3.0 HOV/MANAGED LANES

This section address major design treatments for HOV/managed lanes and related support facilities commonly applied to these lane treatments. Also addressed are HOV bypass lanes associated with ramp meters.

3.1 Lane and Roadway Geometrics

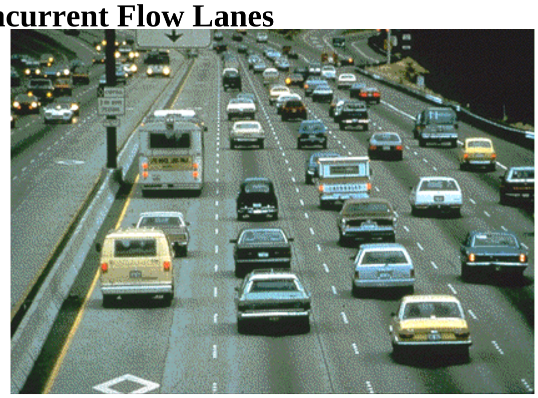
Each type of HOV lane design has its own set of lane design features, ancillary access, traffic control conditions and options. Each general type of design, shown through typical sections and example applications, is briefly presented in this section. Designs include concurrent-flow lanes, reversible lanes and ramp meter HOV lane bypasses. Access features are described in Section 3.2; supporting facilities are presented in Section 3.3; and related treatments addressing enforcement, incident management and systemwide issues are presented in subsequent sections 3.4 through 3.8.

3.1.1 Concurrent-Flow Lanes

Concurrent-flow lanes operate in the same direction of travel as the adjacent lanes, and typically, one lane is provided in each direction. Where possible, full inside median shoulders and a buffer separation with the general purpose lanes is included. These lanes may be physically separated from adjacent lanes, or not separated (Figure 3-1).

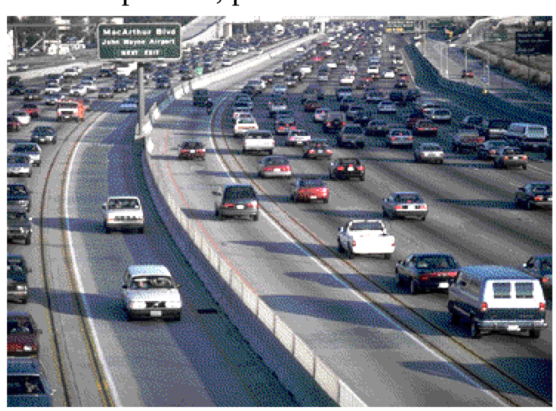
Figure 3-1 Concurrent Flow Lanes

Non-separated, full-time



Non-separated, part-time

Barrier-separated



Buffer-separated

Some form of delineation is needed for any kind of concurrent-flow lane to differentiate it from adjacent lanes. The minimum separation needs to be a wider than standard pavement marking, according to the latest federal guidance. Each type of concurrent-flow lane is described in more detail in the next sections.

<u>Non-separated Treatment</u>
Where a buffer is not provided and the HOV/managed lane is opened to all traffic during off-peak periods, the treatment may not be separated and should appear as a general use lane. The minimum lateral clearance, or shy distance to a median barrier, should be at least two feet. Desirably, a full width (8 feet to 10 feet) inside shoulder is provided. Separation lane marking between the HOV and general purpose lanes must include a wider than standard skip stripe (eight inches or more) and diamonds placed in the centerline of the lane at regular intervals in accordance with the latest guidance contained in the MUTCD. Further pavement marking guidance is provided in section 3.6.

<u>Buffer-separated Treatment</u>
AASHTO's latest guidance (Reference 1) recommends buffers for concurrent-flow lanes. Figure 3-4 shows typical sections for desirable and minimum conditions. A variety of design techniques exist for buffer separated lanes. The buffer width should nominally be four feet and no less than 1.5 feet. A much wider buffer width of six to eight feet may appear as a refuge for vehicle breakdowns where high speed traffic exposes the driver to a safety hazard on both sides. It is difficult to accommodate the requisite pavement markings in a buffer of less than 18 inches. A buffer separated lane may apply a conventional four-foot buffer and reduce the buffer area around such isolated restrictions as bridge columns for short distances. Ideally such conditions are appropriately facilitated by varying the inside shoulder width to keep the lane alignment straight through the impediment.

If continuous access is allowed, double skip stripes placed around and within the buffer area may be appropriate. If access is restricted, dual solid stripes are applied and broken wherever access is permitted (Figure 3-2).

Many candidate settings for concurrent flow lanes typically have many bridge and related impediments that make widening to full design standards extremely difficult. In such cases, careful study of the proper trade-offs for lane, shoulder and buffer widths are warranted. These conditions are herein referred to as minimum designs, which often involve the removal or reduction in existing inside breakdown shoulders and perhaps slight reductions in some lane widths for the added lane. While trade-offs in each case will vary depending on site conditions, Table 3-1 provides a reference of commonly applied priorities when trying to accommodate key design features in constrained settings.

Figure 3-2: Concurrent Flow Buffer Separated Cross Sections

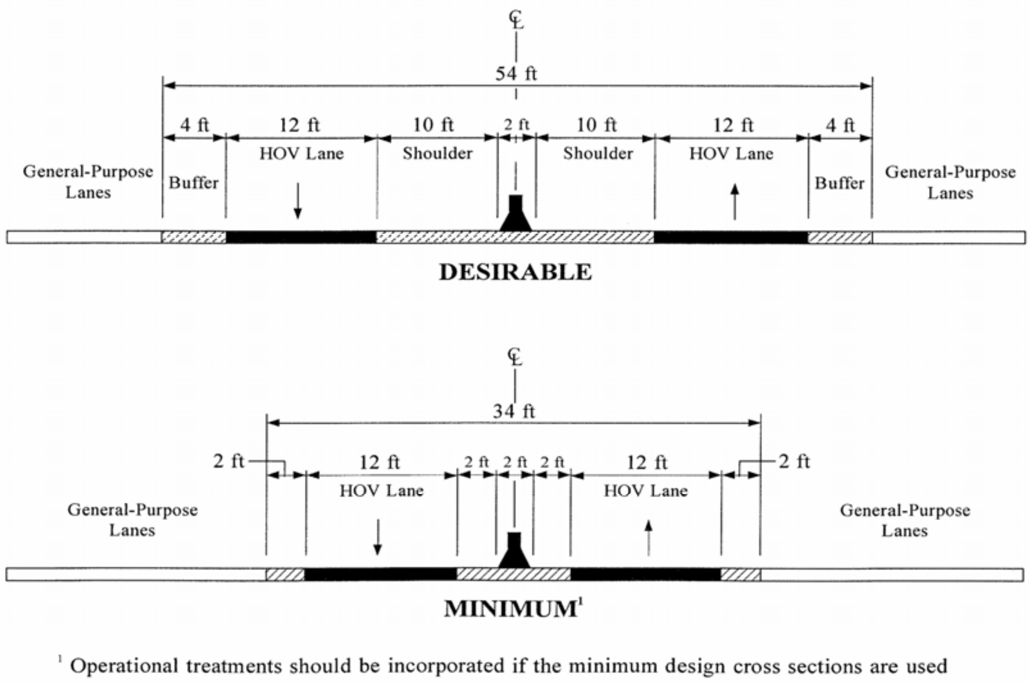


Table 3-1 Suggested Design Sequence of Trade-offs for Concurrent-Flow HOV Lanes

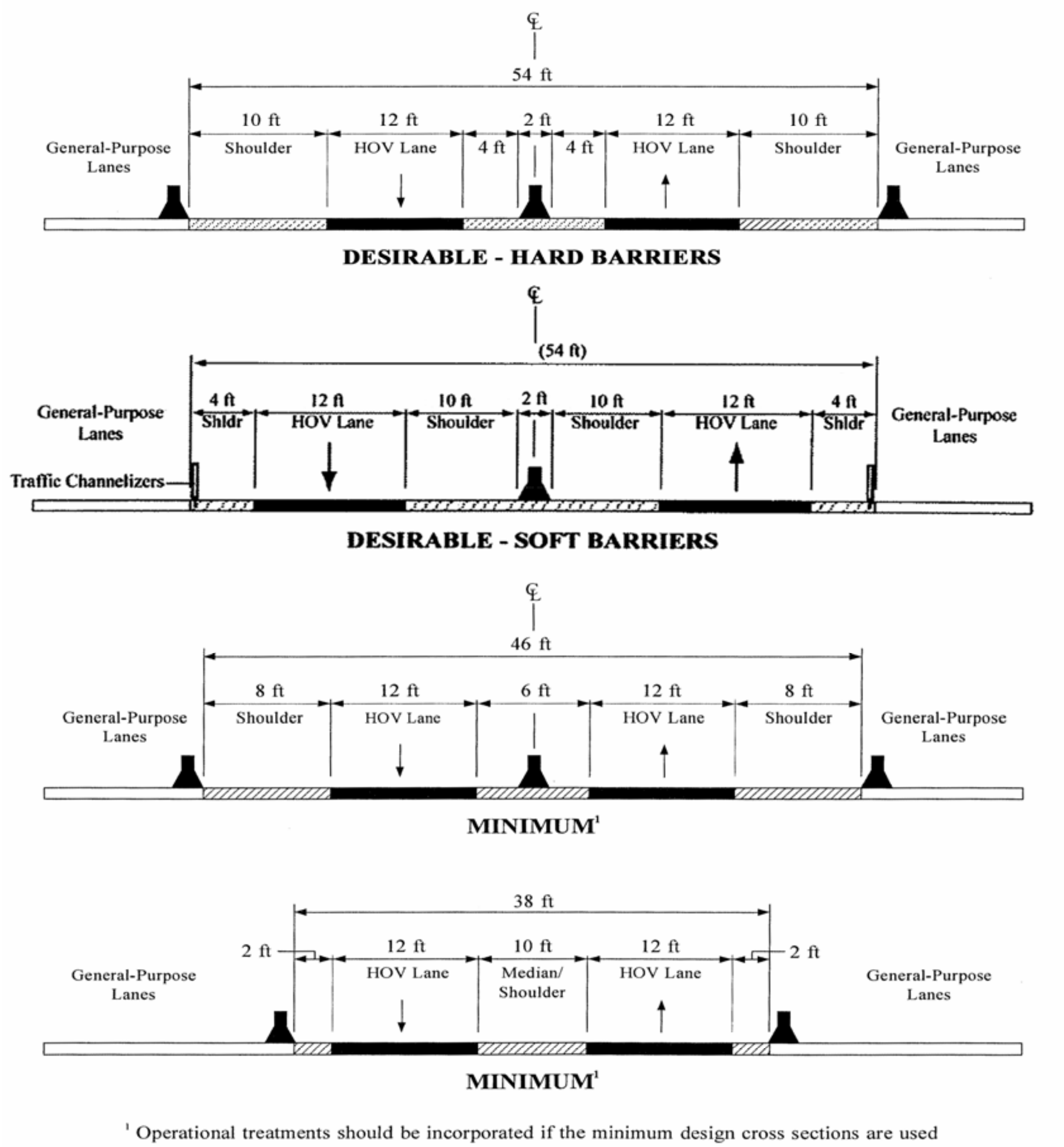
Suggested Sequence	Cross Section Design Change
First	Reduce HOV lane left lateral clearance to no less than 2 feet.
Second	Reduce freeway right lateral clearance (shoulder) from 10 feet to no less than 8 feet.
Third	Reduce buffer separation between HOV and general purpose lane to no less than 1.5 feet.
Fourth	Reduce HOV lane width to no less than 11 ft. (Some agencies prefer reversing the fourth and fifth trade-offs when buses or trucks are projected to use the managed lane. The buffer markings may encroach on the 11-foot width.).
Fifth	Reduce selected mixed-flow lane widths to no less than 11 feet. (Leave at least one 12-foot outside lane for trucks).
Sixth	Transition barrier shape at columns to vertical face, or remove buffer separation between the HOV lane and general purpose lanes.

Source: Reference 1.

Barrier-separated Treatment

A variety of lane treatments are separated by concrete barriers or pylons. The former is called a hard barrier; the latter is a soft barrier. Barrier-separation provides a more effective, controlled environment which can improve operational performance, enforcement and safety. However, barrier separation can consume more right-of-way and raise project costs because separate breakdown shoulders are needed for both traffic streams. Access is more restrictive. Pylon separation, in lieu of concrete barriers, may reduce cost but add to maintenance since pylons are more likely to be damaged and need replacement. Some form of barrier separation may be required for pricing concepts. Alternative barrier-separated typical sections for desirable and reduced design settings are shown in Figure 3-3.

Figure 3-3: Two-way Barriered HOV Facility Cross Sections



Access to barrier separated lanes may be via at-grade weave sections and openings in the barrier separating the concurrent roadways, or via two-way flyover ramps or local drop ramps with intersecting streets.

3.1.2 Reversible Lanes

Reversible lanes operate in the median and are separated from adjacent oncoming traffic by permanently placed barriers. Reversible designs can accommodate single or multiple travel lanes. A variety of cross sections are common to both. Figure 3-4 provides alternate cross sections for a single lane, and Figure 3-5 provides similar guidance for a multi-lane roadway. While lane widths are nominally 12 feet, options exist in a single lane setting for placing a full shoulder on one side, or placing a shy distance (half shoulder) of four feet on both sides. Some locales favor a split shoulder to discourage vehicles attempting to pass in the shoulder. The combination of lane, shoulder and shy distance should add up to at least 20 feet so that moving traffic can bypass a stalled vehicle. Barrier openings or gates for emergency vehicles may be needed at periodic intervals.

In a dual lane setting, a full shoulder is provided on one or both sides. A minimum shy distance to the barrier should be two feet.

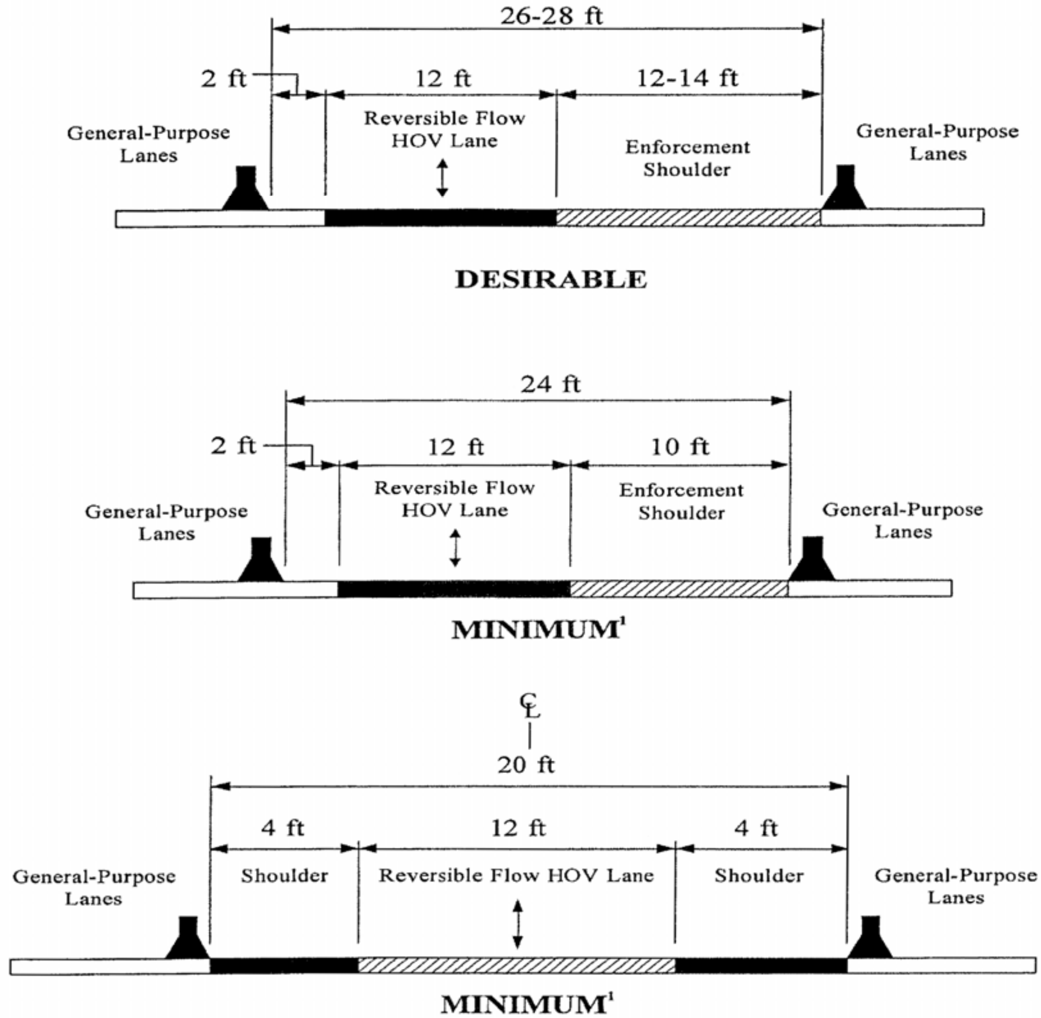
Potential trade-offs in fitting reversible lanes into constrained roadway settings are provided in Table 3-2.

Table 3-2: Suggested Design Sequence of Trade-offs for Reversible-Flow HOV Lanes

Suggested Sequence	Cross Section Design Change
First	Reduce HOV envelope to 42 feet according to the highest level minimum envelope in Figure 3-5.
Second	Reduce freeway left shy distance to no less than 2 feet.
Third	Reduce freeway right side shoulders to 8 feet.
Fourth	Reduce HOV lane width to no less than 11 feet (some agencies prefer reversing the fourth and fifth trade-offs when buses and trucks are projected to use the HOV/managed lane).
Fifth	Reduced selected general purpose lane widths to no less than 11 feet.
Sixth	Convert barrier shape at columns to vertical face (Refer to Figure 3-8)

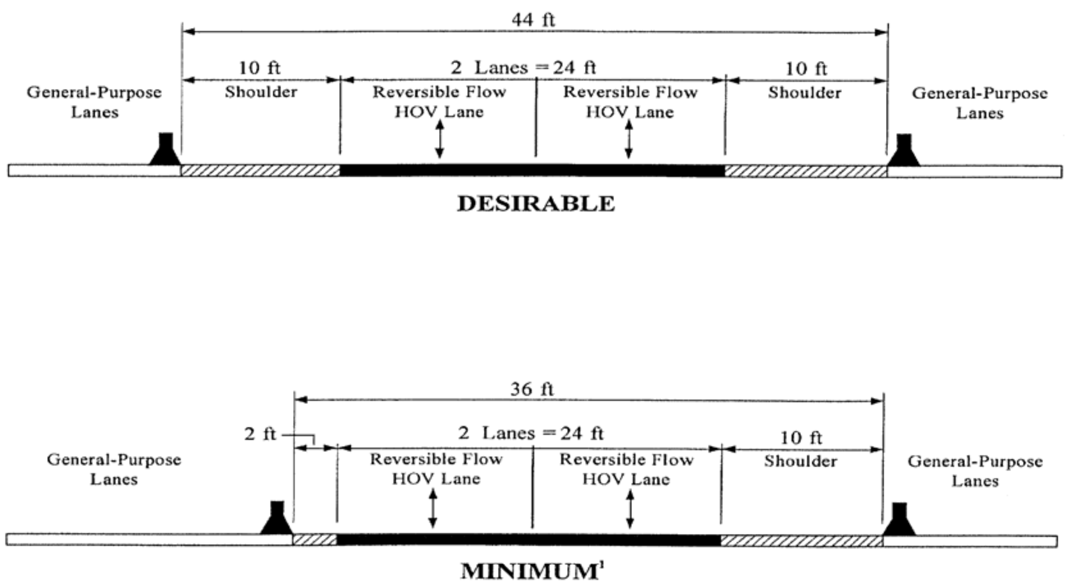
Source: Reference 1.

Figure 3-4: Reversible Single Lane Cross Sections



[1] Operational treatments should be incorporated if the minimum design cross sections are used

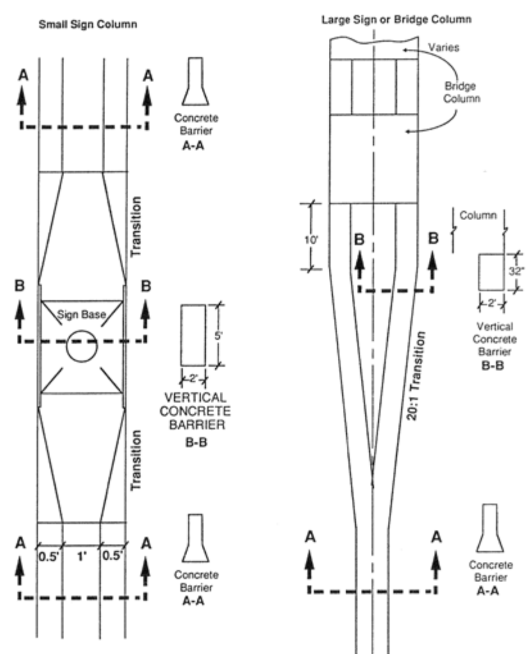
Figure 3-5: Reversible Multiple Lane Cross Sections



[1] Operational treatments should be incorporated if the minimum design cross sections are used

Circumventing columns is most common for a reversible lane. Figure 3-6 shows how typical jersey barrier alignments are adjusted approaching bridge and sign columns.

Figure 3-6: Converting Barrier Shape to Vertical at Columns



A key design component of freeway reversible lanes is access and related traffic control equipment at each access location. Access may be made from the left or right side of a freeway via a flyover ramp, but in either case the access must be channelized, gated and signed to control the correct movement of traffic into and out of the reversible roadway. Typical access requirements include the following features:

- A single lane channelized with barriers to guide traffic into and out of the reversible roadway
- A series of gates and a catchment screen at each high speed entrance to thwart wrong way movements when the gate is closed
- Dynamic signing (at least one advance sign and one at the entrance) to indicate if the entrance is open or closed
- Lane controls (considered optional) to help communicate lane operating status
- Other traffic control devices, such as cones, pylons or dynamic signs to reinforce operating status of the ramp

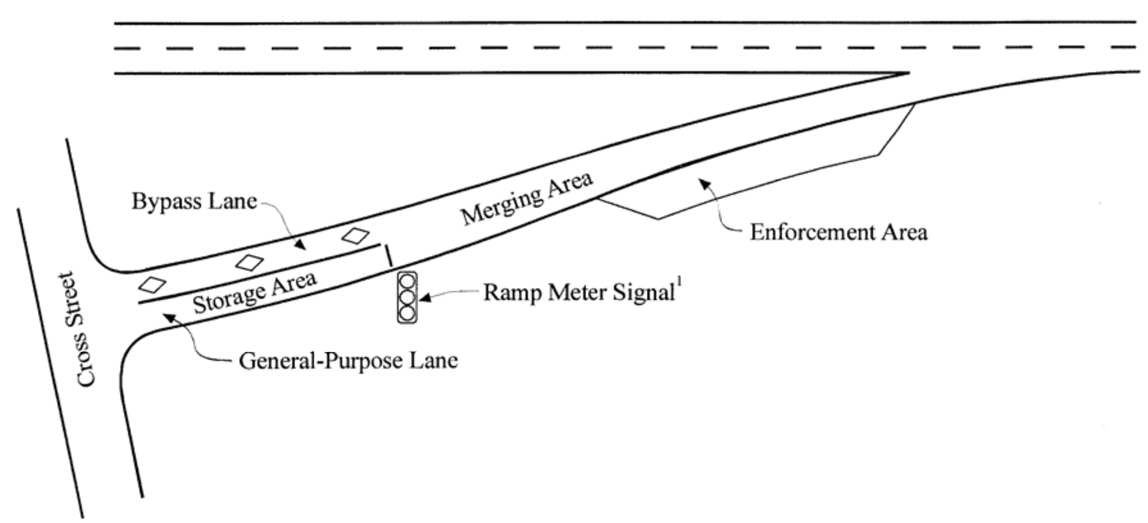
For low speed entrances from a street or park & ride lot, a single gate and dynamic sign may suffice, and channelization may be via curb and gutter treatment.

3.1.4 Metered Ramp HOV Bypasses

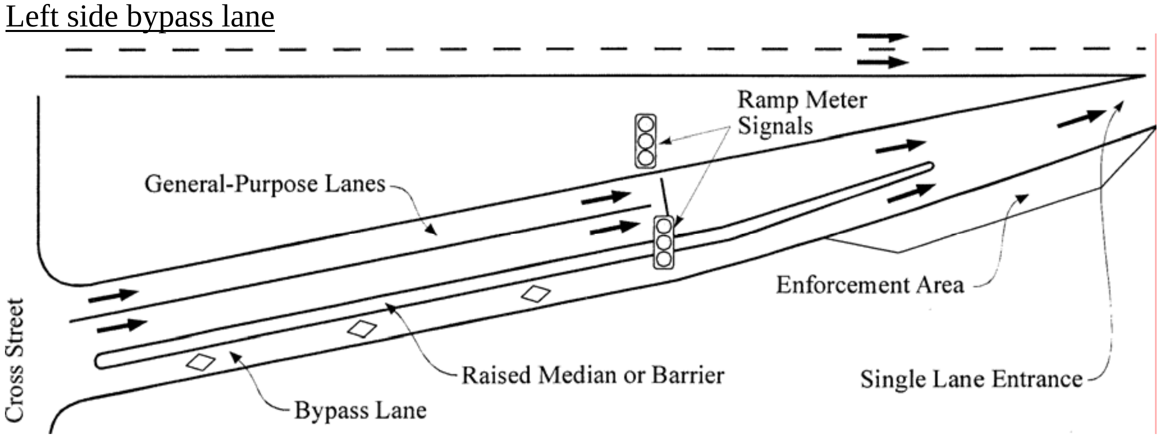
HOV ramp meter bypasses are widely applied and represent the largest number of HOV lane treatments. Some metropolitan areas have up to 300 such sites where HOVs can bypass a metered ramp. HOV bypasses may be oriented to the left or right side of the meter. Specific orientations should consider the specific design setting and origins of HOVs upstream. California cities—San Diego, Bay Area and LA basin—exhibit a wide range of both left and right side oriented bypass lanes.

During design, consideration for a ramp meter bypass should be given to good sight distance, adequate lane delineation to preclude metered traffic from getting trapped, and adequate downstream merge distance. Example layouts are provided in Figure 3-7 for common ramp orientations. The bypass lane is commonly located to the right of entering ramp traffic, but may be oriented to the left if the predominate HOV traffic movements upstream are left turns. A downstream monitoring area on a right side shoulder for police enforcement is desirable. More detailed design guidance for metered ramp meter treatments is provided in Section 2.0.

Figure 3-7: Right and Left Side HOV Bypass Orientations at Ramp Meters



Left side bypass lane



Right side bypass lane

3.2 ACCESS

This section reviews access treatments associated with mainline HOV/managed lanes. Access consideration is needed for any design. As a minimum, design consideration is needed for how a lane transitions to and from adjacent general purpose lanes. Access along a concurrent-flow lane may be allowed at any point, or access may be restricted. If access is restricted, designated access zones or direct access ramps will be needed. If a reversible or contraflow lane is designed, all access features will need to be through designated access ramps to control the direction of traffic.

3.2.1 Transition Treatments

HOV/managed lanes require special attention at the beginning and end of the project. Providing HOV/managed lanes that otherwise save time should not cause users to lose time where they terminate and merge back into general purpose lanes.