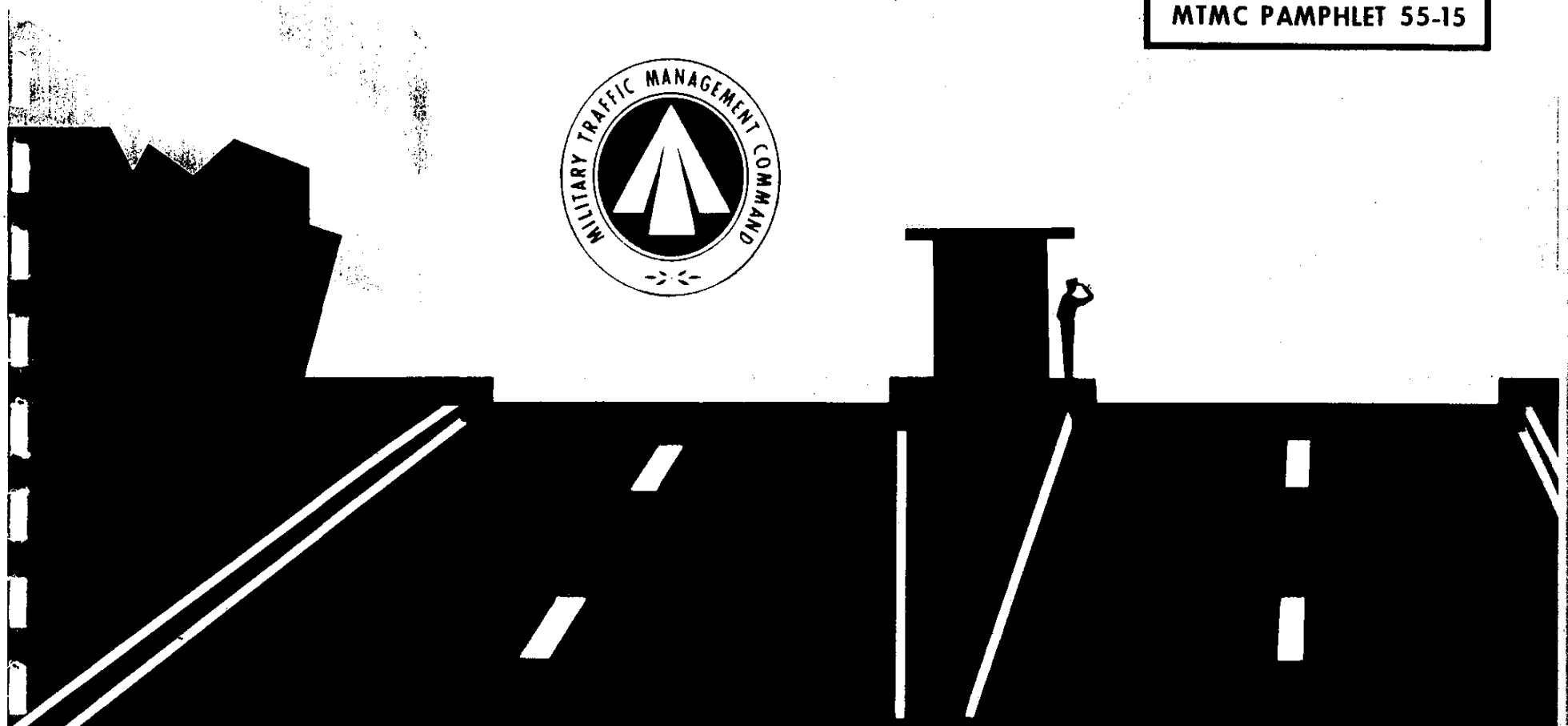
MTMC PAMPHLET 55-15



TRAFFIC ENGINEERING FOR BETTER GATES

The Military Traffic Management Command (MTMC), a jointly staffed major Army command, is the DOD worldwide single-manager for common-user ocean terminals, military traffic, and land transportation. In this capacity, MTMC represents DOD in matters pertaining to highways for national defense and serves as liaison with federal, state, and local highway agencies. In addition to these services, MTMC operates a full program for providing traffic engineering services to all DOD components. Guidance for obtaining MTMC traffic engineering service is available in AR 55-80/OPNAVINST 11210.1A/AFR 75-88/MCO 11210.2B/DLAR 4500.19; or interest should be directed to the Commander, Military Traffic Management Command, ATTN: MT-SA, WASH, DC 20315.

MILITARY TRAFFIC MANAGEMENT COMMAND
DECEMBER 1982

TRAFFIC ENGINEERING FOR BETTER GATES

Thomas A. Gaskin, *PROJECT ENGINEER*
Whitefield W. Mayes, *PROJECT MANAGER*
Alice S. Langford, *EDITOR*
Lois W. Vallandingham, *GRAPHIC DESIGNER*
Maureen Cassada, *ILLUSTRATOR*

ANOTHER LOOK AT TRAFFIC ENGINEERING . . .

Traffic engineering deals with **the planning and design of transportation facilities and with the safe, efficient control of traffic.** The most commonly traveled facility is the **roadway,** and the most frequently used vehicle is the **automobile.** To provide basic technical guidance on these subjects, in 1978 the Military Traffic Management Command published Pamphlet 55-10, *Traffic Engineering for Better Roads,* which deals with the planning, location, and design of roadways on the typical military installation. Recently, a pamphlet to clarify design and location of signs and pavement markings was published, MTMC Pamphlet 55-14, *Traffic Engineering for Better Signs and Markings.*

Traffic Engineering for Better Gates is the latest in a series of specially designed aids for use by installation officials to improve and expand their road system. Because **gates** at military installations often are the source of severe traffic problems, it is most appropriate that this pamphlet focus on their planning and design.

CONTENTS

CONTENTS

CONTENTS

CONTENTS

ACKNOWLEDGMENTS

By nature, traffic engineering is very complex and is built on the experience of others. Therefore, many of the standards in this pamphlet have been taken from other publications that are referenced within the text. In particular, the author wishes to acknowledge major contributions in publications of the following organizations: the American Association of State Highway and Transportation Officials, the Federal Highway Administration, and the Institute of Transportation Engineers.

INTRODUCTION

Volumes of standards and of design principles exist for traffic engineering in general, but only a small part of these are applicable to the design of military entrance gates. This pamphlet contains the applicable bits and pieces of information, combined to form a basic guide in gate planning and design. It is not intended to be technically exhaustive, but rather, to be an idea generator and an index to more specific manuals dealing with each aspect of design.

TRAFFIC ENGINEERING FOR BETTER GATES

A GUIDE
TO IMPROVE THE DESIGN
AND OPERATION OF GATES

SECTION I
Planning Process

Broad principles, objectives, and procedures of gate planning

SECTION II
Design Criteria

Criteria for converting planning and location decisions into actual designs

SECTION III
Model Gates

Drawings and details of recommended gate designs

SECTION I

Planning Process

BROAD PRINCIPLES, OBJECTIVES, AND PROCEDURES OF GATE PLANNING

What problems are caused by existing gates?

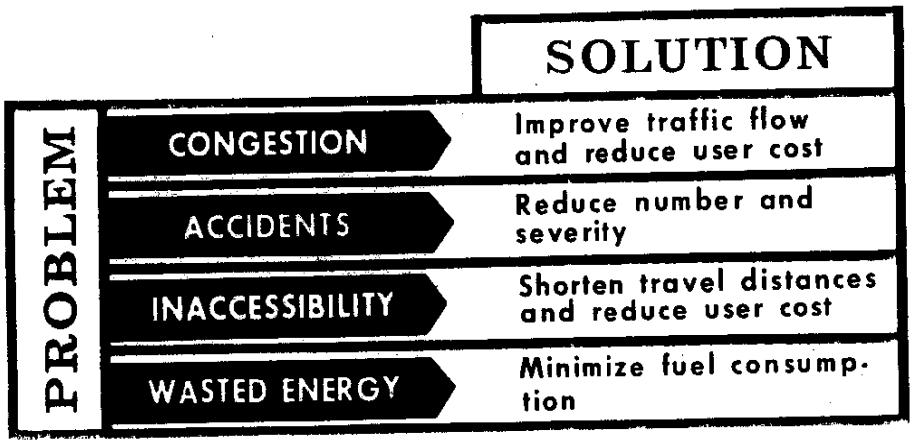
How serious are these problems?

PROBLEM DEFINITION

Chapter 1

Before an existing gate is improved or a new one is constructed, **all traffic problems must be clearly identified.** Once problems are identified, **goals must be established for each.** Each goal should have one or more measurable objectives — for use in evaluating the overall success of the solution.

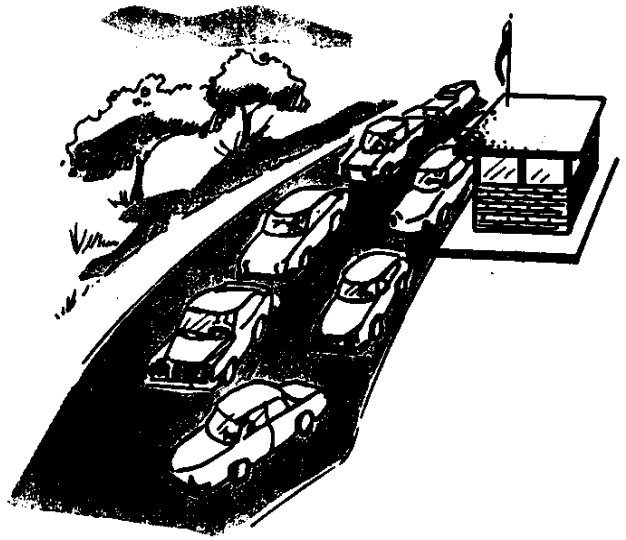
FOR EVERY GATE PROBLEM,
A SOLUTION CAN BE FOUND



CONGESTION

PROBLEM

Congestion frustrates motorists. It increases **vehicle operating cost** and **travel time.** For example, on a free-flow roadway with a 30-mile-per-hour speed limit, three 30-second stops within a 1-mile distance will increase the total operating cost of a car about 90 percent. Time cost, however, is more difficult to measure; but evidence shows that, given a choice, motorists often will forfeit operating economy to save time.



SOLUTION

STEP 1 — Stagger duty hours and increase carpooling to reduce concentration of vehicles using gate. (See *MASTERing Ridesharing,* MTMC Pamphlet 55-16, Volume II.)

STEP 2 — If congestion still occurs, **modify existing gate design** to improve capacity. For example, remove lateral restrictions, widen or add lanes, or reduce security measures during peak periods.

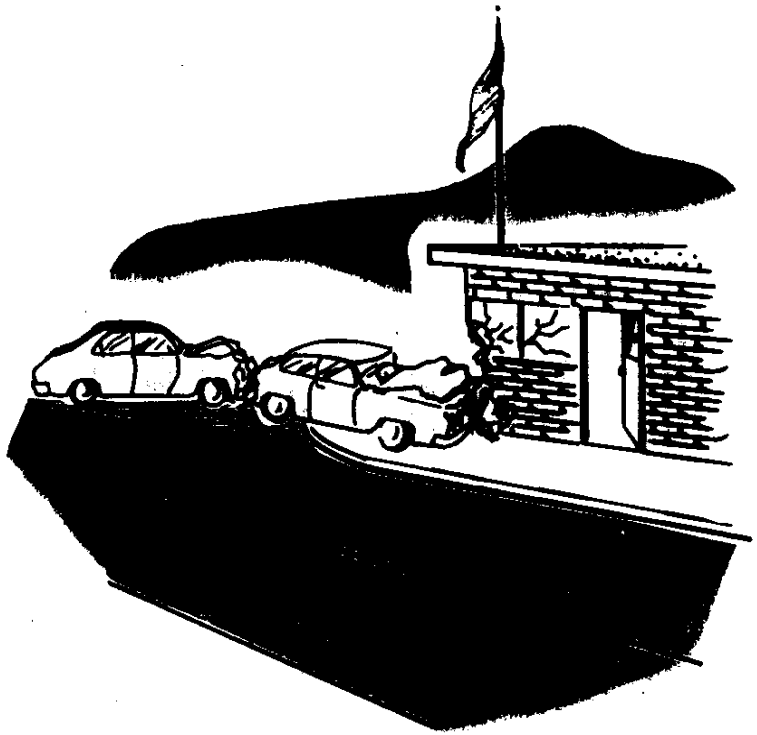
STEP 3 — Finally, **direct traffic to other gates or build a new gate.** Existing travel patterns between on- and off-installation destinations must be determined. Site and design new gate with adequate capacity, both for today's needs and for future expansion.

ACCIDENTS

PROBLEM

Traffic accidents on military installations are increasing. They cost DOD and its personnel an estimated **$100 million annually.**

A large number of accidents occur at gates and adjacent intersections because of the volume of vehicles funneled through these points. Other contributing factors are lateral restrictions, stop-and-go security procedures, and driver distractions.



SOLUTION

Design gate facilities that are safe for drivers and security personnel through the use of good standards and practice. Reduce human suffering by eliminating accidents.

If budget restrictions are compromising good design practice, check with your legal advisors to see what your current accidents would cost the Government if accident claims were awarded.

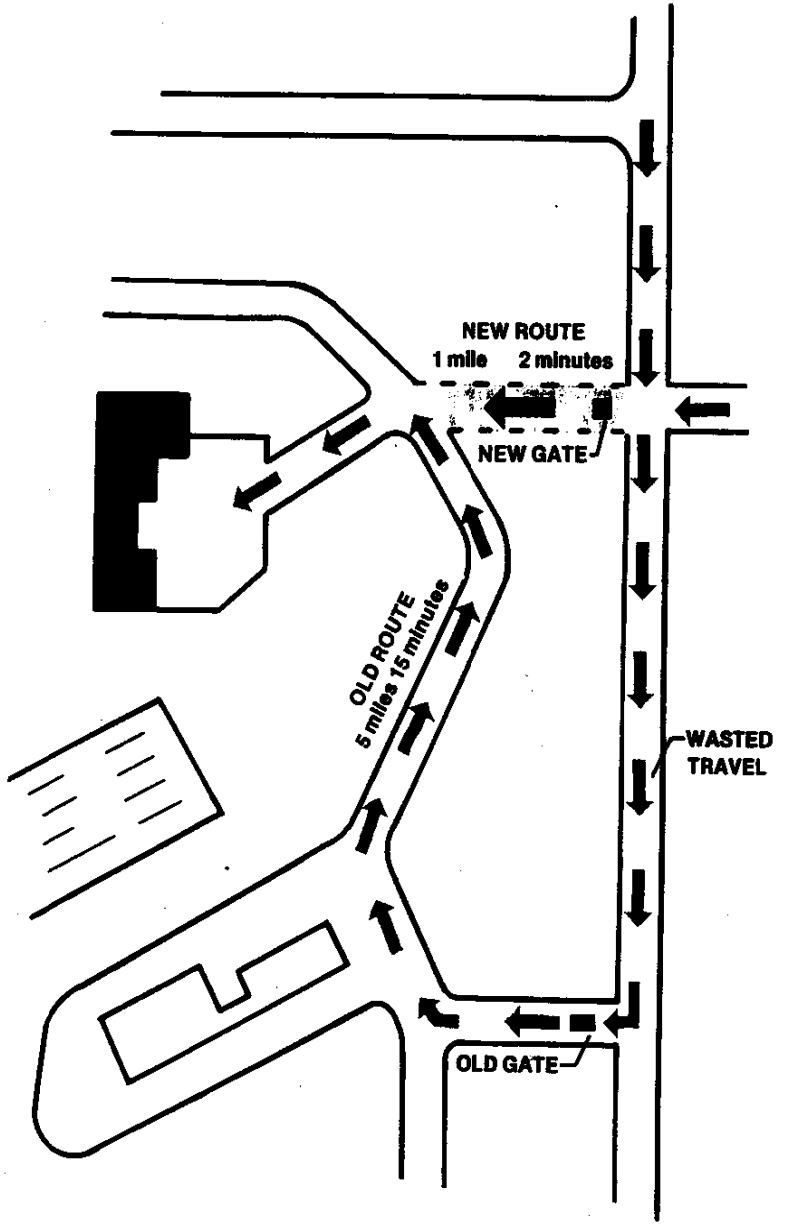
INACCESSIBILITY

PROBLEM

When a large facility is built or an activity increases its employment level, a substantial amount of additional traffic may be generated or redistributed. This may increase congestion on existing roadways and at critical intersections. If the facility is located in a remote area of the installation, **the use of existing gates may require excessive driving distances** to and from outside destinations.

SOLUTION

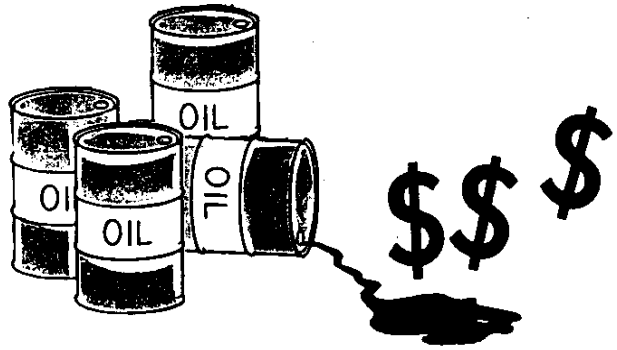
Build a new gate where it can shorten travel distances and time for a significant number of drivers and reduce existing roadway congestion. But before doing so, carefully study the alternatives and select an appropriate location.



WASTED ENERGY

PROBLEM

Traffic congestion results in wasted fuel. At a gate with a daily volume of 10,000 vehicles, an average 15-second-per-vehicle weekday delay wastes **6,500 gallons of fuel a year!** This waste costs road users about $10,000 per year. In a few years, the expense of wasted fuel will exceed that of building a new gate or improving an old one to reduce congestion.



SOLUTION

Reduce travel delay through proper gate design and operation.

POTENTIAL FUEL SAVINGS

GATE VOLUME (ADT) [1]	AVERAGE DELAY ELIMINATED (SEC)	FUEL SAVED/YR (GAL) [2]
5,000	15	3,250
	30	6,500
10,000	15	6,500
	30	13,000
15,000	15	9,750
	30	19,500
20,000	15	13,000

FOOTNOTES:
[1] Average daily traffic
[2] Assuming 0.6 gallons of fuel is saved each hour from idling

What data are needed to develop the best solution to a gate problem?

What are some good features to look for when choosing among alternatives?

What method is used to evaluate alternatives?

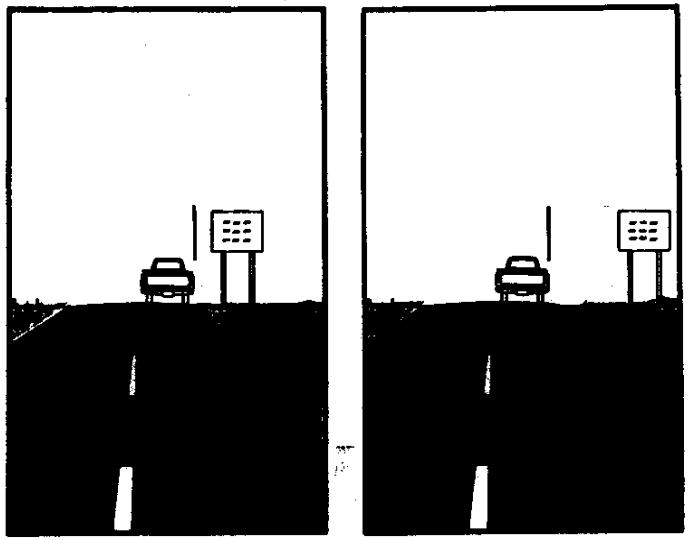
Chapter 2

DECISION PROCESS

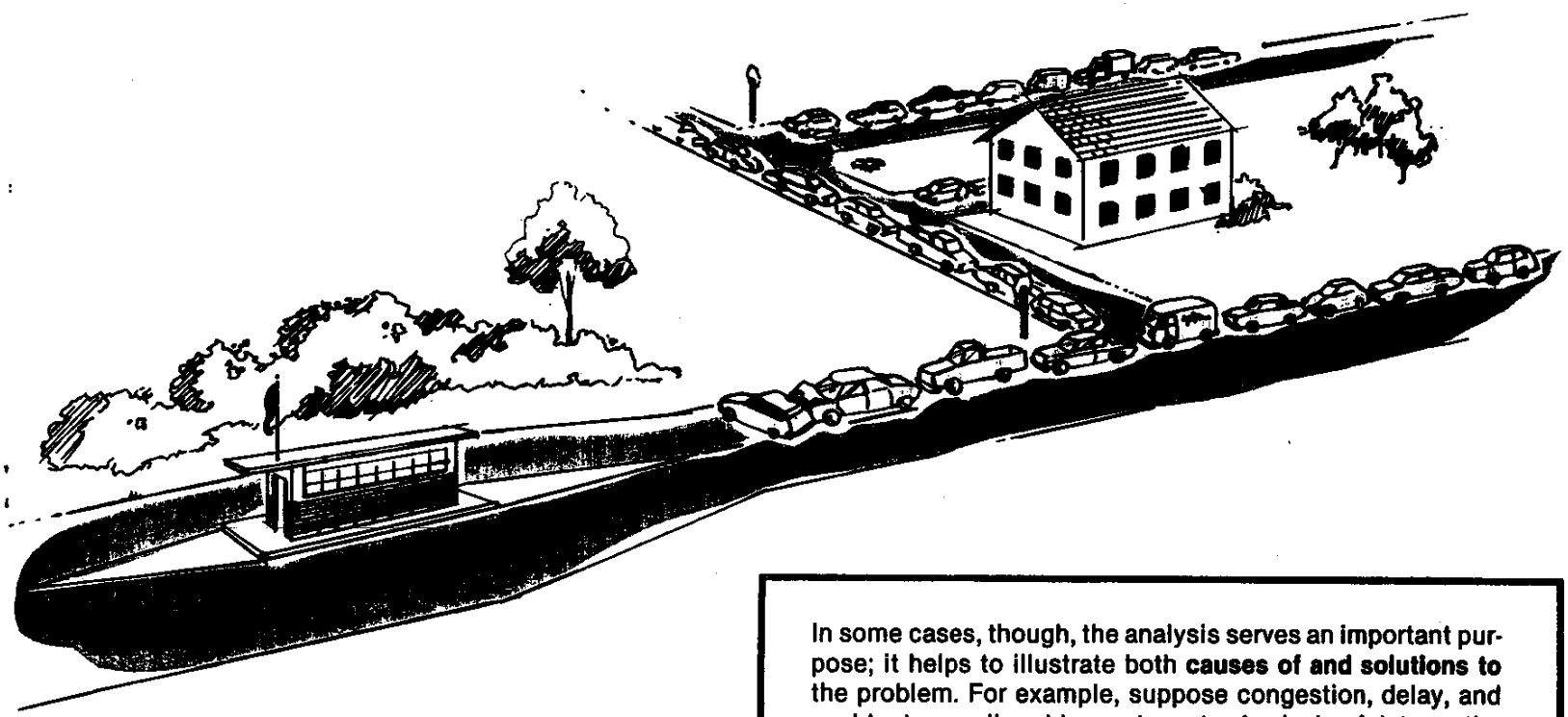
After defining problems created by, and deficiencies in, existing gate locations, the next phase of the planning process is deciding what to do about those problems. Several steps are involved in this phase:

STEPS INVOLVED

- DATA COLLECTION AND ANALYSIS
- TRAVEL FORECASTING
- DEVELOPING ALTERNATIVES
- EVALUATION AND SELECTION



Sometimes a solution will be easy, bypassing this process. For example, if the problem is simply that vehicles have been hitting a sign posted too near the road, the solution may be to remove or to relocate the sign. An in-depth analysis is not needed.



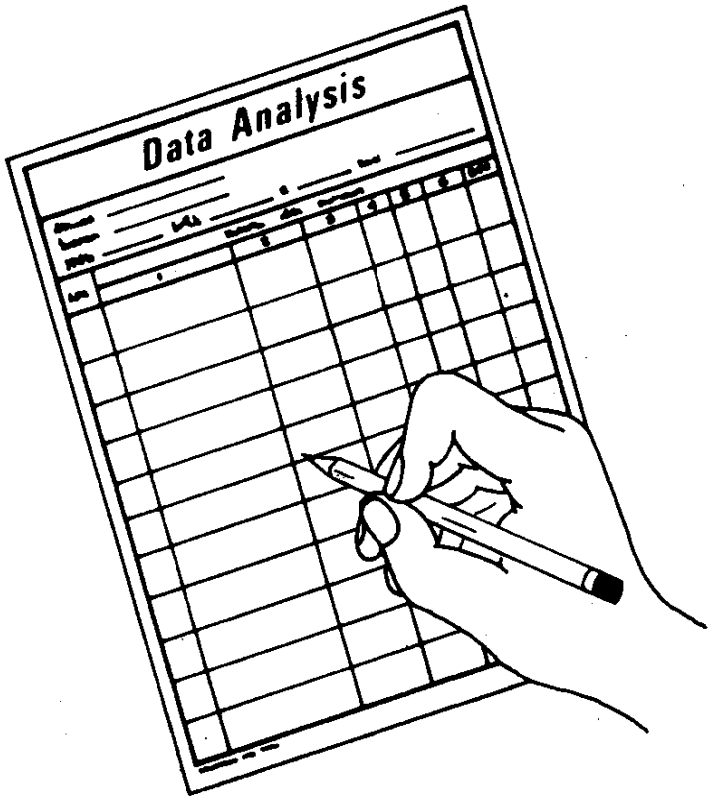
In some cases, though, the analysis serves an important purpose; it helps to illustrate both **causes of and solutions to** the problem. For example, suppose congestion, delay, and accidents are all problems at a gate. Analysis of data on the existing road network shows that, during the worst traffic periods, these problems compound those on other nearby roadways. Perhaps traffic using that gate also hampers operation of roadways several miles away both on and off the installaton. Also, travel forecasts show a major shift in travel desires in the future. One alternative would be to solve the problem by widening roadways, gates, and intersections to improve traffic flow and increase capacity. This may not be the best alternative, especially if travel desires shift away from this gate. Using the steps above will provide a method to get the information needed to solve the real problems, not just the causes. Valuable tax dollars can then be spent in a cost-effective way.

DATA COLLECTION AND ANALYSIS

This step involves **reviewing existing roadways**, along with travel characteristics of motorists, **to see how gate traffic relates to the overall highway network.** It will help locate other problems related to the gate and will show which parts of the total highway network may be weak links. Also, it will determine motorists' destinations and whether the gate really serves travel desires.

Analysis involves putting these data into a usable form and drawing conclusions. For example, if traffic through the gate were to increase, could the gate handle the added traffic? Does traffic using the gate concentrate in certain areas? If so, why? Are any accidents in the network attributable to peak hour traffic or gate congestion? Is the gate location well suited to travel desires? Is gate congestion really caused by delay at a nearby intersection?

A complete discussion of traffic study methods, including decisions on what information is important, how it can be assembled, and its significance, can be found in MTMC Pamphlet No. 55-8, *Transportation and Travel, Traffic Engineering Study Reference.*



Data are collected by surveying various aspects of the highway system. These surveys determine:

- **Condition of gates and roadways**
- **Traffic flow patterns on the roadway network**
- **Accident concentrations**
- **Travel desires**

TRAVEL FORECASTING

Travel forecasts are used to determine the traffic demands that will result from a change in land use. For example, can existing gates and roads adequately handle the traffic projected for a proposed maintenance depot, or would a new gate provide better transportation service and relieve the traffic burden at other locations? Forecasting can provide the information to project the number of trips to and from an activity **(trip generation),** where these trips begin and end **(trip distribution),** and over which routes the trips will be made **(trip assignment).**

Forecasting can be very complex and should, therefore, be limited to only what is needed to establish travel demand. **At a military installation, maximum travel demand generally is created by the highly directional employee home-to-work vehicle trips during the morning and evening rush hours.**

Travel forecasts identify problem areas and gate needs. If a gate-related problem surfaces, solutions are developed.

More details on travel forecasting techniques are covered in MTMC Pamphlet 55-10, *Traffic Engineering for Better Roads.*

LOOKING AHEAD

DEVELOPING ALTERNATIVES

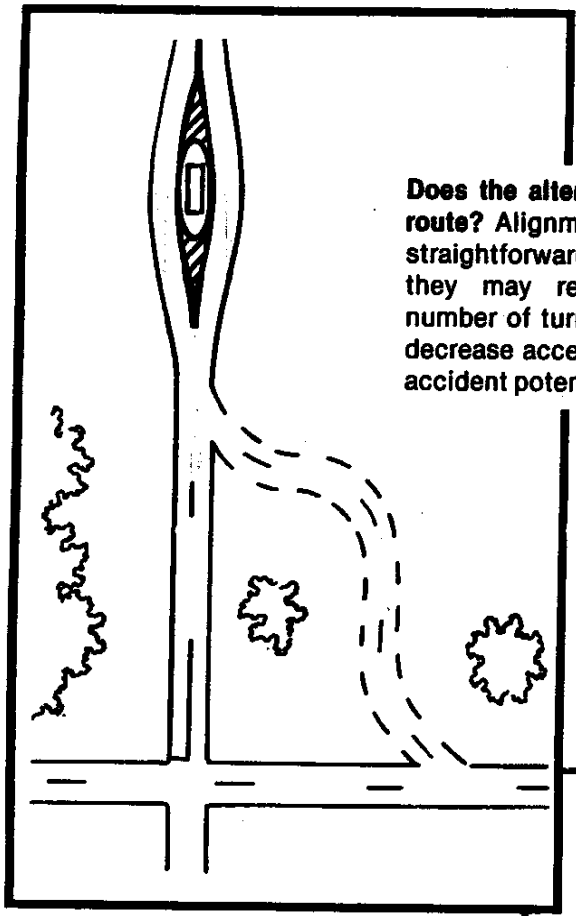
This phase of gate planning concerns **reducing traffic surveys and travel forecasts into various acceptable gate and access route designs.** The development of alternatives, which, by nature, is a creative function, usually begins after estimating future travel on the existing road system.

Once one or more alternative solutions are developed, they are then tested to examine their adequacy under forecasted conditions. **Congestion** should be tested first, looking at the total network to determine effects. As alternatives pass the congestion test, they should be evaluated in more detail, such as **travel time, travel distance, safety, security, user costs, and environmental impact.** The development and testing should produce a sufficient number of alternatives that are acceptable in all phases. These alternatives then pass on to the selection stage.

When testing alternative plans for adequacy, several desirable gate-corridor features should be kept in mind. These features apply to existing and proposed gates:

- **Simple route design**
- **Ample storage space**
- **Adequate approach roads**
- **Adequate corridor width**
- **Compatibility with adjacent land uses**
- **Compatibility with future master plan goals**

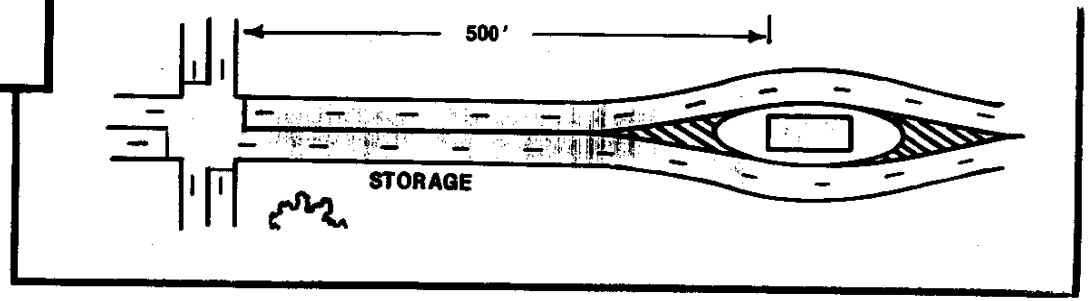
SIMPLE ROUTE DESIGN



Does the alternative allow a simple access route? Alignments should be as direct and straightforward as possible, even though they may require new construction. A number of turns, curves, hills, and dips will decrease access road capacity and increase accident potential.

AMPLE STORAGE SPACE

Does the route allow the gatehouse to be at least 500 feet from any intersection? If not, queued vehicles may clog the intersection and cause accidents.

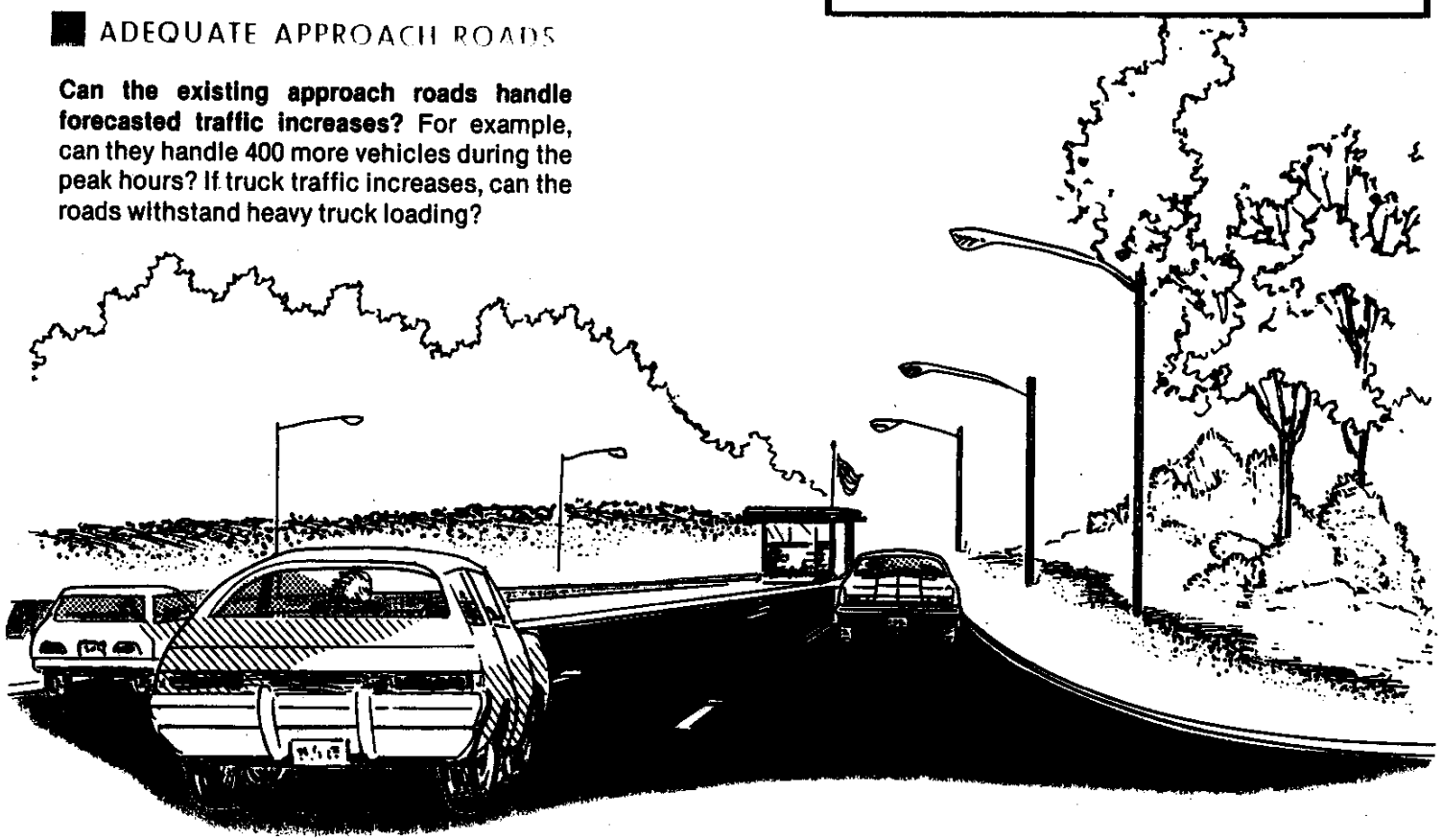


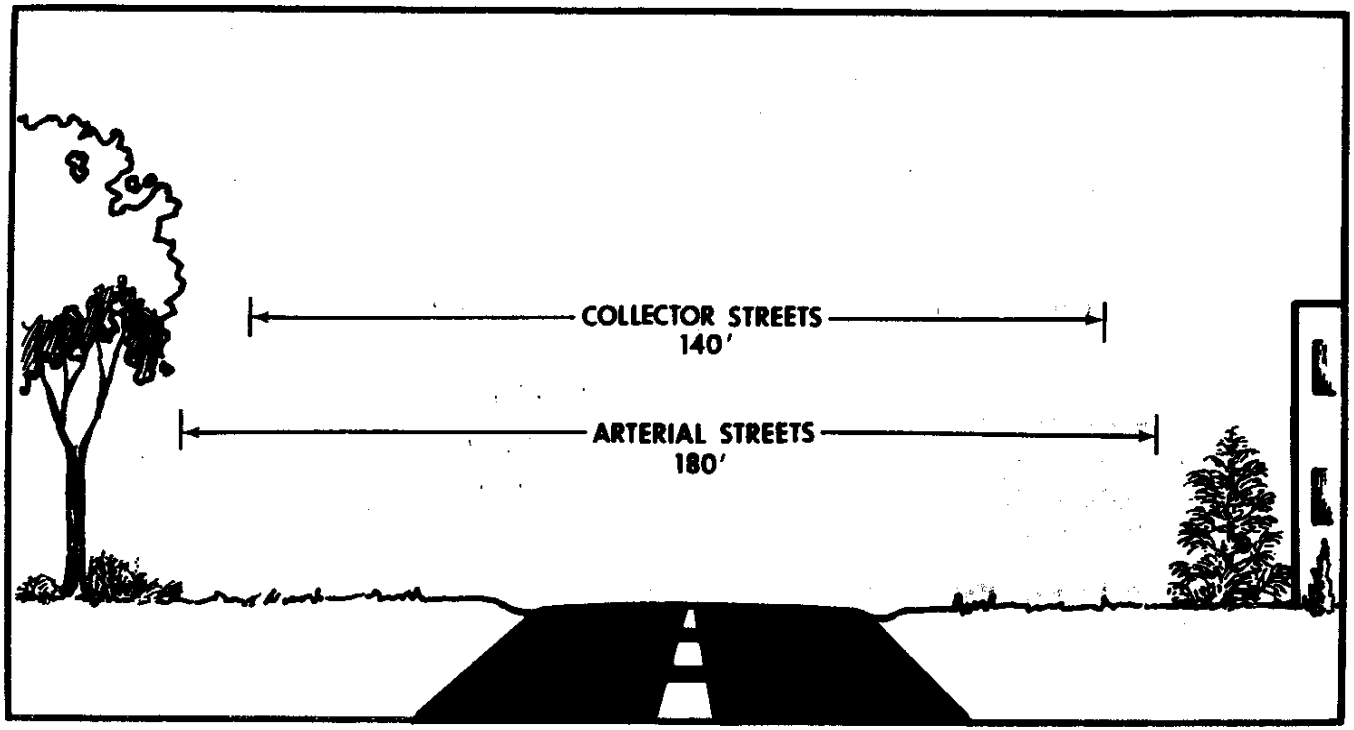
Things to consider when comparing approach roads are:

- **Pavement condition**
- **Shoulder width**
- **Lane width**
- **Sidewalks**
- **Restrictive curves and clearances**
- **Traffic control devices**

ADEQUATE APPROACH ROADS

Can the existing approach roads handle forecasted traffic increases? For example, can they handle 400 more vehicles during the peak hours? If truck traffic increases, can the roads withstand heavy truck loading?



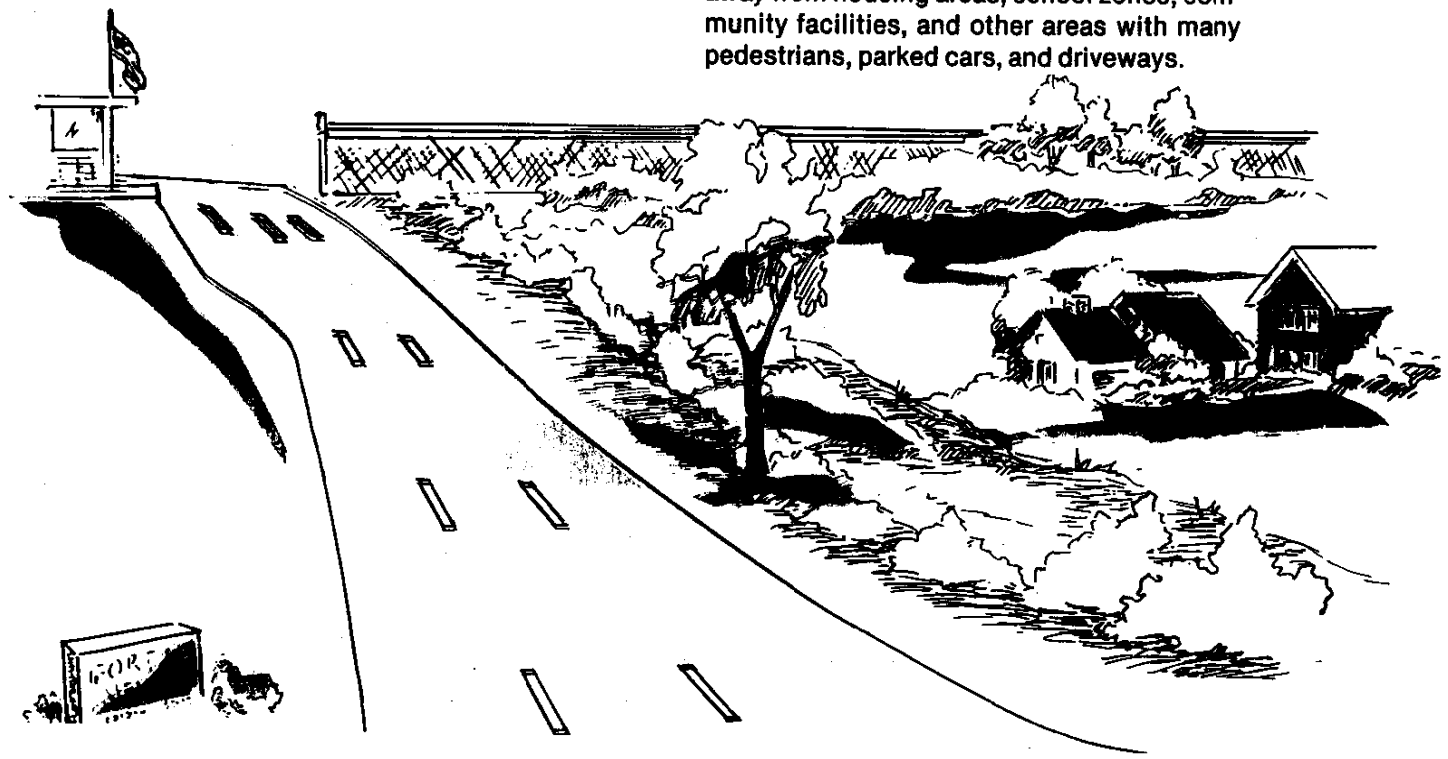


ADEQUATE CORRIDOR WIDTH

Is there room for future expansion? Good design practice requires a corridor at least 140 feet wide for collector streets (2,000 to 8,000 vehicles per day (vpd)) and 180 feet wide for arterial streets (8,000 to 25,000 vpd). These corridors must have a dedicated right-of-way that will protect them from encroachment by buildings, trees, and other objects. This will provide a safe, clear roadway and will allow for future expansion, if needed.

COMPATIBILITY WITH ADJACENT LAND

Are land uses bordering the new route compatible with an arterial highway, which generates noise and pollution and which acts as a physical barrier to pedestrian traffic? Heavily traveled gates should be located away from housing areas, school zones, community facilities, and other areas with many pedestrians, parked cars, and driveways.



COMPATIBILITY WITH FUTURE MASTER PLAN GOALS

Will the proposed route be rendered unusable by future changes in land use? Or, conversely, can a corridor be developed by changing existing and projected land use, such as demolition of temporary buildings?

EVALUATION AND SELECTION

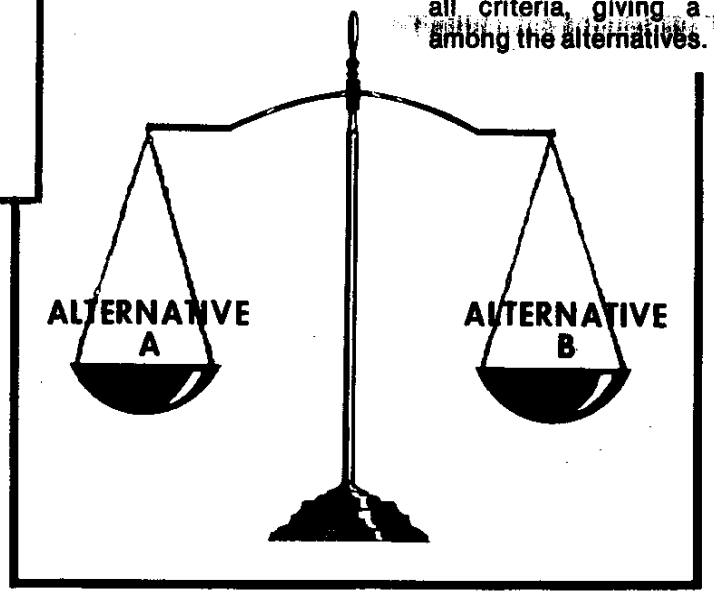
In the evaluation stage, all acceptable alternatives are considered and compared to determine the best solution to a gate problem. Each alternative presented for evaluation has already been found acceptable as a potentially good design and for compatibility with existing and future land use.

The most common method of evaluating a gate location and its access roads is to examine and compare all acceptable alternatives and then to make a judgment-based decision. The following criteria should be considered:

- **Safety**
- **Travel time**
- **Travel distance**
- **Construction cost**
- **Maintenance cost**
- **Environmental impact**

If one alternative clearly stands out among the rest as superior, a quick judgment is possible without elaborate deliberation. Conversely, one or more alternatives may clearly stand out as inferior and may be discarded.

When the differences are subtle, a more objective evaluation method is needed to weigh the alternatives. One effective and simple method is to assign a relative importance to each of the evaluation criteria. Each alternative can then be rated for its performance in each criterion. Finally, each alternative is scored for its overall performance in all criteria, giving a commercial comparison among the alternatives.



SAMPLE EVALUATION METHOD*

1

ESTABLISH CRITERIA

- Safety
- Travel time
- Travel distance
- Construction cost
- Maintenance cost
- Environmental impact

2

DETERMINE WEIGHT OF EACH CRITERION

CRITERIA	WEIGHT**
Safety	8
Travel time	7
Travel distance	6
Construction cost	5
Maintenance cost	3
Environmental impact	5

3

SPECIFY RELATIVE PERFORMANCE OF EACH ALTERNATIVE IN EACH CATEGORY

CRITERIA	PERFORMANCE RATING	
	ALT A	ALT B
Safety	10	5
Travel time	6	8
Travel distance	4	8
Construction cost	5	7
Maintenance cost	5	8
Environmental impact	9	4

10 = Good
1 = Bad

*Values shown here are for demonstration only. Actual values used should be determined by the gate planning committee.

**A scale of 1 through 10 should be used. For example, in this case safety has a weight of 8, meaning it has been given nearly twice the importance of construction cost, which has a weight of 5.

4

MULTIPLY THE WEIGHT OF EACH CRITERION BY THE PERFORMANCE RATING, THEN SUM PRODUCTS

CRITERIA	ALT A WEIGHT × PERFORMANCE = PRODUCT RATING	ALT B WEIGHT × PERFORMANCE = PRODUCT RATING
Safety	8 × 10 = 80	8 × 5 = 40
Travel time	7 × 6 = 42	7 × 8 = 56
Travel distance	6 × 4 = 24	6 × 8 = 48
Construction cost	5 × 5 = 25	5 × 7 = 35
Maintenance cost	3 × 5 = 15	3 × 8 = 24
Environmental impact	5 × 9 = 45	5 × 4 = 20
	231	223

5

SELECT BEST PLAN

ALT A

SECTION II

Design Criteria

CRITERIA FOR CONVERTING PLANNING AND LOCATION DECISIONS INTO ACTUAL DESIGNS

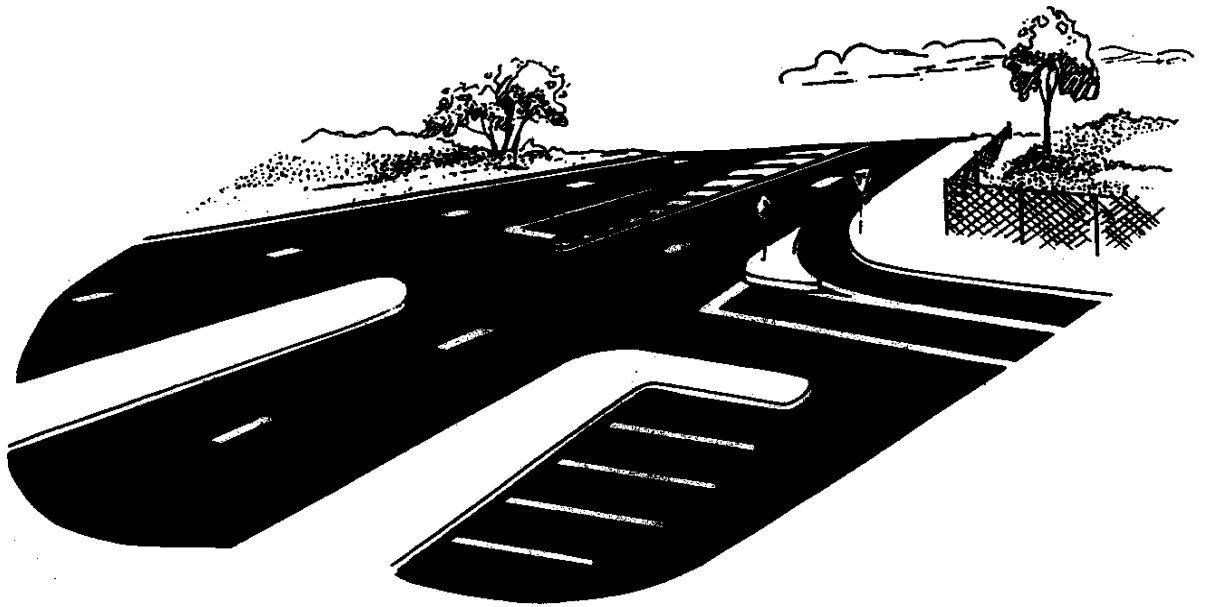
GEOMETRIC DESIGN

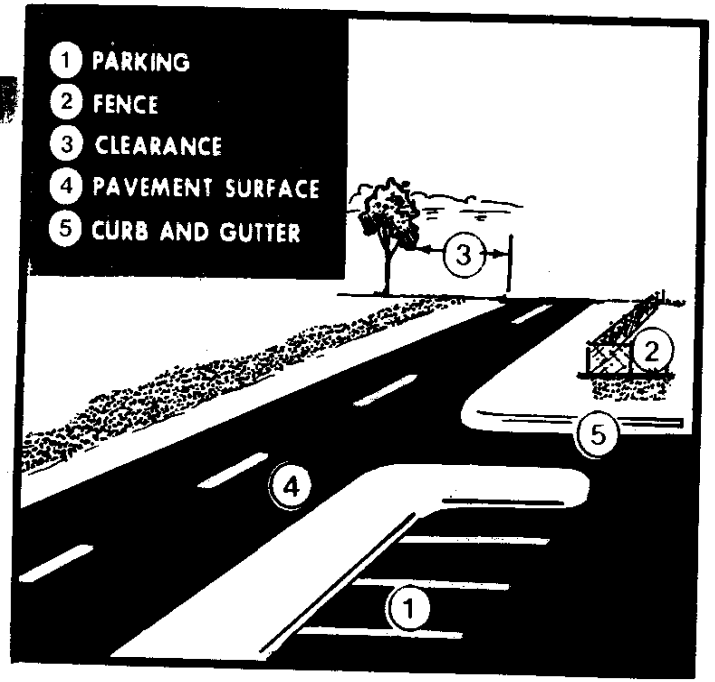
Chapter 3

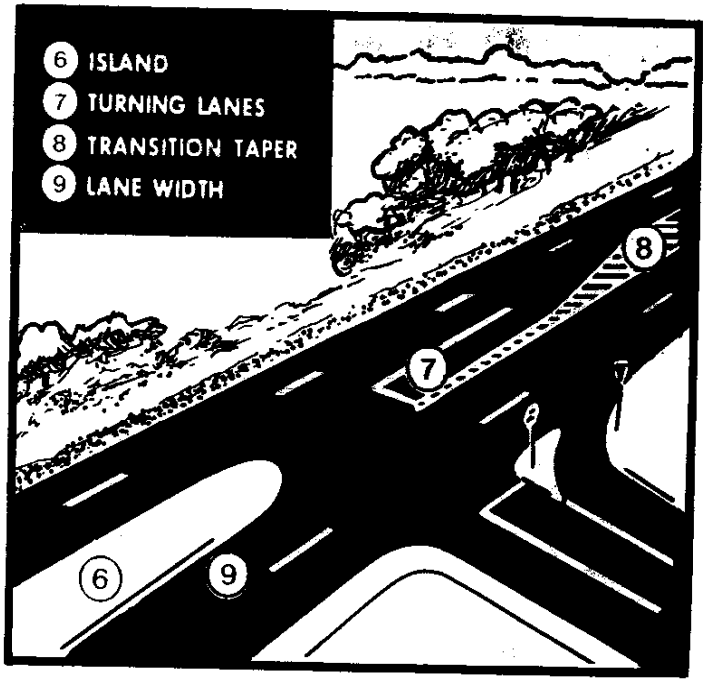
How should entrance gate roadways be designed?

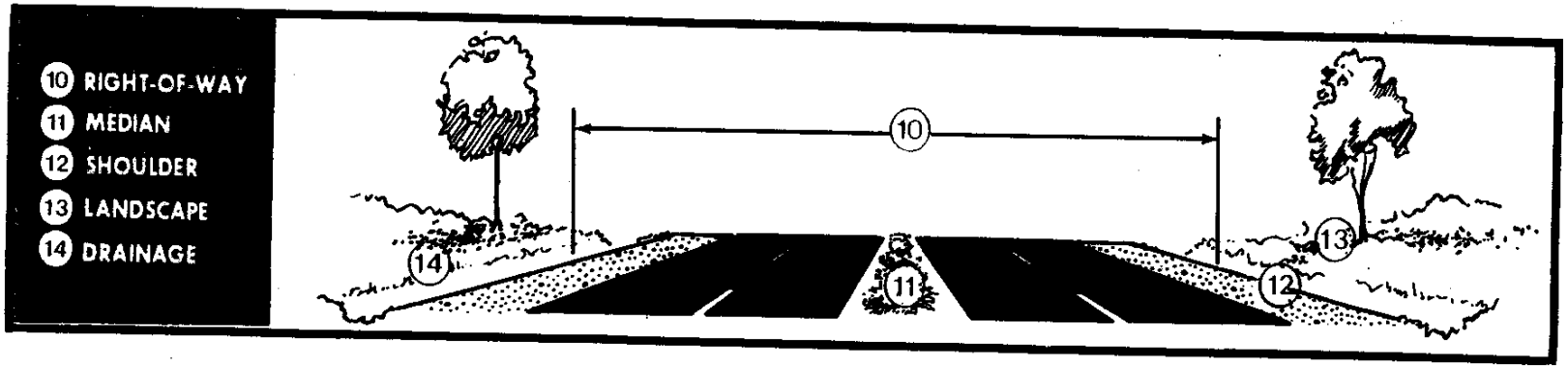
Geometric design of gate roadways will depend on the type of approach roadway (local, collector, or arterial), type of gate, security level, space available, speed limit, traffic volume, and other factors. Accordingly, this chapter presents design standards for the many components that make up a roadway, giving minimum as well as desirable and preferred criteria.

Whenever possible, minimum design standards should be exceeded and the driver should be allowed maximum possible freedom and safety of operation. The design criteria should include large curve radii, wide lanes, greater clearances, wide medians, paved shoulders, good drainage, high-quality pavement, and anything else within economic reason to create a comfortable and hazard-free driving environment. Accidents and potential liabilities will be reduced, while aesthetics and operations will be enhanced.




1 PARKING
2 FENCE
3 CLEARANCE
4 PAVEMENT SURFACE
5 CURB AND GUTTER


6 ISLAND
7 TURNING LANES
8 TRANSITION TAPER
9 LANE WIDTH


10 RIGHT-OF-WAY
11 MEDIAN
12 SHOULDER
13 LANDSCAPE
14 DRAINAGE

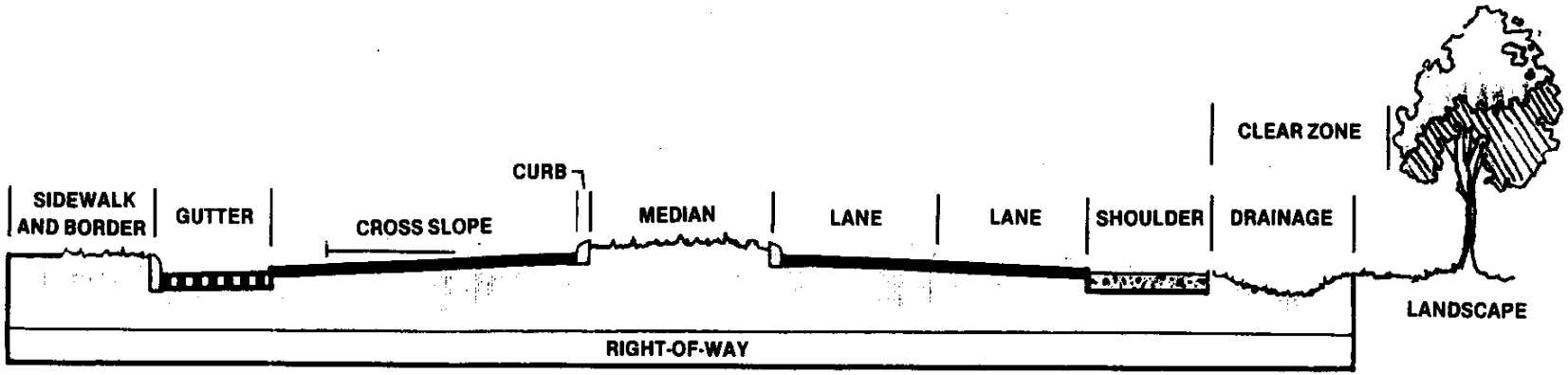
RIGHT-OF-WAY

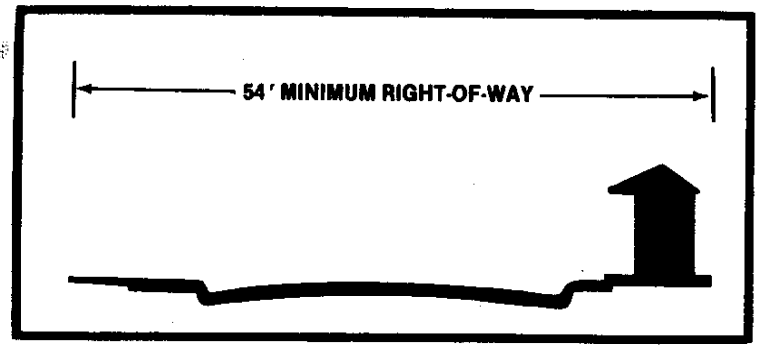
The **right-of-way** is a corridor of the entire cross section of the roadway through the gate, including **traffic lanes, median, shoulders, borders, sidewalks, curbs and gutters, drainage, and clear zones.** On it or adjacent to it are placed all components of the gate, such as gatehouses, pass deposit lanes, holding areas, and parking lots.

The width of the right-of-way depends upon the type of access road the gate serves. A **local road** (up to 2,000 vpd) right-of-way should be no less than **54 feet wide.** A **collector road** (2,000 to 8,000 vpd) needs a right-of-way between **70 and 80 feet wide.** An **arterial road,** the busiest of the three (more than 8,000 vpd), right-of-way should be between **82 and 120 feet wide.**

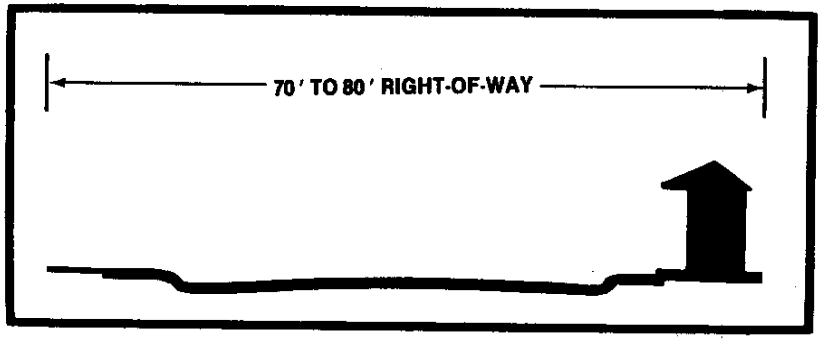
The right-of-way through a gate should be as wide as practical, especially if there is any indication that future expansion might be needed. Once an area is built up, extra land can be nearly impossible to obtain.

RIGHT-OF-WAY SHOULD BE SUFFICIENT TO CONTAIN ALL ANTICIPATED PAVEMENT, SIDEWALK, UTILITY, PARKING, AND GUARDHOUSE FACILITIES

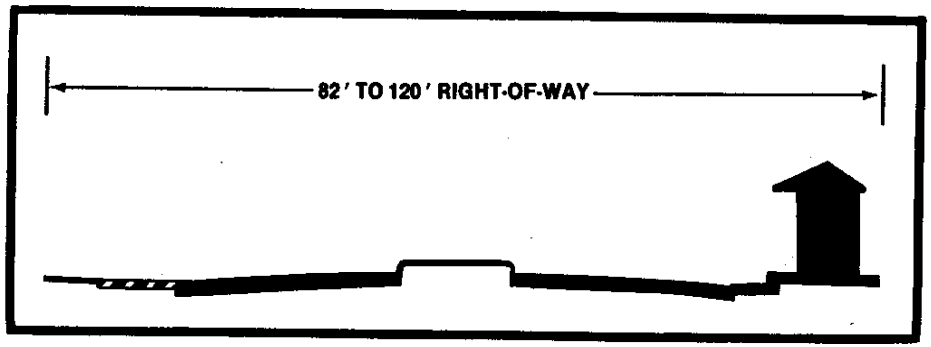




LOCAL



COLLECTOR

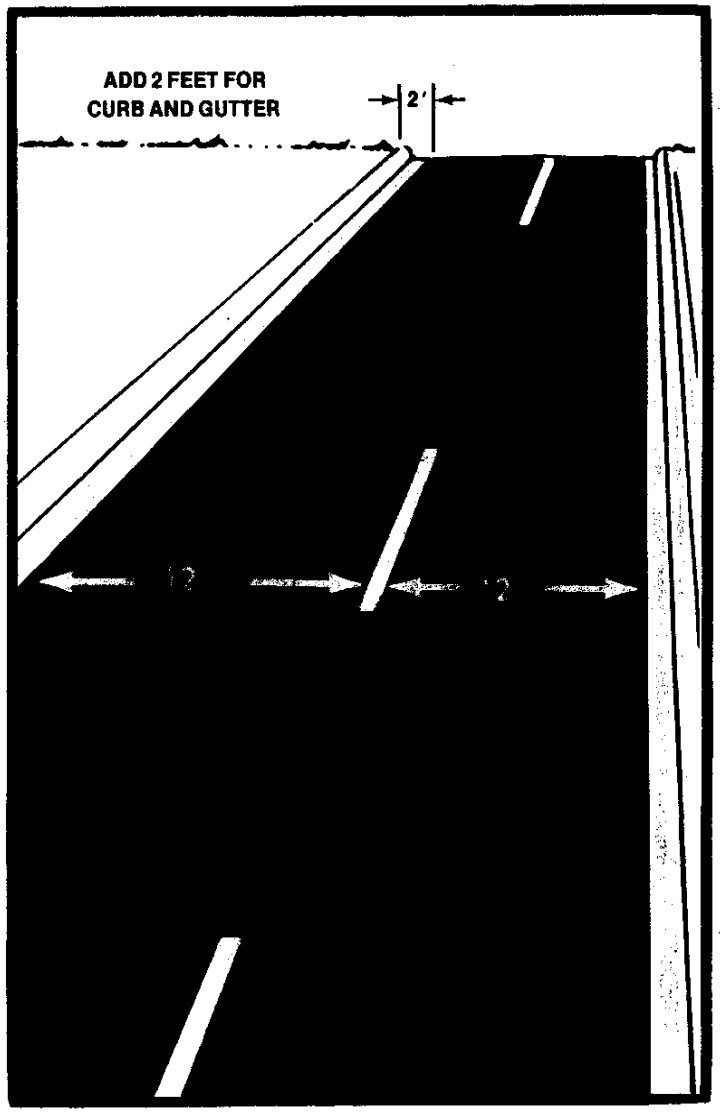


ARTERIAL

LANE WIDTH

As a general rule, when free flow through a gate is desired, **travel lanes should be at least 12 feet wide.** Narrower lanes will restrict the flow and contribute to congestion. If moderate to heavy bicycle traffic is expected on the street, a width of 15 feet is needed and 17 feet is desirable.

Where tight security mandates the slowing or stopping of vehicles, a lane width of 10 feet at the gate will not impede traffic flow, as congestion is inherent with the stopping or slowing. Narrow lanes through the gate should be used only when restrictive security is expected to be in effect throughout the useful life of the gate and when no truck traffic is expected to use the gate. If not, 12-foot lanes should be used.

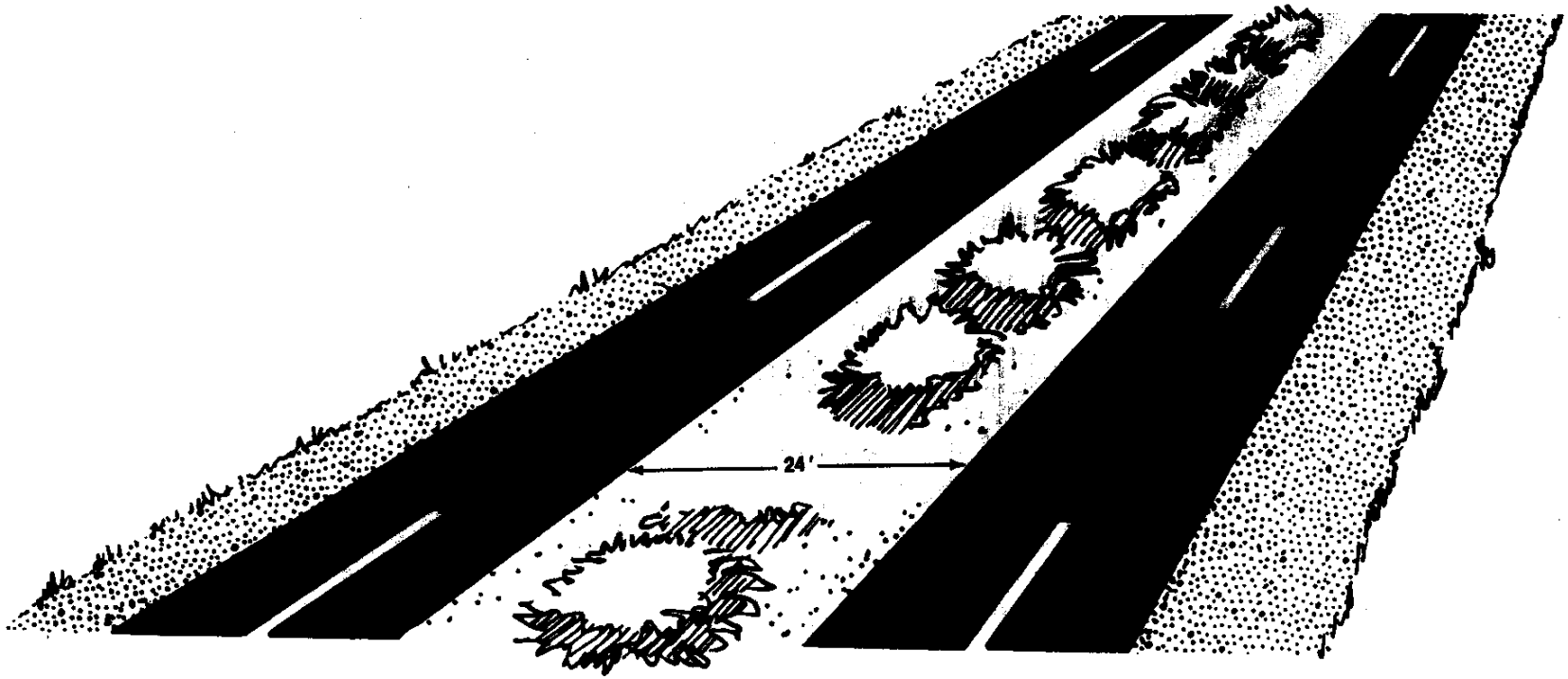


STANDARD LANE WIDTH
THROUGH GATES - 12 FEET

MEDIAN

Medians are used to physically **separate opposing traffic** and, when properly constructed, **increase safety.** Near gates they can also help minimize headlight glare; provide space for signs, pedestrian refuge, and U-turning vehicles; and provide an open green space for aesthetics. The desired minimum median width between opposing travel lanes is **24 feet.** Where space is limited, a width of 16 feet is permissible. Raised medians typically are used on arterials where left turns are regulated or for narrow medians, often with plantings. A slightly depressed median provides contrast, efficient drainage, easy snow removal, and emergency parking. Generally, continuous medians should not confine either side of the roadway to fewer than two lanes.

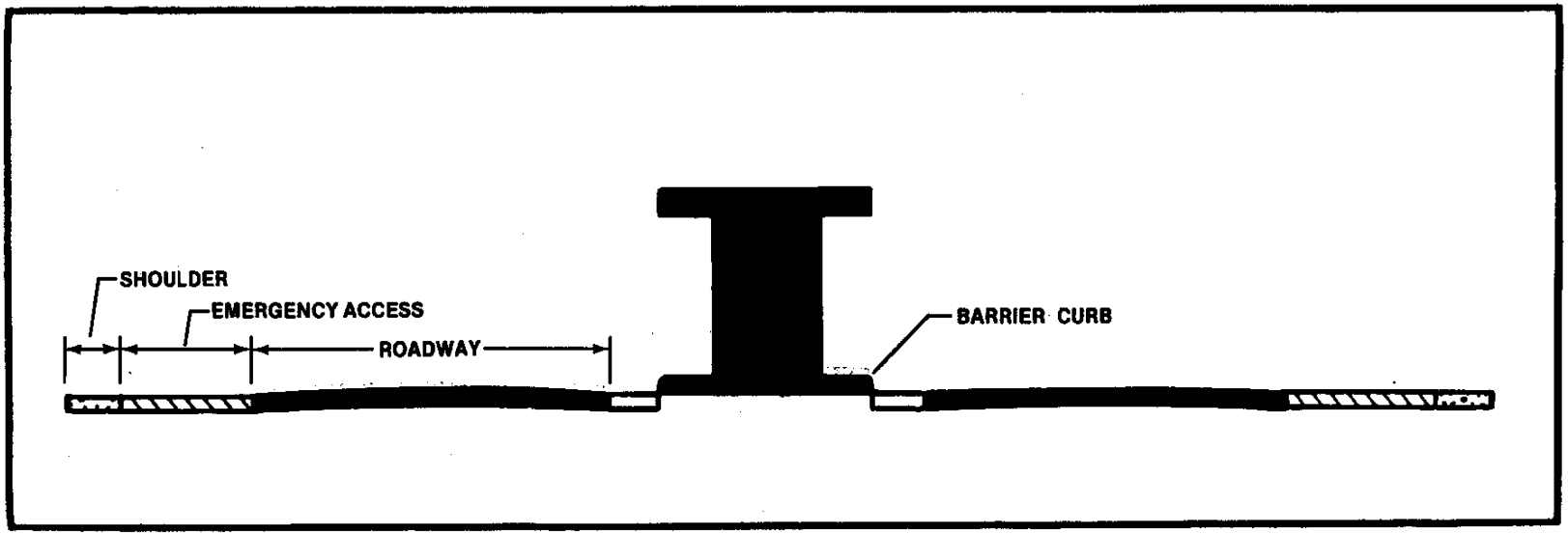
MEDIAN FUNCTION	MINIMUM WIDTH (FT)	DESIRED WIDTH (FT)
Separate opposing traffic	4	10
Pedestrian refuge and sign location	6	14
Left-turn storage	10	20
U-Turns	22	24
Protection for crossing vehicles	25	30



CURB AND GUTTER

Since **curbs** discourage or prevent disabled vehicles from getting off the road to safety, they **should be avoided in the gate area except in parking lots, around islands, and outside full-width paved shoulders.**

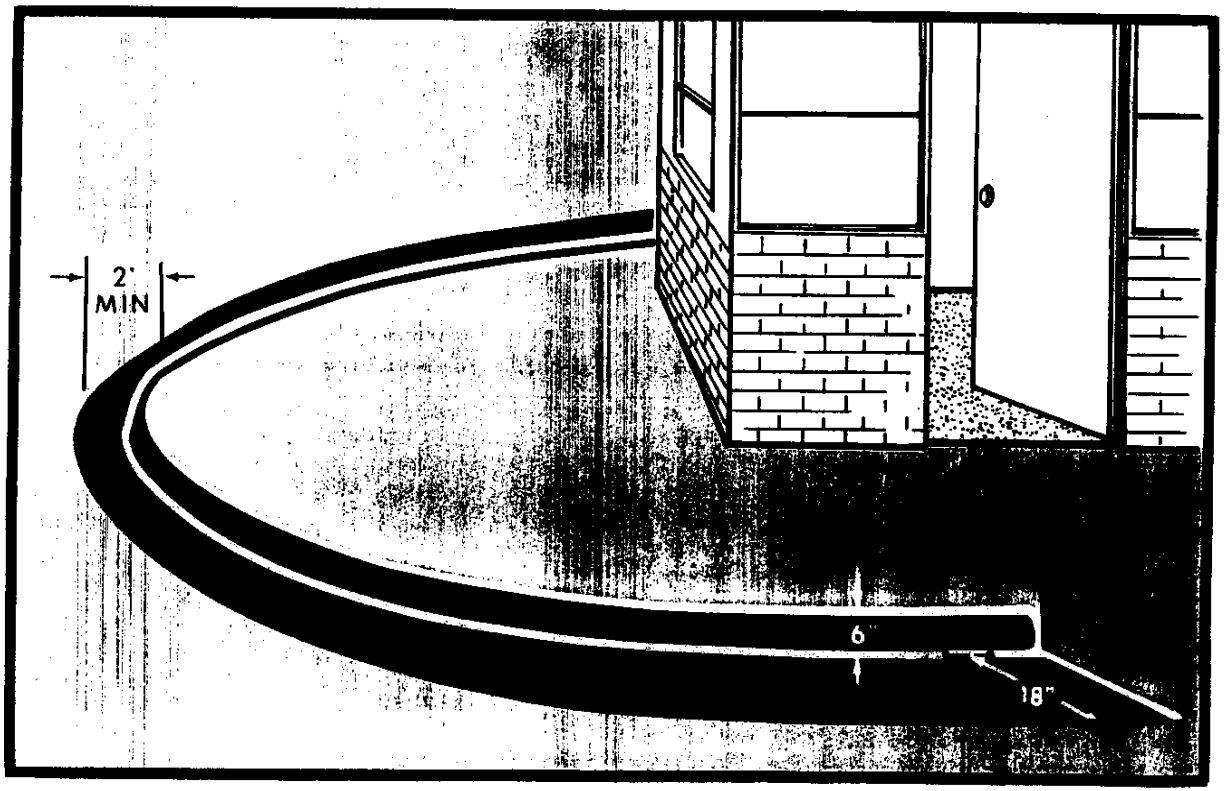
Six-inch barrier curbs should be used around a gatehouse island, particularly between two opposing through lanes.



A curbed island is more prominent than a painted island and will stand above most puddles. Also, it increases the view of both the guard and the driver. Though a 6-inch curb is more a psychological than a physical barrier to vehicles, it is a very tangible demarkation in inclement weather and at night for both the guard and the driver.

If the gutter section is different in color and texture from the travel lane and has a visible longitudinal joint, it should not be considered a part of the travel lane width. Drivers generally avoid the gutter section as if there were no surface past the joint.

GUTTER NOT CONSIDERED A PART OF THE TRAVEL LANE



SHOULDERS

On all streets approaching gates, **shoulders** are desirable for accommodation of stopped vehicles and for lateral support of base and surface courses.

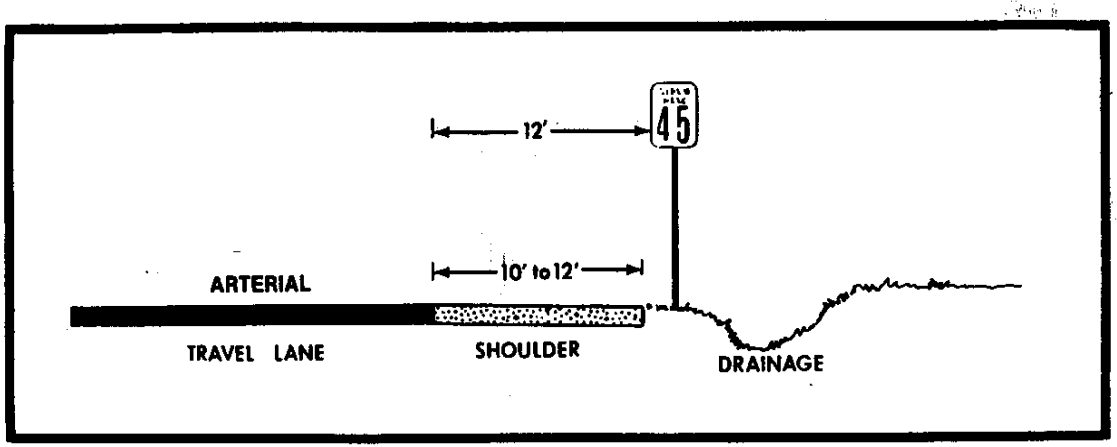
The shoulder width needed depends upon the type of roadway. **Ten to twelve feet** should be used on arterials, **6 to 8 feet** on collectors, and at least **4 feet** on local roadways.

As a minimum, when an uncurbed shoulder is present, all **fixed objects,** such as signs, fence posts, structures, and trees, should be at least **6 feet from the shoulder or 12 feet from the lane edge,** whichever provides the greater clearance from the lane edge.

Shoulders should be pitched to drain away from the road surface, but not so much as to make their use hazardous. Their design should be a compromise between slope needs and driveability.

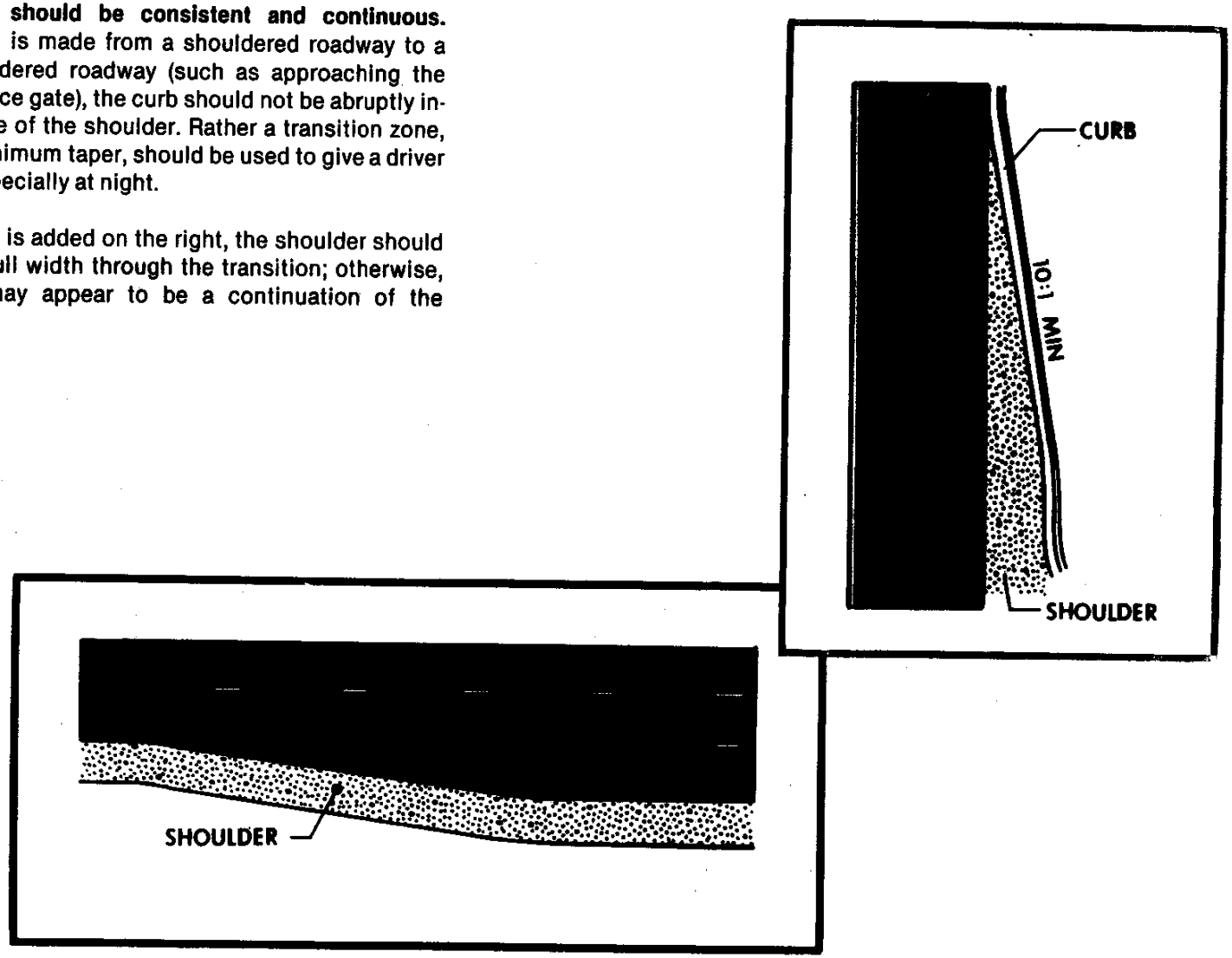
Roadway shoulders at gates provide:

- **A sense of openness, adding to driving freedom and improving capacity**
- **Emergency stopping space**
- **An accident escape route/recovery zone**
- **Improved sight distance**
- **Lateral support of roadway base and surface courses**



Shoulder width should be consistent and continuous. Where transition is made from a shouldered roadway to a curbed, unshouldered roadway (such as approaching the gatehouse or fence gate), the curb should not be abruptly introduced in place of the shoulder. Rather a transition zone, with a 10 to 1 minimum taper, should be used to give a driver time to react, especially at night.

When a new lane is added on the right, the shoulder should continue to be full width through the transition; otherwise, the new lane may appear to be a continuation of the shoulder.



LATERAL CLEARANCE

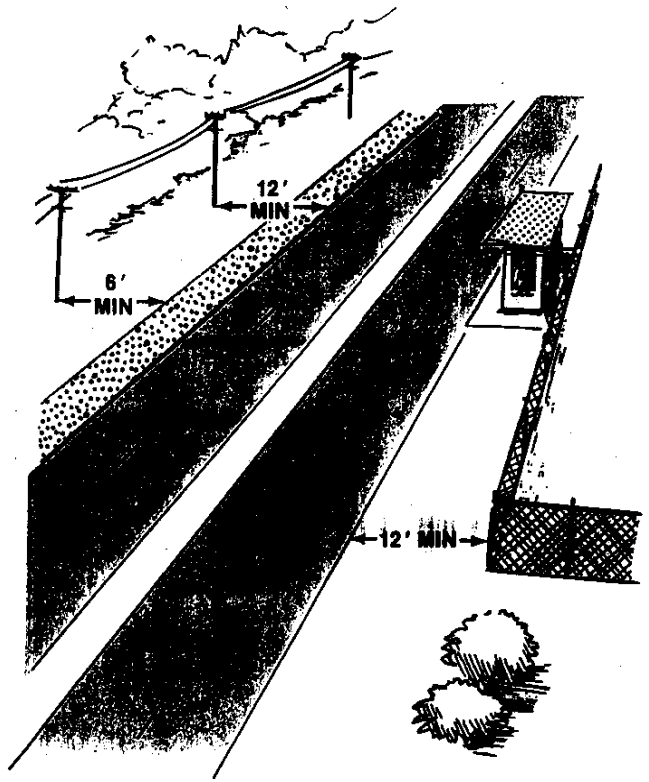
Where free flow through the gate is desired, a **minimum lateral clearance of 6 feet** should be provided between fixed objects and the edge of the travel lane. Drivers perceive smaller clearances as hazardous, so traffic will slow down. However, low curbs (under 6 inches) have little influence on traffic operations and may be placed next to the pavement edge.

For safety, the lateral clearances along a gate approach road should be as wide as possible to provide a recovery zone for errant vehicles; that is, design a forgiving roadside. All fixed objects, such as trees, drainage fixtures, poles, and structures, that are within 12 feet of the lane edge or within 6 feet of the paved shoulder edge (whichever is greater) should be removed or shielded by curbs or barriers. A 15-foot clearance is desirable for vehicle speeds of 50 miles per hour (mph) or less.

Even an isolated restrictive clearance can influence the effective width of an otherwise open roadway. Thus, where the sentry or guard is standing directly on the pavement edge or very close to it, he or she will be perceived as a hazard, and the capacity of the roadway may be reduced as much as 30 percent.

Clearances may be more restrictive where security requires vehicles to stop or slow down, since the stopping or slowing will affect capacity more adversely than will the restrictive clearances.

MAINTAIN CLEAR ZONES
ON EITHER SIDE OF GATE

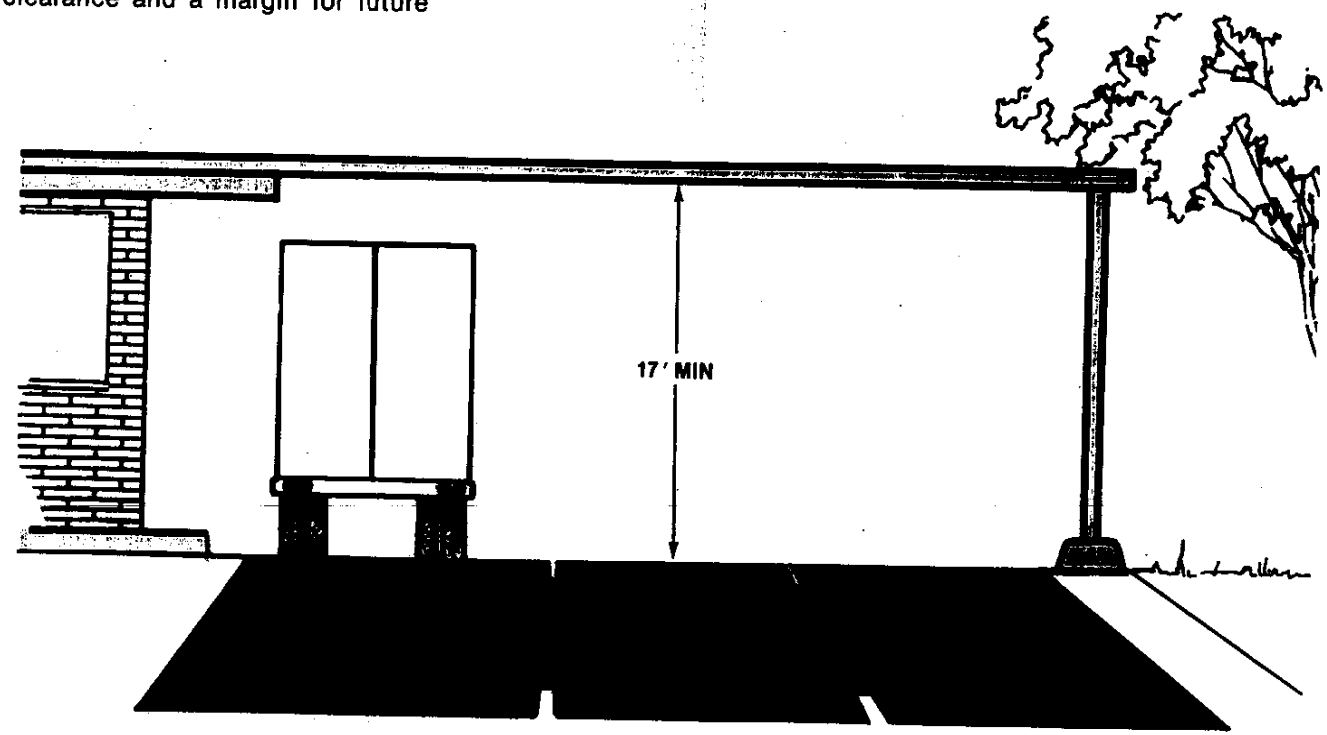


VERTICAL CLEARANCE

Ample vertical clearance must exist at gates to permit the safe passage of large trucks, heavy equipment transporters, and engineering maintenance equipment. Most public highways are designed with a minimum clearance of 16 or 17 feet; however, **vertical clearance at a gate should be at least 17 feet at all points over the roadway surface.** This provides a margin for future resurfacing and contributes to the aesthetics of the entrance.

Vertical clearance should be at least **17 feet** from the highest point of the roadway cross section. This provides the minimum required clearance and a margin for future resurfacing.

MAINTAIN A 17-FOOT VERTICAL CLEARANCE ON ALL ENTRANCE/EXIT ROADWAYS



TRANSITION TAPERS

Properly constructed tapers enhance safety and efficient use of pavement. They allow drivers to recognize a change in conditions and to react accordingly.

Tapers should be used whenever:

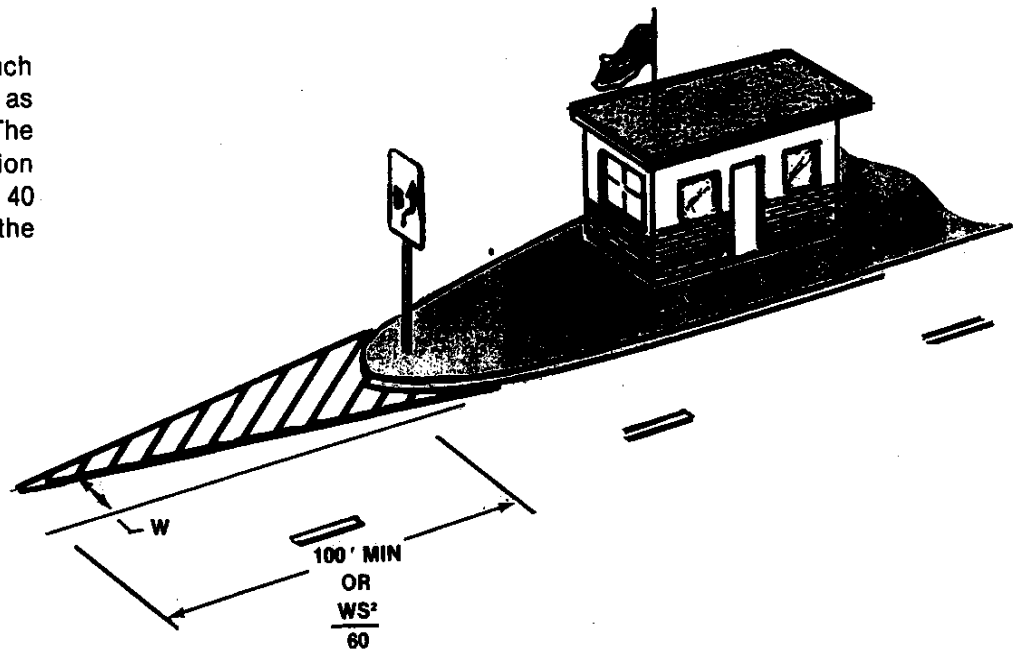
- **Lanes are separated approaching an obstruction or island**
- **Lanes are added or dropped**
- **Lanes are redirected**

APPROACH LENGTH

Tapers for lane redirection approaching an obstruction such as a gatehouse or where lanes are redirected should be as long as practical and **in no case less than 100 feet.** The length should be $WS^2/60$, where w = width of transition and s = the 85-percentile or design speed (maximum 40 mph). The minimum allowable length is the product of the equation or 100 feet, whichever is greater.

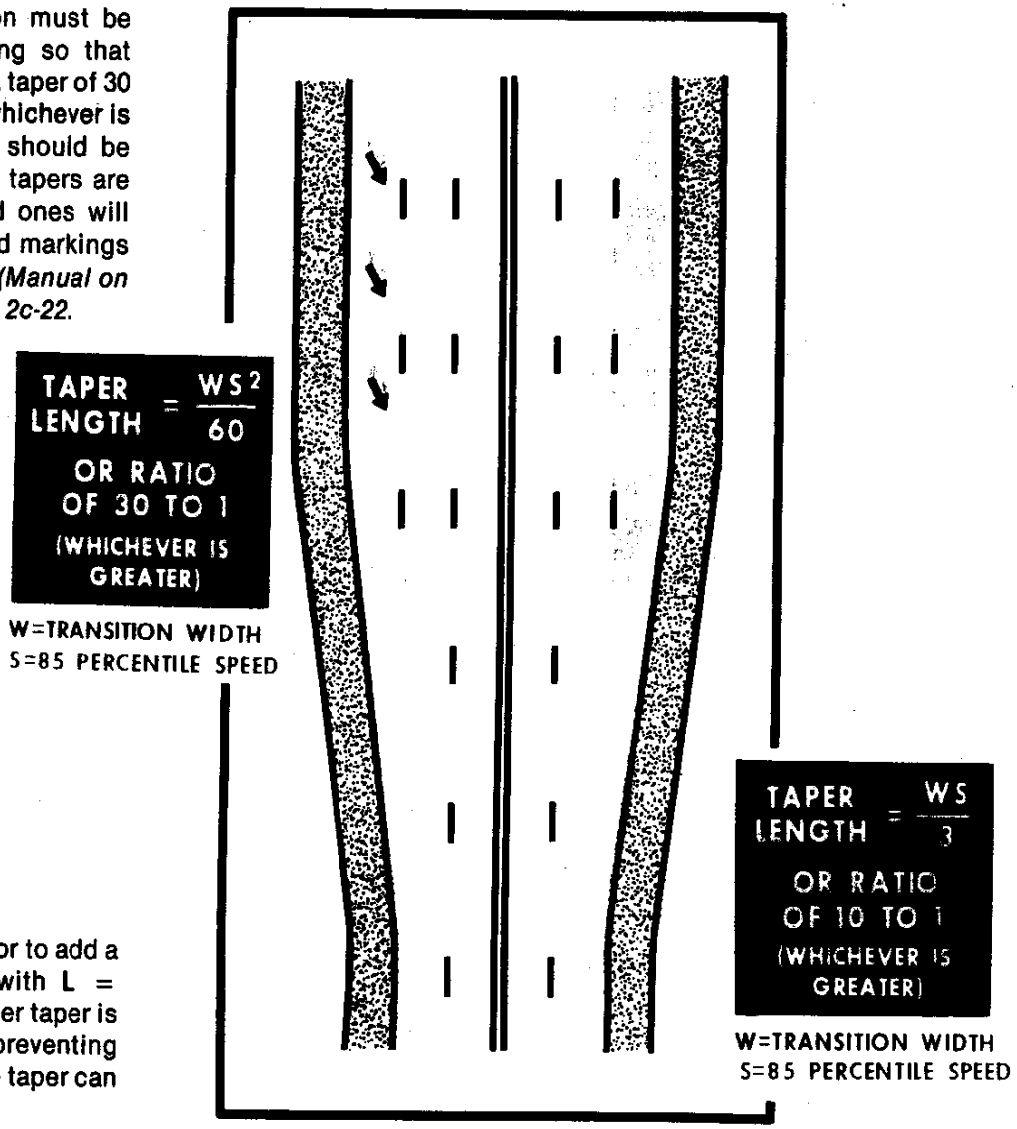
TYPICAL TAPER LENGTH (USING $\frac{WS^2}{60}$)

SPEED (MPH)	W=5 FEET	W=10 FEET
20	100	100
25	100	104
30	100	150
35	102	204
40	133	267



LANE DROPPED

When a lane is dropped, the taper or transition must be made gradually and should be sufficiently long so that drivers can merge safely into the adjacent lane. A taper of 30 to 1 is desirable; $L = WS^2/60$ or a 10 to 1 taper, whichever is greater, should be the absolute minimum and should be used only when space is not available. Straight tapers are operationally adequate in this case, but curved ones will make better use of pavement. Warning signs and markings should be used in accordance with the MUTCD, *(Manual on Uniform Traffic Control Devices), p 2c-1 through p 2c-22.*



LANE ADDED

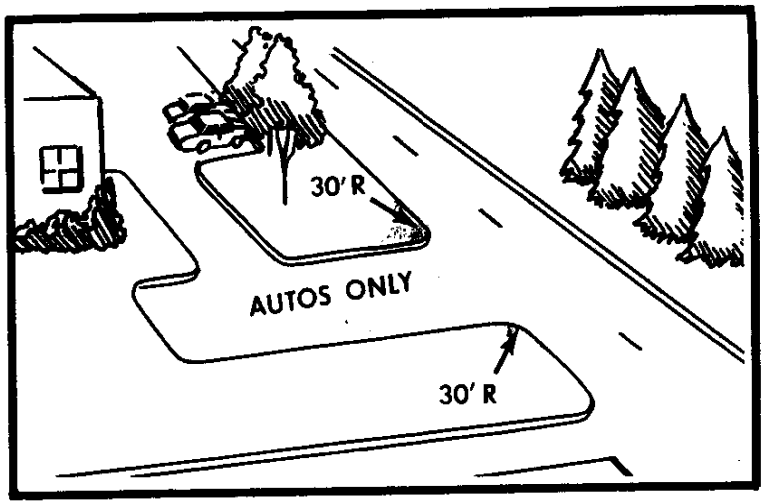
When a lane is added, either to increase capacity or to add a right-turn lane, the taper can be fairly short, with $L = WS/3$, or a ratio of 10 to 1 being adequate. A longer taper is not necessary; it tends to hinder operations by preventing drivers from moving quickly into the new lane. The taper can be a straight line or a set of curves.

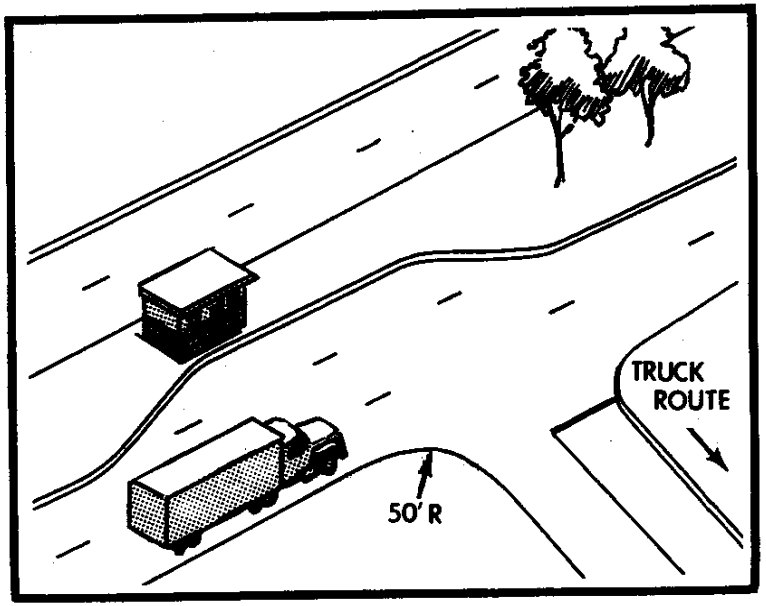
TURNING LANES

The **radius** of a corner or turning lane **depends on** several factors; most important are the **turning characteristics of the largest expected vehicle and the expected turning speeds.** Other factors are available right-of-way, angle intersection, and pedestrian needs.

The largest expected vehicle will depend on the type of gate being considered. Truck gates should be designed to handle 40-foot semitrailer rigs (WB-50), using minimum 50-foot radii. All other gates without truck traffic should be able to accommodate buses (SU size), using at least 35-foot radius turns. Minor gates may be designed to accommodate passenger cars only. The radius required is 15 to 30 feet.

At major gates with many visitors or trucks, where vehicles must quickly get out of the main traffic flow to stop for security checks, large turning radius (l00 to 300 feet) and a separate turning roadway should be used. This will reduce accident potential and severity, as well as preserve the free flow of traffic.



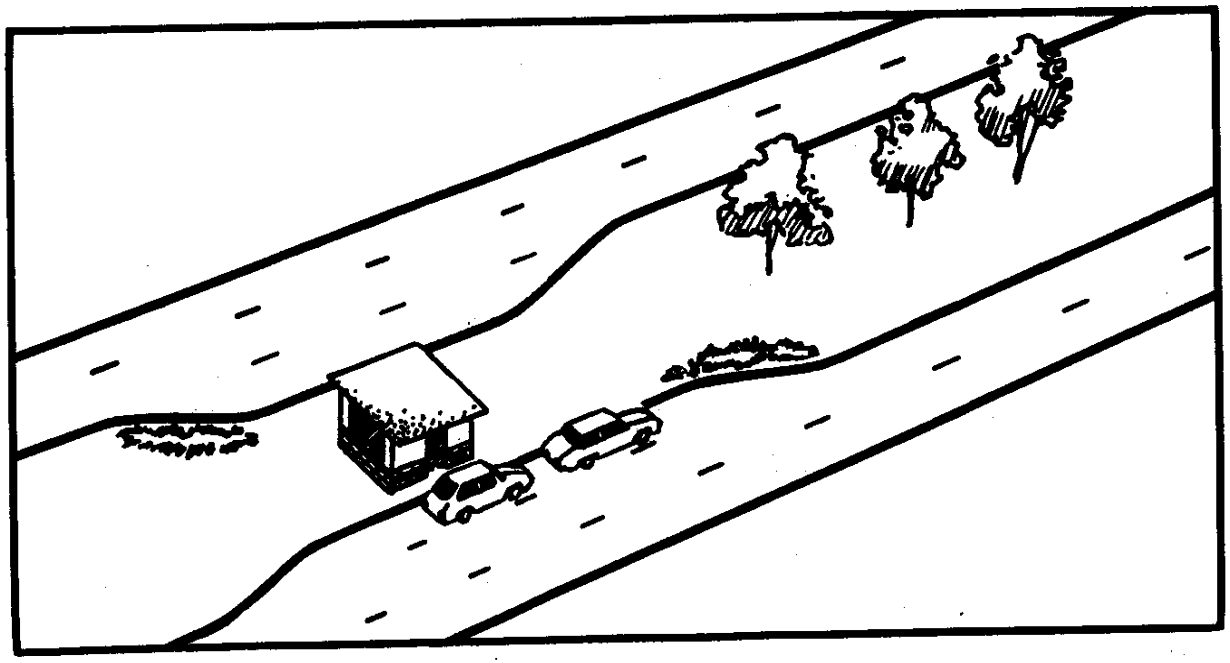


PARKING TURNOUT

Angle parking adjacent to the through lanes, or where vehicles must back into the through lanes, **should never be used.** Parking or stopping in the through lanes at a gate also can cause congestion and accidents. In addition, parallel parking adjacent to the through lane at a busy gate can cause backups and accidents.

To avoid these problems at a low-volume gate, a **visitor turnout should be used.** It should be large enough for at least two vehicles. At higher volume gates, an **off-street visitor parking lot should be provided.**

LOW VOLUME GATE



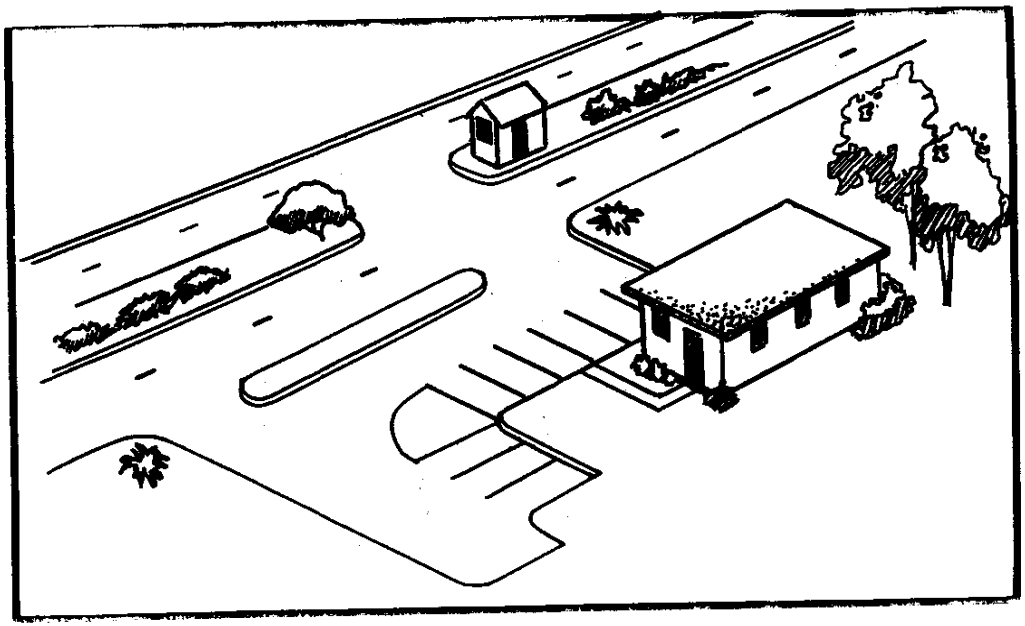
PARKING LOTS

If often more than two visitors will be at the gate simultaneously, or if visitors must park their vehicles to obtain passes, a separate parking lot with an access driveway should be used.

Parking should be provided as close as possible to the visitor center or gatehouse to minimize walking distances and pedestrian interference with traffic. Such interference not only is dangerous to both parties but reduces the efficiency of operation. In some cases, such interference cannot be avoided and, where volumes warrant, sidewalks should be provided.

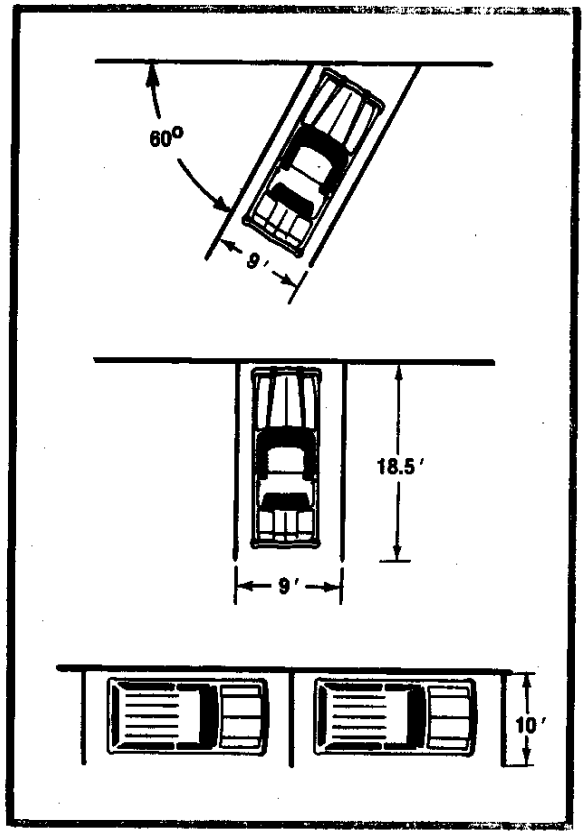
LOCATE VISITOR AND TRUCK PARKING IN AN AREA PHYSICALLY SEPARATED FROM THE THROUGH ROADWAY AND NEXT TO PASS OFFICE

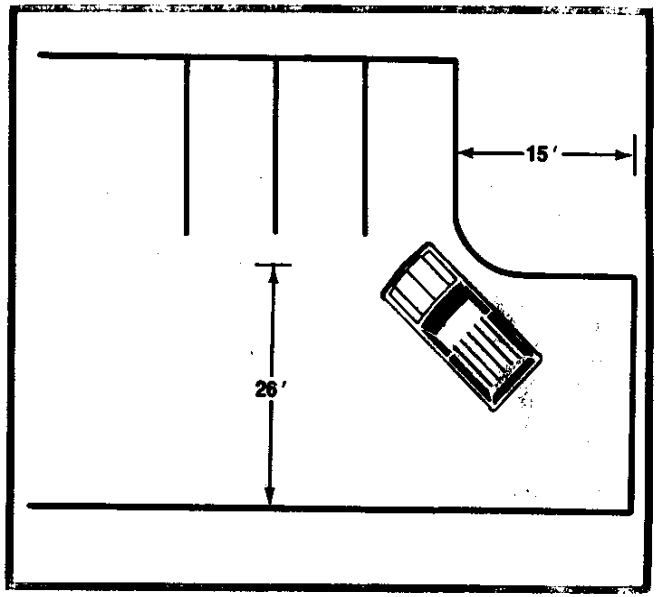
HIGH VOLUME GATE



PARKING SPACES

Parking should be made convenient and comfortable rather than cramped. Accident potential in parking areas is high due to close clearances. Bare minimum dimensions merely aggravate the situation. In a small parking lot, desirable dimensions require little extra space and make a noticeable difference in operation and safety.



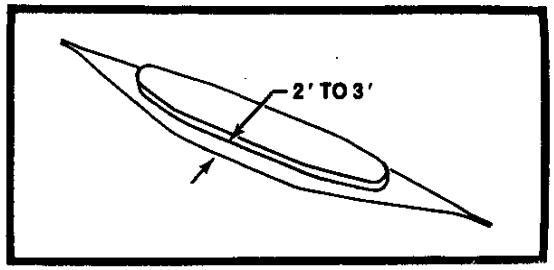


USE STANDARD-SIZE PARKING STALLS
IN PARALLEL, 90-DEGREE,
OR 60-DEGREE CONFIGURATION

CHANNELIZATION ISLANDS

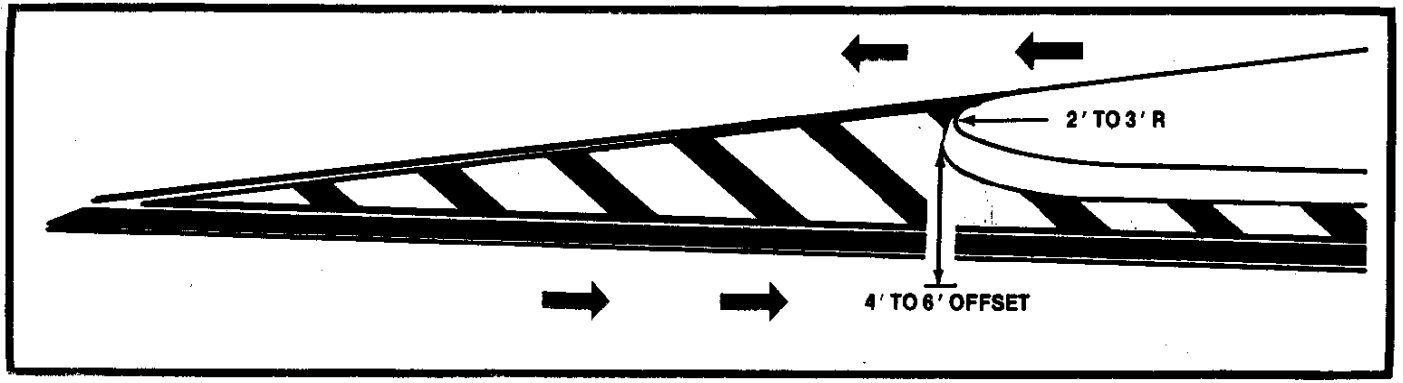
The proper paths through or around channelization islands should be readily visible, especially at night or in adverse weather. Islands should be of contrasting color and texture from the surrounding pavement and should be well marked.

Size of the island determines visibility to a great extent, so certain minimums should be observed.



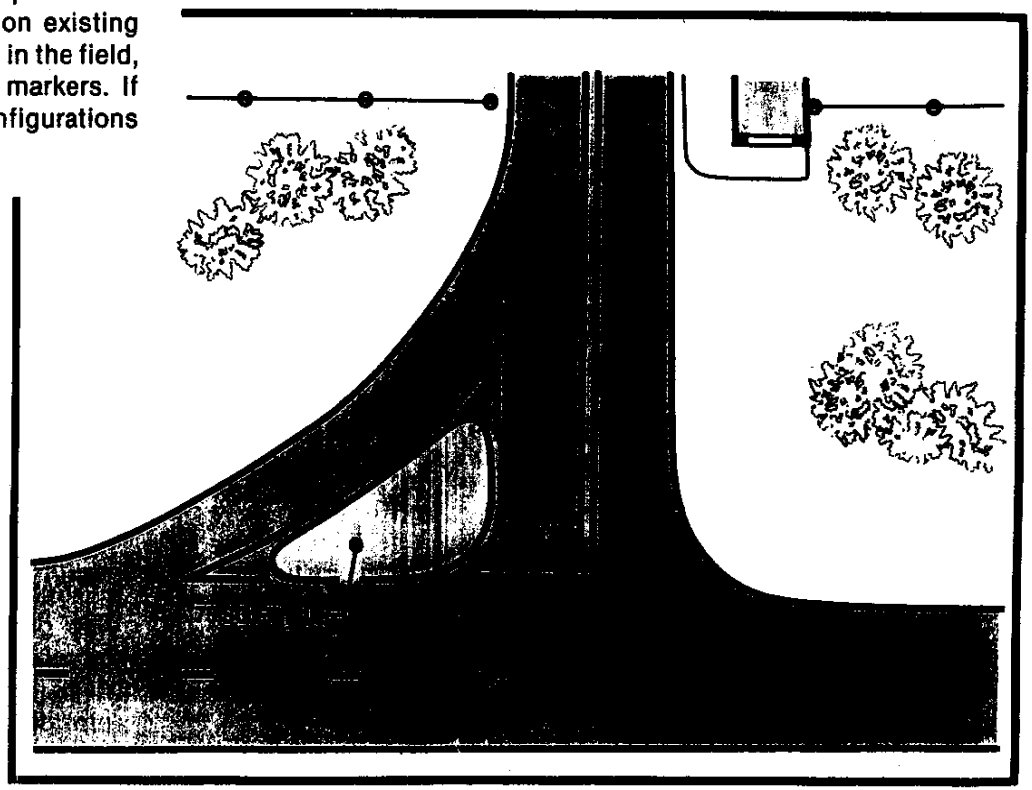
Raised islands generally are more visible than painted islands, but they also are physical obstructions. They should be offset **2 to 3 feet** from the roadway to minimize vehicle contact and enhance driveability.

The island curb to the right of the approach lane should be tapered to deflect traffic in the diverging direction and should be offset 4 to 6 feet from the diverging lane. Diagonal striping should be applied and, if desired, road surface texture should be changed by adding raised buttons or rough pavement.



Islands should be placed to provide travel paths that are obvious and continuous, not hazards. It is best to make island patterns as simple as possible. Usually, this is done by using a few carefully placed medium-size islands rather than many minimum-size islands. What may look good on paper in the planning stages may be totally confusing at ground level.

Since islands occupy roadway space that would otherwise be used by vehicles, they can be dangerous if placed improperly. Where new islands are to be placed on existing roads, it may be desirable first to test the islands in the field, using cones or other high-visibility temporary markers. If placements are found to be suboptimal, new configurations can be tried until the best ones are found.



MINIMUM AREA OF AN ISLAND - 75 SQUARE FEET

PAVEMENT SURFACE

Due to highly variable traffic and control conditions, rear-end collisions are common at entrance gates. A driver's ability to stop short of collision is improved if skidding or loss of vehicle control can be avoided.

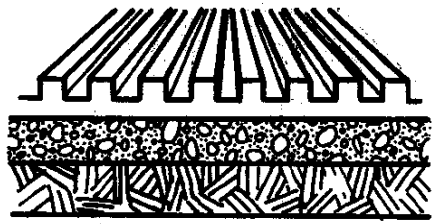
So, in pavement design, it is important to **insure proper pavement mix specifications to prevent bleeding, provide adequate drainage, and insure surface durability under design traffic.** Worn pavement should be restored by **applying a chipseal or coarse mix overlay** to increase the number of drainage voids and the friction coefficient of the pavement.

FIRST RAIN CAUSES SLICK, OILY COATING ON PAVEMENT

Most dry pavements provide adequate skid resistance at most speeds encountered in gate areas. However, this adequacy can be drastically reduced by:

- **Dirty or polished pavement**
- **Flushing or bleeding of asphalt**
- **Inadequate drainage**

PAVEMENT SAW-GROOVES ENHANCE DRAINAGE AND LATERAL STABILITY

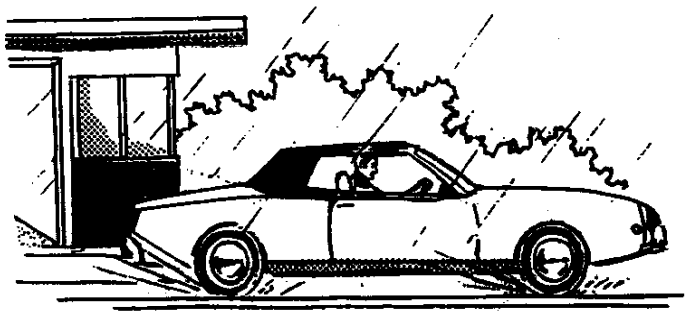


Saw grooving on portland cement concrete pavement can be effective, whereas, asphalt tends to heal the grooves in itself. Longitudinal grooving increases skid resistance by providing lateral stability and drainage. But, it should not be considered a substitute for a skid-resistant mix design.

DRAINAGE

Good roadway drainage is important to efficient gate operation. Standing water or icing in a gate area increases accident potential, causes traffic to slow down, and reduces gate capacity and guard efficiency.

For cold-weather areas, a crowned slope, rather than a single slope, should be used on each side of a divided roadway. Although a crowned slope complicates intersection design and requires nearly twice as many drainage facilities, it prevents dangerous ice buildup where snowmelt on the median runs across the entire roadway.



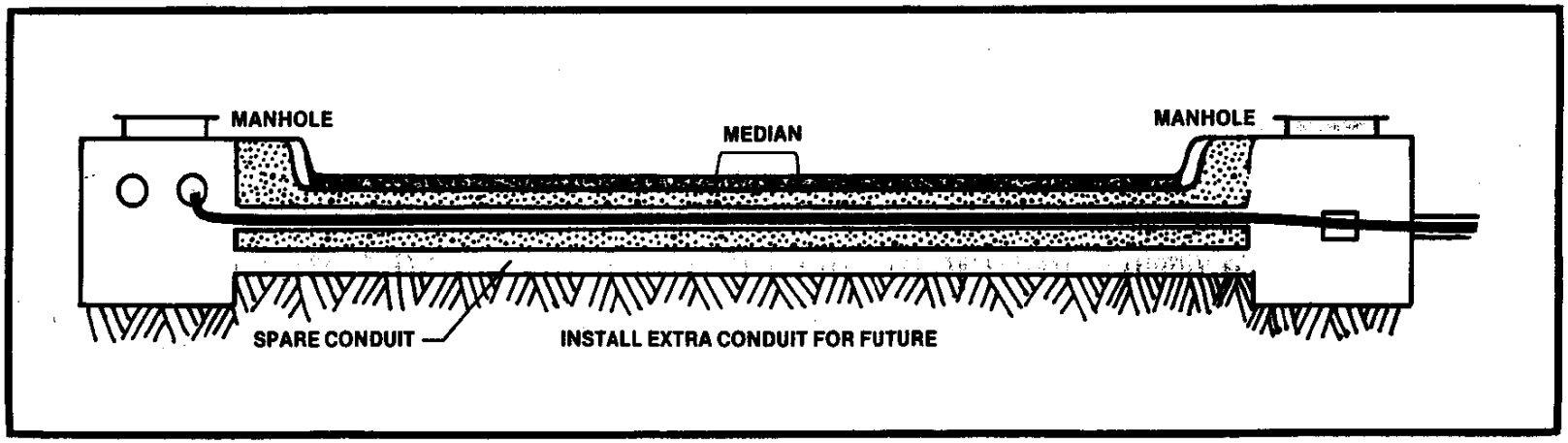
PROVIDE GOOD DRAINAGE

Cross slope of pavement should be 1/8 inch to 1/4 inch per foot

UTILITY LOCATION

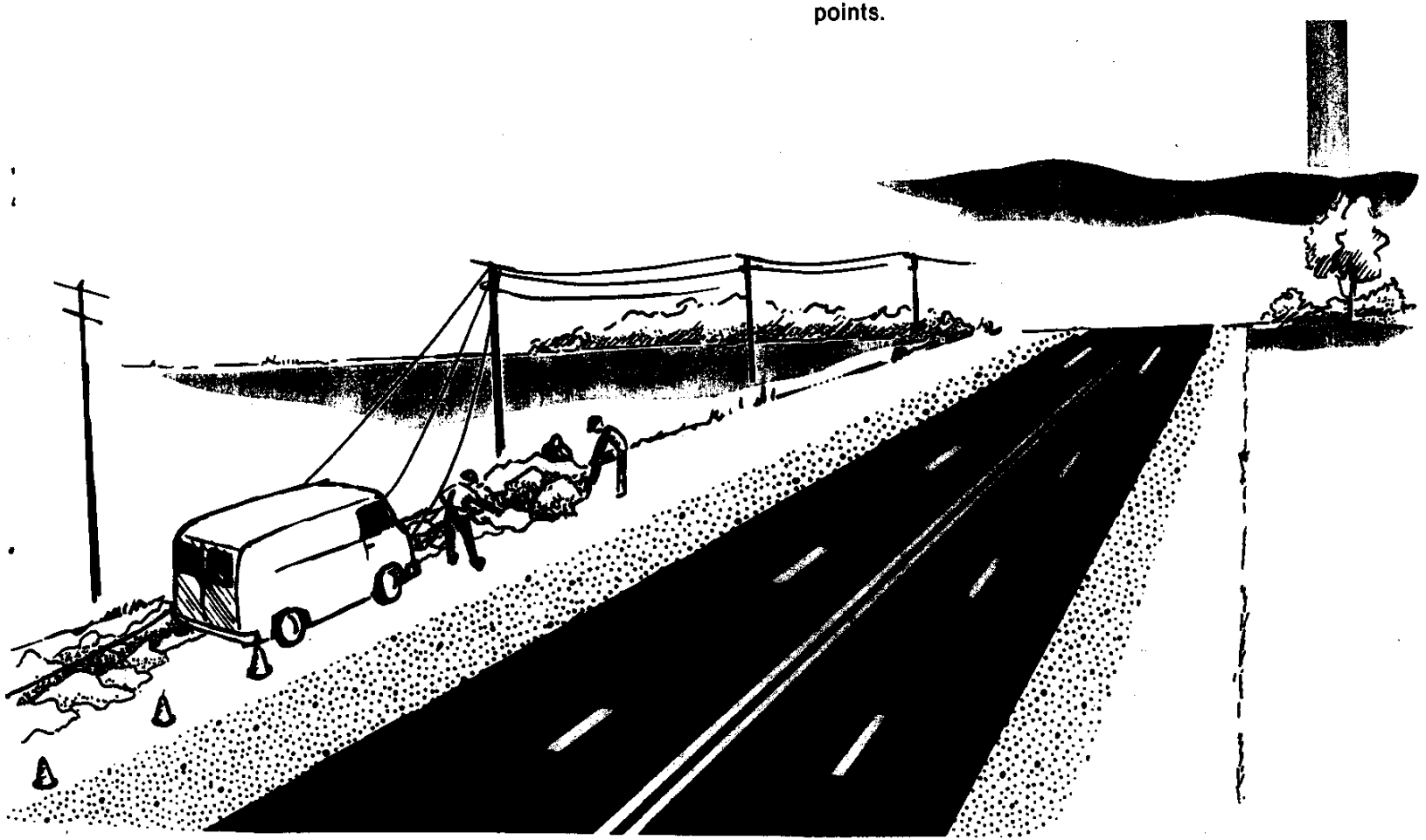
Sharing roadway right-of-way (ROW) by underground utilities is common practice. Once the roadway is in place, adjustment of utilities will disrupt traffic. This can be a serious problem when a gate access is disrupted; a gate access often is one of the most congested and critical routes on an installation and often has poor or no alternate routings available. Such utility adjustments can cause long-term severe delays because of the piecemeal approach needed to provide service during construction. The problem should be anticipated in the gate design stages of the project. For example, when installing a communications conduit bank, an extra conduit for future use can be installed at a fraction of what it would cost to tear up the road for later installation. Also, use of special low-maintenance joints under pavement sections can help avoid future problems.

KEEP MEDIAN FREE OF UTILITIES



LOCATE UTILITIES OUTSIDE CLEAR ZONE OR UNDERGROUND

Utility poles, other than breakaway lighting standards, should not be placed in medians or islands, especially in narrow ones. They should be located outside the roadway clear zone. If possible, utilities should be located underground to improve the appearance of main entrance points.

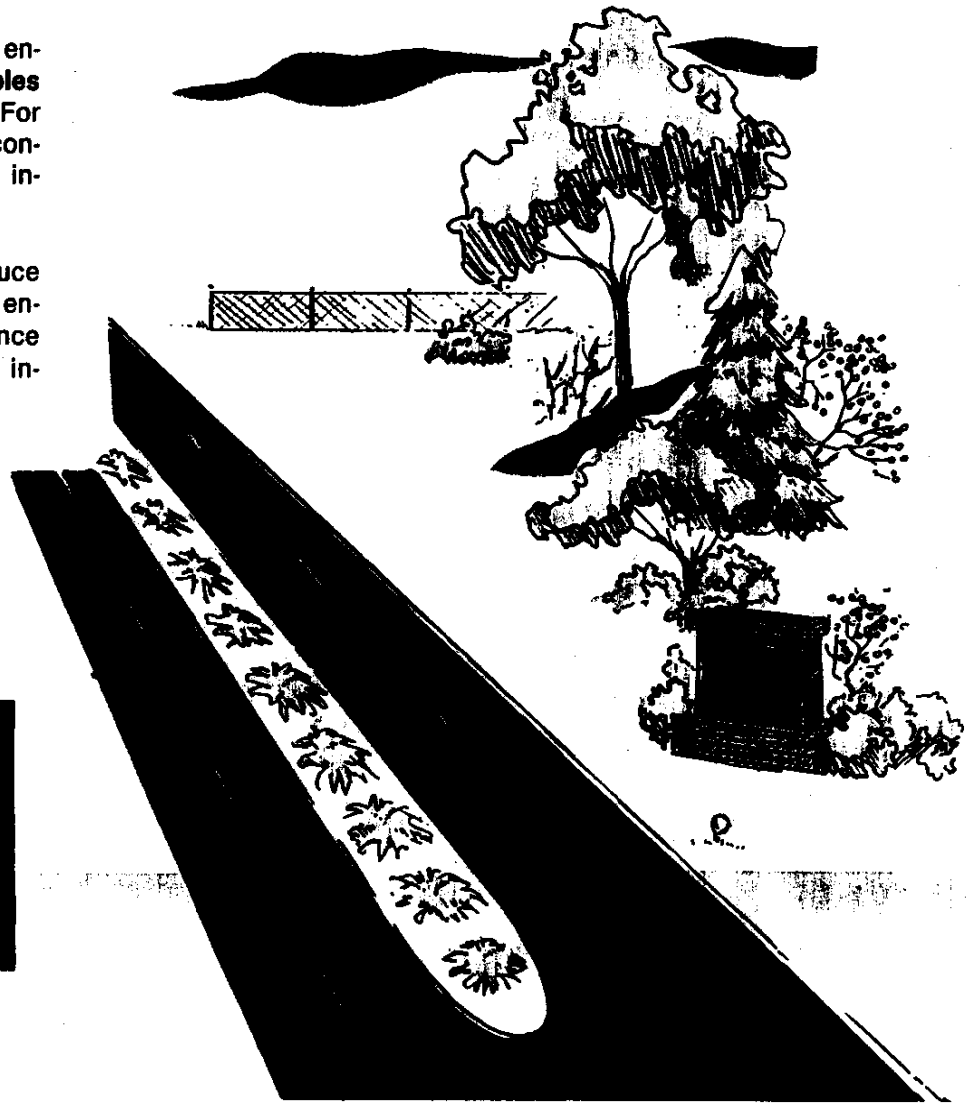


LANDSCAPE

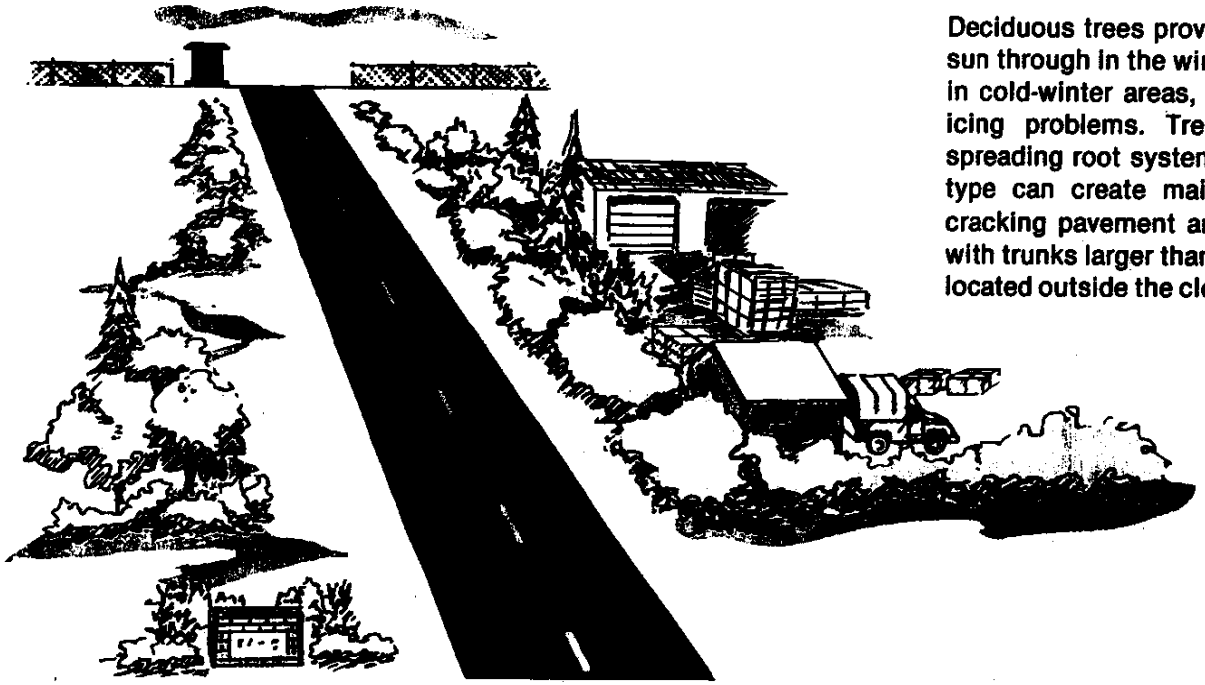
To integrate the gate and approach highways into the environment in the best way, **landscape design principles should be considered during all design phases.** For aesthetic and safety benefits, landscape should not be confined to the gate vicinity but should continue into the installation.

Landscaping protects the land from erosion and can reduce roadside maintenance requirements. It also can make an entrance gate aesthetically pleasing, which is important since often this contributes to a visitor's first impression of installation facilities.

KEEP . . .
- NATURAL SURROUNDINGS
- AN OPEN FEELING
- SAFETY IN MINE
- TRAVEL WAY, CLEARLY DEFINED



The landscape architect should work closely with the gate design engineer in order to provide multiple uses for landscape designs as well as to improve the environment. For example, plantings can be useful in screening housing and opposing traffic from headlight glare. Also, they can be used to prevent driver distraction by screening activities near the road or to improve aesthetics by blocking unsightly areas. Often property involved is privately owned, and installations must cooperate with local agencies to implement improvements.



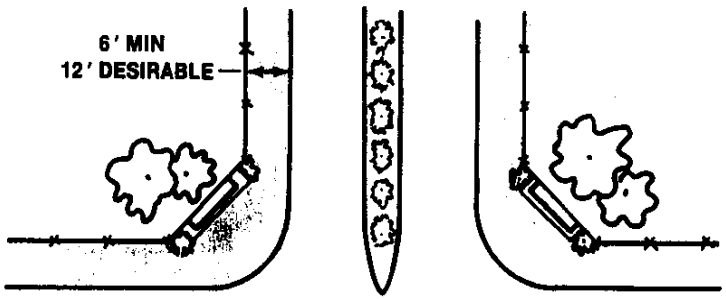
Deciduous trees provide road shade in the summer and let sun through in the winter. They are preferable to evergreens in cold-winter areas, since shade in the winter can cause icing problems. Trees that have taproots rather than spreading root systems should be selected. The spreading type can create maintenance problems when roots lift, cracking pavement and clogging drainage systems. Trees with trunks larger than 4 inches in diameter should be cut or located outside the clear zone.

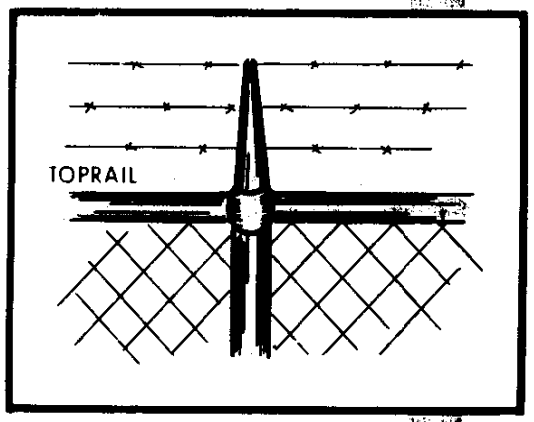
FENCES

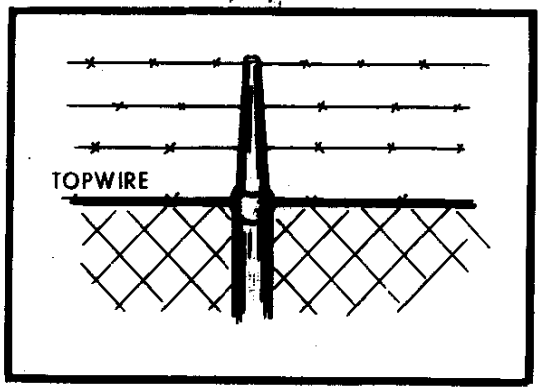
Fences, for either security or decoration, **should not obstruct the sight distance of either the guard or the driver.** Even at the expense of having some Government-owned land in an unsecured area, fences should be located so that good visibility is maintained for drivers, pedestrians, and gate personnel.

For smooth traffic flow, fence end posts should be located at least **6 feet** from the travelway and protected by a curb or barrier (see Lateral Clearances). At gates without curbs, they should be at least **12 feet** from the lane edge. Whenever security regulations permit, a topwire instead of a toprail should be used on fences paralleling the roadway. Toprails, when broken, can act as a spear and pierce a vehicle.

At intersections, especially unsignalized ones, fences should be set back from the corners so as not to obstruct sight distances. Not only will this help drivers to see oncoming traffic, but it will enhance the operation and appearance of the intersection.







What details should be considered in designing a gatehouse and its immediate area?

Where should a gatehouse be located?

Chapter 4

GATEHOUSE DESIGN

Gatehouse design will vary with location, intended function, and required security, as well as with each Service requirement and with installation architectural standards. A gatehouse can be located between lanes, in the median, or to the side of the roadway. Also, it can be a main or an auxiliary gatehouse and operated for 24 hours, limited hours, cars only, truck entry/exit, visitor, high-security, medium-security, information only, night security only, and so on.

DESIGN GATEHOUSES
TO MEET REQUIREMENTS
AND COMPLIMENT
LOCAL ARCHITECTURAL MOTIF

A gatehouse should be just large enough for its intended use. In general, three sizes of gatehouses are built:

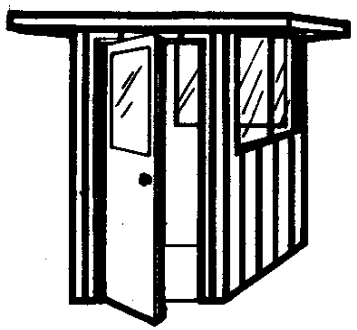
SMALL (4 feet x 4 feet)*, for peak-hour operation only

MEDIUM (6 feet x 8 feet)*, for 10- to 24-hour operation, with occasional visitors or trucks

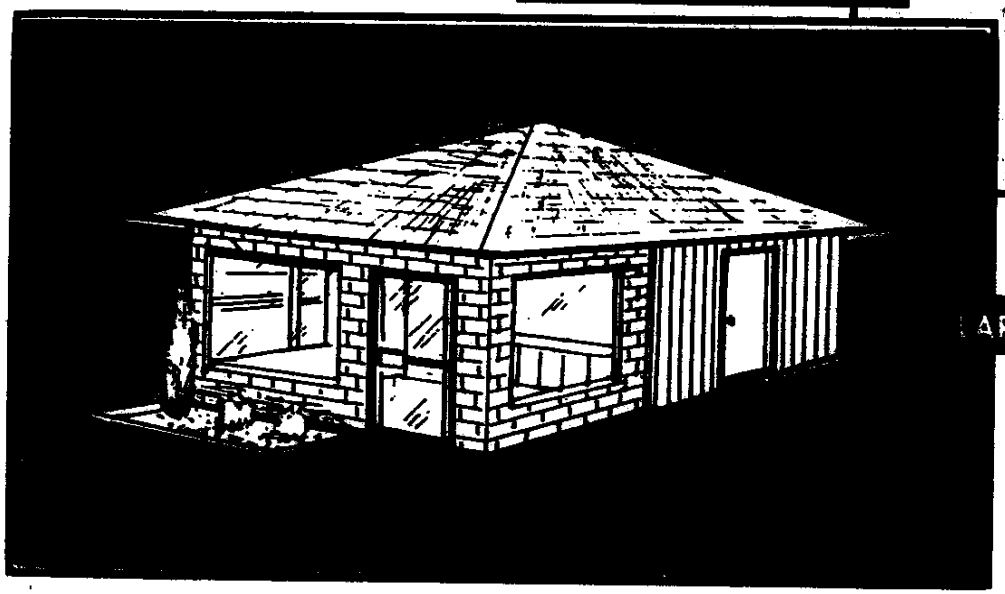
LARGE (8 feet x 20 feet)*, for 24-hour operation, with integral visitor processing facilities

***These dimensions are to show relative sizes only.**

SMALL GATEHOUSE



MEDIUM GATEHOUSE



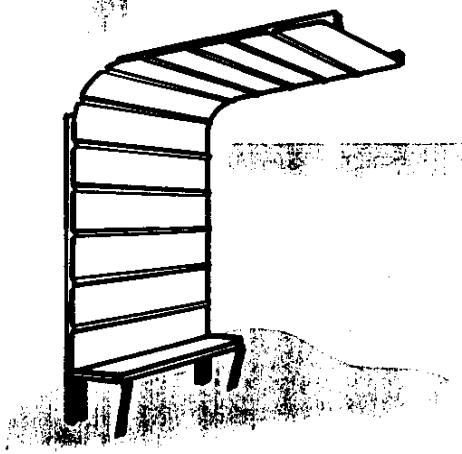
ARGE GATEHOUSE

SMALL GATEHOUSE

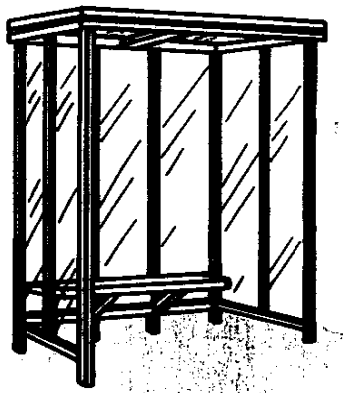
A small gatehouse can be simply a shelter, a canopy, or an enclosure to protect the guard and to provide space for comfort and for processing visitors and trucks. Such facilities increase visibility of guards in places where the guards might be in danger of being struck by vehicles.

A gatehouse needs only to be large enough for its intended purpose. Sanitary facilities are not needed.

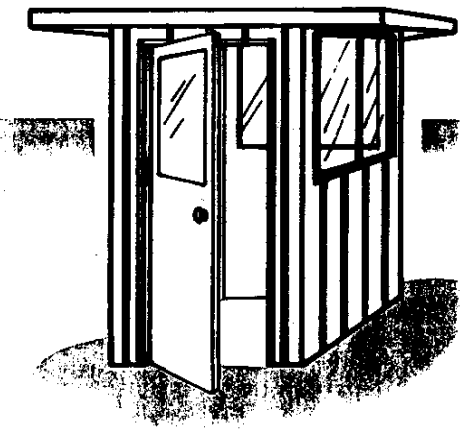
SHELTER



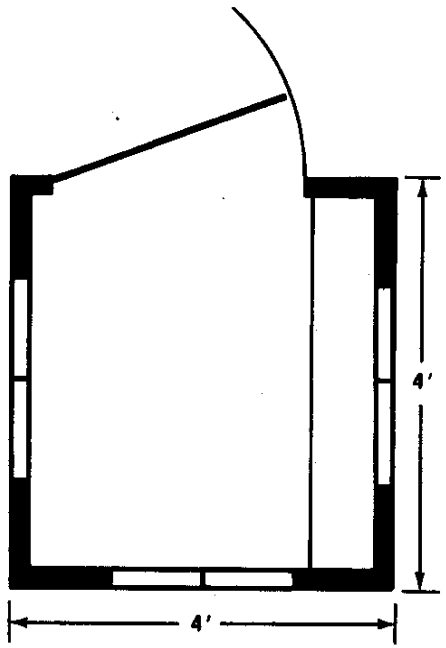
CANOPY



ENCLOSURE



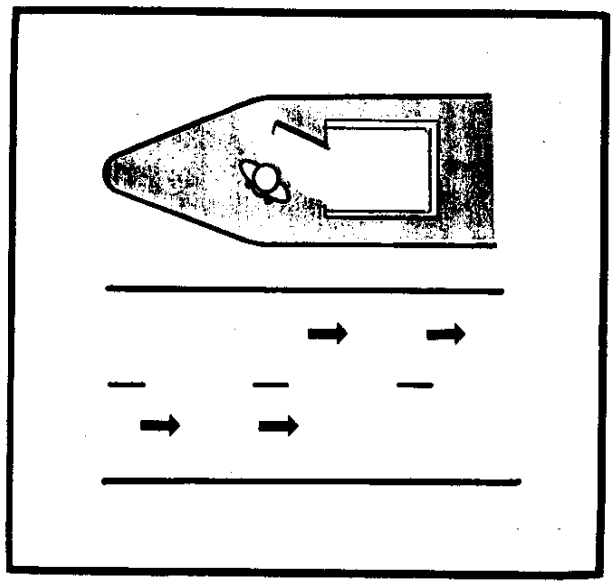
SMALL GATEHOUSE PLAN



Required visibility around the local area from the gatehouse is 360 degrees, so that the guard can see and be seen. Also, eaves should be constructed in a manner to protect the guard from rain, sun, and snow. However, care should be taken so that the eaves will not be clipped by trucks or other high, wide vehicles.

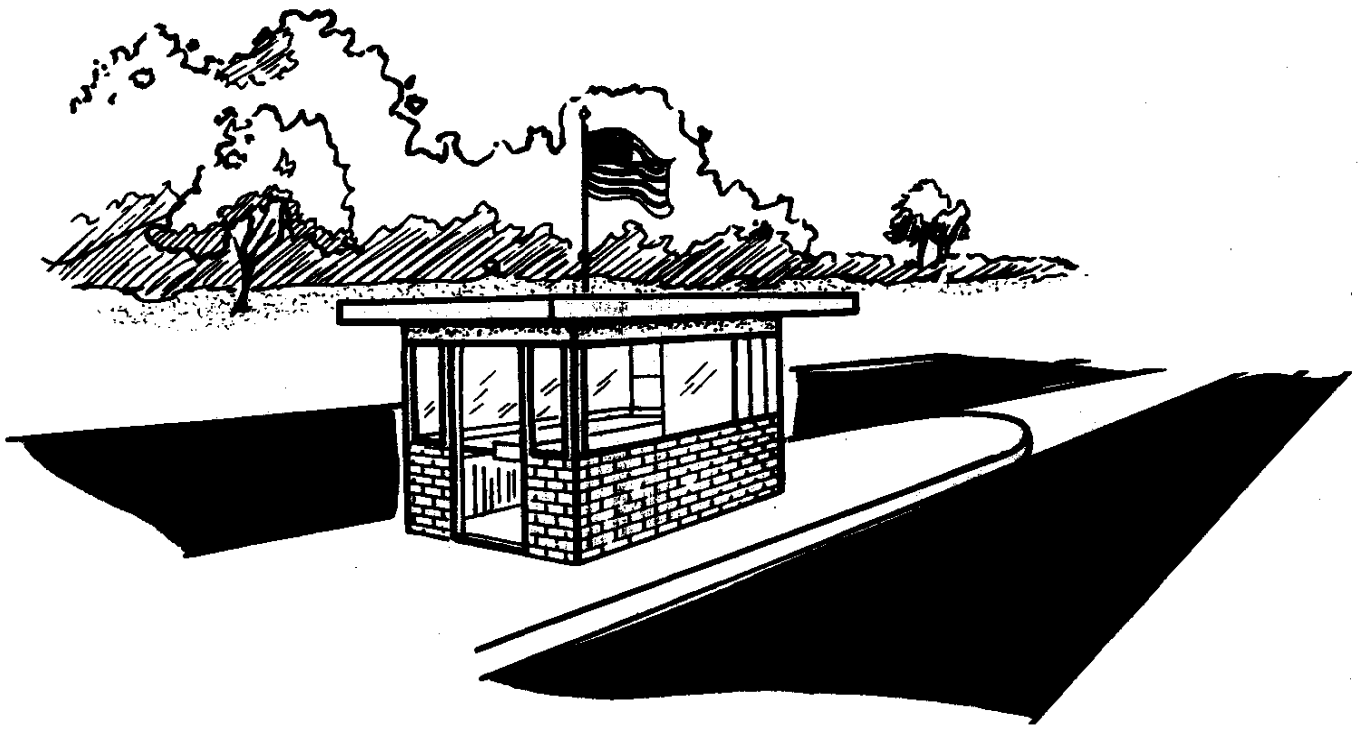
When a gatehouse is used on a small island as an auxiliary gatehouse and its door faces the lane, a 2-foot-wide platform is needed for guard mobility.

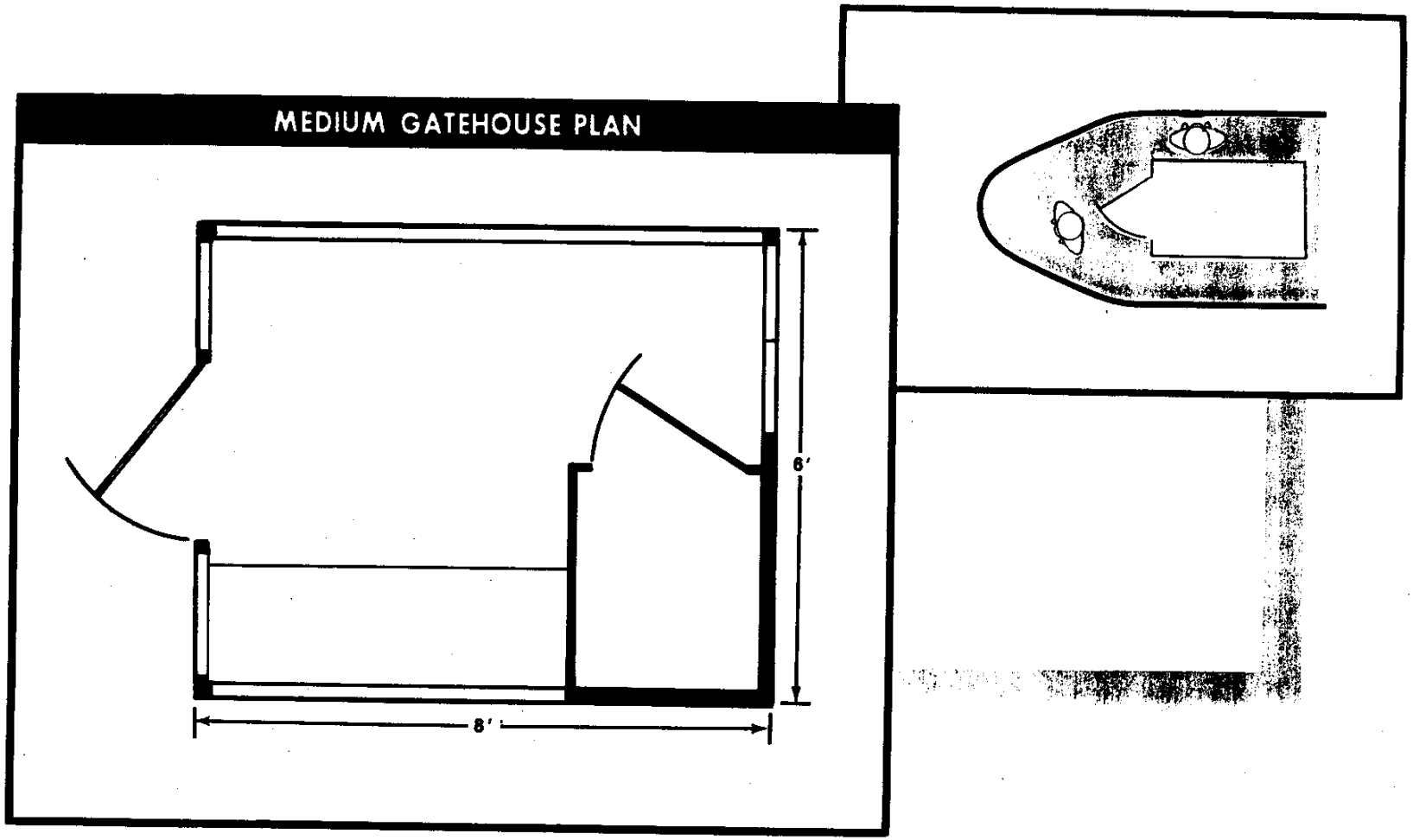
When lateral clearance is restricted, the gatehouse door should face the end of the island. The guard would stand between the gatehouse and the end of the island.



MEDIUM GATEHOUSE

The medium gatehouse is a fully enclosed, heated, and air-conditioned structure to provide long-term comfort to guards. Lighting, counter and storage space, tinted windows, and visitor processing space are also desirable. Unless 360-degree visibility is necessary, sanitary facilities should be included.

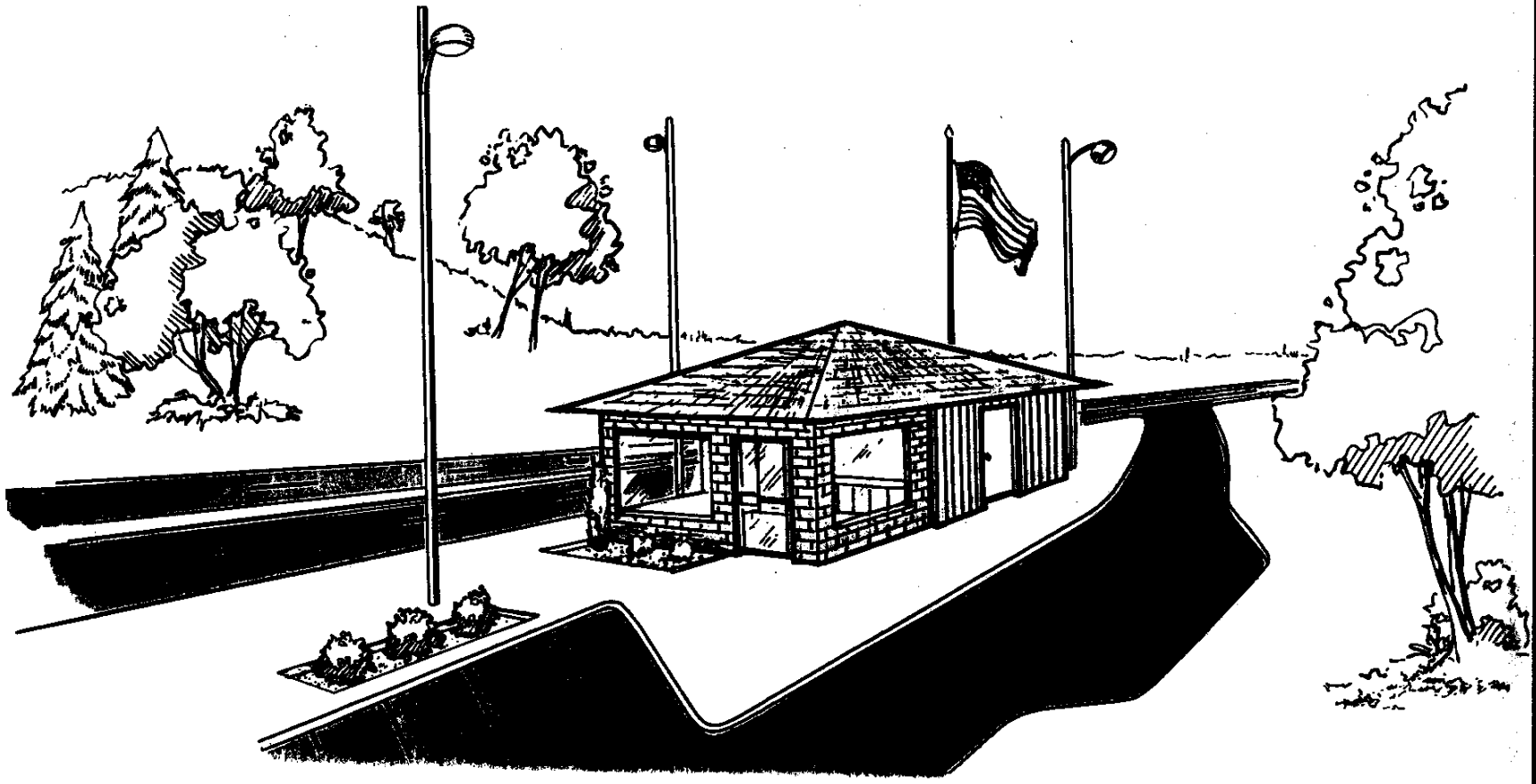




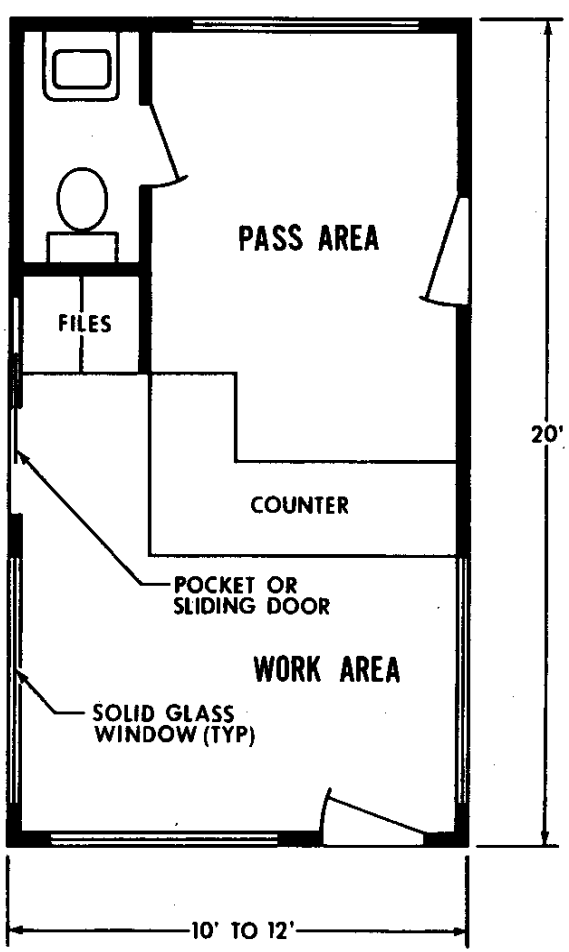
When the gatehouse is used on an island that separates opposing traffic, its door should face the end of the island. This allows the guard freedom of movement outside the door and requires less platform width and, consequently, less overall island width — an important consideration where space is at a premium. Where space is ample, or on roadside locations, the door orientation is not critical.

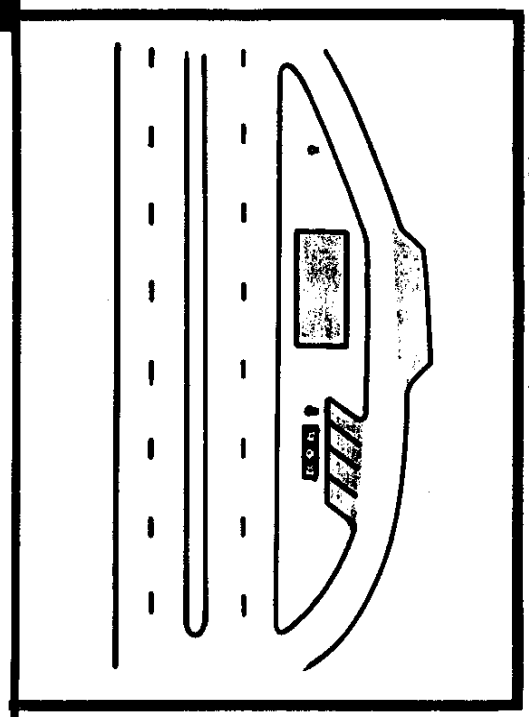
LARGE GATEHOUSE

A large gatehouse combines security and high-volume visitor processing capabilities into one structure. This structure normally contains office and sanitary facilities, as well as a visitor waiting room.



LARGE GATEHOUSE PLAN





By placing the gatehouse on the right-hand side of the roadway, instead of on an island that separates opposing traffic, it can be oriented in such a manner that one end can be used to monitor inbound through traffic and the other end, to process visitors on a drive-up or walk-up basis. At night the through lanes can be coned off and all traffic directed to the gatehouse for identification.

Where a median is 26 feet or wider, the large gatehouse and its parking facilities can be located on the left-hand side of the roadway. This requires neither the length nor the width that the same facility on the right-hand side of the road would require. It can also be used to monitor outbound traffic. However, it cannot easily accommodate trucks.

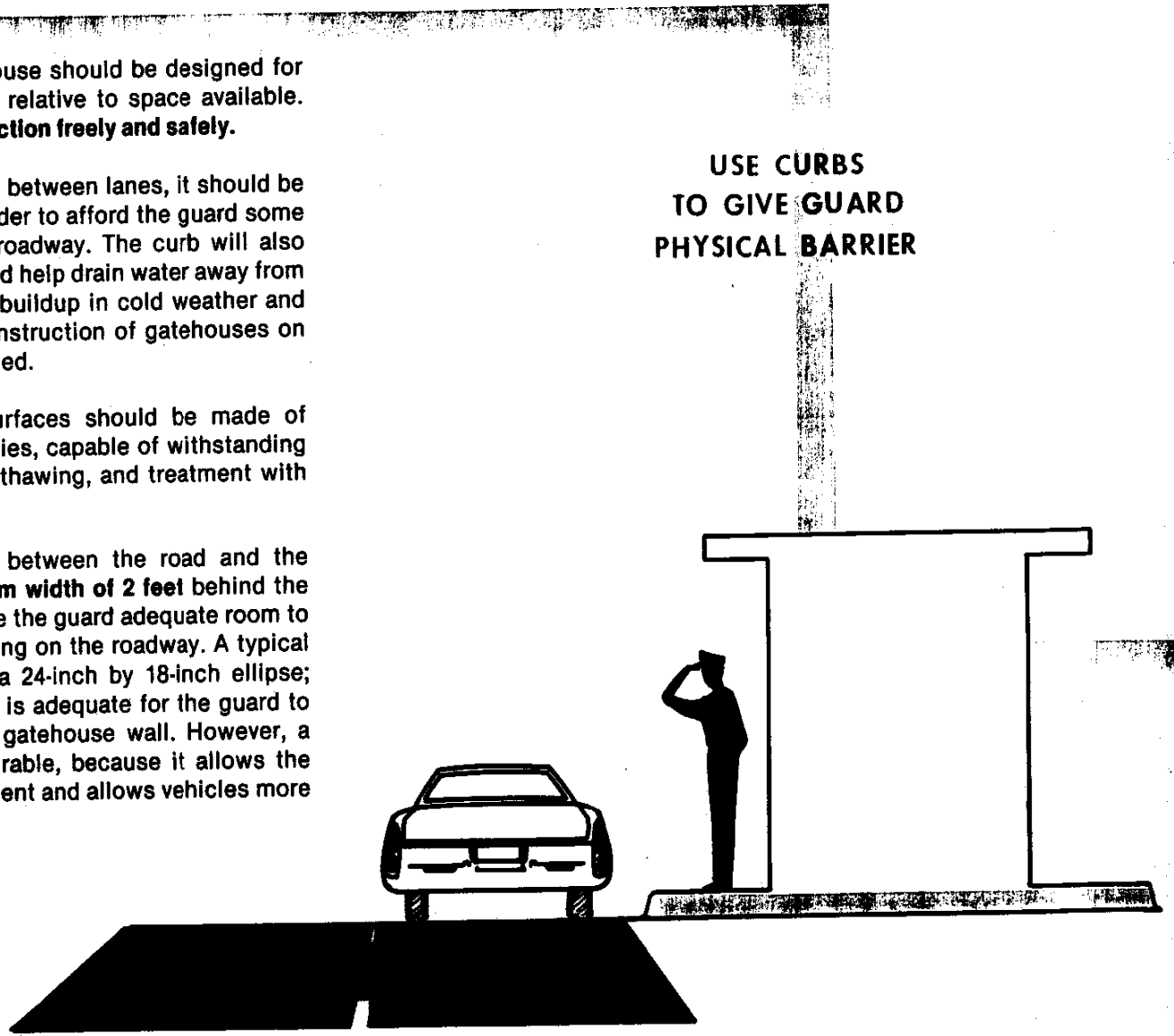
PLATFORM

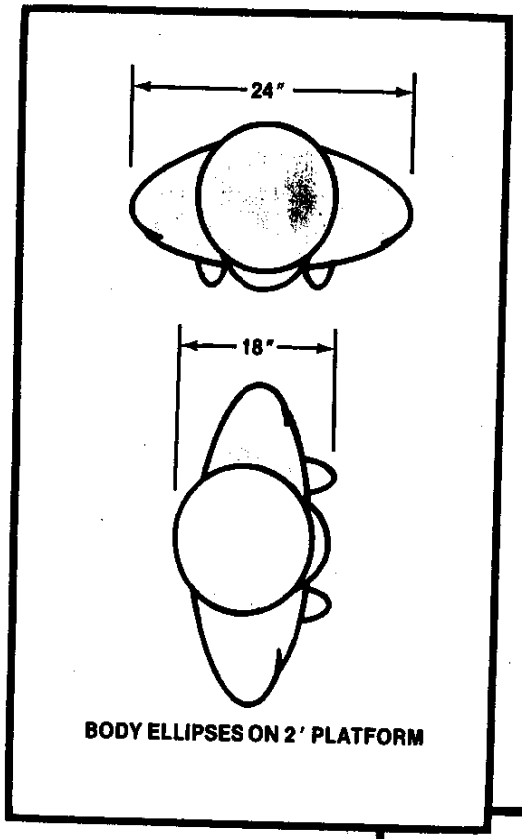
The exterior area of the gatehouse should be designed for the convenience of the guard, relative to space available. **The guard should be able to function freely and safely.**

When the gatehouse is located between lanes, it should be placed on a curbed island in order to afford the guard some physical separation from the roadway. The curb will also make the island more visible and help drain water away from the gatehouse, preventing ice buildup in cold weather and puddling in warm weather. Construction of gatehouses on painted islands should be avoided.

In cold climates, platform surfaces should be made of materials with nonskid properties, capable of withstanding repeated seasons of freezing, thawing, and treatment with deicing chemicals.

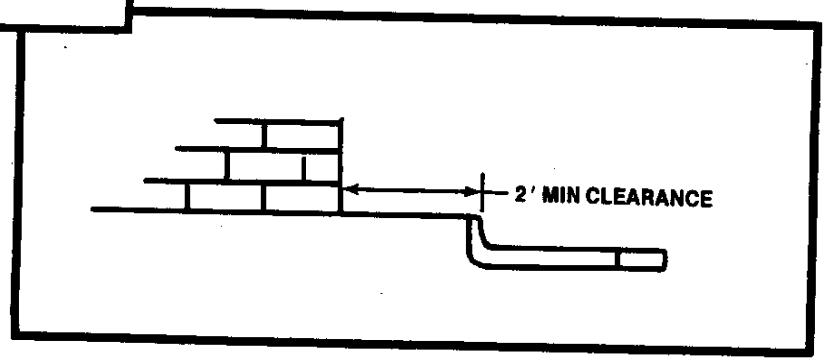
When the guard is to stand between the road and the gatehouse, a **minimum platform width of 2 feet** behind the curb should be provided to give the guard adequate room to move about without encroaching on the roadway. A typical adult male occupies roughly a 24-inch by 18-inch ellipse; therefore, the 2-foot minimum is adequate for the guard to stand in any position by the gatehouse wall. However, a wider platform is always desirable, because it allows the guard more freedom of movement and allows vehicles more lateral clearance.





BODY ELLIPSES ON 2' PLATFORM

When the guard is to stand at the end of the gatehouse to enforce strict security measures, the gatehouse can occupy the entire island width from face-of-curb to face-of-curb, provided the gutter is of different texture from the travel lane and at least 18 inches wide. This is similar to some tollbooth situations, where narrow lanes and close clearances are used to bring vehicles close to gate personnel and to encourage slow speeds.

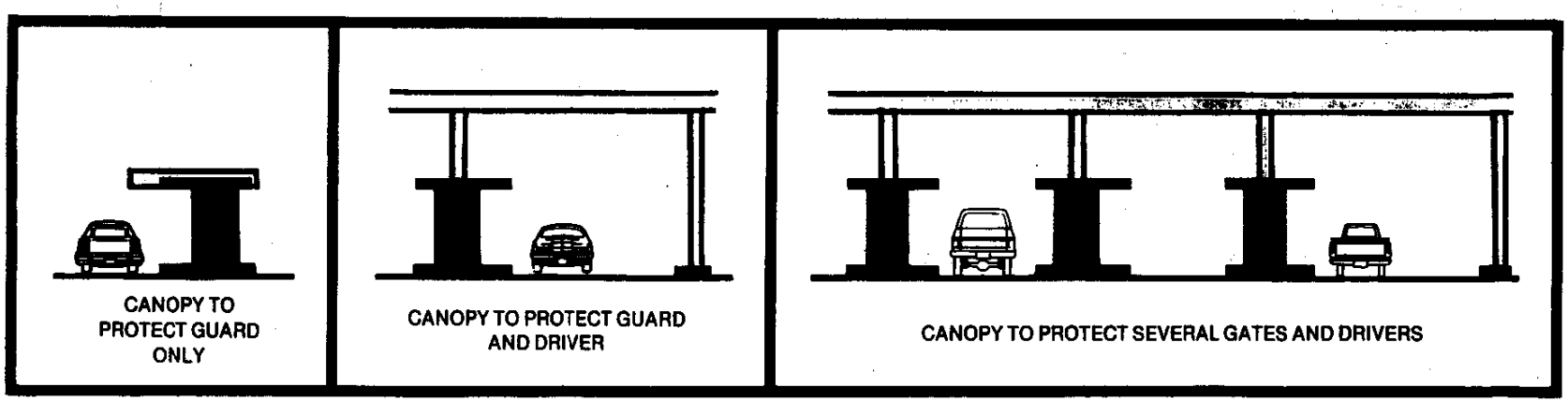


CANOPY

Gatehouse eaves and canopies can be used to **provide outdoor shelter to guards and, sometimes, drivers.** They should be positioned to drain rainwater away from walkways and to give the guard a comfortable working area. Roof drainage should fall outside the guard's work area. This is particularly important in cold weather when snowmelt, if not diverted elsewhere, can cause dangerous ice patches on the platform.

At gates with more than one gatehouse, a large canopy, with a vertical clearance of at least **17 feet** from the pavement surface, spanning the entire entrance, can be used for both weather protection and visual impact. This arrangement, similar to a set of tollbooths, shelters not only the guards but also the motorists.

USE GUTTERS OR CANOPY, WHERE RUNOFF CAN FORM ICE PATCHES



CANOPY TO PROTECT GUARD ONLY

CANOPY TO PROTECT GUARD AND DRIVER

CANOPY TO PROTECT SEVERAL GATES AND DRIVERS

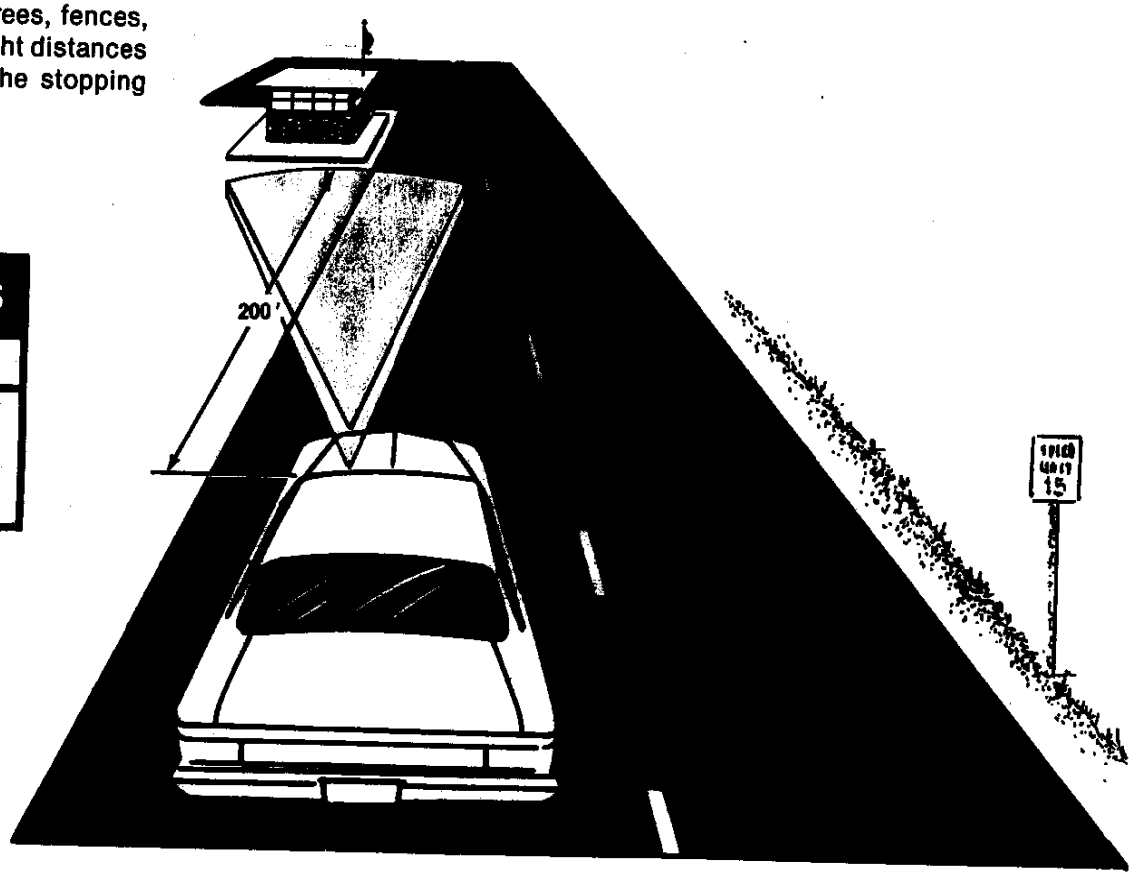
VISABILITY

As a driver approaches the gate area, he looks first for the gatehouse and the guard. The exterior color of the gatehouse should be visible against its background, yet aesthetically pleasing. While its tones should complement, and harmonize with, the surrounding scenery, **the gatehouse should be distinctly visible both day and night.**

The gatehouse should not be hidden behind trees, fences, large parked vehicles, or other obstructions. Sight distances should be as long as possible and at least the stopping distance for an average vehicle.

DESIRABLE SIGHT DISTANCES	
MPH	FEET
40	400
30	300
20	200

ARRANGE FACILITIES SO THAT VISIBILITY AND SIGHT DISTANCES ARE MAINTAINED



VISITOR'S PASS RETURN

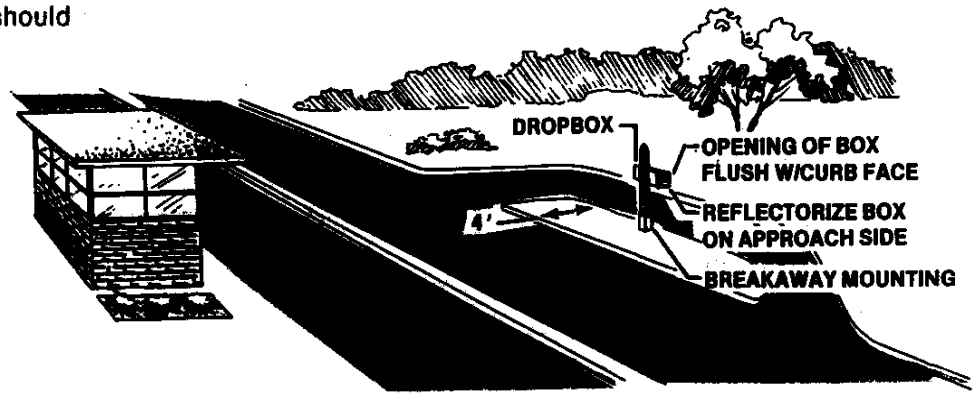
Except at local-service gates (fewer than 2,000 vpd), **a visitor pass should not be returned in a through outbound lane.** Stopping may cause rear-end collisions.

To eliminate the need for outbound vehicle stoppages at the gate, visitor passes should be turned in at the last agency visited. If this is not practicable, a pass-return dropbox must be made available in a separate turn-off lane.

Of primary importance is to get stopping vehicles out of the through lanes. Where a 16-foot or wider median is available, a turnout to the left can be used and is desirable, as no auxiliary island is necessary for the dropbox and the narrower transition requires less taper length and less pavement.

Where the median is not wide enough, the dropbox must be mounted on an auxiliary raised, curbed island between a righthand turnout lane and the through lanes. This island must be at least 4 feet wide with a minimum approach taper of 10 to 1. Length of the turnout lane should be such that most of the deceleration required to stop can be accomplished after the vehicle clears the through lanes. The lane width should be at least 10 feet. Departure taper should be 15 to 1.

LOCATE PASS DROPBOX IN SEPARATE TURNOFF



What kinds of signs, signals, and pavement markings are needed at gates?

Chapter 5

TRAFFIC CONTROL DEVICES

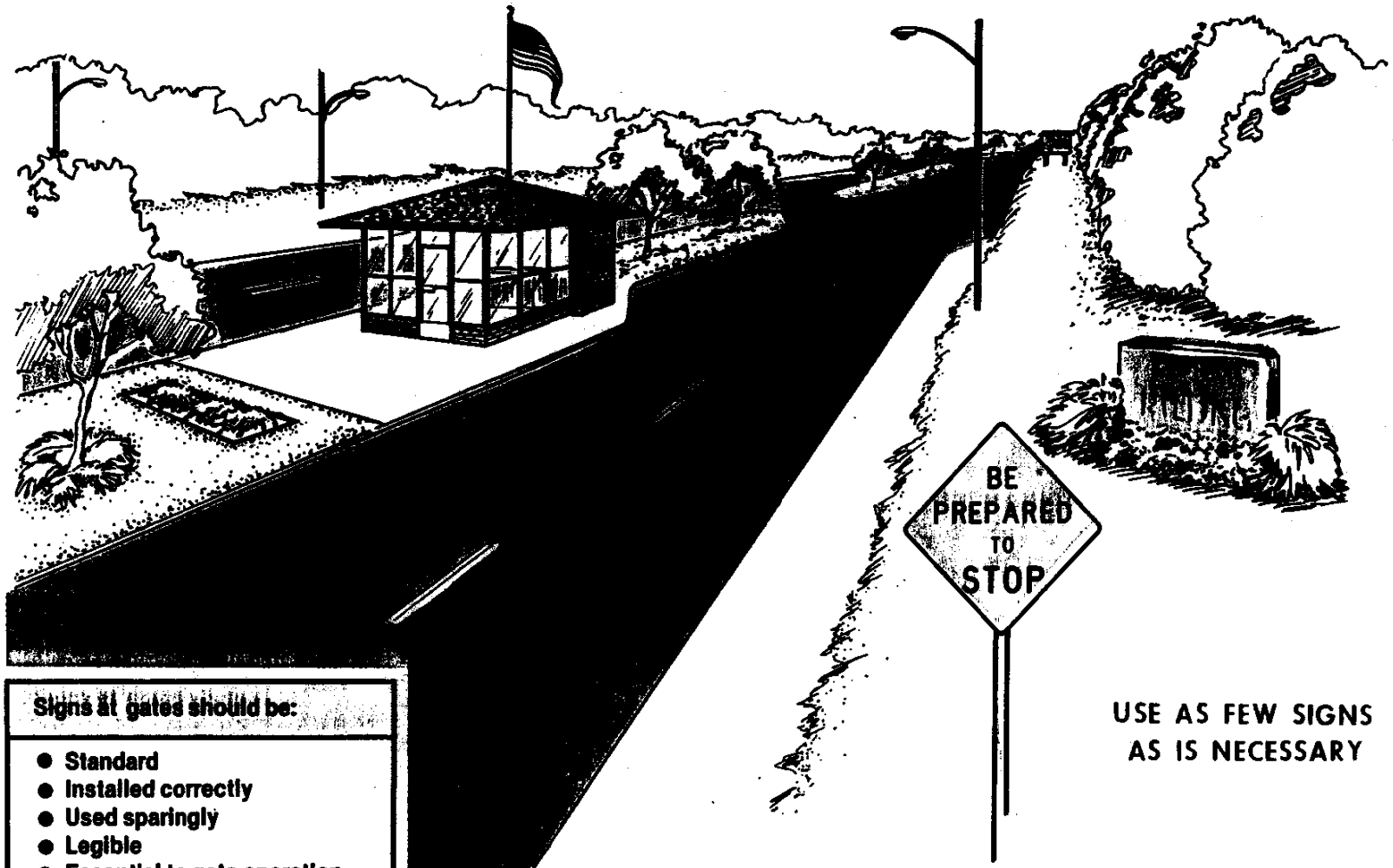
Signs should be placed so that the legend is clearly visible. Also, the location of the sign should permit ample time for the motorist to respond to the message. Excellent visibility of and liberal response times to signs should be assured by sign placement. Normally, signs should be spaced 150 to 250 feet apart to permit only one driving decision at a time. However, gates are a special case, where often several signs are needed at the same location.

Details of sign size, lettering, and placement can be found in MTMC Pamphlet *55-14, "Traffic Engineering for Better Signs and Markings."*

"Traffic signs shall be placed only by the authority of a public body or official having jurisdiction, for the purpose of regulating, warning, or guiding traffic. No traffic sign or its support shall bear any message that is not essential to traffic control," (source *Manual on Uniform Traffic Control Devices, p 24-2).*

ORDER OF SIGN PLACEMENT

- REGULATORY
- WARNING
- NAVIGATIONAL GUIDE
- EMERGENCY SERVICE
- MOTORIST SERVICE
- PUBLIC TRANSPORTATION
- TRAFFIC GENERATION
- GENERAL INFORMATION



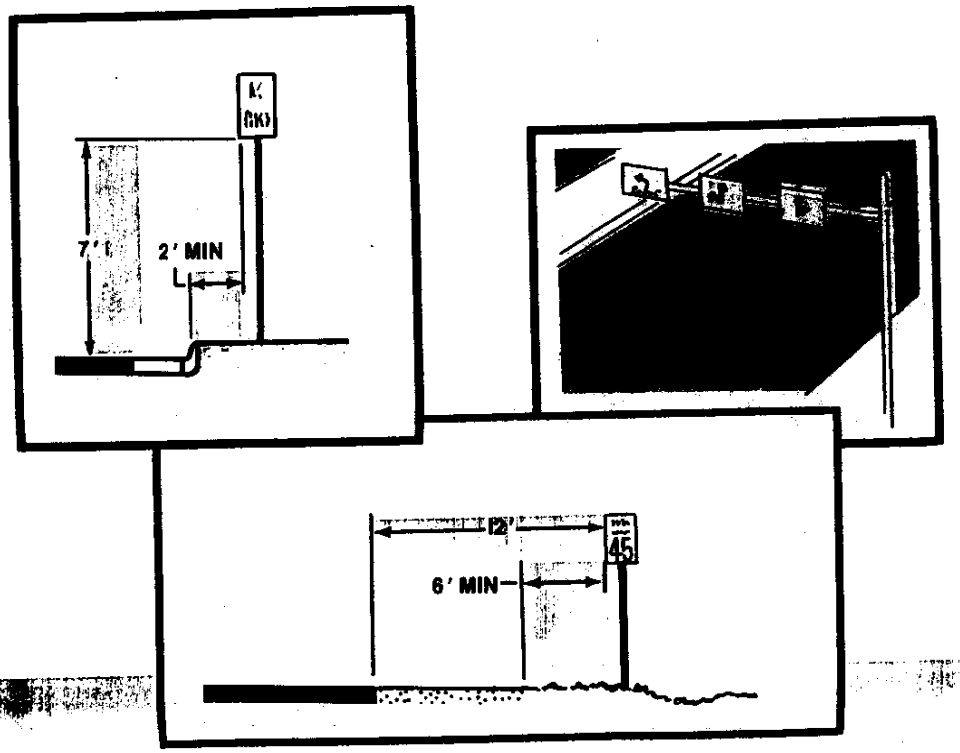
Signs at gates should be:

- Standard
- Installed correctly
- Used sparingly
- Legible
- Essential to gate operation
- Well designed

USE AS FEW SIGNS
AS IS NECESSARY

Signs and their legends should inform drivers without overburdening them. A confused driver is a hazard to both himself/herself and those around him/her. **Irrelevant and ineffective signs not only are costly to maintain properly but also add more fixed-object hazards along the roadway.**

Warning signs such as GATE AHEAD, BE PREPARED TO STOP, and MILITARY GATE are not always heeded or effective. The best warning of a gate ahead is **good visibility** of the gate, both day and night, through good clearances, contrasts, and lighting. Visibility should be the first consideration before extensive use of warning signs is undertaken.



Signs, if not placed behind guardrails, should be offset at least **6 feet from a paved shoulder** or, if none, **12 feet from the outer lane edge.**

In urban or built-up areas, signs should be offset from the face of the curb by a minimum of **2 feet.** Signs should have **breakaway or yielding** supports. More details on sign placement can be found in MTMC Pamphlet 55-12, *Traffic Engineering for Better Signs and Markings.*

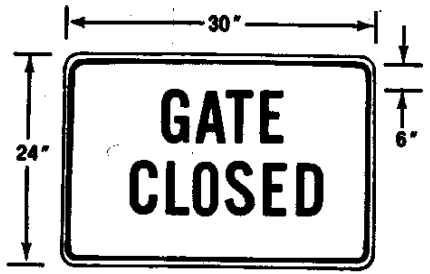
Overhead [illegible]

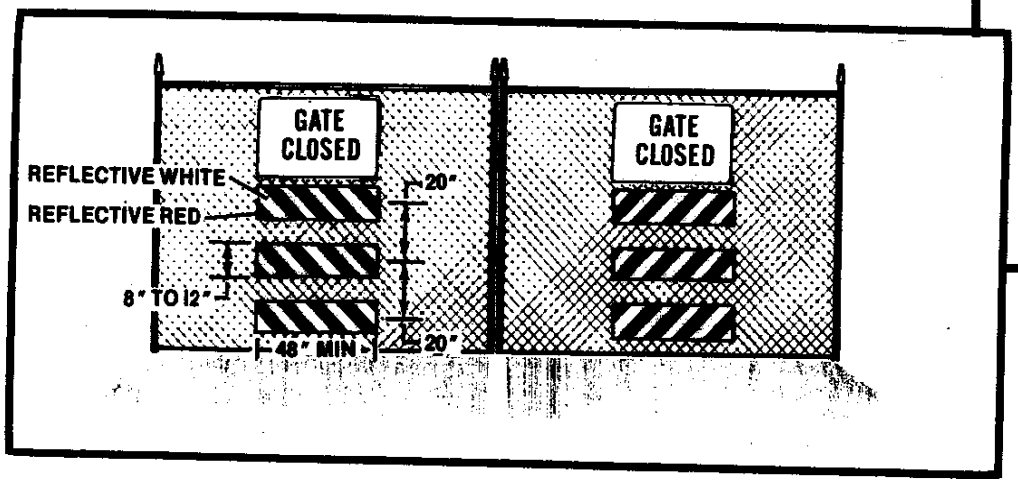
- **Traffic volume is at or near capacity**
- **There are three or more lanes in each direction**
- **Lanes serve different movements or destinations**

REGULATORY SIGNS

Regulatory signs inform drivers of traffic laws or regulations. Typical regulatory signs are STOP, YIELD, Speed Limit, Lane Use, ONE WAY, and Parking.

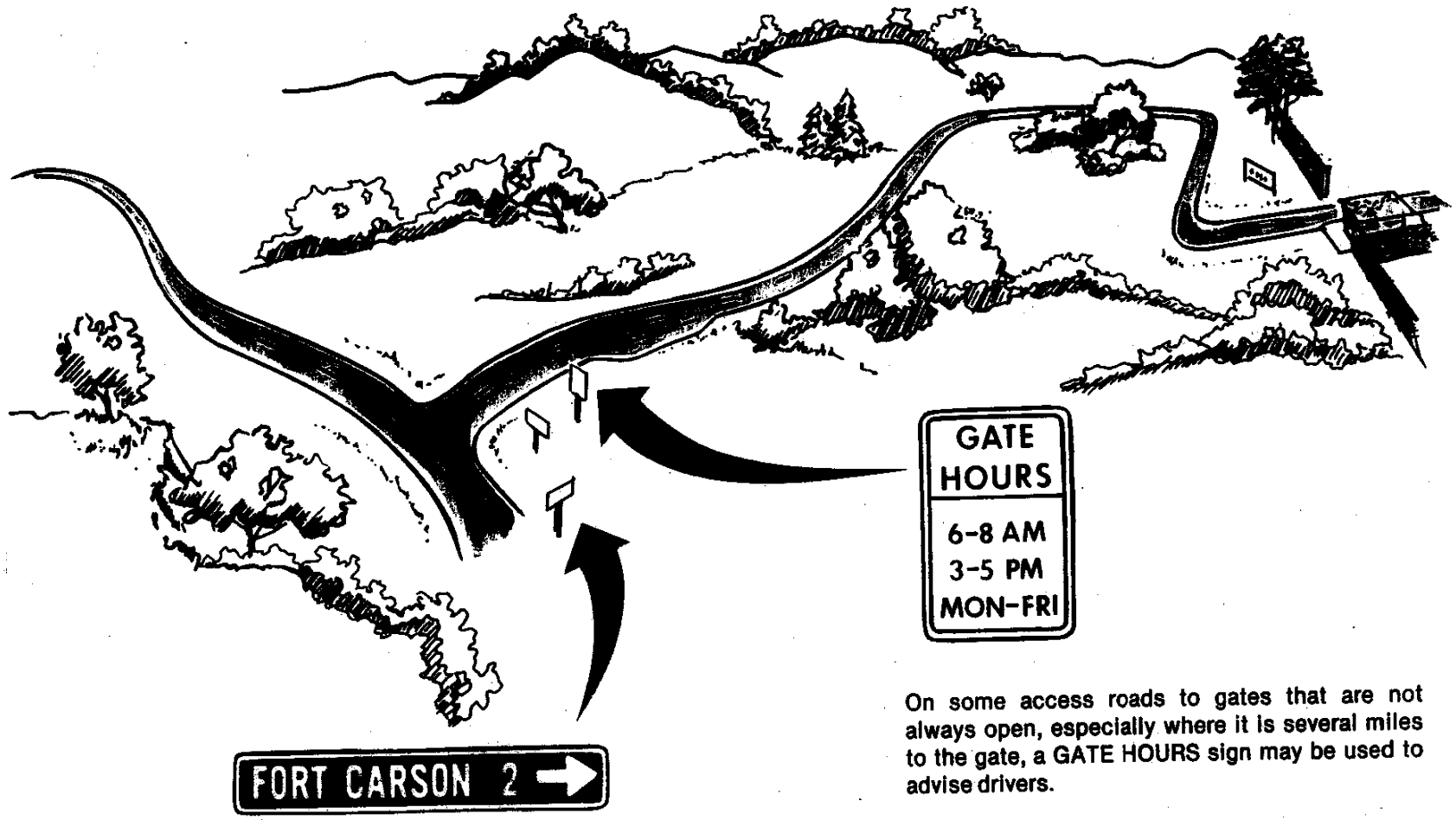
The GATE CLOSED sign should be used whenever a gate is physically closed. An auxiliary sign below the GATE CLOSED sign should show the operational hours if the gate is opened on a scheduled basis.





STOP signs, permanent or portable, **should not be used for gate control unless every vehicle is always required to stop,** such as at high-security gates. For more flexible control, the guard should use manual gestures.

Type III barricades also **should be used to mark closed gates** and should be mounted on both faces of each gate.



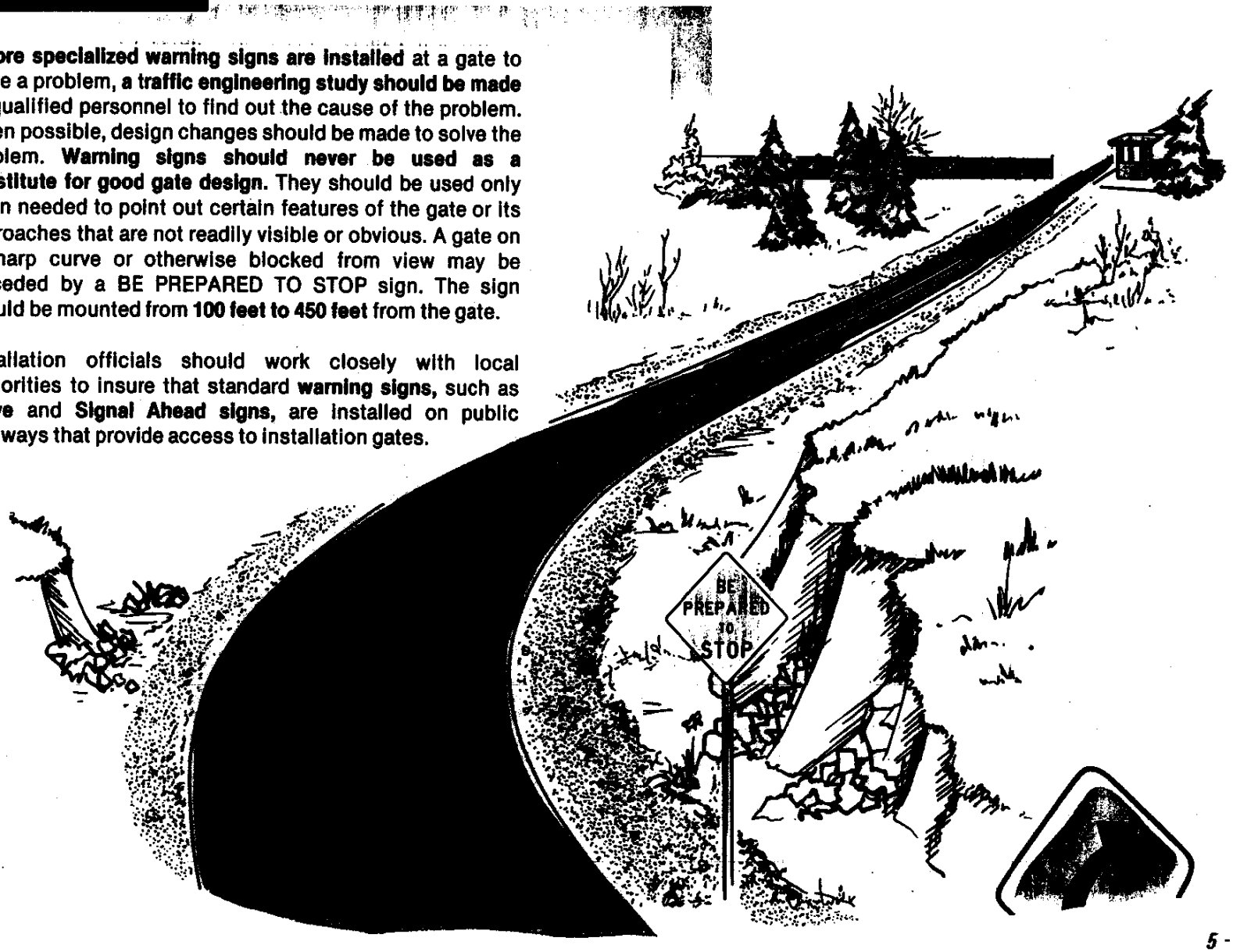
On some access roads to gates that are not always open, especially where it is several miles to the gate, a GATE HOURS sign may be used to advise drivers.

The GATE HOURS sign should be placed at a point where it will prevent needless travel when the gate is closed. Hours should be shown in civilian time. Military hours should not be used. The sign should be reflective white with black lettering.

WARNING SIGNS

Before specialized warning signs are installed at a gate to solve a problem, **a traffic engineering study should be made** by qualified personnel to find out the cause of the problem. When possible, design changes should be made to solve the problem. **Warning signs should never be used as a substitute for good gate design.** They should be used only when needed to point out certain features of the gate or its approaches that are not readily visible or obvious. A gate on a sharp curve or otherwise blocked from view may be preceded by a BE PREPARED TO STOP sign. The sign should be mounted from **100 feet to 450 feet** from the gate.

Installation officials should work closely with local authorities to insure that standard **warning signs,** such as **Curve** and **Signal Ahead signs,** are installed on public highways that provide access to installation gates.

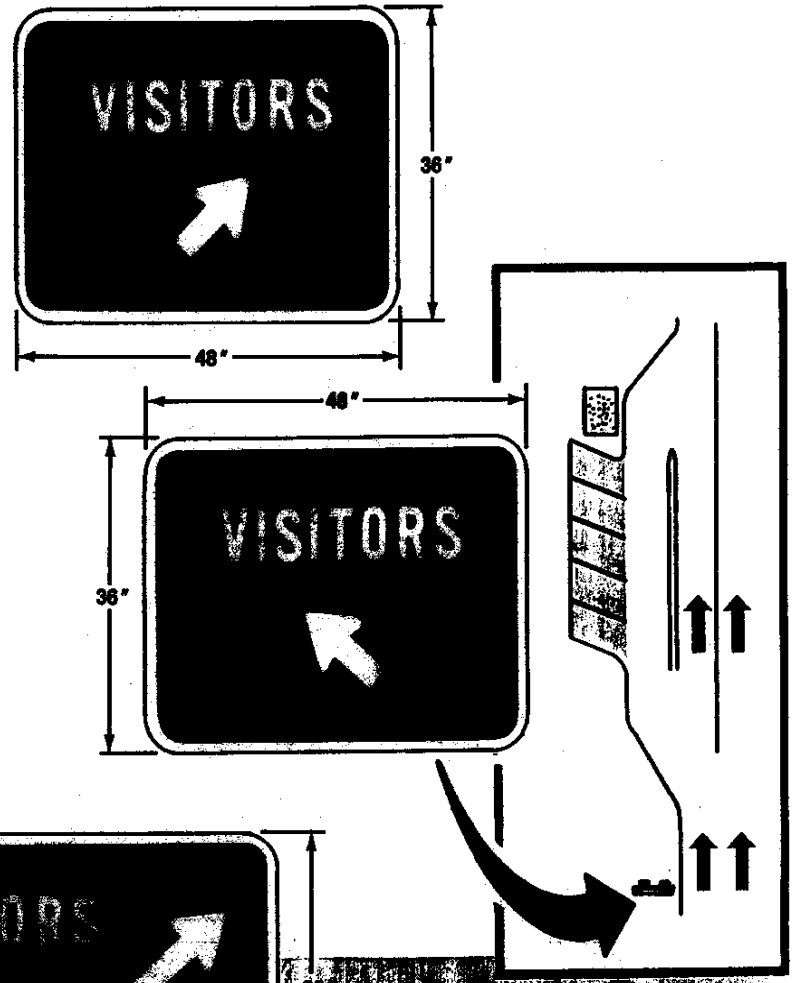


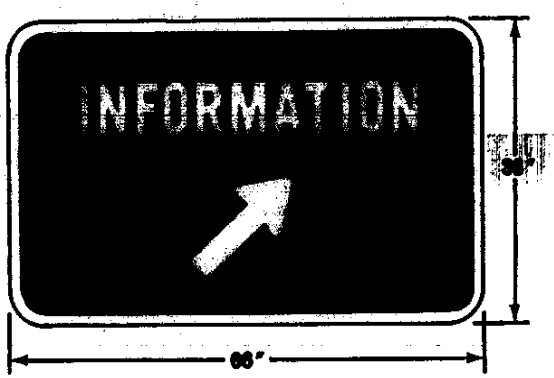
GUIDE SIGNS

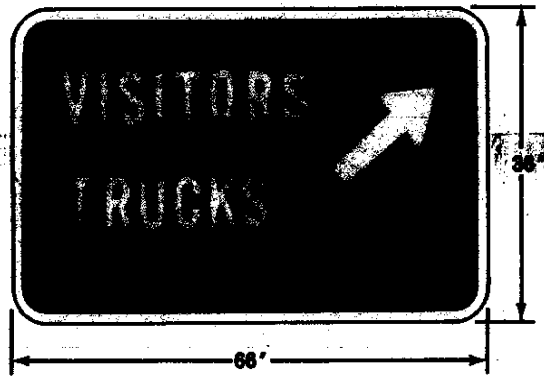
Guide signing at military installations generally violates most principles of good signing practice. These signs often have letters that are too small, contain too many words for a driver to comprehend, and are located so that a driver cannot safely make the desired change in direction.

Guide signs should be made with a reflective green background and uppercase Series—D reflective white lettering (Standard Alphabets; see references). **Lettering,** in most cases, should be at least **6 inches** high, preferably **8 inches.** The arrow angle on the sign should approximate the exit angle of the turning roadway.

Left-hand arrows should be used at left-hand exits and be mounted on the left side of the roadway. Advance signing should always be used for left-hand exits.

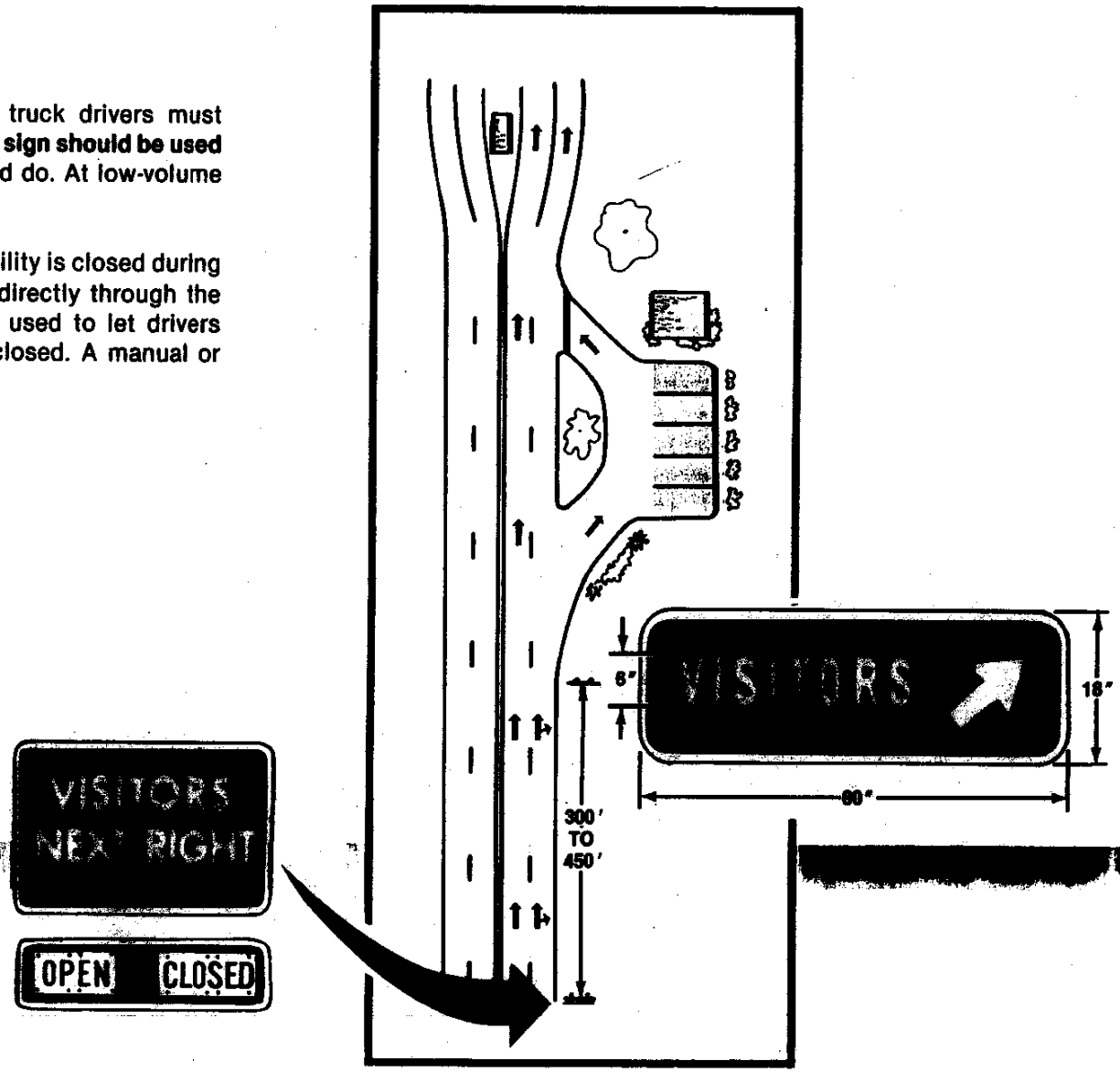






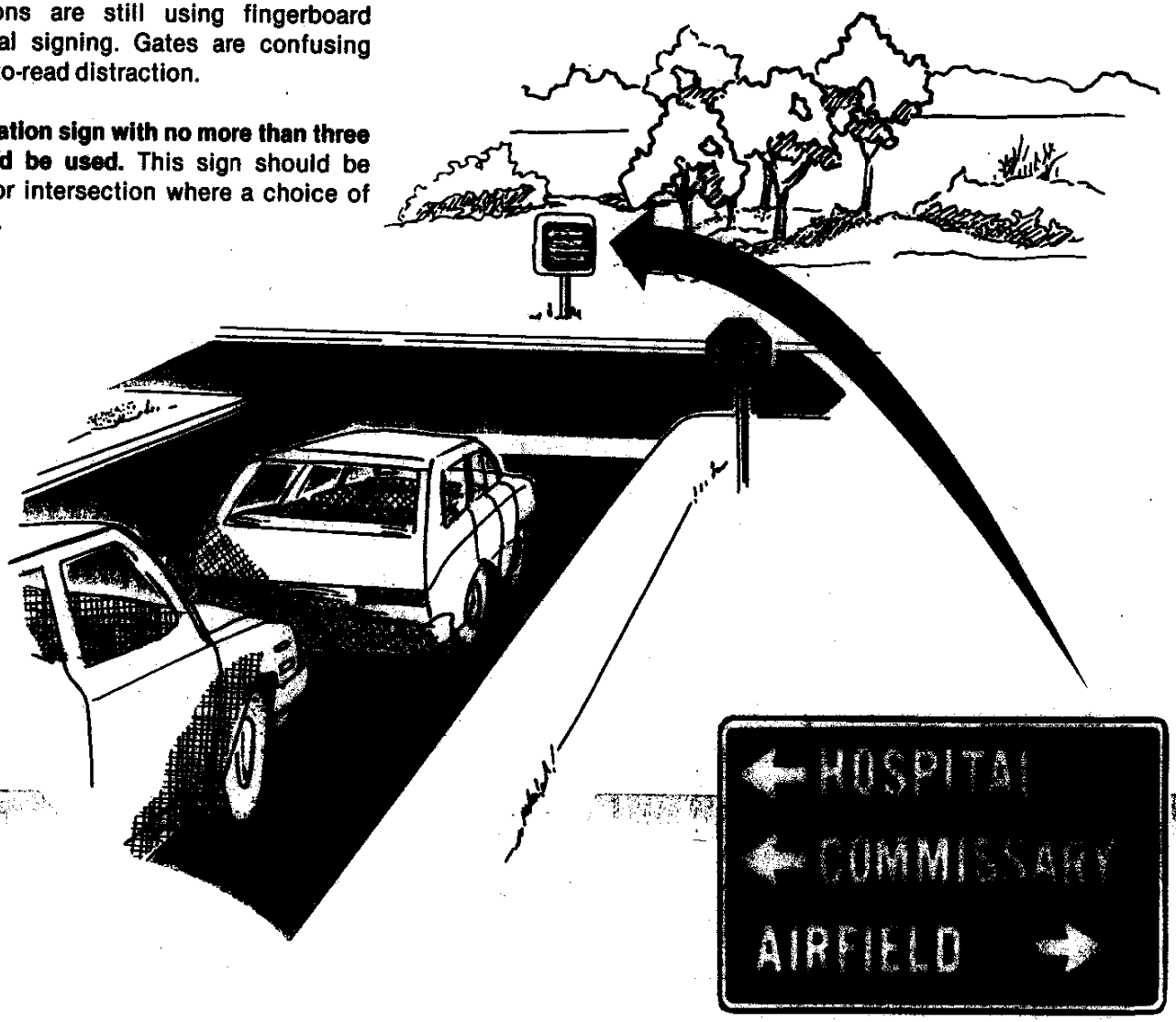
At multilane gates where visitors or truck drivers must register prior to entry, an **advance guide sign should be used** to inform visitors of what to expect and do. At low-volume gates, advance signing is optional.

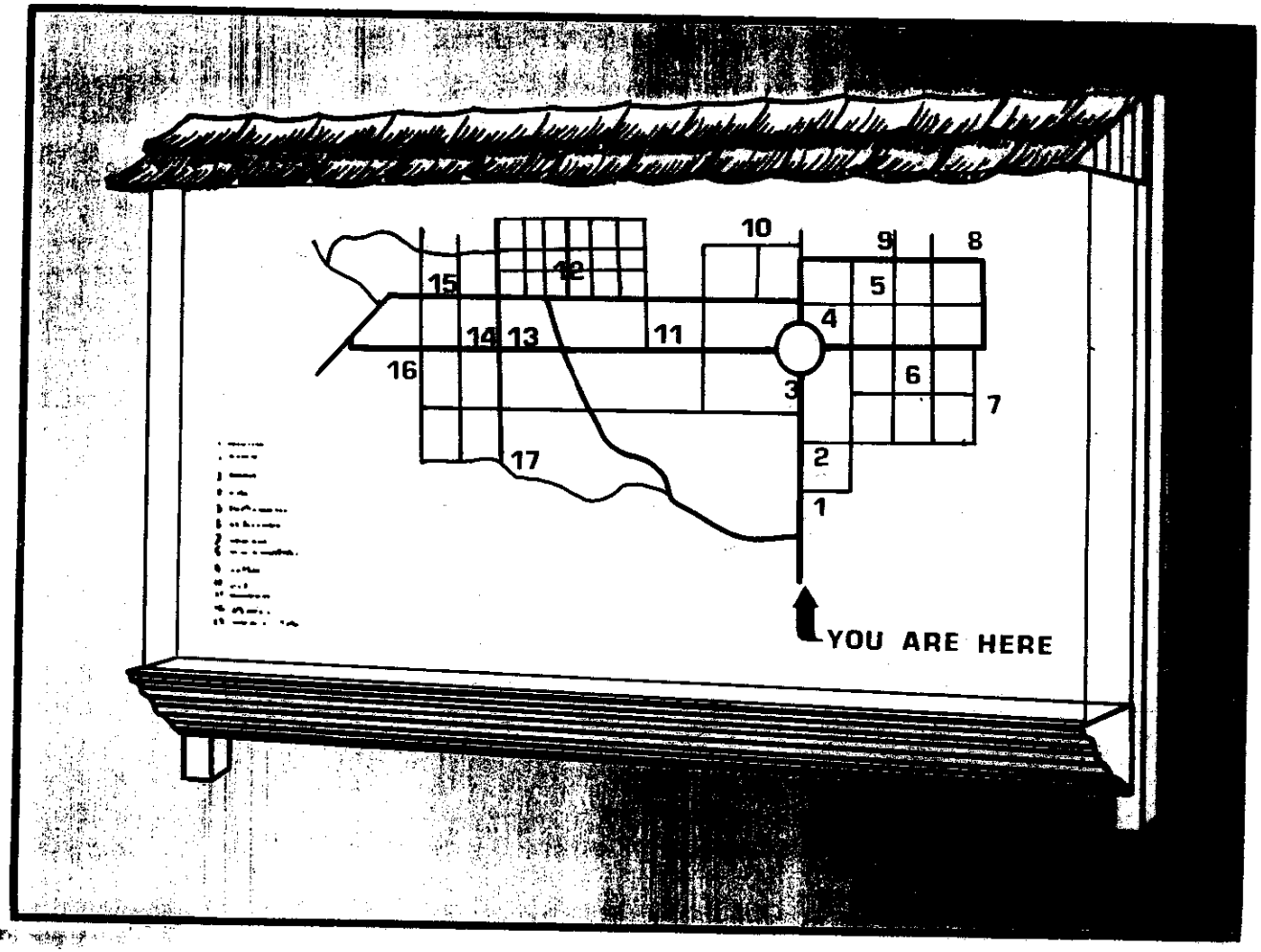
When the visitor or truck processing facility is closed during certain hours and all traffic is routed directly through the gate, a variable-message sign may be used to let drivers know whether the facility is open or closed. A manual or remote control system may be used.



Many military installations are still using fingerboard assemblies for directional signing. Gates are confusing enough without this hard-to-read distraction.

Instead, **a standard destination sign with no more than three major destinations should be used.** This sign should be placed near the first major intersection where a choice of destination must be made.





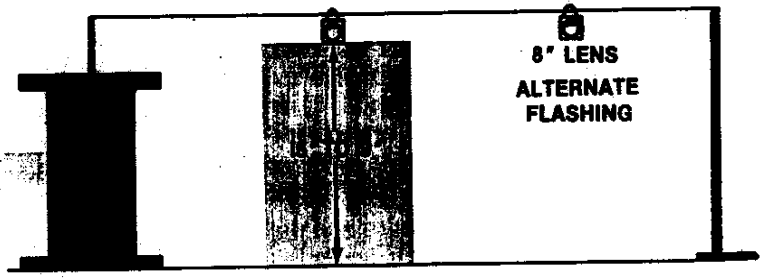
In addition, **visitors should be provided with easy-to-read maps that show major visitor destinations.** Large map signs, showing driver location and major destinations, should be installed at gate visitor turnouts and handout copies should be provided for drivers. Small maps can also be printed on the back of visitor passes.

FLASHING SIGNALS

Flashing CIRCULAR YELLOW signals, or hazard beacons, are used to call attention to hazards that, due to curvature, surroundings, or other factors, may not be obvious or visible. The preferred use of hazard beacons near gates is to supplement warning signs, such as the BE PREPARED TO STOP sign. However, they should be used only if the sign, by itself, has proved ineffective. **Hazard beacons should not be used on the gatehouse or right at the gate.** Instead, good area lighting should be used during periods of darkness to warn the driver of the gate.

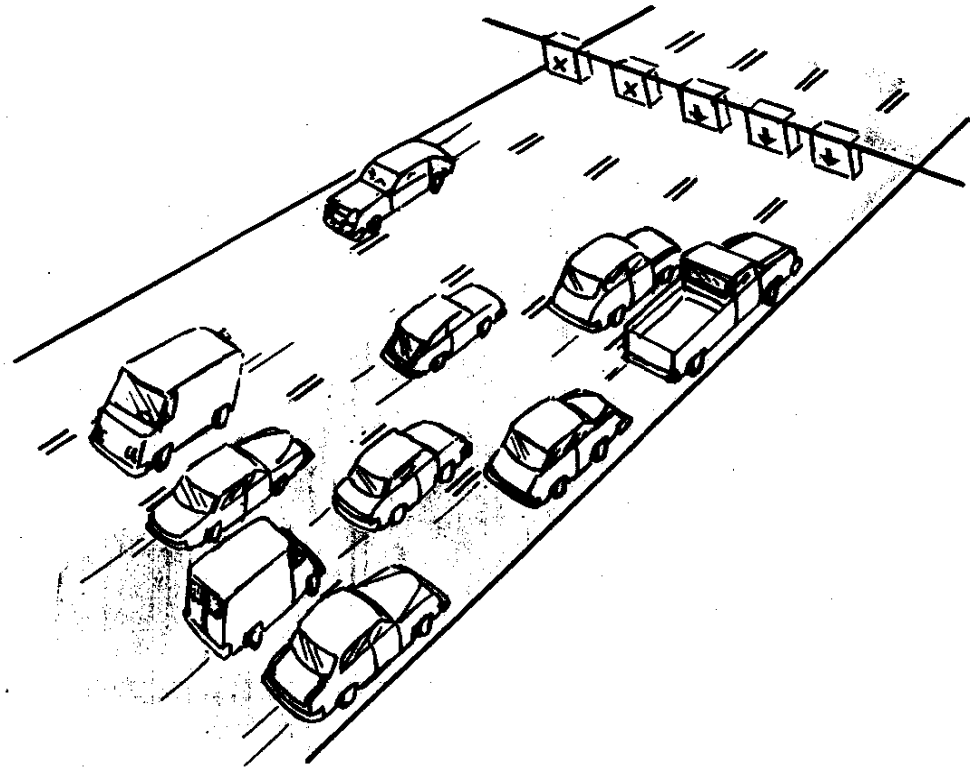
At high-security gates, flashing CIRCULAR RED signals may be used when:

- **All vehicles must stop. When a full stop is not required, the signal must be turned off. Example: If vehicles are checked for decals and waved through during the day and are stopped for an ID check only at night, the signal is turned off during the day.**
- **A traffic study by qualified traffic engineers has shown that accidents at the gate can be prevented by installing a flashing CIRCULAR RED signal. A steady CIRCULAR RED signal should not be used at a gate.**



LANE REVERSAL

Lane reversal *involves assigning certain traffic lanes to flow* in one direction during part of the day and in the opposite direction during another part of the day in order to meet highly directional demands. This can be a cost-effective tool to increase the capacity of an existing gate and its access roads. However, because of the disastrous consequences if reversible lanes are used improperly, lane reversal should be **used only after a traffic engineering study shows it to be practical and safe.** Lane-reversal signals, markings, and other pertinent devices must conform to the MUTCD.

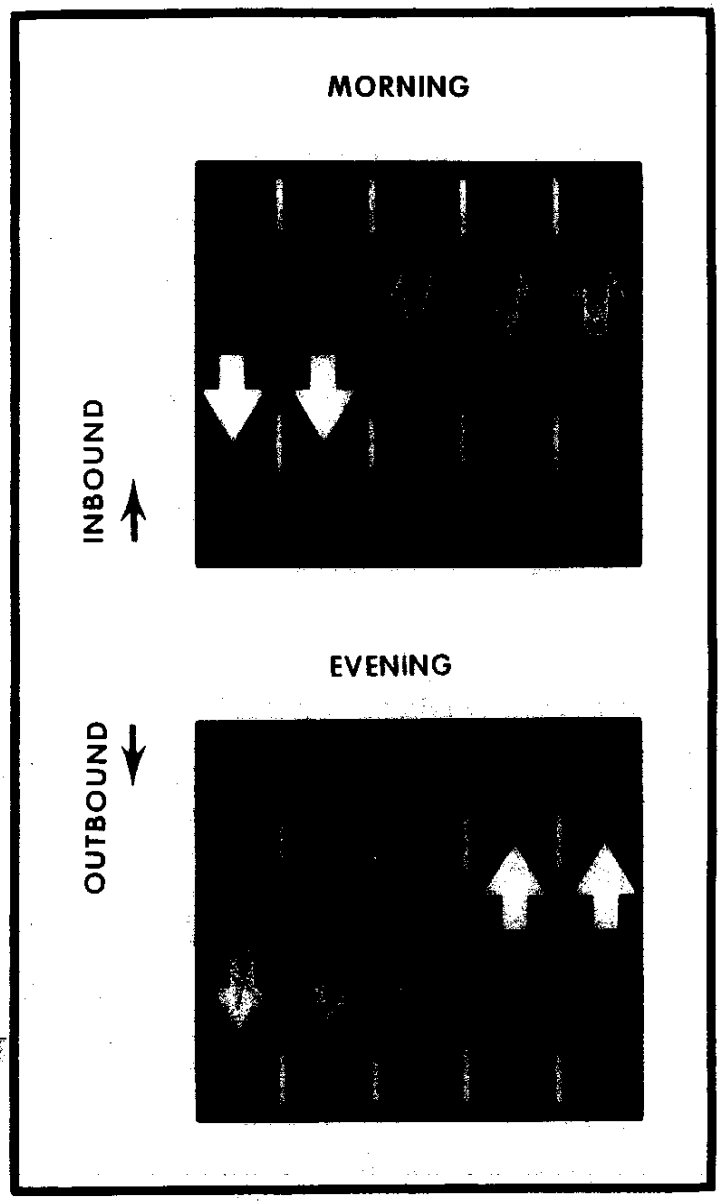


INCREASE GATE CAPACITY AT LOW COST BY LANE REVERSAL

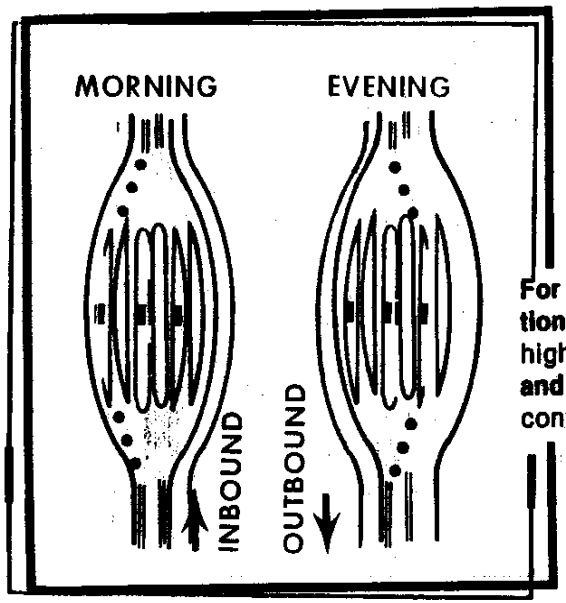
If the following [illegible] reversal may be [illegible]

- **Roadway cannot be widened because of physical or monetary constraints.**
- **At least 65 percent or preferably 75 percent of the traffic is traveling in one direction during peak periods.**
- **Cyclic congestion is evident.**
- **Off-peak direction capacity is adequate during reversal.**
- **Route and width are continuous.**

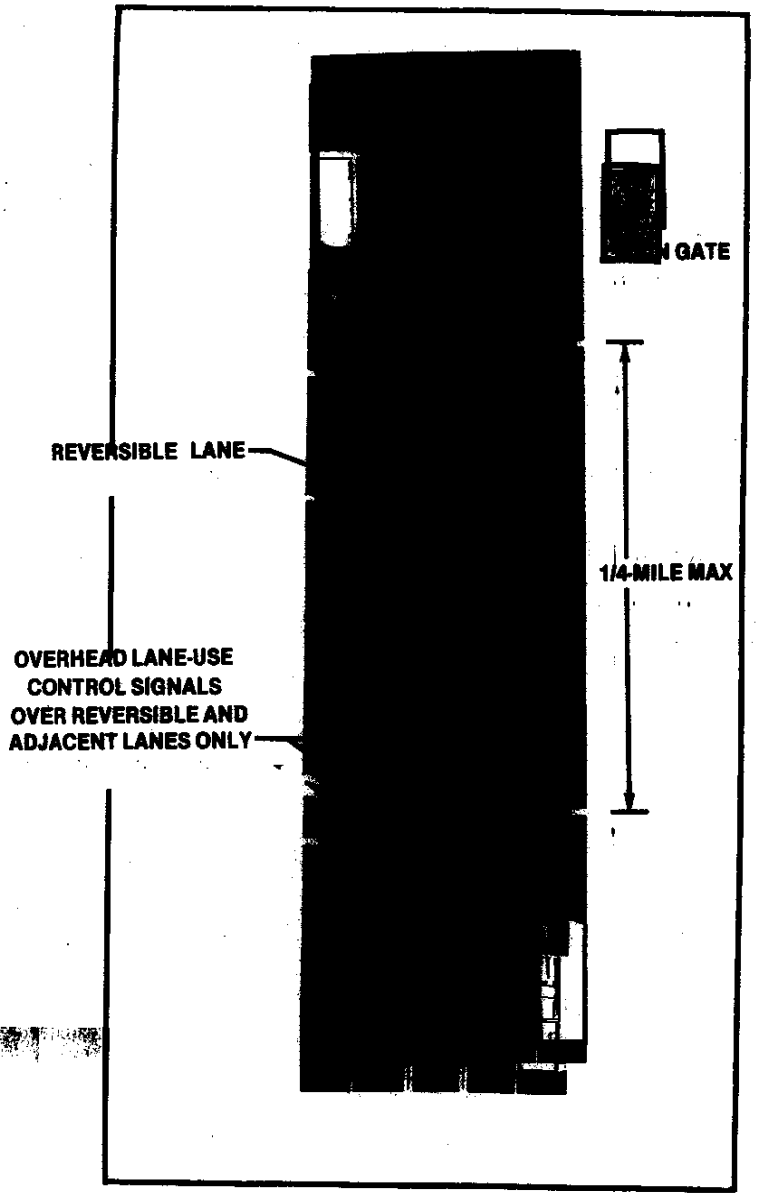
To accommodate lane reversal, a roadway must be at least two lanes wide but preferably three to five lanes. This many lanes would accommodate through traffic and emergency situations, such as breakdowns or other vehicle stoppages, in the minor flow direction. Left turns and parking are restricted.



For long lane-reversal sections, overhead lane-use control signals are necessary. These have 12-inch rectangular faces displaying a RED X or a DOWNWARD GREEN ARROW. A YELLOW X indication is not necessary for gate applications. When changing cones would endanger workers because of heavy traffic during off-peak hours, overhead lane-use control signals could provide a safe and fast method of changing lane configurations. Overhead signals should be spaced so that a driver always has at least one in view, with a maximum spacing of 1/4 mile.



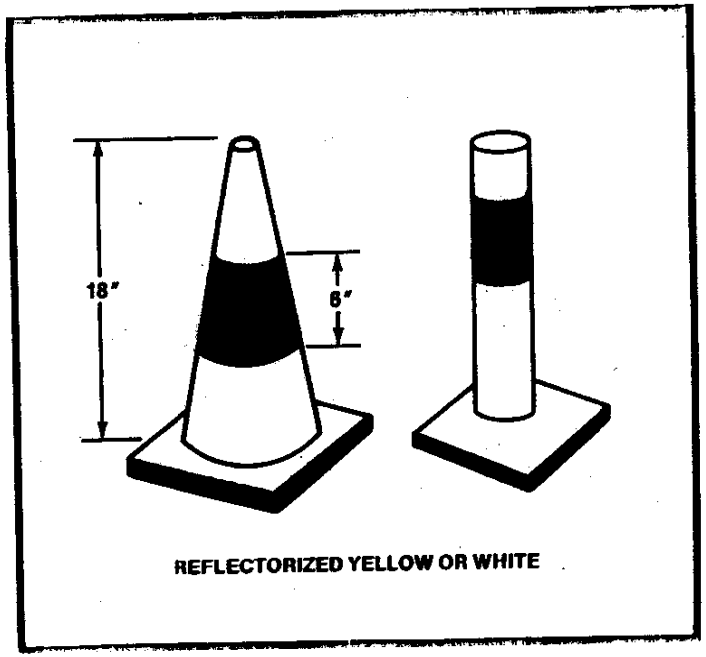
For short lane-reversal sections, such as just through a high-security gate area, **cones and signing are adequate** for control.

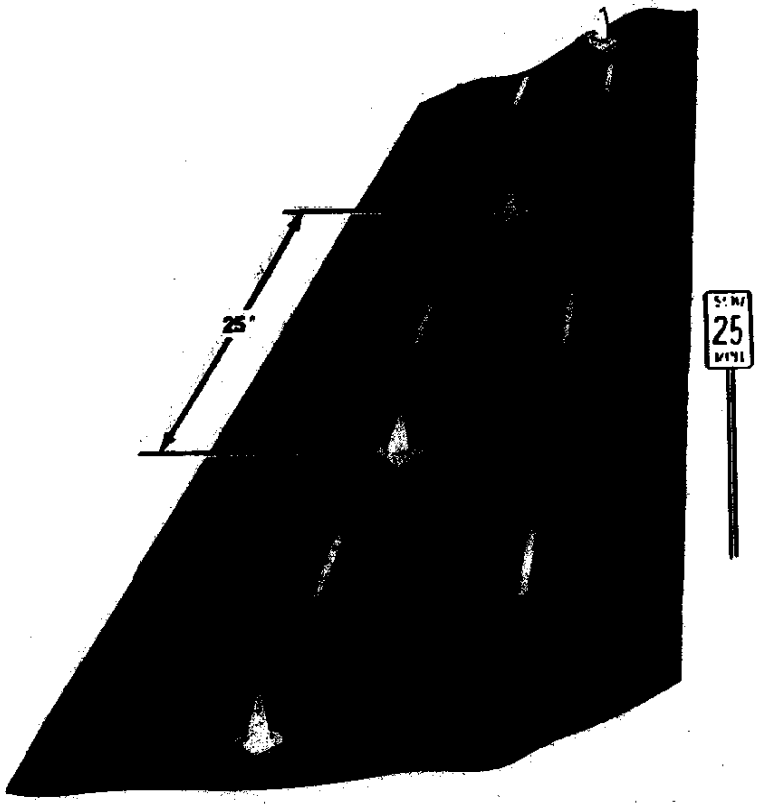


CONES

Traffic cones and tubular markers can be used effectively for temporary channelization of traffic during lane reversal, night operations, or testing an island configuration. These devices are convenient since, unlike steel drums, they can be quickly placed and removed and, if struck, will not damage vehicles.

For maximum effectiveness, the distance (in feet) between cones should be equal to the local speed limit. For example, in a 25-mile-per-hour zone, cones should be spaced 25 feet apart.

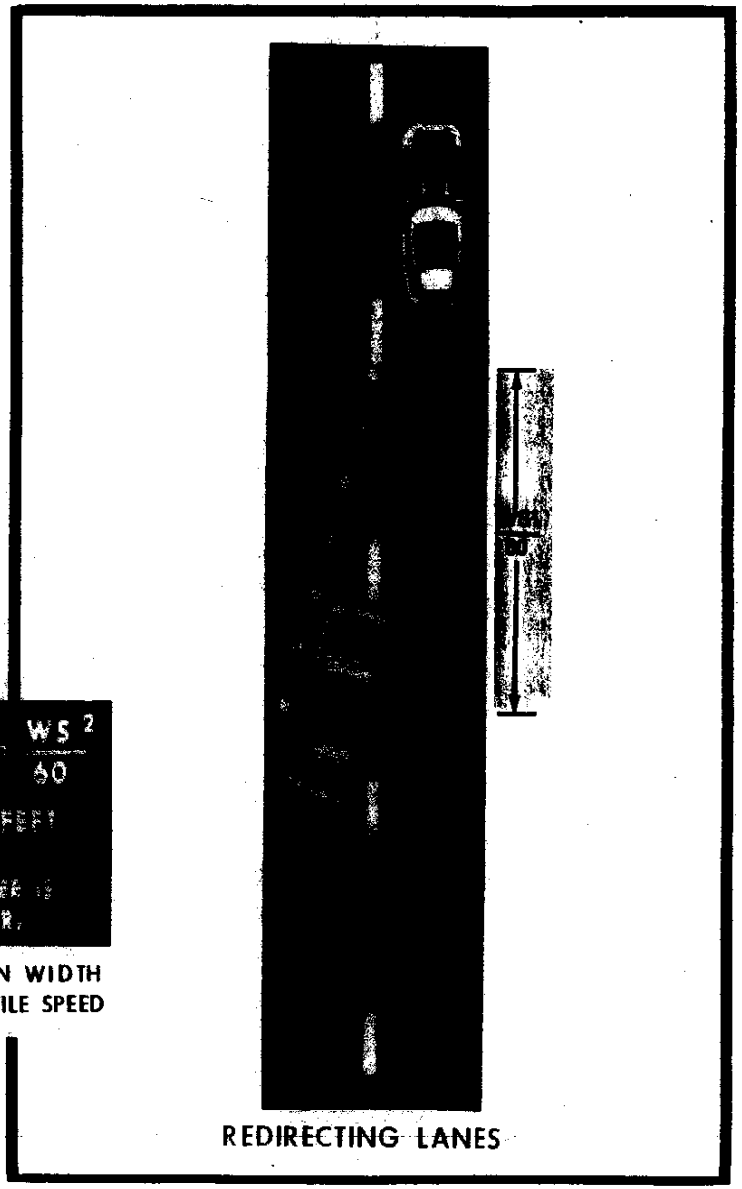




DISTANCE IN FEET BETWEEN CONES = LOCAL SPEED LIMIT

Cones should be:

- **Minimum of 18 inches high**
- **Reflectorized**
- **Same color as pavement markings**



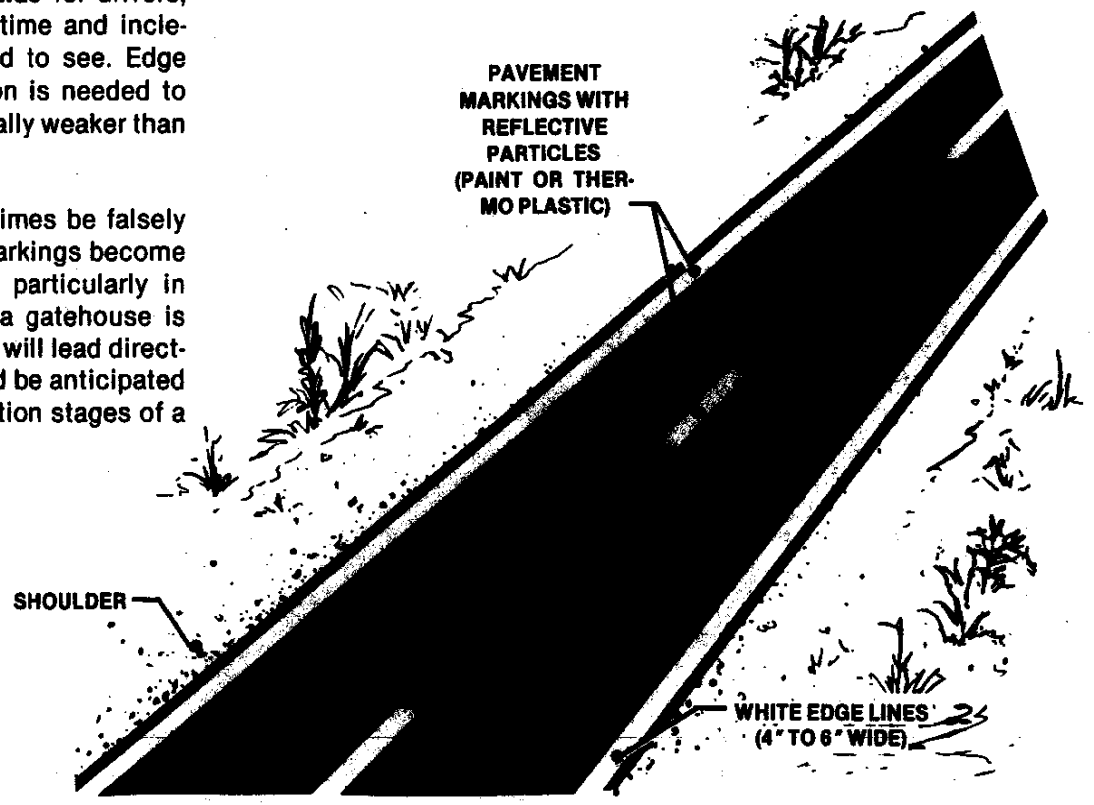
PAVEMENT MARKINGS

Pavement markings and delineation are economical ways to increase safety. **Pavement markings** shall be **reflectorized.** Un-reflectorized markings that may be adequate in the daytime are useless at night or when wet. Special reflective paints and thermoplastics tapes are available. Inlaid blocks, bricks, or metal strips should not be used as pavement markings.

Edge lines provide an **edge-of-pavement guide** for drivers, which is especially important during nighttime and inclement weather when road alignment is hard to see. Edge lines are often used where edge delineation is needed to reduce encroachment on shoulders structurally weaker than the adjacent pavement.

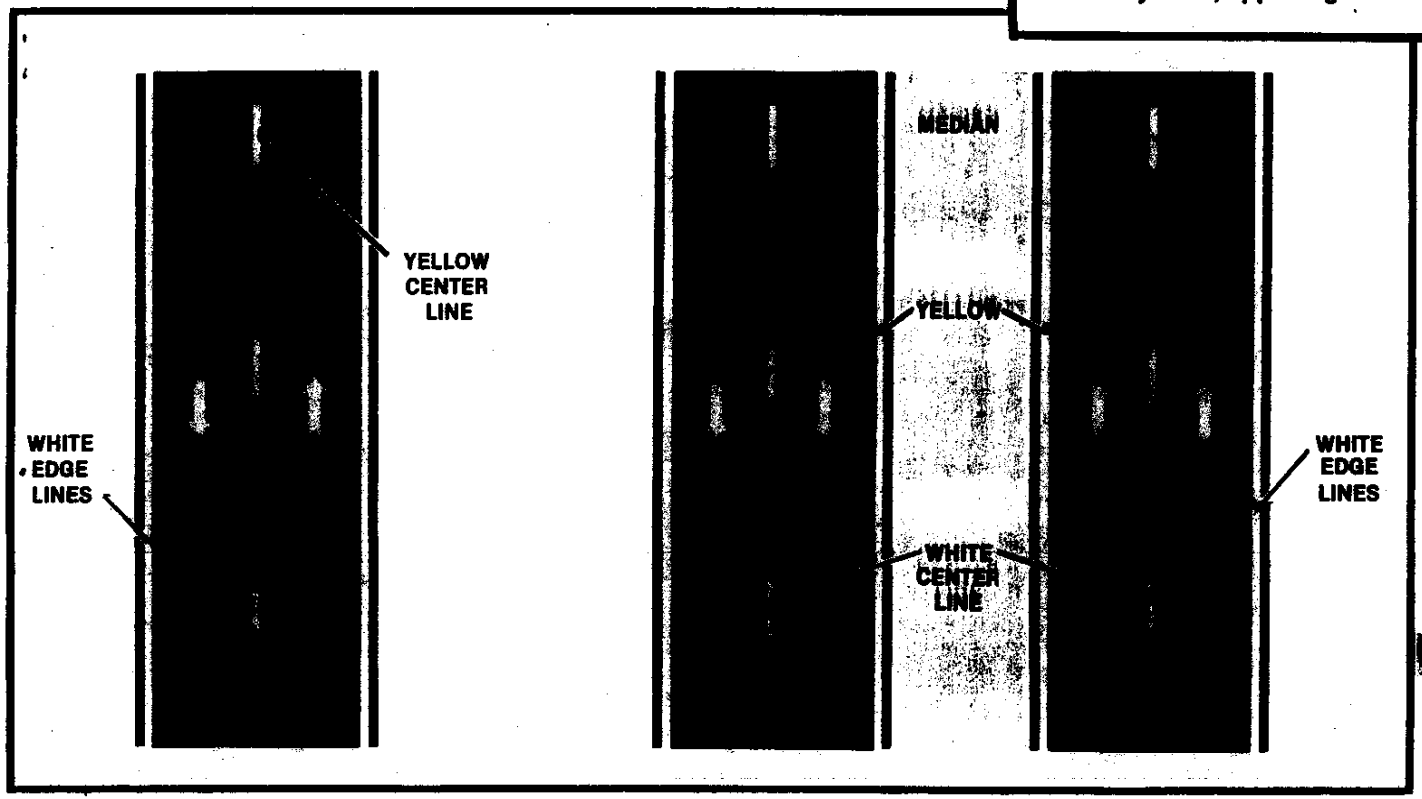
Longitudinal construction joints can sometimes be falsely interpreted as pavement markings. When markings become worn, drivers tend to follow these joints, particularly in adverse weather or at night. Often, when a gatehouse is placed on an old road, the construction joint will lead directly into the gatehouse. Such problems should be anticipated and provided for in the design and construction stages of a gate project.

FOR IMPROVING SAFETY, PAVEMENT MARKINGS AND DELINEATION ARE VERY COST EFFECTIVE

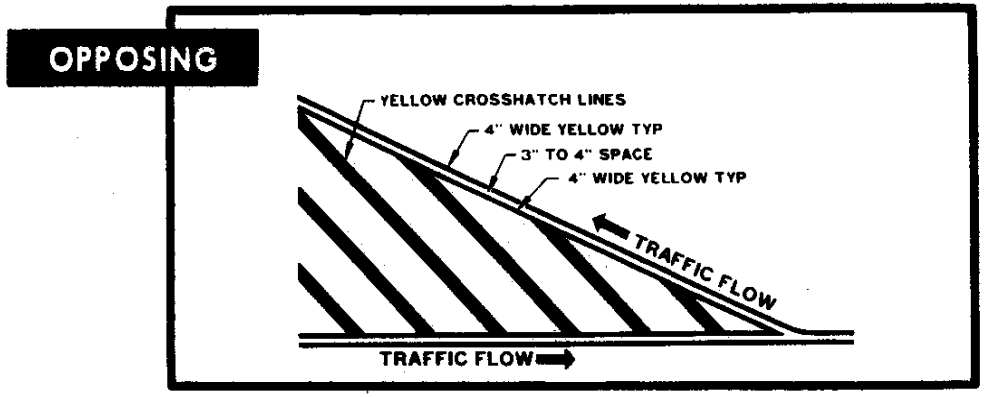


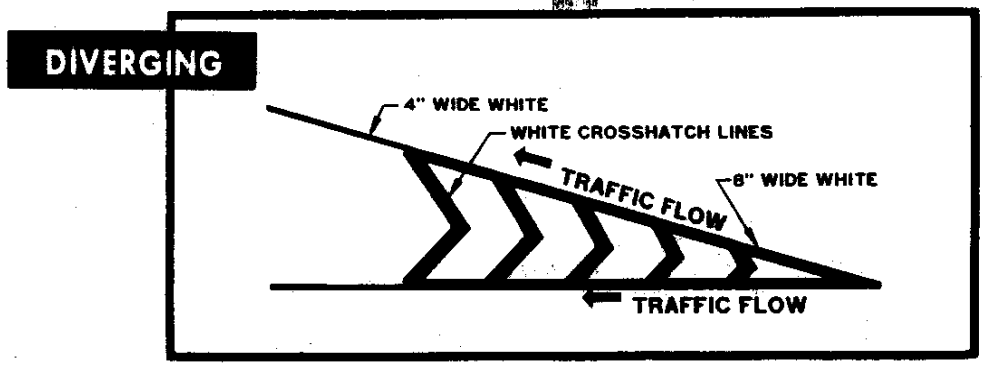
Proper colors for lane lines

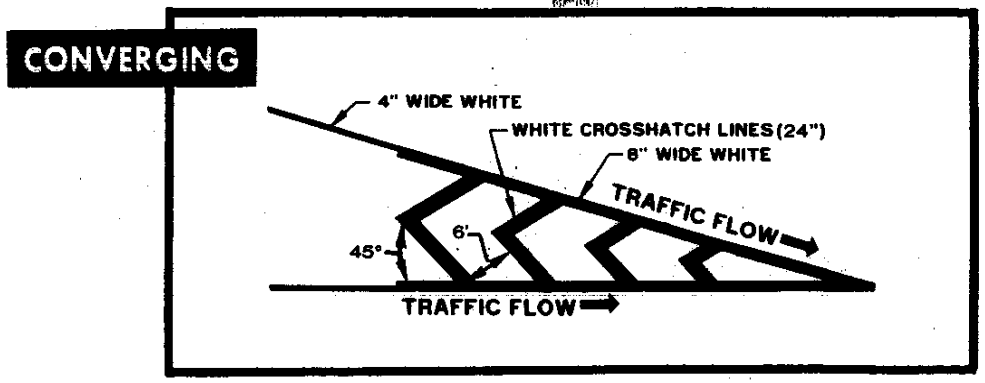
- Yellow for the left edge line on divided, multilane roads.
- White for the right edge line and between traffic lanes in the same direction.
- Broken double yellow lines between adjacent, opposing traffic lanes.



Island approaches and gore areas must be well marked. The nose should be preceded by gradually diverging pavement markings. Crosshatches within the taper lines attract attention and guide motorists past the area they should not use. Where the island separates opposing traffic, the markings must be **yellow.** Where it divides traffic moving in the same direction, the markings must be **white.**



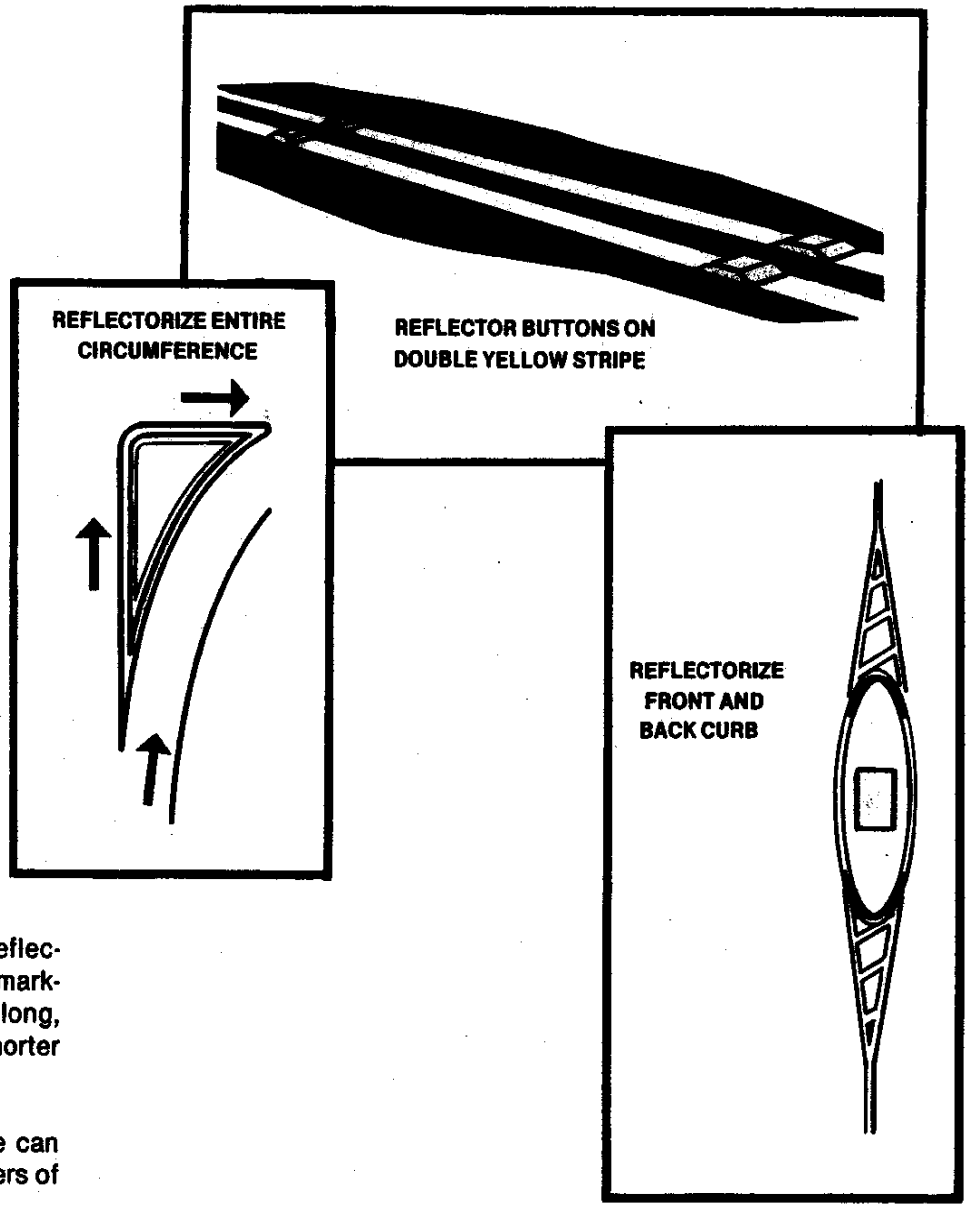




Raised reflective pavement markings (RPMs) should be used to increase the visibility of all lane and channelization pavement markings. They should be the same color as the pavement markings they supplement (except on divided roadways, where the backside facing wrong-way traffic may be red).

RPMs now can be used in snow zones through depressed mounting or the use of special snowplow blades that will not damage them. Also, snowplowable RPMs are now readily available.

RPMs ARE HELPFUL
AT NIGHT OR
IN INCLEMENT WEATHER

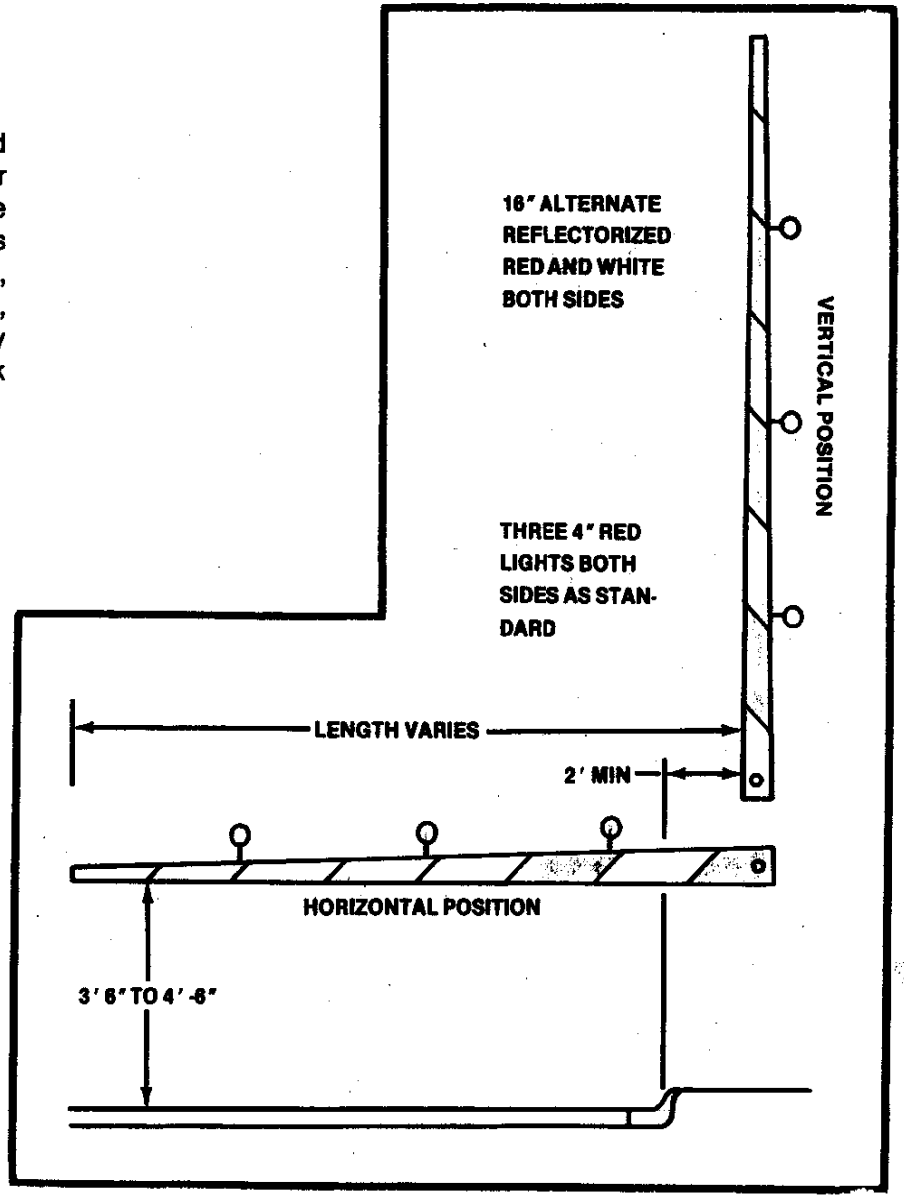


The nose curbs on raised islands can be treated with reflective material or RPMs the same color as the approach markings. Curbs need not be reflective for the full length of long, straight stretches, but should be reflective on shorter islands, particularly on curved sections.

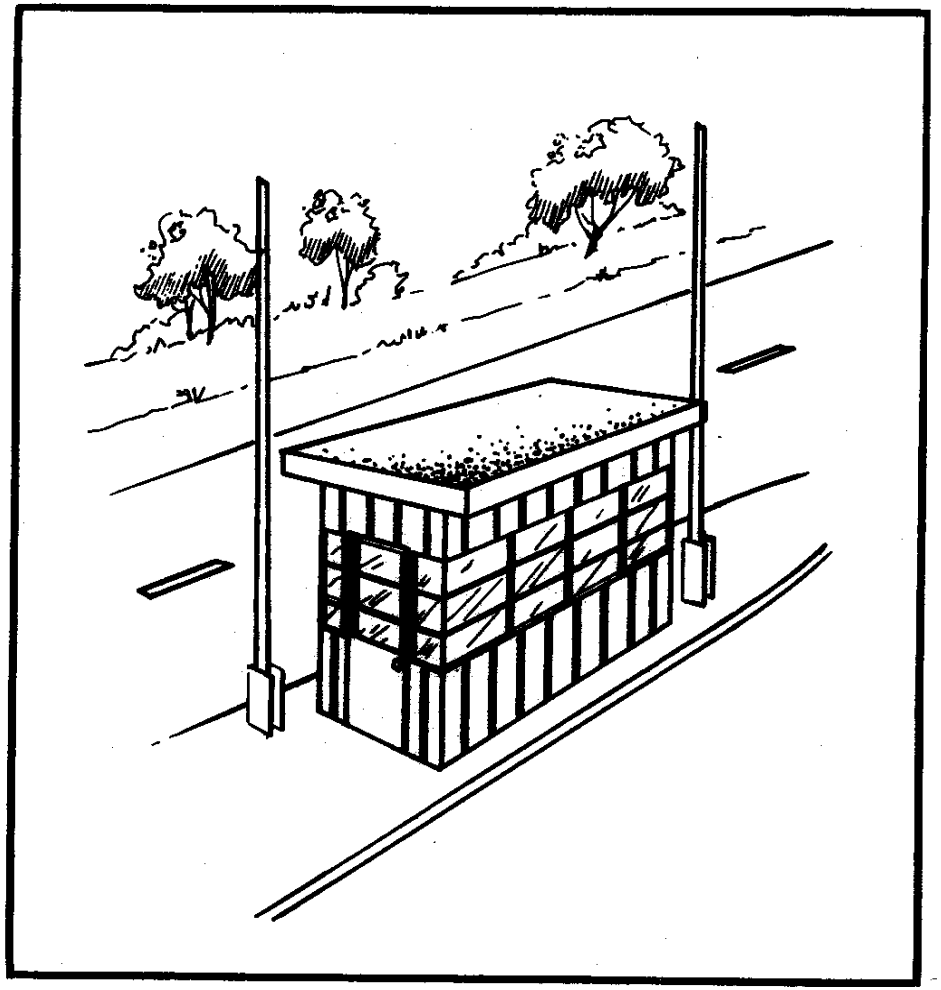
A coarse pavement, chip seal, or other rumble device can also be used within the taper lines to audibly warn drivers of zone violation.

EMERGENCY CLOSURE

A drop gate or bar can be used to quickly stop both inbound and outbound traffic flow at gate areas in emergencies or during military exercises. The gate must have 45-degree diagonal, reflectorized red and white stripes, each 16 inches wide. Three small circular red lights, 4 inches in diameter, should be mounted similar to standard railroad equipment, except that, when the gate is in the lowered position, they should be lit constantly rather than flashing. The crossbuck and large flashing lights must not be used.



NOTE: RAISING AND LOWERING DEVICE NOT SHOWN.



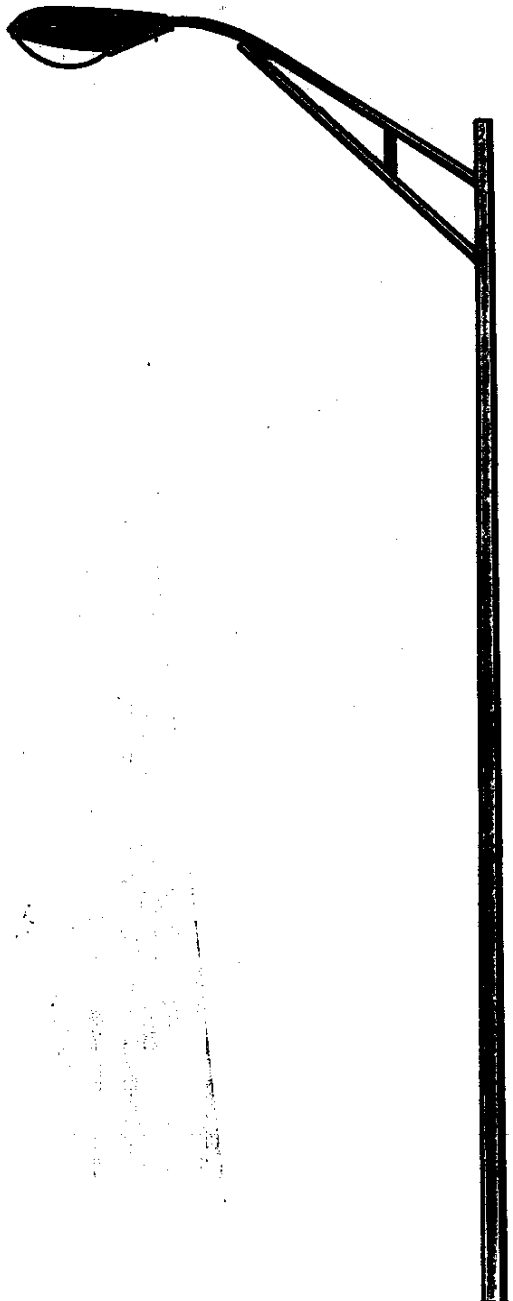
The drop gate should be located in a manner that will not interfere with the guard's view of traffic, and where it is not a fixed-object hazard. If the gate assembly will not break away upon vehicle impact, a deflective barrier may be necessary. Standard clearances should be used.

Portable red and white Type III Barricades may also be used for emergency gate closure. See REGULATORY SIGNS for details.

ROADWAY LIGHTING

Chapter 6

What kinds of lighting could be used at gates?

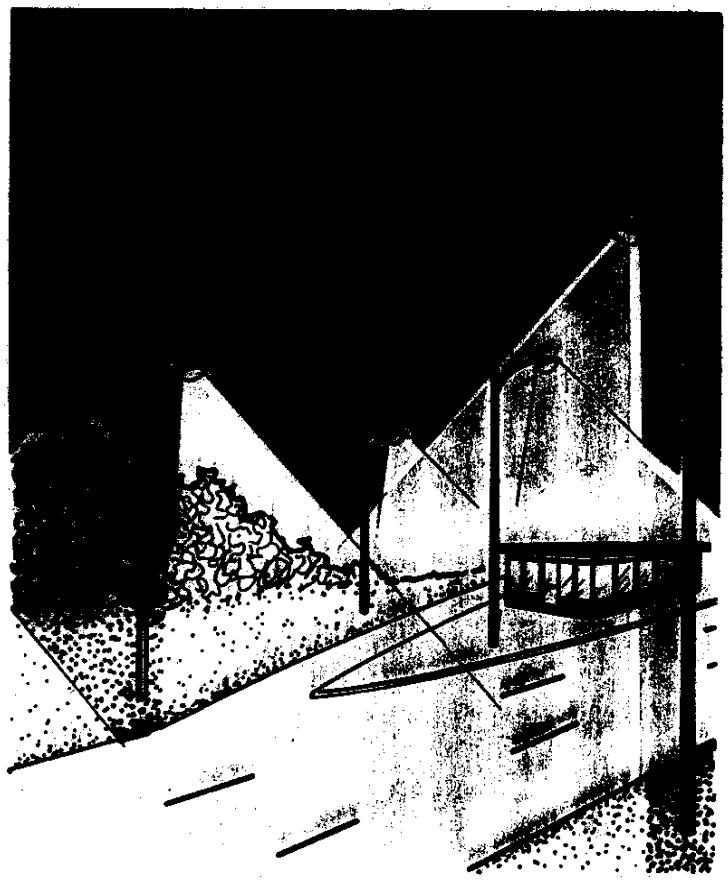


All gates need good overhead lighting at night to help drivers make the many decisions facing them while approaching a gate. Lighting should be continuous and complete, illuminating both the overall area and critical decision points in the roadway. This will **increase safety and efficiency, aid law enforcement, and enhance appearance.**

ALL GATES NEED OVERHEAD LIGHTING

LIGHT SOURCES

Light sources for gate roadway lighting should be chosen for their **luminous efficacy** and **color quality.** High-pressure sodium and metal halide lamps are good to excellent in color quality and very good to excellent in luminous efficacy. Lamps to be avoided, and why, are: low-pressure sodium, its yellow color; mercury vapor, its relatively low efficacy flourescent, its poor optical control; and incandescent and tungsten-halogen, their short life expectancy and low luminous efficacy. However, the last two are recommended for spotlighting where "instant-on" capability is needed.



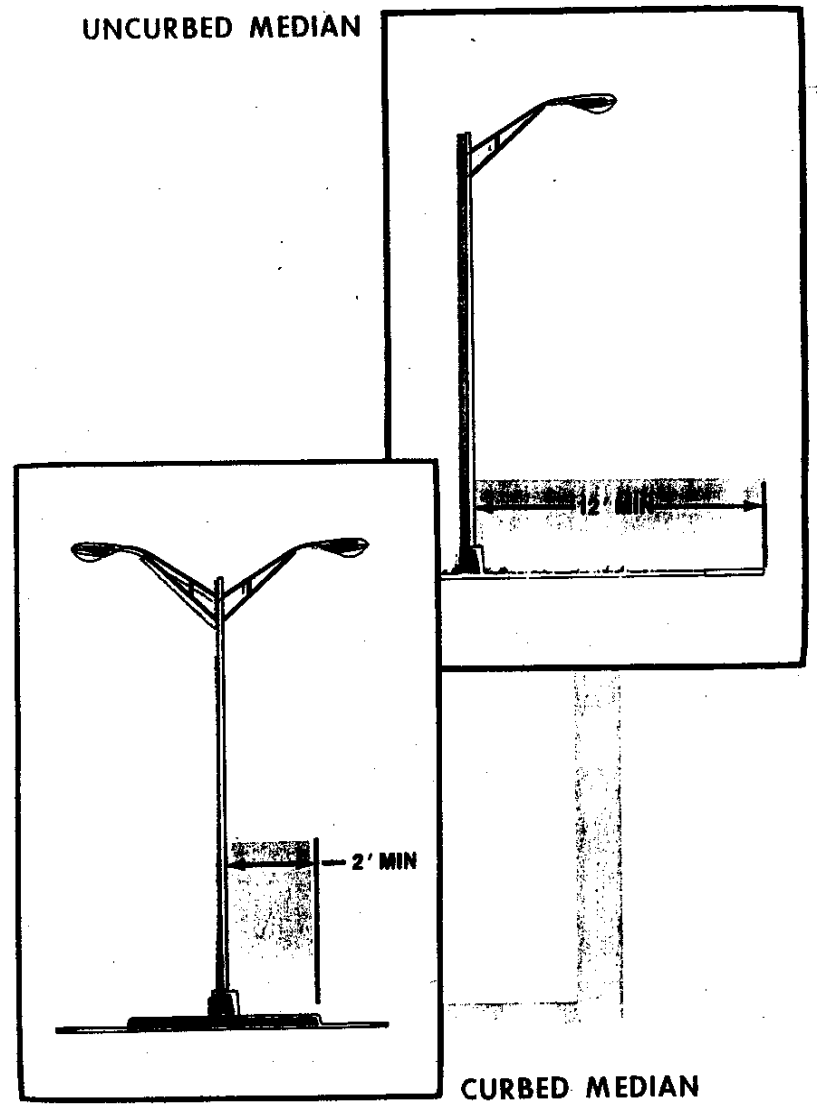
Each lighting situation is unique. Light sources that are not good in some cases may be ideal in others. Lighting requirements should be surveyed and sources chosen to fit conditions.

PLACEMENT

Light poles should be mounted in the median where **a median of acceptable width** is available. Median mounting requires fewer poles than does roadside mounting, resulting in less cost and fewer fixed-object hazards.

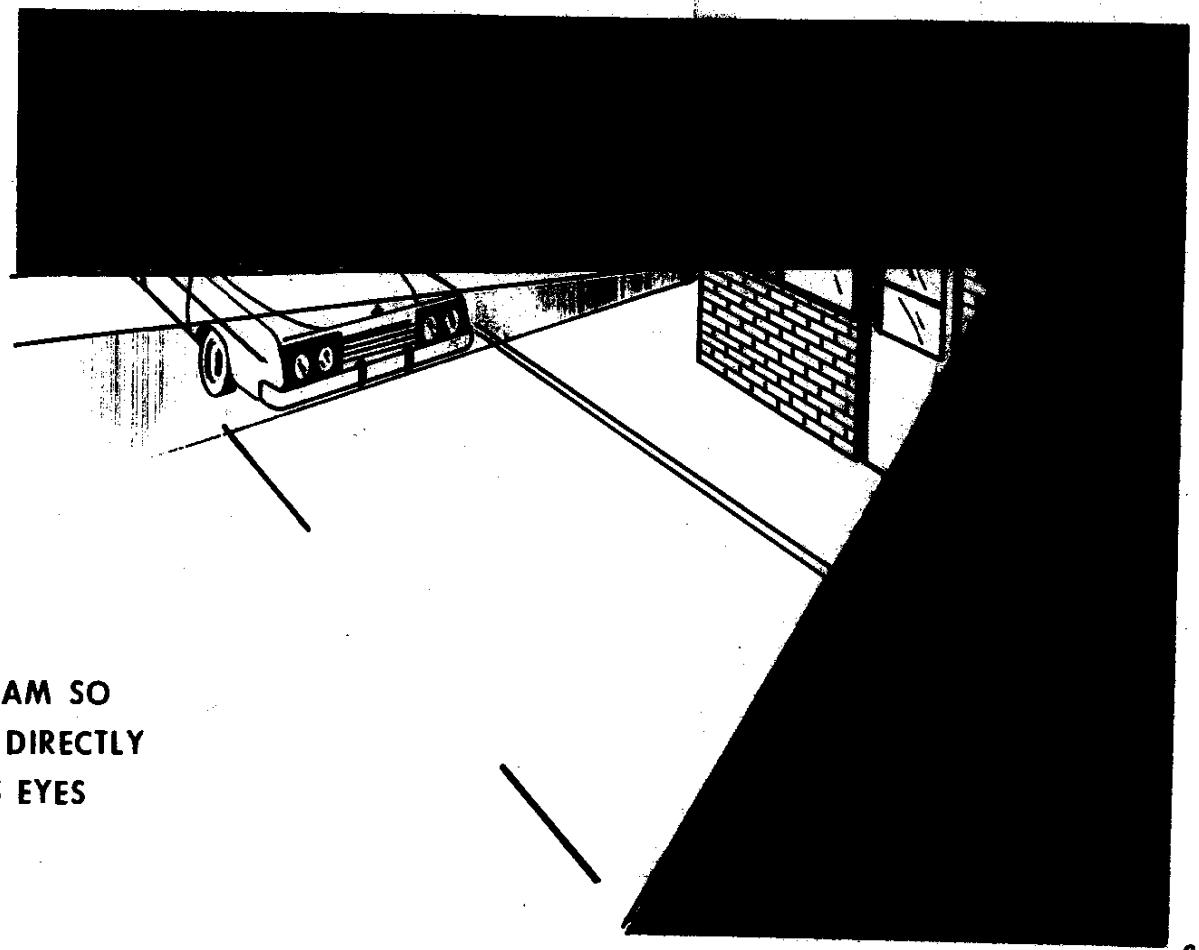
On a **curbed median,** at least a **2-foot** clearance from the curb face to the pole is required; a **6-foot** clearance is desirable so as not to affect road capacity. On an **uncurbed median, the pole should be at least 12 feet** from the lane edge or **6 feet** from the shoulder edge, whichever is greater.

Where the median is not wide enough, poles should be placed to the right side of the road. Poles on the right-hand side of the road should be breakaway, except where the falling pole would do more harm to persons than the fixed pole would to the errant driver, such as in a crowded or built-up area or around the gatehouse or visitor center. Both metal and wood poles can be made to break away.



Lighting of the gatehouse (other than roadway lighting) is important both for drivers to see the gatehouse and for guards to see drivers and vehicles; but, to be useful, it **must be applied carefully.**

Lighting should be mounted to shine transversely to the roadway; it will then illuminate the roadway in front of the gatehouse, the bumper decal, the driver, and the guard. Bright lights should not be directed into the driver's face or strongly backlight important signs.



DIRECT LIGHT BEAM SO
AS NOT TO SHINE DIRECTLY
INTO DRIVER'S EYES

LIGHTING NEEDS

So that pedestrians, islands, guards, and other hazards may readily be seen, a minimum surface-lighting average of 2 **horizontal footcandles should be used at low-volume gates, 3 at medium-volume gates, and 4 at high-volume gates.** Even more intensity is desirable. For example, in the central business districts of some cities, 10 or more footcandles are used to give an almost daytime appearance.

Where practical, high mast lighting (80 to 180 feet high) is recommended because it gives a broader, more natural light distribution, uses fewer poles (less hazardous to the driver), and is generally considered more aesthetically pleasing than standard lighting.

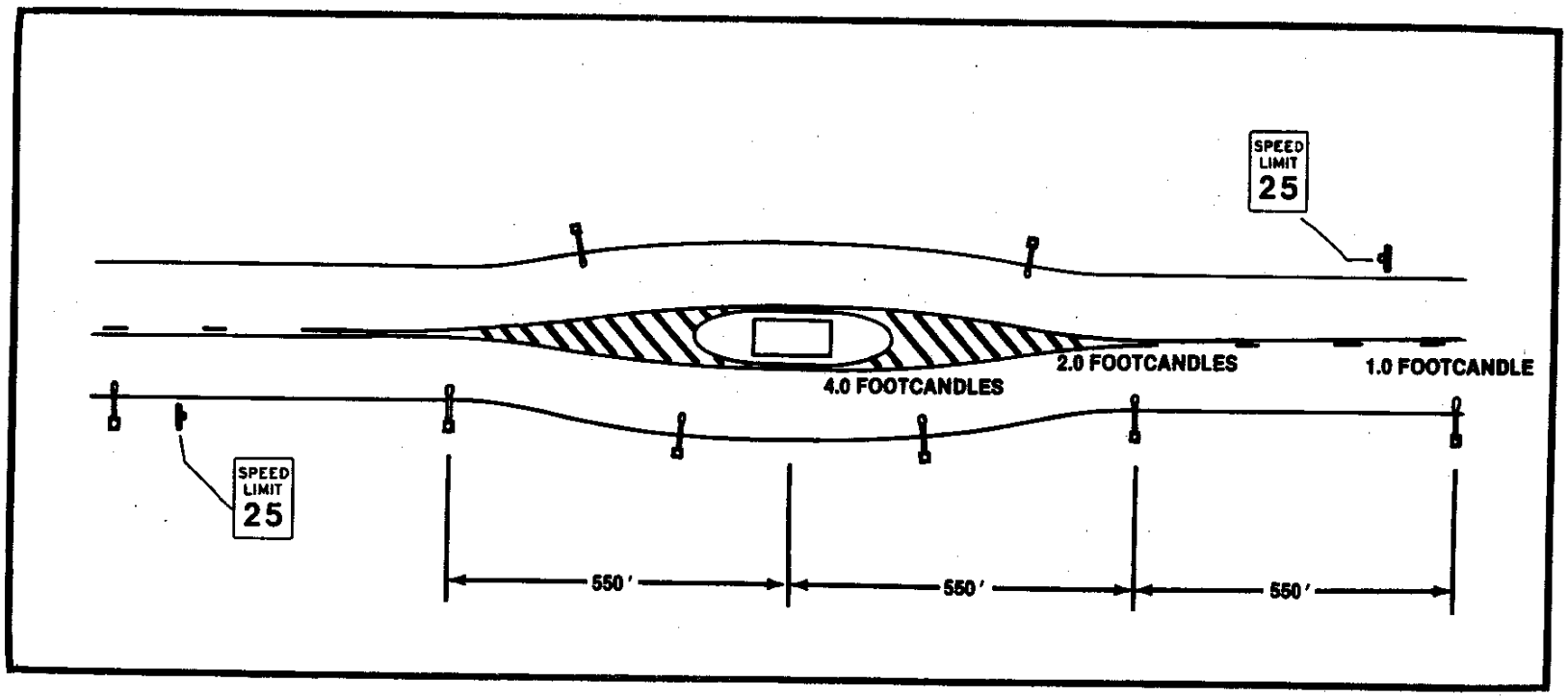
Transitional lighting is necessary on gate approaches so that drivers are not blinded during arrival or departure. Departure is more critical since the eye has more trouble adjusting from light to dark than from dark to light. High mast lighting provides its own transition through distance, while standard lighting **(30 to 50 feet high)** must be transitioned by using progressively brighter or dimmer light sources.

SPEED AND DISTANCE

SPEED (MPH)	DISTANCE TRAVELED IN 15 SECONDS
10	220
15	330
20	440
25	550
30	660
35	770
40	880
45	990

The illumination level should be reduced by 50 percent within the average distance traveled in 15 seconds. For example, at a 25-mph gate, if the illumination were 4 footcandles, 550 feet beyond that the illumination level should be 2 footcandles. At 1,100 feet, it should be 1 footcandle. A third transition is not needed. Actual lighting locations must be determined on a case-by-case basis and will depend on luminaire height, light source type, and lens distribution.

PLACE SIGNS SO THAT SIGN FACES ARE ILLUMINATED, NOT SHADOWED

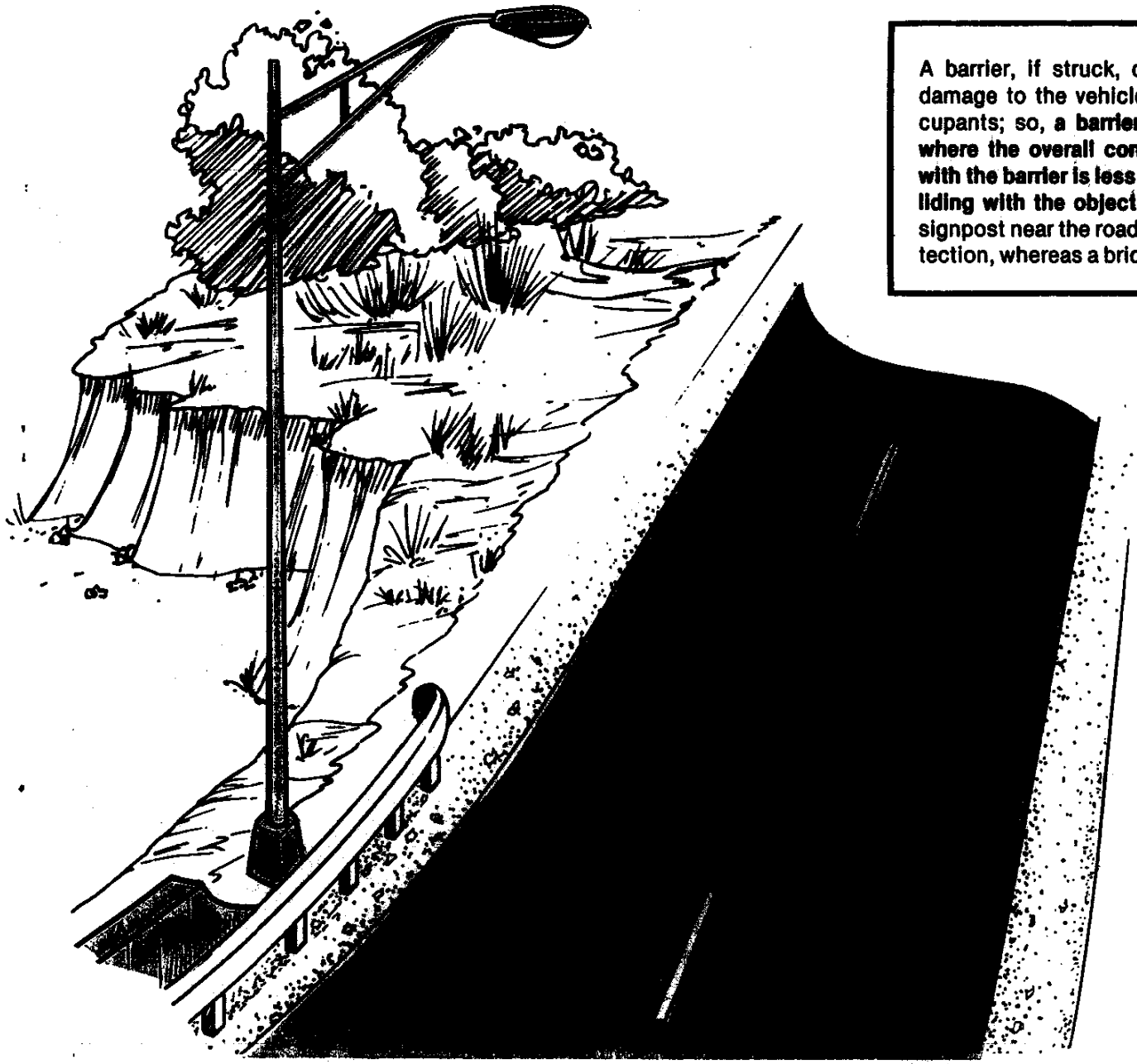


Chapter 7

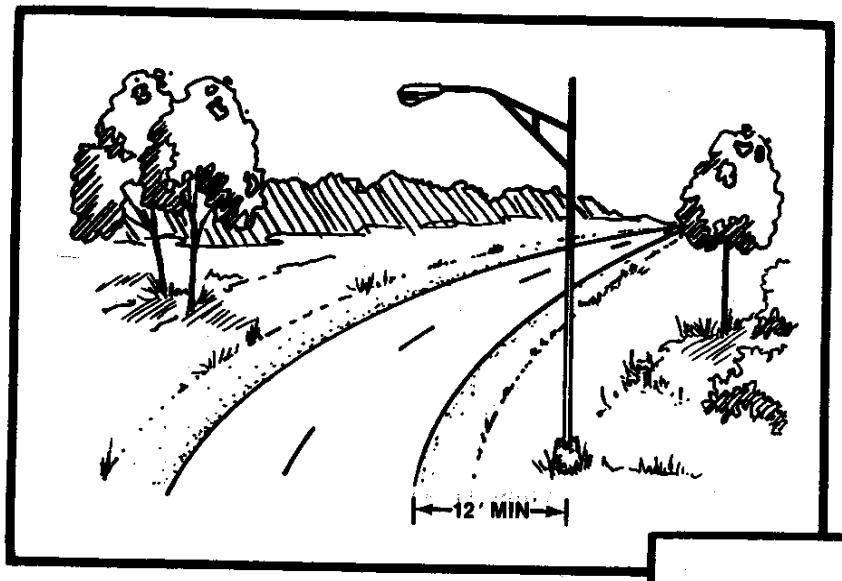
PROTECTIVE BARRIERS

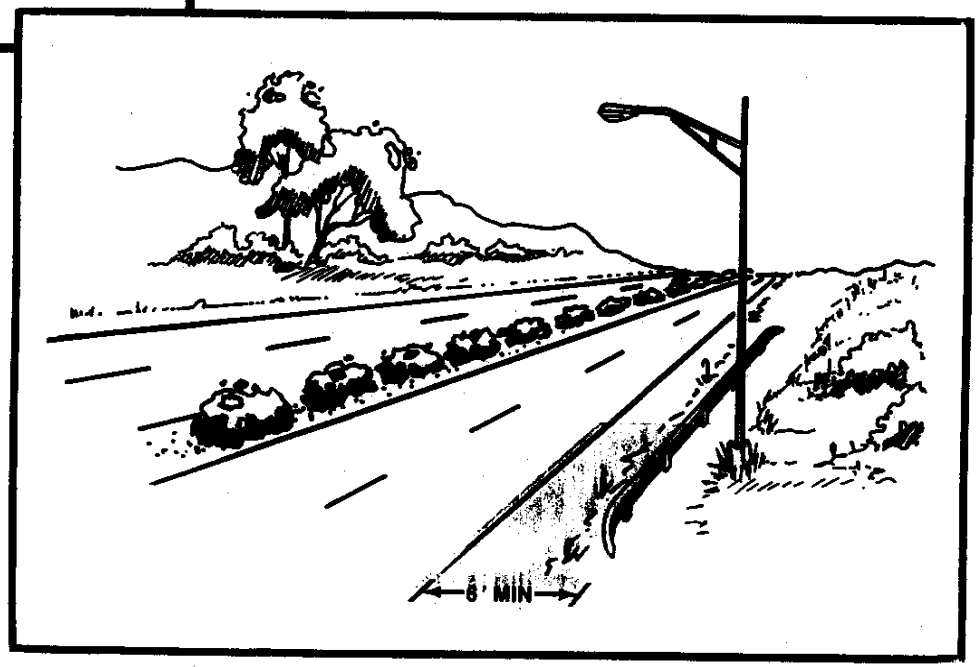
How should guards and drivers be protected?

Barriers, such as **guardrails and attenuators (crash cushions),** are used to **prevent vehicles from colliding with fixed objects,** such as poles, large trees, buildings, and so forth, near the roadway. Such barriers minimize or alter impact forces on the car and driver by deflecting or gradually decelerating the vehicle. This also prevents damage to the fixed object, which may be more expensive to replace than would be a section of the barrier.



A barrier, if struck, could cause extensive damage to the vehicle and injury to the occupants; so, **a barrier should be used only where the overall consequence of colliding with the barrier is less severe than that of colliding with the object.** For example, a small signpost near the road would not warrant protection, whereas a bridge abutment would.

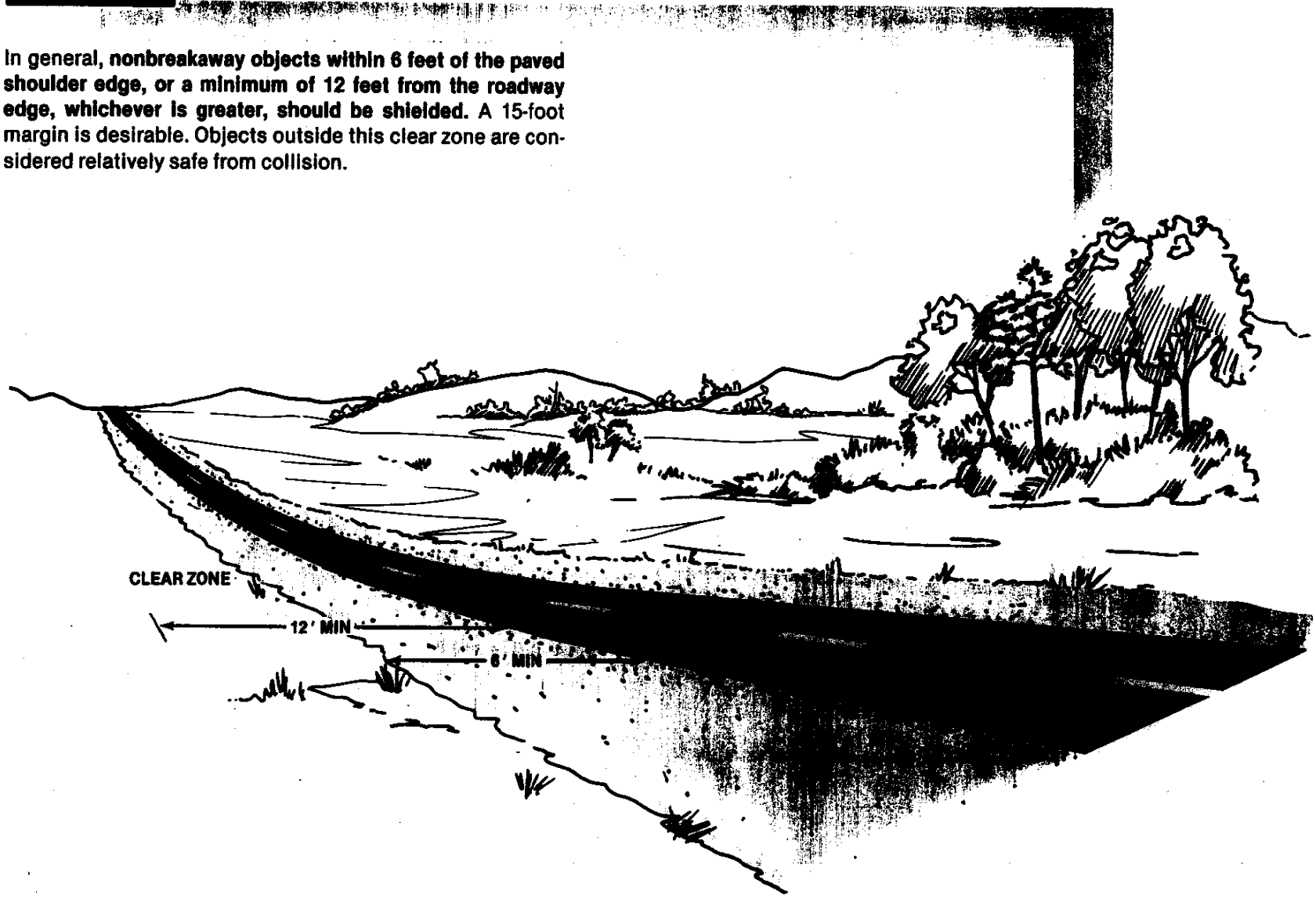


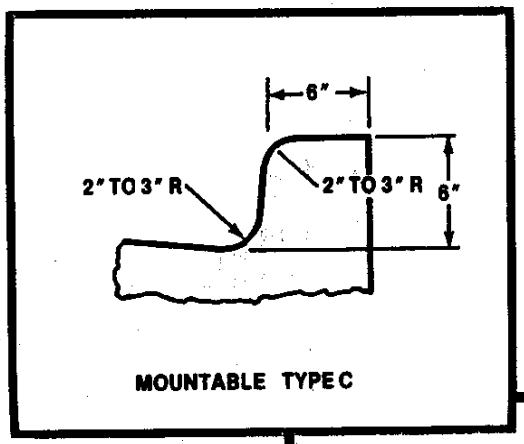


In some instances, a barrier may actually increase accidents, since it is closer to the roadway and often a wider target than the object it protects. Before a barrier is designed into a gate project, the object or obstruction it is to protect should be critically observed to determine whether the object can be relocated or made to break away. If the hazard cannot be removed, relocated, or redesigned, then a barrier should be used.

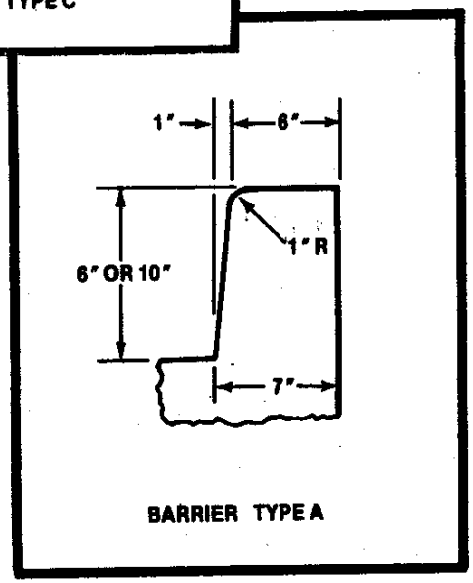
WARRANTS

In general, **nonbreakaway objects within 6 feet of the paved shoulder edge, or a minimum of 12 feet from the roadway edge, whichever is greater, should be shielded.** A 15-foot margin is desirable. Objects outside this clear zone are considered relatively safe from collision.





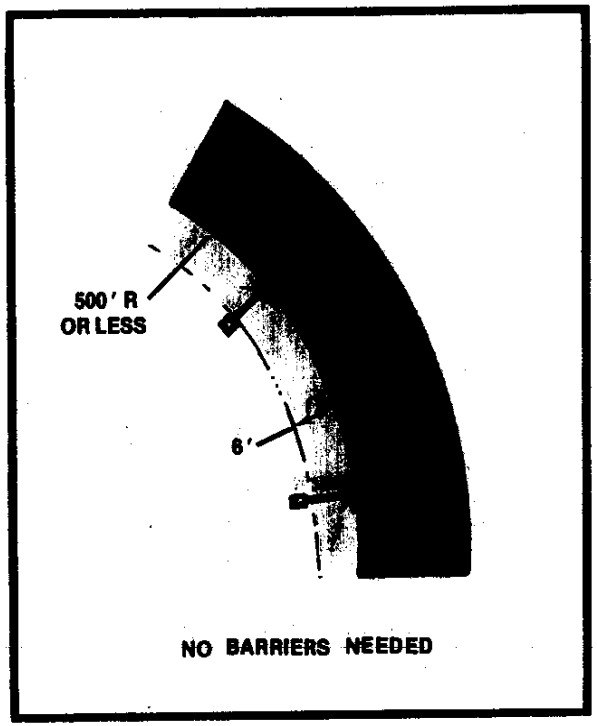
MOUNTABLE TYPE C



BARRIER TYPE A

Where a 6-inch (Type C only) or larger (Type A) curb is present, barriers may not be necessary, because the curb itself will deflect most stray vehicles at speeds below 40 mph. Objects should be placed at least 2 feet behind the curb face. Other types of 6-inch and smaller curbs are not adequate for protection and barriers should be used with them.

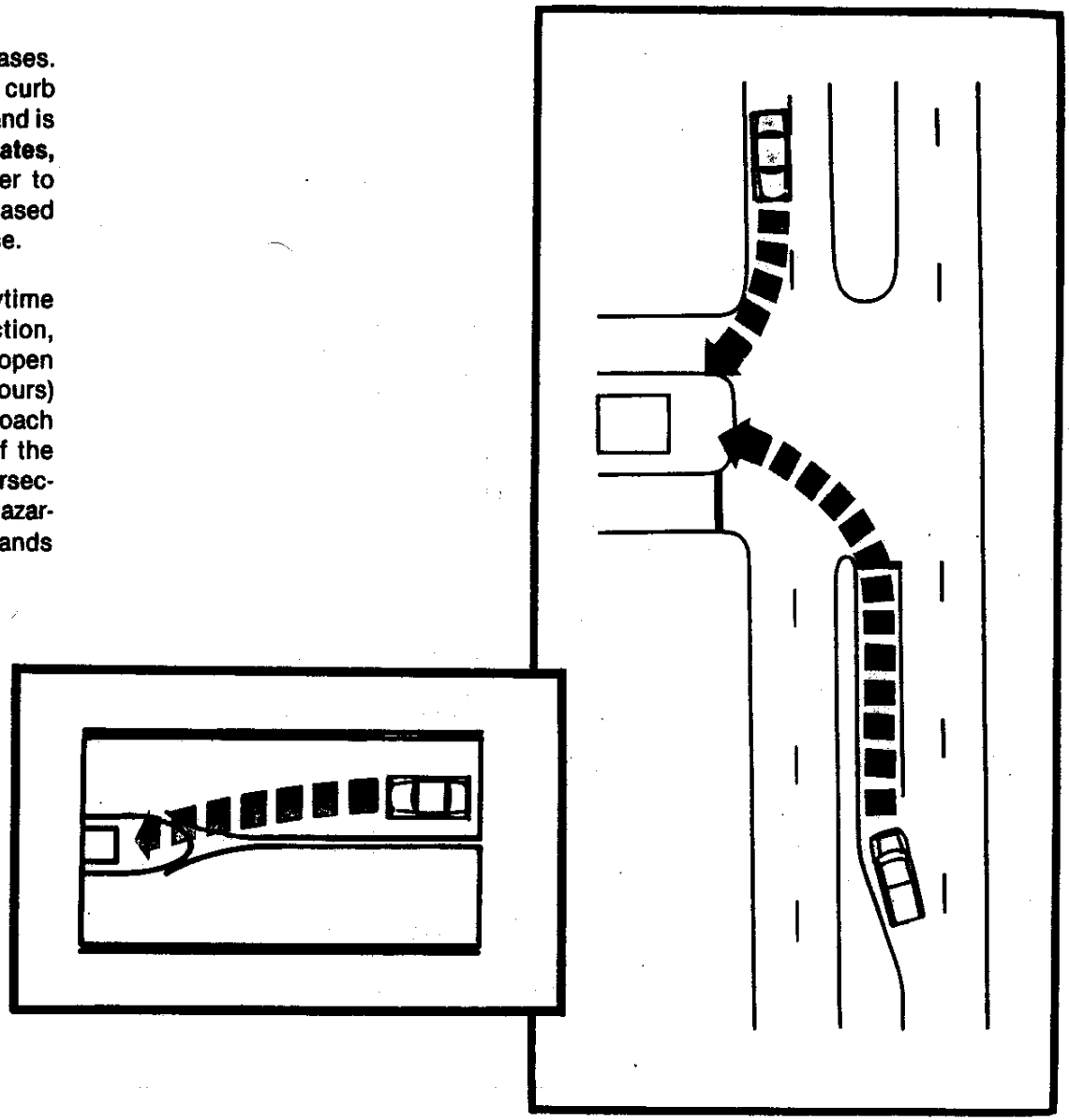
Barriers are not needed for objects on the inside of a sharp curve with a 500-foot or smaller radius, but fixed objects still should be located away from the roadway.



NO BARRIERS NEEDED

Gatehouse islands are special cases. Although, in most cases, an adequate curb will protect the island and guard, the island is **vulnerable at the nose and, at wide gates, from the side.** The decision on whether to provide barrier protection should be based on traffic volume, speed, and hours of use.

For example, a low-volume, two-lane daytime gate might not warrant barrier protection, whereas a high-volume gate that also is open at night (high-accident probability hours) would probably need a barrier. If approach speed is high (more than 40 mph), or if the gatehouse is within 50 feet of an intersection, barriers should be considered. Hazardous objects on painted, flush islands should always be protected.

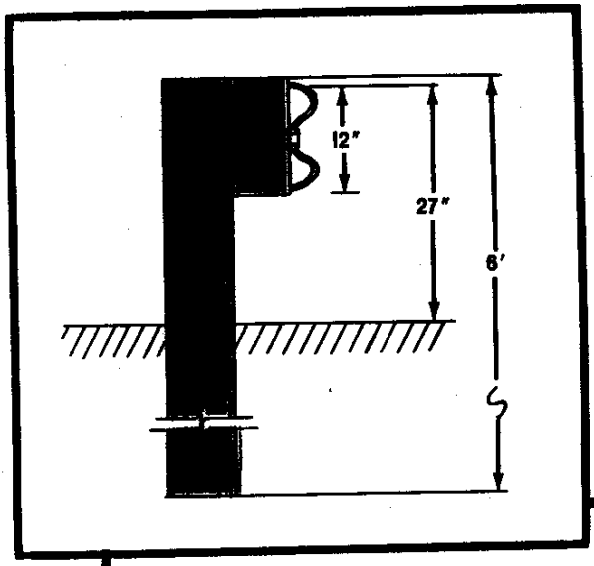


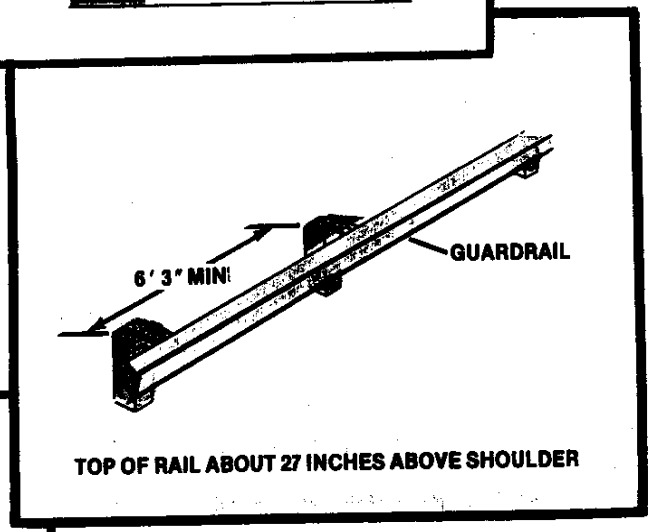
PROTECTIVE BARRIERS

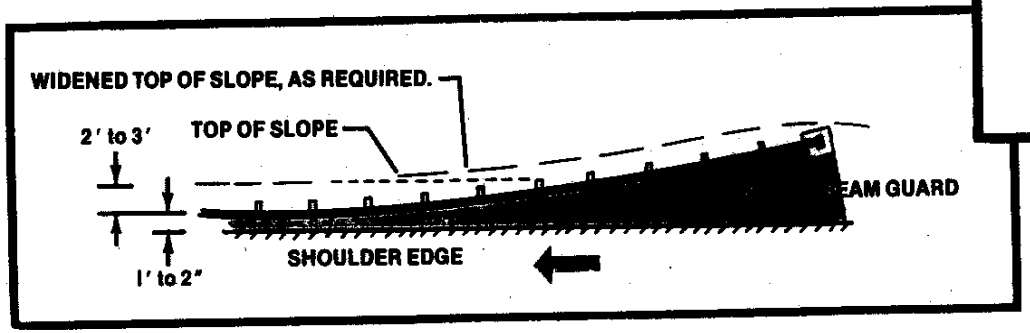
...ole are **"deflective"** and **"at-**

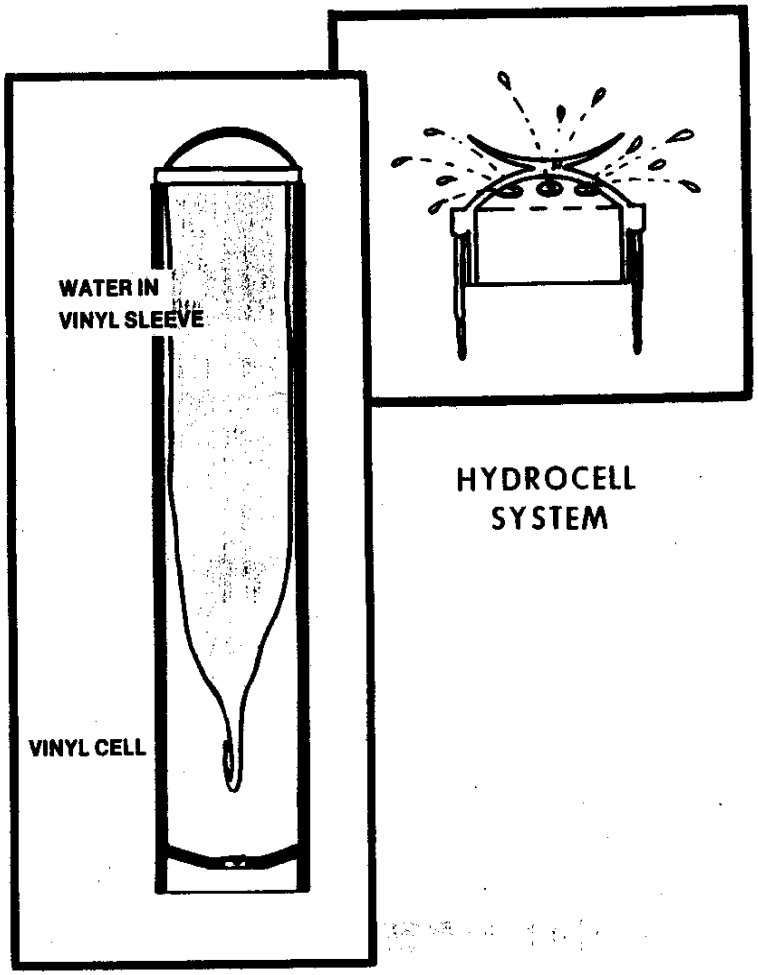
...ER

Defle... **...better protect long or repetitive hazards,** such as ... ...and strings of utility poles. They can be used to prote... the gatehouse and other structures, but must have breakaway cable terminal ends (BCTs) to meet Federal standards.







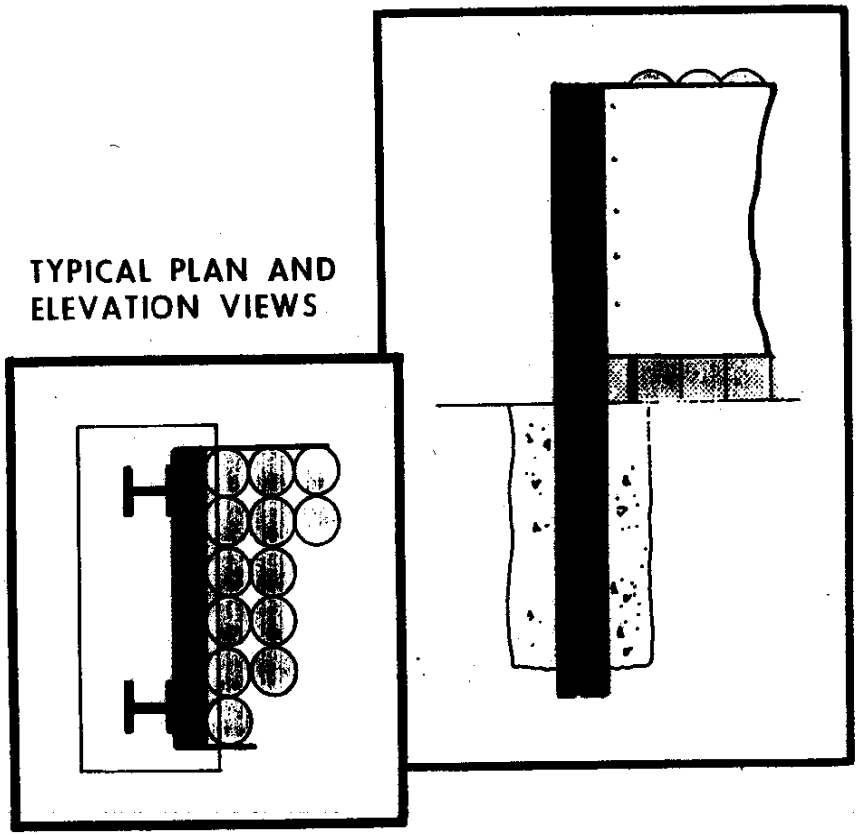


HYDROCELL
SYSTEM

CRASH-CUSHION BARRIER (ATTENUATORS)

Attenuators can be used for any hazard but are particularly useful to **shield the gatehouse.** They provide the good head-on protection that is not possible with a deflective barrier and are preferable for this use. However, they usually cost more than deflective barriers.

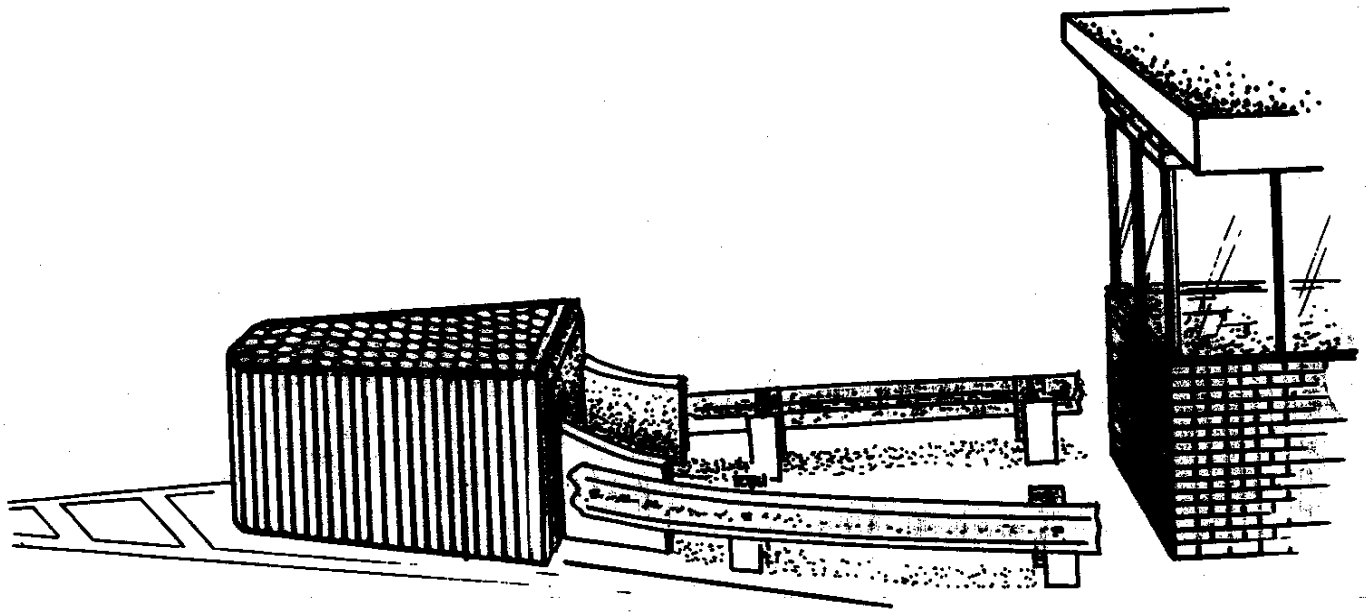
TYPICAL PLAN AND
ELEVATION VIEWS



Engineering judgment and discretion, based on road geometrics, speeds, accident probability, object distance from road, curbing used, and other factors, should be used to determine the better type of barrier system in each specific case. Specific warrants are beyond the scope of this pamphlet.

The barrier system used should not decelerate a vehicle too quickly, because an errant driver could be killed. For example, gatehouses should not be protected with reinforced concrete walls or decorative planters. Safe systems are available and should be used.

Many different barrier systems, each with its own characteristics, are on the market. Design data and advice can be obtained from the manufacturers.



What is the capacity of various types of gates?

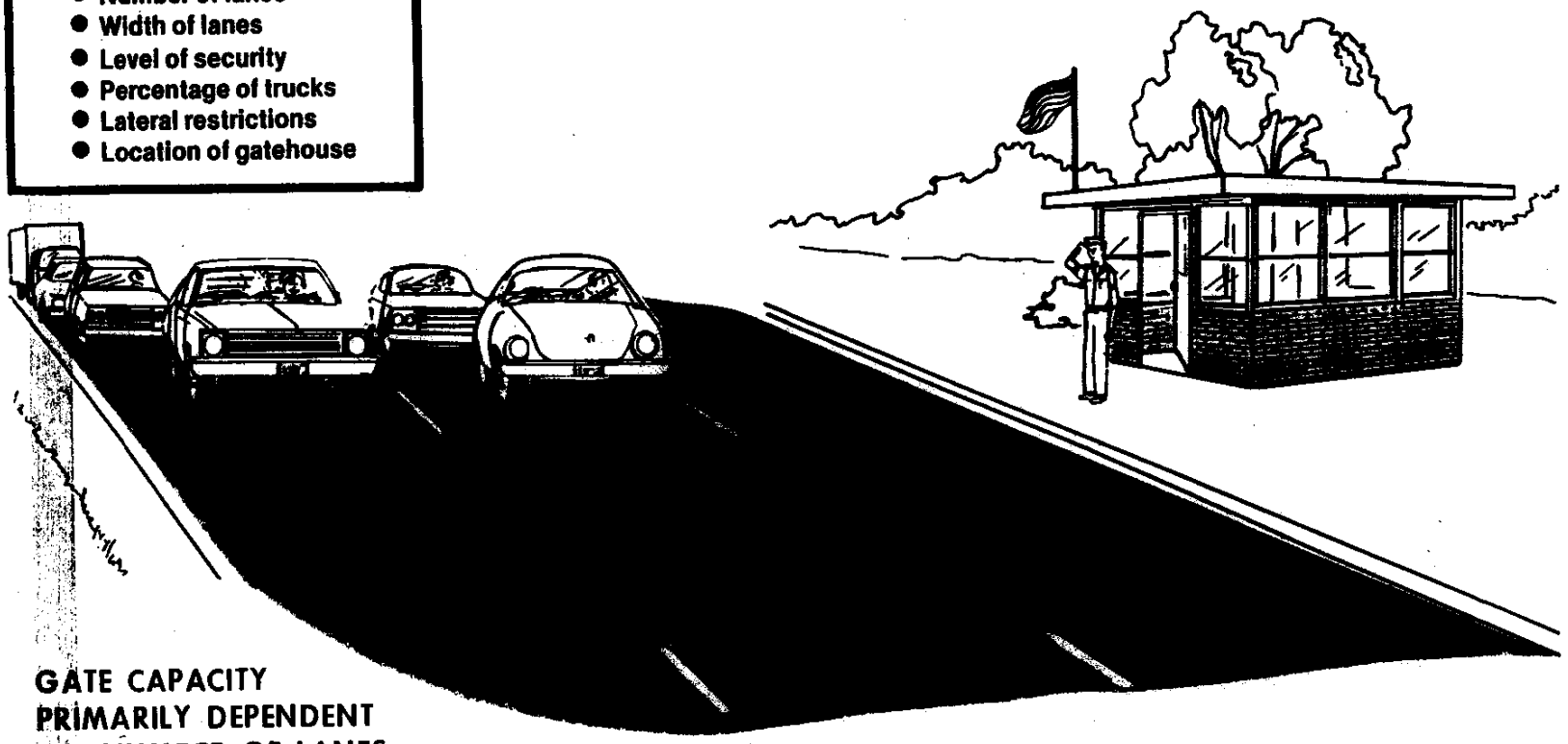
What affects a gate's capacity?

Chapter 8

GATE CAPACITY

Gate capacity depends upon:

- Number of lanes
- Width of lanes
- Level of security
- Percentage of trucks
- Lateral restrictions
- Location of gatehouse



GATE CAPACITY PRIMARILY DEPENDENT ON NUMBER OF LANES AND LEVEL OF SECURITY

It is important to remember that gate capacity per lane is usually less than the approach road capacity per lane. Because of security measures, gates tend to meter vehicles through at a slower rate than does the approach road with free flow. Unless gate capacity is at least as great as approach capacity, backups may occur at the gate during peak traffic flows.

LANE CAPACITY

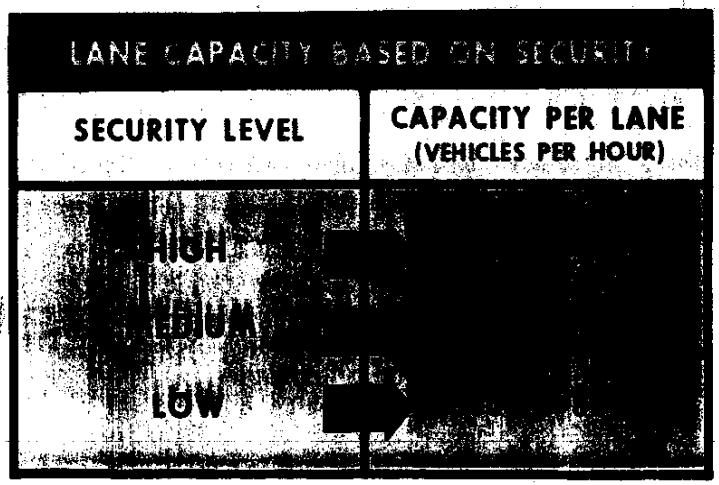
At **high-security gates,** employees must stop and show their identification. Each lane can process, at most, **200 to 400 vehicles per hour.**

Vehicles are not required to stop at **medium-security gates.** They are identified by bumper decals or by other means. Each lane can process, at most, **400 to 600 vehicles per hour.**

Low-security gates are found at installations that are open to the public. No identification is required, and traffic flows in and out as on a normal road. Each lane can handle about **600 to 800 vehicles per hour.**

Some installations use medium or low security during the day and high security at night. The security level in force will determine the lane capacity during different hours of the day.

SECURITY LEVEL AFFECTS LANE CAPACITY



DESIGN CAPACITY

Once traffic demand at a gate has been reduced as much as possible, how many lanes does a gate need? The answer depends upon how much gate congestion is acceptable. So, the first determination is the level of service that is reasonable for a specific location, and then, how much capacity is needed.

Congestion is caused by vehicles arriving at a gate faster than they can be processed. For example, a one-lane, low-security gate may be designed to handle 800 vehicles per hour (vph). If vehicles arrive uniformly at the rate of 800 vph, no congestion will occur. However, work schedules make most rush-hour traffic arrive at gates in one or more 15-minute peaks. So, when 400 vehicles arrive at the gate within a 15-minute period, the real capacity needed is 1,600 vph. As a result, congestion will occur.

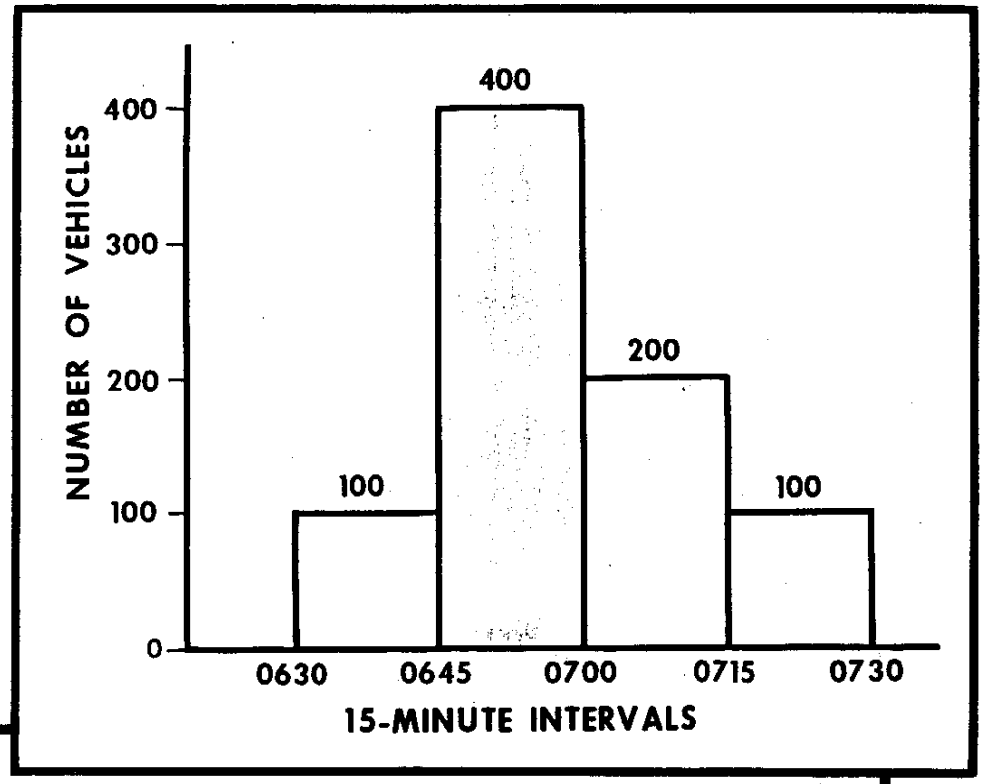
Designing congestion into a gate should be avoided. The gate should be designed to handle the heaviest 15-minute peak after reducing concentrated volumes by staggering duty hours and increasing carpooling.

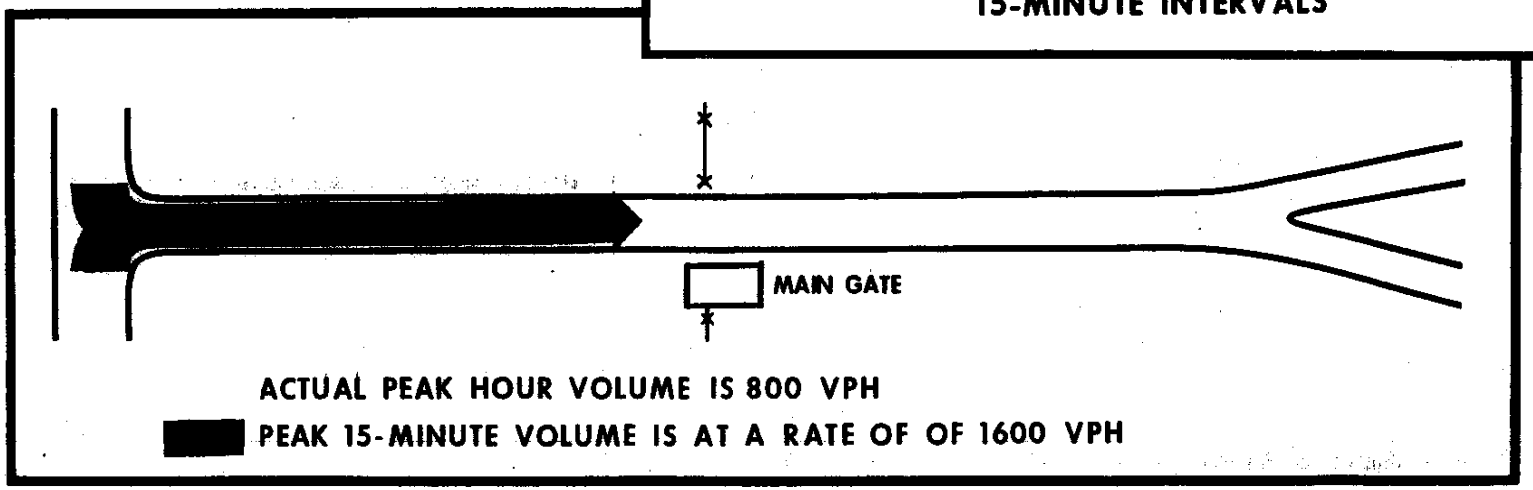
Before constructing a new gate or new lanes, reduce rush-hour traffic congestion by:

- **Lowering the security level**
- **Increasing carpooling**
- **Staggering work schedules**
- **Changing security boundaries**
- **Increasing mass transit use**

DETERMINE THE LEVEL OF SERVICE THAT IS REASONABLE FOR THE LOCATION AND THEN DECIDE HOW MUCH CAPACITY IS NEEDED

DESIGN FOR PEAK TRAFFIC FLOW
TO AVOID CONGESTION





SECTION

Model Gates

DRAWINGS AND DETAILS OF RECOMMENDED GATE DESIGN

USE OF DESIGN MODELS

Chapter 9

How can the best model design be selected for a particular situation?

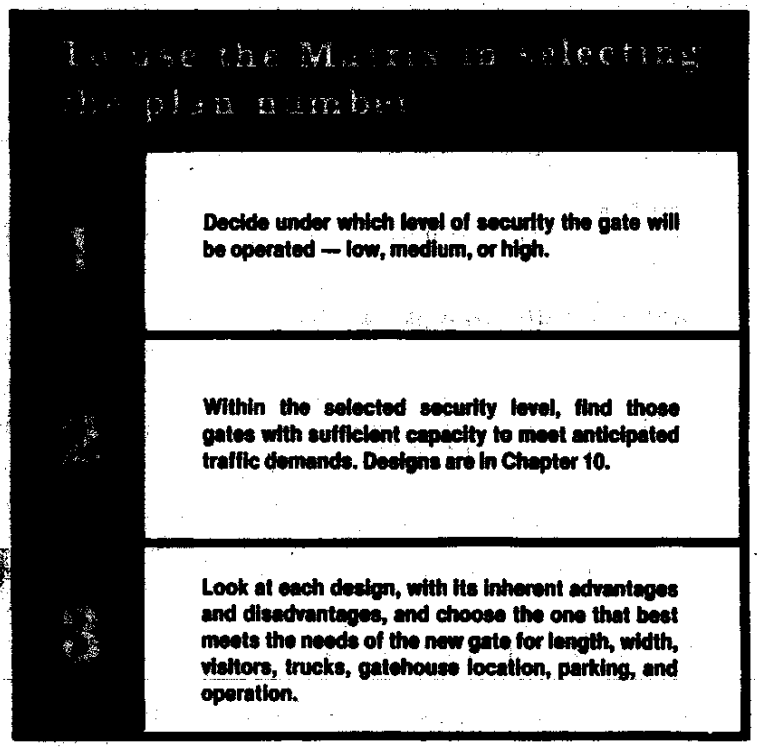
USE OF DESIGN MODELS

This section presents **model gate designs to aid in designing new gates for specific locations and conditions.** Remember that these designs are only models, suggested basic configuraurations to fit general conditions, and are not intended to fit all situations. Choose the model that most closely fulfills the requirements of a prospective new gate, and, then, using the design criteria in section II, modify it. Unlimited options, using different types of visitor facilities, parking, lighting, barriers, road types, and so forth, are available.

Each gate model was developed with specific security and operational characteristics in mind. The chart on this page summarizes these and is provided as a quick reference to help in deciding which design is appropriate for a particular situation.

In the modification of these designs, it must be remembered that they have dimensions consistent with good operation. Decreasing radii, lane widths, and clearances will decrease capacity and increase accident potential.

For assistance in gate design to meet specific needs, MTMC Transportation Engineering Agency, AUTOVON 927-4641, may be called.



QUICK REFERENCE MATRIX

SECURITY LEVEL	APPROACH ROAD: TWO LANE	APPROACH ROAD: FOUR LANE UNDIVIDED	APPROACH ROAD: FOUR LANE DIVIDED
LOW Open to the public 35 + mph approach speed Bumper decal may be required at night	1,2	4,5	8,9
MEDIUM ID may be required at night 25 to 35 mph approach speed Bumper decal usually required	1,2	4,5,6	8,9
HIGH ID card or badge must be shown day or night 25 mph approach speed	1,3	6,7	10

*NUMBER OF THE CHOSEN PLAN FROM CHAPTER 10.

Which design best meets the requirements?

Chapter 10

DESIGN MODELS

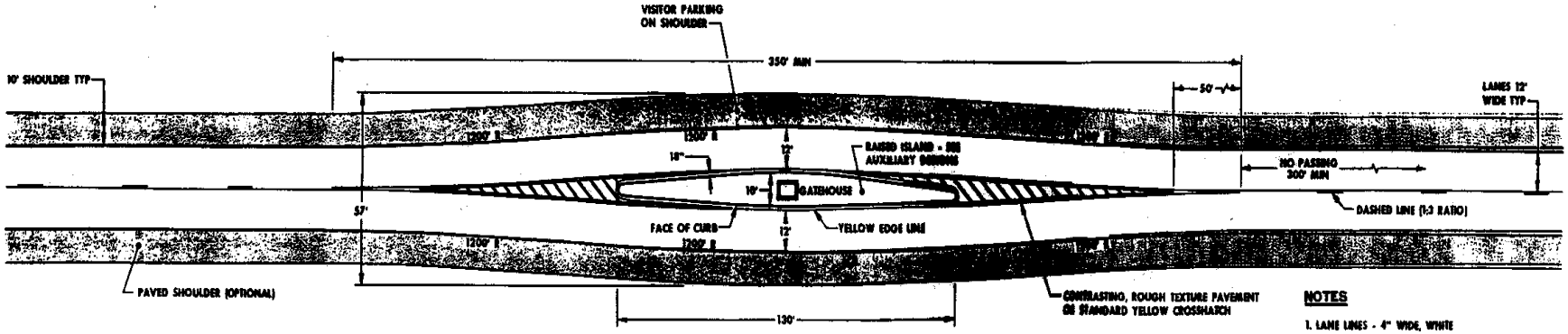
BASIC DESIGN

These drawings are suggested plans for each gate condition. Some are useful for more than one type of gate (see chart, p 9-3). Others, such as those for high-security gates, are not recommended for lower security needs because their capacity is low.

These plans are not intended to be the only designs that should be used. Many acceptable designs are possible using different visitor, truck, parking, and gatehouse facilities. However, where space is available, these configurations are recommended.

NOTES:

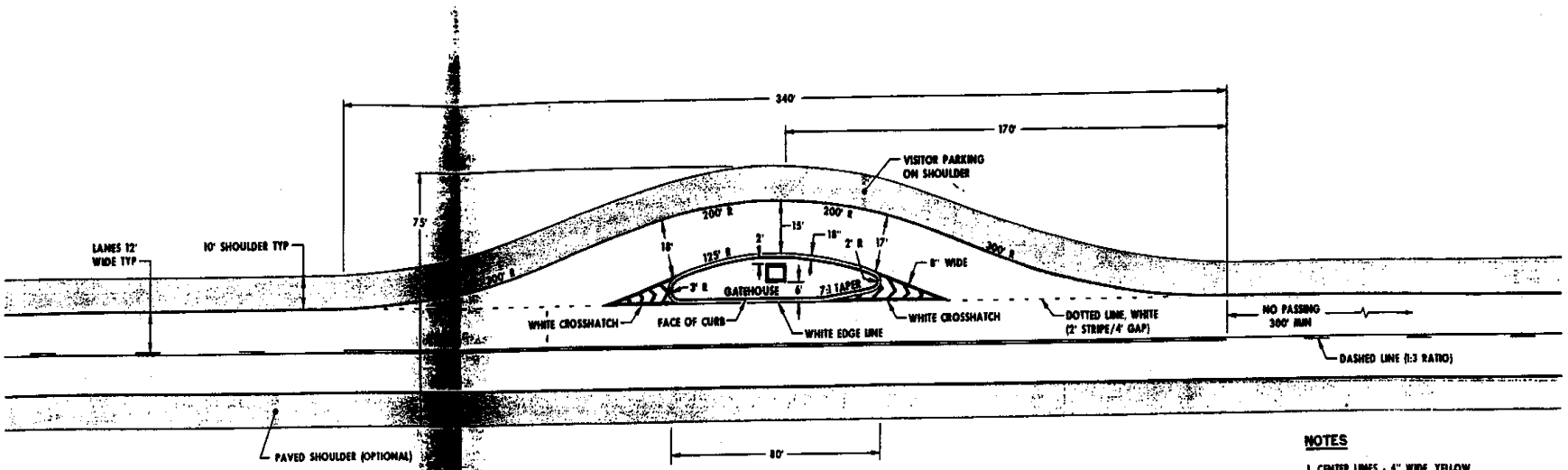
- **Capacities shown are for inbound traffic only. Because security levels will usually be less for outbound lanes, outbound capacity generally will be greater than the inbound capacity.**
- **Shoulders are shown for all outer lanes. Curbs may be substituted in built-up areas.**
- **Inbound direction is at the top of each plan.**
- **Assumed approach speed is 25 miles per hour and, so, minimum taper lengths are shown. With increased approach speeds, taper lengths should be increased.**



NOTES

1. LANE LINES - 4" WIDE, WHITE
2. CENTER LINES - 4" WIDE, YELLOW
3. PAVEMENT EDGE LINES - 4" WIDE, WHITE
4. INBOUND CAPACITY:
   - LOW SECURITY - 600-800 VPH
   - MEDIUM SECURITY - 400-600 VPH
   - HIGH SECURITY - 200-400 VPH
5. LAND REQUIRED:
   - 350' x 57' MIN
6. WHEN APPROACH SPEEDS EXCEED 25 MPH, LENGTHEN TAPERS
7. FOR AHIDS, LOW-VOLUME GATE, GATEHOUSE CAN BE LOCATED ON INBOUND SIDE OF ROAD

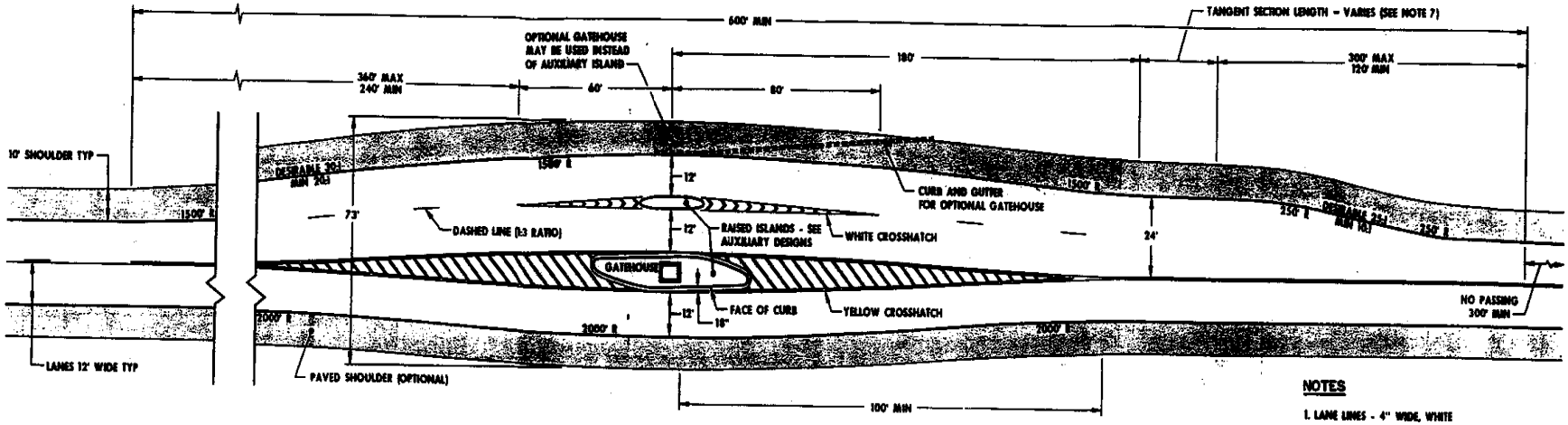
PLAN 1



NOTES

1. CENTER LINES - 4" WIDE, YELLOW
2. PAVEMENT EDGE LINES - 4" WIDE, WHITE
3. INBOUND CAPACITY:
   LOW SECURITY - 600-800 VPH
   MEDIUM SECURITY - 400-600 VPH
4. LAND REQUIRED:
   340' x 75' MIN

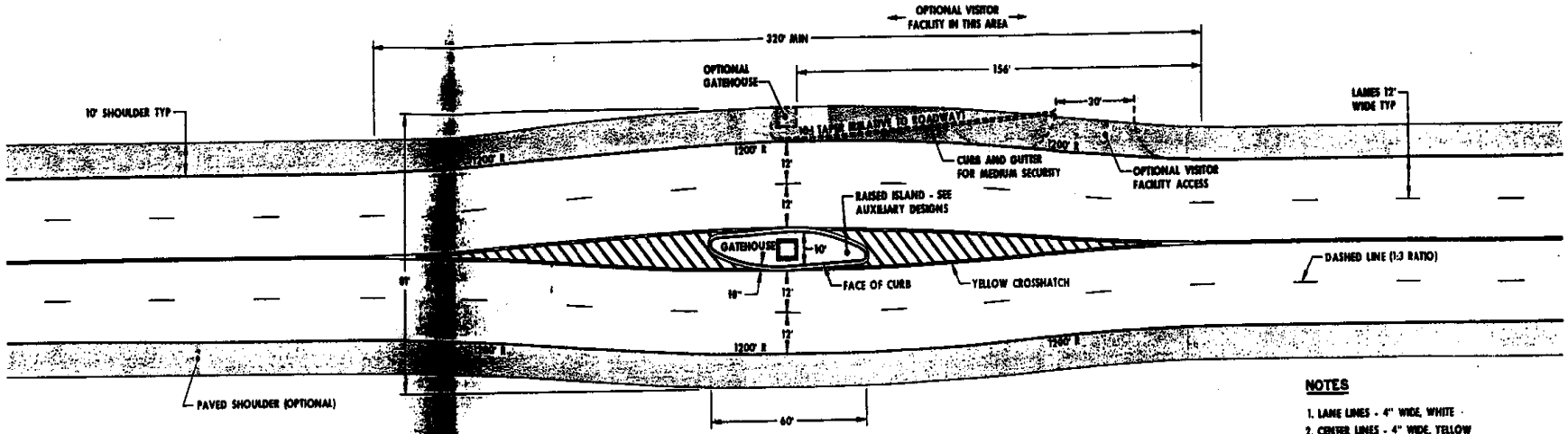
PLAN 2



NOTES

1. LANE LINES - 4" WIDE, WHITE
2. CENTER LINES - 4" WIDE, YELLOW
3. PAVEMENT EDGE LINES - 4" WIDE, WHITE
4. INBOUND CAPACITY:
   MEDIUM SECURITY - 800-1000 VPH
   HIGH SECURITY - 600-800 VPH
5. LAND REQUIRED:
   600' × 73' MIN
6. WHEN APPROACH SPEEDS EXCEED 25 MPH, LENGTHEN TAPERS
7. VARIES WITH EXPECTED QUEUE LENGTH
8. INBOUND DESIGN MAY BE REPEATED ON OUTBOUND SIDE IF OUTBOUND SECURITY IS DESIRED

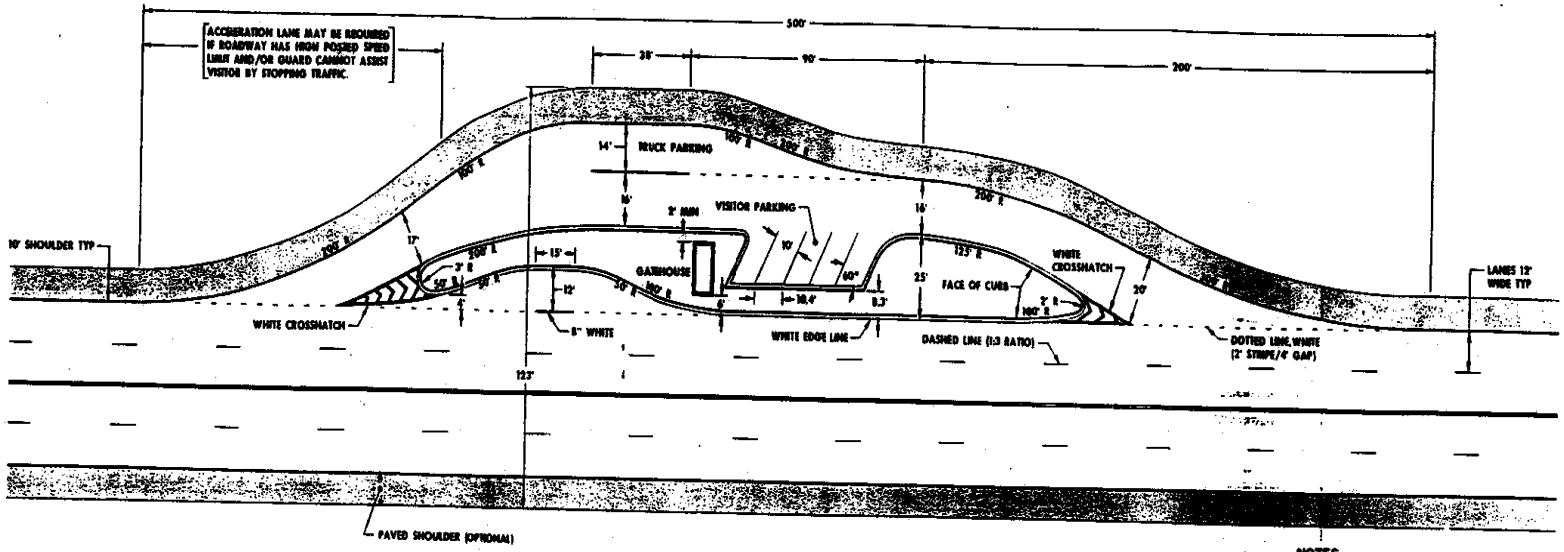
PLAN 3



NOTES

1. LANE LINES - 4" WIDE, WHITE
2. CENTER LINES - 4" WIDE, YELLOW
3. PAVEMENT EDGE LINES - 4" WIDE, WHITE
4. INBOUND CAPACITY:
   LOW SECURITY - 1200-1600 VPH
   MEDIUM SECURITY - 800-1200 VPH
5. LAND REQUIRED:
   320' x 81' MIN
6. WHEN APPROACH SPEEDS EXCEED 25 MPH, LENGTHEN TAPERS
7. AT LOW SECURITY GATES WITHOUT NIGHT SECURITY NO GATEHOUSE OR ISLAND IS NEEDED. A GATEHOUSE MAY BE PLACED TO THE SIDE OF THE ROAD WITH 48' PAVEMENT WIDTH.

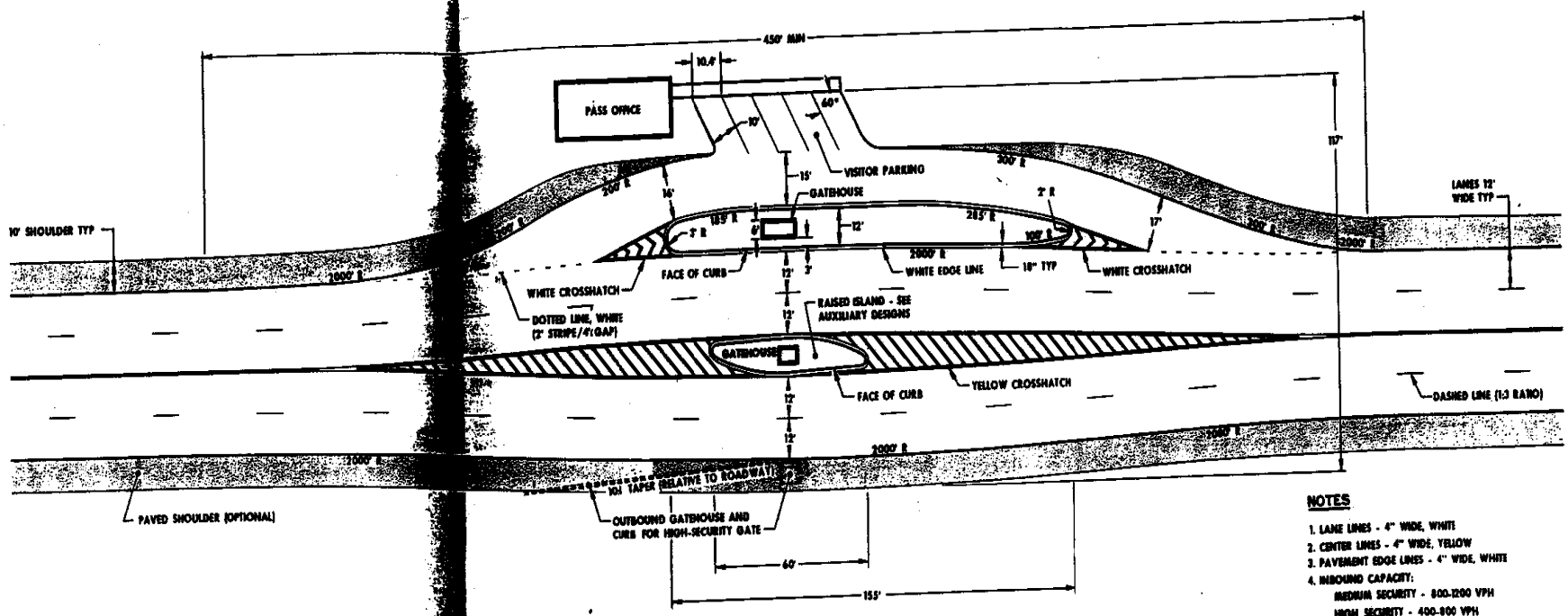
PLAN 4



NOTES

1. LANE LINES - 4" WIDE, WHITE
2. CENTER LINES - 4" WIDE, YELLOW
3. PAVEMENT EDGE LINES - 4" WIDE, WHITE
4. INBOUND CAPACITY:
   LOW SECURITY - 1200-1600 VPH
   MEDIUM SECURITY - 800-1200 VPH
5. LAND REQUIRED:
   500' × 123' MIN

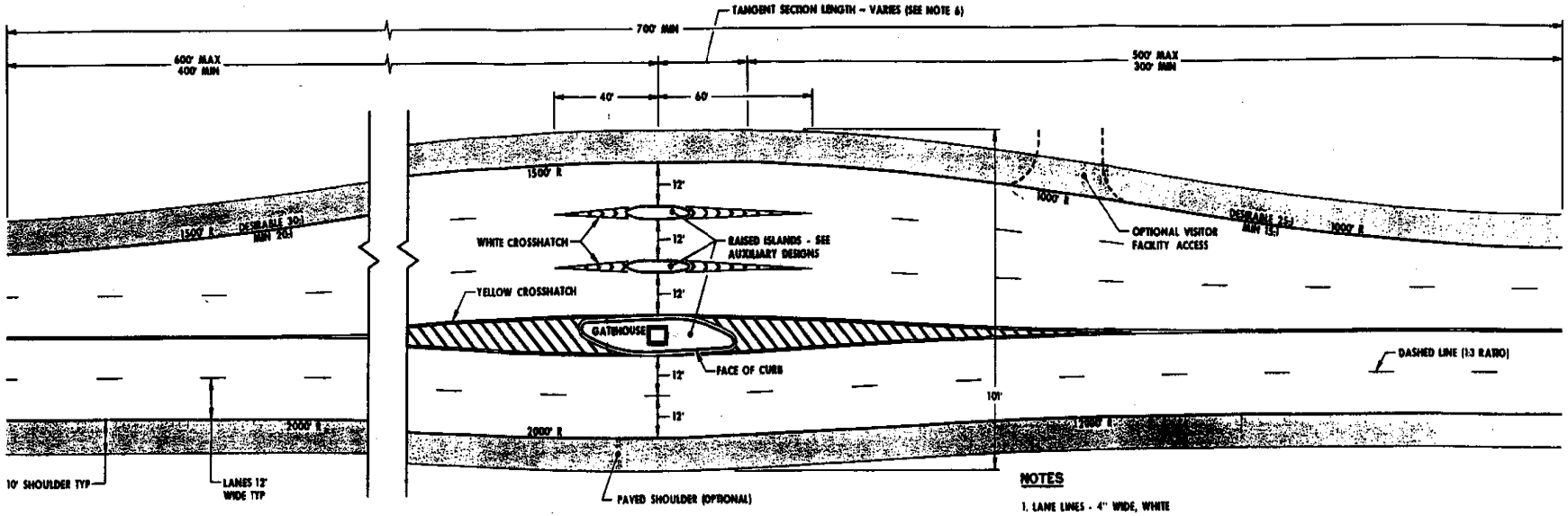
PLAN 5



NOTES

1. LANE LINES - 4" WIDE, WHITE
2. CENTER LINES - 4" WIDE, YELLOW
3. PAVEMENT EDGE LINES - 4" WIDE, WHITE
4. INBOUND CAPACITY:
   MEDIUM SECURITY - 800-1200 VPH
   HIGH SECURITY - 400-800 VPH
5. LAND REQUIRED:
   450' x 117' MIN

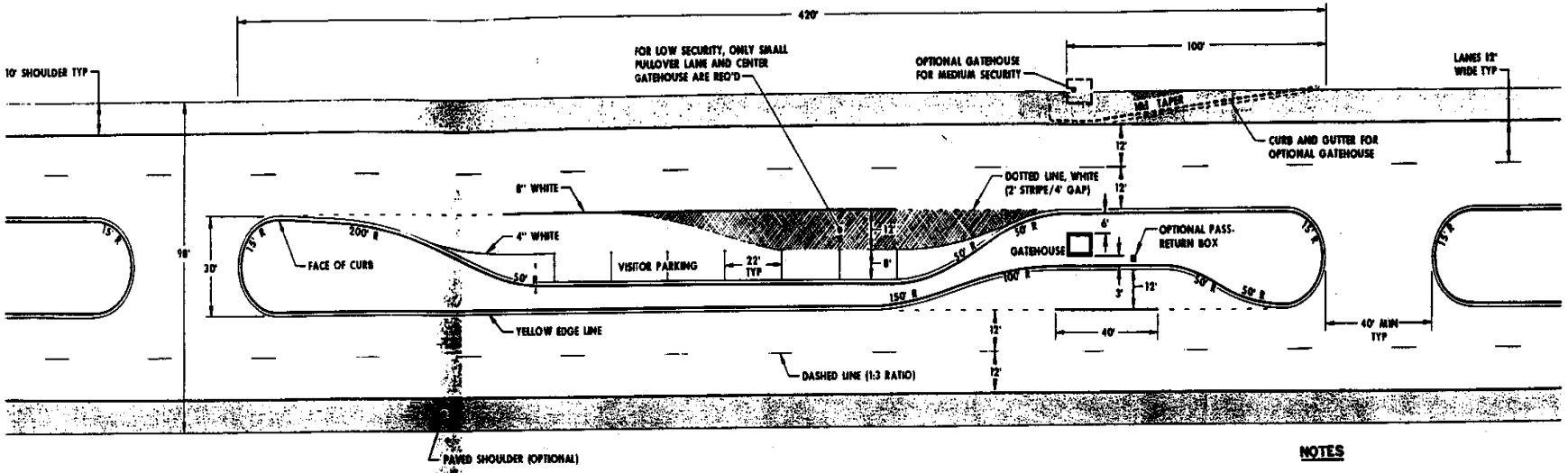
PLAN 6



NOTES

1. LANE LINES - 4" WIDE, WHITE
2. CENTER LINES - 4" WIDE, YELLOW
3. PAVEMENT EDGE LINES - 4" WIDE, WHITE
4. INBOUND CAPACITY:
   HIGH SECURITY - 600-1000 VPH
5. LAND REQUIRED:
   700' x 101' MIN
6. VARIES WITH EXPECTED QUEUE LENGTH
7. INBOUND DESIGN MAY BE REPEATED ON OUTBOUND SIDE IF OUTBOUND SECURITY IS NEEDED

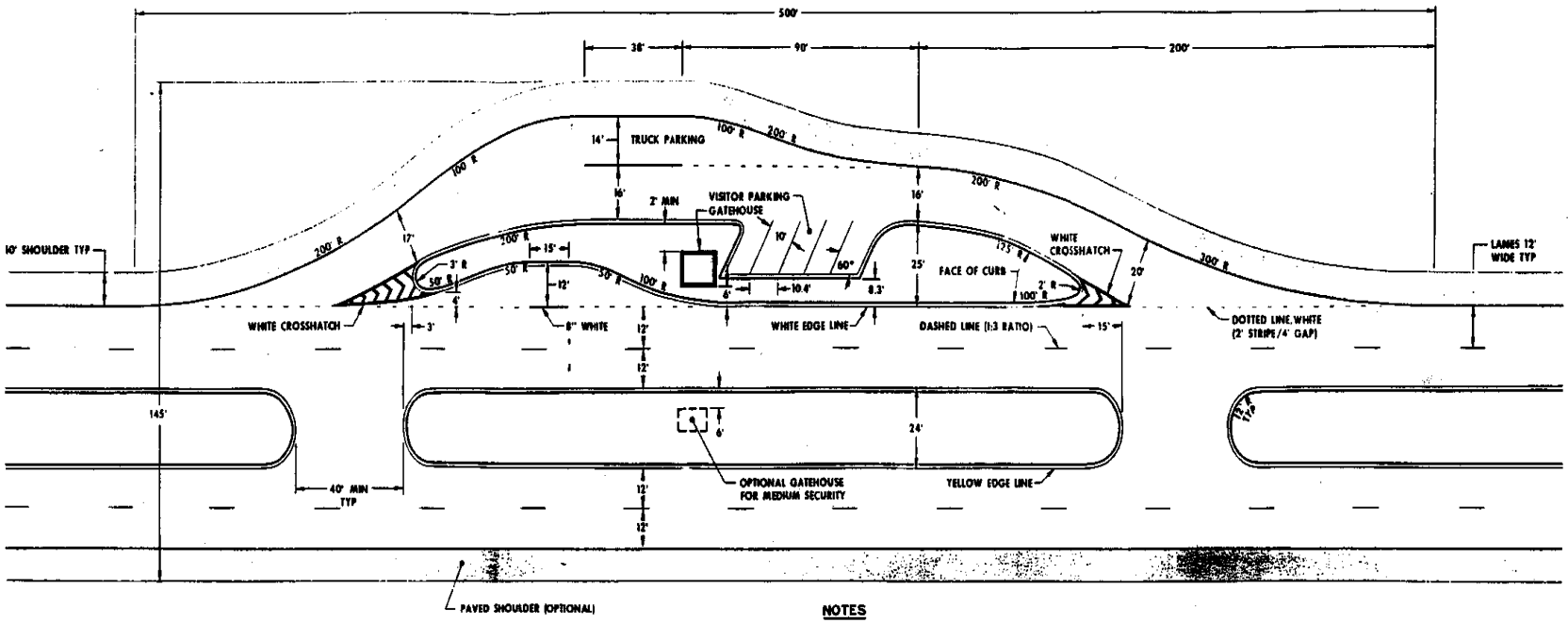
PLAN 7



NOTES

1. LANE LINES - 4" WIDE, WHITE
2. CENTER LINES - 4" WIDE, YELLOW
3. PAVEMENT EDGE LINES - 4" WIDE, WHITE
4. INBOUND CAPACITY:
   LOW SECURITY - 1200-1600 VPH
   MEDIUM SECURITY - 800-1200 VPH
5. LAND REQUIRED:
   420' x 98' MIN

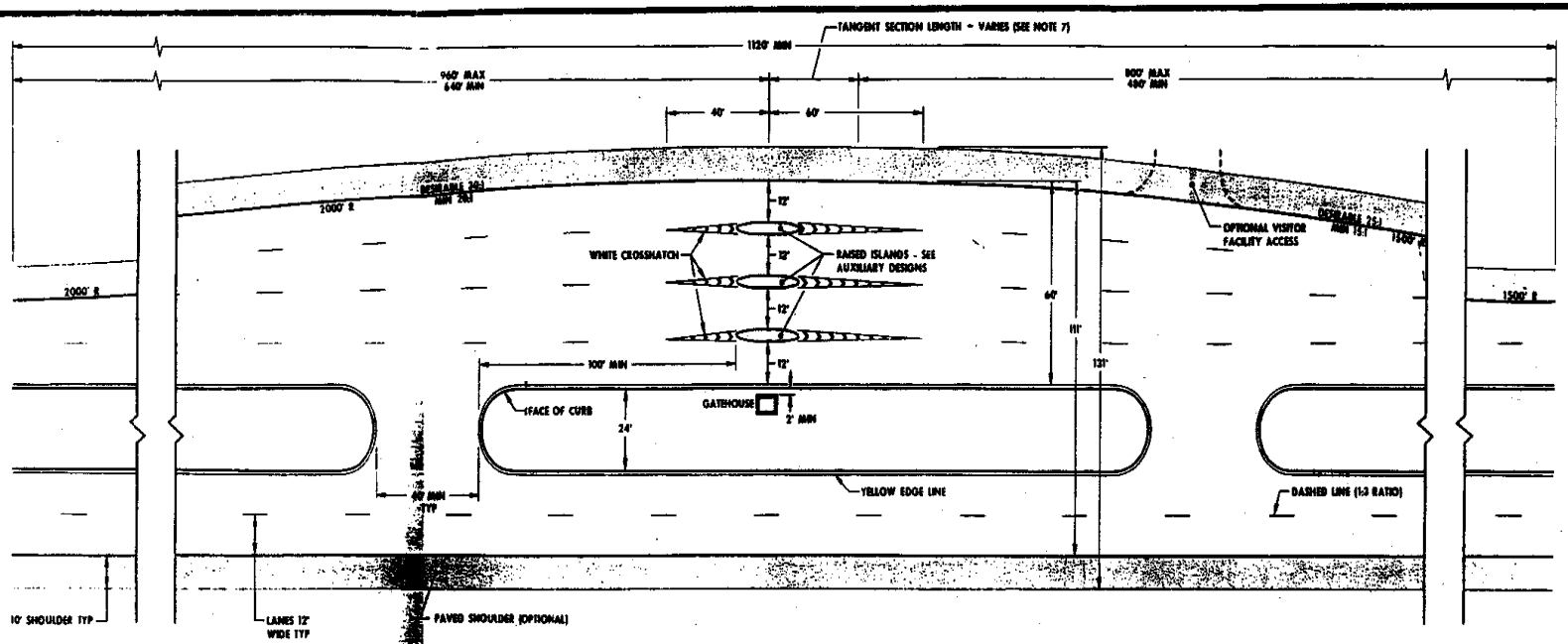
PLAN 8



NOTES

1. LANE LINES - 4" WIDE, WHITE
2. CENTER LINES - 4" WIDE, YELLOW
3. PAVEMENT EDGE LINES - 4" WIDE, WHITE
4. INBOUND CAPACITY:
   LOW SECURITY - 1200-1600 VPH
   MEDIUM SECURITY - 800-1200 VPH
5. LAND REQUIRED:
   500' × 145' MIN

PLAN 9



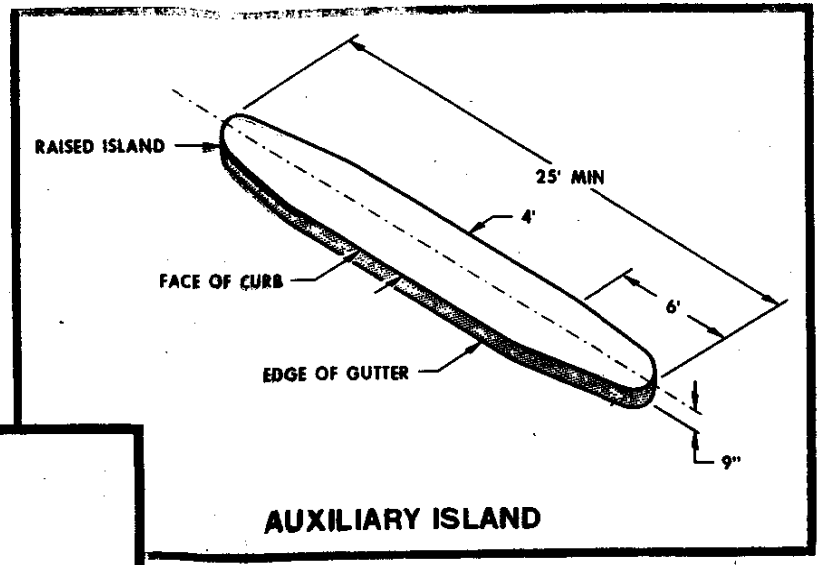
NOTES

1. LANE LINES - 4" WIDE, WHITE
2. CENTER LINES - 4" WIDE, YELLOW
3. PAVEMENT EDGE LINES - 4" WIDE, WHITE
4. INBOUND CAPACITY:
   HIGH SECURITY - 800-1200 VPH
5. LAND REQUIRED:
   820' x 139' MIN
6. WHEN APPROACH SPEEDS EXCEED 25 MPH, LENGTHEN TAPERS
7. VARIES WITH EXPECTED QUEUE LENGTH

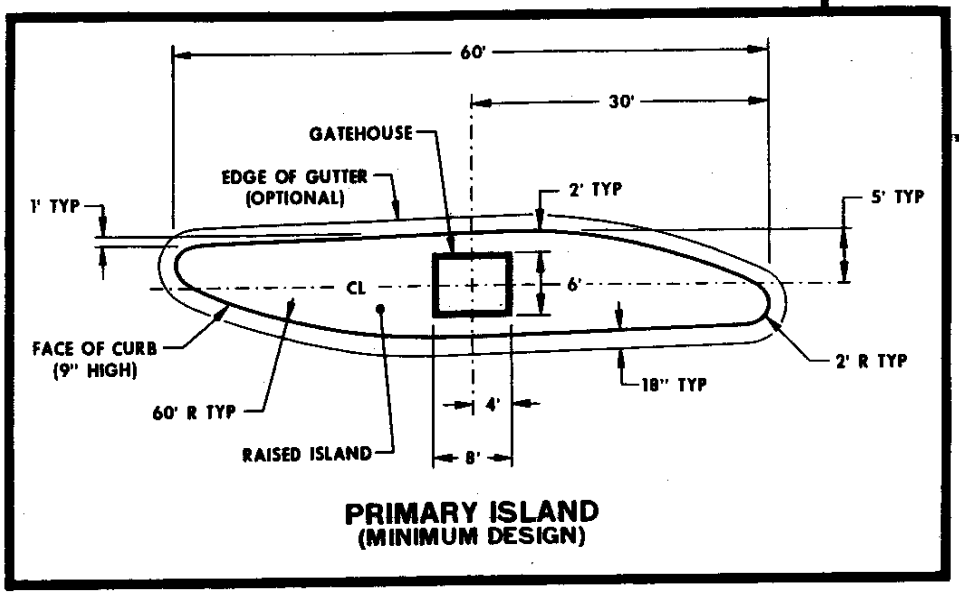
PLAN 10

AUXILIARY DESIGN

The following drawings are auxiliary gate components that are not shown or detailed in the previous section. These components, such as islands, visitor parking areas, and turnouts, can be incorporated into, or substituted for, other items in the model gate designs. However, care should be taken to provide a proper interface between components.



AUXILIARY ISLAND



PRIMARY ISLAND
(MINIMUM DESIGN)

REFERENCES

A Guide for Highway Landscape and Environmental Design, The American Association of State Highway and Transportation Officials, Washington, DC, 1970.

A Handbook of Highway Safety Design and Operating Practices, US Department of Transportation, Federal Highway Administration, Washington, DC, 1973.

A Policy on Design of Urban Highways and Arterial Streets, American Association of State Highway Officials, Washington, DC, 1973.

A Policy on Geometric Design of Rural Highways, American Association of State Highway Officials, Washington, DC, 1965.

An Informational Guide for Roadway Lighting, American Association of Highway and Transportation Officials, Washington, DC, 1976.

Claire, William H., ed., *Urban F 'ng Guide,* American Society of Civil Engineers, New York, New York, 1969.

Crawford, George L., and Clyde E. Sweet, "Citizen's Participation in Planning Transportation," *Traffic Engineering,* May 1973.

Creighton, Roger L., *Urban Transportation Planning,* University of Illinois Press, Chicago, 1970.

Do's and Don'ts for Transportation Master Planning, MTMC Pamphlet No. 55-9, Headquarters, Military Traffic Management Command, Washington, DC, 1976.

Driver Expectancy Checklist, American Association of State Highway Officials, Washington, DC, 1972.

General Provisions and Geometric Design for Roads, Streets, Walks, and Open Storage Areas, Departments of the Army, Navy, and Air Force, Washington, DC, 1977.

Geometric Design Guide for Local Roads and Streets, American Association of State Highway Officials, Washington, DC, 1971.

Geometric Design Standards for Highways Other Than Freeways, American Association of State Highway Officials, Washington, DC, 1969.

Gordon, Michael E., and T. Darcy Sullivan, "Public Opinion Surveys: An Adjunct to Highway Planning and Design," *Traffic Engineering,* August 1975.

Guide for Selecting, Locating, and Designing Traffic Barriers, American Association of State Highway and Transportation Officials, Washington, DC, 1977.

Highway Capacity Manual, Highway Research Board, Special Report 87, Washington, DC, 1965.

Highway Design and Operating Practices Related to Highway Safety, American Association of State Highway and Transportation Officials, Washington, DC, 1974.

ITE Technical Council Committee 6Y-1, "Levels of Service Provided by Urban Transportation Systems," *Traffic Engineering*, January 1976.

Loutzenheiser, D. W., and C. L. King, "Geometric Design", *Transportation and Traffic Engineering Handbook*, ed. John E. Baerwalk, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1976, pp. 599-674.

Management Solutions for Traffic and Energy Reduction, MTMC Pamphlet No. 55-16, Headquarters, Military Traffic Management Command, Washington, DC, 1981.

Manual on Uniform Traffic Control Devices for Streets and Highways, US Department of Transportation, Federal Highway Administration, Washington, DC, 1978.

Mitchell, Richard H., "Citizen Participation in Transportation Decision Making," *Traffic Engineering*, August 1975.

Optimizing Flow on Existing Street Networks, National Cooperative Highway Research Program Report 113, Highway Research Board, National Academy of Sciences, Washington, DC, 1971.

Paquette, R. J., Ashfor, N.; Wright, P. H.; *Transportation Engineering*, Ronald Press, New York, 1972, pp. 320-360.

Pignataro, Louis J., *Traffic Engineering, Theory and Practice*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1973.

Proceedings, 31st Annual Meeting, American Bridge, Tunnel, and Turnpike Association, Incorporated, and International Division, Montreal, Quebec, Canada, 1963.

Relationship of Traffic Volume Characteristics to Military Roadway Design Criteria, US Army Transportation Engineering Agency Report 66-5, Fort Eustis, Virginia, 1966.

Roadway Lighting Handbook, Implementation Package 78-15, US Department of Transportation, Washington, DC, 1978.

Standard Alphabets for Highway Signs and Pavement Markings, Federal Highway Administration, US Department of Transportation, Washington, DC, 1977.

Traffic Control Devices Handbook, An Operating Guide, The National Advisory Committee on Uniform Traffic Control Devices, Federal Highway Administration, US Department of Transportation, Washington, DC, 1975.

Traffic Engineering for Better Roads, MTMC Pamphlet No. 55-10, Headquarters, Military Traffic Management Command, Washington, DC, 1978.

Traffic Engineering for Better Signs and Markings, MTMC Pamphlet No. 55-15, Headquarters, Military Traffic Management Command, Washington, DC, 1981.

Traffic Engineering Study Reference, MTMC Pamphlet No. 55-8, Military Traffic Management Command, Washington, DC, 1976.

Traffic Volume Trend Study, MTMC Report T8-18, Military Traffic Management Command Transportation Engineering Agency, Newport News, Virginia, 1978.

Transportation System Management, US Department of Transportation, Washington, DC, 1977.

TSM, An Assessment of Impacts, US Department of Transportation, Washington, DC, 1978.

Upchurch, Jonathan E., "Reversible Flow on a Six Lane Urban Arterial", *Traffic Engineering*, December 1975, pp 11-14.

Warren, Forrest, and Ivan Lohay, "Residential Street Lighting With High Pressure Sodium Lamps", *Technical Notes, Vol. 4, No. 1*, Institute of Transportation Engineers, Arlington, VA (April 1977), pp 3-6.

Witheford, David K., "Urban Transportation Planning", *Transportation and Traffic Engineering Handbook*, ed. John E. Baerwald, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1976, pp 502-558.