30th Peak Hour Factor Trend

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•ONE of the problems of forecasting future traffic volumes is how the 30th peak hour ratio to the annual average daily traffic (AADT) reacts to an increase in the AADT. Experience has indicated that the design hour volume (DHV) rate of growth is not in the same ratio as the rate of growth of the AADT, although in the Highway Capacity Manual and AASHO Policy on Geometric Design Rural Highways, the following recommendations are made:

1. "The thirtieth highest hourly volume on a percentage basis changes very little from year to year.... For example, if conditions indicate that a 20 percent rise in the annual average may be expected in 10 years, a similar 20 percent increase should be expected in the thirtieth highest hour; that is, if the facility is able to handle that much traffic." (1)
2. "Thus, the percentage of ADT for 30 HV from current traffic data on a given facility generally can be used with confidence in computing the 30 HV from an ADT volume determined for some future year. This consistency may not hold in instances where there is change in the use of the land area served by the highway. In such case, where the character and magnitude of future development can be foreseen, the relation of 30 HV to ADT may be based on experience with other highways serving areas with similar land-use characteristics." (2)

William Walker's findings showed that the earlier assumption of factor consistency was incorrect and that downward trends generally existed over the years (3).

The purpose of this study was to determine the relationship of the design hour factors to the AADT in the hope that developed trends would furnish a guide to predict future design hour factors.

DATA FOR STUDY

Sixty-nine counting stations that have been in operation in New Jersey for 10 years were selected as the basis of this study because they furnished the ADT, DHV and DHV factors. An analysis of these 69 stations indicated the following data (also see Tables 1 and 2):[1]

1. The Stations were located in all of New Jersey's 21 counties.
2. The ADT volumes ranged from 1,022 to 35,064.
3. The DHV's ranged from 200 to 4,280.
4. The DHV factors ranged from 7.6 to 71.5.
5. Sixteen locations are permanent counting stations and are counted 365 days per year.
6. Twenty-one locations are major counting stations and are counted one week out of every four.
7. Thirty-two locations are minor counting stations and are counted for one week out of every eight.
8. Thirty-six of the locations are located on rural highways and 33 locations are on urban highways.

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[1] All volumes quoted in this study are one-way volumes.

TABLE 1

GROUP	1951 A. A.D. T. RANGE	1951 A. A.D. T. AVERAGE	1951 D. H. V. RANGE	1951 D. H. V. AVERAGE	1951 D. H. V. % RANGE	1951 D. H. V. % AVERAGE	1960 A. A.D. T. RANGE	1960 A. A.D. T. AVERAGE	1960 D. H. V. RANGE	1960 D. H. V. AVERAGE	1960 D. H. V. % RANGE	1960 D. H. V. % AVERAGE
10 % LESS	29,235 3,887	13,140	2,430 350	1,310	8.3 9.3	9.0	25,550 4,929	15,450	2,480 460	1,470	8.4 12.1	9.8
10 % – 15 %	28,657 1,658	10,660	3,070 210	1,310	10.2 14.5	12.5	34,557 2,204	14,080	3,790 270	1,510	7.6 14.9	11.0
15 % – 20 %	16,425 1,161	4,400	2,920 200	760	15.2 18.8	17.1	22,115 1,489	6,150	3,100 240	820	10.9 16.4	13.4
20 % – 25 %	8,396 1,155	5,100	2,070 260	1,180	20.8 24.7	22.8	33,673 2,615	9,930	4,180 620	1,550	12.4 24.3	17.1
25 % – 30 %	8,010 1,022	4,820	2,170 280	890	25.0 29.0	26.9	12,466 1,689	6,580	2,130 290	1,350	17.1 23.8	20.7
30 % – 40 %	5,868 2,523	4,020	1,900 950	1,320	30.7 37.7	33.2	10,634 4,094	6,860	2,100 1,420	1,700	19.7 34.6	26.6
40 % – 50 %	3,007 1,426	2,000	1,490 580	910	41.0 49.6	45.0	6,321 2,223	4,270	1,870 800	1,330	29.6 35.8	32.7
50 % PLUS	2,265 1,420	1,980	1,230 850	1,070	50.4 60.0	54.9	2,967 1,379	2,130	1,180 640	870	31.7 56.8	42.8

TABLE 2

30th HOUR FACTOR GROUPS	STATIONS	PERMANENT CONTROL	MAJOR CONTROL	MINOR CONTROL	RURAL	URBAN	1951 A. D. T. GROUPS 1 – WAY: 0 to 2000	2000 to 3000	3000 to 5000	5000 to 10,000	10,000 PLUS	ROAD TYPE: 2 LANES	4 LANES	DUAL	VARIABLE
10 % LESS	7	0	6	1	2	5	0	1	1	1	4	3	2	2	0
10 % – 15 %	21	4	4	13	5	16	1	2	4	4	10	6	1	14	0
15 % – 20 %	15	5	2	8	12	3	3	4	3	4	1	10	2	2	1
20 % – 25 %	11	2	3	6	4	7	2	1	2	6	0	4	1	6	0
25 % – 30 %	5	3	1	1	4	1	1	0	2	2	0	2	0	3	0
30 % – 40 %	4	1	2	1	3	1	0	1	2	1	0	1	1	2	0
40 % – 50 %	3	0	2	1	3	0	2	0	1	0	0	2	0	1	0
50 % PLUS	3	1	1	1	3	0	1	2	0	0	0	3	0	0	0
TOTAL	69	16	21	32	36	33	10	11	15	18	15	31	7	30	1
	100%	23%	31%	46%	52%	48%	14%	16%	22%	26%	22%	45%	10%	44%	1%

GROUPING OF STATIONS

Since the design hour factor trends were the main purpose of this study the 69 locations were grouped according to their 1951 design hour factors as follows:

DHV Groups (%)	Stations in Group
10 or Less	7
10 - 15	21
15 - 20	15
20 - 25	11
25 - 30	5
30 - 40	4
40 - 50	3
50 - Plus	3

The average ADT, DHV, and DHV factors were calculated for each of the groups and the results and trends of the DHV factors are plotted in Figure 1.

Figure 2 shows the cumulative number of traffic counter locations having DHV factors of various values for 1951 and 1960. Figures 1 and 2 definitely show that the DHV factors have reduced over the 10-year period.

The yearly trend reduction rate for each group is as follows:

DHV Groups (%)	Yearly Change Trend (%)
10 or Less	+ 0.067
10 - 15	- 0.133
15 - 20	- 0.370
20 - 25	- 0.609
25 - 30	- 0.684
30 - 40	- 0.597
40 - 50	- 1.033
50 - Plus	- 1.190

From this illustration, it is clear that the reduction rate for the higher design hour factors is much greater than for the low design hour factors. These trend changes are similar to those of Walker (3).

The high design hour factor roads are generally those in sparsely populated areas. As the population and development along these roads increase, the DHV increases, but not in the same proportion as the ADT. This causes the design hour factors to decrease at their group reduction rate. When the design hour factor has reached a lower group rate, it then decreases at the new group rate. This cycle continues as the factor becomes smaller.

DETERMINATION OF REDUCTION RATE AND CURVE

To determine a trend rate of reduction for the DHV factors, a logarithmic straight-line trend was calculated based on the average DHV factors of all the groups. This trend gave a reduction rate of 2.3 percent compounded per year.

The exponential curve $Y = ab^x$, which represents a trend with a constant rate of decrease, was used to plot a curve. This curve seemed to fit the basic data reasonably; however, it approaches zero and the design hour factors can never be less than 4.2 percent of ADT.

To correct this, 4.2 was added to all points on the curve and to the basic data so that it would fit the curve (Fig. 3). This curve can be expressed by Eq. 1.

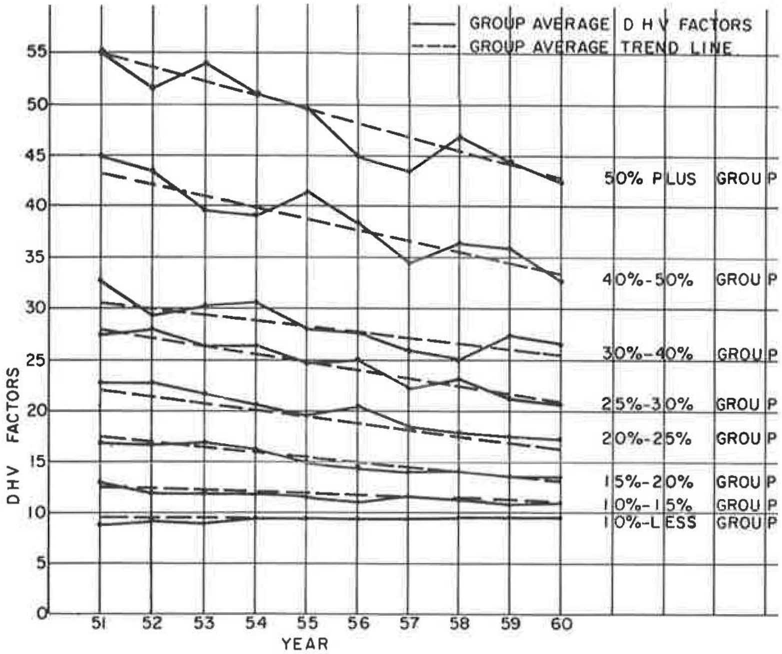

Figure 1. Group average DHV factor trends.

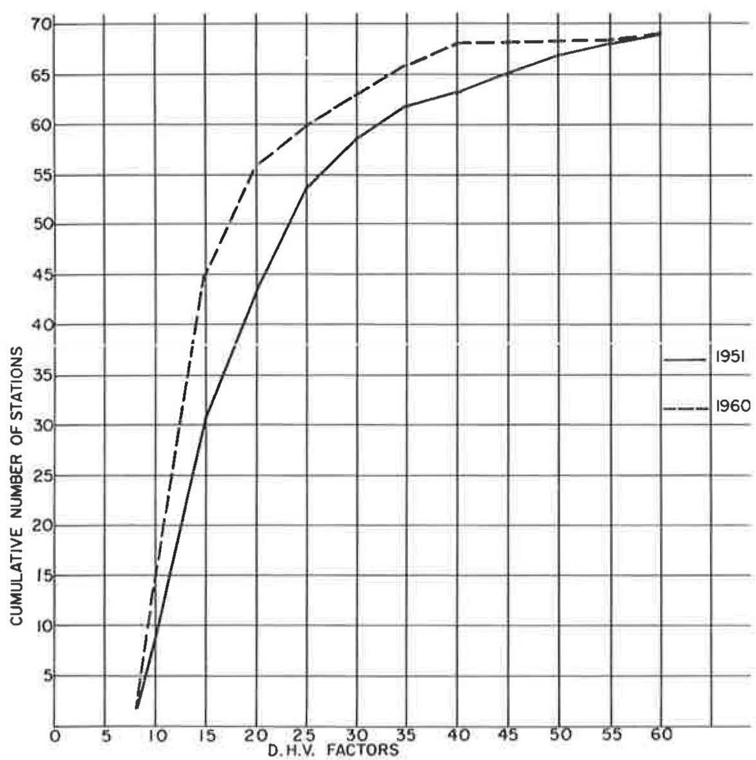

Figure 2. Cumulative number of traffic-counter stations having DHV's of various values.

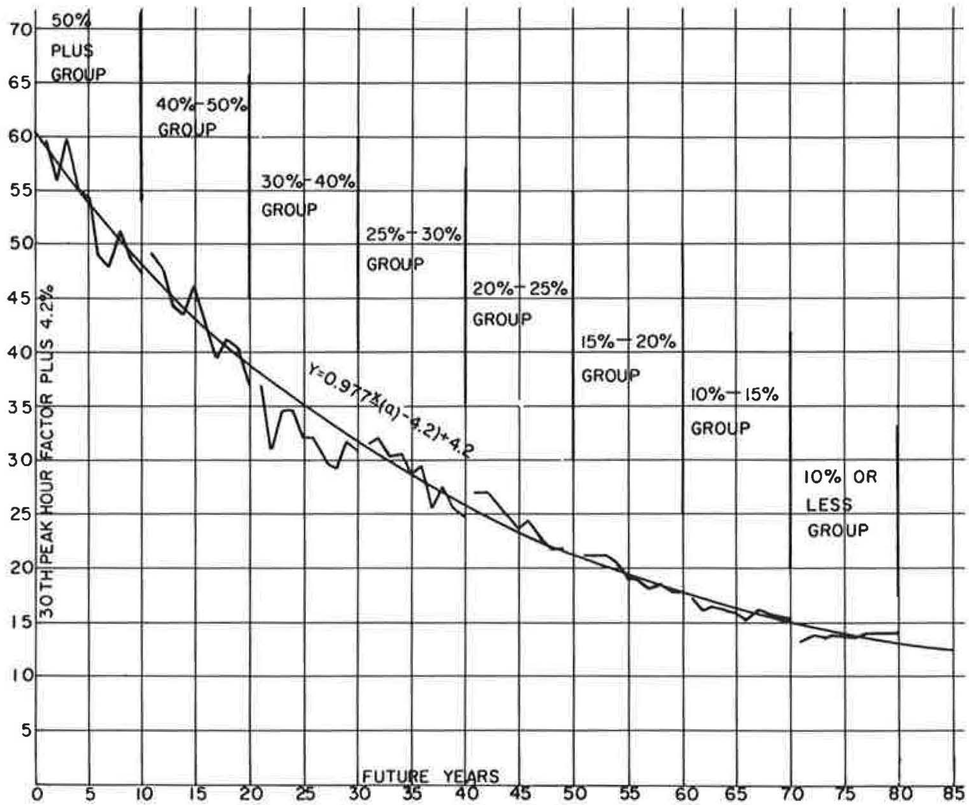

Figure 3. Trend curve and basic data.

TABLE 3
FUTURE DHV FACTORS (EQ. 1)

a	X = 5	X = 10	X = 15	X = 20	X = 25	X = 30	X = 50	X = 100
100	89.5	80.1	71.7	64.4	57.8	51.9	34.1	13.6
90	80.6	72.2	64.7	58.1	52.2	46.9	31.0	12.6
80	71.7	64.2	57.6	51.8	46.6	41.9	27.8	11.6
70	62.8	56.3	50.6	45.5	41.0	37.0	24.7	10.6
60	53.9	48.4	43.5	39.2	35.4	32.0	21.6	9.7
55	49.4	44.4	40.0	36.1	32.6	29.5	20.0	9.2
50	45.0	40.5	36.5	33.0	29.8	27.0	18.5	8.7
45	40.5	36.5	33.0	29.8	27.0	24.5	16.9	8.2
40	36.1	32.6	29.4	26.7	24.2	22.0	15.4	7.7
35	31.6	28.6	25.9	23.5	21.4	19.5	13.8	7.2
30	27.2	24.6	22.4	20.4	18.6	17.0	12.2	6.7
25	22.7	20.7	18.9	17.3	15.8	14.6	10.7	6.2
22.5	20.5	18.7	17.1	15.7	14.4	13.3	9.9	6.0
20	18.3	16.7	15.3	14.1	13.0	12.1	9.1	5.7
17.5	16.0	14.7	13.6	12.6	11.6	10.8	8.3	5.5
15	13.8	12.8	11.8	11.0	10.2	9.6	7.6	5.3
12.5	11.6	10.8	10.1	9.4	8.8	8.3	6.8	5.0
10	9.4	8.8	8.3	7.8	7.4	7.1	6.0	4.8
7.5	7.1	6.8	6.5	6.3	6.0	5.8	5.2	4.5
5	4.9	4.8	4.8	4.7	4.6	4.6	4.4	4.3

$b^{1} = 0.977$ $b^{15} = 0.705$ $b^{30} = 0.498$
$b^{5} = 0.890$ $b^{20} = 0.628$ $b^{50} = 0.312$
$b^{10} = 0.792$ $b^{25} = 0.559$ $b^{100} = 0.098$

APPLICATION OF CURVE AND REDUCTION RATE

Table 3 gives existing DHV factors and their future DHV factors for 5-yr intervals based on

$$Y = b^{x}(a - 4.2) + 4.2 \qquad (1)$$

in which

Y = future DHV factor;
b = rate of reduction (constant 0.977 based on 2.3 percent compounded);
x = number of future years; and
a = existing DHV factor.

DHV FACTORS VS ADT

To determine the magnitude of the 30th peak hour factors for various volumes of traffic, the 69 counting locations were grouped as follows:

One-Way ADT Group	No. of Stations
2,000 or Less	10
2,000 - 3,000	11
3,000 - 5,000	15
5,000 - 10,000	18
10,000 - Plus	15

The average DHV factors of each group were calculated and the results are as follows (also see Fig. 4):

One-Way ADT Group	DHV (%)		Change	
	1951	1960	10-Year	Annual
2,000 or Less	28.3	21.1	- 7.2	- 0.7
2,000 - 3,000	25.8	18.8	- 7.0	- 0.7
3,000 - 5,000	21.5	16.8	- 4.7	- 0.5
5,000 - 10,000	19.7	15.2	- 4.5	- 0.5
10,000 - Plus	11.8	10.3	- 1.5	- 0.15

The following gives the DHV factor range for each ADT (one-way) group in 1951 and 1960 and the average DHV factor (also see Fig. 5):

One-Way ADT Group	DHV (%)			
	1951		1960	
	Range	Average	Range	Average
2,000 or Less	60.0 - 12.6	28.3	56.8 - 12.1	21.1
2,000 - 3,000	54.4 - 12.7	25.8	39.9 - 9.4	18.8
3,000 - 5,000	49.6 - 9.1	21.5	29.6 - 9.1	16.8
5,000 - 10,000	32.4 - 9.2	19.7	22.2 - 8.7	15.2
10,000 - Plus	17.8 - 8.3	11.8	14.0 - 7.6	10.3

Figures 4 and 5 show that the high design hour factors are on low-volume roads, and high-volume roads do not have high design hour factors. However, Figure 5 indicates that it is possible for both high and low volumes to have low design hour factors.

DHV FACTORS VS POPULATION CHANGES

Since it was felt that the population of the area might influence the DHV factor, an analysis was made at the 69 counting stations of the change in population and DHV factors. The population figures used were both those of the municipality and the county in which the counting station was located. Figures 6 and 7 indicate that an increase in population was accompanied by a decreased DHV factor. Samples of decreased population are too few to be significant (Table 4).

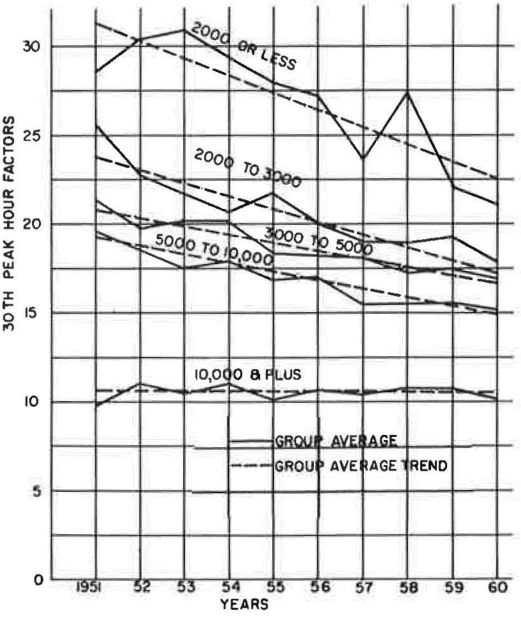

Figure 4. ADT group DHV factor trends.

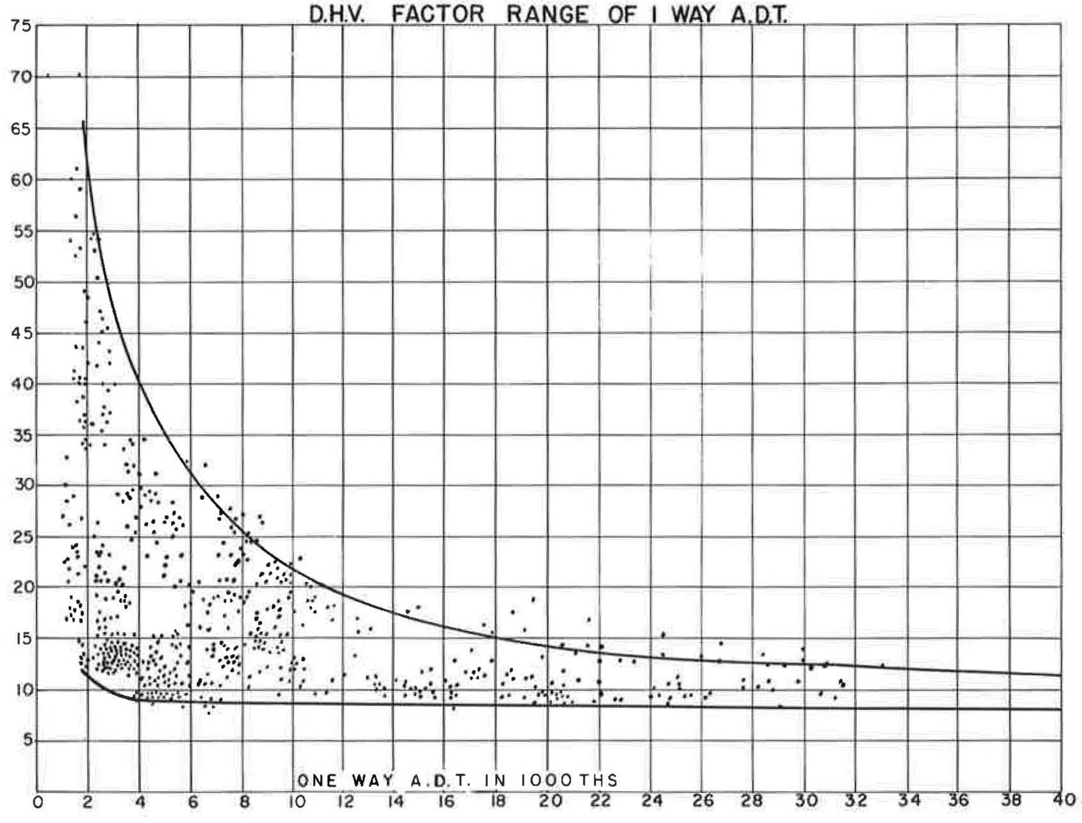

Figure 5. DHV factor range of one-way ADT.

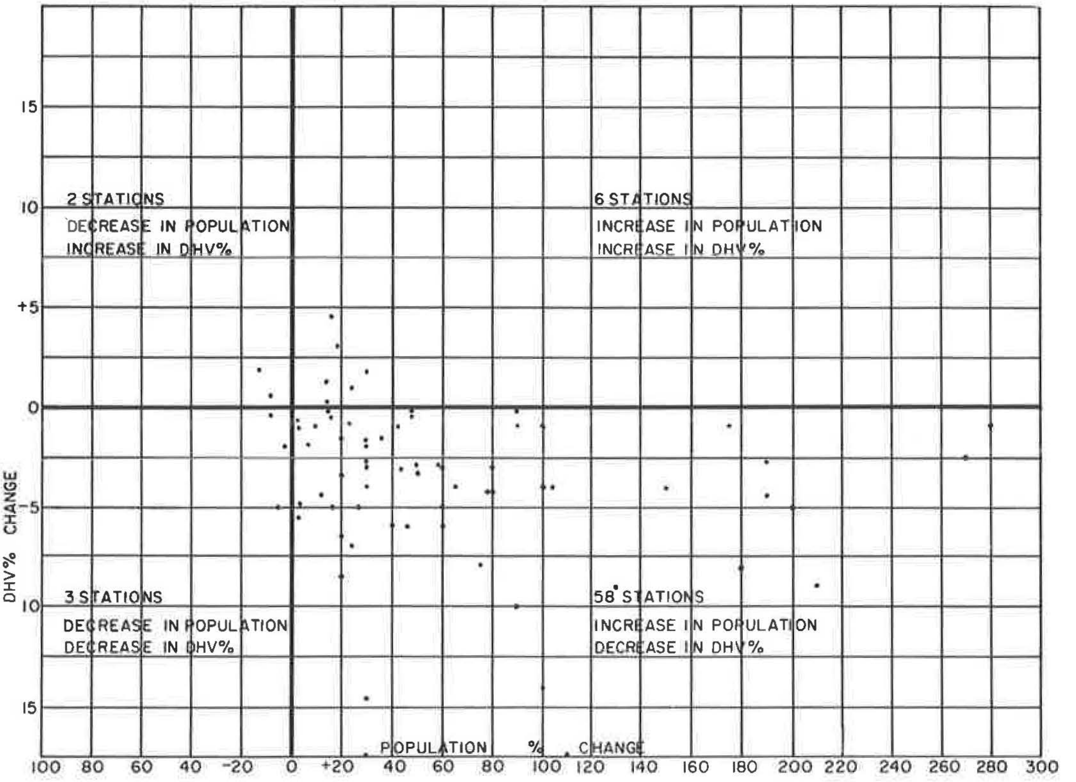

Figure 6. Ten-year DHV percent change vs ten-year population change of station municipality.

The average DHV factor and population of the station municipality for each DHV factor group was calculated for 1951 and 1960 (Fig. 8). The results also support the theory that a change in population of the area influences the DHV factors.

DHV FACTORS VS ROADWAY CAPACITY

To determine if the capacity of the roadway had any influence on the DHV factors, the satisfactory capacity and the tolerable capacity were determined for each of the 69 counting locations used in this study. (Satisfactory capacity is a level of service with 750 cars per hour one way on a 2-lane road and 1,950 cars per hour on 2 lanes of a 4-lane road; tolerable capacity is a level of service with 1,000 cars per hour on one way of a 2-lane road and 2,400 cars per hour on one way of a 4-lane road.) Having the yearly DHV for each location, the number of locations over or under these capacities was found for 1951 and 1960 (Table 5).

An analysis of the 69 locations indicated that the capacities had little influence on the DHV factors. Those over or under either of these capacities reacted like their respective group's DHV factors.

If the theory that capacities influenced the DHV factor is correct to any extent, then DHV factors would increase as the ADT decreased. This is not so.

Table 6 gives such locations. It is clear that the DHV factors were reduced as well as the ADT and DHV, indicating that capacity had little influence on the DHV factors.

Table 7 gives locations with increases in ADT and emphasizes the fact that the DHV does not increase in the same proportion as the ADT, which is the chief reason for the DHV factors decreasing.

The present recommended method of determining future DHV's is to apply the present DHV factors to the predicted future ADT.

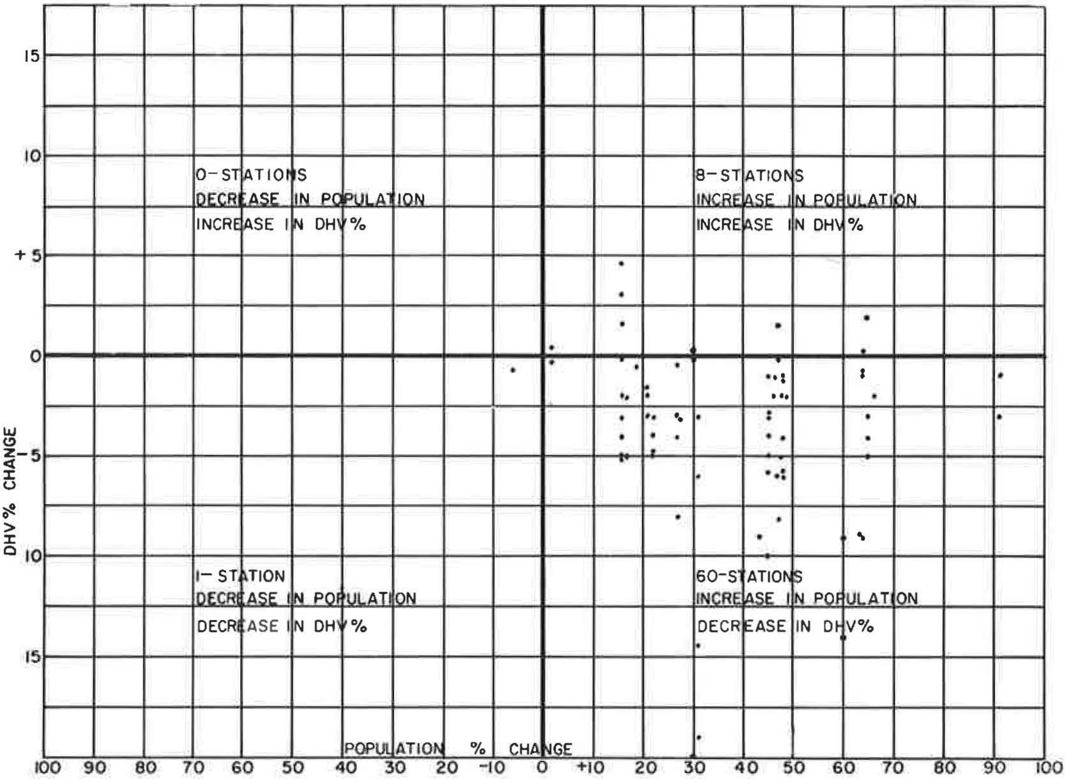

Figure 7. Ten-year station DHV percent change vs ten-year population change of station county.

TABLE 4

DHV FACTORS VS POPULATION CHANGES

DHV Factor Group (%)	Station (No.)	10-Yr Population Increase		10-Yr Population Decrease	
		DHV Factor Increase	DHV Factor Decrease	DHV Factor Increase	DHV Factor Decrease
10 - Less	7	3	2	2	0
10 - 15	21	2	17	0	2
15 - 20	15	0	15	0	0
20 - 25	11	1	9	0	1
25 - 30	5	0	5	0	0
30 - 40	4	0	4	0	0
40 - 50	3	0	3	0	0
50 - Plus	3	0	3	0	0
Total	69	6	58	2	3

Because this study indicated that the DHV factors reduce and do not remain constant, a comparison is made of the 1960 actual DHV's with the predicted 1960 DHV's by both methods at the 69 locations used in this study and at 19 locations that have been in operation only seven years.

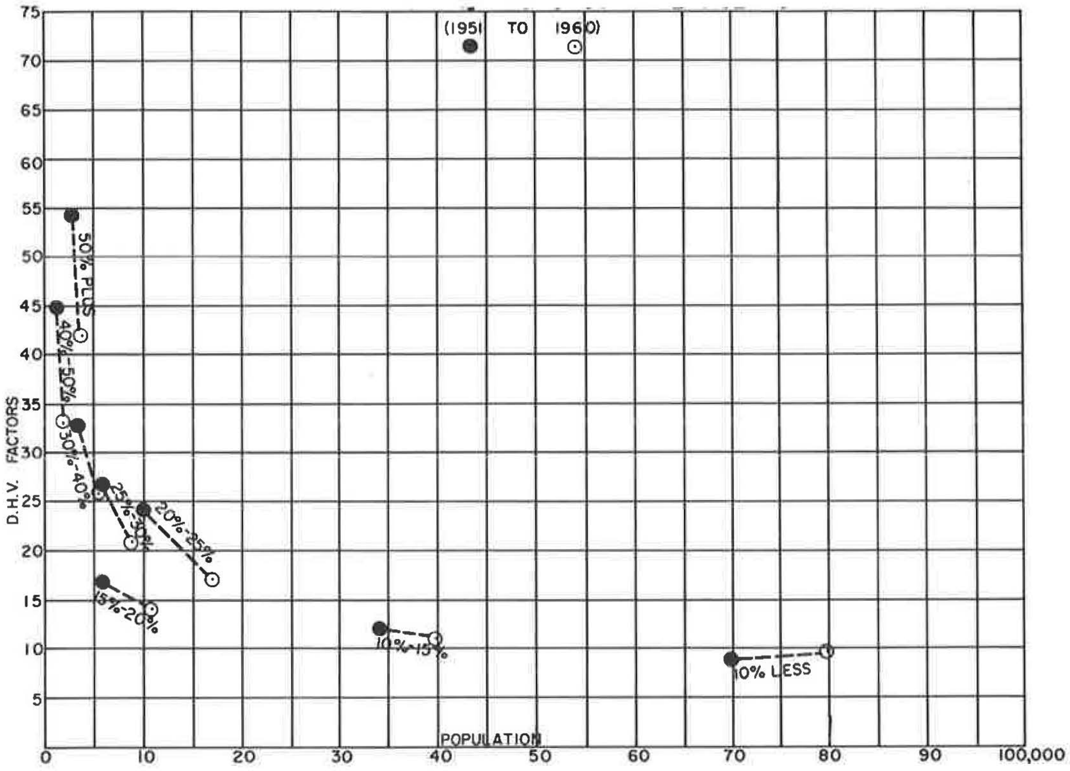

Figure 8. Group average DHV percent vs group average population.

TABLE 5

LOCATIONS OVER SATISFACTORY OR TOLERABLE CAPACITY

D. H. V. % GROUP	NO. OF STAS.	1951								1960							
		SATISFACTORY CAPACITY				TOLERABLE CAPACITY				SATISFACTORY CAPACITY				TOLERABLE CAPACITY			
		OVER	%	UNDER	%	OVER	%	UNDER	%	OVER	%	UNDER	%	OVER	%	UNDER	%
10 % LESS	7	2	29	5	71	1	14	6	86	3	43	4	57	1	14	6	86
10 % – 15 %	21	6	29	15	71	3	14	18	86	9	43	12	57	5	24	16	76
15 % – 20 %	15	2	13	13	87	2	13	13	87	2	13	13	87	1	7	14	93
20 % – 25 %	11	4	36	7	64	0	–	11	100	4	36	7	64	1	9	10	91
25 % – 30 %	5	2	40	3	60	1	20	4	80	2	40	3	60	1	20	4	80
30 % – 40 %	4	1	25	3	75	0	–	4	100	2	50	2	50	1	25	3	75
40 % – 50 %	3	0	0	3	100	0	–	3	100	1	33	2	67	0	–	3	100
50 % PLUS	3	3	100	0	–	2	67	1	33	2	67	1	33	1	33	2	67
TOTAL	69	20	29	49	71	9	13	60	87	25	36	44	64	11	16	58	84

TABLE 6

LOCATIONS WITH DECREASES IN ADT AND A DECREASE IN DHV FACTORS

US 1, New Brunswick, Middlesex County	1951	1952
ADT (1 way)	21,443	16,105
DHV factor	11.0	10.4
DHV (1 way)	2,360	1,670
US 130, Pennsauken, Camden County	1951	1952
ADT (1 way)	11,953	9,432
DHV factor	11.6	9.6
DHV (1 way)	1,390	910
US 130, Bordentown, Burlington County	1951	1952
ADT (1 way)	10,083	5,636
DHV factor	12.1	9.5
DHV (1 way)	1,220	540
US 130, E. Windsor, Mercer County	1951	1952
ADT (1 way)	8,670	4,823
DHV factor	12.4	10.1
DHV (1 way)	1,080	490
US 9, Pine Beach, Ocean County	1954	1955
ADT (1 way)	3,261	2,951
DHV factor	20.1	17.2
DHV (1 way)	660	510
US 9, Freehold, Monmouth County	1953	1954
ADT (1 way)	4,391	3,901
DHV factor	26.4	25.4
DHV (1 way)	1,160	990
N.J. 35, Middletown, Monmouth County	1954	1955
ADT (1 way)	9,429	9,307
DHV factor	17.4	14.5
DHV (1 way)	1,640	1,350
N.J. 35, Brielle, Monmouth County	1954	1955
ADT (1 way)	6,941	6,310
DHV factor	19.6	17.9
DHV (1 way)	1,360	1,130
N.J. 33 and 34, Wall Monmouth County	1954	1955
ADT (1 way)	7,084	6,202
DHV factor	27.4	24.5
DHV (1 way)	1,940	1,520

TABLE 7

LOCATIONS WITH INCREASES IN ADT AND A DECREASE IN DHV FACTORS

Garden State Parkway, Clark, Union County	1952	1960
ADT (1 way)	8,519	33,673
DHV factor	20.3	12.4
DHV (1 way)	1,730	4,180
N.J. 4, Paramus, Bergen County	1951	1960
ADT (1 way)	18,393	31,240
DHV factor	11.8	9.3
DHV (1 way)	2,170	2,910
US 22, Hillside, Union County	1950	1960
ADT (1 way)	20,580	31,511
DHV factor	12.0	10.1
DHV (1 way)	2,470	3,180
US 206, Bordentown, Burlington	1951	1960
ADT (1 way)	7,221	10,953
DHV factor	12.4	9.7
DHV (1 way)	900	1,060
US 46, Clifton, Passaic County	1951	1960
ADT (1 way)	12,424	21,976
DHV factor	13.4	10.8
DHV (1 way)	1,660	2,370
N.J. 3, Clifton Passaic County	1951	1960
ADT (1 way)	17,259	30,802
DHV factor	14.2	12.3
DHV (1 way)	2,450	3,790
N.J. 69, Hopewell, Mercer County	1951	1960
ADT (1 way)	3,064	4,231
DHV factor	15.2	10.9
DHV (1 way)	470	460
N.J. 18, Madison, Middlesex County	1951	1960
ADT (1 way)	3,409	7,362
DHV factor	22.1	13.6
DHV (1 way)	750	1,000
US 46, Ledgewood, Morris County	1951	1960
ADT (1 way)	8,010	12,466
DHV factor	27.1	17.1
DHV (1 way)	2,170	2,130
N.J. 23, Pequannock, Morris County	1951	1960
ADT (1 way)	5,868	10,634
DHV factor	32.4	19.7
DHV (1 way)	1,900	2,090
N.J. 73, Voorhees, Camden County	1951	1960
ADT (1 way)	3,007	6,321
DHV factor	49.6	29.6
DHV (1 way)	1,490	1,870

The following are the results of that comparison, showing at how many locations the predicted DHV's were closest to the actual DHV:

No. of Actual DHV Locations		Trend Method	No Change Method
1951 - 1960	69	50	19
1953 - 1960	19	13	6
Total	88	63	25

This clearly indicates that predicting the future DHV by use of the trend curve, developed by this study, is a more reliable method than the no change method.

CONCLUSIONS

1. The 30th peak hour factors generally decline as the AADT increases.
2. The reduction rate for high 30th peak hour factors is much greater than for low 30th peak hour factors.
3. Low population and sparsely developed areas, on the average, have a high 30th peak hour factor. Any marginal growth, such as housing developments, industry, or shopping centers, tends to lower the design hour factors.
4. Population changes in an area influence the DHV factors accordingly; an increase in population decreases the factors.
5. The capacity of a roadway has no great influence on the DHV factors or the rate of change. It is the increase in ADT due to the increase in the off hours that tends to reduce the DHV ratio to the ADT. Nevertheless, it is recognized that logically, when the potential 30th peak hour volume greatly exceeds the possible (absolute) capacity (such as may be experienced when the number of lanes are reduced for construction), the 30th peak hour factor may be reduced. But this is not supported by the study. This degree of over capacity condition has not been permitted to persist in New Jersey; therefore, this theory could not be tested.

REFERENCES

1. "Highway Capacity Manuel." U.S. Dept. of Commerce, Part VIII, 140-42 (1950).
2. "Policy on Geometric Design Rural Highways." AASHO, p. 56 (1954).
3. Walker, W.P., "Trends in the 30th-Hour Factor." HRB Bull. 167, 75-83 (1957).

Appendix

APPLICATION OF REDUCTION CURVE

To determine design hour factor for any future year when existing factor is known:

1. Locate the existing DHV factor on the curve (Fig. 9) and determine the year at this point.
2. This year point plus the number of future years for which the DHV factor is desired will locate the point on the curve where the future DHV factor can be read.

EXAMPLE

Existing DHV factor 50%.
What will it be in 20 yr?
1. Under 50% point on curve the year 15 is located.
2. 15 + 20 = 35
Above the year 35 the DHV factor of 33% is found.
Therefore, if the existing DHV factor is 50% in 20 yr hence it will be 33%.

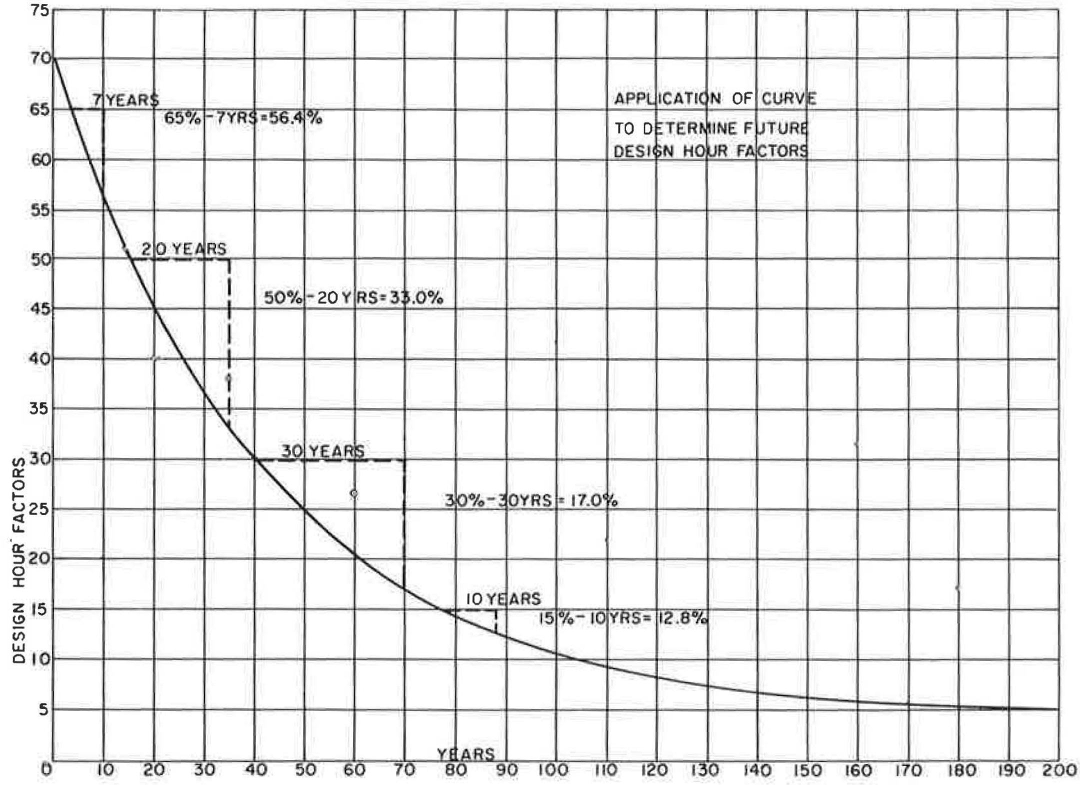

Figure 9. Modification of 2.3 percent reduction curve to approach 4.2 percent.

ESTIMATING THE 30TH PEAK HOUR

Four representative weekly counts of 168 hr each, one for each of the four seasons of the year, are selected as samples for each control counting station. The hourly volumes of traffic are then tabulated on a frequency table in an array arranged in convenient volume classes from the highest to the lowest volume. Since these four weeks of counts account for 672 hr, the total number of hours in each volume class is expanded by using a factor of 13. The total number of expanded hours then becomes 8, 736 hr, which is 24 hr short of the number of hours in a 365-day year.

The average volume for each class is divided by the AADT for the station and percentages are computed for use as ordinates on the final graph. These ordinates are plotted against abscissas derived from an array of the accumulated hours from the 13th to the 8, 736th hour.

The 30th peak hour is then estimated from the curve that was produced on the graph.