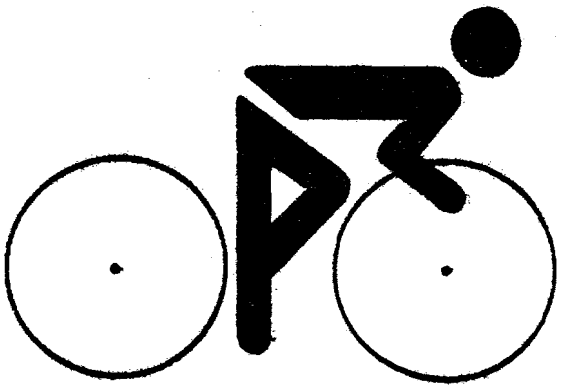
MANUAL
FOR
LOCAL GOVERNMENT PARTICIPATION
IN DEVELOPING BICYCLE FACILITIES
IN RHODE ISLAND



State of Rhode Island
EDWARD D. DIPRETE, GOVERNOR

RHODE ISLAND
DEPARTMENT OF TRANSPORTATION
PLANNING DIVISION
STATE OFFICE BUILDING
SMITH STREET
PROVIDENCE, RHODE ISLAND · 02903

MAY, 1985

R. I. DEPT. OF TRANSPORTATION
JOSEPH PEZZA, DIRECTOR

PLANNING DIVISION

JOSEPH F. ARRUDA, ASSISTANT DIRECTOR
JOHN E. BROWNELL, DEPUTY ASSISTANT DIRECTOR
JOHN J. DONALDSON, SUPERVISING PLANNER/MASS TRANSIT
MARIO J. MARCACCIO, CHIEF CARTOGRAPHER

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PLANNING DIVISION
State Office Building
Smith Street
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Executive Summary

This manual has been written for municipalities in the State of Rhode Island interested in bicycle facilities development. It is intended to outline a specific set of procedures for local governments to follow that will enable them to work with the Rhode Island Department of Transportation (RIDOT) in developing bicycle facilities.

The state's primary objective is to provide for bicycle travel between Rhode Island cities and towns through incorporation of bicycle tolerant design in the construction and reconstruction of state roads, wherever feasible, and provision of independent bicycle paths, where the goal of connectivity between major trip attractors would be served. Bicycle tolerant design is reflected in federal and state regulations and guidelines delineated later in this report.

This manual establishes the context for municipalities to approach bicycle facilities by delineation of the Department's policies in Part 2. Major areas of concern include:

- Facilities Construction and Operation
- Maintenance of Facilities
- Safety and Education
- Bicycle Facilities Planning
- The State-Local Connection

Following this the Local, State, and Federal roles are discussed in Parts 3, 4 and 5 respectively.

The Local Role revolves around developing a local facilities plan and program. In such a plan construction of new bikeways, storage facilities, and safety education programs should be addressed. Sections identifying major attractors, potential routes and comparison with State plans should also be included. A survey of local streets is desirable including information about conditions of the surface, width of pavement, traffic volumes, speed, and barriers to bicycling. This information weighed against the criteria of safety, demand and connectivity aid the municipality in identifying the best local opportunities, problems and constraints for developing bicycle facilities. The process for local governments to follow is summarized in the following list:

1) Identify a project;

2) Establish a need;

3) Conduct a preliminary study to assess project merit and public support;

4) Contact RIDOT and provide map and description of project;

5) Participate in a feasibility study along with RIDOT, if warranted;

6) Participate in facility design and construction as appropriate;

7) Participate in maintenance and law enforcement activities as appropriate;

8) Disseminate information to the public.

The State Role is basically one of providing information, guidance and technical support for localities seeking State and/or Federal actions or funding for facilities development. The RIDOT will provide local communities with information on where state construction and reconstruction projects will occur. The RIDOT's Six Year Plan identifies which projects are already scheduled. The Planning Division will aid in identification of additional bicycle projects beyond those included in a statewide bicycle system plan. The Department will be available to assist in the feasibility analysis of projects showing merit and eligible for federal funds. Final design and engineering may be provided by the RIDOT. The final step in the process is the commitment by the RIDOT to construct the facility, which will be opened for use and maintained according to the agreements signed by the RIDOT with other local agencies. In addition, the RIDOT will continue to disseminate safety, educational, and informational materials statewide.

The Federal Role centers on Federal Highway Administration (FHWA) review and approval for projects to be constructed with FHWA funding. The FHWA reviews a project at several stages of development.

These are:

- Conceptual Plan
- Scope of Work
- Feasibility/Preliminary Design
- Feasibility/Final Design
- Construction

In Part 6 planning and design guidelines for bikeway right-of-ways are described. The right-of-way for a bikeway can fall into one of four categories. These are:

(1) A shared roadway with vehicles

(2) A reserved bicycle lane adjacent to the right lane

(3) The highway shoulder

(4) A separate right of way on which motor vehicles are prohibited

Variations and circumstances under which each would be appropriate are described in detail.

There are six appendices to this report. Appendix A discusses the methodology for establishing need and demand. Appendix B discusses approaches to local funding alternatives. Appendix C discusses design guidelines for bicycle facilities as reprinted from the AASHTO Guide For Development of New Bicycle Facilities 1981. Special treatments for design of roadway improvements, bicycle paths, and supplemental facilities are described. Appendix D describes traffic controls for bicycle facilities as reprinted from the FHWA Manual for Uniform Traffic Control Devices. General requirements, definitions, scope, legal authority and colors are discussed, as are the location, application and design of signs, markings and signals. Appendix E offers an example of how a city may respond to the parking needs of bicycles through zoning. The zoning ordinance shown is illustrative of efforts to elevate the bicycle to parity with automobiles as vehicles. Appendix F specifies FHWA policy for

funding bicycle projects. This memorandum states that, "no bicycle project shall be authorized by this section unless the Secretary shall have determined that such project will be principally for transportation, rather than recreation, purposes."

PART ONE: INTRODUCTION

The Rhode Island Department of Transportation (RIDOT or the Department) has recognized the opportunity to expand bicycle facilities and programs and, in the process, to contribute toward the achievement of important transportation objectives. Among these are energy savings, reduction of traffic congestion, provision of greater choice among transportation modes and increased access to key facilities. This opportunity is supported by changes in Federal law relating to highways and Federal Highway Administration (FHWA) guidelines encouraging the inclusion of bicycle facilities with highway projects, in addition to their treatment as separate and independent (off-highway) facilities.

A statement of policies for state involvement and responsibilities in planning for and providing bicycle facilities has been prepared by the Department and a Policy Summary is included as Part Two of this Report. (See RIDOT Rhode Island Bicycle Facilities Policy Document 1985). That document establishes the context for bicycle facilities planning, development and maintenance. This manual explains how local governments can work with the state in developing bicycle facilities.

The objective of state-local cooperation in this area is to eventually develop a system of state and local bicycle facilities which will enable safe and efficient bicycle travel between and within Rhode Island communities. Just as a system of state and local roadways and public transportation services now facilitate automobile and transit travel, a system of state and local bicycle facilities can provide for this mode of transportation.

This manual is intended to outline a specific set of procedures for local governments to follow that will best enable municipalities to work with the Department in developing bicycle facilities. It is important that there be a common understanding of state policies and the procedures that will best result in state/local cooperation.

The state policy for bicycle facilities which underlies and supports all other bicycle facility policies is a uniform policy for incorporating bicycle tolerance in the construction and reconstruction of state roads, wherever feasible. That is, road shoulders, lane markings, signing, provision of bicycle-compatible drainage grates, road surfacing, and maintenance, where possible or feasible, will be provided to accommodate bicycles. This will assist in developing a basic set of bicycle facilities which can be inter-connected by additional state and local actions to develop a more complete network.

The first type of bicycle facility, the state-provided bicycle tolerant roadways, will be built and marked (signed) according to standards contained in the American Association of

State Highway and Transportation Officials (AASHTO) (Guide for Development of New Bicycle Facilities, 1981) and the Federal Highway Administration (FHWA) Manual on Uniform Traffic Control Devices (MUTCD). The Department encourages local governments to use these standards in any bicycle facilities planning and design they may do.

A second type of bicycle facility, the independent bikeway that accommodates bicycles off of existing automobile roadways, is an additional option considered by the Department. Such bicycle facilities may follow unused rail rights-of-way or other linear elements such as sewer trunk line easements or utility (power line) rights-of-way. Such facilities must be shown to be transportation, rather than recreation, facilities, if FHWA funds are to be used.

These two facility types together with storage facilities comprise the state bikeway program. The state's primary objective will be to provide "trunk line" service between Rhode Island cities and towns. Local government objectives should be to work with the state in identifying where additional facilities might be constructed on roads eligible for federal aid within their communities by interconnecting the state facilities with local independent bikeways. Local efforts should be directed towards linking local bikeway and facility projects with the existing and planned state system.

PART TWO: POLICY SUMMARY

The Rhode Island Department of Transportation recognizes that, in its continuing program for bicycle facilities, a systematic delineation of basic policies is needed. For this purpose, the RIDOT has completed a separate document on bicycle facilities policies.[1] The broad purpose of the document is to identify the policies and procedures for bicycle facilities planning that provide proper roles and directions for the many state, local and private interests concerned with bicycling.

The RIDOT is concerned that the bicycle mode is a very viable but underutilized transportation mode. For this reason the policy document and this manual focus on the bicycle as a mode of transportation. As a result, a set of policies have been articulated and adopted by the RIDOT for Bicycle Facilities Planning in Rhode Island. The following is a summary of these policies, listed by area of concern.

Facilities Construction and Operation

- All roads and highways (excluding Interstates), where feasible, shall accommodate bicycle transportation.
- Bicycle compatible elements will be incorporated, where feasible, in the reconstruction and new construction of highway facilities to meet the goal of a bicycle tolerant system.
- The connectivity of bicycle facilities has a high priority within the context of a system-wide plan.

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1 Rhode Island Bicycle Facilities Policy Document 1985.

- Design criteria developed by the American Association of State and Highway Transportation Officials (AASHTO) will serve as a minimum design standard for all bicycle facilities, unless compelling safety reasons indicate the need for stricter standards.

- The Manual on Uniform Traffic Control Devices will serve as a guide in developing a consistent system of signing for all bicycle facilities.

- Existing rights-of-way that coincide with transportation destination objectives will be utilized wherever possible.

- Where needed, bicycle storage facilities will be installed on state properties to serve inter-modal transportation (park & ride) or for State offices or other state land and buildings.

- Private establishments and employers (i.e., shopping centers, employment centers, etc.) will be encouraged to install bicycle parking facilities.

- Funding for and encouragement of local governments to include bicycle storage facilities for schools, local shopping centers, recreational facilities, parks, and playfields will continue.

- Technical assistance to private and local agencies relative to different types of facilities and relative safety of these facilities will be provided.

- Provision of facilities to a accommodate bicycles on public transportation vehicles will be encouraged.

- Signs used on all bikeways will conform with Part IX of the Manual on Uniform Traffic Control Devices.

- Regulation and warning signs will be used where warranted for bicycling safety.

- Bicycle routes that are designated and signed will meet one of the following criteria:
  - The route is a separate bike path;
  - The route provides access to an important attraction;
  - It is desirable to direct bicycle traffic to the route to avoid other less safe highways.

- Bicycle facilities construction eligible for federal funds will be administered by the RIDOT.

- The development of a system plan which will integrate bicycle tolerant roads with independent bicycle paths and supportive facilities will help achieve the goal of connectivity within the State of Rhode Island.

Maintenance and Security

- The maintenance activity for state roadways will incorporate the proper and necessary maintenance of bikeways incidental to these roads.

- A maintenance agreement will be a prerequisite for the participation of the RIDOT in construction of independent bicycle paths of local significance.

- Responsibility for the maintenance of bicycle storage facilities on state property lies with the State.

- The maintenance of bicycle storage facilities at locally-owned sites will be the responsibility of the municipality.

Safety and Education

- The RIDOT will continue to take the lead role in the promotion of safety through education.

- Increasing the safety of the bicycle-using population can be accomplished through the educational efforts of education, civic and bicycle organizations.

- Revisions to the Motor Vehicle Code to provide consistency or elaborate on safety issues for the bicycle riding community may, at some time, be necessary. The RIDOT will support appropriate legislation when change is deemed necessary.

- The preparation of bicycle facility maps at the state and local level support bicycle transportation and can be a valuable resource for bicyclists and motorists.

The Institutionalization of Bicycle Facilities Development

- The established transportation planning process will continue to be used for incorporating bicycle facilities into the transportation system.

- The inclusion of bicycle facilities in the Ground Transportation element of the State Guide Plan prepared by the Rhode Island Office of State Planning is supported and encouraged.

- The inclusion of bicycle facility projects in the Transportation Improvement Plan is required for federal funding.

- Bicycle Facility projects will be included in the RIDOT's Six Year Plan and Annual Program of Projects.

- A continuous planning process for Bicycle Facilities and Programs will be maintained by the RIDOT.

- The lead responsibility for coordination of state-level bicycle programs will be assumed by the RIDOT Division of Planning.

- Cooperative efforts in the implementation of the RIDOT bicycle facilities policies will continue to be handled by the Divisions of Planning and Public Works - Design Section.

- All state highway-related projects will be reviewed for compliance with the RIDOT adopted guidelines for bicycle compatibility.

- Advisory committees may be formed when appropriate to offer advice and support for the RIDOT efforts. Public participation and input will be emphasized through the committees as well as in public workshops and hearings, when appropriate.

The State-Local Connection

- Technical assistance to local government will continue to be provided through the Division of Planning at the RIDOT.

- Rhode Island's cities and towns will be provided with a manual delineating the state and local roles in bicycle facilities planning.

These policies form the foundation of the RIDOT's approach to planning and construction of bicycle facilities. Using them as a guide to feasibility, design, and implementation, it is the Department's intention to develop an efficient and understandable system for the individual cities and towns to follow. This manual is the result of that effort. Where unique circumstances necessitate special treatment for a particular issue or area, the RIDOT Division of Planning is prepared to offer guidance and assistance to the localities.

PART THREE: LOCAL ROLE

Developing a Local Facilities Plan and Program

The Department recommends that each municipality develop a plan for a local system of bicycle facilities. This plan should be a comprehensive plan covering the construction of new bikeways, storage facilities, and safety education programs and other bicycle related issues. In establishing a municipal bicycle facilities program, it is advisable to seek input from local residents and bicyclists.

Safety and education programs, conducted in the schools or through civic organizations, are a natural component of a local bicycle facilities program. Such programs also increase the public awareness of bicycling as a transportation mode. Federal funding is available through the RIDOT for non-construction projects which include activities such as safety and education programs and the development of route maps for transportation purposes.

In developing a local system of bicycle facilities, the following steps are suggested.

1. Identification of major attractions and residential areas that need to be served and connected by the system.
2. Identification of potential routes on existing highways.
3. Comparison of the identified routes against State plans to determine the extent to which they overlap.

4. Identification of the segments of the local system that are not included in current State plans.

5. Identification of potential routes for independent bike paths which can provide important links in the local system or between the local system and the State system.

Some of the segments identified in step 4 may be on State highways, some may be on local federal aid highways, and some may be on local roads. It will be the responsibility of local communities to initiate projects on all of these segments. Local communities may seek funding through the Department for transportation-related facilities that are on State highways, on local federal-aid highways, for those that are eligible independent bike paths, and for storage facilities. Federal funding opportunities under the category of construction projects include:

- the improvement of roadways through shoulder widening;
- the construction of transportation-related independent bicycle paths;
- the replacement of non-compatible drainage grates;
- the signing of roadways to guide, regulate, and warn bicycle (and motorist) traffic; and
- the development and installation of bicycle parking facilities such as bicycle racks.

During the process of developing a local plan, potential routes (Step 2) and segments of the local system that are not included in State plans (Step 4) will be identified. A survey of local streets - arterial, collector, and neighborhood roads - will also be needed to provide information about the conditions of the surface, width of pavement, traffic volumes and speed, and barriers to bicycling. Hazardous conditions such as drainage grates with parallel bars, debris, narrow pavement, high traffic volumes and speeds, and hazardous intersections should be noted. Such conditions not corrected will be barriers to bicycling and prohibit full connectivity of the local system. Alternative routes should be considered if the results of the survey indicate that the problems are too severe.

In assessing the results of the survey and prioritizing the needs of the community, three criteria, in particular, need consideration: first, the safety and protection of the bicyclist; second, demand for access to particular destinations; and third, the connectivity of the system. All of these criteria should be examined in light of local opportunities, problems, and constraints for developing bicycle facilities.

The safety and protection of the bicyclist is a primary reason for providing bicycle accommodations. Safety criteria should play a prime role in planning bicycle tolerant roadways and independent bicycle paths. Particular attention should be given to improving streets with the highest bicycle use,

hazardous intersections, and streets with high traffic volumes and speeds. Although the reporting of bicycle accidents is often limited, accident statistics can help identify problem areas.

An assessment of demand, discussed in more detail in Appendix A, must consider destinations with high bicycling commutation potential, such as schools, civic centers, employment sites, commercial and shopping areas and recreation centers. Access to these locations is best provided by routes that are direct and expeditious. Bicycle storage facilities at end-of-route destinations will encourage bicycling as a transportation mode. In communities where high bicycle usage is experienced (i.e., densely populated urban centers), the need for provisions for bicycle parking facilities may arise. In Appendix E, zoning code adaptations for inclusion of bicycle parking facilities in Portland, Oregon are shown. This example is illustrative of how one city responded to the space demands of this vehicle type by designating minimum bicycle parking requirements in commercial, industrial and high density residential areas according to a formula similar to that for auto parking. By use of the zoning mechanism this city indicates its desire to elevate the bicycle to parity with the automobile.

Linked with safety and demand issues are those of system connectivity. The safety of the bicyclist is enhanced where bikeways are continuous and the rider is not exposed to hazardous conditions. The connectivity of destination points to state and local systems will also influence bicycle usage.

The more information collected about bicycle usage, road compatibility and connectivity, the better the opportunity will be for the community to assess current local needs. It will also provide valuable information to the state in the review of proposed state road reconstruction projects and to the state transportation planning process. In consultation with the Rhode Island Office of State Planning and the Rhode Island Department of Transportation, municipalities can identify bicycle transportation projects for inclusion in the State's Transportation Improvement Program (TIP). Projects listed on the TIP are eligible for federal funding.

The local municipality will not have to develop detailed design criteria for the construction phase of these bicycle facilities. The Department has adopted the standardized AASHTO guidelines for the construction of independent bicycle paths and the improvement of shoulders for bicycle tolerant roadways. Similarly, the Manual for Uniform Traffic Control Devices will be used as the standard by the Department for signing trails, shoulders, and intersections. Use of this Manual statewide assures consistency and will avoid confusion for bicyclists and motorists. Design criteria for bicycle facilities developed by AASHTO is reprinted in Appendix C. Part IX of the Manual for Uniform Traffic Control Devices which identifies traffic control devices for bicycle facilities appears in Appendix D.

When local communities plan, design, and finance bicycle facility projects independently of state and federal funding, the Department strongly urges that they adopt the accepted AASHTO and MUTCD standards for state-wide compatibility. AASHTO and MUTCD standards are used by the Department for all state highway and bicycle projects.

A process for local government to follow in working with the Department in planning, designing, constructing, and maintaining an eligible bicycle facility has been developed. Local governments are, of course, free to undertake these steps independently for facilities they intend to fund and operate themselves. These would be local facilities such as a recreational bicycle facility or bikeways that do not meet federal funding requirements but which serve local internal needs.

In short, the process for local governments to follow for the development of independent bicycle paths, signing systems, or bicycle storage facilities is:

1. Identify a project. This consists primarily of looking for routes from all the potential routes and segments identified in the local system plan, where need can be established for bicycle paths and where opportunities exist for using appropriate land and/or rights-of-way.

2. Establish need using the suggested procedures detailed in Appendix A of this manual. The level of detail for this step will depend upon the size and type of project. It is important to note that the creation of a new bicycle facility, route or path, may result in new users. Simple extrapolation of past trends in bicycle ridership may understate future ridership, given a new facility.

3. Conduct a study to assess project merit as a transportation facility. The assessment should incorporate information gathered in Steps 1 and 2 about need and opportunities with an overview of major constraints or problems and will vary depending on the type of project proposed.

4. Contact the Department to verify project merit and assess Federal/State funding availability. Local funding alternatives are suggested in Appendix B. It is at this step in the process that the local community should provide the Division of Planning at the RIDOT with a map and description of the project and the results of the project assessment. A sample checklist of project description items is shown in Figure 1. Documentation of local support for the project signed by the local council president or chief elected official is required. Federal funding requests should be made through the State's Transportation Improvement Program (TIP) and/or the RIDOT's Six-Year Program processes.

5. For high cost independent bicycle projects not incidental to other highway construction, which show merit, work with the Department to conduct a feasibility study. If a proposed facility has merit and is eligible for federal funds, the Department will fund a formal feasibility study subject to the availability of federal funds. A specific route, crossings, structural improvements, and landscape and design features should be specified in the feasibility analysis. Problems and solutions for land acquisition, traffic control, signing, and maintenance should be included, as should preliminary design, engineering, and cost analysis for required features. This study should also include specific elements such as bicycle racks or lockers that are felt to be important in the overall facility.

6. Sign agreement of conceptual approval to the final design of bicycle facility. This step follows the standardized procedures that include the review of preliminary design and engineering studies and public hearings for the project and is subject to FHWA approval (See Federal Role, Part V).

Figure 1

Rhode Island Community Check-List for Bicycle Facilities Proposal

Name of City/Town Date

Address

Contact Person Telephone

	Yes	No
1. Are the following included:		
a. A letter of support from chief elected official (town council, etc)	/___/	/___/
b. A detailed map of the route or site (including location of trip generators and attractions along the route)	/___/	/___/
c. A description of the route or site (including information about trip generators and attractions along the route)	/___/	/___/
d. A brief discussion of the transportation benefits of the project (include any information that indicates the expected number of daily trips use)	/___/	/___/
2. Is the route or site part of a local bicycle plan? If yes, include map or plan.	/___/	/___/
3. Does the route connect existing bicycle paths, routes, or tolerant roadways? If yes, describe.	/___/	/___/

7. Negotiate and sign an agreement with the Department that specifies the responsibilities for maintenance and law enforcement.

8. Take necessary steps to enforce maintenance and law enforcement agreements signed with the Department. This step would be taken when the Department has completed the project. It may be necessary for a local government to designate a bicycle law enforcement officer in the local police department, send her/him for special training, acquire special maintenance equipment such as a small sweeper, or institute an increased maintenance schedule for improved bicycle tolerant roads. Other additional actions may include establishing sites for bicycle storage facilities or procedures for renting or assigning bicycle lockers to individuals.

9. The last step in the process is the dissemination of information about new bicycle facilities in conjunction with ongoing safety and education programs.

PART FOUR: STATE (RIDOT) ROLE

Planning Procedures

In carrying out its program the Department, through its Planning Division and Design Section, proposes to undertake the following activities in accordance with the procedures outlined in the previous section and policies stated in Part Two.

- The Department will provide local cities and towns with the information that will enable them to know where state highway construction and reconstruction projects will occur. The RIDOT's Six-Year Plan for highway improvements prepared and published by the RIDOT, identifies which projects are already scheduled and budgeted. From this information the local community can determine those actions with potential for bicycle tolerance components. A Bicycle System Plan for Statewide Facilities is proposed as a future effort by the Department. In the plan both scheduled projects and proposed facilities will be identified which together constitute a statewide bicycle facilities network.

- The Division of Planning will aid in identification of additional projects beyond those to be included in a statewide bicycle system plan. These projects include independent bicycle paths, signing, and storage/parking facilities. The state plan will be based primarily on completing a system of inter-city and town facilities and insuring bicycle access to key regional facilities and activities. The Department will take the lead in identifying and evaluating the bicycle facilities needed to accomplish this. However, the Department will also work with local communities in identifying additional facilities beyond the state plan. The primary initiative for such projects should, however, come from local

communities. The Department will be available, through its staff bicycle coordinator in the Division of Planning, to respond to local community initiatives. Federal funding requests must be requested through the TIP and/or Six-Year Plan procedures.

- For proposed projects that show merit and are eligible for federal funds, the Department will be available to assist in the feasibility analysis of these projects. Using procedures and standards contained in this manual, it will be the responsibility of local government to assess the merit of bicycle projects in which it desires state assistance. General assistance will be available for this purpose. As indicated, if a proposed facility has merit, is eligible for federal funds and requires a separate feasibility study, the Department will fund a formal feasibility study subject to the availability of federal funds and the approval of FHWA. The Department specifies the feasibility study must address the alternatives and include a discussion of social, economic, historical, archaeological and environmental effects of each. It is to be developed in accordance with the requirements of 23 CFR Part 771.115(b) for categorical exclusions. In lieu of extensive environmental assessment, the Department will assist in the preparation of a programmatic 4(f) statement discussing the anticipated historic and environmental effects of the project. Other information required may include bicycle trip estimates, discussions of consistency with local community plans, design elements, maintenance, cost, potential effect on wetlands, and characteristics unique to the proposed project. In all cases the Rhode Island Department Of Transportation will contribute pertinent background materials as well as staff time where possible.

- Following feasibility studies, hearings, and final community and FHWA approvals, and if an eligible project proceeds through the written agreement stage, final design and engineering needed will be provided by the Department staff or by contract through the local community. The Department will negotiate an

agreement covering such items as responsibilities for facility maintenance, law enforcement, and safety with each local community or state agency involved in the project. The final step in the process is the commitment by the Department to construct the facility, which upon completion will be opened for use and maintained according to the agreements signed by the Department with local governments or other state agencies.

- The Department will continue to disseminate safety, education, and informational materials statewide. Local education, civic and bicycle organizations can receive the RIDOT publications upon request.

Funding

There are three related programs for funding roadway and bikeway improvements administered through the Department. These three programs have been established and funded by the federal government. They are based on a uniform road classification system used throughout the United States, which categorizes roadways by their function in the system and their location in either an urban or rural area. The three funding categories are: (1)Consolidated Primary, (2)Urban Systems and, (3)Rural Secondary.

There is no separate pool of funds for creating bicycle tolerance in roadway construction or reconstruction projects. The costs of constructing additional width for the shoulder, signing the route, and/or converting to bicycle compatible drainage grates are built in to the overall project costs. At present urban, primary, and rural secondary projects are funded 75 percent federal and 25 percent state. The state share of the funding formula can be paid in whole or in part by local

government thereby accelerating the project; the contribution of a local government can include the value of right-of-way or design work.

Independent bicycle projects are 100 percent federally funded. Independent bicycle projects may include construction of bicycle lanes, paths, shelters, bicycle parking facilities, and other roadway and bridge work necessary to accommodate bicyclists. Non-construction bicycle projects, also eligible for 100 percent federal funding, must be related to the safe use of bicycles for transportation. These projects can include the development of educational materials and maps.[2] Independent bicycle facilities, however, are constrained by a federally established limit of $4.5 million per year per state.

2 Department of Transportation Federal Highway Administration, Final Rule, Effective April 23, 1984, 23:CFR Part 652, Pedestrian and Bicycle Accommodations and Projects.

PART FIVE: THE FEDERAL ROLE

For any project where federal monies are the anticipated source of funding, the Federal Highway Administration (FHWA) reviews and approves/disapproves the project at several stages of its development.

For an independent bicycle facility, the first approval is sought after preliminary discussions regarding a specific route have begun by the state or the state in combination with a local community(ies). This sets the stage for the conceptual approval of the project by FHWA. FHWA is provided with a map and description of the proposed route(s). One basic criteria for FHWA approval is that the facility be primarily utilized for transportation purposes. This approval must be in accordance with FHWA memorandum dated May 21, 1984 "Guidance on Transportation Use for Bicycle Projects," (see Appendix F). After the project has been reviewed and approved by FHWA, the state/local government develops a scope of work.

The scope of work specifies and defines the needs that must be addressed in the feasibility and preliminary design study conducted for the project. Within the scope of work, objectives of the project are clarified. The documentation of the project as a transportation facility and the identification of trip generators/attractions and the connectivity of the facility are elements of the scope of work. When the scope of work has been developed, FHWA must approve the scope of work.

Upon approval of the scope of work, the feasibility/ preliminary design study is conducted by the Department or by a consultant. The feasibility/preliminary design study must document the transportation benefits of the project. Additionally, the Department specifies that the feasibility study address the alternatives and include a discussion of social, economic, historical, archaeological, and environmental effects of each. Due to the categorical exclusion classification granted by the federal government for bicycle facilities, historical, archaeological and environmental effects need only be addressed in a programmatic 4(f) statement. Following public workshops, the feasibility/design work is reviewed and commented on by FHWA. After approval of the feasibility/design study, final design plans are prepared. The FHWA reviews and comments on the final plans, specifications, and estimates prior to the solicitation of bids.

FHWA gives the final authority to proceed with the construction of the project. During the construction phase, FHWA inspects and reviews the work at the site. The final payment of funds for the project are released pending final inspection and approval by the FHWA.

PART SIX: GENERAL PLANNING AND DESIGN GUIDELINES

Rights-of-Way For Bicycles

The right-of-way for a bicycles can fall into one of four categories. These are:

(1) A shared roadway with vehicles in the right hand travel lane of the highway.

(2) A reserved bicycle lane adjacent to the right lane of the highway.

(3) The highway shoulder.

(4) A separate right-of-way on which motor vehicles are prohibited.

The right-of-way width needed for each of these categories varies; the following discussion suggests the variations that are available to the Department.

The bicycle can share the roadway with motor vehicles where traffic is light and speeds are low. A shared right travel lane is considered satisfactory for roads that carry average daily traffic (ADT) of less than 1200 vehicles.[3] The right lane should be no less than 12 feet wide and should be widened to 15 feet on sections where vehicles need to pass bicycles without leaving their travel lane, that is on sections of 2-lane roads marked by a double yellow line. Widening is also suggested on steep grades. This type of bicycle right-of-way is appropriate for low volume roads which do not have a shoulder.

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3 New Jersey Department of Transportation, Bicycle Compatible Roadways - Planning and Design Guidelines.

The primary advantage to using a wide travel lane, instead of a shoulder, is that the bicycle travel path will be kept free of debris by motor vehicles riding over it when bicycles are not present. There are, however, some severe disadvantages to the use of a wide right lane. The wide lane could encourage reckless driving and doubling up of vehicles especially at intersections.

For roads with moderate to heavy ADT (greater than 1200 vehicles), a 15-foot lane could be shared by bicyclists and motor vehicles if the volume of heavy trucks is minimal and speeds are less than 55 mph, or if the volume of trucks is moderate to heavy but speeds are less than 45 mph. An alternative to this could be a 12-foot travel lane and a 4-foot shoulder. Additional shoulder width is desirable if motor vehicle speeds exceed 35 mph, a high percentage of trucks use the road, or if obstructions exist on the right side.

For roads with moderate to heavy traffic, moderate to high volume of trucks, and speeds over 45 mph, an 18-foot width is required. This could be a 12-foot lane with 6-foot shoulders.

On highways which do not typically have shoulders, mostly urban highways, a bike lane can be reserved adjacent to the right lane of the highway designated by striping and pavement markings. Right-of-way widths should conform to AASHTO standards.[4] This bikeway width is a 5-foot minimum on a curbed street.

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4 AASHTO, Guide for Development of New Bicycle Facilities, 1981.

Widths required for separate bicycle paths should also conform to AASHTO guidelines. (See Appendix C). In most cases a 10-foot minimum paved width and 8-foot vertical clearance is desirable. However, these may need to be increased to 12 and 10 feet respectively in areas where maintenance vehicles must be accommodated. Much like highways, the design criteria for bicycle paths include horizontal alignment, sight distance requirements, signing, markings, design speed, grade, and pavement structure among other things.

Appendix A:

Establishing Need and Demand

APPENDIX A

Establishing Need and Demand

Importance of Demand Estimation

There are four reasons for estimating demand for bicycle facilities. First, when bicycle facilities of any considerable cost are contemplated in Federal Highway Administration-funded projects, the FHWA requires that costs be "consistent with the anticipated benefits to the community."[1] A second reason is to determine if state efforts and/or funds should be expended. Third, demand estimation can be used for prioritization of projects. Finally, if local authorities are contemplating the investment of resources in bicycle facilities, it is important that they know where the greatest transportation need exists. The methods outlined in this Appendix are recommended for demand estimation.

The estimation of demand is in keeping with accepted transportation planning procedures. Planners analyze transportation systems in terms of supply and demand. Demand, an expression of need, can be quantified in terms of the number of trips per day or per year between specific origins and destinations. Using modal split and traffic assignment models, transportation planners can translate origin-destination demand into the number of people or vehicles using a specific mode and route.

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1 Federal Highway Administration, "Bicycle and Pedestrian Facilities in the Federal-Aid Highway Program" (1984) p. 3.

However, past origin destination studies and modeling have not considered the bicycle as a separate mode of transportation. There is, therefore, very little data available at this time to support detailed demand studies. Demand for bicycle facilities must therefore be assessed qualitatively using demand indicators or by simplified quantitative methods. The following discussion presents methodology for using either demand indicators, singly or in combination, or a simplified quantitative method. The quantitative approach presented here draws upon work done for the East Bay Bicycle Facility[2,3].

The bicycle facility service area

An important first step in establishing demand is the definition of the bicycle facility service area. Past studies have shown that five miles is the limiting length for commuter bicycle trips[4]. In one study average trip lengths for shopping were found to be approximately the same as for commuting. It is suggested that if a bikeway clearly serves a major attractor, the service area could be defined to include all points within a five-mile travel distance of the attractor. A facility serving more than one attractor will have a composite service area resulting from the combination of service areas for all the

2 Rhode Island Department of Transportation, Providence-Bristol Bicycle Facility Trip Estimates, August, 1982.
3 Lee Pare and Associates Inc., East Bay Bicycle Facility Final Report, October, 1983.
4 Elaine Power Institute of Transportation Studies, The Demand for Commute Bicycling, A Review of Selected Literature, University of California, Berkeley, 1984.

attractors. The five-mile boundary may be extended for some types of attractors if there is data to support this.

For a bikeway which does not directly serve major attractors or for trips where the destination is not a major attractor, the service area can be defined as a strip of some specified width on each side of the bikeway. It should be recognized that factors such as terrain (hilly or flat), trip purposes, and age distribution of population will affect the extent of the facility service area. A strip width of one half mile on each side of the bicycle path was used for the East Bay Bicycle Facility[5].

Historical data

The United States Census Bureau collects data pertaining to transportation, and special tabulations can be obtained for individual standard metropolitan statistical areas. Of particular interest is Table 1-17 which shows all workers not working at home by mean travel time, means of transportation, and car pooling. Means of transportation includes the bicycle. The data are available by analysis zones.[6] From the data it is possible to find the number of work trips that were by bicycle and, perhaps more importantly, the number of work trips that are of a distance (actually measured by travel time) which makes them potential bicycle work trips.

The special tabulation of data also includes population figures by sex and age, school enrollment, numbers of housing

5 Rhode Island Department of Transportation, Providence - Bristol Bicycle Facility Trip Estimates, August, 1982.

6 United States Census Bureau, 1980 Census of Population Journey to Work: Metropolitan Community Flow. PC 80-2-6C

units, and many other tabulations. Local communities can contact the Rhode Island Office of State Planning to obtain data for their use.

Demand indicators

A preliminary estimation of the level of demand for a specific bicycle facility can be made by reviewing the characteristics of the service area and its population. Based on the information gathered at this stage a decision can be made regarding the advisability of processing an in-depth demand analysis for the facility.

Population as a demand indicator. There is obviously a relationship between population and the number of bicycle trips generated in any locality. Furthermore, the number of bicycle trips is a function of the age distribution of the population. Surveys of communities have found that 81% of bicyclists are under the age of 36. The incidence of bicycling has been found to drop off dramatically over the age of 45.[7] This upper age limit can be expected to go up as more people develop bicycling habits early in life.

The effect of age distribution on the number of bicycle trips will depend to some extent on the characteristics of the service area. For example, if a high school is in the service area, the

7 Elaine Power Institute of Transportation Studies, The Demand for Commute Bicycling, A Review of Selected Literature. University of California Berkeley, 1984.

number of people between the ages of 14 and 18 will be important. If the bicycle facility serves an area of high employment, the number of people in the 18 to 45-year age group will be important.

At the local or project level, the number of potential utilitarian bicycle users within the service area of a proposed facility can be used as an indicator of level of need. To obtain this information, statistics for population by age distribution within the bicycle facility service area are needed.

Population density as a demand indicator. The destinations or trip attractors for shopping trips, personal and business trips, and other trip purposes are for the most part very diverse. The number of opportunities for making such trips by bicycle (i.e., trips of reasonable length for biking) is closely related to population density. The concept of relating bicycle demand directly to population density and identifying high demand, medium demand and low demand areas is therefore intuitively attractive. The Florida Department of Transportation[8] established such demand areas on the basis of density desire lines joining producer and attractor nodes. Such a step is time consuming and will most likely lead to the same conclusions as those based directly on population density.

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8 Florida Department of Transportation, Bicycle Facilities Planning Manual, 1982.

The bicycling season in Rhode Island. The bicycling season in Rhode Island can be estimated at seven to nine months in length. The length of the bicycle season has several implications. First, if schools are a primary attractor in the service area, a decline in use would be expected during the summer when bicycling customarily peaks. Similarly, attendance at the summer sessions of colleges and universities is lower than in other seasons, and there will be less daily trips during the warm summer than during the regular sessions. These factors should be taken into account if bikeway traffic is expected to be predominantly school trips.

A third implication is that travel to recreational facilities highly used in summer is a prime candidate for bikeways. Promotion of bike use for travel to beaches and parks will provide some relief from highly congested access routes and parking facilities during the peak summer season.

Bicycle ownership as a demand indicator. According to the Rhode Island Department of Environmental Management,[9] there are nearly 500,000 bicyclists in Rhode Island, just over 50% of the population. Nationwide, in 1982, the number of bicyclists was 72 million[10] or 32% of the population.

The Bicycle Manufacturers Association estimates that there are 65 million bicycles in use in the United States today and

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9 Rhode Island Department of Environmental Management, Bikes, Parks, and People, Prepared by Abt Associates, Boston.

10 A.C. Nielson Co. poll conducted in 1982.

that 9 million bicycles were shipped for sale in 1983.[11] The projected number for 1984 is 9.8 million bicycles. Bicycles shipped for sale peaked at 15 million in 1973.

While bicycle availability is obviously a necessity for a bicycle trip and therefore very significant to individual decisions, it is not considered to be a particularly good predictor of numbers of trips at the aggregate level. Low incidence of bicycle ownership in a specific locality may merely reflect hazardous bicycling conditions and is therefore likely to change quickly in response to the availability of good bicycling facilities.

Quantitative estimation of demand

Quantitative estimation of demand is useful for setting priorities. However, it should be kept in mind that thorough, detailed studies can be very costly and may even exceed the cost of the improvement being considered. Detailed estimations are required for high cost independent bike projects. These projects may be bicycle paths or bicycle lanes or shoulder widening provided along a highway which is not otherwise undergoing reconstruction. These kinds of projects are not the focus of a bikeway system but may be necessary to provide connectivity where existing highways are not safe for bicycling.

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11 Bicycle Manufacturers Association of America, Inc. Washington, D.C.

Bicycle trip generation factors. In order to estimate the number of bicycle trips generated in the bicycle facility service area, factors can be applied as follows:

For work trips	- bicycle trips per 1000 employees living within 5 miles of their work.
For school trips	- bicycle trips per 1000 students
For other utilitarian trips	- bicycle trips per 1000 population

This method has been used in Rhode Island for the East Bay Bicycle Facility[12]. The factors used in this case were 4.9 bicycle trips per 1000 employees for work trips, 20.3 bicycle trips per 1000 students for school trips, and 112.9 bicycle trips per 1000 population for other utilitarian trips. These factors were taken from a survey done in Harrisburg, Pennsylvania. The work trip factor is supported by local (2.7 bicycle trips per 1000 work trips) and national (6.0 bicycle trips per 1000 work trips) figures[13]. It is reasonable to use 4.9 bicycle trips per 1000 work trips of 5 miles or less when a bicycle facility is being built, because bicycle use is expected to rise above current state levels when facilities are available. The other factors from the Harrisburg study are not supported by local or national data, as comparable data does not exist.

12 Providence - Bristol Bicycle Facility Trip Estimates and East Bay Bicycle Facility Final Report, cited previously.

13 United States Census Bureau, 1980 Census of Population Journey To Work: Metropolitan Community Flow. PC 80-2-6C

After estimating the number of bicycle trips generated in the service area, some method of trip distribution is needed to obtain an estimate of the number of daily trips on each section of the facility. This will depend to some extent on the location of major trip attractors and knowledge of the area. A simplified approach is suggested here. The user is cautioned to consider the results gained through these calculations as general estimations of what actual usage will be. In order to obtain an average number of trips on the facility, the following equations can be applied:

1. Estimate Assigned Trips.

$$AT = TN \times PT$$

Where AT = Trips assigned to the facility.

TN = Total number trips generated in the service area.

PT = Percent of trips that will use the facility.

2. Estimate Vehicle Miles of Travel on the facility.

$$VMT = AT \times TL$$

Where VMT = Vehicle miles of travel on the facility.

AT = Trips assigned to the facility.

TL = Average trip length on the facility.

3. Estimate Average Volume on a segment. The bikeway should first be divided into logical segments to assess the trip contribution of individual homogeneous areas. These segments need not be of equal length.

AN = VMT/SL

Where AN = Average trips at any point on a segment.

VMT = Vehicle miles of travel on the facility.

SL = Segment length.

The average trip length on the bikeway will depend on the width of the service area, and relative locations of residential areas and trip attractors. A length of two miles is suggested if no other data is available. The user is cautioned that this formula assumes equal distribution of trips on the bikeway. It should be understood that the results gained through use of this assumption may not reflect actual occurrences. It does, however, allow useful estimates for the purposes of a preliminary study to be made.

In summary, this method of estimation of need for bicycle facilities requires the following steps:

(1) Definition of the service area and subdivision into homogeneous zones;

(2) Determination of total population, number of employees, and number of students in each zone;

(3) Determination of the appropriate factors to use for numbers of bicycle trips generated in each zone;

(4) Calculation of the average number of bicycle trips at any point on the bikeway.

When applying this method, users should be aware that the trip generation factors suggested earlier were not developed from Rhode Island data. As more bicycle facilities are built, it will be possible to develop more accurate trip generation factors in the future. Trip generation factors may be modified if there is

data to support the change. For example, age distribution of population in a specific zone may indicate lower than normal factors should be used. Terrain may also affect the factors.

Summary

When evaluating need and desirability for specific bicycle facilities, local communities can apply some or all of the methods discussed above. The level of detail needed will depend upon the specifics of each case. The methods are summarized here in ascending order of level of detail:

(1) Define the bicycle facility service area identifying major attractors and trip boundaries;

(2) Divide the area into homogeneous zones for analysis zone data presentation and trip generation;

(3) Collect available analysis zone data on population by age distribution, population densities, and transportation mode for work trips;

(4) Evaluate the effect of the length of the bicycling season for the specific types of trips served by the facility;

(5) Estimate demand using the four steps outlined above under Bicycle Trip Generation Factors;

This Appendix is intended as a guide for demand evaluation and estimation. Other methods may be used. The characteristics of the specific facility and trip purposes that predominate should always be taken into account. Simple surveys of bicycle use may be useful, and data gathered from other regional facilities can be used to continuously enhance the accuracy of bicycle trip generation factors. Once computed, these demand estimates can be used to determine whether or not to go forward with further studies.

Appendix B:

Local Funding Alternatives

APPENDIX B

Local Funding Alternatives

Local governments can directly fund or facilitate funding for bicycle facilities. These are activities undertaken without federal transportation funds. Several alternatives are possible:

- To directly appropriate funds for facilities from local tax and fee revenues. Such actions frequently occur when public facilities are built, such as town libraries which normally would include bicycle racks for parking. Cities and towns can also appropriate local funds for more costly bike facilities, such as paved pathways through parks and along town roads.

- To direct locally received state and federal grant money toward the creation of bicycle facilities. For example, UDAG, CDAG, CDBG, Small Cities and Economic Development Program funds can all be used to include bicycle tolerant or support facilities in larger projects, such as housing, sewer, water, roads, landscaping and streetscaping, and building or adaptive reuse of structures for industry and business. Such funds can also be used to combine with state transportation funds to create bicycle projects.

- To establish a local transportation improvement fund consisting of contributions from developers, certain transportation related fees (e.g., parking) and voluntary contributions (e.g., from local business and civic groups). Contributions from developers would have to be written into local ordinances, (e.g., zoning and/or subdivision regulations) in the same way that developers contribute open space or its equivalent based on the needs of the population anticipated by the development.

- To require developers to include bicycle facilities in projects *vis-a-vis* zoning and subdivision ordinance provisions. In addition, to negotiating for payments for bicycle and/or other transportation facilities from developers, cities and towns can simply require that bicycle compatibility and facilities be included in private projects. Bicycle compatibility in roadway design can be required *via* subdivision regulations, and bike storage or parking facilities can be required *via* zoning provisions. The requirement of bicycle compatibility and other bicycle facilities where a development intersects an existing system of bicycle facilities is similar to the required inclusion of sidewalks where the development intersects the local sidewalk network.

The local planning staff can best determine which alternatives are most appropriate for the community.

Appendix C:

AASHTO Design Guidelines for Bicycle Facilities

Chapter 2

Copies of the full report are available for a nominal fee through the American Association of State, Highway and Transportation Officials 444 North Capital Street, N.W. Suite 225, Washington, D.C. 20001.

All references should be made as follows: Guide For Development of New Bicycle Facilities, 1981, Washington, D.C.: American Association of State Highway and Transportation Officials, Copyright 1981. Used by permission.

CHAPTER 2 - DESIGN

There is a wide range of facility improvements which can enhance bicycle transportation. Improvements can be simple and involve minimal design consideration (e.g., changing drainage grate inlets) or they can involve a detailed design (e.g., providing a bicycle path). The controlling feature of the design of every bicycle facility is its location (i.e., whether it is on the roadway or on an independent alignment). Roadway improvements such as bicycle lanes depend on the roadway's design. On the other hand, bicycle paths are located on independent alignments; consequently, their design depends on many factors, including the performance capabilities of the bicyclist and the bicycle.

Improvements for motor vehicles through appropriate planning and design can enhance bicycle travel and in any event should avoid adverse impacts on bicycling. A community's overall goals for transportation improvements should, whenever possible, include the enhancement of bicycling. Public involvement in the form of public meetings or hearings or bicycle advisory groups is desirable during the design process.

Guidelines are presented in this chapter to help design and construct both roadway improvements and separate paths that accommodate the operating characteristics of "bicycles" as defined in this guide. Modifications to facilities (e.g., widths, curve radii, superelevations, etc.) that are necessary to accommodate adult tricycles, bicycle trailers, and other special purpose human powered vehicles and accessories should be made in accordance with expected use, using sound engineering judgment.

ROADWAY IMPROVEMENTS

To varying extents, bicycles will be ridden on all highways where they are permitted. All new highways, except those where bicyclists will be legally prohibited, should be designed and constructed under the assumption that they will be used by bicyclists. Bicycle-safe design practices, as described in this guide, should be followed to avoid the necessity for costly subsequent improvements. Because most highways have not been designed with bicycle travel in mind, there are often many ways in which roadways should be improved to more safely accommodate bicycle traffic. Roadway conditions should be examined and, where necessary, safe drainage grates and railroad crossings, smooth pavements, and signals responsive to bicycles should be provided. In addition, the desirability of adding facilities such as bicycle lanes, bicycle routes, shoulder improvements, and wide curb lanes should be considered. Information on each of the different roadway improvements is contained in this section.

Drainage Grates

Drainage grate inlets and utility covers are potential problems to bicyclists. When a new roadway is designed, all such grates and covers should be kept out of bicyclists' expected path. On new construction where bicyc-

lists will be permitted, curb inlets should be used wherever possible to completely eliminate exposure of bicyclists to grate inlets. It is important that grates and utility covers be adjusted flush with the surface, including after a roadway is resurfaced.

Parallel bar drainage grate inlets can trap the front wheel of a bicycle causing loss of steering control and, often, the bar spacing is such that they allow narrow bicycle wheels to drop into the grates, resulting in serious damage to the bicycle wheel and frame and/or injury to the bicyclist. These grates should be replaced with bicycle-safe and hydraulically efficient ones. When this is not immediately possible, consideration should be given to welding steel cross straps or bars perpendicular to the parallel bars to provide a maximum safe opening between straps. This should be considered a temporary correction.

While identifying a grate with a pavement marking, as indicated in the MUTCD, would be acceptable in most situations, parallel bar grate inlets deserve special attention. Because of the serious consequences of a bicyclist missing the pavement marking in the dark or being forced over such a grate inlet by other traffic, these grates should be physically corrected, as described above, as soon as practicable after they are identified.

Railroad Crossings

Railroad-highway grade crossings should ideally be at a right angle to the rails. The greater the crossing deviates from this ideal crossing angle, the greater is the potential for a bicyclist's front wheel to be trapped in the flangeway causing loss of steering control. It is also important that the roadway approach be at the same elevation as the rails.

Consideration should be given to the materials of the crossing surface and to the flangeway depth and width. If the crossing angle is less than approximately 45 degrees, consideration should be given to widening the outside lane, shoulder, or bicycle lane to allow bicyclists adequate room to cross the tracks at a right angle. Where this is not possible, commercially available compressible flangeway fillers can enhance bicyclist safety. In some cases, abandoned tracks can be removed. Warning signs and pavement markings should be installed in accordance with the MUTCD.

Pavements

Pavement surface irregularities can do more than cause an unpleasant ride. Gaps between pavement slabs or drop-offs at overlays parallel to the direction of travel can trap a bicycle wheel and cause loss of control; holes and bumps can cause bicyclists to swerve into the path of motor vehicle traffic. Thus, to the extent practicable, pavement surfaces should be free of irregularities and the edge of the pavement should be uniform in width. On older pavements it may be necessary to fill joints, adjust utility covers or, in extreme cases, overlay the pavement to make it suitable for bicycling.

Traffic Control Devices

At intersections where bicycle traffic exists or is anticipated, bicycles should be considered in the timing of the traffic signal cycle, as well as the traffic detection device. Normally, a bicyclist can cross an intersection under the same signal phasing arrangement as motor vehicles; however, on multi-lane streets special consideration should be given to ensure that short clearance intervals are not used. If necessary, an all-red clearance interval may be used.

To check the clearance interval, a bicyclist's speed of 10 mph (16km/h) and a perception/reaction/braking time of 2.5 seconds should be used. Detectors for traffic-actuated signals should be sensitive to bicycles and should be located in the bicyclist's expected path, including left turn lanes. Where programmed visibility signal heads are used, they should be checked to ensure that they are visible to bicyclists who are properly positioned on the road.

The MUTCD should be consulted for guidance on signs and pavement markings. Where bicyclists are expected to use different routings than motorists, directional signing should be used to confirm to bicyclists that the special routing leads to their destination.

Shoulders

Wide curb lanes and bicycle lanes are usually preferred over shoulders for use by bicyclists. However, if it is intended that bicyclists ride on shoulders, smooth paved shoulder surfaces must be provided. Pavement edge lines supplement surface texture in delineating the shoulder from the motor vehicle lanes. Rumble strips can be a deterrent to bicycling on shoulders and their benefits should be weighed against the probability that bicyclists will ride in the motor vehicle lanes to avoid them.

Shoulder width should be a minimum of 4 feet (1.2m) when intended to accommodate bicycle travel. Roads with shoulders less than 4 feet (1.2m) wide normally should not be signed as bikeways. If motor vehicle speeds exceed 35 mph (55km/h), if the percentage of trucks, buses, and recreational vehicles is high, or if static obstructions exist at the right side, then additional width is desirable.

Adding or improving shoulders can often be the best way to accommodate bicyclists in rural areas, and they are also a benefit to motor vehicle traffic. Where funding is limited, adding or improving shoulders on uphill sections first will give slow moving bicyclists needed maneuvering space and decrease conflicts with faster moving motor vehicle traffic.

Wide Curb Lanes

On highway sections without bicycle lanes, a right lane wider than 12 feet (3.7m) can better accommodate both bicycles and motor vehicles in the same lane and thus is beneficial to both bicyclists and motorists. In

many cases where there is a wide curb lane, motorists will not need to change lanes to pass a bicylist.

Also, more maneuvering room is provided when drivers are exiting from driveways or in areas with limited sight distance. In general, a lane width of 14 feet (4.3m) of usable pavement width is desired. Usable pavement width would normally be from curb face to lane stripe, or from edge line to lane stripe, but adjustments need to be made for drainage grates, parking, and longitudinal ridges between pavement and gutter sections. Widths greater than 14 feet (4.3m) can encourage the undesirable operation of two motor vehicles in one lane, especially in urban areas, and consideration should be given to striping as a bicycle lane when wider widths exist.

Bicycle Routes

It may be advantageous to sign some urban and rural roadways as bicycle routes. When providing continuity to other bicycle facilities, a bicycle route can be relatively short. However, a bicycle touring route can be quite long. For long bicycle routes, a standard bicycle route marker with a numerical designation in accordance with Part IX of the MUTCD can be used in place of a bicycle route sign. The number may correspond to a parallel highway, indicating the route is a preferred alternate route for bicyclists. It is often desirable to use supplemental plaques with bicycle route signs or markers to furnish additional information, such as direction changes in the route and intermediate range distance and destination information. Bicycle route signing should not end at a barrier. Information directing the bicyclist around the barrier should be provided.

Overall, the decision whether to provide a bicycle route should be based on the advisability of encouraging bicycle use on a particular road, instead of on parallel and adjacent highways. The roadway width, along with factors such as the volume, speed, and type of traffic; parking conditions; grade; and sight distance should be considered when determining the feasibility of a bicycle route. Generally, bicycle traffic cannot be diverted to a less direct alternate route unless the favorable factors outweigh the inconvenience to the bicyclist. Roadway improvements, such as safe drainage grates, railroad crossings, smooth pavements, maintenance schedules, and signals responsive to bicycles, should always be considered before a roadway is identified as a bicycle route.

Further guidance on signing bicycle routes is provided in the MUTCD.

Bicycle Lanes

Bicycle lanes can be considered when it is desirable to delineate available road space for preferential use by bicyclists and motorists, and to provide for more predictable movements by each. Bicycle lane markings can increase a bicyclist's confidence in motorists not straying into his/her path of travel. Likewise, passing motorists are less likely to swerve to the left out of their lane to avoid bicyclists on their right.

Bicycle lanes should always be one-way facilities and carry traffic in the same direction as adjacent motor vehicle traffic. Two-way bicycle lanes on one side of the roadway are unacceptable because they promote riding against the flow of motor vehicle traffic. Wrong-way riding is a major cause of bicycle accidents and violates the Rules of the Road stated in the Uniform Vehicle Code. Bicycle lanes on one-way streets should be on the right side of the street, except in areas where a bicycle lane on the left will decrease the number of conflicts (e.g., those caused by heavy bus traffic).

Under ideal conditions, minimum bicycle lane width is 4 feet (1.2m). However, certain edge conditions dictate additional desirable bicycle lane width. To examine the width requirements for bicycle lanes, Figure 1 shows three usual locations for such facilities in relation to the roadway. Figure 1(a) depicts bicycle lanes on an urban curbed street where a parking lane is provided. The minimum bicycle lane width for this location is 5 feet (1.5m). Bicycle lanes should always be placed between the parking lane and the motor vehicle lanes. Bicycle lanes between the curb and the parking lane create hazards for bicyclists from opening car doors and poor visibility at intersections and driveways, and they prohibit bicyclists from making left turns; therefore this placement should never be considered.

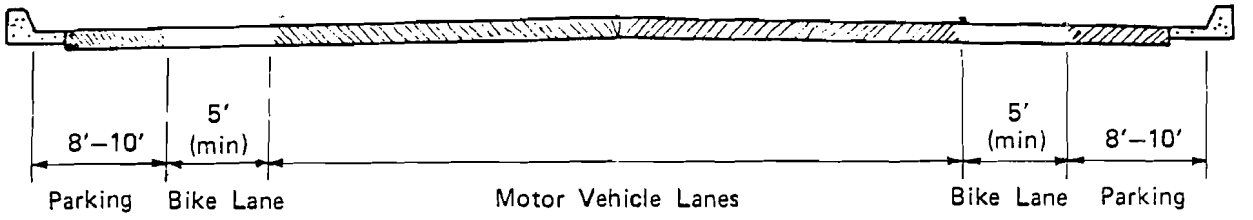
Where parking is permitted but a parking lane is not provided, the combination lane, intended for both motor vehicle parking and bicycle use, should be a minimum of 12 feet (3.7m) wide. However, if it is likely the combination lane will be used as an additional motor vehicle lane, it is preferable to designate separate parking and bicycle lanes as shown in Figure 1(a). In both instances, if parking volume is substantial or turnover is high, an additional 1 or 2 feet (0.3 or 0.6m) of width is desirable for safe bicycle operation.

Figure 1(b) depicts bicycle lanes along the outer portions of an urban curbed street where parking is prohibited. Bicyclists do not generally ride near a curb because of the possibility of debris, of hitting a pedal on the curb, of an uneven longitudinal joint, or of a steeper cross-slope. Bicycle lanes in this location should have a minimum width of 5 feet (1.5m) from the curb face. If the longitudinal joint between the gutter pan and the roadway surface is uneven and falls within 5 feet (1.5m) of the curb face, a minimum of 4 feet (1.2m) should be provided between the joint and the motor vehicle lanes.

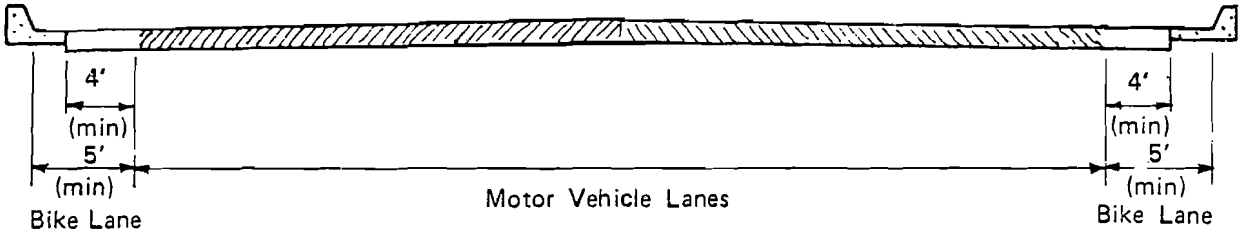
Figure 1(c) depicts bicycle lanes on a highway without curb or gutter. Bicycle lanes should be located between the motor vehicle lanes and the roadway shoulders. Bicycle lanes may have a minimum width of 4 feet (1.2m), where the shoulder can provide additional maneuvering width. A width of 5 feet (1.5m) or greater is preferable; additional widths are desirable where substantial truck traffic is present, where prevailing winds are a factor, on grades, or where motor vehicle speeds exceed 35 mph (55km/h).

Bicycle lanes tend to complicate both bicycle and motor vehicle turning movements at intersections. Because they encourage bicyclists to keep to

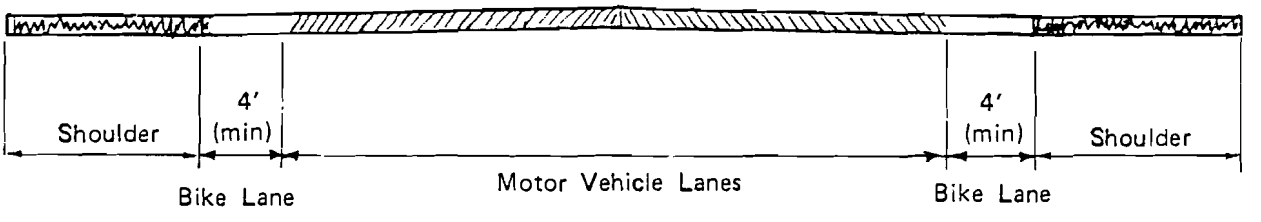
(a) CURBED STREET WITH PARKING



(b) CURBED STREET WITHOUT PARKING



(c) STREET OR HIGHWAY WITHOUT CURB OR GUTTER



(Not to Scale)

(Metric Conversion: 1 Ft. = 0.3m.)

Figure 1. Typical Bicycle Lane Cross Sections

the right and motorists to keep to the left, both operators are somewhat discouraged from merging in advance of turns. Thus, some bicyclists will begin left turns from the right-side bicycle lane and some motorists will begin right turns from the lane to the left of the bicycle lane. Both maneuvers are contrary to established Rules of the Road and result in conflicts.

At intersections, bicyclists proceeding straight through and motorists turning right must cross paths. Striping and signing configurations which encourage these crossings in advance of the intersection, in a merging fashion, are generally preferable to those that force the crossing in the immediate vicinity of the intersection. To a lesser extent, the same is true for left-turning bicyclists; however, in this maneuver, most vehicle codes allow the bicyclist the option of making either a "vehicular style" left turn (where the bicyclist merges leftward to the same lane used for motor vehicle left turns) or a "pedestrian style" left turn (where the bicyclist proceeds straight through the intersection, turns left at the far side, then proceeds across the intersection again on the cross street).

Figure 2 presents examples of details on pavement markings for bicycle lanes approaching motorist right-turn-only lanes. Where there are numerous left-turning bicyclists, a separate turning lane, as indicated in Part IX of the MUTCD, should be considered. The design of bicycle lanes should also include appropriate signing at intersections to reduce the number of conflicts. General guidance for pavement marking of bicycle lanes is contained in the MUTCD.

Adequate pavement surface, bicycle-safe grate inlets, safe railroad crossings, and traffic signals responsive to bicycles should always be provided on roadways where bicycle lanes are being designated. Raised pavement markings and raised barriers can cause steering difficulties for bicyclists and should not be used to delineate bicycle lanes.

BICYCLE PATHS

Bicycle paths are facilities on exclusive rights-of-way and with minimal cross flow by motor vehicles. Bicycle paths can serve a variety of purposes. They can provide a commuting bicyclist with a shortcut through a residential neighborhood (e.g., a connection between two cul-de-sac streets). Located in a park, they can provide an enjoyable recreational opportunity. Bicycle paths can be located along abandoned railroad rights-of-way, the banks of rivers, and other similar areas. Bicycle paths can also provide bicycle access to areas that are otherwise served only by limited access highways closed to bicycles. Appropriate locations can be identified during the planning process.

Bicycle paths should be thought of as extensions of the highway system that are intended for the exclusive or preferential use of bicycles in much the same way as freeways are intended for the exclusive or preferential use of motor vehicles. There are many similarities between design criteria for

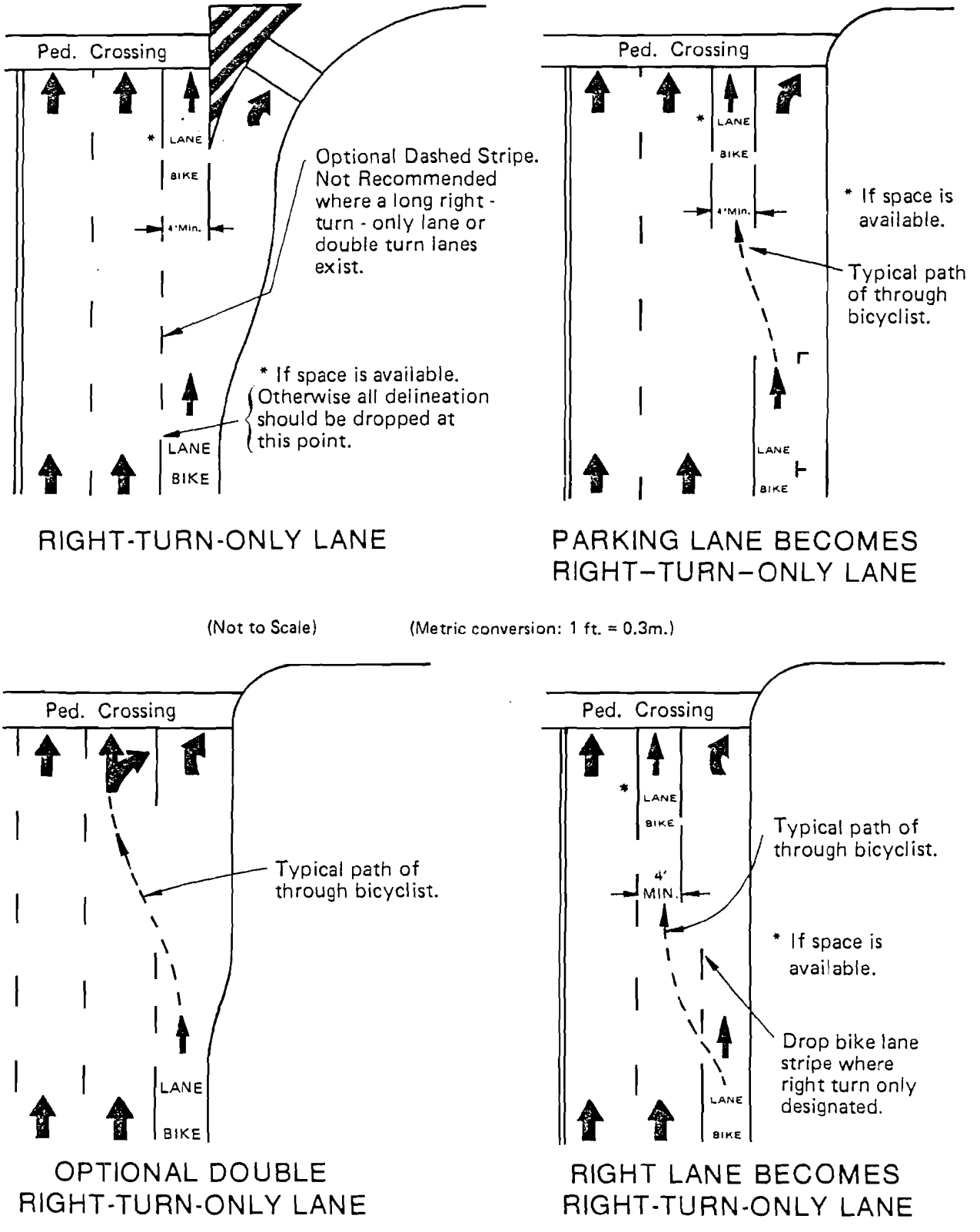


Figure 2. Bicycle Lanes Approaching Motor Vehicle Right-Turn-Only Lanes

bicycle paths and those for highways (e.g., in determining horizontal alignment, sight distance requirements, signing, and markings). On the other hand, some criteria (e.g., horizontal and vertical clearance requirements, grades, and pavement structure) are dictated by operating characteristics of bicycles that are substantially different from those of motor vehicles. The designer should always be conscious of the similarities and the differences between bicycles and motor vehicles and of how these similarities and differences influence the design of bicycle paths. The following sections provide guidance for designing a safe and functional bicycle path.

Width and Clearance

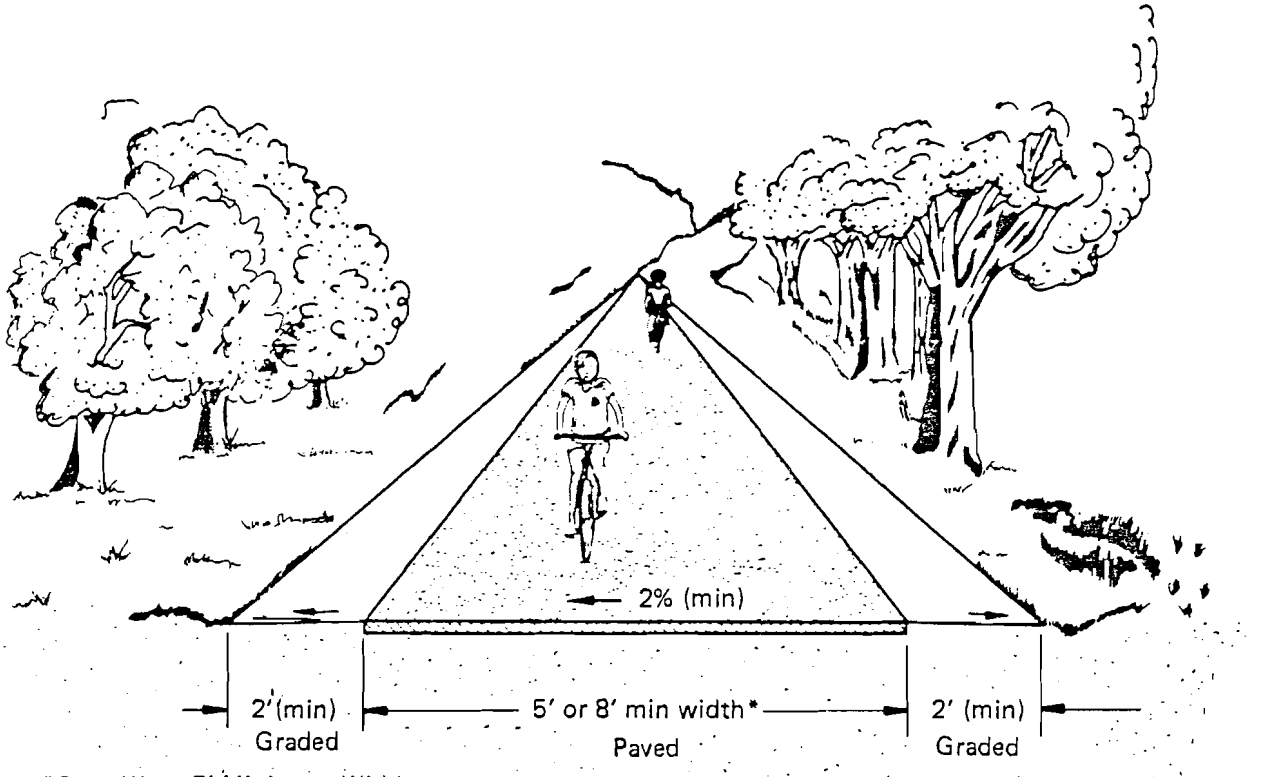
The paved width and the operating width required for a bicycle path are primary design considerations. Figure 3 depicts a bicycle path on a separated right-of-way. Under most conditions, a desirable minimum all paved width for a two directional bicycle path is 10 feet (3m). In some instances, however, a minimum of 8 feet (2.4m) can be adequate. This minimum should be used only where the following conditions prevail: (1) bicycle traffic is expected to be low, even on peak days or during peak hours (2) pedestrian use of the facility is not expected to be more than occasional, (3) there will be good horizontal and vertical alignment providing safe and frequent passing opportunities, (4) the path will not be subjected to maintenance vehicle loading conditions that would cause pavement edge damage. Under certain conditions it may be necessary or desirable to increase the width of a bicycle path to 12 feet (3.7m); for example, because of substantial bicycle volume, probable shared use with joggers and other pedestrians, use by large maintenance vehicles, steep grades and where bicyclists will be likely to ride two abreast.

The minimum width of a one directional bicycle path is 5 feet (1.5m). It should be recognized, however, that one-way bicycle paths often will be used as two-way facilities unless effective measures are taken to assure one-way operation. Without such enforcement, it should be assumed that bicycle paths will be used as two-way facilities and designed accordingly.

A minimum 2-foot (0.6m) width graded area should be maintained adjacent to both sides of the pavement; however, 3 feet (0.9m) or more is desirable to provide clearance from trees, poles, walls, fences, guardrails, or their lateral obstructions. A wider graded area on either side of the bicycle path can serve as a separate jogging path.

A wide separation between a bicycle path and an adjacent highway is desirable to confirm to both the bicyclist and the motorist that the bicycle path functions as an independent highway for bicycles. When this is not possible and the distance between the edge of the roadway and the bicycle path is less than 5 feet (1.5m), a suitable physical divider, such as a fence, dense shrubs or other barrier may be considered. Such dividers serve both to prevent bicyclists from making unwanted movements between the path

BICYCLE PATH ON SEPARATED
RIGHT-OF-WAY



*One–Way: 5' Minimum Width
Two–Way: 8' Minimum Width
Metric Conversion: 1 ft. = 0.3m.
(Not to Scale)

Figure 3.

and the highway shoulder and to reinforce the concept that the bicycle path is an independent facility. Where used, the divider should be a minimum of 4.5 feet (1.4m) high, to prevent bicyclists from toppling over it, and it should be designed so that it does not become a hazard in itself.

The vertical clearance to obstructions should be a minimum of 8 feet (2.4m). However, vertical clearance may need to be greater to permit passage of maintenance vehicles and, in undercrossings and tunnels, a clearance of 10 feet (3m) is desirable for adequate vertical shy distance.

Design Speed

The speed that a bicyclist travels is dependent on several factors, including the type and condition of the bicycle, the purpose of the trip, the condition and location of the bicycle path, the speed and direction of the wind, and the physical condition of the bicyclist. Bicycle paths should be designed for a selected speed that is at least as high as the preferred speed of the faster bicyclists. In general, a minimum design speed of 20 mph (32km/h) should be used; however, when the grade exceeds 4 percent, or where strong prevailing tailwinds exist, a design speed of 30 mph (48km/h) is advisable.

On unpaved paths, where bicyclists tend to ride slower, a lower design speed of 15 mph (24km/h) can be used. Similarly, where the grades or the prevailing winds dictate, a higher design speed of 25 mph (40km/h) can be used. Since bicycles have a higher tendency to skid on unpaved surfaces, horizontal curvature design should take into account lower coefficients of friction.

Horizontal Alignment and Superelevation

The minimum radius of curvature negotiable by a bicycle is a function of the superelevation rate of the bicycle path surface, the coefficient of friction between the bicycle tires and the bicycle path surface, and the speed of the bicycle. The minimum design radius of curvature can be derived from the following formula:

$$R = \frac{V^2}{15\,(e+f)}$$

Where R = Minimum radius of curvature (ft),
V = Design speed (mph),
e = Rate of superelevation,
f = coefficient of friction.

For most bicycle path applications, the superelevation rate will vary from a minimum of 2 percent (the minimum necessary to encourage adequate drainage) to a maximum of approximately 5 percent (beyond which maneuvering difficulties by slow bicyclists and adult tricyclists might be expected). The minimum superelevation rate of 2 percent will be adequate for most conditions and will simplify construction.

The coefficient of friction depends upon speed; surface type, roughness, and condition; tire type and condition; and whether the surface is wet or dry. Friction factors used for design should be selected based upon the point at which centrifugal force causes the bicyclist to recognize a feeling of discomfort and instinctively act to avoid higher speed. Extrapolating from values used in highway design, design friction factors for paved bicycle paths can be assumed to vary from 0.30 at 15 mph (24km/h) to 0.22 at 30 mph (48km/h). Although there are no data available for unpaved surfaces, it is suggested that friction factors be reduced by 50 percent to allow a sufficient margin of safety.

Based upon a superelevation rate (e) of 2 percent, minimum radii of curvature can be selected from Table 1.

TABLE 1 - DESIGN RADII FOR PAVED BICYCLE PATHS

(e = 2 percent)

Design Speed - V (mph) (1mph = 1/6km/hr)	Friction Factor - f	Design Radius - R (Feet) (1 ft = 0.3m)
20	0.27	95
25	0.25	155
30	0.22	250
35	0.19	390
40	0.17	565

When substandard radius curves must be used on bicycle paths because of right-of-way, topographical or other considerations, standard curve warning signs and supplemental pavement markings should be installed in accordance with the MUTCD. The negative effects of substandard curves can also be partially offset by widening the pavement through the curves.

Grade

Grades on bicycle paths should be kept to a minimum, especially on long inclines. Grades greater than 5 percent are undesirable because the ascents are difficult for many bicyclists to climb and the descents cause some bicyclists to exceed the speeds at which they are competent. Where terrain dictates, grades over 5 percent and less than 500 feet (150m) long are acceptable when a higher design speed is used and additional width is provided.

Sight Distance

To provide bicyclists with an opportunity to see and react to the unexpected, a bicycle path should be designed with adequate stopping sight distances. The distance required to bring a bicycle to a full controlled stop is a function of the bicyclist's perception and brake reaction time, the initial speed of the bicycle, the coefficient of friction between the tires and the pavement, and the braking ability of the bicycle.

Figure 4 indicates the minimum stopping sight distance for various design speeds and grades based on a total perception and brake reaction time of 2.5 seconds and a coefficient of friction of 0.25 to account for the poor wet-weather braking characteristics of many bicycles. For two-way bicycle paths, the sight distance in the descending direction, that is, where "G" is negative, will control the design.

Figure 5 is used to select the minimum length of vertical curve necessary to provide minimum stopping sight distance at various speeds on crests. The eye height of the bicyclist is assumed to be 4.5 feet (1.4m) and the object height is assumed to be zero to recognize that hazards to bicycle travel exist at pavement level.

Figure 6 indicates the minimum clearance that should be used to line-of-sight obstructions for horizontal curves. The desired lateral clearance is obtained by entering Figure 6 with the stopping sight distance from Figure 4 and the proposed horizontal radius of curvature.

Bicyclists frequently ride abreast of each other on bicycle paths and, on narrow bicycle paths, bicyclists have a tendency to ride near the middle of the path. For these reasons, and because of the serious consequences of a head-on bicycle accident, lateral clearances on horizontal curves should be calculated based on the sum of the stopping sight distances for bicyclists traveling in opposite directions around the curve. Where this is not possible or feasible, consideration should be given to widening the path through the curve, installing a yellow center stripe, installing a curve ahead warning sign, in accordance with the MUTCD, or some combination of these alternatives.

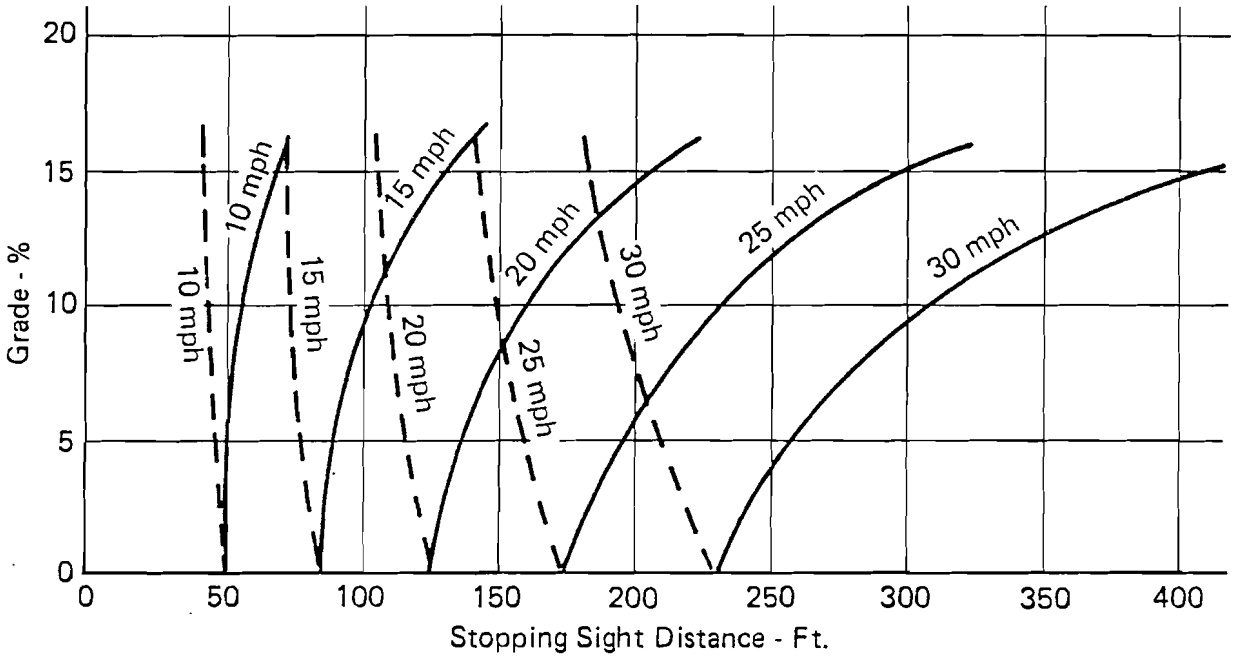
Intersections

Intersections are an important consideration in bicycle path design. If alternate locations for a bicycle path are available, the one with the fewest intersections and/or the most favorable intersection conditions should be selected. For crossings of freeways and other high speed, high volume arterials, a grade separation structure may be the only possible or practical treatment. Unless bicycles are prohibited from the crossing highway, providing for turning movements must be considered. In most cases, however, the cost of a grade separation will be prohibitive.

When intersections occur at grade, a major consideration is the establishment of right of way. The type of traffic control to be used (signal, stop sign, yield sign, etc.) should be selected by application of the warrants in the MUTCD. Bicycles should be counted as vehicles in these determinations and thus, bicycles may be given priority at some intersections.

Sign type, size and location should also be in accordance with the MUTCD. Care should be taken to ensure that bicycle path signs are located so that motorists are not confused by them and that highway signs are placed so that bicyclists are not confused by them.

It is preferable that the crossing of a bicycle path and a highway be at a location away from the influence of intersections with other highways.



$$S = \frac{V^2}{30(f \pm G)} + 3.67\ V$$

Decend (−G) ——————

Ascend (+G) — — —

Where: S = Stopping Sight Distance, Ft.
V = Velocity, mph
f = Coefficient of Friction (use 0.25)
G = Grade Ft./Ft. (rise/run)

(Metric conversion: 1 ft. = 0.3m, 1 mph = 1.6 km/h)

Figure 4. Stopping Sight Distances

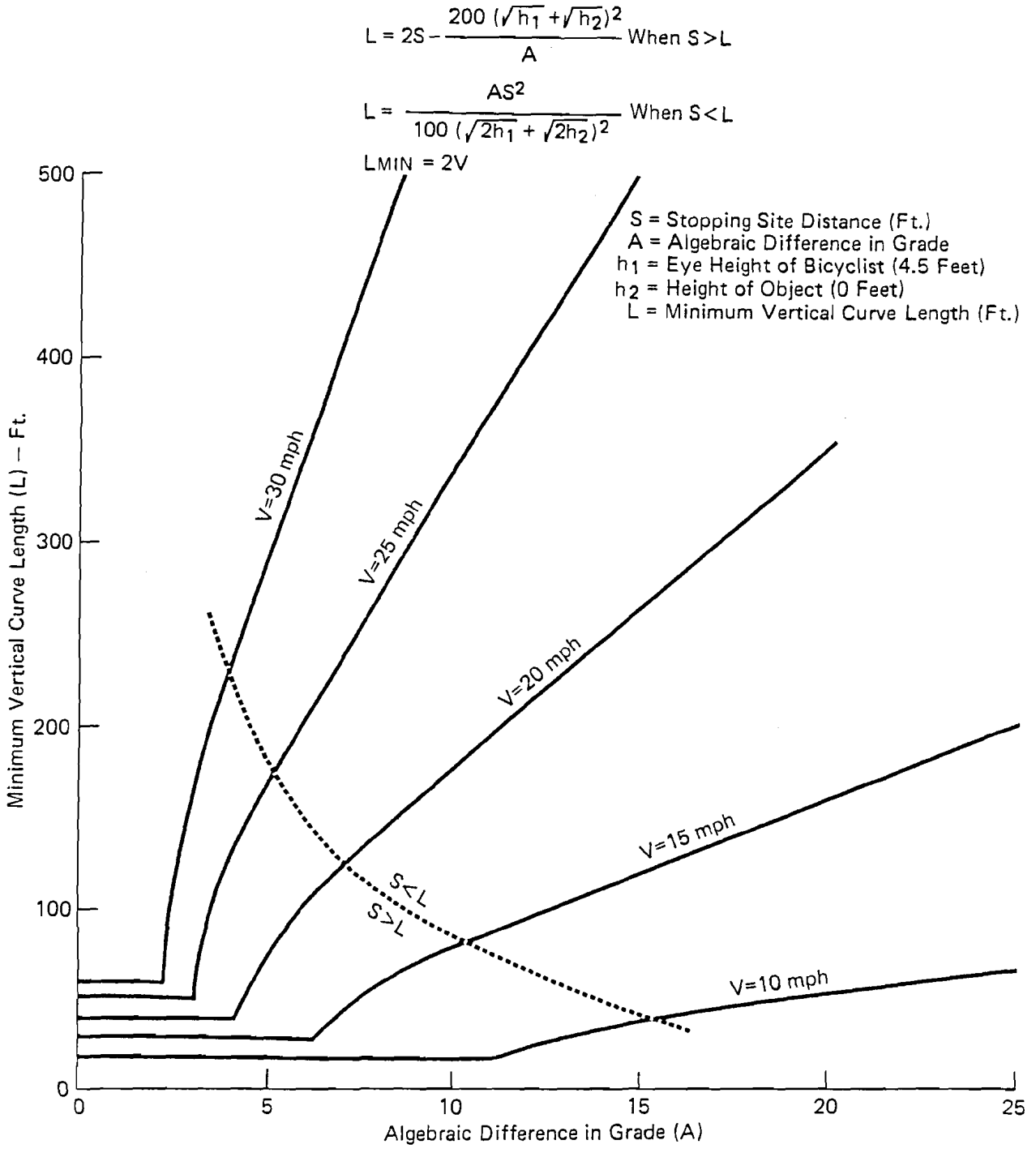
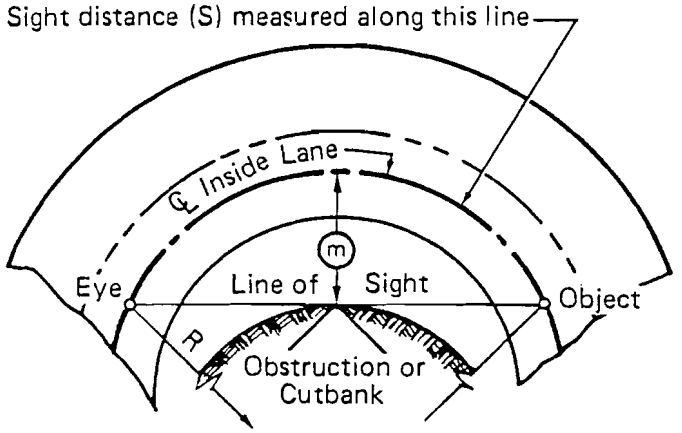


Figure 5. Sight Distances for Crest Vertical Curves



Line of sight is 2.0′ above ℄ inside lane at point of obstruction.

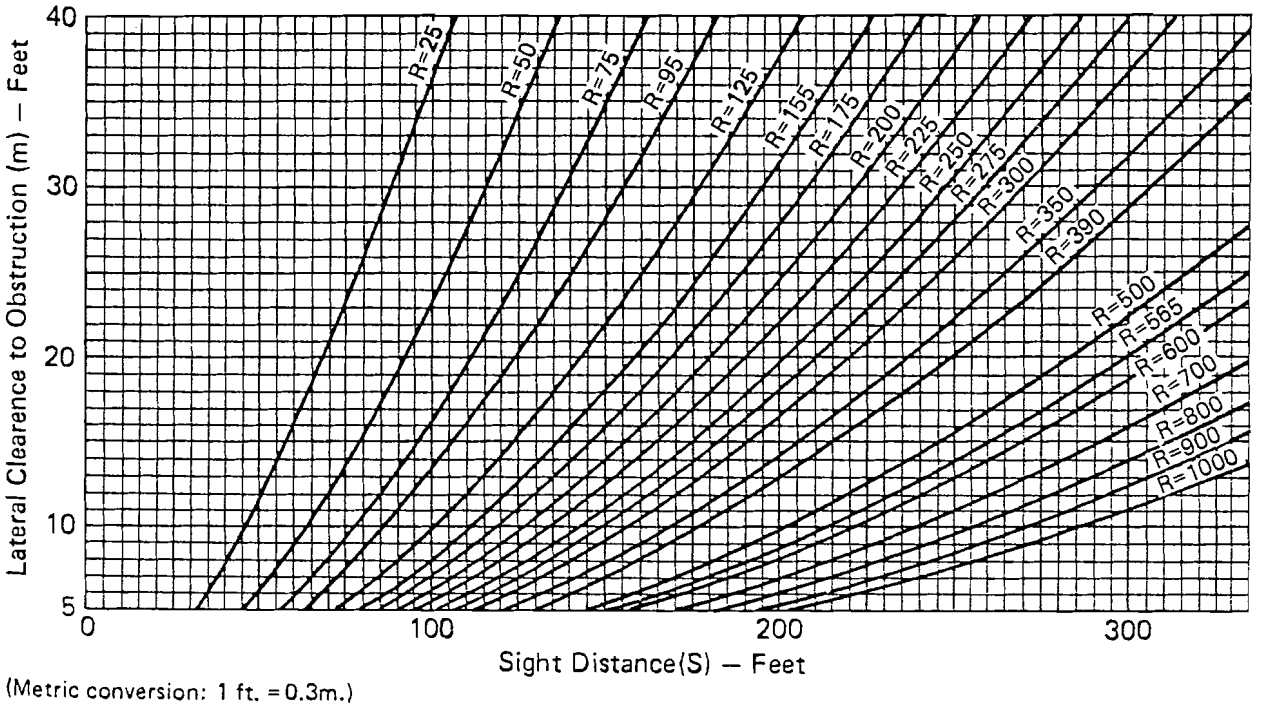
S = Sight distance in feet.
R = Radius of ℄ inside lane in feet.
m = Distance from ℄ inside lane in feet.
V = Design speed for S in mph.

Angle is expressed in degrees

$$m = R\left[\text{vers}\left(\frac{28.65S}{R}\right)\right]$$

$$S = \frac{R}{28.65}\left[\cos^{-1}\left(\frac{R-m}{R}\right)\right]$$

Formula applies only when S is equal to or less than length of curve.



(Metric conversion: 1 ft. = 0.3m.)

Figure 6. Lateral Clearances on Horizontal Curves

Controlling vehicle movements at such intersections is more easily and safely accomplished through the application of standard traffic control devices and normal Rules of the Road. Where physical constraints prohibit such independent intersections, the crossings may be at or adjacent to the pedestrian crossing. Rights of way should be assigned and sight distance should be provided so as to minimize the potential for conflict resulting from unconventional turning movements. At crossings of high-volume multilane arterial highways where signals are not warranted, consideration should be given to providing a median refuge area for crossing bicyclists.

Bicycle path intersections and approaches should be on relatively flat grades. Stopping sight distances at intersections should be checked and adequate warning should be given to permit bicyclists to stop before reaching the intersection, especially on downgrades.

Signing and Marking

Adequate signing and marking are essential on bicycle paths, especially to alert bicyclists to potential hazards and to convey regulatory messages to both bicyclists and motorists at highway intersections. In addition, guide signing, such as to indicate directions, destinations, distances, route numbers, and names of crossing streets, should be used in the same manner as they are used on highways. In general, uniform application of traffic control devices, as described in the MUTCD, will tend to encourage proper bicyclist behavior.

A designer should consider a 4-inch (10cm) wide yellow centerline stripe to separate opposite directions of travel. This is particularly beneficial in the following circumstances: (1) for heavy volumes of bicycles, (2) on curves with restricted sight distance, and (3) on unlighted paths where night-time riding is expected. Edge lines can also be very beneficial where night-time bicycle traffic is expected.

Care should be exercised in the choice of pavement marking materials. Some marking materials, for example, are slippery when wet and should be avoided in favor of more skid resistant materials.

General guidance on signing and marking is provided in the MUTCD. Part IX of the MUTCD refers specifically to traffic controls for bicycle facilities.

Pavement Structure

Designing and selecting pavement sections for bicycle paths is in many ways similar to designing and selecting highway pavement sections. A soils investigation should be conducted to determine the load carrying capabilities of the native soil and the need for any special provisions. The investigation need not be elaborate, but should be done by, or under the supervision of, a qualified engineer.

In addition, there are several basic principles that should be followed to recognize some basic differences between the operating characteristics of

bicycles and those of motor vehicles. While loads on bicycle paths will be substantially less than highway loads, paths should be designed to sustain without damage wheel loads of occasional emergency, patrol, maintenance, and other motor vehicles that are expected to use or cross the path.

Special consideration should be given to the location of motor vehicle wheel loads on the path. When motor vehicles are driven on bicycle paths, their wheels will usually be at or very near the edges of the path. Since this can cause edge damage that, in turn, will result in the lowering of the effective operating width of the path, adequate edge support should be provided. Edge support can be either in the form of stabilized shoulders or in constructing additional pavement width. Constructing a typical pavement width of twelve feet, where right-of-way and other conditions permit, eliminates the edge raveling problem and offers two other additional advantages over shoulder construction. First, it allows additional maneuvering space for bicyclists and second, the additional construction cost can be less than for constructing shoulders because the separate construction operation is eliminated.

It is important to construct and maintain a smooth riding surface on bicycle paths. Bicycle path pavements should be machine laid; soil sterilants should be used where necessary to prevent vegetation from erupting through the pavement; and, on portland cement concrete pavements, transverse joints, necessary to control cracking, should be saw cut to provide a smooth ride. On the other hand, however, skid resistance qualities should not be sacrificed for the sake of smoothness. Broom finish or burlap drag concrete surfaces are preferred over trowel finishes, for example.

In areas where climates are extreme, the effects of freeze-thaw cycles should be anticipated and designed for. At unpaved highway or driveway crossings of bicycle paths, the highway or driveway should be paved a minimum of ten feet on either side of the crossing to reduce the amount of gravel being scattered along the path by motor vehicles. The pavement structure at the crossing should be adequate to sustain the expected loading at that location.

Hard, all weather pavement surfaces are usually preferred over those of crushed aggregate, sand, clay, or stabilized earth since these materials provide a much lower level of service.

Good quality pavement structures can be constructed of asphaltic or portland cement concrete. Because of wide variations in soils, loads, materials and construction practices, it is not practical to present specific or recommended typical structural sections that will be applicable nationwide. Attention to the local governing conditions and to the principles outlined above is needed. Experience in highway pavement, together with sound engineering judgment, can assist in the selection and design of a proper bicycle path pavement structure and may identify energy-conserving practices, such as the use of sulfur-extended asphalt, asphalt emulsions, and fused waste.

An overpass, underpass, small bridge or facility on a highway bridge may be necessary to provide continuity to a bicycle path. On new structures, the minimum clear width should be the same as the approach paved bicycle path; and the desirable clear width should include the minimum 2-foot (0.6m) wide clear areas. Carrying the clear areas across the structures has two advantages: first, it provides a minimum horizontal shy distance from the railing or barrier, and, second, it provides needed maneuvering space to avoid conflicts with pedestrians and other bicyclists who are stopped on the bridge. Access by emergency, patrol, and maintenance vehicles should be considered in establishing the design clearances of structures on bicycle paths. Similarly, vertical clearance also may be dictated by occasional motor vehicles using the path. However, where practical, a vertical clearance of 10 feet (3m) is desirable for adequate vertical shy distance.

Railings, fences, or barriers on both sides of a bicycle path bridge should be a minimum of 4.5 feet (1.4m) high. Smooth rub rails should be attached to the barriers at a handlebar height of 3.5 feet (1.1m).

Bridges designed exclusively for bicycle traffic may be designed for pedestrian live loadings. On all bridge decks, special care should be taken to ensure that bicycle safe expansion joints are used.

Where it is necessary to retrofit a bicycle path onto an existing highway bridge, several alternatives should be considered in light of what the geometrics of the bridge will allow.

One option is to carry the bicycle path across the bridge on one side. This should be done where: (1) the bridge facility will connect to a bicycle path at both ends, (2) sufficient width exists on that side of the bridge or can be obtained by widening or restriping lanes and (3) provisions are made to physically separate bicycle traffic from motor vehicle traffic as discussed above.

A second option is to provide either wide curb lanes or bicycle lanes over the bridge. This may be advisable where (1) the bicycle path transitions into bicycle lanes at one end of the bridge, and (2) sufficient width exists or can be obtained by widening or restriping.

A third option is to use existing sidewalks as one-way or two-way facilities. This may be advisable where (1) conflicts between bicyclists and pedestrians will not exceed tolerable limits and (2) the existing sidewalks are adequately wide.

Because of the large number of variables involved in retrofitting bicycle facilities onto existing bridges, compromises in desirable design criteria are often inevitable. Therefore, the width to be provided is best determined by the designer, on a case by case basis, after thoroughly considering all the variables.

Drainage

The recommended minimum pavement cross slope of 2 percent adequately provides for drainage. Sloping in one direction instead of crowning is preferred and usually simplifies the drainage and surface construction. A smooth surface is essential to prevent water ponding and ice formation. Where a bicycle path is constructed on the side of a hill, a ditch of suitable dimensions should be placed on the uphill side to intercept the hillside drainage. Such ditches should not create hazards for bicyclists. Where necessary, catch basins with drains should be provided to carry the intercepted water under the path. Drainage grates and manhole covers should be located outside of the travel path of bicyclists. To assist in draining the area adjacent to the bicycle path, the design should include considerations for preserving the natural ground cover. Seeding, mulching, and sodding of adjacent slopes, swales, and other erodible areas should be included in the design plans.

Lighting

Fixed-source lighting reduces conflicts along paths and at intersections. In addition, lighting allows the bicyclist to see the bicycle path direction, surface conditions, and obstacles. Lighting for bicycle paths is important and should be considered where riding at night is expected, such as bicycle paths serving college students or commuters, and at highway intersections. Lighting should also be considered through underpasses or tunnels, and when nighttime security could be a problem. Depending on the location, average maintained horizontal illumination levels of 0.5 foot-candle (5 lux) to 2 foot-candles (22 lux) should be considered. Where special security problems exist, higher illumination levels may be considered. Light standards (poles) should meet the recommended horizontal and vertical clearances. Luminaires and standards should be at a scale appropriate for a pedestrian or bicycle path.

Restriction of Motor Vehicle Traffic

Bicycle paths often need some form of physical barrier at highway intersections to prevent unauthorized motor vehicles from using the facilities. Provisions can be made for a lockable, removable post to permit entrance by authorized vehicles. The post should be permanently reflectorized for nighttime visibility and painted a bright color for improved daytime visibility. When more than one post is used, a 5-foot (1.5m) spacing is desirable. Wider spacing can allow entry to motor vehicles, while narrower spacing might prevent entry by adult tricycles and bicycles with trailers.

An alternative method of restricting entry of motor vehicles is to split the entry way into two 5-foot (1.5m) sections separated by low landscaping. Emergency vehicles can still enter if necessary by straddling the landscaping. The higher maintenance costs associated with landscaping should be acknowledged, however, before this alternative method is selected.

Multi-Use

In general, multi-use paths are undesirable; bicycles and pedestrians do not mix well. Whenever possible, separate bicycle and pedestrian paths should be provided. If this is not feasible, additional width, signing and striping should be used to minimize conflicts.

Providing a sidewalk bicycle path is unsatisfactory for a variety of reasons. Sidewalks are typically designed for pedestrian speeds and maneuverabilities and are not safe for higher-speed bicycle use. Conflicts are common between pedestrians traveling at low speeds (or exiting stores, parked cars, etc.) and bicyclists, as are conflicts with fixed objects (e.g., parking meters, utility poles, sign posts, bus benches, trees, fire hydrants, mail boxes, etc.). Walkers, joggers, and roller skaters can, and often do, change their speed and direction almost instantaneously leaving bicyclists insufficient time to react to avoid collisions. Similarly, pedestrians often have difficulty predicting the direction an oncoming bicyclist will take. At intersections, motorists are often not looking for bicyclists (who are traveling at higher speeds than pedestrians) entering the crosswalk area, particularly when motorists are making a turn. Sight distance is often impaired by buildings, walls, property fences, and shrubs along sidewalks, especially at driveways.

Bicycles riding on sidewalks can be expected in residential areas with young children. With lower bicycle speeds and lower motor vehicle speeds, potential conflicts are somewhat lessened, but still exist. This type of sidewalk bicycle use is generally accepted, but it is inappropriate to sign a sidewalk as a bicycle path or bicycle route if to do so would prohibit bicyclists from using an alternate facility that might better serve their needs.

It is also undesirable to mix mopeds and bicycles on the same facility. Where it is necessary to do so, the facility should be designed to account for the higher operating speeds of mopeds, the additional maneuvering requirements of mopeds, and the increased frequency of passing maneuvers. Many of the design guidelines prescribed in Chapter 2 under "Bicycle Paths" (e.g., widths, design speeds, horizontal alignments, grades, etc.) would be inadequate for facilities intended for moped use. Mopeds also contribute to a lessening of the quiet, relaxing experience most bicyclists desire on bicycle paths.

Using a path for bicycles and horses creates an unsatisfactory and possibly dangerous mix. Horses startle easily and may kick out suddenly if they perceive bicyclists as a danger. A bicycle path and a bridle path are also incompatible in their surface design requirements. Bicycles function best on hard surfaces; horses function best on soft surfaces. A compromise to accommodate both would result in a less than adequate surface for both.

During the winter months, where there is insufficient bicycle traffic to justify plowing snow, operators of bicycle paths may allow them to be used by cross-country skiers or snowmobile operators.

SUPPLEMENTAL FACILITIES

Providing bicycle parking facilities is an essential element in an overall effort to promote bicycling. People are discouraged from bicycling unless adequate parking is available. Bicycle parking facilities should be provided at both the trip origin and the trip destination and should offer protection from theft and damage.

The wide variety of bicycle parking devices fall into two categories of user needs; commuter or long-term parking, and convenience or short-term parking. The minimum needs for each differ in their placement and protection. Long-term parking is needed at locations such as employment centers, transit or subway stations, and multifamily dwellings. Facilities should be provided which secure the frame, both wheels, and accessories and which offer protection from the weather. Bicycle lockers and attended storage areas are good examples of long-term parking facilities. Short-term parking is needed at locations such as shopping centers, libraries, recreation areas, and post offices. Facilities should be very convenient and be near building entrances or other highly visible areas which are self-policing. The facility should be designed so that it will not damage bicycles (bent rims are common with racks that only support one wheel). If bicycle parking is not properly designed and located, bicyclists will use trees, railings, and other appurtenances. This practice can damage the appurtenances and create a hazard for pedestrians.

Several factors should be considered when planning and providing bicycle parking facilities. Care should be given in selecting the location to ensure that bicycles will not be damaged by motor vehicles. Parking facilities should not interfere with the normal pedestrian flow. Also, facilities should be designed so that persons parking their bicycles will not disturb other parked bicycles. The amount of security needed to prevent theft needs to be evaluated for each area.

Facilities should be able to accommodate a wide range of bicycle shapes and sizes including tricycles and trailers if used locally. Finally, facilities should be simple to operate. If possible, signs depicting how to operate the facility should be posted.

In addition to bicycle parking facilities, there are several other improvements that complement bicycle paths and roadway improvements. Provisions should be considered for interfacing bicycle travel with public transit, such as racks on buses, buses converted to carry bicycles aboard, or allowing bicycles on rapid rail facilities. Printing and distributing bicycle route maps is a high-benefit, low-cost project that is easily accomplished. Maps can help bicyclists locate bikeways, parking facilities, and identify the relative suitability of different segments of the road system. Also, maps can help bicyclists avoid narrow, high-speed, or high-volume roads, one-way streets, barriers, and other problems to bicyclists. In addition, maps can provide information on Rules of the Road, bicycle safety tips, and interfacing with mass transit.

Appendix D:

Part IX of Manual for Uniform Traffic Control Devices

Copies of the full report are available for a fee through:

Superintendant of Documents

U.S. Governmental Printing Office

Washington, D.C. 20402.

All references should be made as follows: Manual on Uniform Traffic Control Devices, Washington, D.C.: U.S. Department of Transportation, Federal Highway Administration, Copyright 1978. Used by permission.

Part IX. TRAFFIC CONTROLS FOR BICYCLE FACILITIES

A. GENERAL

9A-1 Requirements for Bicyclist Traffic Control Devices

Traffic control devices, whether they are intended for motorists or bicyclists, must adhere to five basic requirements to be able to perform their intended function. They must:

1. Fulfill a need.
2. Command attention.
3. Convey a clear, simple meaning.
4. Command respect of road users.
5. Give adequate time for proper response.

The design, placement, operation, maintenance, and uniformity of traffic control devices must be considered to meet the above requirements. Design is a critical feature to permit the device to fulfill a need and to command respect of road users. The placement—lateral, vertical, and longitudinal—plays an important part in making the device effective and in giving adequate time for proper response. The operation of traffic in response to the device is, of course, the critical test of the device's effectiveness and a check on all five of the basic requirements.

Uniformity, achieved by following the recommendations and standards of this Manual, greatly enhances the ability of a device to convey a clear, simple meaning to the user.

Whenever devices are installed, they should be warranted and based on a prior engineering study. Where the guidance provided by this part of the Manual does not fully define where particular devices should be used, qualified traffic engineers should determine the application of devices on any bicycle facility before installation is made. It is intended that this Manual define the standards for traffic control devices, but shall not be a legal requirement for their installation.

9A-2 Scope

This Part covers bicycle-use related signs, pavement markings and signals which may be used on highways or bikeways.

9A-3 Definitions Relating to Bicycles

The following terms are used throughout Part IX:

1. Bikeway—Any road, street, path, or way which in some manner is specifically designated as being open to bicycle travel, regardless of whether such facilities are designated for the exclusive use of bicycles or are to be shared with other transportation modes.
2. Bicycle Trail—A separate trail or path from which motor vehicles are prohibited and which is for the exclusive use of bicycles or the shared use of bicycles and pedestrians. Where such trail or path forms a part of a highway, it is separated from the roadways for motor vehicle traffic by an open space or barrier.
3. Designated Bicycle Lane—A portion of a roadway or shoulder which has been designated for use by bicyclists. It is distinguished from the portion of the roadway for motor vehicle traffic by a paint stripe, curb, or other similar device.
4. Shared Roadway—A roadway which is officially designated and marked as a bicycle route, but which is open to motor vehicle travel and upon which no bicycle lane is designated.
5. Bicycle Route—A system of bikeways designated by appropriate route markers, and by the jurisdiction having authority.

9A-4 Standardization of Devices

Standards for basic design elements and devices using these standards are given in this Manual. These standard devices generally will serve most applications. Where particular conditions require the use of a device that is not included in this Manual, the general principles in this Manual as to color, size, and shape should be followed wherever practical. Such devices should also follow the design, installation and application concepts contained in the Manual.

9A-5 Maintenance

Bicycle signs and markings should be properly maintained to command respect from both the motorist and the bicyclist. When installing signs and markings on bicycle facilities, care should be taken to have an agency designated to maintain these devices.

9A-6 Legal Authority - See Section 1A-3.1

9A-7 Meanings of "Shall," "Should," and "May"

In this Part as in other parts of the Manual, the words "shall," "should," and "may" are used to describe specific conditions concerning traffic control devices. To clarify the meanings intended by use of these words, the following definitions are provided:

1. SHALL—A *mandatory* condition. Where certain requirements in the design or application of the device are described with the "shall" stipulation, it is mandatory that these requirements be met.
2. SHOULD—An *advisory* condition. Where the word "should" is used, it is considered to be advisable usage, recommended but not mandatory.
3. MAY—A *permissive* condition. No requirement for application is intended. If a particular device is used under a "may" condition, however, its design shall follow the prescribed format.

9A-8 Relation to Other Documents

The Uniform Vehicle Code and Model Traffic Ordinance published by the National Committee on Uniform Traffic Laws and Ordinances, have provisions for bicycles and are used as the legal basis for the control devices included herein. Under the Uniform Vehicle Code, bicycles are generally considered to be vehicles, so the bicyclists have the same privileges and obligations as other drivers.

Informational documents used during the development of the signing and markings recommendations in this part of the Manual include the following:

1. Guide for Bicycles, American Association of State Highway and Transportation Officials, 1974.
2. Bikeways, State of the Art, Federal Highway Administration, 1974.
3. Bicycle Facility Location Criteria, Federal Highway Administration, 1976.
4. Bicycle Facility Design Criteria, Federal Highway Administration, 1976
5. State and municipal design guides.

Other documents which relate to the application of traffic control devices in general, are listed in section 1A-7 of this Manual.

9A-9 Colors

The use of colors for bicycle facility traffic control devices should conform to the color code specified in section 1A-8 for signs and markings. This in part is as follows:

YELLOW—General warning
RED—Stop or prohibition
BLUE—Service guidance

GREEN—Indicated movements permitted, direction guidance
BROWN—Public recreation and scenic guidance
ORANGE—Construction and maintenance warning
BLACK—Regulation
WHITE—Regulation

B. SIGNS

9B-1 Application of Signs

Bicycle-use related signs on highways and bikeways serve three basic purposes: regulating bicycle usage, directing bicyclists along preestablished routes, and warning of unexpected conditions. Care should be taken not to install too many signs. A conservative use of regulatory and warning signs is recommended as these signs, if used to excess, tend to lose their effectiveness. The frequent display of guide signs, however, aids in keeping the bicyclist on the designated route and does not lessen their value. Some signs for the bicyclist can also serve the motorist and the pedestrian.

9B-2 Location and Position

Where signs are to serve both bicyclists and motorists, mounting heights and lateral placement shall be as specified in Part II, Signs. Figure 9-1 illustrates typical signing placement for bicycle trails. Overhead sign clearance on bicycle trails shall be a minimum of 8 feet. The clearance provided should also be adequate for the typical maintenance vehicles used on the bikeway. Where signs are for the exclusive use of bicyclists, care should be taken that they are located so that motorists are not confused by them.

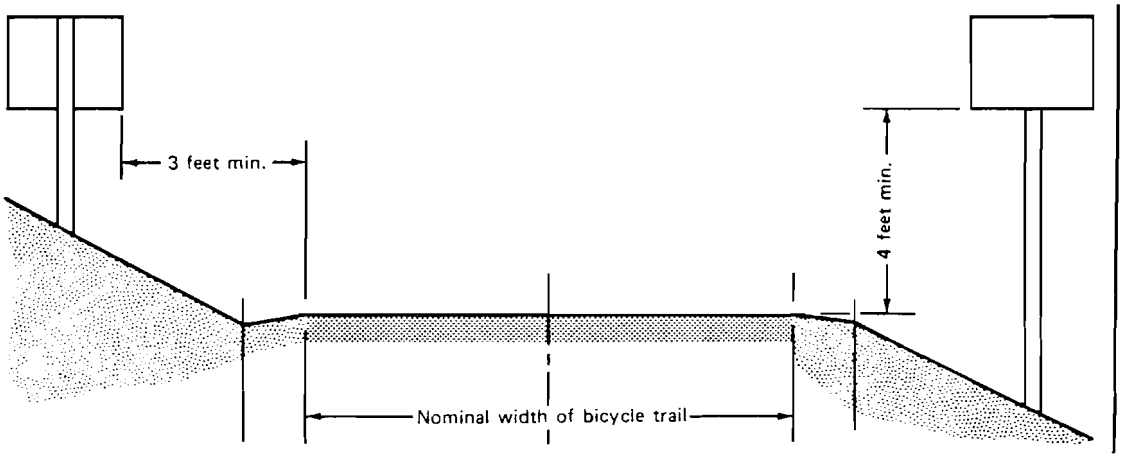


Figure 9-1. Bicycle sign placement on a trail.

9B-3 Design

The design of signs for bicycle facilities should, whenever possible, be identical to that specified in this Manual for motor vehicle travel. Uni-

formity in design includes shape, color, symbols, wording, lettering, and illumination or reflectorization. Detailed drawings of the standard signs illustrated in this Manual are available to State and local highway and traffic authorities, sign manufacturers, and similar interested agencies.* Standardization of these signs does not preclude further improvement by minor changes in the proportion of symbols, stroke width, and height of letters, or width of borders. However, all shapes and colors shall be as indicated, all symbols shall be unmistakably similar to those shown and (where a word message is applicable) the wording shall be as provided herein.

The sign dimensions shown in this part of the Manual shall be considered standard for application on all types of bicycle facilities. Where signs shown in other parts of this Manual are intended for exclusive bicycle use, smaller sign sizes from that specified may be used. Incremental increases in special bicycle facility signs are also desirable to make the sizes compatible with signs for motor vehicles, where both motorists and bicyclists benefit by a particular sign.

The sign lettering shall be in upper-case letters of the type shown in the Standard Alphabets for Highway Signs and Pavement Markings*

All signs should be reflectorized for bicycle trails as well as for shared roadway and designated bicycle lane facilities.

9B-4 Regulatory Signs

Regulatory signs are to inform bicyclists, pedestrians and motorists of traffic laws or regulations and indicate the applicability of legal requirements that would not otherwise be apparent.

Regulatory signs normally shall be erected at the point where the regulations apply. The sign message shall clearly indicate the requirements imposed by the regulations and shall be easily visible and legible to bicyclists and where appropriate, motorists and pedestrians.

9B-5 Bicycle Prohibition Sign (R5-6)

This sign is intended for use at the entrance to facilities, such as freeways, where bicycling is prohibited. Where pedestrians and motor—driven cycles are also prohibited from using these facilities, it may be more desirable to use the R5-10a word message sign (sec. 2B-28).

In reduced size (18 × 18 inches), this sign may be used on sidewalks where bicycle riding is prohibited.

9B-6 Motor Vehicle Prohibition Sign (R5-3)

This sign is intended for use at the entrance to a bicycle trail.

* Available from the Federal Highway Administration (HTO-20) Washington, D.C. 20590

R5-6
24″×24″

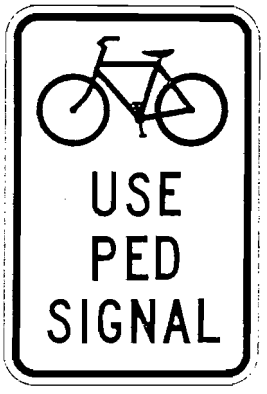
R5-3
24″×24″

9B-7 Bicycle Restriction Signs (R9-5 & 6)

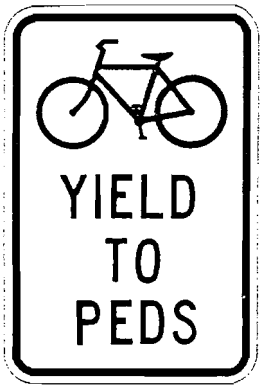
This series of signs is intended for use where pedestrian facilities are being used for bicycle travel. They should be erected off the edge of the sidewalk, near the crossing location, where bicyclists are expected to dismount and walk with pedestrians while crossing the street.

The R9-5 sign may be used where bicycles can cross the street only on the pedestrian walk signal indication.

The R9-6 sign may be used where bicycles are required to cross or share a facility used by pedestrians and are required to yield to the pedestrians.



R9-5
12″×18″

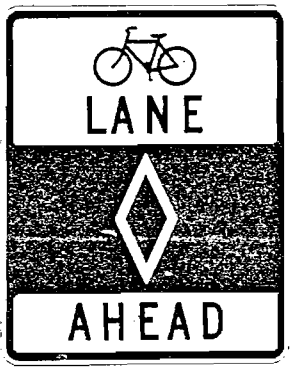


R9-6
12″×18″

9B-8 Designated Lane Signs (R3-10 & 11)

The R3-16 sign should be used in advance of the beginning of a marked designated bicycle lane to call attention to the lane and to the possible presence of bicyclists. The R3-16 and R3-17 signs should be used only in conjunction with the Preferential Lane Symbol pavement marking and erected at periodic intervals along the designated bicycle lane and in the vicinity of locations where the preferential lane symbol is used (sec. 9C-4).

Where appropriate, the message ENDS may be substituted for AHEAD on the R3-16 sign and LEFT or CURB can be substituted for RIGHT on the R3-17 sign.



R3-16
24″×30″

R3-17
24″×30″

9B-9 Travelpath Restriction Signs (R9-7)

The R9-7 sign is intended for use on facilities which are to be shared by pedestrians and bicycles and on which a designated area is provided for each (sec. 9C-3). Two of these signs may be erected back-to-back with the symbols reversed for the opposite direction.

R9-7
12″×18″

9B-10 STOP and YIELD Signs (R1-1, 2)

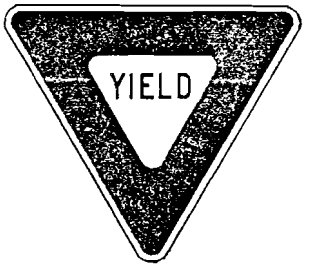
STOP signs are intended for use on bicycle facilities where bicyclists are required to stop. Where conditions require bicyclists and not motorists to stop, care should be taken to place the sign so it is not readily visible to the motorist.

YIELD signs are intended for use where the bicyclist can see approaching traffic and where bicyclist must yield the right of way to that traffic. The visibility of approaching traffic must be adequate to permit the bicyclist to stop or to take other measures to avoid that traffic.

For added emphasis STOP and YIELD signs in regular 30 × 30-inch and 36 × 36 × 36-inch sizes may be used.

The smaller signs shown below are intended for use on bicycle trails where bicyclists are required to stop or yield the right of way. If the sign applies to motorists and bicyclists, then the size should be as shown in Part II-B.

R1-1
18″×18″



R1-2
24″×24″×24″

9B-11 No Parking Signs (R7-9, & 9a)

Where it is necessary to restrict parking, standing, or stopping in a designated bicycle lane, appropriate signs as described in sections 2B-31 through 2B-33 may be used, or signs R7-9 or R7-9a shall be used.

R7-9
12″×18″

R7-9a
12″×18″

9B-12 Lane-Use Control Signs (R3-7, R4-4)

Where right turning motor vehicles must merge with bicycle traffic on designated bike lanes, the R3-7 and R4-4 signs may be used. The R4-4 sign is intended to inform both the motorist and the bicyclist of this merging maneuver. Where a designated bicycle lane is provided near the stop line, an R3-7 sign may be used to prevent motorists from crossing back over the bike lane.

R3-7
30″×30″

R4-4
36″×30″

9B-13 Warning Signs

Warning signs are used when it is deemed necessary to warn bicyclists or motorists of existing or potentially hazardous conditions on or adjacent to a highway or trail. The use of warning signs should be kept to a minimum because the unnecessary use of them to warn of conditions which are apparent tends to breed disrespect for all signs.

Warning signs specified herein cover most conditions that are likely to be met. If other warnings are needed, the signs shall be of standard shape and color for warning signs, and the legends shall be brief and easily understood.

9B-14 Bicycle Crossing Sign (W11-1)

The Bicycle Crossing sign is intended for use on highways in advance of a point where a bikeway crosses the roadway. It should be erected about 750 feet in advance of the crossing location in rural areas where speeds are high, and at a distance of about 250 feet in urban residential or business areas, where speeds are low.

If the approach to an intersection is controlled by a traffic control signal, stop sign or yield sign, the W11-1 sign may not be needed.

9B-15 Hazardous Condition Sign (W8-10)

The Hazardous Condition sign is intended for use where roadway or bicycle trail conditions are likely to cause a bicyclist to lose control of his bicycle. These conditions could include slippery pavement, slick bridge

W11-1
30″×30″

W8-10

Roadway Signs	Bicycle Trail Signs
30″×30″	18″×18″
24″×18″	12″×9″

decking, rough or grooved pavement, or water or ice on the roadway. The W8-10 sign may be used with a supplemental plaque describing the particular roadway or bicycle trail feature which might be of danger to the bicyclist such as SLIPPERY WHEN WET, STEEL DECK, ROUGH PAVEMENT, BRIDGE JOINT, or FORD.

9B-16 Turn and Curve Signs (W1-1, 2, 4, 5, 6, 7)

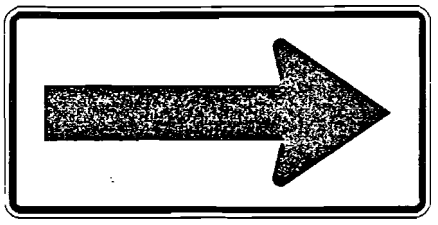
On bicycle trails where it is necessary to warn bicyclists of unexpected changes in path direction, appropriate turn or curve signs should be used. They should normally be installed no less than 50 feet in advance of the beginning of the change of alignment.

W1-1
18″×18″

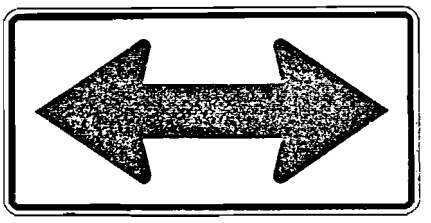
W1-2
18″×18″

W1-4
18″×18″

W1-5
18″×18″



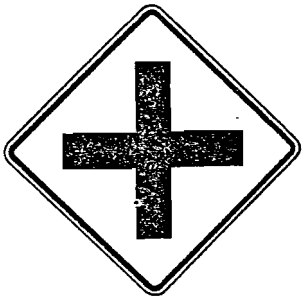
W1-6
24″×12″



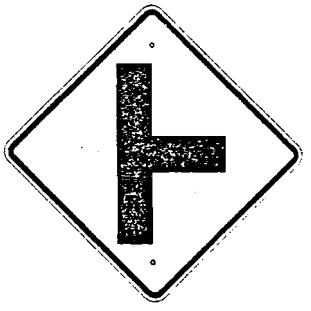
W1-7
24″×12″

9B-17 Intersection Signs (W2-1, 2, 3, 4, 5)

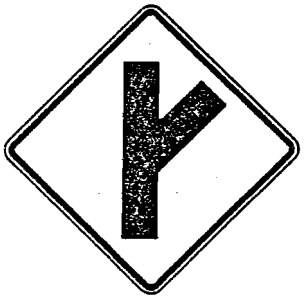
Intersection signs are intended for use as appropriate to fit the prevailing geometric pattern on bike trails where connecting routes join and where no STOP or YIELD signs are required. They should be used wherever sight distance at the intersection is severely limited, and may be used for supplemental warning at intersections where STOP and YIELD signs are erected.



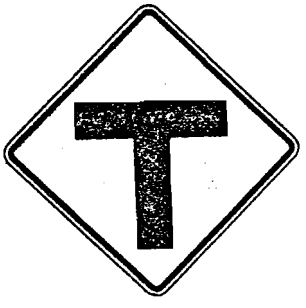
W2-1
18″×18″



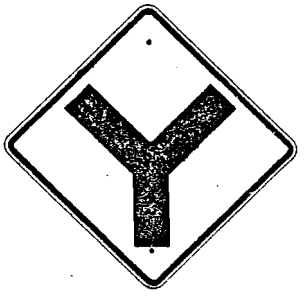
W2-2
18″×18″



W2-3
18″×18″



W2-4
18″×18″



W2-5
18″×18″

9B–18 Other Warning Signs

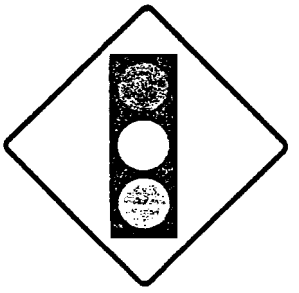
Other warning signs may be required on bicycle facilities to warn riders of unexpected conditions. The intended use of these signs generally is self-explanatory. They should normally be installed no less than 50 feet in advance of the beginning of hazards.

Where construction or maintenance activity is present on bicycle trails, appropriate signs from Part VI of the Manual should be used.

9B–19 Guide Signs

On highways where a bicyclist is sharing a lane with motor vehicles or is using an adjacent bikeway, the regular guide signing as described in Part II of this Manual will serve both modes of travel. Where a designated bikeway exists, special bicycle route signing should be

W3-1
18″ x 18″



W3-3
18″ x 18″

W5-4
18″ x 18″

W7-5
18″ x 18″

W11A-2
18″ x 18″

W12-2
18″ x 18″

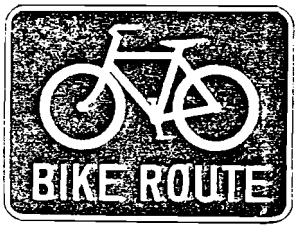
W10-1
18″ Diameter

provided at decision points along the bikeway, including signs to inform cyclists of bicycle route direction changes and confirmatory signs to ensure that route direction has been accurately comprehended.

Figure 9–2 shows an example of the signing for the junction of a bicycle trail with a highway. Figure 9–3 shows the signing and marking for the beginning and ending of designated bikeways. Guide signing should be repeated at regular intervals to ensure that bicyclists approaching from side streets know they are traveling on an officially designated bikeway. Similar guide signing should be used for shared lane bikeways with intermediate signs placed frequently enough to ensure that cyclists already on the bikeway do not stray from it and lose their way.

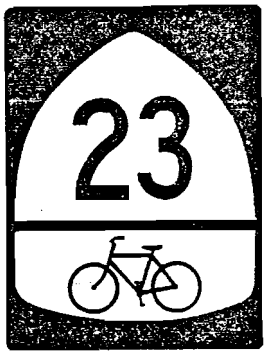
9B–20 Bicycle Route Sign (D11–1)

This sign is intended for use where no unique designation of routes is desired. It should be placed at intervals frequent enough to keep bicyclists informed of changes in route direction and to remind motorists of the presence of bicyclists.



D11-1
24″ x 18″

M1-8
12″ x 18″



M1-9
18″ x 24″

9B–21 Bicycle Route Markers (M1–8, M1–9)

Where it is desired to establish a unique identification (route designation) for a State or local bicycle route, the standard Bike Route Marker (M1–8) should be used. The route marker (M1–8) shall contain a numerical designation and shall have a green background with a reflectorized white legend and border.

Where a bicycle route extends for long distances in two or more States, it is desirable to establish a unique numerical designation for that route. A coordinated submittal by the affected States for assignment of route number designations should be sent to the American Association of State Highway and Transportation Officials, 444 North Capitol Street NW., Suite 225, Washington, D.C. 20001. The route marker (M1–9) shall contain the assigned numerical designation and have a black legend and border with a reflectorized white background. IX-1 (c)

Bike Route Markers are intended for use on both shared facilities and on designated bikeways, as required, to provide guidance for bicyclists.

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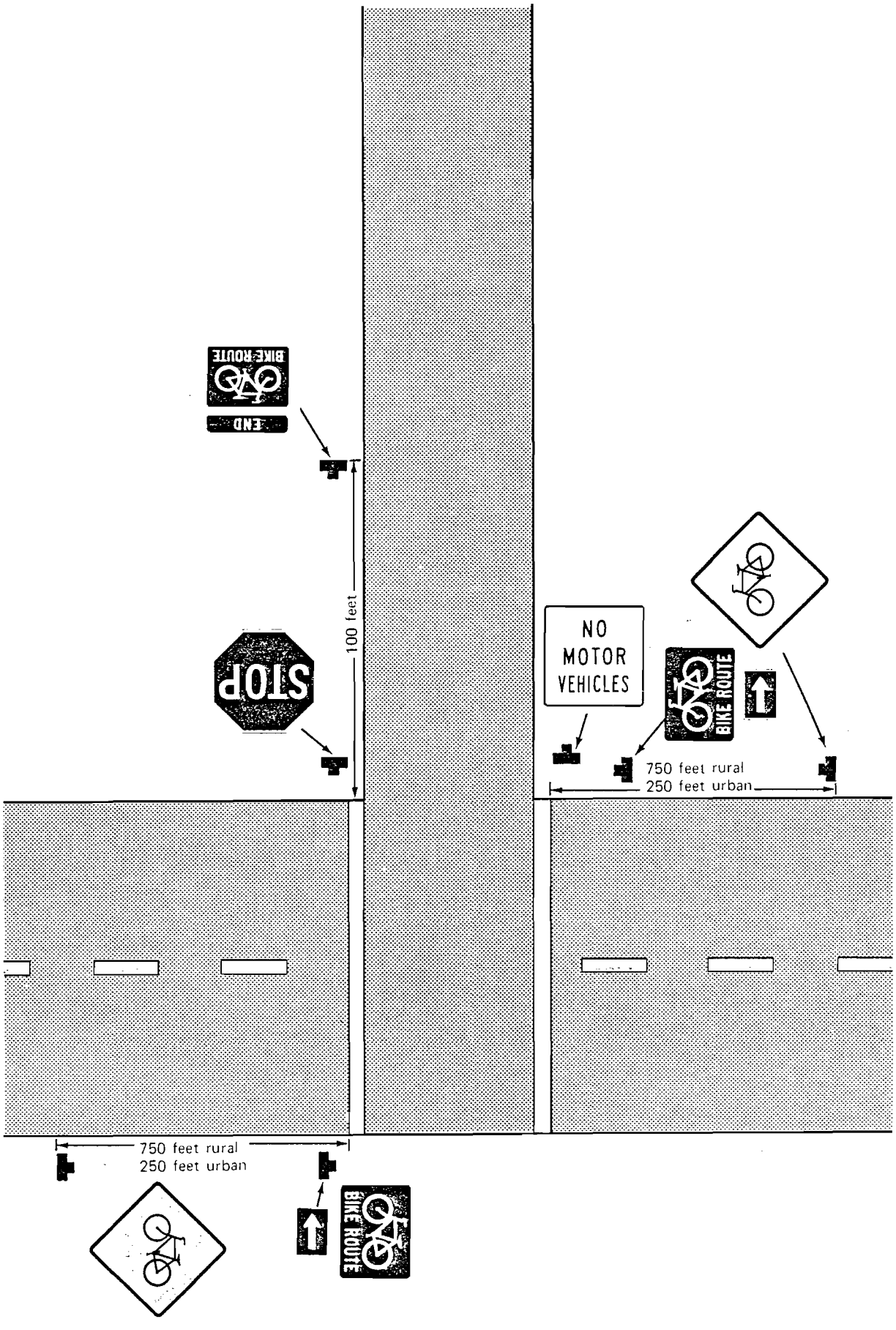


Figure 9-2. Typical signing for beginning and ending of bicycle trail.

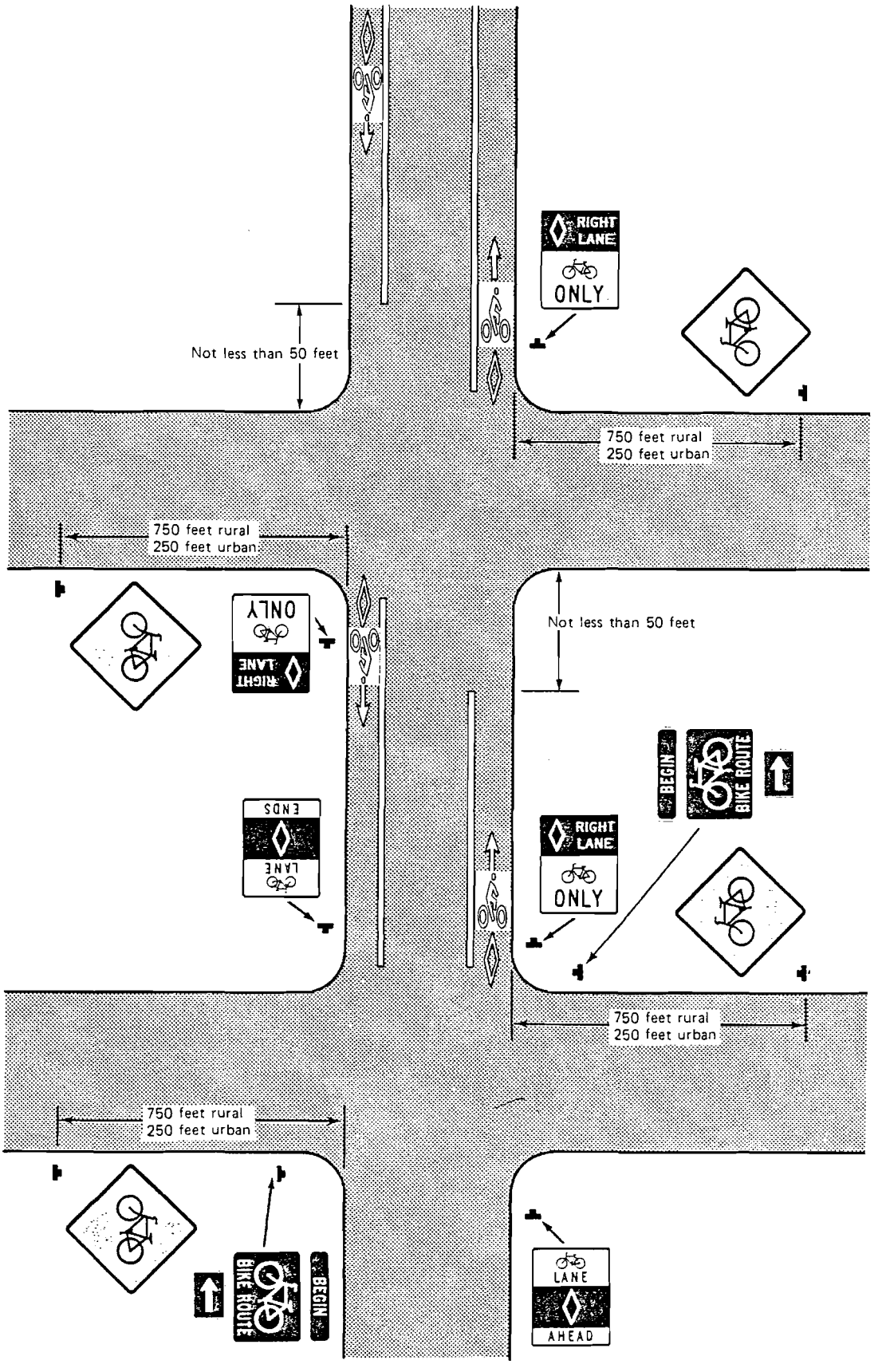


Figure 9-3. Typical signing for beginning and ending of designated bicycle lane.

9B-22 Supplemental Plaques for Route Signs and Route Markers

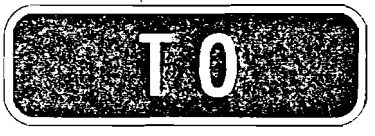
Where desired, supplemental plaques can be used with the D11-1 and M1-8 signs to furnish additional information, such as directional changes in the route, and intermediate range distance and destination information. The M4-11 through M4-13 signs may be mounted above the appropriate Route Signs or Route Marker. Supplemental plaques D1-1b and c are intended for use with the D11-1 Bicycle Route Sign. The appropriate arrow sign (M7-1 through M7-7), if used, should be placed below the Route Sign or Route Marker. These signs shall have a white arrow on a green background.

M4-11
24″ × 6″ or 12″ × 4″

D1-1b(L)
24″ × 6″

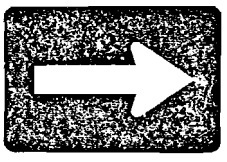
M4-12
24″ × 6″ or 12″ × 4″

D1-1b(R)
24″ × 6″

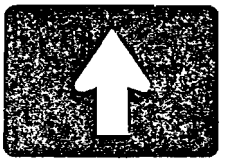


M4-13
24″ × 6″ or 12″ × 4″

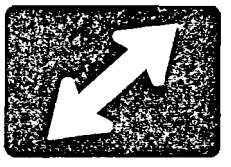
D1-1(c)
24″ × 6″



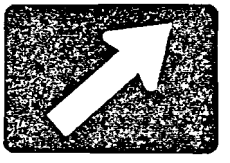
M7-1



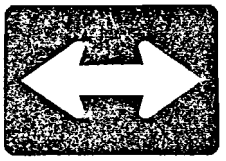
M7-2



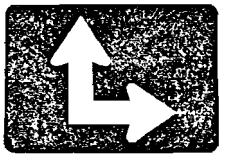
M7-3



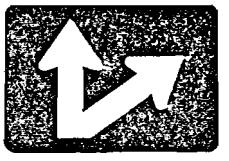
M7-4



M7-5



M7-6



M7-7

M7-1 through M7-7
12″ × 9″

9B-23 Bicycle Parking Area Sign (D4-3)

The Bicycle Parking Area sign may be used where it is desired to show the direction to a designated bicycle parking area within a parking facility or at other locations. The sign shall be a vertical rectangle of a standard size of 12 by 18 inches. It shall carry a standard bicycle symbol, the word PARKING, and an arrow. The legend and border shall be green on a reflectorized white background. IX-2 (c)

D4-3
12″×18″

C. MARKINGS

9C-1 Functions and Limitations of Markings

Markings are important on roadways that have a designated bicycle lane. Markings indicate the separation of the lanes for motor vehicle and bicycles, assist the bicyclist by indicating assigned travel paths, and can provide advance information for turning and crossing maneuvers.

9C-2 General Principles

Although bicycles are generally not equipped with strong lighting equipment, the added visibility of reflectorized pavement markings is desirable even where there is exclusive use by bicyclists.

Markings shall be reflectorized on bicycle trails and on facilities used by both motor vehicles and bicycles.

Recognized bikeway design guides should be used when laying out markings for a bicycle lane on a highway facility (sec. 9A-8).

The frequent use of symbols and word messages stenciled in the bike lanes, is a desirable method of supplementing sign messages. Figures 9-4 through 9-6, show acceptable examples of the application of lines, word messages and symbols on designated bikeways with and without parking for motor vehicles.

If a specific path for a bicylist crossing an intersection is to be designated, a dotted line may be used to define such a path.

9C-3 Marking Patterns and Colors

The color and type of lines used for marking bicycle facilities shall be as defined in section 3A-7. Normally, center lines would not be required on bicycle paths. Where conditions make it desirable to separate two directions of travel at particular locations, a double solid yellow line should be used to indicate no passing or no traveling to the left of the line.

Where bicycle paths are of sufficient width to designate two minimum width lanes, a broken yellow line may be used to separate the two directions of travel.

Broken lines used on bicycle paths should have the normal 1 to 3 segment-to-gap ratio. To avoid having gaps excessively long, a nominal 3-foot segment with a 9-foot gap is recommended.

Where bicycles and pedestrians use a common facility, it may be desired to separate the two traffic flows. A solid white line should be used to mark this separation of path use. The R9-7 sign may be used to supplement the pavement marking (sec. 9B-9).

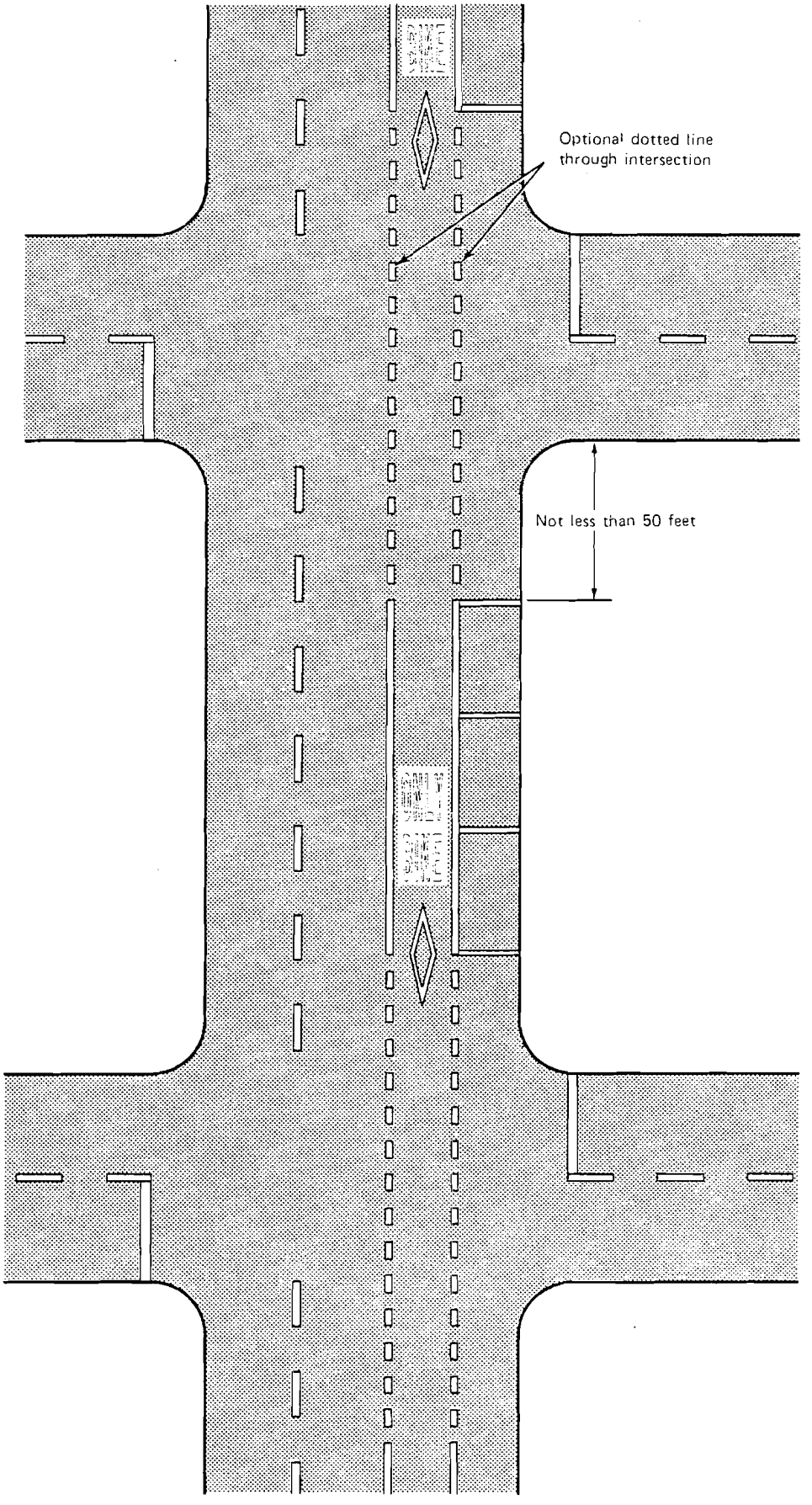


Figure 9-4. Typical pavement markings—designated bicycle lane, two-way traffic with parking and low right turn volume.

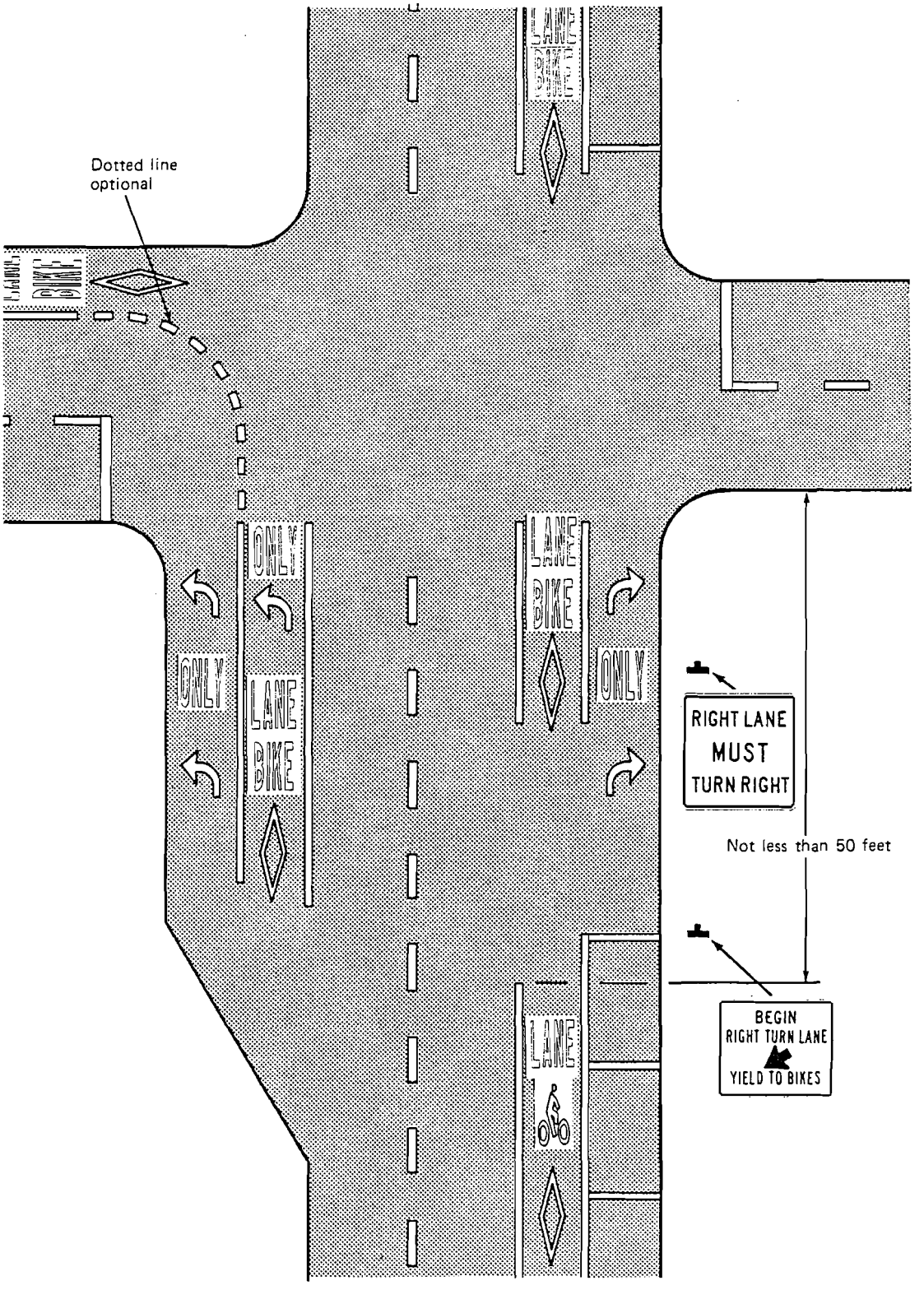


Figure 9-5. Intersection pavement markings—designated bicycle lane with left turn area, heavy turn volumes, parking, one-way traffic or divided roadway.

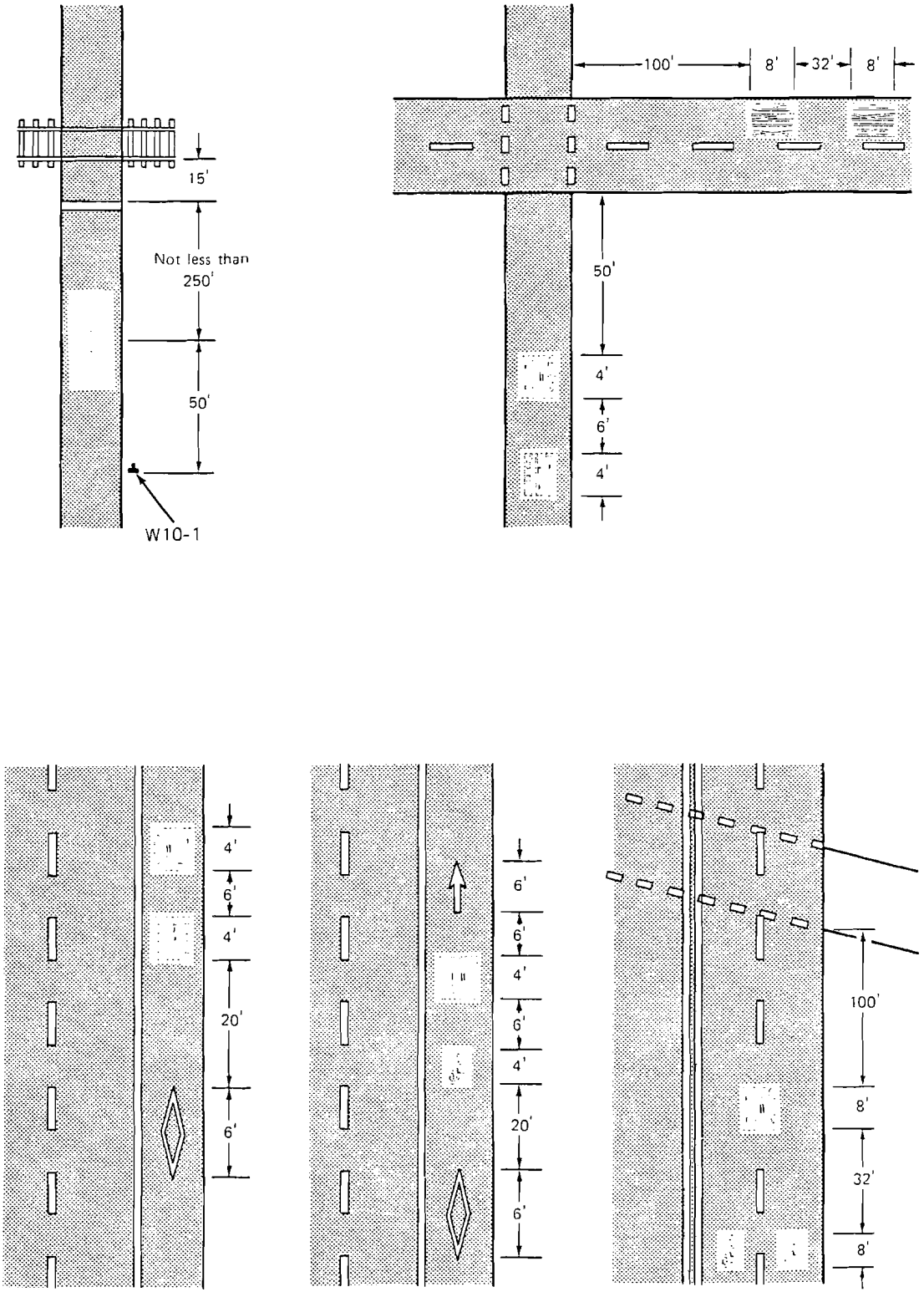


Figure 9-6. Word and symbol pavement markings for bicycle facilities.

9C-4 Marking of Designated Bikeways

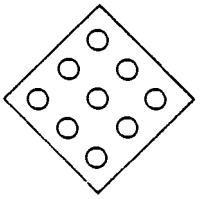
The diamond-shaped Preferential Lane Symbol is intended for use on highway facilities where lanes are reserved for exclusive use by a particular class of vehicle. Designated bikeways are considered as this type of lane and shall include use of the Preferential Lane Symbol as a pavement marking and on appropriate signing (sec. 9B-8). The symbols as a pavement marking shall be white and shall be used immediately after an intersection to inform motorists turning of the restricted nature of the lane. If the Preferential Lane Symbol is used in conjunction with other word or symbol messages, it shall precede them. A supplemental lane symbol or word may be used following as shown in figures 9-4 through 9-6.

9C-5 Word Messages and Symbols Applied to the Pavement

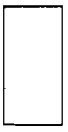
Where messages are to be applied on the pavement, smaller size letters can be used on exclusive bike lanes than are used on regular highways. Where arrows are needed, half-size layouts of the arrows can be used (sec. 3B-17). Optional word and symbol markings considered appropriate for use with the Preferential Lane Symbol marking are shown in figure 9-6. Standard pavement marking alphabets and symbols have been prepared.*

9C-6 Object Markings on Bicycle Trails

There may be hazardous objects located adjacent to bicycle trails which, if visible to the rider, can be avoided with little difficulty. Such objects can be marked with highly visible markings to make their identification by approaching riders more certain. Care should be taken to avoid having object markers become hazardous objects. Corners of object markers as well as signs should be rounded to prevent their becom-



Type I
18″×18″



Type II
6″×12″

Type III
12″×36″

* Available from the Federal Highway Administration (HTO-20) Washington, D.C. 20590

ing a hazard. All object markers should be designed using reflective materials or coatings. Where practical, markers such as those described in section 3C-1 of this Manual should be used.

Where a storm drain hazard cannot be eliminated, it may be made more visible to bicyclists by defining with a white marking applied as shown in figure 9-7.

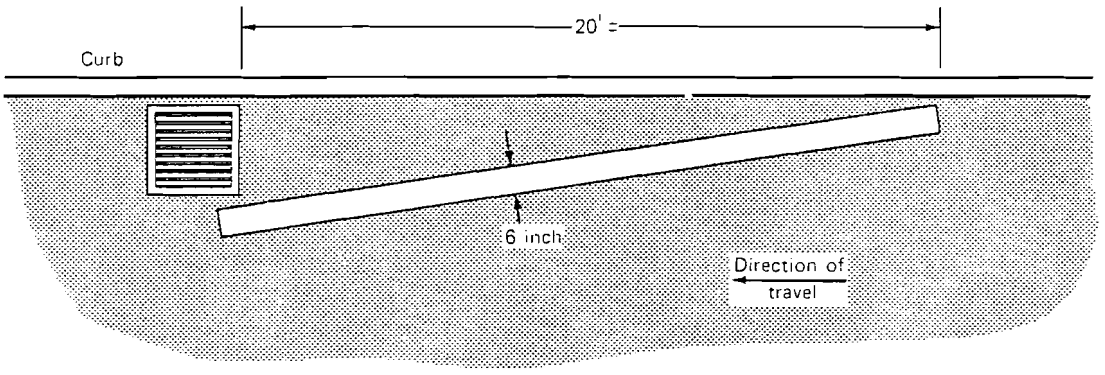


Figure 9-7. Typical marking in advance of drainage hazard.

D. SIGNALS

9D-1 Application

It is rare when a traffic signal is installed solely for bicyclists; however, at some locations there may be a need to install signal devices to facilitate bicycle travel through the intersection. For warrants and other requirements relating to signal installations, see Part IV of this Manual. Warrants used for motor vehicles are considered appropriate for use in determining the need for signals to serve bicyclists. Warrant Four for school crossings is considered to be appropriate for bicyclists also.

9D-2 Visibility Requirements

At installations where programmed signals are used, special attention should be given to adjusting the signals so bicyclists on the regular bicycle lanes or travel paths can see the signals. If programmed signals cannot be aimed to serve the bicyclist, then separate signals shall be provided.

9D-3 Signal Operation for Bicycles

Bicycles generally can cross intersections under the same signal timing arrangement as motor vehicles. Where bicycle use is expected, extremely short change intervals should not be used and an all red clearance interval may be necessary.

Appendix E

Zoning Code Adaptations for Inclusion of Bicycle Parking Facilities[1]

The following zoning code requirements were established as an experimental project for the City of Portland, Oregon in 1981. They define bicycle parking requirements and design standards for eleven land use zones in the City. After two years, the project was evaluated and susequently incorporated permanently into the Zoning Code.

1 Oregon Statewide Bicycle Master Plan, 1983.

THE CITY OF
PORTLAND
OREGON

DEPARTMENT OF PUBLIC WORKS
MIKE LINDBERG
COMMISSIONER

OFFICE OF PUBLIC WORKS ADMINISTRATOR

821 S.W. ALDER
PORTLAND, OR 97205

Zoning Code Adaptations For Inclusion Of Bicycle Parking Facilities

March 10, 1981

MEMORANDUM

TO: Interested Persons

FROM: City of Portland Bicycle and Pedestrian Program

SUBJECT: Changes to Zoning Code to Require Bicycle Parking

Starting January 1, 1981, new construction in most Portland commercial, light industrial, and high density residential zones has been required to include bicycle parking. This memorandum summarizes the bicycle parking options and requirements for uses in the following zones:

Definitions
R2 Multi-Family Residential
RI Multi-Family Residential
RH High Density Multi-Family Residential
C4 Neighborhood Commercial
C3 Local Commercial
C2 General Commercial
MU Light Manufacturing
M2 General Manufacturing
MI Heavy Manufacturing
Z Downtown Development
Elderly and Handicapped High Density
Design Standards for Bicycle Parking

Definitions

Specifies minimum area of 125 feet for each adult tricycle parking space and 25 feet for each bicycle parking space. (33.12.590)

R2 Multi-Family Residential Zone, and RI Multi-Family Residential Zone

Offers bicycle parking option for developments with minimum of 5 automobile parking units. A developer may substitute bicycle parking for required motor vehicle parking at a ratio of 4 bicycle parking spaces for every automobile parking space not provided, up to a maximum 20% reduction in motor vehicle parking. Reductions in automobile parking must be approved by the Bureau of Traffic Engineering. Bicycle parking must be covered if the development includes a basement or provides covered motor vehicle parking. (33.30.030 and 33.32.030)

RH High Density Multi-Family Residential Zone

Requires provision of bicycle parking according to the following schedule:

Project Size	Number of Bicycle Parking Spaces
Less than 10 units	2
10-19 Units	3
20-39 Units	5
40-80 Units	8
Over 80 Units	1 space for every 10 dwelling units

Covered bicycle parking is required where the development includes a basement of provides covered motor vehicle parking.

Required automobile spaces may be reduced at the rate of 1 space for every 4 covered bicycle spaces provided, up to a minimum 20% reduction in motor vehicle parking. Reductions must be approved by the Bureau of Traffic Engineering. (33.34.030)

C4 Neighborhood Commercial Zone

Requires 2 bicycle parking spaces for every 4,000 square feet of floor are (33.40.040)

C3 Local Commercial Zone

Requires bicycle parking in the following amounts for uses in groups of 1-

Group 1, 2: For retail stores, general offices, and all other uses in group 1 and 2, 5 bicycle parking spaces or 1 space for each 20 motor vehicle spaces provided, whichever is greater.

Group 3: For gymnasiums and indoor arenas, 10 bicycle parking spaces of 1 space for every 20 motor vehicle parking spaces provide whichever is greater. For all other group 3 uses, such as wholesal businesses, 5 bicycle parking spaces of 1 space for every 20 motor behicle parking spaces provided, whichever is greater.

Group 4: For parking garages, bicycle shops, and all other group 4 uses, 2 bicycle parking spaces or 1 space for every 20 motor vehicl parking spaces provided, whichever is greater.

* Complete listing of uses by group may be found under Principle Uses, 33.41.020, Portland City Code.

Group 5: For auditoriums, exhibition halls, libraries, museums and theaters, 10 bicycle parking spaces or 1 space for every 20 motor vehicle parking spaces provided, whichever is greater. Billboards and cemetaries are not required to provide bicycle parking spaces. For all other group 5 uses, such as hotels, restaurants, and medical offices, 5 bicycle parking spaces or 1 space for every 20 motor vehicle parking spaces provided, whichever is greater.

Group 6: For elementary and high schools, 1 bicycle parking space for every 10 students. For colleges, 1 bicycle parking space for every 10 motor vehicle parking spaces provided. For all other group 6 uses, such as churches and hospitals, 5 bicycle parking spaces or 1 space for every 20 motor vehicle parking spaces provided, whichever is greater.

For all the above uses, except schools and colleges, wherever 10 or more bicycle parking spaces are provided, 50% of all the required spaces must be covered. All bicycle parking required for schools and colleges must be covered. (33.41.030, 33.41.045)

C2 General Commercial Zone

Bicycle parking is required for groups 1-6 in the same amounts specified for C3 - Local Commercial Zone. Required automobile spaces may be reduced at the rate of 1 space for every 2 bicycle parking spaces provided, up to a maximum 20% reduction in motor vehicle parking. Reductions in automobile parking must be approved by the Bureau of Traffic Engineering. (33.42.040 and 33.42.045)

M3 Light Manufacturing Zone

Bicycle parking is required in the same amounts specified for groups 1-6 in C3 - Local Commercial Zone and C2 - General Commerical Zone. For all manufacturing and other uses in group 7, 2 covered bicycle parking spaces or 1 covered space for every 20 motor vehicle spaces. (33.50.045)

M2 General Manufacturing Zone, and
M1 Heavy Manufacturing Zone

Offers option to reduce required motor vehicle parking spaces by 1 space for every 2 covered bicycle parking spaces provided, up to a maximum 10% reduction in motor vehicle parking. Reductions in automobile parking must be approved by the Bureau of Traffic Engineering. (33.52.040, 33.54.030)

Z Downtown Development Zone

Requires bicycle parking in both new construction and building remodelings, based on the following schedule:

Category of Use	Bicycle Parking Required
Residential	One space for every 4 dwelling units.
Hotel or Motel	One space for every 20 employees.
All Other Uses	Ten spaces, or 1 space for every 20,000 gross square feet of building area, or 1 space for every 20 passenger automobile spaces allowed, whichever is greater.

Remodeling buildings must include bicycle parking if the renovation exceeds 50% of the building's assessed value before the renovation and if the building has a loading dock, motor vehicle access, or service entrance.

All required bicycle parking in residential projects must be covered. Fifty percent of required bicycle parking in all other projects with 10 or more bicycle parking spaces must be covered.

An off-street parking structure providing 300 or more motor vehicle parking spaces for public use must include 1 bicycle parking space for every 20 motor vehicle parking spaces. Bicycle parking must be available for general public use. (33.56.090)

Elderly and Handicapped High Density

Offers the option of reducing required motor vehicle parking by 1 space for every 4 bicycle or adult tricycle parking spaces provided, so long as at least 1 automobile space is maintained for every 12 dwelling units for elderly or handicapped persons. The Bureau of Traffic Engineering must approve the substitution. (33.81.030)

Bicycle Parking Design Standards

For bicycle parking in all zones:

1. Bicycle parking requirements can be met in any of the following ways:
   (a) Providing storage space inside the building in view of the bicycle owner.
   (b) Providing a bicycle storage room, bicycle lockers, or racks inside the building.
   (c) Providing bicycle lockers or racks in an accessory parking structure or outside the main building.
   (d) Providing bicycle racks on the public right-of-way. Must be approved by the City of Portland Bureau of Street and Structural Engineering.

2. Bicycle parking spaces located outside a structure must be placed no farther from the structure's main entrance than the closest off-street motor vehicle parking space.

3. Bicycle parking spaces located outside a structure must be visible from the sidewalk adjacent to the building's main entrance.

4. Bicycle parking racks or lockers must be anchored securely.

5. Bicycle racks must support the bicycle in the center of the frame and allow the frame and both wheels to be secured with a single cable or chain and padlock.

6. An aisle for bicycle manuevering must be provided and maintained beside or between each row of bicycle parking. This aisle must be at least five feet wide.

7. Each required bicycle parking space must be accessible without moving another bicycle.

8. Bicycle spaces required by this chapter may not be rented or leased except where required motor vehicle parking is rented or leased.

9. Areas set aside for required bicycle parking shall be clearly marked and reserved for bicycle parking only. (33.82.030)

These bicycle parking requirements will stay in effect until December 31, 1982. The City Planning Commission and Portland City Council will decide at that time whether to retain the requirements.

JS:mmc

Appendix F

Guidance On Transportation Use For Bicycle Project

U.S. Department of Transportation
Federal Highway Administration

Memorandum

Subject: Guidance on Transportation Use for Bicycle Projects

Date: May 21, 1984

From: Federal Highway Administrator

Reply to Attn of: HNG-22

To: Regional Federal Highway Administrators
Regions 1-10
Direct Federal Program Administrator

Section 126 of the Highway Improvement Act of 1982, which amended 23 U.S.C. Section 217, Bicycle Transportation and Pedestrian Walkways, requires that "no bicycle project shall be authorized by this section unless the Secretary shall have determined that such bicycle project will be principally for transportation, rather than recreation, purposes." The Final Rule (Federal Register, March 22, 1984) makes "principally for transportation use" an eligibility requirement. There have been a number of requests for clarification of this requirement. Therefore, in order to provide further clarification for planning and programming purposes to State agencies, we offer the following information on bicycle construction projects.

Where Federal-aid highway funds are used, bicycle construction projects must be integrated into the existing transportation system to provide for bicycle travel to and from specific trip generators (home, work, school, transit stops, shopping, etc.). To be principally for transportation use the project must provide for utilitarian trips by bicycle, i.e., trips for travel to work, to school, shopping, and other activity centers. A transportation-related bicycle facility will generally provide a means of encouraging use of bicycles as an alternative to travel in an automobile. A recreational trip on the other hand is considered to be travel for exercise or leisure, without a specific destination or utilitarian trip purpose. Such trips can only be made by bicycle and present no alternative to use by an automobile.

The nature and purpose of a bicycle project can best be determined on a case-by-case basis considering the location and proximate land uses. For all proposals, an assessment to ensure that specific trip generators are within a reasonable distance of the bicycle facility is appropriate. The Division Administrator is to determine if the proposed expenditure of funds is cost-effective and will serve the intent of the law.

R. A. Barnhart

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