Maryland State Highway Administration
Office of Traffic and Safety

Portable Changeable Message Sign (PCMS) Speed Study

August 23, 2004

Introduction

- The Maryland State Highway Administration is testing tools to improve safety in work zones.
- SHA identified the work zone along I-695 from West of I-83 Southbound to East of Thornton Road as a candidate location for reducing vehicle speeds approaching a work zone.

Introduction

- Rented Two Ver-Mac 1500 PCMS signs with Radar and Cellular Connection options from National Capital Industries
- Signs located on I-695 Inner Loop between Greenspring Ave and I-83 SB (JFX)
- Signs were deployed on 06/21/2004

Previous Research

- Illinois (1992)
  - I-57
  - Short-term evaluation (One day after deployment)
  - Speeds reduced on a range of 3 to 5 MPH
- Virginia (1994)
  - Conducted on seven Interstate work zones.
  - Speed reduced by about 4 MPH within seven days of deployment

Previous Research

- Virginia (1998)
  - Work zones on Interstate and primary highways
  - Seven week evaluation
  - Data Collected One week, Three weeks, Five weeks, and Seven Weeks after deployment
  - Speed reduced by 8 to 10 MPH
- Texas (2000)
  - I-40 (four-lane limited access highway)
  - PCMS was located 1½ mi prior to lane closure
  - Short-term evaluation (within seven days of deployment)
  - Small speed reductions were observed (2 to 3 MPH).

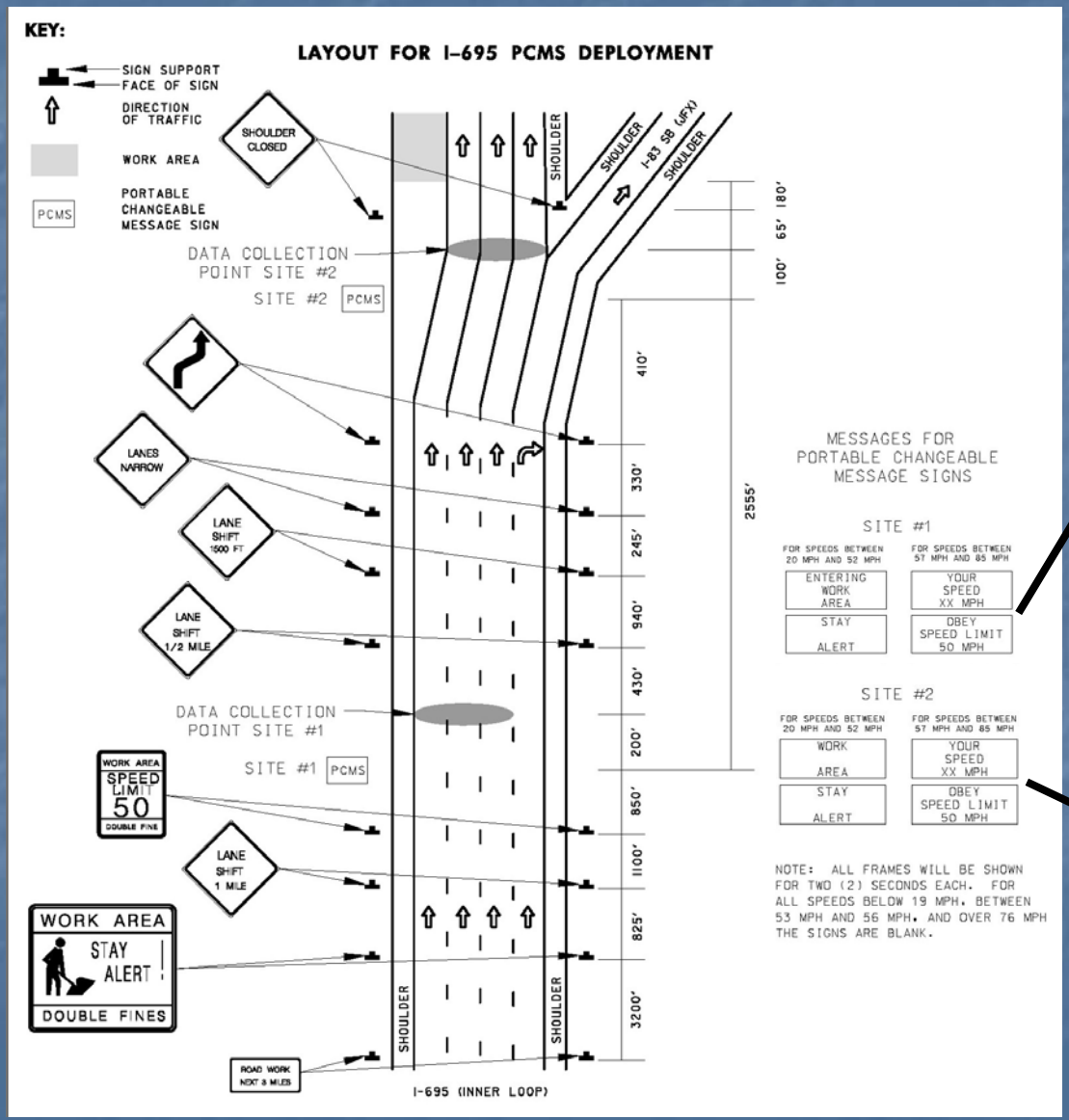
Previous Research

- Utah (2003)
  - Speed display trailer
  - Six Interstate highways and one state route
  - Short-term evaluation (within seven days of deployment)
  - Average vehicle speed was reduced 7 MPH

Ver-Mac PCMS-1500

- Full-Matrix
- Display Panel 131” x 78”
- 4 LEDS in optical lens per pixel (48 x 30 pixels)
- Solar Powered
- Options included
  - Remotely programmable from your PC with cellular modem
  - Speed display with radar

Layout for Test Deployment



SITE #1

FOR SPEEDS BETWEEN 20 MPH AND 52 MPH	FOR SPEEDS BETWEEN 57 MPH AND 85 MPH
ENTERING WORK AREA	YOUR SPEED XX MPH
STAY ALERT	OBEY SPEED LIMIT 50 MPH

SITE #2

FOR SPEEDS BETWEEN 20 MPH AND 52 MPH	FOR SPEEDS BETWEEN 57 MPH AND 85 MPH
WORK AREA	YOUR SPEED XX MPH
STAY ALERT	OBEY SPEED LIMIT 50 MPH

PCMS Signs in Operation

Data Collection

- Spot Speed Study
- One speed reading was taken in each lane per minute
- Utilized Laser Radar guns provided by SHA

Type of Study	Date of Study	Time of Study
Before Deployment	06/15/2004	8:00 AM to 11:00 AM & 6:00 PM to 10:00 PM
	06/16/2004	8:00 AM to 11:00 AM & 6:00 PM to 10:00 PM
One Day After Deployment	06/22/2004	8:00 AM to 11:00 AM & 6:00 PM to 10:00 PM
Two Days After Deployment	06/23/2004	8:00 AM to 11:00 AM & 6:00 PM to 10:00 PM
One Week After Deployment	06/28/2004	6:00 PM to 10:00 PM
	06/29/2004	8:00 AM to 11:00 AM
Three Weeks After Deployment	07/13/2004	8:00 AM to 11:00 AM & 6:00 PM to 10:00 PM
Five Weeks After Deployment	7/28/2004	6:00 PM to 10:00 PM
	7/29/2004	8:00 AM to 11:00 AM
Seven Weeks After Deployment	8/10/2004	8:00 AM to 11:00 AM & 6:00 PM to 10:00 PM
One Week After PCMS were Removed	8/17/2004	9:30 AM to 12:30 PM & 6:00 PM to 10:00 PM
	8/18/2004	9:30 AM to 12:30 PM & 6:00 PM to 10:00 PM

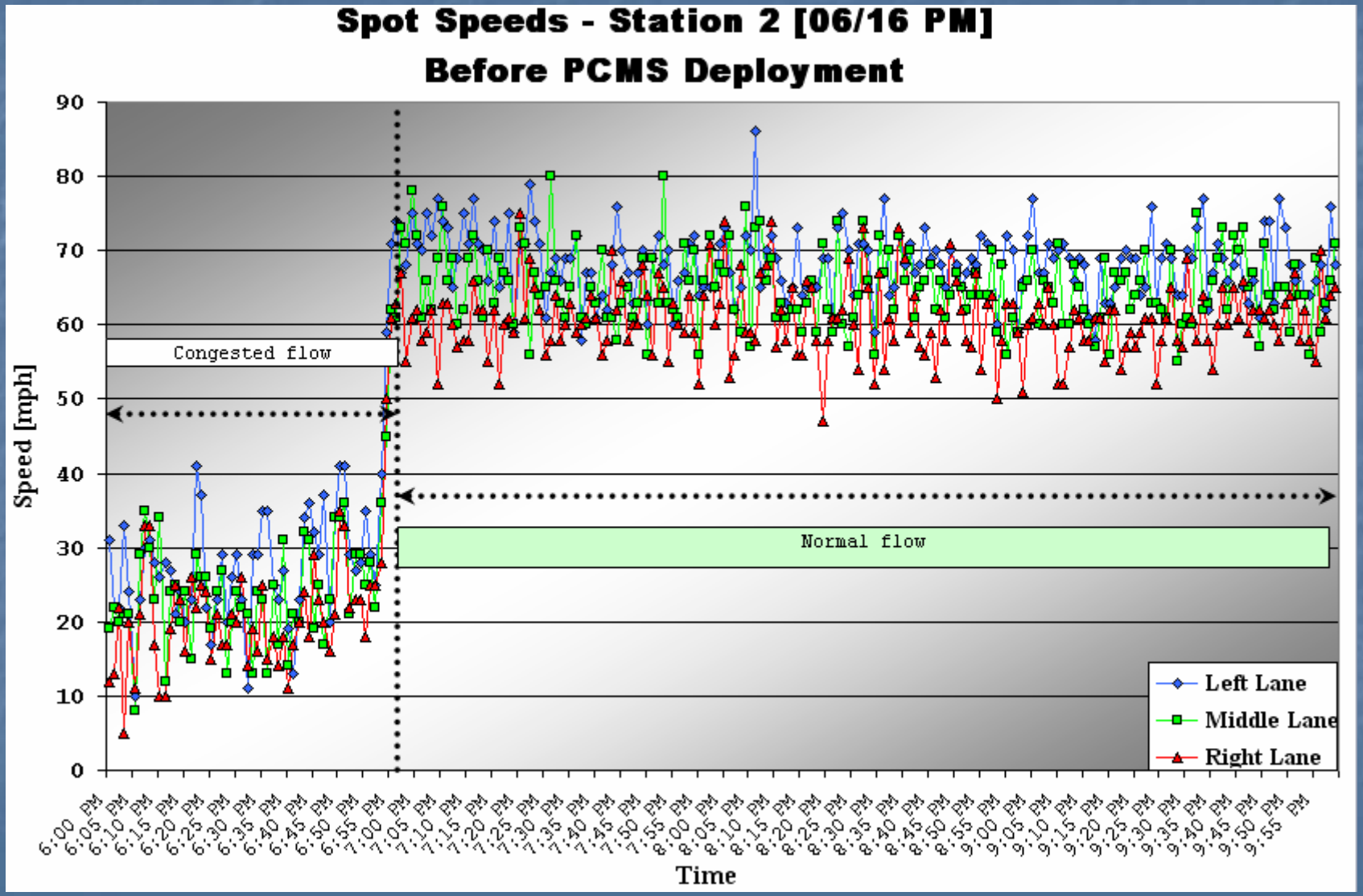
Sample Size – Station #1

Site	Period		No. of Vehicles		
			Observed	Included in the Analysis	Percentage
❶	A.M.	Before PCMS Deployment	1,080	594	55%
		After PCMS Deployment	1,080	378	35%
		One Week After PCMS Deployment	531	396	75%
		Three Weeks After PCMS Deployment	540	354	66%
		Five Weeks After PCMS Deployment	540	90	17%
		Seven Weeks After PCMS Deployment	540	314	58%
		One Week After PCMS were Removed	1,041	1,041	100%
	Subtotal		**5,352**	**3,167**	**59%**
	P.M.	Before PCMS Deployment	1,392	1,252	90%
		After PCMS Deployment	1,332	1,038	78%
		One Week After PCMS Deployment	723	723	100%
		Three Weeks After PCMS Deployment	720	492	68%
		Five Weeks After PCMS Deployment	722	722	100%
		Seven Weeks After PCMS Deployment	723	723	100%
		One Week After PCMS were Removed	1,446	1,203	83%
	Subtotal		**7,058**	**6,153**	**87%**

Sample Size – Station #2

Site	Period		No. of Vehicles		
			Observed	Included in the Analysis	Percentage
❷	A.M.	Before PCMS Deployment	1,080	522	48%
		After PCMS Deployment	1,080	278	26%
		One Week After PCMS Deployment	540	347	64%
		Three Weeks After PCMS Deployment	540	329	61%
		Five Weeks After PCMS Deployment	540	60	11%
		Seven Weeks After PCMS Deployment	540	302	56%
		One Week After PCMS were Removed	1,086	539	50%
	Subtotal		**5,406**	**2,377**	**44%**
	P.M.	Before PCMS Deployment	1,440	1,275	89%
		After PCMS Deployment	860	1,140	133%
		One Week After PCMS Deployment	723	723	100%
		Three Weeks After PCMS Deployment	720	483	67%
		Five Weeks After PCMS Deployment	723	723	100%
		Seven Weeks After PCMS Deployment	723	719	99%
		One Week After PCMS were Removed	1,446	1,326	92%
	Subtotal		**6,635**	**6,389**	**96%**
Total			**24,451**	**18,086**	**74%**

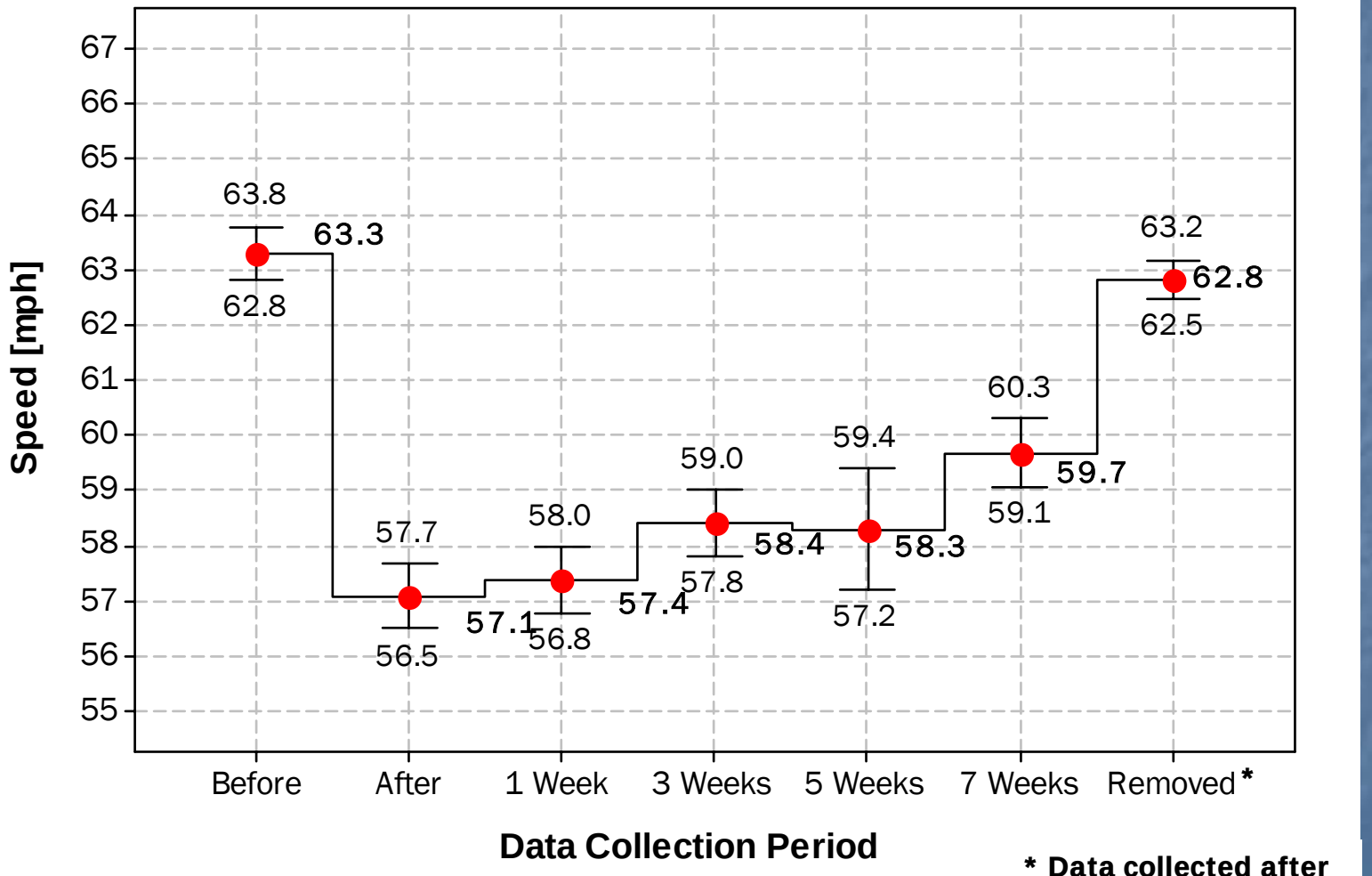
Data Reduction – PM



Statistical Analysis

- Analysis of Variance (ANOVA) General Linear Model.
- Bonferroni's multiple pairwise comparison procedure.
- Level of significance $\alpha = 0.05$.
- Minitab ® Release 14.

Results – Station #1 (AM)



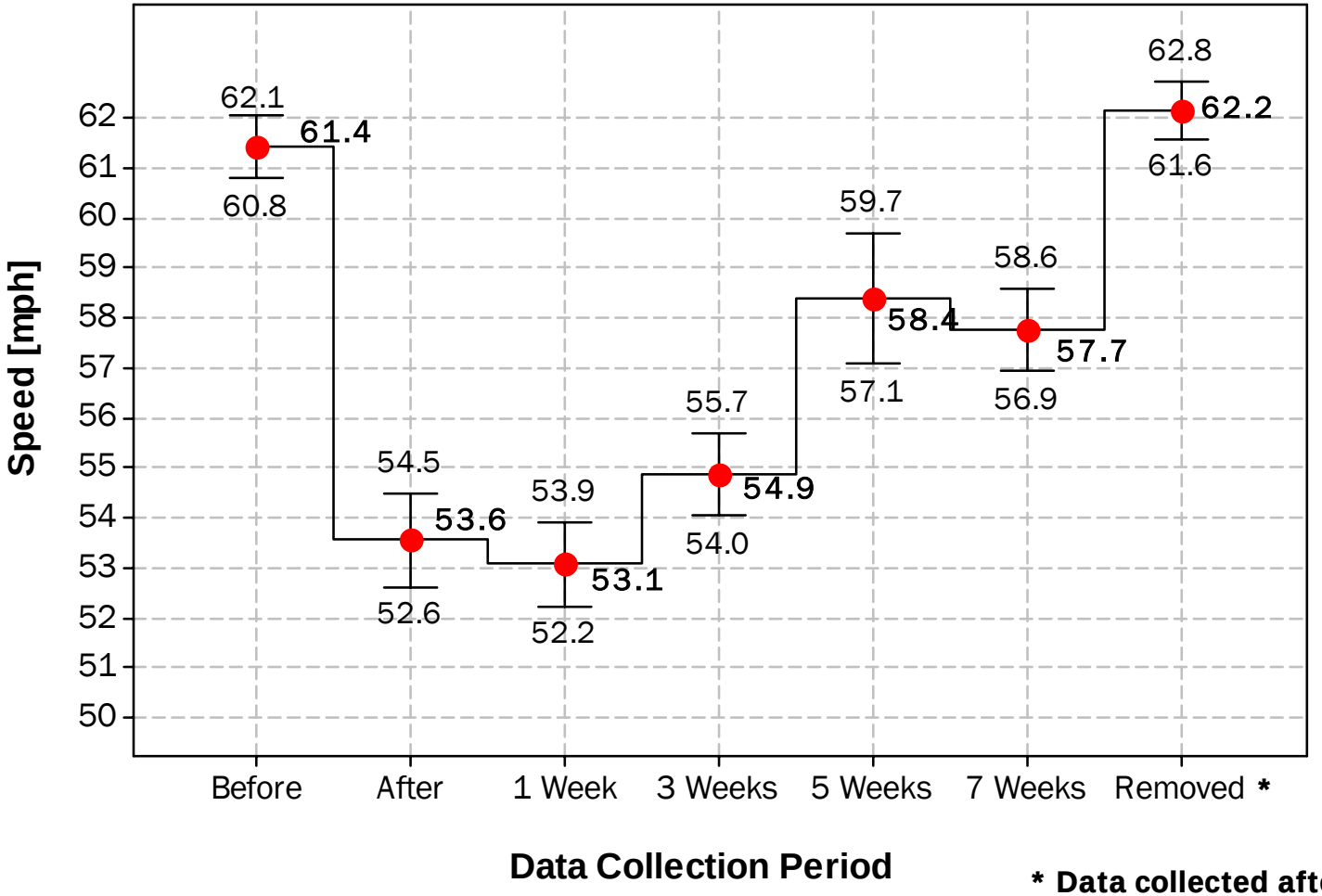
*** Data collected after signs were removed**

Results – Station #1 (AM)

Condition	$\bar{x}$	$\bar{x}$ -63.3 (a)	$\bar{x}$ -57.1 (b)	$\bar{x}$ -57.4 (c)	$\bar{x}$ -58.4 (d)	$\bar{x}$ -58.3 (e)	$\bar{x}$ -59.7 (f)
(a) Before	63.3						
(b) After	57.1	-6.2**					
(c) One Week After	57.4	-5.9**	0.3^{NS}				
(d) Three Weeks After	58.4	-4.9**	1.3^{NS}	1.0^{NS}			
(e) Five Weeks After	58.3	-5.0**	1.2^{NS}	0.9^{NS}	-0.1^{NS}		
(f) Seven Weeks After	59.7	-3.6**	2.6**	2.3**	1.3^{NS}	1.4^{NS}	
(g) PCMS Removed	62.8	-0.5^{NS}	5.7**	5.4**	4.4**	4.5**	3.1**

(*) Statistically significant difference at the 0.05 level or less
(**) Statistically significant difference at the 0.01 level or less
(NS) Not statistically significant (i.e., data were insufficient to reject the null hypothesis)

Results – Station #2 (AM)



*** Data collected after signs were removed**

Results – Station #2 (AM)

Condition	$\bar{x}$	$\bar{x}$ -61.4 (a)	$\bar{x}$ -53.6 (b)	$\bar{x}$ -53.1 (c)	$\bar{x}$ -54.9 (d)	$\bar{x}$ -58.4 (e)	$\bar{x}$ -57.7 (f)
(a) Before	61.4						
(b) After	53.6	-7.9**					
(c) One Week After	53.1	-8.3**	-0.5^{NS}				
(d) Three Weeks After	54.9	-6.6**	1.3^{NS}	1.8^{NS}			
(e) Five Weeks After	58.4	-3.0**	4.8**	5.3**	3.5^{NS}		
(f) Seven Weeks After	57.7	-3.7**	4.2**	4.7**	2.9**	-0.6^{NS}	
(g) PCMS Removed	62.1	0.7^{NS}	8.6**	9.1**	7.3**	3.8**	4.4**

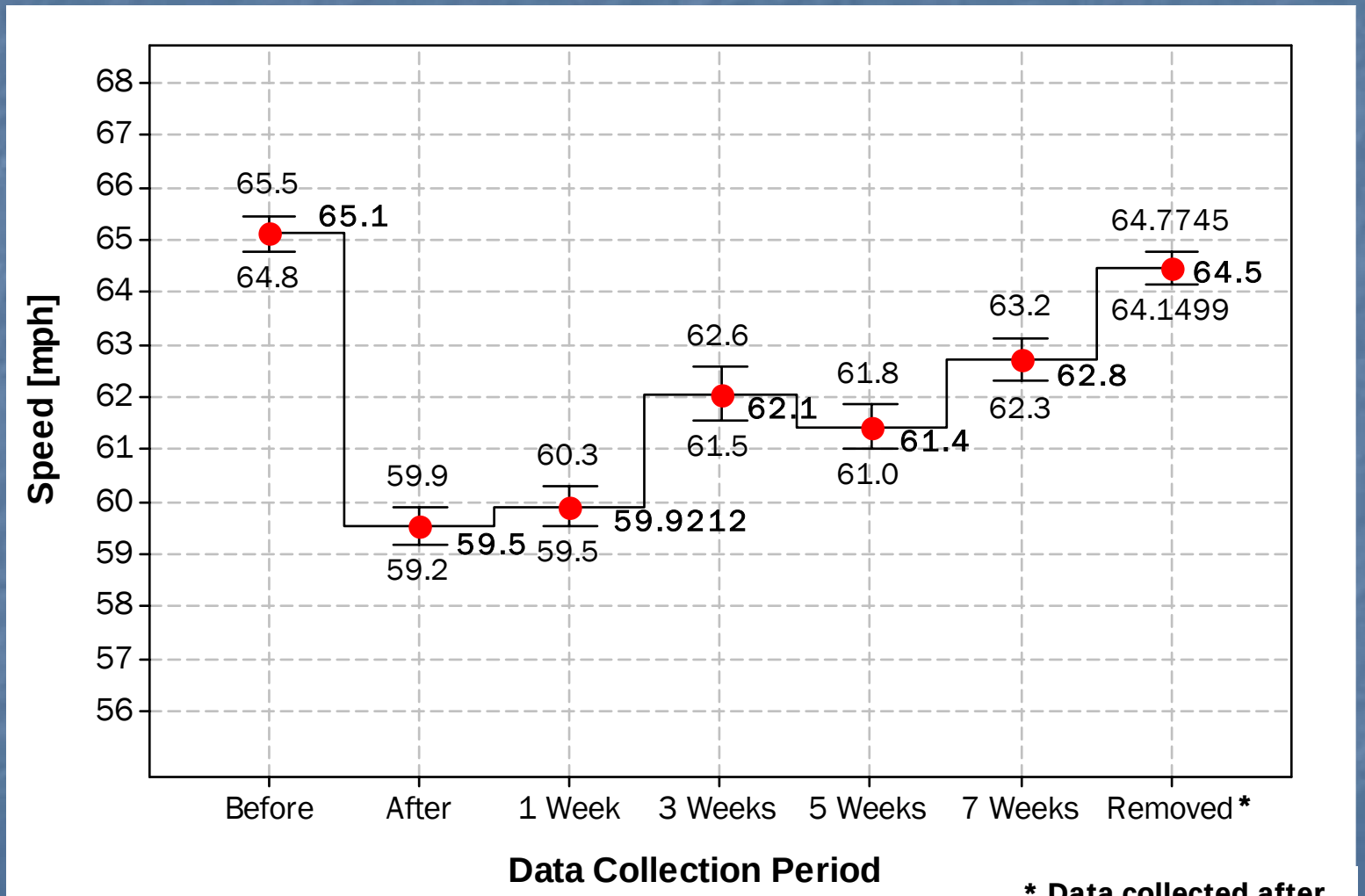
(*) Statistically significant difference at the 0.05 level or less
(**) Statistically significant difference at the 0.01 level or less
(NS) Not statistically significant (i.e., data were insufficient to reject the null hypothesis)

AM Summary

- Station #1
  - Maximum speed reduction approximately 6 MPH
  - Speed reduction realized for at least one week after deployment
- Station #2
  - Maximum speed reduction approximately 8 MPH
  - Speed reduction realized for at least one week after deployment

- Speed reduction increased at second location.
- Speeds slowly increased as the test progressed.
- Speeds returned to “Before” levels after signs were removed (within 1 MPH).

Results – Station #1 (PM)



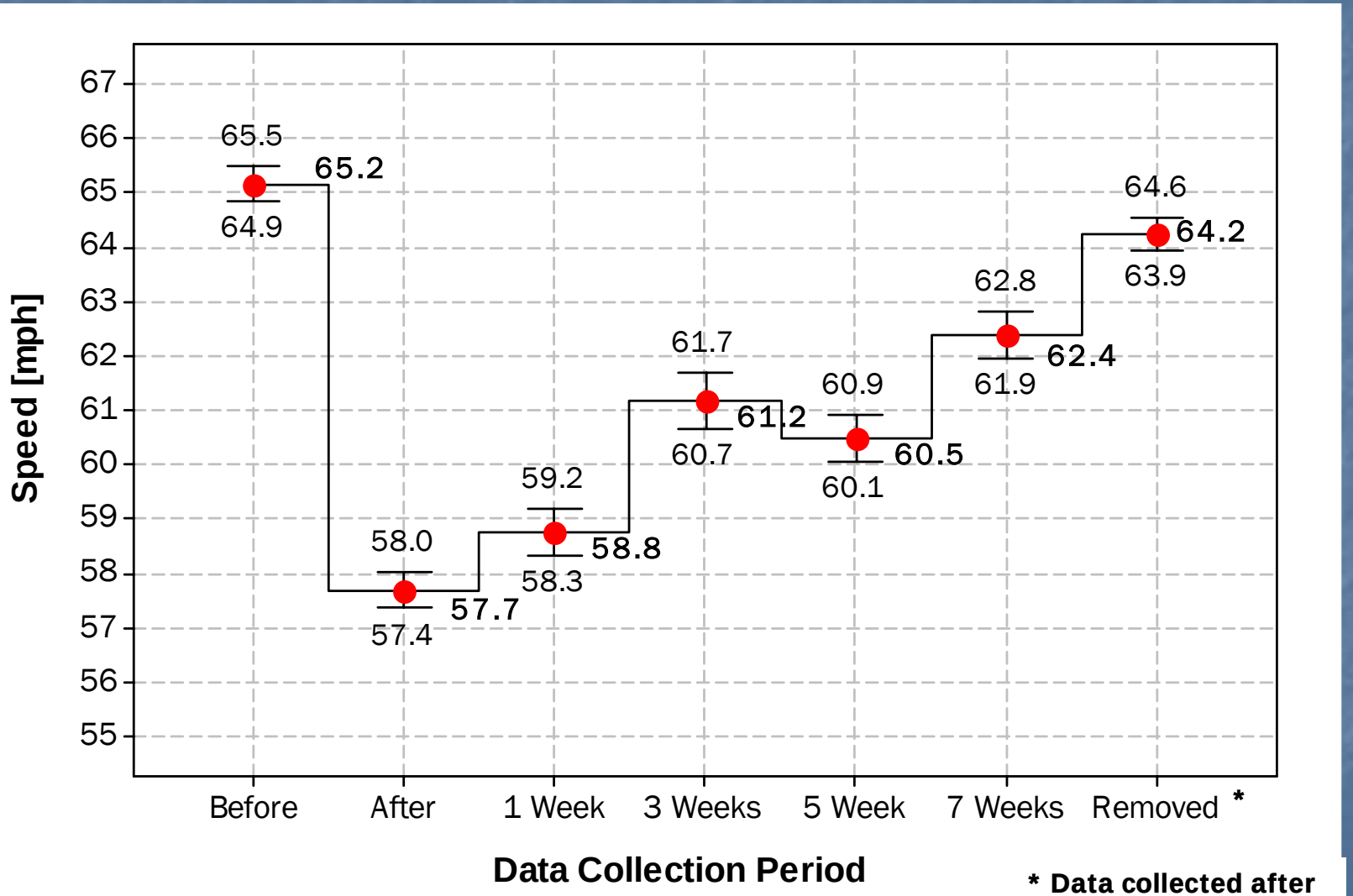
*** Data collected after signs were removed**

Results – Station #1 (PM)

Condition	$\bar{x}$	$\bar{x}$ -65.1 (a)	$\bar{x}$ -59.5 (b)	$\bar{x}$ -59.9 (c)	$\bar{x}$ -62.1 (d)	$\bar{x}$ -61.4 (e)	$\bar{x}$ -62.7 (f)
(a) Before	65.1						
(b) After	59.5	-6.2**					
(c) One Week After	59.9	-5.9**	0.3^{NS}				
(d) Three Weeks After	62.1	-4.9**	1.3**	1.0**			
(e) Five Weeks After	61.4	-5.0**	1.2**	0.9**	-0.1^{NS}		
(f) Seven Weeks After	62.7	-3.6**	2.6**	2.3**	1.3^{NS}	1.4**	
(g) PCMS Removed	64.5	-0.5^{NS}	5.7**	5.4**	4.4**	4.5**	3.1**

(*) Statistically significant difference at the 0.05 level or less
(**) Statistically significant difference at the 0.01 level or less
(NS) Not statistically significant (i.e., data were insufficient to reject the null hypothesis)

Results – Station #2 (PM)



Results – Station #2 (PM)

Condition	$\bar{x}$	$\bar{x}$ -65.2 (a)	$\bar{x}$ -57.7 (b)	$\bar{x}$ -58.8 (c)	$\bar{x}$ -61.2 (d)	$\bar{x}$ -60.5 (e)	$\bar{x}$ -62.4 (f)
(a) Before	65.2						
(b) After	57.7	-6.5**					
(c) One Week After	58.8	-5.5**	-3.6**				
(d) Three Weeks After	61.2	-3.1**	-1.2**	0.7**			
(e) Five Weeks After	60.5	-3.8**	-1.9**	0.0**	-0.7^{NS}		
(f) Seven Weeks After	62.4	-1.9**	0.0**	1.9**	1.2*	3.6**	
(g) PCMS Removed	64.2	0.0^{NS}	1.9**	3.8**	3.1**	5.5**	6.5**

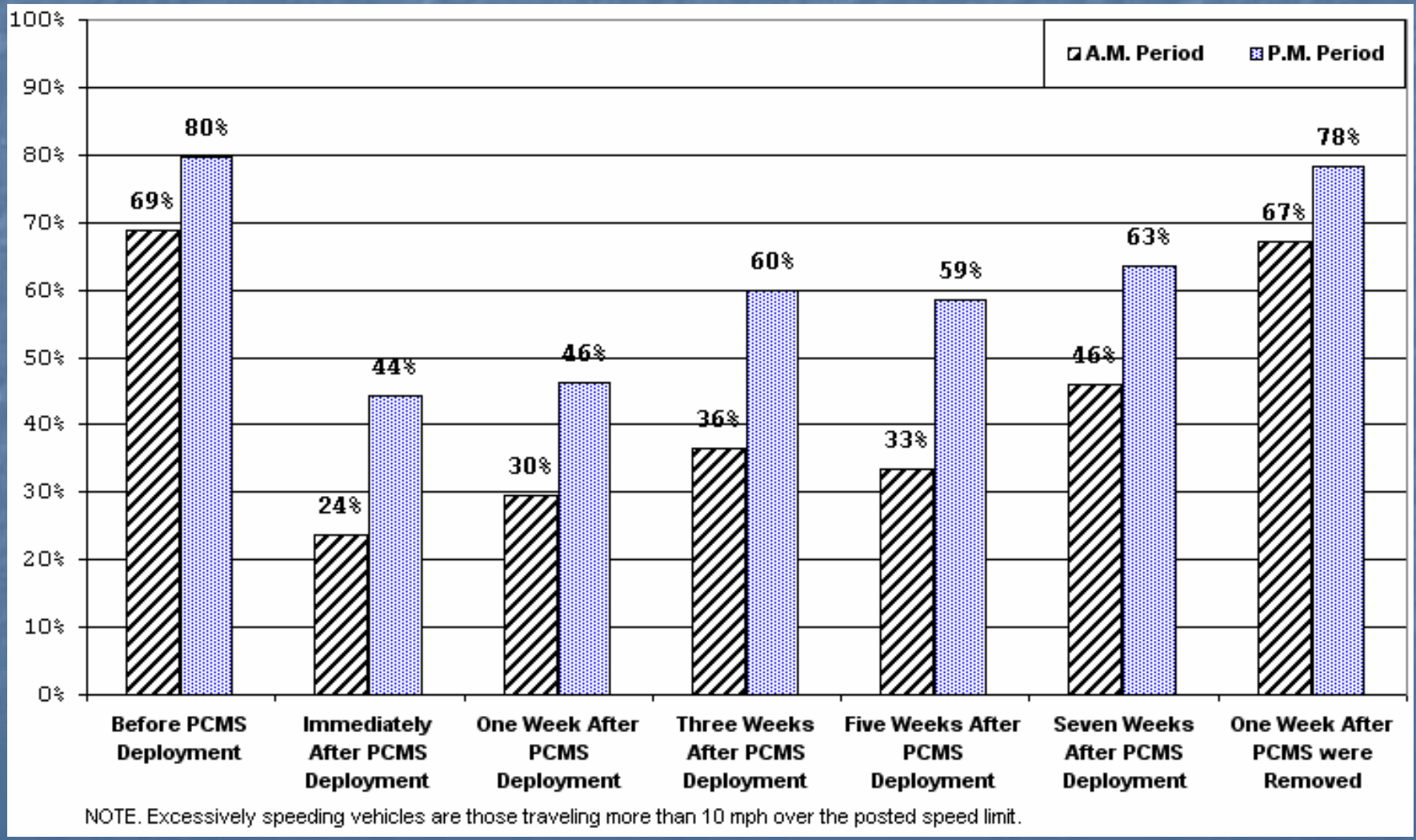
(*) Statistically significant difference at the 0.05 level or less
(**) Statistically significant difference at the 0.01 level or less
(NS) Not statistically significant (i.e., data were insufficient to reject the null hypothesis)

PM Summary

- Station #1
  - Maximum speed reduction approximately 5.5 MPH
  - Speed reduction realized for at least one week after deployment
- Station #2
  - Maximum speed reduction approximately 7.5 MPH
  - Speed reduction realized for a couple days after deployment

- Speed reduction increased at second location.
- Speeds slowly increased as the test progressed.
- Speeds returned to “Before” levels after signs were removed (within 1 MPH).

Proportion of Excessively Speeding Vehicles (Station #1)

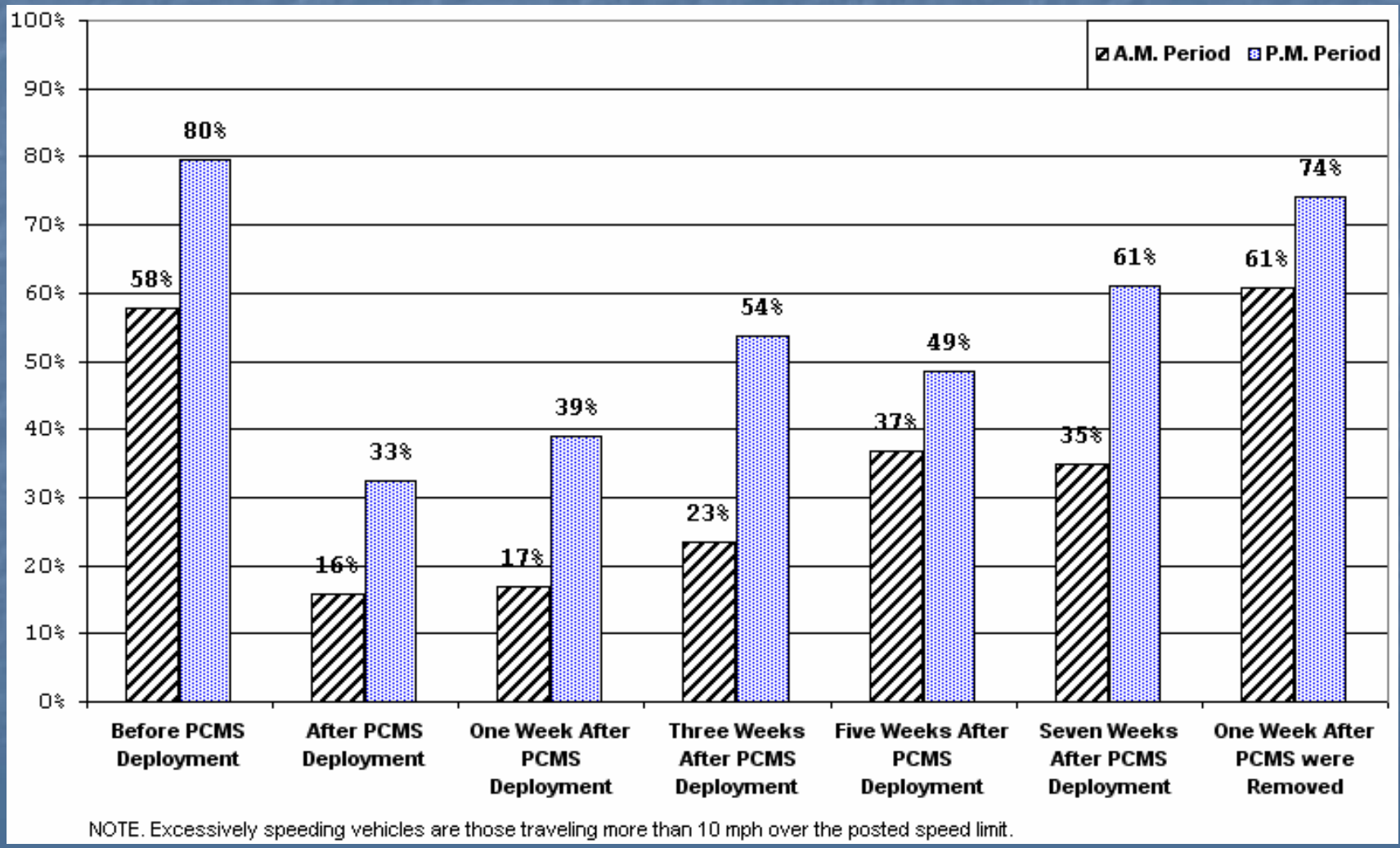


NOTE. Excessively speeding vehicles are those traveling more than 10 mph over the posted speed limit.

Proportion of Excessively Speeding Vehicles (Station #1)

- One week after deployment of the PCMSs, the percentage of excessively speeding vehicles:
  - Decreased from 69% to 24% in the AM period
  - Decreased from 80% to 46% in the PM period
- Percentage slowly increased to “Before” levels as the test progressed.

Proportion of Excessively Speeding Vehicles (Station #2)



NOTE. Excessively speeding vehicles are those traveling more than 10 mph over the posted speed limit.

Proportion of Excessively Speeding Vehicles (Station #2)

- One week after deployment of the PCMSs, the percentage of excessively speeding vehicles:
  - Decreased from 58% to 17% in the AM period
  - Decreased from 80% to 39% in the PM period
- Percentage slowly increased to “Before” levels as the test progressed.

Conclusions

- Speed reductions range from 5 MPH to 8 MPH for the first week.
- Reductions of 3 MPH to 7 MPH are sustained for three weeks.
- Speed reductions still realized after seven weeks.
- Speeds returned to “Before” levels after signs were removed (within 1 MPH).
- Speed reductions are statically significant.
- All observed reductions are similar to previous research.
- Workers perceived a reduction in speeds.

Recommendations

- PCMS with a speed display option is an effective tool in reducing speeds approaching work zones.
- The signs should be placed to target the higher speed vehicles.
  - Note: PCMS used in this test was 13’ wide, therefore a shoulder/median greater 15’ is recommended.
  - For roadways with smaller shoulders, smaller PCMS or Speed Display trailers may be used