TECHNICAL MEMORANDUM

Date:	September 25, 2017
To:	Ms. Allison Anderson, P.E. – City of Columbia
From:	Mr. Srinivas Yanamanamanda, P.E., PTOE, PTP Mr. Nirav Patel
CBB Job Number:	059-16-2
Project:	Nifong Intersection Columbia, Missouri

CBB has completed traffic operations analysis for the existing all-way stop controlled intersections along Nifong Boulevard at Sinclair Road and Old Mill Creek Road/Country Wood Road in the City of Columbia, Missouri. The purpose of this traffic operations study was to evaluate the intersections under the existing all-way stop control, proposed roundabout, and proposed signalization scenarios during the existing and 20-Year forecast traffic volume conditions. **Figure 1** illustrates the general location of the study intersections relative to the surrounding area. We have prepared this technical memorandum to summarize the traffic operations evaluation of the Nifong Boulevard intersections.

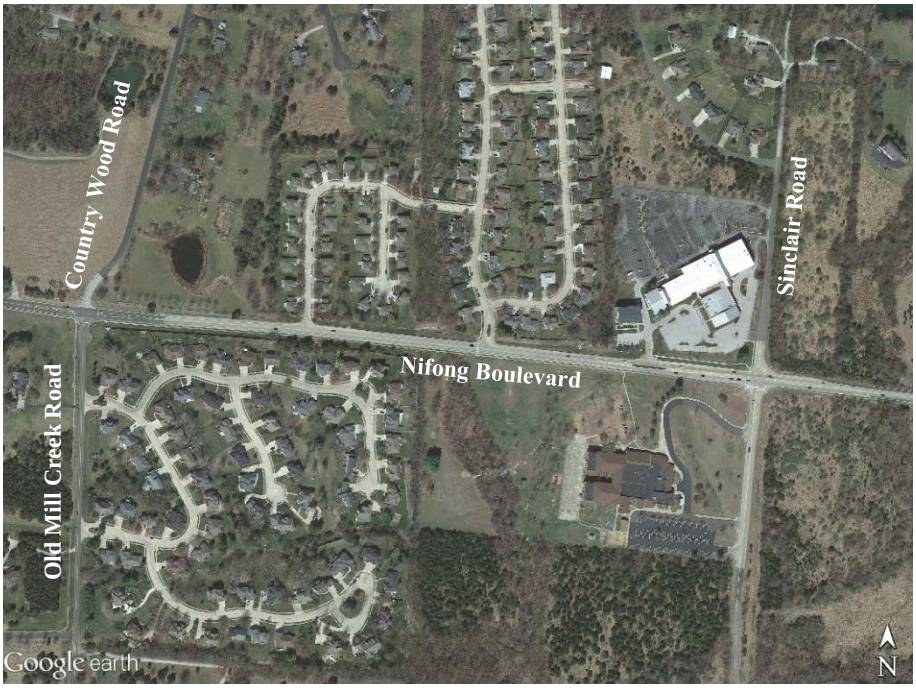

Figure 1: Site Location

Existing Traffic Volumes

Manual turning movements counts were complete in December 2016 and January 2017 at the study intersections during the weekday AM peak period (7:00 to 9:00 AM) and the weekday PM peak period (4:00 to 6:00 PM). Based on the counts, the peak hours were determined to be 7:30 AM to 8:30 AM during the morning and 5:00 PM to 6:00 PM for the afternoon. The Existing Traffic Volumes are summarized in **Exhibit 1**.

As can be seen in Exhibit 1, the predominant travel patterns at the study intersections are heavier to the east during the AM peak hour and to the west during the PM peak hour. The northbound right-turn movement at Nifong Boulevard at Old Mill Creek Road/Country Wood Road is heavy during the AM peak hour and the westbound left-turn movement is moderate during the PM peak hour. The northbound left-turn movement at Nifong Boulevard at Sinclair Road is moderate during the AM and PM peak hour as well as the northbound right-turn movement is moderate during AM peak hour. Furthermore, the eastbound right-turn movement is heavy during the AM peak hour.

Traffic Forecasts

Traffic forecasts were developed using outputs from the Columbia Area Transportation Study Organization (CATSO) model and expected development potential. Based on the model and the undeveloped land south of Nifong Boulevard along Sinclair Road, a potential residential development was assumed. The potential residential development was assumed to be 200 homes. In addition, the Columbia Public School (CPS) District has proposed a middle school, south of Southampton Drive along Sinclair Road. The proposed middle school would operate with 700 students and 60 staff members.

Trip generation for the 200 homes was estimated based on information provided in the "Trip Generation Manual", Ninth Edition, published by the Institute of Transportation Engineers (ITE). This manual, which is a standard resource for transportation engineers, is based on a compilation of nationwide studies documenting the characteristics of various land uses. The regression equation was utilized for Land Use: 210 – Single-Family Detached Housing for the potential residential development. Trip generation for the proposed middle school was estimated based upon information provided by the CPS District.

The peak hour of adjacent street traffic (one hour between 7 AM and 9 AM) was utilized for the AM peak hour, and the peak hour of adjacent street traffic (one hour between 4 PM and 6 PM) was utilized for the PM peak hour trip generation. As can be seen in **Table 1**, the potential residential development and the proposed middle school would generate 547 vehicular trips during the AM peak hour and 200 vehicular trips during the PM peak hour. It should be noted that the proposed middle school is in session between 7:30 AM and 2:35 PM. The arrival of the site-generated middle school trips is expected to occur during the AM peak hour. However, the

dismissal of the site-generated middle school trips is expected to occur prior to the PM peak hour.

Table 1: Estimated Trip Generation for Potential Developments

ITE Land Use (ITE Code)	***Dwelling Units***	***Daily Trips***	***AM Peak Hour***			***PM Peak Hour***		
			In	***Out***	***Total***	***In***	***Out***	***Total***
Single-Family Detached Housing (210)	200 Units	1,985	35	110	145	125	75	200
Proposed Middle School*	700 Students and 60 Staff Members	--	231	171	402	--	--	--
Total	**--**	**--**	**266**	**281**	**547**	**125**	**75**	**200**

*Based upon information provided by the CPS District

The traffic generated by the potential residential development was assigned to the adjoining roadway system based on the existing traffic patterns. The anticipated directional distribution during the AM and PM peak hours for the trips to and from the potential residential development was estimated to be 80% to/from the east and 20% to/from the west.

The traffic generated by the proposed middle school was assigned to the adjoining roadway system based on upon the attendance boundary provided by the CPS District. Based upon the provided attendance boundary, the anticipated directional distribution during the AM peak hour for the trips to and from the proposed middle school development was estimated to be 60% to/from the north and 40% to/from the south.

In addition to the trips generated by the potential residential and middle school developments, an approximate annual background growth rate of 1% was applied to the existing traffic volumes. The 20-Year Forecast Traffic Volumes are summarized in **Exhibit 2**. It should be noted that the increase in traffic expected from the south along Sinclair Road at Nifong Boulevard is an increase of 97% during the AM peak hour and 53% during the PM peak hour compared to the existing traffic volumes.

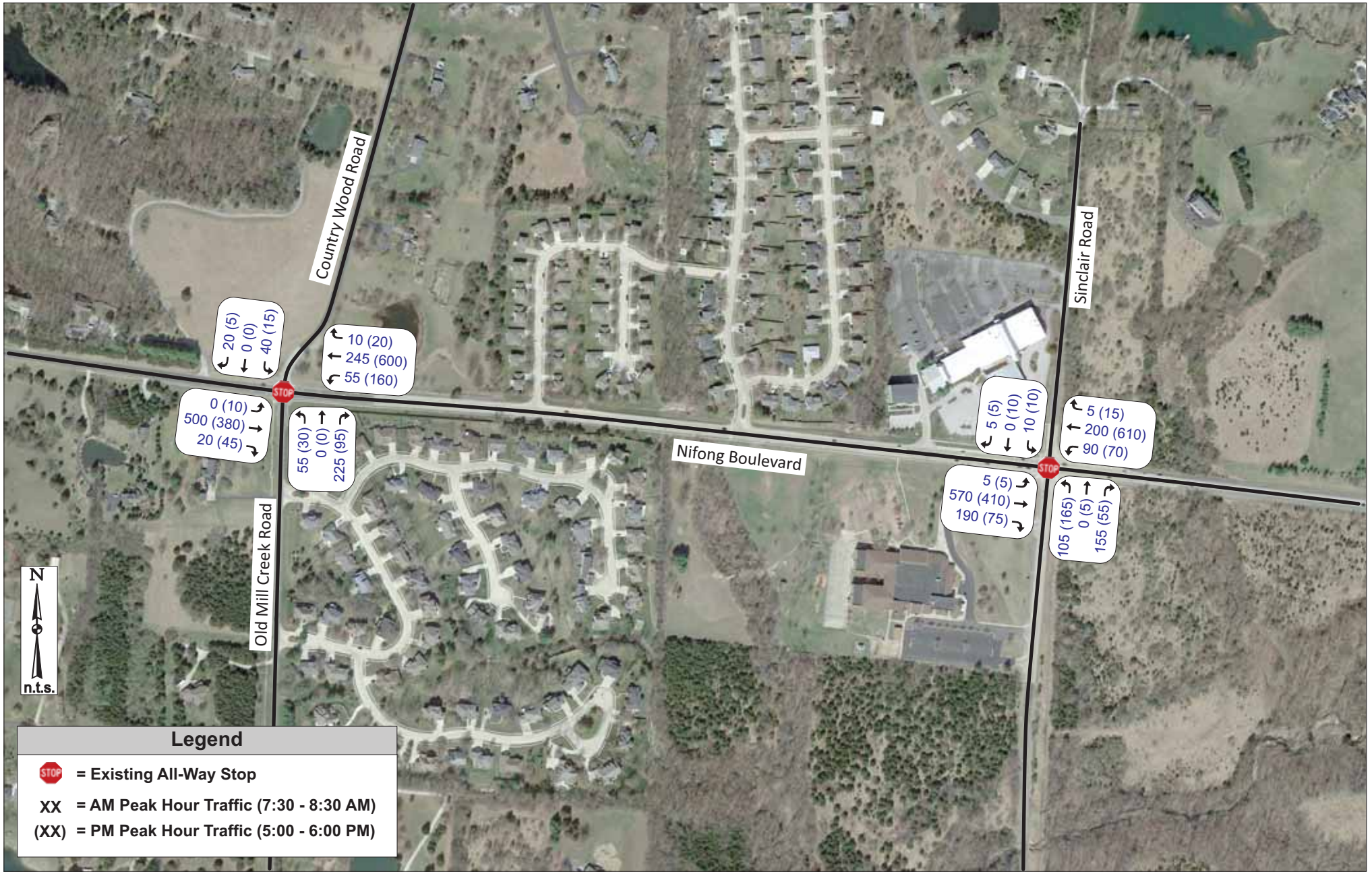

Exhibit 1: Existing Traffic Volumes

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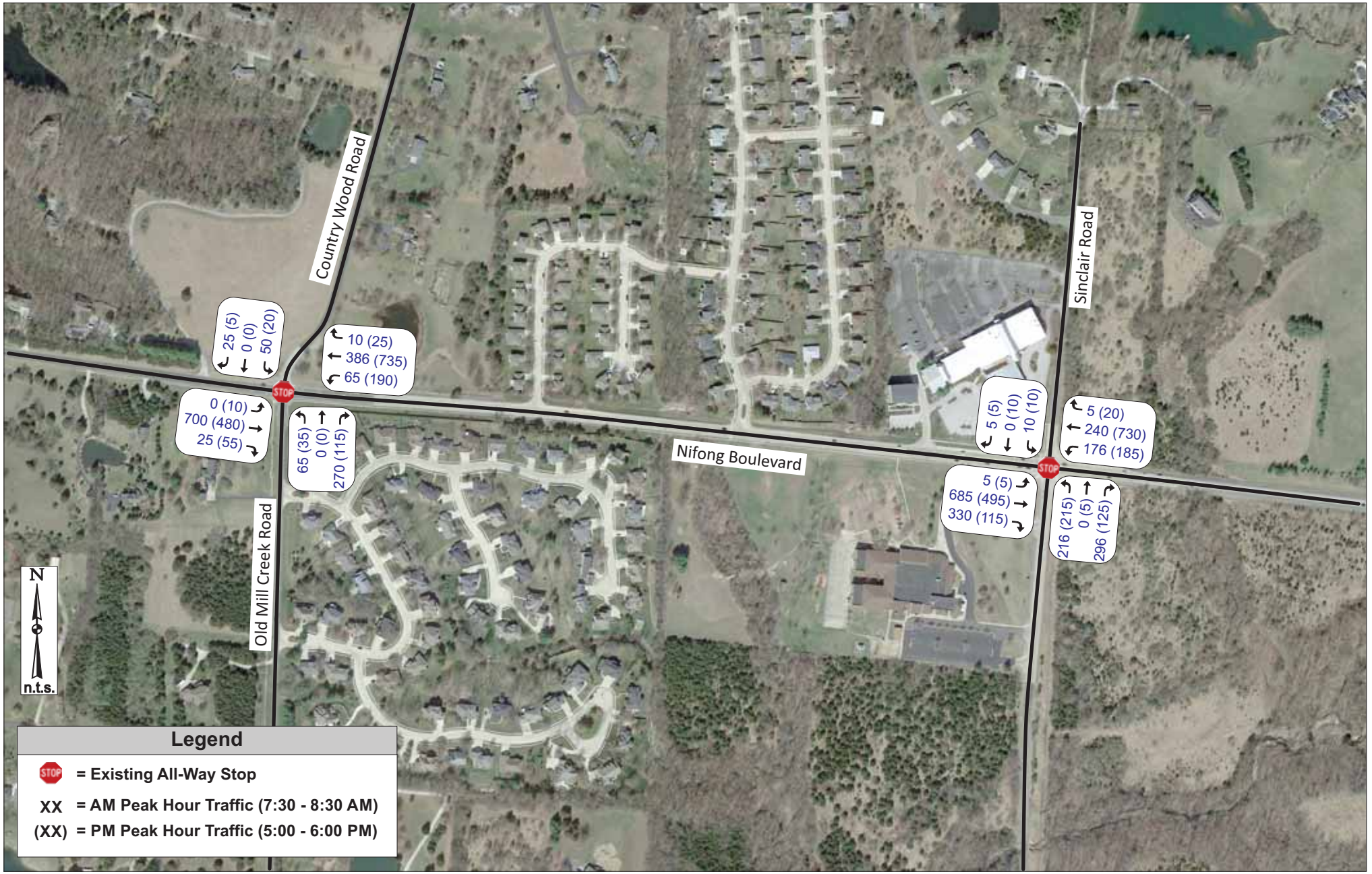

Exhibit 2: 20-Year Forecast Traffic Volumes

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Traffic Operational Analysis

The operating conditions for the study area intersections were evaluated using PTV VISSIM, a micro-simulation traffic flow model that specializes in the analysis of complex transportations systems. It is especially useful for analyzing sophisticated driver behavior based on algorithms that accurately reflect lane changing, and queueing impacts from closely spaced intersections.

The operating conditions were graded in accordance with six levels of traffic service (Level A "Free Flow" to Level F "Fully Saturated") established by the *Highway Capacity Manual*. Levels of service (LOS) are measures of traffic flow which consider such factors as speed, delay, traffic interruptions, safety, driver comfort, and convenience. Level C, which is normally used for highway design, represents a roadway with volumes ranging from 70% to 80% of its capacity. However, Level D is generally considered acceptable for peak period conditions.

It must also be acknowledged that the perception of acceptable traffic service varies widely by area. Specifically, more delay is usually tolerated in urban areas compared to rural areas. Based on the character of this area, we believe that overall intersection LOS D would be an appropriate target for overall peak period traffic operations.

The thresholds that define levels of service at an intersection are based upon the type of control used (i.e., whether it is signalized or unsignalized) and the calculated delay. For signalized and all-way stop intersections, the average control delay per vehicle is estimated for each movement and aggregated for each approach and the intersection as a whole. At intersections with partial (side-street) stop control, delay is calculated for the minor movements only since motorists on the main road are not required to stop. Furthermore, criteria differ for the two, since control types create different driver expectations. **Table 2** summarizes the level of service thresholds used in this analysis.

Table 2: Level of Service Thresholds

Level of Service (LOS)	**Control Delay per Vehicle (sec/veh)**	
	Signalized Intersections	***Unsignalized Intersections***
A	≤ 10	0-10
B	> 10-20	> 10-15
C	> 20-35	> 15-25
D	> 35-55	> 25-35
E	> 55-80	> 35-50
F	> 80	> 50

Analysis Scenarios

The following scenarios were evaluated:

- Existing Traffic Volume Scenario; and
- 20-Year Forecast Traffic Volume Scenario.

Existing Traffic Volume Scenarios

Each of the study area intersections were evaluated using the methodologies described above under the existing all-way stop control, proposed roundabout, and proposed signalization scenarios during the existing traffic volume conditions during the AM and PM peak hours. The evaluation results for each study intersection during each scenario are summarized in **Tables 3, 4,** and **5**, respectively.

As can be seen in Table 3, under the existing all-way stop control geometrics, the study intersections do not operate at overall acceptable levels of service (LOS D) during the AM and PM peak hours. During the AM peak hour, the eastbound approach is the heaviest approach at both study intersections and are operating at LOS F with maximum queue lengths reaching over 1,500 feet. During the PM peak hour, the westbound approach is the heaviest approach at both study intersections and are operating at LOS F with maximum queue lengths reaching over 1,400 feet. As can be seen in Table 4, under the proposed roundabout scenario the study intersections are expected to operate at acceptable levels of service.

Additionally, as can be seen in Table 5, under the proposed signal scenario the study intersections are expected to operate at acceptable levels of service. Furthermore, the expected delay for the proposed signal scenario is slightly higher than the expected delay for the proposed roundabout scenario.

Table 3: Operating Conditions – Existing Traffic Volumes for All-Way Stop Control Scenario

Intersection/Approach	AM Peak Hour		PM Peak Hour	
	LOS (Delay)	*Max Queue Length (FT)*	*LOS (Delay)*	*Max Queue Length (FT)*
Nifong Boulevard and Old Mill Creek Road/Country Wood Road				
Eastbound Nifong Boulevard	F (78.09)	645'	C (22.03)	325'
Westbound Nifong Boulevard	B (11.60)	110'	F (108.82)	1400'
Northbound Old Mill Creek Road	C (18.21)	165'	A (7.49)	75'
Southbound Country Wood Road	B (12.85)	60'	A (7.01)	45'
Overall Intersection	**E (42.55)**	--	**F (66.42)**	--
Nifong Boulevard and Sinclair Road				
Eastbound Nifong Boulevard	F (105.21)	1515'	B (14.43)	195'
Westbound Nifong Boulevard	B (11.45)	115'	F (248.60)	1670'
Northbound Sinclair Road	A (6.08)	85'	B (14.56)	105'
Southbound Sinclair Road	A (7.54)	45'	B (12.13)	50'
Overall Intersection	**F (62.06)**	--	**F (119.61)**	--

X (XX.X) - Level of Service (Vehicular delay in seconds per vehicle) XX' – Maximum Queue Length

Table 4: Operating Conditions – Existing Traffic Volumes for Roundabout Scenario

Intersection/Approach	AM Peak Hour		PM Peak Hour	
	LOS (Delay)	*Max Queue Length (FT)*	*LOS (Delay)*	*Max Queue Length (FT)*
Nifong Boulevard and Old Mill Creek Road/Country Wood Road				
Eastbound Nifong Boulevard	A (3.11)	115'	A (3.39)	110'
Westbound Nifong Boulevard	A (3.37)	85'	A (5.06)	165'
Northbound Old Mill Creek Road	A (4.65)	110'	A (2.75)	50'
Southbound Country Wood Road	A (2.39)	25'	A (5.47)	25'
Overall Intersection	**A (3.51)**	--	**A (4.31)**	--
Nifong Boulevard and Sinclair Road				
Eastbound Nifong Boulevard	A (6.18)	215'	A (5.77)	150'
Westbound Nifong Boulevard	A (3.58)	80'	A (7.41)	300'
Northbound Sinclair Road	A (6.08)	110'	A (3.59)	90'
Southbound Sinclair Road	A (2.90)	15'	A (6.28)	15'
Overall Intersection	**A (5.55)**	--	**A (6.23)**	--

X (XX.X) - Level of Service (Vehicular delay in seconds per vehicle) XX' – Maximum Queue Length

Table 5: Operating Conditions – Existing Traffic Volumes for Signal Scenario

Intersection/Approach	AM Peak Hour		PM Peak Hour	
	LOS (Delay)	*Max Queue Length (FT)*	*LOS (Delay)*	*Max Queue Length (FT)*
Nifong Boulevard and Old Mill Creek Road/Country Wood Road				
Eastbound Nifong Boulevard	B (11.13)	235'	A (7.46)	165'
Westbound Nifong Boulevard	B (11.47)	110'	A (8.14)	210'
Northbound Old Mill Creek Road	A (8.16)	65'	A (7.85)	55'
Southbound Country Wood Road	A (9.92)	45'	B (11.91)	35'
Overall Intersection	**B (10.41)**	--	**A (7.94)**	--
Nifong Boulevard and Sinclair Road				
Eastbound Nifong Boulevard	A (9.44)	195'	B (12.75)	240'
Westbound Nifong Boulevard	B (12.26)	105'	B (13.59)	285'
Northbound Sinclair Road	B (12.08)	85'	B (12.00)	120'
Southbound Sinclair Road	A (6.00)	20'	A (9.36)	20'
Overall Intersection	**B (10.53)**	--	**B (13.00)**	--

X (XX.X) - Level of Service (Vehicular delay in seconds per vehicle) XX' – Maximum Queue Length

20-Year Forecast Traffic Volume Scenarios

Each of the study area intersections were evaluated using the methodologies described above under the existing all-way stop control, proposed signalization, and proposed roundabout scenarios for the 20-year forecast traffic volume conditions during the AM and PM peak hours. The evaluation results for each study intersection during each scenario are summarized in **Table 6, 7,** and **8**, respectively.

As can be seen in Table 6, under the existing all-way stop control geometrics the study intersections are expected to not operate at overall acceptable levels of service during the AM and PM peak hours. As can be seen in Table 7, under the proposed roundabout geometrics the study intersections are expected to operate at acceptable levels of service. Additionally, as can be seen in Table 8, under the proposed signal geometrics the study intersections are expected to operate at acceptable levels of service.

Table 6: Operating Conditions – 20-Year Traffic Volumes for All-Way Stop Control Scenario

Intersection/Approach	AM Peak Hour		PM Peak Hour	
	LOS (Delay)	*Max Queue Length (FT)*	*LOS (Delay)*	*Max Queue Length (FT)*
Nifong Boulevard and Old Mill Creek Road/Country Wood Road				
Eastbound Nifong Boulevard	F (337.94)	1675'	F (87.76)	815'
Westbound Nifong Boulevard	B (14.43)	175'	F (159.91)	1670'
Northbound Old Mill Creek Road	F (79.84)	370'	A (8.45)	85'
Southbound Country Wood Road	F (52.09)	65'	A (7.30)	45'
Overall Intersection	**F (155.06)**	--	**F (112.12)**	--
Nifong Boulevard and Sinclair Road				
Eastbound Nifong Boulevard	F (167.87)	1670'	C (19.02)	265'
Westbound Nifong Boulevard	B (12.36)	135'	F (464.60)	1675'
Northbound Sinclair Road	A (7.27)	115'	F (65.54)	180'
Southbound Sinclair Road	A (7.87)	45'	C (22.72)	50'
Overall Intersection	**F (81.52)**	--	**F (205.37)**	--

X (XX.X) - Level of Service (Vehicular delay in seconds per vehicle) XX' – Maximum Queue Length

Table 7: Operating Conditions – 20-Year Traffic Volumes for Roundabout Scenario

Intersection/Approach	AM Peak Hour		PM Peak Hour	
	LOS (Delay)	*Max Queue Length (FT)*	*LOS (Delay)*	*Max Queue Length (FT)*
Nifong Boulevard and Old Mill Creek Road/Country Wood Road				
Eastbound Nifong Boulevard	A (5.42)	165'	A (4.77)	180'
Westbound Nifong Boulevard	A (6.03)	305'	A (6.51)	320'
Northbound Old Mill Creek Road	C (19.73)	510'	A (3.85)	65'
Southbound Country Wood Road	A (4.22)	40'	A (8.67)	30'
Overall Intersection	**A (8.65)**	--	**A (5.72)**	--
Nifong Boulevard and Sinclair Road				
Eastbound Nifong Boulevard	C (21.98)	1645'	A (8.82)	265'
Westbound Nifong Boulevard	A (6.31)	220'	C (17.92)	730'
Northbound Sinclair Road	D (25.99)	360'	A (5.87)	145'
Southbound Sinclair Road	A (5.66)	20'	C (17.00)	40'
Overall Intersection	**C (19.52)**	--	**B (12.80)**	--

X (XX.X) - Level of Service (Vehicular delay in seconds per vehicle) XX' – Maximum Queue Length

Table 8: Operating Conditions – 20-Year Traffic Volumes for Signal Scenario

Intersection/Approach	AM Peak Hour		PM Peak Hour	
	LOS (Delay)	*Max Queue Length (FT)*	*LOS (Delay)*	*Max Queue Length (FT)*
Nifong Boulevard and Old Mill Creek Road/Country Wood Road				
Eastbound Nifong Boulevard	B (14.04)	385’	A (8.23)	195’
Westbound Nifong Boulevard	B (17.47)	265’	B (12.26)	405’
Northbound Old Mill Creek Road	B (12.26)	65’	A (8.93)	55’
Southbound Country Wood Road	B (10.35)	45’	B (13.57)	40’
Overall Intersection	**B (14.38)**	--	**B (10.66)**	--
Nifong Boulevard and Sinclair Road				
Eastbound Nifong Boulevard	A (9.18)	235’	B (10.12)	220’
Westbound Nifong Boulevard	B (19.06)	290’	B (12.75)	375’
Northbound Sinclair Road	B (17.07)	245’	B (15.77)	185’
Southbound Sinclair Road	A (7.29)	20’	B (13.59)	25’
Overall Intersection	**B (13.21)**	--	**B (12.49)**	--

X (XX.X) - Level of Service (Vehicular delay in seconds per vehicle) XX’ – Maximum Queue Length

Summary and Recommendations

- Our analysis and observations conclude that the existing all-way stop control intersections operate over capacity and at failure conditions with significant delay and queuing. This operation is anticipated to be exacerbated by the 20-year forecast.
- Based on our analysis, both the roundabout and signal alternatives are anticipated to significantly improve operations and provide acceptable capacity for 20-year forecast.
- Based on our engineering judgement, it is our opinion that the roundabout would provide significantly optimized operations during non-peak hours.
- It should also be noted that our evaluations considered a single-lane roundabout. If Nifong Boulevard requires widening in the future, we recommend upgrading the roundabouts to dual-lanes.

We trust that this addendum adequately describes the traffic analysis related to Nifong Boulevard Intersections. If additional information is desired, please feel free to contact me at 314-878-6644 or syanamanamanda@cbbtraffic.com.