AUGUST 2019

WIM #48
CSAH 5,
MP 15.05
STORDEN, MN

MONTHLY REPORT

Your Destination...Our Priority

WIM Site Location

WIM #48 is located on CSAH 5 near Storden in Cottonwood county.

System Operation

WIM #48 was operational for the entire month of August 2019. Volume was computed using all monthly data.

System Calibration

WIM #48 was most recently calibrated on 2019-05-15. Table 1 summarizes the front axle weights of class 9s by lane [1]. Figure 1 shows the distribution of gross vehicle weights (GVW) in Class 9 vehicles at this site for the last 12 months of operation [2]. Figure 2 depicts the average front axle weight as a percent difference from the first full month following calibration.

Summary of Volume Statistics

Total Monthly Volume: 12345 | Passenger Vehicles: 10346 | Heavy Commercial Vehicles: 1999

Monthly Average Daily Traffic (MADT): 394 | Monthly Heavy Commercial Average Daily Traffic (MHCADT): 64

See Table 2 for vehicle class breakdown

Passenger Vehicles (PVs) and Heavy Commercial Vehicles (HCVs)

Volume trends. NB vehicles typically reached highest volume levels on Tuesdays, with lowest volumes reported on Saturdays. SB vehicles typically reached highest volume levels on Sundays, with lowest volumes reported on Saturdays (see Figure 3 and 4).

Passenger Vehicles (PVs)

Volume trends. On an average 24-hour day (see Figure 5), NB PVs generally reached peak volume levels between 07 AM and 05 PM. Similarly, SB PVs peaked in volume between 02 PM and 06 PM

Heavy Commercial Vehicles (HCVs)

Volume trends. On an average 24-hour day, HCVs traveling NB typically reached peak volume levels between 07 AM and 05 PM, while volume going SB peaked between 02 PM and 06 PM. See Figure 6. Out of all HCVs, the two highest traffic volumes were generated by Class 9's and Class 5's.

Overweight HCVs

Volume trends. Of a total of 1999 HCVs, 334 of them were overweight [3]. These overweight HCVs contributed to 3.1% of total monthly volume, and 19.1% of total monthly HCV

volume. NB overweight vehicles typically reached highest numbers on Wednesdays, with lowest volumes reported on Sundays. SB overweight vehicles tended to reach highest volumes on Thursdays, with lowest volumes reported on Saturdays. See Figure 3 .
The top two overweight violators by class were the class 9 and class 10 vehicles . Overall, overweight vehicles tended to reach peak volume concentrations during typical business hours, with 50.4% of all overweight vehicles traveling NB this month (see Figure 7 & 8).
Figure 9 shows the number of vehicles exceeding 88,000 pounds that crossed the WIM over the last 12 months. The highest number of 88,000+ vehicles within the last 12 months occurred in September.
WIMs are currently used as a screening tool for weight enforcement, and it is estimated that the WIM scales can measure gross vehicle weights (GVW) within 90-95% of static weight scale measurements. Due to the possibility of measurement error, vehicles exceeding 10% of their legal weight limits (or 1.1 times their legal weight limits) are considered overweight in this report [4].
Using normal load limits ,59 NB vehicles exceeded 88,000 pounds (24 vehicles were Class 13's; 22 vehicles were Class 10's). Of vehicles traveling SB,

78 NB vehicles exceeded 88,000 pounds (30 vehicles were Class 9's; 26 vehicles were Class 10's). Refer to Table 3 for the Top 10 highest recorded GVWs from Classes 9 and 10 from August 2019.

Loaded vs. Unloaded HCVs. Figure 10 shows the GVW distributions of Class 9s and 10s in August 2019. Data suggests that there were greater numbers of fully_loaded Class 9's than empty Class 9's traveling NB, while there were more fully_loaded Class 9's than empty traveling SB. Data also suggests that there were more fully_loaded Class 10's than empty traveling in the NB direction. In the SB direction, there were more fully_loaded class 10 vehicles.

Freight Totals. A total of 17054 tons of freight was recorded to have crossed the WIM. More freight was shipped NB (50%) than SB (50%). See Table 4 and Figure 11 for more freight information.

####**Infrastructure Considerations Bridge.** Bridge No. 97506 (a precast box culvert) is approximately 1.3 miles north of WIM #48. Bridge No. 97666 (a precast box culvert) is approximately .45 miles south of WIM #48. WIM #48 recorded a total of 12345 vehicles with a combined GVW of 133277 kips (1 kip = 1,000 pounds = 0.5 tons) in August 2019. See Table 5 and Figures 12-13 for GVW information by vehicle class and lane.

Pavement Design. A total of 1590 equivalent single axle loads (ESALs) passed over the pavement at this site. Approximately 53.8% of all ESALs were recorded SB while 46.2% was observed NB. In particular, 53% of all ESALs were generated by the Class 9's (Class 9's were also responsible for generating 35% of total GVW observed this month). See Table 6 and Figures 14-15 for more information on ESALs (Table 6 also provides flexible ESAL factors for each vehicle class using a terminal serviceability of 2.5 and a structural number of 5).

#####WIM monthly reports can be found at:
http://www.dot.state.mn.us/traffic/data/reports-monthly-wim.html MnDOT's vehicle

classification scheme and vehicle class groupings for traffic forecasting can be found at: http://www.dot.state.mn.us/traffic/data/data-products.html#weight

- [1] Front axle weights of Class 9s are monitored on a monthly basis to assure performance between calibrations. The current goal of the WIM scale calibration is to have each individual axle weight stay within a range of ?9% of baseline calibration values

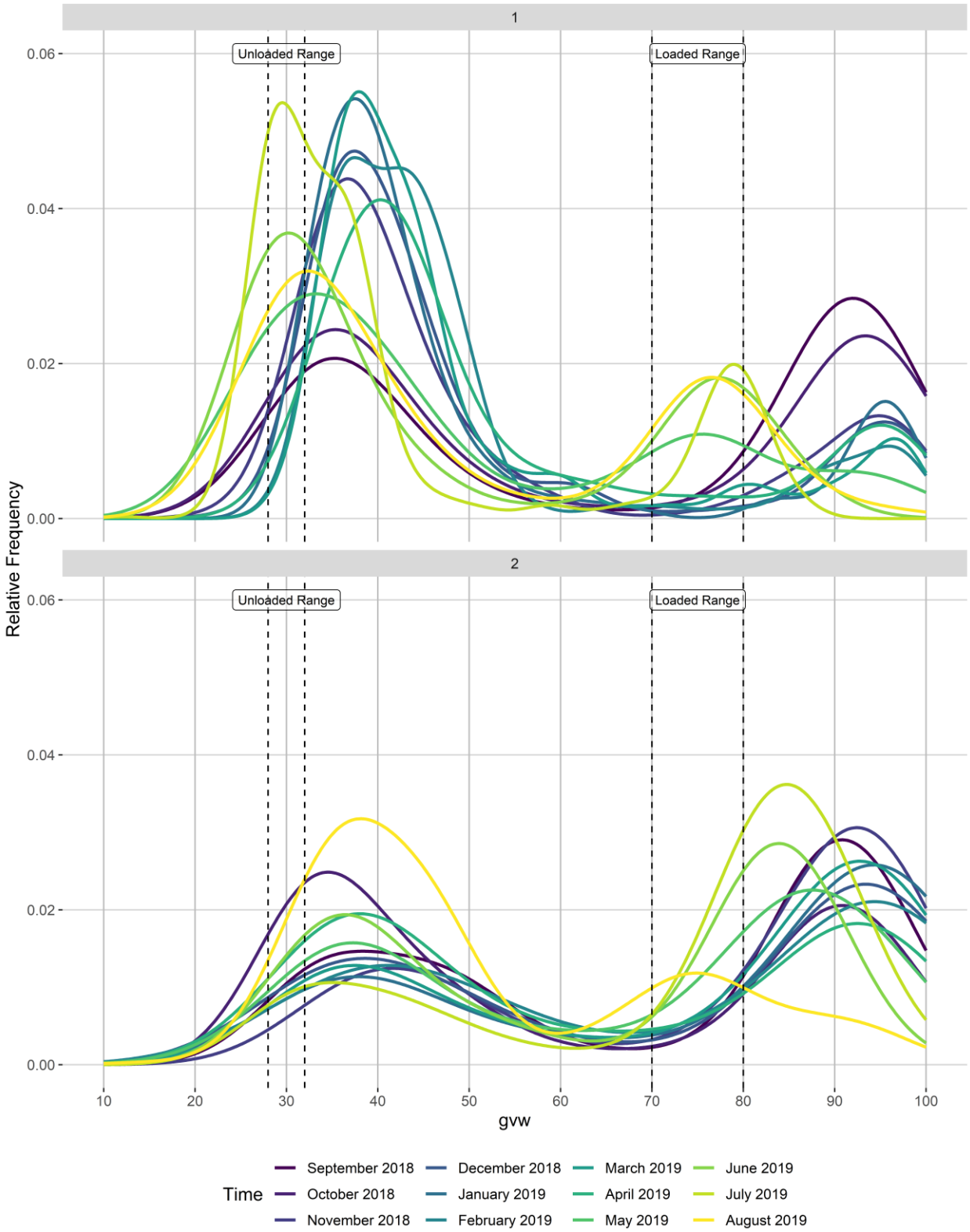
- [2] Previous WIM research indicates that unloaded Class 9s typically weigh 28-32 kips, while loaded Class 9s generally fall in the 70-80 kip range. More recent data from several WIM sites suggests that the unloaded Class 9 range may have moved a little higher over time (due to increased presence of sleeper cabs, etc.), although these ranges are also thought to be site-specific.

- [3] An HCV is considered overweight during normal load limits in this report if they satisfy any of the following 1) exceed a gross vehicle weight (GVW) of 80,000 pounds, 2) exceed any of the legal weight maximums on any axle configurations (legal maximums are: single axle = 20,000 pounds; tandem axles spaced 8' or less = 34,000 pounds; tridem axles spaced 9' or less = 43,000 pounds; quad axles spaced 13' or less = 51,000 pounds). Monthly reports use this standard regardless of the time of year however, the Winter Load Increase (WLI) allows a 10% across the board increase in axle and gross vehicle weights without a permit on US, state routes, and county roads. An HCV is considered overweight during Winter Load Increase(WLI) if they satisfy any of the following 1) exceed a gross vehicle weight (GVW) of 88,000 pounds, 2) exceed any of the legal weight maximums on any axle configurations (legal maximums are: single axle = 22,000 pounds; tandem axles spaced 8' or less = 37,400 pounds; tridem axles spaced 9' or less = 47,300 pounds; quad axles spaced 13' or less = 56,100 pounds). An overweight HCV is only included once in the overweight volume calculations regardless of how many of the aforementioned conditions are violated. For information on MN weight limit dates and statutes: http://www.mrr.dot.state.mn.us/research/seasonal_load_limits/sllindex.asp

- [4] For example, Class 9s and 10s can legally have gross vehicle weights up to 80,000 lbs (with the exception of permitted loads) during normal load limits. To account for measurement error on the WIM scales, those exceeding 10% of the legal GVW maximum (or 1.1 times the legal GVW) should be screened (e.g., 80,000 lbs + 8,000 lbs = 88,000 lbs). Similarly during WLI vehicles weighing 96,800 lbs should be screened.

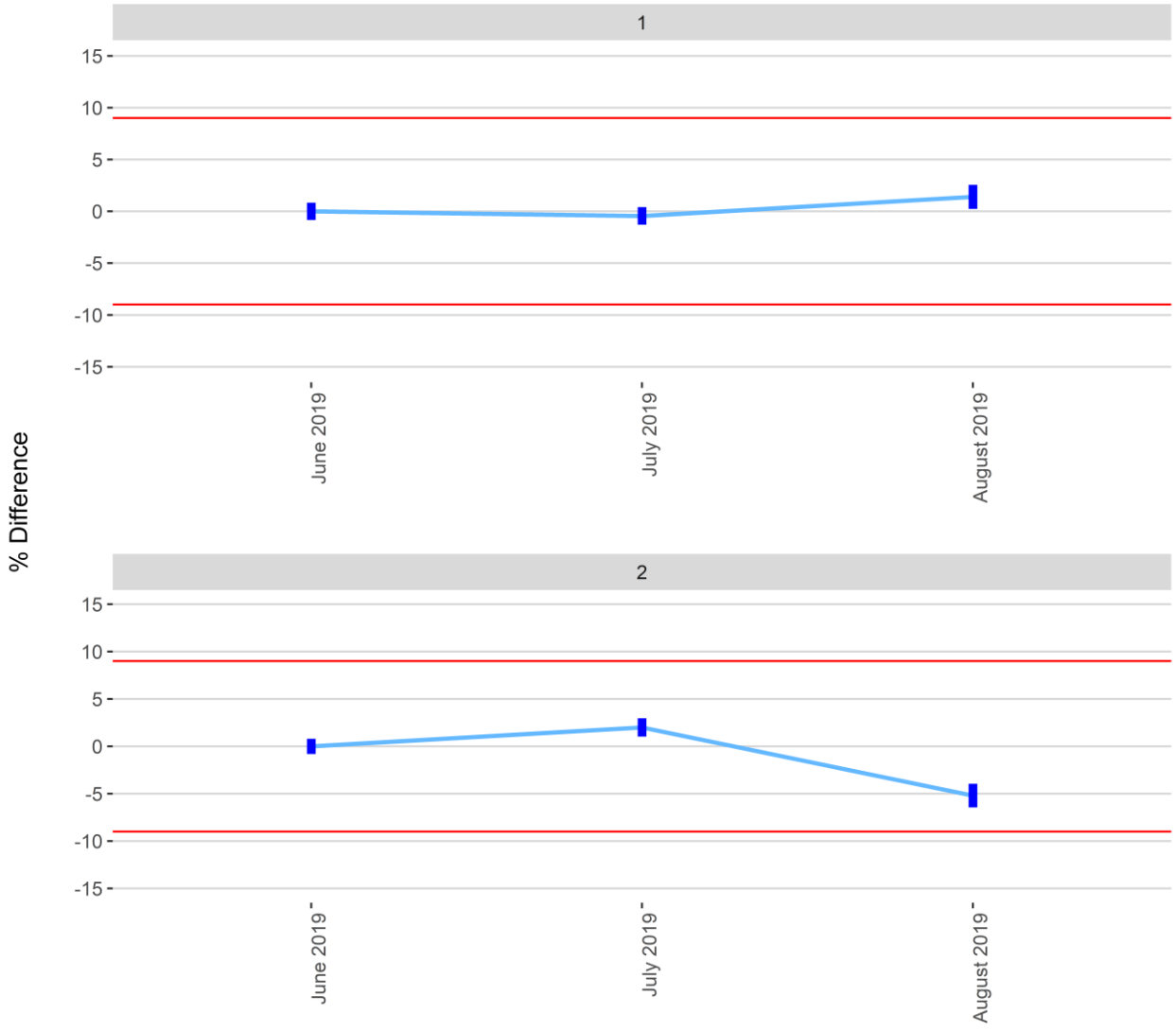
To request this document in an alternative format, please call 651-366-4718 or 1-800-657-3774, or email your request to ADArequest.dot@state.mn.us. Please request at least one week in advance.

Figure 1 - Monthly Class 9 GVW Histogram



Months that have not passed QC parameters are not displayed

Figure 2 - Percent Difference of Front Axle Weight from Last Calibration (+/- 95% CI)



Months that have not passed QC parameters are not displayed

Figure 2 - Average Vehicle Volume vs. Day of the Week

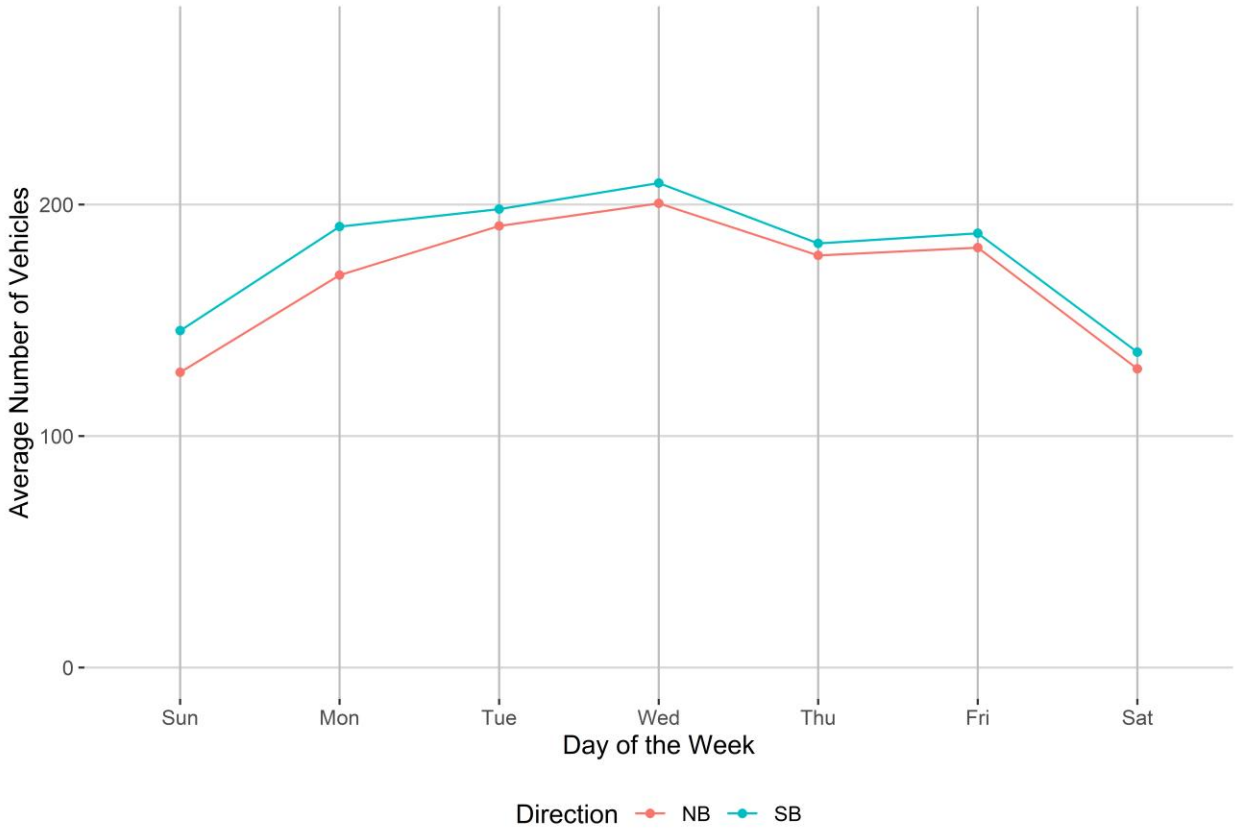


Figure 3 - Average Overweight Vehicle Volume vs. Day of the Week

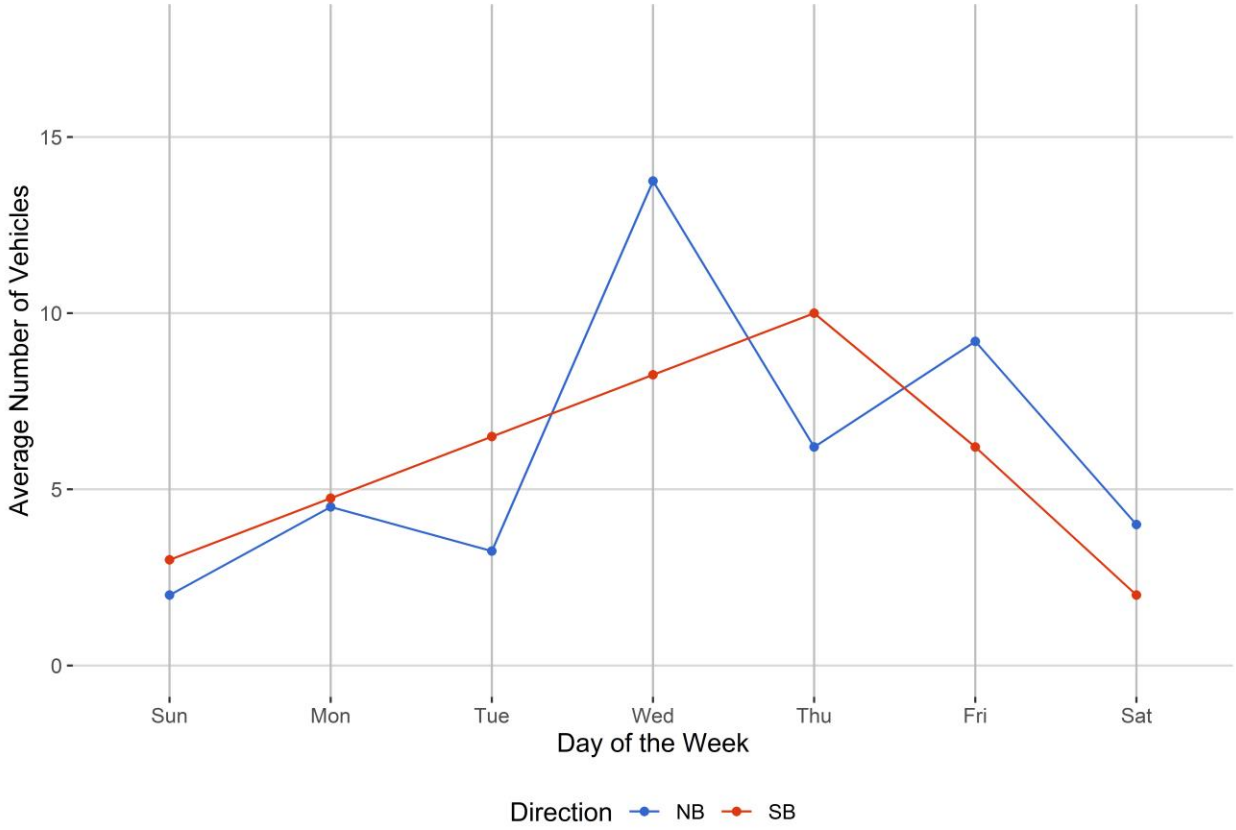


Figure 4 - Passenger Vehicles
vs. Hour of the Day

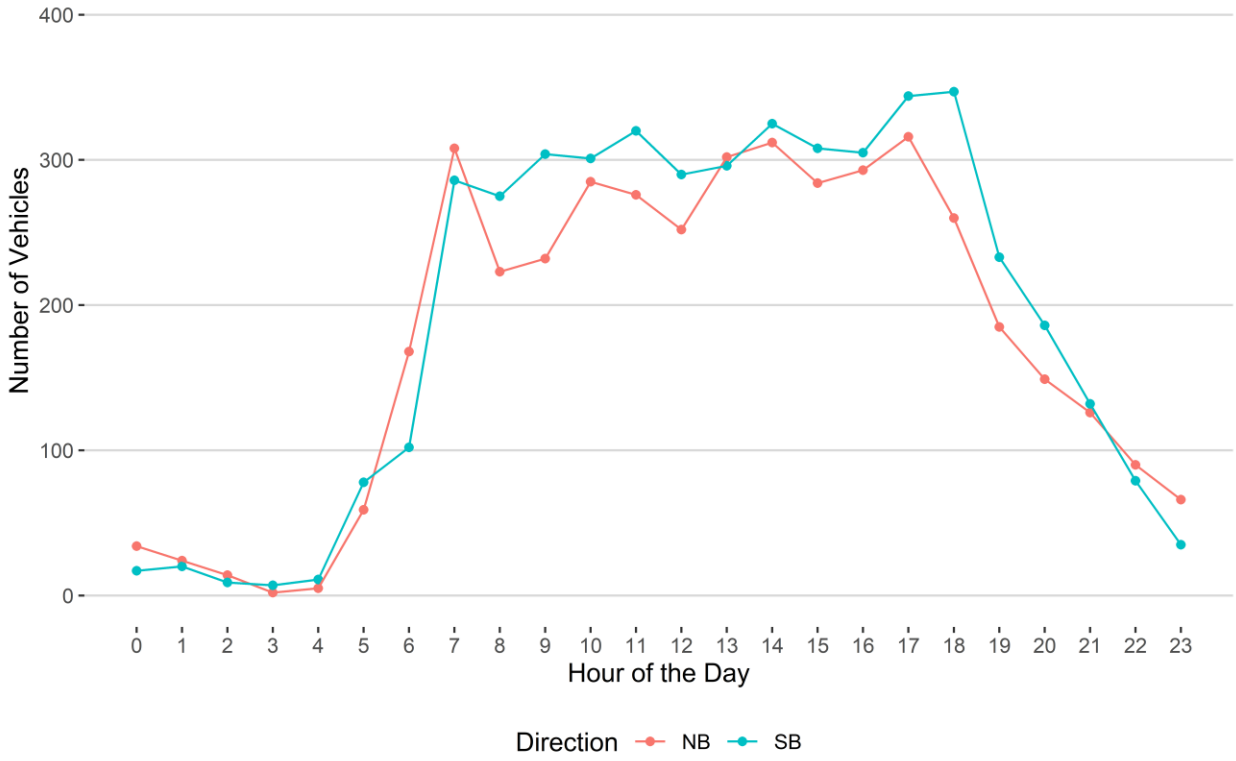


Figure 5 - Heavy Commercial Vehicles
vs. Hour of the Day

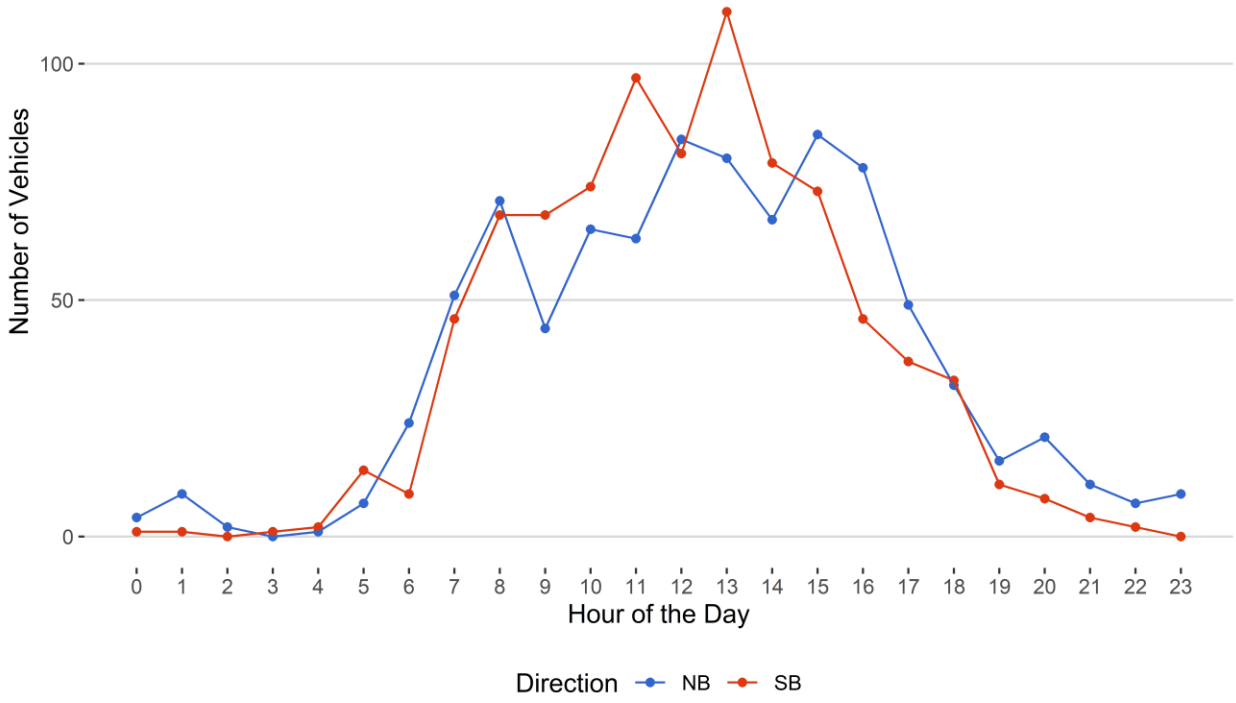


Figure 6 - Overweight Vehicles by Class vs. Hour of the Day

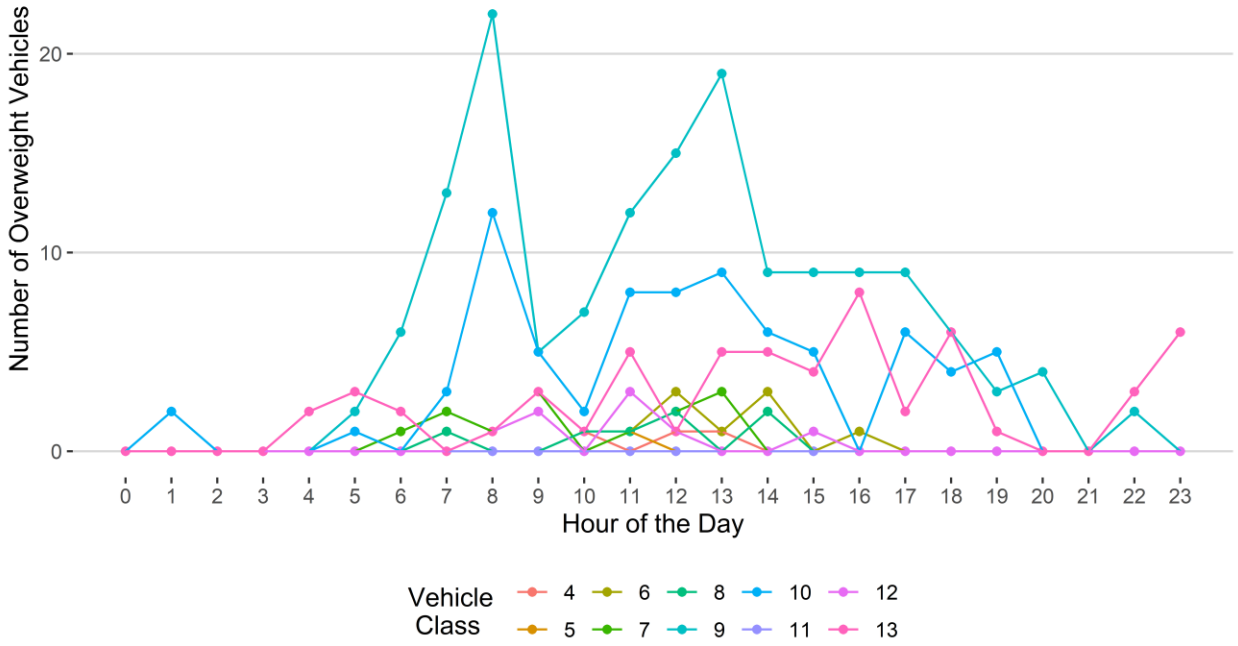


Figure 7 - Overweight Vehicles by Direction
Hour of the Day

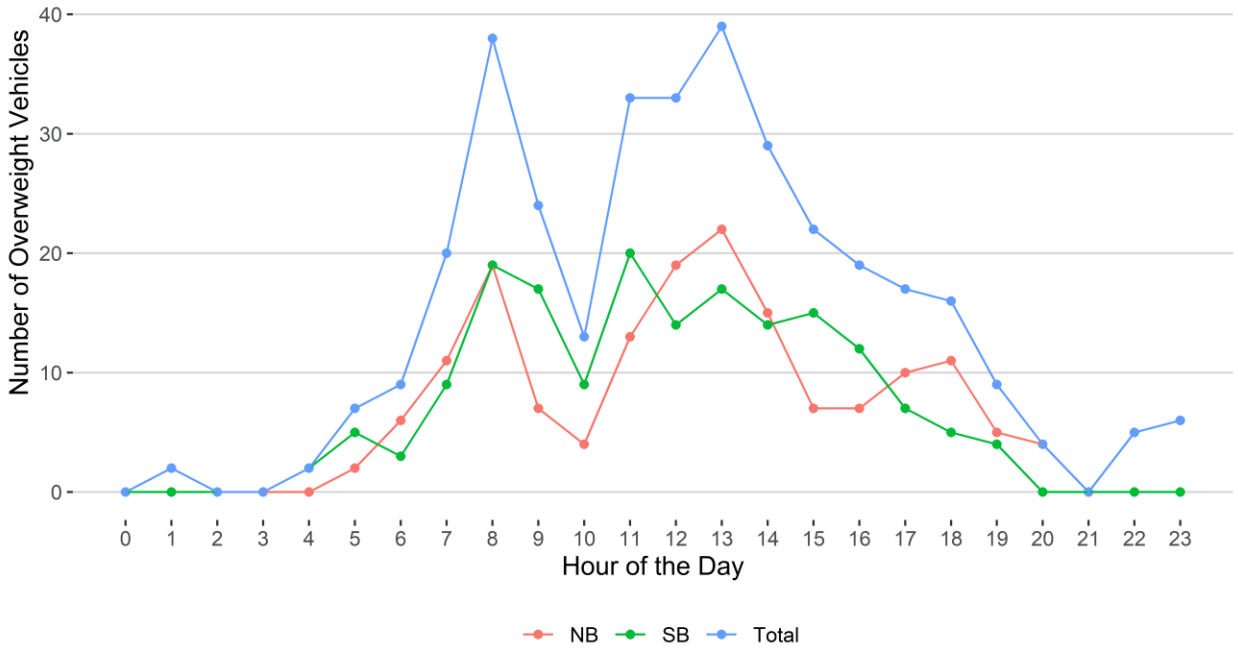
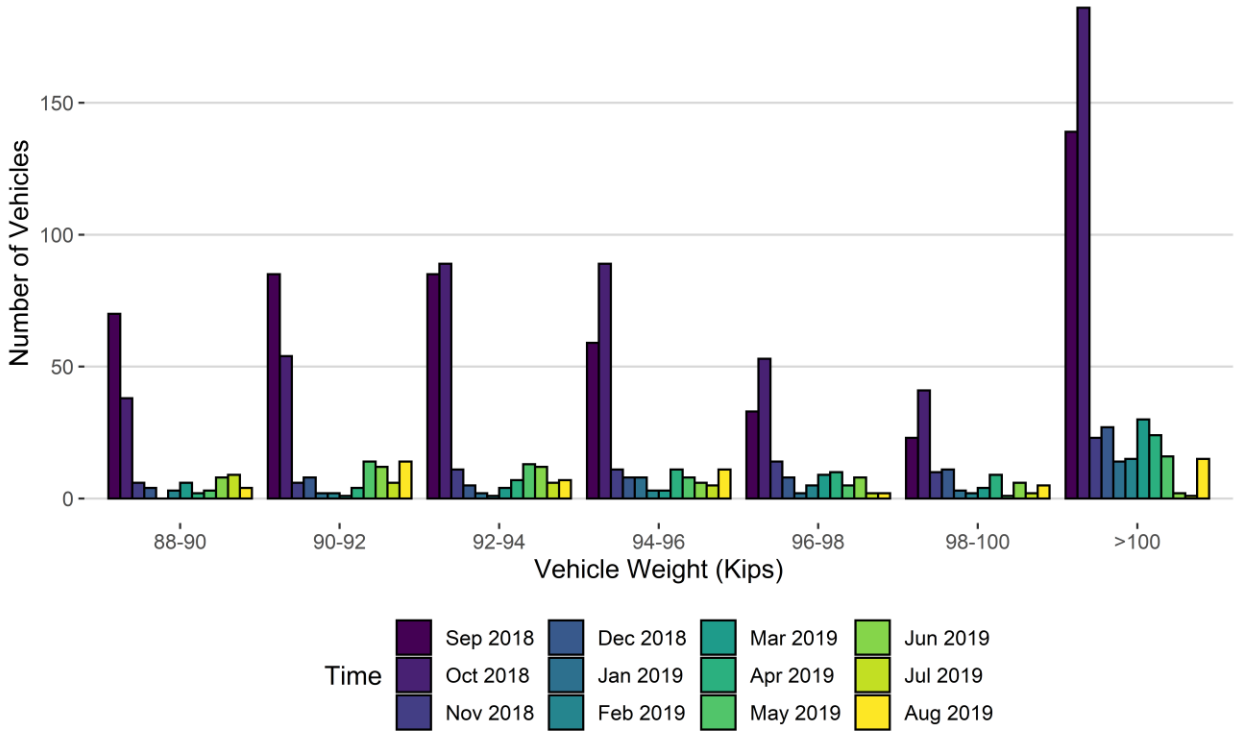
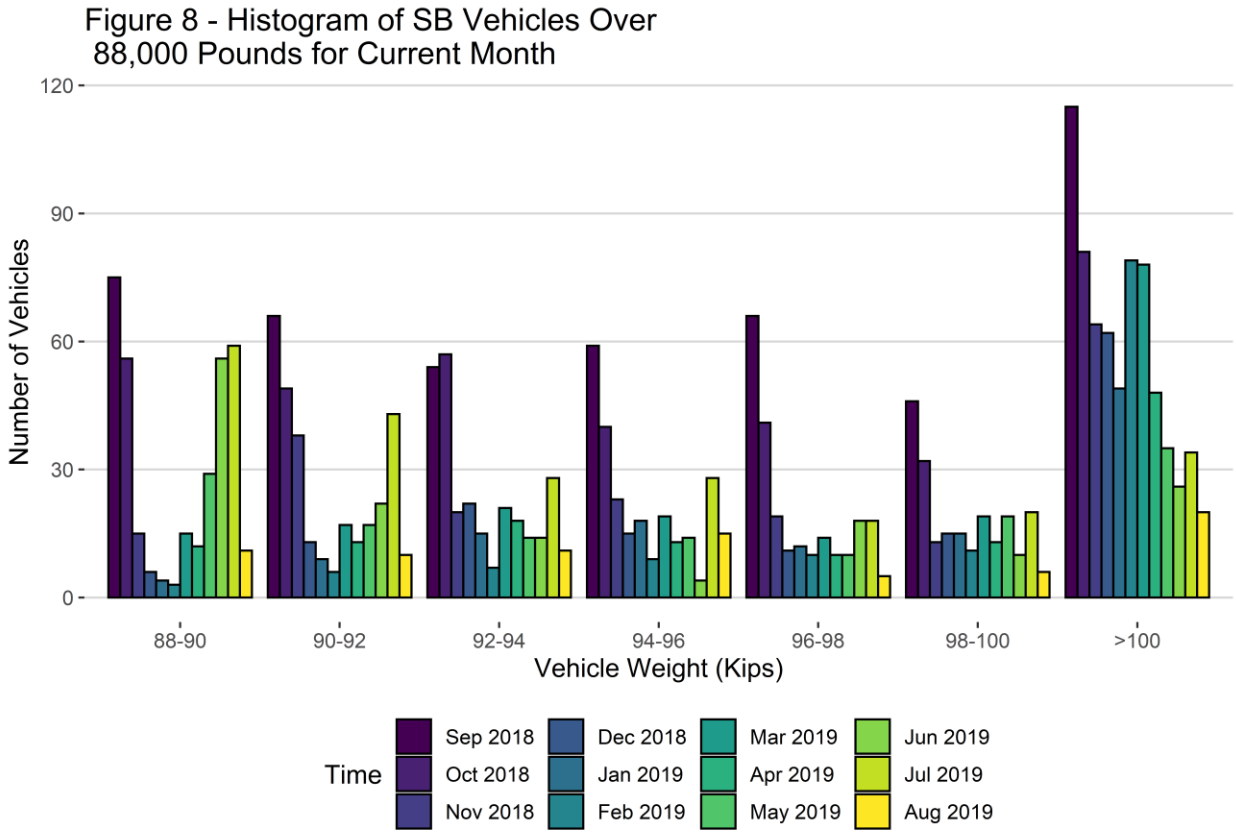


Figure 8 - Histogram of NB Vehicles Over 88,000 Pounds for Current Month



Vehicle Weights (Kips)	*Sep 2018*	*Oct 2018*	*Nov 2018*	*Dec 2018*	*Jan 2019*	*Feb 2019*	*Mar 2019*	*Apr 2019*	*May 2019*	*Jun 2019*	*Jul 2019*	*Aug 2019*
88-90	70	38	6	4	0	3	6	2	3	8	9	4
90-92	85	54	6	8	2	2	1	4	14	12	6	14
92-94	85	89	11	5	2	1	4	7	13	12	6	7
94-96	59	89	11	8	8	3	3	11	8	6	5	11
96-98	33	53	14	8	2	5	9	10	5	8	2	2
98-100	23	41	10	11	3	2	4	9	1	6	2	5
>100	139	186	23	27	14	15	30	24	16	2	1	15
Total	494	550	81	71	31	31	57	67	60	54	31	58



Vehicle Weights (Kips)	*Sep 2018*	*Oct 2018*	*Nov 2018*	*Dec 2018*	*Jan 2019*	*Feb 2019*	*Mar 2019*	*Apr 2019*	*May 2019*	*Jun 2019*	*Jul 2019*	*Aug 2019*
88-90	75	56	15	6	4	3	15	12	29	56	59	11
90-92	66	49	38	13	9	6	17	13	17	22	43	10
92-94	54	57	20	22	15	7	21	18	14	14	28	11
94-96	59	40	23	15	18	9	19	13	14	4	28	15
96-98	66	41	19	11	12	10	14	10	10	18	18	5
98-100	46	32	13	15	15	11	19	13	19	10	20	6
>100	115	81	64	62	49	79	78	48	35	26	34	20
Total	481	356	192	144	122	125	183	127	138	150	230	78

Figure 8 - Class 9's and 10's by Direction vs Gross Vehicle Weight

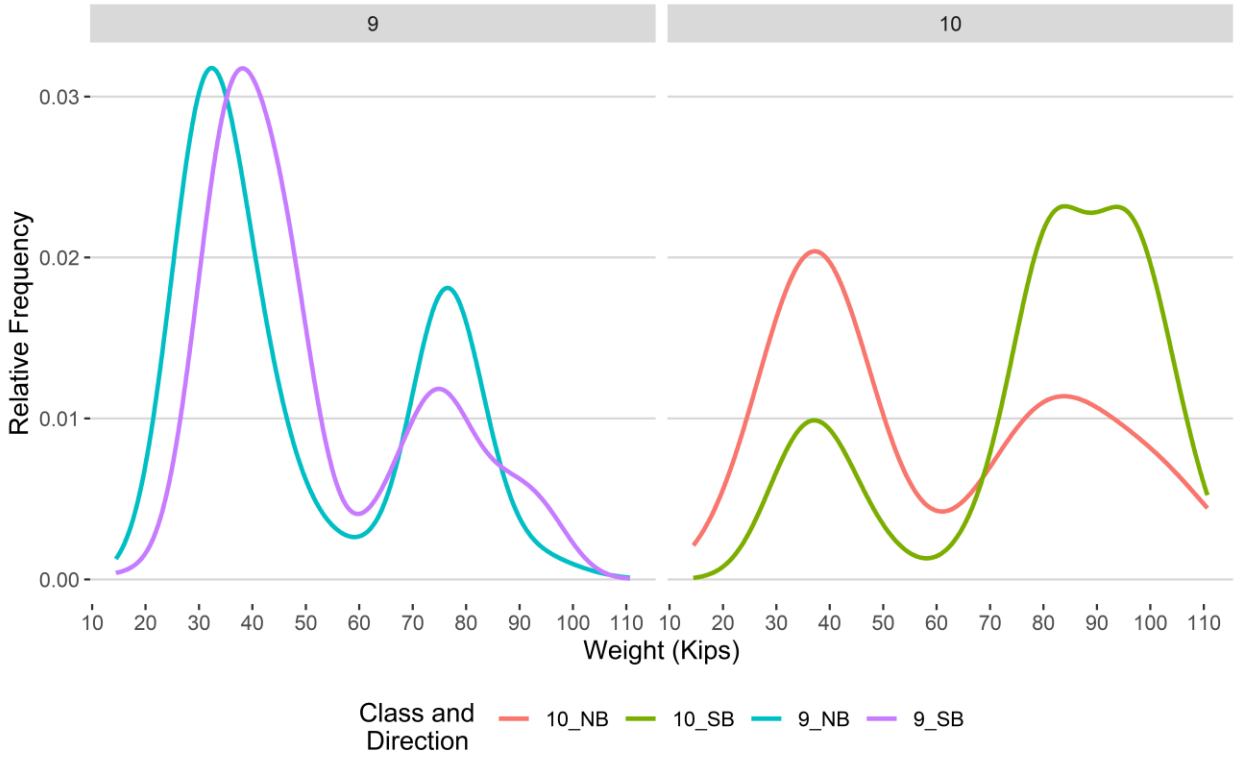


Figure 9 - Freight Percentage by Direction and Class

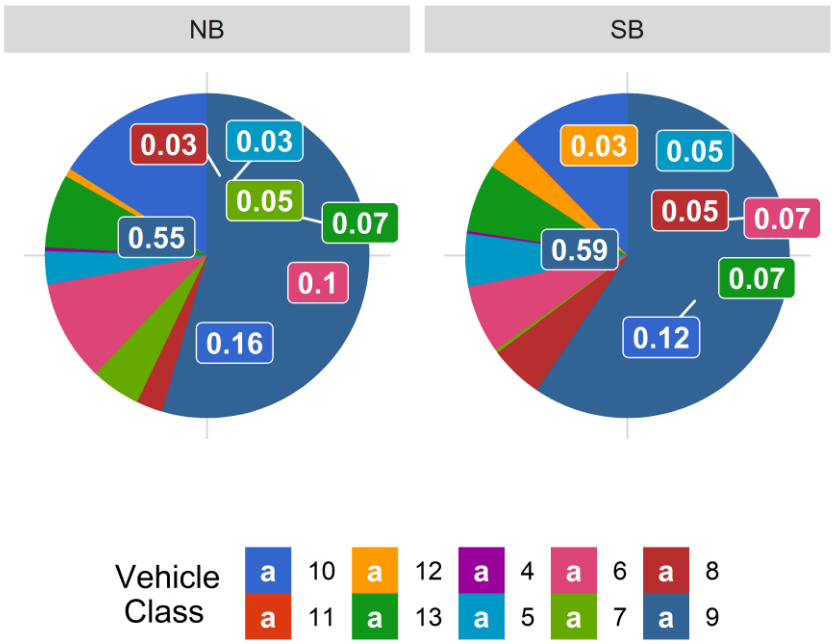


Figure 10 - Total Gross Vehicle Weight Percentage by Class and Lane

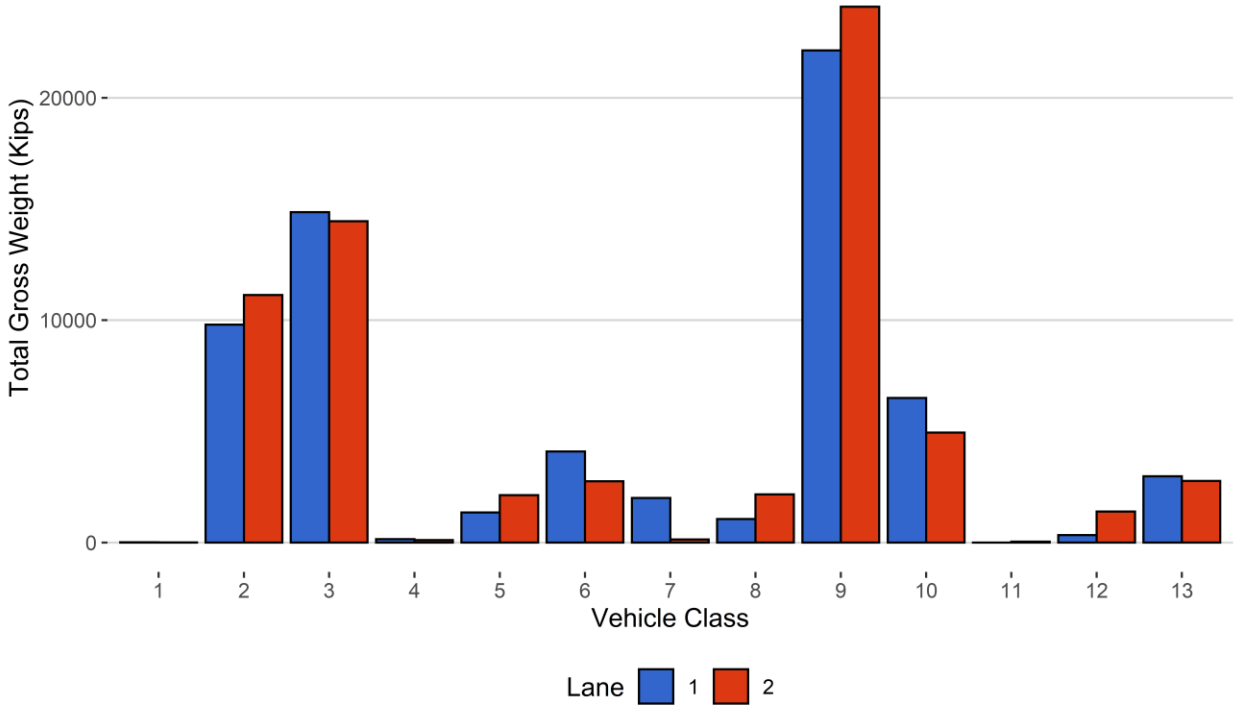


Figure 11 - Total Gross Vehicle Weight b

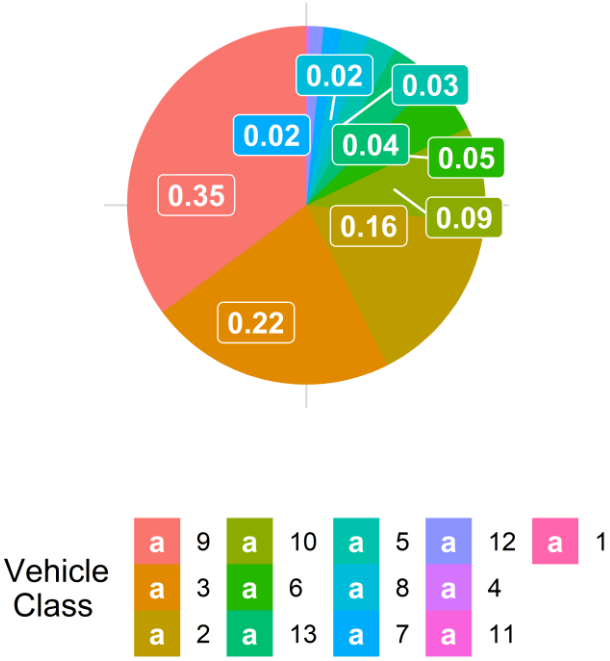


Figure 12 - Total ESALs by Class and Lane

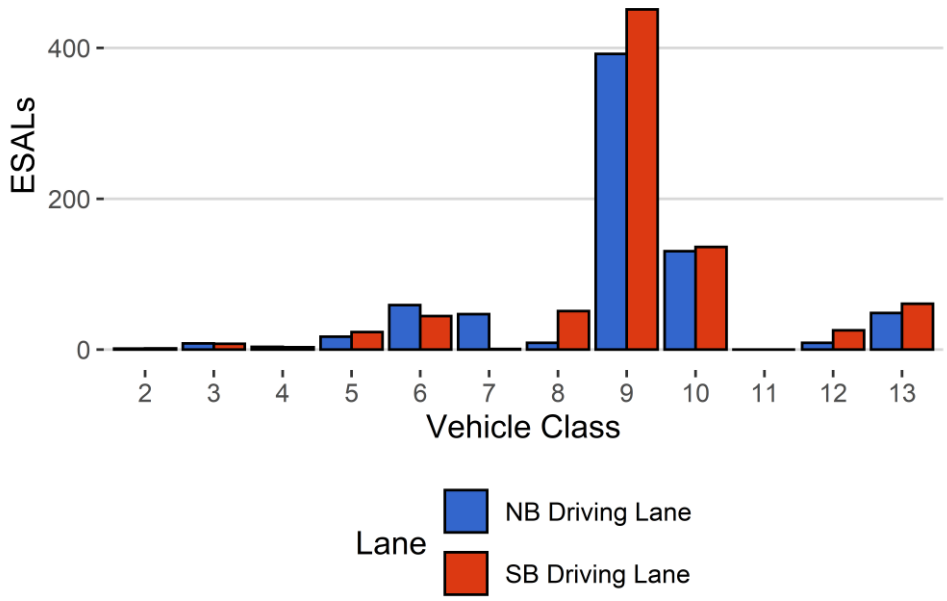


Figure 13 - ESALs by Class

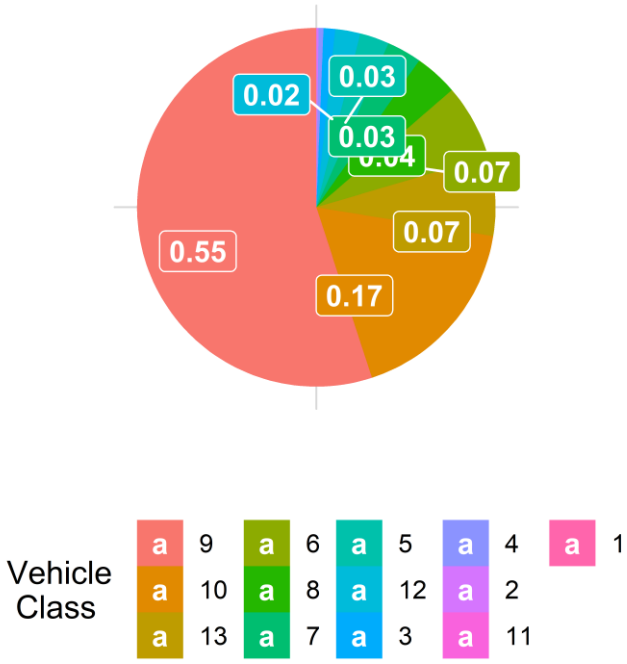


Table 1 Class 9 Front Axle Weight by Lane

Month	*Lane 1 (Kips)*	*Front Axle +/- 9%*	*Lane 2 (Kips)*	*Front Axle +/- 9%*
June 2019	10.37	0.00	11.18	0.0
July 2019	10.32	-0.45	11.41	2.0
August 2019	10.51	1.39	10.60	-5.2

Table 2 Vehicle Classification Data

Vehicle Class	*Monthly Average Daily Volume*	*Monthly Total Volume*	*Monthly Total Volume Percentage*	*Monthly Total Overweight Vehicles*	*Monthly Total Overweight Percentage*
1	0	14	0.1	0	0
2	184	5711	46.3	0	0
3	149	4622	37.4	0	0
4	0	10	0.1	3	0.9
5	8	260	2.1	1	0.3
6	8	244	2	15	4.5
7	1	38	0.3	14	4.2
8	3	100	0.8	7	2.1
9	34	1051	8.5	152	45.5
10	6	196	1.6	76	22.8
11	0	2	0	0	0
12	1	27	0.2	8	2.4
13	2	71	0.6	58	17.4
TOTAL	**398**	**12345**	**100**	**334**	**100**

Table 3 Top 10 Gross Vehicle Weight, Class 9 and 10

Date	*Day of Week*	*Time*	*Vehicle Class*	*Direction*	*Lane*	*GVW (lbs)*
2019-08-22	Thursday	19:09:31	10	NB	1	110.67
2019-08-22	Thursday	19:16:25	10	NB	1	108.8
2019-08-28	Wednesday	15:29:10	10	SB	2	108.5
2019-08-23	Friday	08:30:47	10	NB	1	108.44
2019-08-21	Wednesday	12:53:27	10	NB	1	108.28
2019-08-28	Wednesday	16:28:21	10	SB	2	106.5
2019-08-21	Wednesday	17:26:28	10	NB	1	106.02
2019-08-28	Wednesday	17:30:51	10	SB	2	105.51
2019-08-25	Sunday	19:28:05	10	SB	2	105.48
2019-08-27	Tuesday	16:21:25	10	SB	2	104.92

Table 4 Freight Summary

Vehicle Class	*Direction*	*Weight of Empty Vehicle (Kips)*	*Total Number of Vehicles*	*Number of Empty Vehicles*	*Percentage of Empty Vehicles*	*Total Weight of Vehicles with Freight (Kips)*	*Total Weight of Empty Vehicles (Kips)*	*Total Weight of Freight (Tons)*
4	NB	15	5	0	0	153	0	39
5	NB	8	90	7	7.8	1298	50	317
6	NB	19	126	2	1.6	4061	31	853
7	NB	11.5	29	0	0	2006	0	836
8	NB	31	34	19	55.9	582	476	59
9	NB	33	451	149	33	17761	4370	3897
10	NB	33.5	108	11	10.2	6178	326	1464
12	NB	36.5	4	0	0	335	0	95
13	NB	31.5	33	0	0	2978	0	969
TOTAL	****	****	**880**	**188**	****	**35352**	****	**8529**
Vehicle Class	Direction	Weight of Empty Vehicle (Kips)	Total Number of Vehicles	Number of Empty Vehicles	Percentage of Empty Vehicles	Total Weight of Vehicles with Freight (Kips)	Total Weight of Empty Vehicles (Kips)	Total Weight of Freight (Tons)
4	SB	15	4	0	0	109	0	24
5	SB	8	137	2	1.5	2117	14	519
6	SB	19	87	6	6.9	2663	89	562
7	SB	11.5	4	0	0	134	0	44
8	SB	31	53	10	18.9	1892	274	279
9	SB	33	467	51	10.9	22564	1533	4418
10	SB	33.5	63	4	6.3	4818	128	1421
11	SB	36.5	2	2	100	0	38	0
12	SB	36.5	20	1	5	1357	34	332
13	SB	31.5	29	0	0	2767	0	927
TOTAL	****	****	**866**	**76**	****	**38420**	****	**8525**
GRAND TOTAL	****	****	**1746**	**264**	**258**	**73773**	**7364**	**17054**

Table 5 Gross Vehicle Weight by Class and Lane

Vehicle Class	*NB*	*SB*	*Total*	*Percentage*
1	13	4	17	0
2	9796	11128	20924	15.9
3	14856	14453	29309	22.3
4	153	109	261	0.2
5	1348	2131	3479	2.6
6	4092	2753	6845	5.2
7	2006	134	2140	1.6
8	1059	2166	3224	2.5
9	22131	24097	46228	35.2
10	6504	4946	11450	8.7
11	0	38	38	0
12	335	1391	1726	1.3
13	2978	2767	5746	4.4
TOTAL	**65271**	**66116**	**131386**	**100**
GVW/LANE	**49.68**	**50.32**	**100**	**0.08**

Table 6 ESALs by Class and Lane and Flexible ESAL Factors

Vehicle Class	*NB*	*SB*	*Total*	*Percentage*	*Flexible ESAL Factor*
1	0	0	0	0	0.0769
2	1	2	3	0.2	0.0017
3	8	8	16	1	0.0089
4	4	3	7	0.4	1.38
5	17	23	41	2.6	0.38
6	59	45	104	6.8	1.01
7	47	1	48	3.1	2.65
8	9	51	60	3.9	1.39
9	392	451	843	55	1.89
10	130	136	266	17.4	3.1
11	0	0	0	0	0.85
12	9	26	35	2.3	2.32
13	49	61	110	7.2	3.19
TOTAL	**726**	**806**	**1532**	**100**	**18**
ESALS/LANE	**47.4**	**52.6**	**100**	**–**	**–**

Table 7 Site Summary: Volume and Vehicle Class

Month	*Total Volume*	*Monthly ADT*	*Monthly HCADT*	*Passenger Vehicles*	*Passenger Vehicles %*	*Heavy Commercial Vehicles*	*Heavy Commercial Vehicles %*
Sep 2018	14017	467	98	11073	79	2944.3	21
Oct 2018	14892	480	112	11407	76.6	3485.3	23.4
Nov 2018	11107	370	47	9686	87.2	1421.5	12.8
Dec 2018	9594	310	39	8393	87.5	1201.4	12.5
Jan 2019	7052	282	28	6187	87.7	864.7	12.3
Feb 2019	7600	271	38	6535	86	1065.2	14
Mar 2019	9909	320	46	8474	85.5	1435.2	14.5
Apr 2019	10547	352	44	9227	87.5	1320.3	12.5
May 2019	12728	404	53	11098	87.2	1629.9	12.8
Jun 2019	12277	409	53	10701	87.2	1576.4	12.8
Jul 2019	13187	390	94	10276	77.9	2911.1	22.1
Aug 2019	12345	394	64	10346	83.8	1998.6	16.2
TOTAL	**135255**	**–**	**–**	**113403**	**–**	**21854**	**–**
AVERAGE	**11271**	**371**	**60**	**9450**	**84**	**1821**	**16**

###ESALs

Month	*ESALS NB Driving Lane*	*ESALS SB Driving Lane*	*Total ESALS*	*Pavement Life Decrease Months*
Sep 2018	2756	3014	5769	85
Oct 2018	3327	2736	6063	97
Nov 2018	707	1320	2027	88.4
Dec 2018	581	1022	1603	97.2
Jan 2019	315	859	1173	100.9
Feb 2019	426	1097	1523	116.2
Mar 2019	617	1276	1894	103.2
Apr 2019	589	898	1486	78.3
May 2019	606	1263	1869	61.4
Jun 2019	955	2099	3054	30.8
Jul 2019	868	1894	2762	37.4
Aug 2019	734	856	1590	41.3
TOTAL	**12480**	**–**	**–**	**–**
AVERAGE	**1040**	**1528**	**2568**	**78**

###Gross Vehicle Weight

Month	*GVW NB Driving Lane*	*GVW SB Driving Lane*	*Total GVW Kips*
Sep 18	101402	112503	213905
Oct 18	120755	111263	232018

Nov 18	53687	60504	114190
Dec 18	46511	49899	96410
Jan 19	27108	36968	64076
Feb 19	32684	39784	72467
Mar 19	47910	55089	102999
Apr 19	51115	53745	104860
May 19	60319	69785	130104
Jun 19	107647	132267	239913
Jul 19	88299	95336	183635
Aug 19	65508	67768	133277
TOTAL	**802943**	**884911**	**1687854**
AVERAGE	**66912**	**73743**	**140655**

###Overweight Vehicles

Month	*Total Number of Overweight Vehicles*	*Overweight / Total Volume*	*Overweight / Heavy Commercial Volume*	*Number Over 88,000 lbs*	*Number Over 98,000 lbs*
Sep 2018	1229	10.1	47.7	976	324
Oct 2018	1250	9.4	39.9	907	341
Nov 2018	401	3.9	30.1	274	110
Dec 2018	286	3.2	25.2	216	116
Jan 2019	216	3.6	29.4	154	82
Feb 2019	237	3.8	26.4	156	107
Mar 2019	339	3.9	26.3	240	131
Apr 2019	261	2.7	21.2	194	94
May 2019	389	3.3	25.3	200	71
Jun 2019	716	3.2	24.7	204	44
Jul 2019	795	6.9	30.9	261	57
Aug 2019	347	3.2	19	137	47
TOTAL	**6466**	**–**	**–**	**3919**	**1524**
AVERAGE	**538.8**	**4.8**	**28.8**	**326.6**	**127**

###Freight

Month	*NB Freight Tons*	*SB Freight Tons*	*Total Freight*	*NB Freight %*	*SB Freight %*
Sep 2018	19864	22935	42800	46.4	53.6
Oct 2018	23691	19714	43405	54.6	45.4
Nov 2018	5662	9780	15442	36.7	63.3
Dec 2018	4620	7430	12050	38.3	61.7
Jan 2019	2455	5954	8409	29.2	70.8
Feb 2019	3307	6523	9830	33.6	66.4
Mar 2019	4989	9102	14091	35.4	64.6

Apr 2019	5153	7228	12381	41.6	58.4
May 2019	6527	9850	16377	39.9	60.1
Jun 2019	10389	17912	28301	36.7	63.3
Jul 2019	10842	19097	29939	36.2	63.8
Aug 2019	8529	8525	17054	50	50
TOTAL	**106028**	**144049**	**250077**	**–**	**–**
AVERAGE	**8835.7**	**12004.1**	**20839.8**	**39.9**	**60.1**