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A Benefit-Cost Analysis of a State Freeway Service Patrol: A Florida Case Study

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by

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A BENEFIT-COST ANALYSIS OF A STATE FREEWAY SERVICE PATROL: A FLORIDA CASE STUDY

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ABSTRACT

The Road Ranger program is a freeway service patrol (FSP) designed to assist disabled vehicles along congested freeway segments and relieve peak period non-recurring congestion through quick detection, verification and removal of freeway incidents in Florida. It consists of approximately 88 vehicles in fleet and provides free service to about 918 centerline miles. The program is funded by the Florida Department of Transportation (FDOT) and its partners, and is bid out to private contractors. The objective of this study is to examine and evaluate the benefits of the Road Ranger service against their operating costs in five of the seven FDOT Districts and Florida Turnpike Enterprise. The five Districts were chosen due to the availability of Road Ranger program data and activity logs for analysis.

The Road Ranger program provides direct benefits to the general public in terms of reduced delay, fuel consumption, air pollution and improved safety and security. The benefits would be expected to be more significant during the peak period when demand reaches or exceeds capacity than in the off-peak and the mid-day period where capacity may not be as significant an issue. The costs considered in this analysis include costs of administration, operation, maintenance, employee salaries, and overhead costs.

Incident data were obtained from the daily logs maintained by the Road Ranger service provider containing important information about the time, duration, location, and type of service provided. Other data collected for this study include average daily traffic volume, geometric characteristics of the freeways, unit cost of Road Ranger service, etc.

The Freeway Service Patrol Evaluation (FSPE) model developed by the University of California-Berkley was calibrated and used to estimate the benefit-cost ratio for the Road Ranger program. The estimated benefit/cost ratios based on delay and fuel savings indicate that the Road Ranger program produces significant benefits in all the five Districts and Turnpike. The range of benefit-cost ratio of the Road Ranger program in different districts is from 2.3:1 to 41.5:1. The benefit -cost ratio of the entire Road Ranger program is estimated to be in excess of 25:1.

CHAPTER 1
INTRODUCTION

1.1 Background

Highway congestion represents a daily problem for commuters and commercial carriers on many freeways across the country. It costs travelers more than $40 billion annually in our nation's 50 largest cities *(1)*. Incidents are the unplanned random events occurring on freeways, resulting in a reduction in the capacity of the freeway system due to either lane blockage or rubbernecking. It has been found that the actual reduction in the capacity is much more than that one would anticipate. For example, a closure of one-lane on a three-lane freeway causes more than 50% reduction in capacity instead of 33%. Even an incident on the shoulder causes a reduction in capacity or flow because curiosity leads to driver distraction and a reduction in speeds. A recent study *(2)* has evaluated the rubbernecking impacts of accidents on traffic in the opposite direction based on archived traffic and accident data.

In order to reduce non-recurring delays caused by incidents, many states run freeway service patrols. The first service patrol known is the Chicago Emergency Traffic Patrol (ETP), which began in 1960. Since then, over 50 freeway service patrols have been established in United States, most of which were implemented after 1990 *(3)*. Most state DOTs operate their freeway service patrol either with their own staff or on a contract basis. Freeway service patrol programs from Michigan and Texas obtained partial funds from their respective DOT and local businesses *(4)*.

The patrol vehicles rove around the freeways and provide a low tech incident detection, response, and removal system. The number of patrol vehicles and their timing depend upon the frequency of incidents, traffic on freeway, and the budget. It is very important to have a cost-effective freeway service patrol system to ensure the amount of savings due to reductions in delay, fuel, and emissions are more than the operational and administrative cost of the freeway service patrol program. To quantify the necessity of such a program, a detailed benefit-cost analysis is necessary.

1.2 Florida Road Ranger Program

To reduce the impacts of the incidents occurring on freeways, the Florida Department of Transportation (FDOT) has been running a freeway service patrol called the Road Rangers since December 1999. The program was initially used for the management of traffic incidents in the construction zones. This program has expanded to respond to all type of incidents, and has become one of the most effective elements of the Department's incident management program *(5)*. The Road Ranger mission is to provide free highway assistance services during incidents to reduce delay and improve safety for the motoring public. It consists of about 88 vehicles in fleet and provides free service to about 918 centerlines miles *(5)*. The Road Ranger Service Patrol is funded by the FDOT and its partners and is bid out to private contractors. The Road Rangers are roving vehicles which patrol congested areas and high-incident locations of the urban freeways and are equipped, as a minimum, with the following equipment to assist as needed: cell phones, first aid kits, 2 ton jacks, fire extinguishers, flashing arrow board, reflective cones, booster cables, wood blocks, 5 gallon of sand, auto fluids, flares, radiator water, and a public address system *(5)*. Although each contractor has a different make of vehicle, the vehicles are typically white in color with the Road Rangers logo affixed to the rear and sides of the vehicle. Currently, all the seven Districts and Florida Turnpike provide the Road Ranger services except District 3. The hours of operation for District 1, 4, 5, 6 and 7 are 24 hours a day and 7 days a week; District 2 operates from 5:30 am to 7:30 pm each day; Florida Turnpike operates from 6:00 am to 10:00 am & from 4:00 pm to 8:00 pm and 365 days a year. The number of assists provided by the Road Ranger program since its inception is listed in Table 1.1

Table 1.1 Number of Assists by Road Rangers in Year 2000-2003

Year	No. of Assists
2003	316,883
2002	279,525
2001	198,372
2000	112,000

1.3 Objectives of the Study

The objective of this study is to examine and evaluate the benefits of the Road Ranger service patrol against their operating costs in Florida. The five Districts and Turnpike were chosen due to the availability of Road Ranger program data and activity logs for analysis. The year of analysis for the present study is 2004. This project was funded by the FDOT.

1.4 Organization of Thesis

The rest of the thesis is organized as follows. The thesis is divided into 8 chapters. Chapter 2 covers the literature review of the similar studies conducted in the past. Chapter 3 describes the methodology adopted for the present service patrol evaluation. Chapter 4 presents the data and parameter requirements and data sources. Chapter 5 presents the details of incident data analysis for District 2, District 7, District 4, District 5 and Florida’s Turnpike. Chapter 6 summarizes the estimates of benefits of the Road Ranger program and also the B-C ratio. Chapter 7 shows the results of the sensitivity analysis performed to measure the effect of various input variables on the model output. Finally, chapter 8 includes the summary of findings and conclusions. Chapter 8 is followed by the list of references and appendix tables.

CHAPTER 2
LITERATURE REVIEW

The major benefits of a freeway service patrol program include: delay savings, reduced fuel consumption and emissions, improved traffic flow, reduced potential for secondary incidents, reduced stress, and an increased sense of security. Past studies have concentrated on the methodologies to quantify the delay savings and fuel consumption. These two aspects make up the majority of total benefits in terms of dollar value. Few studies were found to deal with the reduction in secondary incidents and other benefits that are difficult to quantify.

Over the last decade, various methodologies have been used to calculate delays caused by incidents and savings in delay due to service patrols. There are certain challenges in estimating such benefits, mainly due to the measurement and collection of certain important variables such as incident detection and response times (with and without freeway service patrols), reduction in roadway capacities, travel time value, and method for calculating delay. Therefore, researchers often calculated benefit-cost ratio by assuming suitable values based on experience.

The benefits of delay savings for a freeway service patrol are often determined based on the detection and response times, amount of capacity reduction, type of incident, time of day, traffic volumes, etc. However, it is impractical to collect all of the data necessary for the precise measurement of these delay savings. Some reasonable assumptions must be made.

2.1 Detection and Response Time

The main objective of a freeway service patrol is to reduce the response time of incidents and provide assistance for their quick clearance. A study in Colorado reported, based on actual observations, that the response and clearance times were reduced by an average of

10.5 minutes for in-lane incidents, and an average of 8.6 minutes for incidents occurring outside the traveled way *(6)*. Another study in Houston reported an average incident duration reduction of 16.5 minutes based on before-and-after incident data *(7)*. A recent research by the Institute of Transportation Studies at University of California, Berkley recommended the use of 30 minutes mean response time without freeway service patrol. This study also suggested calculation of response time with freeway service patrol based on patrol size, beat characteristics, patrol vehicle speeds and time of day (peak, off-peak and mid-day) *(8)*. It is very important to have appropriate values of incident duration with and without the freeway service patrol, in order to get an accurate estimate of its benefits.

2.2 Restoration Time

Restoration time is the time required for traffic to restore to its original form after clearing the incident. This time is from the moment when queues begin to dissipate to the moment when traffic gets back to its original pre-incident flow rate. The restoration time can be very long for severe incidents, with long durations and heavy traffic volumes. The duration of an incident has a significant impact on the recovery time. Freeway service patrols mostly handle minor accidents. A majority of these incidents occur on the shoulders or medians. In these cases, there is actually no lane blockage or traffic backup on the freeway main lanes. Therefore, the difference in restoration time with or without freeway service patrols was not considered in the benefit analysis in past studies.

2.3 Capacity Reduction

Many past analyses have focused on estimating the capacity reduction due to an incident. The factors determining the percentage of capacity reduction include: location of the incident (in lane, shoulder, or median), number of lanes on freeway, and number of lanes blocked. Some key findings include: 1) the actual reduction in capacity of the freeway is much more than just blockage of lane; 2) the loss in capacity is likely to be greater than simply the proportion of original capacity that is physically blocked; 3) the effect of an incident on capacity depends on the proportion of the traveled roadway that is blocked by the stopped vehicles, as well as the number of lanes on the roadway at that point *(Highway Capacity Manual)*; 4) in case of multiple incidents at the same time, the capacity reduction used for the analysis should be the incident which has the maximum impact on the capacity.

Cuciti and Janson *(6)* made assumptions on roadway capacity reduction for evaluation of freeway service patrols in Colorado, in terms of number of lanes lost, at the following incident locations: right or left shoulder, 0.7; left or right lane, 1.7; middle lane, 2.3; off road, 0.3. A study by Hawkins *(7)* measured the extent of roadway capacity reduction during incident occurrence through field studies in Houston. Hawkins estimated, for a three lane freeway segment, a 29 percent reduction in roadway capacity for a stalled vehicle located on the shoulder and roadway capacity reduction of 52 percent for a stall or a crash blocking one lane. Similarly for a 4-lane freeway segment, Hawkins reported a 43 percent reduction in roadway capacity for a stalled vehicle blocking one lane, a capacity reduction of 82 percent for blocking 3 lanes and 12.5 percent decrease for a stall blocking a shoulder.

Goolsby *(9)* made the first efforts in calculating the effective capacity during the incidents for certain lane and shoulder blockages. It was concluded that "the effective capacity loss due to incidents is more than the effective loss due to removing a single lane on a four lane roadway". Goolsby used detailed incident logs coupled with video surveillance. By comparing the volumes under normal and incident conditions, he was able to predict the capacity reductions during incident conditions. Smith *(10)* performed a similar study, with much more detailed data using loop detectors and comparing the volumes under normal and incident conditions.

Highway Capacity Manual (HCM) also gives a capacity reduction table for various types of incident blockages, as shown in Table 2.1. But in order to use these tables, lateral location of the incident is required. A Freeway Service Patrol Evaluation (FSPE) model recently developed by University of California, Berkley *(8)* adopted the percent of capacity remaining due to an incident as provided by the HCM.

Table 2.1 Remaining Freeway Capacity (%) Recommended by HCM

Incident Type	Location	No. of Freeway Lanes/Direction			
		2	3	4	5+
Accident	Rt Shdr	81.00	83.00	85.00	87.00
	Median	81.00	83.00	85.00	87.00
	1-Lane	35.00	49.00	58.00	65.00
Breakdown	Rt Shdr	95.00	98.00	98.00	98.00
	Median	95.00	98.00	98.00	98.00
	1-Lane	35.00	49.00	58.00	65.00
Debris	Rt Shdr	95.00	98.00	98.00	98.00
	Median	95.00	98.00	98.00	98.00
	1-Lane	35.00	49.00	58.00	65.00

2.4 Type of Incidents

Incidents include crashes and a vast array of small events: stalls, flat tires, spills, debris on the road, and even highway maintenance work that diverts drivers' attention and disrupts the normal flow of traffic. The incident location is very important to estimate the capacity reduction on the freeway. A recent study by University of California-Berkley *(8)* defined nine types of incident based on the incident type and location to estimate the benefits of a freeway service patrol program. These types included: accident (right shoulder, in lane, left shoulder), breakdown (right shoulder, in lane, left shoulder), and debris (right shoulder, in lane, left shoulder). The average time spent by a service patrol vehicle in each incident category is quite different. A clear classification by type of incident is very helpful to correctly estimate the average incident duration and roadway capacity reduction.

2.5 Delay Calculation

Delay saving is a major portion of the benefits of a freeway service patrol program. The difference in delay between with and without freeway service patrol is the net benefit of the program. Two studies were conducted to estimate the delay due to incidents on I-880 in San Francisco by Skarbardonis *(11)* and Garib *(12)*. Loop detectors were used to measure the speed of vehicles and probe vehicles were used to detect incidents.

Skarbardonis *(11)* developed a general equation which calculated delay as a function of traffic volume, time of congestion, length of impacted freeway segment, average travel speed, and travel speed during an incident.

Garib *(12)* conducted a regression analysis of I-880 incident data to develop two models to predict incident-induced delay. The first model used four variables that included number of lanes involved, number of vehicles involved, incident duration and traffic demand upstream of the incident. The second model excluded traffic demand upstream.

Another method of calculating incident induced delay is queuing theory. Morales *(13)* developed a cumulative volume approach to calculate the delays on freeways. In his approach, two cumulative volume curves for arrival and departure were plotted against the time axis. The area between the two curves represented the extra delay due to an incident. Lindley *(14)* performed a study on recurrent and nonrecurrent delay using traffic counts from 37 cities across the nation. Sullivan *(15)* also used queuing theory to estimate incident-related delay. His delay model included 4 sub-models: an incident rate sub-model, an incident severity sub-model, an incident duration sub-model, and delay sub-model. He obtained capacity reductions from previous studies and classified incidents into seven category types. Each incident type was then matched to incident duration to formulate weighted average delay. Al-Deek *(16)* developed a method which was primarily an improvement to Morales' method. Vehicle speeds were incorporated in conjunction with traffic volumes to develop a delay formula. Historical speed data were used to distinguish between incident and non-incident congestion. However, this method requires a one-minute time interval which may result in formation of "noisy" data, while larger time intervals may not allow for accurate estimation of queue boundaries. In this method, individual slices are summed up to calculate the total delay for a given segment. Pierce and Sun *(17)* used a video reidentification method to estimate the delay due to incidents. A cubic polynomial model was developed to describe the travel time versus elapsed time during the incident duration. Delays were calculated by taking the difference between actual and the normal travel times. This method is very time consuming and labor intensive.

Many service patrol agencies have used the deterministic queuing model to evaluate the benefit-cost ratio of their program. Colorado, Michigan and New York have previously evaluated their programs with queuing type models. In addition to queuing and real time traffic data based approaches, computer simulation is another effective approach in modeling traffic delays due to incidents. By changing the incident durations with and without freeway service patrol, the delay savings can be calculated. A Houston *(7)* study used FREQ10PC, a deterministic and macroscopic model to find incident related delays. FREWAY3, CORSIM and XXEXQ are other simulation models that have been used for measuring nonrecurrent delays. University of California-Berkley developed a freeway service patrol evaluation (FSPE) model to estimate the benefit-cost ratio for the California Service Patrol (CSP). The model handles multiple time periods with different number of FSP tow trucks per time period. The FSPE model was extensively tested and applied to all existing FSP beats in California. The FSPE model is implemented in a Microsoft Excel workbook using Visual Basic for Applications (VBA) routines in the workbook itself and in a Microsoft Excel add-in file. This method uses a deterministic queuing model and few assumptions about response time reductions to evaluate delay savings. The model is also equipped with the latest emission sub-model to calculate savings on emissions. The model specification or parameters can be changed to suit local conditions.

2.6 Costs of Freeway Service Patrol

Most state Departments of Transportation fund and operate the freeway service patrol, either on their own or on a contract basis. In some cases, local and state police or metropolitan transportation authorities fund the patrolling services.

The source of funding comes from fuel taxes, Department of Motor Vehicles fees, and/or a percentage of state or local sales taxes. In case of funding from the federal government, the dollars frequently come from congestion mitigation and air quality (CMAQ) funds, construction funds, or highway safety funds. In some cases, the funding is sponsored exclusively by private agencies. An example of this is the Samaritan patrol program. The Samaritan patrols operate in 11 northeastern United States metropolitan areas. The patrols are operated by Samaritan, Inc. and funded by large corporations such as CVS pharmacies, First Union Bank, and Bank of Boston. Some privately operated programs get their funds from turnpike authorities, which use collected tolls to support the program.

The main cost components of a service patrol program are capital, administrative and operating costs. The annual cost of a freeway service patrol depends upon the number of center-line miles covered, hours of operation, and number of vehicles maintained. Metro freeway service patrol in Los Angeles, which maintains a fleet of 150 vehicles and covers about 650 center line miles, costs about $20 million annually*(3).* Chicago, Washington D.C., Oakland, Orange county (CA) are other places which maintain a fleet of over 50 vehicles and provide 24 hour service. These programs cost a few million dollars annually. There are places which have freeway service patrols operating only during the peak hours. These systems typically maintain a low fleet of vehicles and cost just a few hundred thousand dollars annually *(3).*

2.7 Benefit-Cost Ratio

Past studies carried out for various freeway service patrols showed greater benefit value than cost. The benefit-cost ratio ranges from low 2:1 to high 36:1 *(4*). Table 2.2 table shows the reported benefit-cost ratio of several existing programs *(3)*.

Table 2.2 Results of Service Patrol Benefit-Cost Studies

Patrol Location	Patrol Name	Year Performed	Results
Charlotte, NC	Incident Management Assistance Patrol	1993	3:1 to 7:1
Chicago, IL	Emergency Traffic Patrol	1990	17:1
Dallas, TX	Courtesy Patrol	1995	3.3:1 to 36.2:1
Denver, CO	Mile High Courtesy Patrol	1996	20:1 to 23:1
Detroit, MI	Freeway Courtesy Patrol	1995	14:1
Fresno, CA	Freeway Service Patrol	1995	12.5:1
Houston, TX	Motorist Assistance Program	1994	6.6:1 to 23.3:1
Los Angeles, CA	Metro Freeway Service Patrol	1993	11:1
Minneapolis, MN	Highway Helper	1995	5:1
New York, NY	Highway Emergency Local Patrol	1995	23.5:1
Norfolk, VA	Safety Service Patrol	1995	2:1 to 2.5:1
Oakland, CA	Freeway Service Patrol	1991	3.5:1
Orange Co., CA	Freeway Service Patrol	1995	3:1
Riverside Co., CA	Freeway Service Patrol	1995	3:1
Sacramento, CA	Freeway Service Patrol	1995	5.5:1

CHAPTER 3
METHODOLOGY

There have been many previous studies on the evaluation of the freeway service patrol programs. The methodologies have been focused on how to estimate the benefits of delay and fuel savings by a freeway service patrols. Most of these studies rely on extensive field data to estimate the delay caused by incidents, which is very time and labor consuming. Also most of these delay models are region specific and need additional efforts for the calibration and data collection before it can be applied to other regions. Few past studies have focused on developing a complete evaluation tool for estimating the benefit and cost ratio of a freeway patrol program.

The Freeway Service Patrol Evaluation (FSPE) Version 12.1 tool developed by University of California at Berkeley is one such tool that was developed to evaluate freeway services patrol. The FSPE model uses Microsoft Excel workbooks for all inputs and outputs. The MS Excel interface makes the model user-friendly, convenient, and simple in terms of entering the data and obtaining the results. The inputs are used by FSPE's internal Visual Basic for Applications (VBA) program to estimate the hourly traffic flows that are then used to estimate the incident induced vehicular delays and delay reductions due to Freeway Service Patrol (FSP) service. The model uses a deterministic queuing model for the purpose of calculating delay. The delay model uses VBA code implemented as built-in modules (directly contained in the workbook's sheets) to accommodate the more detailed queuing model. The model estimated delay saving benefits based on the beat's geometric and traffic characteristics, and the frequency and type of FSP-assisted incidents. For measuring fuel and emission savings, it uses the Emissions Factor (EMFAC) model with the latest mobile source emission rates published by California Air Resource Board (CARB). The inputs required by the model mainly include the beat characteristics, traffic volumes, and incidents. The model distributes the various incident types over the study segment during the service period proportional to the Vehicle Miles Traveled (VMT) in that segment during different periods of the day. It uses traffic profiles of the study area and AADT volumes on the study segments to calculate VMT during different times of the day and assigns incidents accordingly. It calculates the benefits for one average day using the input information and multiplies it by number of days of service to give the total benefit. The model uses the capacity reduction factors given by HCM 2000 to calculate the delay caused by incidents and uses a deterministic queuing model. The difference in delay with and without the patrol service would be the vehicle-hours saved and the net benefit of the service patrol. The model recommends 30 minutes response and detection time without the service patrol. Response time with service patrol is calculated using the beat length, truck speed, and number of trucks patrolling at time of evaluation on the study beat.

To apply the FSPE model to evaluate the Florida Road Ranger Program, the model has to be calibrated to suit Florida traffic and roadway conditions.

The California freeway service patrol is provided in peak periods, and there is no service during the non-peak periods. Hence, the model input for hours of operation doesn't account for non-peak hours. Since most of the Florida Road Ranger programs provide 24 hour service, the model has to be calibrated to evaluate and account for non-peak hours. The FSPE model calculates the benefits by considering average daily traffic and distributing incidents on the selected beat segment proportional to the VMT traveled. An important feature of the model is that it distributes incidents based on the VMT traveled, which is estimated by Average Annual Daily Traffic volume data and traffic profiles. In this way, the model output is not affected by how the hours of operation are distributed over AM peak, mid-day and PM-peak periods. The model is formulated for California Freeway Service Patrol, which is a peak period service. So, if an incident is entered for 11:45 PM and its average duration is 45 minutes, then the program enters into the next day and gives erratic results. This is because the program has not been developed in a manner to evaluate complete 24 hours. So, while performing delay benefit estimation for Florida Service Patrols, the total time of evaluation was kept from midnight to 11:15 PM, so that the incident will not go into the next day.

Model parameters are the default values used to estimate hourly traffic volumes, delay, and fuel consumption savings. The model provides default values for various parameters in the PARAMS worksheet. These default values can be changed to replicate the local conditions. Below are listed several of the parameters used in the model to estimate B-C ratio.

1. The freeway capacity for mixed use lanes is taken from the Highway Capacity Manual (*HCM*). According to the HCM, the speed of passenger cars at flow rates that represent capacity is about 55 mph, and the flow rate corresponding to this speed could be approximated as about 2250 pcphpl. However, for actual analysis a lower capacity of 2100 pcphpl is used considering the high percentage of older driver population.

2. The reduction values in HCM will be used to estimate the remaining capacity on freeway due to various incidents.

3. Reduction in response times is the difference between response time without Road Ranger service and the headway of patrolling vehicles. It has been found that without patrol service detection/response times are generally approximately 30 minutes. The headway of patrolling vehicle was computed by using the beat length divided by the number of patrolling vehicles and the speed of patrolling vehicles. Average speed of patrolling vehicles is assumed to be approximately 30 mph.

4. The average fuel costs per gallon in Florida are: $ 1.52 in 2002, $ 1.63 in 2003, and $ 1.96 in 2004, respectively *(18)*.

5. According to Texas Transportation Institute (TTI) Urban Mobility Report 2005, travel time value for each person hour of travel is $13.45 in 2004, and for trucks is $71.05. Assuming average vehicle occupancy of 1.5 (NHTS Survey 2001), and percentage of trucks in total traffic as 5%, the travel time value for present analysis is taken as $ 22.71.

$$\text{Travel Time Value} = \$13.45*1.5*0.95 + \$71.05*0.05=\$22.71$$

Finally, the traffic volumes, roadway geometry, and traffic profiles for each district were collected and input to FSPE models. The calibrated FSPE models for each district were then applied to perform the benefit-cost analysis of Road Ranger program in each FDOT district and the Turnpike.

CHAPTER 4

DATA COLLECTION AND PROCESSING

In this study, the FSPE model was calibrated to fit Florida roadway, traffic and Road Ranger service conditions. The calibrated FSPE model will be used to perform the benefit-cost analysis of the Road Ranger program in FDOT districts and the Florida Turnpike. The data required for evaluating the Florida Road Ranger program using the FSPE model can be classified into 4 chief categories:

1. Beat/Service description
2. Beat design characteristics
3. Traffic data
4. Incident data

4.1 Beat/Service Description

The service description includes only information such as district name, beat name, date, and name of analyst. Beat characteristics include information related to the Road Ranger program on the beat that is being evaluated such as hours of operation, number of patrolling vehicles, number of service days per year, cost of each vehicle ($/truck-hr), and total number of assists per year. Costs of truck include the cost paid by FDOT to the private contractor per truck hour for running the Road Ranger program. All the data regarding cost and operation of the Road Ranger program were obtained from respective Road Ranger District managers or the contractor providing the service. Each district in which the Road Ranger program is operational has its own contractor and also maintains the Road Ranger logs recording information about the type, time and duration of the incident assisted. As each district has its own contractor, the cost of program varies from district to district. The cost of the truck per hour is about in the range of $27.00 to $41.00.

4.2 Beat Design Characteristics

Each study beat is divided into various segments for each travel direction. Each segment is similar in geometric design, capacity (number of lanes) and traffic volumes. Data are entered for each travel direction on a segment, including: length (miles), number of mixed flow lanes, HOV lane (if any), and presence of shoulders. All the data regarding beat design characteristics can be obtained from Florida Traffic Information CD (FTI, 2003).

4.3 Traffic Data

For each segment of the study beat, the Average Annual Daily Traffic and Directionality factors (AM, Mid-day and PM peak periods) are required for analysis. Traffic data are obtained from FTI CD. Also the program requires traffic profiles for various districts in order to calculate the hourly traffic volumes for each beat segment. Traffic profiles are estimated using the Florida Traffic Information CD (2003). The FSPE model requires traffic profiles for the entire district to calculate the hourly distribution of traffic for each segment of the beat being evaluated. Traffic profile is the percentage distribution of traffic volumes during the day. Each hour in a day corresponds to a percentage value, which represents the percent of total daily volume that flows during that hour. To estimate the traffic profiles for each district, 24 hour traffic counts along (and around) freeways being evaluated are determined. These traffic volume values are then used to calculate the percentage of traffic during a particular hour of day, for each of the 24 hours. It should be noted that hourly traffic counts from all the sites on the service roads in a district are used to calculate percentage of traffic. Table 4.1 shows the traffic profiles of all the districts and Turnpike in Florida. Traffic data used for this study are contained in Appendix A.

Table 4.1 Traffic Profiles (Time of the Day Distribution of Traffic) of Various Districts in Florida

Hourly Interval	District 1	District 2	District 4	District 5	District 6	District 7	Turnpike
Midnite-1	0.87	0.94	1.09	1.01	1.29	1.18	1.07
1-2	0.56	0.57	0.67	0.64	0.79	0.77	0.67
2-3	0.43	0.57	0.57	0.51	0.54	0.62	0.54
3-4	0.40	0.46	0.59	0.57	0.55	0.65	0.54
4-5	0.74	0.62	0.90	0.88	0.84	0.97	0.82
5-6	1.86	1.53	2.14	2.33	1.93	2.19	2.00
6-7	4.77	4.53	5.52	5.34	4.75	5.20	5.02
7-8	7.38	7.39	7.70	7.07	6.60	6.72	7.14
8-9	6.92	7.09	7.39	6.71	6.42	6.32	6.81
9-10	5.67	5.33	5.55	5.88	5.58	5.58	5.60
10-11	5.73	5.20	5.00	5.28	5.23	5.56	5.33
11-Noon	5.60	5.75	4.94	5.61	5.43	5.72	5.51
Noon-1	5.59	6.29	4.99	5.53	5.54	5.68	5.61
1-2	5.84	6.08	5.16	5.67	5.61	5.53	5.65
2-3	6.05	6.10	5.66	5.79	5.32	5.54	5.74
3-4	7.25	6.53	6.40	6.35	6.79	6.03	6.56
4-5	7.62	7.56	7.48	6.47	6.85	6.81	7.13
5-6	8.39	8.10	8.11	7.36	7.37	7.26	7.76
6-7	5.81	5.66	6.57	5.91	6.26	5.89	6.02
7-8	3.87	4.01	4.39	4.27	4.76	4.40	4.28
8-9	2.97	3.14	2.98	3.32	3.57	3.32	3.22
9-10	2.47	2.75	2.54	3.22	3.42	3.28	2.95
10-11	1.95	2.17	2.19	2.44	2.69	2.59	2.34
11-Midnite	1.26	1.62	1.48	1.83	1.89	2.16	1.71

4.4 Incident Data

The incident data required for the FSPE model include typically the total number of assists during the evaluation period, type of incident, and mean duration (in minutes) of incident. Herein the mean duration of a particular incident type is the actual time spent by the Road Ranger team at the site of an incident. It does not include response and detection time of the incident. The FSPE model has divided all the incidents into nine categories depending upon the lateral location of incidents. The model considers three types of incidents: - accident, breakdown and debris. For each category, there is a subcategory for location of incident. For instance, if the incident has occurred on right shoulder, left shoulder, or blocked a lane. The incident location will directly affect the capacity reduction on the freeway as taken from the HCM. The HCM suggests that the reduction in freeway capacity is same for incidents occurring on the left or right shoulders.

The incident related information is obtained from Road Ranger logs. After reviewing Road Ranger logs, it was found that the incidents were classified into ten main categories. They are: - accidents, flat tires, fuel, cell phones, jump start, debris, minor repairs, overheated, abandoned and tow to shoulder. In order to use the FSPE tool, these ten categories needed to be regrouped into the same three categories as the FSPE model. The accident and debris from Road Ranger logs are defined the same as in the FSPE model. All the others, such as flat tires, fuel, cell phones, jump start, minor repairs, overheated and abandoned vehicles, are considered in the breakdown category. However the Road Ranger logs do not have any information regarding the lateral location of incidents. The model however requires the lateral location for each incident type. Empirically, it has been found that about 35 percent of the accidents occur in the lane. Breakdowns mostly occur on right shoulder while 82 percent of debris is in the lane incidents. It should be noted that the incidents blocking more than one lane are very rare and hence are ignored during the present study. Table 4.1 gives an approximate percentage for lateral occurrences of three incident types. In absence of sufficient data from the Road Ranger logs, these percentages are used to evaluate the freeway patrol program.

Table 4.2 Percentage of Incident Occurrence by Lateral Location

Incident	% Incidents
Type/Location	
Accident Right Shoulder	55.9%
Lt Shldr (Median)	9.4%
1-Lane	34.6%
Breakdown Right Shoulder	89.6%
Lt Shldr (Median)	5.3%
1-Lane	5.0%
Debris Right Shoulder	14.2%
Lt Shldr (Median)	3.3%
1-Lane	82.4%

4.5 Limitations of the Incident Data

The present study obtained all the incident related data from the Road Ranger incident logs. This data typically included: type of incident, duration, location, time and date of the incident. The accuracy and consistency of the data is very important factor in the delay estimation process. Any discrepancies and inconsistencies in the data can influence the results of the study. During the present study many inconsistencies in the data were observed in terms of type of data collected and the data recording process. No District (except for District 6) provided any information related to the lane blockage due to the incident, which is an important parameter in determining the decrease in capacity of the roadway section. In numerous cases the data was entered as text; such type of data entries can be understood only when read in person and through computer queries. However, in dealing with large data sets like incident logs, the data should be entered in a format easily queried and searched through computer software. In many occasions the type of incident was written down as text in single column instead of having different columns for each type and assigning a dummy variable. It was also found that there was no uniformity in entering the text description e.g. an incident caused due to "break down" can be written as: Brk down, Break Down, breakdown, vehiclebreak down etc. Use of different abbreviations and text descriptions slows down the process of data processing and querying. Also, there is no standardization about the classification of incidents across the Districts. Similarly, the location of the incidents is described based on the nearest interchange which again had different text descriptions for the incidents occurring at the same location. Noting the incidents based on the mile point, makes location more precise and easy to locate or geocode. The incident time and duration information is absent in some Districts. In that case the duration values for these districts had to be assumed as an average of other districts. This can have some impact on the benefit-cost ratio estimation process. Duration of incident is an important value in delay calculations. All incident logs provide information only about the time of arrival at the scene of incident and departing time. The difference of these two times is the clearance time of the incident during which the Road Rangers were present and not the total duration of the incident. Also lots of data entries regarding the time were found to be absurd and incorrect. During data analysis a large number of incidents with zero and negative durations were detected. It is necessary to have consistent and error free data for effective evaluation and analysis.

CHAPTER 5

INCIDENT DATA ANALYSIS

5.1 Incident Frequency and Characteristics

The incident data were obtained from reviewing Road Ranger logs in each district. The incident data formats are different in different districts. Since some districts have different service period, incident rate was defined as the average number of incidents served or assisted per hour of the service period. Incident rates do not represent the actual number of incidents occurring. This is because the entire incident data is extracted from the Road Ranger logs, which implies the data only include the incidents that have been assisted by the Road Rangers during the service period. Table 5.1 shows the number of incident and incident rates in each district per month.

Table 5.1 Number of Incident and Incident Rates in Each District

District	Service Period (Hours per day)	Coverage Area (miles)	No. of Incidents Per Month	Incident Rate (Incidents Per Service Hour)
2	14	102	1103	2.5
4	24	111	3638	4.9
5	24	74.5	2704	3.6
6	24	85	7273	9.8
7	24	34.5	2573	3.5
Turnpike	8	332	4468	18.0
Florida	20	739	21759	7.1

Table 5.2 shows the percentage of incidents by type in various districts and the Turnpike. It is noted that approximately 81% of all the incidents are the breakdown type incidents. Flat tires are the most frequently occurring incident (average 23% of all incidents) in the

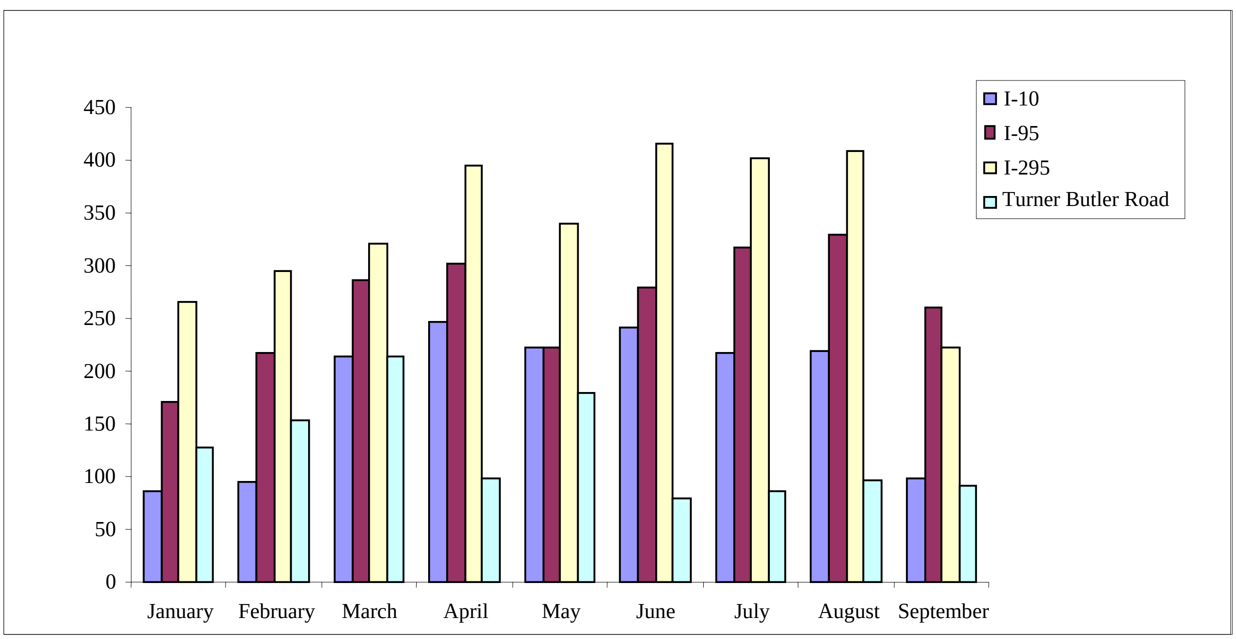
breakdown category. Accidents and debris account for a very small portion of the total incidents.

Table 5.2 Percentage Distribution of Incidents by Type in Various Districts

Percentage Distribution of Incidents by Type in Various Districts and Turnpike												
	Breakdown											
District	Flat Tire	Fuel	Cell Phone	Jump Start	Minor Repairs	Over heat	Abandoned	Tow to Shoulder	Call Wrecker	Break-down	Accident	Debris
2	32	17	1	5	8	N/A	21	6	N/A	91	4	4
4	34	12	2	4	7	7	14	4	N/A	85	8	7
5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6	21	10	4	4	7	8	25	5	N/A	84	13	4
7	28	11	4	4	6	7	26	5	N/A	91	9	0
Turn-pike	15	8	0	2	10	N/A	17	0	6	59	6	35
Average Florida	23	10	3	6	9	5	19	4	1	81	9	10

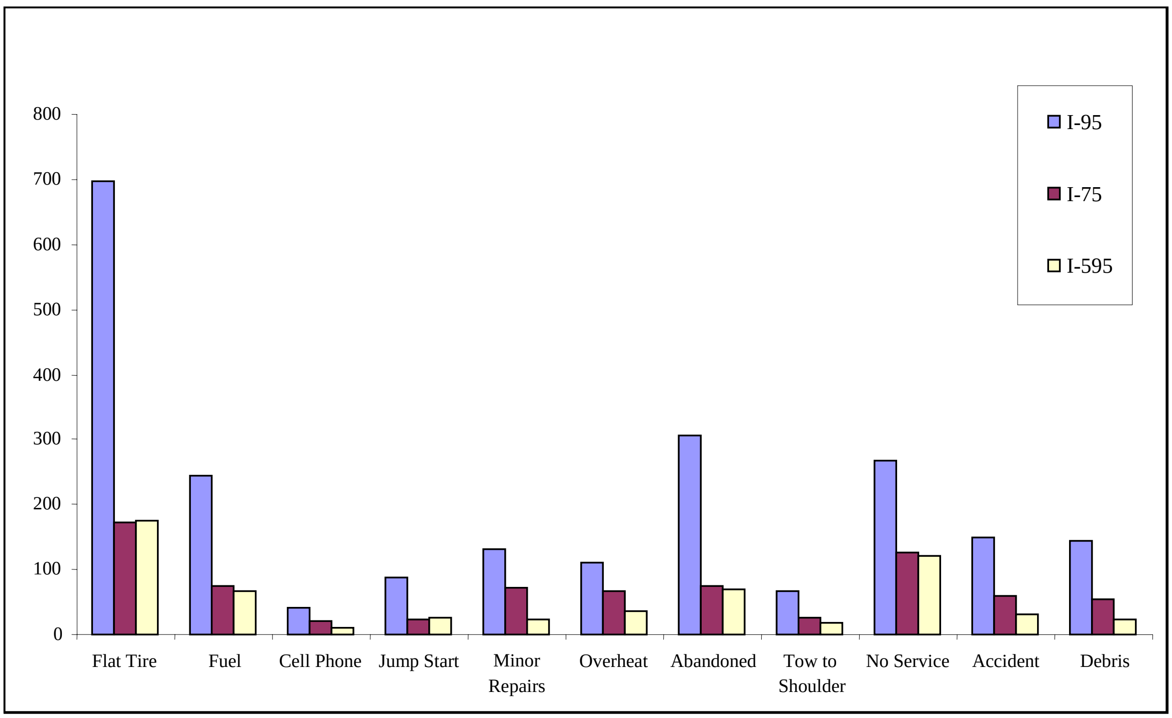
The District 2 Road Ranger program is not a 24 hour service and is operational on 4 highways, I-95, I-10, I-295 and the Turner Butler road. The hours of operation are 5:30 AM through 7:30 PM. All the incident data is taken from Road Ranger logs and hence the records show the incidents occurring during the 14 hour period of service and for 9 months (Jan-Sep). All the incidents reported in the logs are classified into the following 9 main categories: - accident, debris, cell phone, jump start, tow-transport, minor repairs, fuel, abandoned and flat tires. The Road Ranger logs contained information about the break (restroom or fuel) taken by the driver and about weather related delays. All those cases were deleted for the present analysis as they don't contribute to any benefit. As the FSPE model recognizes only 3 main types of incidents i.e. accident, debris and breakdowns, all the categories namely, flat tires, fuel, minor repairs, tow-transport etc. were clubbed together as break downs for the purpose of calculating the benefit-cost ratio. It was found that during most months I-295 recorded the maximum number of incidents about 340 incidents per month, which makes it almost 24 assists every hour. Interestingly, I-295 has low AADT volumes compared to other roads but has the highest incident rate. This might also be due to the fact that I-295 has the highest coverage (34.35 miles) followed by I-95 (31.76 miles), I-10 (20.33 miles) and the Turner Butler (12.31 miles). The monthly distribution of incidents in District 2 are shown in figure 5.1. For all interstates (I-95, I-295 and I-10) the incident rate is higher during the summer months (April-August). The number of incidents for January, February and September are considerably low compared to other months. It was also found that May recorded less incidents when compared to other summer months. However on Turner Butler the number of incidents remained same throughout the study period (Jan-Sep) with an average of 103 incidents each month except for March and May where number of incidents bumped up. Of all the incidents during a 9 month period in District 2, flat tires are the most frequent ones. Almost 22-35 % of all the incidents are flat tires. Flat tire, fuel and abandoned vehicles alone comprise of about 60-70 % of the total incidents across all the months and on all the roads in District 2. Accidents and debris, though low in number cause more delay and capacity reduction. Also, the probability of an accident or debris blocking a lane is higher than that for breakdown type of incidents.

Figure 5.1 Monthly Distribution of Incidents in District 2



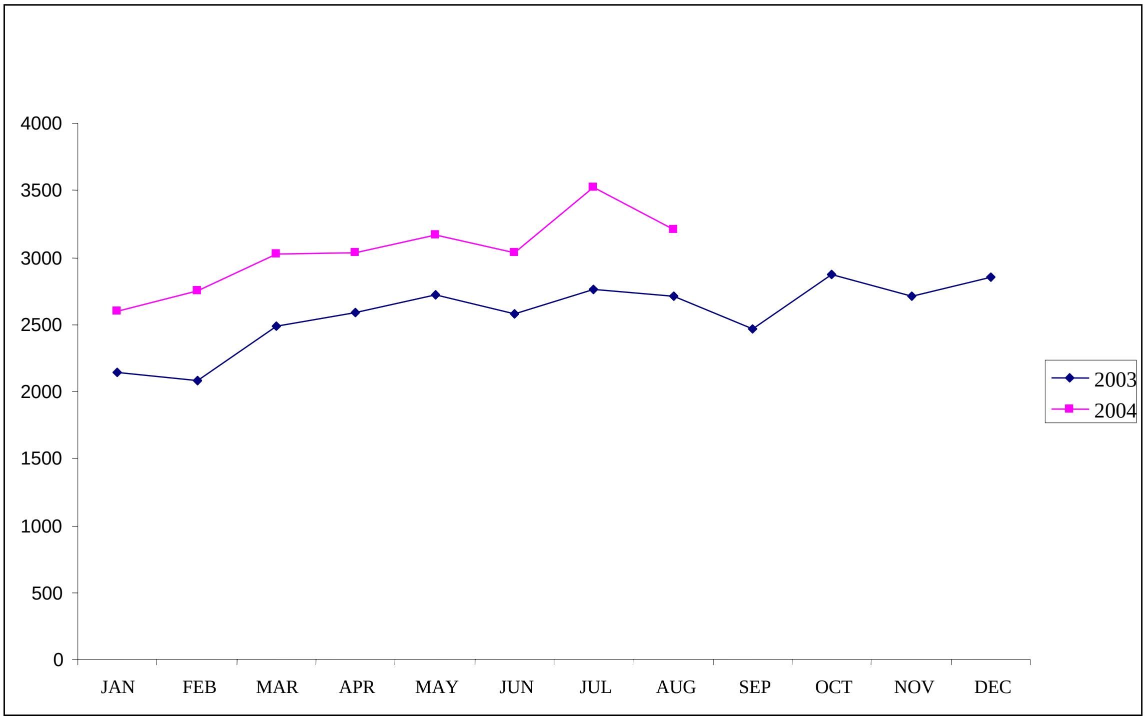
The Road Ranger program in District 4 operates on I-95 (Broward County and Palm Beach County), I-75 and I-595. Data taken from Road Ranger logs reported a total of 3615 incidents. Out of the total 3615 reported incidents, 2248 happened on I-95. Service on I-95 is almost 68 miles long and has high traffic volumes and therefore accounts for most incidents in District 4. Flat tire is the most frequent type of incident followed by fuel (see figure 5.2). On I-95 alone, about 700 flat tire incidents occurred during a single month. I-75 and I-595 have almost the same number of reported incidents of different types with most incidents of the flat tire and fuel type. On I-95 flat tire, fuel and abandoned vehicles cover about 63% of the total incidents. Each freeway had about 8% accidents and almost the same percentage of debris. It is observed that flat tire and fuel type incidents are more common than any other kind of incident.

Figure 5.2 Number of Incidents by Type in District 4



The data from District 5 records contain only the number of stops for each month. For 2004, the data is available only for months January through August. There is no information regarding the type of incident or duration. The only information provided is the total number of stops by month. In 2003, the Road Ranger service made a total of 30,965 stops and already about 24,338 stops from January to August in 2004. Monthly distribution of total incidents in District 5 are shown in figure 5.3. The analysis for B-C ratio requires incident types and their duration. For district 5, due to unavailability of data these values were assumed. The percentage of breakdowns, debris and accidents were assumed to be 86, 6 and 8% respectively. The incident durations used for estimating benefits are the average incident durations from the other districts.

Figure 5.3 Monthly Distribution of Incident Number in District 5



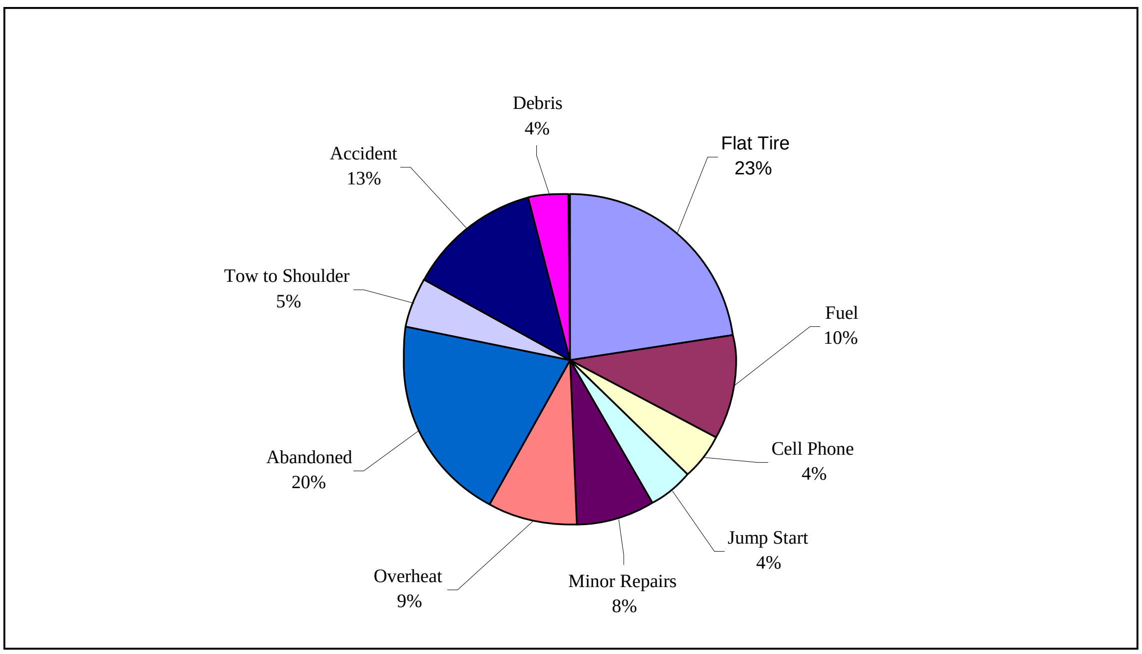
District 6 Road Ranger logs provide complete information about the incidents on 10 service freeways for one year. The Road Ranger logs provided the complete incident information on all the patrolled freeways along with the lateral location of each incident. District 6 reported about 96,000 incidents for year 2004. After removing incomplete data and double counted incidents, a total of 88,114 incidents were analyzed in this study. The Road Ranger service in District 6 is a 24 hour service and covers about 89 miles. Table 5.3 shows incident rates on different freeways. Incident rates have been expressed as the

number of incidents per hour. It can be seen that I-95, SR 836 and SR 826 have the highest incident numbers and corresponding rates. This is because these freeways have high coverage miles and they experience very high traffic volumes. Incident analysis shows that 46% of the incidents attended by the Road Ranger program were flat tire and abandoned vehicles. The percentage of accidents in District 6 was high compared to other districts. Accidents were 13% of the total incidents. Breakdown type incidents form the highest percentage. Almost 83% of the incidents were breakdowns. Figure 5.4 shows the distribution of various incidents by their type in District 6.

Table 5.3 Incident Rates on the Freeways in District 6

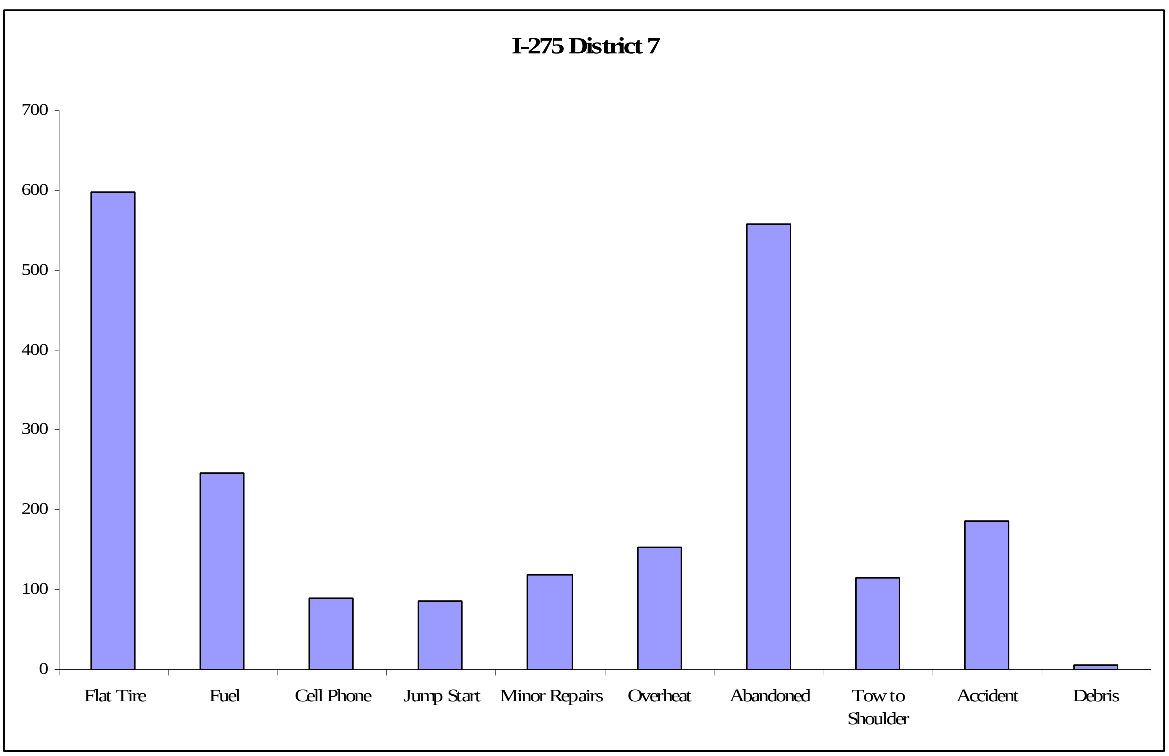
Freeway	Study Period	Service Period (Hours per day)	Coverage Area (miles)	No. of Incidents	Incident Rate (No. of incidents per hour)
I-75	1 year	24	6.978	4927	0.56
I-95	1 year	24	17.26	18667	2.13
I-395	1 year	24	4.27	1439	0.16
I-195	1 year	24	4.341	1661	0.19
SR 836	1 year	24	11.952	12067	1.37
SR 112	1 year	24	4.112	3839	0.44
SR 878	1 year	24	3.118	1203	0.14
SR 826	1 year	24	24.19	31882	3.63
SR 924	1 year	24	5.378	3310	0.38
SR 874	1 year	24	6.949	9119	1.04
District 6	1 year	24	89	88114	10.03

Figure 5.4 Percentage Distribution of Incidents by Type in District 6



The Road Ranger program in District 7 is a 24 hour service and is operational on I-275, I-4 and SR-60. However, due to data unavailability, only one stretch of I-275 was analyzed for the month of August. All the data was taken from Road Ranger logs and was in MS-Access format. There were many incidents that were double counted e.g. an incident marked as fuel and flat tire, accident and minor repair or accident and debris. All such double counted incidents were removed and assigned to either accident or debris with priority to accident. Since most accidents involved debris removal, most of them were counted and assigned as accidents only. The incidents which said "no service" were completely removed as these are the cases where Road Ranger patrols didn't provide any benefit/help. It was found that on I-275 almost 53 % of the incidents attended by the Road Ranger patrols were flat tires and abandoned vehicles. Debris had a very low percentage (about 0.23 %). Interestingly, the number of accidents is quite high on I-275 with almost 186 accidents occurring during the 1 month period. All other breakdown type incidents are very low in number varying between 9-13 %. Figure 5.5 shows the number of incidents by each type on I-275.

Figure 5.5 Number of Incidents by Type on I-275 in District 7



Road Rangers cover the entire Turnpike mainline (mile point 0 to 309), Turnpike Golden Glades Spur (mile point 0X to 4X) and Sawgrass Expressway. However, service operates only during the peak hours during 6 to 10 in the morning and 4 to 8 in the evening. The entire region is divided into 14 patrol zones with one truck assigned to each zone. The zones 1 to 7 lie in southern zone and 8 to 14 in northern zone. The data is available for North and South zones; however zone wise data is not available. However, since each zone varies with respect to AADT volumes and number of lanes the benefit-cost ratio is calculated for each zone separately. Since zone wise data is not available, so the number of incidents is distributed to each zone according to the VMT traveled in that zone. The VMT in each zone was determined by multiplying AADT into segment length. The data classifies incidents into 11 different categories: - accident, abandoned vehicle, dead/injured animals, large debris, small debris, fuel, flat tire, jump start, minor repairs, car wrecker and no assistance. All “no assistance” type incidents are deleted and dead animal, small and large debris are grouped together as debris. The 8 hour daily Road Ranger service attended almost 59,622 incidents through out the year. Surprisingly, unlike other districts, for the turnpike region, debris is the most frequent incident type. Debris account for almost 35% of the total incidents. Flat tire and abandoned vehicles are next most occurring incidents (see figure 5.6). January and February have low incident rates compared to the other months while November has the highest incident rate (see figure 5.7).

Figure 5.6 Number of Incidents by Type in Turnpike Region

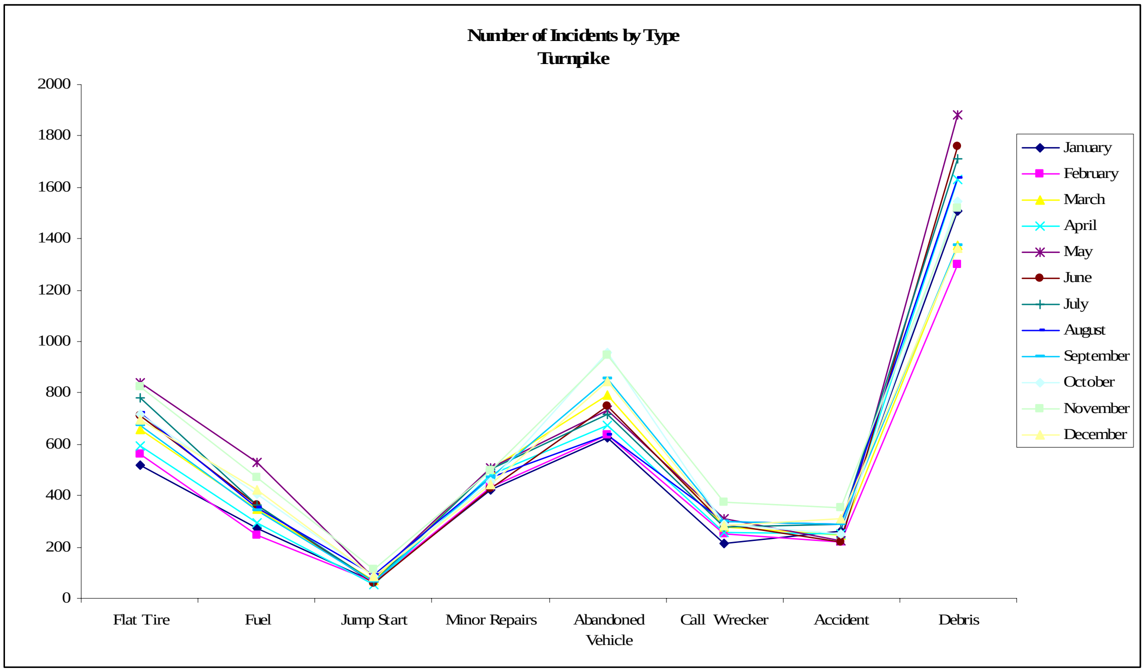
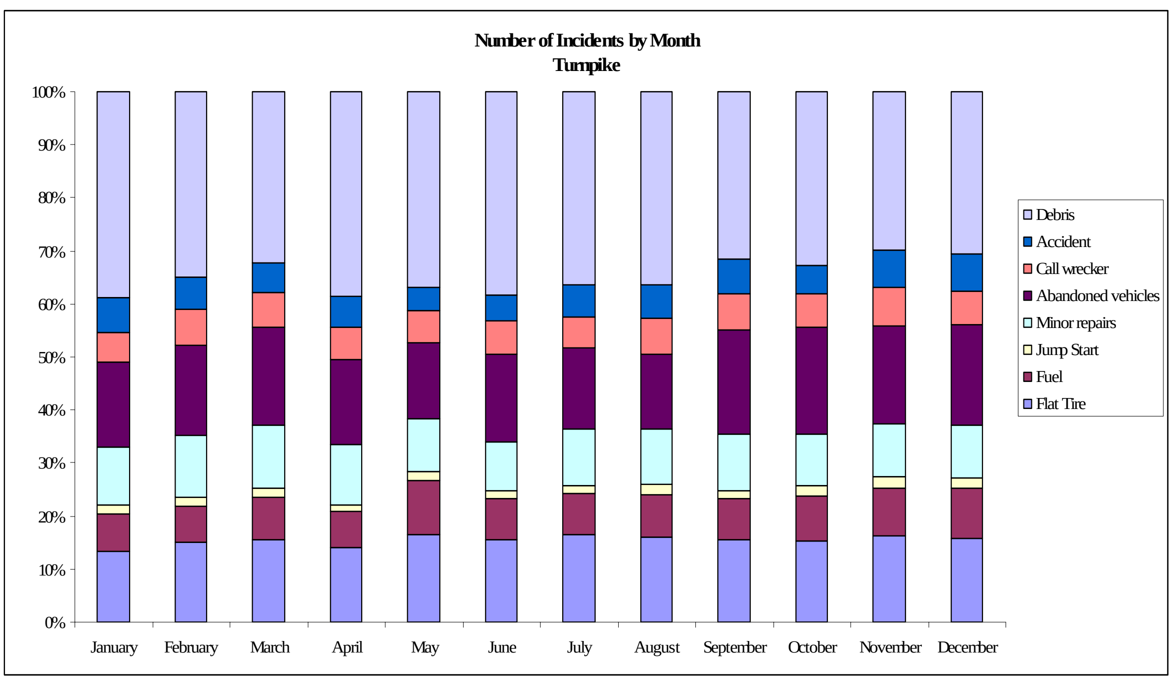


Figure 5.7 Monthly Distribution of Incidents on Turnpike



5.2 Incident Duration

The total incident duration includes the incident clearance time and response time. The incident clearance time is calculated as the difference between the Road Ranger truck arrival time and the time it leaves the incident scene. The response time is calculated as the difference between the time the incident happened and the Road Ranger arrival time. The average response time is computed by the FSPE model using the beat length, average truck speed and number of patrol trucks. Table 5.4 shows the incident duration by type of incident in each district. It should be noted that the incident duration here does not include response time. It is the difference in time from when Road Ranger service arrives at the scene of an incident and the time when the incident is cleared. It is found that flat tire, jump start, minor repairs, and tow to shoulder have a duration of about 20 minutes. Accidents averaged about 44 minutes for all of Florida. Breakdown type incidents have a duration of 14 minutes and debris averaged about 10 minutes.

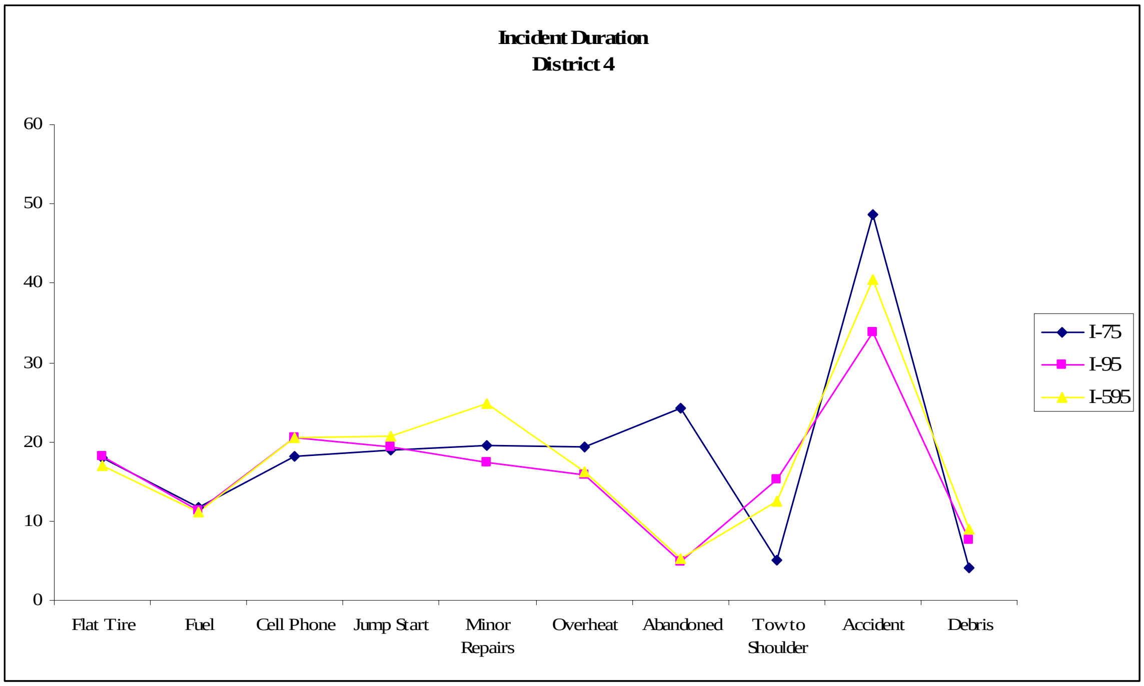
Table 5.4 Incident Duration by Type in Minutes in Each District

District	Breakdown									Break down	Accident	Debris
	Flat Tire	Fuel	Cell Phone	Jump Start	Minor Repairs	Overheat	Abandoned	Tow to Shoulder	Call Wrecker			
2	15	10	11	13	10	N/A	9	11	N/A	12	23	5
4	18	11	20	20	19	17	5	17	11	15	38	7
5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6	20	14	8	20	21	18	8	22	N/A	15	49	14
7	17	9	23	19	18	16	6	25	11	14	40	13
Turnpike	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Florida	19	13	9	19	20	18	8	20	11	14	44	10

In District 2, it was found that accidents had the highest duration with an average of 23 minutes. Among the breakdowns, flat tires had the maximum duration; and the occurrence of flat tire incidents is more frequent than any other type of incident. In this way flat tires are causing more delay than any other type of incident. Most other break-down type incidents have a duration around 10 minutes.

In District 4, it is observed that duration of incidents is almost the same irrespective of the incident type for the 3 freeways. Figure 5.8 shows the incident durations for three freeways in District 4. Accidents have a higher duration than other incidents. On average, an accident lasted for 48, 33 and 40 minutes on I-75, I-95 and I-595, respectively. Fuel and debris have lesser durations of about 11 and 6 minutes. All other break-down type incidents have a duration within the range of 16-20 minutes for all the 3 freeways.

Figure 5.8 Incident Duration in Minutes by Type of Incident in District 4



Since there is no incident duration data available for District 5, the incident durations used for estimating benefits are the average incident durations for all other districts. Durations for breakdown, debris, and accidents are assumed to be 14, 10 and 44 minutes respectively

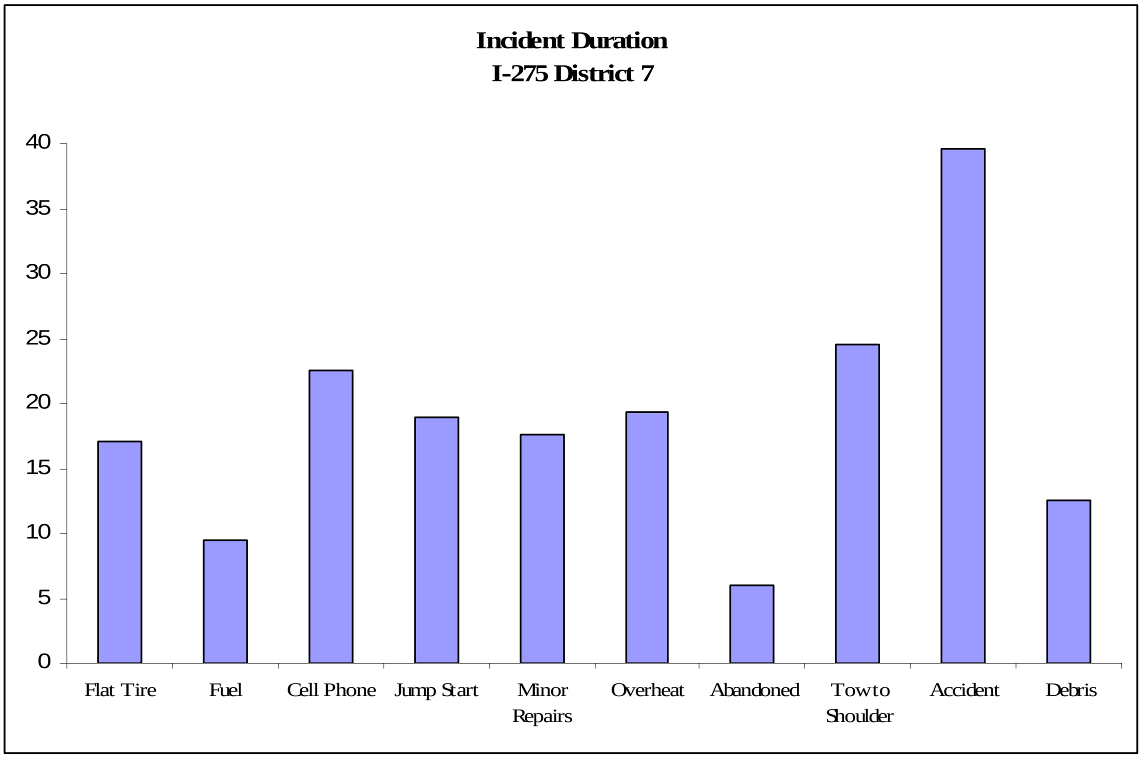
In District 6, flat tire, jump start, minor repairs and tow to shoulder have a duration of about 20 minutes. Cell phone and abandoned vehicles have a low duration of 8 minutes while accidents have the highest duration, 50 minutes. The detail of incident durations on each of the patrolled freeway is shown in table 5.5.

Table 5.5 Average Duration in Minutes by Type of Incident in District 6

Freeway	Flat Tire	Fuel	Cell Phone	Jump Start	Minor Repairs	Overheat	Abandoned	Tow to Shoulder	Accident	Debris
I-75	19	21	24	19	21	21	14	25	34	12
I-95	24	19	23	25	27	23	9	26	53	15
I-395	20	22	7	21	26	19	22	20	57	10
I-195	18	18	11	24	22	20	11	26	59	19
SR 836	27	20	19	27	25	25	16	25	46	12
SR 112	30	21	21	30	29	29	24	29	63	12
SR 878	23	17	9	33	32	27	19	21	57	15
SR 826	22	20	21	23	23	23	20	25	48	19
SR 924	24	21	15	26	29	27	15	26	55	8
SR 874	26	21	18	27	30	27	14	22	55	8
District 6	24	20	19	25	26	24	16	25	50	15

In District 7, accidents have the maximum average duration of 40 minutes followed by tow to shoulder type incidents (average 24 minutes). Except for fuel and abandoned vehicles, all other breakdown type incidents had an average duration between 17-19 minutes. Fuel and abandoned vehicles have a low average duration of 9 and 6 minutes respectively. Figure 5.9 shows the average incident durations on I-275.

Figure 5.9 Incident Durations in Minutes on I-275 in District 7



The Road Ranger logs for the Turnpike don't have any information about the duration of incidents. Hence, for the analysis and calculation of benefit-cost ratio, the average duration in other districts was used as the incident duration for the Turnpike Enterprise.

5.3 Lateral Distribution of Incidents

Lateral distribution of incident refers to the location of the incident on the road i.e. on lane or shoulder (left or right). This information is important to determine the loss in freeway capacity. Different incident types have different tendencies to occur along the road width. An accident would be more likely to block one or more lanes as compared to a flat tire (breakdown) type incident which is more likely to occur on the shoulder. While estimating B-C ratio for the Florida Road Ranger program, it was found that logs maintained by the contractors did not contain sufficient information related to the lateral distribution of the incidents in most of districts. Hence, a suitable assumption based on the past studies had to be made to evaluate the benefits of the program. Only District 6 logs maintained information about the lateral position of the incident attended. Table 5.6

shows the percentage of incidents of each type according to their position along the road width. All values are in percentage and the all the freeways are in District 6. Also shown in the table is the percentage that was assumed for the present study. According to the HCM, the capacity reduction in case of an incident is same for left and right shoulder.

Table 5.6 Lateral Distribution (%) of Incidents in District 6

	I-95	I-395	I-195	SR 836	SR 112	SR 878	SR 826	SR 924	SR 874	District 6	Assumption for other districts
Accident											
Right Shoulder	43.24	45.64	45.89	51.20	27.64	34.67	74.57	35.48	30.48	58.74	55.90
Left Shoulder	26.32	10.76	20.54	20.09	7.72	22.67	19.03	17.42	21.57	20.52	9.40
Lane	30.44	43.60	33.57	28.70	64.63	42.67	6.40	47.10	47.95	20.74	34.60
Breakdown											
Right Shoulder	80.12	80.66	86.42	73.21	51.04	46.34	85.70	53.34	48.98	74.43	89.60
Left Shoulder	14.76	7.55	3.96	9.54	6.50	12.89	13.05	6.21	14.02	12.18	5.30
Lane	5.12	11.79	9.62	17.25	42.46	40.78	1.25	40.45	37.00	13.39	5.00
Debris											
Right Shoulder	27.36	17.70	6.75	32.19	23.17	11.00	74.63	27.61	16.57	43.15	14.20
Left Shoulder	4.56	50.00	10.81	14.17	5.69	9.00	1.28	5.22	5.43	6.22	3.30
Lane	68.08	32.30	82.44	53.64	71.14	80.00	24.09	67.16	78.00	50.63	82.40

CHAPTER 6
BENEFIT AND COST ANALYSIS

The benefits of the Road Ranger Program include reduced vehicular delays and fuel savings to the motorists because of the reduction in the incident delay and fuel consumption, and the reduction in the vehicular emissions. Apart from these visible benefits, a freeway service patrol reduces the number of potential secondary crashes by quickly removing and clearing incidents. It also benefits the road users by reducing mental agony and anxiety. However, these benefits are difficult quantify. For the present study, only vehicular delay, fuel and emission savings have been included.

6.1 Delay and Fuel Savings

Delay and fuel savings by the Road Ranger service were calculated by the FSPE model described previously. The model was calibrated for each district by inputting traffic profile, incident data, traffic volumes, and beat information. As mentioned earlier, the travel time value has been estimated at $22.71 and fuel price at $1.96. The study also estimates savings in three types of emissions, nitrogen oxides (NOX), carbon monoxide (CO) and reactive organic gases (ROG). However, due to difficulty in assigning a dollar value to the pollution, they have not been included in the final benefit-cost ratio. The monthly delay and fuel savings for each district are summarized in Table 6.1. I-75 has B-C ratio less than 1 as incident occurrence and traffic volumes are low compared to the capacities. SR 924 for District 6 is not included in the table as it showed 0 benefits for similar reasons. However, in computing the overall B-C ratio for entire District 6 the cost of operation on SR 924 was included.

Table 6.1 Benefit-Cost Ratio of Road Ranger Program in Each District

District 2	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
I-10	2,916	66,212	3,599	7,054	74,831	13,665	6
I-295	683	15,518	1,031	2,020	17,538	27,330	1
I-95	2,628	59,677	3,963	7,768	67,444	27,330	3
Turner Butler Road	1,163	26,402	1,753	3,436	29,838	13,665	2
Total	7,389	167,809	10,346	20,278	189,651	81,990	2
District 4	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
I-75	16,522	375,215	24,922	48,847	424,062	90,036	5
I-595	18,260	414,685	27,544	53,986	468,671	90,036	5
I-95	239,809	5,446,062	361,734	708,999	6,155,061	150,060	41
Total	274,591	6,235,962	414,200	811,832	7,047,794	330,132	21
District 5	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
I-4	29,947	680,105	45,173	88,540	768,645	60,375	13
District 6	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
I-75	115	2,610	173	340	2,950	25,550	0
I-95	224,574	5,100,073	338,754	663,958	5,764,032	77,390	75
I-395	8,970	203,704	13,530	26,519	230,223	17,155	13
I-195	2,503	56,845	3,776	7,400	64,246	17,155	4
SR 836	296,902	6,742,648	447,856	877,799	7,620,447	52,025	147
SR 112	6,751	153,319	10,184	19,960	173,279	35,950	5
SR 878	20,216	459,096	30,494	59,768	518,864	23,325	22
SR 826	87,594	1,989,267	132,130	258,975	2,248,242	127,750	18
SR 874	57,378	1,303,045	86,550	169,638	1,472,683	35,960	41
Total	705,003	16,010,608	1,063,448	2,084,357	18,094,965	435,584	42
District 7	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
I-275	80,051	1,817,958	120,751	236,672	2,054,630	117,400	18
Turnpike	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
Northern Zone	13,299	302,028	20,058	39,313	341,341	53,802	6
Southern Zone	28,589	649,245	43,088	84,453	733,698	53,802	14
Overall Turnpike	41,888	951,273	63,146	123,766	1,075,039	107,604	10
FLORIDA	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
	1,138,869	25,863,715	1,717,064	3,365,445	29,230,724	1,133,085	26

6.2 Costs

The costs of the Road Ranger service are different in each District. The monthly costs of the Road Ranger program in each district are listed in Table 6.1.

6.3 Benefit and Cost Ratio

A measure of the Road Ranger program cost-effectiveness was estimated by calculating the benefit/cost ratio based on the monthly delay and fuel benefits to the motorists. The value of time for estimating the delay savings was taken as $22.71 per hour assuming average vehicle occupancy of 1.5 and percentage of trucks in total traffic as 5%. The cost of fuel was taken as $1.96 per gallon for the year 2004. The monthly benefit/cost ratios for five districts and Florida Turnpike are summarized in Table 6.1.

As shown in Table 6.1, the overall benefit/cost ratio for the whole Florida Road Ranger program is 25.8:1. The range of benefit/cost ratios for each district varies from 2.3:1 to 41.5:1. The average benefit and cost ratio of entire Road Rangers program is approximately 26:1.

Two freeways (I-75 and SR 924 in District 6) show a benefit/cost ratio less than 1. The possible reason is low incident rates and low traffic volumes on these highways as compared to their capacities. When v/c is very small, the FSPE model will not be able to estimate delay and fuel savings.

The Turnpike is divided into total of 14 zones (named 1 through 14). The zones 1-7 lie in southern region and 8-14 in the northern region. The evaluation results from the model output showed no benefits in zones 9, 10, 11 and 14 for the Turnpike District. The reason that these four zones show no benefit is that traffic volumes on these zones are considerably low compared to their capacities. It was found that in the above zones the maximum volume/capacity (v/c) ratio was below 0.3. When the v/c ratio is very small, the FSPE model will not estimate delay and fuel savings. Although there is no benefit of the program in 4 of the 14 zones, overall the benefits exceed the total cost of the Road Ranger program in the Turnpike with a B/C ratio of almost 10.

Appendix C contains the additional detail regarding the benefit-cost ratio on each freeway segment in each district. The savings in vehicle emissions are included in Appendix D.

CHAPTER 7
SENSITIVITY ANALYSIS

7.1 Introduction

Sensitivity Analysis is the study of how the output changes with change or variation in the conditions that effect the output. There are many situations when a system needs to be studied in terms of how the various inputs into the model change the model output. Example of these systems include simulation models used to forecast weather, traffic flow models, traffic delay models, chemical reactions, etc. These models are built to simulate or mimic reality. Many of these models are theoretical in nature, consisting of a series of equations, input factors and parameters to describe a certain process. The aim of these models is to approximate the real life processes. Sensitivity Analysis is closely tied to uncertainty analysis, which determines to find the uncertainty in output by using the variation in the input variables. The basic intent of conducting all sensitivity analysis is to determine: the factors that mostly contribute to the output variability, region in the space of input factors for which the model output variation is maximum, the optimal regions, the model parameters that are insignificant and can be eliminated from the final model, etc. In the present benefit-cost ratio study of the Road Rangers Program, a delay model is used to estimate the delay savings due to the freeway service patrol program. The model uses various input parameters and set of complex mathematical equations to find the delay savings. As the model has been developed as a computer software using Visual Basic Applications (VBA), it becomes difficult to find the effect of various input variables on the model output. It is impossible to do all calculations and observe the effects of change in input variables on the output. Therefore, to know this effect a sensitivity analysis is conducted. Broadly, all methods of sensitivity analysis can be classified into two categories: local analysis and global analysis. Local analysis concentrates on measuring the local impact of the factors or input variables. Global methods describe sensitivities over a whole area of interest. They need more observations and more complex sampling design. Sensitivity in one variable at a time is usually called a one at a time (OAT) method. This method cannot give information about the interactions in the prediction variables. Local methods have simple procedures and an easy sample design which does not demand much observations. In this study OAT method is used to know the trend in the output on affecting the input variables. A more general attempt has been made in the present study to know how the various input factors affect the delay estimation. Delay savings (and hence Benefit-Cost ratio) estimated by the FSPE model is mainly affected by the following input factors: Average Annual Daily Traffic Volumes (AADT), mean response time to incidents without Road Ranger service, frequency of incidents on the segment, capacity of segment, number of service trucks, Segment length etc. There are other factors such as, incident durations, percent of incidents by type, directional AADT factors, traffic profiles and lateral distribution of incidents of each type that affect the incident related delays. But these parameters have been kept constant in evaluating the sensitivity as their effect is significantly less. In this study the Florida wide average values have been used for these set of parameters as discussed earlier in the section. The input factors and how they influence the output are discussed in the following sections.

7.2 Mean Response Time Without Road Ranger Service

Response time is the time in minutes that is required for the emergency vehicles to reach and respond to the incident. It is the time elapsed between the occurrence of the incident and the time at which the response vehicle reaches the incident scene. This is an important variable as the difference between the response times with and without Road Ranger service directly affects the amount of delay savings and hence Road Ranger benefits. This study used the average response time without Road Rangers Service to be 30 minutes. The response time with the service is computed using number of trucks, segment length, truck speeds, etc. To perform the sensitivity analysis for mean response time 2 sections of 5 mile and 15 mile were considered. Both sections are 6 lanes wide with an average AADT of 150000. Mean response time without the Road Rangers Service is varied between 25-35 minutes with an interval of 5 minutes, and B-C ratio is computed for the two segments. Also, for each segment B-C ratio is calculated separately for different number of patrolling trucks. Truck speeds have been kept constant at 30 mph. It is important to include the number of patrolling trucks and segment length as they would straightaway affect the time to detect and respond to the incidents. Figures 7.1 and 7.2 show the results for 5 mile and 15 mile segment respectively. The results are as expected i.e., there is an increase in B-C ratio with increase in response time without Road Rangers program. However, it can be seen that the for 5 mile section the B-C ratio is highest for 1 patrolling truck and for 15 mile section highest B-C ratio is for 3 patrolling trucks. This is because in 5 mile segment 3 trucks would not drastically bring down the response times. Though a slight decrease would be observed, but the cost of the program would also go up due to increased cost of 3 patrolling trucks. However on the 15 mile segment keeping 3 trucks would be more beneficial in terms of reducing the response times compared to a single truck on a 15 mile stretch. As the segment length is more, three trucks are more effective compared to single truck patrolling the long segment. In order to understand the general effect of mean response time without Road Rangers service, another analysis on a 10 mile section with two patrolling trucks was completed. The results are shown in figure 7.3. It is observed that the benefit-cost ratio increases considerably as the mean response time without Road Rangers is increased. This means the Road Ranger service has more benefit in areas where other services available are poor than the areas where the existing services are efficient or have lower mean response times.

Figure 7.1 Change in Benefit-Cost Ratio With Mean Response Time Without the Service on a 5 mile Section With Different Number of Service Trucks

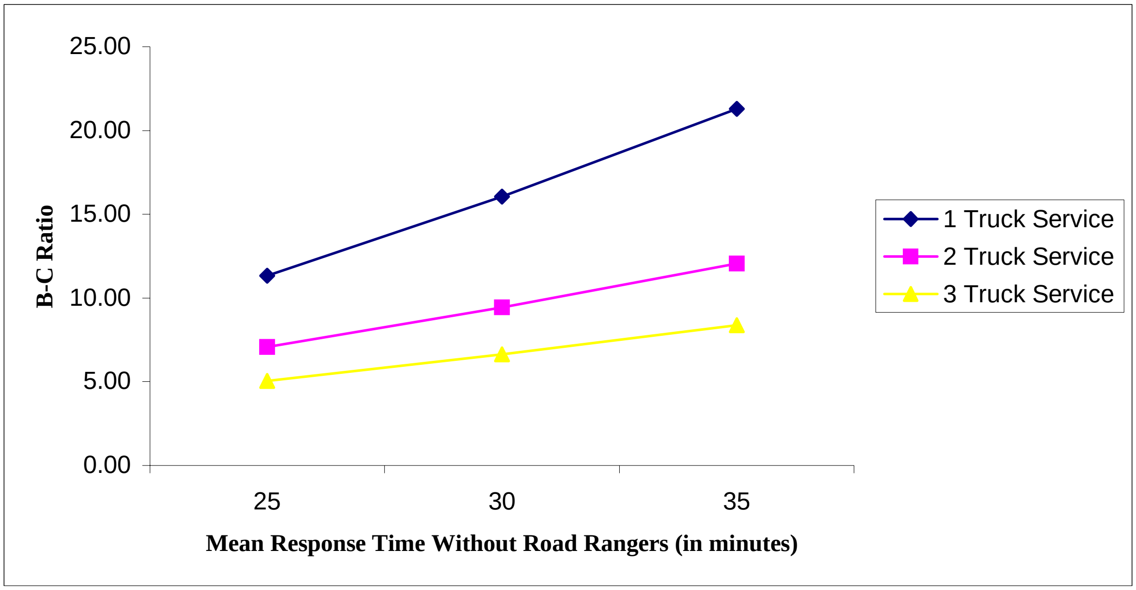


Figure 7.2 Change in Benefit-Cost Ratio With Mean Response Time Without the Service on a 15 mile Section With Different Number of Service Trucks

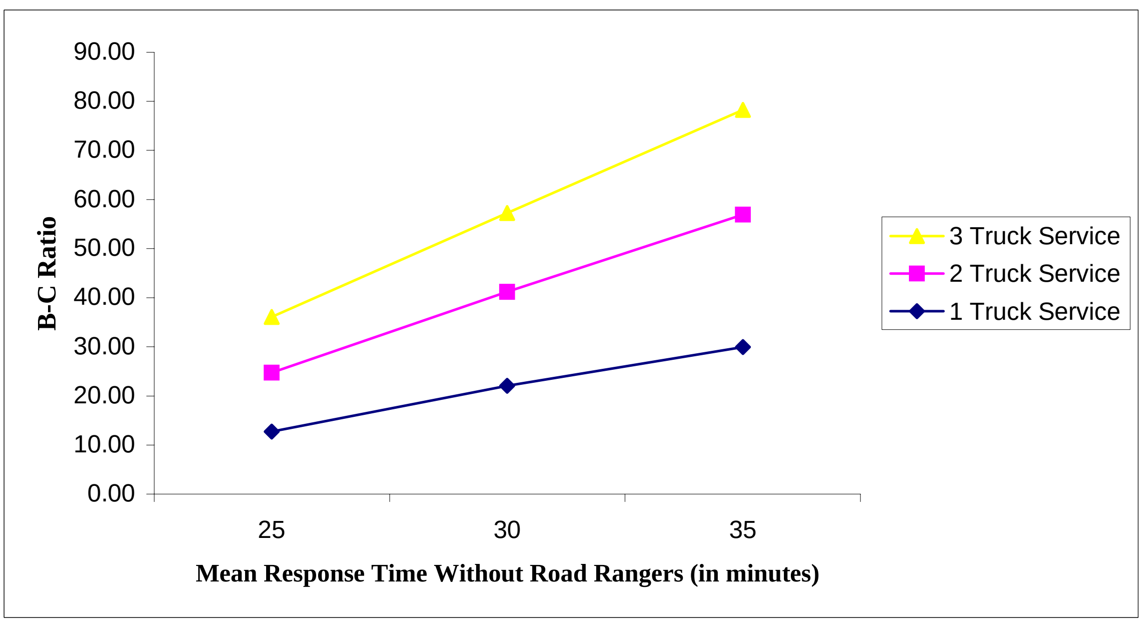
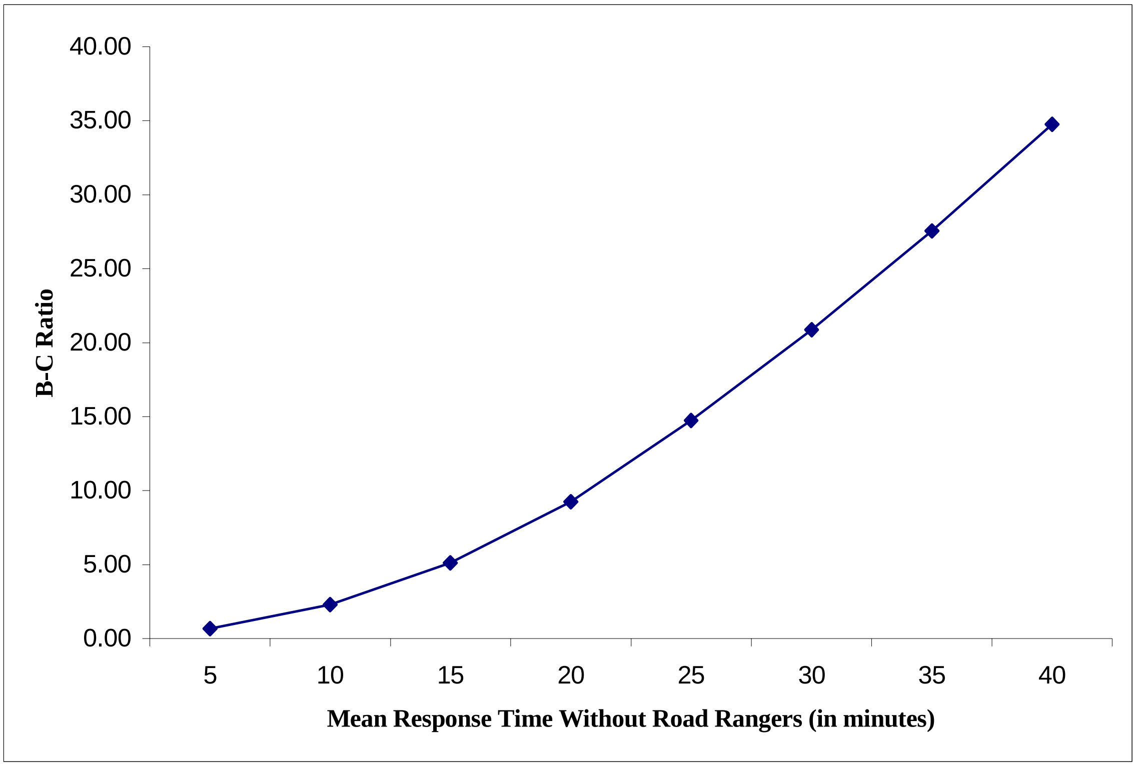


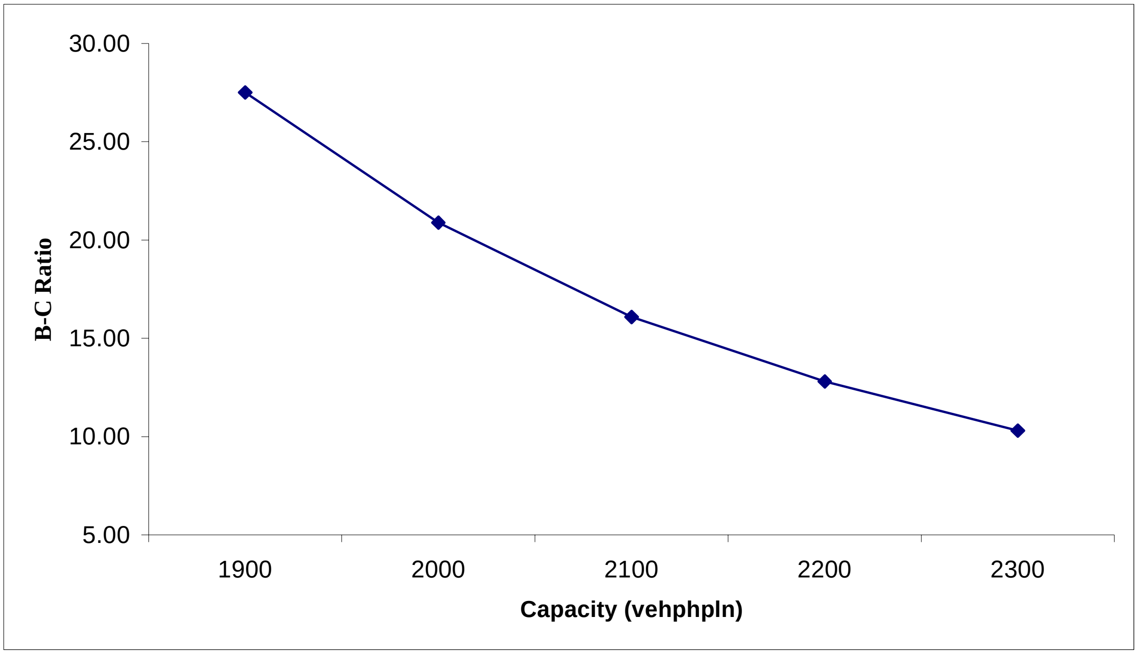
Figure 7.3 Change in Benefit-Cost Ratio With Mean Response Time Without the Service on a 10 mile Section With Two Service Trucks



7.3 Capacity

Capacity of the roadway is the maximum flow it can accommodate. Capacity is one of the parameters that has to be provided to the FSPE model for B-C ratio estimation. It is very exhaustive to go in the field and measure capacities of different roadway sections. Using past experience, capacity for the present study is assumed to be 2100 pcphpl. Volume-capacity ratio (V/C) would directly influence the benefit of the Road Rangers program. That means clearing an incident during the full capacity would save more on vehicular delays than assisting an incident during the non-peak hours. Freeways having high capacity (other characteristics remaining same) would give lesser benefit. To understand the sensitivity of B-C ratio to capacity, a 6 lane 10 mile segment with average AADT of 150,000 was chosen. B-C ratio on the segment was calculated by changing the capacity parameter only. Figure 7.4 shows the results. It is found that the B-C ratio drops down as the road capacity is increased. This is expected because each incident causes a specific reduction in capacity. If capacity of the road section is high, it implies that for the same incident patterns V/C ratios are lower for high capacity roads.

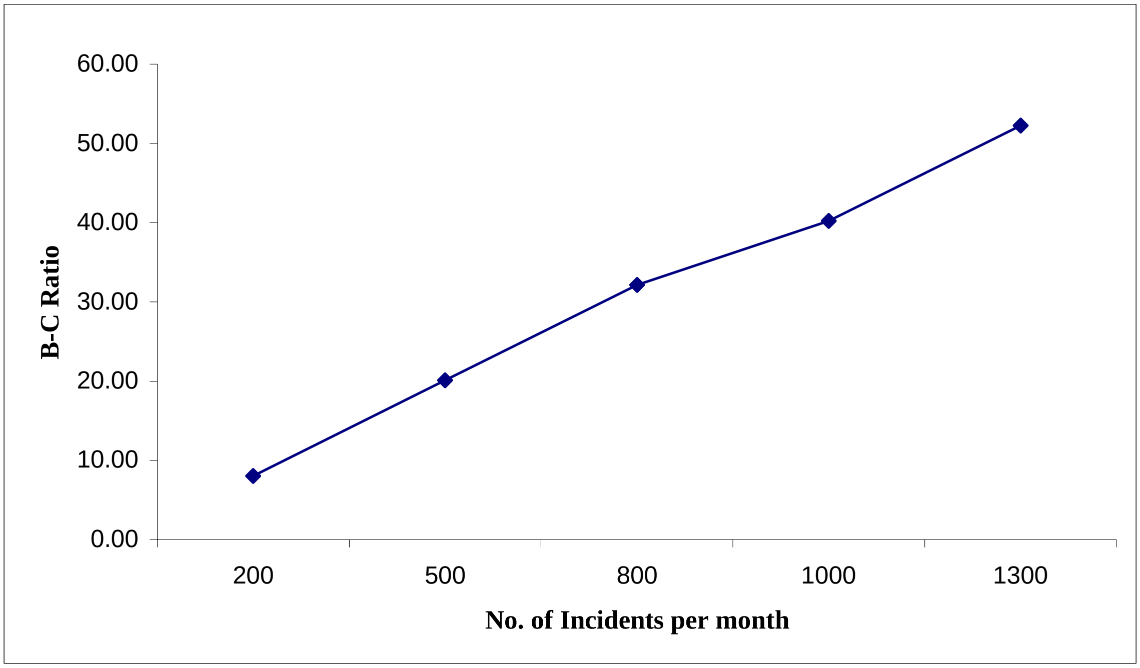
Figure 7.4 Change in Benefit-Cost Ratio With Freeway Capacity



7.4 Number of Incidents

Number of incidents should directly increase the benefits. During the study it was found that many road segments showed much less benefit because incident rates on those segments were low. In Florida the average incident rates for year 2004 were found to be about 30 incidents per mile per month. Road Rangers would have more benefit on freeways receiving more incidents. The results are shown in figure 7.5. The graph was plotted by running the model for a 10 mile, 6 lane freeway with AADT of 150,000. All the other parameters were kept constant and the number of incidents for a one month period were increased between 200 and 1300. The graph shows an increase in B-C ratio at almost a constant gradient.

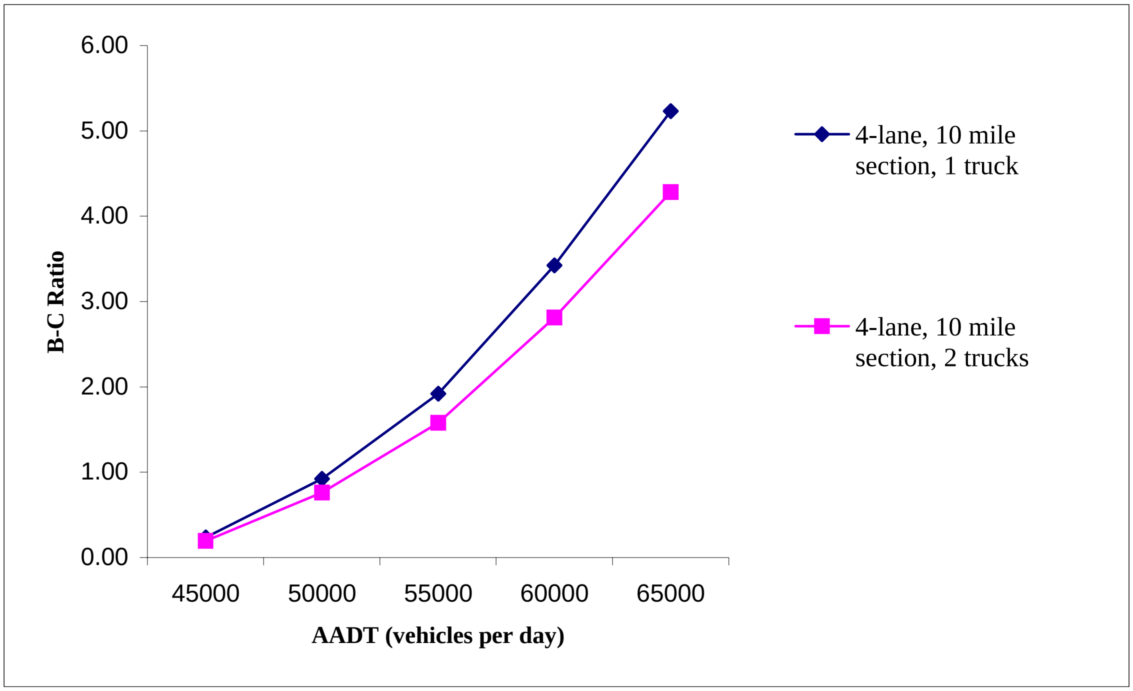
Figure 7.5 Change in Benefit-Cost Ratio With Number of Incidents Per Month on the Beat Segment



7.5 Average Annual Daily Traffic

The amount of traffic on the segment would determine the savings in vehicle hours. If the traffic on a segment is very low, then the reduced capacity of roadway could be sufficient for the flowing traffic to pass without causing much delays. In this case Road Rangers program would be less beneficial. Similarly, the program would be more effective during the peak hour compared to off peak hours. This way we can see that the B-C ratio for the program would be high in the areas with high traffic volumes. To test the sensitivity, the model was run for a 4-lane segment of 10 miles. Separate curves were plotted for 1 and 2 trucks. Figure 7.6 shows that increase in AADT keeping other variables constant, increased the B-C ratio. It can be seen that the rate of growth gets rapid on increase in AADT volumes.

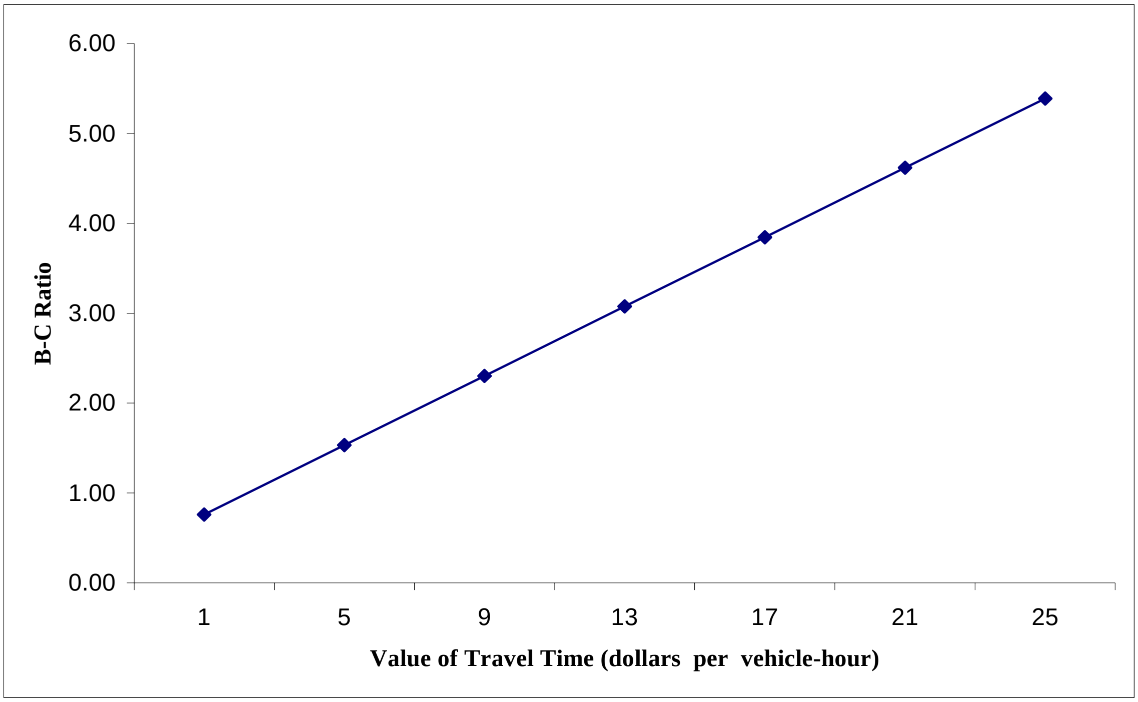
Figure 7.6 Change in Benefit-Cost Ratio With AADT Volumes



7.6 Value of Travel Time (Dollars Per Vehicle-hour)

The value of travel time for the present study for all delay quantifying purpose was used to be $22.71. Vehicular delay savings is the main component of the benefits of the Road Rangers program, hence value of travel time would be very critical in estimation of B-C ratio. High value of travel time value would estimate higher benefits and consequently higher B-C ratio study. As the main delay components are vehicle delay savings and fuel savings, therefore for a particular case if all other variables are kept constant and only travel time value is varied then a linear relationship between B-C ratio and travel time value would be seen as shown in figure 7.7. Here a 10 miles section with AADT of 150,000 and 500 incidents a month is considered.

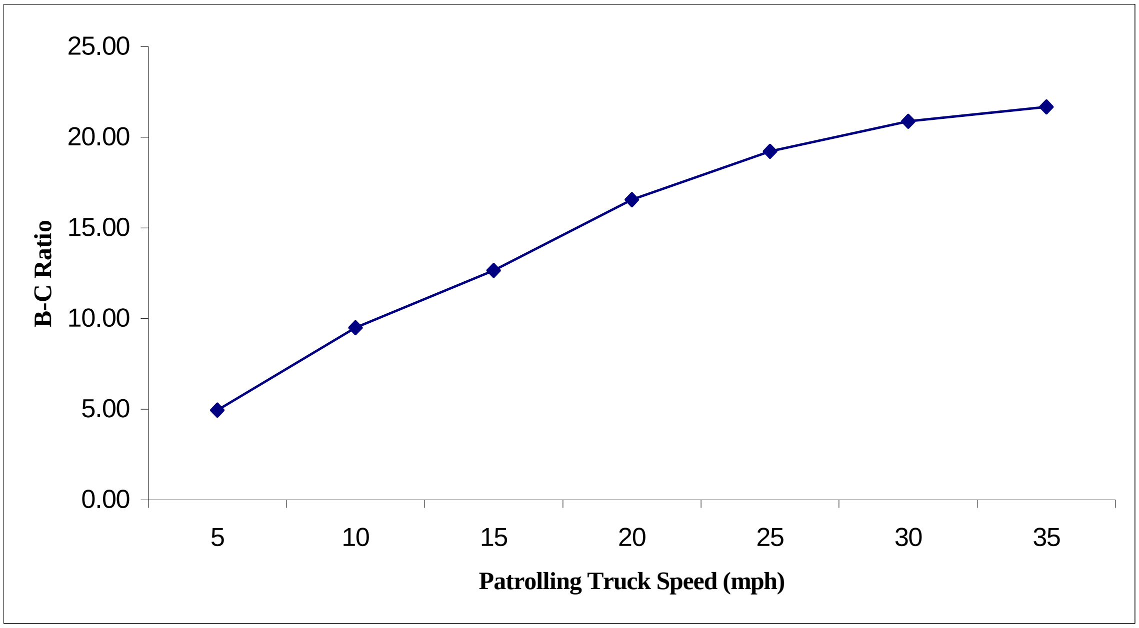
Figure 7.7 Change in Benefit-Cost Ratio With Value of Travel Time



7.7 Patrolling Truck Speed

The speed of patrolling truck is essential in determining the response time to the incidents. Higher truck speeds would reduce mean response time to incidents and consequently increase the benefits. Figure 7.8 shows the variation of B-C ratio with truck speed. As the truck speed is increased initially there is greater change in the benefit-cost ratio but the curve flattens out at the speed of about 30 mph. This means increasing further speed beyond 30 mph would not produce any significant increase in the benefits. As the truck speed is increased the response time to an incident, i.e. time required to detect and respond to the incident decreases. Consequently, the effective duration of the incident goes down and it is cleared off quickly. Therefore, the benefits of the program would also increase due to quick detection, response and removal of the incident.

Figure 7.8 Change in Benefit-Cost Ratio With Patrolling Truck Speed



7.8 Summary

The benefit-cost ratio of the Road Ranger program depends on variety of factors that include: beat characteristics and service characteristics. The beat characteristics include traffic conditions (AADT), length, number and type of incidents, number of lanes etc. Service characteristics include number of patrolling trucks, service period, speed of trucks, etc. The existing traffic volumes have greater impact on the benefits of the service than any other variable. If there is a Road Ranger service on a high traffic volume segment its service would be more useful than on a segment with low traffic volumes. This is because on high traffic volume segments even a small reduction in capacity due to incident can cause queue build up and traffic delays. However, in low traffic volume segments, the remaining capacity may be sufficient for traffic to go through. Similarly, as the capacity of the freeway is increased, the benefit is reduced considerably. The mean response time without Road Ranger service determines the impact that Road Rangers can make in quickly detecting and clearing incidents. Suppose, if the mean response time to incidents without Road Rangers service is not significantly different from the response time with the service, then presence of Road Ranger service would not give any benefit.

So, the areas with high response time without the Road Ranger service will have more benefit from such a service than the areas which are already having good response times without any Freeway Patrol service. Also, program would yield greater benefit on areas experiencing high incident rates.

CHAPTER 8
CONCLUSIONS

The purpose of this study was to evaluate the effectiveness of the Road Ranger program in Florida. Five FDOT Districts and Florida's Turnpike were selected for analysis due to the availability of Road Ranger data and activity logs. The FSPE model was calibrated for each district to estimate delays, fuel saving, and benefit/cost ratios.

Traffic incident data were collected from each district Road Ranger activity log. Incident data were collected for at least one month and as long as one year depending on the availability of electronic Road Ranger logs. Additional data including the traffic volumes, geometry and capacity information, traffic profile and the cost of the Road Ranger program in each district were also complied.

The findings from the analysis of incident data and benefits of the Road Ranger program are summarized below:

1. The Road Rangers have been found to assist over 7.1 incidents every hour in a given district. The number of per hour assists in the Turnpike area is about 18.31; showing the need for expansion of such an incident management program.

2. The type and duration of incidents vary from one district to another. In general it is found that the most frequent incident types occurring are breakdowns. Accidents and debris have a very small portion. However, in the Turnpike it is found that debris is almost 30 % of the incidents. In other districts, debris formed a very small percentage. Flat tire is the most frequent incident followed by fuel type incidents. In District 2, flat tires are about 22-35 % of all the incidents during different months. In the same district flat tire, fuel and abandoned vehicles make up almost 65% of the total incidents. On I-275 in District 7 during a one month period (August) 53% of the incidents assisted were flat tires or abandoned vehicles. The Road Ranger program on I-95 in District 4 had 700 flat tire

incidents assisted during a single month (July). This shows that flat tires are the most frequently attended incidents by Road Rangers followed by fuel type. It is clear that small incidents like flat tire, fuel and minor repairs occur more often than accidents and debris. Frequency of occurrence of accidents in most districts is low compared to other type of incidents, but accidents last much longer than any other type of incident.

3. The study found that on average an accident lasted for about 44 minutes; break down and debris average duration is 14 minutes and 10 minutes respectively. It is observed that the incident durations for a particular incident in a district are quite close irrespective of the freeway.

4. The latest FSPE Beat Evaluation (FSPE) Model was found to be effective in evaluating the freeway service patrol. The model uses capacity reduction values from the HCM and assigns incidents on freeway segments according to the vehicle miles traveled on that segment. The reduction in incident detection and response times with freeway service patrols is an important parameter in determining the savings in delay with freeway patrol as opposed to not having one. The model estimates reduction in response times using number of patrol vehicles, their speed, beat length, etc. A deterministic queuing model is used to estimate the congestion related delay savings.

5. The estimated net benefits based on the average incident delay and fuel savings indicate that the Road Ranger program produces significant benefits in all the five districts. The overall benefit/cost ratio for the Florida Road Ranger program is 25.8:1. The range of benefit/cost ratios is from 2.3:1 to 41.5:1. The benefit/cost ratios for District 2, 4, 5, 6, 7, and Turnpike are approximately, 2:1, 21:1, 13:1, 42:1, 18:1, and 10:1, respectively.

6. The Road Ranger service provided additional benefits that were not included in the calculation of the benefit/cost ratio. The daily reductions in air pollutant emissions include a total of 3690 kg of reactive organic gases, 160 kg of carbon monoxide and 740 kg of oxides of nitrogen. In addition, the presence of Road

Ranger service provides a sense of security on the freeway, and the quicker removal of incidents could reduce secondary accidents.

The results of this study confirm that the Florida Road Ranger service is a successful, cost-effective operational program. The calibrated FSPE models for each district can be directly applied for future performance evaluation. Efforts should be directed to collect and maintain consistent formatted activity logs. Currently, the Road Ranger logs do not contain any information regarding the lateral location (shoulder or in lane) of the incidents except for District 6. Road Ranger logs from certain districts do not have any information regarding the duration of incidents. There is a need to investigate and quantify the safety benefits of the Road Ranger service. Evaluation of safety effects requires data on incident patterns, accidents, and congestion levels over a long period of time.

The present study required incident data like: the average duration by type and lateral location of the incidents. All the data for the study was taken from the Road Ranger logs. However, because of lack of certain information that was required to perform the evaluation, the study utilized many key variables from other research. The Road Ranger logs do not contain any information regarding the lateral location of the incidents (shoulder or in lane). So, for the purpose of the present study, the percent distribution of various incidents laterally was taken from previous researches on this topic. Road Ranger logs from certain districts do not have any information regarding the duration of incidents and hence the duration values for these districts was assumed to be the same as the average over other districts. Duration of incidents can significantly impact the calculated delay savings and accuracy of the results. Many of the freeways for which the incident duration is available does not contain complete information like: - response times and restoration times. Road Ranger logs should record information related to response and restoration times. Response time can be approximated by interviewing the person being assisted and restoration time is from when the incident is cleared to the time the traffic is restored to normal. The reduction in response times with and without Road Ranger service is an important variable and can affect the accuracy of the results. To find the complete duration of incidents from the point it started to the point it is cleared would require extensive field studies and data collection. To fully understand the incident pattern and duration more realistic data would be required. The present study does not account for savings in secondary crashes and in this way the benefits of the Road Ranger services are underestimated. The secondary crash reduction estimation would require database of past years and real time current data. The ambiguity in travel time value and the average fuel cost could also affect the results of the present study.

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APPENDICES

Appendix A: Traffic Data

Table A.1 Traffic Profiles of Various Districts in Florida

Hourly Interval	District 1	District 2	District 4	District 5	District 6	District 7	Turnpike
Midnite-1	0.87	0.94	1.09	1.01	1.29	1.18	1.07
1-2	0.56	0.57	0.67	0.64	0.79	0.77	0.67
2-3	0.43	0.57	0.57	0.51	0.54	0.62	0.54
3-4	0.40	0.46	0.59	0.57	0.55	0.65	0.54
4-5	0.74	0.62	0.90	0.88	0.84	0.97	0.82
5-6	1.86	1.53	2.14	2.33	1.93	2.19	2.00
6-7	4.77	4.53	5.52	5.34	4.75	5.20	5.02
7-8	7.38	7.39	7.70	7.07	6.60	6.72	7.14
8-9	6.92	7.09	7.39	6.71	6.42	6.32	6.81
9-10	5.67	5.33	5.55	5.88	5.58	5.58	5.60
10-11	5.73	5.20	5.00	5.28	5.23	5.56	5.33
11-Noon	5.60	5.75	4.94	5.61	5.43	5.72	5.51
Noon-1	5.59	6.29	4.99	5.53	5.54	5.68	5.61
1-2	5.84	6.08	5.16	5.67	5.61	5.53	5.65
2-3	6.05	6.10	5.66	5.79	5.32	5.54	5.74
3-4	7.25	6.53	6.40	6.35	6.79	6.03	6.56
4-5	7.62	7.56	7.48	6.47	6.85	6.81	7.13
5-6	8.39	8.10	8.11	7.36	7.37	7.26	7.76
6-7	5.81	5.66	6.57	5.91	6.26	5.89	6.02
7-8	3.87	4.01	4.39	4.27	4.76	4.40	4.28
8-9	2.97	3.14	2.98	3.32	3.57	3.32	3.22
9-10	2.47	2.75	2.54	3.22	3.42	3.28	2.95
10-11	1.95	2.17	2.19	2.44	2.69	2.59	2.34
11-Midnite	1.26	1.62	1.48	1.83	1.89	2.16	1.71

Appendix A (Continued)

Table A.2 Freeway and Traffic Characteristics in District 2

District 2					**Segment**					
I-10	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	3.28-11.48	11.48-15.65	15.56-16.16	16.16-17.27	17.27-18.55	18.55-19.25	19.25-20.12	20.12-20.53	20.53-21.17	21.17-21.67
Segment L	8.2	4.17	0.6	1.11	1.28	0.7	0.87	0.41	0.64	0.5
Lanes	4	4	4	4	6	6	6	6	6	6
AADT	45735	57500	70500	99500	102000	110000	117500	122000	147022	116500
I-10	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	0.75-2.60									
Segment L	1.85									
Lanes	6									
AADT	139000									
District 2					**Segment**					
I-295	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	3.07-4.87	4.87-9.59	9.59-11.70	11.70-15.93	15.93-17.44	17.44-19.37	19.37-20.61	20.61-22.19	22.19-24.7	24.7-27.66
Segment L	1.8	4.72	2.11	4.23	1.51	1.93	1.24	1.58	2.51	2.96
Lanes	6	6	6	6	6	6	6	6	6	6
AADT	108000	119000	88000	83500	96000	108500	106000	78000	65000	54000
I-295	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	27.66-29.96	29.96-31.64	31.64-33.31	33.31-35.06	35.06-35.51	0-.37	0.37-1.91			
Segment L	2.3	1.68	1.67	1.75	0.45	0.37	1.54			
Lanes	6	6	6	6	6	6	6			
AADT	47500	47500	44000	52500	47000	47000	43500			
District 2					**Segment**					
I-95	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	0.7-2.6	2.6-3.89	3.89-4.62	4.62-5.22	5.22-5.83	5.83-7.13	7.13-7.89	7.89-9.26	9.26-10.59	0.2.23
Segment L	1.9	1.29	0.73	0.6	0.61	1.3	0.76	1.37	1.33	0.2
Lanes	6	6	6	6	6	6	6	6	6	4
AADT	139000	147500	124500	124000	132500	115000	88000	89500	78500	46000
I-95	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	2.23-3.77	3.77-6.36	0-5.46	5.46-6.59	6.59-7.36	7.36-9.31	9.31-11.64	11.64-13.09	13.09-13.47	13.47-15.27
Segment L	1.54	2.59	5.46	1.13	0.77	1.95	2.33	1.45	0.38	1.8
Lanes	6	4	6	6	6	6	6	6	6	6
AADT	62000	47500	71000	131000	127000	98000	121000	134500	110500	12220
I-95	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	15.27-16.79	0-0.75								
Segment L	1.52	0.75								
Lanes	6	6								
AADT	119000	160500								
District 2					**Segment**					
TB Road	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	0.51-1.11	1.11-3.03	3.03-4.11	4.11-5.22	5.22-6.30	6.30-8.22	8.22-10.05	10.05-12.09	12.09-12.82	
Segment L	0.6	1.92	1.08	1.11	1.08	1.92	1.83	2.04	0.73	
Lanes	4	4	4	4	4	4	4	4	4	
AADT	78500	73000	81500	82000	8500	74500	61500	57500	39000	

Appendix A (Continued)

Table A.3 Freeway and Traffic Characteristics in District 4

District 4					Segment					
I-595	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	0-1.1	1.1-2.09	2.09-3.07	3.07-4.07	4.07-4.59	4.59-6.13	6.13-8.39	8.39-10.44		
Segment L	1.1	0.99	0.98	1	1.52	1.54	2.26	2.05		
Lanes	6	6	6	8	8	8	8	6		
AADT	140000	154000	143500	172000	181725	164500	182500	97500		
District 4					**Segment**					
I-95	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	24.63-25.29	0-1.54	1.54-2.78	2.78-5.22	5.22-8.37	8.37-14.78	14.78-16.26	16.32-17.75	17.79-20.31	20.31-21.59
Segment L	0.66	1.54	1.24	2.44	3.15	6.41	1.48	1.43	2.52	1.28
Lanes	8	8	8	8	8	8	6	6	6	6
AADT	203000	203000	195000	186000	181500	168000	154500	141000	168500	168500
I-95	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	21.58-23.56	23.56-24.94	24.98-25.95	25.96-27.21	27.22-28.43	28.47-31.28	31.28-33.00	33.03-34.76	34.76-36.95	37.00-40.38
Segment L	1.98	1.38	0.97	1.25	1.21	2.81	1.72	1.73	2.19	3.38
Lanes	6	6	6	6	6	6	6	6	6	6
AADT	166500	166500	140000	140000	148631	153000	171500	142000	115000	99000
I-95	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	40.38-44.18	44.18-46.02	0-7.49	7.61-12.29	12.29-13.96	14.06-21.77	16.56-17.26	0-7.4	0.75-1.52	1.52-2.54
Segment L	3.8	1.84	7.49	4.68	1.67	7.71	0.7	7.4	0.77	1.02
Lanes	6	6	6	6	6	6	8	8	8	6
AADT	88526	67500	67500	58500	49500	42000	220000	212000	239394	259000
I-95	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	2.54-5.15	5.15-6.16	6.16-7.66	7.66-9.24	9.24-9.79	9.79-11.28	11.29-13.41	13.51-14.09	14.09-15.08	15.08-16.26
Segment L	2.61	1.01	1.5	1.58	0.55	1.49	2.12	0.58	0.99	1.18
Lanes	8	8	8	8	8	8	8	8	8	8
AADT	272000	279000	275000	275000	288000	288000	278000	259000	259000	260000
I-95	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	16.29-20.38	20.43-21.59	21.59-23.68	23.68-24.63	24.63-25.28	0-1.54				
Segment L	4.09	1.16	2.09	0.95	0.65	1.54				
Lanes	8	8	8	8	8	8				
AADT	243000	222800	200460	206000	203000	203000				
District 4					**Segment**					
I-75	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	0-2.2	2.20-4.02	4.02-4.78	4.78-5.44	0-1.54	1.54-5.44	5.44-7.71	7.71-9.48	9.54-12.13	
Segment L	2.2	1.82	0.76	0.66	1.54	3.9	2.27	1.77	2.59	
Lanes	6	6	6	6	6	6	6	6	6	
AADT	107000	102500	95500	138500	143500	113500	116500	125000	131500	

Appendix A (Continued)

Table A.4 Freeway and Traffic Characteristics in District 5

District 5					Segment					
I-4	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	0-3.63	3.63-4.18	4.18-6.58	6.58-7.89	0-1.09	1.09-2.63	2.63-5.52	5.52-6.27	6.27-8.26	8.26-9.95
Segment L	3.63	0.55	2.4	1.31	1.09	1.54	2.89	0.75	1.99	1.69
Lanes	6	6	6	6	6	6	6	6	6	6
AADT	91000	61000	85000	116060	124000	147500	119000	151000	155582	122000
I-4	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	9.95-11.07	11.07-12.30	12.30-13.65	13.65-15.02	15.02-15.53	15.53-16.84	16.84-17.18	17.18-17.5	17.5-18.31	18.31-18.8
Segment L	1.12	1.23	1.35	1.37	0.51	1.31	0.34	0.32	0.81	0.49
Lanes	6	6	6	6	6	6	6	6	6	6
AADT	127500	120500	147000	146500	171000	184500	175083	171500	154500	138000
I-4	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	18.8-19.65	19.65-20.41	20.41-21.30	21.30-22.85	22.85-24.02	24.02-24.67	0-1.46	1.49-3.47	3.47-8.26	8.26-10.49
Segment L	0.85	0.76	0.89	1.55	1.17	0.65	1.46	1.98	4.79	2.23
Lanes	6	6	6	6	6	6	6	6	6	6
AADT	160000	134000	165000	166000	143000	103000	103000	126000	123133	95000
I-4	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	10.49-14.13	0-3.51	3.51-6.37	6.37-9.52	9.52-11.64	11.64-14.2	14.2-24.5	24.5-28.02		
Segment L	3.64	3.51	2.86	3.15	2.12	2.56	10.3	3.52		
Lanes	6	6	6	6	6	6	6	6		
AADT	84500	79500	79500	74500	53500	49500	45000	39000		

Appendix A (Continued)

Table A.5 Freeway and Traffic Characteristics in District 6

District 6					**Segment**					
I-95 (9)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	0-0.975	0.975-1.535	1.535-3.234	3.234-5.455	5.455-6.069	6.069-6.236	6.236-7.261	7.261-8.792	8.792-9.795	9.795-10.798
Segment L	0.975	0.56	1.699	2.221	0.614	0.167	1.025	1.531	1.003	1.003
Lanes	4	6	6	6	8	10	10	10	10	10
AADT	64500	64500	138000	207000	207000	207000	225000	262000	220000	221000
I-95 (9)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	10.798-12.091	12.091-12.653	12.653-13.208	13.208-13.669	13.669-14.351	14.351-16.555	16.555-17.26			
Segment L	1.293	0.562	0.555	0.461	0.682	2.204	0.705			
Lanes	10	8	8	8	8	8	8			
AADT	237000	237000	185000	185000	185000	176000	220000			
District 6					**Segment**					
I-195 (1)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	4.794-4.91	4.423-4.794	2.136-4.423	0.793-2.136	0.569-0.793					
Segment L	0.116	0.371	2.287	1.343	0.224					
Lanes	4	5	6	6	3					
AADT	99000	99000	96580	96580	96580					
District 6					**Segment**					
I-395 (2)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	3.174-2.454	2.454-0	13.048-11.952							
Segment L	0.72	2.454	1.096							
Lanes	6	6	4							
AADT	74000	90344	106500							
District 6					**Segment**					
I-75 (7)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	0-0.251	0.251-2.202	2.202-4.019	4.019-4.778	4.778-5.442	0-1.536				
Segment L	0.251	1.951	1.817	0.759	0.664	1.536				
Lanes	6	8	8	8	8	8				
AADT	107000	107000	102500	95500	138500	143500				
District 6					**Segment**					
SR 836 (6)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	0-0.828	0.828-1.261	1.261-3.28	3.28-4.263	4.263-4.801	4.801-6.36	6.36-7.919	7.919-8.462	8.462-9.497	9.497-10.579
Segment L	0.828	0.433	2.019	0.983	0.538	1.559	1.559	0.543	1.035	1.082
Lanes	5	6	6	6	6	6	6	6	6	6
AADT	92000	92000	131893	119500	201500	191500	185000	139500	167500	146500
SR 836 (6)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	10.579-11.381	11.381-11.952								
Segment L	0.802	0.571								
Lanes	6	4								
AADT	127500	121000								
District 6					**Segment**					
SR 874 (4)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	0-1.545	1.545-2.181	2.181-3.703	3.703-4.114	4.114-6.949					
Segment L	1.545	0.636	1.522	0.411	2.835					
Lanes	6	4	8	4	4					
AADT	74000	74000	118000	118000	45500					
District 6					**Segment**					
SR 878 (3)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	2.271-2.658	2.271-0.512	0-0.512	0.46-0						
Segment L	0.387	1.759	0.512	0.46						

Appendix A (Continued)

Table A.5 Continued

District 6					**Segment**					
SR 924 (8)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	0-2.004	2.004-3.837	3.837-4.527	4.527-5.378						
Segment L	2.004	1.833	0.69	0.851						
Lanes	6	6	6	8						
AADT	63500	37500	42000	42000						

District 6					**Segment**					
SR 826	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	0-0.861	0.861-0.946	0.946-1.324	1.324-1.864	1.864-2.876	2.876-3.623	3.623-3.926	3.926-5.015	5.015-6.041	6.041-6.521
Segment L	0.861	0.085	0.378	0.54	1.012	0.747	0.303	1.089	1.026	0.48
Lanes	4	4	9	6	4	4	8	8	8	8
AADT	44500	63500	63500	63500	98500	109500	109500	191000	194500	198500
SR 826	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	6.521-7.04	7.04-7.234	7.234-8.363	8.363-9.208	9.208-10.381	10.381-11.372	11.372-12.227	12.227-13.161	13.161-14.362	14.362-14.972
Segment L	0.519	0.194	1.129	0.845	1.173	0.991	0.855	0.934	1.201	0.61
Lanes	8	7	8	8	8	8	8	8	8	8
AADT	191000	205000	205000	218000	204000	160000	191000	203000	181000	169500
SR 826	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	14.972-15.484	15.484-16.378	16.378-18.985	18.985-20.013	20.013-21.014	21.014-22.015	22.015-23.024	23.024-23.449	23.449-23.814	23.814-24.19
Segment L	0.512	0.894	2.607	1.028	1.001	1.001	1.009	0.425	0.365	0.376
Lanes	6	6	6	6	6	6	8	8	8	4
AADT	169500	119000	118000	134000	144500	144500	162000	141500	160500	160500

District 6					**Segment**					
SR 112	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	0-0.964	0.964-0.994	0.994-1.156	1.156-1.668	1.668-2.192	2.192-2.7	2.7-3.644	3.664-4.132		
Segment L	0.964	0.03	0.162	0.512	0.524	0.508	0.944	0.468		
Lanes	4	4	6	6	6	6	6	8		
AADT	26000	97000	97000	100500	90000	102500	109000	109000		

Appendix A (Continued)

Table A.6 Freeway and Traffic Characteristics in Turnpike

District 7					Segment					
I-275	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	0.5-1.19	0.5-2.30	2.30-2.55	2.55-3.23	3.23-3.55	3.55-4.51	4.51-5.29	5.29-6.29	6.29-7.32	7.32-8.339
Segment L	0.69	1.8	0.25	0.68	0.32	0.96	0.78	1	1.03	1.019
Lanes	6	6	6	4	4	6	8	6	8	6
AADT	4600	78500	74000	93000	80500	89000	97500	114500	144000	168000
I-275	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	8.339-10.53	10.53-12.46	12.46-13.75	13.75-14.54	14.54-19.65	0-1.31	1.31-2.15	2.15-2.62	2.62-3.25	3.25-3.84
Segment L	2.19	1.93	1.29	0.79	5.11	1.31	0.84	0.47	0.63	0.59
Lanes	8	4	4	6	8	6	6	6	6	6
AADT	134000	90000	81500	117500	129000	129000	131000	131000	171500	170500
I-275	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	3.84-4.62	4.62-5.12	5.12-6.44	6.44-6.86	6.86-7.25	0-.15	0.45-0.71	0.71-1.44	1.44-2.45	2.45-3.46
Segment L	0.78	0.3	1.32	0.42	0.39	0.15	0.26	0.73	1.01	0.84
Lanes	6	6	6	6	8	8	6	6	6	6
AADT	176500	187500	157500	163500	228000	133417	133417	150000	159500	153500
I-275	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	3.45-4.29	4.29-5.01	5.01-6.51	6.51-7.51	7.51-8.80					
Segment L	1.01	0.72	1.5	1	1.29					
Lanes	6	6	6	6	6					
AADT	152000	120500	124500	93500	69500					

Appendix A (Continued)

Table A.7 Freeway and Traffic Characteristics in Turnpike

Turnpike					Segment					
Zone 1	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	0-1	1-2	2-5	5-6	6-9	9-10	10-11	11-12	12-13	13-16
Segment L	1	1	3	1	3	1	1	1	1	3
Lanes	6	6	6	6	6	6	6	6	6	6
AADT	40400	40400	40400	47500	53500	54800	54800	54800	93200	119200
Zone 1	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	16-18	18-19								
Segment L	2	1								
Lanes	6	6								
AADT	149400	79900								
Zone 2	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	19-20	20-22	22-25	25-26A	26A-26B	26B-29	29-30	30-34	34-35	
Segment L	1	2	3	1	0.5	3	1	4	1	
Lanes	6	6	6	6	6	6	6	6	6	
AADT	86000	105700	105700	163600	90000	90500	91300	91300	82600	
Zone 3	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	29-30	30-34	34-35	35-39	39-43	43-47	47-49			
Segment L	1	4	1	4	4	4	2			
Lanes	6	6	6	6	6	6	6			
AADT	91300	91300	82600	77900	40500	52500	70000			
Zone 4	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	OX-3X	3X-47	47-49	49-53	53-54	54-58				
Segment L	0.5	0.5	2	4	1	4				
Lanes	6	6	6	6	6	6				
AADT	62100	72400	97600	105400	105200	107100				
Zone 5	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	53-54	54-58	58-62	62-63	63-66	66-67	67-69			
Segment L	1	4	4	1	3	1	2			
Lanes	6	6	6	6	6	6	6			
AADT	105200	107100	104100	95100	95100	83600	86900			
Zone 6	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	0-1	1-2	2-3	3-6	6-8	8-10	10-12	12-15	15-16	16-23
Segment L	1	1	1	3	2	2	2	3	1	7
Lanes	6	6	6	6	6	6	6	6	6	6
AADT	82300	63800	69000	62600	52600	42400	49100	61500	58900	59100
Zone 7	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	69-71	71-75	75-81	81-86	86-88	88-93				
Segment L	2	4	6	5	2	5				
Lanes	6	6	6	4	4	4				
AADT	78000	92700	86300	80200	66500	66500				
Zone 8	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	93-97	97-98	98-99	99-106	106-109	109-116				
Segment L	4	1	1	7	3	7				
Lanes	4	4	4	4	4	4				
AADT	62400	59800	59800	53900	53900	39300				
Zone 9	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	116-133	133-138	138-142	142-144	144-152					
Segment L	4	1	1	7	3	7				
Lanes	4	4	4	4	4	4				
AADT	30500	34600	34600	34600	28100					

Appendix A (Continued)

Table A.7 Continued

Zone 10	1	2	3	4	5	6	7	8	9	10
Mile Point	152-193									
Segment L	41									
Lanes	4									
AADT	25300									
Zone 11	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	193-229									
Segment L	36									
Lanes	4									
AADT	24300									
Zone 12	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	229-236	236-242	242-244	244-249	249-254					
Segment L	7	6	2	5	5					
Lanes	4	4	4	4	4					
AADT	24300	24300	22900	38600	48500					
Zone 13	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	254-265	265-267A	267A-267B	267-272						
Segment L	11	2	0.5	5						
Lanes	4	4	4	4						
AADT	58000	86200	67100	63000						
Zone 14	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mile Point	272-285	285-288	288-296	296-304	304-309					
Segment L	13	3	8	8	5					
Lanes										
AADT	37100	37100	28300	34400	32800					

Appendix B: Benefit/Cost Ratio In Each District

Table B.1 Road Ranger Benefits in District 2 (Jan-Sep)

District 2 (Jan-Sep)	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
I-10	26240	595910	39574	77565	673475	210980	3.19
I-295	6877	156177	10372	20328	176505	210980	0.84
I-95	23650	537092	35668	69909	607000	210980	2.88
Turner Butler Road	1001	22733	1510	2959	25692	210980	0.12
Total	57768	1311911	87123	170761	1482672	843920	1.76

Table B.2 Monthly Road Ranger Benefits in District 2 on I-10 (Jan-Sep)

I-10	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
January	1046	23755	1578	3092	26847	23870	1.12
February	1077	24459	1624	3184	27642	22330	1.24
March	4079	92634	6152	12057	104692	23870	4.39
April	4096	93020	6177	12108	105128	23100	4.55
May	3753	85231	5660	11094	96324	23870	4.04
June	2289	51983	3452	6766	58749	23100	2.54
July	3814	86616	5752	11274	97890	23870	4.10
August	4717	107123	7114	13943	121066	23870	5.07
September	1369	31090	2065	4047	35137	23100	1.52
Total	26240	595910	39574	77565	673475	210980	3.19

Table B.3 Monthly Road Ranger Benefits in District 2 on I-295 (Jan-Sep)

I-295	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
January	538	12218	811	1590	13808	23870	0.58
February	328	7449	495	970	8418	22330	0.38
March	600	13626	905	1774	15400	23870	0.65
April	1078	24481	1626	3187	27668	23100	1.20
May	1038	23573	1565	3068	26641	23870	1.12
June	1084	24618	1635	3204	27822	23100	1.20
July	750	17033	1131	2217	19249	23870	0.81
August	1046	23755	1578	3092	26847	23870	1.12
September	415	9425	626	1227	10651	23100	0.46
Total	6877	156177	10372	20328	176505	210980	0.84

Appendix B (Continued)

Table B.4 Monthly Road Ranger Benefits in District 2 on I-95 (Jan-Sep)

I-95	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
January	1598	36291	2410	4724	41014	23870	1.72
February	2083	47305	3141	6157	53462	22330	2.39
March	2021	45897	3048	5974	51871	23870	2.17
April	2955	67108	4457	8735	75843	23100	3.28
May	1437	32634	2167	4248	36882	23870	1.55
June	2909	66063	4387	8599	74662	23100	3.23
July	3088	70128	4657	9128	79257	23870	3.32
August	3685	83686	5558	10893	94579	23870	3.96
September	3874	87979	5843	11451	99430	23100	4.30
Total	23650	537092	35668	69909	607000	210980	2.88

Table B.5 Monthly Road Ranger Benefits in District 2 on Turner Butler Road (Jan-Sep)

TB	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
January	114	2589	172	337	2926	23870	0.12
February	181	4111	273	535	4646	22330	0.21
March	186	4224	281	550	4774	23870	0.20
April	78	1771	118	231	2002	23100	0.09
May	64	1453	97	189	1643	23870	0.07
June	87	1976	131	257	2233	23100	0.10
July	91	2067	137	269	2336	23870	0.10
August	117	2657	176	346	3003	23870	0.13
September	83	1885	125	245	2130	23100	0.09
Total	1001	22733	1510	2959	25692	210980	0.12

Table B.6 Road Ranger Benefits in Districts 4, 5 and District 7

District 4 (July)	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
I-75	16522	375215	24922	48847	424062	90036	4.71
I-595	18260	414685	27544	53986	468671	90036	5.21
I-95	239809	5446062	361734	708999	6155061	150060	41.02
Total	274591	6235962	414200	811832	7047794	330132	21.35
District 7 (August)	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
I-275	80051	1817958	120751	236672	2054630	117400	17.50
District 5 (Jan-Aug)	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
I-275	239579	5440839	361387	708319	6149158	483000	12.73

Appendix B (Continued)

Table B.7 Average Monthly Road Ranger Benefits in District 6

District 6	Study Period	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
I-75	12 Months	115	2610	173	340	2950	25550	0.12
I-95	11 Months	224574	5100073	338754	663958	5764032	77390	74.48
I-395	9 Months	8970	203704	13530	26519	230223	17155	13.42
I-195	10 Months	2503	56845	3776	7400	64246	17155	3.75
SR 836	12 Months	296902	6742648	447856	877799	7620447	52025	146.48
SR 112	12 Months	6751	153319	10184	19960	173279	35950	4.82
SR 878	12 Months	20216	459096	30494	59768	518864	23325	22.24
SR 826	12 Months	87594	1989267	132130	258975	2248242	127750	17.60
SR 874	12 Months	57378	1303045	86550	169638	1472683	35960	40.95
Total		705003	16010608	1063448	2084357	18094965	435584	41.54

Table B.8 Monthly Road Ranger Benefits on I-75 in District 6

I-75	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
January	103	2339	155	305	2644	25550	0.10
February	53	1204	80	157	1360	25550	0.05
March	80	1817	121	237	2053	25550	0.08
April	62	1408	94	183	1591	25550	0.06
May	94	2135	142	278	2413	25550	0.09
June	117	2657	176	346	3003	25550	0.12
July	165	3747	249	488	4235	25550	0.17
August	170	3861	256	503	4363	25550	0.17
September	106	2407	160	313	2721	25550	0.11
October	132	2998	199	390	3388	25550	0.13
November	133	3020	201	393	3414	25550	0.13
December	164	3724	247	485	4209	25550	0.16
Total	1379	31317	2080	4077	35394	306600	0.12

Appendix B (Continued)

Table B.9 Monthly Road Ranger Benefits on I-95 in District 6

I-95	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
January	155323	3527385	234294	459216	3986602	77390	51.51
February	202537	4599615	305513	598806	5198421	77390	67.17
March	232701	5284640	351013	687986	5972626	77390	77.18
April	236154	5363057	356222	698195	6061252	77390	78.32
May	114373	2597411	172524	338147	2935557	77390	37.93
June	n/a	n/a	n/a	n/a	n/a	n/a	n/a
July	225630	5124057	340347	667081	5791138	77390	74.83
August	235924	5357834	355875	697515	6055349	77390	78.24
September	233396	5300423	352062	690041	5990464	77390	77.41
October	261009	5927514	393714	771680	6699194	77390	86.56
November	273058	6201147	411889	807303	7008450	77390	90.56
December	300208	6817724	452843	887572	7705296	77390	99.56
Total	2470313	56100808	3726297	7303542	63404350	851290	74.48

Table B.10 Monthly Road Ranger Benefits on I-395 in District 6

I-395	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
January	7952	180590	11995	23510	204100	17155	11.90
February	7129	161900	10754	21077	182977	17155	10.67
March	9337	212043	14084	27605	239648	17155	13.97
April	12265	278538	18501	36262	314800	17155	18.35
May	4120	93565	6215	12181	105746	17155	6.16
June	n/a	n/a	n/a	n/a	n/a	n/a	n/a
July	n/a	n/a	n/a	n/a	n/a	n/a	n/a
August	n/a	n/a	n/a	n/a	n/a	n/a	n/a
September	11132	252808	16792	32912	285720	17155	16.66
October	10821	245745	16323	31993	277737	17155	16.19
November	10148	230461	15308	30003	260464	17155	15.18
December	7824	177683	11802	23132	200815	17155	11.71
Total	80728	1833333	121773	238674	2072007	154395	13.42

Appendix B (Continued)

Table B.11 Monthly Road Ranger Benefits on I-195 in District 6

I-195	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
January	2143	48668	3233	6336	55003	17155	3.21
February	2300	52233	3469	6800	59033	17155	3.44
March	3597	81688	5426	10635	92322	17155	5.38
April	3001	68153	4527	8873	77025	17155	4.49
May	1353	30727	2041	4000	34727	17155	2.02
June	n/a	n/a	n/a	n/a	n/a	n/a	n/a
July	n/a	n/a	n/a	n/a	n/a	n/a	n/a
August	1957	44443	2952	5786	50229	17155	2.93
September	3158	71718	4764	9337	81055	17155	4.72
October	2609	59250	3935	7714	66964	17155	3.90
November	2190	49735	3303	6475	56210	17155	3.28
December	2723	61839	4107	8051	69890	17155	4.07
Total	25031	568454	37758	74005	642459	171550	3.75

Table B.12 Monthly Road Ranger Benefits on SR-836 in District 6

SR-836	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
January	263849	5992011	397998	780076	6772087	52025	130.17
February	260820	5923222	393429	771121	6694343	52025	128.68
March	336891	7650795	508177	996027	8646821	52025	166.21
April	278841	6332479	420612	824400	7156879	52025	137.57
May	263571	5985697	397579	779254	6764952	52025	130.03
June	302450	6868640	456225	894201	7762840	52025	149.21
July	301646	6850381	455012	891824	7742205	52025	148.82
August	323257	7341166	487611	955717	8296884	52025	159.48
September	217916	4948872	328711	644274	5593146	52025	107.51
October	344479	7823118	519623	1018461	8841579	52025	169.95
November	340027	7722013	512907	1005298	8727311	52025	167.75
December	329079	7473384	496393	972930	8446314	52025	162.35
Total	3562826	80911778	5374277	10533583	91445362	624300	146.48

Appendix B (Continued)

Table B.13 Monthly Road Ranger Benefits on SR-112 in District 6

SR-112	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
January	8318	188902	12547	24592	213494	35950	5.94
February	6954	157925	10490	20560	178485	35950	4.96
March	7389	167804	11146	21846	189650	35950	5.28
April	6396	145253	9648	18910	164163	35950	4.57
May	5853	132922	8829	17305	150226	35950	4.18
June	5636	127994	8502	16663	144657	35950	4.02
July	7483	169939	11288	22124	192063	35950	5.34
August	8973	203777	13535	26529	230306	35950	6.41
September	6153	139735	9281	18191	157926	35950	4.39
October	4894	111143	7382	14469	125612	35950	3.49
November	6742	153111	10170	19933	173044	35950	4.81
December	6223	141324	9387	18398	159723	35950	4.44
Total	81014	1839828	122204	239520	2079348	431400	4.82

Table B.14 Monthly Road Ranger Benefits on SR-826 in District 6

SR-826	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
January	69521	1578822	104868	205541	1784362	127750	13.97
February	73669	1673023	111125	217804	1890827	127750	14.80
March	85612	1944249	129140	253114	2197363	127750	17.20
April	80380	1825430	121248	237645	2063075	127750	16.15
May	92105	2091705	138934	272311	2364015	127750	18.51
June	126578	2874586	190934	374231	3248817	127750	25.43
July	89503	2032613	135009	264618	2297231	127750	17.98
August	72416	1644567	109235	214100	1858667	127750	14.55
September	79318	1801312	119646	234506	2035817	127750	15.94
October	95081	2159290	143423	281109	2440399	127750	19.10
November	82469	1872871	124399	243822	2116693	127750	16.57
December	104480	2372741	157601	308898	2681639	127750	20.99
Total	1051132	23871208	1585560	3107698	26978906	1533000	17.60

Appendix B (Continued)

Table B.15 Monthly Road Ranger Benefits on SR-874 in District 6

SR-874	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
January	53104	1205992	80104	157003	1362995	35960	37.90
February	66266	1504901	99958	195917	1700818	35960	47.30
March	62842	1427142	94793	185794	1612936	35960	44.85
April	55414	1258452	83588	163833	1422285	35960	39.55
May	57892	1314727	87326	171159	1485886	35960	41.32
June	58465	1327740	88190	172853	1500593	35960	41.73
July	53704	1219618	81009	158777	1378395	35960	38.33
August	56180	1275848	84744	166098	1441945	35960	40.10
September	48058	1091397	72492	142085	1233482	35960	34.30
October	65124	1478966	98235	192541	1671507	35960	46.48
November	53358	1211760	80487	157754	1369514	35960	38.08
December	58124	1319996	87676	171845	1491841	35960	41.49
Total	688531	15636539	1038602	2035659	17672198	431520	40.95

Table B.16 Monthly Road Ranger Benefits on SR-878 in District 6

SR-878	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
January	5295	120249	7987	15655	135904	23325	5.83
February	32119	729422	48449	94961	824383	23325	35.34
March	9532	216472	14378	28182	244653	23325	10.49
April	31252	709733	47141	92397	802130	23325	34.39
May	26492	601633	39961	78324	679958	23325	29.15
June	8667	196828	13074	25624	222452	23325	9.54
July	27150	616577	40954	80270	696846	23325	29.88
August	30005	681414	45260	88711	770124	23325	33.02
September	5403	122702	8150	15974	138676	23325	5.95
October	27181	617281	41001	80361	697642	23325	29.91
November	12250	278198	18478	36217	314415	23325	13.48
December	27241	618643	41091	80539	699182	23325	29.98
Total	242587	5509151	365926	717214	6226365	279900	22.24

Appendix B (Continued)

Table B.17 Overall Annual Benefit of Road Ranger Program in Turnpike Region

Annual	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
Northern Zone	159592	3624334	240690	471752	4096087	645624	6.34
Southern Zone	343062	7790938	517060	1013437	8804375	645624	13.64
Overall Turnpike	502654	11415272	757750	1485190	12900462	1291248	9.99

Table B.18 Monthly Road Ranger Benefits in Zone 1

Zone 1	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
January	6988	158697	10542	20662	179360	7812	22.96
February	6053	137464	9130	17895	155358	7308	21.26
March	6527	148228	9845	19296	167524	7812	21.44
April	7192	163330	10849	21264	184594	7560	24.42
May	8684	197214	13099	25674	222888	7812	28.53
June	7892	179227	11905	23334	202561	7560	26.79
July	7709	175071	11629	22793	197864	7812	25.33
August	7409	168258	11176	21905	190163	7812	24.34
September	6752	153338	10185	19963	173301	7560	22.92
October	7800	177138	11765	23059	200197	7812	25.63
November	8486	192717	12801	25090	217807	7560	28.81
December	7478	169825	11280	22109	191934	7812	24.57
Total	88970	2020509	134206	263044	2283552	92232	24.76

Appendix B (Continued)

Table B.19 Monthly Road Ranger Benefits in Zone 2

Zone 2	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
January	7422	168554	11195	21942	190496	7812	24.39
February	6418	145753	9681	18975	164728	7308	22.54
March	6924	157244	10444	20470	177714	7812	22.75
April	7926	179999	11504	22548	202547	7560	26.79
May	9207	209091	13888	27220	236311	7812	30.25
June	8364	189946	12617	24729	214676	7560	28.40
July	8185	185881	12346	24198	210080	7812	26.89
August	7846	178183	11835	23197	201379	7812	25.78
September	7160	162604	10801	21170	183774	7560	24.31
October	8272	187857	12478	24457	212314	7812	27.18
November	9007	204549	13587	26631	231179	7560	30.58
December	7938	180272	11975	23471	203743	7812	26.08
Total	94669	2149933	142351	279008	2428941	92232	26.34

Table B.20 Monthly Road Ranger Benefits in Zone 3

Zone 3	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
January	558	12672	841	1648	14321	7812	1.83
February	594	13490	896	1756	15246	7308	2.09
March	640	14534	966	1893	16428	7812	2.10
April	706	16033	1065	2087	18121	7560	2.40
May	853	19372	1287	2523	21894	7812	2.80
June	775	17600	1170	2293	19893	7560	2.63
July	758	17214	1143	2240	19454	7812	2.49
August	727	16510	1096	2148	18658	7812	2.39
September	662	15034	999	1958	16992	7560	2.25
October	766	17396	1156	2266	19662	7812	2.52
November	833	18917	1257	2464	21381	7560	2.83
December	735	16692	1108	2172	18864	7812	2.41
Total	8607	195465	12984	25449	220914	92232	2.40

Appendix B (Continued)

Table B.21 Monthly Road Ranger Benefits in Zone 4

Zone 4	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
January	3880	88115	5853	11472	99587	7812	12.75
February	3356	76215	5063	9923	86138	7308	11.79
March	3612	82029	5449	10680	92709	7812	11.87
April	3982	90431	6007	11774	102205	7560	13.52
May	4803	109076	7246	14202	123278	7812	15.78
June	4361	99038	6579	12895	111933	7560	14.81
July	4271	96994	6443	12629	109623	7812	14.03
August	4099	93088	6184	12120	105208	7812	13.47
September	3746	85072	5651	11076	96148	7560	12.72
October	4320	98107	6517	12774	110881	7812	14.19
November	4705	106851	7098	13912	120762	7560	15.97
December	4151	94269	6262	12274	106543	7812	13.64
Total	49286	1119285	74352	145730	1265015	92232	13.72

Table B.22 Monthly Road Ranger Benefits in Zone 5

Zone 5	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
January	3011	68380	4542	8903	77283	7812	9.89
February	2606	59182	3931	7705	66888	7308	9.15
March	2998	68085	4523	8865	76949	7812	9.85
April	3102	70446	4680	9172	79619	7560	10.53
May	3734	84799	5633	11041	95840	7812	12.27
June	3391	77010	5116	10027	87036	7560	11.51
July	3323	75465	5013	9826	85291	7812	10.92
August	3189	72422	4811	9429	81852	7812	10.48
September	2907	66018	4385	8596	74613	7560	9.87
October	3357	76237	5064	9926	86164	7812	11.03
November	3657	83050	5517	10813	93864	7560	12.42
December	3227	73285	4868	9542	82827	7812	10.60
Total	38502	874380	58084	113844	988224	92232	10.71

Appendix B (Continued)

Table B.23 Monthly Road Ranger Benefits in Zone 6

Zone 6	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
January	14	318	21	41	359	7812	0.05
February	14	318	21	41	359	7308	0.05
March	15	341	23	44	385	7812	0.05
April	17	386	26	50	436	7560	0.06
May	21	477	32	62	539	7812	0.07
June	19	431	29	56	488	7560	0.06
July	18	409	27	53	462	7812	0.06
August	18	409	27	53	462	7812	0.06
September	16	363	24	47	411	7560	0.05
October	19	431	29	56	488	7812	0.06
November	20	454	30	59	513	7560	0.07
December	18	409	27	53	462	7812	0.06
Total	209	4746	315	618	5364	92232	0.06

Table B.24 Monthly Road Ranger Benefits in Zone 7

Zone 7	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
January	4942	112233	7455	14613	126845	7812	16.24
February	4272	97017	6445	12632	109649	7308	15.00
March	4605	104580	6947	13616	118196	7812	15.13
April	5084	115458	7670	15033	130490	7560	17.26
May	6124	139076	9239	18108	157184	7812	20.12
June	5560	126268	8388	16440	142708	7560	18.88
July	5443	123611	8211	16094	139705	7812	17.88
August	5224	118637	7881	15446	134084	7812	17.16
September	4777	108486	7207	14125	122610	7560	16.22
October	5506	125041	8306	16280	141322	7812	18.09
November	5999	136237	9050	17738	153975	7560	20.37
December	5283	119977	7970	15621	135598	7812	17.36
Total	62819	1426619	94768	185745	1612365	92232	17.48

Appendix B (Continued)

Table B.25 Monthly Road Ranger Benefits in Zone 8

Zone 8	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
January	1207	27411	1820	3567	30978	7812	3.97
February	1083	24595	1634	3203	27798	7308	3.80
March	1156	26253	1744	3418	29671	7812	3.80
April	1384	31431	2087	4091	35521	7560	4.70
May	1468	33338	2214	4339	37678	7812	4.82
June	1498	34020	2259	4428	38447	7560	5.09
July	1472	33429	2220	4351	37780	7812	4.84
August	1408	31976	2123	4161	36137	7812	4.63
September	1154	26207	1740	3410	29618	7560	3.92
October	1141	25912	1721	3373	29285	7812	3.75
November	1049	23823	1583	3103	26925	7560	3.56
December	960	21802	1448	2838	24640	7812	3.15
Total	14980	340196	22593	44282	384478	92232	4.17

Table B.26 Monthly Road Ranger Benefits in Zone 12

Zone 12	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
January	6807	154587	10266	20121	174708	7812	22.36
February	6108	138713	9212	18055	156768	7308	21.45
March	6505	147729	9811	19229	166957	7812	21.37
April	7837	177978	11819	23166	201144	7560	26.61
May	8269	187789	12471	24443	212232	7812	27.17
June	8010	181907	12080	23677	205584	7560	27.19
July	8301	188516	12519	24538	213053	7812	27.27
August	7945	180431	11982	23485	203916	7812	26.10
September	6505	147729	9811	19229	166957	7560	22.08
October	6435	146139	9705	19022	165161	7812	21.14
November	5905	134103	8906	17455	151558	7560	20.05
December	5388	122361	8126	15927	138288	7812	17.70
Total	84015	1907981	126707	248347	2156327	92232	23.38

Appendix B (Continued)

Table B.27 Monthly Road Ranger Benefits in Zone 13

Zone 13	Veh-hrs	Delay Savings ($)	Fuel (gallons)	Fuel Savings ($)	Total ($)	Cost ($)	B-C Ratio
January	4912	111552	7408	14520	126071	7812	16.14
February	4409	100128	6649	13033	113161	7308	15.48
March	4705	106851	7096	13908	120758	7812	15.46
April	5633	127925	8495	16651	144576	7560	19.12
May	5975	135692	9011	17662	153354	7812	19.63
June	5760	130810	8687	17026	147836	7560	19.56
July	5991	136056	9035	17709	153765	7812	19.68
August	5728	130083	8639	16932	147015	7812	18.82
September	4697	106669	7084	13884	120553	7560	15.95
October	4646	105511	7007	13733	119244	7812	15.26
November	4233	96131	6384	12513	108644	7560	14.37
December	3908	88751	5894	11552	100303	7812	12.84
Total	60597	1376158	91390	179124	1555282	92232	16.86

Appendix C: Savings In Vehicle Emissions In Each District

The FSPE model used to estimate Road Ranger service in present study estimates the savings in vehicular emissions for three types of gases, Carbon Monoxide (CO), Nitrogen Oxides (NOX) and Reactive Organic Gases (ROG). Since, it is difficult to assign dollar value to the emissions/pollution; the savings in emissions was not included in the final Benefit-Cost ratio. The following tables in this section describe the estimated savings in vehicular emissions for various Districts and Turnpike in Florida.

Table C.1 Savings in Vehicular Emissions in District 2 on I-10 (Jan-Sep)

I-10	ROG (kg)	CO(kg)	NOX(kg)
January	157	7	33
February	161	7	34
March	611	27	127
April	614	27	128
May	563	24	117
June	343	15	71
July	572	25	119
August	707	31	147
September	205	9	43
Total	3933	171	817

Table C.2 Savings in Vehicular Emissions in District 2 on I-295 (Jan-Sep)

I-295	ROG (kg)	CO(kg)	NOX(kg)
January	81	4	17
February	49	2	10
March	90	4	19
April	162	7	34
May	156	7	32
June	162	7	34
July	112	5	23
August	157	7	33
September	62	3	13
Total	1031	45	214

Appendix C (Continued)

Table C.3 Savings in Vehicular Emissions in District 2 on I-95 (Jan-Sep)

I-95	ROG (kg)	CO(kg)	NOX(kg)
January	240	10	50
February	312	14	65
March	303	13	63
April	443	19	92
May	215	9	45
June	436	19	91
July	463	20	96
August	552	24	115
September	581	25	121
Total	3545	154	736

Table C.4 Savings in Vehicular Emissions in District 2 on Turner Butler Road (Jan-Sep)

TB	ROG (kg)	CO(kg)	NOX(kg)
January	17	1	4
February	27	1	6
March	28	1	6
April	12	1	2
May	10	0	2
June	13	1	3
July	14	1	3
August	18	1	4
September	12	1	3
Total	150	7	31

Table C.5 Savings in Vehicular Emissions in Districts 4, 5 and 7

District 4 (July)	ROG (kg)	CO(kg)	NOX(kg)
I-75	2471	104	484
I-595	2731	115	535
I-95	35869	1504	7030
Total	41071	1723	8049
District 7 (August)	ROG (kg)	CO(kg)	NOX(kg)
I-275	11973	502	2347
District 5 (Jan-Aug)	ROG (kg)	CO(kg)	NOX(kg)
I-275	35834	1502	7023

Appendix C (Continued)

Table C.6 Savings in Vehicular Emissions on I-75 in District 6

I-75	ROG (kg)	CO(kg)	NOX(kg)
January	15	1	3
February	8	0	2
March	12	1	2
April	9	0	2
May	14	1	3
June	17	1	3
July	25	1	5
August	25	1	5
September	16	1	3
October	20	1	4
November	20	1	4
December	25	1	5
Total	206	9	40

Table C.7 Savings in Vehicular Emissions on I-95 in District 6

I-95	ROG (kg)	CO(kg)	NOX(kg)
January	23232	974	4553
February	30294	1270	5937
March	34806	1459	6821
April	35322	1481	6922
May	17107	717	3353
June	n/a	n/a	n/a
July	33748	1415	6614
August	35288	1479	6916
September	34910	1464	6842
October	39040	1637	7651
November	40842	1712	8004
December	44903	1883	8800
Total	369490	15491	72412

Appendix C (Continued)

Table C.8 Savings in Vehicular Emissions on I-395 in District 6

I-395	Veh-hrs	ROG (kg)	CO(kg)	NOX(kg)
January	7952	1189	50	233
February	7129	1066	45	209
March	9337	1397	59	274
April	12265	1835	77	360
May	4120	616	26	121
June	n/a	n/a	n/a	n/a
July	n/a	n/a	n/a	n/a
August	n/a	n/a	n/a	n/a
September	11132	1665	70	326
October	10821	1619	68	317
November	10148	1518	64	297
December	7824	1170	49	229
Total	80728	12075	506	2366

Table C.9 Savings in Vehicular Emissions on I-195 in District 6

I-195	ROG (kg)	CO(kg)	NOX(kg)
January	321	13	63
February	344	14	67
March	538	23	105
April	449	19	88
May	202	8	40
June	n/a	n/a	n/a
July	n/a	n/a	n/a
August	293	12	57
September	472	20	93
October	390	16	76
November	328	14	64
December	407	17	80
Total	3744	157	734

Appendix C (Continued)

Table C.10 Savings in Vehicular Emissions on SR-836 in District 6

SR-836	ROG (kg)	CO(kg)	NOX(kg)
January	39464	1655	7734
February	39011	1636	7645
March	50389	2113	9875
April	41707	1749	8174
May	39423	1653	7726
June	45238	1897	8866
July	45118	1892	8842
August	48350	2027	9476
September	32594	1367	6388
October	51524	2160	10098
November	50859	2132	9967
December	49221	2064	9646
Total	532899	22342	104437

Table C.11 Savings in Vehicular Emissions on SR-112 in District 6

SR-112	ROG (kg)	CO(kg)	NOX(kg)
January	1244	52	244
February	1040	44	204
March	1105	46	217
April	957	40	187
May	875	37	172
June	843	35	165
July	1119	47	219
August	1342	56	263
September	920	39	180
October	732	31	143
November	1008	42	198
December	931	39	182
Total	12117	508	2375

Appendix C (Continued)

Table C.12 Savings in Vehicular Emissions on SR-826 in District 6

SR-826	ROG (kg)	CO(kg)	NOX(kg)
January	10398	436	2038
February	11019	462	2159
March	12805	537	2510
April	12023	504	2356
May	13776	578	2700
June	18933	794	3710
July	13387	561	2624
August	10831	454	2123
September	11864	497	2325
October	14221	596	2787
November	12335	517	2417
December	15627	655	3063
Total	157220	6592	30812

Table C.13 Savings in Vehicular Emissions on SR-874 in District 6

SR-874	ROG (kg)	CO(kg)	NOX(kg)
January	7943	333	1557
February	9912	416	1942
March	9399	394	1842
April	8288	348	1624
May	8659	363	1697
June	8745	367	1714
July	8033	337	1574
August	8403	352	1647
September	7188	301	1409
October	9741	408	1909
November	7981	335	1564
December	8694	364	1704
Total	102985	4318	20183

Appendix C (Continued)

Table C.14 Savings in Vehicular Emissions on SR-878 in District 6

SR-878	ROG (kg)	CO(kg)	NOX(kg)
January	792	33	155
February	4804	201	942
March	1426	60	279
April	4674	196	916
May	3962	166	777
June	1296	54	254
July	4061	170	796
August	4488	188	880
September	808	34	158
October	4066	170	797
November	1832	77	359
December	4074	171	799
Total	36284	1521	7111

Table C.15 Savings in Vehicular Emissions in Zone 1 in Florida's Turnpike

Zone 1	ROG (kg)	CO(kg)	NOX(kg)
January	1045	44	205
February	905	38	177
March	976	41	191
April	1076	45	211
May	1299	54	255
June	1180	49	231
July	1153	48	226
August	1108	46	217
September	1010	42	198
October	1167	49	229
November	1269	53	249
December	1118	47	219
Total	13306	556	2608

Appendix C (Continued)

Table C.16 Savings in Vehicular Emissions in Zone 2 in Florida's Turnpike

Zone 2	ROG (kg)	CO(kg)	NOX(kg)
January	1110	47	218
February	960	40	188
March	1036	43	203
April	1141	48	224
May	1377	58	270
June	1251	52	245
July	1224	51	240
August	1174	49	230
September	1071	45	210
October	1237	52	242
November	1347	56	264
December	1187	50	233
Total	14115	591	2767

Table C.17 Savings in Vehicular Emissions in Zone 3 in Florida's Turnpike

Zone 3	ROG (kg)	CO(kg)	NOX(kg)
January	83	3	16
February	89	4	17
March	96	4	19
April	106	4	21
May	128	5	25
June	116	5	23
July	113	5	22
August	109	5	21
September	99	4	19
October	115	5	22
November	125	5	24
December	110	5	22
Total	1289	54	251

Appendix C (Continued)

Table C.18 Savings in Vehicular Emissions in Zone 4 in Florida's Turnpike

Zone 4	ROG (kg)	CO(kg)	NOX(kg)
January	580	24	114
February	502	21	98
March	540	23	106
April	595	25	117
May	718	30	141
June	652	27	128
July	639	27	125
August	613	26	120
September	560	24	110
October	646	27	126
November	704	30	138
December	621	26	122
Total	7370	309	1443

Table C.19 Savings in Vehicular Emissions in Zone 5 in Florida's Turnpike

Zone 5	ROG (kg)	CO(kg)	NOX(kg)
January	450	19	88
February	390	16	76
March	448	19	88
April	464	19	91
May	558	23	109
June	507	21	99
July	497	21	97
August	477	20	93
September	435	18	85
October	502	21	98
November	547	23	107
December	483	20	94
Total	5758	242	1127

Appendix C (Continued)

Table C.20 Savings in Vehicular Emissions in Zone 6 in Florida's Turnpike

Zone 6	ROG (kg)	CO(kg)	NOX(kg)
January	2	0	0
February	2	0	0
March	2	0	0
April	3	0	0
May	3	0	1
June	3	0	1
July	3	0	1
August	3	0	1
September	2	0	0
October	3	0	1
November	3	0	1
December	3	0	1
Total	31	1	6

Table C.21 Savings in Vehicular Emissions in Zone 7 in Florida's Turnpike

Zone 7	ROG (kg)	CO(kg)	NOX(kg)
January	739	31	145
February	639	27	125
March	689	29	135
April	760	32	149
May	916	38	179
June	831	35	163
July	814	34	159
August	781	33	153
September	714	30	140
October	823	35	161
November	897	38	176
December	790	33	155
Total	9394	394	1839

Appendix C (Continued)

Table C.22 Savings in Vehicular Emissions in Zone 8 in Florida's Turnpike

Zone 8	ROG (kg)	CO(kg)	NOX(kg)
January	181	8	35
February	162	7	32
March	173	7	34
April	207	9	41
May	220	9	43
June	224	9	44
July	220	9	43
August	211	9	41
September	173	7	34
October	171	7	33
November	157	7	31
December	144	6	28
Total	2243	94	439

Table C.23 Savings in Vehicular Emissions in Zone 12 in Florida's Turnpike

Zone 12	ROG (kg)	CO(kg)	NOX(kg)
January	1020	44	212
February	916	40	190
March	975	42	203
April	1175	51	244
May	1239	54	257
June	1201	52	249
July	1244	54	258
August	1191	52	247
September	975	42	203
October	965	42	200
November	885	38	184
December	808	35	168
Total	12593	548	2616

Appendix C (Continued)

Table C.24 Savings in Vehicular Emissions in Zone 13 in Florida's Turnpike

Zone 13	ROG (kg)	CO(kg)	NOX(kg)
January	736	32	153
February	661	29	137
March	705	31	146
April	844	37	175
May	896	39	186
June	863	38	179
July	898	39	187
August	859	37	178
September	704	31	146
October	696	30	145
November	634	28	132
December	586	25	122
Total	9083	394	1887

Appendix D: FSPE Model Excel Sheets

The FSPE model uses Microsoft Excel workbook for all inputs and outputs. MS excel interface makes the model user friendly and convenient to enter data and read the results. Figures E.1 (Input) and E.2 (Output) show the excel sheets used by the model.

Figure D.1 FSPE Model MS-Excel Input Sheet

FSP Beat Evaluation & Prediction Routines (version 12.1)												
Input Data Worksheet												
A. Beat/Service Description				**B. Beat Design Characteristics**								
District	6			**Beat Length (miles)**	4.11							
Analyst	Harkanwal			**#Segments**	8							
Date	July			**DIRECTION-1**	NB							
Beat #/Name	281			**Segment#**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Beat Description	I-95			**Length (mi)**	0.964	0.03	0.162	0.512	0.524	0.508	0.944	0.468
				# Mixed-Flow Lanes	2	2	3	3	3	3	3	4
	Start-Time	**End-Time**	**# FSP**	**HOV Lane**	N	N	N	N	N	N	N	N
Hours of Operation/# FSP Trucks	**(hr:min)**	**(hr:min)**	**Trucks**	**Rt Shdr**	Y	Y	Y	Y	Y	Y	Y	Y
AM Peak	0:01	6:00	2	**Lt Shdr (Median)**	Y	Y	Y	Y	Y	Y	Y	Y
Midday	6:01	18:00	3									
PM Peak	18:01	22:30	2	**DIRECTION-2**	SB							
				Segment#	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Number of Service Days/Yr	**31**			**Length (mi)**	0.964	0.03	0.162	0.512	0.524	0.508	0.944	0.468
Cost of FSP Service ($/truck-hr)	$35.00			**# Mixed-Flow Lanes**	2	2	3	3	3	3	3	4
				HOV Lane	N	N	N	N	N	N	N	N
				Rt Shdr	Y	Y	Y	Y	Y	Y	Y	Y
				Lt Shdr (Median)	Y	Y	Y	Y	Y	Y	Y	Y
D. Incident Characteristics												
Total FSP Assists (Inc/yr)	400			**C. Beat Traffic Characteristics**								
Incident	**# Incidents**	**Mean time**		**Segment #**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Type/Location	**or (%)**	**spent (min)**		**AADT**	26000	97000	97000	100500	90000	102500	109000	109000
Accident Right Shoulder	**3.59**	51.13		**AM PEAK Dir.**	NB	NB	NB	NB	NB	NB	NB	NB
Lt Shldr (Median)	**1.00**	51.13		D factor (%)	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
1-Lane	**8.40**	51.13		**MD PEAK Dir.**	NB	NB	NB	NB	NB	NB	NB	NB
Breakdown Right Shoulder	**43.13**	14.68		D factor (%)	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Lt Shldr (Median)	**5.50**	16.82		**PM PEAK Dir.**	SB	SB	SB	SB	SB	SB	SB	SB
1-Lane	**35.88**	16.82		D factor (%)	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Debris Right Shoulder	**0.53**	6.50										
Lt Shldr (Median)	**0.13**	6.50										
1-Lane	**1.64**	6.50										

Appendix D (Continued)

Figure D.2 FSPE Model Output in MS-Excel

FSP Beat Evaluation & Prediction Routines (version 12.1)						
Summary Evaluation Results Worksheet						
Input Data				**FSP Operational Parameters**		
District	4			Delay Cost ($/veh-hr)	$13.45	
Analyst	Harkanwal			Fuel Cost ($/gal)	$1.96	
Date	July					
Beat #, Name	281			Mean Response time w/o FSP (min)	30.0	
Beat Description	I-95					
Beat Length (miles)	17.26			FSP Response Time (min)		
				AM Peak	11.5	
	Start	**End**	**# FSP**	Midday	8.6	
Hours of Operation/ # FSP trucks	**Time**	**Time**	**Trucks**	PM Peak	11.5	
AM Peak	0:01	6:00	3			
Midday	6:01	18:00	4	FSP Response Time Reduction (min)		
PM Peak	18:01	23:00	3	AM Peak	18.5	
				Midday	21.4	
Number of Service Days/Yr	365			PM Peak	18.5	
Cost of FSP Service ($/truck-hr)	$35.00					
Total FSP Assists (Incidents/yr)	1,654			Traffic Profile	Weekday	
Time Period				**Daily/Annual**		
Savings-Performance Measures	**AM Peak**	**Midday**	**PM Peak**	**Savings-Performance Measures**	**Daily**	**Annual**
Delay (veh-hrs)	3.2	619.4	23.7	Delay (veh-hrs)	646.37	235,924
Fuel Consumption (gal)	4.8	934.4	35.8	Fuel Consumption (gal)	975.00	355,873
Emissions				Emissions		
ROG (kg/day)	0.48	92.65	3.55	ROG (kg/day, kg/yr)	96.68	35,288
CO (kg/day)	0.02	3.88	0.15	CO (kg/day, kg/yr)	4.05	1,480
NOx (kg/day)	0.09	18.16	0.70	NOx (kg/day, kg/yr)	18.95	6,916
Cost Effectiveness				**Cost Effectiveness**		
Delay Benefits ($/day)	$43	$8,331	$319	Delay Benefits ($/day, $/yr)	$8,694	$3,173,172
Fuel Benefits ($/day)	$9	$1,831	$70	Fuel Benefits ($/day, $/yr)	$1,911	$697,511
Total Benefits ($/day)	$53	$10,163	$389	Total Benefits ($/day, $/yr)	$10,605	$3,870,684