

Table A-6. Stop sign minimum SIA values.

Recommended Minimum SIA Values for a STOP Sign

Speed (mph)	Stopping Distance (feet)	Area Complexity		
		High	Medium	Low
65	569	*	*	150
60	484	*	*	71
55	407	*	155	30
50	337	170	63	14
45	272	70	25	8
40	215	30	11	4
35	164	16	5	3
30	121	8	3	2

* Supplemental Warning Required

Source: Olson (17)

Table A-7. Warning signs minimum SIA values.

Recommended Minimum SIA Values for Warning Signs (Yellow)

Speed (mph)	Area Complexity					
	Low		Medium			High
	Number of Choices 0-3	3 or more	Number of Choices			Number of Choices
			0-1	2-3	3 or more	0-1 2 or more
65	15	31	15	86	630	230 *
60	15	25	15	63	414	173 1115
55	15	21	15	52	276	144 750
50	15	17	15	38	180	110 520
45	15	15	15	29	126	80 345
40	15	15	15	23	80	63 230
35	15	15	15	17	52	52 150
30	15	15	15	15	35	38 100

*Supplementary devices required.

Source: Olson (17)

Table A-8. Overhead guide signs minimum SIA values.

Recommended Minimum SIA Values for Overhead Guide Signs (Green)									
Speed (mph)	Area Complexity								
	Low			Medium			High		
	Words on Sign			Words on Sign			Words on Sign		
	3	6	9	3	6	9	3	6	9
70	8	15	27	13	31	70	35	82	200
60	8	13	22	12	25	54	32	70	150
50	7	11	17	11	20	37	28	54	100
40	7	9	13	10	15	25	25	40	68
30	6	8	10	8	12	17	22	33	46

Sign placement is 20 feet high over a 24 foot roadway.

Source: Olson (17)

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message recognition, and legibility occurred. The times were converted to distances. Each sign was then screened, thereby reducing SIA, until the sign was determined to be barely adequate. Table A-9 provides the recommended "end of service life" values for white, yellow, green, and red sheeting colors.

The Oregon DOT provides a specification for retroreflection at 7 and 10 years of inservice performance. Under this specification the manufacturer is responsible for all cost in restoring sign panels to the original effectiveness if the retroreflection falls below the values specified in Table A-10. For years 7 and 10 of inservice placement the manufacturer is obligated to replace the sheeting to its original effectiveness if the retroreflectivity falls below the standards listed on the right column of Table A-10. In addition, sign agencies are responsible for dating all signs at the time of installation.

Research has been conducted which is relevant to the question of standards, but standards have not yet been implemented which reflect fundamental driver needs. This is because the problem of specifying luminance standards for traffic signs is complex and multidimensional. Driver requirements of different signs change across situations. Also the population of signs is not uniform in purpose or function. Signs are created in different designs to serve various needs, and these differences create varying levels of luminance requirements for signs to function properly at night.

The ongoing Federal Highway Administration (FHWA) project entitled "Minimum Visibility Requirements for Traffic Control Devices" is to determine the minimum visibility requirements for signs and markings. Based on these minimum visibility requirements, it will be possible to determine the retroreflectivity needed to make a sign visible at a given distance.

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Table A-9. End of service life SIA values

Sheeting Color	End of Service Life SIA Values ¹	
	Type II ²	Type II A, III A, III B ³
White	40	140
Yellow	16	40
Green	5	5
Red	na	10

na - not available

¹ SIA values measured at 0.2° observation and -4° angles.

² Engineering grade sheeting (Type II).

³ Super-engineering grade (Type II A), high performance (Type III A), and prismatic (Type III B) sheeting.

Source: Florida DOT (19)

Table A-10. Minimum warranties for retroreflective sheeting as specified by Oregon DOT.

Sheeting Color	Minimum Coefficient of Retroreflection (Seven Years)	Minimum Coefficient of Retroreflection (Ten Years)
White	212	200
Yellow	144	136
Green	38	36
Red	38	36
Blue	17	16
Brown	10	9

Another difficulty in the implementation of standards has been an absence of conclusive performance data. The FHWA project entitled "Service Life of Retroreflective Traffic Signs" (20) investigated the relationship between the retroreflectivity performance of sign sheeting with respect to such factors as sheeting age, weather conditions, ground elevation, etc. Based on these relationships, equations were developed to predict approximate inservice SIA of signs. The accuracy of the equations in predicting inservice SIA is limited since the initial SIA values of new sheeting are quite variable.

Finally, there is no fast, practical, and reliable way of measuring luminance in the field, and therefore one cannot easily determine if the requirements are met. The National Cooperative Highway Research Program (NCHRP) study 5-10 "Mobile System for Measuring Retroreflectance of Traffic Signs" (3) has determined the feasibility of developing instrumentation suitable to rapidly measure retroreflectivity from a moving vehicle during daylight hours. A prototype of the system has been constructed and consists of a video camera, electronic flash gun, laser range finder and a data acquisition image analysis system to evaluate the video image for average legend and background retroreflectance. Figure A-5 is a schematic illustration of the system components which are housed in the van shown in Figure A-6. The results of the above three projects and this project will help in development, measurement and implementation of sign performance standards.

SIGN MAINTENANCE PRACTICES

The existing federal standards for luminance of retroreflective materials for traffic signs are purchase specifications and provide no differentiation based upon driver needs. The *Manual on Uniform Traffic Control Devices* (2) simply specifies that all traffic signs be retroreflectorized or illuminated to show the same color and shape by day and night unless

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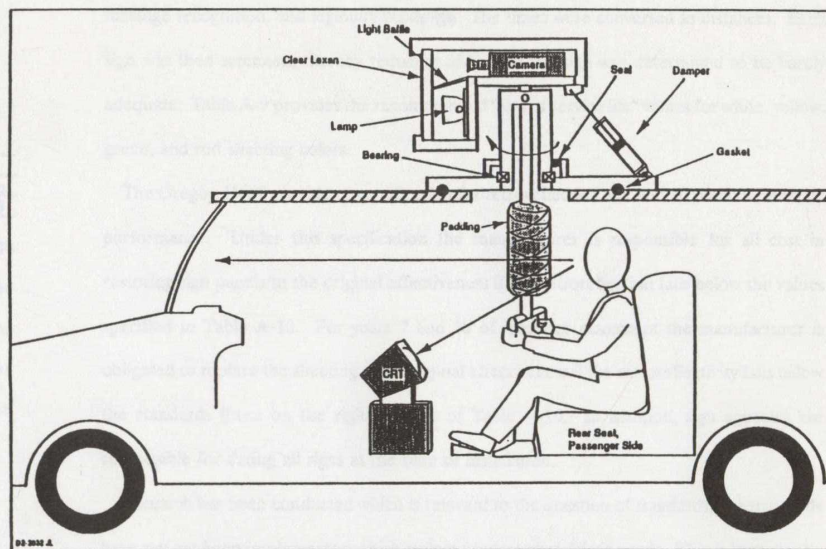


Figure A-5. Schematic illustration of system components.

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Figure A-6. Prototype mobile retro-reflectivity measurement system.

specifically excepted in the standards. There are no minimum initial or replacement requirements for retroreflective signs. Based on the agencies surveyed, replacement is left to practices which vary between States, counties and cities. The need for inspection of signs for retroreflectivity is typically not determined under a regimented policy but scheduled by casual, visual inspection. This deficiency is due to the lack of a minimum legibility standards, the competing demands on personnel's times, and the absence of a rapid and reliable retroreflectance measurement device. However, the development of automated sign inventories, minimum performance standards, mobile system for measuring retroreflectance and implementation strategies will provide an opportunity for more efficient and objective solutions to the problems of sign maintenance management.

APPENDIX B—COLLECTION OF RETROREFLECTIVITY DATA

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The objective of the national data collection effort was to obtain estimates of sign retroreflectivity conditions across several subgroups including: sign type, sheeting type, and jurisdiction control. To achieve this goal a intensive data collection plan was developed and initiated. The data collection plan addressed the following:

- Identification of key variables
- Determination of sample size
- Selection of study locations
- Development of effective data collection methodology

Each of these data collection plan elements are discussed in the following subsections.

VARIABLES OF INTEREST

Initially, the dependent and independent variables were identified. The dependent variable, the object of effort, was the measure (i.e., SIA value) of retroreflective condition of traffic signs. The independent variables were segregated into four main categories.

1. Geographic Area -- Weather conditions presumably influence the retroreflectivity and service life of sign sheeting. However, as found in the FHWA "Service Life of Retroreflective Traffic Signs" project (20) the effects of climate are difficult to isolate as the climatic influences are very interrelated and tend to disguise the impacts of any specific element. Due to the interrelationship of climatic variables and the influences of highly variable SIA values of new sheeting, the geographic zone system derived for the FHWA project was removed from the final service life models. However, prior to the results of the FHWA project an eight geographic zone system was developed for the data collection effort

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described here. It is still reasonable to expect climatic/geographic influences on sheeting deterioration but quantifying these influences remains difficult. The zone system encompassed the continental United States as the goal of this project was to conclude with national estimates of sheeting retroreflectivity conditions.

2. Jurisdiction Levels -- Adopting retroreflectivity standards could have different economic implications depending upon the type and size of jurisdiction. Data was collected across various jurisdiction types to assess the economic impacts of a retroreflectivity standard. The jurisdiction levels identified for sampling were State, county, city, and town/township. The jurisdiction levels generally follow the levels delineated in the Highway Performance Monitoring System (HPMS) from which total roadway mileage was obtained. No data was collected on Federally controlled roadways.

3. Sign Type -- Traffic signs are made of different colors and vary in criticality; therefore, they require different retroreflectivity levels. To accommodate these differences it was necessary to develop the retroreflectivity condition estimates by sign type and color. The MUTCD classifies signs into the following categories:

- Regulatory - black and white, red and white
- Warning - yellow and black
- Guide - green and white, blue and white, brown and white

Data was collected for the following four sign colors by sign type:

- White (Regulatory)
- Red (Regulatory)
- Yellow (Warning)

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- Green (Guide)

Parking series regulatory signs and blue, brown, and all street name guide signs were excluded from the sampling effort.

4. Sheeting Type -- Differences exist in retroreflective properties, service life, and per unit cost among sheeting types. Therefore, it was desirable to sample the various types of sheeting. However, from a visual inspection of inservice signs it is possible to distinguish only two types -- enclosed lens sheeting (Types II and II A from *FP-85*) and encapsulated lens sheeting (Type III A). Type II and II A material appear the same during daytime inspection, although in recent years the major manufacturer of Type II A has a symbol on its sheeting that may be distinguishable on some signs. Hence, all signs were identified as either Type II (Engineering Grade) or Type III (High Performance Grade). In the presentation of the results of the condition of signs, this classification was eliminated and all signs of the same color were grouped. Theoretically, the randomness of the data collected resulted in a mix of sheeting types representative of the Nation's population of signs.

SAMPLE SIZE DETERMINATION AND SITE SELECTION

The overall objective of the data collection was to obtain a representative sample of signs for statistically valid estimates of retroreflective condition and of sign density by roadway jurisdiction control. In order to meet the stated objective a sample of different area types, sign types, sign materials, roadway categories, and jurisdiction level of responsibility was needed.

A cluster sampling approach was selected for developing the data collection plan. It involved dividing the population, the entire country, into heterogeneous subgroups or

clusters. States were used to form clusters because they have well defined boundaries. Weather conditions influence the retroreflectivity and service life of signs and, therefore, it was believed that grouping the States by similar weather conditions would be an effective strategy to define the study areas from which to sample. The eight geographic zones developed for the FHWA "Service Life of Retroreflective Traffic Signs" project were modified slightly to maintain state boundary lines. This zone system considers general climatic conditions and solar radiation levels.

Within each zone a minimum of two primary sampling units (PSU) were selected. Each PSU needed at least three different jurisdictions (city, county, State or town). Individual counties were selected as the most appropriate PSU. Using FHWA's HPMS data, counties with three or more different jurisdictions were segregated. The counties were further segregated by urban and rural designations based on population density.

Establishing the sample size usually involves trading off statistical requirements against time and funds available. Using cost and variance models alternate combinations of total PSUs and roadway segments were selected. The cost model is described as follows:

$$\text{Total Budget} = (\text{Cpsu})(M) + (\text{Cseg})(M)(N)$$

where:

Cpsu	=	Cost per sampled PSU
M	=	Number of PSUs
Cseg	=	Cost per sampled segment
N	=	Number of segments within each PSU

Judgement was used to select the following reasonable alternatives:

- 10 PSUs and 40 segments
- 25 PSUs and 12 segments
- 40 PSUs and 5 segments

Each of these alternatives satisfied the budget constraints.

A variance model was developed to evaluate the variance in SIA conditions between PSUs and within PSUs. The goal of the model was to establish if the between or within variance is greater and then optimize the sample of PSUs and segments. The variance model had the following form:

$$V^2(x) = B^2/m + W^2/mn$$

where:

- $V^2(x)$ = Total variance
 B^2 = Between PSU variance
 W^2 = Within PSU variance
 m = Number of PSUs
 n = Number of segments

B^2 and W^2 were estimated from data obtained from the FHWA "Service Life of Retroreflective Traffic Signs" project. B^2 and W^2 vary by sheeting color and type. B^2 was found greater than W^2 ; therefore, it was concluded to increase the number of PSUs rather than increase the number of segments within each PSU. Table B-1 provides the variance estimates for several alternate design options. It was determined to sample 25 PSUs with 12 segments in each PSU, as minimal improvement in variance was afforded beyond 25 PSUs.

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Table B-1. Estimated variance for three sample designs.

Sheeting Color and Type	Estimated Variance		
	Number PSUs Number of segments		
	10 40	25 12	40 5
Red			
-EG	3.0	1.7	1.6
-HP	7.8	4.0	3.5
White			
-EG	19.8	10.8	10.4
-HP	30.6	17.2	17.0
Yellow			
-EG	13.5	12.0	14.0
-HP	17.0	2.0	2.6
Green			
-EG	2.3	2.0	2.6
-HP	7.0	3.1	2.2

Note: EG = engineering grade sheeting
 HP = high performance sheeting

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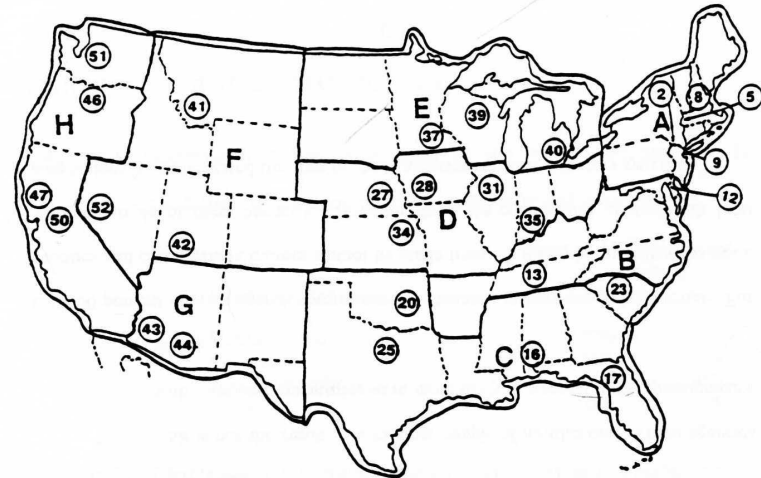
Also, as the number of PSUs increases the total signs to sample greatly decreases.

The 25 PSUs were allocated to the eight zones based on that zone's proportion of total national roadway mileage. Depending on the number of different jurisdiction roadways (i.e. State, county, city or town/township) within a county, four or five segments were selected for each jurisdiction type. The roadway segments under each jurisdiction within a county were identified on county mapping. Approximately 15 traffic signs per segment were measured. Given a starting point on a segment the first 15 traffic signs were selected and measured to insure randomness.

The candidate counties were screened for three or more different jurisdictions roadways and for urban and rural population densities. From the screened list, counties were then randomly selected using the HPMS numbering system. At least one rural and one urban county were selected in each zone. Again, the total number of PSUs per zone was determined by the total roadway mileage. Certain manual selections were necessary for travel and logistical considerations. Figure B-1 provides the geographic location of the data collection sites with the zone system boundaries. As shown 28 sites, or 3 more than the original plan, were actually sampled. This was attributed to the efficiency of the data collection crews.

DATA COLLECTION METHOD

Two teams of two technicians each were used to collect the retroreflectivity data throughout the country. The Advanced Retrotechnology model 920 retroreflectometer with extension pole and remote display was used to collect the measurements. The traffic signs were not cleaned prior to measurement because it was desirable to measure the



Data Collection Sites (County)

Delaware, NY (2)	Shawnee, KS (34)
Berkshire, MA (5)	Vanderburgh, IN (35)
Hillsborough, NH (8)	Fillmore, MN (37)
Westchester, NY (9)	Oneida, WI (39)
Calvert, MD (12)	Wayne, MI (40)
Montgomery, TN (13)	Madison, MT (41)
Washington, AL (16)	Iron, UT (42)
Levy, FL (17)	Yuma, AZ (43)
Pittsburg, OK (20)	Pima, AZ (44)
Greenville, SC (23)	Wasco (46)
Dallas, TX (25)	Mendocino, CA (47)
Butler, NE (27)	Sacramento, CA (50)
Adair, LA (28)	King, WA (51)
Bureau, IL (31)	Clark, NV (52)

Figure B-1. Location of data collection sites.

retroreflectivity as the drivers view the sign. (The FHWA "Service Life of Retroreflective Traffic Signs" project found that sign washing increased SIA by 12% and 8% for Type II and Type III A sheeting signs, respectively). The retroreflectivity readings, segment and county coding, sheeting color, and sheeting type were manually recorded in the field and transferred to computer database in the office. Four readings per sign were taken and later averaged.

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APPENDIX C—QUESTIONNAIRE SURVEY RESULTS

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Questionnaire surveys were used to obtain data including: sign population, existence of sign inventory, sign replacement costs, sign maintenance costs, inventory inputs, etc. The surveys were distributed to 50 state, 790 county and 85 city agencies. Responses were received from 48 states, 170 counties, and 20 cities.

The following paragraphs provide a summary of the responses to key questions. The summary of responses is grouped into two areas -- 1) sign inventory and 2) replacement and maintenance.

SIGN INVENTORY

Question A. Does your agency have a sign inventory?

<u>Agency</u>	<u>Yes</u>	<u>No</u>
State	14	33
County	129*	41
City	13*	7

- * This is not the result of a random sample of jurisdictions. Those agencies with computer inventories were more likely to respond to the questionnaire survey.

Only 30 percent of state agencies were found to maintain statewide sign inventories. For counties and cities, generalizations cannot be made from the survey because this was not a random sample of these agencies. However, from the considerable contact with local jurisdictions it can be stated that few of these agencies maintain inventory systems.

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Question B. What is your inventory format?

<u>Format</u>	<u>Agency</u>		
	<u>State</u>	<u>County</u>	<u>City</u>
Card/Paper	11%	43%	24%
Main/Mini Computer	37%	20%	23%
Micro Computer	48%	32%	30%
Other (photolog,maps,etc.)	4%	5%	15%

Approximately 85 percent of statewide inventories are computerized. Only approximately 50 to 60 percent of the counties and cities responding with inventories had computerized systems. Over 40 percent of the counties responding as having inventories maintained card or paper records. The majority of the "other" responses were inventories on aerial photography and other mapping materials. The percentage of county and city agencies having micro-computer format is likely to increase as these programs are becoming readily available.

Question C. Does your inventory include the following elements?

<u>Data Element</u>	<u>Agency</u>		
	<u>State</u>	<u>County</u>	<u>City</u>
Sign Type	93%	97%	92%
Installation Date	78%	82%	77%
Replacement Date	74%	83%	77%
Sheeting Type	56%	50%	54%

SIGN REPLACEMENT AND MAINTENANCE

Question D. Approximately how many signs do you replace per year due to vandalism, knockdown, poor retroreflectivity and other causes?

<u>Reason for Replacement</u>	<u>Percent of All Replacement Agency</u>	
	<u>County</u>	<u>City</u>
Vandalism and Theft	39%	24%
Knockdown	23%	27%
Poor Retroreflectivity	16%	30%
Other	22%	19%

Question E. What is your total annual cost for sign maintenance and replacement?

<u>Item</u>	<u>County</u>		<u>City</u>	
	<u>Average Cost</u>	<u>No. of Responses</u>	<u>Average Cost</u>	<u>No. of Responses</u>
Total Cost	\$96,000	148	\$277,000	16
Per Mile Cost	\$92.00	141	\$132.30	10
Per Capita Cost	\$1.00	72	\$1.20	16

Question F. What is your average cost to replace a sign?

<u>Item</u>	<u>County</u>		<u>City</u>	
	<u>Average Cost</u>	<u>No. of Responses</u>	<u>Average Cost</u>	<u>No. of Responses</u>
Materials Cost/SF	\$ 5.17	7	NA	0
Labor Cost/Hour	\$14.97	19	NA	0
Equipment Cost/Hour	\$10.35	16	NA	0
Material Cost/Sign	\$38.24	117	\$29.56	17
Labor Cost/Sign	\$18.92	103	\$14.49	14
Equipment Cost/Sign	\$10.81	98	\$ 9.84	13
Total Cost/Sign	\$65.72	168	\$54.66	13

NA - Not Available

Question G. How many traffic signs are under the control of your agency?

ITEM	TOTAL SIGNS PER CAPITA AND PER MILE ¹							
	COUNTY				CITY			
	Signs Per 100 Persons	No. of Responses	Signs Per Mile	No. of Responses	Signs Per 100 Persons	No. of Responses	Signs Per Mile	No. of Responses
Regulatory Signs ²	7.1	35	3.7	39	7.0	13	18.2	12
Warning Signs	6.3	35	4.3	39	3.8	12	9.8	11
Guide Signs ³	2.0	32	2.6	36	0.6	11	1.2	11
Total Signs	17.6	42	11.9	45	22.6	17	63.9	16

¹Includes actual and estimated sign totals

²Does not include parking series signs

³Does not include street name signs

The replacement cost and sign density information obtained here became the basis for the economic analysis and the development of the implementation strategies.

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APPENDIX D—SIGN REPLACEMENT COSTS

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Sign replacement cost for State, county, city, and town controlled roadways were developed for red, yellow, green, and white sheeting based on the minimum SIA criteria identified in Chapter 3. Each sheeting color was tested using the lower and upper minimum SIA standards. The economic model was run for a total of 11 years to obtain the annual replacement costs for the years after implementation of the minimum standards.

Tables D-1, D-2, D-3, and D-4 provide the sign replacement cost in terms of dollars per roadway mile for State, county, city, and town controlled roadways, respectively. The shaded boxes in the tables highlight the annual replacement costs for each year of the implementation schedule. The unshaded boxes show the annual cost to maintain the minimum standards after implementation is completed.

There is a considerable difference in replacement costs between the lower and upper standards, especially for the red, green, and white sheeting. The replacement cost for green sheeting represents 65 to 75 percent of the total replacement cost. Several reasons for this are apparent:

1. Average cost per sign to replace green guide signs is nearly twice the of standard warning and regulatory signs due to sign size.
2. Majority of green guide signs are constructed using engineering grade sheeting which has lower retroreflectivity characteristics than the other sheeting types.
3. Minimum retroreflectivity standards for green sheeting tested here were high and in the case of the upper value (i.e. 10 SIA) higher than the delivered new specification for green, engineering grade sheeting listed in *FP-85*.
4. Many of the green sheeting samples collected across the country had SIA values less than 8 SIA which was the lower minimum standard tested here.

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Table D-1 Sign replacement costs for state roadways.

State		RED				YELLOW				GREEN				WHITE			
		One Yr \$/Mile	3 Yrs \$/Mile	5 Yrs \$/Mile	10 Yrs \$/Mile	One Yr \$/Mile	3 Yrs \$/Mile	5 Yrs \$/Mile	10 Yrs \$/Mile	One Yr \$/Mile	3 Yrs \$/Mile	5 Yrs \$/Mile	10 Yrs \$/Mile	One Yr \$/Mile	3 Yrs \$/Mile	5 Yrs \$/Mile	10 Yrs \$/Mile
Lower Standards	Year 1	22	14	17	21	9	5	5	8	154	69	48	39	6	3	2	4
	Year 2	10	14	17	21	2	5	5	8	20	69	48	39	1	3	2	4
	Year 3	11	14	17	21	4	5	5	8	33	69	48	39	1	3	2	4
	Year 4	16	16	17	21	4	4	5	8	10	10	48	39	1	1	2	4
	Year 5	27	27	17	21	8	8	5	8	20	20	48	39	3	3	2	4
	Year 6	26	26	26	21	8	8	8	8	30	30	30	39	4	4	4	4
	Year 7	21	21	21	21	10	10	10	8	28	28	28	39	4	4	4	4
	Year 8	16	16	16	21	11	11	11	8	43	43	43	39	5	5	5	4
	Year 9	31	31	31	21	8	8	8	8	30	30	30	39	5	5	5	4
	Year 10	25	25	25	21	13	13	13	8	20	20	20	39	7	7	7	4
	Year 11	30	30	30	30	6	6	6	6	40	40	40	40	4	4	4	4
Upper Standards	Year 1	167	83	62	48	85	40	32	24	221	90	68	45	18	9	8	7
	Year 2	17	83	62	48	20	40	32	24	20	90	68	45	4	9	8	7
	Year 3	66	83	62	48	16	40	32	24	30	90	68	45	6	9	8	7
	Year 4	23	23	62	48	21	21	32	24	25	25	68	45	6	6	8	7
	Year 5	39	39	62	48	19	19	32	24	43	43	68	45	5	5	8	7
	Year 6	23	23	23	48	13	13	13	24	30	30	30	45	5	5	5	7
	Year 7	35	35	35	48	14	14	14	24	30	30	30	45	5	5	5	7
	Year 8	32	32	32	48	9	9	9	24	28	28	28	45	5	5	5	7
	Year 9	40	40	40	48	33	33	33	24	15	15	15	45	6	6	6	7
	Year 10	38	38	38	48	11	11	11	24	10	10	10	45	9	9	9	7
	Year 11	30	30	30	30	13	13	13	13	93	93	93	93	4	4	4	4

Table D-2 Sign replacement costs for county roadways.

County		RED				YELLOW				GREEN				WHITE			
		One Yr \$/Mile	3 Yrs \$/Mile	5 Yrs \$/Mile	10 Yrs \$/Mile	One Yr \$/Mile	3 Yrs \$/Mile	5 Yrs \$/Mile	10 Yrs \$/Mile	One Yr \$/Mile	3 Yrs \$/Mile	5 Yrs \$/Mile	10 Yrs \$/Mile	One Yr \$/Mile	3 Yrs \$/Mile	5 Yrs \$/Mile	10 Yrs \$/Mile
Lower Standards	Year 1	17	12	14	19	18	8	7	8	140	75	52	38	6	3	2	3
	Year 2	9	12	14	19	1	8	7	8	36	75	52	38	1	3	2	3
	Year 3	10	12	14	19	4	8	7	8	29	75	52	38	2	3	2	3
	Year 4	20	20	14	19	4	4	7	8	15	15	52	38	1	1	2	3
	Year 5	16	16	14	19	6	6	7	8	22	22	52	38	2	2	2	3
	Year 6	20	20	20	19	4	4	4	8	15	15	15	38	2	2	2	3
	Year 7	27	27	27	19	8	8	8	8	36	36	36	38	4	4	4	3
	Year 8	21	21	21	19	10	10	10	8	7	7	7	38	3	3	3	3
	Year 9	25	25	25	19	17	17	17	8	36	36	36	38	5	5	5	3
	Year 10	27	27	27	19	11	11	11	8	22	22	22	38	4	4	4	3
	Year 11	27	27	27	27	15	15	15	15	22	22	22	22	6	6	6	6
Upper Standards	Year 1	166	89	66	45	101	46	34	28	247	92	65	44	16	8	7	7
	Year 2	26	89	66	45	17	46	34	28	22	92	65	44	4	8	7	7
	Year 3	75	89	66	45	21	46	34	28	7	92	65	44	4	8	7	7
	Year 4	23	23	66	45	18	18	34	28	36	36	65	44	4	4	7	7
	Year 5	39	39	66	45	15	15	34	28	15	15	65	44	4	4	7	7
	Year 6	18	18	18	45	21	21	21	28	22	22	22	44	6	6	6	7
	Year 7	35	35	35	45	21	21	21	28	29	29	29	44	7	7	7	7
	Year 8	19	19	19	45	13	13	13	28	15	15	15	44	7	7	7	7
	Year 9	24	24	24	45	45	45	45	28	36	36	36	44	7	7	7	7
	Year 10	23	23	23	45	11	11	11	28	7	7	7	44	10	10	10	7
	Year 11	18	18	18	18	14	14	14	14	102	102	102	102	5	5	5	5

Table D-3 Sign replacement costs for city roadways.

City		RED				YELLOW				GREEN				WHITE			
		One Yr \$/Mile	3 Yrs \$/Mile	5 Yrs \$/Mile	10 Yrs \$/Mile	One Yr \$/Mile	3 Yrs \$/Mile	5 Yrs \$/Mile	10 Yrs \$/Mile	One Yr \$/Mile	3 Yrs \$/Mile	5 Yrs \$/Mile	10 Yrs \$/Mile	One Yr \$/Mile	3 Yrs \$/Mile	5 Yrs \$/Mile	10 Yrs \$/Mile
Lower Standards	Year 1	75	34	27	22	45	16	13	13	141	83	73	52	16	6	5	6
	Year 2	14	34	27	22	0	16	13	13	78	83	75	52	1	6	5	6
	Year 3	13	34	27	22	3	16	13	13	31	83	75	52	2	6	5	6
	Year 4	11	11	27	22	8	8	13	13	63	63	75	52	3	3	5	6
	Year 5	20	20	27	22	7	7	13	13	63	63	75	52	4	4	5	6
	Year 6	21	21	21	22	8	8	8	13	78	78	78	52	5	5	5	6
	Year 7	17	17	17	22	7	7	7	13	16	16	16	52	5	5	5	6
	Year 8	15	15	15	22	16	16	16	13	31	31	31	52	7	7	7	6
	Year 9	19	19	19	22	15	15	15	13	0	0	0	52	6	6	6	6
	Year 10	14	14	14	22	19	19	19	13	16	16	16	52	8	8	8	6
	Year 11	11	11	11	11	31	31	31	31	31	31	31	31	7	7	7	7
Upper Standards	Year 1	213	99	69	44	164	68	48	35	313	151	100	55	33	15	12	10
	Year 2	4	99	69	44	18	68	48	35	63	151	100	55	6	15	12	10
	Year 3	80	99	69	44	23	68	48	35	78	151	100	55	7	15	12	10
	Year 4	8	8	69	44	21	21	48	35	16	16	100	55	7	7	12	10
	Year 5	39	39	69	44	14	14	48	35	31	31	100	55	7	7	12	10
	Year 6	16	16	16	44	12	12	12	35	0	0	0	55	6	6	6	10
	Year 7	22	22	22	44	8	8	8	35	31	31	31	55	6	6	6	10
	Year 8	15	15	15	44	8	8	8	35	16	16	16	55	6	6	6	10
	Year 9	21	21	21	44	64	64	64	35	0	0	0	55	6	6	6	10
	Year 10	20	20	20	44	15	15	15	35	0	0	0	55	13	13	13	10
	Year 11	19	19	19	19	12	12	12	12	125	125	125	125	3	3	3	3

Table D-4 Sign replacement costs for town roadways.

Town		RED				YELLOW				GREEN				WHITE			
		One Yr \$/Mile	3 Yrs \$/Mile	5 Yrs \$/Mile	10 Yrs \$/Mile	One Yr \$/Mile	3 Yrs \$/Mile	5 Yrs \$/Mile	10 Yrs \$/Mile	One Yr \$/Mile	3 Yrs \$/Mile	5 Yrs \$/Mile	10 Yrs \$/Mile	One Yr \$/Mile	3 Yrs \$/Mile	5 Yrs \$/Mile	10 Yrs \$/Mile
Lower Standards	Year 1	39	23	17	15	1	0	0	5	129	42	70	50	3	1	2	3
	Year 2	21	23	17	15	0	0	0	5	37	42	70	50	0	1	2	3
	Year 3	8	23	17	15	0	0	0	5	18	42	70	50	1	1	2	3
	Year 4	9	9	17	15	0	0	0	5	55	55	70	50	2	2	2	3
	Year 5	9	9	17	15	0	0	0	5	111	111	70	50	3	3	2	3
	Year 6	12	12	12	15	3	3	3	5	55	55	55	50	3	3	3	3
	Year 7	18	18	18	15	6	6	6	5	37	37	37	50	2	2	2	3
	Year 8	9	9	9	15	9	9	9	5	18	18	18	50	4	4	4	3
	Year 9	15	15	15	15	19	19	19	5	37	37	37	50	2	2	2	3
	Year 10	14	14	14	15	12	12	12	5	0	0	0	50	4	4	4	3
	Year 11	14	14	14	14	19	19	19	19	37	37	37	37	4	4	4	4
Upper Standards	Year 1	134	68	52	36	71	33	28	24	259	142	96	55	14	7	5	7
	Year 2	12	68	52	36	16	33	28	24	92	142	96	55	2	7	5	7
	Year 3	58	68	52	36	12	33	28	24	74	142	96	55	4	7	5	7
	Year 4	18	18	52	36	19	19	28	24	18	18	96	55	3	3	5	7
	Year 5	38	38	52	36	21	21	28	24	37	37	96	55	4	4	5	7
	Year 6	32	32	32	36	13	13	13	24	18	18	18	55	5	5	5	7
	Year 7	24	24	24	36	18	18	18	24	0	0	0	55	8	8	8	7
	Year 8	17	17	17	36	18	18	18	24	18	18	18	55	10	10	10	7
	Year 9	14	14	14	36	34	34	34	24	0	0	0	55	9	9	9	7
	Year 10	14	14	14	36	16	16	16	24	37	37	37	55	11	11	11	7
	Year 11	15	15	15	15	15	15	15	15	129	129	129	129	6	6	6	6

On all roadways the need for replacement of red sheeting signs was quite high. The problems of color fade of this sheeting type contributes to the overall poor condition of these signs. In several instances the annual maintenance cost actually increased after the implementation schedule was completed. The population of signs for this evaluation was deteriorated using the equations and relationships developed in FHWA's "Service Life of Retroreflective Traffic Signs". High annual costs after the standards implementation are the product of a large population of signs of similar age (i.e., 5 or more years) failing to meet the minimum in the years after the schedule has been fulfilled.

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