PRINCETON

bicycle master plan

2017

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Contributors

Municipality of Princeton
Lee Solow, AICP/PP, *Director of Planning*
Deanna Stockton, PE, *Assistant Municipal Engineer*

New Jersey Department of Transportation
William Riviere, *Office of Bicycle and Pedestrian Programs*

WSP | Parsons Brinckerhoff
Peter Kremer, AICP/PP
Reed Sibley, AICP/LEED AP
Daniel Turner, AICP
Ruchi Shrivastava

Susan G. Blickstein
Susan G. Blickstein, AICP/PP, PhD

Study Advisory Committee

Princeton Municipal Government
Liz Lempert, *Mayor*
Jenny Crumiller, *Council*
Patrick Simon, *Council*

Princeton Planning Board
Lee Solow, AICP/PP, *Director of Planning*
Wanda Gunning, *Chair*
Cecilia Birge, *Member*
David Cohen, *Member*
Mildren Trotman, *Member*
Gail Ullman, *Member*

Princeton Engineering Department
Deanna Stockton, PE, *Assistant Municipal Engineer*

Princeton Department of Public Works
Dan Van Mater, *Director*

Princeton Pedestrian and Bicycle Advisory Committee
Laurie Harmon, *Member*

Princeton Traffic and Transportation Committee
Sam Bunting, *Member*

Princeton Environmental Commission
Lisa Marcus Levine, *Member*

Princeton Police Department
Thomas Murray, *Sergeant, Traffic Safety Bureau*

Princeton Senior Resource Center
Susan Hoskins, *Executive Director*

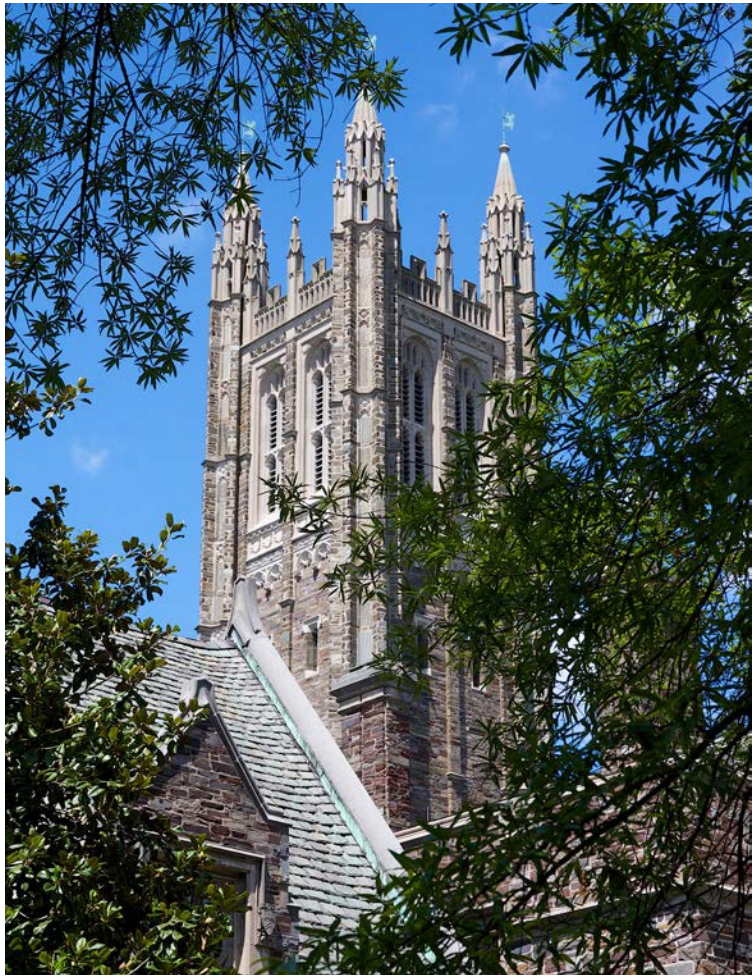
Mercer County Planning Department
Matt Lawson, PhD, AICP/PP, *Principal Planner*

Greater Mercer TMA
Jerry Foster

Latin American Legal Defense and Education Fund
Leticia Fraga, *Vice Chair*

Princeton University
Kim Jackson, *Transportation Director*

Other Residents
Janet Heroux, *Health Advocate*
Douglas Rubin, *On-Street Parking Advocate*

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Introduction

Princeton welcomes cycling as an essential, comfortable, convenient, and safe form of transportation for residents and visitors of all ages and abilities. Bicycling will play a critical role in Princeton's future, not only as a recreational activity, but as an everyday and viable means of transportation – as an easy way to get to school, run errands, commute to work, and see friends. Investing in bicycle infrastructure and programs will attract more people to bicycling, encourage them to ride more often and with greater confidence, and have many positive impacts on the quality of life in Princeton, including its livability, safety, affordability, health, equity, economy, and environment.

Princeton already attracts many cyclists because of its compact development patterns, vibrant downtown, extensive trail network, and the presence of Princeton University, where cycling is prevalent among students, faculty, and staff. However, there are a number of factors that make cycling in Princeton difficult for many existing riders and discourage new riders, including:

- Heavy traffic volumes and turning movements
- Lack of dedicated bicycling infrastructure
- High traffic speeds, particularly outside of the central core
- Existing bicycle and multi-use paths that are narrow and/or in need of maintenance

In developing this plan, a robust public engagement and outreach process was conducted to ensure that the recommendations reflect the community's goals and vision for the future. The result is a Bicycle Master Plan (BMP) that will help Princeton implement its Complete Streets policy and achieve its goal of creating streets and corridors that are safe and accessible to users of all modes, ages, and abilities.

The Princeton Bicycle Master Plan provides the Princeton community with a framework for the future of bicycling in the Municipality. It provides clarity to the purpose of bicycle improvements, as well as the strategy for implementing where and what type of bicycle facilities will be developed in the future. The BMP will guide Princeton towards realizing its vision of a town where users of all ages can safely and comfortably ride a bicycle regardless of their abilities, the purpose of their trip, or their destination.

0.1 Developing the Princeton Bicycle Master Plan

Following the traditional planning process, the Princeton BMP presents an assessment of needs and existing conditions, defines a community-wide vision for the future, establishes achievable goals and objectives, develops feasible improvement concepts and alternatives, determines the plans and policies to support the alternatives, and outlines strategies and actions for implementing the plan.

The Princeton BMP was developed using a multifaceted approach that combines extensive data analysis and research with a comprehensive public involvement and outreach effort. This approach was used throughout the entire master planning process, and includes both traditional and state-of-the-art planning tools and methodologies. Public involvement activities included:

- Public meeting
- Four focus group meetings and small group interviews
- Online interactive Wikimap
- Online Survey
- Comment form submittals

The Princeton Bicycle Master Plan will help Princeton advance its Complete Streets policy by making Princeton's streets more accommodating for users of all ages, modes, and abilities and create a more comfortable and safe environment, encouraging increased bicycling in Princeton.

0.2 How Princeton Bicycle Master Plan Will Be Used

The Princeton Bicycle Master Plan will inform the development, over time, of a comprehensive cycling network in Princeton. The BMP provides a vision and framework for the future of cycling in Princeton that should be implemented in three ways:

- As roads are due for resurfacing or other routine maintenance, the BMP should guide the design of streets to appropriately accommodate bicyclists and further the implementation of the bicycle network
- The BMP should be used to support applications for grants and other funding, or to direct local funding towards bicycle and Complete Streets projects
- The BMP should guide the development of programs and policies that support a bicycle friendly community and encourage more people to bicycle as a means of daily transportation

The vision and framework outlined in the BMP are the result of an inclusive process that reflects a community supported vision. The BMP should help provide context and justification for future bicycle infrastructure projects and assist the community and stakeholders in understanding why a bicycle facility is being included in a project and where that particular facility fits in the overall network and vision. The BMP should be used not only by public officials, but also by the public to better understand and support the development of a safer, healthier, and more mobile Princeton.

01

Planning Context and Goals

Settled in the late 17th century, Princeton is one of the country's most historic communities. It is a university town and has been a center for learning and culture since its inception, home to world-renowned scholars, scientists, writers, and statesmen. While Princeton has retained much of its historic character and elements of its colonial past, the community has continuously evolved and grown. Today, Princeton is also a thriving regional center, encompassing 18.36 square miles and home to approximately 30,000 residents and over 30,000 jobs.

1.1 Geography/ Transportation

Princeton is a diverse community, in both its population and geography. Until 2013, Princeton was two separate entities – Princeton Borough and Princeton Township, which is reflected in the consolidated municipality's land use and development patterns. Princeton has its highest population density near its downtown, at the center of the former Borough. The development pattern becomes less dense as you move farther from the downtown core and transition into the former Township. This diverse geography means that the specific needs and challenges to bicycling in Princeton can vary significantly depending on where you are in the municipality.

Princeton has strong, multimodal regional transportation connections. It is well connected to the regional transit network, with connections to New York City, Newark, New Brunswick, Trenton, and Philadelphia via rail services on the Northeast Corridor. It has local transit services, including NJ Transit bus services, as well as bus services operated by the municipality and Princeton University. Princeton is also located at the

crossroads of NJ Route 27 and US Route 206, and offers access to US Route 1, providing key routes for motorists.

Finally, Princeton is also connected to a regional trail network, providing off-road links for bicyclists, including the Delaware and Raritan Canal, which runs north to New Brunswick and south to Trenton, and is part of the East Coast Greenway; the Lawrence Hopewell Trail, offering connections to Lawrence and Hopewell Townships; the Lenape Trail in Plainsboro; the Freedom Trail beginning in Kingston; and Mercer County Park with designated mountain bike trails.

In part because of these regional connections and Princeton's place as a regional center, approximately 170,000 motor vehicles travel through Princeton every day.[1] An estimated 23,000 people commute into Princeton daily for work, and approximately 6,400 leave Princeton for work elsewhere.[2,3] Princeton's draw as a center for business, culture, and education, as well as its location at the intersection of significant regional roadways, mean that the streets and sidewalks in the town, particularly in its core, are often very busy. This creates challenges for bicyclists, motorists, and pedestrians trying to get where they would like to go.

While Princeton has blossomed as a regional center, its roadway network has changed little since the 1970s, handling far more traffic than when it was originally constructed. Having essentially reached full build-out, there is little opportunity for capacity improvements to address traffic congestion issues.

Meanwhile, the density of the downtown has grown in recent decades. Surface lots have been replaced by structured parking, allowing room for important public spaces such as Hinds Plaza and the Princeton Public Library, as well as supporting opportunities for redevelopment, such as Palmer Square North. On-going redevelopment activity, such as along Witherspoon Street and Alexander Street, will continue to support the need for alternative travel modes, including bicycling, to help alleviate vehicular traffic demand on the roadway network and on parking availability.

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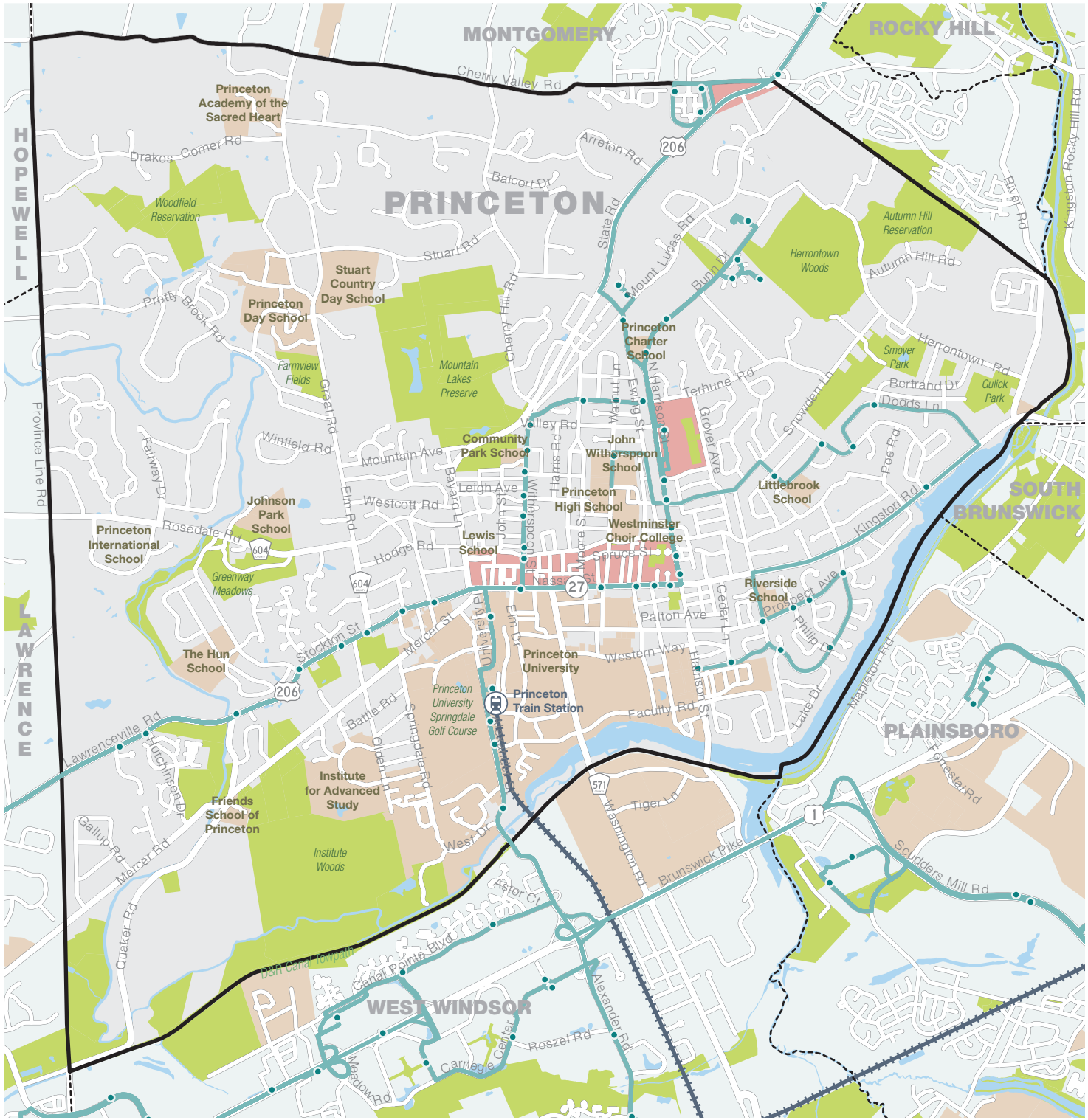
Princeton has a vibrant downtown, historic character and great natural resources. While the commercial base is concentrated in the core, residential neighborhoods, parks, and schools are located throughout the Municipality, contributing to Princeton's diverse geographic and transportation needs.

Map 01

Points of Interest

- NJ Transit Bus Stop
- NJ Transit Bus Route
- School
- Park
- Commercial Area

0 0.25 0.5 1 Miles



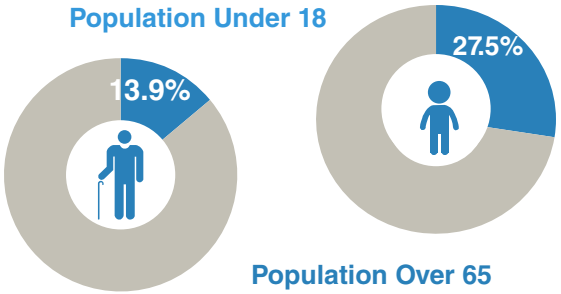
1.2 Demographics

Population and Employment

Princeton is a community of 30,108 residents.[4] It's relatively dense population (1,640 persons/square mile, approximately 50% higher than the state average) and compact center help make biking a viable alternative to driving. As shown in the map to the right, the population is concentrated around the central core, indicating potential higher demand for bicycle access in this area.

Approximately 41% of the population is under 19 or over 65, two age groups with lower driving rates. While young people are often associated with higher bicycle usage, national data indicate that middle-age and older adults are actually boosting the recent growth in bicycling, with adults ages 60-79 accounting for 22% of new bicycle trips.[8]

Figure 1.3 | Age Demographics[5]



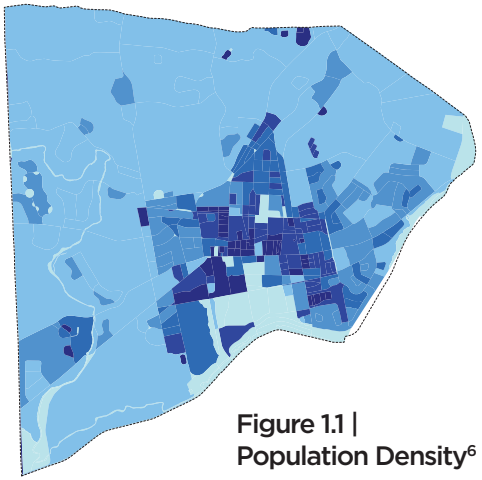


Figure 1.1 | Population Density[6]

Princeton is a regional center and major employment hub, drawing large numbers of commuters from within and outside the municipality. Princeton ranks 23rd as a center for employment in New Jersey, with over 30,000 jobs.[9] As illustrated in Figure 1.2, these jobs are concentrated around the downtown, again underscoring a potential higher demand for bicycle access in this area.

The combination of high population and employment densities make alternatives to driving, such as bicycling, an attractive commuting option for many Princeton residents. Over 50% of employed Princeton residents also work in town (8,011 residents), much higher than the average of approximately 21% for most suburbs in New Jersey.[10] Given the proximity between home and work for many residents, many Princeton residents do not drive. Over 5% bike to work.

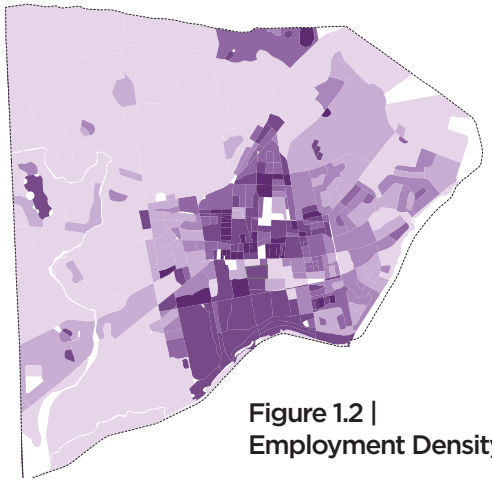


Figure 1.2 | Employment Density[7]

While this appears low, it is significantly higher than the statewide average (0.4%). Additionally, 58% of residents have a commute less than 20 minutes, which suggests that most residents do not travel far to work, and might well be within a reasonable bicycling distance.[11]

Many Princeton residents also do not have a car, or have limited access to a car, whether by choice or due to the cost of car ownership. Approximately 12% of households do not own a car, and 34% of households have one car, both significantly higher than the state average (6.7% and 22.7%, respectively).[12]

Figure 1.4 | Zero and One-Car Households[13]

University Town

Princeton is a university town, which is vital to the local economy and significantly shapes both the population and employment characteristics of the community. As home to Princeton University, as well as Westminster Choir College, Princeton Theological Seminary, and the Institute for Advanced Studies, Princeton benefits from a large population of students, faculty, and staff. University students account for nearly 30% of Princeton's population.[14] These educational institutions are also major employers. Princeton University has more than 6,000 benefits-eligible faculty and staff, making it the largest private employer in Mercer County.[15] For the large number of university students and university employees living in Princeton, bicycling may be a preferred, or even necessary, way to travel to class, work, downtown businesses, and other destinations.

1.3 Policies, Programs, and Previous Studies

The municipality, as well as other jurisdictions and institutions that impact local transportation, have a variety of existing policies, programs, and previous studies relevant to bicycling and the Princeton Bicycle Master Plan. These programs and previous work support bicycling initiatives and growth in bicycle ridership in Princeton, as well as help shape and guide the planning process.

Complete Streets

Complete Streets policies apply to all roadway jurisdictions in Princeton. The Municipality of Princeton, Mercer County, and the New Jersey Department of Transportation have all passed Complete Streets policies, requiring all roadway projects to safely accommodate travel by pedestrians, bicyclists, public transit, and motorized vehicles. These policies shift the focus from a transportation system centered around the car, to creating a multi-modal network with better access and safety for all travel modes, including bicyclists.

Complete Streets Defined

"Complete streets are designed and operated to enable safe access for all users. Pedestrians, bicyclists, motorists and transit riders of all ages and abilities must be able to safely move along and across a complete street."

~National Complete Street Coalition

Princeton Complete Streets Policy

In 2012, both the former Princeton Borough and Princeton Township adopted municipal Complete Streets policies. These policies call for the community to create a "comprehensive, integrated, connected multi-modal network by providing connection to bicycling and walking trip generators such as employment, education, bicycle and transit facilities."

Circulation Element of the Master Plan

The Princeton BMP is consistent with and advances the Circulation Element of the Master Plan. The Circulation Element emphasizes the need for reduced dependency on motor vehicles in order to "ensure long-term sustainability of the community's social diversity, neighborhood quality of life and vibrancy of its town center." As the Municipality approaches full build-out, there will be few opportunities for future roadway capacity improvements, particularly surrounding the historic center of the community. Instead, efforts should be made in line with the adopted Complete Streets policy to make it easier for residents to choose walking or bicycling over driving, particularly for making local trips.

A central goal of the Circulation Element is to "promote and encourage pedestrian/bicycle mobility." To achieve the goal, the plan identified the need to improve pedestrian and bicyclist safety, implement a bicycle network connecting key destinations, and promote education and enforcement programs. Developing this Bicycle Master Plan is a stated strategy of the adopted Circulation Element.

> *"The policy of this Master Plan is to promote bicycling as a safe choice for personal transportation. The Princeton community is served by a comprehensive system of pedestrian and bicycle paths. In order to achieve this policy it is necessary to plan and provide appropriate facilities which will accommodate all levels of bicycling skill."*
>
> **~Princeton Master Plan**

Bronze Level Bicycle Friendly Community

The League of American Bicyclists designated Princeton as a Bronze Level Bicycle Friendly Community (BFC) for 2013-2017. The recognition was the result of a number of local initiatives, many of which Princeton's Pedestrian and Bicycle Advisory Committee helped to achieve. Key factors contributing to the designation included: incorporation of pedestrian /bicycle mobility goals Princeton's Master Plan, existing bicycle facilities, and education and enforcement efforts to increase bicycling safety.

Going forward, the Municipality's goal is to achieve Silver status during the renewal cycle. Completion of the BMP, as well as plans to extend bike paths, develop a robust bicycle network, and implement more amenities for bicyclists such as wayfinding signage and additional bike parking, will be key factors for the renewal application.

Bicycle Circulation Plan for the Princeton Community (2002)

The Bicycle Circulation Plan for the Princeton Community was completed in 2002. Although it was not formally adopted by the Planning Board as an element of the Master Plan, it developed a comprehensive package of recommendations to improve conditions for bicycling in Princeton. The principal components of the plan's recommendations included providing access to potential bicycle trip attractors, establishing a complete bicycle network, implementing roadway improvements to improve access and comfort for bicyclists, and improving safety through education and enforcement efforts.

The bicycle network outlined in the plan identifies roadways and opportunities for off-road paths that might form the spine of a future town-wide bicycle network.

"This Master Plan, with the inclusion of its Complete Streets Policy, recommends that a community-wide bicycle system that addresses all levels of bicycle riding ability be developed. Special attention should be given to developing routes which allow school-aged children to safely ride bicycles to and from school, parks, the Library and other areas in the community."

~Princeton Master Plan

Shared-Lane Markings for Bicycles

In 2010, the Princeton Joint Pedestrian and Bicycle Advisory Committee compiled a report summarizing best practices for using shared-lane markings ("sharrows") and promoting their use in Princeton to improve safety, increase awareness of bicyclists among motorists, and help bicyclists better position themselves in the roadway. Due to various constraints, such as narrow roadways and the high priority for maintaining on-street parking, shared-lanes were recommended as an important first step towards improving conditions for bicyclists and adhering to Complete Streets principles. Following the report, Princeton Township and Princeton Borough worked with the New Jersey Department of Transportation and Mercer County to implement a network of shared-lane markings on major north/south and east/west routes in the community, including NJ Route 27, Harrison Street, Witherspoon Street, and Paul Robeson/Wiggins/Hamilton Street.

Ad-Hoc 2012 Bicycle Plan

Developed by the Princeton Joint Pedestrian and Bicycle Advisory Committee (PBAC) in 2012, the plan provides an overview of the existing bicycle network in Princeton and outlines potential improvements to enhance it. Recommendations consist of: providing better access to paths, improving the condition of paths, and suggestions for revisions to the municipal Master Plan.

The overall goal of the Ad-Hoc Plan is to promote bicycle use and develop a safer bicycling environment by improving the facilities that are currently available. Although not a formal municipal planning document, it identified recommendations for each section of the Municipality to support a comprehensive bicycle network.

Route 206 Joint Vision Plan and Traffic Calming Study

Completed in 2006, the Route 206 Joint Vision Plan and Traffic Calming Study developed a comprehensive vision for the Route 206 corridor from Nassau Street to Cherry Valley Road. The study identified a series of improvement concepts to address existing congestion, safety, and access issues that fit the varying needs and context along the corridor.

The proposed concepts would support a more bicycle friendly environment along the corridor. A series of traffic calming elements would slow vehicular traffic and improve crossings. Roundabouts at several major intersections, including Nassau Street, would improve traffic flow and moderate speeds through Princeton.

Princeton Bike Map

Princeton created a Bike Map to promote bicycle use and enhance the bicycling experience. It identifies available bicycle routes and route characteristics (off-street path, designated bike route, etc.). Bicyclists can utilize the map to identify which routes might be more fitting for their experience level. Notable destinations are highlighted, as are connections to transit systems and bike-friendly businesses –all the basic information necessary to simplify and facilitate bicycle wayfinding.

Princeton University Plans/Policies

Princeton University promotes the use of bicycles as a mode of transportation on campus and commuting for students, faculty, and staff. The University maintains a campus-wide network of paths and walkways suitable for biking, as well as bicycle parking throughout campus.

The University began operating a bicycle rental system in November 2014 based at the Dinky station. The success of the program demonstrated the demand for access to short-term bike rentals, and the University is planning to upgrade the program to a full bike share system in 2016. The University also actively promotes bicycle commuting through a variety of education and encouragement initiatives, such as access to shower facilities, bike drives to repurpose abandoned bicycles, and support of a student-run bicycle repair service. On-going work on the updated Campus Master Plan is expected to include improved bicycling infrastructure. The League of American Bicyclists has designated the University a Bicycle Friendly University.

Princeton Bike Share

In October 2015, Princeton received a grant from the Delaware Valley Regional Planning Commission to support implementation of a bike share system. The system is expected to include 50 bikes and will be rolled-out during 2016. The Municipality and Princeton University are working together to create an integrated bike share system that will include stations on-campus and at major destinations throughout the community.

Mayor's Challenge for Safer People, Safer Streets

Princeton joined the U.S. Department of Transportation (USDOT) 2015 "Mayor's Challenge for Safer People, Safer Streets" initiative. The program focuses on advancing bicycle and pedestrian safety and accessibility goals by tackling one or more of the Challenge activities: implement a Complete Streets approach, identify and fix barriers to safety and access, gather data on walking and biking, use context sensitive design, create bicycle and pedestrian networks, improve safety laws, and educate and enforce proper road use behaviors by all.

Bike to School Survey

In the fall of 2015, schools in the Municipality conducted a survey of the number of students cycling to school. Data was collected by inventorying the number bicycles parked at each school. The data is summarized in Table 1.1, and provides a baseline for future surveys.

Table 1.1 | Bike to School Survey, 2015

School	% of Student Body
Princeton H.S.	5%
John Witherspoon M.S.	8%
Littlebrook E.S.	7.5%
Community Park E.S.	6%
Riverside E.S.	11%
Johnson Park E.S.	1.5%

**October 29th - November 4th, 2015*

END NOTES

1 Widner, R. *Princeton's Profile 2014, A Report to Princeton Future,* 2014
2 ibid
3 U.S. Census, 2014 ACS, 5 year estimates
4 U.S. Census, 2014 estimate
5 U.S. Census, 2014 ACS, 5 year estimates
6 ibid
7 U.S. Census, 2013 LODES data
8 Andersen, M. *Bike Use is Rising Among the Young, but it is Skyrocketing Among the Old,* 2014
9 Widner, R. *Princeton's Profile 2014, A Report to Princeton Future,* 2014
10 U.S. Census, 2014 ACS, 5 year estimates
11 ibid
12 ibid
13 ibid
14 ibid
15 http://www.princeton.edu/main/administration/working/ [accessed January 2016]

02

Developing the Vision

Princeton is a diverse community with a wide range of stakeholders with an interest in improving bicycling in Princeton. It includes a passionate bicycling community, school children, young families, health advocates, businesses, long-time residents, commuters, lower-income service workers, seniors, university students, and many others. The Princeton Bicycle Master Plan used an extensive public outreach process in order to capture input and local knowledge from the people who know the municipality best – those who live, work, and travel through Princeton.

Through a variety of public forums, meetings, hand-written forms, and online tools, the Princeton Bicycle Master Plan gathered information and feedback on existing conditions for bicycling; key issues, challenges, and constraints related to bicycling and bicycle infrastructure in Princeton; preferred or desired routes; and the proposed bicycle network. The community's input was central to the vision, goals, and recommendations of the Princeton Bicycle Master Plan, creating a plan that ultimately reflects the needs and vision for the future of the community.

2.1 Community Involvement Activities

The project team used several methods to engage the community in the planning process, be it meeting with formal planning bodies, groups of interested stakeholders, or general public outreach. The following sections summarize the various activities and tools used to gather input from the Princeton community throughout the development of the Princeton BMP.

VISION STATEMENT

Princeton values cycling as an essential form of transportation for residents, workers, and visitors. Implementation of the Bicycle Master Plan over time creates a community that allows bicyclists of all ages and abilities to safely, comfortably, and conveniently access major destinations throughout Princeton. As a result, Princeton is a more livable, vibrant, equitable, healthy, and sustainable place, whose streets encourage people to bicycle for fun, recreation, and daily transportation.

Planning Board Updates

The Princeton Planning Board is the governing body that will oversee implementation of the BMP. Four updates were provided to the Princeton Planning Board at regular intervals, keeping the board, as well as the public, informed on the progress of the plan and providing an opportunity to gather input and feedback.

Planning Board Meeting #1

A kick-off presentation to the full Princeton Planning Board was held on September 17, 2015. The presentation introduced the project team and provided an overview of the plan methodology, schedule, and key products.

Planning Board Meeting #2

The project team met with the Master Plan Subcommittee of the Planning Board on February 10, 2016. The team presented results of the existing conditions analysis and public outreach activities to date, including the survey, wikimap, comment forms, focus groups, and first public meeting. Based on these activities, "desire lines" identified an initial potential network. The group also reviewed and provided comments on the draft vision and goals.

Planning Board Meeting #3

The project team met with the Master Plan Subcommittee of the Planning Board on May 23, 2016, to present the draft bicycle network. The group provided feedback on the recommendations for further refinement.

Study Advisory Committee

A local Study Advisory Committee (SAC) was convened to provide input and guidance to the BMP throughout the planning process. Committee members represented a diversity of stakeholders, including elected officials, municipal staff, police department, municipal committees, Mercer County, the Hispanic community, local schools, and Princeton University. The SAC met on three occasions.

SAC Meeting #1

The first SAC meeting was held on October 27, 2015. The project team presented an overview of the plan methodology, examples of bicycle facility types, and the benefits of improved bicycle infrastructure for a community. The SAC then held a brainstorming session to discuss a vision for the future of bicycling in Princeton, goals of the Plan, and critical challenges to achieving the vision.

SAC Meeting #2

The project team met with the SAC on February 23, 2016, to present results of the existing conditions analysis and public outreach activities to date, including the survey, wikimap, comment forms, focus groups, and first public meeting. Based on these activities, "desire lines" identified an initial potential network. The group also reviewed and provided comments on the draft vision and goals.

Princeton BMP Study Advisory Committee Meeting

Focus Groups and Stakeholder Interviews

The project team conducted a series of focus groups and interviews to engage additional stakeholders in more detail on particular topics related to bicycling in Princeton.

Princeton University Interview

The project team met with Princeton University's Transportation and Parking Services on November 3, 2015, to discuss the University's bicycle policies, programs, and planning efforts. The University actively encourages alternative modes, such as bicycling, among its students, faculty, and staff in order to help decrease reliance on the automobile for commuting and for inter- and intra-campus trips, and to help decrease demand for parking. The University is an integral part of the community, and opportunities to integrate it into the bicycle network are critical to the success of the BMP.

Focus Group – Transportation

The project team met with stakeholders with professional and/or local expertise in transportation on December 2, 2015. Nine people attended the focus group. Attendees provided input on existing programs that their respective organizations provide to support or encourage bicycling, the greatest needs related to bicycling in Princeton, and problem areas and gaps in bicycle facilities in Princeton. The group stressed that the BMP should represent the needs of a diverse group of stakeholders, utilize a data driven approach, and balance private and public property interests.

Focus Group – Education and Social Services

A second focus group was held with stakeholders from local schools, the recreation department, and social services on December 2, 2015. Ten people participated in the meeting. Attendees provided input on existing programs that their respective organizations provide to support or encourage bicycling, the greatest needs related to bicycling in Princeton, and problem areas and gaps in bicycle facilities in Princeton. Attendees expressed strong interest in incorporating bicycle safety and education programs into the BMP and expanding those efforts already in place. Bicycling was acknowledged as an important means of getting to the schools, and bicycle improvements should focus on strengthening connections between the schools and the library, residential neighborhoods, and the commercial core.

Focus Group – Businesses

The third focus group engaged the local

business community. Eight representatives from businesses in and around Princeton attended the meeting on January 20, 2016. The attendees emphasized bicycling as an important element of the transportation network. Moving people, both customers and employees, is critical to the business community, and bicycling is one tool to do so. Shifting trips to bicycling frees up parking for other customers, helps keep retail shopping in the local economy, and helps alleviate congestion issues. The group also noted the following key points: concerns about safety, particularly for employees who rely on cycling; potential for tourism and longer bicycle commuter trips with better connections outside of Princeton (e.g., Princeton Junction train station, Forrestal Campus); and a preference for improvements implemented by the municipality or flexible programs to address bicycle parking needs rather than requirements of small local businesses.

Public Meeting

The Princeton BMP public meeting was held on November 12, 2015. Over 60 people attended the meeting. The project team gave a brief presentation to outline the plan methodology, schedule, and key products. This was followed by a question and answer period, where members of the public asked specific questions about the BMP and planning process, voiced concerns, and identified important issues and challenges. Many indicated support for improving bicycling in Princeton, while others expressed concerns about potential changes and impacts. The Q&A session was followed by a general open-house session, where the public could view information about the Plan, provide input, and chat with project staff. The open house stations included poster boards summarizing demographic characteristics of the municipality, the benefits to the community associated with improved bicycling infrastructure, example bicycle facilities, and design resources; large maps of the municipality where attendees could mark problem areas and desired bicycle routes; computer stations to add comments to the Wikimap and complete the online survey; and a station to submit comment forms.

Public Engagement Tools

In addition to formal meetings, the project team used a variety of outreach tools engage the general public. These tools provided a means to disseminate and gather information from those unable to attend meetings in person, and thereby interact with a broader portion Princeton's residents.

Web Page

The Municipality established and maintained a Princeton BMP web page to house all plan-related information and products and keep community members up to date on plan activities and products. It

Business Focus Group Meeting

included up-coming meetings, factsheet, draft and final products, meeting presentations, a comment form, and links to the BMP survey and Wikimap.

Comment Forms

A project comment form was made widely available to gather input on existing conditions, issues, and desired bicycle routes. The form, available in English and Spanish, was distributed at public meetings, through e-mail blasts, and available online. Additional efforts were made to distribute the form and gather input among the Hispanic community in Princeton by distributing them through local community groups and stakeholders. Overall, over 120 people submitted input through the comment form.

Wikimap

An online Wikimap website was launched in November 2015 to collect place-based comments about bicycling in Princeton. Open to the general public, users were asked to identify corridors and spot locations that were difficult for bicycling, desired bicycle routes, and locations for new or additional bike parking. The results from the Wikimap are discussed in Section 2.4.

Survey

The Princeton Bicycle Master Plan used input from an online survey to help inform the Plan. Open from October 2015 through January 2016, the survey was intended to give the project team a better understanding of the unique needs and characteristics of the community. In addition to general demographic questions, the survey sought information about the types of cyclists in the community, how often and for what purpose(s) they currently bicycle, and what key benefits they associate with bicycling. It also collected information on what members of the community view as barriers to bicycling, key destinations in Princeton, and how comfortable they feel bicycling on various kinds of bicycle facilities and roadways. A better understanding of the types of bicyclists, user preferences, and perceived barriers helped inform development of a bicycle network that would be accessible and comfortable for the largest number of users and encourage more people to bicycle. The results from the survey are discussed in the Section 2.3.

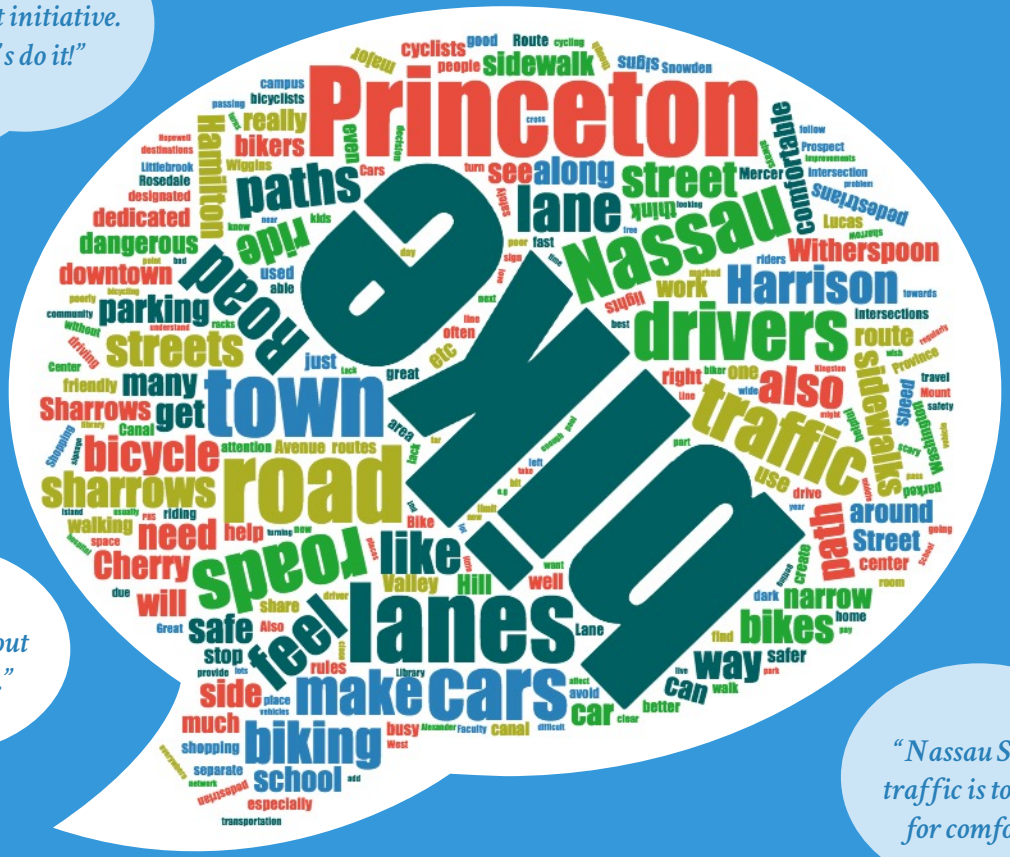
Princeton BMP comment booth at the National Night Out event

National Night Out

The project team had a booth at Princeton's National Night Out event on August 4, 2015. Held at the very early stages of the project, the booth publicized the upcoming planning study, and passersby were invited to fill out comment forms and mark-up a map to identify problem areas and desired bicycle routes.

WHAT WE HEARD

"Word cloud" and sample comments from Princeton BMP comment forms



"It is important that there be a major communications/ educational campaign about what sharrows mean."

"I'd also like to get cyclists off the sidewalks."

"...a bike network that safely and conveniently connects bike facilities together."

"I don't feel safe when my daughter bikes to her school every morning."

"I would feel most comfortable if there were bike lanes that connected the schools, library, pool, shopping center – places in town kids are most likely to go."

"Great initiative. Let's do it!"

"Safe routes to school to encourage more walking and biking to school."

"The sharrows are comforting and make me feel like I have a right to be there, although they are a poor substitute for a bike lane."

"I bike all over for fun, errands, work, out to dinner, parties, and any other function possible."

"Sharrows would not make me feel safer for me and my kids."

"Biking is about destinations."

"I don't [bike] because of the lack of safety and road conditions."

"Nassau Street traffic is too fast for comfort."

"Traffic calming needs to be part of this conversation."

"My bicycle is my only form of transportation most of the time."

"Bikers who are not respectful of the rules of the road, which in turn sets up an 'us' and 'them' situation."

2.2 Informing the Vision

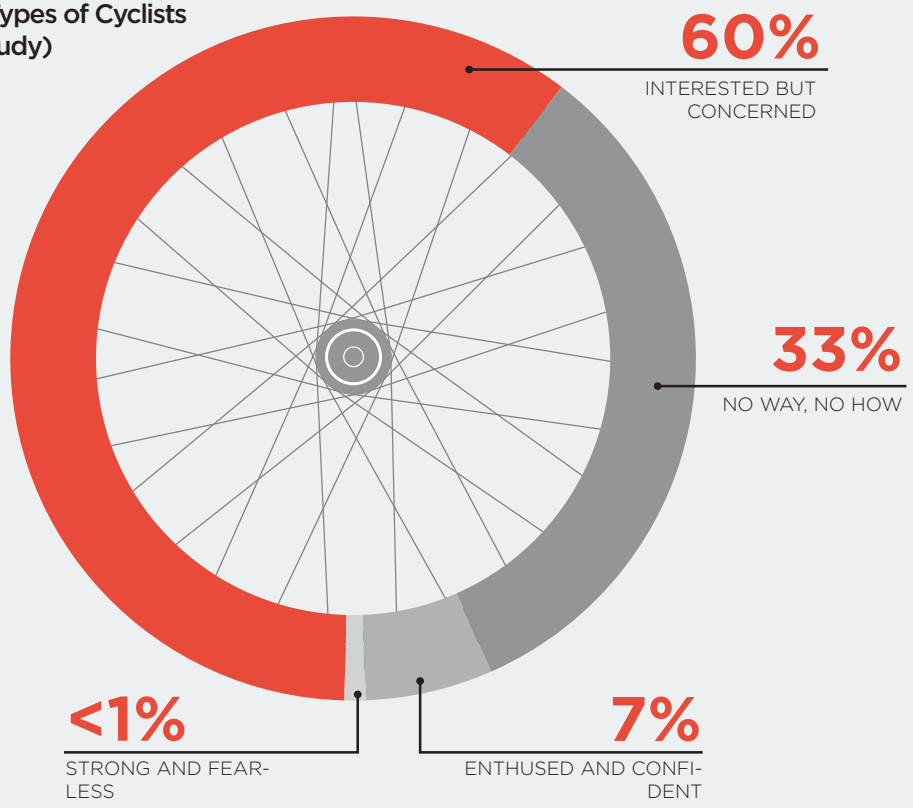
The vision for the Princeton Bicycle Master plan is to develop a bicycle network in Princeton that is accessible and attractive to cyclists of all ages and abilities. The guiding principle used to achieve this vision is to follow the "Five C's." That is, bike networks must be continuous, connected, convenient, complete, and comfortable.

In the United States many bike lanes disappear at intersections and other stressful spots. To be successful, bike lanes must be continuous through these spots. Similarly, gaps in a bicycle network can discourage potential riders. Bike routes should be connected between all routes. Bike networks must also be convenient to connect cyclists to key destinations. A successful network takes into account what happens when a bike ride ends. This means considering how complete a street is, including the presence of sidewalks, bike parking, and access to transit. Finally, a bicycle network should be comfortable and inviting for all riders, providing the sense that cycling is a safe and convenient activity.

The "Five C's" are intended to accommodate cyclists of all ages and abilities. A 2006 study by the Portland Department of Transportation identified four ways that people relate to riding a bicycle: "Strong and Fearless, Enthused and Confident, Interested and Concerned, and No Way No How."

A 2012 follow up survey conducted by Portland State University found that 60 percent of respondents, when asked if they would ride a bicycle, said that they fell into the "interested, but concerned" category. The primary cause of this concern was fear over safety and interacting with automobiles on the road. This population also reported the highest level of comfort on separated paths and quiet residential streets, indicating that reducing traffic speeds and increasing separation between bicycles and motor vehicles increases levels of comfort and can lead to higher rates of bicycling.

Figure 2.1 | Four Types of Cyclists (Portland DOT Study)



This finding is consistent with a large body of research, particularly in northern Europe, where, following this principle, many nations and cities have seen dramatic increases in bicycling rates. A 2015 national survey conducted by Portland State University similarly found that 51% percent of respondents identify themselves as "interested, but concerned."

The "interested, but concerned" group of cyclists represents the largest population of riders and potential riders. Building bicycle networks that are continuous, connected, convenient, complete, and comfortable accommodates this group. This strategy for bicycle network development offers the transformative potential of dramatically increasing bicycle ridership by appealing to this group.

The Five C's

Bicycle routes should be:

- ✓ *Continuous*
- ✓ *Connected*
- ✓ *Convenient*
- ✓ *Complete*
- ✓ *Comfortable*

Following the "Five C's" approach helps ensure that bicycle routes accommodate cyclists of all ages and abilities.

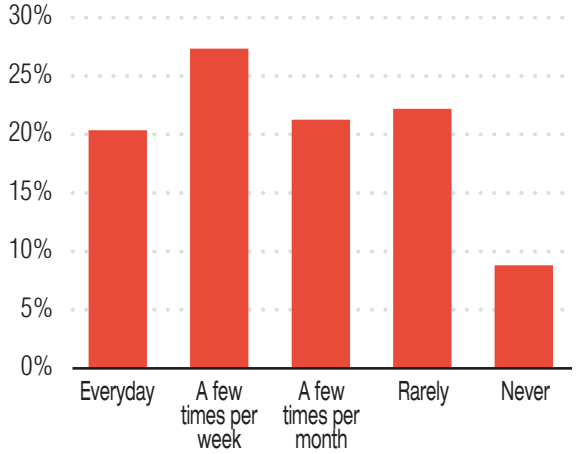
2.3 Survey Results

The Princeton Bicycle Survey was conducted online from November 15, 2015 to January 31, 2016. Over 470 people responded to the survey during this time. The survey was designed to determine what types of bicycle facilities are most comfortable for adults and for children, what are some of the challenges faced by cyclists in Princeton, and what outcomes are desired from the Bicycle Master Plan.

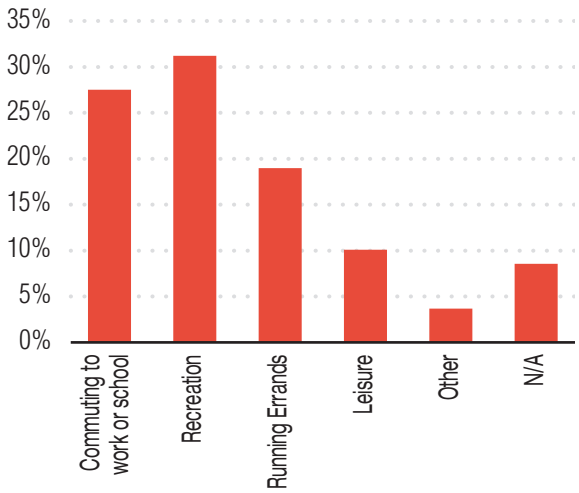
While it was live, the survey was open to anyone who accessed the website. Respondents were not required to answer every question. Results provided in this summary reflect only those who responded to each particular question.

The demographics of survey respondents were diverse. About 51 percent of respondents were male and the average age of respondents was 46. About 40 percent of respondents indicated that they have at least one child under 18 living in their home. About 82 percent of respondents live in Princeton, 48 percent work in Princeton, and 15 percent are students (undergraduate and above).

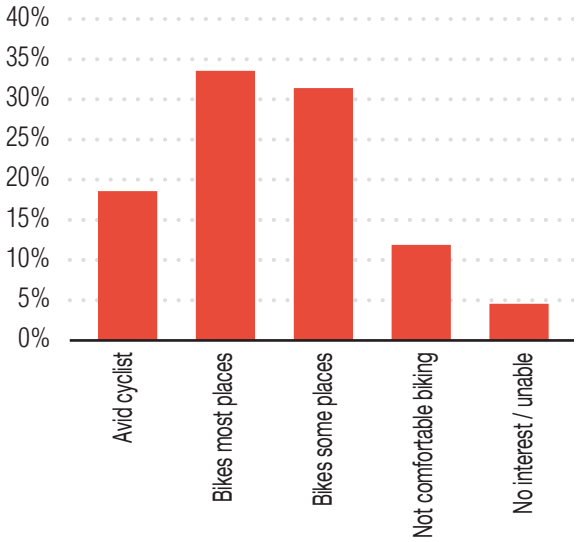
How frequently do you ride a bicycle in Princeton?



What is the typical purpose of your bicycle trip?



How would you describe yourself?



Who took the survey?

Respondents were asked a few questions to identify what type of cyclist they would describe themselves as, how often they cycle in Princeton, and what the typical purpose of their trip is. The purpose of these questions, along with the demographics questions, was to better understand the experiences and points of view of survey respondents.

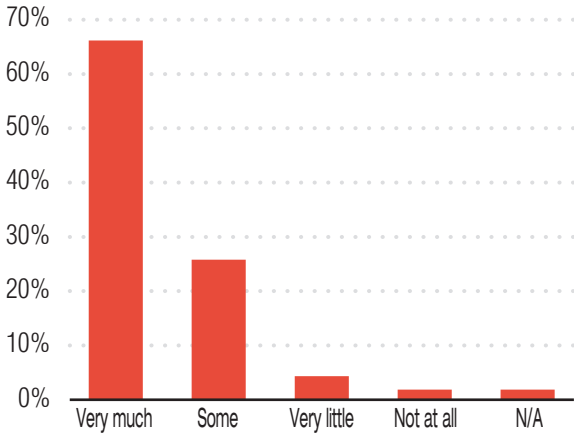
When asked how they would describe their bicycling habits, the majority of respondents indicated that they either "bike most places," or "bike some places." When asked how frequently they ride a bicycle in Princeton, the responses were fairly evenly distributed between those that said they bike "every day," "a few times per week," "a few times per month," or "rarely." Less than 10 percent indicated that they never bicycle.

Survey participants were asked what the typical purpose of their bike trip is. Respondents indicated that recreation or commuting to work or school account for the majority of bicycle trips.

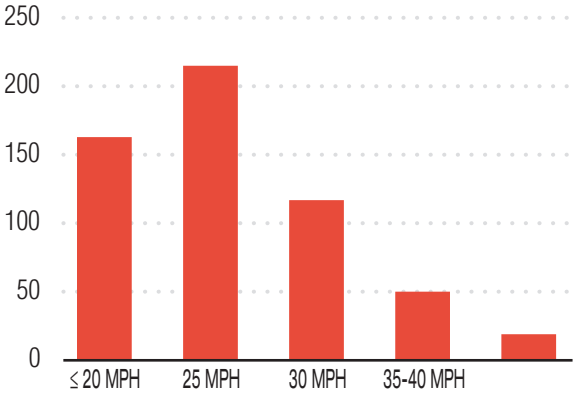
The results of these questions indicate that typical respondents were a mix between frequent and casual cyclists who either ride for transportation or for pleasure.

Survey respondents represented a mixture of different types of cyclists, including those that don't bicycle at all. Overall, 23% of respondents identified as a cyclist that "enjoys biking most places," while 22% identified as a cyclist that "bikes some places."

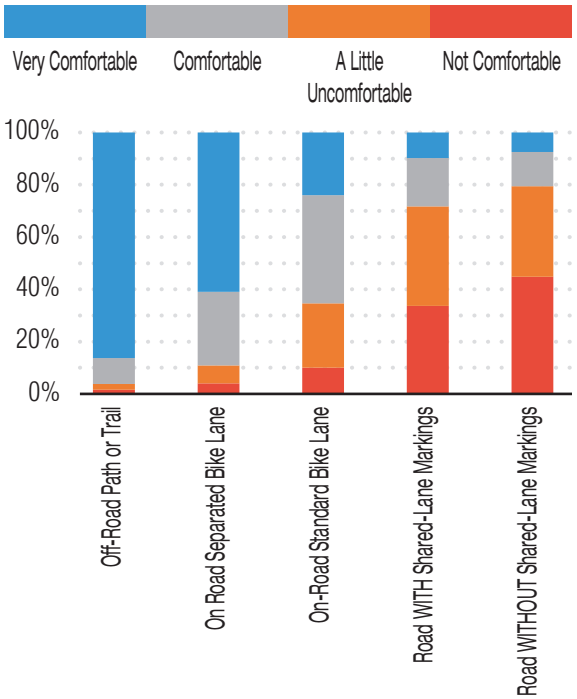
How much does the speed of motor vehicle traffic influence where you feel comfortable riding a bicycle?



If you were riding a bicycle on the road, at what prevailing speed of motor vehicle traffic would you feel comfortable riding with? (check all that apply)



How comfortable do you feel riding on the following facilities?



Comfort Level

A series of questions were asked to determine what influences the comfort level of cyclists in Princeton. The results indicated that there are several roadway characteristics and facility types that influence comfort level.

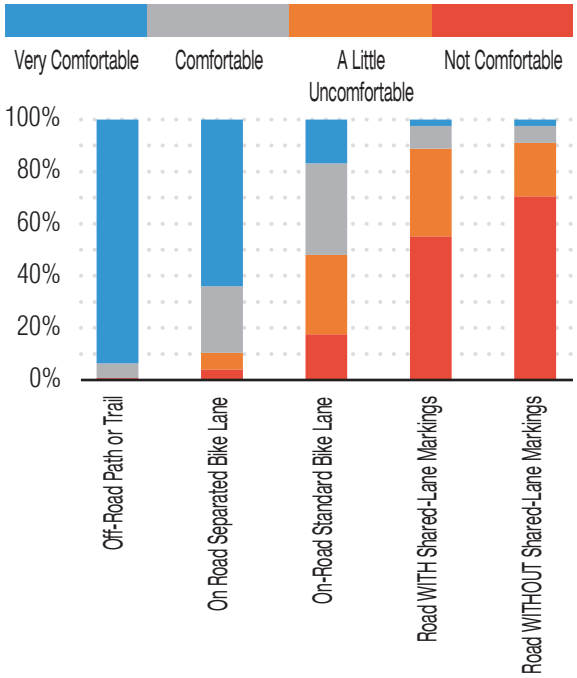
When asked to what degree the speed of motor vehicle traffic influences their comfort level, over 65 percent of respondents indicated "very much" while an additional 25 percent indicated "some." Respondents were also asked to indicate the motor vehicle speeds that they would feel comfortable riding with. Most respondents indicated motor vehicle speeds of 25 mph and below.

Survey respondents were asked how comfortable they would feel riding on a street with different facility types: off road path or trail, on-road separated bike lane, on-road standard bike lane, road with shared-lane markings, or a road without shared-lane markings. Not surprisingly, respondents indicated that they feel most comfortable using facilities with more separation between cyclists and motor vehicle traffic. Respondents indicated that feel most comfortable on off-road paths or trails and roads with separated bike lanes. They indicated that they feel the least comfort riding in mixed traffic. The presence of shared-lane markings had a small positive impact on comfort level.

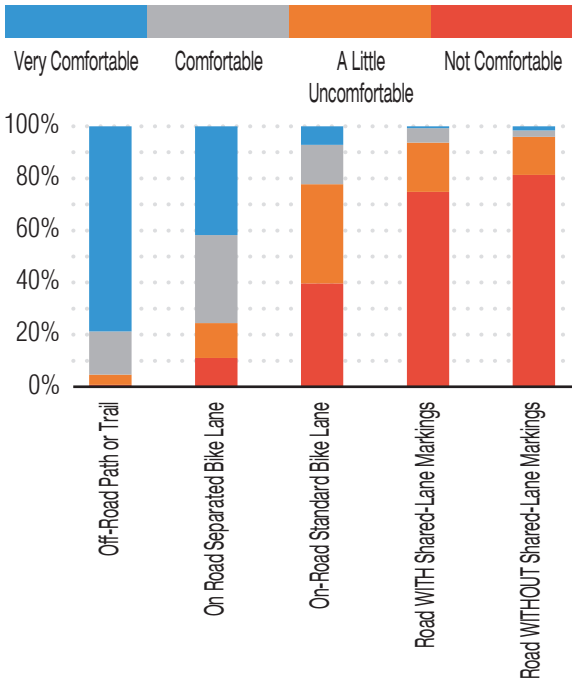
85% of respondents indicated that they feel "very comfortable" riding on an off-road path or trail."

Only 8% of respondents felt the same about riding in mixed-traffic without shared-lane markings.

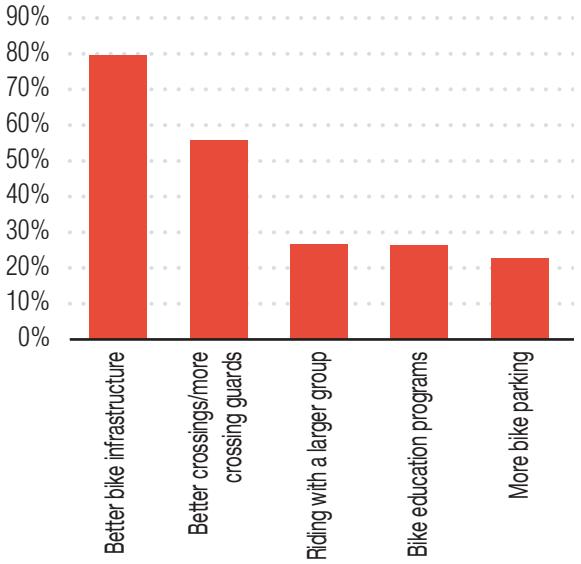
How comfortable do you feel about your children riding on the following facilities WITH an adult?



How comfortable do you feel about your children riding on the following facilities WITHOUT an adult?



Please rate to what degree the following items would make you more comfortable with your child biking to school, with 1 being the least important and 10 being the most important*



For display purposes, chart shows the percentage of respondents who indicated 8-10

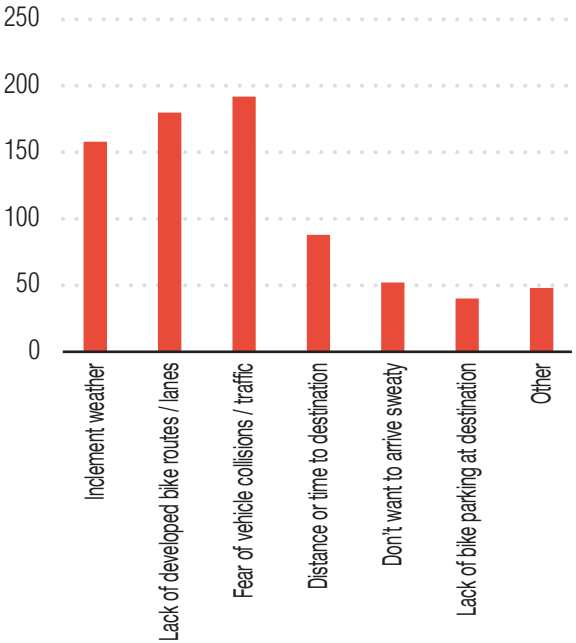
Comfort Level Biking with Children

Respondents who indicated that they have a child under 18 living in their home were asked a series of questions to indicate their comfort levels for their child riding with or without an adult. Similar to the results of the question about their own personal comfort level, most respondents to these questions felt high levels of comfort for their children traveling on off-road paths or trails either with or without an adult. Similarly, although there were higher levels of comfort for children traveling with an adult on a separated bike lane than without an adult, both scenarios yielded relatively high levels of comfort (64 percent very comfortable with an adult; 42 percent very comfortable and 34 percent comfortable without an adult).

Parents or guardians generally felt uncomfortable with their children biking in mixed-traffic, either with or without shared-lane markings. While 70 percent of these respondents felt uncomfortable with their children biking in mixed-traffic with an adult, 81 percent felt uncomfortable with their children biking in mixed traffic without an adult.

When asked to rate what improvements might make them more comfortable with their children biking to school, about 80 percent indicated “better bicycle infrastructure” and over 55 percent indicated “better crossings / more crossing guards.”

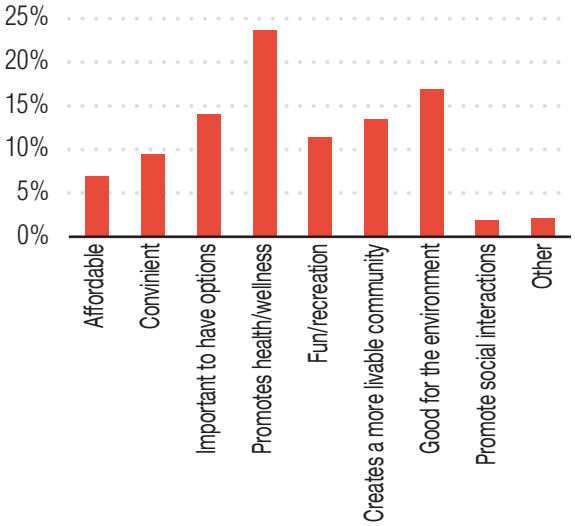
What prevents you from riding your bicycle more?



Why Not Bicycle?

Respondents were asked what factors prevent them from bicycling more. The most frequent response was the "fear of vehicle collisions / traffic." This is consistent with the other findings in the survey, which indicated that most riders feel more comfortable with increased separation from motor vehicle traffic and/or riding with motor vehicles traveling at lower speeds. The second most common response to this question was the "lack of developed bike routes/lanes," which might provide some of the separation that the respondents value.

Why is biking important as a part of community infrastructure?



Why Is Bicycling Important?

In order to gauge what the community values from cycling, respondents were asked why cycling is an important part of the community infrastructure. Answers varied, but respondents indicated that "health and wellness," "good for the environment," "important to have transportation options," and "creates a more livable community" were the most important benefits of cycling.

What does the survey say?

As a university town with a traditional development pattern (density in its core, decreasing as you move farther out) Princeton is in many ways an ideal place to ride a bicycle. However, because of the volume of motor vehicle traffic as well as the lack of any dedicated bicycle facilities in its core, bicycling in Princeton can be very challenging.

The Princeton Bike Survey indicates that at least among respondents (who represented a reasonably diverse group), concerns about riding with motor vehicle traffic makes cycling less comfortable, while lower speeds and dedicated and separated bicycle facilities have a significant impact on user comfort level.

2.4 Wikimap Results

The Princeton BMP Wikimap was open for public comment from November 2015 through January 2016, during which 516 comments were received from 84 unique users.

One role of the site was to help locate existing problem areas. Wikimap users identified a total of 33 problem corridors and 61 problem spots, which are shown in Figure 2.2 based on the frequency of comments. Generally, many of the locations tend to be along the Municipality's busier roadways, with many of the spot locations around the downtown. Nassau Street had the most comments, typically related to conflicts with vehicular traffic.

The comments indicated that problem locations were selected for a range of issues, such as difficult intersections and trail crossings, poor pavement condition, or traffic conflicts, and included both roadways and off-road facilities. Table 2.1 shows the results of the Wikimap survey for each problem area that was created. High volumes of traffic (46%) and high speeds (34%) were common issues, as were motorist awareness (46%) and behavior (34%).

Figure 2.2 | Heat Map Indicating Frequency of Comments on Problem Corridors (line) and Spot Locations (circle), and Sample Wikimap Comments

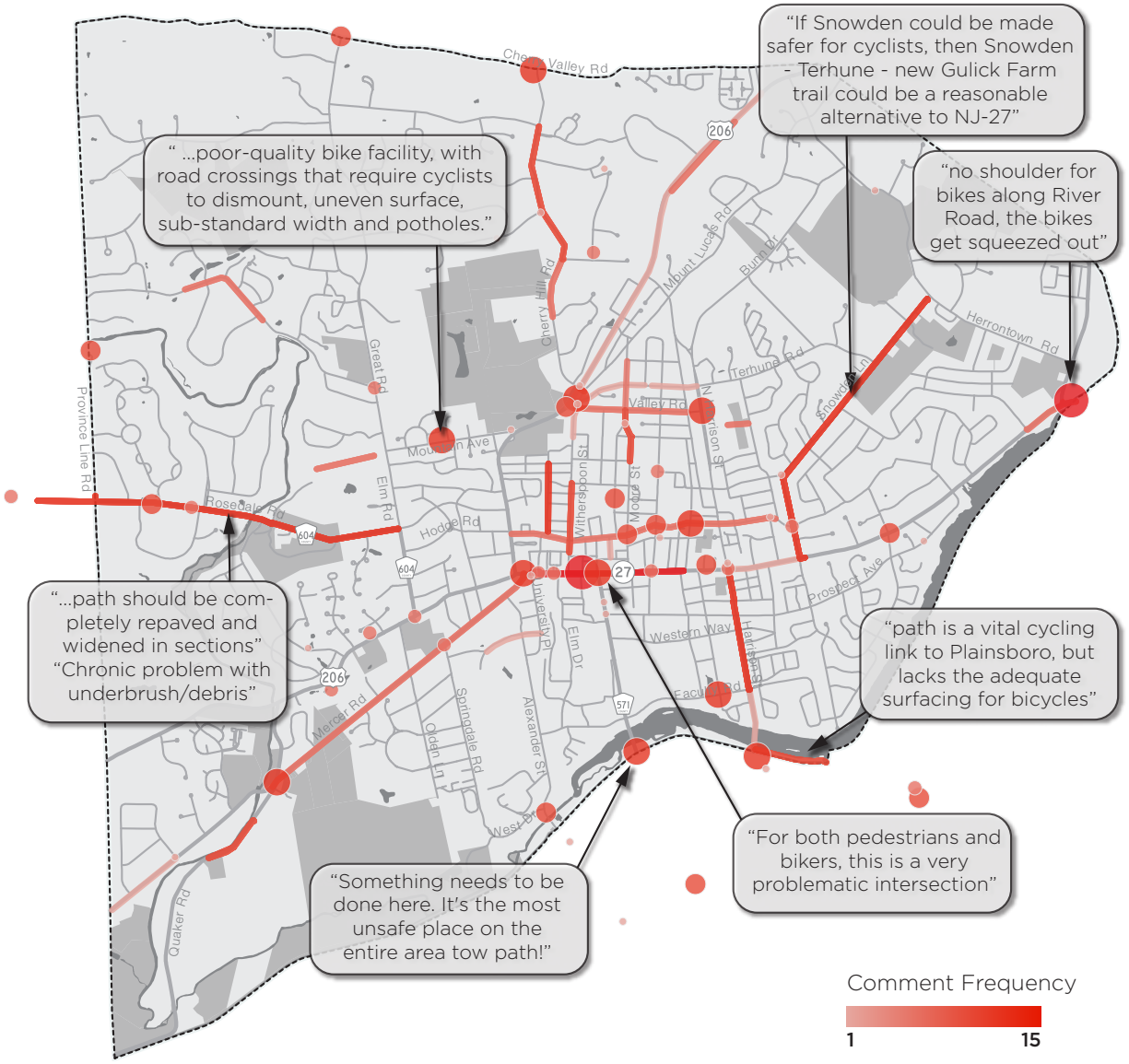
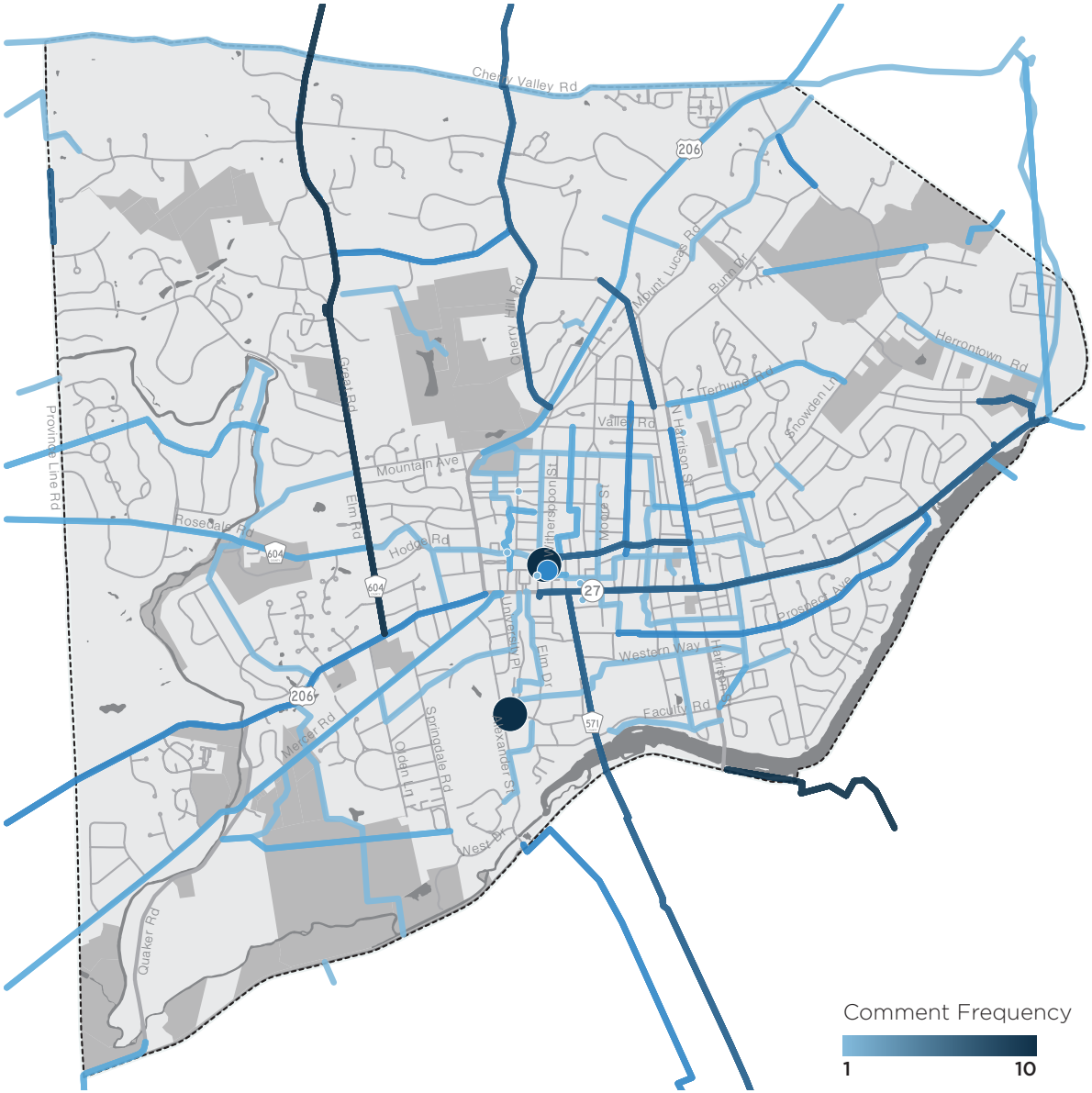


Figure 2.3 | Heat Map of "Desire Lines" Indicating Preferred Bicycle Routes (line) and Locations for Additional Bike Parking (circle)



The Wikimap was also a tool for the public to indicate the locations of preferred routes. These "desire lines" are shown in Figure 2.3, with the darker color indicating a higher number of comments. A total of 71 preferred route segments were identified. The top routes were an improved connection between the D&R Canal Trail and the Forrestal Campus and Plainsboro Hospital, improvements to the Great Road sidepath, Hamilton Street between Witherspoon Street and Harrison Street, a trail through the Gullick Preserve, and NJ Route 27.

Commenters also identified needs for additional bike parking at the library, Princeton Train Station, and inside the Spring Street parking garage.

Table 2.1 | Results of Wikimap Survey on Typical Problem Area Issues

Issue	% of Problem Locations
High volumes of traffic	46%
Motorists often unaware of bicyclists	46%
Difficult intersection	37%
High motor vehicle speeds	34%
Motorist behavior	34%
Poor pavement conditions	28%
Inadequate lighting	18%
High freq. of turning traffic	18%
Narrow roadway	15%

2.5 Goals, Metrics, and Indicators

As defined at the start of this chapter (page 13), the Princeton Bicycle Master Plan presents a vision for the future of cycling in the community. To support this vision, the Princeton BMP seeks to achieve the following goals:

Goals

1. **Policy** – Advance and support the Municipality's Complete Streets Policy and Master Plan.
2. **Safety** – Improve safety for all roadway users and prioritize bicycle safety for those with limited transportation options, including school-age children and other vulnerable roadway users.
3. **Accessibility and Comfort** – Create a low-stress bicycle network that is accessible to cyclists of all ages and ability levels.
4. **Connectivity and Convenience** – Develop a core bicycle network with seamless and convenient connections throughout the municipality and across the region, including schools, offices, public library, parks, local shopping, and residential neighborhoods.
5. **Mobility** – Encourage higher bicycle use for short, local trips to mitigate roadway congestion and parking demand issues in the downtown core.
6. **Health** – Encourage and promote cycling as an active and environmentally sustainable form of transportation to improve community health and wellness.
7. **Equity and Social Justice** – Recognize cycling as an essential transportation mode, especially for those who cannot afford to own cars, and as an integral part of maintaining the community's social diversity. Acknowledge that streets are public spaces, both in terms of their legal status and in terms of their appropriate use to benefit the community as a whole.
8. **Awareness and Mutual Respect** – Promote safe cycling practices and a mutual respect and better understanding of the rules of the road among all roadway users through education, enforcement, and encouragement programs.
9. **Process and Implementation** – Establish a clear framework for implementation of the Bicycle Master Plan and creation of a core bicycle network that reflects local context, recognizes the spectrum of travel needs and facility types, and acknowledges the need for balance and trade-offs in the design of specific improvements.

Metrics and Indicators

To monitor and evaluate progress towards realizing the Princeton BMP's long-term vision and goals, the following targets will help track implementation:

- Implement one new bike facility project every year
- Double the number of students who bike to school within 5 years
- All residents live within one-half mile of a low-stress bicycle facility within 5 years
- All residents live within one-quarter mile of a low-stress bicycle facility within 10 years
- Double number that bike to work by 2025
- Implement annual bike count program
- Implement bike share system by 2017
- Implement a Vision Zero safety initiative
- Double the amount of bicycle parking available in the downtown core within 5 years
- Attain Silver Level Bicycle Friendly Community status

2.6 Reaching our Goals

The goal of this BMP is not to make it harder for people to drive their car in Princeton. On the contrary, by improving bicycle infrastructure and encouraging more people to bicycle more often, road conditions and parking constraints could be improved for all roadway users in Princeton, especially those making short local trips. Many of the people who choose to ride a bicycle might still own a car, and may even use that car for most of their trips. However, by encouraging more people to choose to ride a bicycle for more of their trips, the effect on motor vehicle travel in Princeton would be positive. Replacing vehicle trips with bicycle trips would alleviate strain on the downtown's limited parking supply, reduce the proportion of traffic that is simply circling to find parking, and decrease congestion on local roads, all of which would improve overall mobility and making Princeton a more accessible place.

03

Why Bicycling in Princeton

Increased bicycling (spurred on by improvements to bicycle infrastructure) has many benefits, and not only for people on bikes. A growing body of research from around the country illustrates that bicycle infrastructure positively impacts many facets of community life. Bicycle facilities can improve safety for all roadways users, spark local economic activity, improve public health, and mitigate the need for costly roadway and parking improvements. Even small increases in the percentage of people who bicycle can have significant spillover effects.

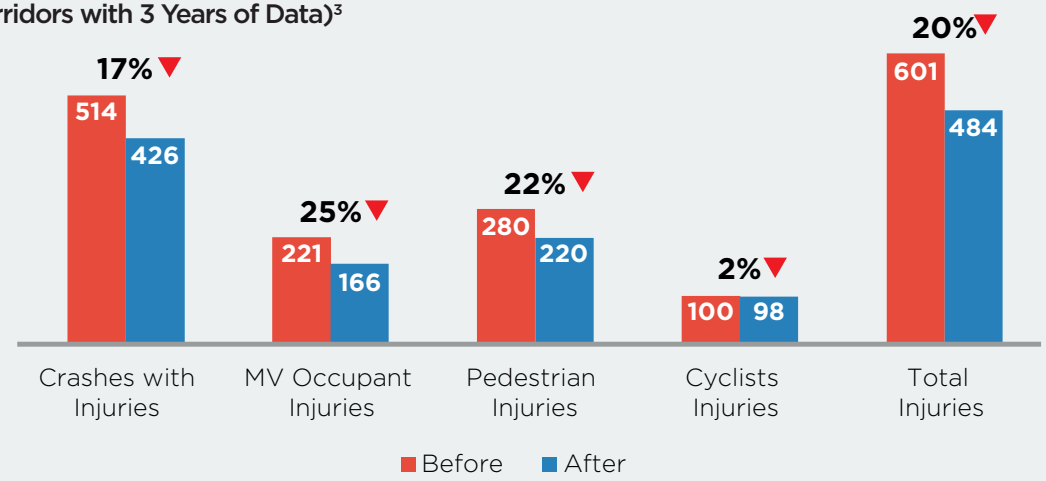
3.1 Safety

Safety concerns are one of the principal reasons that the "interested, but concerned" prefer increased separation and reduced motor vehicle speeds. A 2004 Safe Routes to School survey found that 30% of parents expressed traffic-related danger concerns as the primary barrier to allowing their children to walk or bike to school.[1]

These results were similar to those found in the Princeton Bicycle Survey, where nearly 80% of parents/guardians who responded indicated that "better bicycle infrastructure" would make them more comfortable letting their children bicycle to school. Additionally, "fear of vehicle collisions / traffic" was the number one response when asked what prevents respondents from bicycling more, and the "lack of developed bike routes / lanes" was the second most common response.

Many studies have identified perceptions of safety as the single greatest reason people do not bicycle. Allaying safety concerns is essential to increasing bicycle mode share. Providing dedicated bicycle infrastructure can address this issue in several ways. As stated by the National Association of City Transportation Officials (NACTO), bicycle lanes

Figure 3.1 | NYC Separated Bicycle Lanes: Before/After Safety Trends (Corridors with 3 Years of Data)[3]



"facilitate predictable behavior and movements between bicyclists and motorists," which decreases the likelihood of a crash.[2]

Bicycle infrastructure also has a traffic calming effect on vehicle traffic. It creates either a real or visual narrowing of the travel lane, and adds "friction" alongside the travel lanes, similar to the effect of on-street parking.

Many studies have shown that slower motor vehicle speeds exponentially increase the survival rates for vulnerable road users (pedestrians and bicyclists) who are involved in a collision with a motor vehicle. Most studies have focused on pedestrians, who, similar to bicyclists, are unprotected and cannot absorb the impact of a crash with a motor vehicle.

The analysis found that pedestrians have an 85% chance of being killed by a vehicle traveling at 40 mph, but only a 5% chance of being killed by a vehicle traveling at 20 mph.[4]

Vehicle speed not only increases the severity of a crash for all road users, it also impedes the ability of a driver to react to activities occurring along the roadway, and thus increases the risk of a crash. For example, for a vehicle driving at 20 mph, the vehicle will travel an additional 45 feet in the time it takes the driver to react to a situation and come to a stop. For a vehicle traveling 40 mph, it will travel an additional 145 feet before stopping.[5]

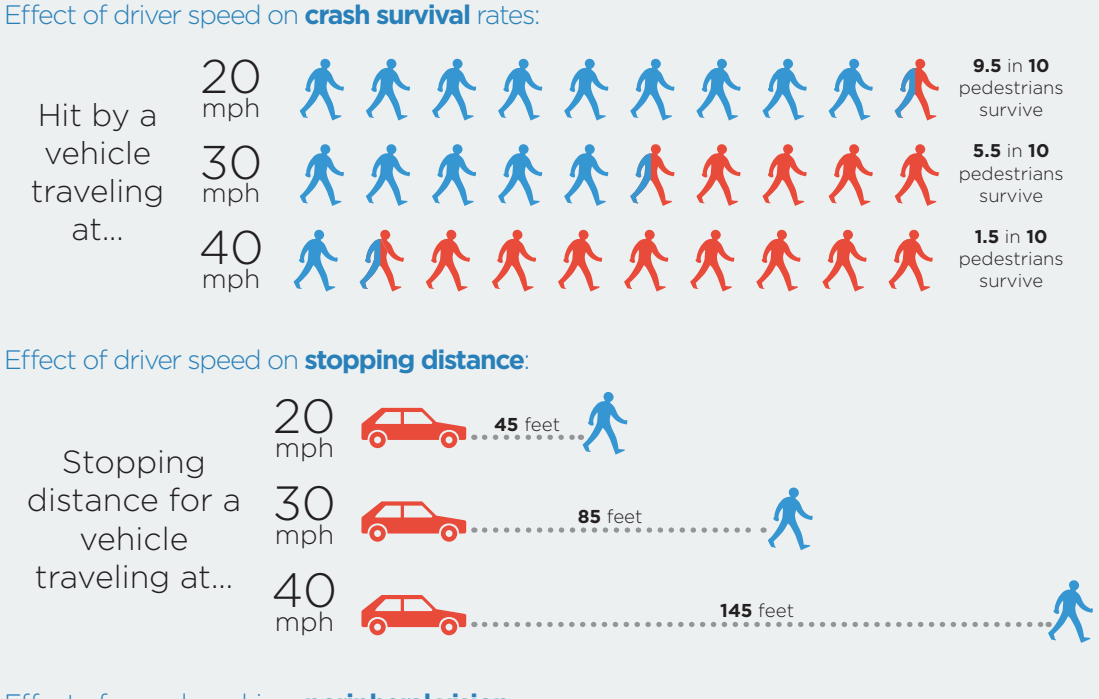
As speed increases, the brain cannot process all of the information that is taken in across the entire field of vision. Consequently, drivers "see" less of what occurs on the periphery, resulting in a higher degree of "tunnel vision" as travel speed increases. This is particularly an issue on local streets with roadside activity, pedestrians, and on-street parking.[6] The impacts of vehicle speed are illustrated in Figure 3.2.

Studies have also suggested that not only can bicycle infrastructure help slow motorists down, but increasing the presence of cyclists and pedestrians has a traffic calming effect as well.[7] This means that there is a demonstrated safety in numbers that not only makes cycling safer through its traffic calming effect, but will actually encourage even more people to cycle.

The net impact of traffic calming effects related to bicycle infrastructure is a safer environment for all roadway users. The New York City Department of Transportation (NYCDOT) conducted a corridor analysis of its separated bike lane facilities. The before/after analysis, as illustrated above, found that the number of crashes decreased for all travel modes. While the pure number of bicycle crashes had a more modest decrease than the other modes, the bicycle crash rate decreased significantly due to the substantial increase in bicycle volumes.

Figure 3.2 | Effect of Vehicle Speed on Safety

The traveling speed of a motor vehicle is one of the largest determining factors on the likelihood and severity of a crash. Faster travel increases stopping distance and the severity of a crash, and decreases the driver's field of vision.



3.2 Equity

Transportation options, including bicycling, are significant factors that influence the equity and economic mobility of a community. Car ownership is very expensive and difficult for many residents to achieve. Bicycling, however, is a widely available and affordable alternative. Bicycles can be found in most American households, with an average of 0.86 adult-size bicycles per household.[8] Bicycles are also a very cost effective mode of transportation, with the average annual operating cost of a bicycle of $308, compared to $8,220 for owning a car.[9]

Additionally, many residents might choose not to own a car for economic or lifestyle reasons. Twelve percent of households in Princeton do not own a car compared to 6.7% statewide.[9] Transportation choices for these residents may include walking, riding a bicycle, taking transit, or carpooling. Based on the 2010-2014 American Community Survey estimates, 18% of the working population in Princeton walked and 10.5% used public transportation to get to work.[11] This means there is a significant segment of the population that commute by means other than driving.

3.3 Transportation Behavior

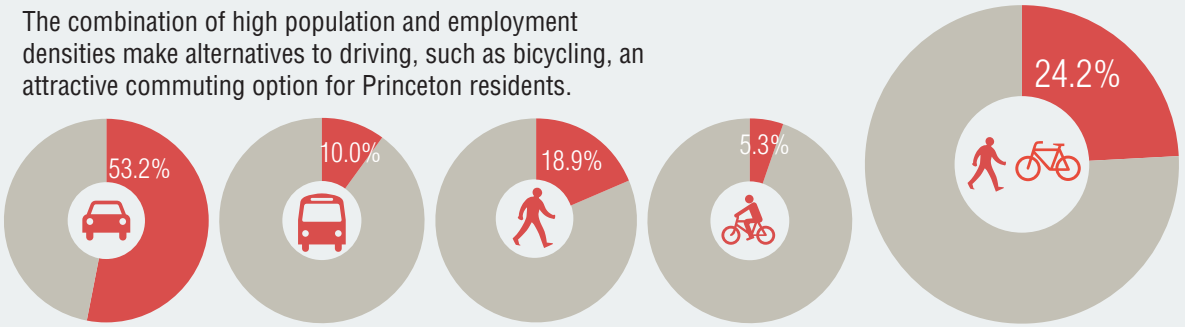
Parking availability and traffic congestion are common issues in Princeton, where a typical day sees throngs of workers and visitors to Princeton's downtown business and cultural amenities. Even on a typical day, navigating the downtown environment can be tricky for bicyclists and pedestrians because of the volume of motor vehicles, many of which are just searching for parking. This condition is heightened many times throughout the year when there is a special event in town. Expanding the municipality's bicycle infrastructure would provide another transportation choice for residents, visitors, and employees. As an alternative to driving, increasing bicycling ridership could contribute to a reduction in automobile travel and alleviate challenging parking and congestion conditions.

Nationally, nearly half of all trips in metropolitan areas are three miles or less, and 28% are one mile or less. These short trips are easily made by bicycle, yet 60% of trip under one mile are typically made by car.[12]

Data from cities throughout the country indicate that the provision of dedicated bicycle facilities can have a significant impact on travel behavior. In New Jersey, the replacement of the Route 52 Causeway in 2012 included a shared-use path connecting Somers Point to Ocean City. With the provision of a separated facility, bicycle and pedestrian traffic soared. In August 2014, an average of 1,457 people used the 2-mile facility, 40% of which were cyclists.[14]

Figure 3.3 | How Princeton Residents Get to Work[13]

The combination of high population and employment densities make alternatives to driving, such as bicycling, an attractive commuting option for Princeton residents.



In New York City, 140 miles of new on-street bicycle facilities, including 30 miles of separated bike lanes, have been added since 2007. This has contributed to a doubling of commuter cycling between 2009 and 2013.[15] New separated bicycle lanes on 1st Avenue and Broadway, for example, have seen the volumes of cyclists increase by 160% and 108%, respectively.[16]

Beyond a simple growth in bicycle ridership, installing bicycle facilities has also been shown to have a positive impact on other modes. Cities with high bicycling rates tend to have lower crash rates for all road users. On Stone Way North Street in Seattle, a road diet was implemented to reduce the number of travel lanes and install bicycle lanes. After completion of the project, a before/after comparison found that the bicycle volume increased 25%, motor vehicle volume decreased 12-34% on adjacent streets, speeding decreased 80%, and collisions dropped 14%.[17]

This data is important to consider in Princeton, where there might be concerns that the addition of bicycle infrastructure could increase congestion or that improvements might add cost to standard roadway improvement projects. Building bicycle infrastructure that is connected and comfortable for most users has been proven in many different contexts and geographies, to increase bicycle ridership which can decrease congestion and maintenance costs of roadway. Bicycle infrastructure is a smart, generally low-cost investment that can pay dividends in the short- and long-term.

3.4 Economic Benefits

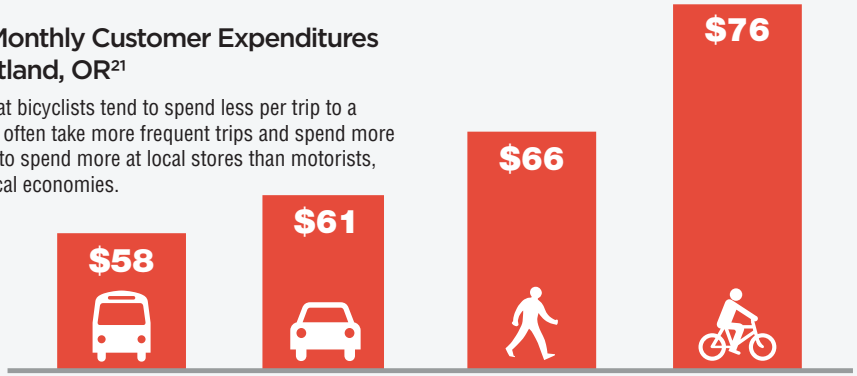
Based on the growing body of data, there is an increasing understanding of the positive economic impact that bicycling can have on a community. Statewide, active transportation-related infrastructure, businesses, and events contributed an estimated $497M to the New Jersey economy in 2011, nearly eight times the $63M invested in infrastructure, supporting several thousand jobs and generating millions in tax revenue.[18]

Numerous studies have shown that while cyclists tend to spend less per trip than drivers, they also tend to make more frequent trips, pumping more money into the local economy over time. For example, an intercept survey conducted in Seattle found that people arriving to retail stores on foot or bicycle visit more frequently than those who drive and spend more money over the course of a month.[19] Data from Portland, OR (shown in Figure 3.4) revealed a similar trend, as did a study of spending behavior in downtown Davis, CA, another university town.[20]

A better and more inviting bicycle environment enhances opportunities for people to participate in the social, cultural, and economic life of the community without using a car. Not only does a bicyclist tend to spend as much, or more, at retail stores as a motorist, but

Figure 3.4 | Average Monthly Customer Expenditures by Travel Mode in Portland, OR[21]

Although studies have found that bicyclists tend to spend less per trip to a retail store than motorists, they often take more frequent trips and spend more per month. Bicyclists also tend to spend more at local stores than motorists, generating more revenue for local economies.



many studies show that they tend to make their purchases locally. This is extremely beneficial to the economic strength and financial stability of a community because money that is spent at locally owned businesses tends to have a far greater impact than when it is spent at national chains. One study demonstrated that money spent at a local book store netted over three times as much return to the local economy as that spent at a national chain.[22]

Recent data in New York City found that, after improvement projects were completed, businesses along corridors with new separated bike lanes had stronger growth in retail sales than the surrounding area, by up to 38%. In one district, commercial vacancies fell by 49% after a separated bicycle lane was installed.[23] Additionally, a survey of residents on 1st and 2nd Avenues in the East Village, both home to separated bike lanes, found that bicyclists spent $163 per week on average at local businesses, as opposed to $143 for drivers.[24]

The many economic benefits of cycling are also demonstrated by the comparatively inexpensive nature of cycling infrastructure: an estimated $30 million in government expenditures could buy one mile of street widening, 20 miles of physically separated cycle tracks, 30 miles of high-quality off-road bike trails, 120 miles of bike boulevards, or 100 miles of sidewalk.[25]

People who ride a bicycle instead of driving save the public money on roadway maintenance and services. Not only do bicycles produce significantly less wear and tear on the roads compared to automobiles, but when a person chooses to bicycle rather than drive, they are reducing overall roadway congestion and the need for expensive capacity enhancements.

3.5 Health

Bicycling can have many positive health benefits for a community. The national rise in childhood obesity has been shown to be correlated with declining rates of children walking and bicycling to school.[26] In response, programs such as Safe Routes to Schools are seeking to improve the built environment and promote walking and biking to and from schools among students and parents. A bicycling network that is built for all ages and abilities encourages increased physical activity and healthy lifestyles. In addition to the physical health benefits associated with increased physical activity, children who walk or bike to school have also been found to be more attentive and able to concentrate and have mental alertness that is one-half school year more advanced than their counterparts.[27]

Among adults, bicycle infrastructure encourages wider bicycle usage for utilitarian and commuter trips, integrating physical activity into daily life. Data show that places with a higher percentage of people walking and cycling to work also have a higher share of the population meeting the recommended levels of physical activity and lower rates of obesity, high blood pressure, and diabetes.[28]

Complete Streets and Livability

Complete Streets help create livable communities. Wide, attractive sidewalks and well-defined bike routes encourage healthy and active lifestyles. Creative repurposing of street space, such as seen in the above photo of a parklet on Witherspoon Street, helps connect the community by providing fun and attractive public space for residents and visitors to gather. A Complete Street accommodates users of all ages, abilities and modes. By designing streets for everyone, Princeton will continue to be a more livable and accessible community.

3.6 Environment and Sustainability

Bicycling is a sustainable and environmentally friendly activity. As mentioned previously, bicycling has a reduced impact on the roadway, both in terms of wear and tear, but also in the amount of space consumed. By reducing congestion, bicycling reduces the need or desire to widen or build new roadways, reducing the physical impact of a community's transportation needs. Bicycles are also far more compact when parked, which differs dramatically from the impact of the parking needs for motor vehicles, which consumes land that could otherwise be used for different, and more productive purposes. Parking lots raise development costs, increase the footprint of development projects, and produce no taxable income for the municipality. There are 800 million car parking spaces in the U.S., totaling 160 billion square feet of concrete and asphalt. The environmental impact of all car parking spaces is estimated to add 10% to the CO_2 emissions of the average automobile.[29] Bike parking on the other hand, is very cheap and space efficient. The average vehicle parking space can accommodate 8-12 bikes.

Even small changes in transportation behavior can have enormous impacts on the environment. More CO_2 is emitted in the United States' transportation sector than any other nation's entire economy, except for China.[30] The 260,000 miles bicyclists ride daily in Philadelphia saves 747,450 tons of CO_2 from being emitted by cars.[31] Interestingly, when car travel restrictions reduced morning traffic by 23% during the 1996 Olympics in Atlanta, ozone concentrations decreased 28% and acute care visits for asthma decreased 41%.[32] Not only is increased bicycling beneficial from a personal health perspective, but the decreased motor vehicle use that accompanies more bicycling is beneficial to everyone by creating a healthier environment overall.

END NOTES

1 Safe Routes to School, *The Decline of Walking and Bicycling*, 2004

2 NACTO, *Urban Bikeway Design Guide*, 2012

3 NYC DOT, *Protected Bicycle Lanes in NYC*, 2014

4 Leaf and Preusser, *Literature Review on Vehicle Speeds and Pedestrian Injuries*, 1999

5 Chicago DOT, *Complete Streets Chicago, 2013*

6 ibid

7 Jacobsen and Rutter, *Cycling Safety, 2012*

8 Cambridge CDD, *City of Cambridge Bicycle Plan*, 2015

9 Bureau of Labor Statistics, *Pocket Guide to Transportation*, 2009

10 U.S. Census Bureau, 2014 ACS, 5 year estimates

11 ibid

12 FHWA, *National Household Travel Survey*, 2009

13 U.S. Census Bureau, 2013 ACS, 5 year estimates

14 NJDOT Traffic Counts, 2014

15 U.S. Census, 2013 ACS, 1 year estimates

16 NYC DOT, *Protected Bicycle Lanes in NYC*, 2014

17 Seattle DOT, S*tone Way N Rechanalization: Before and After Study*, 2010

18 Vorhees Transportation Center, *The Economic Impacts of Active Transportation in NJ, 2012*

19 Seattle Department of Economic Development, *Neighborhood Business District Access Survey*, 2012

20 Popovich and Handy, *Bicyclists as Consumers*, 2014

21 Kelly Clifton et al., *Business Cycles: Catering to the Bicycle Market*

22 Houston, D., *Economic Impact Analysis. Rep. Civic Economics*

23 NYC DOT, *The Economic Benefits of Sustainable Streets*, 2013

24 Transportation Alternatives, *East Village Shoppers Study*, 2012

25 Pucher, *Shifting Gears 2013 Lecture Series*, 2013

26 Alliance for Biking and Walking, *2012 Benchmarking Report*

27 Egelund, N. et al., *Mass Experiment*, 2012

28 Alliance for Biking and Walking, *2014 Benchmarking Report*

29 Chester, M., et al., Env. *Research Letters: Parking Infrastructure: energy, emissions, and automobile life-cycle environment accounting*, 2010

30 Pedroso, M., S*afe Routes to School: Steps to a Greener Future*, 2008

31 Bicycle Coalition of Greater Philadelphia, *Double Dutch: Bicycling Jumps in Philadelphia*, 2008.

32 Friedman, M., et al., *Journal of the American Medical Association: Impact of Changes in Transportation and Commuting Behaviors During the 1996 Summer Olympics Games*, 2001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04

Bicycling in Princeton Today

The bicyclist experience in Princeton today is complex and varied. Using field observations and available data, the project team conducted a technical assessment of existing conditions to better understand this experience, including existing infrastructure and roadway characteristics. It identifies what is working well and opportunities to expand the bicycle network, as well as key problem areas, constraints, and challenges.

The analysis includes a review of crash data to evaluate potential safety issues and trends. A bicycle network analysis was also performed using the bicycle level of traffic stress metric. Based on roadway characteristics, the metric quantifies the perceived comfort level of the roadway network for cyclists of varying abilities, and identifies existing roadway segments that are suitable for all bicyclists. The analysis also includes an assessment of Princeton's network of sidepaths, as well as a bicycle parking inventory.

A comprehensive bicycle count program was not a part of the data collection effort due to the difficulty and relative cost ineffectiveness of obtaining reliable data. This aspect of transportation analysis is still in its infancy compared to vehicle and transit counting methodologies and tools. In the future, as implementation of the BMP moves forward, it would be useful to initiate a count program at select locations in order to set a baseline, monitor changes in bicycle volumes, and track the impacts of improvements to the bicycle network over time.

4.1 The Nature of Cycling in Princeton

Unlike motor vehicles, cyclists and pedestrians are not strictly confined to a dedicated and regulated space or travel lane. The inherent, untethered freedom associated with cycling and walking leads some to seek the shortest path, an option simply unavailable to motorists. Some are irked by what they see as the unruly, chaotic, and disrespectful nature of cyclist behavior; for others these same features are instead exceptional advantages that make the bicycle the perfect urban machine. Among our many and varied travel options, only cyclists and pedestrians can actually travel from door-to-door; the bicycle provides the ultimate and often elusive one-seat ride.

The purposes, routes, and needs of cyclists in Princeton are as complex and diverse as the many thousands who live, work, play, and do business here. If you were to spend a typical day observing and tracking cycling activity you might see some or many of the following:

- In the early morning hours, many low-income service economy workers take to the only means of travel available to them – their bicycles – to come to Princeton for a day's work. Some live locally, including the Witherspoon district, while others travel from neighboring communities along the U.S. Route 206 and NJ Route 27 highway corridors. Time and direct access to and from work are essential to these workers. On the opposite end of the spectrum, small numbers of professionals transform themselves into skilled, long distance cycling commuters, some coming into Princeton and others passing through town to catch the train to New York via the Dinky or Princeton Junction.
- Between 7 and 8 am, Princeton's school-age children take to the streets to make the daily trip to school. Some come from as far as Edgerstoune and Farrand Roads or the southern reaches of Mercer Road. Vehicular and pedestrian flows are also heavy, particularly in the area around the High School. Traffic queues form along U.S. Route 206 and Cherry Hill and Mount Lucas Roads and then to Valley Road, before turning to Jefferson Road, Walnut Lane, and others. Significant numbers of bicycles can be observed daily at the bike racks at local schools, proof positive of existing demand for safe, accessible, and adequate facilities.
- Well in excess of 3,000 children attend Princeton's many public and private K-12 schools. Many more are taken to daycare and pre-school programs by their parents and guardians.
- Soon afterwards, cyclists already dressed for work, some riding practical, sturdy bicycles, make their way at a steady, deliberate pace through town for jobs at the

Family crossing Nassau Street at Chestnut/Olden Street intersection

(clockwise from top-left) (1-3) Commuters along Witherspoon Street, Nassau Street, and Olden Street, respectively. (4) Students walking and biking to school along Franklin Terrace. (5) Commuter along Witherspoon Street. (6) Shopper along Nassau Street.

University and the many small offices and centers along Princeton's main corridors. Some make stops in the central district or along Nassau Street's northern node, for a coffee or a quick bite to eat, before starting their day. Others have small children in tow in bicycle trailers. Others still ride their trendy fixies, vintage 10-speeds, or state of the art carbon fiber machines. Limited numbers of adequate racks are available for these cyclists, and many improvise by locking or leaning their bikes against whatever street signs, parking meters, railings, and small trees are available at or near their intended destination.

- Throughout the day, local residents make short trips by bike for a variety of everyday trip purposes – shopping, dining, and visits to the library, parks, and other local destinations. Many are dressed in their street clothes as they go about their errands and social activities.
- Late morning and midday bring still more cyclists to Princeton for lunch, socializing, and shopping. These cyclists mix and navigate an often-busy downtown and local streets flush with drivers coming to town for many of the same reasons as their two-wheeled counterparts, circulating the local street system and looking for a place to park their cars.
- The mid-afternoon finds many Princeton streets and sidewalks busy with throngs of school children, some on two feet and others on two wheels, as they engage in various activities – snacking, studying, and having fun with friends – before making their way home.
- Mid- to late-afternoon is also a shift change for many workers in the local service economy. Lower income workers working multiple jobs leave their first shift at a café, landscaping, or other job, and bike to their evening shift at a local restaurant.
- The end of the work day sees much the same but in reverse as cycling laborers, professionals, and commuters make their way home.
- The evenings bring many to town to dine, socialize, and seek out the various entertainment and cultural activities and events that take place in Princeton on a daily basis.
- Weekends bring both much of the same - and much that is different - to Princeton and many take to two wheel travel for a wide variety of purposes. A typical Saturday or Sunday may see hundreds of cyclists make their way along the Nassau, Wiggins, and Witherspoon corridors, or take to the D&R Canal Trail and other recreational facilities, enjoying all that Princeton has to offer.

No single facility, type, design or alignment can meet the needs of such a diverse and multi-varied group of purposes, routes, and needs. Research, investigation of conditions, and outreach undertaken for the Princeton BMP confirm this basic fact. The outcomes will include a variety of facilities, routes, and intersection improvements to create safer, more accessible, and more convenient transportation options in Princeton to the mutual benefit of all travelers, regardless of mode, age, or ability.

4.2 Crash Data

Bicycle crashes are widely regarded as significantly under-reported in the United States. Crashes that do not result in injury, have minimal property damage, or do not involve a motor vehicle are less likely to be reported to the police, where most crash data is collected and tracked. A survey of over 800 bicyclists in Los Angeles, for example, found that 30% had been involved in an unreported crash.[1] Additionally, there is little data on bicycle volumes and no reliable data on how many miles people travel by bicycle each year, which would allow an assessment of crash risk. Crash rates for motor vehicles, for example, are often expressed in terms of their relative frequency (i.e., crashes per vehicle miles traveled).

Furthermore, a lack of reported crashes does not necessarily indicate a safe bicycling environment. Perceived safety issues and conflicts with motor vehicle traffic are often indicated as the highest concerns that deter more people from bicycling. Thus a road perceived as "unsafe" may have few actual reported

crashes in part because few people bicycle along it.

Despite the known limitations, analysis of reported crashes can provide important insights. If a significant number of bicycle crashes in the same area were severe enough to be reported, it can indicate a potential safety issue and problem area for further assessment.

The New Jersey Department of Transportation maintains a statewide database of all crash records. The project team used the database to analyze bicycle crash data in Princeton for the most recent five-year period – 2010 through 2014. A total of 70 bicycle crashes, involving 74 bicyclists, were reported during the study period. None of the crashes resulted in severe injury or a fatality.

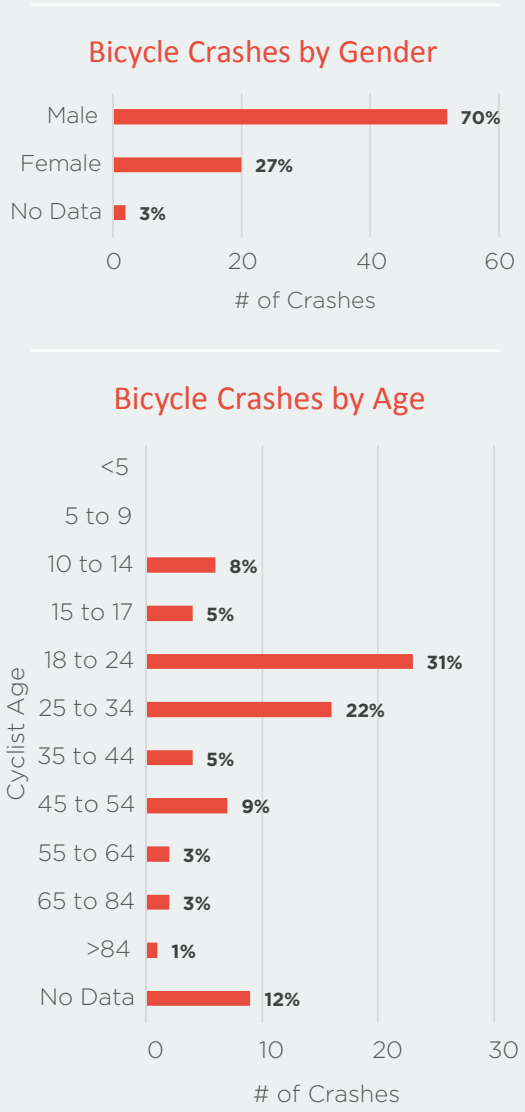
As shown in Map 2 on the following page, the majority of crashes are dispersed around the center of the Municipality (generally within the former Borough), with only a handful of crashes towards the more rural portions. This is expected given the higher density of residences and major destinations surrounding the downtown core, and hence higher volumes of both motorists and bicyclists and greater mixing of traffic and conflicts between the two modes. Although there are several roadways with multiple crashes (e.g. Nassau Street, Harrison Street), there are no locations with more than two reported crashes during the five-year period.

The common characteristics of the bicycle crashes in Princeton are consistent with trends seen throughout New Jersey and nationally. A slight majority of the crashes occurred at intersections (57%) and most occurred during daylight hours (83%).

The majority of crashes involved males (70%), which is slightly lower than the state average (81%). This could suggest higher female ridership in Princeton than the state average, although there are no detailed bicyclist demographic data to verify this hypothesis. Young people were also involved in the majority of crashes. Thirty-one percent involved people age 18-24 (12% state average), and 22% were aged 25-34 (10% state average).

NJDOT crash data attribute up to four contributing circumstances to each crash, two related to vehicle behavior and two related to cyclist behavior. The most common factors noted were driver inattention (41%), vehicle failed to yield right of way (21%), failure of cyclist to obey traffic control device (13%), and cyclist failed to yield right of way (9%).

Figure 4.1 | Notable Bicycle Crash Demographics[2]



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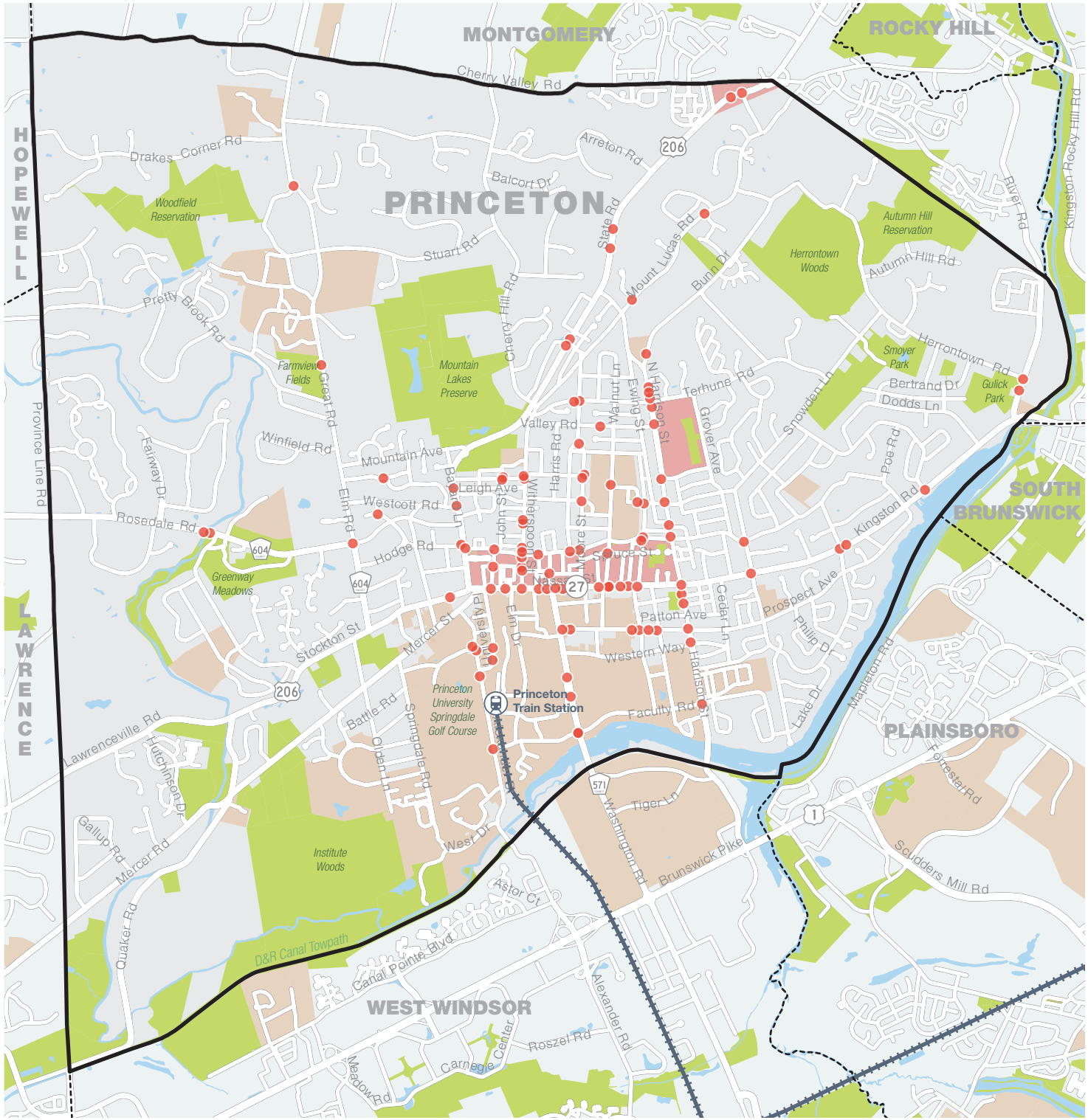
Bicycle crashes in Princeton tend to be concentrated in the downtown core. A total of 70 bicycle crashes were reported between 2010 and 2014, none resulting in severe injury or a fatality.

Map 02

Bicycle Crash History

- Bicycle Crash (2010-2014)
- Park
- Commercial Area
- School

0 0.25 0.5 1 Miles



4.3 Bicycle Level of Traffic Stress

One of the principal goals of the Princeton Bicycle Master Plan is to create a network of bicycle routes in Princeton that are comfortable for users of all ages and abilities. A comprehensive bicycle network would accommodate the ability of a wide variety of cyclists to travel between their homes, jobs, and schools and other destinations, including downtown Princeton, public transportation, recreational paths, and connections to adjacent communities.

The Bicycle Level of Traffic Stress (LTS) analysis is a tool used to quantify a cyclist's comfort level given the current conditions of the roadway. The LTS metric is based on the Dutch concept of low-stress bicycle facilities, which has proven influential in the advancement of bicycle planning in the United States. Because different bicyclists have different tolerances for stress created by volume, speed, and proximity of automobile traffic, the LTS method identifies four levels of stress:

- Level of Stress 1: the level most users can tolerate (including children and seniors)
- Level of Stress 2: the level tolerated by most adults
- Level of Stress 3: the level tolerated by "enthusiastic" riders who might still prefer dedicated space
- Level of Stress 4: the level tolerated by the most experienced riders

In general, lower stress facilities have increased separation between cyclists and vehicular traffic and/or have lower speeds and lower traffic volumes. Higher stress environments generally involve cyclists riding in close proximity to traffic, multi-lane roadways, and higher speeds or traffic volumes.

Figure 4.2 | Four levels of traffic stress:

The level of traffic stress analysis categorizes streets based on four levels. These level of stress categories, discussed below, were determined through significant research in the Netherlands, and adapted for the United States by researchers at Northeastern University.

1 - Most Users

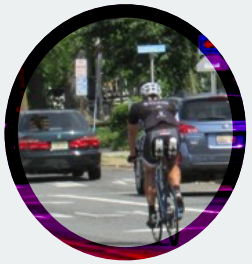
Suitable for almost all cyclists, including children. On LTS 1 links, cyclists are either physically separated from traffic, in an exclusive bicycling zone next to slow traffic, or on a shared-street with a low speed differential.

2 - Most Adults

Suitable for most adults, but demands more attention than might be expected from children. Similar cross sections to LTS 1 but with more likeliness for interaction with motor vehicles.

3 - Enthusiastic Riders

Welcoming level for many people currently riding bikes in this country. Cyclists either ride in an exclusive on-street lane next to moderate speed traffic or on shared lanes on non-multi-lane streets.



4 - Experienced Riders

Suitable only for the most experienced riders or not suitable for any riders. Roadway is characterizes by high travel speeds, multiple lanes, and/or are lacking in dedicated bicycle facilities.

Basis for the Criteria

Extensive research into cycling behavior has made clear what many cyclists, and potential cyclists, might already know implicitly, namely that: most cyclists do not feel comfortable sharing the road with motor vehicles when the prevailing speed of traffic is above 25 mph. High vehicle volumes add further complications to sharing the road, even at lower speeds. This discomfort manifests itself in a couple ways. A street network built

only to accommodate motor vehicles will discourage many bicyclists from riding, particularly if there are perceived barriers between the origin and the destination. Further, those that do choose to ride will typically be adults who feel more confident riding in mixed traffic, which often excludes the majority of the population.

When asked in the Princeton Bicycle Survey what their biggest barrier is to cycling more, the two most common responses were "fear of vehicle collisions/ traffic" (192 respondents) and "lack of developed bicycle routes/lanes" (180 respondents). When asked how comfortable they would feel riding in mixed-traffic, most people (45 percent) responded "not-comfortable," and an additional 35 percent responded "a little uncomfortable." This indicates that even among respondents to the Princeton Bicycle Survey, responses are similar to other surveys and research indicating that the major barrier to increasing cycling is the lack of dedicated bicycle infrastructure.

Methodology

The LTS analysis is based on the Mineta Transportation Institute's research on low-stress bicycling and network connectivity. The LTS metric analyzes roadways in two ways: as segments between two points, and at intersections, where conditions often vary from the leading segment. For segments, roads are primarily rated based on their number of lanes and prevailing traffic speed. At intersections, stress level is determined based on the number and character of turning lanes, presence or absence of traffic lights, and the level of stress of the roadway being crossed.

The intersection analysis is conducted because of the importance of connectivity in bicycle networks (and transportation networks in general). For many cyclists, a high stress intersection in a network can discourage them from riding, or significantly limit the destinations and routes they feel comfortable biking to. When thought of in terms of automobiles, this principle becomes more clear. The vast majority of roadways accommodate automobile travel. If there were gaps in the roadway network where cars couldn't drive, the usefulness of the automobile would be severely limited. The same is true for bicycles.

Data was collected for the entire roadway network in Princeton, including typical roadway characteristics and geometry, which drives the basic LTS analysis. To account for the influence of high traffic volumes on cyclist stress, traffic volumes were also incorporated into the analysis (where available).

A detailed look at the criteria used to determine LTS can be found in Appendix A.

Results

Map 3 displays the results of the Level of Traffic Stress analysis for Princeton roads. As shown in the map, the vast majority of roads in Princeton are classified as Level of Stress 1 (suitable for all users) or Level of Stress 2 (suitable for most adults). Most roads in Princeton have one or two travel lanes and have a speed limit of 25 MPH. This configuration will yield a classification of LTS 1 on non-commercial streets, and LTS 2 on commercial streets (because of the presumption of increased traffic). A number of streets in Princeton are classified as LTS 1 because of the presence of an off-road facility, which is automatically considered an LTS 1. The presence of off-road facilities helps lower the LTS on key routes in and out of Princeton.

Because the LTS methodology aggregates and generalizes roadway facilities and speed limits to generate a score, it is important to contextualize and provide further analysis into the LTS results. This is particularly important when measuring the impact that off-road paths have on the overall stress network. In Princeton,

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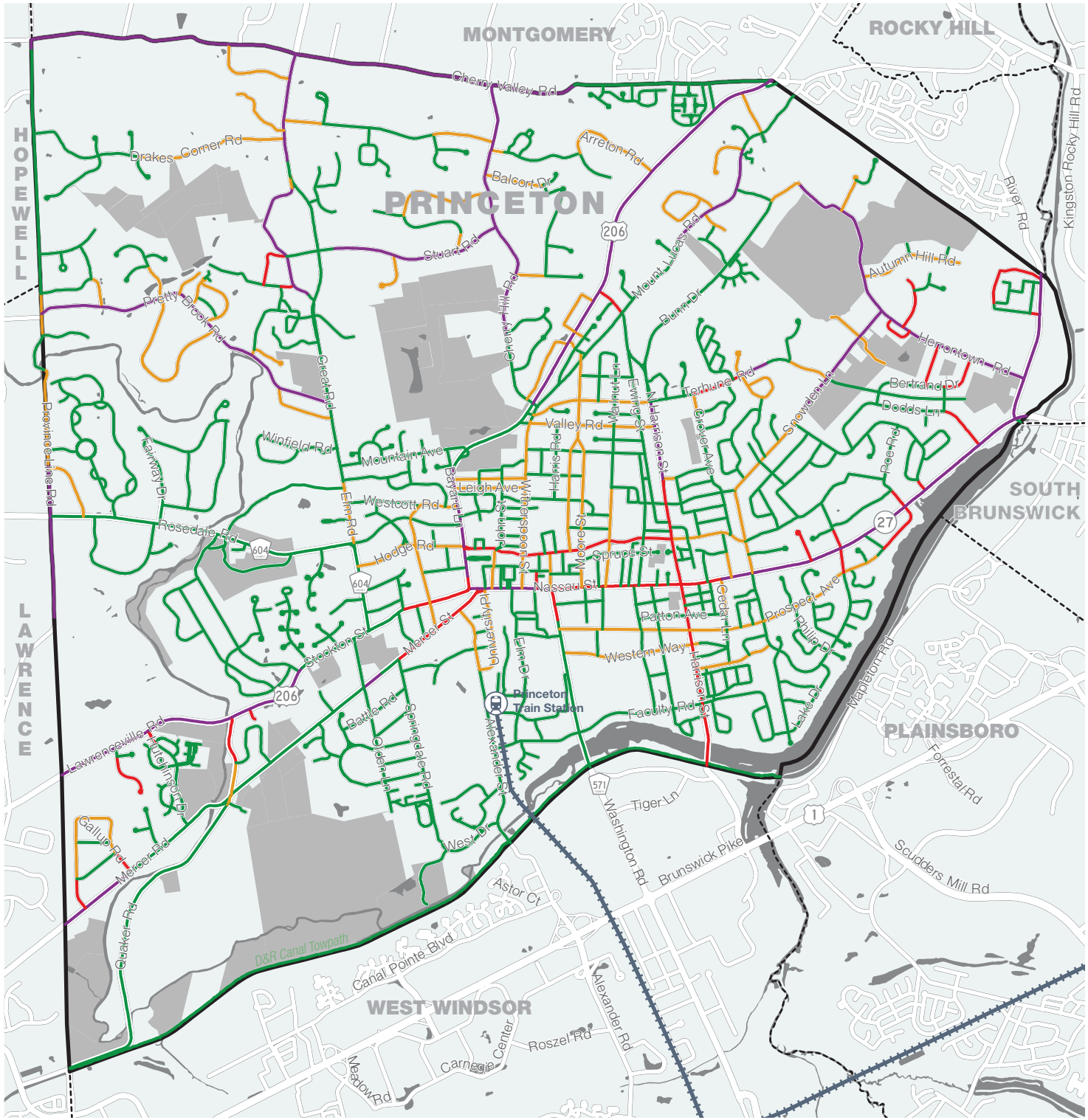
Although most of Princeton's roads can be characterized as "low-stress," there is a lack of connectivity between these roads that makes it difficult to travel far by bicycle on a continuous "low-stress" path. High speed roadways outside of the core, and traffic dense streets downtown, impede low-stress travel.

Map 03

Bicycle Level of Traffic Stress

- Level of Stress 1
- Level of Stress 2
- Level of Stress 3
- Level of Stress 4



0 0.25 0.5 1 Miles

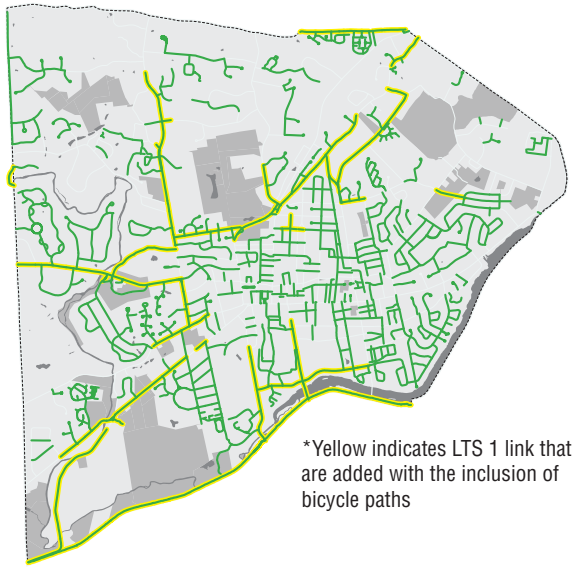
there are many off-road paths; however, most of these facilities do not meet the minimum design standards for off-road facilities that are recommended in many design guides (including those by AASHTO and FHWA). Many paths are narrow, bumpy, and lack lighting at night. These conditions limit their comfort and usefulness, particularly for utilitarian trips such as commuting. Beyond the mere presence or absence of a designated off-road path, the following characteristics influence the cyclists' comfort level on a facility and whether that facility is convenient and useful for cyclists:

- Width
- Maintenance
- Accessibility
- Lighting

Many off-road paths in Princeton run parallel to the roadway. These paths can provide a place for cyclists to ride in a lower-stress environment than the roadway itself. However, many of these paths are only about the width of a typical sidewalk (~5 feet), which does not allow for comfortable and convenient passing of other users. On more highly used pathways, such as on Alexander Street, this narrow width can lead to congestion on the path and limit its usefulness.

Because of the highly variable quality and accessibility of Princeton's off-road paths, it is very difficult to determine an entirely accurate rating for how the paths impact the bicycle level of traffic stress

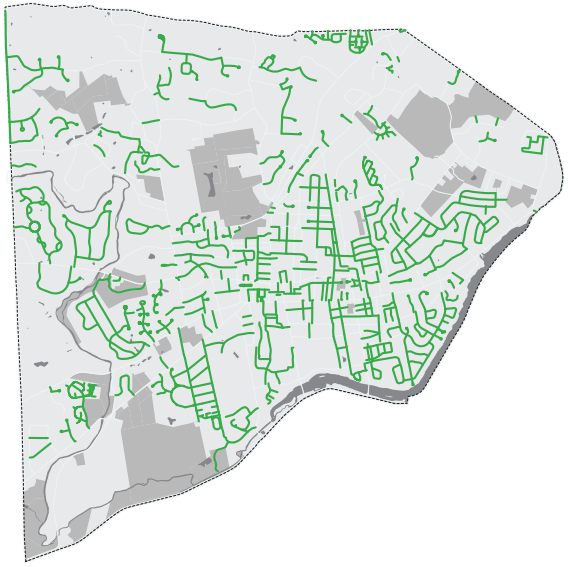
Figure 4.3 | LTS 1 Facilities with Bicycle Paths



in Princeton. Since many of the major roadways in Princeton feature off-road paths along certain segments, including the off-road paths in the stress analysis as an LTS 1 facility has a large impact on the overall stress network and the accessibility measures used to understand Princeton's bikeability. The primary stress map used in this section assumes that where a path exists, that roadway segment becomes an LTS 1 facility. In many cases, without the path, these segments would have a higher stress rating.

Figure 4.3 above shows the stress level of Princeton roadways including the off-road paths, and Figure 4.4 shows the stress network without the off-road paths. As

Figure 4.4 | LTS 1 Facilities without Bicycle Paths



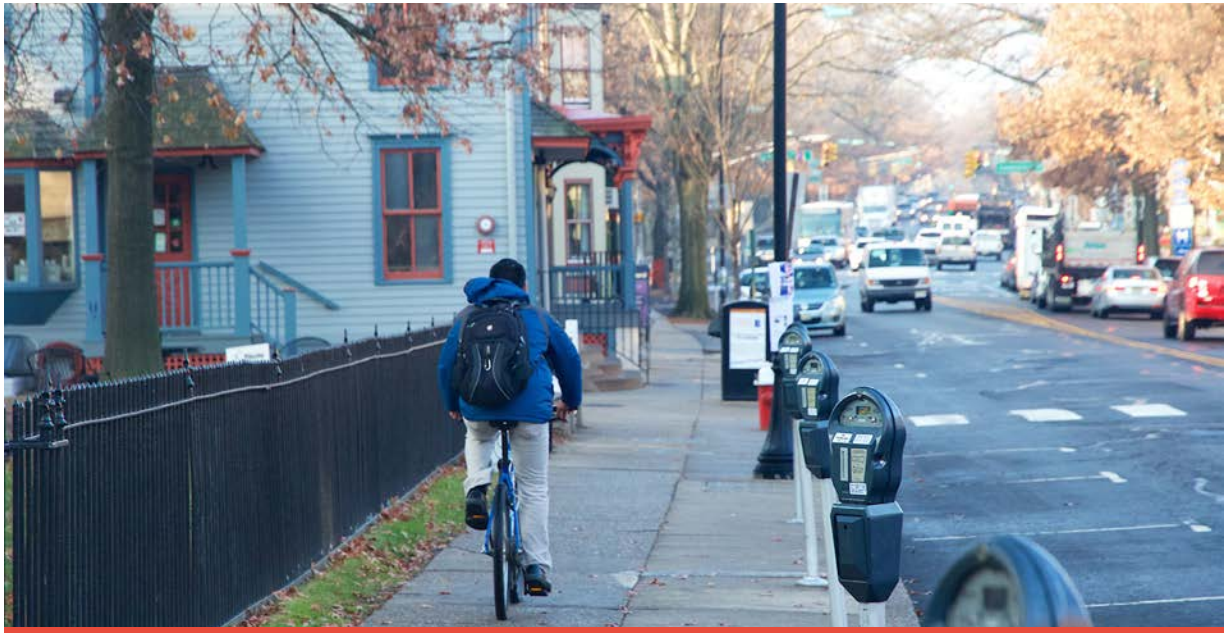
can be seen, the off-road paths have a significant positive impact on the overall stress level of Princeton roads.

Bicycle Network Connectivity

As discussed earlier, one of the biggest factors influencing an area's bikeability is the level of connectivity of its low-stress routes. Princeton's off-road paths are critical in connecting low-stress areas throughout the municipality. It is very important to look at not only improving the condition of the paths (including improving lighting), but also ensuring that connections to the paths are low-stress and easy to use.

In many ways, cycling in downtown Princeton is a more complex and challenging experience than outside of the downtown. Although most of the downtown streets have a 1 or 2 travel lane profile and a 25MPH speed limit, many are characterized as LTS 2 because of their high traffic volumes. Heavy motor vehicle traffic is a deterrent for many cyclists. The current need to ride in mixed traffic among these heavy volumes can be challenging for many existing and potential riders, particularly children.

Nassau Street (NJ 27) can be particularly challenging for cyclists. The street carries heavy traffic volumes (10,000-18,000 vehicles per day, based on recent NJDOT traffic counts) and the roadway profile shifts from 2 to 4 lanes depending on the segment. In addition, NJ Transit and regional bus service runs frequently along the roadway, as well as many delivery trucks for nearby businesses, tour buses, and taxis. Despite these challenges, Nassau Street is an important part of the street network for cyclists, as it connects and provides direct access to most of Princeton's downtown and Princeton University. Nassau Street is categorized as an LTS 4 between U.S. Route 206 and Washington Road, and between Cedar Lane and the Kingston border. It is categorized as an LTS 3 between Washington Road and Cedar Lane.



Congestion and high-vehicle speeds and volumes can deter many cyclists from riding in the roadway or along a particular route and many potential cyclists are deterred from riding at all. The lack of dedicated bicycle facilities along key routes often leads to cyclists riding on the sidewalk (such as in the above photo of Nassau Street in Downtown Princeton). This behavior often leads to conflicts with pedestrians, particularly in Princeton's busy downtown.

Bike Penalty Metric

In order to better understand the bicycle network connectivity in Princeton, a technique called Bicycle Penalty was used. The guiding principle behind this analysis is that high stress links in a bicycle network can penalize and hamper cyclists' ability to access the entire network, when compared to an automobile. The analysis works by measuring the percent difference in the ability of a user at one point in the network to access any other point in the network. The analysis compares a user in an automobile, where the entire network is available, to a user on a bicycle who can only use LTS 1 roads (shown in Figure 4.5) or LTS 1 and 2 roads (shown in

Figure 4.6). This analysis was conducted for all parcels is Princeton.

The Bike Penalty measurement is expressed on a percentage scale from 0 to 100 percent, which indicates, at a given point, the percentage of the network that is accessible by car but not by bike. For example, a Bike Penalty of 50 percent indicates that a cyclist from that point can access 50 percent less of the network compared to a motorist.

Figure 4.5 shows the Bicycle Penalty for a cyclist using only LTS 1 roads. As shown in the figure, the central core of Princeton is hard to navigate for LTS 1 cyclists compared to a motorist. This is largely due to the preponderance of LTS 2 roads in this area. Many other areas of the municipality are shown to have a high Bicycle Penalty, indicating that there is a lack of connectivity between LTS 1 routes, which limits the mobility of these users, who are often children. This finding is consistent with feedback heard from many parents who have expressed concern with allowing their children to bicycle around Princeton.

Figure 4.6 shows the Bicycle Penalty for a cyclist using LTS 1 and 2 roads and it tells a different story. In this figure, most of Princeton has a low Bicycle Penalty, indicating that the municipality has good bicycle connectivity for LTS 2 (or most adult) cyclists. The highest Bicycle Penalty in this model exists along the periphery of the municipality where there are fewer

Figure 4.5 | Bicycle Penalty for LTS 1 Roads

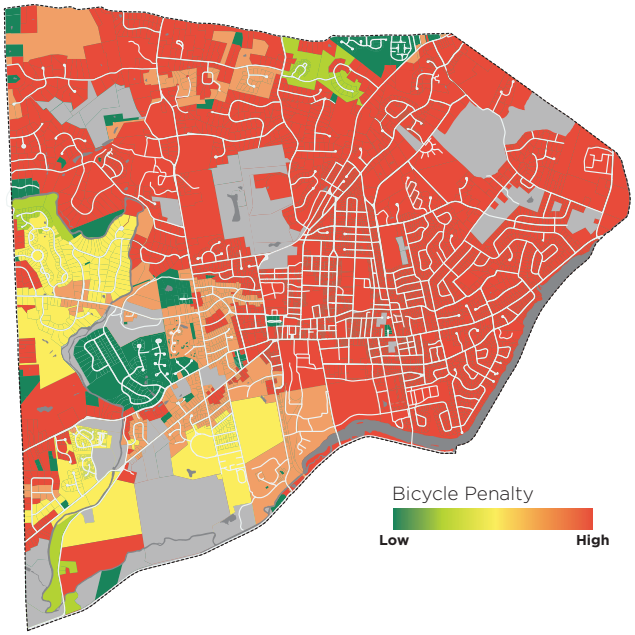
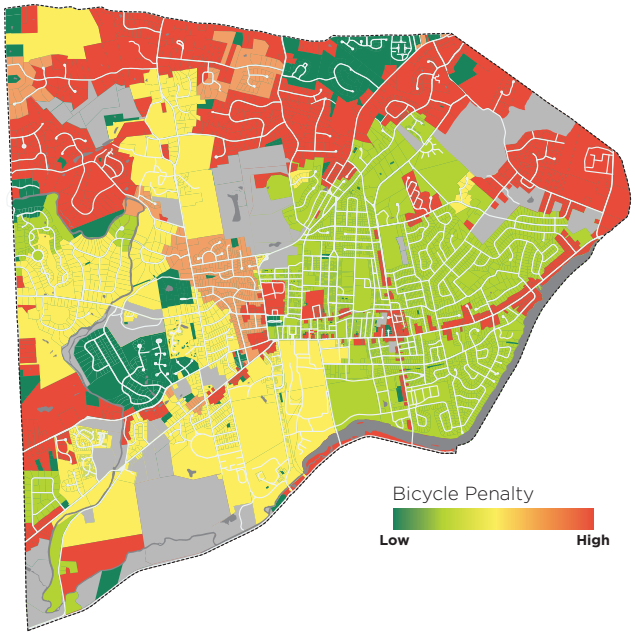


Figure 4.6 | Bicycle Penalty for LTS 1 and 2 Roads



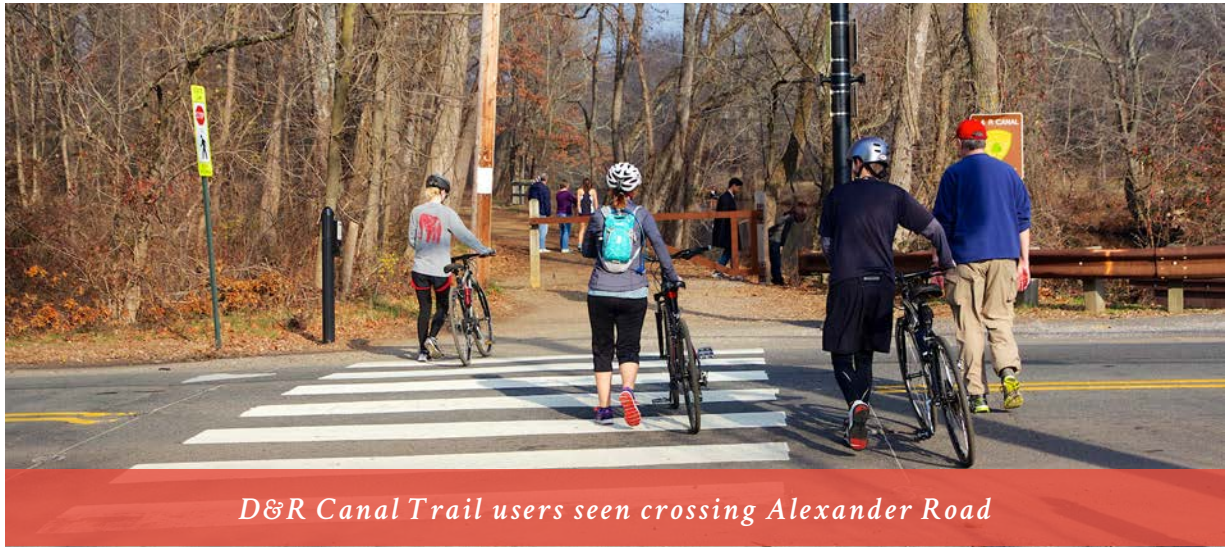
route options and the impact of higher speed/higher stress roads (including U.S. 206 and Great Road) have a large impact on Bicycle Penalty. Major destinations along arterials such as NJ Route 27 and Harrison Street similarly lack connectively to the low street network.

These higher stress roads are barriers to low-stress bicycle travel and significantly limit the mobility of LTS 1 and 2 cyclists. Providing low-stress connections to these areas should improve lower stress connectivity.

(Top Left) Student biking to school on Moore Street
(Top Right) Cyclist seen traveling in mixed traffic on Nassau Street
(Bottom Left) Cyclist and pedestrians using the Alexander Road path. The existing width makes passing difficult

4.4 Bicycle Paths

As discussed in the bicycle network analysis, Princeton's many off-road paths provide a varying degree of benefits to cyclists. While the existing network of paths provides alternative routes to high stress roadways, there are a variety of deficiencies that limit their appeal to potential new cyclists. The following are the primary off-road facilities in Princeton that offer benefits for utilitarian bicycle trips, as well as recreation. The entire trail network is shown in Map 4.



D&R Canal Trail users seen crossing Alexander Road

D&R Canal Trail

The D&R Canal Trail runs 77 miles between New Brunswick and Trenton along the Delaware and Raritan Canal, and from Trenton to Frenchtown along the Delaware River. The trail is heavily used by walkers, runners, cyclists, fishermen, and others. The trail material varies by segment, from dirt, to crushed gravel, to coarse aggregate. The lack of a paved surface on the trail helps maintain a rustic and historic feel, but also means that the trail is often muddy and has many puddles after rainstorms. This limits the trail's usefulness for commuting cyclists; despite the fact that the trail near Princeton largely parallels U.S. Route 1, where numerous businesses and employers are located. The lack of lighting along the trail also limits the usefulness of the trail for this purpose, particularly in the winter when the sun sets earlier.

From a recreational standpoint, the D&R Canal Trail provides a unique and fun resource for Princeton residents and visitors, with access to many great towns and natural areas along its 77-mile run. Connections to the trail are limited, however, with entry points within Princeton at Harrison Street, Washington Road, Alexander Road, and Quaker Road. The trail crosses these roads at-grade. The crossings at Harrison Street and Alexander Street feature painted crosswalks, signage, and flashing beacons.

The crossings at Washington Road and Quaker Road lack adequate crossing infrastructure. The crossing at Washington Road is not marked and does not have a flashing beacon, despite the high vehicle travel speeds on the westbound approach (50 mph speed limit). A severe crash occurred at this crossing in November 2014, in which a motorist struck two cyclists walking their bikes across the trail crossing.

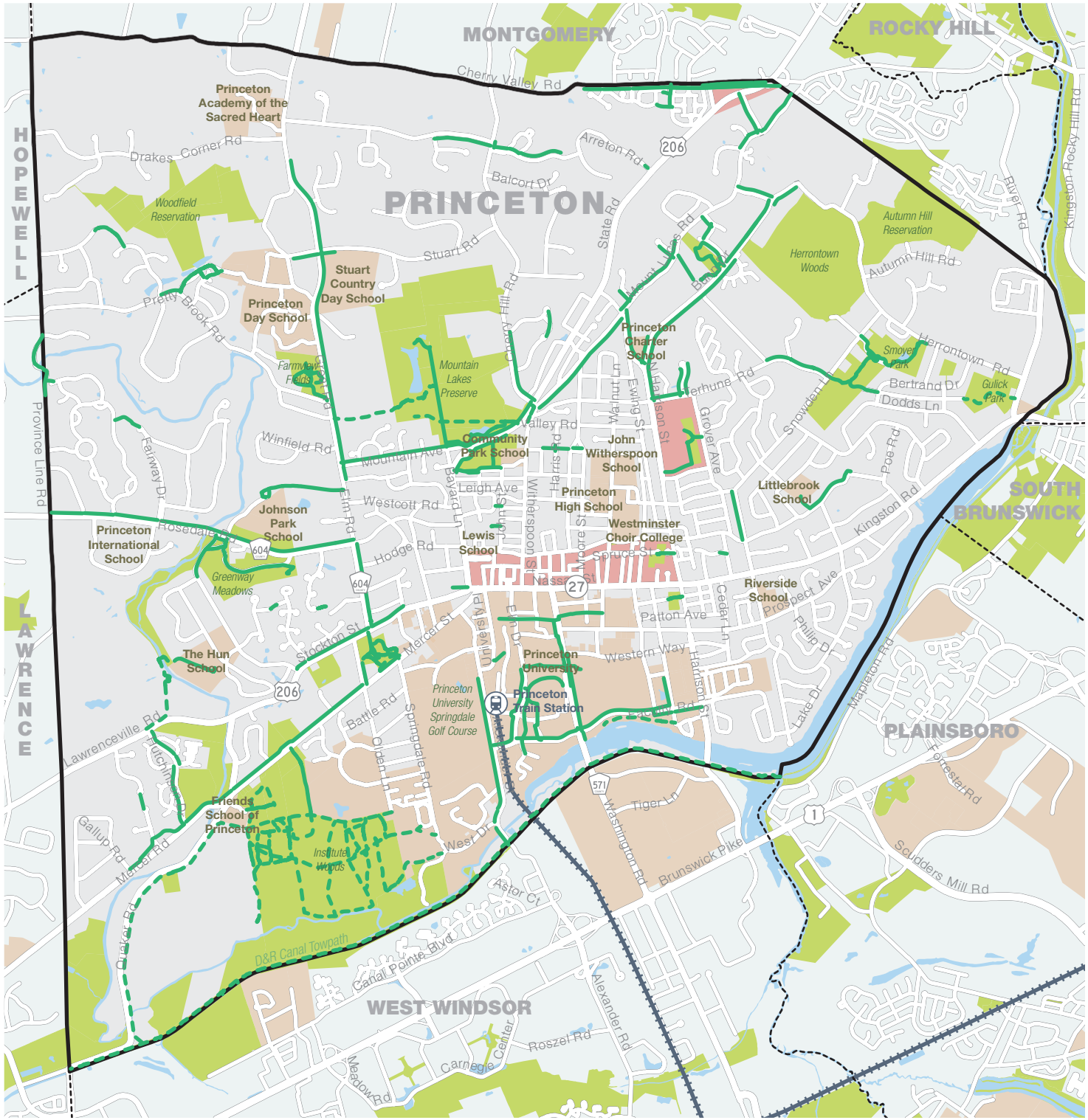
The Quaker Road crossing is particularly challenging for trail users. The trail intersects the roadway at a ninety-degree bend in the road. Trail users traveling southbound cannot see if vehicles are approaching to their right. There is also no indication for drivers on Quaker Road that there is a trail crossing nearby (either via a sign or roadway markings). This difficult crossing reduces the comfort level of trail users making this intersection a barrier for low-stress trail use.

PRINCETON
bicycle master plan

Princeton features many bicycle paths and multi-use trails. These facilities help provide additional low-stress connectivity and are a great resource for recreational cyclists. However, the lack of wayfinding to-and-between these paths, as well as varying degrees of maintenance, lighting, and width, hinder the benefit these paths provide from a transportation perspective.

Map 04
Bicycle Paths

- School
- Park
- Commercial Area
- Off-Street Bike Path (Paved)
- Off-Street Bike Path (Unpaved)



0 0.25 0.5 1 Miles

Alexander Street

The 0.8 mile pathway connects the Princeton Train Station and Princeton University with the D&R Canal Trail on the eastbound side of Alexander Road. This pathway provides a critical connection between these destinations and is heavily traveled by cyclists, runners and other users for recreation and commuting. The buffer between the roadway and the path varies widely between nonexistent and 15+ feet. The path itself is generally 5-6 ft wide, which does not allow comfortable passing space for the various users. Because of the popularity of the pathway, the lack of comfortable passing width can reduce its usefulness and ability to provide a truly low-stress cycling experience. However, given the slope of Alexander Road and high traffic volumes, the path provides a critical low LTS connection for cyclists between the D&R Canal Trail, the Train Station, and the University campus, particularly for those cyclists traveling uphill westbound.

Mercer Road

The 1.4-mile Mercer Road sidepath runs between Lovers Lane and Hale Drive. While the path does provide a separated space for cyclists off the busy Mercer Road corridor, its narrow width, uneven pavement, and lack of accessibility limits the pathway's usefulness.

Quaker Road

The 1.4-mile long Quaker Road sidepath is a dirt and crushed gravel path that connects the D&R Canal Trail to the Princeton Friends School and trails to the Princeton Battleground, terminating approximately 0.1 miles south of the intersection of Quaker Road and Mercer Road. While this is an important recreational connection between two significant off-road facilities, a few factors limit the effectiveness and attractiveness of this connection from an everyday utility perspective. The path connects to Mercer Road through the Princeton Battlefield and a striped continental crosswalk. This crossing can be challenging because of the high traffic volumes and speeds on Mercer Road at this location. Additionally, partly because of the dirt and crushed gravel material and its location along the flood-prone Quaker Road, the path is often soggy and difficult to use. The lack of lighting along the path also makes the path difficult to use past dark.

Rt 206 – State Road

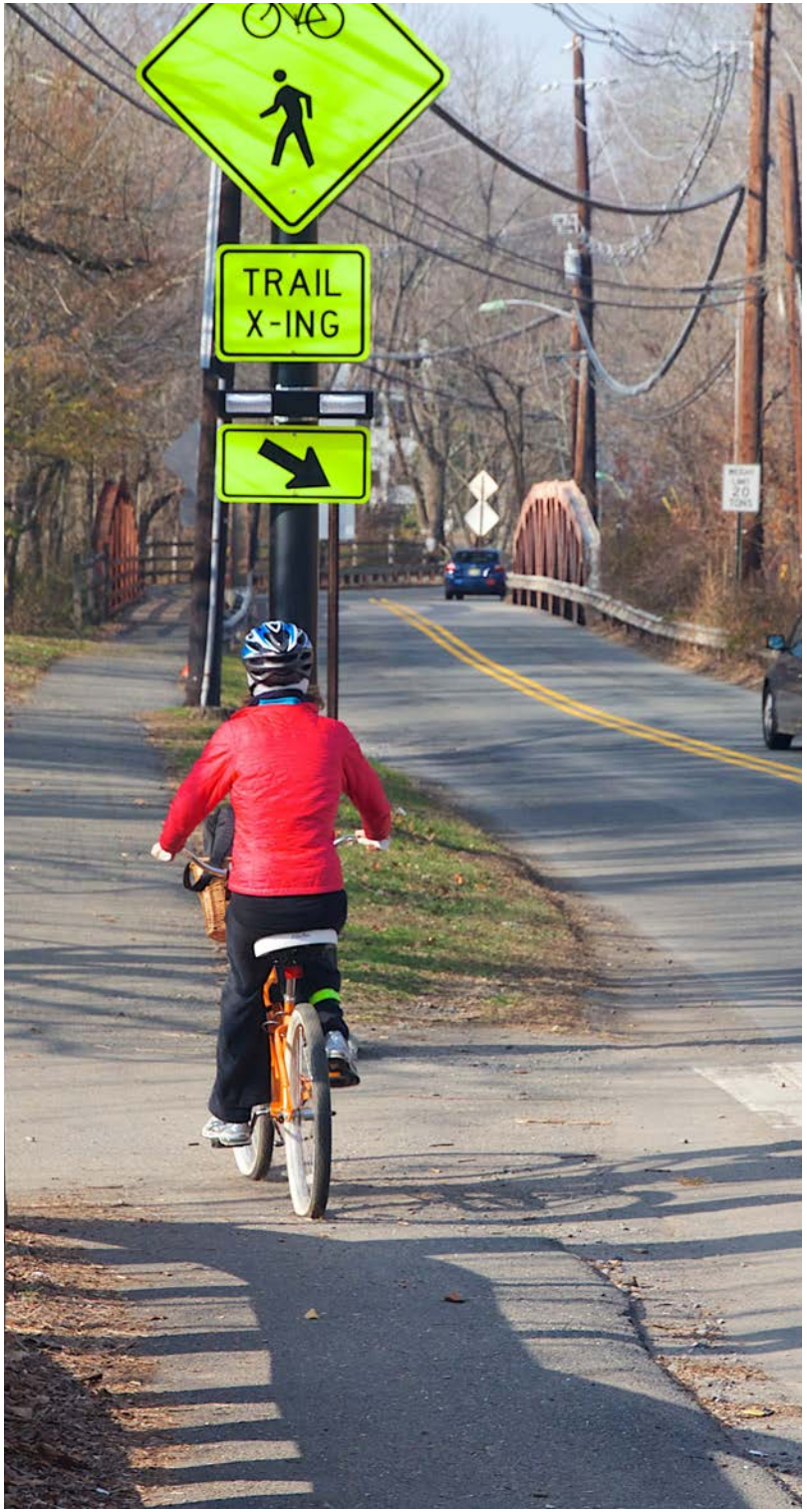
The 0.57 mile asphalt sidepath runs along U.S. Route 206 southbound from Cherry Hill Road to Mountain Avenue, where it crosses U.S. Route 206 and is located on the northbound side until the southern edge of Community Park South, where the path transitions to a concrete sidewalk. The path connects and provides access to Mountain Lakes Preserve/Community Park North, Community Park South, and a sidepath along Mountain Avenue. The path is generally in good condition and sections are set back from the roadway with a tree-lined buffer, increasing user comfort. However, it is typically six feet wide, narrower than the preferred minimum design width of eight-feet.

Rt 206 – Stockton Street

The 0.6 miles asphalt sidepath runs along U.S. Route 206 southbound between Cambelton Road and Edgerstoune Road, providing connections to the Hun School and Marquand Park. While it provides a separated space for cyclists along the high-stress U.S. Route 206, the path is typically narrow (5-6 ft) and the surface often uneven.

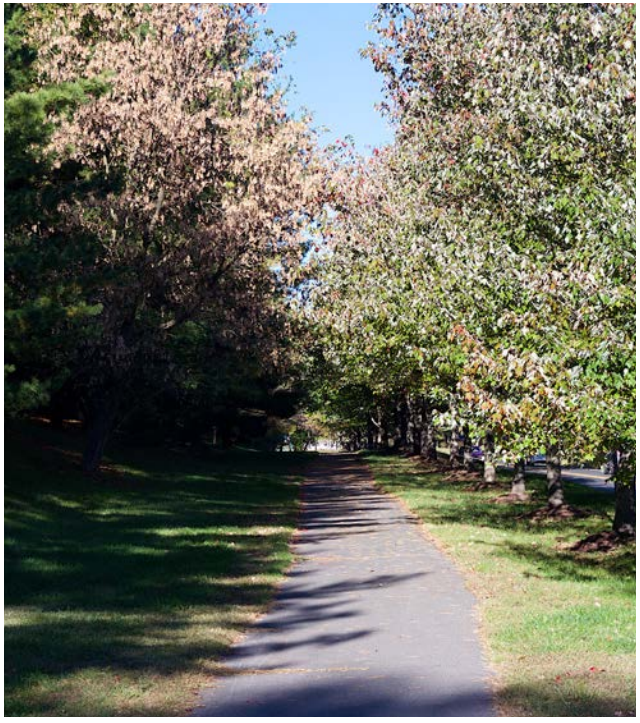
Rosedale Road

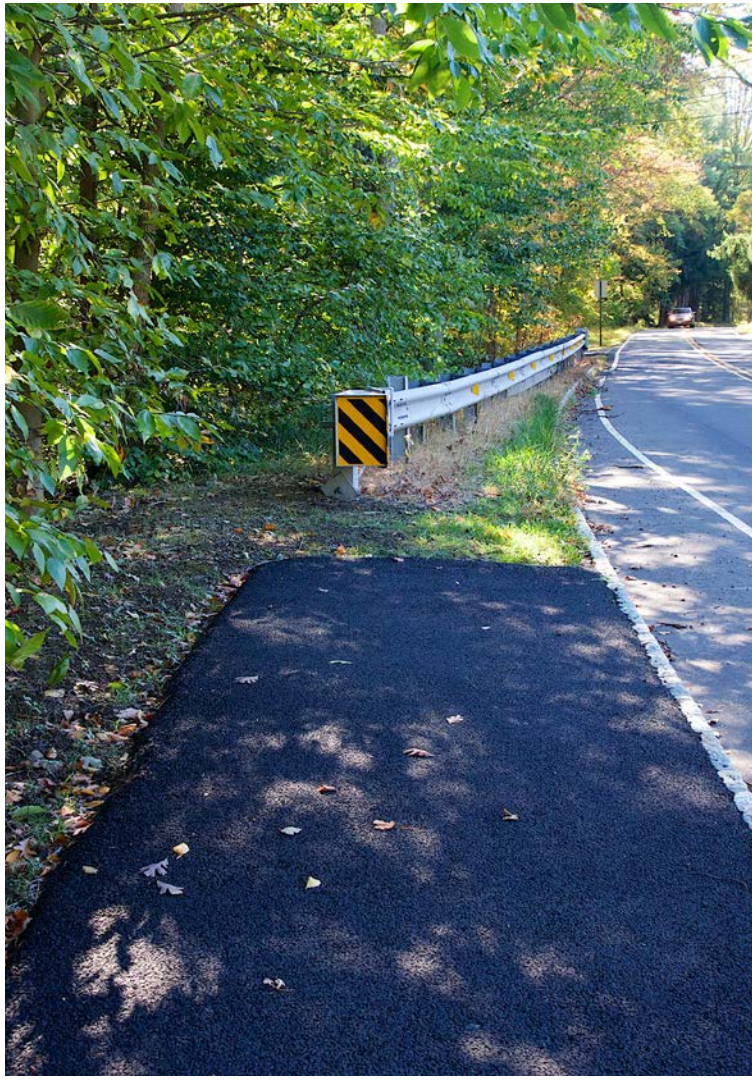
This 1.5-mile long asphalt sidepath connects Elm Road to Province Line Road, providing access to numerous residential neighborhoods, the D&R Land Trust, and the Johnson Park School. The path varies in width and pavement quality. Its location provides a low-stress facility for many cyclists, but the narrowness of many segments of the path impedes the ability for cyclists to safely and comfortably use the path, particularly among other users.



(clockwise from far left) (1) Cyclist on Alexander Road path at the D&R Canal Trail crossing. (2) Sidepath along Bunn Drive. (3) Cyclists riding along the D&R Canal Trail. (4) Overgrown vegetation and the narrow width reduce the utility of the sidepath along Mt. Lucas Road

(clockwise from top-left) (1) Path connecting Elm Road to the Johnson Park Elementary School is in need of resurfacing. (2) Poor visibility and lack of markings or signage create a difficult crossing of the D&R Canal Trail at Quaker Road. (3) Sections of the sidepath along Quaker Road are washed out and in need of maintenance. (4) Trolley Track Trail through the Institute Woods. (5) Tree-lined buffer along U.S. Route 206 sidepath improves user comfort





(Top-Left) Cyclist on sidepath along Mt. Lucas Road
(Top-Right) Terminus of sidepath along Cherry Valley Road
(Bottom-Left) Bicycle/pedestrian-only bridge over Stony Brook, connecting segments of Province Line Road

Guyot Avenue

The 0.22 mile asphalt path connects residential neighborhoods with the High School, John Witherspoon Middle School, Community Park Elementary School, Municipal Complex, and the Community Park Complex. It provides a lower stress and more direct connection for cyclists to these destinations than Valley Road, one-block to the north. Unlike Valley Road, however, it does not provide a through connection to Harrison Street and the Princeton Shopping Center. The path also lacks lighting, has sections of uneven pavement, and is too narrow to facilitate easy passing of other path users. An adjacent stream also constrains potential improvements.

Elm Road/Great Road

A 2-mile asphalt sidepath runs along Elm Road/Great Road northbound between U.S. Route 206 and a mid-block location before Drakes Corner Road, where the path terminates. The path is not continuous. There is a 0.3 mile segment between Cleveland Lane and Westerly Road that can be more accurately categorized as a sidewalk, as it is concrete and narrower than the asphalt path. This path connects residential neighborhoods with a number of schools, including the Princeton Day School, the Stuart Country Day School, and the Johnson Park School, via the Rosedale Road path, or an off-road trail connection via Elm Road.

Mt. Lucas Road

An approximately 1.1 mile asphalt sidepath runs along the northbound side of Mt. Lucas Road from Terhune Road to Ewing Street, where is switches to the southbound side until just north of Stuart Road. After Dogwood Hill, the path resumes on the southbound side approximately 0.47 miles to Princeton Avenue. Mt. Lucas provides a parallel, lower stress alternative to U.S. Route 206. The significant elevation gain along the roadway also leads to lower cyclist speeds in the uphill direction, giving increased importance and impact to the presence of a the sidepath on cyclist comfort. While the southern portion was recently repaved and is an excellent condition, the northern portion has many narrow sections and the pavement is in poor condition. Additionally, the gap in connectivity and lack of lighting limit its usefulness to some riders.

Bunn Drive

A 1.25 mile asphalt sidepath along Bunn Drive connects residential neighborhoods in the northeast portion of the Municipality to the Princeton Shopping Center, Princeton Charter School, and several employment centers. Although typically narrower than current standards, the path is generally in good condition and provides a separated space for cyclists adjacent to a higher speed roadway.

4.5 Recreational Facilities and Open Space

In addition to the existing network of major trails and side paths discussed in the previous section, Princeton residents have access to a variety of trails and an abundance of open space that creates a greenbelt of preserved land around the Municipality. The proximity of several regional trail networks, such as the D&R Canal, the Lawrence-Hopewell Trail, the Freedom Trail, and "the Circuit" regional trail system of Greater Philadelphia and central New Jersey, offers opportunities for both recreation and regional connections to neighboring municipalities.

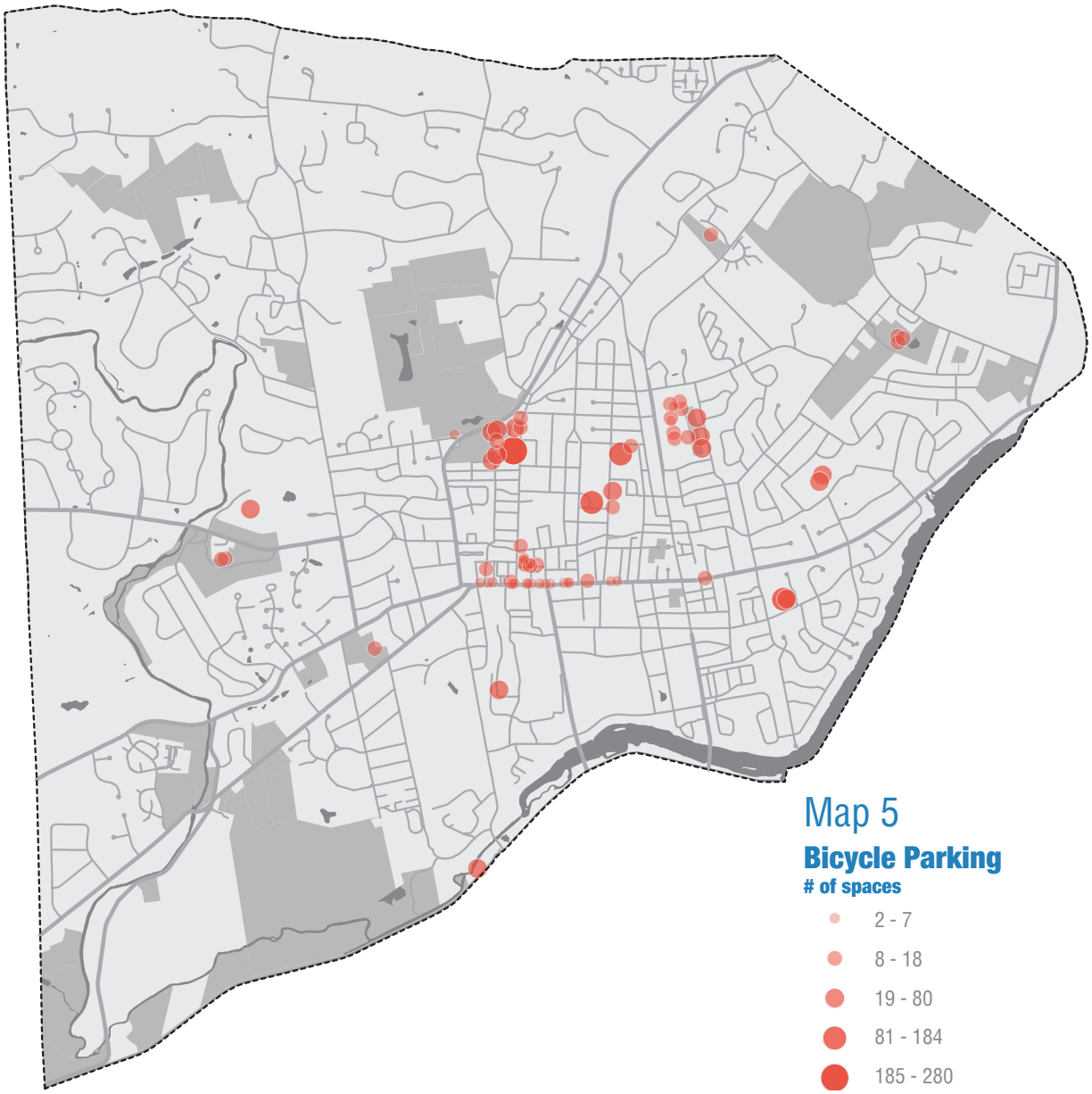
The Princeton Bike Map, created in 2014, illustrates the Municipality's existing trails and open space resources. Many of the existing trails are largely unpaved and designed for recreational use, with meandering routes and/or limited network connectivity. However, these facilities may offer opportunities to improve or extend various trail segments to make them suitable for utilitarian cycling trips, create greenways that accommodate cycling, and enhance the overall connectivity of the bicycle network.

4.6 Bicycle Parking

The Municipality of Princeton conducted a bicycle parking inventory in August 2015. The inventory targeted key destinations, including the central business district, schools, and parks. The inventory documented the location of bicycle parking, the rack type, capacity, and condition.

The Municipality has 106 bicycle racks with a total capacity of 1,633 spaces. The location and capacity of existing bike parking is illustrated in Map 5. There is a significant amount of parking provided at local schools. While there are many smaller racks throughout the downtown, additional capacity is needed as bikes are also commonly secured to signs, trees, and other fixed objects.

Of the existing bike parking, 58% of the racks, composing 92% of the total capacity, are the older style "comb" or "wave" racks. These racks are typically less intuitive to use, and do not support the bicycle as well or as securely as the newer "inverted U", "A", and "post-and-loop" styles.



END NOTES

1 Lantz, A., *Cycling in Los Angeles: Findings from a survey of Los Angeles cyclists*, 2010
2 2010-2014 NJDOT Crash Data

(clockwise from top-left) (1) Older design "comb" racks heavily utilized at the John Witherspoon Middle School. (2) Inverted-U rack along Witherspoon Street over capacity. (3-4) Bicycles chained to trees and parking meters along Nassau Street. (5) Older design "bollard" racks along Nassau Street

05

Bicycle Facility Design

The Princeton Bicycle Master Plan seeks to create standardized bicycle treatments that can be implemented throughout Princeton. As Princeton's bicycle network develops, adhering to these standards will ensure uniform, effective and recognizable treatments throughout the Municipality. These treatments fit various contexts and purposes and aim to make bicycling in Princeton safer, more comfortable, and more desirable.

The design treatments recommended in this chapter utilize guidance from NACTO's *Urban Bikeway Design Guide*, NACTO's *Urban Streets Design Guide*, FHWA's *Separated Bike Lane Planning and Design Guide*, and AASHTO's *Guide for the Development of Bicycle Facilities*. The standards recommended in these guides should be adhered to when implementing bicycle facilities. These guides provide detailed information that is necessary to implement the preferred bicycle treatments outlined in this chapter, and should be consulted as needed.

Not all bicycle treatments described in this chapter have an obvious application in the Municipality today. However, should the opportunity arise to implement one of these treatments, the guidance provided here should be followed.

The bicycle facilities outlined in this chapter can be considered a hierarchy, where increased separation between bicyclists and motorists is the preferred treatment to accommodate bicyclists of all ages and abilities.

This chapter provides guidance for the following:

- Bicycle Lanes
- Buffered Bicycle Lanes
- Separated Bicycle Lanes
- Two-Way Separated Bicycle Lanes
- Shared-Lane Markings
- Bicycle Boulevards
- Side Paths and Multi-Use Paths
- Intersection Treatments Wayfinding
- Bicycle Parking

5.1 On-Street Bicycle Facilities

Bicycle Lane

Bicycle lanes are used to provide an exclusive space for bicyclists through the use of pavement markings and signage. Bicycle lanes are intended for one-way travel and are typically used on both sides of a two-way street and on one side of a one-way street (the preferred location for bicycle lanes on a one-way street, in most cases, is on the left-side of the roadway). Bicycle lanes enable bicyclists to ride at their preferred speed, free from interference from motorists and help facilitate predictable behavior between bicyclists and motorists. Bicyclists may leave the bicycle lane to pass other bicyclists, make turns, or avoid obstacles and conflicts. Motorists may pass through the bicycle lane to access parking or make other turning movements, but they may not stand or park in the lane.

Buffered Bicycle Lane

Buffered bicycle lanes are conventional bicycle lanes that are paired with a marked buffer space separating the bicycle lane from the adjacent motor vehicle travel lane. While buffers are typically used between bicycle lanes and travel lanes to increase bicyclist comfort, they can also be used between bicycle lanes and parking lanes where there is high parking turnover to discourage cyclists from riding too close to parked vehicles, decreasing the risk of conflicts with drivers opening their car door.

Separated Bicycle Lane

Separated bicycle lanes are bikeways that are at street level and use a variety of methods for physical separation from passing traffic, such as bollards, planters, on-street parking, curbing, or medians. Unlike a conventional or buffered bike lane, a separated bicycle lane provides vertical separation to prevent encroachment, improve safety, and deter double-parking. The separation of the bicycle lane from motor vehicle traffic makes a separated bicycle lane more attractive for bicyclists of all ages and abilities. Separated bicycle lanes also have a reduced risk of "dooring" compared to conventional bicycle lanes. *[above photo courtesy of the City of Newark]*

Design Guidelines

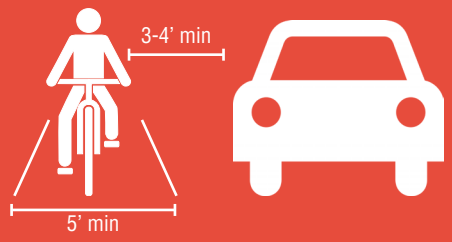
On-street bicycle facilities in Princeton should follow the guidance of the:

NACTO Urban Bikeway Design Guide

FHWA's Separated Bike Lane Planning and Design Guide

When installing bicycle facilities, the following basic and minimum guidelines should be adhered to:

- Bicycle lanes shall be 5' wide minimum adjacent to curbing, 4' minimum without curbing. When adjacent to parking, increased width should be provided to minimize risk of conflicts with parked cars.
- A striped buffer, when provided, should be minimum 1.5' feet wide, but preferably 3' wide.
- Vertical separation provided as part of a separated bicycle lane design must be at least 7 feet from the nearest curb.
- The desired total width of a two-way separated bicycle lane is 10-12' (8' minimum)



*Passing motor vehicles should provide a cyclist with at **least 3-4' of distance**. Bicycle facilities should be designed to enforce this principle.*

Two-Way Separated Bicycle Lane

Two-way separated bicycle lanes are physically separated bicycle lanes that allow bicycle movement in both directions on one side of the road. Two-way separated bicycle lanes share many of the same design characteristics as one-way separated bicycle lanes, but might require additional considerations at driveway and side-street crossings. Two-way separated bicycle lanes reduce the detour length for bicyclists by providing contra-flow movement, permitting more convenient and direct routes. Research indicates that two-way separated bicycle lanes are more attractive to bicyclists of all ages and abilities.

Shared-Lane Markings

On roadways where it is not feasible or appropriate to provide dedicated bicycle facilities, shared-lane markings may be used to indicate a shared environment for bicycles and automobiles. Shared-lane markings should be used to connect and provide a designated route to dedicated bicycle facilities. A shared-lane marking is not a facility type, but can be used to assert the legitimacy of bicyclists on the roadway, and offer directional and wayfinding guidance. Shared-lane markings help direct bicyclists to ride in the most appropriate location on the roadway and provide motorists visual cues to anticipate the presence of bicyclists. Shared-lane markings are appropriate on streets with a speed limit of 25 MPH or less.

Enhanced Shared-Lane Markings

Painted Marking: A variety of shared-lane marking designs have been implemented around the United States in an effort to increase effectiveness of the marking. The City of Newark, NJ, for example, includes a high-visibility painted green box around their shared-lane markings (shown in the above photo). This design dramatically improves the visibility of the marking.

Striped Share-Lane: Another design enhancement is the painted shared-lane, sometimes called the "super sharrow." This design has been implemented in several places in the United States, and there are several design variations. For example, in Oakland, CA (shown in the above photo), the shared-lane is painted green, and in Boston, MA, the shared-lane is outlined by dashed white striping. The purpose of this design is not only to increase the visibility of the marking, but also to significantly change the visual quality of the roadway and reinforce that the street is meant to be shared. *[above photo courtesy of streetsblog.org]*

Hybrid Bike Lane

In some locations it isn't possible, given physical roadway dimensions, to install dedicated bicycle facilities in both directions of travel. In some of these cases, however, it may be possible to install a dedicated bicycle facility in one direction and mark a shared-lane in the other direction. This design, often called a "hybrid" (shown in the above illustration), may be appropriate in a variety of situations.

One of the more common applications for this design is on streets with a significant incline, where a bicycle lane will be striped for the uphill direction (where cyclists are traveling at a much lower speed relative to motorized vehicles) and a shared-lane marking is striped in the downhill direction (where the speed differential is minimal).

5.2 Bicycle Boulevard

What are bicycle boulevards?

Bicycle boulevards are traffic-calmed streets where bicyclists are afforded an enhanced level of safety and comfort. Many local streets that have existing low motor vehicle travel speeds and volumes create the basic components of a safe and comfortable bicycling environment. These streets can be enhanced by a variety of design treatments that discourage high vehicle speeds and volumes to create a bicycle boulevard. Many of these treatments benefit not only bicyclists, but by creating a safe and quiet environment, they benefit all users of the street.

Bicycle boulevard treatments include signs, pavement markings, and other traffic calming measures to discourage through trips by motor vehicles while accommodating local access. Intersection crossing treatments are crucial to creating more comfortable streets for users of all ages and abilities.

Why bicycle boulevards in Princeton?

Princeton's character is defined, in part, by its many narrow, tree-lined streets. While these streets are often very pleasant for pedestrians, their physical constraints can make them challenging or impossible to implement dedicated bicycle facilities. On streets where automobiles and bicyclists must share the same space, bicycle boulevard treatments can be used to improve the comfort level of all users. In Princeton's constrained environment, bicycle boulevard treatments provide a means to reduce motor vehicle speeds and create a comfortable bicycle route for bicyclists of all abilities and a more pleasant environment for pedestrians and residents.

A variety of tools are available to help manage vehicle travel speeds and create a comfortable environment for bicyclists and pedestrians:

- Reduced Speed Limits
- Signage and Markings
- Speed Management
- Volume Management

Reduced Speed Limits

Bicycle boulevards should have a maximum posted speed limit of 25 MPH. A speed limit of 20 MPH is preferred. Speed limits alone, however, will do little to reduce vehicle travel speeds and should be considered in conjunction with physical infrastructure improvements and enforcement as a method for reducing vehicle travel speeds.

Signage and Markings

Signs and pavement markings are important elements of a bicycle boulevard. While signs and markings alone do not create a safe and low speed environment, they indicate and reinforce that a roadway is intended as a shared, slow street. The NACTO *Urban Bikeway Design Guide* provides additional guidance on sign and marking types and applications.

According to NACTO's Urban Bikeway Design Guide:

Bicycle boulevards should have 85th percentile speeds at 25 mph or less (20 mph preferred)

(Top-Left) Bicycle boulevard in Berkeley, CA uses chicanes, speed humps, and pavement markings to discourage vehicle through traffic and high speeds - photo courtesy of Payton Chung (flickr)

(Top-Right) Bicycle boulevard sign in Berkeley, CA - photo courtesy of The City of Berkeley, CA

(Bottom-Left) Median along bicycle boulevard in Ocean City, NJ restricts vehicle through traffic, and curb extensions reduce speeds

Speed Management

Speed management treatments aim to reduce motor vehicle speeds, bringing them closer to those of bicyclists. Reducing vehicle speeds is a critical feature of a bicycle boulevard. Lower speeds improve the bicycling environment by reducing instances of vehicles overtaking bicyclists, enhancing the drivers' ability to see and react to bicyclists, and reducing the severity of crashes, if they occur. Speed management treatments can be divided into two types: horizontal and vertical deflection. These treatments can be implemented individually or in combination to increase their effectiveness.

Benefits of speed management techniques include:

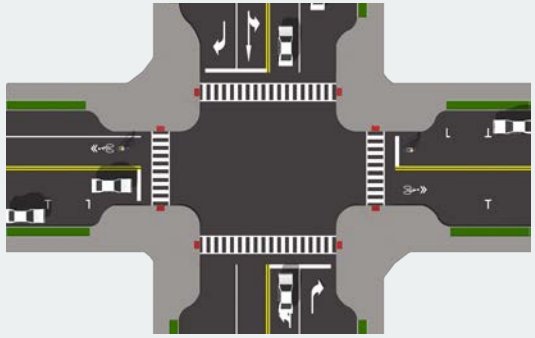
- Decreased motor vehicle speeds
- Decreased crash likelihood
- Decreased chance of injury resulting from crash
- Improved bicyclist comfort
- Improved conditions for pedestrians and residents by reducing vehicle speeds
- Establishes and reinforces bicycle priority on bicycle boulevard
- Provides opportunity for landscaping and other community features, such as benches, communal space, and artistic painted intersections, benefiting all roadway users and residents

Horizontal Deflection

Horizontal speed control devices are used to slow motorists by either visually narrowing the roadway or deflecting motorists through an artificial curve. Where possible, sufficient space should be provided for bicyclists to pass around the outside of the elements. **The following are examples of horizontal deflection:**

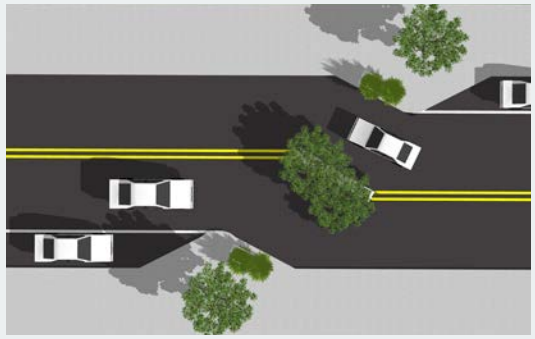
Curb Extensions

Curb extensions, or bulb-outs, extend the sidewalk or curbface into the parking lane at an intersection. Curb extensions narrow the roadway at intersections, contributing to lower motor vehicle speeds, as well as reducing the crossing distance for pedestrians and increasing the amount of space available for street furniture and green stormwater management features. They are typically applied at locations with on-street parking and should not extend into bicycle lanes.



Chicanes

Chicanes are a series of raised or delineated curb extensions, edge islands, or parking bays, that are placed on alternating sides of a street to create an S-shaped bend in the roadway. Chicanes reduce vehicle speeds by requiring drivers to shift laterally through narrow travel lanes.



Neighborhood Traffic Circles

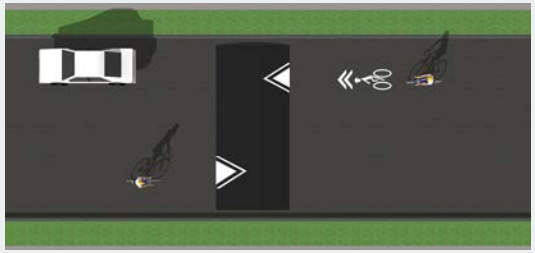
Neighborhood traffic circles are raised or delineated islands used at minor street crossings to reduce vehicle travel speeds by reducing turning radii, narrowing the travel lanes, and, if planted, obscuring the visual corridor along the roadway

Vertical Deflection

Vertical speed control measures are composed of wide, slight changes in pavement elevation that self-enforce a slower speed for motorists. Narrow and abrupt speed bumps that are often used in private driveways and parking lots are not recommended for public streets and are hazardous to bicyclists.

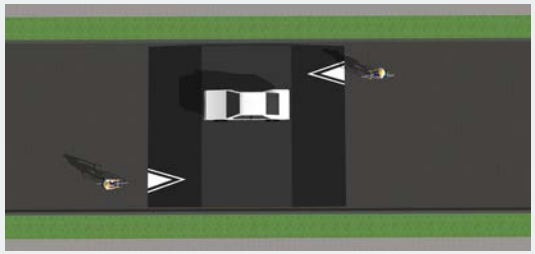
Speed Humps

Speed humps are 3 to 4 inches high and 12 to 14 feet long, with an intended vehicle speed of 15 to 20 mph. Speed hump design should adhere to the guidelines of the New Jersey "Speed Hump Law," (C.39:4-8.9, C.39:4-8.11), which adopted the ITE design standards for Speed Humps.



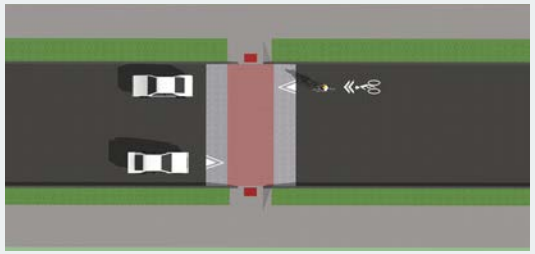
Speed Tables

Speed tables are longer than speed humps and have a flat top, with a typical height of 3 to 3.5 inches and a length of 22 feet. Intended vehicle operating speeds range from 25 to 35 mph, depending on the spacing. Speed tables may be used on collector streets, transit, and/or emergency responder routes.



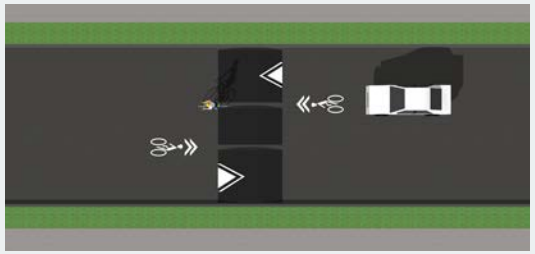
Raised Crosswalk

A raised crosswalk is a speed table that is signed and marked as a pedestrian crossing. It extends the full width of the street and is typically 3 inches high. At minor intersections the entire intersection can be raised to reduce motor vehicle speeds in all directions.



Speed Cushions

Speed cushions are speed humps or speed tables that include wheel cutouts that allow larger vehicles to pass unaffected, but reduce passenger vehicle speeds. They are often used on key emergency response routes to allow emergency vehicles to pass unimpeded. Speed cushions should be used with caution, however, as drivers will often seek out the space in between the humps.



Volume Management

Volume management techniques reduce or discourage through traffic by physically reconfiguring select intersections. Bicycle boulevards should be designed for motor vehicle volumes under 1,500 vehicles per day. Short off-street links may also be used to link adjacent or dead-end streets to improve connectivity for bicyclists and create a bicycle boulevard.

Volume management techniques include:

- **Forced Turn at Intersection:** Restriction on through-movements for motor vehicles using signage. This can allow passage for buses and emergency vehicles, but reliance on signage along can lead to reduced compliance by passenger vehicles.
- **Channelized Right-In/Right-Out Island:** Forces motor vehicles to turn right, while providing an opening for bicyclists to continue straight through the intersection.
- **Partial Closures:** Used to close one direction of vehicular traffic at an intersection while still allowing full access and easy passage of bicyclists.

Additional Guidance

The design guidance provided here includes a sample of the tools that planners and engineers have at their disposal to create a bicycle boulevard. Further guidance can be found in NACTO's *Urban Bikeway Design Guide*.

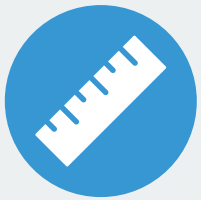
5.3 Shared-Use Paths

Princeton's shared-use paths are a major component of the municipality's bicycle and recreational network. As noted in Chapter 4 of this Bicycle Master Plan, however, these paths often do not meet current standards of path design, and as a result, are often uncomfortable to ride on, difficult to navigate, or lead to frequent conflicts with other path users. In order to create a more comfortable, connected, and, ultimately, a more usable bicycle network, the retrofit of existing paths and construction of new paths should adhere to the guidelines provided in this chapter. More specific recommendations for the retrofit of existing paths can be found in the following chapter.

Further guidance on the design of shared-use paths can be found in:

AASHTO's **Guide for the Development of Bicycle Facilities**

5 Key Elements for the Construction of Shared-Use Paths



Width

Paths should provide a typical width of at least 10-14 feet. Paths may narrow to 8 feet if necessary at pinch points. Where high use is anticipated, particularly with a mixture of modes, increased width is desirable. In these areas, narrow widths can lead to increased conflicts with pedestrians and create unnecessary antagonism between bicyclists and pedestrians.

Lighting

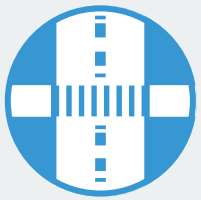
Paths that provide utilitarian connections in Princeton's bicycle network should be well lit to facilitate continued use beyond daylight. Lighting can be provided using a variety of techniques that fit the context of each path (discussed further on the following page).

Surface

Paths must provide a consistently level surface that is suitable for all users. A level surface ensures that paths are not only comfortable for cyclists, but are safer and more usable for all users, including those with limited mobility. **Paths should be paved, where possible, using pervious paving techniques** (discussed further on page 70) to ensure proper drainage during or after periods of rain (and reduce impacts of surface runoff).

Connectivity

As discussed on page 44, the success of a bicycle network depends on how connected each link is to the overall network. This is especially important with paths, which are more attractive to riders who might not feel as comfortable using on-road or higher-stress facilities. Therefore, **paths must be well connected to other low-stress routes on the network and signage must be provided to indicate the location of these routes**.



Intersections

A critical component of path connectivity and comfort, as well as surface quality, is the proper design and construction of intersections. Where a path intersects with a roadway, **transitions between path and roadway must adhere to ADA standards, crossings should be well marked and signed**, and, if signals are triggered by either push buttons or vehicle detections, **accommodations must be provided for cyclists to trigger the signal.**

Providing Lighting for Shared-Use Paths

Where possible, lighting should be provided along paths, particularly at intersections, to ensure that key routes along the Princeton bicycle network are accessible after dark (this is particularly important during the winter, when the sun sets before many people are out of work). In some locations, there might be concerns that lighting would detract from the character of a path, spill over onto neighboring properties, or lead to increased light pollution. In order to address these concerns, lighting should be provided in a manner that fits the context and minimizes light pollution. Many low-impact solutions can be used in areas where the above concerns are most prevalent, such as paths that are near or within wildlife preservation areas.

The following techniques can be used in a variety of contexts to meet the lighting needs of Princeton's paths:

Overhead Lighting

For many paths in Princeton, particularly those adjacent to a roadway, overhead lighting is an appropriate treatment. Overhead lighting illuminates the path surface, area around the path, and trail users.

Bollard Lighting

In locations where excessive ambient light is a concern, bollard lighting can be used to provide low-level light that is focused on the path itself. This is an appropriate treatment in locations where a path is directly adjacent to houses or near or within wildlife preservation areas.

Get Creative!

Similar to the 2015 parklet on Witherspoon Street, shared-use path lighting provides an opportunity to engage Princeton's artistic community to devise creative and iconic bicycle facilities. The above photo illustrates the potential for creativity in lighting. The Dutch designer Daan Roosegaard used glow-in-the-dark paint to illuminate this path in Nuenen, Holland. The design was inspired by Vincent Van Gogh's "Starry Night." Additional lighting is provided by solar powered LEDs. (photo courtesy of Volt Bikes)

LED Bulbs

LED bulbs should be used in all trail lighting. In comparison to incandescent bulbs, LEDs produce more light, use very little power, and are more efficient and durable.

Reflective Striping

Reflective striping is not a source of lighting in and of itself, but it can supplement already existing light by defining the edges of the path. Reflective striping is an appropriate treatment for dark spots and trail ends.

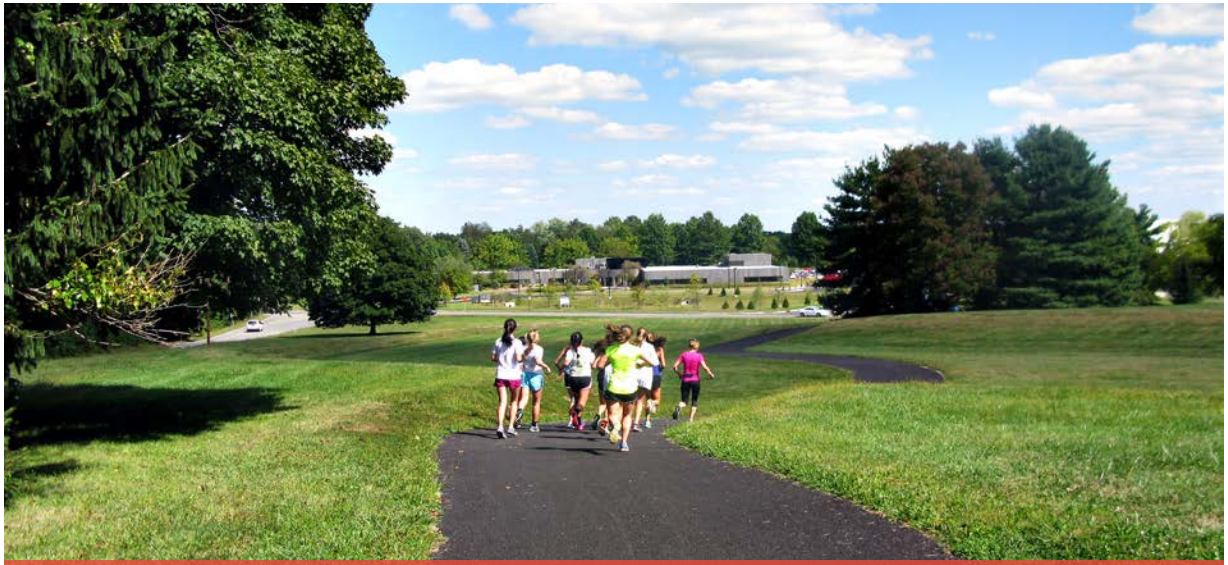
Path Surfaces

Princeton's shared-use paths feature a variety of surface types, including asphalt, concrete, crushed gravel, and dirt. These different surface types each come with their own benefits and challenges. Harder surfaces such as asphalt and concrete provide a more level surface for riders, are easier to maintain and can withstand more frequent use. These surfaces, however, can be much more expensive to install. Softer surfaces, such as crushed gravel or dirt, are cheaper to install but require more routine maintenance, can be uncomfortable for cyclists, and can become muddy or impassible during and after rain events.

Surface material selection for a shared-use path requires a context sensitive approach and depends on intended use of a path. While softer surfaces might be appropriate for paths whose primary purpose is recreation, shared-use paths that are intended to provide utilitarian bicycle connections should feature a harder and more level surface.

Available and appropriate surface materials include:

- Asphalt (preferably permeable)
- Concrete (preferably permeable)
- Soil Cement
- Resin-Based Stabilized Material
- Boardwalk
- Recycled Materials



Permeable asphalt section of Lawrence-Hopewell Trail

The Rails-to-Trails Conservancy (**www.railstotrails.org**) provides a resource for understanding available options for path surfaces, estimated costs, and funding sources.

Permeable Paving Techniques

Permeable paving materials allow stormwater runoff to infiltrate through the material into the ground instead of being diverted as runoff into storm drain systems or nearby waterways. In addition to reducing runoff, permeable pavement traps pollutants, reducing the environmental impact of runoff and reducing the need for expensive filtration and water conveyance systems. Permeable, or porous, paving is a common treatment for shared-use paths and should be considered in appropriate locations.

Permeable pavements are typically laid on top of an infiltration bed and subgrade soil. Examples of permeable materials include:

Permeable asphalt

Permeable asphalt is produced and placed using the same methods as conventional asphalt concrete; it differs in that fine aggregates are omitted from the asphalt mixture. The remaining large, single-sized aggregate particles leave open voids

Permeable Surface Maintenance

Maintenance is extremely important to the life and performance of permeable pavement. Once permeable surfaces become clogged they lose their effectiveness and can become unrecoverable. This is particularly true with permeable asphalt. Permeable surfaces should be frequently inspected and vacuumed, as needed, to unclog sand and debris.

that give the material its porosity and permeability. Generally, porous asphalt pavements are designed with a subsurface reservoir that holds water that passes through the pavement, allowing it to evaporate and/or percolate slowly into the surrounding soils. Permeable asphalt has been used on segments of the Lawrence Hopewell Trail (shown on previous page) and the Cherry Valley Road sidepath.

Permeable concrete

Permeable concrete is similar to permeable asphalt and is designed to have more void spaces that allow air and water to pass through the material.

Keeping the Path Level

One of the primary deficiencies of Princeton's existing path network is the prevalence of uneven surfaces, often caused by tree root growth. This unevenness, and often cracking, can lead to potential hazards for trail users, excessive puddling, and generally make the trail riding experience unpleasant.

It is important to construct and maintain a smooth riding surface on shared-use paths. Pavements should be machine-laid and soil sterilizers should be used where needed to prevent vegetation from erupting through the pavement.

On concrete pavements, the transverse joints needed to control cracking should be saw cut, rather than tooled, to provide a smoother ride. On the other hand, skid resistance qualities should not be sacrificed for the sake of smoothness. Broom finish or burlap drag concrete surfaces are preferred.

Boardwalk

A boardwalk treatment is most often used on trail segments through wetlands, as it allows adequate drainage and minimizes impacts to the fragile ecosystem compared to other surface types. However, boardwalks can be slippery when wet and can be expensive to install and maintain. A boardwalk treatment can be effectively used on short segments over areas that experience frequent flooding or puddling to maintain a continuous, level, dry path.

Innovative Materials

Developments in flexible pavement materials provide an additional option for path surfacing. Flexible pavement bends but does not crack, making it an ideal, cost effective treatment in constrained areas near tree roots to maintain a smoother riding surface. The materials are also often porous, providing the stormwater benefits of permeable pavement. Flexible pavement has been used in areas around the United States. Washington, D.C., for example has used Flexi-Pave effectively in hundreds of locations throughout the city in situations such as those shown in the photo below. Flexible pavement is an appropriate treatment for many constrained areas along Princeton's network of shared-use paths (as well as sidewalks).

Flexible pavement in Washington, D.C.

5.4 Intersection Design

Good intersection design is a critical component of shared-use path and overall bicycle network connectivity. Poorly designed intersections can amplify conflicts between bicyclists and other modes, reduce network connectivity, and discourage many bicyclists from taking certain trips.

A properly designed intersection should reduce conflicts between bicyclists (and other vulnerable road users) and vehicles by heightening the level of visibility, denoting a clear right-of-way, and facilitating eye contact and awareness between different modes. The level of treatment required for bicyclists at an intersection depends on the bicycle facility type used, as well as the adjacent street function and land use.

On-Road Cycling and Intersection Design

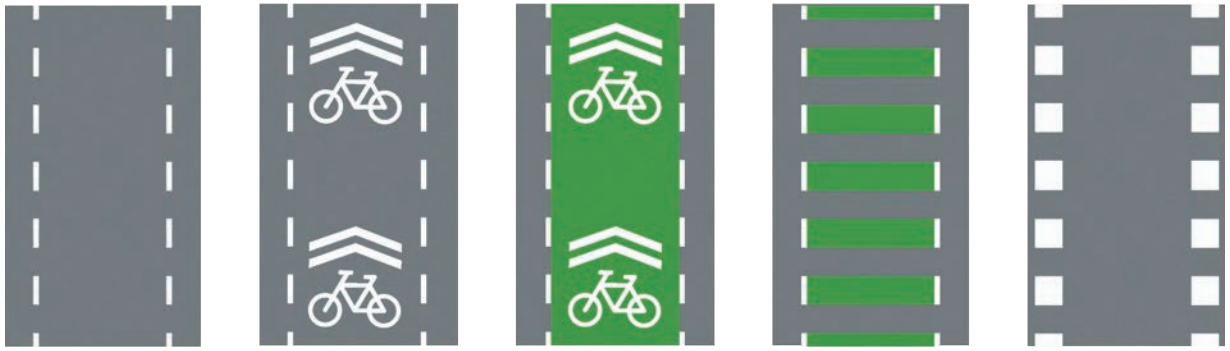
Bicycle Detection

Bicycle detectors can be installed at signalized intersections to detect the presence of bicyclists. Bicycle detectors are strongly recommended at intersections with existing motor vehicle detection, as standard loop detectors may not detect bicyclists.

Pavement Markings

Intersections can be a confusing and stressful environment for bicyclists. There is an inherent mixing of traffic that often occurs at intersections, creating conflicts between vehicular traffic and bicycle traffic. The stress can be exacerbated when bicycle lanes appear to temporarily end at intersections and intersection approaches, or the roadway widens to provide turning lanes for vehicles.

Figure 5.1 | Bike Lane Intersection Marking Treatments



Dotted Line Extensions | Pavement Markings | Colored Bicycle Lane | Dashed Colored Bicycle Lane | Elephant's Feet Markings

Extending Bike Paths Through the Intersection

Bicycle markings may be extended through intersections and major driveways to guide bicyclists through the intersection and mitigate bicyclist stress.

This treatment has several benefits:

- Increases the visibility of bicyclists
- Reduces bicyclist stress by clearly delineating roadway space for bicyclists and guiding them through the intersection in a direct path
- Reinforces that through bicyclists have priority over turning vehicles or vehicles entering the roadway
- Helps bicyclists position themselves within the intersection
- Improves driver awareness of bicycle activity and movement through a high conflict area
- Makes bicyclist movement at intersections more predictable

There are several common treatment types for intersection markings (illustrated in Figure 5.1 to the left). The standard treatment is a white dotted line extension of the bicycle lane, which maintains the continuity of the bicycle lane through the intersection. The MUTCD contains guidance on this treatment in Section 3B.08. This treatment may be enhanced to improve the visibility of the bicycle facility through various combinations of pavement markings, colored pavement, or higher visibility striping.

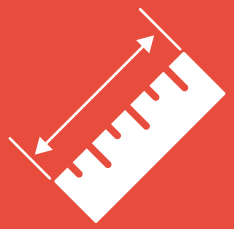
Bike Boxes

A bike box is a designated area at the head of a traffic lane at a signalized intersection, providing bicyclists with a safe and visible way to position themselves ahead of queuing traffic during the red signal phase. There is no volume threshold of vehicular volume where bike boxes would or would not be appropriate. Bike boxes should typically be prioritized in locations with high volumes or difficult left turns for bicyclists.

A bike box has several key benefits:

- Increases the visibility of bicyclists
- Reduces signal delay for bicyclists
- Facilitates left-turn positioning at intersections for bicyclists
- Provides priority for bicyclists at crossings
- Mitigates conflicts between through-bicycle movements and vehicle right-turns ("right-hook" crashes)
- Groups bicyclists together, allowing bicycle traffic to clear the intersection more quickly and minimizing impediments to transit and other traffic, particularly for vehicular right-turn movements
- Reduces vehicle encroachment into the crosswalk, creating a more comfortable crossing for pedestrians

Bike Box on Dr. MLK Jr. Boulevard in Newark, NJ



Bike Box Design

The NACTO Urban Bikeway Design Guide provides detailed guidance on the design and placement of Bike Boxes:

- ↔ Bike boxes, formed by transverse lines, should be 10 to 16 feet deep
- ↔ Stop lines should be used to indicate the point behind which motor vehicles are required to stop
- ↔ Pavement markings should be used and centered between the crosswalk line and stop line
- ↔ Pavement markings may be a Bike Symbol (MUTCD 9C-3A) or Helmeted Bicyclist Symbol (MUTCD 9C-3B)
- ↔ Where bike boxes are installed, a "No Turn on Red" sign should be used

Shared-Use Paths and Roadway Crossings

Although shared-use paths are low-stress facilities for bicyclists, poor intersection design can limit the continuity and connectivity of these paths. There are a variety of tools available to increase bicyclist comfort level and motor vehicle compliance at intersections. Princeton has already installed these treatments at various locations in the Municipality. These designs should be replicated at other locations.

Rectangular Rapid Flashing Beacon

Rectangular Rapid Flashing Beacons (RRFBs) are a type of active warning beacon that uses an irregular flash pattern to alert drivers to stop for bicyclists or pedestrians crossing the road at unsignalized or stop controlled intersections. RRFBs significantly increase driver compliance at intersections when supplementing standard crossing signs and markings. Research cited by NACTO has shown RRFBs to increase driver compliance by over 50% when the flashers were activated.

Intersection Approach Angle

At intersections, shared-use paths should be oriented at a 90 degree angle to the cross street to improve visibility of both path and roadway users.

Elements of Quality Path Crossing: D&R Canal Trail at Alexander Road

Warning Signage

Fluorescent yellow-green trail crossing signage (MUTCD W11-15) should be installed at shared-use path intersections (as shown in above photo). Fluorescent yellow-green trail crossing ahead signage (MUTCD W11-15, W16-9p) should be installed on approach to shared-use path crossings.

Crosswalk Striping

Shared-use path crossings should be marked with high-visibility continental crosswalk striping (shown in the above photo).

Accessibility

All shared-use paths should be designed to accommodate all users, including those with limited mobility. Paths must adhere to the Americans with Disabilities Act (ADA) and the ADA Accessibility Guidelines (ADAAG). Shared-use path intersections should include ADA-compliant curb ramps and other accommodations for those with limited mobility.

5.5 Wayfinding

As with any mode of transportation, good wayfinding is a key component of network usability. While Princeton currently features many shared-use paths, it is often difficult for users to find existing paths, know where the paths can take them, and understand how each path fits into the overall network.

The fundamental goal of wayfinding is to help users understand where they are and how they can get to where they want to go.

The Municipality's bicycle map, developed in 2014, is a step forward in helping cyclists understand where existing facilities are. However, in order to make the bicycle network more accessible for everyone, a comprehensive system of wayfinding should be developed and implemented for existing and new routes along the Princeton bicycle network.

Wayfinding can come in many forms, but the fundamental goal is to help system users (including bicyclists *and* pedestrians) understand where they are and how they can get to where they want to go. A system of consistently designed signage should be implemented along the Princeton bicycle network, particularly along shared-use paths. Signage should, at a minimum, be placed along a route to indicate where the user is ("Confirmation Signs") and at decision points to indicate where a user can go ("Decision Point Signs").

Wayfinding signage should adhere to the Manual of Uniform Traffic Control Device (MUTCD) standards.

The NACTO *Urban Bikeway Design Guide* provides guidance on the development of a wayfinding system.

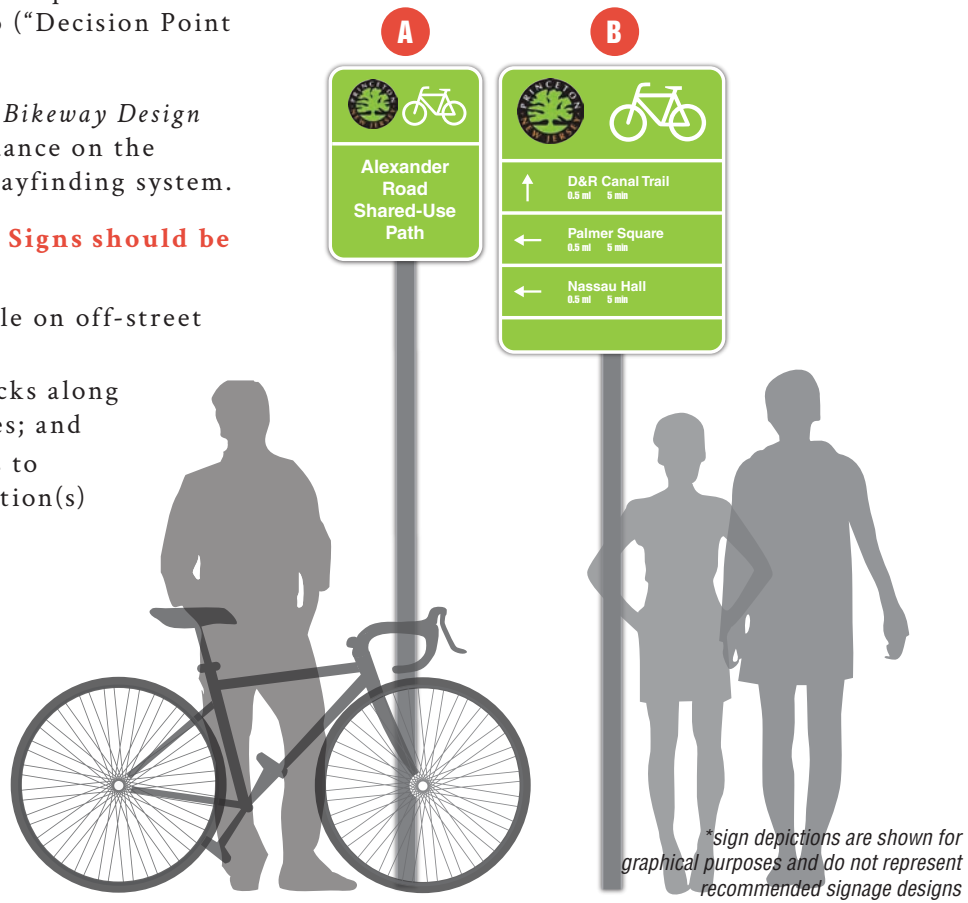
A Confirmation Signs should be placed:

- every ¼ to ½ mile on off-street facilities;
- every 2 to 3 blocks along on-road facilities; and
- soon after turns to confirm destination(s)

B Decision Point Signs should be placed:

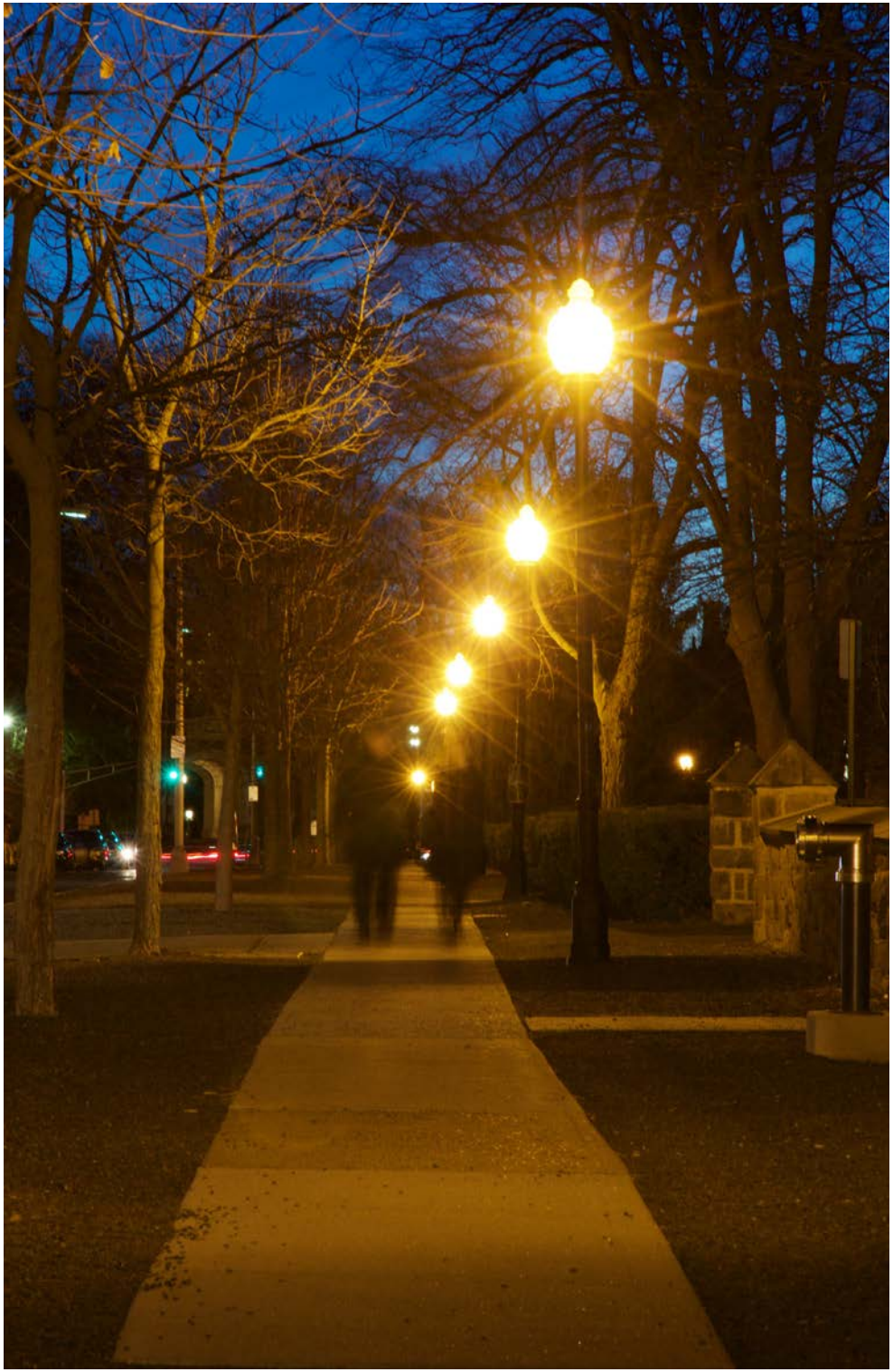
- near-side of intersections in advance of a junction with another bicycle route; and
- along a route to indicate a nearby destination

Decision point signage should also include destinations, directional arrows, distances, and travel times.



*sign depictions are shown for graphical purposes and do not represent recommended signage designs

(Above-Left) Cyclist on Guyot Avenue shared-use path
(Above-Right) Cyclists crossing Witherspoon Street to Guyot Avenue
(Left) Cyclist crossing the Stony Brook on the Stony Brook Regional Bicycle and Pedestrian Pathway



Path Lighting in Princeton

Several examples of pedestrian-scale lighting are already in place in Princeton, illustrating techniques that could be replicated on paths elsewhere in the Municipality. The pedestrian-scale fixtures along Prospect Avenue (right) fit with the surrounding context and create a well-lit and inviting environment for pedestrians and bicyclists after dark. The low-level bollard lighting at the Princeton train station is illustrative of a lower impact alternative that focuses light on the path surface, minimizing ambient light.

06

Bicycle Network

To achieve the goals of the Princeton BMP, the Municipality should create a bicycle network that is continuous, connected, convenient, complete, and comfortable for cyclists of all ages and abilities. Improving Princeton's roadways, paths, and trails to make the community more attractive and accommodating to cyclists will enhance mobility and encourage higher rates of bicycling in Princeton. Using input from the public involvement process, existing conditions analysis, and other data and information summarized in Chapters 1-4, as well as bicycle facility design guidance outlined in Chapter 5, this chapter identifies a core bicycle network and accompanying infrastructure improvements to create an interconnected bicycle network in Princeton. The proposed network represents a long-term vision for the future of bicycling in Princeton that can be implemented incrementally over time.

6.1 Identifying the Network and Facility Types

Developing the bicycle network was an iterative process of identifying potential routes and potential bicycle facility types for each route. The selection of routes and facility types was driven by the following factors.

User Needs

The bicycle network must reflect the needs of its users. To achieve the BMP's goals related to convenience, connectivity, and mobility, it must link residential areas with key destinations, including schools, the downtown core, Princeton University, the library, parks and regional trails, the Princeton train station, and the Princeton Shopping Center.

The "desire lines" identified by the public during outreach activities provided the basis for the draft network. These routes

were supplemented with additional links to enhance overall network connectivity and provide some redundancy and route choice.

In order to encourage higher ridership, the bicycle facilities implemented along each part of the network must support the BMP's goals of safety, accessibility, and comfort. The focus is on developing a low-stress bicycle network that accommodates the 60% of the population who are interested in cycling, but do not bicycle regularly due to a variety of concerns often related to safety. The proposed network should enhance mobility for children. Increased bicycling rates by this age group (ages 12 to 18) is an indicator of a quality low-stress network, where both children and their parents feel the network provides a comfortable and safe bicycling environment.

In line with the BMP's goals related to equity and social justice, the network must also support the needs of residents who rely on bicycling as a form of transportation. It must make bicycling a safe, comfortable, and convenient mode of transportation for those that do not have access to a car. The network must connect residential areas of the Municipality to the downtown and areas of employment, as well as regional linkages to neighboring municipalities.

As was shown in the Princeton survey responses, as well as national data, exposure to high traffic speeds and busy streets are a significant barrier to cycling and there is a strong user preference for separated facilities. Creating a network that emphasizes low speeds and separated facilities are therefore key components of an effective low-stress bicycle network.

The desire lines overlaid with the existing bicycle level of traffic stress analysis (Map 6) combined critical information on user needs. It illustrates where users want to bicycle, and what routes would need to be improved in order to better accommodate them.

This provided the starting point for identifying the network and developing targeted bicycle improvements to create a low-stress network. A design target of LTS 1 is desired to create a comfortable network for all bicyclists.

Student biking to school along Nassau Street

PRINCETON
bicycle master plan

Desire lines obtained from the Wikimap website and Public Meeting map mark-ups provided a starting point for the preliminary bicycle network. An overlay of the existing Level of Traffic Stress (LTS) analysis helped identify targeted areas for improvements.

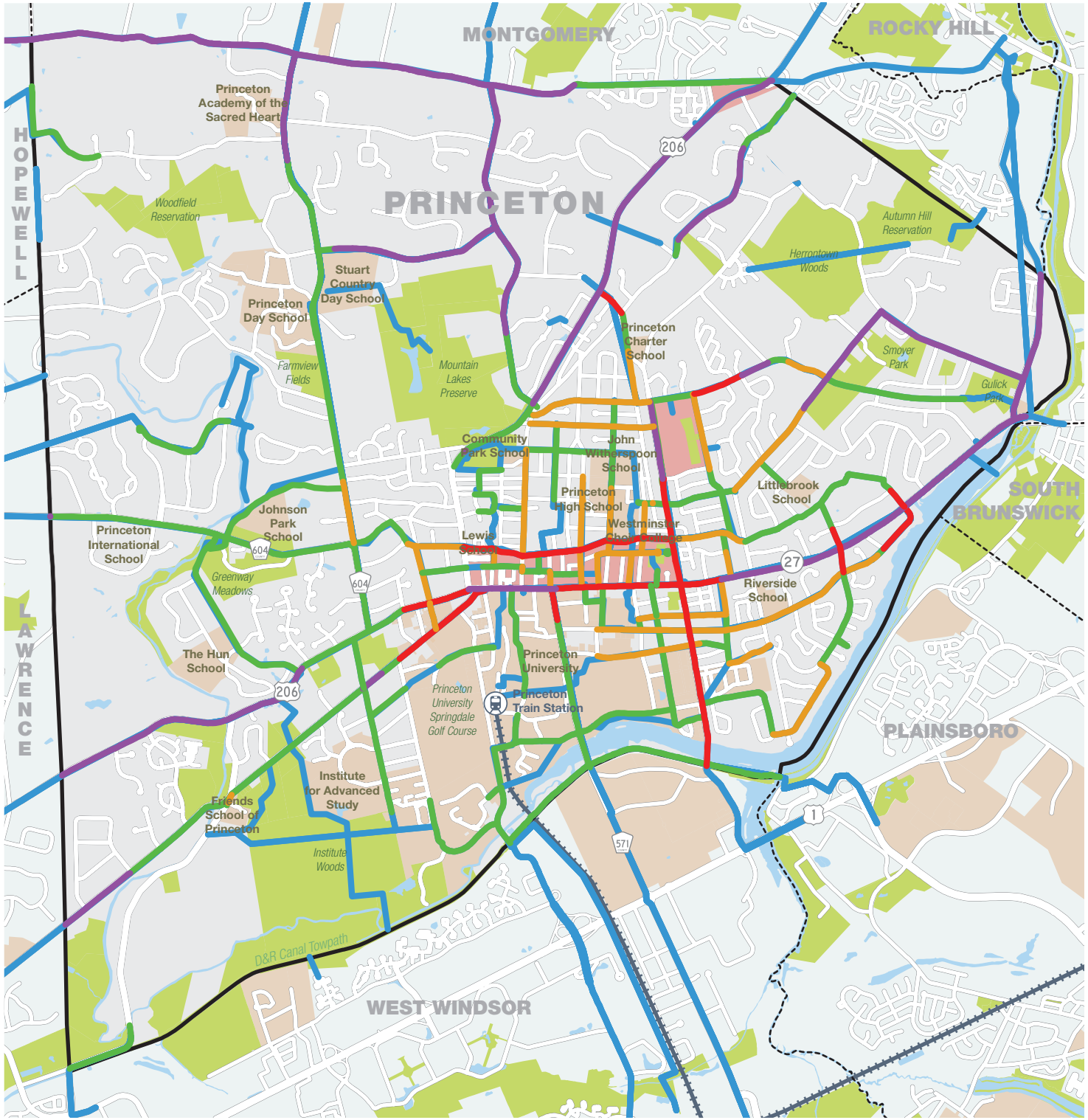
Map 06

Desire Lines and LTS

- School
- Park
- Commercial Area

Desire Lines

- LTS 1 Roadway
- LTS 2 Roadway
- LTS 3 Roadway
- LTS 4 Roadway
- New off-road link or outside Princeton



0 0.25 0.5 1 Miles

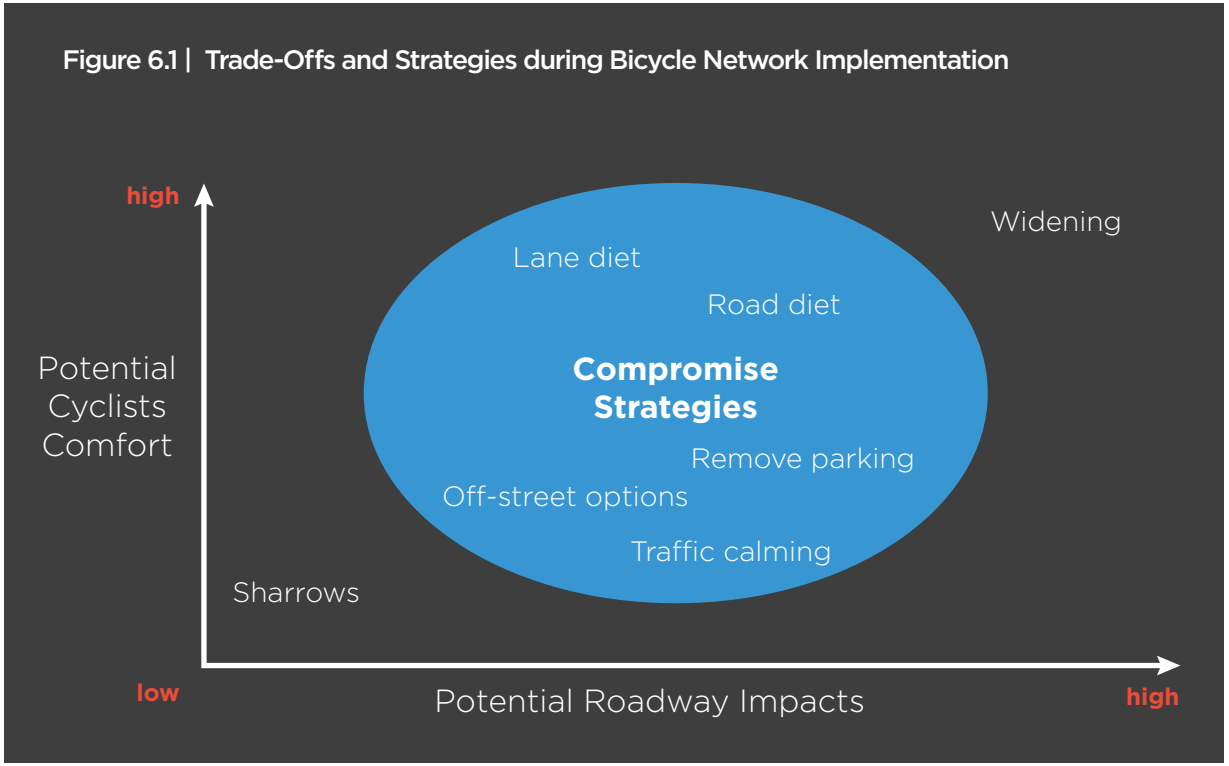
Context and Trade-Offs

The proposed facility type is driven largely by the context of each link of the network. Factors such as the surrounding land use and density, traffic volume and speed, frequency of driveways, on-street parking demand, proximity of off-street parking options, historical context, constraints such as street trees and utilities, and existing roadway widths were used to help identify appropriate bicycle facilities. The proposed network leverages Princeton's existing shared-use paths by improving conditions to bring them up to current standards. It also utilizes the Municipality's low speed, low volume local street network to provide parallel, alternative routes where feasible.

Implementation of the bicycle network will inevitably involve trade-offs as Princeton strives to implement its Complete Streets policy and create a more balanced, multimodal transportation network. For each section of the network, alternatives range from striping shared-lane markings to roadway widening and right-of-way acquisition. The shared-lane marking alternative does not impact the roadway, but essentially maintains the status quo for cyclists and provides no benefit from the perspective of traffic stress. The Municipality typically owns a minimum of 50 feet of right-of-way along each roadway. This provides an opportunity to widen or realign roadways in order to provide dedicated facilities for cyclists, but requires more significant capital costs and potential impacts to residential landscaping, street trees, utilities, driveways, etc.

Where there is limited existing curb-to-curb pavement width, the proposed facilities attempt to minimize capital costs and right-of-way impacts while still striving to create a low-stress network. This requires reconfiguring the existing roadway through signing and striping changes, while recognizing potential trade-offs may be necessary to improve overall community mobility. Examination of changes to public streets must consider not only the needs of local residents, but the needs all residents and street users. Trade-offs include narrowing travel lanes or removing on-street parking in order to provide additional space for bicycle facilities. One-way pair alternatives were also considered, but were not advanced due to potential impacts on traffic speed and overall circulation patterns and a limited area where this option is possible. Ultimately, any changes must be approved by the town council on a project-by-project basis.

Figure 6.1 | Trade-Offs and Strategies during Bicycle Network Implementation



6.2 Proposed Network

The full Proposed Bicycle Network Map is shown in Map 7. This map illustrates the proposed on-road bicycle facilities, shared-use path improvements, and intersection improvements recommended as part of the Princeton BMP. A closer look at the proposed network through the center of Princeton is provided in Map 8.

The proposed bicycle network includes approximately 67 miles of on-road and off-road bicycle facilities. The types of bicycle facilities are described in Chapter 5, and the total mileage of each facility type is shown in the table to the right.

In addition to corridor improvements for bicyclists, intersection improvements are also recommended at several locations throughout the network. Intersection improvements are critical to the connectivity and performance of the proposed low-stress network and overall user comfort. A high-stress intersection can create a significant barrier on an otherwise low-stress corridor, causing the network to become fragmented and discontinuous. Improvements are recommended to support the corridor recommendations and develop a network that is accessible for cyclists of all ages and abilities.

Table 6.1 | Total Mileage of Proposed Bicycle Network (by type)

Facility Type	Length (miles)	% of Network
Improved Shared-Use Path	18.7	28%
New Shared-Use Path	10.9	16%
Separated Bicycle Lane	0.4	1%
Bicycle Lane	9.0	13%
Bicycle Lane + Shared-Use Path	0.9	1%
Bicycle Lane + Shared-Lane Markings	0.4	1%
Bicycle Boulevard	12.1	18%
Shared-Lane Markings	2.2	3%
Enhanced Shared-Lane Markings	3.9	6%
Pipeline Recreational Trail	7.5	11%
Complete Street Corridor Plan	1.1	2%
TOTAL	**67.0**	**100%**

Design Considerations

The design guidance in Chapter 5 provides a framework for developing the bicycle network. The narrative in Appendix C describes how this framework would be applied for each corridor of the network, segment by segment. Implementation of the proposed bicycle network will require detailed design decisions to be made for each route that are beyond the ability of the BMP to anticipate.

While application of the bicycle facility types to each element of the network is generally straightforward, several components of the network were identified during the planning process that include more unique features or additional design considerations. These more unique segments are described in the following sections.

Delaware and Raritan Canal Trail Corridor

The D&R Canal Trail is a hub of recreational activity and a key component of the regional trail network. One of the most heavily used segments of the D&R Canal Trail is through Princeton. To better accommodate demand for this popular facility, the Municipality should work with the Delaware and Raritan Canal Commission and local partners (West Windsor Township, Princeton University) to investigate opportunities for trail improvements to the east/south side of the Canal, particularly between Alexander Street and Harrison Street. Worn paths indicate that this area is already used informally, and trail improvements would effectively "double track" this part of the Canal to increase capacity and more

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Map 07

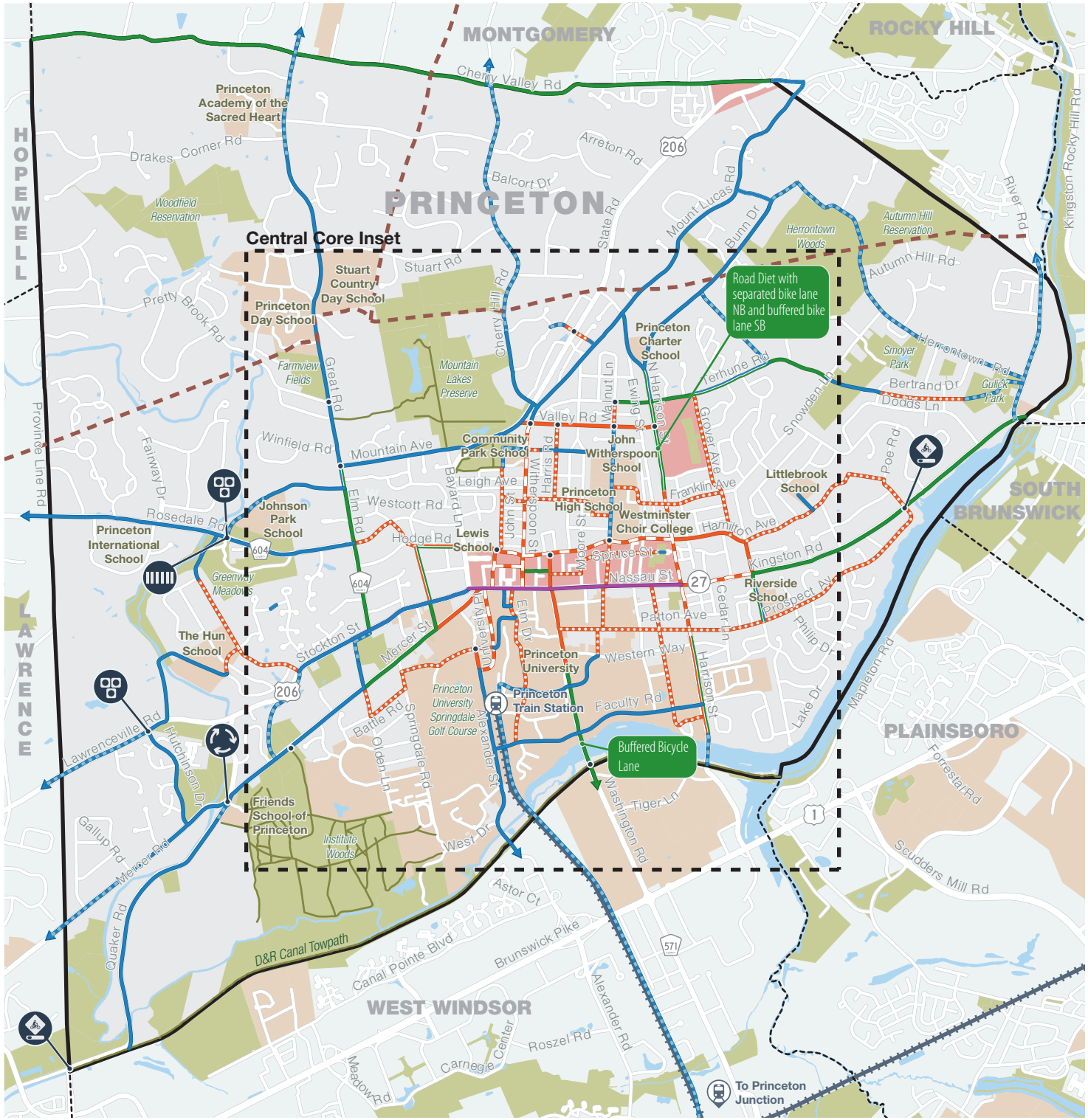
Proposed Bicycle Network

- Complete Street Corridor Plan
- Improved Shared-Use Path
- New Shared-Use Path
- Separated Bike Lanes
- Bicycle Lane
- Bicycle Lane + Path
- Bicycle Lane + Shared Lane
- Bicycle Boulevard
- Shared-Lane Markings
- Enhanced Shared Markings
- Pipeline Recreational Trail
- School
- Park
- Commercial Area
- Existing Trail

Intersection Improvement

- Roundabout
- RRFB
- HAWK
- Bike Box
- Crosswalk Enhancements
- Inset Intersection Improvement

0 0.25 0.5 1 Miles



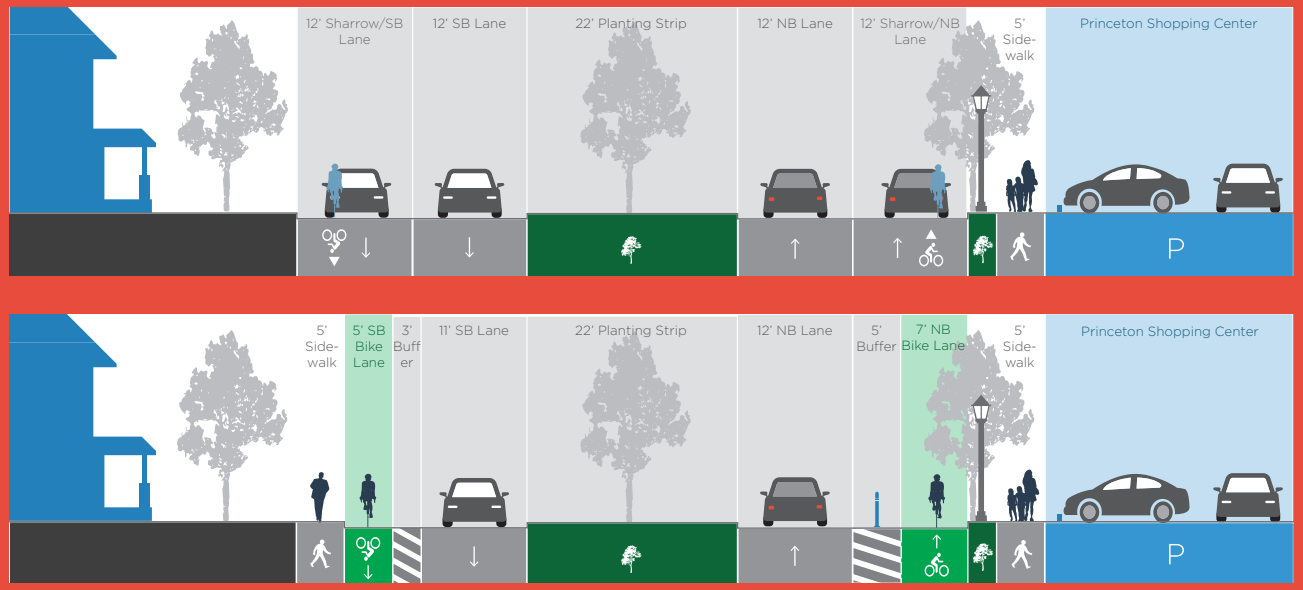
comfortably accommodate trail users.

The Municipality should also work with the Delaware and Raritan Canal Commission and local partners to investigate improvements that would enhance the ability of the D&R Canal Trail to meet the needs of non-recreational cyclists. The trail provides a parallel corridor to U.S. Route 1 with regional connections to the Princeton Forrestal Campus and Forrestal Village to the north and commercial and employment hubs to the south in West Windsor and Lawrence Townships. The feasibility of improvements such as porous pavement surfacing to improve conditions during and after wet weather should be examined. Providing lighting and removing the existing dusk-to-dawn use restriction should also be considered to better meet the needs of commuters.

North Harrison Street (Clearview Avenue to Terhune Road)

This segment of North Harrison Street is configured as a boulevard, with a tree-lined median separating two 12-foot travel lanes in both the northbound and southbound directions. To accommodate bicycle lanes, a road diet is proposed to provide one travel lane in each direction, which is consistent with the rest of the Harrison Street corridor. A road diet allows a Complete Streets retrofit, with the addition of a buffered bicycle lane and sidewalk in the southbound direction, and a separated bicycle lane in the northbound direction. The existing and proposed cross sections are shown below.

North Harrison Street
Road Diet
(top) Existing Cross Section
(bottom) Proposed Cross Section



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Map 08

Proposed Bicycle Network:

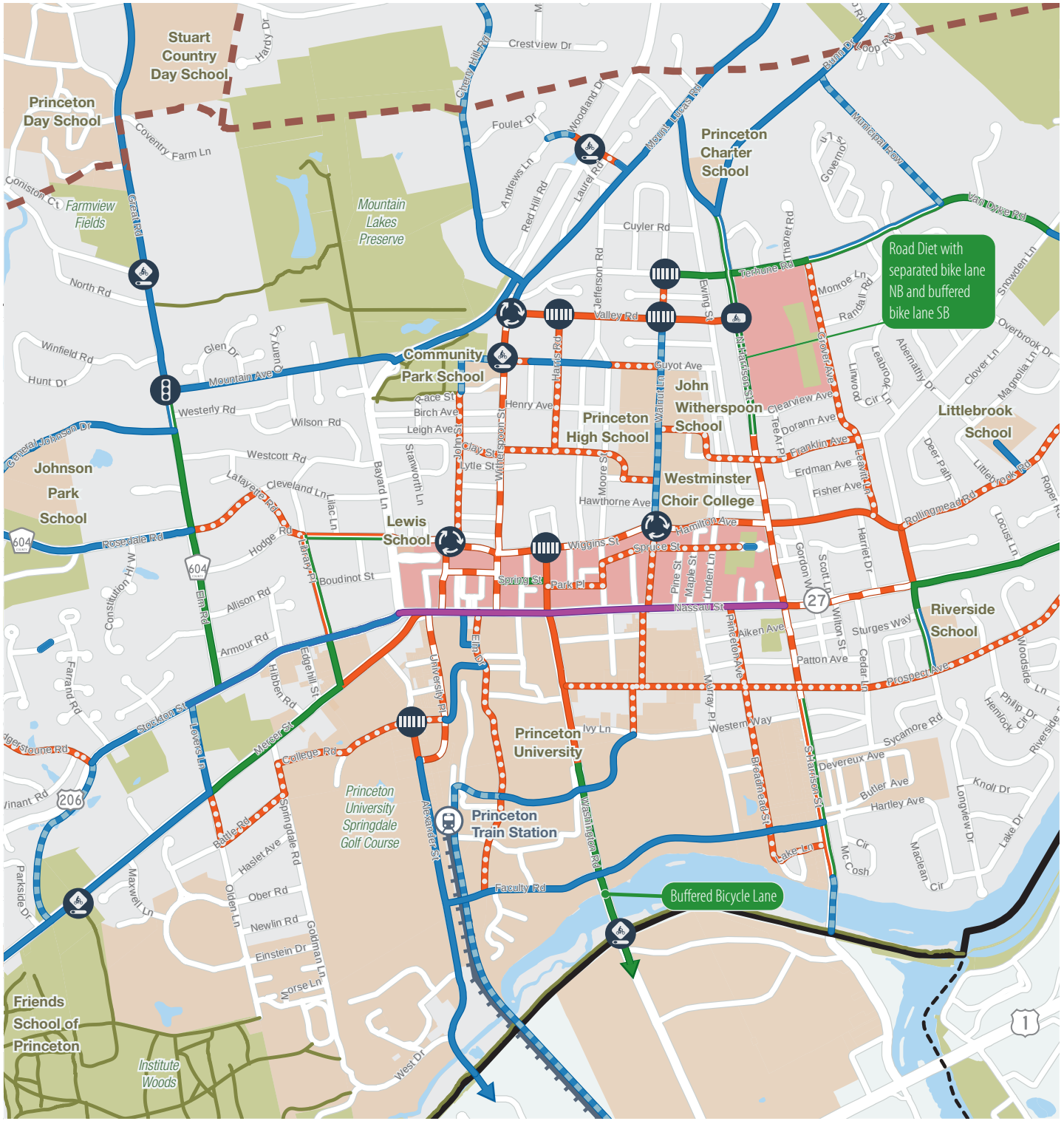
Central Core

- Complete Street Corridor Plan
- Improved Shared-Use Path
- New Shared-Use Path
- Separated Bike Lanes
- Bicycle Lane
- Bicycle Lane + Path
- Bicycle Lane + Shared Lane
- Bicycle Boulevard
- Shared-Lane Markings
- Enhanced Shared Markings
- Pipeline Recreational Trail
- School
- Park
- Commercial Area
- Existing Trail

Intersection Improvement

- Roundabout
- RRFB
- HAWK
- Bike Box
- Crosswalk Enhancements
- Traffic Signal

0 0.25 0.5 1 Miles



Prospect Avenue Corridor

The Prospect Avenue corridor connects NJ Route 27 to Washington Road, providing a low-stress alternate route to NJ 27 across the southeastern portion of Princeton, improving access to Princeton University, the downtown, and Princeton Train Station.

Prospect Avenue is envisioned as a traditional bicycle boulevard between Murray Place and NJ 27, supporting a traffic calmed, residential street that prioritizes bicycle movement and creates a comfortable environment for children to bike to Riverside Elementary School. The existing low speed, low volume residential street is suitable for bicycle boulevard designation and supportive improvements, including a 20 mph speed limit, wayfinding signage, and appropriate traffic calming treatments. The bicycle boulevard will build upon existing traffic calming features along the corridor. A photosimulation of the Prospect Avenue bicycle boulevard concept is shown at right.

Between Washington Road and Murray Place, the long-term vision for Prospect Avenue is for a shared street. In a shared street, strict divisions between modes are removed to allow greater mixing of pedestrians, bicyclists, and motorists. Greater use of the street as public space is encouraged. Curbs are removed, allowing all roadway users to operate at the same grade. Informal divisions of the street are created by different surface textures and materials, green stormwater facilities, street furniture, bike parking, vehicle parking, and transit stops. Without curbing, pedestrians can easily follow desire lines and cross the street as needed, improving pedestrian circulation among Princeton University-affiliated buildings. The raised roadway, mixing of modes, and street activity encourages slow vehicle speeds.

Existing conditions

Simulation of bicycle boulevard concept on Prospect Avenue

The shared street would serve as a gateway between the residential neighborhood and Princeton University campus. It would discourage through traffic from Washington Road through the residential section of Prospect Avenue, and better link the University section of the corridor with the core campus via a raised intersection at Washington Road. A photosimulation of the Prospect Avenue shared street concept is shown at right.

Existing conditions

Simulation of shared street concept on Prospect Avenue

6.3 Impact on Stress Level

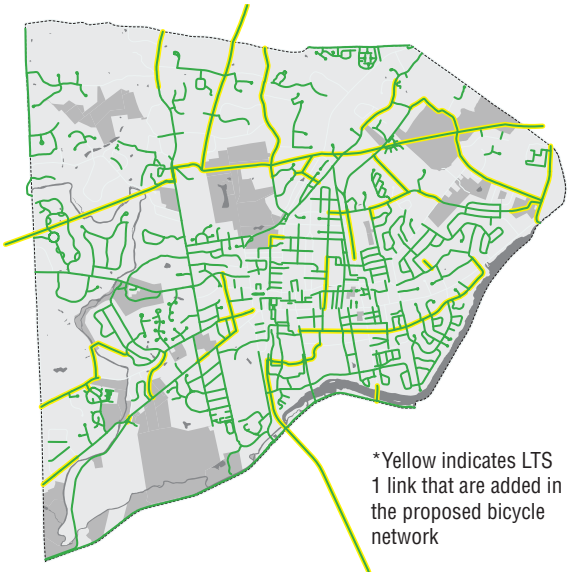
As stated in the vision statement and goals, a principle objective of the BMP is to create a bicycle network that is accessible and comfortable for bicyclists of all ages and abilities, supporting a higher bicycle mode share in Princeton. To guide the planning process, the Bicycle Level of Traffic Stress (LTS) method was used to quantify the level of traffic stress, or comfort, that cyclists typically experience while riding on Princeton's roads and paths. In order to evaluate the impact of the recommendations on cyclist comfort level, the analysis was re-run assuming full implementation of the proposed bicycle network. The result is illustrated on Map 9 on the following page.

Improvements to the LTS 1 network are highlighted in the thumbnail maps to the right. The LTS 1 facilities provide the separated bicycle facilities (shared-use paths or separated bicycle lanes) or low-speed and low-volume streets (e.g., bicycle boulevards) that create a comfortable bicycling environment for children and cyclists of all ability levels.

The proposed bicycle network builds upon Princeton's local residential streets and existing paths to improve the overall connectivity of the LTS 1 network. Long LTS 1 corridors are created, knitting the entire LTS 1 network together.

Figure 6.2 | Existing LTS 1 Facilities

Figure 6.3 | LTS 1 Facilities in Proposed Bicycle Network



Across the northern third of the Municipality, new shared-use paths on Great Road, Cherry Hill Road, and Mount Lucas Road, as well as the proposed Pipeline Trail, better link residential neighborhoods to each other and the town center. Similarly, new shared-use paths along U.S. 206 and Mercer Road, as well as a proposed bicycle lane along Mercer Street, enhance bicycle connectivity in Princeton's southwestern neighborhoods.

In central Princeton, a new shared-use path improves access to the Middle and High Schools. While Nassau Street remains a critical gap in the low-stress network in the near-term, a Complete Street Corridor Plan would address the issue in a comprehensive and consistent manner, in coordination with additional multimodal plans and needs of the corridor.

A proposed road diet enables high quality bicycle facilities to be installed on Harrison Street to enhance access to the Princeton Shopping Center. In the southeastern neighborhoods, bicycle boulevard improvements on Prospect Avenue create a continuous LTS 1 facility, connecting residents to the downtown and providing an alternative route to NJ Route 27.

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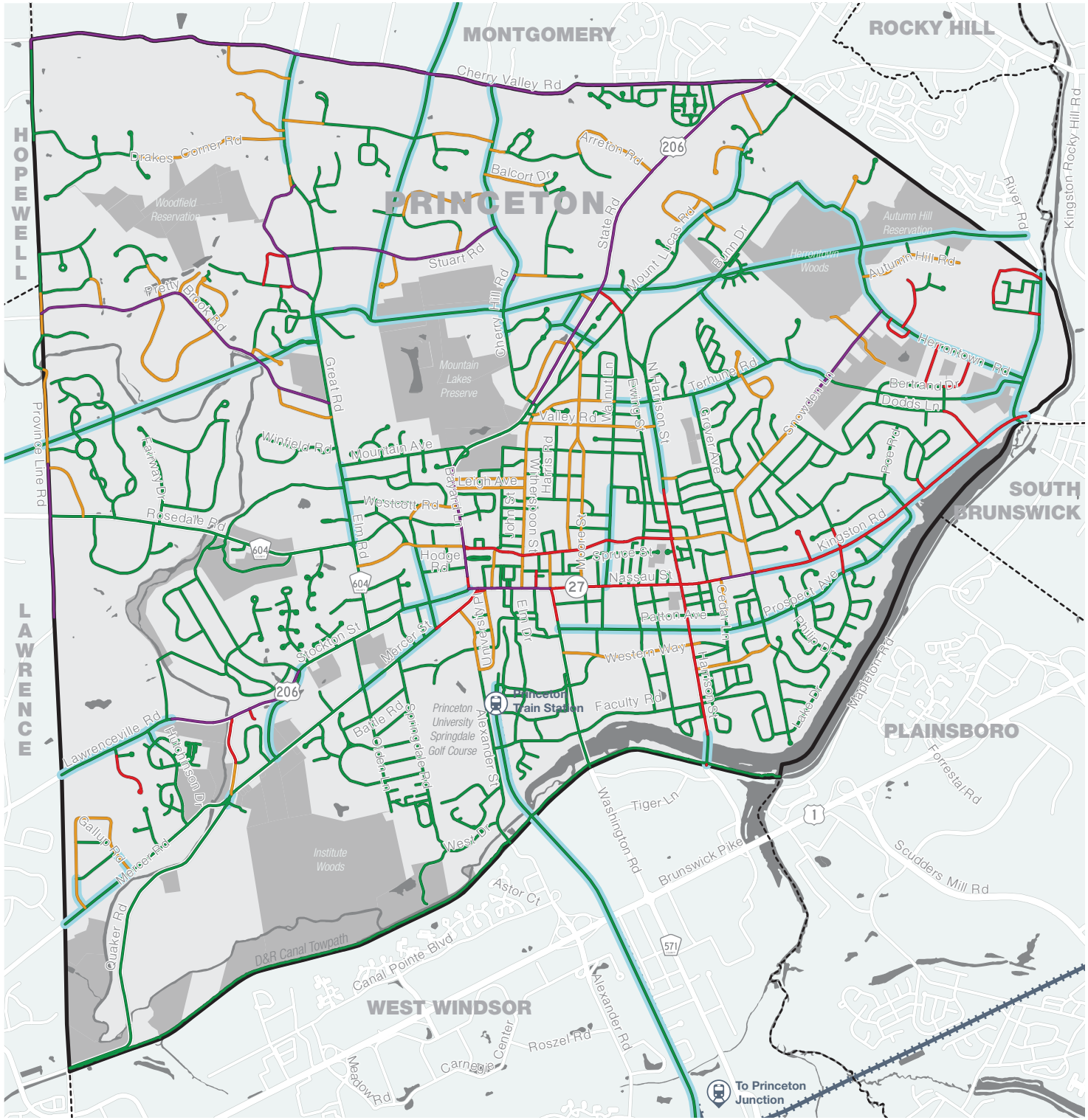
Running the bicycle level of traffic stress (LTS) analysis for the proposed bicycle network illustrates the expected results of a full build-out of the network, with the potential to significantly improve the connectivity of the low-stress network.

Map 09

Proposed Network:

Bicycle Level of Traffic Stress

- Level of Stress 1
- Level of Stress 2
- Level of Stress 3
- Level of Stress 4
- LTS Change from Existing



0 0.25 0.5 1 Miles

6.4 Implementation

The network outlined in this chapter is intended to be conceptual in nature and based on typical roadway characteristics. Detailed design will occur during implementation on a project-by-project basis, following the design guidance outlined in Chapter 5 and supplemented with more detailed best practice design guidance from NACTO, AASHTO, and FHWA, also referenced in Chapter 5. The design of a bicycle boulevard, for example, may vary slightly from street to street. While a 20 mph speed limit and signature wayfinding signage should be consistent, the type of traffic calming elements will be determined by the unique needs and context of the street.

As discussed at the beginning of this chapter, each project must consider user needs, the surrounding context, and potential trade-offs required to meet the needs of all street users. The proposed network minimizes the need for trade-offs, while still meeting the goals of the BMP. Potential trade-offs are limited to:

Speed limit reduction

- All bicycle boulevards (20 mph)
- NJ Route 27
- Snowden Lane/Van Dyke Road
- Washington Road

Potential impacts to on-street parking

- Harrison Street (Prospect Avenue to Carnegie Lake)
- Hodge Road (Library Place to U.S. Route 206)
- Library Place (Hodge Road to Mercer Street)
- Mercer Street (Library Place to Lovers Lane)
- NJ Route 27 (Washington Road to U.S. Route 206; actual impact dependent on which alternative is advanced)
- Riverside Drive (NJ Route 27 to Prospect Avenue, prohibited on southbound side only)

Potential right-of-way impacts

- Widening of existing or construction of new shared-use paths may involve minor right-of-way impacts, and will vary on a project-by-project basis.

The Princeton BMP provides a baseline core network to prioritize improvement strategies. The network is intended to be a starting point and updated periodically as needs change. The network may be expanded or additional improvements made as needs arise or opportunities are available through other roadway projects.

Project Prioritization

The proposed bicycle network can be developed incrementally, integrating improvements into routine maintenance and resurfacing projects to reduce costs and create a comprehensive network over time. Two factors should help drive project prioritization:

- Build out the network around projects already identified in the Municipality's six-year capital program
- Target projects that improve access to schools and major activity hubs (downtown, Princeton Shopping Center, train station, D&R Canal)

Through these strategies, Princeton can create an initial core that improves bicycle mobility to major destinations. Over time, additional links can be added to enhance network connectivity and create more route choices.

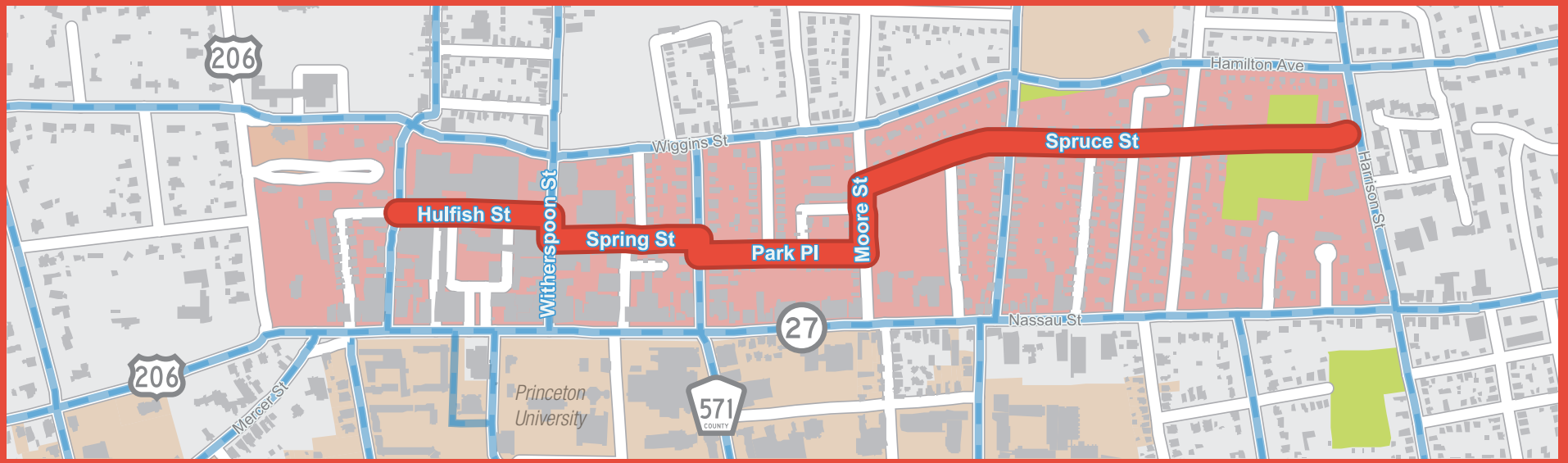
Priority projects include a mix of both low hanging and more transformative projects. Low hanging fruit, such as bicycle boulevard improvements, restriping, or enhancements to existing paths can be implemented relatively quickly and at lower cost. Transformative projects, such as the proposed Nassau Street Complete Street Plan and Harrison Street road diet, require more substantial investment but impact high demand areas and create highly visible bicycle infrastructure that can generate excitement and spur faster growth in bicycle ridership.

The Princeton Wiggle

The Wiggle is a famous bike route that zigzags across San Francisco for 1 mile, connecting Market Street to Golden Gate Park. Although it is circuitous, it serves an important function by minimizing the incline for cyclists as it traverses the City's hills, creating an easier and more comfortable ride.

The proposed bicycle network (shown in blue below) emphasizes access to the downtown core via enhancements to Nassau Street (pending a complete street corridor plan) and the Hamilton Avenue/Wiggins Street corridor. These roadways best accommodate longer distance trips, connectivity to other routes, and direct access to major destinations.

However, once within the downtown core, there is a parallel alternative that winds its way between Nassau Street and Hamilton Avenue/Wiggins Street. The combination of Hulfish Street/Spring Street/Park Place/Spruce Street/Quarry Park runs approximately one mile across the downtown from Chambers Street to Harrison Street. The circuitous nature of the route creates a bike boulevard that is low speed and has low traffic volumes, providing a low-stress facility that enhances bicycle mobility. With the addition of a contra-flow bike lane on Spring Street, the corridor can provide continuous, comfortable east/west bicycle travel within the downtown core.



The proposed priority projects to develop an initial core network include the following corridors:

- Hodge Road/Hamilton Avenue (Elm Road to NJ Route 27)
- Prospect Avenue (NJ Route 27 to Washington Road)
- Walnut Lane/Chestnut Street/Olden Street (Terhune Road to Princeton Station)
- Terhune Road (Walnut Lane to Harrison Street)
- Harrison Street (Terhune Road to Hamilton Avenue)
- Franklin Avenue (Walnut Lane to Leavitt Lane)
- Leavitt Lane (Franklin Avenue to Hamilton Avenue)
- Guyot Avenue/Path (Walnut Lane to John Street)
- Nassau Street (US 206 to Harrison St)
- Elm Road / Lovers Lane (Mountain Avenue to Mercer Street)
- Johnson Trolley Path (Elm Road to Rosedale Road)

These improvements are listed by corridor and facility type in the table in Appendix D. This table can be used to help plan implementation of the network and incorporate projects into future capital programming. As additional opportunities arise through resurfacing projects, development, or other roadway projects, other segments of the network can be added to the list and advanced more quickly.

Project Costs

Table 6.2 indicates the approximate order-of-magnitude costs for each type of facility considered within the proposed network, including options for green paint where applicable. These figures are meant to convey approximate construction costs to assist with capital planning, and do not include engineering or any impacts to curbing, drainage, right-of-way, or other factors that would be determined at the project level.

Table 6.2 | Order-of-Magnitude Costs

Facility Type	Cost (per lane mile)
Shared-Use Path	$578,800.00
Standard Bicycle Lane	$13,200.00
Standard Bicycle Lane (green paint)	$145,200.00
Buffered Bicycle Lane	$15,100.00
Buffered Bicycle Lane (green paint)	$147,100.00
Separated Bicycle Lane	$41,500.00
Separated Bicycle Lane (green paint)	$173,500.00
Shared-Lane Markings	$6,600.00
Green Box Shared-Lane Markings	$11,900.00
Enhanced Shared-Lane Markings (striping only)	$22,600.00
Enhanced Shared-Lane Markings (green paint)	$138,600.00

Network Gaps and Future Initiatives

The needs of the bicycle network will evolve as Princeton itself continues to grow and evolve. The proposed network should be considered a living document, and adjustments made to address shifting needs. The Municipality should continue to collaborate with Mercer County, NJDOT, and neighboring municipalities to develop a regional network, as well as Princeton University to ensure the network ties-in with future campus plans and improvements.

Some existing gaps in the proposed network will require a re-examination of needs and trade-offs to incorporate enhanced bicycle facilities into longer term corridor improvements. Three of the key remaining gaps in the low-stress network are described below.

Nassau Street

Nassau Street (NJ 27) is the center of the community, with its vibrant downtown, shops, and restaurants on one side and the Princeton University campus on the other. As the primary hub of community activity, there is a strong demand and need for improved bicycle access.

The Princeton BMP considered two alternatives for incorporating separated bicycle lanes through the core of the downtown between Washington Road and University Place, which are summarized in Appendix E. While these concepts provide

a starting point for discussion, a series of constraints would need to be addressed, such as limited right-of-way, on-street parking, transit accommodations, and loading zones.

In addition to the BMP, several recent and on-going studies have also analyzed potential improvements to Nassau Street and the downtown, including:

- *Princeton Community Traffic Study Final Report* (2015)
- *Nassau Streetscape Design Standards* (2016)
- *Princeton Parking: Inventory, Analysis and Recommendations to Support Economic Growth* (on-going)

Each of these studies tends to focus on a particular corridor need or mode - motor vehicle traffic, bicyclists, pedestrians, and parking. In addition to these users, the corridor also handles NJ TRANSIT and local bus services, goods movement, deliveries to local businesses, and taxi services. The needs of each of these types of users must also be considered within the context of the corridor's variable roadway width and right-of-way, historic character, and constraints of mature street trees.

In order to address the many competing needs of the corridor and weigh potential trade-offs, a comprehensive Complete Street Corridor Plan should be undertaken for Nassau Street between Bayard Lane and Harrison Street. The multimodal study, advanced in collaboration with NJDOT, should build upon the work of these previous efforts, incorporating the Municipality's long-term parking strategies, streetscape design standards, and appropriate bicycle facilities. The comprehensive study would create a vision and cohesive, Complete Street design for the entire corridor.

Hub of the Community

Nassau Street is the primary hub of community activity. Home to a vibrant downtown with shops, restaurants, and the Princeton University campus, the area is a major regional destination for residents and visitors alike. Comments from the Wikimap and other community input highlighted the need and strong demand for improved bicycle access.

Witherspoon Street

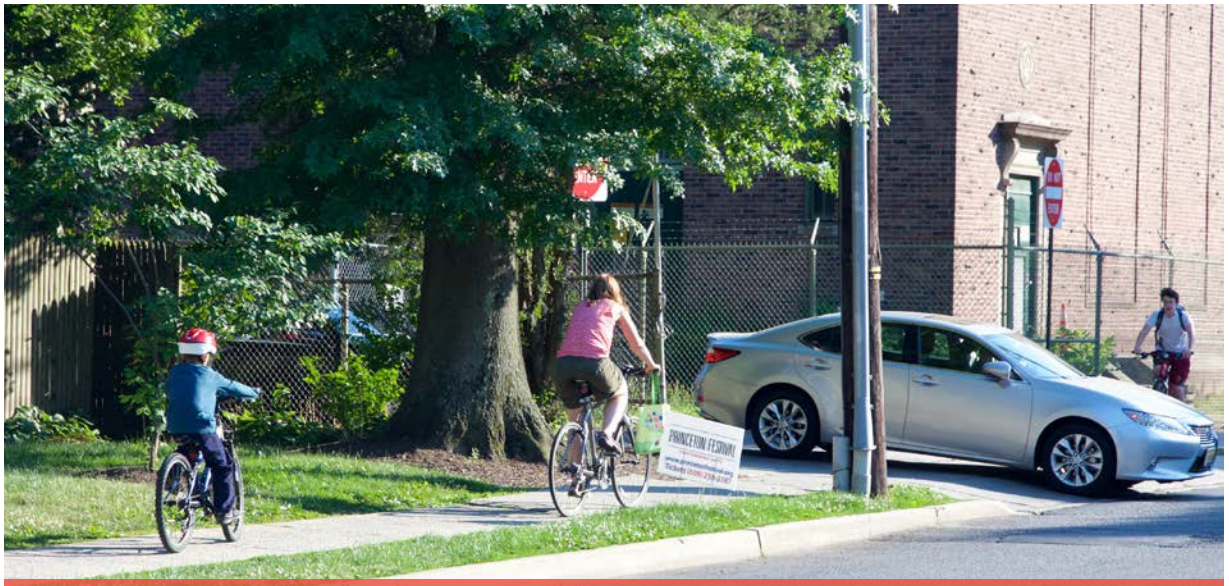
Witherspoon Street is currently undergoing significant redevelopment. The corridor is anchored by the commercial downtown to the south and the municipal complex and Community Park to the north. The completion of the current residential development will create new demand for walking and biking trips along the corridor, as residents seek an easy and convenient way to reach nearby local shopping, dining, and recreational destinations. The character of the corridor may also evolve, as the influx of new residents may spur additional commercial activity, shops, and cafes along the Witherspoon corridor itself.

As the corridor evolves, the Municipality should advance streetscape improvements, including improved sidewalks, lighting, and crossings, and on-road bicycle lanes to accommodate higher demand. These improvements will need to be coordinated with parking demand management strategies, such as additional off-street, structured parking capacity or shared parking agreements, to accommodate the needs of local businesses along the corridor.

Hamilton Avenue Corridor

The Hamilton Avenue corridor (Lafayette Road to Rollingmead Street) also remains a gap in the low-stress network in the near-term. The corridor is an important east-west link across the Municipality. It provides the most direct and convenient link between many residential neighborhoods and the library, downtown commercial core, the Middle School, the High School, and the Littlebrook Elementary School.

In the near-term, the proposed enhanced shared-lane markings can help improve the visibility of bicycling and emphasize the street as an important bicycling route. However, the markings alone do not create an all ages and all abilities bicycle connection to the local schools. Achieving this objective will require trade-offs to implement more substantial improvements in the long term. While the typical roadway width of 30 feet is the minimum necessary to accommodate standard bicycle lanes, minor widening may be required in some sections. Existing on-street parking would also need to be removed. As with Witherspoon Street, long term bicycle improvements for the Hamilton Avenue corridor should be incorporated into on-going efforts to evaluate parking demand management strategies in the downtown.



Bicyclists riding on the sidewalk along Wiggins Street


Olives
HOLSOME
La MezzaLuna
A Taste of Italy
ONE WAY

07

Bicycle Parking

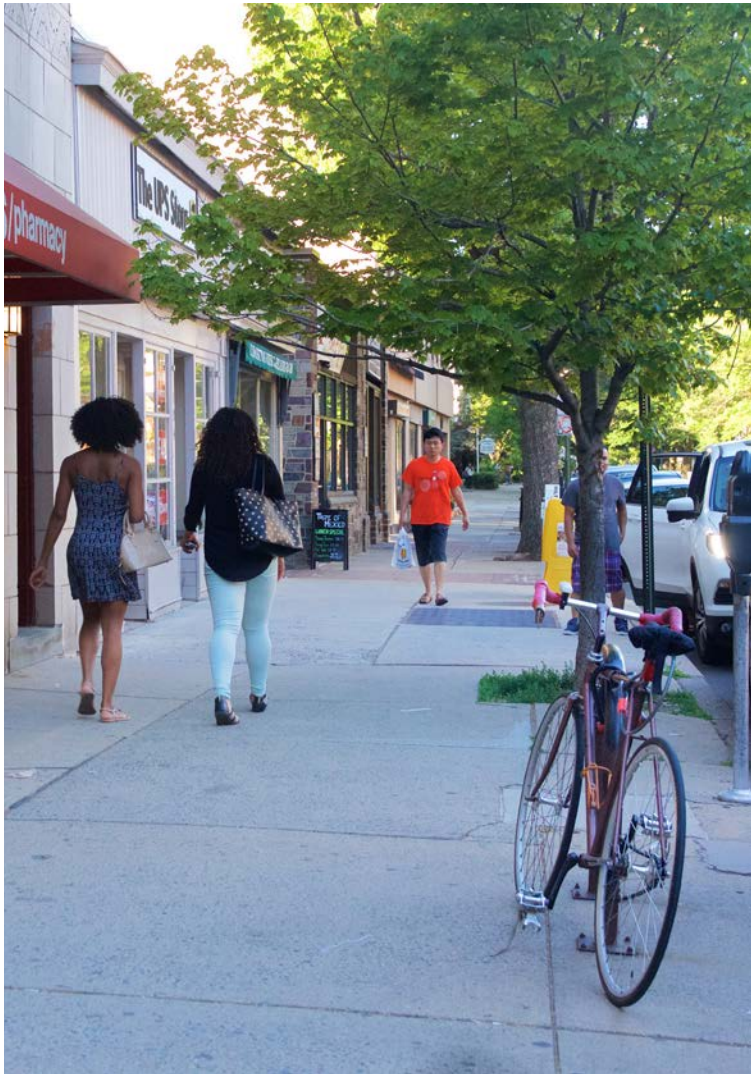
Bicycle parking facilities are needed to extend bicycle use from an opportunity for recreation to a feasible mode of transportation. Providing adequate, secure bicycle parking is an important measure to accommodate and encourage cycling as an alternative travel mode. Proper parking facilities increase the convenience of cycling for commuting, utilitarian, or recreational purposes while also alleviating the threat of theft. Appropriate infrastructure design and siting standards, additional bicycle parking capacity, and a bicycle parking ordinance can all help improve options for bicycle parking in Princeton.

Through the community involvement process, as well as field observations and analysis of existing conditions, improved bicycle parking was identified as an area of need. The majority of existing bicycle racks are an older design. As they are replaced and additional capacity is added, rack choice should follow the design guidelines summarized in the following section.

Two types of bicycle parking should be considered as Princeton improves and expands its bicycle parking infrastructure: short-term and long-term parking. Each type has slightly different user and slightly different needs.

Short-term parking is typically intended for customers and guests and is expected to be used for less than three hours. It should be highly visible, conveniently located, and easy to use. It should also be lit to provide secure and comfortable use after dark.

Long-term parking is generally intended for use by residents, employees, and commuters. It should be fully protected from the weather and secure from theft. Long-term parking can include both public and private facilities, such as an indoor storage room (locked); bike lockers; covered parking enclosed by fence and locked gate; covered area within view of attendant, security guard, or security camera; or covered area visible from employee work areas.



(Top-Left) Inverted-U rack integrated into the streetscape along Nassau Street
(Top-Right) Older design "comb" rack is over capacity near the intersection of Leigh Avenue and John Street
(Bottom-Left) Older design "wave" rack is heavily used along Witherspoon Street

7.1 Bicycle Parking Guidelines

Parking should be conveniently located, well lit, and easily visible for cyclists arriving at a destination. There are a variety of bicycle parking racks available to meet different capacity needs or accommodate space constraints.

Based on guidelines from the Association of Pedestrian and Bicycle Professionals (APBP), a bicycle rack should meet the following requirements:

- Be intuitive to use
- Support the bicycle upright by its frame in two locations
- Prevent the wheel of the bicycle from tipping over
- Enable the frame and one or both wheels to be secured
- Accommodate a variety of bicycles and attachments, including bicycles without a diamond shaped frame and horizontal top tube
- Allow both front-in and back-in parking with a U-lock through the frame and front or rear wheel
- Resist the cutting or detaching of any rack element with hand tools

Older style racks, such as the "comb"/ "schoolyard", "toast", and "wave" are not recommended because they do not properly support the bicycle frame, generally do not facilitate locking of the frame to the rack, and frequently cause interference between the handlebars of adjacent bikes when the rack is near capacity. **The preferred rack is Princeton is the "inverted U"**, (shown on the following page). Other acceptable designs include the "post and ring", and "wheelwell secure." These rack types are illustrated in the figure on the following page.

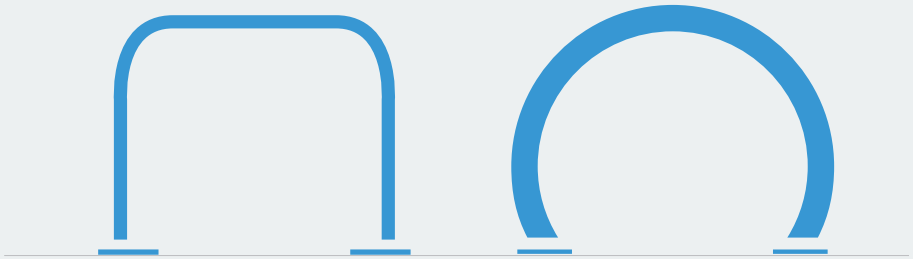
Covered bike parking at the Princeton train station is heavily utilized

Bike racks should also be properly spaced to allow easy, independent access to each bike. This includes providing sufficient space between racks and buildings, walls and parked cars, as well as between other bikes. Additional guidance on bike rack design and placement can be found in the Association of Bicycle and Pedestrian Professionals' (APBP) guide: *Essentials of Bike Parking* (2015).

The preferred rack design in Princeton is the "inverted U"

Recommended Bike Rack Designs

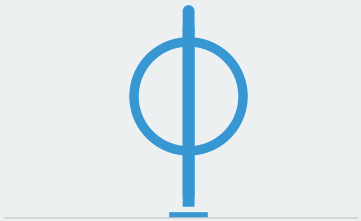
Preferred Design



Inverted U

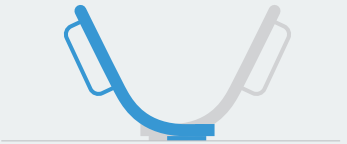
Common style appropriate for many uses; two points of ground contact. Can be installed in series on rails to create a free-standing parking area in variable quantities. Available in many variations.

Other Acceptable Designs



Post and Ring

Common style appropriate for many uses; one point of ground contact. Compared to inverted-U racks, these are less prone to unintended perpendicular parking. Products exist for converting unused parking meter posts.



Wheelwell Secure

Includes an element that cradles one wheel. Design and performance vary by manufacturer; typically contains bikes well, which is desirable for long-term parking and in large-scale installations (e.g. campus); accommodates fewer bicycle types and attachments than the two styles above.

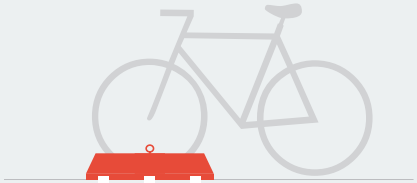
Racks to Avoid

Wave

Not intuitive or user-friendly; real-world use of this style often falls short of expectations; supports bike frame at only one location when used as intended.

Wheelwell

Racks that cradle bicycles with only a wheelwell do not provide suitable security, pose a tripping hazard, and can lead to wheel damage.

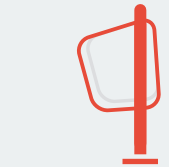


Schoolyard (comb)

Does not allow locking of frame and can lead to wheel damage. Inappropriate for most public uses, but useful for temporary attended bike storage at events and in locations with no theft concerns.

Coathanger

This style has a top bar that limits the types of bikes it can accommodate.

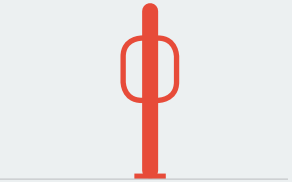


Spiral

Despite possible aesthetic appeal, spiral racks have functional downsides related to access, real-world use, and the need to lift a wheel to park.

Bollard

This style typically does not appropriately support a bike's frame at two separate locations, which limits its framelock capability and bicycle stability.



Images and descriptions courtesy of APBP *Essentials of Bicycle Parking*

7.2 Bicycle Parking Recommendations

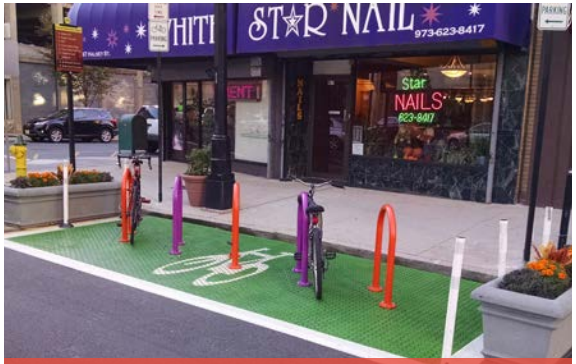
While Princeton has a significant amount of bicycle parking at major destinations throughout the community, including schools, parks, and the downtown, it is insufficient to meet existing demand. Bicycles are frequently chained to sign posts, fences, or other objects to create additional makeshift parking or more conveniently located parking.

Recommendations for bicycle parking locations are shown on Map 10. These locations were determined based on community input through the Wikimap and public meetings, as well as the need to locate additional parking near major destinations and along the proposed bicycle network. These recommendations can help achieve the of doubling bicycle parking in the downtown within 5 years.

In addition to standard bicycle rack installations, per the design guidelines in the previous section, bicycle parking recommendations include the following three typologies.

Bike Corrals

Bike corrals are rows of bike racks installed in the parking lane of the street instead of on the sidewalk. Bike corrals help provide highly visible and ample bicycle parking without occupying sidewalk space, making them particularly



Bike corral in Newark, NJ

useful in areas with constrained sidewalk space and/or high pedestrians activity. They can convert a parking space for a single automobile to parking for 8 to 12 bicycles, creating more convenient access for more customers of nearby businesses. Additionally, bike corrals help "daylight" an intersection by preventing motor vehicles from parking close to the intersection. This helps improve the visibility of all road users at the intersection and creates an easier crossing for pedestrians.

Downtown Parking

Bicycle parking should continue to be integrated into the streetscape in commercial areas throughout Princeton, including Nassau Street, Witherspoon Street, and the commercial node at the intersection of John Street and Leigh Avenue. These are areas of high demand for short-term parking. Inverted-U racks are currently installed along the curb-zone in these areas, and additional racks should be installed to increase capacity. Racks integrated into the streetscape provide frequent parking opportunities that are convenient to local businesses and fit the context of the area.

Covered Parking Stations

Covered parking stations accessible to the general public can help meet demand for longer term bicycle parking. Although they make not provide the same degree of convenience as curb-side parking at individual destinations, centralized stations that provide protection from the elements can be attractive to employees that work in the surrounding area or to visitors and customers planning to spend a longer period of time in the area.

Opportunities for covered bicycle parking locations in the downtown include:

- Downtown parking garages: Bicycle corrals can be installed on the ground floor in a visible location near the garage entrance. Bicycle parking can often be installed in areas that cannot accommodate an automobile parking spot and would otherwise be "dead space" in the garage.
- Covered alcoves: Existing covered alcoves and passageways in Palmer Square may accommodate several parking places by installing inverted-U racks. While each would provide relatively small capacity, it would offer convenience to area businesses.
- Palmer Square U-turn: Repurposing the U-turn area at the western end of the Palmer Square park (between Palmer Square and Nassau Street) as covered bicycle parking would provide additional capacity in a central location in the downtown. It would also enhance an under-utilized public space and help better link the park to Palmer Square proper.
- Hinds Plaza: Upgrading the existing bicycle parking to covered or providing additional covered parking along the periphery, such as adjacent to the library, would provide enhanced bicycle parking in a central location of the downtown.
- YMCA: Covered parking at the YMCA could also be paired with access to shower facilities, providing an amenity to commuters cycling to work near the downtown.
- Witherspoon surface parking lot: Allocate space in the surface lot to covered bicycle parking
- Hulfish to Paul Robeson pathway: Existing parking could be upgraded to covered along this pathway connector.

7.3 Bicycle Parking Ordinance

Princeton should adopt a bicycle parking ordinance to further integrate bicycling into the Municipality's planning process and development regulations. The ordinance would ensure that appropriate bicycle parking is provided as redevelopment occurs, supporting additional parking capacity throughout the community and increasing the convenience of bicycling.

The ordinance should reflect different demands for different types of land uses, including residential development, commercial and office space, and educational and civic institutions. Parking needs should be scaled based on an appropriate metric for the land use, such as square footage, number of bedrooms, or number of classrooms. The ordinance should also address both short-term and long-term parking needs. While customers or visitors making quick trips may require a simple bicycle rack, employees and residents often desire more secure parking options protected from the weather.

Existing ordinances from comparable communities in New Jersey and elsewhere in the country, as well as guidance from the Association of Pedestrian and Bicycle Professionals, provide examples and templates for Princeton to develop its own ordinance.

Covered bike parking installed as part of the recent Merwick-Stanworth residential development.

In addition to setting capacity requirements, the ordinance should also stipulate the design standards summarized in this chapter and reference best practice design guidelines from the Association of Pedestrian and Bicycle Professionals.

Princeton should also create a municipal bicycle parking program to support flexible implementation of the bicycle parking ordinance. Where small businesses or developments who (1) have low bicycle parking requirements or (2) no suitable location to appropriately site the bicycle parking along their frontage, can contribute a fee to the municipal program. The Municipality would then purchase and install the equipment. The funding can support installation of bicycle racks as part of streetscape improvements or bicycle corrals to support a group of small businesses along a given block.

As an incentive, the Municipality may also consider allowing developers to provide additional bicycle parking and/or higher quality facilities (e.g., covered parking) to offset vehicular parking requirements.


THE RED ONION DELI
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morning glory
THE RED ONION
Gourmet Deli
TREK
TREK
BONTRAGER

08

Programs and Policies

While proper design and physical infrastructure improvements are essential to creating a safe and comfortable environment for cycling in Princeton, they are only one part of the process. Underlying programs and policies can also influence conditions for bicyclists. Programs sponsored by the Municipality, as well as partnerships with non-governmental organizations, can help create a bicycle-friendly community, support and promote higher rates of bicycling, and foster mutual respect between cyclists and other road-users. Similarly, supportive policies will facilitate implementation, maintenance, and operation of infrastructure improvements, and incorporate cyclists' needs into day-to-day planning, engineering, and development processes, procedures, and decisions.

8.1 Programs

A variety of programs can be implemented to support the Princeton BMP's goals and foster a culture that values and promotes cycling. As described in the sidebar to the right, programs typically include education, encouragement, enforcement, evaluation and planning, and equity measures. The following sections outline potential programs and supportive resources that may be applicable to Princeton. Programs can be implemented as needed, as staff and funding resources allow, and/or in collaboration with partner organizations.

Education

Educational programs can include distribution of information in a wide range of formats to improve motorist, cyclist, or pedestrian awareness and understanding of traffic laws and safe practices. Larger efforts could include more structured, hands-on training to improve individual skills and abilities. Education programs should be tailored to specific audiences, including school-age children, parents, adults, seniors, or motorists. Specific recommendations for Princeton include:

For Children

As noted in the Chapter 4, the largest number of bike crashes during the five year analysis period involved young people. Providing educational programs tailored for children and young adults should be an important element of the overall municipality-wide campaign, promoting life-long safe cycling habits. Several types of resources are available:

- **Safe Routes to School (SRTS):** Resources are available through SRTS, a federal and state program designed to enable and encourage children to walk and bike to school. The SRTS traffic safety curriculum provides a resource to encourage traffic safety habits from an early age. Lesson plans tailored to different age groups from kindergarten through Grade 8 can be found on the SRTSNJ **website**.[1]
- **Traffic Safety Learning Progression Component:** Funded by the Division of Highway Traffic Safety and developed by Kean and Rowan Universities, the curriculum includes lessons on pedestrian, bicycle, and traffic safety. Lesson plans for tailored to Grades 9 -12 are available **online** to all New Jersey schools free of charge.[2]
- **Drivers' Education:** Incorporate a driver and cyclist/pedestrian safety component into High School driver's education/training courses.
- **Physical Education Curriculum:** Local schools should consider integrating bicycle skills, safety and mechanics as part of the curriculum in their Physical Education curriculum for children, fourth grade and up, in order to promote safe bicycling habits starting at an early age. Hudson County has paired up with the Voorhees Transportation Center of Rutgers University to develop a complete bicycling curriculum, which it made available to its school district free of charge. Princeton should team up with local resources to develop such a program for its schools.
- **Training by Princeton Police Department:** The Princeton Police Department has given presentations at local schools on roadway safety. This program should be continued and implemented at all local schools on an annual basis.

Other nearby communities are pursuing similar endeavors. Greater Mercer Transportation Management Association (GMTMA), for example, in conjunction with Bike New York and NJ Association for Health, Physical Education, Recreation and Dance (NJAHPERD), has sponsored bike safety training targeted to physical education teachers in Mercer County. The training provided information on how to implement a bicycle skills program for pre-teen/teen cyclists for use in PE classes, after school programs, and summer camps. Bike New York offers assistance to New Jersey counties with SRTS Programming and offers a range of valuable education **resources**.[3]

The "6E's" of Bicycle Planning

Bicycle and pedestrian planning often follows the "6E's" framework of engineering, education, encouragement, enforcement, evaluation and planning, and equity. This framework provides a holistic approach to creating a more bicycle and pedestrian friendly community, combining physical infrastructure improvements with supportive programs and policies.

Engineering | Identifies physical infrastructure improvements to create a well-connected, convenient, and comfortable bicycle network

Education | Provides all roadway users – cyclists, pedestrians, and motorists – with information about their rights and responsibilities and applicable laws, promoting mutual respect and courteous and safe interaction among all users

Encouragement | Creates a bike-friendly culture, spurring a change in travel habits and enticing more residents to bike more regularly

Enforcement | Reinforces engineering and education efforts, and ensures the safety of all road users

Evaluation & Planning | Collects data and tracks implementation of the Princeton BMP over time

Equity | Incorporates concerns related to geographic, demographic, and modal equity throughout the other E's

Partnerships

Creating a bicycling-friendly environment is a community effort. In addition to Municipal resources, departments, and staff, there are many opportunities to share resources and costs with other organizations and entities to support and promote bicycle programs in Princeton.

Potential partners include:

- NJDOT
- NJ TRANSIT
- Mercer County
- Delaware Valley Regional Planning Commission
- Greater Mercer TMA
- NJ Bike & Walk Coalition
- Princeton University
- Westminster Choir College
- Institute for Advanced Studies
- Hun School
- Sustainable Princeton
- Code for Princeton
- Local businesses

and many more....

For the Community

- **Community-Oriented Traffic Calming Campaign:** A community-oriented traffic calming campaign raises awareness about speeding and safety. Campaigns such as "20 is Plenty" are directly applicable to Princeton's local residential streets, several of which are already posted at 20 mph. Such a campaign would also support implementation of the Princeton BMP's proposed bicycle boulevards.

  Campaigns typically include lawn signs and car magnets or bumper stickers. The signage may be focused near major destinations or along key routes, such as near schools or along bicycle boulevards. The campaign can be timed to coincide with back to school activity in September. The campaign can also include variable message signs (VMS) at gateways into the Municipality and along main corridors, use of Princeton's website and social media, posters and flyers at municipal buildings, and/or mailings.

  Public Service Announcements (PSAs): Distribute PSAs and brochures on topics such as speeding, traffic law, safe bicycling tips, proper helmet fitting, and how to bicycle with traffic at the public library, the Princeton Municipal Building, schools, and/or Princeton community events. PSAs may also be printed in the local newspaper or posted on the Municipality's website.

  Resources with safety information and sample brochures include the Greater Mercer TMA; NJDOT's Biking in New Jersey website; the Pedestrian and Bicycle Information Center, a national clearinghouse of information related to walking and biking sponsored by the FHWA and operated by the University of North Carolina Highway Safety Research Center; and the National Highway Traffic Safety Administration (NHTSA).

  Two topics relevant to Princeton include:

  - **Shared-Lane Markings PSA:** A particular need noted by local residents is for better driver education on the significance of shared-lane markings. A feature in the local newspaper could be used to inform residents. Leverage existing educational materials and brochures developed by NJDOT.
  - **"Watch for Bikes" PSA:** The campaign provides information to motorists on how to properly share the road with cyclists. Materials can include a decal for rearview mirrors to remind drivers to check for cyclists before changing lanes, turning, or opening a car door. The campaign has been used in other municipalities, such as Cambridge, MA.
- **Social Media:** Promote safety tips, PSAs, and brochures through social media outlets.

- **PSA Distribution to Residents:** One way to ensure residents see PSA brochures is to distribute information in conjunction with other Municipal services, such as when a resident applies for a resident parking permit or parking Smart Card.
- **Cyclist Training:** Partner with local community groups, schools, the police department, businesses, local advocacy groups, or other interested parties to organize bicycle training through the League of American Bicyclists (LAB). The LAB offers a range of courses by certified instructors for different ages and different abilities. The New Jersey Bike & Walk Coalition also offers classes led by LAB-certified instructors. These interactive training courses are a good way to educate cyclists on traffic rules and safety equipment, as well as to practice cycling skills that enable novices and experts to ride confidently and safely with traffic.
- **Outreach for Non-English Speakers:** The community has voiced the need for Spanish language clinics and resources. Many members of Princeton's Hispanic community rely on bicycling as a daily form of transportation. Bike safety education materials, classes, and events should therefore be available for Spanish speakers to ensure they have access to safety information and guidance on best practices. The FHWA provides bicycle and pedestrian resources for Spanish speakers online.[4] The NHTSA also provides resources for Spanish speakers or ESL individuals.[5]
- **Ambassadors in Motion:** The Voorhees Transportation Center of Rutgers University's Ambassadors in Motion (AIM) program is an additional resource for bicycle education and encouragement activities. AIM provides training on helmet fittings, bicycle skills, bike safety checks, and a variety of other topics related to biking and Complete Streets. They also offer education programs and events in Spanish to support outreach to non-English speakers.[6]
- **Education/enforcement campaign:** Collaborate with GMTMA to implement an education/enforcement campaign. Similar to the NJTPA's Street Smart campaign, the program will help educate the community about proper multimodal roadway safety measures.[7]

For Professional Staff

- **Complete Streets Training:** Provide training for municipal officials, planners, engineers, and public works staff about Complete Streets and its implementation. Princeton's adoption of a Complete Streets policy ensures that transportation projects should provide for all expected users, including pedestrians and cyclists. Providing training on effective implementation and maintenance will reinforce the Municipality's policy and help make it part of all future transportation investments in Princeton. NJDOT has educational materials available and periodically conducts Complete Streets workshops.
- **LAB Instructor Training:** Consider providing training for a member of staff, such as a police officer or teacher, to become an LAB-certified instructor and able to lead bicycle training workshops for the community.

"Help slow traffic in and around our towns and schools"

Hopewell, Pennington, and Titusville have collaborated on a community-oriented traffic calming campaign by distributing Drive 25 Pace Car stickers and car magnets to area residents.

Encouragement

Encouraging active modes of transportation such as walking and biking has a host of benefits for residents and the community, including better health, reduced road congestion, environmental benefits, and lower per-trip costs. By supporting and promoting walking and bicycling activities, the Municipality can spur a change in travel habits among residents and visitors, and entice more residents to walk and bike more regularly. Recommendations include:

Events

- **Bike Month:** Continue to publicize and participate in Bike Month activities, typically held in May. Events include Bike to School Day, Bike to Work Day, and Bike to Work Week. Use the events to encourage cycling throughout the month and the year.
- **PARK(ing) Day:** Encourage participation PARK(ing) Day, an annual worldwide event where artists, designers and citizens transform metered parking spots into temporary public parks. Typically held the third Friday of September, the event helps residents, businesses, and visitors envision how street space can be repurposed to enhance public space and create a more vibrant and inviting environment.
- **Open Streets Events:** Open streets events temporarily close a street to vehicular traffic, allowing enjoyment of the space for other purposes and activities, from walking and biking, to fitness classes, music, food vendors, or other creative uses. First held in 2014, Princeton should continue to hold an annual Cyclovia. For maximum benefit, the event should be held near the downtown, making it more accessible to more residents, encouraging broader community participation, and spurring more involvement from and benefit to local businesses.
- **Social Rides:** Group bicycle rides provide a fun way to ride with friends, encourage and attract new cyclists, and reinforce safe cycling habits. The Municipality should continue events such as the annual Mayor's Ride of the Falling Leaves, and support and host other social rides on a monthly basis.

For Children

- **Biking School Buses:** Encourage the use of "Biking School Buses" to promote physical activity for children and parents traveling to and from schools. Work with school staff, parent volunteers, and the police department to organize the biking school buses. Assistance is available through the Greater Mercer TMA.
- **Safe Routes to School:** Continue Princeton's SRTS programs at local schools. Utilize resources through SRTS to provide activities that encourage bicycling and walking at local schools, such as bike rodeos or other events. Princeton schools should strive for Gold Level in the NJ SRTS Recognition Program.
- **Measure Cycling Activity:** Implement a program or technology to track how many students are biking or walking to school. Seeing the data in real-time raises awareness, generates interest, spurs friendly competition, and encourages more students to walk or bike to school. In Montclair, NJ, the Edgemont Montessori Elementary School uses "Boltage," a program that counts the number of students arriving by bike or by foot using radio frequency identification tags given out to students on a voluntary basis. The system lets students track their mileage online, and provides a way to recognize and reward those with the most trips or highest mileage, further encouraging participation.

For the Community

- **Bike Map:** Update Princeton's Bike Map (originally published in 2014) as the bicycle network evolves, and make it available both online and in print. Providing information on Princeton's bicycle facilities and best routes promotes Princeton as a bicycle-friendly community and encourages more people to try cycling.
- **Equipment Giveaways:** Provide inexpensive or free safety equipment such as helmets, reflective equipment/ clothing, and lights at the public

library, schools, or municipal buildings to promote safe cycling.

- **Helmet Usage:** Partner with local cycling clubs, businesses, schools, parent groups, the police department, and other interested organizations to promote higher bicycle helmet utilization in Princeton. At schools and/or community events, a booth can be set-up to provide instruction on proper bicycle helmet fit and offer reduced prices on helmets.
- **Publicize Success:** Highlight bicycle improvements through press releases, the Municipality's website, and social media. By focusing on these facilities, improved conditions, and support for and expansion of the bicycle network, more people will be encouraged to bike.
- **Bike Share:** Continue efforts to implement and maintain a bike share system for Princeton, collaborating with Princeton University and building upon their recent efforts. Bike share can make cycling more convenient and accessible to more users. The presence of bike share stations also raises the visibility of cycling in the community, which in turn fosters a more bike friendly environment and encourages more people to bicycle more often.

(top) Princeton's annual Communiversity ArtsFest open streets event attracts tens of thousands of visitors to the downtown

(right) Princeton University expanded its bikeshare system in spring 2016 to include 70 bikes at nine stations

Enforcement

Combined with education, enforcement is a key element to ensuring safe travel for all roadway users. While the police department cannot dedicate significant amounts of resources to enforce traffic regulations, targeted enforcement campaigns, through warnings and tickets, are effective at correcting unsafe behaviors. Enforcement should apply to both motorists (speeding, failure to stop for pedestrians) and cyclists (riding on the wrong side of the street, failure to adhere to traffic control devices). Princeton-specific recommendations include:

- **Mobile Radar Units:** Implement variable message signage and mobile radar units on roadways throughout Princeton to make motorists more aware of their actual travel speed and the posted speed limit. A vehicle traveling faster than is appropriate for the surrounding land use and/or roadway design reduces the driver's awareness of surrounding activity, such as pedestrians or cyclists, and negatively impacts the safety of all roadway users. Consequently, high-speed traffic also generally discourages bicycle activity. Data collected can also be used by the municipality to identify areas with high incidents of speeding, and target them for enforcement or engineering improvements that reduce speeds.
- **Crossing Guards:** Continue to utilize crossing guards at key intersections along routes to school, particularly at crossings with high traffic volumes. Crossing guards reinforce traffic laws and facilitate easier and safer crossings for students walking or biking to school. Establishing a safe, regulated pedestrian environment encourages parents to consider walking and biking as viable means for their children to get to school. SRTS provides training **resources** for cross guards.[7]
- **Bike Patrols Units:** Consider the use of bicycles for police patrol work, particularly surrounding the downtown core. Bicycle patrols can help improve the visibility of police and foster increased interaction and building relationships with residents. They can also be an effective means of patrolling congested areas, parks, and trail facilities. The presence of bicycle patrols also raises awareness of cycling in the community, helps police officers understand first-hand the challenges faced by bicyclists and motorists, and provides a means to educate road users and enforce traffic laws. West Windsor is an example of a nearby community that has implemented a bicycle patrol unit.
- **Bike Enforcement Training:** Provide training to police officers to help them better understand how New Jersey's motor vehicle code applies to bicyclists. The training also helps officers deal with motorists as well, who often do not understand that bicyclists have a right to use the road in the same way that motorists do. The Voorhees Transportation Center and NJ Bike & Walk Coalition have a course available ("Title 39: A Bike's Eye View") designed specifically for local law enforcement.

Mobile radar unit in Highland Park, NJ

Evaluation and Planning

As resources allow, the Municipality should collect data and information related to bicycle activity and infrastructure. The data will help monitor implementation of the Princeton BMP, gather feedback, and make adjustments as needed. The evaluation program should support the Performance Indicators defined in Chapter 2.

- **Count Program:** Implement an annual count program at set locations along key bicycle routes in the community. Developing a count program can be a valuable to tool to gather baseline data and track changes in bicycle volumes and patterns as the network develops. There are a variety of potential resources and partners available to assist with a program. DVRPC operates a bicycle count program around the region, and may be able to incorporate locations within Princeton or provide guidance and expertise. Implementing a count program is also an opportunity to engage local universities and engineering and planning students.

  Count technology continues to evolve, as applications and devices for video-based data collection and other innovative methods become less expensive and more accessible. Integrating new technology may be an opportunity to work with local organizations such as Code for Princeton.

- **Bicycle Friendly Community:** Strive for Silver status when the Municipality applies to renew its Bicycle Friendly Community designation.
- **Bike Parking Survey:** Conduct a periodic survey of bicycle parking to monitor usage and identify locations where additional capacity is needed. This may be conducted by Municipal staff during typical parking enforcement patrols.
- **School Travel Surveys:** Conduct a school travel survey each fall and spring to track the number of students who walk and bike to school.

Periodic Updates

Review and update the Princeton BMP every ten years, making adjustments to the proposed network, proposed facilities, and supportive programs, as needed, to ensure it reflects current best practices and continues to meet the needs of the community.

Periodic bicycle parking surveys can be used monitor usage and identify areas where additional capacity is needed

8.2 Policy

Effective policy can help support and facilitate implementation of the bicycle network, integrate cycling issues into local governance and municipal operations, and foster a more bicycle friendly community. The following policy changes should be considered to support the vision and goals of the Princeton BMP.

- **Traffic Calming (Resolution 13-201):** Revisit the Municipality's policy eliminating forms of vertical deflection as a design option for new traffic calming. Traffic calming counter measures are recommended by FHWA to improve safety for all roadway users. Traffic calming is also an integral part of the bicycle boulevard concept. While vertical deflection is not appropriate for every roadway, having all design tools available for consideration is an important part of a flexible design process and developing a context sensitive solution that meets the needs of a given street. Speed bumps are typically not appropriate for a public street, but well-designed speed humps, speed tables, and speed cushions, which accommodate wide vehicles, can mitigate many concerns about vertical deflection. Emergency services should also be represented in discussions related to traffic calming projects.
- **Speed Limits:** Adjust the speed limit on all bicycle boulevards to 20 MPH. Make additional speed limit adjustments on several key roadways as detailed in the bicycle network defined in Chapter 6.
- **Design Standards:** Update the Municipality's roadway design standards to reflect current best practices and the multimodal needs of Princeton's street network. Standards should allow for flexibility in design to meet the needs of a given street and its users. The minimum traffic lane widths should be reduced from 12 feet to 10 feet, which is consistent with guidance from FHWA, NACTO, and AASHTO. Design standards for bicycle facilities should also reference current best practice guidelines available from FHWA, NACTO, and AASHTO.
- **Path Maintenance and Repair Program:** Create a path maintenance and repair program and identify funding to monitor the condition of the Municipality's network of shared-use paths. As a part of the program, revisit the Municipality's maintenance policy for shared-use paths and sidewalks and consider a program led by municipal funding. To encourage biking and walking as viable transportation options, the supporting infrastructure must be kept in a state of good repair.

Supportive Land Use and Zoning

Zoning and site plan regulations can impact transportation options. Large parking requirements and large building setbacks create dispersed development patterns that often necessitate driving and exacerbate traffic and parking concerns. Land use and transportation strategies should work in tandem to create a built environment that supports transportation choices and a vibrant community.

- **Roadway Classification Standards:** Add "Bicycle Boulevard" to the Municipality's list of roadway classifications and create an inventory of these streets based on the network defined in Chapter 6. Categorizing them separately recognizes their unique function, and helps prioritize these streets when funding is available for bicycle and pedestrian improvements.

- **Complete Streets Checklist:** Formally integrate a Complete Streets checklist into the planning, engineering, and design process for transportation projects. The checklist will ensure that the needs of bicyclists, pedestrians, transit passengers, and motorists are considered in the design process, and support the Municipality's implementation of its Complete Streets policy.
- **Wayfinding:** Integrate a wayfinding component into the Circulation Element of the Master Plan. Wayfinding is particularly important for pedestrians, bicyclists, and transit users and can encourage greater use of these modes. Wayfinding can also assist motorists searching for parking. It simplifies navigation for residents and visitors alike, making a given route or mode more attractive and convenient. Wayfinding is a critical element of establishing a convenient and accessible bicycle network.
- **Site Plan and Subdivision Review:** Require new development to provide accommodations for bicyclists that are consistent with and supportive of the Princeton BMP, such as bicycle parking, shared-use paths, and on-road facilities.
- **Bicycle Parking Policy:** Adopt a bicycle parking ordinance, as discussed in Chapter 7.
- **Abandoned Bike Policy:** Implement a program to identify and remove bicycles that have been locked and left for a prolonged time period at municipal bike racks. Abandoned bicycles take up valuable space, limit the available parking capacity, and can detract from the aesthetics of the streetscape.
- **Accommodating Residential On-Street Parking Impacts:** Investigate opportunities to provide flexibility for homeowners impacted by changes in on-street parking ordinances as a result of transportation improvement projects.

Parking Management

Dynamic signage showing real-time parking utilization information at area parking garages, in conjunction with wayfinding strategies to direct motorists to these garages, can alleviate concerns about a lack of parking availability and reduce the number of vehicles on the road simply searching for parking.

END NOTES

1 http://www.saferoutesnj.org/resources/education/
2 http://teensafedriving.bianj.org/wp-content/uploads/sites/12/2015/09/Grade9-12-Traffic-Safety.pdf
3 http://www.bike.nyc/education/
4 http://safety.fhwa.dot.gov/ped_bike/hispanic/materials/
5 http://www.nhtsa.gov/Bicycles
6 http://njbikeped.org/nj-ambassadors-in-motion-njaim/
7 http://bestreetsmartnj.org/
8 http://www.njcrossingguards.org/


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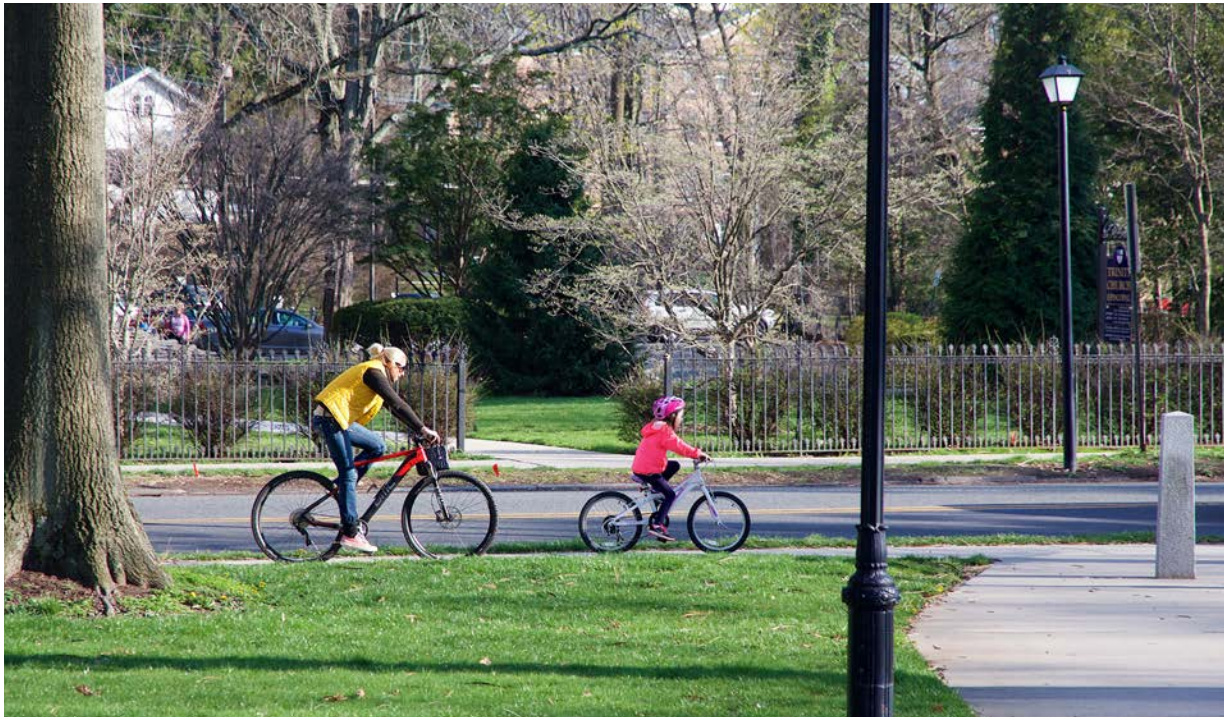


HAMILTON JEWELERS
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