

 **VDOT**

The logo for the Virginia Department of Transportation (VDOT). It features a stylized orange icon on the left that resembles a road or a ribbon curving upwards and then downwards. To the right of this icon, the letters "VDOT" are written in a bold, blue, sans-serif font.



# Baltimore-Washington Regional Traffic Signal Forum

## Traffic Signal Optimization

Nhan Vu  
Systems Operations Manager  
VDOT

March 14, 2007



## Congestion Cost (2003)

Urban Area	\$ (millions)	Rank
Los Angeles, CA	\$12,840	1
New York NY- Northeastern, NJ	\$8,435	2
Chicago, IL-Northwestern, IN	\$4,170	3
San Francisco-Oakland, CA	\$3,380	4
Dallas-Fort Worth, TX	\$2,735	5
<b>Washington, DC-MD-VA</b>	<b>\$2,490</b>	<b>6</b>

Congestion Cost – Value of travel time delay and excess fuel consumption

Urban Mobility Study, Texas Transportation Institute 2003

Urban Area	\$ (millions)	Rank
Los Angeles, CA	\$10,686	1
New York NY- Northeastern, NJ	\$6,780	2
Chicago, IL-Northwestern, IN	\$4,274	3
San Francisco-Oakland, CA	\$2,605	4
Dallas-Fort Worth, TX	\$2,545	5
Miami, FL	\$2,486	6
<b>Washington, DC-MD-VA</b>	<b>\$2,465</b>	<b>7</b>

Congestion Cost – Value of travel time delay and excess fuel consumption

Urban Mobility Study, Texas Transportation Institute 2005

**IMPROVE**

Improve Traffic Flow, Safety

**QUALITY**

Reduce Travel Time, Delay Stops, Fuel  
Consumption and Emissions

**OF LIFE**

**PROACTIVELY**

Provide Optimal Signal Coordination

**MANAGE THE**

Improve System Response Time

Through Real-time Monitoring of Traffic

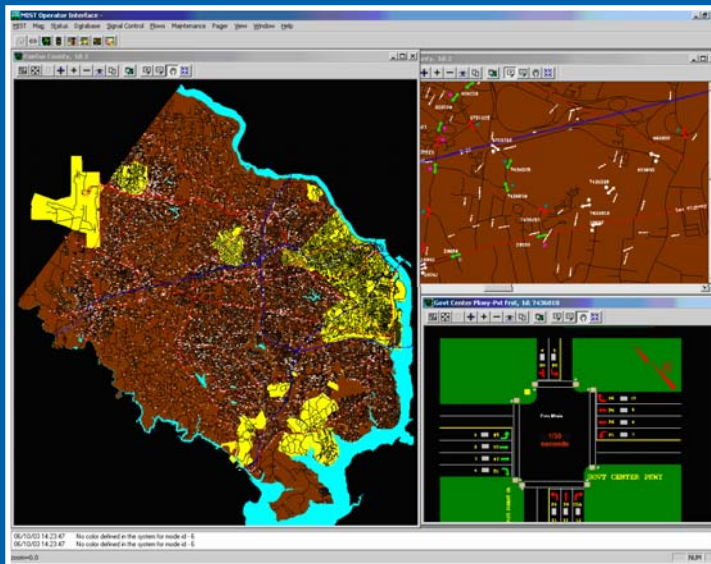
Signal System Status

**TRANSPORTATION**

**NETWORK**

## MIST (Management Information System for Transportation)

- Completed in 1998
- Fairfax, Prince William, and Loudoun Counties
- Over 1200 Signals
- 15,000 detectors

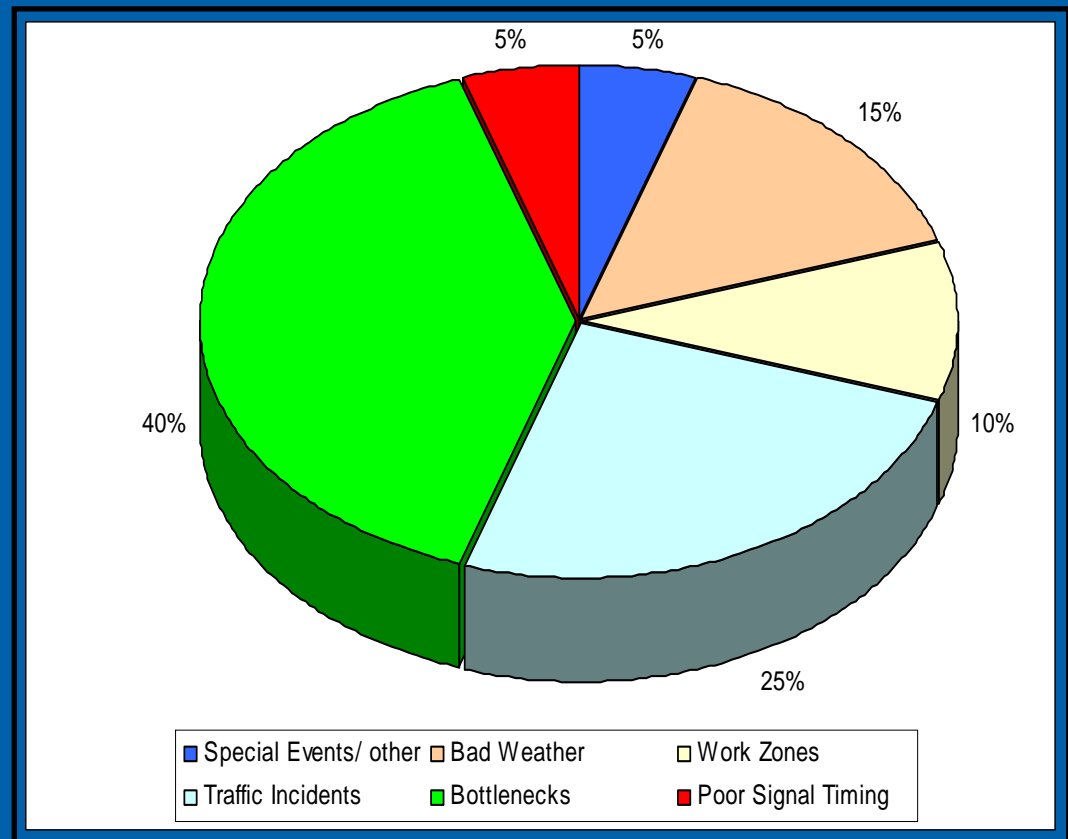


- Traffic Data Collection
  - Volume, Speed, and Occupancy
- Real-time Traffic Control
  - Upload and Download Signal Timing
- Real-time Traffic Monitoring
  - Failure Alarms
  - Traffic Flow

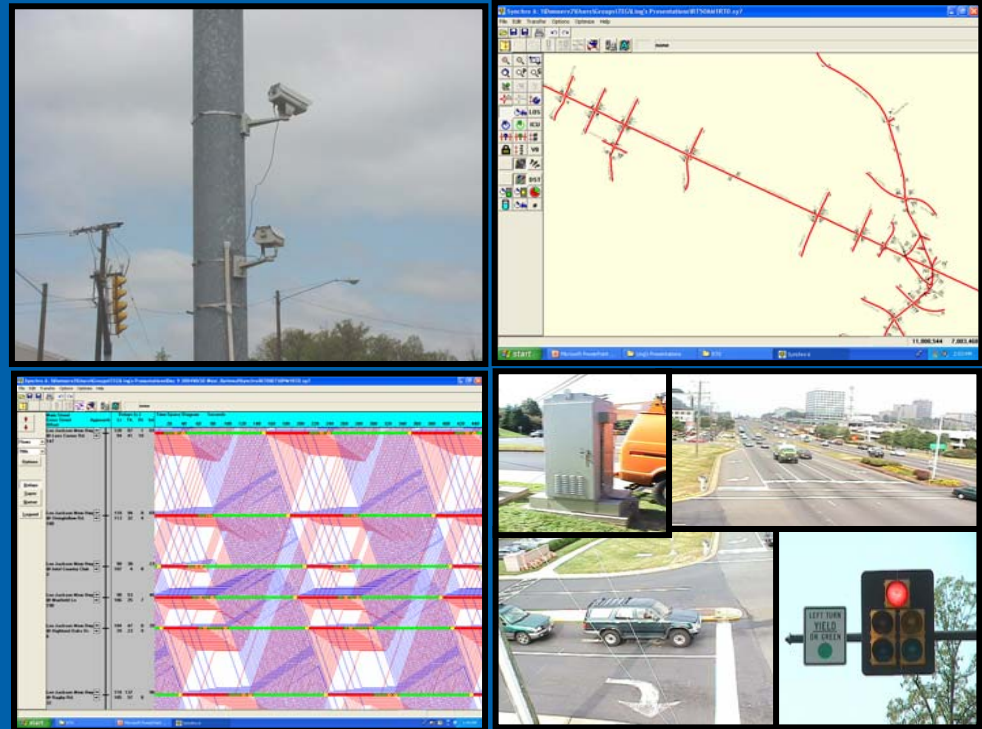
- Traffic Signals Not Optimized (Re-timed) Until 1991
- VDOT Staff Began Effort in 1998
- Consultants Brought on Board in 1999
- First Round Completed in 2002 (806)
- Second Round in Progress

## Signal Timing Optimization

- Recurring
- Non-recurring



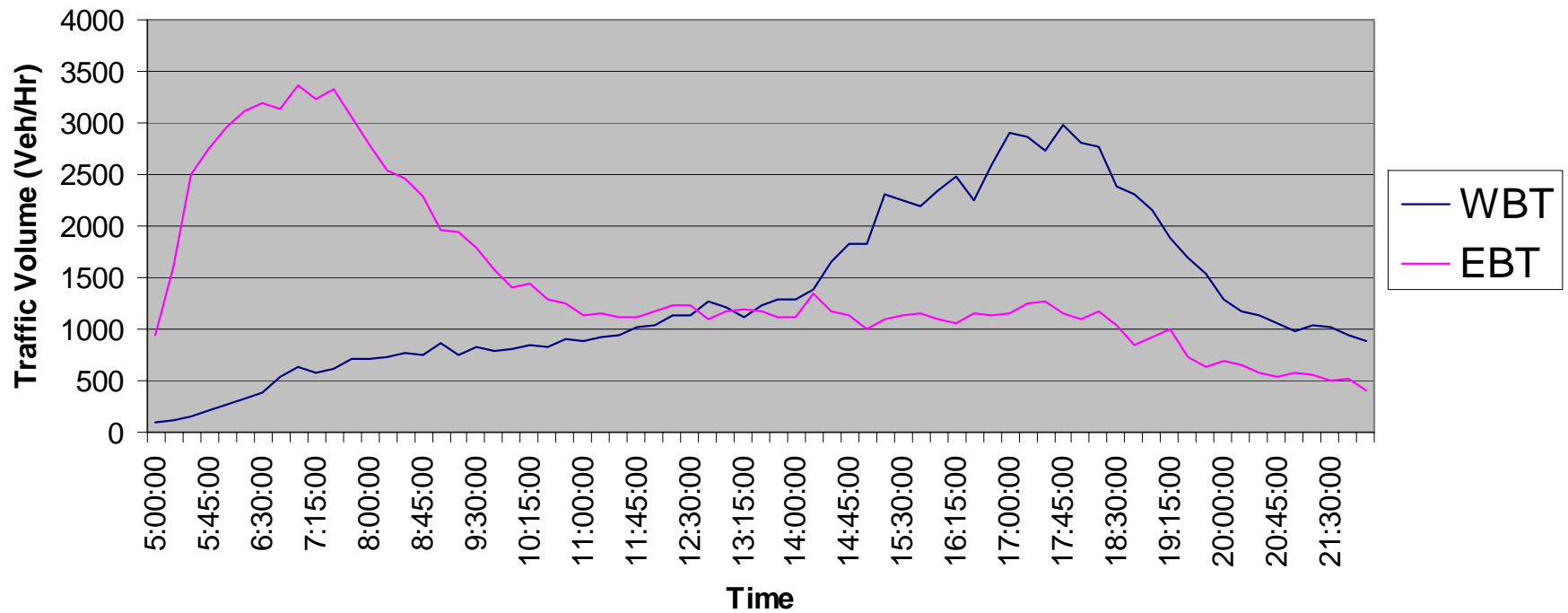
- Data Collection
- Data Analysis
- Network Setup
- Optimization
- Simulation
- Implementation & Fine Tuning
- Evaluation & Recommendation

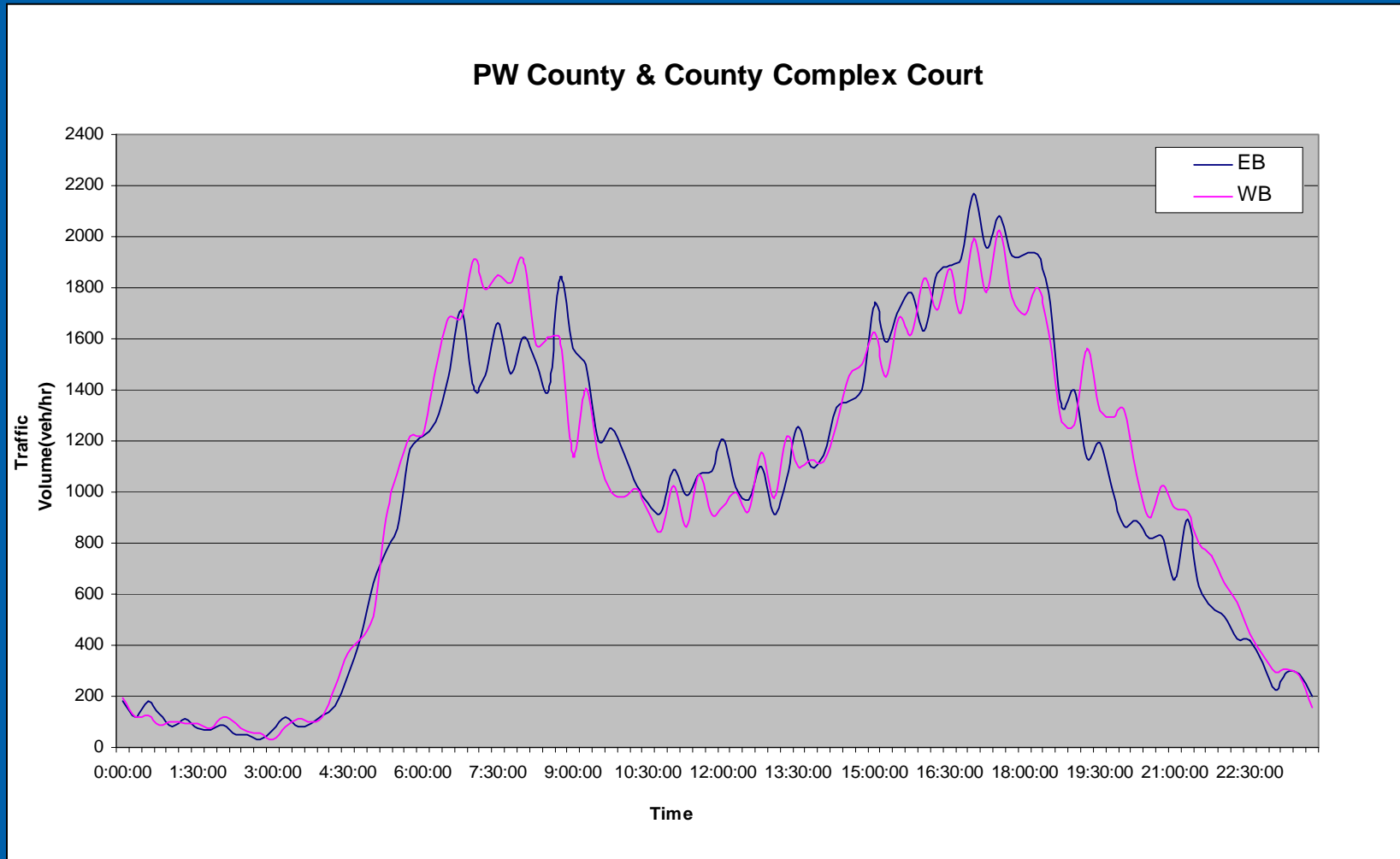


- Intersection Geometry
- Existing Signal Timings
- Turning Movement Counts (TMC)



## Old Bridge Road and Rolling Brook Drive







# Network Setup

- Synchro (Signal Optimization Software, Used by Traffic Engineers Nationwide)

Synchro 6: W:\mserv\21\ansrv2d1\Groups\TEG12004 Clearance Time\Reviewed\SILN01\Synchro\RT1\WD Plans\SFLN01AMRT1.sy7

File Edit Transfer Options Optimize Help

2 Richmond Hwy & Huntington Ave

TIMING WINDOW		EBL	EBT	EBR	WBL	WBT	WBR	SEL	SET	SER	NWL	NWT	NWR	PED	HOLD
Controller Type:	Lanes and Sharing (#RL)	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔		
Actuated-Coordi	Traffic Volume (vph)	380	2400	27	60	916	1	140	184	164	28	540	1		
Cycle Length: 180.0	Turn Type	Prot	Perm	Prot	Perm	pm+pt	Perm	pm+pt							
Actuated C.L.: 180.0	Protected Phases	5	2		1	6		7	4		3	8			
Natural C.L.: 125.0	Permitted Phases		2					4		4	8				
Max v/c Ratio: 0.88	Detector Phases	5	2	2	1	6		7	4	4	3	8			
Int. Delay: 31.6	Minimum Initial (s)	8.0	20.0	20.0	5.0	20.0		5.0	8.0	8.0	5.0	8.0			
Int. LOS: C	Minimum Split (s)	15.5	27.5	27.5	12.5	27.5		12.0	15.0	15.0	12.0	40.0			
ICU: 86.6%	Total Split (s)	45.5	92.5	92.5	22.0	69.0		25.5	47.0	47.0	18.5	40.0			
ICU LOS: E	Yellow Time (s)	4.5	4.5	4.5	4.5	4.5		4.0	4.0	4.0	4.0	4.0			
Lock Timings	All-Red Time (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0	3.0	3.0	3.0			
Offset Settings	Lead/Lag	Lead	Lead	Lead	Lag	Lag		Lead	Lag	Lag	Lead	Lag			
Offset: 139.0	Allow Lead/Lag Optimize?	Fixed	Fixed	Fixed	Fixed	Fixed		Fixed	Fixed	Fixed	Fixed	Fixed			
Begin of Yellow	Recall Mode	None	C-Min	C-Min	None	C-Min		None	None	None	None	None			
2+6 - EBT WBT	Actuated Effct. Green (s)	28.7	96.6	96.6	13.0	80.9		61.4	48.7	48.7	48.2	35.8			
Master	Actuated g/C Ratio	0.16	0.54	0.54	0.07	0.45		0.34	0.27	0.27	0.27	0.20			
Single	Volume to Capacity Ratio	0.69	0.88	0.03	0.24	0.40		0.50	0.19	0.30	0.08	0.77			
	Control Delay (s)	84.1	21.5	4.7	52.6	9.7		47.6	51.1	7.6	35.7	71.6			
	Queue Delay (s)	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0			
	Total Delay (s)	84.1	21.5	4.7	52.6	9.7		47.6	51.1	7.6	35.7	71.6			
	Level of Service	F	C	A	D	A		D	D	A	D	E			
	Approach Delay (s)	29.9			12.4			35.5			69.9				
	Approach LOS		C			B			D			E			
	Queue Length 50th (ft)	202	804	1	35	58		115	88	0	19	317			
	Queue Length 95th (ft)	251	917	m4	m60	338		173	126	62	m37	392			
	Clearance (ft)	323	1733	7	55	430		00	120	10	00	504			

LANE WINDOW	EBL	EBT	EBR	WBL	WBT	WBR	SEL	SET	SER	NWL	NWT	NWR
Lanes and Sharing (#RL)	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔
Ideal Satd. Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width (ft)	12	12	12	12	12	12	12	12	12	12	12	12
Grade (%)	0	0	0	0	0	0	0	0	0	0	0	0
Area Type	Other	Other	Other	Other	Other	Other	Other	Other	Other	Other	Other	Other
Storage Length (ft)	460	150	210	450	425	180	0	0	0	0	0	0
Storage Lanes (#)	2	1	2	1	1	1	0	0	0	0	0	0
Total Lost Time (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Leading Detector (ft)	35	200	5	35	200	5	35	35	5	35	35	5
Trailing Detector (ft)	-5	100	0	-5	100	0	-5	-5	0	-5	-5	0
Turning Speed (mph)	15	9	15	15	9	15	15	9	15	15	9	15
Right Turn Channelized	None	None	None	None	None	None	None	None	None	None	None	None
Curb Radius (ft)	50	50	50	50	50	50	50	50	50	50	50	50
Add Lanes (#)	0	0	0	0	0	0	0	0	0	0	0	0

VOLUME WINDOW	EBL	EBT	EBR	WBL	WBT	WBR	SEL	SET	SER	NWL	NWT	NWR
Traffic Volume (vph)	380	2400	27	60	916	1	140	184	164	28	540	1
Conflicting Peds. (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Conflicting Bikes (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Growth Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Heavy Vehicles (%)	2	2	2	2	2	2	2	2	2	2	2	2
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Adj. Parking Lane?	No	No	No	No	No	No	No	No	No	No	No	No
Parking Maneuvers (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Traffic from mid-block (%)	0	0	0	0	0	0	0	0	0	0	0	0
Link OD Volumes	EB	WB	SE	NW								
Adjusted Flow (vph)	380	2400	27	60	916	1	140	184	164	28	540	1
Lane Group Flow (vph)	380	2400	27	60	917	0	140	184	164	28	541	0

Number of lanes and sharing. (0 to 8, L, R) v/c ok Mins ok



# Optimization Minnieville Rd. & Prince William Co. Pkwy.

Before →

Options >		TIMING WINDOW													
Controller Type:		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	PED	HOLD
Actuated-Coordination		Lanes and Sharing (#RL)													
Cycle Length: 180.0		Traffic Volume (vph)													
Actuated C.L.: 180.0		Turn Type													
Natural C.L.: 130.0		Protected Phases													
Max v/c Ratio: 1.12		Permitted Phases													
Int. Delay: 73.7		Detector Phases													
Int. LOS: E		Minimum Initial (s)													
ICU: 100.0%		Minimum Split (s)													
ICU LOS: G		Total Split (s)													
<input type="checkbox"/> Lock Timings		Yellow Time (s)													
Offset Settings		All-Red Time (s)													
Offset: 100.0		Lead/Lag													
Begin of Yellow		Allow Lead/Lag Optimize?													
2+6 - NBT SBT		Recall Mode													
<input type="checkbox"/> Master		Actuated Effct. Green (s)													
Single		Actuated g/C Ratio													
		Volume to Capacity Ratio													
		Control Delay (s)													
		Queue Delay (s)													
		Total Delay (s)													
		Level of Service													
		Approach Delay (s)													
		Approach LOS													
		Queue Length 50th (ft)													
		Queue Length 95th (ft)													

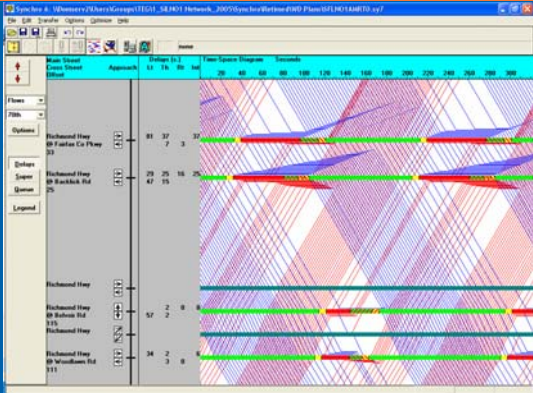
Options >		TIMING WINDOW													
Controller Type:		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	PED	HOLD
Actuated-Coordination		Lanes and Sharing (#RL)													
Cycle Length: 180.0		Traffic Volume (vph)													
Actuated C.L.: 180.0		Turn Type													
Natural C.L.: 130.0		Protected Phases													
Max v/c Ratio: 1.08		Permitted Phases													
Int. Delay: 73.5		Detector Phases													
Int. LOS: E		Minimum Initial (s)													
ICU: 100.0%		Minimum Split (s)													
ICU LOS: G		Total Split (s)													
<input type="checkbox"/> Lock Timings		Yellow Time (s)													
Offset Settings		All-Red Time (s)													
Offset: 126.0		Lead/Lag													
Begin of Yellow		Allow Lead/Lag Optimize?													
2+6 - NBT SBT		Recall Mode													
<input type="checkbox"/> Master		Actuated Effct. Green (s)													
Single		Actuated g/C Ratio													
		Volume to Capacity Ratio													
		Control Delay (s)													
		Queue Delay (s)													
		Total Delay (s)													
		Level of Service													
		Approach Delay (s)													
		Approach LOS													
		Queue Length 50th (ft)													
		Queue Length 95th (ft)													

← After





# Implementation & Fine Tuning

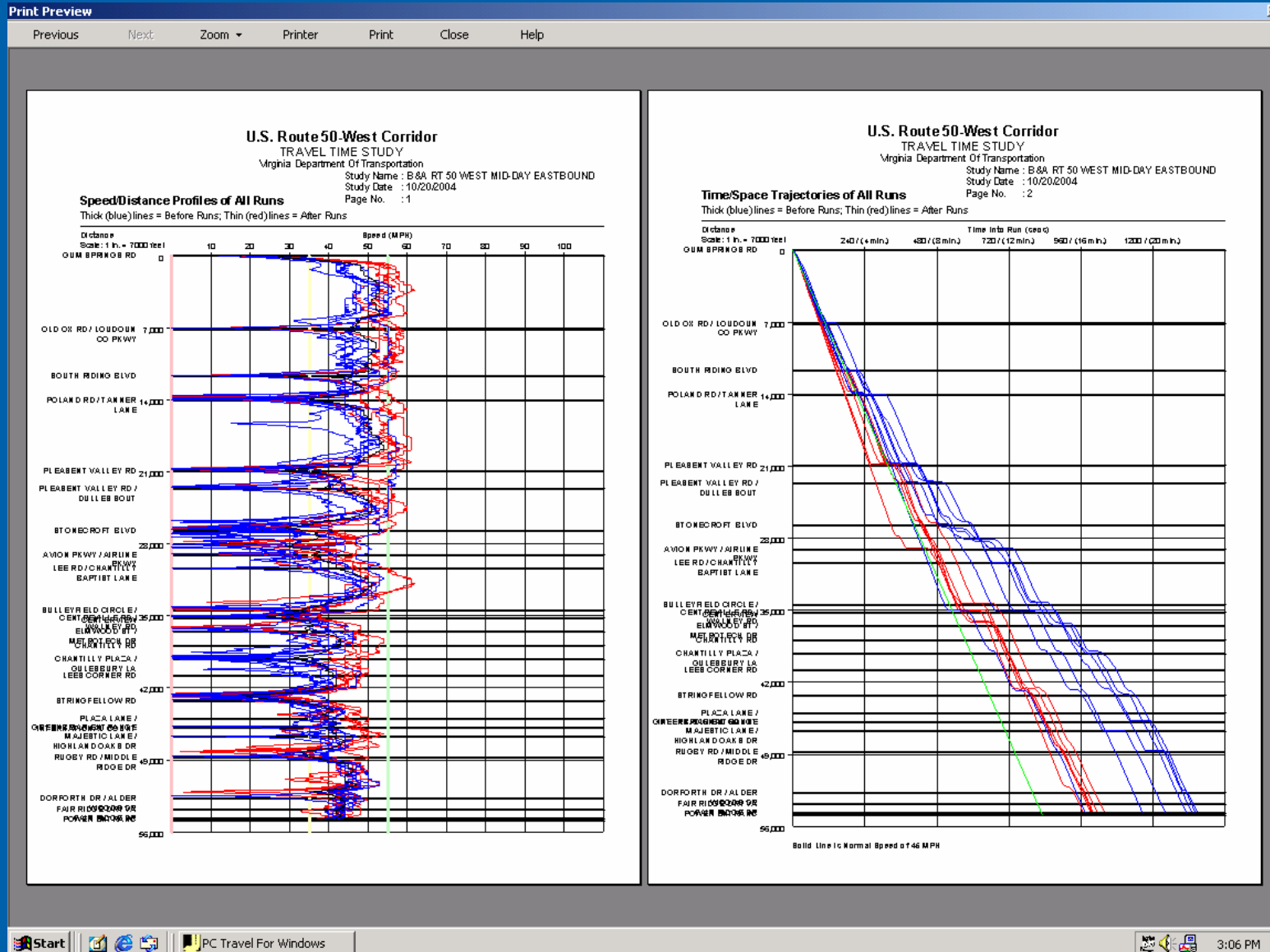


## Measures of Effectiveness (MOE)

- Delay
- Stops
- Fuel Consumption
- Pollutant Emissions
- Travel Time



# Travel Run Result





# Total Annual Savings First Round

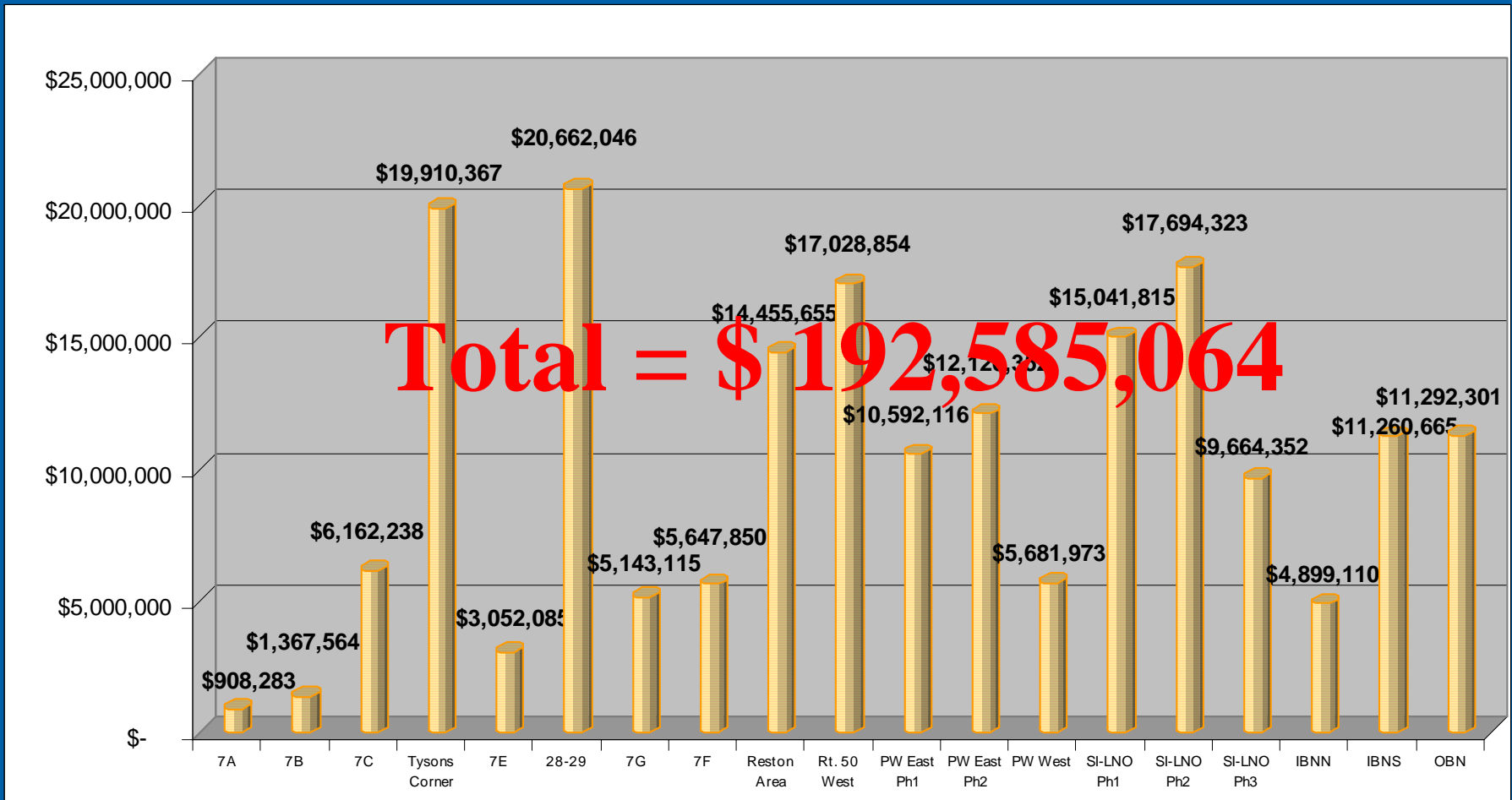
June-1998 to October-2001

Network	Number of Intersections	Stop	Total System Delay	Fuel Consumption	Annual Savings
7A	4	\$ 17,588	\$ 795,600	\$ 95,095	\$ 908,283
7B	8	\$ 38,366	\$ 1,182,480	\$ 146,718	\$ 1,367,564
7C	7	\$ 293,206	\$ 5,351,486	\$ 517,546	\$ 6,162,238
Tysons Corner	40	\$ 418,396	\$ 18,008,032	\$ 1,483,940	\$ 19,910,368
7E	8	\$ 128,312	\$ 2,554,976	\$ 368,797	\$ 3,052,085
28-29	61	\$ 460,666	\$ 18,014,420	\$ 2,186,960	\$ 20,662,046
7G	8	\$ 286,878	\$ 3,977,415	\$ 878,822	\$ 5,143,115
7F	26	\$ 354,943	\$ 4,376,525	\$ 916,382	\$ 5,647,850
Reston Area	76	\$ 449,592	\$ 12,284,204	\$ 1,721,858	\$ 14,455,654
Rt. 50 West	51	\$ 768,561	\$ 13,867,565	\$ 2,392,728	\$ 17,028,854
PW East Ph1	58	\$ 752,143	\$ 8,307,702	\$ 1,532,271	\$ 10,592,116
PW East Ph2	57	\$ 823,362	\$ 9,460,012	\$ 1,836,978	\$ 12,120,352
PW West	43	\$ 301,301	\$ 4,554,482	\$ 826,190	\$ 5,681,973
SILNO Ph1	71	\$ 858,256	\$ 11,968,749	\$ 2,214,810	\$ 15,041,815
SILNO Ph2	85	\$ 577,730	\$ 15,033,564	\$ 2,083,029	\$ 17,694,323
SILNO Ph3	53	\$ 605,166	\$ 7,589,182	\$ 1,470,004	\$ 9,664,352
IBNN	34	\$ 182,661	\$ 4,116,434	\$ 600,015	\$ 4,899,110
IBNS	50	\$ 677,360	\$ 9,088,279	\$ 1,495,026	\$ 11,260,665
OBN	66	\$ 575,335	\$ 9,487,390	\$ 1,229,576	\$ 11,292,301
<b>Total</b>	<b>806</b>	<b>\$ 8,569,822</b>	<b>\$ 160,018,497</b>	<b>\$ 23,996,745</b>	<b>\$ 192,585,064</b>



# Total Annual Savings First Round

June-1998 to October-2001



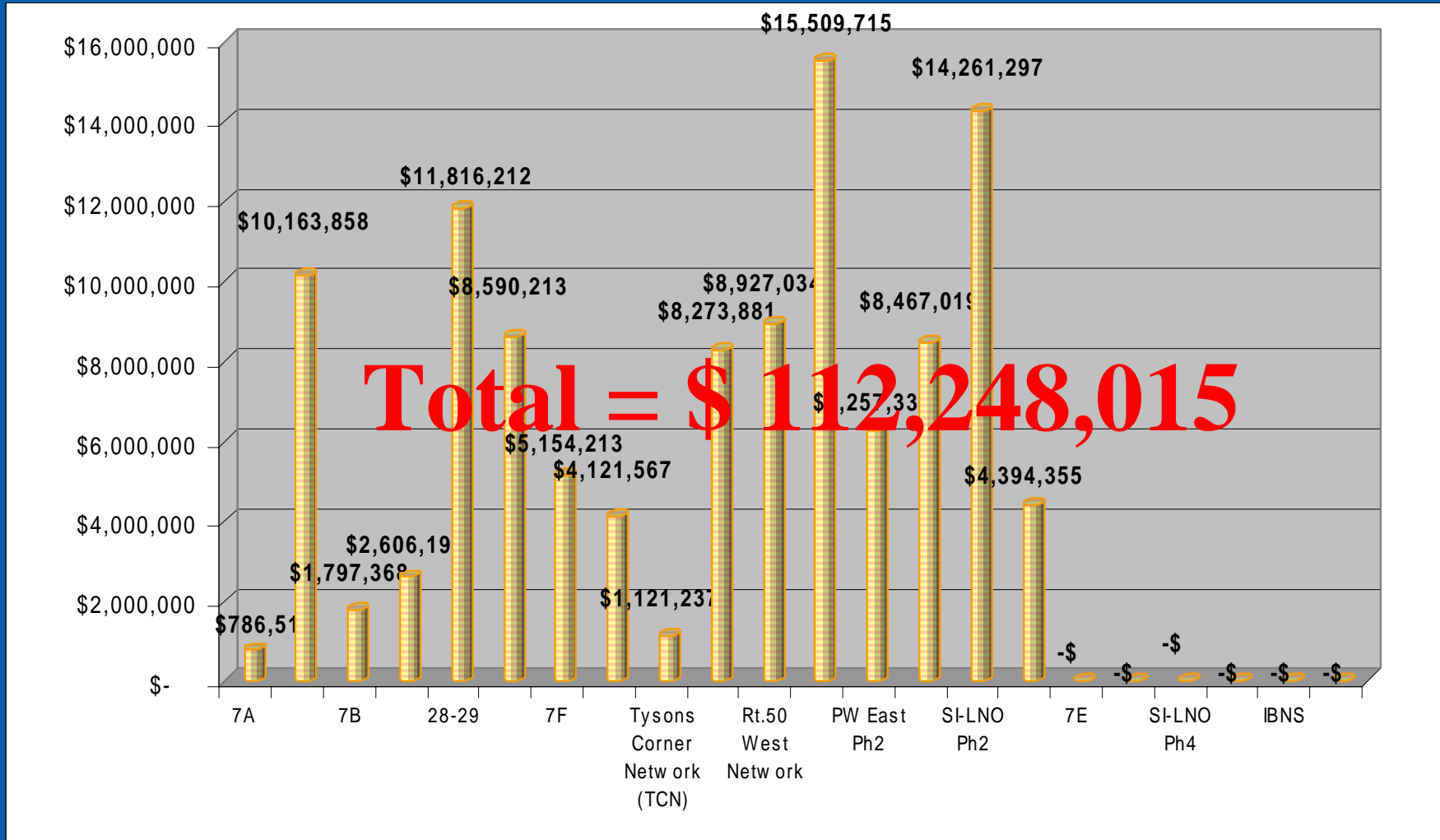


# Total Annual Savings First Round 2002 to Present

Network	Number of Intersections	Stop	Total System Delay	Fuel Consumption	Annual Savings
7A	18	\$ 92,298	\$ 585,281	\$ 108,937	\$ 786,516
SI-LNO Ph4	45	\$ 438,678	\$ 8,571,443	\$ 1,153,737	\$ 10,163,858
7B	14	\$ 141,878	\$ 1,439,170	\$ 216,320	\$ 1,797,368
Telegraph	24	\$ 74,608	\$ 2,233,741	\$ 297,843	\$ 2,606,192
28-29	54	\$ 476,611	\$ 9,780,030	\$ 1,559,571	\$ 11,816,212
DSN	38	\$ 618,857	\$ 6,345,004	\$ 1,626,352	\$ 8,590,213
7F	17	\$ 389,489	\$ 3,663,481	\$ 1,101,243	\$ 5,154,213
7D	16	\$ 241,634	\$ 3,197,142	\$ 682,791	\$ 4,121,567
Tysons Corner	42	\$ 225,820	\$ 638,212	\$ 257,205	\$ 1,121,237
Reston Area	93	\$ 490,573	\$ 6,563,115	\$ 1,220,193	\$ 8,273,881
Rt.50 West	66	\$ 219,678	\$ 7,502,114	\$ 1,205,242	\$ 8,927,034
PW East Ph1	73	\$ 673,072	\$ 12,371,617	\$ 2,465,027	\$ 15,509,716
PW East Ph2	66	\$ 254,091	\$ 4,990,744	\$ 1,012,503	\$ 6,257,338
SILNO1	64	\$ 319,761	\$ 6,511,863	\$ 1,635,395	\$ 8,467,019
SILNO2	107	\$ 432,981	\$ 11,039,600	\$ 2,788,715	\$ 14,261,297
PW West	85	\$ 52,599	\$ 3,445,943	\$ 895,813	\$ 4,394,355
7E	51				
SI-LNO Ph3	49				
SI-LNO Ph4	58				
IBNN	30				
IBNS	56				
OBN	69				
<b>Total</b>	<b>1135</b>	<b>\$ 5,142,628</b>	<b>\$ 88,878,500</b>	<b>\$ 18,226,887</b>	<b>\$ 112,248,016</b>



# Total Annual Savings Second Round 2002 to Present



Direct

\$ Savings

Emissions Reduction

Indirect

Digital Library

- Private Sector
- Public Sector

Recommendations



Options

**TIMING WINDOW**

Options	EBL	EBL	EBL	WBL	WBL	WBL	NBL	NBL	NBL	SEB	SEB	SEB	PED	HOLD
Contractor Type:	Lanes and Shading (BRL)	1	1	1	1	1	1	1	1	1	1	1	1	1
Actualized-Consider	Traffic Volume (vph)	300	1156	228	180	468	657	64	1812	32	316	1000	172	
Cycle Length: 200.0	Turn Type	Per-P	Per-P	Per-P	Per-P	Per-P	Per-P	Per-P	Per-P	Per-P	Per-P	Per-P	Per-P	Per-P
Actualized C.L.: 200.0	Prohibited Phases	5	2	1	6	7	3	8	7	4	5			
Natural C.L.: 118.0	Permitted Phases	2	2	6	6	6	3	8	8	7	4	5		
Int. v/c Ratio: 1.12	Detector Phases	5	2	2	1	6	7	3	8	8	7	4	5	
Int. Delay: 73.9	Minimum Interval (s)	5.0	20.0	20.0	5.0	20.0	5.0	5.0	12.0	12.0	5.0	12.0	5.0	
Lock Timeout: 5	Maximum Split (s)	11.0	28.0	28.0	11.0	28.0	11.0	11.0	28.0	28.0	11.0	28.0	11.0	
Offset Settings:	Total Split (s)	38.0	52.0	52.0	21.0	35.0	30.0	30.0	117.0	117.0	38.0	117.0	38.0	
Offset: 4.0	Yellow Time (s)	4.5	5.5	5.5	4.5	5.5	4.5	4.5	5.5	5.5	4.5	5.5	4.5	
Reference Style:	All Red Time (s)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
Begin of Yellow:	Lead/Lag	Lead	Lag	Lag	Lead	Lag	Lead	Lag	Lead	Lag	Lag	Lead	Lag	Lead
Reference Phase:	Allow Lead/Lag Optimizer?	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
4-0 - CBT NO	Recall Mode	None	None	None	None	None	None	None	Good	Good	None	Good	None	
Master Intersect:	Actualized EBL Green (s)	70.0	52.0	52.0	47.0	31.0	62.0	19.0	114.0	114.0	27.1	139.5	168.4	
	Actualized g/C Ratio	0.32	0.24	0.24	0.21	0.15	0.20	0.05	0.52	0.52	0.12	0.59	0.77	
	Volume to Capacity Ratio	1.05	0.36	0.44	0.65	0.91	1.41	0.39	0.99	0.84	0.75	0.48	0.14	
	Percentage Signal Delay (s)	126.0	76.7	14.4	57.5	101.3	240.0	108.0	38.0	2.7	81.6	23.0	3.2	
	Level of Service	F	E	B	E	F	F	F	C	A	F	C	A	
	Queue Length 50th (ft)	470	608	0	186	308	1250	47	1391	0	224	530	27	
	Queue Length 95th (ft)	8700	8742	101	166	8463	81525	n70	81524	n0	307	647	40	
	Queueing Penalty	44	15	0	0	0	363	0	2	0	0	129	0	
	Stops (vph)	426	1092	150	81	463	1303	61	1638	11	294	600	22	
	Fuel Used (gph)	15	40	4	3	18	50	3	50	1	15	34	3	
	Diagnosis Vehicles (R/V)	15	23	5	5	11	11	1	37	1	15	38	1	

Left or Right Turn Treatment

W/C 3 1 Miss 08



# Non-recurring Congestion Management

Traffic Incidents

Planned Special Events

Work Zones

Weather



- Develop Incident Plans
- Monitor & adjust signal timing in real-time
- Coordinate with other agencies



- July 4, 1998-2006
- George Mason University
- Shopping Malls (Thanksgiving-Christmas)
- April 15, Tax day



- Roadway Closures
- Construction Projects
  - Rt.28 PPTA
  - Springfield Interchange
  - WWB

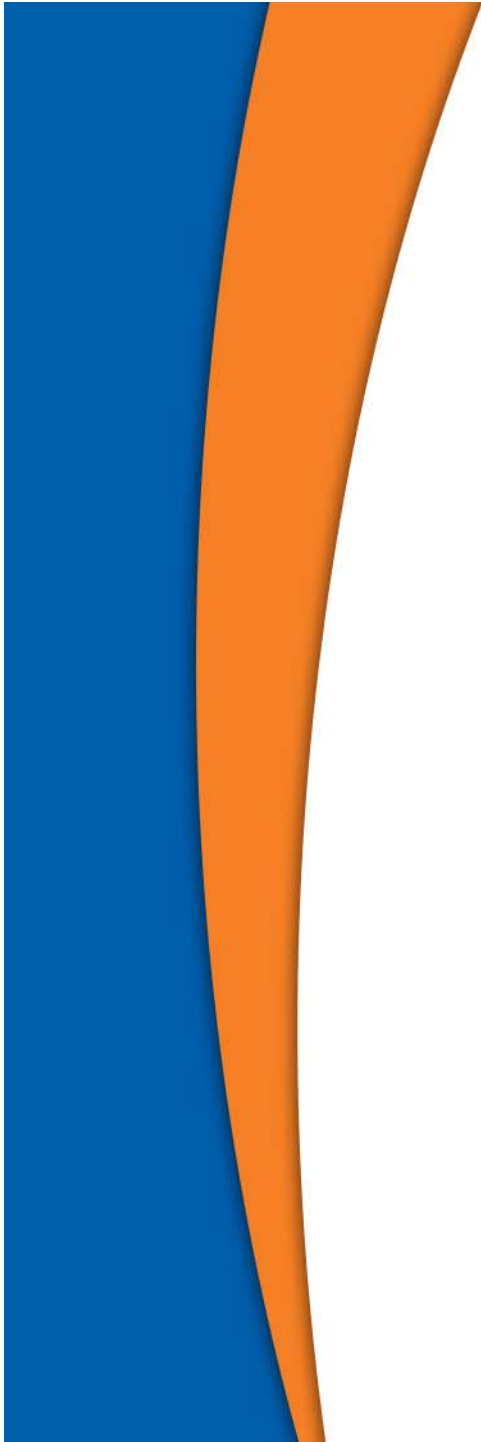


- Snow storm
- Hurricane
- Flooding



- Town of Herndon
- Town of Vienna
- City of Alexandria
- City of Falls Church
- City of Fairfax
- City of Manassas
- Manassas Park
- County of Arlington
- DC
- Maryland
- COG





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