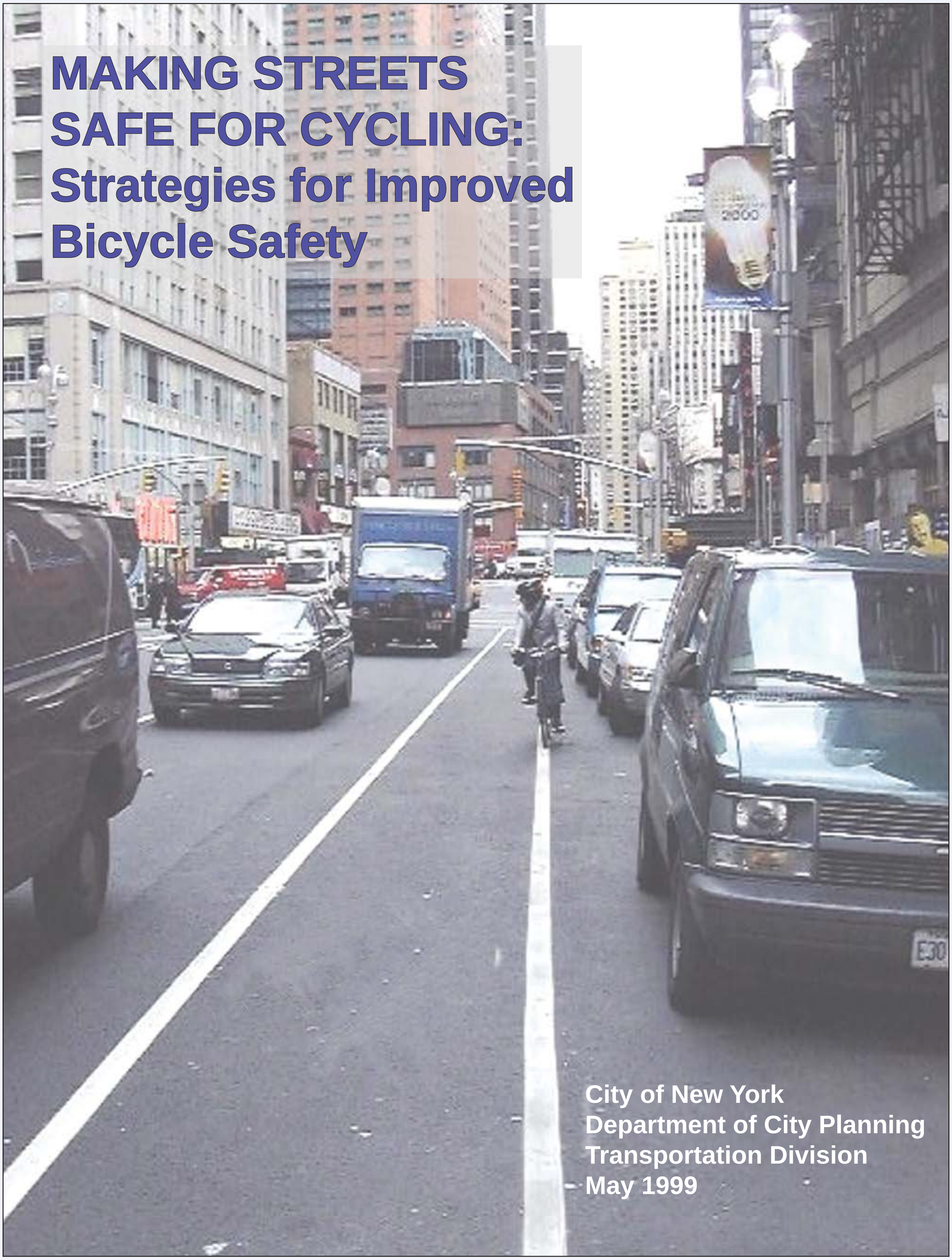
MAKING STREETS SAFE FOR CYCLING: Strategies for Improved Bicycle Safety



City of New York
Department of City Planning
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MAKING STREETS SAFE FOR CYCLING: Strategies for Improved Bicycle Safety

Final Report

Rudolph W. Giuliani, Mayor
The City of New York

Joseph B. Rose, Director
Department of City Planning

May 1999

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EXECUTIVE SUMMARY

This document is a compilation of three previous reports. The first, *Task 2: Literature Review*, provided an overview of bicycle facility research and implementation guides, followed by a selective case study survey of on-street cycling infrastructure implemented in both the United States and abroad (Appendix E). The second report, *Task 3: Existing Conditions*, contained a contextual review of New York City cycling data (including ridership and safety statistics) and on-street facilities, followed by a detailed review of Manhattan study area locations. The *Task 4: Recommendations* report drew on both of these documents to recommend innovative on-street cycling prototypes for evaluative testing in New York City.

Facility Recommendations

In this final report, eight facilities are recommended to improve safe cycling on New York City streets:

- ***Advanced Stop Box***
  Broadway at 17th Street
- ***Cycle Crossings***
  Lafayette Street/Fourth Avenue bicycle lane, at Astor Place
- ***Improved Lane Definition: color/texture***
  Fifth Avenue bicycle lane, 23rd to 7th Streets
- ***Improved Lane Definition: physical delineation***
  Broadway to Fifth Avenue, 24th to 23rd Streets
- ***Contra-Flow Bicycle Lane***
  West Broadway, Grand to Walker Streets
- ***Center-Median Bicycle Lane***
  17th Street, Broadway to Park Avenue
- ***Combined Bicycle/Bus Lane***
- ***Centerline Non-Compulsory Lane***

Cyclist on 17th Street near Union Square Park.

This report first describes a typical installation of each facility, then lists potential locations for testing in New York City. A specific pilot test is described for six facilities. The siting of pilot tests was informed by “critical (unsafe) locations” identified in the *Task 3: Existing Conditions* report. Recommendations in this document are based *first* on the selection of a facility type appropriate to New York City, and *second* on the selection of a location for successful implementation.

Associated Recommendations

Other associated recommendations address enforcement of on-street cycling facilities and the collection of cycling related safety/accident data. Consistent enforcement of on-street cycling facilities is as important to the success of implementation as proper engineering and placement. Systematic identification, collection and analysis of cycling-related safety data is critical to the successful evaluation of protoype facilities recommended in this report and future implementation efforts.

INTRODUCTION

New York City's first inter-agency coordinated bicycle program, the Bicycle Network Development Program (BND), was created in 1994 with a federal grant from the Intermodal Transportation Efficiency Act (ISTEA). The program began as a partnership between the NYC Departments of City Planning (NYCDCP) and Transportation (NYCDOT), and was joined by the Department of Parks and Recreation (NYCDPR) in 1996. Prior to this time, bicycle planning done by NYCDCP and NYCDPR had been largely incorporated with planning for off-street, greenway and recreational facilities. At NYCDOT, planning and implementation of on-street cycling facilities had been performed since the 1970's, although primarily in a project-specific context.[1]

The BND Program established the City's first coordinated on-street cycling program and bicycle policy, including suggestions for enforcement, encouragement and education programs for cycling. In addition, it identified a 550-mile citywide network of on-street cycling facilities which is gradually being implemented. These recommendations are contained within the *NYC Bicycle Master Plan*, released in 1997 by NYCDCP and NYCDOT.

The perception and reality, however, that New York City streets remain unsafe for cycling continues to discourage many potential cycling commuters. Difficulties in installing conventional[2] five-foot bike lanes on narrow and congested city streets are compounded by frequent double parking in existing bike lanes.

Focus on Facility Implementation

"Making Streets Safe for Cycling" is a targeted response to these problems which builds on the comprehensive bicycle agenda outlined by the BND program. Its focus is on-street facility implementation, a physical accommodation for cyclists using the roadway (e.g., Class II bikeways). For the purposes of this study, this definition includes specialized and standard bicycle lanes, various intersection treatments and traffic calming techniques. It excludes off-street paths (Class I bikeways), and bicycle routes identified by signs only (Class III bikeways).

Project Description

This study is based on research and analysis of prototype and existing on-street cycling facilities designed to minimize conflicts between cyclists and other roadway users. The final report recommends innovative on-street cycling design prototypes for evaluative testing, based on a study area defined as Manhattan and the major bridges that provide bicycle access to Manhattan from other boroughs.

At the same time, the study evaluates the effectiveness of New York Police Department (NYPD) bike patrols in reducing conflicts between cyclists and other mode users (pedestrians and cars). Detailed on-street facility recommendations are accompanied by broader recommendations to improve enforcement and create public awareness of on-street cycling facilities.

[1] *"Bikeway Planning and Policy Guidelines for New York City," released by the NYCDOT in 1978, established broad guidelines for bikeway planning but proposed implementation of only 23.5 miles of on-street (class II) bike lanes and little public outreach (i.e. encouragement, enforcement programs).*

[2] *Bike lanes which conform to guidelines identified by the American Association of State Highway and Transportation Officials (AASHTO) 1991 "Guide to the Development of Bicycle Facilities ."*

OVERVIEW:
Existing Conditions Review

The following is a contextual review of the current physical on-street cycling environment in the Manhattan study area, primarily through a detailed assessment of unsafe spot locations currently used by cyclists -- both those that do and do not support dedicated cycling facilities. This report also examines implementation, curbside regulation and enforcement issues to frame a discussion of how to implement cycling facility design prototypes.

Cycling Data and Statistics

In the past five years, overall increases in cycling ridership have been accompanied by increases in cycling accidents and injuries. In addition, the propensity to cycle can be linked to safety concerns about taxi and double-parked road users. However, a systematic identification of sites at which the greatest number of vehicular/bicycle accidents occur is not currently in place to guide on-street safety improvement efforts addressing these concerns.

On-Street Cycling Facilities

Portions of a planned network of on-street cycling facilities are currently in place, with plans for continued implementation in progress at the Departments of City Planning and Transportation. These plans provide opportunities for the strategic placement of innovative cycling facility prototypes to improve on-street safety.

Curbside parking regulations which affect cycling facilities may require modification to address future implementation of prototype facilities. Enforcement of both parking and moving regulations have been a focus of NYPD Traffic Control Division's bicycle patrol. A continued and increasingly focused enforcement effort is integral to ensuring that on-street facilities are accessible and safe.

Study Area Review

Ultimately, this report seeks to identify unsafe on-street locations currently used by cyclists for the implementation of prototype facilities (and new conventional bicycle lanes). Initial identification of these sites was based on the results of a questionnaire distributed to cyclists by the Department of City Planning.

A subset of ten roadways was identifed through analysis of questionnaire results. The chosen roadways reflect respondents' concern about north-south versus east-west roadways (approximately an 80/20 split). Specific study segments were identified on each roadway and reflect an overall concentration of responses below 59th St. In addition, respondents' concerns about poor bridge access prompted the addition of the Brooklyn and Queensboro Bridges entrances to the list of roadways, raising the number of selected study locations to a total of twelve.

Questionnaire results were then cross-referenced with NYCDOT Midtown Manhattan Bicycle Volumes (screenline counts) and NYPD vehicular Accident-Prone Location data, to confirm locations most heavily used by cyclists and most dangerous for roadway users, respectively. The results of this comparison were used to compile a final list of study locations as starting points for continued fieldwork and implementation recommendations. Maps are presented which illustrate recommended study segments and other locations critical to the network of existing facilities and recommended cycling routes.

NEW YORK CITY CYCLING DATA and STATISTICS

An overview of New York City's cycling environment provides an intital context in which to catalogue on-street physical conditions. This overview includes data on ridership levels and safety (injury and fatality) statistics, accompanied by a qualitative assessment of the greatest safety threats to on-street cyclists. Finally, safety research currently underway at the New York City Department of Transportation (NYCDOT) and federal agencies is reviewed.

Cycling Ridership

Since 1980, NYCDOT has been monitoring bicycle travel in selected locations. Bicycle volumes are recorded on the Staten Island Ferry, on three East River bridges on which Class I bicycle paths exist, and across 50th Street in Midtown Manhattan (Table 1).

Midtown Manhattan bicycle counts assess ridership levels on north-south avenues. These screenline counts are performed manually on a typical summer weekday between 7 am and 7 pm. In 1998, an additional screenline count on 23rd St. was performed to augment 50th St. screenline data. NYCDOT issues an annual report, *New York City Bicycle Statistics*, which compares annual statistics on cycling volumes, crashes, summons issuance, theft and theft recovery.

Table 1 is a three-year comparison of bicycle volumes (excluding 23rd St. counts) which reveals a slight decrease in ridership levels from 1996 to 1998, a difference of approximately 13% (2092 cyclists). This contradicts trends leading up to 1996, which saw an 8% increase in bicycle volumes in the Manhattan Central Business District in that year alone, and an increase of 142% since 1980.

Table 1
NYCDOT Average Daily Bicycle Volumes (50th Street Screenline, Bridge and Ferry)

Facility	1996	1997	1998
First Ave.	380	521	329
Second Ave.	874	933	879
Third Ave.	872	1311	1481
Lexington Ave.	640	855	927
Park Ave.	836	871	516
Madison Ave.	1030	1397	961
Fifth Ave.	1204	932	1098
Sixth Ave.	1506	1090	982
Seventh Ave.	820	666	730
Eighth Ave.	1345	856	1162
Broadway	875	956	410
Ninth Ave.	1090	1214	929
Tenth Ave.	341	298	241
Eleventh Ave.	113	136	160
Twelfth Ave.	35	31	62
Brooklyn Br.	1613	1698	1115
Queensboro Br.	1314	786	692
Williamsburg Br.	791	1022	966
Staten Island Ferry	387	318	335
Total	**16,066**	**15,891**	**13,974**

A preliminary look at 1998 data (23rd and 50th St. data only) shows overall higher numbers of cyclists near 50th St. in Midtown:

Table 2
1998 NYCDOT Average Daily Bicycle Volumes

Facility	23rd	50th	Total
First Ave.	1039	329	1368
Second Ave.	577	879	1456
Third Ave.	465	1481	1946
Lexington Ave.	434	927	1361
Park Ave.	1266	516	1782
Madison Ave.	143	961	1104
Fifth Ave.	1425	1098	2523
Sixth Ave.	134	982	1116
Seventh Ave.	799	730	1529
Eighth Ave.	1065	1162	2227
Broadway	0	410	410
Ninth Ave.	449	929	1378
Tenth Ave.	694	241	935
Eleventh Ave.	207	160	367
Twelfth Ave.	262	62	324
Total	**8,959**	**10,867**	

Accident Statistics

The City and State of New York compile data pertaining to every traffic accident (vehicular, pedestrian, cycling) that occurs within their boundaries. All data is derived from police reports written by the officer called to the scene of the accident. By definition, these reports are often highly imperfect; details may be vague or missing; judgements about the cause of accidents are often subjective. However, these on-site reports and summaries derived from them constitute the legal record of accidents in the City and State of New York.

Accident data can be reviewed both through an Interim Accident Summary Report and by individual location node. The summary data is compiled from individual police reports every six months, and offers a condensed view of nodes (by intersection) used to determine a pattern of accidents.

However, accident summary data refers only to vehicles and pedestrians specifically, not cyclists. Although accident data specific to cyclists is contained in individual accident reports, it can be primarily used only to review traffic patterns involving cyclists at pre-selected locations (not to initially identify a set of intersections continually problematic for cyclists).

General summary data are available, however, for the total number of bicycle/vehicular accidents in New York City. These are compiled by the New York Metropolitan Transportation Council (NYMTC), the Metropolitan Planning Organization (MPO) for the New York City region, and are based on New York State Department of Motor Vehicles data, available through 1996. This data shows a 43% overall increase in yearly accident totals since 1990 (Table 3):

Table 3
NYMTC Technical Notes Summary of Total NYC Vehicular/Bicycle Accidents

Year	Accidents
1990	3706
1991	4031
1992	4236
1993	4834
1994	4709
1995	5331
1996	5306
1997	N/A

Finally, current yearly summary data of citywide cycling injuries and fatalities is available from the New York Police Department (NYPD):

Table 4
NYPD[3] Total Bicycle Injuries and Fatalities

Year	Injuries	Fatalities
1996	5551	15
1997	5757	13

Table 5
NYPD Year-To-Date (YTD)[3] Bicycle Injuries and Fatalities

Year	Injuries	Fatalities
1997	5486	13
1998	4887	11

NYPD 1996 data shows higher cycling injury and fatality totals than NYMTC 1996 cycling accident totals (5566 versus 5306). Both 1996 and 1997 NYPD figures support a continued trend in decreased cycling safety seen since 1990, contrasting accident increases with concurrent decreases in the total number of cyclists recorded in NYCDOT bicycle counts (Table 1). NYPD 1998 figures reveal slight reductions in both the number and severity of cycling accidents, which are concurrent with decreased ridership levels recorded in 1998 NYCDOT bicycle counts.

[3] *Received (confirmed) from the Office of the Chief of Patrol. YTD: January 1 to November 23.*

Qualitative Safety Assessment

A qualitative assessment of on-street safety for cyclists was performed through a recent questionnaire distributed by the New York City Department of City Planning (DCP); (Appendix A). Bicycle safety questions were asked in addition to questions about bicycle travel habits and bicycle parking. From a total 1378 questionnaires returned, a majority of respondents (51.1%) resided in Manhattan:

Table 6
DCP Questionnaire
Borough Residence of Respondents

Borough	% Total
Manhattan	51.1%
Brooklyn	25.6%
Queens	12.1%
Staten Island	4.7%
Bronx	3.2%
outside NYC	3.2%
Total	**100%**

More than half (59.8%) of all respondents used their bicycle to commute to work, averaging 6.2 miles and 36 minutes per commute. Of questionnaire respondents who did not use their bicycle to commute to work, relative percentages of reasons given for not commuting by bicycle were well distributed among the top three categories:

Table 7
DCP Questionnaire
Reasons for Not Commuting by Bicycle

Reason	% Total
Nowhere to store my bike safely	29.2%
No shower/change facilities at work	25.7%
Fear of motorists	23.2%
Poor roadway surface conditions	12.7%
Work too far from home	9.2%
Total	**100%**

A question more specifically related to on-street safety asked cyclists the following:

Which roadway users are the greatest threats to your safety when riding in traffic?

For this question, survey respondents were asked to assign given categories with numbers from 1 to 5 (1-low to 5-high threat). To tabulate responses where no number was given, a zero was entered. With this correction, the question could be evaluated for 94.7 % of all surveys.

Results from this question are shown on Chart 1 (next page). Taxis and double-parked cars were ranked by respondents as the greatest roadway threats (4.1 and 3.7, respectively), followed by private passenger cars (3.5) and trucks (3.1).

A second question related specifically to on-street safety asked respondents to summarize accident information:

Have you been in an accident while riding in traffic? (check all that apply):

A police report was filed	*(_yes/_no)*
Someone was injured	*(_yes/_no)*
Someone was taken to the hospital	*(_yes/_no)*
I was doored	*(_ # times)*
I collided with a vehicle	*(_ # times)*
I collided with a person	*(_ # times)*

The results from this question are shown in Charts 2 and 3 (next page). A little more than half of all survey respondents (52.8 %) indicated that they had been involved in an accident by checking at least one of the given categories. In Chart 2, most responses were given from cyclists who had been doored, followed by collisions with vehicles.

Chart 3 shows a comparison of incidents of dooring, vehicle and pedestrian-related cycling accidents listed by number of occurences. Pedestrian-related accidents represented the greatest number of singular accidents; "dooring" and vehicular collisions represented the greatest number of multiple accidents, respectively.

Chart 1: Safety Threats in Traffic

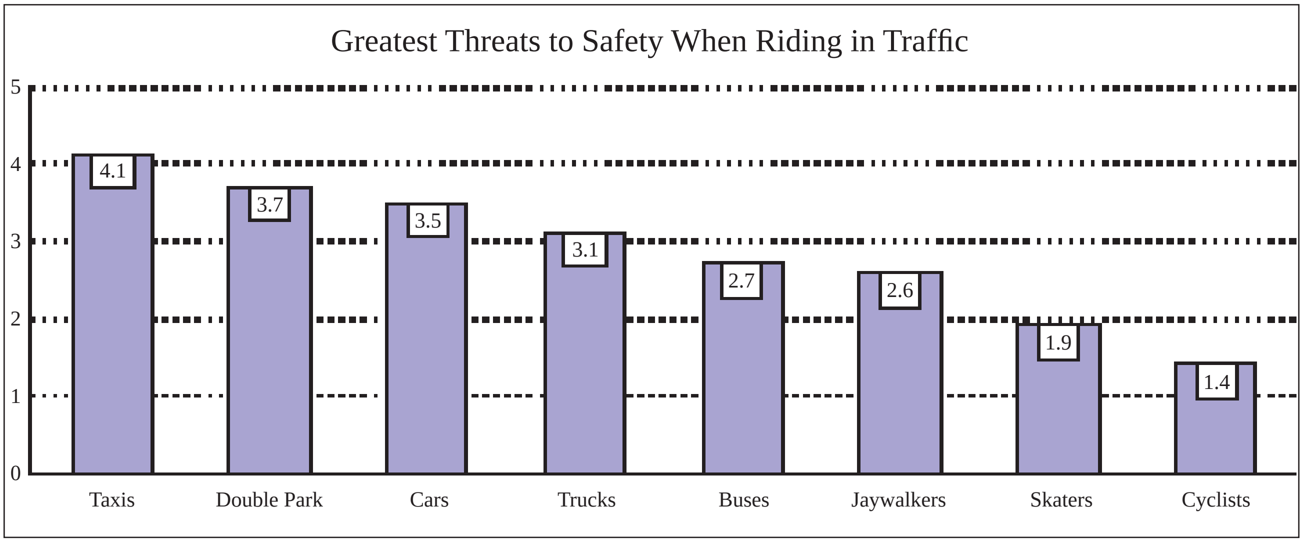


Chart 2: Accident Summary Information

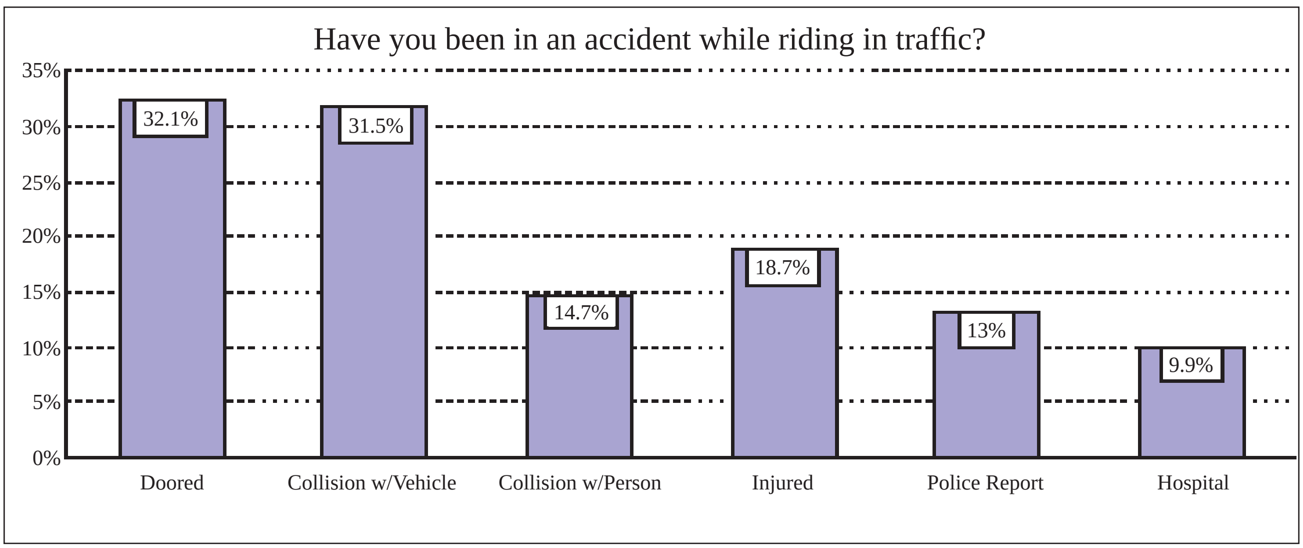
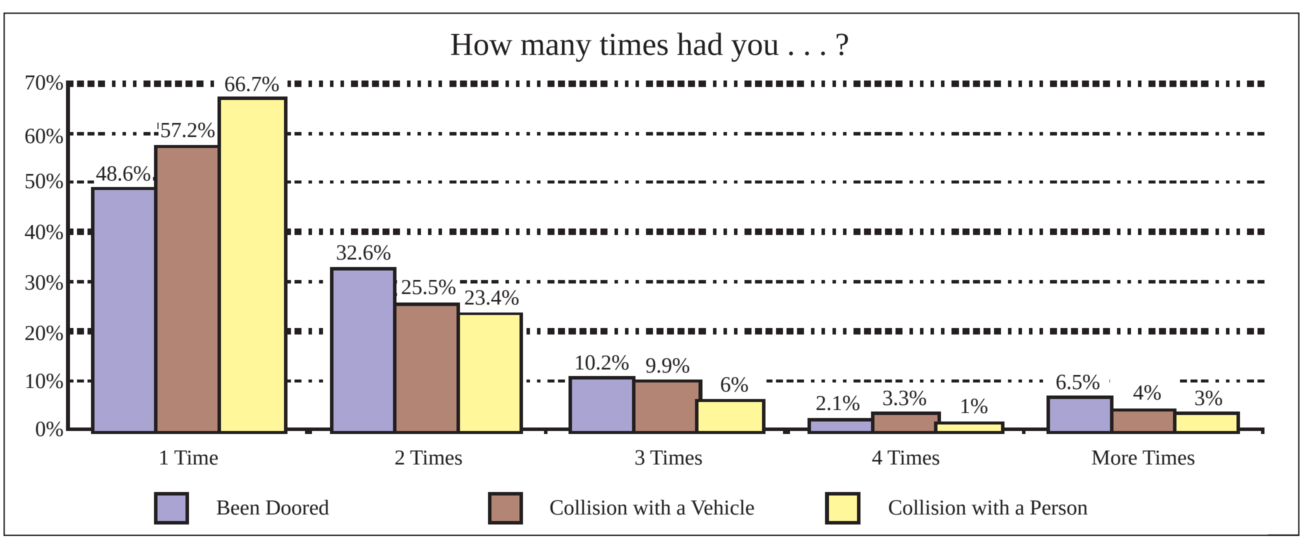


Chart 3: Accident Frequency Information



Safety Research

In a effort to provide a formulated approach to the analysis of safety and accident data, the Safety Division of NYCDOT is developing a Computer - Aided Safety Index for Urban Streets (CASIUS). CASIUS is an attempt to provide a safety index for New York City street links and nodes (intersections) based upon factors that affect accident experience.

Elements that comprise CASIUS are categorized into two basic areas: the first historical, the second predictive. Historical accident experience is necessary to examine the past safety perfomance of a location, focusing on accident severity and frequency. It indicates the presence or absence of particular problems through repeated occurrences of accident types.

The predictive category captures and analyzes the physical configuration, traffic congestion level, traffic markings and controls, pedestrian interaction and other information to determine the level of safety at a site. It also provides a means to evaluate remedial actions prior to implementation.

To date, CASIUS remains in developmental phases as research to define historical and predictive factors has yet to be completed. As a comprehensive, citywide tool, however, CASIUS may provide opportunities to develop increasingly systematic approaches to both quantitative and qualitative cycling safety research.

A related research effort is also currently in progress by federal agencies. A software program called the Pedestrian and Bicyclist Crash Analysis Tool (PBCAT) is currently being prepared under the sponsorship of the Federal Highway Administration and the National Highway Traffic Safety Administration. This tool, scheduled for availability in 1999, will automatically classify crashes, build a database and produce reports for use by a jurisdiction. Potential use of this tool for New York City will likely require improved summary tracking of cycling accidents.

Overall in the past five years, New York City has experienced growing numbers of on-street cyclists, accompanied by rising levels of cycling accidents. Most recently, slight decreases in cycling ridership have occurred, accompanied by similar decreases in the number of cycling injuries and fatalities. In the recent DCP effort to qualitatively assess on-street safety concerns of cyclists, the propensity to cycle was strongly linked to a “fear of motorists,” particularly taxi, car and double-parked road users. On-street facility improvements which address these concerns could help ensure a continued growth in cycling ridership without concurrent increases in accident rates.

NEW YORK CITY ON-STREET CYCLING FACILITIES

To begin cataloging the current physical on-street cycling environment in New York City (and Manhattan in particular), an overview of existing, past and planned bicycle facilities is given. This is accompanied by a description of the process used by NYCDOT to implement new cycling facilities, curbside regulation and NYPD enforcement affecting implemented facilities.

Existing and Planned Facilities

Existing bicycle lanes on New York City roadways generally conform to recommended standards established by the American Association of State Highway and Transportation Officials (AASHTO). These standards are presented in the *New York City Bicycle Master Plan*, and described in detail in the *Safe Streets Task 2 Literature Review* (pp.4-9).

In accordance with AASHTO recommendations, existing bicycle lanes are approximately five feet wide, marked with white thermoplastic striping, and cyclist and diamond stenciling. The Broadway, First, Fifth and Sixth Avenue lanes (Table 9) were implemented prior to the release of the AASHTO guidelines, and are approximately four feet wide.

The beginning of a five-foot bicycle lane, with six-foot buffer, on Lafayette St. (at Spring St.).

In contrast, several recently implemented lanes, including Lafayette, Hudson and Second Avenue lanes, have surpassed AASHTO recommended standards through inclusion of a six-foot striped buffer separating vehicle and bicycle travel. The width for each buffer was made possible through the reconfiguration or elimination of travel lanes.

To date, a total of 72.42 miles of on-street bicycle lanes have been implemented in four of five boroughs in New York City:

Table 8
Existing Citywide On-Street Bicycle Lanes

Borough	Total Miles (2-way)	%Total
Queens	21.40	29.55%
Manhattan	22.34	30.85%
Brooklyn	20.38	28.14%
Staten Island	8.30	11.46%
Total	**74.07**	**100%**

Within the Manhattan study area, 22.34 miles of lanes have been implemented in nine locations:

Table 9
Existing Manhattan On-Street Bicycle Lanes

Roadway	From	To	Miles
AC Powell Jr./ St. Nicholas	110th St.	168th St.	5.60
Broadway	59th St.	17th St.	2.60
Central Park	(drives)		6.24
First Ave.	72nd St.	125th St.	2.70
Hudson St./ Eighth Ave.	Dominick	14th St.	1.00
Lafayette St./ Fourth Ave.	Spring St.	14th St.	1.00
Second Ave.	14th St.	Houston	0.75
Fifth Ave.	23rd St.	7th St.	0.80
Sixth Ave.	8th St.	40th St.	1.65

An additional 39.5 miles of on-street (Class II) bicycle lanes outside of Manhattan are in the design stage at NYCDOT, the majority of which are planned for the Bronx (19.8 miles) and Brooklyn (15.1 miles).

Finally, approximately 90 miles of additional lanes are currently proposed for implementation during the next four years by the NYC Departments of City Planning and Transportation, including 50 miles in Manhattan and 10 miles in each of the four remaining boroughs.

Plans for continued on-street implementation provide opportunites for the strategic placement of innovative cycling facility prototypes which this study seeks to recommend. In making recommendations, however, it is important to note past and current attempts at innovative facility implementation in New York City.

Remnant of Sixth Ave. curb separated lane.

In 1980, a curb-separated bicycle lane was installed on Sixth Avenue in Manhattan, and removed within several months. Protected from motor vehicle traffic, the lane became a refuge for street vendors and pedestrians, and impassible for cyclists. A one-block (33th St. to 34th St.) portion of the lane and accompanying bicycle-traffic signal still exists at Herald Square.

A more recent cycling facility innovation is currently in place in Brooklyn. A red pigmented bicycle lane was implemented in November 1998 as part of a reconstruction of Adams Street by the New York City Economic Development Corporation (NYCEDC). The five-foot wide pigmented lane is bounded by granite pavers, and runs for approximately two blocks in both directions (from Tillary St. to Willoughby St.).

Pigmented bicycle lane on Adams Street.

The blocks adjacent to this newly installed lane contain several court buildings, a major post office, hotel and the New York City Techinical College. Cars accompanying these uses at times ignore the curbside parking prohibition that was implemented with the new lane, rendering it inaccessible to cyclists.

Finally, raised markings have been implemented by the New York State Department of Transportation (NYSDOT) on a recently constructed portion of the Route 9A Hudson River bicycle path in Manhattan's West Village. Series of raised markings are meant to alert cyclists at pedestrian intersections. Although these markings have been implemented on an off-street (Class I) path, the potential exists to use similar markings in conjunction with innovative on-street lane design through high-volume pedestrian areas.

Newly implemented bike path on Route 9A.

Bicycle Lane Implementation

NYCDOT is primarily reponsible for implementing on-street cycling facilities. The following steps are used to plan for the implementation of on-street bicycle lanes:

1. Identify specific alignment for consideration;
2. Measure width and ride to determine suitability, including stress level determination (a function of the number of lanes, curb lane width, traffic volume and vehicle speed);
3. Compile Automated Traffic Recorder (ATR) vehicle counts;
4. Compile vehicle turning counts, classification counts and signal timing diagrams;
5. Conduct capacity analysis using Highway Capacity Software (HCS) and above data;
6. Create an engineering design for lane implementation, including a diagram of proposed “typical” lane widths;
7. Present this design to community boards in which the lane is proposed;
8. Collect inventories of curb use, regulation and signage;
9. Write orders for sign implementation;
10. Inform the NYCDOT Borough Commissioner.

The feasibility of implementing recommended cycling facilities relies heavily on step 5: HCS analysis. HCS analysis allows the NYC DOT to determine the impact a proposed facility will have on existing traffic in a specific location, based primarily on the percentage change in vehicular traffic delay.

Change in the level of service (LOS) rating (A/best through F/worst) assigned to a location before and after proposed implementation is also used to determine traffic effects of a new cycling facility. Acceptable changes in LOS are in part dependent on existing levels of service (i.e., a change from LOS A to LOS D is more severe than a change from LOS C to LOS D).

If impacts are considered significant, lane implementation will be deemed infeasible, halting further work. In certain cases, however, a compelling need for a lane may outweigh traffic impacts, allowing the implementation process to continue.

Associated Curbside Regulation

Traffic rules, including curbside regulation, are outlined in the NYC Department of Transportation *Traffic Rules* manual. This document contains provisions both specifically and generally related to the operation of on-street bicycle facilities.

Regulations which specifically address bicycle lanes appear in Section 4-08 of the NYCDOT *Traffic Rules*. These include:

> (e) ***General No Stopping Zones*** (stopping, standing and parking prohibited in specified places). No person shall stop, stand or park a vehicle in any of the following places, unless otherwise indicated by posted signs, markings or other traffic control devices, or at the direction of a law enforcement officer:
>
> > (9) Bicycle lanes. Within a designated bicycle lane.

Double-parking, cited by DCP questionnaire respondents as the second highest roadway threat to cyclists (p.4), is addressed through regulation of standing vehicles. This section does not, however, address bicycle lanes as a specific subset, and mentions them only in relation to loading and unloading commericial vehicles. Language used for this purpose is somewhat unclear, indicating that commercial vehicles should stand on the “roadway side of bicycle lanes,” without specifically stating that vehicles are prohibited from standing in bicycle lanes:

> (f) ***General No Standing Zones*** (standing and parking prohibited in specified places). No person shall stand or park a vehicle in any of the following places, unless otherwide indicated by posted signs, markings or other traffic control devices, or at the direction of a law enforcement officer:
>
> > (1) Double parking. On the roadway side of a vehicle stopped, standing or parked at the curb, except a person may stand a commercial vehicle alongside a vehicle parked at the curb at such locations and during such hours that stopping, standing, or parking is not prohibited, while expeditiously making

> pickups, deliveries or service calls, provided that there is no unoccupied parking space or designated loading zone on either side of the street within 100 feet that can be used for such standing...A person may stand a commercial vehicle *along the roadway side of a bicycle lane* provided all other conditions of this paragraph (1) are met.

NYCDOT's planned expansion of the city's network of cycling lanes will require increasingly explicit curbside regulation and signage to accompany new facilities. Double parking, identified by cyclists as a leading threat to on-street safety, should be a target of focused regulation.

In addition, future implementation of innovative on-street cycling facilities will require modified curbside regulations which address all relevant cycling facilities (not just bicycle lanes). New facilities should also be implemented in conjuction with improved signage to make delivery vehicles aware of loading/unloading regulations (outside of bicycle lanes), and to alert motorists to double-parking and standing regulations (outside of bicycle lanes). Regulation efforts need to be coordinated with effective enforcement, discussed below.

In addition, the ability of commercial vehicles, buses and taxis to use *designated curbside areas* also affects cyclists' safe use of clear bicycle lanes; bicycle lanes are often inadvertantly blocked by trucks, buses and taxis when illegally parked passenger cars prevent the use of these designated areas. These areas require explicit signage to identify regulations near new and existing cycling facilities, in addition to targeted enforcement efforts.

In addition to ticket issuance, Traffic Enforcement Agents are authorized by Section 4-08 of the *Traffic Rules* to affix a sticker to the rear side window of unattended stopped, standing or parked cars which violate parking regulations and interfere with the free flow of traffic. Finally, summons issuance by NYPD officers is a critical enforcement effort related to curbside use, and is discussed in the following section.

Enforcement

Uniformed Bicycle Patrols were initiated through a 1992 NYPD Community Policing Bicycle Patrol pilot program in the 24th Precinct. The objective of this pilot program was to provide each beat officer with a bicycle to be utilized as a "tool" to enhance patrol capacity, giving police officers increased mobility and community visibility.

After one year, the Community Policing Bicycle Patrol was deemed successful and ten additional precincts were equipped with bicycles. In 1995, increasing popularity of the Bicycle Patrols led to their expansion to approximately 59 precincts, an expansion funded by community donations channeled through the New York City Police Foundation. In 1997, the NYPD took over the funding of the Bicycle Patrol, expanding it to every Precinct,Task Force, the Traffic Control Division and the Housing Bureau.

Currently there are approximately 1700 marked police bicycles citywide. A smaller additional number of unmarked bicycles are also ultized by Anti-crime personnel and the Street Crime Unit.

Work performed by Bicycle Patrol officers generally falls into two categories: (1) community policing and (2) traffic enforcement (all traffic).

COMMUNITY POLICING

Bicycle Patrols have been primarily used to emphasize quality of life enforcement,[4] particularly at parks, playgrounds and housing developments. In most instances, officers use the bikes as a tool to address a wide variety of law enforcement issues, not only those that are specifically bicycle-related. Policy for the bike patrols is set at the precinct level, with direction from the Office of the Chief of Patrol. This policy reflects community concerns and prevalent local conditions and concerns.

Community police work which involves cyclists ranges from officers who target the use of bicycles for criminal activity (including robberies in which bicycles are used as a "get-away" and drug dealers who use bicycles for quick relocation and as “look-outs” for police officers), to officers who target cyclists for moving offenses. Inspector John White, Office of the Chief of Patrol, has stated, however, that criminal enforcement is often prioritized over moving offense enforcement by precinct Bicycle Patrols.[4] Concern about drug activity in Washington Square Park, for example, has led bicycle patrol officers in that precinct to focus their work on suspected drug behavior in lieu of other offenses, including moving violations that involve cyclists.

In specific instances, however, community concern about cycling moving violations has led officers to focus their efforts on summons issuance. In recent months, for example, community complaints about speeding cyclists at entrances to the Brooklyn Bridge have prompted targeted summons efforts by patrol officers.

Summonses issued by the Bicycle Patrols are now tracked on a daily (v. weekly) basis by the Office of the Chief of Patrol.

TRAFFIC ENFORCEMENT

Overview

Traffic enforcement of cyclists has increased concurrently with expansion of the Bicycle Patrol Program, evident from the annual numbers of summons issued to cyclists. These numbers reflect NYPD totals, including but not limited to summonses issued by Bicycle Patrols:

Table 10
Citywide Bicycle Summonses Issued

Year	Total	Increase
1993	1794	N/A
1994	1961	9%
1995	2389	18%
1996	5966	150%
1997	N/A	N/A

These numbers show dramatic increases in summonses issued to cyclists in years immediately following major expansions of the Bicycle Patrol Program (described earlier). Most dramatic is a 150% increase in cycing summonses that occurred after the 1995 expansion of the Program. A second major Program expansion occurred in 1997, for which summary data is not available.

However, a comparison of 1997 and 1998 year-to-date (YTD) reports[5] of moving traffic summonses shows a 67% increase in the number of moving summonses issued to cyclists from 1997 (5,702 summons) to 1998 (9,532 summonses):

Table 11
Citywide YTD Moving Violations

1997 Moving Summonses	
Issued to Motor Vehicles	711,121
Issued to Cyclists	5,702
Issued to Pedestrians	9
Total	**716,832**
1998 Moving Summonses	
Issued to Motor Vehicles	830,724
Issued to Cyclists	9,532
Issued to Pedestrians	151
Total	**840,407**

This data also allows comparison between the relative percentage growth of traffic summonses issued to cyclists to those issued to motor vehicles. As a total percentage share, summonses issued to cyclists increased from 0.8% to 1.13%, or 0.33%. The percentage share of motor vehicle summonses decreased from 99.2% to 98.8%, or 0.4% (Table 3).

[4] *Interview with Inspector John White, Office of the Chief of Patrol, 9/30/98.*

[5] *January 1 to August 31, NYPD summary report which includes data for each precinct command; Housing, Transit, Port Authority, Highway and Traffic Control Division.*

Table 12
1997-1998 YTD Relative Percentage Change in Moving Violations Issuances

Issued to	Relative Change
Cyclists	+0.33%
Motor Vehicles	-0.4%

In summary, from 1997 to 1998, an increasing *total* number of cycling summonses reflects a rising *percentage* of cycling summonses relative to motor vehicle summonses. These results occurred in tandem with continual expansion of the NYPD Bicycle Patrol program. Based on these results, a preliminary conclusion can be drawn that, on the whole, an expanded Bicycle Patrol Program has resulted in greater emphasis on the enforcement of cyclists than of motor vehicles.

Traffic Control Division (TCD)

NYPD's Traffic Control Division contains a uniformed Bicycle Patrol whose primary function is to enforce parking regulations on bicycle lanes and double parking conditions generally in Patrol Borough Manhattan South[6] (below 59th St.)

The Bicycle Patrol is employed during day (8 am to 4 pm) and evening (4 pm to 12 am) tours of the TCD Enforcement Unit. Each shift is staffed by one sergeant and approximately nine police officers. Target areas covered by the TCD Bicycle Patrol fluctuate and are based on input from each precinct on problem areas requiring increased enforcement. These assignments are not currently influenced by the location of existing bicycle lanes. In addition to their regular assignments, Bicycle Patrol officers also cover major events (parade, presidential visit), civil disturbances (fire, building collapse) and other emergencies.

In 1998 (YTD), approximately half of all borough command summonses to cyclists were issued by the TCD Bicycle Patrol.[7] Summary data of all summons issued by the Patrol offers the most detailed profile of cycling-related enforcement activity. Through October 1998, the Patrol issued a total **10,674** summonses[8] (Table 13).

Table 13
TCD Bicycle Patrol
YTD Total Summonses

Moving Violations	6,834
Parking Violations	3,673
Criminal Court summonses	167
Total	**10,674**

Of these 10,674 total summonses, 4,608 (43.2%) were specifically related to cycling -- issued either directly to cyclists or to motor vehicles in bicycle lanes. A further analysis of cycling-related summonses reveals a 3:1 ratio of summonses issued to cyclists versus motor vehicles parked illegally in bicycle lanes: 3,441 (74.7%) were issued to cyclists; 1,167 (25.3%) were issued to motor vehicles (Table 14).

Table 14
TCD Bicycle Patrol
YTD Total Cycling Related Summonses

Summonses Issued to Cyclists	3,441
Summonses Issued to Motor Vehicles in Bicycle Lanes	1,167
Total	**4,608**

Further comparisons can be made among cycling-related summonses. The breakdown of the 1,167 summonses to motor vehicles included:

Parking in Bicycle Lane	1,160
Driving in Bicycle Lane	2
Other	5
Total	**1,167**

A breakdown of the 3,441 summonses issued directly to cyclists[9] included:

Disobeying Red Lights	1,088
Riding Wrong Way	1,185
Riding on the Sidewalk	509
Other[10]	659
Total	**3,441**

Finally, analysis of the total number of moving violation summonses issued to motor vehicles versus cyclists shows approximately a 3:2 ratio: 4052 (59%) were issued to motor vehicles; 2782 (41%) were issued to cyclists (Table 15).

Table 15
TCD Bicycle Patrol
YTD Total Moving Violations Summonses

Issued to Motor Vehicles	4,052
Issued to Cyclists	2,782
Total	**6,834**

Summary of TCD Analysis

Overall, work performed by the TCD Bicycle Patrol (both general traffic enforcement and enforcement specific to cycling) contributes to safer on-street conditions which benefit cyclists. However, as the only NYPD Patrol whose assignments *specifically* include enforcement of on-street cycling conditions, the TCD Bicycle Patrol is particularly important to the existence of bicycle facilities that remain clear and safe for cyclists' use.

Considering this, detailed analysis of summonses issued by the Bicycle Patrol related to cycling (43.2% of total summonses) was performed. This analysis showed a 3:1 ratio of summonses given to cyclists versus motor vehicles disrupting use of bicycle lanes. This figure contrasts sharply with DCP survey results discussed earlier in this report (p.4), which cited double-parked vehicles as the second greatest threat to cyclists riding in traffic. Overall, the TCD Bicycle Patrol issued summons to cyclists at a 2:3 ratio over the sum total issued to motor vehicles (for both cycling-related and non-cycling specific offenses).

With the continued expansion of the network of bicycle lanes, preliminary recommendations can be made for an (1) increased emphasis on motor vehicle enforcement *directly related* to on-street cyclists, and (2) specific targeting of locations where NYCDOT has installed cycling facilities to make these investments usable.

[6] *Text taken from "History of the Uniformed Bicycle Patrol," issued by the Office of the Chief of Patrol.*

[7] *TCD Bicycle Patrol issued 2457 of 4626 borough command summonses to cyclists. Office of the Chief of Patrol Bicycle Enforcement Report, reporting from January 1 thru September 21.*

[8] *Summary data is for evening tour only; the bike unit of the day tour was initiated 10/98 and data not yet available.*

[9] *See Appendix B for a summary listing of cycling infractions and associated fines.*

[10] *Includes criminal court summones to store owners who utilize bicycles for delivery and have not maintained proper records.*

STUDY AREA REVIEW

Ultimately, this report attempts to identify *unsafe* on-street locations *currently used by cyclists* for the implementation of prototype facilities (and new conventional bicycle lanes). A total of ten roadway locations and four bridge entrances were selected for preliminary field work based on these two criteria.

Initial Identification of Study Locations

As discussed earlier, the diffuse nature of New York City and State accident report data precluded its use to determine study locations (p.3). As an alternative, the questionnaire distributed to cyclists by the Department of City Planning (p.4) included two open-ended questions which asked respondents to list on-street locations they considered most dangerous, as well the reasons why:

- Along your typical routes, are there any particularly bad intersections or stretches of roadway? Describe the exact location;

- What is the nature of the problem?

Approximately 800 questionnaires were received. Multiple entries to the above questions resulted in 1361 location entries that were tabulated by borough:

Table 16
DCP Questionnaire
Problem Locations by Borough

Borough	# Entries	% Total
Manhattan	871	64.0%
Brooklyn	278	20.4%
Queens	110	8.1%
Staten Island	40	2.9%
New York[11]	34	2.5%
Bronx	28	2.1%
Total	**1361**	**100%**

In keeping with the scope of this study, however, only those locations within Manhattan and access points for bridges to Manhattan (in other boroughs) were analyzed. A "Manhattan subset" database that included **1022** entries was created to identify study locations (representing 76.1% of total responses).

Analysis

These 1022 locations were first classified as roadways (R), intersections (I) or bridges/points of bridge access (B). Totals for each classification were fairly evenly distributed:

Table 17
DCP Questionnaire -- Manhattan Subset
Classification of Problem Locations

Classification	# Entries	% Total
Roadway	409	38.7%
Intersection	343	32.5%
Bridge/Access	304	28.8%
Total	**1056**[12]	**100%**

Of roadways listed, the majority ran in a north-south direction (versus an east-west direction), approximately an 80/20 split:

Table 18
DCP Questionnaire -- Manhattan Subset
Problem Roadways by Direction

Roadway Direction	% Total
North-South	78%
East-West	22%

Problems at Manhattan subset locations were entered into the database and identified using 19 classification keywords based on typical responses. More than one keyword was generally used to describe each response; where applicable keyword descriptions overlapped, the most specific ones were used (descriptions of

[11] *34 responses were entered as "NY," denoting reference to a bridge/path between boroughs (not assigned to only one).*

[12] *34 entries were listed as "R, B" or "I, B" and appear twice.*

each keyword are contained in Appendix C). A list of keywords and the total number and percentage of each appears in the following table:

Table 19
DCP Questionnaire -- Manhattan Subset
Problem Keywords Given for Locations

Keyword	# Listed	% Listed
Poor bridge access	237	15.3%
Congestion	211	13.6%
Poor road condition	182	11.7%
No defined cycling space	168	10.8%
Double parked vehicles	107	6.9%
Conflicts w/ turning vehicles	86	5.6%
Vehicular speeds	77	5.0%
Intersection design	75	4.8%
Aggressive driving	69	4.5%
Pedestrians in cycle space	60	3.9%
Traffic signal problem	59	3.8%
Unlawful driving	53	3.4%
Stopping taxis	32	2.1%
Jaywalking	30	1.9%
Narrow roadway	30	1.9%
Merge problems	30	1.9%
Narrow bicycle lane	21	1.4%
Construction	12	0.8%
Unlawful cycling	10	0.6%
Total	**1549**[13]	**100%**

Finally, the 1022 total problem locations were queried to identify initial study locations for preliminary fieldwork. Locations with the highest concentrations are listed by roadway (includes references to associated intersections):

Table 20
DCP Questionnaire -- Manhattan Subset
Most Problematic Locations by Roadway

No.	Roadway	# Listed[14]
1.	Broadway	147
2.	Sixth Ave.	86
3.	Eighth Ave.	54
4.	59th St.	52
5.	Second Ave.	47
6.	Seventh Ave.	42
7.	34th St.	39
8.	Fifth Ave.	35
9.(1)	LafayetteSt./Fourth Ave.	32
9.(2)	42nd St.	32
11.	Houston St.	29
12.	Third Ave.	26
13.	Ninth Ave.	25
14.	Canal St.	23
15.	First Ave.	18

Of these 15 roadways, nine are located entirely in the southern half of Manhattan, below (including) 59th St. The remaining six north-south roadways were analyzed to determine general areas of concentration, north or south of (including) 59th St:[15]

Table 21
DCP Questionnaire -- Manhattan Subset
Problematic North-South Roadways;
Percent of Responses below/above 59th St.

Roadway	% below	% above
Broadway	86%	14%
Second Ave.	93%	7%
Fifth Ave.	90%	10%
Third Ave.	91%	9%
Ninth Ave.	100%	0%
First Ave.	71%	29%

Five of 15 roadways in Table 20 run in an east-west direction. A closer look at the total entries

[13] *Total has no relation to total number of entries; each entry was eligible for more than one keyword. Percentage given as a part of total number of keywords listed (not entries).*

[14] *Intersections references included in totals with each roadway.*

[15] *Area consistent with NYPD accident data.*

for each roadway[16] shows differences in the type of responses each received -- referenced either as roadway segments (a block or more), or in relation to specific intersections. Forty-second St. and 34th St., in particular, both ranked as top ten *Problematic Locations by Roadway* (Table 20) but were cited far more often in relation to discrete intersections than as roadway segments.

For this reason, 42nd St. and 34th St. are not included in a final list of study locations; problematic intersections on these roadways will be addressed as components of the roadways they intersect.[17]

Major intersection areas that were identified as problematic locations were catalogued and listed separately from roadways and other minor intersections. These areas are generally irregularly shaped or excessively large cross-roads.[18] Queries of these areas sought to establish concentrations of responses beyond those associated with discrete intersections or roadways. Major intersection areas most frequently cited by questionnaire respondents were traffic irregularities created by Broadway:

Table 22
DCP Questionnaire -- Manhattan Subset
Top Problematic Major Intersection Areas

Intersection area	**# Listed**
Herald Square	41
Columbus Circle	31
Times Square	18
Union Square	17
Madison Square	12

Finally, a query of all bridges to and from Manhattan from other boroughs was conducted, focusing on locations which provide immediate access to bridge entrances:

Table 23
DCP Questionnaire -- Manhattan Subset
Top Bridge /Access Recommendations

Bridge	**Total**[19]	**Entrance**
Brooklyn Bridge	173	
Manhattan Entrance		83
Brooklyn Entrance		81
Queensboro Bridge	85	
Manhattan Entrance		55
Queens Entrance		25
Williamsburg	19	
Manhattan Entrance		6
Brooklyn Entrance		12

Results
The total analysis of questionnaire results provides both specific location recommendations and overall guidelines to be used to determine a final list of study locations.

In Table 17, *Classification of Problem Locations*, the greatest number of respondents cited unsafe locations as roadway segments (R). Roadways, in combination with their associated intersections, provided the highest concentrations of responses in Table 20, *Most Problematic Locations by Roadway*, as well. As a result, roadways are used as the primary basis for the final selection of study sites in the continutation of this project.

Of the fifteen roadways listed in Table 20, ten will be targeted as study locations for preliminary field work. Based on Table 21 results, *Problematic North-South Roadways*, study segments of these roadways should be concentrated below (including) 59th St. Following the trend established by Table 18, *Problem Roadways by Direction*, eight of the ten roadways selected should run in a north-south direction. Using a

[16] *Excludes major intersection areas, which are listed in Table 23.*
[17] *Based on an assumption that roadways used as travel corridors would be primarily referenced by questionnaire respondents as roadways (R), versus a series of linked intersections (I).*
[18] *Major intersection areas are described in Appendix D.*
[19] *Bridge totals include general references (not specific to entrances or assigned to a specific borough).*

roadway-based approach, major intersections identified inTable 22 will be addressed as critical locations along appropriate roadways.

Bridge entrances (Table 19 and Table 23) cannot be adequately addressed as roadway components. In particular, the Brooklyn Bridge and Queensboro Bridge entrances should be addressed as unique study locations, in addition to the ten targeted roadway study locations.

Based upon questionnaire results, an initial identification of study locations for preliminary fieldwork follows:

Table 24
Initial Identification of Study Locations

No.	Roadway	Study Segment
1.	Broadway	Canal to 59th St.
2.	Sixth Ave.	9th to 59th St.
3.	Eighth Ave.	14th to 59th St.
4.	59th St.	First to Eighth Ave.
5.	Second Ave.	14th to 61st St.
6.	Seventh Ave.	8th to 59th St.
7.	Fifth Ave.	23rd to 59th St.
8.	Lafayette/Fourth	Spring to 14th St.
9.	Houston St.	A to Seventh Ave.
10.	Third Ave.	42nd to 60th St.
11.	Brooklyn Bridge Manhattan and Brooklyn entrances	
12.	Queensboro Bridge Manhattan and Queens entrances	

Table 24 reflects an 80/20 split between north-south and east-west roadways (Table 18); two east-west roadways appearing on the list show relatively high percentages of roadway segment versus intersection references. Study segments recommended for each roadway contain major intersection areas which were identified by questionnaire respondents (Table 22), and reflect the highest concentrations of total responses. These typically occurred south of 59th St., consistent with Table 21 results.

As a final note, safety problems used to classify Manhattan location entries (Table 19) were compared with the "safety threats to cyclists" identified by DCP questionniare respondents (pp.4-5). Problems related to road conditions, a lack of defined cycling space, turning conflicts at intersections, high vehicle speeds and aggressive driving were most commonly cited in Table 19, expanding the list of general safety concerns ranked earlier. Safety problems associated with buses, which ranked third on pp.4-5, did not appear in Table 19.

Additional Data Sources

Two additional data sources were referenced against Table 24, *Initial Identification of Study Locations*: (1) NYCDOT Screenline Counts and (2) NYPD vehicular Accident-Prone Locations. These sources were used to further clarify locations most heavily used by cyclists, and locations considered most dangerous for roadway users, respectively.

NYCDOT SCREENLINE COUNTS

NYCDOT Midtown Manhattan Bicycle Volumes recorded at 23rd and 50th Streets were compared with questionnaire results. These volumes are referenced in Table 2 (p.2) of this report, which lists avenues with the highest total ridership counts as:

Rank	Roadway	Total Volume
1.	Fifth Ave.	2523
2.	Eighth Ave.	2227
3.	Third Ave.	1946
4.	Park Ave.	1782
5.	Seventh Ave.	1529

Four of these roadways are listed in Table 24, *Initial Identification of Study Locations*. Park Avenue is not listed; however, it is not heavily referenced by survey respondents nor is it referenced on NYPD safety data (below). Several roadways are included on Table 24 despite lower NYCDOT ridership counts due to high survey response. Study segments identified for each roadway on Table 24 encompass NYCDOT peak ridership counts (p.2).

NYCDOT screenline data was also used to evaluate the relevance of NYPD vehicular accident-prone location data to cyclists (below).

NYPD ACCIDENT-PRONE LOCATIONS

Questionnaire Table 24 results were also compared with lists of vehicular accident-prone locations tabulated monthly by each of the 22 Manhattan NYPD precincts.

An Accident-Prone Location (APL) index is assigned to each location where accidents occurred in a given month (typically at intersections). This number equals the total number of accidents plus the number of injuries/deaths that occurred at each location. Individual precinct lists of top accident-prone locations are aggregated by Patrol Boroughs Manhattan South and North to identify the top ten accident-prone intersections in each jurisdiction, south and north of 59th St., respectively.

An analysis of NYPD data first ranked borough-wide accident-prone locations by total APL number for a six-month period. Intersections were included only if they appeared more than once during that time period, to focus on chronic locations:

Table 25
NYPD Accident-Prone Locations
Intersections with Ten Highest APL Totals

Intersection	APL Total
Second Ave. at 59th St.	78
Eighth Ave. at 34th St.	71
Seventh Ave. at 34th St.	69
Second Ave. at 36th St.	67
Amsterdam at 181st St.	67
Fifth Ave. at 34th St.	67
Eighth Ave. at 42nd St.	57
Eleventh Ave. at 42nd St.	52
Eighth Ave. at 23rd St.	50
65th St. Transverse Rd.	50
Seventh Ave. at 65th St.	50
Canal St. at Bowery	49
Second Ave. at 57th St.	48

Of Table 25 intersections, eight appear within roadway segments listed in Table 24, *Initial Identification of Study Locations*. These are noted as critical locations within appropriate roadway segments in a final list of study locations (p.18). The remaining four intersections are located outside of the identified study area focus (below 59th St.), or on roadways with low or no NYCDOT ridership counts available.

Further analysis of NYPD data ranked each roadway by the APL total of its individually listed locations, and by the total number of locations which appeared on precinct APL lists:[20]

Table 26
NYPD Accident-Prone Locations
Roadways with Ten Highest APL Totals

Roadway	# sites	APL Total
34th St.	7	294
23rd St.	7	245
42nd St.	7	243
57th St.	7	226
Eighth Ave.	4	215
Second Ave.	4	154
Twelfth Ave.	4	132
Tenth Ave.	4	127
Third Ave.	4	127
Canal St.	3	110
Sixth Ave.	3	93

Of these roadways, four (Eighth, Second, Third and Sixth Avenues) appear on Table 24, *Initial Identification of Study Locations*. Three of these roadways (excluding Sixth Avenue) were also among the top five NYCDOT recorded bicycle volumes, meeting both high ridership and poor safety criteria for this study.

[20] *Roadways shown were tabulated from Patrol Borough Manhattan South APL lists only (determined as the focus of the study area). APL Roadways in Manhattan North are listed in Appendix D.*

Final List of Study Locations

Final study locations were identified by referencing three sources of available data to identify locations both unsafe for and well-used by cyclists: (1) NYCDCP Questionnaire responses, (2) NYCDOT Midtown Manhattan Bicycle Volumes and (3) NYPD vehicular accident-prone location data. Critical locations identified within roadway study segments target both the highest concentrations of questionnaire responses and NYPD accident-prone locations.

Table 27
Final List of Study Locations for Preliminary Fieldwork

No.	Roadway	Study Segment	Critical Locations[21]
1.	Broadway	59th St. to Canal St.	Union Square area, 34th St. to 23rd St. Herald Square area (34th St.) Times Square area (44th St.)
2.	Sixth Ave.	9th St. to 59th St.	14-57th St. Herald Square area (34th St.)
3.	Eighth Ave.	14th St. to 59th St.	23rd St. intersection 34th St. intersection 34th St. to 42nd St. (40th to 42nd St.) 42nd St. intersection Columbus Circle
4.	59th St.	First Ave. to Eighth Ave.	Second Ave. intersection Columbus Circle
5.	Second Ave.	61st St. to 14th St.	36th St. intersection 42nd St. to 36th St. 57th St. intersection 59th St. intersection
6.	Seventh Ave.	59th St. to Greenwich Ave.	34th St. intersection 42nd St. intersection 59th St. to 42nd St.
7.	Fifth Ave.	59th St. to 23rd St.	23rd St. intersection 34th St. intersection 59th St. to 42nd St.
8.	Lafayette/Fourth	Spring St. to 14th St.	Astor Place/8th St. intersection 14th St. intersection
9.	Houston St.	Ave. A to Seventh Ave.	Sixth Ave. intersection
10.	Third Ave.	42nd St. to 60th St.	57th St. to 59th St.
11.	Brooklyn Bridge	Manhattan & Brooklyn entrances	
12.	Queensboro Bridge	Manhattan & Queens entrances	

[21] *Locations which overlap address cyclists travelling through an area, using specific roadways. Major intersection areas are defined in Appendix D.*

Study Location Maps

Maps identifying final roadway and bridge study area segments are presented in the following pages. Accompanying each is a description of typical roadway widths, lane configuration, associated bus routes and defining land use based on preliminary fieldwork. Roadway widths and traffic lanes indicated on each segment include both travel and parking lanes.

The maps also identify critical locations within study segments. These locations provide initial starting points for continued field work and, ultimately, recommendations for on-street innovative and conventional cycling facilitiy implementation (to be contained in a final Task 4 report, *On-Street Cycling Facility Recommendations)*.

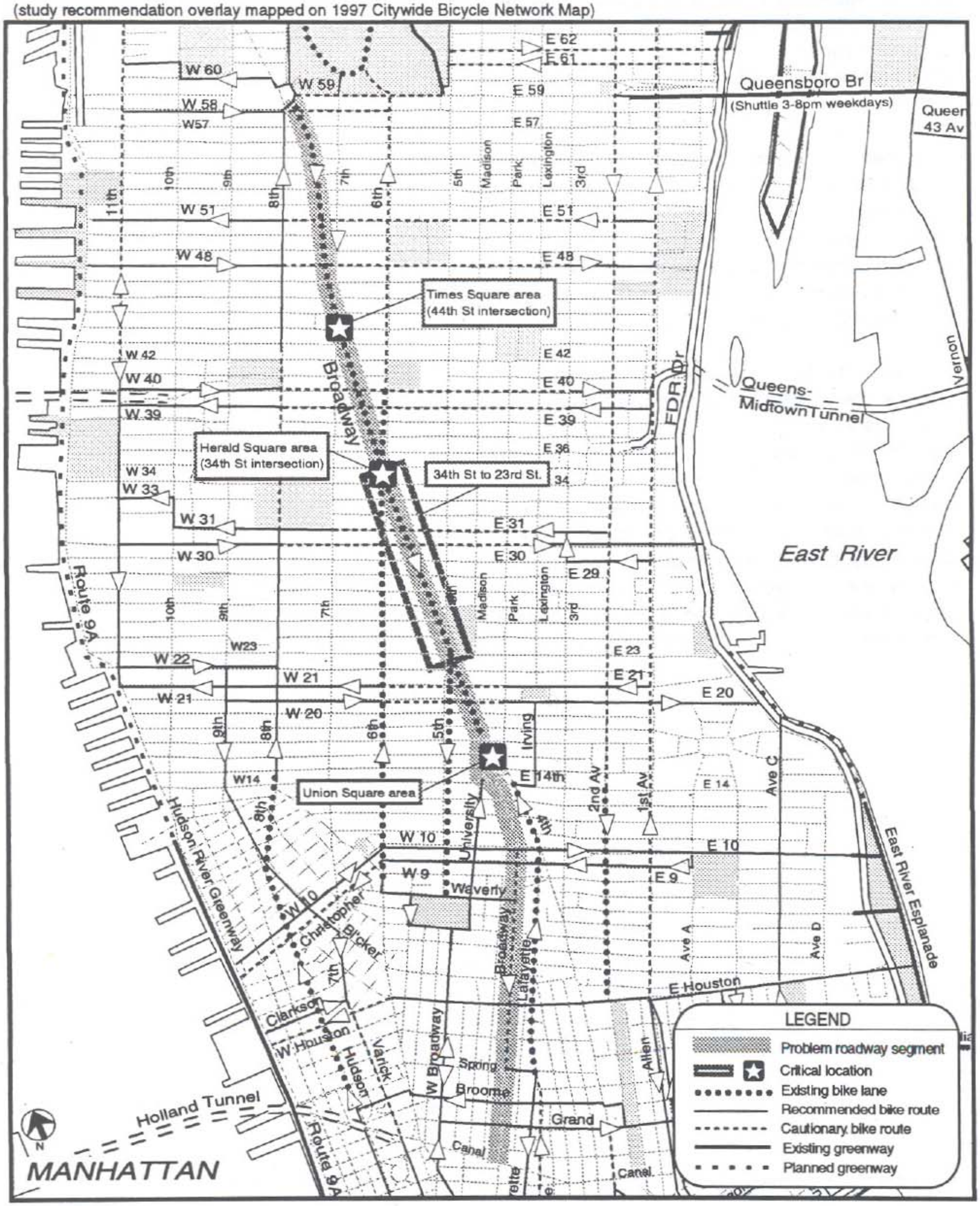
Most importantly, study segments and critical locations are mapped relative to the network of existing and proposed cycling travel routes illustrated in the *New York City Bicycle Master Plan* and Cycling Maps. Implementation recommendations made by this study will seek congruity with the recommended network, identifying opportunities to improve unsafe locations most heavily used by cyclists through the implementation of select innovative on-street facilities profiled in the Task 2 report, *Literature Search*.

Study Segment 1

Broadway: 59th St. to Canal St.

A major southbound arterial, Broadway runs diagonally through Midtown Manhattan creating irregularly shaped intersections, three of which appear as critical locations in this report. Roadway width varies throughout the study segment, from 34 to 60 feet. The M1, 5, 6, 7,10, 27, and 104 bus routes each use portions of this segment, often accommodated by a bus lane. A 4 to 5-foot bicycle lane exists from 59th to 17th

(study recommendation overlay mapped on 1997 Citywide Bicycle Network Map)

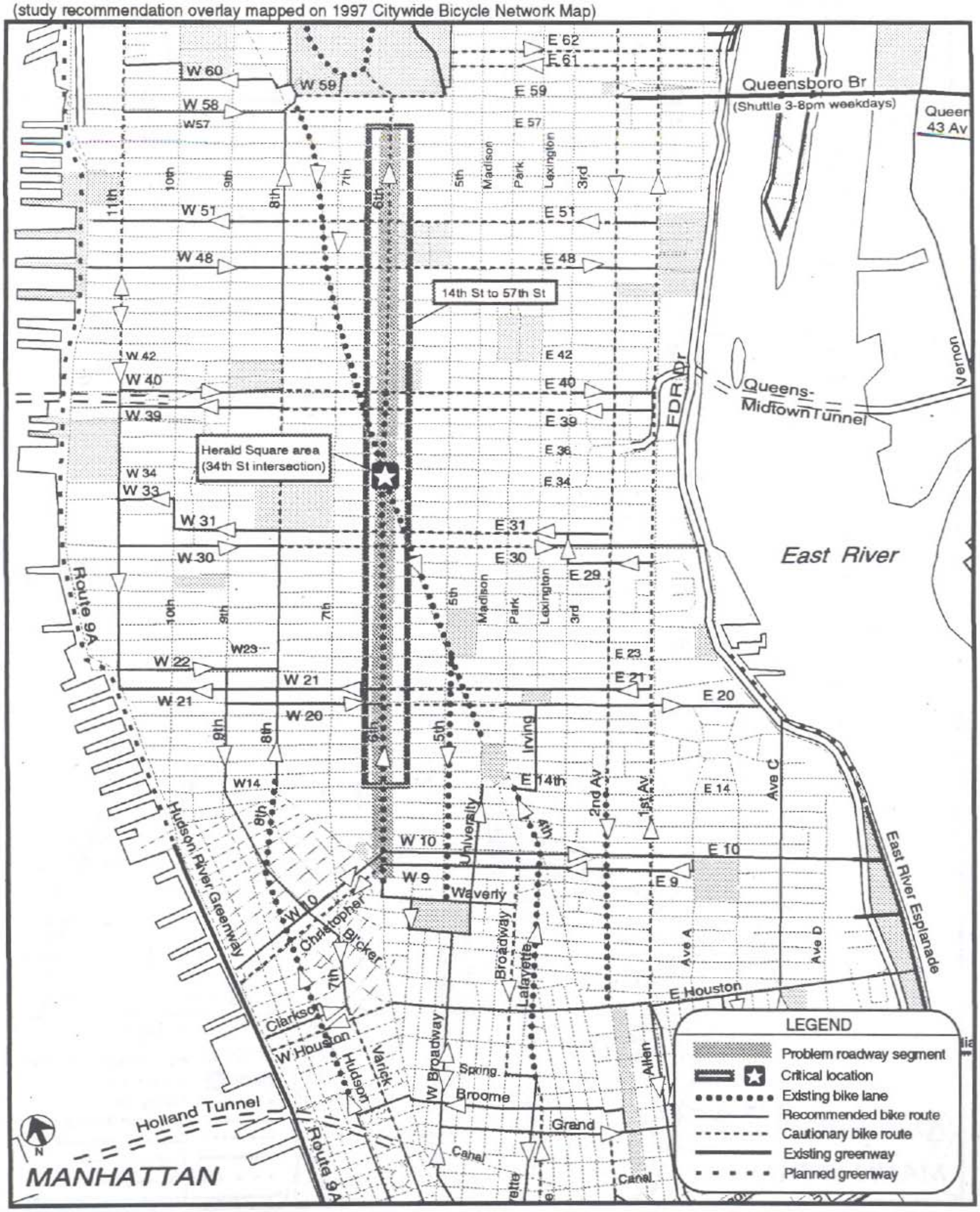


Study Segment 2

Sixth Ave: 9th St. to 59th St.

A major northbound arterial, Sixth Avenue has a roadway width of approximately 65 feet and accommodates seven traffic lanes. An atypical intersection exists where Sixth Ave. intersects Broadway, at 34th St. (Herald Square). The M5, 6, and 7 bus routes run along this study segment. A 4 to 5-foot bicycle lane exists from 9th St. to 40th St.

(study recommendation overlay mapped on 1997 Citywide Bicycle Network Map)

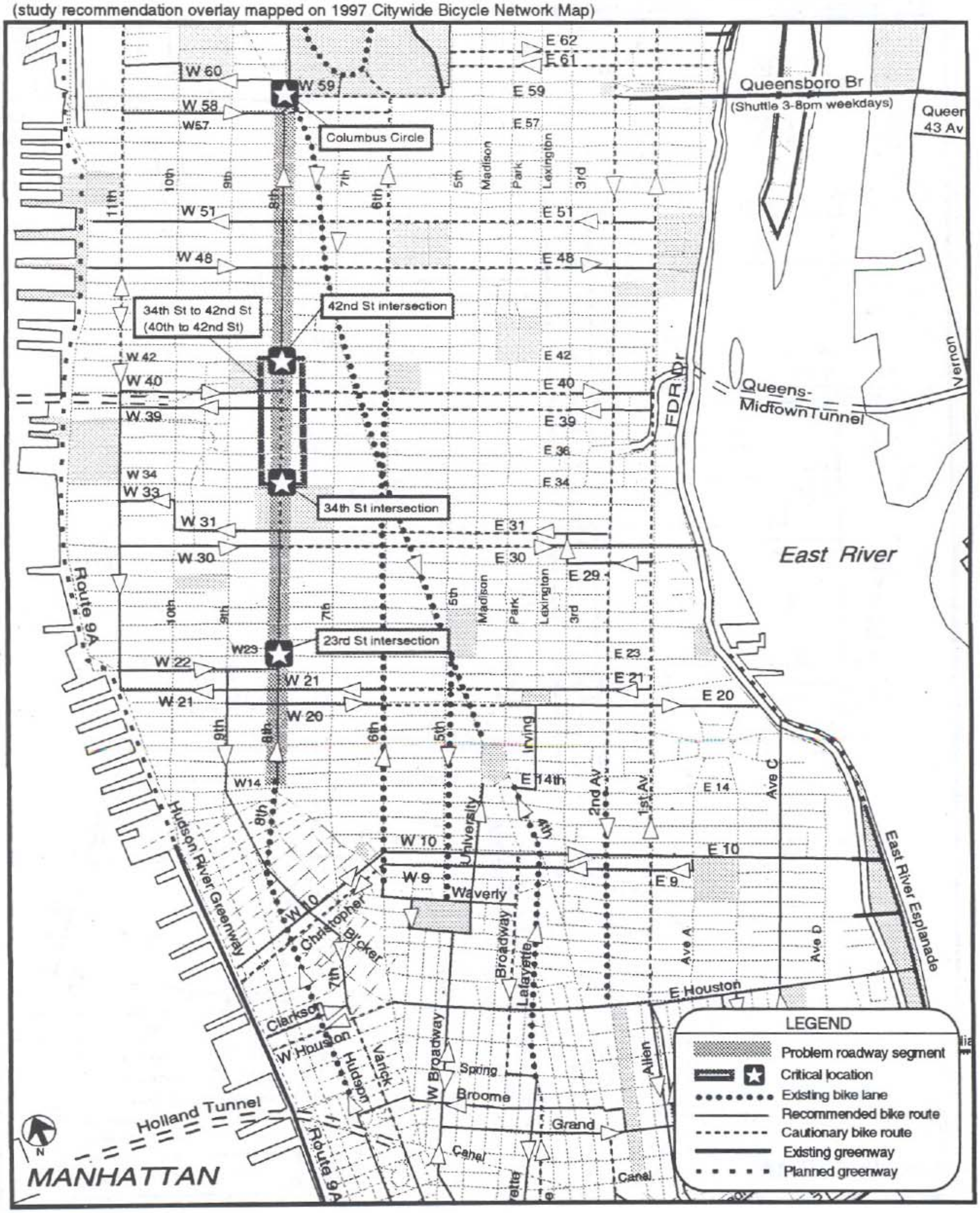


Study Segment 3

Eighth Ave: 14th St. to 59th St.

The Eighth Avenue study segment is typically 70 feet wide, accommodating six traffic lanes. Penn Station and the Port Authority Terminal, major facilities for bus, subway and rail transfer, are located along Eighth Ave. from 31st-33rd Sts. and 40th-42nd Sts., respectively. The M10, 16, 27, and 104 bus routes also use portions of the study segment. A 5 to 6-foot bicycle lane with buffer exists south of 14th St. (continued from the Hudson St. lane).

(study recommendation overlay mapped on 1997 Citywide Bicycle Network Map)

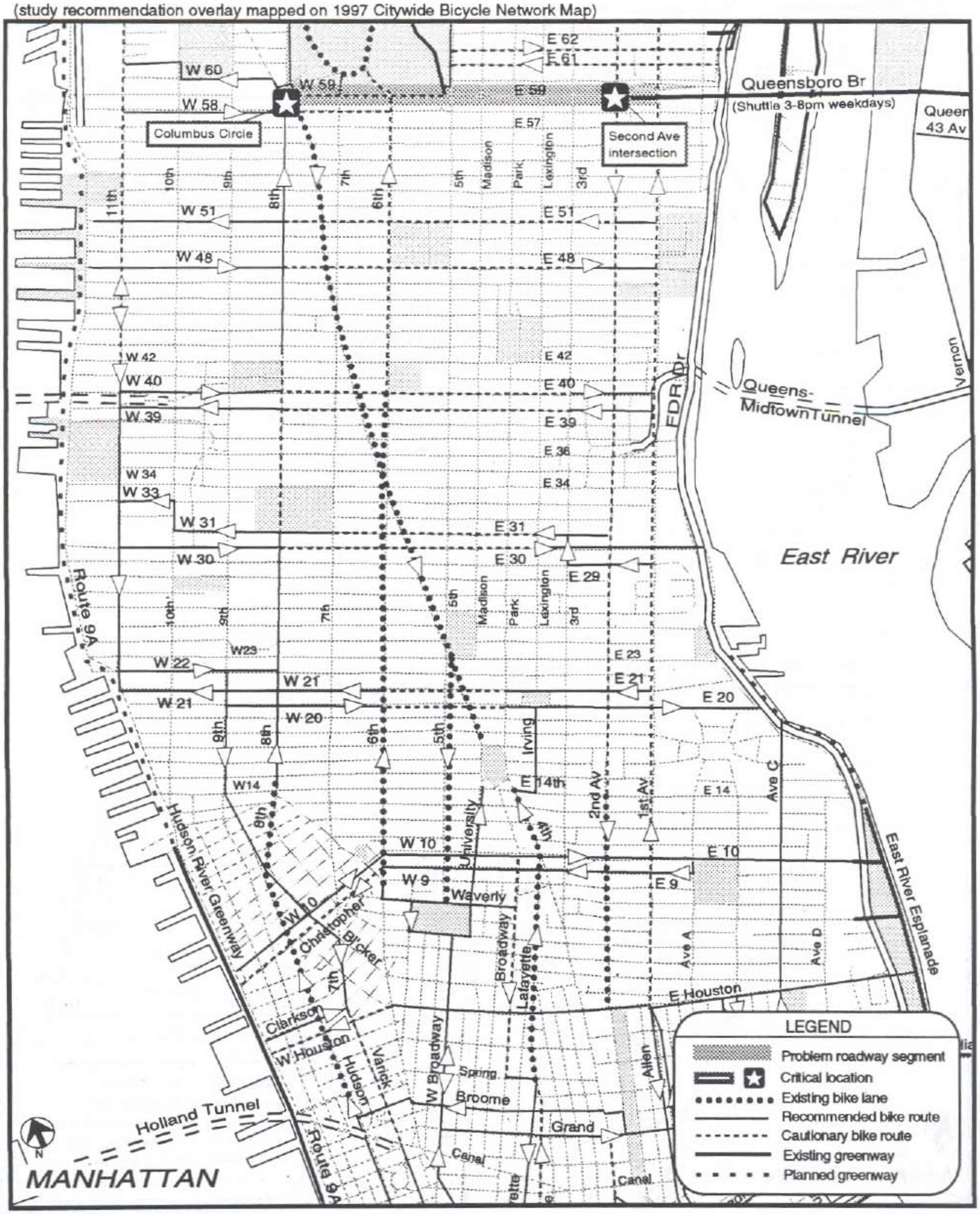


Study Segment 4

59th St: First Ave. to Eighth Ave.

Located at the southern edge of Central Park, 59th Street provides a major east-west connection across Manhattan. Roadway width varies widely throughout the study segment, from 33 feet (at Second Ave.) to 72 feet (at Columbus Circle), accommodating three to six lanes. 59th St. also changes from two-way to east-bound travel only, east of Fifth Ave. The M5, 6, 7 and Q32 bus routes use portions of this segment.

(study recommendation overlay mapped on 1997 Citywide Bicycle Network Map)

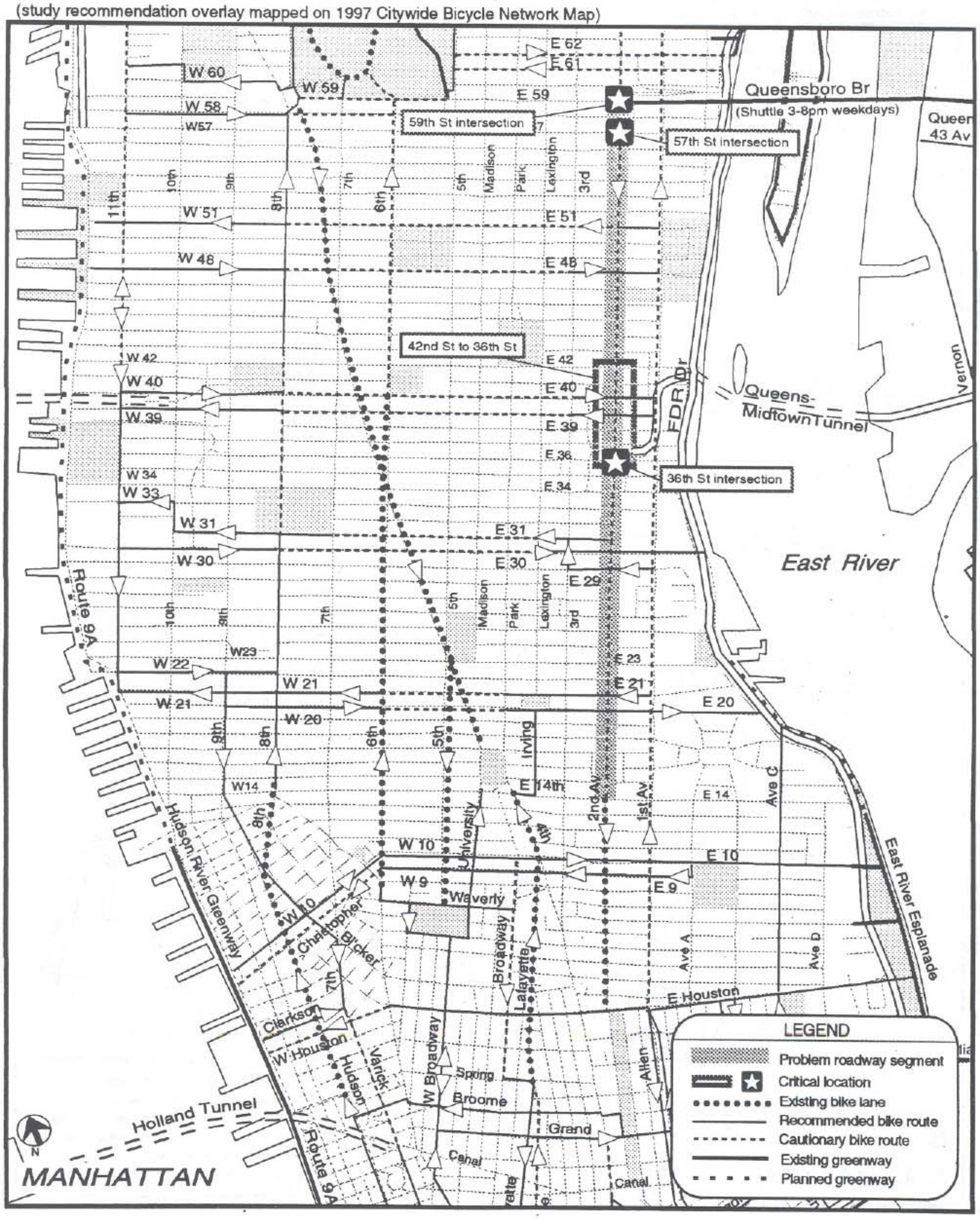


Study Segment 5

Second Ave: 61st St. to 14th St.

A southbound roadway, Second Ave. is approximately 70 feet wide, accommodating seven traffic lanes. Exits and entrances to the Queensboro bridge can be accessed from Second Ave. at 59th St.; access to the Queens-Midtown Tunnel is located at 36th St. The M15, 16, 27 and 50 bus routes use portions of this segment, accommodated by a bus lane. A bicycle lane with buffer exists south of 14th St.

(study recommendation overlay mapped on 1997 Citywide Bicycle Network Map)

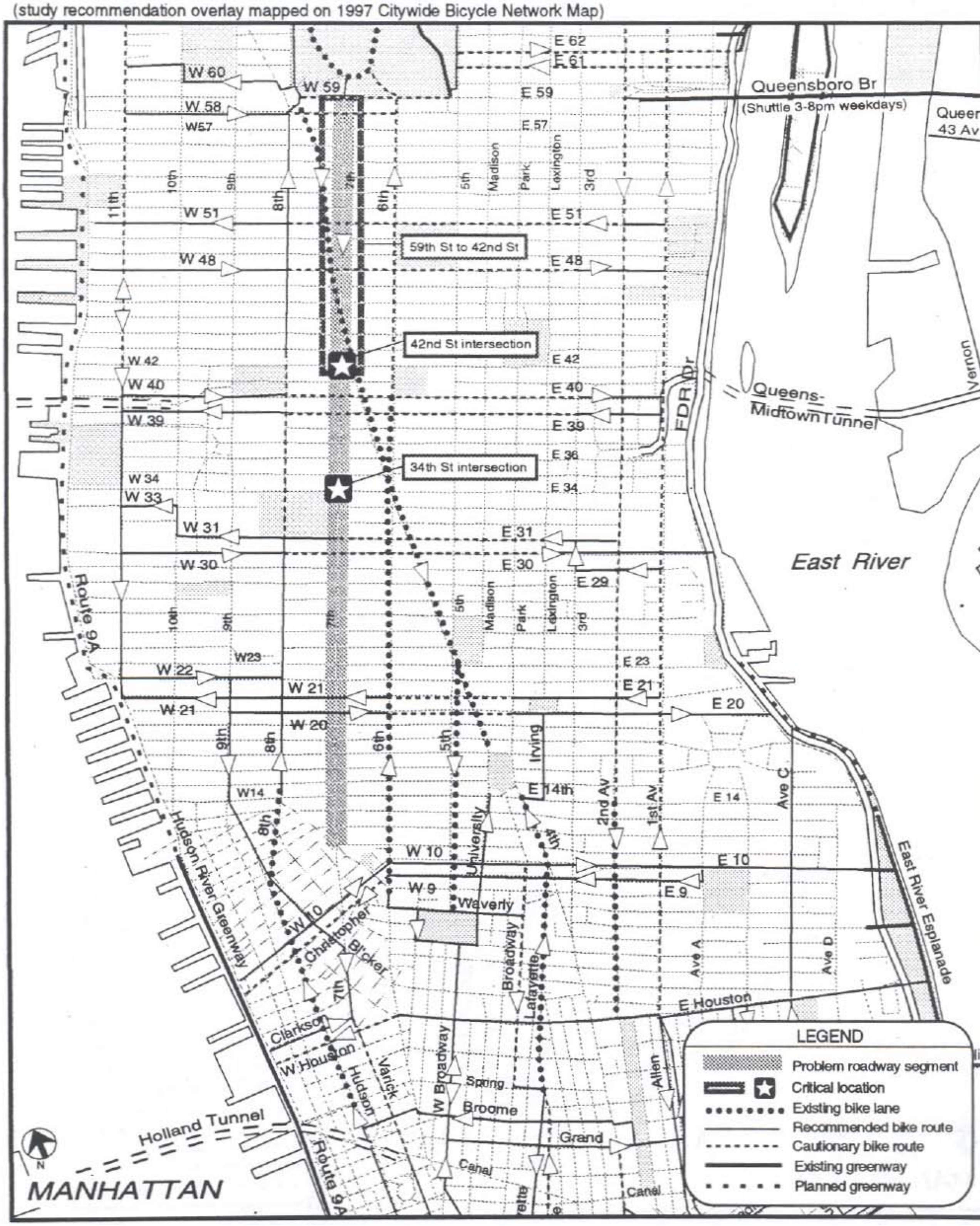


Study Segment 6

Seventh Ave: 59th St. to Greenwich Ave.

A major southbound arterial, Seventh Avenue has a roadway width of approximately 60 feet and accommodates six traffic lanes. An atypical intersection exists where Seventh Ave. intersects Broadway, from 44th St. to 42nd St. (Times Square). Penn Station, a major facility for bus, subway and rail transfer, is located along Seventh Ave. from 31st-33rd Sts. The M5, 6, and 7 bus routes also run along this study segment.

(study recommendation overlay mapped on 1997 Citywide Bicycle Network Map)

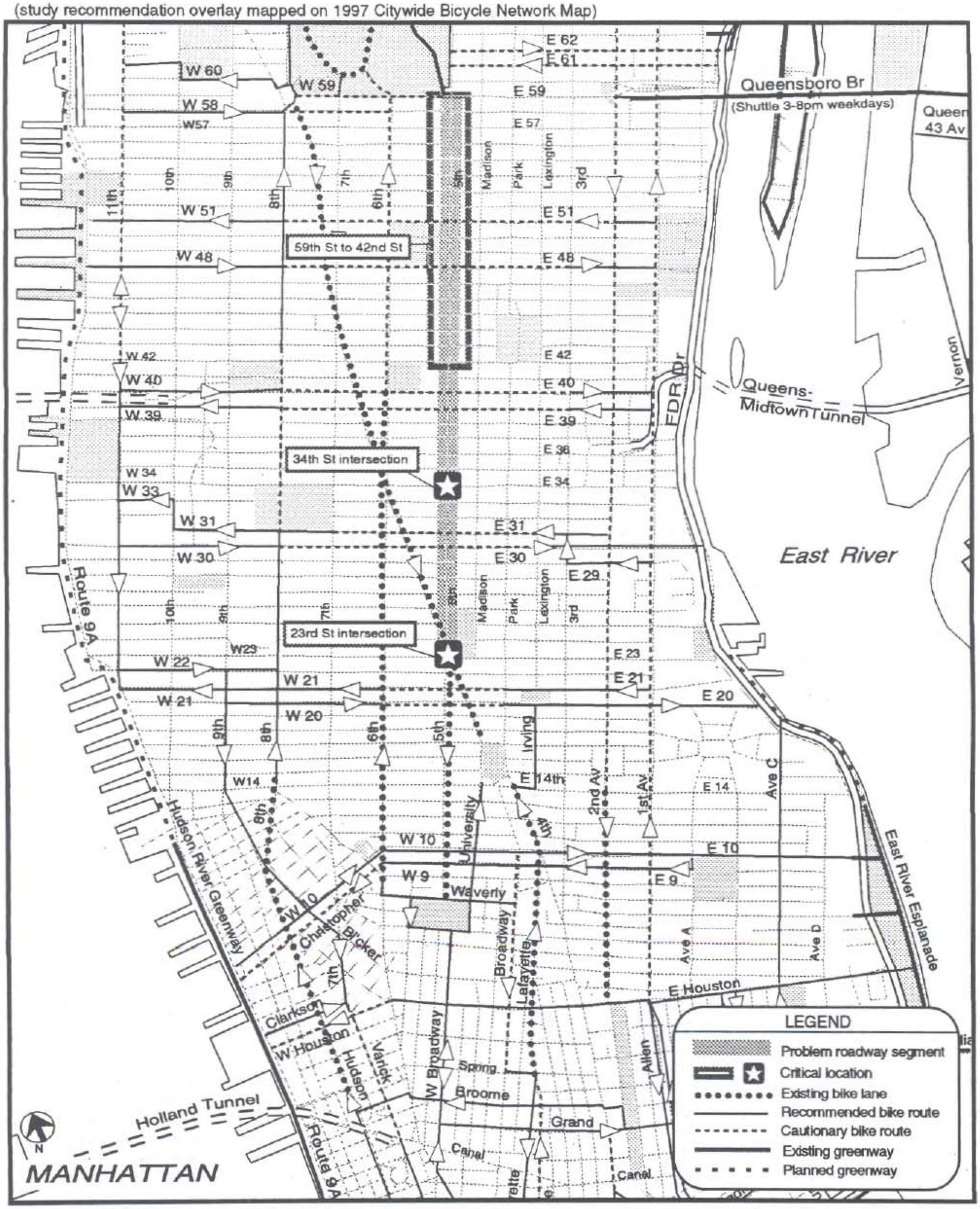


Study Segment 7

Fifth Ave: 59th St. to 23rd St.

Fifth Ave. is approximately 54 feet wide, accommodating five southbound traffic lanes. An atypical intersection exists where Fifth Ave. meets Broadway at 23rd St. (at Madison Square Park). The M1, 2, 3, 4, 5 and Q32 bus routes use portions of this segment, accommodated by a bus lane. A 5-foot bicycle lane exists south of 23rd St.

(study recommendation overlay mapped on 1997 Citywide Bicycle Network Map)

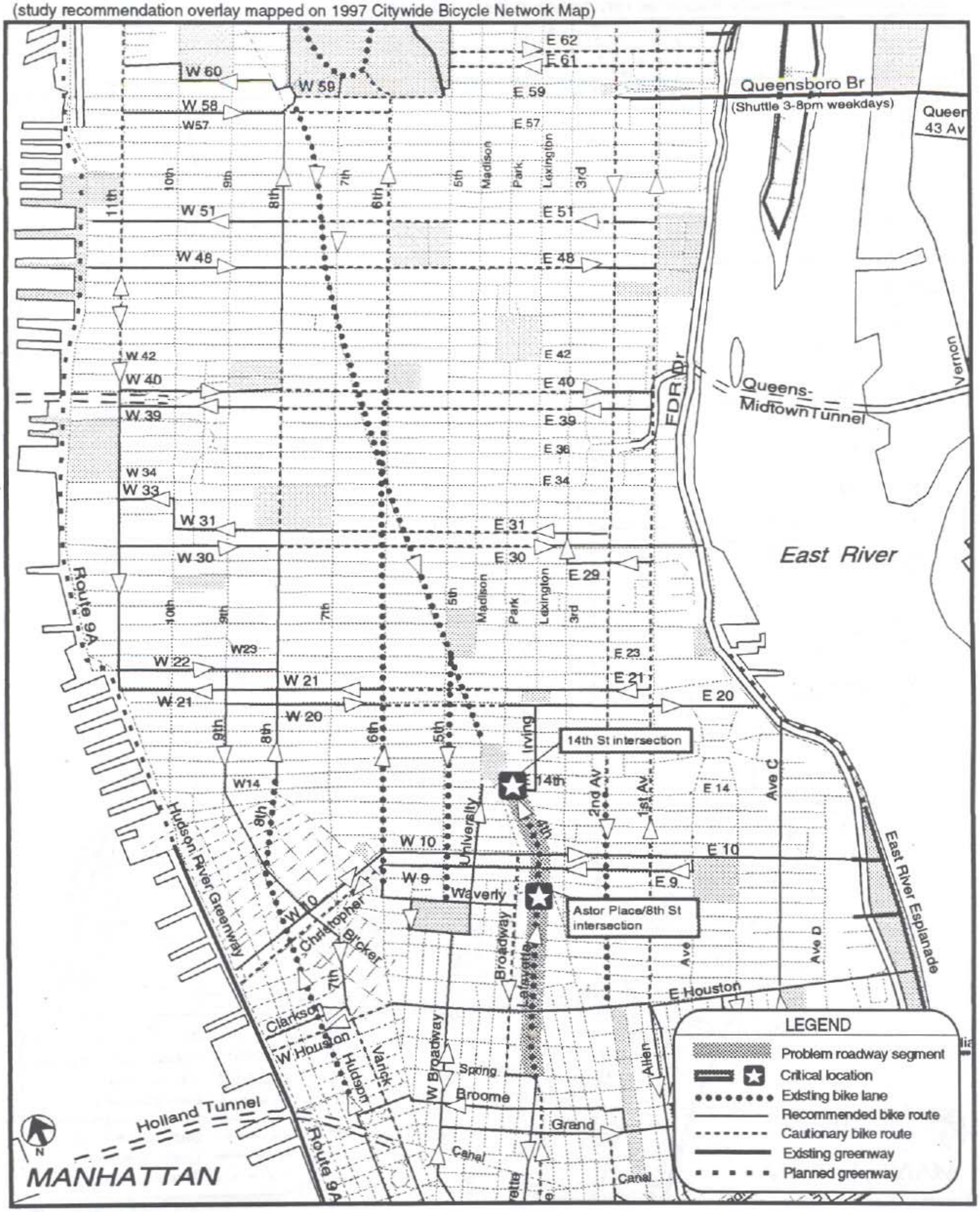


Study Segment 8

Lafayette St/Fourth Ave: Spring St. to 14th St.

Lafayette St. has a roadway width of approximately 46 feet, accommodating five travel lanes, including a six-foot bicycle lane with buffer. An atypical intersection exists at Astor Place/8th St., where Lafayette St. merges into Fourth Ave. The bicycle lane continues on Fourth Ave. until 14th St., where Park Ave begins. The M1 and 2 bus routes run along this study segment; bus overlays occur near the Astor Place/8th St. intersection.

(study recommendation overlay mapped on 1997 Citywide Bicycle Network Map)

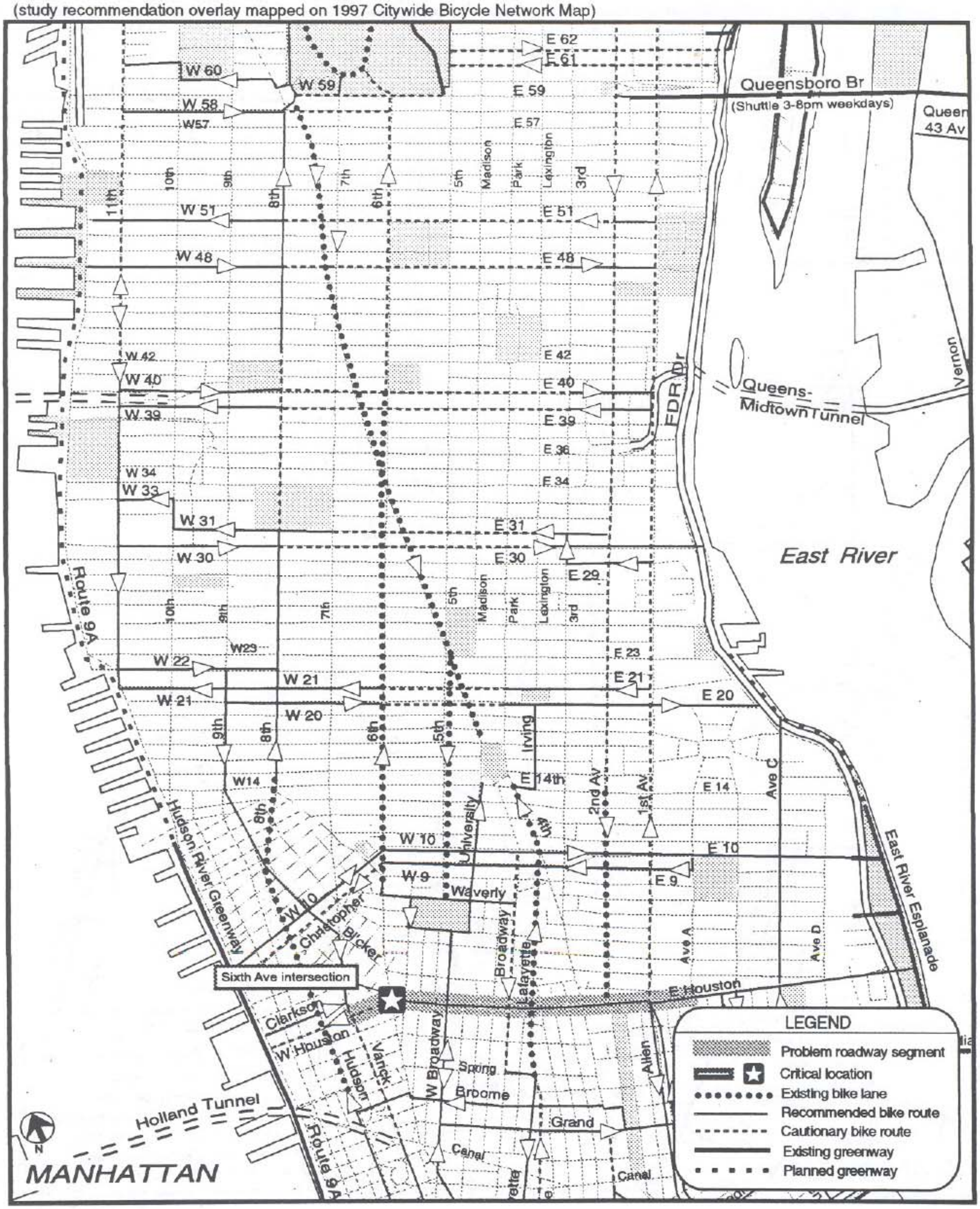


Study Segment 9

Houston St: Avenue A to Seventh Ave.

Houston St. is a major two-way corridor across lower Manhattan. An approximate 92-foot roadway width accommodates eight traffic lanes throughout most of the study segment. West of Sixth Ave. this roadway width narrows, and traffic flows west-bound only. The M5, 15 and 21 bus routes each use portions of this segment.

(study recommendation overlay mapped on 1997 Citywide Bicycle Network Map)

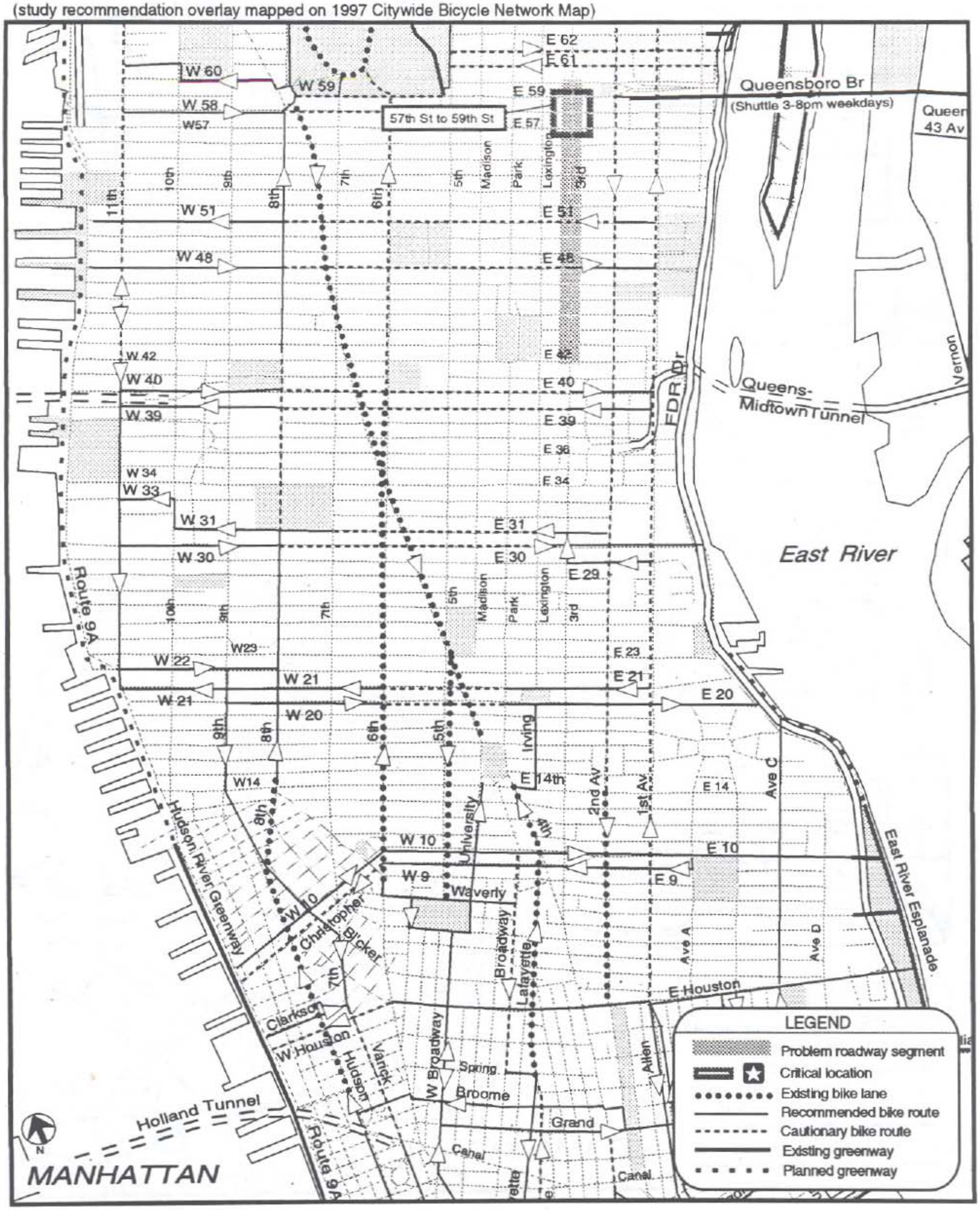


Study Segment 10

Third Ave: 42nd St. to 60th St.

Third Avenue is a northbound arterial throughout the study segment (changing from a two-way roadway north of 14th St.). A roadway width of approximately 70 feet accommodates seven traffic lanes, including a bus lane. The M98, 101, 102 and 103 bus routes run along this study segment.

(study recommendation overlay mapped on 1997 Citywide Bicycle Network Map)

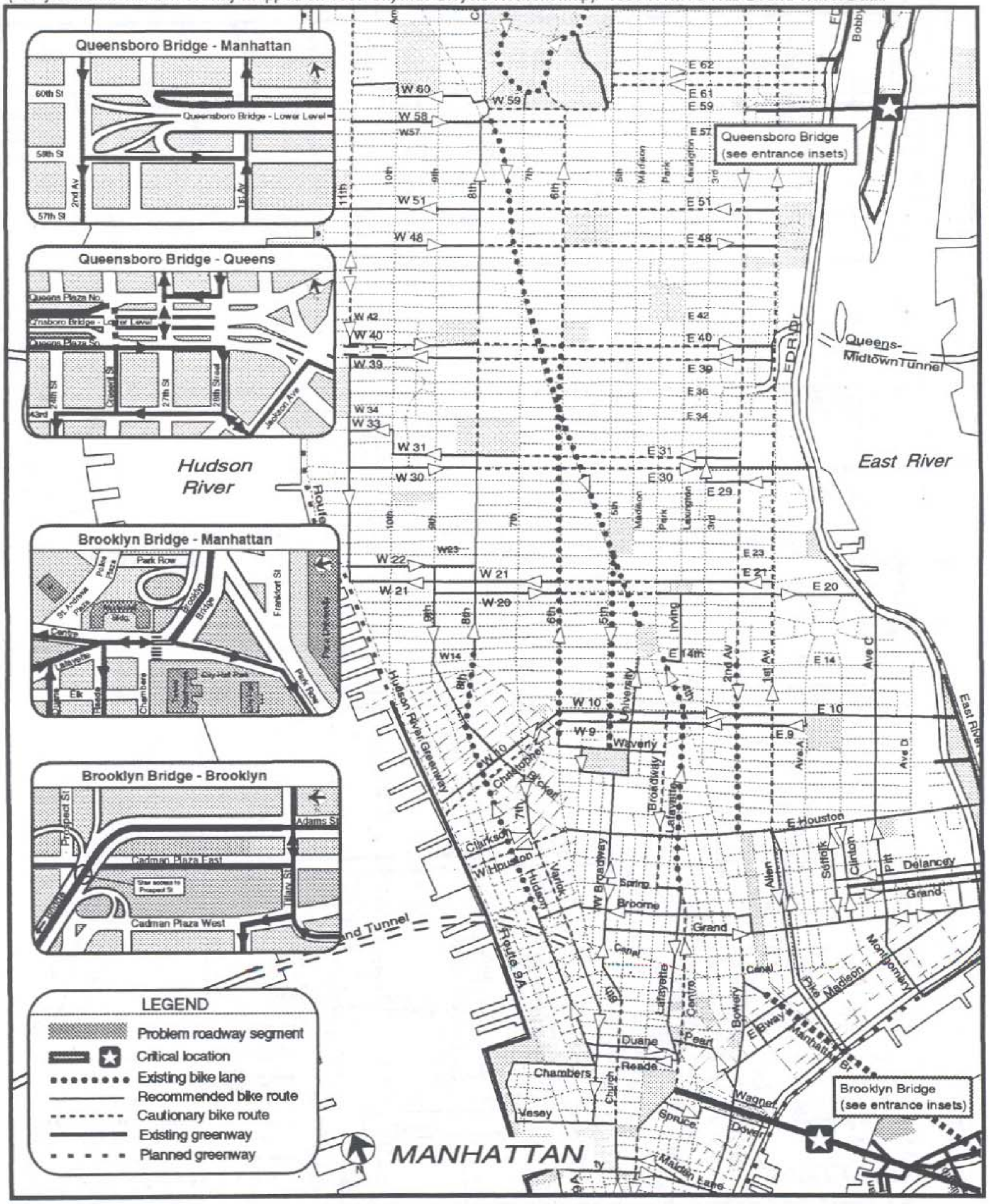


Study Segments 11 and 12

Brooklyn and Queensboro Bridge Entrances

The Brooklyn and Queensboro Bridges are the first and second most frequently used East River Bridge crossings to Manhattan from other boroughs, for both cyclists and motor vehicles.* Both bridges accommodate cyclists and pedestrians on a dedicated path, although the Queensboro Bridge is closed to cyclists from 3-8pm weekdays (van service is provided as an alternative). No bicycle lanes directly access entrances to either bridge.

(study recommendation overlay mapped on 1997 Citywide Bicycle Network Map)/*1996 NYMTC Hub Bound Travel Data.



OVERVIEW:
Recommendations

The following recommendations are divided into three components: Facility Recommendations, Enforcement Recommendations and Data Recommendations. Eight facilities are recommended for test implementation, six of which are linked to specific locations. Enforcement recommendations apply to all existing and proposed on-street cycling facilities. Data recommendations apply to accident data currently available from NYPD, NYDMV and NYSDOT, and document research efforts for this study to assist future planning work.

Prototypical Cycling Facilities

Eight facilities are recommended to improve safe cycling on New York City streets:

- Advanced Stop Box
- Cycle Crossings
- Improved Lane Definition: color/texture
- Improved Lane Definition: physical delineation
- Contra-Flow Bicycle Lane
- Center-Median Bicycle Lane
- Combined Bicycle/Bus Lane
- Centerline Non-Compulsory Lane

The report first describes a typical installation of each facility, then lists potential locations for testing in New York City. A specific pilot test is described for six facilities. The location of pilot tests was informed by “critical locations” listed in the *Task 3: Existing Conditions* report; however, recommendations in this document are based *first* on the selection of a facility type appropriate to New York City, and *second* on the selection of a location for successful implementation.

***Facility Pilot Test Locations*:**

Advanced Stop Box:
Broadway at 17th Street

Cycle Crossings:
Lafayette Street/Fourth Avenue bicycle lane, at Astor Place.

Improved Lane Definition: color/texture
Fifth Avenue bicycle lane, 23rd to 7th Sts.

Improved Lane Definition: physical delineation
Broadway to Fifth Ave, 24th to 23rd Sts.

Contra-Flow Bicycle Lane:
West Broadway, Grand to Walker Streets

Center-Median Bicycle Lane:
17th Street, Broadway to Park Avenue

Associated Recommendations

Consistent enforcement of on-street cycling facilities is as important to the success of implementation as proper engineering and placement. A series of enforcement recommendations are described, with emphasis on a “zero tolerance” intiative -- a targeted approach to ticketing motor vehicles unlawfully occupying bicycle lanes. Other recommendations include revisions to the parking summons form, use of a “public awareness summons form” to regularly distribute safe cycling information and changes to the traffic code.

Finally, a description of existing bicycle-safety data sources is provided, as well as recommendations to facilitate access to location-specific cycling accident information. Systematic identification, collection and analysis of cycling-related safety data is critical to the successful evaluation of protoype facilities recommended in this report, and future implementation efforts.

FACILITY RECOMMENDATIONS

Eight facilities are recommended for prototype testing to improve safety for on-street cyclists, based on research contained in the Appendix E*: Literature Review*:

- ***Advanced Stop Box***
- ***Cycle Crossings***
- ***Improved Lane Definition: color/texture***
- ***Improved Lane Definition: physical delineation***
- ***Contra-Flow Bicycle Lane***
- ***Center-Median Bicycle Lane***
- ***Combined Bicycle/Bus Lane***
- ***Centerline Non-Compulsory Lane***

Recommendations are based first on the selection of facility type, and second on the selection of appropriate locations for successful implementation. Potential locations are listed for each facility type; for facilities, a recommended pilot test location is also described. Both potential and pilot test locations generally target unsafe areas identified in the *Task 3 Existing Conditions Report*. However, several recommendations encompass other areas -- particularly where improved roadway conditions are likely to facilitate route connections between segments of the City's proposed bicycle network (*see New York City Bicycle Master Plan*).

Prototype installation of some recommended facilities will require further capacity analysis (HCS described in *Task 3*) to determine feasibility. Potential locations are listed in addition to "pilot test" locations in the event that a location is deemed infeasible through HCS analysis.

In some cases, several prototypical facilities are recommended for use simultaneously. For example, techniques to improve conventional lane definition are recommended in conjuntion with improved cycle crossings; flexible bollards (or other physical separators) are recommended in conjunction with center-median and contra-flow bicycle lanes.

Finally, successful evaluation of each prototype facility requires site-specific analysis *before* and *after* implementation. Analysis should be conducted by the implementing agency.

To help analysis efforts, City agencies are encouraged to foster partnerships with research organizations, following an example set by the Florida State Department of Transportation (FLDOT), and the cities of Portland and Eugene, Oregon. Each recently partnered with the University of North Carolina (UNC) Highway Safety Research Center (HSRC), studying bikeway safety issues and techniques around the country (discussed in Task 2 *Literature Review*). HSRC's research efforts are currently funded through a grant by the Federal Highway Administration.

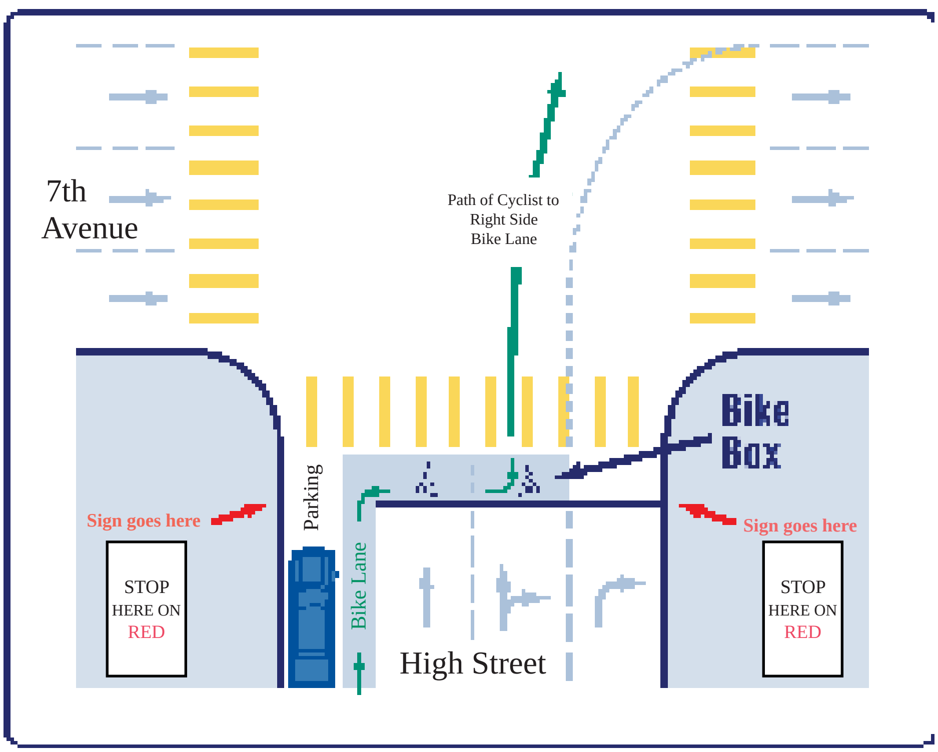
Ultimately, the following pilot tests are intended to provide starting points for continued future implementation of innovative cycling facilities -- provided that they can be shown to improve safey for cyclists in accord with other roadway users.

Advanced Stop Box: *Nearside approach*

Description

Advanced stop boxes are placed in front of motor vehicles to allow cyclists to move ahead of traffic at signalized intersections. At a red traffic signal, advanced stop boxes allow cyclists to make safe lane changes at an intersection (across a roadway), make turning movements ahead of motor vehicles, and avoid conflicts with turning vehicles. These facilities also provide additional queuing space at high-volume intersections. (Note: stop boxes do not affect traffic movements at a green signal.)

Advanced stop boxes are typically six to ten feet wide, pigmented and stenciled, with eight-inch wide edge line striping. The boxes should span the width of the roadway, behind and adjacent to striped crosswalks, to limit conflicts with crossing pedestrians. The box should include a cycle lane approach located either (1) nearside (near a curb) or (2) as a center lane approach (see Appendix E: *Literature Review* for more details).



Bicycle box design at High Street, Eugene OR:

11-foot crosswalk
9-foot bicycle box
8-foot parking lane
5-foot bicycle lane
11/10/11-foot travel lanes

Source: City of Eugene web site

Potential Test Locations:

Lafayette Street at Houston Street
Fourth Avenue at 14th Street
Broadway at 17th Street
Sixth Avenue at 42nd Street
(with extension of the bicycle lane from 40th Street).

Pilot Test 1: *Advanced Stop Box (nearside approach)* Broadway at 17th Street

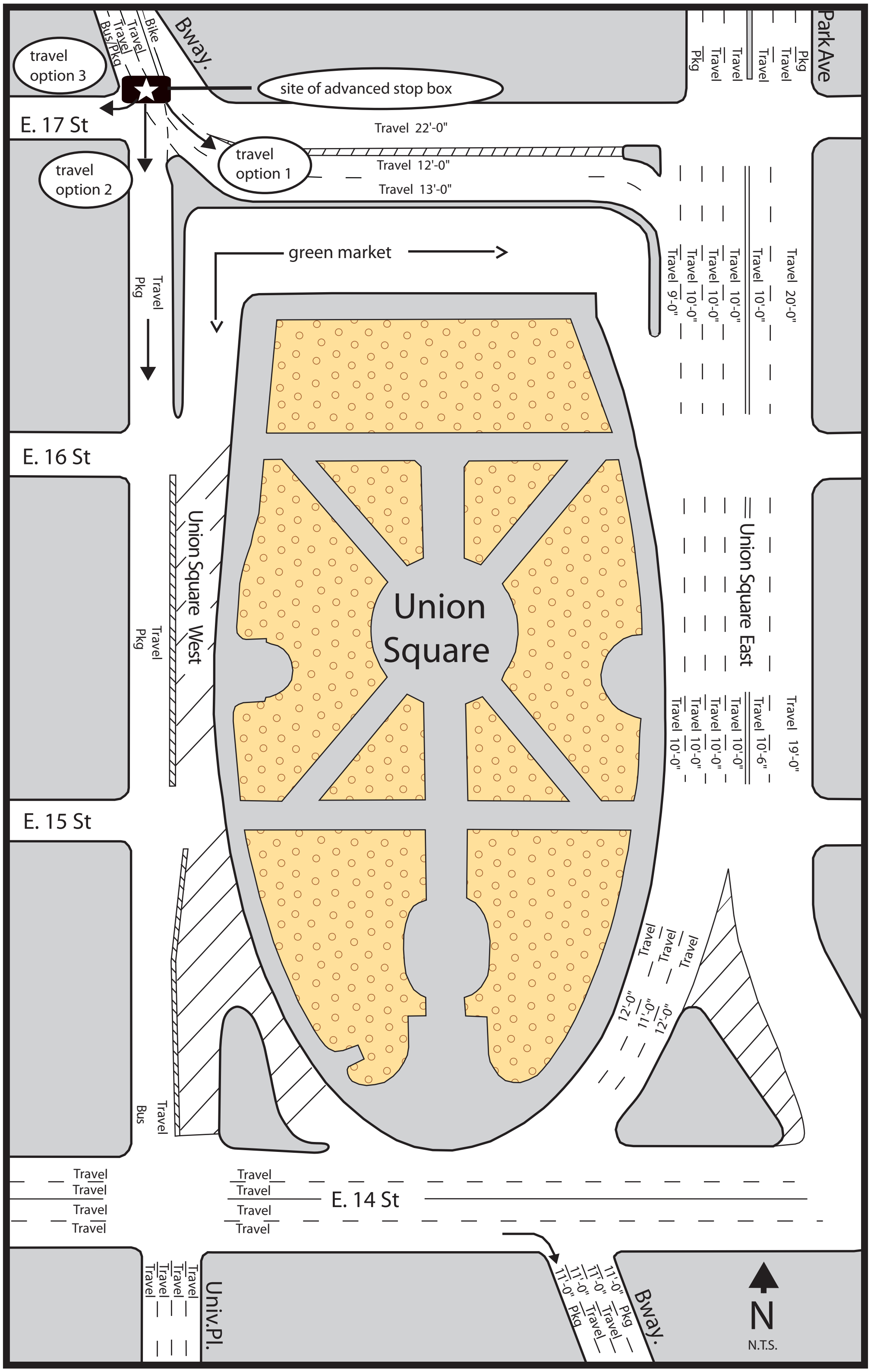
A cyclist stopped with traffic on Broadway, at 17th Street intersection. The 2.6-mile bicycle lane on Broadway begins at 59th Street and ends at this location. The existing crosswalk is approximately 18 feet wide.

The southbound Broadway bicycle lane ends at 17th Street (the northwest corner of Union Square), with no further provision to accommodate cyclists. From this point, motor vehicles may proceed in one of three directions (see diagram): (1) traffic making a left turn onto east-bound 17th Street (center and east-side lanes);(2) traffic continuing southbound on Union Square West, a low-volume single lane roadway with parking (west-side and center lanes); or (3) traffic turning right to travel westbound on 17th Street towards Fifth Avenue.

Implementation of an advanced stop box would allow cyclists to move safely across motor vehicle traffic stopped at a red light, to access Union Square West to continue traveling in a southbound direction (Travel Option 2) or to turn right and head west on 17th Street (Travel Option 3). The stop box would have no affect when the traffic signal is green -- cyclists wishing to access Union Square West would either need to wait for the red signal to use the stop box, attempt to change lanes while riding during breaks in traffic before the intersection, or wait and cross with pedestrians.

A stop box at this location would be most helpful for less experienced cyclists unwilling to cross multiple lanes while riding in traffic. The box would also help keep cyclists clear of pedestrian traffic. Pedestrian volumes at this intersection are heavy,[22] particularly on days during which the “green market” located along the north and west sides of Union Square Park is in operation. Additionally, a well-used pedestrian corridor is striped along the entire west side of the park, encouraging frequent pedestrian crossings on Union Square West from 17th to 14th Streets. Accommodating cycle travel southbound ahead of vehicle traffic should help reduce conflicts between pedestrians and cyclists at this busy intersection, and also reinforce a clear a right-of-way for cyclists on Union Square West.

[22] *Pedestrian volumes and crosswalk levels of service (LOS) for this intersection are cited in the 14th Street Transportation Study, Department of City Planning, 1998.*

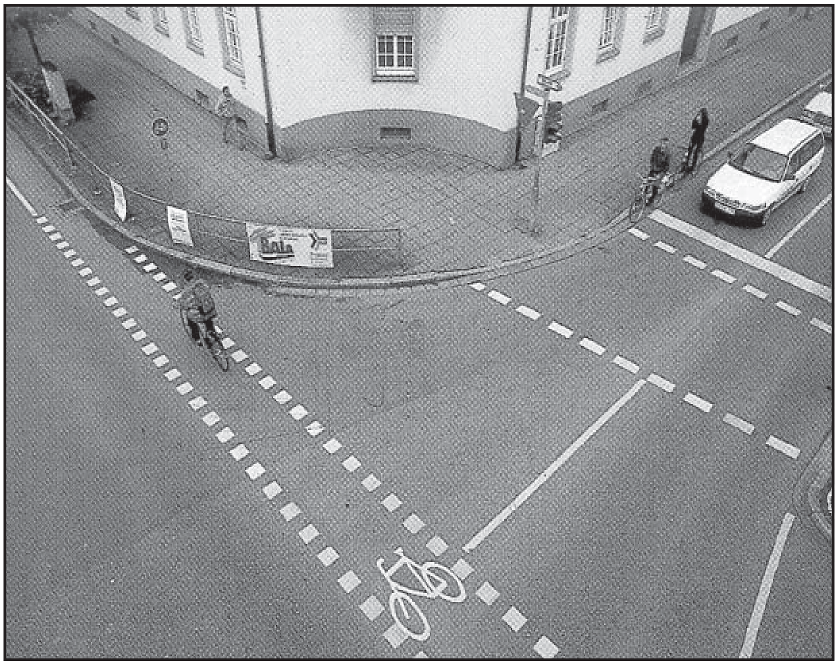


Plan view at Union Square. Location of proposed advanced stop box shown on Broadway, at (north of) 17th Street intersection. Travel Option 1 shows the route of cyclists traveling with traffic onto eastbound 17th Street, where no dedicated cycling facility currently exists (see p.18); Travel Options 2 and 3 show the route of cyclists continuing southbound on Union Square West or westbound on 17th Street (respectively). An advanced stop box would facilitate travel for cyclists following route 2 or 3.

Cycle Crossings: ***Pigmented, Pegga-tracked crossing; Bollards with accompanying signage***

Description

Pigmentation, pegga-tracked (dashed) markings and changes in pavement material (e.g. pavers, concrete) can be used to extend a cycle lane through an intersection, to provide continuity for cyclists and to heighten driver and pedestrian awareness of cyclists in an intersection[23] (especially for turning vehicles). At high-volume pedestrian intersections, bollards placed at the curb edge (with accompanying signage) can also alert pedestrians to the presence of cyclists passing through a crosswalk in a marked bicycle lane.



Left: Pegga-tracked (broken line) cycle crossing in Freiburg (Germany). Above: Yellow bollard with attached blue sign denotes a bicycle lane traveling through a crosswalk. Source: Cities Make Room for Cyclists.

Potential Test Locations:

Cycle crossing markings are recommended at intersections throughout the on-street bicycle network. Additionally, bollards (with accompanying signage) are recommended at high-volume pedestrian crossings. High-volume pedestrian areas (Lafayette St. bicycle lane at Astor Place), and wide or irregularly shaped intersections (Madison Square, Herald Square) should be targeted for priority implementation.

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[23] *Note: Implementation of pigmented pavement and/or pavers generally requires an additional expense, and is not part of the normal implementation process of roadway (re)construction. See also Pilot Test 3, p. 9, pigmented bicycle lane.*

Pilot Test 2: Pigmented, pegga tracked cycle crossing, with bollards Lafayette Street/Fourth Avenue bicycle lane, at Astor Place

Northbound view from the bicycle lane of pedestrians waiting on and off the curb to cross Lafayette Street, at Eighth Street. The bicycle lane passes close to the curb through this area and is often blocked by pedestrians.

Cycle crossing improvements are recommended on Lafayette Street/Fourth Avenue, at the Astor Place and 8th Street (consecutive, south to north) intersections where cycle paths are frequently blocked by pedestrians standing on and off the curb. Existing travel lane widths are wide and vary throughout this roadway segment as it curves northbound from Lafayette to Fourth Avenue (lanes listed west to east):

Approaching Astor Place intersection:		*South side; 8th Street intersection: (pictured above)*		*North side; 8th Street intersection: (pictured above)*	
parking	*9'*	*buffer*	*5'*		
bicycle lane	*5'*	*bicycle lane*	*6'*	*buffer*	*3'*
buffer	*6.5'*	*buffer*	*5.5'*	*bicycle lane*	*5'*
travel lane	*11.5'*	*travel lane*	*12.8'*	*travel lane*	*14.5'*
travel lane	*12'*	*travel lane*	*12.8'*	*travel lane*	*12'*
parking/bus	*11.5'*	*buffer*	*14.5'*	*buffer*	*14.5'*
TOTAL	*55.5'*	*TOTAL*	*56.6'*	*TOTAL*	*49'*

Specific recommendations for 8th Street and Astor Place intersections include:

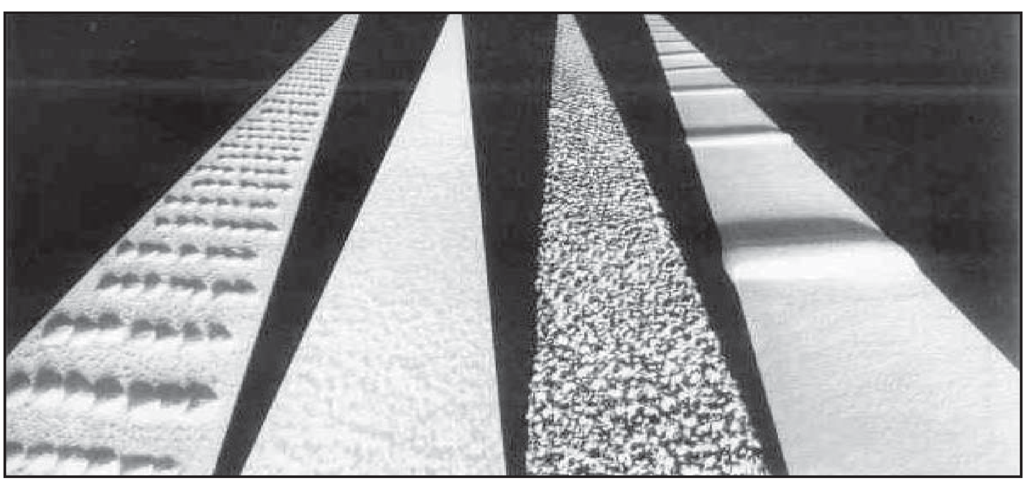
(1) Blue pigmented and pegga-tracked extensions of the bicycle lane through currently unmarked areas (consistent with pigmentation recommended in Pilot Test 3, p. 9);
(2) Bollards with accompanying signage placed on the sidewalk at the curbline at the northwest corner of the 8th Street intersection, to identify the presence of a bicycle lane to pedestrians: "Bike lane, stand clear" (see bollard/sign example on previous page);
(3) An eastward shift of existing lanes (or a narrowing of existing travel lanes or buffers) to create a minimum 5 ft buffer between the curb and bicycle lane at the 8th St intersection, northwest corner (pictured above). To maintain proper alignment, lanes south of this intersection may need to be shifted. Pegga-track markings should be kept to visually connect new alignments.

Improved Lane Definition: Color/Texture
Pigmented lanes, Profiled markings

Description

Improved marking techniques can be used to more clearly identify bicycle lanes for both cyclists and motor vehicles, particularly in locations where vehicles regularly drive, stand or park in the lanes. Blue-colored pigmented lanes are recommended, based on research and successful testing and implementation of these lanes by the City of Portland. Profiled markings should be slightly raised to attract the attention of drivers, but suitable for cyclists entering and exiting a lane.

Blue pigmented bicycle lane in Portland, OR, at the east end of the Broadway Bridge. Portland's efforts to reduce conflicts between cyclists and motorists using pigmented lanes are based on research of European techniques. Preliminary evaluation of the lanes has found them to be effective. Source: City of Portland Bicycle web site.



Examples of profiled markings manufactured by Agomer GmbH. Additional manufacturers of profiled markings are listed at the end of this document.

Potential Test Locations:
Pigmented cycle lanes are recommended throughout the on-street bicycle network; profiled marking is recommended on the Broadway, Fifth and Sixth Avenue bicycle lanes.

Pilot Test 3: Pigmented bicycle lane, with profiled marking
Fifth Avenue bicycle lane, 23rd Street to 7th Street (Washington Square North)

Existing pavement markings for bicycle lanes consist solely of white, reflective thermoplastic, which wears quickly on high-volume roadways and makes it difficult for motorists to identify exclusive right-of-ways for cyclists. Worn pavement markings can also undermine police officers' attempts to enforce clear bicycle lanes to motorists.

A recommendation for testing of improved lane markings on Fifth Avenue has two components:

(1) *Blue pigmentation of the existing bicycle lane, with identifying signage (see photo previous page).* To speed implementation, pigmentation should occur initially as a paint overlay, or as colored concrete if reconstruction of the roadway occurs. Pigmentation will help *visually* define the presence of the bicycle lane, distinguishing its striping from other roadway markings. Pigmented lanes are recommended in conjuction with pigmented intersection crossings described in Pilot Test 2 (p. 7). As cited in the *Task 3: Existing Conditions* report, a red pigmented lane was recently installed on Adams Street, in Brooklyn. No formal evaluation of this lane has been performed.

(2) *Profiled marking to define the existing bicycle lane*. The use of profiled marking along the bicycle lane will help *physically* define its presence to motor vehicles; raised texture should offer enough to be felt by motorists travelling at both high and low speeds, yet be slight enough for cyclists to move in and out of the lane without difficulty. Several examples of profiled markings are shown on the previous page. In addition, the Arizona Department of Transportation (ADOT) has been testing profile thermoplasic as a pavement marking system. From ADOT's experience, profiled markings have proven to be durable, and perform as a longitudinal rumble strip for both edge and lane lines. Other, less expensive options which could be investigated include ground-in or rolled-in rumble strips.

Temporary (simulated) tests of profiled marking on Fifth Avenue could also be performed using "Quick Stripe," or a similar installation. Rubber panels are folded onto the pavement and can be easily installed or removed, before a more permanent striping test is implemented.

A cyclist on the Fifth Avenue bicycle lane, near 21st Street.

Improved Lane Definition: Physical delineation
Rubberized curbs, Beveled-edge reflectors, Flexible bollards

Description

Raised markings physically define cycle travel lane apart from motor vehicle travel lanes. Installation must ensure that raised curbs and reflectors are not able to deflect a bicycle wheel, causing cyclists to lose control. Equipment, and size and spacing of marking must allow vehicles to access curbside parking (where existing). In addition, implementation of raised markings requires coordination with snow removal operations.

In Paris (pictured right), rubberized curbs and flexible bollards have been used to define 33 km (of 101 km) of on-street lanes (1997 implementation status). This design is mainly used when no parking exists along the curbside. Preliminary testing has found this treatment to significantly improve on-street safety for cyclists. However, problems associated with these lanes include parked or stopped vehicles in locations where parking demands are high, and pedestrians who stand in the cycle lane at intersections waiting to cross the roadway.

As pictured right, the curbs are 5 cm high, 0.12 m (0.4 feet) wide and anchored into the street pavement with 12 cm deep bolts (pavement in Paris has a superficial bituminous layer of 5 cm and a 20 cm thick layer of concrete; the 12 cm depth was chosen to keep the pavement water tight). The curbs are spaced approximately 3 m (10 feet) apart.

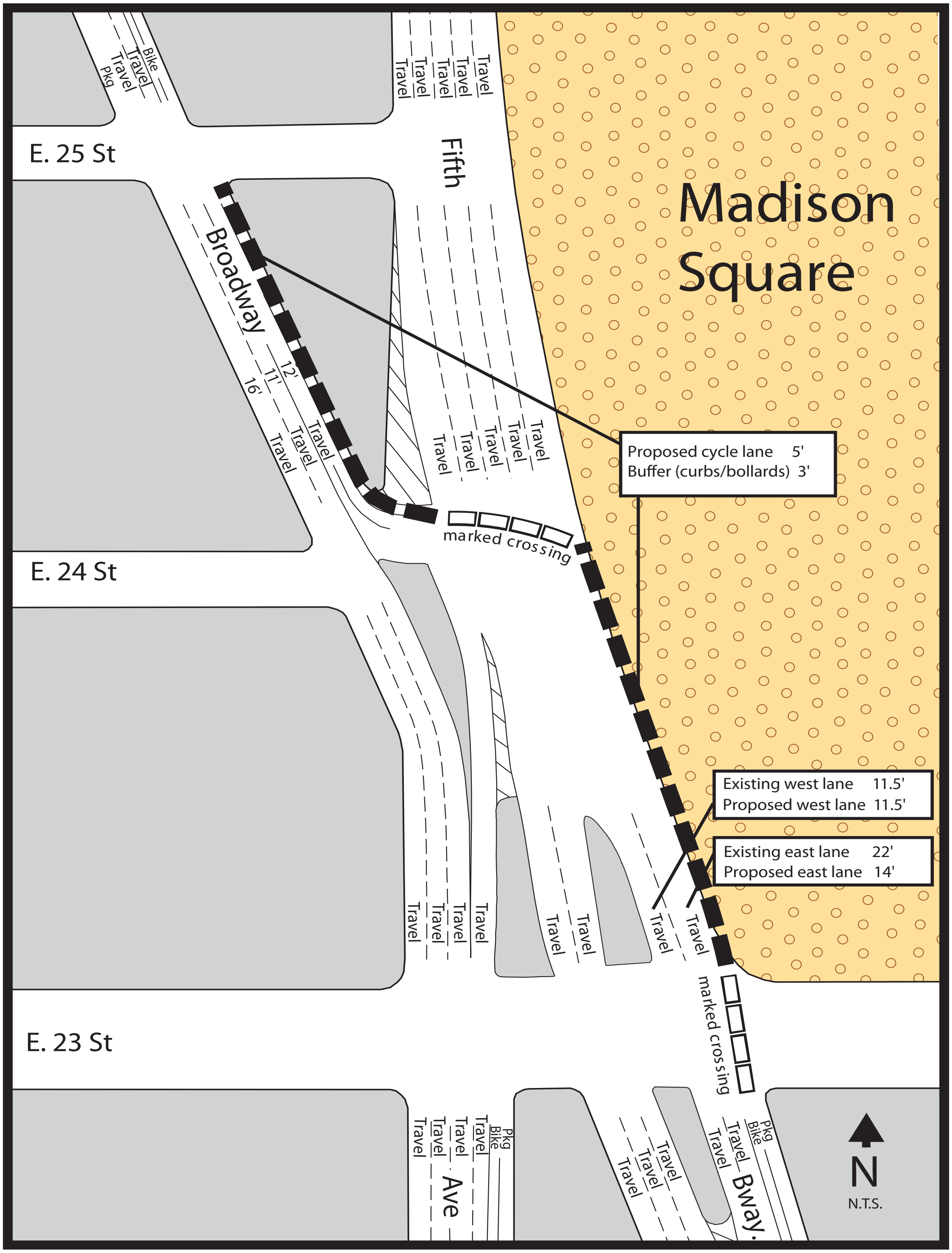
Flexible bollards are approximately 75 cm (30 inches) high with a 20 cm (8 inches) diameter, placed at the ends of the lane.

Rubberized curbs (with reflective strips) and flexible bollards used on a bike lane in Paris.

Potential Test Locations: High-volume bicycle lanes, including Broadway, Fifth and Sixth Avenue bicycle lanes.

Adam Clayton Powell Blvd.

Pilot Test 4: Bicycle lane with rubberized curbs and flexible bollards Broadway to Fifth Avenue, from 25th to 23rd Streets



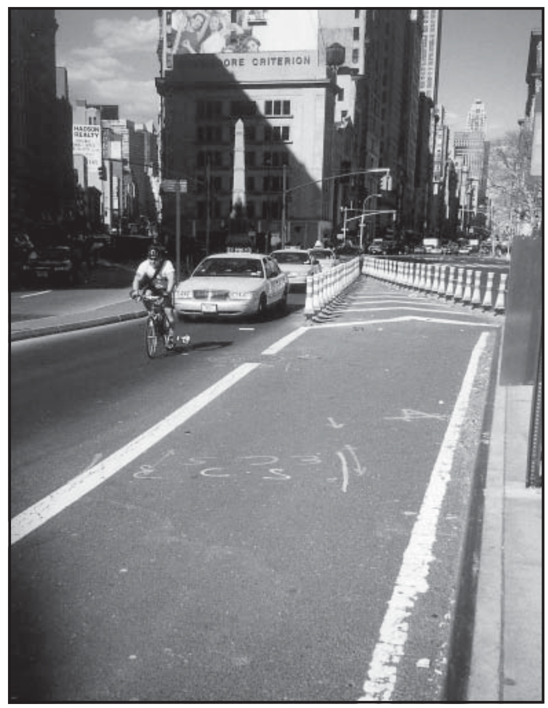
Plan view west of Madison Square Park. Location of proposed bicycle lane with rubberized curbs and flexible bollards shown beginning on Broadway, south of 25th Street. A marked cycle crossing is proposed to connect this portion of the lane to its southbound continuation along the west side of Madison Square Park, from 24th Street to 23rd Street. The proposed lane is 5 feet, with a 3-foot buffer containing curbs and bollards. This design assumes a narrowing of an existing east travel lane from 22 feet to 14 feet (south of 24th St.) to accommodate the new facility. See p.12 for further description.

As seen on the diagram on the previous page, a physically delineated bicycle lane on Broadway is proposed south of 25th Street (occupying one edge of an existing traffic island for one block). Wide travel lanes on Fifth Avenue (leading to Broadway) from 24th to 23rd Streets permit the continuation of this exclusive bicycle lane adjacent to the park: a 22-foot wide east-side travel lane could be narrowed to 14-feet, allowing space for a 5-foot bicycle lane with 3-foot buffer (containing curbs and bollards).

A pilot test of a “Paris-style” bicycle lane (using rubber curbs and flexible bollards) is particularly appropriate for this location: no vehicular parking exists along the curb, and pedestrian crossings are restricted by metal barriers. This space is sometimes occupied by charter buses; however, private bus standing could be accommodated north of 24th Street.

Rubberized curbs are recommended at 10-foot intervals (similar to Paris the installation described on the previous page). Bollards are recommended throughout the length of this proposed facility (in addition to marking the ends of the lane), supplementing the curbs at 5-foot intervals. Continuous placement of bollards will help (1) keep the lane definition within the vertical sightline of cyclists, and (2) define an exclusive space for cyclists for motorists, particularly approaching the 23rd Street intersection where left-turning vehicles will conflict with cyclists traveling from the end of the proposed facility through the intersection (to access an existing east-side bicycle lane south of 23rd Street). The proposed “Paris-style” implementation should also occur in conjunction with a marked cycle crossing through the 23rd Street intersection (see Cycle Crossings, p.6).

A plan for maintenance will be required to keep the exclusive bicycle lane clear of road debris.



Left: A cyclist riding southbound on Fifth Avenue (leading to Broadway) approaching 23rd Street, adjacent to Madison Square Park where the propsed facility will be located. Above: Flexible bollards used to direct traffic block a portion of the existing bicycle lane on Broadway (leading to Fifth Avenue, south of 25th Street). This same type of bollard could be used to define the proposed cycle lane along Madison Square Park.

Contra-Flow Bicycle Lane

Description

Contra-flow lanes permit bicycle travel against the flow of motor vehicle traffic. Successful installations in other cities have used the lanes, in short lengths of one to three blocks, as connectors between cycling facilities and destinations. Contra-flow lanes are recommended for use on streets with limited on-street parking and a minimum number of driveway crossings. Additional signage may be needed to alert vehicles making left turns to look in two directions. The contra-flow lane may also be raised to provide better visual identification of cyclists to motorists.

A contra-flow bicycle lane in Minneapolis places cyclists between north-bound vehicles lanes and a southbound bus-only lane on Hennepin Avenue, a major commercial arterial.

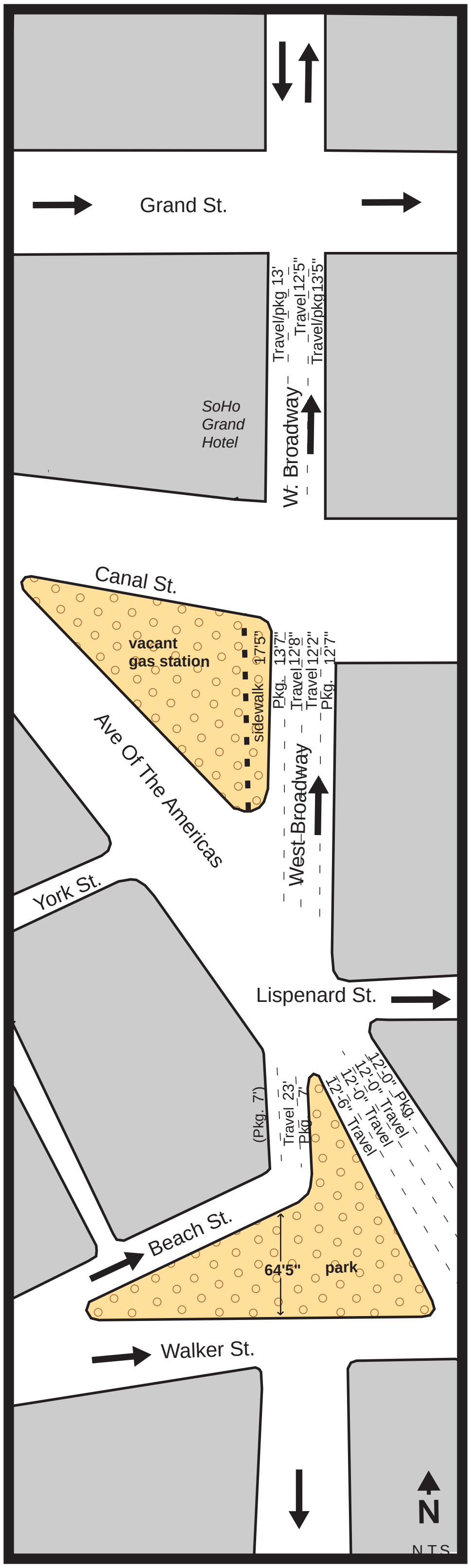
Potential Test Locations: West Broadway, from Grand Street to Walker Street.

Queensboro Bridge (dependent on the completed construction of the Bridge pedestrian/bicycle paths):

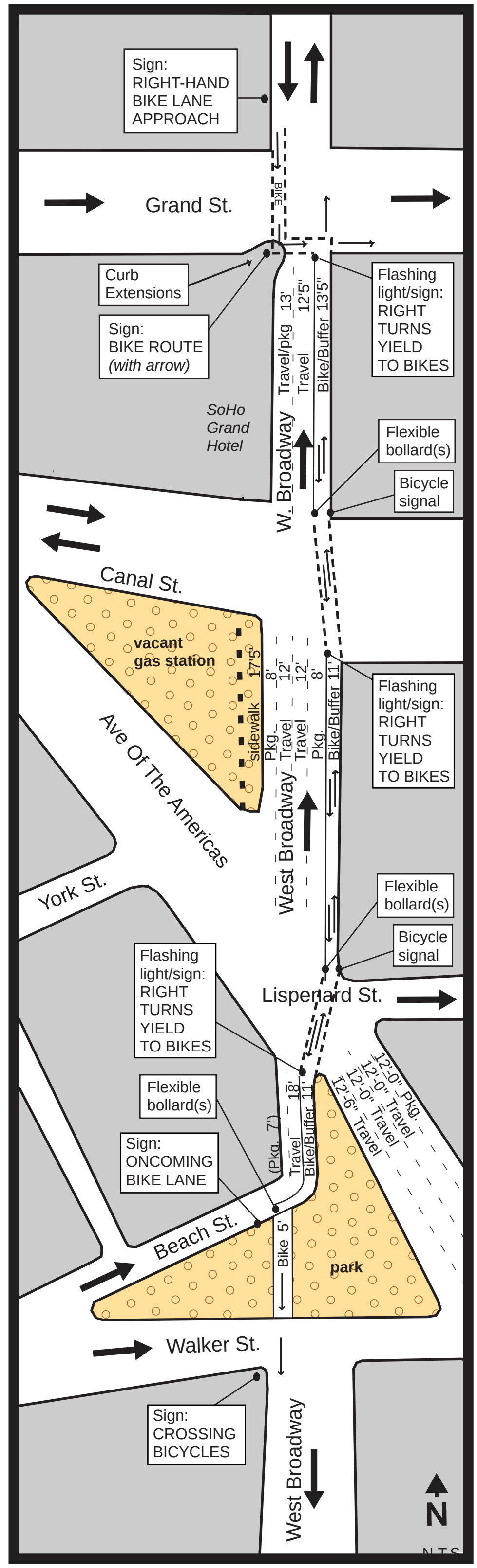
Second Avenue, from 60th to 59th Streets -- to accommodate cyclists exiting a *southside* Queensboro Bridge bicycle path (allowing cyclists to continue north).

60th Street, from First to Second Avenues -- to accommodate cyclists using a *northside* Queensboro Bridge bicycle path (allowing exiting cyclists to continue to Second Avenue, and providing east-side access from 60th Street).

Pilot Test 5: Contra-flow bicycle lane (bi-directional)
West Broadway, Grand Street to Walker Street



Plan view of West Broadway, existing conditions.

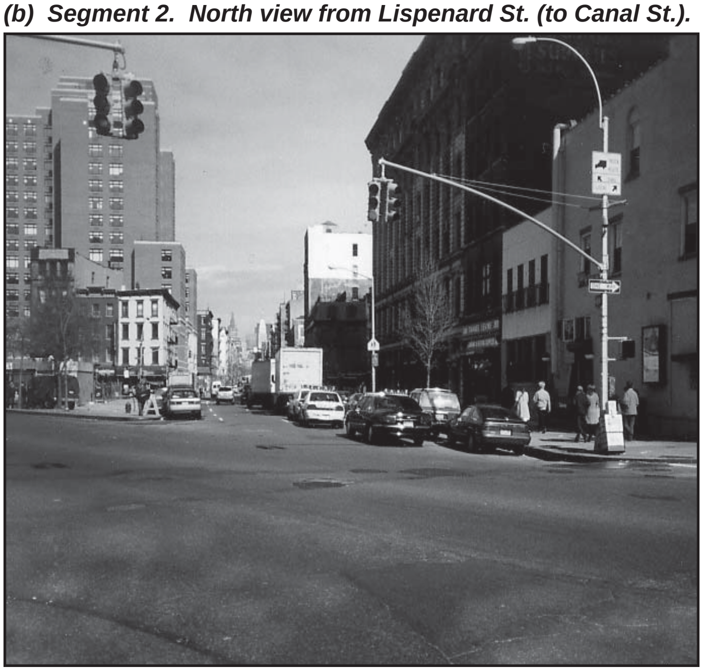


Plan view of West Broadway, with proposed bi-directional contra-flow bicycle lane.

The proposed contra-flow bicycle lane on West Broadway (from Grand to Walker Street) would facilitate a southbound route between previously unconnected segments of the *New York City bicycle network* (see maps, Task 3 report). A signed and striped west-side approach to the lane would begin north of Grand Street. Having crossed Grand, signage would direct cyclists to cross with pedestrians to safely access the lane. The lane would continue south of Grand Street adjacent to the east curb, to avoid conflicts with delivery and passenger vehicles in front of the SoHo Grand Hotel (between Grand and Canal Streets). The lane is proposed (typically) as eight feet wide, with a three-foot buffer lined continuously with flexible bollards to differentiate the lane from vehicular traffic, particularly at intersections. Signage is recommended at all driveway exits to alert motorists to cycle traffic in two directions.

(a) Segment 1. North view from Canal St. (to Grand St.).

(b) Segment 2. North view from Lispenard St. (to Canal St.).



Segment 1: Canal St. to Grand St.

Existing conditions: West Broadway is one-way northbound between Canal and Grand Streets. Traffic originates from either Canal Street or West Broadway, south of Canal Street. Curbside parking is restricted from 8am to 6pm on both curbsides, but cars, trucks and taxis use the curbside space continuously to access the SoHo Grand Hotel (on the west side of the street).

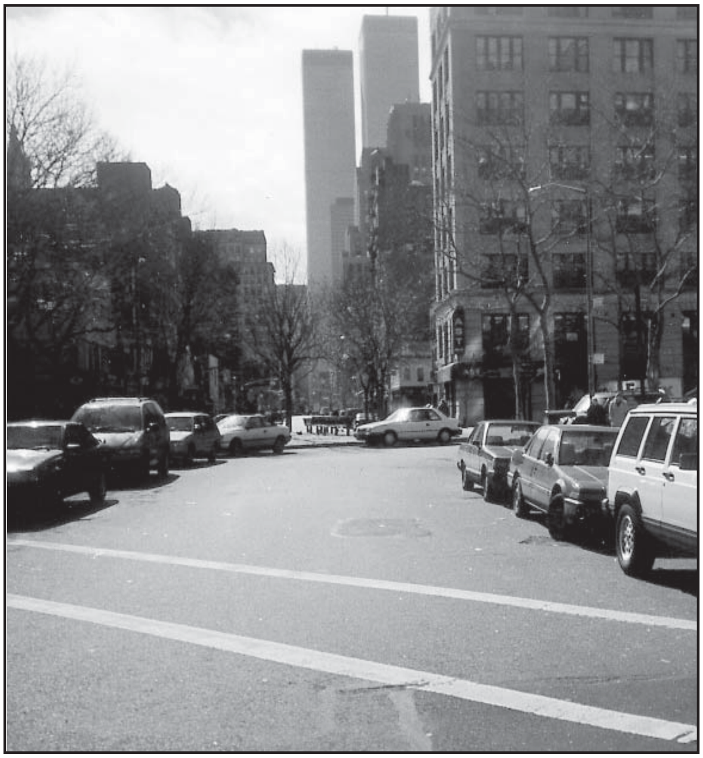
Proposed facility: An eight-foot contra-flow bicycle lane with a five and 1/2-foot buffer is proposed on the east side of the street. The roadway would be limited to one travel lane and one travel/parking lane against the west curb. Curb extensions would be required at the southwest intersection of West Broadway and Grand Street to protect crossing cyclists from on-coming northbound vehicles.[24] A flashing light and/or signage would be required to direct right-turning motorists to yield to through cyclists, south of the intersection of West Broadway with Grand Street.

Segment 2: Lispenard St. to Canal St.

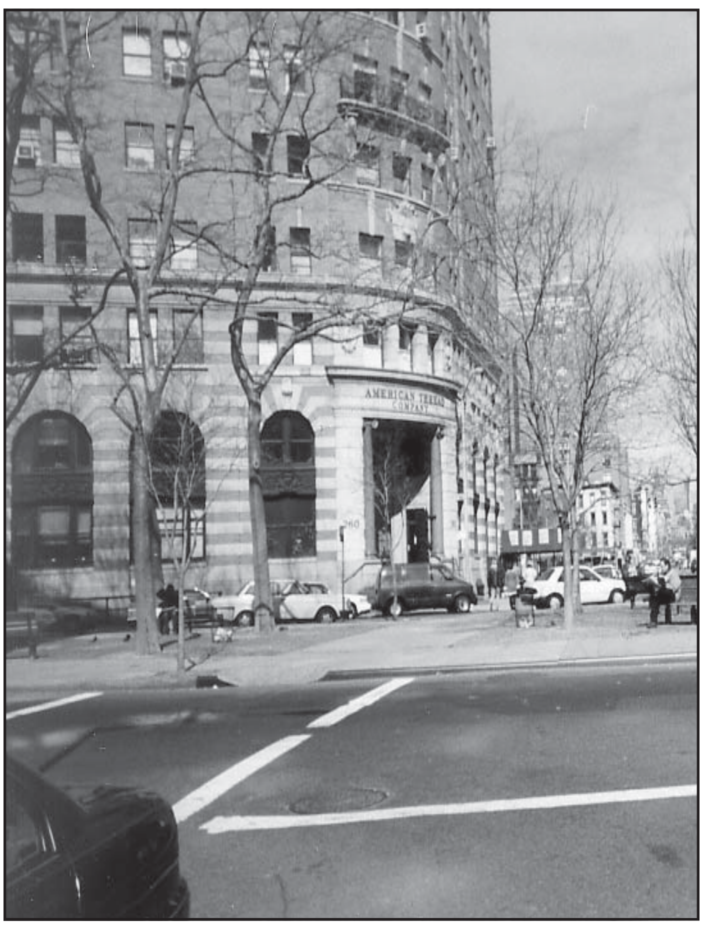
Existing conditions: West Broadway is one-way northbound. Traffic enters this one block segment of West Broadway from Sixth Avenue (to the south). Parking exists on both sides of the street. A vacant gas station with a wide sidewalk occupies the west-side block.

[24] Northbound vehicle travel at this intersection would be limited to one lane; however, traffic is currently forced to merge right to a single lane north of Grand Street (to accommodate southbound (two-way) traffic). There are no left turns. As with other recommendations, LOS analysis is required.

(c) Segment 3. South view along Beach Street to park (from Lispenard).



(d) Segment 3. North view from Walker St. (south of park).



Proposed facility: An eight-foot contra-flow bicycle lane with a three-foot buffer is proposed on the east side of the street. Existing vehicular lanes would be retained but would be narrowed to eight-foot parking and 11-foot travel lanes. A bicycle signal would be needed north of the intersection with Lispenard, to direct crossing southbound cyclists. A flashing light and/or signage would also be required south of the intersection to direct right-turning motorists to yield to through cyclists before the intersection of West Broadway with Lispenard Street and Sixth Avenue.

Segment 3: Walker St. to Lispenard St.

Existing conditions: South of Lispenard Street, West Broadway transitions to Beach Street (adjacent to a small park). There is parking on both sides of the street, and no marked travel lanes exist. The park has trees and benches on its east end; the west end has no street furniture. From Beach Street, an access ramp leads to a walkway through the park, which cyclists currently use to cross through the park to continue southbound on West Broadway.

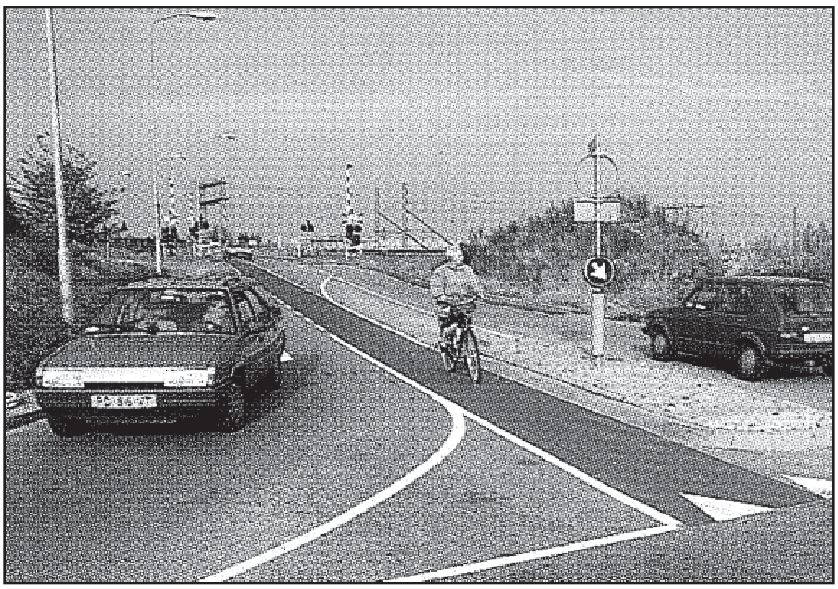
Proposed facility: An eight-foot contra-flow bicycle lane with a three-foot buffer is proposed on the east side of the street (adjacent to the park). The roadway would be limited to one eight-foot parking lane and one 18-foot travel lane for one-half block. The contra-flow lane would end as cyclists continue to travel southbound through the park, towards Walker Street. Cyclists turning southwest at the bend on Beach Street (moving toward the park entrance) should be protected from oncoming vehicles by the presence of parked vehicles (or implementation of a buffer) along the south side of the roadway, west of the park entrance.

A flashing light and/or signage would be required to direct right-turning motorists to yield to through cyclists, south of the intersection of West Broadway with Lispenard Street. Signage would also be required to warn motorists of the start of the oncoming (contraflow) bicycle lane near the entrance to the park, and as cyclists exit the park at the intersection of Walker Street and West Broadway.

Center-Median Bicycle Lane

Description

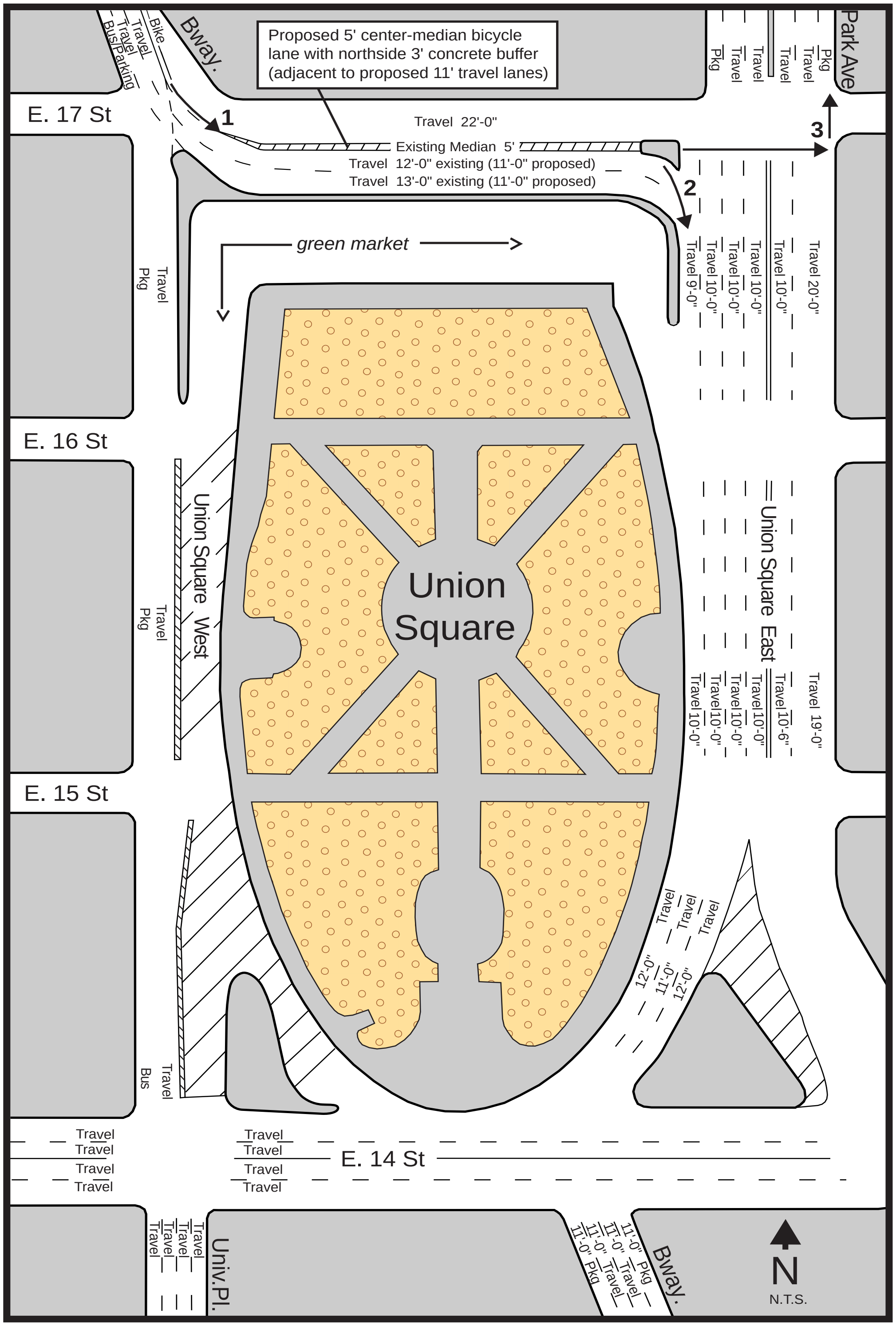
Center-median bicycle lanes provide a cycling space against (or within) the center median of a roadway, and are recommended for use on continuous roadways with few turning movements. A recent installation of a center-median lane can be found in Minneapolis, where bi-directional cycling traffic is accommodated between motor vehicle lanes and a bus-only lane. Center-median lanes have also been successfully implemented in Seattle, WA. Intersections where motor vehicles make left turns through the median should be designed similarly to intersections where cyclists using a right-side bicycle lane face right-turning traffic (AASHTO recommended treatment).



A cycle lane adjacent to an intersection center-median in Apeldoorn, The Netherlands. The lane has a bright red pigment with white markings, highly visible on the roadway. Source: Cities Make Room for Cyclists.

Potential Test Locations: 17th Street, from Broadway to Park Avenue.
Park Avenue, from 14th to 17th Streets.

Pilot Test 6: Center-median bicycle lane (with flexible bollards) 17th Street, Broadway to Park Avenue



Plan view at Union Square. Location of proposed center-median bicycle lane shown on 17th Street, between Broadway and Park Avenue. Arrow #1 shows cyclists traveling with traffic onto eastbound 17th Street from the Broadway bicycle lane. From the east end of 17th Street segment, Arrows #2 and #3 show the potential routes of cyclists as they continue southbound on Union Square East or northbound on Park Avenue (respectively). Implementation of the new lane should include an eastward shift of the vehicle stop line on the northside of 17th St. (for westbound traffic), to facilitate cyclists' clear access to the lane through the intersection.

The proposed one-way (eastbound) center-median lane would extend from the Broadway bicycle lane, allowing cyclists to safely continue traveling with the flow of vehicular traffic onto eastbound 17th Street. Currently, eastbound cyclists moving alongside traffic from the Broadway bicycle lane confront on-coming traffic as they make the turn onto 17th Street.

The new lane would replace an existing five-foot painted median (pictured left) with a five-foot blue pigmented lane adjacent to a three-foot, northside concrete median buffer. The additional three feet required for the buffer could be obtained by creating two 11-foot westbound travel lanes.

The lane would end at Union Square East (see diagram), where cyclists could safely continue north or south. If possible, plans to reconstruct Union Square Park and the surrounding roadways should accommodate an extension of this facility southbound on Union Square East.

A pegga-tracked cycle crossing connecting the end of the existing Broadway bicycle lane to the proposed center-median lane would be required to alert turning motorists to the presence of cyclists in the intersection (see p.6).

Top: Cyclist using the existing unprotected, painted median on 17th Street to travel eastbound to Union Square West.

Left: Southeast view from 17th Street, at Union Square West, where the proposed center-median lane would end. From this point, cyclists using the lane would move along the traffic island to continue traveling southbound (arrow #2) or northbound (arrow #3).

Combined Bicycle/Bus Lane

Description

These lanes provide an exclusive travel lane for both cyclists and buses, during continual or restricted (peak-traffic) hours. Successful implementation of these lanes may require additional training for bus drivers, to educate them about operating safely with cyclists. These lanes are recommended on routes using compressed natural gas buses.

Potential Test Locations:
Tests of combined bicycle/bus lanes are recommended for existing city-wide priority bus lanes, particularly on roadways with double lanes (e.g. Madison Avenue). However, successful implementation of the lanes will require a dedicated enforcement effort to keep them clear of motor vehicles for cycle and bus use. One model for improved enforcement of priority bus lanes was pilot tested by the Metropolitan Transportation Authority (MTA) in 1994. This study was developed as a follow-up to an MTA September 1994 report, *Faster Than Walking?: Street congestion and New York City Transit Buses*, which questioned the cost-effectiveness of bus lane enforcement and recommended the implementation of self-enforcing bus lane designs.

During a three-month period, the MTA New York City Transit and NYCDOT implemented a program of sustained enforcement of bus lane regulations. Evaluation of this program showed a nearly “break-even” result from revenue alone, and a potential positive cost/benefit of over $70,000 per quarter from reduced running time.

A similar, coordinated and targeted effort would be required in conjunction with prototype testing of bicycle/bus lanes, to keep the lanes clear of motor vehicles to allow predictable (and safe) travel movements by both users.

Left: A southbound cyclist using the bus lane on Broadway (south of Houston). Despite frequent bus scheduling, cyclists can be observed using the lane during hours restricted to bus-only travel.
Below: A delivery truck standing illegally at a bus stop on Broadway (below Canal).

Centerline Non-Compulsory Lane

Description

A limited width, unmarked centerline lane may be used to improve comfort and safety levels for cyclists on rough or cobbled roadways, and reduce motor vehicle speeds by visually narrowing the roadway surface. These lanes can be used to facilitate travel connections within the bicycle network on roadways with poor cycling surfaces. Surface treatments for a non-compulsory lane include: leveled cobbles, pavers, brick, concrete and asphalt.

Pavers line a cobbled street, to facilitate pedestrian and bicycle traffic. Source: An Improved Traffic Environment, Report 106, Denmark Ministry of Transport.

Potential Test Locations:
Citywide streets with surfaces unsuitable for cycling, particularly those which facilitate route connections in the *New York City Bicycle Master Plan*. One roadway for test implementation is Varick St. south of Canal St., to connect southbound cyclists on Seventh Avenue to West Broadway.

Mercer Street (pictured left, south view from Prince Street) in SoHo provides a safe, low-volume, though somewhat bumpy southbound route for cyclists.

ENFORCEMENT RECOMMENDATIONS

The successful implementation of cycling facilities depends as much on enforcement as proper engineering and placement. To help ensure that new facilities are available for use by cyclists and not occupied by motor vehicles, a series of enforcement recommendations are listed below.

Curbside Regulation

In addition to enforcing curbside regulations that typically accompany traditional bicycle lanes, enforcement of newly implemented on-street cycling facilities will (in some cases) require modified curbside regulations, particularly where protoypical improvements are recommended. Double parking, identified by cyclists as a leading threat to their safety, should be a target of focused regulation. An improved definition of on-street cycling space and its associated regulations (through signage, striping and other prototypical measures) may assist enforcement efforts by clarifying usage of these areas for other roadway users.

Ultimately, however, consistent enforcement of curbside and traffic regulations provides the clearest definition of their applicability to on-street bicycle facilities. NYPD-based recommendations include increased motor vehicle enforcement directly related to on-street cyclists (i.e., parking in bike lane, driving in bike lane, failing to yield right of way to cyclists) and targeted enforcement of bicycle facilities, such as a “zero tolerance” program.

Zero Tolerance Enforcement Program

Following the example of initiatives currently in place for speed, seat belt and bus lane enforcement, a targeted approach to ticketing motor vehicles unlawfully occupying bicycle lanes is recommended. This type of initiative would be most effective occurring at least once a month, in coordination with public relations efforts to provide publicity (including, but not limited to, *National Bike Month* and local *Bike-to-Work Week* activities). Public awareness of targeted enforcement of cycling lanes is critical to the success of a non-continuous program.

As with other NYPD zero tolerance initiatives, data on enforcement activity should be collected from each precinct after a target day and tabulated by the Office of the Chief of Patrol. An evaluation of this data could be used to aid future planning and enforcement efforts.

This initiative is anticipated to affect a greater number of precincts as new portions of the planned 550-mile on-street bicycle network are implemented over the next five years.

“Public Awareness” Summons Form

Safety information currently distributed by the NYPD (in conjunction with NYCDOT) has a limited and targeted circulation. To improve distribution, revision of both parking and moving summons forms to include traffic safety information (on the back of the copy of forms given to traffic violators) is recommended. Information printed on summons forms could provide a broad, routinized form of outreach for safe cycling and “Share the Road” information for motor vehicles, in addition to providing information about seat belt use, speeding, child safety seats, and hazards of driving under the influence of alcohol or drugs (DUI).

Revised Parking Summons Form

In particular, minor revision to the parking summons form currently used by NYPD would allow officers to more accurately track and ticket motor vehicles unlawfully parked in bicycle lanes. The form lists a number of common violations which officers can quickly check without having to reference code or fine information, including *double parking* and *no parking* violations. These violations are more easily referenced, and often checked in placed of, *parking in bicycle lane*, which is not readily listed.

A space on the form for officers to identify the type of violation as *bicycle lane-related*, or the addition of a line specific to *parking in a bike* *lane*, would allow officers to more easily record cycling-related enforcement information, and provide better data to assist on-street cycling improvement efforts by other City agencies.

Amended Traffic Code

In addition to on-street enforcement efforts, revision of the *New York City Traffic Rules and Regulations* is recommended to institutionalize the protection of existing on-street bicycle facilities. A revision could be based, in part, on language found in the San Francisco Traffic Code:

> ***San Francisco Traffic Code. Article 5B. Section 110. Protection of Existing Bicycle Facilities.***
> (a) the following activities are prohibited unless the Board of Supervisors expressly grants prior approval:
> (1) the narrowing of right hand travel lanes with parking, including turn lanes to less than twenty-two (22) feet or the narrowing of right hand travel lanes without parking, including turn lanes to less than fourteen (14) feet;
> (2) the narrowing or elimination of any bicycle lanes;
> (3) the narrowing or removal of bicycle paths; or
> (4) the addition of traffic lanes, except where such lanes consist of left or right turn pockets.
> (b) This Section only applies to the streets, lanes and paths on the City's official bicycle route system as defined in the most recent update of the Transportation Element of the S.F. Master Plan.

DATA RECOMMENDATIONS

To effectively plan and locate on-street cycling facilities, regular and systematic collection of cycling data is needed. Detailed accident data, in particular, is needed to continue to identify unsafe locations which should be addressed as priorities for facility improvement.

Existing Data Sources

Accident data is presently available through a number of different State and City agencies: the New York Police Department (NYPD), the New York Department of Motor Vehicles (NYDMV), and the New York State Department of Transportation (NYSDOT).

The **NYPD** provides a primary source of accident data for all road users through police report. From this information, NYPD is able to produce current yearly summary data of citywide cycling injuries and fatalities. This data does not, however, identify locations dangerous for cyclists.

The **NYDMV** receives data directly from the police reports. Using that information, they produce a summary report of New York City motor vehicle accidents and a report on New York City bicycle accidents. The reports have a variety of details, including the time of day accidents occurred; age and sex of accident victims; a distinction between injuries or deaths resulting from accidents; details about the severity of injuries; and information about pre-accident bicycle action/movements. These reports, however, do not cite specific locations where accidents occurred.

In addition, the NYDMV has the ability to produce special reports, by request, referring specifically to cyclists. The information is updated as far as June 1998, and can be sorted by borough, precinct, year, and accidents specific to cyclists. These reports cannot provide location information more specific than precinct-level, and the process to receive information is time consuming.

The **NYSDOT** receives the accident data that has been coded by the NYDMV. NYSDOT's current safety management system consists of two components: SASS (state accident surveillance system) a program with the capacity to compile accident summary reports on roadways under the jurisdiction of the state; and CLASS (centralized local accident surveillance system) a program with the capacity to show local crash statistics by summary and by individual node.

Both of these systems are being integrated into one automated Safety Management System (SMS) that would make queries easier and allow agencies direct access to all of the information. SASS has already been incorporated into SMS, but plans for the incorporation of CLASS (which is what would be required for local system bike data in NYC) have been held up indefinitely.

Using SASS data accessed via the SMS, NYSDOT was able to disseminate summaries of bicycle and pedestrian accidents that occurred on the state highway system between 1990 to 1993, in a 1995 report. However, this report contained no detailed information for local accident sites.

Within the current CLASS system there are two reports that are regularly produced, the Interim Summary Report, and the Local Accident Surveillance Reports:

- The Interim Summary Report, compiled every six months, has data that refers to vehicle and pedestrian accidents; however, there are no statistics in the summary report referring to cycling accidents.

- Cycling accident data is available in the Local Accident Surveillance Reports (individual police reports compiled by node), but they are compiled with vehicular and pedestrian accidents, making it necessary to sort through piles of impertinent information to find individual bicycle reports. Even once the reports are sorted this data is only useful when the dangerous location has already been identified.

Although cycling data is not included in the standard issue reports, NYSDOT is able to accommodate individual requests for cycling accident data. NYSDOT, similar to NYDMV, can produce a limited number of reports -- including a list of bicycle accident prone locations in New York City. Unfortunately the availability of this service is not well-publicized, and the preparation of such reports can be very time consuming.

Recommendations

Accident data needed for effective bicycle facility planning is not currently readily available. In order to begin “making streets safe for cyclists,” accident prone locations for cyclists need to be regularly and systematically identified, showing precisely where and how accidents occurred.

Given NYSDOT’s ability to sort information by location, specific recommendations are that:

- NYSDOT include bicycle accident data in their Local Accident Surveillance Summary.

- NYSDOT produce an annual report identifying the most dangerous locations for cyclists in New York City.

APPENDIX A:
Department of City Planning Bicycle Questionnaire

The City of New York / Department of City Planning, Transportation Division
Bicycle Questionnaire

№ 5827

Please answer the following questions as completely as possible - thank you!

The Bicycle Program at the Department of City Planning, Transportation Division has been very active in providing better cycling conditions in New York City. This survey will help our continued planning efforts, which include studies and implementation projects to improve bicycle parking and safety. Thanks for your help!

I. BICYCLE TRAVEL HABITS

Do you ever use your bicycle to commute to work? ____ **yes** ____ **no**
(If no, go directly to part B)

A. *If yes:*
Describe the route of your typical commute:
(i.e. Park Slope, Brooklyn to Midtown Manhattan)

Begins at___________________________

and ends at___________________________

The streets that I typically use are:___________________________

How long have you been commuting to work? ____ **years**

Approximately how far is your commute? ____ **miles**

How long does it usually take you? ____ **hrs.** ____ **min.**

I commute:
(choose one)
☐ once a week
☐ twice a week
☐ 3 or more times a week
☐ once a month
☐ twice a month

(choose one)
☐ year round
☐ seasonally

B. *If no:*
What is(are) your primary reason(s) for not commuting by bicycle?
(check all that apply)
☐ I work too far from home
☐ Fear of motorists
☐ Roadway surface conditions are poor
☐ Nowhere to store my bike safely
☐ No shower/change facilities at work

C. Please tell us a little about yourself *(optional)*.
What is your age? ☐ Under 21 ☐ 21-40 ☐ 41-62 ☐ Over 62
Are you ☐ Male ☐ Female

Please fold here

II. BICYCLE SAFETY (all trips)

Which roadway users are the greatest threats to your safety when riding in traffic?
(Please assign numbers 1-5 to each category (1 if low threat - 5 if high threat)

____ taxi cab drivers
____ private passenger car drivers
____ bus drivers
____ truck drivers
____ double parked cars
____ jaywalking pedestrians
____ in-line skaters
____ other cyclists

Along your typical routes, are there any particularly bad intersections or stretches of roadway? Describe the exact location: ___________________________

What is the nature of the problem? ___________________________

If you have been in an accident while riding in traffic: *(check all that apply)*

☐ a police report was filed
☐ someone was injured
☐ someone was taken to the hospital
☐ I was doored (# ___ times)
☐ I collided with a vehicle (# ___ times)
☐ I collided with a person (# ___ times)

III. BICYCLE PARKING (all trips)

Where would you like racks, lockers, etc.: ***(please be site specific)***

A) Bike Racks *(including lots and garages)* **B) Bike Lockers**

C) Additional Bike Racks *(where facilities are available but more are needed)*

D) Bike Service Station *(including guarded bike parking, repairs, bike rental, coffee, snacks, and a nice atmosphere)*

If safe and secure bike parking were available (such as indoor and/ or guarded facilities), how much would you be willing to pay?

$____ an hour $____ per day

THANK YOU for your time and effort! Please fold here > use seal provided (no staples), and mail. No postage necessary.

APPENDIX B:
Summary Listing of Cycling/Skating Summonses and Associated Fine Structure for New York City

Law Code	Description	Plea Fine 1st occurance	Plea Fine 2nd occurrance	Plea Fine 3rd occurrance
1111D1B	Red light violation	50	100	250
1111D1C/ 30C1B	NYC red light	100	200	500
1230A	Parent or guardian allows child to violate regulations	40	40	40
1232A/ 412P1	Improper operation (off seat or pedals)	40	40	40
1232B	Too many riding on bike	40	40	40
12331	Clinging to moving vehicle	40	40	40
12332	Attach self to moving vehicle	40	40	40
12333	Permit clinging to moving vehicle	40	40	40
1234A	Failure to keep right	40	40	40
1234B	More than 2 abreast	40	40	40
1234C	Riding on path	40	40	40
1234D	Failure to stop before entering a roadway (from driveway, etc).	40	40	40
1235	Carry articles (without one hand on steering wheel)	40	40	40
12336A	Inadequate light/reflectors	40	40	40
1236C	Inadequate brake	40	40	40
1236D/ 1236E/ 1238.10	No/improper reflectors (afer sunset)	40	40	40
1238	Parent or guardian allows child under 14 to bike/skate without helmet	40	40	40
1229AB	Non-motorized on exp/hwy	40	40	40
407C31	Ride/skate on sidewalk	40	40	40

APPENDIX C:
Description of problem keywords applied to DCP questionnaire responses (listed in order as appear on Table 19)

Poor bridge access: applied generally to bridge entrance references; additional keywords listed as appropriate.

Congestion: refers to “crowded” conditions, “too many cars,” etc.

Poor road condition: roadway surface and related conditions, including lighting.

No defined cycling space: applied generally to complaints about a lack of exclusive cycling space and poor design/ indication of space meant to be exclusive.

Double parked vehicles: includes mention of loading and unloading delivery trucks.

Conflicts w/ turning vehicles: primarily at intersections.

Vehicular speeds: specific category of *unlawful driving* (see below).

Intersection design: applied generally to references about overall design, including “too many roads come together,” “intersection too wide,” and “confusion” at locations where roadways intersect.

Aggressive driving: applied to driving behavior that is aggressive but not necessarily in violation of traffic laws, i.e. “crazy drivers,” “cut off.”

Pedestrians in cycle space: applied to general references about pedestrians in roadway/cycling space, particularly at intersections (see *jaywalking* below).

Traffic signal problem: applied to references about signal timing, crossing difficulty at signalized intersections, and traffic phase confusion.

Unlawful driving: applied generally to references about illegal driving except speeding (see *vehicular speeds*, above), i.e. “running a red light,” “driving in the bike lane,”vehicles not staying in a lane.”

Stopping taxis: generally applied to each reference; includes livery vehicles.

Jaywalking: specific to illegal pedestrian crossings, i.e. against a light, in the middle of a roadway (see *pedestrians in cycle space*, above).

Narrow roadway: specific to roadway widths (for *congestion*, see above).

Merge problems: applied to references about converging lanes, or the ability to cross moving traffic lanes at locations other than intersections.

Narrow bicycle lane: specific to width references (see *no defined cycle space*, above).

Construction: as stated.

Unlawful cycling: includes on-street and cycling on bridge paths.

APPENDIX D:

(1) Major Intersection Area Search Locations

Herald Square
Including Greeley Square, this area is defined by the intersection of Broadway and Sixth Avenue, from 32nd St. to 36th St.

Columbus Circle
This area currently operates as a traffic circle at the intersection of Broadway and Eighth Avenue, at the southwest corner (Merchants' Gate Entrance) of Central Park.

Times Square
Including Duffy Square, this area is defined by the intersection of Broadway and Seventh Avenue, from 43rd St. to 47th St.

Union Square
This area encompasses Union Square Park, bounded by Park Avenue (Union Square East) and Broadway (Union Square West), from 14th St. to 17th St.

Madison Square
Including Worth Square, this area is defined by the intersection of Broadway, Fifth and Madison Avenues, from 22nd St. to 26th St, immediately west of Madison Square Park.

(2) NYPD Accident Prone Locations, Patrol Borough Manhattan North, Roadways with Highest Accident-Prone Location (APL) Totals

Roadway	# sites	APL Total
Broadway	7	294
125th St.	7	245
Second Ave.	7	243
Amsterdam Ave.	7	226
Seventh Ave.	4	215

OVERVIEW:
Literature Review

The following information is a contextual review of bicycle facility research and implementation guides, accompanied by a selective case study survey of innovative on-street cycling implementations in both the United States and abroad. This information is intended to serve as a catalogue of ideas on which to base facility recommendations for local implementation.

Existing Documents

As U.S. federal transportation policy increasingly supports the development of alternative transportation options, planning for bicycle facilities has emerged on federal, state and local levels. With its initial release in 1981and 1991 update, AASHTO's *Guide to the Development of Bicycle Facilities* has continued to serve as the primary reference for standardized bicycle facility design and implementation.

The 1997 *New York City Bicycle Master Plan* released by the Department of City Planning offers a local context for the implementation of AASHTO recommended facilities. However, it provides few recommendations for the implementation of innovative facilities increasingly seen in use in other cities in the United States and internationally. These facilities can be used to serve cyclists more safely in locations where standardized facilities (AASHTO recommended) are not easily implementable or desirable.

Literature search

Outreach for this report focused on large metropolitan areas somewhat comparable to New York City, in addition to cities with a reputation for innovative cycling programs. Literature was received from more than 30 national bicycle programs and 10 international cycling programs.

National case studies

A review of written materials and phone interviews with local bicycle coordinators shows that the majority of bicycle facility implementation currently done in the United States centers on the installation of conventional bicycle lanes. A growing number of cities surveyed, however, have experienced successful installations of innovative facilities in recent years. These cities include Minneapolis, MN, Cambridge, MA, Portland, OR, Philadelphia, PA, and San Francisco, CA.

Nationally implemented facility innovations can be grouped into three categories: (1) intersection treatments, (2) improvements to standardized facilities and (3) new roadway accommodations. Intersection treatments used to reduce conflicts between cyclists and turning vehicles include advanced stop boxes and combination turn lanes; improvements to standardized facilities include the use of pigmented lanes and improved road marking programs; new roadway accommodations include bicycle/bus lanes, contra-flow bicycle lanes, center-median lanes and various traffic calming installations.

International case studies

Information received from other countries reflects a higher level of bicycle facility innovation and evaluation than that seen in the United States. Denmark and the United Kingdom, in particular, provided literature documenting extensive research and evaluation which expands upon U.S. facility implementations.

Successful implementation of innovative facilities in the United States provides a realistic basis upon which New York City can find innovative ways to safely accommodate cyclists on highly trafficked city streets. In addition, national testing of international bicycle facilities will likely continue as planning for cycling becomes more pervasive in the United States, particularly with increased levels of federal funding. Examples of cycling facilities used in other countries can be used to broaden the scope of innovation used in the United States to date, and supplement evaluation and safety data to guide local implementation efforts.

EXISTING DOCUMENTS

An expanding array of bicycle facility literature has been published in the decade following the 1991 Intermodal Transportation Efficiency Act (ISTEA). Moreover, with authorization of the federal 1998 Transportation Efficiency Act for the 21st Century (TEA 21), a continued national emphasis on bicycle research and implementation will occur.

Bicycle Facility Research

For the past twenty years, a major point of research and debate both in the United States and abroad has been the relative merits of separating bicyclists from motor vehicles versus integrating them into traffic flow.

A 1995 report published by the Federal Highway Administration (FHA), *Bicycle Safety-Related Reseach Synthesis*, summarizes this debate as one in which both sides used “safety” as the cornerstone of their argument:

- proponents of separation argue that bicycles and motor vehicles do not mix well because of speed differentials, operator skill, visibility and other factors;

- proponents of integration contend that seperated facilities create dangerous intersections, and that all bicyclists can be trained to ride confidently in traffic.

The nature of this debate, however, has changed over the past twenty years as much has been learned about the planning, design, operation and maintenance of bicycle facilities. In particular, the FHA’s *Research Synthesis* cites a number of case studies showing reductions in bicycle accident rates upon the implementation of bike lanes (pp.80-84). This report also cites growing evidence that the presence of bike lanes is a significant determinant of the level of bicycle use in a community:

> “In the context of the current Federal policy goal of increasing bicycle use, the issue of perceived safety and the comfort of bicyclists assumes much greater significance. Study after study reports that potential bicyclists... want a designated space in which to operate -- and that without the feeling of safety this confers on them, they simply will not ride in current traffic conditions” (p.82).

Current FHA research includes a three-year comparative analysis of bike lanes versus wide curb lanes. The study is being reviewed and should be finalized before the end of 1998. At that time, a Transportation Research Board (TRB) paper will be prepared that summarizes the results.

Overall, there has been an emerging recognition in research literature that a range of potential facilities can be used to accommodate bicyclists, and that the major issues are those of design and selection. The safety of bicyclists is influenced more by the design of a particular facility than the decision to implement that type of facility.

Implementation Guides

A number of federal, state and local guidelines have been developed for the implementation of bicycle facilities. The following pages provide a context for the *Making Streets Safe for Cycling* report by briefly describing a number of these documents.

Descriptions are organized into federal, New York State and New York City listings, paying specific attention to design guidelines and standards. These are not intended to provide an exhaustive listing of bicycle literature. Those documents listed, however, have emerged as widely referenced and recognized national guidelines and standards, or standards and reports specifically applicable to the New York City area.

Federal literature contains planning and design guidelines that are widely referenced by nearly every state (including New York). In addition, this literature offers a comprehensive review of both national and international programs, policies and design adaptations for bicycle facilities in the 1990’s.

Literature produced by New York State focuses on streamlining federal bicycle guidelines into planning for state and local projects.

New York City planning and policy documents apply coordinated state and federal guidelines to a local network. Design standards recommended in this literature generally rely on a limited number of AASHTO recommended facility types. Brief descriptions of innovative on-street facilities are contained in these documents, although none recommends implementation specific to the local network.

Federal Documents

***Selecting Roadway Design Treatments to Accommodate Bicycles*, 1994**
Federal Highway Administration (FHA)

This manual provides comprehensive guidelines for the selection of roadway design treatments to accommodate bicycles, and fills in many of the policy and planning gaps that the American Association of State Highway and Transportation Officials (AASHTO) did not address in its 1991 *Guide to the Development of Bicycle Facilities* [1] (described below). More specifically, this manual recommends design treatments and specifications for roadways to serve different types of bicyclists under various sets of traffic operational factors. Two types of design bicyclists are recognized: group A (advanced) and group B/C (basic adult and child).

Bicycle facilities recommended for implementation by the manual are limited to standard bike lanes and wide curb lanes, although shared motor vehicle/bicycle lanes (no special provision for cyclists) and roadway shoulders are also listed. Separate tables are provided for highways with urban sections, both with and without on-street parking.

Specific dimensions are suggested for the width of the recommended facility type. The manual is careful to note that these suggestions:

> "...reflect the current state of the practice in the design of bicycle-friendly roadways. Users of this manual are encouraged to treat these recommendations as 'guidelines' rather than absolute standards" (p.11).

Unfortunately, the manual provides only limited information on retrofitting existing streets for bicycles, stating that "...the recommended design treatments in the tables are most easily implemented when new construction or reconstruction is planned" (p.13).

***Guide to the Development of Bicycle Facilities*, 1991**
American Association of State Highway and Transportation Officials (AASHTO)

Uniform guidelines in the United States were established in 1981 by AASHTO, and continue to provide a national reference which most states and cities, including New York City, have adopted entirely or with minor changes as standards for the design of cycling facilities. The most recent update of the *Guide* was published in 1991, much of which is devoted to facility design.

Following a section on safe roadway conditions for facility implementation (i.e. safe drainage grates and good pavement quality), the AASHTO *Guide* describes several on and off-street facility types available to engineers and planners. On-street facility types covered by the *Guide* include bicycle lanes and wide curb lanes, in addition to the cyclists' use of shoulders and bicycle routes.

In creating the 1991 edition, notable changes were made to the 1981 AASHTO *Guide for the Development of Bicycle Facilities* based on research and experience gained during the 1980's.[2] These include:

- *Shoulders*. "Wide curb lanes and bicycle lanes are usually preferred in restrictive urban conditions and the widened shoulder will generally be more accommodating in rural circumstances" (p.13). Previously no distinction was made between rural and urban areas.

- *Wide curb lanes*. "Restriping to provide wide curb lanes may also be considered on some existing multi-lane facilities by making the remaining travel lanes and left-turn lane narrower. This should only be performed after careful review of traffic characteristics along the corridor" (p.15).

The *Guide* includes detailed cross sections and photographs of properly designed bicycle facilities. Many of its on-street design recommendations (including recommended lane widths) are referenced in detail by both the *New York State Department of Transportation Design Manual* and the *New York City Bicycle Master Plan* (see p.7 for detailed dimensions).

However, the *Guide* offers no specific guidance for selecting roadway improvements other than a general listing of topics to consider in planning. The *Guide* also offers few recommendations on the operation and maintenance of bicycle facilities.

Although the *Guide* has become the basic comprehensive reference for facility designers across the country, it is intentionally vague and

> "...not intended to set forth strict standards, but, rather, to present sound guidelines that will be valuable in attaining good design sensitive to the needs of both bicyclists and other highway users" (pp.1-2).

A revision of the AASHTO *Guide for the Development of Bicycle Facilities* is currently in progress, and is expected to be released next year.

***Manual on Uniform Traffic Control Devices (MUTCD)*, 1988, FHA**

First released in 1935, the *MUTCD* is the national manual for streets and highways that established guiding principals for the design and usage of traffic control devices, including signs, signals, pavement markings and traffic islands. Conformance with *MUTCD* standards for highway and street traffic control is required in nearly every state by statute, including New York.

Chapter 9 of the *MUTCD* contains traffic controls for bicycle facilities, including signage, markings and signals. Bicycle-use related signs are categorized as either regulatory, directional or warning, and together with pavement markings are well-covered in the *Manual*. The *Manual* does not, however, present much information on bicycle-use related signals or intersection treatments.

***National Bicycling and Walking Study*, 1992-94, FHA**

The *National Bicycling and Walking Study* was an effort by the federal government to develop a national policy on bicycling and walking. This study produced a series of 24 case studies, including several directly related to the design of on-street bicycle facilities:

- "*Traffic Calming, Auto Restricted Zones, and Other Traffic Management Techniques: Their Effect on Bicyclists and Pedestrians*" (No. 19)
- "*The Effects of Environmental Design on the Amount and Type of Bicycling and Walking*" (No. 20)
- "*Current Planning Guidelines and Design Standards Being Used by State and Local Agencies in the Design of Pedestrian/Bicycle Facilities*" (No. 24)

Report no. 24, "*Current Planning Guidelines and Design Standards Being Used by State and Local Agencies in the Design of Pedestrian/Bicycle Facilities*," is a case study of state and local programs. Emphasis is placed on state and local adaptations of AASHTO and *MUTCD* recommended guidlines, including the design of on-street roadway and signage improvements.

***Improving Conditions for Bicycling and Walking: A Best Practices Report*, 1998 FHA**

Although this report does not present specific guidelines for facility design, it is the most recent national effort to track outstanding bicycle and pedestrian projects at state and metropolitan levels of government. Its intent is to "...highlight exemplary projects and to show what has been done that can be replicated in other places." Projects described in the report formed a basis for the *Making Street Safe for Cycling* literature review.

[1] *It is important to note this manual is not meant to serve as a comprehensive guide to the design of bicycle facilities, and explicitly refers users to the AASHTO Guide for detailed specifications.*

[2] *Taken from "Bicycle Safety-Related Research Synthesis," a 1995 FHA publication.*

New York State Documents

***New York State Bicycle and Pedestrian Plan*, 1997. NYS Department of Transportation (NYSDOT)**

The *New York State Bicycle and Pedestrian Plan* fulfills the requirements of section 1025 of ISTEA, and consists primarily of broad objectives for the development of statewide pedestrian and bicycle infrastructure and program elements. One of the top ten priority actions listed in the *Plan* is the development of,

> "...a user friendly design manual, ...including provisions for on-street bicycle facilities, road shoulders, sidewalks, crosswalks, intersection design, signage, pavement markings, multi-use paths, etc." (p.iii).

Highway Design Manual
***Chapter 18: Facilities for Pedestrians and Bicycles, Revision 29,* 1996**
NYSDOT

The *Highway Design Manual* provides design guidance for pedestrian and bicycle facilities to be included in NYSDOT projects, to meet needs identified during project scoping or preparation of design approval documents. The AASHTO *Guide for the Development of Bicycle Facilities* is used as the basis for establishing the minimum requirements for the design and construction of bicycle facilities on Department projects, and is frequently referred to in the NYSDOT manual.

The *Highway Design Manual* also directly references the FHA manual *Selecting Roadway Design Treatments to Accommodate Bicycles*. It specifically states, however, that the FHA manual,

> "... is not a standard, nor is it a comprehensive guide to the design of bicycle facilities. It is intended to provide a rational and consistent method for determining widths for accommodating bicyclists on roadways... [and] should not be used as the only reference for decision making where its guidelines cannot be met" (p.18-5).

The *Highway Design Manual* does state that on-street accomodations for cyclists can usually be met through use of wide curb lanes, bike lanes, shared roadways or paved shoulders. With regard to the placement of edge stripes for wide curb lanes, it adds that,

> "...where this has the potential for encouraging the undesirable operation of two motor vehicles in one lane, it may be preferable to place the edge stripe at the edge of the travel lane, provided that a 1.2 m wide "shoulder" space (approximate) would remain between the curb face and lane stripe" (p.18-42).

***Pedestrian and Bicycle Facility Scoping Guide*, 1995**
NYSDOT

The Scoping Guide is largely a synopsis of the NYSDOT *Highway Design Manual* guidelines and criteria used to facilitate decisions about the inclusion of bicycle and pedestrian facilities as components of roadway construction and improvements. In addition to meeting design criteria, selected facilities must be consistent with the projected cost and scope of an overall project, and be necessary or desirable at the project location.

For scoping on-street bicycle facilities, this guide refers to minimum design standards and guidelines from AASHTO and the NYSDOT *Highway Design Manual*, and also recommends use of wide curb lanes, standard bike lanes, shared lanes and roadway shoulders.

New York City Documents

New York City Bicycle Master Plan, May 1997
BND Program, Transportation Division
NYC Department of City Planning

The *New York City Bicycle Master Plan* was released by the NYC Department of City Planning as a comprehensive policy document for bicycling in New York City. The *Plan* contains specific recommendations for an on-street network, bridge access, off-street and greenway facilities, access to mass transit, and design guidelines. It was released in conjunction with a series of maps depicting a 900-mile on and off-street network for the five boroughs.

The *Plan* directly refers to both the AASHTO *Guide to the Development of Bicycle Facilities* and the *MUTCD* signage guidelines for facility design. Recommendations for on-street accommodation of bicyclists emphasize the installation of bike lanes, although the use of wide curb lanes, shoulders and shared roadways are also noted.

Recommended bicycle lane widths are consistent with both AASHTO and NYSDOT guidelines:

- overall; 4-foot minimum bicycle lane width requirement for all situations;
- with parking; 5-foot bicycle lane on an urban street between a motor vehicle lane and parking lane (no bicycle lane recommended *between* a curb and a parking lane);
- with parking; 12-foot minimum curb lane for combined bicycle travel and motor vehicle parking;
- no parking; 4-foot minimum bicycle lane between motor vehicle lane and the curb face;
- no parking; 4-foot minimum bicycle lane between traffic lane and roadway shoulder (on a highway without curb or gutter);
- no parking; 12-foot minimum and 14-foot (or more) preferred wide curb lane accommodating both cyclists and motor vehicles.

The *Plan* also briefly describes AASHTO recommended movements for cyclists at intersections. Cyclists proceeding straight through intersections are typically allowed to cross the path of motorists turning right, and intersection design that encourages these crossings in advance of the intersection in a merging fashion are preferable to those that force the crossing in the immediate vicinity of the intersection. Left-turning cyclists are generally permitted to turn either as a vehicle (in traffic) or as a pedestrian (following crosswalks).

Finally, the *Plan* briefly highlights selected innovative on-street facilities:

Pigmented bicycle lane: used to reinforce the exclusivity of use of the bicycle lane by cyclists, reduce vehicle speeds by creating the impression of a more narrow roadway, and discourage motor vehicle parking in the bike lane.

Center median bike lane: a lane adjacent to the center median of a roadway (far left side of a travel direction). Use of these lanes can sometimes reduce the number of conflicts between bicycles and motor vehicles, as bicyclists are not forced to cross the path of right-turning vehicles.

Shared bike/bus lane: recommended as a 14 to 16-foot wide curb lane on roadways with peak bus headways of 1.5 to 2 minutes, limited right-turn movements, prominent sign and pavement markings and consistent enforcement.

Contra-flow lane: a one or two-way bicycle lane located adjacent to a one-way motor vehicle lane. This alternative allows cyclists to ride against oncoming traffic and is therefore contrary to the “rules of the road.” These lanes are often recommended to provide direct access on routes that have few intersections, where cyclists can merge into typical traffic flow, and where a substantial number of cyclists are already using the roadway in a contra-flow direction. The design of contra-flow lanes may include some form of physical separation or buffer zone.

“Bicycle-exclusive” signal phase: adjusts timing of motor vehicle signal to allow adequate time for cyclists to cross two or more lanes of traffic. Signal phase is activated by pushbuttons or metal detection loops embedded in the pavement.

Advanced stop line/box: bicycle-only stop line or box placed in front of motor vehicles at signalized intersections to give cyclists a head start to make turning movements across multiple lanes of traffic.

Separated or raised bicycle lane: "on-street" bicycle lane physically separated from motor vehicle lanes through the installation of unit paver safety strips or rubberized curbs, or construction of bike lane on a slightly raised path on a mountable curb.

Curb separated bicycle lane on Sixth Avenue
Source: NYCDOT

In 1980, a curb separated bicycle lane was installed on Sixth Avenue in Manhattan, and removed within several months. This installation is cited by the *Masterplan* as a lesson on the "... importance of designing a site specific facility." By locating a new, protected right-of-way on one of the city's most heavily used pedestrian corridors, the lane became more a refuge for street vendors than cyclists.

Traffic calming devices: changes to the physical street geometry and design used to reduce the amount and speed of motor vehicle traffic. These include speed tables (elongated speed bumps), traffic circles, chicanes (navigable barriers), bicycle boulevards (on which barriers prevent through movement of motor vehicles but allow clear bicycle access), and slow streets (a concentration of various traffic calming devices heavily signed to prioritize non-motorized traffic).

***Bicycle Blueprint,* 1993**
Transportation Alternatives

In 1993, Transportation Alternatives (a local cycling advocacy group) released its *Bicycle Blueprint: A Plan to Bring Bicycling Into the Mainstream in New York City*. This plan presented a comprehensive bicycling agenda, including recommendations for improvements to the physical infrastructure, "on the job" cycling, security, accident prevention and bicycle education.

Specific and extensive suggestions for short and long-term on-street design improvements contained in the *Blueprint* (pp.37-38) include:

- Pigmented and texturized bike lanes;
- Painted lines delineating bike lanes several inches wider than regular lane stripes (e.g. 4-inch v. 6-inch wide);
- Replacement of diamond markings with bicycle profile stencils;
- Upgrade of existing signage (additional signs and signs directing cyclists to bicycle lanes from adjacent streets);
- Bike lanes continued through intersections using dashed lines ("pegga tracking");
- 5-foot or wider lanes between sidewalks and parking lanes;
- 5-foot or wider lanes next to center islands or medians on two-way routes;
- 5-foot or wider curbside lanes displacing on-street parking lanes;
- Bicyclist waiting areas in front of motor vehicle stop lines (e.g. advanced stop box);
- Slightly raised bicycle lanes across intersections without traffic lights (speed hump);
- Grade separated curbside bicycle lanes (with mountable curb);
- Curbside or median bike lanes with no grade separation from motor vehicle lanes, with a line of paving stones or other tactile visual and boundary markers.

In addition to design suggestions, the *Blueprint* also offers a list of specific recommendations for improvements to the street network. More general proposals included in the plan are pilot traffic calming projects, experimentation with lower speed limits, a gradual elimination of taxi cruising, and the removal of street surface hazards, including temporary steel construction covers and raised or lowered catch-basin covers problematic for cyclists.

***Bikeway Planning and Policy Guidelines for New York City*, May 1978**
NYC Department of Transportation (NYCDOT)

New York City's first comprehensive report on bicycle planning included broad policy recommendations and a skeletal framework for what later became the BND's recommended 550-mile on-street network. This 1978 document was released two years prior to uniform AASHTO guidelines, and recommended a minimum bicycle lane width of 3 1/2 feet, and a preferred width of 4 feet or more.

LITERATURE SEARCH

In the past decade, information on national and international bicycle planning and design guidelines, including on-street facility innovations, has been well-documented. Few attempts, however, have been made to incorporate innovative facilities into the NYC bicycle network.

Scope of the literature search

The literature search performed for this report does not provide a comprehensive update of bicycle policies and programs well-documented in other reports. Rather, it is a selective case study review of national and international on-street innovative cycling facility *implementations*. Ultimately, experience learned from cycling implementations in other places will be used to make recommendations for similar facilities in New York City.

Although this study focuses on innovative facilities in other U.S. cities, it is also an attempt to catalogue innovations seen in other parts of the world. National testing of international cycling facilities is likely to continue as planning for cycling becomes more pervasive in the United States, particularly with increased levels of funding available through TEA 21. Larger international cities (including London and Munich) experience high volume traffic conditions similar to those found in New York City.

The literature reviewed in this report was collected by reaching out to a wide number of national and international cycling programs. Outreach focused on large metropolitan areas somewhat comparable to New York City, in addition to cities with a reputation for innovative cycling programs.

Implementation in the U.S.

Written information was received from over 30 United States city-based cycling programs; phone interviews were conducted with 18 state and local bicycle program coordinators and planners (Appendix C).

Information received from these sources show that the majority of current on-street (Class II) bicycle facility planning work being done in the United States is the implementation of standardized bicycle lanes (5 to 6 feet wide) on streets where one or more lanes of motor vehicle travel or parking had been removed or narrowed. Examples of innovative on-street (Class II) facilities, the focus of this report, were less prevalent. In addition, these types of facilities rarely received formal, written evaluation.

International research

The international literature seach conducted for this study reached out to a total of 12 countries. The best responses were those from countries with well-established cycling programs and high levels of ridership, including Germany, Great Britain, Denmark, Finland, Japan and The Netherlands.

Many facilities about which written information was received were implemented as part of larger, national campaigns to promote cycling and walking as alternatives to automobile use. This national prioritization of improved cycling facilities was often reflected through a broad range of facility implementations, extensive evaluation of those facilities and overall safety research.

International case studies contained in this report are meant to compliment the survey of national case studies in two ways: (1) to broaden the scope of facility innovation seen in the U.S. to date and (2) to supplement evaluation and safety data not yet available for national implementation of comparable facilities.

United States

As network and policy planning for bicycles in the United States has expanded, a number of cities have implemented innovative on-street facilities. These facilities are used to serve cyclists more safely in locations where standardized facilities (AASHTO recommended) are not easily implementable or desirable.

Facility implementations focused almost exclusively on creating safe interaction between cyclists and vehicular traffic, without significant disruption to overall traffic flow.

Following is a brief description of many of these prototype facilities, listed first by facility type and then by city (also see pp. 7-8 for descriptions of facility types given by the *New York City Bicycle Master Plan*). Facilities are grouped into three categories:

- **Intersection treatments**
- **Improvements to standaridized facilities**
- **New roadway accommodations**

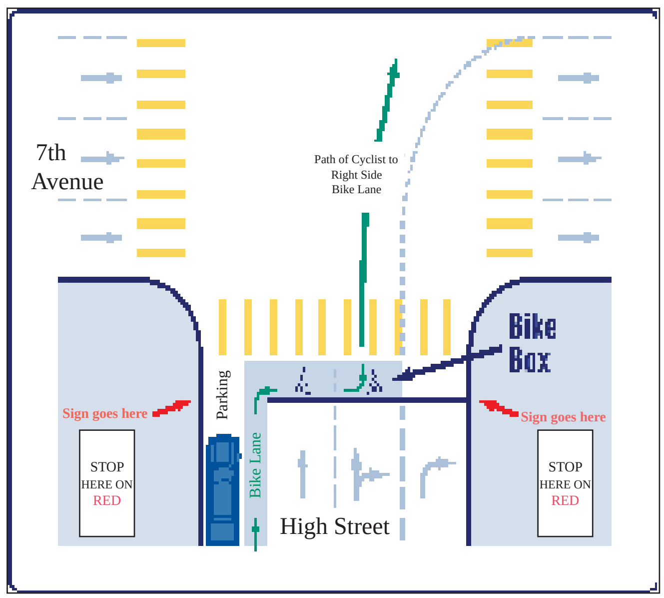
Evaluation, enforcement and public awareness issues specificly linked to innovative facility implementation are also noted.

INTERSECTION TREATMENTS

Advanced stop box

Eugene, OR

In Eugene, an advanced stop box, or "bike box," was installed in spring of1998 on High Street at Seventh Avenue, a busy intersection in downtown Eugene. An advanced stop box is similar to an advanced stop line, and allows cyclists to wait ahead of motor vehicles at signalized intersections to create safe and effective through movements.



Bicycle box design at High Street, Eugene OR
Source: City of Eugene web site

Eugene's bike box on High Street (a one-way street) allows cyclists to move from a left-side bike lane with parking into a protected zone at the head of the middle traffic lanes when the signal is red. Then, when the signal changes to green, cyclists can proceed through the intersection ahead of motor vehicles and safely switch to the through bike lane on the right-hand side of the street after the intersection.

The box is not meant to be used when the signal is green. Signs indicate that traffic, except bikes, should stop prior to the box at a red signal ("stop here on red except bikes").

Using the bike box, cyclists are placed ahead of other traffic and have the right-of-way as they ride through the intersection. Because cyclists generally are able to accelerate quickly through the intersection and because vehicles are not allowed to turn on red at that intersection, the new safety box is not expected to significantly delay or inconvenience motorists.

Before the bike box was in place, cyclists continuing through the intersection (using the left-side bike lane) were forced to make a left turn at the following intersection. Cyclists wishing avoid this left turn had to either find a gap and cross two lanes of through traffic, or dismount and use the crosswalk with pedestrians.

Preliminary evaluation of this facility by the City of Eugene's bicycle program has found that the box creates a safe bicycle route for commuters, which is "exactly what [it] is intended to provide." A description of the box and accompanying diagram can be accessed through the City's web site at www.ci.eugene.or.us.

Formal evaluation of this facility is currently being performed by the University of North Carolina Highway Safety Research Center (HSRC). Cyclists traveling through the intersection have been videoptaped before and after placement of the box. One measure of effectiveness is to ascertain if cyclists use the box and if the box is used correctly. Another is whether motor vehicles encroach into the box. Conflicts between bicycles and motor vehicles will also be examined. This evaluation will be completed near the end of 1998, and published after FHA review.

Cambridge, MA

Cambridge recently installed a bike box at an atypical intersection where cyclists need to access a left-side bike path entrance from a right-side bicycle lane. The box allows cyclists stopped at the intersection to move in front of traffic to make a quick left turn onto the path without confusing or conflicting with motor vehicle traffic not allowed to make the turn.

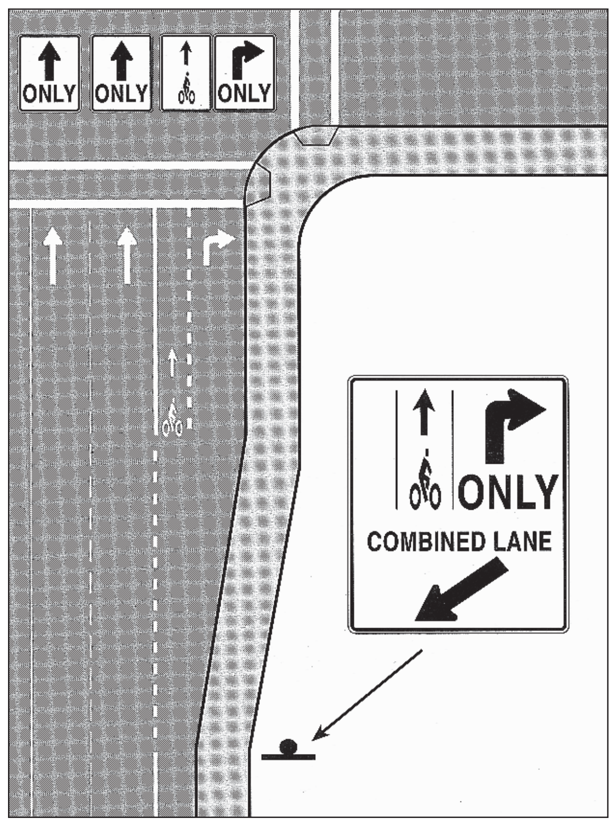
This facility is described as highly successful by the city's bicycle program, but has received only informal visual evaluation. Future steps under consideration for the intersection include the addition of a dedicated bike signal to allow cyclists to make the left turn from the box more easily.

Combination turn lane

Eugene, OR

In addition to its advanced stop box, Eugene has installed a 12-foot shared right-turn lane at several intersections on 13th Street. The design is innovative in the way that it deals with limited right of way in the right turn area, which leaves insufficient room to mark a bike lane to the left of the vehicle right turn lane.

At the intersection, a 5-foot bike lane along the right side of 13th Street converts to a 5-foot bike pocket. This leaves only 7-feet for motor vehicles next to the bike pocket.



Combination turn lane configuration and signage. Source: Oregon Bicycle Master Plan

It had been assumed that motor vehicles and bicycles would tend to queue behind each other with the limited space, but this appears to happen only when trucks, buses, or other large vehicles are in the space. Cars and bicycles usually ride next to each other.

Preliminary videos recorded for an evaulation of this installation by the University of North Carolina HSRC indicate that this happens quite safely. The HSRC evaluation will be completed for FHA review at the end of 1998, after which a report will be published.

IMPROVEMENTS TO STANDARDIZED FACILITIES

Pigmented bicycle lane

Blue pigmented bicycle lane in Portland, east end of the Broadway Bridge (eastbound at Larabee). Source: City of Portland bicycle web site

Portland, OR

In an effort to reduce conflicts between bicyclists and motor vehicles, the City of Portland has installed a test of blue pigmented bicycle lanes. The test lanes are intended to increase motorists' awareness that it is illegal to drive and park in bike lanes, and of their need to yield to cyclists when crossing a bicycle lane to turn right or get into a right-turn only lane. The painted area and its accompanying signs are also intended to caution cyclists to be careful in the conflict area.

Initially, the city selected a dozen conflict areas about which motorists and cyclists had complained. From these, seven sites were chosen for evaluative testing. In each case, the conflict area had already been defined with dashed lines, in addition to signs indicating the need for motorists to yield to cyclists.

A blue color was selected based on research of European techniques to reduce conflict; blue pigmentation was found to be the most promising, cost-effective technique to delineate a conflict area.

The city has partnered with the University of North Carolina HSRC to evaluate the efffectiveness of the blue lane test areas. Each intersection was videotaped and analyzed before and after painting, and a report will be submitted for FHA approval at the end of 1998.

Portland is one of the few cities surveyed (in addition to Eugene) to have made information about its bike lane installations widely available. Approximately six pages of information about the test lanes are available from the City of Portland's Bicycle Program web site, which can be accessed through the City's web site at: www.trans.
ci.portland.or.us.

Alternate paving materials

Tucson, AZ

One of the most well-researched examples of the use of alternate paving materials for bike lanes is the Mountain Avenue demonstration project in Tucson. This project involved the construction of new bike lanes, sidewalks, street lighting and landscaping for 3 miles along Mountain Avenue, from Speedway Boulevard to Grant Road. Mountain Avenue is a collector street, linking the University campus with residential neighborhoods to the north, and receives heavy automobile, bicycle and pedestrian use.

To accommodate cyclists, the project featured 6-foot bicycle lanes (one in each direction) constructed of concrete, next to a 3-foot buffer lane constructed of dark brown precast concrete pavers. The roadway is constructed of asphalt, and the contrast created between the three lanes, bikeway, buffer and roadway, creates a clear division of space between cyclists and motorists.

A detailed evaluation of the demonstration project was performed by Tucson's Department of Transportation in 1992, which surveyed 1,035 residents living near the project to determine travel behavior, changes in corridor use patterns and general perceptions on user safety. Of the 416 respondents,

- 74% used Mountain Avenue five or more times per week;
- 86% regularly used Mountain Avenue as a motor vehicle operator;
- 87% agreed that the improved roadway is safer for bicyclists;
- 85% agreed that the improvement is safer for pedestrians;
- 73% agreed that the volume of bicycle use has increased as a result of the improvements;
- 34% agreed that the volume of motor vehicle use had increased.

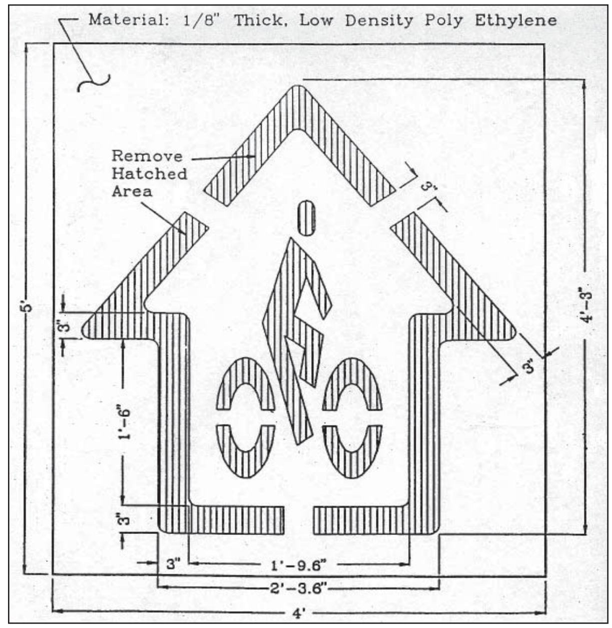
Improved striping and marking

San Francisco, CA

On streets where Class II facilities for cyclists are not continuous, San Francisco has created specialized roadway stencils to increase motorists' awareness of a shared roadway. Although stenciling does not provide an area for the exclusive use of cyclists, this program is included in the scope of the report for its role in creating specialized connectors for Class II facilities.

Green pavement stencils are placed every 200 feet on the outside traffic lane of designated streets, 11 feet from the edge of a curb with parking (3 feet if parking is not allowed). Recently, the city performed a "door zone" survey (of opened car doors) to provide justification for these dimensions. Priority placement for stencils is on segments of Class II routes where bike lanes are discontinuous.

San Francisco's stencils are intended to delineate the right-hand travel corridor that bicyclists will likely use, reinforce the correct direction of travel, and educate bicyclists and motorists of bicyclists' need to ride away from the "door zone" to minimize the risk of being struck by opening car doors, particularly on narrow roadways.



Green pavement stencil used to delineate bikeways. Source: City of San Francisco Bicycle Program

Chicago, IL

The city of Chicago plans to implement fifteen miles of new or improved bike lanes in its downtown area with several enhanced features:

- A second pavement marking line wherever the bike lane is beside parking, to distinguish the bike lane from the parking area;
- A more reflective, longer lasting and less confusing bike pavement marking;
- A special "Share the Road" pavement marking wherever a bike lane cannot be provided, to remind motorists of the priority bike route (similar to stencil pictured above);
- Taper lines and signs to advise motorists wherever two lanes of traffic narrow to one;
- Poor sections of pavement repaved before the bike lane is striped.

Spot Improvements

Seattle, WA

Beyond routine roadway maintenance, Seattle is one of the few cities with a program specifically designed to address public requests for low-cost improvements benefitting cyclists. The “Bike Spot Safety Program” solicits public information through a “Citizen Bicycling Improvement Request Form” distributed to bike shops, community centers and bicycle club publications. Individuals provide the location and nature of a roadway problem, as well as their name, address and phone number.


Citizen Bicycling Improvement Request
City of Seattle Bicycle Program

The Bike Spot Program makes low cost improvements to enhance bicycle safety and access.
We do maintenance work, signs and striping, and small construction projects. Almost anything is possible!

Location: Roadway Name
Landmarks: (cross street, # of feet from curb, address). Be specific!

Description of Problem: (What is it, and why is it a problem)

Reported by: Name
Address
Day Phone
Zip
Date

Return to: Seattle Engineering Bicycle Program, Room 708 Municipal Building, Seattle, WA 98104
For further information, call 684-7584

Source: FHA Best Practices Report (1998)

When the form is received by the city’s bicycle program, staff assess the request and call the person who filled out the form to let them know that: (a) the problem will be fixed; (b) the problem needs further investigation; or (c) the problem is something that the bike spot program cannot address. In all cases, the citizen knows about how long it will take to respond to their request.

After a field check is performed (if necessary) and a work improvement is approved, a work instruction is sent electronically to the appropriate City crew who do the work, and then notify the bicycle program that the work has been completed. Bicycle program staff then call the citizen who originally made the request to complete the loop.

Seattle’s Bicycle Program regards Bike Spot Safety as,

> “...the single most important program we administer. Citizens appreciate the quick turn-around on the initial phone call. The program is popular with elected officials and other decision makers since it generates thank you letters and phone calls. Finally, it helps the City defend itself against liability claims since we can demonstrate that we have a safety program that quickly responds to maintenance concerns.”

The program works with existing maintenance programs that pay for many of the bike spot projects (e.g. pothole requests). However, new facilities are directly paid by the bike spot program at a cost of approximately $500,000 to $700,000 per year.

NEW ROADWAY ACCOMMODATIONS

Bicycle/bus lane

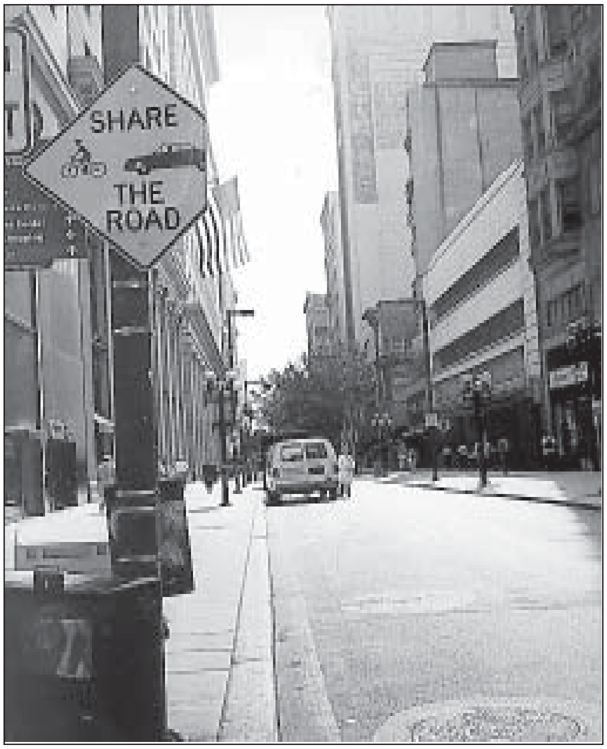
Philadelphia, PA

Philadelphia is implementing an 11-foot bicycle/bus lane in its Center City district. The shared lane will run from 6th to 18th Streets on Chestnut Street (one-way) as part of an effort to reintroduce motor vehicle traffic to a former pedestrian mall.

Currently there are two lanes on Chestnut Street on which vehicle traffic is prohibited from 6am to 7pm. This restriction does not apply to delivery trucks, service trucks, buses and hotel shuttles with permits. Delivery trucks are able to stop and unload in the left lane, the right lane is dedicated to bus traffic, and bicyclists travel where space is available.

Wide and distinctively paved sidewalks on the street will be narrowed to create three lanes. A right-hand 11-foot shared bicycle/bus lane will be next to a center 10-foot motor vehicle lane, then a left-hand 7-foot parking lane.

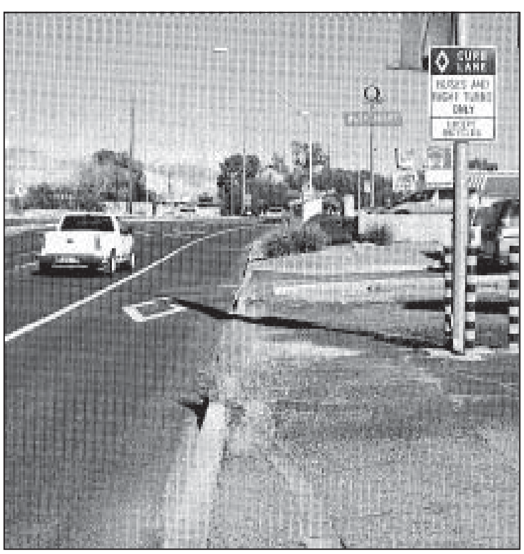
These lane widths are consistent with lane widths on an increasing number of bike lane streets in Philadelphia striped with 7-foot parking lanes and 10-foot travel lanes. Transportation planners have cited the beneficial traffic- calming effect created by the narrowed travel and parking lanes, in addition to more mangeable pedestrian crossing distances.



Current (July 1998) configuration on Chestnut street, Philadelphia (to be converted to bicycle/bus use).

Tucson, AZ

Tucson began implementing bicycle/bus lanes in 1986. The lanes accommodate cyclists and the fixed route transit system (Sun Tran), and are also utilized as right turn lanes for vehicles. No accidents have been reported as a result of these lane installations.



Tanque Verde Rd. bicycle/bus lane (in Tucson).

A Bicyclist Advisory Committee (with members appointed by the mayor and city council) has played an active role in the operation of the lanes by the transit authority, providing training information for bus drivers about cyclists in the roadway.

Contra-flow bicycle lane

Minneapolis, MN

In the past several years, Minneapolis has installed some of the most innovative on-street contra-flow bicycle lanes in the country. One such lane exists on Hennepin Avenue, a commercial street which runs through Minneapolis' central business district .

The Hennepin Avenue bicycle lane runs for a total of 10 blocks, beginning as a one-direction contra-flow lane.

Contra-flow lane on Hennepin Avenue at 2nd Street, looking south (lane begins at 1st Street).

After 2 blocks, the lane widens to beome a 10-foot wide *bi-directional* bicycle lane with a 1-foot buffer on each side, and continues for approximately 10 blocks. The lane is located between a 12-foot south bound (contra-flow) bus lane and three lanes of north bound automobile traffic (variable widths). The bicycle lane is seal coated in a red quartz; traffic and bus lanes are treated with black seal coat. One lane of automobile traffic was removed to create the bicycle lane.

Bi-directional contra-flow bicycle lane on Hennepin Avenue between 4th and 5th Streets, looking south.

Primarily because Hennepin Avenue is a highly trafficked route (25,000 cars/day), initial concerns were raised about the safety of the new bicycle lane. Of particular concern was the high percentage of northbound automobile traffic making left turns on 5th and 3rd Streets to access a nearby freeway, requiring drivers to look in two directions for oncoming cyclists.

Left-turn treatment on Hennepin Avenue at Washington Avenue, looking north.

Instead of prohibiting vehicle turns along the bicycle path, however, signs were installed to alert motorists to cycling movements ("Left turns yield to bikes"), giving cyclists the right-of-way.

The Hennepin Avenue bike lane is seen as a successful installation by city officials, improving conditions for cyclists without resulting in increased bicycle or vehicle accidents or negatively impacting high volume traffic flows.

However, the Hennepin Avenue lane has been met with mixed review from some cyclists, who cite abrupt endpoints which leave them mid-traffic at intersections. In addition, cyclists uncomfortable riding in traffic may prefer to use Nicollet Mall, a pedestrian street parallelling Hennepin Avenue one block east.

Additional contra-flow bicycle lanes are scheduled for implementation in downtown Minneapolis in Summer 1998, on Marquette and 2nd Avenues. These streets make up a one-way pair located two and three blocks east of Hennepin Avenue (past Nicollet Mall).

Similar to Hennepin Avenue, these contra-flow lanes will be located between a southbound (contra-flow) bus lane and three northbound motor vehicle lanes. Each bicycle lane, however, runs in one direction only (with buses).

Presidio, San Francisco, CA

A recent demonstration project run by the National Park Service at the Presidio is a bi-directional (contra-flow) bicycle lane with special signage. The bicycle lane is a 1000-foot long test facility on a one-way park street. The right-hand bicycle lane is 5-feet; the bi-directional left lane is also 5-feet. A 4-foot striped and reflectorized buffer separates that lane from motor vehicle traffic.

Signs posted along the route indicate special turning allowances for bicycles, exempting them from motor vehicle restrictions with the statement, "except for bicycles." Park police were initially uncomfortable with the lane, in part because of its location at a conversion from a two to a one-way street. The demonstration, however, has not resulted in any increase in bicycle or motor vehicle accidents.

Madison, WI

Madison has a 12-block contra-flow bike lane on University Avenue (from Bassett St. to Babcock Dr.), which was created from a converted contra-flow bus lane in 1984. The lane is central to the University of Wisconsin campus in Madison, and is used by over 3,000 commuters each day. No real increases in accident rates, however, have occurred along the avenue.

To help prevent conflicts between cyclists and left-turning vehicles (across the bicycle lane) at several of the avenue's busiest intersections, advanced red lights have been installed for the bike lane. These halt contra-flow bicycle movements while a longer green light allows cars to make left turns (to keep automobile traffic moving through the intersection). Regulatory signs for motorists have also been installed at several of these intersections which read, "Left turn yield on green to bikes."

Arthur Ross, the Bicycle Coordinator for the City of Madison, recommends the use of contra-flow lanes in special circumstances, particularly on streets with few crossings (outside of a traditional street grid).

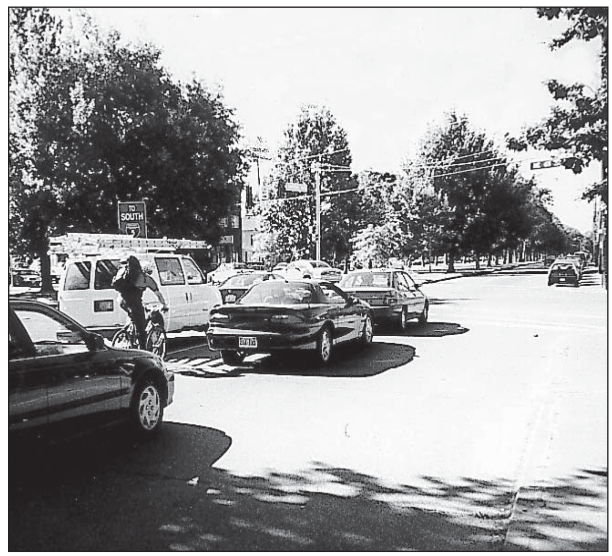
Seattle, WA

Seattle currently has two 5-foot contra-flow bicycle lanes. Each lane runs a length of two blocks, and was implemented in the late 1970's to create site-specific access.

Contra-flow bicycle lane on N. 34th St. at Evanston Ave., facing east.

Although no extensive evaluation of these lanes has been performed, neither has resulted in increased bicycle or motor vehicle accidents. Peter Lagerwey, the Bicycle and Pedestrian Coordinator for the City of Seattle, recommends the use of contra-flow lanes as access connectors (to other on-street facilities or destinations) for a length of one to three blocks. These lanes are also recommended for use on blocks without on-street parking, with a minimum number of driveway crossings.

Center-median bicycle lane



Center-median lane located on Ravenna Blvd. at NE 65th (Seattle) places cyclists between a vehicle left-turn lane and through lane at major intersections.

Seattle, WA

Seattle has had a center median bicycle lane since the late 1970's. The lane runs for approximately two miles, and is located next to a 100-foot wide median. The lane is widely considered a success, although the unusual circumstances of its placement have not led to recommendations for similar lanes elsewhere in the city.

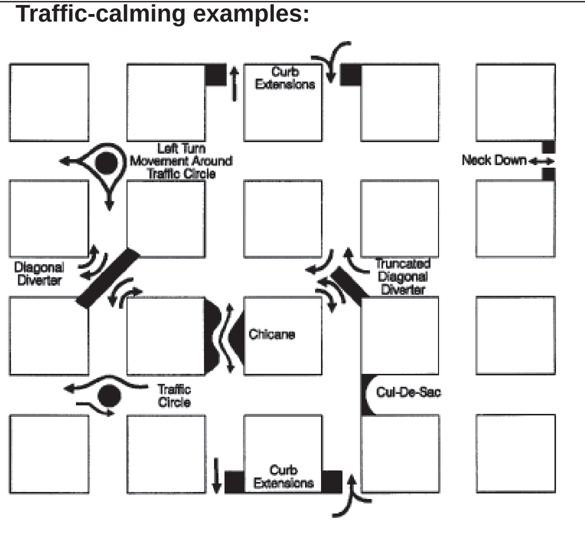
As with Seattle's contra-flow lanes, Peter Lagerwey recommends center median lanes for use on continuous roadways with few turning movements. Intersections where motor vehicles make left turns through the median should be handled similarly to intersections where cyclists using a right-side bicycle lane face right turning motor vehicles (AASHTO recommended). To accommodate a left turn:

- the center median (left side) bike lane ends before the intersection;
- a short space exists where cyclists merge right as vehicles move into the far left turning lane;
- a dedicated through bike lane picks up again through the intersection (to the right of the vehicle turning lane).

Traffic-calming techniques

Traffic-calming implementations are used to reduce the amount and speed of vehicle traffic, generally benefitting both pedestrians and cyclists. Examples of traffic-calming techniques include traffic circles, raised crosswalks (speed tables), and chicanes (obstacles that interrupt roadway alignment), and are described in the *New York City Bicycle Master Plan* (referenced on p.8).

Traffic-calming examples:



Source: NYC Bicycle Master Plan

A number of traffic-calming programs have been successfully implemented throughout the United States, including those in Seattle, WA and Cambridge, MA. Although traffic calming often creates safer traffic conditions, some facilities pose potential hazards for cyclists without careful installation. Speed bumps and raised reflectors or rumble strips, in particular, can deflect a bicycle wheel, causing a cyclist to lose control. Placement of these facilities which leaves an open path along the edge of a roadway for cyclists to use, or the use of speed tables instead of bumps (with a more gradual incline) could create safer conditions for cyclists. In addition, proper maintenance of these facilities is needed to ensure that roadway barriers do not increase the amount of debris collected on the sides of roadways where cyclists typically ride.

For these reasons, specific examples of traffic calming installations sought for this literature review were those (1) specifically used to accommodate cyclists on a roadway or (2) evaluated specifically for cyclists.

Bicycle boulevard
Palo Alto, CA

A bicycle boulevard is a street upon which bicyclists have precedence over automobiles, through the installation of barriers which prevent through movement of motor vehicles. It is important to note that these facilities do not deny or reduce access to residents and their cars, but simply prevent them from being used as a cut-through by commuters or other users.

The Bryant Street Boulevard in Palo Alto is a 3-mile residential street that parallels two major arterials and connects south Palo Alto to the Downtown north city limits. The first 2 miles of Bryant Street were converted into a bicycle boulevard in 1982. In 1992, the city extended the boulevard 1.25 miles north to the city limit, first with temporary barriers (6 months), then with permanent fixtures.

Improvements to Bryant Street included:

- Elimination of nine (of thirteen) stop signs to reduce travel time for bicyclists;
- Two street closures passable only by bicycles installed to create a discontinuous route for motor vehicles;
- Two pedestrian/bicycle bridges over natural (creek) barriers;
- Traffic signals for bicyclists installed at Embarcadero Road, a major arterial, to provide protected crossing phase for bicyclists, but not motor vehicles;

- One traffic circle installed as a traffic calming measure in the neighborhood just south of Downtown;
- Cross street traffic controlled by stop signs.

No striped bike lanes were necessary on the street, and no changes in on-street parking were made. Evaluations of the boulevard show it to be highly successful: bicycle counts exceed 600 bicyclists a day at various points along the route. Vehicular traffic volumes range from 200 to 2000 ADT at various points.

Concerns of nearby residents that traffic would be diverted from Bryant Street to adjacent streets prompted the city to put a traffic circle in one intersection to slow motor vehicles instead of block them. This compromise won the support of many local officials in addition to residents.

From its experience, the City of Palo Alto recommends the use of temporary fixtures during trial periods to improve bicycle boulevard design and gain public acceptance for it. The City also recommends residential streets flanked on both sides by arterial streets as the best candidates for bicycle boulevard installation.

International

A survey of international on-street cycling facilities was conducted for this literature review to broaden the scope of innovative facility types seen in the United States. Countries with well-established cycling programs, including Germany, Great Britain, Denmark, Finland, Japan and The Netherlands, were most responsive to requests for written materials.

Overall, information received from these countries reflects a higher level of bicycle facility innovation and evaluation than seen in the United States to date. In many countries, however, the need for facility innovation was secondary to a need to expand the network of conventional bike lanes and facilities.

Of the available case studies of innovative facilities, those contained in this report generally include specific guidelines and dimensions for implementation, as well as formal evaluation. A number of these installations were specifically designed to create safe interaction between cyclists and pedestrians in the roadway, *in addition to* safe interaction between cyclists and vehicular traffic.

As with the previous section on national case studies, a brief description of international innovations are listed first by facility type, then by country.

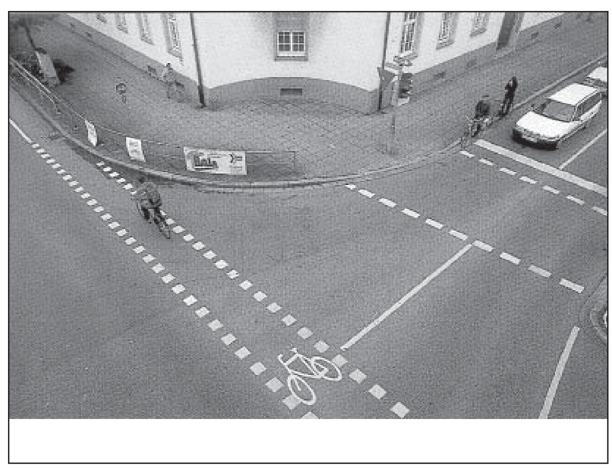
INTERSECTION TREATMENTS

Crossing-area markings

Denmark

To draw attention to the potential conflict between cyclists and cars at signalized intersections, Denmark (and other European countries) commonly use three different types of bicycle areas at intersections: minimum, left-hand edge, international and blue surface. Bicycle pavement symbols are generally marked with each type of treatment.

Minimum cycle crossing:
The cycle crossing is marked with a broad, broken line extending to the separation between opposing traffic lanes of the intersecting roads. If the width of the roadway of the intersecting road is less than 5.5 meters (18 feet), the line should extend completely through the intersection. Only the left-hand edge of the bicycle lane should be marked, with a line of 50 cm (20 inch) long and 30 cm (12 inch) wide markings. The strokes of the line must be of equal length. The width of the cycle crossing is often the same as the bicycle lane which is interrupted.



Broken line cycle crossing at a junction in Freiburg (Germany). Source: Cities Make Room for Cyclists

Left-hand edge/international cycle crossing:
At complex junctions, both a left and right-side wide, broken demarcation line are used straight through the intersection. Where the right-hand edge of the crossing is bounded by another marking (e.g. a pedestrian area or give-way

line), the broken line at the right-hand edge can be omitted.

Blue surface crossing:
Blue pigmentation is used to define the crossing area, often in combination with a broken left-side demarcation line.

Blue pigmented crossing in Odense (Denmark), used in conjunction with a left-hand broken line marking. Source: Cities Make Room for Cyclists

A blue surface (including cycle symbols) is the most visually powerful type of marking. This type is normally used at junctions where there are many cyclists and/or high safety risks for cyclists. The visibility of the other types is lower; these are used in junctions with lower volumes and accident rates. Blue surfaces at cycle crossings are used most often in Copenhagen, although the three other types of crossings have been implemented throughout Denmark.

Each type of cycle crossing is intended to increase drivers' attentiveness to cyclists and show how far it is possible to drive into the intersection without conflicting with them, especially during right-hand turns. The separation of road users from one another also helps "control" the behavior of cyclists at an intersection.

A Danish study concluded that the safety of cyclists at intersections increased with cycle crossings. Traffic accident studies showed a decrease in the number of personal injuries with the use of demarcated cycle crossings, and a 57% decrease in the number of serious injuries.

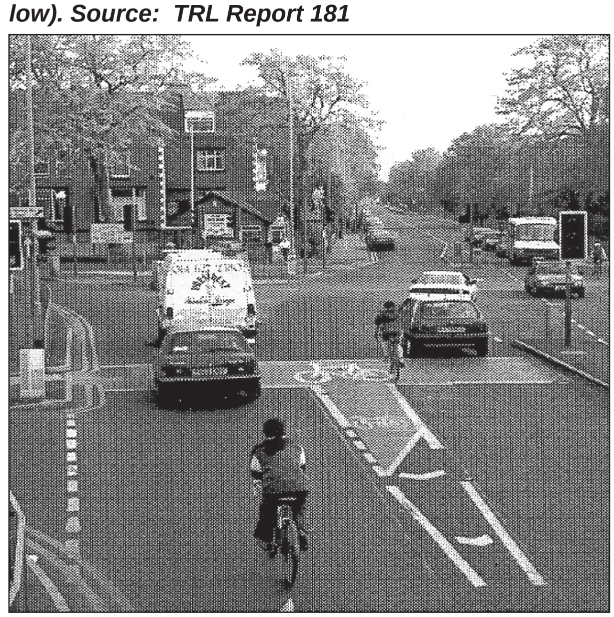
A comparison of the the different types of cycle crossings showed that the blue markings have the best effect on safety. Crossings marked with a 30 cm (12 inch) wide broken line showed no significant change in the number of accidents and personal injuries.

Advanced stop box

United Kingdom

In 1996, the Transport Research Library published a study (commissioned by the Department of Transport) on advanced stop boxes. The box allows cyclists to stop ahead of motor vehicles at signalized intersections, and includes a cycle lane approach located either (1) "nearside" (near the curb and most common) or (2) as a center lane approach:

Nearside lane (above); center lane approach (below). Source: TRL Report 181



Since the introduction of advanced cycling facilities in 1984, research work in the U.K. had established that they operated satisfactorily. This project expanded on previous reseach to:

- investigate the value of a non-nearside approach lane, with reference to the turning movements of left-turning motor vehicles versus "ahead" cyclists;
- assess the effect of different signal timings on the value of an advanced stop line.

These aims were explored with reference to the turning movements of cyclists and motor vehicles at intersections. It is important to note that because drivers in the U.K. regularly use the *left*-hand side of the roadway, turning directions should be applied to a U.S context accordingly (in the reverse).

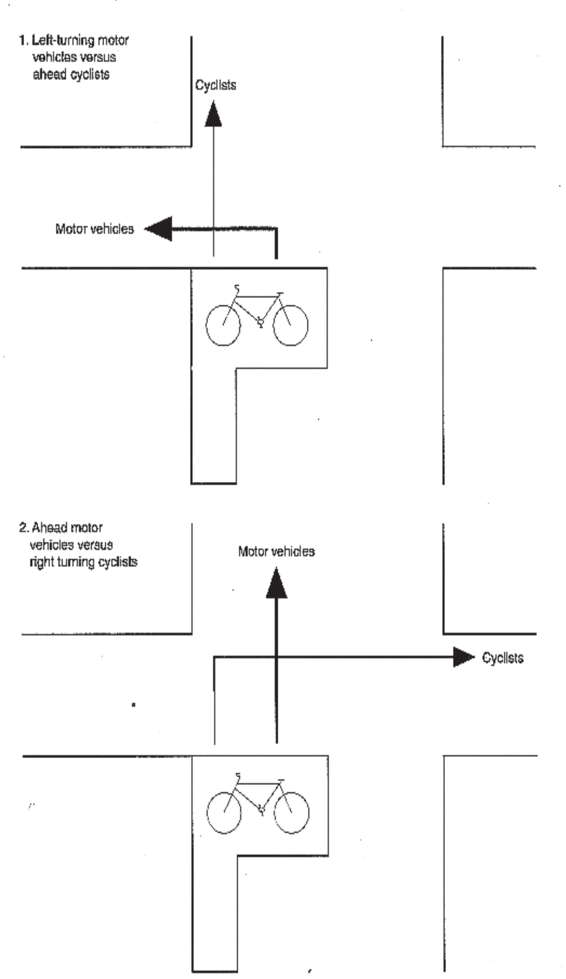


Fig. 1 Types of conflicting turning movements

Source: TRL Report 181

Video recordings were made at six sites with varying degrees of cyclist and motor vehicle flows. Sites at Manchester and Chelmsford, for example, had busy roads leading into city centers with high motor vehicle flows (665 and 661 per hour); a site at Cambridge (part of a main cycle route into the city centre) had almost as many cyclists as motor vehicles during the day.

From the film, cyclists' movements were coded approaching the junction, at the junction and making turning movements. "Conflicting turning movements" were recorded if either a cyclist or motorist was forced to do something other than a standard movement. Examples include being forced to stop, wait, brake or swerve while turning.

The results of the study were summarized under its two main aims of resesearch:

The value of a non-nearside approach lane:

- Although a large proportion of cyclists will use a nearside cycle lane approach to turn left or continue ahead, very few cyclists use the whole length of a nearside cycle lane to turn right. Instead, cyclists either tend to use part of the cycle lane and move before the reservoir, or ignore the cycle lane altogether (and remain in the all-vehicle lane).
- As vehicle flow increases, right-turning cyclists will use a nearside cycle lane less. This study suggests a threshold of 200-300 motor vehicles per hour. A central cycle lane could be an option if there are a sufficient number of cyclists making right-turns at an intersection;
- Central cycle lanes are useful at sites with more than one all-vehicle lane, a large proportion of left-turning motor vehicles and a large proportion of "ahead" cyclists;
- A central cycle lane performs the function of putting cyclists to the right of vehicles in an all-vehicle lane, usually a left-turn filter lane;
- There appears to be a relationship between the location of the cycle lane approach and the conflicting turning movements of left-turning motor vehicles versus "ahead" cyclists: more are occurring at sites with a nearside cycle lane approach than at sites with a central cycle lane approach;

- There are no apparent safety problems for cyclists entering a central cycle lane.

The effect of different signal timings:

- Cyclists benefit from advanced stop boxes when they arrive at an intersection on red, allowing them to cycle ahead of vehicles and position themselves in the reservoir;
- More cyclists arrive at an intersection when the signals are red in SCOOT mode. SCOOT (Split Cycle and Offset Optimisation Technique) is a sophisticated system where signal timings are constantly adjusted in response to traffic flows;
- Conflicting turning movements tend to occur more frequently for cyclists who arrive at the intersection when the signals are green;
- There does not appear to be a strong relationship between signal timings and the conflicting turning movements of "ahead" vehicles versus right-turning cyclists. These conflicting turning movements could be related to the way right-turning cyclists approach the stop box and their expectation of the signals at the intersection.

Additional recommended guidelines:

- It is preferable for the cycle lane and the advanced stop box reservoir to have a different surface coloring from the rest of the roadway. The cycle logo should be included in the reservoir. The cycle lane should ideally be at least 1.5 meters (5 feet) wide. An "anti-skid" material may also be of value;
- Advanced stop boxes can be installed at junctions with wide-ranging motor vehicle flows. In this study, motor vehicle flows were up to 8000 vehicles in one day (over 650 per hour at several sites);
- An advanced stop box layout which does not have a second signal head at the motorist stop line has proven to be as safe as the original layout, and cheaper to install.

Germany (Munich)

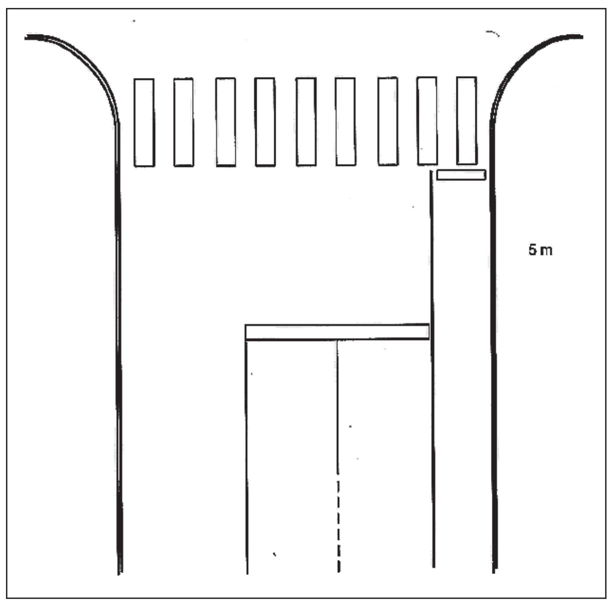
In Munich, advanced stop boxes are currently being considered for some locations but have not yet been widely implemented. The boxes allow cyclists to approach a traffic light in front of motor vehicles, and are used in combination with a separate signal to give them an advanced start to clear the intersection ahead of cars.

According to the Director of the Traffic Control Division of Munich, this type of bicycle facility is not recommended for use when the modal split of cyclists is low compared to that of motor vehicles. This is due to concern that the box will cause confusion and disrupt traffic flow if only a few cyclists are using it, especially throughout colder seasons.

Recessed motor vehicle stop line

Denmark

In 1991, the Road Safety and Environment Department of Denmark's Road Directorate launched a three-year research program to study the safety of cyclists in urban areas. In a study of signalized intersections with bicycle lanes leading up to the pedestrian crossing, vehicle stop lines were moved back by 5 meters (16.5 feet) relative to the cyclists' stop line (at the side of the roadway). It is important to note that unlike advanced stop boxes, the use of recessed stop lines *does not place cyclists directly ahead of motorists* at intersections.



Intersection layout with recessed stop line.
Source: Report 10, Road Directorate, Denmark

The underlying idea was to improve the visibility of cyclists, especially to vehicles turning right at the intersection, after both parties had been waiting at a red light. An assumption was made that recessed stop lines would also benefit pedestrians on the crossing, as pedestrians and drivers of vehicles would have a clearer view and more time in which to assess each others' intentions at signal changes. For motorists, it was determined that moving the stop line would not normally incur any extension of signal timing (see Appendix F).

Analysis was based on a comparison of all Type 312 accidents (a conflict between a right-turning vehicle and cyclist continuing straight through an intersection). Accidents included in the study occurred at the beginning of the green period at 30 intersections, before and after recessed stop lines were implemented.

A total of 382 accidents were studied; of these 28 were Type 312 accidents; of these it was possible to refer 11 to the start of the green period. Ten of these accidents were recorded before implementation of the recessed vehicle stop line (advanced cycle line), and only one accident was recorded after implementation.

Despite the limited amount of accident material available for this study, it was concluded that the recessing of vehicle stop lines increases the safety of cyclists at signalized intersections, where there are extended bicycle paths. This analysis is supported by a similar study conducted in Sweden, described below.

Sweden

A study of the effects of recessed stop lines conducted in Sweden used video recordings for analyses of four intersections. The study assumed that the beneficial effects of recessed stop line implementation included not only the safety of cyclists, but also reduced exposure to the exhaust fumes emitted by idling vehicles.

The results of this study showed that the average risk reduction was 35% per cyclist (measured as the reduction in the number of serious conflicts per cyclist). One inconvenience noted after implementation was that the time taken for vehicles to cross the junction increased by approximately one second.

Intersection redesign (bicycle lane with profiled markings)

Profiled marking intersection redesign (variation 1). Source: Report 10, Road Directorate, Denmark

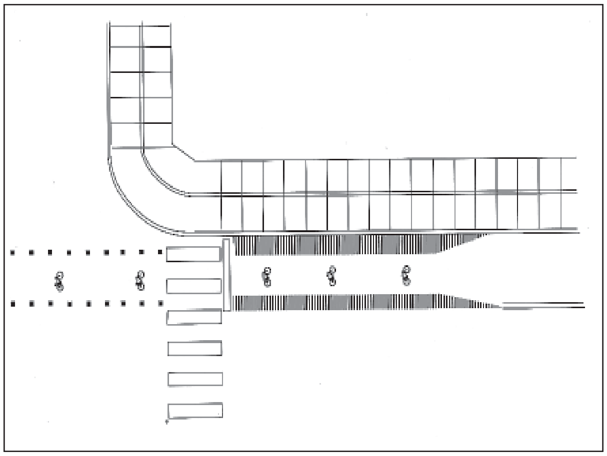
Denmark

Two new designs for cyclists at major, urban intersections which used profiled (slightly raised) markings were studied as part of the research program of the Danish Road Directorate. Both designs were tested at junctions where (1) a cycle path extended up to the pedestrian crossing and (2) at junctions where a cycle path was truncated, causing cyclists and vehicle traffic to share the right-hand turning lane.

Variation 1 (profiled markings)

A total of seven junctions were reconstructed for the first design variation, two of which initially had truncated cycle paths. The new design was intended to give cyclists an exclusive (but narrowed) area right up to the pedestrian crossing, to make cyclists and drivers more alert to one another's presence. Cycle paths which had previously been raised above the level of vehicle lanes were lowered to grade, and any curbs were removed 20 to 30 meters (66 to 99 feet) before the intersection. The width of the cycle area was reduced to between 1.1 and 1.7 meters (3.6 and 5.6 feet), and cyclists and drivers were separated from each other by a white line, 30 cm (1-foot) wide, implemented as a profiled marking.

At each intersection a cycle area (marked with cycle symbols) was laid through the crossing in either blue thermoplastic, or demarcated by two broken strips.



Profiled marking intersection redesign (variation 1). Source: Report 10, Road Directorate, Denmark

From video recordings made before and after reconstruction, the interaction between cyclists and right-turning drivers was analyzed as they approached the intersection. Only cyclists whose progress was not impeded by other cyclists, and who arrived at the intersections at the same time as a vehicle were studied. Interactions in which the cyclists and driver entered the junction without first being required to stop for a red light were recorded separately.

The difference in early and late interactions that occurred before and after the profiled lane was implemented was sought. Special attention was given to interaction on the part of drivers, as their alertness in relation to their duty to give way was considered highly significant to the safety of cyclists.

An interaction was considered early if a driver reacted visibly to the presence of a cyclist more than 1.5 seconds before passing the intersection point; an interaction was considered late if a reaction could only be seen less than 1.5 seconds before passing the conflict point. The conflict point was defined as the point at which the paths of the parties intersected.

An overall evaluation of the results of analysis showed that, in most cases, the profiled lane design led to changes in road-user behavior, which are expected to result in an increased level of road safety for cyclists at major urban junctions. In particular, it was concluded that with the new intersection design:

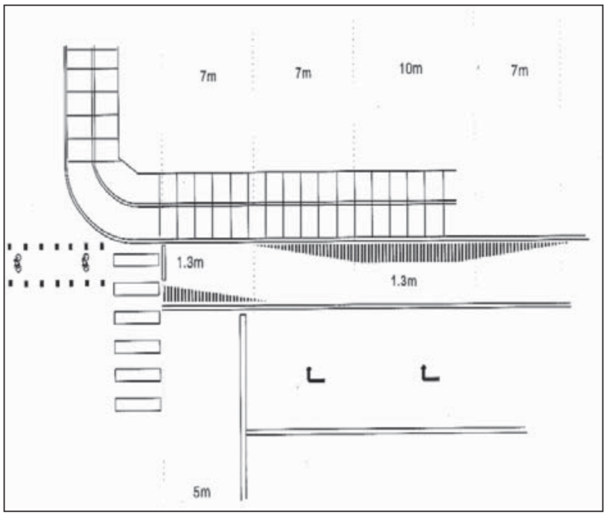
- overall, the proportion of drivers engaging in early interaction increased, as did the implementation of a cycle area extending through a junction;
- the overall trend indicates no change in the proportion of late driver interactions;
- more drivers adapt their speed to cyclists and keep behind the stop line;
- fewer drivers turn right in front of cyclists (neglecting their duty to give way to them);
- at all junctions, the new design brought cyclists an average of 0.26 meters (0.9 feet) closer to vehicles (which is expected to increase the likelihood that the various parties will notice each other in time, thereby avoiding accidents).

Variation 2 (profiled markings)

Profiled marking intersection redesign (variation 2). Source: Report 10, Road Directorate, Denmark

A second profiled bicycle lane design for cyclists at urban intersections was also studied by the Danish Road Directorate. A total of four junctions were reconstructed for this study, of which two initially had truncated cycle paths.

The second junction design used a long, profiled strip on the nearside of the cycle path, towards the curb, and a shorter strip on the offside. The lengths and locations of the strips are shown in the figure below:



Profiled marking intersection redesign (variation 2). Source: Report 10, Road Directorate, Denmark

The width of the profiled strips reduced the cycle areas to 1.3 meters (4.3 feet). These strips had a height of between 8 and 10 mm. (.32 and .4 inches). The purpose of the nearside strip on the cycle path was to guide the cyclists closer to vehicles as they approach the junction, in order to increase the attentiveness of both parties. The distance between the parties was then increased again at the junction, giving drivers up to 0.5 seconds more time in which to react if they had overlooked a cyclist. In addition, the stop line for drivers was moved back by 5 meters (16.5 feet) in all lanes.

A cycle area, demarcated using either blue pigment or two broken lines and marked with cycle symbols, was also implemented through the intersection. The width of the cycle area was increased from 1.3 meters to the cycle-path width on the opposite side of the junction.

A cycle lane across the junction was intended to increase drivers' attentiveness to any cyclists and to show them how far into the junction they could drive without inconveniencing bicyclists, as well as control the behavior of cyclists.

Similar video recordings were used to evaluate intersection redesign variations 1 and 2. From these, analyses recorded the speed of cyclists, the distance between the reaction point and the junction and the lateral location of cyclists on the cycle path. The behavior of drivers as they approached the junction was also recorded. Finally, the time separation between cyclists and vehicles at a junction and the number of serious conflicts were recorded. A "serious conflict" was considered to occur when either one or both of the road users undertook precipitate evasive action in order to avoid a collision.

Overall, the behavior study indicated that the new junction design changed the behavior of cyclists and drivers in a way that will likely result in improved road safety. Specifially, it was found that:

- the average distance between cyclists' reaction points and the stop line increased by between 1 and 3 meters (3.3 and 9.9 feet) at all four junctions. Thus, cyclists reacted between 0.2 and 0.6 seconds earlier after the intersection was reconstructed;
- at three junctions, the proportion of drivers exhibiting "good driving behavior" (drivers who adapted their speed to cyclists and remained at rest behind the stop line) increased by 8 to 18%;
- at three junctions, the time elapsing between cyclists and vehicles passing the conflict point increased by between 0.4 and 0.7 seconds, meaning that the physical distance between these road users had also increased;
- at all junctions, the number of simultaneously arrived drivers who made right turns in front of cyclists (despite the fact that they were bound to give way) dropped from between 12 and 24% to between 3 and 6% after implementation.

Bicycle lane left of motor vehicle right-turn lane

Denmark

In Denmark, two-thirds of accidents involving cyclists happen at intersections, and many of these accidents happen between right-turning cars and cyclists continuing straight ahead. To improve traffic safety for cyclists, several municipalities and counties have carried out experiments by establishing a bicycle lane between the right-turning lane and the other lanes at intersections with much right-turning traffic. This bicycle lane can be constructed either as a blue lane or as a lane marked by two flattened white lines, in both cases with bicycle symbols. Cyclists should cross the right-turn lane at its beginning.

The idea behind this installation is that conflict between right-turning cars and cyclists going straight ahead will be replaced by a presumably less dangerous weaving conflict before the junction. By letting the cars and cyclists merge before the junction, each will have fewer objects to survey. In addition, cyclists continuing straight ahead will be more visible to oncoming left-turning cars when they meet at the intersection.

A Danish study of bicycle lanes placed between the vehicle right-turn lane and other lanes resulted in few registered accidents involving cyclists related to its construction. Although it is not yet possible to evaluate whether construction affected the total number of accidents, the study does suggest that there is no increase in the number of accidents involving cyclists and right-turning cars at the point where the cycle lane crosses the right-turning lane.

IMPROVEMENTS TO STANDARDIZED FACILITIES

Non-compulsory bicycle lane in cobbled street

Belgium

A component of road infrastructure policy in the city of Brugge is the integration of non-compulsory bicycle lanes into city streets. Non-compulsory lanes function much the same way as standardized lanes; however, no legal consequences exists for motorists who use that part of the roadway.

On Boeveriestraat, a cobbled street within the historic inner town of Brugge, an important link for cyclists was created. In 1995, non-compulsory bicycle lanes made of red, painted asphalt were placed in the street to improve comfort levels for cyclists. City officials cite the positive influence of the lanes on vehicle traffic, reducing speeds by visually narrowing the road surface.

The Belgian Institute for Road Safety recommends a minimum width of 1.5 meters (approximately 5 feet) for non-compulsory cycle lanes.

On other streets, non-compulsory lanes were created to indicate which part of the road is intended for use by cyclists. Similar measures have been implemented in other cities in Belgium (including Gent), and other European countries (including The Netherlands).

Various locations

Other bicycle lane improvements considered innovative in the United States can be widely seen in regular use in other countries. Examples include the use of pigmentation (red and blue), alternate paving materials, staggered bicycle lane elevation (between sidewalk and roadway height) and the use of various roadway barriers to create an exclusive space for cyclists. Although no formal safety evaluations of the following facilities were made available, their widespread use implies routinely successful implementation:

(1) Denmark

Source: Report 106, Road Directorate, Denmark

Picture (1): Elevated bicycle lanes between the roadway and sidewalk are common throughout Europe, and often pigmented. Picture (2): A centerline brick cycle-way makes it more comfortable for cyclists to use a cobble-stone street. Picture (3): Rubberized curbs (with reflective strips) and flexible bollards keep the bicycle lane free of automobile traffic. Picture (4): A curb-separated bicycle lane (with blue pigment) creates an exclusive space for cyclists. Separated lanes need to be carefully located to avoid misuse (see p.8). Picture (5): A signed bollard and brick paved bicycle lane channel on-street bicycle and motor vehicle traffic after exiting a bridge. Picture (6): White pavers delineate the path of a contra-flow bicycle lane through a turn. Picture (7): Traffic islands give cyclists a protected and defined space at a turn not permitted for motor vehicles.

(2) Oldenburg, Germany

Source: Department of City Planning, Oldenburg

(3) Champs-Elysees, Paris

(4) Rue St. Germaine, Paris

(5) Utrecht, The Netherlands

Source: Cities Make Room for Cyclists

(6) The Netherlands

Source: Sign up for the Bike (CROW)

(7) Oxford, U.K.

Source: Department of Transport, U.K.

NEW ROADWAY ACCOMMODATIONS

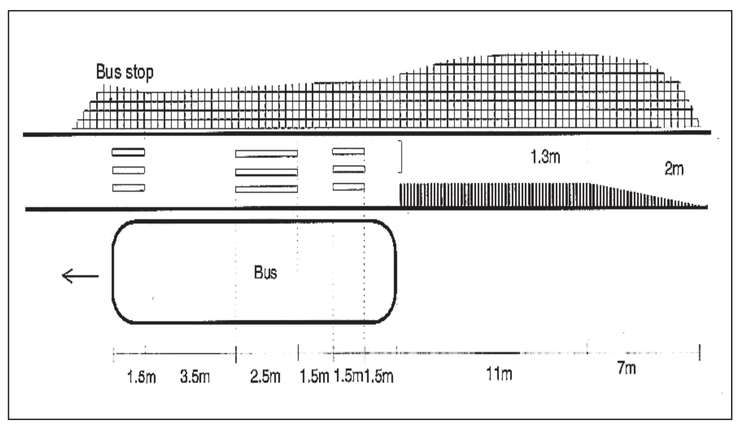
Bus stop redesign (for bicycle/bus lane)

Denmark

In order to reduce the number of conflicts between bus passengers and cyclists at bus stops in urban areas, the Danish Road Directorate has studied three new types of design for bicycle lanes at bus stops which are adjacent to those lanes. These designs differ most notably from bicycle/bus lane design in the United States in their focus on the interaction between cyclists and pedestrian at the stop, rather than the accommodation of free-flow roadway traffic.

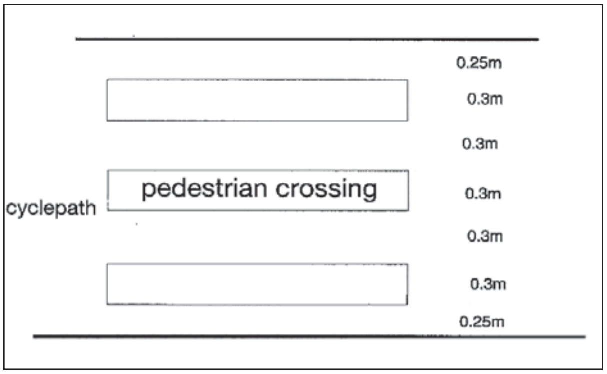
The bus stop designs were created and tested based on the assumption that conflicts between bus passesngers and cyclists could be reduced by making the conflict area visible at bus stops, and if possible, clarifying which party has a right-of-way.

Variation 1: Pedestrian crossing combined with profiled marking



Bus stop redesign (variation 1).
Source: Report 10, Road Directorate, Denmark

The first design consisted of three areas, each of which had three white strips painted across the bicycle lane. These areas resembled pedestrian crossings and were located outside the doors of the bus (the length and location of the strips took into account buses with two or three sets of doors). These areas were implemented in order to increase the attentiveness of cyclists and bus passengers and to guide the alighting passengers across the bicycle lane at right angles. The dimensions of the pedestrian crossings for a 2 meter (6.6 foot) bicycle lane are shown below:

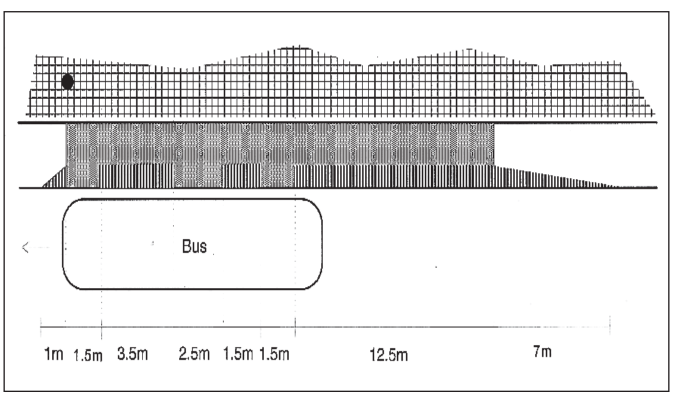


Bus stop redesign (variation 1).
Source: Report 10, Road Directorate, Denmark

A 0.5 meter (1.65 foot) broad profiled marking was also implemented on the offside of the bicycle lane towards the vehicle lane. This profiled marking was implemented on the bicycle path as narrow, lateral strips, with a breadth of 5 cm (2 inches)and a height of 8 mm (0.32 inches) in white thermoplastic material.

(Analysis and evaluation of design variations are given after description of all three).

Variation 2: Profiled marking on offside of cycle area

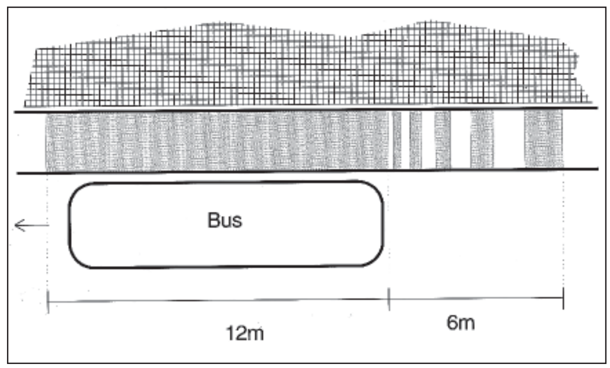


Bus stop redesign (variation 2).
Source: Report 10, Road Directorate, Denmark

This design consisted of a 0.5 meter (1.65 foot) broad profiled strip laid along the offside of the bicycle lane. This strip was implemented in white thermoplastic material, in the form of narrow, lateral strips, with a width of 5 cm (2 inches) and a height of 8 mm (0.32 inches). The rest of the conflict area was painted white.

The profiled strip had the visual effect of reducing the width of the bicycle lane and also caused physical inconvenience when ridden over, to discourage cyclists from doing so. Such a clearly noticeable strip was expected to reduce the speed of cyclists while clarifying the conflict area. Apart from these effects, it also gave alighting bus passengers a small, free area on which to descend.

Variation 3: Painted pattern with visual brake



Bus stop redesign (variation 3).
Source: Report 10, Road Directorate, Denmark

This design consisted of a painted area of the bicycle lane around the bus stop, supplemented with a 6 meter (19.8 foot) warning area. This warning area was comprised of a number of painted areas, the length of which became shorter as cyclists approach the conflict area. It was expected that this would impel cyclists to reduce their speed.

Painting was carried out so that cycling on the strips caused no physical effects, in the form of rumble, while its coefficient of friction was the same as that of the surface of the rest of the bicycle lane. White and yellow colors were tested.

Evaluation of effects:
Overall, it was concluded that the three new designs for cycle areas at bus stops (pedestrian crossing, profiled marking and painted pattern)

brought about a change in behavior expected to increase road safety. There was a tendency for the "pedestrian crossing" design to give better results than the other 2 designs. It was also concluded that:

- all three designs gave a reduction in the average minimum speed of cyclists when there was a bus at the bus stop (between 10% and 42%);
- the new designs increased the distance between the cyclists' reaction point and the nearest conflict point. The number of cyclists that did not react also dropped. Also in this case, the "pedestrian crossing" design gave a slightly better result than the other two designs;
- only designs that included a profiled strip increased the distance between cyclists and passengers alighting from buses. The distance was increased by an average of 0.3 meters (1 foot);
- the proportion of cyclists who waited for bus passengers and allow them to pass first remained unchanged for all three designs;
- the number of serious conflicts dropped significantly at bus stops with painted patterns. The proportion of serious conflicts was very small at the other bus stops both before and after redesign;
- none of the designs necessitated significant modification of bus passengers' behavior.

A re-evaluation of the "profiled strip" and "painted pattern" designs one year after implementation showed that the effects of the new designs remained largely unchanged. Both designs, however, gave a small increase in the number of cyclists who waited for bus passengers and allowed them to pass.

Contra-flow bicycle lane

Belgium (Brugge)

Most Belgian cities allow cyclists to travel in the opposite direction of vehicle traffic on many one-way streets. Brugge, Belgium, for example, has implemented an extended traffic circulation scheme using one-way streets and left turn prohibitions to limit automobile traffic in its inner town. An exception is made for cyclists, however, who can travel both ways on most streets.

One-way traffic for cyclists is less common, and used only when a nearby parallel street provides a sufficient and practical alternative. Approximately 50 streets have been converted from one-way into bi-directional streets for cyclists. The number of cyclists in the city of Brugge has increased 21% after the introduction of the new traffic scheme. To date, no negative safety effects have been noted.

The Belgian Institute for Road Safety provides several recommendations for the introduction of bi-directional use of one-way streets. Overall, the minimum width of the main carriage way should be:

- 3.5 meters (11.5 feet) if lorries (trucks and service vehicles) are expected in the street;
- 3 meters (10 feet) if car traffic volume is low and almost no lorries are expected.

In streets with much and/or fast car traffic an exclusive bicycle lane is recommended. Special attention should be paid to possible conflicts between parking cars and cyclists moving in the opposite direction. Cars parked on the left side of the street (facing cyclists in the opposite direction) should be avoided under certain conditions. Specific traffic signing has been created for bi-directional use of one-way streets in Brugge. Small refuges (traffic islands) are also recommended to prevent cars from making sharp turns.

Other road layout elements are recommended to draw attention to the possible presence of cyclists at road junctions, including continuous colored (red) bicycle lanes. Frequent repetition of a cyclist road pavement marking symbol is recommended to remind both car drivers and crossing pedestrians of the presence of cyclists in the opposite direction.

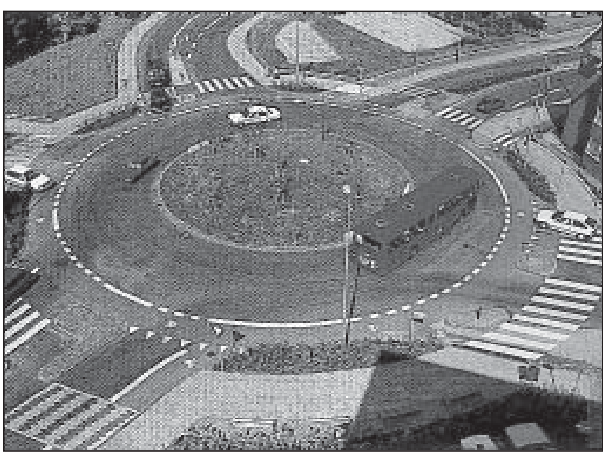
The Netherlands (Utrecht)

Due to the increasing conversion of two to one-way streets in urban areas and town centers, many Dutch cities allow cyclists to use one-way streets in both directions to create direct route access and avoid detours. One-way streets in Utrecht are divided up into "partial one-way streets with a tight profile," and "partial one-way streets with a spacious profile" (see "***Traffic calming techiques***" for profile descriptions).

Partial one-way traffic with a tight profile:
Motor vehicles have to remain behind cyclists; a bicycle lane in the oncoming direction can help promote this. With a roadway width of about 3.85 meters (12.7 feet), approximately 2.25 meters (7.4 feet) should be allocated for joint motor vehicle and cyclist use; approximately 1.5 meters (5 feet) should be allocated for a single bicycle lane in the other direction. An alternative with a deterrent strip and adjacent parking strip is also used. The design speed for motorized traffic should not be more than 30 km/h. This tight profile is not recommended if a greater part of the motorized traffic consists of heavy goods vehicles.

Partial one-way traffic and spacious profile:
A car and cyclist in one direction and a cyclist in the other can simultaneously encounter/overtake, with a recommended total roadway width of 5.5 meters (18 feet). A minimum roadway width of 6.3 meters (21 feet) is needed if a greater part of the motorized traffic consists of heavy goods vehicles. A speed level of 30 km/h is required.

Roundabout design



A roundabout with pigmented (red) cycle lanes. Source: Report 106, Road Directorate, Denmark

United Kingdom (U.K.)
In *Cycle-Friendly Infrastructure: Guidelines for Planning and Design* (1996), the U.K. Department of Transport makes recommendations for roundabout design based on past studies and implementation efforts. The guide cites that cyclists are often 14 to 16 times more likely than car users to suffer an accident at a roundabout. More than 50% of these accidents are due to motorists entering the roundabout and hitting cyclists circulating within the right-of-way.

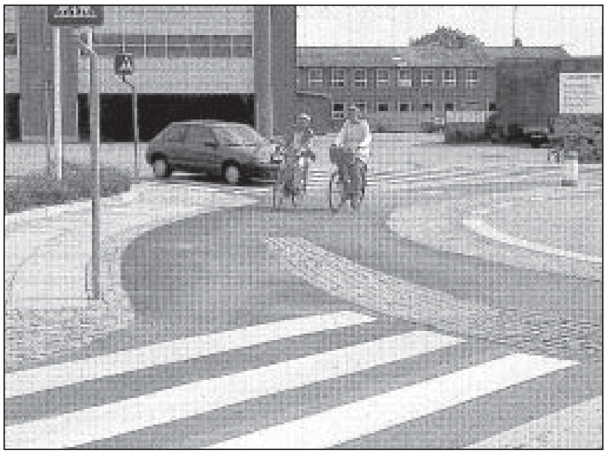
Small roundbouts with flared entries and large roundbouts which allow high speeds were found to be particularly hazardous for cyclists. Mini, conventional and signalized roundabouts presented fewer problems. In one study, accidents to cyclists were reduced by 66% on roundabouts with full-time signals on all or some arms. Part-time signals, however, produced no significant change. In addition, segregated (dedicated) left turns lanes, unless controlled by signals, were found to be inherently unsafe for cyclists.

To make roundabouts safer for cyclists, the Department of Transport recommends reduced circulatory roadway widths, use of advanced stop lines at signals, increased deflection on entry and improved signage and road markings. Three basic traffic layouts are recommended: mixed traffic (motor vehicles and cyclists), a physically-segregated cycle lane with cyclist priority, and free-standing cycle paths with cyclist priority.

The mixed traffic layout, in particular, is based on an external diameter of 24 to 32 meters (approximately 79 to 106 feet), low entry speeds, a narrow circulatory roadway that prevents motor vehicles from overtaking cyclists on the roundabout and single lane entry arms. The Department of Transport is careful to note that high volumes of cyclists in the U.K. may account for drivers accepting cyclist priority layouts.

Denmark
In Nakskov, a two-lane roundabout situated on the outskirts of a 1.3 km bicycle route in Nakskov was specifically redesigned to accommodate cyclists in 1991. The bicycle area of the roundabout was marked with a red asphalt coating. In addition, a row of paving stones and white painted border lines were installed to separate

cyclists from motor vehicles. At each entry the bicycle lane was divided by paving stone islands, each shaped like a banana. Ramps of paving stone were constructed at each entry point, to help reduce the speed of cars and bring attention to crossing pedestrians and cyclists.



Roundabout with pigmented cycle lanes in Nakskov. Source: Report 106, Road Directorate, Denmark

Danish behavioral studies show that road users typically use roundabouts as intended. Of the conflicts that do occur, however, many involve cyclists who use the roundabout in a wrong way (e.g. riding in the wrong direction). Although the installation of roundabouts does not reduce the number of personal injury accidents involving cyclists, they do reduce the seriousness of the accidents.

This is also the case for the Nakskov installation. In addition, it has been shown that cyclists, as a result of the special construction of the stone islands, do not show hand signals when they turn from the circulation areas to the exits. The stone islands do, however, make it easier for motorists to see at an early stage whether cyclists intend to turn or not.

Traffic-calming techniques

Traffic calming techniques widely used in Europe often focus on the use of "shared streets," incorporating pedestrians, cyclists and motor vehicles. From among many traffic calming examples and studies, only those that specifically addressed provisions for cyclists are discussed here.

United Kingdom (U.K.)

In 1997, the Transport Research Library published a study (commissioned by the Department of Transport) examining the safety and convenience of cyclists at road narrowings created by three traffic-calming installations: central islands, chicanes and pinch points (mirrored chicanes). The study used (1) information from local highway authorities and cyclists' organizations, (2) detailed site reconnaissance of 28 road narrowing schemes, (3) filming of 15 selected sites to obtain data on cyclist and driver maneovers and (4) attitude surveys with cyclists carried out at three sites in London and Oxford.

Safety: Accidents for all vehicles and accidents involving cyclists either fell or stayed the same after installation of the road narrowings. Overall, accidents involving cyclists fell from an average of 1.51 accidents per year to an average of 0.96 accidents per year. However, this was not statistically significant and changes in cycle flows were not available.

Driver behavior: At central island sites with lane widths between 3.5 and 4.2 meters (11.5 and 14 feet), less than 15% of drivers waited behind cyclists. At the pinch point sites, motor vehicles were more likely to wait behind cyclists, probably due to oncoming vehicles, lower speeds, and lower traffic flows. Motor vehicle encroachment into cycle lanes was high at sites with a residual lane width for motor vehicles of less than 3 meters (9.9 feet).

Cyclist behavior: Where a cycle bypass was provided, most cyclists used it, particularly when the bypass was long and straight. Where a cycle lane was marked, most cyclists stayed within the lane. Cycle bypass and cycle lane use was higher at sites with higher traffic volumes. At sites where no specific facility for cyclists was provided, most cyclists said that they took extra care or rode "defensively." A minority kept their line speed or moved out towards the middle of the roadway when cycling through the scheme.

From interviews, cyclists' opinions of the narrowings varied according to the details of individual site layouts. In general, they tended to dislike narrowings, but, overall, felt that cycling conditions had improved due to better traffic behavior. This finding is most likely attributable to feelings of anxiety and nervousness expressed by cyclists at road narrowings, even if they did not feel that accidents were more likely to occur. The report speculates that reasons for this anxiety may include uncertainty about driver behavior, the reduced distance between cyclists and overtaking vehicles, and situations where drivers are forced to slow and wait behind cyclists.

Recommendations: Recommendations of the Transport Research Library based on the results of its study are cited below:

- In the context of promoting cycling as a means of transport, road narrowings that increase the perception of danger amongst cyclists, even if they do not result in increased cyclists casualties, should be avoided;
- Adequate width (4.5 meters; 15 feet) for motor vehicles to overtake cyclists, or cycle bypasses, should be provided at road narrowings, particularly at sites with high motor vehicle flows, significant numbers of large vehicles, or vehicle speeds above 30 mph;
- Where bypasses or adequate width cannot by provided due to site constraints, speed reducing measures in advance of the narrowing should be considered;
- Attention to scheme design, drainage arrangements; maintenance and parking enforcement can reduce or prevent problems of obstruction;
- It could be stipulated in the Highway Code that motor vehicles should not overtake cyclists within, say, 20 meters (66 feet) of a road narrowing;

The Netherlands (Utrecht)

"Cycle streets" implemented in Utrecht allow mixed traffic where cyclists have a dominant position and motorized traffic is allowed (but should not be dominant). With regard to roadway dimensions, a distinction is made between a (1) spacious profile, (2) critical profile and (3) tight profile.

With a <u>spacious profile</u> there is enough room for motorists to overtake cyclists. As a result, this profile risks higher (and therefore dangerous) vehicle speeds. It is not recommended by city officials.

A <u>critical profile</u> lies in between a spacious and tight profile, leaving just enough room for motorists to overtake cyclists closely. As with a spacious profile, this can lead to dangerous situations for cyclists and a higher speed for motorized traffic. As a result, this profile is also not recommended from a point of view of safety for cyclists.

A <u>tight profile</u> does not provide enough space for overtaking maneuvers. Motorists that wish to overtake cyclists have to wait until cyclists offer the space to overtake. Although this type of street design leads to lower driving speeds, cyclists can feel pressed or threatened by motor vehicles wishing to overtake them. This design is recommended only for streets with low volumes of motorized traffic and with relatively short road sections. Speeds should not be higher than 30 km/h.

Denmark (Aalborg)

"Combi-hump" traffic-calming design.
Source: Report 106, Road Directorate, Denmark

A combined traffic-calming installation was designed in Aalborg for easy use by both cyclists and buses. A path at the right-side of the roadway easily allows bicycles to pass the site without disruption. "Combi-humps" installed in the center of the motor vehicle roadway force cars to pass a cobbled and fairly steep hump, but contain two less-steep asphalt humps designed for the track gauge of buses. The humps were marked by 30km/h road signs and were indicated by bollards as well.

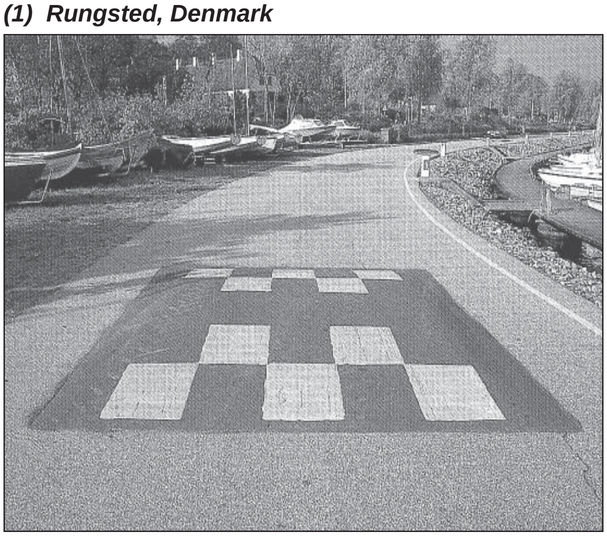
Most drivers chose to cross with a wheel on one of the asphalt lanes, but this did not change the speed reducing effect: cars crossed the hump at an average speed of 25 km/h, and the mean speed of heavy vehicles was 20 km/h.

Various locations

Although no formal evaluations were received about the following installations, they are depicted below to illustrate a conscientious incorporation of cyclists into overall traffic-calming schemes:

Picture (1): Dome-shaped humps (with hatch marking) cover only the center of the roadway, allowing space on either side for cyclists to pass unimpeded. Picture (2): Traffic-calming scheme with road narrowing and trapezoidal hump gives cyclists an exclusive and protected right-of-way. Picture (3): A cobbled-strip slows cars at an intersection but does not obstruct a pigmented cycle lane. Picture (4): A smoothly paved track channels cyclists in a pedestrian-only street.

(1) Rungsted, Denmark



Source: Report 106, Road Directorate, Denmark

(2) Birkerod, Denmark

Source: Report 106, Road Directorate, Denmark

(3) Nakskov, Denmark

Source: Cities Make Room for Cyclists

(4) Oldenburg, Germany

Source: Department of City Planning, Oldenburg

APPENDIX F:
Recessed Motor Vehicle Stop Line Study:

Calculation of consequences of traffic lights' timing sequence at junctions controlled by traffic lights, where the vehicle stop line is recessed by 5 m

Conditions:

1) Existing stop lines located 0.5 m from pedestrian crossing

2) New stop lines implemented 5.5 m from pedestrian crossing

3) Guide lines of road rules on traffic lights for calculation of intervals. It is assumed here that the last cyclist passes the stop line 2 seconds into the amber period and the last vehicle, 3 seconds into the amber period. The cycle is assumed to be 2 m long and the vehicle, 8 m.

Calculation for a 20*20 m junction

a) Latest cyclist and earliest vehicle (Fig. a).

Interval between existing stop line (0.5 m from pedestrian crossing)

time taken by latest cyclist to pass the junction:
t1 = (21 + 2 m)/(5 m/sec) = 4.6 seconds

time taken by earliest vehicle to enter the junction:
t2 = (5 m)/(13 m/sec) = 0.4 seconds

Minimum interval: T = t1-t2+2 sec = 6.2 seconds

Interval with new stop line (5.5 m from pedestrian crossing)

time taken by latest cyclist to pass the junction:
t1 = (21+2 m)/(5 m/sec) = 4.6 seconds

time taken by earliest vehicle to enter the junction:

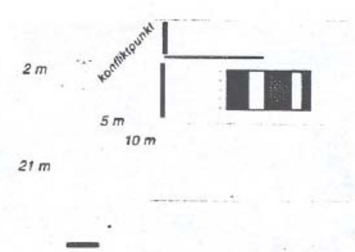


Figure a. Latest cyclist and earliest vehicle.

$t2 = (10\ m)/(13\ m/sec) = 0.8$ seconds

Minimum interval: $T = t1 - t2 + 2$ sec $= 5.8$ seconds

Thus, the new stop line requires a 0.4 second shorter interval than the existing stop line.

b) Latest vehicle and earliest cyclist (Fig. b).

Interval with existing stop line (0.5 m from pedestrian crossing)

time taken by latest vehicle to pass the junction:

$t1 = (23+8\ m)/(13\ m/sec) = 2.4$ seconds

time taken by earliest cyclist to enter the junction:

$t2 = (7\ m)/(8\ m/sec) = 0.9$ seconds

Minimum interval: $T = t1 - t2 + 3$ sec $= 4.5$ seconds

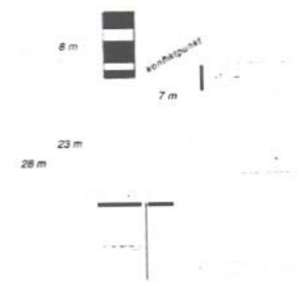


Figure b. Latest vehicle and earliest cyclist.

Interval with new stop line (5.5 m from pedestrian crossing)

time taken by latest vehicle to pass the junction:

$t1 = (28+8\ m)/(13\ m/sec) = 2.8$ sec

time taken by earliest cyclist to enter the junction:

$t2 = (7\ m)/(8\ m/sec) = 0.9$ seconds

Minimum interval: $T = t1 - t2 + 3$ sec $= 4.9$ seconds

Thus, the new stop line requires a 0.4-second longer interval than the existing stop line.

c) Latest vehicle and earliest vehicle (Fig. c).

Interval with existing stop line (0.5 m from pedestrian crossing)

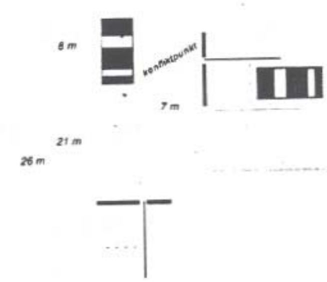


Figure c. Latest vehicle and earliest vehicle.

time taken by latest vehicle to pass the junction:

$t1 = (21+8\ m)/(13\ m/sec) = 2.2$ seconds

time taken by earliest vehicle to enter the junction:

$t2 = (7\ m)/(13\ m/sec) = 0.5$ seconds

Minimum interval: $T = t1 - t2 + 3\ sec = 4.7$ seconds

Interval with new stop line (5.5 m from pedestrian crossing)

time taken by latest vehicle to pass the junction:

$t1 = (26+8\ m)/(13\ m/sec) = 2.6$ seconds

time taken by earliest vehicle to enter the junction:

$t2 = (12\ m)/(13\ m/sec) = 0.9$ seconds

Minimum interval: $T = t1 - t2 + 3\ sec = 4.7$ seconds

Thus, the new stop line requires the same interval as the existing stop line.

Overall, however, it is Case a), latest cyclist earliest vehicle, that determines the dimensions. In this calculation, therefore, recessing the stop line has no influence on the dimensioning minimum interval.

Source: Kenneth Kjemtrup, Secretariat of Road Standards, Road Directorate.

APPENDIX G:
Interviews with State and Local Bicycle Coordinators:

Dave Bachman, PENNDOT Bicycle and Pedestrian Program Coordinator. PENNDOT Bureau of Highway Safety and Traffic Engineering, P.O. Box 2047, Harrisburg, PA 17105-2047. (5/27/98)

Mia Birk, City of Portland Bicycle Program Manager. Bureau of Traffic Management, 1120 S.W. 5th Avenue, Room 730, Portland, OR 97204. (5/21/98)

Diane Bishop, City of Eugene Bicycle Coordinator. Public Works Department, 858 Pearl Street, Suite 300, Eugene, OR 97401. (6/1/98)

Tom Branigan, City of Philadelphia Bicycle Coordinator. 1401 JFK Blvd., Room 830, Philadelphia, PA 19102-1676. (6/1/98)

Tim Bustos, City of Davis Public Works Department. 23 Russell Boulevard, Davis, CA 95616. (5/20/98)

Charles Cadenhead, Jr., Minnesota State Bicycle Coordinator. Office of Advanced Transportation Systems, Mail Stop 315, 10th Floor Kelly Inn, 395 John Ireland Blvd., St. Paul, MN 55155-1899. (5/29/98)

Ben Gomberg, City of Chicago Bicycle Program Manager. Chicago Department of Transportation, Room 400, 30 N. LaSalle, Chicago, IL 60602. (5/20/98)

Adam Gubser, City of San Francisco Bicycle Program. San Francisco Department of Parking and Traffic, 25 Van Ness Avenue, #345, San Francisco, CA 94102-6033. (6/1/98)

Karel Hanson, County of San Diego Bicycle Coordinator. Department of Public Works, County Operations Center, 5555 Overland Avenue, San Diego, CA 92123-1295. (5/98)

William W. Hunter, Associate Director, Engineering Studies, Highway Safety Research Center, University of North Carolina, CB #3430, 730 Airport Road, Chapel Hill, NC 27599-3430. email: bill_hunter@unc.edu (6/98)

Kimble Koch, The Presidio Project, National Park Service, San Francisco, CA. (6/4/98)

Peter Lagerwey, City of Seattle Bicycle and Pedestrian Coordinator. Seattle Engineering Department, 600 Fourth Avenue, Suite 708, Seattle, WA 98104-1879. (6/1/98)

Theo Petritsch, Florida State Pedestrian and Bicycle Coordinator. Florida DOT, 605 Suwannee Street, Tallahassee, FL 32399-0450. (5/98)

Michael Ronkin, Oregon State Bicycle and Pedestrian Program Manager. Oregon DOT, Transportation Building, Room 210, Salem, OR 97310. (5/20/98)

Arthur Ross, City of Madison Bicycle and Pedestrian Coordinator. Madison DOT, 215 Martin Luther King Jr. Blvd., P.O. Box 2986, Madison, WI 53701. (6/3/98)

Cara Seiderman, City of Cambridge Bicycle and Pedestrian Coordinator. 57 Inman Street, Cambridge, MA 02139. (6/11/98)

Keith Walzak, City of Tucson Alternate Modes Coordinator. City of Tucson DOT, 201 N. Stone Avenue, 6th Floor, Tucson, AZ 85701. (6/4/98)

Katherine Watkins, City of Cambrige Traffic Calming Project Manager. Community Development Department, 57 Inman Street, Cambridge, MA 02139. (6/4/98)

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www.ci.eugene.or.us

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www.cycling.org
National Transportation Library:
www.bts.gov/NTL/DOCS/mapc.html

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cycling: *www.bikelane.com*

cycling: *www.bikeplan.com*

Manufacturer Listings for Bicycle Facility Test Materials:

(note: This list constitutes a partial source of information. Additional manufactuers are available which are not listed here).

profiled markings (textured striping)

Agomer GmbH
Postfach 13 45
D-63403 Hanau
Germany
Tel: 06181 59-3252
Fax: 06181 59-2995

3M
Traffic Control Materials Division
25 Van Nostrand Avenue
Roslyn Heights, NY 11577
Tel: 800.736.2725

3M Center, Building 225-5S-08
P.O. Box 33225
St. Paul, MN 55133-3225
Tel: 612.733.1110

The RainLine Corporation
"Rainline with a Bump"
P.O. Box 210818
Montgomery, AL 36121-0818
Tel: 334.277.0237

Stimsonite Corporation
"AquaLite"
7542 North Natchez Avenue
Niles, IL 60714
Tel: 800.327.5917

Briteline
"VibraLine"
104 Revere Street
Canton, MA 02021-2996
Tel: 888.201.6448

raised curbs/reboundable delineators

Qwick Kurb, Inc.
"Qwick Kurb" (curb)
"L120 Stubby" (flexible bollard)
"L125 Thin Sister" (flexible bollard)
"L94 Flat Delineator" (flexible panel)
"L104 Air Panel" (flexible panel)

2818 Parkway Street
Lakeland, FL 33811
Tel: 800.324.8734

Atelier Parisien d'Urbansime
(contact for manufacturer reference)
17 Bd Morland
75004 Paris, France
Fax: 33.1. 42.76.24.05

Credits:

New York City Department of City Planning
Joseph B. Rose, Director
Andrew S. Lynn, Executive Director
Sandy Hornick, Deputy Executive Director for Strategic Planning

Transportation Division
Floyd Lapp, Director
Jack Schmidt, Deputy Director
Glen A. Price III, Deputy Director
Gretchen Heine, Project Manager
Sameera Ansari
Marisa Cravens
Andrew English
Fiona Grieg
Altan Kolsal
Hayes Lord
Karen Morris
Sabine Muller
Jeff Mulligan
Mary Kay Santore
Petra Staats
Jackson Wandres
Scott Wise
Dieckmann Wolfe

Report Production
Antonio Mendez
Gerald Anderson
Alfred Smith

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