Onondaga County Department of Transportation

# Traffic Signal Optimization Project
# (West Genesee Street)
# (Existing Coordinated Corridor)

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Onondaga County Department of Transportation

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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Outdated traffic signal timings account for a significant amount of traffic delay on urban and suburban roadways across the country.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 West Genesee Street 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:

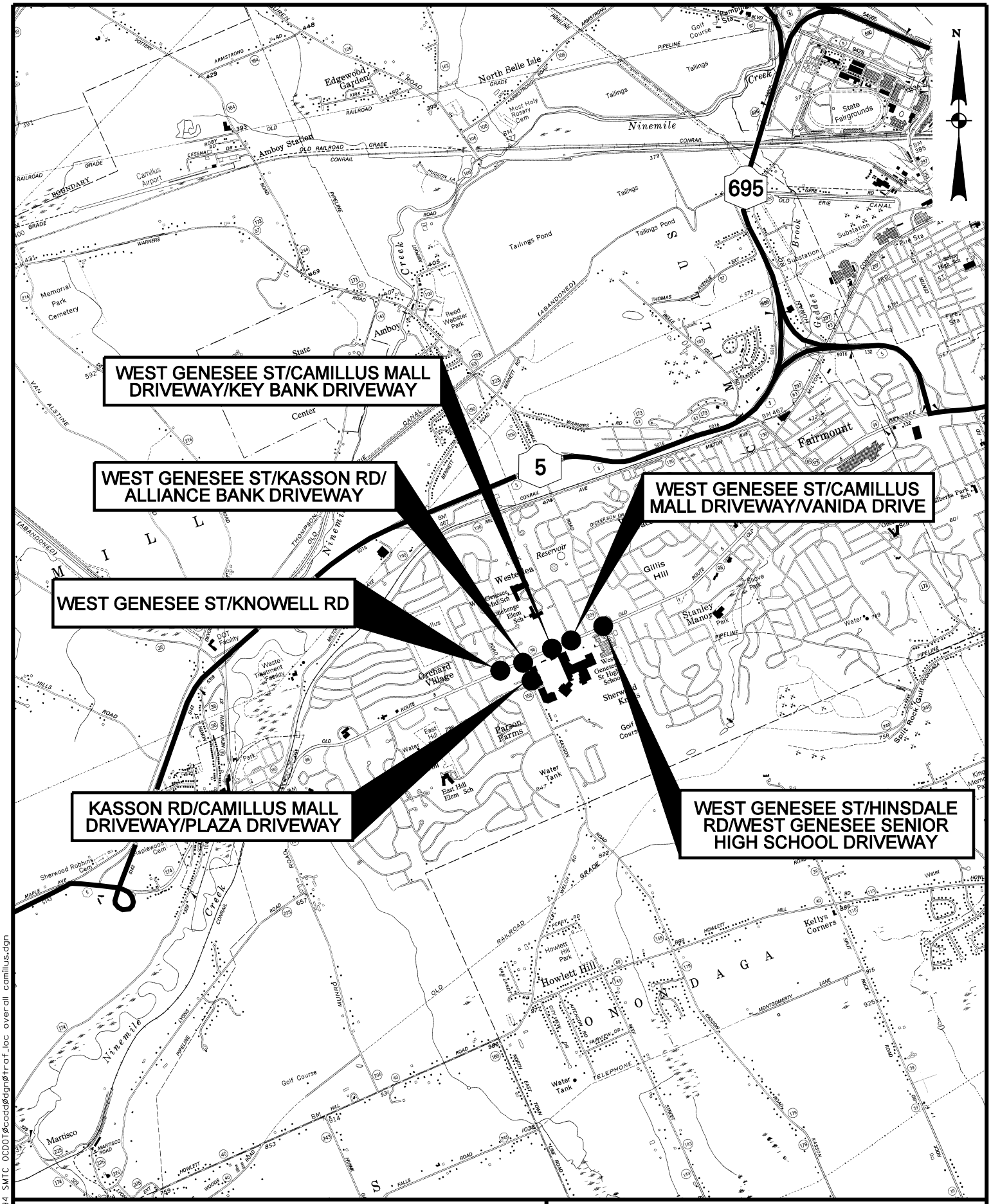
- West Genesee Street (County Road 98)/Knowell Road
- West Genesee Street (County Road 98)/Kasson Road/Alliance Bank Driveway
- West Genesee Street (County Road 98)/Camillus Mall Driveway/Key Bank Driveway
- West Genesee Street (County Road 98)/Camillus Mall Driveway/Vanida Drive
- West Genesee Street (County Road 98)/Hinsdale Road/West Genesee Senior High School Driveway
- Kasson Road/Camillus Mall Driveway/Plaza Driveway

## 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.




PROJECT LOCATION

TRAFFIC SIGNAL OPTIMIZATION
ONONDAGA COUNTY
SYRACUSE, NEW YORK

CME
CREIGHTON MANNING ENGINEERING, LLP

| PROJECT: 09-094d | DATE: 8/10 | FIGURE: 1 |
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# 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 PM and Saturday peak hour Synchro models of the corridor which included proposed network signal timings and offsets. In addition, the OCDOT provided actual traffic signal timing plans at the study area intersections. Therefore, the models were updated to reflect the current traffic signal timings while the offsets included in the original simulation models remain the same. These revised models provided existing conditions of each intersection, which 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.

The six study area intersections on West Genesee Street and Kasson Road were also evaluated to determine how the improvement of the existing traffic signal coordination plan would impact traffic progression through the corridor.

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.

## A. West Genesee Street/Knowell Road

This three-leg intersection operates under a two-phase traffic signal with an 82-second maximum cycle length. A coordinated, minimum recall is set on the eastbound and westbound West Genesee Street approaches. The eastbound West Genesee Street approach provides two through lanes with a shared left-turn lane while the westbound West Genesee Street approach provides two through lanes

and a shared right-turn lane. The southbound Knowell Road approach provides separate left and right turn lanes. Presence detection is provided on the southbound approach. No sidewalks, crosswalks, or pedestrian controls are provided. The posted speed limit on West Genesee Street is 35-mph while the posted speed limit on Knowell Road is 30-mph. Table II.A.1 summarizes the detailed levels of service for existing and proposed conditions.

**Table II.A.1 – West Genesee Street/Knowell Road LOS Summary**

| Intersection | | Control | PM Peak Hour | | Saturday Peak Hour | |
|---|---|---|---|---|---|---|
| | | | Existing Coordinated | Revised Coordinated | Existing Coordinated | Revised Coordinated |
| West Genesee Street/Knowell Road | | S | | | | |
| W. Genesee St EB | LT,T | | A (7) | A (5) | A (4) | A (3) |
| W. Genesee St WB | T,TR | | A (7) | A (3) | A (4) | A (2) |
| Knowell Rd SB | L | | C (34) | D (52) | D (37) | D (38) |
| | R | | C (33) | D (44) | C (31) | C (32) |
| | Overall | | A (10) | A (9) | A (7) | A (5) |

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 A during the PM and Saturday peak hours. After revising the optimization of the traffic signal and the addition of point detection on the eastbound/westbound approaches, the intersection will continue to operate at an overall LOS A during both peak hours with all movements operating at LOS D or better.

To improve operations, point detection was added to eastbound and westbound West Genesee Street through lanes, 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 110-second cycle length during the PM peak hour and an 80-second cycle length during the Saturday peak hour. The PM and Saturday 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 signals located to the east. Review of the actuated green times indicated that each approach will generally operate below the maximum allowable split for all levels of traffic. Table II.A.2 summarizes the suggested changes in the signal timing parameters.

**Table II.A.2 – West Genesee Street/Knowell Road Parameter Summary**

| Parameter | Existing | Proposed |
|---|---|---|
| Detection | SB | Point detection added to EB/WB throughs |
| Recall | C-Min EB/WB throughs | No Change |
| Minimum Green | 8-sec SB; 10-sec EB/WB | 10-sec EB/WB/SB |
| Yellow/All Red: | 4/2-sec | 3.5/1.5-sec for 30-40-mph |
| Vehicle Extension | 4-sec | 1.8-sec SB[1], 2.5-sec EB/WB[2] |
| Cycle Length | PM/Saturday – 82-sec | 110-sec PM, 80-sec Saturday |
| Offset | PM – 61, Saturday – 0 | PM – 40, Saturday – 0 |

## B. West Genesee Street/Kasson Road/Alliance Bank Driveway

This four-leg intersection operates under a four-phase traffic signal with a 120-second maximum cycle length. A coordinated, minimum recall is set on the eastbound and westbound West Genesee Street approaches. The eastbound West Genesee Street approach provides an exclusive left-turn lane and two through lanes with a shared right-turn lane while the westbound West Genesee Street approach provides two exclusive left-turn lanes and two through lanes with a shared right-turn lane. The northbound Kasson Road approach provides an exclusive left-turn lane, a shared left-turn/through lane, and a separate right-turn lane while the southbound Alliance Bank Driveway provides a single lane for shared travel movements. Presence detection is provided on all lanes except for the eastbound and westbound through lanes. Sidewalks are provided on both sides of West Genesee Street to the east of the intersection and on the east side of Kasson Road. A crosswalk with pedestrian controls is only provided on the westbound West Genesee Street approach. The posted speed limit on West Genesee Street is 35-mph while the posted speed limit on Kasson Road is 30-mph. The speed limit on the Alliance Bank driveway is not posted. Table II.B.1 summarizes the detailed levels of service for existing and proposed conditions.

[1] Max allowable headway = 3 sec, detection zone = 50 feet, approach speed = 30 mph.
[2] Max allowable headway = 3 sec, detection zone = 6 feet (placed 130 feet from the intersection), approach speed = 40 mph.

**Table II.B.1 – West Genesee St/Kasson Rd/Alliance Bank Driveway LOS Summary**

| Intersection | | Control | PM Peak Hour | | Saturday Peak Hour | |
|---|---|---|---|---|---|---|
| | | | Existing Coordinated | Revised Coordinated | Existing Coordinated | Revised Coordinated |
| West Genesee Street/Kasson Road/Alliance Bank Drwy | | S | | | | |
| W. Genesee St EB | L | | E (60) | D (55) | E (60) | D (42) |
| | T,TR | | D (54) | C (31) | C (22) | C (21) |
| W. Genesee St WB | L,L | | D (42) | D (54) | D (48) | C (23) |
| | T,TR | | B (16) | B (13) | A (9) | A (8) |
| Kasson Rd NB | L | | D (50) | D (51) | D (52) | C (26) |
| | LT | | D (49) | D (49) | D (51) | C (25) |
| | R | | B (16) | C (26) | C (32) | B (19) |
| Alliance Bank Driveway SB | LTR | | E (58) | D (53) | E (58) | D (39) |
| | Overall | | D (38) | C (33) | C (29) | 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) = Level of Service (Delay, seconds per vehicle)

This intersection currently operates at an overall LOS D/C during the PM and Saturday peak hours with the eastbound West Genesee Street left-turn movement and the southbound Alliance Bank Driveway approach operating at LOS E during both peak hours. With the addition of point detection on the eastbound/westbound approaches and revised traffic signal optimization, overall delay will be reduced and drivers on the eastbound and westbound West Genesee Street approaches will be coordinated with the adjacent signals. This intersection will operate at an overall LOS C/B during the PM and Saturday peak hours with these improvements with all movements operating at LOS D or better.

To improve operations as noted above, point detection was added to eastbound and westbound West Genesee Street through lanes, new traffic signal coordination was provided, and the yellow/all-red clearance, minimum greens, and vehicle extension were modified. The signal was optimized using Synchro which resulted in a 110-second cycle length during the PM peak hour and an 80-second cycle length during the Saturday peak hour. It is noted that the walk and pedestrian clear times were increased for the crosswalk on the westbound West Genesee Street approach to ensure that pedestrians have adequate time to traverse the entire roadway width. 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 – West Genesee St/Kasson Rd/Alliance Bank Drwy Parameter Summary**

| Parameter | Existing | Proposed |
|---|---|---|
| Detection | EB/WB lefts, NB/SB | Point detection added to EB/WB throughs |
| Recall | C-Min EB/WB throughs | No Change |
| Minimum Green | 8-sec EB/WB lefts and NB/SB; 10-sec EB/WB throughs | 10-sec NB and EB/WB throughs; 5-sec SB and EB/WB lefts |
| Yellow/All Red: | 3/2-sec | 3.5/2-sec for 30-40 mph speed |
| Vehicle Extension | 4-sec | 1.2-sec NB/SB[3]; 2.5-sec EB/WB throughs[4], 1.6-sec EB/WB lefts[5] |
| Cycle Length | PM/Saturday – 120-sec | 110-sec PM, 80-sec Saturday |
| Offset | PM/Saturday – 0 (Master) | PM/Saturday – (Master) |

## C. West Genesee Street/Camillus Mall/Key Bank Driveway

This four-leg intersection operates under a three-phase traffic signal with a 140-second maximum cycle length. A coordinated, minimum recall is set on the eastbound and westbound West Genesee Street approaches. The eastbound and westbound West Genesee Street approaches provide an exclusive left-turn lane and two through lanes with a shared right-turn lane. The northbound Camillus Mall Driveway approach provides a shared left-turn/through lane and a separate right-turn lane while the southbound Key bank Driveway approach provides a single lane for shared travel movements. Presence detection is provided on all lanes except for the eastbound and westbound through lanes. No sidewalks are provided in the vicinity of this intersection. Crosswalks with pedestrian controls are provided on the eastbound West Genesee Street approach and on the northbound Camillus Mall approach. The posted speed limit on West Genesee Street is 35-mph. The speed limit on the Camillus Mall Driveway and Key Bank Driveway is not posted. Table II.C.1 summarizes the detailed levels of service for existing and proposed conditions.

**Table II.C.1 – West Genesee Street/Camillus Mall Drwy/Key Bank Drwy LOS Summary**

| Intersection | | Control | PM Peak Hour | | Saturday Peak Hour | |
|---|---|---|---|---|---|---|
| | | | Existing Coordinated | Revised Coordinated | Existing Coordinated | Revised Coordinated |
| West Genesee St/Camillus Mall Drwy/Key Bank Drwy | | S | | | | |
| W. Genesee St EB | L | | C (20) | A (6) | C (31) | C (23) |
| | T,TR | | C (29) | A (10) | E (69) | C (28) |
| W. Genesee St WB | L | | B (12) | B (19) | B (20) | C (33) |
| | T,TR | | B (13) | B (11) | A (8) | B (12) |
| Camillus Mall Driveway NB | LT | | D (44) | D (53) | D (47) | D (36) |
| | R | | B (14) | C (22) | A (6) | A (9) |
| Key Bank Driveway SB | LTR | | D (36) | D (39) | D (35) | C (27) |
| | Overall | | B (19) | B (15) | C (33) | 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) = Level of Service (Delay, seconds per vehicle)

[3] Max allowable headway = 3 sec, detection zone = 50 feet, approach speed = 30 mph.
[4] Max allowable headway = 3 sec, detection zone = 6 feet (placed 130 feet from the intersection), approach speed = 40 mph.
[5] Max allowable headway = 3 sec, detection zone = 50 feet, approach speed = 40 mph.

The intersection currently operates at an overall LOS B/C during the PM and Saturday peak hours with the eastbound West Genesee Street through movement operating at LOS E during the Saturday peak hour. With the addition of point detection on the eastbound/westbound approaches and revised traffic signal optimization, overall delay will be reduced and drivers on the eastbound and westbound West Genesee Street approaches will be coordinated with the adjacent signals. This intersection will continue to operate at the same overall levels of service during the PM and Saturday peak hours with these improvements with all movements operating at LOS D or better.

To improve operations, point detection was added to the eastbound and westbound through lanes on West Genesee Street through lanes, 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 110-second cycle length during the PM peak hour and an 80-second cycle length during the Saturday peak hour. 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 – W. Genesee St/Camillus Mall Drwy/Key Bank Drwy Parameter Summary**

| Parameter | Existing | Proposed |
|---|---|---|
| Detection | EB/WB lefts, NB/SB | Point detection added to EB/WB throughs |
| Recall | C-Min EB/WB throughs | No Change |
| Minimum Green | 5-sec EB/WB lefts; 8-sec NB/SB; 10-sec EB/WB throughs | 7-sec NB/SB; 10-sec EB/WB throughs; 5-sec EB/WB lefts |
| Yellow/All Red: | 3/2-sec | 3.5/2.0-sec for 40 mph speed |
| Vehicle Extension | 4-sec | 1.2-sec NB/SB lefts[6]; 2.5-sec EB/WB throughs[7]; 1.6-sec EB/WB lefts[8] |
| Cycle Length | PM/Saturday – 110-sec | 110-sec PM, 80-sec Saturday |
| Offset | PM – 0; Saturday – 12 | PM – 22, Saturday – 70 |

## D. West Genesee Street/Camillus Mall Driveway/Vanida Drive

This four-leg intersection operates under a three-phase traffic signal with a 96-second maximum cycle length. A coordinated, minimum recall is set on the eastbound and westbound West Genesee Street approaches. The eastbound and westbound West Genesee Street approaches provide an exclusive left-turn lane and two through lanes with a shared right-turn lane. The northbound Camillus Mall Driveway approach provides a shared left-turn/through lane and a separate right-turn lane while the southbound Vanida Drive approach provides a single lane for shared travel movements. Presence detection is provided on all lanes except for the

[6] Max allowable headway = 3 sec, detection zone = 50 feet, approach speed = 40-45 mph.
[7] Max allowable headway = 3 sec, detection zone = 6 feet (placed 130 feet from the intersection), approach speed = 40 mph.
[8] Max allowable headway = 3 sec, detection zone = 50 feet, approach speed = 40 mph.

eastbound and westbound through lanes. A sidewalk is provided for a short distance on the north side of West Genesee Street to the west of this intersection. A crosswalk with pedestrian controls is provided on the westbound West Genesee Street approach. The posted speed limit on West Genesee Street is 35-mph while the posted speed limit on Vanida Drive is 25-mph. The speed limit on the Camillus Mall Driveway is not posted. Table II.D.1 summarizes the detailed levels of service for existing and proposed conditions.

**Table II.D.1 – West Genesee Street/Camillus Mall Drwy/Vanida Drive LOS Summary**

| Intersection | | Control | PM Peak Hour | | Saturday Peak Hour | |
|---|---|---|---|---|---|---|
| | | | Existing Coordinated | Revised Coordinated | Existing Coordinated | Revised Coordinated |
| West Genesee St/Camillus Mall Drwy/Vanida Drive | | S | | | | |
| W. Genesee St EB | L | | B (12) | B (13) | A (6) | A (4) |
| | T,TR | | B (11) | A (5) | B (12) | A (5) |
| W. Genesee St WB | L | | A (4) | A (4) | A (4) | A (4) |
| | T,TR | | B (19) | A (9) | B (11) | B (10) |
| Camillus Mall Driveway NB | LT | | C (33) | D (44) | C (33) | C (28) |
| | R | | C (22) | D (36) | C (22) | C (22) |
| Vanida Drive SB | LTR | | C (31) | D (43) | C (32) | C (28) |
| | Overall | | B (17) | B (11) | B (12) | A (10) |

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)

During the AM and PM peak hours, the intersection operates at an overall LOS B. With the addition of point detection on the eastbound/westbound approaches and revised traffic signal optimization, overall delay will be reduced and drivers on the eastbound and westbound West Genesee Street approaches will be coordinated with the adjacent signals. This intersection will operate at an overall LOS B/A during the PM and Saturday peak hours with these improvements with all movements operating at LOS D or better.

To improve operations, point detection was added to the eastbound and westbound through lanes on West Genesee Street, 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 110-second cycle length during the PM peak hour and an 80-second cycle length during the Saturday peak hour. The analysis also includes the addition of pedestrian accommodations across the southbound Vanida Drive approach 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. Review of the actuated green times indicated that each approach will generally operate below the maximum allowable split for all levels of traffic. Table II.D.2 summarizes the suggested changes in the signal timing parameters.

**Table II.D.2 – West Genesee St/Camillus Mall Drwy/Vanida Dr Parameter Summary**

| Parameter | Existing | Proposed |
|---|---|---|
| Detection | EB/WB lefts, NB/SB | Point detection added to EB/WB throughs |
| Recall | C-Min EB/WB throughs | No Change |
| Minimum Green | 8-sec EB/WB lefts and NB/SB; 10-sec EB/WB throughs | 7-sec NB/SB; 10-sec EB/WB throughs; 5-sec EB/WB lefts |
| Yellow/All Red: | 4/2-sec | 3.5/2.0-sec for 25-40 mph speed |
| Vehicle Extension | 4-sec | 1.2-sec NB/SB[9]; 2.5-sec EB/WB throughs[10]; 1.6-sec EB/WB lefts[11] |
| Cycle Length | PM/Saturday – 80-sec | 110-sec PM, 80-sec Saturday |
| Offset | PM – 46, Saturday – 30 | PM – 0, Saturday – 5 |

## E. West Genesee St/Hinsdale Rd/W. Genesee Senior High School Drwy

This four-leg intersection operates under a four-phase traffic signal with a 121-second maximum cycle length. A coordinated, minimum recall is set on the eastbound and westbound West Genesee Street approaches. The eastbound West Genesee Street approach provides two exclusive left-turn lanes and two through lanes with a shared right-turn lane while the westbound West Genesee Street approach provides an exclusive left-turn lane and two through lanes with a shared right-turn lane. The northbound West Genesee Senior High School Driveway approach provides two through lanes with shared left and right turns while the southbound Hinsdale Road approach provides a shared left-turn/through lane and two separate right-turn lanes. Presence detection is provided on all lanes except for the eastbound and westbound through lanes. A sidewalk is provided on the north side of West Genesee Street to the west of this intersection, on the east side of the West Genesee Senior High School Driveway, and on the west side of Hinsdale Road. No crosswalks with pedestrian controls are provided on any of the intersection approaches. The posted speed limit on West Genesee Street is 35-mph while the posted speed limit on Hinsdale Road is 30-mph. The speed limit on the West Genesee Senior High School Driveway is not posted. Table II.E.1 summarizes the detailed levels of service for existing and proposed conditions.

[9] Max allowable headway = 3 sec, detection zone = 50 feet, approach speed = 25-30 mph.
[10] Max allowable headway = 3 sec, detection zone = 6 feet (placed 130 feet from the intersection), approach speed = 40 mph.
[11] Max allowable headway = 3 sec, detection zone = 50 feet, approach speed = 40 mph.

**Table II.E.1 – W. Genesee St/Hinsdale Rd/W. Genesee Sr. High School Drwy LOS Summary**

| Intersection | | Control | PM Peak Hour | | Saturday Peak Hour | |
|---|---|---|---|---|---|---|
| | | | Existing Coordinated | Revised Coordinated | Existing Coordinated | Revised Coordinated |
| West Genesee St/Hinsdale Road/ West Genesee Senior High School Driveway | | S | | | | |
| W. Genesee St EB | L,L | | D (42) | D (39) | D (43) | C (23) |
| | T,TR | | B (18) | A (9) | B (15) | A (7) |
| W. Genesee St WB | L | | E (59) | D (53) | E (58) | D (37) |
| | T,TR | | F (93) | D (46) | D (39) | C (26) |
| W. Genesee Senior High School Drwy NB | LT,TR | | D (52) | D (46) | D (52) | C (32) |
| Hinsdale Road SB | LT | | C (33) | D (43) | C (35) | C (26) |
| | R,R | | C (28) | C (33) | C (25) | C (22) |
| Overall | | | D (53) | C (34) | C (31) | C (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.Y) = Level of Service (Delay, seconds per vehicle)

The intersection currently operates at an overall LOS D/C during the PM and Saturday peak hours with the westbound West Genesee Street through movement operating at LOS E during both peak hours and the westbound West Genesee Street through movement operating at LOS F during the PM peak hour. With the addition of point detection on the eastbound/westbound through lanes and revised traffic signal optimization, overall delay will be reduced and drivers on the eastbound and westbound West Genesee Street approaches will be coordinated with the adjacent signals. This intersection will operate at an overall LOS C during both peak hours with these improvements with all movements operating at LOS D or better.

To improve operations as noted above, point detection was added to eastbound and westbound West Genesee Street through lanes, new traffic signal coordination was provided, and the yellow/all-red clearance, minimum greens, and vehicle extension were modified. The signal was optimized using Synchro which resulted in a 110-second cycle length during the PM peak hour and an 80-second cycle length during the Saturday peak hour. 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. The analysis also includes the addition of pedestrian accommodations across the southbound Hinsdale Road approach 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. It is noted that the inclusion of a potential northbound protected left-turn phase for the West Genesee Senior High School Driveway approach was not included in this analysis as requested by the OCDOT since this phase would only be used during the morning and mid-afternoon peak hours associated with school traffic. It is recommended that this alternative traffic signal phasing be investigated when the corridor is re-evaluated for these conditions in the future. Table II.E.2 summarizes the suggested changes in the signal timing parameters.

**Table II.E.2 – W. Genesee St/Hinsdale Rd/W. Genesee Sr. High School Drwy Parameter Summary**

| Parameter | Existing | Proposed |
|---|---|---|
| Detection | EB/WB lefts, NB/SB | Point detection added to EB/WB throughs |
| Recall | C-Min EB/WB throughs | No Change |
| Minimum Green | 5-sec EB/WB lefts; 7-sec NB/SB; 15-sec EB/WB throughs | 7-sec NB/SB; 10-sec EB/WB throughs; 5-sec EB/WB lefts |
| Yellow/All Red: | 4/2-sec | 3.5/2.0-sec for 30-40 mph speed |
| Vehicle Extension | 4-sec | 1.7-sec NB[12]; 0.6-sec SB[13]; 2.5-sec EB/WB throughs[14]; 1.3-sec EB/WB lefts[15] |
| Cycle Length | PM/Saturday – 121-sec | 110-sec PM; 80-sec Saturday |
| Offset | PM – 44; Saturday – 54 | PM – 19; Saturday – 48 |

## F. Kasson Road/Camillus Mall Driveway/Plaza Driveway

This four-leg intersection operates under a three-phase traffic signal with a 96-second maximum cycle length. A coordinated, minimum recall is set on the northbound and southbound Kasson Road approaches. The northbound Kasson Road approach provides an exclusive left-turn lane and a shared through/right-turn lane while the southbound Kasson Road approach provides an exclusive left-turn lane and two through lanes with a shared right-turn lane. The eastbound Plaza Driveway approach provides a single lane for shared travel movements while the westbound Camillus Mall Driveway approach provides a shared left-turn/through lane and a separate right-turn lane. Presence detection is provided on all lanes except for the northbound and southbound through lanes. A sidewalk is provided on both sides of Kasson Road and on the north side of the Camillus Mall Driveway. A crosswalk with pedestrian controls is provided on the northbound Kasson Road approach and on the westbound Camillus Mall Driveway approach. The posted speed limit on Kasson Road is 30-mph. The speed limit on the Camillus Mall Driveway and on the Plaza Driveway is not posted. Table II.F.1 summarizes the detailed levels of service for existing and proposed conditions.

[12] Max allowable headway = 3 sec, detection zone = 30 feet, approach speed = 30 mph.
[13] Max allowable headway = 3 sec, detection zone = 70 feet, approach speed = 30 mph.
[14] Max allowable headway = 3 sec, detection zone = 6 feet (placed 130 feet from the intersection), approach speed = 40 mph.
[15] Max allowable headway = 3 sec, detection zone = 70 feet, approach speed = 40 mph.

**Table II.F.1 – Kasson Road/Camillus Mall Drwy/Plaza Drwy LOS Summary**

| Intersection | | Control | PM Peak Hour | | Saturday Peak Hour | |
|---|---|---|---|---|---|---|
| | | | Existing Coordinated | Revised Coordinated | Existing Coordinated | Revised Coordinated |
| Kasson Road/Camillus Mall Driveway/Plaza Driveway | | S | | | | |
| Plaza Drwy EB | LTR | | B (14) | C (28) | B (19) | C (22) |
| Camillus Mall Drwy WB | LT | | C (21) | D (49) | C (27) | D (37) |
| | R | | A (9) | C (26) | B (11) | B (17) |
| Kasson Rd NB | L | | B (18) | B (11) | C (15) | A (9) |
| | TR | | E (70) | B (20) | C (30) | B (16) |
| Kasson Rd SB | L | | B (15) | A (2) | B (11) | A (2) |
| | T,TR | | C (21) | A (5) | B (12) | A (2) |
| | Overall | | C (31) | B (18) | B (19) | 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.Y) = Level of Service (Delay, seconds per vehicle)

The intersection currently operates at an overall LOS C/B during the PM and Saturday peak hours with the northbound Kasson Road through movement operating at LOS E during the PM peak hour. With the addition of point detection on the northbound/southbound through lanes and revised traffic signal optimization, this intersection will continue to operate at LOS B during both peak hours with all movements operating at LOS D or better and drivers on the northbound and southbound Kasson Road approaches will be coordinated with the adjacent signal at West Genesee Street.

To improve operations as noted above, point detection was added to northbound and southbound Kasson Road through lanes, new traffic signal coordination was provided, and the yellow/all-red clearance, minimum greens, and vehicle extension were modified. The signal was optimized using Synchro which resulted in a 110-second cycle length during the PM peak hour and an 80-second cycle length during the Saturday peak hour. Review of the actuated green times indicated that each approach 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 – Kasson Road/Camillus Mall Drwy/Plaza Drwy Parameter Summary**

| Parameter | Existing | Proposed |
|---|---|---|
| Detection | NB/SB lefts, EB/WB | Point detection added to NB/SB throughs |
| Recall | C-Min NB/SB throughs | No Change |
| Minimum Green | 5-sec NB/SB lefts; 8-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 | 4.5/2-sec for 30-45 mph speed |
| Vehicle Extension | 4-sec | 1.2-sec NB/SB lefts and EB/WB[16]; 2.3-sec NB/SB throughs[17] |
| Cycle Length | PM/Saturday – 96-sec | 110-sec PM; 80-sec Saturday |
| Offset | PM – 0; Saturday – 22 | PM – 8; Saturday – 5 |

[16] Max allowable headway = 1.2 sec, detection zone = 50 feet, approach speed = 30 mph.
[17] Max allowable headway = 2.3 sec, detection zone = 6 feet (placed 130 feet from the intersection), approach speed = 40 mph.

## G. Corridor Evaluation Summary

Measures of effectiveness (MOEs) serve as performance measures for evaluating the West Genesee Street 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 coordination. Table II.G.1 summarizes the MOEs for the revised coordinated system proposed on West Genesee Street.

**Table II.G.1 – Measures of Effectiveness on West Genesee Street**

| Measure of Effectiveness | PM Peak Hour | | Saturday Peak Hour | |
|---|---|---|---|---|
| | Existing Coordination | Revised Coordination | Existing Coordination | Revised Coordination |
| Total Delay (Hours) | 83 | 54 | 54 | 38 |
| Performance Index | 102.0 | 68.7 | 68.1 | 51.5 |
| Fuel Consumed (gal) | 195 | 159 | 142 | 129 |
| Overall Speed (mph) | | | | |
| EB | 16 | 21 | 15 | 21 |
| WB | 14 | 17 | 17 | 19 |
| Travel Time (seconds) | | | | |
| EB | 208 | 153 | 219 | 161 |
| WB | 234 | 171 | 163 | 149 |

Overall, Table II.J.1 shows that the MOEs along West Genesee Street will improve under the proposed coordinated system. Total delay through the corridor will be reduced and speeds will improve from 2 to 6-mph based on peak hour and approach.

## H. 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 or 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 1.8 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 200 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 2.3 to 2.5-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 PM and Saturday peak hours for the revised coordinated system.

**Table II.H.1 – Revised Coordination Data Table (PM Peak Hour)**

| PM Peak Hour – 110 Second Cycle Length (4:00 to 6:00 PM) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Intersection | Splits | | | | | | | | Offset |
| | Ø1 | Ø2 | Ø3 | Ø4 | Ø5 | Ø6 | Ø7 | Ø8 | |
| Knowell Road | | 83 | | 27 | | 83 | | | 40 |
| Kasson Rd/Alliance Bank | 30 | 40 | | 29 | 11 | 59 | | 11 | 0* |
| Camillus Mall/Key Bank | 38 | 42 | | 30 | 11 | 69 | | 30 | 22 |
| Camillus Mall/Vanida Dr | 11 | 70 | | 29 | 11 | 70 | | 29 | 0 |
| Hinsdale Rd/High School | 24 | 44 | 29 | 13 | 11 | 57 | | | 19 |
| Camillus Mall/Plaza | 16 | 50 | | 44 | 11 | 55 | | 44 | 8 |

**Table II.H.2 – Revised Coordination Data Table (Saturday Peak Hour)**

| Saturday Peak Hour – 80 Second Cycle Length (11:00 AM to 1:00 PM) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Intersection | Splits | | | | | | | | Offset |
| | Ø1 | Ø2 | Ø3 | Ø4 | Ø5 | Ø6 | Ø7 | Ø8 | |
| Knowell Road | | 56 | | 24 | | 56 | | | 0 |
| Kasson Rd/Alliance Bank | 14 | 26 | | 29 | 11 | 29 | | 11 | 0* |
| Camillus Mall/Key Bank | 27 | 24 | | 29 | 11 | 40 | | 29 | 70 |
| Camillus Mall/Vanida Dr | 14 | 37 | | 29 | 11 | 40 | | 29 | 5 |
| Hinsdale Rd/High School | 13 | 25 | 29 | 13 | 11 | 27 | | | 48 |
| Camillus Mall/Plaza | 15 | 36 | | 29 | 11 | 40 | | 29 | 5 |

## I. Peak Holiday Season Sensitivity Analysis

A sensitivity analysis was conducted at the six study area intersections to determine if the proposed signal timing improvements and coordination will continue to provide adequate operations through the corridor for traffic volume conditions that exist during the peak holiday season. The OCDOT provided traffic volume adjustment factors of 0.42% and 27% to be applied to the PM and Saturday peak hours, respectively, to approximate peak holiday season traffic. An intersection level of service summary comparison between typical peak hour conditions and peak holiday season conditions is provided on Table II.I.1. Appendix C includes detailed signal timings/splits and level of service reports for each intersection.

## Table II.I.1 – Peak Holiday Season LOS Summary Comparison

| Intersection | | Control | PM Peak Hour | | Saturday Peak Hour | |
|---|---|---|---|---|---|---|
| | | | Revised Coordinated | Peak Holiday Coordinated | Revised Coordinated | Peak Holiday Coordinated |
| West Genesee Street/Knowell Road | | S | | | | |
| W. Genesee St EB | LT,T | | A (5) | A (5) | A (3) | A (5) |
| W. Genesee St WB | T,TR | | A (3) | A (3) | A (2) | A (3) |
| Knowell Rd SB | L | | D (52) | D (52) | D (38) | D (40) |
| | R | | D (44) | D (44) | C (32) | C (33) |
| | Overall | | A (9) | A (9) | A (5) | A (7) |
| West Genesee Street/Kasson Road/Alliance Bank Drwy | | S | | | | |
| W. Genesee St EB | L | | D (55) | D (54 | D (42) | D (41) |
| | T,TR | | C (31) | C (31) | C (21) | C (30) |
| W. Genesee St WB | L,L | | D (54) | D (54) | C (23) | D (47) |
| | T,TR | | B (13) | B (13) | A (8) | A (6) |
| Kasson Rd NB | L | | D (51) | D (51) | C (26) | C (34) |
| | LT | | D (49) | D (49) | C (25) | C (32) |
| | R | | C (26) | C (27) | B (19) | B (19) |
| Alliance Bank Driveway SB | LTR | | D (53) | D (53) | D (39) | D (43) |
| | Overall | | C (33) | C (33) | B (19) | C (27) |
| West Genesee St/Camillus Mall Drwy/Key Bank Drwy | | S | | | | |
| W. Genesee St EB | L | | A (6) | A (6) | C (23) | B (14) |
| | T,TR | | A (10) | A (10) | C (28) | D (49) |
| W. Genesee St WB | L | | B (19) | B (19) | C (33) | E (60) |
| | T,TR | | B (11) | B (11) | B (12) | A (7) |
| Camillus Mall Driveway NB | LT | | D (53) | D (53) | D (36) | D (50) |
| | R | | C (22) | C (22) | A (9) | A (9) |
| Key Bank Driveway SB | LTR | | D (39) | D (39) | C (27) | C (29) |
| | Overall | | B (15) | B (15) | C (23) | C (36) |
| West Genesee St/Camillus Mall Drwy/Vanida Drive | | S | | | | |
| W. Genesee St EB | L | | B (13) | B (15) | A (4) | A (7) |
| | T,TR | | A (5) | A (5) | A (5) | A (10) |
| W. Genesee St WB | L | | A (4) | A (4) | A (4) | B (12) |
| | T,TR | | A (9) | A (9) | B (10) | A (7) |
| Camillus Mall Driveway NB | LT | | D (44) | D (44) | C (28) | C (34) |
| | R | | D (36) | D (37) | C (22) | C (27) |
| Vanida Drive SB | LTR | | D (43) | D (43) | C (28) | C (33) |
| | Overall | | B (11) | B (11) | A (10) | B (11) |
| West Genesee St/Hinsdale Road/ West Genesee Senior High School Driveway | | S | | | | |
| W. Genesee St EB | L,L | | D (39) | D (38) | C (23) | C (29) |
| | T,TR | | A (9) | A (9) | A (7) | B (16) |
| W. Genesee St WB | L | | D (53) | D (53) | D (37) | D (42) |
| | T,TR | | D (46) | D (48) | C (26) | D (47) |
| W. Genesee Senior High School Drwy NB | LT,TR | | D (46) | D (46) | C (32) | D (36) |
| Hinsdale Road SB | LT | | D (43) | D (43) | C (26) | C (32) |
| | R,R | | C (33) | C (32) | C (22) | C (25) |
| | Overall | | C (34) | C (34) | C (20) | C (32) |
| Kasson Road/Camillus Mall Driveway/Plaza Driveway | | S | | | | |
| Plaza Drwy EB | LTR | | C (28) | C (28) | C (22) | C (23) |
| Camillus Mall Drwy WB | LT | | D (49) | D (49) | D (37) | D (47) |
| | R | | C (26) | C (24) | B (17) | B (18) |
| Kasson Rd NB | L | | B (11) | B (11) | A (9) | B (12) |
| | TR | | B (20) | B (20) | B (16) | C (25) |
| Kasson Rd SB | L | | A (2) | A (2) | A (2) | A (5) |
| | T,TR | | A (5) | A (5) | A (2) | A (3) |
| | Overall | | B (18) | B (18) | B (14) | 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 PM peak hour level of service summary indicates that during peak holiday season conditions, the study area intersections will continue to operate at similar levels of

service as typical conditions under the same timing plan with very little increase in delay through the corridor. However, the corridor analysis also indicates that the proposed Saturday peak hour timing plans and coordination should be modified in order to provide better system wide operations due to the 27% increase in traffic volumes associated with the peak holiday season.

The traffic signals were optimized using Synchro which resulted in a 90-second cycle length during the Saturday peak hour for the holiday season. A review of the level of service summary indicates that all of the study area intersections will continue to operate at adequate overall levels of service with all movements operating at LOS D or better with the exception of the westbound left-turn movement on West Genesee Street at the Camillus Mall Driveway opposite Key Bank (main Wal-Mart entrance). This movement will increase from 548 vehicles to 695 vehicles as a result of the peak seasonal factor. It is noted that that a single left-turn lane typically does not have enough capacity to accommodate this much traffic during one hour, especially with a heavy conflicting movement coming from the eastbound direction. A review of the 95$^{th}$ percentile queue and the SimTraffic simulation indicates that the available westbound left-turn storage bay at this intersection will not accommodate all of the traffic during the Saturday peak hour which will cause vehicles to stack into the through lane thus impacting the adjacent intersection and coordination through the corridor. It is noted that westbound vehicles turning left at this intersection can access the Camillus Mall at the adjacent intersection opposite Vanida Drive and that traffic entering this development may re-distribute itself over both mall entrances if one of the westbound left-turn lanes becomes oversaturated during the peak holiday season.

The following table provides the traffic signal coordination plans for the Saturday peak hour for holiday season conditions. The PM peak hour during the holiday season will continue to use the revised coordination plan as detailed previously.

**Table II.I.2 – Peak Holiday Season Coordination Data Table (Saturday Peak Hour)**

| Saturday Peak Hour – 90 Second Cycle Length (11:00 AM to 1:00 PM) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Intersection** | **Splits** | | | | | | | | **Offset** |
| | **Ø1** | **Ø2** | **Ø3** | **Ø4** | **Ø5** | **Ø6** | **Ø7** | **Ø8** | |
| Knowell Road | | 67 | | 23 | | 67 | | | 39 |
| Kasson Rd/Alliance Bank | 17 | 33 | | 29 | 11 | 39 | | 11 | 0* |
| Camillus Mall/Key Bank | 31 | 30 | | 29 | 11 | 50 | | 29 | 16 |
| Camillus Mall/Vanida Dr | 13 | 48 | | 29 | 11 | 50 | | 29 | 52 |
| Hinsdale Rd/High School | 16 | 32 | 29 | 13 | 11 | 37 | | | 42 |
| Camillus Mall/Plaza | 17 | 40 | | 33 | 11 | 46 | | 33 | 11 |

## CHAPTER IV

## CONCLUSIONS

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

- West Genesee Street/Knowell Road: The intersection currently operates at an overall LOS A during the PM and Saturday peak hours. However it is recommended that point detection be added to the eastbound and westbound approaches and that the timing parameters be adjusted as shown in Table II.A.2 to minimize vehicle delays, minimize the v/c ratio, and to coordinate the timings with adjacent signals. These changes will result in continued acceptable operating conditions.

- West Genesee Street/Kasson Road/Alliance Bank Driveway: This intersection currently operates at acceptable overall levels of service during the PM and Saturday peak hours with the eastbound West Genesee Street left-turn movement and the southbound Alliance Bank Driveway approach operating at LOS E during both peak hours. It is recommended that point detection be added to the eastbound and westbound approaches and that the timing parameters be adjusted as shown in Table II.B.2 to minimize vehicle delays, minimize the v/c ratio, and to coordinate the timings with adjacent signals. These changes will result in continued acceptable operating conditions.

- West Genesee Street/Camillus Mall Driveway/Key Bank Driveway: This intersection currently operates at an overall LOS B/C during the PM and Saturday peak hours with the eastbound West Genesee Street through movement operating at LOS E during the Saturday peak hour. It is recommended that point detection be added to the eastbound and westbound approaches and that the timing parameters be adjusted as shown in Table II.C.2 to minimize vehicle delays, minimize the v/c ratio, and to coordinate the timings with adjacent signals. These changes will result in acceptable operating conditions on all movements during both peak hours.

- West Genesee Street/Camillus Mall Driveway/Vanida Drive: The intersection currently operates at an overall LOS B during the PM and Saturday peak hours. However, it is recommended that point detection be added to the eastbound and westbound 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 southbound Vanida Drive approach as per the request of the OCDOT. These changes will result in continued acceptable operating conditions.

- West Genesee Street/Hinsdale Road/West Genesee Senior High School Driveway: The intersection currently operates at an overall LOS D/C during the PM and Saturday peak hours with the westbound West Genesee Street through movement

operating at LOS E during both peak hours and the westbound West Genesee Street through movement operating at LOS F during the PM peak hour. It is recommended that point detection be added on the eastbound/westbound through lanes and 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 southbound Hinsdale Road approach as per the request of the OCDOT. These changes will result in acceptable operating conditions on all movements during both peak hours.

- Kasson Road/Camillus Mall Driveway/Plaza Driveway: The intersection currently operates at an overall LOS C/B during the PM and Saturday peak hours with the northbound Kasson Road through movement operating at LOS E during the PM peak hour. It is recommended that point detection be added on the eastbound/westbound through lanes and 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 the adjacent signal at West Genesee Street. These changes will result in acceptable operating conditions on all movements during both peak hours.

- A holiday season sensitivity analysis conducted at the six study area intersections indicated the PM peak hour will continue to operate at similar levels of service as typical conditions under the same timing plan with very little increase in delay through the corridor. However, the sensitivity analysis also indicated that the proposed Saturday peak hour timing plans and coordination should be modified in order to provide better system wide operations due to the increase in traffic volumes associated with the peak holiday season.

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.