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ASSESSMENT OF THE EFFECTIVENESS OF PROPOSED "KEEP RIGHT PASS LEFT – IT'S THE LAW" SIGNS ON TWO-LANE RURAL FREEWAYS

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16. Abstract

This study focuses on the problem of unlawful left-lane usage on non-congested two-lane rural freeways in Michigan. According to the Michigan Vehicle Code, vehicles shall remain on the right lane of two-lane sections of rural freeways when not passing other vehicles. While drivers are currently reminded of this rule by signs stating "Slower Traffic Keep Right" installed as part of the normal post-interchange sign sequence, traffic observations suggest that many motorists do not to follow this rule.

As part of an effort to entice drivers to abide by existing rules, this study investigates a proposal to replace current "Slower Traffic Keep Right" signs with new explicit signs stating "Keep Right Pass Left – It's the Law". To assess the effectiveness of this replacement, traffic behavioral data were collected at four rural sites along I-96 in Michigan, first with the existing sign in place and then with the proposed new sign. Tube counters data were collected to compare lane-specific traffic volumes and speed distributions in the presence of each sign. Video data were further collected to obtain information about individual passing events and develop statistics about the validity of left-lane usage by individual vehicles and about left-lane vehicle groupings caused by slow moving vehicles in the freeway left lane.

Results of the analyses provide no indication that replacing existing "Slower Traffic Keep Right" sings would effectively improve left-lane usage behavior on two-lane rural freeways. Depending on the sites considered, either improvements or deteriorations in left-lane behavior were observed following the sign replacement. In all cases, statistical tests further indicate that the observed changes are not statistically significant.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	$candela/m^2$	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	$candela/m^2$	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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1 Introduction

Section 634 of the Michigan Vehicle Code (MCL 257.634) currently states that upon driving on a roadway having two or more lanes for travel in one direction a driver shall drive his vehicle in the extreme right-hand lane available. Exceptions to this rule only allow drivers to lawfully travel on any lane available when both traffic lanes are occupied by vehicles moving in substantially continuous streams and when preparing to make a left turn. For two-lane freeways, this is generally interpreted as meaning that drivers should stay on the right lane except for passing slower vehicles, when preparing to take a left-side exit, or when high traffic volumes result in vehicles continuously occupying both lanes.

According to the vehicle code, drivers not abiding by the above rule are responsible for a civil infraction. However, since the rule is not actively being enforced by police agencies, there has been no incentive for drivers to abide by it. This has resulted in a certain proportion of motorists opting to travel on the left lane of two-lane rural freeways for reasons other than passing or preparing to take a left-side exit. While many left-lane drivers remain courteous and shift to the right lane when being approached by faster vehicles, there are claims of drivers traveling at or below the speed limit stubbornly remaining on the left lane and blocking faster traffic. This often leads to faster vehicles choosing to pass slower ones from the right, a situation that should normally not occur as it goes against conventional driving practice.

Recent efforts to enforce the provisions of MCL 257.634 regarding left lane driving have lead to the adoption by the Michigan Department of Transportation (MDOT) in October 2005 of the use of "Slower Traffic Keep Right" signs on two-lane rural freeways. An illustration of the adopted sign is shown in Figure 1 (MDOT, 2005). This is the only federally-approved sign for emphasizing right-lane driving on two-lane freeways. Current MDOT guidelines require its placement as part of the post interchange sign sequence for rural freeways outside incorporated municipalities (MDOT, 2007). The guidelines simply state that under normal conditions the sign should be placed approximately 3,500 feet from the end of an interchange on ramp. In addition to providing entering freeway traffic a reminder that they should keep driving on the right lane when not passing other vehicles, such a placement would also provide traffic already on the freeway periodic reminders of the normal lane usage rule.

Figure 1. Current right-lane use traffic sign

Despite the addition of "Slower Traffic Keep Right" signs to the normal post sequence at freeway interchanges, traffic observations indicate that many motorists still keep driving on the left lane of two-lane rural freeways in situations in which they are required by law to drive on the right. One frequently mentioned reason to explain this lack of response to the new signs is that drivers tend to view them as merely informational. This perception is further enforced by the fact that many drivers have never received a ticket for driving on the left lane without a legitimate purpose and that they are not expecting to be pulled over for doing so.

To enhance driver awareness about existing laws and entice them to keep driving on the right lane except for passing and other legitimate uses, it was recently argued that motorists would perhaps be more responsive to signs clearly stating that Michigan laws mandate driving on the right lane of two-lane freeways under normal conditions. Based on what is currently done on the Pennsylvania Turnpike, it was proposed to replace current "Slower Traffic Keep Right" signs by signs conveying a more explicit message. Figure 2 illustrates the proposed replacement sign. This sign replaces the reference to slower traffic by an active reference to passing and adds an "It's the Law" note at the bottom to emphasize the legal aspect of the rule.

Figure 2. Proposed right-lane use traffic sign

This report details the results of a study that was conducted by the University of Michigan Transportation Research Institute (UMTRI) for the Michigan Department of Transportation to assess whether replacing current "Slower Traffic Keep Right" signs with "Keep Right Pass Left – It's the Law" signs would effectively entice drivers to stay on the right lane of two-lane rural freeways in the absence of high traffic volumes. This assessment was conducted using a simple "before/after" study in which traffic behavior was observed at specific sites first with the current sign in plance and then with the proposed replacement sign. The remainder of this report details the study approach, the sites selected for the evaluation, the data collection efforts, the primary results of the data analyses, and the main conclusions and recommendations of the study.

2 Study Approach

A typical "before/after" study was conducted to assess the effectiveness of proposed "Keep Right Pass Left – It's the Law" signs in enticing drivers to stay on the right lane of rural sections of two-lane freeways when not passing or preparing to take a left side exit. The plan was to first observe traffic behavior at selected sites where "Slower Traffic Keep Right" signs were already in use. The sign in use at each location were then to be replaced by the proposed "Keep Right Pass Left – It's the Law" signs and traffic behavior observed once again following a two week wait period to allow the novelty effect to wear off. Key behavioral elements that were to be analyzed during each evaluation period included the proportion of traffic using the left freeway lane at each site, the distribution of travel speeds on each traffic lane, and the proportion of valid left-lane usage. Comparisons between the observed traffic behavior with the "Slower Traffic Keep Right" sign ("before" period) and "Keep Right Pass Left – It's the Law" sign ("after" period) in place would then indicate the extent to which drivers react to the new sign and allow conclusions to be drawn regarding the potential effectiveness of the proposed sign in helping enforce current driving regulations.

3 Study Sites

For validity reasons, it was required that traffic observations for the "before" and "after" portions of the study be conducted at the same sites. Comparing traffic behavior at one site featuring one traffic sign against behavior observed at another site featuring a different sign would not lead to valid conclusions regarding the true effects of the proposed sign replacement. All such a comparison would do is assess potential traffic behavior differences between two sites potentially being traveled by different groups of drivers. This also holds true for comparing traffic behavior from a given travel direction at one site against the behavior in the opposite direction. In this case, even though a single site is technically considered, different groups of motorists with different trip purposes may be traveling in each direction, making true comparisons difficult.

This project further required that observations be conducted on two-lane rural freeways with low to moderate traffic. Taking this criterion into consideration, it was thus suggested to conduct the study on two-lane rural sections of I-96 near Lansing, Michigan. As illustrated in Figure 3, sections of interest along this freeway included a segment east of Lansing extending from Exit 110 (Okemos) to Exit 129 (Fowlerville) and another segment on the west side of the city extending from Exit 86 (Wright Road) to Exit 59 (Clarksville).

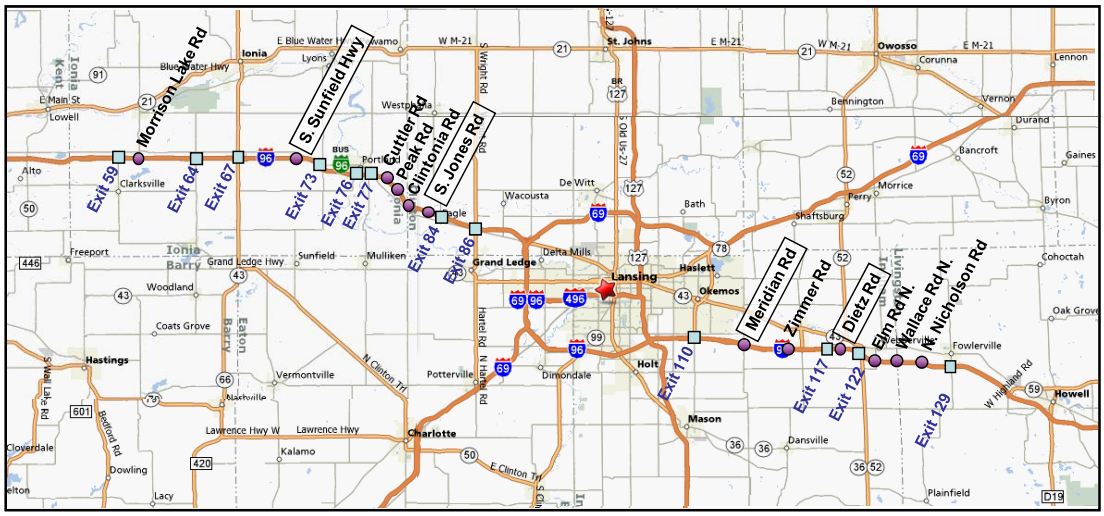

Figure 3. Data Collection sites along I-96

Within each section, ideal locations for traffic observations were observation points sufficiently away from interchanges to avoid capturing lane-changing behavior induced by on-ramp and off-ramp traffic. While the proposed sign change is meant to entice drivers to keep driving on the right except to pass slower vehicles, it is not meant to prevent courtesy lane changes near on ramps to facilitate the insertion of incoming traffic or to pass vehicles slowing down before entering an off ramp. Another constraint was linked to the proposed videotaping of traffic behavior at survey locations to enhance traffic analyses. To maximize the use of video

recordings, it was quickly recognized that these must be shot from a vantage point above traffic so that a relatively clear view of both traffic lanes could be obtained, particularly when trucks are present. This thus pointed to the need to collect videos from overpasses that are not part of an interchange and restricted the pool of potential data collection sites to locations with such an overpass.

Overpasses suitable for data collection along sections of interest on I-96 are listed in Table 1 and geographically located on the map of Figure 3. From this list, it was proposed to use the overpasses at Meridian Road and Dietz Road for data collection on the east side of Lansing, and the overpasses at South Jones Road and South Sunfield Highway on the west side of the city. All the selected locations feature a relatively straight alignment on each side of the overpass, which was an important element for videotaping traffic.

Table 1. Non-interchange overpasses on two-lane sections of I-96 near Lansing

Section	County	Overpass
Exit 129 → Exit 122	Livingston Ingham Ingham	N. Nicholson Road Wallace Road N. Elm Road N.
Exit 122 → Exit 117	Ingham	Dietz Road
Exit 117 → Exit 110	Ingham Ingham	Zimmer Road Meridian Road
Exit 84 → Exit 77	Clinton Clinton Ionia Ionia	South Jones Road Clintonia Road Peak Road Cutler Road
Exit 73 → Exit 67	Ionia	South Sunfield Highway
Exit 64 → Exit 59	Ionia	Morrison Lake Road

Two locations were selected on each side of Lansing to allow comparing motorist behavior following repetitive exposure to the proposed new sign. For instance, for traffic traveling westbound from Lansing, the South Jones Road observation point would capture traffic behavior after motorists would have already encountered two signs reminding them to drive on the right lane downstream of Exit 86 and Exit 84. The South Sunfield Highway observation point would then capture traffic behavior after motorists would have been exposed to three more signs downstream of Exit 77, Exit 76 and Exit 73. Comparison of traffic behavior at the two locations would then allow assessing whether an increasing proportion of motorists tend to adjust their behavior with repeated sign exposure, or whether such a repetitive exposure has no noticeable influence.

4 Data Collection Activities

Two separate data collection activities were executed at each the four selected study sites along I-96:

- Collection of traffic counts and speed distribution data for each travel lane in each travel direction using tube counters.
- Videotaping of traffic behavior for both travel directions using video cameras installed on freeway overpasses.

4.1 Tube Counter Data Collection

Traffic counts and speed distribution data were collected to characterize potential changes in lane utilization following the replacement of current "Slow Traffic Keep Right" signs by "Keep Right Pass Left – It's the Law" signs. It was argued that if a certain proportion of drivers drive on the left lane for reasons other than passing, a reduction in unlawful left-lane usage should result in a reduction in the proportion of vehicles using the left lane and a corresponding increase in the proportion of vehicles using the right lane. Another potential impact may be a change in the distribution of speeds at which individual vehicles travel on each lane. If it is assumed that motorists using the left lane for reasons other than passing often travel at lower speeds than motorists who use the lane for legitimate passing activities, a reduction in unlawful left-lane usage may then result in a decrease in the proportion of left-lane vehicles traveling at low speed (typically around the speed limit) and an increase in the average lane travel speed. Large changes in lane volumes and speed distributions would then be an indication that a significant problem exists and that the proposed new sign is effective in correcting the problem. However, small changes would either indicate that the assumed problem is relatively minor or that the proposed new sign does not have significant impacts on driver behavior.

Figure 4 illustrates the typical setup used for traffic counters. At each study site, the counters were laid across the freeway pavement in a standard speed trap configuration by MDOT personnel allowing separate data collection for each travel lane. For each travel direction, counters were further installed 200 to 300 ft downstream of the freeway overpass. An installation close to the overpass was required to allow the video data to capture the same traffic conditions as those recorded by the tube counters. An installation downstream from an overpass was further desired to allow the videotaping equipment to be concealed from approaching traffic. The idea behind such a placement was to prevent motorists from thinking they may be under some form of surveillance and to consequently minimize the risk of having them altering their behavior in response to the presence of the cameras.

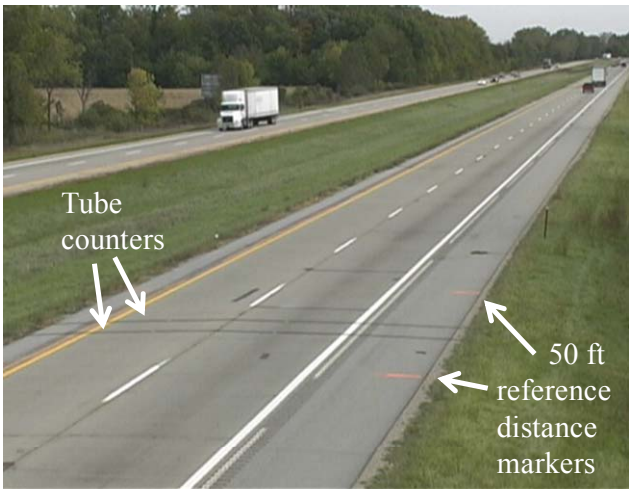

Figure 4. Tube counters setup

Figure 5 indicates the periods for which tube counter data were collected. Initial data collection with the "Slower Traffic Keep Right" signs started on September 23 and ended on September 30 when the tube counters were removed. The signs in place were then replaced by "Keep Right Pass Left – It's the Law" signs on October 17. This was followed by a two-week wait period to allow the novelty effect to wear off. Data collection for the "after" portion of the study then started on November 2 when the tube counters were reinstalled and ended on November 9.

The equipment used for the project allowed one-hour aggregate data to be collected automatically around the clock. While 24-hour data were available, the primary period of interest were the weekday one-hour intervals falling between 10:00 AM and 3:00 PM. As shown in Figure 5, data collection went without a glitch at about half the survey sites. For the other sites, technical problems resulted in some missing or invalid data. In most cases, data reporting failure were due to the tube counters being temporarily ripped off the road. In other cases, the collected data had to be rejected due to the reporting of unusually low or high speeds. Most situations with low-speed reporting were attributed to the occurrence of unusual congestion caused by a downstream lane closure due to an incident or short-term construction. Situations with unusual high-speed reporting could only be explained by technical glitches.

Table 2 illustrates a typical one-hour data report produced by the tube counters. As indicated, each report provided counts of vehicles observed to travel within specific speed bins within the observation period. Counts were further categorized by vehicle type using the standard 13-type FHWA vehicle classification. Within this classification, passenger vehicles were assumed to comprise motorcycles, passenger cars, and vehicles with two axles and four tires (2A-4T). Vehicles with two axles and four tires typically include pickups, vans, campers, motor homes, ambulances, carryalls, and minibuses. All other vehicle types were assumed to be commercial trucks. Very few buses were observed at each study site to warrant considering them in a separate category. Because of their size, these vehicles were then included into the commercial truck category for the purpose of the analyses reported later.

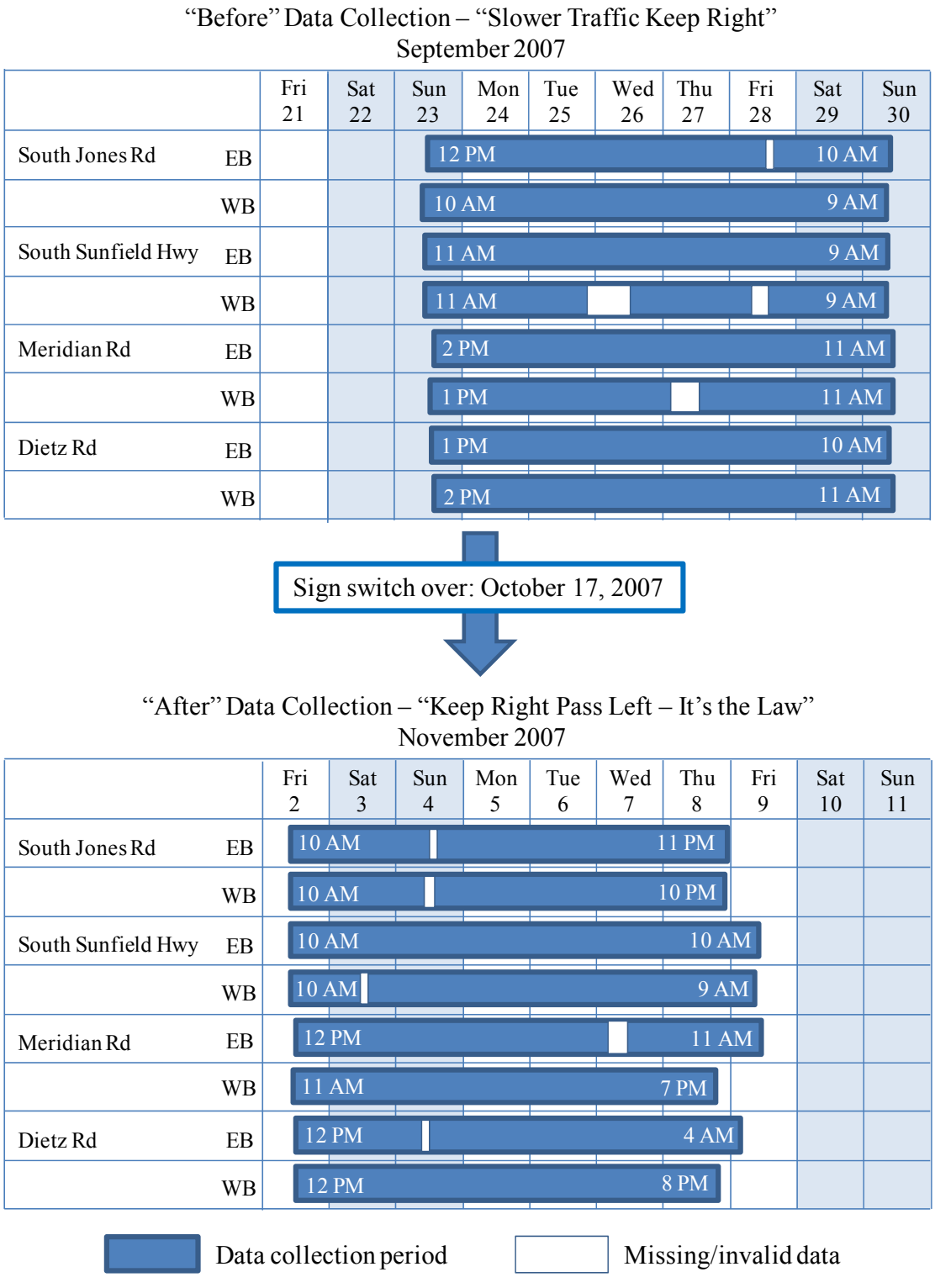

Figure 5. Tube data collection periods

Table 2. Sample of Tube Counter Data

10/04/07 Michigan Department of Transportation Page: 1
07:55:34 I-96 @ MERIDIAN
*** Speed x Axle Report (#206) ***

****

Site ID : 330088 Data Starts : 13:00 on 09/23/07
Info 1 : INGHAM CO Data Ends : 09:00 on 09/30/07
Info 2 : I-96/MERIDIAN Adj. Factor : 1.000%

****

Lane #1 Info : EAST BND 1
Modes : SPDxAXL
Sensors : Axle-Axle Sensor Spacing: 6.5'

********** Lane 1 Speed x Axle Report **********

Sep 23, 2007 Sun		#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14	#15	#16	
		0-	20-	25-	30-	35-	40-	45-	50-	55-	60-	65-	70-	75-	80-	85-		
Time	Bin Type	19.9	24.9	29.9	34.9	39.9	44.9	49.9	54.9	59.9	64.9	69.9	74.9	79.9	84.9	89.9	Other	Total
13:00	#1 Cycle	0	0	0	0	0	0	0	0	0	0	5	5	3	0	0	0	13
	#2 Cars	0	0	0	0	0	0	0	1	8	52	217	374	114	8	0	0	774
	#3 2A-4T	0	0	0	0	0	0	0	0	6	18	53	58	13	2	1	0	151
	#4 Buses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	#5 2A-SU	0	0	0	0	0	0	0	0	2	3	3	0	0	0	0	0	8
	#6 3A-SU	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
	#7 4A-SU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	#8 4A-ST	0	0	0	0	0	0	0	0	4	4	8	3	0	0	0	0	19
	#9 5A-ST	0	0	0	0	0	0	0	0	3	27	1	0	0	0	0	0	31
	#10 6A-ST	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	#11 5A-MT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	#12 6A-MT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	#13 Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	1	23	104	288	440	130	10	1	0	997
14:00	#1 Cycle	0	0	0	0	0	0	0	0	0	3	9	3	2	0	0	0	17
	#2 Cars	0	0	0	0	0	0	0	1	15	50	224	381	87	16	2	1	777
	#3 2A-4T	0	0	0	0	0	0	0	0	4	24	53	72	22	1	0	0	176
	#4 Buses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	#5 2A-SU	0	0	0	0	0	0	0	0	2	4	1	0	0	0	0	0	7
	#6 3A-SU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	#7 4A-SU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	#8 4A-ST	0	0	0	0	0	0	0	0	0	5	6	3	0	0	0	0	14
	#9 5A-ST	0	0	0	0	0	0	0	1	2	15	2	0	0	0	0	0	20
	#10 6A-ST	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	4
	#11 5A-MT	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
	#12 6A-MT	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
	#13 Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	2	24	105	296	459	111	17	2	1	1017

4.2 Video Data Collection

Video data was collected to provide additional insights into freeway left-lane usage. While traffic counts and speed distribution data can provide an indication that a change in lane usage has occurred, the information provided by these data remain anonymous, i.e., provide no specific information regarding whether individual vehicles were lawfully traveling on the left lane. Such information can only be obtained by a visual analysis of traffic patterns. In this case, the categorization of passing events as valid and non valid can be done by comparing the speed of a vehicle traveling in the left lane at a given moment to the speed of the vehicles present in the right lane at the same moment, in addition to considering surrounding traffic conditions. Here, a reduction in the proportion of vehicles found to be using the left lane for non-legitimate reasons following the replacement of "Slower Traffic Keep Right" signs by "Keep Right Pass Left – It's the Law" signs would be a clear indication that the proposed sign has positive effects on traffic behavior. On the opposite, an absence of reduction in unlawful left-lane use would be an indication of the potential ineffectiveness of the sign.

Figures 6 and 7 illustrate the video camera setups adopted for the study. For the study sites located west of Lansing, the video cameras were installed on the deck of the selected overpasses so as to provide a direct overview of the traffic below. As indicated in Figure 6, such a setup was made possible by the presence of a traffic guardrail creating a safety space on the bridge within which the camera could be installed without risks of being hit by passing traffic. This was an important criterion as large trucks traveling at significantly speeds and oversize agricultural machinery were observed to travel on some of the selected overpasses. For the sites east of Lansing, the absence of safe space on the deck of the selected overpasses forced the installation of the video cameras at its extremities, on top of the abutment. While this placement provided a less than ideal view of the traffic below, notably with respect to the potential occlusion of the left-lane traffic by large trucks traveling on the right lane, it provided sufficiently clear view of the two traffic lanes to conduct the required analyses.

Figure 6. Typical video camera setup on sites west of Lansing

Figure 7. Typical video camera setup on sites east of Lansing

The periods for which video data were collected are summarized in Table 3. Because of the need to have someone on site for operating the cameras, primarily for changing tapes every hour, and of the limited battery life of one camera, only 2 to 3 hours of video data could be collected for each travel direction at each study site. To ensure correspondence with the tube counter data, the video data were collected for both the "before" and "after" portions of the study during the same week for which the tube counters were in operation.

Since the study focuses on on lane selection behavior in the absence of heavy traffic, video data were only recorded during off-peak traffic periods when traffic volumes were low enough to allow all vehicles to travel in the right lane. To avoid damaging the video equipment and ensure good visibility on the recorded images, data collection was also restricted to periods without rain. To the extent possible, efforts were made to collect video data from each site for the "after" portion of the project on the same weekday and time period as during the "before portion". This was done to minimize variations in traffic conditions between the two survey periods. One exception is for the westbound I-96 video data collection at the Dietz Road overpass. In this case, a wind storm with heavy rain interrupted the planned "after" data collection effort on the Monday matching the "before" data collection period. For this site, data collection could only resume two days later, after clear weather had returned.

As indicated above, the video data collection typically yielded 2 to 3 hours of traffic data for each travel direction at each study site. While this is much less time coverage than the information provided by the tube counters, this amount of data was deemed sufficient for the study as the primary goal of the video data collection was to obtain a video of sufficient length for the extraction of about 150 passing events per travel direction. For most of the sites, the required number of passing events could be obtained by processing as little as 30 minutes of data, or about a quarter of the collected video data.

Table 3. Video data collection periods

Site	Direction	Before	After
Meridian Rd.	Eastbound	Monday, Sept. 24 8:30 AM – 10:30 AM	Monday, Nov. 5 9:15 AM – 11:15 AM
	Westbound	Monday, Sept. 24 8:35 AM – 11:05 AM	Monday, Nov. 5 9:25 AM – 11:25 AM
Dietz Rd.	Eastbound	Monday, Sept. 24 1:30 PM – 3:25 PM	Monday, Nov. 5 1:15 PM – 2:00 PM [(1)] Wednesday, Nov. 7 9:40 AM – 10:20 AM
	Westbound	Monday, Sept. 24 1:30 PM – 3:30 PM	Monday, Nov. 5 1:25 PM – 2:10 PM [(1)] Wednesday, Nov. 7 9:45 AM – 10:25 AM
South Sunfield Hwy.	Eastbound	Thursday, Sept. 27 1:15 PM – 3:10 PM	Thursday, Nov. 8 12:40 PM – 2:40 PM
	Westbound	Thursday, Sept. 27 1:10 PM – 4:15 PM	Thursday, Nov. 8 12:25 PM – 2:25 PM
South Jones Rd.	Eastbound	Friday, Sept. 28 11:00 AM – 1:20 PM [(2)]	Friday, Nov. 9 11:45 AM – 1:45 PM
	Westbound	Friday, Sept. 28 11:05 AM – 1:05 PM	Friday, Nov. 9 11:50 AM – 1:50 PM

[(1)] Data collection interrupted by a wind storm accompanied by heavy rain

[(2)] Right freeway lane was closed one mile from overpass during entire data collection for construction, invalidating all collected data

4.3 Video Data Extraction

Following collection of the video data, the recorded traffic patterns were analyzed to identify passing events. As indicated in the previous section, the objective was to extract about 150 passing events per direction for each study site.

For this project, a passing event is not necessary counted for each vehicle observed to be traveling on the left lane. While many passing events involve a vehicle traveling alone on the left freeway lane, situations in which a number of vehicles were observed to be traveling in a compact group on the left lane were also counted as single passing events. This definition is illustrated by examples of Figure 8, which illustrate two scenarios categorized as single passing events. The rationale for such a treatment is linked to the fact that left-lane vehicle groupings are often created by a single lead vehicles traveling at a speed lower than the desired speed of the following vehicles. In such a case, it thus becomes difficult to distinguish the behavior of the following vehicles to that of the lead passing vehicle. Counting separate events for each vehicle observed to be traveling on the left lane would then create a risk to bias the results of the study.

Figure 8. Examples of single valid passing events

Table 4 presents a sample of passing event data that has been extracted from the collected videos for the eastbound travel direction at the Sunfield Highway overpass for the "before" portion of the study. For each group of vehicles traveling on the left lane, the speed of the lead vehicle was determined by calculating the time the vehicle took to travel between two markers 150, 200 or 250 ft apart. A similar calculation was also made for the closest vehicle traveling on the right lane. This vehicle could be either ahead or behind the vehicle on the left lane. This allowed comparing the speed of the vehicles on both lanes and assessing how fast a vehicle is taking over the other. The extracted time markers were also used to calculate the time interval separating two vehicles and assess how far behind or ahead a left-lane vehicle is from the closest right-lane vehicle. Occasionally, gaps between two right-lane vehicles were also calculated to assess whether the observed gaps are large enough to assume that a left-lane vehicle should move to the right lane.

Figure 9 illustrates examples of passing events categorized as invalid left-lane uses. For each event, the determination of whether it constitute a lawful or unlawful left-lane usage was made based on a number criteria:

- The first criterion looked whether vehicle was actually being passed on the right. This was determined by considering the time interval separating vehicles on both lanes. Vehicles traveling on the left lane less than 2 seconds behind or ahead the closest right-lane vehicle were generally assumed to be lawfully traveling on the left lane. This criterion was extended to 3 seconds when the closest vehicle was a truck to account for the additional distance that many drivers often choose to maintain when traveling around these vehicles.
- To distinguish between cases in which a vehicle may stay on the left lane to pass multiple vehicles, vehicles that were found to be traveling more than 2 seconds away from right lane vehicles were assumed to unlawfully remain on the left lane if a gap of less than 8 seconds existed between the right-lane vehicles ahead and the right-lane vehicle behind. Gaps of less than 8 seconds were deemed too short to provide sufficient rationale for the left-lane vehicles to temporarily move back to the right lane between passing two vehicles.

Table 4. Sample of Passing Event Data Extracted from Traffic Videos

Location: Sunfield Highway
Direction: I-96 Eastbound
Date: Thursday, September 27, 2007 – 12:40 to 2:40 PM
Sign in use: Slower Traffic Keep Right (Before Period)

Event	Video time (min:sec)	Travelled distance (feet)	Vehicle on left lane	Time at first marker	Time at second marker	Speed of vehicle on left lane	Closest vehicle on right lane	Time at first marker	Time at second marker	Speed of right-lane vehicle	Interval between left-lane and right-lane vehicles at first marker	Interval between left-lane and right-lane vehicles at second marker	Gap between right-lane vehicles	Speed difference between left-lane and right-lane vehicles	Number of Vehicles in passing group	Valid left lane use?
1	0:31	250	Car	31.65	33.53	90.5	Car	31.67	34.13	69.1	0.0	0.6		21.3	1	Yes
2	0:58	250	Car	57.53	59.60	82.2	Car	57.73	60.00	74.9	0.2	0.4		7.2	1	Yes
3	1:15	250	Car	15.73	17.80	82.2	Truck	13.73	16.47	62.1	-2.0	-1.3		20.1	1	Yes
4	1:20	250	Car	20.84	22.87	83.8	Truck	13.73	16.47	62.1	-7.1	-6.4	17.7	21.7	1	**No**
5	1:31	250	Car	31.60	33.60	85.0	Car	31.47	33.53	82.6	-0.1	-0.1		2.5	1	Yes
6	1:55	250	Car	55.80	58.07	74.9	Truck	56.53	59.40	59.3	0.7	1.3		15.7	4	Yes
7	2:05	250	Car	5.40	7.60	77.3	Truck	2.00	4.87	59.3	-3.4	-2.7	8.0	18.0	2	Yes
8	2:15	250	Car	15.05	17.13	81.8	Truck	14.00	16.60	65.4	-1.1	-0.5		16.4	1	Yes
9	2:18	250	Car	18.27	20.27	85.0	Truck	14.00	16.60	65.4	-4.3	-3.7	7.1	19.6	1	Yes
10	2:46	250	Car	46.73	49.00	74.9	Car	41.53	43.73	77.3	-5.2	-5.3	14.7	-2.4	1	**No**
11	3:29	250	Car	29.87	32.20	73.0	Truck	29.60	32.40	60.7	-0.3	0.2		12.3	1	Yes
12	3:55	250	Car	55.20	57.20	85.0	Car	56.80	59.07	74.9	1.6	1.9		10.1	2	**No**
13	3:59	250	Car	58.80	61.00	77.3	Car	59.40	61.93	67.2	0.6	0.9		10.1	3	Yes
14	4:13	250	Car	13.93	16.20	74.9	Truck	4.33	7.00	63.7	-9.6	-9.2	13.0	11.2	3	**No**
15	4:17	250	Car	17.67	19.94	74.9	Truck	17.34	20.20	59.5	-0.3	0.3		15.5	1	Yes
16	4:21	250	Car	21.33	23.73	70.9	Truck	17.34	20.20	59.5	-4.0	-3.5	7.9	11.4	1	Yes
17	4:29	250	Car	28.33	30.53	77.3	Truck	29.00	31.80	60.7	0.7	1.3		16.6	1	Yes
18	4:55	250	Car	53.73	55.87	79.5	Truck	56.80	59.47	63.7	3.1	3.6	26.0	15.8	1	**No**
19	5:29	250	Car	29.80	32.00	77.3	Car	30.62	32.87	75.6	0.8	0.9		1.7	2	Yes
20	6:00	250	Car	0.00	2.27	74.9	Car	1.27	3.87	65.4	1.3	1.6		9.5	3	Yes
21	6:08	250	Car	6.65	9.00	72.4	Truck	8.13	10.87	62.1	1.5	1.9		10.3	1	Yes
22	6:17	250	Car	17.40	19.47	82.2	Car	16.38	18.60	76.6	-1.0	-0.9		5.6	2	Yes
23	6:36	250	Car	36.53	38.93	70.9	Truck	37.60	40.33	62.3	1.1	1.4		8.6	1	Yes
24	7:01	250	Car	1.13	3.13	85.0	Truck	1.00	3.40	70.9	-0.1	0.3		14.2	3	Yes
25	7:15	250	Car	9.27	11.6	73.0	Truck	10.85	13.67	60.3	1.6	2.1		12.7	2	Yes
26	7:25	250	Car	25.33	27.53	77.3	Truck	22.70	25.47	61.4	-2.6	-2.1	5.0	15.9	2	Yes

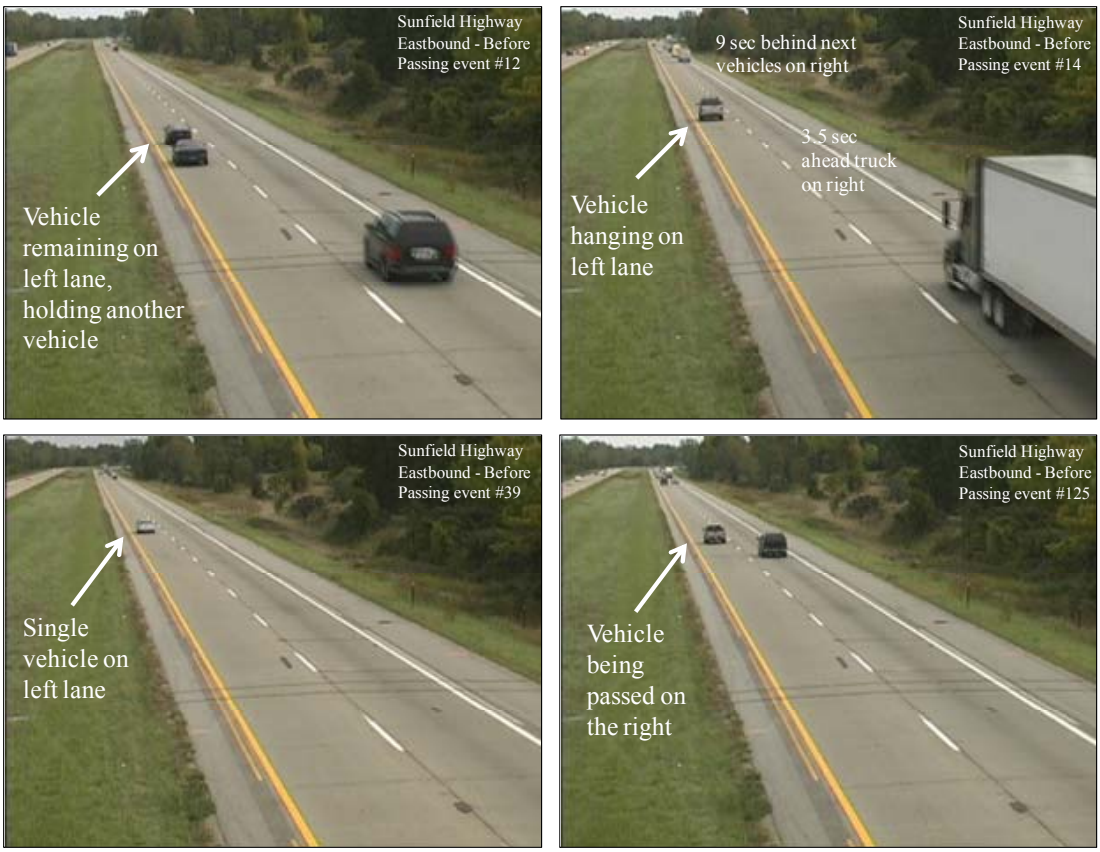

Figure 9. Examples of invalid left lane usage

- Vehicles traveling on the left lane at a speed slower than that of the closest right-lane vehicle behind them were assumed to be about to be passed on the right, and consequently, unlawfully traveling on the left lane. This criterion only applied to cases in which the closest vehicle on the right was less than 2 seconds behind the left-lane vehicle (3 seconds in the right-lane vehicle is a trucks).
- Finally, exceptions to the above rules where occasionally made after considering contextual information provided by the videos, such as types of vehicles being passed, speed differential between vehicles on the left and right lanes, and observed driver behavior within the entire frame of the video.

While the categorization of passing events as valid and non-valid events is heavily influenced by the judgment of the person reviewing the video data, efforts were made to minimize potential bias in the analyses by having the same person processing the video data for each site for both the "before" and "after" portion of the study.

5 Data Analysis

This section details the results of the analyses that were conducted on the collected data to determine whether the replacement of "Slower Traffic Keep Right" signs by "Keep Right Pass Left – It's the Law" signs has had noticeable impacts on how motorists use the left and right traffic lanes on rural two-lane sections of I-96 around Lansing. Results of the analyses conducted on the tube counter data are first provided followed by results of the analyses conducted on the video data. General conclusions are provided in the following section.

5.1 Tube Counter Data Analysis

The tube counter data provided near-continuous vehicle counts and individual vehicle speed observations for each traffic lane at each study site over a one-week period for both the "before" and "after" portions of the study. As was indicated in Figure 5, relatively few data were lost due to counter malfunction or the observation of unusual traffic conditions. This allowed for very solid characterizations of typical mid-day average weekday traffic behavior.

All the analyses reported in this section focus on data collected during each weekday between 10:00 AM and 3:00 PM. Data collected during the morning and afternoon peak period were excluded as the higher traffic levels that normally exist during these periods may lead to the formation of continuous streams of vehicles on both freeway lanes, either temporarily or for extended periods, and create situations in which motorists may legally travel on either lane. Evening and night periods were also excluded, primarily due to the difficulty of collecting video data complementing the tube counter data during these periods. Another element considered was the fact that the significantly lower traffic volumes that normally exist during the evening and night typically lead to very few passing events. There were also concerns that conclusions drawn from observing evening and night traffic may not accurately reflect typical daytime driver behavior.

5.1.1 Characterization of General Traffic Conditions

To ensure that the comparison of data collected during the "before" and "after" survey periods are not affected by significant changes in traffic demand or traffic conditions, the analysis of tube counter first focused on assessing general traffic conditions at each study site during each period.

Figure 10 first compares the general composition of traffic captured by the tube counters at each site on weekdays between 10:00 AM and 3:00 PM during each survey period. The diagrams clearly indicate that similar proportions of passenger vehicles and commercial trucks were observed during both periods. While some variations exist, these remain relatively low and within what can be expected when considering that rural freeway traffic may be composed of both regular and occasional travelers. This conclusion is further supported by results of paired t-tests

that were executed to compare the average proportions of passenger cars and commercial trucks observed across all sites during the "before" and "after" study periods. Results of these tests are shown in Table 5. Both tests indicate that the observed variations in average proportion of passenger vehicles and trucks across all sites are not statistically significant at a 95% confidence level.

Figure 11 further compares the traffic volumes at each site for the same observation periods as Figure 10. Similar to the traffic composition data, the figure generally indicates relatively small variations in traffic volumes at each site for each weekday between both survey periods. While some significant differences are observed on some days, these are generally explained by missing or invalid tube counter data. As can be observed, all the days with significant variations correspond to days marked by a black or white asterisk, which correspond to days with missing or invalid data.

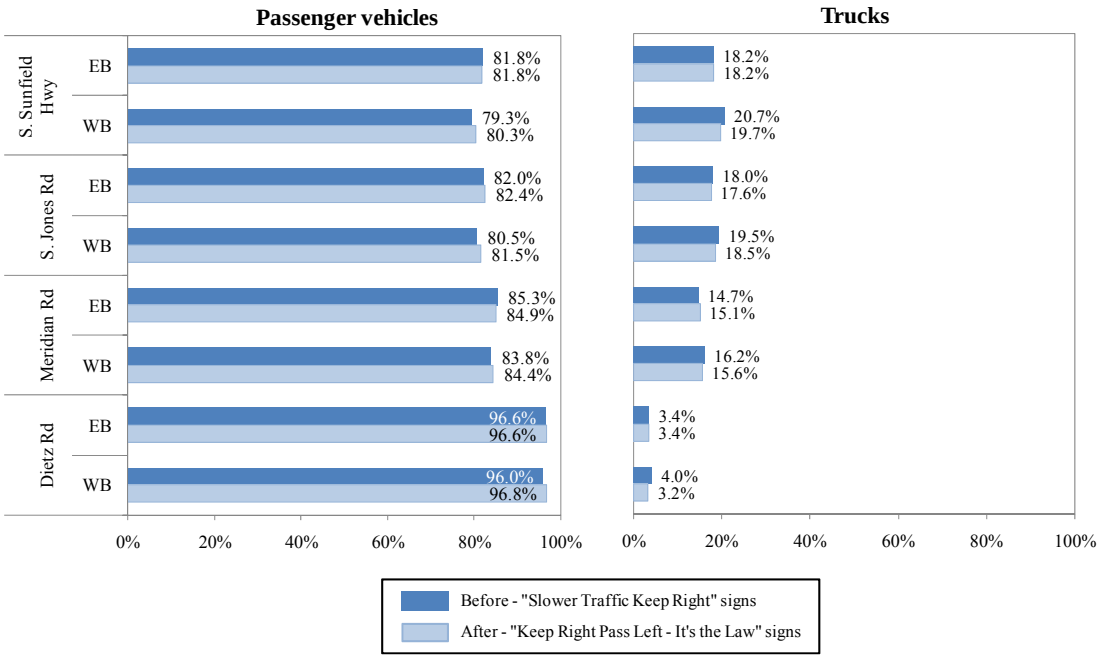

Figure 10. Traffic composition at survey sites

Table 5. Paired t-test for sample means – Traffic composition

	Passenger vehicle		Trucks	
Statistics	Before	After	Before	After
Sample size	8	8	8	8
Mean	85.7%	86.1%	14.3%	13.9%
Variance	0.46%	0.45%	0.46%	0.45%
t statistic (two-tail test)	-2.294		2.294	
t critical (two-tail test)	2.365		2.365	
P ($T \leq t$)	0.055		0.055	
Conclusion	P > 0.05, change not statistically significant at 95% confidence level		P > 0.05, change not statistically significant at 95% confidence level	

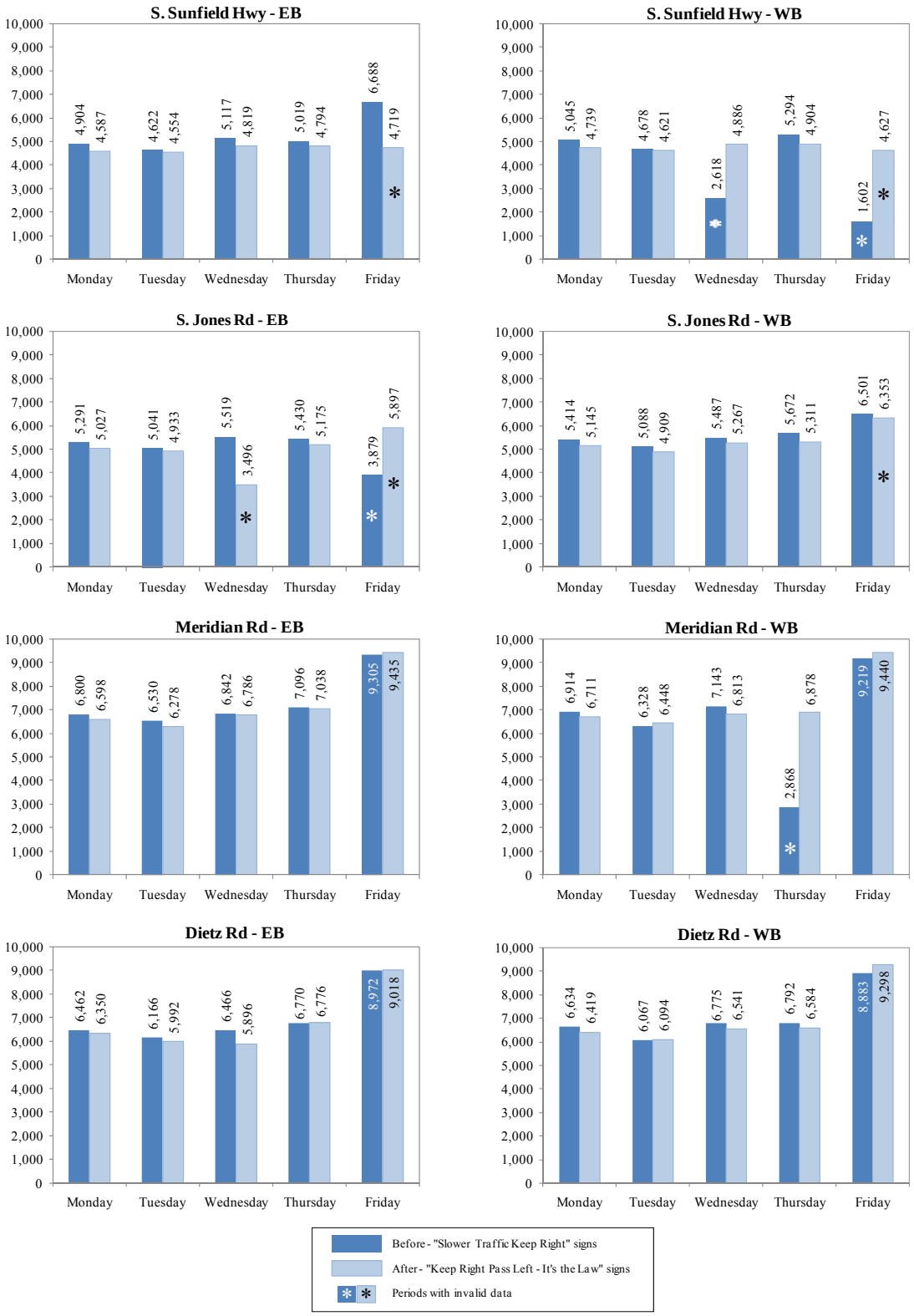

Figure 11. Observed traffic volumes at survey sites

For both the "before" and "after" periods, traffic volumes remained relatively constant during each survey week. In both cases, the only major variation occurs on Friday, when a significant increase in traffic volume is observed. The observed surge is however not significant enough to create congestion. Considering that the observations extend each day over a five-hour period, the observed weekday traffic volumes translate to average hourly rates ranging between 450 and 715 vehicles per hour per lane on Mondays, Tuesdays, Wednesdays and Thursdays, and rates reaching as high as 945 vehicles per hour per lane on Fridays. Assuming a typical capacity of 2350 vehicles/hour/lane for basic freeway segments with free-flow speed of 70 mph, as per the 2000 Highway Capacity Manual (TRB, 2000), these flow rates convert to volume-to-capacity ratios roughly ranging between 0.20 and 0.40, well below congested levels (typically ratios above 0.85).

5.1.2 Proportion of Traffic Using Freeway Left Lane

Figure 12 illustrates the proportion of passenger vehicles and trucks that were detected to be traveling on the left freeway lane at each study site. In this analysis, the tube counter data provide no information about whether individual left-lane vehicles are passing other vehicles on the right lane. Despite this lack of details, the provided information remain useful by offering an assessment of the magnitude of left-lane usage and potential for problems associated with unlawful left-lane usage at each site.

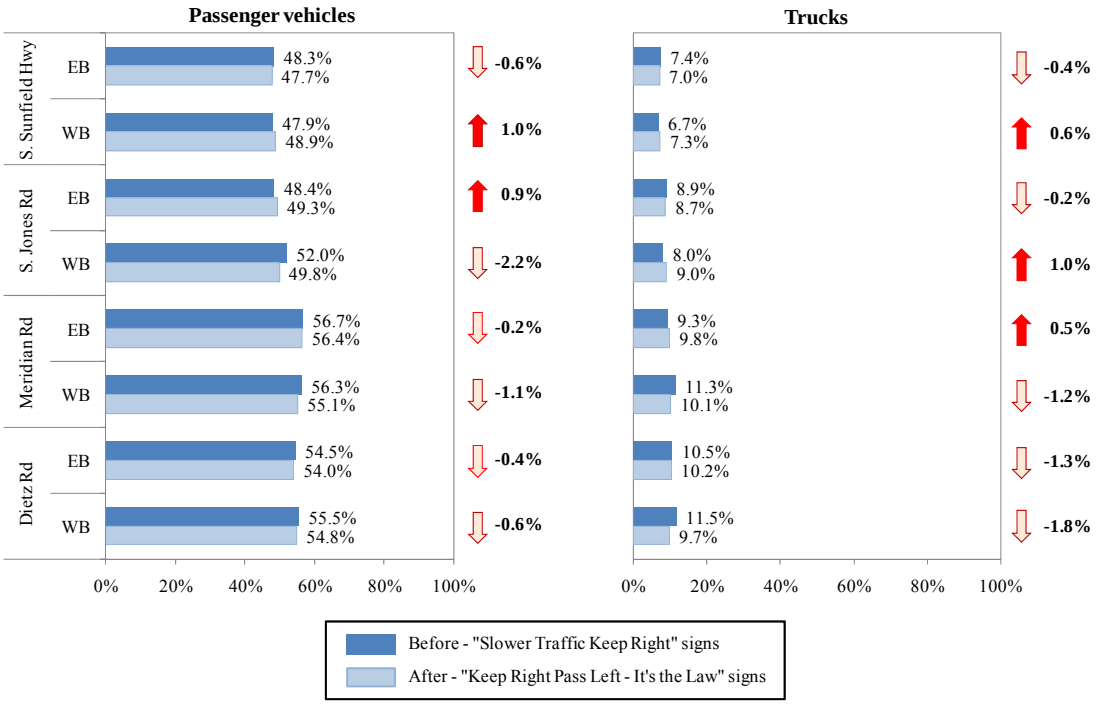

Figure 12. Proportion of vehicles traveling on left lane

As can be observed, and somewhat expected, a significantly larger proportion of passenger cars than commercial trucks use the left lane at each study site. This is in great part explained by the state's lower speed limit for trucks (60 mph) than passenger cars (70 mph). This speed limit differential results in trucks typically traveling at lower speeds than the general traffic and in fewer reasons for these vehicles to travel on the left lane to pass other vehicles. About half of the passenger vehicles were typically observed to be traveling on the left freeway lane at each study site, with slightly higher proportions at sites east of Lansing (54-57%) than sites west of Lansing (48-52%). In contrast, only 7 to 11% of commercial trucks were observed to be traveling on the left lane at each site, again with slightly higher proportions at sites east of Lansing (7-9%) than sites west of the city (9-11%).

Comparisons of the "before" and "after" data indicate no clear trend in left-lane usage following the replacement of "Slower Traffic Keep Right" signs with "Keep Right Pass Left – It's the Law" signs. Depending on the site considered, changes in the proportion of left-lane traffic range from a 2.2% reduction to a 1.0% increase, with more sites reporting a reduction than an increase. When looking at the average trends, no clear direction in reduction in left-lane usage is identified. This is supported by the data of Table 6, which illustrate the results of paired t-tests for sample means that were conducted to assess the significance of observed changes in the average proportions of left-lane traffic between the "before" and "after" periods. While slight reductions in the average proportion of left-lane traffic are observed for both passenger vehicles (52.4% to 52.0%) and trucks (9.2% to 9.0%), these changes are not found to be statistically significant and could therefore be simply the results of stochastic effects.

Table 6. Paired t-test for sample means – Proportion of traffic in left lane

	Passenger vehicle		**Trucks**	
Statistics	**Before**	**After**	**Before**	**After**
Sample size	8	8	8	8
Mean	52.4%	52.0%	9.2%	9.0%
Variance	0.14%	0.12%	0.03%	0.02%
t statistic (two-tail test)	1.151		0.639	
t critical (two-tail test)	2.365		2.365	
P ($T \leq t$)	0.287		0.543	
Conclusion	P > 0.05, change not statistically significant at 95% confidence level		P > 0.05, change not statistically significant at 95% confidence level	

5.1.3 Vehicles Traveling Below Speed Limit

The proportion of vehicles traveling below speed limit is a potential indicator of the degree to which individual motorists may be affected by slower vehicles. A high proportion of slow vehicles on freeway right lanes is an indicator of the need for other vehicles to use the left lane to pass slower traffic. In addition, a high proportion of slow vehicles on the left lane may not only be a reflection of the need to pass slow

moving traffic on the right but also of the potential for these slow vehicles to block other faster moving vehicles.

Figure 13 illustrates the percentage of passenger vehicles in each freeway lane that were observed to be traveling below Michigan's 70 mph general freeway speed limit at each study site during the "before" and "after" survey periods. Figure 14 provides similar information for commercial trucks with respect to Michigan's 60 mph truck speed limit. To facilitate comparisons with passenger car behavior, Figure 15 further compares observed truck speeds against the 70 mph general freeway speed limit.

As can be observed, between 7 and 20% of detected passenger cars were found to be traveling on the left freeway lane below the 70 mph posted speed limit at each site in the presence of "Slower Traffic Keep Right" signs. It can reasonably be assumed that many of these vehicles are traveling on the left lane to pass slower moving vehicles on the right lane. This is supported by the data of Figure 13, which indicate that between 28% and 54% of the passenger cars traveling on the right lane at each site did so at speeds of less than 70 mph. Figures 14 and 15 further indicates that between 29 and 58% of right-lane trucks were observed to be traveling at speeds lower than 60 mph, with virtually all trucks traveling at speeds not exceeding 70 mph.

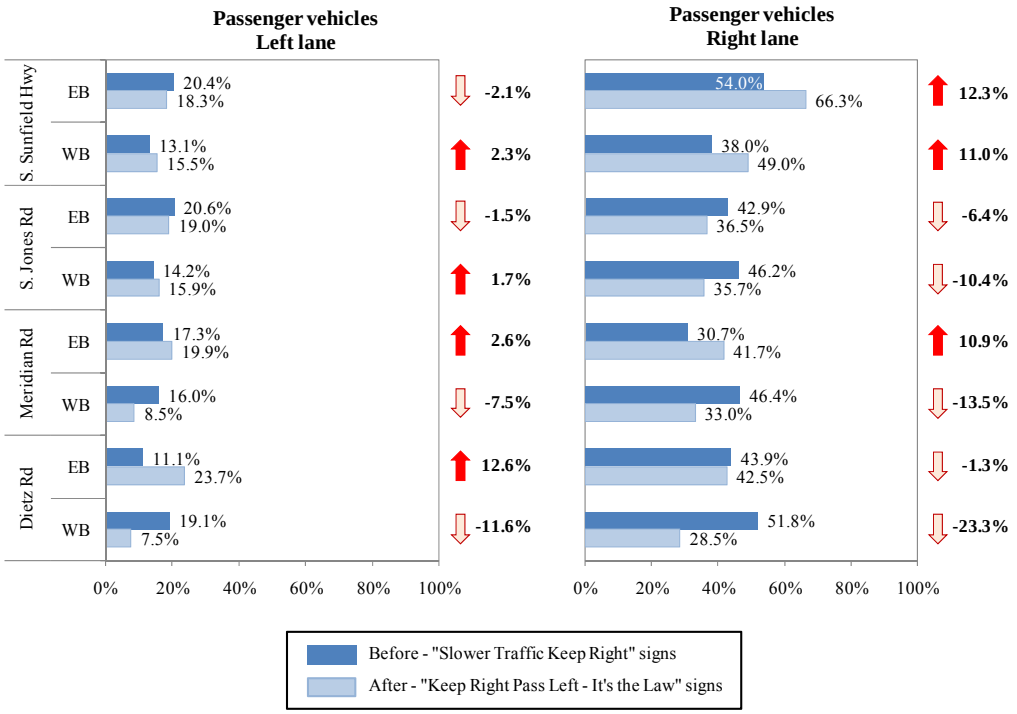

Figure 13. Proportion of passenger vehicles traveling below the general 70 mph freeway speed limit

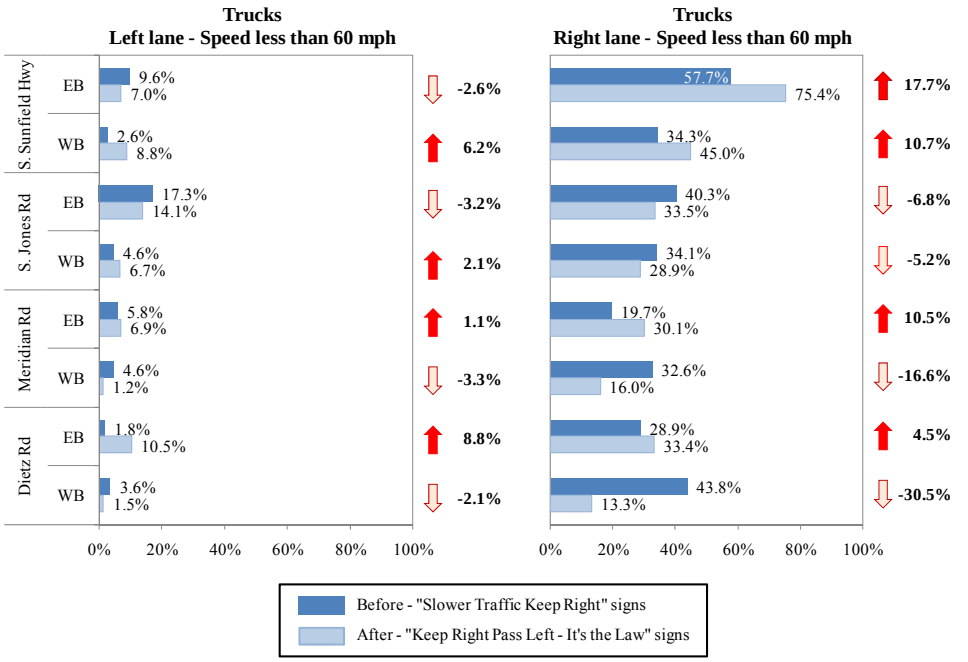

Figure 14. Proportion of trucks traveling below the trucks-specific 60 mph freeway speed limit

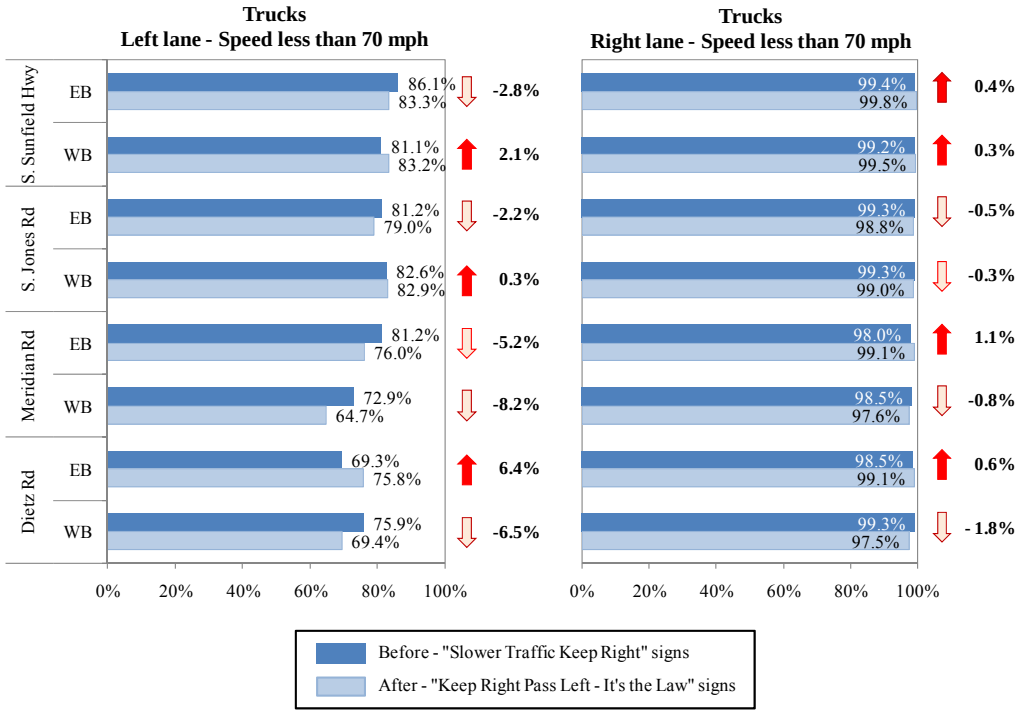

Figure 15. Proportion of trucks traveling below the general 70 mph freeway speed limit

While the above evidence provides strong justification for the use of the left freeway lane at each site, anecdotal evidence suggests that a certain proportion of slow moving vehicles may be traveling on the left lane for reasons other than passing. In this case, replacing "Slower Traffic Keep Right" signs by "Keep Right Pass Left – It's the Law" signs should ideally translate into a reduction in the proportion of slow-moving vehicles using the left freeway lane at each site. However, the collected data provide no conclusive evidence towards such an impact. As can be observed in Figures 13, 14 and 15, no clear trends regarding a possible reduction of the proportion of slow moving vehicles traveling on the left lane can be detected when comparing data from the "before" and "after" survey periods.

The lack of conclusive impact trends is again further emphasized by the results of paired t-tests that were conducted to assess whether the sign replacement significantly altered the proportion of left-lane vehicles observed to be traveling below the posted speed limit at each site. Results of these tests are shown in Tables 7, 8 and 9. While reductions in average proportions of slow left-lane traffic are observed across all study sites for both types of vehicles considered when comparing the "before" and "after" data, the variability of changes observed at individual sites leads to the

Table 7. Paired t-tests for sample means – Proportion of passenger vehicles traveling below speed limit

	Left lane		**Right lane**	
Statistics	**Before**	**After**	**Before**	**After**
Sample size	8	8	8	8
Mean	16.5%	16.0%	44.2%	41.7%
Variance	0.12%	0.31%	0.55%	1.38%
t statistic (two-tail test)	1.167		0.557	
t critical (two-tail test)	2.365		2.365	
P ($T \leq t$)	0.872		0.595	
Conclusion	P > 0.05, change not statistically significant at 95% confidence level		P > 0.05, change not statistically significant at 95% confidence level	

Table 8. Paired t-tests for sample means – Proportion of trucks traveling below truck speed limit (60 mph)

	Left lane		**Right lane**	
Statistics	**Before**	**After**	**Before**	**After**
Sample size	8	8	8	8
Mean	6.2%	7.1%	36.4%	34.5%
Variance	0.26%	0.19%	1.26%	3.76%
t statistic (two-tail test)	-0.534		0.346	
t critical (two-tail test)	2.365		2.365	
P ($T \leq t$)	0.610		0.740	
Conclusion	P > 0.05, change not statistically significant at 95% confidence level		P > 0.05, change not statistically significant at 95% confidence level	

Table 9. Paired t-tests for sample means – Proportion of trucks traveling below car speed limit (70 mph)

	Left lane		Right lane	
Statistics	**Before**	**After**	**Before**	**After**
Sample size	8	8	8	8
Mean	80.5%	76.8%	98.9%	98.8%
Variance	0.81%	0.47%	0.00%	0.01%
t statistic (two-tail test)	0.645		0.407	
t critical (two-tail test)	2.365		2.365	
P ($T \leq t$)	0.178		0.696	
Conclusion	P > 0.05, change not statistically significant at 95% confidence level		P > 0.05, change not statistically significant at 95% confidence level	

assessment that the observed changes are not statistically significant. This is particularly evidenced by the fact that some sites showed a reduction in the proportion of the slow left-lane lane traffic following the installation of the "'Pass Left Keep Right – It's the Law" signs while others showed an increase.

5.1.4 Lane-Specific Speed Distributions

The analysis of the proportions of vehicles traveling below speed limit has already indicated a lack of conclusive trends with respect to the ability of the proposed "Keep Right Pass Left – It's the Law" signs in reducing left-lane slow moving traffic. This section takes a deeper look at the distributions of recorded speed to see whether the tested sign replacement may have resulted in more subtle changes in traffic behavior despite the lack of general trend evidence.

Figures 16 and 17 illustrate the compiled speed distributions for the sites east and west of Lansing respectively. As can be observed, the resulting distributions appear to be virtually identical in most cases. In particular, there are very few noticeable changes in the proportion of low-speed vehicles within each pair of distributions. This is again consistent with the findings of previous sections, which generally found no significant impacts associated with the sign replacements.

Tables 10 and 11 further compare the average traffic speeds obtained by compiling data from the right-and left-lane distributions across all study sites. Of particular interest in this case is the fact that while slight increases in average speed are observed for both left-lane passenger vehicle (73.8 to 74.1 mph) and commercial truck traffic (66.0 to 66.1 mph), similar increases are also observed for vehicles traveling on the right lane. In this case, paired t-tests for sample means reveals once again that the observed changes are not statistically significant based on the variability of observed changes across individual study sites. This once more prevents any general claim to be issued regarding the effectiveness of the proposed sign replacement to alter left-lane traffic behavior.

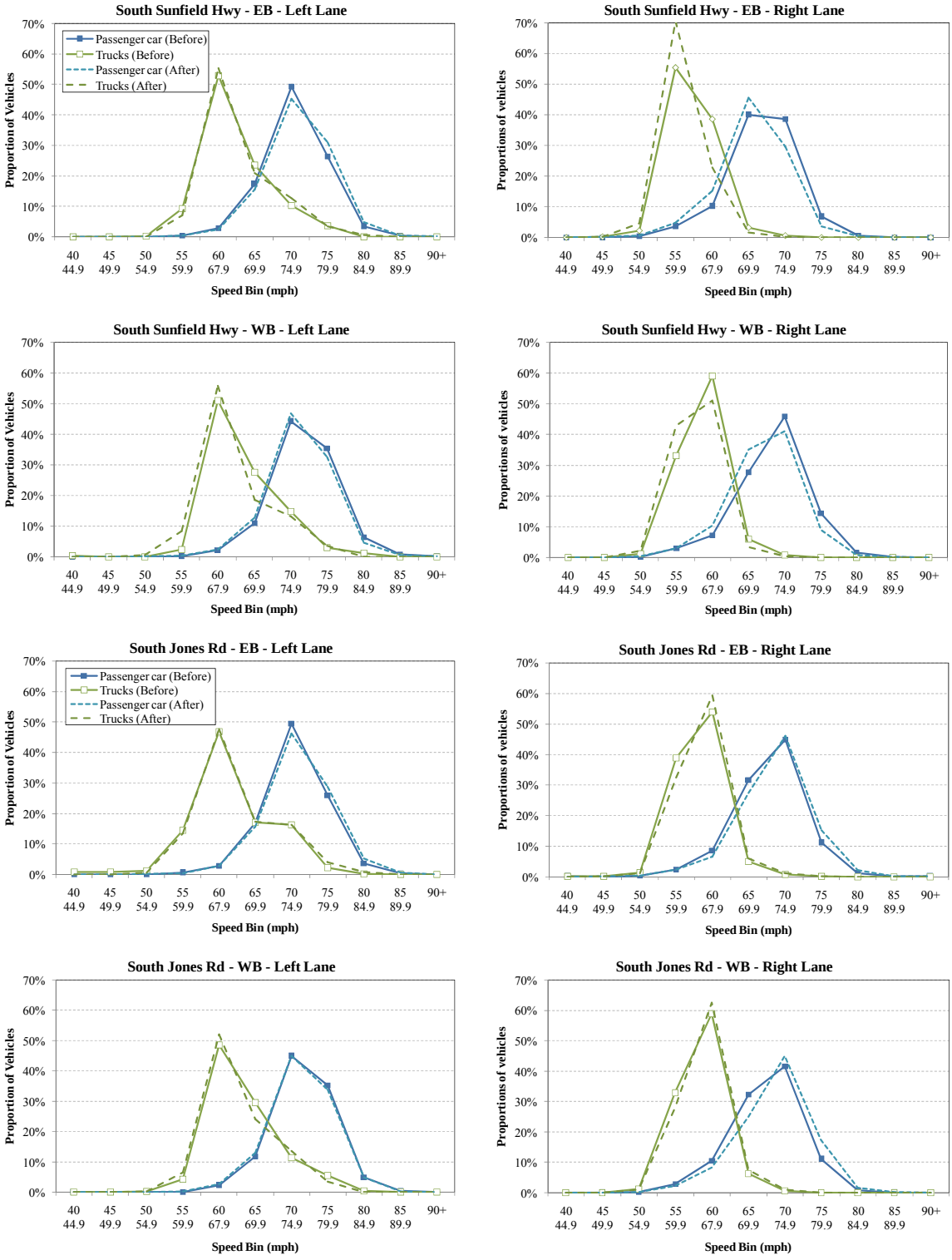

Figure 16. Speed distributions – Sites west of Lansing

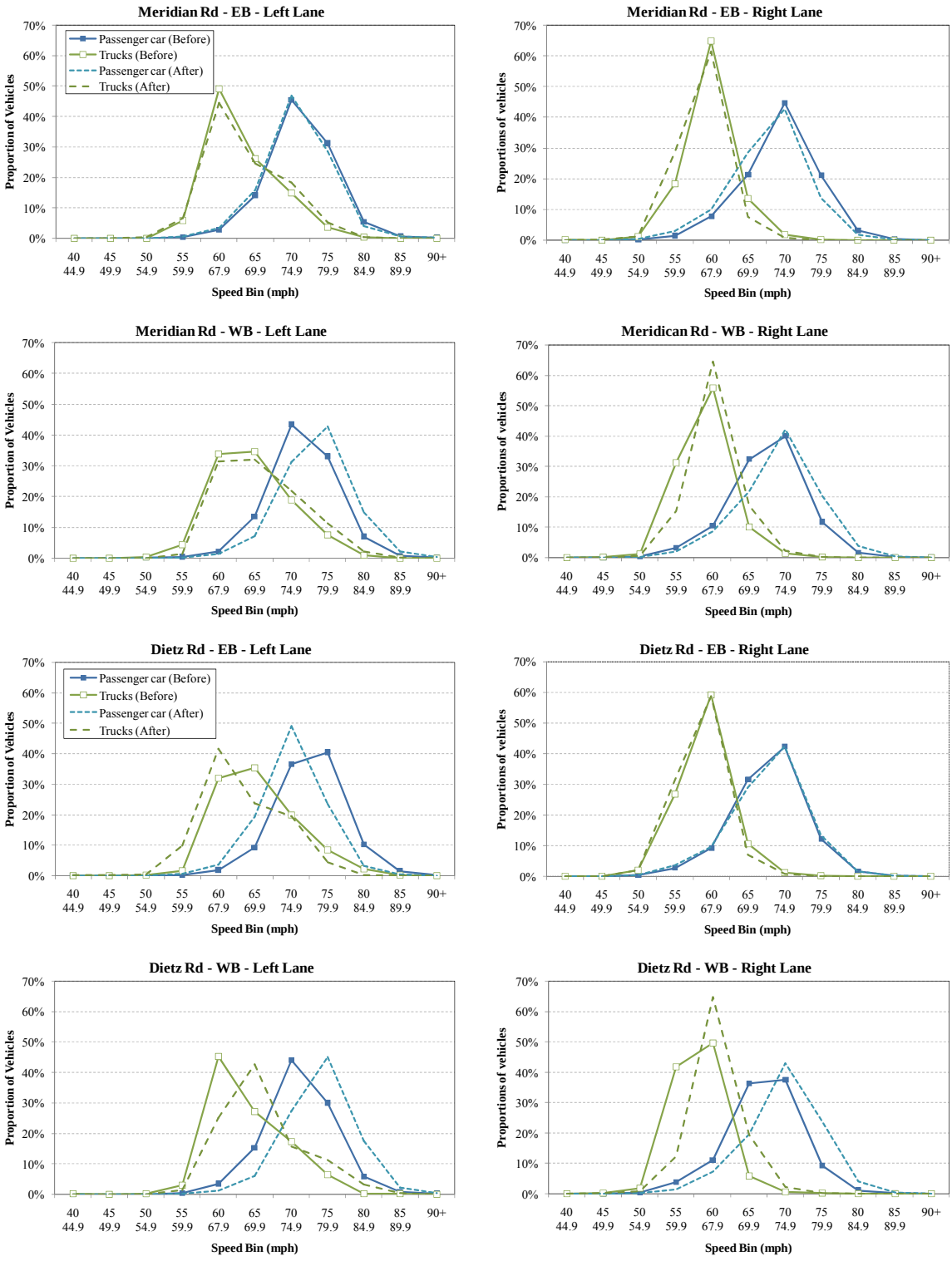

Figure 17. Speed distributions – Sites east of Lansing

Table 10. Paired t-test for sample means – Changes in average left-lane speed

	Passenger vehicle		Trucks	
Statistics	**Before**	**After**	**Before**	**After**
Sample size	8	8	8	8
Mean	73.8	74.1	66.0	66.1
Variance	0.50	1.91	1.42	2.26
t statistic (two-tail test)	-0.460		-0.311	
t critical (two-tail test)	2.365		2.365	
P ($T \leq t$)	0.660		0.765	
Conclusion	P > 0.05, change not statistically significant at 95% confidence level		P > 0.05, change not statistically significant at 95% confidence level	

Table 11. Paired t-tests for sample means – Changes in average right-lane speed

	Passenger vehicle		Trucks	
Statistics	**Before**	**After**	**Before**	**After**
Sample size	8	8	8	8
Mean	70.3	70.6	61.1	61.2
Variance	0.63	1.63	0.62	1.93
t statistic (two-tail test)	-0.597		-0.379	
t critical (two-tail test)	2.365		2.365	
P ($T \leq t$)	0.570		0.716	
Conclusion	P > 0.05, change not statistically significant at 95% confidence level		P > 0.05, change not statistically significant at 95% confidence level	

Table 12. Probability results of Kolmogorov-Smirnov tests for equality of "before" and "after speed distributions

		Passenger vehicle		Trucks	
Statistics		**Left lane**	**Right lane**	**Left lane**	**Right lane**
S. Sunfield Hwy.	EB	0.000	0.000	1.000*	0.000
	WB	0.000	0.000	0.047**	0.000
S. Jones Rd.	EB	0.000	0.000	0.988*	0.000
	WB	0.064***	0.000	0.484*	0.000
Meridian Rd.	EB	0.000	0.000	0.485*	0.000
	WB	0.000	0.000	0.036**	0.000
Dietz Rd.	EB	0.000	0.185*	0.000	0.000
	WB	0.000	0.000	0.000	0.000

* No real evidence against the assumption that the distributions are similar
** Little evidence against the assumption that the distributions are similar
*** Suggestive evidence against the assumption that the distributions are similar

Table 12 adds to the analysis results of Kolmogorov-Smirnogv goodness of fit tests that were conducted to assess whether the "before" and "after" distributions for each site could be considered identical. This test, which was conducted using the Matlab software, analyzes differences between the cumulative probability distributions of the two datasets being compared. Because of the significantly different speed distributions obtained for passenger vehicles and trucks, separate tests were conducted for each vehicle type.

The test results generally indicate that the observed "before" and "after" speed distributions extracted from the tube counter data cannot be considered identical, with a few exceptions, primarily for the left-lane truck speed distributions. These results generally correspond to what can be inferred by looking at the differences between the distributions illustrated in Figures 16 and 17. However, the inability to conclude that the "before" and "after" distributions are from a same underlying distribution does not constitute in this case a proof of the effectiveness of the proposed "Keep Right Pass Left – It's the Law" signs.

A close examination of the distributions illustrated in Figure 16 and 17 indicates that the variations in speed distributions that are causing the tests to reject the hypothesis of a single distribution may not be related to the tested sign replacement. For many sites, there are no notable variations in the proportion of low-speed passenger car or truck traffic on the left freeway lane. In one case, for westbound traffic at the Dietz Rd. overpass, higher proportions of slow passenger cars and trucks are even observed during the "after" period than the "before" period. In an ideal situation, reductions in the proportion of slow left-lane traffic should have been observed at all sites. Similarly, a reduction in the proportion of slow left-lane traffic should be accompanied by an increase in the proportion of slow right-lane traffic. Again, while sites show such an increase, other sites show a contradicting reduction in right lane slow traffic as well. This suggests that changes in general traffic conditions not necessarily related to the signs being tested may be behind the observed changes. Since the expected changes are not consistently observed, there is again no conclusive evidence regarding the effectiveness of the proposed "Keep Right Pass Left – It's the Law" signs in altering traffic behavior.

5.2 Video Data Analysis

Table 13 summarizes key statistics for the passing events that were extracted from the collected traffic videos at each study site. As indicated, 150 events were identified for each site. The only exception is for the eastbound traffic at the South Jones Road overpass, for which no passing events were extracted. For this site, a lane closure located less than a mile downstream of the study site significantly affected traffic behavior around the overpass during the "before" period. Because of this effect, no valid comparisons could be made between the data collected during the "before" and "after" periods.

Table 13. Summary of Extracted Passing Events

		South Sunfield Hwy		South Jones Rd		Meridian Rd		Dietz Rd	
		EB	**WB**	**EB**	**WB**	**EB**	**WB**	**EB**	**WB**
Number of passing events		150	150	n/a	150	150	150	150	150
Observation interval (min)	Before	33:37	26:00	n/a	33:05	25:34	17:15	19:47	25:40
	After	36:00	37:21	n/a	30:48	26:22	20:00	24:42	30:40
Events with passenger car as passing vehicle	Before	97%	98%	n/a	95%	98%	96%	96%	95%
	After	97%	96%	n/a	99%	97%	97%	97%	99%
Events with passenger car as passed vehicle	Before	47%	56%	n/a	52%	54%	63%	65%	65%
	After	54%	59%	n/a	51%	59%	63%	62%	58%

As explained earlier, a passing event was defined for this project as instances in which a single vehicle or group of vehicles were found to be traveling on the left lane. Groups of vehicles were considered as single passing events as there were often no means of determining whether the following vehicles within the group were being held up by the lead vehicle. As indicated, the extraction of 150 passing events typically required the processing of between 17 and 34 minutes of video from each site. For most sites, a relatively similar length of video needed to be processed for the "before" and "after" periods, indicating that generally similar traffic conditions were recorded at each site.

Virtually all identified passing events at each site are events in which the lead passing vehicle is a passenger vehicle. Only 1 to 4% of identified passing events at each study site feature a commercial truck as the lead passing vehicle. The data of Table 13 further indicate that between 47 and 65% of passing events involve the passing of passenger vehicles on the right lane, with the remaining cases involving the passing of a truck. This is reflective of both the fact that the traffic observed at each site includes a significant proportion of trucks, as shown earlier in Figure 10, and the fact that trucks tend to travel at lower speeds than passenger as a result of prevailing speed limit regulations.

5.2.1 Proportion of Unlawful Left Lane Events

The first analysis on left-lane usage that was conducted on the video data compared the proportions of unlawful passing events identified at each site for the "before" and "after" study periods. The primary results of this analysis are shown in Figures 18. As indicated, typically between 11 and 21% of all extracted passing events at each site during both survey periods were categorized as unlawful left-lane uses. This corresponds to between 17 and 32 unlawful events per 150 extracted events. The

more important observation is however the fact that the replacement of "Slower Traffic Keep Right" signs by "Keep Right Pass Left – It's the Law" signs does not appear to have any impact on traffic behavior. While a reduction in the proportion of unlawful events is observed at some sites, increases are observed at other. These results are consistent with the trends observed from the tube counter data. As further indicated in Table 14, while a comparison of the average proportion of passing events extracted across all sites during "before" and "after" periods reveals a slight reduction in unlawful events in the "after" period (25.9 to 23.6 unlawful events per 150 extracted events), a paired t-test reveals once again that the observed change is not statistically significant.

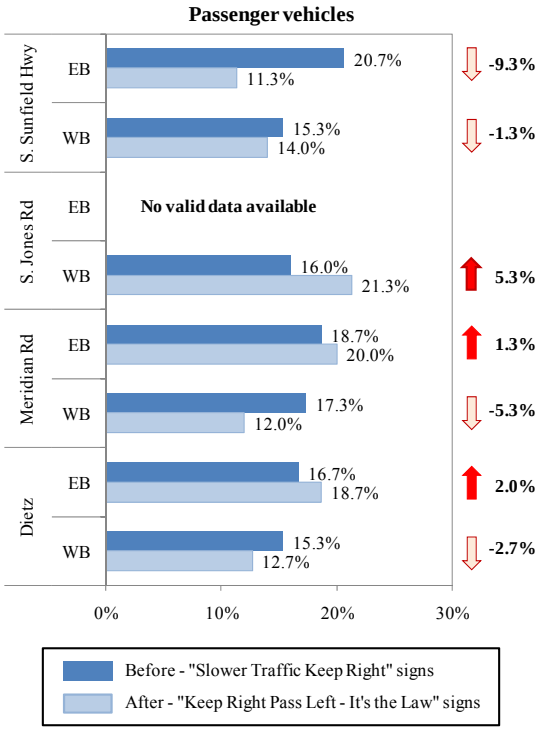

Figure 18. Proportion of invalid passing events

Table 14. Paired t-tests for sample means – Total number of invalid events

	Invalid events per 150 passing events	
Statistics	**Before**	**After**
Sample size	7	7
Mean	25.9	23.6
Variance	10.5	39.0
t statistic (two-tail test)	0.792	
t critical (two-tail test)	2.447	
P ($T \leq t$)	0.458	
Conclusion	P > 0.05, change not statistically significant at 95% confidence level	

Figure 19 and Table 15 provide a more detailed look at the extracted unlawful events by specifically comparing events in which vehicles were found to be hanging on the left lane and events in which left-lane vehicles were being passed on their right side. Similar to previous analyses, the data of Figure 19 and statistical tests reported in Table 15 indicate no clear trend following the test sign replacement.

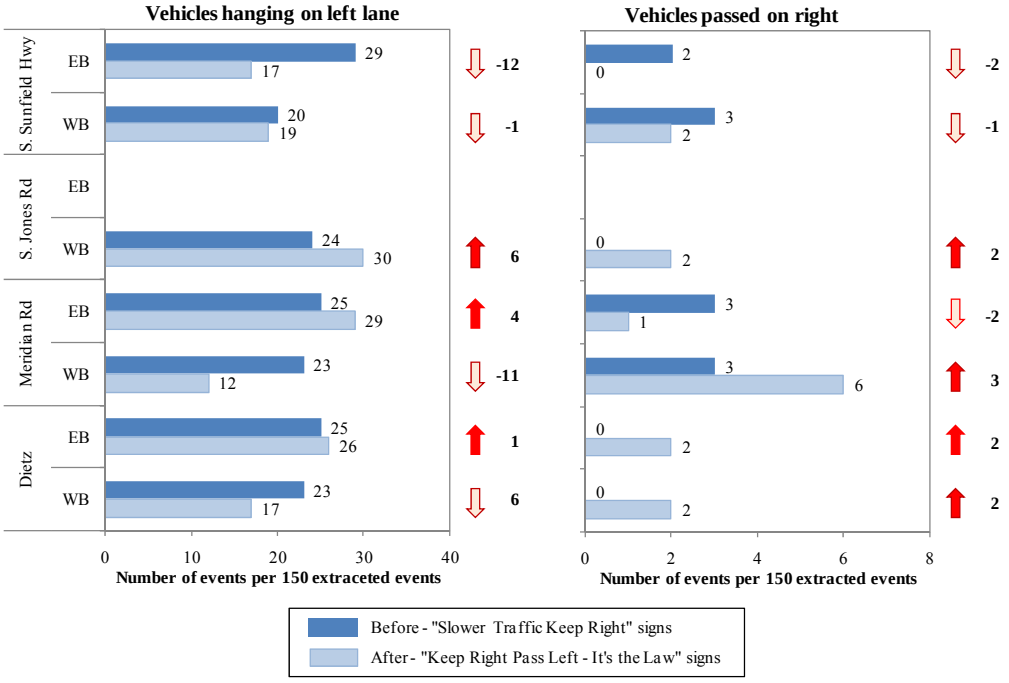

Figure 19. Comparison of event occurrences with vehicles hanging on left lane and vehicles being passed on the right

Table 15. Paired t-tests for sample means – Types of invalid events

	Vehicles hanging on left lane per 150 passing events		Vehicles passed on right per 150 passing events	
Statistics	**Before**	**After**	**Before**	**After**
Sample size	7	7	7	7
Mean	24.3	21.4	1.57	2.14
Variance	9.2	47.6	2.29	3.48
t statistic (two-tail test)	1.031		-0.703	
t critical (two-tail test)	2.447		2.447	
P ($T \leq t$)	0.343		0.508	
Conclusion	P > 0.05, change not statistically significant at 95% confidence level		P > 0.05, change not statistically significant at 95% confidence level	

5.2.2 Left-Lane Vehicle Groupings

A second analysis looked at left-lane vehicle groupings. This analysis was conducting on the basis that a decrease in the number or size of vehicle groupings could be an indication of a reduction in the number of slow moving vehicles blocking other traffic on the left lane. The main results of the data compilations that were conducted as part of this analysis are shown in Figure 20. In the figure, the diagram on the left compares the number of groupings of two or more vehicles observed at each site during the "before" and "after" study periods, while the diagram on the right compares the total number of vehicles being potentially held up within each group. In each case, the number of vehicles being held up was determined by simply compiling the number of vehicles in each grouping while ignoring the lead vehicle. As an example, consider the case of shown in Figure 21. This example shows a group of 3 vehicles passing a single vehicle on the right. In this case, two vehicles would be assumed to be potentially held up by the lead vehicle of the group.

Similar to previous compilations, the data of Figure 20 again indicate no clear trend resulting from the installation of "Keep Right Pass Left – It's the Law" signs. While some sites show a reduction in the number of left-lane vehicle groupings or in the total number of vehicles being potentially held up by other left-lane traffic, other sites show an increase in either or both statistics. This lack of trend is again confirmed by statistical tests. As indicated in Table 16, while a compilation of statistics across all survey sites indicate an overall reduction in the number of groupings (55.0 to 54.6 groupings per 150 events) and number of vehicles potentially being help up in a group (133.6 to 114.1 vehicles per 150 events), these reductions are not statistically significant when considering the stochastic variability of the collected data.

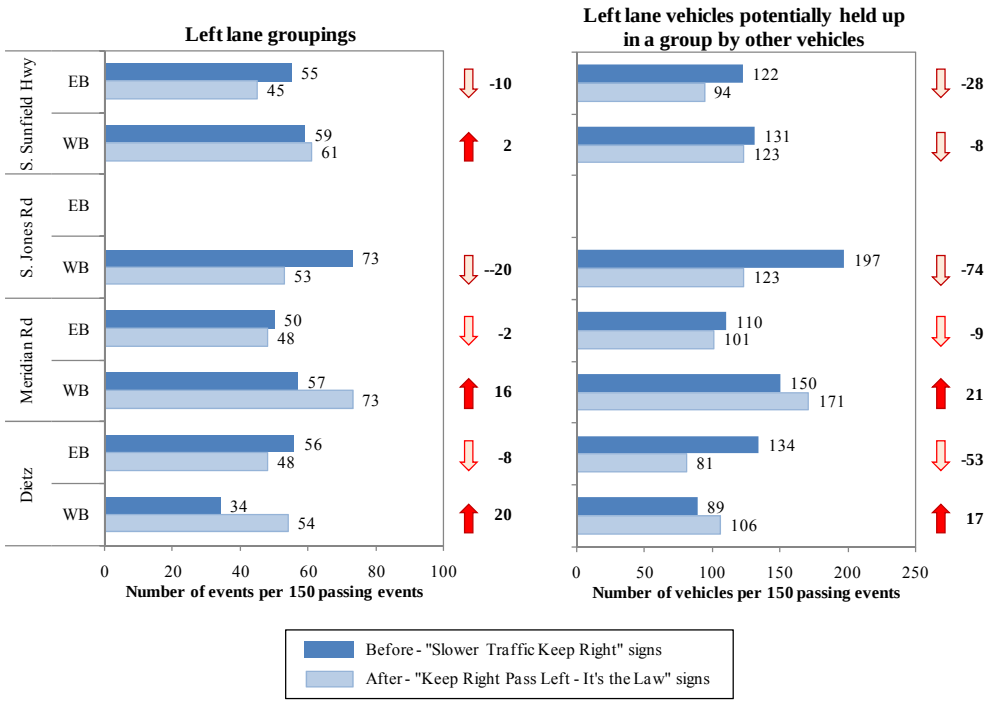

Figure 20. Left lane vehicles groupings

Figure 21. Left-lane grouping analysis example

Table 16. Paired t-tests for sample means – Left-lane vehicle groupings

	Number of groupings of two or more vehicles on the left lane, per 150 passing events		Number of left-lane vehicles potentially held up by other vehicles, per 150 passing events	
Statistics	**Before**	**After**	**Before**	**After**
Sample size	7	7	7	7
Mean	55.0	54.6	133.6	114.1
Variance	135.3	93.6	1155.6	855.5
t statistic (two-tail test)	0.079		1.462	
t critical (two-tail test)	2.447		2.447	
P ($T \leq t$)	0.940		0.194	
Conclusion	P > 0.05, change not statistically significant at 95% confidence level		P > 0.05, change not statistically significant at 95% confidence level	

An interesting observation from the analysis of passing events is that virtually all events deemed invalid involve vehicles traveling on the left lane above the speed limit. If it is assumed that only left-lane vehicles forced to travel below the speed limit are being held up by other traffic, it could then be argued that virtually no vehicles are technically being held up by other traffic while traveling on the left lane. Within this context, while there would certainly be benefits of reducing instances in which slow left-lane vehicles are holding up other left-lane traffic, such as reductions in the number of vehicles being passed on the right or tailgating events from frustrated motorists, improvements in lane usage may potentially lead to increases in average freeway speeds. As average traffic speeds are already slightly above the posted speed limit, a further increase in average traffic speed could lead to increased safety concerns related with the higher traffic speeds.

6 Conclusions

The purpose of the study detailed in this report was to assess whether replacing current "Slower Traffic Keep Right" signs by "Keep Right Pass Left – It's the Law" signs within the normal post-interchange sign sequence of two-lane rural freeway sections would provide an effective way of enticing drivers to stay on the right lane when not passing other vehicles. To evaluate the effectiveness of this proposed sign replacement, a "before/after" study was conducted in which traffic behavior was first observed at a few sites with the existing sign in place and then observed again at the same sites following installation of the proposed sign.

To conduct the desired analyses, data about traffic behavior was collected through the use of tube counters and video cameras. Tube counters were used to collect information about lane usage and typical travel speed distributions in each lane, while video cameras were used to collect specific information about individual passing events. Potential changes in traffic behavior between the two survey periods were then assessed by comparing changes in the proportion of vehicles using the left freeway lane at each study site, the proportion of left-lane vehicles traveling below speed limit, the distribution of observed vehicle speeds on each traffic lane, the proportion of left-lane utilization events judged unlawful, and the number and size of left-lane vehicle groupings.

Results of the analyses lead to the conclusion that no clear trend regarding potential changes in traffic behavior can be associated with the tested sign replacement. While the comparison of data between the "before" and "after" survey periods often indicated changes in traffic behavior, statistical tests generally indicated that these changes were not significant when considering the observed variability of the collected information. In particular, while some sites showed potential improvements, other sites often showed contrary trends. This means that the proposed sign replacement, when considered without any other measures, is likely ineffective in altering traffic behavior with respect to left lane usage.

7 Recommendations

The analyses conducted in this report provided no clear indication that the simple replacement of existing "Slower Traffic Keep Right" signs by "Keep Right Pass Left – It's the Law" signs would have any significant impact on traffic behavior. For this reason, it is recommended that the existing signs be kept in place.

One particular element that may explain the lack of response of motorists to the tested sign may be that drivers generally pay no attention to signs reminding them to drive on the right lane when not passing other vehicles, whatever the sign is. This can be explained by the fact that police agencies do not actively enforce unlawful lane usage. Within this context, a potentially effective way of reducing unlawful left-lane usage may be to conduct some targeted enforcement. For instance, warnings or tickets could be issued to motorists holding up other traffic on the left lane for no apparent reasons. However, while such an enforcement campaign may positively affect traffic behavior, it may also divert valuable police resources from more important traffic issues. The potential benefits associated with the execution of such a campaign would therefore need to be carefully weighted against its potential costs.

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