

Analysis of Weather-Related Crashes on U.S. Highways

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INTRODUCTION

This paper presents results of an analysis of crashes on U.S. highways in poor road weather conditions. Dan Cohen provided crash tabulations for the seven-year period from 1995 to 2001 from National Highway Traffic Safety Administration (NHTSA) databases. The objectives of the analysis were to update a March 2001 report titled “*A Preliminary Analysis of U.S. Highway Crashes Against an Exposure Index*”, and to identify trends in the frequency of weather-related crashes.

CRASH DATA

The crash data summarized in Table 1 and Figure 1 are from the Fatality Analysis Reporting System (FARS) and the General Estimates System (GES) maintained by NHTSA. Only non-fatal injury crash statistics were used from the GES, which derives totals from sample estimates rather than direct counts. Crashes involving only property damage were not included in the analysis. The data do not indicate vehicle type, the number of vehicles or the number of occupants involved in crashes. Weather-related crashes are defined as those crashes that *occur* in poor pavement or weather conditions. It should be noted that these conditions may not necessarily be the *cause* of weather-related crashes. (See Attachment A for a tabulation of crashes by pavement and weather condition.)

Table 1 – Average Weather-Related Crashes (1995-2001)

	Injury Crashes		Fatal Crashes		Injury & Fatal Crashes	
Total	2,084,013		37,375		2,121,388	
Non-Adverse Conditions	1,631,538	78%	30,894	83%	1,622,431	78%
Adverse Conditions	452,475	22%	6,482	17%	458,957	22%
Slick Pavement & No Weather	142,822	32%	2,105	32%	144,927	32%
Slick Pavement & Weather	303,579	67%	4,064	63%	307,643	67%
Dry Pavement & Weather	6,074	1%	313	5%	6,387	1%

In the table above and in the figures below “*Slick Pavement*” includes wet, slushy, or icy pavement. “*Weather*” or “*Adverse Weather*” includes rain, sleet, snow, fog, (rain & fog), or (sleet & fog). “*Non-Adverse Conditions*” include dry pavement with no weather; other pavement conditions (i.e., “sand, dirt, oil”, “other”, and “unknown”); and other weather conditions (i.e., “other” or “unknown”).

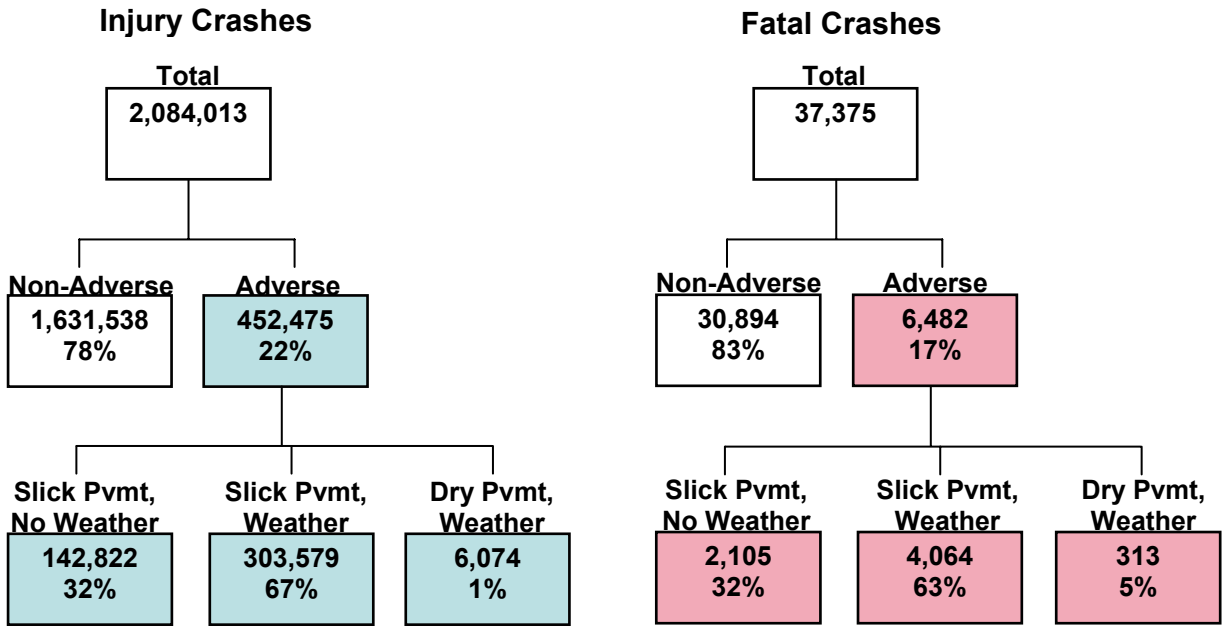
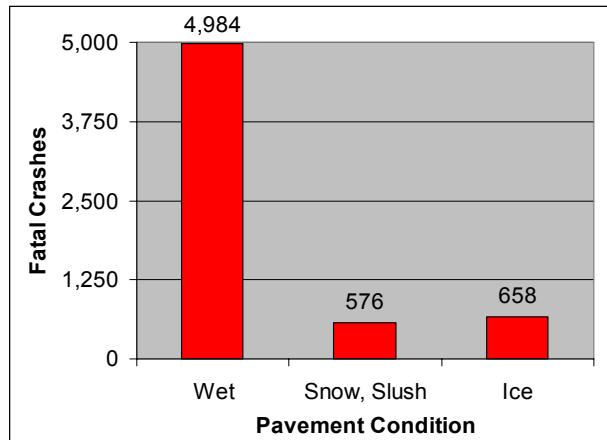
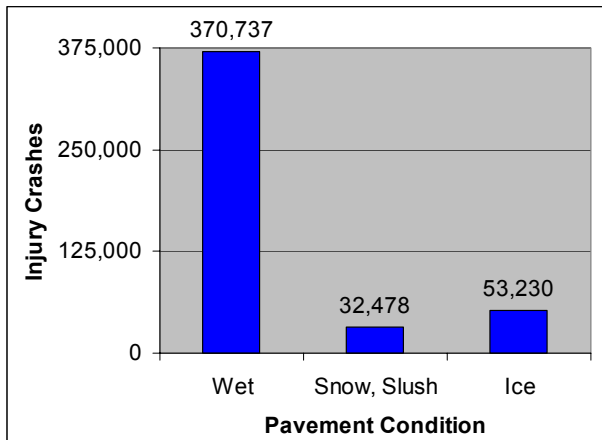


Figure 1 – Average Weather-Related Crashes (1995-2001)

Crashes on “Slick Pavement”

Figures 2A and 2B depict the average number of injury and fatal crashes occurring on “Slick Pavement” from 1995 to 2001. Over 81 percent of injury crashes on “Slick Pavement” occur when the pavement is wet. Nearly 12 percent of these crashes happen on icy pavement, and over seven percent occur when the pavement is snowy or slushy. Most fatal crashes on “Slick Pavement” (80 percent) happen under wet pavement conditions. Icy pavement was present for over 10 percent of these crashes. Over nine percent of fatal crashes on “Slick Pavement” occur on snowy or slushy pavement.



Figures 2A & 2B – Average Injury & Fatal Crashes on Slick Pavement (1995-2001)

In Figure 3 crash trends on “Slick Pavement” are shown from 1995 to 2001. Over this period, wet pavement crashes decreased by more than 23 percent from 427,949 in 1995 to 328,437 in 2001. The number of injury and fatal crashes on icy pavement has generally fallen over time from 62,798 in 1995 to 42,677 in 2001, representing a 32 percent decline. Crashes on snowy or slushy pavement fell from 36,159 in 1995 to 14,595 in 1998 before increasing to 51,808 in 2000. Overall the number injury and fatal crashes on “Slick Pavement” was reduced by 24 percent from 526,905 to 397,937.

Over the seven-year analysis period the average number of crashes on wet pavement was 375,722 per year. An average of 53,888 crashes occurred each year on icy pavement. The annual average crash rate on snowy or slushy pavement was 33,054. From 1995 to 2001 the average number of “Slick Pavement” crashes per year was 462,662.

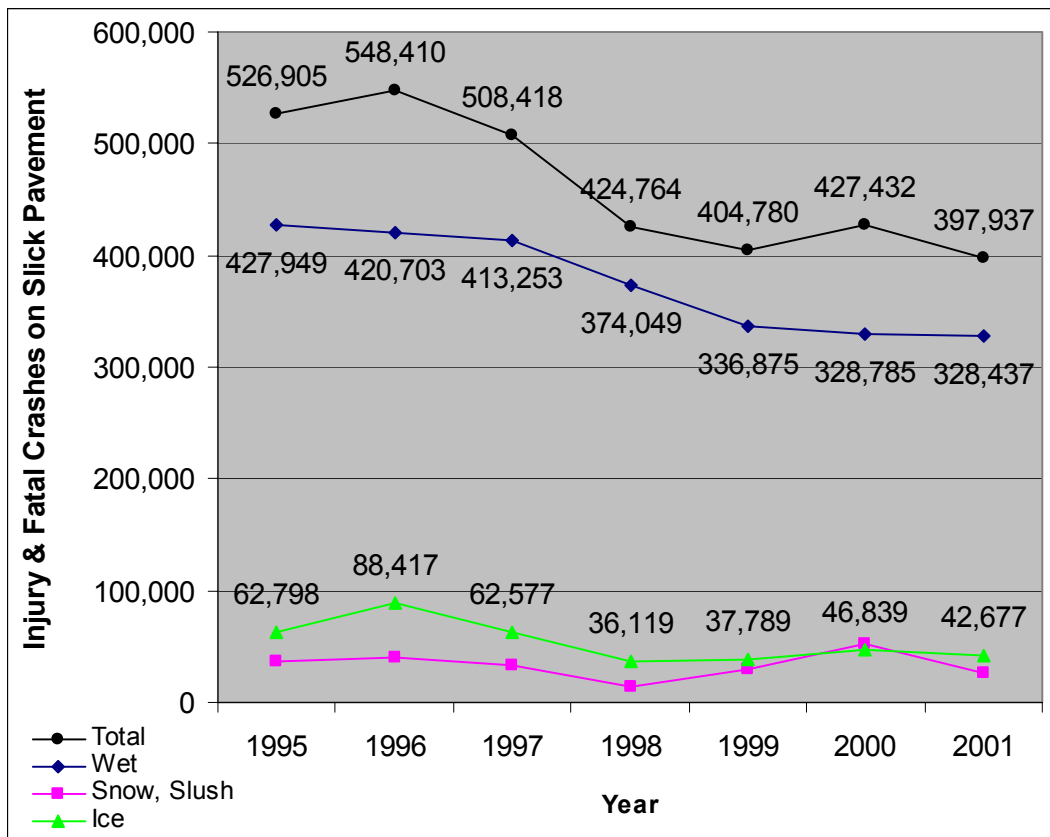
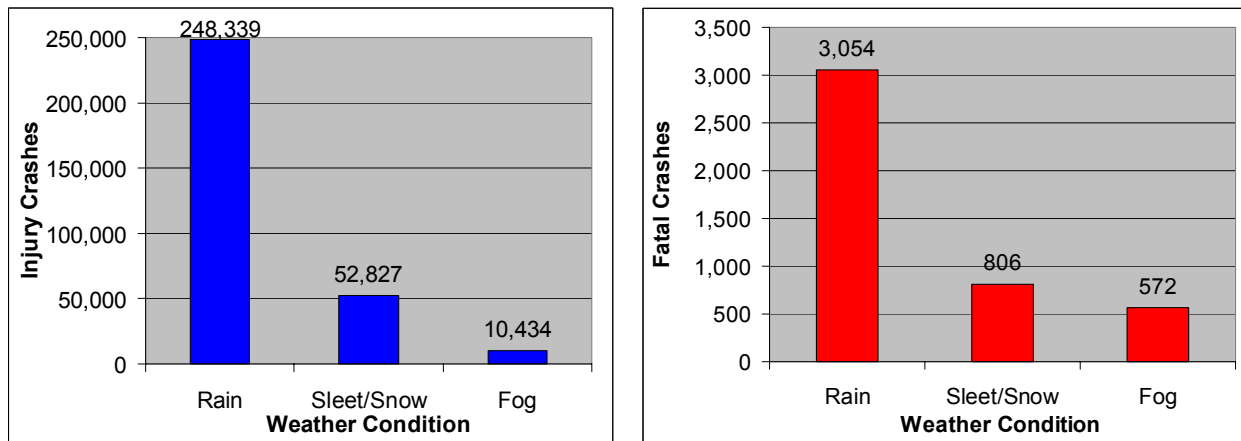


Figure 3 – Injury & Fatal Crashes on Slick Pavement by Year

Crashes in “Adverse Weather”

Because the number of crashes occurring in “rain & fog” and “sleet & fog” is negligible, only three adverse weather categories are included in the figures below. The Rain category includes crashes in “rain” and in “rain & fog”. The Sleet,Snow category includes crashes in “snow”, “sleet” and “sleet & fog”. Similarly, the Fog category includes crashes in “fog”, “rain & fog” and “sleet & fog”.

The average number of injury and fatal crashes occurring in “Adverse Weather” is shown in Figures 4A and 4B. Nearly 80 percent of injury crashes happen in rain and 17 percent occur in snow or sleet. Fatal crashes in rain, sleet/snow and fog account for 69 percent, 18 percent and 13 percent, respectively. Crash trends in “Adverse Weather” from 1995 to 2001 are shown in Figure 5.



Figures 4A & 4B – Average Injury & Fatal Crashes in Adverse Weather (1995-2001)

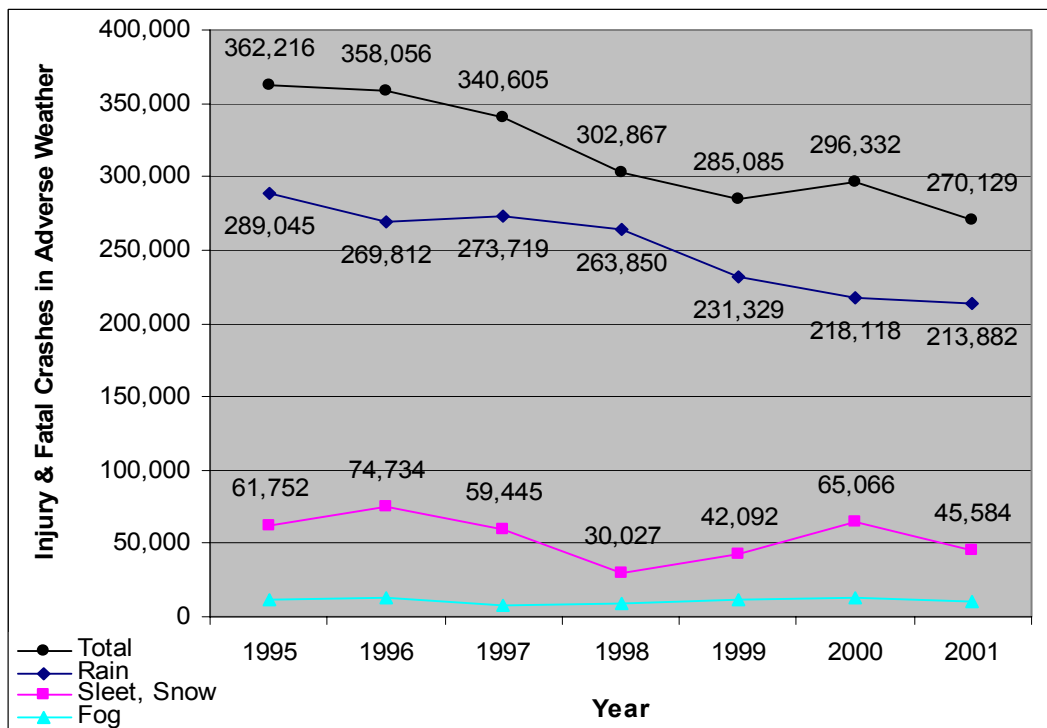


Figure 5 – Injury & Fatal Crashes in Adverse Weather by Year

From 1995 to 2001 the number of injury and fatal crashes in rain fell by 26 percent from 289,045 to 213,882. Crashes in sleet and snow increased from 61,752 in 1995 to 74,734 in 1996, before decreasing to 30,027 in 1998. These crashes then increased to 65,066 in 2000 and fell to 45,584 in 2001. Overall there was a 26 percent decline in sleet and snow crashes. The incidence of injury and fatal crashes in fog rose from 11,420 in 1995 to 13,508 in 1996 before falling to 7,441 in 1997. This rate increased from 8,990 in 1998 to 13,148 in 2000 before decreasing to 10,663 in 2001. The reduction in fog crashes from 1995 to 2001 was less than seven percent. Overall the number injury and fatal crashes in “*Adverse Weather*” decreased by 25 percent from 362,216 to 270,129.

The average number of rain crashes was 251,394 annually. On average 54,100 sleet and snow crashes occur each year, with 6,768 happening in sleet and 47,332 occurring during snowfall. The annual average crash rate in foggy conditions was 10,977. Over the seven-year analysis period the average number of “*Adverse Weather*” crashes was 316,470 per year.

Crashes in Poor Road Weather Conditions

Crashes in poor road weather conditions are summarized in Table 2. Poor road weather conditions are defined as precipitation in the presence of slippery pavement or fog in the presence of slippery pavement. Nearly 15 percent of injury and fatal crashes happen in poor road weather conditions. That is, 308,750 injury and fatal crashes take place each year when “*Adverse Weather*” occurs simultaneously with “*Slick Pavement*”.

Seventy-nine percent of these crashes happen during rainfall with wet pavement. Over 17 percent of poor road weather crashes (or 53,397) occur when sleet and snow fall in the presence of “*Slick Pavement*”. Only two percent of these crashes (or 6,455) happen during fog with “*Slick Pavement*”.

Table 2 – Average Injury & Fatal Crashes by Road Weather Condition
(1995-2001)

Pavement Conditions	Weather Conditions				Total
	Rain	Sleet	Snow	Fog	
Wet	244,041	1,599	8,118	5,390	371,558
Snow, Slush	1,058	1,216	20,161	152	31,693
Ice	3,800	3,880	18,423	913	50,426
Total	250,513	6,714	47,005	10,906	2,073,083

CONCLUSION

Each year 22 percent of injury and fatal crashes happen in adverse conditions (i.e., on “*Slick Pavement*”, in “*Adverse Weather*”, or when “*Slick Pavement*” and “*Adverse Weather*” occur together). Annually, over 450,000 injury crashes and nearly 6,500 fatal crashes take place in these conditions. Most injury and fatal crashes in adverse conditions happen when the pavement is wet and during rainfall. While crashes on “snowy, slushy or icy” pavement and crashes during “sleet or snow” account for less than 20 percent and 15 percent of adverse condition crashes, respectively. As shown in Figure 6 below, the number of crashes in “*Adverse Weather*” and on “*Slick Pavement*” has generally decreased, despite the fact that vehicle miles of travel (VMT) have increased steadily.

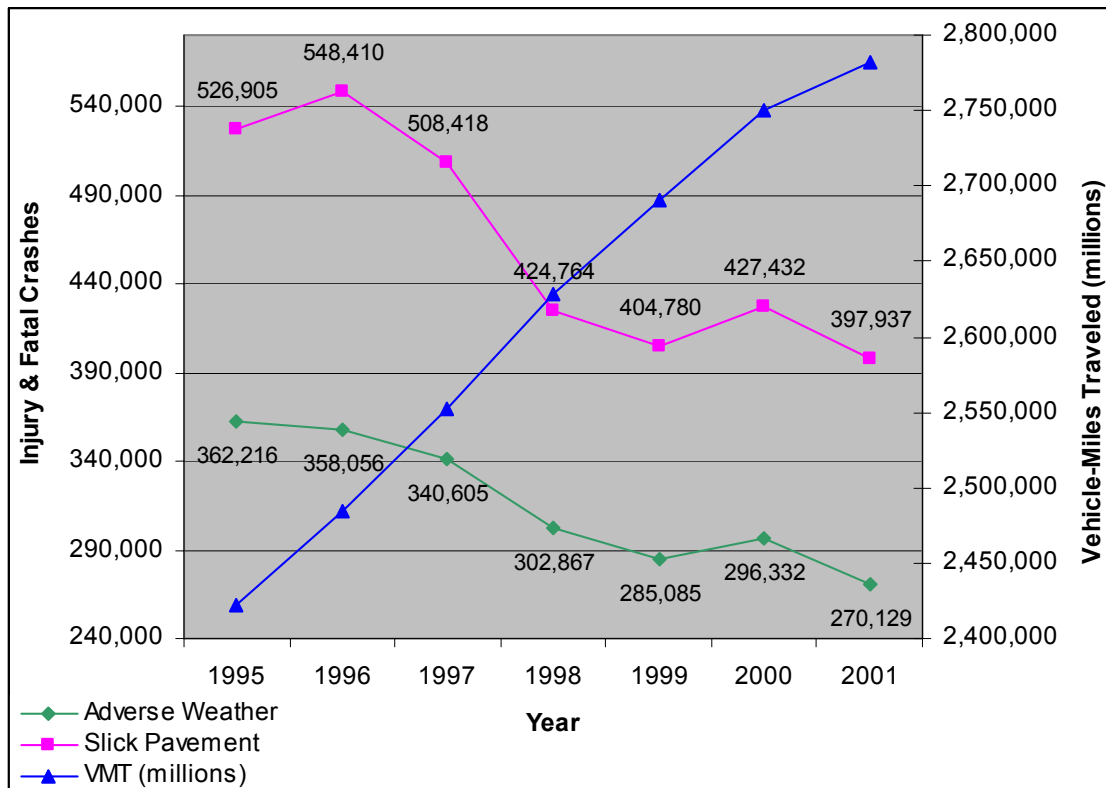


Figure 6 – Weather-Related Crashes and Vehicle-Miles Traveled by Year

REFERENCES

1. Nelson, G., “*A Preliminary Analysis of U.S. Highway Crashes Against an Exposure Index*”, Mitretek Systems, 2001.
2. U.S. DOT, “*Annual Vehicle-Miles, Federal-Aid Highway Travel*”, Table VM-3, Highway Statistics Series, Federal Highway Administration (FHWA) Office of Highway Policy Information, <http://www.fhwa.dot.gov/ohim/ohimstat.htm>.
3. U.S. DOT, “*Fatality Analysis Reporting System (FARS)*”, National Highway Traffic Safety Administration (NHTSA), <http://www-fars.nhtsa.dot.gov/>.
4. U.S. DOT, “*General Estimates System (GES)*”, National Highway Traffic Safety Administration (NHTSA), <http://www-nrd.nhtsa.dot.gov/departments/nrd-30/ncsa/ges.html>.

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Attachment A

The following tables include the average number of fatal and injury crashes occurring in poor road weather conditions each year.

Average Fatal Crashes		Weather Conditions									
		None	Rain	Sleet	Snow	Fog	Rain, Fog	Sleet, Fog	Other	Unknown	Total
Pavement Conditions	Dry	30,424	7	1	8	297	0	0	77	41	30,856
	Wet	1,631	2,950	34	104	190	41	2	15	16	4,984
	Snow, Slush	172	11	23	358	4	1	1	3	3	576
	Ice	301	40	85	191	23	1	5	9	4	658
	Sand, Dirt, Oil	30	1	0	0	0	0	0	1	0	32
	Other	50	2	0	1	4	0	0	2	2	61
	Unknown	57	0	0	1	2	0	0	0	148	208
	Total	32,666	3,011	144	662	520	43	8	107	213	37,375

Average Injury Crashes		Weather Conditions									
		None	Rain	Sleet	Snow	Fog	Rain, Fog	Sleet, Fog	Other	Unknown	Total
Pavement Conditions	Dry	1,582,594	1,607	19	295	4,154	0	0	5,522	4,213	1,598,402
	Wet	110,779	240,480	1,466	8,014	4,490	570	96	2,634	2,208	370,737
	Snow, Slush	8,933	1,046	1,126	19,804	81	0	65	650	772	32,478
	Ice	23,109	3,721	3,503	18,232	559	38	287	1,586	2,196	53,230
	Sand, Dirt, Oil	3,470	46	0	0	0	0	0	95	15	3,626
	Other	4,470	432	17	43	69	0	0	122	110	5,263
	Unknown	10,645	400	27	281	14	0	11	71	8,827	20,276
	Total	1,744,001	247,732	6,157	46,669	9,367	608	459	10,680	18,339	2,084,013

Average Injury & Fatal Crashes		Weather Conditions									
		None	Rain	Sleet	Snow	Fog	Rain, Fog	Sleet, Fog	Other	Unknown	Total
Pavement Conditions	Dry	1,613,018	1,614	19	303	4,451	0	0	5,599	4,254	1,629,258
	Wet	112,411	243,430	1,501	8,118	4,681	611	98	2,649	2,224	375,722
	Snow, Slush	9,106	1,057	1,150	20,161	85	1	66	654	774	33,054
	Ice	23,410	3,761	3,588	18,423	581	39	292	1,594	2,199	53,888
	Sand, Dirt, Oil	3,500	47	0	0	0	0	0	96	15	3,658
	Other	4,520	434	17	44	73	0	0	124	112	5,324
	Unknown	10,702	400	27	282	16	0	11	71	8,975	20,484
	Total	1,776,667	250,742	6,301	47,332	9,888	651	467	10,787	18,553	2,121,388