# APPENDIX A: BICYCLE NETWORK DEVELOPMENT

## 1. Developing a Bicycle Network Plan

The methodology for developing the NRPC regional bicycle network involves identifying where bicyclists begin their trips, the destinations they want to go to, and recommendations for the suitable routes that will get them there. The methodology also involves establishing minimum standards for all streets and highways where bicyclists are permitted. This will ensure that even the streets not on designated bicycle routes would have minimum accommodations for bicyclists.

## 2. Major Bicycle Design Groups

The major bicycle design groups must be considered during the network development process. The Federal Highway Administration classifies bicyclists into three categories to assist in the design of bicycle facilities[1]:

- Group A–Advanced Bicyclist:

These are experienced riders who can operate under most traffic conditions. Experienced bicyclists are best served by direct access to destinations via the existing street and highway systems as well as the opportunity to operate at maximum speed with minimum delays. They also prefer sufficient operating space on the roadway or shoulder to reduce the need for either the bicyclist or the motor vehicle operator to change position when passing. Group A riders should be anticipated and provided for on all roadways where bicycles are not excluded by statute or regulation, regardless of functional classification.

- Group B–Basic Bicyclist:

These are casual or new adult and teenage riders who are less confident of their ability to operate in traffic without provisions for bicyclists. Some will develop greater skills and progress to the advanced level, but there will always be millions of basic bicyclists. The basic bicyclist prefers comfortable and direct access to destinations, preferably on low-speed, low traffic-volume streets or designated bicycle facilities. They also prefer well-defined separation of bicycles and motor vehicles on arterial and collector streets or separated bike paths.

- Group C-Children:

These are pre-teen riders whose roadway use is initially monitored by parents. Eventually they are allowed independent access to the roadway system. They and their parents prefer access to key destinations surrounding residential areas, preferably on residential streets with low motor vehicle speed limits and volumes. They also prefer well-defined separation of bicycles and motor vehicles on arterial and collector streets or separated bike paths.

Group B and C riders value many of the same roadway characteristics as Group A riders. They also value roadway characteristics such as designated bicycle facilities and lower traffic volumes. The recommended bicycle network should accommodate and encourage Group B and C riders. Group A riders will benefit from this network, as well as the establishment of the minimum road design standards mentioned earlier. The methodology for identifying suitable routes is therefore similar for all design groups.

[1] Federal Highway Administration, *1994: Selecting Roadway Design Treatments to Accommodate Bicyclists*

## 3. Major Types of Bicycle Facilities

The design of the bicycle network will affect the level of use and the types of cyclists that will be attracted. The network will consist of the following types of AASHTO facilities:

- **Shared Roadway (no official bikeway designation):** Most bicycle travel in the United States now occurs on streets and highways without bikeway designations. In some cases, the existing street system is fully adequate for bicycle travel and no signing or striping is necessary. In other cases, the roadway could be completely inadequate for biking and it would be inappropriate to encourage bicycle travel by adding such a designation. There are also many rural highways and roads in the NRPC region. In most cases, bicycle facilities in rural areas should only be designated with signs or striping where there is a need to indicate a connection with other designated routes. However, the development and maintenance of 4-foot paved shoulders and 4-inch wide edge stripes can significantly improve the comfort level of bicyclists along such routes.

- **Signed Shared Roadway:** Signed shared roadways are designated by bike route signs, but do not have pavement markings. They serve to provide continuity to other facilities or to indicate preferred routes through high-demand corridors. Signing of shared roadways should indicate to bicyclists that particular advantages exist to using these routes compared to alternatives. They mean that action has been taken to ensure that these routes are suitable as shared routes and will be maintained in a manner consistent with the needs of bicyclists. Signing also serves to alert motorists that bicycles are present. Signed routes are typically installed on quiet, residential, local/collector streets. Such streets have a single lane in each direction, and daily traffic volumes in the range of 8,000 vehicles. Apart from 'bicycle route' signs, there are no physical changes made to the roadway.

- **Bike Lane:** Bike lanes are established with appropriate pavement markings and signing along streets in corridors where there is significant demand and where there are distinct needs that can be served by them. The purpose should be to improve conditions for bicyclists on the streets. Bike lanes are intended to delineate the right of way assigned to bicyclists and motorists and to provide for more predictable movements by each. They are approximately 4 feet wide. Motor vehicles are not allowed to drive, park or stand in a bike lane, but right turning vehicles can enter the lane at intersections to complete their turn.

- **Shared Use Path:** Shared use paths are bicycle and pedestrian facilities that are physically separated from the traffic flow of motorized vehicles. They should be used to serve corridors not served by streets or where wide utility or former railroad right-of-way exists.

## 4. Network Development Methodology

NRPC staff has developed a methodology for identifying the routes that should be recommended for inclusion in the region-wide bicycle network. The methodology has been designed to be used in a GIS environment and to be as quantitative as possible. The steps described below assume that demand for bicycle facilities is influenced by the location, type, and intensity of land use throughout the region as well as by the distribution of population. Factors such as directness, barriers, aesthetics and cost of improvements are also considered. The following six steps were used to develop the recommended NRPC regional bicycle network:

1. Identify and Quantify Trip Productions.
2. Identify and Quantify Trip Attractions.
3. Identify Desired Bicycle Travel Corridors.
4. Apply Suitability Index to Select Alternative Routes.
5. Evaluate Route Alternatives Using Performance Criteria.
6. Identify Recommended Projects.

The details of each of the above steps are described below.

1. Identify and Quantify Bicycle Trip Productions

The first step in developing the bicycle network is to identify where bicycle trips originate. This methodology assumes that a bicycle trip *originates* at the rider's place of residence. Destinations that include retail businesses, recreation areas, schools and the rider's place of employment also generate bicycle trips, but these are considered trip *attractions*.

The methodology uses GIS-based census block attribute data as well as generally recognized bicycle trip generation information to quantify where bicycle trips originate. NRPC staff developed "trip production rates" (Table A-1) that are applied to each census block group. The production rates are applied to the number of people in each of two different age groups. The age groups exhibit the characteristics of the major bicycle design groups that were described earlier. The number of individuals in each age group in each census block is totaled. The total number of individuals in each age group is then multiplied by the trip production rate for that age group. The result is the total number of bike trips produced in each age group in each census block. The number of trips from the two age groups are then added together and the result is the total number of bike trips for that census block. The resulting number of bicycle trips for that block can then be mapped.

**Table A-1: Bicycle Trip Production Rates**

| Major Design Group | Age | Bike & Walk |
|---|---|---|
| A, B | 13+ years | 3 trips/100 adults |
| C | For 0-12 years | 20 trips/100 kids |

2. Identify and Quantify Trip Attractions

The methodology assumes that bicycle trip attractions are the destinations that people travel to for work, shopping, social gatherings, recreation and other personal reasons. Trip attractions for commercial and retail businesses, offices, health care facilities, and public administration facilities are calculated using the number of employees per square foot of building floor area[2]. The NRPC database contains information about the number of employees at various types of businesses in the region. The number of square feet per worker is calculated using this data. Once the number of square feet of floor area is established a trip attraction rate can be applied and the number of attractions that are produced can be calculated (Table A-2a).

[2] U.S. Department of Energy; Energy Information Administration, *1995 Commercial Buildings Energy Consumption Survey.*

**Table A-2a: Bicycle Trip Attraction Rates (business)**

| | Suburban | Mixed-use Urban | Dense or Special Use |
|---|---|---|---|
| Commercial, retail, public admin, office, health care | 4 trips/mil.Sq.ft. | 8 trips/mil.Sq.ft. | 12 trips/mil.Sq.ft. |

The trip attraction rate for schools is different than for businesses. The Center for Disease Control and Prevention (CDC) estimates that 13% of all trips to school are by walking or biking[3]. The National Personal Transportation Survey estimates that walkers to school outweigh bikers by a 10-to-1 ratio[4]. The trip attraction rate for individual schools is determined by first calculating what thirteen percent of total enrolment is for that school. It is then possible to solve for the number of bicycle and pedestrian trips to that school by using the 10:1 ratio.

**Table A-2b: Bicycle Trip Attraction Rates (schools)**

| Type of School | Number of Trips |
|---|---|
| Elementary | Total enrolment x .13 x .09 |
| Middle | Total enrolment x .13 x .09 |
| High | Total enrolment x .13 x .09 |
| College | 2 per 1,000 students |

**Table A-2c: Bicycle Trip Attraction Rates (parks)**

| | Number of Trips |
|---|---|
| Parks | 30 (average) |

3. Identify Desired Bicycle Travel Corridors

Once bicycle trip productions (origins) and attractions (destinations) have been quantified it is necessary to identify "desirable" bicycle travel corridors. The corridors should connect the zones that *generate* a significant number of bicycle trips with the zones that *attract* a significant number of bicycle trips. It is assumed that people on bikes want to go to the same places as do people in cars, within the constraints imposed by distance, and that the existing system of streets and highways reflects the existing travel demands for the community. Desirable travel corridors therefore may be well represented by the traffic flow on the existing road system. It is true, however, that travel patterns of less experienced riders are influenced by their perception of the bicycling environment they face. Uncomfortable or threatening conditions will cause these bicyclists to alter their choice of route from the most preferred alignment[5]. It is therefore important to consider where bicyclists would ideally ride if they could go where they preferred because those ideal routes may not be the same as the routes that bicyclists currently use.

4. Apply Suitability Index to Select Alternative Routes

Bicyclists will ride on what they perceive to be "suitable" routes. NRPC staff has developed a GIS-based suitability index that helps to identify suitable (preferred) routes. The NRPC maintains a regional road network data layer as part of its GIS database. The suitability index is based on data that is included in

[3] Center for Disease Control data
[4] National Personal Transportation Survey, 1995
[5] U.S. Department of Transportation, Federal Highway Administration, Bicycle and Pedestrian Planning overview.

the attribute table of the road network. The attributes used for the suitability index are the speed limit, average daily traffic volume (ADT) and pavement width of the road segment.

For each segment of roadway the speed limit and traffic volume are multiplied together. The product of this calculation is then divided by the width of pavement for that segment. The resulting number is a relative measure of the suitability of that segment of roadway for bicycling. The higher the number, the less suitable the segment. This procedure can be applied to all of the road segments in the network. By doing so it is possible to graphically display on a map of the region the most suitable routes that connect various origins and destinations.

5. Evaluate Route Alternatives Using Performance Criteria

It is important to note that this methodology so far has depended on the accuracy of the GIS database to quantitatively identify suitable bicycle routes. It is possible that in the process a number of alternative routes that connect the same origins and destinations have been identified. At this point in the process it is necessary to apply more specific performance criteria in order to assure the desirability and effectiveness of the bicycle network. During this step it is necessary to field check the alternatives that were identified in earlier steps. The goal of this step is to identify the specific routes that best meet the following performance criteria[6]:

- **Accessibility**: This is measured by the distance a bicycle facility is from a specified trip origin or destination, the ease by which this distance can be traveled by bicycle, and the extent to which all likely origins and destinations are served.
- **Directness:** Studies have shown that most bicyclists will not use even the best bicycle facility if it greatly increases the travel distance or trip time over a less desireable but more direct alternative.
- **Continuity:** The proposed network should have as few missing segments as possible. If gaps do exist, they should not include environments that are threatening to B/C riders.
- **Usage:** This is the degree to which a specific route meets the needs of the anticipated users as opposed to an alternative route.
- **Asthetics:** The network should be physically atractive.
- **Safety:** The route should present few conflicts between bicyclists and motor vehicles.
- **Cost:** When comparing route alternatives, the cost of implementation as well as maintenance should be considered.
- **Ease of Implementation:** Some proposed routes may be easier to implement than others. For example, a potential bike route may already have adequate shoulders and therefore only require proper pavement markings. This route could be up and running in a relatively short amount of time. Other potential routes may need more extensive upgrading and could therefore take a relatively longer period of time to implement.
- **Local or Regional Route:** NRPC recommends that proposed routes be categorized into two major types; Regional routes and local routes. In many cases, the two types of routes will overlap.
- 6. Identify Recommended Projects

[6] U.S. Department of Transportation, Federal Highway Administration, Bicycle and Pedestrian Planning Overview.

Once all of the alternative routes have been evaluated and field checked, specific routes can be recommended. Since this is a regional bicycle plan, recommended projects will emerge based on the following priorities:

- Provide regional continuity and directness;
- Support current and/or potential use patterns;
- Complete bikeways identified in the regional bike corridor concept.

## 5. Summary of Bicycle Network Development Methodology

The methodology for developing the NRPC regional bicycle network involves identifying where bicyclists begin their trips, the destinations they want to go to, and the suitable routes that will get them there. This methodology has also described specific performance criteria that are intended to define the important qualitative and quantitative variables that need to be considered in determining which facilities and routes ultimately get included in the final network recommendations. Finally, this methodology involves establishing minimum standards for all streets and highways where bicyclists are permitted. This will ensure that even the streets not on designated bicycle routes would have minimum accommodations for bicyclists.