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Transportation Management System Data Validation and Data Quality Assessment

FINAL REPORT
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16. Abstract

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I. Introduction

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II. Background

Transportation Data Development's (BTDD) main objectives are to monitor traffic volumes and other characteristics of New Jersey's public roads, provide the data to FHWA directly and through the Highway Performance Monitoring System (HPMS), support the other management systems and provide the data to the MPOs and the public. BTDD has two sections: Traffic and Technology; and Roadway Systems Information. The Traffic and Technology Section (TTS) conducts New Jersey's Traffic Monitoring System (TMS) in accordance with Federal regulations and guidance of the Traffic Monitoring Guide (TMG). The TMS does continuous data collection at permanent sites, data retrieval, processing, editing, archiving, summarizing, reporting, and disseminating of the data. TMS manages consultant contracts that collect short-term traffic data for the HPMS and other management systems, coordinates data collection and dissemination with the Metropolitan Planning Organizations (MPOs) and toll road and bridge authorities and commissions. Most of the data is volume data, but vehicle-type classification and weigh-in-motion (WIM) truck weight data are also collected, processed, reported, and disseminated.

This organization is comprised of a Section Chief who supervises the TTS staff. BTDD employs a project engineer who coordinates the WIM program. BTDD also employs a principal engineer, who is resident engineer of a construction contract to restore the WIM and other permanent traffic monitoring stations. BTDD employs one engineering technician whose responsibility is to trouble-shoot and repair the electronic WIM equipment. A principal engineer manages the three regional consultant contracts. Consultants are hired to implement the short-term monitoring program. Another principal engineer coordinates the continuous traffic counting program. This engineer processes all of the traffic volume counts, along with two engineering technicians who assist with the collection of the continuous data and trouble-shoot and repair the continuous traffic counting equipment.

III. Issues and Challenges Identified by BTDD

A. "Long Term Counts" Environment and Equipment Issues

According to BTDD, collecting continuous traffic monitoring data, when communication between the central office and the field site has failed, or equipment problems have been identified, involves:

- The constant menace of fauna and flora:
  - Cutting brush with a machete while avoiding any poison ivy and other fauna.
  - Freeing rusted locks with lubricant, forcing open the cabinet door while avoiding wasps, snakes, and other animals.
  - Cleaning mouse feces and urine from equipment while avoiding shock from 480-volt transformer and bare 240-volt wires to hot strip heater in bottom of cabinet.
  - Cleaning corroded telephone jacks to reestablish communications.
  - The modem must be reset in most cases by cleaning ant carcasses and spider webs from the DIP switches on the back and reconfiguring the switches with a pencil point; or by going through the ritual of positioning the laptop and "portable shade devices" in order to see the screen again to download a setup string back into the modem.
  - While checking the site setup, problems with sensors are identified, which necessitates opening 60-pound junction box covers with a screwdriver, rousing the toads in the box, pulling the cables from the mud and other muck in the hole, and trying to check the splices/wire-nuts/electrical tape for integrity and the masking tape/ribbons/post-a-notes identifying which cable is supposed to be connected to which loop.

- At the traffic monitoring equipment site, the laptop computer is moved until orientation and cardboard box and jacket are positioned in relation to the sun so that the screen can be read in order to download data from the computer. At this step, some of the equipment has suffered the "Blank Screen Syndrome" and the recorder has ceased to record data. The system must be reset and data recorded until the failure is uploaded to the laptop.

B. "Short Term" Counts Environment and Equipment Issues

- In the case of short-term counts, the technician waits for a trooper to slow traffic enough to run across the highway with a tube prepared with tape. The technician must place the tube with the sticky-side down, stomp on each piece of tape to secure it to the highway, and run to the median or back to the shoulder before the trooper and all of the vehicles behind the cruiser get to the technician.
- To secure the tube the technician must kneel down on the roadway and pound a 6" spike between the concrete slabs or through the asphalt with a 4.5 pound mallet without hitting a finger or thumb. This preventive measure further secures the tube before a truck locks

its brakes crossing the tube ripping up the installation and taking it a quarter-mile down the road. If this happens the technician must take care in avoiding getting whipped by the tube or hit by the flying 6” spike.

C. Resources

- TTD has indicated that there is a lack of staff resources to analyze traffic data.
- Traffic counts are captured and displayed in an incredibly hard to read format. TTD has indicated that they have requested software from OIT to assist with the sorting of the raw traffic data. The current format has prompted TTD to create software “Splitter” to enable the staff to easier process and utilize the traffic data.

IV. Traffic Monitoring

Customers

BTDD relies on feedback from its customers to inform them if the program in place is meeting their expectations. BTDD looks to its clients for data requirements such as traffic data accuracy. FHWA is the primary customer for traffic data. Other BTDD customers include FHWA contractors, other NJDOT units, the MPOs, other transportation agencies, consultants, business communities, and the public. BTDD utilizes proprietary equipment and software. BTDD receives information and assistance from IT services, consultant services, construction services, Maintenance Engineering, ITS Engineering, Maintenance, the State Police; the MPOs, and toll road and bridge authorities and commissions.

Data Requirements

Traffic data and location reference data are critical to the BTDD business process. BTDD has its own standards for data, which are cited in Appendix A. BTDD’s entire program is based on sampling, factoring and estimation. There are two types of counts performed. The first type, “base” counts (the continuous data) need to be very accurate; the rest is based on how representative of average conditions the base counts are; how statistically reliable the sample is, given FHWA’s requirements, and how reflective the cyclical counts are to the general trends the program is designed to track. The special counts are intended to provide data to support operational improvements. The rest of the program is intended to support decisions within other management systems. The entire program is intended to enable FHWA to appropriate and apportion to New Jersey a fair and equitable share of the funds to maintain and operate New Jersey’s public roadway network.

Data Collection

Data is collected continuously and retrieved weekly. Major stations are counted for one week each month. Short-term data is collected for 48 hours at one-third of the sites each year, and each site is counted once every three years. Traffic data is collected by NJDOT, three consulting firms, some consultants to other NJDOT units, MPOs, some county agencies, and the toll road and bridge authorities and commissions. The Traffic and Technology Section are stewards of FHWA's data collection process.

According to BTDD, in the case of continuous traffic data collection, when communication between the central office and a remote field site fail, or equipment problems have been identified, the traffic data collection process is as follows: The technician drives to the NJDOT vehicle yard to get a state vehicle. The technician checks for e-mail, then fuels the state vehicle, checks the oil, coolant, and tires in accordance with state regulations, and begins his or her itinerary on the road. For a "long term" count, to retrieve this traffic data, the technician goes to the traffic monitoring equipment site. The technician downloads the data using various types of electronic equipment along with a laptop computer and then proceeds to the next collection site. For a "short term" count, the technician prepares the traffic collection tube and places the tube across the highway to be monitored. Data is downloaded from the traffic data collection tube counters periodically by the consultants.

This process involves updating the list of HPMS sample locations and ensuring traffic data is periodically collected to represent traffic flow at those locations. The statistical reliability of estimates needs to be periodically reviewed and the network of continuous monitoring stations are expanded as necessary. The list of sites scheduled each year is provided to the consultants, who actually conduct the counts. The results are provided to TTS for inclusion in the databases that support the users of traffic data.

Data Validation

FHWA has processes for evaluating the "continuous count" data sent to them. The HPMS coordinator and his staff evaluate the data submitted to them. Each FHWA Long Term Pavement Performance (LTPP) contractor evaluates WIM data sent to them. The Congestion Management (CMS) staff evaluates the data sent to them. The only comments by the public entail the lack of counts at every location.
BTDD measures the number of counts taken by consultants and identifies locations not counted on schedule and whether there was a valid reason why they were not counted.

The BTDD validation process is intended to meet standards of statistical reliability. According to BTDD, based on its current resources and procedures TTD is currently unable to determine whether it is meeting the standards which are shown in Appendix A. To address this, BTDD has brought in a consultant to review and re-evaluate their program in relation to the IT Strategic Plan and this QA/QC study.

The consultants/contractors are required to validate the data. They do so by comparing their counts to other counts at the same sites during other cycles. If there are significant differences, they must be addressed and the appropriate steps must be taken to verify the data or if necessary re-collect the data.

Data Inconsistency

In the collection phase, data inconsistency is generally a result of traffic incidents; construction or maintenance activities; weather; or the degradation of in-road sensors or detector circuit boards in the equipment. If there is missing data, some of this data can be recovered from the collection equipment through a "total retrieve" function. Missing data is identified through inspection either by staff, FHWA, the LTPP contractor, or by the users of the data. Some data can be recovered. Some data must be recounted. Some data cannot be recovered or repeated. In the data hand off phase, most data inconsistency is a result of the limitations of the equipment in relation to the geometry of the roadway, the flow of traffic, and the weather. Collected data cannot be corrected; it can only be accepted or rejected.

Data Hand Off

Data is sent to the FHWA and its contractors. A Principal Engineer in the Roadway Systems Section of NJDOT posts data to the web site and sends summaries to the MPOs. Other summaries are sent to custodians of the HPMS, the Straight Line Diagram (SLD) database, and other management systems, mainly the safety management system, the pavement management system and the congestion management system. The Section Chief hands off data to the MPOs and the custodians of the HPMS, SLD, and other management systems. A Principal Engineer hands off traffic volume data to FHWA each month. The Project Engineer hands off WIM data to the FHWA and its Long Term Pavement Performance (LTPP) study contractor. Data is then posted on the web site or is sent as an attachment via e-mail. It is the understanding of BTDD that the FHWA owns the data. At this stage, FHWA or its contractor confirms receipt of data handed off to them. Web-based data is spot-checked.

Data Storage

Data is stored on OIT's mainframe, on CD-ROMs, on a shared drive on NJDOT's server, and on individual PCs. Consultants, FHWA and its contractors, and other units also store data. Count data is stored on OIT's mainframe as it is processed. Short Term count data is stored in the Short Term Count database. The system stores station information and traffic volumes, and is compatible with BTDD's proposed Central Database. The short-term program obtains data at ten times the number of sites as the continuous program annually, and thirty times the number of sites over a three-year cycle. WIM data is stored on a PC as it is processed and validated and then periodically stored on CD-ROMs. OIT, the consultants, FHWA, the SHRP contractor, the authorities as well as BTDD all store traffic data. Data inconsistency in stored data may be the result of corrupted files or different generations of the same files. It is our understanding that data is stored periodically either on a weekly or monthly basis.

Data Maintenance

Traffic volume, vehicle-type classification, and weigh-in-motion data is maintained on NJDOT's server; the NJDOT staff maintains the data. Any contributing factors to inconsistencies in the data maintenance process could be because updates or corrections are not always made to all the databases. In the event there is a data-integrity or maintenance problem within the database it is the responsibility of either BTDD or OIT. If the database must be repaired, OIT is responsible for fixing any problems.

Data Usage/Decision Making Process

BTDD uses old data to validate new data. This data is used in trend analysis and combined with other types of data to produce information for a variety of uses. Data is retrieved through modems from remote continuous sites when the communications links are working. If the remote links are not available, then a technician (DOT or consultant) will go to the site(s) and download the data into a laptop computer. Consultants e-mail the data they collect to BTDD. Some data is sent to other units directly. All the data is available to other entities on the web site. Some of the traffic data is used on an ongoing basis and some is used on an annual basis. Most reports are produced on monthly and on an annual basis.

The Section Chief has made a request to OIT for a relational database that would "tie everything together." In the meantime BTDD has started to create its own software known as "Splitter," which checks the station IDs and saves them as single files.

Data Archiving

BTDD archives data. Count data is sent to the mainframe and WIM data is burned onto CD-ROMs. FHWA requires ten year retention of the data.

Disaster Recovery

Traffic data is sent to OIT's mainframe. Short-term data is also retained by the consultants at their facilities. If any important data was lost BTDD will recover the data from somebody else who has it, or from the equipment that originally recorded it. Lost continuous data cannot be recovered. Short-term counts can be repeated if necessary. BTDD reports that they usually do not have to repeat counts.

V. Testing Methodology

Objective

The main objective of the following testing and analysis was to determine whether the traffic data collected by BTDD was consistent. In order to determine this, testing was conducted based on a sampling of one twelve-week period. Traffic data was considered to be consistent for each Tuesday and Thursday per week in this twelve week sample if the analysis of the data showed a low variation among each of the weeks. It was also assumed that there were no other factors that affected the traffic count data outside of the data collection process. If the collected data was shown to be consistent over time, this would suggest that the approach to collecting traffic data is appropriate and the focus should be placed on related issues (e.g. equipment failures, environmental factors, animals, etc.).

Methodology

The NJDOT traffic data that was tested included three files which were comprised of various traffic reports, including traffic counts. The CAIT research team chose to take test samples from the NJDOT report titled (2005 HRLY). It is assumed that current data collection practices by BTDD were performed in collecting the data back in 2005.

Five roads were chosen for the test sampling: Route 287, NJ Route 10, Route 31, US Route 46 and US Route 206. Traffic data was gathered according to specific mileposts which are identified below. All roadway directions were analyzed (North and South bound, East and West bound) for each day. Three shifts were defined:

1. Rush Hour AM: This includes the time periods of 6-7 AM, 7-8 AM and 8-9 AM
2. Off peak: This includes the time periods of 11-12 PM, 12-13 PM and 13-14PM
3. Rush Hour PM: This includes the time periods of 16-17 PM, 17-18 PM and 18-19 PM

The research team chose two days out of the week, Tuesday and Thursday – to avoid any issue with days near weekends or holidays. Twelve weeks of samples were chosen from the months of April until mid June in order to avoid any seasonal factors (e.g. inclement weather in the winter). Careful selection of dates was made so that holidays were not included in the test sample.

6 cases have been selected as a sample of this testing for this report:

1. NJ 31 Northbound Tuesday vs. Thursday Rush Hour AM (Milepost 26.2)
2. US 46 Eastbound Tuesday vs. Thursday Rush Hour PM (Milepost 44.80)
3. NJ 10 Eastbound Tuesday vs. Thursday Rush Hour PM (Milepost 13.9)
4. NJ 10 Westbound Tuesday vs. Thursday Rush Hour PM(Milepost 13.9)
5. US 46 Eastbound (Rush Hour AM) vs. Westbound (Rush Hour PM) (Milepost 44.80)
6. NJ 31 Northbound (Rush Hour AM) vs. Southbound (Rush Hour PM) (Milepost 26.2)

The methodology for cases 1, 2, 3 and 4 are the same and are described in the following 3 steps:

- Twelve weeks of data were collected for the specific shift (Rush Hour AM, Off Peak, Rush Hour PM) for each Tuesday and Thursday in the week. Each roadway has thirty-six samples. This means that one shift has three periods and each time period has twelve samples.

- Data for each shift on Tuesday and Thursday were plotted on a graph to give a brief comparison between two days in a specific shift. One example would be a graphical comparison of the Rush Hour AM shift between Tuesday vs. Thursday for a given road.

- The mean, standard deviation, coefficient of variation, and the behavior of the data was measured and analyzed for these tests for each roadway. In addition, the means of a time period for a road way (Tuesday vs. Thursday) were compared in order to determine if there were any significant differences between the two means. This was accomplished with an ANOVA analysis or "hypothesis" test that was created for this data. The null hypothesis in this analysis shows that there is no significant difference between the means of Tuesday and Thursday in a specific shift. This shows that the average number of cars passing from one bound of the road in Rush Hour AM on Tuesday is similar to the average number of cars passing Thursday from same bound of the road. This hypothesis demonstrates that there is a significant difference between the means for Tuesday and Thursday.

The methodology for case 5 and 6 are as follows:

- Twelve weeks of data were collected for the specific shift (Rush Hour AM, Off Peak, Rush Hour PM) for each Tuesday and Thursday in the week. Each roadway has thirty-six samples meaning that one shift has three periods and each time period has twelve samples.
- Statistical tests performed in two stages:
    a) Statistical analysis were performed for each day (Tuesday vs. Thursday) individually (designed ANOVA Table)
    A hypothesis test was performed to test a null hypothesis. For example, a null hypothesis that would be tested would state that the Rush hour AM and Rush hour PM shifts are not significantly different.
    b) Statistical analysis performed for traffic count data for each of the two days, compared with each other to determine whether data is consistent for both days.

The focus of these tests is to discover any inconsistencies in the data. Five types of inconsistencies have been identified prior to testing:

1. Discrepancies between the Tuesday and Thursday data for the same road. (The consistent data would show little discrepancy between those two days, because we are assuming that there would not be a significant difference between days.
2. Extraordinary traffic counts at hours that significantly deviate from the hours in the time period we have examined.
3. Traffic data that does not fit a particular probability distribution at any confidence level. (The traffic data should be fit to any distribution such as an exponential distribution if it is consistent since a distribution will identify a pattern with the data.
4. Discrepancies between morning rush hour traffic data and the evening rush hour traffic data for the same road. We are assuming that the traffic on the road in the morning rush hour will generally return in the evening rush hour on the same road. Therefore, any discrepancies suggest an issue with the data collection.

5. Discrepancies in the traffic data from week to week suggest an issue with data collection. While variation is expected, any significant increases or decreases from week to week for the same time period is possible source of error.

VI. Testing Results

CASE 1: NJ 31 N Tuesday vs. Thursday Rush Hour AM (Milepost 26.2)

Objective:

The objective of the study was to compare the mean of passing cars for two days (Tuesday vs. Thursday) where traffic data was analyzed in order to see whether they are significantly different from each other.

Methodology:

In this case, just one shift of the day for NJ 31 Northbound (Rush Hour AM) was chosen for comparison between the two days. The twelve weeks' worth of data collected on Tuesday and Thursday for the Rush Hour AM shift is shown in Table 1 and Table 2. Each table has thirty-six data entries for each day for this shift.

A two step statistical analysis was performed and is described below:

Step A: Statistical analyses were performed for each day (Tuesday and Thursday) individually.
Step B: Statistical analyses were performed to test whether there is a significant difference between the means for both days or not.

Table 1: NJ 31 Northbound Tuesday Rush Hour AM

	Tuesday											
	Week 1	2	3	4	5	6	7	8	9	10	11	12
Rush Hour AM												
6-7 AM	569	595	541	558	291	290	311	303	325	303	317	302
7-8 AM	898	1025	984	934	531	517	506	517	532	530	545	542
8-9 AM	1121	1128	1186	1195	636	636	621	618	617	578	593	679

Table 2: NJ 31 Northbound Thursday Rush Hour AM

	Thursday											
	Week 1	2	3	4	5	6	7	8	9	10	11	12
Rush Hour AM												
6-7 AM	575	538	538	526	275	303	302	298	281	295	326	295
7-8 AM	989	961	957	918	524	532	564	514	577	548	520	520
8-9 AM	1161	1129	1091	1186	672	662	603	628	644	636	645	692

Analysis and Results:

The analyzed data was plotted for graphical comparison in Figure 1. This shows a brief comparison between the Tuesday Rush Hour AM shift and the Thursday Rush Hour AM shift for each road. The vertical axis of the graph in Figure 1 is the amount of traffic and the horizontal axis of the chart shows each week. As Figure 1 shows, there does not appear to be a large difference between the different time periods between the two days of data.

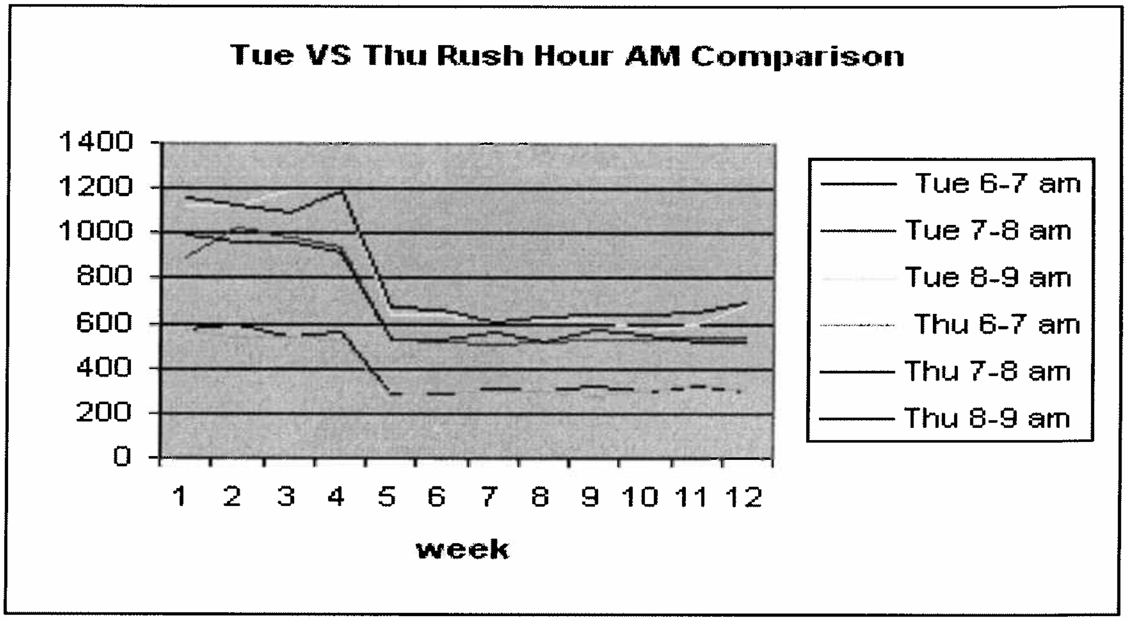

Figure 1 Tuesday vs. Thursday Rush hour AM for NJ 31 Northbound

A two step statistical analysis was performed:

Step A: Statistical analyses were performed for each day (Tuesday and Thursday) individually then the results were compared together:

1a) NJ 31 Northbound Tuesday Rush Hour AM

1b) NJ 31 Northbound Thursday Rush Hour AM

1a) NJ 31 Northbound Tuesday Rush Hour AM

The mean is approximately 621 cars passing the milepost 26.2 during the Rush Hour AM shift each Tuesday. The standard deviation is 268.08 and the coefficient of variation is approximately 0.43. The coefficient of variation states that there is some, not a lot, of variation in the traffic count data from week to week. Figure 2 shows the histogram of the traffic count data, where the horizontal axis is the amount of traffic and the vertical axis of the chart is the percentage of the whole data. For example, 22 percent of traffic counts are between 290 and 344.

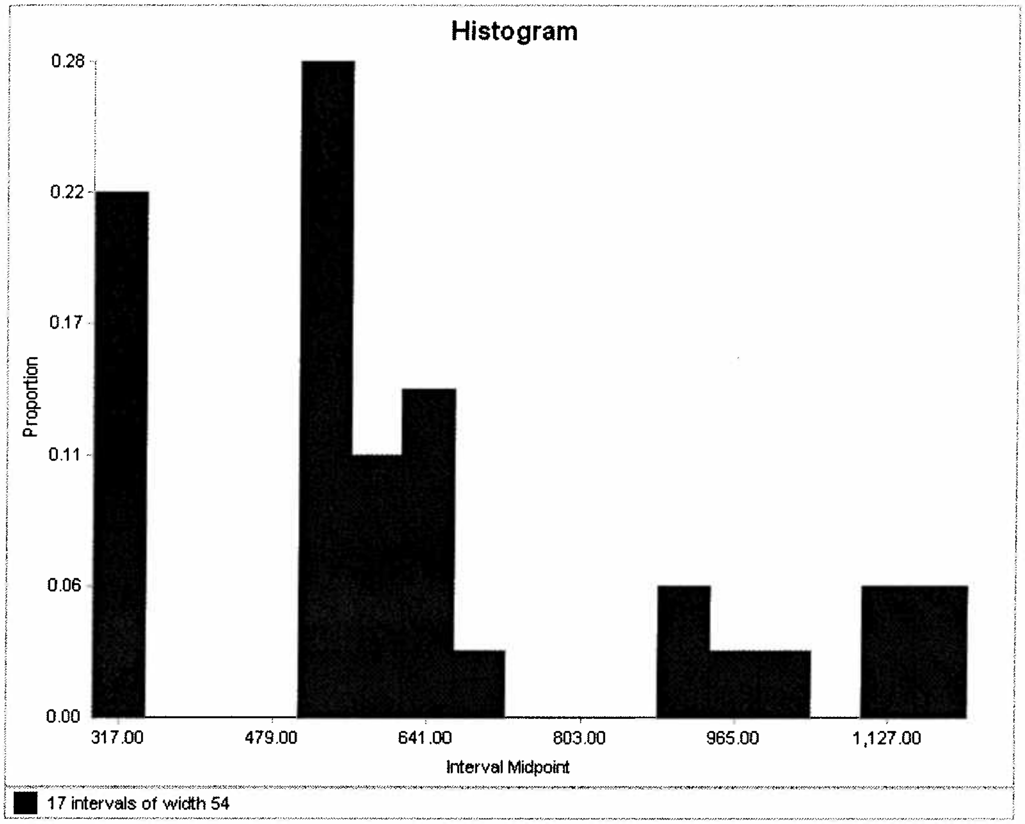

Figure 2 Histogram for NJ 31 Northbound Tuesday Rush Hour AM

1 b) NJ 31 Northbound Thursday Rush Hour AM

The mean is approximately 622 cars passing the milepost 26.2 during the Rush Hour AM shift each Thursday. The standard deviation is 266.16 and the coefficient of variation is approximately 0.42, meaning that there is some variation from week to week. Figure 3 shows the histogram of the traffic count data for Thursday.

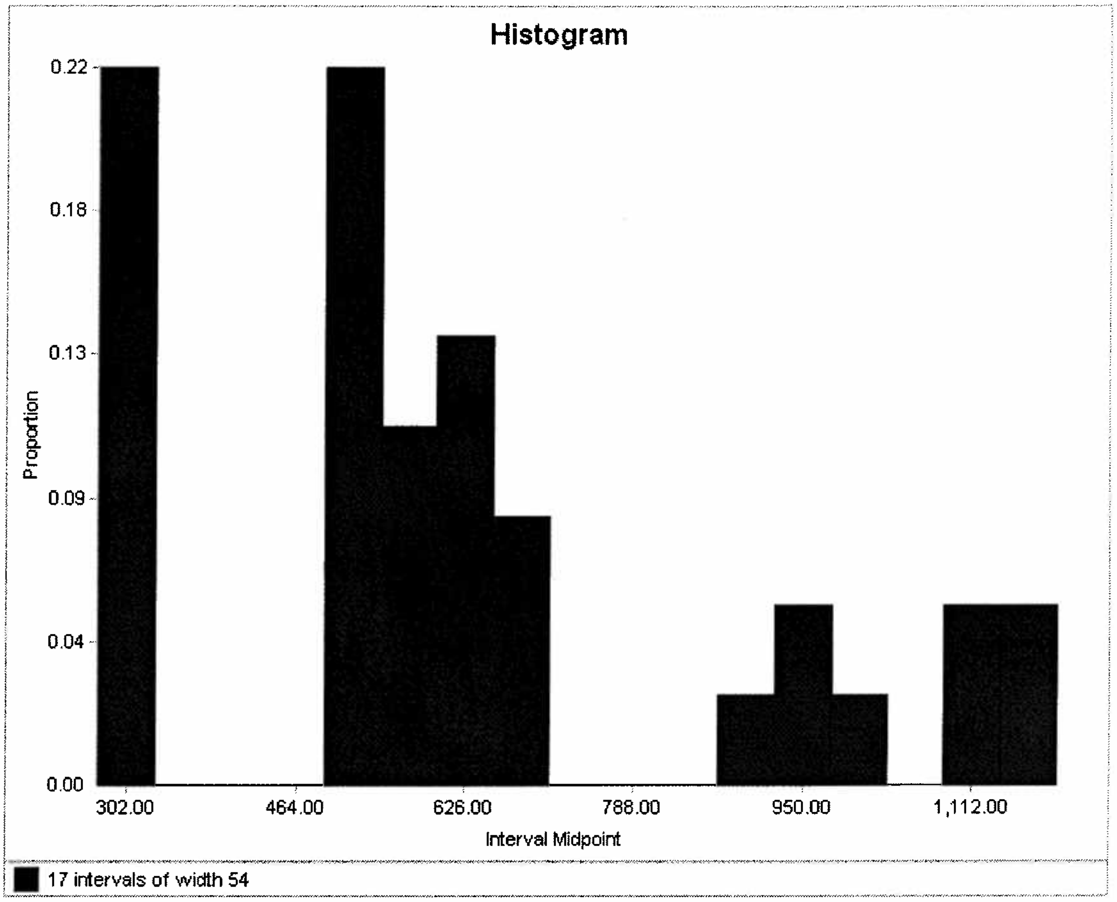

Figure 3 Histogram for NJ 31 Northbound Thursday Rush Hour AM

After calculating the distribution for each day of the NJ 31 Northbound in Rush Hour AM shift, it shows that the data may be consistent over both says since both days yield similar distributions, means, and standard deviation.

Step B: In order to determine whether the mean of the traffic counts for Tuesday was significantly different from the mean for Thursday, an ANOVA analysis was performed to test the null hypothesis. This was done to see that there is no significant difference between the means for both days. The ANOVA analysis yields an ANOVA table, shown in Table 3. Given that the F value is less than F critical value, the null hypothesis cannot be rejected. This shows that there is no significant difference between the mean for Tuesday and Thursday. Therefore, it can be said that the data is consistent over both days for this road.

Table 3: ANOVA Table for NJ 31 Northbound Tuesday vs. Thursday Rush Hour AM

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	36.125	1	36.125	0.000506	0.982113	3.977779
Within Groups	4994955.75	70	71356.51			
Total	4994991.875	71				

CASE 2: US 46 Eastbound Tuesday vs. Thursday Rush Hour PM (Milepost 44.80)

Objective:

The objective of Case 2 was to compare the mean of passing cars for two days (Tuesday vs. Thursday) where traffic data was analyzed in order to see whether they are significantly different from each other.

Methodology:

Similar to Case 1, twelve weeks of data were collected from traffic data for Tuesday and Thursday during the Rush Hour PM shift. This data is shown below in Table 4 and Table 5.

Table 4 US 46 Eastbound Tuesday Rush Hour PM

	Tuesday											
	Week 1	2	3	4	5	6	7	8	9	10	11	12
16-17 PM	1157	1170	1167	1072	1146	1146	1144	1127	1149	1144	1112	1057
17-18 PM	1359	1226	1143	1174	1188	1230	1221	1235	1205	1181	1258	1097
18-19 PM	1103	932	991	977	957	1027	956	1024	931	916	920	839

Table 5 US 46 Eastbound Thursday Rush Hour PM

	Thursday											
	Week 1	2	3	4	5	6	7	8	9	10	11	12
Rush Hour PM												
16-17 PM	1193	1244	1110	1120	1101	1121	1118	1171	1132	1188	1088	1099
17-18 PM	1209	1228	1180	1207	1182	1258	1209	1223	1185	1218	1248	1183
18-19 PM	972	962	916	1032	949	969	941	1039	970	949	1024	941

A two step statistical analysis was performed:

Step A: Statistical analyses were performed for each day (Tuesday and Thursday) individually.
Step B: Statistical analyses were performed to test whether there was a significant difference between the means for both days.

Analysis and Results:

The data shown in Table 4 and 5 was plotted on a graph, shown in Figure 4. This graph shows a graphical comparison between Tuesday and Thursday for the same Rush Hour PM shift. The vertical axis of the graph is the amount of traffic (the traffic count) and the horizontal axis of the chart represents the week. Based on what Figure 4 shows, while there is variation, there does not appear to be a significantly large difference between the two days for each time period in the shift.

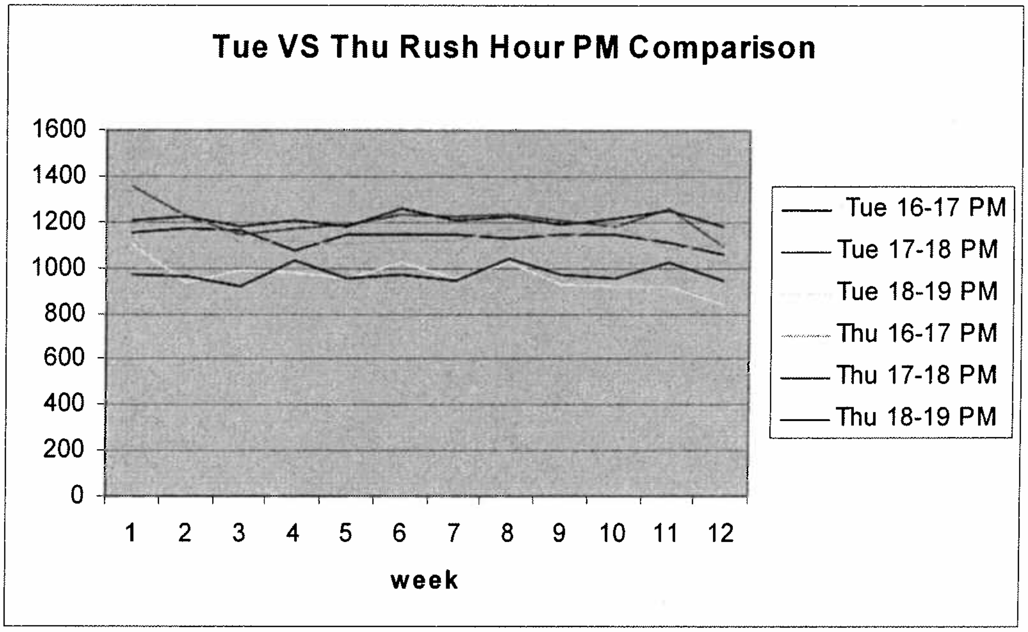

Figure 4: Tuesday Vs Thursday Rush Hour PM for US 46 Eastbound

A two step statistical analysis was performed:

Step A: Statistical analysis were performed for each day (Tuesday and Thursday) individually prior to comparison.

2a) US 46 Eastbound Tuesday Rush Hour PM
2b) US 46 Eastbound Thursday Rush Hour PM

2a) US 46 E Tuesday Rush Hour PM

The mean is approximately 1102 cars passing milepost 44.80 during Rush Hour PM each Tuesday. The standard deviation is 117.99 and the coefficient of variation is about 0.10, representing a very low variation from week to week. Figure 5 shows a histogram of the traffic count data.

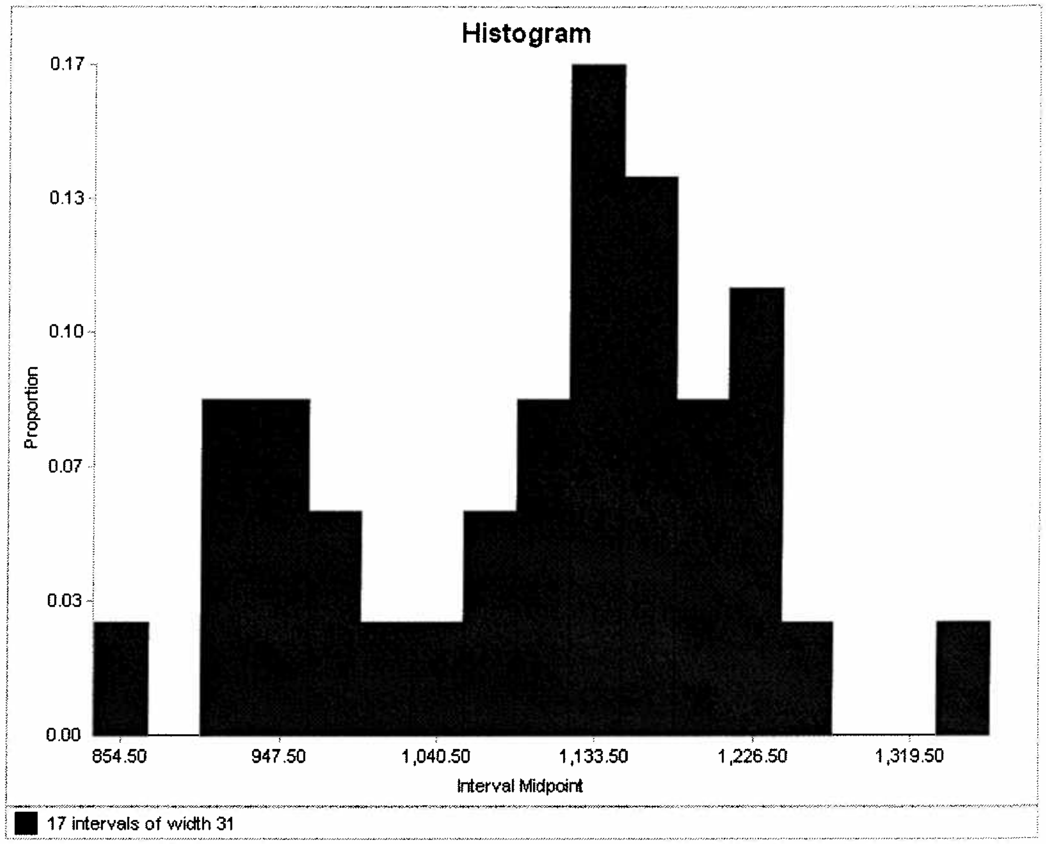

Figure 5: Histogram for NJ 46 Eastbound Tuesday Rush Hour PM

2b) US 46 Eastbound Thursday Rush Hour PM

The mean is approximately 1107 cars passing the milepost 44.80 during the Rush Hour PM shift each Thursday. The standard deviation is 108.34 and the coefficient of variation is about 0.09, resulting in very little variation from week to week. Figure 6 shows the histogram of the traffic count data.

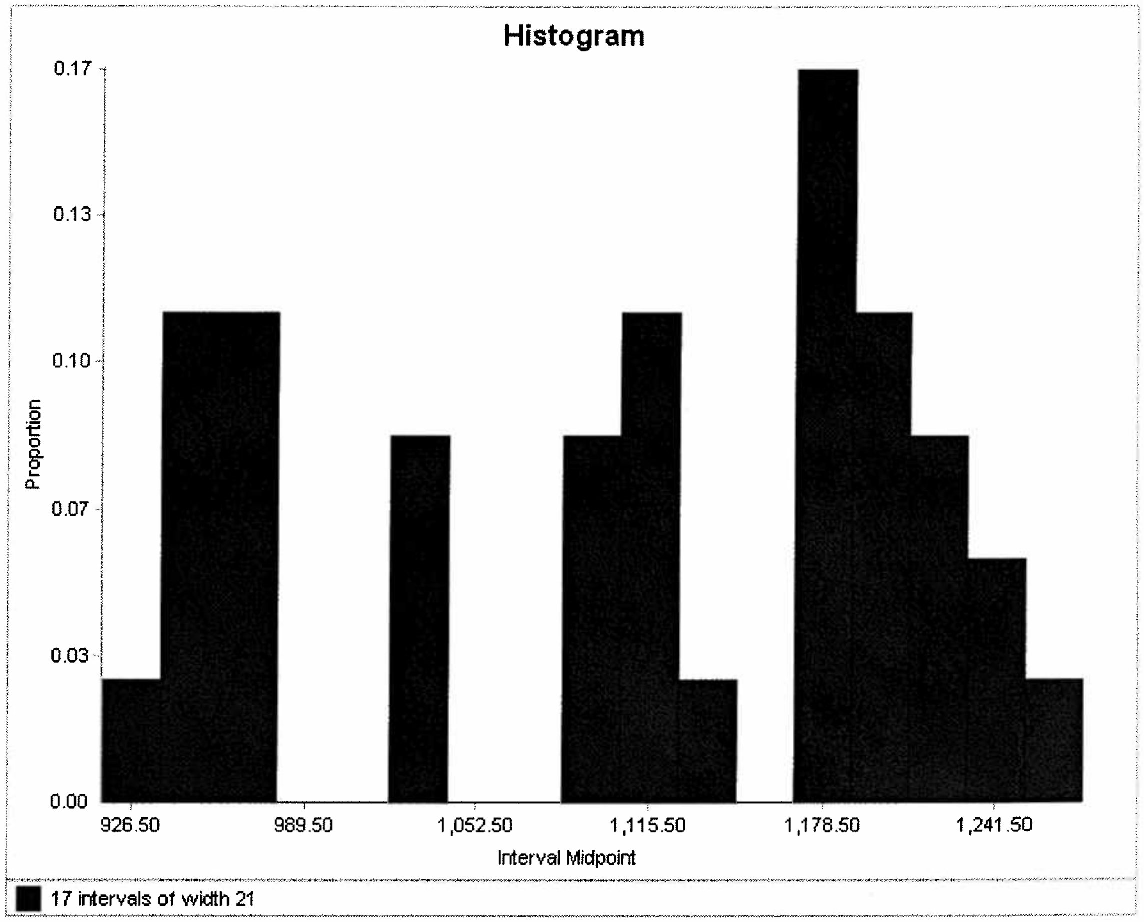

Figure 6: Histogram for NJ 46 Eastbound Thursday Rush Hour PM

The traffic counts taken for each day for NJ 46 Eastbound during the Rush Hour PM shift are consistent for both days since both days yield similar distributions, means and standard deviations.

Step B: The second step is to compare the mean traffic count of Tuesday and Thursday and determine whether they are significantly different. This is accomplished through doing an ANOVA analysis. Similar to Case 1, the null hypothesis used stated that there is no difference between the means of Tuesday and Thursday during the Rush Hour PM shift. An ANOVA analysis shows that the null hypothesis is not rejected; thus, there is no significant difference between the mean for Tuesday and Thursday for this road during this time period.

CASE 3: NJ 10 Eastbound Tuesday vs. Thursday Rush Hour PM (Milepost 13.90)

Objective:

The objective of case 3 was to compare the mean of passing cars for two days (Tuesday vs. Thursday) to determine whether they are significantly different from each other.

Methodology:

Similar to the previous two cases, twelve weeks of data were collected from traffic data for Tuesday and Thursday during the Rush Hour PM shift. The resulting data is illustrated below in Table 6 and Table 7.

Table 6: NJ 10 Eastbound Tuesday Rush Hour PM

	Tuesday											
	Week 1	2	3	4	5	6	7	8	9	10	11	12
Rush Hour PM												
16-17 PM	941	857	686	1086	740	851	1105	864	240	96	658	400
17-18 PM	869	1596	815	925	939	937	1076	812	473	84	282	745
18-19 PM	290	1093	762	234	857	829	1026	734	181	32	543	547

Table 7: NJ 10 Eastbound Thursday Rush Hour PM

	Thursday											
	Week 1	2	3	4	5	6	7	8	9	10	11	12
Rush Hour PM												
16-17 PM	440	1103	1029	573	425	793	789	707	979	516	121	553
17-18 PM	111	800	1018	841	87	749	677	747	950	279	290	212
18-19 PM	313	638	696	1055	503	100	568	607	307	203	448	101

A two step statistical analysis was performed:

Step A: Statistical analyses were performed for each day (Tuesday and Thursday) individually.
Step B: Statistical analyses were performed to test whether there is a significant difference between the means for both days or not.

Analysis and Results:

The data shown in Table 6 and 7 were plotted on a graph, shown in Figure 7. This graph shows a brief comparison between Tuesday and Thursday for the same Rush Hour PM shift. The vertical axis of the graph is the amount of traffic (the traffic count) and the horizontal axis of the chart represents the week. Figure 7 shows that there is a lot of variation within each time period for both days but much less between the two days for the same time period. This suggests that data is not consistent.

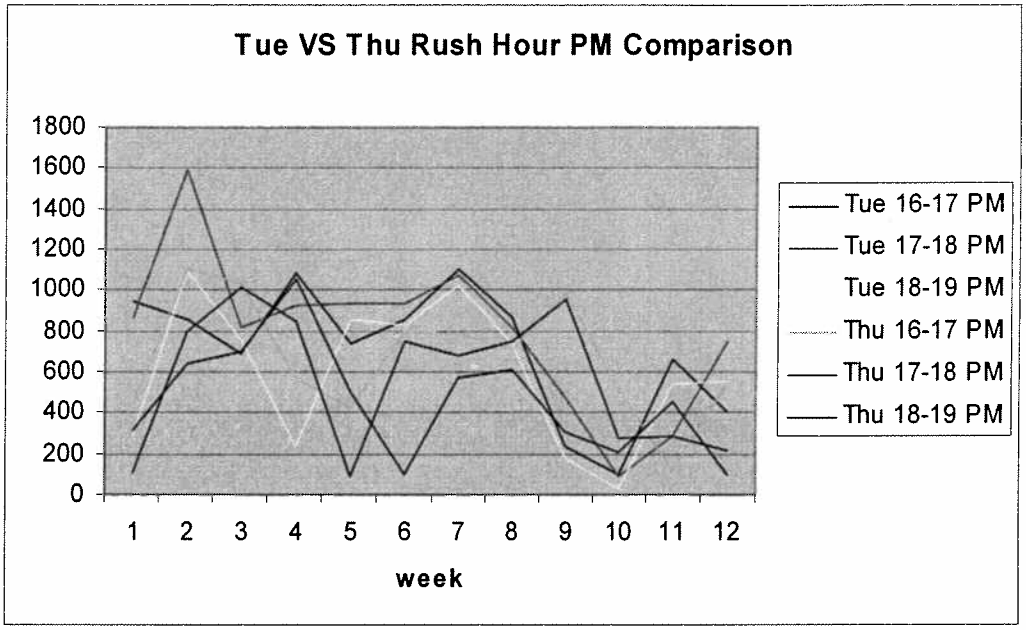

Figure 7: Tuesday vs. Thursday Rush Hour PM for NJ 10 Eastbound

To further determine whether collected data is consistent, further statistical analysis was performed in two steps.

Step A: Statistical analysis was performed for each day (Tuesday and Thursday) individually then compared the results together.

3 a) NJ 10 Eastbound Tuesday Rush Hour PM
3 b) NJ 10 Eastbound Thursday Rush Hour PM

3 a) NJ 10 Eastbound Tuesday Rush Hour PM

The mean is approximately 700 cars passing the milepost 13.90 during the Rush Hour PM shift. The standard deviation is 352.19 and the coefficient of variation is about 0.50, which shows that there is some variation from week to week. Figure 8 shows the histogram of the traffic data collected.

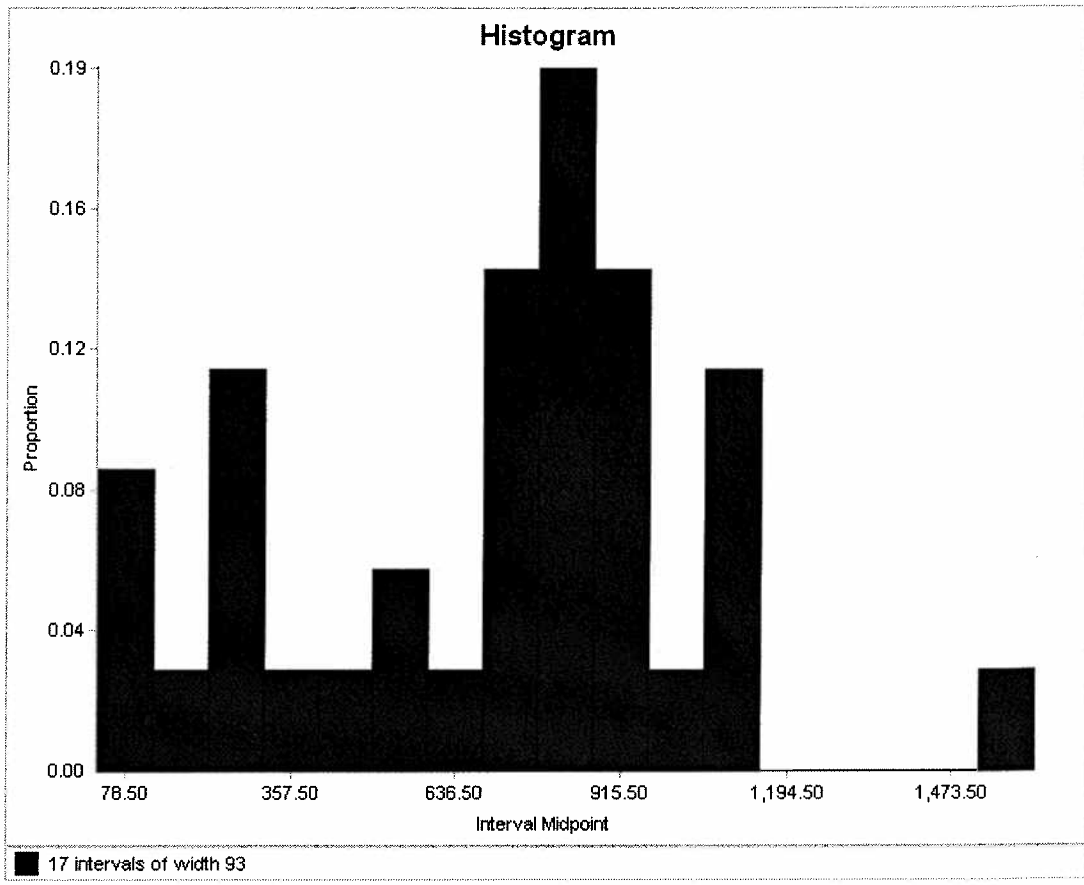

Figure 8: Histogram for NJ 10 Eastbound Tuesday Rush Hour PM

3 b) NJ 10 Eastbound Thursday Rush Hour PM

The mean traffic count is approximately 564 cars each Thursday. The standard deviation is 306.54 and the coefficient of variation is about 0.54. These results show that there is some variation from week to week. Figure 9 shows the histogram of the traffic count data.

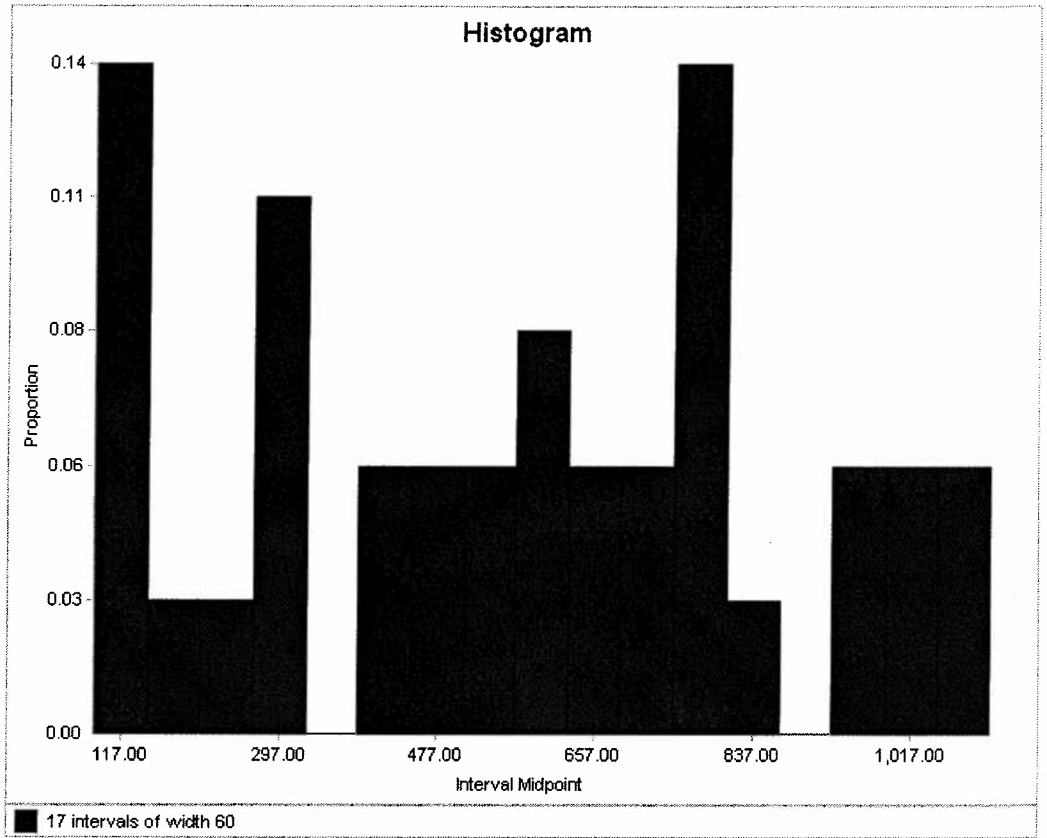

Figure 9: Histogram for NJ 10 Eastbound Thursday Rush Hour PM

As a result of this first step of the statistical analysis, while both the Tuesday and Thursday data have same distribution, the parameters of these distributions as well as their means, standard deviation s and their histograms are different to the point where it suggests that the two days are significantly different. Therefore, unless there is some additional factor that would cause traffic to be heavier on Tuesdays than Thursdays, this suggests a problem with overall data collection for this instance.

Step B: The second step is to compare the mean traffic count of Tuesday and Thursday and determine whether they are significantly different with an ANOVA analysis. Similar to Case 2, the null hypothesis used states that there was no difference between the means of Tuesday and Thursday during the Rush Hour PM shift. After performing an ANOVA analysis, the results in the resulting ANOVA table shows that null hypothesis should be rejected. Therefore, based on this analysis, there was a significant difference between the mean for Tuesday and Thursday. As a result, this suggests that there is a problem with data collection for this road.

CASE 4: NJ 10 Westbound Tuesday vs. Thursday Rush Hour PM (Milepost 13.90)

Objective:

The objective of Case 4 was to compare the mean of passing cars for two days (Tuesday vs. Thursday) to determine whether or not they are significantly different from each other.

Methodology:

Similar to the previous three cases, twelve weeks of data were collected from traffic data for Tuesday and Thursday during the Rush Hour PM shift. This data is shown below in Table 8 and Table 9.

Table 8: NJ 10 Westbound Tuesday Rush Hour PM

	Tuesday											
	Week 1	2	3	4	5	6	7	8	9	10	11	12
Rush Hour PM												
16-17 PM	1016	1446	766	683	773	1149	949	530	1247	806	804	875
17-18 PM	823	1777	1296	609	800	987	763	1472	763	650	814	1576
18-19 PM	975	979	1484	926	830	830	855	1543	845	956	1424	1075

Table 9: NJ 10 Westbound Thursday Rush Hour PM

	Thursday											
	Week 1	2	3	4	5	6	7	8	9	10	11	12
Rush Hour PM												
16-17 PM	797	403	904	407	476	1594	780	521	238	730	928	855
17-18 PM	816	529	433	469	820	1476	785	760	859	977	885	905
18-19 PM	786	769	722	682	1187	1610	1254	1004	437	851	843	838

A two step statistical analysis was performed:

Step A: Statistical analyses were performed for each day (Tuesday and Thursday) individually.
Step B: Statistical analyses were performed to test whether there is a significant difference between the means for both days or not.

Analysis and Results:

The data shown in Table 8 and 9 were plotted on a graph, shown in Figure 10, which shows a brief comparison between Tuesday and Thursday for the same Rush Hour PM shift. The vertical axis of the graph is the amount of traffic (the traffic count) and the horizontal axis of the chart represents the week. Based on what Figure 10 shows there is a lot of variation within each time period for both days, much less between the two days for the same time period. This suggests that data is not consistent.

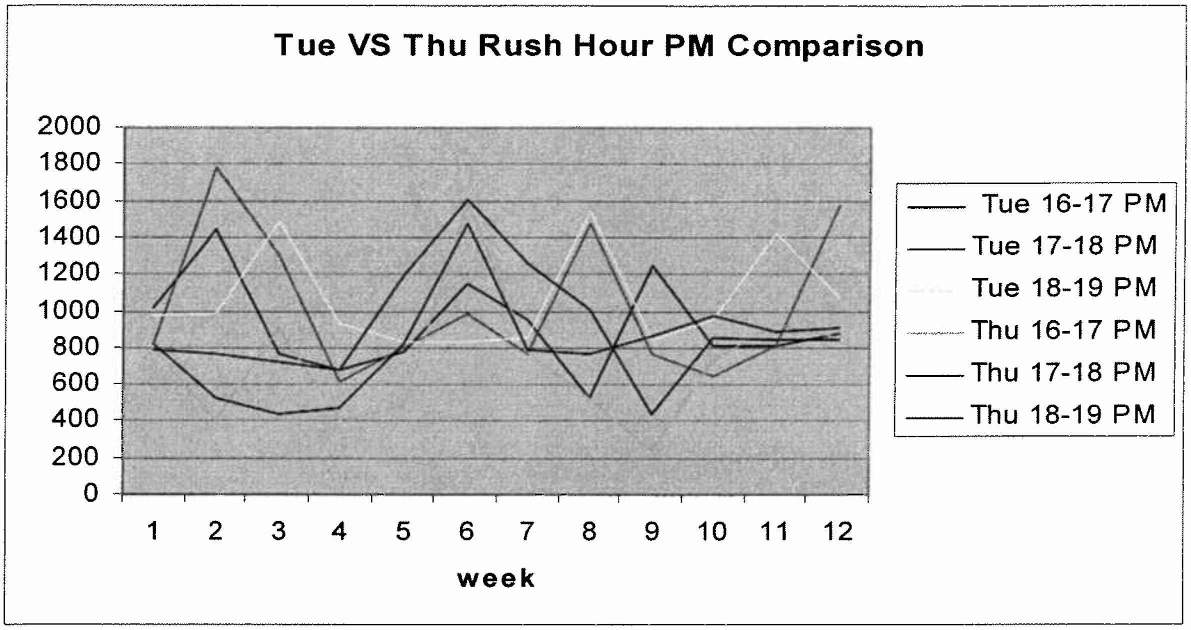

Figure 10: Tuesday vs. Thursday Rush Hour PM for NJ 10 Westbound

Similar to prior cases, further statistical analysis was performed in two steps.

Step A: Statistical analysis were performed for each day (Tuesday- Thursday) and the results were then compared.

4 a) NJ 10 Westbound Tuesday Rush Hour PM

4 b) NJ 10 Westbound Thursday Rush Hour PM

4 a) NJ 10 Westbound Tuesday Rush Hour PM

The mean is approximately 1002 cars passing milepost 13.90 during the Rush Hour PM shift each Tuesday. The standard deviation is 310.28 and the coefficient of variation is about 0.30. This shows that the variation from week to week is fairly low. Figure 11 illustrates the histogram of the traffic count data.

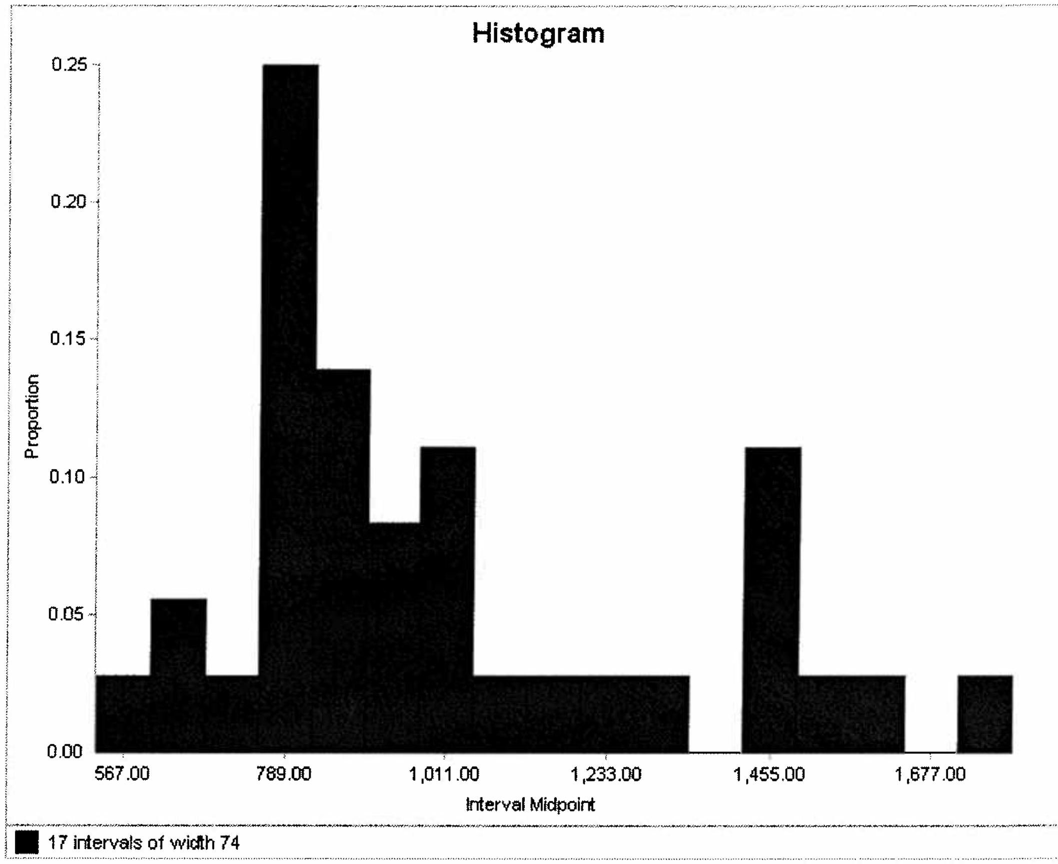

Figure 11: Histogram for NJ 10 Westbound Tuesday Rush Hour PM

4 b) NJ 10 Westbound Thursday Rush Hour PM

The mean is approximately 814 cars passing milepost 13.90 during the Rush Hour PM shift each Thursday. The standard deviation is 316.74 and the coefficient of variation is about 0.38. This shows that some variation of traffic count data does exist from week to week. Figure 12 shows the histogram of the traffic count data.

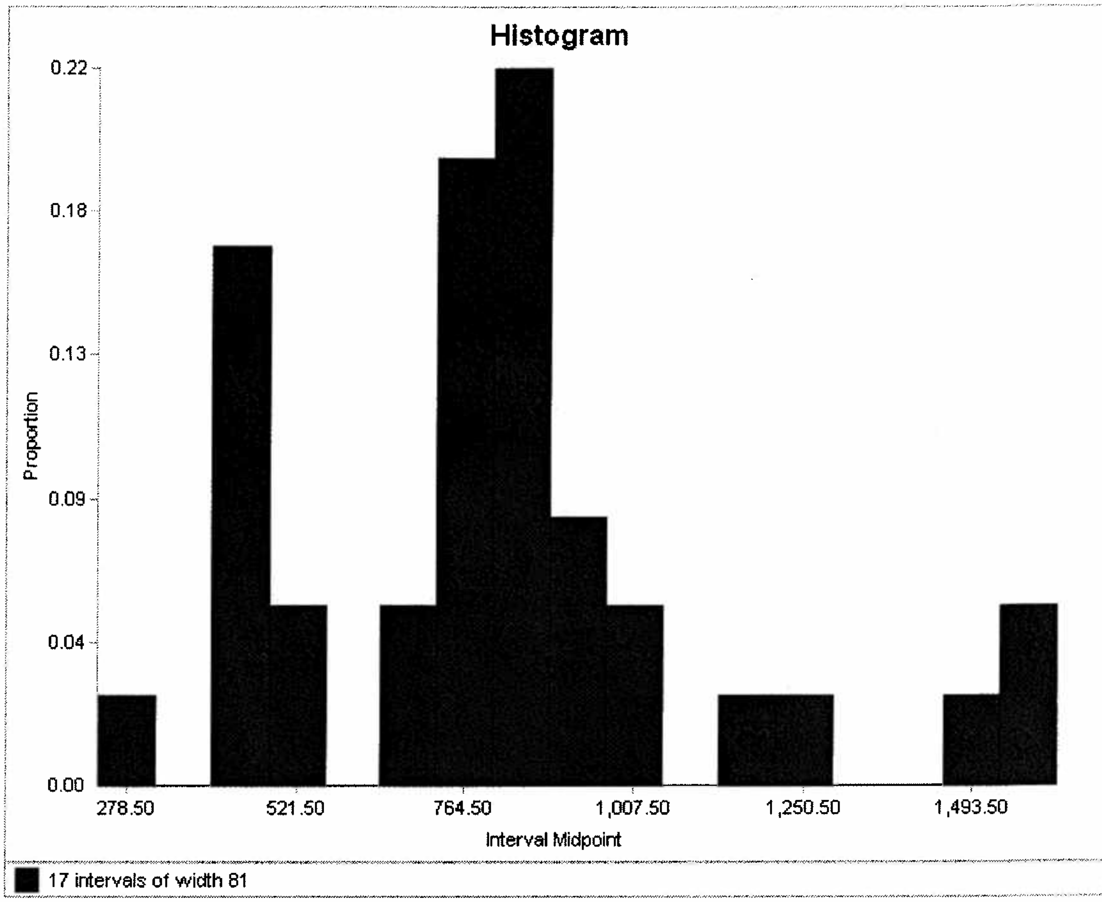

Figure 12: Histogram for NJ 10 Westbound Thursday Rush Hour PM

The values for Tuesday and Thursday data for NJ 10 Westbound "Rush Hour PM" time period were determined. The data from Tuesday to Thursday is shown to be significantly different from each other. Both days have significantly different distributions, means and standard deviations.

Step B: During the second step of the testing process, the mean traffic count of Tuesday and Thursday were compared and it was determined whether or not they were significantly different. This data was gathered used an ANOVA analysis. The results were similar to Cases 2 and 3. The null hypothesis used states that there is no difference shown between the means of Tuesday and Thursday during the Rush Hour PM shift. After performing an ANOVA analysis, the results in the resulting ANOVA table showed that the null hypothesis should be rejected. Therefore, based on this analysis a significant difference between the mean for Tuesday and Thursday is shown. These results suggest that there may be a problem with the data collection for this road.

CASE 5: US 46 Eastbound (Rush Hour AM) vs. Westbound (Rush Hour PM)

Objective:
The objective of Case 5 was to compare the mean of passing cars for just one shift of a day for US 46 Eastbound (Rush Hour AM) with the US 46 Westbound (Rush Hour PM) in order to see whether they are significantly different from each other.

Methodology:

In case 5, twelve weeks worth of traffic count data was collected for each day for the Eastbound Rush Hour AM and Westbound Rush Hour PM time periods. The Tuesday data is shown in Tables 10 and 11. Data for Thursday is shown in Tables 12 and 13.

A two step statistical analysis was performed:

Step A: Statistical analyses were performed for each day (Tuesday and Thursday) individually.
Step B: Statistical analyses were performed to test whether there is a significant difference between the means for both days or not.

Table 10: US 46 Eastbound Rush Hour AM

	Tuesday											
	Week 1	2	3	4	5	6	7	8	9	10	11	12
Rush Hour AM												
6-7 AM	938	962	963	1013	992	983	955	974	979	916	872	766
7-8 AM	1865	1841	1795	1781	1791	1741	1746	1710	1767	1786	1655	1416
8-9 AM	2091	2198	1971	2159	2050	2132	2117	2029	2004	2091	1933	1594

Table 11: US 46 Westbound Rush Hour PM

	Tuesday											
	Week 1	2	3	4	5	6	7	8	9	10	11	12
Rush Hour PM												
16-17 PM	1672	1661	1557	1675	1848	1697	1706	1910	1673	1728	1536	1111
17-18 PM	2039	2051	1879	2118	2114	1914	2005	1788	1917	1820	1873	1427
18-19 PM	1600	1338	1401	1411	1478	1839	1367	1995	1312	1359	1380	1043

Table 12: US 46 Eastbound Rush Hour AM

	Thursday											
	Week 1	2	3	4	5	6	7	8	9	10	11	12
Rush Hour AM												
6-7 AM	977	974	958	952	908	968	924	928	946	933	927	807
7-8 AM	1791	1739	1783	1847	1847	1857	1791	1739	1698	1668	1618	1660
8-9 AM	1957	2053	1977	2078	2013	2060	2088	2001	1987	1779	1756	1923

Table 13: US 46 Westbound Rush Hour PM

	Thursday											
	Week 1	2	3	4	5	6	7	8	9	10	11	12
Rush Hour PM												
16-17 PM	1681	1767	1913	1762	1841	1768	1735	1908	1880	1897	1609	1194
17-18 PM	1858	2091	1870	1963	2047	2085	1937	2077	1733	2089	2063	1510
18-19 PM	1327	1579	1782	1420	1825	1490	1366	1463	1821	1425	1616	1188

Analysis and Results:

Step A: Statistical analysis was performed for each day (Tuesday and Thursday):

5 a) US 46 Eastbound (Rush Hour AM) vs. Westbound (Rush Hour PM) Tuesday
5 b) US 46 Eastbound (Rush Hour AM) vs. Westbound (Rush Hour PM) Thursday

For this step, an ANOVA analysis was performed to determine whether or not the null hypothesis should be accepted. In this case the null hypothesis states that there was no significant difference between the mean traffic count during the Rush Hour AM and the Rush Hour PM shifts for each direction. This means the average number of cars counted from one direction during the Rush Hour AM shift should not be different from the average number of cars passing the same point in the opposite bound during the Rush Hour PM shift.

5 a) US 46 Eastbound (Rush Hour AM) vs. Westbound (Rush Hour PM) Tuesday

An ANOVA analysis was performed and the resulting ANOVA table was designed and shown in Table 14. Given that the F value is less than the F critical value, the null hypothesis is not rejected. Therefore, there is no significant difference between the mean traffic count for the eastbound Rush Hour AM shift and the westbound Rush Hour PM shift on Tuesday.

Table 14: ANOVA Table for US 46 Eastbound (Rush Hour AM) vs. Westbound (Rush Hour PM) Tuesday

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	186660.5	1	186660.5	1.205113	0.276064	3.977779
Within Groups	10842327.44	70	154890.3921			
Total	11028987.94	71				

5 b) US 46 Eastbound (Rush Hour AM) vs. Westbound (Rush Hour PM) Thursday

An ANOVA analysis was performed. The resulting ANOVA table is shown in Table 14. Given that the F value is greater than the F critical value, the null hypothesis will be rejected. Therefore, there is a significant difference between the mean traffic count for the eastbound Rush Hour AM shift and the westbound Rush Hour PM shift on Thursday.

Table 15: ANOVA Table for US 46 Eastbound (Rush Hour AM) vs. Westbound (Rush Hour PM) Thursday

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	617530.8889	1	617530.8889	4.449553	0.038488	3.977779
Within Groups	9714945.556	70	138784.9365			
Total	10332476.44	71				

Step B: The same ANOVA analysis can be done to determine whether the mean traffic counts for Tuesday and Thursday are significantly different. In this case, the results of the prior analyses show that while the traffic count data on Tuesday was consistent, it was not consistent on Thursday. Therefore, this shows that the data is not consistent for the US 46 Eastbound (Rush Hour AM) and Westbound (Rush Hour PM), suggesting that there are problems with the data collection.

CASE 6: NJ 31 Northbound (Rush Hour AM) vs. Southbound (Rush Hour PM)

Objective:

The objective of Case 6 is to compare the mean of passing cars for just one shift of a day for NJ 31 Northbound (Rush Hour AM) with the NJ 31 Southbound (Rush Hour PM) shift in order to see whether they are significantly different from each other.

Methodology:

In this case, twelve weeks' worth of traffic count data was collected for each day for the Northbound Rush Hour AM and Southbound Rush Hour PM time periods. The data for Tuesday is shown in Tables 16 and 17. Tables 18 and 19 show the data for Thursday.

A two step statistical analysis was performed:

Step A: Statistical analyses were performed for each day individually.
Step B: Statistical analyses were performed to test whether there is a significant difference between the means for both days or not.

Table 16: NJ 31 Northbound Rush Hour AM

	Tuesday											
	Week 1	2	3	4	5	6	7	8	9	10	11	12
Rush Hour AM												
6-7 AM	569	595	541	558	291	290	311	303	325	303	317	302
7-8 AM	898	1025	984	934	531	517	506	517	532	530	545	542
8-9 AM	1121	1128	1186	1195	636	636	621	618	617	578	593	679

Table 17 NJ 31 Southbound Rush Hour PM

	Tuesday											
	Week 1	2	3	4	5	6	7	8	9	10	11	12
Rush Hour PM												
16-17 PM	714	774	736	778	754	765	788	773	790	797	740	793
17-18 PM	740	709	745	781	726	771	809	805	753	782	766	790
18-19 PM	583	598	658	647	670	640	661	654	672	635	651	619

Table 18 NJ 31 Northbound Rush Hour AM

	Thursday											
	Week 1	2	3	4	5	6	7	8	9	10	11	12
Rush Hour AM												
6-7 AM	575	538	538	526	275	303	302	298	281	295	326	295
7-8 AM	989	961	957	918	524	532	564	514	577	548	520	520
8-9 AM	1161	1129	1091	1186	672	662	603	628	644	636	645	692

Table 19 NJ 31 Southbound Rush Hour PM

	Thursday											
	Week 1	2	3	4	5	6	7	8	9	10	11	12
Rush Hour PM												
16-17 PM	775	796	842	1280	763	808	826	808	777	774	747	820
17-18 PM	730	728	783	1329	736	771	752	776	842	807	802	790
18-19 PM	639	736	735	1083	718	673	650	704	665	626	609	756

Analysis and Results

Step A: Statistical analysis were performed for each day (Tuesday and Thursday) individually

6 a) NJ 31 Northbound (Rush Hour AM) vs. Southbound (Rush Hour PM) Tuesday

6 b) NJ 31 Northbound (Rush Hour AM) vs. Southbound (Rush Hour PM) Thursday

For this step, an ANOVA analysis was performed to determine whether or not the null hypothesis should be accepted. In this case the null hypothesis states that there is no significant difference between the mean traffic count during the Rush Hour AM and the Rush Hour PM shifts for each direction. This means that the average number of cars counted from one direction during the Rush Hour AM shift should not be different from the average number of cars passing the same point in the opposite bound during the Rush Hour PM shift.

6 a) NJ 31 Northbound (Rush Hour AM) vs. Southbound (Rush Hour PM) Tuesday
An ANOVA analysis was performed and the resulting ANOVA table was designed and shown in Table 20. Given that the F value is greater than the F critical value, the null hypothesis was rejected. Therefore, there is a significant difference between the mean traffic count for the northbound Rush Hour AM shift and the southbound Rush Hour PM shift on Tuesday.

Table 20: ANOVA Table for NJ 31 Northbound (Rush Hour AM) vs. Southbound (Rush Hour PM) Tuesday

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	189420.1	1	189420.1	4.971247	0.028982	3.977779
Within Groups	2667220	70	38103.14			
Total	2856640	71				

6 b) NJ 31 Northbound (Rush Hour AM) vs. Southbound (Rush Hour PM) Thursday
An ANOVA analysis was performed. The resulting ANOVA table shows that there was a significant difference between the mean traffic counts for the northbound Rush Hour AM shift and southbound Rush Hour PM shift on Thursday.

Step B: In comparing the mean traffic count for both Tuesday and Thursday from the previous ANOVA analyses, the means are shown to be significantly different. Therefore, the data collected for Tuesday and Thursday are both inconsistent for both the northbound Rush Hour AM and the southbound Rush Hour PM shifts. This suggests that there is a problem with the data collection process for this road.

A summary of the testing objectives and their associate conclusions are presented in the following tables.

VII. Testing Results Summary

Table 21: Testing Results Summary

Objective: To determine whether or not the traffic data collected is consistent
Methodology: • 5 roads were chosen: Route 287, NJ Route 10, and Route 31, US Route 46 and US Route 206. • The research team chose two days out of the week, Tuesday and Thursday. • Twelve weeks of samples were chosen from the months of April until mid June. • Six cases were chosen for statistical tests. **Conclusion** Our objective was to find out whether or not the collected traffic count data for roads were being done properly. If the data was consistent, it would suggest that this has been done properly. If the data is inconsistent, this would suggest that there is a problem with the overall process of data collection. For the purposes of testing, five roads were selected: Route 287, NJ Route 10, and Route 31, US Route 46 and US Route 206. In this report, six cases were selected to highlight the testing process and the analysis that went into each road. For all cases, graphical representations of the data were created in addition to the statistical analysis that was performed. Our results show that among the six cases, two cases showed consistent traffic count data between days and over weeks. In those two cases, there is no suggestion of any problems with the data collection process. However, four other cases have shown inconsistent data either between days or between directions. These cases may suggest that there are problems with the overall process of data collection resulting in inconsistent data.

Table 22: Testing Results

Analysis			
Case #	**Route Description**	**Test Description**	**Test Results**
1	**NJ 31 Northbound Milepost 26.2 Location: Between Woodschurch RD & Rest Area**	**Tuesday vs. Thursday Rush Hour AM Comparison** I)Analyzed data of each day for 12 weeks of Rush Hour AM II) Plotted data on a graph III) Statistical testing was performed in two steps: a .Statistical analysis was performed for each day (Tuesday and Thursday) individually b .Compared whether or not the means of Tuesday and Thursday was significantly different.	• The means are not significantly different. • The sample data for both days are consistent.
2	**US 46 Eastbound Milepost 44.80 Location: Between Dixon DR & Lackawanna Ave**	**Tuesday vs. Thursday Rush Hour PM Comparison** I) Analyzed data of each day for 12 weeks of Rush Hour PM II) Plotted data on a graph III) Statistical testing was performed in two steps: a. Statistical analysis was performed for each day (Tuesday and Thursday) individually b. Compared whether or not the means of Tuesday and Thursday was significantly different	• The means are not significantly different. • The sample data for both days are consistent.
3	**NJ 10 Eastbound Milepost 13.9 Location: Between RT 511 & Jefferson Rd**	**Tuesday vs. Thursday Rush Hour PM Comparison** I) Analyzed data of each day for 12 weeks of Rush Hour PM II) Plotted data on a graph III) Statistical testing was performed in two steps: a. Statistical analysis were performed for each day (Tuesday and Thursday) individually b. Compared whether or not the means of Tuesday and Thursday are significantly different	• The means are significantly different. • The sample data for both days are inconsistent.

4	**NJ 10 Westbound Milepost 13.9 Location: Between RT 511 & Jefferson Rd**	**Tuesday vs. Thursday Rush Hour PM Comparison** I) Analyzed data of each day for 12 weeks of Rush Hour PM II) Plotted data on a graph III) Statistical testing was performed in two steps: a. Statistical analysis was performed for each day (Tuesday and Thursday) individually b. Comparing how the mean of Tuesday and Thursday are significantly different	• The means are significantly different. • The sample data for both days are inconsistent
5	**US 46 Milepost 44.80 Location: Between Dixon DR & Lackawanna Ave**	**Eastbound (Rush Hour AM) vs. Westbound (Rush Hour PM) Comparison** I) Analyzed data of each day for 12 weeks of Eastbound Rush Hour AM and Westbound Rush Hour PM data. II)Statistical test were performed in two steps: a. Statistical analysis were performed for each day (Tuesday- Thursday) individually b. Compared how the means of Tuesday and Thursday are significantly different	• For Tuesday, no significant difference between the testing data's means is shown. • For Thursday results, there is a significant difference between Eastbound Rush Hour AM and Westbound Rush Hour PM testing results.
6	**NJ 31 Milepost 26.2 Location: Between Woods Church RD & Rest Area**	**Northbound (Rush Hour AM) vs. Southbound (Rush Hour PM) Comparison** I) Analyzed data of each day for 12 weeks of Eastbound Rush Hour AM and Westbound Rush Hour PM data II) Statistical testing was performed in two steps: a. Statistical analysis was performed for each day (Tuesday and Thursday) individually b. Compared how the mean of Tuesday and Thursday are significantly different	• For Tuesday and Thursday there is a significant difference between Northbound Rush Hour AM and Southbound Rush Hour PM

VIII. QA/QC Metrics

Table 23: Data Quality

Data Quality – Accuracy, Precision & Consistency	
Objectives	– The process quality objective is to collect and process reasonable, consistent, and correct traffic count data for BTDD to use in making decisions and in providing traffic counts to other management systems.
Standards & Guidelines	– The NJDOT Traffic Monitoring System/Highway Standards, July 2006 manual is in place to improve and ensure the quality of the traffic information that is used to support decisions at all levels of highway management in the state of New Jersey. See Appendix A.
Methodology	– A full explanation of the methodology in collecting and processing data according to BTDD is in Section IV – How accurate the traffic data must be is dependent on the particular analysis being performed. Standards are shown in Appendix A.
Improvement Procedures	– BTDD relies on feedback from its customers to inform them if the program in place is meeting their expectations and if not how it can improve.
Quality Outcomes as Identified by BTDD	– The quality of the data is in many cases affected by environmental factors. – For inconsistent or missing data, some data can be recovered, some must be recounted, and some cannot be recovered or repeated. – Collected data cannot be corrected – it can only be accepted or rejected
Major Quality Issues – Magnitude and Frequency as defined by BTDD	– According to BTDD any data inconsistency would be a result of many varied environmental and other factors that would affect the equipment used in collecting data in the field. A list of these factors is in Section III. – The initial raw data collected is in a very unintuitive format for human review.
Quality Outcomes as determined by CAIT test results and findings	– From our testing (see Section V), inconsistencies with the final traffic counts being collection were identified: Traffic counts being significantly different among days, shifts, and directions. – These inconsistencies suggest that there are issues with the overall data collection process. However, without accounting for outside factors that could affect data collection in addition to the issues already described by BTDD, it is not certain whether the process itself is a definitive source of quality issues.

Documentations, Manuals & SOPs	– To improve and ensure the quality of the traffic information that is used to support decisions at all levels of highway management in the state of New Jersey, the NJDOT Traffic Monitoring System/Highway Standards, July 2006 is in place. See Appendix A.
Ownership of Data Quality process	– It is our understanding that BTDD is ultimately responsible of the quality of the data and owns the process of collecting, processing, and storing the data. – The consultants who collect the actual data are presumably responsible for handing the data off without additional inconsistencies.
Integration of Quality into the overall process.	– Recently collected data is verified by using older data. – There are processes mandated by the FHWA for data validation in addition to BTDD reviewing and validating data themselves, as described in Section IV. (These steps are all taken after data has been collected, however.)
Recommendations and proposed improvements	– It is recommended that BTDD specify additional factors (e.g. construction) that may be ongoing while data is being collected in the field. These factors could result in inconsistent or missing data being collected and processed. – Any and all issues with equipment used for data collection should be addressed. Equipment issues could lead to many issues with the data (e.g. inconsistencies, incorrect, or missing data). – Any major, long-term changes to a road (e.g. a new lane) should be specified for future data collection of a road. – It is recommended that software be developed to convert raw data into a more intuitive format for all users. – It is recommended that collected data be stored into a database that would allow queries, reports and analysis of reports for decision making processes that utilize this data much easier. – Once previous issues with outside factors, equipment, and the processing of data are addressed, the data collection process should be reviewed and tested again to determine whether the process is definitively a source of further data issues. – Implement new technology when it is reasonable for implementation, if the result would improve the quality of the data collected. – If the preceding recommendations of improvements to the traffic monitoring system have been adopted by BTDD, the organization see that more consistent results may be achieved with optimization of the current system and not necessarily adding more staff.

Table 24: Data Validity

Data Validity – Completeness & Timeliness	
Objectives	– This process validity objective is to collect complete traffic monitoring data; as well as update and publish traffic data on a timely basis for BTDD to use in making decisions and in providing traffic counts to other management systems.
Standards & Guidelines	NJDOT Traffic Monitoring System/Highway Standards, July 2006
Methodology	– BTDD collects traffic count data from collection sites on a periodic basis, depending on the type of counts being collected. Once data is received, the data validation and storage process begins. It is not clear how long these additional processes take. – Every year, BTDD provides its consultants a list of sites that require data collection. If there is missing or inconsistent data, in some cases the data can be recovered from the equipment using a "total retrieve" function. In other cases, the data collection process will need to be repeated if data cannot be accounted.
Improvement Procedures	– BTDD has brought in a consultant to review re-evaluate their program in relation to the IT Strategic Plan and this QA/QC study.
Validity Outcomes as Identified by BTDD	– The BTDD validation process is intended to meet standards of statistical reliability. If there is missing data, some of this data can be recovered from equipment through a "total retrieve" function. – Missing data is identified by inspection either by staff, by FHWA, by the LTPP contractor, or by the users of the data. Some data can be recovered, some must be recounted, and some cannot be recovered or repeated. – Collected data cannot be corrected – it can only be accepted or rejected.
Major Validity Issues – Magnitude and Frequency as defined by BTDD	– BTDD is unable to determine unequivocally whether it is meeting the standards which are shown in Appendix A.
Validity Outcomes as determined By CAIT test results and findings	– While our tests did not indicate any issues with timeliness or completeness, the files used in determining what roads to analyze have had large sections of blank traffic counts. This could be the result of data being collected for just short periods of time during the year or some other issue.
Documentations, Manuals & SOPs	NJDOT Traffic Monitoring System/Highway Standards, July 2006
Ownership of Data Validity process	– BTDD is ultimately responsible for collecting, processing, and producing and therefore owns those processes. The consultants who collect the actual data are presumably responsible for

	handing the data off in a timely fashion.
Integration of Validity into the overall process.	– If data is missing, some of this data can be recovered from equipment through a "total retrieve" function. Missing data is identified by inspection either by staff, by FHWA, by the LTPP contractor, or by the users of the data.
Recommendations and Proposed improvements.	– It is recommended that BTDD specify additional factors (e.g. construction) that may be ongoing while data is being collected in the field. These factors could result in inconsistent or missing data being collected and processed. – Any and all issues with equipment used for data collection should be addressed. Equipment issues could lead to many issues with the data (e.g. inconsistencies, incorrect, or missing data).

Table 25: Data Integrity

Data Integrity	
Objectives	– The process integrity objective is to properly collect and maintain data for BTDD to use in making decisions and in providing traffic counts to other management systems.
Standards & Guidelines	NJDOT Traffic Monitoring System/Highway Standards, July 2006
Methodology	– Data is stored on OIT's mainframe, on CD-ROMs, on a shared drive on NJDOT's server, and on individual PCs. Consultants, FHWA and its contractors, and other units also store data. Count data is stored on OIT's mainframe as it is processed. WIM data is stored on a PC as it is processed and validated, then periodically stored on CD-ROMs. OIT, the consultants, FHWA, the SHRP contractor, the authorities as well as BTDD all store traffic data. – Data inconsistency in stored data may be the result of corrupted files or different generations of the same files. It is our understanding that data is stored periodically either on a weekly or monthly basis. – Traffic volume, vehicle-type classification, and weigh-in-motion data is maintained on NJDOT's server; the NJDOT staff maintains the data. Any contributing factors to inconsistencies in the data maintenance process could be because updates or corrections are not always made to all the databases. In the event there is a data-integrity or maintenance problem within the database it is generally between BTDD and OIT; in any case, OIT is responsible for fixing any problems related to the database. – BTDD archives data. Count data is sent to the mainframe and WIM data is burned onto CD-ROMs. FHWA requires a ten-year retention of the data. – In the case of a disaster, short-term data can usually be recovered from consultants who have also stored such data. BTDD will attempt to recover any important data from anyone who has also stored such data. If necessary, short term counts can be re-taken; but any continuous data is lost.
Improvement Procedures	– BTDD has made a request to OIT for a relational database that would "tie everything together but after beginning to develop an Oracle database to replace the mainframe flat-file system, the effort was terminated without completion. – In the meantime BTDD has started to create its own software known as "Splitter," which checks the station IDs and saves them as single files. These methods would improve the storage of data collected and processed by BTDD.
Integrity Outcomes as Identified by BTDD	– According to BTDD, based on its current resources and procedures TTD is unable to determine unequivocally whether it is meeting the standards which are shown in Appendix A.

Major Integrity Issues – Magnitude and Frequency as defined by BTDD	– The format of the data initially provided to BTDD is in a very unintuitive format and makes processing the data very difficult. – BTDD is in the process of developing software to help perform tasks related to processing and storing data.
Integrity Outcomes as determined by CAIT test results and findings	– There does not seem to be any major issues with respect to integrity other than what has been identified by BTDD.
Documentations, Manuals & SOPs	NJDOT Traffic Monitoring System/Highway Standards, July 2006
Ownership of Data Integrity process	– OIT owns and maintains the mainframe and is responsible for maintenance of data. BTDD is responsible for the data itself, trying to process data for storage, handing data off to multiple users, recovering data in the case of a disaster, and the archiving of data. NJDOT staff is responsible for maintaining traffic data store on NJDOT servers.
Integration of Integrity into the overall process.	– Multiple users of the data do store data as well as BTDD. Additionally, there seems to be standards (e.g. archives) and protocols set up for the storage of data in addition to data archiving and disaster recovery.
Recommendations and proposed improvements.	– It is recommended that BTDD set up an integrated information system that would allow organizations whose activities directly affect BTDD be able to openly communicate any updated situation through daily, regular or as needed updates.

IX. Recommendations

The following points are in response to the findings of this study. BTDD has informed us that some of these issues have already been noted and are currently being rectified.

1. It would be helpful if BTDD were to have more resources allocated to them so that they would be able to hire more staff to work with the raw data.
2. It is recommended that BTDD include additional historical or environmental factors (e.g. construction schedules) with the traffic data counts. The addition of this information could help to explain some of the inconsistencies.
    a. By classifying the roads by these factors and including these factors in advance of the scheduled data collection more efficiency could be achieved.
    b. Daily communication between groups that regularly do work on roadways, (e.g. MMS, Pavement Technology Unit), could allow more productivity.
3. Address any and all equipment issues as defined by BTDD. See pp 4-5 Issues and Challenges Identified by BTDD. Equipment issues almost always lead to issues with the data quality.
4. Specify when there has been long term changes made to the roads (e.g. new off ramp, new lane etc.).
5. It is recommended that software be developed to convert raw data into a more understandable format. In addition, collected data should also be stored into a database that would allow queries, reports and analysis of reports for decision making processes that utilize this data much easier.
6. It is recommended that BTDD set up an integrated information system that would allow organizations whose activities directly affect BTDD can openly communicate any updated situation through daily, regular or as needed updates.
7. A validation process can be included in the updates from the contributing organization. This would insure that those receiving any updates will be responsible for reading them as are the organization sending the updates are responsible for timely alerts to issues as soon as they are presented (e.g. construction).
8. Once the specific issues with equipment, environmental factors, communication and data storage are addressed, it is highly recommended that the data collection process be examined and tested again. This may indicate the true source of the issues.
9. Implement new technology when it is reasonable to implement it; especially if it can improve the quality of collected data.

X. BTDD's Proposed Quality Improvements in Response to This Study

Recognizing that it currently lacks automated filtering tools to identify anomalous data "on the fly", the BTDD has initiated several projects aimed at detecting the kinds of inconsistencies in data as observed by the investigators. The graphical presentation of the data developed in response to the draft report helps identify outliers, general patterns of traffic and deviations from those patterns, and truly inconsistent data. This graphing capability is to be incorporated into the "Loader Modules" that will be developed by one of BTDD's consultants.

Once inconsistencies are identified, by whatever means, it remains to determine the cause of the inconsistencies. Obviously, it is necessary to distinguish random error from systematic error (assuming the results are truly in error). What is identified as random "error" may be factual data affected by factors noted by the investigators such as construction or maintenance activities; weather; crashes; or special events.

Systematic error should be easier to identify *when there is an abrupt change* in results than random errors. The BTDD will seek a software tool to identify abrupt changes in recorded data for further investigation.

The BTDD recognizes that the capabilities and peculiarities of each type of its equipment need to be thoroughly understood to avoid problems with volumes "maxing out" at some arbitrary thresholds such as 3,999 or 9,999 vehicles per hour. Careful thought must be given to decide whether sites prone to this situation need to be treated separately by changing recording intervals or disaggregating the data by lane; or whether treating one or two stations differently than scores of other stations is too labor intensive for the resource limitations discussed elsewhere in this report.

Another issue requiring analysis is the BTDD's practice of averaging the volumes recorded by each of two loops I each lane. Failure of one or the other loop needs to be detected, and more seriously, *intermittent* shorts or opens of one or the other loop in a lane need to be identified. The detection of abrupt changes mentioned above would address the first instance. The intermittent problems would be more difficult to detect. Careful analysis of the graphical display of the data may help in this regard.

The BTDD has come to understand the ongoing problem of contractors routinely installing six or seven turns of loop wire as they are accustomed to doing for traffic signals whereas the traffic monitoring equipment *requires* an inductance achieved with *four* turns of wire. The BTDD, with cooperation from ITS Engineering, has developed Standard Specifications and Construction Details for the sensor arrays peculiar to the traffic monitoring system, and the specific inductance ranges for traffic volume counting stations and for weigh-in-motion stations. The BTDD has also initiated a program, using its own contract and Resident Engineer, to renew traffic monitoring stations ensuring the work is done to meet the unique requirements of the traffic monitoring system

.

Summarizing the issues raised by this investigation, the BTDD needs to address each step enumerated below to ensure the data reaching the Federal Highway Administration and other customers is accurate. These steps are:

1 Identify anomalies. These need to be investigated further to determine whether the observed traffic is real, or incorrectly recorded.

2 Identify the cause of incorrect observation for remedy. This could be to "cut out" failed or failing loops; replace certain circuit boards in the equipment or replace the equipment altogether.

3 Determine whether incorrect observations can be corrected (*e.g.* by reprocessing data without failed loops' "zeroes") or whether it cannot be salvaged and needs to be purged.

4 Follow up to ensure purged data *stays* purged and does not re-emerge through subsequent processing or re-processing.

It remains for further statistical analysis to determine whether random outliers can be ignored; whether they require in-depth study to validate; or whether it is appropriate to purge a day of data for an hour that doesn't "fit the mold". Consideration must be given to the resources necessary to conduct this analysis; the effects on factors and other results by these outliers; and the sensitivity to these effects on the management systems and other uses of the results.

XI. Bibliography

1. http://tmcpfs.ops.fhwa.dot.gov/cfprojects/uploaded_files/Ch7_FinalVersion_051606.doc

Appendix I – NJDOT Traffic Monitoring System/Highways Standards

NEW JERSEY DEPARTMENT OF TRANSPORTATION

TRAFFIC MONITORING SYSTEM/HIGHWAYS

STANDARDS

January 2006

Objective

The primary purpose of these standards is to improve and ensure the quality of the traffic information that is used to support decisions at all levels of highway management in the state of New Jersey.

These standards shall apply to all short-term traffic monitoring activities conducted by or for the New Jersey Department of Transportation (NJDOT) and/or its agents with the intent of guaranteeing that not only raw data from traffic monitoring activities undertaken by NJDOT, but also those undertaken as part of any contractual agreement involving funds administered and/or provided by or through FHWA and/or NJDOT, is in conformance with these standards established for traffic data collection.

These standards shall be periodically reviewed and/or revised as deemed necessary by the Bureau of Transportation Data Development (BTDD) of NJDOT.

Goal

NJDOT maintains a traffic monitoring program consisting of continuous and short-term elements. Both of these elements are conducted by BTDD in accordance with the Federal Highway Administration (FHWA) Traffic Monitoring Guide and the American Association of State Highway and Transportation Officials (AASHTO) Guidelines for Traffic Data Programs. The traffic counting program is designed to utilize, at a minimum, 48-hour short-term counts to produce estimates of Annual Average Daily Traffic (AADT) with a confidence level of 95 percent with an interval of ±10 percent.

Equipment Calibration/Testing of automatic traffic recorder (ATR) and automatic vehicle classification (AVC) equipment must be conducted to ensure that this equipment is recording data accurately. Each machine (ATR and AVC units) shall be tested *at least* once every three years. The equipment test site(s) shall have the following characteristics:

1. Traffic volume shall be greater than 5,000 vehicles per day per lane.
2. Roadway shall be straight with grade less than 3 percent.
3. Road surface shall have no ruts greater than 3/4 inch with no severe potholes or other serious surface distress.
4. There shall be no traffic signals, stop signs, or any other impediment to continuous traffic flow.

ATR and AVC equipment using axle detectors (road hose) for volume counting and vehicle classification shall be installed and hourly data shall be collected for a continuous two (2) hour period. A manual classification will be conducted at the same time and the results compared. A maximum error of 10 percent for axle detections, and an accurate classification of 90 percent of each class of vehicles are required for acceptable performance of each unit of equipment.

ATRs using either permanently installed or temporary inductive loops shall have a maximum error of 2 percent. Accuracy shall be determined by comparing manual volume counts with recorded data from the ATR and AVC units collected for a continuous two (2) hour period.

The following test documentation shall be supplied to BTDD prior to the collection of any data:

1. Test site location and characteristics.
2. Testing procedure.
3. List of equipment by device type, manufacturer, model, serial number, achieved accuracy (volume and/or classification), and dates of current and last tests.
4. Installation and operation procedures.

Maintenance records shall be maintained and provided to BTDD upon request.

Monitoring Periods

Duration of all ATR and AVC volume and classification counts shall be a minimum of 48 continuous hours. The entire 48-hour period shall fall within the normal workweek (12:01 PM Monday through 12:00 Noon Friday) or the normal weekend (12:01 P.M. Friday through 12:00 Noon Monday). The weekend period is acceptable only for the purpose of identifying or monitoring recreational or retail traffic. Weekend data shall not be used to estimate AADTs. No part of any 48-hour count used for AADT estimation shall contain data collected within 36 hours of any extended weekend resulting from a Federal, State, or local holiday unless the purpose is to study holiday traffic. All non-typical conditions shall be avoided.

All data shall be collected by direction with a 15-minute recording interval. Recording shall begin on the hour and end on the hour so that data files do not contain partial data for any hourly subtotal. In the event that intervals less than one hour are collected, summaries in that interval shall ***not*** be submitted to BTDD and shall not be considered as part of the 48-hour count duration.

Installation Procedures

To ensure consistency in automatic traffic data collection, installation procedures shall be defined, documented, and provided by all traffic monitoring agencies, firms, and agents and provided to BTDD.

Pneumatic road tubes shall be installed at a right angle to traffic across a lane or lanes. The outer end shall be plugged. Clamps shall be affixed at the outer end, at the outside edge of pavement, at the inner edge of pavement, and at the outer edge of a paved shoulder. Tubes shall be affixed taut enough to guarantee minimum motion when crossed by vehicles. BTDD strongly recommends mastic tape spaced at 12 to 24 inch intervals to minimize motion of tubes.

When utilizing two tubes in the classification mode, both tubes shall be of the same age, type, length, and tension. The tubes shall be spaced according to the specific roadside unit requirements. Free-flow conditions are required for effective automatic vehicle classification. Where conditions are not free-flow, or speeds are lower than 25 miles per hour, manual vehicle classification counts (see below) are required to verify the accuracy of the electronic AVC monitoring.

On multi-lane roadways with volumes greater than 10,000 one-way AADT, portable loops and electronic axle sensors ***must*** be employed to collect classification data. No more than one lane shall be monitored for vehicle type classification per AVC recorder and pair of tubes on each side of the roadway. On two-lane roads, one AVC recorder and pair of tubes shall be installed on each side of the roadway. On four lane roads with a suitable median, one additional four-channel AVC recorder or two additional two-channel AVC recorders shall be installed in the median to classify traffic in the lanes adjacent to that median.

Pneumatic road tubes shall conform to NJDOT "Road Tube Specifications" or to ASTM "Standard Specifications for Pneumatic Tubing for Roadway Traffic Counters and Classifiers".

Recording units may be located on either side of the lane being monitored. They shall be chained to secure objects and be relatively free of risk from damage by vehicles, flooding, or other hazards. In no case shall recording units be attached to or set on barrier curbs. Excess tubing shall be routed away from the roadway, coiled, tied, and kept clear of potential snagging or damage.

Whether the sensor is pneumatic or electronic, the installation site shall be carefully selected. No sensor shall be placed in proximity to an intersection, driveway, or other vehicle maneuvering location where travel is not at a right angle to the sensor.

No sensor shall be installed where the roadway surface has ruts greater than 0.75 inch or severe potholes.
When monitoring sites in residential neighborhoods, particular attention must be paid to minimizing the effect of noise from traffic traveling over pneumatic tubes. Tubes should be

placed as far as possible from dwellings and securely fastened to avoid "bounce". Mini-tubes may be used if accurate counts can be obtained. If the site must be relocated to another block, the Project Manager must be notified.

Maintenance and Protection of Traffic

If the State and/or the Consultant determine that lane closures are needed in order to safely install and remove traffic monitoring sensors, the Consultant's Project Manager shall submit the appropriate forms -- "Request for Police Assistance" -- to the appropriate State Police coordinator and NJDOT Regional Operations Center; and procure the services of an NJDOT-approved MPT contractor. The cost of the MPT contractor shall be considered in the Consultant's Cost Proposal and shall be billed to the project as a non-salary direct expense.

Equipment Removal

Upon completion of each monitoring session, when the recorder is removed, all sensors, clamps, nails, and other installation devices shall be removed from the site and reused or properly discarded. Mastic or other adhesive tape may be cut and left affixed to the roadway, but pneumatic tubes or other sensor devices must be removed from the roadway and the roadside and taken away from the monitoring site.

Automated Site Identification

All traffic monitoring locations shall be identified by unique traffic station identification numbers. Prior to undertaking any traffic counts, BTDD shall be contacted to coordinate activities and to obtain traffic station identification numbers.

Each count shall be described through the use of the NJDOT Standard Route Identifier (SRI) including route number and name, link limits, mile-point, direction of travel, functional classification, municipality, and county.

A schedule listing the installation date of the count or classification equipment shall be supplied to BTDD. This will be used by BTDD to perform spot checks of ATR and AVC installations.

Notification by BTDD to contractors of station identification numbers shall be considered as authorization to proceed with conduct of the count.

Automated Data Reporting

All short-term count data, regardless of the equipment being used, shall be reported to BTDD on 3.5-inch, 1.44 Mb floppy diskettes, and/or e-mailed to the Project Manager and other designated individuals in the standard NJDOT "Short Count and Classification Reporting" formats.

Transmittal shall be confirmed through the NJDOT Project Manager and/or his designee.

Count acceptance shall be determined based upon the successful processing and editing of the raw count data. Counts that is not acceptable *for any reason* shall be redone and resubmitted at no expense to NJDOT.

Manual Counts

Manual volume counts shall be employed for intersection turning movement data collection and to collect classification data when vehicle speeds restrict use of AVC equipment.

Periods of Manual Traffic Monitoring

For counts that are to be used to develop 24-hour volumes, AADTs and Design Hourly Volumes (DHVs), a minimum of eight (8) hours of data shall be collected between 10:00 AM and 6:00 PM. One hundred percent of every hour shall be counted except for two (2) 15-minute breaks and one 30-minute lunch period. These breaks shall *not* be taken during the peak periods, at the beginning of the first hour, or at the end of the last hour, and shall be noted on the data recording sheet.

Counts are to be completed during the regular work week (12:01 PM Monday through 12:00 Noon Friday). Counts completed during the weekend period (12:01 PM Friday through 12:00 Noon Monday) are acceptable only for the purpose of identifying or monitoring recreational or retail traffic.

No part of a count used for AADT or DHV estimation shall contain data collected within 36 hours of any extended weekend resulting from a Federal, State, or local holiday unless the purpose is to study holiday traffic. All known or observed non-typical conditions shall be avoided.

Manual Data Collection Procedure

Data shall be collected in 15-minute intervals. No enumerator shall be responsible to observe and record more than 12 separate data items when performing an intersection turning movement count.

Manual classification counts, as with automatic equipment, shall be based on the "Scheme F" vehicle classification categories as defined in the Traffic Monitoring Guide unless directed otherwise by the NJDOT Project Manager or his representative.

Manual Data Reporting

All count and classification data shall be submitted to BTDD on 3.5-inch, 1.44 Mb floppy diskettes and/or uploaded to the NJDOT via e-mail. Intersection turning movement counts shall be in an EXCEL spreadsheet format defined by BTDD. Count summaries shall be provided in 15-minute intervals as well as one (1) hour totals. Classified intersection counts shall report volumes by classification plus total vehicles per interval. Manual classification counts shall be in the standard NJDOT classification data reporting format as described for AVC equipment.

Counts shall indicate the project number, route number and street name, municipality, county, date of count, day of week, start time, weather, times of breaks, and the name of the enumerator(s). If NJDOT has pre-assigned a station identification number, it shall also be indicated on the count record.

Listed below is a sample of one direction of the two directional text (.txt) files for a regular TMS location. This format is based on Golden River output files, for which the Department's mainframe processing routines were designed. These files can also be opened in EXCEL format.

```
*BEGIN 00 01 7-0-4082 0015 0 6.0 0 0 CONSULTANT   PKP   0922   12   E
980922 1215  0020 0011 0014 0014 0016 0015 0018 0009 0007 0015 0014 0012
980922 1515  0012 0018 0020 0024 0024 0014 0018 0022 0019 0017 0023 0028
980922 1815  0026 0029 0030 0023 0018 0025 0012 0011 0054 0011 0012 0005
980922 2115  0008 0010 0002 0006 0005 0004 0004 0005 0002 0005 0001 0002
980923 0015  0002 0001 0000 0005 0001 0001 0000 0002 0000 0000 0000 0003
980923 0315  0000 0000 0000 0001 0000 0001 0008 0001 0002 0006 0000 0006
980923 0615  0004 0004 0010 0010 0006 0012 0015 0012 0011 0019 0019 0011
980923 0915  0014 0012 0008 0014 0015 0014 0012 0017 0017 0021 0017 0011
980923 1215  0020 0025 0011 0017 0017 0009 0014 0004 0011 0014 0019 0020
980923 1515  0018 0015 0020 0011 0016 0022 0029 0026 0018 0010 0022 0027
980923 1815  0026 0041 0026 0032 0029 0018 0014 0019 0055 0027 0016 0010
980923 2115  0007 0015 0006 0004 0009 0001 0006 0005 0000 0002 0006 0003
980924 0015  0006 0002 0003 0001 0000 0001 0000 0001 0000 0001 0000 0002
980924 0315  0000 0002 0000 0000 0003 0002 0002 0002 0001 0005 0000 0008
980924 0615  0006 0005 0009 0012 0010 0021 0014 0014 0012 0012 0014 0015
980924 0915  0012 0011 0019 0010 0013 0021 0008 0017 0014 0026 0009 0016
*END   00 01 7-0-4082 0015 0 6.0 0 0
```

Below is a sample file of automatic vehicle classification data in TMG "C-record" format.

```
134093-462310        013          252NORMAN RD. BET.WOODBINE & IVY STS.
C343-46231099020913  00000000230000200000000010000100000000000000000000000000000000000000000000000000
C343-46231099020914  00000000400000600000000010000000000000000000000000000000000000000000000000000000
C343-46231099020915  00000000490000500000000000000000000000000000000000000000000000000000000000000000
C343-46231099020916  00000000390000300000000000000000000000000000000000000000000000000000000000000000
C343-46231099020917  00000000480000800000000010000000000000000000000000000000000000000000000000000000
C343-46231099020918  00000000600000100000000000000000000000000000000000000000000000000000000000000000
C343-46231099020919  00000000390000300000000000000000000000000000000000000000000000000000000000000000
C343-46231099020920  00000000380000400000000000000100000000000000000000000000000000000000000000000000
C343-46231099020921  00000000350000100000000000000100000000000000000000000000000000000000000000000000
C343-46231099020922  00000000230000200000000000000000000000000000000100000000000000000000000000000000
C343-46231099020923  00000000100000200000000000000000000000000000000000000000000000000000000000000000
C343-46231099021000  00000000090000100000000000000000000000000000000000000000000000000000000000000000
C343-46231099021001  00000000050000000000000010000000000000000000000000000000000000000000000000000000
C343-46231099021002  00000000000000000000000000000000000000000000000000000000000000000000000000000000
C343-46231099021003  00000000020000000000000000000000000000000000000000000000000000000000000000000000
C343-46231099021004  00000000020000000000000000000000000000000000000000000000000000000000000000000000
C343-46231099021005  00000000050000000000000000000000000000000000000000000000000000000000000000000000
C343-46231099021006  00000000180000200000000000000100000000000000000000000000000000000000000000000000
C343-46231099021007  00000000480000800000000010000000000000000000000000000000000000000000000000000000
C343-46231099021008  00000000410000300000000000000200000000000000000000000000000000000000000000000000
C343-46231099021009  00000000210000200000000020000100000000000000000000000000000000000000000000000000
C343-46231099021010  00000000200000700001000010000000000000000000000000000000000000000000000000000000
C343-46231099021011  00000000280000000000000010000000000000010000100000000000000000000000000000000000
C343-46231099021012  00000000330000300000000000000000000000000000000000000000000000000000000000000000
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C343-46231099021016  00000000470000400000000010000000000000000000000000000000000000000000000000000000
C343-46231099021017  00000000580000100000000000000200000000000000000000010000000000000000000000000000
C343-46231099021018  00000000530000400000000000000000000000000000000000000000000000000000000000000000
C343-46231099021019  00000000580000200000000000000000000000000000000000000000000000000000000000000000
C343-46231099021020  00000000310000300000000000000000000000000000000000000000000000000000000000000000
C343-46231099021021  00000000350000400000000000000000000000000000000000000000000000000000000000000000
C343-46231099021022  00000000150000300000000000000000000000000000000000000000000000000000000000000000
C343-46231099021023  00000000160000100000000000000100000000000000000000000000000000000000000000000000
C343-46231099021100  00000000100000100000000000000100000000000000000000000000000000000000000000000000
C343-46231099021101  00000000070000000000000000000000000000000000000000000000000000000000000000000000
C343-46231099021102  00000000000000000000000000000000000000000000000000000000000000000000000000000000
C343-46231099021103  00000000010000000000000000000000000000000000000000000000000000000000000000000000
C343-46231099021104  00000000010000000000000000000000000000000000000000000000000000000000000000000000
C343-46231099021105  00000000070000100000000000000000000000000000000000000000000000000000000000000000
C343-46231099021106  00000000110000200001000000000000000000000000000000000000000000000000000000000000
C343-46231099021107  00000000420000600000000000000100000000000000000000000000000000000000000000000000
C343-46231099021108  00000000390000400000000010000000000000000000000000000000000000000000000000000000
C343-46231099021109  00000000250000100000000010000100000000000000000000000000000000000000000000000000
C343-46231099021110  00000000210000200000000000000000000000000000000000000000000000000000000000000000
C343-46231099021111  00000000290000400000000000000000000000000000000000000000000000000000000000000000
C343-46231099021112  00000000330000200000000010000000000000000000000000000000000000000000000000000000
```

Appendix II – Additional Testing of Traffic Data

Report Studies (Tuesday & Thursday) + Wednesday

Case #	Route	Rush Hour	Milepost	Results (12 weeks)	Results (24 Weeks)
1	NJ 31 Northbound	AM	26.2	Consistent	Consistent
2	US 46 Eastbound	AM	44.8	Consistent	Consistent
3	NJ 10 Eastbound	PM	13.9	***Inconsistent***	***Inconsistent***
4	NJ 10 Westbound	PM	13.9	***Inconsistent***	***Inconsistent***

Monday – Comparison within weeks

Case #	Route	Rush Hour	Milepost	Results (12 Weeks)
1	NJ 700 Northbound	AM	0.8	Consistent
2	NJ 31 Northbound	AM	26.2	***Inconsistent***
3	NJ 3 Eastbound	AM	8.7	Consistent
4	I 287 Northbound	PM	31.88	***Inconsistent***
5	I 78 Westbound	PM	25.7	Consistent
6	US 206 Northbound	PM	91	***Inconsistent***

Tuesday, Wednesday, Thursday Comparison in Rush Hour PM

Case #	Route	Milepost	Results (12 Weeks)
1	I 287 Northbound	31.88	Consistent
2	US 206 Southbound	91	Consistent
2	I 78 Westbound	25.7	Consistent
4	NJ 3 Eastbound	8.7	Consistent
5	US 46	44.8	Consistent
6	NJ 31 Northbound	26.2	Consistent

Tuesday, Wednesday, Thursday Comparison in Rush Hour PM

Case #	Route	Milepost	Results (12 Weeks)
1	I 80 Eastbound	9.98	Consistent
2	NJ 17 Northbound	23	Consistent
3	NJ 23 Northbound	12.12	Consistent
4	NJ 3 Eastbound	8.7	Consistent
5	US 9 Southbound	131.78	Consistent
6	NJ 700 Northbound	0.8	Consistent

Some Examples of Inconsistent Data

NJ 31 Northbound Rush Hour AM- Tuesday

	Weeks																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
6-7 AM	**569**	**595**	**541**	**558**	291	290	311	303	325	303	317	302	272	274	291	292	304	286	249	285	260	239	305	282
7-8 AM	**898**	**1025**	**984**	**934**	531	517	506	517	532	530	545	542	507	494	536	516	528	523	525	480	474	486	526	548
8-9 AM	**1121**	**1128**	**1186**	**1195**	636	636	621	618	617	578	593	679	694	632	732	679	686	648	659	613	678	566	582	622

NJ 31 Northbound Rush Hour AM- Thursday

	Weeks																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
6-7 AM	**575**	**538**	**538**	**526**	275	303	302	298	281	295	326	295	277	286	272	289	300	268	296	265	283	255	279	290
7-8 AM	**989**	**961**	**957**	**918**	524	532	564	514	577	548	520	520	561	537	540	569	563	501	564	487	500	505	549	493
8-9 AM	**1161**	**1129**	**1091**	**1186**	672	662	603	628	644	636	645	692	687	675	681	696	708	698	669	646	697	630	615	663

NJ 31 Northbound Rush Hour AM- Wednesday

	Weeks																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
6-7 AM	**574**	**544**	**559**	**488**	314	308	318	279	279	318	306	332	280	281	265	265	293	265	261	286	261	273	290	290
7-8 AM	**929**	**975**	**937**	**831**	514	533	534	516	561	583	523	556	550	536	534	534	557	502	581	452	506	508	525	568
8-9 AM	**1156**	**1179**	**1074**	**1095**	570	616	632	571	701	602	664	651	673	637	692	734	653	665	680	645	625	571	623	616