Center for Advanced Multimodal Mobility Solutions and Education

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IMPACTS OF BICYCLING CORRIDOR IMPROVEMENTS ON USERS' BEHAVIORS IN LARGE CITIES

Final Report

by

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EXCUTIVE SUMMARY

Research has shown that increasing opportunities for bicycle transportation can reduce overall Vehicle Miles Traveled (VMT) and auto trips, promote economic development, and improve environmental quality and public health and physical activity. Furthermore, bike lanes and corridors improve the transportation mobility by reducing interaction between automobiles and bicycles, allowing the cyclist to travel at self-paced speeds, without disrupting traffic flow. Bicycle behavior is more predictable using bike lanes, guiding the interaction between bicycles and automobiles, where bicyclists remain inside the lane unless turning, passing, or avoiding hazards within the bike lane. Reducing hazards within the bicycle corridors reduces erratic bicycle behavior and has greater opportunity to facilitate the overall network benefits from the bike lane.

Bicycling and bike sharing program is one of the first and last mile strategies to maximize mobility in major cities. First and last mile issues essentially refer to connectivity between public transport nodes and the user's origins and destinations in multimodal transportation. Investments in bicycle infrastructure improve mobility and provide cyclists and potential cyclists a safer environment to cycle to work and to public transit nodes. This study identifies the impacts of bicycle corridor improvements, specifically at intersections on user behaviors. The research provides an analysis of the effects of the bicycle facility improvements and it explores bicyclist behavior by using the data collected with and without facility improvement.

Chapter 1. Introduction

1.1 Problem Statement

There has been a heavy push for incorporating bicycle corridor and improving the infrastructure along urban roadways over the past decade. As an example, a five-year Green Lane Project, for example, helped to quadruple the number of protected bike lanes in the United States between 2011 and 2016 (*People for Bikes*). Federal Highway Administration (FHWA) has recognized Houston as one of the designated bicycle and pedestrian safety focus cities. The Houston City Council has approved an ambitious bike plan aiming to build a network of comfortable bikeways, with 700 miles of on-street bike lanes and 450 miles of off-street trails (*Streetsblog*). Also, Harris County Precinct I Commissioner has pledged $10 million of Precinct 1 funds to be used by the City for the project within one year. That is in addition to $5.5 million from the City itself for quick-implementation bike-related projects over five years (*Houston Chronicle*). This study seeks to examine the relationship between bicycle corridor improvements and behaviors of bicyclists to identify the potential impacts of bicycle infrastructure projects, which may help in assessing the effectiveness of existing investments. Bicycle facilities were selected in Houston as the case study for the research.

1.2 Objectives

The goals of this research are to examine the relationship between bicycle infrastructure and behavior of bicyclists so as to assess the effectiveness of existing investments on bicycle corridor improvements. Specific project objectives include:

- Review the literatures related to bicycle corridor and infrastructure improvements;
- Study the standards and guidelines used for the design of bicycle facilities;
- Collect the facility related and bicyclist data at different locations;
- Conduct a statistical analysis on the cyclist data collected at different intersections with and without improvement; and
- Find differences in user behavior at the bicycle facilities with and without improvement.

1.3 Expected Contributions

To accomplish the objectives of the study, several tasks have been undertaken to investigate the impact of bicycle corridor improvement on user behaviors. The findings of this research will add to existing knowledge around the relationship between bicycle infrastructure investments and bicycle travel behavior, and to provide direct policy guidance for future investments.

1.4 Report Overview

This report consists of three main chapters:

- Introduction and Literature Review - Introduces the review on the previous studies on bicycle corridor and infrastructure improvements, and standards and guidelines used for the design of bicycle facilities.
- Solution Methodology – Describes the study locations and the data collection forms that were developed for the study. It also presents the statistical analysis used for the study and the results.
- Summary and Conclusion - Discusses the results, recommendations and limitations.

Chapter 2. Literature Review

2.1 Introduction

Research has shown that increasing opportunities for bicycle transportation can reduce overall VMT and auto trips, promote economic development, and improve environmental quality and public health and physical activity. Furthermore, bike lanes and corridors improve the transportation mobility by reducing interaction between automobiles and bicycles, allowing the cyclist to travel at self-paced speeds, without disrupting traffic flow. Bicycle behavior is more predictable using bike lanes, guiding the interaction between bicycles and automobiles, where bicyclists remain inside the lane unless turning, passing, or avoiding hazards within the bike lane. Reducing hazards within the bicycle corridors reduces erratic bicycle behavior and has greater opportunity to facilitate the overall network benefits from the bike lane.

2.2 Previous Studies on Bicycle Infrastructure Improvement

A modal shift towards active travel modes such as walking and cycling has several possible positive impacts. It could decrease air pollution from burning fossil fuels, mitigate traffic congestion, grow physical activity levels, and commence to more sustainable communities (Banister, 2008; Rissel, 2009; Giles-Corti, et al., 2010). Studies have found a positive correlation between transport interventions and active travel (Moudon, et al., 2005; Mutrie, et al., 2002; Parkin, et al., 2008; Pucher, et al., 2011; Rietveld and Daniel, 2004; Yang, et al., 2010). Infrastructures such as mixed land use where shops and public services are scattered within residential areas, increased housing density, public transit availability, sidewalks, trails, and bike lanes can increase the likelihood that people will walk or bike in order to meet their everyday needs (Saelens, et al., 2003; McGinn, et al., 2007; Hoehner, et al., 2005; National Research Council (US) Special Report 282, 2005). It is more likely that an adult living near the above-mentioned infrastructures, i.e., local shops, transit, sidewalks, and bike facilities, meet physical activity needs (Sallis, et al., 2009). The accessibility of the infrastructure and its connectivity has been seen significant in some studies with the most critical factors reported as travel time (Talihun, Levinson, & Krizek, 2007), safety (Scott, 2009), comfort (width of lanes) (Li, Wang, Liu, & Ragland, 2012), and visual interest (Fleming, 2012). Building bicycle support infrastructures is one of the important steps to promote physical activity (Grow, et al., 2008). Studies focusing on the cost-benefit of walking and bicycle infrastructures address high benefit-cost ratios, implying that construction of such infrastructures can be beneficial to society (Cavill, et al., 2008; Gotschl, 2011; Sælensminde, 2004; Wang, et al., 2005). One cross-sectional research investigating data from 43 large cities in the United States found that for every 1-mile increment in the length of on-street bike lanes, there was a 1% rise in bike commuters (Dill, et al., 2003). A study conducted in New Orleans showed peaks in people cycling after the introduction of bike lanes (Parker, et al., 2013). van Duppen and Spierings (2013) shared a ride with commuters to investigate their social and built environment experiences as they moved through different parts of the city. The cycling infrastructure near to the origin of implied trips and at the destination is a crucial facilitator or possible barrier to promoting cycling. Most surveys show that the perceived traffic danger of cycling is an essential deterrent to more widespread cycling (Cleland and Walton, 2004; Dill, 2009; Snelson, Lawson, & Morris, 1993).

Prior research has also recognized predictability of road-user behavior as a critical component of safety (Wegman, et al. 2008; Elvik 2004; De Leur and Sayed 2003). Loskorn, et al. (2013) conducted a research study to determine the effect of bicycle boxes on bicyclists and motorist behavior. Fournier, et al. (2020) conducted another study, utilized a driving simulator to investigate driver behavior towards different bicycle infrastructure treatments when bicyclists' interaction does not provoke driver behavior. Monsere, et al. (2015) made a comparison of five designs for protected bike lanes at intersections without bicycle signals in order to investigate how this interaction was to occur with lane striping, green pavement markings, shared lane-use markings (sharrows), and vertical flex post delineators. Räsänen M, et al. (1999) analyzed car driver and bicyclist behavior at bicycle crossings. Regular traffic was observed before and after the law change at seven bicycle crossings in two cities (Helsinki and Hämeenlinna), at places where the priority had changed and those where no change had occurred. Dill J, et al. (2012) conducted a before-after study of bike boxes at signalized intersections in Portland, Oregon. Wu C, et al. (2012) conducted a field observational study at signalized intersections in Beijing. Summala H, et al. (1996) studied drivers' behavior at two T-intersections.

2.3 Standards and Guidelines for Bicycle Infrastructure

During the literature review task, a thorough review of several standards and guidelines were conducted. The following guidelines help to identify the level of comprehension of the bicycle infrastructure design and provide an understanding of the standards used for the bicycle infrastructures in the field.

2.3.1 American Association of State Highway and Transportation Officials (AASHTO) Guide for the Development of Bicycle Facilities

This document provides information on how to support bicycle travel and operations in most riding environments. It offers sound guidelines that result in facilities that satisfy bicyclists' needs and other highway users. Adequate compliance can help designs sensitive to the local context and incorporate bicyclists, pedestrians, and motorists' needs. It is important to mention that while the document include important design guidelines, it is not meant to be a complete design or traffic engineering manual that could replace the need for the utilization of sound principles by the knowledgeable design or traffic engineering professional. Knowledge of other elements of an overall bicycle program can be taken from state or local bicycle coordinators and other publications. Signs, signals, and pavement markings for bicycle facilities are presented in the Manual on Uniform Traffic Control Devices (MUTCD), which should be practiced in combination with this guide. If there is any inconsistency between this guide's content and the current edition of the MUTCD, then the MUTCD supersedes this guide for that case.

2.3.2 Federal Highway Administration (FHWA) Manual on Uniform Traffic Control Devices

The Manual on Uniform Traffic Control Devices for Streets and Highways or MUTCD is a document issued by the Federal Highway Administration (FHWA) which sets the standards practiced nationwide to install and maintain traffic control devices on all public streets, highways, bikeways, and private roads permitted to public travel. This manual includes the shapes, colors, and fonts used in road markings and signs, which are updated periodically to support the nation's changing transportation needs and addresses new safety technologies, traffic control tools, and traffic management systems. In the United States, all traffic control devices need to correspond to these standards legally. This manual is used by state and local agencies and private construction firms to ensure that the traffic control devices they practice conform to the national standard. While some states have developed their own sets of standards, including their own MUTCDs, those need to substantially conform to the federal MUTCD.

2.3.3 National Association of City Transportation Officials (NACTO) Urban Bikeway Design Guide

The goal of the NACTO Urban Bikeway Design Guide (part of the Cities for Cycling initiative) is to provide the city engineers with the state-of-the-practice designs in order to support create complete streets that are safe and enjoyable for bicyclists. The NACTO Urban Bikeway Design Guide is based on the experience of the world's best cycling cities. Most of these practices are not directly referenced in the current versions of the AASHTO Guide to Bikeway Facilities or the MUTCD. However, many of the factors are observed within this guide. The Federal Highway Administration has posted information concerning the approval status of various bicycle-related treatments including several of the NACTO Urban Bikeway Design Guide treatments. The NACTO Urban Bikeway Design Guide treatments are in use internationally and in many U.S. cities. The NACTO Guide can be used by individual cities, counties, or states as either a stand-alone document or as an addition to other guidelines. The NACTO Guide is updated regularly and has an extensive website. It is vital to note that many urban conditions are complex; and the procedures must be tailored to the individual cases. Therefore, the NACTO Urban Bikeway Design Guide helps practitioners make the right decisions about urban bikeway design.

2.4 Bicycle Facility Design

This section of the report describes the important elements of bicycle facilities and their characteristics to safely accommodate the users. First, different types of bicycle facilities will be introduced. Then, the related intersection treatments are presented and the signs for bicycle facilities will be presented.

2.4.1 Bike Lane

A bike lane is defined as a portion of the roadway that has been designated by color, striping, signage, pavement markings, and intersection treatments for the preferential or exclusive use of bicyclists. It enables bicyclists to ride at their preferred speed, even when adjacent traffic speeds up or slows down. Bike lanes encourage bicyclists to ride on the roadway in a position where they are more likely to be seen by motorists entering or exiting the roadway than they would be if riding on sidewalks. Bike Lanes are further characterized into four types: conventional bike lanes, buffered bike lanes, contra-flow bike lanes, and left-side bike lanes.

Conventional Bike Lane

Conventional bike lanes run along the curbs on the streets when no parking is present, adjacent to parked cars on the right-hand side of the street or on the left-hand side of the street in specific situations.

Figure 2.1: Conventional Bike Lane (source: *Bike Cleveland*)

Buffered Bike Lane

Buffered bike lanes are similar to conventional bicycle lanes but with the added benefit of providing a buffer space that separates the bicycle lane from the adjacent motor vehicle travel lane and/or parking lane.

Figure 2.2: Buffered Bike Lane (source: *NACTO*)

Contra-Flow Bicycle Lane

Contra-flow bicycle lanes are bicycle lanes designed to allow bicyclists to travel in the opposite direction of motor vehicle traffic on a one-way street. This makes a one-way traffic street into a two-way street while still acting as a one-way for motor vehicles (one direction for motor vehicles and bikes, and the other for bikes only). Contra-flow lanes are separated with yellow center lane striping.

Figure 2.3: Contra-Flow Bike Lane (source: *Randolph RVA*)

Left-Side Bike Lane
Left-side bike lanes are identical to the conventional bike lanes but are located on the left side of one-way streets or two-way median divided streets.

Figure 2.4: Left-Side Bike Lane (source: *Randolph RVA*)

2.4.2 Cycle Track

A cycle track is an exclusive bike facility that combines the user experience of a separated path with the on-street infrastructure of a conventional bike lane. Cycle tracks are distinguished from bike lanes in that they have physical barriers (bollards, medians, raised curbs, etc.). Cycle tracks provide space that is intended to be exclusively or primarily used for bicycles, and are separated from motor vehicle travel lanes, parking lanes, and sidewalks. Cycle Tracks are further characterized into three types: one-way protected cycle track, raised cycle track, and two-way cycle track.

One-Way Protected Cycle Track
One-way protected cycle tracks are bikeways that are at street level and use a variety of methods for physical protection from passing traffic. A one-way protected cycle track may be combined with a parking lane or other barrier between the cycle track and the motor vehicle travel lane.

Figure 2.5: One-Way Protected Cycle Track (Source: *Inspire Boulder*)

Raised Cycle Track

Raised cycle tracks are bicycle facilities that are vertically separated from motor vehicle traffic. Raised cycle track may be paired with a furnishing zone between the cycle track and motor vehicle travel lane and/or pedestrian area.

Figure 2.6: Raised Cycle Track (source: *NACTO*)

Two-Way Cycle Track

Two-way cycle tracks are physically separated cycle tracks that allow bicycle movement in both directions on one side of the road. A two-way cycle track may be configured as a protected cycle track - at street level with a parking lane or other barrier between the cycle track and the motor vehicle travel lane - and/or as a raised cycle track to provide vertical separation from the adjacent motor vehicle lane.

Figure 2.7: Two-Way Cycle Track (source: *Off Track San Francisco*)

2.4.3 Shared Lane

Bicycles may be operated on all roadways except where prohibited by statute or regulation. In most instances, bicyclists and motor vehicles share the same travel lanes. Shared lanes are lanes of traveled ways that are open to bicycle travel and vehicular use.

Figure 2.8: Shared Lane (source: *NACTO)*

2.4.4 Bicycle Boulevards

Bicycle boulevards are streets with low-volume low-speed motorized traffic, designed to offer priority for bicyclists operating within the roadway. Bicycle boulevards combine pavement markings, signs, and traffic-calming measures to enhance the safety, comfort, and priority of bicyclists traveling along the street.

Figure 2.9: Bicycle Boulevard (source: *NACTO)*

2.4.5 Paved Shoulders

Adding or improving paved shoulders can greatly improve bicyclist accommodation on roadways with higher speeds or traffic volumes, as well as benefit motorists. Paved shoulders, similar to bike lanes, provide separated space for the operation of bicycles. However, they are not considered travel lanes (unlike bike lanes), and therefore may be used for temporary storage of disabled vehicles and vehicle parking, unless prohibited. Paved shoulders are most often used on rural roadways.

Figure 2.10: Paved Shoulder (source: *FHWA*)

2.4.6 Intersection Treatment

Intersection treatments are designed to improve bicycle access and safety. Intersections with bicycle facilities should be designed in such a way to reduce conflicts between bicyclists and vehicles by heightening the level of visibility, denoting a clear right-of-way, and facilitating eye contact and awareness with competing modes. The configuration of a safe intersection for bicyclists may include elements such as color, signage, medians, signal detection, and pavement markings. *Bike Box*, *Two-Stage Turn Queue Box*, *Median Refuge Island*, *Through Bike Lane*, *Combined Bike Lane / Turn Lane*, *Cycle Track Intersection Approach*, and *Intersection Crossing Marking* are among the intersection treatments that will be described in this section.

Bike Box
A bike box is a treatment that allows bicyclists to move in front of vehicles when stopped at a signalized intersection. It consists of a marked or colored waiting area that provides bicyclists

with a safe and visible way to get ahead of queuing traffic during the red signal phase and minimizes turning conflicts.

Figure 2.11: Bike Box (source: *WEAU 13 News*)

Two-Stage Turn Queue Box

Two-stage turn queue boxes are designed to provide a safe way for bicyclists to make left turns at multi-lane signalized intersections from a right-side cycle track or bike lane, or right turns from a left side cycle track or bike lane. This type of treatment may also be used at unsignalized intersections to simplify turns from a bicycle lane or cycle track, as for example, onto a bicycle boulevard.

Figure 2.12: Two-Stage Turn Queue Box (source: *Maricopa Association of Governments*)

Median Refuge Island

Median refuge islands are protected spaces located in the center of the street to help improve bicycle and pedestrian crossings. Crossings of two-way streets are facilitated by allowing bicyclists and pedestrians to navigate only one direction of traffic at a time. They minimize bicyclist and pedestrian exposure by shortening crossing distance and increasing the number of available gaps for crossing.

Figure 2.13: Median Refugee Island (source: *NACTO*)

Through Bike Lanes

For bicyclists traveling in a conventional bike lane or from a truncated cycle track, the approach to an intersection with vehicular turn lanes can present a significant challenge. For this reason, it is vital that bicyclists are provided with an opportunity to correctly position themselves to avoid conflicts with turning vehicles. Through bike lanes in intersections are intended to reduce the risk of crashes and increase bicyclist comfort by reducing conflicts between turning drivers and bicycle through traffic.

Figure 2.14: Through Bike Lane (source: *NACTO*)

Combined Bike Lane / Turn Lane

Where there isn't room for an on-street bike lane and a turn lane, a combined bike lane/turn lane creates a shared lane including a suggested bike lane within the inside portion of a dedicated motor vehicle turn lane. This treatment includes signage advising motorists and bicyclists of proper positioning within the lane: shared lane markings within a right-turn only lane. When configured on a cycle track corridor, the combined lane is commonly called a mixing zone, and is intended to minimize conflicts with turning vehicles at intersections as an alternative to an exclusive bike signal phase.

Figure 2.15: Combined Bike Lane / Turn Lane (source: *Arizona Bike Law*)

Cycle Track Intersection Approach

The approach to an intersection from a cycle track should be designed not only to provide connections to intersecting bicycle facility types but also to reduce turn conflicts for bicyclist. This is typically achieved by removing the protected cycle track barrier or parking lane (or lowering a raised cycle track to street level) and shifting the bicycle lane to be closer to or shared with the adjacent motor vehicle lane. At such intersections, the experience is similar to a conventional bike lane and may involve similar applications of merging area treatments, combined bike lane / turn lane, and intersection crossing markings.

Figure 2.16: Cycle Track Intersection Approach (source: *NACTO*)

Intersection Crossing Marking

Intersection crossing markings indicate the intended path of bicyclists across an intersection with dotted lines or elephant feet and optional green paint. They guide bicyclists on a safe and direct path through intersections by providing a clear boundary between the paths of through bicyclists and either through or crossing motor vehicles in the adjacent lane.

Figure 2.17: Intersection Crossing Marking with Dotted Lines (source: *bikeSauce*)

Figure 2.18: Intersection Crossing Marking with Elephant Feet (*source: Flickr*)

Figure 2.19: Intersection Crossing Marking with Dotted Lines and Colored Conflict Area (source: *NACTO*)

Figure 2.20: Intersection Crossing Marking with Dotted Lines and Shared Lane Marking (source: *NACTO*)

Figure 2.21: Intersection Crossing Marking with Dotted Lines and Chevrons (source: *City of Toronto*)

2.4.7 Signs for Bicycles

This section covers the signs specifically related to bicycle operation on both roadways and shared-use paths. Regulatory signs shall be used to inform bicycle facility users of selected traffic laws or regulations and indicate the applicability of the legal requirements (Figure 2.22). Warning signs call attention to unexpected conditions on or adjacent to a bicycle facility and to situations that might not be readily apparent to road users. Warning signs alert users to conditions that might call for a reduction of speed or an action in the interest of safety and efficient traffic operations (Figure 2.23). Guide signs are essential to direct users along bicycle facilities, to inform them of intersecting routes, to direct them to cities, towns, villages, or other important destinations, to identify nearby rivers and streams, parks, forests, and historical sites, and generally to give such information as will help them along their way in the most simple, direct manner possible (Figure 2.24).

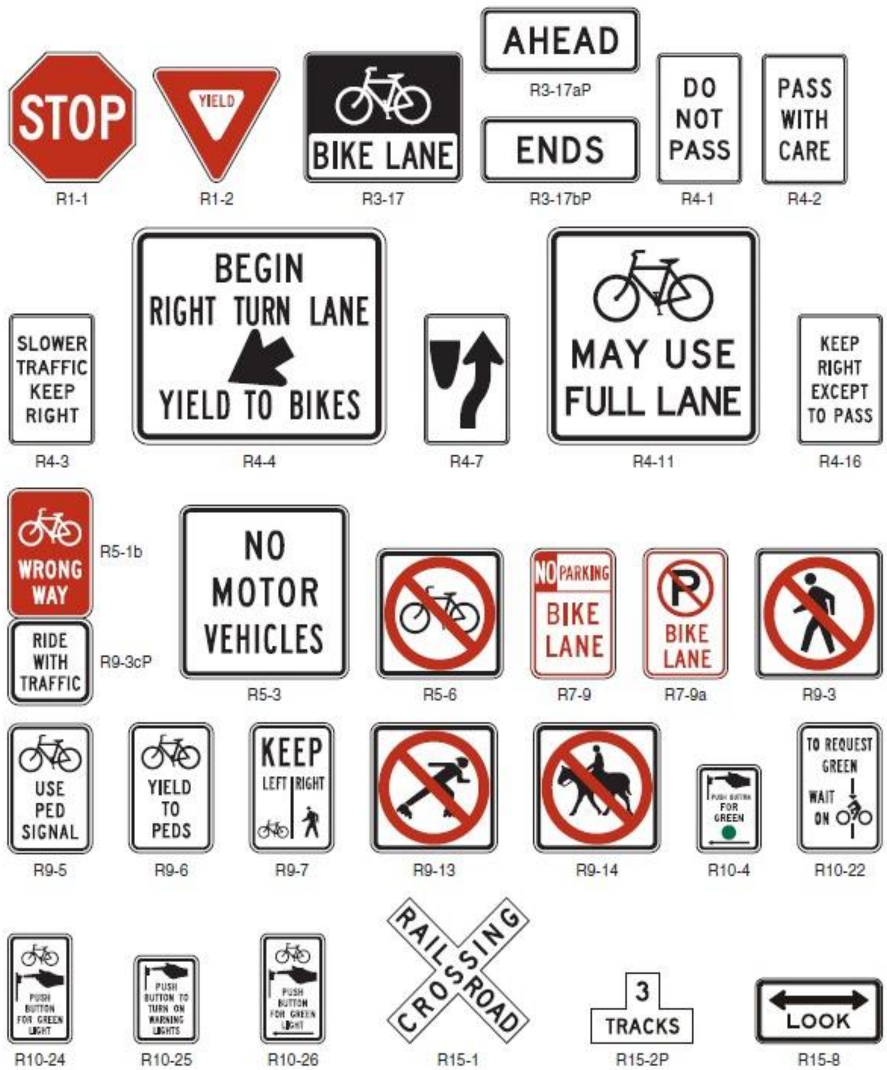
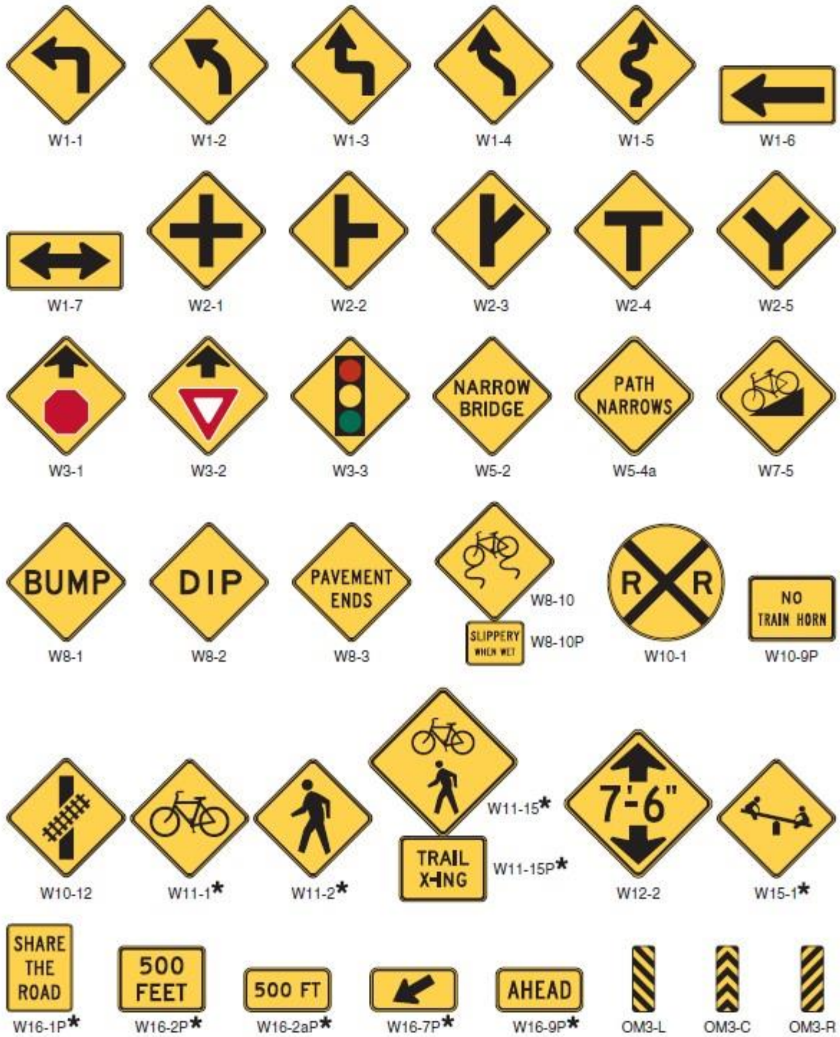


Figure 2.22: Regulatory Signs and Plaques for Bicycle Facilities (source: *MUTCD*)



* A fluorescent yellow-green background color may be used for this sign or plaque. The background color of the plaque should match the color of the warning sign that it supplements.

Figure 2.23: Warning Signs, Plaques, and Object Markers for Bicycle Facilities (source: *MUTCD*)

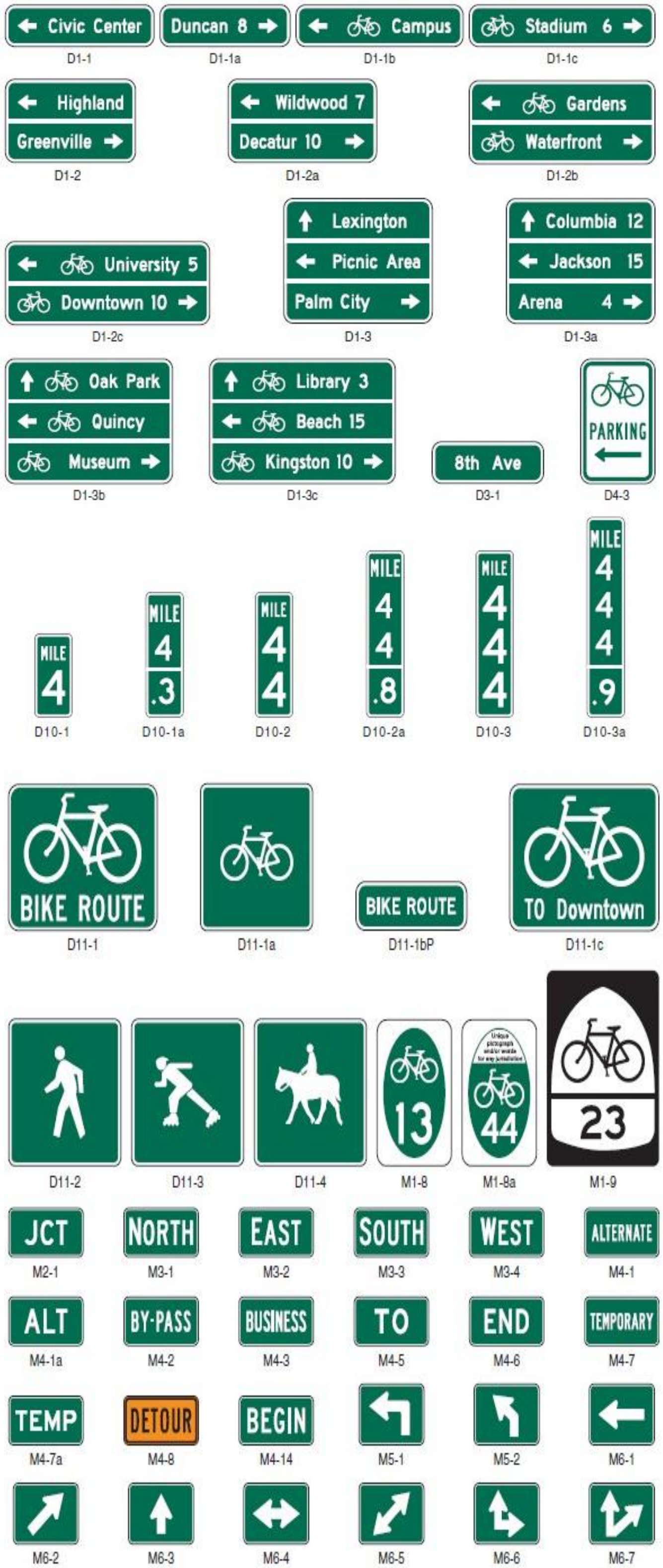


Figure 2.24: Guide Signs and Plaques for Bicycle Facilities (source: *MUTCD*)

2.5 Summary

The studies show that there is a positive correlation between constructing bicycle lanes and increase in bike commuters. However, there is a need to investigate the impact of bicycle corridor improvements on user behaviors. The Houston City Council has approved an ambitious bike plan to improve the city bikeways. While, there hasn't been any previous study the effect of the improvement on the bicyclist.

Chapter 3. Solution Methodology

3.1 Introduction

To investigate the impact of bicycle corridor improvements on user behaviors, the information related to the characteristics of the bicycle facilities at each of the study locations was gathered. Then, the cyclist data at the study locations were collected. After reviewing and summarizing, the data was analyzed to compare the user behaviors in different locations with and without bicycle facility improvement. The following sections describe the locations selected for the study, the forms developed for the data collection, and the data collected at each site with and without improvement. Finally, the last section in the chapter includes the analysis of the collected data in different locations with and without bicycle facility improvement.

3.2 Data Collection Location

The Greater Houston metropolitan area, which is a rapidly growing region, is the fifth most populous metropolitan statistical area in the United States. The City of Houston, which is the principal city in this metropolitan area, itself has a population of 2.3 million and is the fourth most populous city in the nation. However, despite its growth and population, it is one of the least densely populated among the great cities. Like many post-war growth cities, the city is sprawling and car-dependent. It is the reason that, even with an improved transit system, traveling and commuting in the city remains dominated by automobiles. Some major cities have improved their first-mile/last-mile transit problems by motivating the residents to use bicycles. However, in Houston, the low proportion of the people riding bicycle as a part of their daily commute can be attributed in part to the existing fragmented network of bike lanes on uncomfortable and dangerous streets throughout the city. As Figure 3.1 shows, the major part of the Houston bike network includes shared and low-comfort bike lanes.

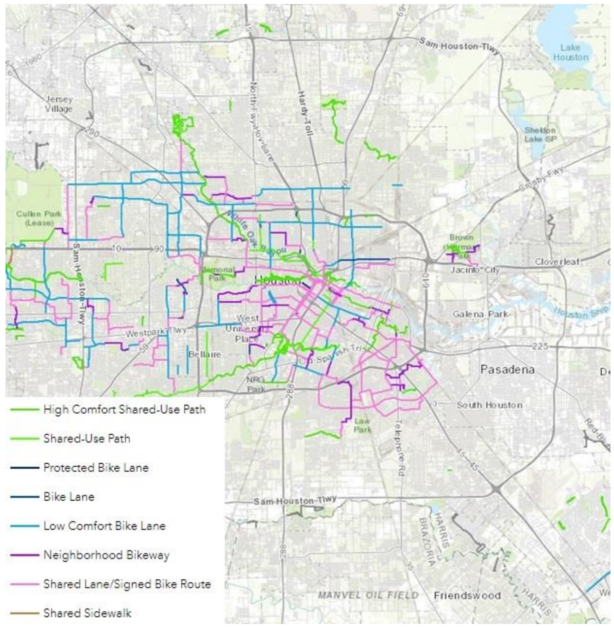


Figure 3.1: Houston Bike Network Map

In the recent years, the city has started planning bicycle infrastructure improvements to help make Houston a safer, healthier, more bike-friendly city for the growing number of people riding bikes. Few projects started and have been already completed, and several other projects are in planning and design phases or under construction. Due to the short duration of this research project, it was not feasible to find the bicycle facilities whose infrastructure improvements had been designed, planned, and implemented during the project in order to compare the user behaviors before and after the improvements. Instead, pairs of locations (bike facilities) with and without bicycle facility improvement were selected which had other similar geometric and environmental characteristics in terms of users (automobile drivers and bicyclists) and traffic volumes. Therefore, each study location was selected geographically close to its corresponding pair. Furthermore, different pairs were selected in different areas of the city: downtown of Houston which is a central business district (CBD), and Greater Heights which is a residential area. The locations selected for the data collection were:

- intersection of Webster St. and Bagby St. (*CBD*)
- intersection of Gray St. and Bagby St. (*CBD*)
- intersection of Lawrence St. and W. 11th St. (*residential neighborhood*)
- intersection of Nicholson St. and W. 11th St. (*residential neighborhood*)

Figures 3.2 and 3.3 show the locations of the pair intersections.

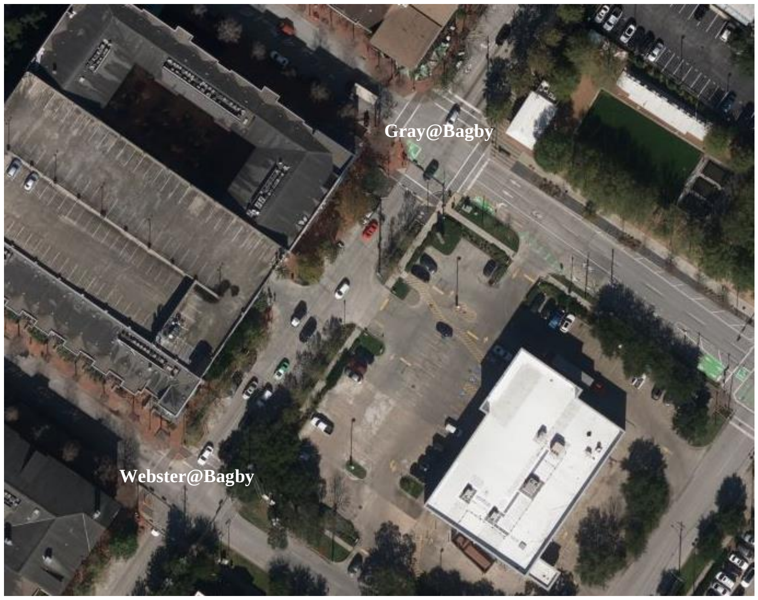


Figure 3.2: Intersections of Webster@Bagby and Gray@Bagby

Figure 3.3: Intersections of Lawrence@W. 11th and Nicholson@W. 11th

3.3 Data Collection

The data for the research were collected from various sources, including City of Houston, and the Houston-Galveston Area Council, and through site visit. The City of Houston and Houston-Galveston Area Council provided the information related to bike lanes and corridor improvements. Google Earth provided the basic geometry of the facilities such as number and width of lanes. However, it was required to conduct site visits to confirm them and collect other information related to the characteristics of the bicycle facilities and infrastructures at each of the study locations. Furthermore, it was necessary to collect the cyclist data in order to compare the behaviors at the different sites with and without bicycle facility improvement. Therefore, all corresponding forms were developed to be used during the site visits and data collection.

3.3.1 Facility Data Collection Form

This part of the report describes the form that was developed for the facility data collection. The data collection form comprised different sections that required to be filled out before and during the site visit. Those sections are detailed below.

Site Location
It includes the information related to the site number, its location and a satellite map view of the intersection.

Street Type
This section identifies if the facility and the crossing street are one-way or two-way streets. Bike infrastructure planning and accommodation can be different for one-way versus two-way streets. Also, one-way street can simplify crossing for cyclists. On the other hand, the vehicles on one-way streets may higher speeds which may create safety hazards for the cyclists.

Figure 3.4: One-Way vs. Two-Way Street
(source: *Florida Bicycle Association* and *Times of San Diego*)

Posted Speed
To examine the cyclists' safety, the form asks what the posted speed limit of the approach street is. The information is important because cyclists usually feel safer when vehicles are traveling at lower speeds. The recommended speed limit for shared lanes is 35 mph or less.

Figure 3.5: Speed Limit (source: *KUT*)

Number of Lanes and Lane Width
It includes the questions about number of lanes, lane width, and bike lane width. Lane widths of 10 feet generally provide adequate safety in urban settings while discouraging speeding. The recommended width for bike lanes is 5 ft (1.5 m). On extremely constrained, low-speed roadways with curbs but no gutter, the preferred width for bike lanes cannot be achieved despite narrowing all other travel lanes to their minimum widths, a 4-ft (1.2 m) wide bike lane can be used (AASHTO).

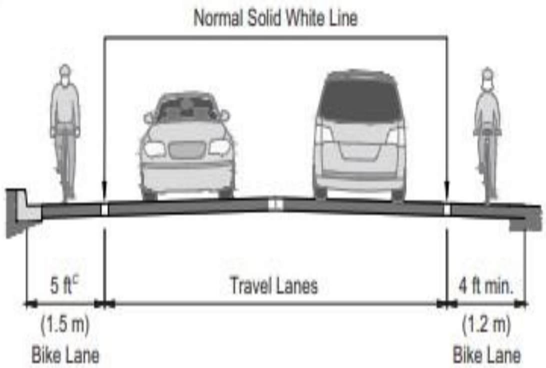


Figure 3.6: Lane Width (source: *AASHTO*)

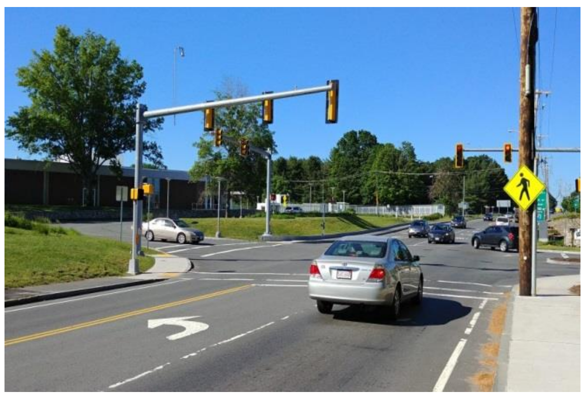
Type of Bicycle Facility
It is to identify the existing facility used by the cyclists, i.e., bike lane, cycle track or protected bike lane, shared roadway, bicycle boulevard, or paved shoulder. It also identifies the type of the facility in case it is a bike lane (i.e. conventional, buffered, contra-flow, or left-side bike lane) or cycle track (i.e. one-way protected, raised, or two-way cycle track).

Type of Intersection Control
Design of intersections has a significant impact on users' comfort and mobility. Intersection design addresses cross-traffic movements and addresses turning movements of riders entering and exiting the path. Due to potential conflicts at intersections, the intersection control design should provide the orderly movement of cyclists and other traffic. The form asks about the type of intersection control, whether it is signalized or unsignalized (yield-sign or stop-sign controlled). Left-turn crashes are one of the most predominant crash types associated with

serious injuries and fatalities. Thus, the next question identifies the type of left-turn control (protected, permitted, or protected-permitted) in case the intersection is signalized

Yield-Sign Controlled Intersection (source: *UIIG*)

Stop-Sign Controlled Intersection (source: *Washington Bikes*)



Signalized Intersection (source: *Bayside Engineering*)

Figure 3.7: Different Types of Intersection

Bicycle and Pedestrian Signal

Signals may be, or to decrease vehicle or pedestrian conflicts.

The form asks about any existing bicycle signal, beacon, or pedestrian signal that can be used by cyclists. Bicycle signals and beacons, installed at major crossings or in a protected bicycle facility such as a cycle track with potential turning conflicts, increase cyclist's safety and operation when crossing the streets. Bicycle signals make crossing intersections safer for cyclists by clarifying when to enter the intersection and by restricting or decreasing vehicle, bicycle, or pedestrian conflicts. An intersection with bicycle signals may reduce stress and delays for a crossing bicyclist, and discourage illegal and unsafe crossing maneuvers. Furthermore, beacons, including Rectangular Rapid-Flashing Beacons (RRFB) and High intensity Activated cross WalK (HAWK) (also known as the pedestrian hybrid beacon), are utilized at unsignalized intersection to facilitate for cyclists and pedestrians crossing the street.

Bicycle Signal Head (source: NACTO)

Pedestrian Hybrid Beacon (HAWK) (source: *Crafton Tull*)

Pedestrian Signal Head (source: *amNY*)

Figure 3.8: Bicycle and Pedestrian Signal

Pavement Type

The next question asks about the pavement condition. Pavement conditions can significantly affect safety and riding experience, as cyclists ride on lightweight two-wheeled vehicles with narrow, high-pressure tires. Rough surfaces and poor pavement conditions can cause cyclists to lose control, resulting in safety issues.

Figure 3.9: Pavement Condition (source: *Seattle Bike Blog*)

Uncovered Storm Drains and Roadway Hazards
Bicyclists prefer smooth surfaces for their trips. However, obstacles such as uncovered storm drains, potholes, utility repairs and road debris require lane changes or even wrecks for cyclists. Surface regularities is also critical to cyclists as irregularities prevent water from entering drain grates. Therefore, the next questions identify if the existing storm drains have appropriate coverings, and if any roadway hazards exist along the bike facilities at the time of data collection.


Sewer Grate Road Hazard (source: *m-bike.org*) **Uncovered Storm Drain (source: *SeeClickFix*)**

Figure 3.10: Roadway Hazards

Nearby Parking Garage and Alley
The form asks if there is any parking garage entrance/exit or alley close to the intersection, as they may cause an additional conflict point for the cyclists using the facility.

Figure 3.11: Parking Garage Entrance/Exit Close to an Intersection (source: *Union Depot*)

Bike Lane Marking
One of the most important aspects of a safe and efficient roadway is the uniform application of pavement markings to delineate the roadway path and specific traffic lanes for motorists and bicyclists. Pavement markings provide continuous information to road users related to the roadway alignment, vehicle and bicycle positioning, and other critical driving-related tasks. The

facility data collection form asks about the type of existing bike lane markings such as lane stripping, shared lane markings (sharrows), and word, symbol, and arrow markings. Sharrows are white pavement markings showing a bicycle symbol with two chevrons on top, used to indicate a shared lane environment for bicycles and automobiles.

Figure 3.12: Shared Lane Markings (Sharrows) (source: *Streetsblog*)

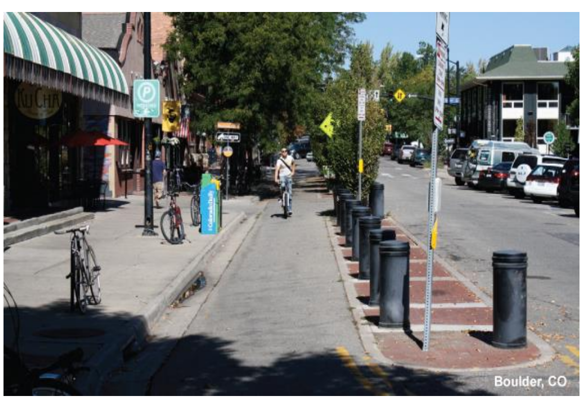
Colored pavement and using word, symbol, and arrow markings within a bicycle lane increases the visibility of the facility, identifies potential areas of conflict, and reinforces priority to bicyclists in conflict areas and in areas with pressure for illegal parking. Colored pavement can be utilized as facility (corridor or spot) improvements and treatments. Colored pavement for corridor improvement/treatment is along the lengths of bike lanes or cycle tracks. Colored pavement for spot improvements/treatments include bike boxes, conflict areas, and intersection crossing markings. Consistent application of color across a bikeway corridor is important to promote clear understanding for all users.

Figure 3.13: Colored Pavement (source: *Transpo*)

Figure 3.14: Word, Symbol, and Arrow Markings (Source: *NACTO* and *City of San Antonio*)

Intersection Crossing Marking
The question is to identify the type of the intersection crossing marking. Dotted lines, dotted lines with chevrons, dotted lines with shared lane marking, dotted lines with colored pavement, and elephant feet are different bicycle pavement markings through intersections that indicate the intended path of bicyclists.

Cycle Track Physical Separation
Cycle tracks and protected bike lanes provide space that is intended to be exclusively or primarily used for bicycles, and are physically separated from motor vehicle travel lanes, parking lanes, and sidewalks. The form asks about the type of physical separation that has been used for the cycle track or protected bike lane. The physical separation can be in the form of flexible delineator posts, boulders, on-street parking, concrete barriers, planters, or trees.



Cycle Track Separated with Boulders

Cycle Track Separated with On-Street Parking

Cycle Track Separated with Planters

Figure 3.15: Physical Separations

(source: *NACTO* and *International Making Cities Livable*)

Intersection Treatment

The form then asks if there has been any improvement or treatment at the intersection. Intersection treatments are designed and implemented to improve bicycle access and safety. Examples of improvements and treatments are implementing bike boxes, two-stage turn queue boxes, median refuge islands, through bike lanes, and combined bike lanes/turn lanes.

Bicycle Facility Sign

And the last question of the facility data collection form is if there are any regulatory signs, warning signs, or guide signs and plaques installed along the bicycle facility.

Figure 3.16 shows the facility data collection form that was developed in this study. The collected facility characteristics data is also in Appendix A of this report.

Facility Data Collection Form

Date and time: Site No.:

Site Location and Satellite Map View of the Intersection

1. Approach street: ☐ one-way ☐ two-way Cross street: ☐ one-way ☐ two-way

2. Posted speed: ……..…… Number of lanes: ……..…… Lane width: ……..…… Bike lane width: ……..……

3. Type of bike facility: ☐ bike lane ☐ cycle track or protected bike lane ☐ shared roadway ☐ bicycle boulevard ☐ paved shoulders

4. Type of bike lane, if any: ☐ conventional bike lane ☐ buffered bike lane ☐ contra-flow bike lane ☐ left-side bike lanes

5. Type of cycle track, if any: ☐ one-way protected ☐ raised ☐ two-way

6. Intersection control: ☐ signal ☐ unsignalized
   If signalized, type of LT control for the approach: ☐ protected ☐ permitted ☐ protected-permitted
   If unsignalized: ☐ stop sign on the approach ☐ yield sign on the approach

7. What type of bike signal, if any? ☐ beacon ☐ bicycle signal head ☐ pedestrian signal

8. Pavement type: ☐ asphalt ☐ concrete Pavement condition: ☐ excellent ☐ good ☐ poor

9. Storm drains (any cover?): ……..……

10. Any roadway hazards? ……..……

11. Any parking garage entrance/exit or alley close to the intersection?

12. Bike lane marking: ☐ shared lane-use (sharrows) ☐ green pavement ☐ lane stripping ☐ word ☐ symbol ☐ arrow

13. Intersection crossing markings (if any): ☐ dotted lines ☐ dotted lines with chevrons ☐ dotted lines with shared lane marking ☐ dotted lines with colored pavement ☐ elephant feet

14. If cycle track, what type of physical separation? ☐ flexible delineator posts ☐ bollard ☐ on-street parking ☐ concrete barrier ☐ planters / trees

15. Intersection treatment: ☐ through bike lane ☐ bike box ☐ median refuge island ☐ combined bike lane/turn lane ☐ two-stage turn queue boxes ☐ cycle track intersection approach

16. Any bike related signing? ……..……

Figure 3.16: Facility Data Collection Form

3.3.2 Cyclist Data Collection Form

This part of the report describes the form that was developed for collecting the data related to the cyclists at different sites with and without bicycle facility improvement. The cyclist data collection form was developed in a tabular format and comprised the columns needed to be filled out for each cyclist as an observation during the data collection. The information in the columns included:

- observation (cyclist) number;
- gender of cyclist;
- observed age of cyclist: young (<30), middle-aged (30-50), and old (>50);
- if the cyclist was driving in the bike facility;
- traffic light status when the cyclist arriving at the intersection;
- if the cyclist ran the red light (in case the intersection was signalized) or stop sign at (in case the intersection was unsignalized);
- if the cyclist stopped in the bike box (in case the traffic light status was red);
- if the cyclist proceeded the intersection earlier than the adjacent motorists (after the red phase at signalized intersection);
- type of the cyclist's movement through the intersection;
- if the cyclist yielded to motorist;
- if the cyclist yielded to pedestrian; and
- any erratic or illegal movements (q-jumping, riding between stopped vehicles, etc.)

Table 3.1 shows the cyclist data collection form that was developed in this study. The data related to bicycle infrastructures along with the cyclist data were collected at different locations with and without bicycle facility improvement. The data collections at all the locations were conducted during the weekday afternoon peak hours. The collected cyclist data is in Appendix B of this report.

Table 3.1: Cyclist Data Collection Form

Site No.:											
	Gender M/F	Observed Age? Young (<30)/ Middle-Aged (30–50)/ Old (>50)	Driving in bike facility? Y/N	Traffic light status when arriving? G/Y/R	Running the red light or stop sign? Y/N	If red, stopped in the bike box? Y/N	Proceeding the intersection earlier than the motorists (after the red phase)? Y/N	Type of movement through the intersection? LT/TH/RT	Yielded to motorist? Y/N	Yielded to pedestrian? Y/N	Any erratic or illegal movements (q-jumping, riding between stopped vehs)? Y/N
1											
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3											
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3.4 Methodology

In this research, we use two proportion z-test. A two-proportion z-test allows us to compare for differences in proportions to see if they are the same (*Applied Statistics*). The section describes two proportion z-test. Consider two separate or independent populations, labeled as population 1 and population 2. We would like to compare a characteristic of interest between two populations. Assuming we take a random sample of size n_1 from population 1 and take a random sample of size n_2 from population 2, p_1 and p_2 are the proportion in the first and second samples with the characteristic of interest. If $n_1p_1 \geq 5$ and $n_1(1-p_1) \geq 5$, then $\hat{p}_1$ will follow a normal distribution with

$$\text{Mean:} \quad p_1 \tag{1}$$

$$\text{Standard Error:} \quad \sqrt{\frac{p_1(1-p_1)}{n_1}} \tag{2}$$

$$\text{Estimated Standard Error:} \quad \sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1}} \tag{3}$$

If $n_2p_2 \geq 5$ and $n_2(1-p_2) \geq 5$, then $\hat{p}_2$ will follow a normal distribution with

$$\text{Mean:} \quad p_2 \tag{4}$$

$$\text{Standard Error:} \quad \sqrt{\frac{p_2(1-p_2)}{n_2}} \tag{5}$$

$$\text{Estimated Standard Error:} \quad \sqrt{\frac{\hat{p}_2(1-\hat{p}_2)}{n_2}} \tag{6}$$

Since we have independent samples, the sampling distribution of $\hat{p}_1 - \hat{p}_2$ is approximately normal with

$$\text{Mean:} \quad p_1 - p_2 \tag{7}$$

$$\text{Standard Error:} \quad \sqrt{\frac{p_1(1-p_1)}{n_1} + \frac{p_2(1-p_2)}{n_2}} \tag{8}$$

$$\text{Estimated Standard Error:} \quad \sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}} \tag{9}$$

The $(1-\alpha)100\%$ confidence interval of $p_1 - p_2$ is given by:

$$\hat{p}_1 - \hat{p}_2 \pm z_{\alpha/2}\sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}} \tag{10}$$

For a test for two proportions, we are interested in the difference. If the difference is zero, then they are not different (i.e., they are equal). Therefore, the null hypothesis will be:

$$H_0: p_1 - p_2 = 0 \qquad (11)$$

In hypothesis testing, we assume the null hypothesis is true. In this case, it means that p_1 and p_2 are equal. Under this assumption, then $\hat{p}_1$ and then $\hat{p}_2$ are both estimating the same proportion, which we name it as p^*. Therefore, the sampling distribution of both proportions, $\hat{p}_1$ and $\hat{p}_2$, will be approximately normal centered around p^*, with standard error:

$$\sqrt{\frac{p^*(1-p^*)}{n_i}} \quad , \quad \text{for } i = 1, 2 \qquad (12)$$

We take this into account by finding an estimate for this p^* using the two sample proportions. We can calculate an estimate of p^* using the following formula:

$$\hat{p}^* = \frac{x_1 + x_2}{n_1 + n_2} \qquad (13)$$

This value is the total number in the desired categories $(x_1 + x_2)$ from both samples over the total number of sampling units in the combined sample $(n_1 + n_2)$.

Putting everything together, if we assume $p_1 = p_2$, then the sampling distribution of $\hat{p}_1 - \hat{p}_2$ will be approximately normal with mean 0 and standard error of:

$$\sqrt{p^*(1-p^*)(\frac{1}{n_1} + \frac{1}{n_2})} \qquad (14)$$

Therefore, z^* will follow a standard normal distribution.

$$z^* = \frac{(\hat{p}_1 - \hat{p}_2) - 0}{\sqrt{\hat{p}^*(1-\hat{p}^*)(\frac{1}{n_1} + \frac{1}{n_2})}} \qquad (15)$$

We can develop our hypothesis test for $p_1 - p_2$. Null:

$$H_0: p_1 - p_2 = 0 \qquad (16)$$

Possible alternatives:

$$H_a: p_1 - p_2 \neq 0 \qquad (17)$$

$$H_a: p_1 - p_2 > 0 \qquad (18)$$

$$H_a: p_1 - p_2 < 0 \qquad (19)$$

The user behaviors in different locations with and without bicycle facility improvement are analyzed through comparison of the numbers and percentage in different cases. To determine if there any significant differences between the cases, tests of statistical significance are used. All proportions are compared using a two-sided test of equality, where the null hypothesis is that no change occurred with the user behaviors and the alternative hypothesis is that the behaviors changed.

3.5 Results and Analysis

The following section describes the results of the analysis. Figures 3.17 to 3.21 show the changes in bicyclist behaviors for different cases at the intersections with and without bicycle facility improvement. Bicyclist stopping behavior is shown in Figure 3.17. The percentage of the bicyclists who stopped for the red lights or stop signs significantly increased at the intersections with improvement ($p < 0.00001$ and $p = 0.0113$).

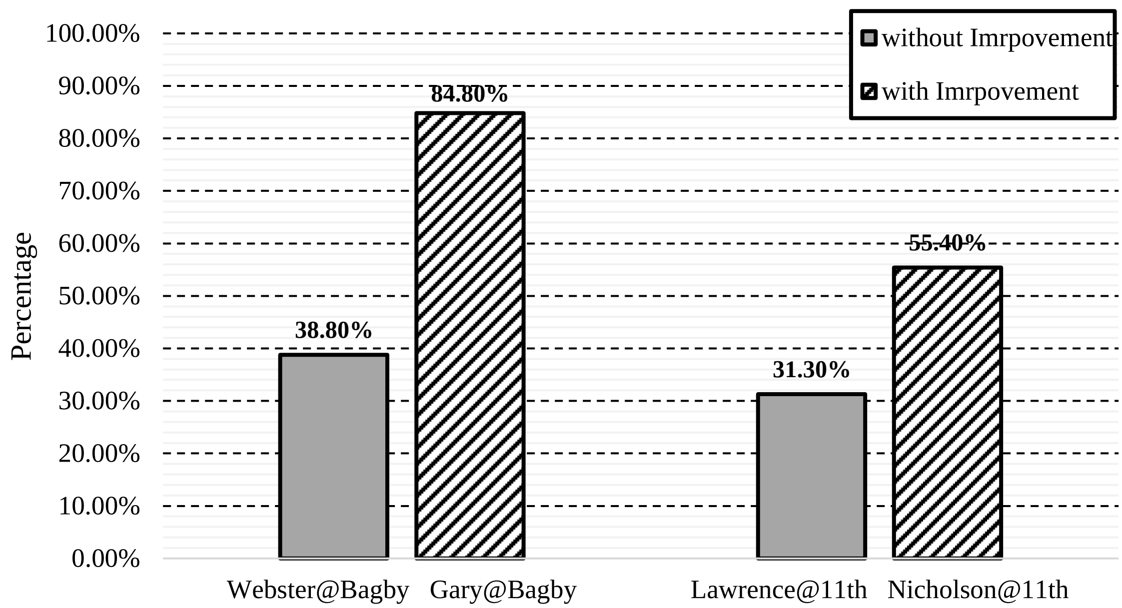

Figure 3.17: Percentage of Bicyclists Stopped for the Red Light or Stop Sign at the Intersections with and without Bicycle Facility Improvement

Figure 3.18 shows the proportion of bicyclists who proceeded the intersection after the adjacent motorists (when the green phase started). The analysis shows that the bicyclist behavior improved significantly from 38.8% to 75.8% at the intersection with bicycle facility improvement ($p = 0.00096$). The bar chart in the figure illustrates only one comparison for this behavior study since the intersections of “Lawrence and Nicholson streets with 11th” were stop-controlled. Therefore, this specific behavior study was not applicable to those intersections.

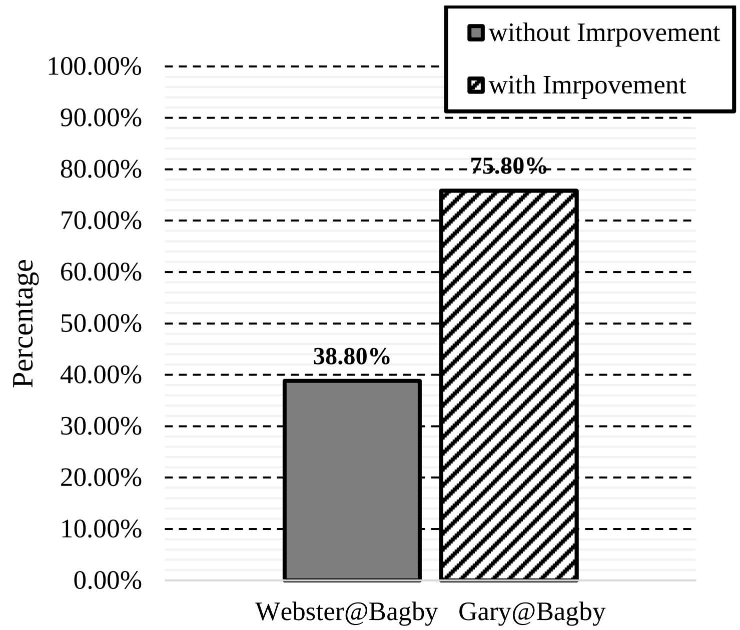

Figure 3.18: Percentage of Bicyclists Proceeded the Intersection not Earlier than the Motorists at the Intersections with and without Bicycle Facility Improvement

There was an increase in percentage of bicyclists who yielded to the motorists (Figure 3.19). However, for all the study sites, the increases were not statistically significant ($p = 0.1902$ and 0.29372).

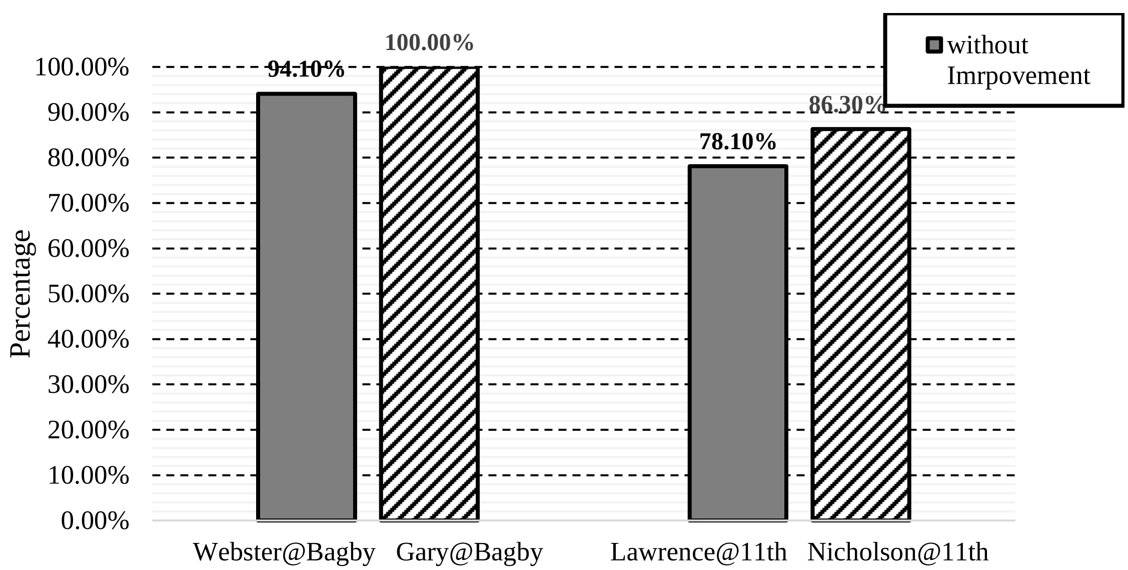

Figure 3.19: Percentage of Bicyclists Yielded to the Motorists at the Intersections with and without Bicycle Facility Improvement

Figure 3.20 shows that all the bicyclists yielded to the pedestrians at the study locations independent of any bicycle facility improvement.

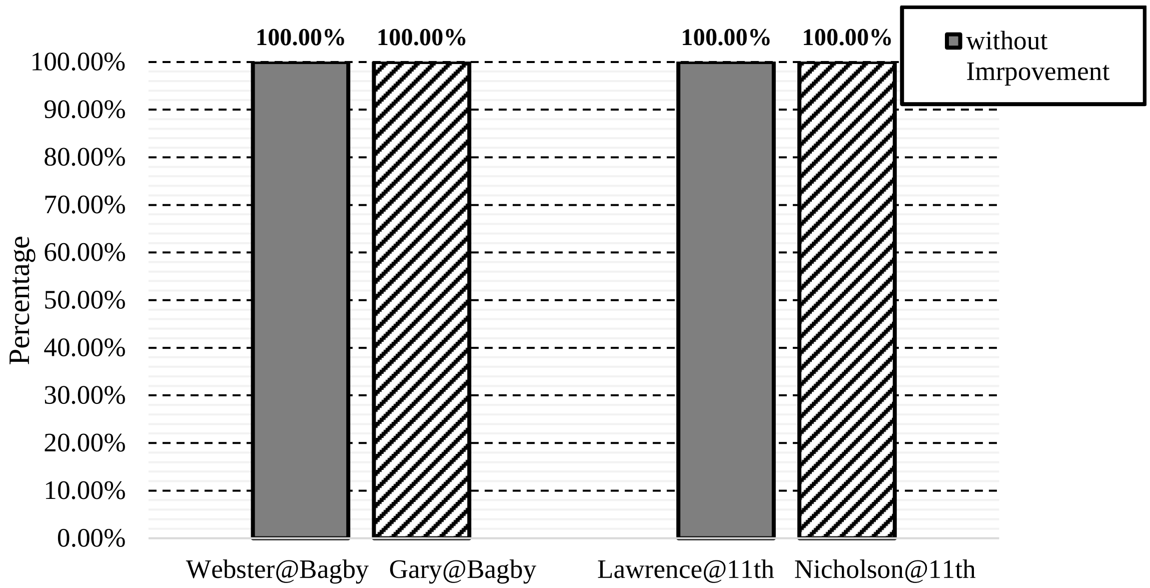

Figure 3.20: Percentage of Bicyclist Yielded to the Pedestrians at the Intersections with and without Bicycle Facility Improvement

Bicyclist non-erratic/illegal movements are compared in Figure 3.21. The figure shows that the percentage of bicyclists with no erratic/illegal movements increased significantly for the intersections with bicycle facility improvement ($p < 0.00001$ and $p = 0.03156$).

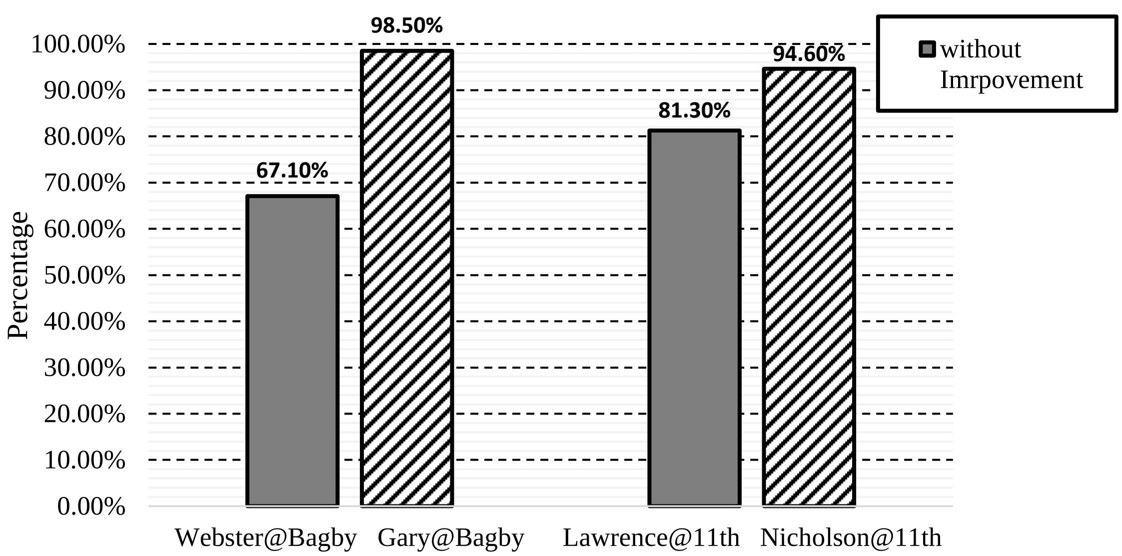

Figure 3.21: Percentage of Bicyclists with no erratic/Illegal Movements at the Intersections with and without Bicycle Facility Improvement

Table 3.2 lists the *p*-values for significance tests and comparisons of bicyclist behaviors at different locations. The second cyclist behavior in the table (*proceeding the intersection earlier than motorists after the red phase*) was required to be measured at signalized intersections. Therefore, that specific behavior study was not applicable to the intersections of "Lawrence and Nicholson streets with 11th" since they were stop-controlled intersections.

Table 3.2: P-values for Comparison of User Behaviors in the Facilities with and without Bicycle Facility Improvement

	p-value for Different Cases of Cyclist Behaviors				
	Stopping for the Red Light or Stop Sign	Proceeding the Intersection not earlier than Motorists	Yielding to Motorists	Yielding to Pedestrians	Non-erratic/illegal Movement
w/o Treatment (Webster@Bagby) vs. w Treatment (Gary@Bagby)	< 0.00001	0.00096	0.1902	1	< 0.00001
w/o Treatment (Lawrence@11th) vs. w Treatment (Nicholson@11th)	0.0113	N/A (unsignalized intersection)	0.29372	1	0.03156

3.6 Summary

The data related to bicycle infrastructures along with the cyclist data were collected at different locations with and without bicycle facility improvement. A two-sided test of equality was chosen as a comparative analysis in order to compare the user behaviors at different locations. The result of the study shows that the improvement of bicycle facilities and infrastructures has positive impacts on the user behaviors.

Chapter 4. Summary and Conclusions

4.1 Introduction

The data related to the bicycle infrastructures and the users were collected at different locations with and without bicycle facility improvement. Statistical analyses were conducted to compare the user behaviors for different cases. The rest of this chapter is organized as follows. Section 4.2 provides a summary of the results, and concludes with the author's views. Section 4.3 describes the limitations and details the directions for further research in order to improve similar studies.

4.2 Summary and Conclusions

Research has shown that increasing opportunities for bicycle transportation can reduce overall VMT and auto trips, promote economic development, and improve environmental quality and public health and physical activity. Furthermore, bike lanes and corridors improve the transportation mobility by reducing interaction between automobiles and bicycles, allowing the cyclist to travel at self-paced speeds, without disrupting traffic flow. Bicycle behavior is more predictable using bike lanes, guiding the interaction between bicycles and automobiles, where bicyclists remain inside the lane unless turning, passing, or avoiding hazards within the bike lane. Reducing hazards within the bicycling corridors reduces erratic bicycle behavior and has greater opportunity to facilitate the overall network benefits from the bike lane. Investments in bicycle infrastructure improve mobility and provide cyclists and potential cyclists a safer environment to cycle to work and to public transit nodes. It also maximizes mobility in major cities by solving the first mile – last mile challenge of public transportation networks. First and last mile issues essentially refer to connectivity between public transport nodes and the user's origins and destinations in multimodal transportation.

The proposed project was to identify the impacts of bicycle corridor improvements on user behaviors. The research provided an analysis of the effects of the corridors treatments and improvements and it explores bicyclist behavior by observing and collecting the data at different locations with and without bicycle corridor improvements. Statistical analyses were conducted to compare the user behaviors at the locations. The result of the study showed that the improvement of bicycle facilities and infrastructures positively impacted on the user behaviors. The analyses show that percentage of the bicyclists that stopped for the red lights or stop signs significantly increased at the intersections with improvement. Additionally, the percentage of bicyclist with no erratic/illegal movements increased significantly for the intersections with improvement. The analysis also showed that the bicyclist behavior in proceeding the intersection after the adjacent motorists (when the green phase started) was improved significantly at the intersection with improvement. However, there was no significant changes in the bicyclist behaviors for the cases of yielding to motorists and pedestrians. In fact, high compliance rates of the bicyclists in terms of yielding to motorists and pedestrians were observed even at the intersections without the improvement.

The findings of this research add to existing knowledge around the relationship between bicycle infrastructure investments and bicycle travel behavior, which may help to provide direct policy guidance for future investments.

4.3 Directions for Future Research

Although this research provides insights into the user behaviors with respect to improving the bicycle facility, one limitation should be noted is that the results of the study would be better to be further confirmed for before- and after- improvements of individual sites. An alternative method could be conducting an experimental study in a controlled environment through designing the before- and after-improvement scenarios in a bike simulator facility.

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Appendix A: Completed Facility Data Collection Forms

The facility data collection forms, which were completed during the site visits, are in the next pages.

Site No.: 1 - Intersection of Webster St. and Bagby St. (without Bicycle Facility Improvement)

1. Approach street: ☒ one-way ☐ two-way Cross street: ☒ one-way ☐ two-way

2. Posted speed: 30 mph Number of lanes: 2 Lane width: 12 ft Bike lane width: N/A

3. Type of bike facility: ☐ bike lane ☐ cycle track or protected bike lane ☐ shared roadway ☐ bicycle boulevard ☐ paved shoulders

4. Type of bike lane, if any: ☐ conventional bike lane ☐ buffered bike lane ☐ contra-flow bike lane ☐ left-side bike lanes

5. Type of cycle track, if any: ☐ one-way protected ☐ raised ☐ two-way

6. Intersection control: ☒ signal ☐ unsignalized
   If signalized, type of LT control for the approach: ☐ protected ☐ permitted ☐ protected-permitted
   If unsignalized: ☐ stop sign on the approach ☐ yield sign on the approach

7. What type of bike signal, if any? ☐ beacon ☐ bicycle signal head ☐ pedestrian signal

8. Pavement type: ☐ asphalt ☒ concrete Pavement condition: ☐ excellent ☒ good ☐ poor

9. Storm drains (any cover?): N/A

10. Any roadway hazards? No

11. Any parking garage entrance/exit or alley close to the intersection? No

12. Bike lane marking: ☐ shared lane-use (sharrows) ☐ green pavement ☐ lane stripping ☐ word ☐ symbol ☐ arrow

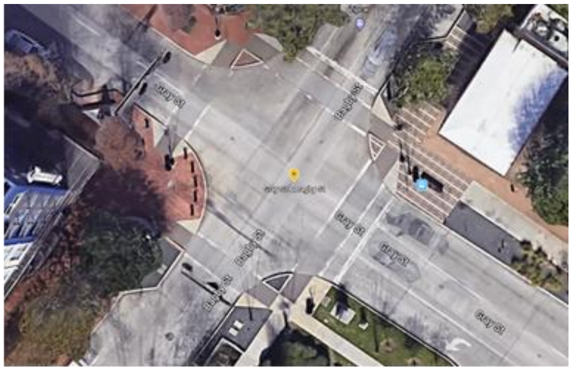
13. Intersection crossing markings (if any): ☐ dotted lines ☐ dotted lines with chevrons ☐ dotted lines with shared lane marking ☐ dotted lines with colored pavement ☐ elephant feet

14. If cycle track, what type of physical separation? ☐ flexible delineator post ☐ bollard ☐ on-street parking ☐ concrete barrier ☐ planters / trees

15. Intersection treatment: ☐ through bike lane ☐ bike box ☐ median refuge island ☐ combined bike lane/turn lane ☐ two-stage Turn queue boxes ☐ cycle track intersection approach

16. Any bike related signing? No

Site No.: 2 - Intersection of Gray St. and Bagby St. (with Bicycle Facility Improvement)



1. Approach Street: ☒ one-way ☐ two-way Cross street: ☒ one-way ☐ two-way

2(a). Posted speed: 30 mph Number of lanes: 3 Lane width: 9 ft Bike lane width: 4 ft

3. Type of bike facility: ☒ bike lane ☐ cycle track or protected bike lane ☐ shared roadway ☐ bicycle boulevard ☐ paved shoulders

4. Type of bike lane (if any): ☐ conventional bike lane ☐ buffered bike lane ☒ contra-flow bike lane ☐ left-side bike lanes

5. Type of cycle track (if any): ☐ one-way protected ☐ raised ☐ 2-way

6. Intersection control: ☒ signal ☐ unsignalized
 If signalized, type of LT control for the approach: ☒ protected ☐ permitted ☐ protected-permitted
 If unsignalized: ☐ stop sign on the approach ☐ yield sign on the approach

7. What type of bike signal, if any? ☐ beacon ☐ bicycle signal head ☒ pedestrian signal

8. Pavement type: ☐ asphalt ☒ concrete Pavement condition: ☒ excellent ☐ good ☐ poor

9. Storm drains (any cover?): N/A

10. Any roadway hazards? No

11. Any parking garage entrance/exit or alley close to the intersection? No

12. Bike lane marking: ☒ shared lane-use (sharrows) ☒ green pavement ☒ lane stripping ☐ word ☒ symbol ☒ arrow

13. Intersection crossing markings (if any): ☐ dotted lines ☐ dotted lines with chevrons ☐ dotted lines with shared lane marking ☒ dotted lines with colored pavement ☐ elephant feet

14. If cycle track, what type of physical separation? ☐ flexible delineator post ☐ bollard ☐ on-street parking ☐ concrete barrier ☐ planters / trees

15. Intersection treatment: ☐ through bike lane ☐ bike box ☐ median refuge island ☐ combined bike lane/turn lane ☒ two-Stage turn queue boxes ☐ cycle track intersection approach

16. Any bike related signing? "*Cyclist Left Turn My Use Side Box*", "*Right Turn Except Bycilcists*", "*Bike Left Turn Box*", R3-17, R9-5, R5-1b

Site No.: 3 - Intersection of Lawrence St. and W. 11th St. (without Bicycle Facility Improvement)

1. Approach street: ☐ one-way ☒ two-way Cross street: ☐ one-way ☒ two-way

2. Posted speed: 30 mph Number of lanes: 2 Lane width: 12 ft Bike lane width: N/A

3. Type of bike facility: ☐ bike lane ☐ cycle track or protected bike lane ☐ shared roadway ☐ bicycle boulevard ☐ paved shoulders

4. Type of bike lane, if any: ☐ conventional bike lane ☐ buffered bike lane ☐ contra-flow bike lane ☐ left-side bike lanes

5. Type of cycle track, if any: ☐ one-way protected ☐ raised ☐ two-way

6. Intersection control: ☐ signal ☒ unsignalized
   If signalized, type of LT control for the approach: ☐ protected ☐ permitted ☐ protected-permitted
   If unsignalized: ☒ stop sign on the approach ☐ yield sign on the approach

7. What type of bike signal, if any? ☐ beacon ☐ bicycle signal head ☐ pedestrian signal

8. Pavement type: ☐ asphalt ☒ concrete Pavement condition: ☐ excellent ☐ good ☒ poor

9. Storm drains (any cover?): N/A

10. Any roadway hazards? No

11. Any parking garage entrance/exit or alley close to the intersection? Yes

12. Bike lane marking: ☐ shared lane-use (sharrows) ☐ green pavement ☐ lane stripping ☐ word ☐ symbol ☐ arrow

13. Intersection crossing markings (if any): ☐ dotted lines ☐ dotted lines with chevrons ☐ dotted lines with shared lane marking ☐ dotted lines with colored pavement ☐ elephant feet

14. If cycle track, what type of physical separation? ☐ flexible delineator post ☐ bollard ☐ on-street parking ☐ concrete barrier ☐ planters / trees

15. Intersection treatment: ☐ through bike lane ☐ bike box ☐ median refuge island ☐ combined bike lane/turn lane ☐ two-stage Turn queue boxes ☐ cycle track intersection approach

16. Any bike related signing? No

Site No.: 4 - Intersection of Nicholson St. and W. 11th St. (with Bicycle Facility Improvement)

1. Approach street: ☐ one-way ☒ two-way Cross street: ☐ one-way ☒ two-way

2. Posted speed: 30 mph Number of lanes: 2 Lane width: 10 ft Bike lane width: 5 ft

3. Type of bike facility: ☐ bike lane ☒ cycle track or protected bike lane ☐ shared roadway ☐ bicycle boulevard ☐ paved shoulders

4. Type of bike lane, if any: ☐ conventional bike lane ☐ buffered bike lane ☐ contra-flow bike lane ☐ left-side bike lanes

5. Type of cycle track, if any: ☐ one-way protected ☐ raised ☒ two-way

6. Intersection control: ☐ signal ☒ unsignalized
   If signalized, Type of LT control for the approach: ☐ protected ☐ permitted ☐ protected-permitted
   If unsignalized: ☒ stop sign on the approach ☐ yield sign on the approach

7. What type of bike signal, if any? ☐ beacon ☐ bicycle signal head ☐ pedestrian signal

8. Pavement type: ☐ asphalt ☒ concrete Pavement condition: ☐ excellent ☒ good ☐ poor

9. Storm drains (any cover?): N/A

10. Any roadway hazards? No

11. Any parking garage entrance/exit or alley close to the intersection? No

12. Bike lane marking: ☐ shared lane-use (sharrows) ☐ green pavement ☒ lane stripping ☐ word ☒ symbol ☒ arrow

13. Intersection crossing markings (if any): ☐ dotted lines ☐ dotted lines with chevrons ☐ dotted lines with shared lane marking ☒ dotted lines with colored pavement ☐ elephant feet

14. If cycle track, what type of physical separation? ☐ flexible delineator post ☒ bollard ☐ on-street parking ☐ concrete barrier ☒ planters / trees

15. Intersection treatment: ☐ through bike lane ☐ bike box ☐ median refuge island ☐ combined bike lane/turn lane ☐ two-stage turn queue boxes ☐ cycle track intersection approach

16. Any bike related signing? W11-15, W16-7P, R5-3, R1-1

Appendix B: Bicycle Data

Tables A.1 to A.4 include the cyclist data that was collected for this study at different locations with and without bicycle facility improvement.

Table 0.1: Cyclist Data at Location No. 1 (Intersection of Webster St. and Bagby St.) without Bicycle Facility Improvement

	Gender M/F	Observed Age? Young (<30)/ Middle-Aged (30–50)/ Old (>50)	Driving in bike facility? Y/N	Traffic light status when arriving? G/Y/R	Running the red light or stop sign? Y/N	If red, stopped in the bike box? Y/N	Proceeding the intersection earlier than the motorists (after the red phase)? Y/N	Type of movement through the intersection? LT/TH/RT	Yielded to motorist? Y/N	Yielded to pedestrian? Y/N	Any erratic or illegal movements (q-jumping, riding between stopped vehs)? Y/N
1	F	Y	n/a	R	Y	n/a	Y	TH	n/a	Y	Y (q-jump)
2	M	Y	n/a	R	Y	n/a	Y	TH	n/a	Y	Y (q-jump)
3	M	Y	n/a	R	Y	n/a	Y	TH	n/a	Y	Y (q-jump)
4	F	Y	n/a	G	-	n/a	-	LT	Y	n/a	N
5	M	Y	n/a	G	-	n/a	-	LT	Y	n/a	N
6	M	Y	n/a	G	-	n/a	-	LT	n/a	n/a	N
7	M	Y	n/a	R	Y	n/a	Y	TH	N	n/a	Y (close encounter)
8	M	Y	n/a	R	Y	n/a	Y	TH	N	n/a	Y (close encounter)
9	F	Y	n/a	R	Y	n/a	Y	TH	Y	n/a	N
10	F	Y	n/a	R	N	n/a	N	TH	n/a	n/a	N
11	F	Y	n/a	R	N	n/a	N	TH	n/a	n/a	N
12	M	M	n/a	G	-	n/a	-	RT	n/a	Y	Y (used side walk)
13	M	Y	n/a	R	Y	n/a	Y	TH	Y	n/a	Y (riding between stopped veh)
14	M	Y	n/a	R	Y	n/a	Y	TH	Y	n/a	Y (riding between stopped veh)
15	M	Y	n/a	R	Y	n/a	Y	TH	Y	n/a	Y (riding between stopped veh)
16	M	Y	n/a	R	Y	n/a	Y	TH	Y	n/a	Y (riding between stopped veh)
17	M	O	n/a	R	N	n/a	N	TH	Y	n/a	N
18	F	O	n/a	R	N	n/a	N	TH	Y	n/a	N
19	M	Y	n/a	G	-	n/a	-	TH	n/a	n/a	N
20	M	Y	n/a	R	Y	n/a	Y	LT	Y	Y	N
21	F	M	n/a	R	Y	n/a	Y	LT	Y	n/a	N
22	M	M	n/a	R	Y	n/a	Y	LT	Y	n/a	N
23	F	M	n/a	R	Y	n/a	Y	LT	Y	n/a	N
24	M	M	n/a	R	Y	n/a	Y	LT	Y	n/a	N
25	M	Y	n/a	G	-	n/a	-	RT	Y	Y	N
26	M	Y	n/a	G	-	n/a	-	RT	Y	Y	N
27	M	Y	n/a	G	-	n/a	-	RT	Y	Y	N
28	F	Y	n/a	R	Y	n/a	Y	LT	N	n/a	Y (q-jump, riding between veh)
29	M	M	n/a	R	Y	n/a	Y	RT	Y	n/a	Y (q-jump)
30	F	M	n/a	R	Y	n/a	Y	RT	Y	n/a	Y (q-jump)
31	M	Y	n/a	R	Y	n/a	Y	TH	Y	n/a	N
32	M	Y	n/a	R	Y	n/a	Y	TH	Y	n/a	N

	Gender M/F	Observed Age? Young (<30)/ Middle-Aged (30–50)/ Old (>50)	Driving in bike facility? Y/N	Traffic light status when arriving? G/Y/R	Running the red light or stop sign? Y/N	If red, stopped in the bike box? Y/N	Proceeding the intersection earlier than the motorists (after the red phase)? Y/N	Type of movement through the intersection? LT/TH/RT	Yielded to motorist? Y/N	Yielded to pedestrian? Y/N	Any erratic or illegal movements (q-jumping, riding between stopped vehs)? Y/N
33	M	O	n/a	Y	-	n/a	-	TH	Y	n/a	N
34	M	Y	n/a	R	N	n/a	N	TH	Y	n/a	N
35	M	Y	n/a	R	N	n/a	N	TH	Y	n/a	N
36	M	Y	n/a	R	N	n/a	N	TH	Y	n/a	N
37	F	M	n/a	R	N	n/a	N	TH	Y	Y	N
38	F	M	n/a	R	N	n/a	N	TH	Y	Y	N
39	M	Y	n/a	R	Y	n/a	Y	LT	Y	Y	Y (q-jump, riding between veh)
40	M	Y	n/a	R	Y	n/a	Y	LT	Y	Y	Y (q-jump, riding between veh)
41	M	Y	n/a	R	Y	n/a	Y	LT	Y	Y	Y (q-jump, riding between veh)
42	M	Y	n/a	R	Y	n/a	Y	LT	Y	Y	Y (q-jump, riding between veh)
43	F	Y	n/a	R	Y	n/a	Y	LT	Y	Y	Y (q-jump, riding between veh)
44	F	Y	n/a	R	Y	n/a	Y	LT	Y	Y	Y (q-jump, riding between veh)
45	M	M	n/a	G	-	n/a	-	TH	Y	n/a	N
46	F	M	n/a	G	-	n/a	-	TH	Y	n/a	N
47	M	M	n/a	G	-	n/a	-	TH	Y	n/a	N
48	M	Y	n/a	R	N	n/a	N	TH	n/a	n/a	N
49	F	Y	n/a	R	N	n/a	N	TH	n/a	n/a	N
50	M	M	n/a	R	N	n/a	N	TH	n/a	n/a	N
51	F	M	n/a	R	N	n/a	N	TH	n/a	n/a	N
52	M	Y	n/a	G	-	n/a	-	LT	n/a	Y	N
53	F	Y	n/a	R	Y	n/a	Y	LT	Y	n/a	N
54	F	Y	n/a	R	Y	n/a	Y	LT	Y	n/a	N
55	F	Y	n/a	R	Y	n/a	Y	LT	Y	n/a	N
56	M	O	n/a	R	N	n/a	N	TH	Y	n/a	N
57	M	O	n/a	R	N	n/a	N	TH	Y	n/a	N
58	F	O	n/a	R	N	n/a	N	TH	Y	n/a	N
59	F	O	n/a	R	N	n/a	N	TH	Y	n/a	N
60	M	Y	n/a	G	-	n/a	-	TH	n/a	n/a	N
61	F	Y	n/a	G	-	n/a	-	TH	n/a	n/a	N
62	M	Y	n/a	G	-	n/a	-	LT	n/a	n/a	Y (q-jump)
63	M	Y	n/a	G	-	n/a	-	LT	Y	n/a	Y (q-jump)
64	M	Y	n/a	G	-	n/a	-	LT	Y	n/a	Y (q-jump)
65	F	U	n/a	R	Y	n/a	Y	TH	Y	n/a	N
66	F	M	n/a	R	N	n/a	N	RT	Y	Y	N
67	F	M	n/a	R	N	n/a	N	RT	Y	Y	N

Table A.2: Cyclist Data at Location No. 2 (Intersection of Gray St. and Bagby St.) with Bicycle Facility Improvement

No	Gender M/F	Observed Age? Young (<30)/ Middle-Aged (30–50)/ Old (>50)	Driving in bike facility? Y/N	Traffic light status when arriving? G/Y/R	Running the red light or stop sign? Y/N	If red, stopped in the bike box? Y/N	Proceeding the intersection earlier than the motorists (after the red phase)? Y/N	Type of movement through the intersection? LT/TH/RT	Yielded to motorist? Y/N	Yielded to pedestrian? Y/N	Any erratic or illegal movements (q-jumping, riding between stopped vehs)? Y/N
1	M	Y	Y	G	-	-	-	LT	Y	n/a	N
2	F	Y	Y	G	-	-	-	LT	n/a	Y	N
3	M	Y	Y	R	N	Y	N	LT	Y	n/a	N
4	F	Y	Y	R	N	Y	N	LT	Y	n/a	N
5	M	M	Y	R	Y	N	Y	LT	Y	Y	Y (used sidewalk)
6	M	M	Y	G	-	-	-	TH	n/a	n/a	N
7	M	O	Y	G	-	-	-	TH	n/a	n/a	N
8	M	Y	Y	R	Y	N	Y	LT	Y	Y	N
9	M	M	Y	R	N	Y	N	RT	Y	Y	N
10	M	M	Y	R	N	Y	N	RT	Y	Y	N
11	M	O	Y	R	N	Y	N	LT	Y	n/a	N
12	M	M	Y	R	N	Y	N	LT	Y	n/a	N
13	M	M	Y	R	N	Y	N	LT	Y	n/a	N
14	F	M	Y	R	N	Y	N	LT	Y	n/a	N
15	M	O	Y	G	-	-	-	TH	n/a	n/a	N
16	M	O	Y	R	N	Y	N	TH	n/a	n/a	N
17	F	M	Y	R	N	Y	N	LT	n/a	Y	N
18	M	Y	Y	G	-	-	-	LT	Y	n/a	N
19	M	Y	Y	G	-	-	-	LT	Y	n/a	N
20	M	Y	Y	R	N	Y	N	TH	n/a	n/a	N
21	F	Y	Y	R	N	Y	N	TH	n/a	n/a	N
22	F	Y	N	G	-	-	-	TH	n/a	n/a	N
23	M	M	Y	R	N	Y	N	LT	n/a	n/a	N
24	M	Y	Y	G	-	-	-	TH	n/a	Y	N
25	F	O	Y	G	-	-	-	LT	Y	Y	N
26	M	O	Y	G	-	-	-	TH	n/a	n/a	N
27	M	M	Y	G	-	-	-	LT	n/a	n/a	N
28	F	Y	Y	R	N	Y	N	LT	n/a	n/a	N

	Gender M/F	Observed Age? Young (<30)/ Middle-Aged (30–50)/ Old (>50)	Driving in bike facility? Y/N	Traffic light status when arriving? G/Y/R	Running the red light or stop sign? Y/N	If red, stopped in the bike box? Y/N	Proceeding the intersection earlier than the motorists (after the red phase)? Y/N	Type of movement through the intersection? LT/TH/RT	Yielded to motorist? Y/N	Yielded to pedestrian? Y/N	Any erratic or illegal movements (q-jumping, riding between stopped vehs)? Y/N
29	M	Y	Y	R	N	N	Y	LT	Y	n/a	N
30	M	Y	Y	R	N	N	Y	LT	Y	n/a	N
31	M	Y	Y	R	N	N	Y	LT	Y	n/a	N
32	M	M	Y	G	-	-	-	LT	n/a	n/a	N
33	F	M	Y	G	-	-	-	LT	n/a	n/a	N
34	F	Y	Y	G	-	-	-	LT	Y	Y	N
35	F	Y	Y	G	-	-	-	LT	Y	Y	N
36	M	Y	Y	R	N	Y	N	TH	n/a	n/a	N
37	F	Y	Y	R	N	Y	N	TH	n/a	n/a	N
38	M	Y	Y	R	N	Y	N	TH	n/a	n/a	N
39	F	Y	Y	R	N	Y	N	TH	n/a	n/a	N
40	M	M	Y	G	-	-	-	LT	n/a	Y	N
41	M	Y	Y	G	-	-	-	TH	n/a	n/a	N
42	M	Y	Y	G	-	-	-	TH	n/a	n/a	N
43	M	M	Y	R	N	Y	N	TH	n/a	n/a	N
44	F	M	Y	R	N	Y	N	TH	n/a	n/a	N
45	M	O	Y	G	-	-	-	LT	Y	Y	N
46	M	O	Y	G	-	-	-	LT	Y	Y	N
47	F	M	Y	G	-	-	-	LT	Y	Y	N
48	F	M	Y	G	-	-	-	LT	Y	n/a	N
49	M	Y	N	R	Y	N	Y	LT	n/a	n/a	N
50	M	Y	N	R	Y	N	Y	LT	n/a	n/a	N
51	M	Y	N	R	Y	N	Y	LT	n/a	n/a	N
52	F	O	Y	G	-	-	-	TH	n/a	n/a	N
53	M	Y	Y	R	N	Y	N	TH	n/a	n/a	N
54	F	M	Y	G	-	-	-	LT	Y	Y	N
55	F	M	Y	G	-	-	-	LT	Y	Y	N
56	F	M	Y	G	-	-	-	LT	Y	Y	N
57	M	Y	Y	R	N	Y	N	LT	n/a	Y	N
58	F	Y	Y	R	N	Y	N	LT	n/a	Y	N
59	M	Y	Y	G	-	-	-	TH	n/a	n/a	N
60	F	M	Y	R	N	Y	N	TH	n/a	n/a	N
61	F	M	Y	G	-	-	-	LT	Y	n/a	N
62	F	O	Y	G	-	-	-	TH	n/a	n/a	N
63	M	O	Y	G	-	-	-	TH	n/a	n/a	N
64	M	Y	Y	R	N	Y	N	LT	Y	n/a	N
65	M	Y	Y	G	-	-	-	LT	n/a	n/a	N

Table 0.3: Cyclist Data at Location No. 3 (Intersection of Lawrence St. and W. 11th St.) without Bicycle Facility Improvement

	Gender M/F	Observed Age? Young (<30)/ Middle-Aged (30–50)/ Old (>50)	Driving in bike facility? Y/N	Traffic light status when arriving? G/Y/R	Running the red light or stop sign? Y/N	If red, stopped in the bike box? Y/N	Proceeding the intersection earlier than the motorists (after the red phase)? Y/N	Type of movement through the intersection? LT/TH/RT	Yielded to motorist? Y/N	Yielded to pedestrian? Y/N	Any erratic or illegal movements (q-jumping, riding between stopped vehs)? Y/N
1	M	Y	n/a	n/a	Y	n/a	n/a	TH	N	n/a	Y
2	M	Y	n/a	n/a	Y	n/a	n/a	TH	N	n/a	Y
3	M	Y	n/a	n/a	N	n/a	n/a	TH	Y	Y	N
4	M	M	n/a	n/a	N	n/a	n/a	TH	Y	Y	N
5	F	Y	n/a	n/a	N	n/a	n/a	TH	Y	n/a	N
6	F	M	n/a	n/a	N	n/a	n/a	LT	Y	n/a	N
7	M	Y	n/a	n/a	Y	n/a	n/a	TH	N	n/a	Y
8	M	Y	n/a	n/a	N	n/a	n/a	TH	N	n/a	Y
9	M	Y	n/a	n/a	Y	n/a	n/a	TH	N	n/a	Y
10	M	Y	n/a	n/a	Y	n/a	n/a	TH	Y	n/a	Y
11	M	Y	n/a	n/a	Y	n/a	n/a	TH	Y	n/a	N
12	M	Y	n/a	n/a	Y	n/a	n/a	TH	Y	n/a	N
13	F	M	n/a	n/a	Y	n/a	n/a	TH	Y	n/a	N
14	M	M	n/a	n/a	Y	n/a	n/a	TH	Y	n/a	N
15	F	M	n/a	n/a	Y	n/a	n/a	TH	Y	n/a	N
16	M	M	n/a	n/a	Y	n/a	n/a	TH	Y	n/a	N
17	F	Y	n/a	n/a	N	n/a	n/a	LT	Y	n/a	N
18	M	Y	n/a	n/a	N	n/a	n/a	LT	Y	n/a	N
19	F	Y	n/a	n/a	Y	n/a	n/a	TH	Y	n/a	N
20	F	Y	n/a	n/a	Y	n/a	n/a	TH	Y	n/a	N
21	M	Y	n/a	n/a	Y	n/a	n/a	TH	Y	n/a	N
22	M	Y	n/a	n/a	Y	n/a	n/a	TH	Y	n/a	N
23	F	O	n/a	n/a	Y	n/a	n/a	TH	Y	n/a	N
24	M	O	n/a	n/a	Y	n/a	n/a	TH	Y	n/a	N
25	M	Y	n/a	n/a	Y	n/a	n/a	TH	Y	n/a	N
26	F	Y	n/a	n/a	N	n/a	n/a	TH	N	n/a	N
27	F	Y	n/a	n/a	Y	n/a	n/a	TH	N	n/a	N
28	M	M	n/a	n/a	Y	n/a	n/a	TH	Y	n/a	N
29	M	M	n/a	n/a	Y	n/a	n/a	TH	Y	n/a	N
30	F	Y	n/a	n/a	N	n/a	n/a	LT	Y	n/a	N
31	F	Y	n/a	n/a	N	n/a	n/a	LT	Y	n/a	N
32	M	Y	n/a	n/a	Y	n/a	n/a	TH	Y	n/a	N

Table 0.4: Cyclist Data at Location No. 4 (Intersection of Nicholson St. and W. 11th St.) with Bicycle Facility Improvement

	Gender M/F	Observed Age? Young (<30)/ Middle-Aged (30–50)/ Old (>50)	Driving in bike facility? Y/N	Traffic light status when arriving? G/Y/R	Running the red light or stop sign? Y/N	If red, stopped in the bike box? Y/N	Proceeding the intersection earlier than the motorists (after the red phase)? Y/N	Type of movement through the intersection? LT/TH/RT	Yielded to motorist? Y/N	Yielded to pedestrian? Y/N	Any erratic or illegal movements (q-jumping, riding between stopped vehs)? Y/N
1	M	M	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
2	M	M	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
3	F	M	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
4	M	Y	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
5	F	Y	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
6	F	Y	Y	n/a	N	n/a	n/a	TH	Y	Y	N
7	M	O	Y	n/a	Y	n/a	n/a	TH	N	n/a	N
8	F	O	Y	n/a	Y	n/a	n/a	TH	N	n/a	N
9	M	Y	Y	n/a	Y	n/a	n/a	TH	N	n/a	N
10	M	Y	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
11	M	M	Y	n/a	Y	n/a	n/a	TH	N	n/a	Y
12	F	M	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
13	M	M	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
14	F	Y	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
15	M	Y	Y	n/a	N	n/a	n/a	LT	Y	Y	N
16	F	Y	Y	n/a	Y	n/a	n/a	TH	n/a	n/a	N
17	M	M	N	n/a	N	n/a	n/a	LT	Y	n/a	N
18	M	Y	N	n/a	N	n/a	n/a	LT	Y	n/a	N
19	M	Y	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
20	F	M	Y	n/a	Y	n/a	n/a	TH	Y	n/a	N
21	F	M	Y	n/a	Y	n/a	n/a	TH	Y	n/a	N
22	F	Y	Y	n/a	Y	n/a	n/a	TH	N	n/a	N
23	F	Y	Y	n/a	Y	n/a	n/a	TH	N	n/a	N
24	M	M	Y	n/a	Y	n/a	n/a	TH	Y	n/a	N
25	M	M	Y	n/a	Y	n/a	n/a	TH	Y	n/a	N
26	F	Y	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
27	M	Y	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
28	M	Y	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
29	F	Y	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
30	M	Y	Y	n/a	Y	n/a	n/a	TH	Y	n/a	N
31	F	Y	Y	n/a	Y	n/a	n/a	TH	Y	n/a	N
32	M	Y	Y	n/a	N	n/a	n/a	LT	Y	n/a	N
33	F	Y	Y	n/a	N	n/a	n/a	LT	Y	n/a	N
34	F	Y	Y	n/a	Y	n/a	n/a	TH	Y	n/a	N
35	M	Y	Y	n/a	Y	n/a	n/a	TH	Y	n/a	N
36	M	Y	Y	n/a	Y	n/a	n/a	TH	Y	n/a	N

	Gender M/F	Observed Age? Young (<30)/ Middle-Aged (30–50)/ Old (>50)	Driving in bike facility? Y/N	Traffic light status when arriving? G/Y/R	Running the red light or stop sign? Y/N	If red, stopped in the bike box? Y/N	Proceeding the intersection earlier than the motorists (after the red phase)? Y/N	Type of movement through the intersection? LT/TH/RT	Yielded to motorist? Y/N	Yielded to pedestrian? Y/N	Any erratic or illegal movements (q-jumping, riding between stopped vehs)? Y/N
37	M	Y	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
38	M	M	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
39	M	M	Y	n/a	Y	n/a	n/a	TH	Y	n/a	N
40	M	M	Y	n/a	Y	n/a	n/a	TH	Y	n/a	N
41	F	Y	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
42	M	Y	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
43	F	O	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
44	M	Y	Y	n/a	Y	n/a	n/a	TH	Y	n/a	N
45	M	Y	Y	n/a	Y	n/a	n/a	TH	Y	n/a	N
46	F	Y	Y	n/a	N	n/a	n/a	LT	Y	n/a	N
47	F	M	Y	n/a	N	n/a	n/a	LT	Y	n/a	N
48	F	Y	Y	n/a	Y	n/a	n/a	TH	Y	n/a	N
49	F	Y	Y	n/a	Y	n/a	n/a	TH	Y	n/a	N
50	M	Y	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
51	F	Y	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
52	M	Y	N	n/a	Y	n/a	n/a	TH	Y	n/a	N
53	F	Y	N	n/a	Y	n/a	n/a	TH	Y	n/a	N
54	M	Y	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
55	M	Y	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
56	M	Y	Y	n/a	Y	n/a	n/a	LT	N	n/a	Y
57	M	Y	Y	n/a	Y	n/a	n/a	TH	N	n/a	Y
58	M	Y	Y	n/a	Y	n/a	n/a	TH	N	n/a	Y
59	F	M	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
60	M	O	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
61	F	Y	Y	n/a	Y	n/a	n/a	TH	Y	n/a	N
62	F	Y	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
63	M	Y	Y	n/a	Y	n/a	n/a	TH	Y	n/a	N
64	F	Y	Y	n/a	Y	n/a	n/a	TH	Y	n/a	N
65	M	Y	Y	n/a	N	n/a	n/a	LT	Y	n/a	N
66	F	Y	Y	n/a	N	n/a	n/a	LT	Y	n/a	N
67	M	M	Y	n/a	Y	n/a	n/a	TH	Y	n/a	N
68	M	M	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
69	F	Y	Y	n/a	Y	n/a	n/a	TH	Y	n/a	N
70	F	Y	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
71	M	Y	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
72	F	M	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
73	M	M	Y	n/a	N	n/a	n/a	TH	Y	n/a	N
74	M	Y	Y	n/a	Y	n/a	n/a	TH	Y	n/a	N