Final Report

June 2017

City of Valdosta Traffic Signal Timing Study

Valdosta, GA

Prepared for:

Southern Georgia Regional Commission

City of Valdosta

Kimley»Horn

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1.0 INTRODUCTION

Southern Georgia Regional Commission (SGRC) and the City of Valdosta has selected the Kimley-Horn (KH) team to perform a traffic signal optimization study for forty-four (44) signalized intersections. The consultant team comprised of KH, Southeastern Engineering, Inc. (SEI), and All Traffic Data Service, Inc. (ATD).

The purpose of this study was to improve traffic signal timing in the City of Valdosta, which in turn reduces fuel consumption, vehicle emissions, driver delay, and driver stops / starts. The scope of services for this project included: data collection, an operational analysis of each of the signalized intersections, timing plan development for the typical weekday peak periods, field implementation and fine tuning of the timing plans, before and after travel time evaluations, timing plan development for typical weekend and holiday peak periods, Fiber mapping and project documentation.

It should be noted that five (5) intersections were upgraded and retimed by the Georgia Department of Transportation (GDOT) through PI 0010116 and one (1) additional intersection were analyzed for operational improvement and signal timing were updated for coordination purposes only.

Table 1 details each of the forty-four (44) intersections and **Figure 1** depicts the intersections and study corridors.

Table 1: Intersection List

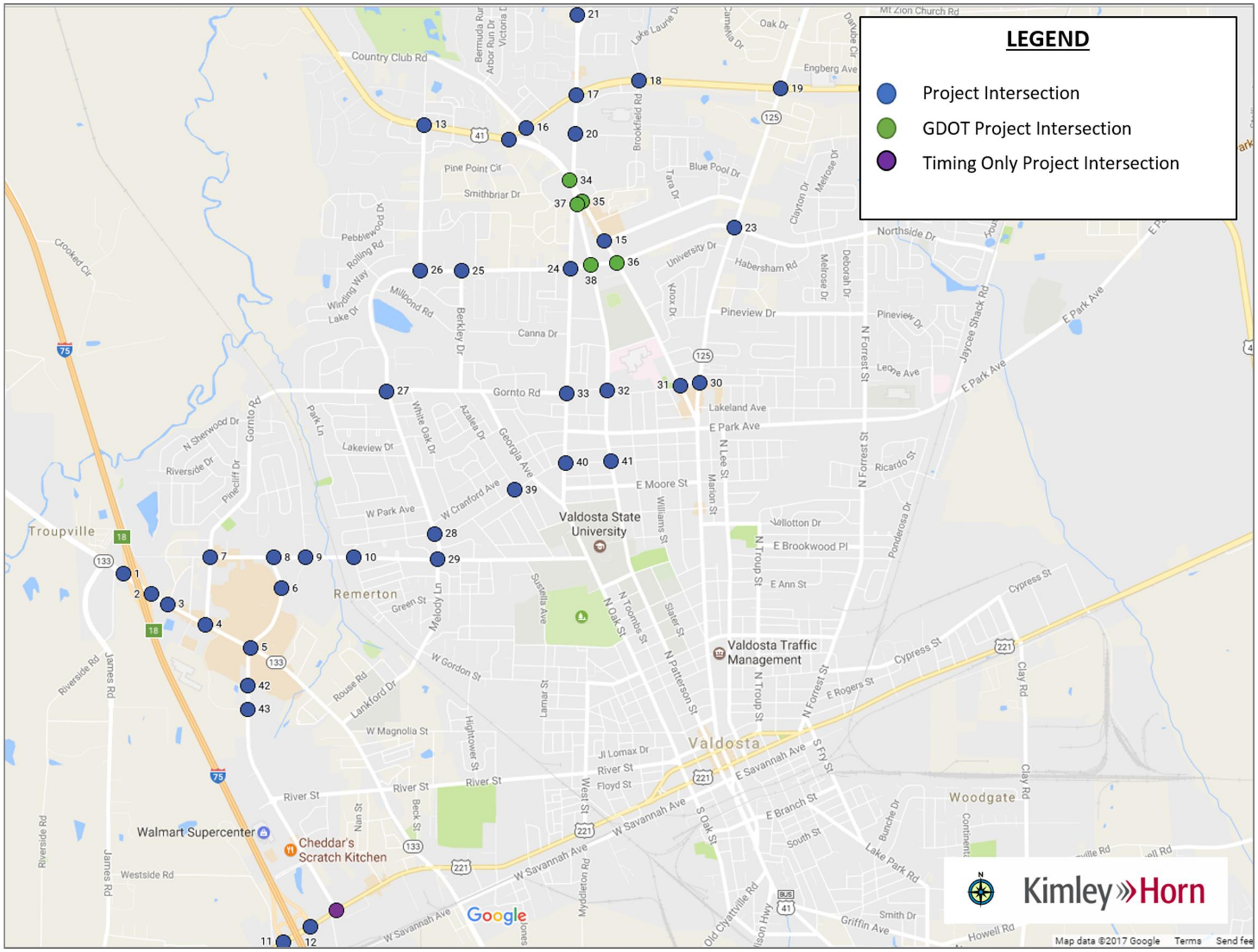
Intersection ID #	Intersection
1	St. Augustine Road (SR 133) @ I-75 SB Ramp
2	St. Augustine Road (SR 133) @ I-75 NB Ramp
3	St. Augustine Road (SR 133) @ Twin Street
4	St. Augustine Road (SR 133) @ Gornto Road
5	St. Augustine Road (SR 133) @ Norman Drive
6	Norman Drive @ Mall Entrance
7	Baytree Road @ Gornto Road
8	Baytree Road @ Norman Drive
9	Baytree Road @ Sherwood Drive
10	Baytree Road @ Gordon Street
11	Hill Avenue (US 84/221/SR 38) @ I-75 SB Ramp
12	Hill Avenue (US 84/221/SR 38) @ I-75 NB Ramp
13	N Valdosta Road (US 41/SR 7) @ Country Club Drive
14	N Valdosta Road (US 41/SR 7) @ Inner Perimeter Road (US 41/SR 7)
15	N Ashley Street (US 41BU/SR 7BU) @ Connell Road
16	Inner Perimeter Road (US 41/SR 7) @ Country Club Road
17	Inner Perimeter Road (US 41/SR 7) @ Oak Street Extension
18	Inner Perimeter Road (US 41/SR 7) @ Brookfield Road/Lake Laurie Drive
19	Inner Perimeter Road (US 41/SR 7) @ Bemiss Road (SR 125)
20	Oak Street Extension @ Murray Road

Intersection ID #	Intersection
21	Oak Street Extension @ Cherry Creek Road
22	Inner Perimeter Road (US 41/SR 7) @ Forrest Street
23	Northside Drive @ Bemiss Road
24	Northside Drive/Eager Road @ Oak Street Extension
25	Eager Road @ Berkley Drive
26	Eager Road/Jerry Jones Drive @ Country Club Drive
27	Jerry Jones Drive @ Gornto Road
28	Jerry Jones Drive @ Alden Avenue
29	Baytree Road @ Jerry Jones Drive/Melody Lane
30	Woodrow Wilson Drive @ Bemiss Road
31	Woodrow Wilson Drive @ N Ashley Street (US 41BU/SR 7BU)
32	Woodrow Wilson Drive/Gornto Road @ N Patterson Street (SR 7 Alt)
33	Gornto Road @ N Oak Street
34*	N Valdosta Road (US 41BU/SR 7BU) @ Oak Street Extension
35*	N Ashley Street (US 41BU/SR 7BU) @ Smithbriar Drive
36*	N Ashley Street (US 41BU/SR 7BU) @ Northside Drive
37*	N Patterson Street (SR 7 Alt) @ Smithbriar Drive
38*	N Patterson Street (SR 7 Alt) @ Northside Drive
39	Alden Avenue @ Azalea Drive
40	Alden Avenue @ N Oak Street
41	Alden Avenue @ N Patterson Street (SR 7 Alt)
42	Norman Drive @ Lowndes High School Driveway
43	Norman Drive @ Valhalla Drive
44**	Hill Avenue (US 84/221/SR 38) @ Norman Drive

* Intersection included in GDOT PI 0010116

** Intersection included for signal timing coordination purposes only

Figure 1: Project Intersections



2.0 DATA COLLECTION

In order to develop the models and simulations for the signal timing study, several types of data were needed. This data was collected by staff from KH, ATD and the City of Valdosta. The data collection efforts included the following items and are further discussed below:

- Field Observations – *performed March 2017 by KH*
- Existing Timing Databases – *provided in March 2017 by City of Valdosta*
- Traffic Volume Data – *collected March and April 2017 by ATD and City of Valdosta*
- Travel Time Data – *collected May 2017 by KH*

In order to develop the GIS Fiber Map, data was collected by staff from KH, SEI, and the City of Valdosta. The data collection efforts included the following items and are further discussed below:

- Field Observations – *performed March and May 2017 by SEI and City of Valdosta*
- 2006 Fiber Optic Plan – *provided in March 2017 by City of Valdosta*

FIELD OBSERVATIONS

KH staff conducted a field survey and verification of the as-built data for the intersections. The survey and verification tasks included the following information:

- Existing intersection geometry and lane assignments
- Storage bay lengths to the nearest five (5) ft increment
- Pedestrian crossing distances
- Approach and departure speed limits
- Approximate approach grades
- Pedestrian and vehicle signal displays
- Traffic signal infrastructure
- Relevant signage and pavement markings
- Photographs for each approach

CONTROLLER DATABASES

City of Valdosta staff provided the existing traffic signal timing databases from the field for the forty-four (44) signalized intersections in March 2017. The traffic signal timing databases provided signal timing information, controller settings, and phasing for each intersection.

The timing databases provided an easy method for data entry into *Synchro 9* software as well as an opportunity for quality control before the data was used in the model.

TRAFFIC VOLUME DATA

Two types of traffic volume data were used for this study. Turning movement counts (TMC) and average daily traffic (ADT) volumes were used for the model development. The TMC data was critical to the operational analysis and signal timing procedure; it was the basis for the level-of-service analysis and development of the timing plans. The ADT data was used to help to determine signal progression and crucial when determining the time-of-day (TOD) clocks for coordinated signal timing plans.

The TMC data was collected by ATD and City of Valdosta staff throughout March and April 2017. Each intersection was counted on a weekday (Tuesday, Wednesday, or Thursday) during the following time frames: AM peak (07:00-09:00), Mid-day (MD) peak (11:00-13:00), and PM peak (16:00-18:00). Weekend TMC data was collected at eight (8) locations near the Valdosta Mall on a Saturday during the Weekend peak period (12:00-16:00).

ADT data was also collected at twenty-two (22) locations by ATD and City of Valdosta staff throughout March and April 2017. The ADT data was collected utilizing automatic traffic recorders (ATR) that records traffic volumes with pneumatic road tubes. The ATR counts consisted of seven day 24-hour volumes counts, classification, and speed data. The City of Valdosta also provided 2016 Holiday 24-hour volume counts collected at locations near the Valdosta Mall.

Figure 2 shows the traffic count locations. The traffic volume data is provided in **Appendix A**, and has been electronically submitted to the City of Valdosta.

Figure 3 shows the ADT data for the system which includes a combination of the collected ATR counts and counts collected from Georgia Department of Transportation (GDOT) count locations.

FIBER MAPPING

The existing fiber optic plans and data collected during the field verifications was used by SEI to develop an editable GIS database which includes the existing fiber optic cable location, splice locations, network/segment IDs, and channel numbers. The data was also used to create digitized diagrams of the City of Valdosta Fiber Optic Plan using and splice diagrams, using AutoCAD, which was linked to the GIS database and geo-referenced at each splice location. The GIS database and digitized fiber plans were submitted by SEI to the City of Valdosta.

The fiber data was also used to develop aa separate *Future Communications Needs Memorandum*. The memorandum has been submitted, as a separate document, to the City of Valdosta.

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Figure 2: Traffic Count Locations

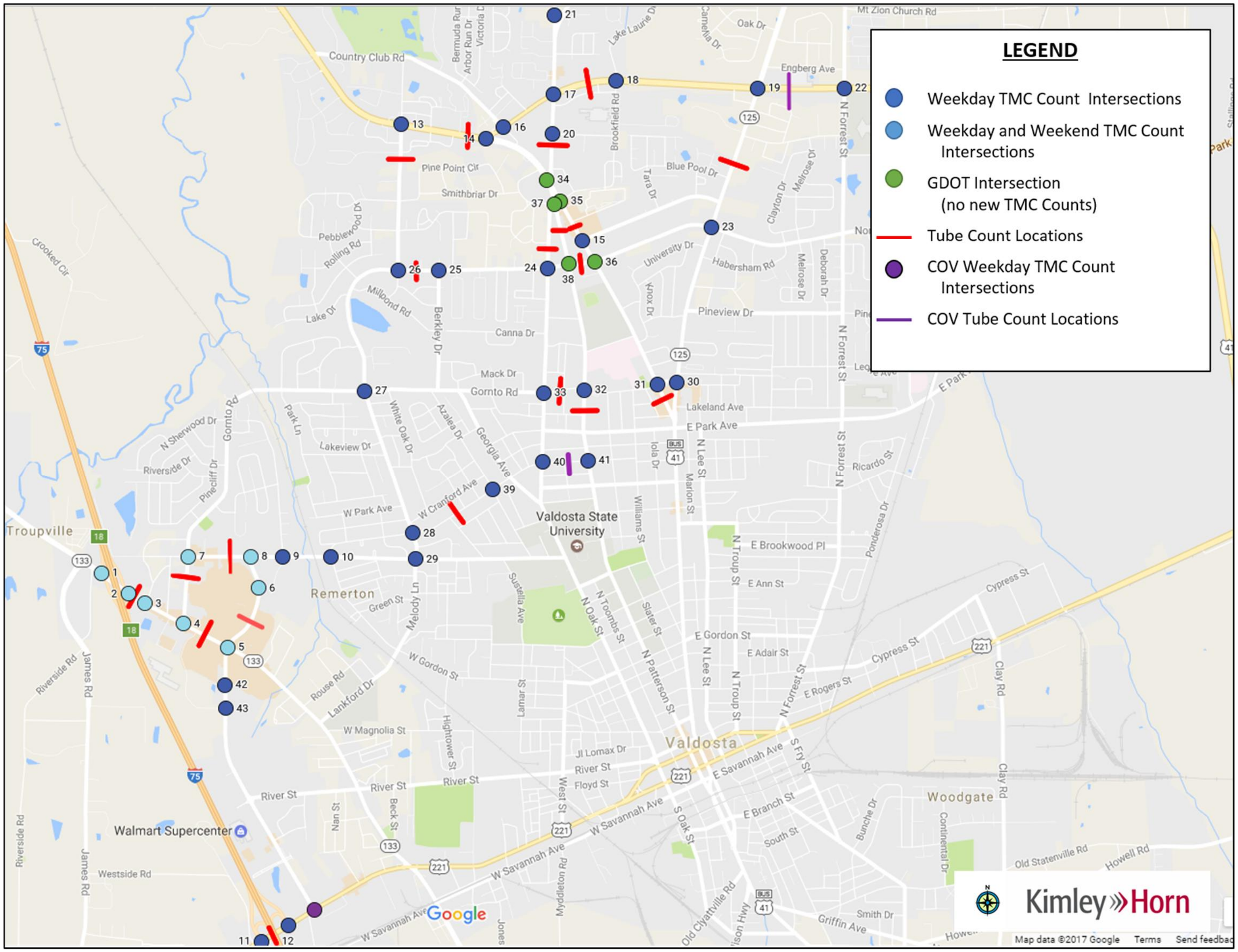
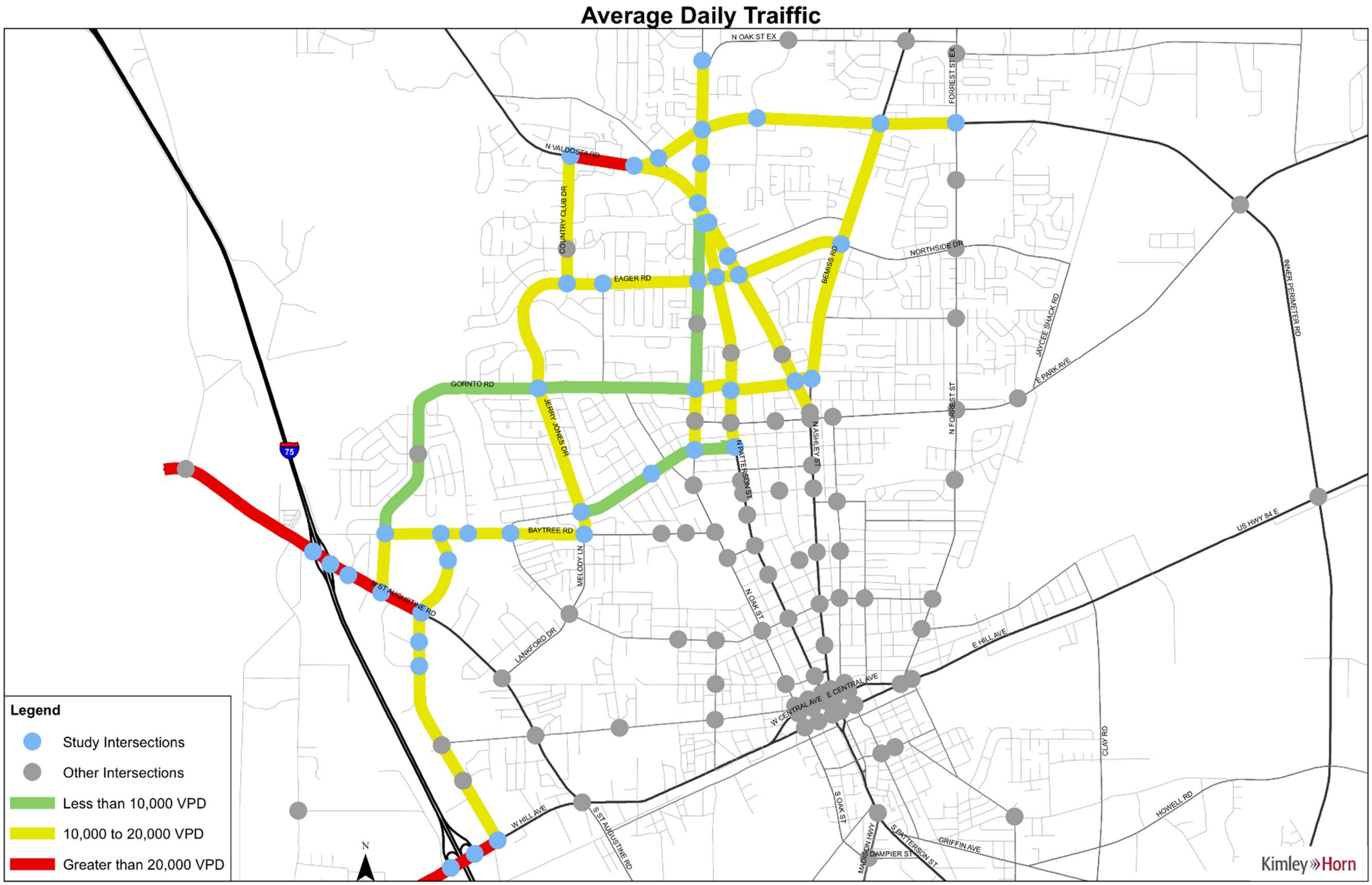


Figure 3: ADT Map



3.0 EXISTING CONDITIONS ANALYSIS

An evaluation was completed of the existing conditions for each of the study intersections within the City of Valdosta. This evaluation included an analysis of existing signal operations, including an assessment of the existing capacity and level-of-service (LOS) for each intersection during a typical weekday morning (AM), mid-day (MD), and evening (PM) peak period.

SYNCHRO ANALYSIS

As discussed earlier, there were a number of field observations, traffic counts, signal settings, and miscellaneous data collection efforts undertaken to collect all of the data needed to evaluate the existing conditions of the corridors. This data was compiled in *Synchro 9*, which is a signal timing/optimization/simulation software package accepted in the industry.

SYNCHRO MODEL DEVELOPMENT

Kimley-Horn created an existing conditions *Synchro* network file for the weekday AM, MD, and PM peak periods. These models were used as the base files from which the existing conditions analysis was performed. Geometric characteristics from the field survey notes were coded into *Synchro*. These characteristics included the following items for each intersection approach:

- Number of lanes
- Lane configurations (left, through, right or shard use)
- Storage bay lengths to the nearest five (5) ft increment
- Approach percent grades
- Link speeds

The traffic data was entered into *Synchro* using the traffic counts. The peak hour factors (per movement) and percent trucks (per movement) were also entered into *Synchro* for each peak period analyzed. The existing local controller settings, timing data, and coordination settings were entered into the model from the databases.

EXISTING SIGNAL OPERATIONS

Most of the study intersections are operating actuated-coordinated during the during the day and Free (actuated-uncoordinated) overnight. The remaining study intersections operate Free during all hours of the day.

During the AM peak hour, the actuated-coordinated signals operate via four (4) different cycle lengths and fourteen (14) intersections operate via Free operations. During the MD peak hour, the actuated-coordinated signals operate via four (4) different cycle lengths and fifteen (15) intersections operate via Free operations. During the PM peak hour, the actuated coordinated signals operate via five (5) different cycle lengths and fourteen (14) intersections operate via Free operations.

During Free operations, the signals are not coordinated with neighboring signals, therefore providing no progression along the corridor. Additionally, there are currently over ten (10) different time-of-day (TOD) schedules within the study network. It should be noted that some intersections operate school plans during part of the peak periods but operate Free operations for the majority of the peak period. It is difficult to provide coordination among signals on different TOD schedules because of the different transition times between plans and cycle lengths.

One method of describing the existing progression of traffic along the project corridors is by determining the length of end-to-end green bands on each corridor. The length of a green band is the amount of time (in seconds) available for traffic to move along the corridor between the first and last traffic signals without being stopped by a red indication. There was no end-to-end progression along most of the corridors due to the different cycle lengths, time-of-day schedules, and number of intersections not coordinated and were in Free operation.

Figures 4, 5, and 6 show the existing AM, MD, and PM cycle lengths respectively. **Figures 7, 8, and 9**, show the existing AM, MD, and PM TOD schedules, respectively.

Figure 4: Existing AM Cycle Lengths

Existing AM Cycle Lengths

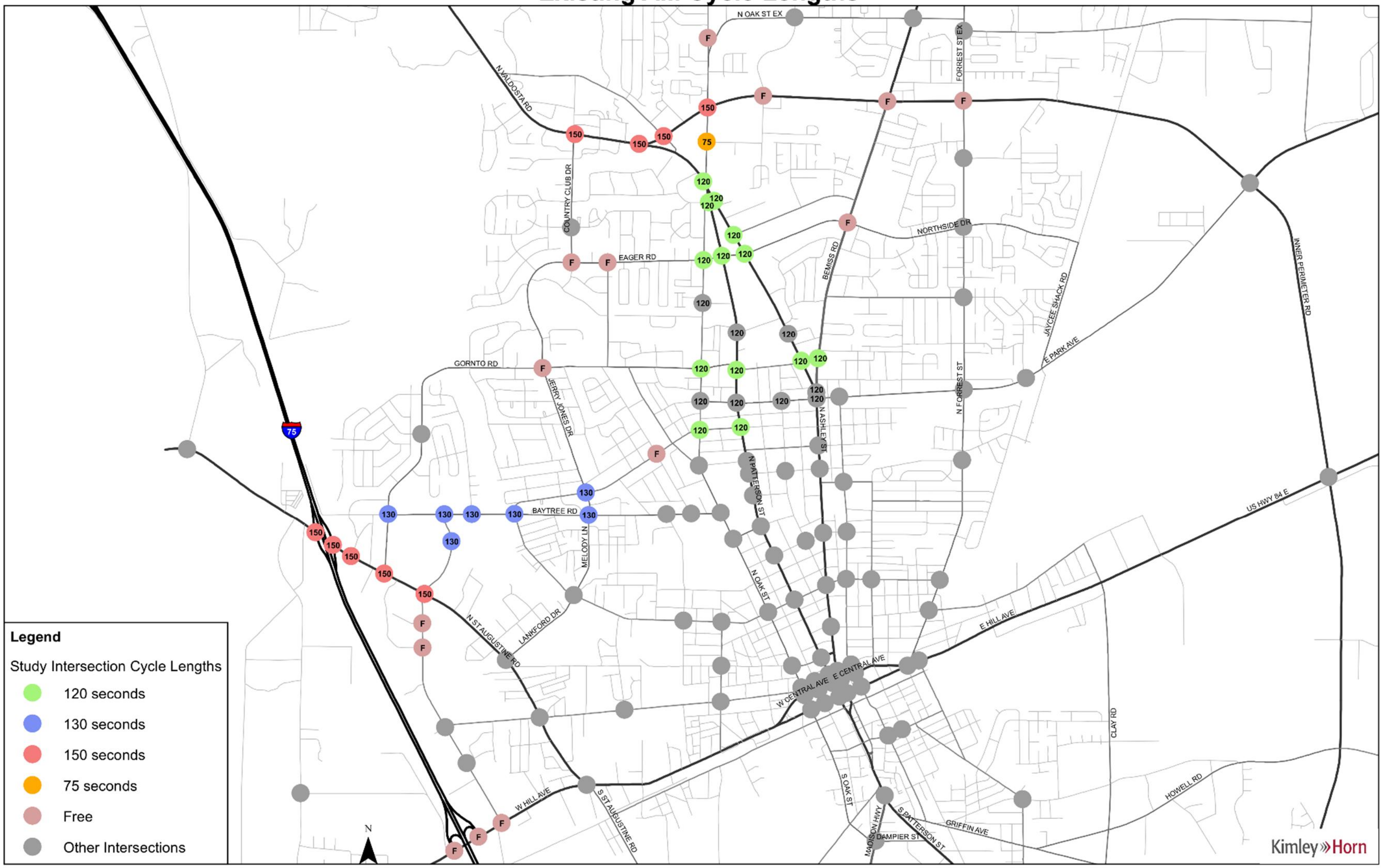


Figure 5: Existing MD Cycle Lengths

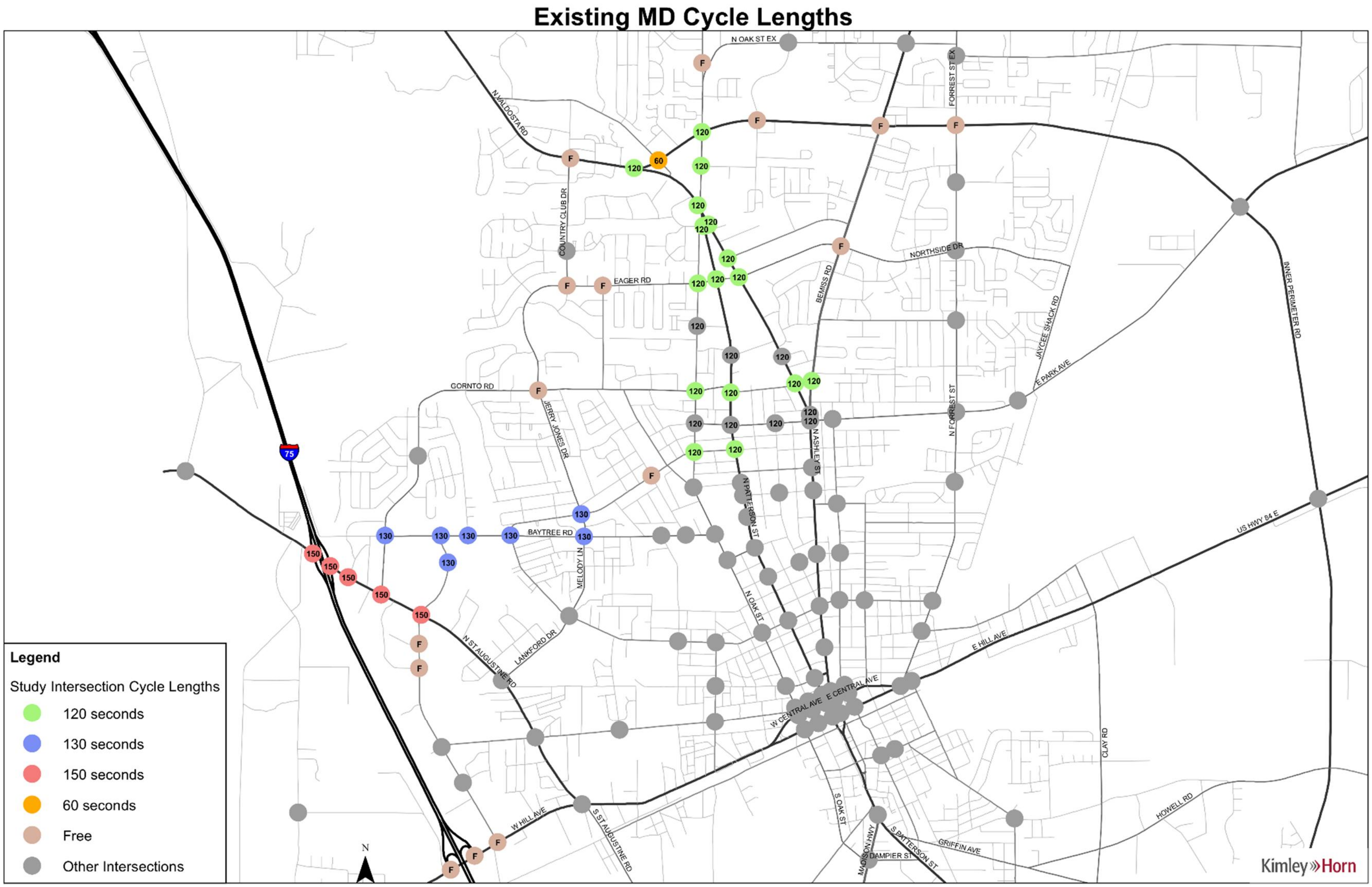


Figure 6: Existing PM Cycle Lengths

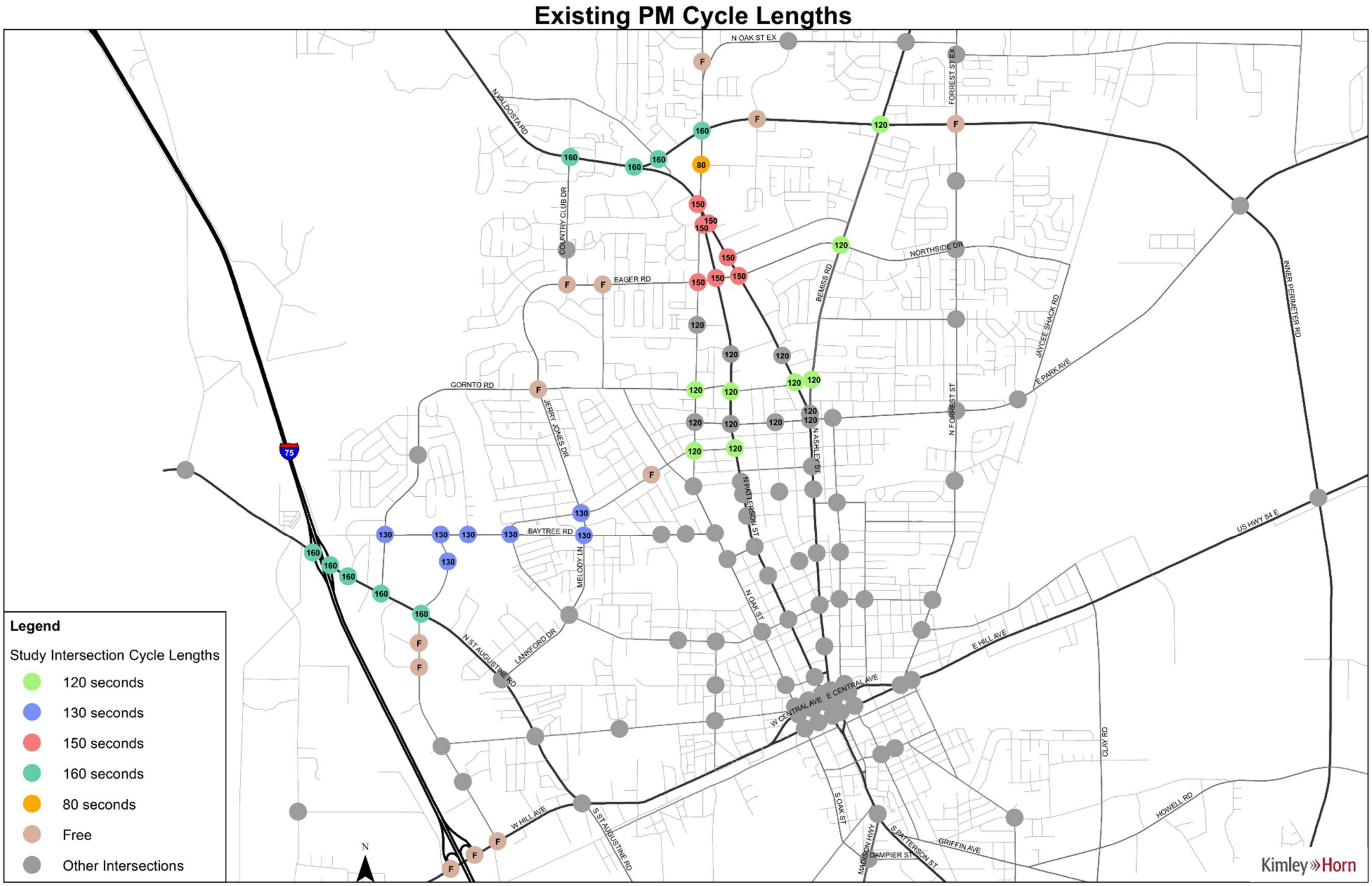


Figure 7: Existing AM TOD Schedule

Existing AM TOD Schedule

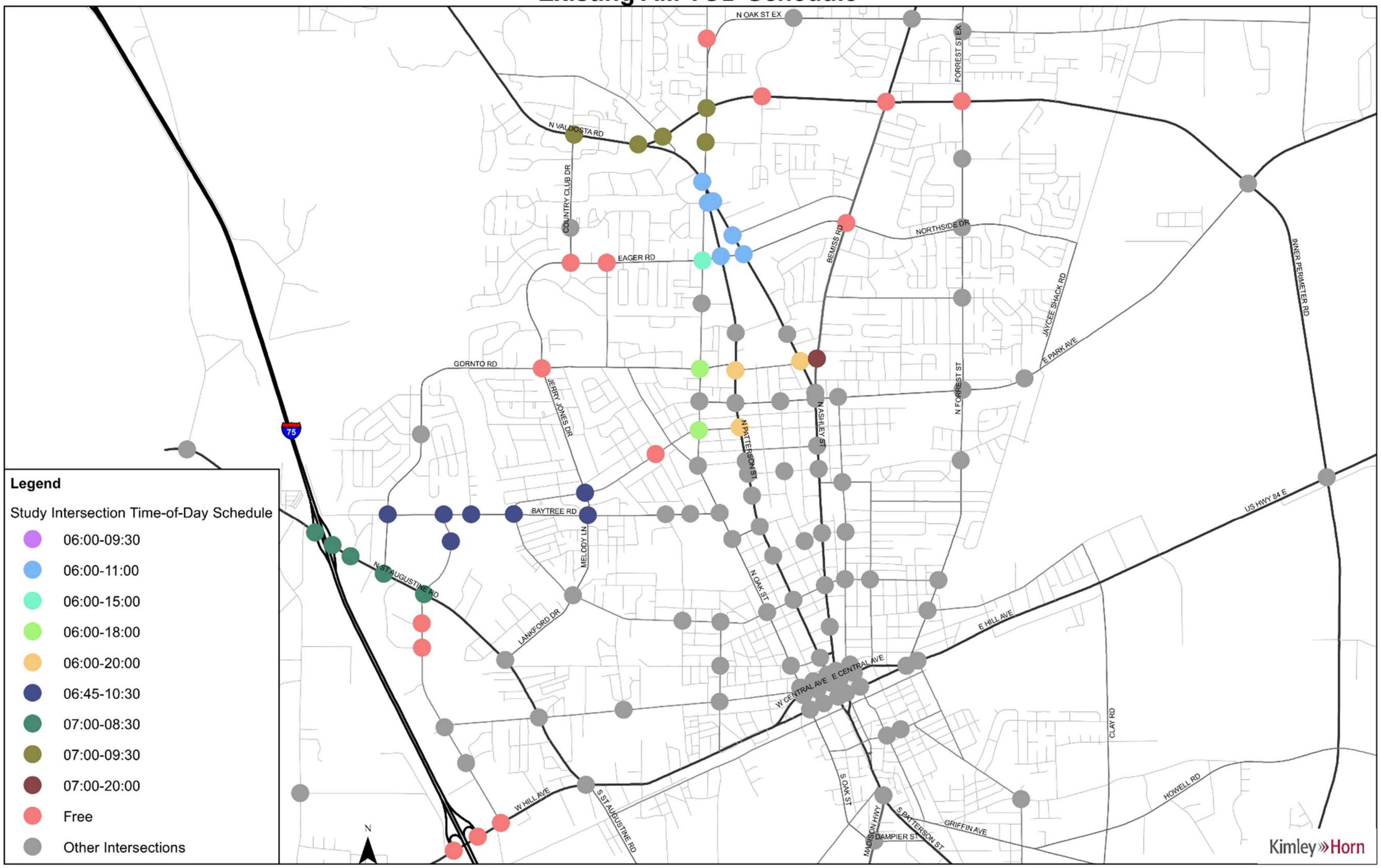
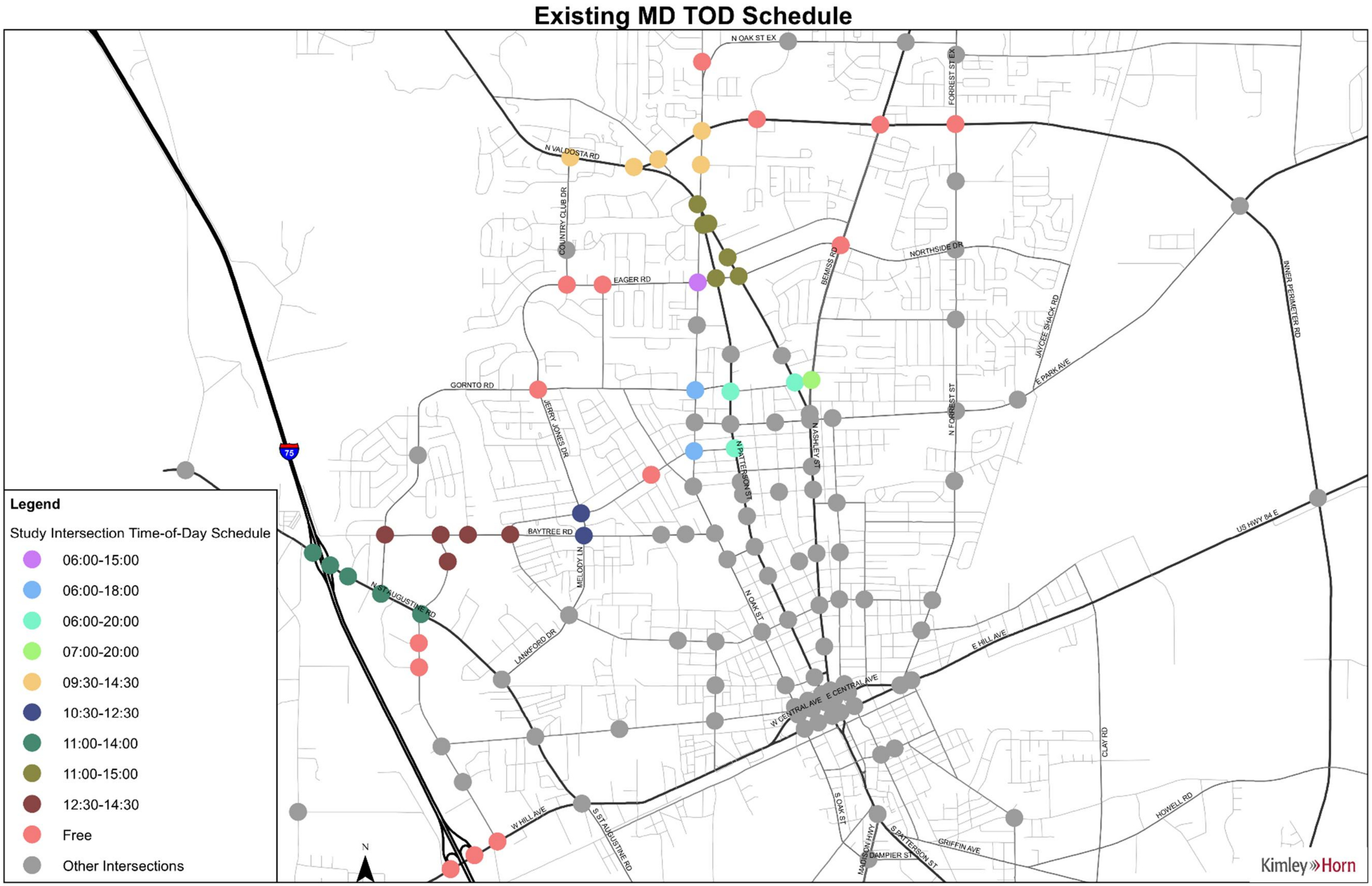
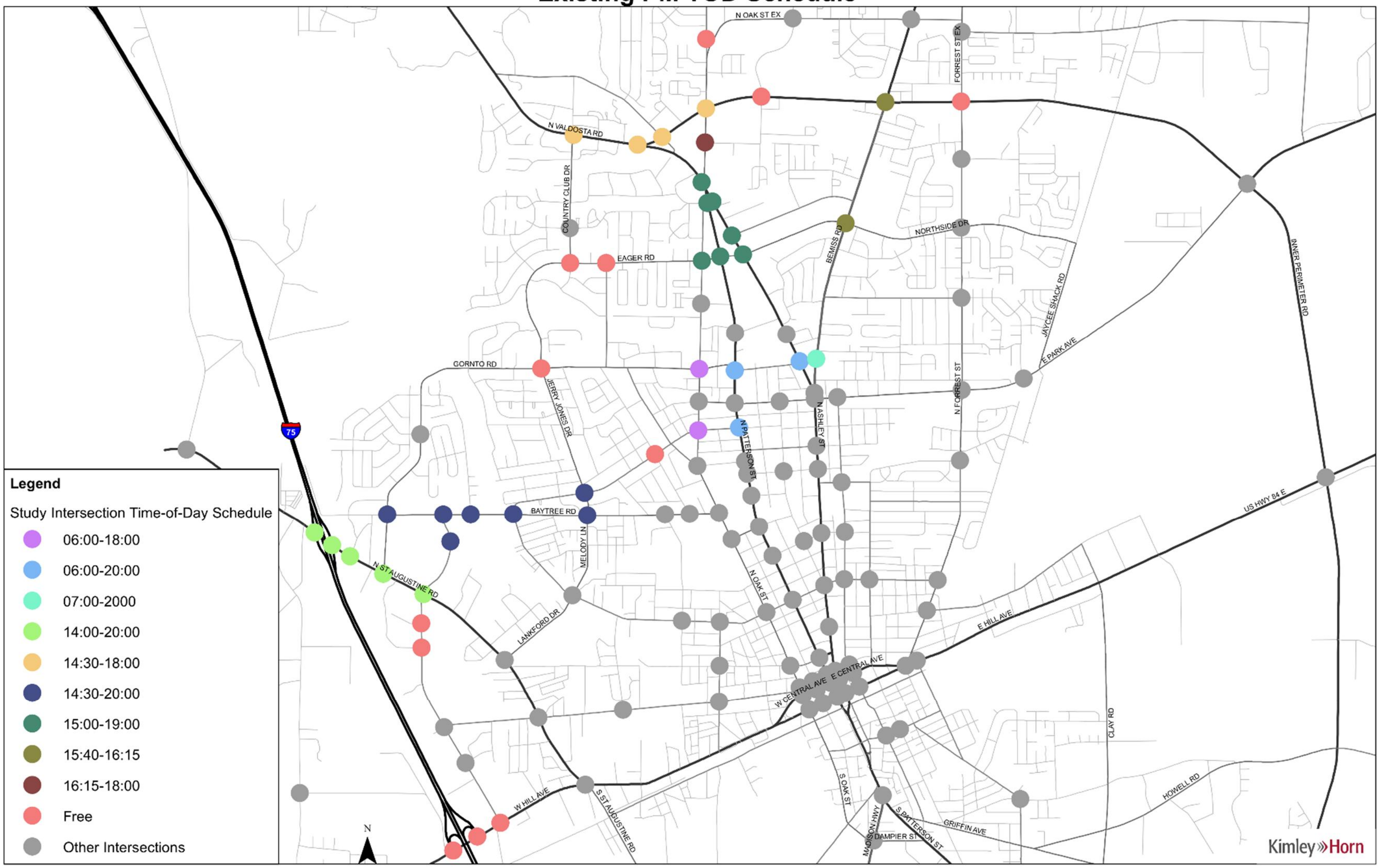


Figure 8: Existing MD TOD Schedule



Existing PM TOD Schedule



EXISTING TRAFFIC FLOW PATTERNS

Traffic flow patterns were determined by reviewing the turning movement count (TMC) data included in **Appendix A**. Based upon these volumes, distinct traffic flow patterns were found for each peak period.

During the AM peak period approximately sixty (60) to seventy (70) percent of traffic is headed inbound Valdosta along the majority of the project corridors. Approximately sixty (60) percent of the traffic travels westbound along Inner Perimeter Rd during the AM peak. As anticipated, traffic during the MD peak is essentially even in all directions along majority of the project corridors. For the PM peak period, approximately fifty-five (55) to seventy (70) percent of the traffic is headed outbound away from downtown Valdosta along the majority of the corridors. Traffic progression along Inner Perimeter Rd is approximately even in both directions. These traffic flow patterns are consistent with the *2011 Signal Timing Optimization Study* completed by KH.

EXISTING INTERSECTION LEVELS-OF-SERVICE

The existing conditions of each intersection within this group were analyzed using *Synchro/SimTraffic 9* software. *Synchro* provides capacity analysis consistent with the methodologies set forth in the *2000 Highway Capacity Manual (HCM)*.

Level-of-service (LOS) is used to describe the operating characteristics of a road segment or intersection in relation to its capacity. LOS – per the *HCM* – is defined as a qualitative measure that describes the operational characteristics in a traffic stream, generally in terms of service measures such as speed and travel time, freedom to maneuver, traffic interruptions, and comfort/convenience. The *HCM* describes six levels of service, LOS A through LOS F, with A being the best and F the worst. An intersection LOS of D or better with turning movements at LOS E or better is generally the accepted minimum threshold for operating conditions at signalized intersections.

Table 2 summarizes the intersection LOS and average vehicle delay per intersection for the existing conditions for each of the signalized intersections in the City of Valdosta, while the detailed capacity analysis summaries can be found in **Appendix B**.

Table 2: Existing Conditions LOS, Average Delay (sec/veh)

#	Intersection	LOS (Average Delay)		
		AM Peak Hour	MD Peak Hour	PM Peak Hour
1	St. Augustine Rd @ I-75 SB Ramp	C (30.3)	C (23.7)	C (24.5)
2	St. Augustine Rd @ I-75 NB Ramp	C (26.4)	B (16.1)	B (17.0)
3	St. Augustine Rd @ Twin St	A (6.9)	A (9.3)	B (13.1)
4	St. Augustine Rd @ Gornto Rd	C (26.5)	C (33.9)	D (41.4)
5	St. Augustine Rd @ Norman Dr	D (39.0)	D (41.3)	D (52.3)
6	Norman Dr @ Mall Ent	B (12.4)	C (34.8)	C (32.5)

#	Intersection	LOS (Average Delay)		
		AM Peak Hour	MD Peak Hour	PM Peak Hour
7	Baytree Rd @ Gornto Rd	C (26.5)	C (31.4)	E (57.7)
8	Baytree Rd @ Norman Dr	D (42.4)	D (35.8)	C (32.2)
9	Baytree Rd @ Sherwood Dr	B (14.0)	B (16.9)	C (22.4)
10	Baytree Rd @ Gordon St	D (40.2)	C (34.4)	C (25.9)
11	Hill Ave @ I-75 SB Ramp	D (46.2)	C (22.7)	C (33.0)
12	Hill Ave @ I-75 NB Ramp	D (41.7)	C (31.6)	C (29.5)
13	N Valdosta Rd @ Country Club Dr	D (49.7)	D (46.1)	E (61.2)
14	N Valdosta Rd @ Inner Perimeter Rd	C (22.9)	C (26.0)	C (25.7)
15	N Ashley St @ Connell Rd	B (14.9)	B (20.0)	B (15.9)
16	Inner Perimeter Rd @ Country Club Rd	B (15.7)	B (11.5)	B (19.6)
17	Inner Perimeter Rd @ Oak St Ext	D (43.6)	D (35.5)	D (44.8)
18	Inner Perimeter Rd @ Brookfield Rd/Lake Laurie Dr	C (21.5)	C (28.0)	D (40.1)
19	Inner Perimeter Rd @ Bemiss Rd	D (53.5)	D (37.5)	D (52.1)
20	Oak St Ext @ Murray Rd	B (11.4)	B (17.8)	C (24.5)
21	Oak St Ext @ Cherry Creek Rd	C (20.9)	B (15.1)	B (14.8)
22	Inner Perimeter Rd @ Forrest St	E (64.6)	D (39.2)	D (53.1)
23	Northside Dr @ Bemiss Rd	C (27.8)	C (26.3)	D (45.9)
24	Northside Dr/Eager Rd @ Oak St Ext	C (29.0)	C (24.7)	D (38.5)
25	Eager Rd @ Berkley Dr	B (10.5)	A (6.6)	A (9.0)
26	Eager Rd/Jerry Jones Dr @ Country Club Dr	D (42.0)	C (34.2)	D (48.7)

#	Intersection	LOS (Average Delay)		
		AM Peak Hour	MD Peak Hour	PM Peak Hour
27	Jerry Jones Dr @ Gornto Rd	C (33.1)	D (38.4)	E (60.6)
28	Jerry Jones Dr @ Alden Ave	B (16.8)	B (18.4)	C (22.5)
29	Baytree Rd @ Jerry Jones Dr/Melody Ln	C (25.3)	C (25.8)	C (34.2)
30	Woodrow Wilson Dr @ Bemiss Rd	A (9.0)	A (7.9)	A (9.3)
31	Woodrow Wilson Dr @ N Ashley St	C (21.1)	C (25.0)	C (24.3)
32	Woodrow Wilson Dr/Gornto Rd @ N Patterson St	B (13.9)	C (22.9)	C (21.8)
33	Gornto Rd @ N Oak St	D (35.7)	C (33.7)	C (34.3)
34	N Valdosta Rd @ Oak St Ext	D (36.1)	E (75.6)	E (69.3)
35	N Ashley St @ Smithbriar Dr	C (20.8)	D (37.4)	F (267.7)
36	N Ashley St @ Northside Dr	C (32.7)	C (33.6)	E (55.9)
37	N Patterson St @ Smithbriar Dr	B (14.9)	B (19.2)	C (21.5)
38	N Patterson St @ Northside Dr	D (48.8)	C (31.5)	D (37.8)
39	Alden Ave @ Azalea Dr	B (12.9)	B (11.9)	B (12.8)
40	Alden Ave @ N Oak St	D (36.3)	C (29.8)	C (32.1)
41	Alden Ave @ N Patterson St	B (15.1)	B (14.0)	B (13.4)
42	Norman Dr @ Lowndes H.S.	B (15.7)	A (9.0)	B (12.7)
43	Norman Dr @ Valhalla Dr	B (12.1)	A (2.5)	C (21.8)
44	Hill Ave @ Norman Dr	B (15.2)	C (26.1)	C (29.3)

As seen above, the majority of the signalized intersections during each of the three peak periods operated at an acceptable level-of-service (LOS D or better). The intersections that were operating at an unacceptable level-of-service have been summarized below. Split allocation was critical at these locations. These intersections are discussed further in **Section 6.0 Operational Analysis**.

- Baytree Rd @ Gornto Rd
    - LOS E – PM Peak Hour
        - This is driven primarily by the eastbound and westbound movements split phasing operations
- N Valdosta Rd @ Country Club Dr
    - LOS E – PM Peak Hour
        - This is driven primarily by the westbound left turn and eastbound through movements and the northbound and southbound movements split phasing operations
- Inner Perimeter Rd @ Forrest St
    - LOS E – AM Peak Hour
        - This is driven primarily by the northbound and southbound movements split phasing operations
- Jerry Jones Dr @ Gornto Rd
    - LOS E – PM Peak Hour
        - This is driven primarily by the Free operations
- N Valdosta Rd @ Oak St Ext
    - LOS E – MD and PM Peak Hours
        - This is driven primarily by the heavy northbound right turn and westbound left turn movements
- N Ashley St @ Smithbriar Dr
    - LOS F – PM Peak Hour
        - This is driven primarily by the heavy eastbound left turn movement
        - While there is significant delay during the PM, due to intersection spacing with N Patterson St at Smithbriar Dr and unique turning movements at the intersections combined with limitations within *Synchro*, the delay is overstated at this intersection
- N Ashley St @ Northside Dr
    - LOS E – PM Peak Hour
        - This is driven primarily by the heavy southbound left turn movement opposing the heavy northbound through movement and the heavy eastbound and westbound left turn movements

4.0 OPTIMIZATION ANALYSIS

The timing plan development process for each intersection was developed with three key objectives:

(1) Progress all through movements on the primary arterial routes

(2) Favor progression in the predominant direction

(3) Minimize overall system vehicular delay at all signalized intersections

The timing plan development process includes six distinct tasks:

- Vehicular and pedestrian clearance intervals
- Cycle length determination
- Split allocation
- Offset manipulation / optimization
- Phase operation / sequencing
- Time of day clock development

The following subsections describe the methodology and tools used in each of the components of the timing plan development process.

VEHICULAR AND PEDESTRIAN CLEARANCE INTERVALS

As part of this study, a review of both the vehicular (yellow and all red times) and pedestrian (Walk and Flashing Don't Walk times) clearance intervals was performed at all intersections, with the exception of the five (5) GDOT project intersections and the one (1) additional City of Valdosta intersection. The calculations for the clearance intervals were based upon the *Manual of Uniform Traffic Control Devices (MUTCD), 2011 Edition*. Recommendations were made to City of Valdosta and final determination of clearance intervals were made by City of Valdosta staff. The approved clearance intervals were included in the database and implemented at the same time as the new signal timings. The spreadsheets for the approved vehicular and pedestrian clearance intervals have been submitted electronically to City of Valdosta staff, and the summary sheets are included in **Appendix C**.

CYCLE LENGTH DETERMINATION

In order to have signal coordination to allow for designated progression of traffic along the primary corridors, a cycle length analysis was completed by KH. As discussed in **Section 3.0 Existing Conditions Analysis**, the existing cycle lengths vary greatly throughout the study network.

The study network was divided into three (3) zones based on natural coordination breaking points of the system. The North Zone includes the corridors of N Valdosta Rd, N Ashley St, N Patterson St, Inner Perimeter Rd, Oak St Ext, Northside Dr, Eager Rd/Jerry Jones Dr, Woodrow Wilson Dr, and Alden Ave. The Middle Zone includes the mall area of St. Augustine Rd, Baytree Rd, and Norman Dr. The South Zone includes Hill Ave. **Figure 10** shows the project intersections within the three (3) zones.

Each zone was evaluated for each peak period using *Synchro* analysis tools and observations of the existing characteristics. The cycle lengths were evaluated for a range of 100 seconds to 250 seconds at ten (10) second intervals. The proposed cycle lengths for each zone for AM, MD, and PM peak periods are shown in **Figures 11, 12, and 13**, respectively. **Figures 14 and 15** show the proposed cycle length for the Off-peak (OP) and Weekend (WKND) peak periods, respectively. Half-cycle lengths were considered at smaller intersections, where applicable, during all peak periods after the corridor and zone cycle lengths were determined. **Figure 16** shows the proposed cycle length for the Middle and South Zone for the Holiday peak period.

Figure 10: Project Zone Map

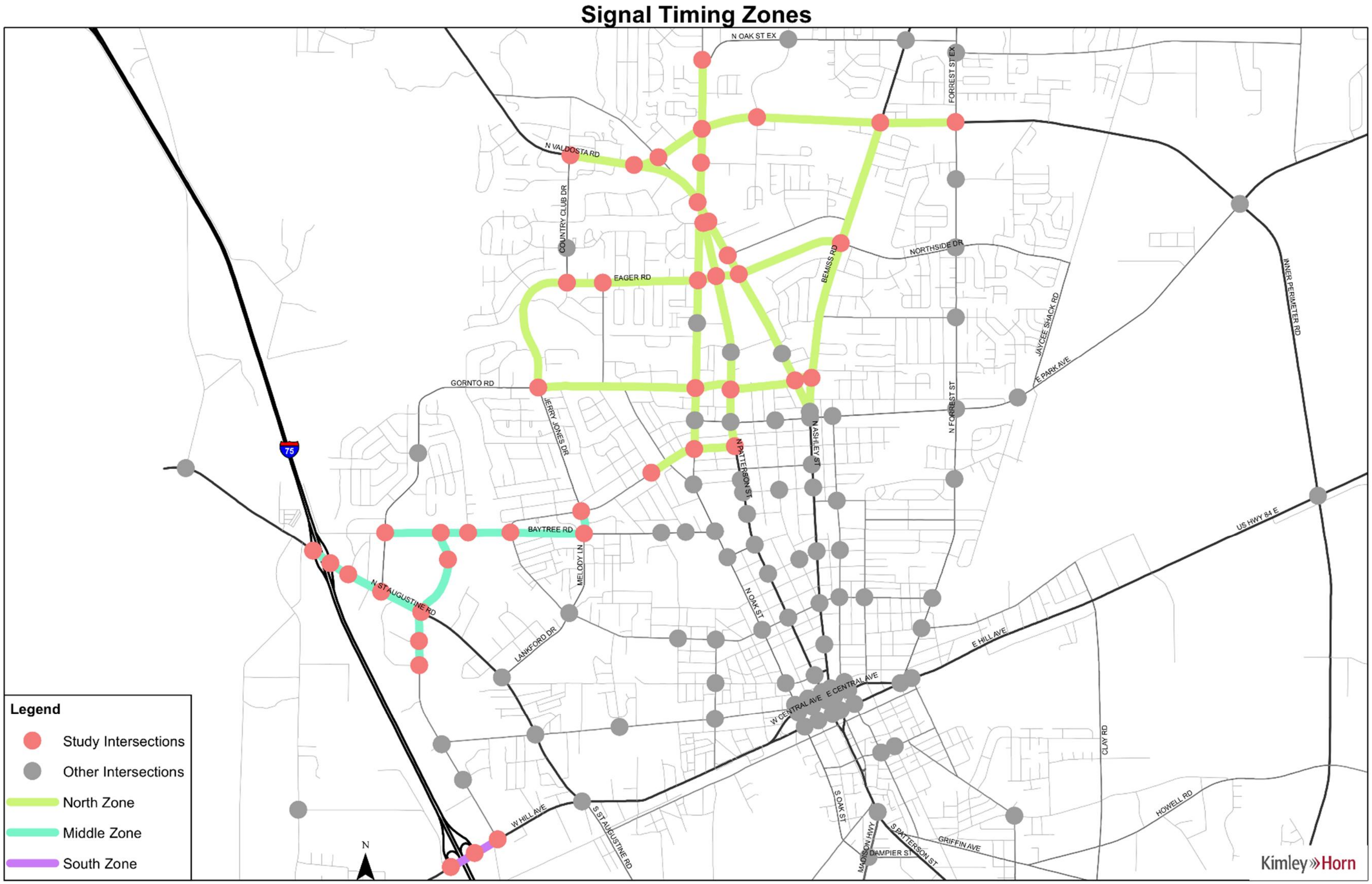


Figure 11: Proposed AM Cycle Lengths

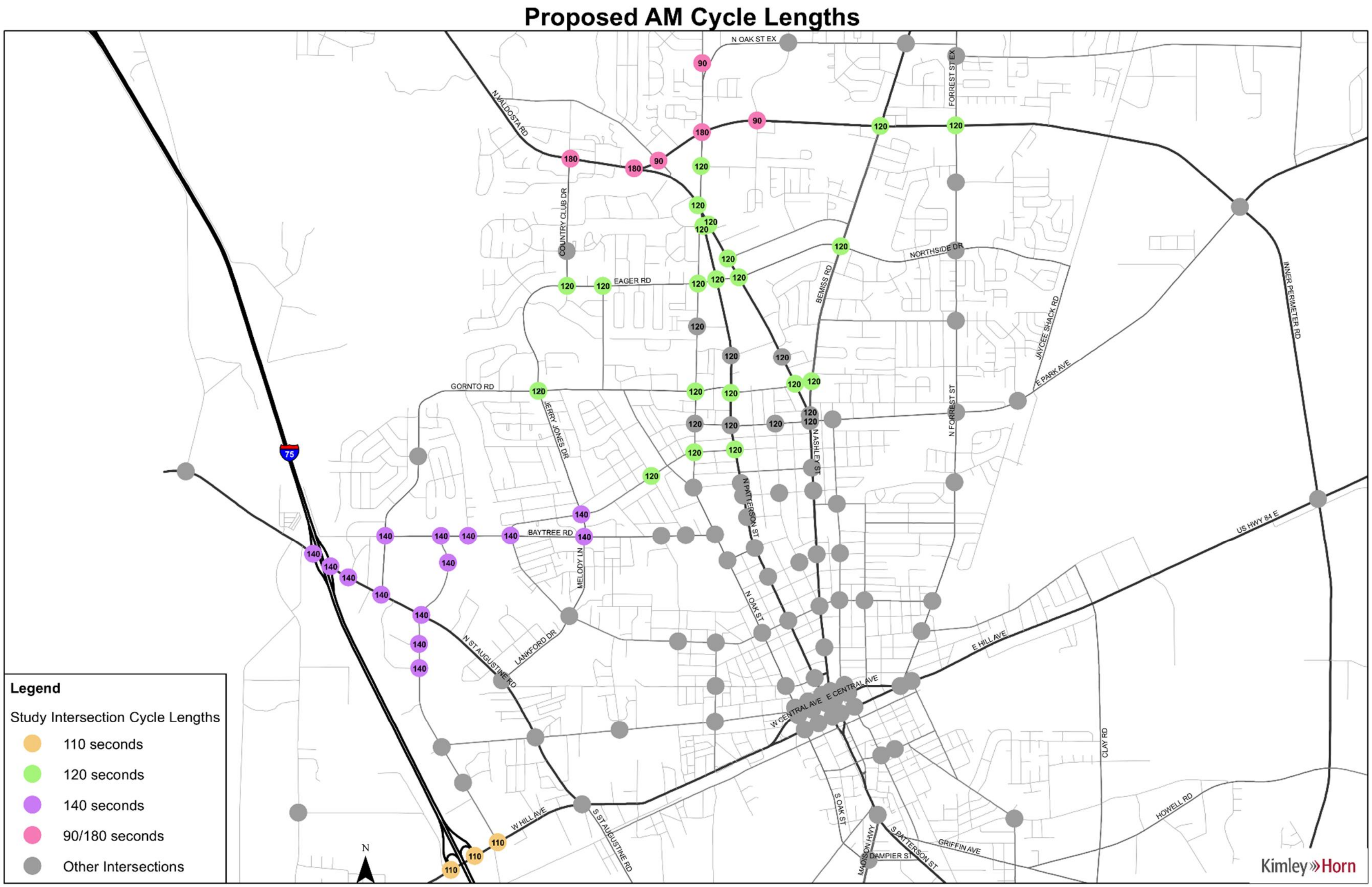


Figure 12: Proposed MD Cycle Lengths

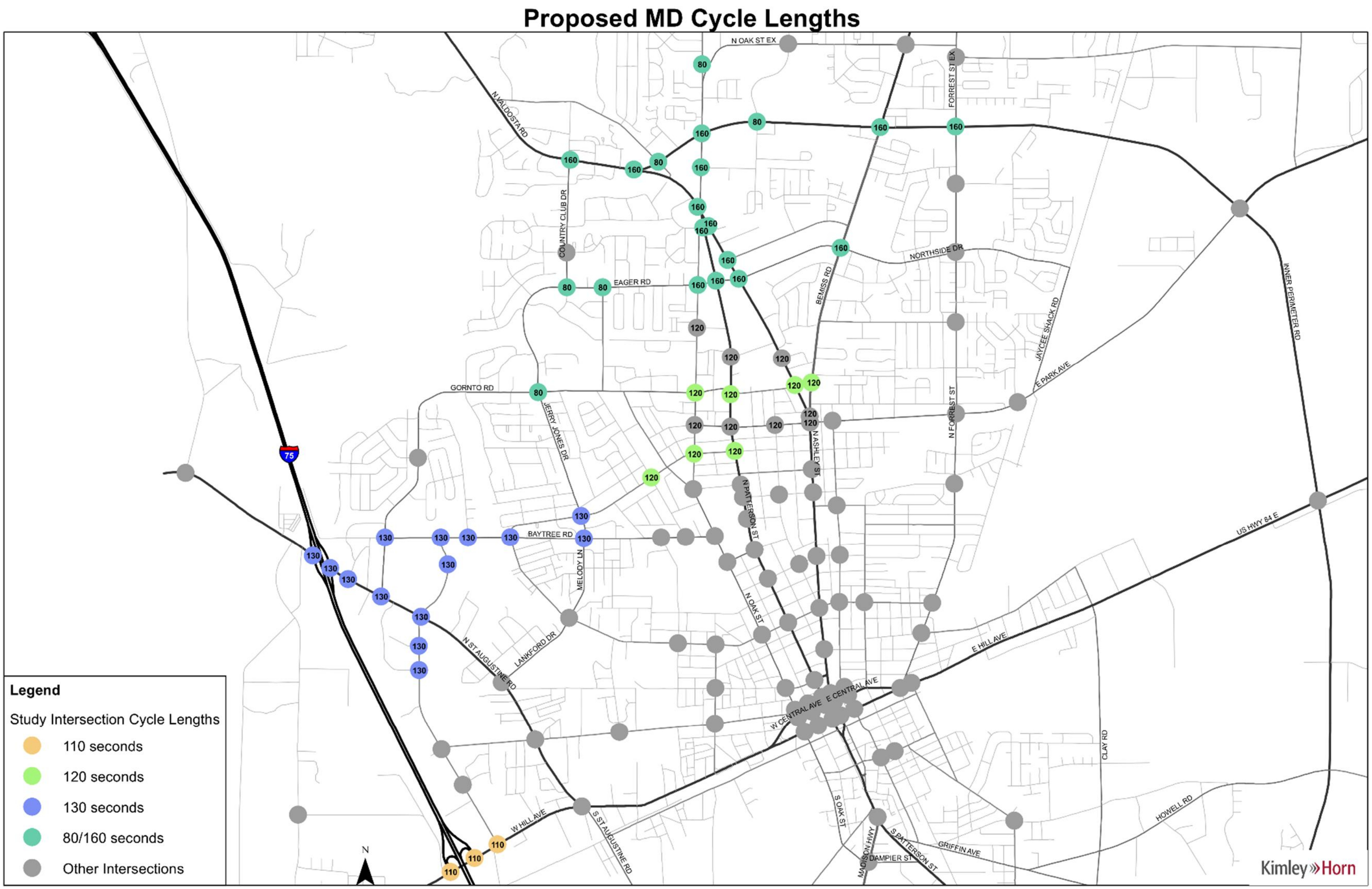


Figure 13: Proposed PM Cycle Lengths

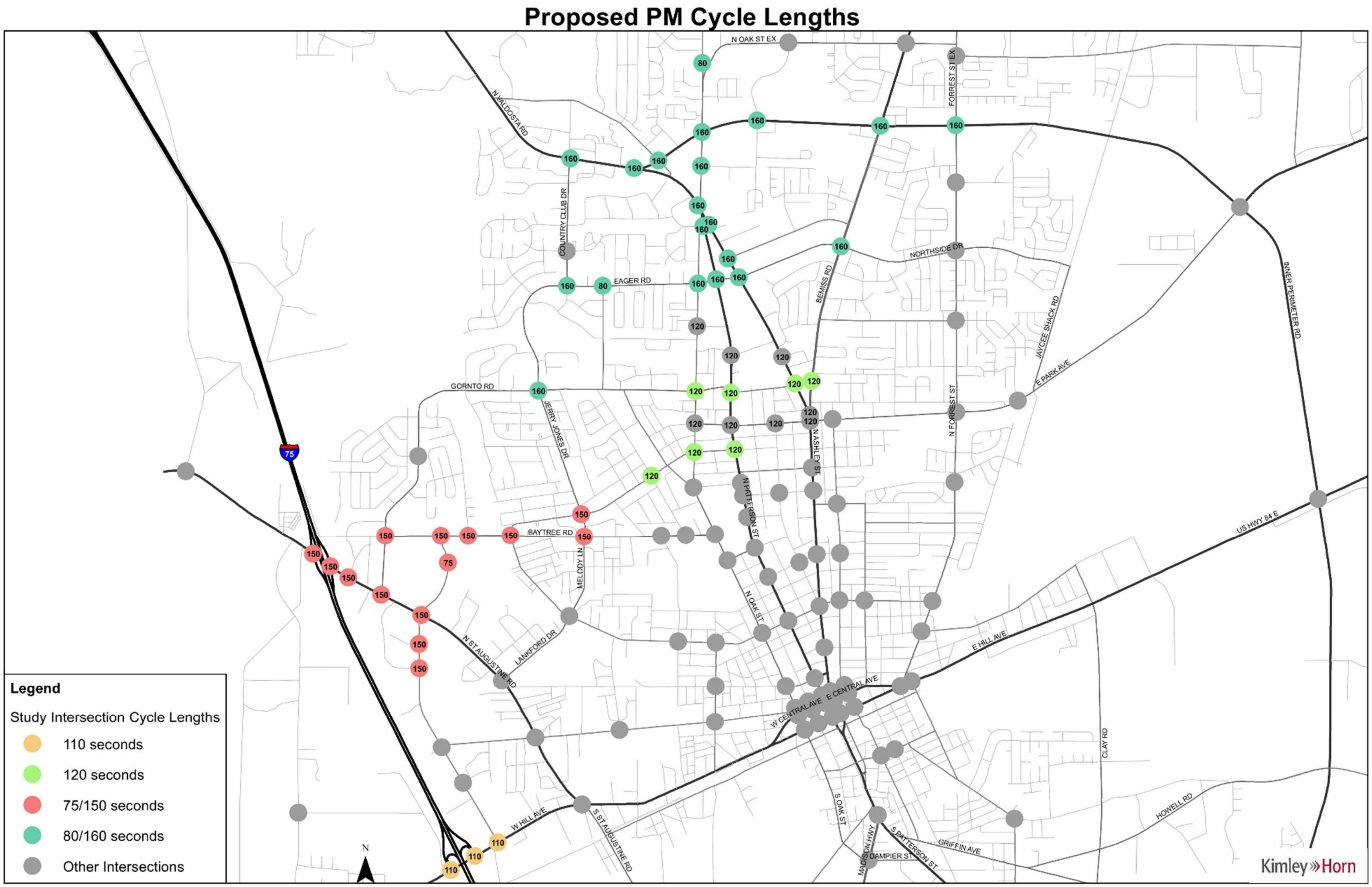


Figure 14: Proposed Off-Peak Cycle Lengths

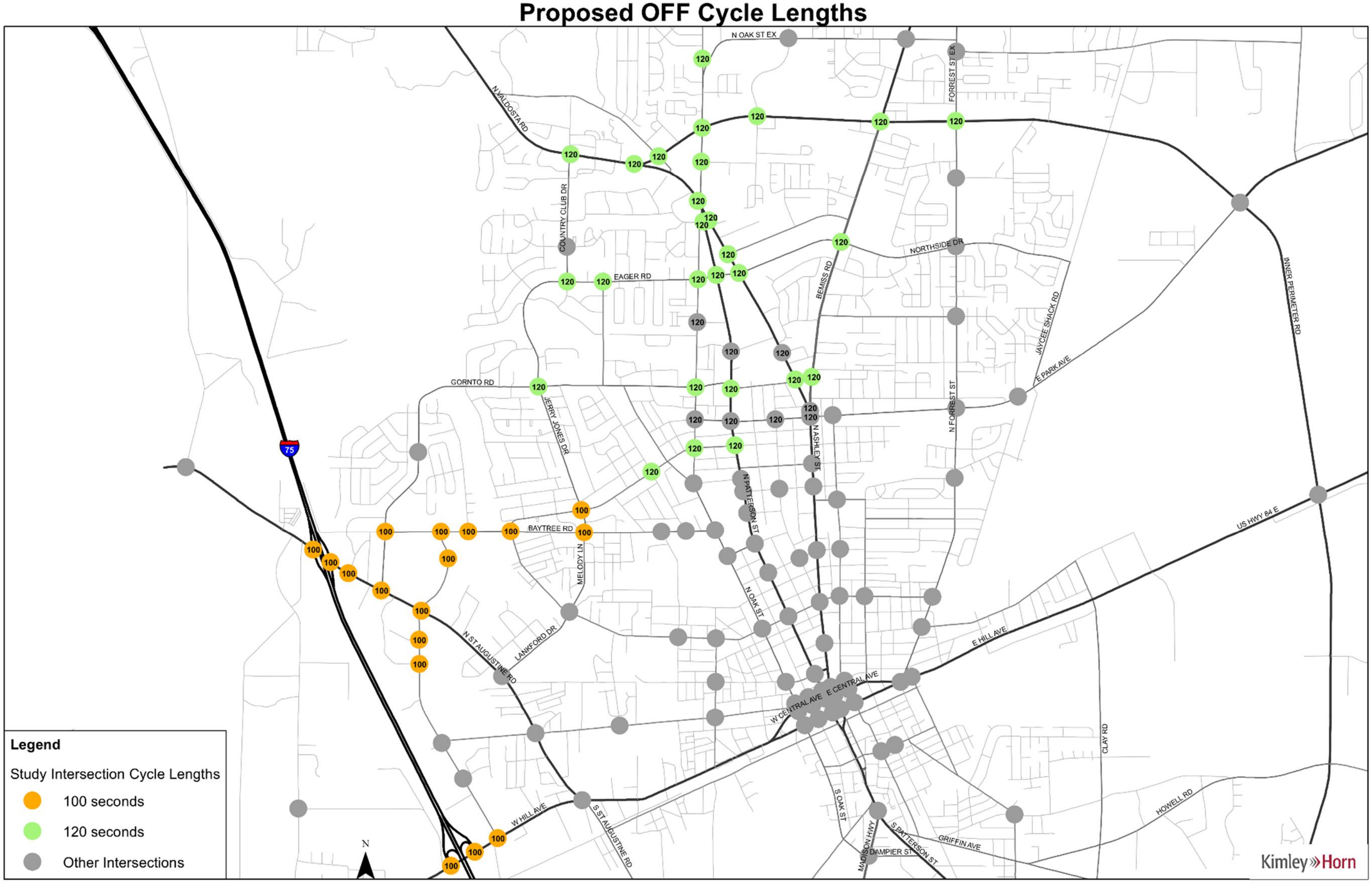


Figure 15: Proposed Weekend Cycle Lengths

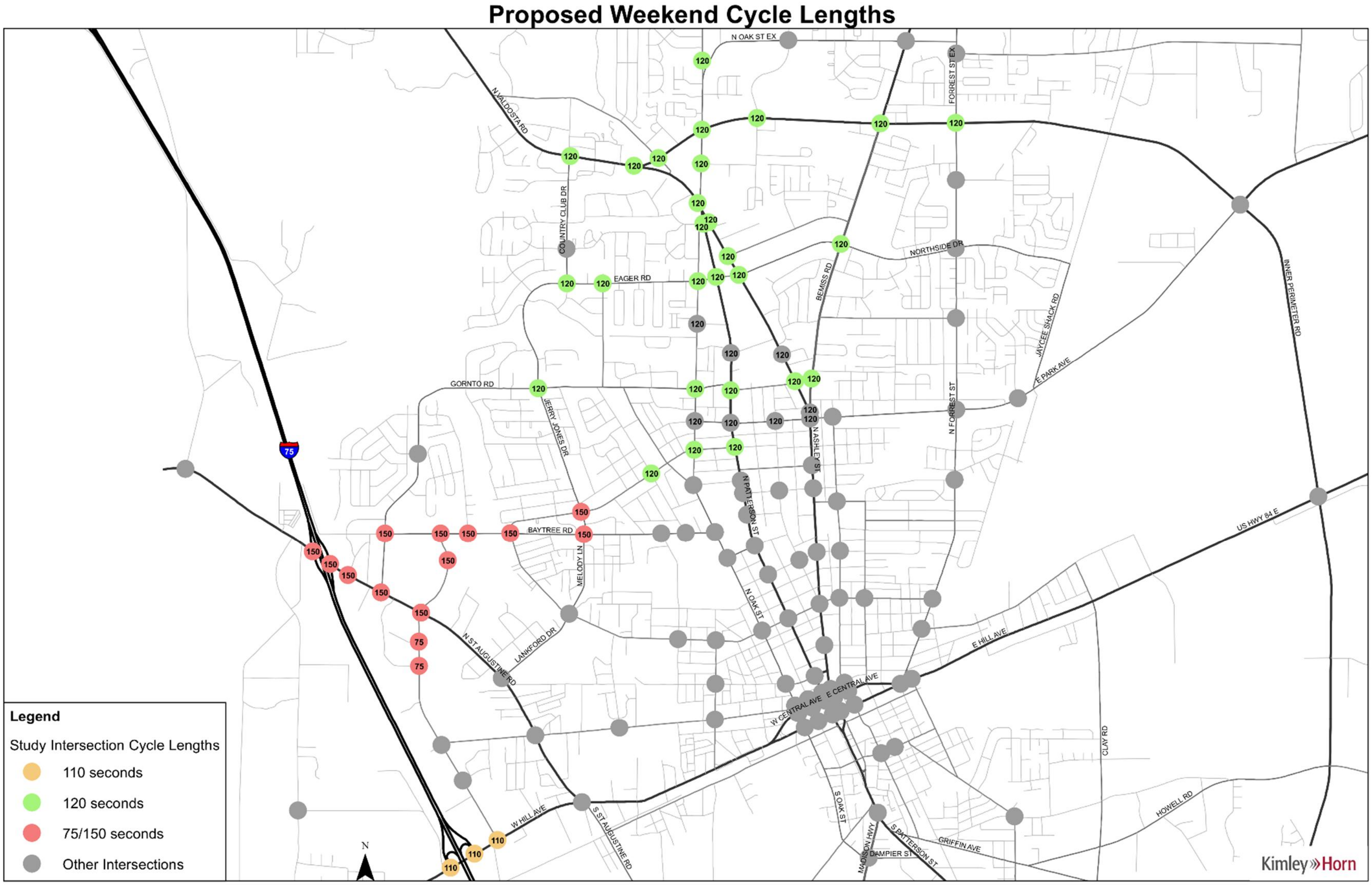
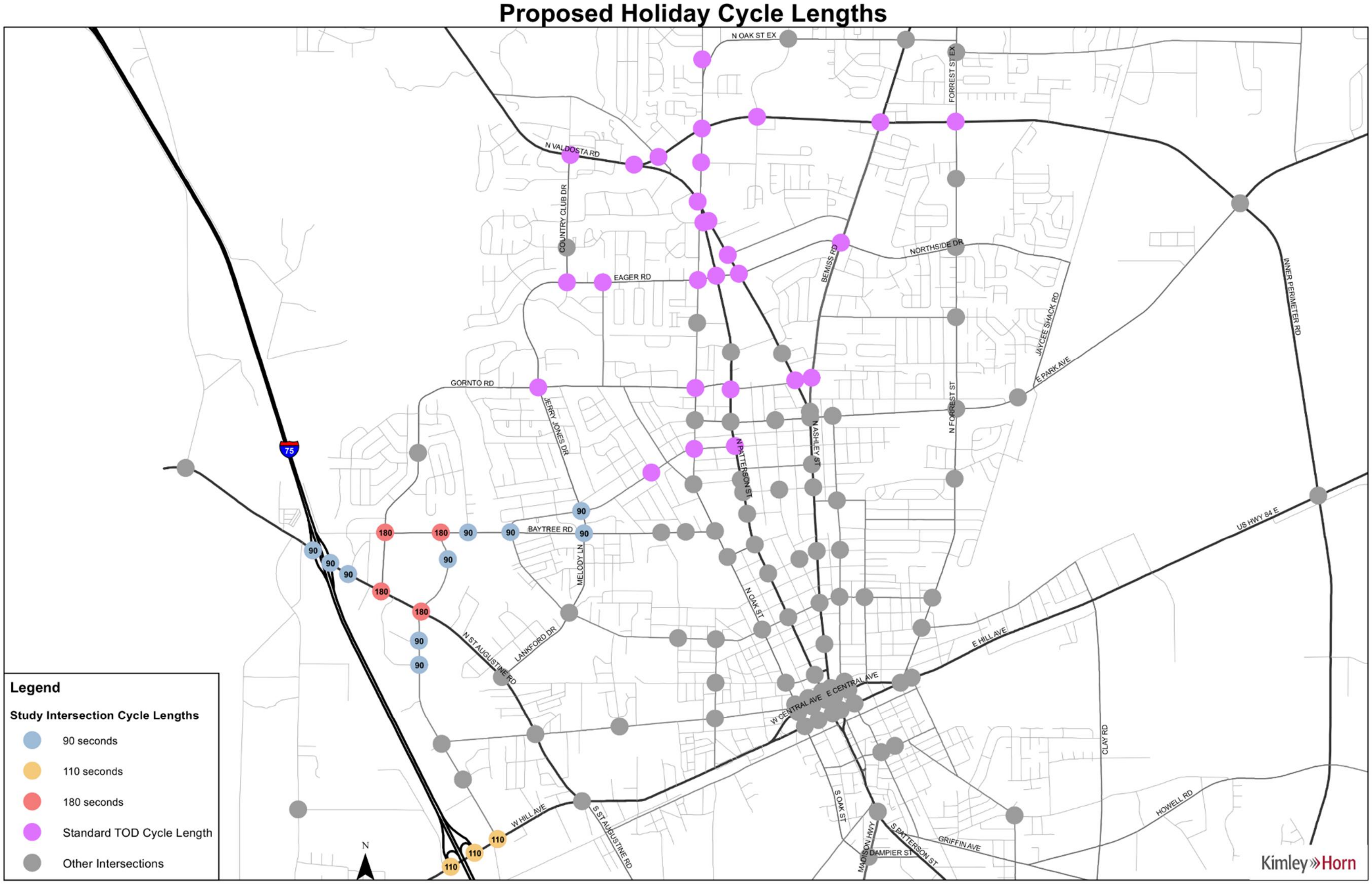


Figure 16: Proposed Holiday Cycle Lengths



NORTH ZONE

The proposed cycle lengths are longer than the existing cycle lengths in some areas, and allow for additional coordination along the corridors within the zone. The longer cycles and coordination provide the advantages of increasing the throughput for critical intersection and movements.

- AM: 120 second cycle length
    - Will allow for better coordination with adjacent City signals toward downtown Valdosta which run a 120 second cycle
    - Will keep the cycle length low to help manage side street and pedestrian delay
    - Note: the intersection of N Valdosta Rd at Country Club Dr cannot operate at a 120 second cycle length due to pedestrian minimum splits and volume demands. N Valdosta Rd at Country Club Rd, N Valdosta Rd at Inner Perimeter Rd, and Inner Perimeter Rd at Oak St Ext will operate with a 180 second cycle length, which will increase throughput along N Valdosta Rd and will provide a two-third (2/3) cycle coordination relationship with the rest of the signals.
    - Note: the intersections of Inner Perimeter Rd at Country Club Rd and Oak St Ext at Cherry Creek Rd will operate with a 90 second cycle length which will provide a half (1/2) cycle relationship with the 180 second cycle length and two-third (2/3) cycle relationship with the 120 second cycle length.
- MD: 160 second cycle length and 120 second cycle length south of Northside Dr
    - Will allow for smaller intersections to operate at an 80 second half (1/2) cycle length to reduce side street delay
    - Analysis showed reduced intersection delay and total number of stops
    - Will increase bi-directional green bands and throughput along the corridors, particularly at intersections currently experiencing significant mainline delay such as N Valdosta Rd at Oak St Ext
    - Note: due to the surrounding signals operating at a 120 cycle length the intersections south of Northside Dr will operate at 120 second cycle length for coordination
- PM: 160 second cycle length and 120 second cycle length south of Northside Dr
    - Will allow for smaller intersections to operate at an 80 second half (1/2) cycle length to reduce side street delay
    - Analysis showed reduced intersection delay and total number of stops
    - Will increase bi-directional green bands and throughput along the corridors, particularly at intersections currently experiencing significant mainline delay such as N Valdosta Rd at Oak St Ext and Inner Perimeter Rd at Oak St Ext
    - Note: due to the surrounding signals operating at a 120 cycle length the intersections south of Northside Dr will operate at 120 second cycle length for coordination
- OP: 120 second cycle length
    - Allows for coordination with surrounding signals: however, the analysis showed a lower cycle length could be chosen
    - Analysis shows reduced intersection delay and total number of stops
    - Shorter cycle length will help manage side street delay

- WKND: 120 second cycle length
    - Allows for coordination with surrounding signals: however, the analysis showed a lower cycle length could be chosen
    - Analysis shows reduced intersection delay and total number of stops
    - Shorter cycle length will help manage side street delay

MIDDLE ZONE

The proposed cycle lengths are the same for St. Augustine Rd, Baytree Rd, and Norman Dr, which allows for coordination around the entirety of the mall area. The cycle lengths are generally the same or lower than the existing cycle lengths in some areas, which allows for reduced side street delay and better coordination around the mall.

- AM: 140 second cycle length
    - Will allow for better coordination with all signals and operate as a system
    - Will allow for coordination with Baytree Rd, Gornto Rd, and St. Augustine Rd
    - Analysis shows reduced intersection delay and total number of stops
    - Shorter cycle length will manage side street delay along St. Augustine Rd
- MD: 130 second cycle length
    - Will allow for better coordination with all signals and operate as a system
    - Will allow for coordination with Baytree Rd, Gornto Rd, and St. Augustine Rd
    - Analysis shows reduced intersection delay and total number of stops
    - Shorter cycle length will manage side street delay along St. Augustine Rd
- PM: 150 second cycle length
    - Will allow for better coordination with all signals and operate as a system
    - Will allow for coordination with Baytree Rd, Gornto Rd, and St. Augustine Rd
    - Analysis shows reduced intersection delay and total number of stops
- OP: 100 second cycle length
    - Will allow for better coordination with all signals and operate as a system
    - Analysis shows reduced intersection delay and total number of stops
    - Shorter cycle length will help manage side street delay
- WKND: 150 second cycle length
    - Will allow for better coordination with all signals and operate as a system
    - Will allow for coordination with Baytree Rd, Gornto Rd, and St. Augustine Rd
    - Analysis shows reduced intersection delay and total number of stops

- Holiday: 180 second cycle length and 90 second half (1/2) cycle length
  - Will allow for better coordination with all signals and operate as a system
  - Will allow for coordination with Baytree Rd, Gornto Rd, and St. Augustine Rd
  - Will allow for greater throughput and green bands at the four (4) main intersections of St. Augustine Rd at Gornto Rd, St. Augustine Rd at Norman Dr, Baytree Rd at Gornto Rd, and Gornto Rd at Norman Dr
  - Shorter half (1/2) cycle length will help manage side street delay

SOUTH ZONE

The proposed cycle lengths will allow for coordination between these critical intersections that were in Free operation.

- AM: 110 second cycle length
  - Will allow for better coordination between signals
  - Analysis showed reduced intersection delay and total number of stops
  - Will allow for reduced queuing between intersections
- MD: 110 second cycle length
  - Will allow for better coordination between signals
  - Analysis showed reduced intersection delay and total number of stops
  - Will allow for reduced queuing between intersections
- PM: 110 second cycle length
  - Will allow for better coordination between signals
  - Analysis showed reduced intersection delay and total number of stops
  - Will allow for reduced queuing between intersections
- OP: 100 second cycle length
  - Will allow for better coordination between signals
  - Analysis showed reduced intersection delay and total number of stops
  - Will allow for reduced queuing between intersections
  - Shorter cycle length will help manage side street delay
- WKND: 110 second cycle length
  - Will allow for better coordination between signals
  - Analysis showed reduced intersection delay and total number of stops
  - Will allow for reduced queuing between intersections

- Holiday: 110 second cycle length
  - Will allow for better coordination between signals
  - Analysis showed reduced intersection delay and total number of stops
  - Will allow for reduced queuing between intersections

SPLIT ALLOCATION

Once cycle lengths and clearance intervals were determined, each intersection was evaluated to determine the optimal vehicle split allocations. Split allocations were determined by using a “uniform arrival approach,” which is based upon the Poisson distribution. This methodology calculates all movements based upon the uniform arrival of vehicles. An equal amount of green time is assigned to the first three vehicles in the queue. This is followed by a smaller allocation for the remaining vehicles in the queue, as these vehicles gain momentum, thereby requiring less time to clear the intersection. These values were compared against the minimum vehicle splits and any pedestrian timing requirements. The chosen splits were then input into the proposed *Synchro* models and simulated in *SimTraffic* to identify any queuing issues or storage bay spillovers prior to implementation of the timing plans.

Appropriate split determination is important such that mainline coordination improvements are not made at the expense of overall system delay. In essence, proper split allocation is critical to provide sufficient mainline progression, and to provide sufficient split times for all of the remaining intersection movements.

OFFSET MANIPULATION / OPTIMIZATION

Once the cycle length was chosen and the splits were allocated for each phase, the next step was the determination of the optimal offset per intersection in order to optimize traffic progression along the corridor. The optimization task was performed on the *Synchro* models for each timing plan. The focus on selecting the individual offsets was to maximize the amount of time (green band width) a platoon of vehicles has to pass through the individual zones without incurring a stop. Progression of traffic along the heavier direction of travel was favored during heavy inbound and outbound periods of the day. Dual progression (equal allotments of green band widths in both directions) was the goal during the MD and Off-peak timing plan as traffic is typically more balanced during these periods of the day.

PHASING OPERATION / SEQUENCING

When developing the optimized timing plans, each intersection is analyzed for potential changes to the phase operation or sequencing. In particular, intersections with split phase operations were analyzed to determine if sequence changes could be made to improve progression along the corridor. Additionally, intersections with leading protected-only or leading permissive protected flashing yellow arrow left turns were analyzed to determine double-serve left-turn phasing or lead/lag left turn sequencing could be utilized.

The removal of split phasing was considered as part of the signal timing optimization analysis, but it was not implemented with the proposed timings due to the additional improvements required, such as re-stripping and signal head upgrades. These improvements are further discussed in **Section 6.0 Operational Analysis**.

TIME OF DAY CLOCK DEVELOPMENT

A time-of-day (TOD) analysis was performed for each zone based upon hourly volumes along the corridors. Exiting TOD schedule for surrounding GDOT and City of Valdosta signals were also taken into consideration when developing recommendations. It is recommended that the TOD schedules be as consistent as possible to maximize citywide coordination, minimize system breaks, and enhance mainline green band throughput on the major corridors. The TOD schedule of the five (5) intersections that were included in the GDOT project PI No. 0010116 were modified to match the surrounding signals for coordination.

Volume information summary spreadsheets that support the following recommendations can be found in **Appendix D** of this document.

After review of the ADT data and the exiting TOD clock settings, the decision was made to use similar TOD clock for the three (3) zones. The Middle and South Zone TOD clock is different than the North Zone due to the traffic patterns and demands near the Valdosta Mall. The TOD clock was part of the implemented databases, and is shown **Tables 3, 4, and 5** for the North, Middle, and South Zones respectively.

Table 3: North Zone TOD Schedule

North Zone				
Day	Time	Dial/Split/Offset	Description	Cycle Length (sec)
Monday – Friday	00:00 – 06:00	D0/S0/O4	Free	
	06:00 – 09:00	D1/S1/O1	AM	180 / 90 and 120
	09:00 – 14:30	D2/S1/O1	MD	160 / 80 and 120
	14:30 – 18:00	D3/S1/O1	PM	160 / 80 and 120
	18:00 – 21:00	D4/S1/O1	OP	120
	21:00 – 24:00	D0/S0/O4	Free	
Saturday - Sunday	00:00 – 08:00	D0/S0/O4	Free	
	08:00 – 21:00	D4/S2/O1	WKND	120
	21:00 – 24:00	D0/S0/O4	Free	

It should be noted that the intersections of N Valdosta Rd at Country Club Dr, N Valdosta Rd at Inner Perimeter Rd, Inner Perimeter Rd at Country Club Rd, and Inner Perimeter Rd at Oak St Ext operate the PM plan until 18:30 to maintain coordination and delay plan transitioning due to high volumes and coordinated turning movements.

Table 4: Middle Zone TOD Schedule

Middle Zone				
Day	Time	Dial/Split/Offset	Description	Cycle Length (sec)
Monday – Thursday	00:00 – 06:00	D0/S0/O4	Free	
	06:00 – 09:00	D1/S1/O1	AM	140
	09:00 – 14:00	D2/S1/O1	MD	130
	14:00 – 18:30	D3/S1/O1	PM	150
	18:30 – 21:00	D4/S1/O1	OP	100
	21:00 – 24:00	D0/S0/O4	Free	
Friday	00:00 – 06:00	D0/S0/O4	Free	
	06:00 – 09:00	D1/S1/O1	AM	140
	09:00 – 11:00	D2/S1/O1	MD	130
	11:00 – 21:00	D3/S1/O1	PM	150
	21:00 – 24:00	D0/S0/O4	Free	
Saturday - Sunday	00:00 – 07:00	D0/S0/O4	Free	
	07:00 – 09:00	D4/S1/O1	OP	100
	09:00 – 20:00	D4/S2/O1	WKND	150
	20:00 – 21:00	D4/S1/O1	OP	100
	21:00 – 24:00	D0/S0/O4	Free	

Table 5: South Zone TOD Schedule

South Zone				
Day	Time	Dial/Split/Offset	Description	Cycle Length (sec)
Monday – Thursday	00:00 – 06:00	D0/S0/O4	Free	
	06:00 – 09:00	D1/S1/O1	AM	110
	09:00 – 14:00	D2/S1/O1	MD	110
	14:00 – 18:30	D3/S1/O1	PM	110
	18:30 – 21:00	D4/S1/O1	OP	100
	21:00 – 24:00	D0/S0/O4	Free	
Friday	00:00 – 06:00	D0/S0/O4	Free	
	06:00 – 09:00	D1/S1/O1	AM	110
	09:00 – 11:00	D2/S1/O1	MD	110
	11:00 – 21:00	D3/S1/O1	PM	110
	21:00 – 24:00	D0/S0/O4	Free	
Saturday - Sunday	00:00 – 07:00	D0/S0/O4	Free	
	07:00 – 09:00	D4/S1/O1	OP	100
	09:00 – 20:00	D4/S2/O1	WKND	110
	20:00 – 21:00	D4/S1/O1	OP	100
	21:00 – 24:00	D0/S0/O4	Free	

5.0 PROJECT IMPLEMENTATION AND BENEFITS

FIELD IMPLEMENTATION / FINE TUNING

Prior to implementing the newly developed timing plans, KH staff performed simulations for each timing plan utilizing *SimTraffic*. Progression and platooning of mainline traffic was checked as well as side street and mainline left turn lane split allocations. Time-space diagrams were generated using *Synchro* for each timing plan developed. These were instrumental during the field implementation process to give a graphical representation of the timing plans and traffic volumes.

Implementation of the new timing plans began with KH staff transferring the timing plan data from *Synchro* into the EPAC signal timing database. Each intersection's database was tested on test controllers in order to determine any errors for each timing plan prior to field implementation. Field implementation began with the KH staff downloading the new timing plans to the local controller from the City of Valdosta's Traffic Management Center via TACTICS or at the local controllers via laptop with the new EPAC databases. Once the data was downloaded and the system was operating with the new timing plans, KH staff extensively observed and fine-tuned the entire system during the AM, MD, PM, OP and WKND peak periods. All zones within the system were observed by KH staff from May 8 to May 14, 2017. The following items were performed during the fine-tuning efforts:

- Confirm cycle length
- Confirm offsets
- Monitor vehicle splits
- Observe progression and platooning of vehicles
- Check for unexpected queuing
- Drive the corridor during each peak period for multiple runs (at the beginning of the platoon, the middle of the platoon, and the trailing end of the platoon)

There were instances during fine tuning where offsets, splits, and TOD clock settings were adjusted in order to better accommodate the actual field conditions observed during the fine-tuning process. The databases and the *Synchro* files have been updated to reflect the fine-tuned timing plans.

After completion of the field implementation and fine tuning, KH developed the Holiday timing plans. The databases with the fine-tuned timing plans were updated to include the Holiday timing plans and have been submitted electronically to the City of Valdosta. The *Synchro* files can be found in **Appendix E**.

TRAVEL TIME STUDY

In order to effectively determine whether or not the development and implementation of the new coordinated timing plans was successful, a "before" and "after" travel time study was performed. This study provides data to determine the effectiveness of the new signal timing plans. It is important to note that the results from the travel time studies give "real – world" data and not the output from a model or simulation.

A travel time study was conducted for "before" and "after" conditions along the study corridors. For both conditions, at least five runs were completed for both directions in the AM, MD, and PM peak periods. These runs were conducted during weekdays from 06:00 – 09:00 for the AM peak, 10:30 – 13:30 for the MD peak, and 15:00 – 18:00 for the PM peak. The study network was evaluated the following four (4) corridors:

- N Valdosta Rd/N Ashley St/N Patterson St couplet from Country Club Dr to Woodrow Wilson Dr
- Inner Perimeter Rd from N Valdosta Rd at Country Club Dr to Forrest St
- St. Augustine Rd from I-75 SB to Norman Dr
- Baytree Rd from Gornto Rd to Jerry Jones Dr/Melody Ln

The travel time study was conducted using a GPS antenna connected to a laptop computer, which recorded data points once per second using Ridge Engineering, Inc.'s *GPS2LT* data collection software. The floating car method was utilized, by which the data collection vehicle travels with the flow of traffic along the corridor and the driver passes as many cars as pass the driver. The study vehicle was unmarked and operated as inconspicuously as possible. The "before" travel time runs were performed prior to implementation of the new timing plans, and the data was collected May 1 through May 5, 2017. The "after" travel time data was collected May 15 through May 19, 2017, after the new timing plans had been implemented and fine-tuned. Both the "before" and "after" travel time data was collected when Valdosta State University was not in session, due to the limitations of the project schedule, to minimize variables that may cause discrepancies in the travel time results. The data collected was compiled and analyzed using Ridge Engineering, Inc.'s *PC-Travel for Windows 2.3.0.* The summary reports generated from the analysis are provided in **Appendix F**.

Tables 6-9 show the summary results of the travel time study for the AM, MD, and PM peak periods for the N Valdosta Rd/N Ashley St/N Patterson St, Inner Perimeter Rd, St. Augustine Rd, and Baytree Rd corridors, respectively. The data includes the average travel time in seconds, the average number of stops, the average stopped time in seconds, and the average speed in miles-per-hour (mph). The percent change is also shown for each criteria mentioned.

Other benefits not considered in this analysis include lower driver frustration levels and a potential reduction of accidents. All of the improvements mentioned in the report are for sixteen (16) hours a day for each weekday during the AM, MD, and PM peak periods. New signal timing plans were also implemented during the Off-peak and weekend hours. However, because benefit/cost "before" and "after" studies were not conducted during these time periods, additional savings could not be quantified during these periods.

Table 6: Comparison of Optimized and Existing Network Operations – N Valdosta Rd/N Ashley St/N Patterson St

MOE	Existing Conditions	Optimized Conditions	Change (%)
AM Peak Hour			
Northbound			
Travel Time (sec)	249.5	269.7	8.1%
Number of Stops	1.5	2.0	33.3%
Average Travel Speed (mph)	30.1	27.9	-7.3%
Total Delay (sec)	61.7	83.3	35.0%
Southbound			
Average Travel Time (sec)	229.9	225.7	-1.8%
Number of Stops	1.4	1.3	-7.1%
Average Travel Speed (mph)	31.1	31.7	1.9%
Total Delay (sec)	55.6	50.2	-9.7%
MD Peak Hour			
Northbound			
Travel Time (sec)	284.7	234.0	-17.8%
Number of Stops	2.1	1.0	-52.4%
Average Travel Speed (mph)	26.4	32.1	21.6%
Total Delay (sec)	97.4	51.9	-46.7%
Southbound			
Average Travel Time (sec)	264.3	235.3	-11.0%
Number of Stops	1.8	1.7	-5.6%
Average Travel Speed (mph)	27.1	30.4	12.2%
Total Delay (sec)	84.3	62.5	-25.9%
PM Peak Hour			
Northbound			
Travel Time (sec)	343.8	271.3	-21.1%
Number of Stops	2.2	1.7	-22.7%
Average Travel Speed (mph)	21.9	27.7	26.5%
Total Delay (sec)	156.0	82.7	-47.0%
Southbound			
Travel Time (sec)	250.2	241.0	-3.7%
Number of Stops	1.3	1.3	0.0%
Average Travel Speed (mph)	28.6	29.7	3.8%
Total Delay (sec)	73.0	65.0	-11.0%

Nearly all time periods and directions for the N Valdosta Rd/N Ashley St/N Patterson St corridor experienced reductions in average travel time, number of stops, and travel time delay with corresponding increases in average speed. Specifically, during the PM peak hour, northbound direction, which is the primary direction of travel, experienced a twenty-one percent (21%) reduction in total travel time, a sixty-six percent (66%) reduction in total delay, and twenty-seven percent (27%) increase in average travel speed.

It should be noted that the travel time analysis does not capture queuing reduction at the beginning of corridors due to limitations of the travel time analysis. The observed queuing reduction along eastbound N Valdosta Rd at Country Club Dr was not captured in the travel time runs. Furthermore, the AM peak hour experienced little to no reduction in travel time due to the matching of the existing cycle lengths, as well as increased volume throughput from the N Valdosta Rd area.

Table 7: Comparison of Optimized and Existing Network Operations – Inner Perimeter Rd

MOE	Existing Conditions	Optimized Conditions	Change (%)
AM Peak Hour			
Eastbound			
Travel Time (sec)	301.9	282.0	-6.6%
Number of Stops	2.1	2.3	9.5%
Average Travel Speed (mph)	25.6	27.4	7.0%
Total Delay (sec)	132.3	107.8	-18.5%
Westbound			
Average Travel Time (sec)	308.7	311.3	0.8%
Number of Stops	1.8	2.2	22.2%
Average Travel Speed (mph)	25.2	25.0	-0.8%
Total Delay (sec)	135.0	136.8	1.3%
MD Peak Hour			
Eastbound			
Travel Time (sec)	328.3	297.1	-9.5%
Number of Stops	2.6	2.0	-23.1%
Average Travel Speed (mph)	23.6	26.0	10.2%
Total Delay (sec)	154.6	130.0	-15.9%
Westbound			
Average Travel Time (sec)	321.3	288.5	-10.2%
Number of Stops	2.8	2.7	-3.6%
Average Travel Speed (mph)	24.2	27.0	10.7%
Total Delay (sec)	147.5	114.3	-22.5%
PM Peak Hour			
Eastbound			
Travel Time (sec)	367.2	351.3	-4.3%
Number of Stops	2.8	2.0	-28.6%
Average Travel Speed (mph)	21.1	22.0	4.3%
Total Delay (sec)	193.2	177.1	-8.3%
Westbound			
Travel Time (sec)	355.8	266.8	-25.0%
Number of Stops	3.2	1.2	-62.5%
Average Travel Speed (mph)	21.9	29.1	32.9%
Total Delay (sec)	181.8	91.8	-49.5%

Nearly all time periods and directions for the Inner Perimeter Rd corridor experienced reductions in average travel time, number of stops, and travel time delay with corresponding increases in average speed. Specifically, during the PM peak hour, westbound direction, which is the primary direction of travel, experienced a twenty-five percent (25%) reduction in total travel time, a fifty percent (50%) reduction in total delay, and thirty-three percent (33%) increase in average travel speed.

Table 8: Comparison of Optimized and Existing Network Operations – St. Augustine Rd

MOE	Existing Conditions	Optimized Conditions	Change (%)
AM Peak Hour			
Eastbound			
Travel Time (sec)	112.4	88.1	-21.6%
Number of Stops	0.6	0.4	-33.3%
Average Travel Speed (mph)	25.2	32.1	27.4%
Total Delay (sec)	34.1	12.9	-62.2%
Westbound			
Average Travel Time (sec)	83.6	83.6	0.0%
Number of Stops	0.6	0.5	-16.7%
Average Travel Speed (mph)	33.1	33.1	0.0%
Total Delay (sec)	10.2	11.3	10.8%
MD Peak Hour			
Eastbound			
Travel Time (sec)	129.6	92.7	-28.5%
Number of Stops	1.1	0.3	-72.7%
Average Travel Speed (mph)	21.8	30.5	39.9%
Total Delay (sec)	49.7	13.3	-73.2%
Westbound			
Average Travel Time (sec)	110.0	83.0	-24.5%
Number of Stops	0.7	0.0	-100.0%
Average Travel Speed (mph)	25.2	33.3	32.1%
Total Delay (sec)	32.7	5.4	-83.5%
PM Peak Hour			
Eastbound			
Travel Time (sec)	100.5	101.3	0.8%
Number of Stops	0.8	0.5	-37.5%
Average Travel Speed (mph)	28.1	27.9	-0.7%
Total Delay (sec)	21.7	21.0	-3.2%
Westbound			
Travel Time (sec)	154.9	83.4	-46.2%
Number of Stops	1.7	0.0	-100.0%
Average Travel Speed (mph)	17.9	33.2	85.5%
Total Delay (sec)	75.0	6.4	-91.5%

Nearly all time periods and directions for the St. Augustine Rd corridor experienced significant reductions in average travel time, number of stops, and travel time delay with corresponding increases in average speed. Specifically, during the PM peak hour, westbound direction, which is the primary direction of travel, experienced a forty-six percent (46%) reduction in total travel time, a ninety-two percent (92%) reduction in total delay, and eighty-six percent (86%) increase in average travel speed.

Table 9: Comparison of Optimized and Existing Network Operations – Baytree Rd

MOE	Existing Conditions	Optimized Conditions	Change (%)
AM Peak Hour			
Eastbound			
Travel Time (sec)	135.9	150.3	10.6%
Number of Stops	0.3	1.0	233.3%
Average Travel Speed (mph)	31.7	28.7	-9.5%
Total Delay (sec)	16.0	25.4	58.8%
Westbound			
Average Travel Time (sec)	210.3	226.5	7.7%
Number of Stops	2.3	1.0	-56.5%
Average Travel Speed (mph)	20.5	19.1	-6.8%
Total Delay (sec)	87.7	101.7	16.0%
MD Peak Hour			
Eastbound			
Travel Time (sec)	188.0	145.1	-22.8%
Number of Stops	1.7	0.4	-76.5%
Average Travel Speed (mph)	22.9	29.7	29.7%
Total Delay (sec)	63.7	20.4	-68.0%
Westbound			
Average Travel Time (sec)	212.3	180.2	-15.1%
Number of Stops	1.8	1.5	-16.7%
Average Travel Speed (mph)	20.3	24.0	18.2%
Total Delay (sec)	89.2	55.3	-38.0%
PM Peak Hour			
Eastbound			
Travel Time (sec)	234.9	150.8	-35.8%
Number of Stops	2.6	0.3	-88.5%
Average Travel Speed (mph)	18.3	28.6	56.3%
Total Delay (sec)	110.4	25.9	-76.5%
Westbound			
Travel Time (sec)	248.6	246.7	-0.8%
Number of Stops	2.0	1.5	-25.0%
Average Travel Speed (mph)	17.4	17.5	0.6%
Total Delay (sec)	125.7	121.7	-3.2%

Nearly all time periods and directions for the Baytree Rd corridor experienced reductions in average travel time, number of stops, and travel time delay with corresponding increases in average speed. Specifically, during the PM peak hour, eastbound direction, which is nearly the primary direction of travel, experienced a thirty-six percent (36%) reduction in total travel time, a seventy-seven percent (77%) reduction in total delay, and fifty-six percent (56%) increase in average travel speed.

The AM peak hour travel time analysis shows an increase in travel time and total delay along Baytree Rd in both the eastbound and westbound directions. Baytree Rd is a primary route for students attending Valdosta State University. Since travel time data was collected when the University was not in session, the volumes along Baytree Rd were lower during the AM Peak, which could cause the split phase intersections to provide the unused time to only one direction of travel along Baytree Rd instead of to both directions, resulting in additional stops and delays along the corridor. Removal of split phase operations should help progression and reduce travel time and total delay along Baytree Rd ad discussed in **Section 6.0 Operational Analysis**.

ECONOMIC EVALUATION

Many economic benefits are realized by developing and implementing optimized signal timing plans along a corridor. The principal benefit is a reduction in road user costs as a result of reduced travel time (delay) and fuel consumption. Additional benefits of improved signal timing plans may include a reduction in accidents and vehicle emissions due to improved progression along the corridor. These benefits are primarily achieved by adjusting offsets to reduce the total number of stops, and by making changes to left-turn phasing when appropriate.

It should be noted that the economic benefits of reduced accidents and emissions are difficult to quantify, and are therefore not included in this evaluation. Likewise, it is important to note that delay and fuel consumption reductions are measured only for the arterial, mainline movements along the corridor. Any delay reductions that are realized for the remainder of the system, including side-street and left-turn phases are not included in this analysis. These limitations result in a conservative benefit-to-cost (B/C) analysis.

The following economic evaluation utilizes travel time data from *PC-Travel* to quantify the benefits of the improved signal timing plans in terms of an annual dollar value. Certain assumptions were made to calculate the B/C ratio. To determine the cost savings of the reduction in travel time, a dollar value was assigned to the delay. For purposes of this study, the cost of delay was assumed to be $13.75 per hour, which represents the time value of the motoring public. This value falls within the acceptable range of USDOT road user cost[1]. The timing plans were assumed to be in operation for 250 days per year, which represents the average number of workdays in a given year. Finally, average vehicle occupancy was assumed to be 1.1. This information was used in conjunction with the following formula to determine an annual savings associated with the improved signal timing plans:

$$S = R \times V \times D \times O \times C$$

Where: S = Dollars Saved ($)
R = Reduction in Travel Time (Hours)
V = Volume of Traffic (Veh/Hour)
D = Number of Days Timing Plans are in Effect (Days/Year)
O = Average Vehicle Occupancy (Persons/Veh)
C = Cost of Delay Per Person ($/Person)

[1] The Value of Travel Time Savings; Revision 2. USDOT, September 2011.

The reduction in travel time is a direct output of the travel time study, and hourly volume is the rate of vehicles per hour.

A second component of the economic benefit is reduced fuel consumption. An analysis was completed to estimate the changes in fuel consumption resulting from the implementation of the new timing plans. Fuel consumption was summed across all links to arrive at the total fuel consumption for each peak period before and after implementation. In order to provide a conservative analysis, fuel was assumed to cost $2.25 per gallon.

The annual travel time and fuel reduction benefits were calculated for each peak period in each direction. The AM peak is analyzed from 06:00 – 09:00, the MD (Off) Peak is analyzed from 09:00 – 14:00 and 19:00 – 22:00, and the PM peak is analyzed from 14:00 – 19:00. Traffic volumes for each hourly time period at a sampling of major and minor intersections across the corridor are utilized in the analysis to develop an average for the corridor. Annual reductions by time of day are summarized in **Table 10-13** for the N Valdosta Rd/N Ashley St/N Patterson St, Inner Perimeter Rd, St. Augustine Rd, and Baytree Rd corridors, respectively.

Table 10: Annual Savings Based on Travel Time and Fuel Consumption – N Valdosta Rd/N Ashley St/N Patterson St

N Valdosta Rd/N Ashley St/N Patterson St - Annual Reductions					
Time Period	Travel Time		Fuel Consumption		Total
	Veh-Hrs	Value	Gallons	Value	
Northbound					
AM Period	-1,920	-$29,047	-1,408	-$3,169	-$32,216
MD Period	26,849	$406,089	16,550	$37,238	$443,327
PM Period	25,925	$392,111	16,007	$36,016	$428,126
Southbound					
AM Period	407	$6,155	3,126	$7,033	$13,189
MD Period	21,261	$321,572	9,873	$22,214	$343,786
PM Period	-618	-$9,348	1,201	$2,703	-$6,644
Annual					
All TOD	71,903	$1,087,533	45,349	$102,034	$1,189,567

Table 11: Annual Savings Based on Travel Time and Fuel Consumption – Inner Perimeter Rd

Inner Perimeter Rd - Annual Reductions					
Time Period	Travel Time		Fuel Consumption		Total
	Veh-Hrs	Value	Gallons	Value	
Eastbound					
AM Period	3,314	$50,117	3,431	$7,721	$57,838
MD Period	-2,362	-$35,731	8,578	$19,301	-$16,430
PM Period	13,570	$205,249	17,360	$39,061	$244,310
Westbound					
AM Period	-641	-$9,702	2,493	$5,610	-$4,092
MD Period	8,614	$130,295	17,454	$39,272	$169,567
PM Period	15,069	$227,924	16,863	$37,942	$265,867
Annual					
All TOD	37,564	$568,152	66,181	$148,907	$717,059

Table 12: Annual Savings Based on Travel Time and Fuel Consumption – St. Augustine Rd

St. Augustine Rd - Annual Reductions					
Time Period	Travel Time		Fuel Consumption		Total
	Veh-Hrs	Value	Gallons	Value	
Eastbound					
AM Period	3,592	$54,332	2,012	$4,526	$58,858
MD Period	16,253	$245,823	13,153	$29,594	$275,417
PM Period	-407	-$6,151	713	$1,603	-$4,547
Westbound					
AM Period	34	$519	1,007	$2,266	$2,785
MD Period	11,830	$178,933	13,031	$29,319	$208,253
PM Period	20,446	$309,242	17,853	$40,169	$349,410
Annual					
All TOD	51,749	$782,698	47,768	$107,478	$890,176

Table 13: Annual Savings Based on Travel Time and Fuel Consumption – Baytree Rd

Baytree Rd - Annual Reductions					
Time Period	Travel Time		Fuel Consumption		Total
	Veh-Hrs	Value	Gallons	Value	
Eastbound					
AM Period	-801	-$12,117	-580	-$1,306	-$13,423
MD Period	11,417	$172,687	12,476	$28,702	$200,759
PM Period	16,082	$243,235	15,667	$35,250	$278,485
Westbound					
AM Period	-84	-$1,263	1,581	$3,558	$2,294
MD Period	5,239	$79,242	6,671	$15,009	$94,251
PM Period	-422	-$6,380	1,464	$3,294	$3,086
Annual					
All TOD	31,432	$475,404	37,278	$83,877	$559,281

As shown, the total benefit for each corridor is the sum of the annual travel time and fuel reduction benefits. However, the new signal timing plans will be used for longer than one year. The end of the useful life of signal timing plans is reached when increases in development, roadway construction, and traffic demand are such that traffic flow is no longer efficiently accommodated by the plans. Typically, the useful life for signal timing plans is said to be about three (3) years. For purposes of this benefit/cost analysis, total project savings and B/C ratio are presented for both 1-Year and 3-Year time periods in **Table 14**.

Table 14: Benefit/Cost Summary

Corridor	Project Cost	1-Year Savings	1-Year B/C Ratio	3- Year Savings	3-Year B/C Ratio
N Valdosta Rd/N Ashley St/N Patterson St	$35,870	$1,189,567	33.16	$3,568,701	99.49
Inner Perimeter Rd	$23,110	$717,059	28.53	$2,151,177	85.67
St. Augustine Rd	$17,935	$890,176	49.63	$2,670,529	148.90
Baytree Rd	$17,935	$559,281	31.18	$1,677,842	93.55
Total	$96,848	$3,356,082	34.65	$10,068,247	103.96

The cost of each corridor was developed by determining the cost per intersection from the total signal timing project cost and multiplying it by the number of project intersections within the travel time corridor. The total project cost of these four (4) corridors includes approximately two-thirds (2/3) of the total signal timing project. Therefore, the additional benefits at the remaining one-third (1/3) project intersections is not captured in the analysis.

As shown, the improved timing plans for the N Valdosta Rd/N Ashley St/N Patterson St corridor have a yearly benefit/cost ratio of **33 to 1**, for the Inner Perimeter Rd corridor have a yearly benefit/cost ratio of **29 to 1**, for the St. Augustine Rd corridor have a yearly benefit/cost ratio of **50 to 1**, and for the Baytree Rd corridor have a yearly benefit/cost ratio of **31 to 1**. The improved timing plans for the project have a benefit/cost ratio of **35 to 1**. Expressed in another way, the timings pay for themselves every **7.2 days**.

Benefits in reduced vehicle emissions due to reduced delay and stopped vehicle idling are also realized with this project. Carbon monoxide (CO), hydrocarbon (HC) compounds, and oxides of nitrogen (NOx) are three (3) types of vehicle emissions that are regulated by Federal law. The vehicle emissions study was derived from the *PC-Travel for Windows 2.3.0* emissions model, which is based off the MICRO2 emissions model developed by the Colorado Department of Highways. **Table 15** shows the reduction in emissions for each corridor and the total project which resulted from this project. As discussed previously, these reductions were only calculated during the travel time periods along the travel time study corridors; additional emissions reductions are not quantified for the other periods of the day, along the side streets, and along the remaining project locations.

Table 15: Emissions Reduction Summary

MOE	Existing (lbs/day)	Optimized (lbs/day)	Change (%)	Yearly Reduction (tons/year)
N Valdosta Rd/N Ashley St/N Patterson St				
CO	6330.7	6070.9	-4.1%	29.5
HC	585.7	532.5	-9.1%	6.0
NOx	343.3	323.3	-5.8%	2.3
Inner Perimeter Rd				
CO	6936.8	6075.5	-12.4%	97.7
HC	643.5	576.3	-10.4%	7.6
NOx	370.9	327.0	-11.9%	5.0
St. Augustine Rd				
CO	2295.3	1920.5	-16.3%	42.5
HC	232.7	182.1	-21.8%	5.7
NOx	135.9	109.7	-19.2%	3.0
Baytree Rd				
CO	2241.0	1927.8	-14.0%	35.5
HC	238.7	205.4	-14.0%	3.8
NOx	125.4	108.7	-13.3%	1.9
Total				
CO	17,803.8	15,994.8	-10.2%	205.2
HC	1700.7	1496.3	-12.0%	23.2
NOx	975.5	868.7	-10.9%	12.1

The results of this project produce a reduction of 205 tons/year (10 percent) in CO emissions, a reduction of twenty-three (23) tons/year (12 percent) in HC emissions, and a reduction of twelve (12) tons/year (11 percent) in NOx emissions. As discussed previously, these reductions were only calculated during the travel time periods along the travel time study corridors; additional emissions reductions are not quantified for the other periods of the day, along the side streets, and along the remaining project locations.

Appendix G includes the summary spreadsheet for the travel time, benefit-to-cost, and emissions analysis, for each corridor.

6.0 OPERATIONAL ANALYSIS

An operational analysis was performed for each of the study intersections by studying the data collected. By observing the traffic flow patterns and the existing LOS and delay for each intersection and movement, an analysis was made to determine any modifications to the intersection that would enhance its operation. Also, any deficiencies in regard to the *Manual on Uniform Traffic Control Devices, 2011 Editions* (MUTCD) or Georgia Department of Transportation (GDOT) standards were noted and improvements were recommended. Operational issues that were addressed included possible geometric modifications, phasing modifications, and pavement marking/lane utilization changes.

One global recommendation is to ensure pedestrian infrastructure provided is consistent and sufficient. If an intersection has crosswalk striping, then pedestrian signal heads and push buttons should be present, as well as vice versa. This can be remedied by either removing the crosswalk striping if there are no pedestrian signal heads and push buttons, or installing pedestrian signal heads and push buttons. The intersections are not identified in the operational analysis summary by intersection table later in this section.

Another global recommendation is the replacement of all five-section doghouse protected-permissive left turn signal heads to four-section Flashing Yellow Arrow (FYA) signal heads. FYA signal heads provide additional benefit of allowing lead/lag left turn phasing to improve progression along the corridor, as wells as double-serve left turn phasing to reduce left turn queuing. If the approach opposing a four-section FYA is permissive-only, a three-section FYA signal head should be installed to optimize the signal timing flexibility and benefits of FYA. If opposing permissive-only left turn approach does not have a three-section FYA signal the protected left turn phase is unable to provide lead/lag phasing flexibility. These intersections are identified in the operational analysis summary by intersection table later in this section.

An additional recommendation that is discussed throughout the operational analysis is the removal of split phasing operation. The term split-phase signal operation describes a signal phasing sequence where one approach is given exclusive right-of-way into the intersection followed by the opposing approach being provided exclusive right-of-way into the intersection. This operation eliminates left turn conflicts; however, it can produce inefficient signal phasing since the entire intersection is given a red indication to service only one of the four signalized approaches. Split phasing also greatly reduces the ability to maximize the end-to-end progression along a coordinated signal system, as the green band is constrained by the time required to serve the side street split phasing. Nonetheless, there are situations where its use should be considered.

Situations where split phasing should be considered:

- Where offset approaches exist that may cause motorists conflicts/confusion if permissive phasing were implemented.
- Where intersection width prevents opposing left turn movements from operating concurrently. Prior to implementing split-phase operation due to this geometric limitation, the installation of lead/lag left turn phasing should be considered.
- When a crash problem exists between left turn and through movement conflicts that has not been successfully remedied via other operational improvements.
- Where a sizeable volume imbalance exists on the side street approaches, the need to serve the left turn volume is relatively close to the time needed to serve the through movement volume, and permissive-protected and lead/lag left turn phasing has been implemented and the signal is operating with excessive un-needed delay.
- Where a second left turn lane is needed, but must be shared with the through movement lane due to geometry and right-of-way restriction. Prior to implementing split-phase operation due to this geometric limitation, the installation of lead/lag and double-serve left turn phasing should be considered.

It should be noted that the recommendations in this document to remove split phasing were completed using field observations, the traffic counts, and aerial photography. A more detailed traffic study should be conducted at each intersection prior to the removal of split phasing to verify geometric constraints and to perform a capacity analysis comparing the split-phase timing operations versus other signal phasing options.

Table 16 itemizes each intersection and details recommended improvements including associated LOS reductions for critical peak periods. Hand sketches, for visual purposes only, are provided in **Appendix H** to illustrate some of the more complex recommendations.

Table 16: Operational Analysis Summary by Intersection

#	Intersection	Proposed Operational Improvements	Peak Period	
			Existing LOS (Avg. Delay)	Build LOS (Avg. Delay)
1	St. Augustine Rd @ I-75 SB Ramp	None		
2	St. Augustine Rd @ I-75 NB Ramp	None		
3	St. Augustine Rd @ Twin St	None		
4	St. Augustine Rd @ Gornto Rd (see sketch in Appendix H)	• Remove split phase operation for northbound and southbound approaches • Restripe southbound approach to one exclusive left turn lane, one exclusive through lane, and one exclusive right turn lane • Restripe northbound approach to one exclusive left turn lane and one shared through/right turn lane per GDOT guidelines • Install westbound exclusive right turn lane • Install protected/permissive left turn phasing for southbound approach, permissive-only left turn phasing for northbound approach, and right turn overlap phasing for southbound right turn and westbound right turn approaches • Install 4-section flashing yellow arrow for eastbound, westbound, and southbound approaches • Install 3-section flashing yellow arrow for northbound approach	PM Peak D (41.4)	C (21.9)
5	St. Augustine Rd @ Norman Dr (see sketch in Appendix H)	• Install eastbound exclusive right turn lane • Install right turn overlap phasing for eastbound right turn approach • Install 4-section flashing yellow arrow for eastbound, westbound, northbound, and southbound approaches *Long-Term: Install dual northbound left turn lanes with protected-only left turning phasing*	AM Peak D (39.0)	C (32.5)
6	Norman Dr @ Mall Ent (see sketch in Appendix H)	• Remove split phase operation from eastbound and westbound approaches • Restripe eastbound approach to one exclusive left turn lane and one shared through/right turn lane per GDOT guidelines • Install permissive-only left turn phasing on eastbound and westbound approaches • Install 4-section flashing yellow arrow for northbound and southbound approaches	PM Peak C (32.5)	B (12.8)

#	Intersection	Proposed Operational Improvements	Peak Period	
			Existing LOS (Avg. Delay)	Build LOS (Avg. Delay)
7	Baytree Rd @ Gornto Rd (see sketch in Appendix H)	• Remove split phase operation from eastbound and westbound approaches • Restripe westbound approach to one exclusive left turn lane, one exclusive through lane, and one exclusive right turn lane • Install protected/permissive left turn phasing for westbound approach and permissive-only left turn phasing for eastbound approach • Install 4-section flashing yellow arrow for southbound and westbound approaches • Install 3-section flashing yellow arrow for northbound and eastbound approaches • Install right turn overlap phasing for northbound right turn and westbound right turn	PM Peak E (57.7)	C (32.7)
8	Baytree Rd @ Norman Dr (see sketch in Appendix H)	• Remove split phase operation from eastbound, westbound, northbound, and southbound approaches • Restripe westbound approach to include one exclusive left turn lane, one exclusive through lane, and one shared through/right turn lane • Restripe northbound approach to include one exclusive left turn lane, one exclusive through lane, and one exclusive right turn lane • Install protected/permissive left turn phasing on eastbound, westbound, and northbound approaches, and permissive-only left turn phasing on southbound approach • Install 4-section flashing yellow arrow eastbound, westbound, and northbound approaches • Install 3-section flashing yellow arrow for southbound approach • Consider double-serve left turn phasing operation for westbound left turn movement	AM Peak D (42.4)	C (24.2)
9	Baytree Rd @ Sherwood Dr	• Remove split phase operation from northbound and southbound approaches • Install permissive-only left turn phasing on northbound and southbound approaches • Install 4-section flashing yellow arrow on eastbound and westbound approaches	PM Peak C (22.4)	B (17.8)
10	Baytree Rd @ Gordon St	• Install 4-section flashing yellow arrow on northbound and eastbound approaches • Install 3-section flashing yellow arrow on southbound and westbound approaches	PM Peak C (25.9)	B (18.8)
11	Hill Ave @ I-75 SB Ramp	• Remove split phase operation on northbound and southbound approaches • Install permissive-only left turn phasing for northbound and southbound approaches	AM Peak D (46.2)	C (34.4)
12	Hill Ave @ I-75 NB Ramp	• Remove split phase operation on northbound and southbound approaches • Install permissive-only left turn phasing for northbound and southbound approaches	AM Peak D (41.7)	C (23.6)

#	Intersection	Proposed Operational Improvements	Peak Period Existing LOS (Avg. Delay)	Peak Period Build LOS (Avg. Delay)
13	N Valdosta Rd @ Country Club Dr (see sketch in Appendix H)	• Remove split phase operation on northbound and southbound approaches • Restripe northbound approach to one exclusive left turn lane, one exclusive through lane, and one exclusive right turn lane • Install protected/permissive left turn phasing on northbound and southbound approaches • Install 4-section flashing yellow arrow for eastbound, westbound, northbound, and southbound approaches • Consider double-serve left turn phasing operation for westbound left turn movement *Long-Term: Install dual westbound left turn lanes with protected-only left turn phasing and second southbound departure lane (maintaining above northbound approach geometry)*	PM Peak E (61.2)	PM Peak D (53.3)
14	N Valdosta Rd @ Inner Perimeter Rd	• Replace eastbound and westbound protected only left turn red ball signal heads with new signal heads with red arrow per MUTCD requirements		
15	N Ashley St @ Connell Rd	None		
16	Inner Perimeter Rd @ Country Club Rd	None		
17	Inner Perimeter Rd @ Oak St Ext	• Install 4-section flashing yellow arrow for northbound, southbound, eastbound, and westbound approaches • Install right turn overlap phasing for southbound right turn *Long-Term: Consider installing dual eastbound left turn lanes with protected-only left turn phasing and additional northbound receiving lane* *Long-Term: Consider widening of Oak St Ext to 5-lanes as growth continues in area*	PM Peak D (44.8)	PM Peak D (38.2)
18	Inner Perimeter Rd @ Brookfield Rd/Lake Laurie Dr	None		
19	Inner Perimeter Rd @ Bemiss Rd	• Install 4-section flashing yellow arrow for northbound and southbound approaches	PM Peak D (52.1)	PM Peak D (42.1)
20	Oak St Ext @ Murray Rd (see sketch in Appendix H)	• Install exclusive northbound right turn lane • Install 4-section flashing yellow arrow for southbound approach *Long-Term: Consider widening of Oak St Ext to 5-lanes as growth continues in area*	PM Peak C (24.5)	PM Peak B (18.2)
21	Oak St Ext @ Cherry Creek Rd	*Long-Term: Oak St Ext widening* *At the Oak St Ext split just south of intersection, one exclusive northbound lane will continue northbound along Cherry Creek Rd and one exclusive northbound lane will veer right going northeastbound along Oak St Ext*		

#	Intersection	Proposed Operational Improvements	Peak Period	
			Existing LOS (Avg. Delay)	Build LOS (Avg. Delay)
22	Inner Perimeter Rd @ Forrest St (see sketch in Appendix H)	• Remove split phase operation on northbound and southbound approaches • Install exclusive left turn lanes for northbound and southbound approaches • Install permissive-only phasing for northbound and southbound approaches • Install 4-section flashing yellow arrow for eastbound and westbound approaches	AM Peak E (64.6)	C (24.0)
23	Northside Dr @ Bemiss Rd	• Install 4-section flashing yellow arrow for northbound, southbound, eastbound, and westbound approaches	AM Peak C (27.8)	B (18.6)
24	Northside Dr/Eager Rd @ Oak St Ext	• Install 4-section flashing yellow arrow for northbound, southbound, eastbound, and westbound approaches	AM Peak C (29.0)	C (23.7)
25	Eager Rd @ Berkley Dr	None		
26	Eager Rd/Jerry Jones Dr @ Country Club Dr	• Remove split phase operation on northbound and southbound approaches • Install permissive-only phasing for northbound and southbound approaches • Install 4-section flashing yellow arrow for eastbound and westbound approaches • Install right turn overlap phasing for southbound right turn • Remove channelized right turn pavement markings and yield sign for southbound right turn	AM Peak D (42.0)	C (23.0)
27	Jerry Jones Dr @ Gornto Rd	• Install 4-section flashing yellow arrow for northbound, southbound, eastbound, and westbound approaches • Install right turn overlap phasing for southbound right turn	PM Peak E (60.6)	D (50.9)
28	Jerry Jones Dr @ Alden Ave	• Install 4-section flashing yellow arrow for westbound approach • Install 3-section flashing yellow arrow for eastbound approach	N/A	N/A
29	Baytree Rd @ Jerry Jones Dr/Melody Ln	• Install 4-section flashing yellow arrow for northbound, southbound, eastbound, and westbound approaches • Install right turn overlap phasing for southbound right turn	N/A	N/A
30	Woodrow Wilson Dr @ Bemiss Rd	None		
31	Woodrow Wilson Dr @ N Ashley St	• Install 3-section flashing yellow arrow for southbound approach	AM Peak C (21.1)	B (19.9)
32	Woodrow Wilson Dr/Gornto Rd @ N Patterson St	• Install 3-section flashing yellow arrow for eastbound approach	PM Peak C (21.8)	B (17.6)

#	Intersection	Proposed Operational Improvements	Peak Period	
			Existing LOS (Avg. Delay)	Build LOS (Avg. Delay)
33	Gornto Rd @ N Oak St	• Install 4-section flashing yellow arrow for northbound, southbound, eastbound, and westbound approaches	AM Peak	
			D (35.7)	C (30.5)
34	N Valdosta Rd @ Oak St Ext (see sketch in Appendix H)	• Install exclusive northbound right turn lane with storage extending to intersection of N Ashley St at Smithbriar Dr *Long-Term: Consider widening of Oak St Ext to 5-lanes as growth continues in area and converting the northbound right turn lane to a free-flow added lane for northbound Oak St Ext*	PM Peak	
			E (69.3)	D (38.7)
35	N Ashley St @ Smithbriar Dr (see sketch in Appendix H)	• Install one new northbound departure lane to create a total of three northbound departure lanes • Restripe northbound exclusive right turn lane to a shared through/right turn lane	PM Peak	
			F (267.7)	F (156.0)
36	N Ashley St @ Northside Dr	• Install 3-section flashing yellow arrow for westbound approach	PM Peak	
			E (55.9)	D (54.3)
37	N Patterson St @ Smithbriar Dr	None		
38	N Patterson St @ Northside Dr	• Install 3-section flashing yellow arrow for northbound and eastbound approaches	AM Peak	
			D (48.8)	B (18.7)
39	Alden Ave @ Azalea Dr	• Install exclusive left turn lanes for eastbound and westbound approaches • Install permissive-only left turn phasing for eastbound and westbound approaches	N/A	N/A
40	Alden Ave @ N Oak St	• Remove protected/permissive left turn phasing for northbound approach	PM Peak	
			C (21.8)	B (17.0)
41	Alden Ave @ N Patterson St	None		
42	Norman Dr @ Lowndes H.S.	• Consider half cycling throughout the day	N/A	N/A
43	Norman Dr @ Valhalla Dr	• Consider half cycling throughout the day • Consider omitting northbound left turn phase during posted restricted left turn hours • Install 4-section flashing yellow arrow for northbound approach	PM Peak	
			D (21.8)	B (17.0)
44	Hill Ave @ Norman Dr	• Install 4-section flashing yellow arrow for eastbound approach • Install right turn overlap phasing for southbound right turn	PM Peak	
			C (29.3)	C (21.4)

Table 17 shows the comparison of LOS and average intersection delay between the existing conditions and the fine-tuned timings with the addition of the recommended operational improvements for the study network.

Table 17: Existing vs. Fine-Tuned with Improvements Conditions LOS, Average Delay (sec/veh)

#	Intersection	Existing Condition			Fine-Tuned with Improvements Condition		
		AM Peak	MD Peak	PM Peak	AM Peak	MD Peak	PM Peak
1	St. Augustine Rd @ I-75 SB Ramp	C (30.3)	C (23.7)	C (24.5)	C (26.2)	B (18.8)	C (20.9)
2	St. Augustine Rd @ I-75 NB Ramp	C (26.4)	B (16.1)	B (17.0)	C (21.0)	B (10.5)	B (12.4)
3	St. Augustine Rd @ Twin St	A (6.9)	A (9.3)	B (13.1)	A (5.6)	A (8.6)	A (8.6)
4	St. Augustine Rd @ Gornto Rd	C (26.5)	C (33.9)	D (41.4)	C (21.8)	C (33.3)	C (21.9)
5	St. Augustine Rd @ Norman Dr	D (39.0)	D (41.3)	D (52.3)	C (32.5)	D (38.6)	D (45.2)
6	Norman Dr @ Mall Ent	B (12.4)	C (34.8)	C (32.5)	A (5.7)	C (22.3)	B (12.8)
7	Baytree Rd @ Gornto Rd	C (26.5)	C (31.4)	E (57.7)	C (26.3)	C (31.5)	C (32.7)
8	Baytree Rd @ Norman Dr	D (42.4)	D (35.8)	C (32.2)	C (24.2)	C (24.6)	C (32.5)
9	Baytree Rd @ Sherwood Dr	B (14.0)	B (16.9)	C (22.4)	B (11.8)	B (14.4)	B (17.8)
10	Baytree Rd @ Gordon St	D (40.2)	C (34.4)	C (25.9)	D (39.9)	C (31.1)	B (18.8)
11	Hill Ave @ I-75 SB Ramp	D (46.2)	C (22.7)	C (33.0)	C (34.4)	B (17.8)	C (26.6)
12	Hill Ave @ I-75 NB Ramp	D (41.7)	C (31.6)	C (29.5)	C (23.6)	C (23.3)	B (17.2)
13	N Valdosta Rd @ Country Club Dr	D (49.7)	D (46.1)	E (61.2)	D (44.5)	C (34.3)	D (53.3)
14	N Valdosta Rd @ Inner Perimeter Rd	C (22.9)	C (26.0)	C (25.7)	C (22.9)	C (25.0)	C (29.2)
15	N Ashley St @ Connell Rd	B (14.9)	B (20.0)	B (15.9)	B (16.1)	B (19.6)	B (17.2)
16	Inner Perimeter Rd @ Country Club Rd	B (15.7)	B (11.5)	B (19.6)	B (10.7)	B (12.7)	B (18.5)
17	Inner Perimeter Rd @ Oak St Ext	D (43.6)	D (35.5)	D (44.8)	D (39.3)	C (34.8)	D (38.2)
18	Inner Perimeter Rd @ Brookfield Rd/Lake Laurie Dr	C (21.5)	C (28.0)	D (40.1)	C (20.7)	C (20.1)	C (33.7)
19	Inner Perimeter Rd @ Bemiss Rd	D (53.5)	D (37.5)	D (52.1)	D (44.7)	D (43.0)	D (42.1)

#	Intersection	Existing Condition			Fine-Tuned with Improvements Condition		
		AM Peak	MD Peak	PM Peak	AM Peak	MD Peak	PM Peak
20	Oak St Ext @ Murray Rd	B (11.4)	B (17.8)	C (24.5)	B (13.7)	B (17.5)	B (18.2)
21	Oak St Ext @ Cherry Creek Rd	C (20.9)	B (15.1)	B (14.8)	C (22.9)	B (19.5)	B (18.8)
22	Inner Perimeter Rd @ Forrest St	E (64.6)	D (39.2)	D (53.1)	C (24.0)	C (34.1)	C (29.9)
23	Northside Dr @ Bemiss Rd	C (27.8)	C (26.3)	D (45.9)	B (18.6)	C (25.4)	D (42.4)
24	Northside Dr/Eager Rd @ Oak St Ext	C (29.0)	C (24.7)	D (38.5)	C (23.7)	C (33.1)	D (37.6)
25	Eager Rd @ Berkley Dr	B (10.5)	A (6.6)	A (9.0)	B (16.7)	A (5.6)	A (9.0)
26	Eager Rd/Jerry Jones Dr @ Country Club Dr	D (42.0)	C (34.2)	D (48.7)	C (23.0)	B (15.3)	D (37.2)
27	Jerry Jones Dr @ Gornto Rd	C (33.1)	D (38.4)	E (60.6)	C (31.9)	C (26.9)	D (50.9)
28	Jerry Jones Dr @ Alden Ave	B (16.8)	B (18.4)	C (22.5)	B (18.1)	B (19.4)	C (24.5)
29	Baytree Rd @ Jerry Jones Dr/Melody Ln	C (25.3)	C (25.8)	C (34.2)	C (29.8)	C (31.7)	C (34.3)
30	Woodrow Wilson Dr @ Bemiss Rd	A (9.0)	A (7.9)	A (9.3)	B (14.9)	A (6.8)	A (8.0)
31	Woodrow Wilson Dr @ N Ashley St	C (21.1)	C (25.0)	C (24.3)	B (19.9)	C (23.3)	C (21.2)
32	Woodrow Wilson Dr/Gornto Rd @ N Patterson St	B (13.9)	C (22.9)	C (21.8)	B (19.1)	B (16.1)	B (17.6)
33	Gornto Rd @ N Oak St	D (35.7)	C (33.7)	C (34.3)	C (30.5)	C (30.5)	C (27.7)
34	N Valdosta Rd @ Oak St Ext	D (36.1)	E (75.6)	E (69.3)	C (35.0)	D (38.9)	D (38.7)
35	N Ashley St @ Smithbriar Dr	C (20.8)	D (37.4)	F (267.7)	C (21.9)	C (29.4)	F (156.0)
36	N Ashley St @ Northside Dr	C (32.7)	C (33.6)	E (55.9)	C (25.8)	C (34.1)	D (54.3)
37	N Patterson St @ Smithbriar Dr	B (14.9)	B (19.2)	C (21.5)	B (18.9)	B (19.2)	C (29.0)
38	N Patterson St @ Northside Dr	D (48.8)	C (31.5)	D (37.8)	B (18.7)	C (33.0)	C (30.0)
39	Alden Ave @ Azalea Dr	B (12.9)	B (11.9)	B (12.8)	B (14.6)	B (12.6)	B (11.7)

#	Intersection	Existing Condition			Fine-Tuned with Improvements Condition		
		AM Peak	MD Peak	PM Peak	AM Peak	MD Peak	PM Peak
40	Alden Ave @ N Oak St	D (36.3)	C (29.8)	C (32.1)	C (23.8)	C (25.6)	C (24.7)
41	Alden Ave @ N Patterson St	B (15.1)	B (14.0)	B (13.4)	A (6.6)	B (11.0)	B (10.7)
42	Norman Dr @ Lowndes H.S.	B (15.7)	A (9.0)	B (12.7)	B (13.1)	A (8.4)	B (13.9)
43	Norman Dr @ Valhalla Dr	B (12.1)	A (2.5)	C (21.8)	A (5.0)	A (1.5)	B (17.0)
44	Hill Ave @ Norman Dr	B (15.2)	C (26.1)	C (29.3)	B (11.7)	C (21.8)	C (21.4)

As shown above, the proposed timings and recommended operational improvements reduce the overall intersection delay for the majority of the intersections during the peak hours. While a few intersections show a slight increase in delay, field observations indicated that the increase was negligible and that progression along the corridors was greatly improved and may not be captured in the *Synchro 9* model.

The fine-tuned timings with the recommended improvements reduced the level-of-service to an acceptable LOS D or better at all intersections except at the intersection of N Ashley St at Smithbriar Dr. However, due to the intersection spacing with the intersection of N Patterson St at Smithbriar Dr and the unique turning movements at the intersections along with the limitations of *Synchro*, the delay is overstated at this intersection in both the existing and fine-tuned with improvements conditions. **Figures 17, 18 and 19** show a side-by-side comparison of the LOS for the Existing and Fine-tuned with Improvements at each project location for the AM, MD, and PM peaks, respectively.

Figure 17: Existing vs. Fine-Tuned with Improvement AM LOS Comparison

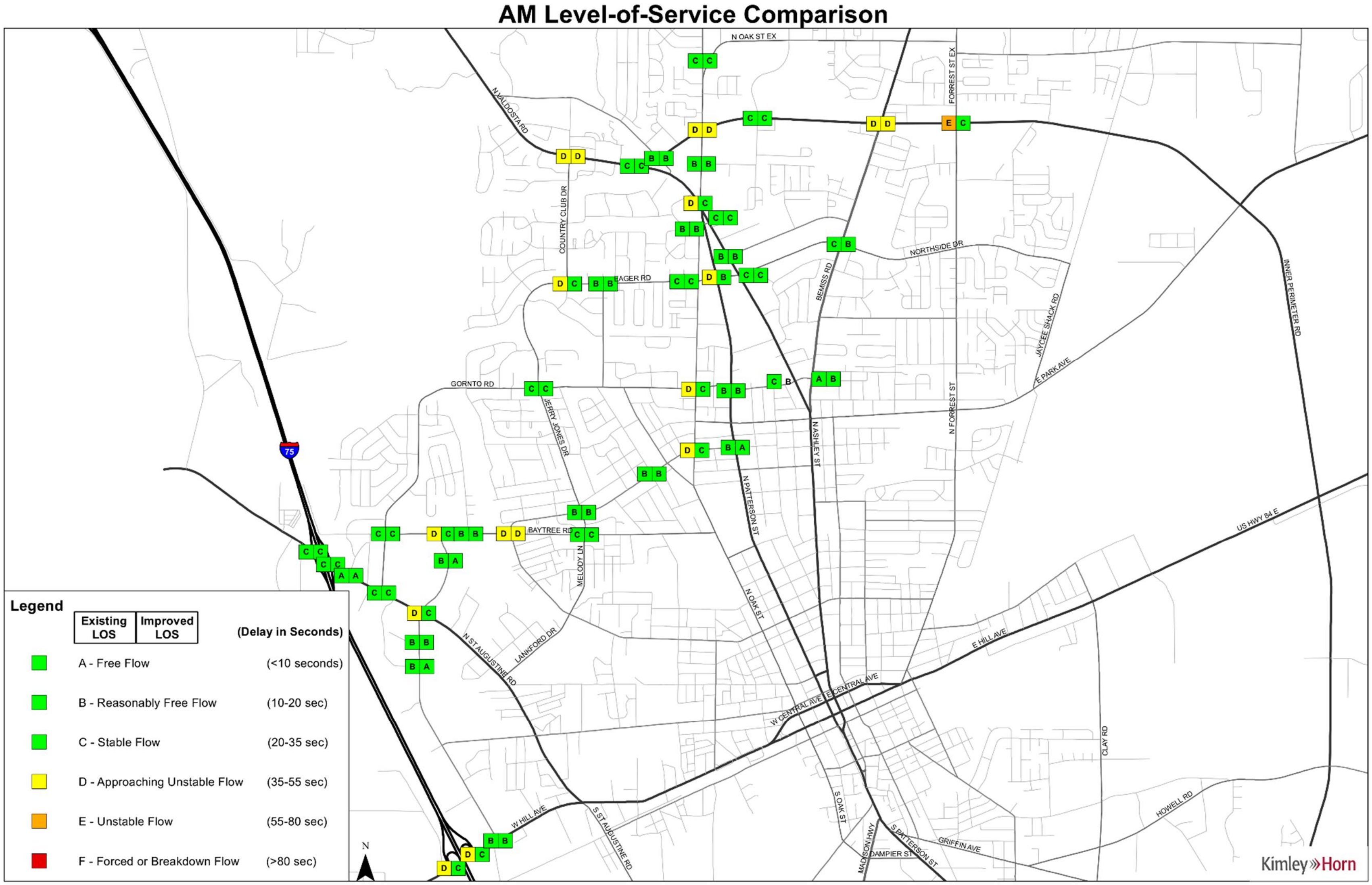


Figure 18: Existing vs. Fine-Tuned with Improvement MD LOS Comparison

MD Level-of-Service Comparison

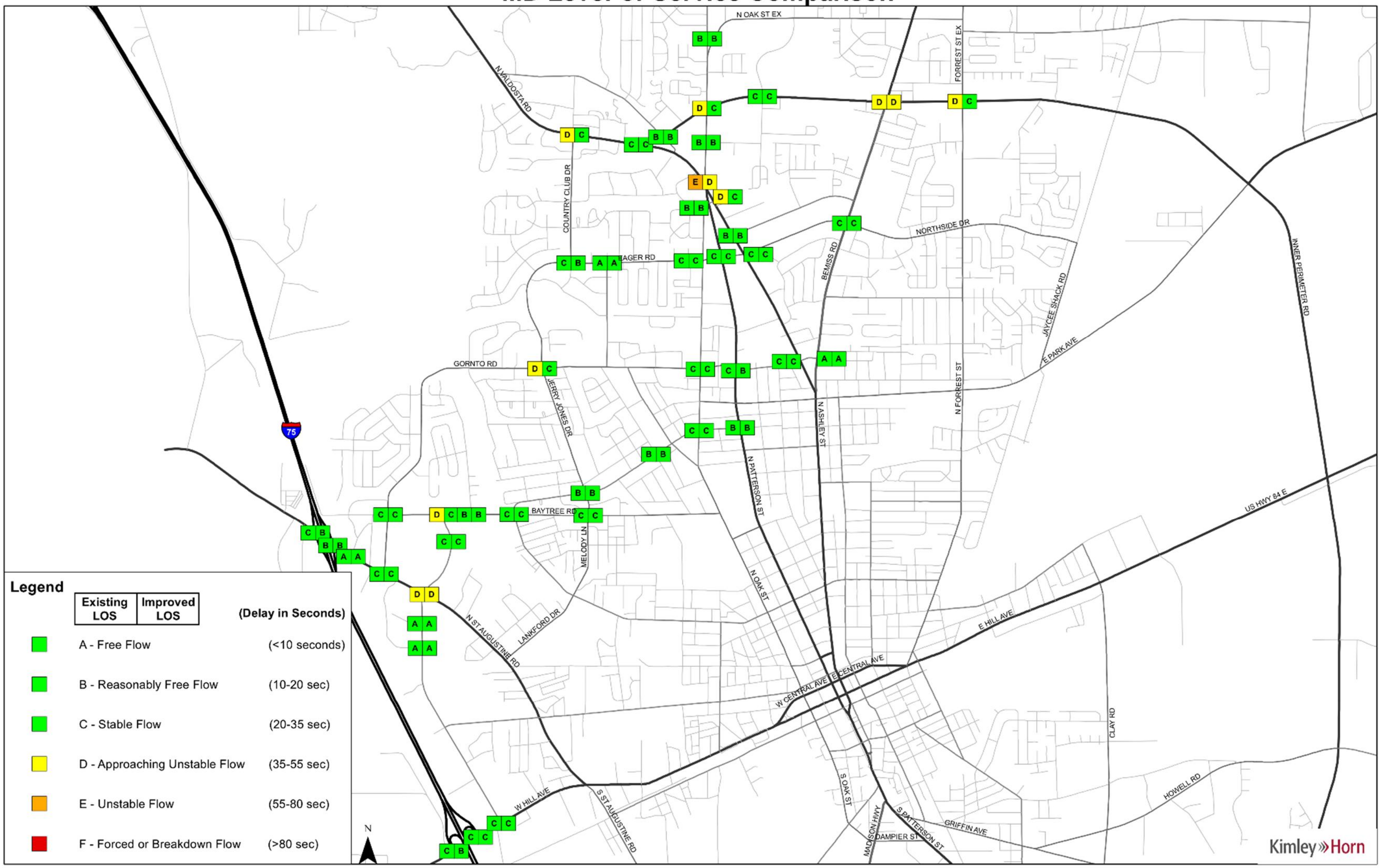
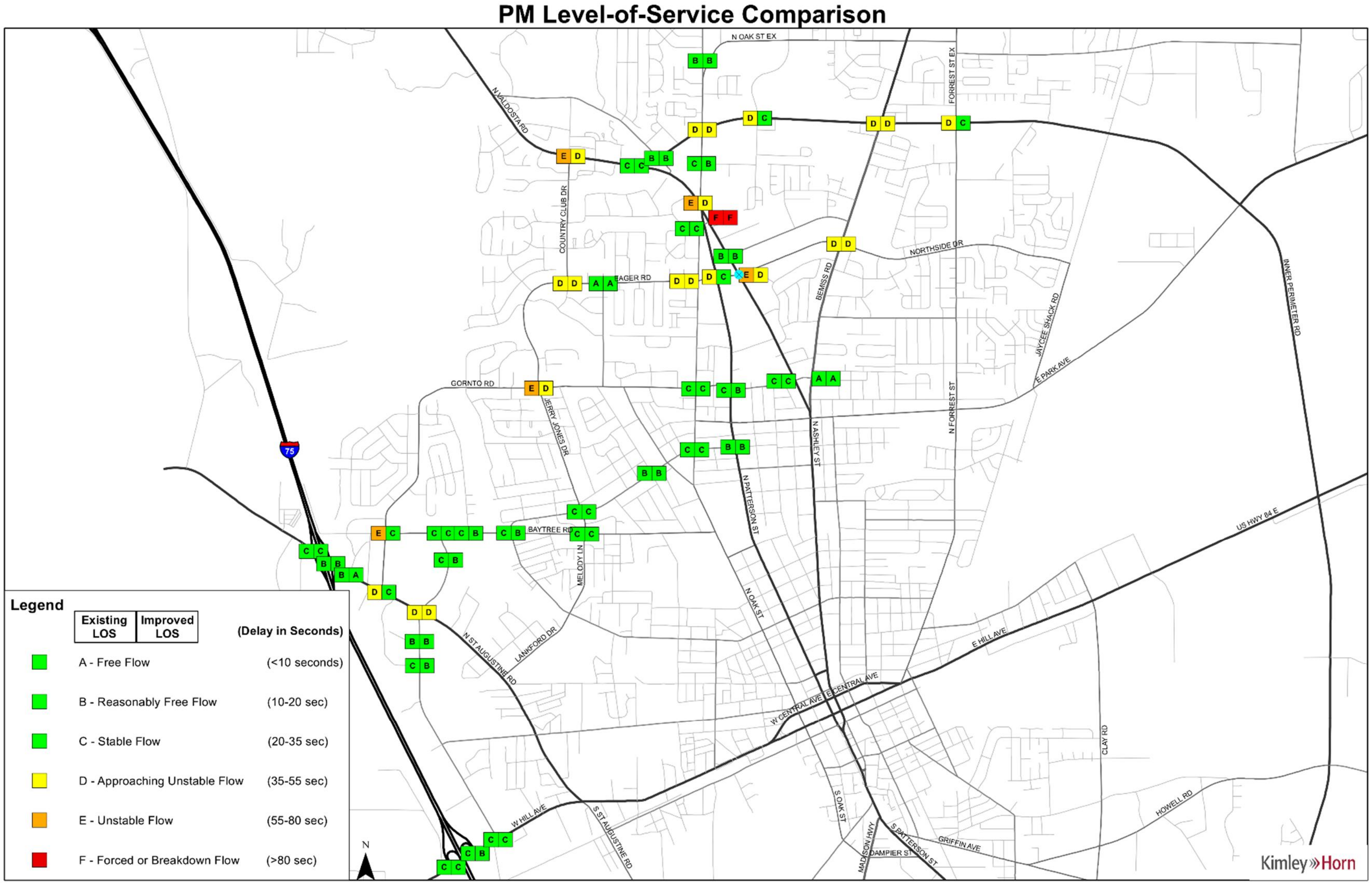


Figure 19: Existing vs. Fine-Tuned with Improvement PM LOS Comparison



7.0 TRAFFIC RESPONSIVE

KH evaluated the need for traffic responsive throughout the City of Valdosta. For traffic responsive to produce noticeable benefits over traditional time of day plans, there has to be a high frequency of inconsistent traffic patterns. Corridors which are highly likely to be impacted by incidents, extreme weather, detour routes, shift work, special events, or holiday events are good candidates for traffic responsive systems. Traffic responsive requires a higher level of analysis and operational maintenance, so the occurrence of these types of disruptions has to be high enough to provide enough benefit to outweigh the potential challenges of managing a traffic responsive system. Throughout the system, there are several locations which experience somewhat unpredictable traffic patterns.

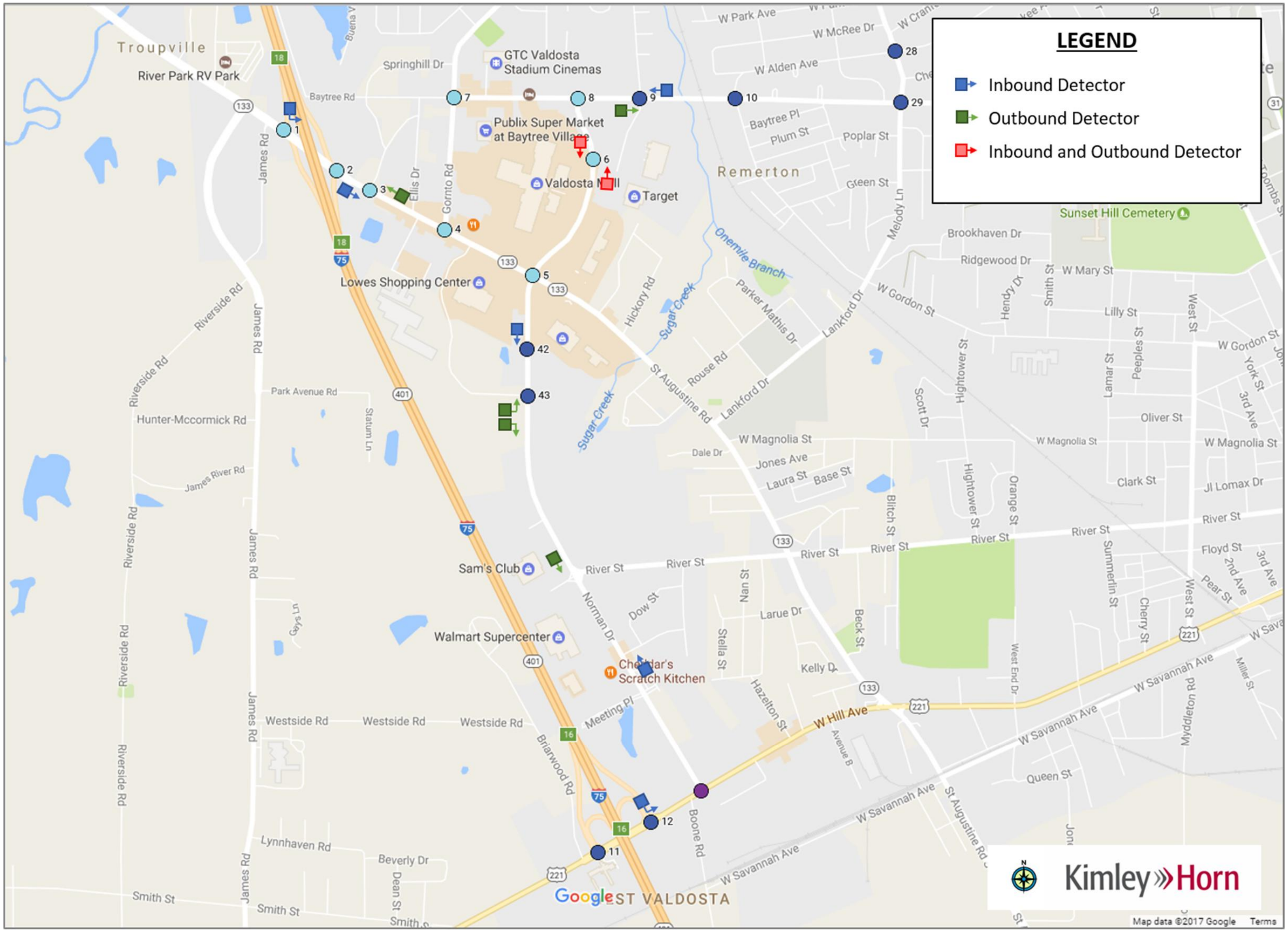
The City of Valdosta will be upgrading their controller and central server software to MaxTime/MaxView. Within the MaxTime/MaxView software the traffic responsive program can assign certain intersection detectors to collect historic count data to determine thresholds for each timing plan. The City of Valdosta currently uses upstream mainline detection along with stop bar detection for side street and left turns. For traffic responsive to be successful, the detection system needs to be heavily maintained to ensure traffic responsive is working correctly, and in most cases some additional detectors are required due congestion creating volume count discrepancies at the intersection detectors.

The North Zone of the system, currently, does not experience frequent unpredictable traffic patterns that would warrant traffic responsive timing over providing traditional time of day plans. Flush plans for incident management could be developed for this area and could be called up when needed by the City of Valdosta's Traffic Management Center (TMC).

The Middle and South Zones of the system do experience somewhat unpredictable traffic patterns that could potentially warrant traffic responsive timings. The area around the Valdosta Mall and Lowndes High School do generate events which could warrant traffic responsive; however, these events are typically scheduled or known events where it would be easy to simply put a special time of day plan in and schedule the timing plan to come in during those events. Examples of this are football games Friday nights at Lowndes High School and the Holiday shopping season around the Valdosta Mall.

The consistency of these disruptions does not appear to be frequent enough to recommended traffic responsive timing over providing traditional time of day plans with additional special event and holiday timing plans. If traffic responsive is considered for this area, the special events in the area have similar traffic flow patterns of vehicles traveling inbound or outbound to the AM and PM plans, respectively. The intersection detectors can be set to collect historic count data for these traffic flow patterns and then reviewed to determine if the flow patterns are varying from the standard time of day schedule and timing plans to warrant traffic responsive. The intersection detectors and movements which could be set to collect historic count data to monitor inbound, outbound, or both traffic flow patterns for this area are illustrated in **Figure 20**.

Figure 20: Traffic Responsive Detector Map



8.0 ITEMS FOR FURTHER CONSIDERATION

Each of the project intersections were operationally analyzed by studying all the data collected. By observing the traffic flow patterns and the existing LOS, delay, and crash histories for each intersection movement, an analysis was made to determine any modifications to the intersection that would enhance its operation. Also, any deficiencies in regards to the *Manual on Uniform Traffic Control Devices*, *2011 Edition* (MUTCD) were noted, and improvements were recommended. Operational issues that were addressed included possible geometric modifications and pavement marking/lane utilization changes. The full list of operational improvements is located in **Section 6.0 Operational Analysis** of this report.

LONG-TERM CONSIDERATIONS

As the northern area of the City surrounding Oak St Ext between N Valdosta Rd/N Ashley St and Inner Perimeter Rd develops, the widening of Oak St Ext from Smithbriar Dr to Cherry Creek Rd should be considered. In existing conditions, the northbound right turn from N Ashley St onto Oak St Ext experiences heavy queuing and the geometry of the intersection would allow for an exclusive right turn lane. Widening of Oak St Ext to a four or five lane section (two northbound lanes and two southbound lanes with/without a center two-way left turn lane) would provide additional roadway capacity. The northbound widening should begin with the addition of a northbound exclusive free-flow right turn lane at the intersection of N Valdosta Rd at Oak St Ext, with storage extending to the intersection of N Ashely St at Smithbriar Dr and end at the existing northbound roadway split at the intersection of Oak St Ext at Cherry Creek Rd. The southbound widening should begin north of the intersection of Inner Perimeter Rd at Oak St Ext and continue to the intersection of N Valdosta Rd at Oak St Ext.

Installation of dual westbound left turn lanes at the intersection of N Valdosta Rd at Country Club Dr, can be considered in the future if permissive/protected left turn phasing and/or double-serve left turn phasing operations are no longer able to accommodate the demand. The installation of dual westbound left turn lanes would require the installation of a southbound County Club Dr receiving lane. This lane should be installed in addition to the existing southbound receiving lane, while maintaining the recommended northbound Country Club Dr laneage and non-split phased operations.

TOD SCHEDULE

The City of Valdosta has received complaints about long cycle lengths before the AM peak and after the PM peak period. During field implementation and fine-tuning it was recommended to keep the TOD schedule as proposed due to the long transition times and volumes beginning to build during those times. However, if these complaints continue the AM peak period could begin at 06:30 instead of 06:00 and the Off-peak period could end at 20:30 instead of 21:00 on all corridors except the N Valdosta Rd/N Ashley St/N Patterson St corridor north of Northside Dr and the Inner Perimeter Rd corridor east of Brookfield Rd/Lake Laurie Dr. Due to the coordination between the closely spaced vehicles and earlier/later heavy volumes before and after the peak periods it is not recommended that the TOD be adjusted for the northern section of N/Valdosta Rd/N/Ashely St/N Patterson St corridor and Inner Perimeter Rd corridor.

FLASHING YELLOW ARROW UPGRADES

Flashing Yellow Arrow (FYA) signal head upgrades provide the operational benefits of lead/lag left turn phasing operations and double-serve left turn phasing operations to accommodate progression along the corridor and reduce queuing. The intersections with FYA recommendations as discussed previously in

Section 6.0 Operational Analysis, were divided below into three tiers of priority based on the potential intersection and corridor operational benefits, to aid the City in future project development.

- Tier 1
    - St. Augustine Rd @ Gornto Rd
    - St. Augustine Rd @ Norman Dr
    - Baytree Rd @ Gornto Rd
    - Baytree Rd @ Norman Dr
    - N Valdosta Rd @ Country Club Dr
    - Inner Perimeter Rd @ Country Club Rd
- Tier 2
    - Baytree Rd @ Gordon St
    - Inner Perimeter Rd @ Bemiss Rd
    - Inner Perimeter Rd @ Forrest St
    - Northside Dr @ Bemiss Rd
    - Baytree Rd @ Jerry Jones Dr
    - Hill Ave @ Norman Dr
- Tier 3
    - St. Augustine Rd @ Mall Ent
    - Baytree Rd @ Sherwood Dr
    - Inner Perimeter Rd @ Brookfield Rd/Lake Laurie Dr?
    - Oak St Ext @ Murray Rd
    - Northside Dr/Eager Rd @ Oak St Ext
    - Eager Rd/Jerry Jones Dr @ Country Club Dr
    - Jerry Jones Dr @ Gornto Rd
    - Jerry Jones Dr @ Alden Ave
    - Gornto Rd @ N Oak St
    - Norman Dr @ Valhalla Dr

Below is a list of intersections which have been or are planned for 4-section FYA upgrades under the GDOT project PI 0010116 and are recommended to be upgraded with 3-section FYA on opposing left turn movements to allow for lead/lag and double-serve left turn phasing operations.

- Woodrow Wilson Dr @ N Ashley St
- Woodrow Wilson Dr/Gornto Rd @ N Patterson St
- N Ashley St @ Northside Dr
- N Patterson St @ Northside Dr

DATABASE UPGRADES

When the City of Valdosta upgrades their signal timing and central server software to MaxTime/MaxView additional considerations can be made to improve the operations of the signals in the network. Along with flashing yellow upgrades, lead/lag and double-serve left turn phasing operations should be considered. The lead/lag left turn phasing allows for the left turn phases to be adjusted to provide greater throughput along the major and minor corridors of the system.

Additionally, MaxTime provides faster transitions between time-of-day patterns and will help to maintain coordination along the corridor. This will also provide the opportunity to tighten the time-of-day schedule to operate the larger cycle lengths for shorter periods of time during the peak periods.

ACCESS MANAGEMENT

The Valdosta Mall and surrounding area has many driveways and access points along St. Augustine Rd, Baytree Rd, Norman Dr, and Gornto Rd. These driveways create opportunities for tuning movement conflicts, increased delay, and disruptions in progression along the corridors. An additional access management study should be considered to determine if the number of driveways can be reduced in this area. This study should include vehicle counts and observations at all driveway locations to understand the traffic demands and traffic flow patterns to determine which driveways can be removed. Additionally, inter parcel connectivity at key locations can help reduce the number of access points along the corridors. Along the north side of Baytree Rd there are some locations with inner parcel connectivity, and continuing the connectivity and reducing the number of driveways can help increase progression and throughput as well reduce delay along Baytree Rd. Similar inner parcel connectivity opportunities should be considered around Valdosta Mall area and along the east side of Norman Dr.

Figure 21 shows possible locations of inter parcel access points that could help minimize vehicular traffic along the major corridors surrounding Valdosta Mall. Lastly, the removal of split phasing operations at three (3) of the major Mall corner intersections as recommended in **Section 6.0 Operational Analysis** will also help in minimizing congestion near the Mall, which will reduce vehicular conflicts with driveways adjacent to the intersections.

Figure 21: Proposed Inter Parcel Access