CITY OF ALBUQUERQUE
CITY WIDE-ON CALL ENGINEERING SERVICES
(TRANSPORTATION & STORM DRAINAGE)
5015.00

TASK 3
MULTI-USE TRAIL BOLLARD ASSESSMENT

Prepared For:

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September 5, 2013

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1. INTRODUCTION

The purpose of this report is to identify relevant design criteria for bollards on multi-use trail facilities, review the installation of bollards on multi-use trails at several locations identified by the City, and develop best practices for implementation by the City of Albuquerque.

Common problems associated with bollards and multi-use trail facilities in Albuquerque include the following:

- Bollards present a collision hazard when placed on a multi-use trail.
- Inconsistent installations lead to user confusion and do not meet a consistent user expectation.
- Inadequate spacing between bollards results in users being unable to access facilities and don not comply with ADA requirements.
- Removable bollards are illegally removed from their locations when not locked.
- When not in place, removable bollards have a 1-inch high collar that becomes a trip hazard.
- When bollards are not in place, unauthorized motorized vehicles may utilize multi-use facilities.

2. AASHTO CRITERIA

2.1 Multi-Use Trails and Bollards

Bollards are a commonly used method of controlling vehicular access to multi-use trails. However, per the American Association of State Highway and Transportation Officials (AASHTO) *Guide for the Development of Bicycle Facilities, 2012 (Fourth Edition)*:

> *"The routine use of bollards and other similar barriers to restrict motor vehicle traffic is not recommended. Bollards should not be used unless there is a documented history of unauthorized intrusion by motor vehicles. Barriers such as bollards, fences, or other similar devices create permanent obstacles to path users."*
>
> *"Furthermore, physical barriers are often ineffective at the job they were intended for – keeping out motorized traffic. People who are determined to use the path illegally will often find a way around the physical barrier, damaging path structures and adjacent vegetation. A three-step approach may be used to prevent unauthorized motor vehicle entry to shared use paths:*
>
> 1. *Post signs identifying the entry as a shared use path and regulatory signs prohibiting motor vehicle entry.*
> 2. *Design the path entry locations so that it does not look like a vehicle access and make intentional access by unauthorized users difficult. A preferred method of restricting entry of motor vehicles is to split the entry way into two sections separated by low landscaping.*
> 3. *Assess whether signing and path entry design prevents or reduces unauthorized traffic to tolerable levels. If motor vehicle incursion is isolated to a specific location, consider targeted surveillance and enforcement."*

There are no standards or recommended guidelines that have been established to identify a threshold for what constitutes a history of unauthorized motorized vehicular use on a multi-use trail, and the City of Albuquerque does not have a policy for when bollards should be considered.

2.2 AASHTO and MUTCD Bollard Guidelines

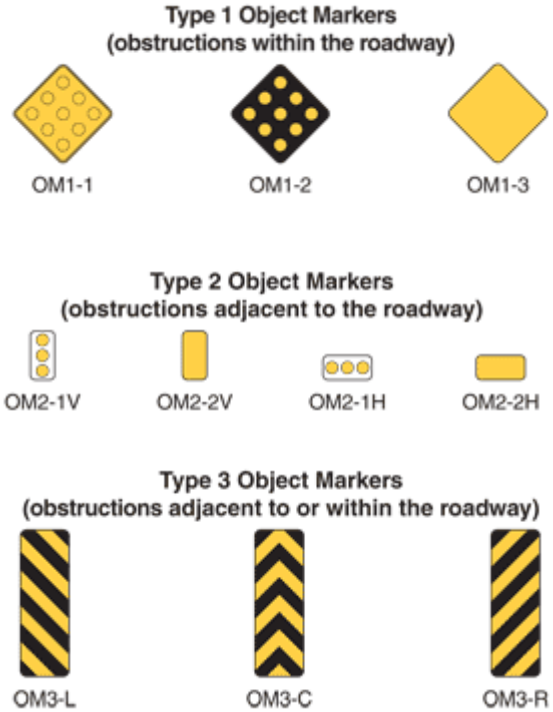
If a need for the implementation of bollards for a multi-use trail is identified, AASHTO has set forth several guidelines for the design of vertical barriers to make them as compatible as possible with the needs of path users and bicyclists. It should be noted that the parameters listed below are recommended practices and not design standards.

- Bollards should be marked with a retroreflectorized material on both sides or with appropriate object markers, per Section 9B.26 of the *Manual of Uniform Traffic Control Devices* (MUTCD).
  - MUTCD Section 9B.26 Object Markers

    Fixed objects adjacent to shared-use paths may be marked with Type 1, Type 2, or Type 3 object markers. If the object maker is not intended to also be seen by motorists, a small version of the Type 3 object marker may be used.

    Standard:

    - Obstructions in the traveled way of a shared-use path shall be marked with retroreflectorized material or appropriate object markers.
    - All object markers shall be retroreflective.
    - On Type 3 object markers, the alternating black and retroreflective yellow stripes shall be sloped down at an angle of 45 degrees toward the side of which traffic is to pass the obstruction.



- Bollards should permit passage, without dismounting, for adult tricycles, bicycles towing trailers, and tandem bicycles. Bollards should not restrict access for people with disabilities.
    - Outdoor Developed Areas Accessibility Guidelines: 3 feet for clear tread width
    - Architectural and Transportation Barriers Compliance Board (Access Board): 5-feet is the minimum clear width for shared use paths
- Bollard placement should provide adequate sight distance to allow users to adjust their speed to avoid hitting them.
- Bollards should be a minimum height of 40 inches and minimum diameter of 4 inches.
- Striping an envelope around the approach to the post is recommended as shown below, to guide users around the object.

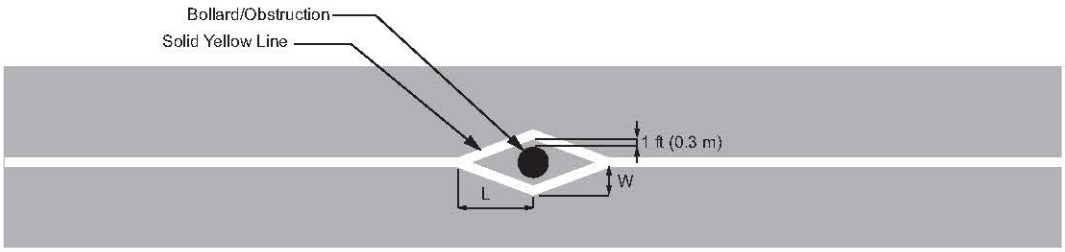


Figure 5-21. Bollard Approach Markings

Source: AASHTO *Guide for the Development of Bicycle Facilities, 2012 (Fourth Edition)*:

- One strategy is to use flexible delineators, which may reduce unauthorized vehicle access without causing the injuries that are common with rigid bollards.
- Bollards should be installed in locations where vehicles cannot easily bypass the bollard. Use of one bollard in the center of the path is preferred. When more than one post is used, an odd number of posts spaced at 6 feet is desirable. However, two posts are not recommended, as they direct opposing path users towards the middle, creating conflicts and the possibility of a head-on collision. Wider spacing can allow entry to motor vehicles, while narrower spacing might prevent entry by adult tricycles, wheelchairs users, and bicycles with trailers.
- Bollards should be set back from the roadway a minimum of 30 feet. Bollards set back from the intersection allow path users to navigate around the bollard before approaching the roadway.
- Hardware installed in the ground to hold a bollard or post should be flush with the surface to avoid creating an additional obstacle.
- Lockable, removable (or reclining) bollards allow entrance by authorized vehicles.

3. CITY OF ALBUQUERQUE BOLLARD INSTALLATIONS

The City of Albuquerque has installed bollards at numerous locations throughout the City's trail system to control vehicular access on trails. Currently, standards or recommended practices to ensure consistent application are not fully established by the City of Albuquerque to govern the design and installation of trail bollards. The only City Standard Drawing established for bollard installation pertains to an installation for access to a drainage facility (see **Appendix A**). As part of this assessment, the City

of Albuquerque requested that bollards at the following locations be reviewed and compared to AASHTO design guidelines:

- Bear Canyon Arroyo Bridge (East Entrance), at the north end of Brentwood Lane (**Figure 1**)
- Bear Canyon Arroyo Bridge (West Entrance), adjacent to the east side of Jefferson Street, north of Balloon Park Road (**Figure 2**)
- Bear Canyon Arroyo Trail, adjacent to the west side of Jefferson Street, north of Balloon Park Road (**Figure 3**)
- Gail Ryba Bridge (East Entrance), which crosses over the Rio Grande, adjacent to the Bosque Trail (**Figure 4**)

It should be noted that during the development of this assessment, changes were made to the bollard installations at the Bear Canyon Arroyo Bridge (East Entrance) and at the Bear Canyon Arroyo Bridge (West Entrance). For the purpose of this assessment, only the new installations were documented and evaluated as compared to AASHTO design guidelines. **Table 1** summarizes the relevant design criteria for the each of the installations and indicates if the criteria meet or exceed AASHTO criteria.

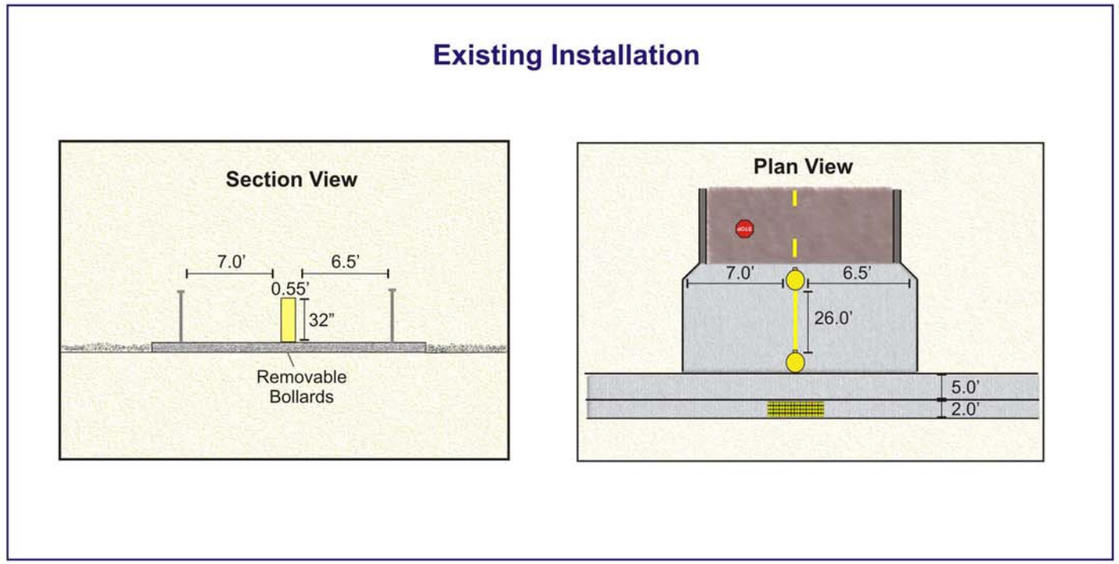
Table 1: Multi-Use Trail Design Criteria Summary

		Bear Canyon Arroyo Bridge (East Entrance)	Bear Canyon Arroyo Bridge (West Entrance)	Bear Canyon Arroyo Trail (West Jefferson)	Gail Ryba Bridge (East Entrance)
Visibility	Retroreflectorized Material	✗	✗	✓	✓
	Appropriate Object Markers	✗	✗	-	-
Permit Passage	ADA Accessible (3 feet)	✓	✓	✗	✓
	Clear Width (5 feet)	✓	✓	✗	✓
Adequate Sight Distance		✓	✓	✓	✓
Bollard Dimensions	Height (40 inches)	✗	✗	✗	✗
	Width (4 inches)	✓	✓	✓	✓
Striped Envelope		✗	✗	✗	✓
Flexible Delineators		✗	✗	✗	✗
Placement	One Bollard in Center	✓	✓	✗	✗
	Odd Number of Posts with 6 foot Spacing	-	-	✗	✗
Setback(30 foot)minimum		✗	✓	✗	-
Flush Mounting Hardware		✓	✓	✗	✓
Removable Bollards for Access		✓	✓	✓	✓

✓ - Criteria Met

✗ - Criteria Not Met

Figure 1: Bear Canyon Arroyo (East Entrance)



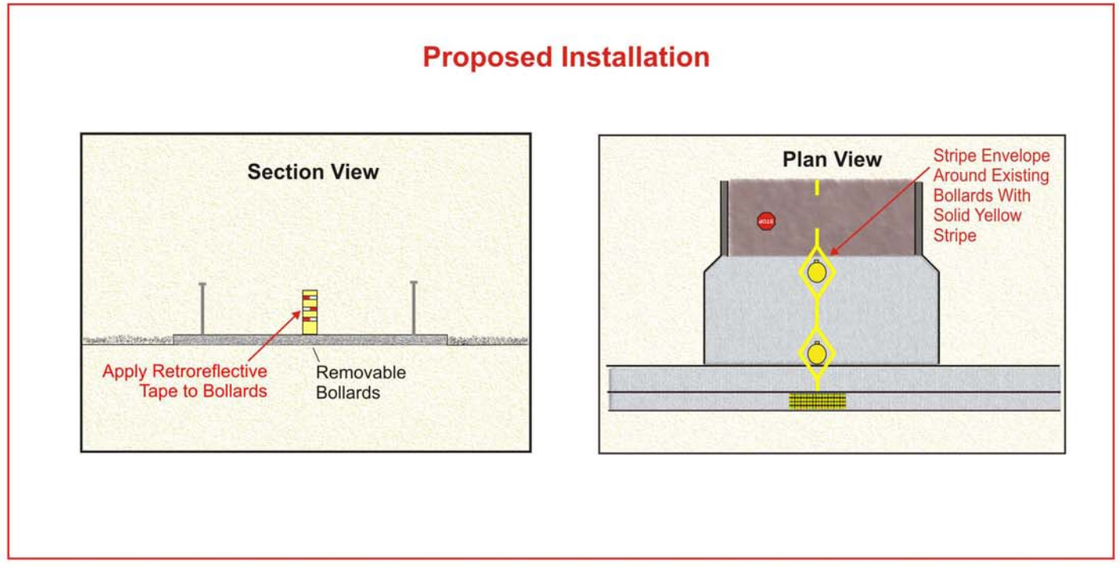
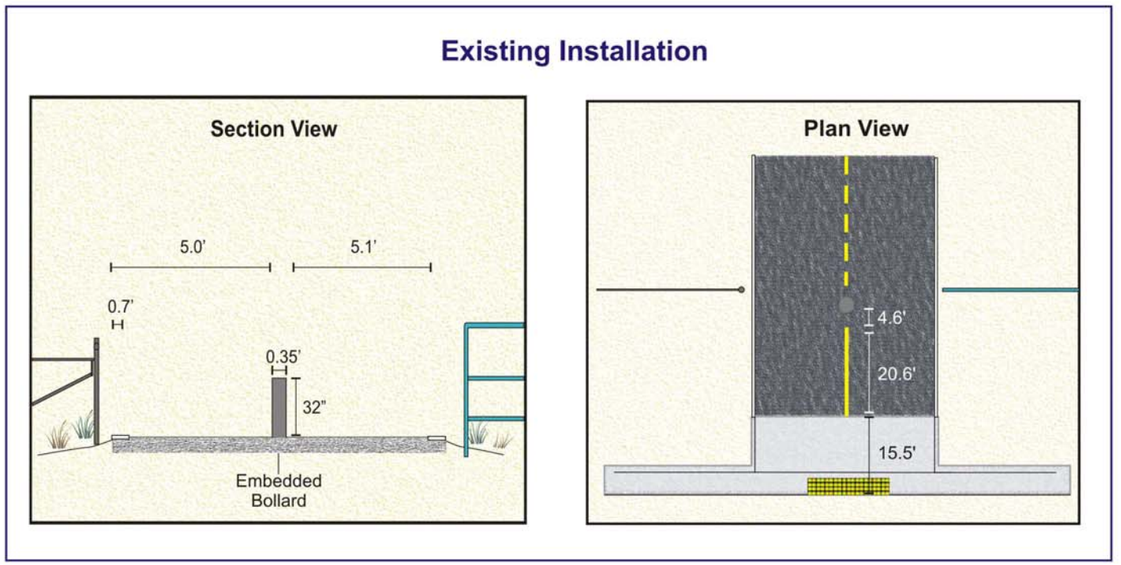


Figure 2: Bear Canyon Arroyo (West Entrance)



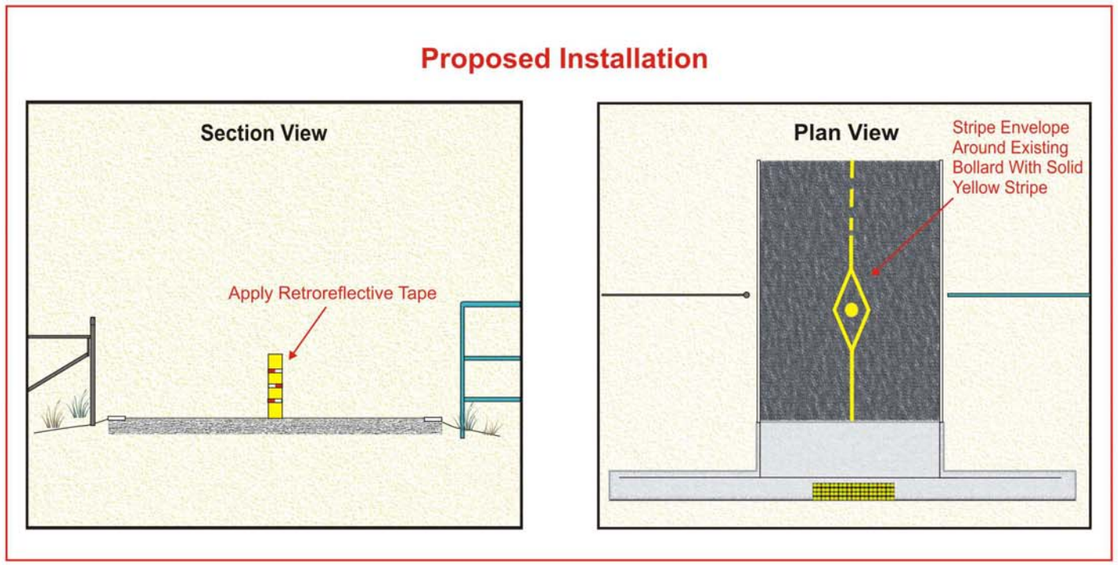
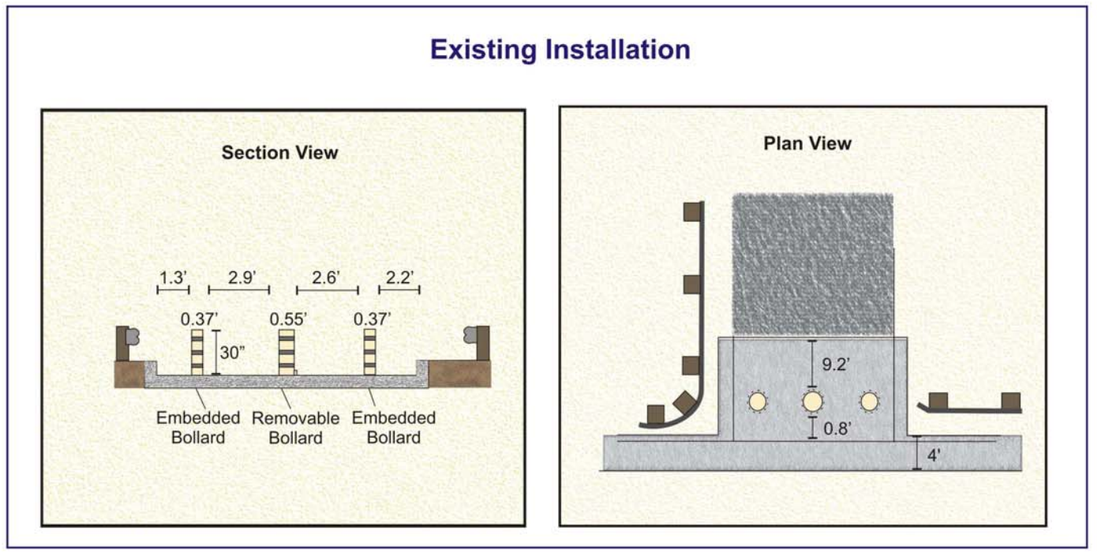


Figure 3: Bear Canyon Arroyo Trail



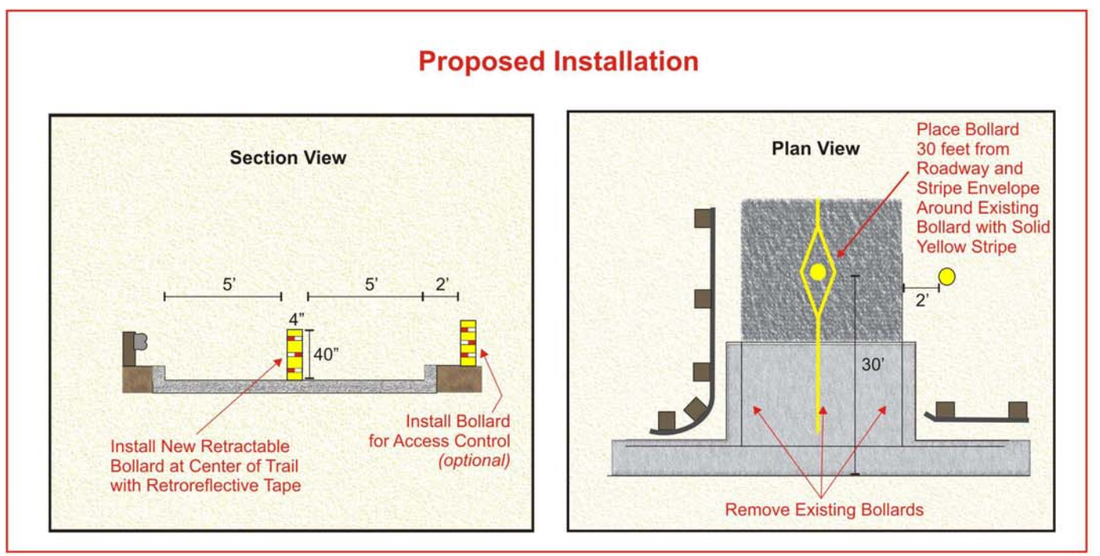
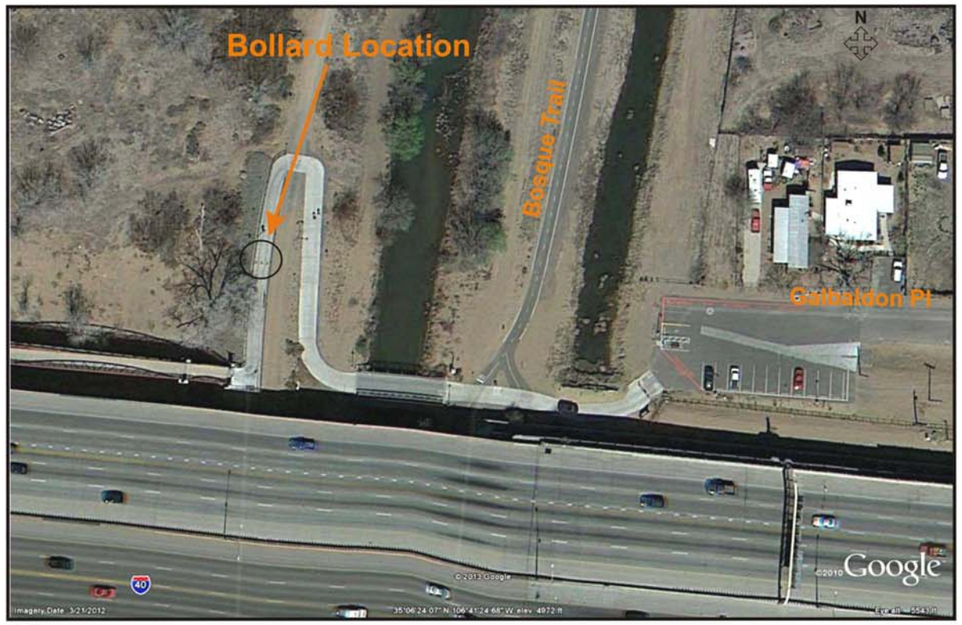
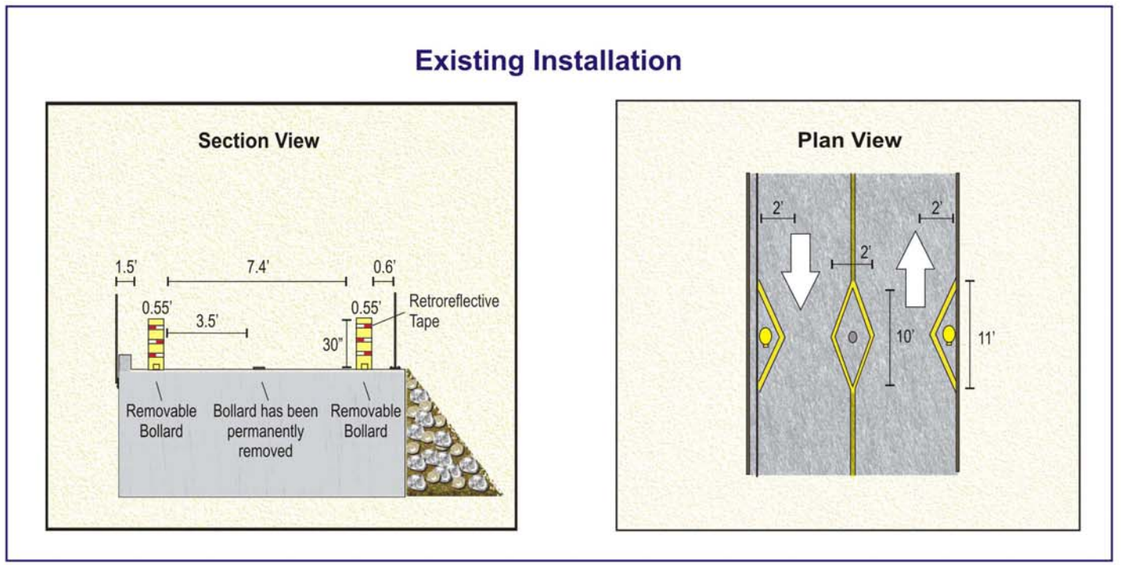
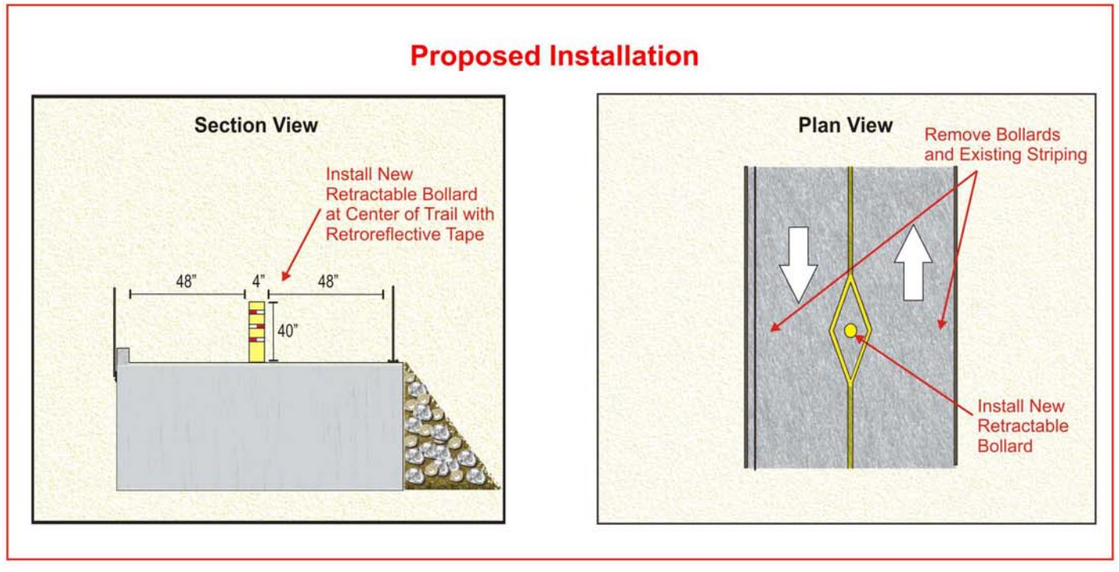


Figure 4: Gail Ryba Bridge







The evaluation findings show that the bollard installations reviewed are not in compliance with AASHTO and MUTCD recommendations. In conjunction with a cursory review of additional locations, the following issues are consistent throughout the City of Albuquerque:

- Bollards are rarely retroreflectorized or emblazoned with retroreflectorized tape.
- Bollards are not 40 inches in height and were always much shorter.
- Striping is inconsistent between sites and even within a given trail segment.
- Bollard placement (number and spacing) is inconsistent throughout the City.
- Bollards are often placed too close to the roadway, frequently at the back of the entrance ramp to the trail.

The proposed modifications to the existing installations maintain existing equipment and enhance conditions with retroreflective paint and tape and optimization of bollard placement. Retractable, 40-inch bollards were not specified unless a new bollard was required.

4. NATIONAL GUIDANCE

Since national standards governing the placement of bollards on multi-use trails do not currently exist, different agencies, committees and coalitions have developed best practices or suggested guidance for bollard types, placement, and locations. The common thought is that bollards should be utilized to increase trail safety by providing separation between motorized vehicles and trail users. A trail entry point should provide safe access to users and keep unauthorized vehicles out.

The following are a summary of best practices and guidelines, including a summary of recommended revisions to the MUTCD (California), Section 9C-101, for the implementation of bollards on multi-use trails developed in California by the City of Sacramento and California Department of Transportation:

- The first steps to control entry at a trail approach should be to install signs that state vehicle entry is prohibited, and to design the entry to discourage vehicle access.
- Barriers should be placed out of the path of travel. Place bollards on the centerline or lane line of a trail.
- Bollards should be permanently reflective for nighttime visibility and coated with a bright color for daytime visibility.
- Bollards should be placed so that there is sufficient sight distance to allow users to adjust speed.
- Bollards should permit passage, without dismounting, for adult tricycles, bicycles towing trailers, and tandem bicycles. Five feet of clearance should be measured face to face and not center to center.
    - When placed off the pavement, bollards should be placed a minimum of 2-feet from the edge of the trail or outer lane line.
- Fold down and sleeve bollards should not be used on trails because when they are not in use, they are a hazard to users.
    - If removable bollards are used, the foundation shall be flush with the surface.
- Use special advance warning signs or pavement markings where sight distance is a concern.
- Develop a separate access for authorized vehicles when warranted on shared facilities.

These guidelines are largely consistent with other agency practices and recommendations. A summary of agency and organization guidelines and standard drawings are included in **Appendix B**.

5. SUMMARY AND RECOMMENDATIONS

The Albuquerque metropolitan area has more than 175 miles of paved multi-use trails. While bollards are commonly used on these facilities, the City of Albuquerque does not have established standards defining the appropriate installation of bollards on a multi-use trail and the applications are inconsistent. AASHTO together with the MUTCD, has developed recommended criteria for the installation of bollards on multi-use trails, which are not design standards, but have been established as best practices.

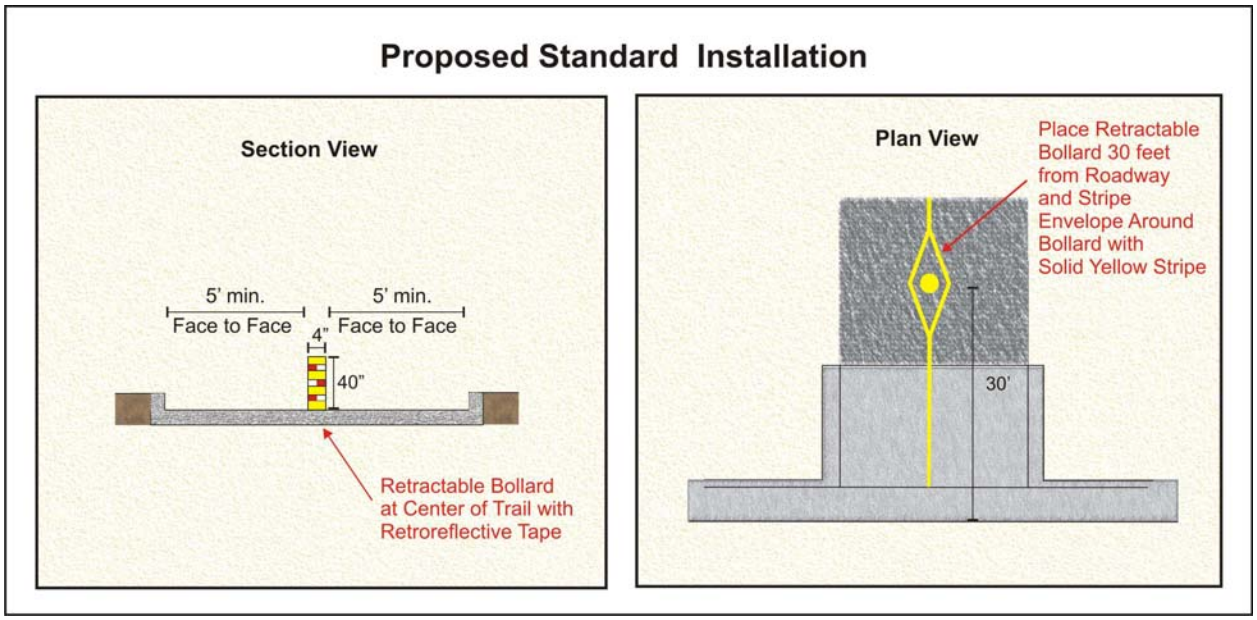
The goal of bollards should be to balance the need to discourage unauthorized motorized vehicle access on a trail with the need to provide the trail users a facility without unnecessary obstructions. Therefore, developing a series of best practices for the installation of bollards on the City of Albuquerque trail system is critical for the purpose of not only providing consistency within the trail system, but also establishing a level of expectancy with the trail users that will result in less confusion and improvements in accessibility for all types of users.

Following is a list of best practices that should be consistent when installing bollards at any trail facility by the City of Albuquerque (**Figure 5**):

- Only apply bollards if the need is demonstrated, or if the trail entrance cannot be designed or modified to discourage use by unauthorized motor vehicles. Bollard use should be reserved for problematic locations.
    - Bollards should not be installed on trail facilities that parallel a roadway unless it is identified as a problematic location.
    - Bollards should be considered along obscured facilities that are not readily visible and at other problematic locations.
- All bollards should be made of a retroreflectorized material or have retroreflectorized tape affixed to them for easy visibility from both approaches to the bollard.
    - Where possible, retractable bollards should be implemented. Appropriate usage ensures that the bollards will remain in place and cannot be removed from the site and when retracted, the bollard will not be a hazard.
- Bollards should be 40 inches in height (minimum) and 4 inches (minimum) in diameter to ensure visibility.
- In most instances, a single bollard should be placed at the centerline of the trail, where adequate sight distance is available.
    - Two bollards should not be used as they typically will be placed in the center of the travel way for each travel direction.
    - If it is necessary to restrict access adjacent to the multi-use trail to restrict motorized traffic, bollards should be placed a minimum of 2-feet off of the edge of the trail.
- A minimum clear width of 5 feet should be provided between the edge of trail and the bollard.

- A striped envelope (4 inch, retroreflective yellow) should be striped around the bollard to provide guidance to divert users around the bollard. A striped yellow centerline should also be provided along the trail for 25-feet on either side of the bollard.
- Bollards should be set back 30-feet from the roadway to separate the conflict point for users between the roadway and bollards, or as far back as is practical based on site conditions.

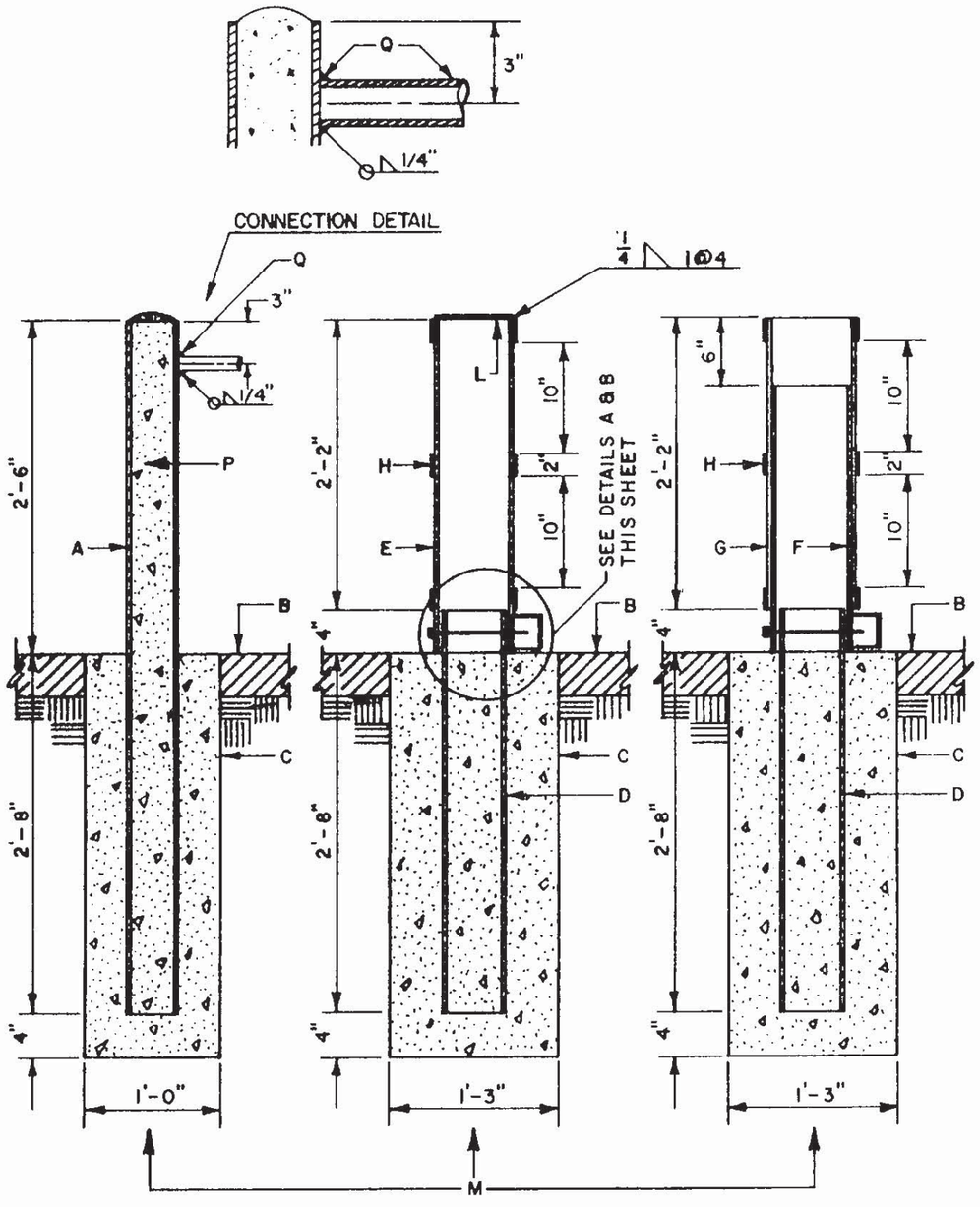
Figure 5: Recommended Practice for Bollard Placement



These recommendations are consistent with a draft policy being developed by the Greater Albuquerque Recreational Trails Committee (GARTC) (**Appendix C**) and current practices of the City of Albuquerque Parks and Recreation Department (coordination meeting held July 22, 2013). Standards to ensure consistent application should be implemented by all departments of the City of Albuquerque. Every trail and entrance are unique and special consideration will need to be given to each site to determine how best to place bollards, if the need for bollards is demonstrated.

Appendices

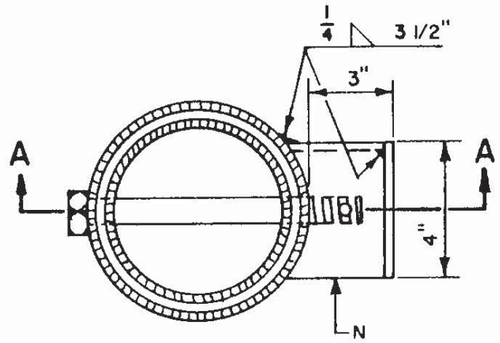
Appendix A: City of Albuquerque Standard Detail



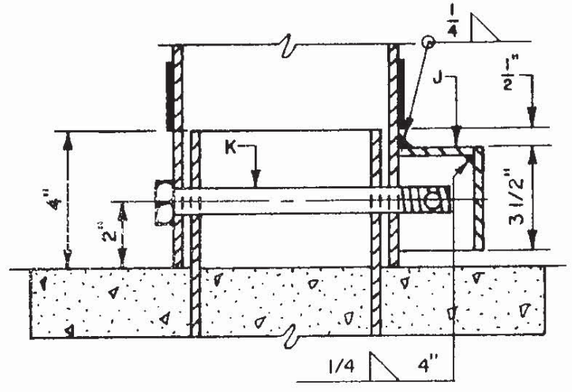
STATIONARY POST

REMOVABLE POST

REMOVABLE POST WITH RUBBER SLEEVE



DETAIL A PLAN



DETAIL B SECTION A-A

GENERAL NOTES:

1. FOR SLEEVE, USE GATES NO. 37 W WATER HOSE, DISCHARGE HOSE OR EQUIVALENT. I.D. 6.625" O.D. 7.29", 6 PLY WITH BLACK NEOPRENE COVER.
2. WELDS ARE TO BE GROUND SMOOTH.
3. EXPOSED STEEL AND SLEEVE TO BE PAINTED WITH AN OIL BASE ALKYD PRIMER AND AN OIL BASE ALKYD ENAMEL TOP COAT. COLOR TO BE BRIGHT YELLOW.

CONSTRUCTION NOTES:

A. 4" NOMINAL DIA. SCHEDULE 40 GALV. STEEL PIPE, 5'-2" TO BE FILLED W/CONC. PAINT PIPE BRIGHT YELLOW ABOVE FINISHED GRADE.

B. PAVEMENT OR FINISHED GRADE.

C. CONC. COLLAR, 3000 PSI AT 28 DAYS, W/SMOOTH OR BROOM FINISH WHERE PAVEMENT IS ADJACENT.

D. 5" NOMINAL DIA. SCHEDULE 40 GALV. STEEL PIPE, 3'-0" TO BE FILLED W/CONC. TO LEVEL SHOWN.

E 6" NOMINAL DIA. SCHEDULE 40 GALV. STEEL PIPE, 2'-8" PAINT PIPE BRIGHT YELLOW (REMOVABLE).

F. 6" NOMINAL DIA. SCHEDULE 40 GALV. STEEL PIPE, 2'-0" (REMOVABLE).

G. SLEEVE, 2'-2" PAINT BRIGHT YELLOW, SEE NOTE NO. 1 THIS SHEET.

H. 2" WIDE REFLECTIVE TAPE, AS APPROVED BY ENGINEER, LOCATE AROUND PIPE AS SHOWN.

J. 1/4" THICK STEEL SAFETY GUARD BOX. OPEN ON ONE SIDE & BOTTOM. WELD ALL SEAMS.

K. 3/4" X 8" GALV. HEX. BOLT W/A 3/8" DIA. HOLE FOR PADLOCK. (PADLOCK FURNISHED BY CITY).

L. 1/4" X 6 5/8" DIA. GALV. STEEL PLATE COVER, WELDED TO PIPE.

M. PLACEMENT OF POSTS SHOULD BE WELL AWAY FROM TRAFFIC ON MAJOR ROADWAYS & PREFERABLY AT THE R.O.W. LINE. TRAFFIC ENGINEERING SHOULD BE CONSULTED ON LOCATION WHEN NEAR TRAFFIC.

N. ALIGN WITH TRAFFIC FLOW IN EASEMENTS OR BIKEPATH TO AVOID TRIPPING HAZARDS WITH BOX.

P. PIPES ARE NOT TO BE FILLED W/CONC. WHEN PIPES ARE LOCATED WITHIN 15' OF STREET FLOWLINE. USE WELDED STEEL CAP INSTEAD.

Q WHERE CONNECTING BOLLARDS ARE SPECIFIED, WELD 1-1/4" NOM., SCH. 40 PIPE BETWEEN BOLLARDS.

CITY OF ALBUQUERQUE

REVISIONS

DRAINAGE STATIONARY & REMOVABLE POST DETAILS

DWG. 2250

AUG. 1986

Appendix B: Agency Bollard Standard Details

American Association of State Highway Transportation Officials (AASHTO)

Guide to Bicycle Facilities, 4th Edition

Shared Use Path Chicanes

Chicanes (i.e., horizontal curvature) can be designed to reduce path users' approach speeds at intersections where users must stop or yield, or where sight distance is limited. Care should be taken to end chicanes far enough in advance of the intersection to allow the user to focus on the curves in the pathway first, then the approaching intersection (rather than both at the same time). A solid centerline stripe is recommended at chicanes to reduce the instances of bicyclists "cutting the corners" of the curves. Chicanes should not be designed for speeds less than 8 mph (13 km/h).

Restricting Motor Vehicle Traffic

Unauthorized use of pathways by motor vehicles occurs occasionally. In general, this is a greater issue on pathways that extend through independent rights-of-way that are not visible from adjacent roads and properties. Per the MUTCD (*7*), the R5-3, "No Motor Vehicles" sign can be used to reinforce the rules.

The routine use of bollards and other similar barriers to restrict motor vehicle traffic is not recommended. Bollards should not be used unless there is a documented history of unauthorized intrusion by motor vehicles. Barriers such as bollards, fences, or other similar devices create permanent obstacles to path users. Bollards on pathways may be struck by bicyclists and other path users and can cause serious injury. Approaching riders may shield even a conspicuous bollard from a following rider's view until a point where the rider lacks sufficient time to react.

Furthermore, physical barriers are often ineffective at the job they were intended for—keeping out motorized traffic. People who are determined to use the path illegally will often find a way around the physical barrier, damaging path structures and adjacent vegetation. Barrier features can also slow access for emergency responders. A three-step approach may be used to prevent unauthorized motor vehicle entry to shared use paths:

1. Post signs identifying the entry as a shared use path and regulatory signs prohibiting motor vehicle entry. For example, the R5-3, "No Motor Vehicles" sign may be placed near where roads and shared use paths cross and at other path entry locations.
2. Design the path entry location so that it does not look like a vehicle access and make intentional access by unauthorized users difficult. A preferred method of restricting entry of motor vehicles is to split the entry way into two sections separated by low landscaping. Each section should be half the nominal path width; for example a 10-ft (3-m) path should be split into two 5-ft (1.5-m) sections. Emergency vehicles can still enter, if needed, by straddling the landscaping. Alternatively, it may be more appropriate to designate emergency vehicle access via protected access drives that can be secured. The approach to the split should be delineated with solid line pavement markings to guide the path user around the split.
3. Assess whether signing and path entry design prevents or reduces unauthorized traffic to tolerable levels. If motor vehicle incursion is isolated to a specific location, consider targeted surveillance and enforcement. If unauthorized use persists, assess whether the problems posed by unauthorized vehicle entry exceed the risks and access issues posed by barriers. Where the need for bollards or other vertical barriers in the pathway can be justified despite their risks and access issues, measures should be taken to make them as compatible as possible with the needs of bicyclists and other path users (*6*):

- Bollards should be marked with a retroreflectorized material on both sides or with appropriate object markers, per Section 9B.26 of the MUTCD (*7*).
- Bollards should permit passage, without dismounting, for adult tricycles, bicycles towing trailers, and tandem bicycles. Bollards should not restrict access for people with disabilities. All users legally permitted to use the facility should be accommodated; failure to do so increases the likelihood that pathway users will collide with the bollards.
- Bollard placement should provide adequate sight distance to allow users to adjust their speed to avoid hitting them.
- Bollards should be a minimum height of 40 in. (1.0 m) and minimum diameter of 4 in. (100 mm). Some jurisdictions have used taller bollards that can be seen above users in order to reinforce their visibility.
- Striping an envelope around the approach to the post is recommended as shown in Figure 5-21 to guide path users around the object.
- One strategy is to use flexible delineators, which may reduce unauthorized vehicle access without causing the injuries that are common with rigid bollards.
- Bollards should only be installed in locations where vehicles cannot easily bypass the bollard. Use of one bollard in the center of the path is preferred. When more than one post is used, an odd number of posts spaced at 6 ft (1.8 m) is desirable. However, two posts are not recommended, as they direct opposing path users towards the middle, creating conflict and the possibility of a head-on collision. Wider spacing can allow entry to motor vehicles, while narrower spacing might prevent entry by adult tricycles, wheelchair users, and bicycles with trailers.
- Bollards should be set back from the roadway edge a minimum of 30 ft (10 m). Bollards set back from the intersection allow path users to navigate around the bollard before approaching the roadway.
- Hardware installed in the ground to hold a bollard or post should be flush with the surface to avoid creating an additional obstacle.
- Lockable, removable (or reclining) bollards allow entrance by authorized vehicles.

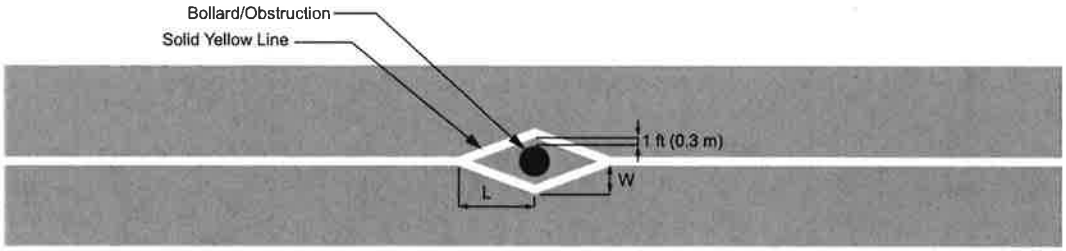


Figure 5-21. Bollard Approach Markings

Edgeline Striping

Edgeline striping may be considered for use on shared use paths under several situations. The use of 4 to 6 in. (100 to 150 mm) wide, white edge lines may be beneficial on shared use paths where nighttime use is not prohibited. The use of white edge lines may be considered at approaches to intersections to alert path users of changing conditions, and if the pathway design includes a separate area for pedestrian travel, it should be separated from the bicycle traveled way by a normal white line. Refer to Section 5.2.1 for more information on segregation of traffic.

Approach Markings for Obstructions

Obstructions should not be located in the clear width of a path. Where an obstruction on the traveled portion occurs (for example, in situations where bollards are used), channelizing lines of appropriate color (yellow for centerline, otherwise white) should be used to guide path users around it. An example of a centerline treatment is given in Figure 5-21. For obstructions located on the edge of the path, an obstruction marking (see Figure 4-30) should be used. Approach markings should be tapered from the approach end of the obstruction to a point at least 1 ft (0.3 m) from the obstruction (See Table 4-1 to determine taper length).

Pavement Markings to Supplement Intersection Control

Stop and yield lines may be used to indicate the point at which a path user should stop or yield at a traffic control device. Design of stop and yield lines is described in Chapter 3B of the MUTCD (*7*). Stop or yield lines may be placed across the entire width of the path. If used, the stop or yield line should be placed a minimum of 2 ft (0.6 m) behind the nearest sidewalk or edge of roadway if a sidewalk is not present.

Supplemental Pavement Markings on Approaches

Advance pavement markings may be used on roadway or path approaches at crossings where the crossing is unexpected or where there is a history of crashes, conflicts, or complaints. If a supplemental word marking (such as "HWY XING") is used, its leading edge should be located at or near the point where the approaching user passes the intersection warning sign or advance traffic control warning sign that the marking supplements. Additional markings may be placed closer to the crossing if needed, but should be at least 50 ft (15 m) from the crossing. Advance pavement markings may be placed across the entire width of the path or within the approach lane. Pavement markings should not replace the appropriate signs. Pavement markings may be words or symbols as described in Part 3 of the MUTCD (*7*).

Advance Stop or Yield Lines

Advance stop lines or yield lines may be used on multilane roadway approaches to a path crossing where the path is given priority. The applicability of either a stop line or a yield line is governed by state law. Figure 5-23 shows an application of advanced yield lines, and Figures 5-18 and 5-20 illustrate the use of both applications where the path is given priority. Advance stop and yield lines reduce the likelihood for a multiple-threat crash between the path user and a vehicle. The advance stop or yield line provides a clearer field of vision between path users who are crossing the road and approaching vehicles in both lanes. These treatments have shown promising results (*16*), (*17*).

Bicycling Info.org

Design Details (web)

bicyclinginfo.org
Pedestrian and Bicycle Information Center

Design Details

Width and clearance

Ten feet or 3 meters is the recommended minimum width for a two-way, shared use path on a separate right of way. Other critical measurements include:

- 8 feet (2.4m) may be used where bicycle traffic is expected to be low at all times, pedestrian use is only occasional, sightlines are good, passing opportunities are provided, and maintenance vehicles will not destroy the edge of the trail.
- 12 feet is recommended where substantial use by bicycles, joggers, skaters, and pedestrians is expected, and where grades are steep (see later).
- 2 feet of graded area should be maintained adjacent to both sides of the path.
- 3 feet of clear distance should be maintained between the edge of the trail and trees, poles, walls, fences, guardrails or other lateral obstructions.
- 8 feet of vertical clearance to obstructions should be maintained; rising to 10 feet in tunnels and where maintenance and emergency vehicles must operate.

Design speed, horizontal and vertical alignment

The design of a shared use path should take into account the likely speed of users, the ability of bicyclists to turn corners without falling over, skidding, or hitting their pedal on the ground as they lean over. The AASHTO Guide for the Design of Bicycle Facilities has a number of tables, and equations to help designers meet the tolerances of a bicyclist based on the following key numbers:

- 20 miles per hour (30 km/h) is the minimum design speed to use in designing a trail
- 30 miles per hour (50 km/h) should be used where downgrades exceed 4 percent
- 15 miles per hour (25 km/h) should be used on unpaved paths where bicyclists tend to ride more slowly (and cannot stop as fast without skidding or sliding on a loose surface)

The result is a series of recommended desirable minimum curve radii for corners that should be safe for bicyclists.

Lighting

Shared use paths in urban and suburban areas often serve travel needs both day and night, for example commuter routes and trails accessing college campuses. Fixed source lighting improves visibility along trails and at intersections, and is critical for lighting tunnels and underpasses. The AASHTO guide recommends using average maintained illumination levels of between 5 and 22 lux, and the Florida DOT recommends 25 as the average initial lux. Also, there needs to be a periodic monitoring of the lights and a maintenance program.

Preventing motor vehicle use of paths

In some locations, shared use paths may be mistaken for motor vehicle roads or may suffer from illegal or unauthorized motorized use. At intersections with roadways, therefore, the path should be clearly signed, marked and/or designed to discourage or prevent unauthorized motorized access. A variety of alternatives exist to achieve this:

a. bollards. Probably the most common device is the bollard, often lockable, collapsible or removable to allow for authorized access to the trail. Great care should be used in locating the bollard to ensure that they are visible, allow trail users through, and are not placed so as to channel both directions of trail users towards the same point in the trail. If bollards are to be used, they should be retro-reflective, brightly colored, and have pavement markings around them. On a ten foot trail, one bollard should be used in the center of the trail. If more than one bollard is necessary, there should be five feet between them.
b. splitting the trail in two. Many manuals suggest the option of splitting a ten foot trail into two five foot approaches to an intersection, with a planted triangle between them. This may increase maintenance costs.
c. medians. The Florida DOT manual notes that "curbing with tight radii leading up to the roadway can often prevent motorists from attempting to enter the path. Medians should be set back from the intersection 25 feet (8m) to allow bicyclists to exit the roadway fully before navigating the reduced pathway width."

Signing and marking

While fewer signs may be needed on paths compared to on-street facilities, adequate signing and marking are essential on shared use paths, just as they are on streets and highways. Trail users need to know about potential conflicts, regulatory information, destinations, cross streets etc. The Manual on Uniform Traffic Control Devices (MUTCD) provides some minimum traffic control measures that should be applied and a range of options.

Striping: a yellow center line stripe is recommended where trails are busy, where sight distances are restricted, and on some unlit trails where night time riding is expected. The line should be dashed when adequate passing sight distance exists, and solid when no passing is recommended.

A solid white line may be used to separate pedestrians from bicycle/blading traffic, and solid white edge stripes may also be useful where nighttime riding is expected.

Warning signs: a range of warning signs can be used to inform users that recommended design criteria cannot be met, for example curve radii or grades or where unexpected conditions may exist.

Informational signs: trail users need to know where they are, where they are going, what cross streets they are crossing, how far destinations are away, and what services are available close to the trail. The MUTCD has information on the appropriate signs to use in these instances. Although not in the MUTCD, many trails post signs encouraging uniform trail user etiquette (e.g. "give audible signal when passing" or which type of trail user has the right-of-way).

Intersection markings and signs: pavement marking and signs at intersections should channel users to cross at clearly defined locations and indicate that crossing traffic is to be expected. Similar devices to those used on roadways (STOP and YIELD signs, stop bars etc) should be used on trails as appropriate.

The AASHTO Guide notes that in addition to traditional warning signs in advance of intersections, motorists can be alerted to the presence of a trail crossing through flashing warning lights, zebra-style or colored pavement crosswalks, raised crosswalks, signals, and neck-downs/curb-bulbs. However, some devices such as flashing warning lights are expensive to install and maintain and should be kept to a minimum.

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Caltrans

Caltrans Highway Design Manual Chapter 1000

CHAPTER 1000 BICYCLE TRANSPORTATION DESIGN

Topic 1001 - Introduction

Index 1001.1 – Bicycle Transportation

The needs of non motorized transportation are an essential part of all highway projects. Mobility for all travel modes is recognized as an integral element of the transportation system. Therefore, the guidance provided in this manual complies with Deputy Directive 64-Revision #1: Complete Streets: Integrating the Transportation System. See AASHTO, "Guide For The Development Of Bicycle Facilities".

Design guidance for Class I bikeways (bike paths), Class III bikeways (bike routes) and Trails are provided in this chapter. Design guidance that addresses the mobility needs of bicyclists on all roads as well as on Class II bikeways (bike lanes) is distributed throughout this manual where appropriate.

See Topic 116 for guidance regarding bikes on freeways.

1001.2 Streets and Highways Code References

The Streets and Highways Code Section 890.4 defines a "bikeway" as a facility that is provided primarily for bicycle travel. Following are other related definitions, found in Chapter 8 Nonmotorized Transportation, from the Streets and Highway Code:

(a) Section 887 -- Definition of nonmotorized facility.

(b) Section 887.6 -- Agreements with local agencies to construct and maintain nonmotorized facilities.

(c) Section 887.8 -- Payment for construction and maintenance of nonmotorized facilities approximately paralleling State highways.

(d) Section 888 -- Severance of existing major non motorized route by freeway construction.

(e) Section 888.2 -- Incorporation of non motorized facilities in the design of freeways.

(f) Section 888.4 -- Requires Caltrans to budget not less than $360,000 annually for non motorized facilities used in conjunction with the State highway system.

(g) Section 890.4 -- Class I, II, and III bikeway definitions.

(h) Section 890.6 - 890.8 -- Caltrans and local agencies to develop design criteria and symbols for signs, markers, and traffic control devices for bikeways and roadways where bicycle travel is permitted.

(i) Section 891 -- Local agencies must comply with design criteria and uniform symbols.

(j) Section 892 -- Use of abandoned right-of-way as a nonmotorized facility.

1001.3 Vehicle Code References

(a) Section 21200 -- Bicyclist's rights and responsibilities for traveling on highways.

(b) Section 21202 -- Bicyclist's position on roadways when traveling slower than the normal traffic speed.

(c) Section 21206 -- Allows local agencies to regulate operation of bicycles on pedestrian or bicycle facilities.

(d) Section 21207 -- Allows local agencies to establish bike lanes on non-State highways.

(e) Section 21207.5 -- Prohibits motorized bicycles on bike paths or bike lanes.

(f) Section 21208 -- Specifies permitted movements by bicyclists from bike lanes.

(g) Section 21209 -- Specifies permitted movements by vehicles in bike lanes.

(h) Section 21210 -- Prohibits bicycle parking on sidewalks unless pedestrians have an adequate path.

(i) Section 21211 -- Prohibits impeding or obstruction of bicyclists on bike paths.

(j) Section 21400 – Adopt rules and regulations for signs, markings, and traffic control devices for roadways user.

with adequate stopping sight distances. **The minimum stopping sight distance based on design speed shall be 125 feet for 20 miles per hour, 175 feet for 25 miles per hour and 230 feet for 30 miles per hour.** The distance required to bring a bicycle to a full controlled stop is a function of the bicyclist's perception and brake reaction time, the initial speed of the bicycle, the coefficient of friction between the tires and the pavement, and the braking ability of the bicycle.

Stopping sight distance is measured from a bicyclist's eyes, which are assumed to be 4 ½ feet above the pavement surface to an object ½-foot high on the pavement surface.

(11) Length of Crest Vertical Curves. Figure 1003.1C indicates the minimum lengths of crest vertical curves for varying design speeds.

(12) Lateral Clearance on Horizontal Curves. Figure 1003.1D indicates the minimum clearances to line of sight obstructions, *m*, for horizontal curves. It is assumed that the bicyclist's eyes are 4 ½ feet above the pavement surface to an object ½-foot high on the pavement surface.

Bicyclists frequently ride abreast of each other on bicycle paths, and on narrow bicycle paths, bicyclists have a tendency to ride near the middle of the path. For these reasons, lateral clearances on horizontal curves should be calculated based on the sum of the stopping sight distances for bicyclists traveling in opposite directions around the curve. Where this is not possible or feasible, the following or combination thereof should be provided: (a) the path through the curve should be widened to a minimum paved width of 14 feet; and (b) a yellow center line curve warning sign and advisory speed limit signs should be installed.

(13) Grades. Bike path grades must meet DIB 82. The maximum grade rate recommended for bike paths should be 5 percent. Sustained grades should be limited to 2 percent.

(14) Pavement Structure. The pavement material and structure of a bike path should be designed in the same manner as a highway, with a recommendation from the District Materials Branch. It is important to construct and maintain a smooth, well drained, all-weather riding surface with skid resistant qualities, free of vegetation growth. Principal loads will normally be from maintenance and emergency vehicles.

(15) Drainage. For proper drainage, the surface of a bike path should have a minimum cross slope of 1 percent to reduce ponding and maximum of 2 percent Per DIB 82. Sloping of the traveled way in one direction usually simplifies longitudinal drainage design and surface construction, and accordingly is the preferred practice. However, the unpaved shoulders slope away from the path at 2 percent. Ordinarily, surface drainage from the path will be adequately dissipated as it flows down the gently sloping shoulder. However, when a bike path is constructed on the side of a hill, a drainage ditch of suitable dimensions may be necessary on the uphill side to intercept the hillside drainage. Where necessary, catch basins with drains should be provided to carry intercepted water across the path. Such ditches should be designed in such a way that no undue obstacle is presented to bicyclists.

Culverts or bridges are necessary where a bike path crosses a drainage channel.

(16) Entry Control for Bicycle Paths. Obstacle posts and gates are fixed objects and placement within the bicycle path traveled way can cause them to be an obstruction to bicyclists. Obstacles such as posts or gates may be considered only when other measures have failed to stop unauthorized motor vehicle entry. Also, these obstacles may be considered only where safety and other issues posed by actual unauthorized vehicle entry are more serious than the safety and access issues posed to bicyclists, pedestrians and other authorized path users by the obstacles.

The 3-step approach to prevent unauthorized vehicle entry is:

(a) Post signs identifying the entry as a bicycle path with regulatory signs prohibiting motor vehicle entry where roads and bicycle paths cross and at other path entry points.

(b) Design the path entry so it does not look like a vehicle access and makes intentional

access by unauthorized users more difficult. Dividing a path into two one-way paths prior to the intersection, separated by low plantings or other features not conducive to motor vehicle use, can discourage motorist from entering and reduce driver error.

(c) Assess whether signing and path entry design prevents or minimizes unauthorized entry to tolerable levels. If there are documented issues caused by unauthorized motor vehicle entry, and other methods have proven ineffective, assess whether the issues posed by unauthorized vehicle entry exceed the crash risks and access issues posed by obstacles.

If the decision is made to add bollards, plantings or similar obstacles, they should be:

- Yielding to minimize injury to bicyclists and pedestrians who may strike them.
- Removable or moveable (such as gates) for emergency and maintenance access must leave a flush surface when removed.
- Reflectorized for nighttime visibility and painted, coated, or manufactured of material in a bright color to enhanced daytime visibility.
- Illuminated when necessary.
- Spaced to leave a minimum of 5 feet of clearance of paved area between obstacles (measured from face of obstacle to face of adjacent obstacle). Symmetrically about the center line of the path.
- Positioned so an even number of bicycle travel lanes are created, with a minimum of two paths. Odd number of openings increases the risk of head-on collisions if traffic in both directions tries to use the same opening.
- Placed so additional, non-centerline/lane line posts are located a minimum of 2 feet from the edge of pavement.
- Delineated as shown in California MUTCD Figure 9C-2.
- Provide special advance warning signs or painted pavement markings if sight distance is limited.
- Placed 10 to 30 feet back from an intersection, and 5 to 10 feet from a bridge, so bicyclists approach the obstacle straight-on and maintenance vehicles can pull off the road.
- Placed beyond the clear zone on the crossing highway, otherwise breakaway.

When physical obstacles are needed to control unauthorized vehicle access, a single non-removable, flexible, post on the path centerline with a separate gate for emergency/maintenance vehicle access next to the path, is preferred. The gate should swinging away from the path,

Fold-down obstacle posts or bollards shall not be used within the paved area of bicycle paths. They are often left in the folded down position, which presents a crash hazard to bicyclists and pedestrians. When vehicles drive across fold-down obstacles, they can be broken from their hinges, leaving twisted and jagged obstructions that project a few inches from the path surface.

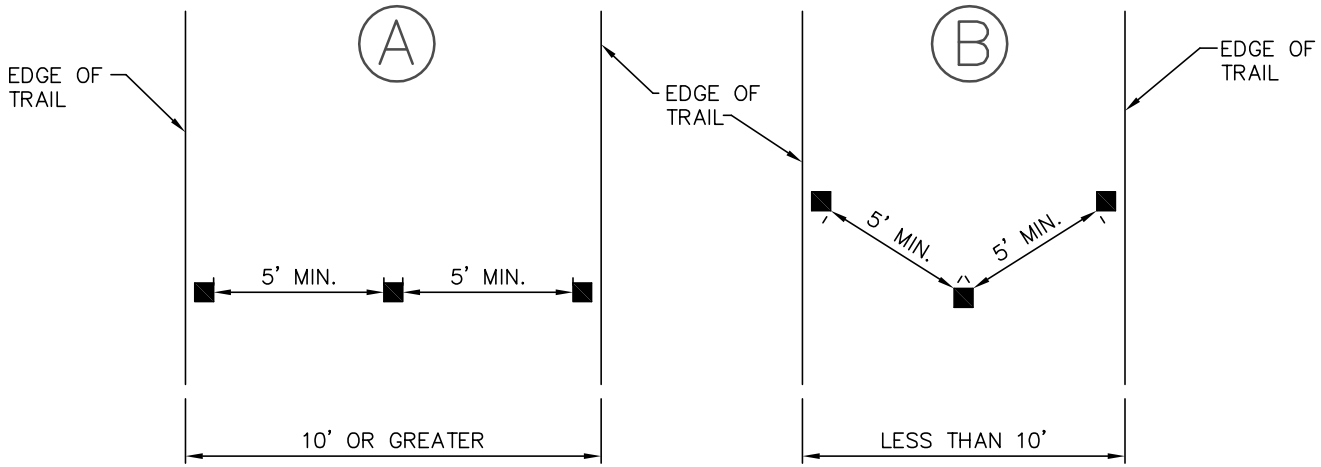
Obstacle posts or gates must not be used to force bicyclists to slow down, stop or dismount. Treatments used to reduce vehicle speeds may be used where it is desirable to reduce bicycle speeds.

For obstacle post visibility marking, and pavement markings, see the California MUTCD, Section 9C.101(CA).

(17) Lighting. Fixed-source lighting raises awareness of conflicts along paths and at intersections. In addition, lighting allows the bicyclist to see the bicycle path direction, surface conditions, and obstacles. Lighting for bicycle paths is important and should be considered where nighttime use is not prohibited, in sag curves (see Index 201.5), at intersections, at locations where nighttime security could be a problem, and where obstacles deter unauthorized vehicle entry to bicycle paths. See Index 1003.1(16). Daytime lighting should also be considered through underpasses or tunnels.

City of Bellevue (WA)

Standard Details

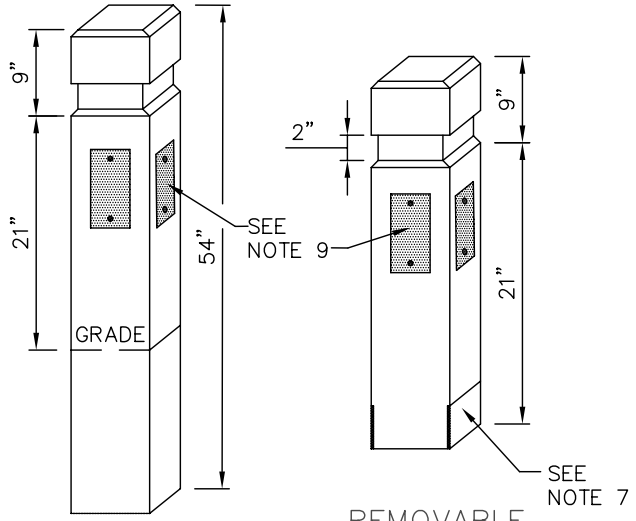


BOLLARD PLACEMENT

City of Bellevue

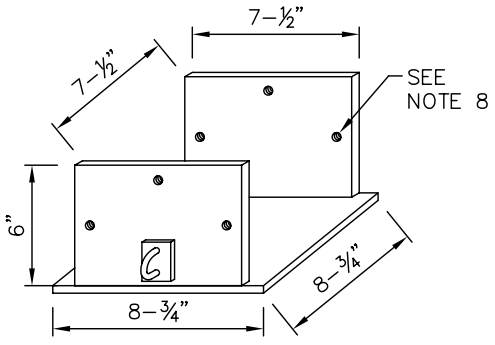
TYPICAL BOLLARD PLACEMENT ON PATHWAYS

DRAWING NUMBER	DEV-13
SCALE	NONE
REVISION DATE	12/05
DEPARTMENT	TRANS

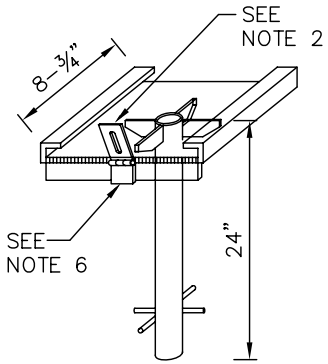


FIXED BOLLARD

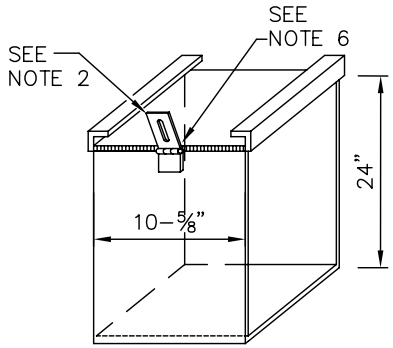
REMOVABLE BOLLARD



SLIDE–THROUGH POST BRACKET
(FOR REMOVABLE BOLLARD)



2" SCHEDULE 40
GALVANIZE PIPE
(FOR SUPPORT PLATE)



GALVANIZED STEEL PLATE
(FOR SUPPORT PLATE)

ALTERNATE BRACKET SUPPORT
(FOR REMOVABLE BOLLARD)

NOTES

1. ALL PLATE MATERIALS SHALL BE ⅜" GALVANIZED STEEL.
2. LOCKING HINGE SHALL BE HEAVY DUTY CLASP. PROVIDE ADEQUATE CLEARANCE BETWEEN PAVEMENT & CLASP TO ALLOW CLASP TO LIE FLAT WHEN OPEN.
3. BOLLARD SHALL BE MANUFACTURED FROM 8" X 8" DOUGLAS FIR #2 OR BETTER AND PRESSURE–TREATED WITH LP–22.
4. REMOVABLE BOLLARD INSTALLATION: PIPE BASES ARE SET IN A 12" DIAMETER HOLE, 32" DEEP; PLATE BASES ARE SET IN A HOLE WITH 2" OF CLEARANCE ON ALL SIDES AND BOTH ARE TO BE BACKFILLED WITH CONCRETE. LOCK HASP FACES THE STREET.
5. FIXED BOLLARD INSTALLATION: SET FIXED BOLLARDS IN A IN A 16" DIAMETER HOLE, 24" DEEP, AND BACKFILL WITH CONCRETE.
6. USE ¼" WELD (BOTH SIDES) TO MOUNT CLASP.
7. FOR REMOVABLE BOLLARD BASE BRACKET INCISE ¼" TO FIT BOLLARD BASE.
8. FOR REMOVABLE BOLLARD SLIDE THROUGH POST BRACKET. DRILL THREE HOLES FOR ½" x 1.5" MACHINE SCREWS (STAINLESS STEEL) AS SHOWN.
9. FOR BOLLARD REFLECTIVITY USE HIGH INTENSITY DELINEATOR 4" x 8" ZUMAR OR EQUIVALENT; USE WHITE COLOR ONLY. INSTALL ON ALL SIDES OF THE BOLLARD VISIBLE FROM APPROACHING BICYCLIST. FASTEN WITH STAINLESS STEEL LAG SCREWS.
10. DELINEATORS SHOULD BE ATTACHED TO ALL BOLLARDS THAT ARE LOCATED WITHIN THE CITY OF BELLEVUE BICYCLE SYSTEM (PER THE BELLEVUE PEDESTRIAN AND BICYCLE TRANSPORTATION PLAN, 1999) OR AS SPECIFIED BY THE ENGINEER.

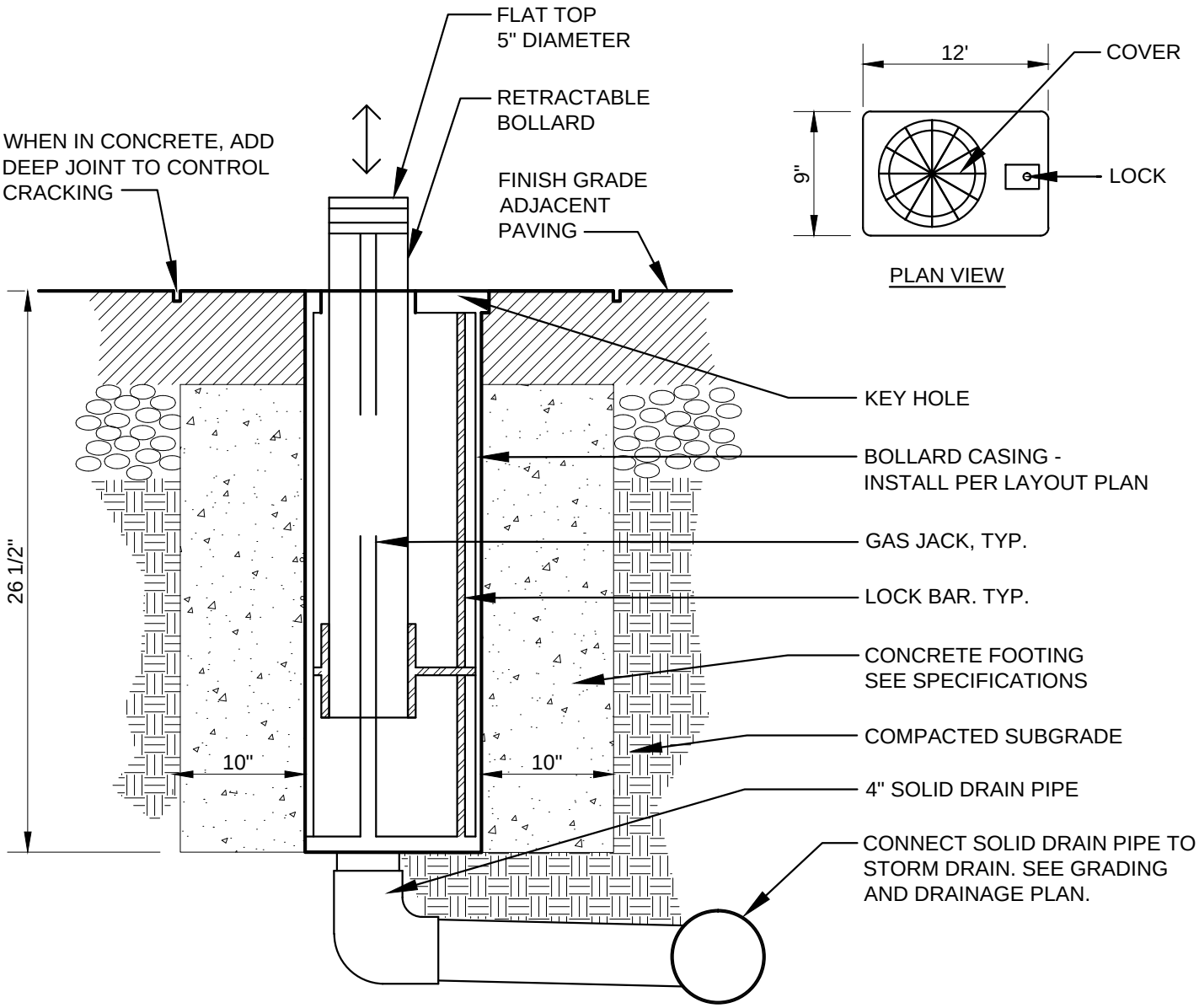
City of Bellevue

REMOVABLE AND FIXED BOLLARD

DRAWING NUMBER	DEV–14
SCALE	NONE
REVISION DATE	01/08
DEPARTMENT	TRANS

City of Fremont (CA)

Retractable Bollard Standard Detail



ACCEPTABLE MANUFACTURER, OR APPROVED EQUAL:

URBACO
CHATEAUNEUF SEMI-AUTOMATIC RETRACTABLE BOLLARD
MODEL #9240, 26" HEIGHT ABOVE GROUND LEVEL
PHONE #: (888) 987-2220

NOTES:
1. COLOR: BLACK; SEE SPECIFICATIONS
2. SUBMIT COLOR SAMPLE TO CITY LANDSCAPE ARCHITECT FOR APPROVAL PRIOR TO ORDERING.
3. INSTALL PER MANUFACTURER'S SPECIFICATIONS.
4. WHERE STORM DRAIN IS NOT AVAILABLE INSTALL DRAIN SUMP WITH CITY APPROVAL. SUMP TO BE CLASS II WASHED DRAIN ROCK WRAPPED IN MIRAFI 140 FABRIC, OR APPROVED EQUAL. SEE PSD SF-4.

NO.	REVISED	DATE

REVISIONS

CITY OF FREMONT
PARK STANDARD DETAILS

RETRACTABLE BOLLARD

DATE APPROVED BY CITY COUNCIL: December 13, 2011
RESOLUTION NO.: 2011-65
SENIOR LANDSCAPE ARCHITECT
COMMUNITY SERVICES DIRECTOR

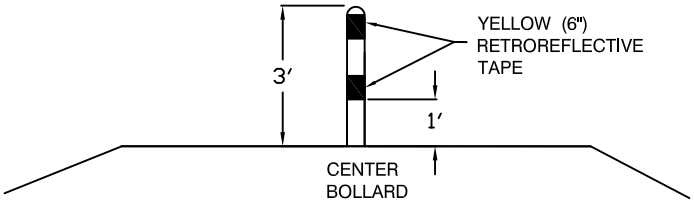
FILE NO.	SCALE	DRAWN	CHECKED	DATE	DWG NO.	
PSD SF-2.DWG	N.T.S.	EL/TB	RER	05/06/0211	PSD SF-2	1 OF 1

City of Oakland (CA)

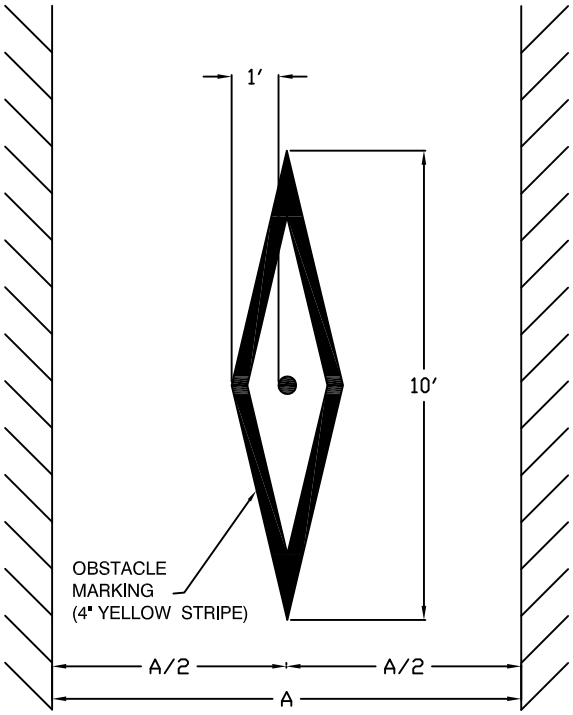
Bollard Placement and Markings Standard Drawings

CENTER BOLLARD

SECTION VIEW



PLAN VIEW



NOTE:
MUTCD Section 9C.101(CA) Barrier Posts on Class I Bikeways

Support: Before a decision is made to install barrier posts, consideration needs to be given to the implementation of other remedial measures, such as Bike Path Exclusion (R44A(CA)) signs (see Section 9B.07) and/or redesigning the path entry so that motorists do not confuse it with vehicle access.

Guidance: Such devices should be used only where extreme problems are encountered.

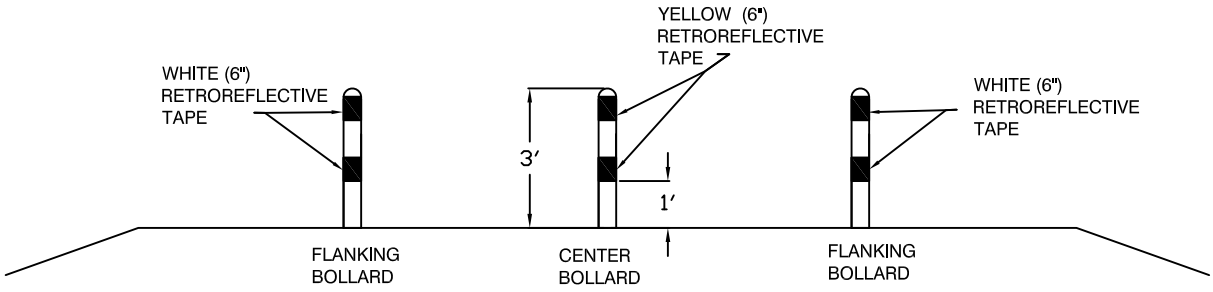
Oakland Standard:

1. Avoid the use of bollards wherever possible.
2. When deemed necessary, a center bollard shall be located in the middle of path and delineated by yellow (6") retroreflective tape at the top and midpoint of the bollard and by a yellow (4") obstacle marking stripe around the base of the bollard.
3. When additional bollards are deemed necessary, flanking bollards shall be placed in line with the center bollard and perpendicular to the direction of travel. The bollards shall be spaced with a minimum 5' clearance between bollards and all other vertical elements. Each flanking bollard shall be delineated by white (6") retroreflective tape at the top and midpoint of each bollard and by a white (4") obstacle marking stripe around the base of the bollard. See Dwg. X-2.
4. Removable bollards shall have a mount point that is flush with the travel surface.

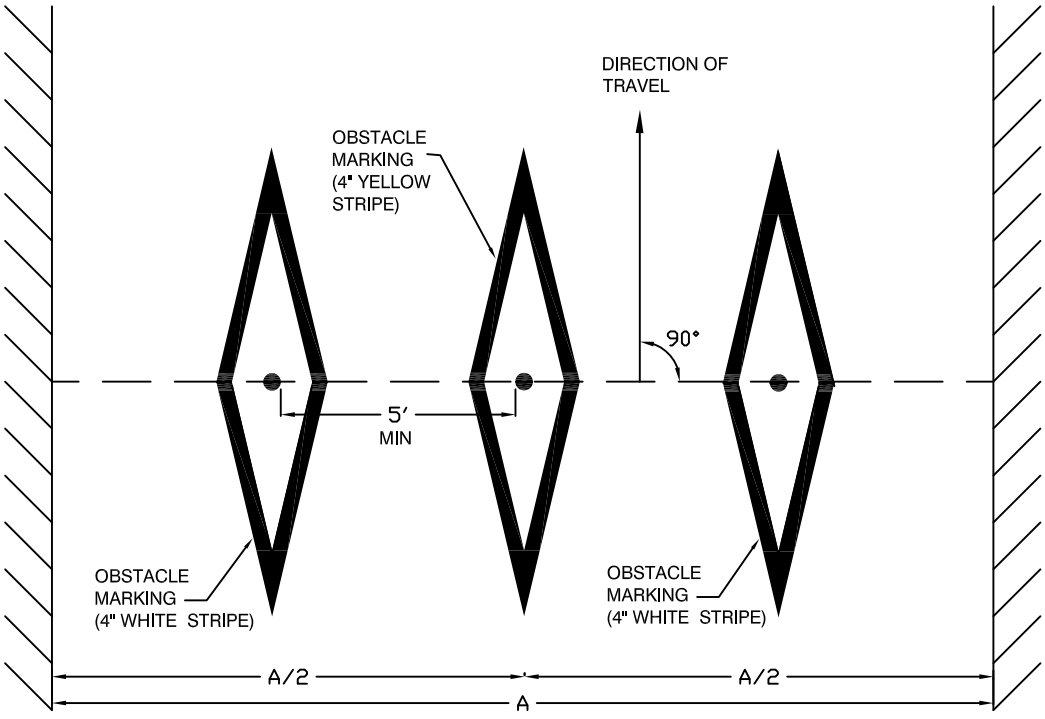
CITY OF OAKLAND	DEPARTMENT OF ENGINEERING AND CONSTRUCTION		
	BOLLARD PLACEMENT AND MARKINGS FOR BICYCLE AND PEDESTRIAN PATHS	DATE: APRIL 2009 REV. DATE:	DWG. X-1

CENTER BOLLARD WITH FLANKING BOLLARDS

SECTION VIEW



PLAN VIEW



CITY OF OAKLAND	DEPARTMENT OF ENGINEERING AND CONSTRUCTION		
	BOLLARD PLACEMENT AND MARKINGS FOR BICYCLE AND PEDESTRIAN PATHS	DATE: APRIL 2009 REV. DATE:	DWG. X-2

Federal Highway Administration (FHWA) – Trail Program

Bollards, Gates, and other Barriers (web)

Recreational Trails Program

Bollards, Gates, and other Barriers

Thank you to information sources and reviewers: John Ciccarelli, Bicycle Solutions; Jakob Helmboldt, Virginia Department of Transportation; Richard Moeur, Arizona Department of Transportation; Mark Plotz, National Center for Bicycling and Walking and NCBW Forum; John Williams, Tracy-Williams Consulting; *Trails for the Twenty-First Century, 2nd Edition,* Rails-to-Trails Conservancy; Jennifer Toole, Toole Design Group; Jim Lazar, Olympia (WA) Safe Streets Campaign; Maggie O'Mara, Bicycle Design Reviewer, California Department of Transportation, John F. Cinatl, Associate Transportation Planner - Bike Facilities, California Department of Transportation.

Photo of bollards on the Delaware and Hudson Rail Trail in Pawlet VT. Trail users created a new trail to get around the bollards.
Photo by Jon Kaplan, Bicycle and Pedestrian Program Manager, Vermont Agency of Transportation.

FHWA RTP Contact

Christopher Douwes
Trails and Enhancements Program Manager
Federal Highway Administration
FHWA HEPH-10 Rm E74-474
1200 New Jersey Ave SE
Washington DC 20590-0001
Phone: 202-366-5013
Fax: 202-366-3409

State RTP Contacts

Contact your State RTP Administrator to ask about policies and funding in your State.

See also: Federal Agency Contacts

Some trail managers install bollards, gates, or other barriers to restrict unauthorized use. Trail managers should question whether bollards, gates, fences, or other barriers are needed at all. *For the purpose of the bullets below, "bollard" includes bollards, gates, fences, or any other barrier constructed or installed next to, within, or across a trail presumably to restrict unauthorized access.*

- Even "properly" installed bollards constitute a serious and potentially fatal safety hazard to unwary trail users. In addition, no bollard layout that admits bicycles, tricycles, and bicycle trailers can exclude single-track motor vehicles such as motorcycles and mopeds. For these reasons, bollards should never be a default treatment, and should not be used unless there is a documented history of intrusion by unauthorized cars, trucks, or other unauthorized vehicles.
- A landscaped median may be an appropriate method to reduce the likelihood that somebody might think the shared use path is a public street or driveway. See "What kind of barrier will keep cars off a bike path?" *by John Williams and Kathleen McLaughlin*, originally published in *Bicycle Forum (Issue 30, August 1992)*, now *NCBW Forum*. See Article.
- Bollards are often ineffective: a determined person is likely to go around or go through. This may result in additional maintenance costs for the trail, either to repair or replace the bollards, or to repair trail or landscaping damage where vehicles go around the bollards.
- Bollards are often a hazard to trail users, who can crash into them, possibly resulting in serious injury or death. Poorly installed bollards can lead to head-on collisions. Bollards are involved in "second user" crashes, where the first user hides the bollard until it is too late to avoid it, even if the first user has adequate sight distance. These crashes can produce serious or incapacitating injuries. This can happen to pedestrians as well as bicyclists or other higher speed users.
- Unjustified bollards can create liability exposure. Trail managers should consider whether or not they increase their liability if they install bollards, gates, fences, or other barriers.
- Bollards, gates, fences, or other barriers can slow access for emergency response.

If installed, bollard, gates, fences, or other barriers:

- **Must not** restrict access for people with disabilities (ABA, Rehabilitation Act, and ADA: cited above).
- Must be easily visible, especially in low light conditions. Section 9C.03 of the Manual on Uniform Traffic Control Devices (MUTCD) *requires* retroreflectorization of any obstruction in the traveled way of a shared-use path. This includes posts along the edge of a path (within a path's "shoulder"). In addition, MUTCD Figure 9C-2 defines a diamond-shaped marking that should be used around bollards or other obstructions within a path.
- Should have sufficient sight distance to allow users to adjust speed. This is especially important on paths that have traffic calming features such as curves or landscaping near the bollards. Insufficient sight distance increases the likelihood that bollards will be dangerous hazards.
- Should permit passage, without dismounting, for adult tricycles, bicycles towing trailers, and tandem bicycles. All users legally permitted to use the facility should be accommodated; failure to do so increases the likelihood that the bollards will be dangerous hazards.

According to *Trails for the Twenty-First Century, 2nd Edition* (April 2001), published by the Rails-to-Trails Conservancy:

If you determine that a traffic barrier is necessary, ensure that barriers are well marked and visible to bicyclists, day or night... Bollards must be at least 3 feet tall and should be placed at least 10 feet from the intersection. This will allow trail users to cross the intersection before negotiating the barrier posts...

One bollard is generally sufficient to indicate that a path is not open to motorized vehicles. The post should be placed in the center of the trail tread. Where more than one post is necessary, a 5-foot spacing is used to permit passage of bicycle trailers, adult tricycles, and wheelchairs. Always use one or three bollards, never two. Two bollards, both placed in the paved portion of the trail, will channel trail users into the center of the trail, causing possible head-on collisions. Bollards should be designed to be removable or hinged to permit entrance by emergency and service vehicles... (Pages 85-86).

Additional Notes:

- Spacing between bollards should permit passage of bicycle trailers and adult tricycles without dismounting, and manual and motorized wheelchairs. A "5-foot spacing" means 5-foot gaps between bollards, not a 5-foot center-to-center placement.
- Bollards should be designed to be knock-down, removable, or hinged to permit entrance by emergency and service vehicles. A knocked-down bollard must be reinstalled or removed immediately to avoid having an additional safety hazard.
- Hardware installed in the ground to hold bollard or posts must be flush with the surface to avoid having an additional safety hazard.
- Bollards, gates, fences, or other barriers outside the trail tread (on each side) may be acceptable if there is sufficient clear trail tread to avoid head-on collisions and to ensure accessibility. But the purpose of the bollards, gates, fences, or other barriers should be questioned.

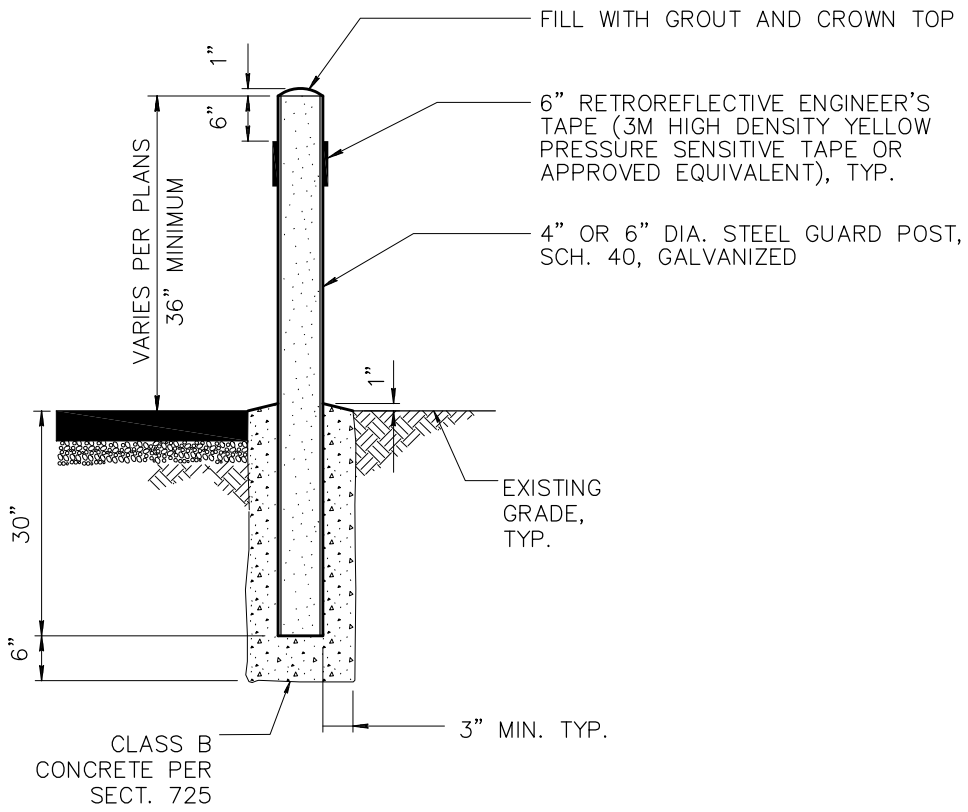
Additional Resources:

- **Presentation: Bicycle Path Entry Control.** (Ed Cox, Bicycle and Pedestrian Coordinator, City of Sacramento, CA and Maggie O'Mara, Senior Transportation Engineer, California Department of Transportation)
  This presentation discusses methods to control entry to shared use paths. It considers issues related to bollards, gates, and other barriers. It looks at examples and discusses what works well and what doesn't.
  Disclaimer: This presentation is provided in the interest of information exchange,

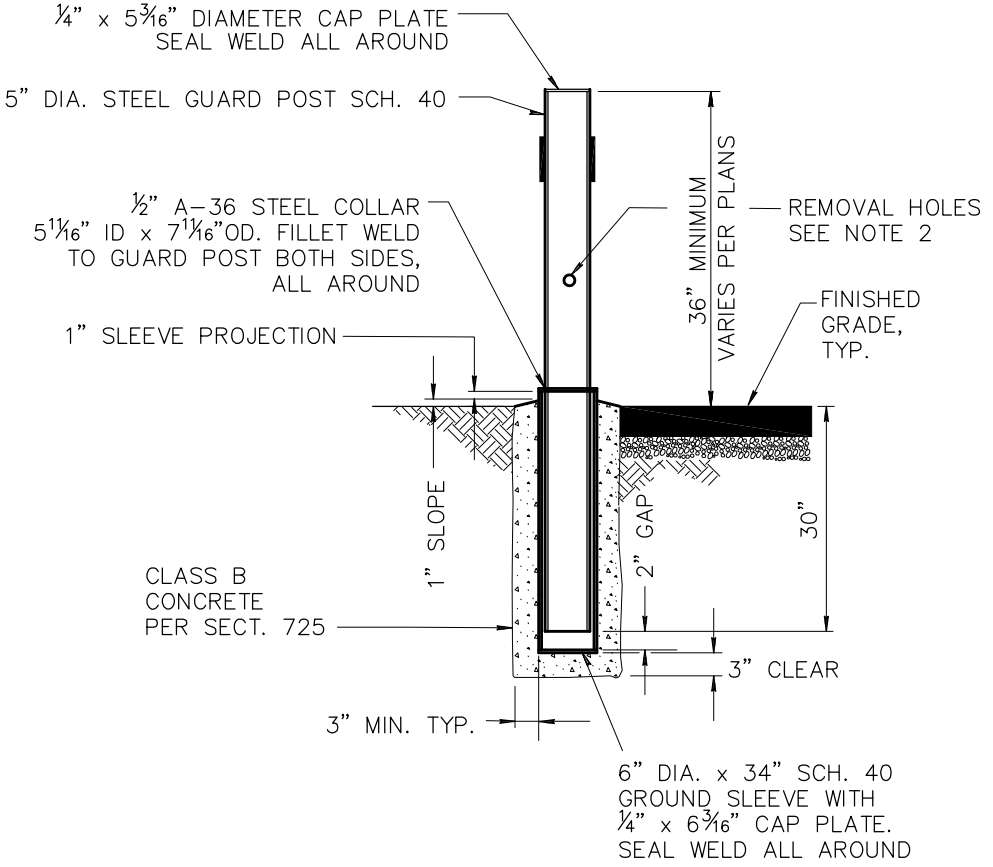
and reflects the views of the authors. Providing this resource does not necessarily represent endorsement by the U.S. Department of Transportation.

Maricopa Association of Governments (AZ)

Standard Detail



TYPE 1 PERMANENT



TYPE 2 REMOVABLE

NOTES

1. BOLLARDS SHALL HAVE A HEIGHT OF 3 FEET OR BE EQUAL TO THE HEIGHT OF THE BACK SCREEN WALL OF BIN ENCLOSURES. POSTS SHALL BE PLACED A MINIMUM OF 4" FROM THE WALL.
2. REMOVABLE POSTS SHALL HAVE 1" DIA. HOLES DRILLED THROUGH AT A DISTANCE ⅓ THE OVERALL POST LENGTH FROM TOP.
3. REMOVABLE POST – GRIND SMOOTH ALL SHARP EDGES PRIOR TO GALVANIZATION. GALVANIZE PER ASTM A54 AFTER FABRICATION.

DETAIL NO.				REVISED	DETAIL NO.
140	MARICOPA ASSOCIATION of GOVERNMENTS — STANDARD DETAIL ENGLISH	BOLLARD		01-01-2009	140

Minnesota Department of Transportation (Mn/DOT)

Mn/DOT Bikeway Facility Design Manual

Chapter 5: Shared-Use Paths

5-1.0 Introduction

This chapter provides guidelines for design of bicycle transportation facilities that are separated from the roadway. In most cases, a path separated from the roadway may be used by bicyclists, pedestrians, roller skaters, and individuals in wheel chairs, as well as other users, and the path must be designed for shared use. This manual does not provide guidance on design or construction of recreational off-road mountain biking paths. The 2006 Department of Natural Resources, *Trail Planning Design, and Development Guidelines*, provides detailed guidance on shared use paved trails, natural surface trails, winter use trails and bikeways.

5-1.1 Types of Off-Roadway Bicycle Facilities

In addition to shared-use paths, several other types of off-roadway facilities may meet the needs of various users, as described below.

5-1.1.1 Shared-Use Paths

Shared-use path is a term adopted by the 1999 AASHTO Guide for the Development of Bicycle Facilities in recognition that paths are seldom, if ever, used only by bicycles. As shown in Figure 5-1, a shared-use path is typically located on exclusive right-of-way, with no fixed objects in the pathway and minimal cross flow by motor vehicles. Portions of a shared-use path may be within the road right-of-way but physically separated from the roadway by a barrier or landscaping. Users typically include bicyclists, in-line skaters, wheelchair users (both non-motorized and motorized) and pedestrians, including walkers, runners, people with baby strollers or dogs with people.

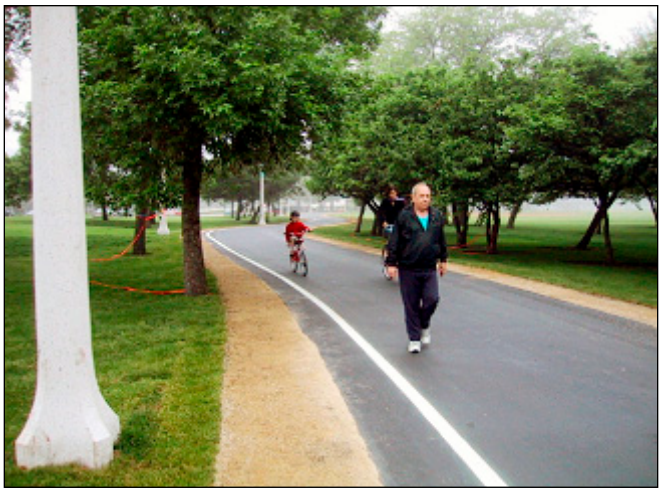


Figure 5-1:
Example of typical shared-use path

Shared-use paths are a valuable element of bicycle networks and serve both a transportation and recreation function, providing route continuity for commuting and recreation trips, access to destinations not otherwise available to bicyclists on the street and road system, and access between buildings and other discontinuities in the street network. Where shared-use paths have been added to the transportation network, they have proven to be significant

5-4.3.3 Curb Ramp Design and Arrangements

Use curb ramps at every intersection between a shared-use path and a roadway. If the approaching path is perpendicular to the curb, the width of the curb ramp should be at least as wide as the average width of the shared-use path. If the path is parallel to the curb, the width of the curb ramp should equal the path width or 2.7 m **(9 ft)**, whichever is greater.

If a crossing or crosswalk is intended for bicyclists, the curb ramp or sloping pavement should be flush with the street. The slope of the curb ramp shall be no greater than 8.3 percent (12:1), and the slope of the curb ramp flares should be no greater than 10 percent (10:1).

Curb ramps shall include a 0.6 m **(2.0 ft)** wide strip of detectable warnings at their base to ensure that path users with vision impairments are aware of the intersection, according to the Americans with Disabilities Act Accessibility Guidelines (ADAAG). According to ADAAG and Mn/DOT Standard Plate 7036, detectable warnings should consist of raised truncated domes that meet the following specifications:

- Bottom diameter 23 mm **(0.9 in)** to 36 mm **(1.4 in)**
- Top diameter 50 to 65 percent of base diameter
- Height of 5 mm **(0.2 in)**
- Center-to-center spacing of 41 to 61 mm **(1.6 to 2.4 in)**
- A color contrasting with adjacent pavement, either light on dark or dark on light, which can help all path users to locate the curb on the opposite corner as well as provide visual cue of the truncated dome strip.

Other detectable surfaces, such as aggregate and grooves, are less detectable and less easily understood by people with vision impairments. ADAAG specifies truncated domes over rounded domes because they provide greater access to people with mobility impairments.

5-4.3.4 Controlling Motor Vehicle Access

A good method of controlling access onto a path by motor vehicles is to split the entry into two one-way sections of path, each 1.5 m **(5 ft)** wide, separated by low landscaping or other material. Emergency vehicles can still enter if necessary by straddling the landscaping. In most situations, this is preferable to bollards, chicanes, or other methods.

Example of swing-down bollard to allow emergency and maintenance vehicle access

Too many bollards inhibit path access.

Figure 5-20: Bollards

A bollard may also be used at the entrance to a bicycle path. See Figure 5-20. When used, a single bollard may be installed in the middle of the path to deny access to motor vehicles. Removable or hinged flexible bollards are recommended so service vehicles can use the path. When more than one bollard is used, there should always be one in the center of the path, and bollards on both edges, 1.5 m **(5 ft)** from the center bollard. This spacing will accommodate any type of bicycle or wheelchair.

Gates and other devices that require path users to maneuver around objects are strongly discouraged. See Figure 5-21.

Figure 5-21:
Gates across a bicycle path (not recommended)

5-4.3.5 One-Way Paths and Signalized Intersections

One-way paths have the advantage of increased visibility and safety at signalized intersections. Where there are substantial numbers of right-turning motorists and through bicyclists, the one-way path intersection design shown in Figure 5-22 should be considered. End the one-way path 20 to 30 m **(65 to 100 ft)** before the intersection and let bicyclists continue on a bicycle lane in the roadway.

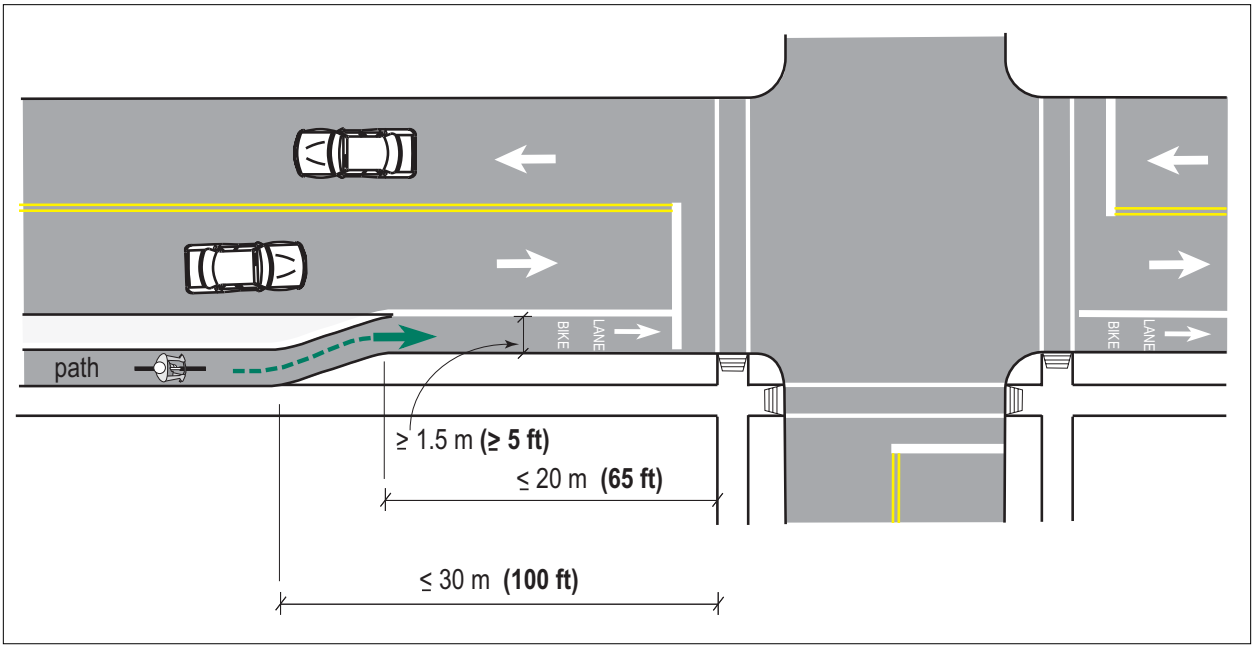


Figure 5-22:
One-Way Path Approaching Intersection

New York City Department of Parks and Recreation (NYC DPR)

NYC Bicycle Master Plan

Design Guidelines

Design standards are a critical component in the Network implementation process. They help ensure a consistent, safe level of service for users and protect local government agencies from liability issues in the event of injury. NYC DOT is in the process of developing Bicycle Facility Design Standards. This chapter of the *Plan* offers the following Design Guidelines to be used while the DOT Standards are being developed.

The Design Guidelines are a compilation of national guidelines and examples of existing and proposed facilities in New York City. The Guidelines are intentionally broad, providing designers with the flexibility that is often required in a locale as complex as New York City.

Most local design guidelines have been based in whole or in part on national and state standards. The national standards are listed below.

1. *Guide to the Development of Bicycle Facilities*, AASHTO

Released in 1981, and updated in 1991, the AASHTO Guide has become the basic reference for facility designers across the country.

2. *Manual on Uniform Traffic Control Devices (MUTCD)*, Federal Highway Administration

Released in 1935, and updated in 1988, the MUTCD is the national manual for streets and highways. Conformance with the manual's standards is required in nearly every state by statute (New York included).

3. *Guidelines for Greenways,* The Greenway Collaborative

This document provides detailed advice on the planning, design and maintenance of multi-use paths and trails.

4. *Design & Maintenance Manual for Multi-use Trails*, Rails-to-Trails Conservancy

This document provides information similar to that found in Guidelines for Greenways, but with an emphasis on abandoned rail corridors and canal tow paths.

5. *Guidelines for Establishing In-Line Skate Trails in Park and Recreation Areas,* International In-Line Skating Association

As noted on page 5, bicycle facilities are divided into the following three categories:

Multi-use Path, separated from motor vehicle traffic

On-Street Bicycle Lane, designated by lane markings and signs

Signed Bicycle Route, designated by signs only

On-Street Facilities

Bicycle Lanes - Width

AASHTO: The minimum bicycle lane width requirement is **4 feet**. However, certain edge conditions dictate additional desirable bicycle lane width, see Figures A - C.

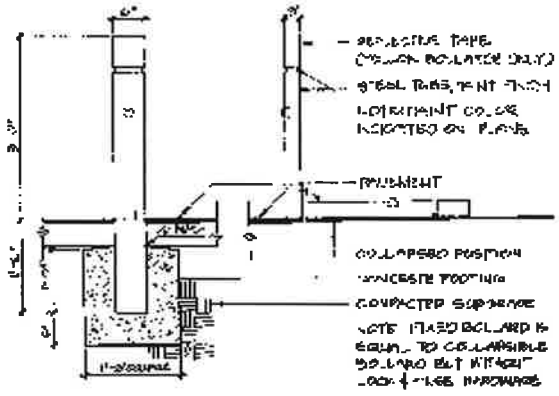
Vehicle Access Controls

Bicycle paths often need some form of physical barrier at roadway intersections to prevent unauthorized motor vehicles from entering. Barriers are especially warranted when paths are located near sensitive natural habitats. However, access for maintenance and emergency vehicles must be provided. Listed below are some possible examples of physical barriers:

Gates / Bollards: Lockable gates or collapsible bollards permit entrance by authorized vehicles. AASHTO recommends that, when more than one post is used, a 5 foot spacing is desirable; wider spacing can allow motor vehicle entry, while narrower spacing might prevent safe entry by bicycles. NYC DPR has developed several guard rail and bollard details for various locations throughout the city.

Additional methods for restricting access include curbing, fence and barrier rails or changes in elevation, such as graded berms.

Vegetation: A path can be divided into two narrow entryways and separated by low landscaping to prevent unauthorized access. Emergency vehicles could enter by straddling the landscaping. All terrain vehicles (ATVs) can usually drive over most plantings, rendering this alternative less effective.



Detail for a collapsible steel bollard.
Source: Reconstruction of the Shore Parkway Bicycle Path, DPR

Steel barrier rail installed along the perimeter of Marine Park, Brooklyn.

Vegatated berm along Flatbush Avenue and Floyd Bennett Field, Brooklyn.

Vehicular access controls.

Oregon Department of Transportation

Bicycle and Pedestrian Design Guide (2011)

Bicycle and Pedestrian Design Guide

2011

Oregon Department of Transportation

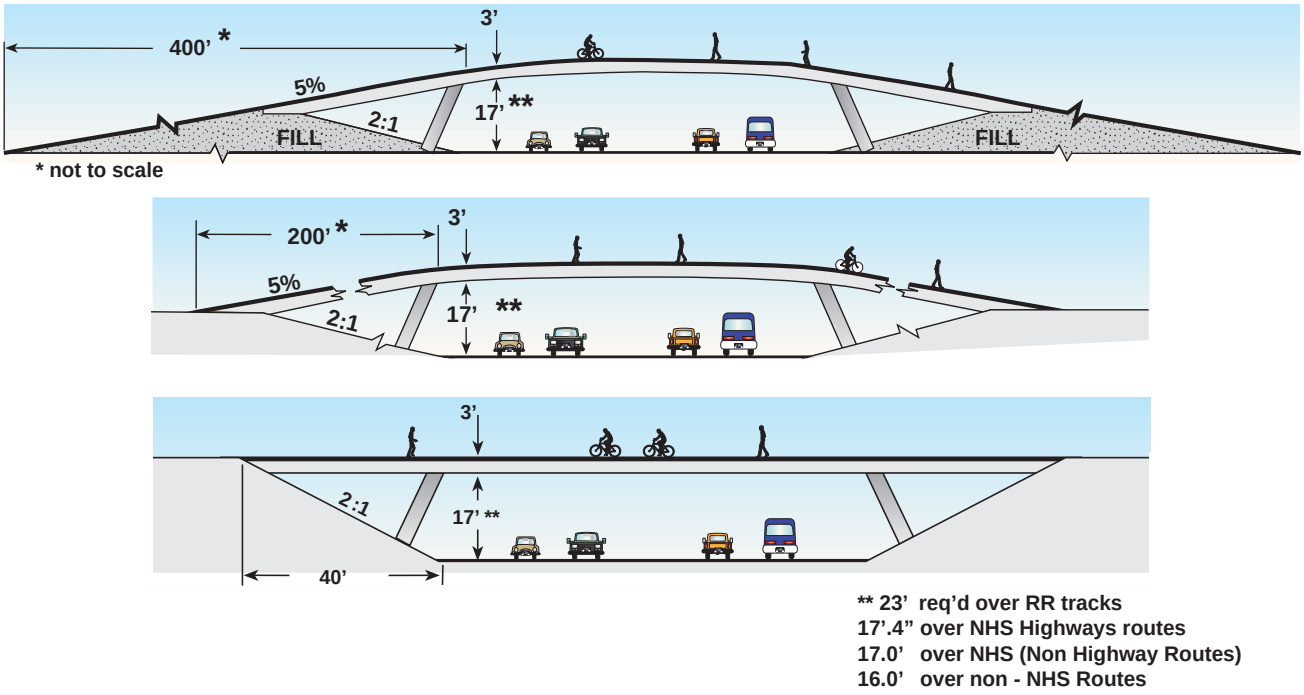


Figure 7-19: Path overcrossings, various configurations

Preventing Motor-Vehicle Access

Geometric Design

The most effective way to discourage motor vehicle access to paths is to make it physically difficult to do so. One method branches the path into two narrower one-way paths just before it reaches the roadway, making it difficult for a motor vehicle to gain access to the path.

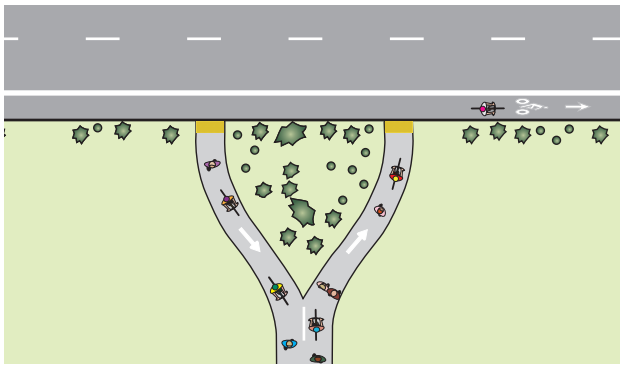


Figure 7-20: Path splits to prevent it appearing like a driveway

Another method is to create very tight curb returns to make it difficult for motorists to enter a path from the roadway.

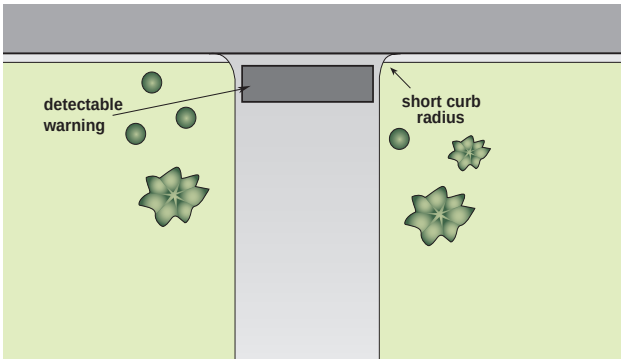


Figure 7-21: Tight curb radii prevent motor vehicle access

Bollards

Bollards may be used to limit vehicle traffic on paths. However, they are often hard to see, cyclists may not expect them and injuries result when cyclists hit them. Overuse of bollards is a serious hazard to bicyclists and may prevent path use by trailers, wheelchairs and other legitimate path users. In a group of riders, the riders in front block the visibility of those behind, setting up cyclists in the back of the pack for a crash.

Bollards should only be used when absolutely necessary. When used, they must be spaced wide enough (min. 5 feet) for easy passage by cyclists, bicycle trailers and adult tricycles as well as wheelchair users. A single bollard is preferred, as two may channelize bicyclists to the middle opening, with a potential for collisions. They should not be placed right at the intersection, but set back 20 feet or more, so users can concentrate on motor vehicle traffic conflicts rather than on avoiding the bollard. They should be painted with bright, light colors for visibility, illuminated and/or retro-reflectorized. A striped envelope around the bollard will direct path users away from the fixed object hazard. Flexible delineators, that collapse when struck by a bicyclist, should be considered.

Bollards are overused and can cause injury

Split path entry eliminates need for bollards

Offset Fencing

Placing railing or other barrier part way across a trail makes it possible for intended users to accesses the trail; maintenance vehicle operators are provided with keys to unlock the fences when they need access. The fences, like bollards, can be hazards to bicyclists and can restrict certain trail users from gaining access to the trail. They should be coated with retro-reflective material and well-lit.

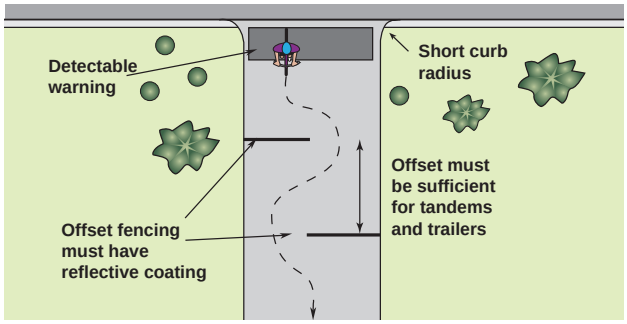


Figure 7-22: Offset gates prevent motor vehicle access

Offset fencing

Washington State Department of Transportation (WSDOT)

WSDOT Design Manual Chapter 1515

WSDOT Standard Plans

Chapter 1515 Shared-Use Paths

1515.01 General

Shared-use paths are designed for both transportation and recreation purposes and are used by pedestrians, bicyclists, skaters, equestrians, and other users. Some common locations for shared-use paths are along rivers, streams, ocean beachfronts, canals, utility rights of way, and abandoned railroad rights of way; within college campuses; and within and between parks as well as within existing roadway corridors. A common application is to use shared-use paths to close gaps in bicycle networks. There might also be situations where such facilities can be provided as part of planned developments. Where a shared-use path is designed to parallel a roadway, provide a separation between the path and the vehicular traveled way in accordance with this chapter.

As with any roadway project, shared-use path projects need to fit into the context of a multimodal community. Exhibits are provided throughout this chapter to illustrate possible design solutions, which should be treated with appropriate flexibility as long as doing so complies with corresponding laws, regulations, standards, and guidance. Engage various discipline experts, including landscape architects, soil and pavement engineers, maintenance staff, traffic control experts, ADA and bicycle coordinators, and others. Additionally, when designing such facilities, consider way-finding.

This chapter includes technical provisions for making shared-use paths accessible to persons with disabilities. Design shared-use paths and roadway crossings in consultation with your region's ADA Coordinator, Bicycle Coordinator, and State Bicycle and Pedestrian Coordinator. For additional information on pedestrian and bicycle facilities, see Chapters 1510 and 1520, respectively.

1515.02 References

(1) Federal/State Laws and Codes

Americans with Disabilities Act of 1990 (ADA)

ADA (28 CFR Part 35, as revised September 15, 2010)

23 CFR Part 652, Pedestrian and Bicycle Accommodations and Projects

49 CFR Part 27, Nondiscrimination on the Basis of Disability in Programs or Activities Receiving Federal Financial Assistance (Section 504 of the Rehabilitation Act of 1973 implementing regulations)

(1) Fencing

Limited access highways often require fencing or other forms of controlling access. Shared-use paths constructed within these corridors, such as shown in Exhibit 1515-13, likely require fencing. For guidance on fencing, limited access controls, and right of way, refer to Division 5 of the *Design Manual*. Evaluate the impacts of fencing on sight distances.

Shared-Use Path in Limited Access Corridor

Exhibit 1515-13

(2) Restriction of Motor Vehicle Traffic

Shared-use paths often need some form of physical barrier at roadway intersections to prevent unauthorized motor vehicles from entering.

Bollards have been used by many path owners to prevent unauthorized vehicle access. However, bollards should not be applied indiscriminately, and there are other considerations to bollard installation.

(a) Landscaped Islands

A preferred method of restricting entry of motor vehicles is to split the entry way into two sections separated by low landscaping, thereby splitting a path into two channels at roadway intersections. This method essentially creates an island in the middle of the path rather than installing a bollard. Such an island could be planted with low-growing, hardy vegetation capable of withstanding the occasional authorized vehicle traveling over it. When splitting a path, employ MUTCD pavement markings and signing, such as is used for bollards and obstructions.

(b) Bollard Considerations

Typically, one bollard located in the center of the path is sufficient to control motor vehicle access to the path. If more than one bollard is needed, the additional bollards should be placed at the edge of the shared-use path.

Install bollards at entrances to shared-use paths to discourage motor vehicles from entering. Do not use bollards to divert or slow path traffic. When locating such installations, stripe an envelope around the bollards and paint and reflectorize them to be visible to path users both day and night. Bollards located on or adjacent to shared-use paths represent an object that needs to be avoided by bicyclists and pedestrians. To increase the potential for appropriate maneuvering to occur, provide designs where the post is clearly visible and recognizable.

When designing bollards, the following apply:

- The desirable design is to provide a single bollard, installed in the middle of the path to reduce confusion.
- When multiple bollard posts are used in wide path sections, use a minimum 5-foot spacing between the edge of concrete footings to permit passage of bicycle-towed trailers, wheelchairs, and adult tricycles, with room for bicycle passage without dismounting.
- Provide 4 feet minimum (5 feet desirable) clear width between the edge of concrete footing and edge of path.
- At a minimum, provide stopping sight distance to bollards. An ideal location for bollard placement is in a relatively straight area of the path where the post placement has the stopping sight distance given in Exhibit 1515-14a and 14b. Do not place bollards in difficult-to-see locations (for example, immediately upon entering a tunnel).
- For cases where multiple posts are used longitudinally along the path, locate them at least 20 feet apart, with the first post in line from each direction having stopping sight distance.
- Use a contrasting striping pattern on the post.
- Use reflective materials on the post, such as a band at the top and at the base.
- Design all bollards along a corridor to be uniform in appearance. Frequent cyclists can become familiar with the posts and recognize them easily.
- Provide pavement markings in accordance with the *Standard Plans* and MUTCD at all bollards on paved paths.
- Use removable bollards (Bollard Type 1) to permit access by emergency and service vehicles.
- Nonremovable bollards (Bollard Type 2) may be used where access is not needed.

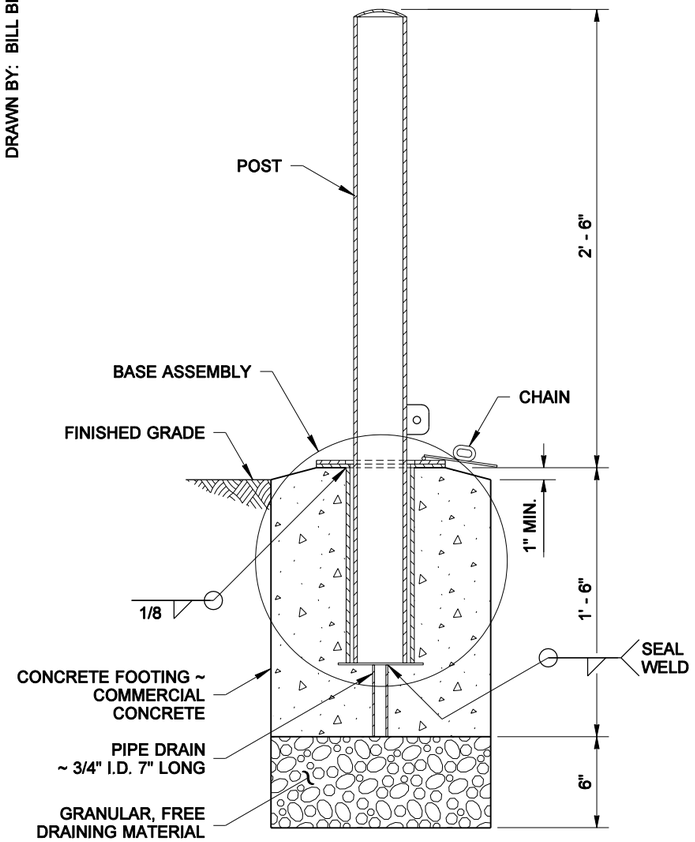
Refer to the *Standard Plans* for bollard designs and the *Standard Plans* and MUTCD for pavement markings at bollards.

When bollards need to be placed near the roadway, see Chapter 1600 for clear zone requirements.

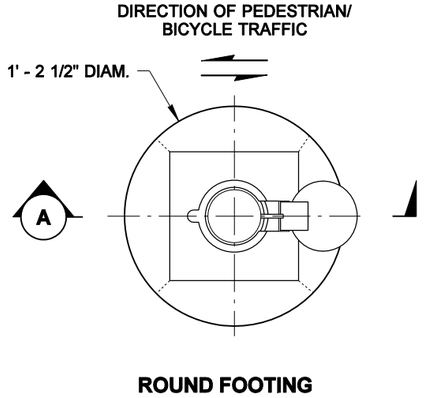
1515.09 Documentation

For the list of documents required to be preserved in the Design Documentation Package and the Project File, see the Design Documentation Checklist:
www.wsdot.wa.gov/design/projectdev/

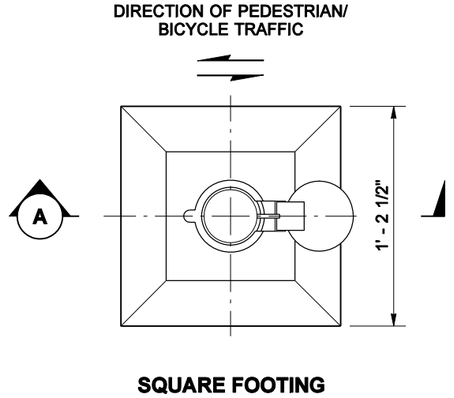
DRAWN BY: BILL BERENS



SECTION (A)

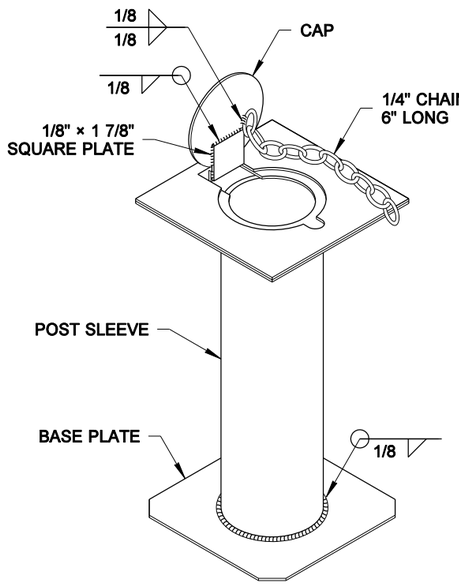


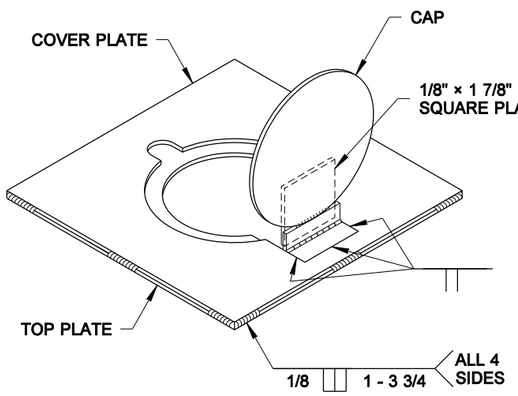
ROUND FOOTING



SQUARE FOOTING

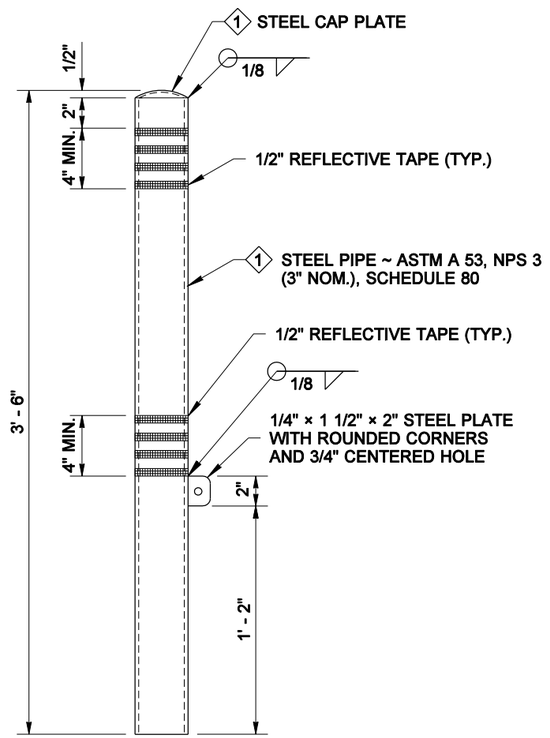
PLAN VIEW





① PAINT ASSEMBLY WITH A "HIGHLY VISIBLE" COLOR. (SAFETY YELLOW IS ACCEPTABLE)

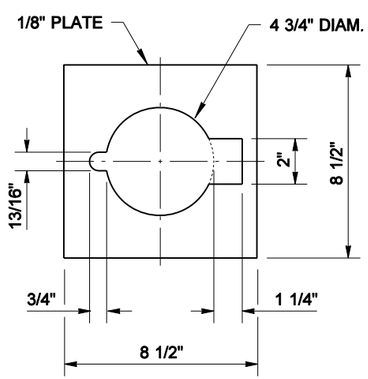
① BASE ASSEMBLY



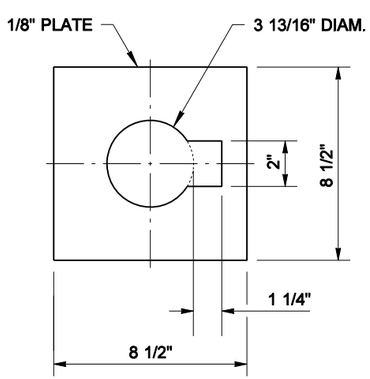
POST

NOTE

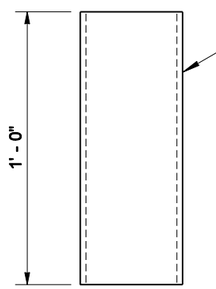
This bollard does not have an effective breakaway design feature and cannot be installed within the Design Clear Zone.



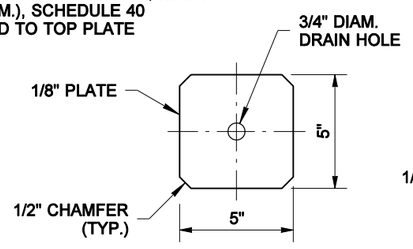
COVER PLATE



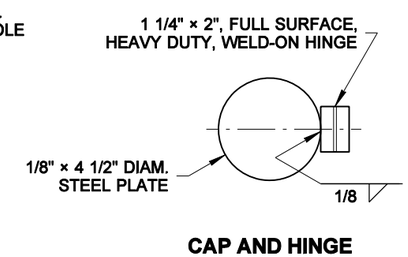
TOP PLATE



POST SLEEVE



BASE PLATE



CAP AND HINGE

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STATE OF WASHINGTON
24557
REGISTERED
PROFESSIONAL ENGINEER

EXPIRES JUNE 19, 2010

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BOLLARD TYPE 1

STANDARD PLAN H-60.10-01

SHEET 1 OF 1 SHEET

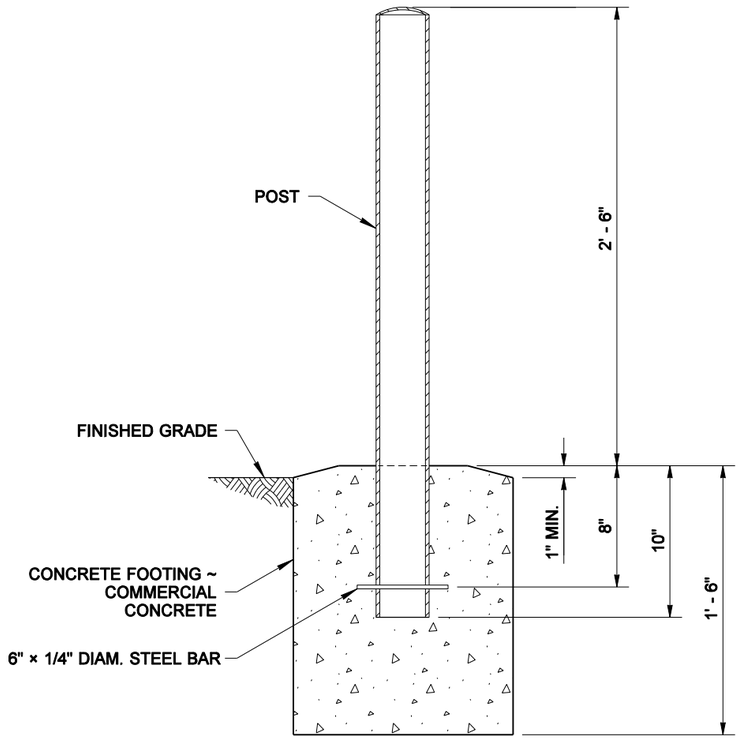
APPROVED FOR PUBLICATION

Pasco Bakotich III — STATE DESIGN ENGINEER

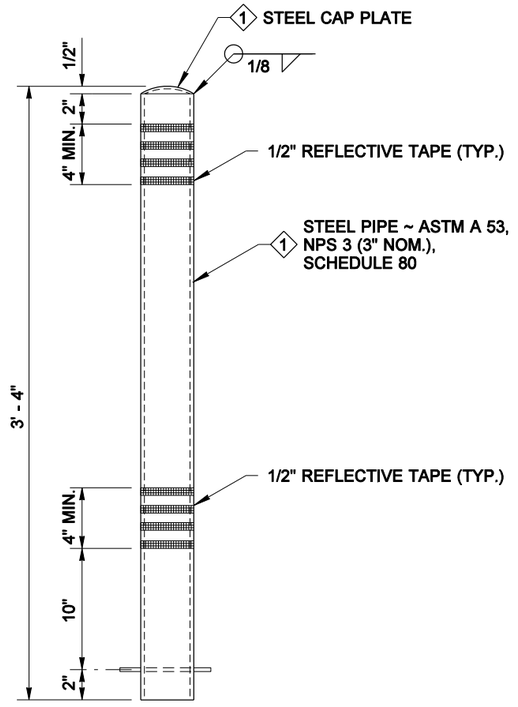
07-03-08 — DATE

Washington State Department of Transportation

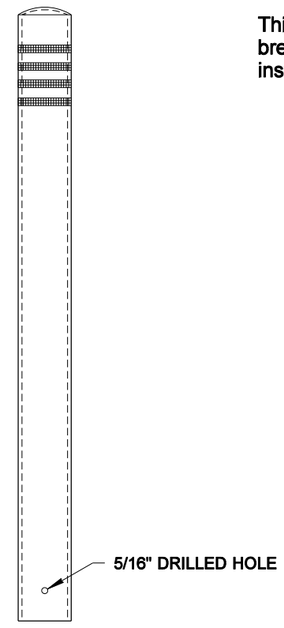
DRAWN BY: BILL BERENS



SECTION (A)



FRONT VIEW



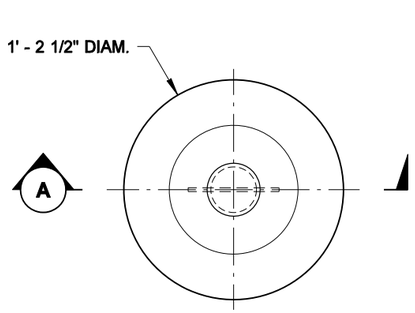
SIDE VIEW

1 PAINT ASSEMBLY WITH A "HIGHLY VISIBLE" COLOR. (SAFETY YELLOW IS ACCEPTABLE)

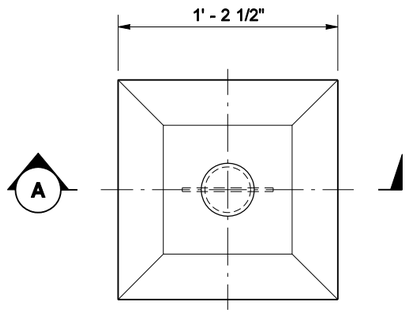
POST

NOTE

This bollard does not have an effective breakaway design feature and cannot be installed within the Design Clear Zone.



ROUND FOOTING



SQUARE FOOTING

PLAN VIEW

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BOLLARD TYPE 2

STANDARD PLAN H-60.20-01

SHEET 1 OF 1 SHEET

APPROVED FOR PUBLICATION

Pasco Bakotich III — STATE DESIGN ENGINEER

07-03-08 — DATE

Washington State Department of Transportation

Appendix C: GARTC Draft Bollard Policy

DRAFT

Policy and Standards for the Use of Bollards In Bernalillo County, New Mexico

The Greater Albuquerque Recreational Trails Committee is an advisory committee created by the City of Albuquerque. This committee is authorized to advise all executive branches within the City of Albuquerque, the Bernalillo County government, AMAFCA, and other government entities within Bernalillo County regarding multi-use trails.

Various government entities have chosen to use bollards (metal barrier posts) to prevent entry of illegal motor vehicles onto multi-use trails in Bernalillo County. Multi-use trails are separate paths or trails dedicated to use by cyclists, skaters, runners and other pedestrians. These trails should be open and accessible to the elderly and the disabled. Disabled and elderly citizens have various conveyances that require more space than typical bicycles and bollard designs should reflect that reality.

Bollards present a hazard to the users of multi-use trails and GARTC members think their use should be carefully considered. Instead of automatically installing many, closely spaced bollards at entrances to multi-use trails, the City departments and other government entities should really think out the need for bollards and whether the bollards themselves may pose more of a hazard to the public than illegal motor vehicles. Dealing with a law enforcement problem with an "engineering solution" may cause grave harm to the public. Children are thought to be more at risk because of undeveloped skills and the elderly are more vulnerable because of diminished vision, spatial resolution and slower reaction times.

We at GARTC think that all government entities in Bernalillo County should adopt a bollard policy based upon the three step approach outlined in the 2012 Guide for the Development of Bicycle facilities (AASHTO), pages 5-46 and 5-47.
A worthwhile goal is to establish a uniform bollard utilization policy throughout Bernalillo County.
Other considerations are:

1) AASHTO recommendations for spatial dimensions should be codified as City of Albuquerque standards in all cases. For instance, bollards should not be placed closer together than 6 feet.

2) If it is determined by a thoughtful and judicious process that bollards are truly necessary, then the configuration should be a single bollard on the centerline of the trail. The configuration commonly used in Albuquerque, i.e., a triplet of closely spaced bollards, should be banned because it can block disabled people and endangers all people.

3) The City of Albuquerque should consider using signs on multi-use trails requesting the public to report illegal vehicles and should provide the appropriate telephone number.

4) If law enforcement is difficult to execute or ineffective, surveillance cameras should be used to control illegal motor vehicles. Many of the City and AMAFCA multi-use trails are isolated and difficult to police. Therefore, the City should also consider mounted police patrols to deal with illegal activities on such trails.

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