinds and tailwinds can be significant.*
6	**Turning radius**	Less than a car, except for unusual multiple-trailer configurations. For single-rider bicycles, similar to a motorcycle.	*Should not be a limiting factor for on-road accommodation.* *Street/path junctions should accommodate turns by long bikes and bikes towing long trailers.*
7	**Rear overhang**	Not an issue for single-unit bicycles, even tandems and long recumbents Cargo trailers with long rear overhangs can drag their tail if a grade change is too abrupt.	*Vertical alignments of curb ramps and path junctions should accommodate bikes towing cargo trailers with long overhangs*

How Bicyclists Travel on the Expressways

As is true for any road user, bicycle travel on the expressway involves sequences of movements through several types of situation. However, because the through bicycle travel area traverses exits, entrances, and auxiliary lanes, expressway cyclists vary their line of travel more than motorists in order to indicate that they are proceeding through, and to deter cutoffs by exiting motorists. At intersections, cyclists choose the right-most lane or space serving their destination because they accelerate slower than vehicles and have a lower top speed. Table B-2 summarizes expressway bicycle movements:

Table B-2: How Bicyclists Travel on the Expressways

Situation	Bicycle Travel Or Movement	Accommodation: Width And Striping
All	Same direction as motor traffic	Accommodate one direction of travel on each side of road
Between intersections, interchanges, exits and merges	In a shoulder or bike lane if present, but not in the gutter pan. Otherwise, as close as practicable (i.e. feasible and safe) to right edge or curb, as required by CVC.	Provide striped shoulder or bike lane of sufficient width
Intersections	(All movements) Rightmost lane or space that serves the cyclist's destination.	For any movement that does not recall to green, mark lead loop in rightmost lane
	Right turn: In line with right turning vehicles in the rightmost turn lane. Optionally, if there is width, to the right of the rightmost turning vehicles.	Provide wide right turn lanes where possible, but prioritize through width higher
	Through: Start in rightmost through lane, through bike lane, or gore area to left of island. If using a through/right lane, start centered in the lane. Move toward right side of through traffic stream when beyond the through/right conflict area.	Mark rightmost through lane if no automatic recall to green. Rightmost through lane should not be a through+right option lane.
	Left turn: Start centered in rightmost left turn lane. When beyond left/through conflict area, move toward right side of left-turning stream.	Mark rightmost left turn lane. It should not be a left+through option lane.
	U-turn: Start centered in rightmost U-turn lane. When beyond left/U conflict area, move toward right side of U-turning stream.	Mark rightmost U-turn lane (may be same as rightmost left turn lane)
	Multiple-destination lanes: In the queue, center the bicycle in it to block cutoffs. Choose a line of travel that blocks cutoffs until past the point in the intersection where cutoffs can occur.	Except for left+U, do not design multiple destination lanes, in particular through/right
Exiting on the right	To the right of exiting vehicles if the exit is wide enough, otherwise in line with vehicles	If width available, stripe bike area to right of ramp or turn lane
Crossing free-flow exit	Continue straight across diverge on prolongation of bike lane or shoulder. Advanced cyclists move slightly left to deter cutoffs from behind.	Carry dotted bike lane across ramp
Entering from right	To the right of entering vehicles if the area is wide enough, otherwise in line with vehicles	If width available, stripe bike area to right of ramp or merge lane
Crossing free-flow merge	Cross to the right side after merge gore point, as soon as it is safe	Begin shoulder or bike lane at or before merge gore point
Traversing an auxiliary lane ("weaving area")	Depending on the length, grade, sightlines and other conditions, either: • "Hold a line" past the weaving area, along right side of the through lane to its left, or • Cross to right edge at start of aux lane, ride on right side or shoulder, cross back to the left before it ends.	Dotted through bike lane between the auxiliary lane and the through lane to its left
Moving left across a long added exit lane	At a point depending on conditions, move left into the added lane, then to its left side, then out of it into the through lane to its left. (Example: Central WB exit to Middlefield)	Provide through bike lane to left of added exit lane, starting far enough before diverge to enable leftward cyclist movement to be executed safely in several steps

Appendix C - Reference Documents

Source	Document / Web address / [Items]
Santa Clara County Department of Roads and Airports	Standard Details, September 1997 [Type 1C drain grate]
	Policy Memo Re: Accommodating Bicycles On Expressways (August 1991)
Santa Clara Valley Transportation Authority (VTA)	Bicycle Technical Guidelines, September 1999
Santa Clara County Parks Department	Santa Clara County Uniform Interjurisdictional Trail Design, Use, and Management Guidelines
City of Palo Alto	Standard Plans [Modified circular detector loop ES5B]
California Department of Transportation (Caltrans)	Standard Plans [A24C: Bicycle Loop Detector Symbol, Bike Lane symbol (cyclist graphic) ES5B: Loop Detector types]
	Traffic Manual
	Ramp Meter Design Manual (1995)
	Deputy Directive DD-64: Accommodating nonmotorized travel
	Highway Design Manual - Chapter 1000 - Bikeway Planning and Design (July 1, 1995)
California Department of Motor Vehicles (DMV)	California Vehicle Code
American Association of State Highway Transportation Officials (AASHTO)	Guide for the Development of Bicycle Facilities (1999)
Oregon Department of Transportation	Oregon State Bicycle Plan *www.odot.state.or.us/techserv/bikewalk/planimag/toc-imag.htm*
Florida Department of Transportation	Bicycle Facility Planning and Design Handbook *www11.myflorida.com/safety/ped_bike/ped_bike.htm*
Federal Highway Administration (FHWA)	Trail Best Practices Guidelines