Research Report
KTC-11-03/UI56-09-1F

Maintenance Customer Survey

By

R. Clark Graves, P.E., P.G
Program Manager,
Pavements, Materials and Geotech

and

David L. Allen, P.E., P.G
Research Engineer

Kentucky Transportation Center
College of Engineering
University of Kentucky
Lexington, Kentucky

In cooperation with

Transportation Cabinet
Commonwealth of Kentucky

and

The Federal Highway Administration
U.S. Department of Transportation

March 2011

1. Report No. KTC-11-03/UI56-09-1F	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle **Maintenance Customer Survey**		5. Report Date March 2011
		6. Performing Organization Code
		8. Performing Organization Report No. KTC-11-03/UI56-09-1F
7. Authors Clark Graves and David Allen		10. Work Unit No. (TRIAS)
9. Performing Organization Name and Address University of Kentucky College of Engineering Kentucky Transportation Center 176 Oliver Raymond Building Lexington, KY 40506-0281		11. Contract or Grant No.
12. Sponsoring Agency Name and Address Kentucky Transportation Cabinet 200 Mero Street Frankfort, KY 40622		13. Type of Report and Period Covered
		14.Sponsoring Agency Code
15. Supplementary Notes Prepared in cooperation with the Federal Highway Administration, US Department of Transportation		

16. Abstract

To evaluate the public's perception of the Maintenance Activities a telephone survey of 1,222 licensed drivers from all 12 Highway Districts was conducted. The survey focused on five general areas of highway maintenance; Roadside Features, Pavement Surfaces, Shoulders, Drainage and Signs/Markings

The results indicate the areas which have the highest rating for current level of maintenance are; Signs, guardrail, and Striping, indicating the public is reasonably satisfied with these areas. The area with the lowest rating was that of Pavement Surfaces and Potholes, followed by Shoulders and Roadway Drainage. This is not entirely unexpected since the smoothness of roadways is easily detected by the public.

The desired level of maintenance of all the items surveyed was nearly identical across the entire state. There were no differences between items relating to pavement surfaces or safety items.

An analysis was also completed to review the sample size necessary in the collection of the Maintenance Rating Program (MRP) data.

17. Key Words Maintenance, Survey, Maintenance Rating,		18. Distribution Statement Unlimited, with approval of the Kentucky Transportation Cabinet	
19. Security Classification (of this report) None	20. Security Classification (of this page) None	21. No. of Pages	22. Price

Form DOT 1700.7 (8-72) Reproduction of completed page authorized

Table of Contents

List of Figures

List of Tables

Executive Summary

To evaluate the public's perception of the Maintenance Activities of the Kentucky Transportation Cabinet, a telephone survey of 1,222 licensed drivers from all 12 Highway Districts was conducted. This survey focused on five general areas of highway maintenance; Roadside Features, Pavement Surfaces, Shoulders, Drainage and Signs/Markings. Each participate was asked to rate the existing and desired level of maintenance for each item from unacceptable (1) to excellent (5). In addition they were asked what they thought the spending priority should be on a scale of low priority (1) to high priority (5).

The results of this survey indicate the areas which have the highest rating for current levels of maintenance are; Signs, Guardrail, and Striping. Each of these may impact the safety of the traveling public. This would indicate that the public is reasonably satisfied with these areas.

The area with the lowest rating for current level of maintenance was that of Pavement Surfaces and Potholes, followed by Shoulders and Roadway Drainage. This is not entirely unexpected since the smoothness of roadways is easily detected by the public.

The desired level of maintenance of all the items surveyed was nearly identical across the entire state. There were no differences between items relating to pavement surfaces or safety items.

The same trend did not continue when the participants were asked the question relating to spending priorities. The item with the highest priority of spending was that of pavement surfaces, which would not be unexpected since this was the area perceived to have the lowest level of current maintenance. This is further supported by the fact that 40 percent of the responses for areas which needed improvement were for pavement surfaces and potholes. The second spending priority was that of signs and markings, which is interesting in that this was also one of the highest rated areas for current maintenance.

The results of this survey clearly indicate the public is the least pleased with the current maintenance of roadway surfaces, with only about 5 percent rating them as excellent, while more than 10 percent rate them as unacceptable. However 50 percent feel that pavement surfaces and signs and markings should have the highest spending priority.

An analysis has also been conducted to review the sample sizes currently being used by the Cabinet to collect the Maintenance Rating Program (MRP) data. The results of this study of sample size and the survey results can be utilized to refine the data collection procedures currently utilized. This will allow the Cabinet to track the items which are of highest priority to both the traveling public and the Transportation Cabinet.

Introduction

To evaluate the traveling public's perception of the Kentucky Transportation Cabinet's maintenance activities, a telephone phone survey was conducted by the Survey Research Center at the University of Kentucky in the fall of 2009. This survey consisted of phone interviews with 1,222 licensed drivers selected randomly across all 12 highway districts. A total of 2,715 surveys were attempted of that number, 1,197 indicated they did not want to participate, 296 were not eligible to participate (had not driven recently or unable to drive), yielding 1,222 valid surveys.

This survey focused on the following five general areas of highway maintenance

- Roadside Features (overall appearance, visual obstructions, fencing, guardrail)
- Pavement Surfaces
- Shoulders
- Drainage
- Signs/Markings (signs and striping)

In each area the participants were asked to rate the existing and desired levels of maintenance on the following scale:

1 – Unacceptable
2
3
4
5 – Excellent

They were asked to rank the spending priorities for these features on the following scale:

1 – Low Priority
2
3
4
5 – High Priority

The margin of error for this sample size, on a statewide basis is +/- 2.8% at the 95% confidence level. For each Highway District, the margin of error is +/- 9.8% at the 95% confidence level

The statewide survey results were evaluated using both arithmetic averages across the districts along with weighted averages based on district population. A summary of these results for Perceived Level of Maintenance, Desired Level of Maintenance and Spending Priorities are given in Figures 1 through 3. It may be seen across each of these areas that the weighted and the arithmetic averages are nearly identical. The remainder of the statewide analysis will be conducted on the arithmetic averages obtained across the districts.

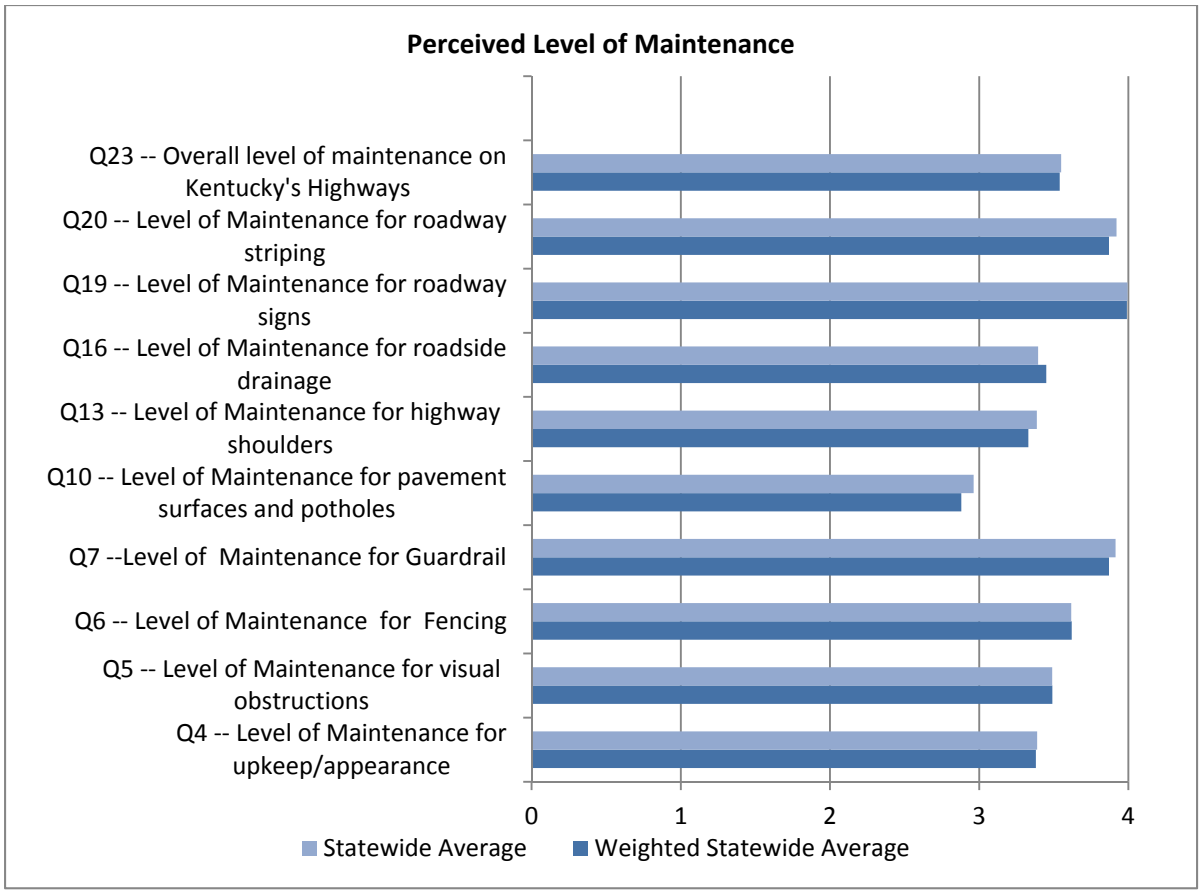

Figure 1 Summary Perceived Level of Maintenance

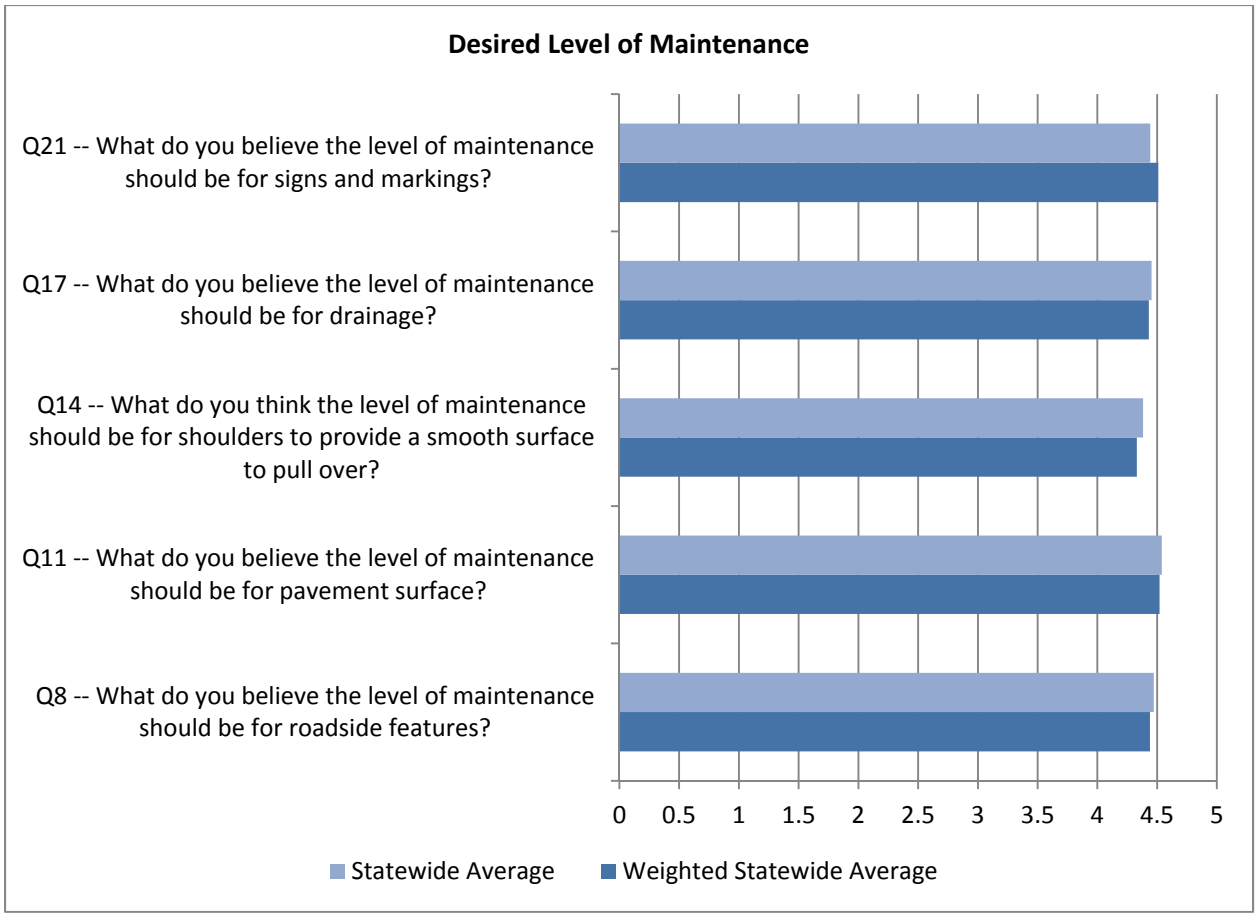

Figure 2 Summary Desired Level of Maintenance

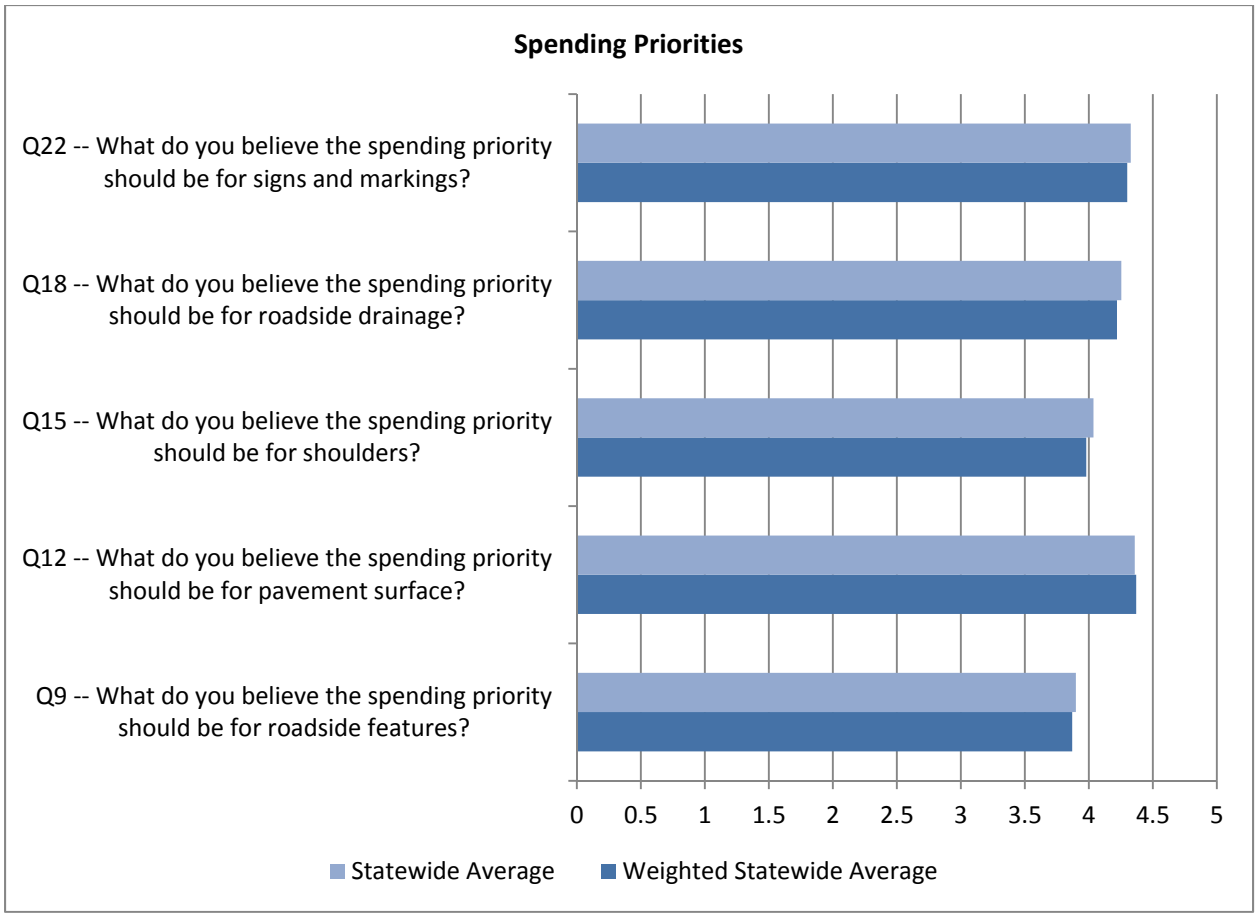

Figure 3 Summary of Spending Priorities

Roadside Features

In the evaluation of roadside features, individual questions regarding the existing level of maintenance were asked for items such as; overall appearance, visual obstructions, fencing, and guardrail. It may be seen from Figure 4 that the results between these different features was relatively small. The overall average response of these features combined was 3.6. All the features were combined when asking what the desired level of service would be along with what the spending priority should be.

Figure 5 illustrates the distribution of the statewide responses. It may be seen from this figure that 56 percent of the respondents rated the existing level of maintenance for roadside features a "4" or "5"(Excellent), while the desired level of maintenance of "4" or "5" (Excellent) was 88 percent.

Figures 6 – 9 illustrate the variability of the responses across each district. Figure 10 provides a summary of the desired level of maintenance for all roadside features across each District. It may be seen from these figures that the expectations for level of maintenance is relatively similar across the state. There is some slight variation regarding the perception of the existing level of maintenance among a few districts, but in general it is relatively similar across the state.

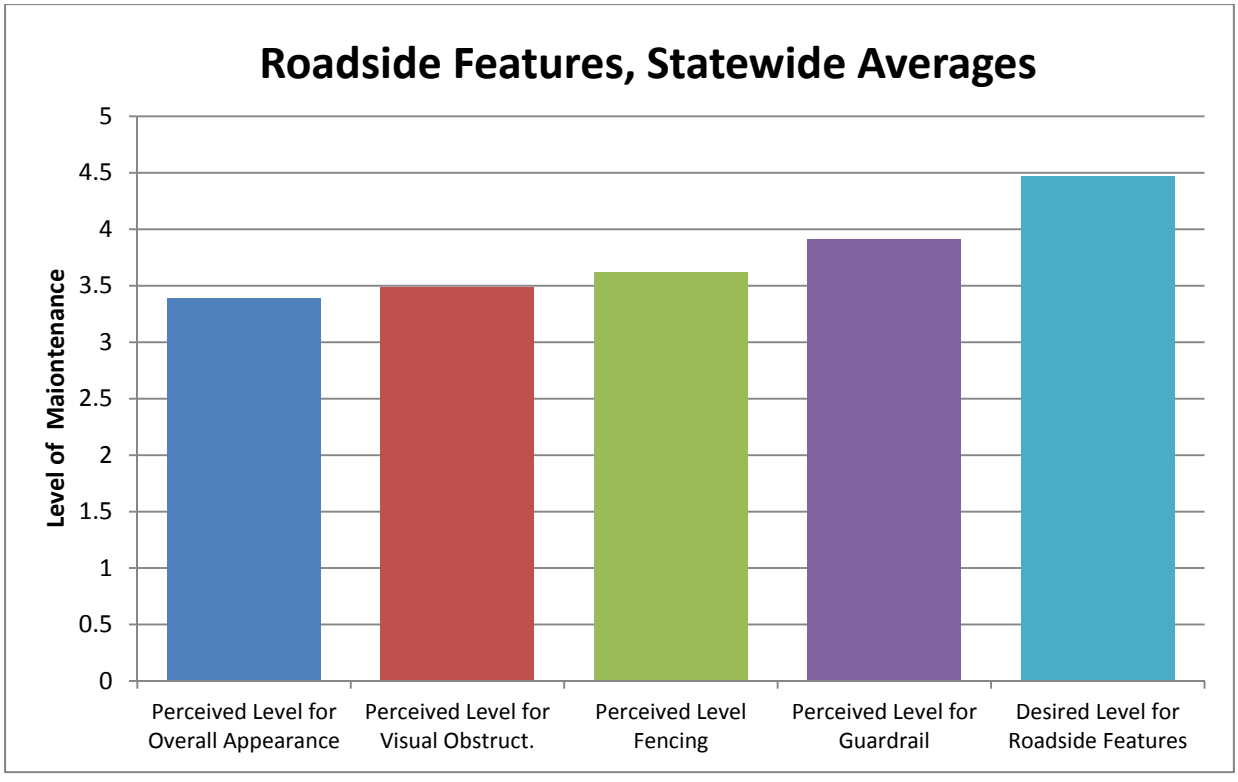

Figure 4 Summary of Statewide Roadside Features

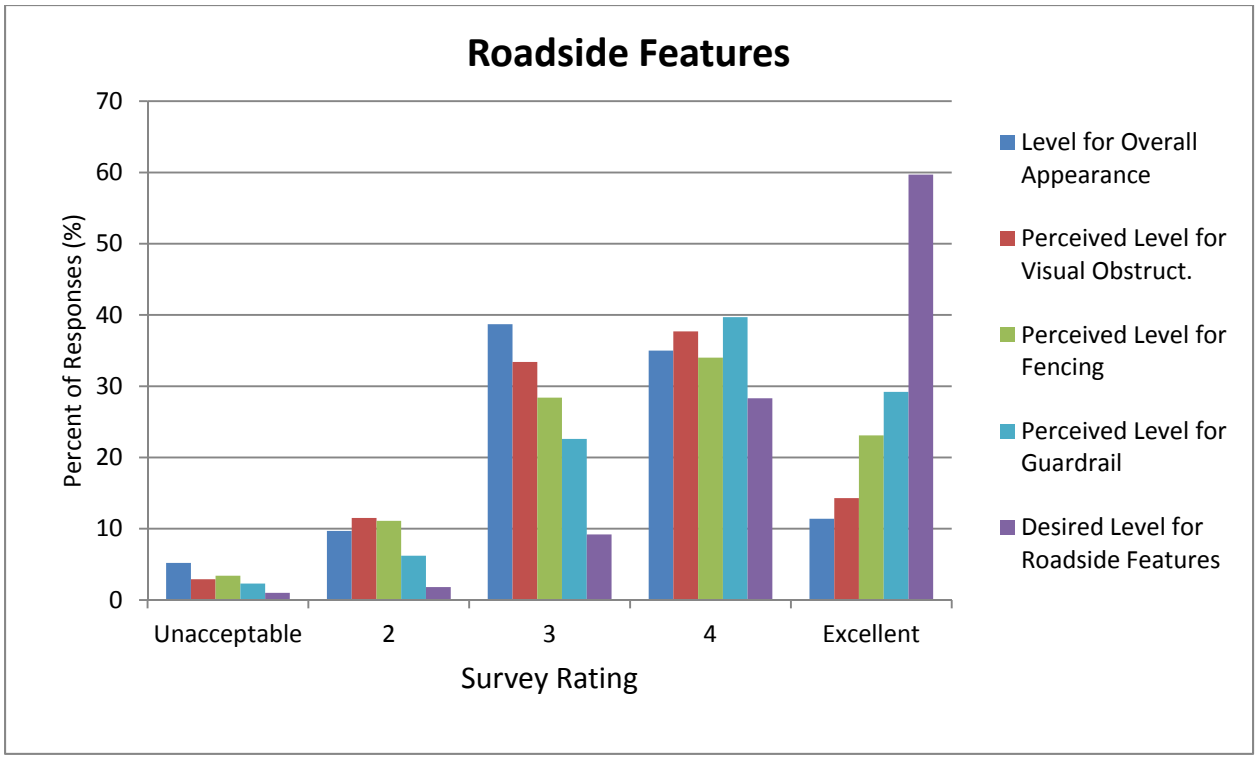

Figure 5 Statewide Distribution of Roadside Features

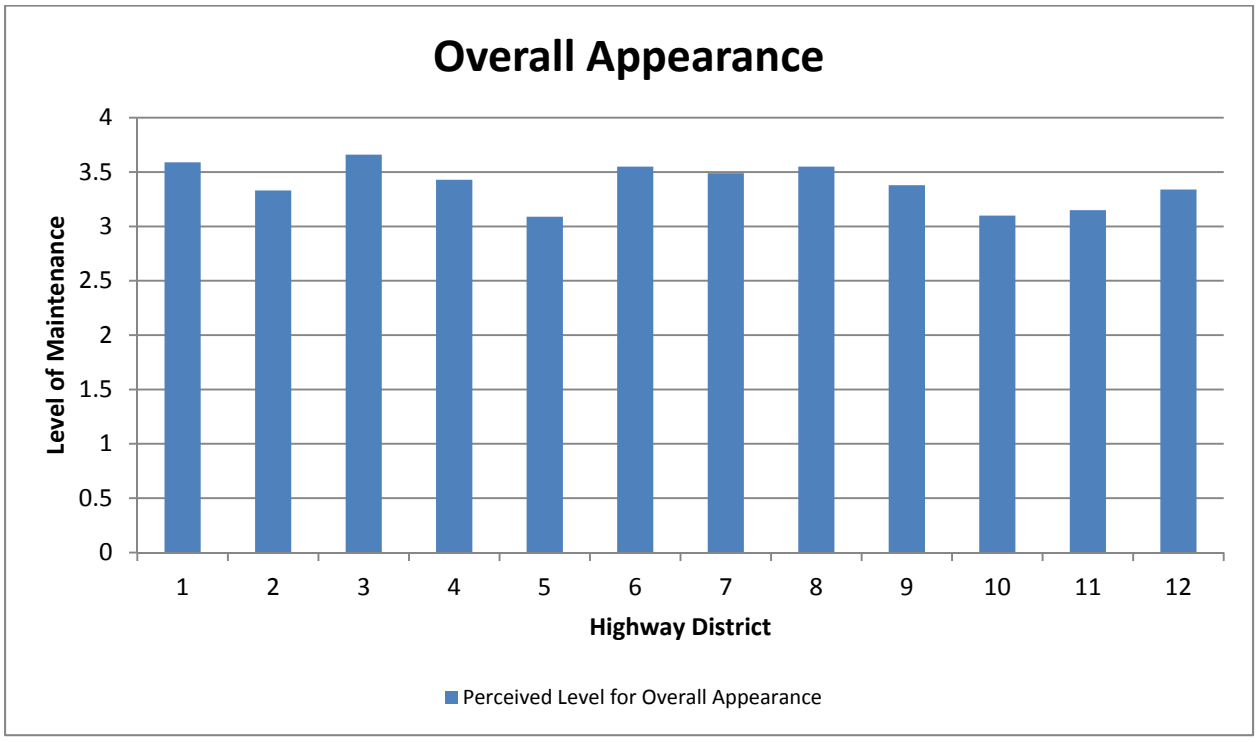

Figure 6 District Level Overall Appearance

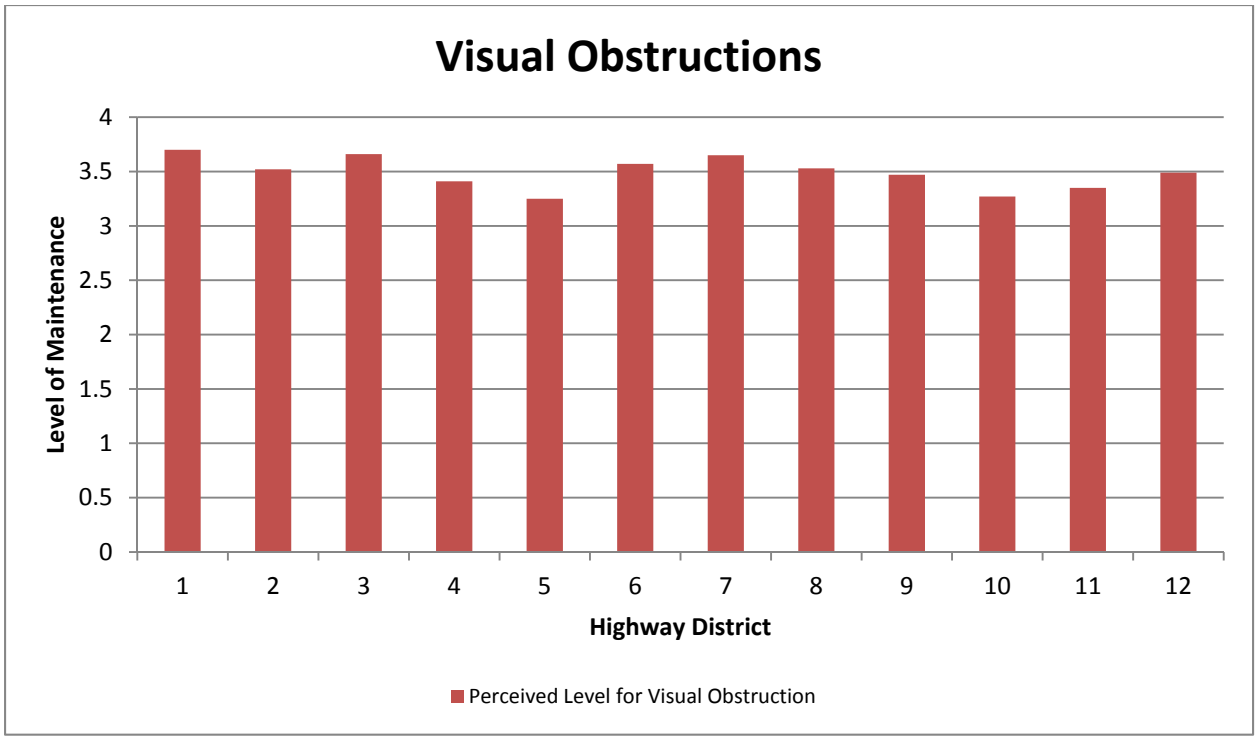

Figure 7 District Level Visual Obstruction

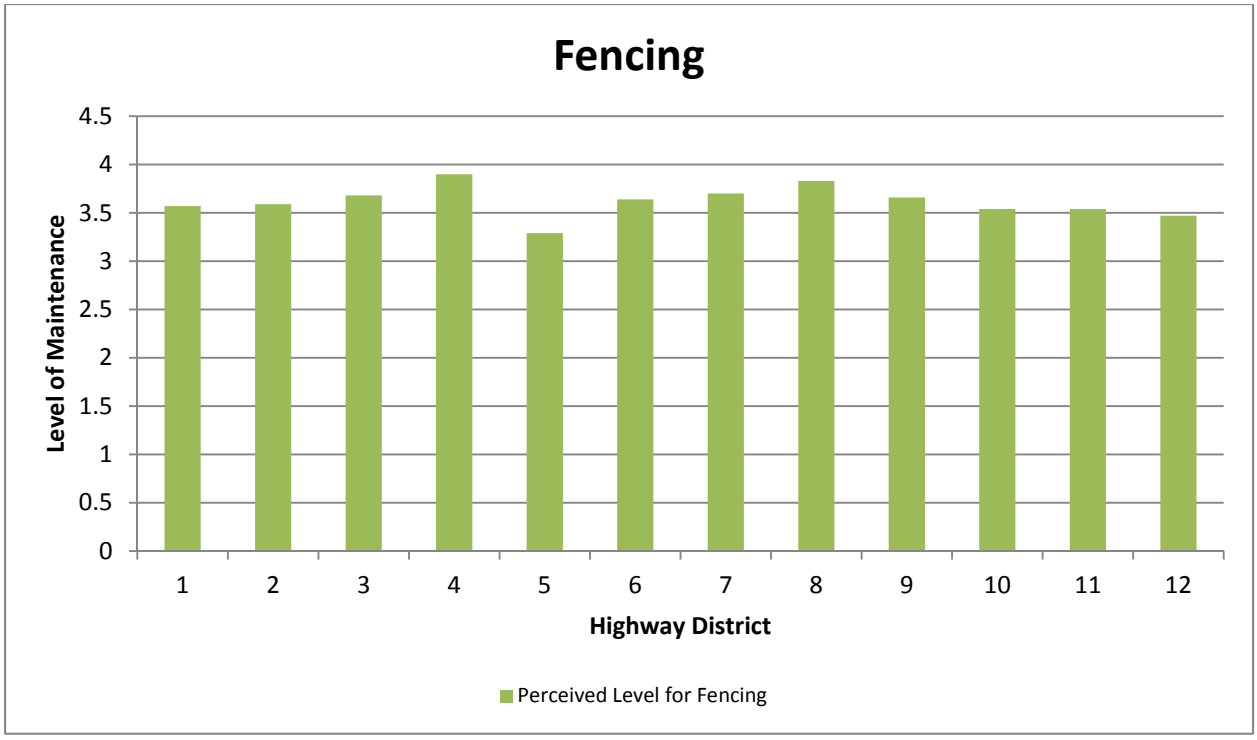

Figure 8 District Level Fencing

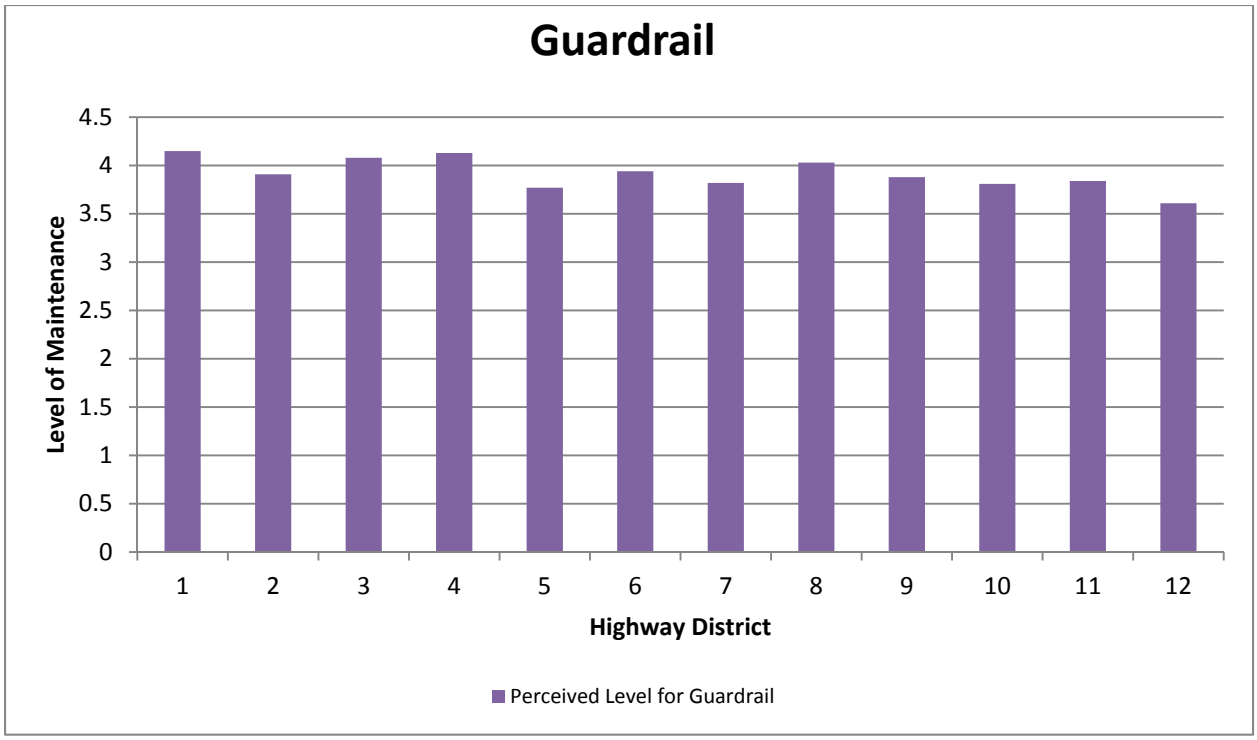

Figure 9 District Level Guardrail

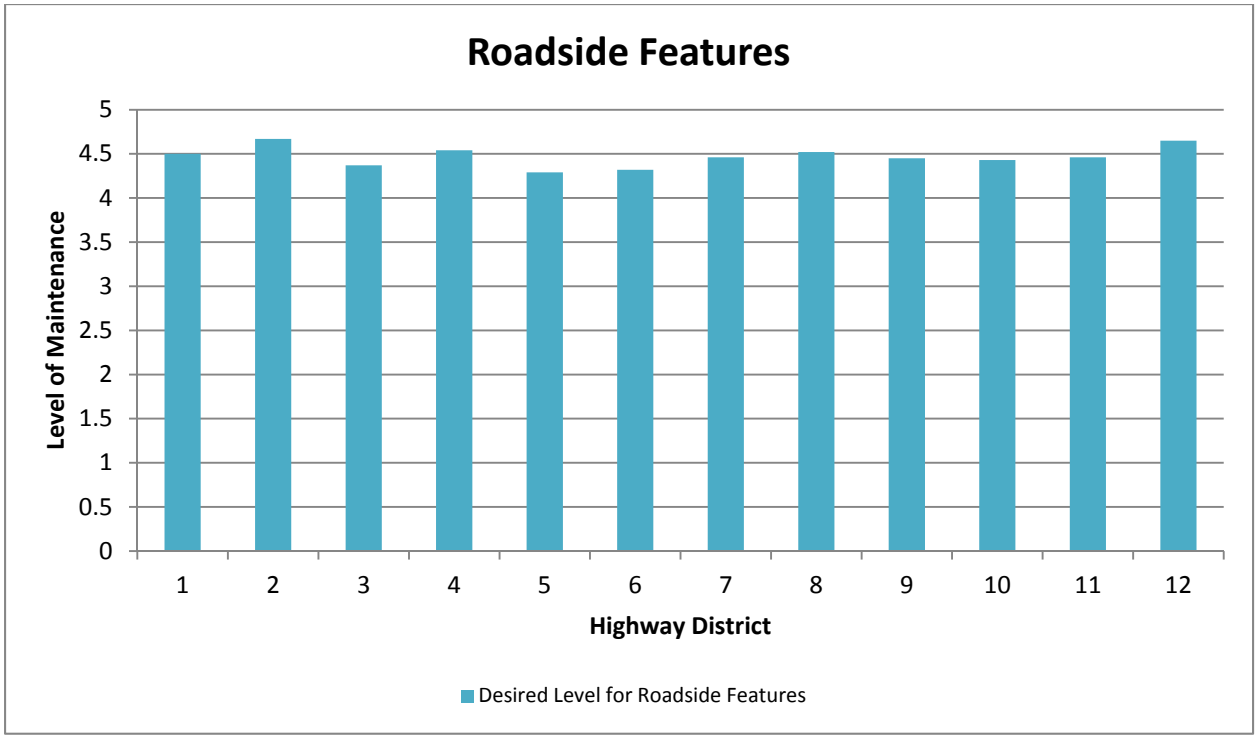

Figure 10 District Level Desired Level for Roadside Features

Pavement Surface and Potholes

A single question was asked during the survey to rate the current level of maintenance for pavement surfaces and potholes. It may be seen from Figure 11 that the average statewide perception of pavement surfaces was below 3.0, while the desired rating would be 4.5, indicating the current level of maintenance is significantly lower than is desired.

Figure 12 illustrates the distribution of the statewide responses. It may be seen from this figure that 27 percent of the respondents rated the existing level of maintenance for roadside features a "4" or "5" (Excellent), while the desired level of maintenance rated a "4" or "5" (Excellent) was 94 percent. It is also interesting to note that 87 percent of the respondents indicated that spending should be in the highest two categories as well.

Figure 13 illustrates the variability of the responses across each district. It may be seen from this figure that the expectations for level of maintenance and spending priority are relatively similar across the state. More variability can be seen in the responses of the existing level of maintenance across the districts, with several at or very near the rating of "2.5".

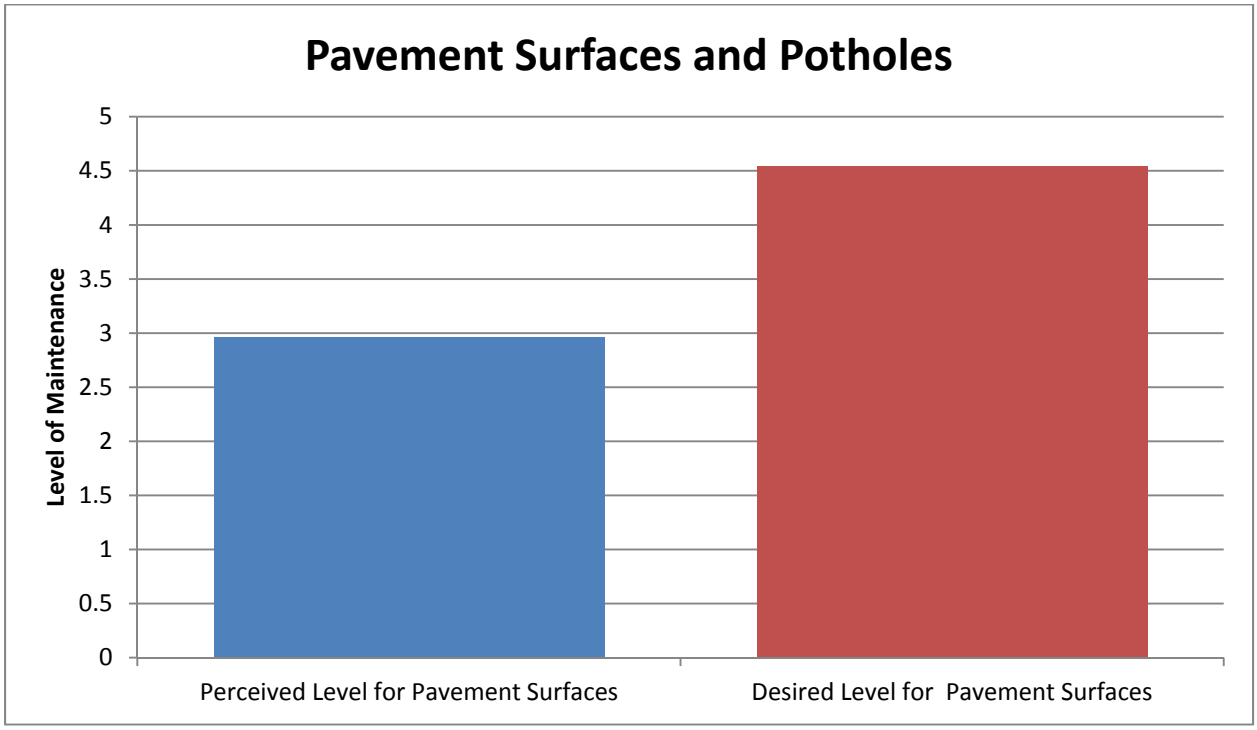

Figure 11 Summary of Statewide Maintenance of Pavement Surfaces and Potholes

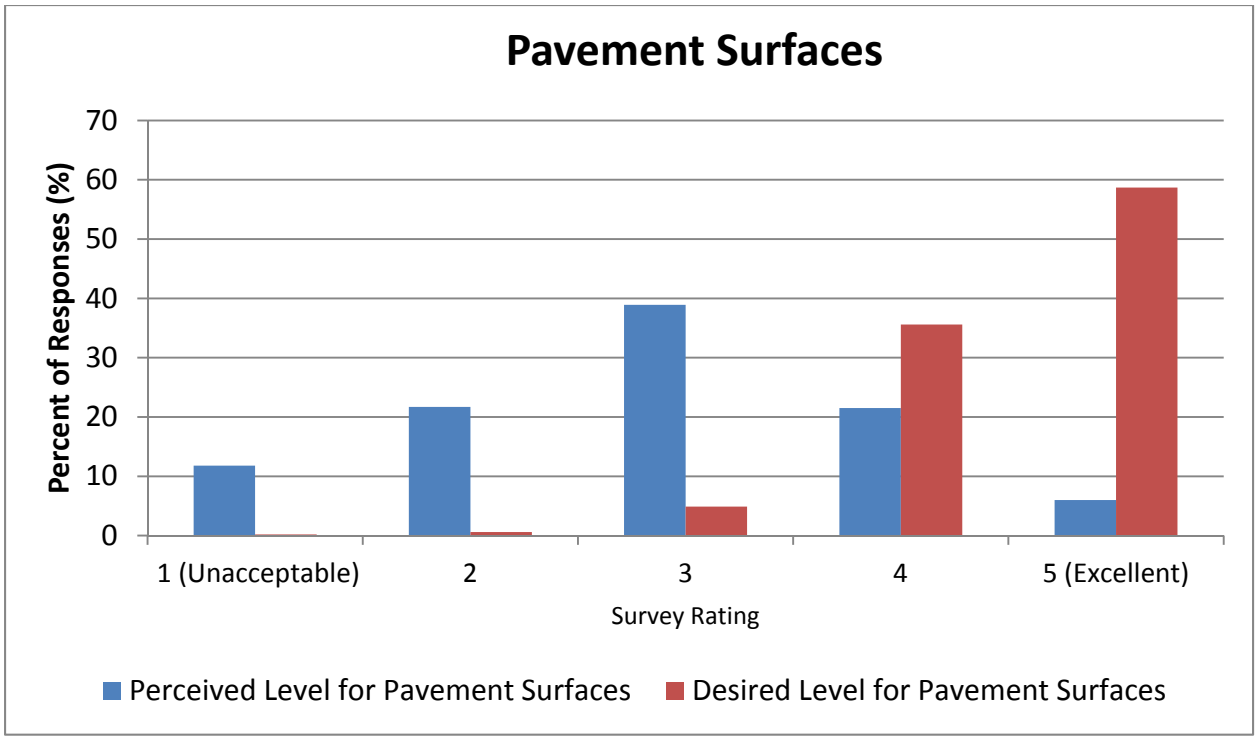

Figure 12 Statewide Distribution Maintenance of Pavement Surfaces and Potholes

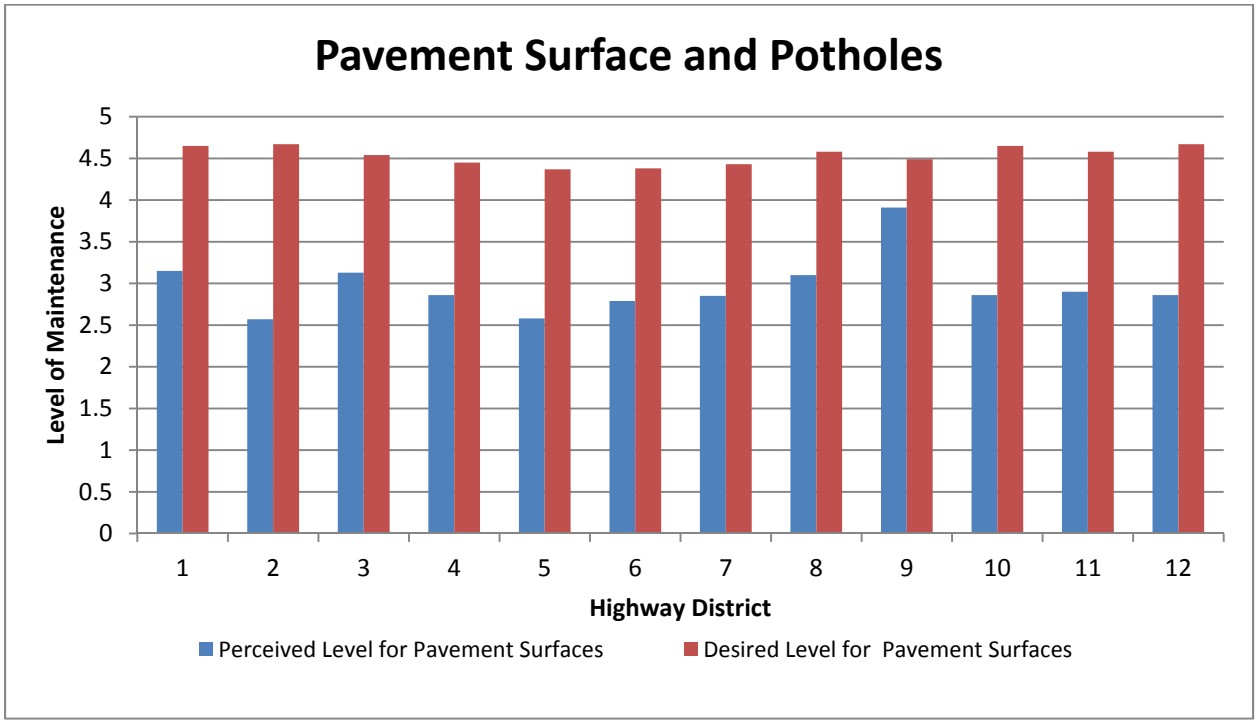

Figure 13 District Level Maintenance of Pavement Surfaces and Potholes

Highway Shoulders

A single question was asked during the survey to rate the maintenance for highway shoulders, described as a smooth level place to pull off the roadway. It may be seen from Figure 14 that the average statewide perception of pavement shoulders was 3.4, while the desired rating would be 4.4, indicating the current level of maintenance is somewhat lower than is desired.

Figure 15 illustrates the distribution of the statewide responses. It may be seen from this figure that 47 percent of the respondents rated the existing level of maintenance for shoulders a "4" or "5" (Excellent), while the desired level of maintenance of "4" or "5" (Excellent) was 88 percent. It is also interesting to note that the rating for spending priority for shoulders is 47 percent of the respondents, indicating that spending should be in the highest two categories.

Figure 16 illustrates the variability of the responses across each district. It may be seen from this figure that the expectations for level of maintenance and spending priority are relatively similar across the state. Slightly more variability can be seen in the responses of the existing level of maintenance across the districts.

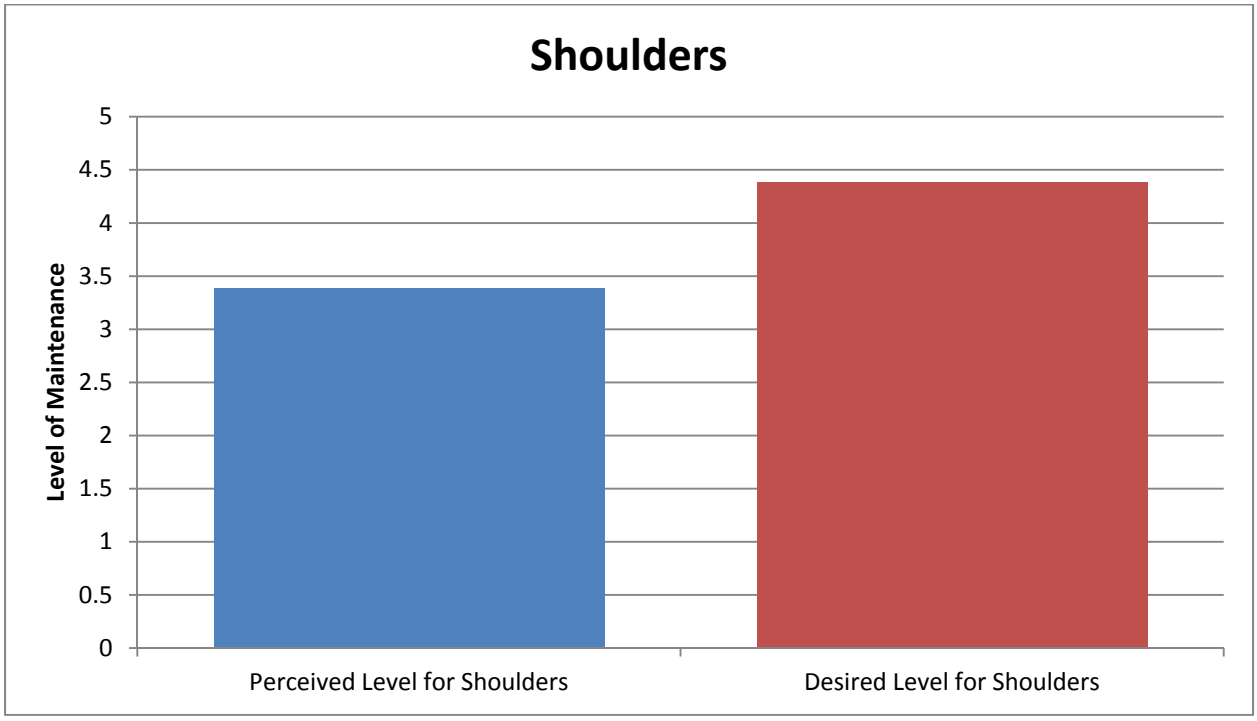

Figure 14 Summary of Statewide Shoulder Maintenance

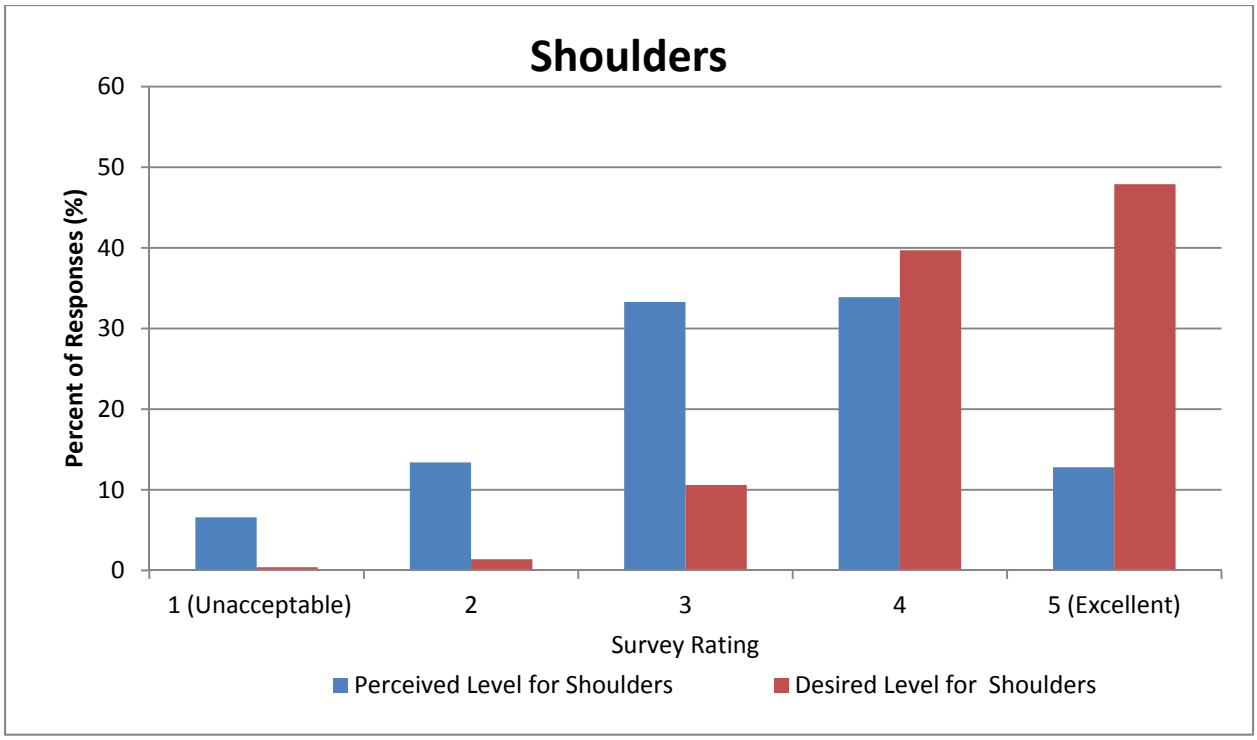

Figure 15 Statewide Distribution of Shoulder Maintenance

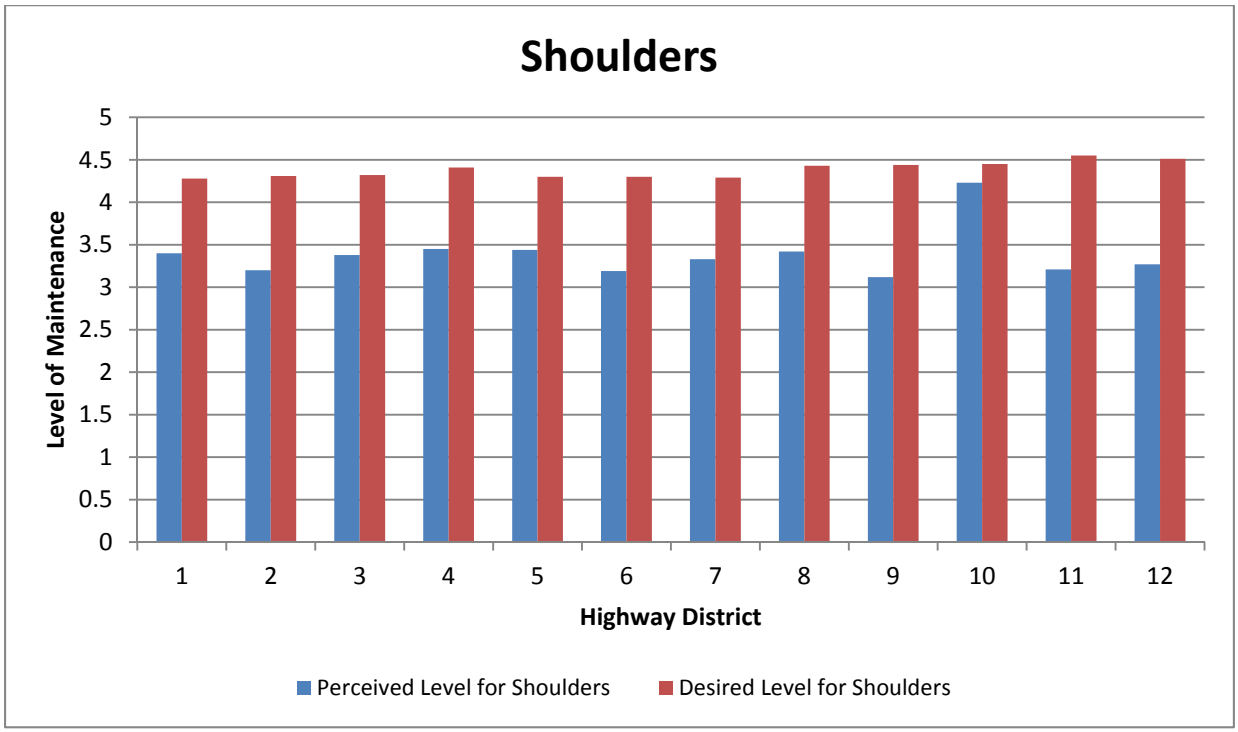

Figure 16 District Level Shoulder Maintenance

Highway Drainage

A single question was asked during the survey to rate the maintenance of roadside drainage. It may be seen from Figure 17 that the average statewide perception of roadway shoulders was 3.4, while the desired rating would be 4.45, indicating the current level of maintenance is somewhat lower than is desired.

Figure 18 illustrates the distribution of the statewide responses. It may be seen from this figure that 50 percent of the respondents rated the existing level of maintenance for drainage a "4" or "5" (Excellent), while the desired level of maintenance of "4" or "5" (Excellent) was 88 percent. It is also interesting to note that the rating for spending priority for shoulders is 82 percent of the respondents indicating that spending should be in the highest two categories.

Figure 19 illustrates the variability of the responses across each district. It may be seen from this figure that the expectations for level of maintenance and spending priority are relatively similar across the state. Slightly more variability can be seen in the responses of the existing level of maintenance across the districts.

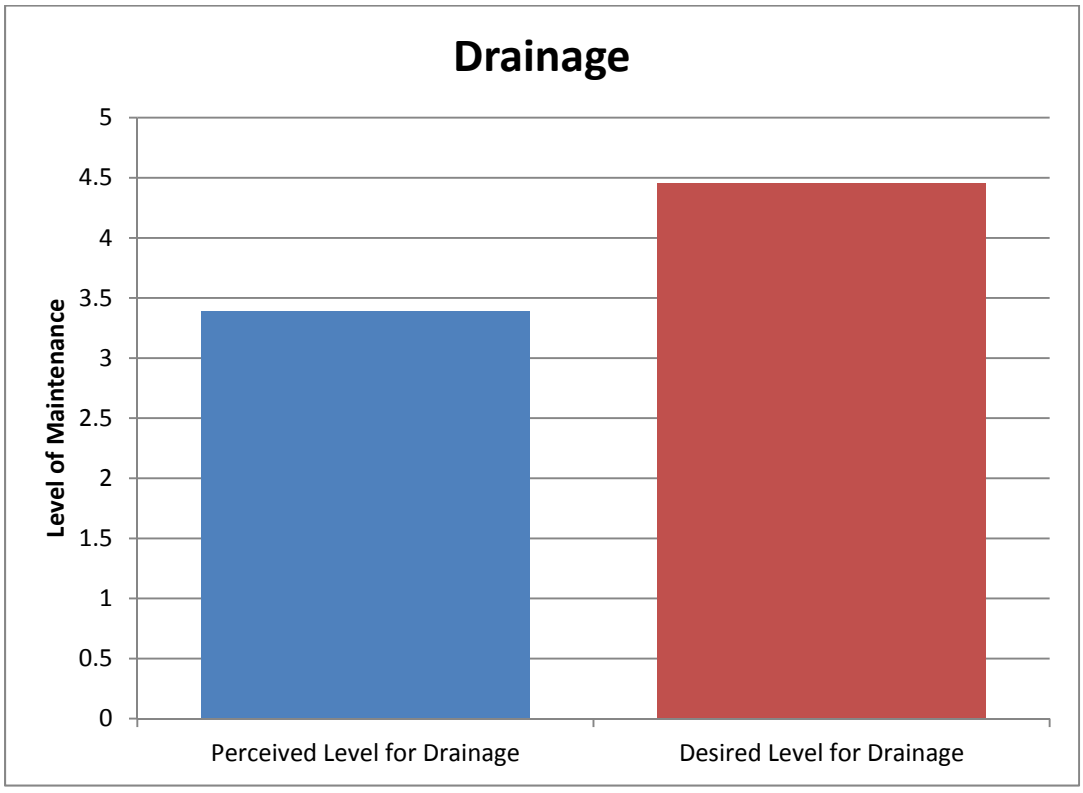

Figure 17 Summary of Statewide Drainage Maintenance

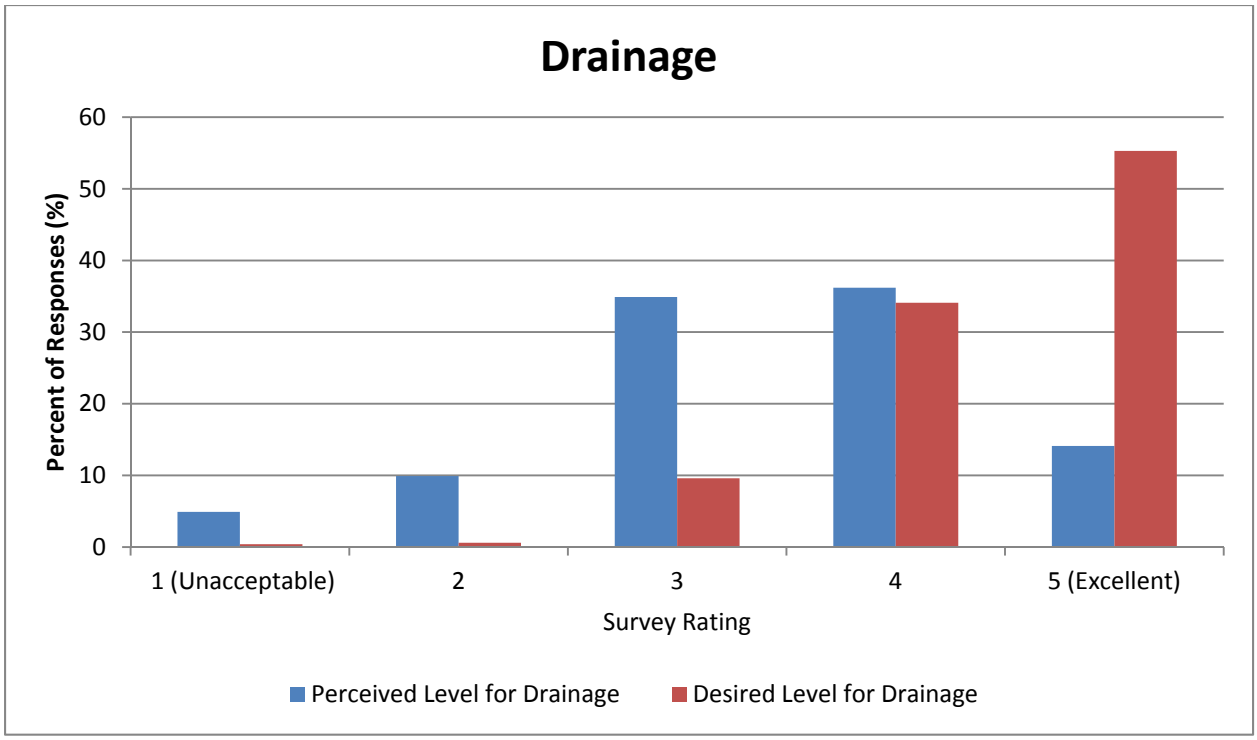

Figure 18 Distribution of Statewide Drainage Maintenance

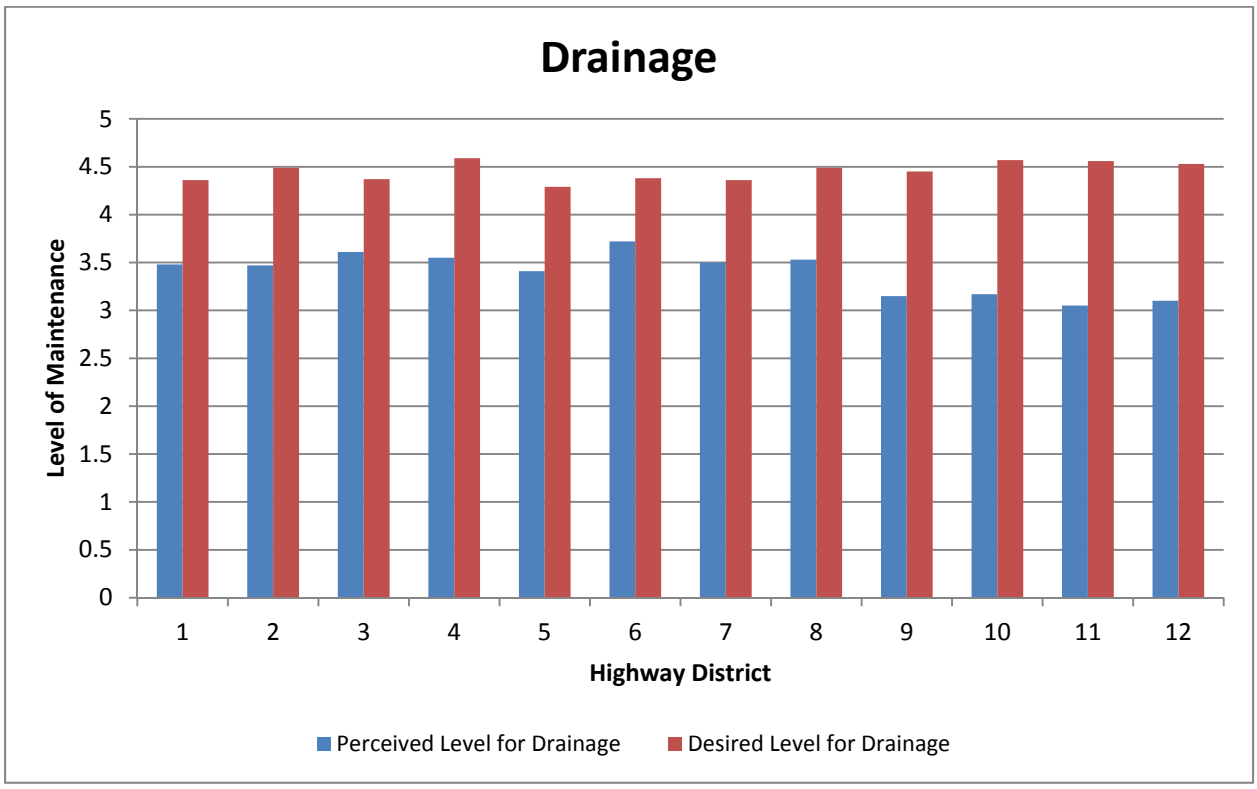

Figure 19 District Level Drainage Maintenance

Signs and Markings

Two questions were asked during the survey, one dealing with roadway signs and the second dealing with roadway markings. It may be seen from Figure 20 that the ratings for both of these items were nearly identical (signs 4.0 and markings 3.92); while the desired rating was 4.44, indicating the current level of maintenance is nearly at the level that would be desired.

Figure 21 illustrates the distribution of the statewide responses. It may be seen from this figure that respondents who rated the existing level of maintenance a "4" or "5" (Excellent) was 74 percent for signs, and 64 percent for markings, while the desired level of maintenance for the combined features was 91 percent for these levels. It is also interesting to note that the rating for spending priority for signs and markings was 81 percent of the respondents, indicating that spending should be in the highest two categories.

Figure 22 illustrates the variability of the responses across each district. It may be seen from this figure that there is some slight variability for perceived and desired level of maintenance.

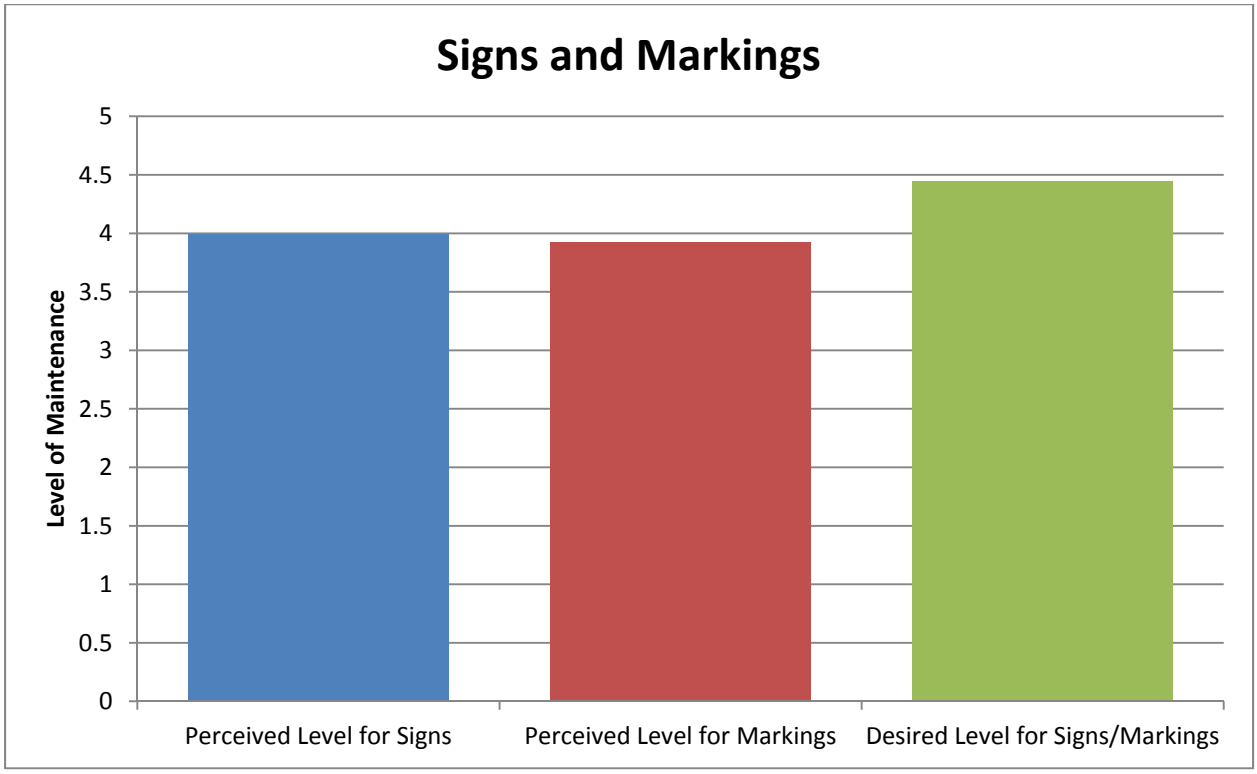

Figure 20 Statewide Summary of Maintenance for Signs and Markings

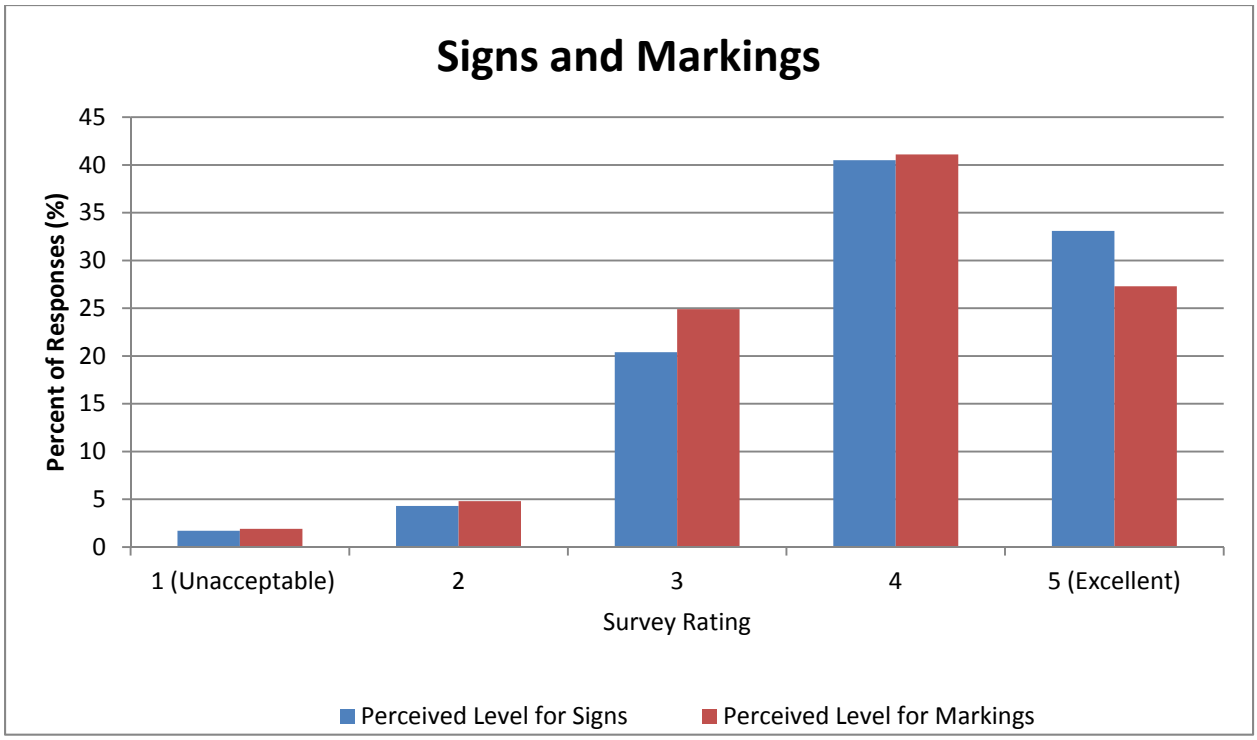

Figure 21 Distribution of Maintenance for Signs and Markings

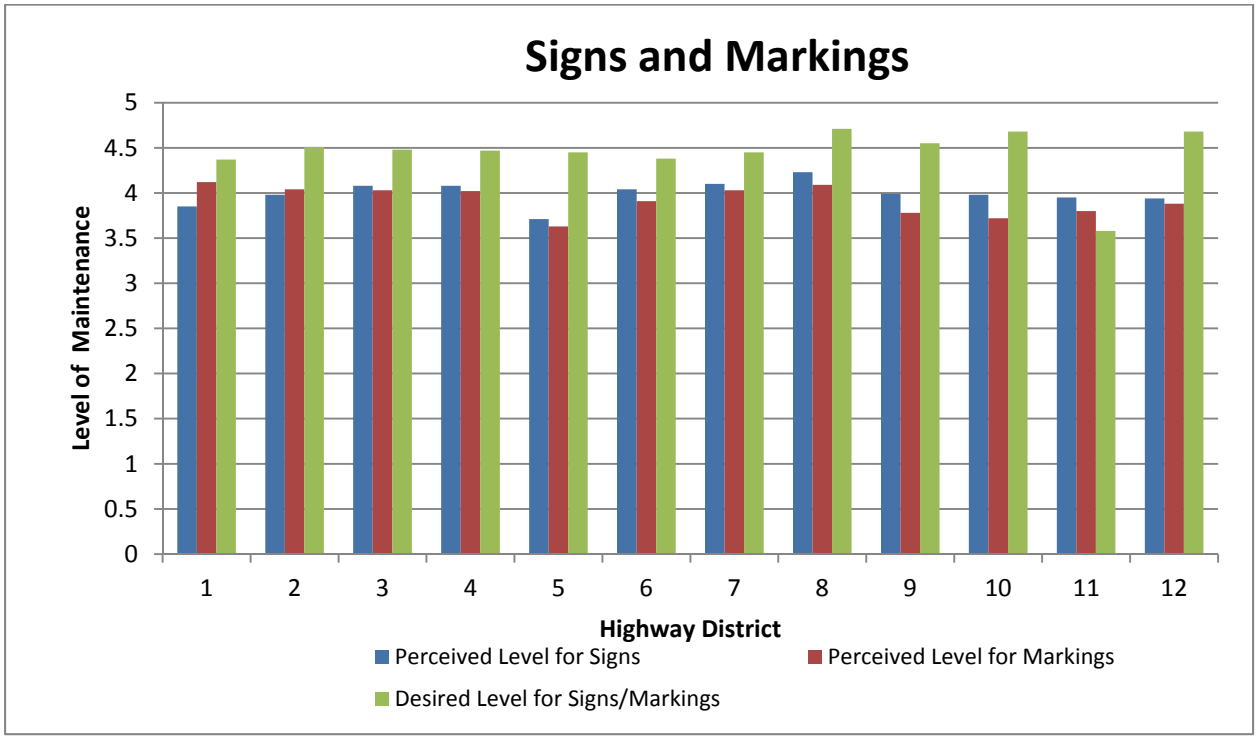

Figure 22 District Level Maintenance for Signs and Markings

Overall Maintenance Summary

Two additional questions were asked during the survey dealing with the overall maintenance of Kentucky's roadways. The first question asked the respondents to rate the overall maintenance of Kentucky's roadways. The average rating for overall maintenance was 3.6; the distribution of overall maintenance is given in Figure 23. It may be seen that 55 percent of the respondents rated the overall maintenance a "4" or "5" (Excellent). Figure 24 provides the distribution of the perceived overall maintenance level across the highway districts.

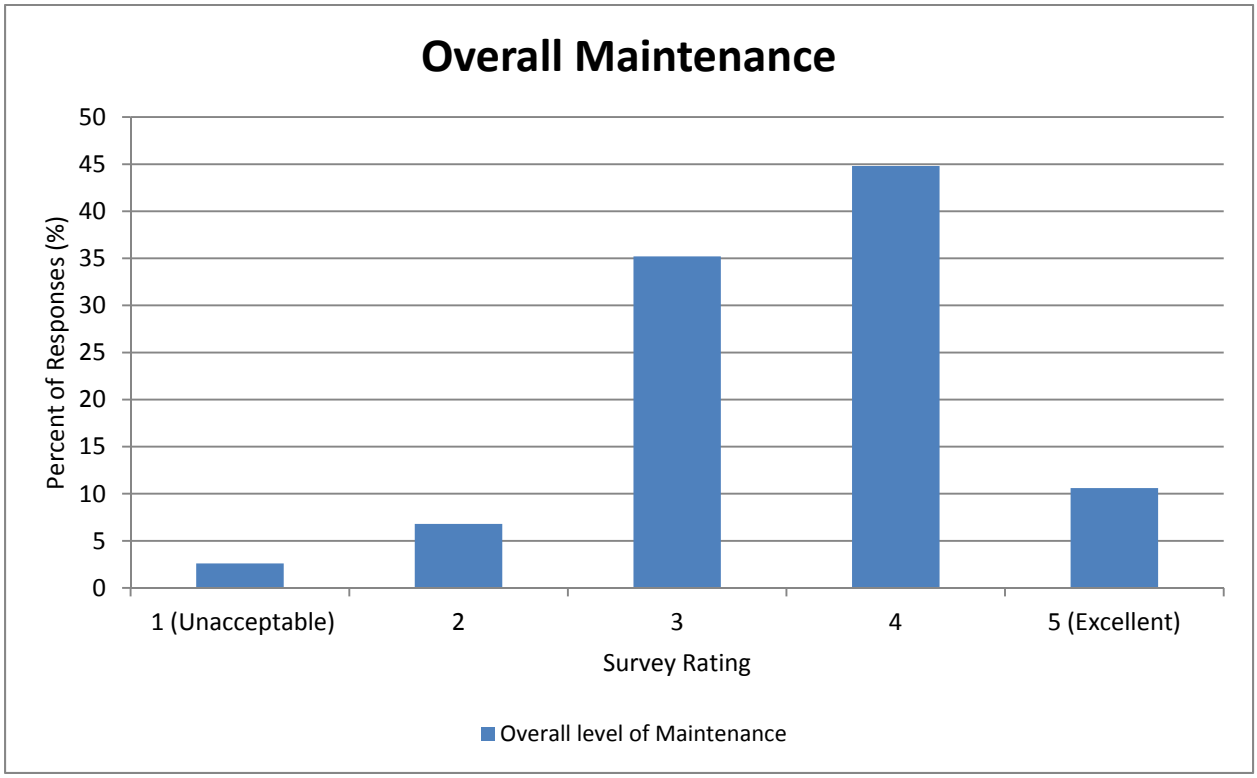

Figure 23 Distribution of Overall Maintenance

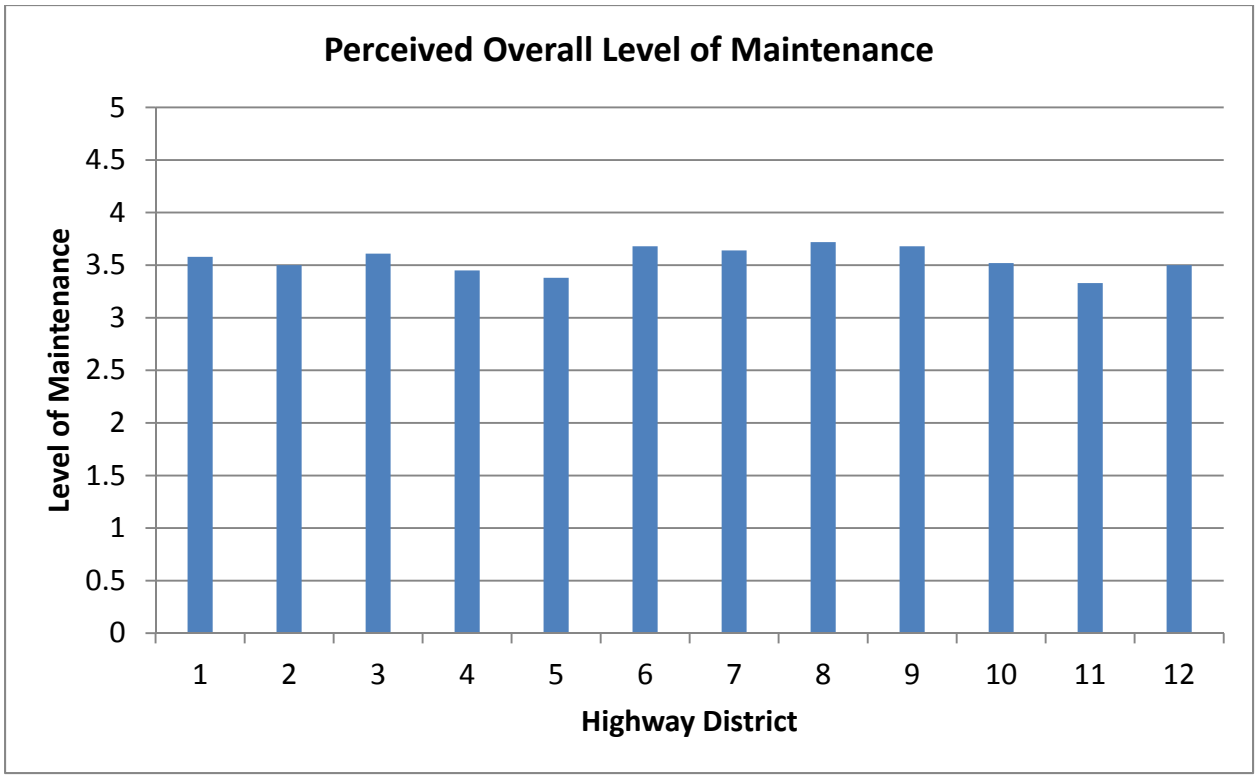

Figure 24 Summary of District Level Overall Maintenance Rating

The second question asked the respondents to indicate which area needed improvement. The results of this question are given in Figure 25. It may be seen from this figure that 40 percent of the respondents indicated that the pavement surfaces and potholes needed improvement, while 30 percent indicated there was no particular area which needed improvement.

An overall picture of the comparison of perceived and desired level of performance for all of these items is given in Figure 26. It is interesting to note that the desired level of maintenance is nearly identical across all areas, while the perceived level varies significantly.

A comparison of the distributions of the desired level of maintenance is given in Figure 27. As would be expected the vast majority of the respondents desired a level of "4" or "5" (Excellent). To look at the extremes of the responses for the perceived level of maintenance, the percentage of responses for each feature for both "Excellent and "Unacceptable" ratings are given in Figures 28 and 29.

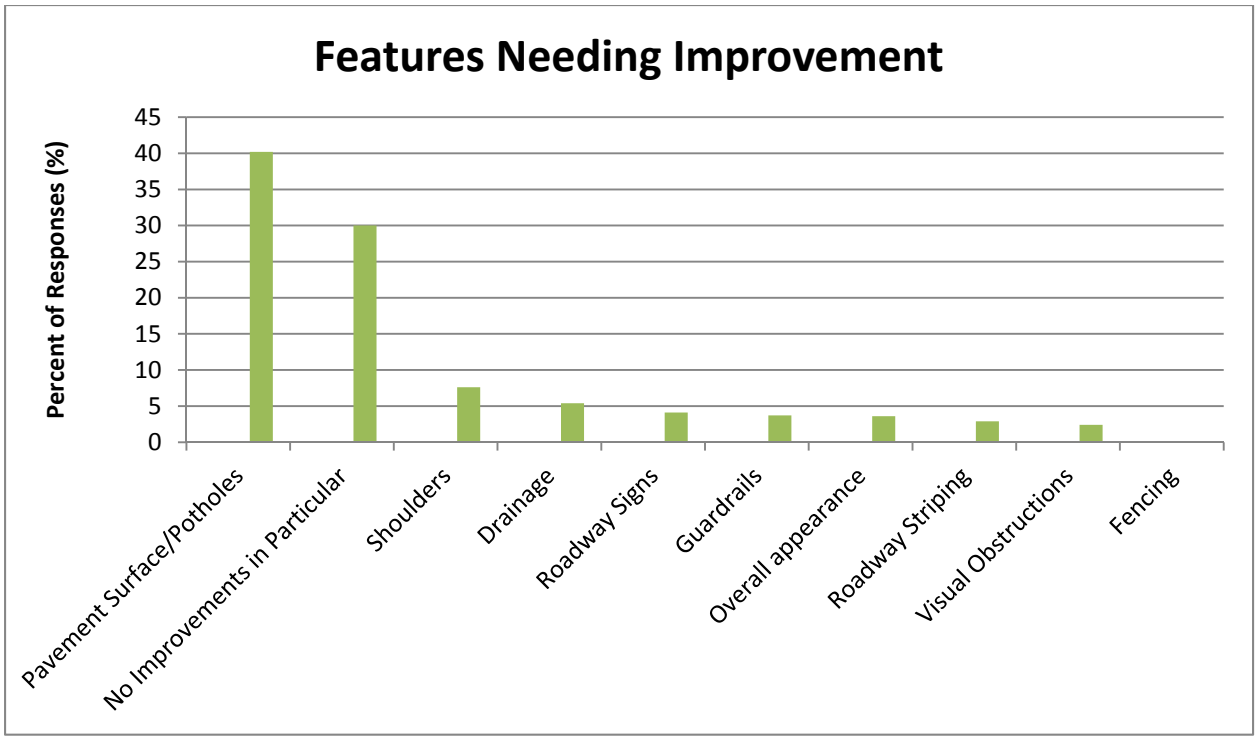

Figure 25 Summary of Features Needing Improvement

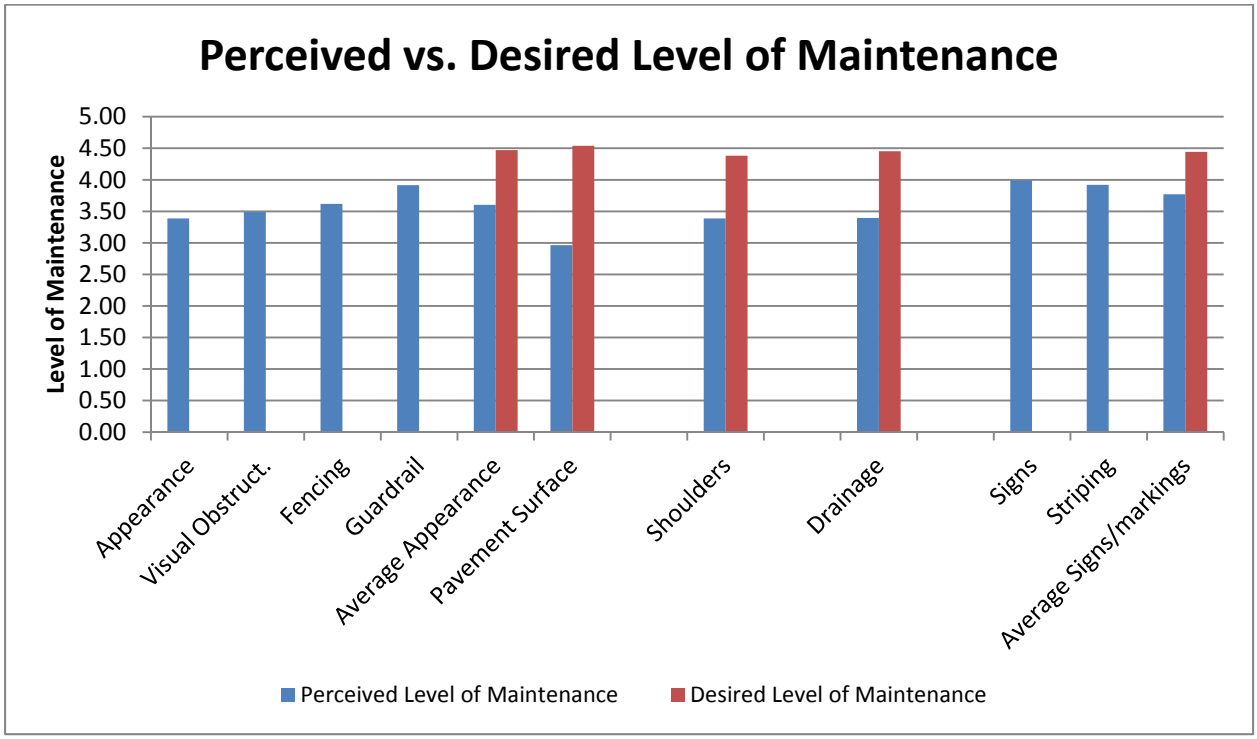

Figure 26 Comparison of Perceived and Desired Level of Maintenance

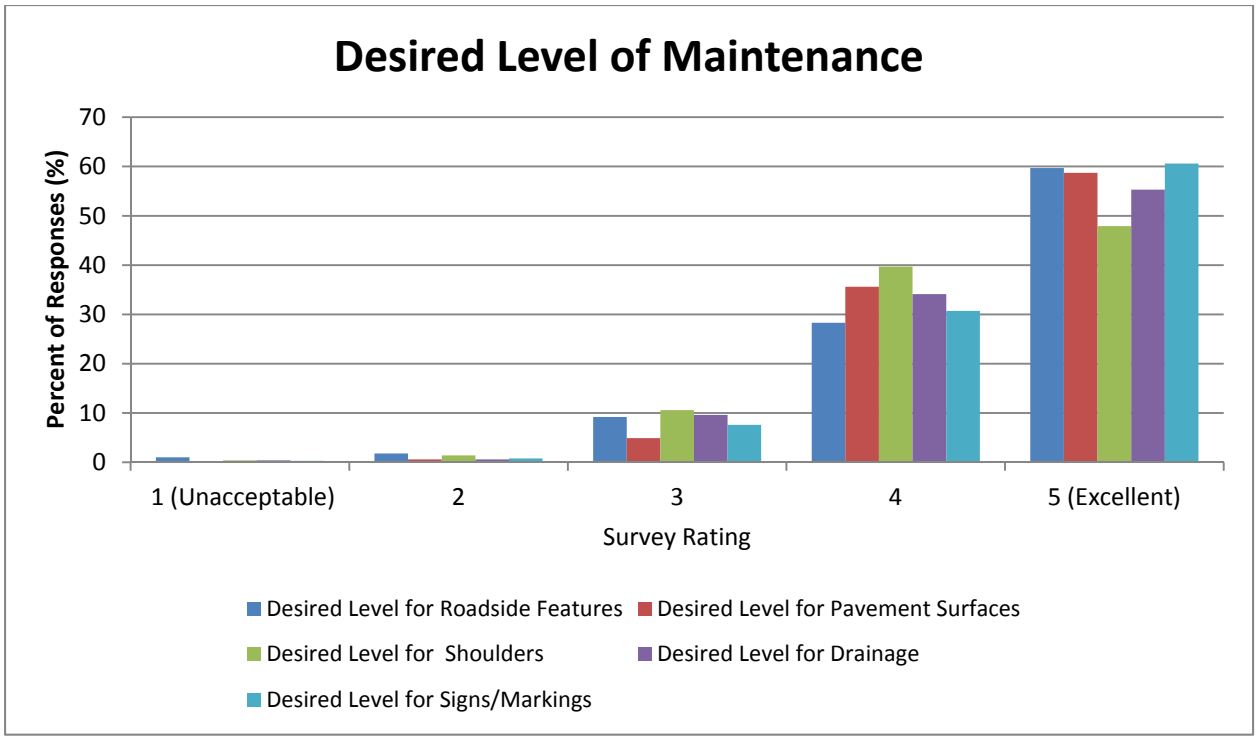

Figure 27 Distribution of Desired Level of Maintenance

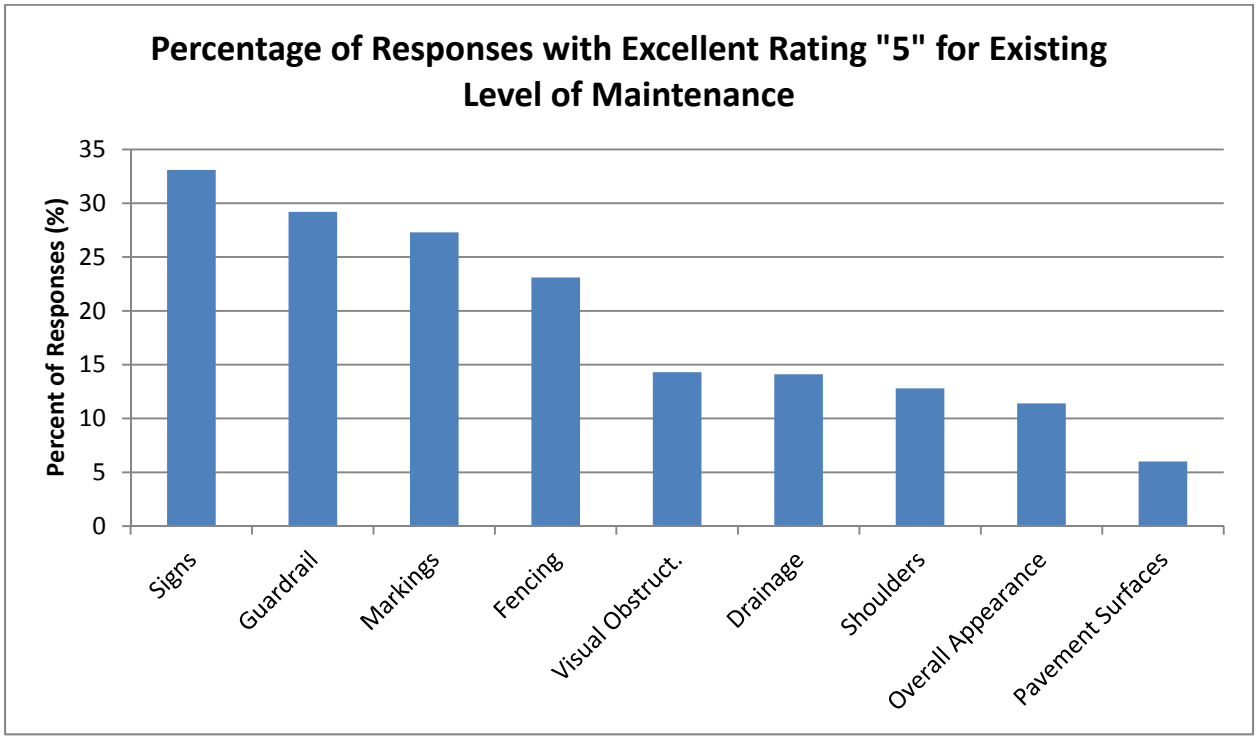

Figure 28 Percentage of Responses with Excellent Rating for Existing Level of Maintenance

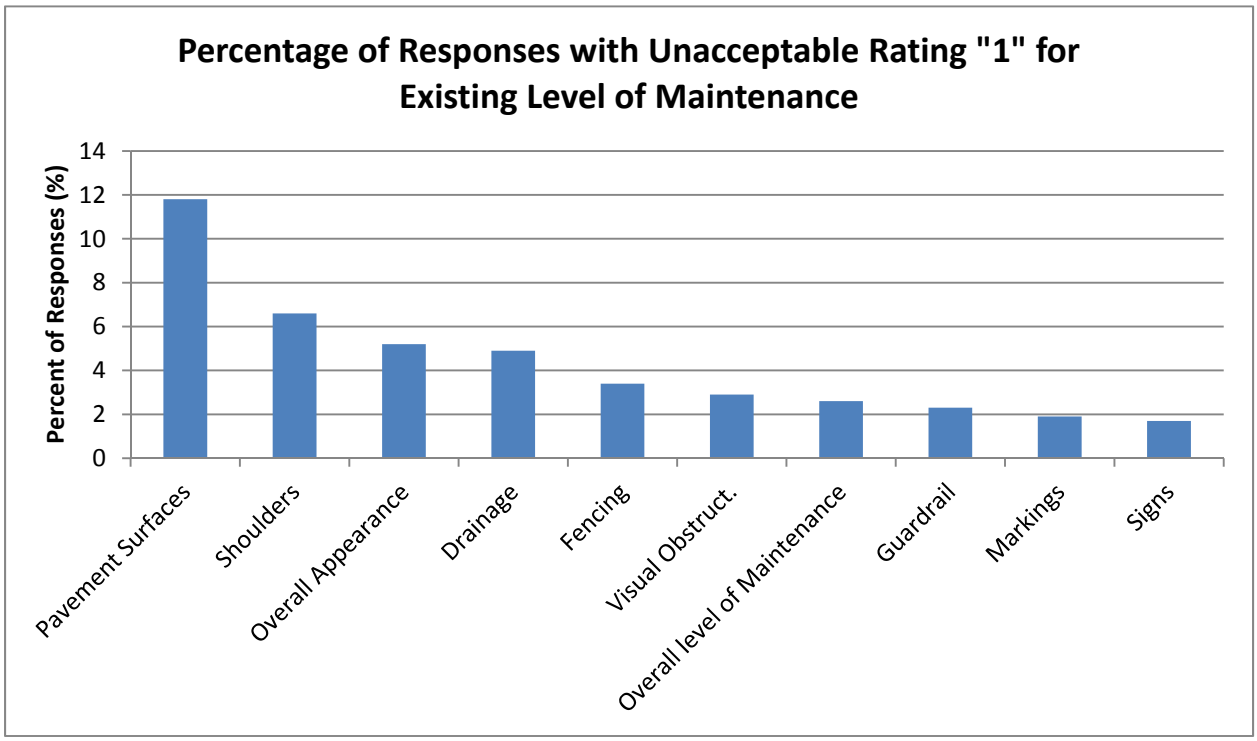

Figure 29 Percentage of Responses with an Unacceptable Rating for Existing Level of Maint.

Spending Priorities Summary

The distribution of spending priority for all the features is given in Figure 30, while the percentage of responses for each feature, indicating a spending level of "5" (High Priority) is given in Figure 31. It is interesting to see that there is a clear distinction for spending on pavements surfaces, signs and markings and spending priorities for shoulders and roadside features.

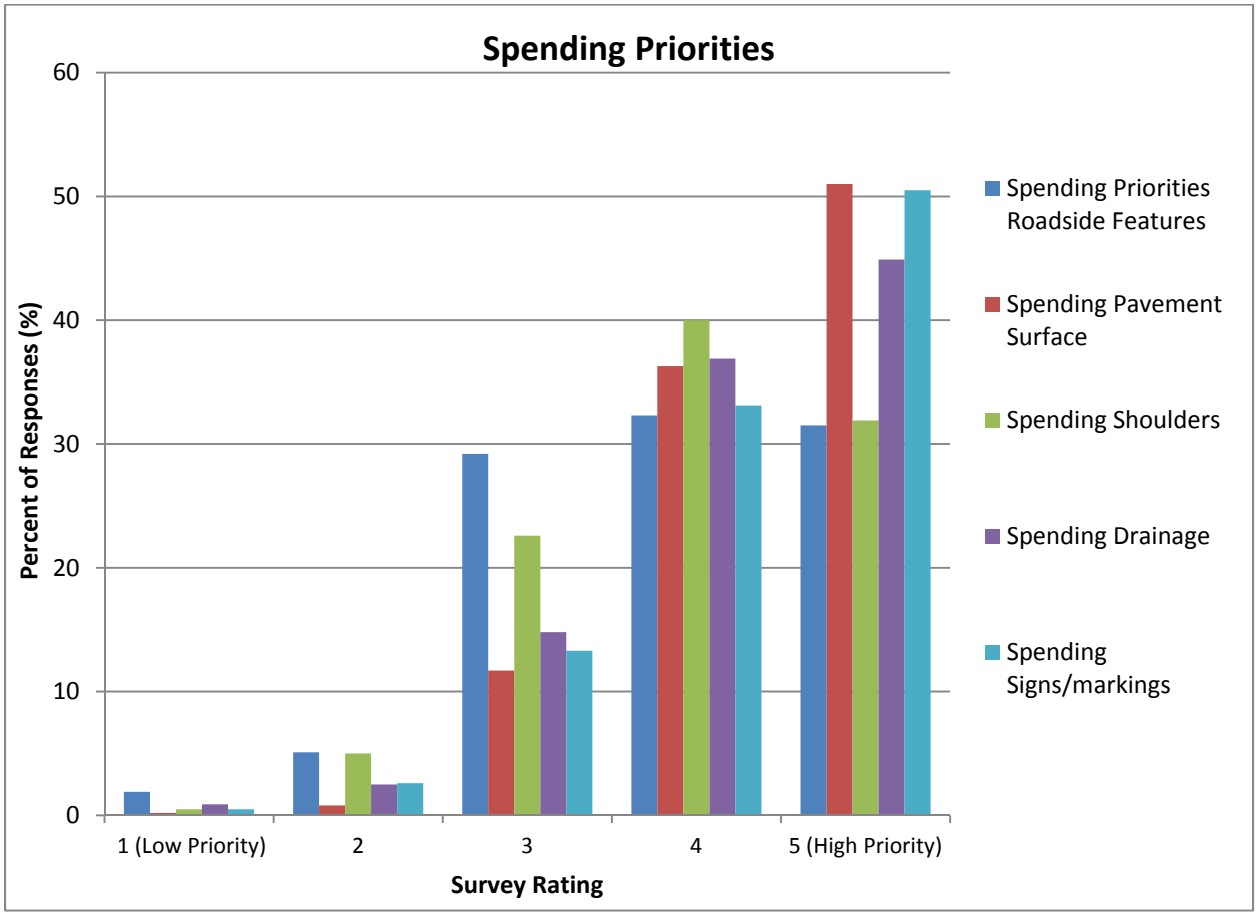

Figure 30 Distribution of Desired Level of Spending

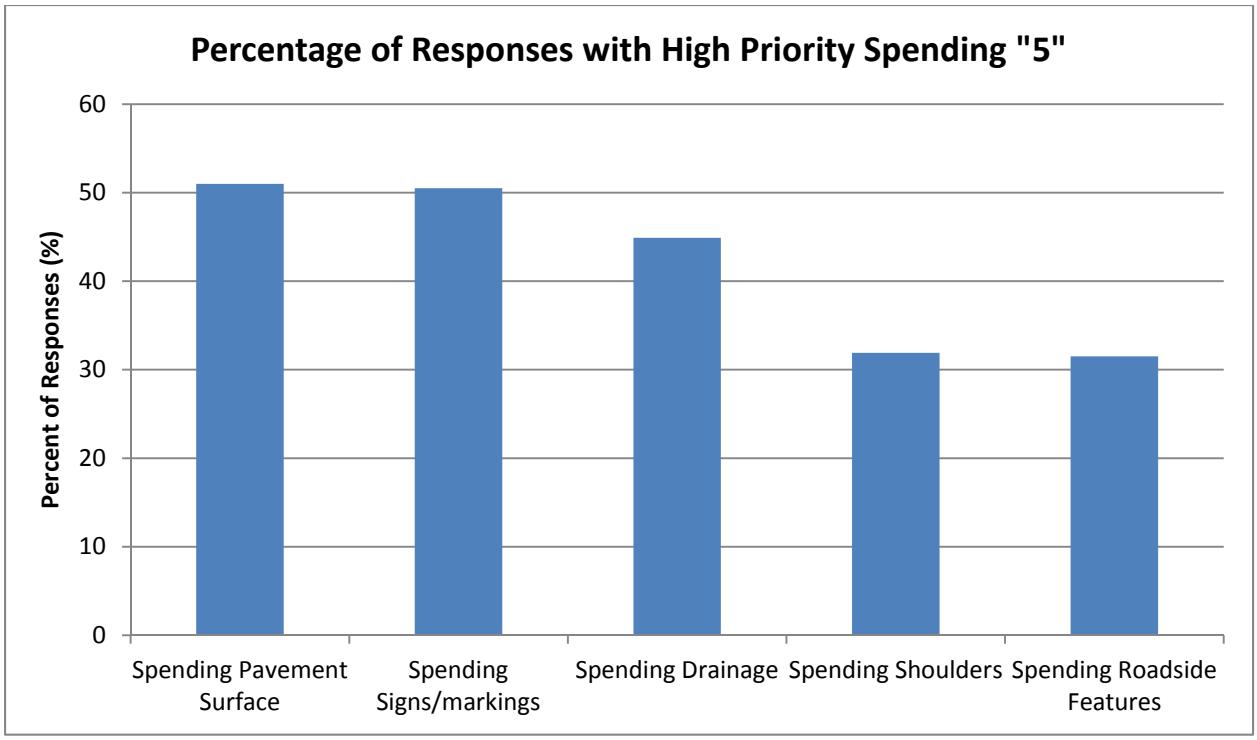

Figure 31 Summary of High Priority Spending "5"

Appendix A Summary of Required Sample Size

Introduction

The Division of Maintenance, Operations and Pavement Management Branch of the Kentucky Transportation Cabinet requested that the Kentucky Transportation Center at the University of Kentucky review the sampling techniques and sample sizes for the current Maintenance Rating Program that is managed by that Division. Therefore this research study was initiated to determine the sample sizes necessary to adequately describe the individual highway networks for a predetermined level of confidence.

Current Program

Each year all of the highway mileage in each roadway classification in each of the 12 highway districts is divided into 500-foot survey sections. A number of these sections are then randomly chosen to be visually surveyed. The method for randomly choosing the survey sections was not reviewed under this study.

All of the highway mileage is divided into four roadway classes as follows:

Interstate,
Other National Highway System (OTHER NHS),
Other State Primary and State Secondary (OTH. SS+SP), and
Rural Secondary (RURAL SEC.).

The surveys are conducted according to the *Field Data Collection Manual* developed for the Maintenance Rating Program. Currently, there are 38 individual elements on each roadway survey section that are cataloged and quantified. They are

RIDEABILITY – Rideability (measured as IRI)
AESTHETICS – General Appearance
VCLEAR – Vertical clearance
VISOBSTR – Visual Obstructions
FENCING – Right-of-way Fence
FENCEBARR – Fence Providing Positive Barrier?
GUARDRAIL – Presence of Guardrail?
OUTOFSPEC – Guardrail Out of Spec?
GR DAMAGE – Damage to Guardrail?
ATTENUATE – Number of Guardrail Attenuators/Rail Ends
ATTENDAM – Number of Attenuators/Rail Ends Damaged
POTHOLES – Number of Pavement Potholes
RUTTING0 – Rutting Outside Wheel Path at 0 Feet
RUTTING100 – Rutting Outside Wheel Path at 100 Feet
PVMNT DROP – Pavement Drop Off to Shoulder (>= 1.5”)
SHLDR DROP – Shoulder Drop Off to Ground (>= 3.0”)
HIGHSHLDR – Is There a High Shoulder?
SHLDRPOTHO – Number of Shoulder Potholes
DRAINS – Number of Drainage Structures
DRAINBLOCK – Drainage Structures with 25% or Greater Flow Inhibited
DITCH – Ditches Present?

DITCHFLOW – Are there Ditches with Flow Inhibited?
CURBS – Curbs and Gutters Present?
CURBFLOW – Curbs and Gutters with Flow Inhibited?
WHITE1 – Striping Reflectivity (Reading 1)
WHITE2 - Striping Reflectivity (Reading 2)
WHITE3 - Striping Reflectivity (Reading 3)
YELLOW1 - Striping Reflectivity (Reading 1)
YELLOW2 - Striping Reflectivity (Reading 2)
YELLOW3 - Striping Reflectivity (Reading 3)
GUIDESIGNS – Number of Guide Signs
GDNOCNFRM – Number of Non-Conforming Guide Signs
GUIDEASBLY – Number of Guide Sign Assemblies
GDASSNOCFM – Number of Non-Conforming Guide Sign Assemblies
WARNSIGN – Number of Warning/Regulatory Signs
WARNNOCNFM – Number of Non-Conforming Warning/Regulatory Signs
WARNASSBLY – Number of Warning/Regulatory Sign Assemblies
WNASSNOCFM – Number of Non-Conforming Warning/Regulatory Assemblies.

Each year the division publishes a report entitled *Maintenance Condition of Kentucky Highways (Statewide Maintenance Rating Program – FY 20XX).*

Available Data

At the initiation of this research study, all currently available data was delivered to the research team. A review of that data indicated there were 10 years of data that were available. These were from Fiscal Year 2000 to Fiscal Year 2009.

There are also two EXCEL spreadsheet programs that are used to analyze the survey data. The first program is entitled *Data Analyzer* which reduces the raw survey data, and the second program entitled *Weighted Data* weighs the data according to lane miles and predetermined importance factors.

There was a data format change made in the raw data between FY 2006 and FY 2007. Because of this change in format, the data prior to FY 2007 was not used in the data analysis that was conducted in this study.

Methodology

In analyzing the data to determine the necessary sample size in order to obtain a predetermined level of confidence, the variability and characteristics of the raw data will be the controlling factor in making that determination. Therefore, only the raw, unprocessed data were used in this study.

It was the understanding of the research team that each roadway class network in each district was divided into 500-foot survey sections, and the number of sections to be surveyed in a particular year was chosen randomly. The process of randomization and selection was not a part of the scope of this study and, therefore, was not analyzed in this research effort. In calendar years 2007 through 2009, highway personnel surveyed from as low as 30 sections per functional class, per district, per year to over 100 sections. If any functional class for a particular year in any highway district had less than 19 sections that had been surveyed, the Operations and Pavement Management Branch considered that as insufficient data and the data were not analyzed. It was not clear to the research team nor to the current personnel of the Operations and Pavement Management Branch how that number was originally determined.

Binary Data (YES/NO or 1/0)

Of the 38 individual elements that are reported for each survey section, 15 are binary data (Yes/No, 1/0 or <=1/4"- >1/4").

Sample sizes for binary data where the sample size is relatively small compared to the population size (sample size less than 5% total population) can be calculated from Equation 1. A graphical representation of this equation confidence of +/- 5% is given in Figure A.1. It may be seen from this figure that the largest sample size is required when the proportion of Yes/No answers is 0.5.

$$ss = \frac{Z^2 * (p) * (1 - p)}{c^2} \qquad (1)$$

where:

ss = sample size required
Z = value taken from the normal distribution 1.96 for 95% confidence level or 1.645 for 90%
p = proportion of choices with given answer, expressed as a decimal (50% = 0.5)
c = confidence interval, expressed as a decimal

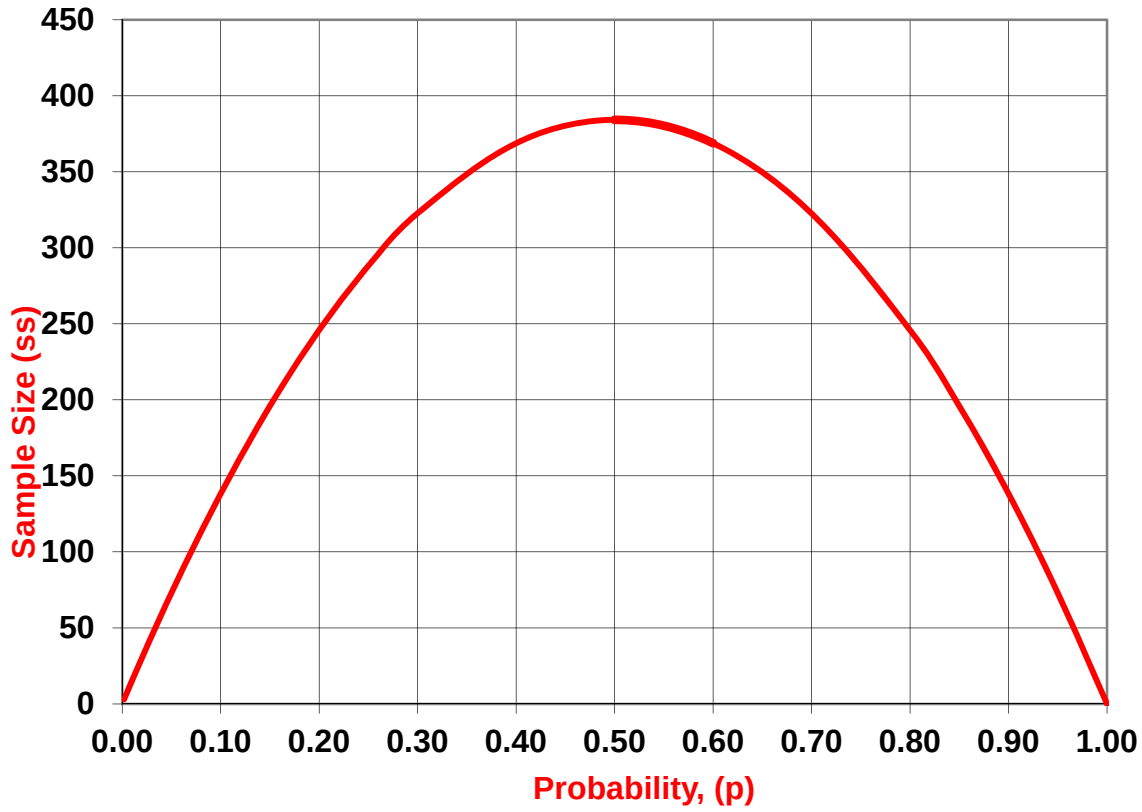

Figure A.1 Sample Size Versus Probability (Proportion) for Unlimited Sample Size for a 95 percent confidence of +/- 5%

For sample sizes where a finite population is known or where the sample size would be greater than 5 percent of the population an adjustment in the sample size for finite populations can be made. The equation for reducing the sample size required is given in Equation 2. A graphical representation of this equation at 95 percent confidence of +/- 5% is given in Figure A.2 across various finite sample sizes. Figure A.3 provides a similar comparison for a 90 percent confidence of +/- 5%.

$$\text{new ss} = \frac{\text{ss}}{1 + \left[\frac{\text{ss} - 1}{\text{pop}}\right]} \qquad (2)$$

where:

new ss = sample size required for finite population
ss= sample size determined from Equation 1
pop = size of population

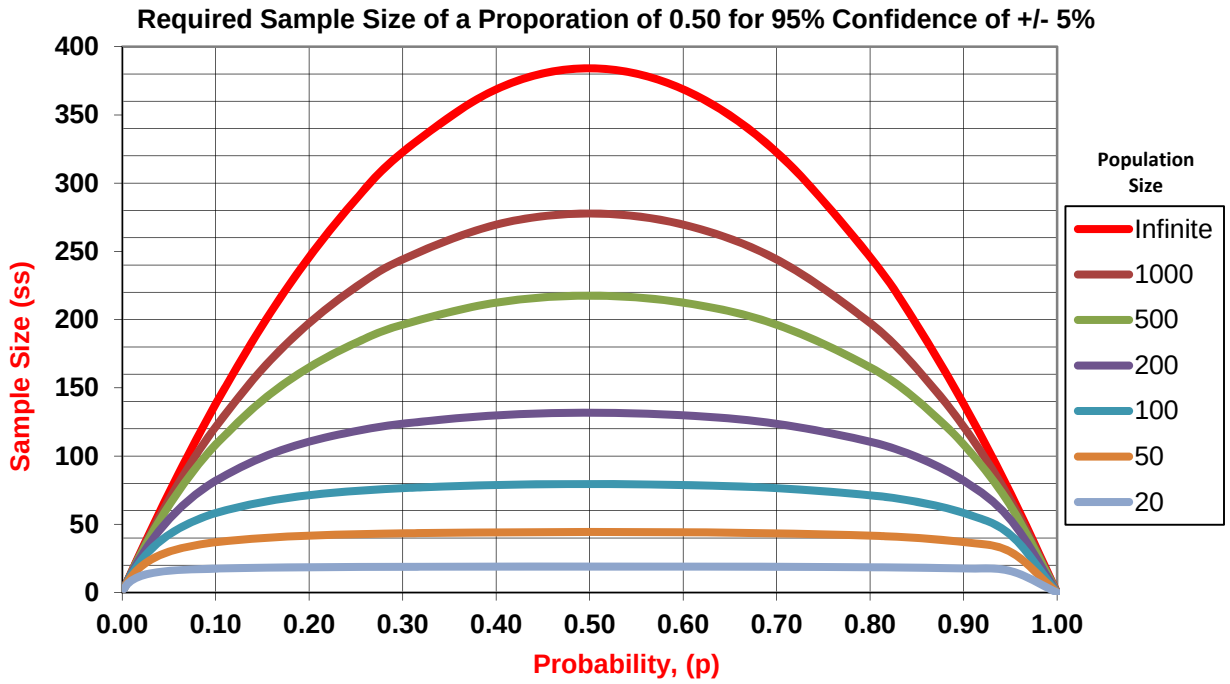

Figure A.2 Sample Size Versus Probability (Proportion) for Various Sample Sizes at 95 percent confidence of +/- 5%

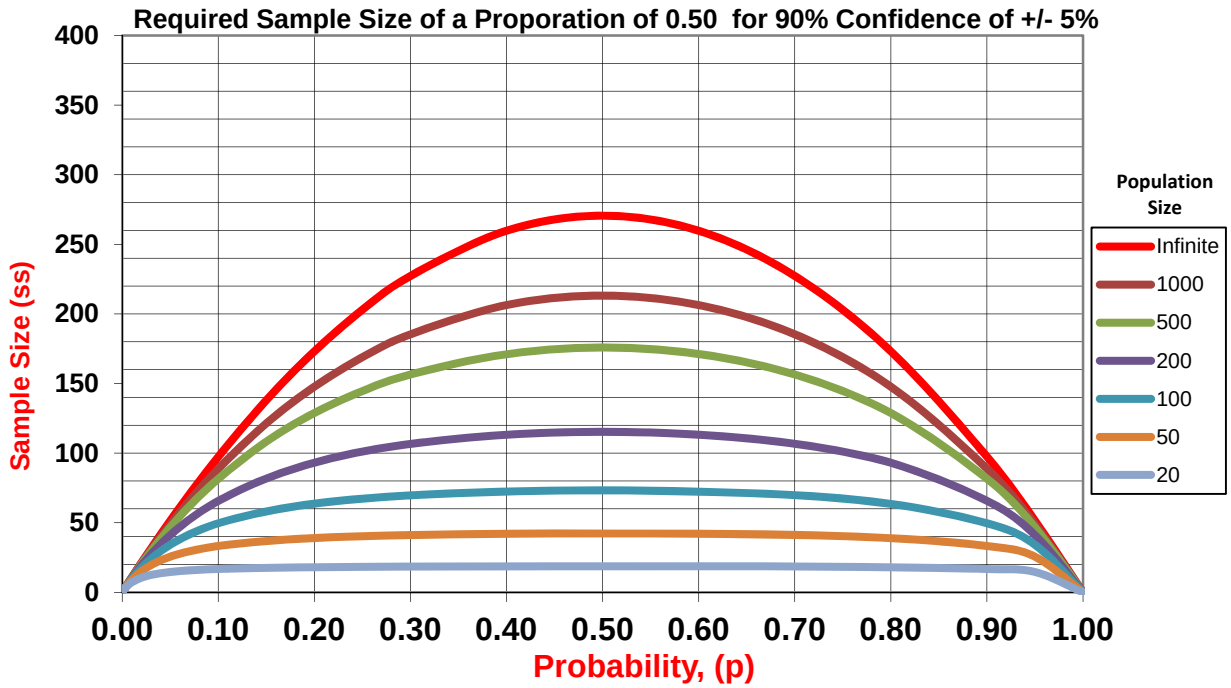

Figure A.3 Sample Size Versus Probability (Proportion) for Various Sample Sizes at 90 percent confidence of +/- 5%

To explain the procedure for calculating probability (proportion), p, in Equation 1, we will use an example. The quantity identified as VCLEAR (vertical clearance) in the MRP data receives a NO answer in the survey data if there are no locations where there is less than 15 feet vertical clearance over the roadway or shoulder. The survey is answered YES if a survey section has a site that has less than 15 feet of clearance. The probability, p, of a Yes occurring is calculated as the ratio of the number of YES answers to the total number of sections surveyed (for a particular roadway class network and district). As an example, the probability of a YES occurring for VCLEAR on the OTHER NHS network in District 1 equals 0.085 (or 8.5%). Utilizing this information and Equation 1 above the maximum sample would be 120.

A study of Equations 1 and 2 above shows that the number of samples, ss, necessary for a particular confidence level is dependent on total population size, *pop* (or the number of survey sections possible on a particular highway network). In addition, *ss* is highly dependent on the probability of a particular event occurring. Figure A.2 is a graphical display of the relationship between *ss, pop* and *p*.

Figure A.1 shows that Equation 1 is symmetrical about a probability of 0.5. This means that the further the probability is from 0.5 (either above or below 0.5) the fewer the samples that are required.

Non-Binary Data

Fourteen of the elements reported for each section are non-binary data. This is data that has a range of numbers such as 0, 1, 2, 3 and etc. In this type of data, the number that has the highest probability of occurrence is the number that controls the sample size. It is best to illustrate this by example.

> One survey element is the number of *guardrail attenuators* per section (ATTENUATE). The number ranges from 0 to 5. Again, the controlling number for this section in determining sample size is the number with the highest probability of occurring. In this case, the number 0 occurs most often, therefore, determining the sample size. Assuming there are a large number of samples within the given network then required sample sizes would be as follows, (data taken from years 2007 through 2009 and 95% confidence) based on Equation 1 above:

Number	***Probability***	***Required Sample Size***
Zero	0.824	223
One	0.108	148
Two	0.046	67
Three	0.010	15
Four	0.008	12
>Four	0.003	5

It is clear from this example that the probability of no guardrail attenuators occurring on any particular section is 82.4% (for this network and district). Consequently, all of the sections that had ***no*** guardrail attenuators would control the number of samples required. Therefore, all of the non-binary data can, in fact, be treated as binary data.

The historical probabilities of each element, for each district and roadway class are given in Table A.1 below. The probabilities were calculated for the years 2007 through 2009. The analysis showed that there was very little change in probability from one year to the next for any particular element. The probabilities from these tables can be used to determine required sample size in conjunction with Equations 1 and 2 above. Values have been highlighted where the probability is between 0.5 and 0.6 which would yield the highest required sample sizes.

Table A.1 Historical Probability

District	General Aesthetics (AESTHETICS)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.87	0.55	0.59	0.55
2	0.27	0.74	0.44	0.45
3	0.48	0.51	0.31	0.21
4	0.13	0.21	0.24	0.14
5	0.38	0.32	0.35	0.35
6	0.54	0.57	0.40	0.28
7	0.66	0.54	0.48	0.38
8	0.67	0.51	0.42	0.34
9	0.67	0.49	0.41	0.22
10		0.47	0.26	0.18
11	0.30	0.34	0.47	0.54
12		0.51	0.53	0.28

District	Vertical Clearance (VCLEAR)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1		0.09	0.18	0.30
2		0.01	0.31	0.38
3		0.10	0.34	0.42
4		0.24	0.28	0.40
5		0.12	0.13	0.24
6		0.03	0.37	0.44
7		0.04	0.25	0.39
8		0.04	0.15	0.34
9		0.01	0.38	0.59
10		0.10	0.60	0.72
11		0.02	0.34	0.51
12		0.12	0.63	0.83

District	Visual Obstructions (VISOBSTR)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.01	0.01	0.01	0.03
2		0.01	0.09	0.13
3		0.01	0.23	0.34
4	0.13	0.03	0.09	0.16
5		0.03	0.07	0.13
6	0.02	0.00	0.23	0.21
7		0.01	0.11	0.18
8	0.01	0.03	0.20	0.23
9		0.00	0.07	0.17
10		0.04	0.14	0.15
11		0.00	0.11	0.13
12		0.01	0.02	0.05

District	Right-of-Way Fencing (FENCING)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.96	0.54	0.04	0.00
2	0.93	0.67	0.03	0.01
3	0.94	0.90	0.05	0.01
4	1.00	0.81	0.08	0.00
5	0.76	0.15	0.01	0.00
6	0.85	0.56	0.01	0.00
7	0.99	0.28	0.05	0.01
8	1.00	0.38	0.06	0.00
9	1.00	0.61	0.02	0.00
10		0.53	0.01	0.01
11	0.99	0.33	0.02	0.00
12		0.17	0.02	0.00

Table A.1 Historical Probability (cont.)

District	Fence Providing Positive Barrier (FENCEBARR)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.02	0.03	0.01	0.00
2	0.03	0.02	0.01	0.00
3	0.00	0.01	0.00	0.00
4	0.03	0.00	0.00	0.00
5	0.03	0.00	0.00	0.00
6	0.06	0.04	0.00	0.00
7	0.01	0.02	0.02	0.00
8	0.13	0.02	0.00	0.00
9	0.07	0.05	0.00	0.00
10		0.05	0.00	0.00
11	0.00	0.05	0.00	0.00
12		0.03	0.02	0.01

District	Guardrail Present (GUARDRAIL)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.34	0.26	0.14	0.06
2	0.12	0.44	0.08	0.03
3	0.42	0.37	0.14	0.05
4	0.46	0.56	0.13	0.05
5	0.52	0.15	0.17	0.11
6	0.51	0.51	0.19	0.10
7	0.45	0.32	0.14	0.09
8	0.56	0.51	0.17	0.08
9	0.66	0.61	0.30	0.10
10		0.85	0.21	0.09
11	0.69	0.58	0.30	0.07
12		0.66	0.44	0.23

District	Guardrail Outside Height Specification (OUTOFSPEC)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.04	0.01	0.02	0.02
2	0.00	0.02	0.03	0.01
3	0.11	0.07	0.06	0.04
4	0.01	0.11	0.01	0.02
5	0.05	0.02	0.04	0.04
6	0.02	0.01	0.04	0.01
7	0.00	0.03	0.02	0.01
8	0.04	0.13	0.04	0.03
9	0.05	0.22	0.15	0.07
10		0.14	0.05	0.01
11	0.04	0.11	0.08	0.03
12		0.03	0.11	0.07

District	Guardrail Damaged (GR DAMAGE)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.03	0.02	0.01	0.01
2	0.01	0.03	0.02	0.01
3	0.09	0.05	0.03	0.02
4	0.02	0.01	0.00	0.00
5	0.10	0.03	0.02	0.01
6	0.06	0.05	0.03	0.02
7	0.05	0.04	0.04	0.01
8	0.09	0.05	0.04	0.01
9	0.01	0.06	0.04	0.01
10		0.08	0.02	0.00
11	0.07	0.11	0.06	0.02
12		0.08	0.06	0.02

Table A.1 Historical Probability (cont.)

District	Number of Attenuators (ATTENUATE)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.78	0.78	0.89	0.94
2	0.89	0.89	0.97	0.99
3	0.73	0.73	0.88	0.95
4	0.75	0.75	0.91	0.95
5	0.70	0.70	0.87	0.92
6	0.66	0.66	0.87	0.95
7	0.75	0.75	0.89	0.94
8	0.66	0.66	0.89	0.93
9	0.72	0.72	0.77	0.92
10			0.82	0.93
11	0.61	0.61	0.83	0.95
12			0.68	0.81

District	Number of Attenuatros Damaged (ATTENDAM)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	1.00	0.99	1.00	0.99
2	1.00	0.98	1.00	1.00
3	0.99	0.98	1.00	1.00
4	1.00	0.99	1.00	1.00
5	0.98	0.98	0.99	0.99
6	0.98	0.99	1.00	1.00
7	0.99	0.98	1.00	0.99
8	1.00	0.99	0.99	1.00
9	0.99	0.97	0.99	1.00
10		0.96	0.99	0.99
11	1.00	0.93	0.98	0.99
12		0.97	0.97	0.99

District	Number of Potholes (POTHOLES)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.93	0.98	0.99	0.99
2	0.95	0.93	0.89	0.88
3	0.86	0.97	0.94	0.96
4	1.00	1.00	1.00	0.98
5	0.90	0.85	0.91	0.87
6	0.83	0.95	0.86	0.81
7	0.92	0.87	0.93	0.92
8	0.98	0.99	1.00	0.98
9	1.00	0.98	0.90	0.87
10		0.99	0.97	0.94
11	0.85	0.96	0.93	0.91
12		0.97	0.91	0.83

District	Pavement Dropoff (PVMNT DROP)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.01	0.08	0.14	0.32
2	0.24	0.10	0.15	0.30
3	0.07	0.10	0.16	0.32
4	0.00	0.02	0.07	0.36
5	0.01	0.05	0.22	0.45
6	0.08	0.01	0.23	0.38
7	0.00	0.02	0.11	0.14
8	0.00	0.08	0.24	0.48
9	0.02	0.01	0.34	0.84
10		0.00	0.18	0.33
11	0.11	0.22	0.21	0.19
12		0.03	0.26	0.56

Table A.1 Historical Probability (cont.)

District	Shoulder Dropoff (SHLDR DROP)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.08	0.17	0.25	0.19
2	0.02	0.12	0.44	0.48
3	0.11	0.14	0.48	0.50
4	0.13	0.05	0.08	0.07
5	0.21	0.05	0.36	0.44
6	0.25	0.31	0.53	0.52
7	0.05	0.09	0.35	0.44
8	0.02	0.17	0.49	0.71
9	0.02	0.22	0.37	0.09
10		0.11	0.29	0.04
11	0.11	0.11	0.36	0.48
12		0.15	0.31	0.18

District	High Shoulder (HIGH SHLDR)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.14	0.04	0.08	0.13
2	0.11	0.06	0.21	0.21
3	0.07	0.17	0.39	0.32
4	0.00	0.00	0.04	0.04
5	0.06	0.15	0.09	0.10
6	0.02	0.03	0.19	0.28
7	0.05	0.20	0.33	0.44
8	0.00	0.08	0.26	0.37
9	0.02	0.09	0.44	0.44
10		0.02	0.13	0.16
11	0.08	0.09	0.32	0.31
12		0.07	0.21	0.29

District	Number of Shoulder Potholes (SHLDRPOTHO)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.96	0.98	0.99	0.99
2	0.95	0.92	0.86	0.88
3	0.84	0.86	0.87	0.89
4	1.00	0.96	0.96	0.98
5	0.95	0.90	0.83	0.79
6	0.83	0.94	0.88	0.85
7	0.93	0.91	0.90	0.91
8	0.97	0.91	0.95	0.97
9	1.00	0.95	0.89	0.90
10		0.96	0.94	0.90
11	0.85	0.81	0.83	0.85
12		0.95	0.87	0.91

District	Number of Drainage Structures (DRAINS)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.28	0.28	0.63	0.63
2	0.27	0.27	0.69	0.69
3	0.37	0.37	0.63	0.63
4	0.63	0.63	0.55	0.55
5	0.58	0.58	0.61	0.61
6	0.53	0.53	0.57	0.57
7	0.36	0.36	0.63	0.63
8	0.80	0.80	0.65	0.65
9	0.43	0.43	0.42	0.42
10			0.46	0.46
11	0.32	0.32	0.55	0.55
12			0.34	0.34

Table A.1 Historical Probability (cont.)

District	Number of Drains Blocked (DRAINBLOCK)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.79	0.93	0.93	0.96
2	0.71	0.77	0.94	0.95
3	0.91	0.93	0.80	0.83
4	0.98	0.98	0.93	0.94
5	0.94	0.97	0.88	0.88
6	0.87	0.91	0.81	0.84
7	0.78	0.86	0.91	0.85
8	1.00	0.93	0.90	0.85
9	0.99	0.98	0.89	0.83
10		0.94	0.84	0.87
11	0.96	0.96	0.87	0.90
12		0.87	0.81	0.84

District	Ditches Present (DITCH)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.98	0.92	0.90	0.94
2	1.00	0.92	0.91	0.97
3	0.94	0.99	0.92	0.96
4	0.86	0.82	0.97	0.99
5	0.94	0.63	0.79	1.00
6	0.83	0.74	0.91	0.98
7	0.98	0.82	0.86	0.94
8	0.87	0.86	0.91	0.97
9	0.98	0.91	0.93	0.98
10		0.76	0.98	0.95
11	0.99	0.89	0.90	0.94
12		0.81	0.96	0.95

District	Ditch Flow Inhibited (DITCHFLOW)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.10	0.13	0.29	0.30
2	0.01	0.05	0.19	0.26
3	0.27	0.29	0.55	0.62
4	0.02	0.12	0.05	0.06
5	0.01	0.07	0.12	0.18
6	0.12	0.26	0.40	0.45
7	0.09	0.16	0.28	0.43
8	0.35	0.37	0.47	0.64
9	0.08	0.10	0.28	0.37
10		0.13	0.14	0.22
11	0.02	0.08	0.33	0.39
12		0.11	0.28	0.33

District	Curb and Gutter Present (CURBS)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.17	0.06	0.03	0.00
2	0.01	0.06	0.07	0.01
3	0.00	0.14	0.07	0.01
4	0.05	0.05	0.04	0.00
5	0.09	0.48	0.23	0.01
6	0.14	0.29	0.09	0.00
7	0.01	0.30	0.15	0.02
8	0.00	0.07	0.04	0.01
9	0.00	0.16	0.07	0.01
10		0.06	0.00	0.00
11	0.15	0.06	0.04	0.02
12		0.19	0.03	0.01

Table A.1 Historical Probability (cont.)

District	Curb and Gutter Flow Inhibited (CRUBFLOW)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.07	0.01	0.01	0.00
2	0.00	0.02	0.01	0.00
3	0.00	0.07	0.04	0.01
4	0.00	0.00	0.00	0.00
5	0.00	0.05	0.04	0.00
6	0.02	0.00	0.01	0.00
7	0.00	0.01	0.03	0.01
8	0.00	0.01	0.00	0.00
9	0.00	0.05	0.01	0.00
10		0.01	0.00	0.00
11	0.00	0.00	0.00	0.00
12		0.01	0.00	0.00

District	Number of Guide Signs (GUIDESIGNS)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.72	0.64	0.69	0.79
2	0.77	0.77	0.78	0.82
3	0.57	0.80	0.82	0.90
4	0.73	0.89	0.76	0.88
5	0.59	0.57	0.69	0.80
6	0.47	0.64	0.82	0.92
7	0.75	0.64	0.78	0.92
8	0.80	0.69	0.81	0.87
9	0.86	0.65	0.82	0.93
10		0.74	0.77	0.88
11	0.70	0.82	0.86	0.89
12		0.68	0.83	0.88

District	Number of Guidesigns Not Conforming (GDNOCFRM)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.98	0.99	0.96	0.98
2	1.00	1.00	0.98	0.99
3	0.97	0.98	0.97	0.97
4	0.99	1.00	1.00	0.99
5	0.97	0.92	0.96	0.97
6	0.99	0.97	0.97	1.00
7	0.99	0.91	0.96	0.97
8	1.00	0.99	1.00	0.99
9	0.98	0.98	0.97	0.99
10		1.00	1.00	0.99
11	0.97	0.97	0.97	0.98
12		0.97	0.99	0.99

District	Number of Guide Assemblies (GUIDEASBLY)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.72	0.65	0.74	0.80
2	0.77	0.77	0.79	0.82
3	0.57	0.80	0.82	0.90
4	0.73	0.89	0.76	0.88
5	0.59	0.57	0.69	0.81
6	0.52	0.75	0.87	0.93
7	0.75	0.72	0.81	0.93
8	0.79	0.70	0.81	0.87
9	0.85	0.65	0.82	0.93
10		0.75	0.77	0.90
11	0.70	0.83	0.86	0.90
12		0.68	0.84	0.88

Table A.1 Historical Probability (cont.)

District	Number of Guide Assemblies Not Conforming (GDASSNOCFM)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.99	0.99	0.99	0.98
2	0.99	0.98	0.99	0.99
3	1.00	0.96	0.98	1.00
4	1.00	1.00	1.00	1.00
5	0.97	1.00	0.97	0.98
6	1.00	0.99	0.99	0.99
7	0.97	0.96	0.98	0.99
8	1.00	1.00	1.00	1.00
9	0.99	0.97	0.98	1.00
10		1.00	0.99	1.00
11	0.99	0.99	1.00	1.00
12		0.98	0.97	0.97

District	Number of Warning Signs (WARNSIGN)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.84	0.63	0.63	0.71
2	0.86	0.80	0.67	0.66
3	0.86	0.76	0.55	0.74
4	0.89	0.83	0.66	0.79
5	0.87	0.52	0.42	0.51
6	0.84	0.52	0.53	0.58
7	0.91	0.64	0.59	0.75
8	0.94	0.69	0.50	0.62
9	0.90	0.58	0.58	0.82
10		0.46	0.53	0.76
11	0.86	0.77	0.62	0.78
12		0.63	0.54	0.79

District	Number of Warning Signs Not Conforming (WARNNOCNFM)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	1.00	0.98	0.95	0.92
2	1.00	0.99	0.97	0.96
3	0.97	0.97	0.88	0.94
4	1.00	1.00	0.99	1.00
5	0.99	0.92	0.87	0.86
6	1.00	1.00	0.93	0.95
7	1.00	0.95	0.90	0.93
8	1.00	0.99	0.97	0.97
9	0.99	0.97	0.96	0.97
10		0.99	0.99	0.99
11	1.00	0.96	0.91	0.94
12		0.98	0.90	0.97

District	Number of Warning Assemblies (WARNASSBLY)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	0.84	0.67	0.67	0.72
2	0.86	0.80	0.67	0.66
3	0.86	0.76	0.56	0.74
4	0.89	0.83	0.65	0.79
5	0.89	0.52	0.43	0.52
6	0.88	0.65	0.59	0.60
7	0.91	0.75	0.71	0.84
8	0.94	0.69	0.50	0.62
9	0.91	0.58	0.59	0.82
10		0.45	0.55	0.77
11	0.86	0.79	0.65	0.80
12		0.63	0.55	0.79

Table A.1 Histrocial Probabilities (cont.)

District	Number of Warning Sign Assemblies Not Conforming (WNASSNOCFM)			
	Interstate	Other NHS	Other SP+SS	Rural Sec.
1	1.00	1.00	0.95	0.96
2	0.98	1.00	0.99	0.97
3	0.97	0.98	0.96	0.96
4	1.00	1.00	0.99	1.00
5	0.98	1.00	0.95	0.93
6	1.00	1.00	0.95	0.93
7	0.99	0.96	0.95	0.97
8	1.00	0.99	0.98	1.00
9	1.00	0.97	0.96	0.97
10		1.00	0.99	0.99
11	1.00	0.99	0.99	0.98
12		0.98	0.93	0.95

Rideability Data

The rideability data is the only survey element that cannot be treated as binary data. In order to estimate sample size for the rideability data, the *standard deviation* of the rideability data must be estimated, and sample size can then be calculated using Equation 3:

$$ss = \frac{Z^2 * sd^2}{c^2} \qquad (3)$$

where:

ss = sample size required
Z = value taken from the normal distribution 1.96 for 95% confidence level, 1.645 for 90% confidence level
sd = "estimated" standard deviation
c = confidence interval (example +/- 10 IRI)

The only way to estimate the *standard deviation* is to use the historical standard deviations. Table A.2 shows the calculated historical standard deviations for years 2007 through 2009, by functional class, by district, by year. The required sample size based on the historical standard deviations for a 95% confidence of +/- 10 IRI is also shown in that table. Sample sizes for a 90% confidence of +/- 10 IRI are given in Table A.3. If sample sizes for other confidence intervals were desired other than +/- 10 IRI, Equation 3 above could be utilized, and updated tables generated.

Table A.2 Rideability - Number of Samples Required for 95% Confidence Level for +/- 10 IRI Based on Historical Standard Deviations

DISTRICT	INTERSTATE						OTHER NHS					
	2007		2008		2009		2007		2008		2009	
	sd	ss	sd	ss	sd	ss	sd	ss	sd	ss	sd	ss
1	47	85	27	28	40	61	33	42	31	37	36	50
2	27	28	36	50	27	28	38	55	34	44	36	50
3	42	68	33	42	25	24	21	17	21	17	21	17
4	15	9	23	20	16	10	27	28	32	39	30	35
5	34	44	44	74	44	74	37	53	37	53	40	61
6	22	19	34	44	40	61	32	39	49	92	55	116
7	43	71	16	10	19	14	39	58	35	47	41	65
8	12	6	16	10	9	3	18	12	16	10	27	28
9	47	85	15	9	15	9	22	19	27	28	33	42
10		0		0		0	17	11	16	10	38	55
11	34	44	34	44	42	68	23	20	48	89	28	30
12		0		0		0	45	78	25	24	45	78

DISTRICT	OTHER SP+SS						RURAL SEC.					
	2007		2008		2009		2007		2008		2009	
	sd	ss	sd	ss	sd	ss	sd	ss	sd	ss	sd	ss
1	30	35	25	24	33	42	26	26	18	12	34	44
2	47	85	29	32	37	53	38	55	33	42	39	58
3	25	24	26	26	34	44	37	53	16	10	29	32
4	38	55	27	28	33	42	38	55	25	24	33	42
5	32	39	34	44	40	61	39	58	34	44	36	50
6	33	42	40	61	48	89	51	100	38	55	48	89
7	35	47	36	50	42	68	38	55	31	37	51	100
8	27	28	28	30	31	37	22	19	19	14	33	42
9	32	39	27	28	38	55	34	44	36	50	46	81
10	33	42	29	32	54	112	52	104	43	71	87	291
11	42	68	37	53	44	74	42	68	39	58	57	125
12	42	68	28	30	57	125	39	58	34	44	54	112

Table A.3 Rideability - Number of Samples Required for 90% Confidence Level for +/- 10 IRI Based on Historical Standard Deviations

DISTRICT	INTERSTATE						OTHER NHS					
	2007		2008		2009		2007		2008		2009	
	sd	ss	sd	ss	sd	ss	sd	ss	sd	ss	sd	ss
1	47	60	27	20	40	43	33	29	31	26	36	35
2	27	20	36	35	27	20	38	39	34	31	36	35
3	42	48	33	29	25	17	21	12	21	12	21	12
4	15	6	23	14	16	7	27	20	32	28	30	24
5	34	31	44	52	44	52	37	37	37	37	40	43
6	22	13	34	31	40	43	32	28	49	65	55	82
7	43	50	16	7	19	10	39	41	35	33	41	45
8	12	4	16	7	9	2	18	9	16	7	27	20
9	47	60	15	6	15	6	22	13	27	20	33	29
10		0		0		0	17	8	16	7	38	39
11	34	31	34	31	42	48	23	14	48	62	28	21
12		0		0		0	45	55	25	17	45	55

DISTRICT	OTHER SP+SS						RURAL SEC.					
	2007		2008		2009		2007		2008		2009	
	sd	ss	sd	ss	sd	ss	sd	ss	sd	ss	sd	ss
1	30	24	25	17	33	29	26	18	18	9	34	31
2	47	60	29	23	37	37	38	39	33	29	39	41
3	25	17	26	18	34	31	37	37	16	7	29	23
4	38	39	27	20	33	29	38	39	25	17	33	29
5	32	28	34	31	40	43	39	41	34	31	36	35
6	33	29	40	43	48	62	51	70	38	39	48	62
7	35	33	36	35	42	48	38	39	31	26	51	70
8	27	20	28	21	31	26	22	13	19	10	33	29
9	32	28	27	20	38	39	34	31	36	35	46	57
10	33	29	29	23	54	79	52	73	43	50	87	205
11	42	48	37	37	44	52	42	48	39	41	57	88
12	42	48	28	21	57	88	39	41	34	31	54	79

Review of Historical Sample Size

Data for 2008 has been used to determine the level of confidence which is currently being obtained for the existing sample sizes. The first step in this process was to determine the total population of potential samples which are available. Table A.4 provides a summary of the centerline mileage for 2008. These lane miles were then divided into 500-foot sample sections to determine the maximum number of available samples which is given in Table A.5. The sample sizes for each roadway classification in each district are given in Table A.6.

Table A.4 Centerline Mileage 2008

Centerline Miles 2008 Data													
	District												
	1	2	3	4	5	6	7	8	9	10	11	12	Totals
Interstate CL	67	26	54	49	180	117	120	23	76	-	28	-	740
Total NHS CL	245	320	205	168	254	172	334	259	253	156	215	264	2,846
Other NHS CL	177	293	151	119	75	55	215	236	177	156	187	264	2,106
Other SP+SS CL	1,264	1,529	1,003	1,356	823	1,007	929	957	930	891	948	783	12,421
Rural Secondary CL	1,291	1,446	1,239	1,380	691	732	914	1,155	826	793	877	820	12,165
Total CL	2,800	3,294	2,447	2,905	1,768	1,911	2,178	2,371	2,009	1,840	2,040	1,868	27,431

Table A.5 Sample Population

Population of Possible 500-foot Samples													
	District												
	1	2	3	4	5	6	7	8	9	10	11	12	TOTALS
Interstate	711	276	570	521	1,897	1,236	1,264	239	801	-	295	-	7,810
Total NHS	2,583	3,375	2,164	1,776	2,684	1,815	3,532	2,736	2,675	1,648	2,269	2,793	30,050
Other NHS	1,872	3,099	1,594	1,255	787	579	2,267	2,497	1,874	1,648	1,974	2,793	22,240
Other SP+SS	13,350	16,143	10,597	14,324	8,689	10,629	9,810	10,107	9,819	9,411	10,011	8,272	131,162
Rural Secondary	13,637	15,272	13,081	14,574	7,299	7,734	9,656	12,194	8,719	8,371	9,263	8,662	128,461
Total	29,570	34,790	25,842	30,674	18,673	20,178	22,997	25,037	21,213	19,429	21,543	19,727	289,672

Table A.6 2008 MRP Sample

MRP Samples 2008													
	District												
	1	2	3	4	5	6	7	8	9	10	11	12	TOTALS
Interstate	38	34	35	40	37	41	40	36	42		28		371
Total NHS	138	132	137	144	137	139	142	138	140	98	127	96	1,568
Other NHS	100	98	102	104	100	98	102	102	98	98	99	96	1,197
Other SP+SS	68	81	51	72	20	26	64	90	65	92	72	106	807
Rural Secondary	100	106	104	110	102	96	104	106	106	102	106	111	1,253
Total	306	319	292	326	259	261	310	334	311	292	305	313	3,628

The information included in tables A.5 and A.6 can be utilized to determine the current confidence interval of the existing sample size. Utilizing Equation 4 below:

$$c = \pm Z * \sqrt{\frac{\mathrm{p}(1-\mathrm{p})}{\mathrm{ss}}} * \sqrt{\frac{\mathrm{pop}-\mathrm{ss}}{\mathrm{pop}-1}} \qquad (4)$$

where:

c = confidence interval, expressed as a decimal
ss = sample size required
Z = value taken from the normal distribution 1.96 for 95% confidence level or 1.645 for 90%
p = proportion of choices with given answer, expressed as a decimal (50% = 0.5)
pop = size of population

As we mentioned earlier, when the proportion is at 0.5 the sample size would be the largest. Therefore to evaluate the largest confidence interval that could be expected from the current sample sizes a proportion of 0.5 was used in the above equation along with the data from Tables A.5 and A.6 to determine the confidence interval for each roadway classification and District. These results for 95% confidence are given in table A.7. Table A.8 contains the information for a 90% confidence level.

Table A.7 Existing Confidence Intervals at 95%

95% Confidence Interval of Existing Sample													
	District												
	1	2	3	4	5	6	7	8	9	10	11	12	TOTALS
Interstate	15.5%	15.8%	16.1%	14.9%	16.0%	15.1%	15.3%	15.1%	14.7%		17.6%		5.0%
Total NHS	8.1%	8.4%	8.1%	7.8%	8.2%	8.0%	8.1%	8.1%	8.1%	9.6%	8.5%	9.8%	2.4%
Other NHS	9.5%	9.7%	9.4%	9.2%	9.2%	9.0%	9.5%	9.5%	9.6%	9.6%	9.6%	9.8%	2.8%
Other SP+SS	11.9%	10.9%	13.7%	11.5%	21.9%	19.2%	12.2%	10.3%	12.1%	10.2%	11.5%	9.5%	3.4%
Rural Secondary	9.8%	9.5%	9.6%	9.3%	9.6%	9.9%	9.6%	9.5%	9.5%	9.6%	9.5%	9.2%	2.8%
Total	5.6%	5.5%	5.7%	5.4%	6.0%	6.0%	5.5%	5.3%	5.5%	5.7%	5.6%	5.5%	1.6%

Table A.8 Existing Confidence Intervals at 90%

90% Confidence Interval of Existing Sample													
	District												
	1	2	3	4	5	6	7	8	9	10	11	12	TOTALS
Interstate	13.0%	13.2%	13.5%	12.5%	13.4%	12.6%	12.8%	12.7%	12.4%		14.8%		4.2%
Total NHS	6.8%	7.0%	6.8%	6.6%	6.8%	6.7%	6.8%	6.8%	6.8%	8.1%	7.1%	8.3%	2.0%
Other NHS	8.0%	8.2%	7.9%	7.7%	7.7%	7.6%	8.0%	8.0%	8.1%	8.1%	8.1%	8.3%	2.3%
Other SP+SS	9.9%	9.1%	11.5%	9.7%	18.4%	16.1%	10.2%	8.6%	10.2%	8.5%	9.7%	7.9%	2.9%
Rural Secondary	8.2%	8.0%	8.0%	7.8%	8.1%	8.3%	8.0%	8.0%	7.9%	8.1%	7.9%	7.8%	2.3%
Total	4.7%	4.6%	4.8%	4.5%	5.1%	5.1%	4.6%	4.5%	4.6%	4.8%	4.7%	4.6%	1.4%

Summary

This analysis has provided a summary of how sample sizes may be determined based on review of historical data. This information should be utilized with the results of the customer survey to refine the sampling procedures to insure acceptable levels of confidence on items which are deemed most important to the traveling public and the Transportation Cabinet.

The target confidence interval for the smallest sample roadway classification by District, was 90% +/- 5%. District totals and roadway classification totals have a confidence interval of 95% +/- 5%, while the statewide total target confidence interval is set as 99% +/- 3%.

In many areas the existing confidence levels are near the targets established in the MRP program documents. In many Highway Districts the sample sizes for Interstates may not be adequate enough, since the confidence intervals for these groupings were generally greater than 10% at the 90% level. It should also be noted that these confidence levels were established based on the proportion of 0.5. Higher existing confidence levels may be achieved for individual elements being inspected.