

Exhibit 34. Benefit Cost Analysis for Existing IMAP Sites by NCDOT Division

<u>Division</u>	Benefits (B)	Costs (C)	B / C Ratio	Net Worth (B-C)
5	\$4,528,800	\$436,900	10.4	\$4,091,900
7	\$3,454,300	\$436,700	7.9	\$3,017,600
9	\$701,100	\$610,600	1.1	\$90,500
10	\$12,382,000	\$1,762,700	7.0	\$10,619,300
12	\$888,400	\$379,000	2.3	\$509,400
14	**	\$285,700	**	(\$285,700)
Statewide	\$21,955,000	\$3,911,600	5.6	\$18,043,400

** Denotes negligible values

Exhibit 35. Planning and Benefit Cost Analysis Results for Raleigh and Asheville

Crashes per 100 Million Vehicle Miles Density



I-26 and I-40 Asheville

- 4-lane facility
- 15 miles in length
- 64000 ADT
- 303 crashes per year
- 4 FSP vehicles (estimated)
- 65th percentile ranking statewide
- B/C = 3.5 (Net worth \$464K)

I-440 Raleigh

- 6-lane facility
- 12 miles in length
- 82000 ADT
- 712 crashes per year
- 3 FSP vehicles (estimated)
- 85th percentile ranking statewide
- B/C = 4.3 (Net worth= \$461K)

Exhibit 36. Proposed Incident Data Collection Form.

IMAP Incident Event Collection Form		Date entered: _____										
Collected by: _____ Date: _____ Time: _____	<u>Response Time</u> (time in minutes from alert to arrival) Time: _____	<u>Truck Involved?</u> (circle one) Yes No										
<u>DOT District</u> _____	<u>Incident Duration</u> (time in minutes from arrival until clearance) Duration: _____	<u>Congestion Level</u> (circle one) None Slow Down Stop and Go										
<u>Location</u> Highway: _____ Milepost: _____ Direction: _____	<u>Response Vehicles</u> # of Vehicles responding: _____	<u>Weather</u> (circle one) Clear Cloudy Rain Snow										
<u>Injuries</u> # of Fatalities: _____ # of Injuries: _____	<u>EMS Present?</u> (circle one) Yes No	<u>Detection Method</u> (circle one) IMAP Patrol Police Motorist Call Detectors Other _____ _____										
<u>Shoulder Present?</u> (circle one) Yes No	<u>Police Present?</u> (circle one) Yes No											
<u>Shoulder Blockage?</u> (only the shoulder is blocked) Yes No	<u>Type of Incident</u> (circle one) Crash Non-Crash											
<u>Number of Lanes</u> Total # for road, one direction: _____	<u>Description of Incident</u> (circle all that apply)											
<u>Lane Blockage</u> Number of Lanes blocked: _____	<table border="0"> <tr> <td>Out of Fuel</td> <td>One Vehicle Crash</td> </tr> <tr> <td>Flat Tire</td> <td>Two Vehicle Crash</td> </tr> <tr> <td>Debris</td> <td>Multi-Vehicle Crash</td> </tr> <tr> <td>Disabled</td> <td>Workzone</td> </tr> <tr> <td>Abandoned</td> <td>Other _____</td> </tr> </table>		Out of Fuel	One Vehicle Crash	Flat Tire	Two Vehicle Crash	Debris	Multi-Vehicle Crash	Disabled	Workzone	Abandoned	Other _____
Out of Fuel	One Vehicle Crash											
Flat Tire	Two Vehicle Crash											
Debris	Multi-Vehicle Crash											
Disabled	Workzone											
Abandoned	Other _____											
<u>Posted Speed Limit</u> _____												

APPENDIX-TRB 2004 PRESENTATION



A Method for Prioritizing and Expanding Freeway Service Patrols

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Carolina Transportation Program

Outline of Presentation

- Project goals and objectives
- Literature review
- Methodology
- Data description and analysis
- Application tool
- Conclusions and recommendations



Project Goal and Objectives

- Develop data-driven criteria for FSP expansion in NC
- Review FSP studies in other areas, synthesize findings, explore implications for North Carolina
- Develop a decision-support tool to evaluate/rank current and future FSP projects



Review

- Nationwide B/C ratios range from 2:1 - 36:1
- Incident management can restore normal capacity— 20%+ incident duration reduction
- Puget Sound region FSP experienced 50% decrease in response times
- Maryland's CHART saved \$30.5 MM in delay and gasoline
- Most studies focus on evaluating existing programs, not identifying high-impact locations



Exhibit 16. Sample Rural Facility Delay Rate Models for Indicated Available % Capacities

15-min Incident Results for 4 Lane Rural Freeway

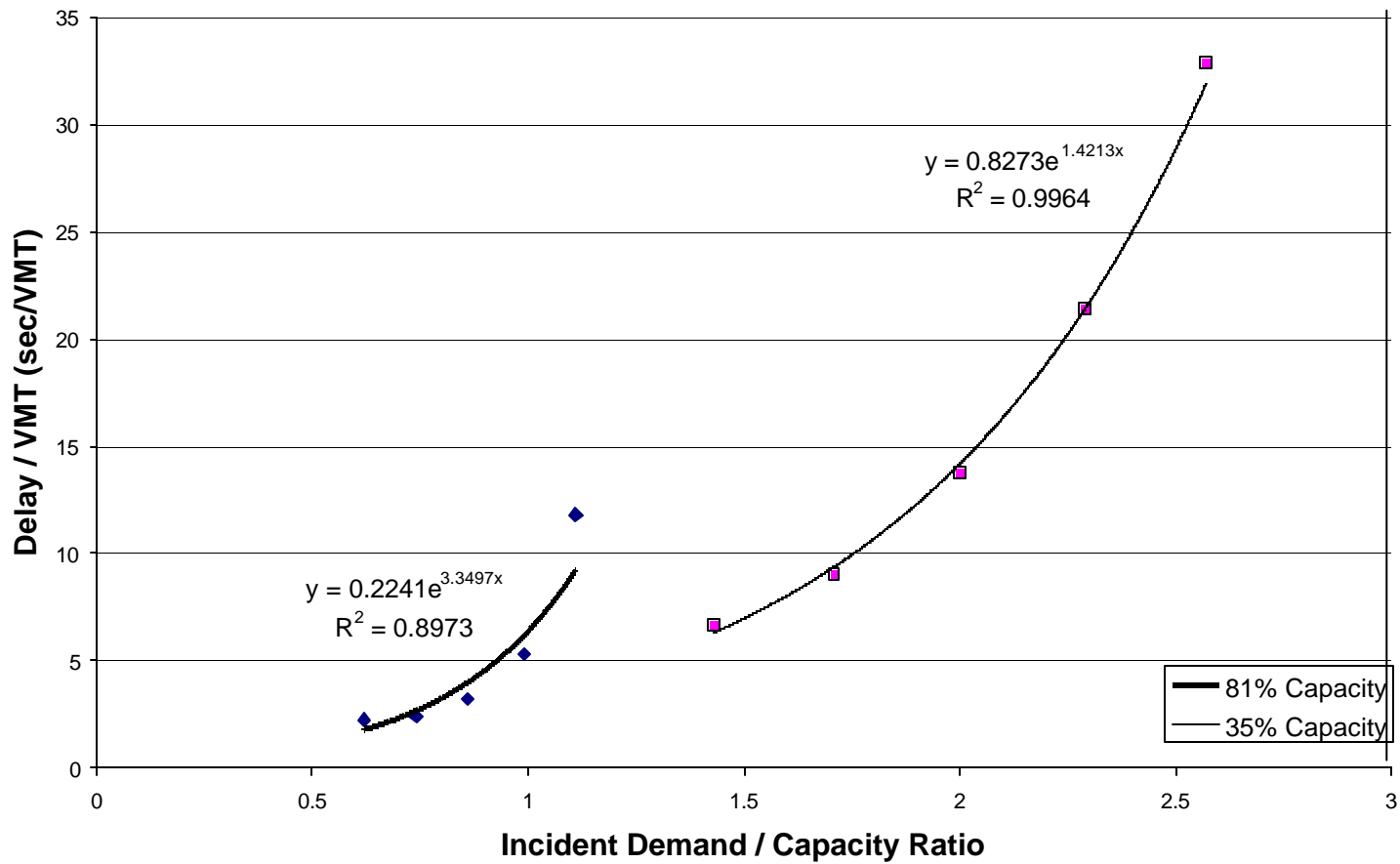


Exhibit 17. FREEVAL Derived Models

Scenario	Area Type	Number of Lanes per Direction	Duration of Incident (min)	Incident Severity	Model Results
1	Urban	2	15	Shoulder	1.0057 e ^{1.9612x}
2	Urban	2	15	1 Lane Blocked	1.4094 e ^{1.2185x}
3	Urban	2	30	Shoulder	0.6229 e ^{2.6077x}
4	Urban	2	30	1 Lane Blocked	2.6655 e ^{1.384 x}
5	Urban	2	45	Shoulder	0.3926 e ^{3.2306x}
6	Urban	2	45	1 Lane Blocked	15.354 x ^{2.4909}
7	Urban	2	60	Shoulder	0.2675 e ^{3.7515x}
8	Urban	2	60	1 Lane Blocked	24.248 x ^{2.7779}
9	Urban	3	15	Shoulder	0.5044 e ^{2.4111x}
10	Urban	3	15	1 Lane Blocked	0.3437 e ^{2.2839x}
11	Urban	3	15	2 Lanes Blocked	3.209 e ^{0.4832x}
12	Urban	3	30	Shoulder	0.3269 e ^{3.0136x}
13	Urban	3	30	1 Lane Blocked	5.1729 x ^{3.9196}
14	Urban	3	30	2 Lanes Blocked	12.287 e ^{0.4207x}
15	Urban	3	45	Shoulder	0.2021 e ^{3.6812x}
16	Urban	3	45	1 Lane Blocked	7.835 x ^{4.3996}
17	Urban	3	45	2 Lanes Blocked	20.948 e ^{0.4932}
18	Urban	3	60	Shoulder	0.1345 e ^{4.2429x}
19	Urban	3	60	1 Lane Blocked	10.917 x ^{4.8819}
20	Urban	3	60	2 Lanes Blocked	19.925 x ^{2.1499}
21	Urban	4	15	Shoulder	0.2474 e ^{3.0174}
22	Urban	4	15	1 Lane Blocked	0.0891 e ^{3.4091x}
23	Urban	4	15	2 Lanes Blocked	1.6222 e ^{0.8647x}
24	Urban	4	30	Shoulder	0.1778 e ^{3.4842x}
25	Urban	4	30	1 Lane Blocked	3.9857 x ^{5.4076}
26	Urban	4	30	2 Lanes Blocked	7.2621 e ^{0.709x}
27	Urban	4	45	Shoulder	0.1199 e ^{4.0404x}
28	Urban	4	45	1 Lane Blocked	5.257 x ^{6.361}
29	Urban	4	45	2 Lanes Blocked	12.547 e ^{0.7931x}
30	Urban	4	60	Shoulder	0.0813 e ^{4.5901x}
31	Urban	4	60	1 Lane Blocked	6.643 x ^{7.1851}
32	Urban	4	60	2 Lanes Blocked	19.537 x ^{2.5227}
33	Urban	5	15	Shoulder	0.2643 e ^{2.9606x}
34	Urban	5	15	1 Lane Blocked	0.0731 e ^{3.7605x}
35	Urban	5	15	2 Lanes Blocked	0.4731 e ^{1.81x}

Exhibit 17. FREEVAL Derived Models (continued)

<u>Scenario</u>	Area Type	Number of Lanes per Direction	Duration of Incident (min)	Incident Severity	Model Form
36	Urban	5	30	Shoulder	$0.2166 e^{3.2508x}$
37	Urban	5	30	1 Lane Blocked	$0.023 e^{5.2249x}$
38	Urban	5	30	2 Lanes Blocked	$6.1435 x^{2.9175}$
39	Urban	5	45	Shoulder	$0.1685 e^{3.6167x}$
40	Urban	5	45	1 Lane Blocked	$0.0098 e^{6.3267x}$
41	Urban	5	45	2 Lanes Blocked	$11.765 x^{2.9978}$
42	Urban	5	60	Shoulder	$0.1282 e^{4.0148x}$
43	Urban	5	60	1 Lane Blocked	$0.0048 e^{7.2413x}$
44	Urban	5	60	2 Lanes Blocked	$18.61 x^{3.269}$
45	Rural	2	15	Shoulder	$0.2241 e^{3.3497x}$
46	Rural	2	15	1 Lane Blocked	$0.8273 e^{1.4213x}$
47	Rural	2	30	Shoulder	$0.1338 e^{4.0456x}$
48	Rural	2	30	1 Lane Blocked	$7.6142 x^{2.39}$
49	Rural	2	45	Shoulder	$0.0874 e^{4.6202x}$
50	Rural	2	45	1 Lane Blocked	$14.421 x^{2.5209}$
51	Rural	2	60	Shoulder	$0.0615 e^{5.0878x}$
52	Rural	2	60	1 Lane Blocked	$23.904 x^{2.7703}$
53	Rural	3	15	Shoulder	$0.0977 e^{4.0555x}$
54	Rural	3	15	1 Lane Blocked	$0.1484 e^{2.7794x}$
55	Rural	3	15	2 Lanes Blocked	$2.5949 e^{0.5141x}$
56	Rural	3	30	Shoulder	$0.0656 e^{4.6082x}$
57	Rural	3	30	1 Lane Blocked	$4.324 x^{4.2185}$
58	Rural	3	30	2 Lanes Blocked	$13.167 e^{0.3841x}$
59	Rural	3	45	Shoulder	$0.041 e^{5.2607x}$
60	Rural	3	45	1 Lane Blocked	$6.9167 x^{4.5917}$
61	Rural	3	45	2 Lanes Blocked	$19.767 e^{0.4882x}$
62	Rural	3	60	Shoulder	$0.0285 e^{5.7633x}$
63	Rural	3	60	1 Lane Blocked	$10.036 x^{5.0181}$
64	Rural	3	60	2 Lanes Blocked	$20.683 x^{2.0521}$
65	Rural	4	15	Shoulder	$0.0414 e^{4.8981x}$
66	Rural	4	15	1 Lane Blocked	$0.0233 e^{4.3598x}$
67	Rural	4	15	2 Lanes Blocked	$1.2976 e^{0.9163x}$
68	Rural	4	30	Shoulder	$0.031 e^{5.3075x}$
69	Rural	4	30	1 Lane Blocked	$2.8649 x^{6.4143}$
70	Rural	4	30	2 Lanes Blocked	$7.6089 e^{0.6761x}$
71	Rural	4	45	Shoulder	$0.0212 e^{5.8451x}$
72	Rural	4	45	1 Lane Blocked	$3.9051 x^{7.2473}$

Exhibit 17. FREEVAL Derived Models (continued)

Scenario	Area Type	Number of Lanes per Direction	Duration of Incident (min)	Incident Severity	Model Form
73	Rural	4	45	2 Lanes Blocked	$13.749 e^{0.7397x}$
74	Rural	4	60	Shoulder	$0.0146 e^{6.3674x}$
75	Rural	4	60	1 Lane Blocked	$4.9955 x^{8.0031}$
76	Rural	4	60	2 Lanes Blocked	$24.686 x^{2.2331}$
77	Rural	5	15	Shoulder	$0.0443 e^{4.9055x}$
78	Rural	5	15	1 Lane Blocked	$0.0148 e^{5.0173x}$
79	Rural	5	15	2 Lanes Blocked	$0.2984 e^{2.0305x}$
80	Rural	5	30	Shoulder	$0.0374 e^{5.1516x}$
81	Rural	5	30	1 Lane Blocked	$0.0049 e^{6.4393x}$
82	Rural	5	30	2 Lanes Blocked	$5.8554 x^{2.9402}$
83	Rural	5	45	Shoulder	$0.0301 e^{5.4684x}$
84	Rural	5	45	1 Lane Blocked	$4.6166 x^{7.798}$
85	Rural	5	45	2 Lanes Blocked	$11.964 x^{2.9056}$
86	Rural	5	60	Shoulder	$0.0234 e^{5.8313x}$
87	Rural	5	60	1 Lane Blocked	$5.7617 x^{8.7629}$
88	Rural	5	60	2 Lanes Blocked	$19.208 x^{3.1466}$

Exhibit 18. Fleet Size Estimation: Regression Model

**Number of Vehicles vs AADT and Centerline
Length of Coverage by NCDOT Division**

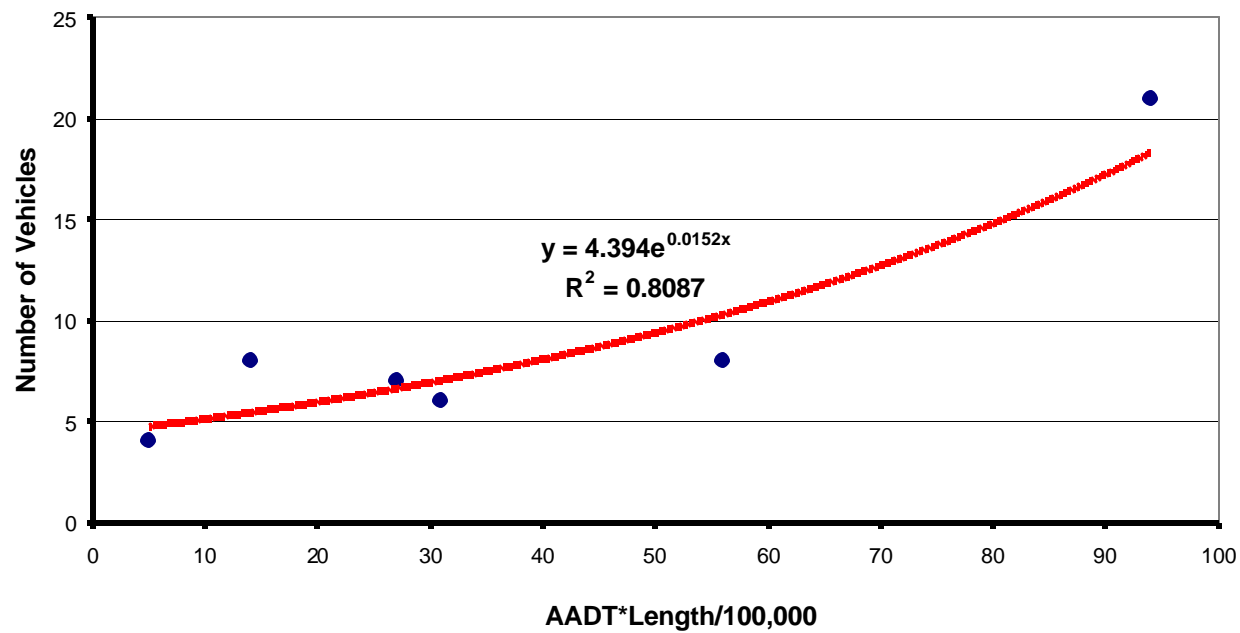


Exhibit 19. Annual Reported IMAP Expenditures by NCDOT Division

Division	Driver Salary (# of Drivers)	Supervisor Salaries	Vehicle Cost w/o Fuel (# of Vehicles)	Equipment Costs	Miscellaneous Costs	<i>Total Costs</i>
5	\$210,700 (7)	\$73,900	\$140,100 (7)	\$7,400	\$4,800	\$436,900
7	\$240,800 (8)	\$15,700	\$156,000 (5)	\$8,600	\$15,600	\$436,700
9	\$235,300 (8)	\$60,500	\$299,500 (9)	\$11,300	\$4,000	\$610,600
10	\$788,000 (21)	\$149,900	\$816,700 (10)	\$4,800	\$3,300	\$1,762,700
12	\$173,600 (6)	\$37,200	\$149,800 (4)	\$7,600	\$10,800	\$379,000
14	\$131,300 (4)	\$52,400	\$78,000 (2)	\$16,900	\$7,100	\$285,700
Total	\$1,779,700 (52)	\$389,600	\$1,640,100 (37)	\$56,600	\$45,600	\$3,911,600

Notes: (1) Cost data given as provided by NCDOT.
(2) Driver salary figures do not include any overhead factor.
(3) Number of supervisors may vary by division and may include part time supervisors.

Exhibit 20. Annual IMAP Implementation Cost/ Route Mile by NCDOT Division

Division	Length of Route (Centerline Miles)	Total Annual Cost	Total Annual Cost per Route Mile
5	43	\$436,900	\$10,200
7	81	\$436,700	\$5,400
9	75	\$610,600	\$8,100
10	108	\$1,762,700	\$16,300
12	57	\$379,000	\$6,600
14	20	\$285,700	\$14,300
		Average Cost	\$10,200

Note: Cost data as provided by NCDOT.

Exhibit 21. Annual Cost per Operating Hour per Week by NCDOT Division

Division	Total Hours Patrolled Weekly	Total Annual Cost	Total Annual Cost per Operating Hour per Week
5	70	\$436,900	\$6,200
7	85	\$436,700	\$5,100
9	80	\$610,600	\$7,600
10	96	\$1,762,700	\$18,400
12	80	\$379,000	\$4,700
14	168	\$285,700	\$1,700
Average Cost			\$7,300

Note: (1) Cost data as provided by NCDOT.

(2) Number of weeks patrolled per year may vary by location.

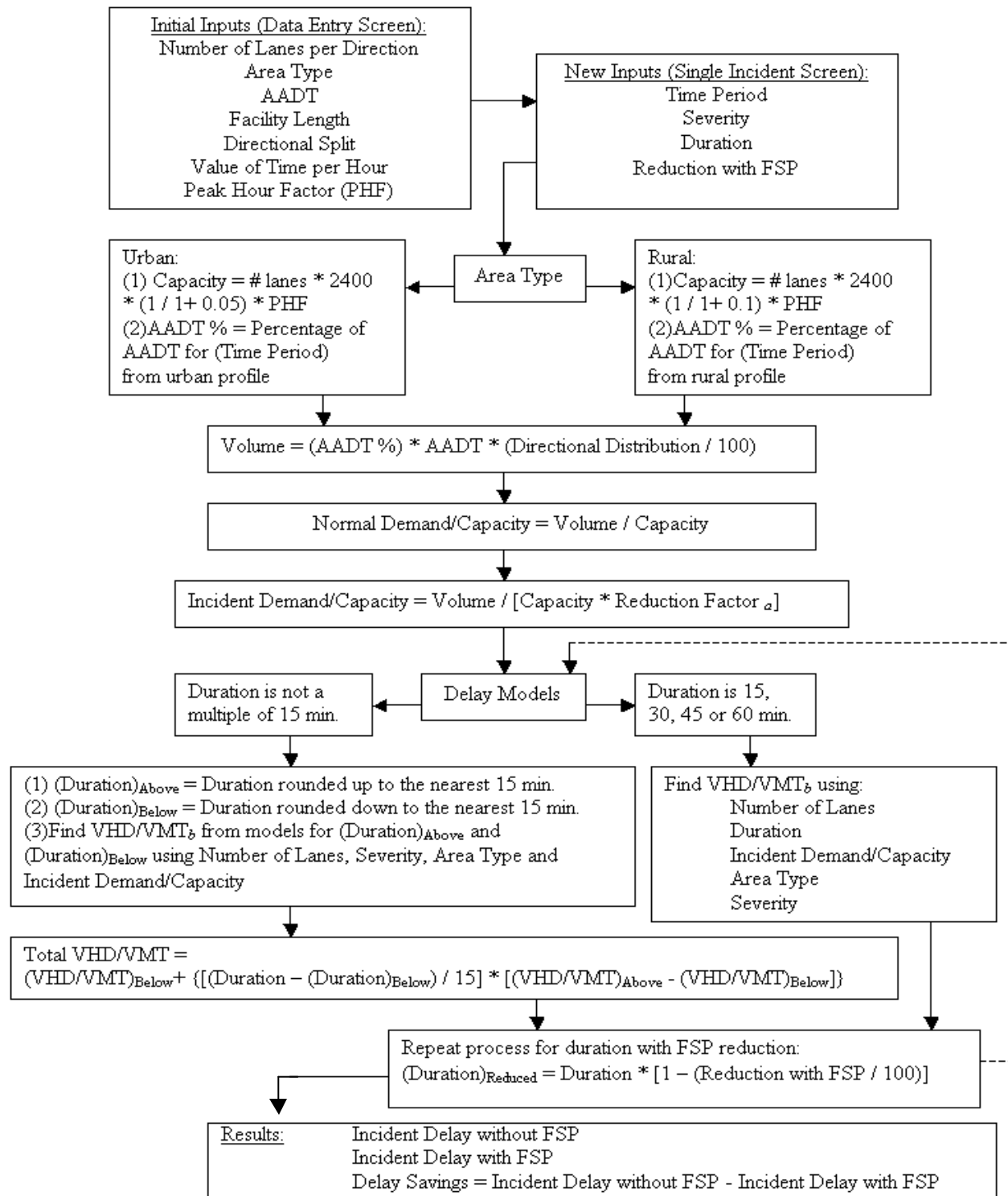
Exhibit 22. IMAP Hourly Costs by NCDOT Division

Division	Total Annual Cost	Total Hours Patrolled Annually	Total Trucks	Hourly Cost per Truck per Hour
5	\$436,900	3600	7	\$17.30
7	\$436,700	3840	8	\$14.20
9	\$610,600	3600	8	\$21.20
10	\$1,762,700	4608	21	\$18.20
12	\$379,000	4608	6	\$13.70
14	\$285,700	8640	4	\$8.30
Average Hourly Cost per Truck				\$15.50
Weighted Average Cost^a				\$16.70

^a Averages are weighted by multiplying the hourly costs times the total trucks for each division, summing the values for all divisions, and dividing by the total number of vehicles

Note: (1) Cost data provided by NCDOT.
(2) Number of weeks patrolled per year may vary by location.

Exhibit 23. Single-Incident Decision Flowchart



^a from Highway Capacity Manual 2000

^b VHD stands for Vehicle Hours of Delay and VMT stands for Vehicle Miles Traveled

Exhibit 24 Decision Support Tool Introductory Screen

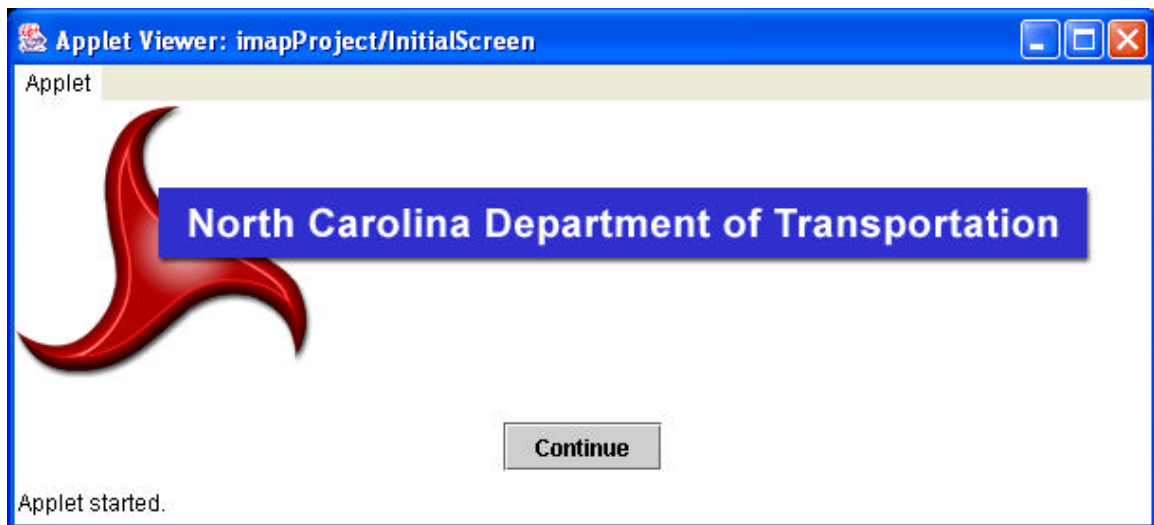


Exhibit 25. Decision-Support Tool Primary Data Entry Screen

NCDOT IMAP Data Entry Menu

File

Facility Name I-440 in Raleigh

County Wake **Area Type:** Urban ▼

Facility Length: 10.44 miles **Number of Lanes Per Direction:** 3 ▼

AADT: 82038 **Directional Distribution:** 60/40 ▼

Annual Total Crashes: 712 **PHF:** 0.90 ▼ **Value of Time:** \$10/hr ▼ **Help**

Planning Level Assessment **Single Incident Assessment** **Operational Benefits Assessment**

Java Applet Window

Exhibit 26. Planning Level Assessment Screen

Planning Level Assessment

File

I-440 IN RALEIGH, WAKE COUNTY

Overall Statewide Ranking

Comparison Criterion	Facility Average	Statewide Average	Statewide Ranking
Crashes per 100 M vehicle miles	227.75	116.41	85
Crashes per mile per year	68.19	22.47	90
AADT per lane	16400	9998	85

Non-IMAP Statewide Ranking

Comparison Criterion	Facility Average	Statewide Average	Statewide Ranking
Crashes per 100 M vehicle miles	227.75	106.97	90
Crashes per mile per year	68.19	13.46	95
AADT per lane	16400	7805	95

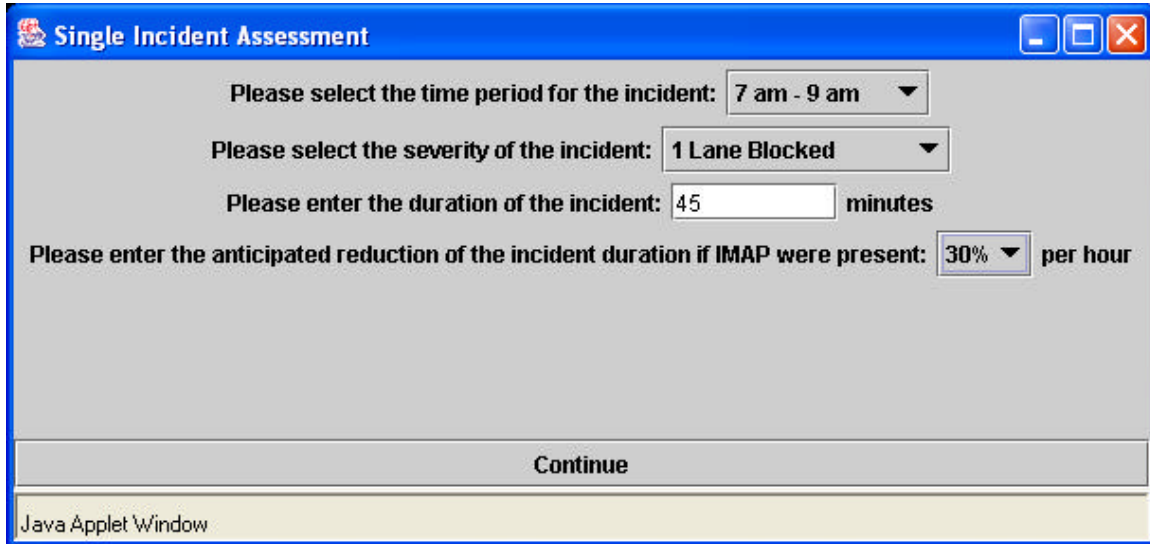
IMAP Statewide Ranking

Comparison Criterion	Facility Average	Statewide Average	Statewide Ranking
Crashes per 100 M vehicle miles	227.75	133.78	85
Crashes per mile per year	68.19	39.04	85
AADT per lane	16400	14034	70

[Help](#) [Continue](#)

Java Applet Window

Exhibit 27. Single-Incident Input Assessment Screen



A screenshot of a Java Applet window titled "Single Incident Assessment". The window has a blue title bar with standard minimize, maximize, and close buttons. The main area is a light gray form with four input fields. The first field is a dropdown menu for "Please select the time period for the incident:" with "7 am - 9 am" selected. The second field is a dropdown menu for "Please select the severity of the incident:" with "1 Lane Blocked" selected. The third field is a text input for "Please enter the duration of the incident:" with "45" entered, followed by the text "minutes". The fourth field is a dropdown menu for "Please enter the anticipated reduction of the incident duration if IMAP were present:" with "30%" selected, followed by the text "per hour". At the bottom of the form is a "Continue" button. Below the form is a yellow status bar that says "Java Applet Window".

Single Incident Assessment

Please select the time period for the incident: 7 am - 9 am ▼

Please select the severity of the incident: 1 Lane Blocked ▼





Please enter the duration of the incident: 45 minutes

Please enter the anticipated reduction of the incident duration if IMAP were present: 30% ▼ per hour

Continue

Java Applet Window

Exhibit 28. Single Incident Analysis Results Screen


Single Incident Results




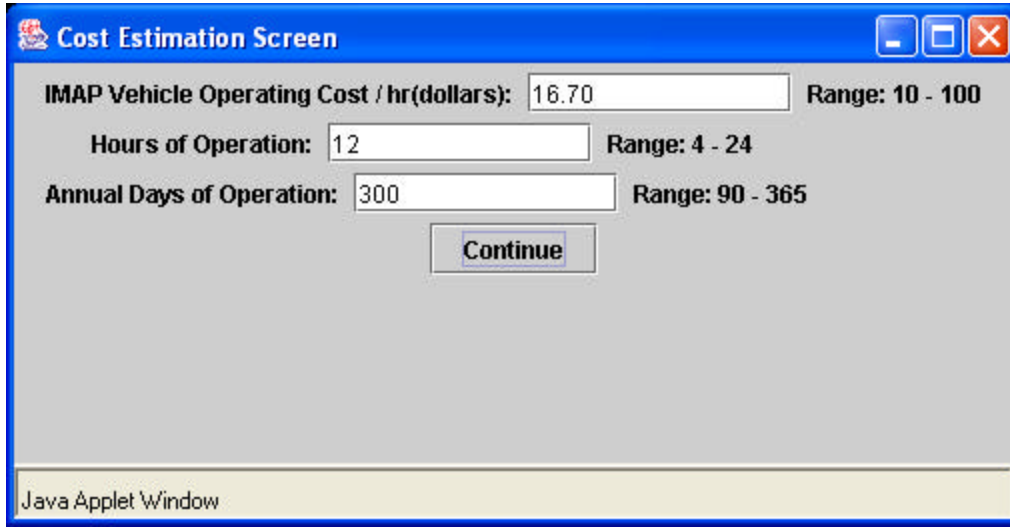
Facility Input Data		Incident Data	
Facility: I-440 IN RALEIGH		Time of Incident: 7 am - 9 am	
WAKE County		Severity: 1 Lane Blocked	
Length: 10.44 miles		Duration: 45 minutes	
Area Type: Urban		IMAP Reduction: 30%	
Number of Lanes per Direction: 3		Value of Time: \$10 /hr	
AADT: 82038	PHF: 0.9	Peak Hour Volume: 3337 vph	

Results for Single Incident

Measure	Units	Without IMAP	With IMAP	Benefits
Facility Delay	veh hrs	211	138	72
Delay/VMT	sec/VMT	14	9	5
Delay/Vehicle	sec	152	99	52
Delay Cost/hr	dollars/hr	\$2110	\$1380	\$720

Java Applet Window

Exhibit 29. Cost Estimation Input Screen



The image shows a Java Applet Window titled "Cost Estimation Screen". It contains three input fields with their respective ranges:

- IMAP Vehicle Operating Cost / hr(dollars): 16.70 Range: 10 - 100
- Hours of Operation: 12 Range: 4 - 24
- Annual Days of Operation: 300 Range: 90 - 365

A "Continue" button is located below the input fields. The window has a blue title bar and standard window controls (minimize, maximize, close) in the top right corner. The bottom of the window displays "Java Applet Window".

Exhibit 30. Fleet Size Estimation Screen

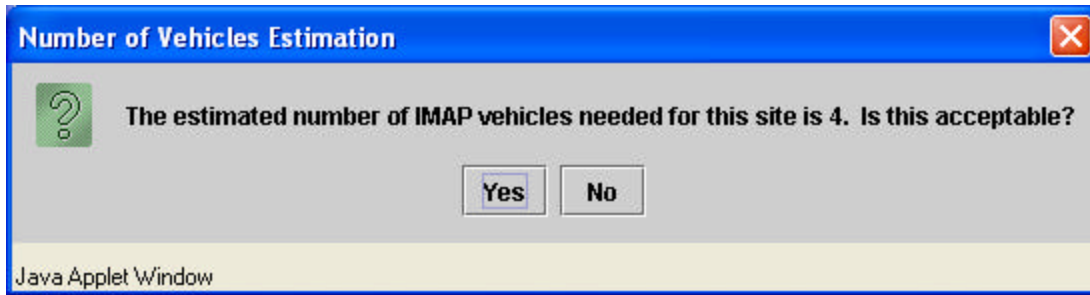


Exhibit 31. Operational Analysis Results Screen

Operational Benefits Results

File

Facility Input Data:
Facility: I-440 IN RALEIGH, WAKE County **Length:** 10.44 miles **Area Type:** Urban **Number of Lanes per Direction:** 3
AADT: 82038 **PHF:** 0.9

Annual Delays(Vehicle Hours)

Incident Category	With IMAP(Peak)	No IMAP(Peak)	With IMAP(Off-Pe...	No IMAP(Off-Peak)	Savings(Peak)	Savings(Off-Peak)	Total
Shoulder	54462	54462	54188	54188	0	0	0
1 Lane Closures	24497	35501	11424	14784	11004	3024	14364
2 Lane Closures	33088	51821	37741	65283	18733	27495	46275
TOTALS	112047	141784	103353	134255	29737	30519	60639

Benefit/Cost Summary:
Number of Vehicles: 3 **Operating Cost per Hour:** \$16.7 **Hours of Operation:** 12 **Annual Days of Operation:** 300 **Value of Time:** \$10 per hour

Comparison Criterion	Annual Benefits	Annual Costs	Benefit/Cost
Excluding Two Lane Closures	\$143640	\$180360	0.79
Including Two Lane Closures	\$606390	\$180360	3.36

Java Applet Window

Exhibit 32. Planning Analysis Results for Existing IMAP Sites- All Sites

Division	Location	Crashes per 100 Million Vehicle Miles (% rank for all sites)	Crashes per Mile per Year (% rank for all sites)	AADT per Lane (% rank for all sites)
5	I-40 Triangle	70	80	90
5	I-85 Triangle	70	75	95
7	I-40 Greensboro	75	85	95
7	I-85 Greensboro	70	75	65
7	I-40 and I-85 Greensboro	55	75	75
9	US 52 Winston-Salem	75	75	80
9	US 421 Winston-Salem	65	70	80
9	I-40 Winston-Salem	50	65	75
9	I-40 Bus. Winston-Salem	75	75	90
10	I-85 Charlotte	65	75	85
10	I-77 Charlotte	70	85	95
10	I-277 Charlotte	85	85	80
10	I-485 Charlotte	**	**	**
12	I-40 Statesville	55	60	80
12	I-77 Statesville	50	60	80
14	I-40 Haywood	45	35	15

** Denotes No Data

Exhibit 33. Planning and Operational Analysis Data for Existing IMAP Sites

Division	Location	Operating Hours	Length (Miles)	AADT	No. Lanes	Crashes per Year
5	I-40 Triangle	6 am to 8:30 pm M-F	28	89000	6	971
5	I-85 Triangle	6 am to 8:30 pm M-F	16	70800	4	402
7	I-40 Greensboro	5 am to 10 pm M-F	14	87000	4	534
7	I-85 Greensboro	5 am to 10 pm M-F	5	58000	6	103
7	I-40 and I-85 Greensboro	5 am to 10 pm M-F	39	87000	8	880
9	US 52 Winston-Salem	5:30 am to 9 pm M-F	18	47000	4	394
9	US 421 Winston-Salem	5:30 am to 9 pm M-F	3	49000	4	50
9	I-40 Winston-Salem	5:30 am to 9 pm M-F	23	65000	6	317
9	I-40 Business Winston-Salem	5:30 am to 9 pm M-F	10	56000	4	239
10	I-85 Charlotte	5:30 am to 9:30 pm M-F and 10 am to 6 pm Sat and Sun	55	80000	6	1361
10	I-77 Charlotte	5:30 am to 9:30 pm M-F and 10 am to 6 pm Sat and Sun	30	100000	6	1159
10	I-277 Charlotte	5:30 am to 9:30 pm M-F and 10 am to 6 pm Sat and Sun	5	72000	6	250
10	I-485 Charlotte	5:30 am to 9:30 pm M-F and 10 am to 6 pm Sat and Sun	**	**	**	**
12	I-40 Statesville	5:30 am to 9 pm M-F	33	48000	4	400
12	I-77 Statesville	5:30 am to 9 pm M-F	24	48000	4	272
14	I-40 Haywood County	24 hours a day, 7 days a week	20	24000	2	100

** Denotes No Data