I-68 Reduced Visibility Fog Detection and Warning System: Evaluation Report

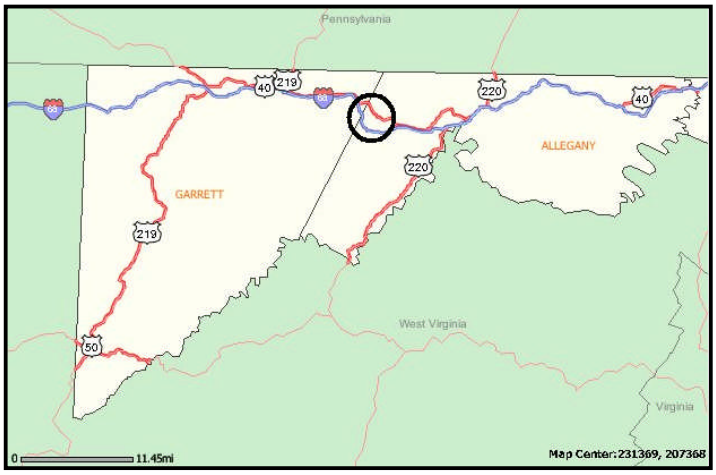
I. INTRODUCTION

This report describes the evaluation of the "Reduced Visibility" warning system on I-68 in Garrett and Allegany Counties in western Maryland. The system uses "Reduced Visibility Possible" signs located in two fog-prone areas, one near Big Savage Mountain and the other near Keysers Ridge. These locations were selected because of the prevalence of fog and to make effective use of existing Roadway Weather Information Stations (RWIS) infrastructure to detect conditions of reduced visibility. There is one warning sign for each direction (see figure 1 for illustration) for each of the two locations for a total of four signs.

Figure 1. Typical "Reduced Visibility" Warning Sign

a. Evaluation Project Location

Because of the cost of traffic flow data collection over long periods, the evaluation concentrated on the effectiveness of one of the four signs; the I-68 westbound sign approaching Big Savage Mountain. At Big Savage Mountain, a key factor to note is the steep grade from the crest of Big Savage Mountain to the Interchange at milepost 33, a distance of approximately two miles. The visibility sensor was located at the eastbound Truck Weigh Station (near milepost 31). The general location is depicted by the circle on the map.



When fog is detected, it is important that this information be communicated with the motorists before they encounter the foggy area. Since the types of fog most frequently expected on Big Savage Mountain are advection fog and upslope fog, and these types form at altitude and descend, it was important to locate the warning devices at lower altitudes. The most appropriate location for the westbound traffic approaching Big Savage Mountain was west of the Interchange with MD 36 (near milepost 34).

b. Visibility Threshold

One of the initial concerns during the deployment of the system was what thresholds should be used to energize the system. Consideration was given to everything from 0.62 miles, a threshold derived from a definition of fog used by Marine operators; to 500 feet, a definition of extremely low visibility used by the California Highway Patrol.

A review of the logged records indicated that the 0.62-mile definition would result in the system being energized far too often. A detailed study of these data suggested that a threshold of 1,000 feet would yield the desired results. The 1,000 foot threshold was selected for the initial setting.

c. Data Collection Period

The primary evaluation effort was conducted during May and June of 2006. This period yielded a total of eleven fog events, only three of which were serious enough to reduce visibility. Because it was possible to extend the data collection efforts (excluding the traffic flow data) with little increase in cost, the data collection period was extended through July. This provided the study with only two additional fog events.

II. EVALUATION OBJECTIVES

The Evaluation Plan had three specific objectives:

1. To evaluate motorists' response to the "Reduced Visibility" sign;
2. To evaluate the system's response based on its concept design; and,
3. To evaluate the system's operation, including all components such as the fog sensor, radio equipment, sign and flashing mechanism and communications interface.

III. EVALUATION PLAN

The evaluation plan itself is comprised of three separate sections, each one geared to one of the three objectives as described below.

a. Evaluate Motorist Response

This part of the evaluation seeks to answer the question; does the driver behavior change as a result of the system? In other words, if the system is effective, then there should be a measurable change in the traffic flow after the drivers see the sign as compared to the traffic flow before they see the sign. This is shown graphically in figure 2.

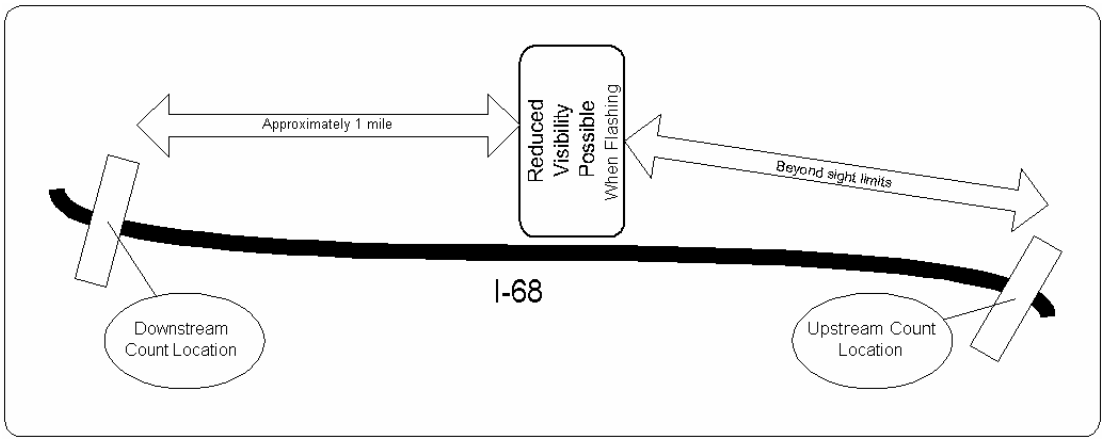


Figure 2. Traffic Measurement Stations.

The basic observation is a 15-minute count and average speed measure of all vehicles driving past the two observation points. Road-tube counters are used to collect the count and speed measures. During periods when the sign is "Off", no significant difference in volume or speed is expected between the two stations. During periods when the sign is "On", no difference in

volume is expected, but there should be a difference in speed indicating that the drivers are heeding the warning message.

Each 15-minute observation consisted of the following:

- The date and begin time;
- The total 15-minute count;
- The average speed of the traffic during the 15-minute period:

b. Evaluate System Response

The second element of the evaluation is to address the question; does the system detect low visibility conditions when in fact there are visibility constraints? To do this the visibility conditions as determined by the system are compared with the actual visibility conditions.

The system actually operates in a binary environment and really only cares about two conditions, the warning system is "ON" or the warning system is "OFF." To record the system state changes, a system log was maintained. This log recorded the time that the system changes state. The system log was generated every ten minutes on average. This provided a record of when the system either turned "ON" or "OFF" to the nearest ten minutes. A small part of one day's log is provided in Figure 3.

Device History

Date/Time	Device Status						User Requests		
	Mode	Control State	Last State Change	Set By	Device Status	Last Status Change	Requested By	Mode	Control State
05/01/2006 07:24	Automatic	Off	04/23/2006 08:33	RPU	Off	04/23/2006 08:33	-	-	-
05/01/2006 07:14	Automatic	Off	04/23/2006 08:33	RPU	Off	04/23/2006 08:33	-	-	-
05/01/2006 07:14	Automatic	Off	04/23/2006 08:33	RPU	Off	04/23/2006 08:33	-	-	-
05/01/2006 07:04	Automatic	Off	04/23/2006 08:33	RPU	Off	04/23/2006 08:33	-	-	-
05/01/2006 06:54	Automatic	Off	04/23/2006 08:33	RPU	Off	04/23/2006 08:33	-	-	-
05/01/2006 06:54	Automatic	Off	04/23/2006 08:33	RPU	Off	04/23/2006 08:33	-	-	-
05/01/2006 06:44	Automatic	Off	04/23/2006 08:33	RPU	Off	04/23/2006 08:33	-	-	-
05/01/2006 06:34	Automatic	Off	04/23/2006 08:33	RPU	Off	04/23/2006 08:33	-	-	-
05/01/2006 06:34	Automatic	Off	04/23/2006 08:33	RPU	Off	04/23/2006 08:33	-	-	-
05/01/2006 06:24	Automatic	Off	04/23/2006 08:33	RPU	Off	04/23/2006 08:33	-	-	-

Figure 3. System Log Report.

To determine the actual condition, however, the actual conditions at the site were observed. Real-time images from the CCTV camera at the Big Savage Mountain RWIS site were recorded as shown on Figure 4, a clear day. It is important to note that the image is clear at night as well, as shown on Figure 5.

Figure 4. Daytime view from the RWIS CCTV Camera at Big Savage Mountain.

Figure 5. Clear night view.

From April 28, 2006 until August 14, 2006, video images were captured approximately once every 15 to 20 minutes and forwarded to the Consultant's (Sabra, Wang & Associates, Inc.) server in Baltimore. These images were used as "ground truth" regarding the visibility situation.

c. Evaluate System Operation

The final element of the Evaluation Plan is an assessment of the operation of the system components. In other words, do all components: the RWIS components, radios, LED signs, and solar power supplies function as designed?

Because the equipment is essentially very reliable, it was considered unlikely that there would be any component failures during the evaluation period. In fact, this was the experience. The system worked flawlessly during the entire evaluation period.

IV. EVALUATION ANALYSIS

The study revealed a total of 13 fog events. Each fog event was initially identified either by the system log or by visible fog in the video. The event continued until the system log showed that the system was in the "OFF" state and the video showed that there was no visible fog.

Each event was unique and is analyzed separately below. However there were no "false positives" events. This means that there was no event where fog was identified in the image that the system did not identify. Conversely, every time that the system sensors identified a fog condition, it was confirmed with the video image. This is a very positive indication of the performance of the fog sensor.

Each fog event is documented with three items: the system log, the traffic speed and count data, and video images. Each of these items is reproduced for the first four events. The system is reproduced for each event; however for the remaining events, the video images and speed and count data are very repetitive and are only reproduced to support a particular observation. All of these data are available in the study database.

a. Fog Event 1

The first event was identified on May 8, 2006 at approximately 6:00 AM. The information relevant to this event is shown in Table 1.

Table 1. System Log Event 1.

Reference	Date	Time	File Reference	Source
Event 1	5/8/2006	5:52	2006-05-08-09-52	Video Images
Event 1	5/8/2006	6:00	FogData060509	System Log
Event 1	5/8/2006	6:24	FogData060509	System Log
Event 1	5/8/2006	6:33	2006-05-08-10-33	Video Images

Each video image is identified by a system-generated, long file name like,

Vid-000551049-00-00-2006-05-08-09-52

Notice the similar numbers in the first data line of Table 1, "2006-05-08-09-52". All images generated by the project have the same first four groupings (Vid-000551049-00-00); the last five groups form a unique name that combines the date in year-month-day order with the time in

hour-minute order. Notice that by this code, the time of the image is 9:52 AM. However, that actual time estimated for this event is 5:52 AM. This is because the computer clock that was used to generate the file name was approximately four hours ahead of the actual time of day.

The visibility situation changes very fast on the mountain. The image to the left in Figure 6 was captured at 9:33 AM, the image to the right was captured 39 minutes later at 10:12 AM.

Figure 6. Left before fog; right typical fog condition 39 minutes later.

Notice that there are approximately four skip lines visible in the image on the right. This indicates a moderately foggy condition, one in which drivers have sufficient sight distance to continue driving at the speed limit.

The third data element used in the study was the traffic measures as shown in Table 2. These measures were taken in the vicinity of the sign at a lower altitude than the RWIS station location near the top of the mountain. The purpose of this sign was to inform drivers of the visibility situation ahead as they ascended the mountain.

Location 1 is upstream from the sign far enough such that the drivers can not see the sign. Location 2 is downstream from the sign approximately 3,000 feet, enough distance to allow drivers to react to the sign message.

The fog event is delineated in Table 2 by the dashed lines, extending from 6:00 AM to 6:45 AM. The results shown in Table 2 allow one to compare the speeds at each location before the sign is energized, while it is energized, and after it is turned off. The expectation was that while the sign was on, there would be a measurable difference in speed between Location 1 and Location 2 as drivers responded to the sign message. This did not happen. During this event and at the other 12 events, no significant change in speed was measured between the two locations. It is important to note, however, that neither one of the count/speed stations were in the immediate vicinity of the fog sensing station. Therefore, motorists may not have encountered reduced visibility conditions at any of the count/speed stations.

While this was not the desired effect, it was not unexpected. While the message conveyed information about a possible reduced visibility ahead, this information may have conflicted with the driver's assessment of the situation. When the message was presented to the driver in advance of the reduced visibility condition, the actual visibility when the sign is first observed was NOT reduced. However, given this message, drivers were likely more alert when they actually encountered the reduced visibility situation than they would have been if the system was not in place.

The data in Table 2 are arrayed to allow an easy comparison of speed between locations at any particular time period. It is also easy to compare speeds across time periods at a particular location. The "Number" shown in the table is a control number that provides a link back to the study database.

Table 2. Speed and Count Data Fog Event 1.

			Location 1:		Location 2:	
Number	Date	Time	Speed	Count	Speed	Count
351	5/8/2006	05:00 AM	58	17	60	16
352	5/8/2006	05:15 AM	61	11	61	11
353	5/8/2006	05:30 AM	59	20	60	19
354	5/8/2006	05:45 AM	65	27	65	27
355	5/8/2006	06:00 AM	61	45	63	43
356	5/8/2006	06:15 AM	65	51	65	53
357	5/8/2006	06:30 AM	64	49	65	53
358	5/8/2006	06:45 AM	62	54	62	54
359	5/8/2006	07:00 AM	64	76	64	76
360	5/8/2006	07:15 AM	64	78	64	78
361	5/8/2006	07:30 AM	65	98	65	103

b. Fog Event 2

The next event was identified on May 11, 2006 at approximately 4:30 AM. The information relevant to this event is shown in Table 3. Notice the close agreement between the system times and the video image times. This is particularly noteworthy since the system data has a resolution of plus or minus 10 minutes and the video has a resolution of 15 to 20 minutes.

Table 3. System Log Event 2.

Reference	Date	Time	File Reference	Source
Event 2	5/11/2006	4:27	FogData060511	System Log
Event 2	5/11/2006	4:32	2006-05-11-08-32	Video Images
Event 2	5/11/2006	14:32	2006-05-11-18-52	Video Images
Event 2	5/11/2006	14:45	FogData060512	System Log

This was a relatively long event of approximately ten hours. As shown in Figure 7, the visibility was reduced more than that shown in Fog Event 1.

Figure 7. Intense fog during Fog Event 2.

The speed and count data for this event are shown in Table 4. These data show the same pattern as observed in Event 1 – no significant change in either location or time of the measured speeds.

Also shown in this and all speed and count tables are the counts at Location 1 and Location 2. Although these measures were not used directly by the study, they did serve an important function. The counts served as a control measure to assure that the two counters were synchronized. Since the two counters were placed approximately 20 to 30 seconds apart, in any none period, it is possible for one or two vehicles to be counted at one location and not the other. It is also possible for a counter to "double" count a vehicle if the vehicle crossed the tube at an angle. If the clocks in the counters were not synchronized, one would expect large differences counts. In spite of these "real world" conditions, the counts as shown in the speed and count tables are remarkably close indicating that the clocks were synchronized.

Table 4. Speed and Count Data Fog Event 2.

			Location 1:		Location 2:	
Number	Date	Time	Speed	Count	Speed	Count
635	5/11/2006	04:00 AM	61	13	61	13
636	5/11/2006	04:15 AM	60	12	56	15
637	5/11/2006	04:30 AM	64	15	64	15
638	5/11/2006	04:45 AM	57	20	58	19
639	5/11/2006	05:00 AM	58	17	59	16
640	5/11/2006	05:15 AM	59	16	60	15
641	5/11/2006	05:30 AM	59	28	61	26
642	5/11/2006	05:45 AM	65	30	65	30
643	5/11/2006	06:00 AM	65	44	65	43
644	5/11/2006	06:15 AM	63	76	64	81
645	5/11/2006	06:30 AM	64	62	66	67
646	5/11/2006	06:45 AM	65	61	65	61
647	5/11/2006	07:00 AM	64	106	64	106
648	5/11/2006	07:15 AM	64	89	65	88
649	5/11/2006	07:30 AM	64	111	64	111
650	5/11/2006	07:45 AM	64	142	65	141
651	5/11/2006	08:00 AM	64	115	65	112
652	5/11/2006	08:15 AM	63	126	63	122
653	5/11/2006	08:30 AM	62	130	63	127
654	5/11/2006	08:45 AM	63	111	63	110
655	5/11/2006	09:00 AM	64	160	64	160
656	5/11/2006	09:15 AM	63	143	64	140
657	5/11/2006	09:30 AM	63	137	63	136
658	5/11/2006	09:45 AM	63	140	63	140
659	5/11/2006	10:00 AM	63	132	64	134
660	5/11/2006	10:15 AM	63	141	63	140
661	5/11/2006	10:30 AM	63	114	63	113
662	5/11/2006	10:45 AM	64	145	64	147
663	5/11/2006	11:00 AM	63	124	63	123
664	5/11/2006	11:15 AM	64	129	64	128
665	5/11/2006	11:30 AM	64	119	64	118
666	5/11/2006	11:45 AM	64	127	63	127
667	5/11/2006	12:00 PM	63	161	64	160
668	5/11/2006	12:15 PM	64	191	64	189
669	5/11/2006	12:30 PM	63	152	63	150
670	5/11/2006	12:45 PM	63	144	63	150
671	5/11/2006	01:00 PM	63	141	63	139
672	5/11/2006	01:15 PM	63	148	63	147
673	5/11/2006	01:30 PM	63	150	64	149
674	5/11/2006	01:45 PM	62	152	63	149
675	5/11/2006	02:00 PM	64	162	64	161
676	5/11/2006	02:15 PM	63	153	63	151
677	5/11/2006	02:30 PM	64	179	64	181
678	5/11/2006	02:45 PM	63	161	64	157
679	5/11/2006	03:00 PM	64	179	64	178
680	5/11/2006	03:15 PM	64	195	64	196
681	5/11/2006	03:30 PM	63	168	63	167

c. Fog Event 3

The next event was identified on May 14, 2006 at approximately 8:15 AM. The information relevant to this event is shown in Table 5.

Table 5. System Log Event 3.

Reference	Date	Time	File Reference	Source
Event 3	5/14/2006	8:13	2006-05-14-12-13	Video Images
Event 3	5/14/2006	8:34	FogData060515	System Log
Event 3	5/14/2006	9:14	2006-05-14-12-13	Video Images
Event 3	5/14/2006	8:49	FogData060515	System Log

This was a minor fog event, not as foggy as Fog Event 2. Visibility was not reduced enough to justify turning on the system. As can be seen in Figure 8, more than six skip lines are visible in the image.

Figure 8. Fog Event 3.

Table 6 shows the same speed comparisons that were observed during the other events with one exception. During this event, the speeds were approximately 5 MPH higher than that observed during other events.

Table 6. Speed and Count Data Fog Event 3.

			Location 1:		Location 2:	
Number	Date	Time	Speed	Count	Speed	Count
169	5/14/2006	07:30 AM	71	38	71	40
170	5/14/2006	07:45 AM	67	38	67	38
171	5/14/2006	08:00 AM	70	39	70	39
172	5/14/2006	08:15 AM	71	56	71	58
173	5/14/2006	08:30 AM	70	68	70	72
174	5/14/2006	08:45 AM	69	56	69	59
175	5/14/2006	09:00 AM	69	104	69	107
176	5/14/2006	09:15 AM	70	88	70	90
177	5/14/2006	09:30 AM	69	91	68	94
178	5/14/2006	09:45 AM	70	110	70	112
179	5/14/2006	10:00 AM	68	128	69	89

d. Fog Event 4

The next event was identified on May 14, 2006 extending to 5:30 AM on May 16, with a typical fog condition shown in Figure 8. The information relevant to this event is shown in Table 7.

Table 7. System Log Event 4.

Reference	Date	Time	File Reference	Source
Event 4	5/14/2006	17:23	FogData060515	System Log
Event 4	5/14/2006	17:53	2006-05-14-21-53	Video Images
Event 4	5/15/2006	5:29	FogData060515	System Log
Event 4	5/15/2006	5:31	2006-05-15-09-31	Video Images

Figure 9. Fog Event 4.

Table 8. Speed and Count Data Fog Event 4.

			Location 1:		Location 2:	
Number	Date	Time	Speed	Count	Speed	Count
207	5/14/2006	05:00 PM	63	160	63	169
209	5/14/2006	05:30 PM	67	169	67	171
210	5/14/2006	05:45 PM	69	117	69	126
211	5/14/2006	06:00 PM	69	133	68	139
212	5/14/2006	06:15 PM	70	123	69	128
213	5/14/2006	06:30 PM	69	143	69	147
214	5/14/2006	06:45 PM	69	137	69	143
215	5/14/2006	07:00 PM	69	99	68	103
216	5/14/2006	07:15 PM	69	118	68	128
217	5/14/2006	07:30 PM	68	124	67	129
218	5/14/2006	07:45 PM	68	111	67	118
219	5/14/2006	08:00 PM	68	93	67	98
220	5/14/2006	08:15 PM	67	114	67	118
221	5/14/2006	08:30 PM	66	75	67	77
222	5/14/2006	08:45 PM	66	84	66	87
223	5/14/2006	09:00 PM	62	65	62	65
224	5/14/2006	09:15 PM	66	60	65	61
225	5/14/2006	09:30 PM	66	44	66	44
226	5/14/2006	09:45 PM	66	57	66	57
227	5/14/2006	10:00 PM	67	42	67	42
228	5/14/2006	10:15 PM	64	42	64	42
229	5/14/2006	10:30 PM	65	49	66	51
230	5/14/2006	10:45 PM	65	26	65	26
231	5/14/2006	11:00 PM	67	31	67	31
232	5/14/2006	11:15 PM	67	47	67	47
234	5/14/2006	11:45 PM	59	23	61	24
235	5/15/2006	12:00 AM	63	25	63	25
236	5/15/2006	12:15 AM	65	15	66	16
238	5/15/2006	12:45 AM	61	20	61	20
239	5/15/2006	01:00 AM	58	12	58	12
240	5/15/2006	01:15 AM	55	15	55	15
241	5/15/2006	01:30 AM	58	10	58	10
242	5/15/2006	01:45 AM	59	10	59	10
243	5/15/2006	02:00 AM	63	9	63	9
245	5/15/2006	02:30 AM	55	11	55	11
246	5/15/2006	02:45 AM	62	11	66	11
247	5/15/2006	03:00 AM	52	12	56	15
248	5/15/2006	03:15 AM	54	12	54	12
250	5/15/2006	03:45 AM	54	13	57	13
251	5/15/2006	04:00 AM	62	10	62	10
252	5/15/2006	04:15 AM	59	14	59	14
253	5/15/2006	04:30 AM	60	20	60	20
254	5/15/2006	04:45 AM	57	17	57	17
255	5/15/2006	05:00 AM	61	30	61	30
256	5/15/2006	05:15 AM	59	12	64	16
257	5/15/2006	05:30 AM	59	19	59	19
258	5/15/2006	05:45 AM	55	39	55	41

Figure 9 and Table 8 indicate the conditions for Fog Event 4. This was one on the foggiest situations encountered during the study.

e. Fog Event 5

The next event was identified on June 2, 2006 at approximately 10:00 PM. The information relevant to this event is shown in Table 9.

Table 9. System Log Event 5. **Table 10. System Log Event 6.** **Table 11. System Log Event 7.**

Reference	Date	Time	File Reference	Source
Event 5	6/2/2006	21:51	2006-06-03-00-12	Video Images
Event 5	6/2/2006	21:54	FogData060602	System Log
Event 5	6/2/2006	23:39	FogData060602	System Log
Event 5	6/2/2006	23:51	2006-06-03-01-51	Video Images

Figure 10. Fog Event 5.

Because the speed and count data do not show anything different for this event nor are there any differences in the following events, the speed and count data table is not shown in this report. It is, however, available in the study database.

f. Fog Event 6

The next event was identified on June 24, 2006 at approximately 0:12 AM. The information relevant to this event is shown in Table 1.

Reference	Date	Time	File Reference	Source
Event 6	6/24/2006	0:12	FogData060624	System Log
Event 6	6/24/2006	0:14	2006-06-24-16-14	Video Images
Event 6	6/24/2006	0:27	FogData060624	System Log

This was a very short event lasting less than one-half hour. The reduced visibility was probably triggered more by heavy rain than by fog.

Figure 11. Fog Event 6.

g. Fog Event 7

The next event was identified on June 25, 2006 at approximately 5:00 AM. The information relevant to this event is shown in Table 12.

Table 12. System Log Event 7.

Reference	Date	Time	File Reference	Source
Event 7	6/25/2006	4:56	FogData060625	System Log
Event 7	6/25/2006	4:52	2006-06-25-04-52	Video Images
Event 7	6/25/2006	11:33	FogData060625	System Log
Event 7	6/25/2006	11:52	2006-06-25-15-12	Video Images

Figure 12 shows the moderate fog conditions exhibited in Fog Event 7.

Figure 12. Fog Event 7.

h. Fog Event 8

The next event also was identified on June 25 beginning at approximately 11:00 PM. The information relevant to this event is shown in Table 13.

Table 13. System Log Event 8.

Reference	Date	Time	File Reference	Source
Event 8	6/25/2006	22:46	FogData060626	System Log
Event 8	6/25/2006	22:52	2006-06-26-02-52	Video Images
Event 8	6/25/2006	23:15	FogData060626	System Log
Event 8	6/25/2006	23:27	FogData060626	System Log
Event 8	6/26/2006	0:49	FogData060626	System Log
Event 8	6/25/2006	1:07	FogData060626	System Log
Event 8	6/25/2006	1:33	FogData060626	System Log
Event 8	6/25/2006	1:46	FogData060626	System Log
Event 8	6/25/2006	2:07	FogData060626	System Log
Event 8	6/26/2006	2:24	FogData060626	System Log
Event 8	6/26/2006	7:51	FogData060626	System Log
Event 8	6/25/2006	7:53	2006-06-26-11-53	Video Images

Each entry in the table labeled as System Log for the Source indicates a change in state. Notice that the system cycled on and off several times during this event indicating that the change lock-

out settings may be too short. As shown in Figure 13, this weather event is a continuation of that depicted in Fog Event 7 with a moderate reduction in visibility.

Figure 13. Fog Event 8 (6-26-04-51)

i. Fog Event 9

The next event was identified on June 26, 2006 at approximately 11:00 PM and lasted for a little under an hour. The information relevant to this event is shown in Table 14.

Table 14. System Log Event 9.

Reference	Date	Time	File Reference	Source
Event 9	6/26/2006	22:52	2006-06-27-02-52	Video Images
Event 9	6/26/2006	23:11	FogData060627	System Log
Event 9	6/27/2006	0:32	2006-06-27-04-32	Video Images
Event 9	6/27/2006	0:34	FogData060627	System Log

Figure 14. Fog Event 9 (06-27-04-12)

j. Fog Event 10

The next event was identified on June 27, 2006 at approximately 5:30 AM. The information relevant to this event is shown in Table 15.

Table 15. System Log Event 10.

Reference	Date	Time	File Reference	Source
Event 10	6/27/2006	5:23	FogData060627	System Log
Event 10	6/27/2006	5:53	2006-06-27-05-53	Video Images
Event 10	6/27/2006	8:07	FogData060628	System Log
Event 10	6/27/2006	8:14	2006-06-27-12-14	Video Images

Figure 15. Fog Event 10 (06-27-07-52).

k. Fog Event 11

The next event was identified later on June 27, 2006 beginning at approximately 10:00 PM. The information relevant to this event is shown in Table 16

Table 16. System Log Event 11.

Reference	Date	Time	File Reference	Source
Event 11	6/27/2006	20:01	FogData060627	System Log
Event 11	6/27/2006	20:33	2006-06-28-00-33	Video Images
Event 11	6/27/2006	22:14	FogData060628	System Log
Event 11	6/27/2006	22:53	FogData060627	System Log
Event 11	6/27/2006	23:44	FogData060628	System Log
Event 11	6/27/2006	23:53	2006-06-28-03-53	Video Images

The moderate fog situation is depicted in Figure 16.

Figure 16. Fog Event 11 (06-28-01-52

l. Fog Event 12

The next event was identified on July 14, 2006 at approximately 4:00 AM. The information relevant to this event is shown in Table 17.

Table 17. System Log Event 12.

Reference	Date	Time	File Reference	Source
Event 12	7/14/2006	4:32	2006-07-14-08-32	Video Images
Event 12	7/14/2006	4:33	FogData060714	System Log
Event 12	7/14/2006	5:47	FogData060714	System Log
Event 12	7/14/2006	6:00	FogData060714	System Log
Event 12	7/14/2006	6:29	FogData060714	System Log
Event 12	7/14/2006	6:42	FogData060714	System Log
Event 12	7/14/2006	7:33	FogData060714	System Log
Event 12	7/14/2006	8:17	FogData060714	System Log
Event 12	7/14/2006	8:33	FogData060714	System Log
Event 12	7/14/2006	8:34	2006-07-14-12-34	Video Images

Each “System Log” entry indicated a system change of state, the six extra state changes indicate that a time lock-out is needed to prevent the rapid switching from Off to On to Off.

Figure 17. Fog Event 12. (07-14-10-53)

m. Fog Event 13

The last event recorded in the study was identified on July 20, 2006 at approximately 6:30 AM. The information relevant to this event is shown in Table 18.

Table 18. System Log Event 13.

Reference	Date	Time	File Reference	Source
Event 13	7/20/2006	6:33	FogData060720	System Log
Event 13	7/20/2006	6:33	2006-07-20-10-33	Video Images
Event 13	7/20/2006	7:34	2006-07-20-11-34	Video Images
Event 13	7/20/2006	7:46	FogData060721	System Log

The moderate fog situation for this event is depicted in Figure 18.

Figure 18. Fog event 13. (07-20-11-14)

V. CONCLUSIONS

Overall, the system must be considered a success in the sense that it detects fog when fog is present and provides the relevant information to drivers on I-68 via the sign message. The system operated flawlessly throughout the study period. Each time the system detected a reduced visibility situation, it could be verified that the visibility was in fact reduced – there were no "False Positive" system errors.

Original Objectives

The research plan was based on responding to three objectives: 1) Evaluate the response of the motorists to the warning sign message; 2) Evaluate and validate that the system would detect fog and illuminate the sign; and, 3) Evaluate the operation of the system itself.

With respect to the motorist response, the speed measures revealed no significant differences either in time or in location whether the sign was illuminated or not. While this was an unanticipated result, in retrospect, the sign and speed measures were intentionally located before the drivers encountered a reduced visibility situation. It is likely that had we measured traffic performance closer to the actual location where visibility was reduced, we would have measured a difference. Anecdotal evidence suggests that the warning system has been well received by area drivers.

With respect to the system operation during the 13 fog events, only two (Fog Events 4 and 5) could be classified as intense as indicated by being able to barely see one or two skip lines. Six events (Fog Events 2, 7, 8, 9, 11, and 13) could be classified as moderate, and the remaining five events are minor with no significant reduction in sight distance. In each case, the system performed as designed.

With respect to the operation of the system itself; this was clearly a success as the components (fog sensors, RWIS logic, radio communications, and the sign itself) all operated as designed.

Lessons Learned

The bottom line is simple, the system works! Positive feedback from road users has indicated that the motoring public perceives the system as a useful resource.

The system, however, was not without problems. In retrospect, it may be that the sensitivity threshold setting of 1,000 feet of visibility is too generous. It is suggested that a setting of 500 or 750 feet be tried to limit the number of actuations during minor fog situations. Another important setting controls the system's hysteresis. This is a setting that prevents rapid changes when the visibility measures are close to the threshold values. It is suggested that a time threshold of one hour be used. In other words, once the system changes state, it must remain in the new state for a period of at least one hour. This would minimize the "hunting" situation as indicated in Events 8, 11 and 12.