Onondaga County Department of Transportation

Traffic Signal Optimization Project
(Old Route 57)
(Existing Coordinated Corridor)

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October 2010

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This document was prepared with financial assistance from the Federal Highway Administration and the Federal Transit Administration of the U.S. Department of Transportation through the New York State Department of Transportation. The Syracuse Metropolitan Transportation Council is solely responsible for its contents.

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CHAPTER I

INTRODUCTION

Outdated traffic signal timings account for a significant amount of traffic delay on urban and suburban roadways across the country. Periodically updating traffic signal equipment and timings based on new technology and current traffic volumes can provide significant benefits at a relatively low cost, alleviate the need for additional infrastructure, and reduce time spent in traffic, fuel consumption, and emissions. This report summarizes the results of a Traffic Signal Timing Optimization study conducted at various county-owned and controlled intersections along the Old Route 57 (CR 91) corridor located in Onondaga County, New York.

A. Study Area

The study area intersections for this report include the following, as shown on Figure 1:

A) Old Route 57 (County Road 91)/I-90 Exit 38 Ramp
B) Old Route 57 (County Road 91)/Liverpool Bypass/Dents Disappear Driveway
C) Old Route 57 (County Road 91)/Hiawatha Plaza Driveway/Plaza Driveway
D) Old Route 57 (County Road 91)/Long Branch Road/Belmont Drive
E) Old Route 57 (County Road 91)/John Glenn Boulevard
F) Old Route 57 (County Road 91)/Wegmans Driveway/M&T Bank Driveway
G) Old Route 57 (County Road 91)/Elmcrest Road/Friendly's Driveway
H) Old Route 57 (County Road 91)/Blackberry Road/Rivercrest Road
I) Old Route 57 (County Road 91)/Wetzel Road
J) Old Route 57 (County Road 91)/Pine Hollow Road/Seneca Mall Driveway
K) Old Route 57 (County Road 91)/Soule Road
L) Old Route 57 (County Road 91)/Gaskin Road/Redwing Drive

B. Purpose and Methodology

The purpose of this study was to update intersection signal timings in order to maximize intersection capacity, reduce driver delays, reduce vehicle emissions, and improve the overall efficiency of traffic operations for the motoring public.

In order to accomplish this task, traffic count data, signal timing parameters, and intersection geometry was provided by the Syracuse Metropolitan Transportation Council (SMTC) and the Onondaga County Department of Transportation (OCDOT) to evaluate the current performance of the intersections. Adjustments in signal timings, off-sets, detection, and other parameters were made to improve intersection performance. Once adjustments were identified, changes to the field equipment could be made to implement improvements. Some adjustments, like converting from a leading protected left turn arrow to a lagging arrow will be easily noticed, while others, such as vehicle detection modifications, or minor changes in the green time allocation, may not be realized by drivers.

Traffic simulation models of each intersection were developed using the Synchro 7 program. Existing traffic operations were documented and summarized and then optimization of the signals was performed. The changes in the signal timing parameters and the resulting performance changes were then documented to identify the net benefits for the actions.

Figure 1 – Project Location and Study Area Intersections

CHAPTER II

ANALYSIS

Traffic volume data, signal timings, intersection sketches, and photos of the study area intersections were gathered from data provided by the OCDOT and the SMTC. The OCDOT also provided existing AM and PM peak hour Synchro models of the corridor which included proposed network signal timings and offsets. In addition, OCDOT provided actual traffic signal timing plans and offsets at the study area intersections. Therefore, the models were updated to reflect current traffic signal conditions. These revised models provided existing conditions of each intersection that were then analyzed to determine their existing performance criteria. With the existing levels of service (LOS) established as the baseline condition, the signals were then optimized. The LOS definitions and a glossary of terms are included in Appendix A.

To maximize the efficiency and performance of each intersection, the traffic volumes for each peak hour were evaluated using a variety of cycle lengths and timing splits. In some cases, the optimized cycle lengths resulted in each signal phase operating at its maximum green time during each cycle of the peak hour. Given that traffic volumes will vary throughout the course of the peak hour, consideration was given to adjusting the cycle length to longer cycles, allowing the signal more flexibility to alter timings as traffic conditions warrant. For example, during low levels of traffic, the controller can reduce the cycle length and serve different approaches quicker. This is particularly useful during off-peak periods. During higher levels of traffic, most notably during peak hours, the cycle length can increase to provide longer green times on approaches that have higher volumes of traffic.

Changes to the existing timings, detection, or parameters such as minimums, maximums, recalls, clearance intervals, and vehicle extensions, are presented in this chapter along with the resulting intersection performance. Changes to these parameters are based on the Onondaga County Department of Transportation's *Traffic Signal Timing Standards* and the *Traffic Signal Timing Manual*, published by the Institute of Transportation Engineers (ITE), 2009. Appendix B includes detailed sketches, photos, controller settings, signal timings/splits, and level of service reports for each intersection.

The twelve study area intersections on CR 91 were also evaluated to determine how the improvement of the existing traffic signal coordination plan would impact traffic progression through the corridor. It is noted that the corridor was broken up into three sections due to intersection spacing and the effectiveness of signal coordination. The *South Segment* includes the intersections of Exit 38 and Liverpool Bypass, the *Mid Segment* consists of the intersections from Hiawatha Plaza to Blackberry Road, while the *North Segment* includes intersections Wetzel Road to Gaskin Road. The model was used to determine that the most efficient coordination plan involved different signal cycle lengths for each of the three segments. The detailed coordination plan for these segments is analyzed in Sections A through N. A separate coordination plan is included in Section O which details the pros and cons of utilizing a consistent cycle length for the entire roadway segment for each peak hour.

A. CR 91/I-90 Exit 38 Ramp

This three-leg intersection operates under a three-phase traffic signal with a 118-second maximum cycle length. A coordinated, maximum recall is set on the northbound and southbound CR 91 approaches. The northbound CR 91 approach provides an exclusive left-turn lane and two through lanes, while the southbound CR 91 approach provides one through lane and a separate right-turn lane. The eastbound I-90 Exit 38 approach provides two exclusive left-turn lanes and a separate right-turn lane. Presence detection is provided on the northbound left-turn movement and on the eastbound approach, while point detection is provided on the northbound and southbound through lanes. No sidewalks, crosswalks, or pedestrian controls are provided. The posted speed limit on CR 91 is 45-mph, while the speed limit on the I-90 Exit 38 is not posted. Table II.A.1 summarizes the detailed levels of service for existing and proposed conditions.

Table II.A.1 – CR 91/I-90 Exit 38 LOS Summary

Intersection			Control	AM Peak Hour		PM Peak Hour	
				Existing Coordinated	Revised Coordinated	Existing Coordinated	Revised Coordinated
CR 91/I-90 Exit 38			S				
	I-90 Exit 38 EB	L,L		D (47)	D (51)	D (44)	D (36)
		R		A (0)	A (0)	A (0)	A (0)
	CR 91 NB	L		D (42)	D (54)	A (9)	B (14)
		T,T		A (3)	A (2)	A (9)	A (8)
	CR 91 SB	T		D (54)	C (25)	B (17)	B (14)
		R		A (1)	A (1)	A (0)	A (0)
		Overall		C (29)	B (18)	B (16)	B (14)

Key: NB, SB, EB, WB = Northbound, Southbound, Eastbound, Westbound intersection approaches
L, T, R = Left-turn, through, and/or right-turn movements
X (Y) = Level of Service (Delay, seconds per vehicle)

The intersection currently operates at an overall LOS C/B during the AM and PM peak hours. After optimization of the traffic signal which includes changing the northbound and southbound through movements to a coordinated minimum recall, the intersection will operate at an overall LOS B during both peak hours with all movements operating at LOS D or better. It is noted that the northbound protected left-turn phase was changed to a lagging phase as per OCDOT standards for a three-leg intersection.

To improve operations, new traffic signal coordination was provided, along with the modification of the yellow/all-red clearance, the minimum greens, and vehicle extension. The signal was optimized using Synchro which resulted in a 110-second cycle length during the AM peak hour and a 90-second cycle length during the PM peak hour. The AM and PM peak hour cycle lengths were adjusted to minimize vehicle delays, minimize the volume to capacity (v/c) ratio, and to coordinate the timings with adjacent signal located to the north at Liverpool Bypass (*South Segment*). During the peak hours, the intersection will operate at the maximum cycle length during the higher percentiles of traffic, and shorter cycle lengths during lower percentiles of traffic. Table II.A.2 summarizes the suggested changes in the signal timing parameters.

Table II.A.2 – CR 91/I-90 Exit 38 Parameter Summary

Parameter	Existing	Proposed
Detection	NB/SB through; EB	No Change
Recall	C-Max NB/SB throughs	C-Min NB/SB throughs
Minimum Green	8-sec NB/EB; 10-sec SB	10-sec NB/SB throughs and EB, 5-sec NB left
Yellow/All Red:	4/2-sec NB/SB; 3.5/2.0 EB	4/2.5-sec for 30-45-mph
Vehicle Extension	4-sec	1.0-sec EB[1], 4.2-sec NB/SB through[2], 1.5-sec NB left[3]
Cycle Length	AM/PM – 117.5-sec	110-sec AM; 90-sec PM
Offset	AM – 2, PM – 72	AM – 78, PM – 25

B. CR 91/Liverpool Bypass/Dents Disappear Driveway

This four-leg intersection operates under a three-phase traffic signal with a 92-second maximum cycle length. A coordinated, maximum recall is set on the northbound and southbound CR 91 approaches. The northbound and southbound CR 91 approaches provide an exclusive left-turn lane and two through lanes with a shared right-turn. The eastbound Dents Disappear Driveway provides a single lane for shared travel movements, while the westbound Liverpool Bypass approach provides a shared left-turn through lane and a separate right-turn lane. Presence detection is provided on the southbound left-turn movement and on the eastbound and westbound approaches, while point detection is provided on the northbound and southbound through lanes. No sidewalks, crosswalks, or pedestrian controls are provided. The posted speed limit on CR 91 is 45-mph, while the speed limit on Liverpool Bypass is 55 mph. Table II.B.1 summarizes the detailed levels of service for existing and proposed conditions.

Table II.B.1 – CR 91/Liverpool Bypass/Dents Disappear Driveway LOS Summary

Intersection		Control	AM Peak Hour		PM Peak Hour	
			Existing Coordinated	Revised Coordinated	Existing Coordinated	Revised Coordinated
CR 91/Liverpool Bypass/Dents Disappear Driveway		S				
Dents Disappear Driveway EB	LTR		C (29)	D (36)	D (36)	D (37)
Liverpool Bypass WB	LT		D (44)	D (52)	D (45)	D (54)
	R		B (17)	C (22)	C (28)	C (33)
CR 91 NB	L		B (16)	B (12)	B (12)	B (11)
	T,TR		B (19)	B (13)	D (44)	C (23)
CR 91 SB	L		B (16)	B (14)	C (21)	C (23)
	T,TR		B (10)	B (10)	A (4)	A (3)
	Overall		B (15)	B (14)	C (31)	B (20)

Key: NB, SB, EB, WB = Northbound, Southbound, Eastbound, Westbound intersection approaches
L, T, R = Left-turn, through, and/or right-turn movements
X (Y) = Level of Service (Delay, seconds per vehicle)

[1] Max allowable headway = 3sec, detection zone = 60 feet, approach speed = 30 mph.
[2] Max allowable headway = 3 sec, detection zone = 6 feet (placed 250 feet from the intersection), approach speed = 45 mph.
[3] Max allowable headway = 3 sec, detection zone = 60 feet approach speed = 45 mph.

The intersection currently operates at an overall LOS B/C during the AM and PM peak hours. After optimization of the traffic signal which includes switching this intersection to the master controller for the *South Segment*, and changing the northbound and southbound through movements to a coordinated minimum recall, the intersection will operate at an overall LOS B during both peak hours with all movements operating at LOS D or better.

To improve operations, new traffic signal coordination was provided, along with the modification of the yellow/all-red clearance, the minimum greens, and vehicle extension. The signal was optimized using Synchro which resulted in a 110-second cycle length during the AM peak hour and a 90-second cycle length during the PM peak hour. The AM and PM peak hour cycle lengths were adjusted to minimize vehicle delays, minimize the v/c ratio, and to coordinate the timings with adjacent signal located to the south at I-90 Exit 38 (*South Segment)*. During the peak hours, the intersection will operate at the maximum cycle length during the higher percentiles of traffic, and shorter cycle lengths during lower percentiles of traffic. Table II.B.2 summarizes the suggested changes in the signal timing parameters.

Table II.B.2 – CR 91/Liverpool Bypass/Dents Disappear Drwy Parameter Summary

Parameter	Existing	Proposed
Detection	EB/WB, NB/SB through, SB left	No Change
Recall	C-Max NB/SB throughs	C-Min NB/SB throughs
Minimum Green	8-sec EB/WB and SB left; 10-sec NB/SB throughs	10-sec WB and NB/SB throughs; 5-sec SB lefts; 7-sec EB
Yellow/All Red:	4/2-sec EB/WB and SB left; 4/3 NB/SB	4/2.5-sec for 30-45 mph speed
Vehicle Extension	4-sec	1.0-sec EB/WB[4]; 4.2-sec NB/SB throughs[5], 1.6-sec NB/SB lefts[6]
Cycle Length	AM/PM – 92-sec	110-sec AM; 90-sec PM
Offset	AM – 7, PM – 70	AM/PM – Master (South Segment)

C. CR 91/Hiawatha Plaza Driveway/Plaza Driveway

This four-leg intersection operates under a three-phase traffic signal with a 73-second maximum cycle length. A coordinated, maximum recall is set on the northbound and southbound CR 91 approaches. The northbound CR 91 approach provides an exclusive left-turn lane and two through lanes with a shared right-turn, while the southbound CR 91 approach provides two through lanes with shared left and right turns. The eastbound Hiawatha Plaza Driveway approach provides a shared left-turn through lane and a separate right-turn lane, while the westbound Plaza Driveway approach provides a single lane for shared travel movements. Presence detection is provided on the northbound left-turn movement and on the eastbound and westbound approaches, while point detection is provided on the

[4] Max allowable headway = 3 sec, detection zone = 60 feet, approach speed = 30 mph.
[5] Max allowable headway = 3 sec, detection zone = 6 feet (placed 250 feet from the intersection), approach speed = 45 mph.
[6] Max allowable headway = 3 sec, detection zone = 60 feet, approach speed = 45 mph.

northbound and southbound through lanes. No sidewalks, crosswalks, or pedestrian controls are provided. The posted speed limit on CR 91 is 40-mph. Table II.C.1 summarizes the detailed levels of service for existing and proposed conditions.

Table II.C.1 – CR 91/Hiawatha Plaza Driveway/Plaza Driveway LOS Summary

Intersection		Control	AM Peak Hour		PM Peak Hour	
			Existing Coordinated	Revised Coordinated	Existing Coordinated	Revised Coordinated
CR 91/Hiawatha Plaza Driveway/Plaza Driveway		S				
Hiawatha Plaza Driveway EB	LT		D (40)	E (60)	C (32)	D (53)
	R		C (27)	D (51)	B (20)	D (38)
Plaza Driveway WB	LTR		D (35)	E (58)	C (28)	D (45)
CR 91 NB	L		B (12)	A (7)	A (5)	A (4)
	T,TR		A (1)	A (1)	A (7)	A (5)
CR 91	LT,TR		B (14)	A (9)	B (11)	A (8)
	Overall		B (12)	A (8)	A (9)	A (8)

Key: NB, SB, EB, WB = Northbound, Southbound, Eastbound, Westbound intersection approaches
L, T, R = Left-turn, through, and/or right-turn movements
X (Y) = Level of Service (Delay, seconds per vehicle)

The intersection currently operates at an overall LOS B/A during the AM and PM peak hours. After optimization of the traffic signal which includes changing the northbound and southbound through movements to a coordinated minimum recall, the intersection will operate at an overall LOS A during both peak hours. However, the eastbound Hiawatha Plaza Driveway shared left-turn/through movement and the westbound Plaza Driveway approach will operate at LOS E during the AM peak hour. The proposed coordination benefits the heavy northbound/southbound movements on CR 91 and the LOS E experienced on these minor AM peak hour movements are acceptable to maintain optimal progression through the corridor.

To improve operations, new traffic signal coordination was provided, along with the modification of the yellow/all-red clearance, the minimum greens, and vehicle extension. The signal was optimized using Synchro which resulted in a 120-second cycle length during the AM peak hour and a 110-second cycle length during the PM peak hour. The AM and PM peak hour cycle lengths were adjusted to minimize vehicle delays, minimize the v/c ratio, and to coordinate the timings with adjacent signals located to the north within the *Mid Segment*. During the peak hours, the intersection will operate at the maximum cycle length during the higher percentiles of traffic, and shorter cycle lengths during lower percentiles of traffic. Table II.C.2 summarizes the suggested changes in the signal timing parameters.

Table II.C.2 – CR 91/Hiawatha Plaza Driveway/Plaza Driveway Parameter Summary

Parameter	Existing	Proposed
Detection	EB/WB/NB/SB	No Change
Recall	C-Max NB/SB throughs	C-Min NB/SB throughs
Minimum Green	5-sec NB left; 1-sec WB; 10-sec EB/NB/SB throughs	7-sec EB/WB; 10-sec NB/SB throughs; 5-sec NB left
Yellow/All Red:	4/2-sec	4/2.5-sec for 30-45 mph speed
Vehicle Extension	4-sec	1.0-sec EB/WB[7]; 4.2-sec NB/SB throughs[8]; 1.6-sec NB/SB lefts[9]
Cycle Length	AM/PM – 73-sec	120-sec AM; 110-sec PM
Offset	AM – 21, PM – 58	AM – 19, PM – 31

D. CR 91/Long Branch Road/Belmont Drive

This four-leg intersection operates under a four-phase traffic signal with a 92-second maximum cycle length. A coordinated, maximum recall is set on the northbound and southbound CR 91 approaches. The northbound CR 91 approach provides an exclusive left-turn lane and three through lanes with a shared right-turn, while the southbound CR 91 approach provides an exclusive left-turn lane, two through lanes, and a separate right-turn lane. The eastbound Long Branch Road approach provides an exclusive left-turn lane, a through lane, and a separate right-turn lane, while the westbound Belmont Drive approach provides an exclusive left-turn lane and a through lane with shared right-turns. Presence detection is provided on the northbound and southbound left-turn movements and on the eastbound and westbound approaches. No sidewalks, crosswalks, or pedestrian controls are provided. The posted speed limit on CR 91 is 40-mph, while the posted speed limit on Long Branch Road and Belmont Drive is 30-mph. Table II.D.1 summarizes the detailed levels of service for existing and proposed conditions.

[7] Max allowable headway = 3 sec, detection zone = 60 feet, approach speed = 30 mph.
[8] Max allowable headway = 3 sec, detection zone = 6 feet (placed 250 feet from the intersection), approach speed = 45 mph.
[9] Max allowable headway = 3 sec, detection zone = 60 feet, approach speed = 45 mph.

Table II.D.1 – CR 91/Long Branch Road/Belmont Drive LOS Summary

Intersection		Control	AM Peak Hour		PM Peak Hour	
			Existing Coordinated	Revised Coordinated	Existing Coordinated	Revised Coordinated
CR 91/Long Branch Road/Belmont Drive		S				
Long Branch Road EB	L		C (28)	D (38)	C (25)	D (50)
	T		D (38)	D (43)	C (33)	D (36)
	R		A (0)	A (0)	A (0)	A (0)
Belmont Drive WB	L		C (21)	D (38)	B (19)	C (31)
	TR		C (34)	D (45)	D (36)	D (47)
CR 91 NB	L		D (41)	E (56)	D (39)	D (52)
	T,T,TR		B (17)	B (15)	D (52)	D (36)
CR 91 SB	L		D (39)	E (63)	D (41)	D (47)
	T,T		F (115)	C (29)	C (27)	C (28)
	R		A (0)	A (0)	A (0)	A (0)
	Overall		E (73)	C (26)	D (38)	C (33)

Key: NB, SB, EB, WB = Northbound, Southbound, Eastbound, Westbound intersection approaches
L, T, R = Left-turn, through, and/or right-turn movements
X (Y.Y) = Level of Service (Delay, seconds per vehicle)

The intersection currently operates at an overall LOS E/D during the AM and PM peak hours with the southbound CR 91 through movement operating at LOS F during the AM peak hour. With the addition of point detection on the northbound/southbound approaches and providing minimum recall on these approaches, the intersection will operate at an overall LOS C during both peak hours. However, the northbound and southbound CR 91 left-turn movements will operate at LOS E during the AM peak hour. The proposed coordination benefits the heavy northbound/southbound movements on CR 91 and the LOS E experienced on these minor AM peak hour movements are acceptable to maintain optimal progression through the corridor.

To improve operations, point detection was added to the northbound and southbound through lanes on CR 91, new traffic signal coordination was provided, and the yellow/all-red clearance, the minimum greens, and vehicle extension were modified. The signal was optimized using Synchro which resulted in a 120-second cycle length during the AM peak hour and a 110-second cycle length during the PM peak hour. The AM and PM cycle lengths were adjusted to minimize vehicle delays, minimize the v/c ratio, and to coordinate the timings with adjacent signals located to the north and south within the *Mid Segment*. The analysis also includes the addition of pedestrian accommodations across the northbound CR 91 approach as per the request of the OCDOT. It is not anticipated that the pedestrian phase will affect the proposed signal timing because the eastbound green time is comparable to the time necessary for the pedestrian phase. During the peak hours, the intersection will operate at the maximum cycle length during the higher percentiles of traffic, and shorter cycle lengths during lower percentiles of traffic. Table II.D.2 summarizes the suggested changes in the signal timing parameters.

Table II.D.2 – CR 91/Long Branch Road/Belmont Drive Parameter Summary

Parameter	Existing	Proposed
Detection	EB/WB throughs and NB/SB lefts	Add point detection to NB/SB throughs
Recall	C-Max NB/SB throughs	C-Min NB/SB throughs
Minimum Green	5-sec EB/WB and NB/SB lefts; 10-sec NB/SB throughs	7-sec WB; 10-sec EB and NB/SB throughs; 5-sec NB/SB lefts
Yellow/All Red:	4/2-sec NB/SB, 4,1.5 WB left, 3.5,1.5 EB, WB through and NB/SB lefts	4/2.5-sec for 30-45 mph speed
Vehicle Extension	4-sec NB/SB throughs, 2.5 EB/WB and NB/SB lefts	1.0-sec WB and EB left[10]; 1.7-sec EB throughs[11]; 3.4-sec NB/SB throughs[12]; 1.6-sec NB/SB lefts[13]
Cycle Length	AM/PM – 92-sec	120-sec AM; 110-sec PM
Offset	AM – 23, PM – 52	AM – 0, PM – 96

E. CR 91/John Glenn Boulevard

This four-leg intersection operates under a four-phase traffic signal with a 101-second maximum cycle length. A coordinated, minimum recall is set on the northbound and southbound CR 91 approaches. The northbound and southbound CR 91 approaches provide an exclusive left-turn lane, two through lanes, and a separate right-turn lane. The eastbound John Glenn Boulevard approach provides two exclusive left-turn lanes and two through lanes with shared right-turns, while the westbound John Glenn Boulevard approach provides an exclusive left-turn lane and two through lanes with shared right-turns. Presence detection is provided on the northbound and southbound left-turn movements and on the eastbound and westbound approaches, while point detection is provided on the northbound and southbound through lanes. No sidewalks, crosswalks, or pedestrian controls are provided. The posted speed limit on CR 91 and John Glenn Boulevard is 40-mph. Table II.E.1 summarizes the detailed levels of service for existing and proposed conditions.

[10] Max allowable headway = 3 sec, detection zone = 60 feet, approach speed = 30 mph.
[11] Max allowable headway = 3 sec, detection zone = 30 feet, approach speed = 30 mph.
[12] Max allowable headway = 3 sec, detection zone = 6 feet (placed 200 feet from the intersection), approach speed = 45 mph.
[13] Max allowable headway = 3 sec, detection zone = 60 feet, approach speed = 45 mph.

Table II.E.1 – CR 91/John Glenn Boulevard LOS Summary

Intersection		Control	AM Peak Hour		PM Peak Hour	
			Existing Coordinated	Revised Coordinated	Existing Coordinated	Revised Coordinated
CR 91/John Glenn Boulevard		S				
John Glenn Boulevard EB	L,L		D (42)	E (67)	F (135)	F (113)
	T,TR		F (117)	F (108)	E (75)	E (69)
John Glenn Boulevard WB	L		D (47)	F (149)	D (40)	F (97)
	T,TR		D (39)	D (48)	D (41)	F (143)
CR 91 NB	L		D (44)	F (165)	F (194)	F (129)
	T,T		C (30)	B (20)	F (345)	D (54)
	R		B (15)	B (11)	B (16)	A (6)
CR 91 SB	L		D (44)	E (63)	D (42)	F (133)
	T,T		F (301)	E (60)	F (162)	E (72)
	R		C (22)	A (8)	C (23)	C (32)
	Overall		F (132)	E (63)	F (169)	E (79)

Key: NB, SB, EB, WB = Northbound, Southbound, Eastbound, Westbound intersection approaches
L, T, R = Left-turn, through, and/or right-turn movements
X (Y.Y) = Level of Service (Delay, seconds per vehicle)

The intersection currently operates at an overall LOS F during both peak hours with several lane groups operating at LOS F. After optimization of the traffic signal which includes switching this intersection to the master controller for the *Mid Segment*, the intersection will operate at an overall LOS E during both peak hours. The analysis indicates that several movements will continue to operate at LOS F during both peak hours. Although it was not included in the evaluation, the construction of a separate eastbound right-turn lane on John Glenn Boulevard could potentially help mitigate overall delay at this intersection.

A review of the *SimTraffic* simulation indicates that the southbound queue on CR 91 currently extends up to and through the signalized Elmcrest Road intersection located almost 0.5-miles away during the AM peak hour. With the proposed signal timing improvements and the reallocation of green time during the AM peak hour, the southbound queue on CR 91 will be reduced and only extend to the unsignalized Wegmans Driveway located 0.2-miles away. However, the simulation indicates that the westbound John Glenn Boulevard left-turn lane will experience longer delays and queuing as a result of the timing improvements. This could cause the queue in this lane to exceed the available storage space and spill back into the through lanes, which would then conflict with the prevailing through movement on John Glenn Boulevard potentially creating an unsafe condition. While the proposed improvements will benefit overall intersection operations and progression through the corridor during both peak hours, other potential safety impacts associated with increased queuing and available storage capacity on auxiliary lanes should be monitored for safety impacts.

To improve operations, new traffic signal coordination was provided, along with the modification of the yellow/all-red clearance, the minimum greens, and vehicle extension. The signal was optimized using Synchro which resulted in a 120-second cycle length during the AM peak hour and a 110-second cycle length during the PM peak hour. The AM and PM cycle lengths were adjusted to minimize vehicle delays, minimize the v/c ratio, and to coordinate the timings with adjacent signals located to the north and south within the *Mid Segment*. The analysis also includes the addition

of pedestrian accommodations across the westbound John Glenn Boulevard approach, in two stages, as per the request of the OCDOT. The pedestrian phase will not affect the proposed signal timing because the westbound green time is longer than the time necessary for the pedestrian phase. During the peak hours, the intersection will operate at the maximum cycle length during the higher percentiles of traffic, and shorter cycle lengths during lower percentiles of traffic. Table II.E.2 summarizes the suggested changes in the signal timing parameters.

Table II.E.2 – CR 91/John Glenn Boulevard Parameter Summary

Parameter	Existing	Proposed
Detection	EB/WB/NB/SB	No Change
Recall	C-Min NB/SB throughs	No Change
Minimum Green	5-sec EB/WB/NB/SB lefts; 12-sec EB/WB throughs; 13-sec NB/SB throughs	10-sec EB/WB/NB/SB throughs; 5-sec EB/WBNB/SB lefts
Yellow/All Red:	4/2-sec	4/2.0-sec for 45 mph speed
Vehicle Extension	4-sec SB through, 3.5 EB/WB/NB and SB lefts	1.6-sec NB/SB lefts and EB/WB[14]; 3.4-sec NB/SB throughs[15]
Cycle Length	AM/PM – 101-sec	120-sec AM; 110-sec PM
Offset	AM – 35, PM – 60	AM/PM – Master (Mid Segment)

F. CR 91/Wegmans Driveway/M&T Bank Driveway

This four-leg intersection operates under a four-phase traffic signal with a 110-second maximum cycle length. A coordinated, maximum recall is set on the northbound and southbound CR 91 approaches. The northbound and southbound CR 91 approaches provide an exclusive left-turn lane and two through lanes with shared right-turns. The eastbound Wegmans Driveway approach provides an exclusive left-turn lane and a through lane with shared left and right-turns, while the westbound M&T Bank Driveway approach provides a single lane for shared travel movements. Presence detection is provided on the northbound and southbound left-turn movements and on the eastbound and westbound approaches, while point detection is provided on the northbound and southbound through lanes. No sidewalks, crosswalks, or pedestrian controls are provided. The posted speed limit on CR 91 is 40-mph. Table II.F.1 summarizes the detailed levels of service for existing and proposed conditions.

[14] Max allowable headway = 3 sec, detection zone = 60 feet, approach speed = 45 mph.
[15] Max allowable headway = 3 sec, detection zone = 6 feet (placed 200 feet from the intersection), approach speed = 45 mph.

Table II.F.1 – CR 91/Wegmans Driveway/M&T Bank Driveway LOS Summary

Intersection		Control	AM Peak Hour		PM Peak Hour	
			Existing Coordinated	Revised Coordinated	Existing Coordinated	Revised Coordinated
CR 91/Wegmans Driveway/M&T Bank Driveway		S				
Wegmans Driveway EB	L		D (43)	D (47)	D (42)	D (42)
	LTR		D (43)	D (47)	D (42)	D (42)
M&T Bank Driveway WB	LT		D (51)	E (56)	D (50)	D (50)
	R		A (0)	A (0)	D (43)	D (44)
CR 91 NB	L		D (53)	D (48)	D (50)	E (57)
	T,TR		A (10)	A (9)	D (41)	B (17)
CR 91 SB	L		D (53)	E (76)	D (50)	E (62)
	T,TR		C (35)	B (16)	C (22)	B (14)
	Overall		C (29)	B (15)	C (34)	B (19)

Key: NB, SB, EB, WB = Northbound, Southbound, Eastbound, Westbound intersection approaches
L, T, R = Left-turn, through, and/or right-turn movements
X (Y.Y) = Level of Service (Delay, seconds per vehicle)

The intersection currently operates at an overall LOS C during both peak hours. After optimization of the traffic signal, which includes changing the northbound and southbound through movements to a coordinated minimum recall, the intersection will operate at an overall LOS B during both peak hours. However, the eastbound Wegmans Driveway shared left-turn/through movement and the southbound CR 91 left-turn movement will operate at LOS E during the AM peak hour. In addition, the northbound and southbound CR 91 left-turn movements will operate at LOS E during the PM peak hour. The proposed coordination benefits the heavy northbound/ southbound movements on CR 91 and the LOS E experienced on these minor AM and PM peak hour movements are acceptable to maintain optimal progression through the corridor.

To improve operations, new traffic signal coordination was provided, along with the modification of the yellow/all-red clearance, the minimum greens, and vehicle extension. The signal was optimized using Synchro which resulted in a 120-second cycle length during the AM peak hour and a 110-second cycle length during the PM peak hour. The AM and PM peak hour cycle lengths were adjusted to minimize vehicle delays, minimize the v/c ratio, and to coordinate the timings with adjacent signals located to the north and south within the *Mid Segment*. During the peak hours, the intersection will operate at the maximum cycle length during the higher percentiles of traffic, and shorter cycle lengths during lower percentiles of traffic. Table II.F.2 summarizes the suggested changes in the signal timing parameters.

Table II.F.2 – CR 91/Wegmans Driveway/M&T Bank Driveway Parameter Summary

Parameter	Existing	Proposed
Detection	EB/WB/NB/SB	No Change
Recall	C-Max NB/SB throughs	C-Min NB/SB throughs
Minimum Green	5-sec NB/SB lefts; 6-sec EB/WB; 10-sec NB/SB throughs	5-sec NB/SB left; 10-sec NB/SB throughs; 7-sec EB/WB
Yellow/All Red:	4/2-sec	4/2.5-sec for 30-45 mph speed
Vehicle Extension	4-sec WB and NB/SB throughs; 2.3-sec EB; 2-sec NB/SB lefts	1.7-sec EB[16]; 2.3-sec WB[17]; 1.6-sec NB/SB lefts[18]; 3.4-sec NB/SB throughs[19]
Cycle Length	AM/PM – 110-sec	120-sec AM; 110-sec PM
Offset	AM – 111, PM – 88	AM – 112, PM – 38

G. CR 91/Elmcrest Road/Friendly's Driveway

This four-leg intersection operates under a three-phase traffic signal with a 92-second maximum cycle length. A coordinated, maximum recall is set on the northbound and southbound CR 91 approaches. The northbound and southbound CR 91 approaches provide an exclusive left-turn lane and two through lanes with shared right-turns. The eastbound Elmcrest Road approach provides a through lane with shared left-turns and a separate right-turn, while the westbound Friendly's Driveway approach provides a single lane for shared travel movements. Presence detection is provided on the northbound and southbound left-turn movements and on the eastbound and westbound approaches, while point detection is provided on the southbound through lanes. No sidewalks are provided at this intersection. However, a crosswalk is provided on the southbound CR 91 approach with pedestrian controls. The posted speed limit on CR 91 is 40-mph, while the posted speed limit on Elmcrest Road is 30-mph. Table II.G.1 summarizes the detailed levels of service for existing and proposed conditions.

[16] Max allowable headway = 3sec, detection zone = 30 feet, approach speed = 30 mph.
[17] Max allowable headway = 3 sec, detection zone = 6 feet, approach speed = 30 mph.
[18] Max allowable headway = 3 sec, detection zone = 60 feet, approach speed = 45 mph.
[19] Max allowable headway = 3 sec, detection zone = 6 feet (placed 200 feet from the intersection), approach speed = 45 mph.

Table II.G.1 – CR 91/Elmcrest Road/Friendly's Driveway LOS Summary

Intersection		Control	AM Peak Hour		PM Peak Hour	
			Existing Coordinated	Revised Coordinated	Existing Coordinated	Revised Coordinated
CR 91/Elmcrest Road/Friendly's Driveway		S				
Elmcrest Road EB	LT		D (39)	D (48)	D (39)	D (44)
	R		C (31)	D (43)	C (24)	C (29)
Friendly's Driveway WB	LTR		D (36)	D (46)	C (35)	D (41)
CR 91 NB	L		D (37)	E (58)	D (37)	D (55)
	T,TR		A (5)	A (6)	A (10)	B (11)
CR 91 SB	L		D (42)	E (63)	D (44)	D (44)
	T,TR		B (15)	A (10)	B (13)	B (16)
	Overall		B (15)	B (14)	B (14)	B (16)

Key: NB, SB, EB, WB = Northbound, Southbound, Eastbound, Westbound intersection approaches
L, T, R = Left-turn, through, and/or right-turn movements
X (Y.Y) = Level of Service (Delay, seconds per vehicle)

The intersection currently operates at an overall LOS B during both peak hours. After optimization of the traffic signal which includes the addition of point detection on the northbound CR 91 approach, and changing the northbound and southbound through movements to a coordinated minimum recall, the intersection will operate at an overall LOS B during both peak hours. However, the northbound and southbound CR 91 left-turn movements will operate at LOS E during the AM peak hour. The proposed coordination benefits the heavy northbound/southbound movements on CR 91 and the LOS E experienced on these minor AM peak hour movements are acceptable to maintain optimal progression through the corridor.

At some intersections within a coordinated segment, operations may only experience a marginal improvement, and in some cases, experience a slight degradation. This is due to operating the intersection at cycle lengths and splits that favor the coordinated segment as a whole, rather than an isolated intersection. As an isolated intersection, individual movements and the overall operations could be improved, but coordination in the segment would be sacrificed.

To improve corridor operations, new traffic signal coordination was provided, along with the modification of the yellow/all-red clearance, the minimum greens, and vehicle extension. The signal was optimized using Synchro which resulted in a 120-second cycle length during the AM peak hour and a 110-second cycle length during the PM peak hour. It is noted that the walk and pedestrian clear times were increased for the crosswalk on the southbound CR 91 approach to ensure that pedestrians have adequate time to traverse the entire roadway width. The AM and PM peak hour cycle lengths were adjusted to minimize vehicle delays, minimize the v/c ratio, and to coordinate the timings with adjacent signals located north and south within the *Mid Segment*. During the peak hours, the intersection will operate at the maximum cycle length during the higher percentiles of traffic, and shorter cycle lengths during lower percentiles of traffic. Table II.G.2 summarizes the suggested changes in the signal timing parameters.

Table II.G.2 – CR 91/Elmcrest Road/Friendly's Driveway Parameter Summary

Parameter	Existing	Proposed
Detection	EB/WB/SB	Add point detection to the NB through lanes
Recall	C-Max NB/SB throughs	C-Min NB/SB throughs
Minimum Green	8-sec EB/WB and NB/SB lefts; 10-sec NB/SB throughs	5-sec NB/SB left; 10-sec NB/SB throughs; 7-sec EB/WB
Yellow/All Red:	3.5/1.5-sec	4/2.5-sec for 30-45 mph speed
Vehicle Extension	2.8-sec	1.0-sec EB[20]; 2.3-sec WB[21]; 1.6-sec NB/SB lefts[22]; 3.4-sec NB/SB throughs[23]
Cycle Length	AM/PM– 92-sec	120-sec AM; 110-sec PM
Offset	AM/PM = Master	AM – 99, PM – 45

H. CR 91/Blackberry Road/Rivercrest Road

This four-leg intersection operates under a three-phase traffic signal with an 89-second maximum cycle length. A coordinated, minimum recall is set on the northbound and southbound CR 91 approaches. The northbound CR 91 approach provides an exclusive left-turn lane, two through lanes, and a separate right-turn lane, while the southbound CR 91 approach provides an exclusive left-turn lane and two through lanes with shared right-turns. The eastbound Rivercrest Road approach provides a single lane for shared travel movements, while the westbound Blackberry Road approach provides a through lane with shared left-turns and a separate right-turn lane. Presence detection is provided on the northbound and southbound left-turn movements and on the eastbound and westbound approaches, while point detection is provided on the northbound and southbound through lanes. No sidewalks are provided at this intersection. However, a crosswalk is provided on the northbound CR 91 approach with pedestrian controls. The posted speed limit on CR 91 is 40-mph, while the posted speed limit on Rivercrest Road and Blackberry Road is 30-mph. Table II.H.1 summarizes the detailed levels of service for existing and proposed conditions.

[20] Max allowable headway = 3 sec, detection zone = 60 feet, approach speed = 30 mph.
[21] Max allowable headway = 3 sec, detection zone = 6 feet, approach speed = 30 mph.
[22] Max allowable headway = 3 sec, detection zone = 60 feet, approach speed = 45 mph.
[23] Max allowable headway = 3 sec, detection zone = 6 feet (placed 200 feet from the intersection), approach speed = 45 mph.

Table II.H.1 – CR 91/Blackberry Road/Rivercrest Road LOS Summary

Intersection		Control	AM Peak Hour		PM Peak Hour	
			Existing Coordinated	Revised Coordinated	Existing Coordinated	Revised Coordinated
CR 91/Blackberry Road/Rivercrest Road		S				
Rivercrest Road EB	LTR		C (24)	C (31)	C (26)	C (34)
Blackberry Road WB	LT		F (146)	F (142)	D (40)	D (55)
	R		B (11)	B (17)	B (16)	C (25)
CR 91 NB	L		D (42)	D (50)	D (39)	E (56)
	T,T		C (24)	C (26)	E (70)	C (27)
	R		B (19)	C (24)	B (18)	B (15)
CR 91 SB	L		C (35)	D (55)	D (35)	D (53)
	T,TR		C (31)	C (34)	B (18)	B (18)
	Overall		D (41)	D (45)	D (43)	C (26)

Key: NB, SB, EB, WB = Northbound, Southbound, Eastbound, Westbound intersection approaches
L, T, R = Left-turn, through, and/or right-turn movements
X (Y.Y) = Level of Service (Delay, seconds per vehicle)

The intersection currently operates at an overall LOS D during both peak hours with the westbound Blackberry Road shared left-turn/through movement operating at LOS F during the AM peak hour, and the northbound CR 91 left-turn movement operating at LOS E during the PM peak hour. After optimization of the traffic signal which includes changing the northbound and southbound through movements to minimum recall, the intersection will operate at an overall LOS D/C during the AM and PM peak hours with the westbound Blackberry Road shared left-turn/through movement operating at LOS F during the AM peak hour, and the northbound CR 91 left-turn movement continuing to operate at LOS E during the PM peak hour.

At some intersections within a coordinated segment, operations may only experience a marginal improvement, and in some cases, experience a slight degradation. This is due to operating the intersection at cycle lengths and splits that favor the coordinated segment as a whole, rather than an isolated intersection. As an isolated intersection, individual movements and the overall operations could be improved, but coordination in the segment would be sacrificed.

To improve operations, new traffic signal coordination was provided, along with the modification of the yellow/all-red clearance, the minimum greens, and vehicle extension. The signal was optimized using Synchro which resulted in a 120-second cycle length during the AM peak hour and a 110-second cycle length during the PM peak hour. It is noted that the walk and pedestrian clear times were increased for the crosswalk on the northbound CR 91 approach to ensure that pedestrians have adequate time to traverse the entire roadway width. The AM and PM peak hour cycle lengths were adjusted to minimize vehicle delays, minimize the v/c ratio, and to coordinate the timings with adjacent signals located to the south within the *Mid Segment*. During the peak hours, the intersection will operate at the maximum cycle length during the higher percentiles of traffic, and shorter cycle lengths during lower percentiles of traffic. Table II.H.2 summarizes the suggested changes in the signal timing parameters.

Table II.H.2 – CR 91/Blackberry Road/Rivercrest Road Parameter Summary

Parameter	Existing	Proposed
Detection	EB/WB/NB/SB	No Change
Recall	C-Min NB/SB throughs	No Change
Minimum Green	4-sec EB/WB; 5-sec NB/SB lefts and WB right; 12-sec NB/SB throughs	5-sec NB/SB left; 10-sec NB/SB throughs; 7-sec EB/WB
Yellow/All Red:	3.5/2-sec EB/WB and NB/SB lefts; 4/2-sec NB/SB throughs	4/2.2-sec for 30-45 mph speed
Vehicle Extension	3.5-sec EB/WB and NB/SB lefts; 3-sec NB/SB throughs	1.0-sec EB/WB[24]; 3.4-sec NB/SB throughs[25]; 1.6-sec NB/SB lefts[26]
Cycle Length	AM/PM– 89-sec	120-sec AM; 110-sec PM
Offset	AM – 12; PM – 34	AM – 90, PM – 44

I. CR 91/Wetzel Road

This four-leg intersection operates under a three-phase traffic signal with a 103-second maximum cycle length. A coordinated, maximum recall is set on the northbound and southbound CR 91 approaches. The northbound and southbound CR 91 approaches provide an exclusive left-turn lane and two through lanes with shared right-turns. The eastbound Wetzel Road approach provides a single lane for shared travel movements, while the westbound Wetzel Road approach provides a through lane with shared left-turns and a separate right-turn lane. Presence detection is provided on the northbound and southbound left-turn movements and on the eastbound and westbound approaches, while point detection is provided on the northbound and southbound through lanes. No sidewalks, crosswalks, or pedestrian controls are provided. The posted speed limit on CR 91 is 40-mph while the posted speed limit on Wetzel Road is 30-mph. Table II.I.1 summarizes the detailed levels of service for existing and proposed conditions.

Table II.I.1 – CR 91/Wetzel Road LOS Summary

Intersection		Control	AM Peak Hour		PM Peak Hour	
			Existing Coordinated	Revised Coordinated	Existing Coordinated	Revised Coordinated
CR 91/Wetzel Road		S				
Wetzel Road EB	LTR		C (29)	B (20)	D (36)	C (32)
Wetzel Road WB	LT		E (66)	D (53)	D (43)	D (50)
	R		B (14)	B (10)	C (23)	C (23)
CR 91 NB	L		D (48)	C (32)	D (48)	D (37)
	T,TR		C (30)	C (29)	E (69)	D (40)
CR 91 SB	L		D (49)	D (40)	D (42)	D (51)
	T,TR		B (17)	B (10)	B (10)	A (4)
	Overall		C (29)	C (23)	D (43)	C (29)

Key: NB, SB, EB, WB = Northbound, Southbound, Eastbound, Westbound intersection approaches
L, T, R = Left-turn, through, and/or right-turn movements
X (Y.Y) = Level of Service (Delay, seconds per vehicle)

[24] Max allowable headway = 3 sec, detection zone = 60 feet, approach speed = 30 mph.
[25] Max allowable headway = 3 sec, detection zone = 6 feet (placed 200 feet from the intersection), approach speed = 45 mph.
[26] Max allowable headway = 3 sec, detection zone = 60 feet, approach speed = 45 mph.

The intersection currently operates at an overall LOS C/D during the AM and PM peak hours with the westbound Wetzel Road shared left-turn/through movement operating at LOS E during the AM peak hour. After optimization of the traffic signal which includes changing the northbound and southbound through movements to a coordinated minimum recall, the intersection will operate at an overall LOS C during both peak hours with all movements operating at LOS D or better.

To improve operations, new traffic signal coordination was provided, along with the modification of the yellow/all-red clearance, the minimum greens, and vehicle extension. The signal was optimized using Synchro which resulted in a 70-second cycle length during the AM peak hour and an 80-second cycle length during the PM peak hour. The AM and PM cycle lengths were adjusted to minimize vehicle delays, minimize the v/c ratio, and to coordinate the timings with adjacent signals located to the north within the *North Segment*. During the peak hours, the intersection will operate at the maximum cycle length during the higher percentiles of traffic, and shorter cycle lengths during lower percentiles of traffic. Table II.I.2 summarizes the suggested changes in the signal timing parameters.

Table II.I.2 – CR 91/Wetzel Road Parameter Summary

Parameter	Existing	Proposed
Detection	EB/WB/NB/SB	No Change
Recall	C-Max NB/SB throughs	C-Min NB/SB throughs
Minimum Green	5-sec NB/SB lefts and WB right; 8-sec EB/WB; 12-sec NB/SB throughs	5-sec NB/SB left; 10-sec NB/SB throughs; 7-sec EB/WB
Yellow/All Red:	4/2-sec	4/2.5-sec for 30-45 mph speed
Vehicle Extension	3-sec	1.0-sec EB/WB[27]; 3.4-sec NB/SB throughs[28]; 1.6-sec NB/SB lefts[29]
Cycle Length	AM/PM– 103-sec	70-sec AM; 80-sec PM
Offset	AM – 77; PM – 88	AM – 37, PM – 33

J. CR 91/Pine Hollow Road/Seneca Mall Driveway

This four-leg intersection operates under a three-phase traffic signal with an 84-second maximum cycle length. A coordinated, maximum recall is set on the northbound and southbound CR 91 approaches. The northbound and southbound CR 91 approaches provide an exclusive left-turn lane and two through lanes with shared right-turns. The eastbound Seneca Mall driveway approach provides a through lane with shared left turns and a separate right-turn lane, while the westbound Pine Hollow Road approach provides a single lane for shared travel movements. Presence detection is provided on the northbound and southbound left-turn movements and on the eastbound and westbound approaches, while point detection is provided on the northbound and southbound through lanes. No

[27] Max allowable headway = 3 sec, detection zone = 60 feet, approach speed = 30 mph.
[28] Max allowable headway = 3 sec, detection zone = 6 feet (placed 200 feet from the intersection), approach speed = 45 mph.
[29] Max allowable headway = 3 sec, detection zone = 60 feet, approach speed = 45 mph.

sidewalks are provided at this intersection. However, a crosswalk is provided on the southbound CR 91 approach with pedestrian controls. The posted speed limit on CR 91 is 40-mph, while the posted speed limit on Pine Hollow Road is 30 mph. Table II.J.1 summarizes the detailed levels of service for existing and proposed conditions.

Table II.J.1 – CR 91/Pine Hollow Road/Seneca Mall Driveway LOS Summary

Intersection		Control	AM Peak Hour		PM Peak Hour	
			Existing Coordinated	Revised Coordinated	Existing Coordinated	Revised Coordinated
CR 91/Pine Hollow Road/Seneca Mall Driveway		S				
Seneca Mall Driveway EB	LT		C (27)	C (23)	C (26)	C (33)
	R		B (20)	B (17)	B (14)	B (14)
Pine Hollow Road WB	LTR		C (32)	C (27)	C (25)	C (24)
CR 91 NB	L		D (35)	D (39)	C (34)	C (26)
	T,TR		A (7)	A (4)	C (20)	C (22)
CR 91 SB	L		D (39)	C (26)	D (37)	D (43)
	T,TR		B (19)	C (24)	C (26)	C (22)
	Overall		B (17)	B (20)	C (24)	C (23)

Key: NB, SB, EB, WB = Northbound, Southbound, Eastbound, Westbound intersection approaches
L, T, R = Left-turn, through, and/or right-turn movements
X (Y.Y) = Level of Service (Delay, seconds per vehicle)

The intersection currently operates at an overall LOS B/C during the AM and PM peak hours. After optimization of the traffic signal which includes changing the northbound and southbound through movements to a coordinated minimum recall, the intersection will continue to operate at the same overall levels of service during both peak hours with all movements operating at LOS D or better.

At some intersections within a coordinated segment, operations may only experience a marginal improvement, and in some cases, experience a slight degradation. This is due to operating the intersection at cycle lengths and splits that favor the coordinated segment as a whole, rather than an isolated intersection. As an isolated intersection, individual movements and the overall operations could be improved, but coordination in the segment would be sacrificed.

To improve corridor operations, new traffic signal coordination was provided, along with the modification of the yellow/all-red clearance, the minimum greens, and vehicle extension. The signal was optimized using Synchro which resulted in a 70-second cycle length during the AM peak hour and an 80-second cycle length during the PM peak hour. The AM and PM cycle lengths were adjusted to minimize vehicle delays, minimize the v/c ratio, and to coordinate the timings with adjacent signals located to the north and south within the *North Segment*. During the peak hours, the intersection will operate at the maximum cycle length during the higher percentiles of traffic, and shorter cycle lengths during lower percentiles of traffic. Table II.J.2 summarizes the suggested changes in the signal timing parameters.

Table II.J.2 – CR 91/Pine Hollow Road/Seneca Mall Driveway Parameter Summary

Parameter	Existing	Proposed
Detection	EB/WB/NB/SB	No Change
Recall	C-Max NB/SB throughs	C-Min NB/SB throughs
Minimum Green	6-sec EB/WB; 8-sec NB/SB lefts and EB right; 10-sec NB/SB throughs	5-sec NB/SB left; 10-sec NB/SB throughs; 7-sec EB/WB
Yellow/All Red:	3.5/1.5-sec	4/2.5-sec for 30-45 mph speed
Vehicle Extension	1-sec SB left; 3.5-sec EB/WB/NB and SB throughs	1.0-sec WB[30]; 1.7-sec EB[31]; 3.4-sec NB/SB throughs[32]; 1.6-sec NB/SB lefts[33]
Cycle Length	AM/PM– 84-sec	70-sec AM; 80-sec PM
Offset	AM – 106; PM – 84	AM – 41, PM – 45

K. CR 91/Soule Road

This four-leg intersection operates under a four-phase traffic signal with a 100-second maximum cycle length. A coordinated, maximum recall is set on the northbound and southbound CR 91 approaches. The northbound CR 91 approach provides an exclusive left-turn lane, three through lanes, and a separate right-turn lane while the southbound CR 91 approach provides an exclusive left-turn lane and three through lanes with shared right-turns. The eastbound Soule Road approach provides an exclusive left-turn lane and a through lane with shared right-turns, while the westbound Soule Road approach provides two exclusive left-turn lanes and a through lane with shared right-turns. Presence detection is provided on the northbound and southbound left-turn movements and on the eastbound and westbound approaches, while point detection is provided on the northbound and southbound through lanes. No sidewalks, crosswalks, or pedestrian controls are provided at this intersection. The posted speed limit on CR 91 is 40-mph, while the posted speed limit on Soule Road is 30-mph. Table II.K.1 summarizes the detailed levels of service for existing and proposed conditions.

[30] Max allowable headway = 3 sec, detection zone = 60 feet, approach speed = 30 mph.
[31] Max allowable headway = 3 sec, detection zone = 30 feet, approach speed = 30 mph.
[32] Max allowable headway = 3 sec, detection zone = 6 feet (placed 200 feet from the intersection), approach speed = 45 mph.
[33] Max allowable headway = 3 sec, detection zone = 60 feet, approach speed = 45 mph.

Table II.K.1 – CR 91/Soule Road LOS Summary

Intersection		Control	AM Peak Hour		PM Peak Hour	
			Existing Coordinated	Revised Coordinated	Existing Coordinated	Revised Coordinated
CR 91/Soule Road		S				
Soule Road EB	L		D (45)	C (31)	D (42)	D (37)
	TR		D (44)	C (31)	D (41)	D (35)
Soule Road WB	L,L		D (37)	D (36)	D (37)	D (38)
	TR		C (31)	C (25)	C (35)	C (31)
CR 91 NB	L		A (0)	A (0)	D (43)	D (49)
	T,T,T		C (28)	B (12)	C (33)	B (15)
	R		B (14)	A (9)	B (15)	A (8)
CR 91 SB	L		D (37)	C (28)	D (43)	D (42)
	T,T,TR		B (11)	A (8)	C (23)	C (21)
	Overall		C (22)	B (17)	C (30)	C (23)

Key: NB, SB, EB, WB = Northbound, Southbound, Eastbound, Westbound intersection approaches
L, T, R = Left-turn, through, and/or right-turn movements
X (Y.Y) = Level of Service (Delay, seconds per vehicle)

The intersection currently operates at an overall LOS C during both peak hours. After optimization of the traffic signal which includes switching this intersection to the master controller for the *North Segment*, and changing the northbound and southbound through movements to a coordinated minimum recall, the intersection will operate at an overall LOS B/C during the AM and PM peak hours with all movements operating at LOS D or better.

To improve operations, new traffic signal coordination was provided, along with the modification of the yellow/all-red clearance, the minimum greens, and vehicle extension. The signal was optimized using Synchro which resulted in a 70-second cycle length during the AM peak hour and an 80-second cycle length during the PM peak hour. The AM and PM cycle lengths were adjusted to minimize vehicle delays, minimize the v/c ratio, and to coordinate the timings with adjacent signals located to the north and south within the *North Segment*. During the peak hours, the intersection will operate at the maximum cycle length during the higher percentiles of traffic, and shorter cycle lengths during lower percentiles of traffic. Table II.K.2 summarizes the suggested changes in the signal timing parameters.

Table II.K.2 – CR 91/Soule Road Parameter Summary

Parameter	Existing	Proposed
Detection	EB/WB/NB/SB	No Change
Recall	C-Max NB/SB throughs	C-Min NB/SB throughs
Minimum Green	3.5-sec NB/SB lefts; 5-sec EB/WB and NB/SB throughs	5-sec NB/SB left; 10-sec WB and NB/SB throughs; 7-sec EB
Yellow/All Red:	4/2-sec	4/2.5-sec for 30-45 mph speed
Vehicle Extension	3-sec SB through; 3.2-sec EB/WB/NB and SB left	1.0-sec EB/WB[34]; 3.4-sec NB/SB throughs[35]; 1.6-sec NB/SB lefts[36]
Cycle Length	AM/PM– 100-sec	70-sec AM; 80-sec PM
Offset	AM – 87; PM – 34	AM /PM – Master (South Segment)

L. CR 91/Gaskin Road/Redwing Drive

This four-leg intersection operates under a three-phase traffic signal with an 88-second maximum cycle length. A coordinated, maximum recall is set on the northbound and southbound CR 91 approaches. The northbound and southbound CR 91 approaches provide an exclusive left-turn lane and two through lanes with shared right-turns. The eastbound Gaskin Road approach and the westbound Redwing Drive approach provide a single lane for shared travel movements. Presence detection is provided on the northbound and southbound left-turn movements and on the eastbound and westbound approaches, while point detection is provided on the northbound and southbound through lanes. No sidewalks, crosswalks, or pedestrian controls are provided at this intersection. The posted speed limit on CR 91 is 40-mph, while the posted speed limit on Gaskin Road and Redwing Drive is 30-mph. Table II.L.1 summarizes the detailed levels of service for existing and proposed conditions.

Table II.L.1 – CR 91/Gaskin Road/Redwing Drive LOS Summary

Intersection		Control	AM Peak Hour		PM Peak Hour	
			Existing Coordinated	Revised Coordinated	Existing Coordinated	Revised Coordinated
CR 91/Gaskin Road/Redwing Drive		S				
Gaskin Road EB	LTR		C (24)	B (11)	C (29)	C (27)
Redwing Drive WB	LTR		F (703)	D (53)	E (55)	E (63)
CR 91 NB	L		D (37)	C (28)	D (44)	D (43)
	T,TR		B (12)	A (10)	B (16)	B (10)
CR 91 SB	L		D (41)	C (32)	D (39)	D (36)
	T,TR		B (18)	C (31)	B (20)	C (20)
	Overall		F (151)	C (26)	C (25)	C (23)

Key: NB, SB, EB, WB = Northbound, Southbound, Eastbound, Westbound intersection approaches
L, T, R = Left-turn, through, and/or right-turn movements
X (Y.Y) = Level of Service (Delay, seconds per vehicle)

The intersection currently operates at an overall LOS F/C during the AM and PM peak hours with the westbound Redwing Drive approach operating at LOS F/E

[34] Max allowable headway = 3 sec, detection zone = 60 feet, approach speed = 30 mph.
[35] Max allowable headway = 3 sec, detection zone = 6 feet (placed 200 feet from the intersection), approach speed = 45 mph.
[36] Max allowable headway = 3 sec, detection zone = 60 feet, approach speed = 45 mph.

during the AM and PM peak hours. After optimization of the traffic signal which includes changing the northbound and southbound through movements to a coordinated minimum recall, the intersection will operate at an overall LOS C during both peak hours with the westbound Redwing Drive approach operating at LOS E during the AM peak hour. Although it was not included in the evaluation, the construction of a separate eastbound right-turn lane on Gaskin Road could potentially help mitigate delay at this intersection since it will allow this movement to run as an overlap with the northbound CR 91 left-turn movement. Therefore, the heavier westbound left-turn volume will be able to utilize more of the eastbound/westbound green-time since there will be less opposing traffic. The intersection will operate at better overall levels of service with this improvement.

To improve operations, new traffic signal coordination was provided, along with the modification of the yellow/all-red clearance, the minimum greens, and vehicle extension. The signal was optimized using Synchro which resulted in a 70-second cycle length during the AM peak hour and an 80-second cycle length during the PM peak hour. The AM and PM cycle lengths were adjusted to minimize vehicle delays, minimize the v/c ratio, and to coordinate the timings with adjacent signals located to the south within the *North Segment*. During the peak hours, the intersection will operate at the maximum cycle length during the higher percentiles of traffic, and shorter cycle lengths during lower percentiles of traffic. Table II.L.2 summarizes the suggested changes in the signal timing parameters.

Table II.L.2 – CR 91/Gaskin Road/Redwing Drive Parameter Summary

Parameter	Existing	Proposed
Detection	EB/WB/NB/SB	No Change
Recall	C-Max NB/SB throughs	C-Min NB/SB throughs
Minimum Green	8-sec EB/WB and NB/SB; 10-sec NB/SB throughs	5-sec NB/SB left; 10-sec EB and NB/SB throughs; 7-sec WB
Yellow/All Red:	4/2-sec	4/2.5-sec for 30-45 mph speed
Vehicle Extension	4-sec	1.0-sec EB/WB[37]; 3.4-sec NB/SB throughs[38]; 1.6-sec NB/SB lefts[39]
Cycle Length	AM/PM– 88-sec	70-sec AM; 80-sec PM
Offset	AM – 27; PM – 14	AM – 60, PM – 50

M. Corridor Evaluation Summary

Measures of effectiveness (MOEs) serve as performance measures for evaluating the CR 91 corridor. The MOEs can include delays, fuel consumption, average speed, emissions, travel time, and the "performance index" (PI) from the traffic simulation model. The PI represents a combination of the delays, stops, and queuing penalty. A lower PI indicates better overall operations. The corridor was optimized and evaluated with

[37] Max allowable headway = 3 sec, detection zone = 60 feet, approach speed = 30 mph.
[38] Max allowable headway = 3 sec, detection zone = 6 feet (placed 200 feet from the intersection), approach speed = 45 mph.
[39] Max allowable headway = 3 sec, detection zone = 60 feet, approach speed = 45 mph.

coordination. Table II.M.1 summarizes the MOEs for the revised coordinated system proposed on CR 91.

Table II.M.1 – Measures of Effectiveness on CR 91

Measure of Effectiveness	AM Peak Hour		PM Peak Hour	
	Existing Coordination	Revised Coordination	Existing Coordination	Revised Coordination
Total Delay (Hours)	276	166	446	234
Performance Index	324.5	209.2	513.5	295.5
Fuel Consumed (gal)	784	680	1071	886
Overall Speed (mph)				
NB	28	28	15	24
SB	19	26	23	26
Travel Time (seconds)				
NB	595	553	1,096	681
SB	966	658	773	658

Overall, Table II.M.1 shows that the MOEs along CR 91 will improve under the proposed coordinated system. Total delay through the corridor will be reduced and speeds will improve from zero to 8-mph based on peak hour and approach.

N. Optimization Summary

The recommendations discussed in the preceding sections are intended to develop consistency in the operations of each signal, improve responsiveness, and increase efficiency. The addition of detection on all approaches enables a signal to respond to changing traffic conditions, which increases the capacity of the intersection. Once vehicle detection is installed, recall settings in the signal controller can be used to create a minimum operating condition that the signal must serve. Beyond that, the controller can respond to the current demand.

Another key component of the recommendations is updating the vehicle extension times to accurately reflect the existing or proposed detection. The vehicle extension adds time to an approach that has already served the initial platoon of traffic with the minimum green, but continues to see additional vehicles arriving on the approach. The traffic signal will not start to "gap out" (i.e., end the current phase) until the vehicle has left the detection zone.

Many of the intersections included in this analysis currently have presence detection (long vehicle detection loops, typically 60 to 70 feet) and a 3 to 4 second vehicle extension time. Depending on the speed of approaching vehicles, this combination of presence detection and a 3 to 4 second vehicle extension will result in the continued extension of the green phase for a dwindling amount of vehicles, which increases the delay for drivers on conflicting approaches waiting for straggling vehicles to pass through the intersection. Therefore, this report generally recommends that the vehicle extension time be reduced to 0.6 to 2.3 seconds for presence detection to allow the signal to serve all approaches more efficiently and reduce overall delay at the intersection.

In contrast, point detection uses a small detection zone; typically a 6-foot detector loop placed 100 to 250 feet from the intersection, and has a much shorter period of detection as a vehicle passes over it. Point detection requires longer vehicle extensions, since the detector has less time to detect a vehicle approaching the intersection. Therefore, for point detection, this report generally recommends using a 3.4 to 4.2-second vehicle extension time to allow the signal to serve all approaches more efficiently and reduce overall delay at the intersection.

The following tables provide the traffic signal coordination plans for the AM and PM peak hours for the revised coordinated system.

Table II.N.1 – Revised Coordination Data Table (AM Peak Hour)

AM Peak Hour – Mixed Cycle Length (7:00 to 9:00 AM)										
	Intersection	Splits								Offset
		Ø1	Ø2	Ø3	Ø4	Ø5	Ø6	Ø7	Ø8	
South Segment	I-90 Exit 38	14	79	17			93			78
	Liverpool Bypass/Dents Drwy		87		23	40	47		23	0 (M)
Mid Segment	Hiawatha Plaza/Plaza Drwy	11	96		13		107		13	19
	Long Branch Rd/Belmont Dr	14	62	12	32	15	61	17	27	0
	John Glenn Blvd	14	55	34	17	18	51	21	30	0 (M)
	Wegmans Drwy/M&T Bank	12	62	14	32	13	61			112
	Elmcrest Rd/Friendly's Drwy	16	72		32	12	76		32	99
	Blackberry Rd/Rivercrest Rd	12	74		34	24	52		34	90
North Segment	Wetzel Rd	12	35		23	20	27		23	37
	Pine Hollow Rd/Seneca Mall	12	26		32	12	26		32	41
	Soule Rd	12	27		17	22	17	14		0 (M)
	Gaskin Rd/Redwing Dr	12	18	40		12	18	40		60

M = Indicates Master controller, from which the other intersection offsets in the zone are referenced to.

Table II.N.2 – Revised Coordination Data Table (PM Peak Hour)

PM Peak Hour – Mixed Cycle Length (4:00 to 6:00 PM)										
	Intersection	Splits								Offset
		Ø1	Ø2	Ø3	Ø4	Ø5	Ø6	Ø7	Ø8	
South Segment	I-90 Exit 38	12	51	27			63			25
	Liverpool Bypass/Dents Drwy		71		19	19	52		19	0 (M)
Mid Segment	Hiawatha Plaza/Plaza Drwy	11	83		16		94		16	31
	Long Branch Rd/Belmont Dr	16	50	12	32	21	45	20	24	96
	John Glenn Blvd	27	36	31	16	11	52	27	20	0 (M)
	Wegmans Drwy/M&T Bank	12	52	14	32	12	52			38
	Elmcrest Rd/Friendly's Drwy	30	48		32	12	66		32	45
	Blackberry Rd/Rivercrest Rd	12	57		41	15	54		41	44
North Segment	Wetzel Rd	12	52		16	19	45		16	33
	Pine Hollow Rd/Seneca Mall	12	36		32	15	33		32	45
	Soule Rd	12	36		18	18	30	14		0 (M)
	Gaskin Rd/Redwing Dr	24	26	30		12	38	30		50

M = Indicates Master controller, from which the other intersection offsets in the zone are referenced to.

O. Corridor Coordination Sensitivity Analysis

A sensitivity analysis was conducted at the twelve study area intersections to provide a comparison between the proposed coordination plan that includes separate signal cycle lengths for three different segments and an alternative coordination plan that consists of one universal cycle length (120 seconds for AM and 110 seconds for PM). A summary of network MOEs is provided on Table II.O.1 which compares the proposed and alternative coordination plans.

Table II.O.1 – Measures of Effectiveness Sensitivity Analysis on CR 91

Measure of Effectiveness	AM Peak Hour		PM Peak Hour	
	Multiple Segment Coordination	Single Segment Coordination	Multiple Segment Coordination	Single Segment Coordination
Total Delay (Hours)	166	162	234	228
Performance Index	209.2	201.0	295.5	284.1
Fuel Consumed (gal)	680	658	886	858
Overall Speed (mph)				
NB	28	28	24	25
SB	26	26	26	26
Travel Time (seconds)				
NB	553	565	681	662
SB	658	646	658	648

In general, Table II.O.1 shows that the MOEs along CR 91 are slightly better with a universal signal cycle length as opposed to the proposed timing plan that includes three separate cycle lengths identified for three specific segments on CR 91. However, it is noted that more individual intersection movements will operate below LOS D under the alternative coordination plan since it forces all of the intersections to operate under a single

cycle length which may be further from the natural cycle length of the intersection. Additionally, a single cycle length for the corridor would favor those drivers that may be traveling through the entire 4.5 mile corridor versus those traveling a portion of the network. Short of conducting an origin-destination survey to determine what percentage of drivers actually travel the entire corridor, based on the volume of traffic added and subtracted from CR 91, it would appear that most drivers only use a portion of the corridor in their commuting patterns. This pattern lends itself to a multiple segment coordination plan.

While it is recommended that the proposed coordination plan detailed in this report be utilized in the corridor, more specific details of the alternative coordination plan can be provided upon request.

CHAPTER IV

CONCLUSIONS

Based on the results of this Traffic Signal Timing Optimization study, the following recommendations are offered for the study area intersections:

- CR 91/I-90 Exit 38 Ramp: This intersection currently operates at an overall LOS C/B during the AM and PM peak hours. It is recommended that the timing parameters be adjusted as shown in Table II.A.2 to minimize vehicle delays, minimize the v/c ratio, and coordinate the timings with adjacent signals for the coordinated condition. It is noted that the northbound protected left-turn phase was changed to a lagging phase as per the OCDOT standards for a three-leg intersection. These changes will result in continued acceptable overall operating conditions with all movements operating at LOS D or better during both peak hours.

- CR 91/Liverpool Bypass/Dents Disappear Driveway: This intersection currently operates at acceptable levels of service during the AM and PM peak hours. However, it is recommended that this intersection be switched to the master intersection of the *South Segment* and that the timing parameters be adjusted as shown in Table II.B.2 to minimize vehicle delays, minimize the v/c ratio, and coordinate the timings with adjacent signals. These changes will result in continued acceptable operating conditions.

- CR 91/Hiawatha Plaza Driveway/Plaza Driveway: During the AM and PM peak hours, this intersection operates at an overall LOS B/A. It is recommended that the timing parameters be adjusted as shown in Table II.C.2 to minimize vehicle delays, minimize the v/c ratio, and coordinate the timings with adjacent signals. These changes will allow the intersection to operate at an overall LOS A during both peak hours. The proposed coordination benefits the heavy northbound/southbound movements on CR 91, and the LOS E experienced on the minor movements during the AM peak hour are acceptable to maintain optimal progression through the corridor.

- CR 91/Long Branch Road/Belmont Drive: During the AM and PM peak hours, this intersection operates at an overall LOS E/C with the southbound CR 91 through movement operating at LOS F during the AM peak hour. It is recommended that point detection be added on the northbound/southbound approaches and that the timing parameters be adjusted as shown in Table II.D.2 to minimize vehicle delays, minimize the v/c ratio, and coordinate the timings with adjacent signals. The analysis also includes the addition of pedestrian accommodations across the northbound CR 91 approach as per the request of the OCDOT. These changes will allow the intersection to operate at an overall LOS C during both peak hours. The proposed coordination benefits the heavy northbound/southbound movements on CR 91, and the LOS E experienced on the minor movements during the AM peak hour are acceptable to maintain optimal progression through the corridor.

- CR 91/John Glenn Boulevard: This intersection currently operates at an overall LOS F during both peak hours with multiple movements operating at LOS E/F during both peak hours. It is recommended that this intersection be switched to the master intersection of the *Mid Segment* and that the timing parameters be adjusted as shown in Table II.E.2 to minimize vehicle delays, minimize the v/c ratio, and coordinate the timings with adjacent signals. The analysis also includes the addition of pedestrian accommodations across the westbound John Glenn Boulevard approach as per the request of the OCDOT. These changes will allow the intersection to operate at an overall LOS E during both peak hours with several movements continuing to operate at LOS F during both peak hours. Although it was not included in the evaluation, the construction of a separate eastbound right-turn lane on John Glenn Boulevard could potentially help mitigate overall delay at this intersection.

- CR 91/Wegmans Driveway/M&T Bank Driveway: During the AM and PM peak hours, this intersection operates at an overall LOS C. It is recommended that the timing parameters be adjusted as shown in Table II.F.2 to minimize vehicle delays, minimize the v/c ratio, and coordinate the timings with adjacent signals. These changes will allow the intersection to operate at an overall LOS B during both peak hours. The proposed coordination benefits the heavy northbound/ southbound movements on CR 91, and the LOS E experienced on the minor movements during the AM peak hour are acceptable to maintain optimal progression through the corridor.

- CR 91/Elmcrest Road/Friendly's Driveway: During the AM and PM peak hours, this intersection operates at an overall LOS B. It is recommended that point detection be added on the northbound/southbound approaches, and that the timing parameters be adjusted as shown in Table II.G.2 to minimize vehicle delays, minimize the v/c ratio, and coordinate the timings with adjacent signals. It is noted that the walk and pedestrian clear times were increased for the crosswalk on the southbound CR 91 approach to ensure that pedestrians have adequate time to traverse the entire roadway width. These changes will allow the intersection to operate at an overall LOS A during both peak hours. The proposed coordination benefits the heavy northbound/southbound movements on CR 91, and the LOS E experienced on the minor movements during the AM peak hour are acceptable to maintain optimal progression through the corridor.

- CR 91/Blackberry Road/Rivercrest Road: This intersection currently operates at an overall LOS D during both peak hours. It is recommended the timing parameters be adjusted as shown in Table II.H.2 to minimize vehicle delays, minimize the v/c ratio, and coordinate the timings with adjacent signals. It is noted that the walk and pedestrian clear times were increased for the crosswalk on the northbound CR 91 approach to ensure that pedestrians have adequate time to traverse the entire roadway width. These changes will allow the intersection to operate at an overall LOS D/C during AM and PM peak hours.

- CR 91/Wetzel Road: This intersection currently operates at an overall LOS C/D during the AM and PM peak hours. It is recommended that the timing parameters be adjusted as shown in Table II.I.2 to minimize vehicle delays, minimize the v/c ratio, and coordinate the timings with adjacent signals for the coordinated condition. These changes will result in similar acceptable overall operating conditions.

- CR 91/Pine Hollow Road/Seneca Mall Driveway: This intersection currently operates at an overall LOS B/C during the AM and PM peak hours. It is recommended that the timing parameters be adjusted as shown in Table II.J.2 to minimize vehicle delays, minimize the v/c ratio, and coordinate the timings with adjacent signals for the coordinated condition. These changes will result in similar acceptable overall operating conditions.

- CR 91/Soule Road: This intersection currently operates at an overall LOS C during both peak hours. It is recommended that this intersection be switched to the master intersection of the *North Segment* and that the timing parameters be adjusted as shown in Table II.K.2 to minimize vehicle delays, minimize the v/c ratio, and coordinate the timings with adjacent signals for the coordinated condition. These changes will result in similar acceptable overall operating conditions.

- CR 91/Gaskin Road/Redwing Drive: This intersection currently operates at an overall LOS F/C during the AM and PM peak hours. It is recommended that the timing parameters be adjusted as shown in Table II.L.2 to minimize vehicle delays, minimize the v/c ratio, and coordinate the timings with adjacent signals. These changes will allow the intersection to operate at an overall LOS C during both peak hours with the westbound Redwing Drive approach operating at LOS E during the PM peak hour. Although it was not included in the evaluation, the construction of a separate eastbound right-turn lane on Gaskin Road could potentially help mitigate overall delay at this intersection.

- A sensitivity analysis, which includes different signal cycle lengths for three different segments and an alternative coordination plan that consists of one universal cycle length, indicates slightly better MOEs with a universal signal cycle length as opposed to the proposed timing plan. However, it is noted that more individual intersection movements will operate below LOS D under the alternative coordination plan since it forces all of the intersections to operate under a single cycle length which may differ from the natural cycle length of the intersection. It is therefore recommended that the proposed coordination plan be utilized in the corridor.

Overall, most intersections can achieve better levels of service and reduced delays with the addition of vehicle detection, updated signal timings, modified controller parameters, and implementing a traffic signal coordination plan. In some instances, these improvements will reduce delays on most movements. Additional physical improvements may be necessary to further reduce delays and congestion.

These recommendations are made solely on the basis of the information provided. Other engineering factors, such as sight distances, accident history, presumed detector

locations, and previous experiences at these intersections need to be considered in the implementation or modification of these recommendations.