MANHATTAN BIKEWAY PLAN

by

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INTRODUCTION

The use of the bicycle in the United States is not a fad. The bicycle was used as a method of transportation long before the automobile became popular. The advent of the lightweight, multi-speed bicycle in approximately 1966 drastically changed the bicycle's image in America. Adults began to ride and the bicycle was no longer considered a child's toy. Since that time bicycle sales have increased at an astronomical rate, 13.7 million being sold in 1972 (12). The sales for the last 8 years parallel, and in some cases exceed, new car sales (see Table 1).

Although there has been this significant increase in the number of bicycles and users in the United States only a few communities have made provisions for them. This is not to say that there is not concern for the bicyclist. The government, for example, has provided funds for the development of bikeways. Still, the development of such systems is not meeting the needs of the bicyclist. The City of Manhattan is also showing concern in that there have already been two bikeway studies made although not adopted (4, 17).

Adults use bicycles for recreation, exercise, and transportation. Some ride because they want to do their part in protectiong the environment. The high price of fuel has encouraged many to ride, since 30% of the trips in the country is under two miles, well within the range of bicycle travel (12). The bicycle is used by the shopper for the bread, milk, and beer runs. Forty-eight percent of the shopping trips taken in this country take less than 6 minutes to complete (12). This would seem to indicate the quantity of merchandise purchased is small and could be carried on a bicycle.

Even though the bicycle is used extensively for shopping and recreation, the largest trip generators are the schools. Sixty-two percent (see DEMAND STUDY, A1) of the bicycle trips in Manhattan are to the University and the various schools. Many of the school riders are quite young, the youngest being eight or nine years old (most schools forbid younger children to ride bikes to school). Children are probably more likely to become involved in car-bike accidents than are adults due to their lack of familiarity with the rules of the road. Table 2 shows the relation of accidents, age group and percent of population. Notice that ages 5 through 14 have a high ratio of accidents per person. Better education of the young might reduce this figure. The next age group (15-19) are mostly high school students who, we have found, make very few trips by bicycle. The college-age people, while having some accidents, have significantly fewer per person than do children.

Table 1

NATIONAL BICYCLE AND AUTOMOBILE SALES (12)

Year	Bicycle Sales (Millions)	New Car Sales (Millions)
1968	7.5	8.8
1969	7.1	8.2
1970	6.9	6.5
1971	8.9	8.6
1972	13.7	11.0

Table 2

REPORTED CAR-BICYCLE ACCIDENTS AND AGE GROUPS*
MANHATTAN, KANSAS

Age	% of Population	Reported Accidents	Persons per Accident
5-9	7.1	3	656
10-14	6.8	4	470
15-19	11.2	0	0
20-24	25.1	6	1154
25-29	8.4	0	0

*Data taken from the 1970 Census and the Manhattan Police Department

SYSTEMS APPROACH TO THE PROBLEM

In studying this problem we have used a "Systems Approach" which is an organized method for solving an open-ended problem. The steps of the procedure are outlined below:

1. State the Problem
2. Research
3. Examine various elements of the problem
4. Generate alternative solutions
5. Evaluate alternative solutions and propose a final plan
6. Implement plan

These six steps represent the thought process behind the work which was done and, serve as an outline for the report.

STATEMENT OF THE PROBLEM

While a network of streets and roads has been built to accommodate vehicular traffic in Manhattan, it only marginally provides for bicycles. This situation causes considerable conflict between the two modes of transportation. Conditions such as the "energy crisis", inflation, and environmental awareness will tend to cause bicycle usage to increase. These conditions plus the fact that bicycle numbers have been increasing lead us to believe that bicycles are not only here to stay, but that there probably will be more in the future.

Three likely solutions to the bicycle-auto conflict are: (a) Restrict bicycles from the streets, (b) provide a bicycle system which will allow the two modes to coexist with a minumum of conflict, or (c) leave the situation as it is at present. The first solution was rejected as it limits the modal choices available to the citizens, and may be a hardship on young people and poor people who can most benefit from bicycle travel. The third solution is suitable only when there is not enough demand to warrant the expenditure necessary to implement a bikeway system.

Our problem, then, was to evaluate the need so that a decision could be made between providing or not providing a bikeway system. We feel that we have found enough need to warrant a bikeway system and have therefore proposed a system to meet these needs.

RESEARCH

A considerable amount of background research was accomplished prior to the time we presented our proposal (see Appendix E). This work continued throughout the project both to provide the necessary background upon which a practical design could be based and to guide the direction of the Demand Study.

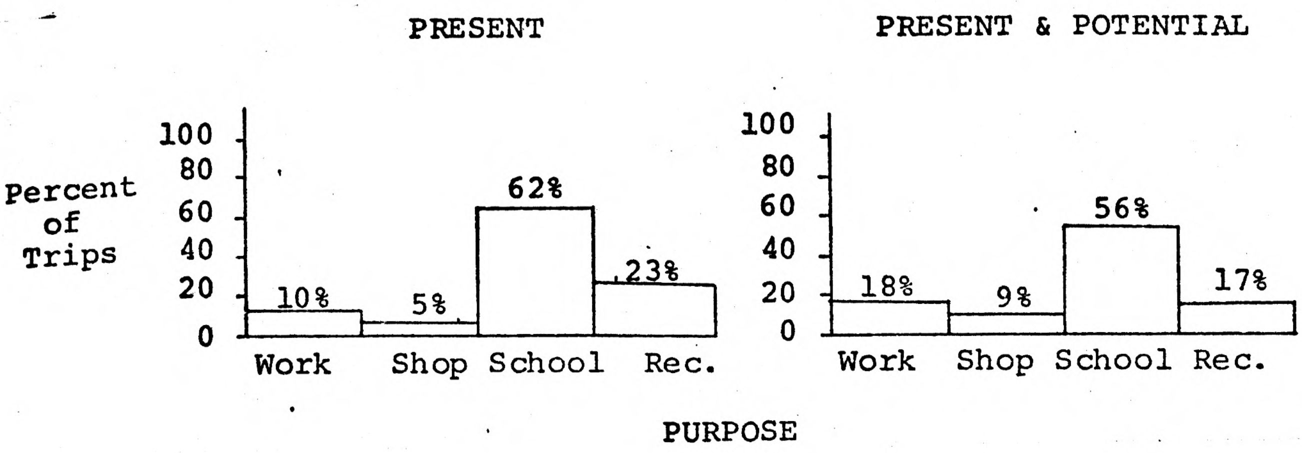
Demand Study

A survey was conducted to determine needs and desires of the people in Manhattan for a bikeway system. The survey was of the origin-destination type which is commonly conducted for other modes of transportation. A complete discussion and analysis of the survey can be found in Appendix A.

The survey indicated that bicycles are used in Manhattan on a typical work day as a means of transportation. Some 7,000 trips are made per day at present. The trips per day would probably grow to 10,000 soon after installation of a bikeway system. The 3,000 estimated additional trips are based on the trips people indicated they would take if a facility were available.

Bicycle users and automobile drivers alike indicated a desire for bikeways. With 84% of the people questioned indicating they want bikeways, one has a clear indication of approval by the citizens. In addition, it was established that a $3.00 annual fee would be considered reasonable if it were used to build and maintain bikeways. A user tax of this nature would provide a considerable amount of revenue, $36,000 annually, if no other city funds can be made available.

The following table shows the distribution of bicycle trips by purpose:



Clearly, most trips are for the purpose of going to school, both university and public. This would imply that a proposed system should serve the schools in our area. The next highest number of trips are for recreational purposes. The recreation, however, is not necessarily bicycling. Approximately 96% of the bicycle trips surveyed had some specific destination. With the addition of the potential trips to the present trips the relative proportions change showing the largest percentage increase is for the purpose of work. Shopping trips would increase also.

Bicycles are used by people of all ages. Further, all age groups indicated they would make more bicycle trips if facilities were available. These new bicycle trips would come principally from the automobile trips and would therefore reduce auto congestion. The total number of present bicycle trips represent approximately 14% of the auto trips.

The average bicycle trip length was established at 1.03 miles. Approximately 90% of all bicycle trips were under two miles. Studies conducted in other cities (13) have also indicated that bicycle trips tend to be short in nature. From this it is clear that biycles are used principally for short trips and that the reduction of automobile trips mentioned above would be short automobile trips, i.e., auto trips less than 2 miles.

The number of zone-to-zone trips for each zone were obtained from the survey data and plotted on a city map as desire lines (See Figure 1). From this map it is clear that bicycle activity centers around the university. The three zones which attract the most bicycle trips are the university, zone 15; "Aggieville," zone 32; and the downtown area, zone 47.

Financial Justification

In order to warrant the implementation of any traffic system, there must be shown, with good reason, that the system is safe, efficient and financially justifiable. While almost everyone will agree that the bicycle is a more economical method of transportation than the automobile, there still remains the question of whether the benefits of a bikeway system in Manhattan will actually exceed the cost of implementing such a system. To answer this question let us look at a benefit-cost ratio for such a system in Manhattan. According to a recent study on bicycle travel (12), the trips made with the bicycle would save the individual approximately 6¢ per mile (as compared to making the same trips by car). Taking the number of potential bicycle miles per day to be 3,791 as determined by the Demand Study (See Appendix A), the savings per day would amount to $278.00. Assuming that most bicyclists would not ride their bicycles on days which the average temperature dropped to 40°F or below, the bicycle season in Manhattan would be approximately 8.25 months long (See Figure 2). Since there will be inclement weather (rain, drizzle, etc.) on approximately 4.2% of the days in this bicycle season (14), the number of days on which bicycles would actually be ridden during the year would be 251. Multiplying this figure by the amount saved per day, $278.00, would give the amount saved during the year by bicyclists, $54,000.00. This is the amount that the city can justifiably spend on a bikeway system in one year. Spending this, $54,000.00, during the year would give a benefit-cost ratio of one, the mini-

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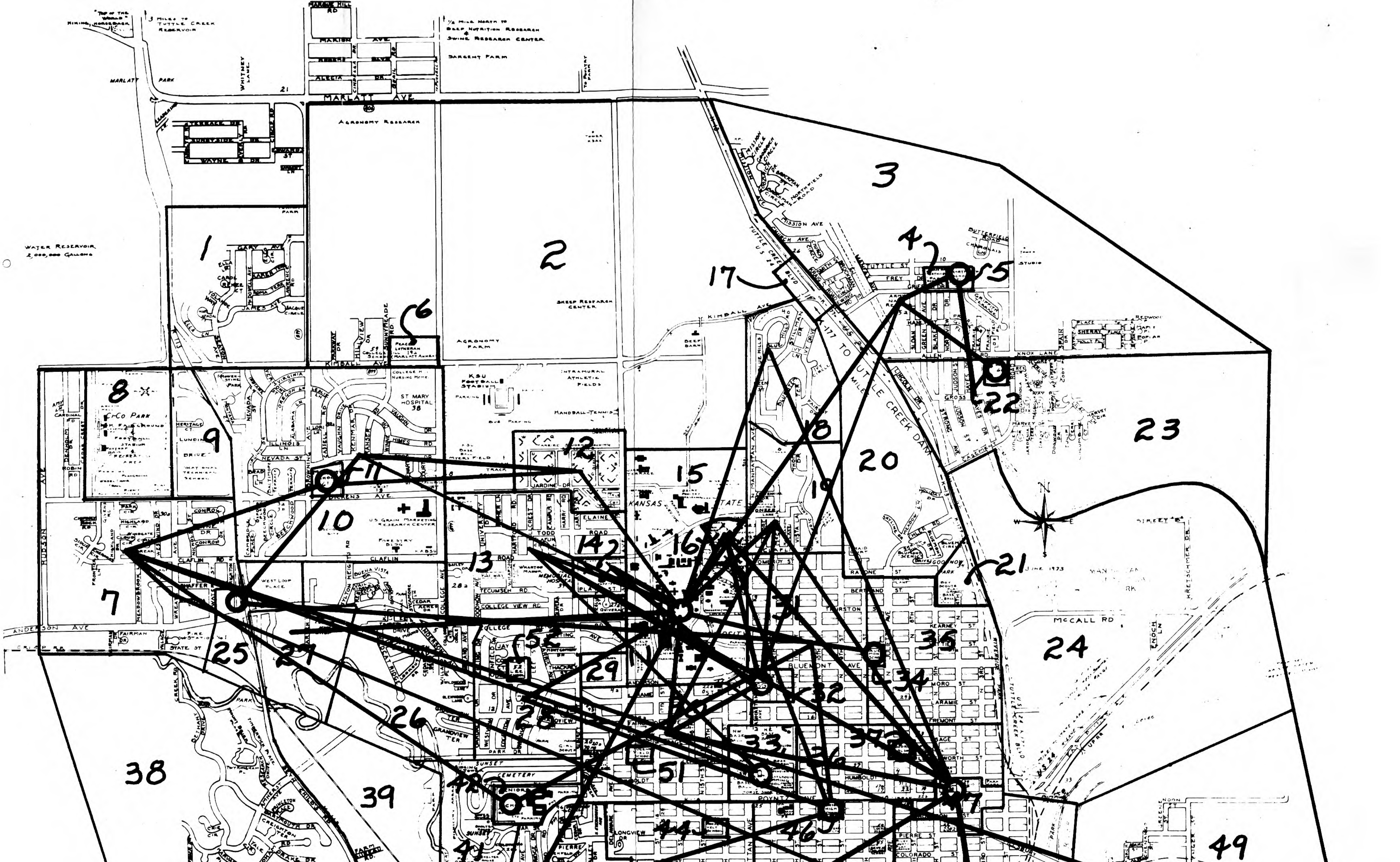
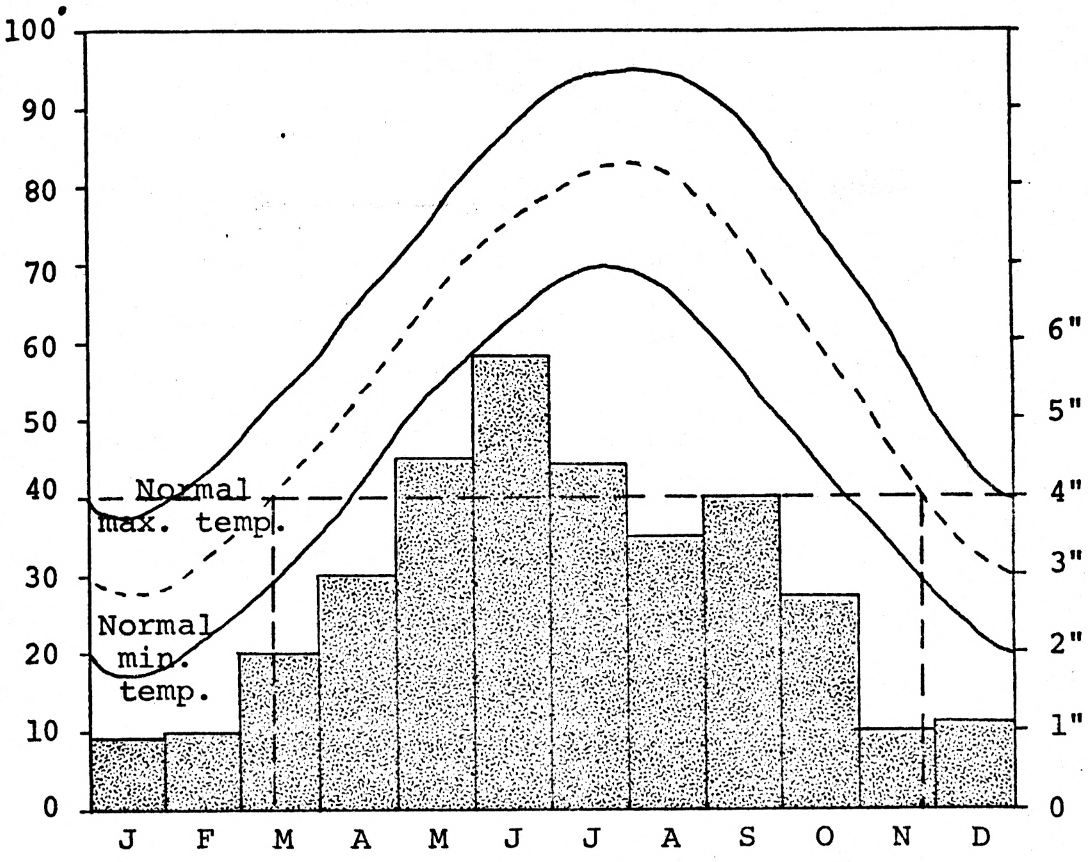


DESIRE LINES

Figure 1



Normal Temperature & Precipitation

Figure 2

mum acceptable value.

Many cities have found that they reduced bicycle-car accidents after installing a bicycle system. This is clearly a benefit, but without before-and-after figures we hesitate to speculate on specific values. We mention it here for the intrinsic value of the thought alone. Another benefit is the reduction of mental stress caused by conflicts between bicycles and motorists when operating on the same street. This is indicated by the fact that cities with bikeway facilities have found that both their motorists and bicyclists like the bikeways and would like to see more (10). Although values are not placed on these benefits, they would tend to increase the benefit-cost ratio.

Decision: Design Bikeway

At this point we have shown that there is considerable desire and need for bikeways in Manhattan. Further, we have shown that approximately $54,000.00 could justifiably be spent per year to provide a bikeway system. Therefore, we decided to design a bikeway system and to recommend phased construction of the system to keep the annual cost within reasonable limits.

ELEMENTS OF BIKEWAYS

Before we could separate a bikeway system into logical parts we had to define precisely what we meant by a bikeway. We feel that the following definition fully describes a bikeway system.

Definition: A Bikeway System

A bikeway system consists of the bicycle rider, his vehicle, the facility he will function in, and the body of regulations which will allow him to function in the system with a minimum of conflict between himself and fellow travelers. The bicycle rider must be able to operate his vehicle with enough skill to perform the turning and stopping maneuvers which will be necessary on the facility. Further, he must have a knowledge of the laws which apply to him and his interaction with other vehicles. Auto drivers have been required to demonstrate a reasonable level of competence in these matters for years. The vehicle should be in a reasonable state of repair so that the rider can perform all necessary maneuvers. The bicycle should be visible at night for both the safety of the bicyclist himself and other travelers, whether bicyclist or auto driver. The bicycle facility should meet the needs of the rider himself. It must provide direct, safe, and efficient routes which are capable of meeting the demand level of usage.

All supporting facilities and functions necessary for the proper operation of the bicycle system should be considered part of the system. In the broad sense this would include parking facilities, maps, an education system, licensing, regulations, regulation enforcement, etc. To have a good bicycle system, all of the parts of the system must function well and must be planned to work well together.

This definition shows the bikeway system to be made up of basically four interrelating parts: the rider, the bicycle, the bicycle lane or trail, and supporting facilities and functions. The following sections discuss various aspects of these four parts and recommend modifications and additions which should be implemented to form a complete bikeway system in Manhattan.

Enforcement

In all traffic systems, there exists a problem of the enforcement of ordinances and laws. A bikeway system is no different in this respect. Ordinances and regulations regarding bicyclists and bikeway facilities warrant enforcement. Such enforcement of laws and ordinances can serve as a means of insuring a safe system, and can also aid in bicycle theft prevention and recovery.

The one agency in Manhattan which seems to be best equipped to carry out an enforcement program is the Riley County Police Department. With this in mind, it seems fairly obvious that full responsibility for the enforcement and the administration of the bicycle ordinances and regulations should rest with this agency (in the case of the K.S.U. campus, responsibility should rest with the Campus Police). The importance of enforcement should be stressed to the officers of both agencies.

Lincensing and Education

The responsibility for licensing bicycles and for educating the bicyclists could probably best be met if a single agency or organization administered these programs. The licensing program should include the registering of bicycles, the issuing of licenses, the collecting of licensing fees, and bicycle safety checks (See Appendix D, Legal Considerations). In addition bicyclists and motorists must be made aware of the bikeways and the ordinances which pertain to them. This may be accomplished through the newspaper, radio, and the distribution of free literature and maps.

The distribution of literature on bicycle ordinances and the location of bikeways is in itself an indirect form of education. In addition to this a program of direct bicycle education should be conducted. It should include presentations to civic groups when requested and regular visits to schools. Topics should include riding techniques, safety, regulations, etc. (See Appendix D, Education).

In order to insure that these programs are carried out, we feel that $1.00 out of the proposed licensing fee should be designated for this purpose. This should provide a sufficient amount of funds to pay a full time employee who could perform all necessary functions and administrative duties.

Several of the agencies within the city and county are capable of administering this portion of the bikeway system. In our opinion, however, the best agency to administer the above program would be the Riley County Police Department. If the licensing and education programs are conducted by a member of this agency, it should have the added effect of increasing the awareness, within the agency, of the ordinances pertaining to the bikeway system and the importance of enforcing them.

<u>Bikeway Ordinances and Regulations</u>

In order for a bikeway system to operate safely and efficiently in the City of Manhattan, a uniform code of bicycle ordinances and regulations must be written, implemented, and enforced. At the present time, Manhattan has some ordinances pertaining to bicycles (See Appendix D). These ordinances are few in number, and not enforced to any great extent. In order to keep pace with the proposed bikeway system, these ordinances may need to be altered and new ones written.

Bicycle laws and ordinances which are difficult to interpret and comprehend can cause problems with adherence and enforcement. Therefore, all amended and new ordinances should be of a nature so as to avoid this problem.

Some of the ordinances which we feel should be adopted concern the restriction of motor vehicles from designated bicycle lanes and trails; bicycle parking; the bicyclists adherence to traffic laws, i.e., stopping at stop signs, yielding right-of-way; licensing; and bicycle equipment requirements, i.e., headlights, reflectors, brakes. These ordinances and others will be instrumental in providing a safe environment for bicyclists, motorists, and pedestrians, alike. A complete list of recommended ordinances can be found in Appendix D.

Bikeway Criteria and Guidelines

The network of bicycle routes which will be designed should be thought of as bicycle arterials. They should function in the same manner as arterials for the automobile transportation system and should carry the majority of bicycle traffic in the city. Local streets will function as connecting links between abutting property and arterial streets just as they do for automobiles.

In terms of moving volumes of traffic, arterials are considered more important than local streets. They are, therefore, given priority over local streets and signed to give the right-of-way to vehicles on the arterials. This same logic should be employed for bicycle arterials. Bicycle arterials, however, should be considered subordinate to automobile collectors and arterials in most instances.

In our study of a bikeway system for the City of Manhattan, Kansas, we have ultimately considered three types of bicycle facilities. The three types are: A bicycle trail, which is a separate path used exclusively by bicycles; a bicyle lane, which is a designated portion of the roadway used exclusively by bicycles; and a shared roadway, which is a roadway that is officially designated and marked as a bicycle route, but which is also open to motor vehicular travel.[1]

Designing any type of bikeway facility requires that certain criteria and guidelines be established and adhered to throughout the design of the facility. Bicycle paths may be specifically designed to satisfy the physical characteristics of the bicycle mode of transportation. Shared roadways and bicycle lanes design criteria may be influenced to a large degree by the characteristics of facilities designed mainly to accommodate other transportation modes. Many of these characteristics are acceptable, while others present the bicyclist with a less than adequate riding environment.

The criteria and guidelines that we set forth to use in our actual design of the facility are an accumulation of criteria that were gathered in the earlier study of other bikeway facilities. These criteria are what we feel should be used in the design of the Manhattan bikeway system. The criteria cover such important aspects as drainage, lighting, design speed, radius of curvature, grade, surface, signing, markings, location, safe sight distances, widths, clearances, and intersections. These guidelines are discussed at length in Appendix B.

Some of the general guidelines that we feel should be adhered to are as follows: All facilities in any one direction should be two lanes wide to provide a passing lane which insures safety and ease of maneuverability; conflicts with vehicular and pedestrian traffic should be avoided if at all possible; all facilities should be readily accessible to bicyclists.

Almost all of the criteria in Appendix B are concerned with the safety of the bicyclist and the efficient operation of the entire bikeway system. These

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[1]Note that in some instances, it may be necessary (though not preferred) to implement a bike route on existing sidewalks.

standards should be adhered to as strictly as possible.

Parking

Bicycle racks are an integral part of the bicycle system. The bicycle racks serve three main purposes: First, to prevent damage to the bicycle; second, to aid in the prevention of theft (3); and third, to avoid conflicts between parked bicycles and pedestrian traffic. Racks should be provided at all major collectors.

Bicycle racks will need to be installed as part of Phase I in the downtown area, Aggieville, the City Park, and CICO Park. The University and the schools, in most cases, already have adequate racks. For the present we recommend parking for 160 bicycles downtown, 110 bicycles in Aggieville, and 50 bicycles in the City Park. CICO Park should be monitered during the summer months to establish its requirements for parking facilities. Specific bicycle rack locations are indicated in Appendix D.

PROPOSED PLAN

The bikeway system proposed for the City of Manhattan is designed to accommodate all types of bicycle travel. This system has bike routes for those bicyclists who use bicycles as a primary means of travel. These routes should, therefore, be designed to meet the requirements of these bicyclists. Routes which we feel will best meet these requirements are routes to the University, to the local grade, junior, and high schools, and to many of the business areas in town. The bikeway system will not only be used by commuters, but by recreationalists. Therefore, the routes should provide access to the city's recreational areas and parks (including the future Linear Parkway System). Figure 3 shows the complete bikeway system. More detailed information is presented in Appendix C.

The complete system would be a major project if attempted all at one time. Phased construction will allow the system to be constructed over a period of years and thus lessen the impact on the city budget. The phases have been selected on a present need basis. The first phase includes the routes where the need is greatest. Phase I (See Figure 4) links the three major centers of bicycle activity; the University, downtown, and Aggieville. Further, it provides routes to some of the city parks, as well as some of the public schools.

The second phase will expand on the first phase and encompass more of the city (See Figure 5). It will add routes to the system which are needed, but for which there is less demand than those in the first phase. More public schools are linked to the system. This should help provide for the students who would like to ride bicycles to school. The third phase will continue to expand the system around the city and the outskirts of the city. This phase includes the proposed recreational route through the future "Linear Park System" which was recommended by the City Planning Department (4). It should provide the city with an excellent recreational route.

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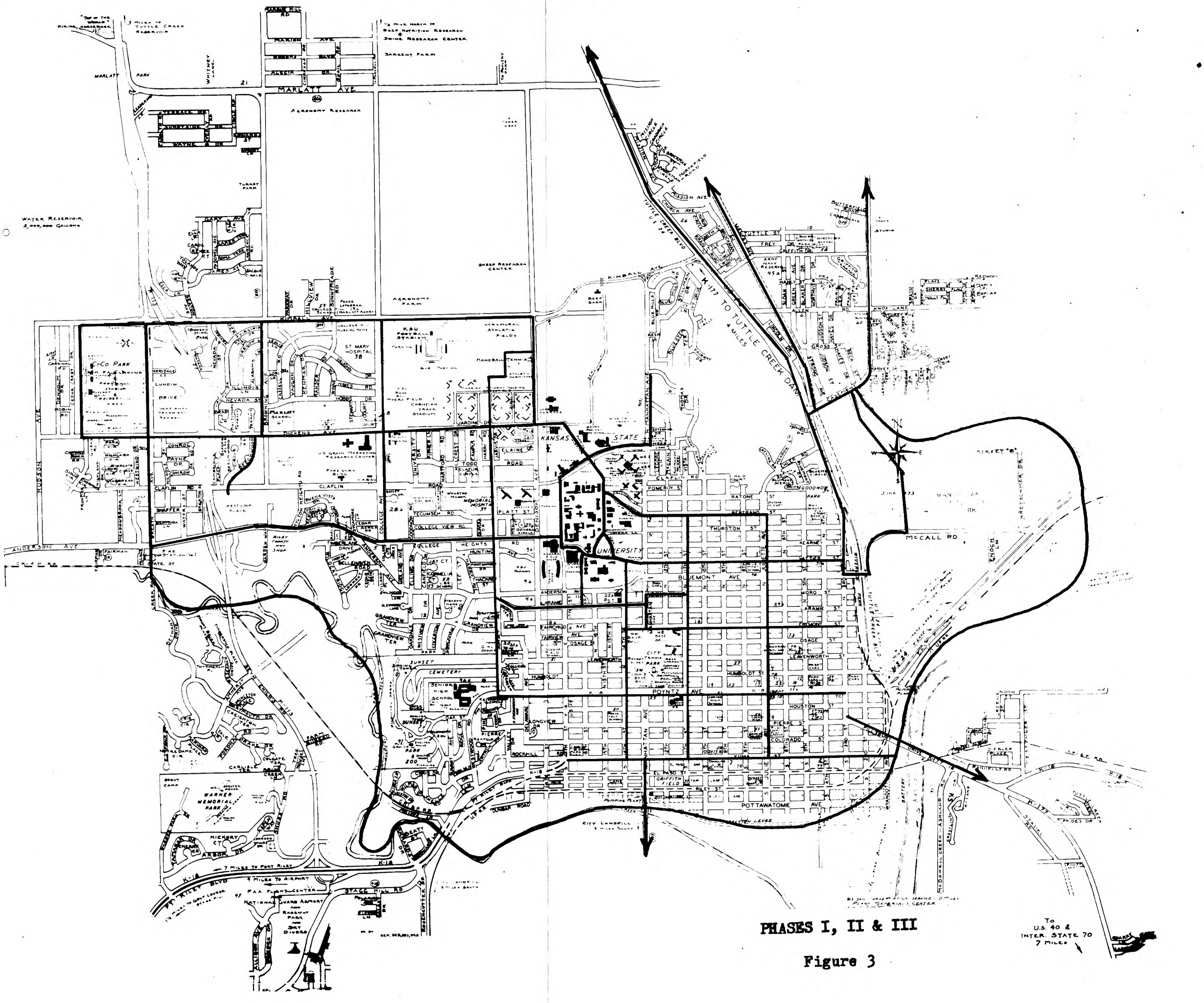

PHASES I, II & III

Figure 3

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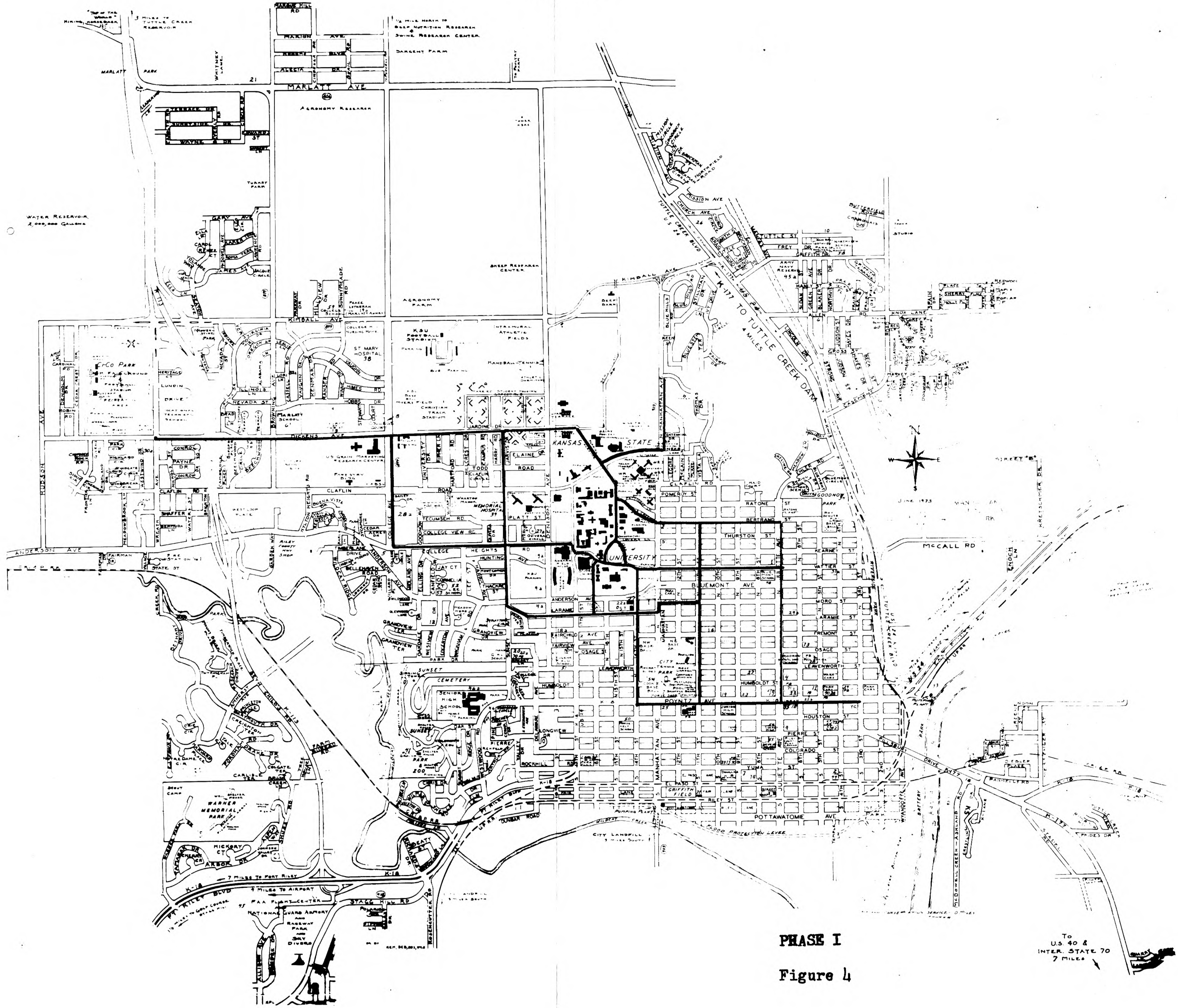

PHASE I

Figure 4

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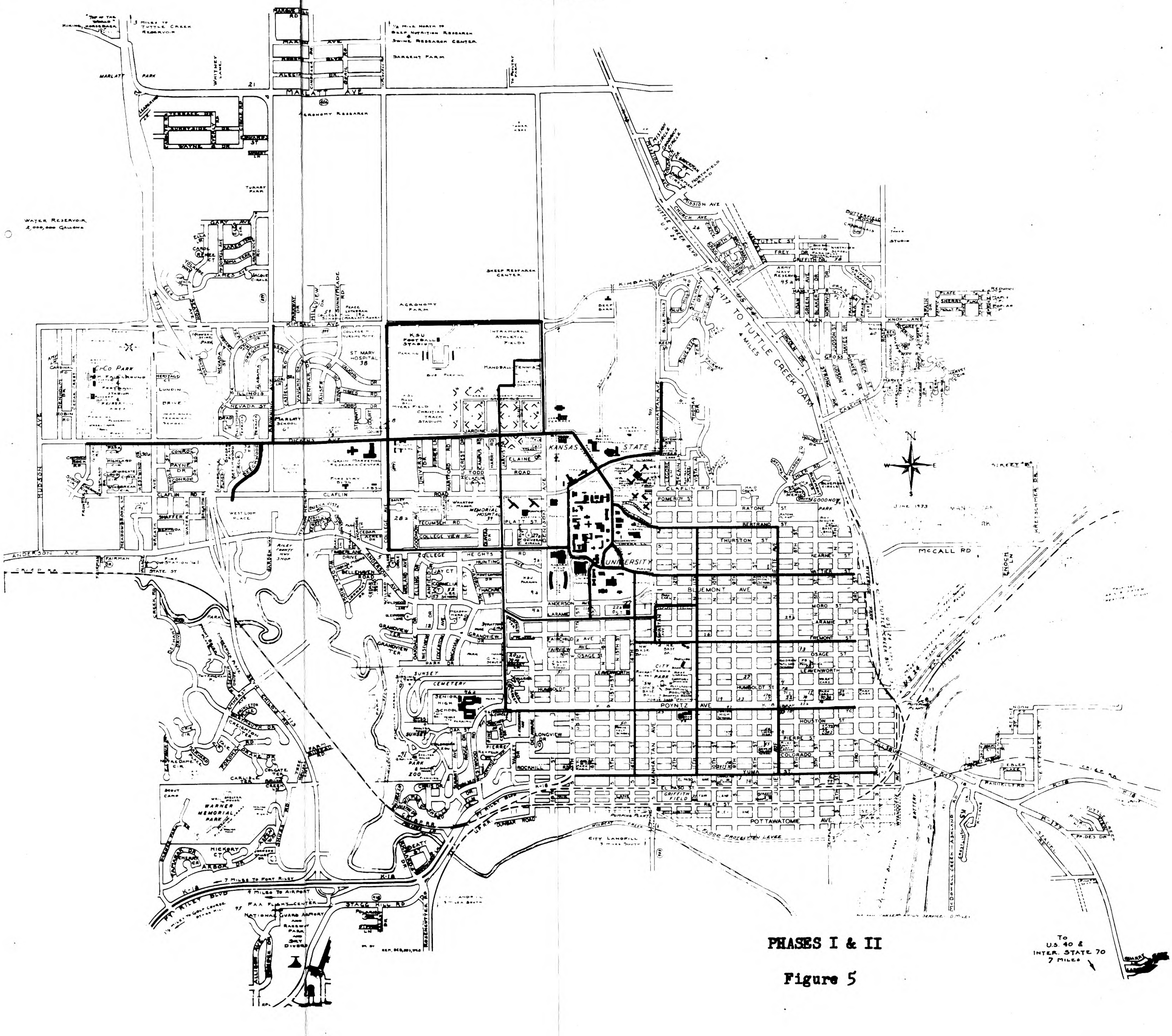

PHASES I & II

Figure 5

A detailed discussion of the proposed plan can be found in Appendix C. The construction cost of Phase I would be approximately $38,000.00 at present prices. A detailed estimate can be found on page C8 .

IMPLEMENTATION

It is not enough to just investigate the need for a bikeway system and to design a system to adequately meet these needs. The plan must take one more step, and that is implementation.

Adoption of the plan is the beginning step in implementation. Adoption serves many purposes which are listed as follows:

1. By adopting the plan certain commitments are made to provide for the needs of the bicycle users.
2. The mere fact of having a plan meets one requirement necessary for the granting of Federal funds.
3. It is understood that initial plans are not perfect and updating will be necessary to meet the changing conditions of the city.
4. Phase I should begin immediately. Phase I will be the first positive step in providing for the needs of the bicyclist. It shall also provide experience which can be used to guide and improve the remainder of the system.

Funding

In implementing a bikeway system, considerations must be given to the possible sources for funding the program. Some of the sources to investigate are the Federal, State, and local governments, bicycle license fees, organizations, bonds, and fines.

The Federal government offers several possible sources for money. The Open Space and Legacy of Parks programs sponsored by the Department of Housing and Urban Development (HUD) and the Land and Water Conservation Fund of the Bureau of Outdoor Recreation (BOR) provide matching funds for bikeways. First priority for these funds is recreational bikeways. As a result, any city application for funding should stress the recreational aspects of the proposed bikeways. Money for the same program can only come from one federal program, so the city must decide which federal program, HUD or BOR, fits its needs more closely.

The Federal Highway Administration has funds available for bikeway projects connected with or adjacent to highway construction. Matching funds 70% federal, 30% state or local) are available for bikeway construction on all new highway work except Interstate.

So far this year there have been no bills passed in the Kansas legislature concerning the funding of bikeways. There was a bill drafted for introduction in 1974, but we received no further status report. This does indicate that the State Legislature is giving serious consideration to funding bikeways and hopefully in the near future state funds will be available. The bicycle route in conjunction with Interstate Route 35W planned through Wichita has construction costs shared by state and federal governments (6).

State and local resources might include the general revenue, sales tax, municipal bonds, revenue sharing, and bicycle license fees and fines. There are no federal restrictions on where the local money must come from. Housing developments should add bike paths as part of a total community plan.

In looking at the various funding measures for several cities across the nation, it appears that some federal money was received by everyone who applied. State sources are less predictable.

A good local source of funds for a Manhattan bikeway plan exists. The licensing fee can be raised to three dollars per year (See Demand Study). This action would raise some $36,000.00 per year. If this action is taken, these funds should be committed to the bikeway system in Manhattan. Of this amount, $24,000.00 would be available for the construction and maintenance of bicycle routes. Monies collected as fines could add to this figure. Additions from the other possible sources could boost this figure beyond what is required. A good phased program will instill interest and cooperation for gathering funds in future years.

A P P E N D I X   A

DEMAND STUDY

DEMAND STUDY

Survey

A survey was conducted to gather information on the residents of Manhattan. Two types of information were gathered: General opinion type information and origin-destination information for design purposes.

The city was first divided into 53 zones (See Figure 1A). These zones were selected on the basis of land use. Land use types considered were: Residential, commercial, industrial, school and public. The residential zones were coordinated with the public school zones so that the expanded grade school population for each school zone could be compared with actual school enrollment.

A 1973 land use study which was conducted by a class in the Planning Department at K.S.U. provided an in-depth study of land use in Manhattan. This study was invaluable in helping select zones for our study.

The zones were classified according to land use as follows: commercial, industrial, public-recreational, school and residential. The commercial zones are areas of concentrated retail and wholesale activities. These zones-- 25, 32 and 47, were isolated as it was anticipated that these would be major traffic generators. There is only one industrial zone in Manhattan--Zone 24. It is largely vacant land for future industrial expansion and some commercial activities are conducted in this area. The city parks and recreational areas--Zones 5, 8, 21, 33 and 41, were isolated in separate zones as it was anticipated that these might be major attractions to bicycle users.

The zones which are classified as residential zones--1, 3, 7, 10, 13, 14, 16, 18, 19, 20, 23, 25, 26, 27, 28, 30, 31, 35, 36, 38, 40, 43, 45, and 48, contain all of the residences within the city limits and some outside the city limits (Zones 1, 49 and 50). The 1970 Federal Census was used to determine the number of dwelling units (D.U.) and the population in each zone. Five

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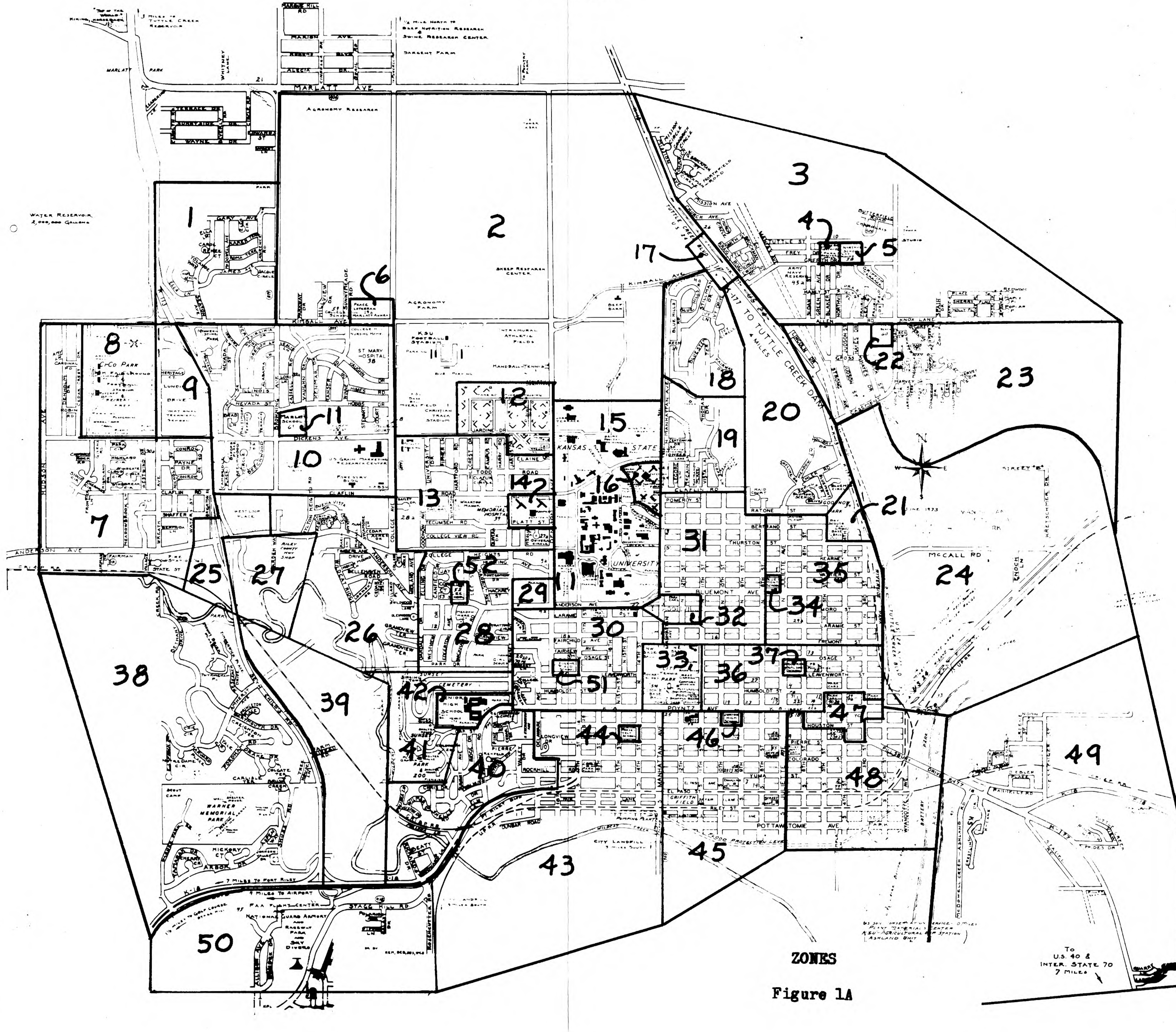


ZONES

Figure 1A

percent of the D.U.s in each zone were selected at random. These residences were selected from a map furnished by the City of Manhattan, which showed all the lots throughout the city. Telephone numbers were then obtained for the selected lots from the Manhattan Cross Directory, which gives telephone numbers by address. In all 353 D.U.' were sampled.

"The Emerging Needs of Bicycle Users" (5) and other articles indicate that bicycle ridership increases with the installation of bikeways. This increase is due to the fact that most cities have a considerable number of residents who would ride bicycles if an adequate system were available to them. This, effect which is called "latent demand", indicates that a study of present users would yield trip values which would be less than the number we could expect to use the facility. We decided, therefore, to predict the number of potential bicycles which would be produced by the latent demand.

The city part of the survey (all zones except 14 and 16) was conducted by volunteers from several service and social organizations. The American Association of University Women was of special service in that they contacted other organizations to obtain volunteer interviewers. Some wives of the class members and some members of The American Association of University Women, The University for Man - Bicycle Touring Group, The League of Women Voters, and Girl Scout Troop 312, participated in the survey. The forty volunteers each committed themselves for two hours of work. This provided the eighty man-hours which were necessary to conduct the survey. These interviewers met in groups to receive materials and to be instructed on how to conduct the interview and how to fill out the questionnaire. The interviews were conducted by telephone using the telephone numbers which were obtained by the method outlined above. Completed questionnaires were returned to the University for coding.

The students who live in the University dorms (zones 14 and 16) were interviewed in person by members of the class. A five percent sample was taken from each dorm. The students were interviewed in the various dorm lobbies during regular school hours.

Zones 13, 19, 28, 30, and 31 were considered special zones as they contain the various fraternity and sorority houses associated with the University. The population of each of these zones was reduced by the number of residents of houses in these zones. A five percent sample of each house was interviewed. This data was recorded as comming from zones 60,61, 62, 63, or 64 representing houses in zones 13, 19, 28, 30, or 31 respectively. The data collected for ten zones mentioned above was expanded separately.

The Questionnaire

The questionnaire (See Figure 2A), is basically a one-page questionnaire. Figure 3A shows an optional page which could be added to the questionnaire if needed.

One questionnaire was used per dwelling unit (D.U.). The top portion of the questionnaire is a group of general questions which were answered by any adult in the D.U. The lower portion of the questionnaire contains information for each individual who lived in the D.U. As can be seen in Figure 2A, the questionnaire contains spaces for information for only two persons. The optional sheets (See Figure 3A) were added if more than two people lived in the D.U. If there were nine people in the family, the first page and three optional pages were used. If the spaces provided for trip information were inadequate for one individual, his trips were continued on the next section down. A large X was drawn through the age-occupation area to indicate that these trips were made by the person in the preceding section. The trips listed represent all the trips made by the individual on the day preceding the interview.

How many bicycles are owned by people living in your home? ___

How many people are living in your home? ___

Family Income: Less than $2,000 ___ $ 8,000 to $10,999 ___
$2,000 to $4,999 ___ $11,000 to $13,999 ___
$5,000 to $7,999 ___ $14,000 and up ___

Yes No (Don't care--check both)

___ ___ Would you like Manhattan to construct a bikeway system?

___ ___ Would you like Manhattan to keep its bus system?

___ ___ Would you like Manhattan to increase its bus system?

What would you consider a reasonable annual bicycle fee to finance and maintain bicycle lanes? (Check one)

$0___ $1___ $3___ $5___ $7___ More than $7___

What are the reasons you don't use a bicycle now or use your present bicycle more?

Safety___ Physical effort___ Social pressure___ Time___ Theft___
Cannot carry packages___ No bicycle racks___ Other___

TRANSPORTATION QUESTIONNAIRE

Age / Occupation

___ 0-5
___ 6-10
___ 11-15
___ 16-18
___ 19-24
___ 25-49
___ 50 up

Purpose				Orig.	Dest.	# Trips	Mode							
Work	Shopping	School	Recreation	(zone)	(zone)		Auto Driver	Auto Pass.	Bicycle	Walk	Taxi	Bus		

Which of these trips would you have made by bicycle if there was an adequate bicycle system?

Which of these trips would you have made by bus if there was an adequate bus system?

Age / Occupation

___ 0-5
___ 6-10
___ 11-15
___ 16-18
___ 19-24
___ 25-49
___ 50 up

Purpose				Orig.	Dest.	# Trips	Mode							
Work	Shopping	School	Recreation	(zone)	(zone)		Auto Driver	Auto Pass.	Bicycle	Walk	Taxi	Bus		

Which of these trips would you have made by bicycle if there was an adequate bicycle system?

Which of these trips would you have made by bus if there was an adequate bus system?

QUESTIONNAIRE

Figure 2A

Age

- ____ 0-5
- ____ 6-10
- ____ 11-15
- ____ 16-18
- ____ 19-24
- ____ 25-49
- ____ 50 up

Occupation

Purpose				Orig.	Dest.	# Trips	Mode							
Work	Shopping	School	Recreation	(zone)	(zone)		Auto Driver	Auto Pass.	Bicycle	Walk	Taxi	Bus		
Which of these trips would you have made by bicycle if there was an adequate bicycle system?														
Which of these trips would you have made by bus if there was an adequate bus system?														

Age

- ____ 0-5
- ____ 6-10
- ____ 11-15
- ____ 16-18
- ____ 19-24
- ____ 25-49
- ____ 50 up

Occupation

Purpose				Orig.	Dest.	# Trips	Mode							
Work	Shopping	School	Recreation	(zone)	(zone)		Auto Driver	Auto Pass.	Bicycle	Walk	Taxi	Bus		
Which of these trips would you have made by bicycle if there was an adequate bicycle system?														
Which of these trips would you have made by bus if there was an adequate bus system?														

Age

- ____ 0-5
- ____ 6-10
- ____ 11-15
- ____ 16-18
- ____ 19-24
- ____ 25-49
- ____ 50 up

Occupation

Purpose				Orig.	Dest.	# Trips	Mode							
Work	Shopping	School	Recreation	(zone)	(zone)		Auto Driver	Auto Pass.	Bicycle	Walk	Taxi	Bus		
Which of these trips would you have made by bicycle if there was an adequate bicycle system?														
Which of these trips would you have made by bus if there was an adequate bus system?														

OPTIONAL SHEET

Figure 3A

After all trips for that day were recorded, the individual was asked which of the trips he would have made by bicycle or bus if there were adequate facilities. A check in the appropriate box indicated the trips he would have made by these modes.

The questionnaire was designed to serve two purposes: First, to provide general information on attitudes of the residents about bicycles and second, to provide origin-destination information on bicycles which would aid in planning and designing bikeways. Normally, these two types of surveys are not conducted simultaneously. Separate surveys would allow one to investigate both areas more thoroughly, however, time considerations did not allow us this luxury. The time allowed for writing and executing the survey was one month.

The following questions we wanted the survey to answer are a combination of questions we felt must be answered, questions raised at the time we presented our proposal (See Appendix E), and questions asked by city government officials when they were interviewed. Interviews of city officials were conducted by members of the "Community Organization and Leadership" class, a sociology class at K.S.U. These students conducted interviews with the mayor, some members of the City Commission and the City Planner, as part of a semester project for their class.

1. Do the citizens want a bikeway system and are they willing to support it?
2. What type of facility is desired, recreational or functional, who would it be for--children, commuters, etc.?
3. What characteristics of the present street system limit or prohibit the use of bicycles?
4. What would be the effect of a bicycle system on the main arterial system of the city?
5. How many bicycles are there in the city?
6. Where are the present cyclists going and where would they go if there was a system?

7. What will the system cost and what will be the benefits of the system?

The questionnaire, shown in Figure 2A, asks these questions, some directly, some indirectly. Questions 1, 3 and 5 are asked directly. Question 2 and 6 are asked indirectly in the O.D. portion of the questionnaire. Questions 4 and 7 are answered more with a combination of results of the O.D. portion and the proposed bikeway design.

A typical O.D. study contains enough specific trip information to predict vehicle movements throughout an area. The area is divided into zones which are homogeneous. This allows one to sample some residents of each zone and say that these people are representative of all who live in that zone. The sample trip data is then expanded and taken to represent the activities of everyone who lives in that zone. This method has proven effective not only for showing current movements of traffic, but also for predicting traffic several years in the future.

In the case of bicycles, if the people were using them principally for recreational purposes, say an evening ride around the neighborhood, few zone-to-zone trips would be indicated and few trips for purposes other than recreation would be indicated. Other studies have indicated that some of the most important reasons people ride biycles is for recreation and exercise. It is our belief, however, that they are fulfilling these desires while taking a trip they must make anyway. That is, they must go to work and shopping, but the correct mode choice can fulfill their desire for recreation and exercise.

The bus information collected in our survey (See survey, page A5) is not included in this report. It was gathered for the A.A.U.W. who assisted us in conducting the survey. They were studying the bus situation in Manhattan, as well as bicycles.

Data Processing

The usable data received was processed by computer. The program, which will be discussed presently, printed two types of information: Tabulations based on sample data and tabulations based on expanded data. Data expansion was done on a zone-by-zone basis, using an expansion factor which was the zone population divided by the number of persons sampled. The program to accomplish this was written in PL/1 language by Mr. Joel Mason, a graduate student in the Planning Department at K.S.U. Both the program and data printout are shown on pages A18 to A30.

Results

The following is a summary of the data printed out by the computer. The expansion of this data and the conclusions we have drawn from it can be found in the next section, Conclusions.

1. The ratio of bicycles per person was 0.41 bicycles per person.
2. The percent of people who would like to see bikeways constructed in Manhattan.

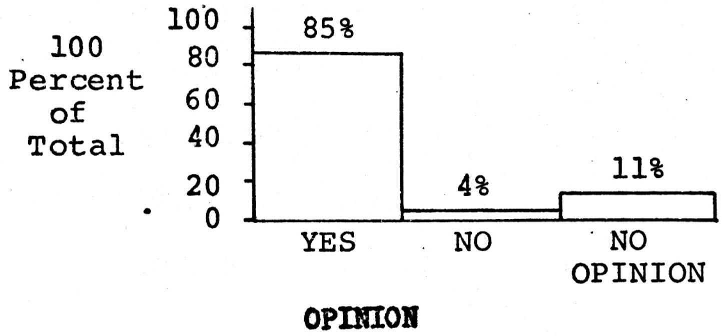


Figure 4A

3. A reasonable fee to construct and maintain bicycle lanes.

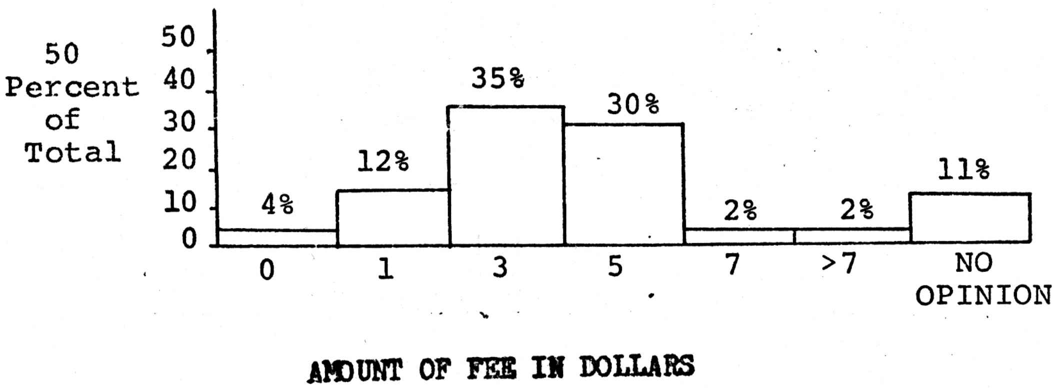
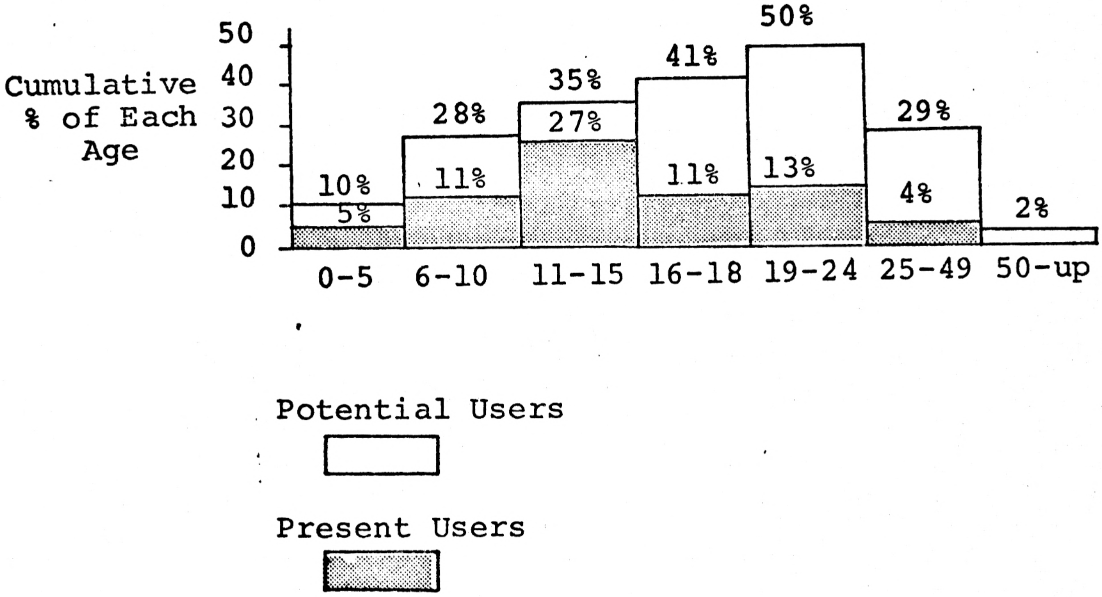


Figure 5A

4. The reasons people don't use bicycles or don't use their present bicycle more are shown below. The percentages shown are based on the number who answered, divided by the number of people questioned.

Safety..................	19%
Physical Effort.........	15%
Social Pressure.........	1%
Time....................	20%
Theft...................	5%
Cannot Carry Packages...	11%
No Bicycle Racks........	3%
Weather.................	20%
No Bike.................	21%

5. Bike User Age Distribution



AGE DISTRIBUTION

Figure 6A

6. **The distribution of bicycle trips by trip purpose**

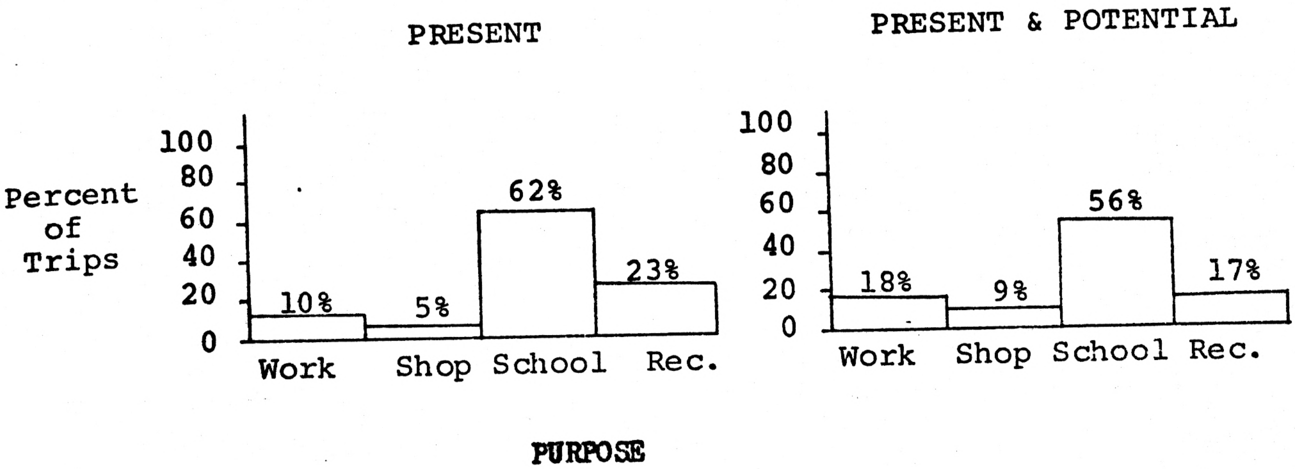


Figure 7A

7. **Trip Length Frequency Diagram**

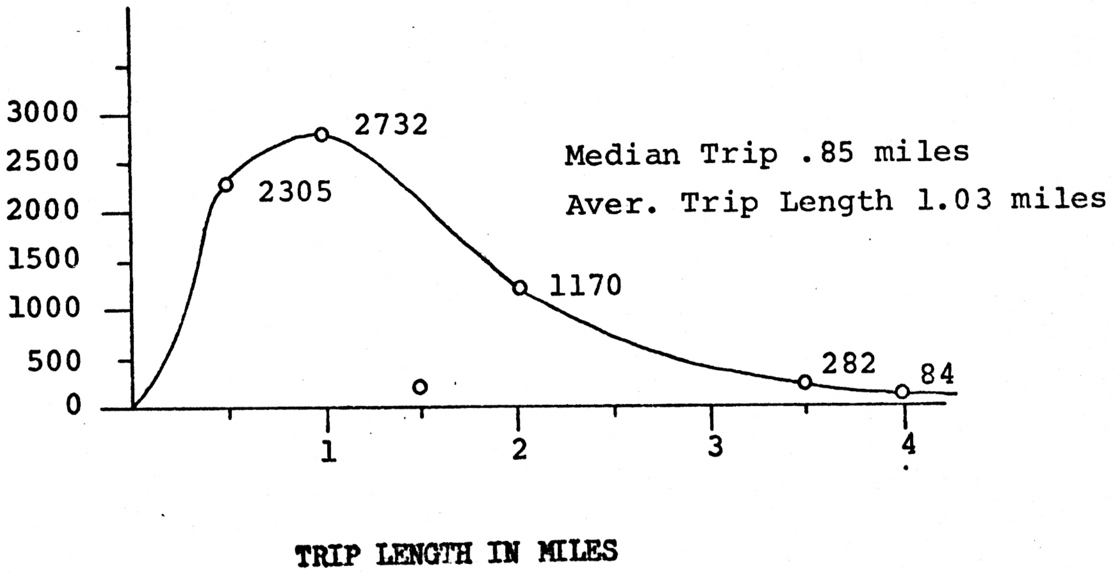
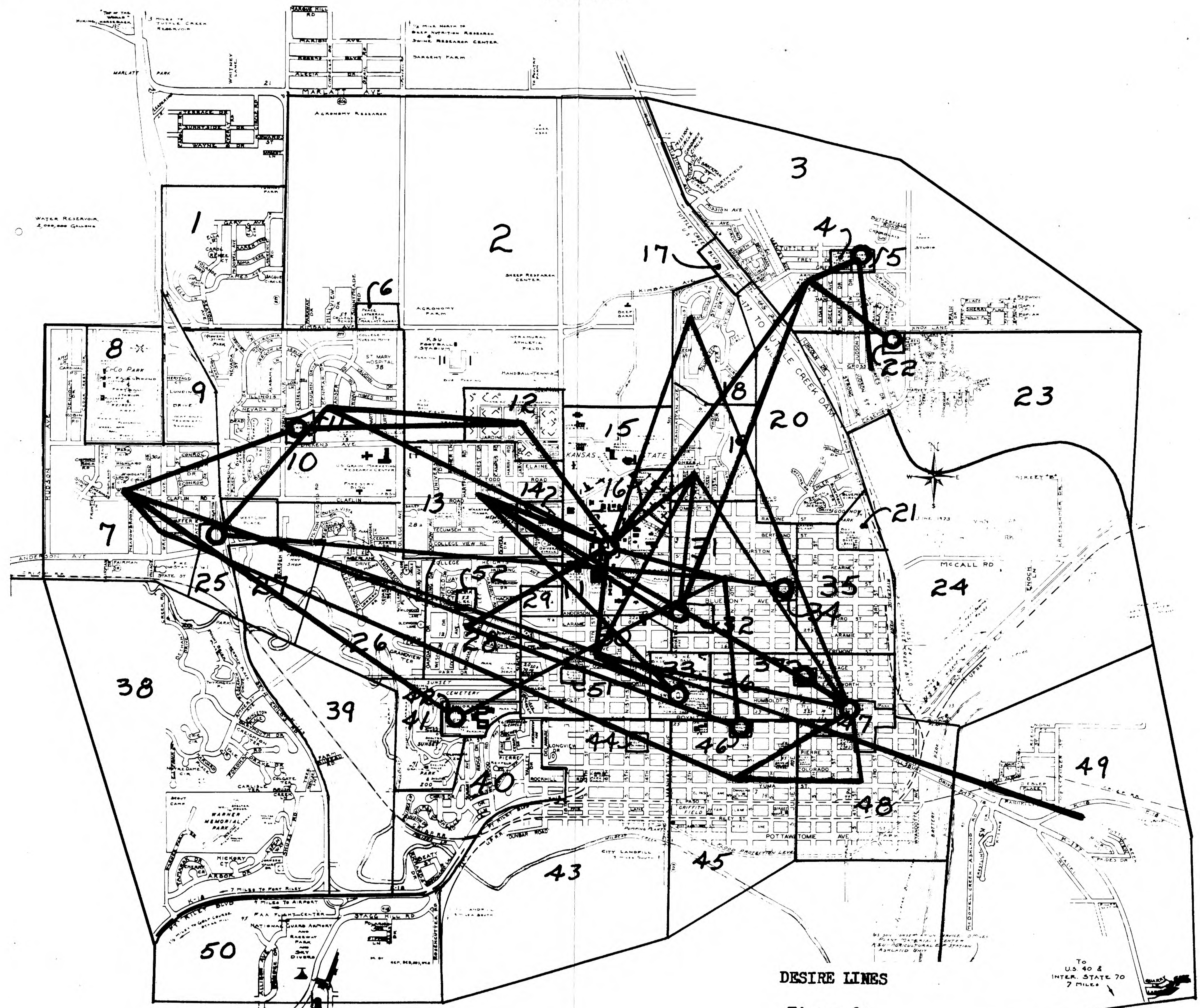


Figure 8A

MANHATTAN
KANSAS



DESIRE LINES

Figure 9A

Conclusions

The number of dwelling units sampled represent approximately 3% of the D.U.'s in the city of Manhattan proper. These D.U.'s are distributed evenly throughout the community and represent a good cross section of the community. This sample represents 2,582 people.

The automobile is clearly the main choice as a mode of transportation in this city. The number of bicycle trips represents about 12% of the combined bicycle-auto driver trips in the city. This number, however, represents some 7,300 bicycle trips per day at present.

How do the citizens feel about bikeways? The "Bicycle Questionnaire Project" (9), conducted in the fall of 1973, indicated that the citizens wanted bikeways and that the desire for bikeways was shared equally by auto drivers and bicyclists. Our questionnaire, based on a larger sample, indicated that 84% of the people questioned wanted Manhattan to construct bikeways. Clearly, this represents approval for the idea of constructing bikeways in Manhattan.

Often times the public wants some type of facility, but is unwilling to provide the funds necessary to construct it. This is not the case with bicycles. The "Bicycle Questionnaire Project" (9) indicates that the bicyclists are willing to pay a reasonable fee to help build and maintain biycle facilities. We would assert that if they are willing to pay for a facility, then they must really want it and they will use it. We tried to tie down more closely what a reasonable fee might be. Our questionnaire asked what the people felt was a reasonable fee, and allowed a choice of $0.00, $1.00, $3.00, $5.00, $7.00, > $7.00, and no opinion (See Figure 5A). The largest number of people, 35%, indicated that $3.00 would be a reasonable fee. Those above $3.00 represent 34%, while those below represent 16%. If one assumes that those who indicated an amount greater than $3.00 would be willing to pay $3.00 per year, there results a combined group of 69% of the people willing to pay $3.00 per year to build and maintain bikeways. Our estimate of the number of bicycles in the city proper, is 11,610. With the additional 1,200 bicycles on campus, a $3.00 fee would provide about $35,000 to $40,000 per year for bikeways.

Who is the average bicycle rider? Is he a person on his way to work, or is he a person exercising in his spare time? Is he a young person or an older person? The actions of the bicycle riders speak for themselves. Only 23% of the bicycle trips are made for recreation while 77% of the trips are made for some specific purpose. Further, 96% of the bicycle trips are interzonal trips with a definate destination while only 4% of the bicycle trips are intrazonal trips. This means that the bicycle in our community is not functioning as a toy for use in off-hours. Rather, it is a means of transportation.

At present the bicyclists are operating on the streets with the automobiles since the streets are the only place they can ride to get easily from one area to another. If the number of bicycles increases at its present rate we can expect to see more bicycles operating on the streets. The university at present is planning to demotorize the campus (7). Many streets on campus are scheduled for closing. This will make it much less desireable to use an automobile around campus, and will probably result in an increase in bicycle usage. The resulting increase in bicycles in the streets will cause increased conflict which will probably result in an increase in the number of automobile-bicycle accidents in 1974 over the 13 reported accidents for 1973.

Bicycle users are of all ages (See Figure 6A). For the young people, 15 and under, it is their only independent mode of transportation other than walking. As a child grows older his interests expand and he is allowed to go further from home. The further he goes the more attractive is a bicycle as compared to walking. This probably accounts for the increase in bicycle usage from 0 to 15 years of age. The sharp drop in bicycle usage at 16 is probably the result of being able to use an automobile. At the college level there seems to be increased interest. This is probably due to the fact that the bicycle is an ideal vehicle for getting around the campus. From college age on up there is a decrease in bicycle usage. This will probably continue as people show less interest in activities which require physical effort as they grow older.

All age groups show an interest in bicycle facilities by the number of trips they say they would make by bicycle if there were adequate facilities. In numbers this would represent a 380% increase in bicycle trips. The commensurate drop in automobile trips would be 50%. This level of usage is rare in the United States, but not unheard of. One college town of 24,000 people has developed into a bicycle community with this level of usage (10). With enough time Manhattan might develope into a community of this type, but for the present one should discount these values. The values do, however, illustrate the principal of latent bicycle demand (5). Upon completion of a bicycle system we can expect an increase in bicycle usage. The increase, however, will probably be more on the order of 50% of the present bicycle usage. This amount of increased bicycle usage would correspond to approximately a 5% reduction in auto driver trips. The 50% latent demand mentioned above is in keeping with values determined in other cities (5).

While the number of potential bicycle trips may be too large there is nothing to indicate that their relative proportions are incorrect. If they are correct then we can expect work trips and shopping trips to increase faster than school trips and recreation trips.

The trip length frequency diagram (See Figure 8A) is derived from the expanded zone to zone trips (See Figure 9A). The curve which has been drawn fits all of the data quite well except for the trips of 1.5 mile in length. The curve is indicative of a normal trip length distribution curve. The place where our data differs from a normal shaped curve is probably due to inadequate zone data. The average zone sample size was 49, which is a small number, statistically speaking. In spite of the discrepancy the remainder of the data seems normal. The median trip length is .85 miles only slightly less than the 1.03 mile average trip length. There are few trips shown to be longer than 2 miles which is normally accepted as the upper limit for bicycle trips. The two points made above justify the use of this data for design purposes even though the sample size was less than desired.

The data collected in the survey certainly represents significantly better information than was available prior to the survey. This information will serve as a guide for the selection of the initial bikeway routes of a Manhattan bikeway system. Knowledge gained through experience with the first phases of the system will help improve the quality and workability of later phases.

Recommendations for Future Surveys

An O.D. survey is a relatively complex and expensive survey to conduct. Due to this complexity only well trained interviewers should conduct the survey. The expense involved in a more thorough survey might be prohibitive unless the survey is combined with a survey for another mode of transportation. It makes a great amount of sense to gather bicycle data at the same time an automobile O.D. study is conducted.

If funds are not available to conduct an extensive O.D. survey, then a user survey of the type outlined in the proposal (See Appendix E) should be considered. A user survey is limited in that it will supply information on the activities of present bicycle users only. It would, however, be less expensive and this type of survey has been quite successful in other cities (13).

KSU'S PL/I NEATENER AND PRECOMPILER PAGE

```
(SUBSCRIPTRANGE,STRINGRANGE):DL:                                        1   1
        PROCEDURE OPTIONS(MAIN);                                        1   1
        ON ENDFILE(SYSIN)                                               1   2
        GO TO PT;                                                       1   3
        ON ERROR                                                        1   4
           BEGIN;                                                       2   5
           PUT SKIP EDIT('ERROR--->       ',X)(A(14),A(8));             2   6
              IF ERR>10 THEN                                            3   7
              GO TO END;                                                3   8
           ERR=ERR+1;                                                   2   9
           GO TO GO;                                                    2  10
           END;                                                         2  11
        DECLARE ERR FIXED(2),(X,R)CHARACTER(8),(NB,NP,ORIG,DEST,T)FIXED 1  12
(2),(PTS,PTBS)CHARACTER(1),NS FIXED(4),B CHARACTER(4),(IG,F,A,O,P,M,U,P 1  12
U,YN(3))FIXED(1),(TNB,TNP,YNQ(3,3),RNRB(8),AD(7,2),PURPOSE(4,2))FIXED(4 1  12
),(FEE(0:6),ID(0:6))FIXED(4),AGE(7)FIXED(4),EF(65)FIXED(3),BPERP FIXED( 1  12
4,2),(PBT(65,65),PBST(65,65),BT(65,65),BST(65,65),ADR(65,65))FIXED(4),( 1  12
CSPZ(65),GSKPZ(65),PPZ(65))FIXED(4),Z FIXED(2),;                        1  13
        ERR=0;                                                          1  14
        TNB,TNP,NS,U,PU=0;                                              1  15
        FEE=0;                                                          1  16
        YNQ=0;                                                          1  17
        RNRB=0;                                                         1  18
        BT=0;                                                           1  19
        PBT=0;                                                          1  20
        BST=0;                                                          1  21
        PBST=0;                                                         1  22
        ADR=0;                                                          1  23
        PURPOSE=0;                                                      1  24
        AD=0;                                                           1  25
        ID=0;                                                           1  26
        PPZ=0;                                                          1  27
        GSKPZ=0;                                                        1  28
        CSPZ=0;                                                         1  29
        AGE=0;                                                          1  30
        EF=1;                                                           1  31
        EF(3)=26;                                                       1  32
        EF(7)=31;                                                       1  33
        EF(10)=23;                                                      1  34
        EF(12)=21;                                                      1  35
        EF(13)=50;                                                      1  36
        EF(14)=47;                                                      1  37
        EF(16)=65;                                                      1  38
        EF(18)=24;                                                      1  39
        EF(19)=24;                                                      1  40
        EF(20)=21;                                                      1  41
        EF(23)=31;                                                      1  42
        EF(23)=31;                                                      1  43
        EF(26)=20;                                                      1  44
        EF(27)=33;                                                      1  45
        EF(28)=16;                                                      1  46
        EF(30)=27;                                                      1  47
        EF(31)=29;                                                      1  48
        EF(35)=44;                                                      1  49
        EF(36)=42;                                                      1  50
        EF(38)=15;                                                      1  51
        EF(40)=32;                                                      1  52
        EF(43)=98;                                                      1  52
```

```
         EF(45)=140;                                                    1    53
         EF(48)=45;                                                     1    54
         EF(60)=22;                                                     1    55
         EF(61)=20;                                                     1    56
         EF(62)=21;                                                     1    57
         EF(63)=25;                                                     1    58
         EF(64)=16;                                                     1    59
 GO:     GET SKIP EDIT(X)(A(8));                                        1    60
            IF SUBSTR(X,5,4)¬='0000' THEN                               2    61
            GO TO NC1;                                                  2    62
         GET EDIT(NB,NP,IC,YN,F,R)(X(5),F(2),X(3),F(2),X(3),F(1),X(4),3F 1   63
(1),X(2),F(1),X(4),A(8));                                               1    63
         TNB=TNB+NB;                                                    1    64
         TNP=TNP+NP;                                                    1    65
         NS=NS+1;                                                       1    66
            DO I=1 TO 3;                                                2    67
            YNO(I,YN(I))=YNO(I,YN(I))+1;                                2    68
            END;                                                        2    69
         FEE(F)=FEE(F)+1;                                               1    70
            DO I=1 TO 8;                                                2    71
               IF SUBSTR(R,I,1)¬=' ' THEN                               3    72
               RNRB(I)=RNRB(I)+1;                                       3    73
            END;                                                        2    74
         ID(IC)=ID(IC)+1;                                               1    75
         GO TO GO;                                                      1    76
 NC1:       IF SUBSTR(X,7,2)¬='01' THEN                                 2    77
               DO;                                                      3    78
               GET EDIT(B)(X(12),A(4));                                 3    79
               GO TO NNP;                                               3    80
               END;                                                     3    81
         GET STRING(X)EDIT(Z)(F(2));                                    1    82
         PPZ(Z)=PPZ(Z)+1;                                               1    83
            IF U=1 THEN                                                 2    84
            AD(A,1)=AD(A,1)+1;                                          2    85
            IF PU=1 THEN                                                2    86
            AD(A,2)=AD(A,2)+1;                                          2    87
         U=0;                                                           1    88
         PU=0;                                                          1    89
         GET EDIT(A,O,B)(X(6),F(1),X(4),F(1),A(4));                     1    90
         AGE(A)=AGE(A)+1;                                               1    91
            IF A=2 THEN                                                 2    92
            GSKPZ(Z)=GSKPZ(Z)+1;                                        2    93
            IF A>4&O=4 THEN                                             2    94
            CSPZ(Z)=CSPZ(Z)+1;                                          2    95
 NNP:    GET EDIT(P,ORIG,DEST,T,M,PTB,PTBS)(F(1),X(4),F(2),X(3),F(2),X(3 1   96
),F(2),X(3),F(1),X(4),A(1),X(4),A(1));                                  1    96
         GET STRING(X)EDIT(Z)(F(2));                                    1    97
            IF M=3 THEN                                                 2    98
               DO;                                                      3    99
               U=1;                                                     3   100
               BT(ORIG,DEST)=BT(ORIG,DEST)+(T*EF(Z));                   3   101
               PURPOSE(P,1)=PURPOSE(P,1)+T;                             3   102
               END;                                                     3   103
            IF M=5 THEN                                                 2   104
            BST(ORIG,DEST)=BST(ORIG,DEST)+(T*EF(Z));                    2   105
            IF PTBS¬=' ' THEN                                           2   106
            PBST(ORIG,DEST)=PBST(ORIG,DEST)+(T*EF(Z));                  2   107
            IF PTB¬=' ' THEN                                            2   108
```

```
               DO;                                                     3  109
               PU=1;                                                   3  110
               PBT(ORIG,DEST)=PBT(ORIG,DEST)+(T*EF(Z));                3  111
               PURPOSE(P,2)=PURPOSE(P,2)+T;                            3  112
               END;                                                    3  113
            IF M=1 THEN                                                2  114
            ADR(ORIG,DEST)=ADR(ORIG,DEST)+(T*EF(Z));                   2  115
         GO TO GO;                                                     1  116
PT:      PUT PAGE;                                                     1  117
            IF U=1 THEN                                                2  118
            AD(A,1)=AD(A,1)+1;                                         2  119
            IF PU=1 THEN                                               2  120
            AD(A,2)=AD(A,2)+1;                                         2  121
         BPERP=TNB/TNP;                                                1  122
         PUT SKIP(2)EDIT('BICYCLES           ',TNB)(A(19),X(5),F(4));  1  123
         PUT SKIP(2)EDIT('PEOPLE             ',TNP)(A(19),X(5),F(4));  1  124
         PUT SKIP(2)EDIT('BICYCLES PER PERSON',BPERP)(A(19),X(5),F(4,2))  1  125
;                                                                      1  125
            DO I=1 TO 3;                                               2  126
               DO J=1 TO 3;                                            3  127
               YNQ(I,J)=(YNQ(I,J)*100)/NS;                             3  128
               END;                                                    3  129
            END;                                                       2  130
         PUT SKIP(10)EDIT(' YES        NO         DONT CARE')(A);      1  131
         PUT SKIP(2)EDIT(YNQ(1,1),YNQ(1,2),YNQ(1,3))(F(4),X(6),F(4),X(10  1  132
),F(4));                                                               1  132
         PUT SKIP(2)EDIT(YNQ(2,1),YNQ(2,2),YNQ(2,3))(F(4),X(6),F(4),X(10  1  133
),F(4));                                                               1  133
         PUT SKIP(2)EDIT(YNQ(3,1),YNQ(3,2),YNQ(3,3))(F(4),X(6),F(4),X(10  1  134
),F(4));                                                               1  134
            DO I=0 TO 6;                                               2  135
            FEE(I)=(FEE(I)*100)/NS;                                    2  136
            END;                                                       2  137
         PUT SKIP(9)EDIT('FEE     PERCENT')(A);                        1  138
         PUT SKIP(2)EDIT('        ',FEE(0))(A(8),F(4));                1  139
         PUT SKIP(2)EDIT(' 0      ',FEE(1))(A(8),F(4));                1  140
         PUT SKIP(2)EDIT(' 1      ',FEE(2))(A(8),F(4));                1  141
         PUT SKIP(2)EDIT(' 3      ',FEE(3))(A(8),F(4));                1  142
         PUT SKIP(2)EDIT(' 5      ',FEE(4))(A(8),F(4));                1  143
         PUT SKIP(2)EDIT(' 7      ',FEE(5))(A(8),F(4));                1  144
         PUT SKIP(2)EDIT('>7      ',FEE(6))(A(8),F(4));                1  145
            DO I=1 TO 8;                                               2  146
            RNRB(I)=(RNRB(I)*100)/NS;                                  2  147
            END;                                                       2  148
         PUT PAGE;                                                     1  149
         PUT SKIP(9)EDIT('REASONS    PERCENT')(A);                     1  150
         PUT SKIP(2)EDIT('SAFETY     ',RNRB(1))(A(11),F(4));           1  151
         PUT SKIP(2)EDIT('EFFORT     ',RNRB(2))(A(11),F(4));           1  152
         PUT SKIP(2)EDIT('PRESSURE   ',RNRB(3))(A(11),F(4));           1  153
         PUT SKIP(2)EDIT('TIME       ',RNRB(4))(A(11),F(4));           1  154
         PUT SKIP(2)EDIT('THEFT      ',RNRB(5))(A(11),F(4));           1  155
         PUT SKIP(2)EDIT('PACKAGES   ',RNRB(6))(A(11),F(4));           1  156
         PUT SKIP(2)EDIT('RACKS      ',RNRB(7))(A(11),F(4));           1  157
         PUT SKIP(2)EDIT('OTHER      ',RNRB(8))(A(11),F(4));           1  158
            DO I=0 TO 6;                                               2  159
            ID(I)=(ID(I)*100)/NS;                                      2  160
            END;                                                       2  161
         PUT SKIP(9)EDIT('     INCOME           PERCENT')(A);          1  162
```

```
        PUT SKIP(2)EDIT('                        ',ID(0))(A(23),F(4));    1  163
        PUT SKIP(2)EDIT(' LESS THAN  $2,000      ',ID(1))(A(23),F(4));    1  164
        PUT SKIP(2)EDIT(' $2,000 TO  $4,999      ',ID(2))(A(23),F(4));    1  165
        PUT SKIP(2)EDIT(' $5,000 TO  $7,999      ',ID(3))(A(23),F(4));    1  166
        PUT SKIP(2)EDIT(' $8,000 TO $10,999      ',ID(4))(A(23),F(4));    1  167
        PUT SKIP(2)EDIT('$11,000 TO $13,999      ',ID(5))(A(23),F(4));    1  168
        PUT SKIP(2)EDIT('$14,000 AND UP          ',ID(6))(A(23),F(4));    1  169
        PUT PAGE;                                                          1  170
           DO I=1 TO 7;                                                    2  171
              IF AGE(I)=0 THEN                                             3  172
              GO TO L1;                                                    3  173
           AD(I,1)=(100*AD(I,1))/AGE(I);                                   2  174
           AD(I,2)=(100*AD(I,2))/AGE(I);                                   2  175
L1:        END;                                                            2  176
        PUT SKIP(9)EDIT('  AGE   USERS      POTENTIAL USERS')(A);          1  177
        PUT SKIP(2)EDIT(' 0-5  ',AD(1,1),AD(1,2))(A(6),F(4),X(12),F(4))   1  178
;                                                                          1  178
        PUT SKIP(2)EDIT(' 6-10 ',AD(2,1),AD(2,2))(A(6),F(4),X(12),F(4))   1  179
;                                                                          1  179
        PUT SKIP(2)EDIT('11-15 ',AD(3,1),AD(3,2))(A(6),F(4),X(12),F(4))   1  180
;                                                                          1  180
        PUT SKIP(2)EDIT('16-18 ',AD(4,1),AD(4,2))(A(6),F(4),X(12),F(4))   1  181
;                                                                          1  181
        PUT SKIP(2)EDIT('19-24 ',AD(5,1),AD(5,2))(A(6),F(4),X(12),F(4))   1  182
;                                                                          1  182
        PUT SKIP(2)EDIT('25-49 ',AD(6,1),AD(6,2))(A(6),F(4),X(12),F(4))   1  183
;                                                                          1  183
        PUT SKIP(2)EDIT('50-UP ',AD(7,1),AD(7,2))(A(6),F(4),X(12),F(4))   1  184
;                                                                          1  184
        PUT SKIP(9)EDIT('PURPOSE      TRIPS      POTENTIAL TRIPS')(A);     1  185
        PUT SKIP(2)EDIT('WORK         ',PURPOSE(1,1),PURPOSE(1,2))(A(11)  1  186
,F(4),X(12),F(4));                                                         1  186
        PUT SKIP(2)EDIT('SHOP         ',PURPOSE(2,1),PURPOSE(2,2))(A(11)  1  187
,F(4),X(12),F(4));                                                         1  187
        PUT SKIP(2)EDIT('SCHOOL       ',PURPOSE(3,1),PURPOSE(3,2))(A(11)  1  188
,F(4),X(12),F(4));                                                         1  188
        PUT SKIP(2)EDIT('RECREATION   ',PURPOSE(4,1),PURPOSE(4,2))(A(11)  1  189
,F(4),X(12),F(4));                                                         1  189
        PUT PAGE;                                                          1  190
        PUT SKIP EDIT('BICYCLE TRIPS')(A);                                 1  191
           DO I=1 TO 65;                                                   2  192
              DO J=1 TO 65;                                                3  193
                 IF BT(I,J)¬=0 THEN                                        4  194
                    DO;                                                    5  195
                    PUT SKIP EDIT(I,J,BT(I,J))(F(2),X(5),F(2),X(5),F(4)   5  196
);                                                                         5  196
                    END;                                                   5  197
              END;                                                         3  198
           END;                                                            2  199
        PUT PAGE;                                                          1  200
        PUT SKIP EDIT('POTENTIAL BICYCLE TRIPS')(A);                       1  201
           DO I=1 TO 65;                                                   2  202
              DO J=1 TO 65;                                                3  203
                 IF PBT(I,J)¬=0 THEN                                       4  204
                    DO;                                                    5  205
                    PUT SKIP EDIT(I,J,PBT(I,J))(F(2),X(5),F(2),X(5),F(4   5  206
));                                                                        5  206
                    END;                                                   5  207
```

```
                    END;                                                         3   208
                 END;                                                            2   209
              PUT PAGE;                                                          1   210
              PUT SKIP EDIT('BUS TRIPS')(A);                                     1   211
                 DO I=1 TO 65;                                                   2   212
                    DO J=1 TO 65;                                                3   213
                       IF BST(I,J)¬=0 THEN                                       4   214
                          DO;                                                    5   215
                          PUT SKIP EDIT(I,J,BST(I,J))(F(2),X(5),F(2),X(5),F(4    5   216
 ));                                                                             5   216
                          END;                                                   5   217
                    END;                                                         3   218
                 END;                                                            2   219
              PUT PAGE;                                                          1   220
              PUT SKIP EDIT('POTENTIAL BUS TRIPS')(A);                           1   221
                 DO I=1 TO 65;                                                   2   222
                    DO J=1 TO 65;                                                3   223
                       IF PBST(I,J)¬=0 THEN                                      4   224
                          DO;                                                    5   225
                          PUT SKIP EDIT(I,J,PBST(I,J))(F(2),X(5),F(2),X(5),F(    5   226
 4));                                                                            5   226
                          END;                                                   5   227
                    END;                                                         3   228
                 END;                                                            2   229
              PUT PAGE;                                                          1   230
              PUT SKIP EDIT('AUTO DRIVER TRIPS')(A);                             1   231
                 DO I=1 TO 65;                                                   2   232
                    DO J=1 TO 65;                                                3   233
                       IF ADR(I,J)¬=0 THEN                                       4   234
                          DO;                                                    5   235
                          PUT SKIP EDIT(I,J,ADR(I,J))(F(2),X(5),F(2),X(5),F(4    5   236
 ));                                                                             5   236
                          END;                                                   5   237
                    END;                                                         3   238
                 END;                                                            2   239
              PUT PAGE;                                                          1   240
              PUT SKIP EDIT('     ZONE     TOTAL     GRADE     COLLEGE')(A);     1   241
                 DO I=1 TO 65;                                                   2   242
                 PUT SKIP EDIT(I,PPZ(I),GSKPZ(I),CSPZ(I))(X(5),F(2),X(5),F(4)    2   243
 ,X(5),F(4),X(5),F(4));                                                          2   243
                 END;                                                            2   244
 END:        END DL;                                                             1   245
```

BICYCLES	1082
PEOPLE	2582
BICYCLES PER PERSON	0.41

REASONS	PERCENT
SAFETY	19
EFFORT	15
PRESSURE	1
TIME	20
THEFT	5
PACKAGES	11
RACKS	3
OTHER	47

YES	NO	DON'T CARE
84	4	10
68	7	24
42	25	32

FEE	PERCENT
	11
0	4
1	12
3	35
5	30
7	2
>7	2

INCOME	PERCENT
	37
LESS THAN $2,000	3
$2,000 TO $4,999	9
$5,000 TO $7,999	10
$8,000 TO $10,999	9
$11,000 TO $13,999	6
$14,000 AND UP	23

AGE	USERS	POTENTIAL USERS
0-5	5	10
6-10	11	28
11-15	27	35
16-18	11	41
19-24	13	50
25-49	4	29
50-UP	0	2

PURPOSE	TRIPS	POTENTIAL TRIPS
WORK	24	192
SHOP	12	91
SCHOOL	157	516
RECREATION	57	151

BICYCLE TRIPS

Zone	Zone	Trips
3	4	156
3	15	52
3	22	156
3	32	52
7	11	62
7	33	62
7	42	62
7	45	124
7	49	62
7	55	62
10	10	46
10	12	46
10	15	138
10	25	46
12	11	42
12	12	84
12	15	378
13	15	250
13	32	100
14	15	235
15	13	50
16	15	260
16	32	130
16	46	130
16	47	130
18	15	48
18	48	48
19	30	48
23	4	62
27	15	198
28	28	16
28	46	64
30	15	54
30	30	81
30	33	162
30	47	54
31	15	200

BICYCLE TRIPS

Zone	Zone	Trips
31	25	58
31	34	142
31	41	116
31	42	116
31	46	232
33	60	22
36	37	84
36	47	84
40	15	64
40	46	64
45	47	280
45	48	80
48	48	45
60	15	132
60	47	22
61	15	280
61	32	40
61	47	40
62	15	546
63	15	700
63	32	100
64	15	4

POTENTIAL BICYCLE TRIPS

Zone	Zone	Trips
2	19	24
2	32	24
2	63	25
3	4	104
3	11	52
3	15	306
3	22	156
3	24	104
3	25	104
3	32	52
3	42	250
3	46	104
3	47	156
3	49	52
7	46	62
7	47	124
7	48	62
7	55	62
10	10	138
10	11	92
10	12	46
10	15	713
10	17	46
10	25	280
10	26	46
10	30	46
10	39	46
10	42	322
10	46	92
12	11	42
12	12	21
12	15	1764
12	16	42
12	25	168
12	26	42
12	42	84
12	44	42
12	46	84
12	49	84
12	50	84
12	51	42
12	55	42
13	15	300
13	30	100
13	32	300
13	45	100

POTENTIAL BICYCLE TRIPS

Zone	Zone	Trips
14	2	94
14	15	2773
14	16	94
14	25	188
14	32	94
14	47	141
15	3	26
15	13	50
15	28	16
15	31	29
15	32	27
15	45	42
15	47	78
15	51	32
15	55	31
16	2	260
16	13	130
16	15	8320
16	24	130
16	31	130
16	32	780
16	33	130
16	47	325
18	15	72
18	36	24
18	48	24
19	2	48
19	15	144
19	30	48
19	32	48
19	40	24
19	42	96
19	47	96
19	55	48
20	41	84
23	19	2
23	32	93
23	36	62
23	42	124
23	48	31
24	14	47
25	13	50
25	16	65
25	32	16
26	15	370
26	42	160

POTENTIAL BICYCLE TRIPS

Zone	Zone	Trips
26	52	40
27	11	66
27	13	132
27	15	66
28	6	32
28	11	32
28	15	96
28	24	32
28	25	48
28	28	16
28	33	64
28	42	80
28	46	96
28	47	64
28	51	32
28	52	32
30	15	351
30	25	108
30	28	54
30	30	54
30	31	54
30	32	54
30	46	270
30	47	54
30	51	189
30	55	54
31	15	1399
31	20	147
31	28	16
31	32	116
31	34	58
31	35	58
31	42	58
31	47	174
32	2	25
32	19	24
32	30	27
32	31	16
32	55	31
35	19	24
35	24	88
35	36	88
35	46	44
35	48	88
36	15	84
36	28	16
36	47	31
36	48	24

POTENTIAL BICYCLE TRIPS

Zone	Zone	Trips
40	15	64
40	35	24
40	36	64
40	46	32
40	51	32
40	52	64
42	28	16
43	42	196
43	46	196
45	15	2800
45	31	42
45	42	280
45	47	591
46	26	48
46	35	44
46	40	32
46	45	64
47	24	47
47	25	65
47	45	31
47	48	76
48	35	24
48	36	31
48	47	90
48	49	31
48	55	90
49	23	31
51	15	32
51	28	27
51	40	32
52	28	16
52	36	16
55	23	31
60	15	396
60	25	44
60	32	176
61	15	200
61	32	40
61	35	40
61	55	40
62	15	210
62	24	42
62	47	42
63	15	800
63	25	50
63	32	25
63	47	50
64	15	128

AUTO DRIVER TRIPS

Zone	Zone	Trips
1	55	24
2	30	27
2	32	24
2	63	25
3	4	104
3	10	52
3	15	728
3	17	208
3	22	208
3	24	104
3	25	260
3	26	104
3	30	52
3	32	52
3	42	312
3	43	104
3	45	260
3	46	182
3	47	544
3	55	156
5	40	32
6	40	32
7	13	62
7	15	91
7	25	62
7	31	29
7	32	62
7	39	62
7	42	62
7	47	124
7	48	62
7	55	124
10	6	46
10	7	115
10	10	207
10	11	138
10	13	92
10	15	805
10	17	115
10	19	24
10	24	115
10	25	648
10	26	115
10	30	46
10	31	46
10	32	46
10	35	46
10	36	45
10	37	46
10	39	46
10	40	23
10	41	46
10	42	391
10	45	92

AUTO DRIVER TRIPS

Zone	Zone	Trips
10	46	92
10	47	532
10	48	184
10	49	46
10	51	46
10	52	46
10	55	368
11	47	16
12	11	42
12	15	672
12	17	42
12	25	441
12	26	126
12	30	42
12	35	84
12	42	84
12	46	84
12	47	42
12	49	84
12	50	84
12	51	126
12	52	42
12	55	294
13	3	150
13	10	50
13	15	500
13	17	100
13	24	100
13	25	200
13	26	50
13	30	100
13	35	100
13	36	150
13	42	200
13	45	100
13	47	100
13	55	200
14	2	94
14	10	94
14	15	188
14	24	94
14	25	210
14	28	16
14	32	188
14	47	235
15	3	26
15	13	50
15	25	76
15	28	16
15	30	81
15	31	29
15	32	54
15	38	16
15	40	32

AUTO DRIVER TRIPS

Zone	Zone	Trips
15	45	74
15	47	172
15	48	27
15	51	32
15	55	101
15	60	22
16	2	130
16	24	390
16	31	130
16	32	455
16	33	130
16	47	455
16	55	195
17	2	27
17	12	21
17	16	65
17	19	24
17	35	44
18	3	48
18	15	72
18	20	48
18	25	72
18	36	48
18	37	96
18	45	24
18	47	120
18	48	48
18	55	96
19	1	24
19	2	24
19	10	48
19	15	48
19	25	72
19	26	24
19	30	48
19	32	72
19	40	24
19	42	48
19	47	216
19	55	72
20	15	42
20	25	42
20	30	27
20	32	42
20	38	84
20	41	42
20	42	21
20	47	42
23	10	62
23	15	248
23	18	124
23	19	2
23	25	93
23	27	62

AUTO DRIVER TRIPS

Zone	Zone	Trips
40	18	48
40	24	64
40	25	64
40	35	24
40	36	96
40	40	64
40	46	32
40	47	56
40	51	32
40	55	64
41	15	22
41	25	16
41	38	15
41	55	42
42	28	16
42	32	21
42	47	66
43	13	196
43	15	196
43	25	196
43	26	392
43	30	196
43	31	196
43	36	243
43	41	15
43	43	196
43	45	196
43	46	392
43	47	196
43	51	196
43	55	392
44	25	29
44	38	58
44	41	16
45	3	142
45	15	3080
45	18	48
45	19	24
45	28	81
45	31	71
45	36	32
45	38	114
45	42	422
45	45	32
45	46	280
45	47	871
45	48	45
45	55	39
46	26	16
46	36	15
46	40	32
46	45	64
47	2	50
47	10	24

AUTO DRIVER TRIPS

Zone	Zone	Trips
47	13	100
47	15	27
47	16	65
47	18	48
47	19	72
47	20	27
47	24	63
47	25	92
47	30	24
47	32	88
47	33	16
47	40	48
47	42	16
47	45	71
47	48	124
47	55	54
48	10	45
48	15	32
48	20	90
48	28	16
48	30	27
48	35	24
48	36	99
48	45	84
48	47	114
48	48	90
48	49	31
48	55	360
49	23	31
50	36	24
50	60	22
51	15	32
51	40	32
52	24	23
55	17	65
55	19	24
55	20	42
55	23	31
55	31	31
55	32	62
55	36	15
55	38	15
55	45	45
55	47	58
55	48	24
55	50	24
60	14	22
60	15	38
60	25	132
60	30	44
60	32	176
60	41	22
60	55	132
61	3	120

AUTO DRIVER TRIPS

Zone	Zone	Trips
61	15	120
61	22	40
61	25	40
61	32	120
61	47	40
61	55	80
62	3	42
62	14	84
62	15	168
62	24	84
62	25	42
62	32	84
62	47	168
62	50	42
62	55	252
62	62	42
63	10	50
63	15	100
63	24	50
63	25	50
63	32	175
63	36	50
63	47	200
63	55	350
64	15	32
64	32	32

APPENDIX B

Design Criteria

BIKEWAY CRITERIA AND GUIDELINES

In the City of Manhattan, Kansas, four types of bicycle facilities were ultimately studied. The four are:

1. "Bicycle Trail"-- A separate trail or path which is for the exclusive use of bicycles.
2. "Bicycle Lane"-- A portion of a roadway which has been designed for preferential or exclusive use by bicycles.
3. "Shared Roadway"-- A roadway which is officially designated and marked as a bicycle route, but which is also open to motor vehicular travel and upon which no bicycle lane is designated.
4. "Pedestrian-Bicycle Path"-- A sidewalk or path intended for use by both pedestrians and bicyclists. Use should be limited (see page B5).

Several forms of criteria and design guidelines are utilized in the design of the four previously mentioned bikeway facilities. The bicycle trail, mainly because of the safety it affords the bicyclist, is a preferred method of providing for bicycle travel. But, because of the cost of implementing such a facility and the lack of available land, bicycle lanes and shared roadways must be given added consideration. The design of bicycle lanes and shared roadways are determined to a large degree by the characteristics of existing facilities designed mainly to accommodate other transportation modes. Some of their characteristics are acceptable, while others present the bicyclist with a less than adequate riding environment.

What follows now, are certain criteria which have been gathered from different bikeway studies, and which are recommended by people knowledgeable in the field of bikeway design.

Location

Where bicycle trails utilize highway right-of-way, they should be located as far from the traveled way as possible so as to minimize bicyclist-motorist conflicts. A recommended distance of separation between the trail and the traveled way is 20-30 ft. (1). This separation may be less if some type of natural or structural barrier is available such as a hedge, ditch, fence, guardrail, etc.

Figure 1B below shows three different cross sections of bicycle trails located along the right-of-way.

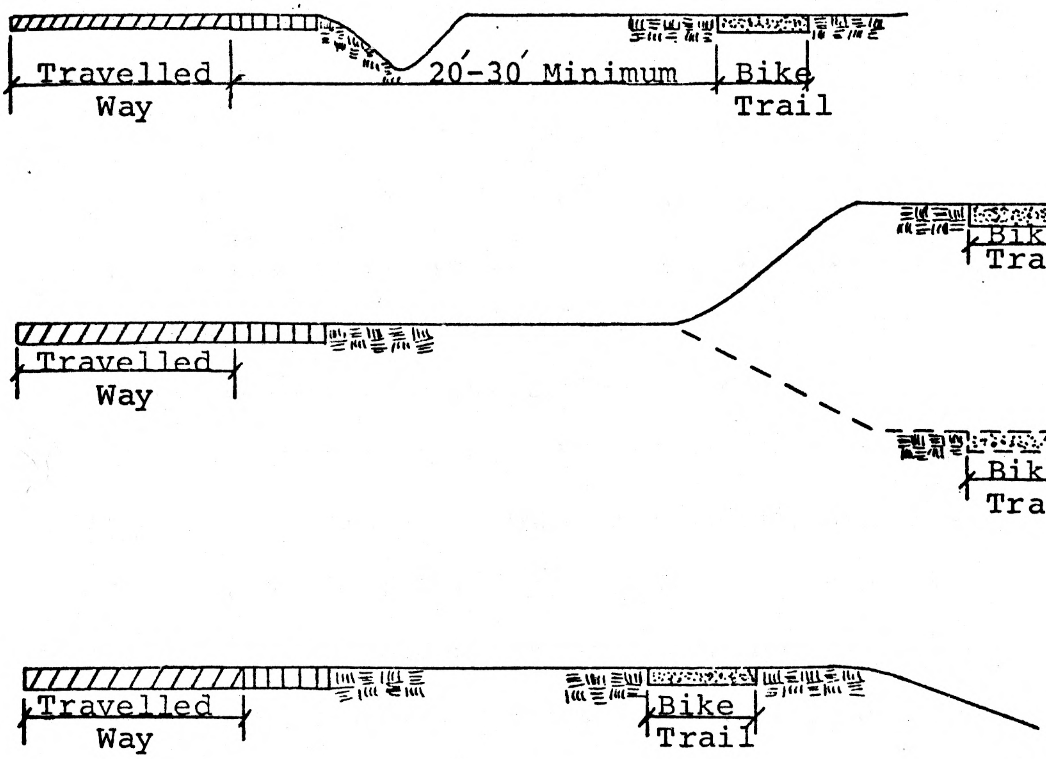
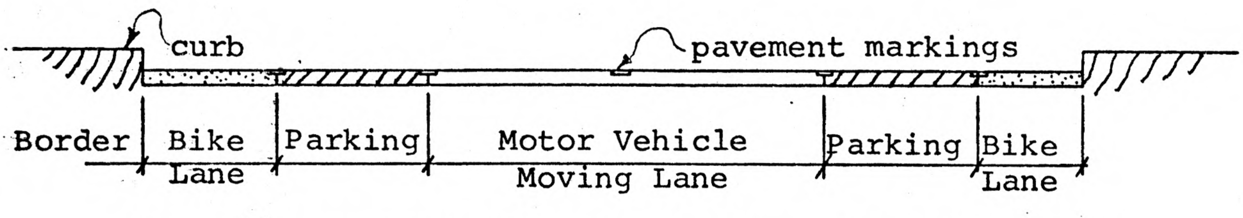


Figure 1B
Typical Bicycle Trails along Highway with Shoulders

The bicycle lane along street right-of-way is delineated by means of pavement markings or physical barriers. Pavement markings are passive in nature and may be easily crossed by motor vehicles but experience has shown these to be quite effective in limiting vehicle incroachment of designated bikeway space and in reducing accidents (2). The markings include striping, full-width pavement coloring or painting, pavement markers (dots) and reflectorized raised pavement markings. Some form of curb, bumper block, or vehicle parking lane provides a more positive means of controlling motor vehicle encroachment, however, such barriers are not beneficial in all instances. They are recommended for use only under special circumstances (2). First, the street should have few or no midblick breaks (driveways, loading zones, taxi or bus stops, etc.). Second, the street should have at least one of the following characteristics: legal speed over 35 m.p.h., average daily traffic over 8,000, parking turnover is high, or inadequate roadway width. This type of protected bike lane has created problems in some cities. Some installations have resulted in increased pedestrian-bicycle accidents, while others have resulted in two-way bicycle traffic where one-way traffic was intended (2). In general this type of lane will not be necessary in Manhattan. They should be recommended only after careful consideration of all aspects of the problem.

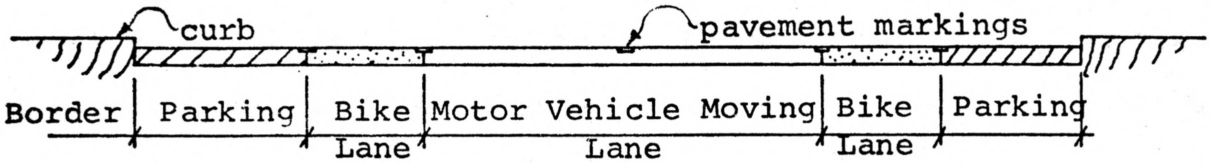
There are three general locations for bicycle lanes with respect to the vehicular roadway, depending on the parking condition along the street, as shown in Figure 2B. Of the three shown, we recommend, because of the effective width of the streets in Manhattan, Figure 2B (c). If Figure 2B (c) is not feasible, we then recommend a modified version of it, in which a one-way bike lane is located along one side of the street and parallel parking along the opposite side of the street (a one-way bike lane in the opposite direction may be located on a parallel street one block from the previously mentioned bike lane).

Figure 2B(1)

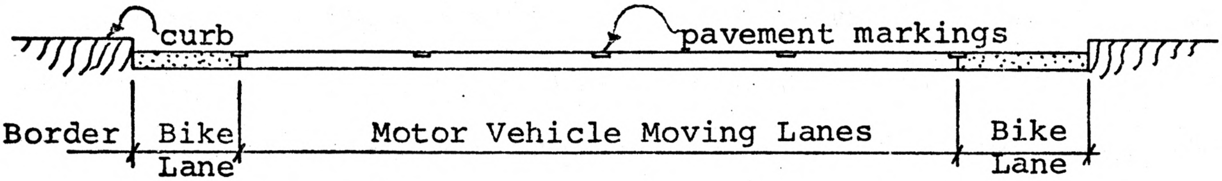


(a) Parking permitted--Bicycle lane located between sidewalk and parking lane.

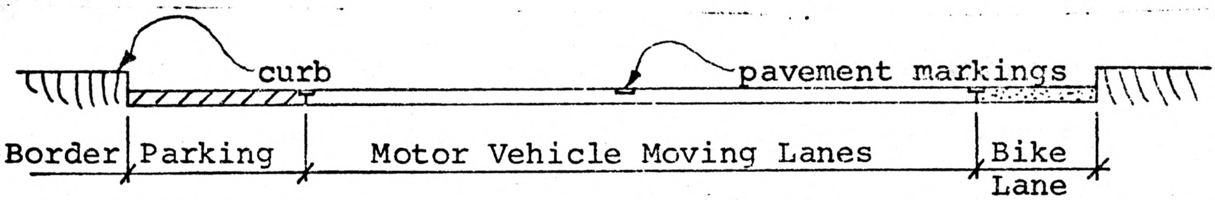
Figure 2B (Cont.)



(b) Parking permitted--Bicycle lane located between parking lane and motor vehicle moving lanes.



(c) Parking prohibited--Bicycle lane located between sidewalk and motor vehicle lanes.



Modified 2(c) Parking permitted on one side--Bike lane located on opposite side between sidewalk and motor vehicle lanes.

The shared roadway differs from the bike lane in that no portion of the roadway is set aside for the exclusive use of bicycles. The shared roadway has no barrier--either symbolic or physical--to delineate a portion of the roadway for bicycles. It is identified by posted signs, or works or symbols printed upon the pavement. We recommend that only streets with very low vehicular thru-traffic be designed as a shared roadway.

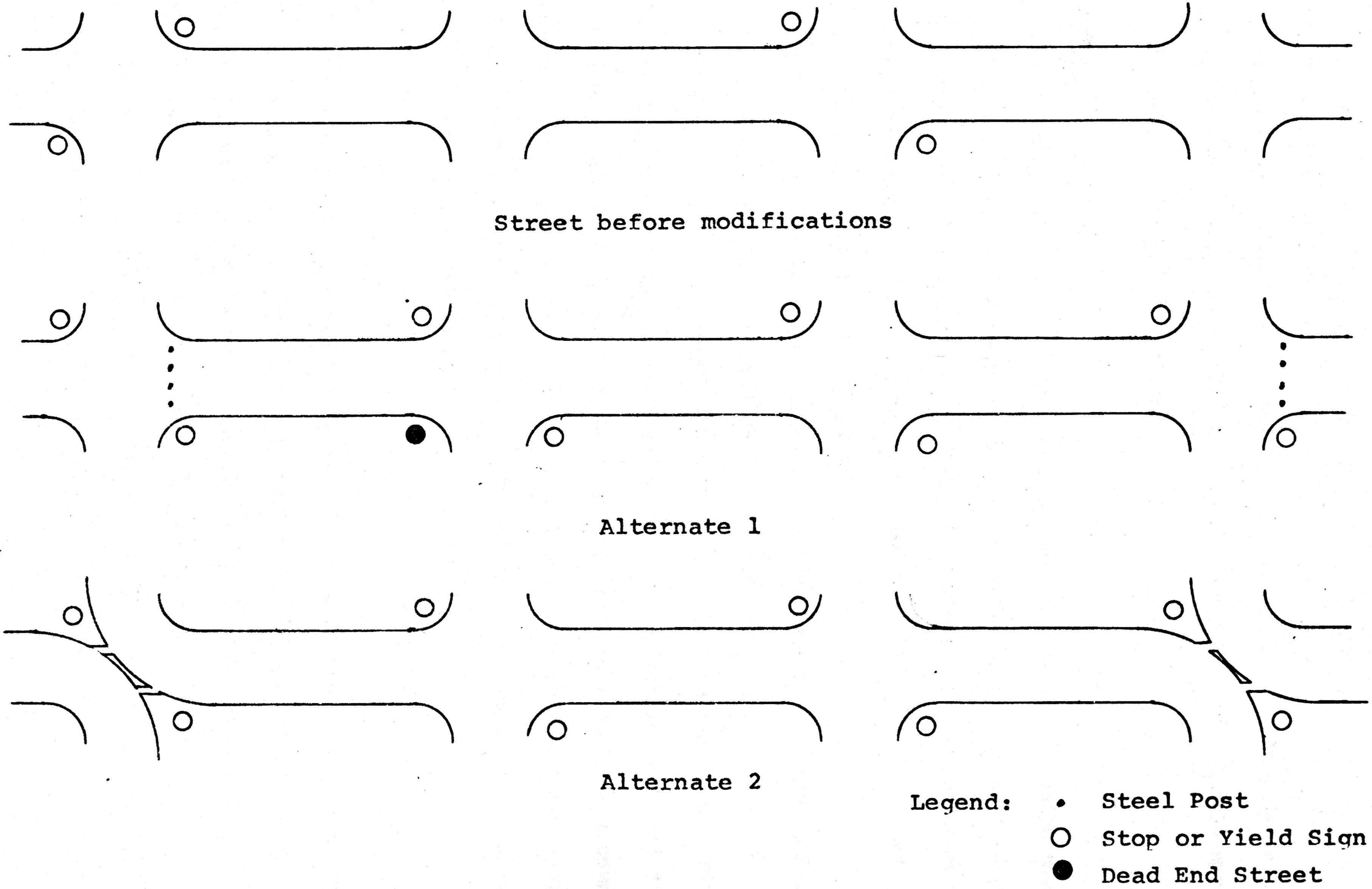
This type of bikeway is suitable for residential streets where traffic is normally low. Streets selected for this type of bikeway should be protected from cross traffic with stop or yield signs. This signing may incourage additional auto traffic which would negate the reason for selecting the street in the first place. For this reason, these streets should either be signed for 20 m.p.h. traffic or be provided with some device which will allow through movement of bicycles only. Two examples of the latter are illustrated in figure 3B.

A pedestrian-bicycle path is any sidewalk or trail intended for use by both bicyclists and pedestrians. When moderate to heavy pedestrian traffic will be encountered, separate lanes on the path should be provided for bicycles and pedestrians. In general pedestrian and bicycle traffic does not mix well (16). Pedestrian-bicycle Paths should, therefore, be used sparingly. They are recommended for use in the following situations: (a) Pedestrian traffic is light, (b) path is long (greater than 2 blocks) with few interruptions (drives, cross streets, etc.) and little or no retail commercial activity is present, (c) channelization at intersections where there is insufficient space on the streets for bicycle lanes, and (d) areas where only pedestrian and bicycle traffic exists such as parks or campuses.

Design Speed

The speed that a bicyclist travels is dependent upon several factors. Among these are types of bicycle and gearing, grade, surface, direction and magnitude of wind, air resistance, physical condition of the bicyclists and bike paths, and length of trip.

Studies have shown that most bicyclists travel within a range of 7-15 m.p.h., with the average between 10-11 m.p.h. On downgrades, speeds are



THROUGH MOVEMENT OF BICYCLES ONLY
Figure 3B

higher than average speeds.

Therefore, the minimum design speed should be 10 m.p.h.. On long or steep downgrades a design speed of 15-20 m.p.h. should be used. Design speeds from 15-25 m.p.h. would be preferable.

Radius of Curvature

The minimum radius of curvature must be consistent with the design speed of the bicycle facility. Bikeway radii, in most cases, are governed by the road alignment on which the bikeway facility is implemented. Since the curves on these road alignment were designed to accommodate motor vehicles, they should be extremely adequate for bicyclists.

For separate bicycle paths, the radius of curvature varies from 15 ft. to 125 ft. depending upon the design speed of the facility.

The minimum radius of curvature can be calculated from the formula (16) $R=1.25V + 1.4$, where "R" is the unbraked radius of curvature in feet, and "V" is the design speed in m.p.h. For the City of Manhattan, Kansas, we recommend a minimum design speed of 10 m.p.h. for bike lanes and shared-right-of-ways on existing streets and roads, and a 15 m.p.h. minimum design speed for all bicycle trails and for bike lanes on future streets.

Grades

The grade which a bicycle can be expected to negotiate is dependent upon the length of grade, characteristics of the bicyclist (age, weight, conditioning, etc.), characteristics of the bicycle (type, gearing, weight, etc.), wind velocity, air resistance and road surface. Since most of these factors are variable, it is difficult to specify definite design grades. Taking all these factors into consideration, though, grades should be kept to a minimum.

Most surveys recommend a maximum grade of 3%, with 5% maximum grades for "short" sections. European practice indicates that a 10% grade over very short sections is allowable, but a 4.5% grade is generally accepted as maximum and this only for short sections. The design values in Table 1B, are values which generally are acceptable for most bikeway facilities. We feel, that in most cases, these values are reasonable for the City of Manhattan, Kansas.

Table 1B

Bikeway Gradient	Desirable Length	Normal Length	Maximum Length
10.0%	Not Recommended	33'	66'
5.0%	Not Recommended	131'	262'
4.5%	82'	167'	334'
4.0%	102'	203'	410'
3.5%	148'	295'	590'
3.3%	148'	295'	590'
2.9%	200'	400'	800'
2.5%	262'	525'	1,050'
1.7%	590'	1,800'	---
1.4%	---	2,100'	---

Source: Ref. 16

For bike paths located on steep grades, "switchbacks" may possibly be used (rest stops may also be provided along long steep grades).

The designer is offered some latitude in selecting profile grades for bicycle trails, but this is not the case for bicycle lanes and shared roadways. Thus, the maximum grades, as recommended above for design, will be considered important factors in locating these latter two types of bicycle facilities.

Sight Distance

To insure safe and efficient operation, all types of bicycle facilities should be designed so that there is adequate sight distance for safe stopping. Design values for stopping sight distance on bicycle facilities may be computed in the same manner as for highways. Sight distance length is dependent upon design speed and profile gradient. Design values of stopping sight distance for various design speeds and grades are provided in Table 2B.

Table 2B

Design Speed	Stopping Sight Distances For Downhill Gradients of:			
	0%	5%	10%	15%
mph	Feet	Feet	Feet	Feet
10	50	50	60	70
15	85	90	100	130
20	130	140	160	200
25	175	200	230	300
30	230	260	310	400

Source: Ref. 1

The values in Table 2B are based on a coefficient of skid resistance of 0.25 and a perception reaction time of 2.5 seconds (1).

In general, there is no problem in attaining adequate stopping sight distances for shared roadways and bicycle lanes because the roadway alignment usually has been designed to accommodate motor vehicle speeds which are equal to or greater than bicycle speeds. Exceptions do occur, though, and the stopping sight distance should be checked in locating such facilities.

<u>Bikeway Width's and Clearances</u>

The width required for a bikeway facility is one of great importance in designing a safe and adequate facility. Since the cost and feasibility of providing the bikeway varies with its width, it is necessary to determine minimum specifications, subject to the space required for cyclist and cycle, allowances for lateral movement between cyclists, allowances for lateral clearance to obstructions (curbs, signs, etc.) and to hazards (shoulders, gratings, etc.), and for a "comfortable" maneuvering allowance.

The approximate average dimensions of an adult-size bicycle are 2 ft. in width at the handlebars and 5 3/4 ft. in length. The vertical space occupied by a cyclist on a cycle (adult-size) is 7 1/2 ft. Vertical pedal clearance above the roadway is one-half foot (1).

In choosing the specifications that we will use for the City of Manhattan, Kansas, there were several factors that we first had to consider. To cite two: If the level of service of the bikeway facility is a prime consideration, it is recommended that the liberal standards be adopted as a minimum. If the bikelane is to be "squeezed" into the least space, and anticipated volumes are not excessive the conservative standards should be used. As previously mentioned, cost and safety are factors affecting the choice of design width specifications.

Most of the specifications that we have looked at, are actually German (16) specifications (modified or unmodified). These specifications list the following space requirements.

1. A vertical clearance of 0.8 ft. This 0.8 feet clearance added to 7.5 feet previously mentioned occupied by the bicyclist on his bicycle, represents a vertical space requiement of 8.3 feet.

2. A comfortable maneuvering distance requirement of 0.67 ft. of paved surface on each side of the handlebars for one-way operation.

3. A lateral clearance of 0.8 feet between the edge of the bikeway pavement and a static obstruction alongside of the bikeway.

4. An interior maneuvering allowance of 1.33 feet between bicyclists, regardless of the direction of each.

A UCLA (16) study has indicated, though, that in contrast to the 1.33 ft. maneuvering allowance recommended in the German specifications, a 2.5 feet maneuvering allowance between cyclists is preferred by most bicyclists. This distance, 2.5 feet, was arrived at as a mean distance at which bicyclists, traveling at 10 m.p.h., felt was a comfortable maneuvering allowance.

Table 3B gives the minimum effective width for bikeway pavement as a function of number of bikeway lanes. We recommend that these values be used for the design of effective bikeway widths.

Table 3B

Minimum Effective Width

Number of Lanes (1 way)	Minimum Effective Bikeway Width (ft.)	Widths Based Upon a Comfortable Maneuvering Allowance at a 10 mph Design Speed (ft.)
1	3.3	3.3
2	5.3	6.4
3	8.5	10.9
4	11.8	15.3

In order to satisfy the bicyclists requirement for safe and comfortable maneuvering there should be a minimum lateral clearance of 0.8 feet. Table 4B lists some of the clearances that should be added to the effective widths of the bikeway lane to insure their safety and comfort of the bicyclists.

Bicycle trails may be readily designed using the criteria mentioned below. The minimum widths listed in Table 3B, along with the clearances mentioned in Table 4B, are directly applicable (it may be necessary to adjust minimum widths and clearance to allow for maintencance vehicles).

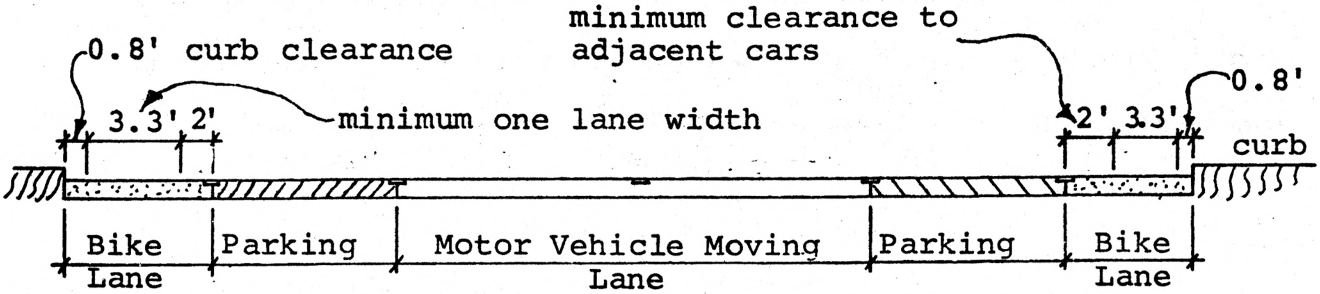
Bicycle lanes should be restricted to one-way traffic. If possible, at least two lanes should be provided so as to allow for a passing lane. The minimum width and horizontal clearances depend on the location of the lane within the roadway and the parking conditions. Figure 4B shows the four types of bicycle lanes being considered and the minimum width and clearances required, for Manhattan.

Table 4B

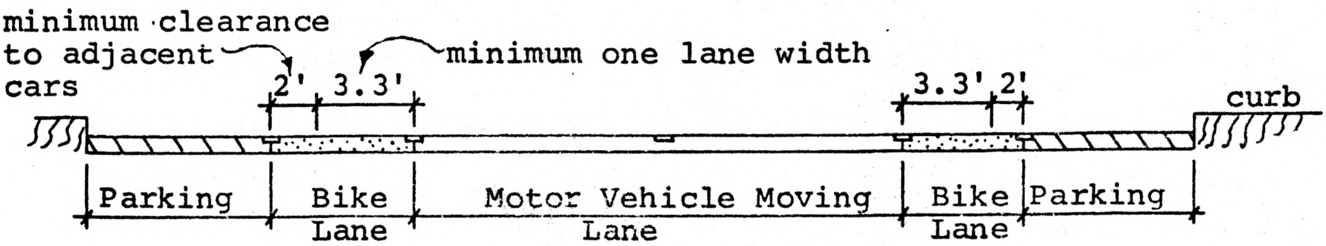
Adjustments to Basic Bikeway Widths

Condition	Additional Width (feet) Minimum	Desirable
Raised curb on one side	0.8	1.6
Parked cars adjacent ("dynamic" obstructions)	2.0	2.0
Soft shoulders	1.6	---
Horizontal Clearance to obstructions (tree, pole, signs, etc.)	0.8	2.3
Horizontal Clearance to sloped drop-off	0.8	1.0

Figure 4B

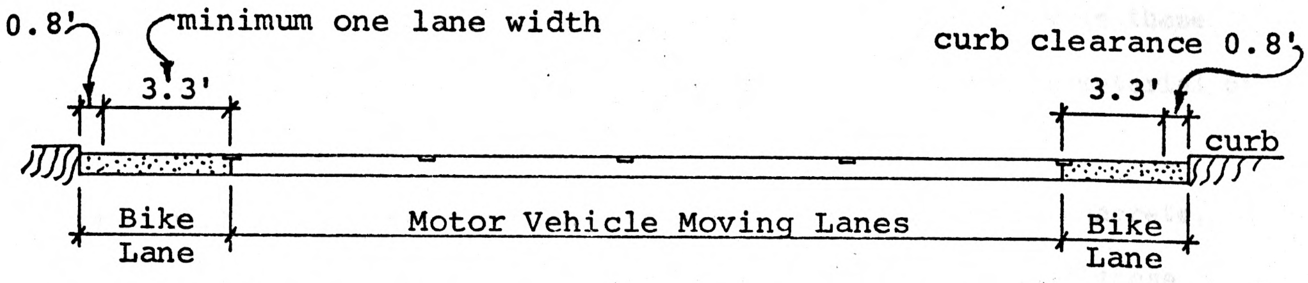


(a.) Parking Permitted - Bicycle lane located between sidewalk and parking lane.

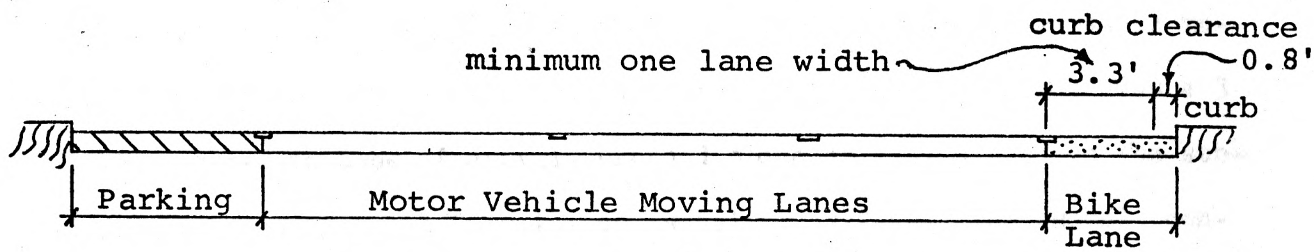


(b.) Parking Permitted - Bicycle lane located between parking lane and motor vehicle moving lanes.

Figure 4B (Cont.)



(c.) Parking Prohibited - Bicycle lane located between sidewalk lane and motor vehicle moving lanes.



(d.) Parking permitted on one side - Bicycle lane located on opposite side between sidewalk and motor vehicle lanes.

A street should be designated as a bicycle route for operation as a shared roadway only in those cases where the width of the outer lane is greater than 10 feet where volumes are light, or greater than 12 feet where volumes are heavier (1).

Bikeway Surface, Base and Subgrade

Bicycle lanes and shared roadways normally will be located upon existing surfaces provided for motor vehicles. These surfaces are usually more than adequate to meet the needs of a bicycle and also of maintenance equipment. Any widening of the pavement to provide a bicycle lane should be done according to the standard street practice.

The basic criterion for the roadway structural section of a bicycle trail is that it be adequate to support the wheel loads of riders and bicycles as well as maintenance vehicles or other types of motor vehicles which may cross or use the facility. Therefore, the type of material and depth of the base cover is of utmost importance. Also, the roadway should be surfaced with a material which is traversable and stable, even in wet weather. With these things in mind, a desirable surface would consist of an asphaltic material or portland cement concrete.

Most Manhattan street surfaces consist of a portland cement concrete, although a few of the roadways are brick streets. The majority of these concrete streets are adequate for bicycle lanes and shared roadways, based upon the condition of the concrete surface--holes, cracks, etc.

Bicycle trails, if at all possible, should be composed of aspaltic material 3 to 6 inches in total thickness. This total thickness includes a 3 to 4 inch aggregate base of gravel, crushed stone or clay placed on the subgrade, over layed by a 1 1/2 to 2 inch asphaltic surface. The asphalt content may be 1.2% higher than used for roads since the bikeway will be subject to lighter loadings than would a typical motor vehicular roadway (16). Listed in Table 5B are suggested hot-mixes and thicknesses to be used in the construction of bike paths surfaces (16).

<u>Drainage and Grate Hazards</u>

For bicycle lanes and shared roadways along existing road right-of-ways, the existing drainage systems will usually suffice. For bicycle paths, a 1/4" to 3/8" per foot slope along the surface course will normally insure water runoff (either to oneside or crowned) (16). Ditches should be provided in flat areas with poor soil drainage properties.

The problem of grating hazards is not as simply handled as one would imagine. Drainage grates normally consist of separated slats running parallel to the curb. Even the narrowest grate slat separations can entrap the narrow tires of today's modern light-weight bicycle. One solution to the

Table 5B

Quality of Existing Sub-Grade	Material (AASHO System)	Total Thickness (Inches)
Very Good	Gravels and sandy gravels: A-1, A-2-4, A-2-5, A-2-6	3
Good	Silts and clays: A-4, A-5, A-6, A-7-5, A-7-6	4
Poor	Silts and clays: A-4, A-5, A-6, A-7-5, A-7-6	6

Silts and clays rate poor only under the following conditions:

1. When they occur in low lying areas with poor natural drainage.
2. Where conditions of the water table and climate are such that severe frost heave can be expected.
3. Where high percentage of mica-like fragments or diatamaceous particles produce a highly elastic condition.
4. Where it is desired to "bury" highly expansive soils deeper in the section to limit the effects of seasonal variation in moisture.

problem would be to replace the existing grates with zig-zag or perpendicular configurations, although this is not hydrodynamically efficient. Another solution, one that should be considered as a last resort, would be to provide clearance around the grate with warning stripes and signs. Probably the best solution would be to weld cross strips on the grate. In the interest of safety for the bicyclists, we recommend that the City of Manhattan make all grates on bikeways bicycle safe, with no exceptions. Also, sufficient drainage should be provided so as to insure that ponded water may be eliminated.

Bridges

A bridge designed exclusively to carry a bicycle trail over a natural barrier or across a highway should have a minimum width of 8 feet, particularly where two-way traffic is to be accommodated. Past experience has shown that bridge structures designed for pedestrian live loading are adequate for bicycle loading.

Where separate bicycle routes are located parallel to a street or road, it is sometimes necessary to carry the route across an existing street or highway bridge structure. On low volume, low speed roads and highways where the roadway shoulder is carried across the bridge, the bridge shoulder can be used as a bicycle trail. On high volume, high speed roads and highways, the bicycle route should be separated from the bridge shoulder by a physical barrier (fence, steel railing or concrete parapet). The minimum effective width of the bikeway can be determined from the values in Table 3B and Table 4B.

On many existing bridges, it is usually necessary to widen the existing structure. This widening can be accomplished by attaching a cantilevered bikeway to the bridge structure. Where it is anticipated that a bicycle facility will be provided in the future, new bridges should be designed to provide the necessary effective bikeway widths.

<u>Intersections and Crossings</u>

Because the number and severity of bicyclist-motorist and bicyclist-pedestrian conflicts are the greatest at intersections and crossings, great care must be employed in designing crossings and intersections which are to accommodate bicycle traffic. This design problem is further complicated by cost and by the usual lack of available space. The safest and most effective way of eliminating the before-mentioned conflicts is grade separation, a solution which usually proves to be economically unfeasible. Therefore, a design which utilizes existing at-grade street intersections usually must be provided.

As channelization is used for motor vehicles and pedestrians at intersections, some form of channelization with specific routings for bicycles should be provided so as to minimize conflicts. Such at-grade channelization is usually necessary for bicycle lanes (See Figure 5B thru 8B). It is not usually necessary for shared roadways except where motor vehicle and bicycle traffic is heavy, motor vehicle speeds are in excess of 30 m.p.h., or where there is a high percentage of motor vehicles making right turns out of the shared roadway (16). Channelization may take several forms, but it usually takes the form of a path delineated by striping or pavement markings. In most cases, these delineated bicycle crossing paths should be adjacent to, but striped separately from, the pedestrian crosswalk.

To minimize conflicts between right-turning motorists and straight-through bicyclists, the bicycle crossing path may be offset some distance from the intersection. To minimize the conflict between left-turning bicyclists and motorists, it is recommended that bicyclists be made to cross the cross street first, and then proceed left on the proper delineated bicycle cross path.

In all cases of bikeway facilities intersecting with streets or highways, safe sight distances for bicyclists and motorists must be considered. This is so that the bicyclists will have sufficient time to safely cross the roadway. This may require an intersection channelization as in Figure 5B, so as to insure safe sight distances.

In most cases, each intersection of the proposed bikeway facility with a street or highway, must be treated separately. Different motor vehicle and bicycle volumes, varying speeds, land availability, costs, and different types of streets (arterial, collector, or local) require a separate design for each intersection.

Illustrated below, are typical examples of channelization arrangements at street intersections.

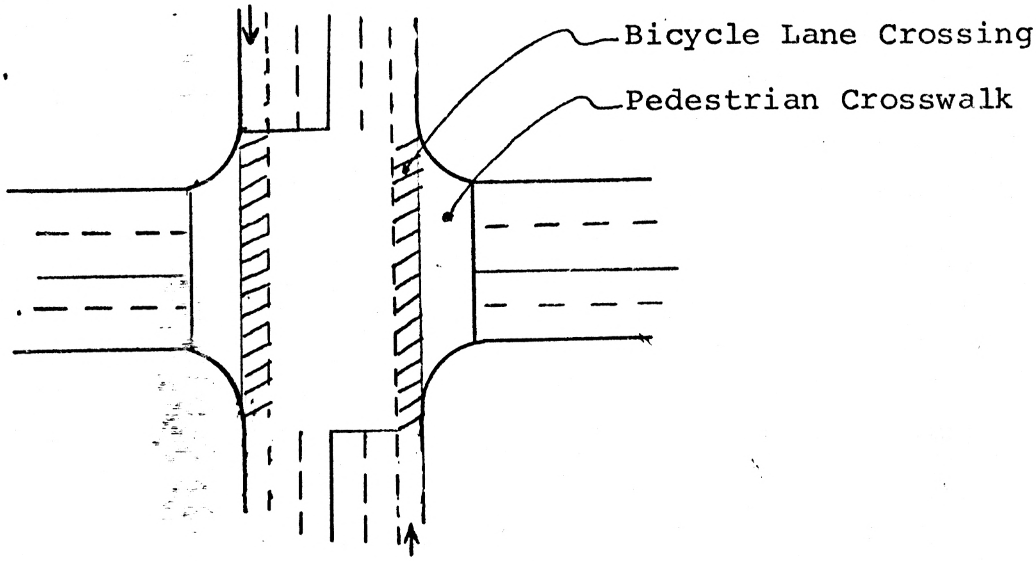


Figure 5B: Bicycle Lanes Crossing Intersection

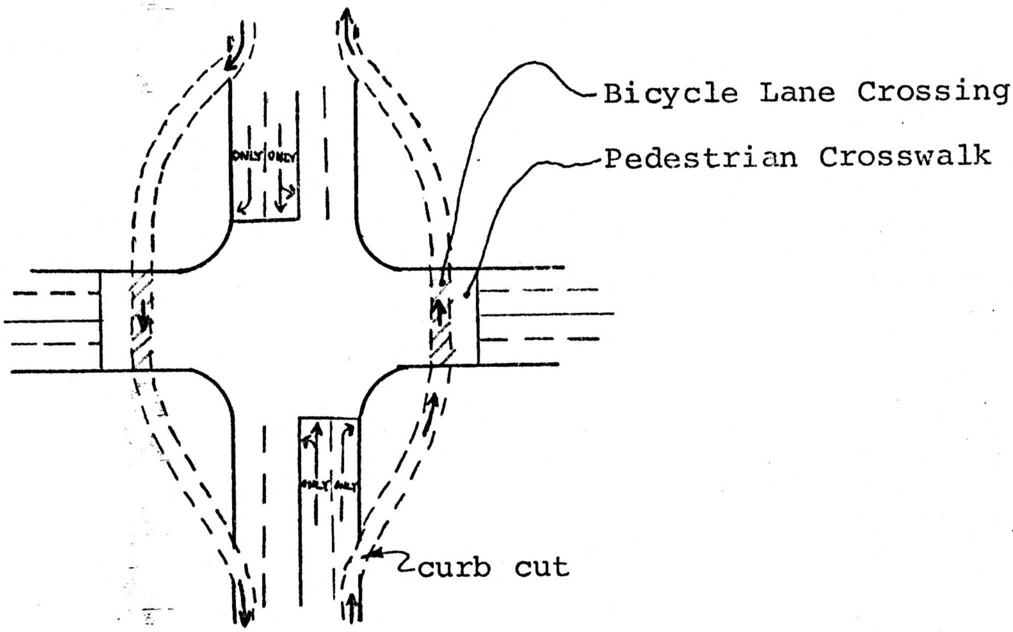


Figure 6B : Bicycle Lanes Offset to Cross Intersection
(Used where there is a heavy vehicular right-turn movement)

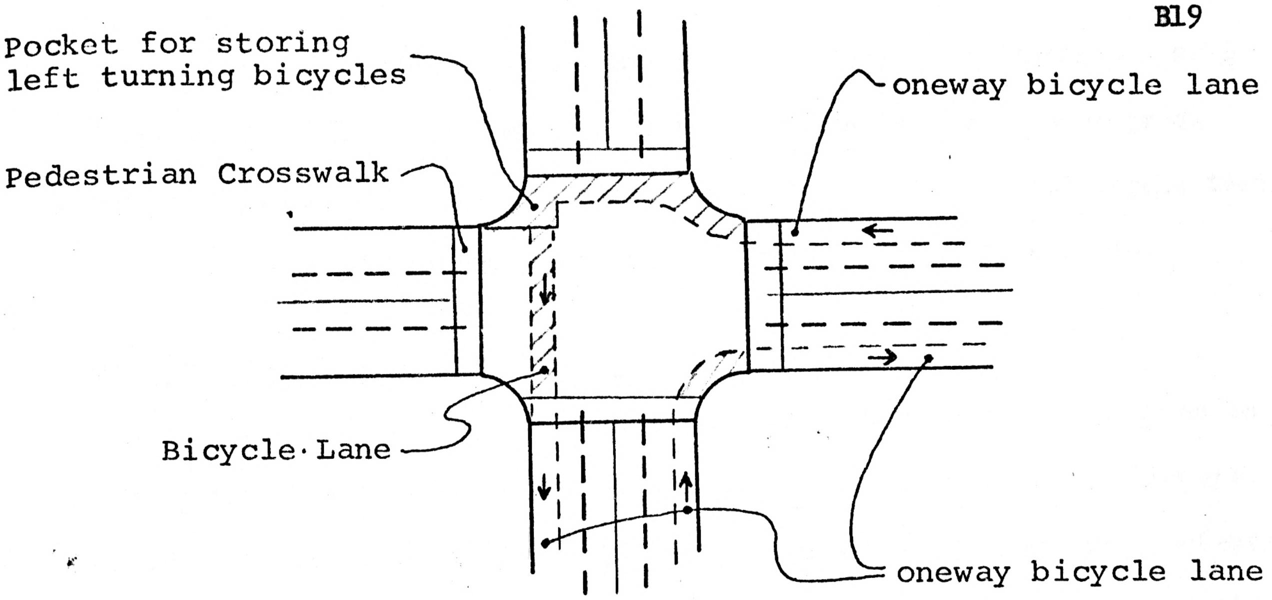


Figure 7B: Bicycle Lanes Continued on Cross Street

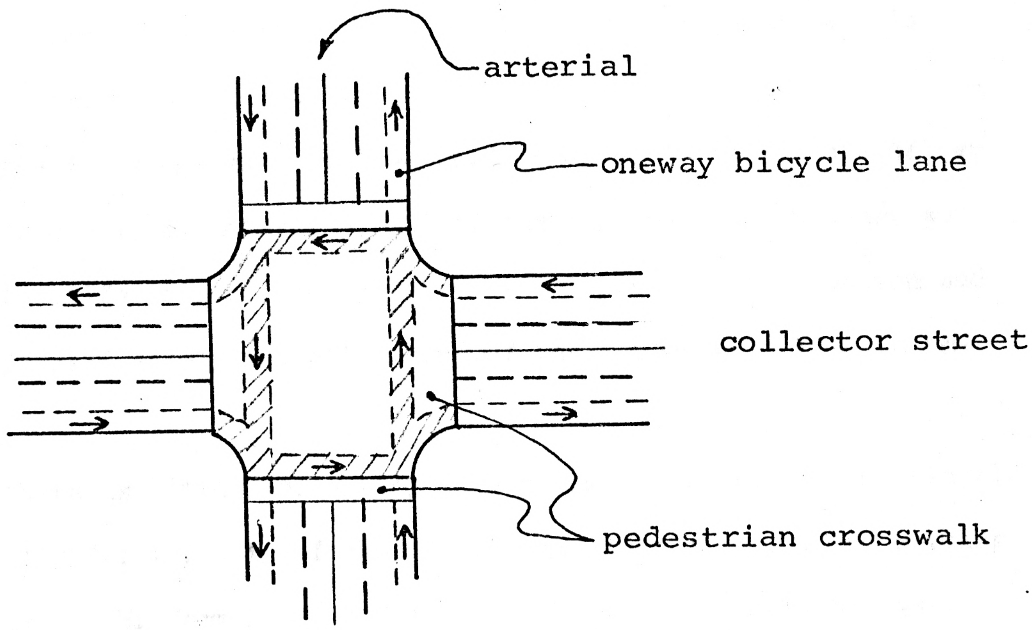


Figure 8B: Bicycle Lanes Continued on each Cross Street

Almost all, if not all, of the intersection designs for Manhattan will be at-grade, channelization designs. The only probable place where grade separation (overpasses, underpasses) may be employed would be on bicycle trails where at-grade street intersections aren't physiographically feasible.

Bikeway Signing, Markings, and Signals

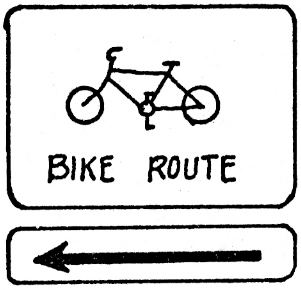
As in all modes of traffic, adequate signing procedures are required in order to insure the safe and efficient operation of all classes of bikeways. These signs and markings will be needed to delineate the bikeway right-of-ways, to warn bicyclists of hazardous conditions and obstacles, to exclude undesired motor vehicles from the bikeway, and to warn pedestrians and motorists of the existence of a bikeway facility. Enforced local ordinances, in addition to the signing, are necessary to insure that the bicyclist's right-of-way is not violated by motorists or pedestrians.

Standard signs and markings should be used in order to facilitate better comprehension by bicyclists, motorists, and if the case be, pedestrians, and also to insure the uniformity of the system. With improved comprehention and uniformity, the overall safety and efficiency of the system will also be improved.

At present there is little uniformity in signing practices for the bicycle. To insure uniformity for the City of Manhattan, the standard signs and markings shown in the Manual on Uniform Traffic Control Devices (11) should be used. These standard signs consist of the following:

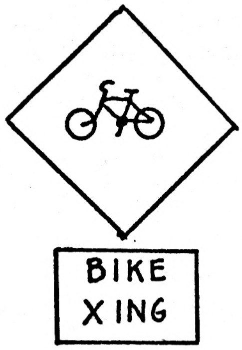
1. BIKE X-ING (WII, black on yellow)--used for warning motorists in advance of a point when an officially designated bike route crosses a roadway. See Figure 9B(a).

2. BIKE ROUTE (DII-I, white on green)--used for marking an offically designated bicycle trail, bicycle lane, or shared roadway. The sign is intended to guide bicyclists along a predetermined route. When necessary, a supplementary sign with a directional arrow may be placed below the BIKE ROUTE sign. See Figure 9B(b).



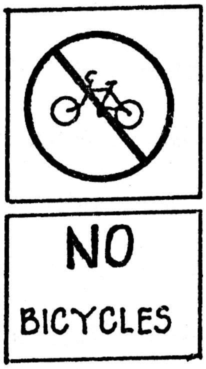
D 11-1
24" x 18"
24" x 6 "

(b)



W 11-1
30" x 30"
24" x 18"

(a)

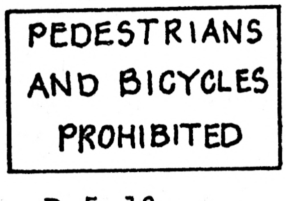


R 5-6
24" x 24"
24" x 18"

(c)

R 5-3
24" x 12"

(d)



R 5-10
30" x 18"

(e)

Figure 9B

Standard Signs Pertaining
to Bikeway Facilities

3. NO BICYCLES (R 5-6), PEDESTRIANS PROHIBITED (R 5-3), and PEDESTRIANS AND BICYCLES PROHIBITED (R 5-10) are selective exclusive signs that regulate types of traffic which may or may not enter a particular right-of-way. See Figure 9B(c), (d), and (e).

4. Any standard warning sign for bicyclists which is relevant to separate bicycle trails may be considered ("Curve", "Winding Road", "Stop Ahead", "Yield", etc.).

In many situations, symbolic or lettered white pavement is a very useful supplement to the posted signs. At intersections, directional markings (arrows) on the pavement have proven particularly effective in channelizing bicycle traffic. Lettered markings with the message BIKE ONLY are desirable legends on bicycle trails and bicycle lanes to reinforce the signing along the route and discourage motorists from encroaching upon the bicyclist's right-of-way. Other markings that can be used include "PED X-ING", "SLOW", "STOP", and "YIELD". Pavement markings of this type are described in Section 3B-18 of the Manual on Uniform Traffic Control Devices.

The AASHO Standing Committee on Engineering and Operations recommend that the following principles be applied in the design of signing along bicycle routes (1):

1. Adequate signing should be provided at all decision points along the route, i.e., signs informing the bicyclist of upcoming directional changes and confirmation signs to insure that route direction has been properly comprehended.

2. Route or guide signs should be provided at regular intervals so that bicyclists are informed that they are traveling on an officially designated bicycle route.

3. Adequate motorist warning signs should be posted wherever a bicycle route crosses a roadway, when a bicycle route begins or ends, or at any other points where large numbers of bicycles may be encountered.

4. In urban areas, warning signs directed to the motorist should be positioned a minimum of one-half block in advance of any point where bicycles may be encountered.

5. Warning signs informing bicyclists of potential hazards should be positioned along all types of bicycle routes not less than 50 ft. in advance of the hazardous condition.

A minimum of 10 and possibly as many as 20 signs per mile could be required, depending upon the type of facility and the before-mentioned principles.

The signs should be placed from 1 to 3 feet from the edge of the bikeway, depending upon the type of facility (one foot for bicycle trails, and 2-3 ft. for bicycle lanes and shared roadways. This lateral displacement is measured from the edge of the bikeway to the nearest edge of the sign). The vertical displacement of the signs should be approximately 7 feet from the lower edge of the plaque to the qround.

In addition to the signs previously mentioned, it is recommended that several appropriate signs be installed so as to direct cyclists to the bikeway facility.

In all instances, signs and pavement markings should be reflectorized in order to improve their visibility at night.

The signal system for the street or highway network should be considered in the planning of bicycle routes. Routes that must cross heavily traveled arterials or collector streets where grade separations are not feasible, should do so at signalized intersections. Where bicycle routes cross streets at signalized intersections, some modification in the signal phasing or control mechanism may be necessary so as to insure the safe and effective flow of bicyclists.

Where the marked route deviates somewhat from a direct crossing it may be desirable to add an additional signal face; however, it is usually undesirable to provide separate signal faces and exclusive phases for bicycles during the signal cycle, since they tend to confuse the motorist as well as the bicyclists. Signals may be warranted at a bicycle trail crossing of a vehicular roadway where there is no existing signal installation. Such signals should be of the semi-actuated type with pedestrian "push-button type" detectors provided for the bicyclists.

Bikeway Lighting

To insure the safe operation of any bikeway for which considerable nighttime travel is anticipated, adequate lighting is a definite requirement. Bicycles do not have headlights powerful enough to illuminate the bikeway anywhere near the distance required for a design speed of 10 m.p.h.; therefore, the bikeway must be illuminated from fixed luminaires. These luminaires must not only light the path, they also must reveal the presence of the bicyclist.

In some portions of the bikeway facility, shared roadway or bicycle lane, existing roadway illumination may be adequate. In most portions of the facility, though, existing illumination is inadequate. Fixed obstacles such as storm drains and gratings, and route features (ramped curbs, sidewalks, and crossings) are usually inadequately illuminated for nighttime use by bicyclists.

There seems to be a lack of published criteria regarding bikeway illumination requirements. Of criteria that is published, most deal with intersections and bikeway crossings. These two bikeway features are potentially the most hazardous for nighttime bicycle usuage.

It is concluded from published studies that back lighting (silhouette type) is indispensable for all bikeway crossings. At the crossing, roadway illumination should be between 0.2 and 2.0 foot-candles, depending on the roadway (16). Luminaires should be asymmetrically positioned, shaded and broad beamed. For both crossings and intersections, transition illumination should be provided on the bikeway not less than 330 feet on either side of the bikeway feature.

APPENDIX C

ROUTE LOCATIONS

DESIGN PROCEDURE

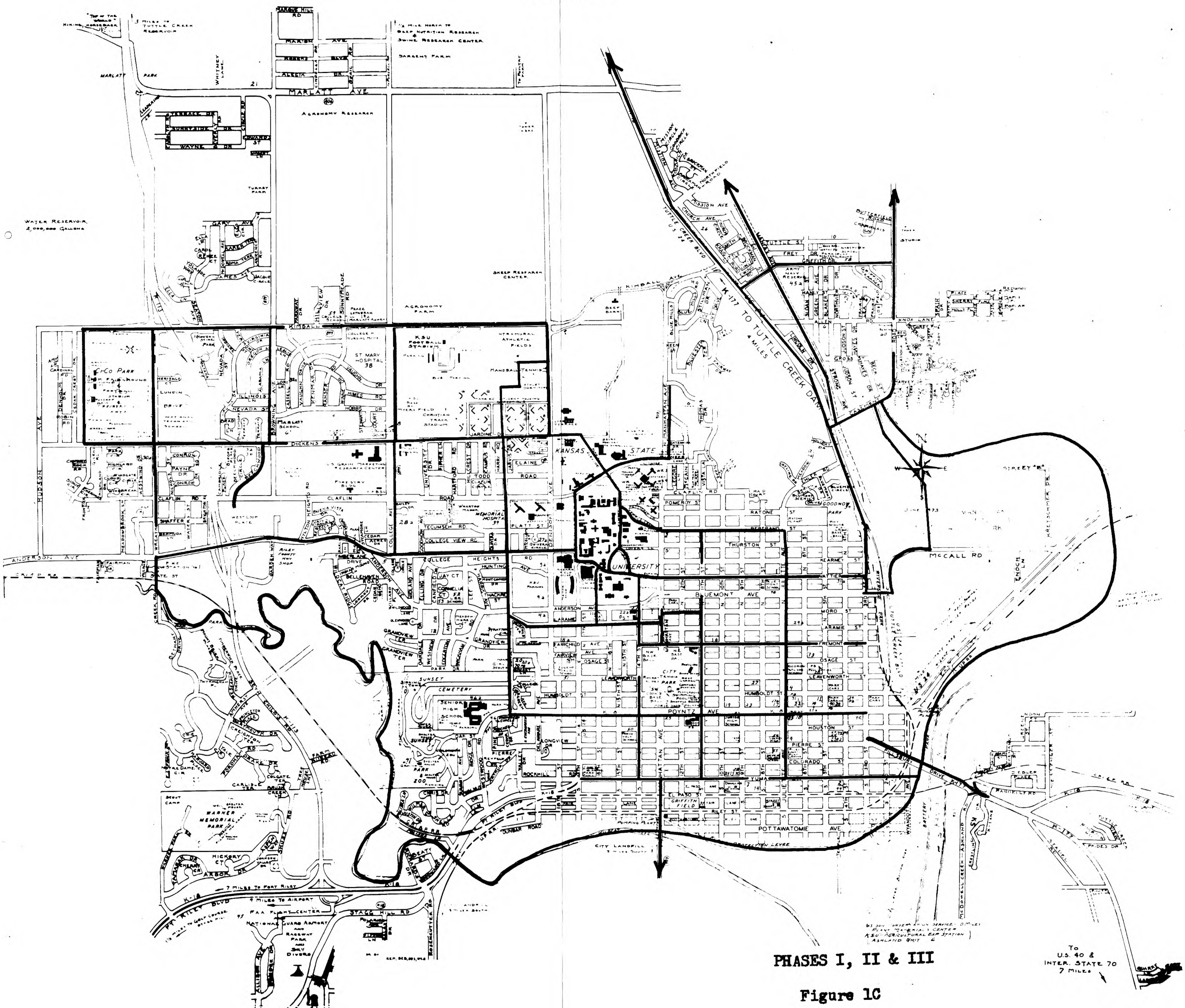
In order to select bicycle routes, we first determined what we felt were the primary attractors of bicyclists; schools, shopping centers, parks, etc.; and located these on a city map. Following this we examined our street criteria, and determined which factors should be taken into consideration for design. These were found to be width, surface, grade, and traffic volume. Knowing these criteria we codemarked each street that did not meet one of the required factors with a color that corresponded to each factor. This marking allowed us to readily see which streets were not acceptable, and allowed us to rate streets that only had a few bad features. We overlayed the same city map with a transparency and drew various on-street bikeway systems that would get the most riders where they wanted to go without going too far out of their way. Next, we drove each of the proposed streets and checked for bad spots such as curb inlets and rough surfaces; we also checked for adequate right-of-way, allowing separate bike paths. With this knowledge we evaluated all the routes under consideration. The final network of routes (See Figure 1C) was selected on the basis of directness, and present and future usage (A.D.T.), as well as the criteria mentioned earlier.

Types of Bikeways

In designing a bikeway system for the City of Manhattan, we considered four main bikeway facilities. Our first consideration was given to bicycle trails, which are forms of bicycle routes completely separated from other forms of transportational facilities. These trails would allow for a high degree of safety for the bicyclists. They would also solve the difficult problem of conflicts between bicyclists and motorists. These bicycle trails could be implemented only where there is adequate right-of-ways, and available land.

Our second choice of a facility was bicycle lanes. This type of facility

MANHATTAN
KANSAS



PHASES I, II & III

Figure 1C

is a lane designated by signs, markings, and striping on the roadway, for exclusive use by bicycles. If properly designed and implemented, bicycle lanes provide an extremely safe riding environment for the bicyclists.

Still another choice is the use of "Shared Roadways". This type of facility could be easily employed on streets with low vehicular traffic volumes. The success of "Shared Roadways" could be further enhanced if deterrents were employed to keep the motor vehicular traffic at both low speeds and low volumes (See Appendix B, Page B5).

Our fourth consideration was a combination pedestrian-bicycle path. This type of facility would be implemented only if the three previous designs proved too difficult to implement. This facility, because of the conflicts between pedestrians and bicyclists, is not generally preferred but could be used if adequate space is available and pedestrian traffic is light.

These are the four main facilities which we have considered in designing a bikeway system for the City of Manhattan. In designing the system, we looked at each possible route location, and attempted to select the facility best suited for that location.

Phases

The bike system should be implemented in phases. Using phased implementation would allow a lower initial cost, with the system being able to pay for itself over a period of time. Also, phasing enables the system to be trial tested before going to the expense of implementing the entire system. The phases were selected on a need basis. The zone-to-zone daily trip volumes from the Demand Study were assigned to the most direct route from origin to destination. A total daily volume for each section of the network was obtained by adding the traffic contributed by each of the zone-to-zone volumes (See Figure 2C).

The first phase routes (See Figure 3C) were selected because of the large

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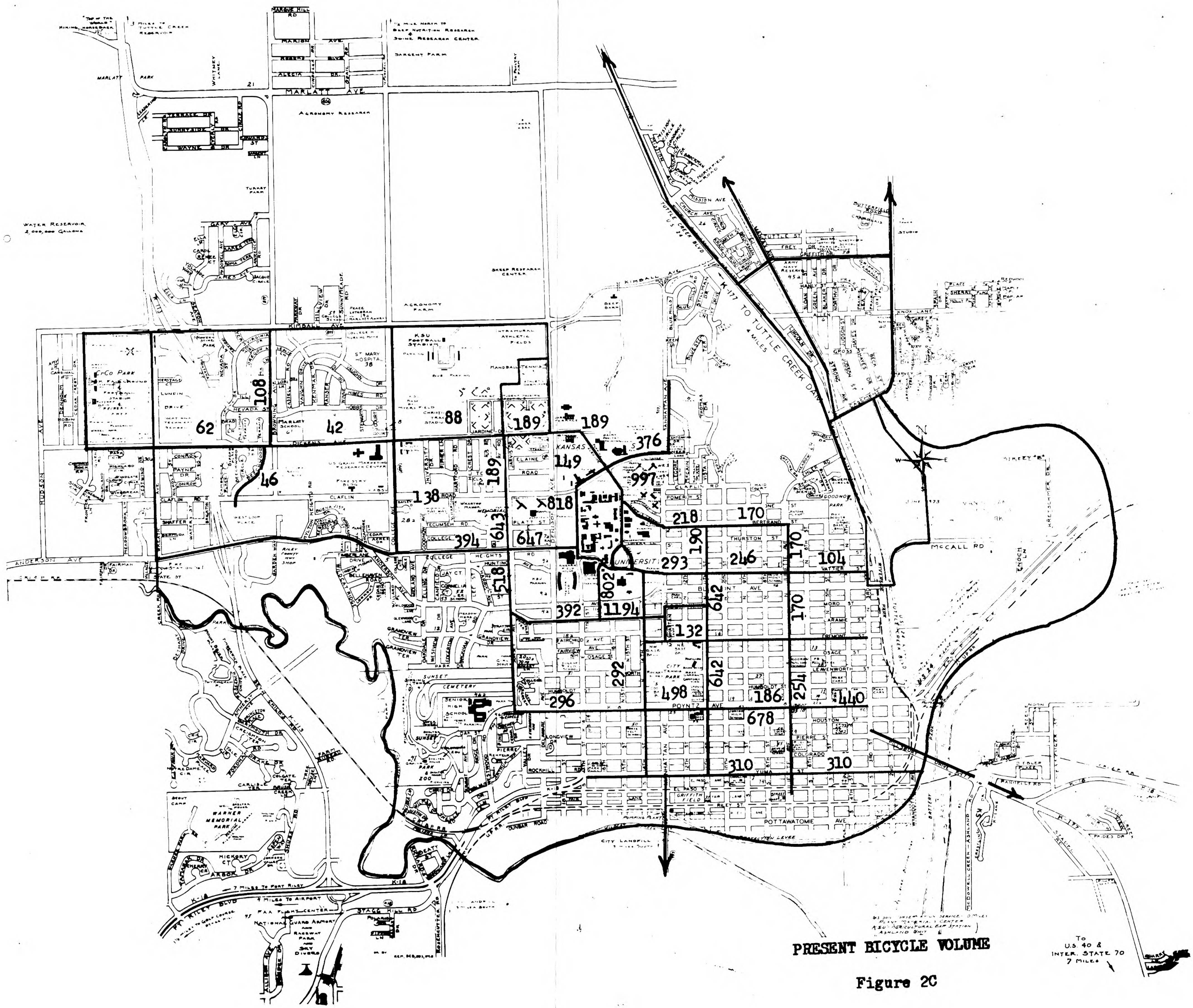

PRESENT BICYCLE VOLUME

Figure 2C

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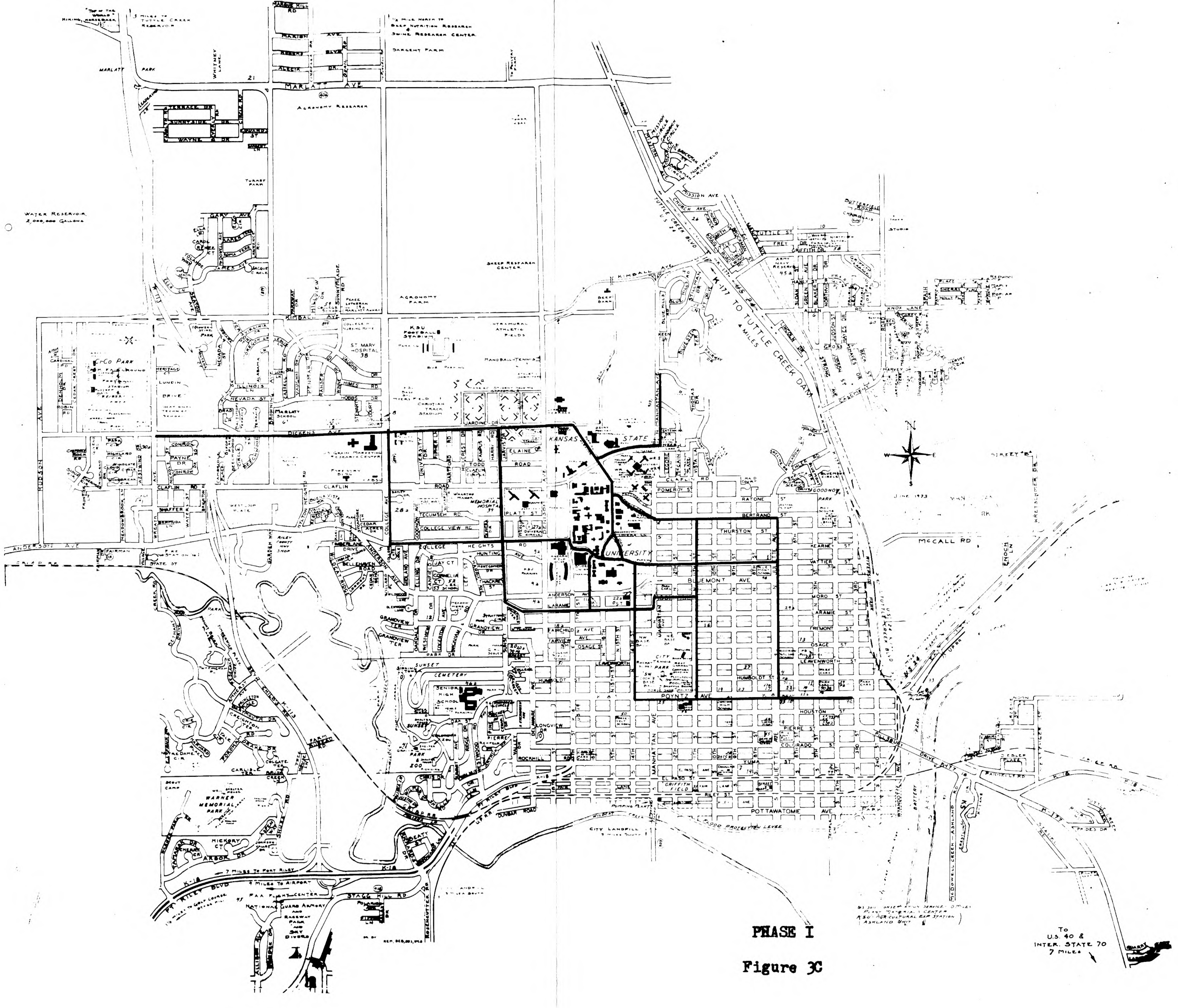

PHASE I

Figure 3C

05

demand for them. They will carry the highest volumes of traffic on the bikeway system. The second phase (See Figure 4C) will expand on the first phase and encompass more of the city. It will add routes which are needed, but have less demand than those in the first phase. The third phase will continue to expand around the city, stretching to the outskirts, including Tuttle Creek. When these phases are finally completed, the city should have an adequate safe bike system that will serve most of its people.

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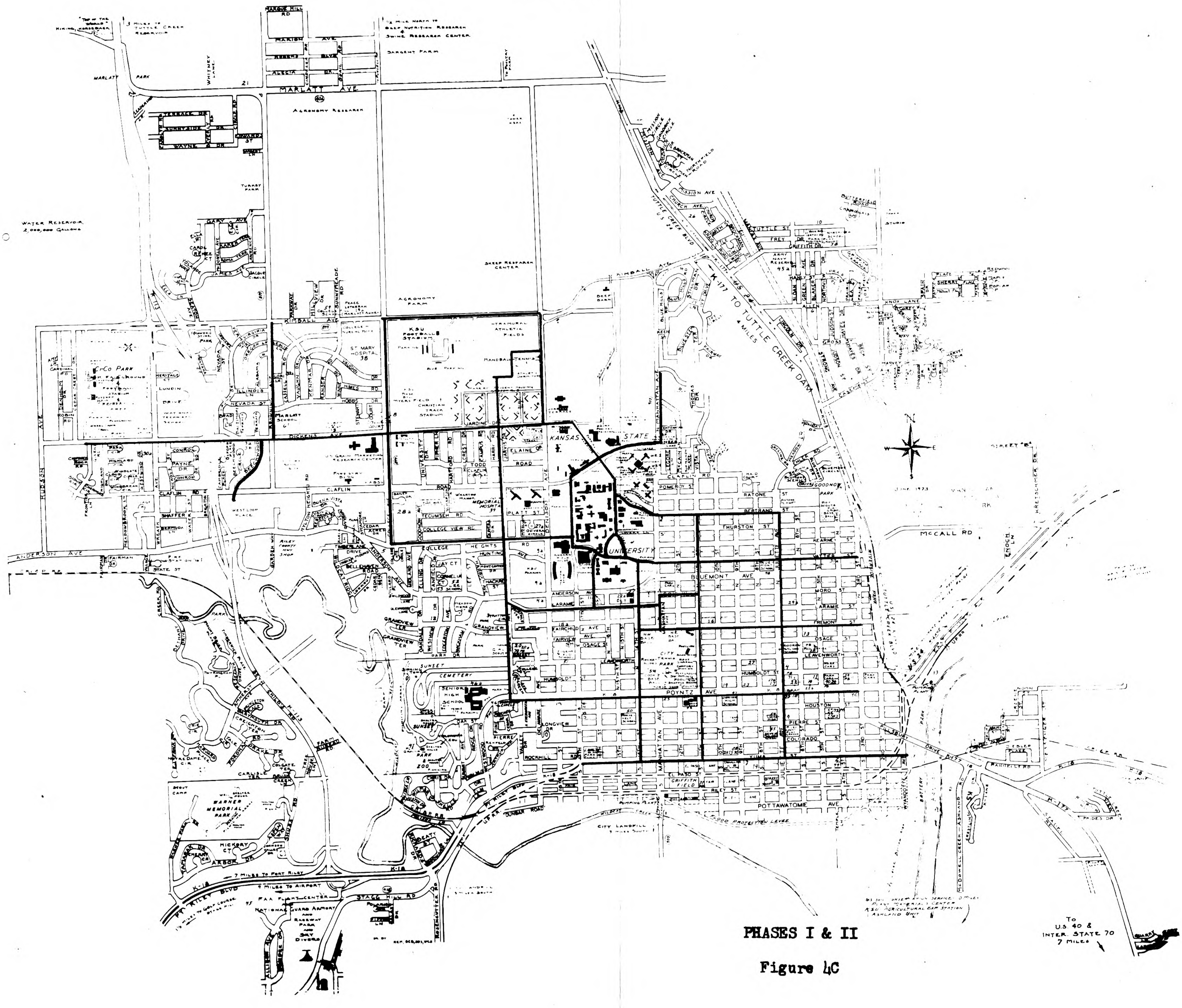

PHASES I & II

Figure 4C

PHASE I

Phase I consists of the following streets:

Juliette Ave. - Bertrand to Poyntz

Bertrand - Juliette to Manhattan

Vattier - Juliette to 17th Street

Poyntz Ave. - 3rd Street to 14th Street

11th Street - Bertrand to Poyntz Ave.

14th Street - Poyntz to Anderson

Laramie - Manhattan Ave. to Sunset

Path from Laramie across Anderson to K.S.U., east of Union (16th Street addition)

Sunset - Laramie to Claflin

Jarvis Drive - Claflin to Jardine Dr.

College Hts. - College Ave. to 17th Street

Jardine Dr. - Hillcrest Dr. to Mid-Campus Dr.

Dickens Ave. - CICO Park to Hillcrest Dr.

N. Manhattan Ave. - McCain Lane to Claflin

Claflin - N. Manhattan Ave. to Mid-Campus Dr.

Mid-Campus Dr. - Vattier to Dennison

COST ESTIMATE - PHASE I

Paint Striping
14 mile @ $300/mile..................$ 4,200

Signing
434 @ $25/sign...................... 10,850

Curb Cuts
28 @ $100.......................... 2,800

Bicycle Racks
17 @ $72
25 @ $ 3........................... 1,299

COST ESTIMATE - PHASE I

(Cont.)

Pedestrian Activated Signal 1 @ $2,200	$ 2,200
Culvert	300
Grading	3,000
Asphalt Paving .75 mile 2" thick @ $2.50/sq. yd.	13,200
	$37,849

Values for the preceeding items were obtained from the Riley County and Manhattan City Engineering Offices.

PHASE II

17th Street - College Hts. to Claflin

Claflin - 17th to Mid-Campus Dr.

Vattier - Juliette Ave. - 3rd.

Fremont - 14th - 3rd.

Manhattan Ave. - Fremont to Laramie

Yuma - 17th - 2nd

Juliette - Poyntz - Yuma

11th Street - Poyntz - Yuma

14th Street - Poyntz to Yuma

Poyntz - 14th to Sunset

Sunset - Poyntz to Laramie

College Ave. - Dickens to Kimball Ave.

Kamball Ave. - Denison to College Ave.

Jardine Drive to intramural field

Browning - Dickens to Kimball

Beachwood - Dickens to West Loop

PHASE III

Phase III consists mainly of recreational routes. They are:

Bike paths in the Linear Park Network

Routes to Tuttle Creek: Tuttle Creed Blvd.
Casement Rd.
Old UPER Right-of-Way

Kamball Ave. from College Ave. to CICO Park

Hayes Dr., McCall Rd. and Northview Area

New Bridge across Kansas River

South Manhattan Ave. to Hunter's Island

DETAILED DESCRIPTION OF BIKEWAY BY PHASES

Phase I

Poyntz Avenue: Poyntz, being a major arterial in Manhattan, has a large volume of traffic, while at the same time being the widest street in town. Because of its width, the large number of businesses, the City Park, and the Junior High School along the route, it has the potential to make an ideal bike route. The diagonal parking from Juliette East would have to be changed to parallel parking. This would eliminate about 11 parking spaces per block. An alternate to Poyntz would be one-way paths running on Humboldt and Leavenworth North of Poyntz and one-way paths on Houston and Pierre South of Poyntz. These alternate streets would eliminate 96 parking spaces and would double the amount of marking paint required.

Juliette Avenue (Bertrand South to Poyntz): This street provides a good North-South arterial. It has good width (35 feet of usable width) for on-street bicycle lanes. At the intersections of Bluemont and Juliette, and Poyntz and Juliette, separate, off-street trails should be provided. These intersections have three lanes of traffic, and should be avoided with on-street lanes. The intersections, however, would provide adequate crossings for pedestrians as well as bicyclists.

Vattier (West from Juliette to 17th): This street would be ideal for a shared roadway bikeway due to low traffic volumes. It provides direct access to the campus. The campus section (Manhattan Blvd. to 17th) is scheduled for closing to vehicular traffic (7) which will make it an excellent bikeway. The intersection at Manhattan Ave. poses a potential hazard due to vehicular traffic on Manhattan Ave. The anticipated level of bicycle usage does not warrant a traffic signal, but special signing should be employed. The Vattier traffic should be signed to stop and the Manhattan traffic should be warned of cross bicycle traffic with the appropriate sign. This intersection should be checked periodically for changes in traffic which may indicate a need for a traffic signal. An alternative plan for Vattier would be bike lanes on Vattier which would require the removal of parking on this street as well as the removal of existing ramps over gutters. A second alternative would be to build protected bike lanes on Bluemont for which there is adequate space between the curbs and sidewalks. This alternative does not have the route continuity through the campus which Vattier offers and may channel some bicycle traffic onto Anderson Avenue.

Bertrand (West from Juliette to Campus): This street would be adequate because it is newly paved concrete and is wide enough to provide for an on-street bike lane. Presently, parking is allowed on the north side of the street only. This would have to be removed. This street provides a route into campus from the north end of the residential section east of campus and could tie in with Petticoat Lane for route continuity through the campus. An alternate to this design would be a shared roadway design. The intersection with Manhattan Blvd. presents the same problems as the Vattier-Manhattan intersection and should be solved in the same manner.

Eleventh Street has adequate width for on-street bike lanes from Bertrand to Poyntz. This route provides access to Aggieville and to the City Park. At the intersections of Eleventh and Bluemont Avenue, and Eleventh and Poyntz Avenue, signals are available for the safe crossing of these two main arterials. Pedestrian-bicycle paths will be required at these intersections. Parking will have to be prohibited from the street.

Fourteenth Street (Poyntz North to Anderson): This street has adequate width to provide on-street bike lanes. It provides a route into campus from the south and gives access to the City Park. At the intersection of Fourteenth and Anderson, pedestrian-bicycle paths should be provided. This street has some bad curb inlets that should be repaired to allow bicycles to ride over them with the least amount of difficulty. Parking will have to be removed from the east side of the street.

Laramie Street (West from Manhattan to Sunset) will intercept bicycle traffic comming from the south to the campus and tend to funnel this traffic through the protected intersections at 14th and Anderson, and the "16th Street Addition" and Anderson. This should help eliminate bicycles from the high volume section of Anderson from Manhattan to Sunset. Due to the high pedestrian activity around the Christian College and the narrow width of Laramie a shared roadway with devices to restrict through vehicular traffic is recommended.

Moro Street (East from Manhattan to 11th Street): This, through Aggieville, is a heavily used bicycle route. Bicycle lanes should be provided by eliminating parking from one side of the street.

Sixteenth Street Addition: A two-way combination pedestrian-bicycle trail should be constructed running from Laramie to Anderson, between 1623 Anderson and 1627 Anderson, where now exists only a sidewalk. This trail would allow a direct entrance to campus from the south, passing just east of the Student Union. Because of the large volume of traffic on Anderson, a push-button type traffic signal should be installed to allow the bicyclist and pedestrians a safe crossing.

Sunset: Sunset North from Laramie has adequate width, good surface, and on-street parking. On-street bike lanes should be constructed on this street. It ties into Jarvis Drive and College Heights which provide direct access to the University, and intramural fields, for the large number of students that live near the route. Pedestrian-bicycle paths will be required at the intersection of Sunset and Anderson. Like Laramie, this route will tend to intercept bicycle traffic approaching the University and direct it onto College Heights.

College Heights Road: College Heights, although a little steep, meets the design criteria on adequate width and surface for on-street bike lanes. Further it provides a direct route to the University which would accommodate the many university students who live along this route in fraternities and sororities. The completion of construction on Dickens will probably increase traffic on that street to such a degree that a traffic signal will be required. In the interim, College Heights should be signed with a yield or stop sign and Dickens signed with bicycle crossing signs.

Jarvis Drive (Claflin to Jardine Drive): Jarvis is principally an extension of the Sunset Ave. route. It will provide a westerly approach to the University for the many students in the University's married student housing complex.

The Dickens - Jardine Drive route from Wreath to Mid-Campus Drive provides an excellent east-west route for many uses. It provides access to CICO Park, services Marlatt Elementry School, and provides a bicycle link through the university for the northwest section of the city. Dickens from Wreath to College Avenue should be provided with bicycle lanes. A bicycle trail should be built to connect Dickens with Jardine Drive. A two-way, off-street bike lane should be constructed on the South side of Jardine from University to Mid-Campus Drive to complete the route.

College Avenue: College Avenue from Claflin to College Heights has adequate width and a good surface for on-street bike lanes. It also has at the present time, parking eliminated from both sides of the street. From Claflin to Dickens Avenue a new pedestrian-bicycle path could be constructed on the east side of College Avenue. Later phases will extend this path to Kimball Ave.

North Manhattan: On North Manhattan Avenue from McCain Lane to Claflin there is adequate room on the east side of the street for a separate two way bike trail. This path would provide access to the University for the many students in that area.

Campus--New Routes

Claflin: Claflin from Denison to North Manhattan Avenue has adequate space on the north side for a pedestrian-bicycle path. This would provide a direct path through the campus. The intersection of North Manhattan and Claflin should receive special consideration with possible signing and marking. From Claflin to Denison, along Mid-Campus Drive, there is adequate room for a two-way bicycle trail on the northeast side of the street. This path should be connected to a bicycle trail running on University land parallel to Denison, from Mid-Campus Drive to Kimball. This path would provide access to the new Veterinary Medicine Complex, Jardine Terrace, and the intramural fields.

The present streets and some of the wide sidewalks on campus can be used as bike lanes and trails because of the low volume and the low speed traffic that is now using them.

Phase II

Yuma (Second West to Tenth): This street has adequate width (30 ft. of usable space) for on-street bike lanes. Parking will have to be removed from the north side of the street. From Tenth Street West to Seventeenth, Yuma is 39 feet wide, which would provide excellent space for bike lanes. Parking would have to be prohibited at all times on Yuma. This route provides access to Long's Park and to the Douglass Center.

Fremont (Third to Fourteenth): This road has good width (33 feet of usable space) for on-street bike lanes. It also has a very smooth surface. Parking will have to be removed from the north side of the street. This street provides access to Aggieville and the park. We feel Fremont is better than Moro and Laramie because of the condition of its surface and extra width, although it is not as direct a route into Aggieville.

North Manhattan Avenue (Fremont to Laramie): This road has adequate width and a very good surface for on-street bike lanes. It would provide a route into Aggieville from Fremont.

Jardine Street Number Three (East from Jarvis to Athletic Dorm parking lot): On the north side of the street there is enough room to put a separate trail between the street and the tree line.

Just west of the Athletic Dorm, on top of the ridge, would be the last leg of the route to intramural fields, etc. A bike trail could be constructed to lead directly to the complex from the intramural fields. A route to Denison from this area should be provided. Another bike trail can be placed on the north side of the parking area at the complex.

College Ave. (North from Dickens to Kimball): The pedestrian-bicycle paths on College Avenue should be extended to provide bicycle access to major athletic events.

Kimball Ave. (West from Denison to College Ave.): Kimball Avenue has sufficient space on the shoulders to provide for bicycle lanes. This section would complete a loop of the K.S.U. athletic fields providing for bicycle traffic to major events.

Browning (Nevada to Kimball): This road should be widened to 36 feet and curbing should be constructed. Presently, Browning is 36 feet wide from Dickens to Nevada and has adequate space for bike lanes. If the road is widened further north, bike lanes could be installed to provide a route to Marlatt School.

Beechwood Terrace (South from Dickens to the West Loop Shopping Center): This route will connect the West Loop Shopping Center, a major generator, to the bikeway system.

Vattier Street (East from Juliette to 3rd Street): The Vattier route should be extended to the light commercial area on 3rd Street.

Poyntz Avenue (West from 14th Street to Sunset Ave.): The Poyntz route should be extended to provide an easterly approach to the highschool. A considerable desire for bikeways to the highschool was indicated by the students.

Sunset Avenue (South from Laramie to Poyntz): Extension of the Sunset route will provide a northerly approach to the highschool.

Phase III

The Linear Park Network, previously proposed, is an excellent opportunity for a recreational bike trail. In the final plans for the Linear Park, provisions for a bike trail system, as proposed in the study Bicycle Paths by the Planning Department, City of Manhattan, should be incorporated (4).

Another recreational system that should be investigated thoroughly is the R/W of the Old Union Pacific Railroad. This would provide an excellent bike trail to Tuttle Creek Reservoir. An alternate route to Tuttle Creek is Casement Road. This road would have to be widened before it could be used for on-street bike lanes. When the new bridge over the Blue River is designed, provisions for an adequate bike path should be included. Use of the right-of-way may provide a separate bike trail. Another alternative for the route to Tuttle Creek is the use of Tuttle Creek Boulevard. The shoulders of the highway could be used for bike trails. This route would provide an additional link between the Northview Area and Manhattan proper.

New Bridge over Kansas River: The final plans for the bridge should include a one-way bike lane. On the old bridge, one of the sidewalks could be utilized as a bike lane, leaving the other walk for pedestrians. The bridge, as it stands now doesn't have enough room for a bike lane. If this is adopted, it would provide a route southeast of Manhattan. The important thing to note is that plans should be made now for lanes on the new bridge.

An on-street bike lane or, if possible, a seperate bike trail on the R/W of South Manhattan Avenue should be installed to provide the residents of Hunter's Island access to Manhattan proper.

Planners should be aware that bicycling is becoming more popular. With this in mind, provisions for the bike trails or lanes should be included in the plans for any new development in or near the City of Manhattan.

Kimball Avenue (West from College to Wreath): The Kimball route should be extended west to CICO Park. In addition to serving the park, this route will provide a grade separated crossing for Seth Child's Road (K 113), a bicycle route to Marlatt School Annex, and a bicycle link to the city for the expanding northwest section of the city.

Anderson Avenue (West from College Heights to Wreath): An Anderson route, while expensive, will yield three benefits: (1) It provides a direct bicycle route to the West Loop Shopping Center, (2) it provides a second grade separated crossing of Seth Child's Road, and (3) it provides for bicycles on one of the two logical routes to link the area Southwest of Wildcat Creek to the city.

Northview Area

Griffith Road: This road has good width (30 ft. of usable space). Parking will have to be removed from the north side of the street. Inlets will have to be reworked and grates provided. There are a few rough spots. This road has access to Northview School, the new swimming pool, and the softball diamond. On-street lanes can be installed on this street. This route should be extended one block north on Tuttle Creek Blvd. to provide a link to the

Blue Hills Shopping Center.

Hayes Drive (Casement Road South to McCall Road): This road has good width for on-street bike lanes (30 feet of usable space). There is no parking. This road is in very poor condition and would have to be repaved before a bike lane could be effectively utilized. This road provides the only feasible route for people in the Northview area to get into Manhattan proper.

McCall Road (Hayes Drive to Bluemont Avenue): This road connects Hayes Drive to Bluemont Avenue. This could be extended to Wal-Mart Shopping Center. It finishes the loop from Northview to Manhattan proper. This road will have to be widened to provide on-street bike lanes.

To provide the cyclist in the Northview Area a feasible route into Manhattan proper, Hayes Drive will have to be resurfaced and McCall road West from Hayes Drive will have to be widened.

COMPUTERIZED ROUTES

There is, in addition to the route system that we designed, a computerized route plan that we received from William L. Smith and Jerry S. Murphy, consulting engineers in the firm of Van Doren, Hazard, and Stallings, from Topeka. We used this computerized plan as a type of check on our plan. Their design was based upon five parameters (values for which we furnished); grade, cost, street characteristics; systems continuity; and node access. The values for these parameters were run through a computer, and each street (the computer was not used to determine possible bicycle trails) was rated accordingly. The streets which were finally chosen by the computer are shown in Figure 5C.

The computerized plan differs in some respects, but is similar overall to our design plans. One of the differences between the plans is whether or not to use Poyntz Avenue or to use parallel side-streets, Houston and Pierre. Our plan would call for two bicycle lanes on Poyntz, while the computerized plan calls for one-way lanes on Houston and Pierre Streets. We feel that the Poyntz route is superior because of its direct access to the downtown area, and because of its width. We also believe that, even though the volume of traffic may be heavy, the slow speed (20 m.p.h.) of the motor vehicles will help considerably to reduce possible hazards at intersections. It also seems reasonable to believe, that most bicyclists would prefer to travel in both directions on the same street, rather than to ride one or two blocks out of the way to change directions.

Another difference in the plan is the use of Twelfth Street versus using Eleventh Street for on-street bicycle lanes. We are aware that Twelfth Street allows direct access to Aggieville and to the City Park, but it does not have traffic signals at its intersections with Poyntz and Bluemont. If this street were used for on-street bicycle lanes, a traffic signal would have to be in-

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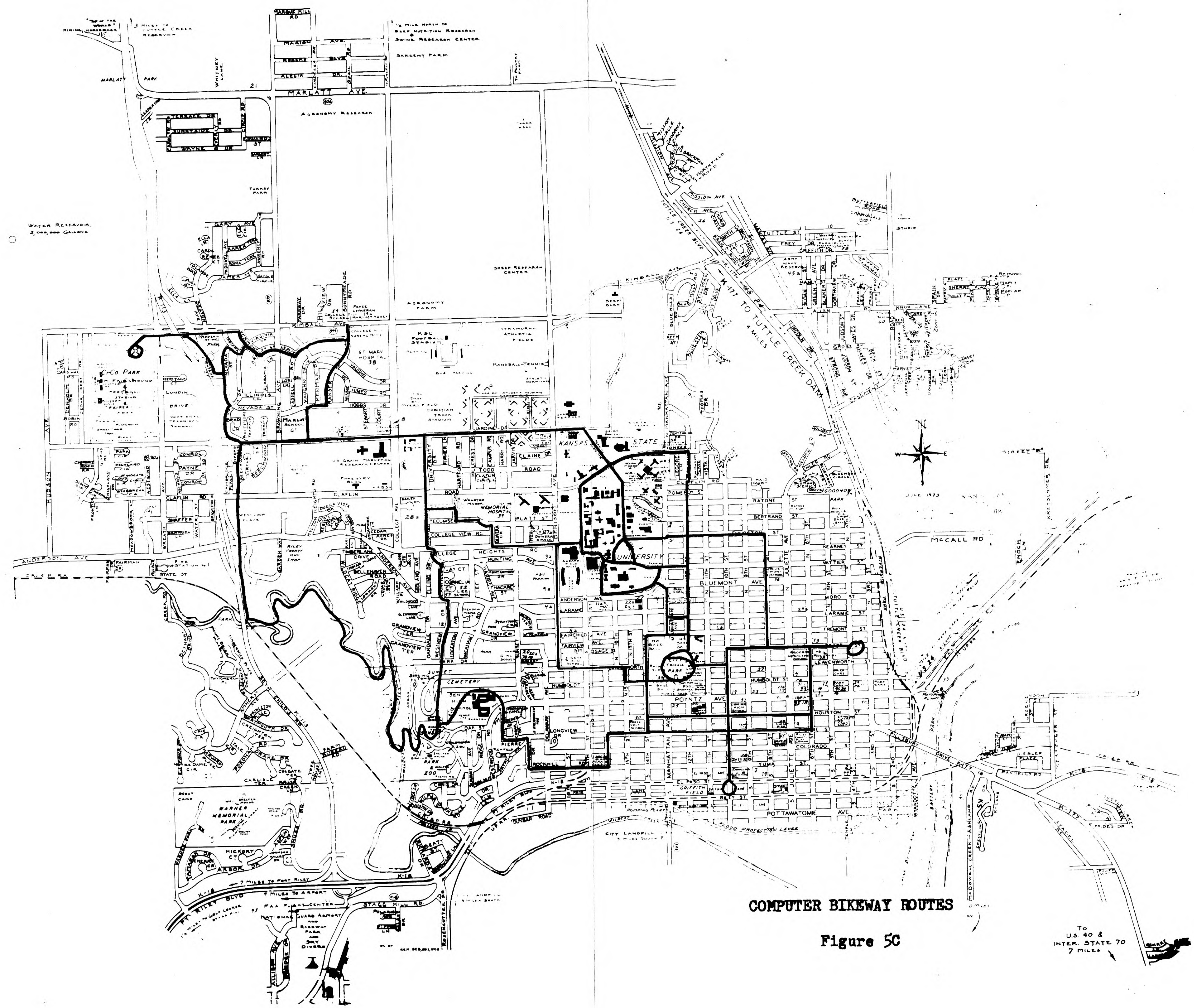


COMPUTER BIKEWAY ROUTES

Figure 5C

stalled. This is a needless expenditure of money, since Eleventh Street already has a traffic signal and it also meets the design standards for on-street bicycle lanes.

One other basic difference between the plans is whether to use Juliette Ave. or Eighth Street for bicycle lanes. We feel that because of its greater width (5 feet) and because of it having traffic signals at each major arterial intersection, Juliette Ave. is best suited for on-street bicycle lanes.

The two plans have some basic differences, but in general, the computerized plan checks with the design plan for route locations.

A P P E N D I X D

SUPPORTING FACILITIES

AND

FUNCTIONS

Parking Facilities

Every complete transportation system must have some sort of terminal facility. For a bicycle, the necessary terminal facility is simply a bicycle rack. This facility, while low in cost, is invaluable to a bikeway system. The bicycle rack functions: First, as a stable parking facility where the cyclist can leave his vehicle to avoid any damage occurring to it from falling over; second, as a fixture to which the bicycle may be chained to prevent theft, and third, as a means of providing a parking space which will not conflict with pedestrian, auto, and bicycle movements.

None of the following racks have any distinct theft-proof advantage, as almost any bicycle can be liberated with a pair of boltcutters. The purpose of these racks is to keep a passerby from climbing on a bicycle and riding off. A near theft-proof rack can be purchased (the cyclist furnishes only the padlock, not the chain) but it is economically unfeasible on a project of this nature, as it costs $20.00 to $25.00 per stall.

The bicycle rack recommended for the downtown area and Aggieville is manufactured by Ron Bales, Inc., Emporia, Kansas (See Figure 1D). This rack comes in eight and ten foot sections and costs $72.00 and $89.00 respectively. The eight foot section will fit in the parking space provided for one car and will park sixteen bicycles. No holes need be made in the pavement as the rack is not anchored on posts. The ten foot section could be used in parking lots where more room is available. The ten foot section parks twenty bicycles.

The steel post rack (used by housing at K.S.U.) is a very economical and versatile method of parking. The rack consists of a regular steel fence post with a small ring set in one flange (See Figure 2D). The rack parks two bicycles for about three dollars. One major advantage to this rack is that it can be pulled and moved to another location as demand changes.

Eight or Ten Foot Bicycle Rack

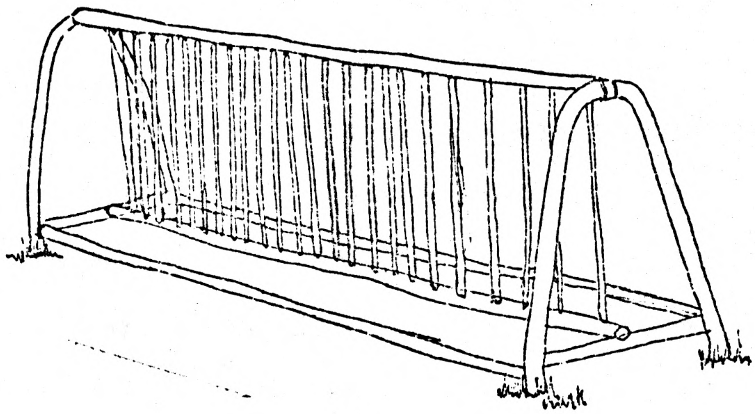
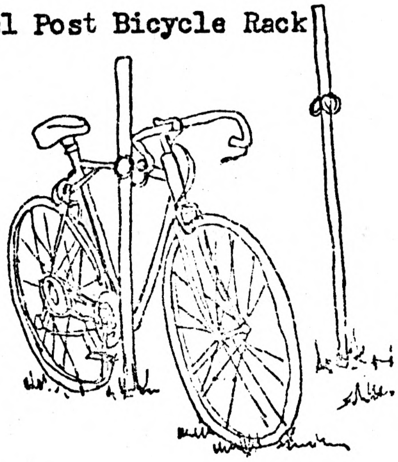


Figure 1D

Steel Post Bicycle Rack



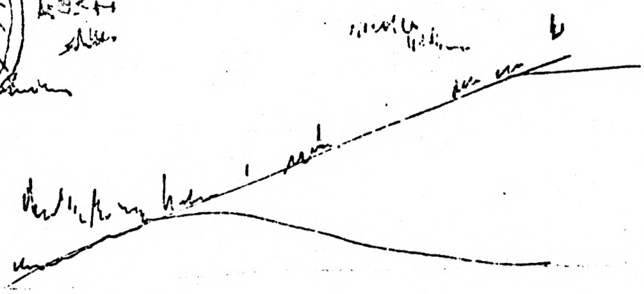


Figure 2D

Chain Bicycle Rack

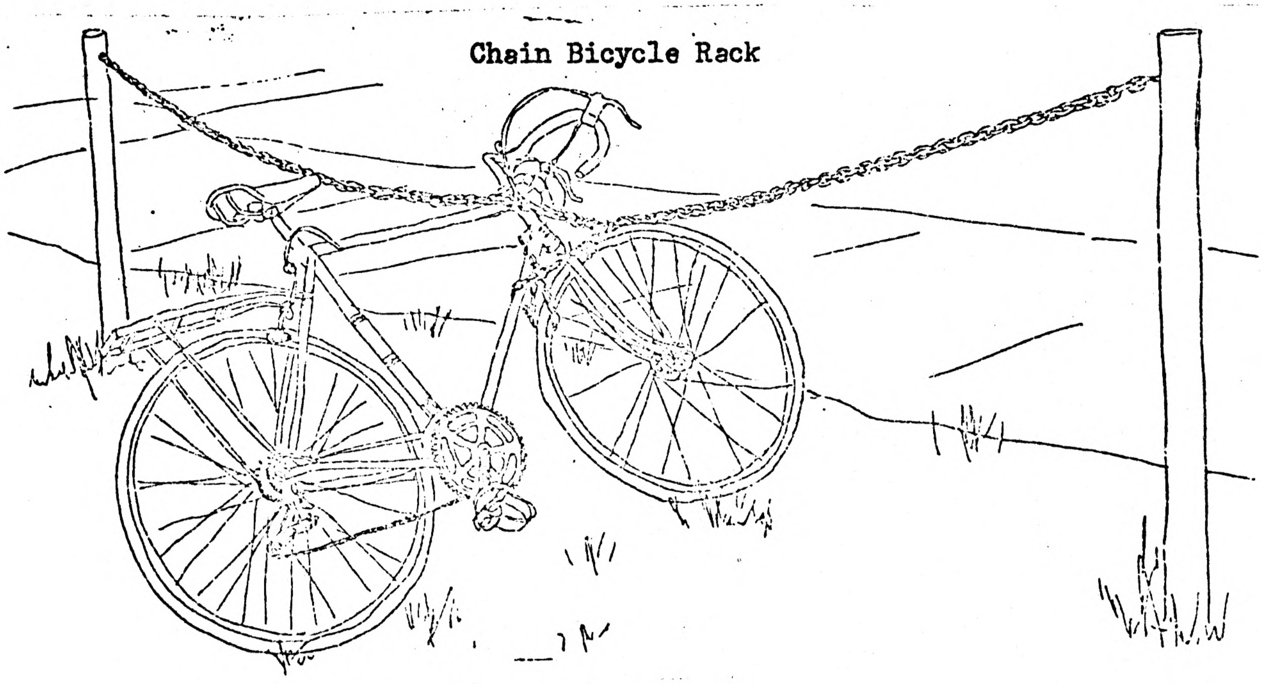


Figure 3D

Several other racks were looked at and although these were not specified, they might serve as alternate solutions. One of these, is the chain rack used at K.S.U. (See Figure 3D). It consists of 24 feet of chain spanning two posts. This rack is practically maintenance-free and costs only about $35.00. It provides room for approximately twelve bicycles. This rack might be a good alternate solution for the parks. It was not specified for street-side parking because the posts might represent a hazard to the motorist.

The University of Iowa has used an excellent bicycle rack (See Figure 4D). It parks twelve bicycles for about $100.00. Very little maintenance is required for this rack. Trash and leaves can easily be raked from beneath it.

One of the circular tree type racks that are common in Europe has been built at K.S.U. (See Figure 5D). This rack has space for eight bicycles and can be built for approximately $125.00. Trash and leaves may accumulate beneath it making it more difficult to maintain; however, it offers the distinct advantage of being able to park several bicycles in a congested area. This rack seems to be very popular with the student as there are usually several bicycles parked in it.

Bicycle Racks in Iowa

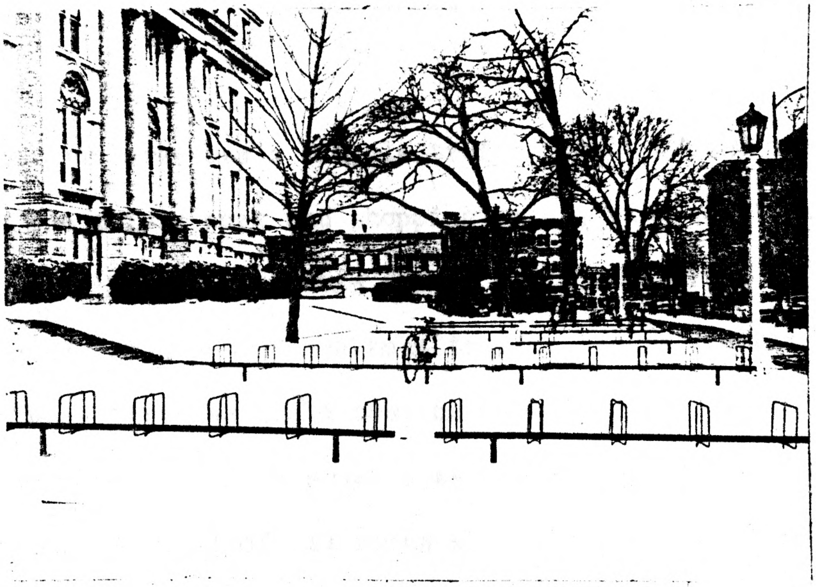


Figure 4D

Circular Tree type Bicycle Rack

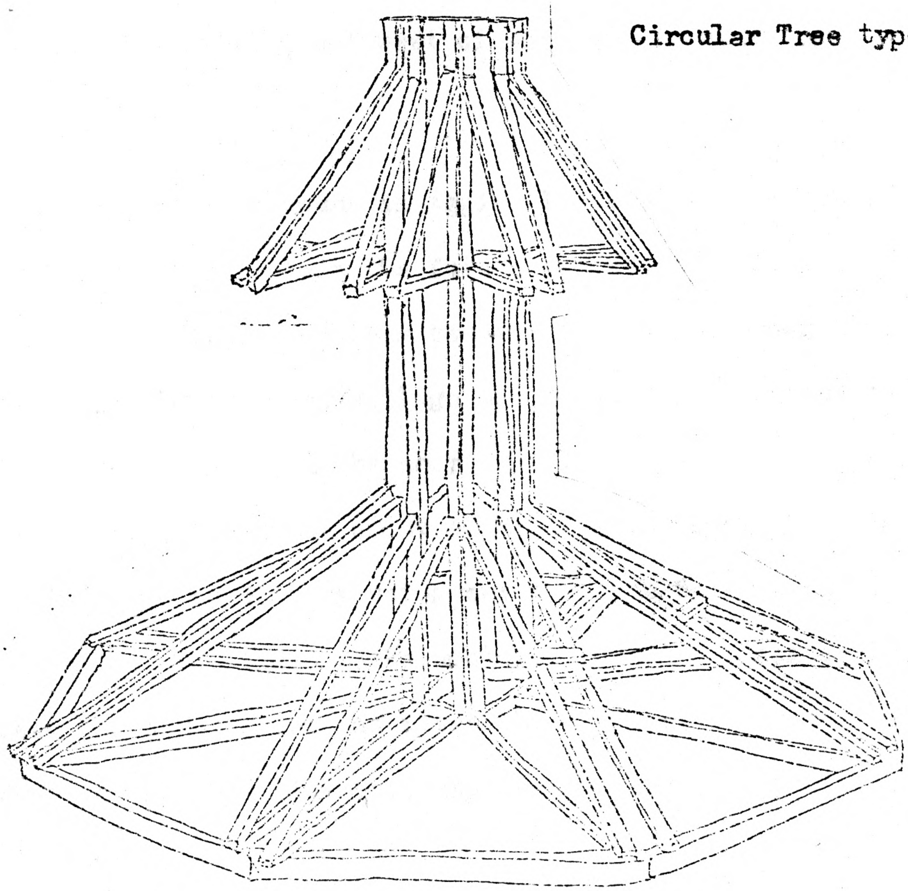


Figure 5D

Parking Recommendations

Downtown

The downtown area has a bicycle traffic count of 440 vehicles per day. These trips are mainly work and shopping trips, with about twice as many being work trips. Multiplying this number by 1.5 to arrive at a future demand and dividing by the 4 hours when most traffic occurs, results in 160 bicycles per hour. These bicycles could best be parked in the Bales 8 ft. rack. This rack could be placed in an average size parking space and would accommodate up to 16 bikes. A total of ten racks would be needed. Locations recommended are as follows: one per block between Second and Sixth Streets on the south side of Poyntz; one per block between Second and Fifth Streets, along the north side of Poyntz; two located on Houston between Penney's and Sears, and one located in the city parking lot west of the Federal Building.

Aggieville

The expanded bicycle count in Aggieville is 657 bicycles per day. By using the 1.5 factor to obtain the future demand and dividing by the 6 most traveled hours, the traffic volume becomes 164 bicycles per hour. Since Aggieville is so close to the college and to much of the student population, the length of the trip should be shorter. If we assume the average time the bicycle is to be parked to be about 40 minutes, we would need to park 110 bicycles. This could be done by using seven of the Bales 8 ft. racks.

The locations for these racks would be one per block on both sides of Moro between North Manhattan and Eleventh; one located on the east side of North Manhattan south of Bluemont, and two located in the city parking lot south of Bluemont.

City Park

The expanded bicycle count for the City Park is only 84; however, the survey was conducted on a weekday when the bicycle volume to this area is not large. Also, the survey was conducted in the spring before the swimming pool was open. Bicycle parking could be handled with the steel posts similar to those used at K.S.U. A ball park figure to start with may be 25 (50 bicycles). More could be added if the demand were greater.

CICO Park

Parking should be provided at CICO Park. This class has no information of relative numbers due to the fact that our survey was conducted in the spring before CICO was in use.

Schools

It is the responsibility of the schools to provide adequate bicycle parking for their students.

Legal Considerations of Bikeway Development

There are certain legal considerations which are associated with the development of the proposed bikeway system. The Manhattan bicycle ordinances were obtained and reviewed to determine if they were adequate for the proposed system. We feel that the existing Manhattan bicycle ordinances must be altered to keep pace with the proposed plan. These alterations can take the form of amendments and new ordinances to insure the proper implementation of the plan.

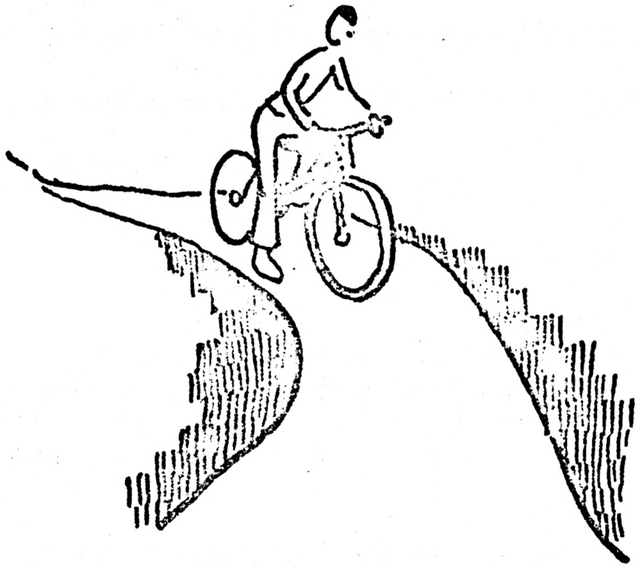
The amendments and new ordinances concern the physical development of the Manhattan bikeway system, the safety and welfare of Manhattan people, and prevention of bicycle thefts. Legislative proposals from many cities across the nation were studied. Ideas were gathered from these proposals and were correlated with the uniqueness of the proposed Manhattan bikeway system to arrive at recommended regulations for Manhattan bikeways.

Bicycle laws which are difficult to interpret and hard to understand can cause problems with obedience and enforcement. The Manhattan bicycle ordinances are not specific in reference to the traffic laws applying to persons riding bicycles. Such an ordinance is an essential foundation for other laws. An ordinance similar to one stated in the Uniform Vehicle Code (15) would clearly state this.

Bicycle lanes separate flows of motor vehicle and bicycle traffic, and reduce mid-block car-bike accidents when used properly. Bike lanes provide a sense of security for both the bicyclist and the motorist along with improving flow of vehicle traffic by removing bicycle traffic from motor vehicle lanes. In order to ensure that bicycle lanes are respected, ordinances will have to be enacted that will prohibit motor vehicles from driving in designated bike lanes. Also it is recommended that cyclists be prohibited from riding in traf-

A P P E N D I X   E

PROPOSAL



A BIKEWAY SYSTEM
FOR THE CITY OF MANHATTAN, KANSAS

A PROPOSAL BY: CIVIL ENGINEERING 585
Department of Civil Engineering, KSU

February 28, 1974

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Faculty Advisor

Preface

The Civil Engineering Design Project class was formed and organized in order to gain practical experience and knowledge in project planning that would be useful to the students in their professional careers. The procedure the class will use is as follows:

1. To practice a methodical approach for attacking an open-ended problem.
2. To define, solve, and then submit our arrived at solution to a problem originating outside the classroom.
3. To work as a team in accomplishing a given goal.

This class is composed of students in Civil Engineering and Landscape Architecture. Consultation is available from the faculty and individuals knowledgeable within the realm of the problem.

The class agreed to investigate the possibility of a bikeway system for Manhattan, Kansas.

Definition of the Problem

Local law enforcement agencies have registered over 4,000 bicycles. They estimate this to be roughly one-third of the total number of bicycles in Manhattan.

While a network of roads, streets, and highways have been built to accommodate the private automobile, these only marginally provide for the bicycle. Add to these the advent of the "energy crisis", environmental awareness, rising inflation, and a public demand for recreational facilities; this class feels a bikeway system in the City of Manhattan is worthy of consideration. Two bikeway studies have already been proposed for Manhattan. While neither of these has been adopted, they do indicate an interest in bicycle transportation.

Background Research

Prior to this proposal, the projects class has spent six weeks in background research. This has been research not only in the problem area itself, but also in the methods of how to approach the problem. The information gathered has come primarily from previous studies of bikeway systems in many cities. Additional information was acquired from discussions with quest speakers.

Goal and Objectives

The goal of this projects class is to design a safe and effective bikeway system suitable for the community of Manhattan, Kansas.

Objectives

Our objectives, the steps we feel will be necessary to accomplish our goal, are the following:

1. Define a bicycle system. A bicycle system is more than just the rider and a bicycle lane. There are legal considerations, financing, design criteria and other matters which must be considered. A full definition of the system will be necessary so that we can fulfill all its needs with our proposed solution.

2. Determine the need. How many people want, and would use a bicycle system in Manhattan? Where are bicycle riders going and where are they coming from? What type of trip; recreational, commuter, shopping, etc., should we provide for? The answers to these questions and others will aid in defining the bikeway needs of Manhattan.

3. Planning and design criteria. Planning criteria must be established to evaluate when the need is sufficient to warrant the economic expenditure necessary for construction a facility or portion of a facility. Design standards must be determined to control the design of the system so that the system will be within the physical capabilities and limitations of the bicyclists.

4. Financing. Federal funds are presently available for some bicycle systems. These shall be investigated and recommendations made so that as much of the proposed system as possible will be able to qualify for Federal funding. The availability of state funds will be investigated in a similar manner. The matter of local funding will be researched and a recommendation made also.

5. Phased construction. The construction of a complete project at one time is seldom possible. We will plan and design a comprehensive bicycle system, but will likely recommend a phased construction plan. This will be based not only on the magnitude of need, but also on the availability of funds.

6. Report and presentation. A written report will be made which will show the results of our investigations. Further, it will contain a recommended plan with recommendations for possible phased construction and implementation.

Planning and Design Criteria

Planning Criteria

The location and extent of the bikeway system will be dependent upon (a) estimates of usage by bicyclists (b) the need for continuity in the bikeway network (or system) (c) safety considerations for bicyclists, vehicular traffic and pedestrians (d) physical constraints (particularly grades) (e) costs vs. benefits.

The decision, by the City of Manhattan, to provide a bikeway system could be based simply upon "demand" by bicyclists for certain routes from home to generator. On the other hand, it may well be that provision of "bicycle mobility" as part of the transportation system for the citizens of Manhattan may be reason enough for provision of bikeways.

Design Criteria

Design criteria will be adapted for control and evaluation of proposed plans. These will be selected primarily from current design criteria established for other areas in the United States. These, however, will be carefully screened to determine whether they are suitable for Manhattan.

Demand Study

Normally, a demand study is conducted before designing begins. In this way, the project design can be based on actual demand or need.

The length of time available for this study does not allow us to follow this procedure. We, therfore, propose to locate and design the bikeways by an inductive logic method (see inductive logic, page E7) and then check the location and design with the results of the need study. Areas of disagreement can then be adjusted.

Most articles and publications on bicycles recommend some method of determining the need for bicycle lanes. The following list is indicative of the type of methods suggested:

Bicycle sales
Bicycle tire sales
Bicycle registration
Questionnaire
Previous surveys

The first three methods will give a good indication of the total amount of activity, but they do not give any indication of where the bicycles are being used. The Manhattan police registered over 4,000 bicycles in 1973, but they estimate that this figure represents only 30% of the bicycles in the city. A search for past surveys yielded nothing. This leaves us with only one suitable solution: conduct a survey.

A user survey was conducted in Iowa City. There they blanketed the city by leaving a questionnaire on every bicycle. This was done in one day which was a typical bicycling day. It required the coordination of many service clubs to distribute the questionnaires. This approach resulted in a 90% return of the questionnaires. This method was considered for our study, but we feel that cold weather has reduced bicycle use to a level which would yield poor results which will not be indicative of the normal level of bicycle usage in this city. We have decided, therefore, to conduct a telephone survey.

The questionnaire will be a typical origin-destination (O-D) study. It should answer questions about who is riding and where they are riding. Further, it should show the relationship of bicycle usage to other modes of travel, as we will be collecting data on trips by all modes: Auto driver, auto passenger, walking, bicycling, bus and taxi.

General information will be collected as well as pertinent O-D information. We will attempt to determine the following:

A. Number of bicycles in Manhattan.

B. Do the residents want a bicycle system?

C. Who would use the system?

1. High School students
2. Grade School students
3. College students
4. Commuters

D. Are the cyclists themselves willing to financially support the system?

E. What are the reasons they don't use bikes now? (Perceived safety, no bike, etc.)

Many articles stress the importance of "latent bicycle demand." Most areas which have constructed a bicycle lane system have discovered that bicycle usage has increased immediately upon completion of their system. They feel that this happens because many people would like to ride bicycles, but do not feel it is safe until a system is constructed. We will attempt to assess latent bicycle demand in Manhattan by asking which of the trips the people have taken by another mode would have been taken by bicycle if a bicycle lane system were already established.

Zones for the survey will be selected on the basis of land use. In this way, major traffic generators can be isolated in separate zones and the amount of bicycle traffic to these generators can be estimated. The zones will also be coordinated with the public school zones so that school bicycle traffic can be clearly established. Zone populations will be determined from the 1970 census, which contains population data on a block-by-block basis for the City of Manhattan.

The sample size will be five percent of the city population. This sample will be expanded to the zone population of the 1970 census. Total trips will be compared with the 1963 origin-destination study for Manhattan and the population of children within school zones will be compared with school enrollment. The total number of college students will be compared with college enrollment. The data from each zone will be adjusted to obtain the best fit with the comparative data.

The trip data thus obtained will be plotted as a desire line map. The desire lines are are actually the ideal least time path for the bicyclists. These need only be adjusted to meet the existing street and geographical constraints, and bicycle lane network constraints. The section of the network which most closely follows the desire line can be assigned the traffic from that desire line. Adding the traffic for each desire line will yield the anticipated traffic volume for each segment of the bicycle network. Phase construction of the network can then be recommended on the basis of need as well as network considerations.

It should be noted at this point that some members of the Local Chapter of American Association of University Women (AAUW) have agreed to assist our class in this project by helping to conduct the O-D study. Their interest in bicycling is an extension of this year's study program on environmental problems and solutions.

Inductive Logic Approach

The Inductive Logic Method was introduced by Mr. Jerry Murphy, on the staff of Van Doren, Hazard and Stallings, a consulting engineering firm in Topeka, Kansas.

The Inductive Logic approach is basically the same system devised by Mr. Murphy's firm in determining the location of highway corridors. Mr. Murphy has indicated that his firm wishes to test this method in locating bicycle lanes and in return has offered us their expertise and services.

The method works on the principle of measuring the least social cost to the environment and the maximum benefits that the system will provide. Models will be furnished to the class by Mr. Murphy in order for the class to gather the data necessary in deriving the measurements. At present the class has been asked to study two important elements; the trip generators (places or areas which attract bike riders) and the streets. The streets will be broken down into three categories: Local, collectors, and arterials. Local streets are those that serve individual homes and neighborhoods and have the least vehicular use. Collectors gather the traffic from the local street and carry it to the arterials, the streets whose principal purpose is to move people and goods. Logically, streets with the heaviest vehicular traffic arterials will be avoided while streets with the lightest traffic, local streets, would be preferred.

Other elements taken into consideration in this approach will be as follows:

1. Grade - the amount of steepness of a slope.
2. Safety - protection of bicyclist, motorist, and pedestrian.
3. Travel time - the time one will spend to go from one place to another.

4. Mode interface - interaction between one mode of travel to another.

5. Aesthetics - pleasing to the eye and the surrounding environment.

6. Reduction of pollution - less air and noise pollution.

7. Cost - amount of construction cost.

8. Standards - the standards necessary to meet present and future conditions.

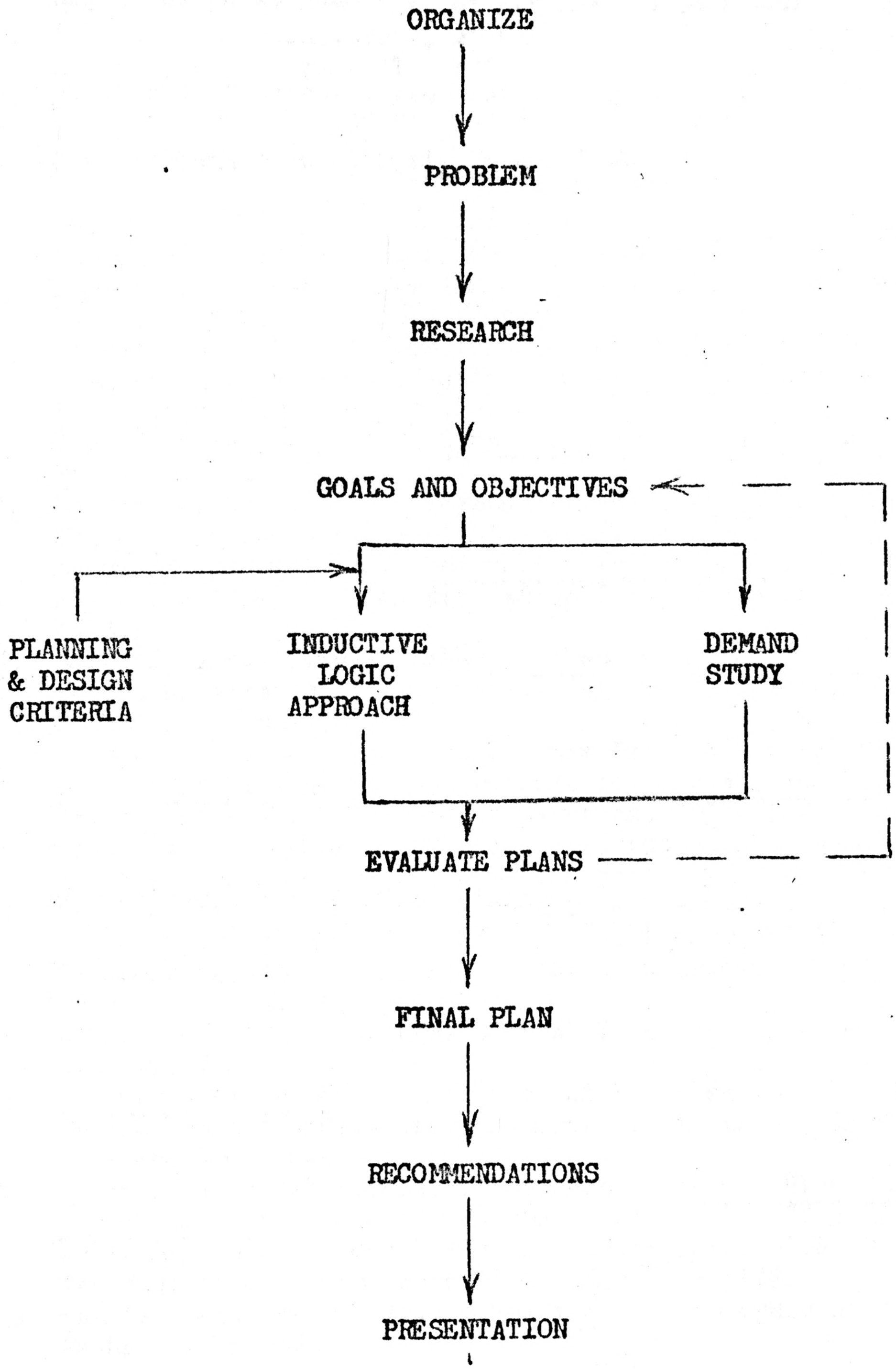
9. Level of service - the provision needed for health, welfare, and safety of the bicyclist.

Planning a bikeway is a fairly new concept and the possibility of selecting a perfect bikeway to meet all the needs of all the people in one plan is pretty remote. The class will therefore design a bikeway which we feel would meet the conditions that have been previously set. The class will use the information gathered by the inductive logic method and design accordingly. At the same time the same data will be sent to Mr. Murphy's firm so that it may be key punched. Computerized models will make use of the information and will indicate, hopefully, the most desirable bikeway routes. This will serve as a check with the class's plan and by overlaying the two, will come up with a composite plan. The information supplied by the demand survey will then be incorporated in order that the plan will meet the needs brought out in the demand survey also.

The final plan will then be selected and specific recommendations layed out, all to be presented in the final presentation.

A time schedule has been constructed and will be closely followed in order that the project can be brought to completion within the allotted time. With the aid of a flow diagram, the basic steps in our procedure can be kept in order. A time schedule and flow diagram are attached.

F L O W   D I A G R A M



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MANHATTAN BIKEWAY PLAN

by

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B. S., University of New Mexico, 1970

AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Civil Engineering

KANSAS STATE UNIVERSITY
Manhattan, Kansas

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ABSTRACT

A bikeway system for Manhattan, Kansas was designed. Bikeway routes were selected on the basis of node access, and feasibility within the existing street network. A demand study was conducted to determine bicycle movements throughout the city, and to determine public opinion on bikeways and related matters. Phased construction was recommended and phases were selected on the basis of the priorities established by the demand study. Support facilities and functions (education, enforcement, ordinances, etc.) were recommended. Design criteria appropriate for the City of Manhattan were selected.