Accidents and Operational Characteristics on Arterial Streets with Two-Way Median Left-Turn Lanes

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The need to expedite through traffic and still provide adequate access to abutting properties resulted in the installation of the first two-way median left-turn lane (2WLTL) by the City of Seattle Traffic Engineering Division in November 1952. Since that time more than twelve 2WLTL's have been installed.

Brief studies conducted by the Division indicated that the 2WLTL's facilitate the movement of through traffic and provide a high degree of access service, yet their use has not resulted in an increase in traffic accidents.

Because the 2WLTL appears to be a useful and effective tool to the traffic engineer, and because its use is not very widespread, it was felt that a detailed accident study on arterials utilizing 2WLTL's was in order as well as an operational study of the 2WLTL with respect to the volume and manner of vehicles using it.

This study considered the effect of the 2WLTL on accident experience along streets serving commercial and industrial areas. Trends in accidents, accident rates, type of motor-vehicle collisions, and accident severity were considered. The report indicates that proper use of the 2WLTL can aid in the reduction of accidents or at least help to attenuate increases in accidents when traffic volume and property development increase.

The 2WLTL is not an accident hazard by itself, because accidents involving the 2WLTL are few in number. Furthermore, although it may be used by traffic in opposing directions of travel, head-on accidents on it are virtually nil. Property damage and injury appear to be less severe for the 2WLTL than for non-2WLTL accidents.

The operations studies showed that the 2WLTL on the arterial through an industrial area was used by 3 percent of the traffic, but on the arterial adjacent to a shopping center and commercial development the 2WLTL was used by 23 percent of the traffic. This latter study also showed that a greater length of the 2WLTL was used for left-turn maneuvering during rush hours than off-peak hours, and that out-of-county drivers used substantially less length of the lane.

The observations showed a need for investigation into more effective signing and/or marking of the 2WLTL in order to insure its proper use by unfamiliar drivers.

In addition to providing for midblock and intersection left turns, the 2WLTL also provides for refuge and separation functions. In actual operation it is used for many of the emergency functions of a median shoulder area, including detour routes when utility cuts and street maintenance are necessary. The lane also allows for easier movement of emergency vehicles, particularly during peak hours.

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There are situations that require the use of a conventional median with unidirectional left-turn lanes. However, under certain conditions the 2WLTL may provide a better design in terms of traffic service and economy of construction.

• THE uncontrolled left turn is closely related to the problems of highway safety and the facilitation of through-traffic flow. The attempted solution to the problems caused by vehicles turning left usually has been either the partial or complete prohibition of left turns or some form of median control and/or channelization of left-turn lanes. However, there are situations where these practices do not offer a satisfactory solution to the problem. Recognizing this fact, the Traffic Engineering Division of Seattle evolved a new method for dealing with left-turn traffic, the two-way median left-turn lane (2WLTL). A 2WLTL consists of a median area delineated only by paint lines and/ or traffic buttons, which may be used by traffic in either direction for making left turns. Left turns may be made from any point along the 2WLTL. Such an installation should not be confused with the conventional, unidirectional median utilizing left-turn lanes where prohibited areas are set off with raised barriers, dividers, or paint lines (Fig. 1A).

The major function of a 2WLTL is to provide a deceleration and storage lane for left turns to minor generators, including both legal streets and abutting properties. Secondary functions of the 2WLTL are the separation of opposing traffic flows, an acceleration lane for vehicles turning left onto the arterial from minor streets and abutting properties, a pedestrian refuge, and an emergency lane for breakdowns or for use by emergency vehicles.

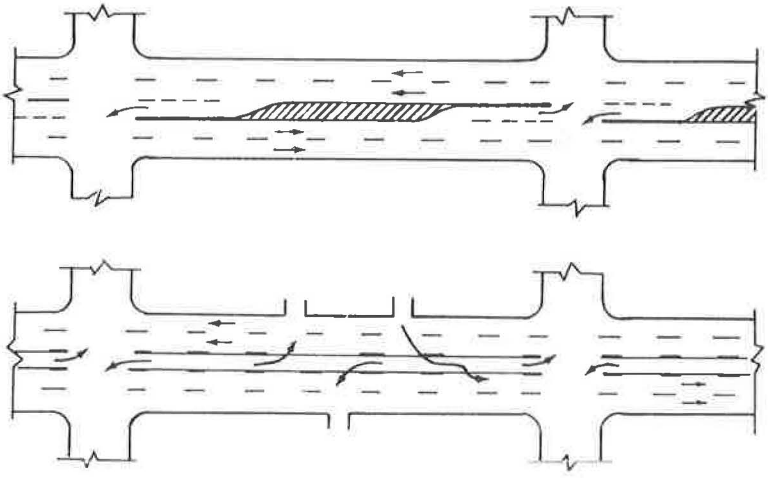
The 2WLTL has been used in Seattle in order to reduce accidents and delay on arterial streets traversing areas where several or all of the following conditions exist: (a) high-volume multilane streets; (b) strip commercial and/or industrial development of small individual vehicle generation; (c) a lack of, or inadequate, cross and parallel streets for around-the-block movements; and (d) adequate distance between arterial intersections.

In many cases the conventional median with left-turn lanes is most desirable. A 2WLTL might be more satisfactory, however, where there is a need for providing access to abutting property from both directions, but the pattern of the locations of the driveways leading to and from the off-street parking areas makes the conventional raised median (or a median with prohibited areas designated by paint lines) impractical. Such would be the case, for example, along a street with various commercial, industrial, or professional buildings with their own off-street parking areas; the parking entrances and exits being staggered so that they are neither uniformly located or closely spaced along the street. A conventional median with openings to provide for this situation would present a rather confusing pattern to the motorist.

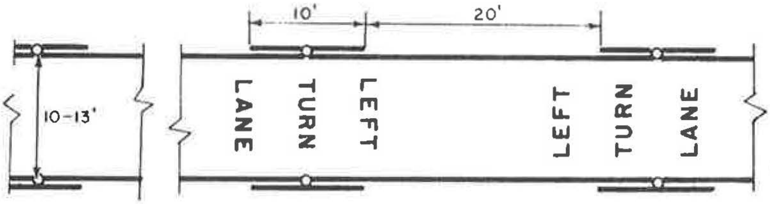
Another possible use of the 2WLTL might be in a situation where cross streets are rather far apart, or there are no parallel streets and midblock left turns from through lanes are undesirable. In this instance, an excessive amount of travel and delay is created by around-the-block movements needed to effect the left turn.

Another condition for use of the 2WLTL would be an arterial with frequent cross streets and streets parallel to the arterial traverse areas where high traffic volumes are undesirable, such as schools, hospitals, or single-dwelling residential areas. The cross and parallel streets may also be substandard with respect to the handling of large commercial vehicles.

Adequate signing and marking of the 2WLTL are necessary in order to insure proper use of the facility and minimize confusion to out-of-town drivers and other motorists not familiar with the 2WLTL. Several signing methods for 2WLTL's have been used by the Seattle Traffic Engineering Division: (a) overhead signs installed on span wire, 18 by 18 in., double-faced with the legend, "TWO WAY LEFT TURN LANE"; and (b) post-mounted signs, 2 by 3 ft, placed about 2 ft above the pavement in medial island areas bearing the legend, "BEGIN TWO WAY LEFT TURN LANE" (these signs are subject to repeated damage unless placed with proper clearance in raised traffic islands). In addition, all installations have "LEFT TURN LANE" painted on the medi-



A. Conventional median with unidirectional left-turn lanes (upper figure) and a two-way median left-turn lane (lower figure).



B. Paint striping and legend for two-way median left-turn lane.

Figure 1. Conventional unidirectional left-turn lane and two-way median left-turn lane.

an lane and facing both directions. The 2WLTL is bounded by solid lines painted parallel to dashed lines. Spherical traffic buttons $2\frac{3}{4}$ in. high and 12 in. in diameter are placed on 40- to 80-ft centers on both double paint lines—latest standard is 100-ft spacing (Fig. 1B).

The clear width of the median lane should be 10 to 13 ft.

Installations of the 2WLTL in Seattle are shown in Figures 2, 3, 4, and 5. The major uses are in strip industrial and commercial areas and on arterials serving shopping centers (Figs. 2 and 3). Many installations have been made by converting arterials with 6 narrow lanes to streets with 4 wider through lanes and the 2WLTL. In some cases, curb parking was prohibited in order to provide wider through lanes and the 2WLTL.

Figure 4 shows before-and-after views of a 2WLTL installation on an arterial serving an outlying shopping center. At the bottom, the existing inside lane to the right of the center line has been marked off as the 2WLTL and the shoulder has been paved over to become the new outside lane. However, many of the 2WLTL's have been added without constructing new lanes. Ordinarily, installation of a 2WLTL costs less than construction of a series of unidirectional left-turn lanes.

Figure 5 shows examples of signing and marking for the 2WLTL. Figure 5A shows the signs placed at the beginning and end. These signs have also been used when the

1st Ave. S.

East Marginal Way

15th Ave. W.

N.W. Market St.

Figure 2. 2WLTL installations serving industrial and commercial areas.

2WLTL is interrupted by a unidirectional left-turn lane. The signs are set in small medial islands demarcated by traffic buttons. They are less likely to sustain damage, however, when placed on raised islands as in Figure 5B. Paint marking and button placement for the lane are shown in 5C. Note the use of the legend, "LEFT TURN LANE." This legend is always placed in a back-to-back manner so that it can be read from both directions of travel.

Sacramento County, Calif., which made some use of the 2WLTL, uses somewhat different methods of signing and marking (1).

Figure 3. 2WLTL installation serving a boating marina and beach area.

ACCIDENT STUDY

The major purpose of this investigation was to study and compare the number, types, and severity of accidents occurring on sections of arterial streets before and after the installation of 2WLTL's.

Site Selection

It was deemed desirable to study only those installations where a minimum of change in traffic volume, traffic control, or adjacent land use had occurred for some time before and after the installation of the 2WLTL. In this way the effect of the 2WLTL itself on traffic accidents could be better determined. A second criterion of site selection was that accident data be available for several years before as well as after the installation. The danger of drawing conclusions from a one-year before-and-after study is appreciated when one considers the following situation: Suppose that one-year before-and-after studies of a certain traffic-control measure show a 15 percent decrease in accidents after one year's use. Although this may seem to be a significant change, it loses its significance when further investigation shows that for several years before installation, the annual number of accidents had been decreasing at the rate of 15 to 20 percent per year. A third criterion was that the 2WLTL be of sufficient length. A relatively fewer total number of accident occurrences on one-and two-block 2WLTL's precluded their use.

From more than a dozen 2WLTL installations, two were selected for detailed accident analysis, and a third site was chosen for a study of only those accidents involving the use of the 2WLTL. The two installations selected for detailed study were those on Airport Way and 4th Avenue South. These 2WLTL sites are located in the industrial area of Seattle where various light and heavy industrial plants, warehouses, and trucking terminals are located. A part of the area served by these streets and close-ups of the streets and typical establishments located along them are shown in Figures 6 and 7. Characteristics of these installations are given in Table 1.

All cross streets along Airport Way and 4th Ave. S. are dead-ended by railroad tracks, except for two cross streets. Airport Way also lies beside a steel hill (Fig. 6B). Thus around-the-block movements cannot be used to effect left turns, making the use of a 2WLTL highly desirable. Fourth Ave. S. originally had a raised median varying from 2½ to 5 ft in width (slightly wider where unidirectional left-turn lanes were located) before the 2WLTL was installed. There were median openings at intersections and also a few midblock openings. Sketches of sections of Airport Way and 4th Ave. S. both before and after installation of the 2WLTL are shown in Figure 8. A unidirectional left-turn lane was added at each of the two major intersections on Airport

Before

After

Before

After

Figure 4. 2WLTL installations serving an outlying shopping center.

Way when the 2WLTL was installed and four unidirectional left-turn lanes were maintained at two intersections on 4th Ave. S.

Volume flow rates for Airport Way and 4th Ave. S. are shown in Figs. 9 and 10, respectively. The weekday traffic volume pattern is essentially constant along the two 2WLTL installations. Peak-hour volumes on these two arterials are approximately 2,500 vehicles. A 16-hr vehicular classification count for Airport Way is given in Table 2. The percentages of various commercial vehicles are similar on 4th Ave. S.

Airport Way satisfies all three criteria of study-site selection. Fourth Ave. S., however, does not fulfill the one requirement of several years' accident experience after installation of the 2WLTL. However, it was believed that a study of the 4th Ave. S. site was worthwhile, and that the study could be updated after several more years of experience.

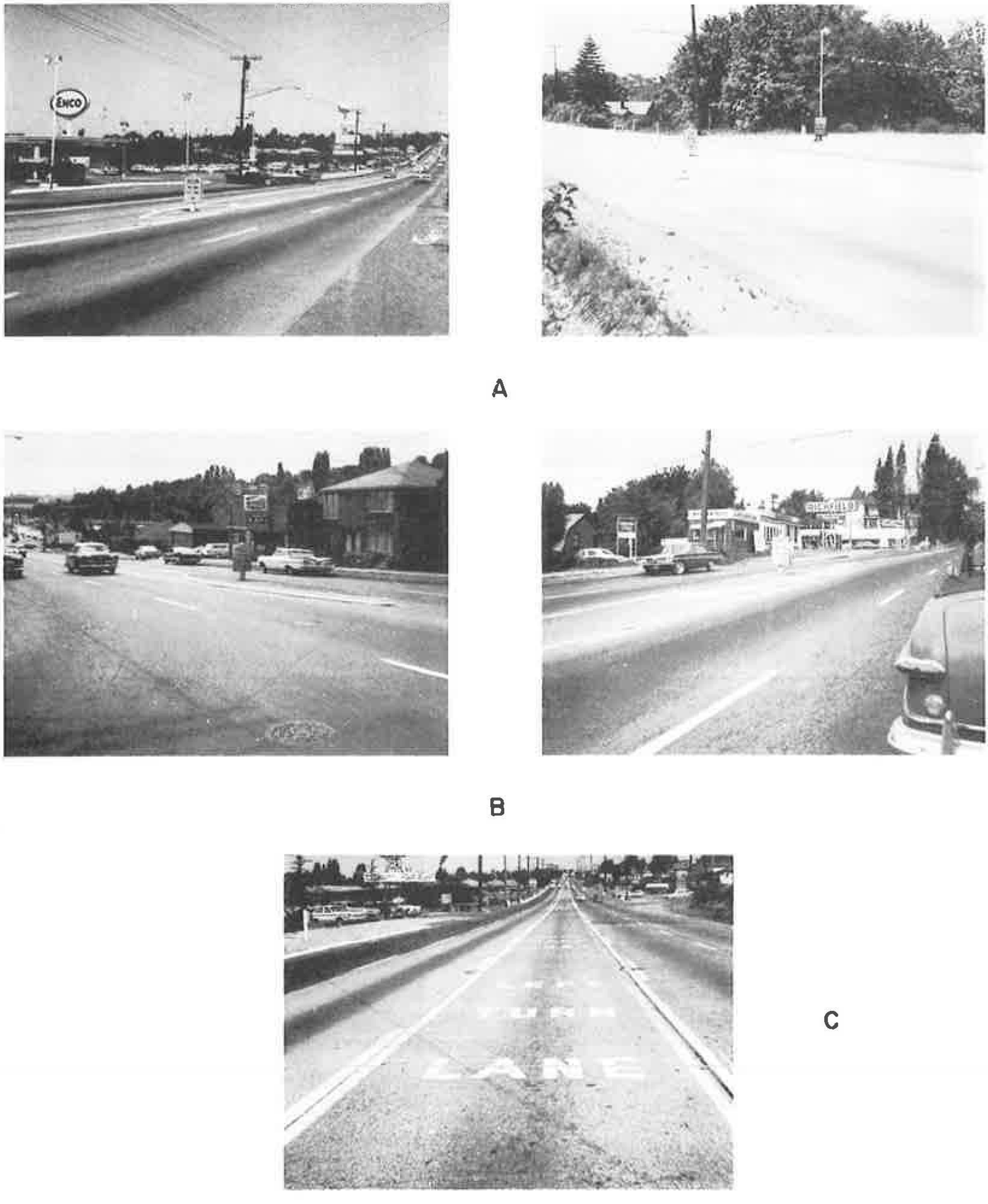
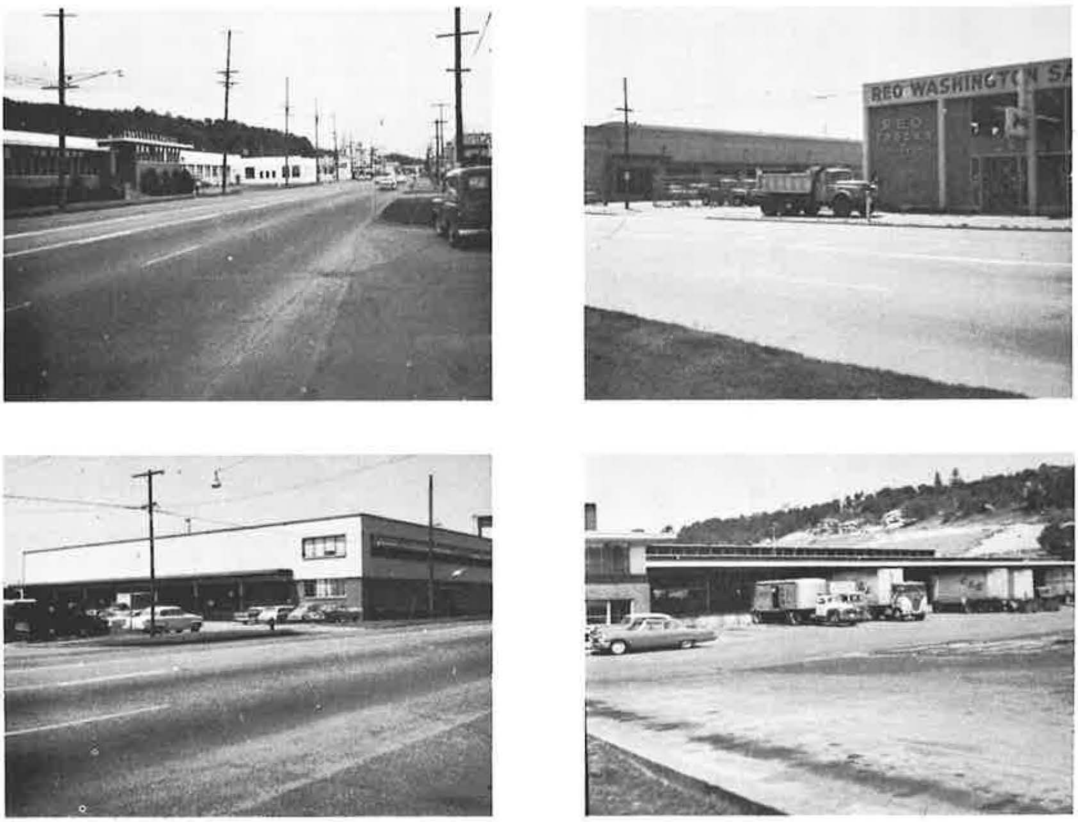


Figure 5. Signing and marking for 2WLTL installations.

A 2WLTL installation on 25th Ave. N. E. (Fig. 7B) was selected for studying only those accidents directly involving the 2WLTL. Because this street was widened from 2 to 5 lanes after installation of the 2WLTL, and because many new generators have been built since the installation, this street could not be used for a detailed before and after accident study. However, the various generators along the 2WLTL section (community shopping center, motels, apartments, filling stations) produce a high usage of the 2WLTL and an attendant greater number of 2WLTL accidents than on Airport Way and 4th Ave. S. This installation was also used in a study of certain operational charac-

A. Area served by Airport Way and 4^{th} Ave. S. 2WLTL'S.



B. Typical generators along Airport Way.

Figure 6. 2WLTL sites used in accident study.

teristics of 2WLTL usage. A section of 25th N. E. is shown in Figure 8, and the volume flow rate in Figure 11. Peak-hour traffic volume on 25th N. E. is approximately

TABLE 1

2WLTL CHARACTERISTICS

Street	Total Length (mi)	Length[1] (mi)	Install. Date	Speed Limit (mph)	1962 ADT	Street Width (ft)	No. of Lanes[2]	Lane Widths[3] (ft)	Parking	Signing	Traffic Movement
Airport Way	1.03	0.95	10/20/58	30	20,900	58	5	11 #2WLTL, 11 and 12 thru	No	Sign islands and paint legends	2-way progression
4th Ave. S.	1.49	1.31	6/28/61	35	27,500	82	8	12 #2WLTL, 10 and 11 thru	Yes		Platoon movement, not progressed
25th Ave. N.E.	0.46	0.42	10/5/59	30	15,800	54	3[4]	12 #2WLTL, 10 and 11 thru	Yes[5]		No signals

1 Excluding unidirectional left-turn lanes.
2 Including 2WLTL.
3 Clear.
4 Five during peak hours.
5 None during rush hours.

1,500 vph. Other characteristics of the 2WLTL site are given in Table 1.

Two additional 2WLTL installations were studied briefly. These sites, located along high-volume radials, Aurora Ave. N. and Bothell Way, serve commercial land uses. The sites did not meet the requirement of minimum change in land use intensity and other requirements necessary for a detailed study of the effect of the 2WLTL on traffic accidents.

Accident Data

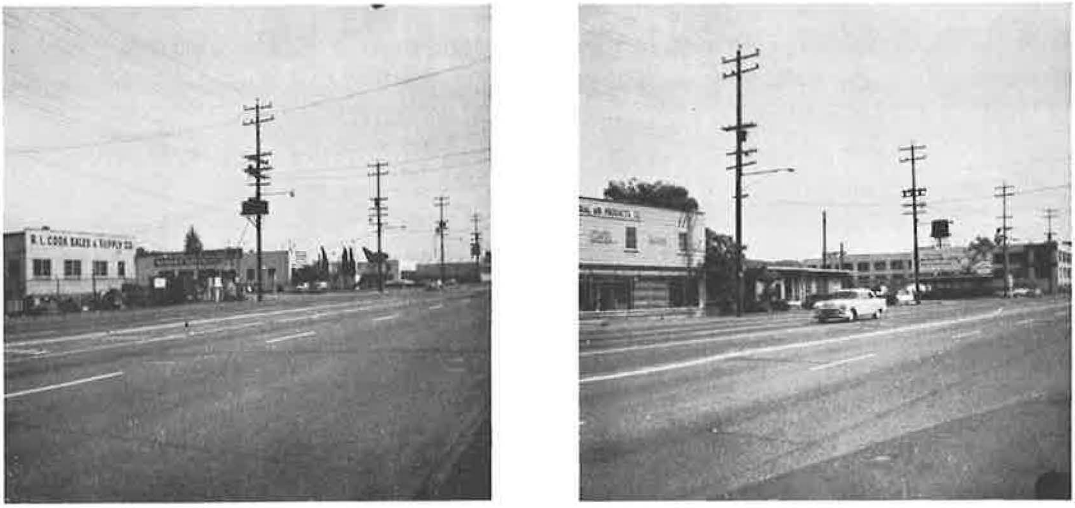
All accident data were taken from copies of the original accident reports filed by the motorists and kept by the Traffic Engineering Division and Police Department. Items recorded for each accident were day and date, location of accident, collision type, injury and injury severity, total property damage, whether the accident involved the 2WLTL, and whether drivers involved were local or out-of-towners.

General collision types are diagramed in Figure 12. The types are head-on, rear-end, left-turn, angle, sideswipe, and "other". The collision types also apply generally to accidents involving the 2WLTL. Potential 2WLTL collisions are shown in Figure 12B.

Injury severity has four degrees. Fatality is severity one; visible signs of injury such as a bleeding wound, distorted member, or having to carry the injured from the scene of the accident is severity two; other visible injuries such as bruises, abrasions, swelling, or limping is severity three; and no visible injury but complaint of pain or momentary unconsciousness is severity four.

Property damage was determined as the sum of the estimated costs to repair the vehicles involved plus damage to property such as fire hydrants, signs, and buildings. This sum was rounded to the nearest $50. If an accident was investigated by an officer, the total property damage was determined as the sum of his estimations rather than those of the drivers involved in the accident. If an accident was not investigated by an officer, the total property damage was determined as the sum of each individual's estimate of the cost to repair his own vehicle. Although many drivers tend to overestimate their own damage somewhat, it has been assumed that this is unimportant when property damage is compared in a relative manner, such as from year to year.

In addition to the determination of property damage, the severity of injury and the



A. 4th Ave. S.

B. 25th Ave. N.E.

Figure 7. 2WLTL sites used in accident study.

type of collision were based on the police officer's report when available.

Original accident reports were available only since the start of 1956. In that year, 21.4 percent of the accidents on Airport Way were investigated with the percentages generally increasing to date. Table 3 gives the percentages for both Airport Way and 4th Ave. S.

GENERAL ACCIDENT TRENDS

Airport Way

Accidents on Airport Way were studied for four years before and three years after the installation of the 2WLTL. Accident data for the first six months of the fourth year

TABLE 2

16-HOUR TOTALS FOR WEEKDAY VEHICULAR CLASSIFICATION COUNT 6:00 AM TO 10:00 PM ON AIRPORT WAY

Vehicle Type	No. of Vehicles[1]	% of All Vehicles	% of Trucks and Buses	Subtotals (%)
Autos[2]	18,757	88.4	-	-
Trucks and buses:				
Total	2,474	11.6	100	100
Single unit:				
SU-2	1,404	6.6	56.8	61.0
SU-3	104	0.5	4.2	
Buses	278	1.3	11.2	11.2
Semi's:				
2-S-1	212	1.0	8.6	23.3
2-S-2	121	0.6	4.9	
3-5-2	243	1.1	9.8	
Full trailer combinations:				
Semi with full trailer	49	0.2	2.0	4.5
Single unit with trailer:				
2-2	7	-	0.3	
3-2	56	0.3	2.2	

[1] Total vehicles: 21,231.
[2] Light trucks without dual tires classed as autos.

after installation were expanded to a full year, thereby giving four years of before and after experience. For this reason, the fourth year after study is shown by a dashed line in the pertinent figures.

Table 4 summarizes the accidents on Airport Way each year with respect to collision types and total accidents. The data from this table have been plotted in Figures 13 and 14. Before installation of the 2WLTL, the total accidents per year were in the range of 60 to 70. There was a moderate increase in accidents during the first year after installation (12.6), a phenomenon not uncommon when new traffic-control measures are installed. The following years show a sharp drop to the level of about 45 accidents per year. Figure 13 shows that a reduction in rear-end accidents accounted for most of the drop, with the other types of collision being fairly constant in number over the years and showing no general trends.

To consider the effects of traffic volume on accident experience, average weekday volumes were obtained and plotted (Fig. 15). Volume over the years of study fluctuates somewhat, but shows no general upward or downward trend. When these volumes are applied to the weekday accidents, the curves in Figure 16 result. Total weekday accidents do not include Saturday and Sunday. Accidents per million vehicles have been used rather than accidents per million vehicle miles because the former is a measure of accident probability (2). Prior to the

TABLE 3

PERCENTAGE OF REPORTED ACCIDENTS INVESTIGATED BY POLICE OFFICER

Year	Airport Way[1]	4th Ave. S.[2]
56-57	21.4	-
57-58	37.2	-
58-59	40.0	41.8
59-60	37.2	45.1
60-61	54.6	46.4
61-62	52.5[3]	54.5

[1] Yearly intervals: Nov. through Oct.
[2] Yearly intervals: July through June.
[3] Estimated.

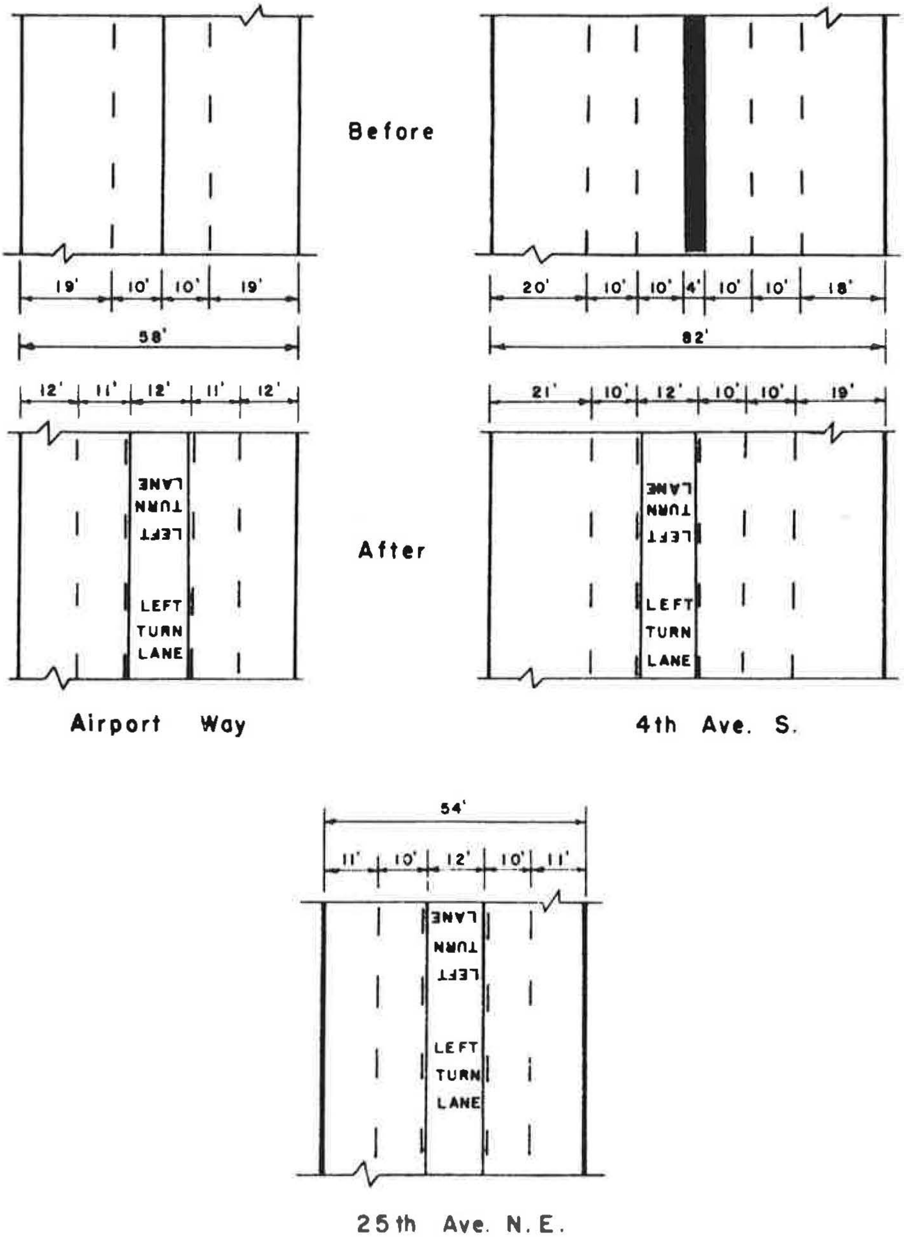


Figure 8. Laning on Airport Way, 4th Ave. S. and 25th Ave. N. E.

installation of the 2WLTL, the weekday accidents seem to be fairly constant each year, but when the study is based on traffic volume, a slight downward trend in accidents appears during these years. This downward trend makes the reduction in accidents in the second, third, and fourth year after installation somewhat less spectacular. Figure 17 shows the volume-based accident rate for weekday rear-end accidents.

Figure 18 shows a comparison of total accidents per year on Airport Way with the total of the reported accidents for the entire city of Seattle (when accidents or other measures of accident experience are given on a yearly basis, the yearly basis is in terms of full years before or after installation of the 2WLTL, and not coinciding with

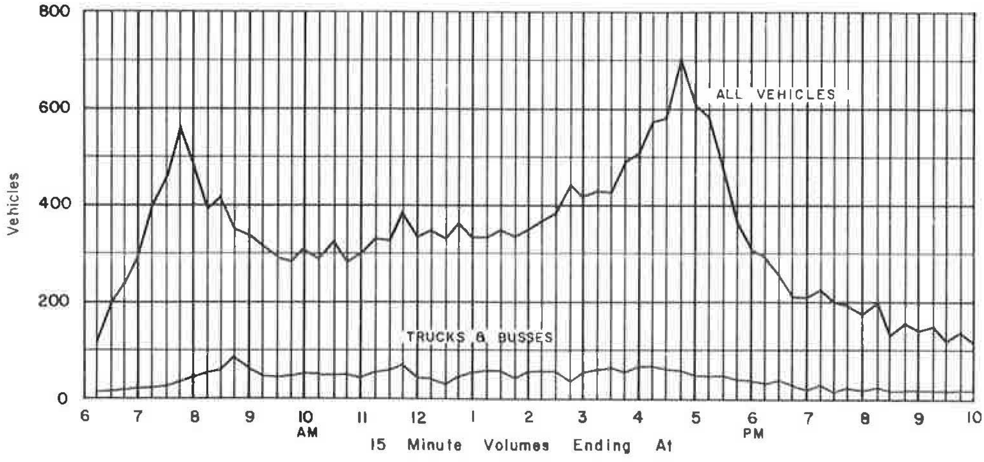


Figure 9. Typical weekday volume variation on Airport Way, 1962.

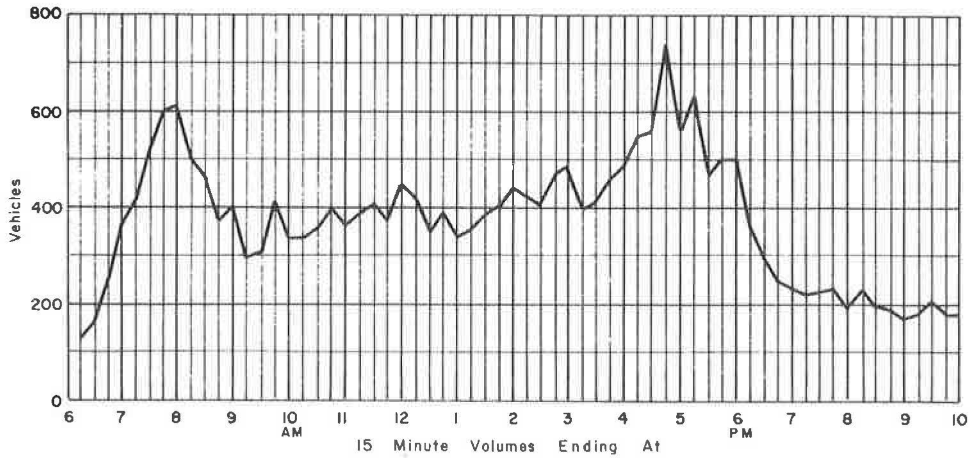


Figure 10. Typical weekday volume variation on 4th Ave. S., 1962.

TABLE 4

SUMMARY OF AIRPORT WAY ACCIDENTS BY TYPE OF COLLISION

Type of Collision	Years Before 2WLTL Installation								Years After 2WLTL Installation							
	4		3		2		1		1		2		3		4[1]	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Rear end	36	58.2	39	53.5	38	54.3	37	59.6	46	65.7	18	41.8	27	61.3	17	42.5
Sideswipe	10	16.1	16	21.9	18	25.7	9	14.5	7	10.0	6	13.9	3	6.8	9	22.5
Angle	3	4.8	5	6.8	9	12.8	6	9.7	9	12.9	9	21.0	6	13.6	3	7.5
Left turn	3	4.8	1	1.4	1	1.4	0	0	4	5.7	1	2.3	4	9.1	3	5.0
Hit parked car	6	9.7	5	6.8	2	2.9	4	6.5	1	1.4	0	0	2	4.6	2	5.0
Other	4	6.4	7	9.6	2	2.9	6	9.7	3	4.3	9	21.0	2	4.6	7	17.5
Total	62	100.0	73	100.0	70	100.0	62	100.0	70	100.0	43	100.0	44	100.0	41	100.0

[1] Estimated on the basis of 6 months' experience.

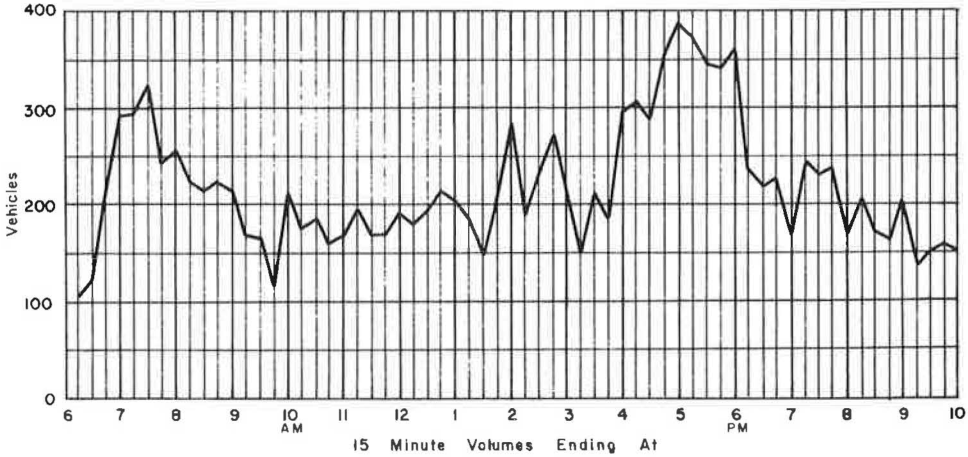


Figure 11. Typical weekday volume variation on 25th Ave. N. E., 1962.

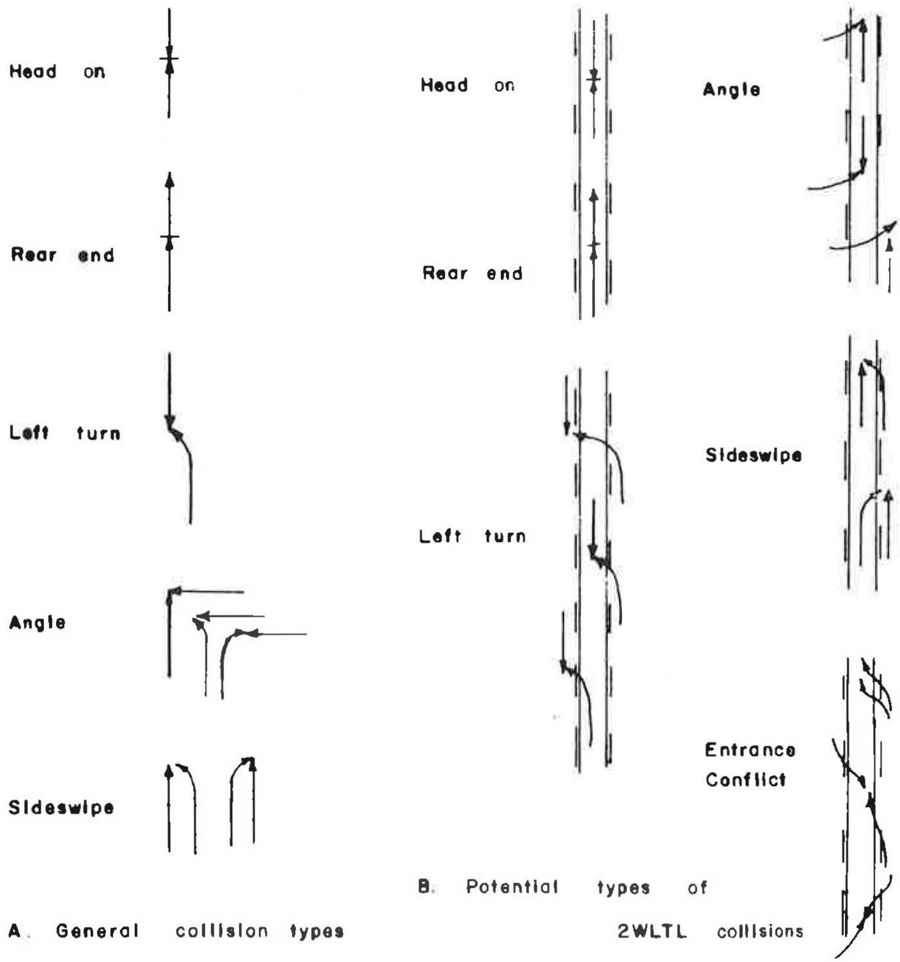


Figure 12. Collision types used in accident study.

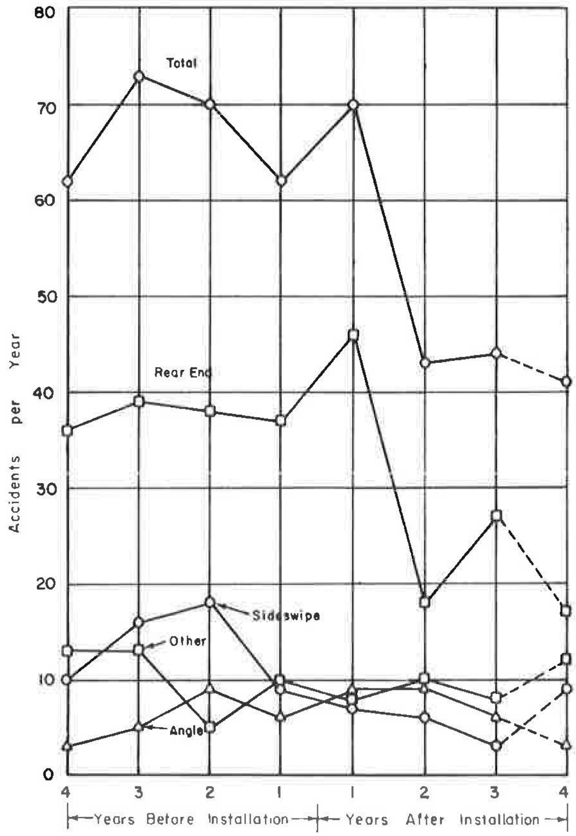


Figure 13. Accidents by collision type on Airport Way.

the calendar year). Figure 19 similarly represents rear-end accidents. Seattle accident experience shows a slight upward trend over the years. Accidents in Seattle for one year after are the highest, correlating with the rise in accidents during that year for Airport Way. Thus the rise in accidents on Airport Way during the first year of 2WLTL use may have been due not only to possible confusion about its proper use, but also to a generally higher level of accidents as a whole that year, possibly due to weather conditions.

The intent of this study is to determine not only the effect of the 2WLTL on the magnitude of accidents but also on their severity. For this reason, injury severity and the percent of accidents with injuries were studied (Fig. 20). It is important that the injury accidents appear to be decreasing during the after period. However, consideration should be given to the percent of accidents with injury that also reflects the decrease in total accidents (Fig. 18). There was no significant change in the degrees of injury severity. Figure 21 compares total injury accidents with weekday injury accidents and also weekday injury accidents per million weekday vehicles. There do not appear to be any definite trends after installation of the 2WLTL, except that the Saturday and Sunday injury accidents appear to have been reduced.

Figure 22 shows another measure of accident severity, property damage estimates. The high points are one year after, corresponding to the peak effect for the number of accidents for the year. Except for the first year, the total property damage appears to be decreasing slightly. The average property damage per accident rose somewhat after installation. It would seem that the accidents are somewhat more severe after installation of the 2WLTL, but considering the differences of 50 to 100 dollars per accident before and after plus the fact that property damage was rounded to the nearest 50 dollars,

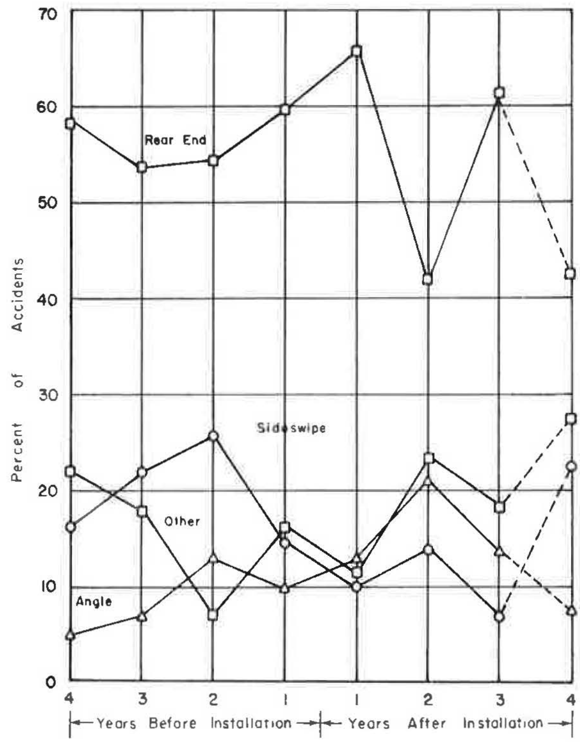


Figure 14. Percent accidents by collision type on Airport Way.

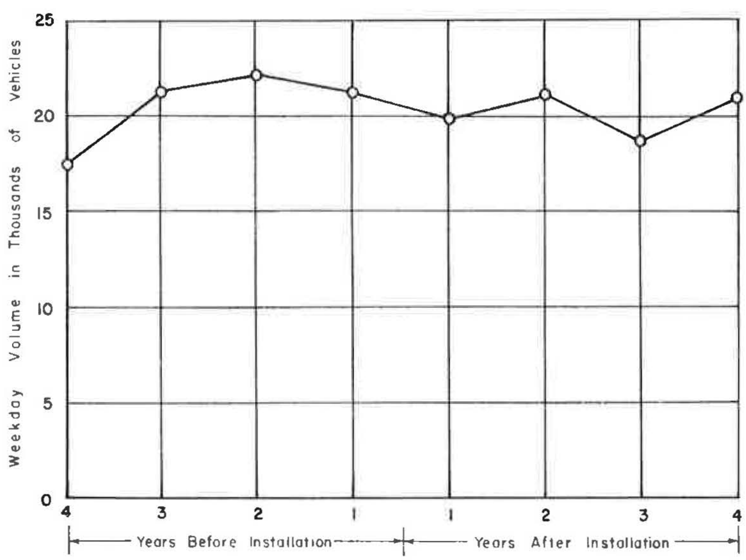


Figure 15. Average weekday vehicular volume on Airport Way.

this trend may not have any valid support for that conclusion. There is close correspondence between total accidents (Fig. 13) and total property damage.

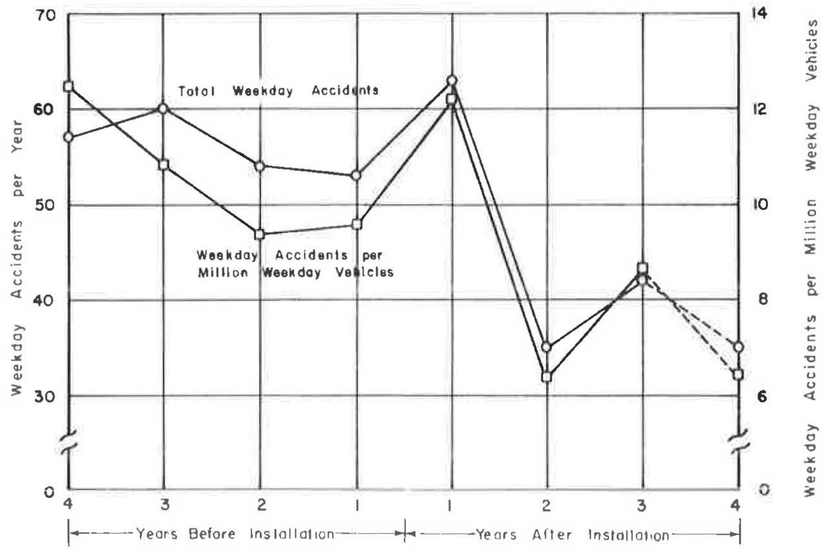


Figure 16. Weekday accidents and weekday accidents per million weekday vehicles on Airport Way.

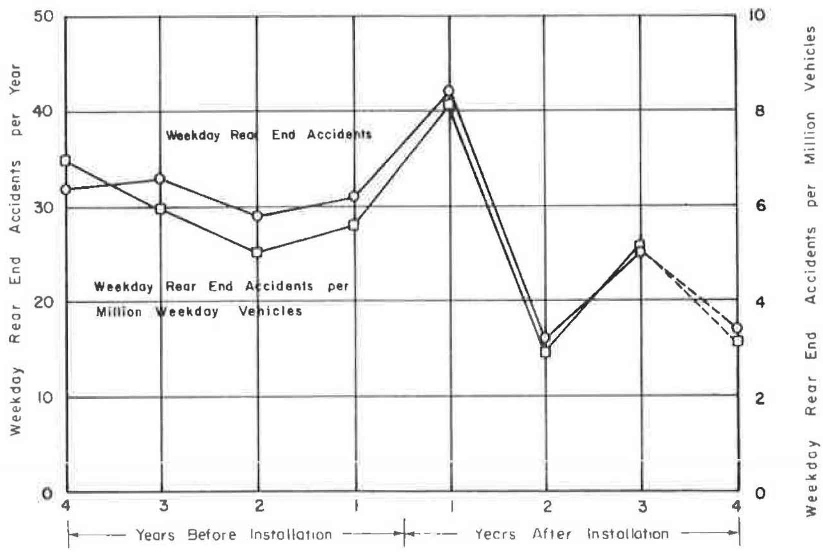


Figure 17. Weekday rear-end accidents and weekday rear-end accidents per million weekday vehicles on Airport Way.

A few words are in order on the problem of determining what percentage of the accident reduction on Airport Way was actually due to the installation of single unidirectional left-turn lanes for westbound traffic at the two major intersections along the study section. In general, accidents decreased along sections of the 2WLTL where the busiest generators existed, and in only one short section (less than a block long) did accidents increase. Apparently the installation of the 2WLTL was responsible for about 75 percent of the general reduction of accidents occurring in the interval after the one-year-after period. Furthermore, it is quite possible that the 2WLTL might

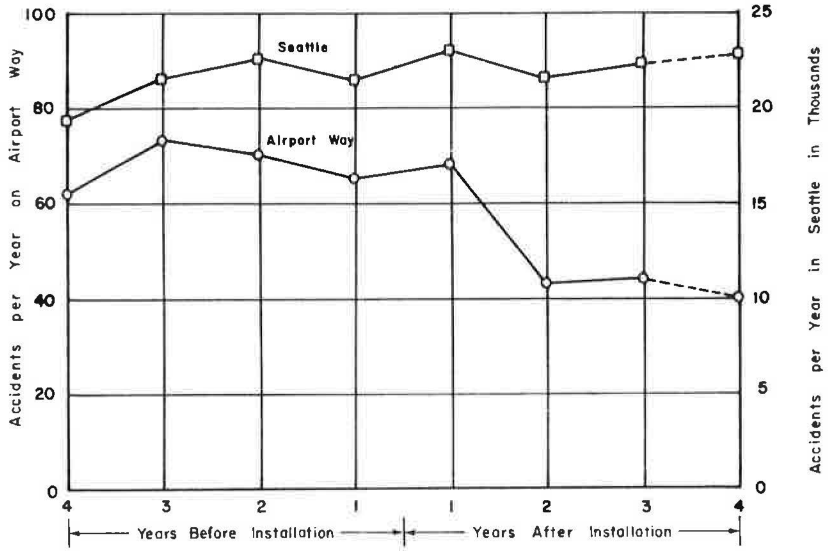


Figure 18. Comparison of total accidents in Seattle with total accidents on Airport Way.

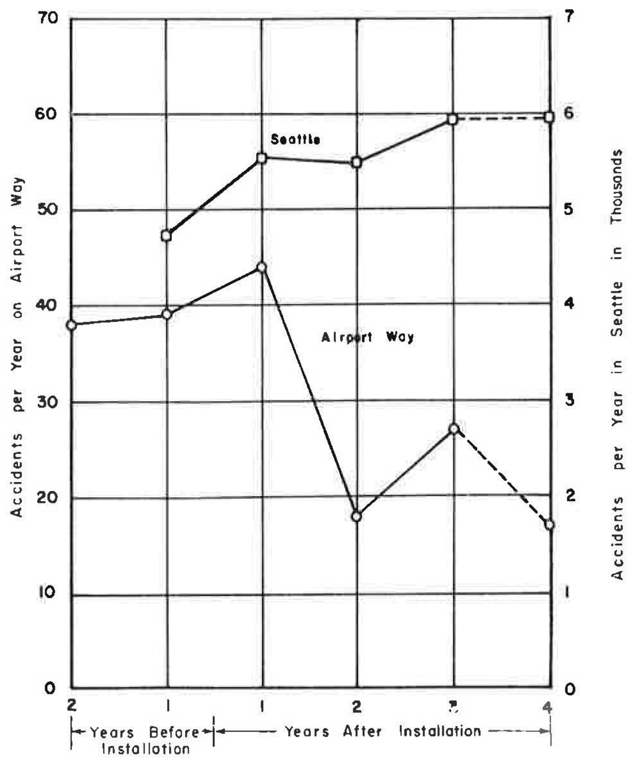


Figure 19. Comparison of total rear-end accidents in Seattle with rear-end accidents on Airport Way.

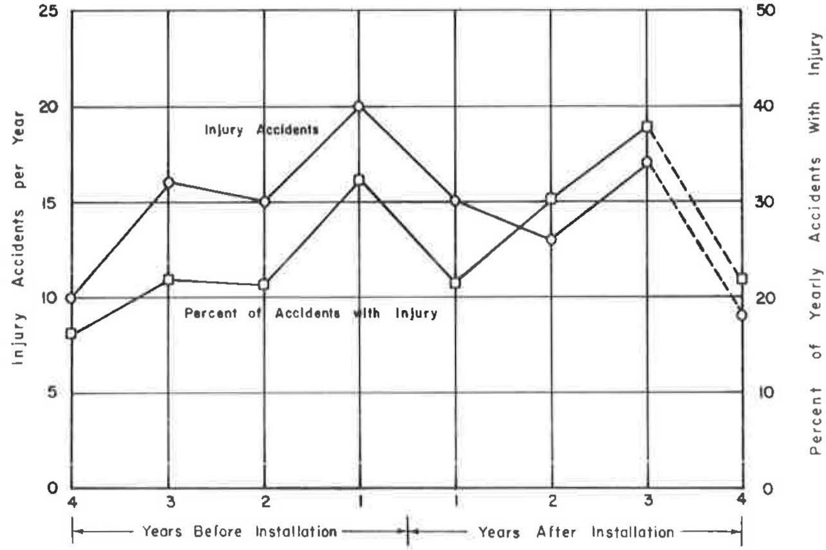


Figure 20. Injury accidents and percent of accidents with injury on Airport Way.

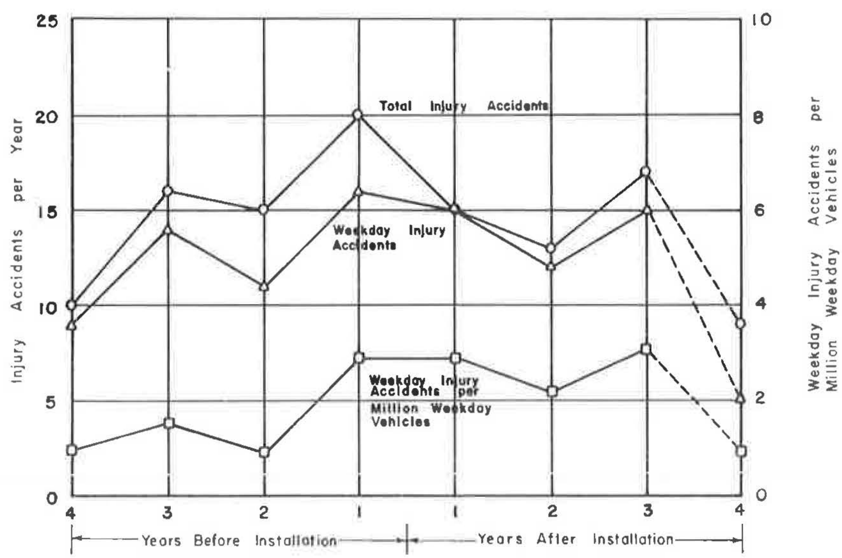


Figure 21. Total injury accidents, weekday injury accidents, and weekday injury per million weekday vehicles on Airport Way.

have served just as well as the conventional unidirectional left-turn lanes in terms of expediting traffic flow and reducing accidents.

4th Avenue S.

Traffic accidents on 4th Avenue S. were studied for three years before and one year after installation of the 2WLTL. The significance of accident trends on 4th Ave. S. is somewhat limited by the short after period. However, the one-year-after experience is valuable in comparison with Airport Way accident experience, since these two sites

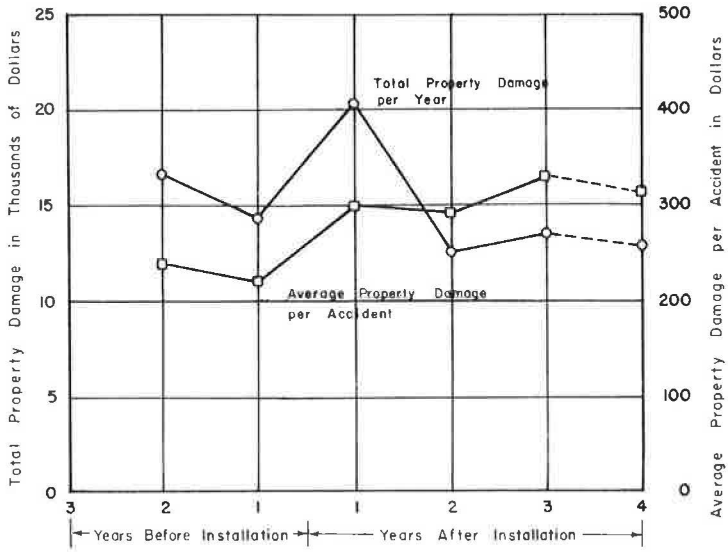


Figure 22. Total property damage per year and average property damage per accident on Airport Way.

TABLE 5

SUMMARY OF 4TH AVE. S. ACCIDENTS BY TYPE OF COLLISION

Collision Type	Years Before 2WLTL Installation						1 Year After 2WLTL Installation	
	3		2		1			
	No.	(%)	No.	(%)	No.	(%)	No.	(%)
Rear end	51	52.0	25	30.5	32	46.4	29	37.3
Sideswipe	22	22.4	17	20.7	12	17.4	14	17.9
Angle	4	4.1	18	22.0	5	7.2	15	19.2
Left turn	14	14.3	11	13.4	9	13.0	8	10.2
Other	7	7.2	11	13.4	11	16.0	12	15.4
Total	98	100.0	82	100.0	69	100.0	78	100.0

are very similar. In addition, this installation offered an opportunity to compare the 2WLTL with a previous conventional median installation. Finally, it is hoped that the 4th Ave. S. study will be updated after several more years of experience.

Collision types and total accidents are given in Table 5 and in Figures 23 and 24. In general, there was a downward trend in accidents before installation of the 2WLTL, but total accidents increased by 14.5 percent during the first year after installation, which also corresponds to a slight increase in volume during this year (Fig. 25). Comparing the total accidents in Figure 23 with volume in Figure 25, a close correlation exists between total accidents and average weekday traffic volume. When either weekday or total accidents are plotted against average weekday volume, a strong linear relationship results. On the other hand, a plot of Airport Way data shows virtually no correlation between traffic volume and accidents.

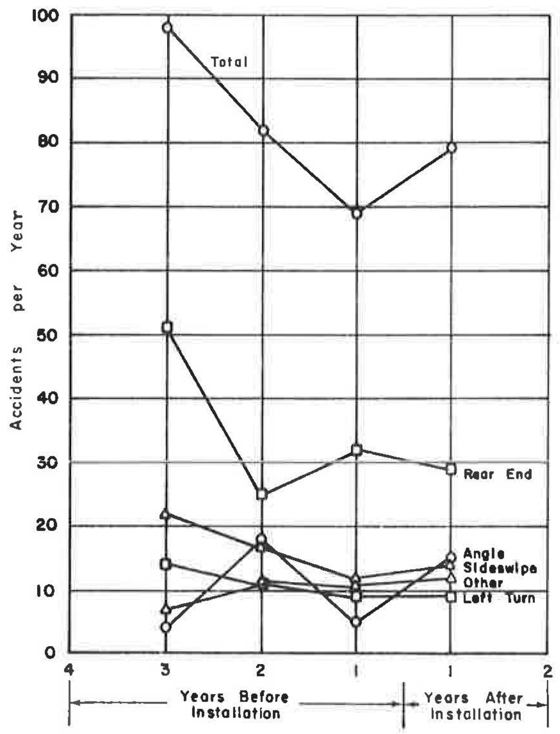


Figure 23. Accidents by collision type on 4th Ave. S.

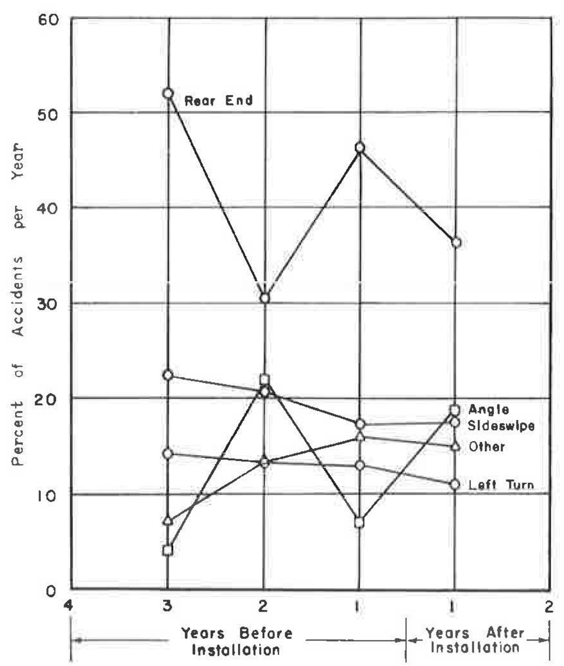


Figure 24. Percent accidents by collision type on 4th Ave. S.

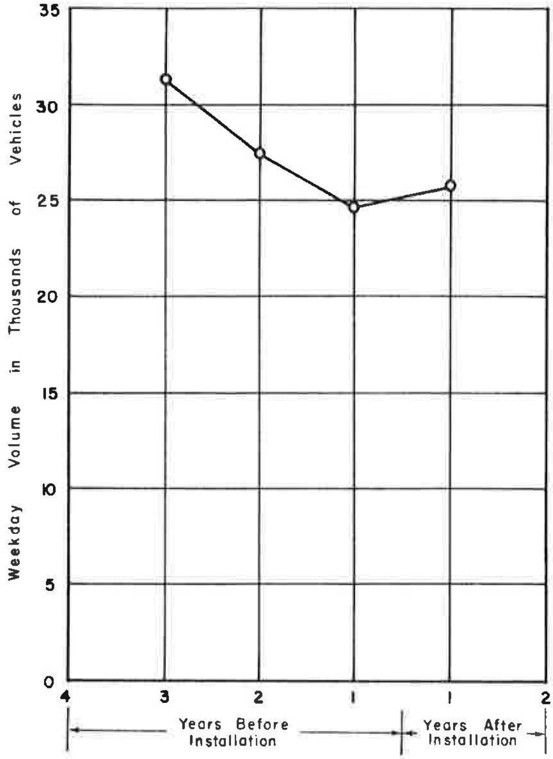


Figure 25. Average weekday vehicular volume on 4th Ave. S.

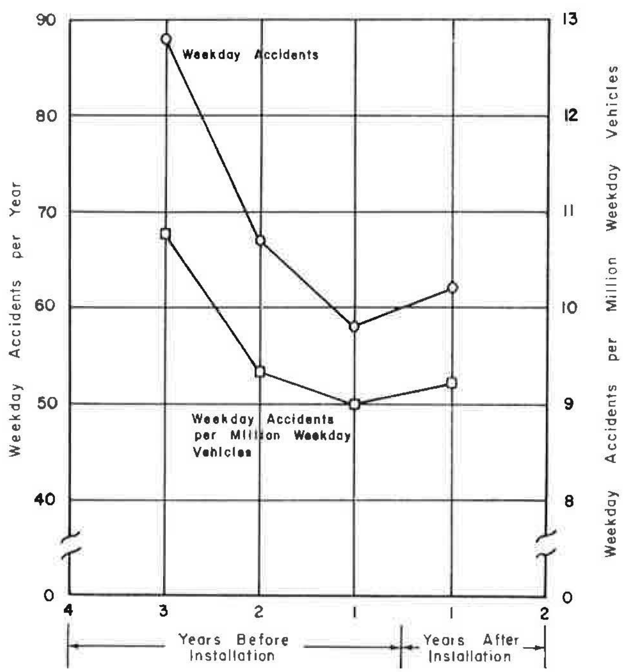


Figure 26. Weekday accidents and weekday accidents per million weekday vehicles on 4th Ave. S.

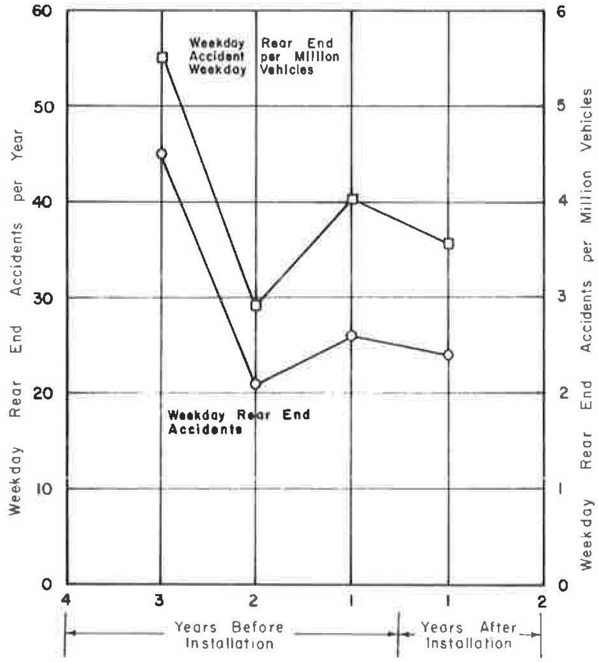


Figure 27. Weekday rear-end accidents and weekday rear-end accidents per million weekday vehicles on 4th Ave. S.

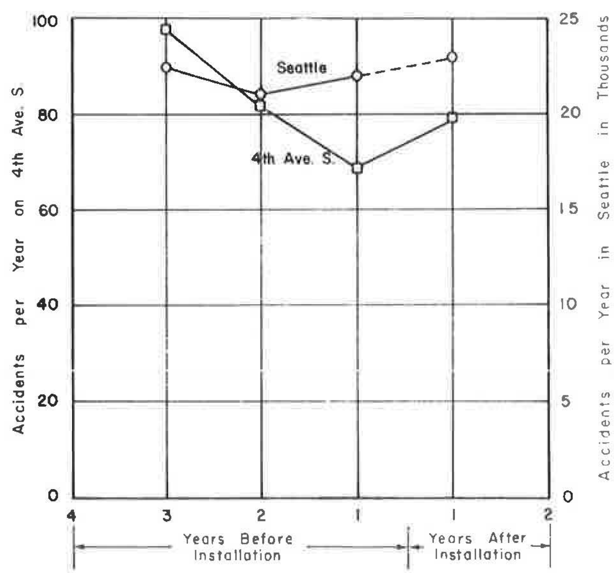


Figure 28. Comparison of total accidents in Seattle with total accidents on 4th Ave. S.

Volume-based accident rates for total weekday accidents and weekday rear-end accidents (Figs. 26 and 27) correspond rather closely to the related curves in Figure 23.

Although Figures 28 and 29 show that total and rear-end accidents have been decreasing as compared to increases in Seattle accidents as a whole, the first year after shows a correspondence between Seattle and 4th Ave. S. data in terms of total and rear-end accidents.

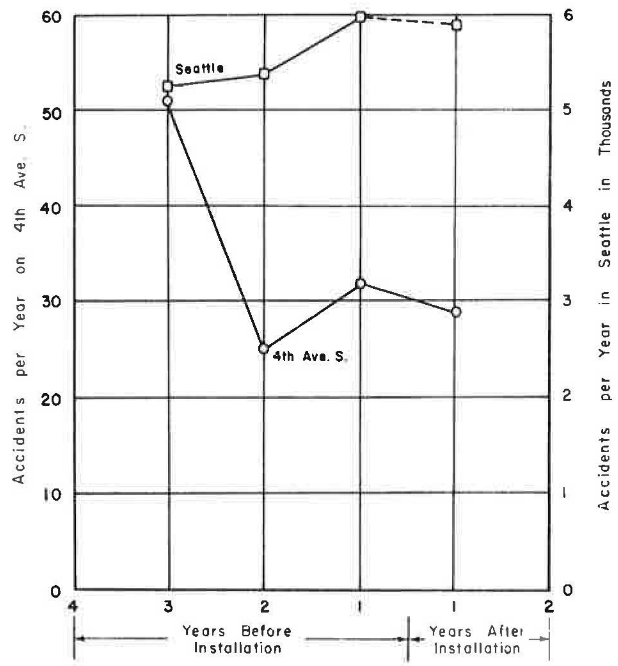


Figure 29. Comparison of total rear-end accidents in Seattle with rear-end accidents on 4th Ave. S.

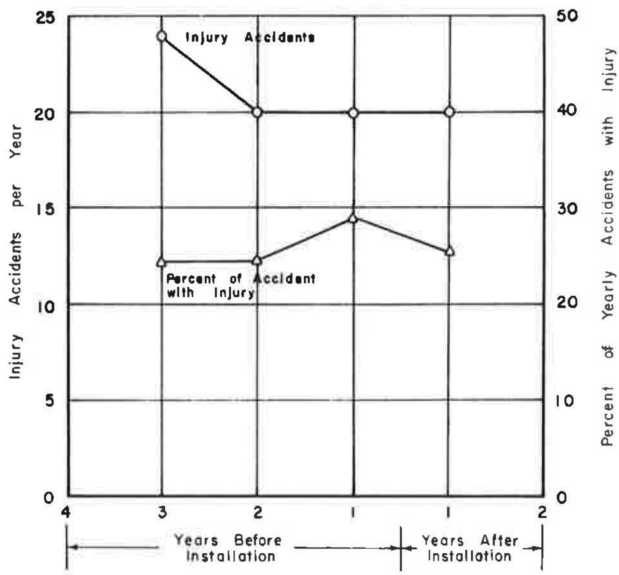


Figure 30. Injury accidents and percent of accidents with injury on 4th Ave. S.

Although injury accidents (Figure 30) showed no change during the one-year-after period, the percent of accidents with injury decreased slightly. Figure 31 shows that the downward trend in weekday injury accidents and weekday injury accidents per million weekday vehicles continued during the first year of 2WLTL use. This would seem

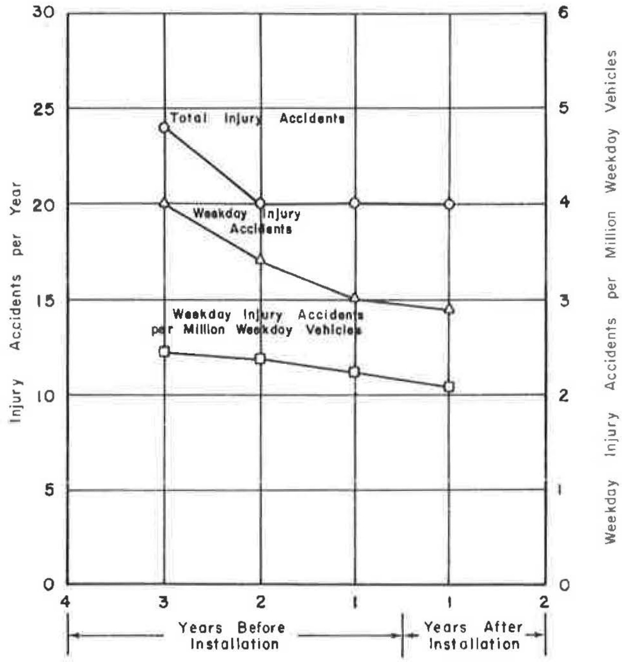


Figure 31. Total injury accidents, weekday injury accidents, and weekday injury accidents per million weekday vehicles on 4th Ave. S.

to indicate that the 2WLTL has little or no effect on accident severity. Considering total property damage as an index of accident severity (Fig. 32), accident severity apparently increased following the installation of the 2WLTL. It is evident, however, that total property damage corresponds rather closely to the total number of accidents, which a comparison of Figures 23 and 32 seems to indicate. Considering this relationship and the rather constant nature of the average-property-damage-per-accident curve, the 2WLTL installation did not really cause an increase in accident severity.

Except for the two major intersection areas, accidents were fairly evenly distributed over the study section. Although the overall number of accidents in the previous year increased during the first year of 2WLTL use, in some locations the accidents decreased. There was a decrease around the two major intersections served by conventional, channelized, unidirectional left-turn lanes both before and after the installation of the 2WLTL. There was also a decrease in accidents in a block-long segment of the study section where there are numerous driveways and where several midblock median openings had previously existed.

Inasmuch as the increase in the number of accidents during the first year of 2WLTL use was not large and apparently was primarily due to an increase in traffic volume, the 2WLTL in this instance seems to serve as well as a median with auxiliary lanes for left turns. There is no reason to believe that a 2WLTL cannot serve as an intersectional left-turn lane almost as well as a conventional left-turn lane in certain localities. Not only does it provide for midblock left-turns, but it also serves as an emergency lane. Vehicles have used the 2WLTL to bypass traffic accidents and stalled vehicles; this could not be done easily with a conventional raised median, even one with mountable curbs. Furthermore, there is the possibility that a 10- or 12-ft wide 2WLTL may serve as a better separator of opposing traffic streams than a narrow 2-ft median or separator. Initial construction and maintenance costs abetted by the ease of street cleaning and snow removal, may well favor the 2WLTL over the conventional median with unidirectional left-turn lanes where midblock left turns are necessary and other conditions of traffic are suitable.

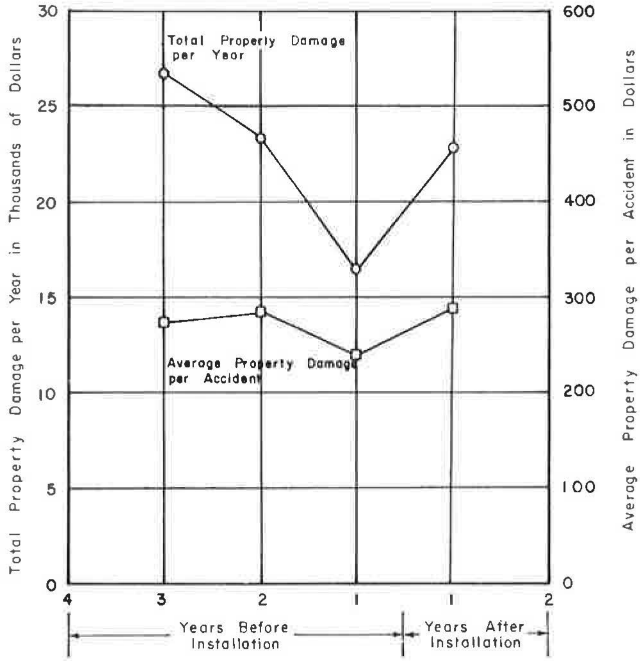


Figure 32. Total property damage per year and average property damage per accident on 4th Ave. S.

Aurora Avenue N. and Bothell Way

Two arterials with 2WLTL installations were studied briefly with respect to the total number of accidents each year. Changes in land use, traffic control, and pavement widths during the study period precluded a detailed study of the effect of the 2WLTL itself on accident experience.

Total accidents per year for both Aurora Ave. N. and Bothell Way are shown in Figure 33. These curves show the limitations of a one-year before-and-after study. Aurora Ave. N., for example, would show almost a 40 percent decrease in accidents with the first year of 2WLTL operation. The sharp increase in accidents during the one-year-before period, when compared with two, three, and four years before installation, along with the increase in accidents during the second-year-after period would be missed by the study.

Weekday traffic volume on Aurora increased from 29,000 vehicles per day during the fourth year prior to installation, to almost 36,000 vehicles per day the second year after installation. One could possibly get a better estimate of the effect of the 2WLTL on accident experience by neglecting the large increase and decrease in accidents one year before and one year after installation and studying, instead, the one year accidents occurring two years before and two years after. If the number of accidents during these one-year periods is divided by the corresponding average weekday traffic volume, a somewhat artificial and limited, yet nevertheless useful, index of accident experience is attained. These calculations yield values of 0.0038 and 0.0037 (weekday volume of 32,000 vehicles) and two years after (weekday volume of 35,000), respectively. Thus it appears that although the number of accidents has increased during the after period, the volume-based accident index has remained about the same. Considering the increases in traffic and increased property development along this arterial, the 2WLTL aids considerably in holding down the accident index.

Weekly traffic of 22,000 vehicles per day ± 1,000 vehicles per day was carried by Bothell Way (Fig. 33). Here, as in the case of the Aurora Ave. installation, a one-

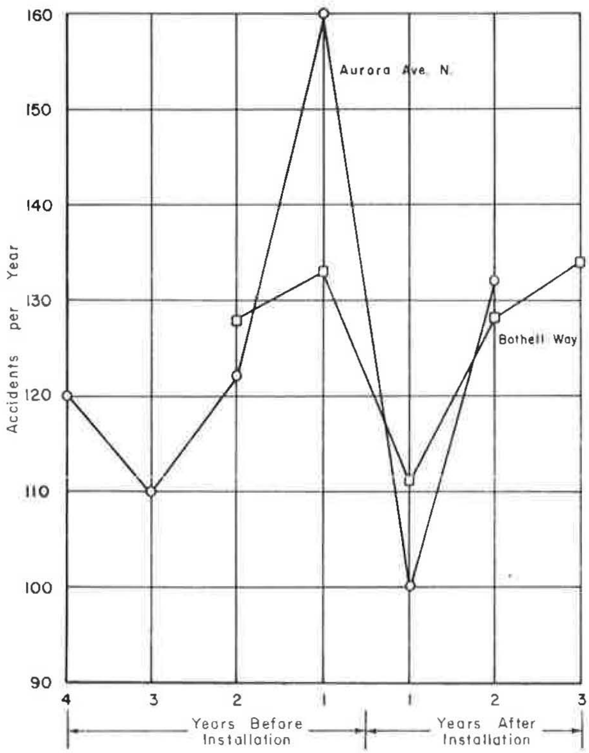


Figure 33. Accidents per year on Aurora Ave. N. and Bothell Way.

year before-and-after study presents a rosy picture in terms of accident reduction occurring with the installation of a 2WLTL. Except for one year after, the total number of reported accidents has held fairly steady at about 130 per year. Considering that traffic volume had been fairly constant for the years studied, it could be assumed that the 2WLTL did not bring about a reduction in the number of accidents. However, the severity of accidents has perhaps declined. It is speculated that on these two arterials during the first year after the installation, the 2WLTL served more as a median divider until the drivers became educated to its use for access purposes.

The preceding examples point out the limitations and pitfalls of trying to state definite conclusions and generalizations from a study of only one year before and after.

TABLE 6

NUMBER OF 2WLTL ACCIDENTS ON AIRPORT WAY

Years After Installation of 2WLTL	No. of 2WLTL Accidents	Percent of Total Accidents for the Year
1	5	7.3
2	2	4.7
3	0	0
4[1]	2	8.3
Total	9	—

[1] First six months of fourth year.

TWO-WAY LEFT-TURN LANE ACCIDENTS

Airport Way

Table 6 summarizes the 2WLTL accidents for Airport Way. These accidents are shown classified as to collision types in Table 7.

These accidents were distributed rather uniformly along the study section. Three of the nine accidents occurred dur-

TABLE 7

TYPES OF 2WLTL ACCIDENTS ON AIRPORT WAY[1]

Collision Type	No. of 2WLTL Accidents	Percent of 2WLTL Accidents
Rear end	1	11.2
Left turn	3	33.3
Angle	3	33.3
Sideswipe	2	22.2
Total	9	100.0

[1] $3\frac{1}{2}$ years experience.

TABLE 8

NUMBER OF 2WLTL ACCIDENTS ON 25TH AVE. N. E.

Years After Installation of 2WLTL	Number of 2WLTL Accidents	Percent of Total Accidents for the Year
1	5	23.8
2	6	28.6
3[1]	6	31.6
Total	17	–

[1] First six months of third year after only.

ing darkness, six during rush hours, and out-of-town drivers were involved in two. Furthermore, an out-of-town driver was at fault in only one of the accidents. There were no head-on collisions in the 2WLTL itself. Injuries occurred in two of the accidents. The small number of 2WLTL accidents does not allow a statistical comparison with non-2WLTL accidents in terms of severity (with injury accidents and property damage as indexes of severity).

There is no real indication that the number of 2WLTL accidents decreases each year as motorists become more familiar with the use of this method. Table 6 gives 5, 2, 0 and 4 (doubling the 1-month number to expand to a full year) 2WLTL accidents for 1, 2, 3 and 4 years after experience.

4th Ave. S.

The 4th Ave. S. 2WLTL installation was studied for one year after, and during that time four 2WLTL accidents occurred. There were two sideswipe collisions and one rear-end accident (caused by a vehicle backing into another waiting to turn left). The 2WLTL accidents represent 3.8 percent of the year's total. Three of the accidents occurred during darkness, one during rush hours, and injury occurred in only one.

25th Avenue N. E.

Table 8 summarizes the 2WLTL accidents for 25th Ave. N. E., which are classified as to collision types in Table 9.

The 2WLTL accidents on 25th Ave. N. E. represent 36 percent of all the accidents that occurred. This percentage is much higher than those for Airport Way and 4th Ave. S., but the 2WLTL usage is much higher at 25th N. E. than at those sites and the installation is relatively short in length (5 blocks long). Only 30 percent of the 2WLTL accidents occurred during rush hours, and 24 percent during darkness. Out-of-town drivers were involved in only one of the 17 2WLTL collisions, or 5.9 percent, while for non-2WLTL accidents during the same period, out-of-town drivers were involved in 12 of 44 accidents, or 27.2

TABLE 9

TYPES OF 2WLTL ACCIDENTS ON 25TH AVE. N. E.[1]

Collision Type	No. of 2WLTL Accidents	Percent of 2WLTL Accidents
Head on	1[2]	5.8
Rear end	2	11.8
Entrance conflict	2	11.8
Left turn	2	11.8
Angle	6	35.3
Sideswipe	4	23.5

[1] $2\frac{1}{2}$ years experience.
[2] Drunk.

TABLE 10

SUMMARY OF 2WLTL ACCIDENTS ON AIRPORT WAY, 4TH AVE. S. AND 25TH AVE. N. E.

Collision Type	No. of 2WLTL Accidents	Percent of 2WLTL Accidents
Angle	9	30.0
Sideswipe	8	26.7
Left turn	6	20.0
Rear end	4	13.3
Head on	1	3.3
Entrance conflict	2	6.7
Total	30	100.0

TABLE 11

VEHICULAR CLASSIFICATION FOR A 6:00 AM TO 10:00 PM WEEKDAY COUNT OF VEHICLES USING THE 2WLTL ON AIRPORT WAY

Vehicle Type	No. of Vehicles[1]	% of Vehicles[1]
Autos	336	45.7
Light trucks[2]	92	12.5
Single units	199	27.1
Combinations	108	14.7
Total	735	100.0

[1] To and from generators.
[2] Light commercial vehicles without dual wheels.

percent. Thus the out-of-town driver is responsible for but a small percentage of 2WLTL accidents.

Approximately two-thirds of the 2WLTL accidents occurred in the vicinity of three busy entrances to the large shopping center located along 25th Ave. N. E.

Summary of 2WLTL Accidents

The foregoing sections on 2WLTL accidents were presented in order to show the types that occur, and to make a comparison of their numbers with the total number of accidents. It is believed worthy of consideration since many traffic engineers probably do not wish to make use of the 2WLTL because they fear that its use will cause too many accidents. These engineers no doubt recall the high frequency of accidents on the 3-lane highways that were once prevalent.

Grouping the after-installation accident experience on Airport Way, 4th Ave. S., and 25th Ave. N. E., which represents 7 study years, there were 30 2WLTL accidents. This represents only 9.4 percent of the total number of accidents occurring at these installations. Considering this grouped experience further, 27.9 percent of the non-2WLTL accidents involved injuries, and injuries occurred in 23.3 percent of the 2WLTL accidents. The average property damage for the non-2WLTL accident was $328, and that for the 2WLTL accidents was $240. Although property damage is based on estimates rounded to the nearest $50, there seems to be some significance in the difference between these two values. Considering the above figures and those for injury accidents, it appears that the 2WLTL accident is somewhat less severe than the non-2WLTL accident. A summary of the collision types for the 2WLTL accidents is given in Table 10.

In general, there is no indication that the number of 2WLTL accidents decreases with use. Although one might expect this to occur, such a trend would be most likely postulated on the assumption of a somewhat high number of 2WLTL accidents during the first years of use. Such is not the case, however, for the number of 2WLTL accidents is relatively small, both in the early and later years of use.

OPERATIONAL CHARACTERISTICS

2WLTL Usage Volumes

Estimates of the volume of vehicles using 2WLTL's serving different types of land uses were thought desirable. Manual counts were made of the number of vehicles using the 2WLTL for left turns to generators from through lanes and left turns from genera-

TABLE 12

VEHICULAR CLASSIFICATION FOR A 7:15 TO 8:15 AM PEAK HOUR COUNT OF VEHICLES USING THE 2WLTL ON AIRPORT WAY

Vehicle Type	No. of Vehicles[1]	% of Vehicles[1]
Autos	52	69.3
Light trucks[2]	10	13.3
Single units	7	9.4
Combinations	6	8.0
Total	75	100.0

[1] To and from generators.
[2] Light commercial vehicles without dual wheels.

TABLE 13

VEHICULAR CLASSIFICATION FOR A 2:15 TO 3:15 PM PEAK HOUR COUNT OF VEHICLES USING THE 2WLTL ON AIRPORT WAY

Vehicle Type	No. of Vehicles[1]	% of Vehicles[1]
Autos	22	30.6
Light trucks[2]	16	22.2
Single units	24	33.3
Combinations	10	13.9
Total	72	100.0

[1] To and from generators.
[2] Light commercial vehicles without dual wheels.

tors and into the through lanes. A usage or 2WLTL movement, then is essentially a crossing of the 2WLTL when making a left turn to or from a generator.

Figure 34 shows a 16-hr record of weekday 2WLTL usage on a typical portion of the 2WLTL on Airport Way. This section is approximately 450 ft long, representing roughly 8 percent of the total 2WLTL length. It is bordered by 8 generators. The morning peak hour of usage primarily represents the arrival of workers to their places of employment. The majority of the usage at other times during the day is by commercial vehicles (ranging from 50 to 90 percent of the total vehicles using the 2WLTL and a 16-hr percentage of 54.3). During the afternoon peak hour of usage, 69.4 percent of the 2WLTL movements were made by commercial vehicles (Tables 11, 12 and 13). During the 16-hr count, 417 vehicles made turns to generators and 318 made turns from generators. The 16-hr 2WLTL usage volume represents 3 percent of the 16-hr total volume.

A 12-hr 2WLTL usage count (9:00 AM to 9:00 PM) was made at the 25th Ave. N. E. installation to determine the magnitude of 2WLTL movements in a commercial area. All the 2WLTL movements along a 600-ft portion of the 2WLTL were counted. This section, comprising about 25 percent of the total 2WLTL length, is bounded by the larger traffic generators in the area. The majority of the movements were those made to and from the several entrances to a community shopping center located off 25th Ave. N. E. Hourly usage of the 2WLTL is shown in Figure 35. Although to generator movements were approximately equal to from generator movements in Figure 34 for Airport Way, the to generator movements are nearly twice the from generator movements throughout the day for 25th Ave. N. E. Other shopping center access points are more convenient to exit from. The rise in 2WLTL usage at 9:00 PM is due to the fact that retail businesses were open until 9:00 PM on the day the count was made, and the rise represents the departure of shoppers and some employees.

During the 12-hr count, 2,494 vehicles used the 2WLTL; 846 traveling from generators and 1,648 moving to generators. The peak hour of usage occurred from noon to 1:00 AM, with 232 2WLTL movements. Throughout the day, automobiles accounted for approximately 90 percent of the 2WLTL usage. The 12-hr 2WLTL volume represents roughly 23 percent of the 12-hr total volume.

Maneuvers

This phase of the operations study was conducted to determine some of the driving characteristics exhibited by motorists using the 2WLTL. There is no doubt that proper use of the 2WLTL can aid in the reduction of accidents, reduce vehicular delay, and in general, expedite the flow of through traffic. The use of the 2WLTL requires no new

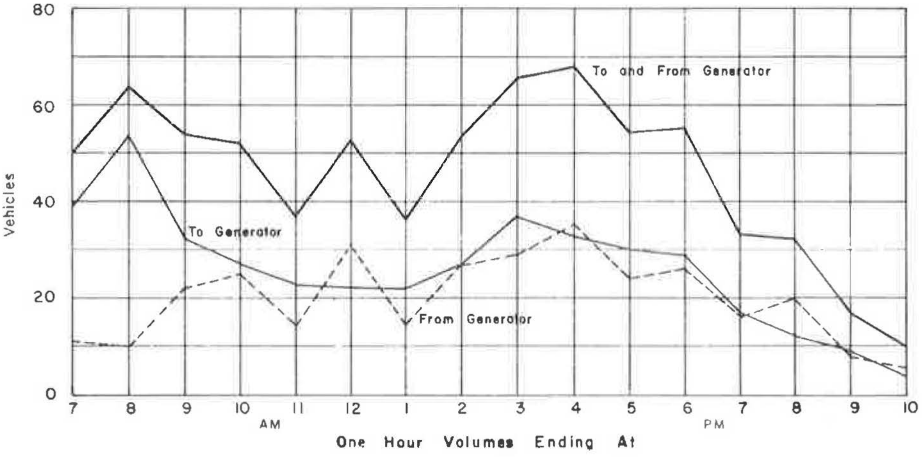


Figure 34. Weekday 2WLTL usage on Airport Way, 1962.

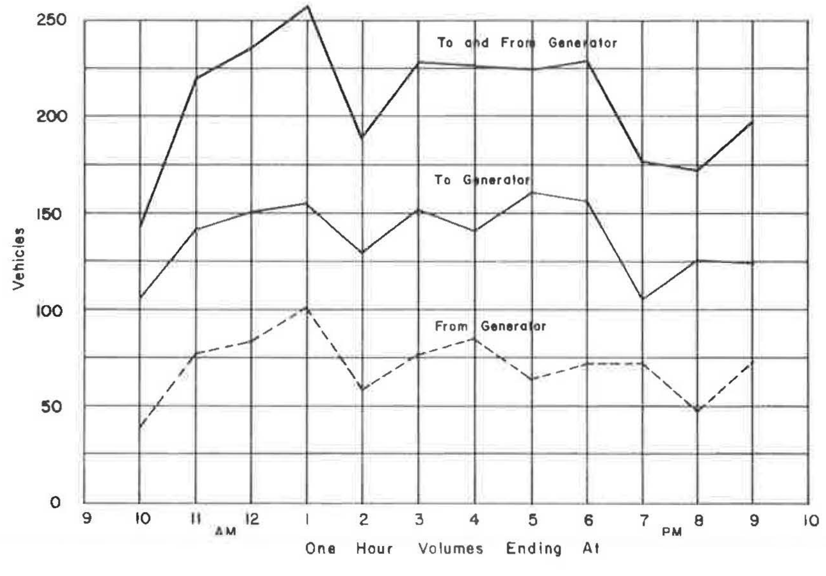
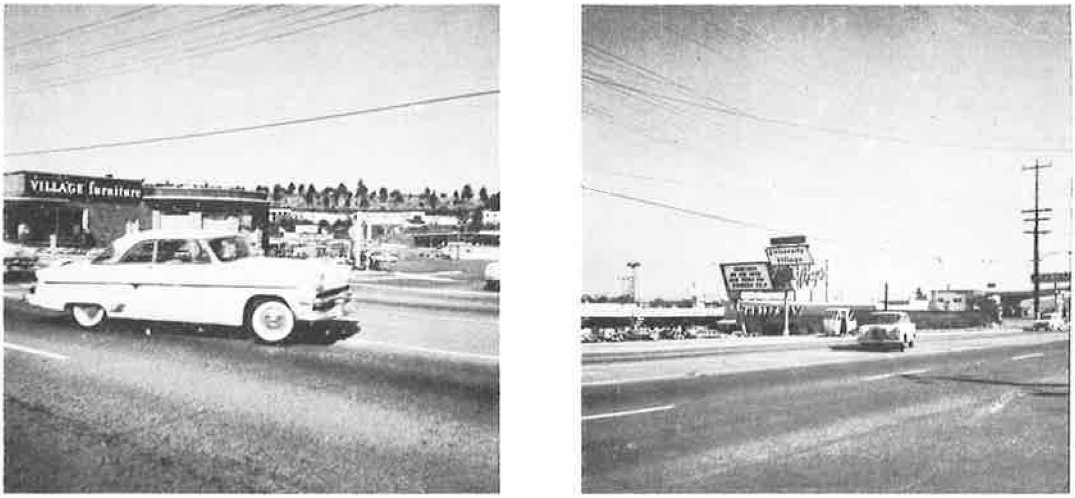


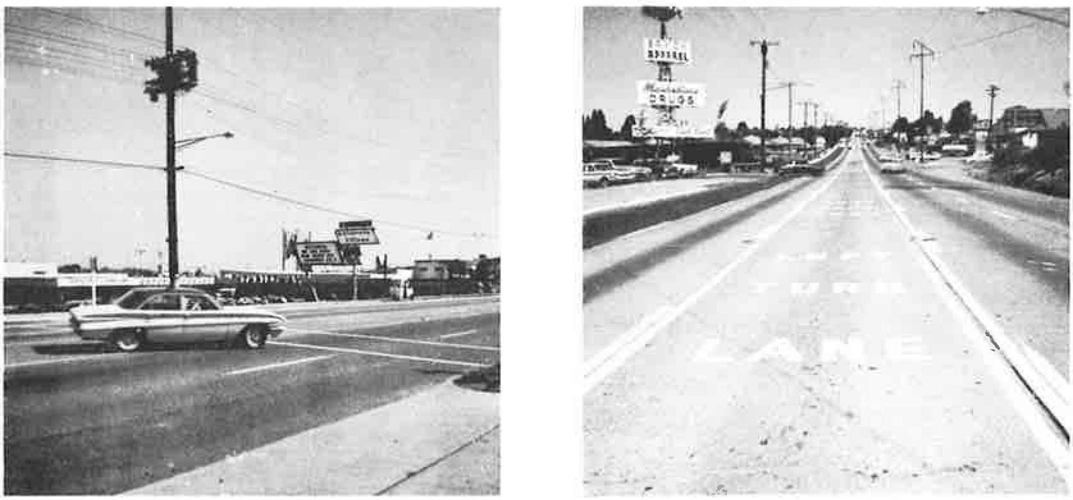
Figure 35. Weekday 2WLTL usage on 25th Ave. N. E., 1962.

driving skills. Two elements are involved in the proper use of the 2WLTL: (a) the motorist must be able to easily recognize the 2WLTL, and (b) he must make use of it.

Confusion over the 2WLTL is obviously greatest among out-of-state drivers. This is reasonable to expect because the 2WLTL is not in common use throughout the nation. Many local drivers from outside the city also do not understand the 2WLTL, and even some of the Seattle drivers fall into this category. Drivers who do not understand the 2WLTL will invariably slow to a stop or near-stop in the inside through lane before executing a left turn to a generator (Fig. 36A). One out-of-state driver did this three consecutive times. In a study of the distance traveled in the 2WLTL before making a left turn to a generator, 17 percent of the out-of-town drivers (most were also out-of-state) made no use whatsoever of the 2WLTL and merely cut directly across it from the inside through lane. Only 3 percent of the local drivers made left turns in this manner.



A. Motorists fail to use 2WLTL in turning left to generators and turn directly from the through lane.



B. Motorists turning left from generators cut directly across 2WLTL. Photo on right shows a vehicle crossing 2WLTL and entering the outside through lane.

Figure 36. Motorists fail to make full use of 2WLTL.

Most automobile drivers enter the 2WLTL on a reverse-curve path and entry is completed within 40 to 50 ft. Typical entry maneuvers by automobiles are shown in Figure 37A. A sample distribution of the distance traveled in the 2WLTL by automobiles at the 25th Ave. N. E. installation is shown in Figure 38. A fairly symmetrical distribu-

A

B C

Figure 37. 2WLTL usage by automobiles on 25th Ave. N. E.

tion is evident for local drivers, with an average travel distance of about 200 ft. Some motorists travel up to 600 ft and more in the 2WLTL. Such excessive use of the 2WLTL can prevent other drivers from entering the 2WLTL and is undesirable. Non-local drivers from outside King County have an average travel distance of about 140 ft. The distribution of travel distances is skewed extremely to the right. Such a difference is not surprising since non-local drivers probably do not realize the purpose of the 2WLTL until they are nearer their point of turning, and they are probably more cautious also. This would result in shorter travel distances for this group. Some research into signing for 2WLTL's would be desirable. Perhaps symbolic signing could supplement the conventional signs to inform the unfamiliar driver with regard to proper use of the 2WLTL.

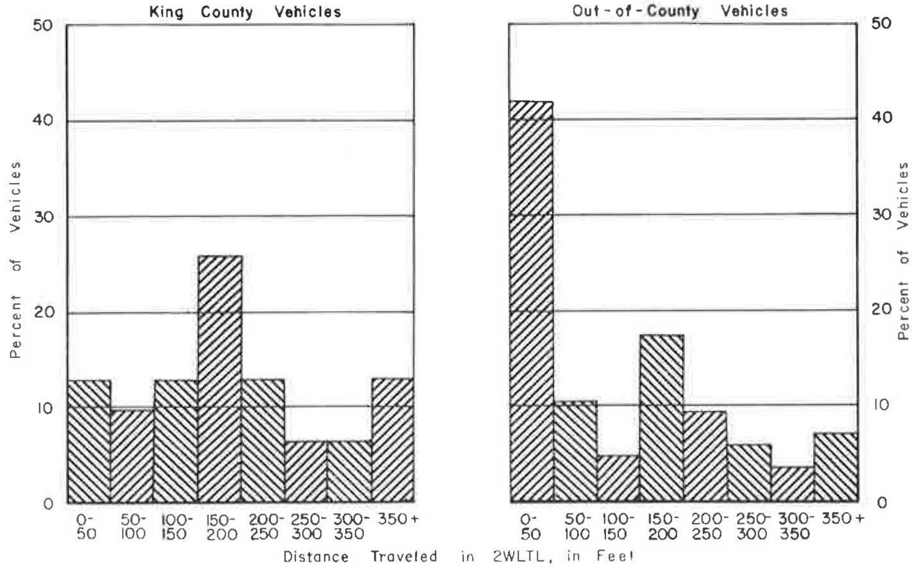


Figure 38. Distance traveled by automobiles in 2WLTL prior to making a left turn.

TABLE 14

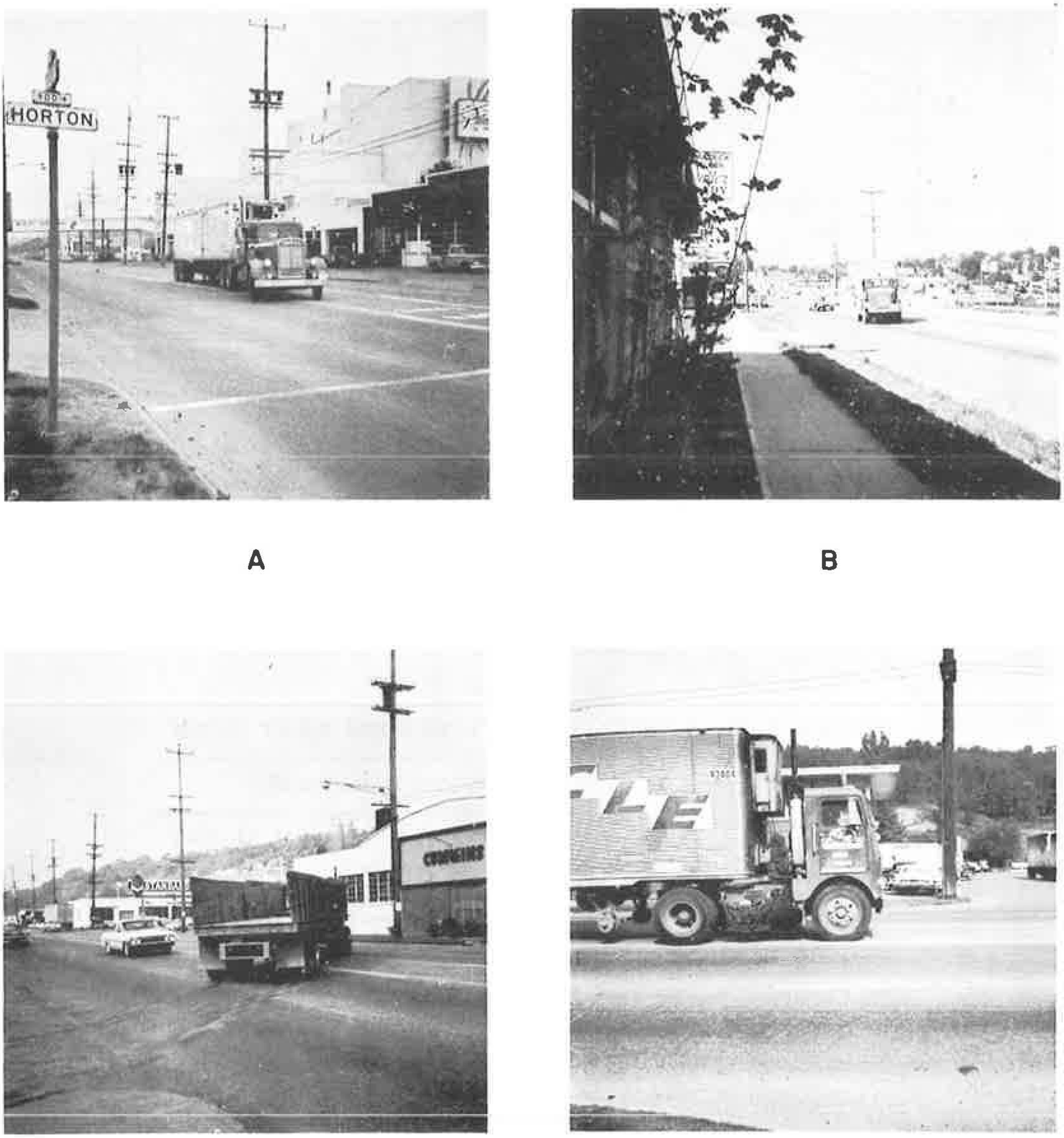
DISTANCE TRAVELED IN 2WLTL BEFORE LEFT TURN

Automobile Registration	Automobiles Sampled	Travel Distance (ft)			
		Average			Median
		Rush Hour	Non-Rush Hour	Rush and Non-Rush Hour	Rush and Non-Rush Hour
King County	62	230	180	200	180
Out-of-county	86	140	130	140	100

Table 14 summarizes the average travel distances for local and out-of-county drivers. Travel distance is longer during rush-hour traffic than during the non-rush-hour period. One might reasonably expect that during non-rush-hour periods, a motorist probably does a larger portion of his deceleration in the through lane because traffic is light and it does not cause undue delay to other vehicles. When traffic is heavy, most of the deceleration will be in the 2WLTL. Furthermore, when traffic is heavy a driver cannot take the chance that the 2WLTL will not be occupied when he desires to enter it. Statistical analysis, however, showed no significant difference between the rush and non-rush-hour groups. Out-of-county motorists apparently do not travel any further in the 2WLTL during rush-hour traffic than during non-rush periods.

On 25th Ave. N. E. during rush hours, 15-min volumes were approximately 350 vehicles, whereas non-rush hour volumes averaged 225 vehicles per 15-min period.

Braking before entering the 2WLTL is not too common for drivers who enter the 2WLTL a reasonable distance ahead of their left turn. Braking before entry occurs more frequently among drivers who make little use of the 2WLTL. Even when drivers do not brake when entering the 2WLTL, many begin to decelerate in the through lane



A B

C D

Figure 39. 2WLTL usage by trucks.

(perhaps from 30 to 25 or 20 mph) just before crossing over into the 2WLTL. This is probably because driving over the rounded steel traffic buttons gives an unpleasant jolt and motorists slow down in order to enter the 2WLTL and avoid the buttons. Smaller buttons with less height and closer spacing would probably be better, although this arrangement might be more expensive.

Figure 37B shows several automobiles waiting in line for the opposing traffic to clear before making their left turn. The 2WLTL offers an advantage over the unidirectional left turn with regard to limitations of storage and stopping in the through lane because the left-turn lane is full. There is fairly even placement of the vehicles in the 2WLTL. Figure 37C, however, shows a left-turning vehicle crowding the 2WLTL lane

TABLE 15

TURN SIGNAL INDICATIONS WHEN USING THE 2WLTL

Movement	Type	Signaling (%)			Not Signaling (%)
		Entering & Exiting 2WLTL	Entering 2WLTL Only	Exiting 2WLTL Only	
To generator	Autos	69.7	-	5.4	21.0
	Trucks	60.8	-	19.6	19.6
From generator	Autos	1.9	30.2	-	67.0
	Trucks	4.5	35.8	-	59.7

line. Such placement is more likely to slow up through traffic as it approaches the vehicle and in general does not appear to be a desirable practice.

Automobiles turning left from generators and into the through lanes usually make little use of the 2WLTL as an acceleration-merging lane. Most drivers wait for a gap in traffic, cross the 2WLTL at nearly a right angle, and turn into either the inside or outside through lane (Fig. 36B).

General observations of the use of the 2WLTL by trucks on Airport Way show that these drivers tend to use the 2WLTL in a fairly satisfactory manner. Figures 39A and B show trucks gradually easing into the through lane as they use the 2WLTL to accelerate to through traffic speed. Truckers make use of the 2WLTL for left turns from the generators to the through lanes (Fig. 39C). The large trucks occupying the 2WLTL in A and D demonstrate the desirability for providing a lane width equal to and perhaps greater than that of the through lane, which should be at least 10 ft wide.

Few drivers use the 2WLTL as a passing lane. The high buttons that Seattle uses on 2WLTL's probably helps to discourage this.

Turn-Signal Indications

Signaling either by hand or turn-signal indicator when changing lanes on a multilane street or highway helps to prevent accidents. This phase of the operation's study was aimed at determining the extent of signal use when vehicles use the 2WLTL for turns to and from generators. For 2WLTL movements from the through lanes and to generators there are four possibilities with respect to signaling: (a) signaling both while entering and exiting the 2WLTL—both left-turn signals; (b) signaling on entry only; (c) signaling on exit only—as the driver is about to begin his left turn; and (d) no signals. For 2WLTL movements from generators to the through lanes, there are also four possibilities: (a) signaling both when leaving the generator (left-turn signal) and when leaving the 2WLTL and entering the through lane (the latter would call for a right-turn signal, assuming that the motorist uses the 2WLTL as an acceleration lane); (b) signaling when leaving the generator only; (c) signaling when entering the through lane only; and (d) no signals. Table 15 is a sampling of automobiles and trucks at 25th Ave. N. E. and Airport Way, respectively. The samples were broken down into rush-hour and non-rush-hour vehicles, and for each vehicle type, the two groups gave virtually the same results.

There does not appear to be much difference between automobiles and trucks in most categories (Table 15). Although the automobile data and truck data were not collected from the same 2WLTL installation, street widths and volumes are fairly similar for these installations. Approximately 80 percent of the vehicles signal at least once when turning into generators, but only about 40 percent signal at least once when turning out of generators. This is not surprising because most drivers realize that a left turn from the main street is more hazardous than one from a generator. In the latter case, drivers usually wait until there is a gap in traffic and probably feel that a signal is not really necessary.

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