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A Bikeway Criteria Digest

THE ABCD'S OF BIKEWAYS

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16. Abstract

The digest is an abstract of FHWA research documents as well as similar references on bikeway facility planning and design. It is intended for use by small government units with limited staff as well as State and Federal agencies with complex specialized staffs.

The digest is functionally organized into four major, topical steps; Planning, Location, Design and Operations. Those steps progress from the bikeway planning stage through implementation and post construction. Sufficient content is provided to enable a planner or designer to establish a bikeway facility wherever desired.

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A BIKEWAY CRITERIA DIGEST

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INTRODUCTION

Bikeway facility planning and design is an expanding Art. To improve this Art, FHWA in 1973 initiated a program of bikeway research resulting in the publication of two "User Manuals" which present extensive studies concerning bikeway planning, location, design and safety. These Manuals serve as a comprehensive reference for bikeway planners and designers. This publication is a "Digest" of these Manuals as well as similar references.

Practical criteria and conclusions were abstracted from the FHWA research documents for this handbook so a user may have, in condensed orderly format, access to current practices. Additional references along with the FHWA documents are listed in this publication under BIBLIOGRAPHY.

To provide utility to both small government units with limited staff as well as State and Federal agencies with complex specialized staffs, this Digest is functionally organized into four major, topical Steps: Planning, Location, Design and Operations. These Steps progress from the bikeway planning stage through implementation and post construction with sufficient content to enable a planner or designer to establish a bikeway facility wherever desired.

Planned and constructed bikeways are not always the solution to bicyclist's needs or desires; sometimes, a bikeway has an adverse impact on bicycle usage and the solution to problems or needs could have been resolved through legislation, law enforcement or perhaps no action at all. This criteria digest first tells you whether a facility is needed; then, if a bikeway is the answer, it tells how to implement one.

GLOSSARY

Each authority involved with the contemporary development of bikeways has also developed their own terminology for the transfer of their information to others. Consequently, misunderstanding is created whenever one source of information is compared to other sources. To reduce repetitive explanation of frequently used words and terms while at the same time insuring singular understanding of them, the following definitions are listed.

AASHTO - American Association of State Highway and Transportation Officials and including their publications.

ACTIVITY CENTER - A public or private facility which acts as a trip generator for bicycle transportation.

AMENITY FACTOR - Any design feature of a bicycle facility over and above what is deemed a basically safe design which induces usership. Examples: weather protected parking and scenic overlooks.

BICYCLE - A vehicle propelled exclusively by human power, having two wheels in tandum or two rear wheels and a front wheel.

BICYCLE FACILITY - Any and all devices, travelways, shelters or any other construction designated for bicycling use.

BIKEWAY - Any trail, path, part of a highway or shoulder, sidewalk, or any other travelway specifically signed and/or marked for bicycle travel.

BIKEWAY, Class I - A bikeway completely separated from vehicular traffic and within an independent right-of-way or the right-of-way of another facility. In this Digest, travelways separated from vehicles but shared by both bicycles and pedestrians are included in this classification.

BIKEWAY, Class II - Any bikeway which is part of the roadway or shoulder and delineated by pavement marking or barriers such as extruded curb or parking bumper blocks. Vehicle parking, crossing or turning movements may be permitted within the bikeway.

BIKEWAY, Class III - Any bikeway sharing its traffic right-of-way with motor vehicles and is designated by signing only.

BIKEWAY POTENTIAL - Projection of future use on a planned or existing facility and premised on relative data.

CAPACITY - Maximum number of bicycles which has a reasonable expectation of passing through a given bikeway section during a given time period under existing facility conditions.

CLEARANCE, Lateral - Width required for safe passage of a bicycle as measured in a horizontal plane.

CLEARANCE, Vertical - Height necessary for the safe passage of a bicycle as measured in a vertical plane.

CLIMATOLOGICAL ELEMENTS - Weather as it affects bicycling in either a positive or negative manner. This includes temperature, precipitation and wind.

CONE OF VISION - The area of roadway and roadside visible to a cyclist when riding seated, with hands on handlebars and eyes in the direction of travel.

CONTROLLED ACCESS HIGHWAY - A vehicular travelway on which ingress and egress locations are predetermined by public authority usually in the form of a grade separation or interchange. Direct residential or commercial access to the highway is prohibited.

CROSS SECTION - Diagramatic presentation of the right-of-way profile which is at right angles to the centerline at a given location.

DESIGN SPEED - A speed determined for design and correlation of the physical features of a bikeway that influence bicycle operation. It is the maximum safe speed that can be maintained over a specified section of bikeway when conditions are so favorable that design features of the bikeway govern.

DETERMINANTS - Data and facts which govern the location and design of a bikeway.

EMPLOYMENT HUB - A high density area of business and/or commercial establishments.

ENGINEERING STUDY - The process of gathering, compiling and studying relative information for the purpose of producing a conclusion concerning a given problem. Likewise applies to Planning Study, Location Study etc.

GEOMETRICS - As related to bikeways, it is the proportional measurement of materials and land use which comprises the physical design of the facility.

GRADE SEPARATION - Vertical isolation of travelways through use of a structure so that traffic crosses without interference.

INTERMODAL TRANSFER POINT - Any location at which a person or persons changes from one transportation mode to another.

LEGEND - Words, phrases or numbers appearing on all or part of a traffic control device.

LEVEL OF SERVICE - In bikeway operation, this is a qualitative measure indicating the effect of factors such as speed, travel time, safety, travel interruptions and maneuverability.

Level of Service, A - Free flow of bicycle traffic with low volumes with free choice of velocity and lateral position. Average velocity 12 m.p.h. (19.31 km/h).

Level of Service, B - Stable bicycle flow with significant volumes and slight slowing of velocity. Average velocity 10 m.p.h. (16.09 km/h).

Level of Service, C - Bicycle flow and speed as well as maneuverability is restricted. Average velocity 8 m.p.h. (12.87 km/h).

LOCATIONAL CRITERIA - Relative predetermined standards selected for use in selecting and weighting bikeway corridors.

LONGITUDINAL PATTERNS - Stripes or markings placed parallel to the flow of traffic.

METRIC SYSTEM - An international language of measurement. This measurement standardization is called "The International System of Units" (abbreviated SI). English - Metric Conversion units used in this Digest are:

LENGTH

English Units	Metric Equivalent
1 mile = 5280 feet	1.6093 kilometers (km)
1 yard = 3 feet = 36 inches	0.9144 meters (m)
1 foot = 12 inches	30.43 centimeters (cm)
1 inch	2.54 centimeters (cm)

VELOCITY

1 mile per hour	1.6093 kilometers per hour (km/h)

MINIMUM ENERGY PATH - The route between two given points requiring the least amount of energy for a cyclist to traverse.

MODEL - Traffic Patterns created through mathematical procedures using socio-economic, lane use and transportation parameters for producing simulated relationships.

MOPED - A vehicle capable of being proprelled by human power as well as a limited capacity motor inclusive of tandem two wheeled vehicles and those in one front and two rear wheeled configuration. Mopeds are also called "Motor-Assist Bicycles."

MUTCD - Abbreviation for Manual on Uniform Traffic Control Devices approved by the Federal Highway Administration as a national standard for placement and selection of all traffic control devices on or adjacent to all highways open to public travel in accordance with Title 23, U.S. Code, Sections 109-b, 109-d and 402-a.

NON-REPRESENTATIVE SAMPLING - Any data collection involving requested information from the public which due to respondee selection gathers data that does not reflect the attitudes or needs of the specific purpose for the sampling.

NORMAL HIGHWAY PRACTICE - Procedural treatment of a situation considered acceptable or standardized by AASHTO.

ORIGIN - DESTINATION STUDY, O & D Study - To determine bikeway needs, a survey of facility users is made to determine trip frequency and termini.

PARAMETERS - Set of physical components whose values determine the characteristics or behavior of a system.

PAVEMENT MARKING - Painted or applied line(s) or legend placed on any bikeway surface for regulating, guiding or warning traffic.

PEDESTRIAN - A person whose mode of transportation is on foot. Within this Digest a person "walking" a bicycle becomes a pedestrian.

PLANNING AREA - A geographic district or region under common jurisdiction selected for planning objectives.

PLANNING SUB-AREA - The smallest geographic unit for which trip behavior is calculated and analyzed in transportation studies. Generally this is part of a collection which provides conclusions for a planning area.

RECREATIONAL CYCLIST - An individual(s) who uses a bicycle for the trip itself. Ultimate destination is of secondary importance.

RIGHT-OF-WAY - A term denoting land, property, or interest therein, usually in a strip, publically acquired for or devoted to transportation purposes.

RULES OF THE ROAD - That portion of a motor vehicle law which contains regulations governing the operation of vehicular and pedestrian traffic.

SHY DISTANCE - The distance between the bikeway's edge and any fixed object capable of injuring a cyclist using the facility.

SIDEWALK BIKEWAY - Any sidewalk signed and/or striped to permit cyclists to share the travel right-of-way with pedestrians.

SIGHT DISTANCE - A measurement of the cyclist's visibility, unobstructed by traffic, along the normal travel path to the furthest point of the roadway surface.

SLURRY SEAL - A thin asphalt emulsion overlay applied over a stabilized base or shoulder which is in good condition to provide a smooth surface for bicycle traffic.

STABILIZED SHOULDER - The portion of roadway contiguous to the travelway is the shoulder which is provided for parked vehicles, emergency use and bikeways. When its subgrade is compacted and the surface given a light bituminous treatment, the shoulder is "stabilized".

STOPPING SIGHT DISTANCE - Is the total distance traveled from the instant a bicycle operator sights an object to the time the vehicle comes to rest. Perception plus reaction and braking distance equals stopping sight distance.

SUPERELEVATION - Raised outside edge of a roadway curve for the purpose of overcoming the force causing a vehicle to skid when maintaining speed. Often this is called a "banked curve."

TERMINUS - One end of the travelway. A trip's beginning or its end location is known as a terminus.

TRAFFIC CONTROL DEVICES - Signs, signals or other fixtures, whether permanent or temporary, placed on or adjacent to a travelway by authority of a public body having jurisdiction to regulate, warn or guide traffic.

TRAFFIC FLOW PATTERNS - Graphic presentation of vehicular and/or pedestrian movement at a given time on given streets.

TRANSPORTATION CORRIDOR - A strip of land between two termini within which traffic, topography, environment and other characteristics are evaluated for transportation purposes.

TRANSVERSE PATTERNS - Pavement markings perpendicular to, or at an angle to, the flow of traffic, such as stop bars, crossover stripes and median delineations.

TRAVEL GENERATORS - Particular areas or locations that offer trip destination points to the utilitarian cyclist: For example libraries, schools, recreation areas and work centers.

TRAVELWAY - Any way, path, road or other travel facility used by any and all forms of transportation.

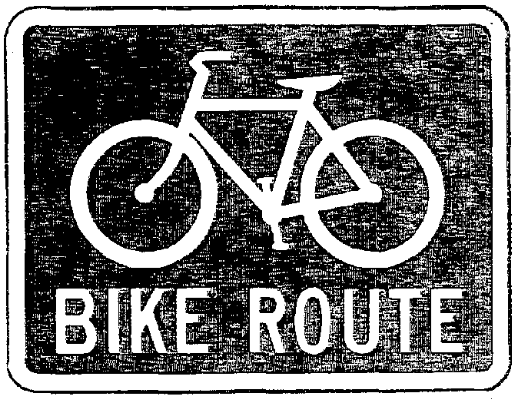
TRIBUTARY AREAS - Geographic locations that act as feeders to major transportation corridors.

UNIFORM VEHICLE CODE - Model ordinances specifically designed to provide the content and language of legislation needed to give uniformity to the "rules of the road" and traffic control devices.

UTILITARIAN CYCLIST - An individual who uses a bicycle primarily to reach a particular destination.

VOLUME - The given number of vehicles that pass a given point for a given amount of time (hour, day, year).

WARRANT - A minimum requirement for justifying the authorization of a traffic control device: For example - traffic volumes, accident statistics and existing design.


BIKE ROUTE

STEP 'A' PLANNING

"BEFORE A FACILITY IS BUILT"

overview

So you want to build a bikeway? or perhaps a network of bikeways? This may be the first time you have initiated a bikeway project and you want the facility to be a public benefit rather than an unused liability. The selected criteria herein can reduce the risk of developing an undesirable facility.

Even as an idea, a bikeway is "planned" to some extent. However, the chances of a successful project are increased in proportion to the application of criteria presented in this Step of the Digest. A planning process replaces "guesswork" with decisions based on studied data and conclusions.

A•1 PLANNING PROCESS

An understanding of the cyclist types, their behavior and needs is fundamental to the planning, location, design and operation of bikeway facilities.

All cycling activity falls into two major categories: recreational and utilitarian. Persons engaged in either of these two types have different goals and objectives; as a result, many elements of bikeway planning and design must respond to different needs within each category.

For recreational cyclists, i.e. tourists, physical fitness and pleasure riders, the trip itself is the objective. Scenic routes with meanders, overlooks, points of interest and even hills to add challenge are desirable features of the recreational facility. For the utilitarian cyclist, the objective is not the trip, but reaching a specific destination such as employment, school, home, store or community activity center. The bicycle is merely a vehicle for making the trip although secondary objectives such as exercise and pleasure may influence the choice of vehicle. The utilitarian cyclist, while appreciating scenic routes where they coincide with specific travel lines, places highest priorities on directness of routes, acceptable grade profiles and minimized delay or inconvenience.

Comprehensive systematic planning is necessary to insure that a useful bikeway is provided for the public. To do this, the following five questions must be addressed:

- What is needed now and in the future?
- Where should the bikeway be located?
- When should the bikeway be built?
- Who should build them?
- How should they be financed?

When determining the answers to these questions, active citizen and community participation and review is strongly recommended. Without this involvement an otherwise well planned facility can fail to obtain political and public support.

A•2 IDENTIFY PROBLEMS

Problems to be considered are varied such as a high rate of bicycle accidents, traffic congestion that might be eased through bicycle use or perhaps public demand for outdoor recreation opportunities. Very likely several problems will be identified.

An important point is that the problem should be defined without reference to any particular solution. For example, a high accident rate should not be immediately interpreted as a need for a bikeway, but rather explicitly as an accident problem. This prevents a hasty narrowing of the scope of concern which may result in overlooking better solutions.

Once the problem is defined, the proper tone is set for identification of the cause. Who is involved? Where? When?

A.3 DETERMINE OBJECTIVE

Objective determination is an important step in problem solution. Specifically the objective should define and describe the future condition which is to be reached. Sometimes the identification of problems and their cause will clearly show that a physical facility is needed; in other instances, it may be necessary to conduct a brief study to answer the question - "Can anything other than a physical facility better solve the problem?" If other candidate solutions are generated, such as street or highway usage, they can be carried through the planning process as alternatives.

A statement of the objective can then be prepared in detail. This statement should present what constitutes a solved problem, i.e. reduction in accidents or perhaps a safe route to school. Now the solution or alternative solutions can be fully developed.

A.4 TRANSPORTATION PLAN

Responsibility for planning and locating most bikeway facilities should be that of local government units since a substantial portion of bicycle travel is for trips entirely within an urbanized area. However, where long or statewide bicycle routes are contemplated, their planning and location should properly be coordinated by the state with appropriate agencies and organizations, as well as transportation and outdoor recreation master plans. Agencies such as forests and parks, planning, public services or recreation and civic organizations will offer recommendations, determine limitations and identify responsibility.

A.5 BIKEWAY USE POTENTIAL

Initially, existing bikeways and active cyclists should be surveyed prior to planning a new facility. Potential facility use can be estimated from related records such as accident, traffic, bicycle sales, and mandatory bicycle registration when available. The accuracy of the evaluation will be directly proportionate to the comprehensiveness of this survey.

A•5•1 EXISTING BIKEWAYS

Inventories of existing bikeways listing each by classification and level of service is fundamental in determining bikeway potential. Additional helpful inventory data is the inclusion of why the bikeway was built? Who constructed it and at what cost?

Bicycle traffic counts can be taken electronically or manually. Systematic counting procedures on an entire bikeway network can be initially taken and analyzed. Later, bicycle volumes for the network can be projected by taking new counts at a limited number of indicator stations.

Network bicycle counts and projections are reasonably accurate only if the usage remains relatively static. Should a new generator or a new facility be added, the entire model must be recalibrated.

Bicycle counts have inherent shortcomings. These counts reveal little about where cyclists are coming from or going to and what the trip purpose is. Origin and destination surveys will supplement the counts with this additional data but the usefulness of the data will depend on both the survey frequency and the spacing of check points.

Bicycle accident records are available from highway or law enforcement agencies and not only show location of vehicle conflict but indirectly reflect cycling activity and other safety considerations. Cyclists avoid areas that are hazardous; therefore, consideration should be given to accident locations that could have bicycle travel if the hazard is removed.

Cyclists tend to have as origin and destination many of the activity centers that motor vehicles have. Utility oriented bicycle traffic, similar to motor vehicle traffic, tends to concentrate on the most direct and fastest routes. Because of this tendency, available vehicle traffic count and flow maps will index cycling potential.

Identification of travel generators is a helpful tool in projecting potential bikeway use. Obvious generators would be schools, shopping areas, parks and recreation areas, transportation terminals, employment hubs and activity centers.

A•5•2 MISCELLANEOUS DETERMINANTS

Other factors which may show bikeway use potential can be applied to facility planning. Adjacent land use influences cycling by either attracting or discouraging bicycle travel. As illustration, densely developed commercial areas deter recreational cyclists while woodland and cultivated roadsides are attractive to users. Bicycle ownership, public attitudes, incentives such as air pollution, energy shortage, economics and available modal transfer areas with bicycle storage facilities are determinants in a bikeway feasibility study.

A•5•3 COMMUNITY INVOLVEMENT

Travel patterns and potential usage can be estimated by asking the people who will be involved. This may be done through formal survey methods or through public and private meetings. Schools, youth organizations, P.T.A., civic groups, cycling clubs, and government agencies are examples of sources from which comments can be elicited and participation in bikeway planning invited.

Public participation can be time consuming and costly so this should be considered in designing a citizen involvement process. Nonetheless, this method is a powerful one which has the benefits of enhancing study credibility and soliciting early public support.

Two precautions should be applied to any public involvement process: Non-representative sampling of the public and overestimating the use of a facility.

Often there is a vast gap between what people say they would like to do (or would do) under certain conditions and what they actually do when those conditions are met. This is particularly true with a popular subject such as bicycling. As a result, people are quite likely to overstate their intended usage of specific facilities.

Capabilities, attitudes and needs of skilled and experienced cyclists (a relatively limited group) differ greatly from those of casual and potential bicyclists. Provisions which seem nonessential to experienced cyclists may be very significant in motivating other types, and vice versa. Thus caution must be used when interpreting citizen participation to avoid biases.

A•6 ESTIMATING BIKEWAY USE

In estimating potential activity on a selected bikeway, a cyclist's need can be evaluated using most or all of the following considerations: Trip length, Trip purpose, Work trips, School trips, Shopping trips, Recreation trips, Climate, Age, Bicycle ownership and Occupation/status.

A•6•1 TRIP LENGTH

Whatever the purpose of a bicycle trip, utilitarian or recreational, there is a "cut-off" distance beyond which only a small percent of the cyclists continue. This distance is generally 3 to 6 miles (4.83 km. to 9.66 km.). Inclusive of other factors, this value can be applied to defining a potential service area of a generator or activity center. Figure A-1, page 7, presents time/distance comparisons with other transportation modes and can be applicable to trip length estimating.

Network bikeway planning essentially connects service areas and is not restricted by reasonable distances between such areas. The "cut-off" distance as described above, will not apply because cyclists' trips on a network overlap throughout the length of the bikeway depending on trip purpose and generators.

A•6•2 TRIP PURPOSE

Utilitarian and recreational cyclists have a purpose for using a bikeway facility. In estimating potential activity both the purpose and trip frequency must be projected.

Employment, school, store, business center or even a newspaper route are the objectives of the utilitarian cyclists. Recreation cyclists tend to use bikeways for touring, exercise, social purposes or as a sport.

Utilitarian trips generally have a greater frequency rate than the recreational, although in planned communities the reverse may be true. Some utilitarian trips may also have a recreational purpose as well, such as cycling to employment for exercise.

A•6•3 WORK TRIPS

Work trips are utilitarian and are very sensitive to travel time. Consideration of trip length and relative travel time is a prime factor in identifying trips which could be served by bikeways.

As indicated on Figure A-1, page 7, bikeways of 5 to 6 miles (8.05 km. to 9.66 km.) in areas of intense urban activity are competitive with motor vehicles in travel time. Work trips to suburban employment centers within 3 to 4 miles (4.83 km. to 6.43 km.) are also potential candidates for cycling. Note that in large urban areas many work trips will be longer than the limits presented here.

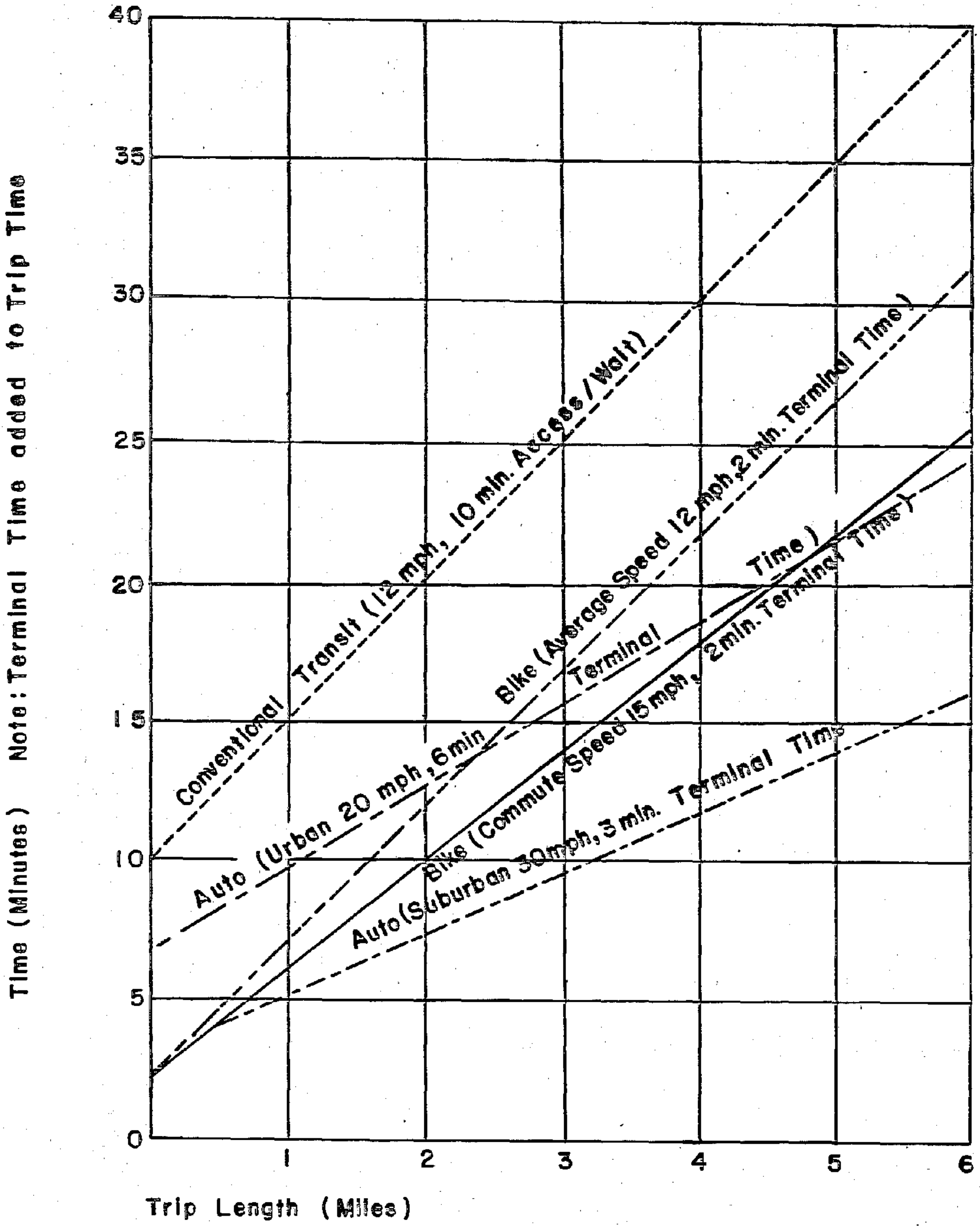


Figure A 1 Travel Time Comparisons

Listed are factors which affect the choice of an individual whose work trip falls within reasonable time/distance range of bike travel:

- Motor vehicle needed/not needed during the day.
- Opportunity to change clothes or shower before work.
- Employment related attire requirements.
- Tiring physical labor involved/not involved at employment.
- Bikeway topography.
- Safety from traffic, harassment, theft et cetera.
- Employment related status concerns.
- Climatic conditions.
- Use of mopeds where lawful.
- Cost differential between available modes.*

*(Figure A-2, page 9)

A•6•4 SCHOOL TRIPS

School trips are utilitarian and have the most probability of being served by bicycle travel. Many school trips are within easy bicycling range. In addition, students below mid-high school grades generally do not have the option to travel by motor vehicle. On college campuses the bicycle is a particularly attractive mode, not only because it eliminates the need to compete for scarce and expensive parking spaces, but also because it is useful for getting directly from one place to another on campus.

For elementary school children riding a bicycle to school is a positive status symbol. For college students it is at least neutral. Only among junior high and high school age groups is riding a bicycle for transportation perceived as a negative status symbol although this is diminishing. For all youth below driving age, the bike is a primary means of independent personal mobility.

Virtually all school trips can be regarded as potential candidates for bikeway travel although heavy traffic, busing, school policy and parental judgment may serve to reduce this potential. Schools of all levels have available information on enrollment districts and their student's residence. With this type of data, bikeway planning and usage estimating become more precise.

A•6•5 SHOPPING TRIPS

Shopping trips pose mixed potential for bikeway activity. A relatively few "convenience" type trips involving the purchase of a few small items are apt to be made by bicycle. Planning related to shopping trips should be limited to simply identifying locations of major

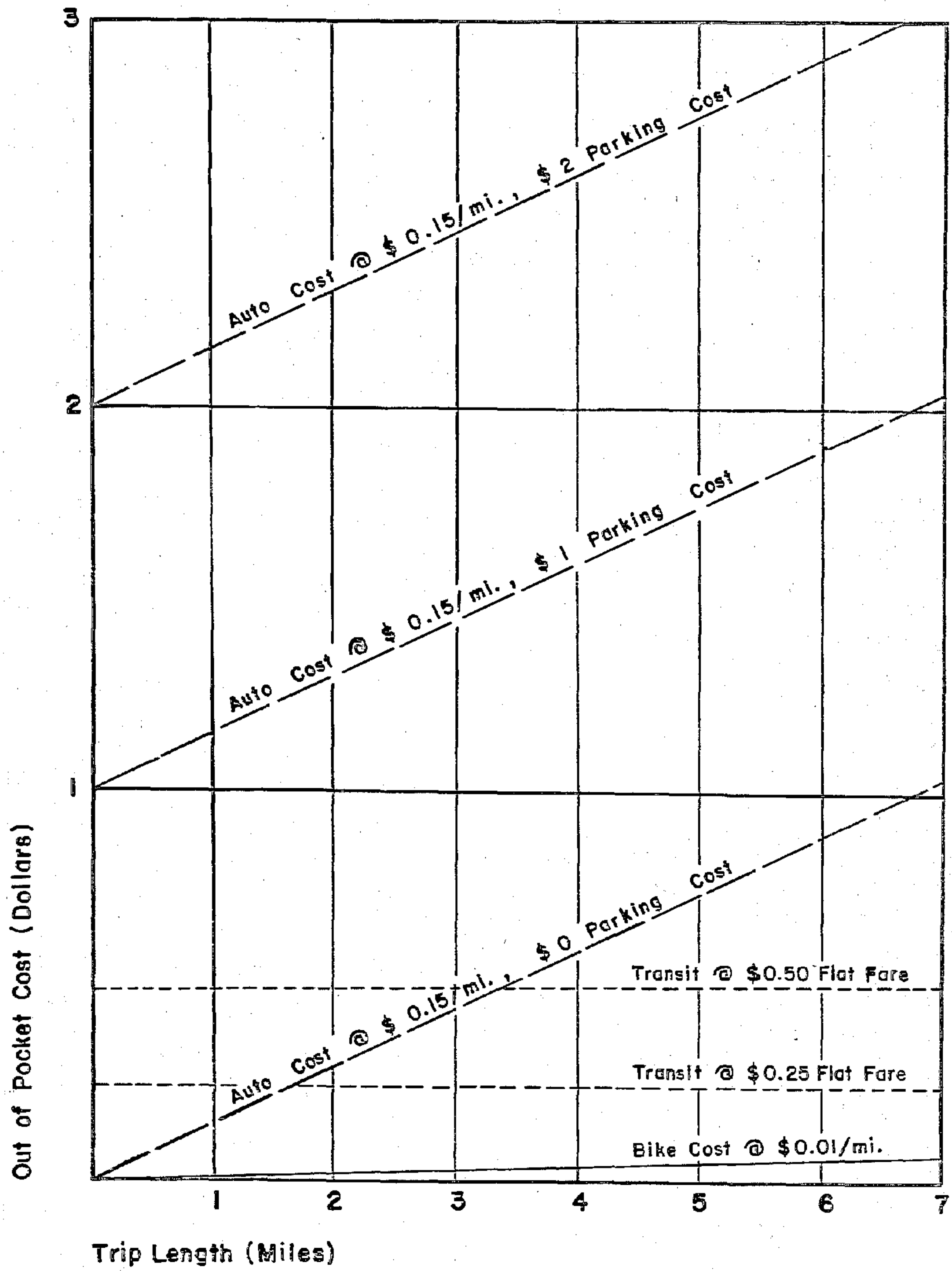


Figure A-2 Travel Cost Comparisons

shopping centers and when possible serve these locations on routes planned primarily for other trip purposes.

A•6•6 RECREATION

Bicycle transportation to recreation activity sites, neighborhood centers and regional recreational centers should be considered separately. Generally the type of bicyclist and the trip purpose is different from the utilitarian. Some grades or indirect routing will be accepted by cyclists using recreation centers whereas on trips to school or employment the rider is sensitive to any situation causing an expenditure of time or effort.

In the case of neighborhood centers, "tributary areas" to competing activity centers should be defined. Normally all trips within a center's tributary area will be within reasonable bicycling range. For each activity center, logical routes from subsegments of the tributary area are defined. Usage potential of any route is proportional to the number of households served, total activity at the recreation center and the character of the activities taking place at the center.

Trip length becomes a factor in planning bicycle travel to regional activity centers. Methods similar to those used to estimate bike trip potential for work trips should be used to estimate requirements for regional centers, Figure A-1, page 7.

A•6•7 CLIMATE

Extreme cold, rain or snow, extreme heat and significant prevailing wind are climatologic elements which directly affect cycling potential. These conditions singly or in combination can adversely affect bikeway activity.

Significantly cold areas with snow covered and icy pavements in winter causes bicycle activity to nearly cease during these periods. This occurs not only because it is unpleasant being exposed to these elements but also because icy pavements make control and balance on a bicycle extremely difficult. Often overlooked in estimating bikeway potential is if an activity is impossible or unattractive for a significant portion of the year then it will also affect utilitarian trips when bicycling is possible and attractive.

A•6•8 AGE

Age distribution of cyclists is in a state of flux with significant growth of the cycling population among adult categories.

Since there is a tendency to clustering by age among residence areas, it may be possible to utilize census data on resident age distribution to identify high potential and low potential generation areas. However, caution is recommended; some clustering may not be relevant. Factors which induce age clustering on an unusually large scale may also induce other changes in expected behavior. For instance; in an adult retirement community or enclave, site conditions and peer reinforcement may induce far more active bicycling by senior citizens than would be the case if the same individuals were dispersed in a normal residential mix. Thus age distribution must be tempered by knowledge of special area characteristics when determining its influence on bicycle potential.

A•6•9 BICYCLE OWNERSHIP

Ignoring the opportunities to rent a bicycle or borrow a bike from a friend, bicycle availability can be presumed to be equivalent to personal ownership of a bicycle or ownership in the household. In 1973, an estimated 37 percent of the United States' population owned bicycles. Considering sales in the intervening period, perhaps as much as 45 percent of the population owns bikes. Since many of these bicycles are available to household members other than their owners, a greater percentage of the population may be potential cyclists.

Lack of available data restricts criteria for comparison of ownership versus ridership, although there's a fairly parallel relationship. For this reason a reasonable growth method of estimating and planning for bikeway activity would be to determine bicycle ownership in various sub-areas of the community, thereafter focusing facilities planning efforts in sub-areas having high ownership levels and placing less emphasis on areas of low bicycle ownership.

Bicycle registration is a major index of bicycle ownership. Voluntary registration, mostly offered as a theft deterrent, reflects only a small percent of actual ownership because most cyclists do not take the time to file or their equipment is owned on a short-term basis. Registration under local law presents a more accurate record but should not be considered absolute. Through registration, geographic distribution of ownership may also be obtained enabling a planner to determine which areas have the largest number of cyclists.

Another source for the assessment of bicycle ownership is a survey of bicycle sales outlets. If a dealer recognizes the purpose and indirect benefit from an inquiry, this source will provide a meaningful response.

A•6•10 OCCUPATION/STATUS

Surveys concerning ownership, status and occupation of cyclists have generally produced inconclusive evidence except when related to work trips. A pattern did form showing bicycle ownership increasing in relation to income and education. The work-trip usage rate is predicated more upon age and employment/residence distance than upon employment category. The surveys did reflect that despite a high percent of bicycle ownership, persons in the Managerial-Business occupations rarely use their bicycles for work trips.

Because of survey findings, a planner should analyze employment centers for potential bikeway interest. Actual usage will be influenced by factors other than the number of persons employed within the center.

A•7 CORRIDOR IDENTIFICATION

Concurrent with determination of potential bikeway usage is the identification of travel corridors and any barriers to bicycle travel. Using a map of appropriate scale and detail, an overlay can be prepared which will facilitate the study of bikeway corridors, alternatives, user and generator linkages as well as other opportunities for bicycle travel.

A•7•1 CORRIDOR AND OBSTACLE STUDY

Screening of routes should identify reasonable candidates for a bicycle facility. On a map of the study area all corridors having continuity and providing important linkages should be "flagged" with notations concerning problems or benefits.

In addition to the corridors flagged, other opportunities for bicycle travel should be identified on the overlay. Some examples of these include - greenbelts, parks, utility rights-of-way, drainage rights-of-way, stream courses, railroad rights-of-way, canal tow paths, freeway rights-of-way and beach fronts.

Bikeway obstacles can be separated into two general types. One type is the absolute barrier to bike travel such as elevated embankments, streams, freeways or large bodies of water. The other type is an impediment such as busy unsignalized intersections, extremely steep grades or incompatible lane use. These obstacles should be included in the overlay as well as any feasible method for breaching the obstacle.

A•7•2 IDENTIFY TRIP PRODUCERS

Bicycle travel generators as presented in Section A 5, page 3, should be identified on the corridor overlay.

A•7•3 IDENTIFY "HIGH-POTENTIAL" CORRIDORS

Having plotted corridor and obstacle studies, patterns of travel potential can now be effectively screened over identified corridor opportunities. Corridors constituting special recreational facilities should be included. The result of this process is the confirmation of corridors that coincide with estimated demand.

Whenever the corridor conflicts with bicycling obstacles then alternate corridors or impediment penetration schemes should be studied.

A•8 PLANNING AREAS

If a master plan of an area is available then appropriately subdividing the area into "subareas" is recommended for the following reasons:

- Planning will then be scaled down so that it relates more directly to individual cyclists and invites participation in decision making.
- Factors which will contribute to success or failure within the system are exposed.
- Smaller planning areas consolidate similar goals and opinions more accurately than larger areas.

- Bikeway implementation can be initiated earlier on a subarea plan basis. The lesser plan demonstrates positive intent while opening the door for measuring effectiveness, public attitude and usage parameters.

A.8.1 SUBAREA PLANS

Major factors that should be considered in establishing and utilizing study subareas are: Size, boundary requirements and local vs. areawide conflicts.

Three considerations influencing the ultimate size of the subarea are: The size of the total area, the intensity of the activity within the total area and existing bikeway barrier conditions. Generally the subarea is about 2 miles (3.22 km.) square.

Planning units which have physical barriers tend to delineate subarea limits. Bodies of water, freeways and similar obstacles form boundaries helpful in designing subareas. These subareas are frequently within boundaries of larger areas such as census tracts, regional divisions or county lines which may or may not have physical definition of their limits.

Potential conflicts between localized and areawide objectives are inherent whether the planning is done on an areawide basis or by use of study subareas. Subarea planning merely brings these conflicts into the open.

In optimizing internal bikeway systems within subareas, a danger exists that the areawide system might lack cohesiveness. This can be minimized by:

- Drawing subarea boundaries along barriers having limited points of penetration, so that the subareas are relatively independent of each other.

- Identifying routes of areawide significance during establishment of study subareas.

- Being continually conscious of the total planning concept while dealing with localized issues.

When a clear conflict is posed between local and areawide systems each case must be considered individually in accordance with overall objectives. For example, if the overriding objectives is safety of young cyclists, an option which favors local area riders may be elected, whereas if the program objective is to encourage bicycling as an alternative to automobile use, an option which optimizes the areawide system may be well justified.

STEP 'B' LOCATION

"WHERE A FACILITY IS BUILT"

overview

Through an orderly process you have decided that a bikeway, or perhaps a bikeway network, is needed. But where shall we locate the facility? What guidelines or criteria can be used? Where will the funds come from?

This Step presents guidelines whereby criteria may be applied to bikeway corridor alternatives. No manual can answer all your questions; engineering judgment and knowledge of the environment involved must be applied to these recommendations.

Funding, in addition to your own resources, may be obtained from the Federal Highway Administration and other Federal or State agencies. STEP B will present some information which will direct you to where possible financial assistance can be requested.

B•1 CORRIDOR STUDIES

STEP A showed how to determine bicycle usage and how to identify corridors; when a bikeway need is demonstrated through planning, the next step is to "locate" the bikeway, determine its estimated cost and to fund implementation. An initial assessment should be the first action in a corridor study. The planner will then be familiar with the site's interrelation of obstacles, land uses, use conflicts and social conflicts. Subsequent to this assessment a roughly drafted corridor treatment and cost estimate can be prepared.

B•1•1 FIELD RECONNAISSANCE

Field review provides an on-site familiarity with the study areas. This review defines barriers and obstacles while producing insights into possible design solutions. If right-of-way acquisition is required, contact jurisdictions responsible for the study area to determine feasibility of possible corridor and design considerations.

B•1•2 USE CONFLICTS

Although resolution of use conflict cannot be determined during the initial corridor field assessment, the existing and potential conflict can be identified. An example of use conflict would be the need to convert a parking lane or a traveled lane to bicycle use.

When a conflict appears, a planner or engineer must ultimately decide if it merits further study. Can an alternative be developed that will fulfill the need and how important is the facility to the highway system?

B•1•3 SOCIAL CONFLICTS

During the field reconnaissance, social conflicts must be recognized for subsequent corridor evaluation. Social conflict can be as great a bikeway barrier as a physical barrier. Examples of social conflict are neighborhood impact, residential security, ethnic discord or a change in life style. Section B•5 developes applicable criteria concerning the social facets of bikeway location.

B.2 ENVIRONMENTAL IMPACT

Local, State and Federal laws require environmental assessment of public works and bikeways are no exception. Whatever environmental review may be required, the necessary documentation should be prepared as soon as the bikeway need is established and corridors selected.

Due to the dimensions of a bikeway and the fact that a cyclist is the principal user, bikeways do not have long term significant environmental impact unless right-of-way must be acquired or public lands are being used. Even when a public park is being utilized, a statement from the park authority concurring in the action may be the only environmental review required.

B.3 LOCATION CRITERIA

Location criteria are not absolutes; they vary in type and importance for each project. Sometimes the criteria are contradictory, i.e. direct service vs. direct route, cost vs. safety. Nonetheless evaluation of criteria is a tool whereby the most feasible bikeway corridor and design is proposed.

B.3.1 POTENTIAL USE

STEP A presented methods of identifying corridors on the basis of need and potential use. Location engineers should reevaluate this data to insure that the need and use still exist.

Existing methods of estimating bikeway usage are imprecise and therefore, are better used for corridor comparisons than for prediction of future use. It is possible to project useful estimates providing the inherent accuracy limitations are understood.

Criterion which cite bicycles per day as a minimum standard usurps a community's right to define its own needs. The correct minimum level of usage should be whatever the community believes is appropriate, given both its needs and constraints. If a location has little existing usage, the conclusion should not only be that demand is lacking but that some impediment may exist that discourages usage.

B•3•2 BASIC WIDTH

Basic width is the fundamental physical requirement of a bikeway. If a location cannot provide 4' (1.22 m.) of operating width, it should not be considered as a potential location for bicycle travel. If a location requires street widening, removal of parking, or reduction in motor vehicle lanes, these should be appropriately reflected in the rating for this category along with cost and competing use considerations.

B•3•3 CONNECTIVITY

Continuity, directness and destination service are the major elements of connectivity.

Cyclists wish continuous service and guidance wherever they travel. They seek logical connection to other reasonable facilities or routes, and must not be led into, and abandoned within, hazardous situations.

Observations have shown that cyclists tend to have a very strong desire to maintain the forward momentum their efforts have created. They also naturally desire to minimize their own delay and usually are more comfortable on the move. Hence a facility with numerous full stops or abrupt turns is likely to be unacceptable. However, in most locations design treatments can be used to maximize the cyclists' ability to maintain momentum. Only where such treatments are infeasible does an alternate route become important.

Directness indicates the degree to which out-of-direction travel is minimized. It is relatively unimportant to the recreatonal bicyclist, but of great importance to the utilitarian user. For the utilitarian cyclist, connectivity is desired along the lines which define the minimum distance or "minimum energy" path from origin to destination; little deviation is tolerated.

The recreational cyclist is more willing to accept deviations from the minimum distance/minimum energy path to avoid unpleasant environmental conditions or hazardous situations so long as the deviations are not out of scale with trip length and perceived severity of the condition avoided. Thus, "direct connectivity" may be said to be the criterion applicable to utilitarian cyclists while a less demanding "linkage continuity" may be acceptable on facilities intended primarily for recreational cyclists.

Research has shown that for both short and long utilitarian trips, little out-of-direction travel is tolerated. For trips of up to .5 mi. (.80 km.), cyclists may object to diversions as short as one block;

however, for trips in the 1 to 2 mile (1.61 km. to 3.22 km.) range, this much diversion will generally be acceptable. Cyclists on longer utilitarian trips will generally not perceive a nearby diversionary route to be beneficial if its extra length is significant.

Closely related to continuity is destination service. The ability to get from one human activity point to another is essential to the fulfillment of the purpose of a utilitarian bicycle trip. If bicycle facilities are to serve such trips, they cannot simply be placed where it is easy to provide bicycle facilities; they must be located to provide convenient, direct access to centers of activity.

B•3•4 SAFETY EVALUATION

When a bicycle safety program is the stimulus for planning of bicycle facilities, then it should be premised on area-wide bicycle accident surveys. Mainly, it is the community's responsiblity to define an "acceptable" safety level for an existing or proposed facility; no single safety measure can be given.

Since no single measure of safety can be defined, two evaluation procedures are suggested for safety input for the location process:

- An area-wide accident survey should be undertaken to identify existing problem locations. Any bicycle facility that can solve an existing problem should be rated accordingly.

- Each route should be evaluated on the basis of potential motor vehicle-bicycle conflict.

Safety evaluation is really a study of existing or potential conflicts. Often the existence of a large volume of cars adjacent to a bicycle facility is taken to be an inherently unsafe situation. This is generally not true. High traffic volume is a hazard only if there is close and continual conflict between vehicles and bicycles.

Potential conflicts can best be categorized into four conditions: Parallel, right-turning, left-turning and crossing conflicts. Each of these conflicts should be evaluated separately and combined for a final safety ranking. Following is a discussion of each type.

- Parallel conflicts are caused by two conditions: close proximity of auto and bike travel, and speed differential between the two. Bicycles and motor vehicles can successfully mix in the traffic stream if speeds of the two types of vehicles are compatible. Although racing cyclists on downgrades can reach speeds approaching 50 m.p.h. (80.47 km/h), the distribution of cyclist speeds on level terrain and in negligible wind conditions are generally lower than motor vehicles sharing the facility.

- The hazards inherent in the conflicts between bicyclists and right-turning traffic are primarily caused by the geometric design of the intersection or driveway involved. An unchannelized intersection presents relatively minor problems for cyclists; a double-right turn lane presents unacceptable hazards. In rating alternatives for this condition, it is not necessary to evaluate all right turning possibilities along a route; only major volume locations and any intuitive problem areas should be investigated. When rating this type of conflict, consideration must be given to costs, if corrective measures are to be implemented.

- Left turning conflicts occur because a bicycle has low visibility and is often observed after initiation of the vehicle's turning movement. This is particularly true at high-volume intersections where bicycle visibility is further masked by vehicles. Thus left-turn conflicts are caused by the turning volume, its opposing through volume, merging traffic and the type of intersection control. Intersections with left-turn phase signalization present no hazards and should be highly rated. Signalized intersections without separate phasing should be rated on the basis of turning volume and opposing traffic, as should major unsignalized intersections and driveways on major streets. Other locations present minimal left-turn hazards.

- Signalized intersections are the most positive means of dealing with crossing traffic and should therefore be highly rated for safety. Any location which controls crossing vehicles by STOP or YIELD signs is also relatively safe. Locations where STOP or YIELD control confronts the cyclist's path are more hazardous, since this situation implies a higher level of motor vehicle cross traffic. The hazard at these locations is caused both by volume and the width of the cross street. They can best be evaluated by on-site observation in the spacing of crossing traffic at the times when bicycling is expected.

- Locations with insufficient gaps for safe crossing are unacceptable unless they are improved through signalization or by a grade separation. A cyclist should have five seconds plus crossing time at 7.35 feet per second (2.24 m. per second) during 75 percent of the peak two hours of bicycle usage for the existing crossing to be acceptable.

B•3•5 GRADES

Grades not only influence a cyclist's route selection, they also affect the operational safety such as the cyclist's maneuverability in the traffic stream. Cyclists may accept out-of-direction travel as well as less safe and attractive conditions to avoid excessively steep grades.

Some moderate grades can add interest and challenge for recreation bikeways. Figure C-7, STEP C, shows the relationship between grade and grade length. Design criteria for grade study is presented in STEP C, Section C•1. Class I Bikeways, Figure C-1, STEP C generally require design features such as grade adjustments.

Steep down-grades entering intersections require greater stopping sight distances and other safety design features to reduce vehicle-bicycle conflict. Whenever possible this conflict should be avoided.

B•3•6 SIGHT DISTANCE

All classes of bikeways should maintain adequate sight distance to insure safe and efficient operation. As shown in STEP C Section C•3, sight distance is dependent on design speed and profile gradient. Bikeways on or adjacent to roadways usually have adequate sight distances since motor vehicle speeds are equal or greater than bicycle speeds.

B•3•7 PAVEMENT QUALITY

Bicycles do not have the shock-absorbing capability of motor vehicles; this means that the quality of the surface will have a significant impact on usage of a facility particularly if there is a more satisfactory alternative. Ride quality as well as tire damage can be involved. High surface quality should be considered as an essential part of the bikeway design. However, if the desire of the community is to use only existing facilities with a minimum of capital improvement, surface quality of candidate routes should be rated.

STEP C, Figure C-13 shows pavement sections and Section C•9 explains when each section is used.

B•4 SECONDARY LOCATIONAL CRITERIA

Given the close interaction between the cyclist and the environment, the attractiveness of that environment should be evaluated. This quality has two imports: for the utilitarian cyclist and for the recreational cyclist. The utilitarian cyclist considers attractiveness nice so long as it coincides with the directness of the trip. In contrast, the recreational cyclist will tend to seek out attractive bikeways. Attractiveness primarily concerns view, sound and smell.

Elements related to attractiveness such as air quality, noise levels and truck traffic can be quantified. Elements that must be evaluated but cannot be quantified may include:

- Natural settings.
- Points of scenic architectural or historic interest.
- Points where interesting human activities may be observed.
- Points where diversion from cycling may be engaged in.
- Routes with horizontal curves and vertical undulations that break cycling monotony without significantly restraining speed.
- Convenient rest areas with shade,water and restroom facilities.

B•4•1 IMAGEABILITY

Appearance to the user as compared to what the facility actually is,describes this characteristic. While two routes may be rated equal, connecting a route that employs clearly defined major streets has this quality. Bikeway markers, destination signs and descriptive route maps improve the imageability of the route, which is a subjective criterion enhancing a bikeway rather than a standard.

B•4•2 AIR QUALITY

Air quality is a potentially important locational criterion since air pollution has serious implications for persons involved in physical exercise such as bike riding. Exercise increases lung intake of a pollutant by minimizing air flow through the nose and maximizing the air flow through the mouth.

Two criterical aspects of air pollution as a locational criterion for bicycle facilities are:

- Concentrations of various types of pollutants which could cause long or short term health effects as a result of exercise, and
- Length of exposure at which concentrations of pollutants would produce such health effects.

Air pollution rarely if ever consists of only one toxicant. Complex mixtures of pollutants are prevalent in the air over most urban centers. In assessing these diverse pollutants as locational criteria for bicycle facilities, it is important to consider how each type exists as a concentration in the atmosphere.

For instance, photochemical oxidant or smog exists as a dispersed area phenomenon. Hence, its presence in concentrations sufficient to pose short or long term health concerns to bicyclists is not meaningful as a criterion for selection of one route over another at a location within an established corridor. On the other hand, since gross concentrations of photochemical oxidant do vary between major subareas of a region, this variance of concentration might be used as a locational guideline for regional recreational bicycle facilities.

Other types of pollutants are typically found in limited site or line concentrations: carbon monoxide (CO) is a typical example. If such concentrations are at levels which could pose potential health effect problems for cyclists, their existence would constitute a reasonable criteria for selection of one route alternative over another. However, examination of available technical data indicates that in all but the most extraordinary conditions, the likely length of exposure of bicyclists to site concentrations of pollutants such as CO at typical ambient worst-case concentrations would not be a concern.

B•4•3 NOISE

Traffic noise, particularly that caused by trucks, is more an amenity factor than a safety criterion. Not until the V.P.H. (vehicles per hour) exceeds 5000 and the cyclists are exposed for a period of hours, does the decibels reach an intensity that merits concern for the health of the cyclists. The presence of heavy vehicles is definitely a negative factor in the acceptability of a Class II or III bikeway candidate; however, generally the volume of trucks or noise levels should not be regarded as an absolute negative criterion.

B•4•4 AERODYNAMIC IMPACT

Aside from the noise impact caused by heavy vehicles, a direct safety concern is the affect the aerodynamic force from these vehicles place on the cyclist. At certain speeds a truck can create enough aerodynamic force to spill a cyclist. Figure B-1, page 26, graphically shows the critical speeds and distances at which cyclists are endangered.

When vehicular speeds exceed the "tolerance limits" shown in Figure B-1, page 26, then a separation should be provided. If the force cannot be reduced, then another bikeway location should be studied regardless of the level of trucking activity.

B•5 GENERAL CRITERIA

Certain aspects of locating a bikeway relate to the non-user public rather than the quality of service to the cyclist. Hence these aspects become relevent locational criteria.

B•5•1 COSTS AND FUNDING

Estimated construction and operating costs as well as the source of funding (Section B•9) are determinants in deciding:

Whether a facility is built?
What facility is built?

Since estimated costs should not be the primary criteria for locating a bikeway, that data should not be available during initial evaluation of alternatives.

B•5•2 COMPETING USES

Conflicts arise when cyclists use a motor vehicle facility, when a bikeway penetrates certain neighborhoods and when more than one agency has authority concerning a bikeway right-of-way. These conflicts are described as follows:

- Aside from the safety concerns a shared bikeway presents social conflicts may also exist. The removal of a parking lane or a traveled lane may be technically feasible yet socially unacceptable because of the adverse affect on roadside business, the constraints on travel or loss of parking spaces. In these situations, the planner may choose to rely on elected officials for decision making after providing them with a studied evaluation of the alternatives.

- Conflict may occur whenever there is a clear difference in apparent lifestyle between the cyclists and the residents whose homes they pass. The conflict may be ethnic, it may be socio-economic, or it may be one of mores. If the planner is aware of this type of conflict, he should attempt to deal with it in the planning process through public participation rather than struggling with adverse reaction when his plans are made public.

- A type of competing use occurs when one agency has responsibility for bicycle planning and another (such as a water or utility district) has responsibility and control over a right-of-way ideal for biking but used for other purposes. Often these other agencies may have no interest in aiding bikeway development and may in fact have sound reasons, such as added maintenance and insurance costs, for opposing bicycle usage of the right-of-way.

- These situations can be compromised. The objective should be to maximize the public's benefit rather than that of the specific agency. In these cases, solutions should be investigated as with any other alternative. Any special costs associated with these facilities on the competing right-of-way should be reconciled.

B•5•3 SECURITY

Cyclists or residents may have real or imagined fear of crime generation with the implementation of a bikeway, as described:

- Bikeways are sometimes perceived as facilities which bring cyclists who are thought to be a threat to the security and safety of the neighborhood. In other cases, it is not the cyclists who are perceived

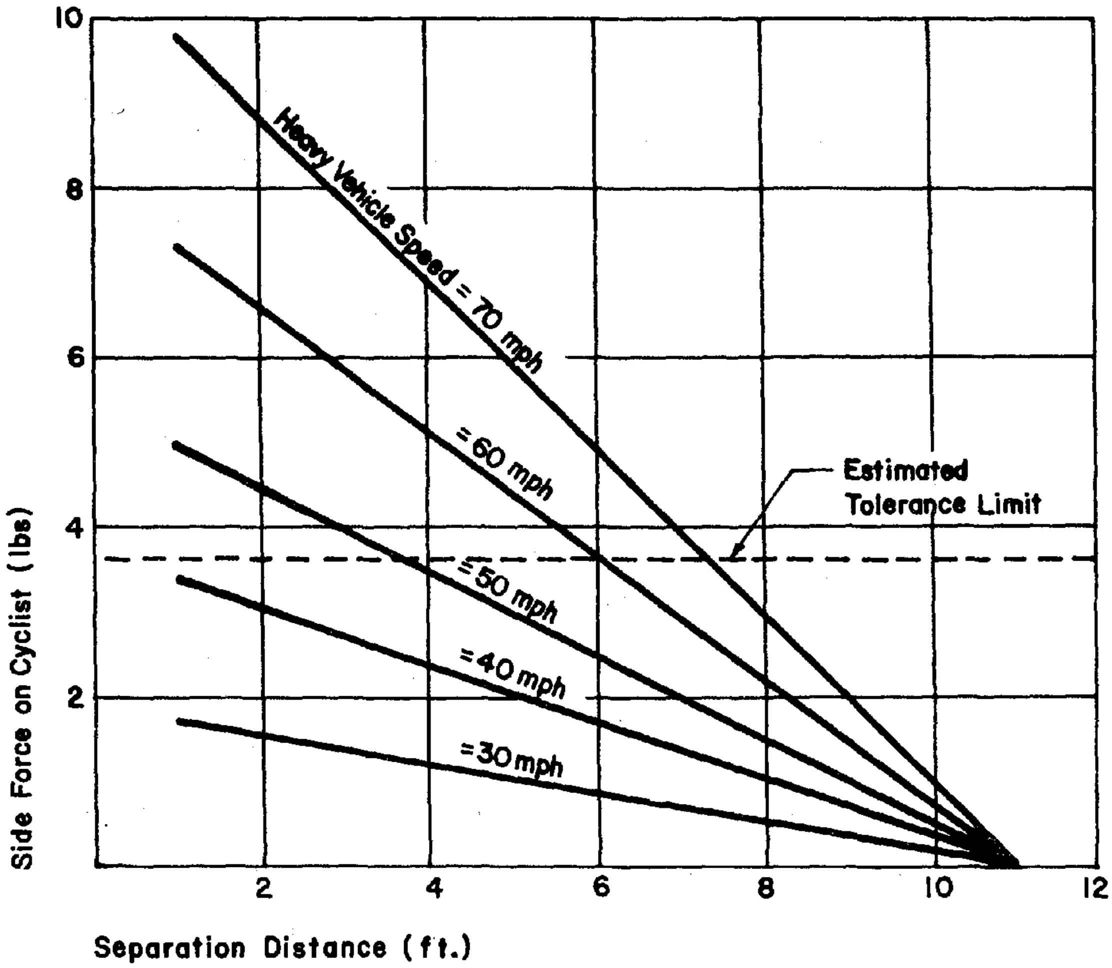


Figure B 1 Aerodynamic Forces on Cyclists as the threat, but other persons who might be able to use a secluded bikeway to gain surreptitious entry to homes and property.

- Bicyclists' concerns for security of their persons and property are genuine and well-founded. An obvious response to concern for property is provisions of effective bicycle parking facilities at bicycle trip activity generators. Unfortunately, all but the most elaborate and costly bicycle parking facilities are little more than theft-retardant and only minimally effective unless open to relatively continuous public view.

- Personal security of bicyclists is of greater concern. A number of locational and design considerations can help minimize this concern. Areas of high street crime can be readily identified from police records or may be identified from survey results. Where these areas interdict potential bike routes, routes should either be modified to skirt the area of concern or the facility should be located where it will be open to relatively continuous public view and ready scrutiny of enforcement officers. For instance, a bicycle path passing through a park area would preferably be located in an open meadow rather than a secluded wooded area. An overpass treatment open to view is preferable to an underpass treatment in shadow. When an underpass is necessary, its sight distance properties should allow cyclists to see, prior to entering, if anyone is loitering there.

- The possibility of street crime should not preclude building a bicycle facility, particularly when there appears to be real potential for use. But it is good reason to use prudent judgment in locating and designing the bicycle facility so as to minimize crime potential.

B.8 ROUTE EVALUATION

After applicable locational criteria have been utilized, then the gathered data can be evaluated for each route alternative. To evaluate the selected routes the process involves:

- Defining criteria to be used, and
- Measuring the acceptability of each route against each criterion.

B•6•1 COMPARING ALTERNATES

When comparing alternatives, first each should be ranked against the others, then ranked against selected criteria as presented and described in Section B 3 through B 5. The differing needs and priorities of communities make it impossible to provide a standard ranking procedure. This again must be done locally. Ranking should be consistent and as objective as possible, and should reflect local needs and values. But it need not be complex.

Sometimes, it may be convenient to assign numerical ratings (e.g., from one to five) to each alternative's performance on each criterion. This may be refined further through identification of the relative importance of each criterion under the circumstances, with weights applied to the ratings to reflect this. Ratings can then be summed across all criteria to yield a weighted average ranking of each alternative.

A formal composite ranking may not be required. In many cases the alternative facility locations will quickly reduce to one simply by elimination of all which fail on one or more important criteria.

The major purpose in this evaluation process is not elegance or rigor, but an appeal to common sense and judgment. Its essential inputs are not explicit rating schemes, but local needs and values.

B•6•2 COST ANALYSIS

Given a budget, a planner may have an option of creating fewer costly bikeways or a larger number of more economical facilities. In choosing between high and low cost options, a planner should confirm that this selection fulfills bicyclist's needs since an unused facility is very costly regardless of amount expended and reflects insufficient planning.

B•7 COMMUNITY INVOLVEMENT

A significant element of the bikeway planning process is to review the "Selected" system with the community. Ideally, community inputs and reactions should be received at all stages of the process; and, at a minimum, the final plan must be reviewed and endorsed by the citizenry. If the public does not endorse and actively support a bikeway plan, that plan is unlikely to be implemented. While more and more State and Federal monies are becoming available to local jurisdictions for planning and implementation of bicycle facilities, the total "external" funding available to local communities in relation to total implementation funding requirements for a bikeway plan is often relatively small.

Thus, funds for a bikeway implementation must in large measure be allocated from local sources. Bikeways must compete for funds with other local facilities and service needs such as schools, fire and police protection, parks, street maintenance, transit services, social services and the like. Without public endorsement of the plan and an active group of citizenry supporting it, meaningful allocations will never be made. To gain such endorsement, public participation throughout the planning process is essential. However, aside from ongoing citizen review and input, at the conclusion of the process there must be a significant event of public affirmation which lends a mandate and momentum to carry the plan through the final stage of funding and implementation, a process which may be more political than technical.

B.7.1 MEETINGS

Appointment of an official bikeway committee composed of appropriate citizens and staff is a productive method of creating a concerned group of diverse backgrounds and alliances to serve as the catalytic nucleus of action. This committee must be prepared to meet regularly, for bikeway review and comment. A committee's involvement can produce public support that would otherwise be opposed to bikeway proposals and cyclist's concerns.

Although a public hearing may not be required for a bikeway proposal, beneficial comments can be solicited from the community at large through a less formal meeting regarding alternatives and public concerns. This function also can alert elected officials to public support for proposed facilities.

B.8 CORRIDOR SELECTION

After the locational criteria has been applied to one or several alternatives, then each route is evaluated for specific weaknesses. A route may require a minor adjustment, or perhaps a major revision of a candidate route may be warranted. When major changes are indicated, it is often advisable to consider the entire planning process a cyclic one and repeat the sequence of steps with the new information gained in the initial evaluations. This aids in keeping the process logical and defensible.

In addition to revisions based on application of locational criteria, one final test should be performed. This is a recheck of the revised facility's location against trip potential/desire lines initially identified. The objective in this step is to insure that the system which has emerged after screening against cost, functional safety, physical design feasibility and other criteria still bears a reasonable relationship to indicated bicycle travel desires. If a system does not respond to travel desires, it simply will not be well used -- no matter how satisfactorily it meets other criteria. In any areas where correspondence is lacking between system and travel desire, either a feedback process is initiated in which corridor searches are reviewed or a specific rationalization for accepting this situation must be prepared as justification for constructing the facility.

B•9 IMPLEMENTATION

F.H.W.A., under several programs, is one of the major sources of bikeway funding that provides all or part of the monies necessary for construction. State, county or local governments may not only provide direct bikeway allocations but may obtain other funds which can be applied, at least in part, to bikeway facilities. Bikeways can be planned and implemented in cooperation with these agencies resulting in more benefits for the cycling public.

B•9•1 PROGRAM DEVELOPMENT

Funding is more readily obtained when a bikeway program has been developed. A comprehensive program permits the plan to be translated into specific actions based on a time schedule and the availablility of funds. To be flexible the program should contain short-term and long-term projects which reflect citizen input, cost-benefits, continuity and available funding.

B•9•2 FEDERAL FUNDING

Various Federal programs can provide financial assistance for bikeways and accessory facilities. The following is a synopsis of these programs. For more detailed information, the agency administering the particular program should be contacted.

- A major source of potential financial assistance is the Federal Highway Administration (FHWA). Funds are available for bikeways as a part of a larger planning or construction project or as a separate project. Under the provisions of the Federal-Aid Highway Act, funding is authorized per State per fiscal year for independent bikeway projects. There are no limitations for incidental bikeway projects.

  For bicycle facilities constructed as incidental features of Interstate projects, FHWA finances 90 percent of the cost. The 90 percent Interstate funds may not be used for independent bikeway projects, but such facilities on the Interstate System can be developed with 70 percent primary Federal-aid funds. For bicycle facilities constructed as incidental features of Federal aid primary, secondary, or urban highway projects, or as independent bikeway projects, the maximum Federal share is approximately 70 percent of the project cost with the remainder of the funds to be supplied from non-Federal sources.

  An important point to remember in dealing with these funds is that the bikeways are competitive with other highway projects for funds. Thus getting a bikeway may well mean giving up some other project such as road surfacing. Requests for use of the Federal highway funds for bikeway projects, including, planning of bikeways, should be processed through the State Highway Agency, which must approve the project.

- The Interior Department is empowered by the Land and Water Conservation Fund Act of 1965 to provide matching fund assistance to States and local units of government for the acquisition and development of outdoor recreational resources. Handling of these outdoor recreation projects is through the Bureau of Outdoor Recreation which has seven regional offices throughout the United States.

  While many forms of recreation are funded, e.g. swimming pools, hiking trails and tennis courts, bikeways are a currently popular project due to their ability to encourage low energy recreation and provide for close-to-home recreational opportunities. This is not to say that projects for funds from the Bureau of Outdoor Recreation are not competitive, they are, but a bikeway request does stand an excellent chance in the competition.

Actual approval of the project is through a State appointed liaison officer who forwards the request for funds to the regional office and works closely with Federal project officers in deciding which projects shall be financed by the Land and Water Conservation Fund. Each State is required to have a statewide comprehensive outdoor recreation plan which sets forth the outdoor recreation needs of the State and recommends priority actions for meeting those needs. Any bikeway proposal submitted must be in accordance with this plan. Funds are available to public agencies on a 50-50 matching basis. Grants in the past for bikeways have ranged from $750 to $425,000; the Bureau has funded citywide recreational bike systems as well as single bike paths.

- Some bikeway development funds are available through the Public Works Impact Program under the auspices of the Economic Development Administration, Department of Commerce. The program is restricted to areas of high unemployment, and is intended to lower the unemployment rate while creating something of public benefit, e.g. parks, sewers, or bikeways. Bikeways, have been built using these funds in eligible areas designated by the Regional Economic Development Administration Office based on current employment statistics.

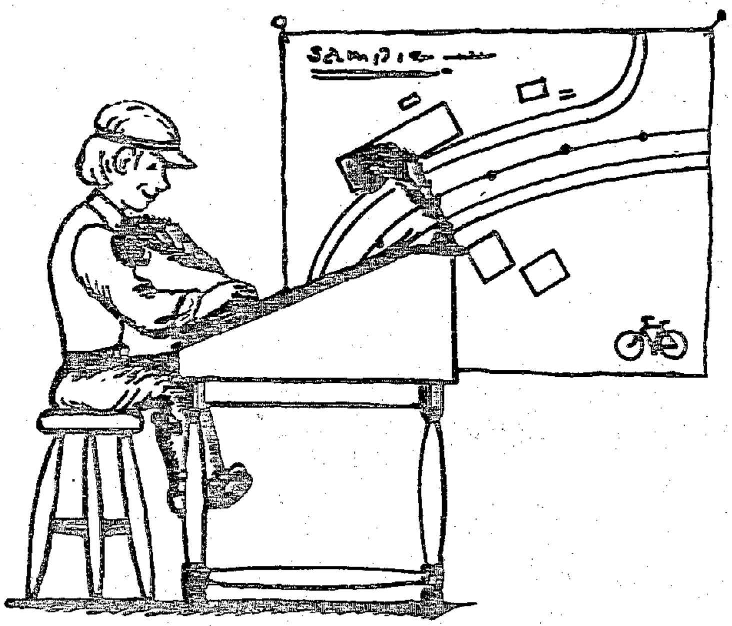
  Application should be through either a designated area representative or the regional office. All projects financed under this program must be able to begin construction within 90 days and be completed within 1 year.

- The Department of Defense, Department of the Army, has occasionally cooperated with local officials to construct a bikeway link on government land. The Golden Gate Bikeway in California is an outstanding example of this type of cooperation. In other cases engineering units of the U.S. Army Reserve, as part of their construction training, have become involved in bikeway construction as civic improvement projects.

The Farmers Home Administration, U.S. Department of Agriculture, is authorized to make loans to develop community facilities for public use in rural areas and towns of up to 10,000 people. The maximum term on all loans under this program is 40 years; but in order to be eligible the community must be unable to obtain needed funds from other sources at reasonable rates and terms. An interesting feature of the program provides that the Farmers Home Administration will assist the applicant in making the first determinations regarding engineering feasibility, economic soundness, cost estimates, organizations, financing and management matters in connection with the proposed project.

While not specifically naming bikeways in the legislation, the act does provide for the use of funds for "community facilities that provide essential service to rural residents." Loan applications are made through the local county offices of the Farmers Home Administration.


BIKE ROUTE



STEP 'C' DESIGN

"HOW A FACILITY IS BUILT"

overview

Before you can apply this Step, understandably you must have selected a corridor and hopefully you have won public support for the bikeway. You must now design the bikeway, then prepare plans and specifications for its construction.

Land may have to be acquired for your corridor; centerline, topographic and cross-section surveys may be necessary. Neither of these requirements is presented in this Digest, namely because this expertise does not require bikeway criteria to fulfill design needs.

If you have been associated with highway or street design, Step C's criteria will guide you as to major design differences. If you have no experience designing travel facilities, this part offers only limited assistance and for this reason should be used in conjunction with the appropriate references listed in the "Bibliography."

C•1 DESIGN CHARACTERISTICS

One of the most influential determinations of bikeway location (STEP B) is feasibility of desirable design; consequently, the location process is interdependent with the design process. Planning and location studies provide the design team with the corridor, the classification of the facility (Class I, II or III) and the level of anticipated service (Level A, B or C). The ultimate design characteristics of a bikeway are generally determined by location recommendations.

A majority of bikeways developed today are Class II, with the highway or street dictating the geometric design such as alignment, grades and drainage. Class I bikeways are seldom needed, as highways and streets capable of embracing adequate Class II bikeway facilities occupy the most desirable corridors. Highways and streets frequently provide ready-made bikeways; in other instances, a minimum of alterations will produce a Class II facility at a fraction of the cost to construct a Class I bikeway. Right-of-way for the existing highway facility is usually available for Class II bikeways and capable of serving a dual facility purpose with added safety and convenience to both modes of travel.

Both bikeway classifications and levels of service are defined in the GLOSSARY: nevertheless, a planner or an engineer should have a graphic, cross-section concept of each type for design purposes. Figure C-1, C-2 page 37 and C-3, C-4 page 38, depict these major classifications through cross-sections and show the differences between them.

Class I bikeways are not always parallel to highways as illustrated; they can be entirely independent such as those constructed in parks, recreation areas, within utility right of way or along greenbelts. This class of bikeway may accommodate other uses, i.e. equestrian trails or pedestrian paths (Figure C-2).

Sidewalk bikeways are employed with a varying degree of success; however, unsatisfactory experience has been reported. Among the factors contributing to this experience are:

- Poor sight distance, often prevail at driveways.
- Poor visual relationship between cyclist and motorist occur at intersections.
- Bi-directional operations compound sight distance/ visual relationship problems.
- Sharing space with pedestrians creates increasing conflict from small children at play to older pedestrians becoming uneasy meeting cyclists along the bikeway.

Sidewalk bikeways are not highly recommended because of these factors. However, if this type of facility is the only feasible alternative the design engineer must strive to improve some adverse factors through wider bikeways, alignment, striping and signs.

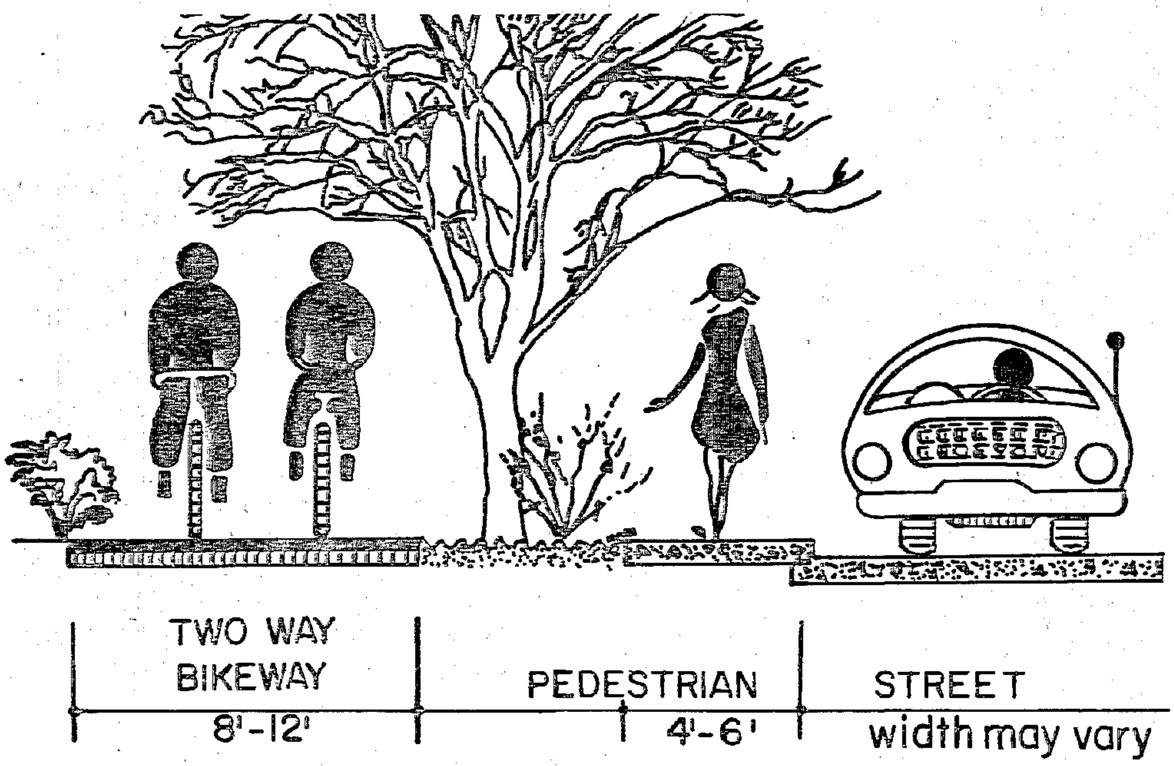


Figure C-1 Class I Exclusive Bikeway

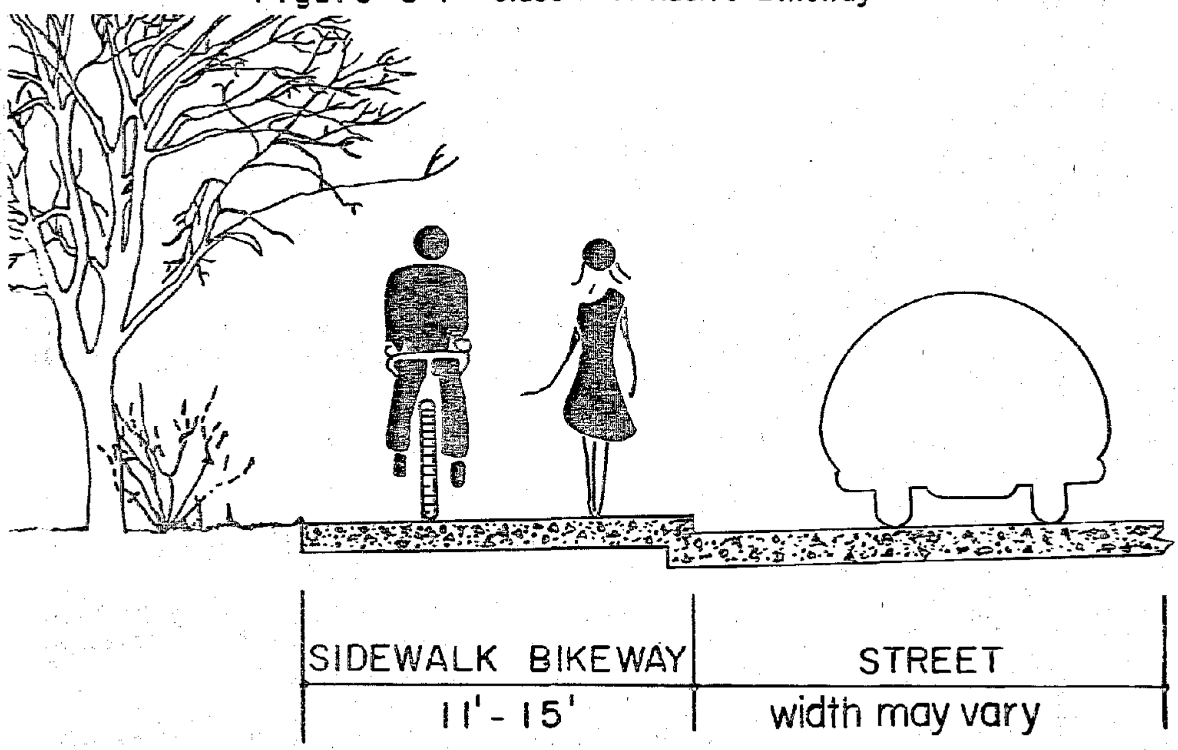


Figure C-2 Class I Sidewalk Bikeway

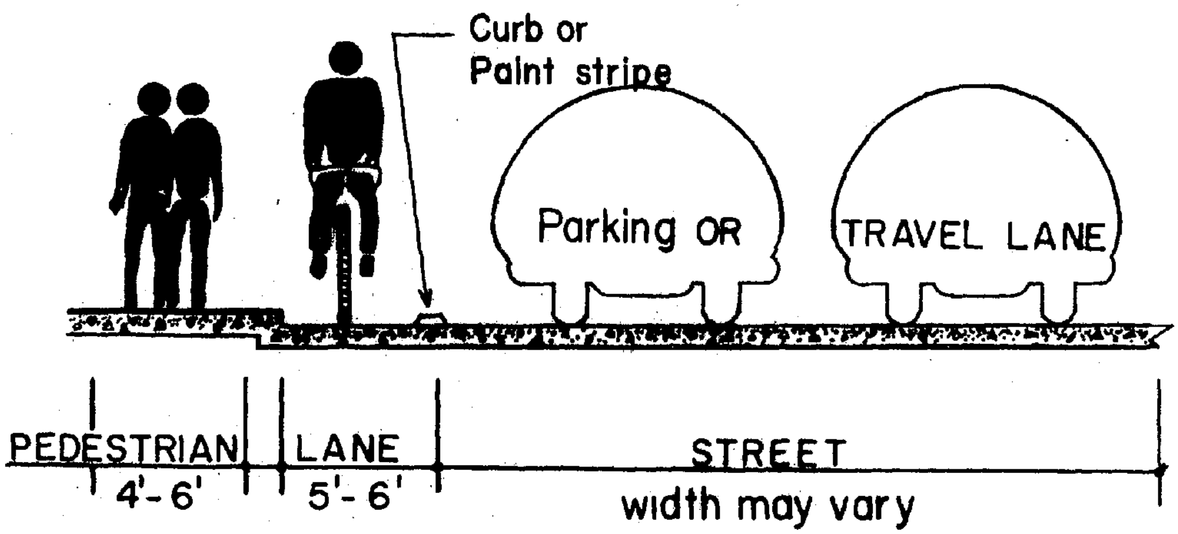


Figure C-3 Class II Bikeway

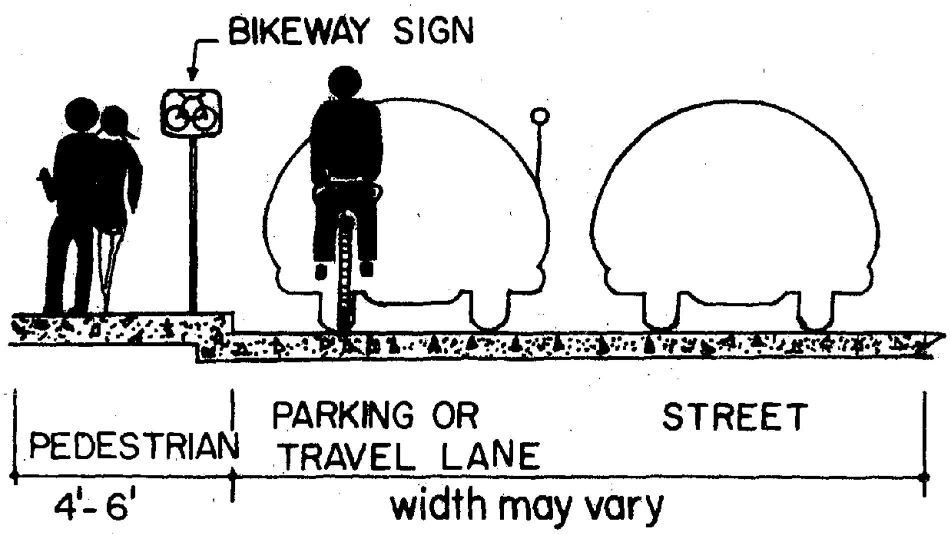


Figure C-4 Class III Bikeway

If part of the existing highway is used as a bikeway, the facility is classified as shown in Figure C-3, page 38. If the sole bikeway feature is a shared facility with only route or message signs, then it would be a Class III bikeway shown in Figure C-4, page 38.

Due to limited right-of-way use and funds, the most serviceable facility should be the ultimate goal. Consequently, variations of the basic classification have been and will be constructed. For criteria selection, the designer must determine which classification and which level of service most appropriately applies to the design variation.

C•2 DESIGN SPEED

Design speed is a critical factor in providing for adequate horizontal curvature and stopping sight distance; it is also an element in assessing the feasibility of grades.

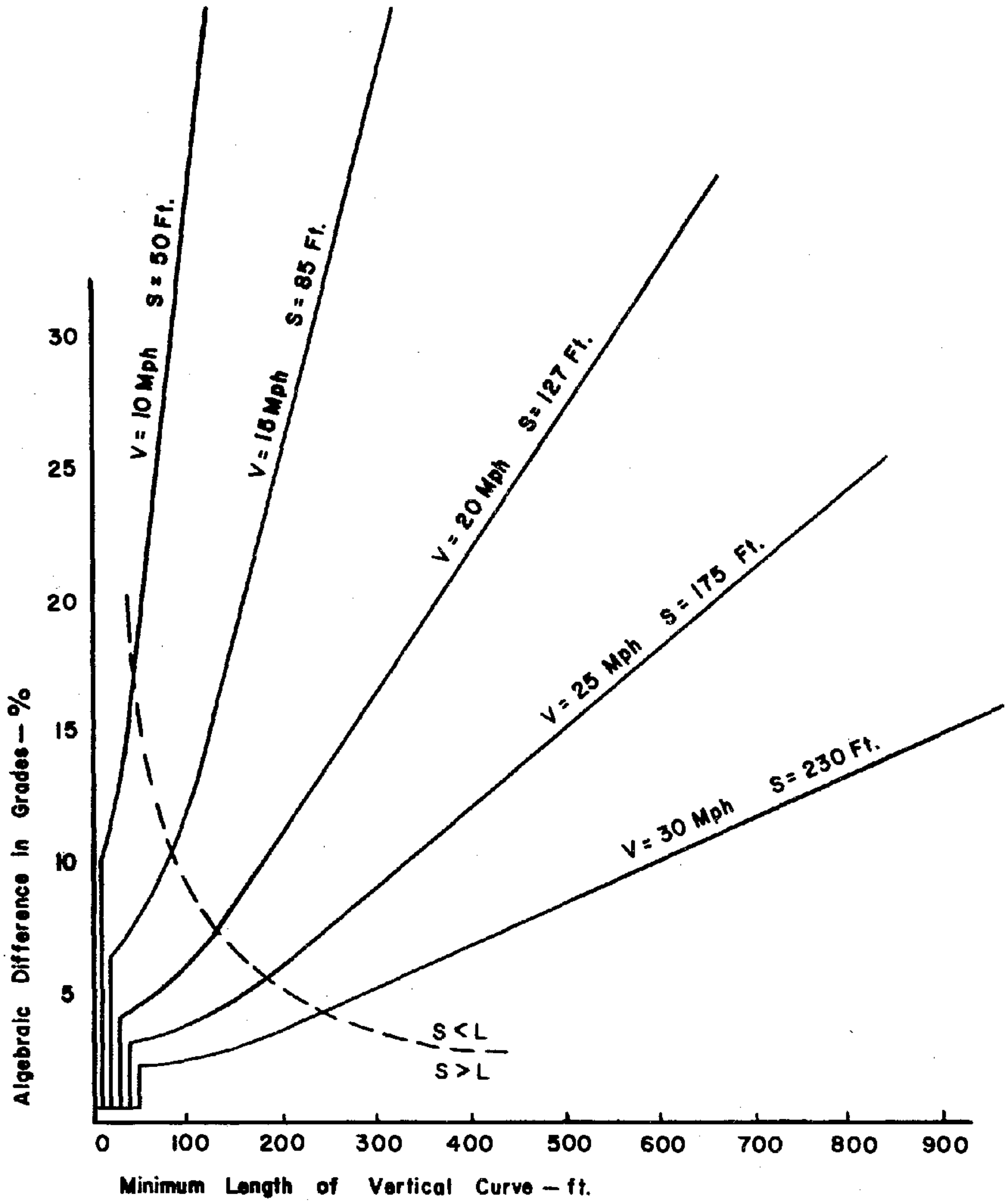
A design speed of 20 m.p.h. (32.19 km/h) is desirable for the correlations of bikeway features which provide safe and comfortable cycling. On grades which exceed 7%, a design speed of 30 m.p.h. (48.28 km/h) is recommended as a safe minimum. On bikeways with "one-way" climbing grades exceeding +3% it is considered sufficient to use a design speed of 15 m.p.h. (24.14 km/h).

After the design speed(s) for a proposed bikeway is determined on the basis of the character of terrain and class of bikeway, then formulation of design features such as sight distance and horizontal curvature can be selected from Figures C-5 page 40 and C-6, page 41.

C•3 STOPPING SIGHT DISTANCE

Unexpected obstacles on a bikeway such as broken glass, broken pavement or other impediment may confront a cyclist causing the individual to brake or swerve. To safely provide the cyclist with an opportunity to see and react, bicycle stopping sight distances have been studied and criteria compiled. Ultimately the study produced stopping sight distance criteria based on a mounted bicyclist's eyes being 4.5' (1.37 m.) from the bikeway surface while the obstacle was on the surface or 0'. The graphics and formulae developed for crest vertical curves is shown in Figure C-5, page 40 while the formulation for horizontal curves is shown in Figure C-6, page 41.

Sight distance criteria based on 'bikeway surface obstacle' would also provide a safety margin in sighting certain cross traffic and on a facility shared with pedestrians.

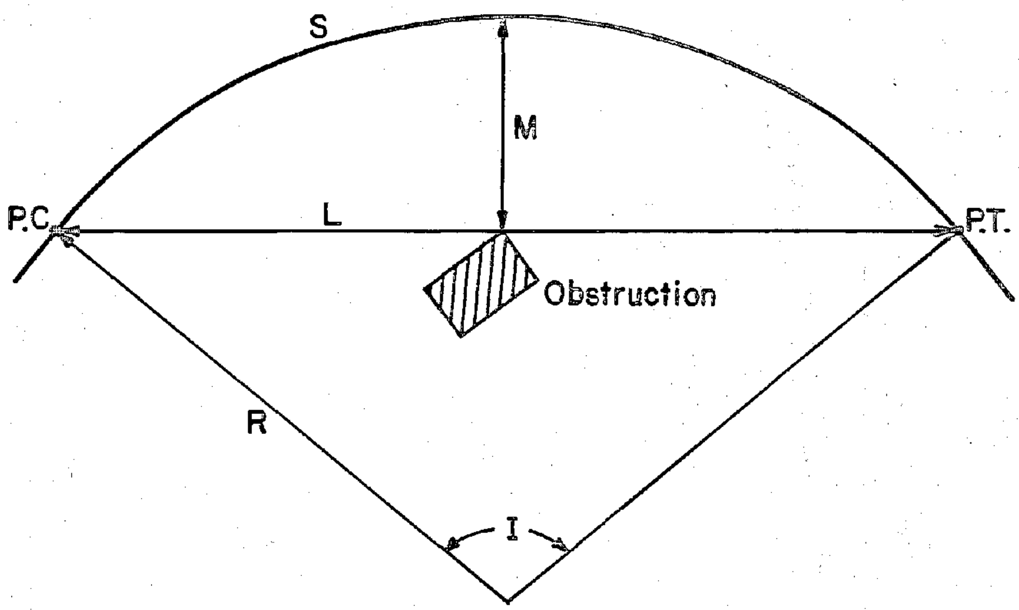


where: S = Stopping Sight Distance

L = Minimum Vertical Curve Length

V = Design Speed

Figure C-5 Stopping Sight Distance For Crest Verticle Curves



M = Obstruction Offset From Lane Centerline

L = Line Of Sight

S = Safe Stopping Distance Along Lane Centerline (Arc Distance)

R = Radius Of Curvature

I = Deflection Angle Between Tangents

P.C. = Point Of Curvature

P.T. = Point Of Tangency

$$M = R(1 - \cos 1/2\, I)$$

$$L = 2R \sin 1/2\, I$$

Figure C-6 Horizontal Sight Distance

Generally, there is no problem in attaining adequate stopping sight distances for bicycle lanes on shared roadways because the roadway alignment usually has been designed to accommodate motor vehicle speeds that are equal to or greater than bicycle speeds. There are exceptions, however, and the stopping sight distance factor should be checked in locating such bicycle facilities.

C•4 GRADES

A level bikeway is preferred by nearly every bicyclist, however, because existing terrain, highway alignment or available right-of-way may not be level most bikeways will have grades. On Class I bikeways grades can be adjusted to reduce the effort required to pedal on the facility. However, the grades on Class II & III bikeways, Figure C-3 & C-4, page 38, are predetermined by the facility they embrace.

When a grade adjustment is desirable, criteria has been compiled which will assist the design engineer in determining optimum standards for the design. Figure C-7, page 43, contains a graph which provides studied recommendations for grades up to 11% and grade distances up to 2000' (0.61 km.). This Figure is a composite of studies establishing the most economical criteria which will meet acceptable energy demands.

Usually ramp and bridge approaches are required to have steeper grades. Acceptable grades in such cases can be adjusted accordingly but should not exceed 15%.

C•5 WIDTHS AND CLEARANCES

Lane width requirements for bicycle facility design are composed of three components:

A basic width related to Level of Service.
A "shy distance" to separate the lane from adjacent boundary obstructions.
Space for pedestrians if present.

Figure C-8, page 44, shows in tabular form, bikeway lane widths for both the class of the facility and its level of service:

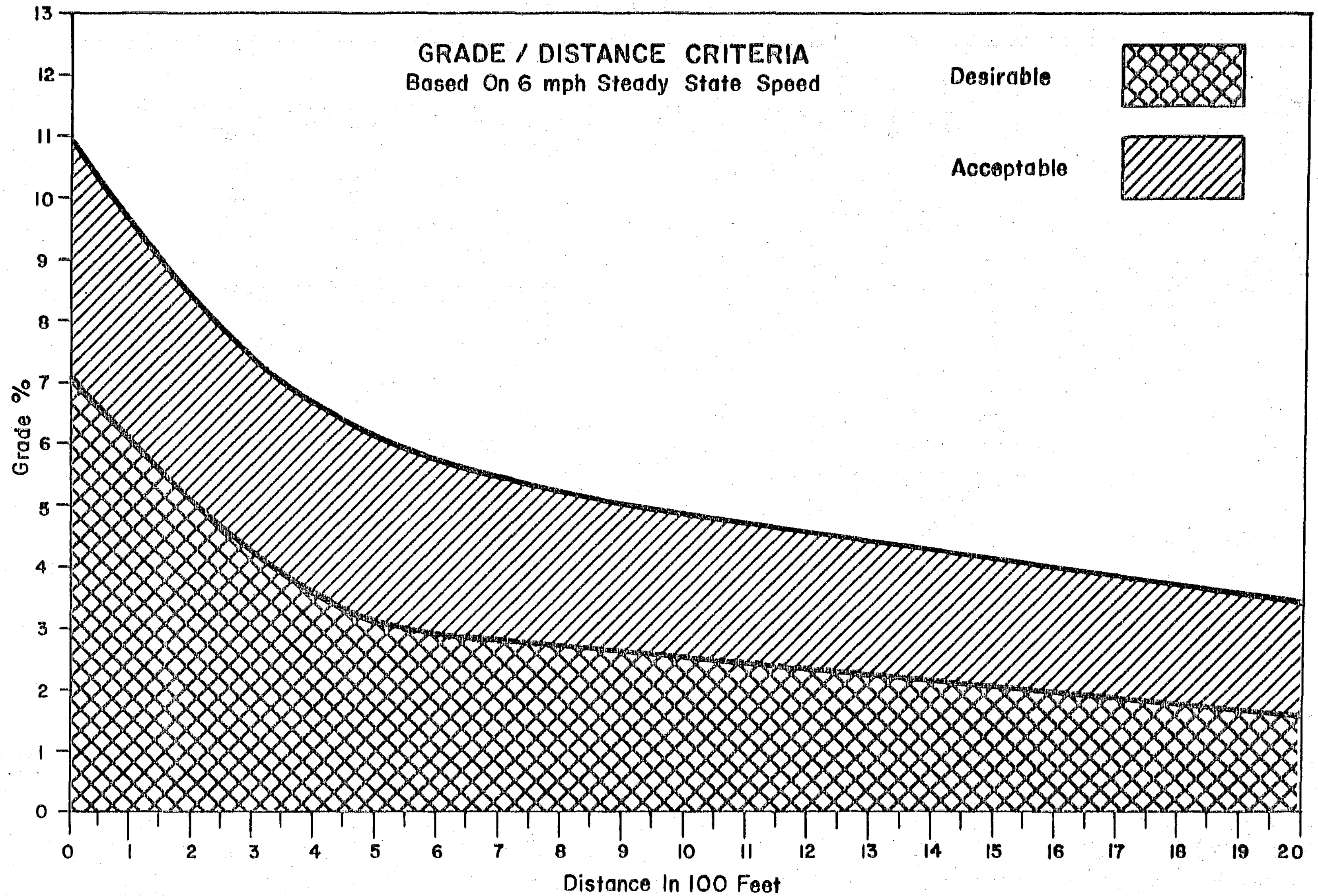


Figure C-7 Bikeway Grade Criteria

Level of Service	A	B	C	Remarks
Class I	12' (3.66 m.)	10' (3.05m.)	8'(2.44 m.)	Two way
Class II	6' (1.83 m.)	4' (1.22m.)	3.5'(1.07m.)	One Way

Figure C-8 Basic Lane Width Requirements

When a bikeway is shared with normal pedestrian traffic, an additional 3' (0.91 m.) is added to the widths recommended in C-8 above. If there is only occasional pedestrian use then only the additional width 1.5' (0.46 m.) is advised.

Minimum lateral and vertical clearance from a paved lane is shown in Figure C-9, page 45, which expands the criteria presented in Figure C-8. A minimum of 8' (2.44 m.) vertical clearance with 10' (3.05 m.) being desirable, is applicable to all bikeway classifications and levels of service. A minimum shy distance of 1.5' (0.46m.) must be maintained between the bikeway and all lateral obstructions or barriers, however this distance is not an increase in the basic lane width.

C•6 HORIZONTAL CURVES

Empirical studies were made of adult cyclists riding standard ten speed bicycles while making 180° unbraked turns at various speeds. An analysis of the resulting data provided an accurate bikeway horizontal curve formula.

$$\boxed{R = 1.528\ V + 2.2}$$

where V = Design Speed in m.p.h.
R = Curve Radius in feet

When bicycling speed is expected to exceed 25 m.p.h. (40.23 km/h) or when it is practical to pedal through a curve such as a short radius curve preceding a significant up-grade then curve values shown in Figure C-10, p. 46, should be used to determine both the curve radius and its superelevation, although normally superelevation beyond that necessary for drainage is not needed to comply with designated design speeds.

Judgement must be carefully exercised by the design engineer in the use of horizontal curve criteria. Some other factors that can influence design and must be considered by the engineer are terrain, costs, and the characteristics of the anticipated users.

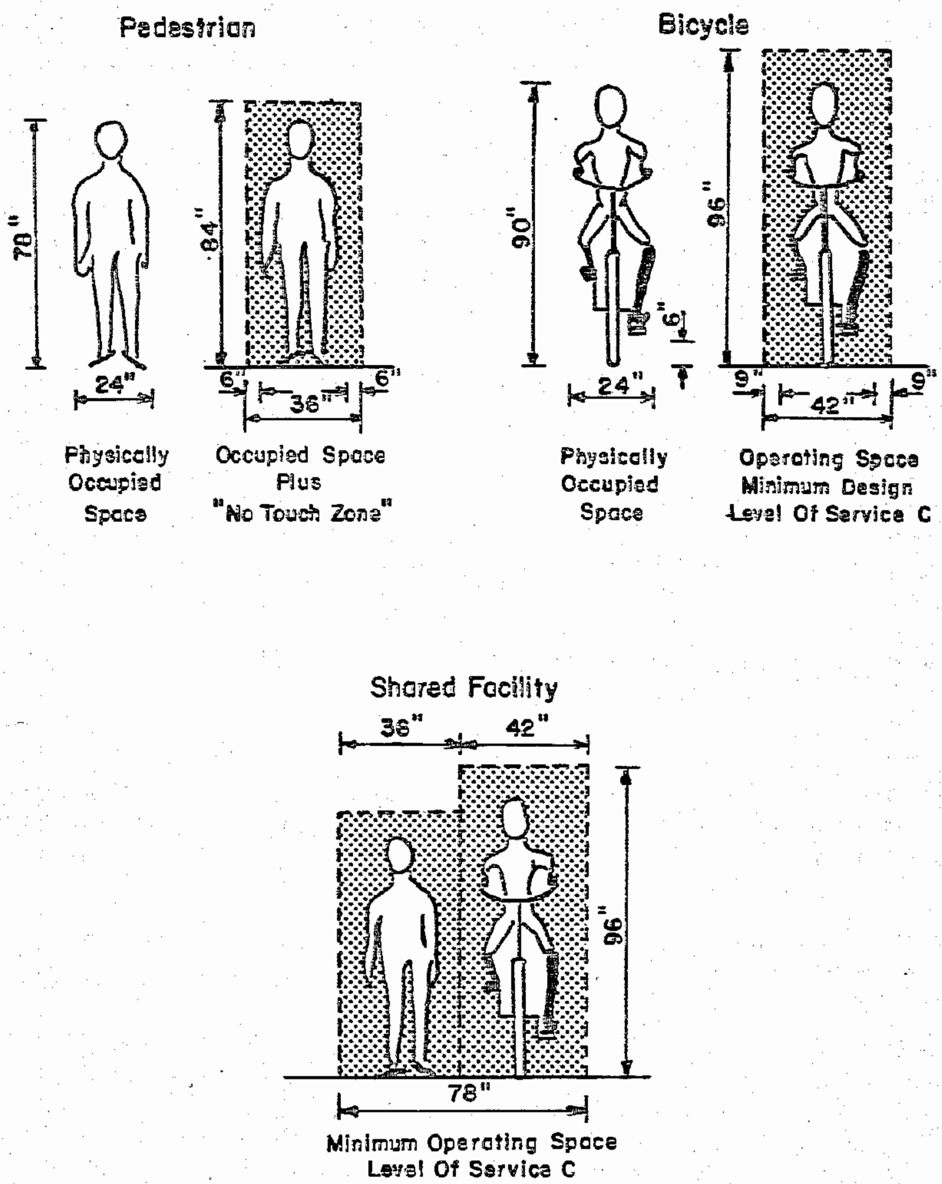


Figure C-9 Lateral And Vertical Bikeway Clearances

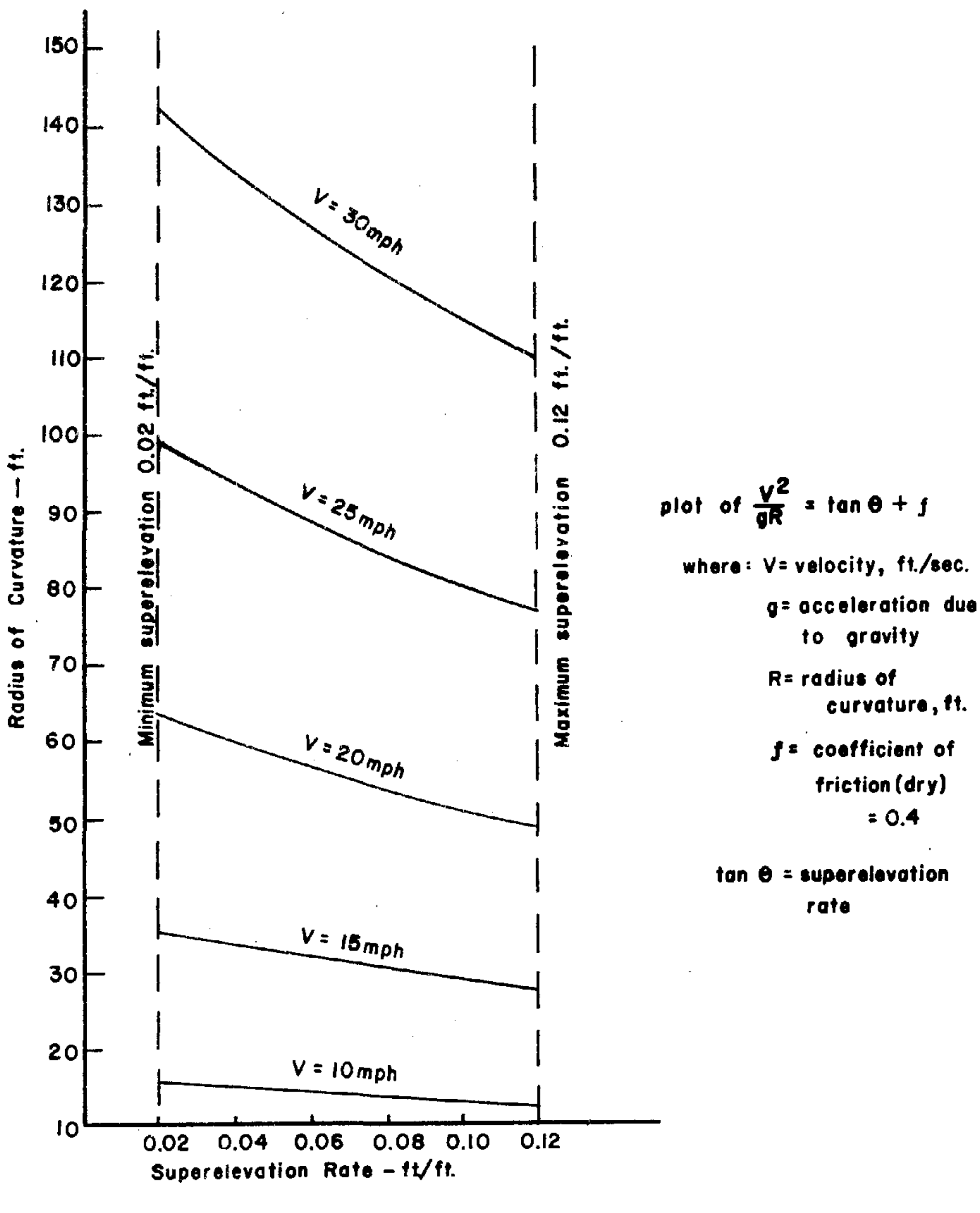


Figure C-10 Standard Bikeway Superelevation

C•6•1 CURVE WIDENING

On two way bikeways or bikeways shared with pedestrians, widening is recommended at short radius curves of less than 100' (30.48 m.). This is to compensate for increased lane occupancy due to cyclists leaning to the inside of the turn and additional maneuvering space that is required to safely negotiate sharp curves. Guidance for curve widening is presented in Figure C-11, page 48, with the maximum widening being limited to 4' (1.22 m.). This treatment is especially recommended in areas where use by mopeds is anticipated and legal.

C•7 INTERSECTIONS

Intersections are by nature places of more intense activity and conflict than other points on a street network. Safe movement of bicycles through them is a topic of concern for bikeway designers. Satisfactory solutions to this problem have been elusive, with each location presenting individual and unique traffic patterns and problems.

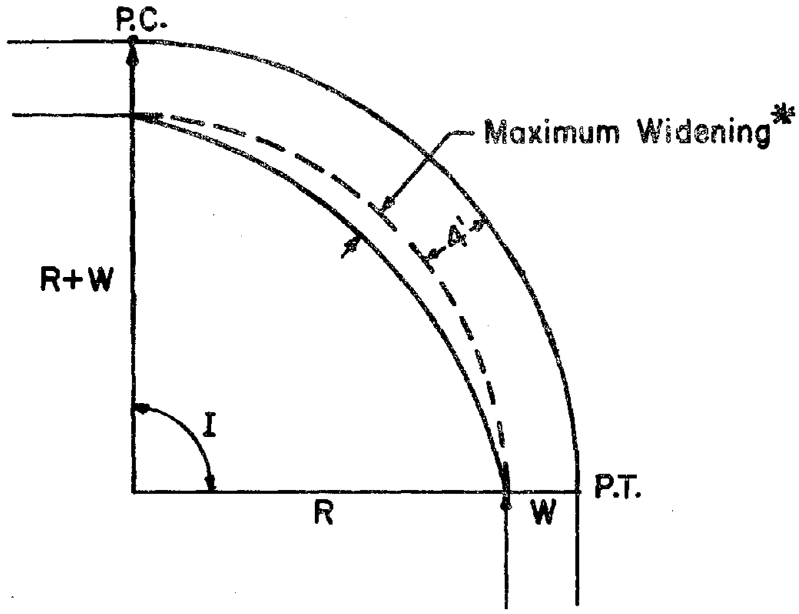
Conflicts at intersections between cyclists and motor vehicles can be abated where at-grade turning lanes are part of the existing design. Figure C-12, page 50, shows bikeway design for two different turning lanes. The primary feature of both designs is the channelization of bicycle traffic to a safer crossover location at the intersection.

After construction of the turning lane design, signing, striping and signalization (STEP D) are implemented to increase the safety objectives. In addition, wherever a bikeway crosses a curb section such as that shown in Figure C-12, that curb should be depressed the entire width of the bikeway. A gradual transition from normal sidewalk elevation must be initiated at each curb depression to avoid a hazardous drop-off.

Bikeway design for grade separations is described under section C-8. However, Example A in Figure C-12, page 50, can be implemented on interchange ingress and egress ramps where the direction of bikeway travel is not diverted to an intersecting highway.

C•8 GRADE SEPARATIONS

Bikeway grade separations are an effective means of eliminating bicycle / motor vehicle conflicts and often the only way of providing bikeway linkage across barriers to bicycle travel such as freeways, rivers, etc. Design of grade separations is predominantly determined by user needs, site conditions and available funds.



$$\text{Maximum Widening}^{*} = W - \frac{W}{\cos \frac{I}{2}}$$

R = Radius Of Curvature

W = Width Of Bikeway

I = Deflection Angle Between Tangents

P.C. = Point Of Curvature

P.T. = Point Of Tangency

*Maximum Widening Shall Not Exceed 4 Feet

Figure C-11 Curve Widening

Grade separation needs are unique to each individual location and cannot be determined because of the many variables. Where signalization is warranted at independent path crossings, grade separations may be substituted. Where severe conflicts between bicycles and motor vehicles at intersections cannot be mitigated by other treatments and substantial bicycle volumes are present, grade separation may be appropriate. In new developments where grade separations can be effectively provided in initial construction this is desirable. In the case of barriers such as streams, the need for a grade separation is obvious, except where the cost is not justifiable.

C-9 PAVING

Bicycles have no suspension system. Shocks are transmitted directly from the surface to the rider. Therefore, a smooth surface is required for efficiency and comfort.

Class II or III bikeways sharing an existing highway facility usually utilize the existing pavement. Whenever there is a widening to create a Class II bikeway, any added pavement structure should conform to the original design standard for the street or highway. If a shoulder is improved for bicycle use, it must be surfaced with a material which is traversable by both motor vehicles and bicycles even in a wet condition.

The pavement design should be included in the plans and specifications for Class I bikeways. Figure C-13, page 50, shows four typical paving sections that could be selected for a bikeway facility.

Several factors will influence the pavement design. Existing soil type, drainage requirements, weather data and available funds are some. Also, to be considered is multiple use of the bikeway by maintenance vehicles, pedestrians and traversing traffic. If vehicles use the facility a thicker section will be required; if pedestrians use the facility a portland cement concrete sidewalk surface is preferred.

Sections (a) and (b) in Figure C-13 are more frequently implemented than section (c) since they have a lower construction cost and better riding quality. Section (c) is generally used when a designer desires minimum maintenance and long term utility, and is also preferred for sidewalk bikeways.

Most bikeways currently being implemented are the Class II shoulder type, Figure C-3, page 38. Many existing highways have sound stabilized shoulders with bikeway feasibility; however, their surface textures are not suitable for today's multi-speed, narrow rimmed bicycles. An economical technique is being developed, with Federal Highway Adminis-

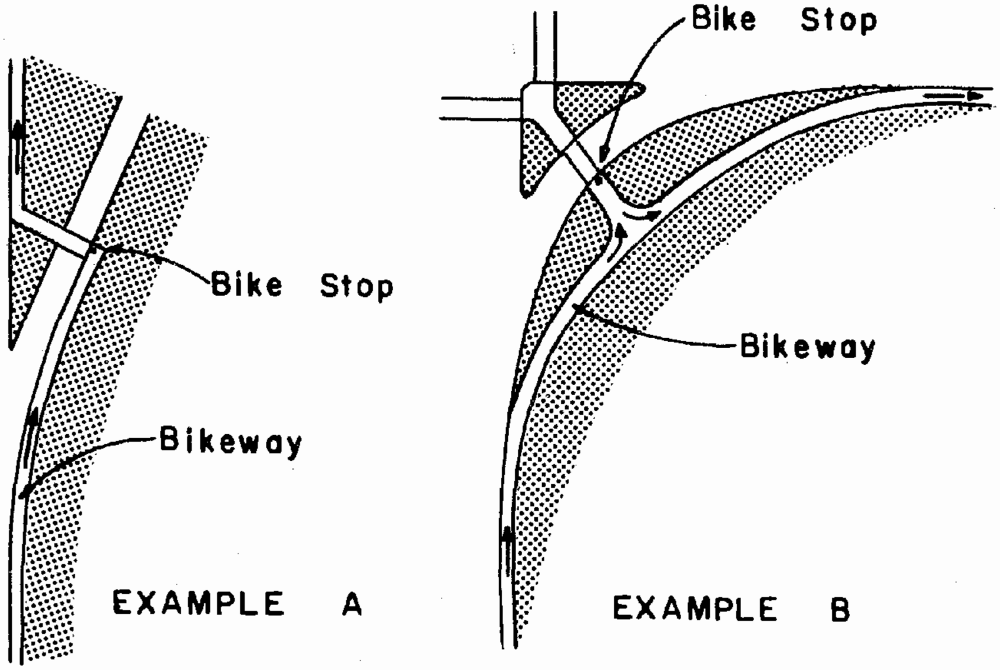


Figure C-12 Turning Lane Design

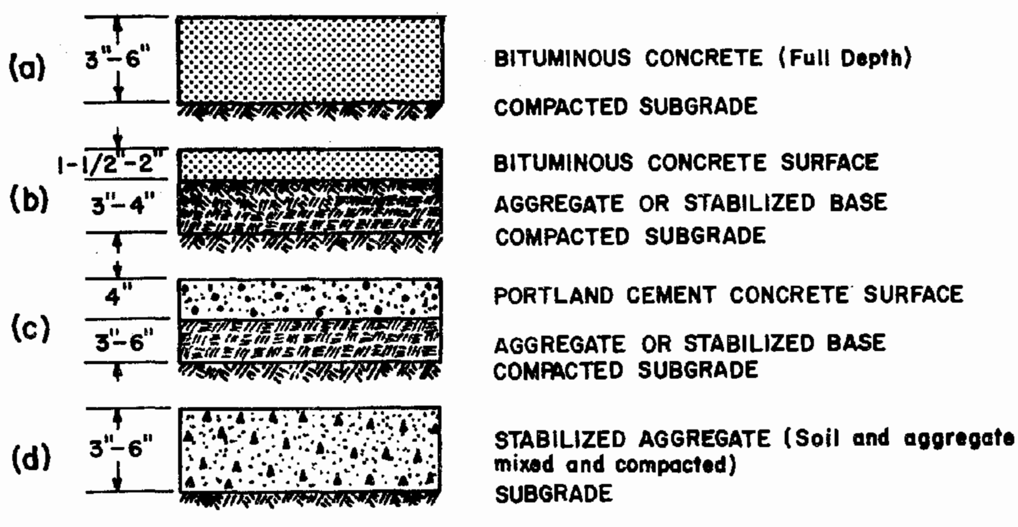


Figure C-13 Typical Bikeway Pavement Sections tration support, which converts stabilized shoulders into a suitable bikeway riding surface. A treatment of 3/16" (0.43 cm.) asphalt emulsion slurry seal is applied to a stabilized shoulder providing a smoother, skid resistant surface. This seal coat accepts traffic almost immediately after application. Other benefits from the slurry seal include extending the life of the shoulder and improving the appearance of the highway. The slurry surface texture can be controlled by either a burlap drag or rolled for smoother surface.

If bicycle travel will be primarily recreational and the surface section environmentally compatible, such as in historical areas, type (d) is recommended. In areas where all weather operation is expected, this pavement section is not considered satisfactory.

C-10 DRAINAGE

To provide an all weather Class I bikeway, drainage studies and computations are important factors and must be incorporated in the design and construction process. A minimum cross slope of .02 ft/ft is required throughout the facility, and wherever necessary ditches and inlets should be constructed to sufficiently cope with the computed storm runoff.

Existing street or highway drainage design on Class II or III can, in most cases, be accepted as being hydraulically adequate. However, drainage grates along selected corridors frequently present cyclist safety problems. The most dangerous grate has bars running parallel with the direction of travel. While this grate is hydraulically efficient, it often traps the cycle wheel between ths bars, resulting in serious accidents. Any hazardous grate within the bikeway should be altered or replaced with a grate which cycles can safely traverse. The replacement design should accept surface water and debris almost as efficiently as paralleled bar grates.

When grate replacement is not feasible due to prohibitive cost excessive grades or other hydraulic requirements then the presence of the hazardous grate should be distinctly marked with warning stripes as shown in Figure D-6, page 69. Provisions should then be made for the bikeway to by-pass the hazard without encroachment into automobile traffic lanes.

C•11 RELATED FACILITIES

At a bikeway terminus or along the route, other facilities can be incorporated into the bikeway design. Just as in highway construction some services do not affect the major function of the artery but the related facilities do enhance the bikeway or add convenience. Some bikeways could provide vehicle parking or a selected rest area for cyclists and other user conveniences. Where vehicles other than bicycles can intrude on a bikeway, barriers could be constructed; also, if usage is of concern to planners, then monitoring devices may be installed. Most related bikeway items can be installed with less expenditure at the design stage of implementation than if they are constructed subsequent to the completion of the bikeway facility.

C•11•1 REST AREAS

Natural features of the surrounding terrain, such as woods, streams, lakes, space for enjoyment of mountain views and the use of adjacent land can become rest area sites for cyclists along some bikeways. Rest area development is dependent on suitable sites, usage and available funding.

Suggested facilities which may be incorporated into a rest area are primarily the same types that could also be implemented at a bikeway terminus. Benches, tables, grills, bike racks, rest rooms, trash receptacles, telephones, bulletin boards and drinking fountains can be included in a rest area as desired by the planners.

If drinking water is provided, the supply must be from a safe source and protected from all surface pollution. A need for toilet facilities is related to the risk of having adjacent land used for sanitary purposes. However, when water, toilets and other services become part of a bikeway then necessary long-term maintenance costs are greatly increased.

C•11•2 TERMINUS PARKING

If a bikeway terminus requires the storage of vehicles and no existing area is available, a new facility will have to be provided. The size and type of parking facility will be based on usage and construction costs. An automobile requires 10' by 20' (3.05 m. by 6.10 m.) parking space whereas a bus or heavy vehicle may require 12' by 60' (3.66 m. by 18.29 m.).

Cyclists must be reasonably assured that safe and adequate parking is available at both the trip source and trip destination or they will seek other methods of transportation. As with other vehicles a bicycle is parked when not in use. Being small, light and valuable they are exposed to increasing theft and vandalism as attested by police records throughout the nation.

When designing bicycle parking sites, parking should be provided for 110 percent of the estimated present peak parking. The site should be separated from motor vehicle parking by at least a curb barrier which would prevent the vehicles from damaging the bicycles. If bike parking has not been provided for an existing bikeway, then estimates will be required to determine the parking needs. Methods for estimating potential bicycle use have been explained in STEPS A & B.

Commercial and office centers, schools, recreational facilities, public buildings, municipal parking facilities and intermodal transfer points (bicycle to bus, subway or train) are areas which can utilize bicycle parking sites. When adequate facilities are available, particularly at intermodal points, bicycle usage and mileage increases.

Without interfering with pedestrian traffic, place bicycle parking devices as close to the destination entrance as is feasible. For safety and security the devices should be adequately illuminated and under public observation. Weather sheltered locations are preferred particularly for the utilitarian cyclists. The device, itself, should provide anchored units spaced not less than 2' (.61 m.) apart.

Moped use is rapidly increasing on streets and highways where their use as a bicycle has been recognized by law. Although a moped is considered a bicycle in many states, its weight and limited manueverability require different dimensional criteria for parking. Mopeds are approximately 70" (1.78 m.) in length and weigh up to 100 lbs. (45.35 kg.) when parking a moped in a device, the user must be able to guide the moped from its right or left side (similar to parking a motorcycle). Spaces for mopeds should be allocated in the same ratio recommended for bicycle parking sites.

C•11•3 MONITORING DEVICES

Bikeway usage data may be collected manually or with electromagnetic loop detectors. While the manual process gathers information which the detectors cannot obtain (type of bicycle, origin-destination, turning movement and user habits) the manual method is time consuming and comparatively expensive. Loop detectors take continuous accurate counts of existing traffic on Class I and II bikeways, but because bicycles share the roadway on Class III bikeways only manual counts can be taken for usage studies.

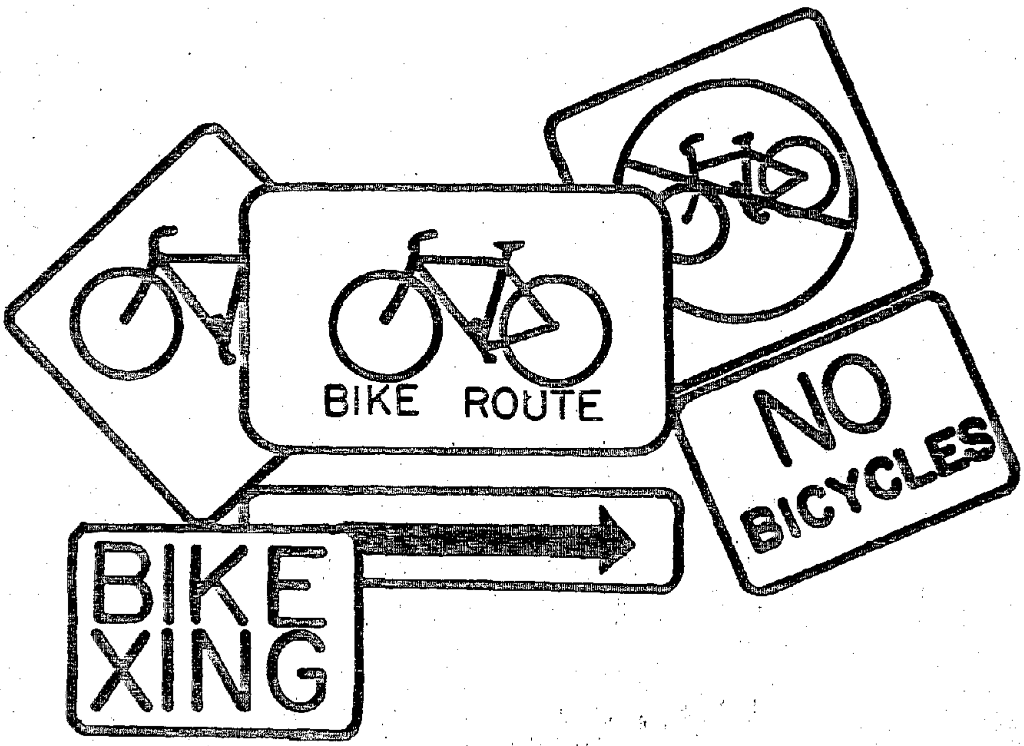
Post construction bikeway monitoring is a necessary instrument in the planning and design of future bikeways.

C•11•4 BARRIERS

Bicycle exclusive facilities need some form of physical barrier to ameliorate the potential conflict or confusion created by motor vehicle intruding on the bikeway. Provision can be made for a lockable, removable barrier section which would admit only authorized vehicles. This barrier should be permanently reflectorized and designed to give safe access to the bikeway for cyclists.

A recommended barrier is comprised of a series of reflectorized posts placed across a Class I bikeway wherever motor vehicles may invade the facility. The design must allow temporary removal of one or more posts for the access of maintence and emergency vehicles. These posts can be padlocked in place.

Illumination of the barrier area after dark and restrictive signing would not only increase safety for cyclists but also reduces the hazard of motor vehicles colliding with the barrier.



STEP 'D' OPERATION

"AFTER A FACILITY IS BUILT"

overview

Whether you provide modifications to a shoulder for bicycle use or create a parkland Class I facility, your bikeway is not finished merely because the construction is completed. Generally, you must add signing, perhaps marking; you must maintain the bikeway, and as well, promote its usage.

Within this Step you are introduced to bikeway post-construction needs which impart safety and convenience to cyclists. By no means is Step D comprehensive, nor is it static. Your imagination along with local recommendations can produce additional improvements which will provide maximum public benefit.

D•1 RULES OF THE ROAD

Rules of the Road are fairly uniform throughout the country. The trend towards greater uniformity is best reflected by the fact that many states continuously revise their laws to conform to such specimen sets of laws as the Uniform Vehicle Code and the Model Traffic Ordinance. Uniform rules provide immeasurable safety benefits such as assisting highway users, police officers, judges, traffic engineers, motor vehicle administrators and educators through similarities of use, of interpretation and of adjudication.

Requiring bicycle users to obey all rules of the road cannot be stressed too greatly. Unique or specific rules directed at bicycle transportation must be compatable with existing rules designed for motor vehicles.

D•2 TRAFFIC CONTROL DEVICES

Traffic Control Devices are the primary elements of communication directed towards road users. Basic principles governing the design and usage of traffic control devices are set forth in the "Manual on Uniform Traffic Control Devices" (MUTCD). The MUTCD presents traffic control device standards for all streets and highways regardless of the type or class or the governmental agency having jurisdiction. All traffic control devices used in conjunction with a bicycle facility should conform to the manual's standards.

D•2•1 BASIC REQUIREMENTS

Five basic requirements that a traffic control device should satisfy to be effective are:

- Fulfill a need.
- Command attention.
- Convey a clear, simple meaning.
- Command respect of road users.
- Give adequate time for response.

Proper design of a device, including size, shape, color and composition of the message, combine to produce a clear simple meaning; thus permitting adequate response time and commanding respect of the road user.

Proper placement of a device, within the cone of vision of the user, should command the attention of the user; and, if properly placed with respect to the situation should allow adequate response time.

Operation of a device is the true test that determines if it is functioning as intended. The device must be operated and placed in a uniform and consistent manner. The vehicle operator can, therefore, properly respond to the device, based upon his previous exposure to similar devices under similar traffic conditions.

Proper maintenance includes both physical and functional maintenance. Physical maintenance is the assurance that the legibility and visibility of the device are retained. Functional maintenance is the assurance that the device is still needed for the purpose for which it was originally intended.

Uniformity means treating similar situations in the same way. Uniformity of traffic control devices provides a safer environment for vehicular movement and aids in the similarity of recognition, understanding and interpretation by all concerned.

While most needs along roadways can be met with standards specified in the MUTCD, there may be other applications which are desirable under special conditions or to aid in the enforcement of other laws and regulations. Care should be taken not to employ a special treatment when a standard treatment will serve the purpose.

D•2•2 LEGAL AUTHORITY

Traffic control devices shall be placed only by the authority of a public body or official having appropriate jurisdiction, for the purpose of regulating, warning or guiding traffic.

D•2•3 ENGINEERING STUDY REQUIRED

The decision to install a device should be based upon a prior engineering study. This digest is not a substitute for good engineering judgement. Whenever the need, design or placement of a particular device is in doubt, a qualified traffic engineer should determine or review the application of that device.

D•3 SIGNS

All traffic control signs are divided into three categories:

- Regulatory
- Warning
- Guide

Each has its own specific application and importance and should be used only in warranted situations. Installing too many signs tends to diminish their importance, particularly regulatory and warning signs.

D•3•1 PLACEMENT

There are five basic requirements in the placement of signs. A sign should be placed to assure that:

- It is within the viewers' normal cone of vision.
- It is properly located with respect to the situation it addresses.
- It is not obscured by other roadside objects.
- It does not constitute a potential roadside hazard.
- Signs requiring different decisions must be spaced sufficiently apart to allow time for the required decisions.

For proper placement of signs along all classes of Bikeways see Figure D-1, page 59.

D•3•2 REGULATORY SIGNS

Regulatory signs inform users of traffic laws and regulations. They govern lane movements, parking, speeds, etc., and indicate legal requirements that would not otherwise be apparent. Examples of this type of sign are shown in Figure D-2, page 60.

D•3•3 WARNING SIGNS

Warning signs are used where necessary to call users attention to potentially hazardous conditions on or adjacent to the roadway. Warning

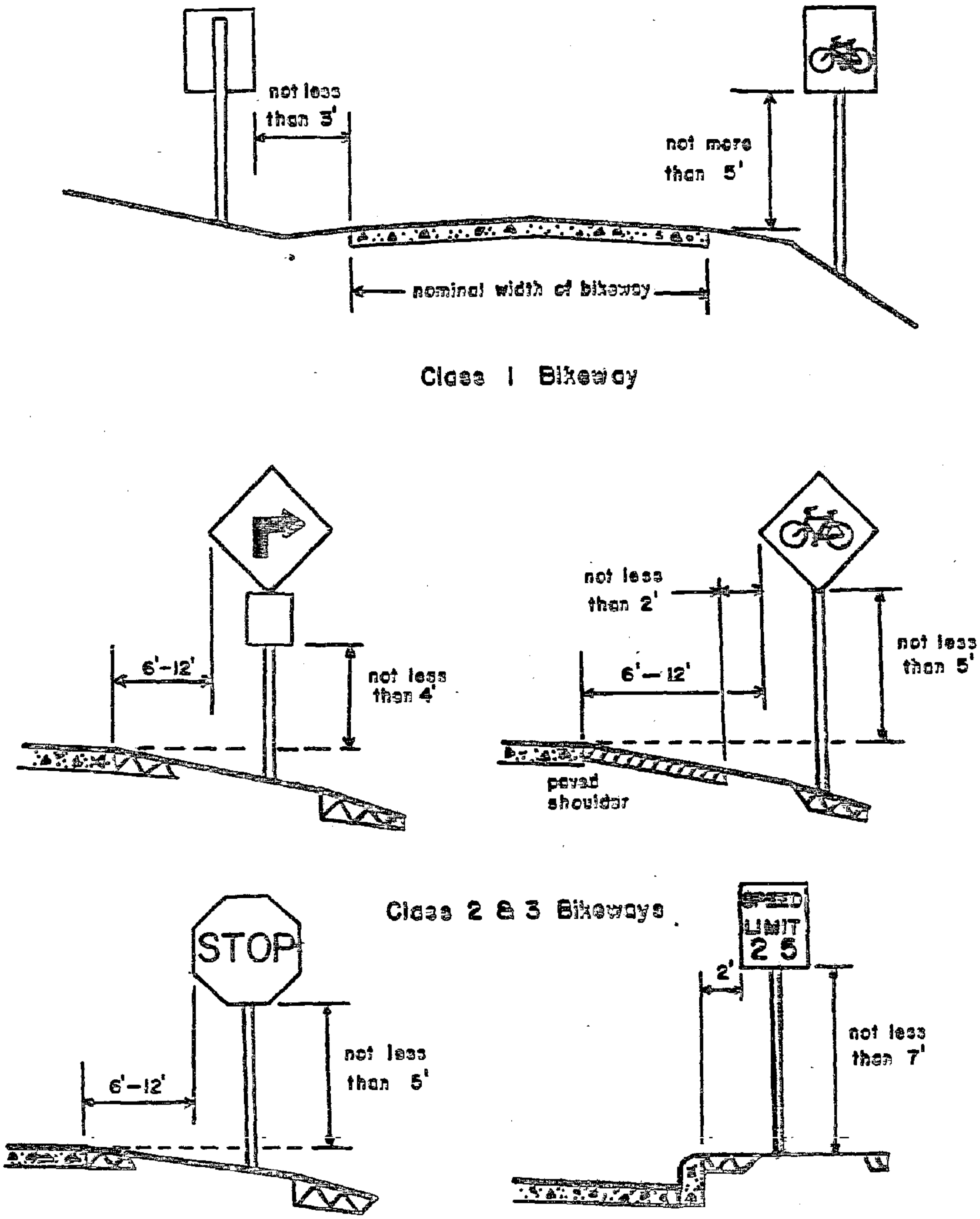


Figure D-1 Bikeway Signing

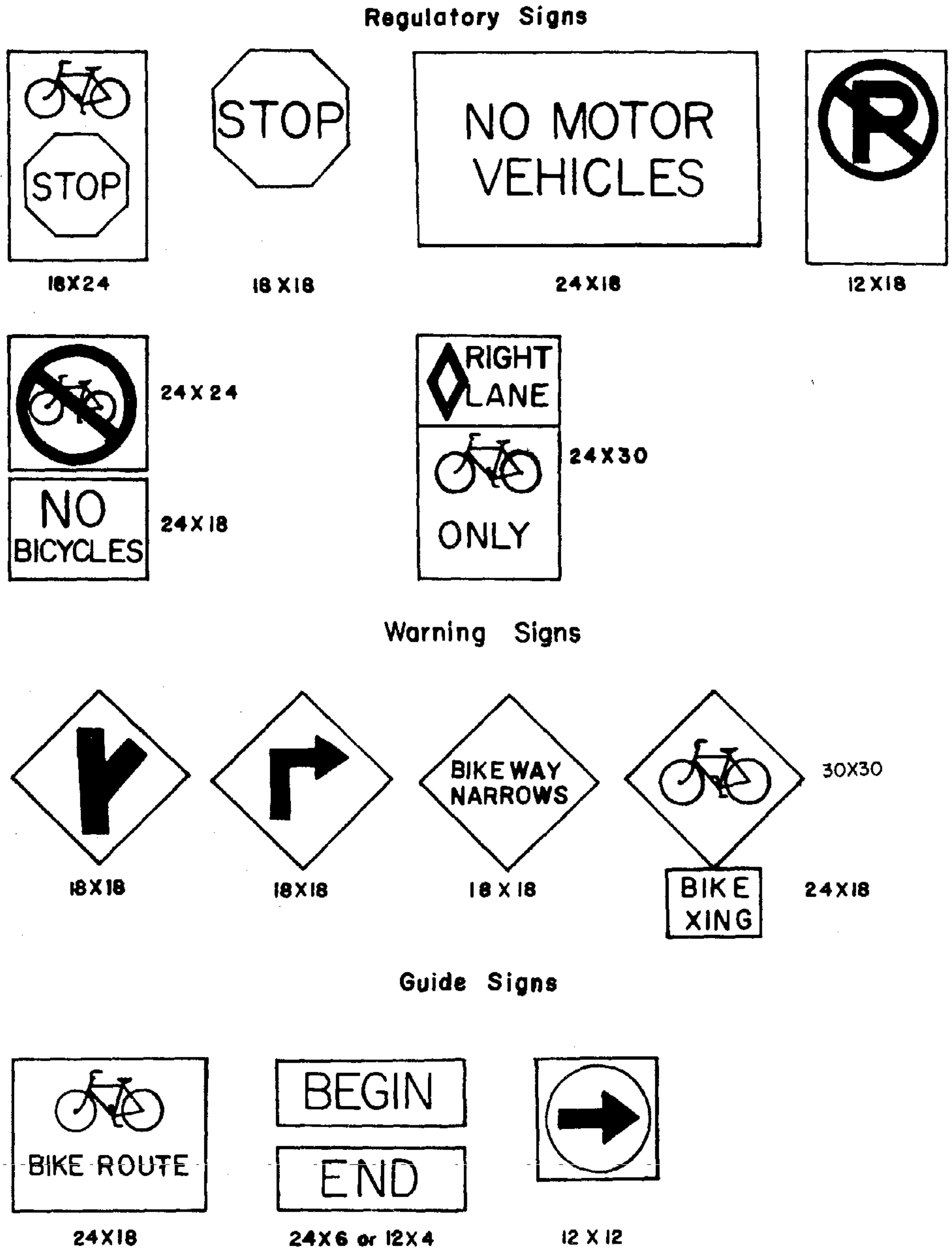


Figure D-2 Bike Signs

signs should be placed sufficiently in advance of the conditions to which they direct attention for bicyclists to take appropriate action.

Although warning signs are of great value to the vehicle operator, their use should be kept to a minimum to avoid possible breeding of disrespect due to overuse. Useful types of warning signs are illustrated in Figure D-1, page 59.

Generally, on Class II and III bikeways, existing roadway signs are sufficient. Unexpected or unique situations to cyclists may require additional warning signs. Examples of additional signing are presented in Figure D-3, page 62.

On Class I bikeways, signing location principles should follow normal highway procedures. Recommendations concerning the signing of the beginning and end of a Class I bikeway are shown in Figure D-4, page 63.

D.3.4 GUIDE SIGNS

Guide signs provide directional, route, recreational, destination and roadside service information to orient and assist users. Guide signs are placed where needed to keep users well informed as to their route's destination and continuity. Typically, guide signs are of most value to the unfamilar bicyclists who do not use the route regularly. Standard guide signs include the BIKE ROUTE sign, supplementary message plates BEGIN, END and TO, and directional plates with a variety of arrow designations.

D.3.5 CONSTRUCTION SIGNS

Construction signing falls into the same three categories as do other signs. No special construction signs have been developed for bikeways and those used for motor vehicles are satisfactory for bikeway application.

D.4 PAVEMENT MARKINGS

Pavement markings are employed both to reinforce signing and to provide a communication. Pavement markings are particularly useful for informing the bicyclist, since they are more directly in the cyclist's normal cone of vision than are signs.

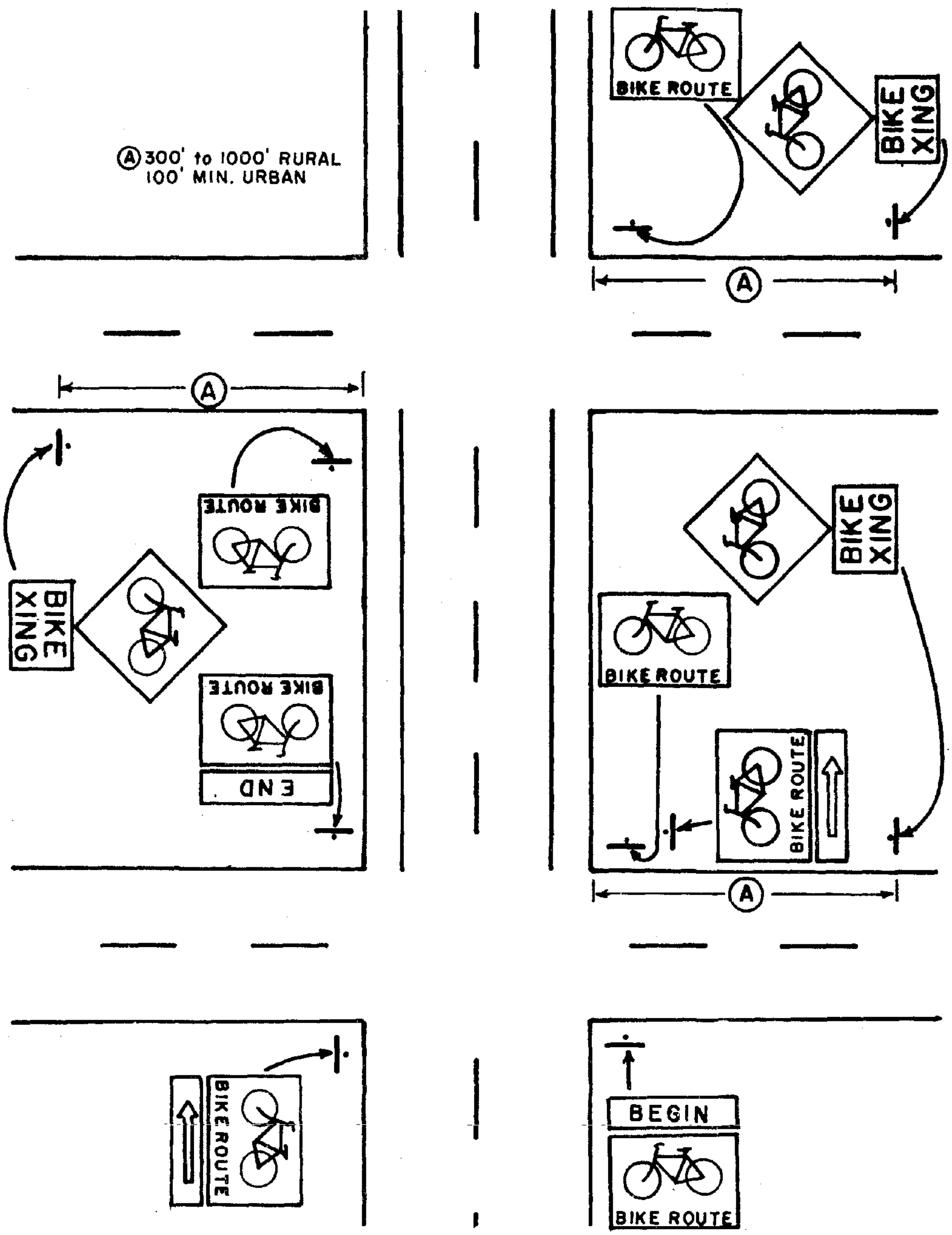


Figure D-3 Class II & III Bikeway Signing

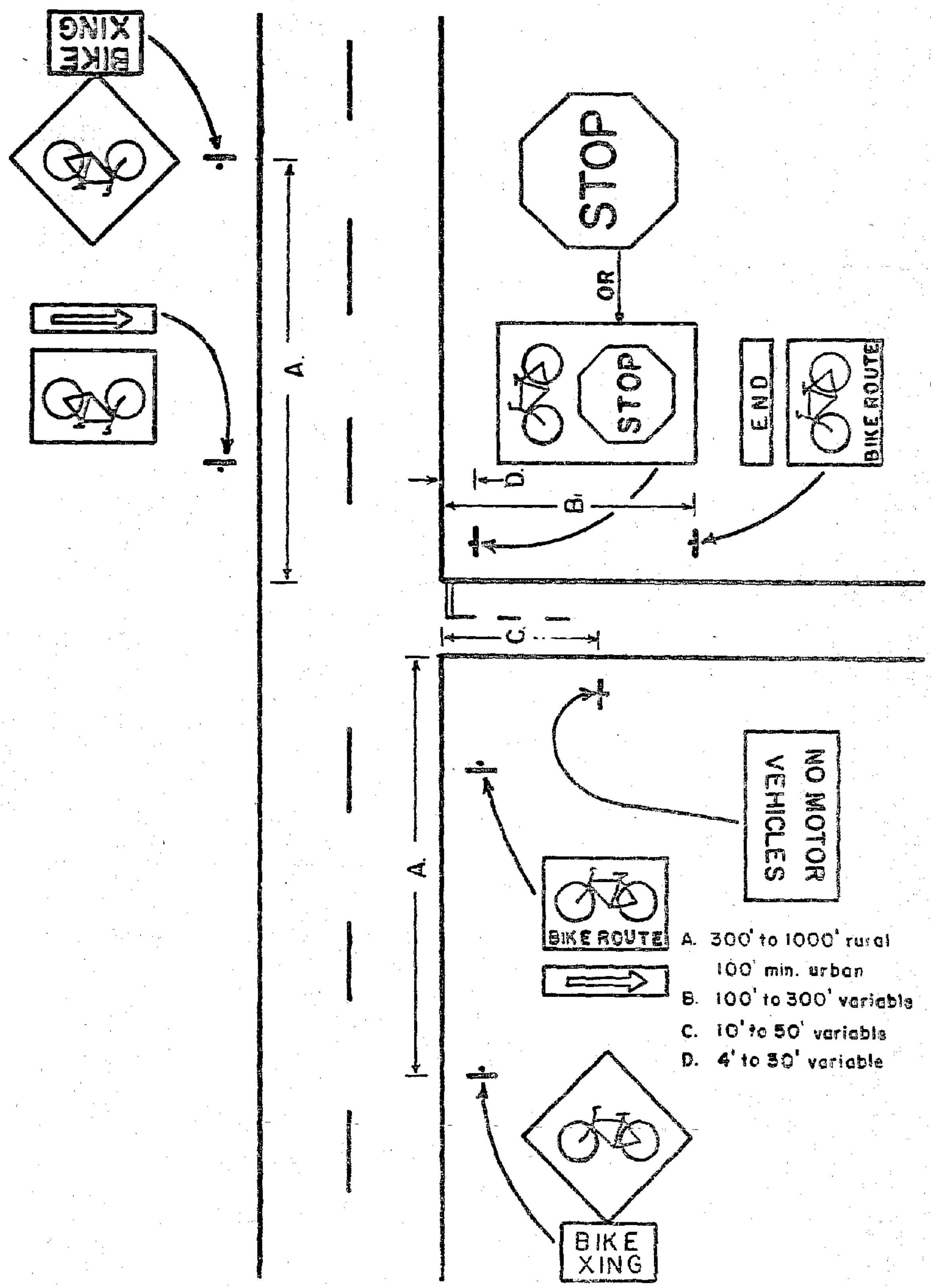


FIGURE D-4 CLASS I BIKEWAY SIGNING

Pavement markings employ various colors, widths, and longitudinal and transverse patterns to provide the cyclist with needed information, and aid in his safe progression.

D•4•1 COLORS

"User Manual Volume II," presents the following comment concerning color:

> "The standard color for bike lane-related pavement marking is WHITE. Numerous jurisdictions have experimented with a wide variety of line colors hoping to increase bike lane recognition. Many of these had poor visibility characteristics and have proven inappropriate. Recently, the National Advisory Committee on Uniform Traffic Control Devices denied request to designate an approved visibility color ('strong yellow-green') as a specific use color for bike lane markings."

However, other colors as listed in MUTCD are to be used for traffic oriented marking. They are:

- Yellow - Delineates the separation of opposing traffic lanes, including painted medians, as well as edge lines where an obstruction restricts use of the roadside as a safety refuge.
- Red - Delineates roadways that shall not be entered or used by the viewer of those markings.
- Black - May be used to give contrast to other colors when the pavement itself does not provide sufficient contrast.

D•4•2 LINE PATTERNS

Broken lines are permissive in character. A broken line is formed by line segments and gaps, usually in the ratio of 3:5. On bicycle facilities, a recommended standard of 6' (1.83 m.) segments and 10' (3.05 m.) gaps is suggested. Dotted lines are formed by short segments normally 2' (.61 m.) in length, and gaps normally 4' (1.22 m.) or longer.

Solid lines are restrictive in nature. Depending upon the type used, they can indicate where crossing of the line is prohibited, or where crossing requires caution.

Width of the line indicates the degree of emphasis. A normal line width is 4" to 6" (10.16 cm. to 15.24 cm.) wide. A wide line is usually twice the width of a normal line.

On facilities where there is joint use by both motor vehicles and bicycles, all markings should be reflectorized. Either reflective paint or inlaid markers is recommended.

D•4•3 LANE LINES

On Class I bikeways all lane, edge and center lines should follow normal highway practice. Combined Bicycle-Pedestrian facilities may have the bicycle use space and pedestrian use space delineated by a solid white line.

On Class II Bikeways a single, solid white line provides delineation between the bike lane and motor vehicle travel lanes. Occasionally a second lane line is employed to separate the bike lane from a parking shoulder. This also should be a single, solid white line. Solid white lane lines should normally be used at intersection approaches, however, broken lines may be employed to indicate mixed traffic is desired. Figure D-7, page 72, illustrates lane line applications.

Infrequently, on very wide bicycle routes, two or more lanes for bicycles traveling in one direction may be provided. These lanes should be separated by a broken white line.

D•4•4 TRANSVERSE LINES

Transverse lines include word and symbol markings, stop lines, crosswalk lines, and parking space markings. All transverse lines shall be white, except transverse median lines shall be yellow and transverse lines recognized only by traffic proceeding in the wrong direction on a one-way travelway shall be red.

Because of the low approach angle at which pavement markings are viewed, it is necessary for all transverse lines to be proportioned to give visibility equal to that of longitudinal lines, and to avoid apparent distortion where longitudinal and transverse lines combine in symbols or lettering.

Stop lines may be desirable, or perhaps necessary, on bicycle facilities under certain conditions. These conditions include:

- Intersection of a Class I bikeway with a highway.
- Intersection of two Class I bikeways.

• Intersection of a Class II bikeway with a controlled intersection.

Stop lines should be used where it is important to indicate the point behind which bicycles are required to stop. They are normally used in conjunction with a STOP sign, traffic signal, officer's direction, or other legal requirement.

Stop lines are solid white lines, 12" to 24" (.30 m. to .61 m.) wide, extending across approach lanes. They should be placed no less than 4' (1.22 m.) from the nearest edge of the intersecting travelway.

D•4•5 WORD AND SYMBOL MESSAGES

Designated bicycle lanes adjacent to motor vehicle lanes, (Class II bikeways) should be provided with exclusive lane use symbols. These should include written messages, and appropriate signing indicating that the lane is for the exclusive use of bicycles.

Stenciled pavement message markings for bicycle facilities include the legend BIKE LANE supplemented by an arrow indicating direction of travel, such as shown in Figure D-5, page 67. A symbolic representation of a bike may be used to supplement the legend, but not used alone. Typically, this type of marking should be reserved for use on Class II bikeways. It is generally inappropriate for Class I and Class III bikeways.

The legend BIKE ONLY may be substituted for BIKE LANE if this message is consistent with local ordinance. Pavement legends should have minimum letter height of 4' (1.22 m.). This height is also a minimum for directional arrows. Longer arrows may be desirable to increase visibility and emphasize the need for proper directional travel by bicyclists. BIKE LANE and BIKE ONLY legends are best placed as the bike leaves an intersection. Midblock placements may be also indicated on long blocks (intersections over 600' [182.88 m.] apart) or downstream of commercial driveways.

Legends BEGIN and END can be added to the BIKE LANE marking. They should be reserved for points of real termination and discontinuity, not placed at every intersection as a matter of routine.

The legend BIKES together with an appropriate directional arrow is used for marking special directional bike turning lanes. Other pavement message markings which may be appropriate along bicycle facilities include STOP, YIELD, PED-XING, SLOW and RR-XING.

Care should be taken to avoid placing pavement markings on critical stopping surfaces and to limit markings to those which are realistically needed.

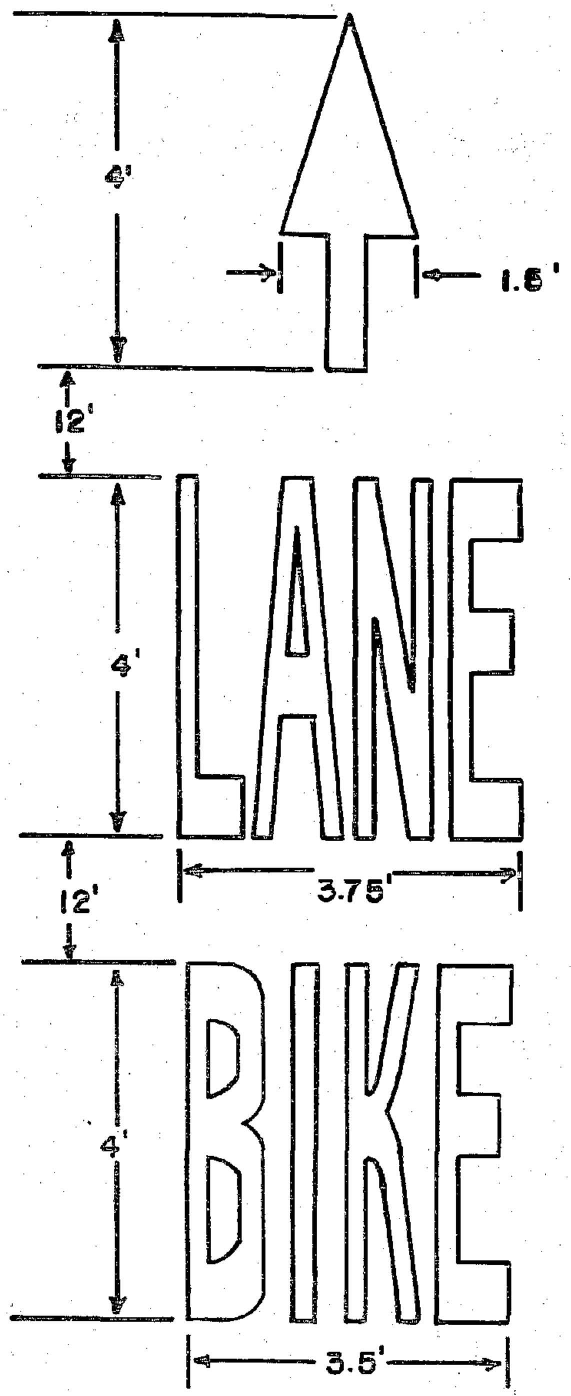


Figure D-5 Class II Bikeway Lane Marking

D•4•6 HAZARD MARKINGS

Vertical barriers and obstructions, such as abutments, piers, parallel bar storm drain grates and other features causing bikeway narrowing or shy distance construction, should be clearly marked to gain the attention of the approaching cyclist. This treatment should only be used in unavoidable circumstances, and is by no means a substitute for good bikeway design. An example of hazard marking is shown in Figure D-6, page 69.

D•5 INTERSECTIONS

When two or more highways are intersecting, vehicle right-of-way must be determined and assigned. In addition, many possible turning movements must be accommodated, which result in numerous potential points of conflict. The introduction of the bicyclist into this environment compounds the situation. Various signing and marking configurations are shown in Figure D-3, page 62, and D-7, page 72.

Care therefore must be taken when applying bicycle related traffic control devices at intersections to assure that they meet the five basic requirements (see Section D•2•1). Regulatory devices must meet the additional requirement of being supported by appropriate laws or other legal authority.

D•6 TRAFFIC SIGNALS

Contemporary bicycle volumes rarely justify signal installation. It has been determined that when applying normal traffic signal warrants to a given intersection containing Class II or III bikeways, bicycles should be counted. Where a sidewalk bikeway is located at a given intersection the bicycles should be counted as pedestrians. Where large numbers of bicycles (greater than motor vehicle volume) use a "bicycle designated" minor street, control warrants relevant to a Class 1 bikeway crossing would be applied.

Intersection accidents involving bicyclists of types susceptible to correction by traffic control should be counted toward meeting standard accident experience warrants such as explained in MUTCD.

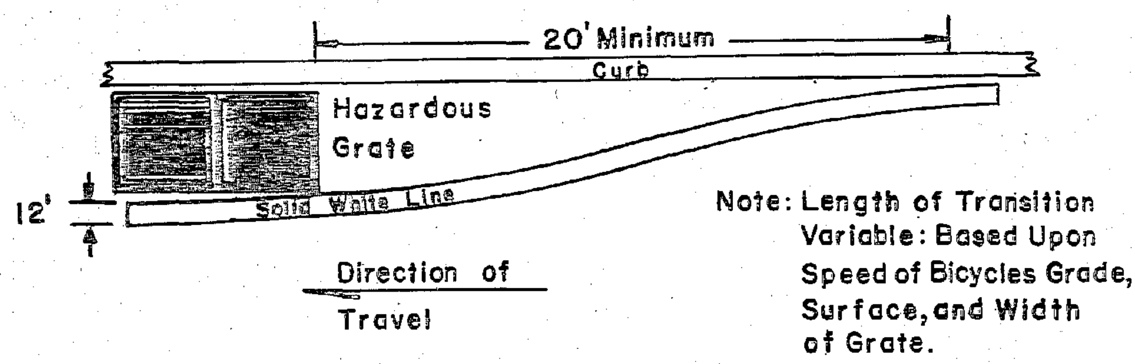


Figure D-6 Hazard Marking

D•6•1 INTERSECTIONS INVOLVING CLASS I BIKEWAYS

Signals may occassionally be warranted at the intersections of motor vehicle travelways and Class I bikeways. The determination of the need for such signals should be based on an engineering study of the adequacy of the bicycle crossing, with regard to the number and length of gaps in the motor vehicle traffic stream. Two possible warrants for the installation of a traffic signal at the intersection of a highway and a Class I bikeway may be derived from two existing signal warrants. These would be modifications of Traffic Signal Warrant No. 1, "Minimum Vehicular Volume" (MUTCD), and modifications of Traffic Signal Warrant No. 2, "Interruption of Continuous Traffic" (MUTCD). Modified warrants are expressed as follows:

Warrant 'A', Minimum Vehicular Volume

The minimum Vehicular Volume warrant is intended for application where the volume of intersecting traffic is the principal reason for consideration of signal installation. The warrant is satisfied when, for each of any 8 hours of an average day, the traffic volumes given in the following table exist on the major street and on the higher-volume bicycle route approach to the intersection.

Minimum Vehicular Volumes

Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)	Bicycles per hour on higher volume bicycle route approach (one direction only)
Major Street	Bicycle Route		
One	One	500	300
Two or more	One	600	300

These major street and bicycle route volumes are for the same 8 hours. During those 8 hours, the direction of higher volume on the bicycle route may be on one approach during some hours and on the opposite approach during other hours.

When the 85 percentile speed of major street traffic exceeds 40 m.p.h. (64.37 km/h), or when the intersection lies within the built-up area of an isolated community having a population of less than 10,000, the minimum vehicular volume warrant is 70 percent of the requirements above (in recognition of differences in the operational characteristics of traffic in urban and rural environments and smaller municipalities).

Warrant 'B' Interruption of Continuous Traffic

The Interruption of Continuous Traffic warrant applies to operating conditions where the traffic volume on a major street is so heavy that traffic on the intersecting bicycle route suffers excessive delay or hazard in entering or crossing the major street. The warrant is satisfied when, for each of any 8 hours of an average day, the traffic volumes given in the following table exist on the major street and on the higher-volume bicycle route approach to the intersection, and the signal installation will not seriously disrupt progressive traffic flow.

Minimum Vehicular Volumes

Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)	Bicycles per hour on higher volume bicycle route approach (one direction only)
Major Street	Bicycle Route		
One	One	750	150
Two or more	One	900	150

These major-street and bicycle route volumes are for the same 8 hours. During these 8 hours, the direction of higher volume on the bicycle route may be on one approach during some hours and on the opposite approach during other hours.

When the 85 percentile speed of major street traffic exceeds 40 m.p.h. (64.37 km/h), or when the intersection lies within the built-up area of an isolated community having a population of less than 10,000, the interruption of continuous traffic warrant is 70 percent of the requirements above (in recognition of differences in the nature and operational characteristics of traffic in urban and rural environments and smaller municipalities).

D•6•2 CLEARANCE INTERVALS

Bicycles can generally cross intersections under the same signal timing arrangement as motor vehicles. However, bicyclists may have difficulties crossing the signalized intersections of multi-lane streets if the clearance interval (amber interval plus optional all-red interval) is not of adequate duration. Where bicycle use can be expected, extremely short clearance intervals should not be used.

On streets with bicycle facilities (Class II and Class III bikeways) and on other streets carrying significant bicycle traffic, clearance intervals should be modified if necessary to provide a sufficient interval for bicyclists to clear the intersection. While this detracts slightly from the intersections traffic carrying capacity, it tends to increase overall (not just bike) traffic safety and is more realistic than the possible alternative: providing a separate signal head for bikes with an advanced yellow setting.

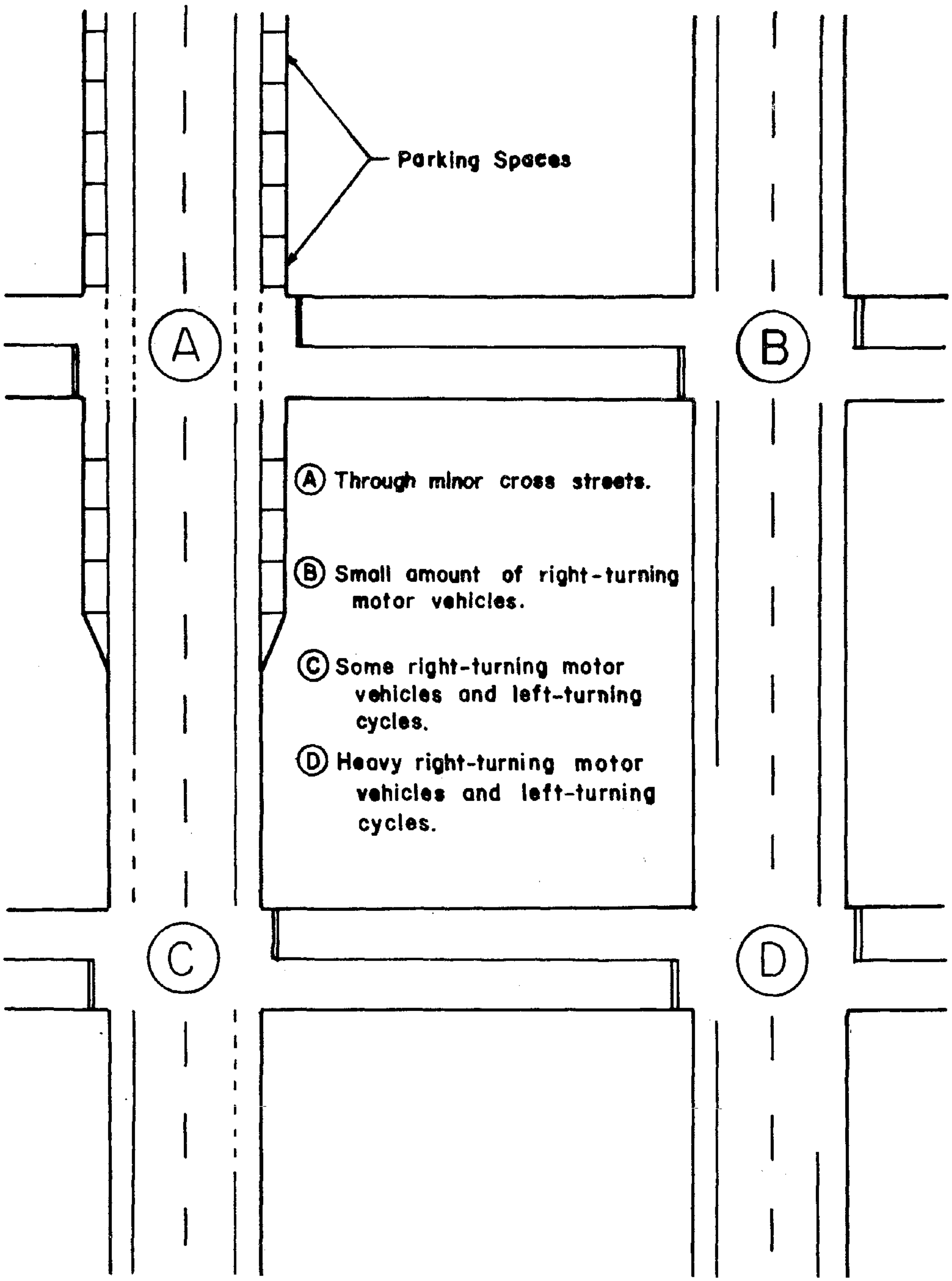


Figure D-7 Bikeway Intersection Marking

Clearance time required for bicycles should be evaluated as standard practice for each signalized intersection along a bikeway. A bicyclist speed of 10 m.p.h. (16.09 km/h) (14.7 ft/sec) should be utilized in the calculations. The number of seconds required to cross a street can then be determined. To this figure is added the amount of time necessary for the bicyclist to perceive, react, and brake to a stop without entering the intersection. Considering that the cyclist is in an "alerted" condition a combined perception/reaction time of one second is reasonable.

Evaluation for a 40' (12.19 m.) intersection being crossed by a bicyclist travelling at 10 m.p.h. (16.09 km/h) is as follows:

Crossing 40' (12.19 m.) wide street at 10 m.p.h.	2.7 sec.
Altered Perception/Reaction Time	1.0 sec.
Braking Time	0.8 sec.
	4.5 sec.
Allowable Bicycle Clearance Time	5.0 sec.

D·7 LIGHTING

Adequate lighting is necessary for safe operation of any bikeway where considerable nightime usage is anticipated. Lighting makes the cyclists visible to motorists and other cyclists, and keeps the cyclist aware of bikeway direction, surface condition, and obstacles. No specific warrants for installation of continuous lighting along bikeways have been developed. Some factors that should be considered in lieu of specific warrants are; present available lighting, extent of night usage by motor vehicles and bicycles, night accident records, night street crime, security needs and nature of the land use abutting right-of-way.

In residential and commercial areas where there is currently a significant volume of daytime cycle traffic, the installation of lighting will serve to increase usage.

D·8 MAINTENANCE

Absence of bikeway maintenance in a short time, causes absence of bikeway users. To properly maintain a facility there must first be consignment of responsibility; and second "What must be maintained and how?" must be decided. Responsibility can be contractual, governmental, civic or a combination of these. Since every improvement on the bikeway requires maintenance sometime in its life span, priority and frequency must be assigned to these needs.

D•8•1 RESPONSIBILITY

Each state, county and city government varies in their method of delegating responsibility for bikeway development. Likewise, after a facility is constructed responsibility for maintenance varies with each jurisdiction. One authority may contract for routine maintenance while another may relegate that phase to a responsible, concerned civic group such as a bicycle club or Boy Scout unit. Others may use the forces of an appropriate government agency.

Often, those assigned to bikeway maintenance fail to responsibly carry out the required tasks. As the bikeway becomes unsafe or unappealing cyclists seek alternate routes, find other recreation, or select a different transportation mode.

D•8•2 REQUISITES

Travelway litter, including broken glass or large pieces of gravel, is the most hazardous of problems demanding maintenance. Despite an abundance of trash receptacles and with anti-littering laws, most bikeways contain litter. Faulty drainage will deposit debris and inlet grates will become clogged with leaves and other trash. The interval between these necessary clean-ups should be periodically determined so that maintenance forces know when a bikeway will require attention.

Vegetation encroaching into the bikeway is not only a nuisance to cyclists, it is also a hazard. Arrangements for the removal of overhanging branches and adjacent growth should be scheduled similar to the aforementioned procedure for litter removal.

Other bikeway facilities such as signs, pavement markings, fixtures etc. require long range maintenance provisions to insure that the bikeway has user appeal and serves its original purpose.

D•9 BIKEWAY PROMOTION

Construction is finished. The bikeway is ready for public usage. Perhaps you already have the bikeway maintenance scheduled. But the "public relations," which is an integral part of successful bikeway development, has just begun. Until every publicity avenue has been utilized, the developer's project is not complete.

Avenues for bikeway promotion are as varied and numerous as imagination and skill can produce. As a Digest this Step merely presents major ideas which can be tailored to bikeway locale and the developer's resources.

D•9•1 CEREMONY

"Ground breaking" and "ribbon cutting" are newsworthy ceremonies when attended by VIP's and cycling enthusiasts. Maximal recognition for the bikeway facility is obtained at small cost using the ceremony procedure, particularly when the program is imaginative enough to arouse public interest.

D•9•2 MAPS AND PAMPHLETS

Put the bikeway on the map.

When available at appropriate locations, bikeway maps and pamphlets not only inform cyclists but can be designed to generate interest in the facility. Bikeway features, development history, planning and laws or regulations can be described along with a cartographic presentation.

Schools, libraries, recreation groups and youth organizations are just a few of many pamphlet distribution outlets that have potential interest in bicycling and bikeways.

D•9•3 USER RECOMMENDATIONS

Unless a recommendation is thought to be substantial, the public rarely comes forward with comments concerning a facility. However, since zealous cyclists have clubs or organizations, user recommendations are presented to authorities through those groups. Never bypass a formal suggestion from the public. Each submission should be conscientiously considered and the determination made known to the party submitting the comment.

Either as part of an origin-destination study or as a separate survey, bikeway users, motorists and pedestrians can be polled for information and comment concerning a planned or existing bikeway.

When active cyclists desire an improvement, interest should be given to their comments. Parking facility improvement or maintenance in their most frequent recommendation while other suggestions concern design, safety, law enforcement and restroom facilities among other improvements. Some "park and ride" terminals may have sufficient bicycle usage to warrant funds for weatherproof parking shelters or bicycle lockers which in turn could increase facility usage. Similarly, on a recreational bikeway comfort stations may be desirable and feasible.

D•9•4 VISUAL AIDS

Motion pictures, slide shows and posters effectively create interest in bikeway development and use. Bikeway facilities, bicycle laws and safety can be entertainingly displayed through this media. Understandably, the preparation and filming of motion pictures requires expertise not always available to bikeway authorities; however, the FHWA pamphlet on Federal-Aid shown in BIBLIOGRAPHY contains sources for prepared films and material which can be readily adopted for speaking programs or bicycling displays.

Film slides are the most economical visual aid type of promotion. They can be subjectively pertinent to a lecturer's program and professional photography is not a necessity. Civic organizations, schools and library groups are examples of potential interest in bikeway slide lectures.

Through subconscious acceptance by repetition, a poster will carry a message favoring bikeway use. BIKEWAYS NOW, as illustration, is only two words, but constant exposure initiates positive attitudes from the public.

D•9•5 "OFFICER FRIENDLY"

Many government authorities in recent years have found public relations value through assignment of a police unit as a direct link with the community. One frequently used name for the unit is "Officer Friendly."

A bikeway authority can promote facility interest wherever a police-community coordinator is available. Bicycle safety education is but one topic that "Officer Friendly" presents to groups although there may not be a bikeway facility in the jurisdiction. An existing bikeway or network can become a tool for the liaison and at the same time usage promotion for the developer.

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