MICHIGAN DEPARTMENT
OF
TRANSPORTATION

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THE USE OF FUNNELING AS A TRAFFIC CONTROL DEVICE TO REDUCE SPEEDS WITHIN FREEWAY CONSTRUCTION ZONES

TLD
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Report TSD-567-87

See Executive Summary

By

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EXECUTIVE SUMMARY

Freeway construction causes problems for motorists and construction workers. One major problem is excessive vehicle speed through construction zones.

The Michigan Vehicle Codes states, in Section CI 257.627 sub paragraph 9;

> Construction, survey, work area.
>
> **A person who operates a vehicle on the highway shall not exceed a speed of 45 miles per hour when entering and passing through a designated work area where a normal lane or part of the lane of traffic has been closed due to highway construction, maintenance, or surveying activities. The department of state highways and transportation, county road commission, or local authority shall identify a designated work area with traffic control devices which are in conformance with the Michigan Manual of Uniform Traffic Control Devices on streets and highways under its jurisdiction. A person shall not exceed the foregoing speed limitation.**

This report represents the finding of a study conducted using funneling techniques to attempt to decrease vehicle speed. Funneling is basically an optical illusion to deceive drivers into thinking the roadway is too narrow to drive through at normal highway speeds. This is done by placing type two barricades on both sides of the roadway in standard taper form and decreasing the distance between them until the roadway is restricted to one lane 11 1/2 to 13 feet wide.

Funneling was done on three construction projects in Southwestern Michigan during the month of July, 1987. Speeds were recorded in the 45 mph and 55 mph zones with and without the funneling effect. The sample size was approximately 200 free flow vehicles whose speeds were recorded by intermittent use of instant-on radar.

The data generated was tabulated and is included in the Appendix in various graphs and tables. The average speed, the 50th and 85th percentile speed, and the pace were computed and compared. The relative change was found to be significant by the means comparison test.

A decrease in vehicle speed was expected. The resulting decrease was a disappointing 3.21 mph. The average speeds in the work zone went from 55.1 mph to 51.9 mph which is still above the limit of 45 mph. Although the decrease was statistically significant, it is not practically significant. The reduction is not sufficient to implement the use of funneling statewide on construction projects. The benefits are not considerable for a decrease that is still above the accepted speed limit.

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INTRODUCTION

Freeway construction produces unusual driving conditions for motorists along with hazardous work conditions for construction workers. One major problem is excessive vehicle speed through construction zones. Michigan Law restricts the speed limit in construction zones. Section CI 257.627 sub paragraph 9, of the Michigan Vehicle Codes states;

> **A person who operates a vehicle on the highway shall not exceed a speed of 45 miles per hour when entering and passing through a designated work area where a normal lane or part of the lane of traffic has been closed due to highway construction, maintenance, or surveying activities. The department of state highways and transportation, county road commission, or local authority shall identify a designated work area with traffic control devices which are in conformance with the Michigan Manual of Uniform Traffic Control Devices on streets and highways under its jurisdiction. A person shall not exceed the foregoing speed limitation.**

One way to attempt to slow traffic is through the use of funneling. Changing roadway conditions tend to make drivers feel insecure about their own safety and in turn causes them to decrease their speed. Funneling is basically just an optical illusion to give the driver a sense of restriction and create a decrease in vehicle speed. The optical illusion provided by funneling is the appearance of the roadway being too narrow to drive through at normal highway speeds. Funneling is accomplished by placing barricades on both sides of the roadway and decreasing

the distance between them until the roadway is "funneled" down to one lane 11 1/2 to 13 feet wide. This procedure will only work on 4-lane highways where it is possible to reduce traffic flow down to one lane.

The purpose of this report is to evaluate the reduction in the driver's average speed, caused by the installation of the funneling technique, through the construction zone. The driver's reaction was measured by intermittent use of "instant-on" radar. The data was accumulated in various forms and is represented in the Appendix of this report.

LOCATION AND IDENTIFICATION

Three sites were chosen to conduct this experiment in vehicle speed control. They are as follows:

- I-94 Westbound from US-131 to 12th Street
  IR 39024 - 24323A
  Kalamazoo County
  Type of Work - Bridge deck and railing replacement

- I-94 Eastbound from 12th Street to US-131
  IR 39024 - 24323A
  Kalamazoo County
  Type of Work - Bridge deck and railing replacement

- US-131 Southbound over Kalamazoo River
  B01 of 03111 - 22724A
  Allegan County
  Type of Work - Bridge deck, pier, and expansion joint repair

All sites were under construction at the investigation time. The projects on I-94 had a typical sequence of signing and channelizing devices for a single lane closure on a divided highway (Figure 1), in place. US-131 had typical signing and channeling devices for a single lane closures with a one lane traffic ~~shfit~~ SHIFT (Figure 1a) in place.

SPEED OBSERVATIONS AND TECHNIQUES

The effects of funneling were studied in the three locations stated above. Funneling was accomplished by placing type two barricades, in this case plastic drums

shown in Figure 2, opposite the taper for a single lane closure in accordance with Figures 3b, 4, and 5. Figure 3a shows an overview of the US-131 southbound project. This view was needed to clarify the position of the lane closure with respect to the work zone. All figures are shown in the Appendix.

Two conditions were evaluated at two independent positions for each project giving four conditions per project. The conditions were as follows:

- 45 mph speed limit in effect with signing and channelizing devices typical for one-lane closure on a divided highway.

- 55 mph speed limit in effect with signing and channelizing devices typical for one-lane closure on a divided highway.

- 45 mph speed limit in effect with signing and channelizing devices typical for one-lane closure on a divided highway with the addition of another taper of barricades to create a funneling effect.

- 55 mph speed limit in effect with signing and channelizing devices typical for one-lane closure on a divided highway with the addition of another taper of barricades to create a funneling effect.

Speed data was recorded at the same location for each similar condition. Meaning that the data for both of the 45 mph conditions was taken at the same position so as to increase the accuracy of the data. The locations of the radar car for

the 45 mph conditions are also shown in Figures 3, 4, and 5 in the Appendix. The locations for the 55 mph zones were approximately 5000 feet upstream from the construction zones.

Speeds were measured by the Kustom's Trooper F. Manufactured by Kustom Electronics, Inc. and is used by the Michigan State Police. This system uses the ultra-high K-Band frequency which enables it to pick up distant targets with increased accuracy. The anti-radar-detector "hold" function, designed by Kustom, was utilized to record more undetected readings. The unit was not calibrated. The same unit was used for each day and the same unit was used eight working days in a row, therefore, the amount of error introduced by the uncalibration is minimal and is discarded. The hold function on the Trooper F enables it to completely escape detection by traffic radar detectors by eliminating all microwave transmission in the hold mode. The hold function was activated by:

1 - Press Hold control button. The unit is on hold.
2 - Visually acquire the target.
3 - Press Hold control button a second time to release the system from Hold. Trooper F acquires target speeds instantly.

SAMPLE ACCUMULATION

The speed samples were taken of free flow vehicles on a random basis without prejudice to size, type, or relative speed. Those vehicles which showed a sudden

decrease in velocity when the radar unit was activated were not used in the sample. These cars obviously had radar detectors and the readings received from them were unrepresentative of their free flow speed. By monitoring the CB radio, the radar operator was able to determine if the drivers had discovered the radar and were slowing down from communications and warning from other drivers. The communications were heard as far as twenty miles in each direction. A typical conversation went as follows:

Eastbound: "Hey, westbound, How's it look behind you?"

Westbound: "Clear back to Mile 110. How's it look back to Benton Harbor?"

Eastbound: "There was something in the construction zone at Mile 75. I'm not sure if it was a cop but there was something with radar."

Westbound: "Thanks for the info."

Through this type of communication many drivers were alerted to the use of radar ahead. Because of the warnings, when the radar operator determined that enough vehicles were slowing down, he left for 20 to 30 minutes to allow traffic to return to unaffected speeds.

Each sample set in the 45 mph zone contained approximately 216 readings with the exception of Southbound US-131 without barrels which contains only 162. This was due to a rain storm which, according to the Trooper F Manual, causes a scattering effect or diffusion which reduces the range and accuracy of the radar unit. The sample set for the 55 mph zone contains approximately 150-160 readings with the exception of Southbound US-131, due to the same inclement weather conditions as the 45 mph zone.

Traffic Speed

The accumulated data has been condensed into a table titled "Summary of Speeds" (Table 3) and two frequency distributions (Figures 6 and 7). These data sheets are provided in the Appendix and are the basis of this report. The summary of speeds provides the overall range of speeds, the average speed, the 85th and 50th percentile speeds, the pace and the percentage under, over, and within the pace. The frequency distributions are graphs of the recorded speeds and provide the mean and standard deviation for the sample set.

Tables 1 and 2 provide the Average and 85th percentile speeds, respectively, for each location and are provided here for convenience of discussion. They also provide the weighted average and the relative changes for all the projects.

TABLE 1
Average Speeds
(In mph)

Speed Limit	45	45	55	55
Barricade in Place	No	Yes	No	Yes
Project:				
US-131 Southbound	54.3	51.2	61.9	61.6
I-94 Westbound	54.1	51.7	61.7	61.7
I-94 Eastbound	56.8	52.9	64.1	62.2
Weighted Average	55.14	51.93	62.63	61.83
Change		-3.21		-.8
% Different		-5.82%		-1.28%

TABLE 2
85th Percentile Speeds
(In mph)

Speed Limit	45	45	55	55
Barricade in Place	No	Yes	No	Yes
Project:				
US-131 Southbound	60	58	66	65
I-94 Westbound	59	58	64	64
I-94 Eastbound	62	58	67	66
Weighted Average	60.37	58	65.68	65
Change		-2.37		-.42
% Different		-3.92%		-1.03%

As can be seen, the average speeds were reduced more than the 85th percentile speeds. It is noted that the speeds within the 45 mph zone decreased more than those in the 55 mph zone. This inconsistency is particularly due to the fact that the vehicles in the 55 mph zone had not gotten the full effect of the optical illusion of funneling provided by the drums on both sides of the roadway. By the time they reached the construction zone, they would be subject to the full effect. The I-94 westbound project had added confusion due to an exit ramp located just before the start of the taper.

A standard Means Comparison Test was applied to the data sample. This test concluded that since the sample size was so large and the standard deviation so small, that it can be said, with a high level of certainty, that the change is statistically significant and was not caused by chance.

Traffic Pace

The traffic pace is defined as that 10 mph increment of speed with the greatest number of recorded observations. If a high percentage of cars are traveling within the pace, then the speed of all vehicles is more uniform. In this study, the pace was determined from the mean speed frequency distributions provided in the Appendix. The frequency distribution is obtained from the sample data collected. Observations of the Summary of Speeds, Table 3 in the Appendix, indicated the effectiveness of the traffic control methods. In this study, it can be seen that the pace speed decreased slightly with the addition of the funneling techniques.

DISCUSSION

Many questions arose during the course of this study such as:

- What happens to the drums at night?
- What about added cost for drums and labor to place and replace them?
- What happens when a "wide load" comes through?
- Why not use radar continuously in all construction zones?
- Is the reduction in speed and accidents going to save lives and money?
- Is the State's cost justified?

While the above questions are valid, the scope of this study is not that broad. Although a few recommendations, or speculations at this point, can be addressed.

Lights could be added to the drums for night operations. Those drums that are knocked out of line would be replaced as needed or the drums can be moved in and out as the work requires. Of the above two methods, the latter makes the most sense. Moving the drums in and out might take 10 to 15 minutes longer each morning and night, but that much time would be needed if they were left overnight anyway. Wide loads are a problem. There is not an easy solution except having the drivers give advance notice to the Department of Transportation as to where and when they are going to be traveling. The use of radar units on project sites to control traffic speed is being used sparsely throughout the state of Michigan and the point of its legality is being debated.

CONCLUSION

The cost of an accident is very high, and it is difficult to say when and where the next accident will happen. The purpose of this report is to evaluate the effectiveness of the funneling technique on reducing traffic velocity in construction zones. The decrease in vehicle speed in the construction zone was found to be statistically significant, but the question of its practicality undermines its significance. The objective of this study was to reduce speeds in construction zones. The speeds decreased by 3.21 mph. The objective has been met, but the problem is not solved.

The reduction from 55.1 mph to 51.9 mph is not practically significant to begin using the funneling technique statewide. The safety benefits are minimized since the resulting speed is still not under the 45 mph speed limit which was set for safe operations in construction zones.

Something needs to be done to reduce vehicular velocities in construction zones, but funneling alone is not the correct solution.

A P P E N D I X

APPENDIX INDEX

WORK ZONE SPEED STUDY
JULY 1987
SUMMARY OF SPEEDS

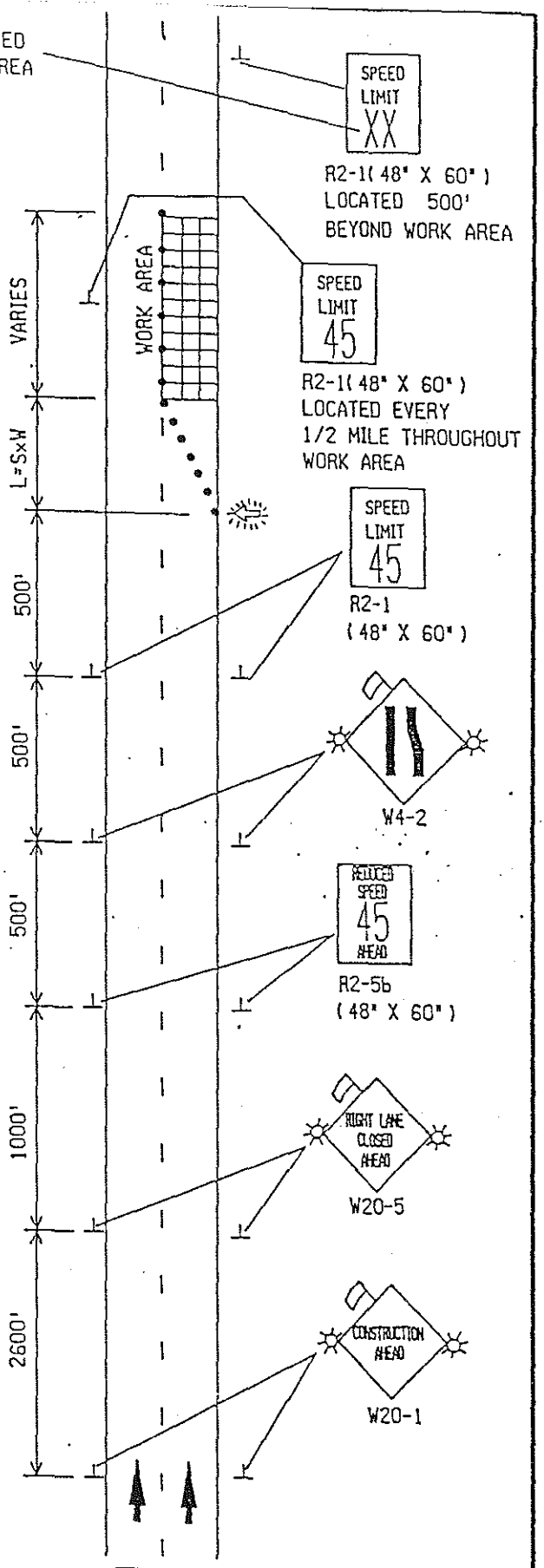
Project	45 Without Barrels	45 With Barrels	55 Without Barrels	55 With Barrels
US-131 Southbound at Plainwell				
RANGE OF SPEEDS	41 - 65	33 - 66	53 - 75	46 - 80
AVERAGE SPEED	54.3	51.2	61.9	61.6
50th % Speed	54	51	62	62
85th % Speed	60	58	66	65
10 MPH PACE SPEED	51 - 60	45 - 54	57 - 66	57 - 66
% in Pace	63.6	62.0	84.0	80.2
% Under Pace	23.4	10.2	6.1	9.9
% Over Pace	13.0	27.8	9.9	9.9
# of Vehicles	162	216	131	162
Change	-3.1		0.3	
% Different	-5.71		-.48	
I-94 at US-131 Eastbound				
RANGE OF SPEEDS	41 - 76	36 - 65	54 - 76	50 - 79
AVERAGE SPEED	56.8	52.9	64.1	62.2
50th % Speed	55	53	63	63
85th % Speed	62	58	67	66
10 MPH PACE SPEED	51 - 60	48 - 57	60 - 69	57 - 66
% in Pace	65.0	69.1	87.0	86.1
% Under Pace	17.3	13.8	9.0	5.0
% Over Pace	17.7	17.1	4.0	8.9
# of Vehicles	217	217	161	158
Change	3.9		1.9	
% Different	-6.87		-2.96	
I-94 at US-131 Westbound				
RANGE OF SPEEDS	38 - 70	36 - 68	49 - 71	41 - 73
AVERAGE SPEED	54.1	51.7	61.7	61.7
50th % Speed	54	51	62	62
85th % Speed	59	58	64	64
10 MPH PACE SPEED	51 - 60	46 - 55	58 - 67	57 - 66
% in Pace	68.5	63.5	88.8	84.5
% Under Pace	22.3	14.3	7.9	6.2
% Over Pace	10.2	22.2	3.3	9.3
# of Vehicles	216	217	152	162
Change	2.4		0.0	
% Different	-4.44		0.0	

TABLE 3

8-21-87,KTS:mrs

NOTES:

1. NONAPPLICABLE WARNING, REGULATORY, CONSTRUCTION AND GUIDE SIGNS WITHIN THE CIA SHALL BE COVERED OR REPOSITIONED.
2. L = LENGTH OF TAPER
   S = POSTED SPEED LIMIT PRIOR TO WORK
   W = WIDTH OF OFFSET
3. DISTANCES SHOWN BETWEEN SIGNS ARE APPROXIMATE AND MAY NEED ADJUSTING AS DIRECTED BY THE ENGINEER.
4. BARRICADE SPACING SHALL BE EQUAL IN FEET TO THE POSTED SPEED LIMIT ON TAPERS AND TWICE THE POSTED SPEED LIMIT IN FEET ON TANGENT SECTIONS, OR AS DIRECTED BY THE ENGINEER.
5. FOR OVERNIGHT CLOSURES, CHANNELIZING DEVICES SHALL BE TYPE II LIGHTED BARRICADES, AND EXISTING PAVEMENT MARKINGS SHALL BE REMOVED THROUGHOUT THE TAPER AREA.
6. WHEN LANE CLOSURES ARE IN THE PROXIMITY OF INTERCHANGES, W20-1 SIGNS SHALL BE PLACED ON THE AFFECTED RAMPS AS DIRECTED BY THE ENGINEER.
7. THE LIGHTED ARROW PANEL SHALL BE LOCATED AT THE BEGINNING OF THE TAPER AS SHOWN. IF PHYSICAL LIMITATIONS RESTRICT ITS PLACEMENT AS INDICATED, THEN IT SHALL BE PLACED AS CLOSE TO THE BEGINNING OF THE TAPER AS POSSIBLE.



KEY

- • • • CHANNELIZING DEVICES; CONES OR BARRICADES
- LIGHTED ARROW PANEL
- FLUORESCENT ORANGE WARNING FLAG (REQUIRED)
- TYPE A WARNING FLASHERS (REQUIRED AT NIGHT)

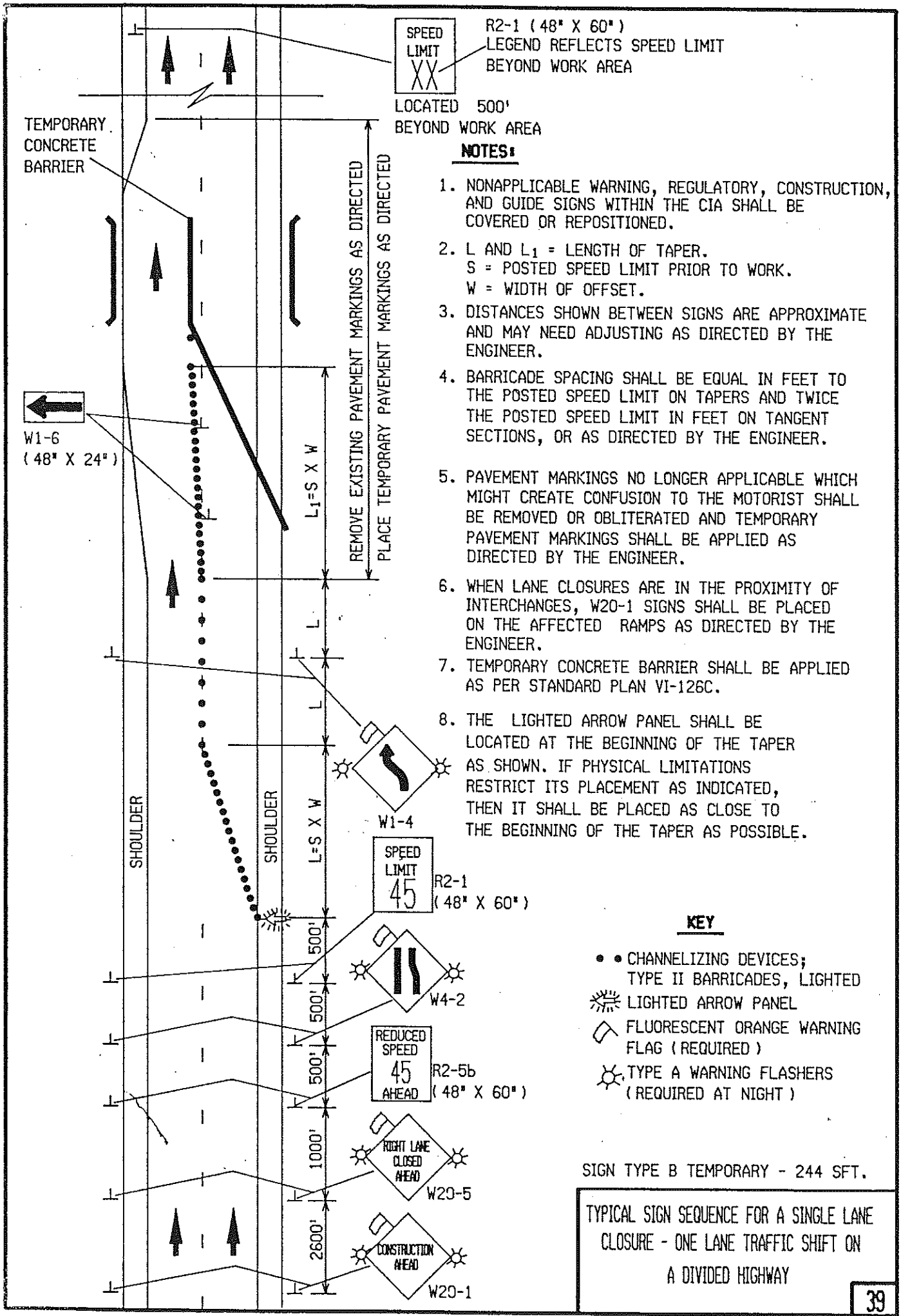
SIGN, TYPE B TEMPORARY - 196 SFT. PLUS R2-1's THROUGHOUT WORK AREA

TYPICAL SIGN SEQUENCE FOR A SINGLE LANE CLOSURE ON A DIVIDED HIGHWAY USING STATUTORY SPEED LIMIT

12

Figure 1

7-25-86



NOTES:

1. NONAPPLICABLE WARNING, REGULATORY, CONSTRUCTION, AND GUIDE SIGNS WITHIN THE CIA SHALL BE COVERED OR REPOSITIONED.
2. L AND L_1 = LENGTH OF TAPER.
   S = POSTED SPEED LIMIT PRIOR TO WORK.
   W = WIDTH OF OFFSET.
3. DISTANCES SHOWN BETWEEN SIGNS ARE APPROXIMATE AND MAY NEED ADJUSTING AS DIRECTED BY THE ENGINEER.
4. BARRICADE SPACING SHALL BE EQUAL IN FEET TO THE POSTED SPEED LIMIT ON TAPERS AND TWICE THE POSTED SPEED LIMIT IN FEET ON TANGENT SECTIONS, OR AS DIRECTED BY THE ENGINEER.
5. PAVEMENT MARKINGS NO LONGER APPLICABLE WHICH MIGHT CREATE CONFUSION TO THE MOTORIST SHALL BE REMOVED OR OBLITERATED AND TEMPORARY PAVEMENT MARKINGS SHALL BE APPLIED AS DIRECTED BY THE ENGINEER.
6. WHEN LANE CLOSURES ARE IN THE PROXIMITY OF INTERCHANGES, W20-1 SIGNS SHALL BE PLACED ON THE AFFECTED RAMPS AS DIRECTED BY THE ENGINEER.
7. TEMPORARY CONCRETE BARRIER SHALL BE APPLIED AS PER STANDARD PLAN VI-126C.
8. THE LIGHTED ARROW PANEL SHALL BE LOCATED AT THE BEGINNING OF THE TAPER AS SHOWN. IF PHYSICAL LIMITATIONS RESTRICT ITS PLACEMENT AS INDICATED, THEN IT SHALL BE PLACED AS CLOSE TO THE BEGINNING OF THE TAPER AS POSSIBLE.

KEY

- CHANNELIZING DEVICES; TYPE II BARRICADES, LIGHTED
- LIGHTED ARROW PANEL
- FLUORESCENT ORANGE WARNING FLAG (REQUIRED)
- TYPE A WARNING FLASHERS (REQUIRED AT NIGHT)

SIGN TYPE B TEMPORARY - 244 SFT.

TYPICAL SIGN SEQUENCE FOR A SINGLE LANE CLOSURE - ONE LANE TRAFFIC SHIFT ON A DIVIDED HIGHWAY

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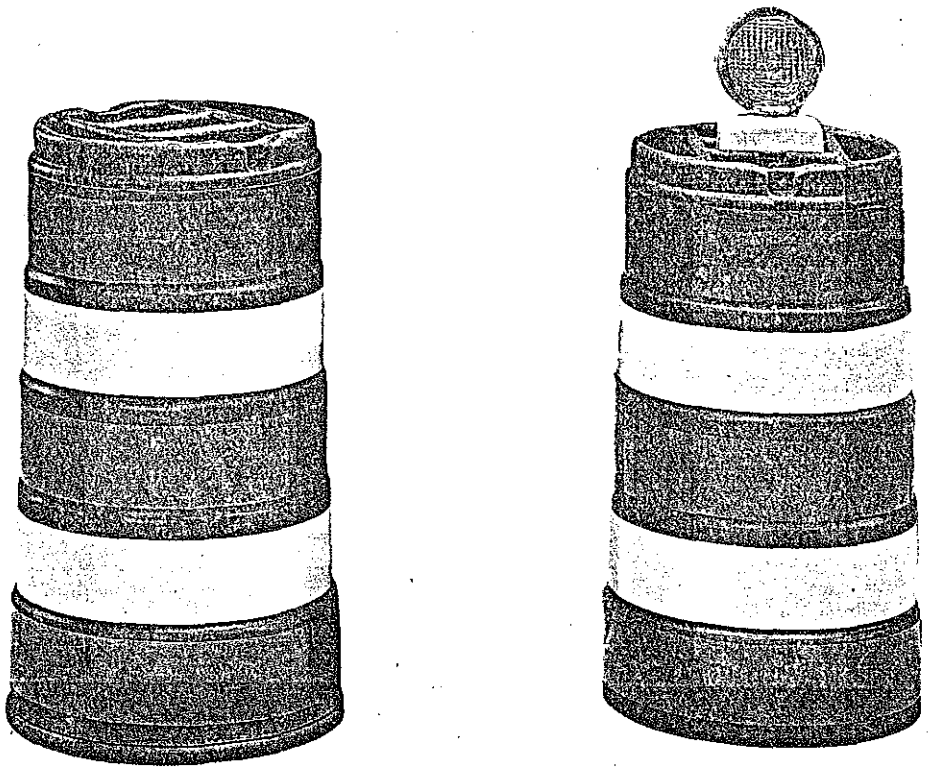
Figure 1

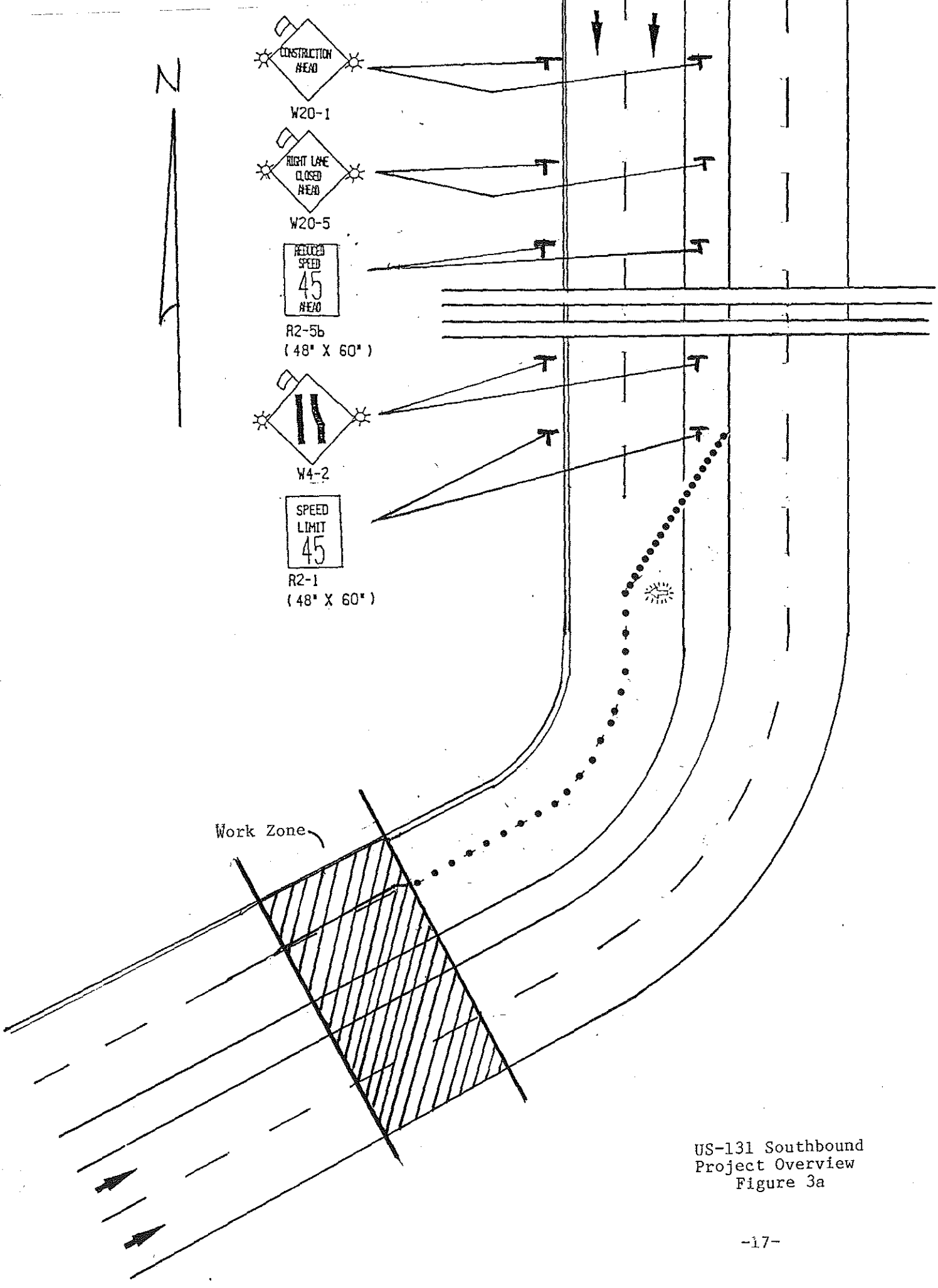
6C-6 Drum Design



Drums used for traffic warning or channelization shall be approximately 36″ in height and a minimum of 18″ in diameter. The markings on drums shall be horizontal, circumferential, alternating orange and white reflectorized strips four to eight inches wide, using a material that has a smooth, sealed outer surface which will display the same approximate size, shape and color day and night.

There shall be at least two orange and two white stripes on each drum. All stripes shall be approximately the same width. The topmost stripe shall be orange and the nonreflectorized space above it shall be less than four inches. Any nonreflectorized space on the vertical sides of the drum shall be orange in color. If there are nonreflectorized spaces between the horizontal orange and white stripes, they shall be no more than two inches wide.

Figure 2



US-131 Southbound
Project Overview
Figure 3a

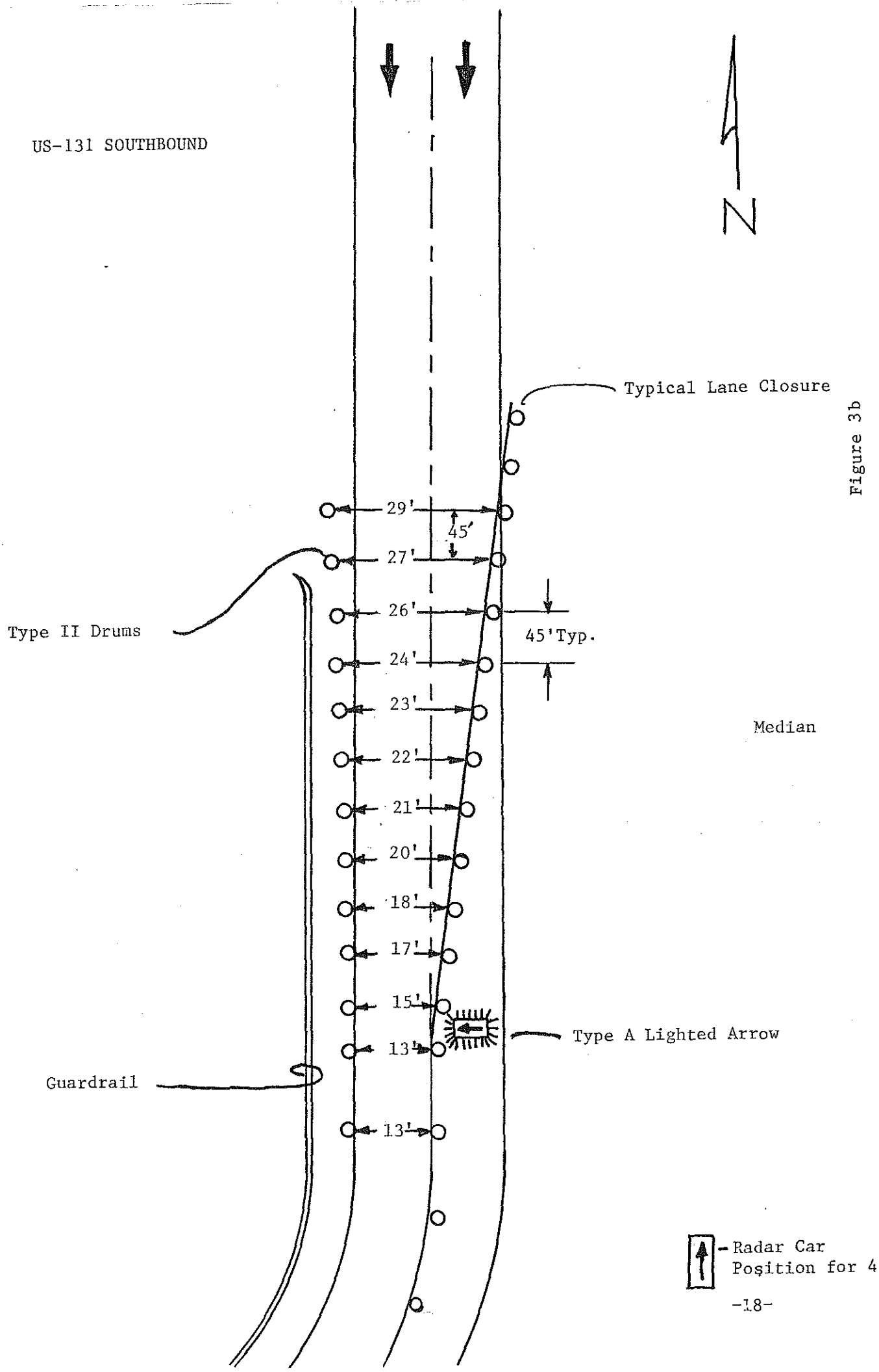

US-131 SOUTHBOUND
N
Typical Lane Closure
29'
45'
27'
26'
45'Typ.
24'
23'
Median
22'
21'
20'
18'
17'
15'
13'
Type A Lighted Arrow
Type II Drums
Guardrail
13'
- Radar Car Position for 45

Figure 3b

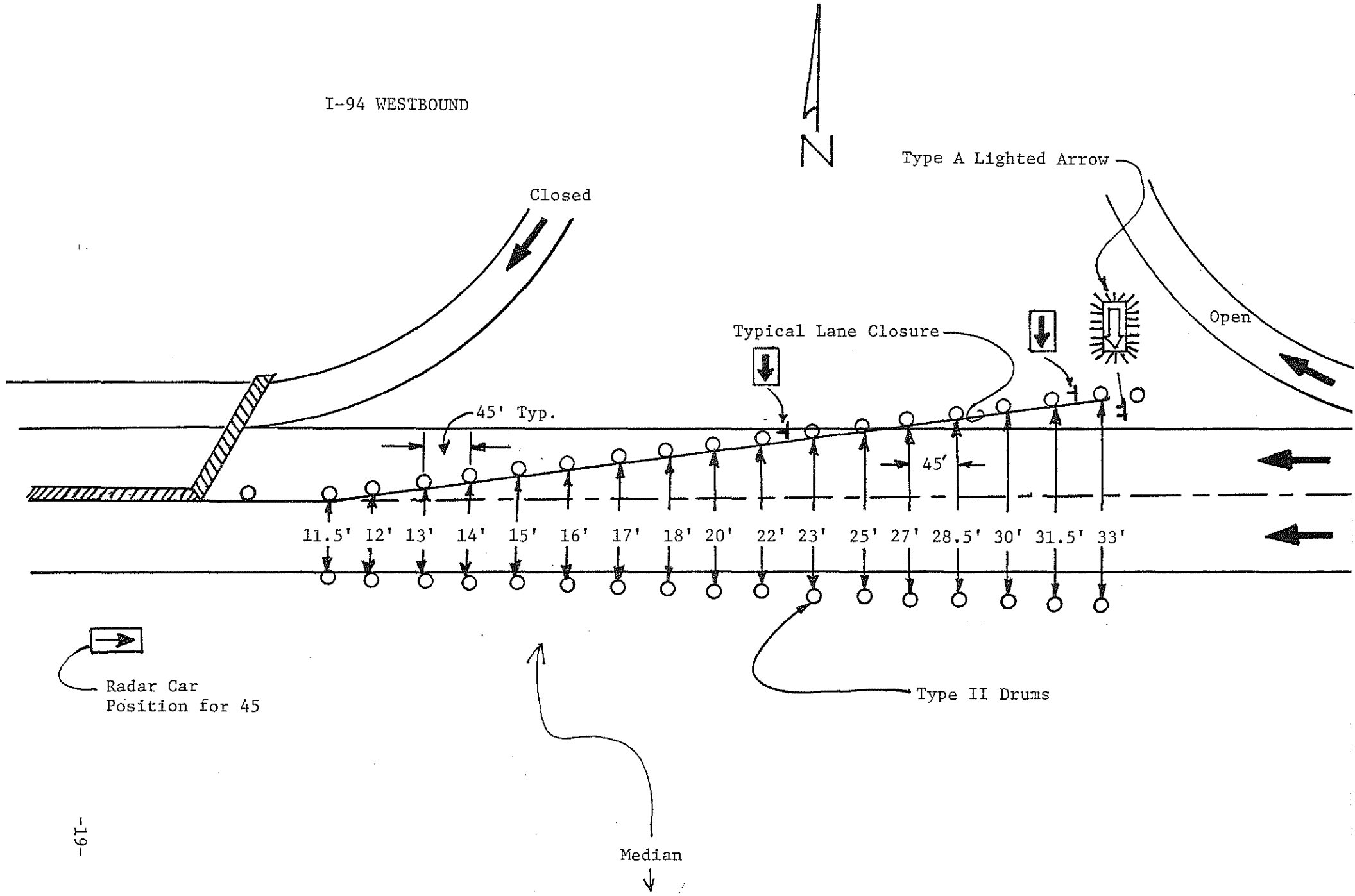
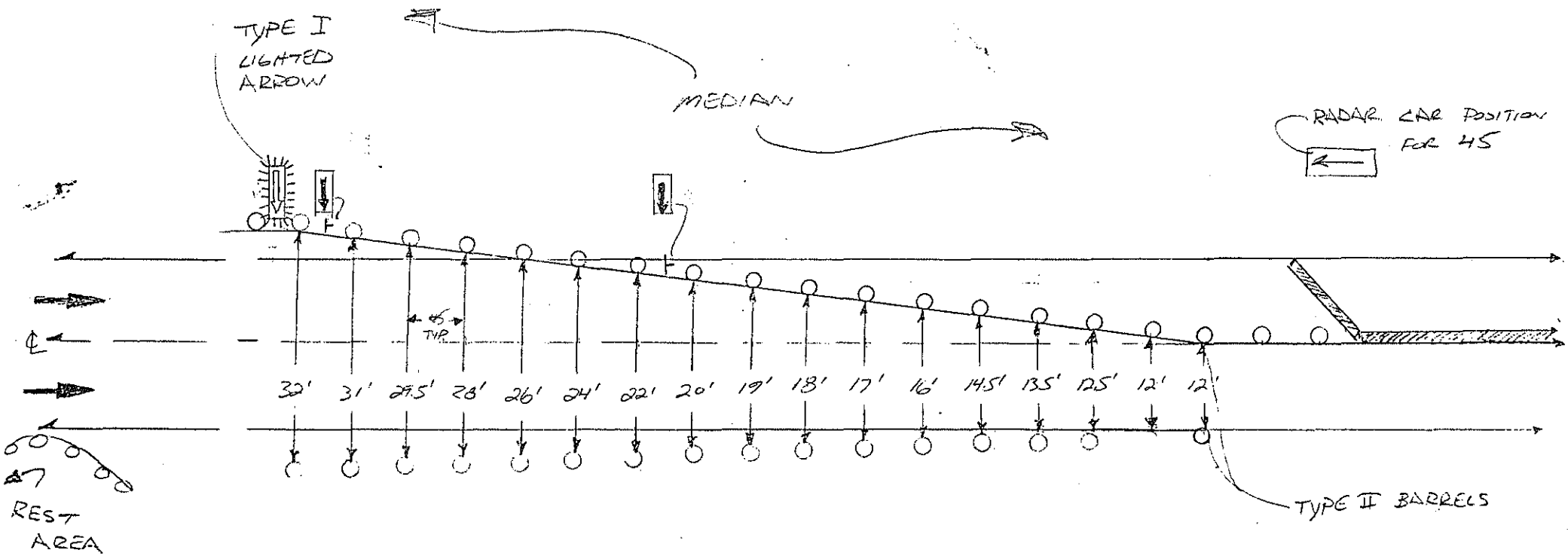

I-94 WESTBOUND
N
Type A Lighted Arrow
Closed
Open
Typical Lane Closure
45' Typ.
45'
11.5' 12' 13' 14' 15' 16' 17' 18' 20' 22' 23' 25' 27' 28.5' 30' 31.5' 33'
Radar Car
Position for 45
Type II Drums
Median

Figure 4



EASTBOUND I-94

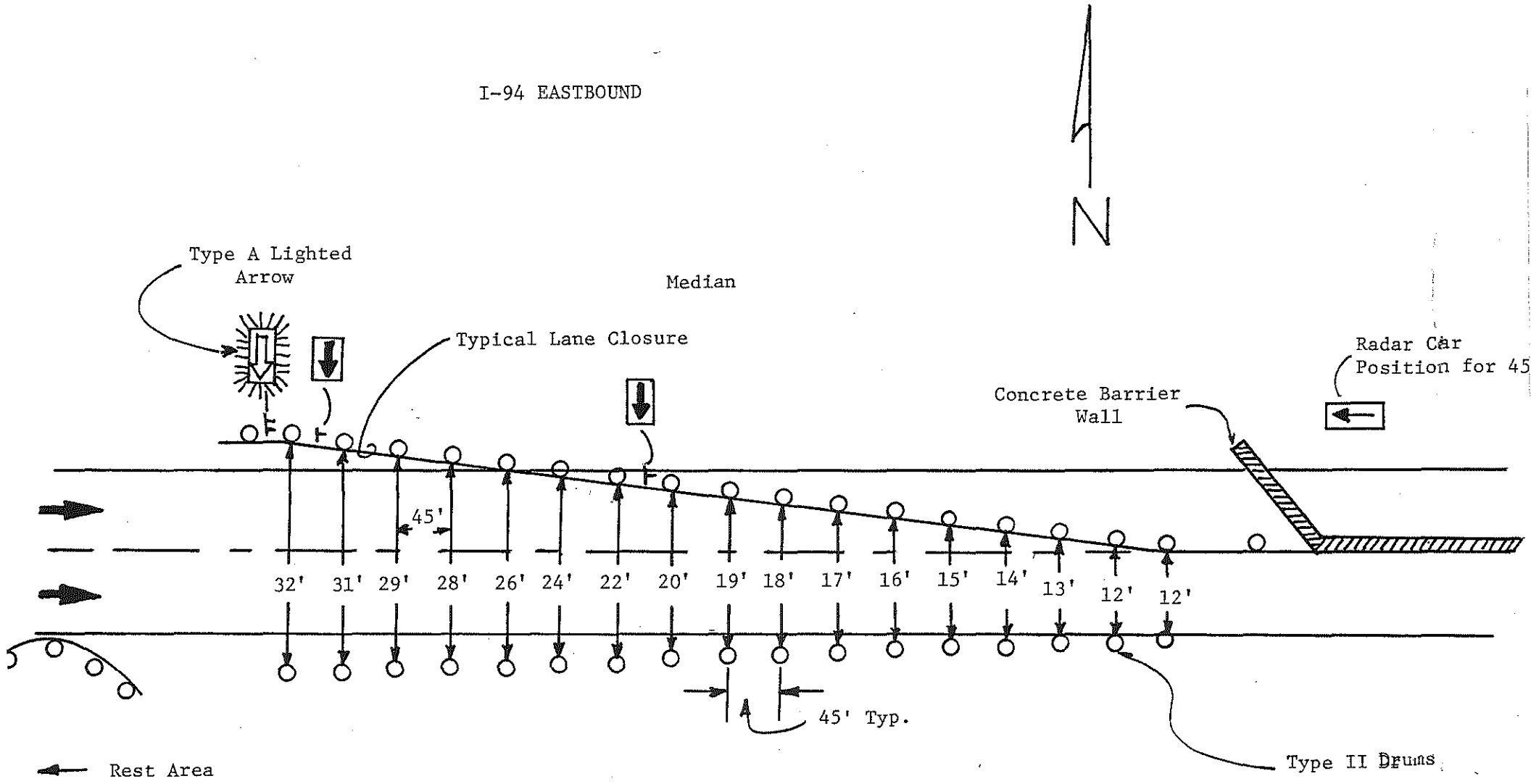

I-94 EASTBOUND
N
Type A Lighted Arrow
Median
Typical Lane Closure
Radar Car Position for 45
Concrete Barrier Wall
45'
32' 31' 29' 28' 26' 24' 22' 20' 19' 18' 17' 16' 15' 14' 13' 12' 12'
45' Typ.
Type II Drums
Rest Area

Figure 5

PROJECT; US-131 SOUTHBOUND @ PLAINWELL

ITEM	45 WITHOUT BAR.	45 WITH BARRELS	55 WITHOUT BAR.	55 WITH BARRELS
RANGE OF SPEEDS	41 - 65	33 - 66	53 → 75	46 - 80
AVERAGE SPEED	54.3	51.2	61.9	61.6
50TH % SPEED	54	51	62	62
85TH % SPEED	60	58	66	65
10 MPH PACE SPEED	51 → 60	45 → 54	57 → 66	57 - 66
% IN PACE	63.6	62.0	84.0	80.2
% UNDER PACE	23.4	10.2	6.1	9.9
% OVER PACE	13.0	27.8	9.9	9.9
# OF VEHICLES	162	216	131	162

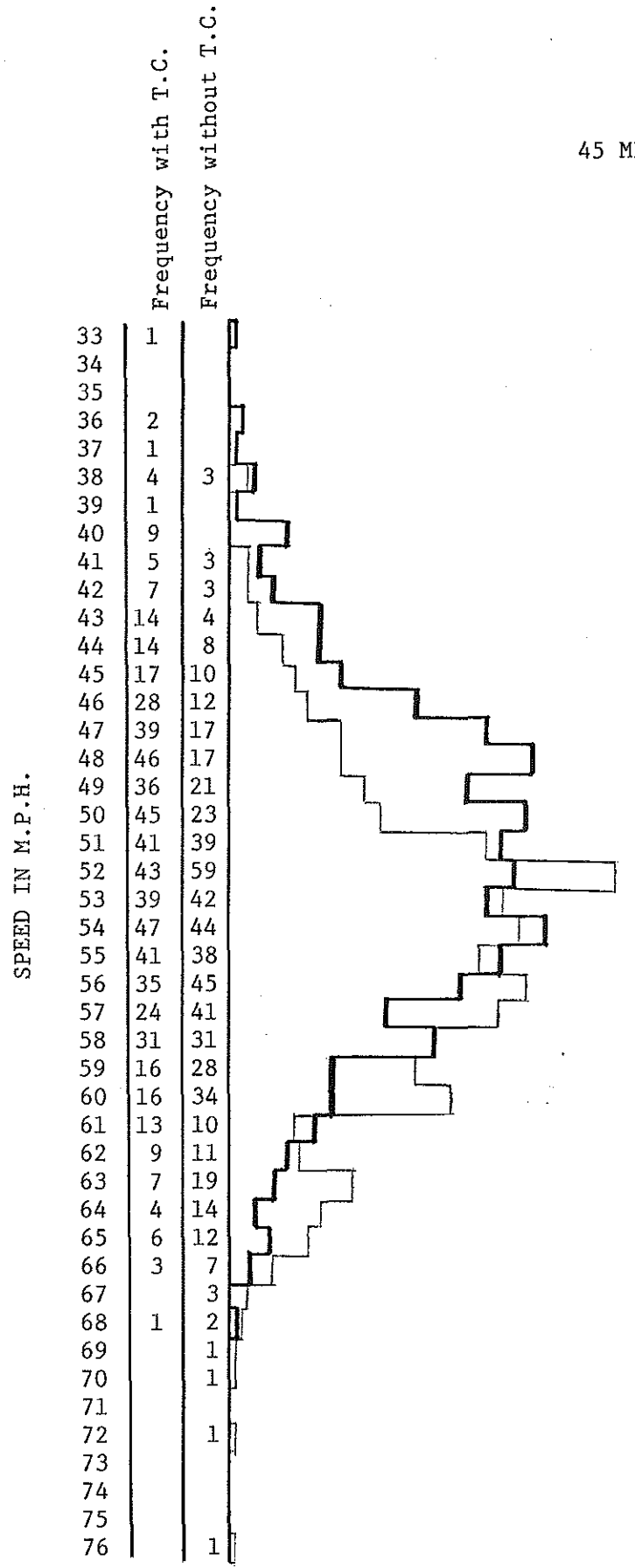
PROJECT; I-94 @ US131 EASTBOUND

RANGE OF SPEEDS	41 → 76	36 → 65	54 → 76	50 → 79
AVERAGE SPEED	56.8	52.9	64.1	62.2
50TH % SPEED	55	53	63	63
85TH % SPEED	62	58	67	66
10 MPH PACE SPEED	51 → 60	48 → 57	60 → 69	57 → 66
% IN PACE	65.0	69.1	87.0	86.1
% UNDER PACE	17.3	13.8	9.0	5.0
% OVER PACE	17.7	17.1	4.0	8.9
# OF VEHICLES	217	217	161	158

PROJECT; I-94 @ US-131 WESTBOUND

RANGE OF SPEEDS	38 → 70	36 → 68	49 → 71	41 → 73
AVERAGE SPEED	54.1	51.7	61.7	61.7
50TH % SPEED	54	51	62	62
85TH % SPEED	59	58	64	64
10 MPH PACE SPEED	51 → 60	46 → 55	58 → 67	57 → 66
% IN PACE	68.5	63.5	88.8	84.5
% UNDER PACE	22.3	14.3	7.9	6.2
% OVER PACE	10.2	22.2	3.3	9.3
# OF VEHICLES	216	217	152	162

45 MPH



Mean With 51.93, Without 55.14

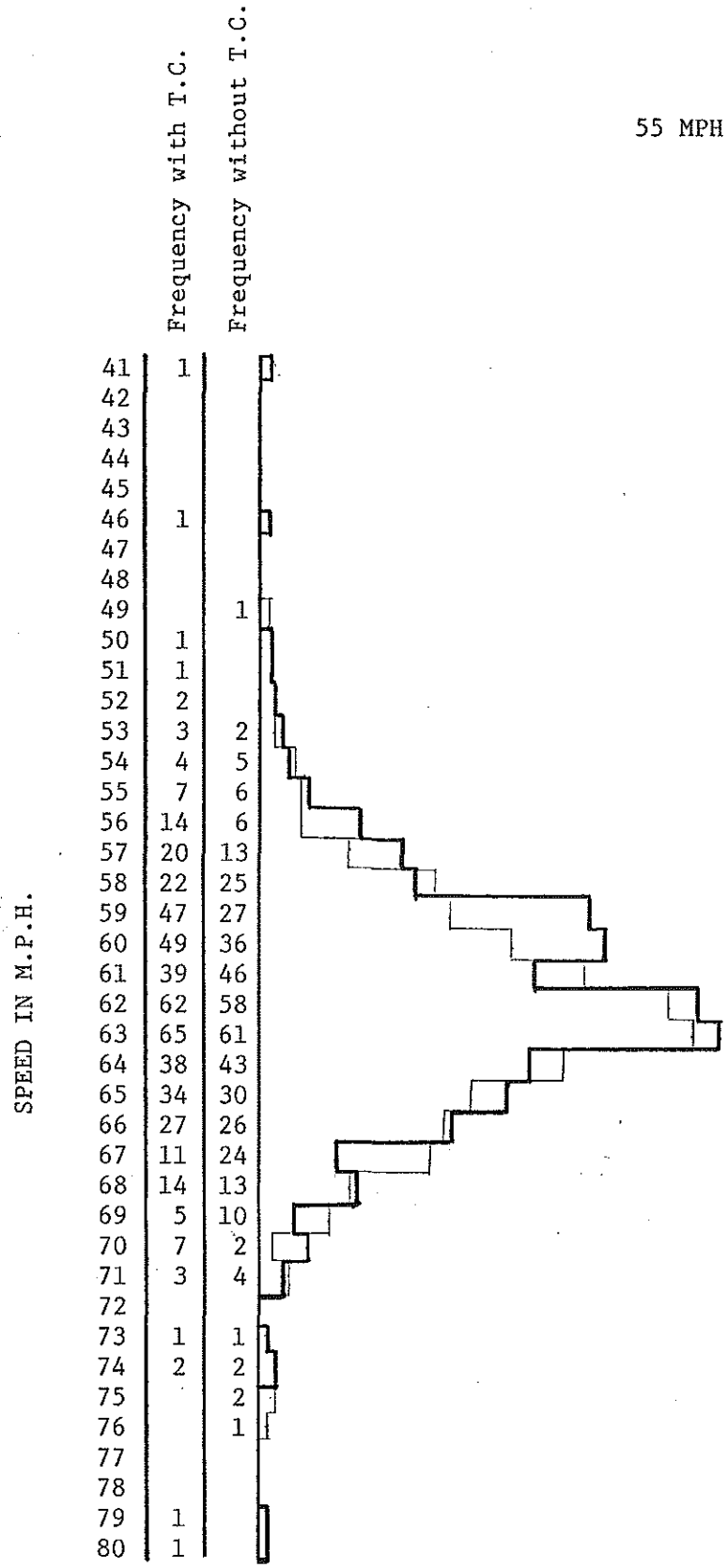
Standard Deviation With 5.15, Without 6.08

With Traffic Control

Without Traffic Control

Frequency Distribution

55 MPH



Mean With 61.83, Without 62.63

Standard Deviation With 2.22, Without 4.00

With Traffic Control

Without Traffic Control

Figure 8

Frequency Distribution

REFERENCES

The following books and reports were extremely helpful in providing information compiled in this report.

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- Kustom's Trooper F Operator's Manual Kustom Electronics, Inc., Chanute, Kansas.
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