COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
FRANKFORT, KENTUCKY 40601

Eugene Goss
COMMISSIONER OF HIGHWAYS

H-3-9
ADDRESS REPLY TO

March 11, 1970

MEMORANDUM TO: A. O. Neiser, State Highway Engineer
Chairman, Research Committee

SUBJECT: Research Report; "Median Design and Accident Histories;" HPR-1(5), Part III-A, KYP-69-9

Perhaps there are many design features in roadways which reflect engineering practices and judgments and which do not need to be substantiated by research or documentary references. On the other hand, good codes or practices should withstand inquiry and evaluation. The extent to which safety considerations may outweigh cost considerations is seemingly a controversial issue. The report we are submitting here concerns a rather singular but consequential aspect of median designs. Apparently heretofore, although it is reasonably known or intuitively presumed that wider, flatter medians -- as well as side slopes -- were "safer", others have been unable to show definite or specific substantiation by accident histories. The toll-road system together with interstate roads in Kentucky provided a unique opportunity to isolate interferring variables which had confounded others. The study appears to have been successful in most respects, and the report is submitted for information and guidance.

Respectfully submitted,

Jas. H. Havens
Director of Research

Attachment

cc's:
Research Committee
Assistant State Highway Engineer, Research and Development
Assistant State Highway Egnineer, Planning and Programming
Assistant State Highway Engineer, Pre-Construction
Assistant State Highway Engineer, Construction
Assistant State Highway Engineer, Operations
Assistant State Highway Engineer, Staff Services
Assistant Pre-Construction Engineer
Assistant Operations Engineer
Executive Director, Office of Computer Services
Executive Director, Office of Equipment and Properties

Director, Division of Bridges
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JHH/cel

Research Report

MEDIAN DESIGN AND ACCIDENT HISTORIES

KYP-9

by
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Research Engineer Associate

Division of Research
DEPARTMENT OF HIGHWAYS
Commonwealth of Kentucky

April 1970

DEFINITIONS

MEDIAN - The portion of a divided highway separating the traveled ways for traffic in opposing directions.

ACCIDENT RATE - The number of accidents per 100 million vehicle miles of travel.

SEVERITY RATE - The number of accidents per 100 million vehicle miles of travel in which a person was killed or severely injured.

TOTAL ACCIDENT RATE - The accident rate based on all the accidents which occurred on a given road section, excluding accidents at toll booths.

TOTAL ACCIDENT SEVERITY RATE - The accident severity rate based on all the accidents which occurred on a given road section.

MEDIAN ACCIDENT RATE AND MEDIAN ACCIDENT SEVERITY RATE - The accident rate and severity rate based on all the accidents which occurred on a given road section in which a vehicle encroached upon the median, i.e. the rate based on median-involved accidents. This rate excludes accidents which occurred at median crossovers and which involved bridge piers and bridge ends.

INTRODUCTION

Highway design is a dynamic process. Design standards are continually being revised and modernized. Generally, these changes result in a better design. Consequently, the new highways of today are safer, longer lasting, and more efficient than ever before. However, engineers are faced with the problems of coping with the ever increasing volumes of automobiles on the highway systems. Traffic deaths are increasing *(1)*. As volumes and the number of accidents increase, many design features once considered adequate have proven to be inadequate. Changes are constantly being made to provide safer highways.

The divided roadway was first conceived as a safety measure. Head-on accidents have always been sensational for the destructive effects in property and lives which they incur. It was hypothesized that roadways separated by a median of some sort would reduce this type of peril. The different types of medians which have been used is large indeed. Medians can be found which are raised, depressed, traversible, non-traversible, earth, concrete, with and without barriers, with and without plants, and so on. Median widths very from 2 feet to more than 100 feet.

As more and more median types were built and accident records became available, studies were conducted in an attempt to determine the best types. By and large, these studies were inconclusive. In studies by Hurd *(2)*, Telford and Israel *(3)*, Crosby *(4)*, and Billion *(5)*, no definite relationship between accident rates and widths of various types of medians was found. Although the overall superiority of wider medians could not be shown, it was apparent that cross-the-median, head-on collisions were reduced by increasing the width *(2,4)*. Largely for this reason, the use of wider medians became commonplace.

In the early 1960's, studies by Hutchinson *(6)*, Stonex *(7)*, and others provided new insights. Hutchinson, in a comprehensive study of encroachments on several medians, found that steep (4:1) slopes cause driver overreaction and vehicle control problems. He concluded that an absolute minimum median width of 30 feet is required under ideal conditions of mild slopes and no median obstacles. Evidence indicated that any irregularities in the median due to crossovers, drainage structures, bridge piers, and other appurtenances could destroy the effectiveness of the median. Stonex concluded that slopes of 6:1 are the minimum required for off-the-road safety. His results were based on tests conducted at the General Motors proving ground.

From this body of information, it was generally accepted that wide, gently sloping medians are superior. The current interstate standard, 60-foot wide median with 6:1 slopes is an example of this type.

This median is illustrated in Figure 1. However, many roads are still being built with lesser width medians. Although widths may exceed the minimum urged by Hutchinson, the mild cross slope requirements have not been met. Lacking from earlier information was conclusive accident data supporting the width and cross slope requirements. This study, therefore, concerns the development of analytical relationships between median accidents and median types or styles.

Figure 1. Interstate Median with 6:1 Slopes

OBJECTIVES AND SCOPE OF STUDY

The purpose of this study was to provide information concerning the accident histories of various median types to verify minimum requirements for width and cross section. Previous accident studies failed to disclose significant relationships between median width and accident rates. Those studies did not recognize or control several important variables that were controlled in the present study. The efforts here are to compare median types on rural, four-lane, fully controlled access facilities with similar geometrics other than median types. An attempt was made to account for some of the variability in the accident data. Thus, this study gives information on the operational performances of several medians and offers persuading analyses with respect to the design or styling of medians.

PROCEDURE

A thorough analysis of previous studies of median accidents yielded four areas where the variability introduced by differences in study road sections could be improved -- thereby increasing the significance of the results These include:

1. Length of road section,
2. Control of access,
3. Other roadway geometrics, and
4. Patrolling agencies (accident reporting level).

It was felt that the influence of these factors, when not duly considered, could cause such a high variance in the accident rates that meaningful conclusions may not be reached.

Generally, previous median accident studies *(2,3,4,5)* selected a data base involving very short study sections. The individual road sections were less than five miles, and frequently less than one mile in length. The use of such short road sections was adopted in an effort to obtain larger sample sizes. However, the results obtained from such a data base are subject to suspicion due to the sensitivity of accident rates to a single accident occurrence and the inability to get reasonably accurate volume information for such small sections. Different peripheral and environmental factors are more likely to be affecting the occurrence of accidents on such short segments. Hopefully, the only variable between locations would be median type, but this is not the case. Thus, local roadway environmental factors are going to have a greater effect on short sections.

Since only a few accidents could be expected to occur in a one-mile section of road in a year, the accident rate would be extremely sensitive to one or two accidents. Thus, if one accident more or less than "average' occurred, the accident rate would reflect a false picture of that section. Unless the time period of the study is so great or the sample size so large that the accident rates can average out into a true picture, the results from studies using sections one to five miles in length must be used with extreme caution.

Some of the previous studies included sections of roads which did not have complete control of access. Although the secuons were reputed to have resembled access controlled facilities, there are operating characteristics such as differences in speed limit, which might disallow comparisons between the two types. The larger sample size allowed by this type of selection may not be worth the consequential variability introduced into the results.

The effects of other roadway geometric features must not be ignored when comparing the accident rates of different road sections. Such things as pavement width, shoulder width, grades, curves, coefficient of friction, sign location, and other design standards could have a greater effect than the variables under study, i.e. median type and width. The geometric features of all road sections in the study should be as similar as possible.

As previous research has shown *(8)*, great care must be exercised when using accident records for evaluation purposes. When different agencies are involved in patrolling a given road, variations in reporting practices, training of police personnel, and amount of surveilance can produce incomplete and inconsistent accident records. Inadequacies found in individual reports involve inaccurate locations, poor sketches, and the like. There can be frequent variations in the number, type, and percentage of accidents reported. The natural variability of accident records can, therefore, make any results obtained from accident studies extremely unreliable, especially in determining the causality of any particular accident.

Experience with accident records provided by the Kentucky State Police indicated a high quality and consistency in reporting methods, especially when compared to other agencies in the state. It was, therefore, decided to select road sections patrolled exclusively by the Kentucky State Police. This would allow a certain degree of uniformity in reporting methods not present in previous studies. Most of the four-lane controlled access roads in Kentucky, with the exception of those roads in Fayette, Jefferson, and Kenton Counties, are patrolled exclusively by the Kentucky State Police. Thus, roads in these counties were excluded from the study.

In summary, it is desirable that study sections in an accident study be:

1. as long as possible,
2. have a similar degree of access control,
3. have similar roadway geometric features, and
4. be patrolled exclusively by one agency.

The toll road and interstate system in Kentucky made it possible to select long road sections with these characteristics. More importantly, a variety of median types could be studied. The road sections selected are shown in Table 1. The similarity in geometric features other than the median should be noted. Figures 2, 3, and 4 illustrate the details of the medians in the study.

A four-year period of analysis was chosen as the maximum necessary for establishment of trends or reasonably stable averages. Four years of accident data were secured for those roads opened in 1965 or earlier. Only three years data were obtained for the Bluegrass Parkway and I 65 in Simpson County, both of which opened in 1966. Two years data were used for the section of I 75. Accident reports for 1965 and 1966 were copied from the original reports kept by the Division of Planning of the Kentucky Department of Highways. These original reports were obtained by Planning personnel from the Kentucky State Police. Copies of the reports for 1967 and 1968 were made from active State Police files.

All available traffic volume data for the study sections were obtained from the Traffic Section of the Division of Planning. Counts were available for two or three of the study years for the interstate roads. Complete monthly summaries for all toll roads were used. Missing volume data for the interstate road sections were extrapolated from the available data.

In order to produce results which would indicate a valid comparison between median types, a strict definition of what constituted a "median-involved accident" was needed. Some accidents involving the median were not representative of whether or not the median was effective as a cause or contributor to the accident. Specifically, there were two types of median-involved accidents that were not considered as "median" accidents. Accidents occurring at median crossovers, such as shown in Figure 5, were not considered because the accidents were, in a sense, "caused" by the crossover. Crossovers were considered as geometric features separate from the median. Therefore, accidents at median crossovers were separated and subjected to special analysis. These findings are published in a separate report *(9)*. There were also a few accidents which involved collisions with fixed objects in the median, specifically bridge piers and bridge ends. These collisions generally resulted in a fatal or severe injury accident and would, therefore, prejudice the results where otherwise the median may have performed satisfactorily. This type of accident was also not considered as a median accident. Generally, all other accidents involving the median were included.

Accident events per 100 million vehicle miles were used as a basis for comparison. Stewart *(10)* reported that the use of accident rates based upon vehicle miles assumes:

(a) all driving involves some exposure to accident hazards,

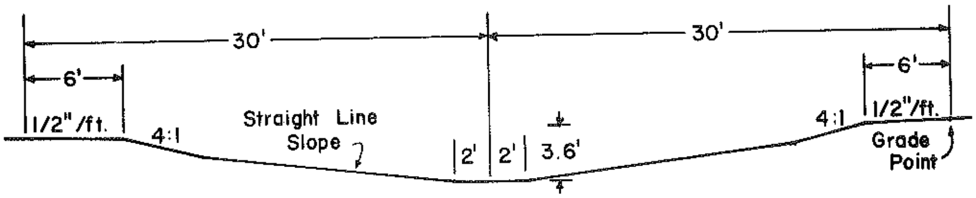
(b) the exposure to accident hazards is proportional to miles driven and

(c) the degree of exposure is the same for all drivers.

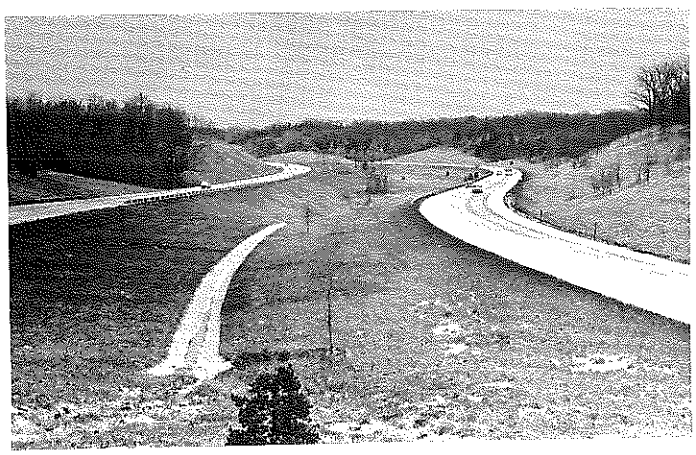
For the long, rural road sections in this study, these assumptions are generally valid, and accident rates were used for comparison purposes with some confidence.

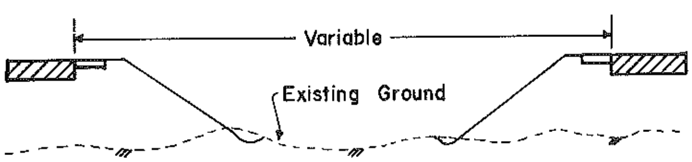
Road	Length (Miles)	Type of Median	Width of Median (Feet)	Access Control	Speed Limit (MPH)	Pavement Width (Feet)	Pavement Cross Slope (Inches/Foot)	Width of Outside Shoulders (Feet)
I 64, Clark County	35	Depressed	60	Full	70	24	3/16	12
I 64, Shelby County	12	Depressed	60	Full	70	24	3/16	12
I 64, Franklin County	17	Irregular	Varies	Full	70	24	3/16	12
I 65, Hardin County	27	Depressed	60	Full	70	24	3/16	12
I 65, Simpson County	26	Depressed	60	Full	70	24	3/16	12
I 75, Scott County	19	Irregular	Varies	Full	70	24	3/16	12
Kentucky Turnpike	39	Raised	20	Full	70	24	3/16	12
Western Kentucky Turnpike	127	Raised	30	Full	70	24	3/16	12
Mountain Parkway	43	Deeply Depressed	36	Full	70	24	3/16	12
Bluegrass Parkway	75	Deeply Depressed	36	Full	70	24	3/16	12

Table 1 - Study Road Sections



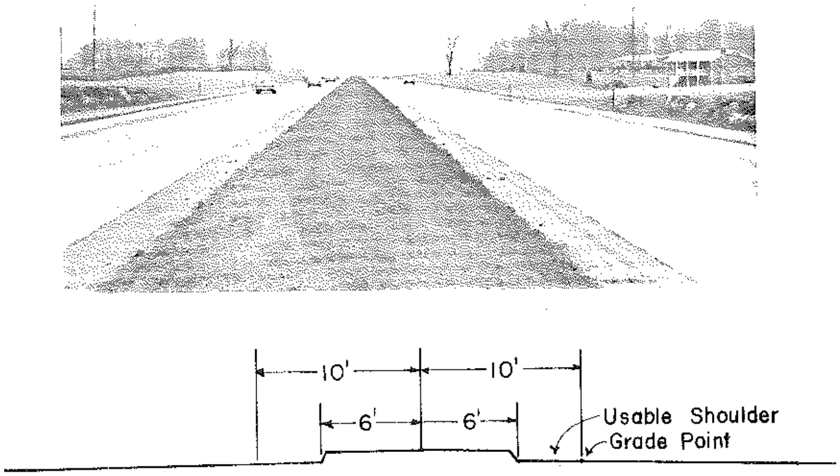
I-65



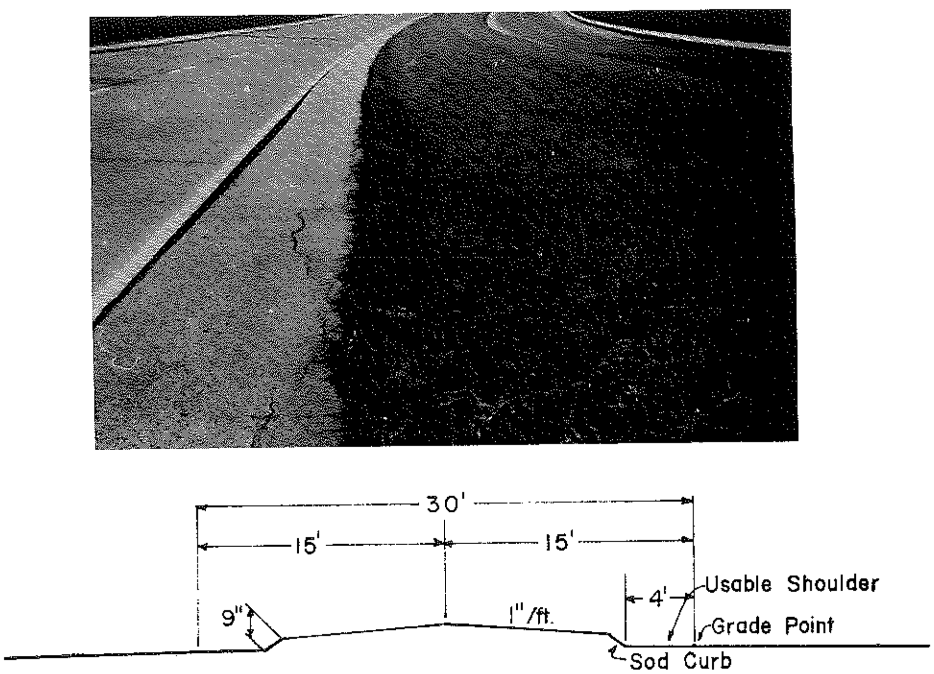


SEPARATE ROADWAYS; NATURAL GROUND MEDIAN

Figure 2. Interstate Medians

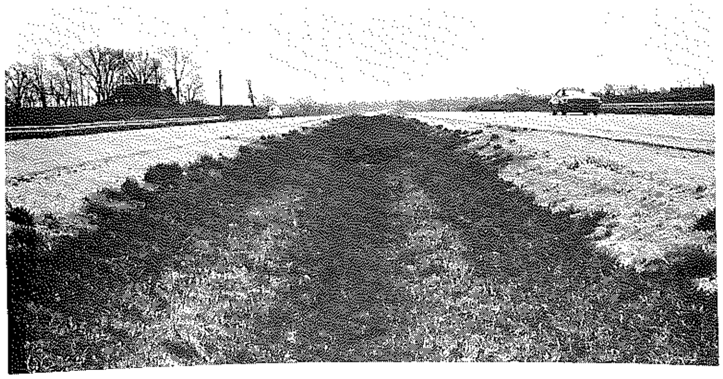


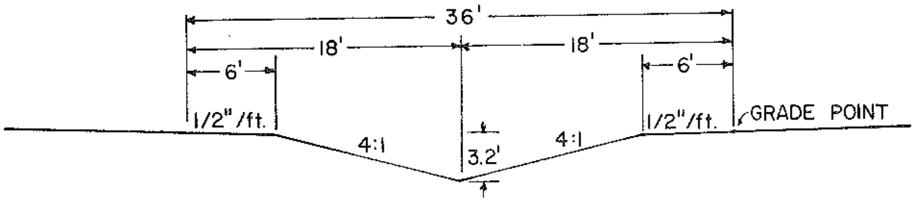
KENTUCKY TURNPIKE



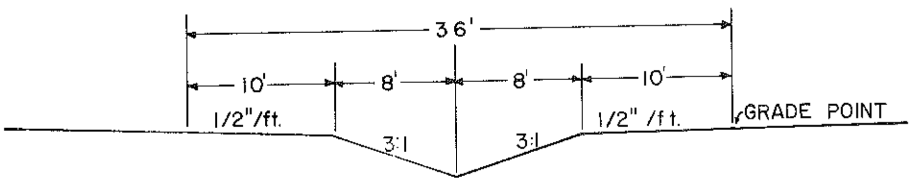
WESTERN KENTUCKY TURNPIKE

Figure 4. Raised Medians





BLUEGRASS PARKWAY



MOUNTAIN PARKWAY

Figure 3. Deeply Depressed Medians

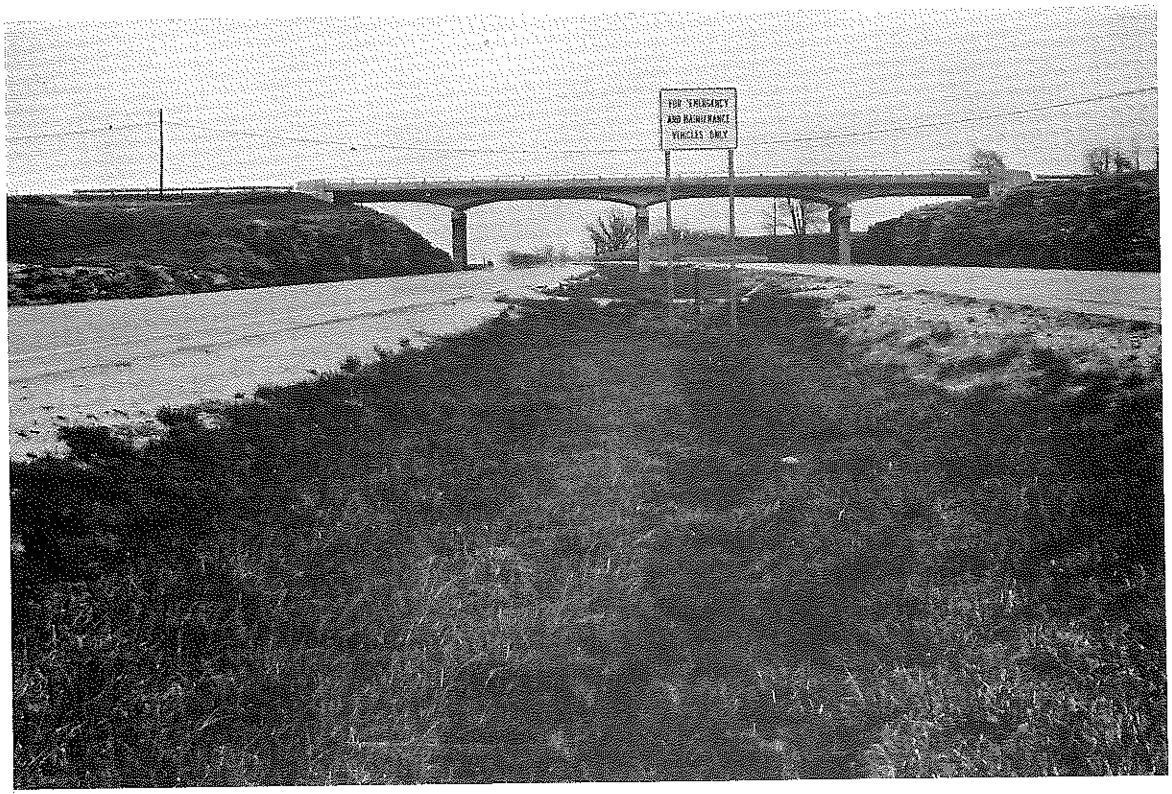


Figure 5. Median Crossover

RESULTS AND DISCUSSION

Any given accident is the result of a complex interaction between the roadway, driver, and vehicle. The contribution of any given factor to the causality of the accident will vary with the conditions. For example, the vehicle will be a primary "cause" in relatively few accidents, the driver in nearly all. Dart and Mann *(11)* suggest that the driver is a major cause in 80-90 percent of accidents, the highway in 40-50 percent, and the vehicle in 10 percent. There is widespread disagreement on the relative percentages of each factor. A concept suggested by Bellis *(12)* would support a much higher contribution by the roadway and off-road environment. Humans, being human, cannot be improved upon very much as drivers, Bellis maintains. Thus, accidents can only be prevented by removing the source of impact. In other words:

> *"An accident is a result of a driver's action combined with an impact-producing situation. If a driver runs off the road intentionally or unintentionally, and there are no physical objects within his path, there will be no accident."(12)*

The improved roadway and off-the-road environment provided by interstate highways constructed to safety standards and resulting low accident and severity rates *(13)* support this view. Thus, it would be logical to assume that the roadway contributes to as many as 75-80 percent of all accidents in rural situations.

However, knowing that the roadway geometrics cannot explain all the variability of accident rates, this study attempts to indicate the influence and importance of two geometric features, median width and cross section. The influence of other variables will be indicated where possible.

EFFECTS OF MEDIAN WIDTH

The results of this study do support the premise that wider medians are safer medians. Figure 6 is a plot of total accident rate versus width of median. There is a general decline in accident rate with increasing width of median. This relationship is statistically significant at the 95 percent level (see **APPENDIX C**). Total accident severity rate (Figure 7) also decreases with increasing width of median. A breaking point or "leveling off" seems to occur between 30 and 40 feet. As previously noted, all the roads in the study have

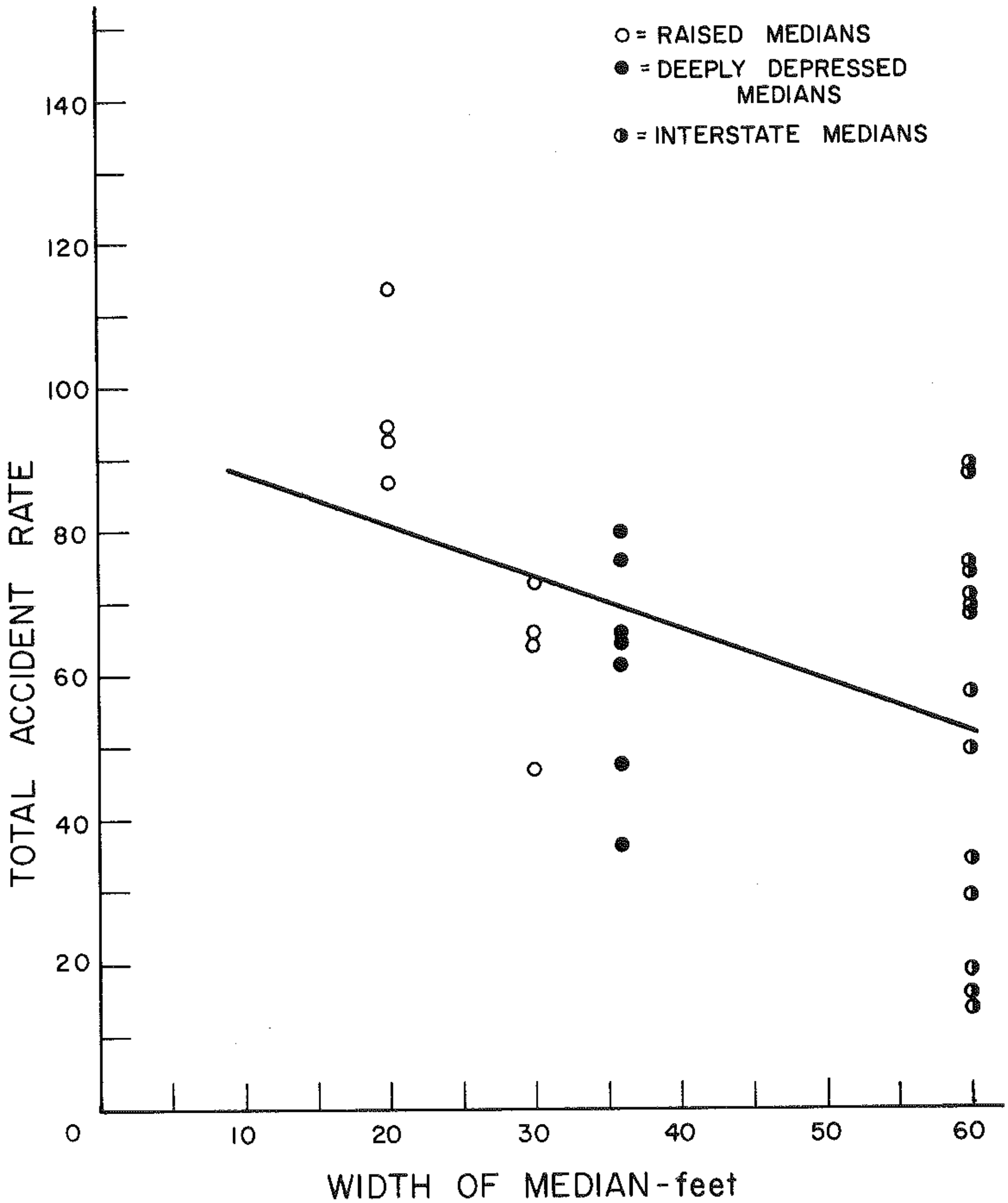


Figure 6. Total Accident Rate Versus Median Width

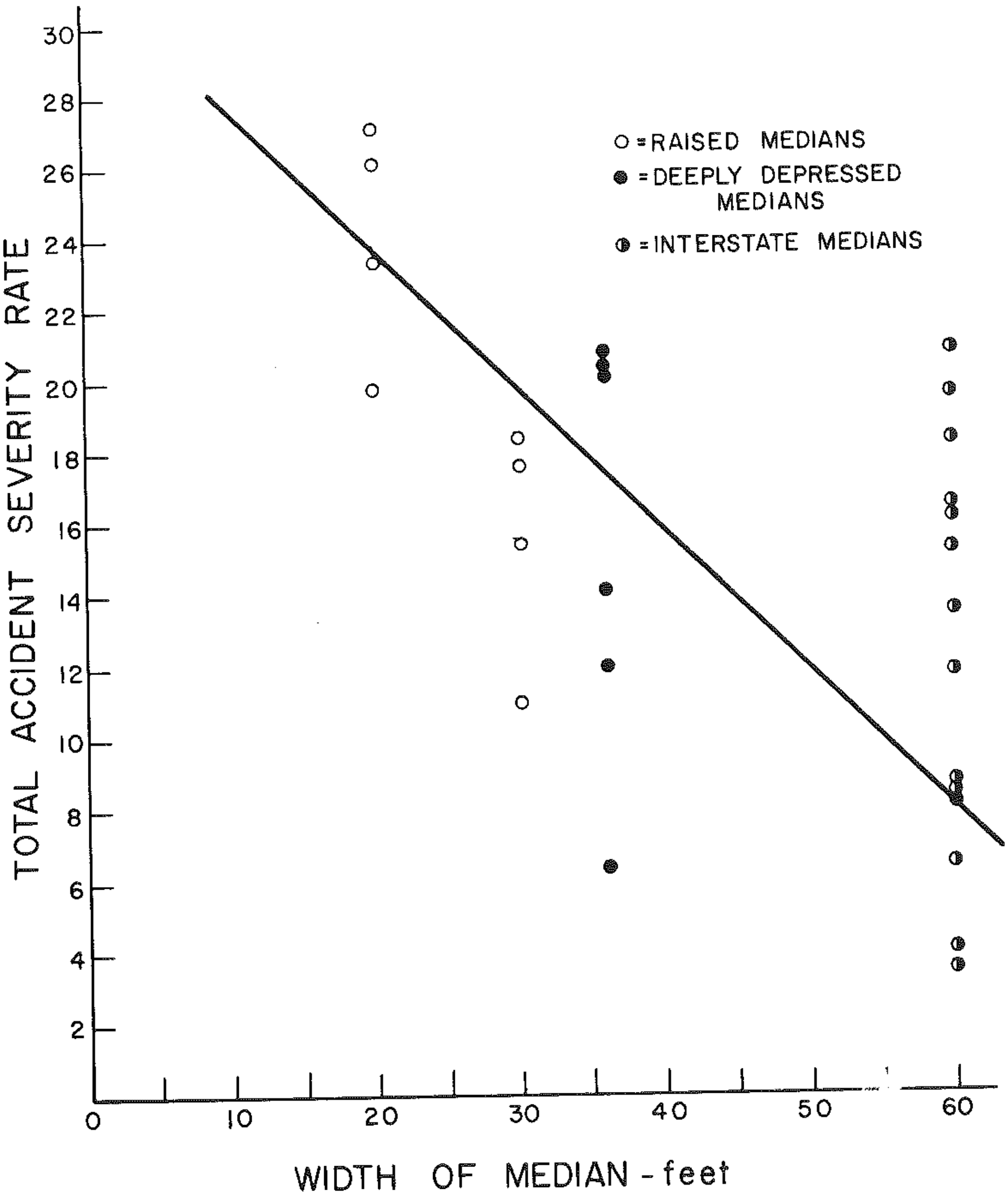


Figure 7. Total Accident Severity Rate Versus Median Width

similar geometrics except for width and type of median.

Another indicator of median effectiveness in providing a recovery area for out-of-control vehicles is shown in Figure 8. There is a statistically significant decrease in the percent of the total median accident involved vehicles which crossed the median as median width increases (see **APPENDIX C**). Wider medians provide a more adequate recovery area and a greatly reduced potential for head-on accidents. Hurd *(2)* found a similar relationship.

Hutchinson's study *(6)* of vehicle encroachments upon the median concluded that medians should be a minimum of 30 feet wide with gentle cross slopes and no obstacles. Hurd *(2)* concluded that a median should be at least 40 feet wide to reduce the possibility of head-on collisions. Webster and Yeatman *(19)* found that at least 33 feet of separation was needed to eliminate disability glare from high-beam headlights. The results obtained here support a minimum width of 40 feet; however, other elements of the median -- cross slopes and the presence of obstructions and irregularities -- can have a greater effect on safety of a median than width.

EFFECTS OF MEDIAN CROSS SECTION

The beneficial effects of wide medians can be completely negated by steep slopes. Figure 9 is a plot of median accident rate versus width of median. The adverse effects of steep 4:1 and 3:1 cross slopes of the 36-foot, deeply depressed median types are clearly indicated by the high median accident rate. The cross slopes of the 20-, 30-, and 60-foot medians are relatively mild when compared to the 36-foot medians. Medians with steep slopes do not provide reasonable recovery areas and are often a hazard in themselves. The higher median accident severity rate for these deeply depressed medians is shown in Figure 10.

The deeply depressed median results in a disproportionate number of vehicles which overturn. The rate of median accidents resulting in one or more vehicles overturning is much greater for the Bluegrass Parkway and Mountain Parkway as shown in Table 2. These roadways have the deeply depressed medians with 4:1 and 3:1 slopes. Figure 11 indicates that the severity of accidents for the depressed median types is related to whether or not the vehicle overturns.

Reported studies wherein mild cross slopes are recommended are many. Hutchinson *(6)* found that steep (4:1) slopes had an adverse effect on vehicle encroachments and estimated that a 40-foot depressed median with 10:1 slopes would allow more than 90% of all encroaching vehicles to recover safely. Stonex *(7)* recommended 6:1 slopes as being minimal from his GM Proving Ground tests. Figure 12 shows the percent grade change at the centerline for various slopes. 4:1 slopes involve a 50 percent grade change while

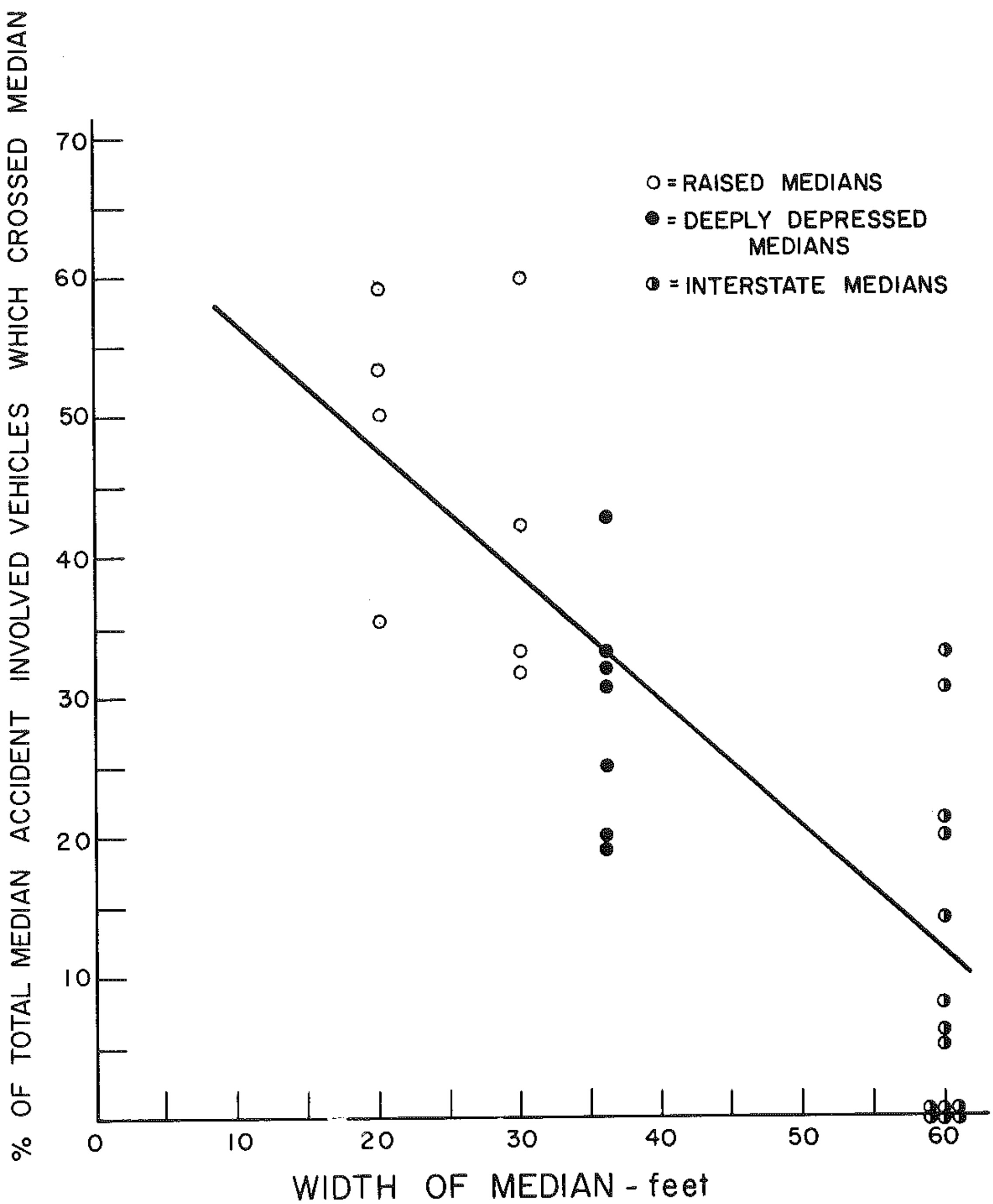


Figure 8. Percent of Total Median Accident Involved Vehicles Which Crossed the Median Versus Median Width

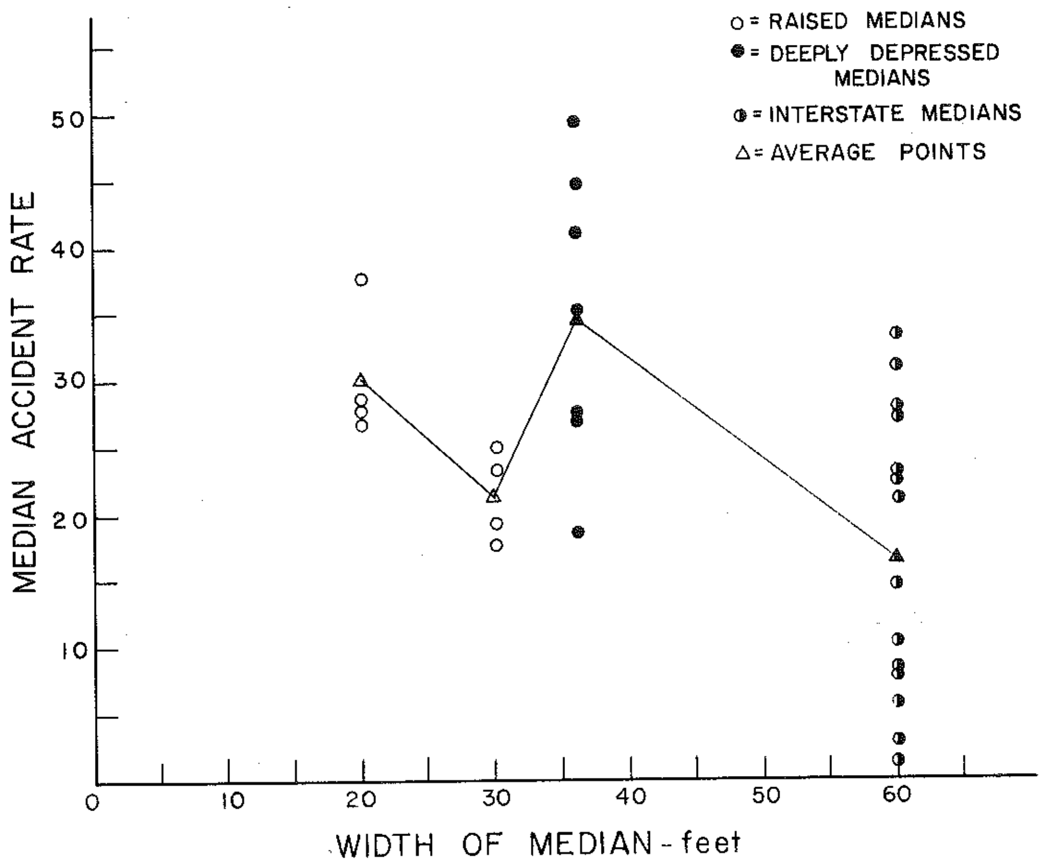


Figure 9. Median Accident Rate Versus Median Width

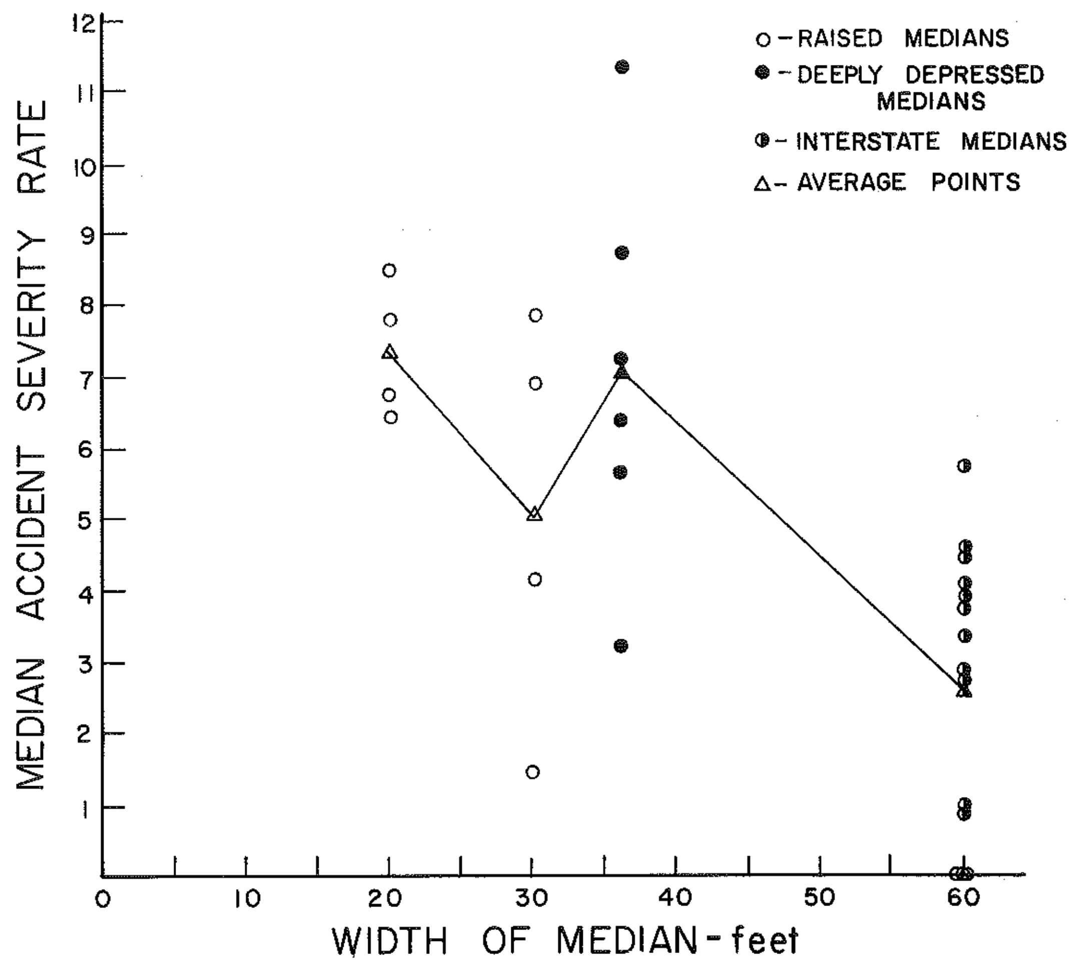


Figure 10. Median Accident Severity Rate Versus Median Width

Table 2. Median Accidents Involving Vehicles Which Overturn

Road Name	Type of Median	Percent	Rate
Kentucky Turnpike	20' Raised	10.7	2.88
Western Kentucky Turnpike	30' Raised	24.0	4.75
I 64 and I 65 (average)	60' Raised	20.1	2.42
Bluegrass Parkway	36' Depressed, 4:1 Slopes	34.7	10.31
Mountain Parkway	36' Depressed, 3:1 Slopes	46.0	16.47

the 6:1 slopes now used on interstate roads involve a 34 percent grade change. The curve begins to level off at 10:1 slopes. The results from this study strongly support the previous recommendations for mild cross slopes.

The raised medians in this study (20 and 30 feet in width) were found to have several disadvantages not entirely explained by narrower width. The raised medians seemed to have a higher number of cross-median accidents. Both the raised median types have a sod "curb" a few feet from the edge of the pavement. Many drivers were found to hit this curb and overreact, causing an accident. Table 3 shows the rate of hit-median, lost-control accidents by type of median. Raised medians also do not provide storage area for snow removal purposes. Moisture will "bleed" from raised medians onto the roadway for days. In cold weather, this allows hazardous ice spots to form.

Table 3. Median Accidents Involving Vehicles Which Hit The Median and Lost Control

Road Name	Type of Median	Left Shoulder Width	Percent	Rate
Mountain Parkway	36' Depressed	10'	4.8	1.70
Bluegrass Parkway	36' Depressed	6'	11.2	3.34
I 64 and I 65 (average)	60' Depressed	6'	16.5	1.99
Kentucky Turnpike	20' Raised	4'	19.2	5.16
Western Kentucky Parkway	30' Raised	4'	30.2	5.99

There are many sections of interstate where a separate, independent roadway is provided in each direction. These sections have a median of varying width and highly irregular nature. Figures 13 and 14 show that the sections of interstate with an irregular median have much higher median and total accident rates and severity rates. The treacherous off-the-road environment provided by these sections can account for the higher rates. The median shoulders are only six feet wide, thus placing the guardrail only six feet from the edge of pavement versus the 12 feet which is provided on the right side. Whereas the typical

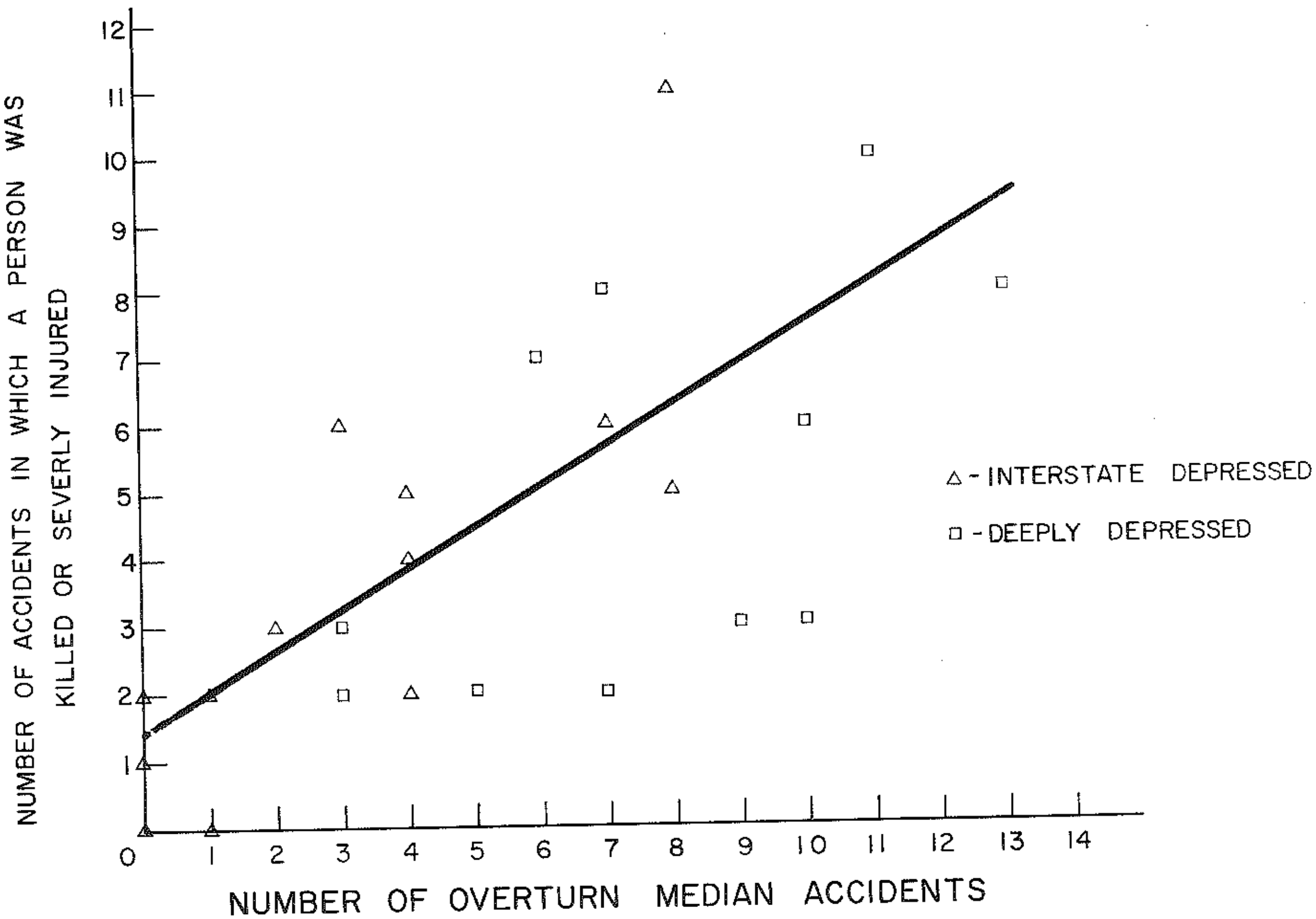


Figure 11. Number of Accidents in Which a Person Was Killed or Severely Injured Versus the Number of Overturn Accidents.

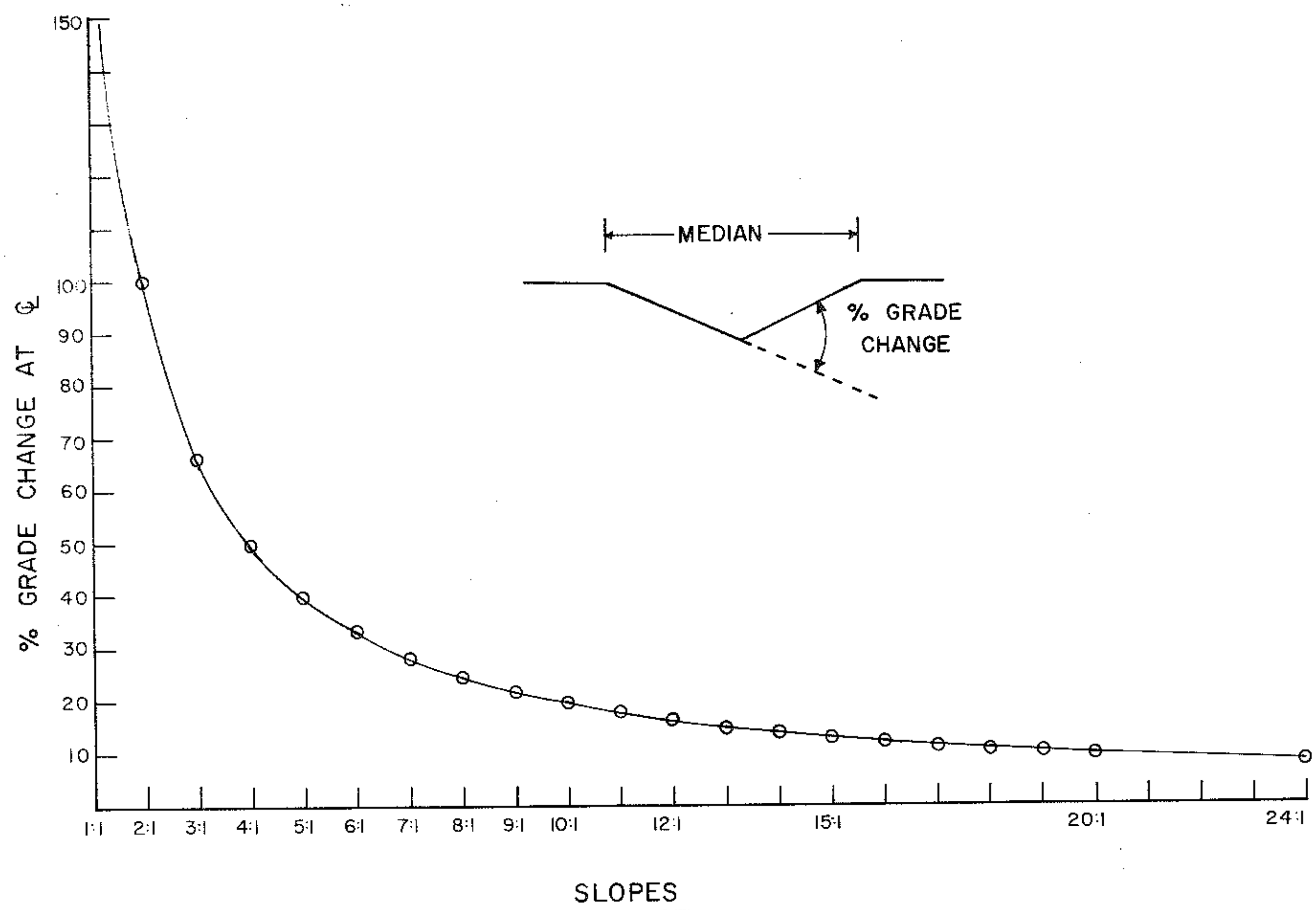


Figure 12. Percent Grade Change at Centerline for Various Slopes

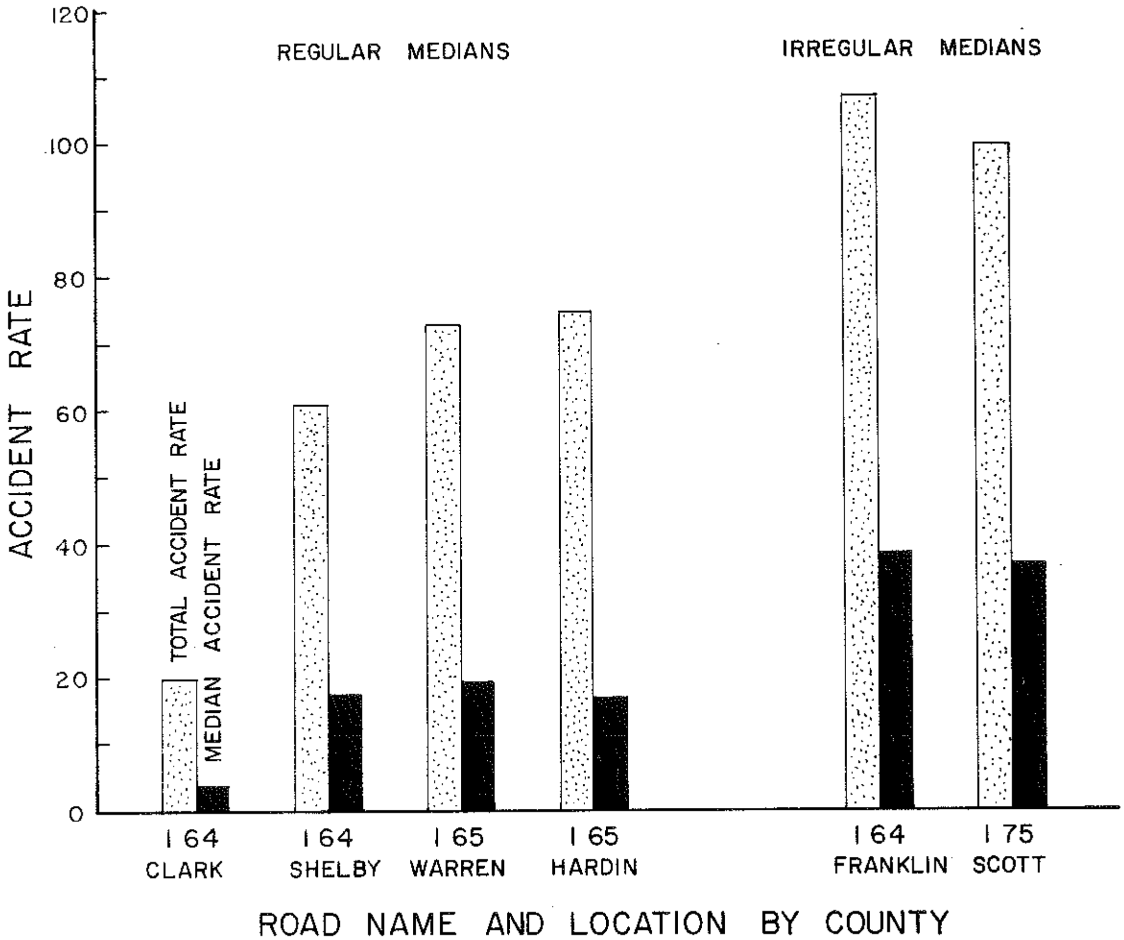


Figure 13. Total and Median Accident Rates for Interstate Medians

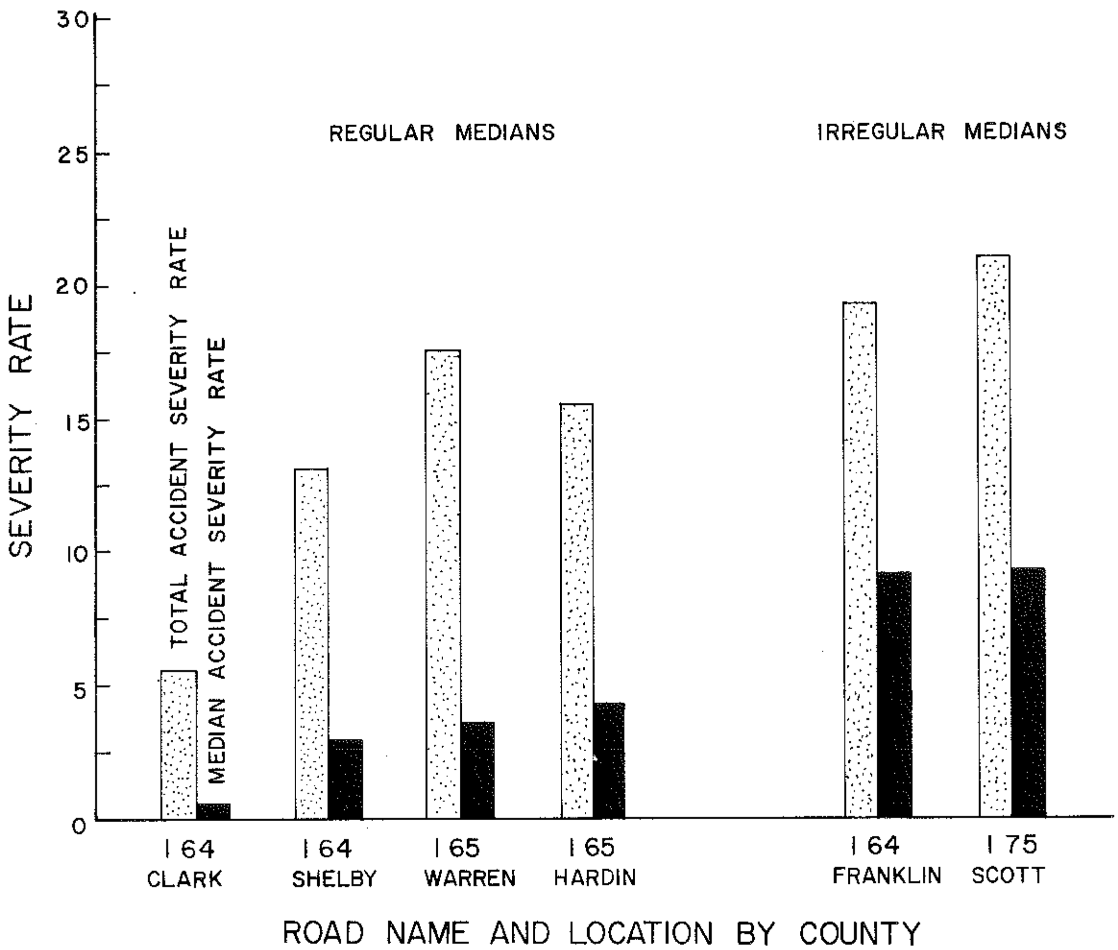


Figure 14. Total and Median Accident Severity Rates for Interstate Medians

section of interstate has a relatively flat, gently sloping recovery area, the divided sections in many cases provide no recovery area at all. In the future use of independent roadway sections, clear zones and recovery space should be provided. Also 12-foot shoulders should be used where guardrail is to be installed.

EFFECTS OF VOLUME

A synopsis of studies concerning the effect of traffic volume on accident rates *(14)* indicates that a correlation does exist between volume and accidents. In general, accident rates will increase with increasing volume. However, the increases are obvious only when very large differences in volume are being considered. For the volume ranges considered in this study, there should be little correlation between volumes and rates. As Figures 15 to 18 indicate, there is no obvious correlation between total and median accident and severity rates and volume expressed as average daily traffic. Other variables have more effect than volume.

That accident rates may increase with increasing volume can be partially explained by the increase in multi-car collisions with increasing volume. The data from this study are plotted in Figure 19. There is an increasing trend showing that multi-vehicle accidents, as a percent of the total, increases with volume. Such a relationship was previously reported by Belmont *(15)*.

Other factors which may account for any increase in accident rate with volume include enforcement levels and age of roadway as related to road roughness and skid resistance. It is general practice for enforcement levels to be adjusted to traffic volumes. In other words, high volume roads are more heavily patrolled than low volume roads. Thus, it is more likely that minor accidents will be reported on higher volume roads.

It has been shown by Burchett and Rizenbergs *(16)* that skid resistance decreases with accumulated vehicle passes for most pavements. Road roughness increases with years since construction as illustrated in Figure 20. The lower skid resistance and higher roughness index are as likely to account for an increase in accident rates as is volume.

The results of this study appear to be unaffected by differences in traffic volume. That accident rates do generally increase with increasing volume may be explained by volume effects such as the increase in multi-vehicle accidents or by volume and age related phenomena such as the decrease in skid resistance and the increase in road roughness.

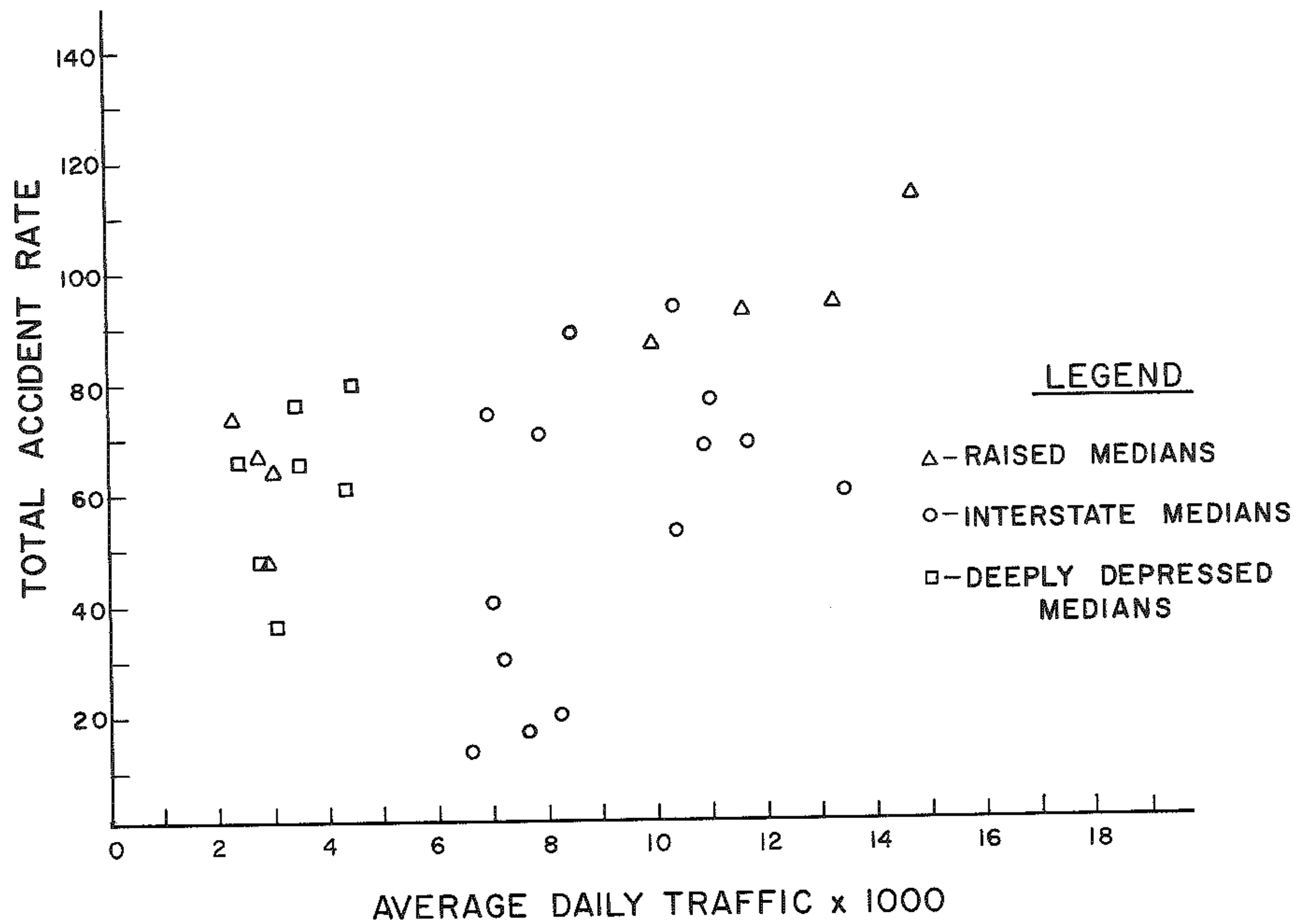


Figure 15. Total Accident Rates Versus Volume

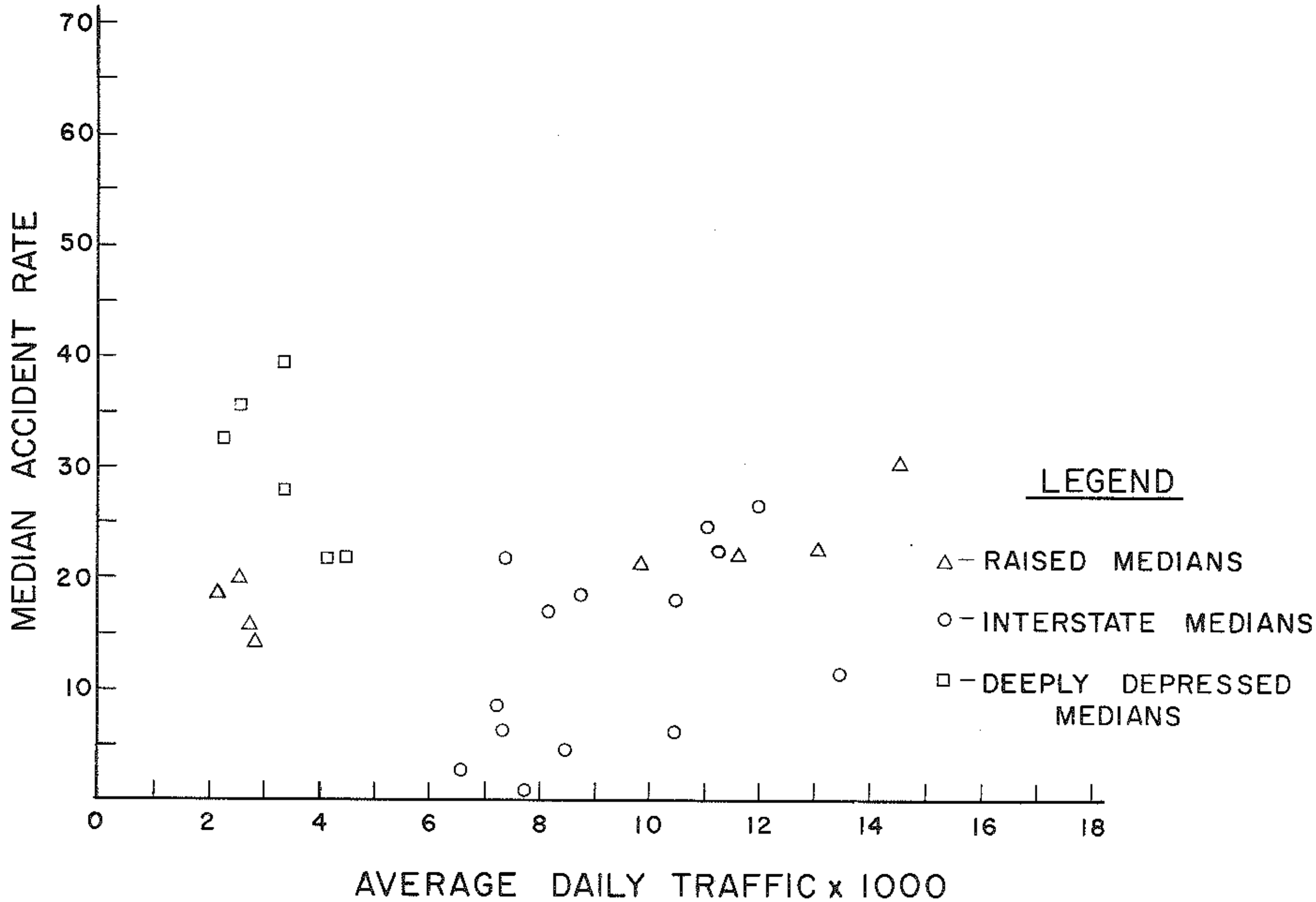


Figure 16. Median Accident Rate Versus Volume

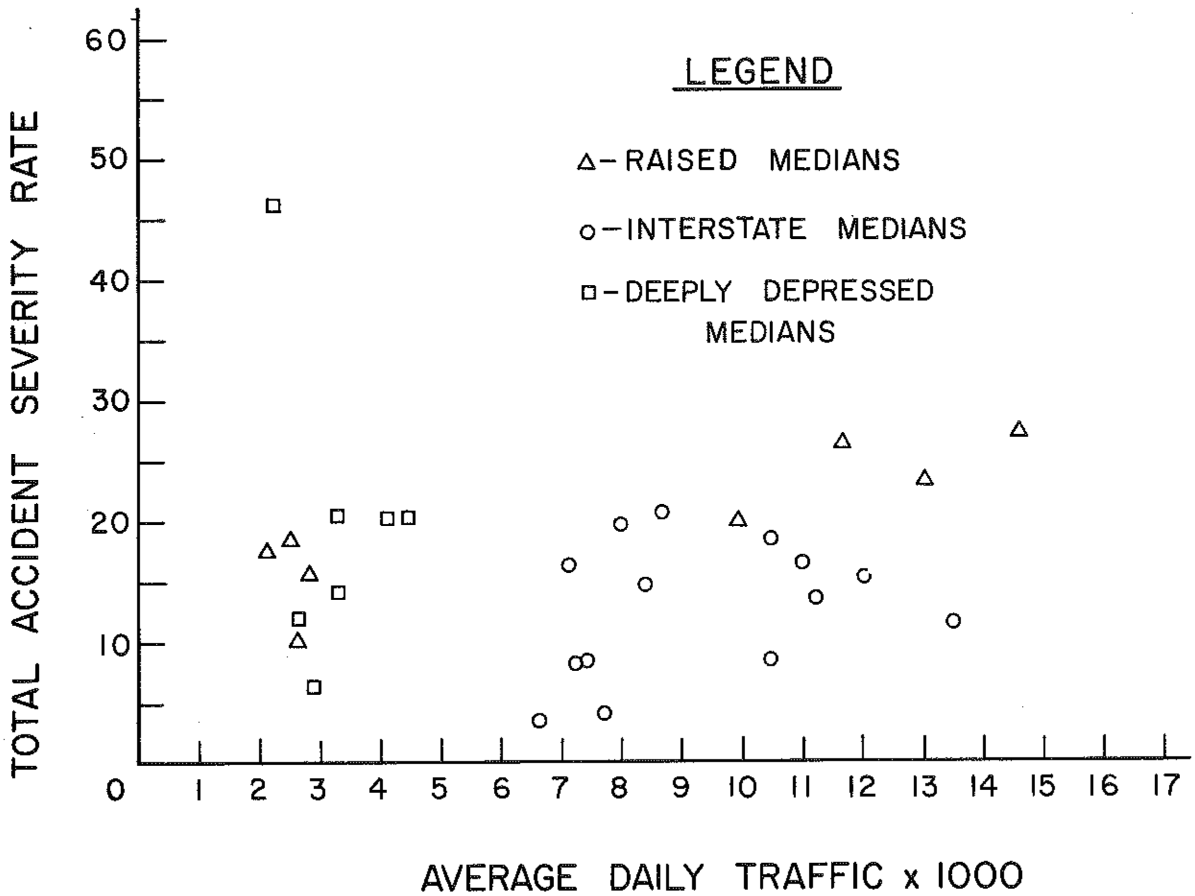


Figure 17. Total Accident Severity Rate Versus Volume

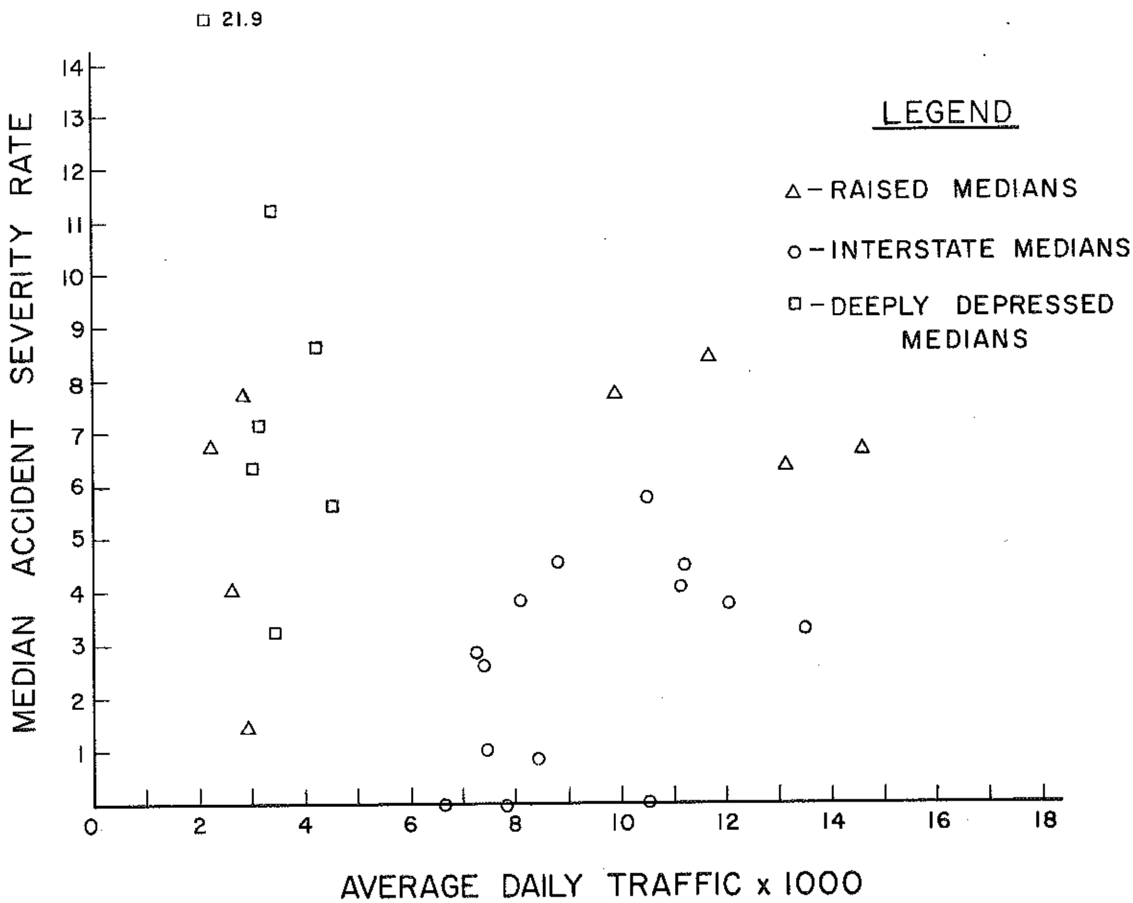


Figure 18. Median Accident Severity Rate Versus Volume

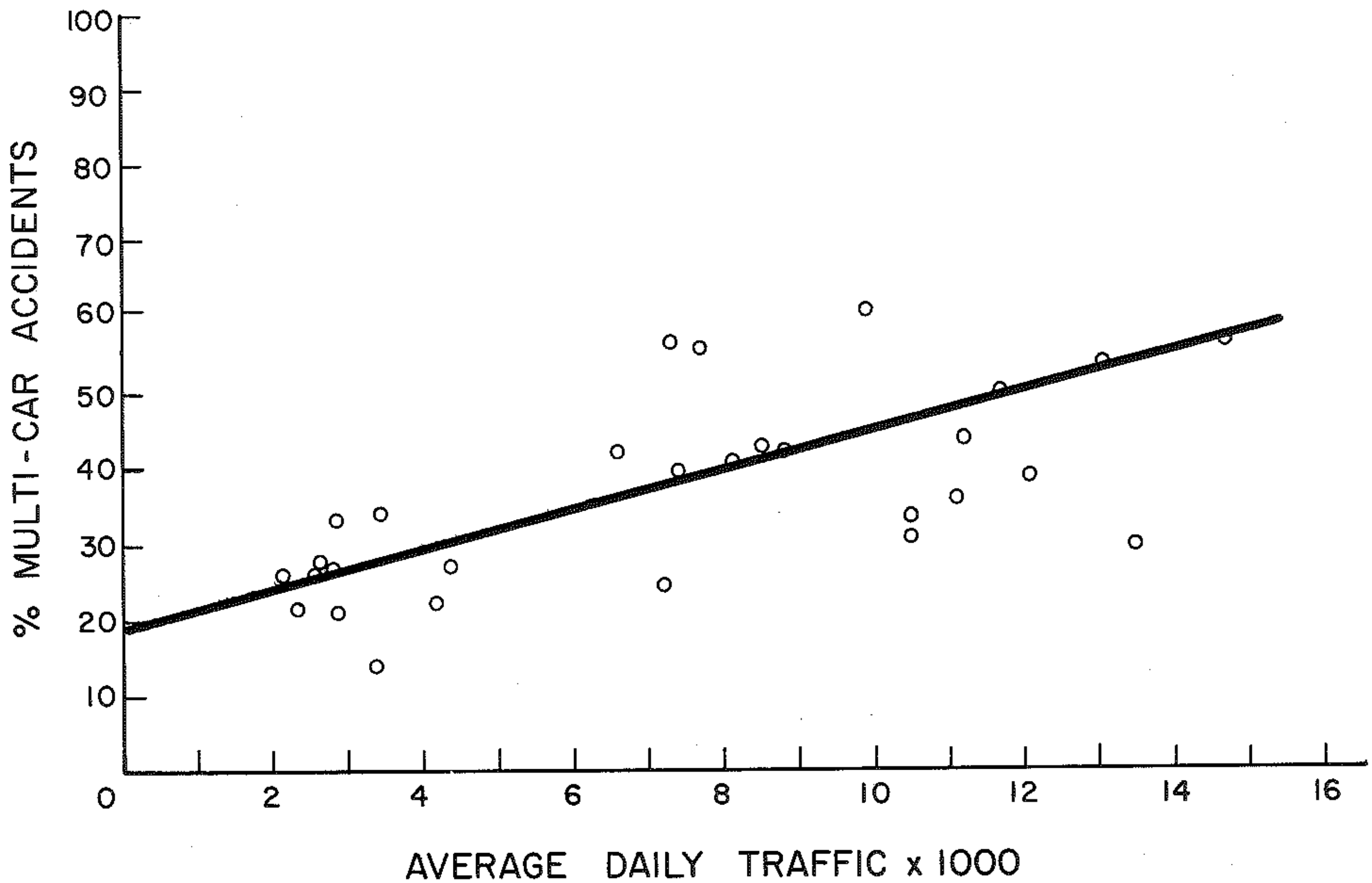


Figure 19. Percent of Multi-Vehicle Accidents Versus Volume

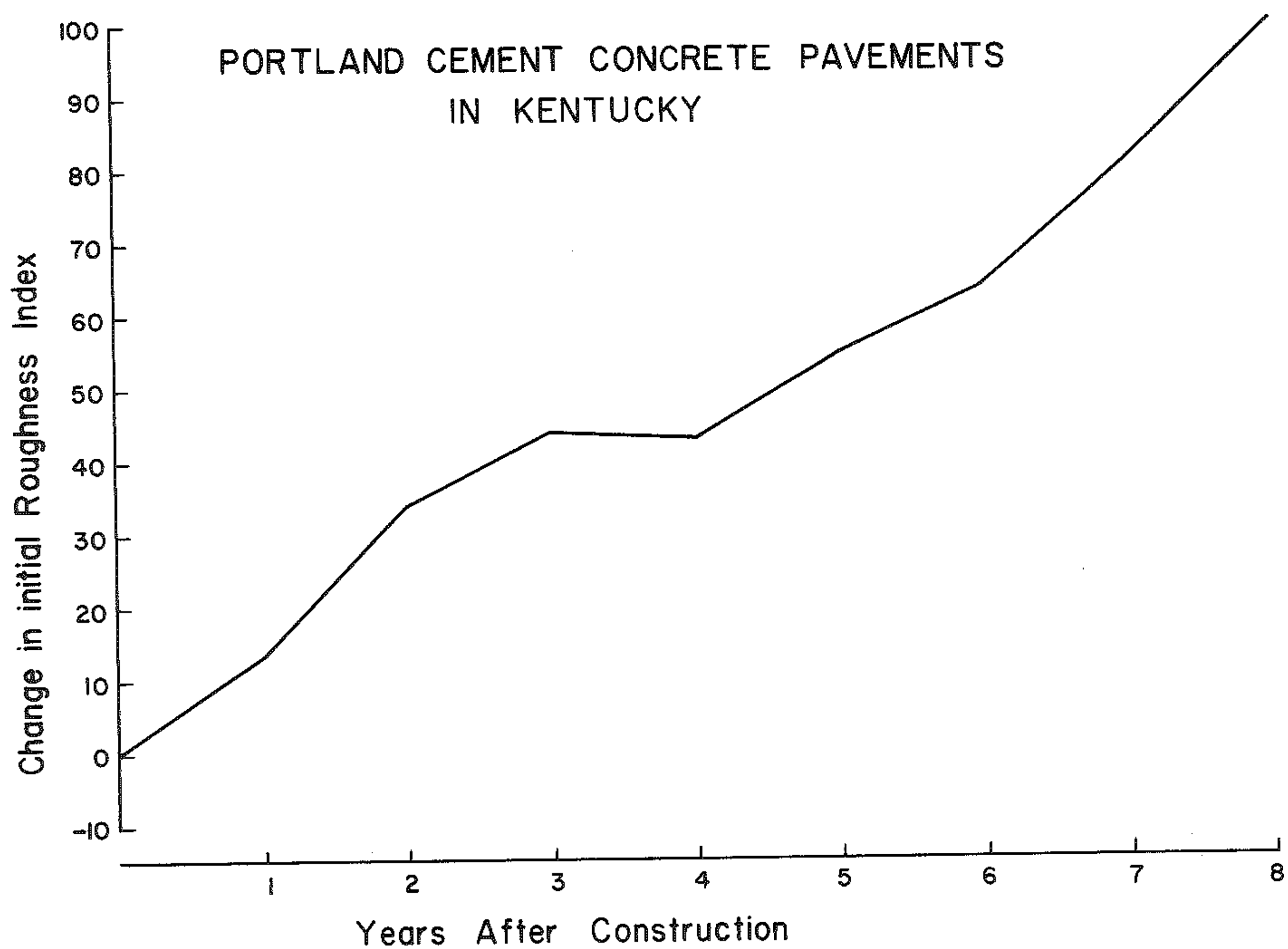


Figure 20. Change in Roughness Index Versus Years Since Construction

EFFECTS OF OTHER VARIABLES

The number of variables which can influence the occurrence of accidents has been shown to be very great. There are any number of variables which can affect accident rates, but the relative effects of each cannot be accurately determined. These variables are likely to account for much of the deviation of accident statistics. A few of these variables will be discussed for illustrative purposes. Weather, bearing of roadway, and enforcement levels are three such factors.

That weather should influence the occurrence of accidents is intuitively obvious. However, few studies have given this full consideration. Hutchinson *(17)* found good correlation between rainfall and intersection accidents in Lexington, Kentucky. An attempt was made here to correlate accidents with the occurrence of precipitation. The methodology employed is presented in **APPENDIX A**. No apparent correlation was found. The inherrent precipitation variables (intensity, duration, etc.), coupled with the variability in length of road sections affected and traffic volume at the time of rainfall, were probably responsible for the inability to obtain significant findings. More precise data collection methods need to be established to accurately determine the effects of weather on accidents on long, rural road sections.

The bearing of the roadway was found to have a significant effect on the occurrence of accidents in a given direction. In all cases except one, the majority of accidents occurred in the southbound direction. Figure 21 is a directional analysis of each of the road sections. The percentage figures are the percent of the total median accidents which occurred in that direction. That these percentages are different from the expected 50-50 split is significant at the 95 percent level using a t-test (see **APPENDIX C**). The actual geographical orientation of the study roads is shown in Figure 22. The probable explanation for this phenomena is related to visibility and glare. Drivers heading into the sun are more likely to be affected by glare, thus exposing them to a greater accident risk.

The variation in patrolling levels found on Kentucky's interstate and toll roads is expressed in Table 4. In 1968, all troopers who patrol interstate or toll roads were given a questionnaire to complete. The values in Table 4 were calculated from state troopers' estimates of actual time per week spent patrolling each road. Generally, high volume roads are more frequently patrolled than low volume roads. This could result in the reporting of a greater number of minor accidents on higher volume roads.

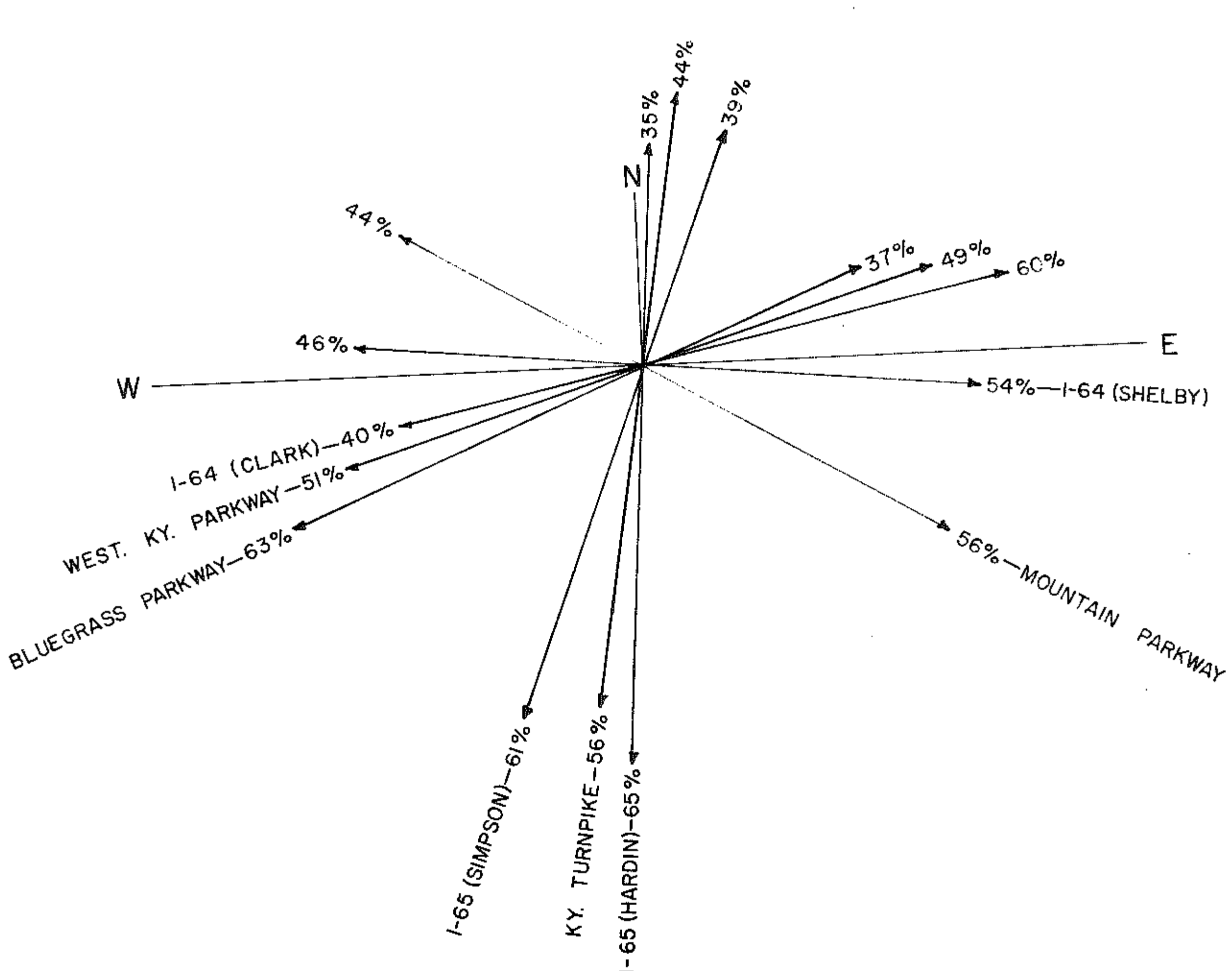


Figure 21. Effect of Roadway Bearing on the Occurrence of Accidents in the Southbound Direction.

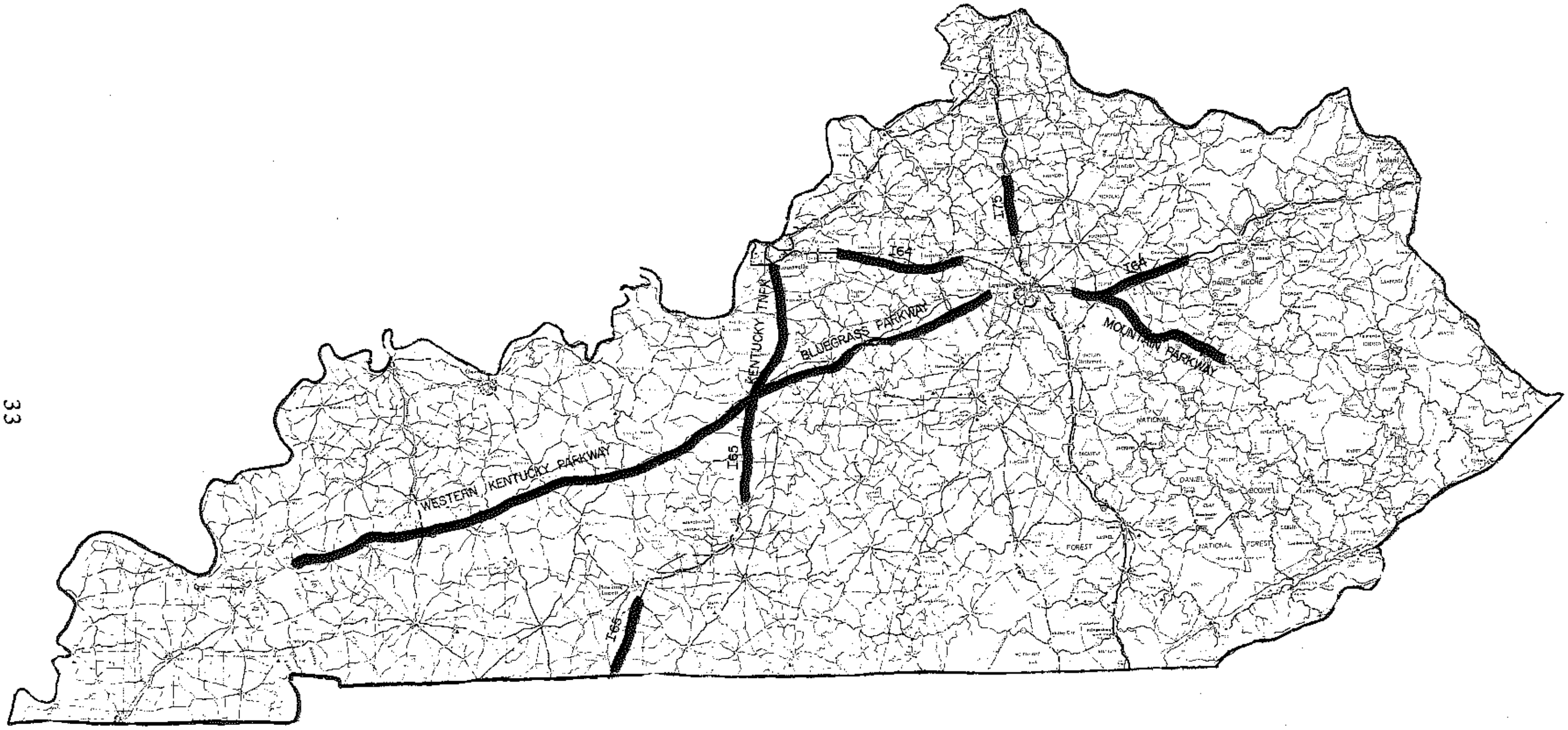


Figure 22. Geographical Orientation of the Study Roads

EVALUATION OF MEDIANS BY FUNCTION

The functions of medians on divided highways with complete control of access have been listed *(18)*. An evaluation of median types included in this study is presented in Table 5. The narrow raised medians satisfy very few of the necessary functions of medians. Deeply depressed medians do not provide an adequate recovery space, and this has been shown to be a significant failing. Only the wide, gently sloping interstate medians adequately satisfy all functions.

Table 4 - 1968 Enforcement Levels on Interstate and Toll Roads

Road	1968 Approximate Average Daily Traffic	Enforcement Level (Man-Hours Per Mile Per Week)
Western Kentucky Turnpike	2,800	0.9
Mountain Parkway	3,600	1.5
Bluegrass Parkway	4,400	1.0
I64 (Clark County)	8,000	2.2
I65 (Simpson County)	8,500	5.2
I65 (Hardin County)	11,000	7.7
I64 (Shelby County)	12,500	8.0
Kentucky Turnpike	13,500	7.7
I75 (Scott County)	17,500	6.8

FUNCTIONS OF MEDIANS (divided highways with complete control of access)	Western Kentucky Turnpike	Kentucky Turnpike	Bluegrass Parkway	Mountain Parkway	Regular Interstate (prior to safety standards)	Interstate	Interstate (current design)
	30' Raised	20' Raised	36' Deeply Depressed	36' Deeply Depressed	60' Depressed w/4:1 transition	Irregular Median	60' Depressed w/6:1 slopes
PRIMARY							
Delineate the left extremity of the roadway	Good	Good	Good	Good	Good	Good-Fair	Good
Separate opposing traffic streams	Fair-Good	Fair-Poor	Good	Good	Good	Very Good	Good
Prevent U-turns	Fair	Poor-Fair	Good	Very Good	Good	Very Good	Good
Stopping or recovery Conditions and space for vehicles running off the left edge of the pavement under various degrees of control	Poor-Fair	Poor	Poor	Poor	Good	Poor	Very Good
Provide Storage or refuge space for disabled vehicles	Fair	Poor	Fair-Poor	Fair-Good (10' Inside Shoulders)	Good	Poor	Good
SECONDARY							
Provide space for drainage and snow storage	Poor	Poor	Good	Good	Good	Good	Good
Provide space for future expansion	Poor	Poor	Fair	Fair	Good	Good	Good
Reduce headlight glare	Poor-Fair	Poor	Fair	Fair	Good	Very Good	Good

Table 5 - Evaluation of Median Types in Study with Respect to the Primary and Secondary Functions of Medians

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to compare the accident histories of different median types and to provide verification of generally recommended minimum widths and slopes. The major limitation of this analysis is the small number of possible combinations of median width and cross slope available for study. For example, only one width of median with a 4:1 side slope was available for inclusion in the sample. The individual effects of width and cross slope were therefore not determined. However, all combined effects evident in the results of this analysis support the contentions from previous research that wider, flatter medians are safer.

1. This analysis provides documentary evidence from accident histories to support the reasonably known and intuitively presumed rule that wider medians are safer medians. It implies that medians should be a minimum of 30-40 feet wide for high speed facilities.

2. Factual support is provided for previous research conclusions which indicate that flat slopes should be provided; 4:1 slopes are inadequate. For medians less than 60 feet wide, there is sufficient cause to use 6:1 or flatter slopes. Specifically, 36-foot medians, such as have been used on Kentucky's toll roads, should have 6:1 or flatter slopes, even though this will require some special drainage considerations.

3. Raised medians provide an unsuitable vehicle recovery area on rural highways and are undesirable from the standpoint of roadway surface drainage. The use of curbed, raised medians in urban areas should be re-examined as the deficiencies of raised medians apparent in this study may be applicable.

4. The irregular interstate medians which result from independent roadway alignment design should be used only with adequate clear zones in the median. Twelve-foot shoulders should be provided where guardrail is to be used.

This study, because similar roadway environments allowed the effects of median type to be separated and analyzed effectively, has conclusively justified the premise that providing a clear, gently sloping, off-the-road environment is one of the best ways to reduce accidents and accident severity on modern divided highways.

BIBLIOGRAPHY

1. Recht, J. L., *The 1969 Traffic Story,* **Traffic Safety**, Vol. 70, No. 3, National Safety Council, pp. 16-19, March 1970.

2. Hurd, F. W., *Accident Experience with Traversible Medians of Different Widths",* **Bulletin No. 137**, Highway Research Board, pp. 18-26, 1957.

3. Telford, E. T., and Israel, R. J., *Median Study (California),* **Proceedings**, 32nd Annual Meeting, Highway Research Board, pp. 208-231, 1953.

4. Crosby, J. R., *Cross-Median Accident Experience on the New Jersey Turnpike* ,**Bulletin No. 266**, Highway Research Board, pp. 63-77, October 1960.

5. Billion, C. E. and Parsons, N. C., *Median Accident Study - Long Island, New York,* **Bulletin No. 308**, Highway Research Board, pp. 64-79, January 1962.

6. Hutchinson, J. W. and Kennedy, T. W., *Safety Considerations in Median Design,* **Record No. 162**, Highway Research Board, pp. 1-29, 1967.

7. Stonex, K. A., *Roadside Design for Safety,* **Proceedings**, 39th Annual Meeting, Highway Research Board, pp. 120-156, 1960.

8. Hutchinson, J. W. and Kennedy, T. W., *Use of Accident Records in Highway Research,* **Highway Research News No. 13**, Highway Research Board, pp. 1-8, June 1964.

9. Garner, G. R., *Accidents at Median Crossovers,* Kentucky Department of Highways, Division of Research, June 1969. (Publication by Highway Research Board Pending).

10. Stewart, R. G., *Driving Exposure: What Does it Mean? How is it Measured?* , **Traffic Safety Research Revue**, Vol. 4, No. 2, pp. 9-11 June 1960.

11. Dart, O. K. and Mann Lawrence, *Rural Highway Geometry Relationship to Accident Rates in Louisiana,* Paper presented at the 49th Annual Meeting, Highway Research Board, January 1970.

12. Bellis, W. R., *To Reduce Accidents,* Paper presented at the 48th Annual Meeting, Highway Research Board, January 1969.

13. Prisk, C. W., *Life-Saving Benefits of the Interstate System,* **Public Roads**, Vol. 31, No. 11, pp. 219-220, December 1961.

14. **Traffic Control and Roadway Elements - Their Relationship to Highway Safety**, Automotive Safety Foundation, 1969.

15. Belmont, D. M., *Effect of Average Speed and Volume on Motor Vehicle Accidents on Two-Lane Tangents,* **Proceedings**, 32nd Annual Meeting, Highway Research Board, pp. 383-395, 1953.

16. Burchett, J. L. and Rizenbergs, R. L., *Pavement Slipperiness Studies - An Interim Report,* Kentucky Department of Highways, Division of Research, 1970.

17. Hutchinson, J. W., Cox, C. S., and Maffet, B. R., *An Evaluation of the Effectiveness of Televised, Locally Oriented Driver Re-education,* **Record No. 292**, Highway Research Board, pp. 51-63, 1969.

18. Hutchinson, J. W., Scott, W. A. and Kennedy, T. W., *Medians of Divided Highways - Current Status of Knowledge and Annotated Bibliography,* **Bibliography No. 34**, Highway Research Board, 1963.

19. Webster, L. A. and Yeatman, F. R., *An Investigation of Headlight Glare as Related to Lateral Separation of Vehicles,* **Bulletin No. 496**, Engineering Experiment Station, University of Illinois, 1968.

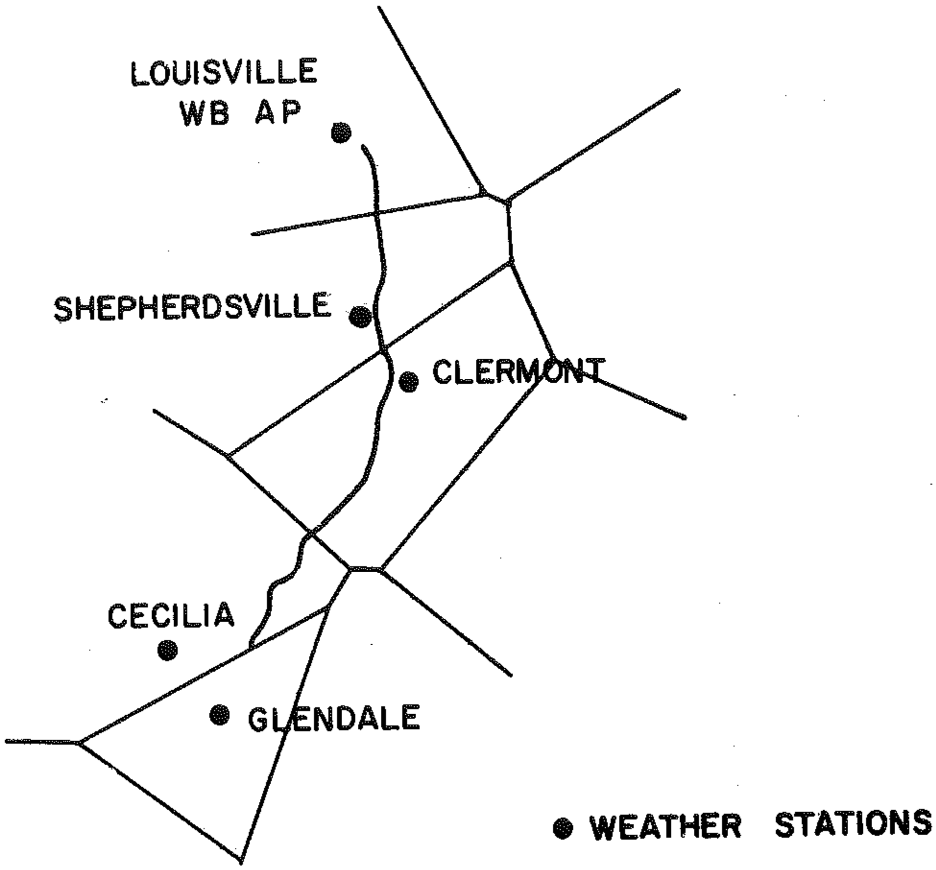
APPENDIX A

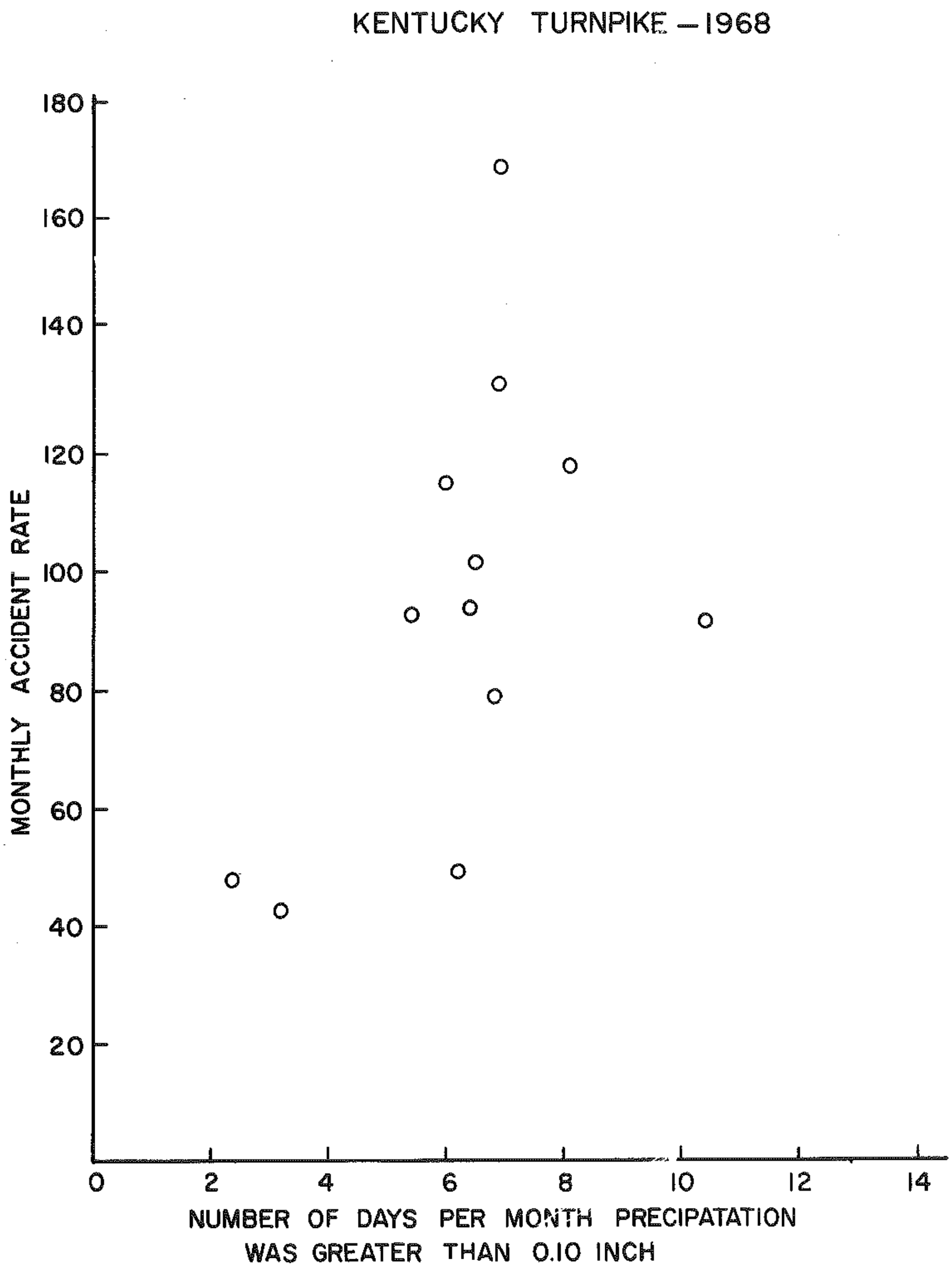
RAINFALL ANALYSIS

1968 Data

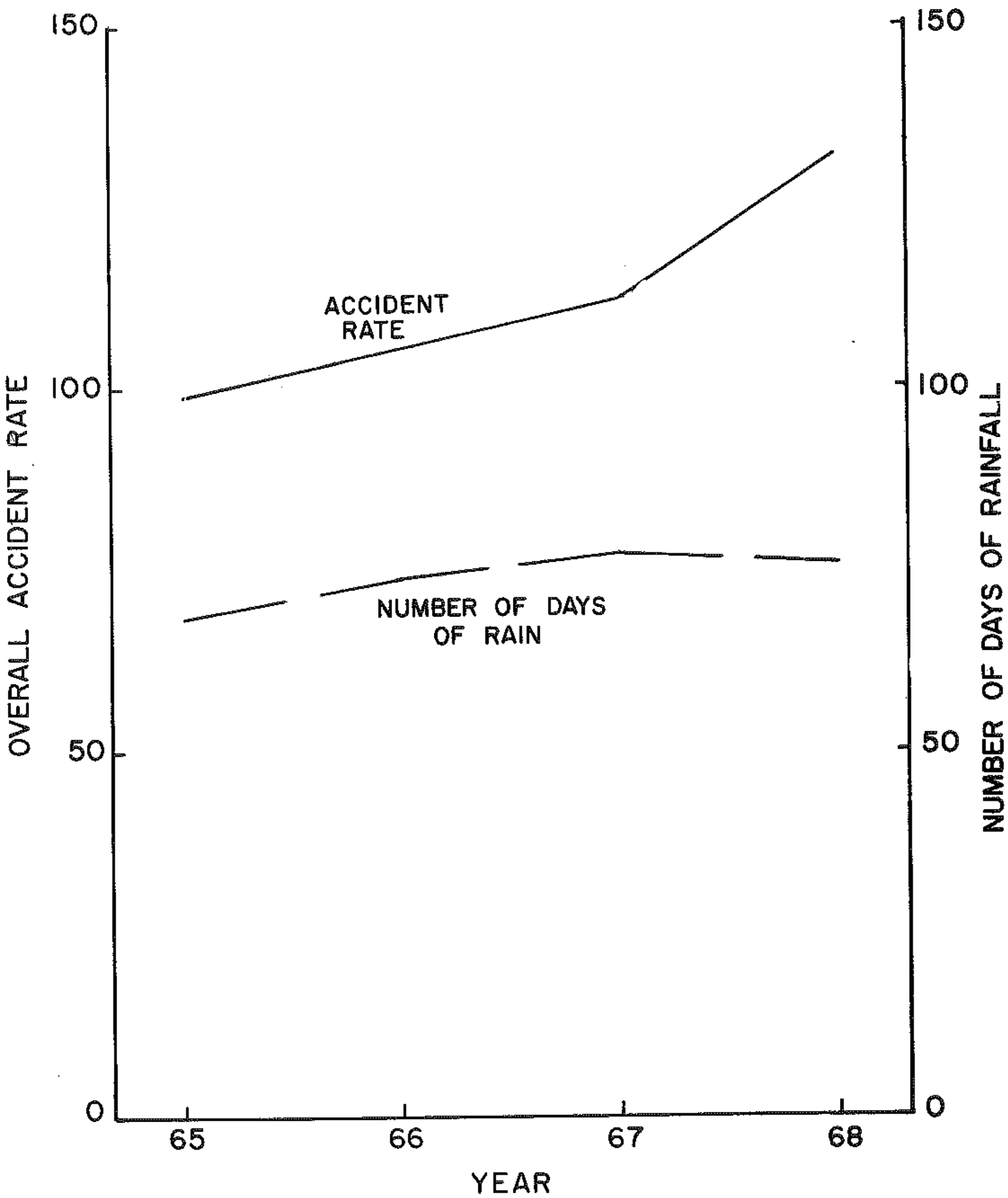
Road Name	Weather Station	Miles Affected	Number of Days Precipitation Was Greater Than 0.10 Inch											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kentucky Turnpike	Cecilia	13	6	1	9	8	10	5	5	3	6	4	8	6
	Clermont	21	6	2	9	5	11	6	7	9	6	3	7	6
	Louisville	8	7	3	8	7	10	5	5	5	6	3	6	9
	Shepardsville	14	9	4	6	6	10	5	8	8	6	3	4	8
	Weighted Average	56	6.9	2.4	8.1	6.2	10.4	5.4	6.5	6.8	6.0	3.2	6.4	6.9
Number of Accidents/Month			26	9	24	12	20	25	29	24	26	9	20	30
Monthly Accident Rate			169.0	48.8	118.1	49.5	91.9	93.0	101.7	79.8	115.2	42.8	94.0	131.9

KENTUCKY TURNPIKE - THIESSON NETWORK




KENTUCKY TURNPIKE — 1968
MONTHLY ACCIDENT RATE
180
160
140
120
100
80
60
40
20
0
2
4
6
8
10
12
14
NUMBER OF DAYS PER MONTH PRECIPATATION
WAS GREATER THAN 0.10 INCH

KENTUCKY TURNPIKE



APPENDIX B

ACCIDENT SUMMARIES

SUMMARY SHEET - ALL ACCIDENTS

Road Name	Year	Location of Accidents: Regular Section	Location of Accidents: Ramps Interchange	Location of Accidents: Toll Booth	Location of Accidents: Detour	Location of Accidents: Bridge or Bridge Abutment	Single Car	Multi Car	Most Serious Injury: K	Most Serious Injury: A	Most Serious Injury: B	Most Serious Injury: C	Most Serious Injury: O	Improper Turn	Total
Kentucky Turnpike	1965	90	21	19	2	9	56	85	1	27	11	12	90	16	141
	66	101	25	21	1	14	81	81	9	31	19	18	85	11	162
	67	123	28	16	10	14	89	100	4	36	15	21	115	10	189
	68	177	19	37	5	17	110	145	10	42	20	13	170	18	255
	Totals	491	93	93	18	54	336	411	24	136	65	64	460	55	747
Mountain Parkway	1965	21	3	0	0	0	18	6	4	13	1	1	5	0	24
	66	17	2	5	1	0	18	7	1	4	4	0	16	0	25
	67	12	4	4	0	1	14	7	0	3	5	1	12	3	21
	68	35	1	4	0	4	29	15	5	6	9	1	24	0	44
	Totals	85	10	13	1	5	79	35	10	26	19	3	57	3	114
Western Kentucky Parkway	1965	57	3	5	11	3	58	21	3	15	10	2	49	4	79
	66	62	4	8	7	5	64	23	4	18	10	1	54	1	87
	67	55	2	8	1	2	50	18	0	14	6	2	46	1	68
	68	74	4	11	0	8	77	20	3	18	9	9	58	1	97
	Totals	248	13	32	19	18	249	82	10	65	35	14	207	7	331
Bluegrass Parkway	1966	45	3	6	2	10	57	9	2	11	8	8	37	1	66
	67	60	6	4	0	6	59	17	2	21	10	3	40	1	76
	68	85	8	10	0	5	78	30	2	24	6	11	65	4	108
	Totals	190	17	20	2	21	194	56	6	56	24	22	142	6	250
I 64 Shelby (Regular Median)	1965	27	4	0	0	2	21	12	2	6	3	3	19	1	33
	66	14	3	0	1	5	16	7	0	4	3	0	16	0	23
	67	29	3	0	0	4	22	14	1	7	4	3	21	0	36
	68	25	6	0	0	3	24	10	1	6	2	2	23	1	34
	Totals	95	16	0	1	14	83	43	4	23	12	8	79	2	126
I 64 Shelby-Franklin (Irregular Median)	1965	64	9	0	0	10	60	23	1	16	12	6	48	1	83
	66	51	7	0	0	11	54	15	1	12	13	2	41	1	69
	67	34	4	0	1	22	38	23	2	10	7	3	39	2	61
	68	56	6	0	2	6	52	18	1	7	8	11	43	0	70
	Totals	205	26	0	3	49	204	79	5	45	40	22	171	4	283
I 64 Clark & Montgomery	1965	10	2	0	0	0	7	5	2	1	4	1	4	1	12
	66	17	8	0	1	2	17	11	2	6	4	4	12	2	28
	67	12	2	0	1	1	7	9	0	4	3	0	9	3	16
	68	16	4	0	0	1	12	9	1	6	3	2	9	2	21
	Totals	55	16	0	2	4	43	34	5	17	14	7	34	8	77
I 65 Hardin & Larue	1965	19	5	3	0	1	12	16	1	5	0	6	16	5	28
	66	60	11	0	0	6	44	33	4	14	10	4	45	8	77
	67	61	29	2	0	2	64	30	2	17	10	9	56	1	94
	68	70	11	2	0	2	48	37	4	11	10	4	54	3	85
	Totals	210	56	7	0	11	168	116	11	47	30	23	171	17	284
I 65 Warren & Simpson	1967	31	16	0	0	4	39	12	0	11	7	3	30	1	51
	68	30	9	0	4	11	32	22	4	11	9	7	23	3	54
	Totals	61	25	0	4	15	71	34	4	22	16	10	53	4	105
I 75 (Irregular Median)	Total	130	1	0	0	0	70	60		27	14	16	72	1	131

SUMMARY SHEET - MEDIAN ACCIDENTS

Road		Weather				Road Surface			Road Character				Light			Vehicle Behavior				Most Serious Injury				
Road		Clear	Rain	Snow	Fog	Dry	Wet	Ice Snow	Level	Grade	Curve	Straight	Day	Dusk	Dark	X-Over	Hit Median Lost Control	Over Turn	Recover In Median	K	A	B	C	O
	1965	20	4	6	0	20	4	6	17	13	4	26	17	2	11	16	5	4	9	0	11	1	5	13
Kentucky	66	21	8	1	4	20	9	5	19	15	8	26	21	)	13	12	12	2	10	6	7	4	3	14
Turnpike	67	23	15	1	0	22	16	1	26	13	11	28	22	1	16	23	7	7	7	1	10	3	5	20
	68	34	16	8	0	31	17	10	38	20	12	46	34	2	21	29	10	6	18	2	11	8	5	32
	Totals	98	43	16	4	93	46	22	100	61	35	126	94	5	61	80	34	19	44	9	39	16	18	79
	1965	8	1	1	1	8	2	1	9	2	3	8	5	0	6	3	0	7	3	2	6	1	0	2
Mountain	66	12	3	0	0	12	3	0	12	3	5	10	12	0	3	5	2	9	2	0	3	3	0	9
Parkway	67	7	0	0	0	7	0	0	5	2	4	3	6	0	1	3	0	3	2	0	3	3	0	1
	68	12	5	2	2	13	5	3	15	6	14	7	10	1	10	4	1	10	9	2	4	4	0	11
	Totals	39	9	3	3	40	10	4	41	13	26	28	33	1	20	15	3	29	16	4	16	11	0	23
	1965	13	4	2	0	12	4	3	11	8	0	19	12	1	6	6	8	7	1	1	6	4	0	8
Western	66	15	3	5	1	10	5	9	11	13	2	22	16	3	5	8	10	6	3	2	3	4	0	15
Kentucky	67	14	5	2	0	12	5	4	11	10	5	16	11	1	9	12	6	6	2	0	10	1	1	9
Parkway	68	13	4	2	0	9	3	7	6	13	6	13	14	0	5	8	5	4	4	1	1	3	5	9
	Totals	54	16	11	1	43	17	23	39	44	13	70	53	5	25	34	29	23	10	4	20	12	6	41
	1965																							
Bluegrass	66	18	2	7	0	17	1	9	12	15	9	18	13	0	14	8	3	10	12	0	3	4	6	14
Parkway	67	19	2	3	0	19	2	3	16	8	7	17	18	1	6	8	5	11	6	2	8	4	2	9
	68	25	2	3	1	23	3	5	19	12	6	25	19	1	11	6	3	13	13	0	8	5	2	16
	Totals	62	6	13	1	59	6	17	47	35	22	60	50	2	31	22	11	34	31	2	19	13	10	39
	1965	12	0	0	0	11	0	1	7	5	0	12	7	1	4	1	0	4	7	1	1	1	1	8
I 64	66	1	0	1	1	2	0	1	2	1	0	3	2	0	1	0	2	0	1	0	0	1	0	2
Shelby	67	10	1	3	0	8	1	5	7	7	0	14	5	2	6	3	6	1	5	0	2	3	0	9
(Regular	68	6	1	0	0	5	1	0	5	2	0	7	3	0	4	1	4	0	2	0	2	0	1	4
Median)	Totals	29	2	4	1	26	2	7	21	15	0	36	17	3	15	5	12	5	15	1	5	5	2	23
I 64	1965	22	10	3	0	22	10	3	22	13	2	33	14	3	18	0	8	8	26	1	10	6	1	17
Shelby-	66	16	5	2	0	15	6	2	15	8	1	22	11	1	11	0	7	3	18	0	6	5	1	11
Franklin	67	10	5	1	0	8	4	4	7	9	3	13	10	2	4	0	4	4	6 stop 3 recov'y	0	2	2	2	10
(Irregular	68	18	8	3	0	15	9	5	9	20	2	27	13	2	14	1	12	4	12	1	4	3	3	18
Median)	Totals	66	28	9	0	60	29	14	53	50	8	95	48	8	47	1	31	19	65	2	22	16	7	56
	1965	2	0	0	0	2	0	0	1	1	0	2	1	0	1	0	0	1	1	0	0	0	1	1
I 64	66	4	3	0	0	4	3	0	3	4	0	7	5	0	2	0	1	0	6	1	0	1	2	3
Clark &	67	1	0	0	0	1	0	0	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0	1
Montgomery	68	4	1	0	0	4	1	0	2	3	0	5	4	0	1	0	0	0	5	0	1	1	1	2
	Totals	11	4	0	0	11	4	0	6	9	0	15	11	0	4	0	1	1	13	1	1	2	3	7
	1965	3	0	3	0	3	0	3	2	4	1	5	5	0	1	2	1	0	3	0	2	0	1	3
I 65	66	12	1	3	1	11	1	5	10	7	0	17	14	0	4	1	2	4	14	1	3	2	1	10
Hardin &	67	14	1	3	0	12	0	5	10	8	1	17	11	0	7	1	2	7	8	1	5	2	1	9
Larue	68	18	4	2	0	15	6	3	13	11	0	24	18	2	4	5	3	8	10	1	4	4	0	15
	Totals	47	6	11	1	41	7	16	35	30	2	63	48	2	16	9	8	19	35	3	14	8	3	37
	1965																							
Warren &	66																							
Simpson	67	8	2	0	0	8	2	0	8	2	0	10	5	0	5	5	1	1	4	0	2	0	0	7
	68	8	5	0	0	7	1	5	6	7	1	12	7	2	4	4	1	2	7	0	3	1	3	5
	Totals	16	7	0	0	15	3	5	14	9	1	22	12	2	9	9	2	3	11	0	5	1	3	12
I 75 (Irregular Median)	Total	24	13	10	1	22	13	13	14	34	5	43	32		15	1	7	9	15	0	11	5	4	27

SUMMARY SHEET - MEDIAN ACCIDENTS

Road Name		Multi Car Accidents	Single Car Accidents	Most Serious Injuries For Single Car Accidents					In-County Driver	Out of County Driver	Out of State Driver Involved	Monthly Breakdown of Accidents												Total
				K	A	B	C	O				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Kentucky Turnpike	1965	16	14	0	4	3	0	7	1	12	17	3	0	4	5	1	2	4	0	5	3	2	1	30
	66	20	14	1	4	2	1	6	1	14	19	3	3	2	3	0	3	2	4	4	4	2	4	34
	67	19	20	0	3	2	3	12	5	15	19	2	1	3	3	2	4	4	9	3	1	4	3	39
	68	32	26	0	6	3	3	14	13	17	28	10	3	6	2	5	5	5	4	4	2	5	7	58
	Total	87	74	1	17	10	7	39	20	58	83	18	7	15	13	8	14	15	17	16	10	13	15	161
Mountain Parkway	1965	2	10	2	6	1	0		1	7	4	0	1	2	0	1	4	0	1	0	1	0	2	12
	66	1	14	0	3	3	0	8	0	8	7	1	1	3	1	1	2	0	3	1	1	1	0	15
	67	0	7	0	3	3	0	1	0	5	2	0	1	0	2	1	0	1	0	0	0	1	1	7
	68	5	16	2	4	2	0	8	2	10	9	0	2	2	1	1	1	0	1	1	3	5	4	21
	Total	8	47	4	16	9	0	18	3	30	22	1	5	7	4	4	7	1	5	2	5	7	7	55
Western Kentucky Parkway	1965	4	15	1	5	3	0	6	0	6	13	3	4	3	0	1	0	0	1	2	3	1	1	19
	66	6	18	1	3	3	0	11	1	8	15	2	0	2	2	3	1	1	3	1	1	2	6	24
	67	4	16	0	5	1	0	9	2	11	7	2	4	1	0	1	1	3	1	4	0	2	1	20
	68	4	15	1	1	2	3	8	1	9	9	4	1	1	1	2	1	4	0	2	1	0	2	19
	Total	18	64	3	14	9	3	34	4	34	44	11	9	7	3	7	3	8	5	9	5	5	10	82
Bluegrass Parkway	1966	2	24	0	3	2	5	14	1	8	17	3	1	3	0	1	1	2	1	3	2	4	5	26
	67	0	25	2	8	4	2	9	0	13	12	0	1	3	2	2	0	5	1	4	1	4	2	25
	68	8	23	0	8	3	1	11	0	15	16	5	2	2	2	2	2	4	2	1	5	3	1	31
	Total	10	72	2	19	9	8	34	1	36	45	8	4	8	4	5	3	11	4	8	8	11	8	82
I 64 Shelby (Regular Median)	1965	6	6	1	1	0	1	3	0	6	5	2	0	0	1	2	1	0	0	0	1	2	2	12
	66	1	2	0	0	1	0	1	0	1	2	0	0	0	0	0	1	0	0	1	0	1	0	3
	67	7	7	0	0	0	0	7	1	8	5	3	2	0	0	2	1	1	1	1	2	0	1	14
	68	1	6	0	2	0	1	3	0	7	0	0	0	0	0	1	1	0	1	1	2	0	1	7
	Total	15	21	1	3	1	2	14	1	22	12	5	2	0	1	5	4	1	2	3	5	3	4	36
I 64 Shelby-Franklin (Irregular Median)	1965	8	25	0	7	6	1	11	0	20	13	4	4	4	2	2	1	4	1	4	2	1	3	33
	66	3	20	0	5	4	0	11	1	15	7	2	3	2	3	1	0	2	2	0	1	4	3	23
	67	4	13	0	1	0	2	10	2	9	6	2	0	0	2	2	1	2	0	3	1	4	0	17
	68	4	25	1	3	2	1	18	2	18	9	2	3	2	2	3	3	2	1	2	5	2	2	29
	Total	19	83	1	16	12	4	50	5	62	35	10	10	8	9	8	5	10	4	9	9	11	8	102
I 64 Clark & Montgomery	1965	0	2	0	0	0	1	1	0	1	1	0	0	0	0	0	0	1	0	0	0	1	0	2
	66	3	3	0	0	0	1	2	0	2	4	0	0	0	0	0	1	0	0	1	2	0	2	6
	67	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1
	68	3	2	0	0	0	0	2	0	2	3	0	0	0	1	0	0	2	0	0	1	0	1	5
	Total	7	7	0	0	0	2	5	0	6	8	0	0	0	1	1	1	3	0	1	3	1	3	14
I 65 Hardin & Larue	1965	3	3	0	1	0	0	2	0	0	6	3	1	0	0	1	0	0	0	0	1	0	0	6
	66	4	12	1	2	1	1	7	0	2	14	3	1	2	0	1	0	1	2	1	2	0	3	16
	67	6	13	0	4	1	1	7	1	3	15	2	1	2	4	0	3	2	1	0	0	0	4	19
	68	10	14	1	1	3	0	9	0	9	15	2	4	0	1	1	1	0	5	3	2	0	5	25
	Total	23	42	2	8	5	2	25	1	14	50	10	7	4	5	3	4	3	8	4	5	0	12	66
I 65 Warren & Simpson	1967	3	12	0	2	2	1	7	2	3	10	1	1	0	1	0	1	1	2	1	0	2	5	15
	68	7	6	0	1	1	0	4	0	3	10	3	0	1	0	1	1	2	0	1	0	2	2	13
	Total	10	18	0	3	3	1	11	2	6	20	4	1	1	1	1	2	3	2	2	0	4	7	28
I 75 (Irregular Median)	Total	10	38	0	9	4	3	21	0	12	35	7	3	6	3	5	4	3	7	3	2	2	3	48

APPENDIX C

STATISTICAL APPENDIX

TOTAL ACCIDENT RATE VERSUS
WIDTH OF MEDIAN - (SEE FIGURE 6)

x	y
60	14.18
60	29.54
60	16.10
60	19.44
60	68.09
60	49.88
60	68.37
60	57.43
36	65.83
36	47.87
36	36.23
36	75.51
30	72.56
30	65.90
30	46.97
30	64.10
60	34.61
60	89.00
60	88.65
60	75.11
60	74.79
60	70.64
20	86.40
20	91.99
20	93.81
20	113.25
36	65.13
36	61.04
36	79.79

1. Regression Equation

$$y = 94.83 - .72x$$

where y = total accident rate
x = median width

2. Correlation Coefficient $r = -.46$

3. Test for Significance of r Value

$$z = \frac{\sqrt{n-3}}{2} \ln \frac{1+r}{1-r}$$

$$= \frac{\sqrt{29-3}}{2} \ln \frac{1-.46}{1+.46}$$

$= (2.55)\ln(.370)$

$= -2.535 < -1.960$

$\therefore$ significant at 95% confidence interval

4. Comparison of Equality of Variances

20 ft. median data vs. 30 ft. median data

$$F = \frac{S_1^2}{S_2^2} = \frac{(11.930)^2}{(10.900)^2} = \frac{142.325}{118.810} = 1.198 < 9.28$$

$\therefore$ variances are not unequal

20 ft. median data vs. 36 ft. median data

$$F = \frac{(15.205)^2}{(11.930)^2} = \frac{231.192}{142.325} = 1.624 < 8.94$$

$\therefore$ variances are not unequal

20 ft. median data vs. 60 ft. median data

$$F = \frac{(26.609)^2}{(11.930)^2} = \frac{708.039}{142.325} = 4.97 < 8.73$$

$\therefore$ variances are not unequal

30 ft. median data vs. 36 ft. median data

$$F = \frac{(15.205)^2}{(10.900)^2} = \frac{231.192}{118.810} = 1.96 < 8.94$$

$\therefore$ variances are not unequal

30 ft. median data vs. 60 ft. median data

$$F = \frac{(26.609)^2}{(10.900)^2} = \frac{708.039}{118.810} = 5.959 < 8.73$$

$\therefore$ variances are not unequal

36 ft. median data vs. 60 ft. median data

$$F = \frac{(26.609)^2}{(15.205)^2} = \frac{708.039}{231.192} = 3.06 < 3.98$$

$\therefore$ variances are not unequal

$\therefore$ no two variances are unequal

TOTAL ACCIDENT SEVERITY RATE
VERSUS WIDTH OF MEDIAN
(SEE FIGURE 7)

x	y
20	19.83
20	26.10
20	23.31
20	27.01
30	17.65
30	18.35
30	10.96
30	15.65
36	46.63
36	11.97
36	6.39
36	20.77
36	14.11
36	20.06
36	20.34
60	3.55
60	8.45
60	4.03
60	6.49
60	16.51
60	8.67
60	15.19
60	11.83
60	8.31
60	20.80
60	18.31
60	13.57
60	16.12
60	19.63

1. Regression Equation

$$y = 31.39 - .389x$$

2. Correlation Coefficient

$$r = -.72$$

3. Test for Significance of r Value

$$z = -4.656 < -1.960$$

$\therefore$ significant at 95% confidence interval.

PERCENT OF TOTAL MEDIAN ACCIDENT INVOLVED VEHICLES WHICH CROSSED THE MEDIAN VERSUS WIDTH OF MEDIAN (SEE FIGURE 8)

x	y
20	53.33
20	35.29
20	58.97
20	50.00
30	31.58
30	33.33
30	60.00
30	42.10
36	25.00
36	33.33
36	42.86
36	19.05
36	30.77
36	32.00
36	19.35
60	8.33
60	0.00
60	21.43
60	14.29
60	0.00
60	0.00
60	0.00
60	0.00
60	33.33
60	6.25
60	5.26
60	20.00
60	33.33
60	30.77

1. Regression Equation

$$y = 65.26 - .892x$$

2. Correlation Coefficient

$$r = -.78$$

3. Test for Significance of r Value

$$z = -5.313 < -1.960$$

$\therefore$ Significant at 95% confidence interval

STATISTICAL TEST TO DETERMINE IF DIRECTION SPLIT OF ACCIDENTS IS SIGNIFICANTLY DIFFERENT THAN THE EXPECTED 50-50 SPLIT (SEE FIGURE 21)

X	$X - \bar{x}$	$(X - \bar{x})^2$
54	- 1.6	2.56
56	+ 0.4	0.16
65	+ 9.4	88.36
56	+ 0.4	0.16
61	+ 5.4	29.16
63	+ 7.4	54.76
51	- 4.6	21.16
40	-15.6	243.36
= 445		= 439.68

$$\bar{x} = \frac{445}{8} = 55.6$$

$$s = 7.93$$

$$n = 8$$

$$t = \frac{\bar{x}-50}{s/\sqrt{n}} = 1.99 > t^*_{.05} = 1.90$$

∴ The hypothesis that the directional split is different from the expected 50-50 split is valid at the 90% significance level.