

# PROGRESS REPORT ON MAINTENANCE COST STUDIES IN RELATION TO TRAFFIC

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## SYNOPSIS

In cooperation with the States of Connecticut, New Hampshire and Rhode Island, the Public Roads Administration is conducting studies of the maintenance cost of different surface types as related to the traffic carried. The study, which began in the spring of 1935 and will cover a period of 5 years, includes 178 sections totaling 622 miles.

The studies are divided into three parts: traffic density, inventory and analysis of maintenance costs. Traffic densities in each State are being determined at 44 stations, with counts being staggered in such fashion as to provide a basis for computing the average 24-hr. traffic for each year. Weights of the various vehicles using the highways will be furnished by the Highway Planning Surveys. A physical inventory of the sections was necessary to determine the items entering into the maintenance cost record. This included descriptions of the surface, base and sub-base, shoulders, culverts, bridges, guard rail, traffic services, etc. Maintenance costs are reported on selected units of measure for six sections: surfacing, shoulders, drainage, structure repair, roadside cleaning, and traffic services.

The Public Roads Administration is cooperating with the Highway Departments of the States of Connecticut and New Hampshire and the Department of Public Works of the State of Rhode Island in making studies of the cost of general highway maintenance on certain selected sections of highway having different types of surfacing and relating the cost of maintaining the surfacing with the traffic.

The studies were begun in the spring of 1935 to continue for a period of five years.

The types of surfacing, number and length of sections for each type on the selected sections are given in Table 1.

The sections are located throughout the States of Connecticut and Rhode Island and the southern half of New Hampshire as indicated on Figure 1—a map of Connecticut; Figure 2—a map of Rhode Island, and Figure 3—a map of New Hampshire.

For convenience, the studies are divided into three separate parts, namely, traffic density, inventory, and analysis of maintenance costs. The first part is a

determination of the amount of traffic that traverses each of the various sections, the second part is the inventory of the various parts of the highway for which annual maintenance costs are reported, and the third part is the analysis of the maintenance cost data in such a manner that comparisons may be easily and readily made at the end of the five-year period.

The traffic density is being obtained by counting the traffic at 44 main stations in each State. The 44 stations are divided into two groups, of 22 stations each. Each group is operated by one man according to a fixed schedule during periods of 26 days each which permits him to be off duty four days during the 26. The stations are operated from 6 a.m. to 2 p.m. and from 2 p.m. to 10 p.m. during alternate periods, thereby obtaining a count at each station on each day of the week for these hours in each year. The stations are also operated from 10 p.m. to 6 a.m. twice during each year. The average 24-hour traffic for each year is computed from the amount of traffic counted during these operations.

A record of the traffic counted on each section of highway during each operation is submitted to the Division of Highway Transport on a form which shows any factors affecting the normal flow of traffic on the date of operation, also all maintenance, and changes in the condition of the surfacing, since the last operation of the station which was 26 days previous. The data on these record forms

For further study of the traffic density, the average 24-hour traffic on each section for each year is copied on a form, Table 3, especially prepared for the purpose.

Table 4 shows the summary of the 24-hour average number of vehicles passing the traffic stations during each year that the traffic has been counted, and the trends compared with the first year. The

TABLE 1

State	Type of surfacing	Number of sections	Length in miles
New Hampshire.....	Concrete.....	17	64.238
	Modified asphalt.....	4	12.173
	Bituminous macadam.....	13	39.891
	Surface treated gravel.....	15	90.798
	Gravel (untreated).....	4	8.151
	Total.....	53	215.251
Rhode Island.....	Concrete.....	21	86.945
	Asphalt.....	14	42.884
	Bituminous macadam.....	27	83.461
	Waterbound macadam, surface treated.....	11	24.179
	Surface treated gravel.....	19	51.420
	Total.....	92	288.889
Connecticut.....	Concrete.....	7	27.181
	Asphalt.....	6	17.018
	Bituminous macadam.....	7	23.070
	Waterbound macadam, surface treated.....	6	26.625
	Surface treated gravel.....	7	23.596
	Total.....	33	117.490
	Total for all states.....	178	621.630

for each section are posted by years on B.P.R. Maintenance Cost Form MT-1 as shown on Table 2. It is to be noted that this form shows the dates, days of the week, and hours of the day when traffic was counted; the classification of the vehicles; the averages for the hourly periods and the average 24-hour traffic; also that the elapsed time between the counting of traffic in the morning and the afternoon on the same day of the week was six months.

traffic at stations in Connecticut affected by the opening of the Merritt Parkway is not included in this tabulation.

In order to make a comparison of the costs of maintenance for the various items, it is necessary to have a physical inventory of each section.

The description of the surfacing including the base and sub-base has been furnished by the States from construction records. The inventory had to be obtained in the field for other items such as

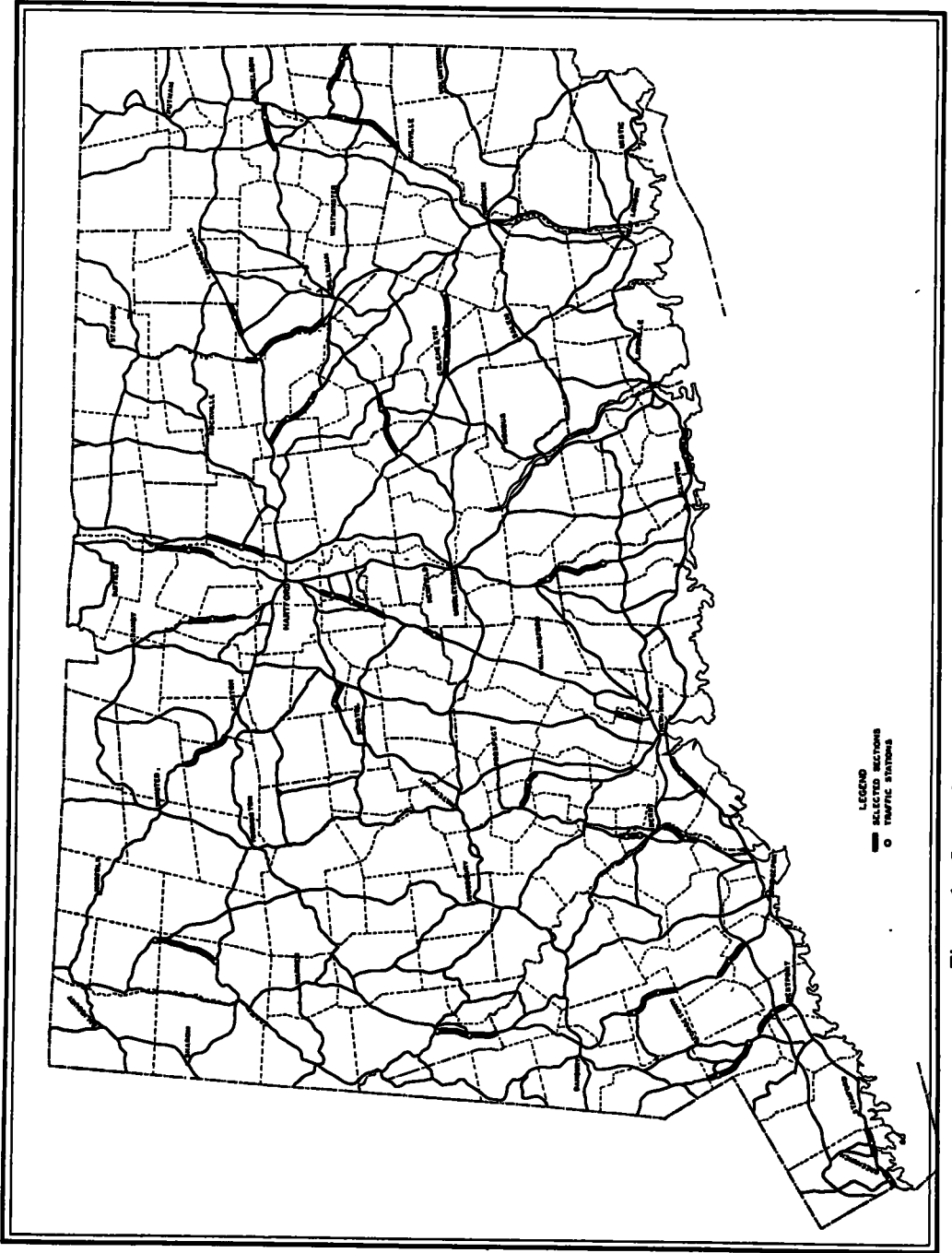


Figure 1. Connecticut Highways, Maintenance Cost Study Sections

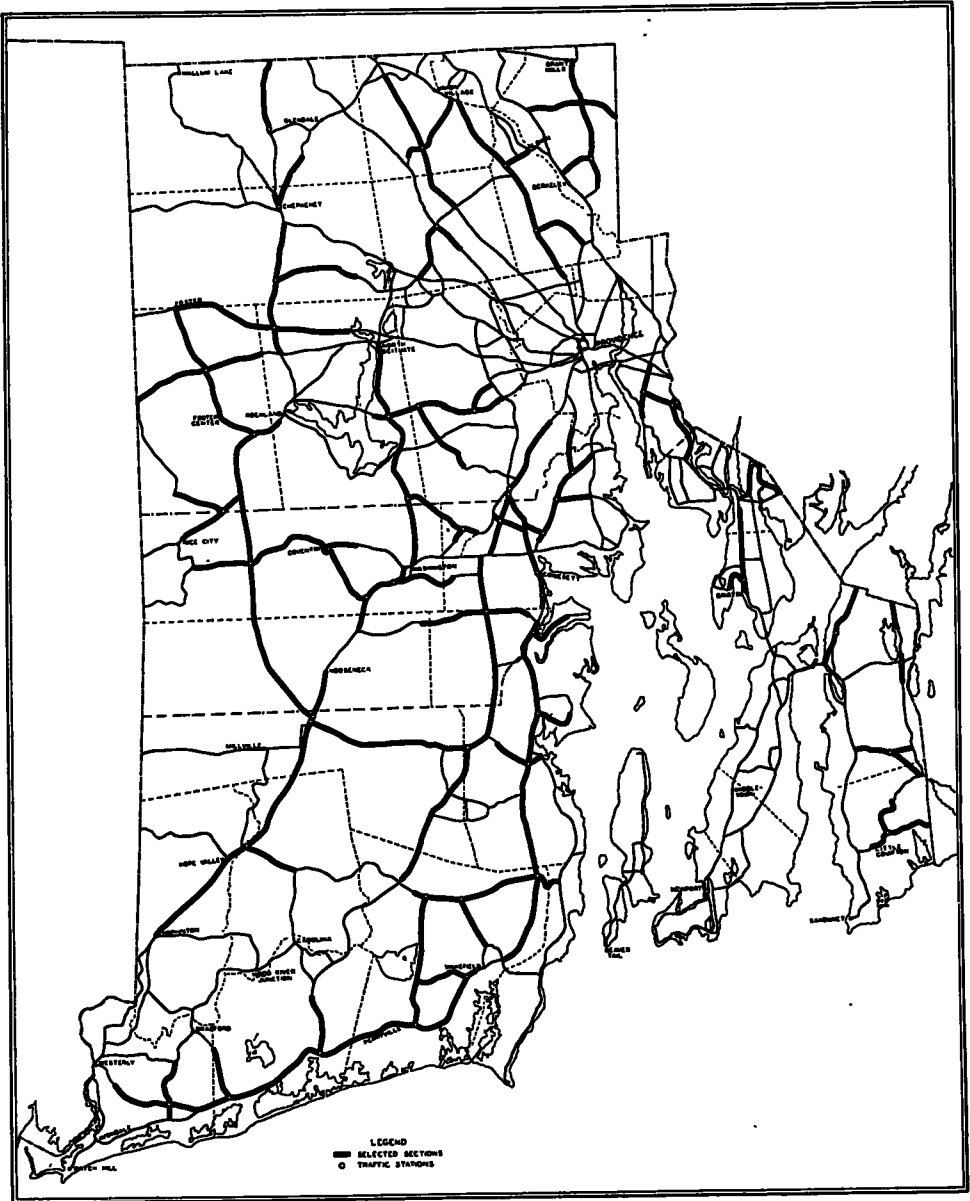


Figure 2. Rhode Island Highways, Maintenance Cost Study Sections

width of treated and untreated shoulders; size, kind, and length of culverts; type and length of guard rail; description and amount of roadside cleaning; number and kind of highway markers; and the

corrugated metal pipe, reinforced concrete pipe, cast iron pipe, or vitrified clay pipe. The side drains for private drives entering the highway are practically all corrugated metal pipe. The

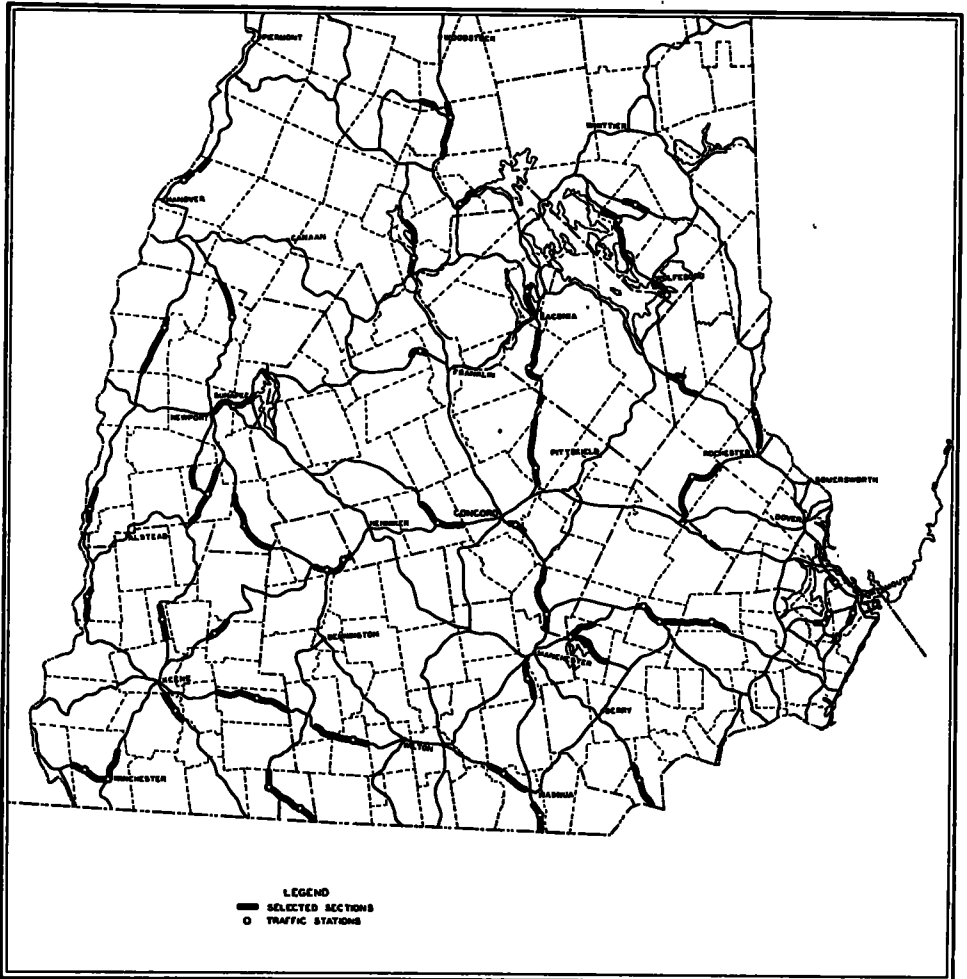


Figure 3. New Hampshire Highways, Maintenance Cost Study Sections

length of guide line painting except in New Hampshire where a record is kept by the paint department. For some of the sections the data for culverts were copied from construction plans.

The field work disclosed that transverse culverts on a section are principally

guard rail in Connecticut is cable on wooden posts for practically all sections; in Rhode Island it is almost without exception a wooden rail type; and in New Hampshire cables on wooden posts, cables on concrete posts, the wooden rail type, and during recent years posts with-

TABLE 2  
MAINTENANCE COST STUDIES

Traffic counted on		Remarks Weather—Extensive repairs— New work—Other circumstances affecting traffic	Pass. cars	Trucks*						Buses			Total vehicles
Date	Day			1½ tons and under	Over 1½ tons, under 5 tons		5 tons and over		Total	25 pass. or less	More than 25 pass.	Total	
					Type A	Type B	Type A	Type B					
HOURS 6 A. M. TO 2 P. M.													
5-2-38	Monday	Clear	1,967	113	169	5	6	54	347	7	9	16	2,330
6-23-38	Thursday	Clear	2,072	150	167	8	8	55	388	3	10	13	2,473
8-21-38	Sunday	Clear	5,280	84	39	..	..	10	133	3	26	29	5,442
10-19-38	Wednesday	Clear	1,646	126	117	7	14	59	323	6	12	18	1,987
12-10-38	Saturday	Rain	1,314	80	105	6	5	47	243	3	10	13	1,570
1-31-39	Tuesday	Snow	558	66	108	3	10	59	246	4	8	12	816
3-24-39	Friday	Clear	1,174	106	107	6	10	59	288	7	9	16	1,478
Week-day average (A)			1,483	112	133	6	10	57	318	5	10	15	1,816
Saturday average (B)			1,314	80	105	6	5	47	243	3	10	13	1,570
Sunday average (C)			5,280	84	39	..	..	10	133	3	26	29	5,442
Total average (5A+B+C)÷7			2,001	104	116	5	7	49	281	5	12	17	2,299
HOURS 2 P. M. TO 10 P. M.													
4-6-38	Wednesday	Clear entire day	1,529	89	113	5	14	77	298	3	15	18	1,845
5-28-38	Saturday	Clear entire day	5,640	129	102	4	11	53	299	5	32	37	5,976
7-26-38	Tuesday	Clear entire day	3,193	103	128	4	15	86	336	7	19	26	3,555
9-23-38	Friday	Clear entire day	3,141	130	135	5	12	74	356	6	16	22	3,519
11-14-38	Monday	Clear entire day	1,563	77	123	6	12	69	287	3	17	20	1,870
1-5-39	Thursday	Clear entire day	1,081	64	77	2	5	36	184	4	12	16	1,281
2-26-39	Sunday	Rain entire day	2,103	57	17	..	2	20	96	3	13	16	2,215
Week-day average (A)			2,102	93	115	4	12	68	292	4	16	20	2,414
Saturday average (B)			5,640	129	102	4	11	53	299	5	32	37	5,976
Sunday average (C)			2,103	57	17	..	2	20	96	3	13	16	2,215
Total average (5A+B+C)÷7			2,607	93	99	4	10	59	265	4	18	22	2,894

TABLE 2—Continued

Traffic counted on		Remarks Weather—Extensive repairs— New work—Other circumstances affecting traffic	Pass. cars	Trucks*						Buses		Total vehicles	
Date	Day			1½ tons and under	Over 1½ tons, under 5 tons		5 tons and over		Total	25 pass. or less	More than 25 pass.		
					Type A	Type B	Type A	Type B					
HOURS 10 P. M. TO 6 A. M.													
6-23-38	Thursday	Clear	469	29	76	2	4	129	240	..	3	3	712
12-10-38	Saturday	Clear 10 p. m. to 4.30 a. m. Rain 4.30 a. m. to 6 a. m.	203	8	23	16	17	41	105	..	4	4	312
Week-day average (A)			406	20	56	1	6	147	230	..	4	4	640
Saturday average (B)			537	10	23	13	27	44	117	..	8	8	662
Sunday average (C)			570	7	6	..	3	13	29	..	8	8	607
Total average (5A+B+C)÷7			448	17	44	3	8	113	185	..	5	5	638

SUMMARY

Total average 6 a. m. to 2 p. m.	2,001	104	116	5	7	49	281	5	12	17	2,299
Total average 2 p. m. to 10 p. m.	2,607	93	99	4	10	59	265	4	18	22	2,894
Total average 10 p. m. to 6 a. m.	448	17	44	3	8	113	185	..	5	5	638
Average 24-Hour Traffic	5,056	214	259	12	25	221	731	9	35	44	5,831

\* TYPE A—Single vehicles with two axles. TYPE B—Single vehicles with three axles and tractor-semitrailers with three or more axles.

TABLE 3  
MAINTENANCE COST STUDIES  
Average Twenty-Four Hour Traffic

Station No.	Maintenance cost studies section				Number of pas. cars	Number of trucks*				Number of buses			Total number of vehicles		
	Num-ber	On route No. or highway	Direction from station	Toward		Length (miles)	Total length of section	1 1/4 tons and under		Over 1 1/4 tons, under 5 tons		5 tons and over		Total	
								Type A	Type B	Type A	Type B	Type A			Type B
344	(1) Traffic census for year ending April 19, 1936. (3) Traffic census for year ending April 17, 1938. 75	U. S. 1	NE and SW	Stamford and Port Chester	.....	(2) Traffic census for year ending April 18, 1937. (4) Traffic census for year ending April 30, 1939.	1,170	631	95	500	445	2,841	27	165	19,156
							1,197	618	258	512	542	3,127	17	164	21,386
							1,093	467	155	514	612	2,841	5	126	20,346
							1,148	391	129	474	629	2,771	7	114	15,785
307	76	U. S. 6A	NW and SE	Bolton Notch and Andover	.....	(1) 1,418 (2) 1,452 (3) 2,070 (4) 2,300	113	46	4	32	15	210	25	4	1,657
							125	40	2	32	12	211	19	7	1,699
							153	37	5	33	27	255	22	3	2,350
							147	41	5	33	27	252	14	2	2,568
308	76	U. S. 6A	N.W.	Bolton Notch	.....	(1) 1,482 (2) 1,551 (3) 1,996 (4) 1,723	130	66	4	35	17	255	23	4	1,762
							145	54	4	35	22	244	19	3	2,262
							143	41	3	35	22	244	19	3	2,262
							137	34	2	31	25	229	13	3	1,968
305	77	U. S. 5A	North	Windsor Locks	.....	(1) 1,513 (2) 1,559 (3) 1,975 (4) 1,710	135	65	8	35	13	256	30	4	1,863
							157	55	4	49	17	282	22	6	1,869
							143	41	3	35	22	244	19	3	2,241
							137	34	2	31	25	229	13	3	1,955
305	77	U. S. 5A	South	Windsor	.....	(1) 3,483 (2) 3,790 (3) 4,785 (4) 4,380	290	178	49	146	94	757	86	52	4,378
							337	153	60	155	170	875	47	55	4,677
							326	130	44	97	126	728	9	55	5,572
							344	113	30	113	153	753	14	43	5,190
305	77	U. S. 5A	South	Windsor	.....	(1) 3,658 (2) 3,984 (3) 5,026 (4) 4,655	180	60	49	147	93	792	90	53	4,593
							160	60	60	160	172	945	48	57	105
							136	43	99	111	111	762	10	58	5,856
							388	117	30	114	151	800	14	47	61

\* Type A—Single vehicles with two axles. Type B—Single vehicles with three axles and tractor-semitrailers with three or more axles.



TABLE 4  
MAINTENANCE COST STUDIES  
Summary of the 24-Hour Average Number of Vehicles Passing the Traffic Stations

State	Year ending	Trucks						Buses			Total vehicles		
		Passenger cars		Over 1½ tons under 5 tons		5 tons and over		Total	25 passenger or less	More than 25 passenger		Total	
		Type A	Type B	Type A	Type B	Type A	Type B						
New Hampshire.....	3-20-1936.....	64,409	5,085	3,801	305	321	405	9,917	202	306	508	74,834	
	3-28-1937.....	72,060	5,928	4,212	348	408	768	11,664	254	349	603	84,327	
	3-27-1938.....	77,087	5,829	4,146	266	342	795	11,378	225	317	542	89,007	
	4-10-1939.....	72,196	5,859	4,259	231	304	999	11,652	223	291	514	84,362	
	Number												
	Percent												
		3-20-1936.....	100	100	100	100	100	100	100	100	100	100	100
		3-28-1937.....	112	117	111	114	127	189	118	126	114	119	113
		3-27-1938.....	120	115	109	87	107	196	115	111	104	107	119
		4-10-1939.....	112	115	112	76	95	247	117	110	95	101	113
	Connecticut.....	4-19-1936.....	97,684	8,714	4,141	789	2,988	2,660	19,292	548	1,294	1,842	118,818
		4-18-1937.....	110,950	9,657	3,797	1,263	3,446	3,534	21,697	431	1,159	1,590	134,237
4-17-1938.....		122,510	9,427	3,274	946	3,207	3,259	20,113	385	1,049	1,434	144,057	
4-30-1939.....		119,939	9,641	2,975	933	3,108	3,378	20,035	341	1,025	1,366	141,340	
Number													
Percent													
		4-19-1936.....	100	100	100	100	100	100	100	100	100	100	100
		4-18-1937.....	114	111	92	160	115	133	112	78	90	86	113
		4-17-1938.....	125	108	79	120	107	123	104	70	81	78	121
		4-30-1939.....	123	111	72	118	104	127	104	62	79	74	119

TABLE 4—Continued

State	Year ending	Passenger cars	Trucks						Buses			Total vehicles
			1½ tons and under	Over 1½ tons under 5 tons		5 tons and over		Total	25 passenger or less	More than 25 passenger	Total	
				Type A	Type B	Type A	Type B					
				Number								
Rhode Island.....	7-18-1936.....	124,007	12,800	3,131	511	1,677	645	18,764	422	1,181	1,603	144,374
	7-17-1937.....	140,346	13,815	3,529	590	1,592	908	20,434	481	1,155	1,636	162,416
	6-21-1938.....	150,271	13,260	3,136	444	1,414	951	19,205	403	1,126	1,529	171,005
	7-11-1939.....	155,689	14,843	3,277	481	1,429	1,158	21,188	379	1,218	1,597	178,474
	7-18-1936.....	100	100	100	100	100	100	100	100	100	100	100
	7-17-1937.....	113	108	113	115	95	141	109	114	98	102	113
	6-21-1938.....	121	104	100	87	84	147	102	95	96	95	118
	7-11-1939.....	125	116	105	94	85	180	113	90	103	100	124
All states.....	First year.....	286,100	26,599	11,073	1,605	4,986	3,710	47,973	1,172	2,781	3,953	338,026
	Second year.....	323,356	29,400	11,538	2,201	5,446	5,210	53,795	1,166	2,663	3,829	380,980
	Third year.....	349,868	28,516	10,556	1,656	4,963	5,005	50,696	1,013	2,492	3,505	404,069
	Fourth year.....	347,824	30,343	10,511	1,645	4,841	5,535	52,875	943	2,534	3,477	404,176
	First year.....	100	100	100	100	100	100	100	100	100	100	100
	Second year.....	113	111	104	137	109	140	112	99	96	97	113
	Third year.....	122	107	95	103	100	135	106	86	90	89	120
	Fourth year.....	122	114	95	102	97	149	110	80	91	88	120

NOTE: TYPE A—Single vehicles with two axles.  
 TYPE B—Single vehicles with three axles and tractor semi-trailers with three or more axles.

out cables or wooden rails have been erected. The kind and type of highway markers are varied; however, each State erects curve, keep single line, and side road or road intersection signs which indicate the alignment and frequent hazards created by vehicles passing on a hill or curve, or entering the highway. The guide line on some sections has been painted continuous for the entire length; on others a continuous line on curves and hills with an intermittent or no line between. The guide lines on U. S. Route No. 1 in New Hampshire have been painted double the width on other sections. White and orange are the principal colors used for guide line painting.

Due to the studies being confined to fact-finding in connection with the maintenance costs, no endeavor is being made to determine why the States have different standards and methods.

The States are performing annual maintenance to keep the selected sections in the same condition for the duration of the studies. Field inspection is being made annually to determine any variation in the degree of maintenance.

The States are furnishing reports of annual cost of general highway maintenance on each section. The forms used for reporting the cost data are shown on pages 300-301 and 304-305 of the report of the Committee on Maintenance Costs.

It is noted that maintenance costs are shown for six main divisions and subdivisions, also other data essential for an analysis of this kind.

Maintenance costs are being analyzed for each State separately and then the maintenance costs for similar items for the various States will be compared.

In order to make a comparison of the maintenance costs reported on B. P. R. Maintenance Cost Form M-1 it is necessary to select units of measurements that

can be used for each section which are as follows:

For surfacing:

- Cost per thousand square yards.
- Cost per lane mile.

For shoulders:

- Cost per thousand square yards.
- Cost per shoulder mile.

For drainage:

- Cost per hundred linear feet of ditches.
- Cost per hundred linear feet of drains.
- Cost per culvert or per hundred linear feet for culvert cleaning.

For structure repairs:

- Cost per bridge.
- Cost per culvert.
- Cost per hundred linear feet of guard rail.

For roadside cleaning:

- Cost per acre.

For traffic service:

- Cost per hundred highway markers.
- Cost per hundred linear feet of guide line painting.
- Cost per section mile for snow removal.
- Cost per section mile for ice control.
- Cost per hundred feet of snow fence.

There are other items for which proper units of measurement have been selected.

Due to the effect of traffic on the surfacing and the maintenance costs incurred being greater than on any other part of the highway, it is the most important item to be studied. In order that various and many summaries may be made, the maintenance costs for concrete surfacing are set up in the manner shown on Table 5 as an example.

It is noted that the maintenance costs for each year will be analyzed and summaries made to show the total and average cost of maintenance per thousand square yards and per lane mile for one, two, three, four, and five years. A tabulation of this kind for each section will permit the summarization of the maintenance costs for each type of surface for the first, second, third, fourth, and fifth year; also for one, two, three, four, and five years.

The next step in the analysis is to determine the effect of traffic on the sur-

TABLE 5  
MAINTENANCE COST STUDIES

Section	Town location	Year built	Length of section miles	Width of pavement lin. feet	Area of pavement sq. yds.	Traffic lane miles	For year ending	Maintenance cost										
								Cost of patching		Cost of joint and crack filling		Cost of all items						
								Total	Per 1,000 sq. yds.	Total	Per 1,000 sq. yds.	Total	Per 1,000 sq. yds.					
C1	Gilsnum	1930	2.936	20	34,444	5.872	1-31-36	\$ 0.00	.....	\$25.14	.73	\$4.28	.....	\$ 25.14	.73	\$4.28		
							1-31-37	0.00	.....	45.45	1.31	7.74	.....	45.45	1.31	7.74		
							Total for two years	.....	.....	70.59	2.04	12.02	.....	70.59	2.04	12.02		
							Annual average for two years	.....	.....	35.30	1.02	6.01	.....	35.30	1.02	6.01		
							Total for three years	.....	.....	38.44	\$1.12	\$6.55	123.97	3.60	21.11	161.41	4.72	27.66
							Annual average for three years	.....	.....	12.81	1.12	6.55	194.56	5.64	33.13	233.00	6.76	39.68
							Total for four years	.....	.....	30.75	.89	5.24	0.00	.....	30.75	.89	5.24	
							Annual average for four years	.....	.....	69.19	2.01	11.79	194.56	5.64	33.13	263.75	7.65	44.92
							Total for five years	.....	.....	17.30	.50	2.95	48.64	1.41	8.28	65.94	1.91	11.23
							Annual average for five years	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
C2	Dublin	1927	1.752	18	18,510	18.712	1-31-36	97.04	.92	5.18	95.16	.90	5.09	192.20	1.82	10.27		
							1-31-37	73.98	.70	3.96	199.29	1.88	10.65	273.27	2.58	14.61		
							Total for two years	171.02	1.62	9.14	294.45	2.78	15.74	465.47	4.40	24.88		
							Annual average for two years	85.51	.81	4.57	147.23	1.39	7.87	232.74	2.20	12.44		
							Total for three years	182.16	1.72	9.73	374.73	3.54	20.02	556.89	5.26	29.76		
							Annual average for three years	353.18	3.34	18.87	669.18	6.32	35.76	1022.36	9.66	54.64		
							Total for four years	117.73	1.11	6.29	223.06	2.11	11.92	340.79	3.22	18.21		
							Annual average for four years	1-31-39	121.51	1.15	6.49	104.10	.98	5.56	235.61	2.13	12.05	
							Total for five years	474.69	4.49	25.37	773.28	7.30	41.32	1247.97	11.79	66.69		
							Annual average for five years	1-31-40	118.67	1.12	6.34	193.32	1.83	10.33	311.99	2.95	16.67	
Total for five years	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....							

NOTE: The above amounts are used for illustrative purposes only.

facing. For this purpose the weights of the various types of vehicles traversing the highways in New Hampshire and Rhode Island have been furnished by the State-wide Highway Planning Surveys and similar information will be fur-

nished for Connecticut as soon as the field work by the surveys is completed.

Since this is a five-year study which will not be completed for another year, no results or conclusions are formulated at this time.