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Final Report

Signing on Very Low Volume Rural Roads

July 1984

Iowa DOT Project HR-262
ERI Project 1653
ISU-ERI-Ames-85027

Iowa Department of Transportation

Sponsored by the Iowa Department of Transportation, Highway Division, and the Iowa Highway Research Board

report

College of Engineering
Iowa State University

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Highway Division of the Iowa Department of Transportation.

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DEPARTMENT OF CIVIL ENGINEERING
ENGINEERING RESEARCH INSTITUTE
IOWA STATE UNIVERSITY, AMES

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EXECUTIVE SUMMARY

Research was undertaken to define an appropriate level of use of traffic control devices on rural secondary roads that carry very low traffic volumes. The goal of this research was to improve the safety and efficiency of travel on the rural secondary road system. This goal was to be accomplished by providing County Engineers with guidance concerning the cost-effective use of traffic control devices on very low volume rural roads. A further objective was to define the range of traffic volumes on the roads for which the recommendations would be appropriate.

Little previous research has been directed toward roads that carry very low traffic volumes. Consequently, the factual input for this research was developed by conducting an inventory of the signs and markings actually in use on 2,069 miles of rural road in Iowa. Most of these roads carried 15 or fewer vehicles per day. Additional input was provided by a survey of the opinions of County Engineers and Supervisors in Iowa.

Data from both the inventory and the opinion survey indicated a considerable lack of uniformity in the application of signs on very low volume rural roads. The number of warning signs installed varied from 0.24 per mile to 3.85 per mile in the 21 counties in which the inventory was carried out. The use of specific signs not only varied quite widely among counties but also indicated a lack of uniform application within counties.

County officials generally favored varying the elaborateness of signing depending upon the type of surface and the volume of traffic on different roads. Less elaborate signing would be installed on an unpaved road than on a paved road. A concensus opinion was that roads carrying fewer than 25 vehicles per day should have fewer signs than roads carrying higher volumes. Although roads carrying 0 to 24 vehicles per day constituted over 24% of the total rural secondary system, they carried less than 3% of the total travel on that system. Virtually all of these roads are classified as area service roads and would thus be expected to carry only short trips primarily by local motorists.

Consequently, it was concluded that the need for warning signs rarely can be demonstrated on unpaved rural roads with traffic volumes of fewer than 25 vehicles per day. It is recommended that each county designate a portion of its roads as an Area Service Level B system. All road segments with very low traffic volumes should be considered for inclusion in this system. Roads included in this system may receive a lesser level of maintenance and a reduced level of signing. The county is also afforded protection from liability arising from accidents occurring on roads designated as part of an Area Service Level B system. A uniform absence of warning signs on roads of this nature is not expected to have any discernible effect on the safety or quality of service on these very low volume roads. The resources conserved may be expended more effectively to upgrade maintenance and traffic control on roads carrying higher volumes where the beneficial effect on highway safety and service will be much more consequential.

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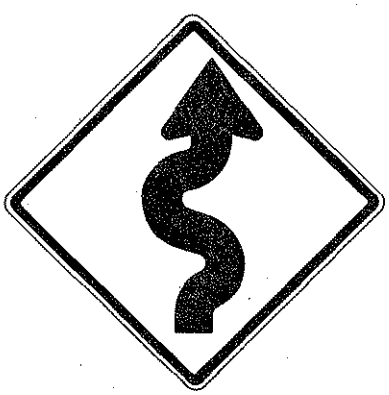
CHAPTER I. INTRODUCTION

Background for the Study



The sophistication of the signing installed on various types of roads has tended to vary quite widely. Paved, high-volume facilities are characterized by relatively high speeds and some number of drivers who are unfamiliar with a road. Thus, a high level of signing is necessary to assure safe travel. On the other hand, roads carrying very low traffic volumes largely serve local residents who are familiar with any potential hazards that may be present. However, since any road may be on the route of an infrequent traveler--a sightseer, thrill seeker, hunter, or a driver who has become lost--or one whose faculties are temporarily impaired, some minimum level of signing has been considered essential for all roads.

It also is commonly assumed that the appearance of a road is suggestive of the standard of care required on the part of a driver. Roads carrying very low volumes usually convey an impression to motorists that, because of lesser geometric design standards and less intensive maintenance, driver expectancies must differ from those on facilities carrying high volumes. The research discussed herein was directed toward an investigation of the extent to which signing is needed on roads carrying very low volumes in order to reinforce appropriate driver expectancies and to counteract inappropriate driver expectancies.

Although relatively few motor vehicle accidents occur on rural roads carrying very low volumes of traffic, problems of signing on such roads have been previously recognized. A conclusion that research was needed to determine "the appropriate levels of traffic control for low volume roads in Iowa which are consistent with driver information needs" resulted from a research project entitled "An Investigation of Signing Needs at Uncontrolled Local Road Intersections" [1]. This final report continues: "Literature research, surveys of other states, and communication with other researchers during the course of this research does not indicate any direct transferability to Iowa of any policy adopted elsewhere to date." The research reported herein was undertaken to help provide an answer as to what level of signing would be most appropriate on rural roads in Iowa carrying very low traffic volumes.

Project Overview

Research Goals and Objectives

The goal of this research was to improve the safety and efficiency of travel on rural secondary roads. This goal was to be accomplished by formulating recommendations that will provide County Engineers guidance on the cost-effective use of traffic control devices on rural roads carrying very low traffic volumes.

A further objective was to define the range of traffic volumes or other conditions of use of the roads for which the recommendations would be appropriate. It was also anticipated that, if the research

was successfully accomplished and, subject to further approval by the Iowa Highway Research Board, a subsequent phase of this research could result in the preparation of a manual or handbook with specific application in Iowa. This manual would present the requirements for traffic control that are unique to very low volume roads.

Research Approach

A task undertaken as part of this research was to determine how signs and markings are currently being used on rural secondary roads in Iowa that carry very low traffic volumes. This was accomplished through a physical inventory of 2,069.0 miles of roads in 21 counties in Iowa that were selected at random. The procedures used for this inventory are described in Chapter II of this report.

Also described in Chapter II is a survey that was used to obtain the opinions of knowledgeable county officials regarding the appropriate level of signing on rural roads carrying very low traffic volumes. Opinions were also solicited as to the traffic volume level, if any was considered desirable, below which signing appropriately could be less elaborate than on high-volume facilities. This was accomplished using a questionnaire directed to each County Engineer and to one Supervisor in each county.

Chapter III includes an analysis of the information obtained from the inventory of signing on a sample of very low volume rural roads. Also included in Chapter III is a summary and analysis of the responses to the survey of opinions of county officials. A further analysis, described in Chapter III, was undertaken to help establish the upper

limit of volumes for roads that may be properly categorized as carrying very low traffic volumes.

The conclusions and recommendations resulting from this research are presented in Chapter IV. Recommendations, prior to their inclusion in this report, were reviewed by an Advisory Panel convened for this purpose. Suggestions received from members of the Advisory Panel have been incorporated in the recommendations.

Previous Research

Reported research relating to traffic control devices has been limited to use on high-type facilities carrying relatively high traffic volumes with the notable exception of a Federal Highway Administration Research Project carried out by Walton, Mounce, and Stockton [2]. However, the Walton report relates to low volume roads (defined as roads carrying fewer than 400 vehicles per day), most of which would have substantially higher volumes than the roads that are the subject of the research being reported here. In general, the Walton report suggests a reduced use of signing on low volume roads. One pair of signs suggested for use on unpaved low volume rural roads carry the messages rural road and no signs. Other signs suggested are intended to reduce the necessity for repetitive warning of changes in horizontal alignment or restrictions in the opportunity for passing.

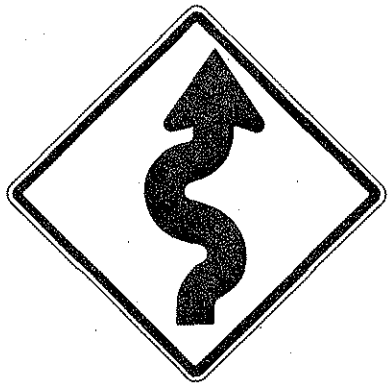
Melvin B. Larsen studied maintenance practices on secondary roads in Iowa in 1960 and again 20 years later [3,4]. In both instances, information on maintenance practices was determined by using a

questionnaire sent to County Engineers in Iowa. Of particular relevance to this research was Larsen's finding that the average number of signs currently in use was 3 per mile on unsurfaced roads and 6 per mile on loose-surfaced roads, up from 1 per mile and 2 per mile, respectively, in 1960. The average life of a sign reportedly is 8.5 years.

A manual addressing sign usage that is intended for use on low volume rural roads has been prepared for the Kansas Department of Transportation and the Kansas County Engineers Association [5]. The stated objective of this handbook is "to assist local government units in providing safe local roads for the traveling public." This objective is to be achieved by promoting "more consistent signing and marking of local roads, thus providing roads which better meet the expectancy of the drivers and are therefore safer." Although largely based upon the Manual on Uniform Traffic Control Devices (MUTCD), the handbook is intended to suggest additional guidelines for traffic control devices on low volume rural roads.

CHAPTER II. DATA ACQUISITION

Field Inventory of Signing Practices



The MUTCD sets forth only generally the conditions under which certain signs are to be used and provides details as to the design of signs. However, with relatively few exceptions, the MUTCD does not specify when or where a sign should be used. That decision is always to be made based on the results of an engineering study. Since engineers may differ in their interpretation of the results of a study, similar conditions at different locations do not always lead to the use of the same signs.

In fact, signing practices vary quite widely among jurisdictions. A physical inventory by research staff personnel was undertaken in order to define the range of current practices in Iowa relating to the use of traffic control devices on secondary roads carrying very low traffic volumes. The sample for this purpose included 21 counties that were selected using random numbers. A county was excluded if a Level B Service System had been designated in that county since designation of such a system implies that signs on the roads so defined would either be removed or not replaced. If a county was excluded for this reason, it was replaced by another randomly selected county until the total sample of 21 counties was constituted. These counties are shown in Figure 1.

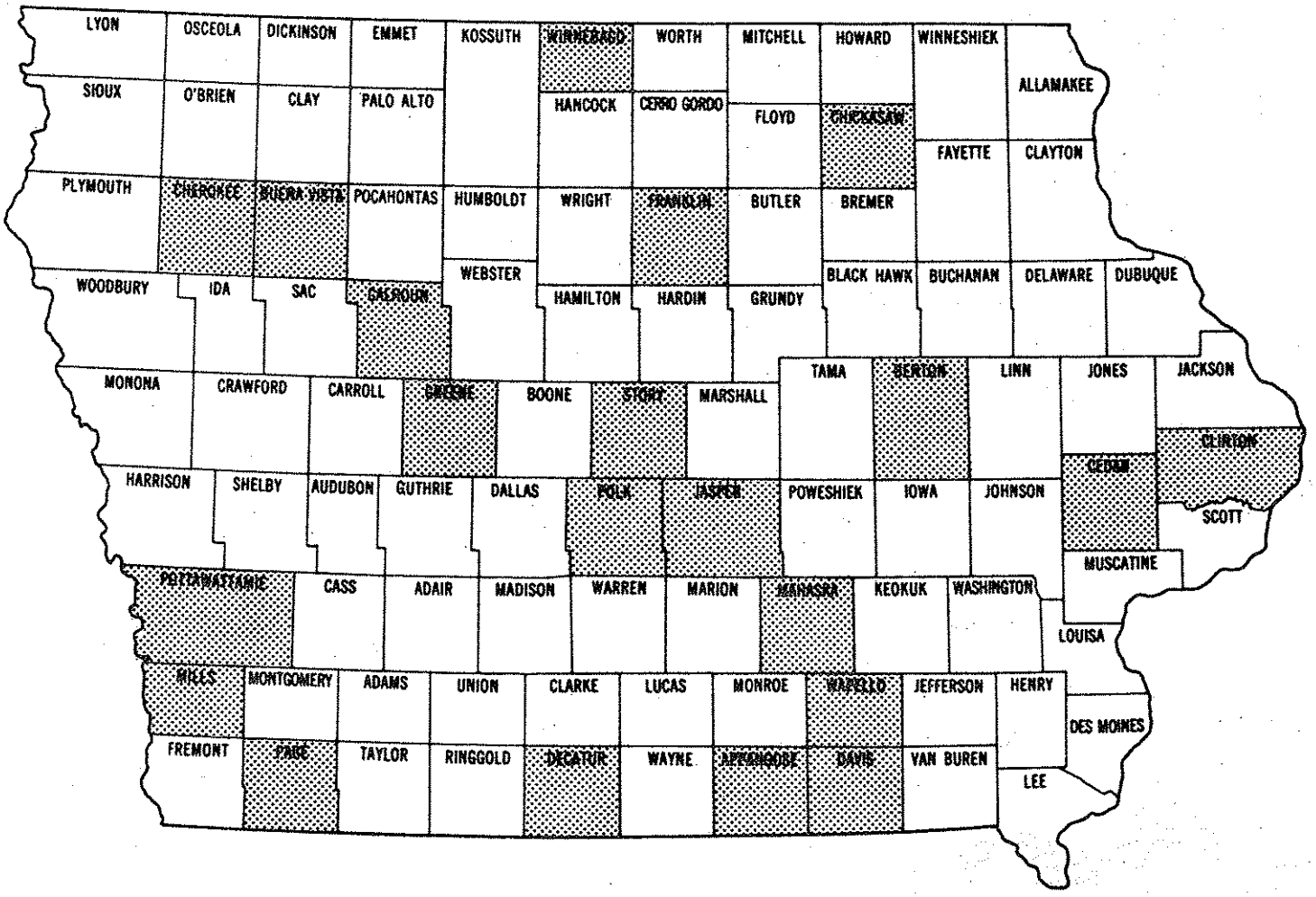


Fig. 1. Counties in which field inventory was carried out.

The next step was to identify the 11% of the secondary road system in each county that had the lowest volumes according to the latest Motor Vehicle Traffic Flow Map of a county (prepared by the Iowa Department of Transportation). This was the sample designated for an inventory of signs and markings. Not all of the roads designated for inventory were passable or were, in fact, open to traffic. The actual mileage of roads inventoried in each county and the range of recorded traffic volumes is displayed in Table 1. The form used in the field to record inventory information is shown in Appendix A.

In some counties, data obtained from the field inventory could be compared with a computerized inventory record of signs and markings on file in the county offices. A conclusion from this comparison was that the field data collection technique provided the required information relating to specific routes more accurately and more quickly than was possible by using a computer print-out from the existing inventory system. It should also be noted that the inventory data file covering secondary roads that is available from the Office of Transportation Inventory, Iowa Department of Transportation, does not include information concerning signs and markings.

Figures 2, 3, and 4 portray some of the roads included in the inventory sample.

Survey of Opinions of County Officials

Knowledgeable county officials were solicited for their opinions regarding the appropriate level of signing on rural roads carrying very

Table 1. Counties in which the field inventory was carried out.

County	Miles of Road	Volume Range, Vehicles per Day
Appanoose	82.0	0-10
Benton	125.2	0-15
Buena Vista	101.7	0-14
Calhoun	100.8	0-15
Cedar	98.5	0-15
Cherokee	101.8	0-12
Chickasaw	83.8	0-15
Clinton	103.5	5-20
Davis	85.7	0-10
Decatur	79.8	0-8
Franklin	108.5	0-15
Greene	102.5	0-13
Jasper	135.0	0-15
Mahaska	101.2	0-15
Mills	69.2	0-12
Page	102.5	0-10
Polk	85.5	0-30
Pottawattamie	155.7	0-14
Story	102.5	0-16
Wapello	68.0	0-15
Winnebago	75.6	0-15
Total	2,069.0	

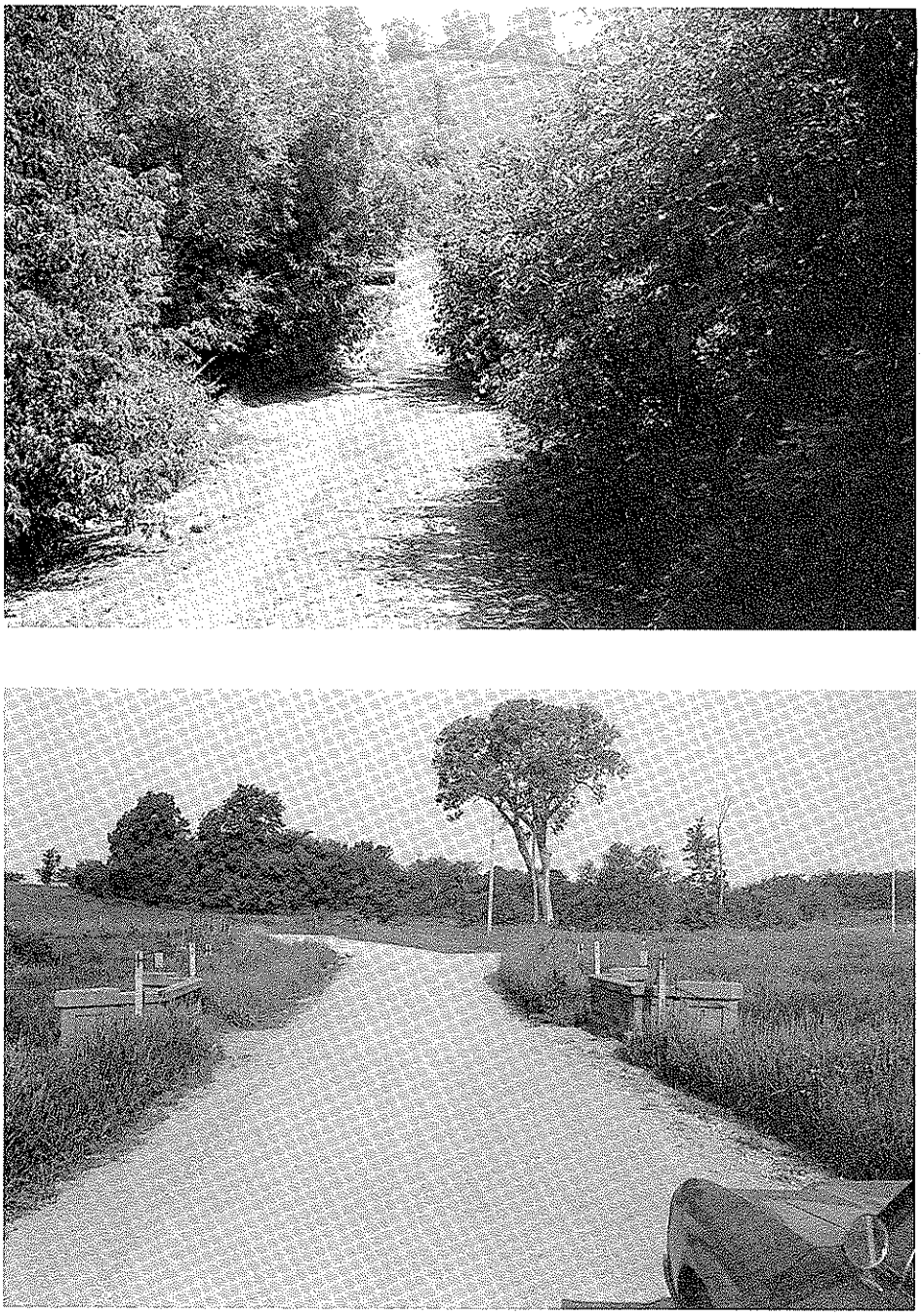


Fig. 2. Typical roads carrying very low traffic volumes.

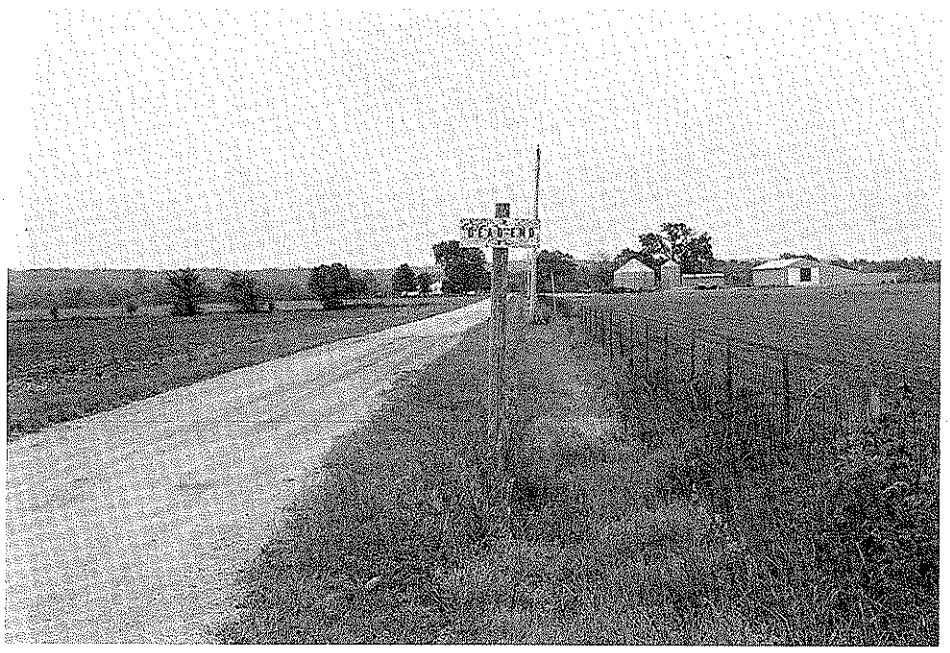


Fig. 2. (Continued).

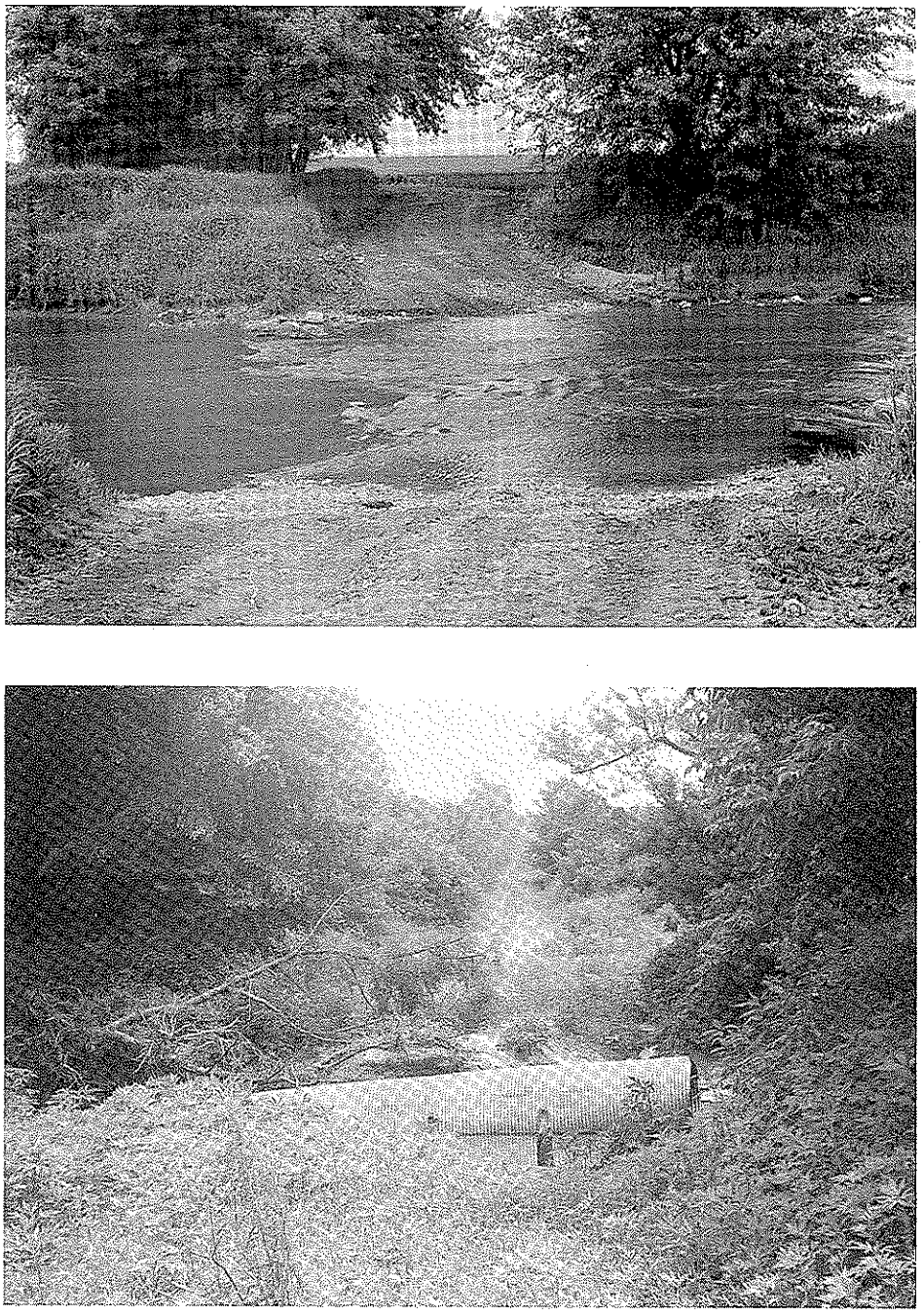
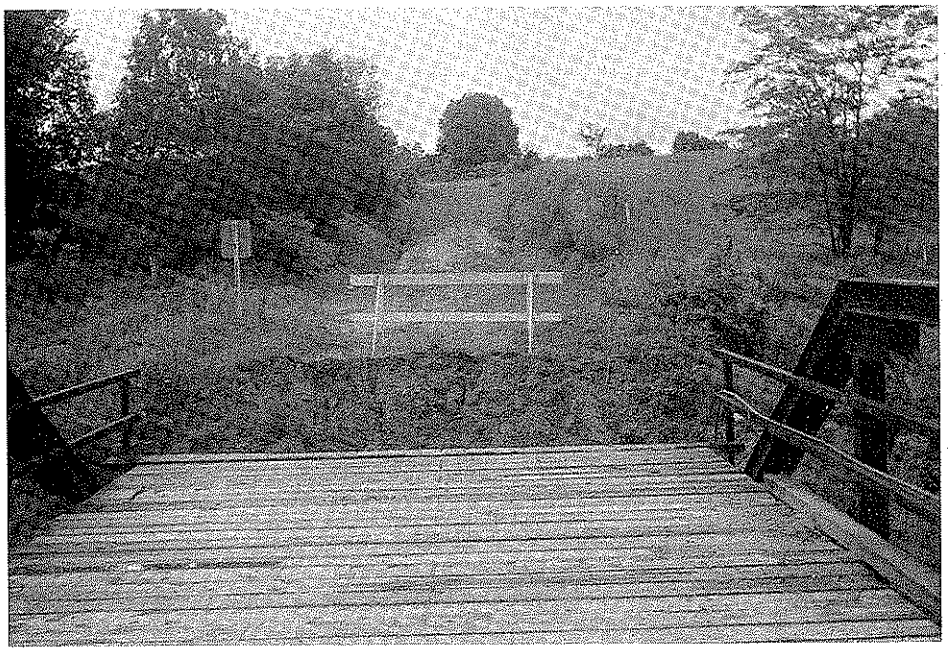


Fig. 3. Atypical roads carrying very low traffic volumes.



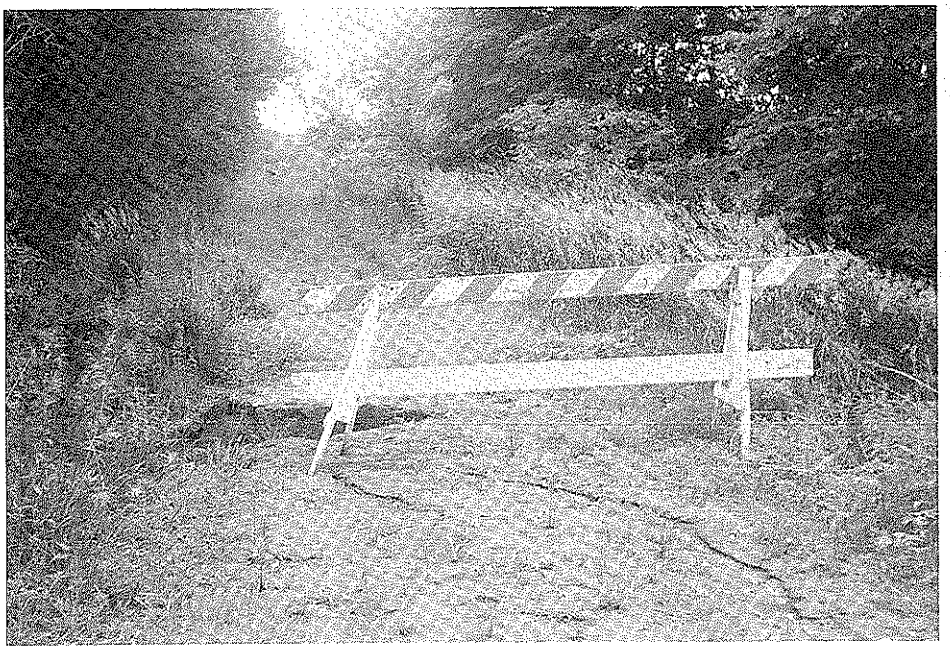


Fig. 3. (Continued).

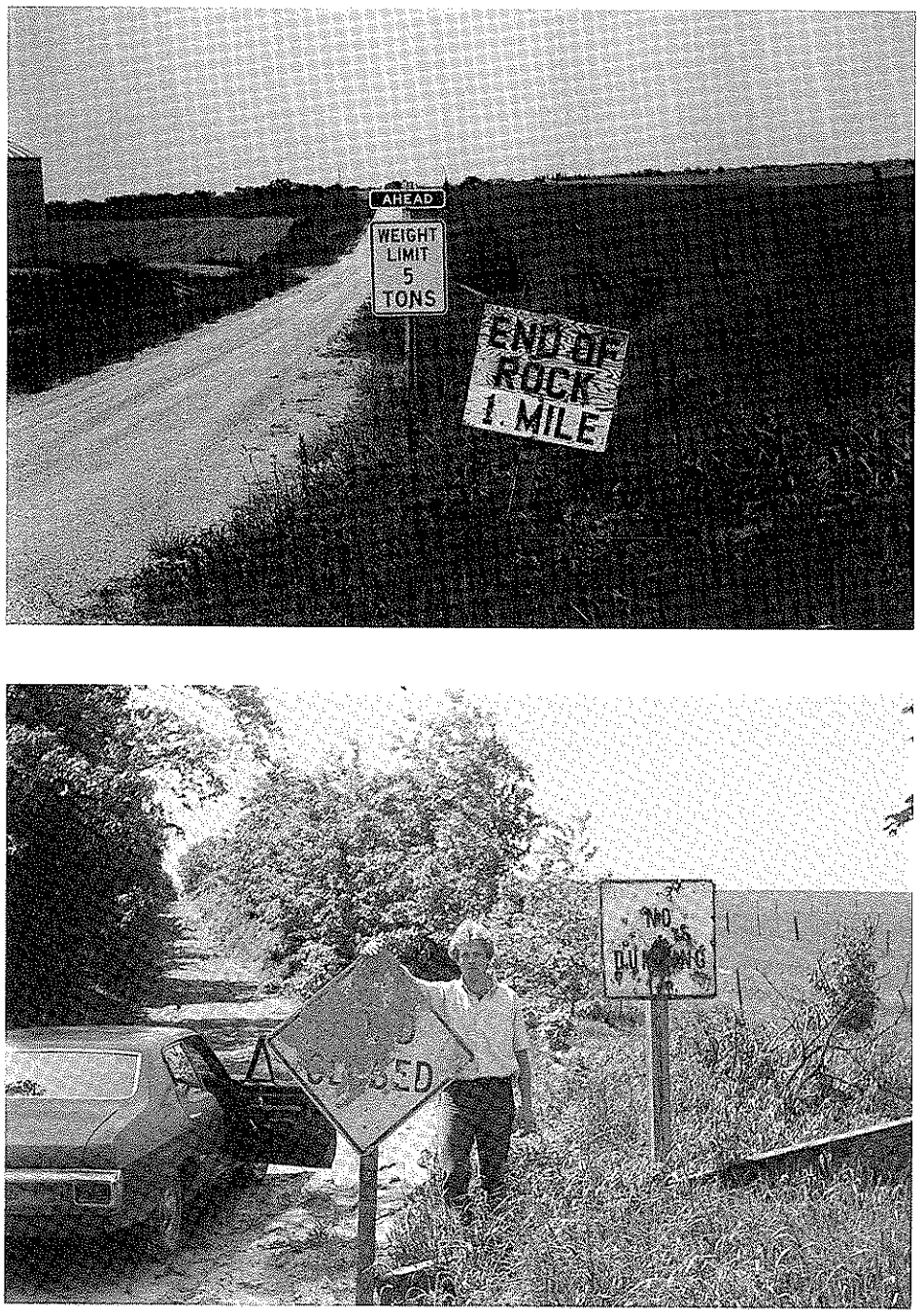


Fig. 4. Signs on roads carrying very low traffic volumes.

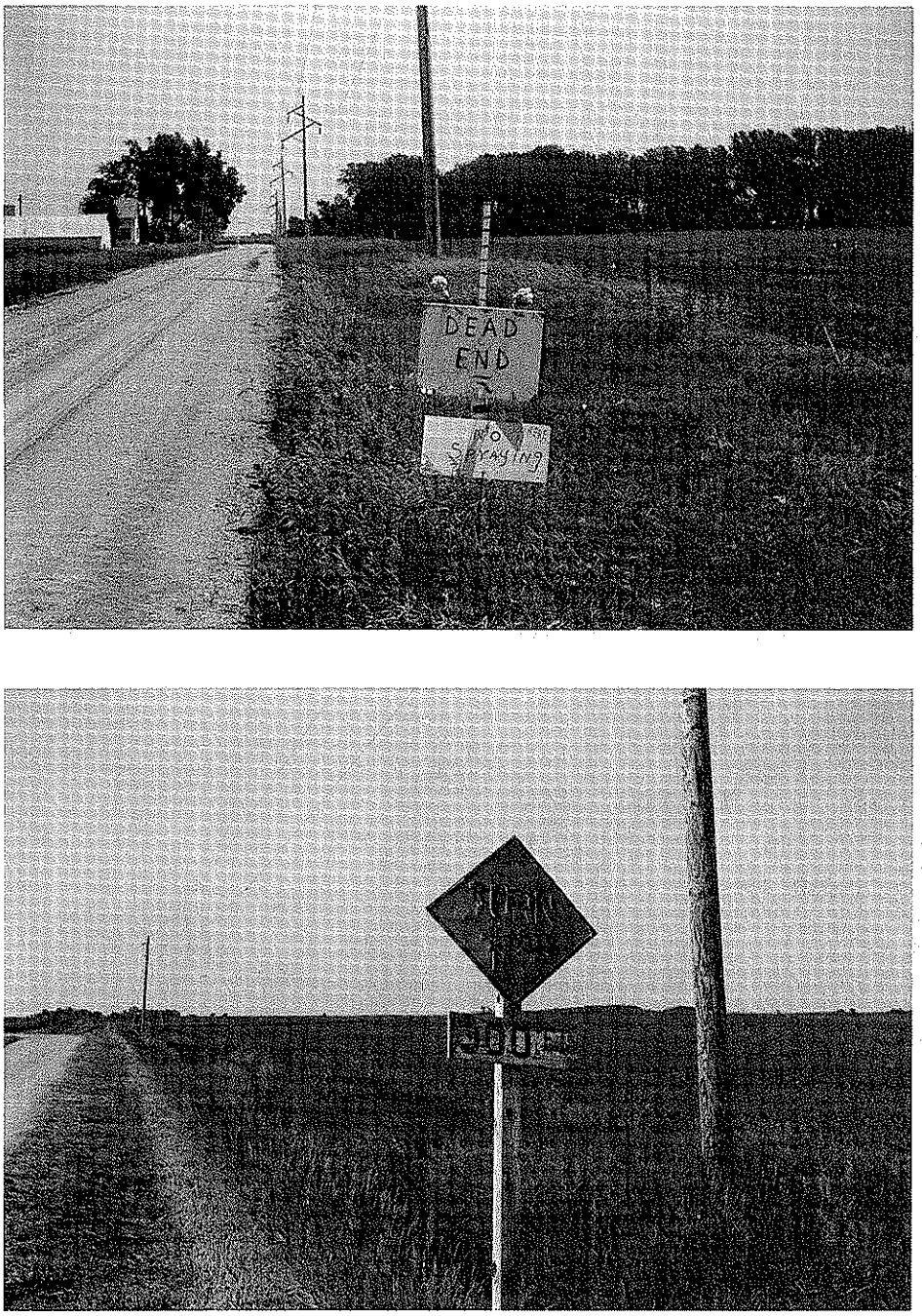


Fig. 4. (Continued).

low traffic volumes. Opinions were also solicited as to the appropriate sign for use in two situations where a variety of signs had been encountered in the field inventory. The county officials were asked whether they felt that signing should vary among roads in a county system based either on traffic volumes or surface type or both.

This survey was accomplished by directing a questionnaire to each County Engineer and to one Supervisor in each county. A copy of the questionnaire is included as Appendix B to this report.

Responses to the questionnaire were received from 93 of 99 County Engineers and from 49 County Supervisors.

CHAPTER III. ANALYSES

Practices Determined from Field Inventory

Some of the data determined from the field inventory are displayed in Tables 2, 3, 4, and 5. Many factors vary from county to county, such as terrain, available resources, and the pattern of the road system, so that direct comparison of one county with another is inappropriate. Consequently, the counties in these tables have been arranged in random order and the county names are not given.

The total number of signs per mile is displayed in Table 2. This total varied from 1.37 to 6.74 signs per mile in the 21 counties with a mean value of 3.19 signs per mile. The median value was 3.14 signs per mile. The number of warning signs per mile varied from 0.24 to 3.85. Also shown in Table 2 is the number of stop signs per mile. Most of the other signs included in the total number were those relating to bridge weight limitations and road terminations or closures. In addition, there were 2,807 markings counted, an average of 1.36 per mile. Most of these were hazard markers at bridges.

Tables 3, 4, and 5 report the usage of certain warning signs. Although use of none of these signs is mandatory according to the MUTCD, the extent of their use is believed indicative of a county's signing practices.

Table 2. Signs per mile on very low volume roads.

County	Stop Signs	Warning Signs	Total Signs
A	0.61	0.89	1.96
B	0.60	2.64	4.04
C	0.72	2.27	3.38
D	1.08	2.90	4.86
E	1.04	1.45	3.28
F	0.82	2.34	3.43
G	0.70	2.49	3.48
H	0.45	1.90	3.08
I	0.86	1.71	3.14
J	0.45	2.77	3.70
K	0.80	0.98	2.26
L	0.69	1.08	2.35
M	1.16	2.75	4.80
N	1.49	1.66	4.00
O	0.61	0.75	1.53
P	0.84	0.24	1.37
Q	1.22	3.85	6.74
R	0.91	0.93	3.13
S	0.53	0.85	1.51
T	1.28	0.26	1.88
U	0.91	0.98	3.00
Mean Value	0.85	1.70	3.19

Table 3. Proportion of stop signs with stop ahead signs.

County	Number of Stop Signs	Stop Ahead Signs		
		Word	Symbol	Total
A	62	8	0	8
B	59	11	17	28
C	75	32	1	33
D	92	37	44	81
E	107	14	0	14
F	69	7	19	26
G	88	61	13	74
H	49	25	12	37
I	87	17	16	33
J	46	46	0	46
K	81	38	0	38
L	70	27	4	31
M	181	45	0	45
N	103	18	6	24
O	46	7	0	7
P	67	2	0	2
Q	164	67	16	83
R	75	11	0	11
S	54	3	0	3
T	87	2	0	2
U	78	20	0	20
Total	1,740	498	148	646

Table 4. Proportion of T intersections with large arrow signs.

County	Number of T Intersections	Large Arrow Sign Used With				
		Stop Sign	T-Symbol Sign	No Sign	Both Stop and T-Symbol Sign	Total
A	103	0	2	4	2	8
B	79	15	23	19	6	63
C	88	15	12	40	0	67
D	65	11	23	4	2	40
E	87	32	8	28	0	68
F	74	12	26	5	3	46
G	70	10	47	1	2	60
H	62	7	24	15	0	46
I	32	4	16	6	1	27
J	55	5	40	3	0	48
K	31	10	5	6	0	21
L	32	5	0	7	0	12
M	128	47	24	8	0	79
N	59	3	0	0	0	3
O	23	2	10	1	2	15
P	72	1	0	0	0	1
Q	107	10	36	1	0	47
R	70	4	0	1	0	5
S	71	6	6	39	0	51
T	66	1	0	0	0	1
U	74	2	0	1	0	3
Total	1,448	202	302	189	18	711

Table 5. Proportion of curve signs or turn signs with advisory speed plates and large arrow signs.

County	Number of Signs		Curve Sign With		Turn Sign With	
	Curve	Turn	Advisory Speed Plate	Large Arrow Sign	Advisory Speed Plate	Large Arrow Sign
A	2	1	0	0	0	0
B	2	24	0	0	0	0
C	16	25	0	0	0	10
D	20	8	0	0	0	1
E	3	4	0	2	0	4
F	8	10	0	0	0	7
G	18	17	0	0	0	3
H	9	13	1	0	0	11
I	20	14	0	0	0	0
J	18	17	0	4	0	17
K	0	2	0	0	0	0
L	0	1	0	0	0	0
M	16	38	7	0	31	6
N	10	9	0	0	0	1
O	4	2	0	0	0	0
P	0	1	0	0	0	0
Q	22	65	0	0	1	16
R	73	5	0	1	0	0
S	2	5	0	0	0	0
T	1	0	0	0	0	0
U	3	4	2	0	3	0
Total	247	265	10	7	35	76

The use of stop ahead signs is displayed in Table 3. As indicated, the usage per county varies from 2.3% to 100%. Overall, 37% of the stop signs in the 21 counties were preceded by a stop ahead sign.

A large (double) arrow sign is sometimes used opposite the stem of the T at a T intersection. As shown in Table 4, this usage was followed at 49% of the T intersections encountered on very low volume roads in the 21 counties. Usage per county varied from 1.4% to over 87%.

The usage of advisory speed plates and large (single) arrow signs with curve and turn advance warning signs is displayed in Table 5. None of these signs was encountered in 10 of the 21 counties. Overall, an advisory speed plate was used with 4% of the curve signs and 13% of the turn signs, but use was limited to 4 counties. Eleven counties used the large (single) arrow sign. This sign followed 3% of the curve signs and 29% of the turn signs that were encountered. What these data do not indicate is the frequency of use of any warning sign with a change in horizontal alignment. The number of curve or turn signs encountered varied from 0.01 per mile to 0.95 per mile. The median value was 0.21 curve or turn signs per mile. These differences are accounted for partly by the fact that the pattern of roads tends to be quite regular (hence, straight) in some counties and very irregular (not straight) in other counties. However, this range of values also reflects considerable variation in the extent to which any sign is used to warn of a change in horizontal alignment on roads carrying very low volumes.

Of the 6,954 signs listed in the inventory, 4,768 (69%) were categorized as being in either good or fair condition. The others were listed as being in poor condition or vandalized. There were 2,807 markers listed. Of these, 2,311 (82%) were in good or fair condition.

As previously indicated, considerable variation was encountered in usage at dead-end roads. Table 6 summarizes this practice in all 21 counties.

Opinions Relating to Signing Versus Volume Level

An objective of the survey of knowledgeable county officials was to determine their opinions relative to the appropriate variation of levels of signing among roads with different surface types and traffic volumes. A summary of these opinions is provided in Table 7.

As indicated in Table 7, 109 (77%) of the 141 respondents who answered this question believed that the elaborateness of signing should vary among the roads in a county system. The other 32 believed that all roads should receive the same treatment regardless of surface type or traffic volume. Including 67 (48%) respondents who expressed the opinion that both surface type and traffic volume were relevant in this regard, 101 (72%) county officials felt that surface type was relevant and 75 felt (53%) that traffic volume was a relevant consideration.

Among respondents who felt that signing levels should vary by traffic volume, 30 (40%) expressed the belief that this variation should be a continuum. These officials suggested volume levels varying from

Table 6. Summary of usage at dead end roads.

Sign(s)	Number Encountered
W14-1, dead end warning sign, only	365
W14-1 and barricade	77
R11-2, road closed warning sign, only	13
R11-2 and barricade	12
R11-2 and W14-1	8
R11-2, W14-1, and barricade	3
Barricade only	29
No sign or barricade	257
Total	764

Table 7. Opinions regarding the elaborateness of signing on county roads.

County Official	Variation by Surface Type Only		Variation by Traffic Volume Only			Variation by Surface Type and Traffic Volume			Same Level	Not Answered	Total
	Two Levels	Three Levels	Two Levels	Three Levels	Continuum	Two Levels	Three Levels	Continuum			
Engineer	6	14	2	2	0	18	11	15	24	1	93
Supervisor	6	8	3	1	0	6	2	15	8	0	49
Subtotal	12	22	5	3	0	24	13	30			
Total	34		8			67			32	1	142

below 10 vehicles per day (vpd) up to 60 vpd for the volume below which there should be a minimum use of warning signs. The median volume suggested was 25 vpd. Nearly as many respondents, 29 (39%), felt that there should be two levels of signing, those carrying over 25 vpd (the median response) having the more elaborate level of signing. The other 16 respondents (21%) felt that there should be three levels of signing with median values of 20 vpd as an upper limit for roads with the lowest level of signing and a lower limit of 100 vpd for the most elaborately signed roads. The responses relating to traffic volumes are summarized in Table 8. Those responses relevant to establishing an upper limit for a lowest level of signing are graphically portrayed in Figure 5.

Opinions Relating to the Use of Specific Signs

The questionnaire sent to county officials included a sketch of a short road segment carrying 15 vpd for which the respondents were asked to answer yes or no as to whether they would use various signs indicated on the sketch. The sketch is shown in Appendix B and responses to the survey are presented in Table 9.

A majority of respondents stated that they would use the turn sign, the two curve signs, the large (double) arrow at the T intersection, and the stop ahead sign. Most also suggested use of the narrow bridge sign, although a number of County Engineers stated that they would substitute a one lane bridge sign. Fewer than half of the respondents elected to use either of the two large (single) arrows or the three speed advisory plates. A number of County Engineers stated that their

Table 8. Opinions as to traffic volumes associated with the elaborateness of signing.

Signing Levels	Volume Level	Traffic Volume (Vehicles per Day)												
		Fewer than 10	10	15	20	25	30	50	60	75	100	Over 100	Not Answered	Total
Continuum	Below	1	5	3	4	9	3	4	1	0	0	0	0	30
Two levels	Above	0	3	2	7	5	2	5	1	0	0	2	2	29
Three Levels	Below	0	3	3	2	6	0	1	0	0	0	0	1	16
	Above	0	0	0	0	0	2	3	0	2	6	2	1	16

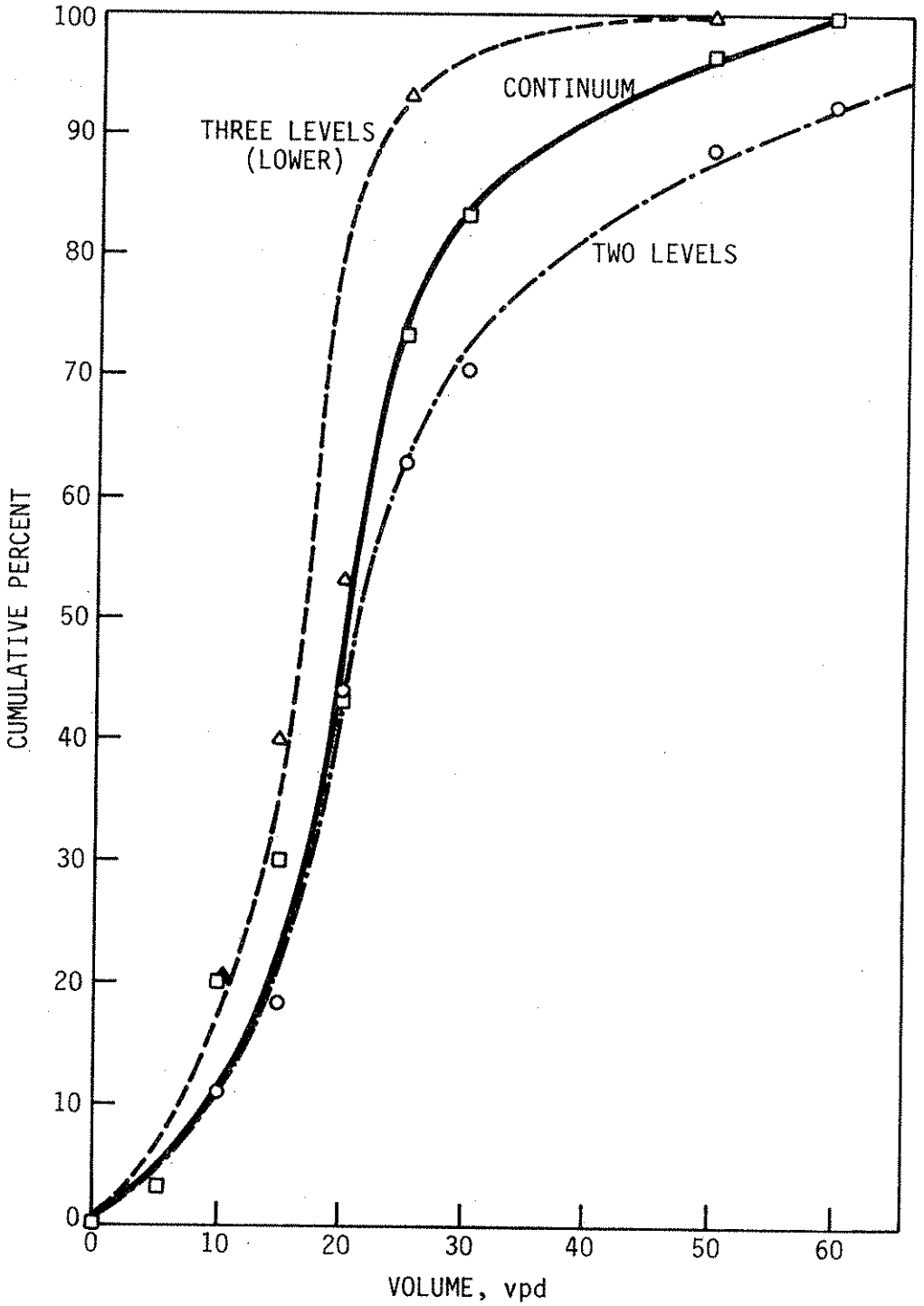


Fig. 5. Opinions as to traffic volumes associated with the elaborateness of signing.

Table 9. Responses to survey of sign usage on a very low volume rural road.

Sign	County Engineer				Supervisor			
	Yes	No	Sometimes	No Response	Yes	No	Sometimes	No Response
Large arrow (double)	76	16	0	1	33	5	0	11
Stop ahead	70	12	10	1	41	4	0	4
Curve	69	23	0	1	33	13	0	3
Advisory speed plate (55 mph)	4	86	0	3	9	35	0	5
Large arrow (single) (after turn)	29	59	2	3	20	26	0	3
Large arrow (single) (after curve)	17	72	1	3	14	32	0	3
Narrow bridge	66	5	20	2	43	3	1	2
Turn	78	14	0	1	36	9	1	3
Advisory speed (25 mph)	33	54	3	3	20	23	0	6
Curve	74	17	1	1	33	12	0	4
Advisory speed (40 mph)	24	64	3	2	11	30	1	7

Survey responses were received from 93 County Engineers and 49 Supervisors.

use of the stop ahead sign would depend upon the sight distance available, a practice suggested by the MUTCD.

Responses to questions regarding the most appropriate sign messages for two specific situations are summarized in Tables 10 and 11. The variety of responses parallels the conditions found during the field inventory where a wide range of sign messages was encountered. As indicated in Table 10 nearly half of the respondents suggested use of sign reading either gravel ends or rock ends, depending upon local usage, for warning that a granular surface is to end and that the road that follows will be unsurfaced. About 30% of those respondents would also use a supplemental message including the distance to this change in surfacing. The responses summarized in Table 11 indicate a clear preference for the dead end warning sign where a road ends without a public road outlet.

Analysis of Volumes on Trunk Collector System

In addition to the traffic volume and surface type, the functional classification of a road is indicative of the number of through trips and average trip lengths on a facility. Roads functionally classified as trunk or trunk collector roads constitute the farm-to-market system of the state. These roads would be expected to justify a higher level of traffic service than roads classified as local or area service roads. Hence, an analysis of the traffic volumes on rural roads that were functionally clasified as trunk collectors was undertaken . The presumption inherent in this analysis was that roads so classified

Table 10. Sign messages for a gravel or crushed stone surface that ends and is followed by a dirt road.

Sign Message	County Engineer	Supervisor	Total
Gravel Ends	21	7	28
Dirt Road Ahead	12	5	17
Rock Ends	11	4	15
Surfacing Ends	8	3	11
Gravel Ends (Distance)	8	3	11
Dirt Road	5	3	8
Rock Ends (Distance)	5	2	7
Rock Surface Ends	3	3	6
Unimproved Road	4	1	5
Rock Ends Ahead	3	2	5
Unimproved Road Ahead	1	3	4
Surfaced Road Ends	1	1	2
Rock Road Ends	1	1	2
Surface Ends	1	0	1
Surface Ends Ahead	1	0	1
End of Surfacing	1	0	1
Unsurfaced Road Ahead	1	0	1
Gravel Ends Ahead	1	0	1
Granular Surface Ends	1	0	1
Road Narrows	1	0	1
No Thru Gravel	0	1	1
Hard Surface Ends	0	1	1
Total[a]	90	40	130

[a]Some county officials suggested more than one message.

Table 11. Sign messages for a road that ends without a public road outlet.

Sign Message	County Engineer	Supervisor	Total
Dead End	75	32	107
Dead End Road	8	2	10
Road Ends	5	3	8
No Outlet	5	2	7
Road Ends (Distance)	2	0	2
Not Thru Road	1	1	2
Road Dead Ends	1	0	1
Private Road	1	0	1
End of Public Road	0	1	1
Dead End Private Property Ahead	0	1	1
Total[a]	98	42	140

[a]Some county officials suggested more than one message.

would have traffic volumes high enough that they could not properly be categorized as having very low traffic volumes.

The sample used for this purpose consisted of the same 21 counties in which the field inventory had been conducted. There were 3,720.45 miles of trunk collector roads in these counties. A breakdown by volume groups is provided in Table 12. A cumulative frequency plot of this breakdown is presented in Figure 6.

Prediction of Accident Rates

The Iowa Department of Transportation makes annual estimates of vehicle-miles of travel and accident totals available by county. An accident rate can be calculated from these data. Combining the accidents and vehicle-miles of travel for 1981 and 1982, the average rate for all counties was 2.76 accidents per million vehicle-miles (MVM). Individual counties varied from 1.43 to 5.03 accidents per MVM. An effort was undertaken to explain, at least in part, this considerable difference in the accident rates among counties. If this effort was successful, it might then be possible to evaluate the effect of signing practices on the accident rate.

The process used for this purpose was regression analysis, a mathematical technique by which the relationships between a dependent variable and any number of independent variables can be quantified and evaluated. This relationship can be quantified by adding or multiplying terms that include those independent variables that are found to have a significant effect in explaining the variation among values

Table 12. Breakdown by volume of trunk collector system in 21 counties.

Volume Range, vpd	Miles	Percent of Total	Cumulative Percent
0-9	14.0	0.4	0.4
10-24	199.2	5.4	5.7
25-49	1,049.85	28.2	33.9
50-99	1,448.1	38.9	72.9
100-149	476.25	12.8	85.7
150-199	217.85	5.9	91.5
200-249	112.1	3.0	94.5
250-299	69.25	1.9	96.4
300 and over	133.85	3.6	100.0
Total	3,720.45		

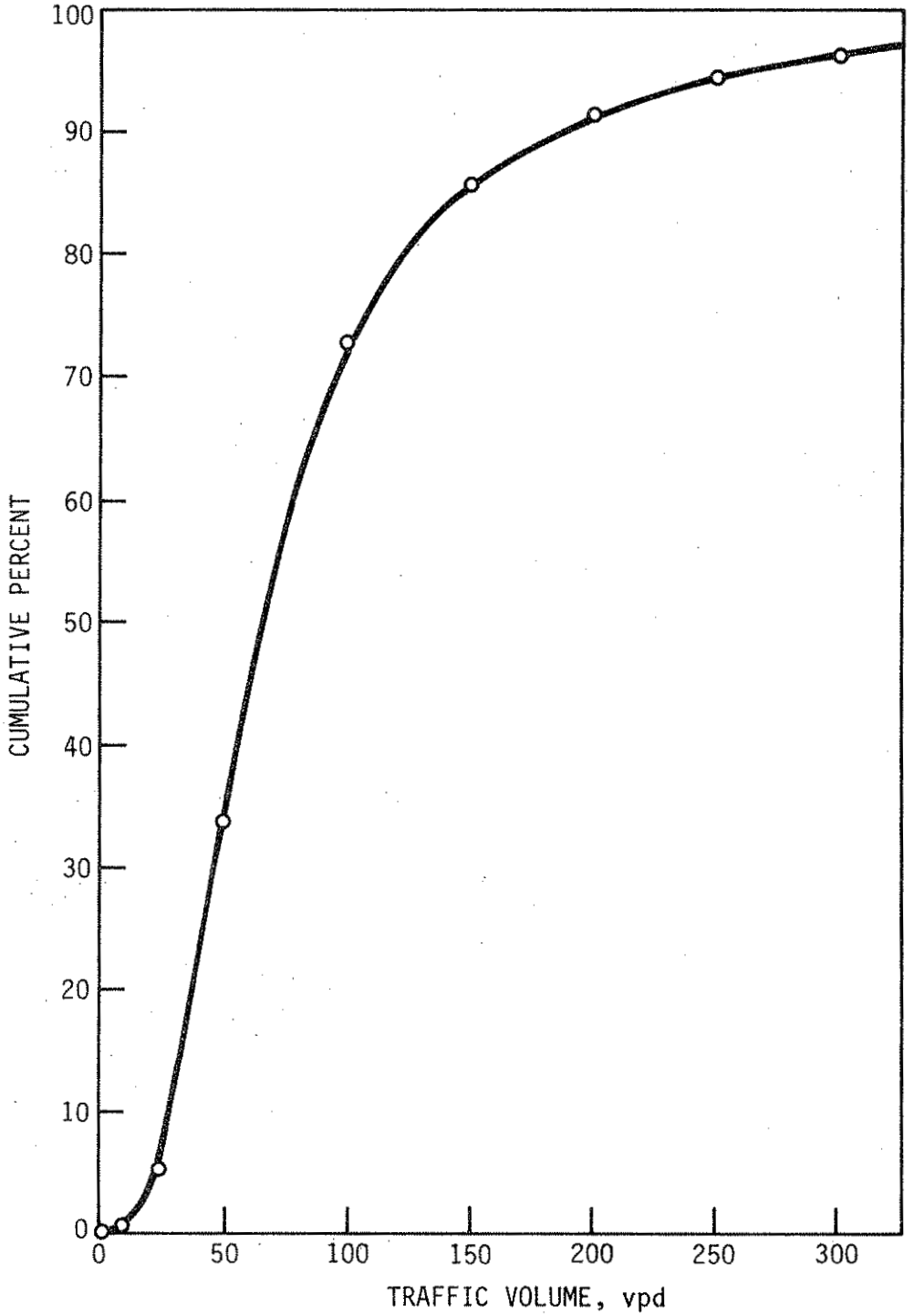


Fig. 6. Cumulative frequency of volumes on trunk collector sample.

for the dependent variable. Terms including the independent variables can be expressed in linear or nonlinear (exponential) form.

Using a data base including all 99 counties in Iowa, a number of models were developed to predict accident rates by county. The independent variables that were tested for inclusion in such a model are shown in Table 13. Also shown in Table 13 are minimum, maximum, and mean values for each candidate independent variable as well as for ACCIDENT, the dependent variable, expressed as a rate in accidents per MVM.

A linear model using these variables was developed as follows:

$$\text{ACCIDENT} = 4.31 + 0.0000489(\text{RPOP}) - 0.000797(\text{TMILE}) - 0.000695(\text{LAND}) + 0.515(\text{D2})$$

All independent variables were significant at the 0.05 confidence level. However, this model explained only 46% ($R^2 = 0.457$) of the variation among accident rates by county. Nonlinear forms had essentially the same explanatory capabilities. These models were substantially lacking in the ability to explain the extremes of accident rates that have actually occurred in different counties.

Table 13. Variables tested for inclusion in explanatory model.

Symbol	Variable	99 Counties	
		Range	Mean
ACCIDENT	Accident rate, 1981-1982, accidents/MVM	1.43-5.03	2.76
TPOP	Total county population, 1980	5,731-303,170	29,432
RPOP	Rural county population, 1980	4,862-30,652	12,178
TMILE	Total miles of secondary roads in county	552.7-1,674.1	912.8
EMILE	Miles of unsurfaced road in county	2.7-543.3	63.4
DOLLAR	Amount spent for signs, 1982, $	2,627-168,076	29,521
LAND	Average value of farm land, 1982, $	922-3,484	2,149
LAT	Latitude of county seat minus 40 degrees	0.4-3.2	1.86
D1	Dummy variable for rolling terrain	0-1	0.60
D2	Dummy variable for hilly terrain	0-1	0.15

CHAPTER IV. CONCLUSIONS AND RECOMMENDATIONS

The objective of this research was to assist County Engineers in making decisions regarding the use of signs on rural roads carrying very low traffic volumes. Guide signs are used infrequently on roads of this nature. The use of a regulatory sign becomes mandatory once a Board of Supervisors has resolved or ordained that a traffic regulation is to be implemented and a sign is required for its implementation. Hence, the discretion available in respect to signing on very low volume rural roads relates almost exclusively to the use of warning signs.

In respect to the use of warning signs, the MUTCD is interpreted differently by different people. An interpretation occasionally urged, particularly in litigation, is that Part 2C of the MUTCD mandates or requires the use of certain warning signs. This part actually includes a listing of "locations and hazards that may warrant the use of warning signs" (emphasis added). General information on the design and placement of warning signs follows. Detailed specifications are presented on several specific warning signs that are intended for the purposes indicated when and if a need for their use has been established. No requirement for use of any warning sign is included in Part 2C of the MUTCD.

The question then arises as to when warning signs should be used. The MUTCD provides the answer. Section 1A-4 states that "the decision to use a particular device at a particular location should be made on

the basis of an engineering study of the location." This section continues with the admonition that "the Manual is not a substitute for engineering judgment." Since the criteria for demonstrating need for most warning signs are entirely subjective, the engineering study required to determine the need for a particular sign becomes almost entirely a matter of exercising judgment.

Conclusions

Upper Limit for Defining Roads Carrying Very Low Volumes

Most county officials responding to the survey were in agreement that less elaborate signing is justified on roads that are not paved and carry very low volumes of traffic. As indicated in Figure 5, most respondents to the opinion survey felt that roads carrying fewer than 25 vpd should have less elaborate signing than roads with higher volumes. The suitability of this volume limit is further suggested by the fact that over 94% of the rural roads in the trunk collector system carry volumes of 25 vpd or more. Roads carrying volumes of up to 24 vpd are almost exclusively area service roads that are used for relatively short trips.

Consequently, it is concluded that less elaborate signing should be used on unpaved roads carrying fewer than 25 vpd as indicated on the latest Traffic Flow Map prepared by the Iowa Department of Transportation. There were 21,936 miles of unpaved rural roads carrying 0 to 24 vpd in 1982--24.3% of the total 90,306 miles of secondary roads

in Iowa. These roads carried less than 3.0% of the total vehicle-miles of travel on secondary roads in the state in 1982.

Level of Signing for Roads Carrying Very Low Traffic Volumes

The most obvious fact developed from the inventory of signing is the absence of uniformity of application of signs on roads carrying very low traffic volumes. Despite the fact that the number of signs in use on very low volume roads is 3 times the number in use in 1960, the number of opportunities for use of signs is substantially greater than the number of signs. This is demonstrated in Tables 3, 4, and 5. The data in these tables and Table 2 demonstrate a considerable variation in the interpretation of need for signs on very low volume roads. It is not possible to determine from the data in these tables the extent to which conditions that provide the opportunity for use of a particular sign are similar. However, these data suggest that many similar conditions are signed differently among counties and within the same county.

The considerable divergence of opinions expressed in response to the opinion survey further suggests that signing practices are not uniform among counties. A comparison of use of certain signs in Tables 3, 4, and 5 with the survey responses in Table 9 also suggests that county officials may intend to use more signs than are in fact in place. For example, 76% of the respondents to the opinion survey indicated that they would use a large (double) arrow at a T intersection. This sign was actually used 49% of the time according to the field inventory data.

It is apparent that there is no single level of signing on secondary roads in Iowa that typifies generally accepted engineering practice. This is in spite of the fact that recent trends in tort liability court decisions and the admonitions of the MUTCD emphasize the importance of uniformity. Section 2A-4 of the MUTCD states that "identical conditions should always be marked with the same type of sign." In practice, actual conditions rarely are identical. Yet, the decisions in several liability cases involving counties have suggested that, in the interest of uniformity, not using certain signs is preferable to the situation where warning signs have been used at some locations and the same signs have not been used at other similar locations. However, signing practices vary so widely among counties that there is no reasonable expectation that such divergent points of view will ever be manifested by the uniform application of signs on county roads in Iowa.

What kinds of hazards properly justify the use of warning signs? For this consideration, a hazard is defined as "any object, condition, or situation which, when the driver fails to respond successfully, tends to produce a catastrophic system failure" [6]. It is evident that a certain degree of hazard is associated with every element of a roadway. Use of a warning sign is suggested when the degree of hazard becomes unacceptable, when the absence of a sign would increase the probability of an accident (the catastrophic system failure alluded to above). This situation will arise when the conditions encountered deviate from the expectations of a driver.

On paved rural highways with operating speeds typically about 55 mph, several geometric or control situations possess the potential

to deviate from driver expectations. Examples are changes in horizontal alignment or stop signs. These two conditions suggest the use of curve signs or stop ahead signs, respectively. The use of a speed advisory plate with a curve sign probably would be appropriate.

Operating speeds on loose-surfaced roads are typically lower than on paved highways. Average speeds on straight, level sections of loose-surfaced roads were found in some recent research to be approximately 43 mph [7]. Driver expectations would differ corresponding to the lower speed and the loose surface. While a curve sign or a stop ahead sign might be used, the need for these signs would be significantly less than on a paved road. Need for a speed advisory plate with a curve sign on a loose-surfaced road probably could not be demonstrated.

On a loose-surfaced or unsurfaced road carrying very low volumes, the operating speed is likely to be even lower. The geometric and surface conditions of such a road often do not permit safe operations at speeds above 35 or 40 mph. Driver expectancies are reduced accordingly. Very few drivers who are unfamiliar with the conditions are likely to find their way onto such roads. Therefore, it is the conclusion of this research that need for warning signs on roads of this nature rarely can be demonstrated.

Usage of Specific Signs on Rural Roads

A number of different signs were encountered at dead end roads during the field inventory, as displayed in Table 6. The most appropriate sign for this purpose is the dead end warning sign (W14-1). As indicated in Table 11, over 70% of the respondents to the opinion survey recommended use of this sign. The MUTCD suggests that the no

outlet sign is a suitable alternative. If there is no alternative vehicle path and if need for such a marking can be demonstrated, the most suitable device for placement at the end of a road is the end of roadway marker covered in Section 3C-4 of the MUTCD.

The largest number of respondents to the opinion survey favored use of a warning sign reading gravel ends (or rock ends) to indicate a change from a surfaced to an unsurfaced road. Where appropriate, a supplemental distance message may be used, as suggested by several respondents. Many other respondents suggested a message that conveyed the same idea but included extraneous words. The most suitable message for this purpose includes only two words, either gravel ends or rock ends depending upon how county officials generally refer to their granular surfaced roads.

The proportion of use of the several signs included on the example road segment as part of the opinion survey paralleled the actual use of these signs. However, the rate of usage was lower as encountered by the field inventory than was suggested by survey respondents. The bridge in this example was described as 16 ft wide so that a narrow bridge sign would be appropriate. Both approaches in the example had about 150 ft of tangent following a curve. According to the MUTCD, the one lane bridge sign would be more appropriate than the narrow bridge sign only if this alignment was considered to be poor.

Recommendations

Although the need for warning signs rarely can be demonstrated, certain signs should be used on unpaved roads carrying very low traffic volumes. Stop signs, signs informing the public of bridge load restrictions, and other regulatory signs are required on very low volume rural roads. Use of railroad advance warning signs (W10-1, used in conjunction with standard crossbucks, R15-1) is made mandatory by the MUTCD. Signs at low water stream crossings fulfill an essential safety need and dead end signs (W14-1) provide a desirable service to unfamiliar drivers.

However, at least two considerations inhibit the substantial elimination of warning signs on roads carrying very low traffic volumes. In the absence of some informational signing, not all drivers might be aware that they are on roads carrying fewer than 25 vpd. The expectations of these drivers could include a level of sign use that was encountered on higher volume roads that might present a similar appearance.

The second consideration is that of liability. Recent trends in Iowa suggest that, in the absence of information advising of a change in signing practice, the lack of demonstrated need for a warning sign would be an insufficient defense if the failure to use such a sign was the basis for an allegation of negligence against a county.

The Code of Iowa provides an alternative that will overcome both of these objections. Counties are able to designate an Area Service Level B system that can have a lesser level of maintenance and signing. It is recommended that each county establish an Area Service Level B

system. All unpaved rural roads carrying volumes of fewer than 25 vpd should be considered for inclusion in such a system.

It is recognized that considerations of system continuity and other factors (such as the presence of residences on a given road segment) will preclude the inclusion of some segments carrying very low traffic volumes in an Area Service Level B system. However, most road segments carrying fewer than 25 vpd would be appropriate as components of such a system.

The extreme variability in signing practices among counties in Iowa suggests that a manual or handbook presenting signing standards for secondary roads might be helpful. However, this same variability suggests that there is little likelihood that counties having vastly disparate philosophies concerning signing practices could agree as to what level of signing should be standard. The result probably would be a set of minimum standards that would not differ materially from those already set forth in the MUTCD. Consequently, no effort is recommended at this time to develop a manual or handbook specifically covering signing practices on low volume roads in Iowa.

Discussion of Recommendations

Using mean values obtained from the inventory of signs on roads carrying very low traffic volumes, the nearly 22,000 miles of unpaved rural secondary roads with volumes from 0 to 24 vpd would have about 70,000 signs, including over 37,000 warning signs. An average county

would have about 220 miles of such roads with over 700 signs including about 375 warning signs.

However, additional signing is required to warn motorists upon entering a road segment that has a lesser level of maintenance and signing than other public roads. The number of signs required is such that many counties will experience an increase in the number of signs along roads designated as part of an Area Service Level B system. Hence, savings resulting from a reduction in the use of signs are not likely to be realized. However, designation of an Area Service Level B system will reduce maintenance expenditures on roads that are part of such a system. The use of these funds to upgrade traffic control on other roads carrying higher traffic volumes or to improve the general conditions of maintenance on a county road system would have a more beneficial effect on highway safety than installing and maintaining warning signs on roads carrying very low traffic volumes.

A recommendation to reduce the use of warning signs on roads designated a part of an Area Service Level B system is made only because their elimination is not expected to exert any discernible effect on the frequency of occurrence of accidents on these roads. Inherent in this expectation is a presumption that drivers on such roads, at least those who reasonably can be expected to perceive and react to warning signs, are able to recognize the geometric limitations in roads that carry very low volumes and will travel at speeds that are reasonable and prudent for the conditions that exist.

Also relevant in this regard is the extremely small number of accidents that occur on roads carrying very low traffic volumes. The

accident rate on all secondary roads in Iowa in 1982 was 2.33 accidents per million vehicle miles, including accidents occurring at intersections. This rate probably does not vary significantly on different types of roads in a county system. The average volume on all roads in the state with fewer than 24 vehicles per day in 1982 was slightly less than 14 vpd. Based on this average volume and the average accident rate, a typical road section one-mile long would experience an accident every 84 years. With little expectation that this will change significantly with more or fewer signs, the current investment in signs on roads carrying very low traffic volumes does not seem justified.

Comments on the Draft Report

Members of the Iowa Highway Research Board were asked to comment upon a Draft Report. These comments have been considered and most have been incorporated into this report. However, some have not been directly addressed but need to be recognized.

Several members of the Board objected that the roads portrayed in Figures 2, 3, and 4 present a distorted view of roads carrying very low traffic volumes. While it is true that the better roads with volumes of up to 25 vpd do not appear different from roads carrying much higher volumes, many low volume roads are of substantially lower quality. It should be recalled that most of the roads on which the sign inventory was conducted had recorded volumes from 0 to 15 vpd. The photographs taken along with this inventory clearly did not focus upon the higher quality roads that were encountered. This lack of

objectivity is reflected in the photographs selected for inclusion in this report. They are intended to be especially enlightening to persons who have not traveled roads of this nature in Iowa or any other state.

Four County Engineers who reviewed the Draft Report expressed opinions regarding the recommendation that no effort be expended to develop a manual or handbook covering signing practices on low volume roads in Iowa. Three of these favored development of such a manual, one did not. The manual developed for low volume roads in Kansas [5] was cited as an example. A final decision in this regard is being left to the members of the Iowa Highway Research Board.

ACKNOWLEDGMENTS

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Research personnel wish to extend their appreciation to the county officials who responded to the questionnaire that provided much of the input to this research. Special thanks are directed to the following persons who participated in this research as an Advisory Panel and reviewed the conclusions and recommendations. Their helpful suggestions increased substantially the value of this research.

Ronald M. Betterton, Greene County Engineer

Robert Ewald, Assistant Attorney General, General Counsel Division, Iowa Department of Transportation

Lee H. Gaudineer, Jr., Attorney at Law, Austin and Gaudineer, Des Moines

Del S. Jespersen, Story County Engineer

Kevin B. Jones, Highway Division, Iowa Department of Transportation

Neil W. Jorgenson, Franklin County Engineer

Nicholas R. Konrady, Lucas County Engineer

Lowell E. Richardson, Highway Division, Iowa Department of Transportation

Stanley L. Ring, Professor of Civil Engineering, Iowa State University

Undergraduate Research Assistants who conducted the field inventories and contributed otherwise to the research were Keith A. Helgevold and Robert S. Logan.

Finally, research personnel are grateful to members of the Iowa Highway Research Board for their guidance throughout the course of this research. Comments from members on the Draft Report were especially helpful.

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APPENDIX A:

FIELD INVENTORY DATA FORM

SIGNING ON VERY LOW VOLUME ROADS IN IOWA

SIGN INVENTORY

County _____ Dir. of Travel _____ Sheet ____ of _____

Twp. ___ Section _____ Beg. Odometer Rdng. _____ Date _____

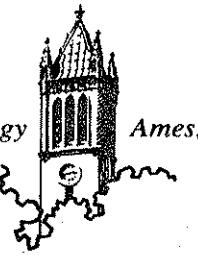
Route _____ End Odometer Rdng. _____ Survey Team _____

Odometer Reading	Side	Direction Controlled	Sign Shape	Sign Color	Sign Legend	Sign Size	Sign Condition	Remarks

APPENDIX B:

QUESTIONNAIRE SENT TO COUNTY OFFICIALS

Iowa State University of Science and Technology Ames, Iowa 50011



September 14, 1983

Engineering Research Institute
College of Engineering
104 Marston Hall
Telephone: 515-294-2336

This is written to solicit your assistance to the Engineering Research Institute, Iowa State University, in the conduct of Research Project HR-262, "Signing on Very Low Volume Rural Roads." This research is sponsored by the Iowa Department of Transportation.

The goal of this research is to improve the safety and efficiency of travel on secondary roads. Specifically, we expect to identify and evaluate the state-of-the-art for signing on roads carrying very low traffic volumes and formulate recommendations for making signing practices on such facilities more nearly uniform.

Your cooperation is requested in completing the enclosed questionnaire and returning it to me. A questionnaire is to be sent to each County Engineer and to one Supervisor in each county (one is being sent to in your county). We estimate that the questionnaire can be completed in not more than five minutes.

Thank you for your assistance.

Sincerely yours,

R. L. Carstens
Professor of Civil Engineering
Principal Investigator

RLC/lj

Return questionnaire to:

R. L. Carstens
Department of Civil Engineering
Iowa State University
Ames, Iowa 50011

HR-262

Survey of Signing Preferences

1. More elaborate signing (largely a more extensive use of warning signs) is commonly observed on high-volume paved county roads than on loose-surfaced or unsurfaced roads carrying very low volumes. Indicate below your preference for an appropriate basis for determining the elaborateness of signing on county roads by checking only one of the four squares for question 1.

☐ Based on surface type only: (Please answer question 2)

☐ Based only on traffic volumes irrespective of surface type. (Please answer question 3)

☐ A higher level on paved roads and lower levels for unpaved roads based on traffic volumes. (Please answer question 4)

☐ All county roads with the same level of signing. (Proceed to question 8)

2. Based on surface type only:

☐ Two levels, paved roads and unpaved roads. (Proceed to question 8)

☐ Three levels, paved roads, gravel or rock roads, and unsurfaced roads. (Proceed to question 8)

3. Based only on traffic volumes irrespective of surface types:

☐ Two levels. (Please answer question 5)

☐ Three levels. (Please answer question 6)

☐ A continuum with full signing on roads with the highest volumes and virtually no signs on roads carrying very low volumes. (Please answer question 7)

4. A higher level on paved roads and lower levels for unpaved roads based on traffic volumes:

☐ Two levels on unpaved roads. (Please answer question 5)

☐ Three levels on unpaved roads. (Please answer question 6)

☐ A continuum on unpaved roads with virtually no signs on roads carrying very low volumes and full signing on roads with the highest volumes. (Please answer question 7)

5. If you believe that the elaborateness of signing should vary by traffic volumes, with two such levels, indicate below the minimum traffic volumes for those roads with the most elaborate level of signing.

Above _____ vehicles per day. (Proceed to question 8)

6. If you believe that the elaborateness of signing should vary by traffic volume, with three levels, indicate below the dividing traffic volumes between the three levels, first, a minimum for the most elaborately signed roads and second, a maximum for the least elaborate level of signing.

   Above _____ vehicles per day for the highest level of signing.

   Below _____ vehicles per day for the lowest level of signing. (Proceed to question 8)

7. If you believe that the elaborateness of signing should be a continuum based on traffic volumes, indicate below the volume below which there should be the minimum use of warning signs.

   Below _____ vehicles per day. (Proceed to question 8)

8. What sign or signs, if any, do you suggest for each of the following purposes?

   a. To indicate that gravel or crushed stone surfacing ends and is followed by a dirt road:

      Sign message _____

      Color and shape of sign _____

   b. To indicate that a road ends without a public road outlet:

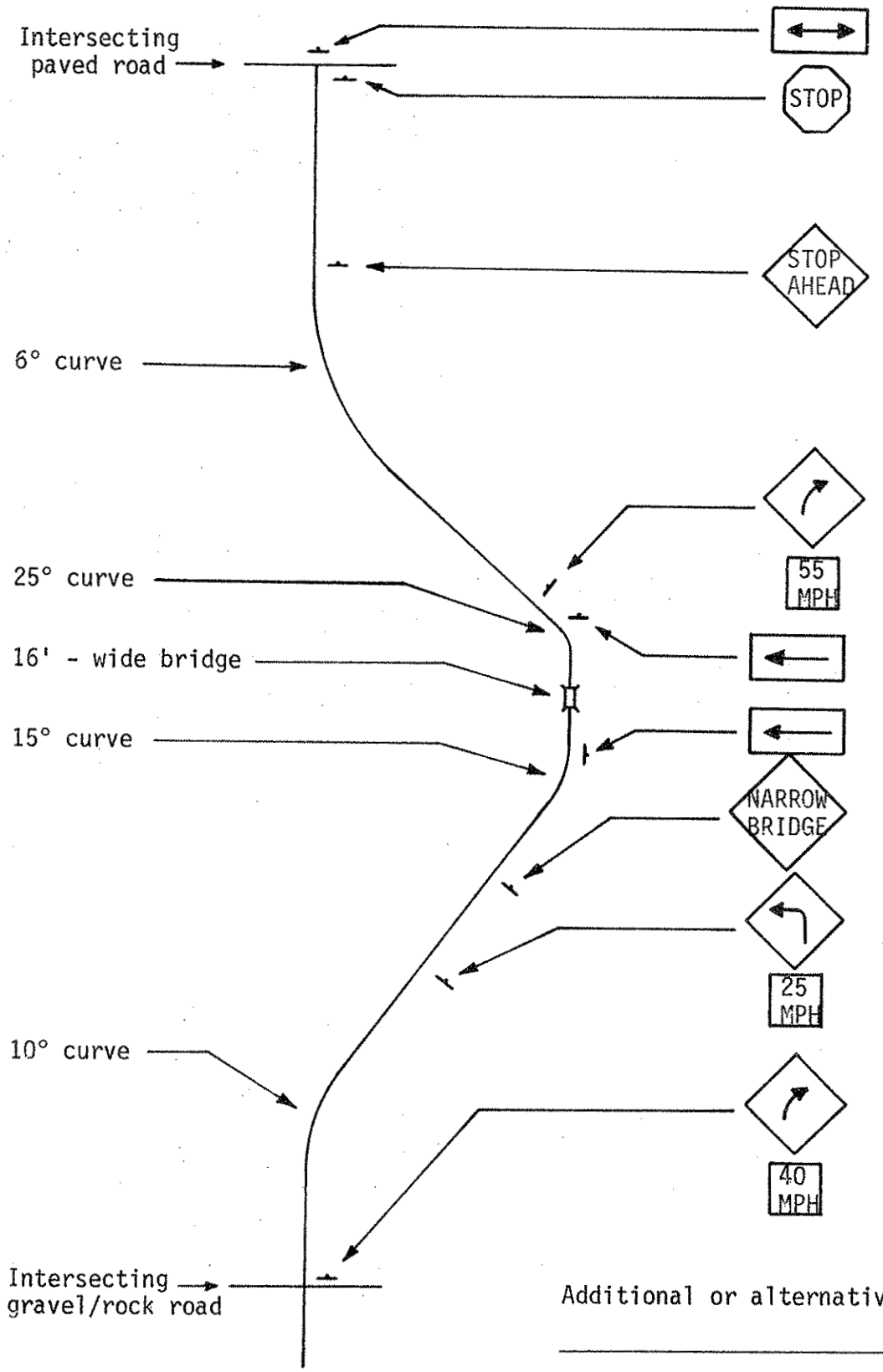
      Sign message _____

      Color and shape of sign _____

9. On the following sheet is a schematic plan of a road segment that includes a number of situations where warning signs could be used. Assume that this road segment has gravel or crushed stone surfacing and a volume of 15 vehicles per day. Warning signs that could be used (for one direction of travel only) are shown on the right. For each sign, indicate by checking either YES or NO whether it would be usual in your county for that warning sign to be used on a road of that type under the circumstances indicated. If neither YES nor NO is an appropriate answer or if you would use a different sign or additional signs, please indicate your suggestions in the space provided at the bottom of the page.

Received from:

County _____ Position _____



	YES	NO
	(check one)	
STOP	✓	
STOP AHEAD		
55 MPH		
NARROW BRIDGE		
25 MPH		
40 MPH		

Additional or alternative signs; comments