MEMORANDUM

To: Bruce Friedman
Office of Transportation Operations
Federal Highway Administration

From: David "DK" Kemp
City of Boulder

Date: June 13, 2016

Project: Harvard Dashed Bike Lane – FHWA RTE 9(09)-70

Subject: FHWA Right to Experiment Final Report

Harvard Dashed Bike Lane Experiment Overview

In the fall of 2014 the City of Boulder received permission from the Federal Highway Administration (FHWA) to experiment with Dashed Bicycle Lanes (DBLs) on Harvard Lane. http://mutcd.fhwa.dot.gov/reqdetails.asp?id=1315. The City of Boulder proceeded with installation of the DBLs in the fall of 2014 after receiving permission from FHWA to experiment. The DBLs were installed for 0.3 miles on Harvard Lane between Dartmouth Avenue and the Bear Creek Greenway multi-use path at Table Mesa Drive (see Figure 1). The DBLs were installed as approved by FHWA with experimental longitudinal markings for an on-street bicycle lane. Evaluation of the DBLs has occurred over the last year based on the approved performance measures from FHWA. This included community feedback, field observations, and "before" and "after" comparison of the performance objectives. This memo summarizes the results of three data collection efforts: before the installation in October 2014, 6 months after installation in April 2015, and one year after installation in October 2015. The key findings that are supported by the technical data at the end of this memorandum follow:

- DBLs resulted in fewer people riding bicycles in the center of the road
- People driving vehicles yielded to other people driving and riding bicycles
- DBLs did not change total crashes, travel speeds or demographics

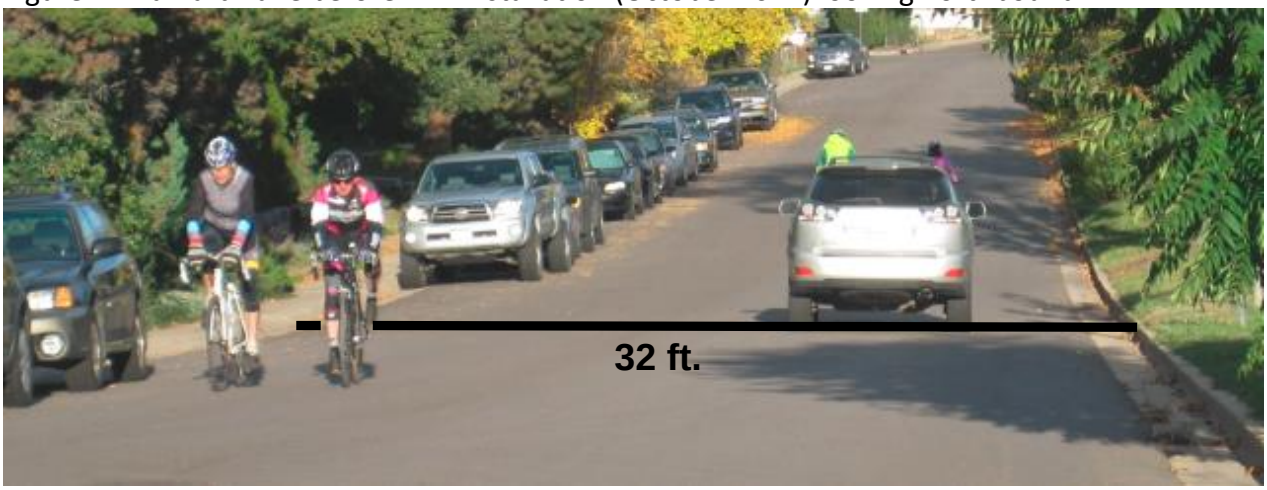
Figure 1: Harvard Lane DBL from Dartmouth to the Bear Creek Multi-use Path

Harvard Lane Before Conditions

Harvard Lane is a low volume residential street that provides a critical link in Boulder's bicycle network. The roadway is bounded on the north end by Dartmouth Avenue and on the southern end by Table Mesa Drive. The average weekday daily traffic on Harvard Lane is approximately 350 motor vehicles and 400 people on bicycles. The motor vehicle traffic is primarily local residential traffic, as northbound access for motor vehicles to Dartmouth Avenue is restricted. People on bicycles are allowed to ride northbound past Dartmouth Avenue. Harvard Lane is a popular connection for people riding bicycles between south Boulder, the University of Colorado and downtown Boulder. The south end of Harvard Lane also provides access to the east-west Bear Creek Greenway multi-use path. The corridor is relatively flat from the north end to Dover Drive. South of Dover Drive is a 4.8% uphill grade in the southbound direction.

Prior to the DBLs installation, Harvard Lane had a 32 feet wide curb-to-curb dimension and was a signed bicycle route (Figure 2). On-street parking was available along the west side of the street, serving the adjacent single and multi-family residential land uses. Parking was restricted along the east side of the street. There is an uphill grade on Harvard Lane in the southbound direction.

Figure 2: Harvard Lane before DBL installation (October 2014) looking northbound



Why Demonstrate with a DBL?

Prior to the DBLs, people riding bicycles often used the full roadway width when riding on Harvard Lane. In some areas people were riding bicycles in the opposing travel lane to access the Bear Creek Trail located at the south end of the corridor. The DBLs were requested and installed to understand changes in people's driving and riding behaviours. The performance measures were established to document changes in all roadway user's safety and understand if DBL reduces possible roadway conflicts. In addition, the experiment would aid FHWA and the City of Boulder in determining if DBLs are a cost-effective and safe for use on similar roadways.

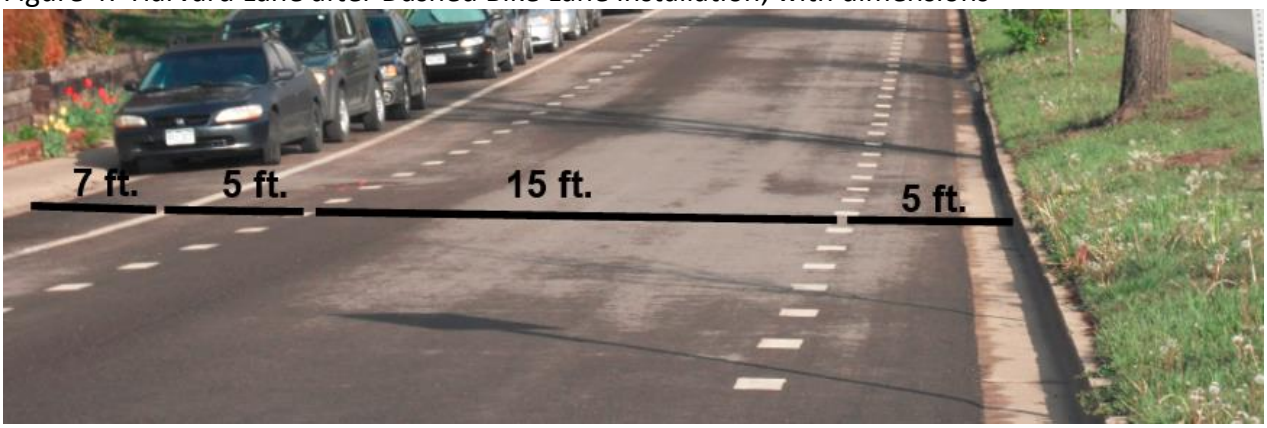
Dashed Bike Lane Installation

The DBLs were installed along Harvard Lane in mid-October of 2014 along the 0.3 miles of roadway (see Figure 3). The installation of DBLs did not require the reconstruction of Harvard Lane, only new pavement markings. A solid line delineating the parking lane was striped at 7 ft. from the west curb. A dashed line pattern was striped 5 ft. east of the solid parking line, designating the 5 ft. bike lane. An additional dashed line pattern was striped 5 ft. west of the east curb, leaving a 15 ft. bi-directional travel lane (see Figure 4). The 32-foot curb-to-curb dimension and on-street parking on the west side of the street were not altered.

Figure 3: Harvard DBL installation (October 2014)

The DBLs require sharing conditions between bicycles and motor vehicles. The dashed markings are meant to convey a permissive message to bicyclists and motor vehicle operators, allowing motorists to encroach into the bike lane when encountering an oncoming motor vehicle. When motor vehicles approach each other with a bicycle present, motorists are still expected to yield right of way to bicyclists.

Figure 4: Harvard Lane after Dashed Bike Lane installation, with dimensions



Technical Results of DBL Field Observations

The project team collected 9 hours of video of people riding and driving in the corridor. This included video recording and field observations of vehicle and bicycle location in the roadway, volume and speed, bicyclist demographics, and bicyclist-vehicle and vehicle-vehicle interactions. The following section summarizes the observation periods:

- Before data on Tuesday, October 14, 2014 from 7:30 a.m. to 9:00 a.m. and from 4:00 p.m. to 5:30 p.m. The weather was sunny and ranged from 50-60 degrees.
- The first after data was collected on Wednesday, April 28, 2015 from 7:30 a.m. to 9:00 a.m. and 4:00 p.m. to 5:30 p.m. The weather was sunny and ranged from 50-60 degrees.
- A second round of after data was collected on Wednesday, October 15, 2015 from 7:30 a.m. to 9:00 a.m. and 4:00 p.m. to 5:30 p.m. The weather was cloudy and 40 degrees.

Figure 5: Sample video from the interactions on Harvard DBL (April 2015)

Table 1 summarizes the 9 hours of data collection in 2014 and 2015. It is important to note that people riding bicycles represent 80% of the AM and PM peak traffic on Harvard Lane during a typical weekday.

Table 1: Total Vehicles Observed During Before and After Harvard Data Collection

	Bicyclists	Motor Vehicles	Total
Before (October 2014)	274	51	325
After (April 2015)	239	76	315
After (October 2015)	207	42	249
Total Observations	**720**	**169**	**889**

Changes in Bicycle Riding Location with the DBL

In video summaries and field data collected after the installation of the DBLs, the riding position of people riding bicycles was observed much like a street with standard on-street bicycle lanes. Prior to the DBLs, 73% of bicyclists were observed riding in the travel lane and 27% in the DBL area. After the DBLs were installed, 43% of all bicyclists were observed riding in the travel lane and 57% were observed riding in the DBLs. This represents a shift of 30% of bicyclists from the travel lane to the DBL.

Table 2: Bicycle Riding Location in Roadway

	Travel Lane Area	Dashed Bike Lane Area
Before (October 2014)	73%	27%
After (April 2015)	46%	54%
After (October 2015)	43%	57%

Elevation and Utility Cover Influences on Bicycle Riding Location with the DBL

Video summaries collected after the DBLs were installed showed that people riding bicycles southbound (uphill) changed their position from the travel lane to the DBL. People riding southbound (uphill) are adjacent to parked vehicles. People riding northbound (downhill) also had changes in riding position. In the northbound direction, bicyclists ride downhill and adjacent to the curb. The higher percentage of northbound bicyclists riding in the travel lane as compared to the southbound bicyclists may be influenced by the faster downhill speeds and the 1.5 foot gutter pan and portions of 2 utility covers located within the southbound DBL.

Table 3: Southbound (uphill) Riding Location

	Travel Lane Area	Dashed Bike Lane Area
Before (October 2014)	60%	40%
After (April 2015)	5%	95%
After (October 2015)	4%	96%

Table 4: Northbound (downhill) Riding Location

	Travel Lane Area	Dashed Bike Lane Area
Before (October 2014)	85%	15%
After (April 2015)	81%	19%
After (October 2015)	65%	35%

Motor Vehicle Yielding Behavior

A total of 118 motor vehicles were observed driving on Harvard Lane after the installation of the DBLs. The following provides a summary of the yielding interactions and behaviour of the 118 observations.

- In 53% of the observations of motor vehicles driving on the roadway, no other motor vehicle or cyclist was present. All but one of these motor vehicles were observed driving in the travel lane.
- In 32% of the observations, a motor vehicle was observed passing a cyclist.
    - In 13% of the observations, the motor vehicle and person riding a bike were traveling in the same direction.
    - In 19% of the observations the motor vehicle and person riding a bicycle were traveling in opposite directions.
    - In every case the motor vehicle maintained at least 4 feet of distance between the vehicle and bike.
- In 10% of the observations, two motor vehicles were observed passing one another without a cyclist present. In every case, the northbound vehicle yielded to the southbound vehicle by moving into the DBL zone. The predominant northbound motor vehicle yielding behavior may reflect a desire by southbound vehicles to avoid the “door area” of the adjacent parked vehicles.
- In 5% of these observations, two motor vehicles were observed passing one another with a cyclist present. In 5 out of the 6 observations, the motor vehicle traveling in the same direction as the cyclist was yielded to by the motor vehicle traveling in the opposite

direction, which moved into the DBL where no cyclist was present. In one case, the motor vehicle traveling in the same direction as the cyclist yielded to the oncoming vehicle by slowing down and moving into the DBL behind the cyclist.

Collisions and Safety

The project team collected prior police reports of collisions and tracked crashes along Harvard Lane during the DBL experiment. There were four collisions reported on Harvard Lane between 2009 and the October 2014 before the installation of the DBLs. Three of the collisions were motor vehicle-motor vehicle collisions and one was a motor vehicle-bicycle collision. None of the collisions before the DBL resulted in serious injuries or fatalities. Between November 2014 and March 2016 there was one collision that involved a motor vehicle hitting an unattended parked car. The collision rate before the DBL was 0.68 per year and the collision rate during the DBL experiment was 0.70 per year. There were no collisions involving bicyclists during the DBL experiment. There were no injuries or fatalities during the DBL experiment.

Motor Vehicle and Bicyclist Speeds

The project team collected speed data on Harvard Lane before and after the DBL installation. The installation of the DBL did not change motor vehicle or bicyclist speed during the peak travel periods. The speed limit along Harvard Lane is 25 mph. The results are listed below.

Table 5: Motor Vehicle Average Speed (Speed Limit = 25 mph)

	Avg. Speed	85th Percentile
Before (10/14)	25 mph	29 mph
After (average 4/15 & 10/15)	24 mph	31 mph

Table 6: Bicycle Average Speed

	Average Northbound Speed	85th Percentile Northbound	Average Southbound Speed	85th Percentile Southbound
Before (10/14)	18 mph	21 mph	12 mph	16 mph
After (average 4/15 & 10/15)	19 mph	23 mph	12 mph	15 mph

Demographics of People Riding Bikes

The gender of people riding bicycles was evaluated in the before and after condition based on bicycle types, clothing, accessories, and conversations in the field. The results are listed below.

Table 7: Gender of People Riding Bikes on Harvard

	Noted as Male Riding Bicycle	Noted as Female Riding Bicycle
Before (October 2014)	78%	22%
After (April 2015)	77%	23%
After (October 2015)	83%	17%

Community Input Obtained Through the Course of the Experiment

The following comments were obtained during the experiment at a Transportation Open House in November 2015 and through an online survey form. Community input regarding the dashed bike lane facility has been mixed. Some people favor the facility and others did not see any value added.

- Harvard Lane did not feel like it needed work. I don't think the lanes as painted are adequate. Without the lane markings, I felt more comfortable riding where I felt most comfortable in the lane.
- I ride this a few times a month. The marked lines were nice but didn't add that much to what is basically a very safe and easy street to ride on.
- Think the dashed bike lanes would be a great opportunity to install a contra flow bike lane on Grant Street from College to Baseline Rd.
- This would be a great tool to use on Grant Street as a contra-flow climbing lane as an alternative to 9th street which is busy and dangerous.
- Good, inexpensive, easy- probably helps a little although I haven't had a problem riding here.
- This should be favored by motorists as it keeps us bikes from being all over the road.
- 2 words: Continue it! Please!
- Impressive results. Sounds like a win-win. Expand!
- Sounds like a great idea.
- This at least acknowledges bike rider potential and driver mindfulness.
- Make bike lane wider. It's too narrow as it stands.
- North bound lane too narrow to dodge uneven spots, so I find myself veering into traffic lanes several times along the route. Can it be widened?
- Like the lanes but they need to be wider. A separated bike path would be optimal. Better snow removal is essential.
- Are there bike symbols indicating where bikes belong?
- The Harvard lanes are I think are less great and I don't see a real improvement to the biking conditions. If anything it sends a message to bike to get over to the side of the road. Due to manhole covers and overgrown vegetation this doesn't work that well. Riding over manhole covers at night is surprising and uncomfortable. On this street with the low traffic volumes I like to ride side by side. If faster moving cars approach from the back they simply drive around. Again this treatment sends a message that cyclist should ride single file. I think sharrows on this section would work better.

Next Steps

The City of Boulder staff recommends maintaining the Dashed Bike Lanes on Harvard Lane. Staff may consider other options for the corridor during future assessments of the City's transportation network. Staff will consider the experimental Dashed Bike Lane treatment for other locations if applicable.