TRANSPORTATION DATA REQUIREMENTS: AN EVALUATION OF MANUAL TRAFFIC COUNTS ON PRIMARY HIGHWAYS

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(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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SUMMARY

The purpose of this study was twofold: (1) to examine the working practices followed in obtaining manual traffic counts on primary highways in Virginia, and (2) to evaluate the accuracy of the counts. The former was achieved by observing and interviewing personnel conducting traffic counts at 26 stations, statewide; for the latter, the results of manual counts were compared with data obtained by using a portable traffic recorder and a motion picture camera at 9 stations.

The study concluded that (1) there is a need to better inform both traffic count personnel and their supervisors about why the counting is important and how it should be done; (2) often either too many or too few personnel are assigned to work at traffic count stations; (3) at some intersections on primary highways there are requirements for manually counting the traffic to and from the secondary roads, but the costs incurred for these are not substantially contributing towards accomplishing the objective of the program; (4) a few traffic count personnel were found to be working at sites where they were exposed to unusual traffic hazards; (5) many traffic count personnel have been routinely scheduled to work for long overtime periods at 1.5 times their normal hourly pay rates; (6) altogether, many working practices that were inefficient or contrary to prescribed procedures were observed at the 26 stations; and (7) an analysis of the accuracy of the traffic count data taken at 9 stations showed that the manual counts for 66% of the stations included unacceptable errors. Also, the results of the study indicated that the mathematical factors used to convert 12-hour manual counts into annual average daily traffic figures should be reevaluated and updated.

It is recommended that the Traffic and Safety Division (1) develop and distribute an updated version of the pamphlet "Traffic Counting on Interstate, Arterial and Primary Routes"; (2) provide supervisory personnel with adequate training and instructions for spot-checking traffic counting activities; (3) confirm how many people should be assigned to work at each count station; (4) cancel the requirements for manually counting traffic on secondary roads where they intersect high volume primary roads; and (5) prohibit traffic count personnel from using work sites at which they would be exposed to unusual traffic hazards. Another recommendation was that resident engineers should avoid the routine scheduling of overtime work by dividing traffic counting assignments among more hourly people. The findings also support the recommendation in another report that the Department consider changing the current traffic count program into one using traffic recorder counts supplemented with a limited statistical sample of manual counts.

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BACKGROUND

An evaluation of the Department's traffic count programs was requested because of interest in finding means of obtaining more useful data than was being collected and at lower costs.(1) In response to the request, two studies were conducted. The first provided an evaluation of the traffic count program and the second evaluated portable traffic recorders. A third study, the one reported here, was initiated because early in the first study it had been determined that there was a need to evaluate the manual traffic counts obtained on primary highways.

The traffic count program for primary highways costs about $522,000 yearly and its objective is to determine the daily number and types of vehicles using the interstate, arterial, and primary routes.(2) The manual traffic counts on primary highways are conducted by observers who usually sit in parked vehicles and use a set of hand counters to record vehicle classification and travel direction data hourly during 12-hour periods. The "Operations Manual: Traffic and Safety Division" explains that manually counted "traffic volumes, in almost any given location, vary with (1) the hour of the day, (2) day of the week, and (3) the month of the year. Because it is not economically feasible to count and classify traffic at every station during every hour of the year, mathematical formulae have been developed and are applied to the counts."(3) Basically, the 12-hour manual counts are conducted at a station on a given section of road either 9, or 4 or 2 times yearly, according to a system of control counts and supplemental counts for use in calculating annual average daily traffic (AADT) statistics. Ideally, the appropriate number of people should be assigned to work at each traffic count station, all of them should be thoroughly instructed in working practices, and they should adhere to these practices so as to obtain reasonably accurate counts.

During the study for evaluating the traffic count program, discussions with Department personnel revealed that there were several possible sources of problems which could affect the accuracy of the results of the manual traffic counts.(4) Accordingly, there was a need to identify these problems and their effects on the accuracy of the manual counts.

PURPOSE

The purpose of the study was twofold: (1) to examine the working practices followed in obtaining manual traffic counts on primary highways in Virginia, and (2) to evaluate the accuracy of these through comparisons with corresponding data obtained with motion pictures and portable traffic recorders.

METHOD

Working Practices

To accomplish the first purpose, working practices were examined by observing and interviewing personnel conducting traffic counts at stations on primary, arterial and interstate routes. In 1976, the Traffic and Safety Division's annual update of traffic data required 12-hour counts at 1,345 traffic count stations.(4)

Traffic Counting Procedures

Since the method for conducting this study had to be oriented to the Department's procedures for having personnel obtain manual traffic counts, these procedures are described here. The schedule [a page of which is shown in Figure 1]"for counting at all stations is prepared annually by the Traffic and Safety Division and distributed to the district and resident engineers prior to the beginning of the annual counting period."(5) Typically, traffic counting personnel assigned to the resident engineer's organization are scheduled to work a 12-hour day for up to 3 days per week. At each counting station, they obtain the data for completing the Traffic and Safety-1 form shown in Figure 2. A variable number of hand counters are mounted to boards, as shown in Figure 3, and used to record the observed number of vehicles by classification and direction of travel.

1978 SCHEDULE OF TRAFFIC COUNTS SALEM DISTRICT

HILLSVILLE RESIDENCY SHEET 1

STATION NO.	DAY	DATE	HOURS	DESCRIPTION
2020				CARROLL COUNTY NEAR NORTH CAROLINA S L INT OF RTS 52N 52S 687E
	SAT	JAN 28	7A 7P	
	WED	MAY 10	7A 7P	
	MON	JULY 31	7A 7P	
	TUES	NOV 07	7A 7P	
2047 KEY				CARROLL COUNTY NEAR HILLSVILLE INT OF RTS 221E 221W 100N 669S
	TUES	FEB 07	7A 7P	
	FRI	MAR 31	7A 7P	
	WED	APR 26	7P 7A NITE	
	MON	MAY 22	7A 7P	
	THUR	JULY 13	7A 7P	
	SUN	SEPT 10	7A 7P	
	THUR	OCT 12	7P 7A NITE	
	WED	OCT 25	7A 7P	
	SAT	DEC 09	7A 7P	
2049				CARROLL COUNTY AT WOODLAWN INT OF RTS 58E 58W 620N 620S
	SAT	FEB 04	7A 7P	
	WED	MAY 17	7A 7P	
	FRI	AUG 18	7A 7P	
	TUES	NOV 14	7A 7P	
2062				CARROLL COUNTY NEAR WYTHE C L INT OF RTS 94N 94SW 601NW
	WED	MAR 08	7A 7P	
	WED	AUG 30	7A 7P	

Figure 1. Schedule of traffic counts.

COMMONWEALTH OF VIRGINIA

DEPARTMENT OF HIGHWAYS

TRAFFIC COUNT STATIONS

T&S-1 (Rev. 9/1/73)

Station Location _____ District _____ County _____

Station No. _____ Weather _____ Date _____ 19____ Day _____ Hours: From _____ To _____

All Traffic using the _____ (North - East - South - West) Leg of Route _____ Between This Station and _____ (Nearest Town or Route)

HOURS	LOCAL VEHICLES					BUSES		OUT OF STATE VEHICLES					Total All Vehicles	BICYCLES
	Passenger Cars	Single Unit Trucks			Trailers			Passenger Cars	Single Unit Trucks			Trailers		
		Panel and Pickup	Other Two Axle	Three Axle	Trailer-Trucks 3,4 and 5 Axle	School	Other		Panel and Pickup	Other Two Axle	Three Axle	Trailer-Trucks 3, 4 and 5 Axle		
Total														

All Traffic using the _____ (North - East - South - West) Leg of Route _____ Between This Station and _____ (Nearest Town or Route)

Total														

Figure 2. Traffic and Safety -1 form.

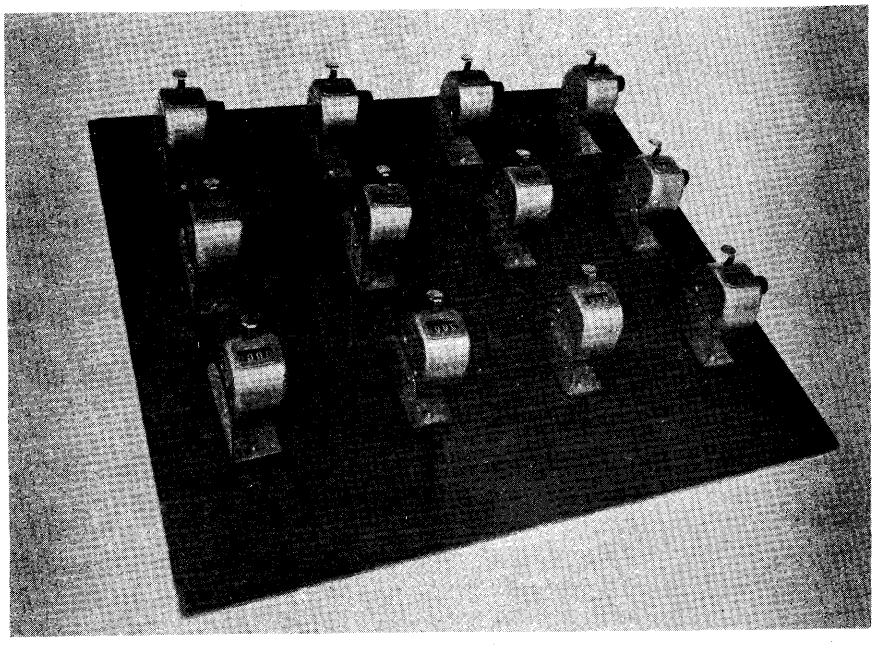

Figure 3. Vehicle classification counter board.

Observations and Interviews

Discussions with three of the Department's district traffic engineers indicated that there would be differences in the types of traffic conditions and the working practices used at the count stations within each district. Therefore, in order to obtain a representative sample, it was decided that a minimum of 3 stations in each of the 8 districts would be selected for study. The 26 stations studied were chosen to include a diversity of (1) traffic volumes, (2) speed limits, (3) highway systems and residency areas, and (4) freeway and intersection geometrics. Visits to the count stations were coordinated through the Department's district traffic and resident engineers.

At each count station, an observation and interview session was directed towards the identification of both the working practices used and the problems experienced in securing manual traffic counts. The working practices examined are discussed later in the analysis section of this report. Also, some supplemental information about supervisory roles was obtained from discussions with district traffic and resident engineers.

The study was concerned with a statewide evaluation of manual traffic counts and was not intended to direct criticism to the

individuals interviewed. Consequently, both the numbers of the traffic count stations and the dates of the interviews are not identified in this report.

Accuracy of Traffic Counts

In meeting the second purpose for the study, the accuracy of the manual traffic counts was evaluated by comparing these with corresponding data obtained with motion pictures and portable traffic recorders.

Motion picture films were taken to obtain physical records of how many of each type of vehicle traveled through the count stations. One disadvantage was that it was not practical to continue motion picture filming for more than 3 hours at each traffic count station. Data for longer periods were obtained by using portable traffic recorders for 24-hours at each station. The disadvantages of the traffic recorders were that they did not identify the types of vehicles and had small errors in the counts.

It was decided that this phase of the study would include a minimum of 1 count station in each of the Department's 8 districts after considering that an extensive amount of time and cost would be required for obtaining, compiling, and analyzing the data needed from each station. The 9 stations chosen for study included diverse types of locations and traffic characteristics.

Data Collection Phases

The three phases of data collection for the count stations are described under the succeeding subheads.

Manual Counts

The personnel assigned by the residency staff conducted their traffic counts from 7 a.m. to 7 p.m. in accordance with their normal routine. Their count data were recorded on Traffic and Safety-1 forms and copies of these were subsequently obtained from either the district traffic engineers or the Traffic and Safety Division. After 6 p.m. the traffic count personnel were asked to participate in the previously described interview and observation sessions.

Traffic Recorder Counts

The day before each manual traffic count was scheduled, either one or two Stevens model traffic recorders were positioned on one intersection leg so as to count the vehicles either approaching or leaving the traffic count station. Counts of pairs of axles were printed on the traffic recorder tapes during 24 consecutive hours ending at 7 p.m.

Motion Picture Camera Counts

Concurrent with the manual and traffic recorder counts, time-lapse motion picture cameras were used to record traffic for up to three 1-hour periods. The study period included both off-peak and peak-hour traffic from 3 p.m. to 6 p.m. Super 8-mm model cameras using 30-minute film cartridges were set to operate at a speed of two frames per second. Generally, the camera was located 10 ft. (3.1 m) above the elevation of the highway and at some distance from the personnel conducting the manual traffic counts so as not to disrupt their normal counting routine. A camera was positioned so as to film all vehicles either approaching or leaving the count station on one particular intersection leg.

For each study site, a series of films were obtained while logging the corresponding time periods. When taking data from the projected films, the speed was controlled so that accurate counts of traffic volumes by vehicle classification and hourly periods could be obtained. The motion picture count data were tabulated both by vehicle classification and by number of axle pairs to facilitate comparisons with both traffic recorder and manual counts.

Data Tables

Three sets of data tables were prepared for the count stations so that the accuracy of the traffic counts could be evaluated. First, for each of the 9 stations, a table was used for comparing manual and motion picture traffic counts during a period which did not exceed 3 hours. Secondly, for the 7 stations where it was feasible to obtain more data, another table was used for comparing motion picture and traffic recorder counts during a period up to 3 hours. Data tables were not obtained for 2 stations. At 1 station it was anticipated that the use of pneumatic hoses for detecting vehicles on seven traffic lanes in one direction on a heavily traveled expressway would not yield accurate traffic recorder data. At another station, the Department's traffic count team was unexpectedly found to be conducting the count 1 day ahead of schedule;

consequently, the research technician proceeded to obtain motion picture data even though it was too late to set up the traffic recorders. And thirdly, for the 6 stations where accurate traffic recorder counts were obtained, another table was used for comparing manual and traffic recorder counts on an hourly basis for the entire 12-hour period of the manual traffic count. The data table for 1 station was excluded because the statistical testing, described in the analysis section of this report, revealed that the traffic recorder data were made inaccurate by an unusual malfunction.

ANALYSIS

Working Practices

The working practices used by the traffic count personnel at 26 stations are grouped by districts and rated as either favorable or unfavorable in Table 1. The ratings were based upon whether the working practices appeared either to be reasonably efficient or in need of improvement.

The 14 working practices included in Table 1 are successively discussed in the following sections of this report. First, the results of combining the ratings from all applicable stations are described. As shown in Table 1, there were variations in the number of applicable stations for which the working practices were rated because some items of pertinent information were not available at all count stations. For instance, information about whether the members of a count team were equally sharing the traffic count activities would not be applicable for the stations where just one person conducted the traffic count. Secondly, examples of certain working practices which were considered to be either efficient, unique, or causing problems are described. These examples are also intended to provide insights concerning how some of the ratings were determined.

Table 1

Working Practice at Count Stations

Working Practice	District and Station												
	Salem				Lynchburg			Bristol			Suffolk		
	1	2	3	4	1	2	3	1	2	3	1	2	3
1. Personnel appear to understand their instructions for traffic counting	*	F	F	F	F	*	F	F	F	F	F	F	F
2. Personnel can explain why counts are made and/or the use of the data	*	U	U	F	F	*	F	F	U	F	U	U	F
3. Personnel are able to record all vehicles during commuter rush hours	*	U	F	F	*	*	F	U	F	F	U	F	F
4. Appropriate number of people are assigned to work at traffic count station	*	F	U	F	F	*	F	U	F	F	U	F	U
5. Count teams of two or more equally share the traffic counting activity	*	U	U	*	*	*	*	*	*	*	F	*	*
6. Personnel are routinely scheduled to work overtime hours	*	F	U	F	F	*	F	F	F	U	U	F	U
7. The traffic count is affected by interruptions for recording hourly data	*	F	F	U	F	*	U	U	U	U	U	U	F
8. Traffic observations are affected by visual obstructions	*	F	F	F	F	*	F	U	F	F	F	F	F
9. Personnel have an adequate work site	*	U	F	F	F	*	F	U	F	F	F	F	F
10. Personnel appear to follow instructions by using correct working practices	*	U	U	F	F	*	F	F	F	F	F	F	F
11. Personnel are using special working practices	*	U	U	F	U	*	U	U	*	*	U	*	*
12. Residency staff makes periodic spot checks of work and traffic conditions at the count station	*	U	F	U	F	*	F	U	U	U	U	U	U
13. Supervisory controls appear to be adequate	*	U	U	U	F	*	F	U	F	U	U	U	U
14. Traffic counts appear to be accurate	U	U	U	F	F	*	U	U	F	F	U	F	F

Code: F — Favorable, U — Unfavorable, * — Not Applicable

Table 1 (cont.)

Working Practice	District and Station												
	Richmond			Staunton			Fredericksburg			Culpeper			
	1	2	3	1	2	3	1	2	3	1	2	3	4
1. Personnel appear to understand their instructions for traffic counting	F	U	F	F	F	F	F	F	F	*	F	F	U
2. Personnel can explain why counts are made and/or the use of the data	F	U	F	U	U	U	U	U	U	*	U	F	U
3. Personnel are able to record all vehicles during commuter rush hours	F	F	F	F	F	U	F	F	U	*	U	F	U
4. Appropriate number of people are assigned to work at traffic count station	F	U	U	F	U	U	U	U	U	*	U	U	U
5. Count teams of two or more equally share the traffic counting activity	U	*	*	*	*	*	F	*	*	*	F	F	*
6. Personnel are routinely scheduled to work overtime hours	F	F	U	F	U	F	F	F	F	*	U	U	F
7. The traffic count is affected by interruptions for recording hourly data	F	F	U	U	F	U	F	F	U	*	F	F	U
8. Traffic observations are affected by visual obstructions	U	F	F	F	F	U	F	F	F	*	U	F	U
9. Personnel have an adequate work site	F	F	F	F	F	U	F	F	F	*	U	F	F
10. Personnel appear to follow instructions by using correct working practices	F	F	F	F	F	U	F	F	F	*	U	F	U
11. Personnel are using special working practices	U	U	U	F	F	U	F	F	*	*	F	U	U
12. Residency staff makes periodic spot checks of work and traffic conditions at the count station	F	F	F	F	F	U	U	F	U	*	U	U	U
13. Supervisory controls appear to be adequate	F	U	U	F	U	U	U	U	U	*	U	U	U
14. Traffic counts appear to be accurate	U	F	F	F	F	U	F	F	U	U	U	F	U

Code: F — Favorable, U — Unfavorable, * — Not Applicable

1. Traffic Counting Instructions

At 91% of the traffic count stations personnel understood their instructions for traffic counting and thus were prepared to record their observations in the correct places on hand counters and the T&S-1 data forms. Although this result was impressive, 100% of the personnel will have to be kept proficient concerning their instructions.

Only two problems with traffic counting instructions were identified. One count team was incorrectly recording motorcycles in the category for other two-axle, single-unit trucks. Elsewhere, a person was incorrectly excluding state-owned vehicles from the counts and was wrongly substituting estimates for eight data items, each hour, by distributing tractor trailers about equally between the categories for Virginia and out-of-state vehicles.

2. Use of Count Data

At 61% of the stations personnel were unable to explain either why the traffic counts were being conducted or how the Department would use the data. Consequently, there is a need to help keep the traffic counters positively motivated by ensuring that they are given adequate information and reminders about why their job is important.

3. Counting During Commuter Rush Hours

Traffic count personnel were unable to keep up with the count of all vehicles during commuter rush hours at 32% of the stations. At 7 stations insufficient personnel were available to record the relatively high traffic volumes during the commuter rush period.

An example of a count team that used efficient working practices during commuter rush hours was identified from data comparisons which are subsequently described in the analysis section of this report. It was found that two ladies had counted relatively high volumes which included 24,977 vehicles in 12 hours and 2,850 in one hour, while obtaining accurate results both by vehicle classification and travel direction at a cross roads. During the peak hour, they successfully sustained an average of 95 clicks per minute on the hand counters.

The most common problem associated with commuter rush hours was encountered by a man who explained that numerous errors were resulting both because he was unable to count all vehicles and some traffic was being scored on the wrong hand counters. It appeared that an alternative way of reducing the error rate at the station would be to have two count team members positioned on diagonally opposite corners so as to have each count the traffic on the nearest two adjacent intersection legs.

4. Number of People Assigned

At 61% of the stations, problems resulted because either too many or too few persons had been assigned to conduct the traffic count.

Altogether, it was determined that two counters had been assigned at 6 stations where a second person was not needed for assisting with the traffic count. Likewise, a 4-man count team was assigned where only two counters were needed. On the other hand, at 7 stations there apparently was a need for additional personnel. At 2 of these stations the need for additional personnel could have been reduced by eliminating the requirements for counting traffic on the secondary roads at intersections.

One problem was identified at a station where one person was found to be successfully counting the traffic. Because of an exceptional one time daily schedule revision, only one person was assigned to the count; however, two people had been assigned for this work throughout the past 14 years. This type of situation clearly demonstrated the absence of justification for assigning more than one person to this traffic count station.

The most common problem was demonstrated by a 2-man count team which readily agreed that only one person was needed at the count station. The two people were pretending to share the work, one was counting traffic while the other waited to write down the hourly data totals. A manpower and cost efficiency problem was evident because the second team member had no real function for 56 minutes of each hour. Elsewhere, it was found that while one member of a 2-man team was counting the traffic, the second, dressed in swimming trunks for sunbathing, was lying in the back of a Department truck.

An unusual problem was introduced because a count team supervisor and an assistant resident engineer arranged a daily schedule for a 4-man crew under which the members were paired and each pair worked alternating one-hour stints, between 7 a.m. and 7 p.m. The justification for having the men work for only 50% of the time on

all daily schedules was based upon the exceptionally high traffic volumes in the residency. Nevertheless, the relatively low to moderate traffic volumes at one station should not have justified the perpetuation of the 50% manpower utilization practice.[6] This situation led to a questioning of the necessity for having 2 men assigned exclusively to the task of counting vehicles entering and leaving a secondary road at a T intersection. In this case, the cost of 24 man-hours was invested in collecting data which were not published in either "Average Daily Traffic Volumes....", "Secondary Traffic Counts....", or "Urban Traffic Counts...," These count data for the secondary road might have been used by someone to check whether it appeared that all of the intersection traffic had been counted. Essentially, the problem is that the costs incurred for obtaining count data for secondary roads do not substantially contribute towards accomplishing the objective of the program, which is to determine the number and types of vehicles using the primary highways daily.

5. Traffic Counting Teamwork

Count team members were not efficiently sharing the traffic counting responsibilities at 43%, or 3 of 7, applicable stations. This situation could have been improved by having supervisors provide instructions specifically for each count station.

One problem was that a count team was found to be struggling with an inefficient special working practice. During a directional (two-way) count, one person counted 3,722 Virginia vehicles while another counted 9,349 out-of-state vehicles, or 72% of the total. Using this practice, both were required to check the license plates of each vehicle in order to decide which individual would count it. Having both people scanning every license plate was a duplicative effort and introduced unnecessary problems. For instance, it was common to find situations where vehicles passed by in groups and 5 to 10 clicks were scored rapidly on the hand counters. This practice confounded team coordination because it was hard to identify license plates and there was no way of checking whether each vehicle was being counted by at least one but not both team members. Clearly, at this station, it would have been more efficient to assign one individual to count all northbound traffic while the other counted southbound traffic.

A couple of problems resulted after a district traffic engineer advised the resident engineers that a second person should be assigned to all high volume stations and that each team member should continuously count about half of the traffic during all 12 hours.

One of the district's counters stated that he and the other member of his team took turns in counting for one hour. However, the Traffic and Safety-1 form showed that only one individual had been recording data for 7 consecutive hours. The assistant district traffic engineer carefully observed the relatively high traffic volumes and concluded that it was impossible for one person to obtain an adequate count at the station.

Another of the district's counters explained that he and his wife always took turns counting for 2 hours each. He also mentioned that residency personnel have insisted that the data on the Traffic and Safety -1 form must "be balanced". Therefore, his wife uses a portable electric calculator to keep their counts "balanced up". In her absence, he was proceeding to incorrectly combine both the 5-6 p.m. and the 6-7 p.m. traffic counts on the hand counters. A far more serious problem was detected when it was found that all 12 hourly traffic count totals had been recorded on the Traffic and Safety -1 data form more than an hour prior to the 7 p.m. conclusion of the traffic count.

6. Counting Schedules and Overtime Hours

At 36% of the stations personnel had been routinely scheduled to work at overtime pay rates for substantial periods. When personnel are scheduled to work beyond 40 hours during a week, they are paid 1.5 times their normal pay rate for the overtime hours. In order to follow the Department's policy of avoiding the routine scheduling of overtime work, reduce the costs due to overtime pay rates, and keep personnel from becoming weary during extended workweeks, most of the overtime scheduling should have been avoided by dividing the work between additional hourly personnel. It was also found that the Traffic and Safety Division could have improved the situation by periodically reviewing residency schedules to identify cases where traffic counts could be more evenly distributed among the various daily and weekly time periods.

One traffic counter, who also worked for the Department as a salaried truck driver, said that he was accumulating 40 hours of overtime for the current week. A unique case was that of an hourly employee who reported that she and her husband had counted traffic on all 7 days, or for 94 hours, during the previous week. They are typically assigned to 12-hour traffic counts during either 5 or 6 days each week.

A typical problem was identified when it was explained that about 2 years ago a resident engineer began arranging to send replacements for a count team whenever they were about to start

working overtime hours. Both of the relieved counters resented the arrangement for taking away the "cream from their job", which is the overtime pay rate. Their replacements were full-time employees from a maintenance crew and they resented having to count traffic. Eventually, the resident engineer changed back to having the hourly employees work overtime schedules.

7. Interruptions for Recording Hourly Data

At 52% of the stations, the traffic counts were affected by interruptions for recording hourly data. The interruptions, which lasted between 3 and 10 minutes each hour, could have been greatly reduced in most cases by providing instructions concerning special working practices. Coincident with counting traffic, personnel should record an hourly data total, turn the corresponding hand counter back to zero, and continue on through for each of the remaining hourly totals.

The most common problem was demonstrated by an individual who interrupted his traffic counting for about 5 minutes in order to record the data totals each hour. Because he missed the count of some vehicles, he "put a few extra counts" on the hand counters in an attempt to account for the missing data.

Another problem was perpetuated by an individual who stopped counting traffic for about 10 minutes in order to record 52 hourly volume counts on a Traffic and Safety -1 form and turn the hand counters back to zero. In an attempt to make up for the missed traffic, he "fudges in" by adding dozens of clicks to the traffic count. Thus during the 12-hour count, his "fudging in" was substituted for nearly 2 hours of traffic count data.

An efficient special working practice was being used by some personnel for writing down hourly traffic totals. During a gap in the traffic flow, one counter wrote down four hourly totals on the Traffic and Safety -1 form and turned one row of hand counters back to zero. Then he picked up the count and repeated the cycle until all 24 of the hourly data items were recorded. This practice appeared to be basically effective even though there were not enough persons assigned for counting at the station. At two other stations, traffic count teams were found to be successfully using very similar special working practices.

8. Traffic Observations and Visual Observations

Only 22% of the stations were situated so that the traffic counters' view was occasionally interrupted by obstructions. At 5 stations, the visual obstructions were due to high traffic volumes that included cases where some vehicles partially or completely blocked others from the observer's line of sight.

Additionally, traffic count personnel frequently mentioned having problems when trying to distinguish between Virginia and out-of-state vehicles. The problems with identifying license plates generally occurred (1) where some traffic lanes were between 50 and 200 feet (15.2 and 60.9 m) from the observer's position, (2) where vehicles were traveling close to 55 mph (89 km/hr), and (3) during periods of darkness.

9. Work Site Safety Characteristics

The safety characteristics of the work sites were adequate at 82% of the stations. At these stations, the traffic counters were not exposed to any unusual traffic hazards.

An unusual problem involved a traffic count team at what appeared to be an unsafe work site. While one person was absent from the station, the other worked from a car parked in the median strip of an interstate highway at a point within 10 ft. (3.1 m) of the 55 mph (89 km/hr) traffic lanes. Less than 2 weeks after being interviewed, but at another count station, the man's parked car was struck by an errant truck traveling off of an interstate highway! He was hospitalized with injuries and did not return to work for 35 days. It was found that hourly employees, including the injured traffic counter, are not allowed to participate in state employee Blue Cross/Blue Shield insurance programs. This accident highlights the need for the Department to review its legal obligations in this area and make certain that everyone is aware of its policies concerning personal safety and the availability of commercial insurance policies for individuals.

Another unusual problem occurred when a traffic counter parked a Department truck at an alternate location on the shoulder of an interstate highway because plowed snow banks covered the median strip areas. Consequently, the truck remained in an exposed position just 5 ft. (1.5 m) from the traffic lanes in a 55 mph (89 km/hr) speed zone.

10. Compliance with Correct Working Practices

Personnel appeared to be correctly following their instructions for traffic counting at 78% of the stations. Here, it is unlikely that improvements are realistically obtainable because supervisors are limited to infrequent contacts with the traffic counters and remain extremely dependent upon the initiative and motivation of each individual.

One type of problem resulted from the failure of some persons to comply with the proper times for conducting traffic counts. In three cases, the research technician completed the planned motion picture filming at 6 p.m., but found problems when attempting to follow through by interviewing and observing the counters at the stations. Interviews were missed because two count team members left a station at 6:25 p.m., and elsewhere four team members left a station by 6:30 p.m. In the latter case at least three of the 1-hour counts were made about 10 minutes ahead of schedule. When the technician arrived at another station at 6:40 p.m., he found that the traffic counter had stopped working and had entered data for the 6-7 p.m. time period on the Traffic and Safety -1 form.

Another problem concerning compliance with instructions involved a traffic counter who was obviously unable to keep up with the traffic count. He explained that it wasn't much of a problem; that some vehicles are missed, but "you just do what you can — it's close enough".

11. Use of Special Working Practices

At 67% of 18 stations, personnel were using incorrect or inefficient special working practices. These types of deficiencies could be minimized by providing an updated version of the 1970 pamphlet "Traffic Counting on Interstate, Arterial and Primary Routes".[7] In addition to providing detailed instructions, it should include examples of both acceptable and unacceptable special working practices.

One problem with special working practices resulted because a person did not have enough hand counters and was instructed to merge out-of-state 3-axle trucks with the tractor trailer category. In order to implement the correct practice, his supervisor should have suggested that a note pad must be used to handle some of the vehicle categories having low hourly counts.

One unique special working practice was used by a count team because their resident engineer had instructed that both could leave any count station for two 15-minute work breaks each day after first doubling the traffic counts taken 15 minutes previously.

Another unique special working practice was identified after the research technician noticed that a count team had left their station for at least 20 minutes. During the interview session, he also noticed that the traffic counts for that time interval were sharply lower than any of the other hourly counts. Afterwards, he checked the Traffic and Safety -1 form sent to the residency and concluded that the data had been altered by replacing the low numbers with more acceptable looking estimates for the uncounted traffic.

12. Spot Checks of Counting Activities

Apparently, neither the residency staff nor other supervisory personnel made periodic spot checks of work progress and traffic conditions at 56% of the stations.

The most common problem involved a counter who had found that supervisory personnel had seldom tried to check the conditions at his traffic counting stations during the last 20 years. Another counter mentioned that he had not been visited by supervisory personnel during the last 16 years.

A unique problem involved a supervisor who made too many daily trips just for checking on one traffic counter. The counter explained that during the past 2 years his supervisor had typically visited the stations between three and four times during each traffic count. The supervisor's responses during the interview session demonstrated that he had not bothered to become knowledgeable about the purpose and procedure for traffic counts. In this case the frequency of his visits to the stations was a poor use of time and driving costs.

13. Adequacy of Supervisory Controls

A review of the accumulated problems at each station showed that supervisory controls appeared to be inadequate at 78% of the count stations. Consequently, there remains a need to provide training for supervisory personnel and ensure that they will make effective spot checks of work progress and traffic conditions at the stations.

14. Traffic Count Results

Overall, the traffic counts appeared to be accurate at only 56% of twenty-five applicable stations. These results were determined by checking whether or not each station had personnel that (1) were able to count all vehicles during commuter rush hours, (2) complied with their instructions for traffic counting, and (3) used efficient special working practices. The results at nine of the stations were also compared with the data which is subsequently described in the analysis section of this report.

Summary

In summary, the interview and observation sessions identified a large number of deficiencies in working practices. The deficiencies were almost evenly distributed among 26 stations in the Department's eight districts. It was also found that the results of one or more traffic counts were found to be unacceptable in each of the districts.

Accuracy of Traffic Counts

In order to evaluate the accuracy of the manual counts, the data from the manual, motion picture, and portable traffic recorder counts obtained at 9 stations were compared. The 9 stations included those listed first in the groupings for each of the Department's eight districts in Table 1. Included also was another station of special interest, which is the second station listed in the grouping for the Culpeper District.

The three sets of tables comprising the basis for the data comparisons were previously described in the method section of this report. The types of data comparisons made with the tables, identified as the first, second, and third sets of tables, respectively, are next discussed.

Types of Data Comparisons

Statistical Testing

Parts of the data from manual and motion picture counts from the first set of tables were used to determine whether the vehicles were accurately classified in the manual traffic counts. For these comparisons, the chi-square statistical test was used to test

for significant differences at the 95% confidence level.[8] In order to conform with statistical testing procedures, the vehicle categories which had a minimum of five accumulated in both the manual and motion picture counts, during each of the hourly periods, were the only categories that could be included in this phase of the statistical testing. In further detail, it was impractical to obtain motion picture data that could be used to classify vehicles into Virginia and out-of-state vehicle categories, because the one motion picture camera used at each count station always had to be set well beyond the 25 ft. (7.6 m) range within which usable pictures of license plates could have been obtained.

Data from the first set of tables were also used for determining whether the numbers of vehicles were accurately totaled in the manual traffic count. These comparisons were chosen for the analysis because they would not have to be considered invalid in cases where there were small or even substantial vehicle classification errors in the hourly manual counts. Accordingly, the numbers of total vehicles by hourly periods were compared by using the t-test to test for significant differences at the 95% confidence interval.[9]

Motion picture and traffic recorder data from the second set of tables were used to determine whether the traffic recorder counts were reasonably accurate. For these comparisons, the t-test was used to test for significant differences at the 95% confidence level.[10] In cases where the traffic recorder counts at a station were accurate as monitored by the motion picture camera for up to three 1-hour periods, it was feasible to proceed with comparing the hourly manual and traffic recorder counts from the entire 12-hour period for the manual count.

Empirical Data Trends

In the method section of this report, it was noted that the traffic recorder counts were expected to have some small errors. Therefore, it was decided that the comparisons between manual and traffic recorder counts would be based upon graphical trends instead of statistical testing.

Data from the third set of tables were used to provide comparisons of manual and traffic recorder counts by hourly periods from 7 a.m. to 7 p.m.

These data were compared on the basis of counts of axle pairs after the manual counts were converted by assuming that 3-axle trucks and tractor-trailer trucks were equivalent to 1.5 and 2.5 traffic recorder axle pairs, respectively. The second assumption

appeared to be reasonable even though it was found that some tractor trailers had less than 5-axles. A check of the films had indicated that the very small decreases from the actual number of axle counts for tractor trailers were cancelled out somewhat when the recorders detected the axles of either towed vehicles or motorcycles, which had not been included in the manual counts.

Data from the third set of tables were also graphically plotted to find whether the trends between manual and traffic recorder counts appeared consistent rather than variable during the 12-hours.

Additional comparisons with the traffic recorder data were developed by using the Department's procedures and mathematical factors (Primary Conversion Tables). These were previously discussed in the background section of this report. The ones listed in Appendix A were used for converting the 12-hour manual counts into annual average daily traffic (AADT). The unlikely but possible occurrence of very unusual traffic patterns meant that a 1-day traffic recorder count might not be close to the number calculated for the AADT. Nevertheless, it was reasonable to assume that the percent of daily traffic counted between 7 a.m. and 7 p.m. should be nearly the same for both the traffic recorder and the AADT data. Thus, for cases where these percentages were not similar, it was likely that the mathematical factors (Primary Conversion Tables) were not adequate.

Statistical Results

Manual and Motion Picture Counts

The data in Appendix B include the differences between manual and motion picture traffic counts by direction, vehicle classification, and time period. One series of statistical tests were performed in order to find whether there were problems with manually classifying vehicles by type and the results for each station are shown in Table 2. The testing showed significant differences at only 2 counting stations, one in the Culpeper District and one in the Richmond District. A count team in the Richmond District generally overcounted passenger cars and two-axle trucks while undercounting pickups and panel trucks. In the Culpeper District, a count team generally undercounted passenger cars and busses while overcounting trailer trucks.

Table 2

Results from Statistical Testing of Manual and Motion Picture Traffic Counts for Significant Difference

District and Count Station	Traffic Count Items Tested	
	Vehicle Classification Counts	Total Vehicle Counts
Salem	Not significant	Significant
Lynchburg	Not significant	Not significant
Bristol	Not significant	Not significant
Suffolk	Not significant	Significant
Richmond	Significant	Significant
Staunton	Not significant	Not significant
Fredericksburg	Not significant	Not significant
Culpeper - 1	Not significant	Significant
Culpeper - 2	Significant	Significant

Appendix B data were also used for finding if there were problems with the manual counts of total vehicles. As shown in Table 2, there were no significant differences between the two types of total vehicle counts at stations in the Lynchburg, Bristol, Staunton, and Fredericksburg Districts, which comprised 56% of all stations; while there were significant differences at the stations in the Salem, Suffolk, Culpeper, and Richmond Districts. The Appendix B data were also used to find that during the study periods which did not exceed 3 hours, the summations of the total differences between manual and motion picture traffic counts from the stations ranged between -11.4% and +11.2%.

Motion Picture and Traffic Recorder Counts

The differences between motion picture and traffic recorder counts are included in Appendix C. As shown by Table 3, the statistical testing determined that the small differences, ranging from -1.6% to +0.7%, between these types of counts were significant in only the Staunton District. Because the mechanical traffic recorder counts were accurate for as many as three 1-hour periods, it was feasible to compare the traffic recorder and manual counts during the entire 12-hour periods for the manual counts at the six districts showing no differences in Table 3. In the case of the Staunton District it was concluded that the traffic recorder counts were inaccurate because of an unusual malfunction. It is the opinion of this writer that passing traffic damaged a pneumatic hose clamp which then pinched the hose and distorted subsequent traffic counting results. As previously noted, traffic recorder

data were not obtained for the Suffolk District and for station No. 2 in the Culpeper District. Consequently, for these last 3 stations it was not feasible to compare traffic recorder and manual counts.

Table 3

Results from Statistically Testing
Motion Picture and Traffic Recorder Counts

District and Count Station	Vehicle Counts*
Salem	Not significant
Lynchburg	Not significant
Bristol	Not significant
Richmond	Not significant
Staunton	Significant
Fredericksburg	Not significant
Culpeper - 1	Not significant

*Vehicle Counts — vehicle axle pairs

Manual and Traffic Recorder Counts

Appendix D includes comparisons between manual and traffic recorder counts during 12 hours and these data were the basis for the graphs shown in Figures 4 through 9. The results from comparing the manual and traffic recorder counts are shown in Table 4, where it can be seen that the differences between the two types of counts after 12-hours ranged from -10.2% to +6.7%. Table 4 also shows that the graphical trends included in Figures 4 through 9 indicated a close relationship between the two types of hourly counts at stations in the Lynchburg and Fredericksburg Districts. The trends also indicated that there were substantial differences between the pairs of hourly counts at stations in the Salem, Bristol, Richmond, and Culpeper Districts. In the Salem District, a count team tended to consistently undercount traffic. An individual in the Bristol District reported a 12-hour count which was only 1.5% above the traffic recorder count. Nevertheless, his data were unacceptable because the hourly totals included consistent overcounts from 8 a.m. to 2 p.m., and consistent undercounts during the afternoon commuter rush period. A Richmond District team consistently undercounted traffic for the first 7 of 12 hours. In the Culpeper District a team counted accurately until 4 p.m., but then reported substantial overcounts for 3 hours and improperly departed the station 30 minutes before the 7 p.m. conclusion of the last traffic counting period. Altogether, it was concluded that counting personnel had failed to sustain accurate traffic counts during the 12 hours at 4, or 67%, of the 6 stations.

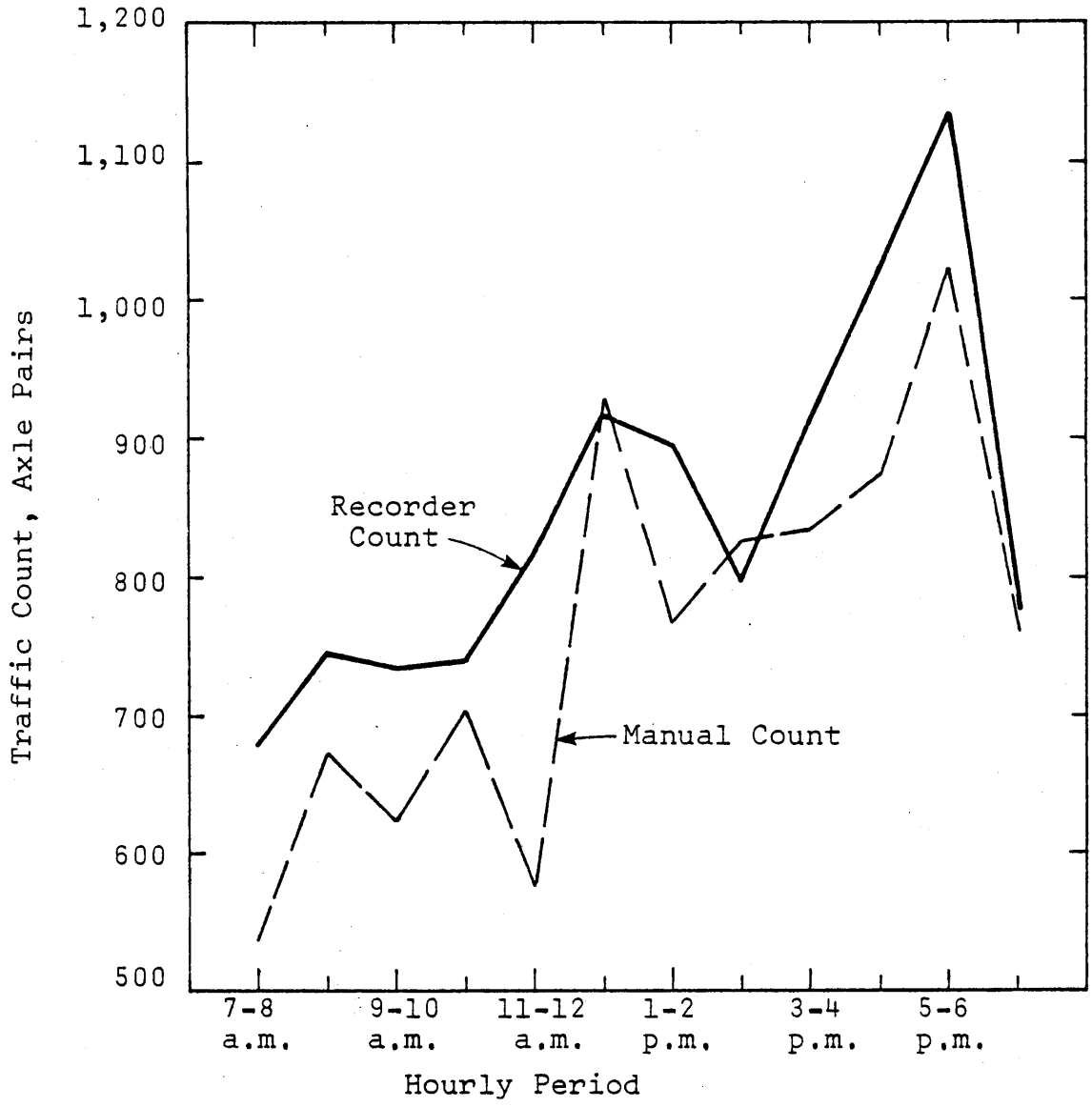

Figure 4. Hourly manual and traffic recorder counts for Salem District.

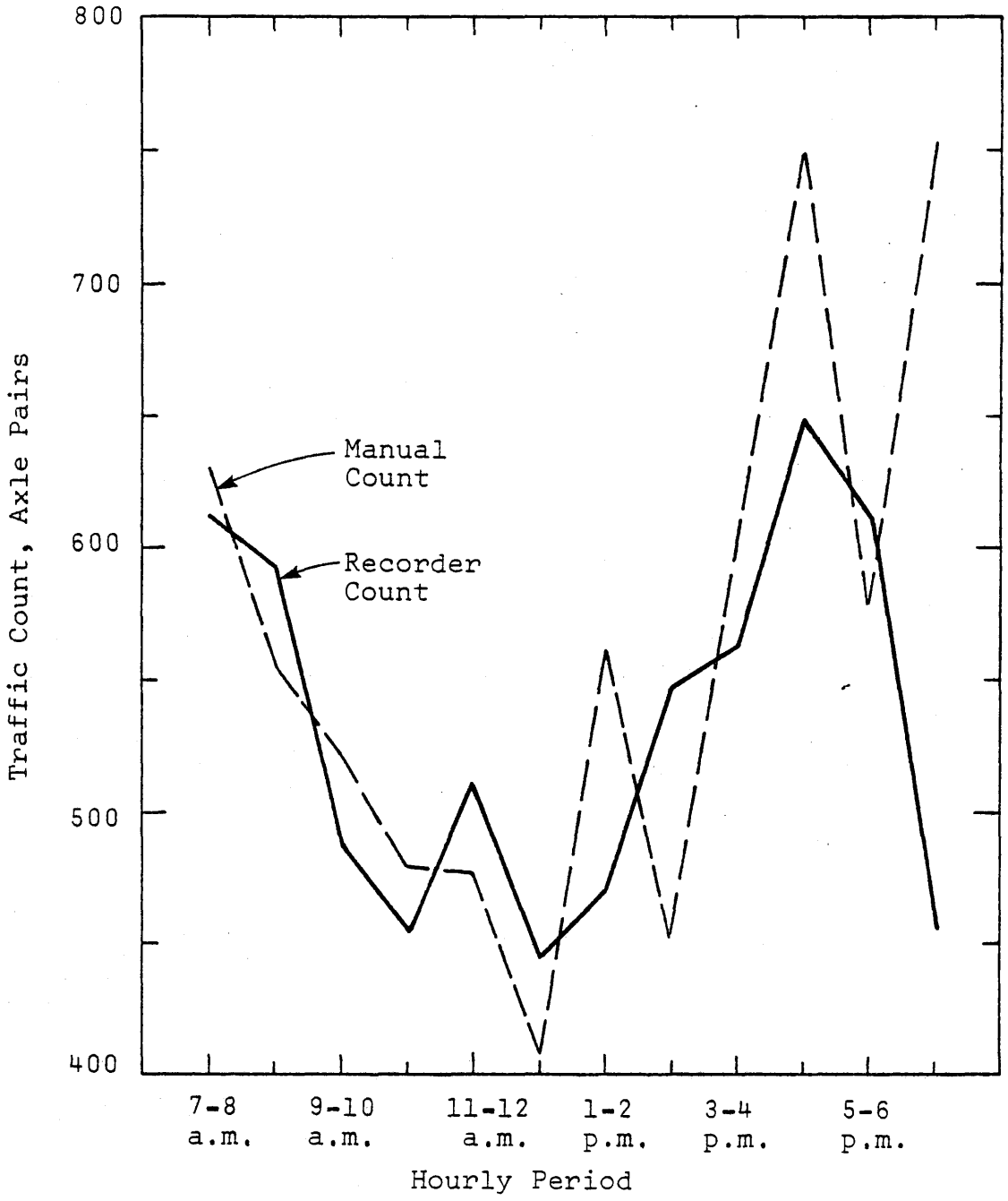

Figure 5. Hourly manual and traffic recorder counts for Lynchburg District.

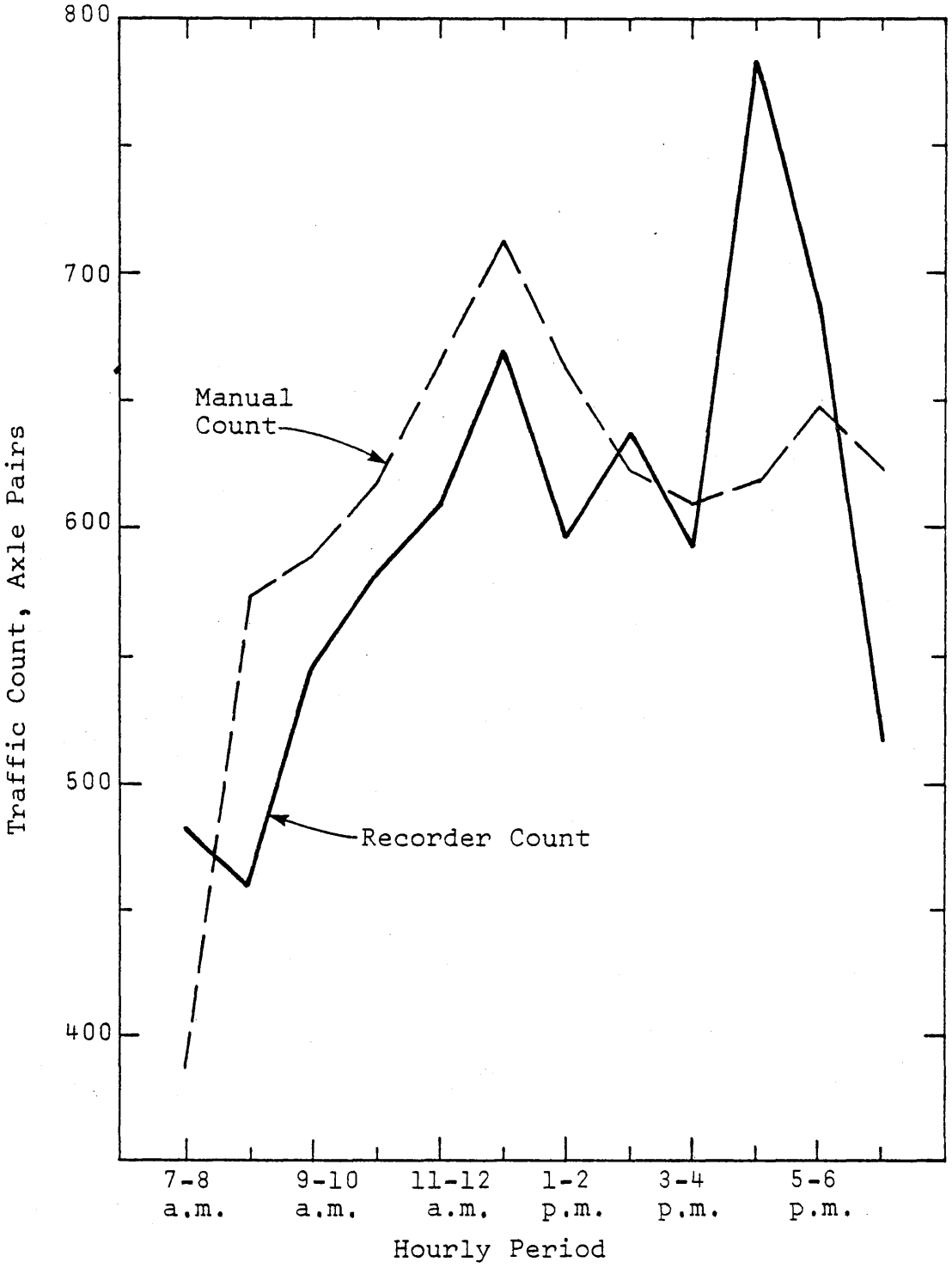

Figure 6. Hourly manual and traffic recorder counts for Bristol District.

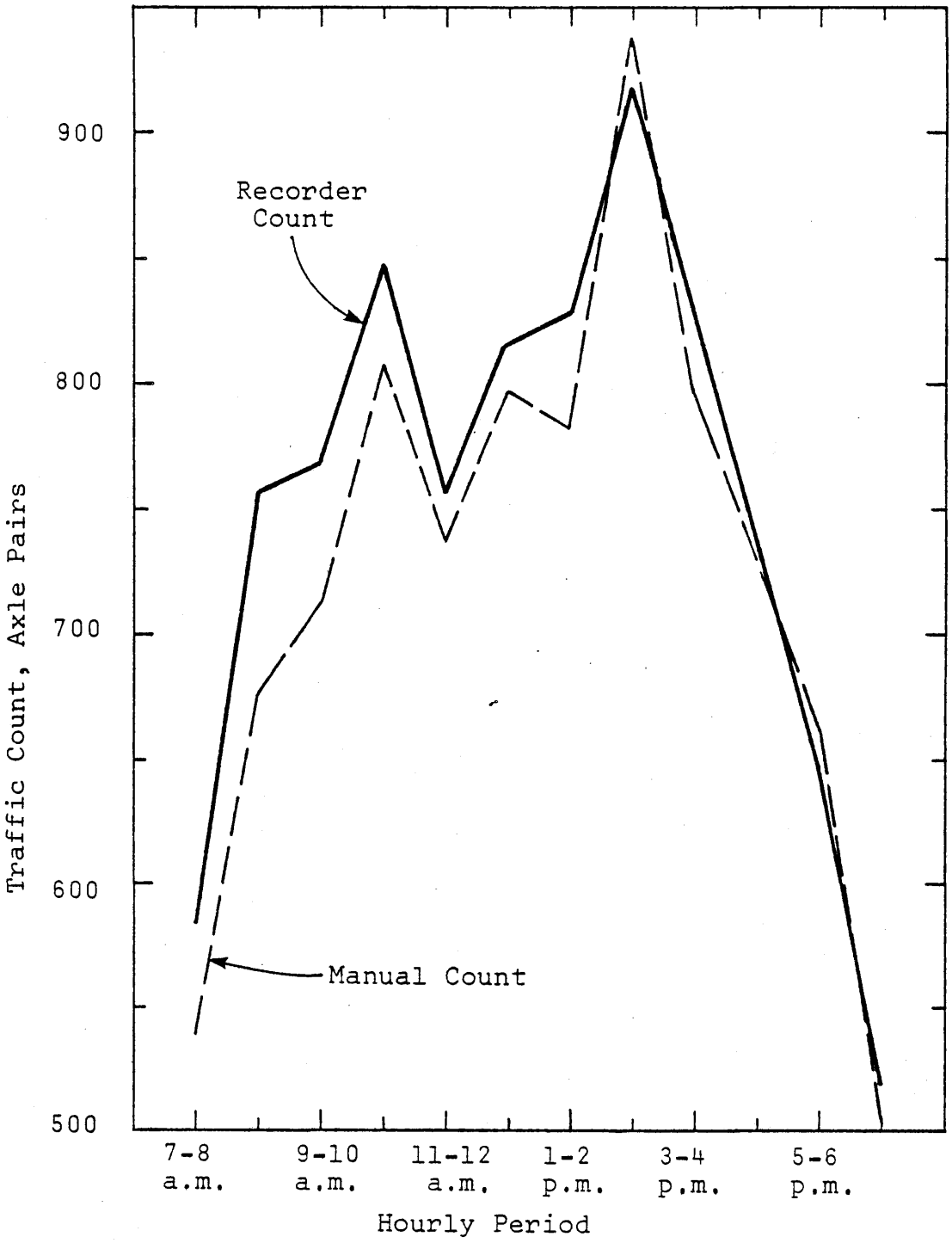

Figure 7. Hourly manual and traffic recorder counts for Richmond District.

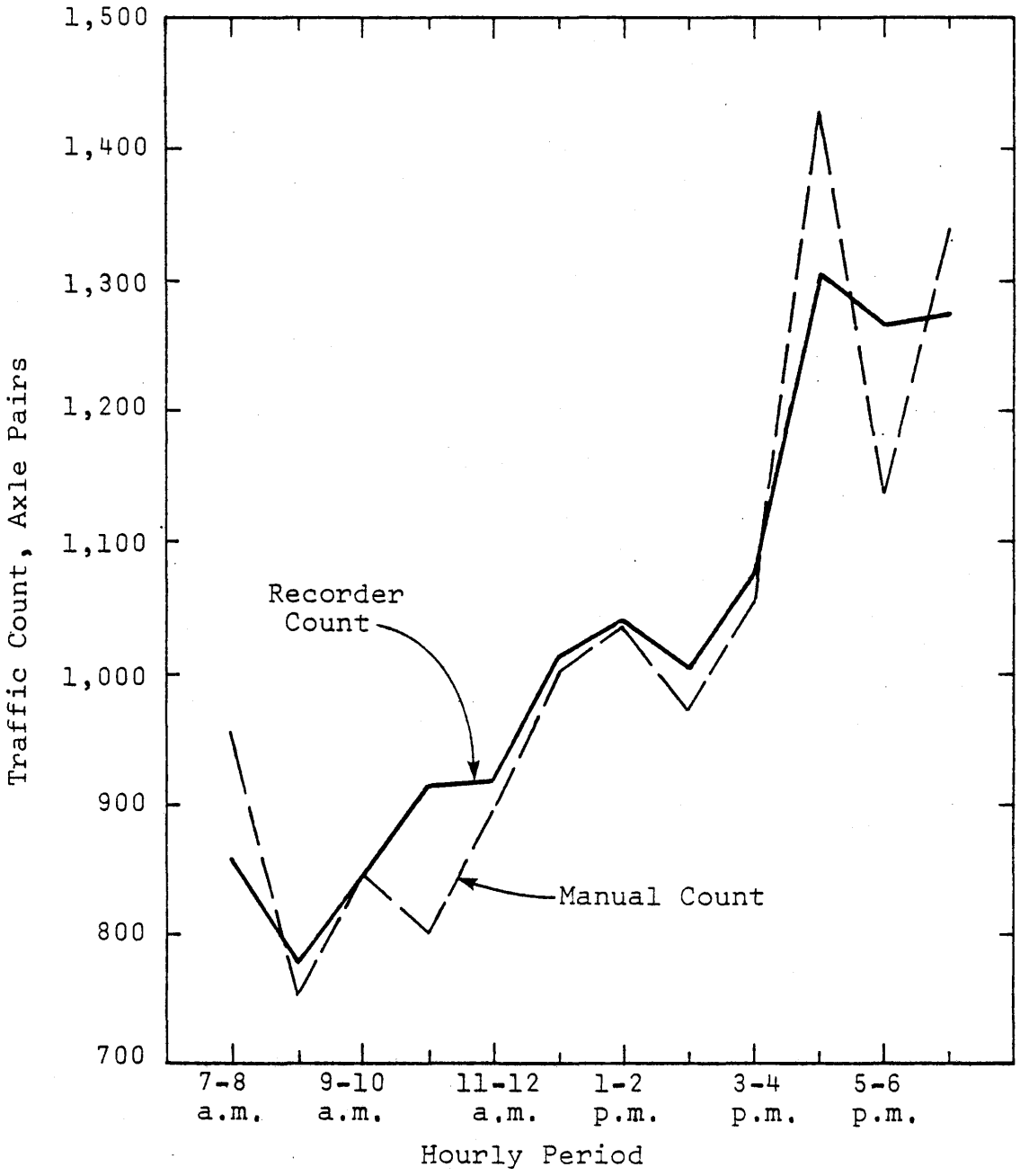

Figure 8. Hourly manual and traffic recorder counts for Fredericksburg District.

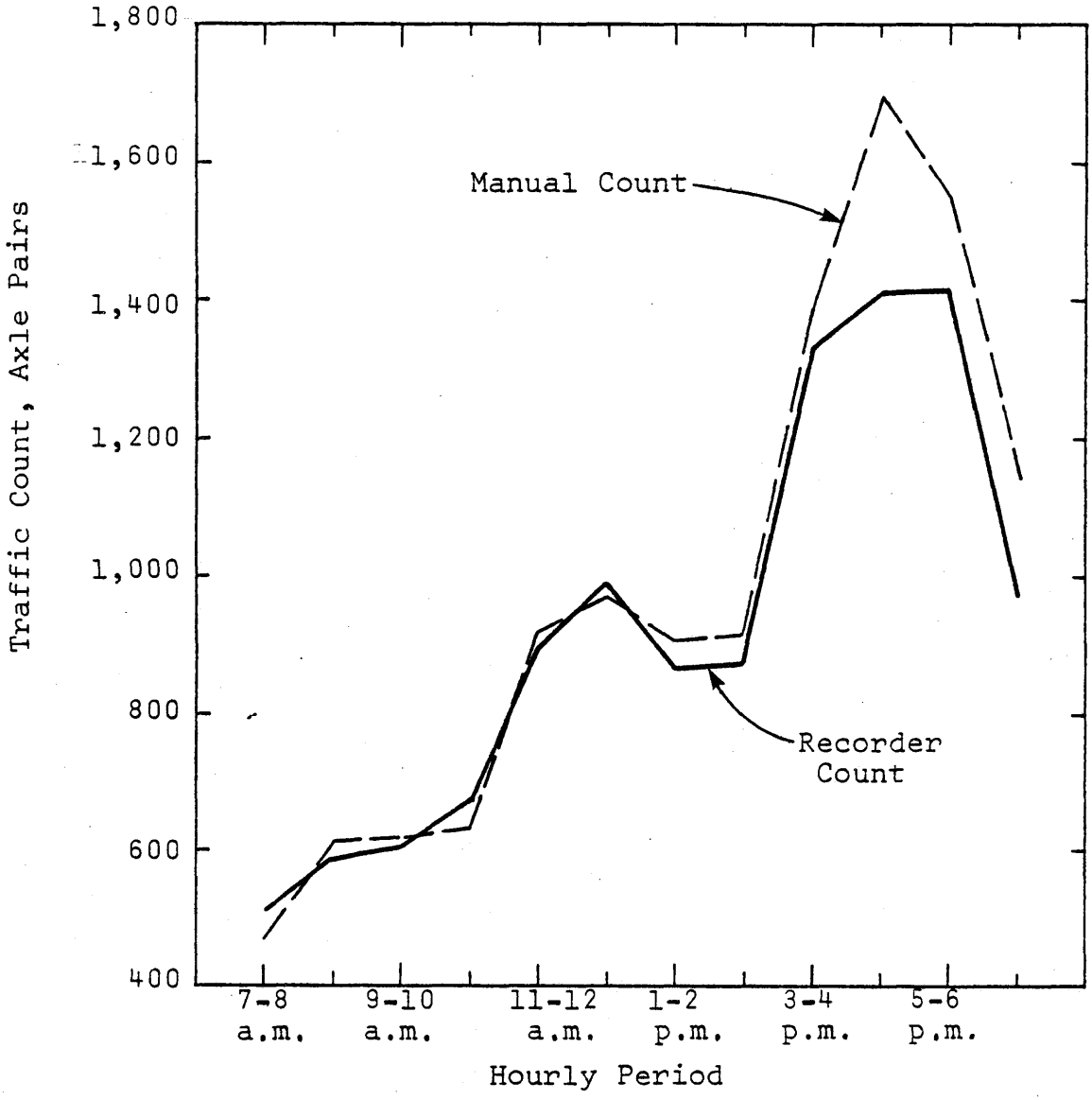

Figure 9. Hourly manual and traffic recorder counts for Culpeper District.

The percentages of the total daily traffic represented by the counts taken during the 12 hours between 7 a.m. and 7 p.m. are listed in Table 5. Comparing the percentages at each station revealed that the accuracy of the mathematical AADT factors was adequate at the count stations in the Salem, Lynchburg, and Culpeper Districts but inadequate for those in the Bristol, Richmond, and Fredericksburg Districts. Accordingly, there is an indicated need to reevaluate and update the Department's mathematical factors (Primary Conversion Tables).

Table 4

Comparisons of Manual and Traffic Recorder Counts

District and Count Station	Summation of Differences After 12 Hours	Graphical Trend Between Hourly Counts During 12 Hours
Salem	-10.2%	Poor correlation
Lynchburg	+ 5.7%	Good correlation
Bristol	+ 1.5%	Poor correlation
Richmond	- 3.6%	Poor correlation
Fredericksburg	- 0.5%	Good correlation
Culpeper - 1	+ 6.7%	Poor correlation

Table 5

Traffic Count Percentages and Accuracy of Mathematical AADT Factors

District and Count Station	Percent of Daily Traffic in 12 Hours (7 a.m. — 7 p.m.)		Accuracy of Mathematical AADT Factors
	Traffic Recorder Count Data	Factored Manual Count Data	
Salem	73.6%	70.3%	Adequate
Lynchburg	70.4%	75.7%	Adequate
Bristol	78.7%	66.4%	Inadequate
Richmond	73.2%	60.3%	Inadequate
Fredericksburg	71.6%	84.2%	Inadequate
Culpeper - 1	77.6%	71.0%	Adequate

Summary

Table 6 summarizes the results of the three data comparisons previously described. There it can be seen that the overall accuracy of the manual counts was considered acceptable at stations in the Lynchburg, Staunton, and Fredericksburg Districts, but unacceptable for the stations in the Salem, Bristol, Suffolk, Culpeper, and Richmond Districts.

Table 6

Summary of Manual Traffic Count Accuracy by Count Station

District and Count Station	Traffic Count Item			Overall Accuracy
	Vehicle Classification Counts	Total Vehicle Counts (2-3 hours)	Total Vehicle Counts (12 hours)	
Salem	Accurate	Inaccurate	Inaccurate	Unacceptable
Lynchburg	Accurate	Accurate	Accurate	Acceptable
Bristol	Accurate	Accurate	Inaccurate	Unacceptable
Suffolk	Accurate	Inaccurate	N/A	Unacceptable
Richmond	Inaccurate	Inaccurate	Inaccurate	Unacceptable
Staunton	Accurate	Accurate	N/A	Acceptable
Fredericksburg	Accurate	Accurate	Accurate	Acceptable
Culpeper - 1	Accurate	Inaccurate	Inaccurate	Unacceptable
Culpeper - 2	Inaccurate	Inaccurate	N/A	Unacceptable

This study of the accuracy of the manual traffic counts identified errors which far exceeded those detected during a previous evaluation study that included two unusually effective types of portable traffic recorders, the Stevens and the Streeter Amet MR 101-A models.(11) In this study, the differences between counts obtained with Stevens model recorders and motion picture counts ranged only between -1.6% and +0.7%. These findings support the recommendation in another report that the Department consider changing the current traffic count program into one using traffic recorder counts which are supplemented with a limited statistical sample of manual counts.(12)

FINDINGS

An analysis of working practices and the accuracy of manual traffic counts revealed the following.

Working Practices

1. The instructions for traffic counting were understood by personnel at 91% of the traffic count stations.

2. At 61% of the stations, personnel did not understand the purpose for conducting the traffic counts nor why their job was important to the Department.

3. During commuter rush hours, count personnel were unable to record all vehicles arriving at 32% of the stations.

4. At 61% of the stations, either too many or too few people were assigned to conduct the traffic count. At 6 stations a second person was assigned but was not needed, while additional people were needed at 7 stations. In two cases the additional personnel needs could have been reduced by ceasing to count traffic on secondary roads.

5. Count team members failed to efficiently share the traffic counting responsibilities at 3 of 7 applicable traffic count stations.

6. Personnel had been routinely scheduled to work overtime at 36% of the stations.

7. At 52% of the stations, the traffic counts were affected by 3-10 minute interruptions for recording hourly data.

8. Only 22% of the stations had situations where the observer's view of traffic was occasionally blocked.

9. The safety characteristics of the work site were adequate at 82% of the stations. In two cases, personnel were conducting the counts from vehicles parked in hazardous locations.

10. Personnel appeared to be correctly following their traffic counting instructions at 78% of the stations.

11. Personnel used incorrect or inefficient special working practices at 67% of the stations.

12. Apparently, periodic spot checks of work progress and traffic conditions were not being conducted by either residency staff or other supervisory personnel at 56% of the stations.

13. It appeared that supervisory controls were inadequate at 78% of the stations.

14. Overall, for 23 stations, the traffic counts appeared to be accurate at only 56%.

15. The deficiencies associated with working practices were almost evenly distributed over the Department's eight districts. The results of one or more traffic counts in each of the districts were found to be unacceptable.

Accuracy of Traffic Counts

1. The Department's traffic count personnel were able to correctly classify vehicles by type at 78% of 9 manual count stations.

2. Hourly manual counts of total vehicles were inaccurate at 56% of the stations. For time periods which did not exceed 3 hours, the summations of the total differences between manual and accurate motion picture traffic counts from the stations ranged between -11.4% and +11.2%.

3. At 67% of 6 stations, assigned personnel failed to sustain accurate counts of total vehicles for 12 hours.

4. The Department's mathematical factors used for converting 12-hour manual counts into 24-hour ADT values were inadequate at 50% of 6 stations. Accordingly, there is an indicated need to reevaluate and update the Department's mathematical factors (Primary Conversion Tables).

5. Overall, the manual traffic count data were unacceptable at 67% of 9 stations. The manual counts showed errors far exceeding those obtained with portable traffic recorders.

RECOMMENDATIONS

In another study it was recommended that the existing manual count program on the interstate and primary routes be replaced with a mechanical recorder program. If the Department adopts this recommendation, the number of manual counts will be reduced drastically; however, many will still be required to determine the traffic mix. The methods of securing counts along with the accuracy of the volume information should be improved and the following recommendations are offered for consideration.

1. It is recommended that the Traffic and Safety Division revise the 1970 pamphlet "Traffic Counting on Interstate, Arterial and Primary Routes". It should contain:

    a. complete information about the importance of traffic counts to the Department,

    b. detailed explanations to ensure that count personnel and their supervisors clearly understand the specific instructions for traffic counting, and

    c. pertinent descriptions of efficient working practices to follow in conducting traffic counts.

2. Supervisory controls should be improved at the count stations both by providing needed training to supervisory personnel and by instructing that they make effective spot checks of work progress and traffic conditions at the stations.

3. It is recommended that the district traffic engineers review traffic conditions and determine the appropriate number of people needed at each station. In cases where count teams are necessary, the resident engineer should be advised about the need for specific instructions concerning the sharing of traffic counting responsibilities and the arrangements for work breaks.

4. The requirements for manually counting traffic on secondary roads at high volume intersections should be cancelled by the Traffic and Safety Division.

5. Action should be taken to prohibit traffic count personnel from using work sites which include traffic hazards.

6. Resident engineers should avoid the routine scheduling of overtime work by dividing traffic counting assignments among a sufficient number of hourly employees. Here, the Traffic and Safety Division should assist by ensuring that the schedule for each residency has the traffic counts evenly distributed throughout the year.

ACKNOWLEDGMENTS

The author acknowledges J. P. Royer, Jr., former director of planning, Virginia Department of Highways and Transportation, for recognizing the need for this study.

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The contributions of several members of the Research Council staff are also acknowledged with thanks. John D. Shelor, traffic technician supervisor, made helpful suggestions, obtained traffic recorder and motion picture film data, and conducted interviews; Stephen N. Runkle, research analyst, provided statistical testing information; R. Neal Robertson, research engineer, assisted with field work and supervised the study; and Barbara A. Turner typed the necessary drafts of the report.

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APPENDIX A

MATHEMATICAL FACTORS FOR CONVERTING 12-HOUR WEEKDAY TRAFFIC COUNTS TO 24-HOUR ANNUAL AVERAGE TRAFFIC

District	Month	Multiplication Factors			
		Local Passenger	Foreign Passenger	Light & Medium Trucks	Trailer Trucks & Busses
Salem	July	1.507	1,007	1.051	1.948
Lynchburg	June	1.434	1,243	0.865	1.621
Bristol	July	1.645	1,128	1.436	1.371
Richmond	May	1,483	1,737	1.144	1.883
Fredericksburg	July	1.249	1.030	0,965	1.619
Culpeper	June	1.267	1,974	0.915	1.315

APPENDIX B

MANUAL AND MOTION PICTURE TRAFFIC COUNTS

Salem District

Hours (p.m.)	Type of Traffic Counts	Passenger Cars	Single Unit Trucks			Trailers	Busses		Total Vehicles
			Pickup and Panel	Other 2-Axle	3-Axle	Trailer Trucks 3-4- & 5-Axle	School	Other	
3-4	Manual	627	137	25	3	16	0	2	810
	Motion Picture	706	133	26	2	13	0	0	880
4-5	Manual	642	175	22	3	14	0	0	856
	Motion Picture	798	162	24	6	11	0	1	1,002
5-6	Manual	818	168	16	4	6	0	0	1,012
	Motion Picture	903	156	20	1	6	0	0	1,086

APPENDIX B cont.

Lynchburg District

Hours (p.m.)	Type of Traffic Counts	Passenger Cars	Single Unit Trucks			Trailers	Busses		Total Vehicles
			Pickup and Panel	Other 2-Axle	3-Axle	Trailer Trucks 3-4- & 5-Axle	School	Other	
3-4	Manual	421	91	25	1	24	7		569
	Motion Picture	385	78	20	20	16	8		527
4-5	Manual	518	139	39	3	19	0		718
	Motion Picture	436	115	23	17	16	1		608
5-6	Manual	403	88	26	4	22	0		543
	Motion Picture	426	94	21	11	21	0		573

APPENDIX B cont.

Bristol District

Hours (p.m.)	Type of Traffic Counts	Passenger Cars	Single Unit Trucks			Trailers	Busses		Total Vehicles
			Pickup and Panel	Other 2-Axle	3-Axle	Trailer Trucks 3-4- & 5-Axle	School	Other	
3-4	Manual	311	162	34	43	7	0	0	557
	Motion Picture	306	154	28	45	14	0	0	547
4-5	Manual	340	164	28	26	19	0	0	577
	Motion Picture	437	209	33	33	21	0	0	733

APPENDIX B cont.

Suffolk District

Hours (p.m.)	Type of Traffic Counts	Passenger Cars	Single Unit Trucks			Trailers	Busses		Total Vehicles
			Pickup and Panel	Other 2-Axle	3-Axle	Trailer Trucks 3-4- & 5-Axle	School	Other	
3-4	Manual	1,630	292	57	12	49	3	0	2,043
	Motion Picture	1,759	302	48	19	45	2	1	2,171
5-6	Manual	2,245	309	27	1	38	0	0	2,620
	Motion Picture	2,325	331	26	8	35	0	0	2,725

APPENDIX B cont.

Richmond District

Hours (p.m.)	Type of Traffic Counts	Passenger Cars	Single Unit Trucks			Trailers	Busses		Total Vehicles
			Pickup and Panel	Other 2-Axle	3-Axle	Trailer Trucks 3-4- & 5-Axle	School	Other	
3-4	Manual	550	67	26	5	58	0	1	707
	Motion Picture	533	83	8	6	63	0	1	694
4-5	Manual	482	69	36	1	52	0	3	643
	Motion Picture	459	81	24	9	61	0	2	636
5-6	Manual	368	66	24	5	78	0	2	543
	Motion Picture	353	76	13	6	77	0	1	526

APPENDIX B cont.

Staunton District

Hours (p.m.)	Type of Traffic Counts	Passenger Cars	Single Unit Trucks			Trailers	Busses		Total Vehicles
			Pickup and Panel	Other 2-Axle	3-Axle	Trailer Trucks 3-4- & 5-Axle	School	Other	
3-4	Manual	201	93	17	0	1	0	2	314
	Motion Picture	181	80	13	2	1	0	2	279
4-5	Manual	257	83	22	4	1	0	0	367
	Motion Picture	264	81	20	4	1	1	0	371
5-6	Manual	261	92	17	2	1	0	0	373
	Motion Picture	272	80	22	3	1	0	0	378

APPENDIX B cont.

Fredericksburg District

Hours (p.m.)	Type of Traffic Counts	Passenger Cars	Single Unit Trucks			Trailers	Busses		Total Vehicles
			Pickup and Panel	Other 2-Axle	3-Axle	Trailer Trucks 3-4- & 5-Axle	School	Other	
3-4	Manual	757	185	43	25	12	0	7	1,029
	Motion Picture	746	208	41	28	12	1	6	1,036
4-5	Manual	1,072	266	36	14	8	0	8	1,404
	Motion Picture	967	263	38	9	8	0	7	1,292
5-6	Manual	875	219	27	1	5	0	8	1,135
	Motion Picture	960	240	27	3	4	0	10	1,244

APPENDIX B cont.
Culpeper District - 1

Hours (p.m.)	Type of Traffic Counts	Passenger Cars	Single Unit Trucks			Trailers	Busses		Total Vehicles
			Pickup and Panel	Other 2-Axle	3-Axle	Trailer Trucks 3-4- & 5-Axle	School	Other	
3-4	Manual	1,138	169	40	11	9	0	4	1,371
	Motion Picture	1,053	176	38	10	9	0	6	1,292
4-5	Manual	1,403	194	46	10	8	1	8	1,670
	Motion Picture	1,195	133	33	9	4	1	7	1,382
5-6	Manual	1,356	119	23	23	1	0	10	1,532
	Motion Picture	1,301	87	16	23	1	0	9	1,437

APPENDIX B cont.

Culpeper District - 2

Hours (p.m.)	Type of Traffic Counts	Passenger Cars	Single Unit Trucks			Trailers	Busses		Total Vehicles
			Pickup and Panel	Other 2-Axle	3-Axle	Trailer Trucks 3-4- & 5-Axle	School	Other	
3-4	Manual	3,871	627	179	92	217	2	5	4,993
	Motion Picture	4,428	913	169	87	177	3	11	5,788
4-5	Manual	5,411	1,037	146	65	192	0	18	6,869
	Motion Picture	6,056	1,036	144	67	151	0	33	7,487

APPENDIX C

TRAFFIC RECORDER AND MOTION PICTURE COUNTS

Salem District

Hours (p.m.)	Vehicle Axle Pairs	
	Traffic Recorder	Motion Picture
3-4	917	911
4-5	1,023	1,031
5-6	1,134	1,110
3-6	3,074	3,052

APPENDIX C cont.

Lynchburg District

Hours (p.m.)	Vehicle Axle Pairs	
	Traffic Recorder	Motion Picture
3-4	561	564
4-5	649	648
5-6	611	613
3-6	1,821	1,825

APPENDIX C cont.

Bristol District

Hours (p.m.)	Vehicle Axle Pairs	
	Traffic Recorder	Motion Picture
3:00-3:30	299	311
3:30-4:00	293	297
4:00-4:30	400	399
4:30-5:00	383	379
3-5	1,375	1,386

APPENDIX C cont.

Richmond District

Hours (p.m.)	Vehicle Axle Pairs	
	Traffic Recorder	Motion Picture
3-4	821	818
4-5	722	752
5-6	647	656
3-6	2,190	2,226

APPENDIX C cont.

Staunton District

Hours (p.m.)	Vehicle Axle Pairs	
	Traffic Recorder	Motion Picture
3-4	267	284
4-5	330	380
5-6	309	383
3-6	906	1,047

APPENDIX C cont.

Fredericksburg District

Hours (p.m.)	Vehicle Axle Pairs	
	Traffic Recorder	Motion Picture
3-4	1,071	1,077
4-5	1,304	1,324
5-6	1,264	1,262
3-6	3,639	3,663

APPENDIX C cont.

Culpeper District - 2

Hours (p.m.)	Vehicle Axle Pairs	
	Traffic Recorder	Motion Picture
3-4	1,321	1,319
4-5	1,408	1,405
5-6	1,418	1,456
3-6	4,147	4,180

APPENDIX D

MANUAL AND TRAFFIC RECORDER COUNTS

Salem District

Hours	Vehicle Axle Pairs	
	Manual	Traffic Recorder
7-8 a.m.	538	630
8-9 a.m.	674	746
9-10 a.m.	624	736
10-11 a.m.	705	740
11-12 a.m.	578	814
12-1 p.m.	929	918
1-2 p.m.	768	894
2-3 p.m.	826	798
3-4 p.m.	835	917
4-5 p.m.	878	1,023
5-6 p.m.	1,023	1,134
6-7 p.m.	761	780
12 hrs., 7 a.m.-7 p.m.	9,139	10,180
24 hrs., 7 p.m.-7 p.m.		13,815
AADT using	conversion factors 12,983	

APPENDIX D cont.

Lynchburg District

Hours	Vehicle Axle Pairs	
	Manual	Traffic Recorder
7-8 a.m.	630	614
8-9 a.m.	556	594
9-10 a.m.	523	489
10-11 a.m.	480	455
11-12 a.m.	477	512
12-1 p.m.	409	444
1-2 p.m.	568	475
2-3 p.m.	452	548
3-4 p.m.	605	561
4-5 p.m.	748	649
5-6 p.m.	578	611
6-7 p.m.	752	458
12 hrs., 7 a.m.-7 p.m.	6,778	6,410
24 hrs., 7 p.m.-7 p.m.		9,096
AADT using	conversion factors	
	8,952	