Report No. CDOT-DTD-91-11

Evaluation of Swareflex Wildlife Warning Reflectors

Dave Woodham
Colorado Department of Transportation
4201 East Arkansas Avenue
Denver, Colorado 80222

Final Report
July, 1991

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
CDOT-DTD-R-91-11		

4. Title and Subtitle	5. Report Date
Evaluation of Swareflex Wildlife Warning Reflectors	July, 1991
	6. Performing Organization Code 90.155/1403N
7. Author(s) Dave Woodham	8. Performing Organization Rpt.No. CDOT-DTD-R-91-11
9. Performing Organization Name and Address Colorado Department of Highways 4201 E. Arkansas Avenue Denver, Colorado 80222	10. Work Unit No. (TRAIS)
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address Colorado Department of Highways 4201 E. Arkansas Avenue Denver, Colorado 80222	13. Type of Rpt. and Period Covered Final Report
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

Swareflex wildlife warning reflectors were installed on a four-mile section of road near Denver. Two half-mile test sections were alternately covered and uncovered for a three-month period to see if any significant change in deer-vehicle accidents could be detected. No accidents occured in the test sections during the evaluation period. The cover/uncover evaluation method proved too costly for the limited budget of this study. Photometric measurements of the reflectors have been made using vehicle headlights as the light source.

Implementation

The use of wildlife warning reflectors should be discontinued until more evidence is available on their effectiveness--especially on mule deer. A regional pooled-fund study should be started to investigate the effect of the reflectors on mule deer. This needs to be a large-scale effort to obtain results in a short period of time and to ensure validity.

17. Key Words	18. Distribution Statement
Deer Reflectors, Swareflex, Wildlife Protection	No Restrictions: This report is available to the public through the National Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	15	

The author would like to acknowledge the help given by the panel members for this study:

Richard Cutler,
Office of Environmental Review and Analysis, CDOT

Dale Reed, Division of Wildlife, Fort Collins.

The author would also like to thank Maintenance Patrol 26 at Waterton for their cooperation in tracking deer-vehicle accidents and changing over the wildlife warning reflectors.

INTRODUCTION

Deer-vehicle accidents result in a significant loss to Colorado motorists in terms of personal injuries and property damage, as well as the loss to the wildlife resource. Conservative estimates of the average cost of vehicle damage as a result of a deer-vehicle collision begin at $500 per incident. Although human injuries do not occur in every accident, the cost of injuries increases the estimated cost to $730 per accident [1]. In addition, the civil value of a deer is currently $500 in Colorado. It seems conservative to say that the average cost of a deer-vehicle accident is at least $1000. The Colorado Division of Wildlife's estimate for deer killed by vehicles was 5300 in 1986. This includes reported and estimated unreported kills. Clearly, these types of accidents cost motorists millions of dollars per year in Colorado alone.

Standard methods for controlling the number of deer-vehicle collisions include high-intensity lighting, the construction of deer fences, and underpasses at migration paths. Deer fence costs approximately $80,000 per mile (both sides) and continuous lighting costs between $56,000 and $154,000 per mile (two sides) depending on whether the installation is in an urban, plains, or mountain area [2]. All methods introduce substantial future maintenance costs as well. In many areas, deer fence may not be practical because of terrain and intersecting roads.

In several other countries and other states in the U.S., tests of deer reflectors have shown reductions in nighttime deer-vehicle accidents with white-tail deer [3]. Other tests have shown inconclusive or negative results [4,5]. The effectiveness of deer reflectors is still unknown - especially with respect to mule deer. Reflectors cost approximately $8,000 per mile for a four-lane, divided highway [2].

BACKGROUND

The objective of this research study was to prove, using a statistically valid experiment design, that the use of Swareflex wildlife warning reflectors influences nighttime deer-vehicle accidents.

There are several problems to overcome in order to evaluate these devices: the effects of deer migration (seasonal and longer term), deer population fluctuations, weather influences, and human impact (e.g. loss of habitat due to construction, increased traffic, etc.) to arrive at some measure of the reflector's effectiveness.

Several other researchers have used a cover/uncover scheme to evaluate deer reflectors. The idea is that if the reflectors are effective, there would be a difference in the deer-vehicle accident rates during the time that the reflectors were covered compared to the time the reflectors were uncovered.

METHODS

A project on State Highway (SH) 121 near Chatfield reservoir installed 1175 Swareflex wildlife warning reflectors in August of 1988. The reflectors in two, one-half mile test sections were alternately covered and uncovered (two weeks each time) over a three-month period during the fall of 1988. However, there were no deer-vehicle accidents in the test areas during this period and it became apparent that covering/uncovering manipulations of the reflectors was cost prohibitive for the scope of the current study. Not only would a much larger test section need to be included, but the evaluation would have to run for perhaps 5 years to gather the 100 deer-vehicle accidents necessary for a statistically valid conclusion.

Attention then turned to the optical properties of the devices. Nighttime observations have shown that the reflectors are only visible at short distances from the roadway and only at certain angles. Luminance measurements, of the reflectors, have been compared with the illuminance from vehicle headlights for several different geometries (vehicle in driving and passing lanes at various distances from the reflectors). This information was used to estimate the visibility of the reflectors and their possible effect on mule deer.

On Wednesday, January 10th, 1991, field measurements were made on the Swareflex wildlife warning reflectors installed on SH 121. The purpose of the trip was to find some quantitative measure of the optical qualities of the reflectors (as installed on a road) using vehicle headlights for illumination. On several previous occasions, researchers had observed the installed reflectors from the roadside and noticed that the reflectors were not very visible. The high visibility of the reflectors is required for the functioning of the devices. According to Swareflex product literature, "Each reflector flashes up for only a short time period by action of the headlights of a passing vehicle. Immediately afterwards, the optical fence collapses and the animal crosses the road as usual." [6]

Several parameters were assumed to influence the effectiveness of the reflectors. The amount of light that reaches the reflector is constantly changing due to the changing geometry and distance between the approaching vehicle and the reflector. As a result, the lane position of the vehicle, the distance between the reflectors and the vehicle, as well as the use of low or high beams, was investigated. The "brightness" of the reflector, as viewed from the side of the road, and the quantity of light available at the front face of the reflector were compared.

Illuminance in a vertical plane at the reflector was measured using a United Detector Technology Model 61 Optometer with standard detector, photometric filter, and cosine diffusor. The detector was taped to the post and oriented towards the oncoming traffic parallel to the roadway axis.

Luminance of the reflector was measured with a Photo Research Model UB 1° spot meter using the built-in photopic filter. The reflector was mounted at the standard mounting height (24 in. to the bottom of the reflector) and was of the type designed for use in areas with flat shoulders. The reflector was located 13.5 feet from the outside shoulder stripe of the southbound lanes. Luminance measurements were taken at the same elevation as the vertical midpoint of the reflector and at an angle of approximately 85° to the roadway axis. The configuration of the test apparatus is shown in Figure 1. in Appendix A.

The procedure used was as follows: after cleaning both the reflector and the vehicle headlights, the vehicle (AMC Eagle) was stopped at known distances from the reflector in the driving lane and on the shoulder. At each stop, values for illumination and luminance were recorded. This procedure was used to acquire five data sets - two with the vehicle in the driving lane with low beams, two with the vehicle in the driving lane with high beams, and one with the vehicle on the shoulder with low beams. The data are plotted in Figures 2 through 4 in Appendix A. The highest luminance measured was 0.11 Footlamberts during testing with the vehicle in the driving lane using the high beams of the headlights. The visual contrast (C) can be calculated from the formula:

$$C = \frac{L_b - L_t}{L_b} \qquad [7]$$

where L_b is the luminance of the background area and L_t is the luminance of the task area.

Since many of the deer-vehicle accidents have occurred at either dusk or dawn, luminance measurements of a standard 18% Kodak grey were taken one hour after sunset. The contrast of the reflectors against the grey card background was calculated (the 18% grey card is often used to simulate an "average" tonal value for establishing the proper exposure in photography). The highest calculated contrast value was 0.9. This corresponds to the lowest background/highest reflector luminances. This is the "best case" for the reflectors as during dawn and dusk the contrast would be lowered because of the higher levels of ambient light. The contrast would also be lower when vehicles use the passing lane and/or do not use the high beams of the headlights.

Although not much is known about how deer eyes react to various levels of light and contrast, the visual response of the human eye can serve as a reference.

Detection of an object (in order of importance) is a function of the luminance of the object, the contrast of the object against its background, the size of the object, the time observed, and the color of the object.

- The measured luminance of the reflector is below the threshold of 8.5 Footlamberts required for <u>accurate</u> detection of an object for humans. It seems likely that deer eyes are much more sensitive to low levels of light.

- For the value of contrast given above, the human eye would not have difficulty determining the presence of the reflectors based on contrast.

- The small size of the reflector reduces the visual impact of the reflector because it occupies only a small part of the visual field.

- The amount of time which the reflector "lights up" is 5-6 seconds for vehicle speeds of 50-60 mph.

- It is not known what effect the red lens of the reflector has on deer. Anecdotal reports from deer hunters state that red lenses on flashlights allow hunters to see in darkness without disturbing deer. Another manufacturer of wildlife reflectors (Robert Bosch Corporation) uses clear prisms.

- the combination of vehicle lights moving at speed and the vehicle noise (tires, engine, wind) provide distractions which would reduce the effect of the reflectors.

FINDINGS

It seems questionable that the wildlife warning reflectors work as claimed, given the many stimuli present when a vehicle travels down a highway at high speed, the small area of the visual field that they occupy, and the low levels of light reflected by them. However, since very little information exists on the visual response of deer to different levels and colors of light, their effectiveness cannot be predicted on a photometric basis.

The cover/uncover method proved to be too time consuming for the available funds on this study. There are also potential inaccuracies if dawn and dusk patrols are not made every day during the evaluation period (deer accidents which occurred during daylight hours may be counted in the statistics). In addition, accident-wounded deer may travel from the right of way and not be included in the statistics.

The before/after method of evaluation has been used in the past but has too many uncontrolled variables. One study has shown that temporary reductions in deer-vehicle accidents may be possible using wildlife reflectors, but that animals will tend to adapt to the reflectors reducing their effectiveness [8].

Other methods of reducing deer-vehicle accidents which may have potential include:

- scent repellents applied at seasonal crossing areas
- providing deer underpasses at permanent crossing areas $\left|\dfrac{\text{width x height}}{\text{length}}\right|$ should not be less than 1.5 (in meters)
- watering and feeding stations away from the road have been used in Utah to reduce the number of deer crossings... however, these have been expensive and create a dependency on humans.

REFERENCES:

[1] Hanson, C.D. 1977. Social Costs of Michigan's Deer Habitat Improvement Program. Ph.D. Diss., U. of Michigan, Ann Arbor.

[2] Cost Estimates Squad of the Staff Design Branch, CDOT

[3] Schafer, J. A., Effectiveness of Wildlife Warning Reflectors in Reducing Deer-Vehicle Accidents in Washington State, Washington State DOT, Olympia.

[4] Zacks, J. L., Do White-Tailed Deer Avoid Red? An Evaluation of the Premise Underlying the Design of Swareflex Wildlife Reflectors, Transportation Research Record 1075.

[5] Reeve, Archie, Hayden-Wing Associates, Laramie, Wyoming. Telephone conversation 8/13/91.

[6] Supplemental Data, Swareflex Wildlife Warning Highway Reflectors, Swarovski Literature

[7] Roadway Lighting Handbook, U.S. Department of Transportation, Federal Highway Administration

[8] Olbrich, P. 1984. Untersuchung der Wirksamkeit von Wildwarnreflectoren und der Eignung von Wilddurchlässen. Forschungsstelle für Jagdkunde und Wildschadenverhütung des Landes Nordrhein-Westfalen.

APPENDIX A

TEST RESULTS

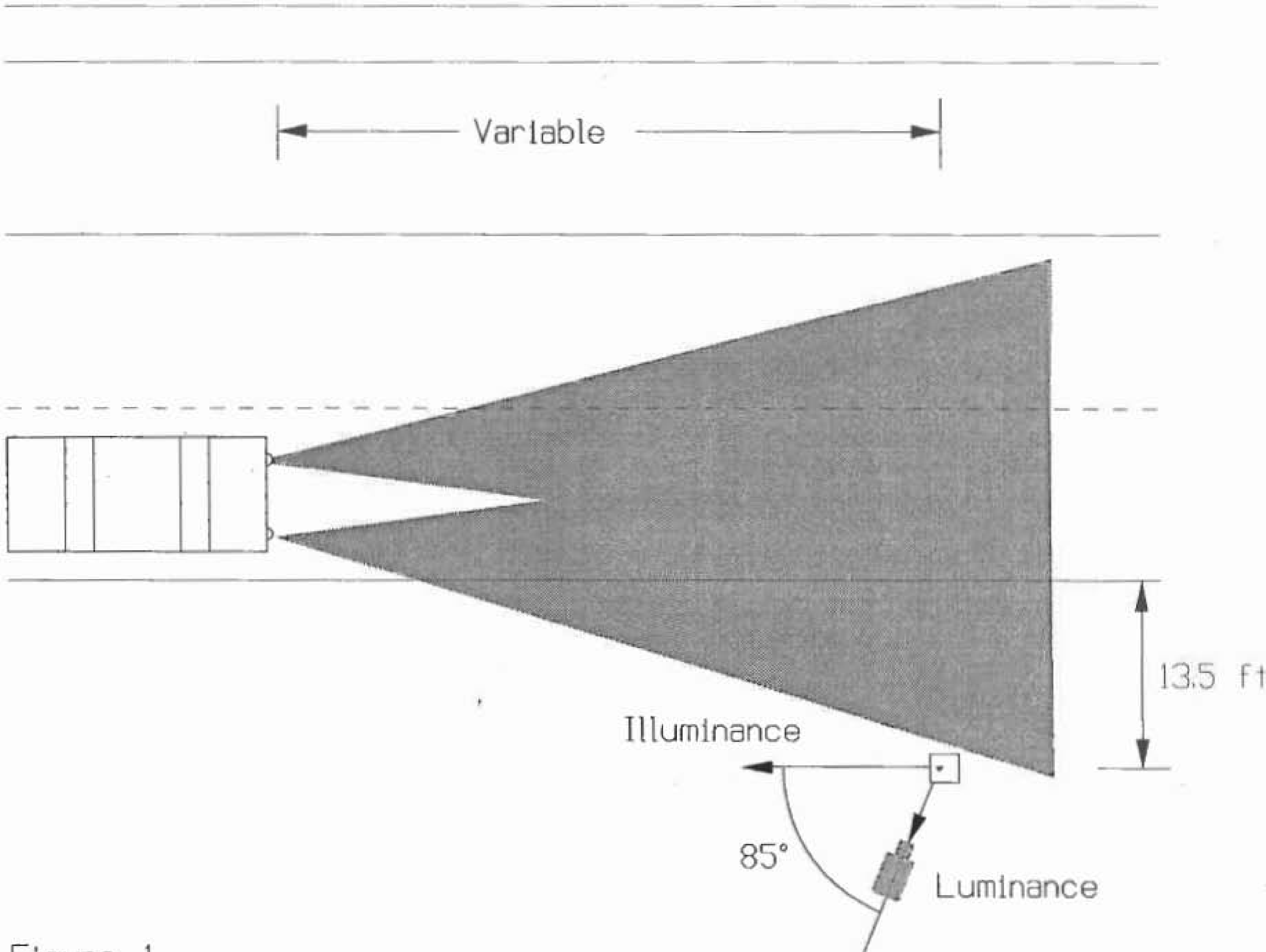
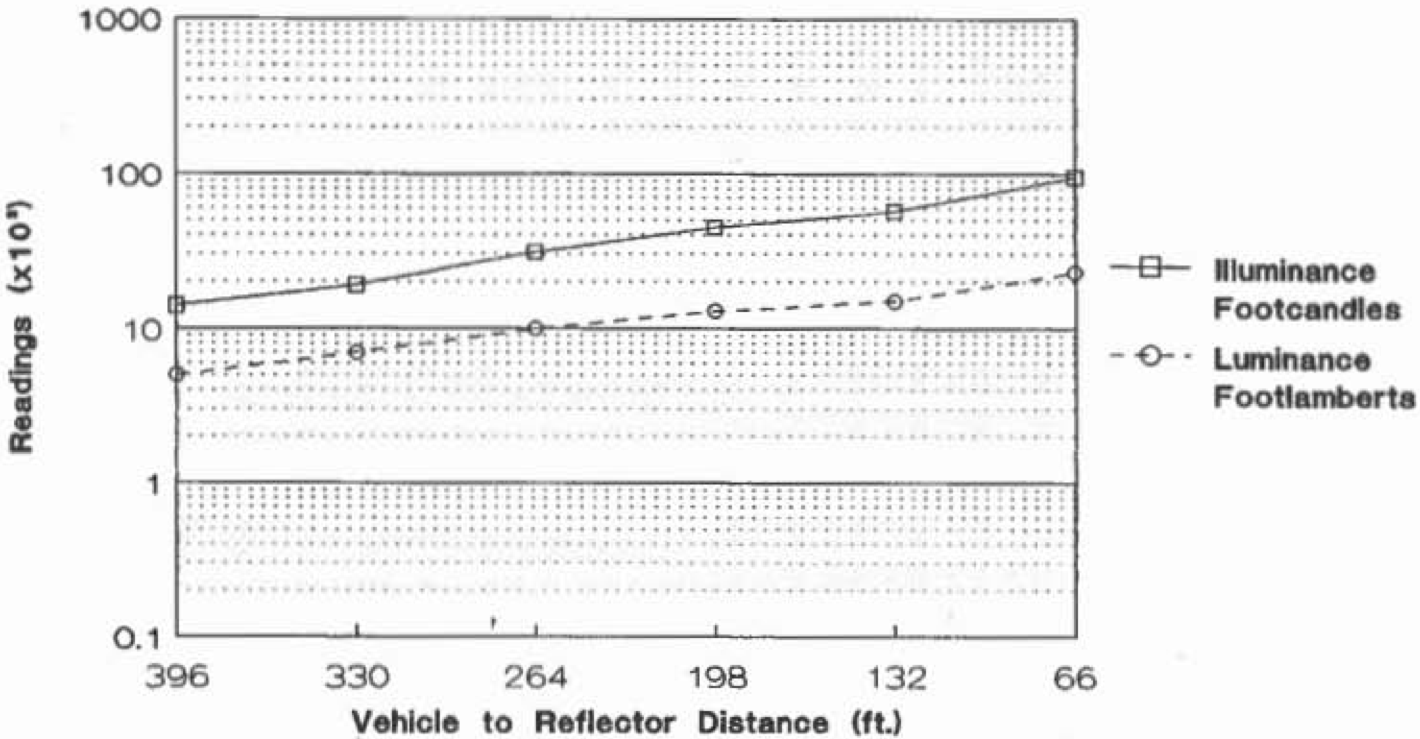


Figure 1.
Test Configuration.

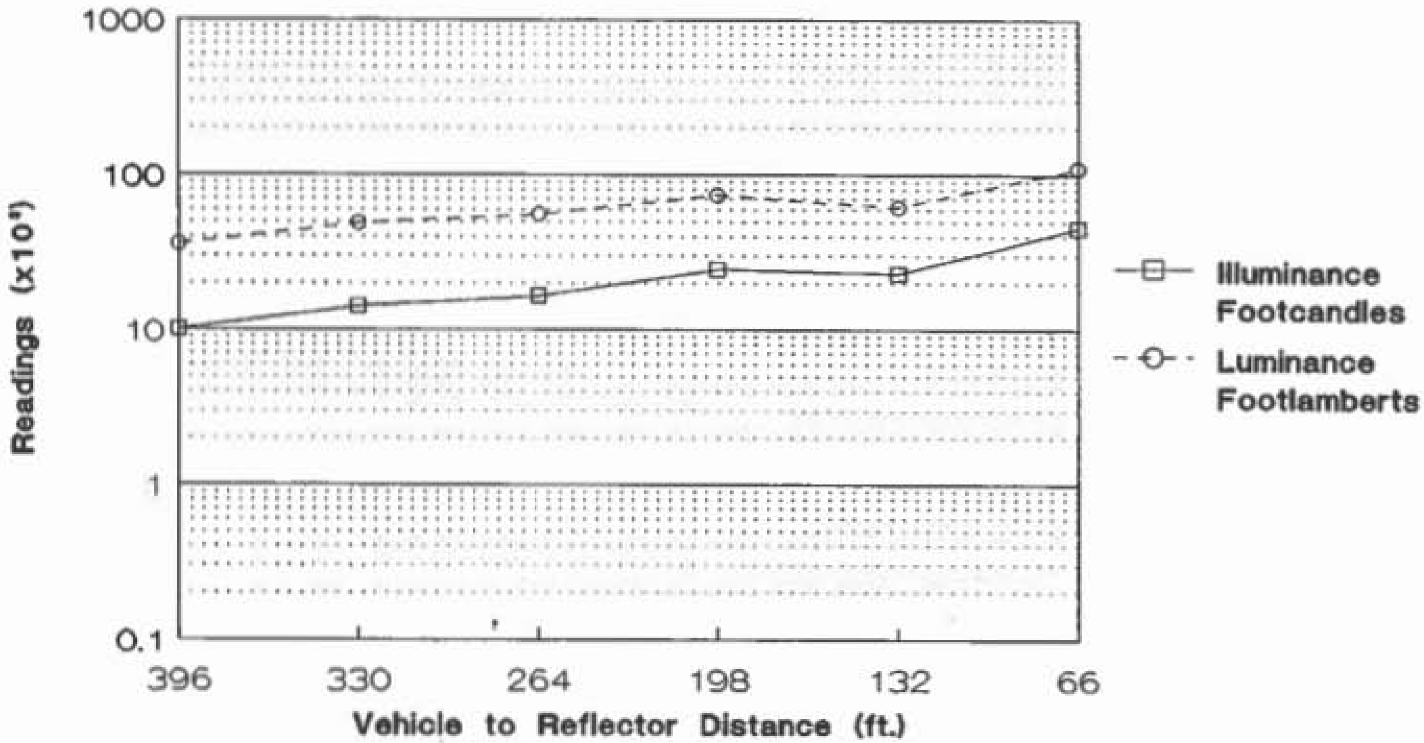
Measurements on Swareflex Reflectors

Lowbeams in Driving Lane



Measurements on Swareflex Reflectors

Highbeams in Driving Lane



Measurements on Swareflex Reflectors

Lowbeams on Shoulder