

**EVALUATION OF RAISED  
AND RECESSED  
PAVEMENT MARKERS**

**Final Report  
State Funded Project**

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16. Abstract  Oregon has been using recessed markers for approximately 10 years on all types of roads, west of the Cascade mountains. The recessed markers are protected from snow plowing operations and may last longer than raised markers, however, their life expectancy or effectiveness has never been evaluated. Standing water and/or debris has been observed in the recessed grooves which reduces the reflectivity of the markers. In addition, the effect of studded tire wear, abrasion from sanding materials, and traffic on markers has never been fully evaluated.  Paint striping and raised markers are still good alternatives for marking state highways. Paint has a minimal life cycle cost with minimal traffic impacts during replacement. Skip lines enhanced by raised markers provide excellent lane delineation both visually and audibly. However, the reflectivity of the markers may drop as much as 70% in the first year. Because the costs of raised markers are around \$250 more per year per mile than paint, they should only be used when it is cost effective or when needed to improve traffic safety.  Skip lines enhanced by recessed markers cost approximately \$100 per year per mile more than skip lines enhanced by raised markers. This cost is based on a three-year life for recessed markers, 12-year analysis period and a discount rate of 4%. Recessed markers also do not perform as well as raised markers. The initial performance is reduced strictly because they are recessed. The slots collect debris, rain and snow and when covered are ineffective. Indications are that a maintenance program to remove the debris would not be viable.  We recommend that :  1) Because of the expense and poor performance, recessed markers should not be used by ODOT. Paint striping and raised markers are the best alternatives for marking our state highways. Consideration should be given to the selection of a marker or paint based on ADT and roadway alignment.  2) Durable markers should be considered for special applications.					
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## SI\* (MODERN METRIC) CONVERSION FACTORS

### APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
<u>LENGTH</u>				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
<u>AREA</u>				
in <sup>2</sup>	square inches	645.2	millimeters squared	mm <sup>2</sup>
ft <sup>2</sup>	square feet	0.093	meters squared	m <sup>2</sup>
yd <sup>2</sup>	square yards	0.836	meters squared	m <sup>2</sup>
ac	acres	0.405	hectares	ha
mi <sup>2</sup>	square miles	2.59	kilometers squared	km <sup>2</sup>
<u>VOLUME</u>				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft <sup>3</sup>	cubic feet	0.028	meters cubed	m <sup>3</sup>
yd <sup>3</sup>	cubic yards	0.765	meters cubed	m <sup>3</sup>

NOTE: Volumes greater than 1000 L shall be shown in m<sup>3</sup>.

#### MASS

oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg

#### TEMPERATURE (exact)

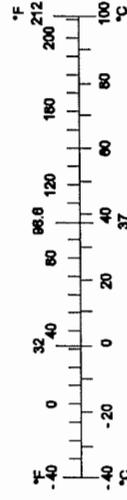
°F	Fahrenheit temperature	5(F-32)/9	Celsius temperature	°C
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### APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
<u>LENGTH</u>				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
<u>AREA</u>				
mm <sup>2</sup>	millimeters squared	0.0016	square inches	in <sup>2</sup>
m <sup>2</sup>	meters squared	10.764	square feet	ft <sup>2</sup>
ha	hectares	2.47	acres	ac
km <sup>2</sup>	kilometers squared	0.386	square miles	mi <sup>2</sup>
<u>VOLUME</u>				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m <sup>3</sup>	meters cubed	35.315	cubic feet	ft <sup>3</sup>
m <sup>3</sup>	meters cubed	1.308	cubic yards	yd <sup>3</sup>
<u>MASS</u>				
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T

#### TEMPERATURE (exact)

°C	Celsius temperature	1.8 + 32	Fahrenheit	°F
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\* SI is the symbol for the International System of Measurement

## **ACKNOWLEDGEMENTS**

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## **DISCLAIMER**

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# Evaluation of Raised and Recessed Pavement Markers

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# 1.0 INTRODUCTION

Oregon has been using recessed markers for approximately 10 years on all types of roads, west of the Cascade mountains. The recessed markers are protected from snow plowing operations and may stay in place longer than raised markers, however, their life expectancy or effectiveness has never been evaluated. Standing water and/or debris has been observed in the recessed grooves which reduces the reflectivity of the markers. In addition, the effect of studded tire wear, abrasion from sanding materials, and traffic on markers has never been fully evaluated.

A research study was initiated in July 1994 to evaluate marker use in Oregon. The study included a literature review, a survey of marker users in Oregon and adjacent states, a cost analysis, and conclusions and recommendations.

## 1.1 OBJECTIVES

The original objectives of the study included evaluating alternative slot designs to increase the reflectivity and the effectiveness of recessed pavement markers; and determining why water is often found standing in the recessed grooves of open-graded mixes. However, through the course of the study, it was determined that current pavement designs do not permit suitable drainage of the grooves. The original objectives were revised and additional research into recessed marker use was dropped.

The revised objectives of the project were to:

- 1) Determine the reflective life of pavement markers,
- 2) Determine the life cycle costs of alternative marker treatments,
- 3) Recommend applications of markers based on traffic volume and road alignment.

## 2.0 LITERATURE SEARCH

New York and Texas among other states have conducted research evaluating pavement markers. New York, for example, has conducted a test of recessed reflector delineation and Texas was studying the reflective life of raised pavement markers.

New York's research which has been documented in a report entitled *Grooved Stripes for Plow-Resistant Wet-Night Lane Delineation Phase II (1)*, studied recessed markers in a variety of situations. The variables included in the installation were pavement type, roadway geometry, and reflector and recess depth and configuration. The final report indicates that sight distances under wet-night conditions range from 480 ft [146 m] to less than 40 ft [12 m] and are influenced by roadway geometry, reflector and recess depths, dirt accumulation, and drainage. Delineation varies from excellent to poor.

The Texas Department of Transportation has sponsored a number of studies to assess how quickly reflective markers lose their reflectivity, and to identify what factors influence the rate of reflectivity loss. They have determined that most reflective markers experience significant losses in reflectivity over very short periods of time. Initial losses in reflectivity were due primarily to dirt accumulation on the reflective lenses. Over time, abrasions and weathering caused reflectivity losses to become permanent. Reflectivity loss rates appeared to depend mostly upon the total traffic volume. (2)

## **3.0 SURVEY RESULTS**

A survey was conducted of all region traffic engineers and maintenance districts within the Oregon Department of Transportation (ODOT) and selected state departments of transportation. The survey data collected included the estimated length of service for different types of markers, the most common mode of failure, and any ideas on improving the slot design for recessed markers to reduce the amount of collected standing water.

### **3.1 ODOT RESPONSES**

Based on the information received from eight offices (see Appendix A), it appears that recessed markers last, on the average, 9 to 18 months longer than raised markers. The average life of a raised marker being 24 months, the average useful life of a recessed marker is approximately 36 months. The anticipated useful life of the markers is a direct correlation between average daily traffic (ADT), the number of times the roadway is sanded and plowed and the number of studded tire passes.

The regions east of the Cascades do not use raised or recessed markers. In eastern Oregon, traditional striping is more cost effective given the amount of plowing and sanding that occurs in the winter months.

Some proposed alternatives for removing standing water in the slots included:

- 1) Using a thicker open-graded mix overlay to allow better drainage;
- 2) Using longer slots;
- 3) Angling the slot so at least half the button is elevated; and
- 4) Filling the slots completely with a hot thermoplastic material with reflective beads.

Since recessed markers were determined to be more expensive and less effective than raised markers, an alternative slot design was not investigated further.

### **3.2 OTHER STATE'S RESPONSES**

Of the four states that responded to the survey (see Appendix A), only California uses recessed pavement markers. Generally, recessed markers are allowed for locations between elevations 1000 and 3000 feet [300 - 900 m] above sea level. The Idaho Transportation Department has very limited experience with raised or recessed markers. Markers in Idaho have been replaced with paint successfully. Both Nevada and Washington do not have any recessed pavement markers.

## 4.0 OBSERVATIONS

Observations about the effectiveness of pavement markers have been made in various locations around the state and in other states with similar climatic conditions. Generally, both raised and recessed pavement markers provide better lane delineation than traditional striping in adverse weather conditions.

Recessed markers, though, have displayed several operational problems, as shown in Appendix B, figures B.1 and B.2. Problems include collecting water, snow, sand, ice and debris in the grooves. Since they are recessed, they also do not provide the same delineation in wet conditions as the raised markers as shown in Appendix B, figures B.3 and B.4.

In Oregon, a significant contribution to failure of reflective markers is studded tire wear. Recessed markers have been thought to last longer because of the additional protection the groove provides. In actuality this is not the case. Recessed markers were placed in the Bend area, and within three months had lost all reflectivity due to damage caused by studded tires. The markers were removed and replaced with another brand of reflective marker and within six months the new markers needed to be replaced. At this time these markers have been completely removed.

## 5.0 COST ANALYSIS

A cost analysis was performed to determine the equivalent uniform annual cost (EUAC) of applying each of the different pavement marking materials.

The life-cycle cost analyses of the marking materials have several assumptions in common. They are:

- 1) The evaluation section is a one mile skip line.
- 2) It is assumed that the pavement section will be overlaid at 12 years. This is the analysis period.
- 3) Although paint striping typically lasts 8 months, because of the added delineation of the markers, paint was assumed to be replaced every year and a half.
- 4) The discount rate is 4%.

Delay costs should be considered when comparing the materials, since the traffic delays or user costs vary significantly by alternative. However, these costs were not included in the analyses. The cost differences in plowing with steel blades vs. rubber blades were also not included in this analysis.

### 5.1 MATERIAL COSTS

#### 5.1.1 Solvent Based Paint

The bid costs for solvent borne paint are approximately \$0.11/ft [ $\$0.36/m$ ]. The cost for a one mile skip line is \$145.00 [ $\$90/km$ ]. Actual annual maintenance costs average \$106.00/mile [ $\$66/km$ ].

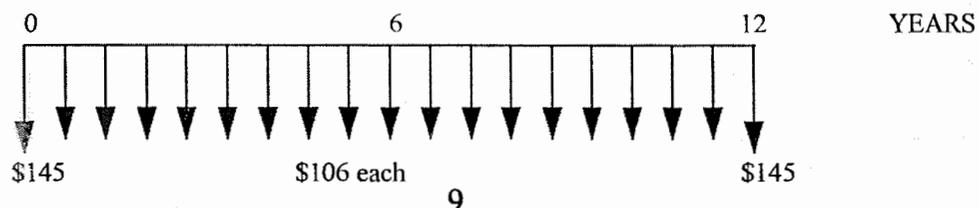
Bid Costs:

$$\text{Cost} = \$0.11/\text{ft}$$

$$\text{Amount of paint/mile} = 5280 * .25$$

$$\text{Cost of paint/mile} = \$0.11 * 5280 * .25 = \$145.00 [\$90/km]$$

The striping is replaced three times every two years. The EUAC for solvent based paint is \$176.00/mile [ $\$110/km$ ]. The cost analysis diagram and EUAC calculations are shown below.



$$\text{PW} = \$145 + \Sigma \$106(\text{P/F}, 4\%, n) + \$145(\text{P/F}, 4\%, 12)$$

where  $n = \{0.66, 1.34, \dots, 11.24\}$  years

$$= \$1671$$

$$\text{EUAC} = \$1671(\text{A/P}, 4\%, 12) = \$1671(.1066)$$

$$= \$176/\text{mile } [\$110/\text{km}]$$

### 5.1.2 Raised Pavement Markers

There are 132 raised pavement markers per one mile of skip line (the markers enhance a painted skip line). Therefore, the cost to initially place the skip line is \$541.00/mile [ $\$336/\text{km}$ ].

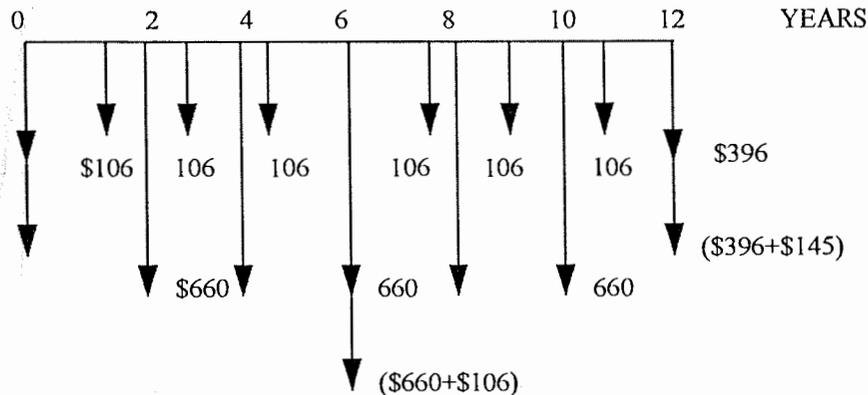
Initial Costs:

$$\text{Cost/marker} = \$3$$

$$\text{Cost of paint/mile} = \$145$$

$$\text{Cost of marker enhanced skip line} = \$3(132) + \$145 = \$541.00 [\$336/\text{km}]$$

The service life of raised pavement markers is typically 2 years. As shown below, the actual replacement costs for the markers at \$5.00 each equals \$660.00/mile [ $\$410/\text{km}$ ] and the costs for replacing the paint striping is \$106.00/mile [ $\$66/\text{km}$ ] every one and a half years. The EUAC for a skip line enhanced by raised pavement markers is \$436.00/mile [ $\$271/\text{km}$ ].



$$\text{PW} = \$541 + \Sigma \$106(\text{P/F}, 4\%, n_1) + \Sigma \$660(\text{P/F}, 4\%, n_2) + \$541(\text{P/F}, 4\%, 12)$$

where  $n_1 = \{1.5, 3, \dots, 10.5\}$  and  $n_2 = \{2, 4, \dots, 10\}$  years

$$= \$4092$$

$$\text{EUAC} = \$4092(\text{A/P}, 4\%, 12) = \$4092(.1066)$$

$$= \$436/\text{mile } [\$271/\text{km}]$$

### 5.1.4 Recessed Pavement Markers

The unit cost of recessed pavement markers is approximately \$8.00. The total cost for a one mile skip line enhanced by recessed pavement markers is \$1162.00 [ $\$722/\text{km}$ ].

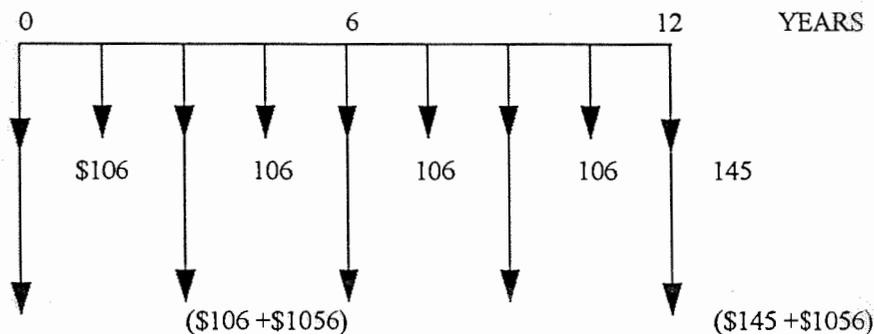
Total Costs:

$$\text{Cost/mile for markers} = \$8(132) = \$1056$$

$$\text{Cost of paint/mile} = \$145$$

$$\text{Total cost for paint enhanced by recessed markers} = \$1162 \text{ } [\$722/\text{km}]$$

The service life for the markers is typically three years. The paint skip line is replaced once every year and a half. The replacement costs for the markers are equal to the initial installation costs because of the additional work involved in removing the epoxy from the grooves or having to recut the grooves. Therefore, the EUAC per mile for a skip line enhanced by recessed pavement markers is \$532.00 [ $\$331/\text{km}$ ]. The cost analysis diagram for recessed pavement markers is shown below.



$$\begin{aligned} \text{PW} &= \$1201 + \Sigma \$106(\text{P/F}, 4\%, n_1) + \Sigma \$1056(\text{P/F}, 4\%, n_2) + \$1201(\text{P/F}, 4\%, 12) \\ &\quad \text{where } n_1 = \{1.5, 3, \dots, 10.5\} \text{ and } n_2 = \{3, 6, \dots, 9\} \text{ years} \\ &= \$5056 \end{aligned}$$

$$\begin{aligned} \text{EUAC} &= \$5056(\text{A/P}, 4\%, 12) = \$5056(.1066) \\ &= \$539/\text{mile} \text{ } [\$335/\text{km}] \end{aligned}$$

## 5.2 SUMMARY OF COSTS

Table 5.1 shows a summary of the equivalent uniform annual costs for each of the three alternatives discussed previously.

Table 5.1 Summary of Costs

<b>ALTERNATIVE</b>	<b>LIFE</b>	<b>EUAC/mile</b>
Paint	8 months	\$176
Raised Markers	2 years	\$436
Recessed Markers	3 years	\$539

## 6.0 DURABLE MARKING MATERIALS

Durable marking materials are products that are thicker, harder, more expensive, and generally more difficult to install than traditional pavement marking materials. Installation of these materials usually requires special equipment.

Generally, thicker is better with durable marking materials. Anything thinner than 40 mils or 0.040 inches [1.0 mm] should actually be considered semi-durable. A material of 120 mils [3.0 mm] is not recommended in snow removal areas, because of the possible removal by snow plows. For those areas, a thicker product inlaid should be considered. At lower elevations, profiled markings, which give a rumble effect similar to raised pavement markers, are an excellent way to delineate lane lines and edge lines.

The use of durable marking materials will reduce the number of times the roadway will need to be re-delineated because of the significant increase in the life of the markings. Due to the added cost, it is especially important to conduct a value engineering study before specifying these products. Table 6.1 compares the durability, thickness, no-track time, and the cost for different marking materials.

Durable marking materials are an excellent alternative to recessed markers in areas of poor roadway alignment and areas of limited snow removal operations.

Table 6.1 Comparison of Marking Materials

Material	Durability (years)	Wet Mil Thickness <sup>6</sup>	No-Track Time (minutes)	Cost/ft. (installed) <sup>5,7</sup>
Alkyd Thermoplastic <sup>1,2</sup>	2-6	Spray: 40-60 Extruded: 90-120	Spray: 1-5 Extruded: 15	\$0.40-\$0.85
Hydrocarbon Thermoplastic <sup>1,2</sup>	2-6	Spray: 40-60 Extruded: 90-120	Spray: 1-5 Extruded: 15	\$0.30-\$0.75
Alkyd Paint	$\frac{3}{8}$	15	$\frac{1}{2}$ -1	\$0.07-\$0.11
Waterborne Paint	$\frac{3}{8}$	15	$\frac{1}{2}$ -1	\$0.08-\$0.11
Preformed Tape <sup>1</sup>	1 $\frac{1}{2}$ -4	60-90	N/A	\$1.50-\$1.75
Epoxy <sup>4</sup>	3-6	15-40	5-20	\$0.35-\$0.50
Methacrylate <sup>2</sup>	3-10	Spray: 50-60 Extruded: 90-120 Profiled: 90/500x4	18-20	Spray: \$0.70-\$0.80 Extruded: \$0.90-\$1.50 Profiled: \$2.25-\$2.50
Reflect. Markers w/Buttons <sup>3</sup>	2-6	750	Bituminous: 2-5 Epoxy: 20-60	\$0.30-\$0.45

<sup>1</sup>Rainy weather versions available.

<sup>2</sup>Rumble version available.

<sup>3</sup>Skip stripes only.

<sup>4</sup>May require substantial surface preparation.

<sup>5</sup>Estimate only. Cost varies, depending on location and quantities.

<sup>6</sup>1 mil = 0.254 mm

<sup>7</sup>To convert from cost/ft to cost/m multiply by 3.28.

## 7.0 CONCLUSIONS AND RECOMMENDATIONS

### 7.1 CONCLUSIONS

Paint striping and raised markers are good alternatives for marking state highways. Paint has a minimal life cycle cost with minimal traffic impacts during replacement. Skip lines enhanced by raised markers provide excellent lane delineation both visually and audibly. However, because the costs of raised markers are around \$250 more per year per mile than paint, they should only be used when it is cost effective or when needed to improve traffic safety. Also, the reflectivity of the markers may drop as much as 70% in the first year.

Skip lines enhanced by recessed markers cost approximately \$100 per year per mile more than skip lines enhanced by raised markers. This cost is based on a three-year life for recessed markers, 12-year analysis period and a discount rate of 4%. Recessed markers also do not perform as well as raised markers. The initial performance is reduced strictly because they are recessed. The slots collect debris, rain and snow and when covered are ineffective. Indications are that a maintenance program to remove the debris would not be viable.

### 7.2 RECOMMENDATIONS

We recommend that:

- 1) Table 7.1 be used for the selection of pavement marking materials. Because of the expense and poor performance, recessed markers should not be used by ODOT. Paint striping and raised markers are the best alternatives for marking our state highways. Consideration should be given to the selection of a marker or paint based on ADT, roadway alignment and adverse weather conditions.
- 2) Durable markers be considered for special applications.

Table 7.1 Recommendation Matrix

	SNOW ZONE (elev. >2,500')	NON-SNOW ZONE		
		<10,000 ADT <sup>1</sup>	10,000 - 30,000 ADT	> 30,000 ADT
GOOD ALIGNMENT	PAINT	PAINT	RAISED/PAINT	RAISED
POOR ALIGNMENT <sup>2</sup>	PAINT	RAISED/PAINT	RAISED/PAINT	RAISED

<sup>1</sup> Raised markers should be considered for high seasonal traffic volumes and for heavy rain and fog zones.

<sup>2</sup> Consider durable markings for special applications.

## 8.0 REFERENCES

- 1) Bryden, James E., Joseph R. Allison, and Gary F. Gurney, Grooved Stripes for Plow-Resistant Wet-Night Delineation Phase II, New York Department of Transportation, 1976.
- 2) Ullman, Gerald L., Retroreflective Raised Pavement Marker Field Testing: Results of the First Year Evaluation, Texas Transportation Institute, 1994.
- 3) Clark, J. Edwin, Suzanna M. Sanders, Review and Recommendations for Pavement Marking Materials, South Carolina Department of Transportation, 1993.

## **APPENDIX A**

**OREGON DEPARTMENT OF TRANSPORTATION  
RAISED AND RECESSED  
PAVEMENT MARKER  
SURVEY**

1. What kind of reflective pavement markers are you using? How long do they last?

Raised:

Standard  \_\_\_\_\_ months

Abrasive Resistant  \_\_\_\_\_ months

Slotted (Recessed)  \_\_\_\_\_ months

Snow Plowable Castings  \_\_\_\_\_ months

Other  \_\_\_\_\_ months  
identify

2. What is the most common form of failure? (e.g. loss from snow plows, broken, loss of reflectivity)

3. If you use abrasive resistant reflective pavement markers, please send us a copy of your requirements?

4. Please describe any problems you have with standing water in the slots of the recessed markers?

5. Please enclose a copy of your slot design.

6. Do you have any additional comments?

If you have any questions please contact Kaaren Hofmann at (503) 986-2851 or Chris Carman at (503) 986-3606.

Return to: **Kaaren Hofmann  
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Post-It™ brand  
Fax Transmittal Memo 7672

To KAAREN HOFFMANN  
Company O.D.O.T.  
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Fax # 986-2844 Telephone #  
Comments

No. of Pages 1 Today's Date 4/3/95 Time 2:15 P.M.  
From PAT MASON  
Company O.D.O.T. - REG. 1 STRIPING  
Location MILWAUKIE Dept. Charge  
Fax # 731-8351 Telephone # 731-8322  
Original Disposition:  Destroy  Return  Call for pickup

OREGON DEPARTMENT OF TRANSPORTATION  
RAISED AND RECESSED  
PAVEMENT MARKER  
SURVEY

1. What kind of reflective pavement markers are you using? STIMSONITE - TYPE 1  
How long do they last?  
Raised:  
Standard - 9 months  
Abrasive Resistant (glass face or ?) - 12 months  
Slotted (Recessed) - 18 Mo. months  
Snow Plowable Castings - N/A months  
Other - \_\_\_\_\_ months  
identify
2. What is the most common form of failure? (e.g. loss from snow plows, broken, loss of reflectivity) LOSS OF REFLECTIVITY
3. Do you have any suggestions on altering the slot design to improve the drainage of standing water when recessed markers are used?  
Please enclose any suggestions or alternatives. NO
4. Any other comments?

If you have any questions please contact Kaaren Hofmann at (503) 986-2851 or Chris Carman at (503) 986-3606.

Return to: Kaaren Hofmann  
Research Unit  
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2950 State Street  
Salem, OR 97310

ODOT Personnel

PAT MASON  
REGION 1 STRIPING SUPV.

APR 1 1995

OREGON DEPARTMENT OF TRANSPORTATION  
RAISED AND RECESSED  
PAVEMENT MARKER  
SURVEY

DATE \_\_\_\_\_  
BY \_\_\_\_\_  
RETURN TO \_\_\_\_\_

By *Wilford Bradshaw*  
*Region 2 Traffic Engineer* 986-2656

1. What kind of reflective pavement markers are you using? Glass Face  
How long do they last?

Raised:

Standard - \_\_\_\_\_ months

Abrasive Resistant (glass face or ?) - 18 months

Slotted (Recessed) - 24-36 months

Snow Plowable Castings- N/A months

Other - \_\_\_\_\_ months

identify

2. What is the most common form of failure? (e.g. loss from snow plows,  
broken, loss of reflectivity)

Recessed

E raised

3. Do you have any suggestions on altering the slot design to improve the  
drainage of standing water when recessed markers are used?

Please enclose any suggestions or alternatives.

"F" mix pavement design.

4. Any other comments?

Use plastic product such as "Durastripe" instead of opaque button  
when opaque is replacing painted skip line.

Recess opaque buttons or use recessed "durastripe" mini skips when delineating  
double turn locations.

If you have any questions please contact Kaaren Hofmann at (503) 986-2851 or  
Chris Carman at (503) 986-3606.

Return to: **Kaaren Hofmann**  
**Research Unit**  
**Oregon Department of Transportation**  
**2950 State Street**  
**Salem, OR 97310**

OREGON DEPARTMENT OF TRANSPORTATION  
RAISED AND RECESSED  
PAVEMENT MARKER  
SURVEY

1. What kind of reflective pavement markers are you using? *Ray-o-Lite*  
How long do they last?

Raised:

Standard  36 months

Abrasive Resistant (glass face or ?)  \_\_\_\_\_ months

Slotted (Recessed)  36 months

Snow Plowable Castings  \_\_\_\_\_ months

Other  \_\_\_\_\_ months

identify

2. What is the most common form of failure? (e.g. loss from snow plows, broken, loss of reflectivity)

*loss of reflectivity*

3. Do you have any suggestions on altering the slot design to improve the drainage of standing water when recessed markers are used?

Please enclose any suggestions or alternatives.

*thicker 'F' mix overlay to drain underneath*

4. Any other comments?

If you have any questions please contact Kaaren Hofmann at (503) 986-2851 or Chris Carman at (503) 986-3606.

Return to: **Kaaren Hofmann**  
**Research Unit**  
**Oregon Department of Transportation**  
**2950 State Street**  
**Salem, OR 97310**

ODOT Personnel

*Region 3*

MAR 22 1995

OREGON DEPARTMENT OF TRANSPORTATION  
RAISED AND RECESSED  
PAVEMENT MARKER  
SURVEY

FOE \_\_\_ OSC \_\_\_

FTC \_\_\_ TSC \_\_\_

FYI TAA FILE Return To: \_\_\_\_\_

1. What kind of reflective pavement markers are you using? None.  
How long do they last?

Raised:

Standard - \_\_\_\_\_ months

Abrasive Resistant (glass face or ?) - \_\_\_\_\_ months

Slotted (Recessed) - \_\_\_\_\_ months

Snow Plowable Castings- \_\_\_\_\_ months

Other - \_\_\_\_\_ months

identify

2. What is the most common form of failure? (e.g. loss from snow plows, broken, loss of reflectivity)

3. Do you have any suggestions on altering the slot design to improve the drainage of standing water when recessed markers are used?

Please enclose any suggestions or alternatives.

4. Any other comments? We tried recessed pavement markers on lava Butte. By the end of winter they had lost all reflectivity - primarily the face of the reflector was scarred and pitted by studs. We elected to not replace them and do not use raised/recessed markers.

If you have any questions please contact Kaaren Hofmann at (503) 986-2851 or Chris Carman at (503) 986-3606.

Return to: **Kaaren Hofmann**  
**Research Unit**  
**Oregon Department of Transportation**  
**2950 State Street**  
**Salem, OR 97310**

in Region 4  
Steve Wilson  
388-6189





MAR 22 1995

OREGON DEPARTMENT OF TRANSPORTATION  
RAISED AND RECESSED  
PAVEMENT MARKER  
SURVEY

OSC \_\_\_\_\_  
STC \_\_\_\_\_ TSC \_\_\_\_\_  
BY FAX FILE Return To: \_\_\_\_\_

1. What kind of reflective pavement markers are you using? Ray O Lite  
How long do they last?

Raised:  
Standard - 36<sup>to 48</sup> months  
Abrasive Resistant (glass face or ?) - 36<sup>to 48</sup> months  
Slotted (Recessed) - 36 months  
Snow Plowable Castings- \_\_\_\_\_ months  
Other - \_\_\_\_\_ months  
identify

2. What is the most common form of failure? (e.g. loss from snow plows, broken, loss of reflectivity) 1. Loss of reflectivity due to sanding  
2. Loss from traffic in curves  
3. Snow plow

3. Do you have any suggestions on altering the slot design to improve the drainage of standing water when recessed markers are used?  
Please enclose any suggestions or alternatives.  
one suggestion is to fill the slot with a hot thermoplastic product with reflective beads, that would eliminate the standing water problem.

4. Any other comments?

If you have any questions please contact Kaaren Hofmann at (503) 986-2851 or Chris Carman at (503) 986-3606.

Return to: **Kaaren Hofmann**  
**Research Unit**  
**Oregon Department of Transportation**  
**2950 State Street**  
**Salem, OR 97310**

ODOT Personnel

District 7

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RESEARCH UNIT

MAR 22 1995

OREGON DEPARTMENT OF TRANSPORTATION  
RAISED AND RECESSED  
PAVEMENT MARKER  
SURVEY

RUE \_\_\_ OSC \_\_\_

FTC \_\_\_ TSC \_\_\_

NY/TAA FILE Return To: \_\_\_\_\_

1. What kind of reflective pavement markers are you using? Striping  
How long do they last?

Raised:

Standard - \_\_\_\_\_ months

Abrasive Resistant (glass face or ?) - \_\_\_\_\_ months

Slotted (Recessed) - \_\_\_\_\_ months

Snow Plowable Castings- \_\_\_\_\_ months

Other - \_\_\_\_\_ months

identify

2. What is the most common form of failure? (e.g. loss from snow plows, broken, loss of reflectivity)

3. Do you have any suggestions on altering the slot design to improve the drainage of standing water when recessed markers are used?

Please enclose any suggestions or alternatives.

4. Any other comments? In Dist. 9, we have no raised or recessed pavement markers

Sam Wilkins

If you have any questions please contact Kaaren Hofmann at (503) 986-2851 or Chris Carman at (503) 986-3606.

Return to: **Kaaren Hofmann**  
**Research Unit**  
**Oregon Department of Transportation**  
**2950 State Street**  
**Salem, OR 97310**

ODOT Personnel

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MAR 22 1995

OREGON DEPARTMENT OF TRANSPORTATION  
**RAISED AND RECESSED  
PAVEMENT MARKER  
SURVEY**

OSC \_\_\_\_\_

TSC \_\_\_\_\_

FYI TAA FILE Return To: \_\_\_\_\_

1. What kind of reflective pavement markers are you using? None  
How long do they last?

Raised:

Standard - \_\_\_\_\_ months

Abrasive Resistant (glass face or ?) - \_\_\_\_\_ months

Slotted (Recessed) - \_\_\_\_\_ months

Snow Plowable Castings- \_\_\_\_\_ months

Other - \_\_\_\_\_ months

identify

2. What is the most common form of failure? (e.g. loss from snow plows, broken, loss of reflectivity)

3. Do you have any suggestions on altering the slot design to improve the drainage of standing water when recessed markers are used?

Please enclose any suggestions or alternatives.

4. Any other comments?

If you have any questions please contact Kaaren Hofmann at (503) 986-2851 or Chris Carman at (503) 986-3606.

Return to: **Kaaren Hofmann**  
**Research Unit**  
**Oregon Department of Transportation**  
**2950 State Street**  
**Salem, OR 97310**

ODOT Personnel

*District 12*



Oregon Department of Transportation  
Highway Maintenance - District 2C

RECEIVED  
RESEARCH UNIT

Oregon

**DATE:** March 30, 1995  
**TO:** Kaaren Hofmann  
Research Specialist

APR 5 1995

INTEROFFICE  
MEMO

RUE \_\_\_ OSC \_\_\_

TRP \_\_\_ TSC \_\_\_

FY1994 FILE Return To: \_\_\_\_\_

File Code:  
MAI 15-6

**FROM:** Terry Sladky *Terry*  
Acting Assistant District Manager

**SUBJECT:** Raised and Recessed Pavement Markers

Thanks for the opportunity to respond to the questionnaire. I met with Shane Ottosen from District 2B and Mike Dunning from our Materials Unit along with a representative from Stimsonite to discuss the pavement markers we had installed last fall. They were interested in our concerns about the lack of reflectivity we felt was a problem. They are currently looking into this problem and will write Shane a letter on their findings. I have filled out the questionnaire and it is attached for you review.

TS:lp\pavemark.doc  
Attachment

OREGON DEPARTMENT OF TRANSPORTATION  
RAISED AND RECESSED  
PAVEMENT MARKER  
SURVEY

1. What kind of reflective pavement markers are you using? RECESSED  
How long do they last?  
Raised:  
Standard - \_\_\_\_\_ months  
Abrasive Resistant (glass face or ?) - \_\_\_\_\_ months  
Slotted (Recessed) - 6 months *is ALL THEY HAVE BEEN installed*  
Snow Plowable Castings- \_\_\_\_\_ months  
Other - \_\_\_\_\_ months  
identify
2. What is the most common form of failure? (e.g. loss from snow plows, broken, loss of reflectivity) *WE HAVE ONLY HAD THEM IN SINCE LAST OCTOBER AND MOST OF OUR FAILURE HAS BEEN DUE TO SNOW PLOWS AND OR STUDDED TIRES.*
3. Do you have any suggestions on altering the slot design to improve the drainage of standing water when recessed markers are used?  
Please enclose any suggestions or alternatives.  
*I FEEL THAT A LONGER SLOT IN AND OUT OF THE PAVEMENT WOULD HELP WITH DRAINAGE. AT THE SAME TIME LONGER SLOTS WOULD IMPROVE THE DISTANCE THAT THE REFLECTOR COULD BE SEEN FROM.*
4. Any other comments?

If you have any questions please contact Kaaren Hofmann at (503) 986-2851 or Chris Carman at (503) 986-3606.

Return to: **Kaaren Hofmann**  
**Research Unit**  
**Oregon Department of Transportation**  
**2950 State Street**  
**Salem, OR 97310**

ODOT Personnel

*Districk  
JC*

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RESEARCH UNIT

APR 3 1995

Oregon

INTEROFFICE MEMO  
District 5 Office

RUE \_\_\_ OSC \_\_\_  
TTC \_\_\_ TSC \_\_\_  
FYI TAA FILE Return To: \_\_\_\_\_

DEPARTMENT OF  
TRANSPORTATION

To: Kaaren Hofmann  
Research Unit

Date: March 30, 1995

From: Terry R. Thames *Terry*  
Asst. Manager

Subject: Pavement Marker Survey

Enclosed is the Pavement Marker Survey for District 5.

TRT:hls

Enc: (1)



3620 Gateway  
Springfield, OR 97477  
(503) 726-2552  
FAX (503) 726-2509

OREGON DEPARTMENT OF TRANSPORTATION  
RAISED AND RECESSED  
PAVEMENT MARKER  
SURVEY

1. What kind of reflective pavement markers are you using? *installed by contractor*  
How long do they last? *(By Stinsonite Corp.)*  
Raised:  
Standard - 18 months  
Abrasive Resistant (glass face or ?) - \_\_\_\_\_ months  
Slotted (Recessed) - 36 months  
Snow Plowable Castings- \_\_\_\_\_ months  
Other - \_\_\_\_\_ months  
identify
2. What is the most common form of failure? (e.g. loss from snow plows,  
broken, loss of reflectivity) *Snowplows, stud tires*
3. Do you have any suggestions on altering the slot design to improve the  
drainage of standing water when recessed markers are used?  
Please enclose any suggestions or alternatives.  
*No*
4. Any other comments?

If you have any questions please contact Kaaren Hofmann at (503) 986-2851 or  
Chris Carman at (503) 986-3606.

Return to: Kaaren Hofmann  
Research Unit  
Oregon Department of Transportation  
2950 State Street  
Salem, OR 97310

ODOT Personnel

*District 5*

OREGON DEPARTMENT OF TRANSPORTATION  
RAISED AND RECESSED  
PAVEMENT MARKER  
SURVEY

1. What kind of reflective pavement markers are you using? *Ray-o-Site 2-window, Aluminate 1-window*  
How long do they last? *Depends on Area, How Good Installation was done.*
- Raised:  
Standard - 12-24 months  
Abrasive Resistant (glass face or ?) - 24+ months  
Slotted (Recessed) - 24+ months  
Snow Plowable Castings - \_\_\_\_\_ months  
Other - 4" Non Reflective 12+ months  
identify

2. What is the most common form of failure? (e.g. loss from snow plows, broken, loss of reflectivity) *Studs or tires are the most common, they make the face dull, loss of reflectivity, also they break the face then water gets inside which results in failure of button*

3. Do you have any suggestions on altering the slot design to improve the drainage of standing water when recessed markers are used?  
Please enclose any suggestions or alternatives. *Problems in recessed buttons is that you find flat spots on the Road you either, got to make a better Crown in Road or angle the Degree a little so at least half the*

4. ~~Any other comments?~~ *button is showing, also by doing this water may run out better. (over please) Extent length from 75' to 83'+*

If you have any questions please contact Kaaren Hofmann at (503) 986-2851 or Chris Carman at (503) 986-3606.

Return to: **Kaaren Hofmann**  
**Research Unit**  
**Oregon Department of Transportation**  
**2950 State Street**  
**Salem, OR 97310**

ODOT Personnel

District 3

\* My suggestion is that someone design a durable tape that when snowplows, studs, snow tires run over it, the water doesn't have any factor. I've done a lot of new work in Area and I have noticed that non-degradable temporary tape last for ever. Find a happy medium, Problem would be solved. Suggestion 1/2 Durastripe  
1/2 tape NON-DEGRADABLE

Any Questions  
Call

David Stearns  
Striping Crew  
2046

986-2705

CELL Phone

931-9873

"4 wide  
"6 long

Raised (yellow) Reflect  
both sides  
(white) Reflect  
one side.  
for one way systems

---

\* Hard Plastic with  
reflectivity all the  
way through, so if  
~~over~~ wear happens  
it will be there all  
the way to asphalt

**DEPARTMENT OF TRANSPORTATION**

1120 N STREET  
P.O. BOX 942873  
SACRAMENTO, CA 94273-0001

(916) 654-2634

TDD (916) 654-4014  
\*AX (916) 653-3055



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RESEARCH UNIT

April 4, 1995

APR 10 1995

Ms. Kaaren Hofmann  
Research Unit  
Oregon Department of Transportation  
2950 State Street  
Salem, OR 97310

FUE \_\_\_ OSC \_\_\_  
TTC \_\_\_ TCC \_\_\_  
FYI TAA FILE Return To: \_\_\_\_\_

Dear Ms. Hofmann:

This is in response to your request for information related to the use of raised and recessed reflective pavement markers on California State highways. (See Enclosures).

Recessed reflective pavement markers have been used as a means of providing delineation for highways in light to moderate snow areas since 1979. The recessed groove is tapered down from the plane of pavement to a depth of 9/16 inch in a distance of two feet with the 9/16 inch depth continuing for one foot. The one foot flat bottom provides ample room for two or three replacement markers prior to requiring removal of the expended units. The width of the groove is 5-3/16 inch which will accommodate both the Stimsonite Model 948 and Ray-O-Lite Model 2002.

Only reflective markers passing the Steel Wool Abrasion Procedure, Federal Specification FF-W-1825 are approved for placement in recessed installations. In addition to the steel wool abrasion procedure, a one year field test is required prior to approval.

Generally recessed marker installations are considered only for those locations between elevations of 1,000 and 3,000 feet above sea level. The anticipated useful life of recessed markers is a direct correlation of the traffic volumes and the number of times the roadway is sanded during low ambient temperatures.

For additional information, please contact Mr. Bill Lane at (916) 654-5869.

Sincerely,

ALEX KENNEDY, Chief  
Office of Signs, Delineation and  
Technical Support

TRAFFIC SECTION  
TE OM TC OP INV  
T-DES SIG SIGN IL DFT

APR 13 1995

Rough Draft Direct Reply Act Info File

Enclosures

**OREGON DEPARTMENT OF TRANSPORTATION**  
Raised And Recessed Pavement Marker Survey

1. *What kind of reflective pavement markers are you using? How long do they last?*

<i>Raised: Standard</i>	<u>36-60</u>	<i>months</i>
<i>Abrasive Resistant</i>	<u>36-60</u>	<i>months</i>
<i>Slotted (Recessed)</i>	<u>12-36</u>	<i>months</i>
<i>Snow Plowable Castings</i>	<u>Not used</u>	<i>months</i>
<i>Other</i>	<u>None</u>	<i>months</i>

2. *What is the most common form of failure? (e.g. loss from snow plows, broken, loss of reflectivity)*

Loss of reflectivity

3. *If you use abrasive resistant reflective pavement markers, please send us a copy of your requirements?*

Enclosed. In addition to laboratory testing, a field test is conducted using the steel tined gutter broom of a mechanical sweeper. Please contact Mr. Richard Hickman, New Technology & Research for additional details (916) 227-7252.

4. *Please describe any problems you have with standing water in the slots of the recessed markers?*

Although standing water may occur in absolute level areas, the slots can be tapered on both sides of the marker to improve drainage from turbulence created by passing vehicles. The cost of tapering both ends of the slot as opposed to only one end is very minimal in comparison to the overall cost of the recessed slots.

5. *Please enclose a copy of your slot design.* Enclosed.

6. *Do you have any additional comments.* The useful life of any pavement marker is a direct correlation of its functional environment. In very high volume metropolitan regions a reflective marker on the outside lane line may only perform adequately for a period of 12 to 24 months. The same product in a lesser abrasive environment may perform adequately for a number of years.

*If you have any questions, please contact Kaaren Hofmann at (503) 986-2851 or Chris Carman at (503) 986-3606.*

*Return to: Kaaren Hofmann  
Research Unit  
Oregon Department of Transportation  
2950 State Street  
Salem, OR 97310*

APR 3 1995

**OREGON DEPARTMENT OF TRANSPORTATION**  
**RAISED AND RECESSED**  
**PAVEMENT MARKER**  
**SURVEY**

RUE \_\_\_ OSC \_\_\_

TTC \_\_\_ TSC \_\_\_

FYI TAA FILE Return To: \_\_\_\_\_

1. What kind of reflective pavement markers are you using? How long do they last?

Raised:

Standard  \_\_\_\_\_ months

Abrasive Resistant  6 to 18 months (*urban areas*)

Slotted (Recessed)  \_\_\_\_\_ months

Snow Plowable Castings  Reflector - 1 Season months

Other  Casing - 3 yrs. + \_\_\_\_\_ months

identify

2. What is the most common form of failure? (e.g. loss from snow plows, broken, loss of reflectivity),

3. If you use abrasive resistant reflective pavement markers, please send us a copy of your requirements? - *Use Stimsonite markers.*

4. Please describe any problems you have with standing water in the slots of the recessed markers?

5. Please enclose a copy of your slot design.

6. Do you have any additional comments? *Stimsonite RPM's have lasted longer than any others but we are still not totally satisfied with their performance on urban freeways.*

If you have any questions please contact Kaaren Hofmann at (503) 986-2851 or Chris Carman at (503) 986-3606.

Return to: **Kaaren Hofmann**  
**Research Unit**  
**Oregon Department of Transportation**  
**2950 State Street**  
**Salem, OR 97310**

AFTER 5 DAYS RETURN TO:

STATE OF NEVADA  
DEPARTMENT OF TRANSPORTATION  
CARSON CITY, NEVADA 89712

ADDRESS CORRECTION REQUESTED

APR 1 1995

**OREGON DEPARTMENT OF TRANSPORTATION**  
**RAISED AND RECESSED**  
**PAVEMENT MARKER**  
**SURVEY**

OSC \_\_\_\_\_  
TSC \_\_\_\_\_  
SYITAA FILE Return To: \_\_\_\_\_

1. What kind of reflective pavement markers are you using? How long do they last?

Raised: STIMSONITE MODEL 948 & 954  
Standard  12 months  
Abrasive Resistant  \_\_\_\_\_ months  
Slotted (Recessed)  \_\_\_\_\_ months  
Snow Plowable Castings  \_\_\_\_\_ months  
Other  \_\_\_\_\_ months  
identify

2. What is the most common form of failure? (e.g. loss from snow plows, broken, loss of reflectivity) 1. STUDDED TIRES 2. SNOW PLOWS/GRADER 3. SWEEPERS.

3. If you use abrasive resistant reflective pavement markers, please send us a copy of your requirements?

4. Please describe any problems you have with standing water in the slots of the recessed markers? WE HAVE NO RECESSED AT THIS TIME.

5. Please enclose a copy of your slot design.

6. Do you have any additional comments? WE ARE EXPERIMENTING MORE WITH MMA PROFILE, THERMO-PLASTIC PROFILE

If you have any questions please contact Kaaren Hofmann at (503) 986-2851 or Chris Carman at (503) 986-3606.

Return to: **Kaaren Hofmann**  
**Research Unit**  
**Oregon Department of Transportation**  
**2950 State Street**  
**Salem, OR 97310**

**Jon H. Carlson**  
Pavement Markings and Signing Supervisor

 **Washington State Department of Transportation**  
District 1 - Traffic Operations  
6431 Corson Avenue South  
MS 8  
Seattle, WA 98108  
(206) 768-5882/SCAN 493-5882  
Fax (206) 768-5887/Home (206) 631-3731



**TRANSPORTATION DEPARTMENT**  
P.O. BOX 7129 • BOISE, ID • 83707-1129 • (208) 334-8000

April 4, 1995

Kaaren Hofmann  
Research Unit  
Oregon Department of Transportation  
2950 State Street  
Salem, Oregon 97310

RE: RAISED AND RECESSED PAVEMENT MARKERS

Due to the retirement of Max Jensen your letter and request for information has been forwarded to me for action.

The Idaho Transportation Department has very limited experienced with raised or recessed pavement marking. These have never been popular because of snow conditions that prevail here in the winter and since they have never proven to be cost effective here.

Most of the pavement markers devices have been used in urban situations and have been raised, ceramic "button" type that afford some degree of channelization. I can find no record of ITD using "abrasive resistant" markers.

Life of the markers appear to be no more than 2 to 3 years with snow plows being the major source of mortality.

The few markers that have been used have not been maintained well and maintenance costs cannot be isolated as they are included with other activities. Recessed markers have displayed problems with standing water, ice, snow and debris and are usually replaced with paint with no apparent problems.

I am enclosing a copy of the ITD Traffic Manual section that addresses these types of markers for your information.

If you need any additional information please feel free to contact me at (208) 334-8557 any time. Also please inform us of your survey results.

Sincerely,

  
RONALD B. MACKELPRANG, P. E.  
ASSISTANT TRAFFIC ENGINEER

RECEIVED  
RESEARCH UNIT

Enclosure

APR 7 1995

CC:CHO  
TRAF

RUE \_\_\_\_\_ OSC \_\_\_\_\_  
TTC \_\_\_\_\_ TSC \_\_\_\_\_  
FYI TAA FILE Return To: \_\_\_\_\_

## **APPENDIX B**



Figure B.1 Recessed Slots Filled with Water and Grass.



Figure B.2 Recessed Slot Filled with Water



Figure B.3 Raised Markers on Rainy Day



Figure B.4 Recessed Markers on Rainy Day