JOINT HIGHWAY RESEARCH PROJECT

JHRP-75-6

EVALUATION OF THE 55 MPH
SPEED LIMIT

Tim M. Borg

Final Report

TO: J. F. McLaughlin, Director
Joint Highway Research Project

March 26, 1975

FROM: H. L. Michael, Associate Director
Joint Highway Research Project

Project: C-36-10E

File: 8-3-5

Attached is a Final Report on the JHRP Research Study titled "Evaluation of the 55 MPH Speed Limit". The Report has the same title and was authored by Tim M. Borg, Graduate Instructor in Research on our staff under the direction of Professor H. L. Michael. Mr. Borg also used the Report for his MSCE degree.

The publication reports the changes in vehicle speeds, traffic volumes, and accidents which occurred on Indiana highways in the first six months of 1974 as compared to those of the first six months of 1971, 1972 and 1973 when the speed limit was 65 and 70 mph. An estimate of savings in fuel used by automobiles on Indiana primary highways is also included.

The Report is submitted for acceptance as fulfillment of the objectives of the Study.

Respectfully submitted,

Harold L. Michael

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by
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Project No.: C-36-10E

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in cooperation with the

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ABSTRACT

Borg, Tim Mitchell. M.S.C.E., Purdue University, May, 1975.
Evaluation of the 55 MPH Speed Limit. Major Professor:
Harold L. Michael.

The purpose of this research was to determine the effect of the 55 mph speed limit on typical measures of speed, compliance of the public to posted limits, accident rates, and anticipated relative gasoline savings on rural primary highways in Indiana.

Spot speed data was collected at twelve established Joint Highway Research Project (JHRP) speed stations so that comparisons to previous years could be made. Speeds for 1974 averaged five to ten mph below their 1973 counterparts. Observed speeds were statistically lower in 1974 for passenger cars and heavy trucks on all but one class of rural highways. The only exception was for heavy trucks on two-lane highways where no significant reduction in mean speeds was found.

An analysis of traffic volumes for the first six months of 1974 indicated that they were 13% less than the projected volumes for 1974 and 6.5% less than the volumes for the first six months of 1973.

Accident data was collected on 125 sections of rural primary Indiana highways. Traffic volumes for the sections were used to find accident rates for interstate, other four-lane, and two-lane highways. Accident rates for the first six months of 1974 were compared to rates for the first six months of the three previous years. The rate for the total number of accidents for each class of highway significantly decreased in the first six months of 1974.

The reduced observed speeds and traffic volumes suggested a 55 million gallon gasoline savings in the first six months of 1974 over the first six months of 1973.

LITERATURE REVIEW

Nature of Speed Limits

Speed limits have been established for the good of the motoring public, primarily for purposes of safety. A study has shown that by reducing the number of violators on freeways, the resulting more uniform speeds contribute to improved capacity and safety (22).

The effectiveness of a speed limit on a facility depends on the degree of enforcement and public support (3,4). The public will support and obey speed limits that are safe and reasonable; however, speed limits that are illogically restrictive cannot be enforced except by tremendous effort and expense, and then usually not for long (3).

It is the duty of traffic engineers to establish speed limits by careful investigation and evaluation. The most commonly used method of establishing speed limits is to take the 85th percentile of the observed speeds (32,26). J. C. Oppenlander suggests another method of establishing the best operating speed by optimizing the three resources expended in highway transportation: the economics of vehicle operation, the value of time, and the safety of travel (33).

Driver Characteristics

The speed a driver chooses is dependent upon his desires and environment; therefore, speed control is difficult because of variations in the driving behavior of individuals (3,22). Psychologist C. H. Lawshe found in a

survey at Purdue University that 21% of the variations in driving speeds could be attributed to attitude (26). Part of that attitude which influences the observance of posted speed limits is the tolerance permitted and the degree of enforcement by the police agencies (3).

Speed Characteristics

Many factors do or do not affect speed characteristics and have been evaluated by numerous researchers. Some of these are noted in the following list:

1. The concealment of the observation vehicle affects the speed recorded (40).
2. The percentage of heavy trucks does not affect the speed of free-flowing traffic (9).
3. The spot speeds of out-of-state drivers are frequently higher than those of in-state drivers (35).
4. It is important to evaluate the standard deviation of spot speeds during periods of low traffic flow in order to approach the maximum standard deviations (34).
5. The horizontal alignment is the principal geometric feature affecting spot speeds (35).
6. It is critical that volumes not be too high, since in traffic with increased volumes drivers are forced to adopt the speeds of slower vehicles due to congestion (36).
7. Higher priced, heavy, vehicles are driven slightly faster than lower priced, light, vehicles (35).
8. Various weekdays during daylight hours cause no significant difference in spot speeds (26,29).

In studying accident rates, a three year period has been found to be the optimum time span (28). Weather need not be considered when studying accident rates unless

the number of days of inclement weather varies significantly from year to year, since nine out of ten fatal freeway accidents occur during clear weather (24).

Nature of Accidents

There are three elements in today's traffic: the driver, the vehicle, and the roadway. Transportation engineers are primarily concerned with altering the roadway. Although the direct causal relationship may be low, the roadway undoubtedly influences the accident rate because the highway can require mental and physical responses above and beyond the abilities of the driver (30). It is up to the engineer to determine what changes in the roadway can make travel safer for the public.

The most commonly used measure of accidents is the number of accidents per million vehicle miles driven. This traditional measure involves three assumptions:

1. All driving involves some exposure to accident hazards.
2. Exposure to accident hazards is proportional to miles driven.
3. Degree of exposure is the same for all drivers.

The uniformity of vehicle operating speeds appears to be a more important effect than the absolute vehicle speed (6). With uniformly flowing traffic, there are fewer hazards due to passing maneuvers.

Accident rates have been found to be related to the classification of highways and their respective average daily traffic volumes. Freeways, because of their greater degree of access control, use of medians and adequate set-back distances for side interference, have lower accident rates than other highways (25). Accident rates increase with increasing volumes until congestion slows the flow of traffic (36). The expected accident rate (R) on freeways

can be related to the volume (V) by the formula:

$$R = 0.17V^{0.18} \quad (27)$$

It must be remembered that calculated accident rates are based on the number of reported accidents. An Illinois traffic report found that 75% of highway accidents are not reported; therefore, a highway may have a greater incidence of accidents than the accident rate indicates. It appears that the public is more concerned with reducing delays and interference than with reducing accident rates (25).

PURPOSE

The objectives of this research were:

1. To determine the speed of free-flowing traffic on various classes of rural arterial highways under the mandatory 55 mph speed limit;
2. To determine if passenger vehicle and heavy truck speeds under the 55 mph speed limit on rural highways are statistically different from the previous years' spot speeds;
3. To evaluate accident rates on rural arterial highways for the first six months of 1974 to see if there has been any change since the 55 mph speed limit;
4. To evaluate the gasoline conservation aspect of the 55 mph speed limit.

The results of this report should be of benefit to those in the traffic and highway safety field and to State Legislatures in appraising the effect of the 55 mph speed limit.

DATA COLLECTION

Spot Speed Observations

In conjunction with the Joint Highway Research Project (JHRP) annual Traffic Speed Study, spot speed data was gathered at the twelve established stations in Indiana shown in Figure 1. Using the speed reports from previous years, speed data for each type of rural highway - interstate, other four-lane, and two-lane - was tabulated. Passenger vehicle speeds were compared as were heavy truck (over 5000 pounds) speeds. For each type of highway and class of vehicle, comparison tables were made to present: average speed, standard deviation, 85th percentile, percent of vehicles exceeding the posted limit, percent of vehicles exceeding the posted limit by more than 5 mph, and percent of vehicles exceeding 65 mph. In addition, the percentage of traffic volume for each year, each class of vehicle, and each type of highway was determined for each 5 mph speed range. The percent of vehicles found in each range was graphically represented to better show the differences.

Selection of Roadway Sections

Three classes of rural Indiana highways were evaluated to determine accident rates. Twenty-four interstate, twenty-six other four-lane, and seventy-five two-lane rural highway sections, each about twelve miles long, were used. For a section to be acceptable, it had to meet certain criteria. The purpose of the criteria was to minimize the chance variations in accident rates due to factors other than volume change. These criteria included:

FIGURE 1. LOCATION OF SPOT SPEED STATIONS

1. Homogeneous cross section
2. Outside metropolitan areas
3. No major change in land use along section during study period
4. No alteration of roadway (other than regular maintenance) during study period
5. Previous speed limit was 65 mph for all highways except 70 mph for rural interstate highways.

Sections were accepted or rejected based on data made available by the Indiana State Highway Commission. The exact length of each section was gathered at the same office. The locations of the sections can be seen in Figure 2.

Roadway Traffic Volume

The traffic volumes for the accepted rural sections were collected from a 1972 ADT map provided by the Indiana State Highway Commission, Division of Traffic. The 1972 ADT for each section was calculated from the map using the method of weighted means. Data provided by permanent counting stations was used to create factors to convert the 1972 ADT of a section to the relative volumes for the first six months of 1971, 1972, 1973 and 1974. The individual factors were made by dividing the average monthly volumes for the first six months of each year by the average monthly volumes for the entire year of 1972. Of the total of twenty-three permanent volume stations in Indiana, seven were rejected because at some time in the four year period, traffic was rerouted due to construction. This would have biased the monthly average by including volumes which were not due to normal changes in driving habits. The locations of the permanent counting stations used in this study are shown in Figure 3.

FIGURE 2. LOCATION OF ACCIDENT STUDY SECTIONS

FIGURE 3. LOCATION OF PERMANENT COUNTING STATIONS

Accident Data

The Indiana State Police in Indianapolis made available the standard accident report forms from which accident data for the first six months of 1971, 1972, 1973 and 1974 was drawn.

For each section, accident rates for the first six months of each year were calculated using volume data, section length and accident counts. While accident counts were tallied into four categories - property damage, personal injury, fatal and total accidents - no attempt was made to confirm the final outcome of an accident, such as an injured person later dying. To assure complete counts, the intersections on each section were checked to see if accidents had been inadvertently indexed to the crossroad. The accident rates for the first six months of 1974 were compared by category to the first six months of the other years. The first six months period of 1974 was used because accident reports would have had sufficient time to be processed and filed. To minimize changes in accident rates due to seasonal variations, only the first six months of 1971, 1972 and 1973 were used in the comparison.

Gasoline Consumption

An evaluation was made of the gasoline savings that were realized in the first six months of 1974 by a change in speeds and volumes from the same period in the previous year. The amount of vehicular travel in Indiana was gathered from a 1972 statistical compilation by the Department of Transportation, Federal Highway Administration. Again, permanent counting station data was used to convert the quantity of travel in 1972 to the relative quantities in the two study periods. The average speed of passenger

vehicles on rural Indiana highways was determined for 1973 and 1974. Using data compiled by Claffey in 1969 (8), the rate of gasoline consumption of an "average American car" was estimated at the observed speeds. The average gasoline consumption rate divided into the number of vehicle miles driven approximated the quantity of gasoline used in that period.

ANALYSIS OF DATA

Speed Data Tables

The tables of speed data for different vehicles on different types of rural highways were assembled using results from previous JHRP speed studies. Speeds from 24 to 89 mph were listed in one mph increments and the cumulative percentage of each type of vehicle for each speed was obtained. Simple subtraction yielded the percentage of vehicles in any given speed range. The data for each class of highway and each type of vehicle can be seen in Tables 1 through 8, and the relative frequency distribution curves for the data can be seen in Figures 4 through 11.

Characteristics of Speed Data

For passenger vehicles on rural interstate highways the average speeds in 1974 decreased from 1973 about 11 mph, on other rural four-lane highways around 6 mph, and on rural two-lane highways about 5 mph (Table 9). The different decreases resulted from the greater speeds that were possible on higher type facilities when speeds were not restricted by the 55 mph limit.

For heavy trucks on rural interstate highways the average speeds in 1974 decreased from 1973 about 5 mph, on other four-lane highways around 3 mph, and on rural two-lane highways merely 2 mph. The lower differences as compared to passenger vehicle speeds are probably due to the superior speed and acceleration characteristics of automobiles.

TABLE 1. PASSENGER VEHICLE SPEEDS ON INTERSTATE HIGHWAYS

	1971	1972	1973	1974
Average speed of vehicles	68.47	69.25	69.58	58.69
Standard deviation	6.31	6.101	6.173	4.682
85th percentile	73.70	74.37	74.78	62.60
Two 5 mph groups with greatest % of vehicles	65-74	65-74	65-74	55-64
% of vehicles in these two 5 mph groups	63.75	65.69	64.26	73.01
% of vehicles exceeding posted limit	39.15	42.35	45.96	77.17
% of vehicles exceeding posted limit by more than 5 mph	8.73	13.45	14.37	31.68
% of vehicles exceeding 65 mph	77.28	81.63	81.33	9.91

TABLE 1 (Continued)

MPH	1971	1972	1973	1974
30-34				
35-39				
40-44	0.27	-	-	0.18
45-49	0.26	0.26	0.27	1.32
50-54	1.68	1.59	1.69	15.58
55-59	6.10	4.56	4.17	41.86
60-64	14.41	11.96	12.54	31.15
65-69	31.39	31.42	25.86	7.79
70-74	32.36	34.27	38.40	1.85
75-79	10.88	11.78	11.91	0.18
80-84	1.77	3.80	4.63	0.09
85-89	0.61	0.18	0.35	
90 >	0.27	0.18	0.18	

of vehicles in range of:

TABLE 2. PASSENGER VEHICLE SPEEDS ON OTHER FOUR-LANE HIGHWAYS

	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
Average speed of vehicles	64.69	64.31	63.94	57.97
Standard deviation	6.964	7.655	8.183	6.172
85th percentile	70.70	70.94	70.85	63.09
Two 5 mph groups with greatest % of vehicles	60-69	60-69	60-69	55-64
% of vehicles in these two 5 mph groups	56.93	53.99	51.15	59.80
% of vehicles exceeding posted limit	45.72	45.93	44.89	67.49
% of vehicles exceeding posted limit by more than 5 mph	5.77	18.50	19.45	29.48
% of vehicles exceeding 65 mph	53.71	51.15	47.45	13.0

TABLE 2 (Continued)

MPH	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
30-34	-	-	-	0.09
35-39	0.17	0.18	0.44	0.09
40-44	0.35	0.62	1.67	1.38
45-49	2.18	2.39	2.64	4.39
50-54	4.19	6.54	7.49	21.25
55-59	13.16	14.16	13.55	35.71
60-64	26.24	24.96	26.76	24.09
65-69	30.69	29.03	24.39	8.97
70-74	16.39	13.98	16.02	3.39
75-79	4.62	5.49	4.05	0.37
80-84	1.84	2.03	2.20	0.18
85-89	0.17	0.44	0.61	
90 >		0.18	0.18	.09

FIGURE 5, OTHER 4-LANE PASSENGER SPEEDS — RELATIVE FREQUENCY DISTRIBUTION CURVES

TABLE 3. PASSENGER VEHICLE SPEEDS ON TWO-LANE HIGHWAYS

	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
Average speed of vehicles	61.31	62.01	62.06	56.74
Standard deviation	7.419	7.655	7.193	6.292
85th. percentile	68.00	68.69	68.72	61.81
Two 5 mph groups with greatest % of vehicles	55-64	60-69	60-69	50-59
% of vehicles in these two 5 mph groups	53.05	53.99	51.41	62.57
% of vehicles exceeding posted limit	44.19	29.86	31.57	56.59
% of vehicles exceeding posted limit by more than 5 mph	6.13	10.63	10.93	22.67
% of vehicles exceeding 65 mph	30.96	34.60	35.19	9.14

TABLE 3 (Continued)

MPH	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
30-34				
35-39	0.46	0.18	-	0.18
40-44	0.93	0.62	0.71	0.96
45-49	3.05	2.39	3.26	7.47
50-54	11.55	6.54	9.87	29.26
55-59	23.29	14.16	20.99	33.31
60-64	29.76	24.96	29.98	19.68
65-69	19.04	29.03	21.43	5.71
70-74	7.48	13.98	9.53	2.20
75-79	3.15	5.49	3.17	0.88
80-84	0.92	2.03	0.80	0.09
85-89	0.19	0.44	0.17	0.08
90 >	0.18	0.18	0.09	0.18

FIGURE 6 , 2 LANE PASSENGER SPEEDS — RELATIVE FREQUENCY DISTRIBUTION CURVES

TABLE 4. PASSENGER VEHICLE SPEEDS ON ALL HIGHWAYS

	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
Average speed of vehicles	64.87	65.20	65.18	57.80
Standard deviation	7.490	7.607	7.904	5.814
85th percentile	72.21	72.57	72.69	62.56
Two 5 mph groups with greatest % of vehicles	60-69	60-69	60-69	55-64
% of vehicles in these two 5 mph groups	50.57	49.57	47.01	61.94
% of vehicles exceeding posted limit	36.95	39.34	40.80	67.05
% of vehicles exceeding posted limit by more than 5 mph	7.90	14.23	14.92	27.91
% of vehicles exceeding 65 mph	54.32	55.84	54.58	10.65

TABLE 4 (Continued)

MPH	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
30-34	-	-	-	0.03
35-39	0.21	0.06	0.15	0.09
40-44	0.50	0.47	0.79	0.83
45-49	1.82	1.85	2.12	4.41
50-54	5.71	6.03	6.31	22.05
55-59	14.05	13.35	12.93	36.97
60-64	23.39	22.40	23.12	24.97
65-69	27.18	27.17	23.89	7.47
70-74	18.90	19.17	21.26	2.47
75-79	6.25	6.79	6.37	0.47
80-84	1.51	2.30	2.53	0.12
85-89	0.33	0.26	0.38	0.03
90 >	0.15	0.15	0.15	0.09

FIGURE 7 , ALL HWYS. PASSENGER SPEEDS --- RELATIVE FREQUENCY DISTRIBUTION CURVES

TABLE 5. HEAVY TRUCK SPEEDS ON INTERSTATE HIGHWAYS

	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
Average speed of vehicles	59.42	60.93	61.56	56.35
Standard deviation	5.993	5.958	5.628	4.400
85th percentile	65.25	66.52	67.01	59.60
Two 5 mph groups with greatest % of vehicles	55-64	60-69	55-64	50-59
% of vehicles in these two 5 mph groups	60.93	54.60	61.43	75.00
% of vehicles exceeding posted limit	1.90	3.95	3.92	63.44
% of vehicles exceeding posted limit by more than 5 mph	0.0	0.0	0.0	11.87
% of vehicles exceeding 65 mph	18.44	30.59	30.07	2.19

TABLE 5 (Continued)

MPH	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
30-34	-	-	-	-
35-39	-	-	-	0.94
40-44	0.94	-	0.65	0.62
45-49	4.37	3.95	1.64	3.75
50-54	15.32	11.51	6.21	25.00
55-59	26.87	23.36	26.14	50.00
60-64	34.06	30.59	35.29	17.50
65-69	14.69	24.01	22.23	1.88
70-74	3.75	5.92	7.51	0.31
75-79	-	0.66	0.33	-
80-84	-	-	-	-
85-89	-	-	-	-
90 >	-	-	-	-

FIGURE 8 , INTERSTATE TRUCK SPEEDS—RELATIVE FREQUENCY DISTRIBUTION CURVES

TABLE 6. HEAVY TRUCK SPEEDS ON OTHER FOUR-LANE HIGHWAYS

	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
Average speed of vehicles	56.36	55.19	57.77	54.36
Standard deviation	6.153	7.126	8.076	6.786
85th percentile	61.99	62.44	65.11	59.81
Two 5 mph groups with greatest % of vehicles	55-64	50-59	55-64	50-59
% of vehicles in these two 5 mph groups	58.54	48.93	50.62	58.39
% of vehicles exceeding posted limit	4.90	4.26	15.35	48.25
% of vehicles exceeding posted limit by more than 5 mph	0.0	0.43	3.73	13.64
% of vehicles exceeding 65 mph	6.4	8.51	17.84	4.20

TABLE 6 (Continued)

MPH	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
30-34	0.30	-	0.83	0.35
35-39	0.92	2.13	1.24	1.75
40-44	2.44	6.81	4.98	7.34
45-49	7.62	12.34	8.30	11.54
50-54	23.78	22.12	16.19	25.87
55-59	31.10	26.81	24.48	32.52
60-64	27.44	21.28	26.14	16.43
65-69	5.79	7.23	12.03	3.15
70-74	0.61	1.28	4.98	0.35
75-79	-	-	0.83	0.70
80-84	-	-	-	-
85-89	-	-	-	-
90 >	-	-	-	-

FIGURE 9 , OTHER 4 LANE TRUCK SPEEDS RELATIVE FREQUENCY DISTRIBUTION CURVES

TABLE 7. HEAVY TRUCK SPEEDS ON TWO-LANE HIGHWAYS

	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
Average speed of vehicles	53.99	55.62	56.42	54.49
Standard deviation	6.765	6.162	6.319	5.525
85th percentile	60.68	61.25	62.09	59.39
Two 5 mph groups with greatest % of vehicles	50-59	50-59	55-64	50-59
% of vehicles in these two 5 mph groups	55.26	55.78	58.07	65.45
% of vehicles exceeding posted limit	2.70	4.55	7.31	47.15
% of vehicles exceeding posted limit by more than 5 mph	0.8	0.41	1.15	11.79
% of vehicles exceeding 65 mph	4.67	6.2	8.85	2.44

TABLE 7 (Continued)

MPH	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
30-34	-	-	-	-
35-39	2.33	0.83	0.38	0.81
40-44	7.40	3.30	4.24	3.66
45-49	14.39	14.47	8.84	13.01
50-54	24.13	19.83	20.00	29.67
55-59	31.13	35.95	33.46	35.78
60-64	15.95	19.42	24.61	14.63
65-69	3.89	5.37	7.31	2.44
70-74	0.78	0.83	1.54	-
75-79	-	-	-	-
80-84	-	-	-	-
85-89	-	-	-	-
90 >	-	-	-	-

FIGURE 10 , 2-LANE TRUCK SPEED — RELATIVE FREQUENCY DISTRIBUTION CURVES

TABLE 8. HEAVY TRUCK SPEEDS ON ALL HIGHWAYS

	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
Average speed of vehicles	56.77	57.56	58.77	55.14
Standard deviation	6.638	6.931	7.019	5.687
85th percentile	62.84	64.33	65.30	59.62
Two 5 mph groups with greatest % of vehicles	55-64	55-64	55-64	50-59
% of vehicles in these two 5 mph groups	56.13	52.62	57.12	66.67
% of vehicles exceeding posted limit	3.21	4.23	8.43	53.64
% of vehicles exceeding posted limit by more than 5 mph	0.2	0.26	1.60	12.44
% of vehicles exceeding 65 mph	10.17	16.39	19.58	2.93

TABLE 8 (Continued)

MPH	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
30-34	.11	-	.25	.12
35-39	.99	.9	.49	1.17
40-44	3.32	3.07	3.10	3.76
45-49	8.40	9.73	5.83	9.03
50-54	20.88	17.29	13.63	26.65
55-59	29.61	28.29	28.00	40.02
60-64	26.52	24.33	29.12	16.32
65-69	8.40	13.19	14.38	2.46
70-74	1.77	2.94	4.83	0.24
75-79	-	0.26	0.37	0.23
80-84	-	-	-	-
85-89	-	-	-	-
90 >	-	-	-	-

FIGURE 11 , ALL HIGHWAYS TRUCK SPEEDS — RELATIVE FREQUENCY DISTRIBUTION CURVES

TABLE 9. AVERAGE VEHICLE SPEEDS

Passenger Cars	1971	1972	1973	1974
Interstates	68.47	69.25	69.58	58.69
Other Four-Lanes	64.69	64.31	63.94	57.97
Two-Lanes	61.31	62.01	62.06	56.74
Trucks	1971	1972	1973	1974
Interstates	59.42	60.93	61.56	56.35
Other Four-Lanes	56.36	55.19	57.77	54.36
Two-Lanes	53.99	55.62	56.42	54.49

The 85th percentile speeds for passenger vehicles on rural interstate highways decreased in 1974 almost 12 mph, on other four-lane rural highways around 8 mph, and on two-lane rural highways slightly over 7 mph from 1973 (Table 10). The 85th percentile for heavy trucks decreased in 1974 on interstates about 7 mph, on other four-lane highways nearly 5 mph, and on two-lane highways about 3 mph from 1973. The same observation as to the difference in 85th percentile speeds of passenger and truck speeds can be made as was made for average speeds. It should be noted that the 85th percentile differences are greater than average speed differences for vehicles on various facilities.

Table 11 shows the two consecutive 5 mph groups with the greatest percentage of vehicles in that range. Passenger vehicles in 1974 on interstates dropped from the 65-74 mph range in 1973 to the 55-64 mph range, and also increased the percentage of vehicles in that range by nearly 9%. Other four-lane highways dropped from the 60-69 mph range to the 55-64 mph range with about 9% more vehicles. Two-lane highways fell from the 60-69 mph range to the 50-59 mph range and increased the percentage of vehicles in that range by almost 11%.

The 10 mph range carrying the heaviest volume of traffic of heavy trucks in 1974 fell 5 mph on interstates, other four lane and two-lane rural highways from 1973 data. The percentage of heavy truck traffic in the 50-59 mph range rose from 1973 nearly 14% on interstates, about 8% on other four-lanes, and slightly over 7% on two-lanes.

It should be noted that heavy trucks had a greater tendency to a more uniform speed range in 1974 from 1973 than did passenger cars. The tendency in 1974 for passenger vehicles and heavy trucks to travel at a more uniform speed was not as great on other four-lane highways as it was for interstates and two-lane highways.

TABLE 10. 85th PERCENTILE VEHICLE SPEEDS

Passenger Cars	1971	1972	1973	1974
Interstates	73.70	74.37	74.78	62.60
Other Four-Lanes	70.70	70.94	70.85	63.09
Two-Lanes	68.00	68.69	68.72	61.81
Trucks	1971	1972	1973	1974
Interstates	65.25	66.52	67.01	59.60
Other Four-Lanes	61.99	62.44	65.11	59.81
Two-Lanes	60.68	61.58	62.09	59.39

TABLE 11. TWO CONSECUTIVE 5 MPH GROUPS WITH GREATEST
TRAFFIC VOLUME, PERCENT OF VOLUMES

Passenger Cars	1971	1972	1973	1974
Interstates	65-74 mph 63.75%	65-74 mph 65.69%	65-74 mph 64.26%	55-64 mph 73.01%
Other Four-Lanes	60-69 mph 56.93%	60-69 mph 53.99%	60-69 mph 51.15%	55-64 mph 59.80%
Two-Lanes	55-64 mph 53.05%	60-69 mph 53.99%	60-69 mph 51.41%	50-59 mph 62.57%
Trucks				
Interstates	55-64 mph 60.93%	60-69 mph 54.60%	55-64 mph 61.43%	50-59 mph 75.00%
Other Four-Lanes	55-64 mph 58.54%	50-59 mph 48.93%	55-64 mph 50.62%	50-59 mph 58.39%
Two-Lanes	50-59 mph 55.26%	50-59 mph 55.78%	55-64 mph 58.07%	50-59 mph 65.45%

Table 12 shows the percentage of vehicles that exceeded the posted speed limit on rural highways. In 1974 the percentage of passenger vehicles exceeding the speed limit (55 mph) increased from 1973 (70 and 65 mph) almost 30% on interstate highways, nearly 22% on other four-lane highways, and around 25% on two-lane highways. In 1974 the percentage of heavy trucks exceeding the speed limit increased from 1973 slightly over 60% on interstates, more than 33% on other four-lane highways, and close to 40% on two-lane highways. While the heavy trucks showed a tremendous increase in violations compared to passenger vehicles, the percentage of passenger vehicles in 1974 exceeding the speed limit was greater than trucks on each facility.

Table 13 shows the percentage of vehicles that exceeded the speed limit by more than 5 mph. In 1974 the percentage of passenger vehicles showed an increase from 1973 of nearly 17% on rural interstates, almost 10% on other four-lane rural highways, and a little over 12% on rural two-lane highways. The percentage of heavy trucks showed an increase from 1973 of nearly 12% on interstates, more than 10% on other four-lanes, and about 11% on two-lanes in 1974. Although the increased violation percentages for passenger cars and trucks on each highway were similar, the actual percentages of passenger cars and of trucks exceeding the speed limit by more than 5 mph were not. In fact, the percentages of passenger vehicles exceeding the speed limit by 5 mph or more were about double that of heavy trucks.

Table 14 shows the percentage of vehicles that exceeded 65 mph on rural highways. The percentage of passenger vehicles in 1974 that exceeded 65 mph dropped from 1973 by more than 71% on interstate highways. It fell almost 34% on other four-lane highways and nearly 26% on

TABLE 12. PERCENTAGE OF VEHICLES EXCEEDING SPEED LIMIT

Passenger Cars	1971	1972	1973	1974
Interstates	39.15	42.35	45.96	77.17
Other Four-Lanes	45.72	45.93	44.89	67.49
Two-Lanes	44.19	29.86	31.57	56.59
Trucks	1971	1972	1973	1974
Interstates	1.90	3.95	3.92	63.44
Other Four-Lanes	4.90	4.26	15.35	48.25
Two-Lanes	2.70	4.55	7.31	47.15

TABLE 13. PERCENTAGE OF VEHICLES EXCEEDING SPEED LIMIT
BY MORE THAN 5 MPH

Passenger Cars	1971	1972	1973	1974
Interstates	8.73	13.45	14.37	31.68
Other Four-Lanes	5.77	18.50	19.45	29.48
Two-Lanes	6.13	10.63	10.93	22.67
Trucks	1971	1972	1973	1974
Interstates	0.0	0.0	0.0	11.87
Other Four-Lanes	0.0	0.43	3.73	13.64
Two-Lanes	0.8	0.41	1.15	11.79

TABLE 14. PERCENTAGE OF VEHICLES EXCEEDING 65 MPH

Passenger Cars	1971	1972	1973	1974
Interstates	77.28	81.63	81.33	9.91
Other Four-Lanes	53.71	51.15	47.45	13.0
Two-Lanes	30.96	34.60	35.19	9.14
Trucks	1971	1972	1973	1974
Interstates	18.44	30.59	30.07	2.19
Other Four-Lanes	6.4	8.51	17.84	4.2
Two-Lanes	4.67	6.2	8.85	2.44

two-lane highways. The percentage of heavy trucks in 1974 exceeding 65 mph fell from 1973 by almost 28% on interstate highways, nearly 14% on other four-lane highways, and slightly more than 6% on two-lane highways. It should be noted that prior to 1974 the percentage of trucks exceeding 65 mph was never nearly as large as the percentage of passenger vehicles. Perhaps this was because trucks do not have the potential to exceed 65 mph as easily as passenger cars.

Spot Speed ANOVA

The rural mean spot speeds of passenger cars, then trucks, were compared for a statistically significant change. For each class of highway, the mean speed was recorded at the four sample stations of that class. Previous JHRP annual speed reports gave the mean speeds at the same stations for 1971, 1972, and 1973.

For each type of vehicle and each class of highway, an analysis of variance (ANOVA) using orthogonal contrasts was used to test if the mean speeds for 1974 were different from 1971, 1972, and 1973. For example, the sum of the squares of the aggregate, the sum of squares due to error, and the sum of the squares of the total were calculated for the observed passenger vehicle speeds on rural interstate highways. The contrast (ω) in question was:

$$\omega = \mu_{1971} + \mu_{1972} + \mu_{1973} - 3\mu_{1974}$$

To test this orthogonal contrast, it was necessary to find the contrast sum of squares (ssw):

$$ssw = \frac{\left(\sum_{i=1}^k C_i T_i \right)^2}{n \sum_{i=1}^k C_i^2}$$

Where:

n = number of sections

T = total of rates for each year

C_i = coefficient of μ_i .

An ANOVA table for passenger vehicle speeds on interstate highways is shown as Table 15.

A level of confidence of 0.95 was used in the F-test. The critical value for this example for $F_{.95(1,12)}$ was 4.75 and the computed F ratio was 855; therefore, it was significant. The hypothesis that the mean speeds of all four years are the same was rejected.

Using similar analysis, the passenger vehicle speeds on interstates, other four-lanes, two-lanes and overall showed a significant change in 1974 over the three previous years. Heavy truck speeds on interstates, other four-lanes and overall also showed a significant change, but no significant change was found for heavy trucks on two-lane highways.

Summary

The overall average rural free-flow speed of passenger cars on all types of facilities decreased 7.4 mph to 57.80 mph in 1974 from 1973. Similarly, heavy truck (over 5000 pounds) speeds fell 3.6 mph to 55.14 mph in 1974 from 1973. The greatest reduction in rural speeds occurred on interstate highways. There was a tendency for average speeds in 1974, besides being lower, to be less variable than in 1973. The average rural speeds for passenger vehicles and heavy trucks showed a statistically significant change in 1974 except for trucks on two-lane highways. The average speed of heavy trucks on two-lane highways, however, did not significantly change, possibly because the geometric design and not the speed limit controlled their speed.

TABLE 15. ANOVA OF PASSENGER VEHICLE SPEEDS ON INTERSTATE
HIGHWAYS

Source	SS	D of F	M.S.	f
Aggregate	327.6	3	109.2	287.4
1,2,3 vs 4	(324.9)	(1)	(324.9)	(855)
Error	4.6	12	0.38	
Total	332.2	15		

Volumes

Seventeen permanent counting stations throughout the state provided the monthly average daily volumes as shown in Table 16. Factors to convert ADTs of 1972 to average daily volumes for the first half of 1971, 1972, 1973 and 1974 were calculated by dividing the average daily volume of the first half of each year by the ADT for the full year. Average daily volumes and conversion factors for the first half of the four study years are shown in Table 17.

Summary

The results clearly indicate that travel in the first half of 1974 did not follow the increasing trend of recent years. The average daily volumes for the first half of 1971, 1972 and 1973 increased about 500 vehicles per day each year. But in the first half of 1974, instead of growing to an average daily volume of about 6900, the average was only 5989 vehicles per day, a drop of over 13%. The average volume decreased by 6.5% in 1974 from 1973. Figure 12 is a graphical representation of the changes in average daily volumes.

Accident Rates

Each of the 125 sample sections had sixteen accident rates to be calculated. Accidents for the first half of each of the four years were classified as property, personal injury, fatality and total. Accident rates were expressed as accidents per hundred million vehicle miles using the formula:

$$\frac{(\text{number of accidents}) \times (100,000,000)}{(\text{section length}) \times (\text{A.D.T.}) \times (365/2)}$$

TABLE 16. MONTHLY AVERAGE DAILY VOLUMES AT SEVENTEEN PERMANENT COUNTERS ON INDIANA
HIGHWAYS

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1971	4399	4501	5032	5758	5977	6672	*	*	*	*	*	*
1972	4737	4990	5699	6042	6578	7108	7400	7620	6616	6197	6010	5667
1973	5328	5604	6089	6728	7039	7642	*	*	*	*	*	*
1974	4847	5085	5613	6405	6768	7214	*	*	*	*	*	*

*Not Required for this study.

TABLE 17. AVERAGE DAILY VOLUMES FOR STUDY PERIODS

Average Daily Volumes for first half of 1971 - 5390; Conversion Factor* = 0.8663
 Average Daily Volumes for first half of 1972 - 5859; Conversion Factor = 0.9417
 Average Daily Volumes for first half of 1973 - 6405; Conversion Factor = 1.0294
 Average Daily Volumes for first half of 1974 - 5989; Conversion Factor = 0.9626

Average for all of 1972 - 6222

*Conversion Factor = $\frac{\text{Average Daily Volume for Appropriate Study Period}}{1972 \text{ ADT}}$

FIGURE 12. AVERAGE DAILY VOLUMES FOR FIRST HALF OF EACH YEAR

Table 18 shows the accumulated accident counts on the study sections of interstate highways in 1971 through 1974 for different types of accidents and the average accident rates of the 24 sections. Similar data for all study sections of other four-lane highways is in Table 19 and for two-lane highways in Table 20. Table 21 presents the total counts and average rates for all 125 test sections of rural Indiana highways.

The rates for any type of accident were lowest on interstates. Accident rates on two-lane highways were nearly four times as great as those on interstate highways. Other four-lane highways experienced accident rates about twice as great as those on interstate highways.

An analysis of variance using orthogonal contrasts was used to test whether the rate change was significant for each class of highway and type of accident. This test was the same as explained in the analysis of variance of speed data. An ANOVA example of property damage accidents on interstates is Table 22. The computed f was within the cited region; therefore, the hypothesis that the 1974 property accident rates for interstates did not differ from the other years was not rejected. A summary of ANOVA calculations can be seen in Table 23.

Summary

There was a decrease in the accident rates in the first half of 1974 from the average accident rates of the same period in the three previous years. The rates of decrease of each type of accident on each class of highway can be seen in Table 24. As seen in Table 23, however, the change in rates was not always statistically significant. While a 50% decrease, as seen in interstate fatality rates, would seem significant, the data was not sufficient to permit the apparent change to be found significant.

TABLE 18. INTERSTATE ACCIDENT COUNTS AND RATES ON STUDY SECTIONS*

	Property Damage	Personal Injury	Fatality	Total
1971	585/55.7**	241/22.5	12/1.0	838/79.2
1972	564/49.4	284/23.9	22/1.8	870/75.1
1973	654/57.4	201/17.5	13/0.9	868/75.8
1974	524/47.4	186/15.3	8/0.6	718/63.3

*24 sections for a total of 408.01 miles.

**Actual no. of accidents/rate expressed as accidents per 100 mvm.

TABLE 19. OTHER FOUR-LANE ACCIDENT COUNTS AND RATES ON
STUDY SECTIONS*

	Property Damage	Personal Injury	Fatality	Total
1971	406/106.0**	228/60.9	13/2.7	647/169.6
1972	384/93.6	211/50.1	12/2.1	607/145.8
1973	414/93.4	188/42.2	11/2.3	613/173.9
1974	370/85.7	149/33.9	4/0.7	523/120.3

*26 sections for a total of 303.76 miles.

**Actual no. of accidents/rate expressed as accidents per
100 mvm.

TABLE 20. TWO-LANE ACCIDENT COUNTS AND RATES ON STUDY SECTIONS*

	Property Damage	Personal Injury	Fatality	Total
1971	729/205.5**	414/117.5	25/8.9	1168/331.9
1972	713/177.9	407/101.5	19/8.9	1139/285.6
1973	807/184.8	341/70.0	25/6.6	1173/261.4
1974	661/164.2	221/65.1	17/2.3	899/231.6

*75 sections for a total of 947.99 miles.

**Actual no. of accidents/rate expressed as accidents per 100 mvm.

TABLE 21. ALL HIGHWAYS ACCIDENT COUNTS AND RATES ON STUDY SECTIONS*

	Property Damage	Personal Injury	Fatality	Total
1971	1720/122.4**	883/67.0	50/4.2	2653/193.6
1972	1661/107.0	902/58.5	53/3.4	2616/168.9
1973	1875/111.9	730/43.2	49/3.3	2654/158.4
1974	1525/99.1	556/38.2	29/1.2	2140/138.5

*125 sections for a total of 1659.76 miles.

**Actual no. of accidents/rate expressed as accidents per 100 mvm.

ALL HIGHWAY ACCIDENT RATES

TABLE 22. ANOVA OF PROPERTY ACCIDENT RATES ON INTERSTATE
HIGHWAY STUDY SECTIONS

Source of Var.	Sum of Sq.	D of F	M.S.	Computed f
Aggregate	1685,6	3	561	1.10
1,2,3 vs 4	(837)	(1)	(837)	1.64
Error	46,828	92	509	
Total	48,513.6	95		

Table $f_{.95(1,92)} = 3.96$

TABLE 23. SUMMARY RESULTS OF ANOVA OF ACCIDENT RATES ON
STUDY SECTIONS

	Type of Accident			
	Property Damage	Personal Injury	Fatality	Total
Interstates	N.C.*	S.C.**	N.C.	S.C.
Other Four-Lane	N.C.	S.C.	S.C.	S.C.
Two-Lane	N.C.	S.C.	S.C.	S.C.
All Highways	N.C.	S.C.	S.C.	S.C.

*No Change in rates.

**Significant Change in rates.

TABLE 24. PERCENTAGE OF DECREASE IN AVERAGE ACCIDENT
RATES IN 1974 FROM THE AVERAGE OF THE THREE
PREVIOUS YEARS

	Type of Accident			
	Property Damage	Personal Injury	Fatality	Total
Interstates	12%	28%	50%	18%
Other Four-Lane	12%	34%	70%	26%
Two-Lane	13%	32%	68%	21%
All Highways	13%	32%	67%	20%

From the data in Table 24, it can be seen that fatality rates were reduced the greatest, injury rates to a lesser degree, and property damage rates the least.

Also from the data in Table 24, it can be seen that interstate highways showed the least reduction in accident rates, and other four-lane highways the most. This is not surprising as interstate highways are better designed for safety at higher speeds. Other four-lane highways had a greater percentage of accident rate reduction than two-lane highways, perhaps because of the heavier traffic volumes and greater development with increased roadside conflicts typically associated with such highways.

It should be noted here that the accident reductions that have been experienced occurred under several changed conditions. This study has found speeds to be reduced, speeds to be more uniform and traffic volumes to be less. All three are recognized as important factors in accidents. There, of course, may be other factors which have not been evaluated but which are important to reductions in accidents. One recent study estimated that reduced and more uniform speeds accounted for 11% of the reduction of fatalities, reduced travel accounted for 5%, and other effects accounted for 7% (23).

Some of the reduction in fatalities and accidents is undoubtedly due to the reduction in speeds resulting from the lower speed limit. The lower speeds of vehicles on highways, especially on older roads not designed for high speeds, places less demand on drivers for safe handling of their vehicles and provides drivers with greater opportunities to react safely in emergency situations. The more uniform speed results in less accidents because there is less internal friction, for example the hazards of passing maneuvers are reduced.

It is also clear that reduced travel accounted for some of the reduction of accidents. Although accident rates take into consideration the vehicle miles of travel, the assumption is made that all drivers are exposed to the same degree of hazard. It can easily be seen that a driver on a higher volume road would have a higher probability of collision than if on a road of lower volume because of greater opportunity for vehicular conflict.

There are other effects that contribute to the savings of lives and property. Everyday, older cars are being replaced by newer and safer cars on the highway. The new cars handle better and offer much more protection to the occupants in the event of collision. Highways are daily being improved, not only by construction of new or improved highways but by pavement repairs and geometric alterations. State and local traffic safety programs also continually educate and assist drivers.

Gasoline Consumption

The rates of gasoline consumption were compared for the first half of 1973 and the first half of 1974. The mean speeds of passenger vehicles on rural roads as found in this study for each year were used in conjunction with Claffey's data (Table 25) on the rate of gasoline consumption of the "average American car" in free-flowing traffic at different speeds (8).

The first approximations made were the amounts of gasoline that probably were saved by the reduction of speeds on interstate, other four-lane, two-lane, and all rural state highways. Claffey's data was used to estimate the rate of consumption based on the mean speeds of passenger vehicles on each facility as found in the speed portion of this study. A final net savings of gasoline was approximated for a one hundred mile trip on each type

TABLE 25. GASOLINE CONSUMPTION AT VARIOUS SPEEDS

Speed	Gasoline Consumption
30 mph	22.7 mpg
40 mph	21.7 mpg
50 mph	19.2 mpg
60 mph	17.2 mpg
70 mph	14.9 mpg

From Claffey (8).

of rural highway in free-flowing traffic. The mean speeds of automobiles on other than interstate four-lane and two-lane highways were nearly the same, resulting in similar savings on a one hundred mile trip. Interstate highways showed the greatest savings due to drastic changes in speeds in 1974 from 1973. Table 26 shows the estimated savings which resulted.

The preceding analysis, however, did not take into consideration the change in traffic volumes in the first half of 1974 from the first half of 1973. An analysis was therefore made that considered both changes in speeds and volumes. Basic data for travel on interstates, U.S. highways and primaries from 1972 statistics from the Department of Transportation, Federal Highway Administration, is as follows:

ALL passenger vehicles in USA in 1972 - 330,605
mpvm* (rural)

ALL motor vehicles in USA in 1972 - 449,030
mvm (rural)

ALL motor vehicles in Indiana in 1972 - 15,572
mvm (rural)

ALL motor vehicles in Indiana in 1972 on inter-
states - 4458 mvm (rural)

*million passenger vehicle miles

Three assumptions must be made in estimating 1973 and 1974 travel from the available 1972 data. First, the proportion of passenger vehicles to total traffic remained the same. Second, the trip lengths in 1972 were the same in 1973 and 1974. Third, the mileages of each type of rural state highway were the same for all three years. Of the total vehicular travel, passenger vehicle travel was:

$$\frac{330,605 \text{ mpvm}}{449,030 \text{ mvm}} = 73.63\%$$

TABLE 26. GASOLINE CONSUMPTION COMPARISONS

Facility	Mean Speeds	Expected Gasoline Consumption in Miles Per Gallon	Expected Gasoline Saved 100 Mile Trip
Interstate	1973 - 69.6 1974 - 58.7	15.0 17.5	.96 gallons
Other Four-Lane	1973 - 63.9 1974 - 58.0	16.3 17.4	.39 gallons
Two-Lane	1973 - 62.1 1974 - 56.7	16.7 17.9	.40 gallons
All Highways	1973 - 65.2 1974 - 57.8	16.0 17.6	.57 gallons

Annual travel is the product of ADTs times trip lengths and since the trip lengths were assumed to be the same, they cancelled each other out. The factors to estimate travel for the first half of 1973 and 1974 on rural Indiana highways were derived by summing the monthly average daily volumes at the permanent counting stations in Indiana for the first half of the subject years and dividing by the sum of the monthly average daily volumes for all of 1972. The monthly average daily volume data was obtained from the data in Table 16.

$$\frac{\sum \text{Volumes first half 1973}}{\sum \text{All of 1972}} = \frac{38430}{74664} = 0.5147$$

$$\frac{\sum \text{Volumes first half 1974}}{\sum \text{All of 1972}} = \frac{35934}{74664} = 0.4813$$

The number of passenger vehicle miles on all rural primary Indiana highways was then estimated by multiplying the appropriate factors by the 1972 FHWA data:

$$(15,572) \times (0.7363) \times (0.5147) = 5901.4 \text{ mpvm on}$$

all rural primary Indiana highways in the
first half of 1973.

$$(15,572) \times (0.7363) \times (0.4813) = 5518.4 \text{ mpvm on}$$

all rural primary Indiana highways in the
first half of 1974.

The average observed speeds on all rural primary Indiana highways as reported in this study (65.2 mph in 1973 and 57.8 mph in 1974) provided a rate of gasoline consumption when correlated with Claffey's data in Table 24. The number of vehicle miles driven divided by rate of consumption gave the relative net volumes of gasoline used. The amount of gasoline estimated as used by passenger cars on all rural state primary highways was:

$$\frac{5,901.4 \text{ mpvm}}{16 \text{ mpg}} = 368,837,000 \text{ gallons in the first half of 1973}$$

$$\frac{5518.4 \text{ mpvm}}{17.6 \text{ mpg}} = 313,545,450 \text{ gallons in the first half of 1974.}$$

A savings of 55,291,550 gallons of gasoline was realized in 1974 over 1973 in passenger car travel on all Indiana primary highways.

A further estimate of the amount of gasoline saved in the first half of 1974 over the first half of 1973 on interstate highways in Indiana by passenger cars was made in the same manner. To estimate the number of passenger vehicle miles on rural Indiana interstates, the 1972 FHWA data was multiplied by the two appropriate factors.

$$(4458) \times (0.7363) \times (0.5147) = 1689.5 \text{ mpvm on interstates in the first half of 1973.}$$

$$(4458) \times (0.7363) \times (0.4813) = 1579.8 \text{ mpvm on interstates in the first half of 1974.}$$

$$\frac{1689.5 \text{ mpvm}}{15 \text{ mpg}} = 112,633,330 \text{ gallons in the first half of 1973}$$

$$\frac{1579.8 \text{ mpvm}}{17.5 \text{ mpg}} = 90,274,285 \text{ gallons in the first half of 1974.}$$

This gave a savings of 22,359,050 gallons.

Summary

Lower speeds and reduced travel accounted for a savings of about 55 million gallons of gasoline on Indiana rural primary highways in the first half of 1974 over the

first half of 1973 for passenger car travel. It was not possible to obtain satisfactory data to estimate similar fuel savings by trucks. Of the savings, approximately 22 million gallons were saved on rural Indiana interstates.

It has been estimated that three billion gallons of gasoline are being saved annually by the lower speed limits in the U.S. (2). But reduced speed must share the credit for gasoline savings with reduced travel. For example, the savings of 55 million gallons estimated above for Indiana by passenger cars was due to a reduction of travel (1974 from 1973) of 383 mpvm and an average improvement of 1.6 mpg. Of the 55 million gallon reduction, about 22 million were due to reduced travel, or 40 percent.

CONCLUSIONS

This study has evaluated changes in speeds, traffic volumes, accident rates and gasoline consumption on Indiana rural primary highways for the first six months of 1971, 1972 and 1973 and 1974. On the basis of the results obtained, the following conclusions are made:

1. Average passenger vehicle speeds in free-flowing traffic have decreased approximately 11 mph on rural interstate highways, 6 mph on other rural four-lane highways, and 5 mph on rural two-lane highways in 1974 from 1973.
2. The 85th percentile speeds for passenger vehicles in free-flowing traffic have decreased approximately 12 mph on rural interstate highways, 8 mph on other rural four-lane highways, and 7 mph on rural two-lane highways in 1974 from 1973.
3. In 1974 the percentage of passenger vehicles that exceeded the posted speed limit on rural highways exceeded the 1973 percentages by about 30% on interstate highways, 22% on other four-lane highways, and 25% on two-lane highways.
4. In 1974 the percentage of passenger vehicles that exceeded the posted speed limit by more than 5 mph on rural highways exceeded the 1973 percentages by about 17% on interstates, 10% on other four-lane highways, and 12% on two-lane highways.
5. In 1974 the percentages of passenger vehicles that exceeded 65 mph on rural highways dropped by about 71% on interstates, 34% on other four-lane highways, and 26% on two-lane highways.

6. Average heavy truck (over 5000 pounds) speeds in free-flowing traffic decreased approximately 5 mph on rural interstates, 3 mph on other rural four-lane highways, and 2 mph on rural two-lane highways in 1974 from 1973.
7. The 85th percentile speeds for heavy trucks in free-flowing traffic decreased around 7 mph on rural interstates, 5 mph on other rural four-lane highways and 3 mph on rural two-lane highways.
8. In 1974 the percentages of heavy trucks that exceeded the posted speed limit on rural highways exceeded the 1973 percentages by about 60% on interstates, 33% on other four-lane highways, and 40% on two-lane highways.
9. The percentages of heavy trucks that exceeded the posted speed limit on rural highways by more than 5 mph in 1974 exceeded the percentages in 1973 by approximately 12% on interstates, 10% on other four-lane highways, and 11% on two-lane highways.
10. In 1974 the percentages of heavy trucks that exceeded 65 mph on rural highways dropped from the 1973 percentages by about 28% on interstates, 14% on other four-lane highways, and 6% on two-lane highways.
11. Average daily volumes of traffic fell in the first half of 1974 by about 13% from a projected average daily volume of 6900 vehicles per day to an observed 5990 vehicles per day.
12. Fatality accident rates on rural primary highways decreased in the first half of 1974 from the same period of 1971, 1972 and 1973 by about 67%, personal injury by around 32% and property damage by approximately 13%.

13. Statistical evaluation of the decline in accident rates was significant for each type of accident on each type of facility investigated except for fatality accidents on interstate highways and for property accidents on all facilities. Inadequate data, however, was available to test adequately interstate fatality rates.
14. The decrease in accident rates occurred under conditions of decreased speeds of travel, more uniform speeds of travel and decreased amounts of travel. It was not possible to evaluate the contribution each of these factors made toward the decrease in accident rates.
15. A savings of approximately 22 million gallons of gasoline was realized by the changes in average speed and volumes on rural Indiana interstates in the first half of 1974 over the first half of 1973.
16. A savings of about 55 million gallons of gasoline was realized from the reduction in speed and volumes on all rural Indiana primary highways in the first half of 1974 over the first half of 1973. Approximately 40 percent of the savings resulted from reduced travel.

RECOMMENDATIONS FOR FURTHER RESEARCH

Through the course of this research study, additional areas were identified that could require further study to more fully understand the effect of the 55 mph speed limit. These are:

1. The change in accident rates of automobiles only, trucks only, and automobiles-trucks would be of interest. The question remains as to which type of accident was most affected by the speed and volume reductions.
2. Studies to determine if increased police enforcement, increased public education or other means would best reduce the disproportionate number of people exceeding the posted speed limit would be of considerable value.
3. A study of the effect on speeds, volumes, accidents and fuel consumption of different maximum speed limits on different types of facilities would be useful. The effect of higher speeds on controlled access facilities (interstates) and possibly lower limits on some classes of 2-lane facilities is of considerable current interest.

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APPENDIX

ANOVA OF VEHICLE SPEEDS AND ACCIDENT RATES

RURAL PASSENGER VEHICLE SPEEDS

ANOVA of Interstate Highway Sample Stations

<u>Source</u>	<u>SS</u>	<u>D of F</u>	<u>M.S.</u>	<u>f</u>
Agg. (1,2,3 vs 4)	327.6 (324.9)	3 (1)	109.2 (324.9)	287.4 (855)
Error	<u>4.6</u>	<u>12</u>	0.38	
Total	322.2	15		

Table $f_{.95(1,12)}=4.75$; therefore f for w is significant and $H_0:\mu_1+\mu_2+\mu_3=3\mu_4$ is rejected.

ANOVA of Other Four-Lane Highway Sample Stations

<u>Source</u>	<u>SS</u>	<u>D of F</u>	<u>M.S.</u>	<u>f</u>
Agg. (1,2,3 vs 4)	120.3 (119.3)	3 (1)	40.1 (119.3)	10.0 (29.8)
Error	<u>48.</u>	<u>12</u>	4.0	
Total	168.3	15		

Table $f_{.95(1,12)}=4.75$; therefore f for w is significant and $H_0:\mu_1+\mu_2+\mu_3=3\mu_4$ is rejected.

ANOVA of Two-Lane Highway Sample Stations

<u>Source</u>	<u>SS</u>	<u>D of F</u>	<u>M.S.</u>	<u>f</u>
Agg. (1,2,3 vs 4)	77.8 (75.95)	3 (1)	25.9 (75.95)	9.36 (27.5)
Error	<u>33.2</u>	<u>12</u>	2.77	
Total	111.0	15		

Table $f_{.95(1,12)}=4.75$; therefore f for w is significant and $H_0:\mu_1+\mu_2+\mu_3=3\mu_4$ is rejected.

ANOVA of All Highway Sample Stations

<u>Source</u>	<u>SS</u>	<u>D of F</u>	<u>M.S.</u>	<u>f</u>
Agg. (1,2,3 vs 4)	474.2 (472.8)	3 (1)	158.1 (472.8)	16.2 (48.3)
Error	<u>430.2</u>	<u>44</u>	9.78	
Total	930.2	47		

Table $f_{.95(1,44)}=4.04$; therefore f for w is significant and $H_0:\mu_1+\mu_2+\mu_3=3\mu_4$ is rejected.

RURAL HEAVY TRUCK SPEEDS

ANOVA of Interstate Highway Sample Stations

<u>Source</u>	<u>SS</u>	<u>D of F</u>	<u>M.S.</u>	<u>f</u>
Agg. (1,2,3 vs 4)	56.5 (47.4)	3 (1)	18.83 (47.4)	20.17 (50.78)
Error	<u>11.2</u>	<u>12</u>	.933	
Total	67.7	15		

Table $f_{.95(1,12)}=4.75$; therefore f for ω is significant and
 $H_0:\mu_1+\mu_2+\mu_3=3\mu_4$ is rejected.

ANOVA of Other Four-Lane Highway Sample Stations

<u>Source</u>	<u>SS</u>	<u>D of F</u>	<u>M.S.</u>	<u>f</u>
Agg. (1,2,3 vs 4)	43.3 (13.7)	3 (1)	14.43 (13.7)	5.6 (5.4)
Error	<u>30.8</u>	<u>12</u>	2.566	
Total	74.1	15		

Table $f_{.95(1,12)}=4.75$; therefore f for ω is significant and
 $H_0:\mu_1+\mu_2+\mu_3=3\mu_4$ is rejected.

ANOVA of Two-Lane Highway Sample Stations

<u>Source</u>	<u>SS</u>	<u>D of F</u>	<u>M.S.</u>	<u>f</u>
Agg. (1,2,3 vs 4)	14.8 (14)	3 (1)	4.93 (1.4)	1.89 (0.54)
Error	<u>31.3</u>	<u>12</u>		
Total	46.1	15		

Table $f_{.95(1,12)}=4.75$; therefore f for ω is not significant and
 $H_0:\mu_1+\mu_2+\mu_3=3\mu_4$ is not rejected.

ANOVA of All Highway Sample Stations

<u>Source</u>	<u>SS</u>	<u>D of F</u>	<u>M.S.</u>	<u>f</u>
Agg. (1,2,3 vs 4)	74.9 (46.14)	3 (1)	24.97 (46.14)	3.59 (6.64)
Error	<u>306.0</u>	<u>44</u>	6.95	
Total	380.9	47		

Table $f_{.95(1,44)}=4.04$; therefore f for ω is significant and
 $H_0:\mu_1+\mu_2+\mu_3=3\mu_4$ is rejected.

RURAL INTERSTATE HIGHWAY SAMPLE SECTIONS

ANOVA of Property Accident Rates

<u>Source</u>	<u>SS</u>	<u>D of F</u>	<u>M.S.</u>	<u>f</u>
Agg.	1685.6	3	561.8	1.10
(1,2,3 vs 4)	(837.1)	(1)	(837.1)	(1.64)
Error	<u>46828.1</u>	<u>92</u>	509.0	
Total	49513.7	95		

Table $f_{.95(1,12)} = 3.96$; therefore f for w is not significant
and $H_0: \mu_1 + \mu_2 + \mu_3 = 3\mu_4$ is not rejected.

ANOVA of Injury Accident Rates

<u>Source</u>	<u>SS</u>	<u>D of F</u>	<u>M.S.</u>	<u>f</u>
Agg.	1185.3	3	395.1	3.57
(1,2,3 vs 4)	(655.2)	(1)	(655.2)	(5.91)
Error	<u>10190.2</u>	<u>92</u>	110.8	
Total	11375.5	95		

Table $f_{.95(1,92)} = 3.96$; therefore f for w is significant and
 $H_0: \mu_1 + \mu_2 + \mu_3 = 3\mu_4$ is rejected.

ANOVA of Fatal Accident Rates

<u>Source</u>	<u>SS</u>	<u>D of F</u>	<u>M.S.</u>	<u>f</u>
Agg.	18.7	3	6.2	2.1
(1,2,3 vs 4)	(6.8)	(1)	(6.8)	(2.3)
Error	<u>270.4</u>	<u>92</u>	2.9	
Total	289.1	95		

Table $f_{.95(1,92)} = 3.96$; therefore f for w is not significant
and $H_0: \mu_1 + \mu_2 + \mu_3 = 3\mu_4$ is not rejected.

ANOVA of All Accident Rates

<u>Source</u>	<u>SS</u>	<u>D of F</u>	<u>M.S.</u>	<u>f</u>
Agg.	3498.2	3	1166.1	1.4
(1,2,3 vs 4)	(3265.0)	(1)	(3265.0)	(11.9)
Error	<u>77582.4</u>	<u>284</u>	2732	
Total	81080.6	287		

Table $f_{.95(1,284)} = 3.84$; therefore f for w is significant and
 $H_0: \mu_1 + \mu_2 + \mu_3 = 3\mu_4$ is rejected.

OTHER RURAL FOUR-LANE HIGHWAY SAMPLE SECTIONS

ANOVA of Property Accident Rates

<u>Source</u>	<u>SS</u>	<u>D of F</u>	<u>M.S.</u>	<u>f</u>
Agg. (1,2,3 vs 4)	5518.9 (2798.4)	3 (1)	1839.6 (2798.4)	0.61 (0.92)
Error	<u>302791.7</u>	<u>100</u>	3027.9	
Total	308310.6	103		

Table $f_{.95(1,100)} = 3.94$; therefore f for ω is not significant and $H_0: \mu_1 + \mu_2 + \mu_3 = 3\mu_4$ is not rejected.

ANOVA of Injury Accident Rates

<u>Source</u>	<u>SS</u>	<u>D of F</u>	<u>M.S.</u>	<u>f</u>
Agg. (1,2,3 vs 4)	10363.7 (5766.6)	3 (1)	3454.6 (5766.6)	4.6 (7.7)
Error	<u>74539.9</u>	<u>100</u>	745.6	
Total	84903.6	103		

Table $f_{.95(1,100)} = 3.94$; therefore f for ω is significant and $H_0: \mu_1 + \mu_2 + \mu_3 = 3\mu_4$ is rejected.

ANOVA of Fatal Accident Rates

<u>Source</u>	<u>SS</u>	<u>D of F</u>	<u>M.S.</u>	<u>f</u>
Agg. (1,2,3 vs 4)	55.4 (50)	3 (1)	18.5 (50.0)	1.7 (4.6)
Error	<u>1078.1</u>	<u>100</u>	10.8	
Total	1133.5	103		

Table $f_{.95(1,100)} = 3.94$; therefore f for ω is significant and $H_0: \mu_1 + \mu_2 + \mu_3 = 3\mu_4$ is rejected.

ANOVA of All Accident Rates

<u>Source</u>	<u>SS</u>	<u>D of F</u>	<u>M.S.</u>	<u>f</u>
Agg. (1,2,3 vs 4)	26746.7 (16649.8)	3 (1)	8915.6 (16649.8)	1.6 (8.9)
Error	<u>573084.3</u>	<u>308</u>	1860.7	
Total	599831.0	311		

Table $f_{.95(1,308)} = 3.84$; therefore f for ω is significant and $H_0: \mu_1 + \mu_2 + \mu_3 = 3\mu_4$ is rejected.

RURAL TWO-LANE HIGHWAY SAMPLE SECTIONS

ANOVA of Property Accident Rates

<u>Source</u>	<u>SS</u>	<u>D of F</u>	<u>M.S.</u>	<u>f</u>
Agg.	66878.5	3	22292.8	1.2
(1,2,3 vs 4)	(35806.1)	(1)	(35806.1)	(2.0)
Error	<u>5396801.4</u>	<u>296</u>	18232.4	
Total	5463679.9	299		

Table $f_{.95(1,296)} = 3.90$; therefore f for ω is not significant
and $H_0: \mu_1 + \mu_2 + \mu_3 = 3\mu_4$ is not rejected.

ANOVA of Injury Accident Rates

<u>Source</u>	<u>SS</u>	<u>D of F</u>	<u>M.S.</u>	<u>f</u>
Agg.	142624.0	3	47541.3	8.4
(1,2,3 vs 4)	55095.8	(1)	(55095.8)	(9.7)
Error	<u>1679281.8</u>	<u>296</u>	5673.3	
Total	1821905.8	299		

Table $f_{.95(1,296)} = 3.90$; therefore f for ω is significant and
 $H_0: \mu_1 + \mu_2 + \mu_3 = 3\mu_4$ is rejected.

ANOVA of Fatal Accident Rates

<u>Source</u>	<u>SS</u>	<u>D of F</u>	<u>M.S.</u>	<u>f</u>
Agg.	1609.5	3	536.5	2.2
(1,2,3 vs 4)	(1298.6)	(1)	(1298.6)	(5.3)
Error	<u>73538.3</u>	<u>296</u>	248.4	
Total	75147.8	299		

Table $f_{.95(1,296)} = 3.90$; therefore f for ω is significant and
 $H_0: \mu_1 + \mu_2 + \mu_3 = 3\mu_4$ is rejected.

ANOVA of All Accident Rates

<u>Source</u>	<u>SS</u>	<u>D of F</u>	<u>M.S.</u>	<u>f</u>
Agg.	197140.3	3	65713.4	1.7
(1,2,3 vs 4)	(67849.8)	(1)	(67849.8)	(5.4)
Error	<u>11304717.0</u>	<u>896</u>	12616.9	
Total	11501857.3	899		

Table $f_{.95(1,896)} = 3.90$; therefore f for ω is significant and
 $H_0: \mu_1 + \mu_2 + \mu_3 = 3\mu_4$ is rejected.

ALL RURAL INDIANA HIGHWAY SAMPLE SECTIONS

ANOVA of Property Accident Rates

<u>Source</u>	<u>SS</u>	<u>D of F</u>	<u>M.S.</u>	<u>f</u>
Agg.	61318.3	3	20439.4	1.4
(1,2,3 vs 4)	(33625.6)	(1)	(33625.6)	(2.3)
Error	<u>7264792.5</u>	<u>496</u>	14646.8	
Total	7326110.8	499		

Table $f_{.95(1,496)} = 3.84$; therefore f for w is not significant and $H_0: \mu_1 + \mu_2 + \mu_3 = 3\mu_4$ is not rejected.

ANOVA of Injury Accident Rates

<u>Source</u>	<u>SS</u>	<u>D of F</u>	<u>M.S.</u>	<u>f</u>
Agg.	123440.3	3	41146.8	9.3
(1,2,3 vs 4)	(51833.4)	(1)	(51833.4)	(11.7)
Error	<u>2190395.6</u>	<u>496</u>	4416.1	
Total	2313835.9	499		

Table $f_{.95(1,496)} = 3.84$; therefore f for w is significant and $H_0: \mu_1 + \mu_2 + \mu_3 = 3\mu_4$ is rejected.

ANOVA of Fatal Accident Rates

<u>Source</u>	<u>SS</u>	<u>D of F</u>	<u>M.S.</u>	<u>f</u>
Agg.	1235.8	3	411.9	2.6
(1,2,3 vs 4)	(1041.8)	(1)	(1041.8)	(6.6)
Error	<u>77782.4</u>	<u>496</u>	156.8	
Total	79018.2	499		

Table $f_{.95(1,496)} = 3.84$; therefore f for w is significant and $H_0: \mu_1 + \mu_2 + \mu_3 = 3\mu_4$ is rejected.

ANOVA of All Accident Rates

<u>Source</u>	<u>SS</u>	<u>D of F</u>	<u>M.S.</u>	<u>f</u>
Agg.	281689.3	3	93896.4	3.6
(1,2,3 vs 4)	(173070.8)	(1)	(173070.8)	(20.1)
Error	<u>12890099.5</u>	<u>1496</u>	8616.4	
Total	13171788.8	1499		

Table $f_{.95(1,1496)} = 3.84$; therefore f for w is significant and $H_0: \mu_1 + \mu_2 + \mu_3 = 3\mu_4$ is rejected.

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