To Members of the Borough Council and Township Committee:

The Princeton Joint Pedestrian and Bicycle Advisory Committee is pleased to present this policy paper on the feasibility of implementing “shared lane markings” (otherwise known as “sharrows”) on key bike routes in both the Borough and Township. These markings have been newly entered into the 2010 version of the Manual of Uniform Traffic Control Devices (MUTCD), the standard used by the engineering and public safety departments of both municipalities. We commissioned a background report pro bono from a local graduate student/consultant to help us consider options. A subcommittee of the Joint Committee prepared this paper and formulated recommendations for action.

Sharrow markings present an opportunity finally to break through previous barriers to creating a safe, convenient network for people who use their bicycles for transportation. That is, Princeton already has a reasonably complete system of sidewalks for the very youngest cyclists. We also have a constantly improving and very beautiful system of recreational off-road paths for all cyclists.

What has been lacking is any accommodation whatsoever for cyclists who need or choose to use their bicycles to commute, shop, reach the train station, school or other essential daily destinations.

Committee members concluded that shared lane markings may be the only feasible and affordable intervention available at this time to improve the safety and comfort of cyclists on Princeton streets. People on bicycles trying to get somewhere—just like those driving cars—often prefer the most direct routes. In Princeton, this generally means sharing roads that are heavily trafficked and often narrow. Sharrows could help in the following ways:

• Alert drivers to cyclists’ presence on the road and indicate to drivers that cyclists legitimately share the road.
• Guide cyclists to travel at an appropriate place in the traffic lane, blocking traffic as little as possible while remaining visible to drivers.
• Keep cyclists out of the way of people who are parked and opening their car doors into the travel lanes to exit their cars.

The Joint Committee considers implementation of sharrows on key routes a top priority in order to complete Princeton’s streets for all users. The report indicates our recommendations for four essential routes to be marked with sharrows, based on:

• Their importance as bicycle routes to key destinations for which there are no safe or convenient alternatives.
• The lack of other feasible and effective interventions.
• The appropriateness of the street conditions per the MUTCD.
• Their minimal cost and ease of implementation.

We urge municipal leaders to act on these recommendations as soon as possible.

Members of the Princeton Joint Pedestrian and Bicycle Advisory Committee
October 8, 2010

Yan Bennett (Borough)
David Cohen (Township)
Laurie Harmon (Borough)
Janet Heroux (Township and Committee Chair)
Steve Kruse (Borough)
Betsy Marshall (Township)
Lori Rotz (Princeton Regional Schools)

Liaison to Borough Council-Andy Koontz
Liaison to Township Committee-Liz Lempert

Shared Lane Markings Study Group:

Yann Bennett
Jennie Crumiller (Borough)
Laurie Harmon
Janet Heroux
Steve Kruse
Recommendations Regarding Shared Lane Markings for Bicycles

Prepared by

The Princeton Joint Pedestrian and Bicycle Advisory Committee

October 8, 2010
Executive Summary

Many residents of Princeton Township and Borough bicycle for both transportation and recreation. Moreover, the numbers of people using their bicycles in Princeton may be rising because of growing public awareness of the major health and environmental benefits of cycling and frustration with ever more congested roadways and tight parking in our community.

Princeton is particularly well-suited to cycling because so many useful and attractive destinations are located within or near residential neighborhoods. However, bicycling is often perceived to be—dangerous: the roads lack accommodation for cyclists to protect them from traffic hazards and guide their use of the roadway.

The purpose of this report is to summarize an assessment of options to improve cycling function and safety, including road markings. Here the Princeton Joint Pedestrian and Bicycle Advisory Committee makes a case for the introduction of shared road markings for bicycles on high priority streets in Princeton Borough and Township. These specific markings, also known as “sharrows”, are newly entered in the updated 2010 Manual of Uniform Traffic Control Devices (MUTCD). The MUTCD is the standard for signs, signals and pavement markings issued by the Federal Highway Administration of the U.S. Department of Transportation. Both municipalities’ engineering and police departments abide by the MUTCD when they consider implementing any form of traffic control device. “Sharrows” are applied to the roadway pavement, depict a bicycle with directional arrows, and are highly visible to drivers.

We predicate our recommendation to implement sharrows on the concept of a “virtuous cycle.” That is, bicycling facilities to increase cyclists’ safety will encourage greater participation in cycling, and the greater presence of cyclists on the roadway will ultimately cause automobile drivers to be more aware of cyclists, and more vigilant in their driving, thereby further increasing safety for cyclists.

The report determines that novice and recreational cyclists are at least partially served by the communities’ continually improving network of sidewalks and off-road pathways. In contrast, those who bicycle for transportation purposes—to get to school, work, shops or other daily destinations—are on their own in this community. There is almost nothing to accommodate or protect bicyclists on our streets. As of early 2010, New Jersey adopted a Complete Streets policy. This policy means that the roadway—including the right of way—should accommodate the needs of all users, including cyclists, pedestrians and people with disabilities, as well as automobile drivers.

The fact that Princeton lacks accommodation for cyclists on its streets makes our community increasingly out of sync with current transportation policy.
State and national transportation authorities recommend dedicated bike lanes as the preferred roadway design to protect cyclists. The narrow streets and priority on parked cars in Princeton Borough and Township, however, do not allow for dedicated bicycle lanes on any in-town street, according to both municipal engineering departments (as of Spring, 2010). Therefore, bike lanes are not discussed as a potential intervention in this paper.

The report gives an overview of safety hazards that these shared markings or “sharrows” would be expected to overcome as well as how such markings add to the inventory of existing bicycling facilities in the municipalities. The committee notes also that road design to reduce speed and the continued strict enforcement of local speed limits are also top priorities to protect not only cyclists but also pedestrians. According to a 1999 review by the National Highway Safety Administration: “…Vehicle speed predicts severity of pedestrian injuries. With vehicle speeds below 20 mph the probability of serious or fatal injury is less than 20%; with speeds above 35 mph, most injuries are fatal or incapacitating.” *

We also reviewed other forms of road design to enhance bicycle safety: bicycle boulevards and bicycle boxes. Bicycle boulevards do not appear to be useful in this community at this point. Bike boxes are not yet incorporated into the MUTCD, so were ruled out.

The paper concludes that shared lane markings, “sharrows”, are—at this time—the best way to make real gains in safety for and public awareness of cyclists on our roads, in an affordable, easily implementable fashion.

The Princeton Joint Pedestrian and Bicycle Advisory Committee recommends that the two municipalities implement shared road markings on segments of four in-town roadways—two north/south, and two east/west— that provide direct routes to the communities’ major destinations. The specific recommended road segments are detailed in this report. The Committee assumes the municipalities’ engineering departments would conduct their own professional study as to the appropriateness and feasibility of these markings on these road segments.

Implementation of sharrows would be an important first step toward achieving a Complete Streets plan in the Princetonos.

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**Introduction**

Princeton Borough and Township are home to 13,381 and 17,404 residents respectively, the most recent data coming from the 2000 Census (Population Finder, factfinder.census.gov). In 2000, 27.2% of the Borough population was in the age bracket of 20-24 years of age, significantly larger than any other age bracket (Population Finder, factfinder.census.gov). This reflects the presence of Princeton University. Princeton Township has a balanced population in terms of age, with the majority between the ages of 20-54 years of age. With respect to gender, 52% of Princeton Borough was male in 2000; 48% in Princeton Township.

Many residents of Princeton Township and Borough bicycle for both transportation and recreation. Moreover, with increased public awareness of the major health and environmental benefits of cycling and ever more congested roadways and tight parking in this area, the numbers of people using their bicycles may be rising.

With a compact and lively downtown, most destinations within residential neighborhoods such as schools, the shopping center, the public pool and parks/playing fields as well as nearby large employers such as Princeton University and Princeton Medical Center, the Princetons are particularly well-suited to cycling.

Despite the widespread presence of cyclists on Princeton’s roadways, bicycling is often perceived to be—and can be—dangerous in our community.

**Purpose of this Report**

The purpose of this report is to make a case for the introduction of shared road markings for bicycles on high priority streets in Princeton Borough and Township. These markings are newly entered in the Manual of Uniform Traffic Control Devices (MUTCD)—the standard that both municipalities’ engineering and police departments use when they consider implementing any form of traffic control device.

The report gives an overview of safety hazards that these shared markings would expect to overcome as well as how they add to existing bicycling facilities in the municipalities.

The report considers other forms of bicycle accommodation that do not exist in the borough and concludes that shared road markings are—at this time—the best way to make real gains in safety for and public awareness of cyclists on our roads, in an affordable, easily implementable fashion.

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1 Because the population’s age data is not available from the more recent Censuses, assumptions have been made that there has been a slight change in population to present day. Hence, one may assume that there has been insignificant change in with respect to age statistics.
The Problem

Bicycle Accidents in Princeton
The accident reports provided by the Borough and Township police departments can be used to get a rough estimate of the annual numbers of bike accidents in Princeton. The reports show that in recent years, 14-16 bicycle accidents per year are typical. The reports also indicate whether or not the bicyclist was injured, although not the severity of the accident, i.e. whether or not the victim was admitted to hospital. The most recent fatal bike accident in Princeton occurred in October 2007.

Nationally, the age of victims most susceptible to a fatal bicycle accident in 2008 was 41, and the age most susceptible to an injury from a bicycling accident was 31 (Traffic Safety Facts, 2009). Correlation of this data with the age data from Princeton Borough and Princeton Township suggests that the predominant age groups in both municipalities may be at risk of bicycling accidents. In fact, the average age for those Princeton bicyclists involved in injuries during the years of 2008, 2009, and as of May 25, 2010 are 33, 28, and 41 years of age, respectively.

With the bicycle accident report for Princeton Borough from 2008 to May 25, 2010 84.2% (16 out of 19), reported bicycle accidents resulted in injury (Appendix A). Similarly, in Princeton Township from 2008 to May 2010, 88.2% (15 out of 17), of the reported bicycle accidents resulted in injury (Appendix B).

We also know from national data “…In 2008, the bicyclist fatality rate per capita was eight times higher for males than for females, and the injury rate per capita was more than four times higher for males” (Traffic Safety Facts, 2009). Given that Princeton Borough has slightly more males than females in its population, this may give rise to more-than-average bicycle-related casualties.

Roughly 64% of bicycle-related accidents nationally occur at non-intersection locations (Traffic Safety Facts, 2009) with the remainder at an intersection.

In Princeton Borough, the largest frequency of bicycle accidents occurs between the hours of 4:01 PM and 6:00 PM (Figure 1). This time frame is most commonly associated with rush hour, the time when traffic is greatest because everyone is leaving work or school.

With 69% of the nation’s bicycling causalities occurring in urban areas, bicycling accidents in the Princeton community may be an increasing concern as we continue to urbanize (Traffic Safety Facts, 2009).
Varied Causes of Accidents Involving Bicycles

Automobiles and Driver Behavior. It must be clearly stated that the greatest danger to bicyclists by far is automobile drivers. The vast majority of bicycle accidents involve automobiles. Some of the leading causes of accidents caused by drivers include: negligent, aggressive or unlawful driving including running a stop sign or traffic light, unsafe overtaking of bicyclists, making unsafe turns by turning into a cyclist’s path, or opening a car door just as a biker is passing. A Canadian study showed that driver error contributed to 90% of all accidents involving bicyclists. (Appendix I).

Nonetheless, cyclists’ behavior can create risks to themselves and sometimes to pedestrians:

Sidewalk Riding. Riding on the sidewalk is a situation that creates problems for bicyclists, motorists, and pedestrians. Riding on sidewalks requires bicyclists to ride by and swerve their way around people. By riding on a bike at a faster-than-walking speed, bicyclists riding on sidewalks create immediate dangers to pedestrians. In the Borough, many shops and stores are alongside sidewalks with customers entering and leaving through doors suddenly. Moreover, children are especially difficult for a bicyclist to see, given the numerous other hazards a bicyclist is on the lookout to avoid. Not only that, but when a bicyclist must enter the street, motorists may be suddenly surprised by a bicyclist’s presence, increasing the probability for a
vehicle-bicycle collision, as the accident statistics on non-intersection locations tend to corroborate. To alleviate this problem, communities suggest, and some even require, that bicyclists ride on the street. New Jersey state regulation requires that bicyclists ride on the road and the municipal codes of both the Borough and Township require bicyclists to ride on the road.²

**Wrong-Way Riding.** This occurs when a bicyclist rides on a street against the flow of traffic. Bicyclists, like motorists, are considered to be vehicle operators and must obey traffic regulations, including following traffic flow. Bicyclists are safer riding in the same direction as other motorists since they are in a position where drivers can expect them. Bicyclists going against traffic flow create problems for oncoming motorists who must react more quickly upon seeing the unsuspected bicyclists. Motorists will move suddenly towards the left side of the lane to allow proper room for the bicyclist, which may lead to accidents with left-oncoming vehicles. Because Princeton’s streets are narrow and also have on-street parking, riding upstream against traffic is highly unadvised. Another example of where a problem may arise is a motorist making a right turn on red, not looking towards his right for an oncoming bicyclist riding the wrong way (Bikesafe, 2006).³

**Noncompliance with Traffic Control Devices (“TCDs”).** Bicyclist accidents also may occur due to noncompliance with TCDs at intersections. “While many of these crashes are not the fault of bicyclists, a frequent factor in these crashes is the bicyclist who ignores either traffic signals or stop signs at intersections” (Bikesafe, 2006). Because bicyclists are vehicle operators, they must obey TCDs as if they were driving an automobile.

**Poor Lateral Positioning.** A key concern to bicyclists is lateral positioning on the road. Bicyclists often prefer to ride near the curb. However, the section of the road near the curb often contains hazards, such as debris and storm drains, to bicyclists. If on-street parking exists, as it does on many roads in the Borough and Township, then bicyclists also must avoid the “door zone,” the area where a bicyclist may encounter someone opening their car door to exit their parked car. This danger often is very sudden and unavoidable to a bicyclist. This requires that bicyclists must be aware of their entire surroundings and look into parked cars to avoid getting “doored.”

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² The Township Police have publicly stated that they give a pass to children riding on the sidewalk due to safety issues.
³ This example also occurs even with right-way riding. Using bike boxes as a solution; however, bike boxes are currently an experimental design that has not been accepted by the FHA.
What Can Be Done?

Safety in Numbers – Reducing Accidents and Ensuring Safety through a “Virtuous Cycle”

This report assumes that improving bicycle safety will create a “virtuous cycle,” that is, that facilities will encourage greater participation in cycling, and that the greater presence of cyclists on the roadway will ultimately cause automobile drivers to be more aware of and vigilant towards cyclists, thereby increasing safety for cyclists. In turn, even more residents may choose to travel by bicycle. Indeed, a study by transportation planners in Portland, Oregon determined that 60% of the population could be described as “Interested but Concerned” – that is, they didn’t feel safe, but might ride more if bike facilities, especially segregated bike lanes, were made available.

Perceived safety, which can increase bike ridership in a community, can also be boosted by education programs (for example bike safety rodeos, or “safe routes to school” initiatives) and by greater enforcement (e.g. enforcing speed limits and other traffic rules, and rules against wrong-way riding, sidewalk riding, riding without lights/reflectors, etc.).

The Virtuous Cycle

Considering Needs of Different Types of Bicycle Riders
For initial planning, we assume a simple three-way categorization of local riders.
• **Novice** – The majority of inexperienced bicyclists are under 12 years old. Local sidewalks, especially those on the approach roads to elementary schools, have been designed with curb cuts, and should be used by novice riders. Novice riders should be made to feel confident when riding on designated bike paths, either paved (e.g. in Smoyer Park) or unpaved (e.g. the towpath), and eventually to progress onto shared roadways. The number of novices cycling has probably decreased in recent decades, for a variety of reasons, but our goal should be to boost younger riders’ enthusiasm about bicycle travel, by enacting “Safe Routes to School” policies etc. The topic of signage (wayfinding) is also important here, in order to make it easier and safer to navigate independently.

• **Recreational Riders** – This category includes fitness-oriented cyclists on training rides, in addition to people riding for the pleasure of it. This contingent may consist of large groups (bicycle clubs) or small groups (families). They may be inclined to follow scenic, lightly-travelled roads, and to avoid busy arteries depending on the time of day. They may or may not use roadside bike paths, depending on their level of experience, and may be more concerned with traversing through town efficiently on their way to a recreational area or the towpath.

• **Transportation Riders** – This category consists of schoolchildren, university students, daily commuters, and people running errands. What they all have in common is that their rides follow a predictable pattern or daily routine, and that their destinations, whether the office, the shopping center, the public library, the gym or pool complex, the university campus, the Dinky station, cannot be reached except *via* one or more of the bigger shared roadways. Some bike traffic in this contingent is active around the clock due to riders who are returning from their night shift jobs. In terms of signage, safety related to road sharing with cars is of the utmost importance, whereas wayfinding is not. Also of importance here are convenient and adequate bicycle parking facilities.

Novice and recreational riders are generally well-served in Princeton because they tend not to use the roadway. Further, the municipalities maintain a network of sidewalks and pathways throughout the community and, although the network is not complete, it is continually being expanded and improved. In contrast, an almost total gap in facilities exists for transportation riders on our roadways.

**Types of Bicycle Facilities and Accommodation in Princeton**

Taking inventory of the types of bike facilities existing in Princeton, we have the following:
• **Sidewalks With Curb Cuts** – These have been prioritized in previous versions of the Princeton Master Bike Plan (1979), but are intended for use by “novice” bicyclists under 12 years of age. In the Master Bike Plan, it advises that experienced bicyclists should avoid riding on sidewalks, except during heavy rainstorms and traffic jams.

• **Off Road Paths** – There are three types of off-road paths or “multi-use trails” in use in the community. The most prevalent is a smooth, asphalt “bituminous” paved sidewalk, examples of which can be found alongside Princeton Pike, Great Road, Mount Lucas, Alexander Road, etc. The second type of bike path or trail typically traverses a park. Examples are found in Smoyer Park, Grover Park, and Petronella Gardens, and include the “trolley line right-of-way trail” between Elm Road and Johnson Park School. The third type of path or trail is unpaved, the primary example being the D&R Canal towpath.

While there exists an extensive network of such paths in the community, the segments are mostly only 6 feet wide (less than the standard 8-10 feet for multi-use paths), sometimes poorly marked and not interconnected. Furthermore, these bike paths exist almost exclusively in the Township. Thus, it isn’t possible for a bicyclist to make a trip through the municipalities without leaving the designated bike paths.

• **Bicycle Signage** Princeton currently has some bicycle signs, some of which may relate to the 1979 bicycle route system. Signs communicate to bicyclists and motorists that bicyclists are allowed to be on the street in addition to providing other details to aid wayfinding, provide warnings or directions.

Currently, there is an ongoing debate whether there is sign pollution in the Borough. Until signs have been effectively placed in the municipality, additional signs may be opposed.

• **Law Enforcement** – As suggested by the United State Department of Transportation, “bicyclist education is [another] remedy, but perhaps more important is law enforcement” (Bikesafe, 2006). Enforcing the law protects all parties, but enforcing speed limits greatly reduces injury and death of pedestrians and bicyclists. According to a 1999 review by the National Highway Safety Administration, “…Vehicle speed predicts severity of pedestrian injuries. With vehicle speeds below 20 mph the probability of serious or fatal injury is less than 20%; with speeds above 35 mph, most injuries are fatal or incapacitating.” Fortunately, both municipalities have a strong police force dedicated to public safety who engage almost continually in speed enforcement efforts.

• **Traffic Calming** -- Traffic calming lowers traffic speeds and reduces traffic chaos through street design particularly in congested areas or where drivers frequently disobey
speed limits in neighborhoods with pedestrian traffic. Traffic calming interventions have already been implemented in the Borough, for example, in the Riverside neighborhood on Prospect Road and in the Western section on Cleveland Lane and Hodge Road. Changes include speed bumps, roundabouts and planted medians.

Some of the traffic calming techniques have created narrower lanes for cyclists sharing the road with automobiles, and some cyclists have reported this narrowing can create a safety problem for cyclists. Lowering traffic speeds, however, increases pedestrian and cyclist safety under almost any circumstance.

The following do not appear viable options for Princeton:

- **Dedicated Bike Lanes** – these are indicated by painted stripes on the shoulders of roadways. Due to the widespread use of curbside metered parking and the general lack of wide roads in the municipalities, coupled with the emphasis on creating bituminous sidewalk “bike paths,” there are no bike lanes in Princeton.

- **Bike Boulevards** – these are roads which run parallel to the main arteries used by the bulk of vehicular traffic. The lower traffic level creates a safer environment for cyclists. Bike Boulevards are designed to discourage motorized traffic, which further enhances their attraction to cyclists. Princeton has several streets which might someday be amenable to this designation, however the volume of bike traffic does not currently appear to warrant this approach.

- **“Bike boxes”**—these are markings painted at intersections that indicate a place for bicycles to wait in front of automobiles at a traffic light. Bike boxes are not approved as signage in the MUTCD.

**Shared Lane Markings (“Sharrows”)—A Good Fit for the Princeton Community**

Shared-lane markings, or “sharrows”, appear to be a positive traffic control device for bicyclists and motorists alike, if implemented correctly. With other cities such as Hoboken, New York City, and Philadelphia installing sharrows on their roads, as well as the inclusion of the sharrow in the MUTCD, these markings appear to offer a viable option where a dedicated bike lane cannot be installed.

This marking is used within travel lanes shared by bicyclists and other vehicles. The primary purposes of a sharrow are:
1. To assist bicyclists with lateral positioning in a shared lane with on-street parallel parking in order to reduce the chance of a bicyclist's impacting the open door of a parked vehicle,
2. To assist bicyclists with lateral positioning in lanes that are too narrow for a motor vehicle and a bicycle to travel side by side within the same traffic lane,
3. To alert road users of the lateral location bicyclists are likely to occupy within the traveled way,
4. To encourage safe passing of bicyclists by motorists, and
5. To reduce the incidence of wrong-way bicycling.

**Figure 2:**
Example and Dimensions of a Sharrow Marking

The MUTCD also indicates as an alternative to the sharrow, a “bicycles may use full lane” sign, which may be used in addition to or instead of the shared lane marking. However, one of the purposes of the sharrow is to assist bicyclists with lateral positioning, which such a sign cannot accomplish. The full guidelines for sharrows in the MUTCD are attached as Appendix J.

**San Francisco Study.** In San Francisco, sharrows have been in use for several years. San Francisco has conducted research on the effectiveness of sharrows on motorists and bicyclists. A
visual representation of the results may be seen in Appendix D and quantitative seen in Figure 3 (Note: Bike-and-Chevron is an alternative name for a sharrow marking).

**Figure 3:**
**Summary of Bicyclists’ and Motorists’ Behavior with Sharrows**

<table>
<thead>
<tr>
<th>Behaviors</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>(No marking)</td>
<td>(No marking)</td>
<td>Bike-and-Chevron</td>
</tr>
<tr>
<td>sample size=1158</td>
<td></td>
<td>sample size=794</td>
</tr>
<tr>
<td>Sidewalk riders</td>
<td>6.5%</td>
<td>4.2%</td>
</tr>
<tr>
<td>Wrong-way riders</td>
<td>3.0%</td>
<td>0.60%</td>
</tr>
<tr>
<td>Hostile behaviors</td>
<td>0.15%</td>
<td>0.12%</td>
</tr>
<tr>
<td>Distance of cyclists to parked cars</td>
<td>3'-4&quot;</td>
<td>4'-0&quot;</td>
</tr>
<tr>
<td>sample size=150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance of cyclists to cars in travel lanes</td>
<td>2'-7&quot;</td>
<td>4'-10&quot;</td>
</tr>
<tr>
<td>sample size=150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance of cars in travel lane to parked cars</td>
<td>4'-8&quot;</td>
<td>5'-6&quot;</td>
</tr>
<tr>
<td>(no bike present)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Significant differences are indicated in **boldface**.

**Source:** San Francisco’s Shared Lane Pavement Markings, 2004

These results clearly show a positive impact on motorists and bicyclists. By reducing the amount of bicyclists riding on the sidewalks, bicyclists riding against traffic, and increasing the distance between bicyclists and passing or parked vehicles, sharrows alleviated many of the troubling situations that may result in a bicycle-related injury. Though sharrows did not contribute to controlling motorist hostile behaviors at a statistically significant level, the slight positive impact on such behavior is promising.

San Francisco also conducted a survey to ask bicyclists and drivers about their understanding of the marking. The bicyclists indicated that the markings were a step in the right direction but that the intended message of the marking was not fully understood; this problem could be easily remedied through a public information campaign. For motorists who did see the marking, the consensus was they seemed to understand that it was not a sign for a dedicated bike lane, but a shared lane marking.

**Bellevue, Washington Study.** Another study was conducted in Bellevue, Washington. The focus of their before/after study was to evaluate the behavioral changes that might occur with the new shared lane markings. While the study did not generally derive strictly statistically significant results, it found that:
“Application of Sharrow markings are showing promising results and give rise to continuing this application on other roadways that are not feasible for widening. Early indications, primarily by way of numerous observations, are that it does promote the increased comfort and safety of cyclists while affirming to motorists the need to share the roadway with bicyclists under state law and reduce the friction between motorists and cyclists often experienced under shared travel lane facilities.”

It also noted that the use of the shared lane marking did not adversely affect accident occurrences. Overall, the city of Bellevue suggests that sharrows be implemented where:

- Current street infrastructure is effectively built out and modification of the roadway section is impractical to include marked bike lanes
- Posted speed limit of 30 mph or less
- Opportunity for evaluating a shared lane marking in conjunction with on-street parking

**Recommendation**

The following north/south routes are tentatively proposed:

- Harrison Street (from the intersections of Faculty Road to Mt. Lucas): Harrison Street has daily bike traffic because of the presence of the Princeton Shopping Center, University student and employee commuters, and recreational riders going to and from the towpath.
- Witherspoon Street (from intersections of Nassau to Valley Road): Witherspoon is a street that falls within the guidelines of a street too narrow to accommodate a bike lane, a 25-mph speed limit, and on-street parking. There are a number of daily bikers who commute to work on this street by riding on the sidewalks, a behavior that the sharrow discourages.

The following east/west routes are tentatively proposed:

- Nassau Street (from Harrison to Bayard): a number of on-street bikers take this route to go downtown and to the University.
- Paul Robeson/Wiggins/Hamilton (from Bayard to Snowden Lane): a number of daily bikers take this route to commute to downtown, the University, and area schools.

These four streets are involved in some 60% of the bicycle accidents from 2008-May 25 2010. More alarming, Nassau and Harrison Streets combined are involved in some 90% of bicycle-related accidents in 2009-May 25, 2010. Appendix E has some data regarding AADT.

The technical details of implementing sharrows in our community are outlined in Appendix J that incorporates suggestions from other municipalities and guidance from the MUTCD. We
assume the municipalities’ engineering departments would conduct their own study as to the appropriateness and feasibility of these markings.

**Estimated Budget**

With the minimum spacing between markings at 250 feet, and the cost of each thermoplastic sharrows estimated at $150, the cost of sharrows would be approximately $13,000 per two-mile stretch of road.

Research indicates that sharrows have proven to be an inexpensive and effective. If this proposed plan were to prevent just one injury, then this plan would have already been worth it.

**Conclusion**

Should the two municipalities implement sharrows, Princeton would begin to achieve a level of bicycling accommodation consistent with our master bike plan and master plan circulation element. We would move significantly in the direction of state of the art standards in transportation design. Bicyclists will feel safer on the road, which in turn will likely increase the bicycling population, with all the benefits to health, the environment and quality of life that more bicycling brings to a community.
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## Appendices


<table>
<thead>
<tr>
<th>Case #</th>
<th>Date</th>
<th>Time</th>
<th>Street</th>
<th>Age</th>
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<td>Injury</td>
</tr>
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<td>04-08-08</td>
<td>1700</td>
<td>Wiggins/North Tulane</td>
<td>10</td>
<td>Injury</td>
</tr>
<tr>
<td>08-8035</td>
<td>05-02-08</td>
<td>0811</td>
<td>Jefferson/Wiggins</td>
<td>14</td>
<td>Injury</td>
</tr>
<tr>
<td>08-11772</td>
<td>06-26-08</td>
<td>0918</td>
<td>Bayard/Hodge</td>
<td>58</td>
<td>Injury</td>
</tr>
<tr>
<td>08-16579</td>
<td>09-18-08</td>
<td>1655</td>
<td>Paul Robeson/Chambers</td>
<td>47</td>
<td>Injury</td>
</tr>
<tr>
<td>08-18075</td>
<td>10-16-08</td>
<td>0740</td>
<td>Chestnut/Sprouce</td>
<td>17</td>
<td>Injury</td>
</tr>
<tr>
<td>08-18102</td>
<td>10-16-08</td>
<td>1503</td>
<td>Bayard/Westcott</td>
<td>53</td>
<td>Injury</td>
</tr>
<tr>
<td>09-1827</td>
<td>02-02-09</td>
<td>1743</td>
<td>Snowden/Hamilton</td>
<td>28</td>
<td>Injury</td>
</tr>
<tr>
<td>09-5885</td>
<td>04-10-09</td>
<td>1026</td>
<td>Nassau/Witherspoon</td>
<td>-</td>
<td>None</td>
</tr>
<tr>
<td>09-7813</td>
<td>05-12-09</td>
<td>1642</td>
<td>Nassau/Vandeventer</td>
<td>-</td>
<td>None</td>
</tr>
<tr>
<td>09-7908</td>
<td>05-14-09</td>
<td>1726</td>
<td>Harrison/Pelham</td>
<td>39</td>
<td>Injury</td>
</tr>
<tr>
<td>09-9955</td>
<td>06-16-09</td>
<td>1001</td>
<td>Witherspoon/Green</td>
<td>21</td>
<td>Injury</td>
</tr>
<tr>
<td>09-13389</td>
<td>08-20-09</td>
<td>2210</td>
<td>Nassau/Harrison</td>
<td>26</td>
<td>Injury</td>
</tr>
<tr>
<td>09-14837</td>
<td>09-14-09</td>
<td>1622</td>
<td>Witherspoon St.</td>
<td>29</td>
<td>Injury</td>
</tr>
<tr>
<td>10-1984</td>
<td>02-05-10</td>
<td>0558</td>
<td>Washington/Nassau St.</td>
<td>58</td>
<td>Injury</td>
</tr>
<tr>
<td>10-3004</td>
<td>02-23-10</td>
<td>1733</td>
<td>Bayard Lane/Paul Robeson Pl.</td>
<td>18</td>
<td>Injury</td>
</tr>
<tr>
<td>10-6725</td>
<td>04-28-10</td>
<td>0847</td>
<td>N. Harrison/Franklin Ave.</td>
<td>65</td>
<td>Injury</td>
</tr>
<tr>
<td>10-6732</td>
<td>04-28-10</td>
<td>1255</td>
<td>Nassau/Chestnut St.</td>
<td>38</td>
<td>Injury</td>
</tr>
<tr>
<td>10-8182</td>
<td>05-25-10</td>
<td>1223</td>
<td>23 Witherspoon St.</td>
<td>28</td>
<td>N/A</td>
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</table>
Appendix B: Princeton Township Bicycle Accident Report - 2008-May 2010

<table>
<thead>
<tr>
<th>Date / Year</th>
<th>Non-injury</th>
<th>Injury</th>
<th>Fatal</th>
<th>Other</th>
<th>Total</th>
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<tbody>
<tr>
<td>May 2010</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>April 2010</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>March 2010</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>February 2010</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>January 2010</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2009 Total</td>
<td>2</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>7</td>
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<tr>
<td>2008 Total</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
</tbody>
</table>

Appendix C: Bike Lanes and Road Cross-Sections

(1) On-Street Parking

* The optional solid stripe may be advisable where stalls are unnecessary (because parking is light) but there is concern that motorists may misconstrue the bike lane to be a traffic lane.

(2) Parking Permitted without Parking Stripe or Stall

* 3.9 m (13 ft) is recommended where there is a substantial parking or turnover of parked cars is high (e.g., Commercial areas).
(3) Parking Prohibited

0.9 m (3 ft) min.  150-mm (6-inch) solid white stripe

1.5 m (5 ft) min.  Bike lane  Motor vehicle lanes  1.2 m (4 ft) min.  Bike lane

(4) Typical Roadway in Outlying Areas Parking Protected

Rumble strip*  150-mm (6-inch) solid white stripe

1.2 m (4 ft) min.  Bike lane  Motor vehicle lanes  1.2 m (4 ft) min.  Bike lane

* If rumble strips exist there should be 1.2 m (4 ft) minimum from the rumble strips to the outside edge of the shoulder.

Appendix D: Results of Sharrows Installation

[Diagram showing the results of Sharrows installation with different markings and their respective clearances for vehicles.]
<table>
<thead>
<tr>
<th>Direction</th>
<th>North or East ADT</th>
<th>South or West ADT</th>
<th>Location Description</th>
<th>Mile</th>
<th>Street Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Princeton Twp</td>
<td>19</td>
<td>39</td>
<td>Just South of Pardee Circle</td>
<td>0.49</td>
<td>Lambert Dr</td>
</tr>
<tr>
<td></td>
<td>201</td>
<td>210</td>
<td>Bet Great Rd &amp; Hunter Rd</td>
<td>0.14</td>
<td>Winstead Rd</td>
</tr>
<tr>
<td></td>
<td>657</td>
<td>541</td>
<td>Bet Prerry Brook</td>
<td>0.32</td>
<td>Princeton Ave</td>
</tr>
<tr>
<td></td>
<td>346</td>
<td>266</td>
<td>Bet Cuyler &amp; Terhune Rds</td>
<td>0.074</td>
<td>Zimmer St</td>
</tr>
<tr>
<td></td>
<td>735</td>
<td>74</td>
<td>Bet Herarstown Rd &amp; Van Dyke Rd</td>
<td>1.23</td>
<td>Prospect Ave</td>
</tr>
<tr>
<td></td>
<td>440</td>
<td>551</td>
<td>Bet Castle Howard &amp; Riverside Dr</td>
<td>1.10</td>
<td>Princeton Av</td>
</tr>
<tr>
<td></td>
<td>738</td>
<td>440</td>
<td>Princeton Twp</td>
<td>1.11</td>
<td>Princeton Av</td>
</tr>
<tr>
<td></td>
<td>633</td>
<td>573</td>
<td>Princeton Twp</td>
<td>1.11</td>
<td>Princeton Av</td>
</tr>
<tr>
<td>Princeton Boro</td>
<td>790</td>
<td>955</td>
<td>Between Bank Street and John Street</td>
<td>0.2</td>
<td>Nassau St</td>
</tr>
<tr>
<td></td>
<td>828</td>
<td>731</td>
<td>Princeton Ave &amp; Harrison St</td>
<td>0.05</td>
<td>Princeton Ave</td>
</tr>
<tr>
<td></td>
<td>103</td>
<td>73</td>
<td>Bet Hodge Rd &amp; Boudinot St</td>
<td>0.48</td>
<td>Monroe Place</td>
</tr>
<tr>
<td></td>
<td>860</td>
<td>478</td>
<td>Princeton Twp</td>
<td>0.08</td>
<td>Princeton Rd</td>
</tr>
<tr>
<td></td>
<td>873</td>
<td>331</td>
<td>Bet Cramerton Rd &amp; Edgewood St</td>
<td>1.17</td>
<td>Nassau St</td>
</tr>
<tr>
<td></td>
<td>573</td>
<td>321</td>
<td>Princeton Boro</td>
<td>1.19</td>
<td>Princeton Boro</td>
</tr>
</tbody>
</table>
Appendix F: Princeton’s Bicycle Route System - 1979
Appendix G: Princeton University Bike Plan
Appendix H: NJDOT Biking Guidelines

While some experienced bicyclists may know some guidelines to biking along a street, many novices many be unaware of some general guidelines suggested by the New Jersey Department of Transportation (NJDOT). Below is a brief list of guidelines that bicyclists should follow for their own safety, as well as for the safety of pedestrians and motorists.

1. Bicyclists should ride on the street, if there is no dedicated bike path.
   • Although there are no such rules or laws governed by the state of NJ, many municipalities may enforce their own rules regarding this policy.
   • In general, riding on the street is safer and more efficient to all.
   • Riding on sidewalks, if allowed by the municipality, may be executed in the case “for very young cyclists under parental supervision” (www.state.nj.us, Biking in NJ)

2. Bicyclists should “position [themselves] several feet out into the lane. . . . On narrower lanes, ten feet or less, a bicyclist might actually ‘take the lane,’ i.e., position themselves at or near the center of the lane” (www.state.nj.us, Biking in NJ)
   • By following this guideline, bicyclists are easily seen by motorists and are less likely to be pushed towards the curb by passing motorists.
   • Motorists will be safer when it comes to bicyclists, since they will not be able to pass the bicyclist in an unsafe manner.

3. Bicyclists should ride in the same direction as traffic flow and follow its respective traffic control devices (TCDs).
   • Bicyclists and motorists must share the road. Because bicyclists are considered as vehicle operators, bicyclists must follow the proper TCDs governing the road, including but not limited to, traffic flow direction, yielding to pedestrians, stopping for red lights/stop signs, etc.
   • “In New Jersey, the law states a bicyclist must obey all state and local automobile driving laws. A parent may be held responsible for the child’s violation of any traffic law” (www.state.nj.us, Biking in NJ).

4. A bicyclists may move left under any of the following conditions (www.state.nj.us, Biking in NJ):
   • To make a left turn from a left turn lane or pocket;
   • To avoid debris, drains, or other hazardous conditions on the right;
   • To pass a slower moving vehicle;
   • To occupy any available lane when traveling at the same speed as other traffic;
   • To travel no more than two abreast when traffic is not impeded, but otherwise ride in single file. Every person riding a bicycle shall ride in the same direction as vehicular traffic.

5. Always wear a helmet, and in night-time have highly-visible clothing or flashing lights.
6. If a bicyclist is not confident enough to ride on the street, he may simply walk the bike on the sidewalk.
Appendix I: Most Frequent Crash Types (Toronto, CAN)

Table 1: Most Frequent Crash Types

<table>
<thead>
<tr>
<th>Crash Type</th>
<th>Number of Cases</th>
<th>Relative Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drive Out at Controlled Intersection</td>
<td>284</td>
<td>12.20%</td>
</tr>
<tr>
<td>Motorist Overtaking</td>
<td>277</td>
<td>11.90%</td>
</tr>
<tr>
<td>Motorist Opens Door in front of Bicyclist</td>
<td>276</td>
<td>11.90%</td>
</tr>
<tr>
<td>Motorist Left Turn - Facing Bicyclist</td>
<td>248</td>
<td>10.70%</td>
</tr>
<tr>
<td>Motorist Right Turn - Other</td>
<td>224</td>
<td>9.60%</td>
</tr>
<tr>
<td>Motorist Right Turn at Red Light</td>
<td>179</td>
<td>7.70%</td>
</tr>
<tr>
<td>Drive Out from Lane or Driveway</td>
<td>179</td>
<td>7.70%</td>
</tr>
<tr>
<td>Ride Out At Controlled Intersection</td>
<td>73</td>
<td>3.10%</td>
</tr>
<tr>
<td>Wrong Way Bicyclist</td>
<td>59</td>
<td>2.50%</td>
</tr>
<tr>
<td>Ride Out At Mid-block</td>
<td>51</td>
<td>2.20%</td>
</tr>
</tbody>
</table>

From: Tomlinson, David. Conflicts Between Cyclists and Motorists in Toronto, Canada (1).

Appendix J: Technical Details and MUTCD Guidelines

Adhering to the MUTCD:

- If used in a shared lane with on-street parallel parking, Shared Lane Markings should be placed so that the centers of the markings are at least 11 feet from the face of the curb, or from the edge of the pavement where there is no curb.

- If used on a street without on-street parking that has an outside travel lane that is less than 14 feet wide, the centers of the Shared Lane Markings should be at least 4 feet from the face of the curb, or from the edge of the pavement where there is no curb.

- If used, the Shared Lane Marking should be placed immediately after an intersection and spaced at intervals not greater than 250 feet thereafter.

Figure 1:
Placement of Sharrow as Suggested by San Francisco
Note that these distances are the minimum required/suggested. The municipal engineers may decide to increase the distance of the marking’s location.

The type of material proposed for the pavement marking is that of thermoplastic material with retro-reflective beads embedded. Such material, though more expensive than regular painted markings, will last 6-8 times longer than paint. As a result, less maintenance will be needed, and economically speaking, the cost will be lower in the long run. This will yield to be very beneficial as one purpose of the marking is to alert motorists of the possible presence of bicyclists. If the paint marking fades, so does the net effect of the marking. The retro-reflective beads also yields this benefit, but in the night-time.

Being a thermoplastic material, the mark will lasts approximately 6-8 times longer than pavement paint. Because the marking should be precut, installation is quick and simple. To install, one would need to

1. Sweep the area of application clean,
2. Lay down the mark, and
3. Apply heat with a hand torch for approximately ten minutes and then let it cool. The heating will lead to the mark to be in a molten state. Upon cooling, the mark will solidify and permanently adhered to the pavement.

Not only is installation simple, but its retro-reflectivity allows the pavement marking to be clearly seen at night. As the thickness of the mark deteriorates by regular use, retro-reflective beads will be revealed, so the retro-reflectivity will not change.