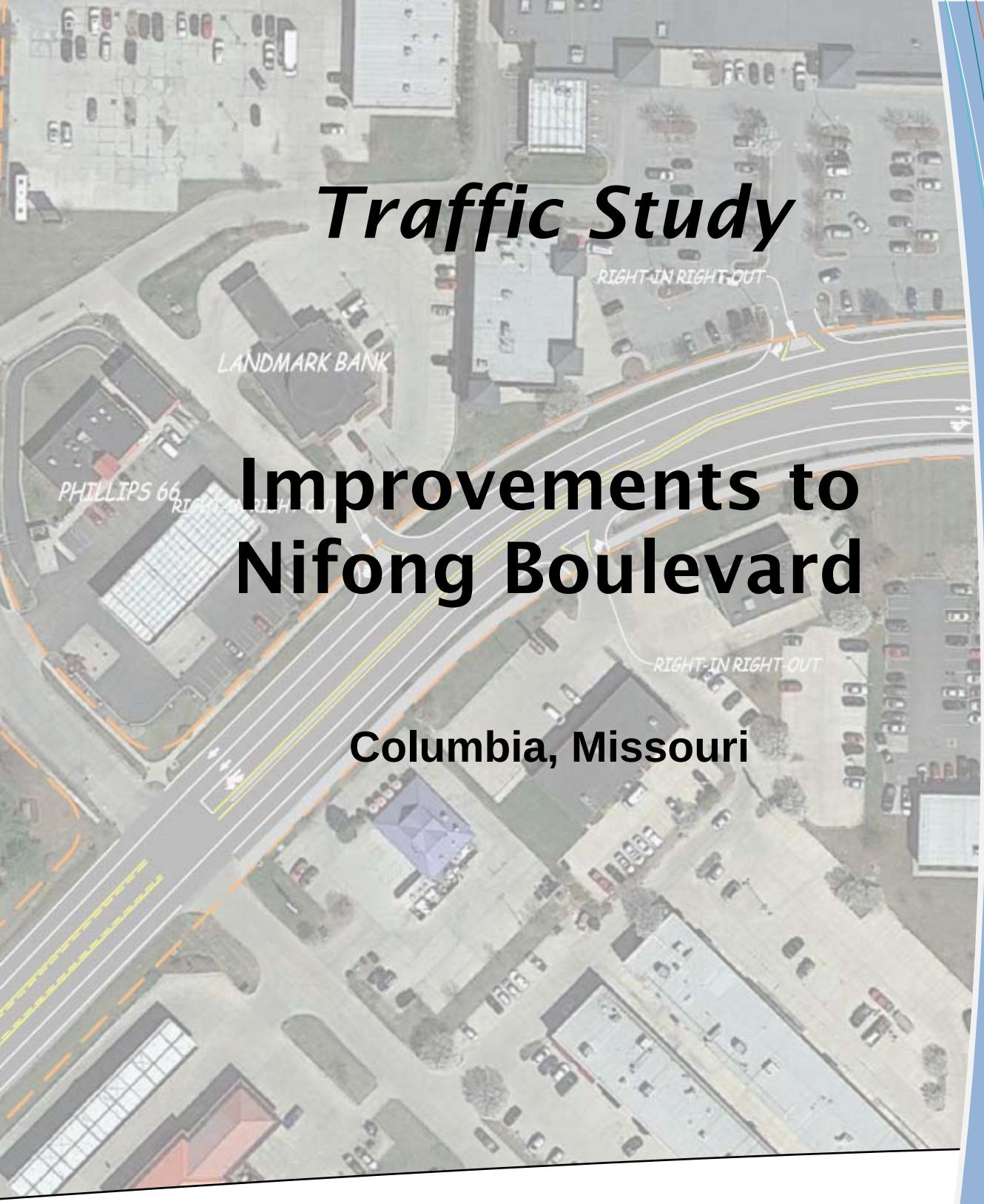

Traffic Study

Improvements to Nifong Boulevard

Columbia, Missouri

STATE OF MISSOURI
MARK M. HUEBBE
NUMBER PE-2008019549
PROFESSIONAL ENGINEER

THIS SHEET HAS BEEN SIGNED, SEALED AND DATED ELECTRONICALLY.

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November, 2017

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EXECUTIVE SUMMARY

Introduction

The purpose and objective of this traffic report is to address poor performance and congestion along Nifong Boulevard, from Providence Road to approximately 1,900 feet west of Forum Boulevard. Various lane, intersection, or corridor enhancements will be evaluated on their ability to satisfy the traffic demands indexed to a forecasted design year of 2040.

Corridor

The Nifong study area can largely be described as a mixture of suburban and mixed use commercial, with Nifong Boulevard classified as a two-lane Major Arterial. The two major north-south intersecting roadways are Bethel Street and Forum Boulevard, which are classified as Neighborhood Collectors. The remaining roadways in the study area are classified as Local Residential or unclassified local streets. Traffic counts were recorded with video cameras from 7AM to 7PM during the week of January 24-26, 2017, and analyzed by Miovision Technologies. The peak periods of the Nifong Boulevard corridor were determined to occur from 7:15-8:15 AM and 4:45-5:45 PM.

Study Methodology

Synchro (v10) and SimTraffic were used for traffic analysis, signal timing optimization, and microscopic vehicular simulation. Traffic performance measures were graded using levels of service in accordance with the Highway Capacity Manual (HCM) and graded from LOS A (free flow) to LOS F (oversaturated). Level of service criteria for intersection performance is based on vehicle delay, where corridors use average speed.

Existing Conditions

During the morning peak hour, volumes along the Nifong Boulevard corridor are significantly heavier in the eastbound direction, whereas in the afternoon peak hour, volumes are heavier in the westbound direction. Volumes at Bethel Street and Forum Boulevard are largely balanced from the north and south during both peak hours. Traffic visiting the commercial drives between Monterey and Providence is generally heavier during the PM peak hour. Conditions along Nifong Boulevard are generally acceptable, while conditions are less favorable the closer to the signalized intersections. On average the corridor has an arterial LOS of C for both morning and afternoon peak periods for the eastbound direction and a LOS D and LOS C for the morning and afternoon peak periods respectively for the westbound direction. However, arterial conditions at the Providence, Bethel, and Forum intersections vary between levels of service E and F during the AM and PM peak periods.

No-Build Forecasted Conditions
A 20-year forecasted design year was prepared to serve as the basis for evaluating the alternative designs to the no-build condition. The existing traffic counts, which were collected in 2017, were extrapolated forward in time, using a 1% compound growth rate, to the estimated design year of 2040 (considering a build year of 2020).

A 2040 no-build analysis was performed as a do-nothing alternative or benchmark from which to compare alternative designs. The increase in anticipated traffic is expected to have significant impacts on the Nifong corridor. In a SimTraffic simulation, total travel time increased 265% in the AM and 284% in the PM peak periods. Total delay increased over 400% and total stops increased over 200% for both periods between 2017 existing and 2040 no-build conditions. On average the corridor has an arterial LOS of E for both morning and afternoon peak periods for the westbound direction and a LOS F and LOS E for the morning and afternoon peak periods respectively for the eastbound direction.

Performance at the commercial drives along Nifong Boulevard, between Monterey and Providence fail completely during the morning and afternoon peak periods. Motorists are nearly unable to find an acceptable gap to make a two-stage left turn, which results in gridlock for exiting vehicles.

Alternative Improvement Options
The Nifong corridor study alternative options development process began with a range of possibilities, which were reduced based on feasibility and performance. Four alternatives were studied, which included a base 5-lane typical section option, two options with varying levels of access management for drives between Monterey and Providence, and finally an option that included roundabouts in-place of signals at Forum and Bethel.

The option that offers the greatest total improvement between simulations of the 2040 No-build and the proposed alternative, in the AM and PM peak periods, is the 5-lane typical with ¾ access commercial drives and a signal at Monterey. Conditions along Nifong Boulevard are generally acceptable for all build alternatives, except for the roundabout option. On average the corridor has a total arterial LOS of C both morning and afternoon peak periods for the eastbound direction and a LOS C or D for the morning and afternoon peak periods for the westbound direction.

Safety Analysis
From a review of the available crash data it appears that the large volume of traffic is the basis for a majority of crashes. Generally as the AADT increases so do the number of crashes. Rear end collisions were the highest occurring crash type for eleven of the seventeen intersections/segments analyzed including two of the three signalized intersections (Forum Boulevard and Providence Road). The

general findings of this crash analysis suggest that wet pavement was not a significant cause for crashes within the study area. With only 6.8% of crashes occurring during darkness without street light on, findings of this crash analysis suggest that lighting conditions may not be a significant contributing factor to crashes. In addition, it is noted that the pattern of the weekday peak traffic periods coincides with approximately half of the crashes recorded. Therefore, as traffic volumes increase, so do the number of crashes.

Conclusions

The alternative that provides the greatest traffic performance improvement over the 2040 No-build condition is the 5-Lane alternative with ¾ drive access between Monterey and Providence. However, the 5-Lane with center median between Monterey and Providence will also satisfy the current and future 2040 traffic needs of this study area, but with additional restricted access management of the commercial drives. Moreover, the center median alternative has an even greater reduction in vehicle and pedestrian conflict points which yields additional safety improvements. It is possible that the best solution for the corridor may include a mix of a center median and ¾ drive access once further detailed design takes into consideration any engineering constraints, and input from the appropriate governing agencies and interested parties.

I. INTRODUCTION

A. Purpose of Report

This traffic report is being submitted to City staff and interested parties to address proposed modifications along Nifong Boulevard, from the eastern terminus of Providence Road (Route 163) and continuing to approximately 1,900 feet west of Forum Boulevard, which is located in Boone County, Missouri. The traffic study report consists of six primary components:

1) Evaluation of existing Level of Service
2) Evaluation of projected design year Level of Service
3) Recommendations for intersection control
4) Recommendations for turn lanes
5) Corridor analysis
6) Safety analysis

B. Study Objectives

The objective of the traffic study is to analyze the various lane, intersection, or corridor enhancements as it relates to the alternative improvement options that are anticipated for construction in the year 2020. A No-build (or do nothing) scenario was evaluated on the basis of the design year forecasted conditions, indexed to year 2040. Each of the alternatives were evaluated quantitatively on the basis of their ability to satisfy the forecasted design year traffic demands.

II. TRANSPORTATION NETWORK

A. Study Area

The project limits include Nifong Boulevard, between Providence Road (Route 163) and approximately 1,900 feet west of Forum Boulevard (near the golf course at Woodrail on the Green) at an approximate distance of 1.7 miles. The study area also includes corridors north and south from the intersections of Bethel Road and Forum Boulevard. The study area locations are depicted in ***Figure II-1*** and ***Figure II-2***, with the intersections depicted in ***Figure II-3***.

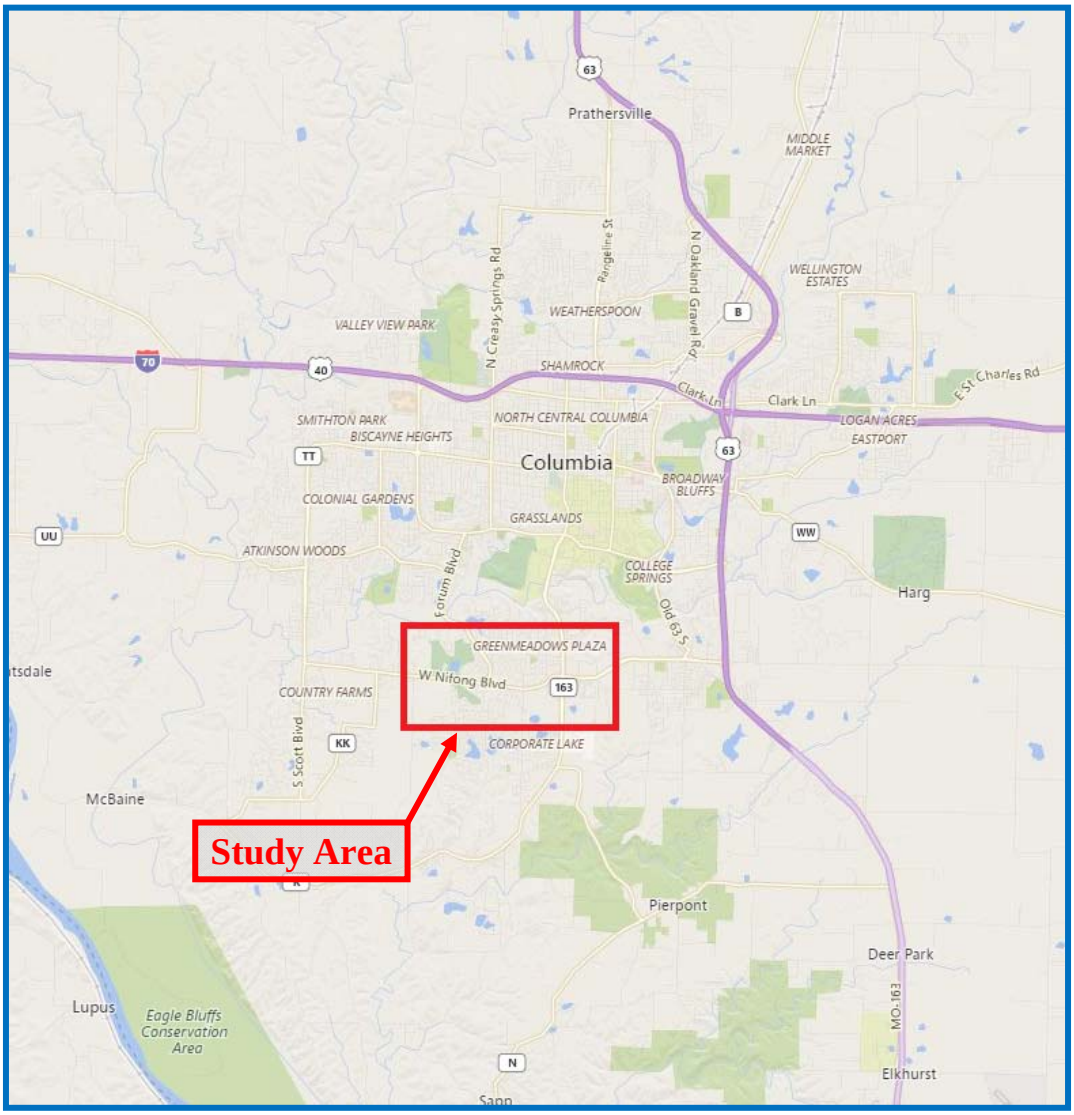


Figure II-1: Project Study Area (Columbia Region Shown)

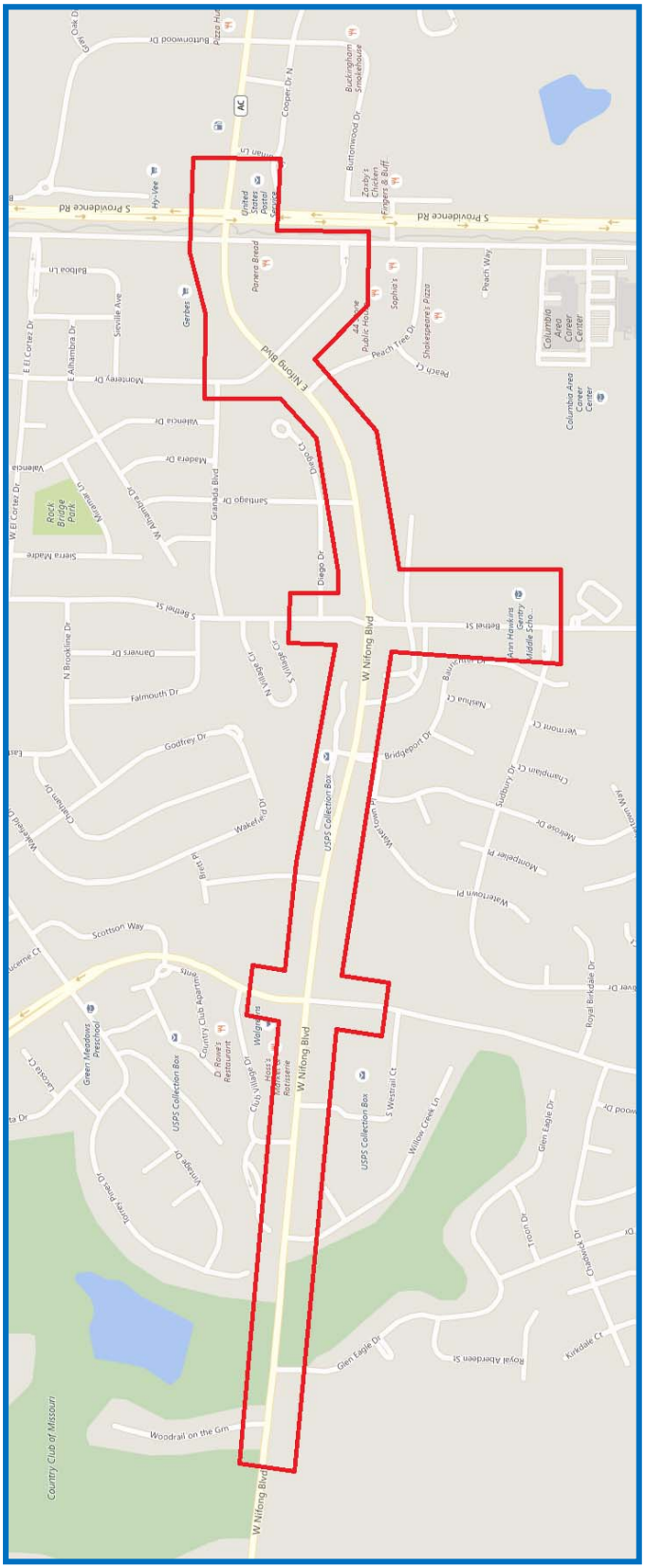


Figure II-2: Nifong Blvd. Study Area

In detail, the study area includes the following:

- Nifong intersections:
  - Providence Road
  - Bank Commercial Drive
  - Gerbes Commercial Drive
  - Urgent Care Commercial Drive
  - Phillips 66 Commercial Drive
  - Monterey Dr
  - Peachtree Dr
  - Aurora
  - Santiago/Mixed Use Commercial 3 Drive
  - Mixed Use Commercial 2 Drive
  - Bethel St
  - Bailey
  - Baurichter/Stone Bridge
  - Barrington/Hospital East
  - Hospital West
  - Forum Boulevard
  - Walgreens Commercial Drive
  - West Rail Court
  - Club Village Drive
  - Willowcreek Lane
  - Gleneagle Drive
  - Woodrail on the Glen
- Bethel:
  - Mixed Use Commercial 1 Drive
  - Bailey
  - Middle School Bus Out Drive
  - Middle School Bus In Drive
  - Middle School Out Drive
  - Sudbury/Middle School In Drive
- West Outer Road:
  - Monterey
  - Providence access
  - Peachtree

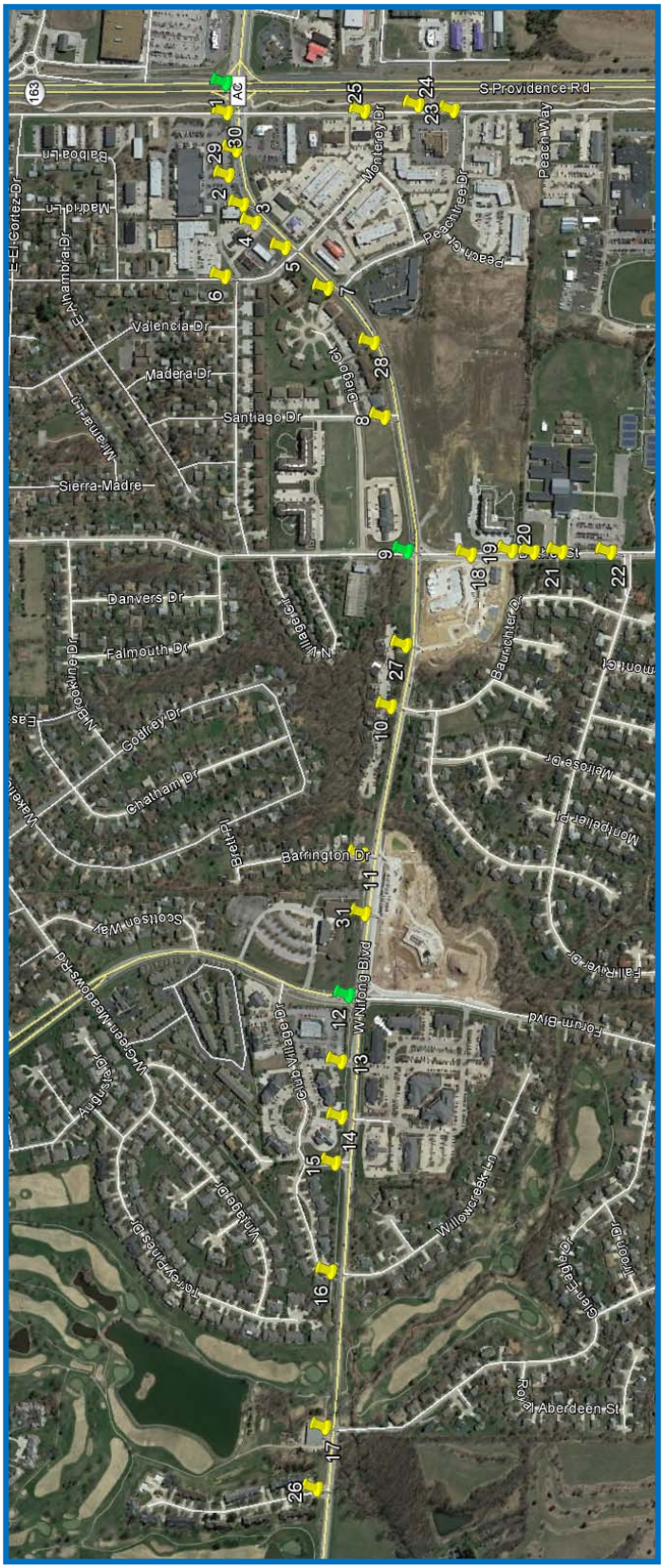


Figure II-3: Nifong Blvd. Study Intersections

B. Study Roadways

The Nifong study area can largely be described as a mixture of suburban and mixed use commercial, with Nifong Boulevard classified as a two-lane Major Arterial, serving as a principal east-west route, which is an important corridor that connects other key north-south routes such as Providence/163, Forum Blvd, and roads outside the study area such as Scott Blvd and US-63. It also provides connections to other minor arterials and collectors along the corridor, in addition to providing access to numerous retail destinations, employment centers, restaurants, and businesses. The posted speed limit is 40 miles per hour. Shoulders are present along most of the corridor, with sidewalks located infrequently where newer commercial developments have made improvements. There are no bicycle lane markings or signage along the corridor west of Providence Road.

Bethel Street is a two-lane Neighborhood Collector, with a posted speed limit of 30 miles per hour. Curb and gutter, bike lanes, and sidewalk are present along both sides of the road. Gentry Middle School is located to the south of Nifong Boulevard and is a notable generator of traffic.

Forum Boulevard is a two-lane Minor Arterial to the north with a posted speed limit of 35 miles per hour. It is classified as a Neighborhood Collector to the south, with a posted speed limit of 30 miles per hour. Curb and gutter, bike lanes, and sidewalk are present along both sides of the road.

The remaining roadways in the study area are classified as Local Residential or unclassified local streets. See ***Appendix B*** for the CATSO Major Roadway Plan Functional Classification map.

C. Data Collection

Video based turning movement counts were collected by TERRA Engineering, Ltd and analyzed by Miovision Technologies. Multiple cameras were placed at each location and captured video from 7AM to 7PM during the week of January 24th to January 26th, 2017, to determine morning and afternoon peak periods. Traffic counts were obtained for bicycles, pedestrians, articulated trucks, buses and single-unit (SU) trucks, and light vehicles. It should be noted that the academic calendar was reviewed to confirm public schools and the University of Missouri were in session to ensure that data was collected during a normal school term.

Historic crash data was obtained for the Nifong corridor from the City of Columbia. The data specified the number of crashes, crash severity (Property damage only, minor injury, disabling injury, fatal), and type of crash (i.e. rear end, head-on).

D. Existing Traffic Volumes

The peak periods were determined to occur from 7:15-8:15 AM and 4:45-5:45 PM for the entire study area. Examination of the video files was also used as an aid to help determine origin-destination paths between closely spaced signals and in order to gain a greater understanding of the existing operational conditions. The weekday school dismissal peak hour occurred between 2:30-3:30 PM, and in general the study area PM peak hour volumes were greater than the volumes during the school dismissal peak hour. Peak hour traffic volume maps are available in ***Appendix A.***

III. STUDY METHODOLOGY

A. Operational Approach

The existing and forecasted traffic volumes were assessed by performing capacity studies of the various intersections for several alternatives within the study area. Each capacity study is evaluated based on many characteristics, including traffic volumes (existing & forecasted), intersection geometry, and unsignalized or signalized intersection traffic control. Each of the different traffic tools (Trafficware Synchro v10 and SimTraffic) were used in the study, taking advantage of each software package, where appropriate, to generate results for analysis and comparison.

B. Synchro/HCS2010

Synchro (version 10) is a macroscopic software package by Trafficware, which provides traffic analysis and signal timing optimization. It supports the Highway Capacity Manual's methodology (2000 & 2010) for unsignalized/signalized intersections and roundabouts. Synchro also implements the Intersection Capacity Utilization method for determining intersection capacity. The software is familiar among traffic engineers for adjusting and improving timing plans at signalized intersections.

The Highway Capacity Software (HCS 2010) is a suite of software tools developed to implement the methodologies outlined in the Highway Capacity Manual (2010) for urban streets, signalized intersections, and interchange ramp terminals. This study used Synchro for signal timing optimization, and outputted HCS 2010 reports for intersection performance.

The traffic performance measures were graded using levels of service in accordance with the Highway Capacity Manual (HCM), last updated by the Transportation Research Board in 2010. Levels of services (LOS), which range from LOS A (free flow) to LOS F (oversaturated), are measures of traffic flow that consider factors such as speed, delay, interruptions, safety, and driver comfort and convenience. LOS C, which is commonly used for highway design purposes, represents a roadway with volumes utilizing approximately 70 to 80 percent of its capacity. For suburban and urban areas, a LOS D is typically used as the threshold for acceptable performance in peak period conditions.

For intersections, levels of service criteria are based on delay. The criteria for signalized intersections reflect higher delay tolerances as compared to

unsignalized intersections because motorists are accustomed to and accept longer delays at signals. The thresholds for intersection levels of service are summarized in ***Table III-1***.

For arterial corridors, levels of service criteria are based on the average speed to traverse the corridor. More specifically, level of service is dictated by the average travel speed as a percentage of the free-flow speed, or the speed at which a motorist would travel if no traffic control devices or vehicle interactions were present. The arterial level of service thresholds are summarized in ***Table III-2***.

Table III-1: Intersection Level of Service Thresholds

Level of Service	Control Delay per Vehicle (sec/veh)	
	Signalized	**Unsignalized**
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

Table III-2: Arterial Level of Service Thresholds

Level of Service	Travel Speed as % of Free-Flow Speed
A	> 85%
B	> 67-85%
C	> 50-67%
D	> 40-50%
E	> 30-40%
F	< 30%

C. Simulation

SimTraffic (by Trafficware), is a leading microscopic software simulation program for vehicular and pedestrian-related traffic flow modeling. With SimTraffic, individual vehicles are modeled and displayed traversing a street network. SimTraffic models signalized and unsignalized intersections, as well as freeway sections with cars, trucks, pedestrians, and buses. Unlike a number of other modeling applications, SimTraffic animation is displayed while the simulation is performed.

IV. EXISTING CONDITIONS

A. Traffic Analysis

During the morning peak hour, volumes along the Nifong Boulevard corridor are significantly heavier in the eastbound direction, whereas in the afternoon peak hour, volumes are heavier in the westbound direction. Volumes at Bethel Street and Forum Boulevard are largely balanced from the north and south during both peak hours. Traffic visiting the commercial drives between Monterey and Providence is generally heavier during the PM peak hour, both entering and exiting, indicating higher customer turnover volume and less emphasis on employee shift change volume. Congestion, queue lengths, and arterial level of service was analyzed using SimTraffic. Max queue lengths seen in the SimTraffic simulations largely matched the field observations from the Miovision traffic count video. HCM2010 reports from Synchro were used to identify problems with volume-to-capacity (V/C), approach delay and level-of-service (LOS), and intersection wide LOS.

B. Providence Congestion

The intersection of Providence Road and Nifong Boulevard acts as a bottleneck on the eastern portion of the study area, mostly for westbound traffic. The traffic signal constrains the free flow of traffic and congestion in the westbound direction is exacerbated by the loss of the second through lane, which is dropped at Monterey. As a result, traffic tends to concentrate in the inside through lane, which can queue east towards Buttonwood Drive.

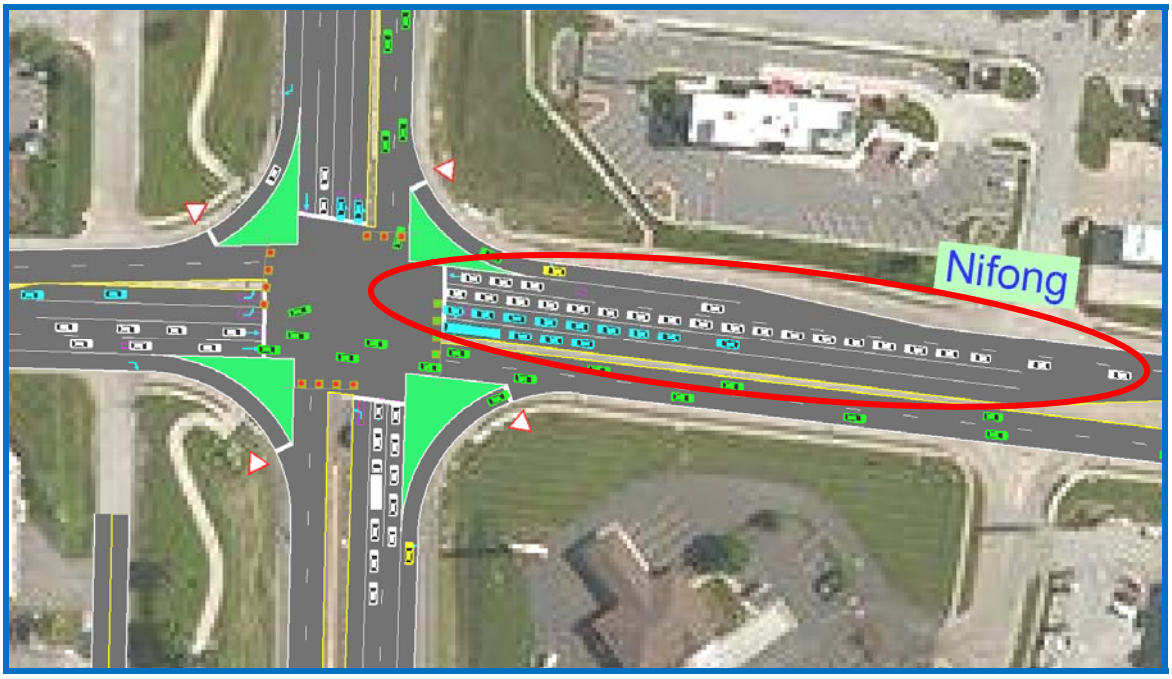


Figure IV-1: 2017 AM – Imbalanced WB lane utilization at Nifong and Providence

Imbalanced lane utilization mostly occurs during the AM peak hour, with slightly more even utilization during the PM peak hour due to higher volumes and drivers wishing to clear the signal in one cycle. However, the signal generally clears the queue during a full cycle length.

C. Bethel Congestion

The intersection of Bethel Street and Nifong Boulevard experiences eastbound congestion during the morning peak hour, with queues extending west beyond Bailey, sometimes reaching Baurichter. This congestion is due to the eastbound approach having a volume to capacity ratio of 1.14, which exceeds the available capacity. Motorists wishing to reach Gentry Middle school are sometimes observed traveling along Baurichter or Bailey during heavy peak flows to avoid the eastbound queues at Bethel. During the afternoon peak hour, westbound queues may extend to Santiago due to a volume to capacity ratio of 1.03 for the westbound approach.

Figure IV-2: 2017 AM – EB queue at Nifong and Bethel

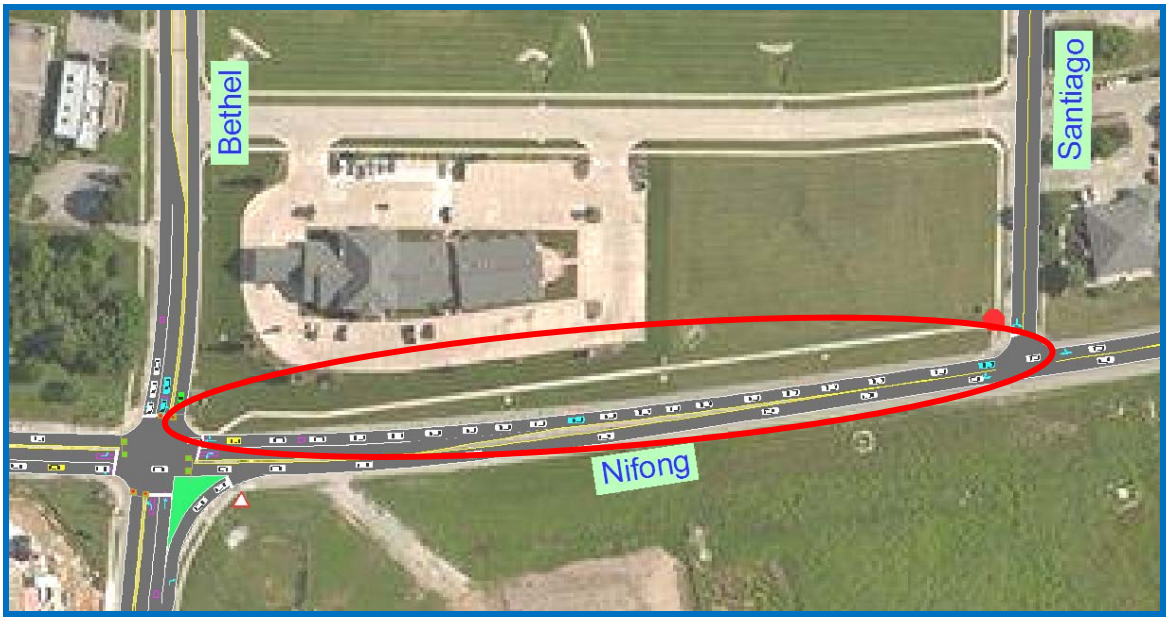


Figure IV-3: 2017 PM – WB queue at Nifong and Bethel

D. Forum Congestion

The intersection of Forum Boulevard and Nifong Boulevard experiences the same eastbound congestion during the AM peak as Bethel. Eastbound queues spill back through the Walgreens drive and at times through the West Rail Court intersection. During the PM peak, queues for the westbound approach may back up through the Hospital West entrance.

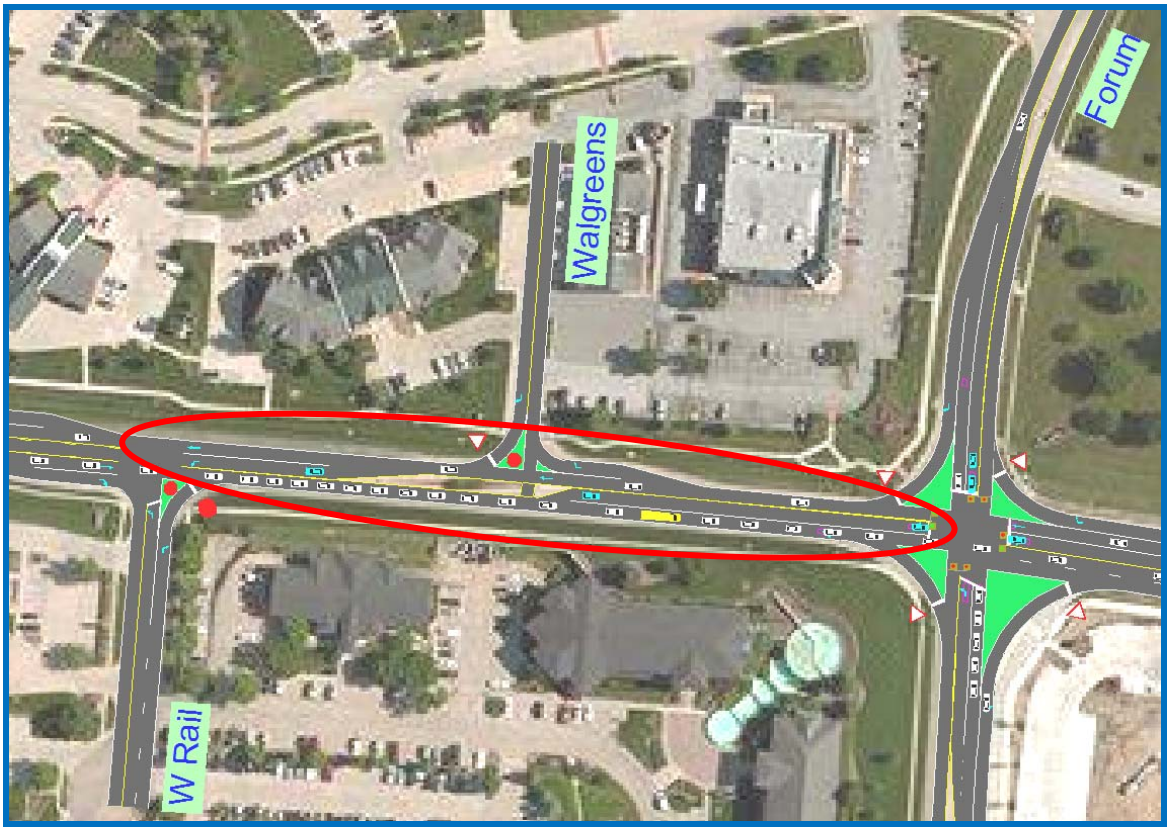


Figure IV-4: 2017 AM – EB queue at Nifong and Forum

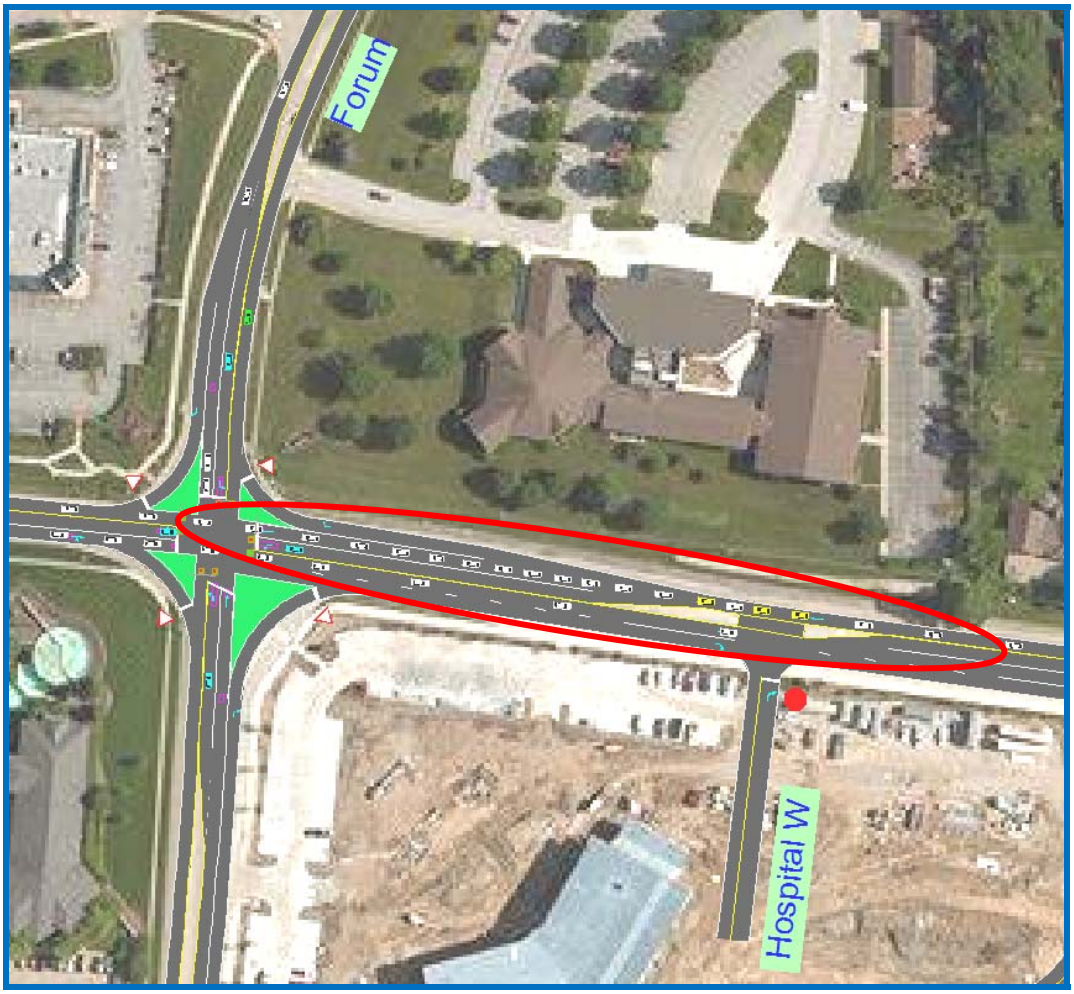


Figure IV-5: 2017 PM – WB queue at Nifong and Forum

E. Commercial Drive Congestion

Several commercial drives along Nifong Boulevard, between Monterey and Providence have long queues during peak periods. Motorists are required to make two-stage left turns while exiting the drives, which can be extremely difficult due to the heavy through volumes on Nifong Boulevard. Queue lengths observed in a typical simulation during the PM peak hour were between 75 and 175 feet at locations such as Gerbes, Phillips 66, and the Bank. Motorists are sometimes queued 3 to 5 vehicles deep, with some waiting 60 to 120 seconds to find an acceptable gap.

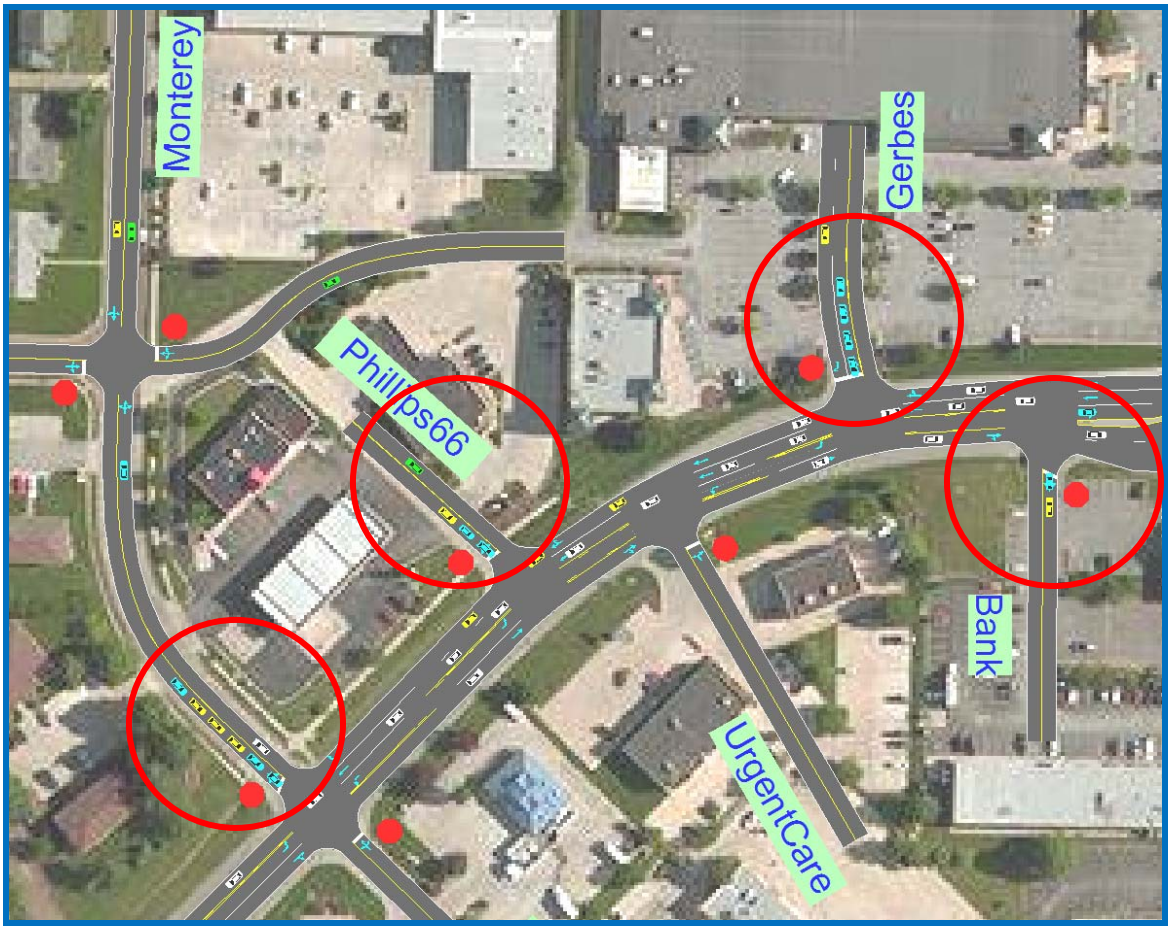


Figure IV-5: 2017 PM – Exiting vehicle queue at commercial drives

F. Arterial Segment LOS

Traffic performance for the corridor was graded using levels of service (LOS) in accordance with the Highway Capacity Manual. For arterial corridors, the LOS is dictated by the average travel speed as a percentage of the free flow speed. The existing segment LOS, by direction, are show in ***Table IV-1***. Conditions along Nifong Boulevard are generally acceptable, while conditions are less favorable the closer to the signalized intersections. On average the corridor has an arterial LOS of C for both morning and afternoon peak periods for the eastbound direction and a LOS D and LOS C for the morning and afternoon peak periods respectively for the westbound direction. As shown, conditions at Providence, Bethel, and Forum are currently at unacceptable levels of service.

Eastbound			Westbound		
Segment	AM	PM	Segment	AM	PM
Woodrail	A	A	Providence	F	F
Gleneagle	A	A	Bank	C	D
Willowcreek	A	A	Gerbes	B	C
Club Village	A	A	UrgentCare	B	C
W Rail	B	A	Phillips66	B	B
Walgreens	E	B	Monterey	B	B
Forum	F	F	Peachtree	A	B
Hospital W	B	B	Santiago	A	A
Hospital E	A	A	Bethel	C	D
Baurichter	A	A	Bailey	B	B
Bailey	B	B	Baurichter	A	B
Bethel	F	E	Barrington	A	A
Santiago	B	B	Hospital W	A	B
Peachtree	B	B	Forum	E	F
Monterey	C	B	Walgreens	B	C
Phillips66	B	B	W Rail	A	A
UrgentCare	B	B	Club Village	A	A
Gerbes	C	B	Willowcreek	A	A
Bank	C	B	Gleneagle	A	A
Providence	F	F	Woodrail	A	A
Average	C	C	Average	D	C

Table IV-1: Existing Nifong Boulevard Arterial Segment LOS

G. HCM Intersection Summary

There are three existing signalized intersections on Nifong Boulevard as well as twenty four existing unsignalized intersections within the study area. Only the signalized intersections and several of the worst performing unsignalized approaches are summarized below in ***Table IV-2***. The HCM 2010 performance reports closely match the results previously described from the SimTraffic observations. Complete HCM reports are available in ***Appendix C***.

Intersection or Approach	AM Peak Hour		PM Peak Hour	
	Delay (s)	LOS	Delay (s)	LOS
Providence & Nifong Intersection	44.5	D	45.9	D
Bethel & Nifong Intersection	68.5	E	47.2	D
Forum & Nifong Intersection	38.6	D	33.4	C
Bank Drive (Northbound approach) & Nifong	22.5	C	20.2	C
Gerbes Drive (Southbound approach) & Nifong	19.0	C	23.9	C
UrgentCare (Northbound approach) & Nifong	18.8	C	17.7	C
Phillips66 (Southbound approach) & Nifong	19.3	C	35.7	E
Monterey (Northbound approach) & Nifong	37.7	E	81.8	F
Monterey (Southbound approach) & Nifong	121.2	F	370.7	F
Santiago (Southbound approach) & Nifong	44.7	E	42.3	E
Baurichter (Southbound approach) & Nifong	50.7	F	122.8	F

Table IV-2: 2017 AM & PM HCM2010 Performance Summary

V. FORECASTED CONDITIONS

A. Traffic Forecasts

A 20-year forecasted design year was prepared to serve as the basis for evaluating the alternative designs to the no-build condition. The existing traffic counts, which were collected in 2017, were extrapolated forward in time to the estimated design year of 2040 (considering a build year of 2020). Full build-out trip volumes from the Bethel Mixed-Use site (gleaned from the CBB report, April 2012) were added to the model to account for anticipated developments beyond what would be accounted for in the background growth. Forecasted volumes were calculated using a compound growth formula shown below.

$$V_{FutureYear} = V_{ExistingYear} \times (1+\text{Growth Rate})^{\wedge(FY-EY)}$$

Equation V-1: Compound growth

Background traffic growth occurs organically over time due to generalized increases in traffic, which can be attributed to population and employment growth, land developments in the surrounding area, or simply additional trip-making by existing populations. Background growth is commonly expressed as an annual rate of traffic increase relative to existing volumes.

The rate of background growth was forecasted considering historic traffic counts as well as population and employment growth forecasts. The *CATSO 2040 Transportation Plan* lists an estimated population growth of +65,384, for the period of 2015-2040. Furthermore, the employment forecast for the Metro Area is 1.30%, which was gathered from the *Missouri Economic Research Information Center* and the *Show Me Model*. EFK Moen staff discussed growth rates with CBB staff, which are examining the Nifong corridor further west, and concluded that a 1% growth rate would be appropriate for 2040 forecasted design year, in addition to the known developments already discussed.

VI. NO-BUILD TRAFFIC ANALYSIS

A. Methodology

A 2040 no-build analysis was performed as a do-nothing alternative or benchmark from which to compare alternative designs. The 2040 no-build forecasted traffic volumes were input into the base model and the analysis was repeated using the same methodology as applied to the existing conditions. The increase in anticipated traffic will have significant impacts on the Nifong corridor.

B. Traffic Simulation Summary

Every intersection along the Nifong corridor is expected to see increases in delay and decreases in overall level of service. The change between simulations of the 2040 no-build and the existing condition is summarized in Table VI-1. Total travel time increased 265% in the AM and 284% in the PM peak periods. Total delay increased over 400% and total stops increased over 200% for both periods. Furthermore, the number of vehicles that entered the simulation do not match closely to the number that exited. This indicates that vehicles may enter the model at commercial drives or side streets and then get stuck waiting for a gap to turn onto Nifong Boulevard. Since they never travel the corridor they are not counted as exiting the model.

Simulation	2017 AM	2040 AM	Change	2017 PM	2040 PM	Change
Vehs Entered	1885	2542	N/A	1993	2615	N/A
Vehs Exited	1840	2391	N/A	1962	2448	N/A
Travel Time (hr)	75.6	200.7	+265%	81.8	232.3	+284%
Total Delay (hr)	36.3	153.0	+421%	37.3	177.4	+476%
Total Stops	2231	5147	+231%	2399	5020	+209%
Fuel Used (gal)	59.3	97.1	+164%	66.8	111.9	+168%

Table VI-1: Change between 2017-2040 No-build simulations

C. Arterial Segment LOS

Traffic performance for the corridor was graded using levels of service in accordance with the Highway Capacity Manual. Arterial segment LOS comparisons are made between the existing 2017 and the 2040 no-build in ***Table VI-2*** and ***Table VI-3***. Conditions along Nifong Boulevard are generally unacceptable, with queues at signalized intersections spilling back to other segments, which in turn decrease the free flow speed and level of service. On average the corridor has an arterial LOS of E for both morning and afternoon peak periods for the westbound direction and a LOS F and LOS E for the morning and afternoon peak periods respectively for the eastbound direction.

Eastbound				
Segment	2017 AM	2040 AM	2017 PM	2040 PM
Woodrail	A	F	A	A
Gleneagle	A	F	A	A
Willowcreek	A	F	A	A
Club Village	A	F	A	A
W Rail	B	F	A	C
Walgreens	E	F	B	F
Forum	F	F	F	F
Hospital W	B	E	B	C
Hospital E	A	F	A	F
Baurichter	A	F	A	F
Bailey	B	F	B	F
Bethel	F	F	E	F
Commercial 2	-	C	-	C
Santiago	B	C	B	C
Aurora	-	E	-	D
Peachtree	B	D	B	C
Monterey	C	C	B	C
Phillips66	B	B	B	B
UrgentCare	B	B	B	B
Gerbes	C	C	B	C
Bank	C	C	B	C
Providence	F	F	F	F
Average	C	F	C	E

Table VI-2: Eastbound Arterial LOS – 2017 Existing / 2040 No-Build

Westbound				
Segment	2017 AM	2040 AM	2017 PM	2040 PM
Providence	F	F	F	F
Bank	C	D	D	D
Gerbes	B	B	C	B
UrgentCare	B	B	C	C
Phillips66	B	B	B	B
Monterey	B	B	B	B
Peachtree	A	B	B	B
Aurora	-	D	-	C
Santiago	A	B	A	B
Commercial 2	-	B	-	C
Bethel	C	E	D	E
Bailey	B	B	B	C
Baurichter	A	B	B	B
Barrington	A	A	A	B
Hospital W	A	B	B	C
Forum	E	F	F	F
Walgreens	B	B	C	C
W Rail	A	A	A	A
Club Village	A	A	A	A
Willowcreek	A	A	A	B
Gleneagle	A	A	A	B
Woodrail	A	A	A	A
Total	D	E	C	E

Table VI-3: Westbound Arterial LOS – 2017 Existing / 2040 No-Build

D. Providence Congestion

The intersection of Providence Road and Nifong Boulevard will continue to act as a bottleneck on the eastern portion of the study area in the forecasted design year. The traffic signal constrains the free flow of traffic and congestion spills back beyond the scope of the model. As a result, not all of the traffic may enter the model.

Figure VI-1: Westbound spill back at Providence (2040 No-Build)

E. Bethel Congestion

The intersection of Bethel Street and Nifong Boulevard is expected to have extreme and prolonged eastbound congestion during the morning peak hour, with an almost unbroken queue extending west beyond the hospital, through the intersection of Forum Boulevard. During the afternoon peak hour, the queues build on all legs of the intersection, spilling back to unsignalized drives, making it difficult for vehicles to exit. The congestion is due to the signal being over capacity with only a single through lane in all directions.

Figure VI-2: Eastbound spill back at Bethel to Forum (2040 No-Build)

F. Forum Congestion

The intersection of Forum Boulevard and Nifong Boulevard experiences the same extreme congestion during the AM and PM peak periods as the rest of the corridor. Eastbound queues during the morning peak spill back

beyond the limits of the model. During the both peak periods, several of the auxiliary turning lanes are blocked by through traffic or also occurring is the reverse where auxiliary lane traffic spills back into the through lanes due to insufficient storage capacity.

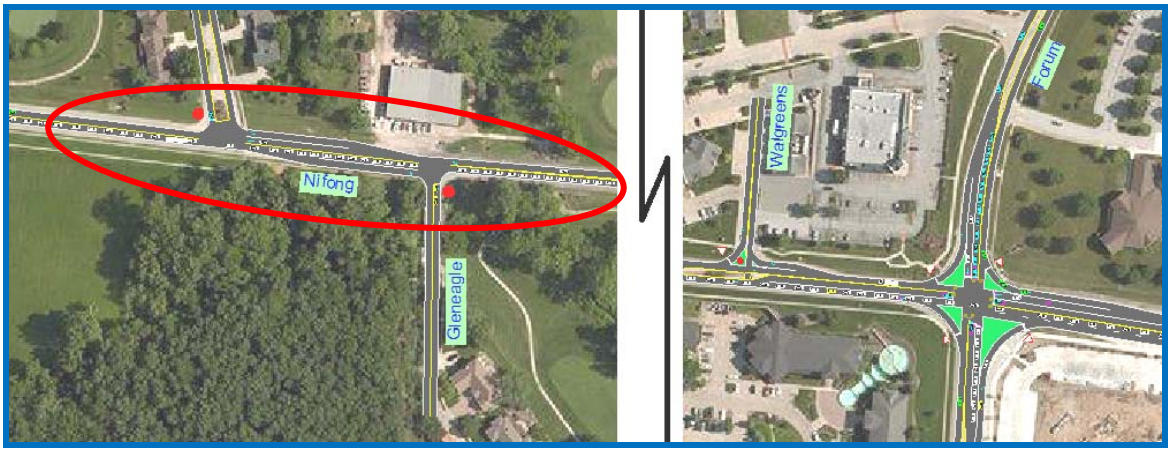


Figure VI-3: Eastbound spill back - Forum to Sinclair (2040 No-Build)

Figure VI-4: Blocked auxiliary lanes at Forum (2040 No-Build)

G. Commercial Drive Congestion

Performance at the commercial drives along Nifong Boulevard, between Monterey and Providence fail completely during the morning and afternoon peak periods. Motorists are nearly unable to find an acceptable gap to make a two-stage left turn, which results in gridlock for exiting vehicles. Queue lengths observed in a typical simulation during the PM peak hour exceeded the available length of the entrance drive. The worst performing entrances were Gerbes, Phillips 66, and the Bank, along with the two-way stop controlled intersection of Monterey.

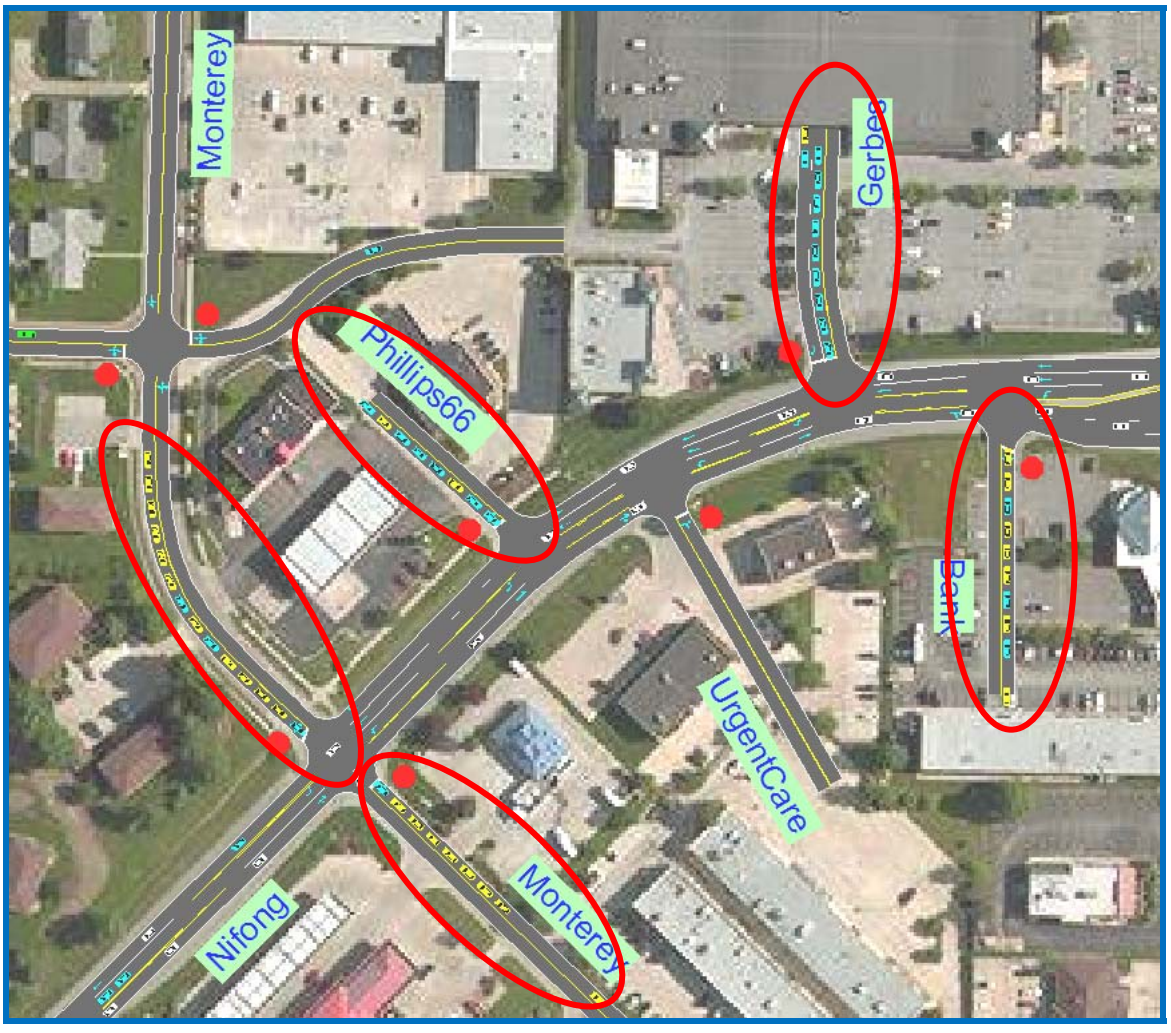


Figure VI-5: Extreme entrance queue gridlock (2040 No-Build)

H. HCM Intersection Summary

There are three existing signalized intersections and one additional signalized intersection of Aurora on Nifong Boulevard in the 2040 No-build scenario, as well as twenty nine unsignalized intersections within the study area. Only the signalized intersections and several of the worst performing unsignalized approaches are summarized below in ***Table VI-4***. The HCM 2010 performance reports closely match the results previously described from the SimTraffic observations. Complete HCM2010 reports are available in ***Appendix C***.

Intersection or Approach	AM Peak Hour				PM Peak Hour			
	2017		2040		2017		2040	
	Delay (s)	LOS	Delay (s)	LOS	Delay (s)	LOS	Delay (s)	LOS
Providence & Nifong Intersection	44.5	D	73.6	E	45.9	D	82.3	F
Bethel & Nifong Intersection	68.5	E	101.2	F	47.2	D	73.7	E
Forum & Nifong Intersection	38.6	D	63.9	E	33.4	C	57.9	E
Aurora & Nifong Intersection	-	-	48.4	D	-	-	13.0	B
Bank Drive (Northbound) & Nifong	22.5	C	45.6	E	20.2	C	40.2	E
Gerbes Drive (Southbound) & Nifong	19.0	C	31.7	D	23.9	C	61.3	F
UrgentCare (Northbound) & Nifong	18.8	C	29.2	D	17.7	C	27.4	D
Phillips66 (Southbound) & Nifong	19.3	C	30.2	D	35.7	E	112.9	F
Monterey (Northbound) & Nifong	37.7	E	351.6	F	81.8	F	4721.0	F
Monterey (Southbound) & Nifong	121.2	F	1678.4	F	370.7	F	6433.4	F
Santiago (Southbound) & Nifong	44.7	E	816.9	F	42.3	E	653.3	F
Baurichter (Southbound) & Nifong	50.7	F	244.0	F	122.8	F	1105.4	F

Table VI-4: HCM 2010 Performance – 2017 Existing / 2040 No-build

VII. ALTERNATIVE IMPROVEMENT OPTIONS

The Nifong corridor study alternative options development process began with a range of possibilities, which were reduced based on feasibility and performance. Increasing the capacity of the roadway alone is not the only answer to relieving traffic congestion. The use of access management, alternative modes of transportation, enhancements to intersections, and improvements to traffic signals can all assist in managing traffic congestion. Displays of the proposed alternatives that were studied are shown in ***Exhibits 1-4*** at the end of this report.

A. Bicycle & Pedestrian Accommodations

There are many pedestrian/bicycle traffic generators (neighborhoods, shopping centers, bike trails) within the study area. Therefore, consideration for safe bicycle and pedestrian access was a priority when developing each alternative for the corridor. Bicycle and pedestrian users, both within and crossing the corridor, can be fully integrated with all alternatives proposed in this report. There is ample room within the right-of-way to incorporate a multi-use path, bike lanes, and sidewalks along Nifong Boulevard. Also, every intersection within the corridor will be designed for pedestrian access, including crosswalks, curb ramps, pedestrian signals, and pedestrian detection.

B. Available Alternatives

5-Lane Alternative
The base alternative to be studied was a typical 5-lane section, with two lanes in either direction and a two-way center turn lane. Additional improvements like auxiliary turning lanes, right turn islands, permitted-protected flashing yellow signal heads, and more, were incorporated along the corridor where necessary. The only signalized intersections used in this alternative were located at Providence, Aurora, Bethel, and Forum.

5-Lane Alternative – Commercial Drive ¾ Access
This alternative uses the base 5-lane typical section, but adds restrictions to access at the commercial drives between Monterey and Providence. The drives would be configured as ¾ access, i.e. left turns out of the drive are not allowed. Left and right turns into the drive from Nifong would be allowed, along with right turns out of the drive, being channeled through a raised island to prevent left turns. Furthermore, a signal at Monterey would be incorporated to allow the affected motorists from the commercial drives to turn left onto Nifong Boulevard.

5-Lane Alternative – Center Median
A continuation or expansion of access management principles for the commercial drives necessitated exploring a center median alternative. Access to the commercial drives would be restricted to right-in right-out traffic, with raised islands at the entrances, along with a raised center median from Providence to Monterey. Westbound left turns, into the drives from Nifong, would be directed to a U-turn at Monterey, where they would turnaround and head east to make a right turn into the drive. Eastbound left turns, into the drives from Nifong, would make a left turn at the new Monterey signal, where they could then access the gas station and grocery store from Monterey and Granada.

5-Lane Alternative – Roundabouts
Instead of signalizing the intersections of Forum and Bethel with Nifong, a 2-lane roundabout would be incorporated at each location. The base 5-lane alternative typical section would be used along Nifong between the intersections. The remaining portion of the corridor to the east of Bethel utilized the ¾ access alternative, but any of the remaining alternatives are compatible with this alternative.

Road Diet
One alternative that was not analyzed with Synchro or SimTraffic is the Road Diet concept. Typically a four-lane undivided highway is converted to a three-lane section, with the reduction of lanes allowing for bike lanes, transit lanes, and/or on-street parking. Due to the 2040 No-Build condition having a similar layout as a Road Diet in regards to the number of through lanes at the signalized intersections, it was determined that performance of a Road Diet concept would be comparable to the 2040 No-build. Therefore, further examination was not conducted as a possible alternative build option.

VIII. TRAFFIC ANALYSIS OF ALTERNATIVES

A. Traffic Simulation Summary

Considering the huge growth potential in the study area for the design year of 2040, almost any improvements along the Nifong corridor are expected to decrease delay and increase overall level of service. However, not all of the alternative options offer the same level of improvements to the corridor. Multiple SimTraffic simulations were performed on all alternatives to help quantifiably compare the potential for improvement.

All four of the build alternatives (5-Lane, 5-Lane+3/4, 5-Lane+Median, 5-Lane+Roundabouts) have mostly balanced vehicle counts entering and exiting the model, indicating that motorists who may enter at a side street or commercial drive are able to access the corridor and exit the model. This is an improvement over the 2040 No-build condition, where over 6% of vehicles were not counted as exiting the model. Furthermore, there is an increase in the total number of vehicles who are able to enter the model when compared to the 2040 No-build condition. This is attributed to the reduction or elimination of the queue spill back seen in the No-build model, where vehicles were never able to enter the model at locations such as the westbound approach of Nifong Boulevard at Providence Road, or several of the commercial drives.

The option that offers the greatest total improvement between simulations of the 2040 No-build and the proposed alternative, in the AM and PM peak periods, is the 5-lane typical with ¾ access commercial drives and a signal at Monterey. The AM and PM periods are summarized in ***Table VIII-1*** and ***Table VIII-2***. Total travel time decreased 47% in the AM and 44% in the PM peak periods. Total delay decreased 66% & 60% and total stops decreased 37% & 15% for the AM & PM periods, respectively.

Simulation	2017 Existing	2040 No-Build	5-Lane	% Change from No-build	5-Lane + 3/4	% Change from No-build	5-Lane + Median	% Change from No-build	5-Lane + Roundabouts	% Change from No-build
Vehs Entered	1885	2542	2619	N/A	2671	N/A	2649	N/A	2619	N/A
Vehs Exited	1840	2391	2598	N/A	2675	N/A	2659	N/A	2563	N/A
Travel Time (hr)	75.6	200.7	102.9	-49%	105.9	-47%	108.4	-46%	133.5	-33%
Total Delay (hr)	36.3	153.0	49.3	-68%	52.1	-66%	54.5	-64%	78.5	-49%
Total Stops	2231	5147	3154	-39%	3253	-37%	3422	-34%	3825	-26%
Fuel Used (gal)	59.3	97.1	83.4	-14%	84.3	-13%	84.8	-13%	89.8	-8%

Table VIII-1: Change between simulation models – AM Peak Period

Simulation	2017 Existing	2040 No-Build	5-Lane	% Change from No-build	5-Lane + 3/4	% Change from No-build	5-Lane + Median	% Change from No-build	5-Lane + Roundabouts	% Change from No-build
Vehs Entered	1993	2615	2759	N/A	2781	N/A	2754	N/A	2631	N/A
Vehs Exited	1962	2448	2705	N/A	2745	N/A	2739	N/A	2634	N/A
Travel Time (hr)	81.8	232.3	150.8	-35%	130.2	-44%	142.9	-38%	151.5	-35%
Total Delay (hr)	37.3	177.4	91.7	-48%	70.7	-60%	84.0	-53%	92.5	-48%
Total Stops	2399	5020	4166	-17%	4255	-15%	4654	-7%	4306	-14%
Fuel Used (gal)	66.8	111.9	100.8	-10%	97.1	-13%	99.2	-11%	99.8	-11%

Table VIII-2: Change between simulation models – PM Peak Period

The 5-Lane alternative has slightly more improvement over the 5-Lane+3/4 alternative in the AM peak hour, but when totaling the travel time and delay for both the AM and PM peak hours, the 5-Lane+3/4 alternative has a greater reduction collectively.

B. Arterial Segment LOS

Traffic performance for the corridor was graded using the same methodology as for the existing condition and 2040 no-build scenarios. Arterial segment LOS comparisons are made between the existing 2017, 2040 no-build, and the four 5-lane alternatives for both the eastbound and westbound directions in the AM and PM peak periods, which are located in ***Table VIII-3*** through ***Table VIII-6***. Conditions along Nifong Boulevard are generally acceptable for all build alternatives, except for the roundabout option. On average the corridor has a total arterial LOS of C both morning and afternoon peak periods for the eastbound direction and a LOS C or D for the morning and afternoon peak periods for the westbound direction.

Arterial segment level of service between Providence and Monterey is slightly better under the base 5-lane alternative, but this performance is at the expense of poor driveway LOS. Motorists are unable to turn onto Nifong Boulevard from the commercial drives, consequently speeds for through traffic are slightly higher than the other alternatives that have more access management and allow for additional traffic to enter the corridor at the commercial drives and the proposed signal at Monterey Drive.

The roundabout alternative has an unacceptable segment LOS of F at Forum Boulevard during the morning peak heading eastbound, and during the evening peak heading westbound. The remaining segments have comparable levels of service to the other alternatives.

The 5-lane with median alternative has a westbound arterial LOS E in the PM peak at Monterey. This level of service is slightly lower when compared to the other alternatives and is due to the additional westbound u-turn traffic slowing to access the left turn bay.

All alternatives show an arterial LOS of F at Providence Road. This is attributed to the poor performance of the intersection and no planned improvements incorporated in any of the alternative options. Improvements to the intersection, beyond lengthening eastbound turn bays, are beyond the scope of this study.

Eastbound - AM						
Segment	2017 Existing	2040 No-Build	5-Lane	5-Lane + 3/4	5-Lane + Median	5-Lane + Roundabouts
Woodrail	A	F	A	A	A	A
Gleneagle	A	F	B	A	B	B
Willowcreek	A	F	A	A	A	A
Club Village	A	F	A	A	A	A
W Rail	B	F	A	A	A	A
Walgreens	E	F	B	B	B	C
Forum	F	F	D	D	D	F
Hospital W	B	E	B	B	B	D
Hospital E	A	F	A	A	A	A
Baurichter	A	F	A	A	A	A
Bailey	B	F	B	B	B	A
Bethel	F	F	D	D	D	D
Commercial 2	-	C	C	C	C	D
Santiago	B	C	B	B	B	B
Aurora	-	E	C	B	B	C
Peachtree	B	D	B	B	B	B
Monterey	C	C	B	C	C	C
Phillips66	B	B	B	B	C	C
UrgentCare	B	B	B	B	B	C
Gerbes	C	C	C	D	D	D
Bank	C	C	D	D	D	E
Providence	F	F	F	F	F	F
Average	C	F	C	C	C	C

Table VIII-3: Eastbound AM Arterial LOS – Alternative Comparison

Eastbound - PM						
Segment	2017 Existing	2040 No-Build	5-Lane	5-Lane + 3/4	5-Lane + Median	5-Lane + Roundabouts
Woodrail	A	A	A	A	A	A
Gleneagle	A	A	A	A	A	A
Willowcreek	A	A	A	A	A	A
Club Village	A	A	A	A	A	A
W Rail	A	C	A	A	A	A
Walgreens	B	F	B	B	B	B
Forum	F	F	E	D	D	C
Hospital W	B	C	B	B	B	C
Hospital E	A	F	A	A	A	A
Baurichter	A	F	A	A	A	A
Bailey	B	F	B	A	A	A
Bethel	E	F	D	D	D	C
Commercial 2	-	C	C	C	C	D
Santiago	B	C	B	B	B	A
Aurora	-	D	C	C	C	C
Peachtree	B	C	B	B	C	B
Monterey	B	C	B	D	D	C
Phillips66	B	B	B	B	D	B
UrgentCare	B	B	B	B	D	B
Gerbes	B	C	C	D	D	D
Bank	B	C	C	D	E	D
Providence	F	F	F	F	F	F
Average	C	E	C	C	C	C

Table VIII-4: Eastbound PM Arterial LOS – Alternative Comparison

Westbound - AM						
Segment	2017 Existing	2040 No-Build	5-Lane	5-Lane + 3/4	5-Lane + Median	5-Lane + Roundabouts
Providence	F	F	F	F	F	F
Bank	C	D	D	C	D	C
Gerbes	B	B	B	B	B	B
UrgentCare	B	B	B	B	B	B
Phillips66	B	B	B	B	B	B
Monterey	B	B	B	C	C	B
Peachtree	A	B	A	B	B	A
Aurora	-	D	B	C	C	C
Santiago	A	B	A	B	B	B
Commercial 2	-	B	A	A	A	A
Bethel	C	E	D	D	C	C
Bailey	B	B	B	B	A	C
Baurichter	A	B	A	A	A	A
Barrington	A	A	A	A	A	A
Hospital W	A	B	A	A	A	A
Forum	E	F	D	D	D	D
Walgreens	B	B	C	C	C	D
W Rail	A	A	A	A	A	A
Club Village	A	A	A	A	A	A
Willowcreek	A	A	A	A	A	A
Gleneagle	A	A	A	A	A	A
Woodrail	A	A	A	A	A	A
Total	D	E	C	C	C	D

Table VIII-5: Westbound AM Arterial LOS – Alternative Comparison

Westbound - PM						
Segment	2017 Existing	2040 No-Build	5-Lane	5-Lane + 3/4	5-Lane + Median	5-Lane + Roundabouts
Providence	F	F	F	F	F	F
Bank	D	D	D	D	D	D
Gerbes	C	B	B	C	D	C
UrgentCare	C	C	B	C	E	C
Phillips66	B	B	B	D	E	D
Monterey	B	B	B	D	E	E
Peachtree	B	B	B	C	C	B
Aurora	-	C	C	B	B	B
Santiago	A	B	B	A	B	A
Commercial 2	-	C	A	B	B	B
Bethel	D	E	D	D	D	D
Bailey	B	C	B	B	B	C
Baurichter	B	B	A	A	A	A
Barrington	A	B	A	A	A	A
Hospital W	B	C	A	B	B	E
Forum	F	F	D	D	D	F
Walgreens	C	C	D	D	D	D
W Rail	A	A	B	B	B	A
Club Village	A	A	A	A	A	A
Willowcreek	A	B	B	B	A	A
Gleneagle	A	B	B	B	B	A
Woodrail	A	A	A	A	B	A
Total	C	E	D	D	D	D

Table VIII-6: Westbound PM Arterial LOS – Alternative Comparison

C. HCM Intersection Summary

A summary of only signalized intersections (or roundabouts) and several of the worst performing unsignalized approaches are summarized below in ***Table VIII-7***. The HCM 2010 performance reports closely match the results previously described from the SimTraffic simulations. Overall, the alternative with the least amount of intersection delay and highest LOS is the 5-lane with ¾ drive access option for both AM and PM peak periods. The commercial drives are all expected to see decreases in delay when compared to the 2040 No-build condition.

Intersection or Approach	AM Peak Hour											
	2017 Existing		2040 No-Build		5-Lane		5-Lane + 3/4		5-Lane + Median		5-Lane + Roundabouts	
	Delay (s)	LOS	Delay (s)	LOS	Delay (s)	LOS	Delay (s)	LOS	Delay (s)	LOS	Delay (s)	LOS
Providence & Nifong - Signal	44.5	D	73.6	E	69.8	E	65.3	E	68.3	E	65.3	E
Bethel & Nifong - Signal	68.5	E	101.2	F	31.3	C	22.6	C	22.6	C	40.0 *	E
Forum & Nifong - Signal	38.6	D	63.9	E	29.5	C	31.2	C	31.2	C	25.3 *	D
Aurora & Nifong - Signal	-	-	48.4	D	4.6	A	5.3	A	5.3	A	14.2	B
Monterey & Nifong - Signal	-	-	-	-	-	-	6.1	A	9.7	A	6.1	A
Bank Drive (Northbound) & Nifong	22.5	C	45.6	E	23.7	C	17.0	C	19.8	C	17.0	C
Gerbes Drive (Southbound) & Nifong	19.0	C	31.7	D	20.8	C	12.2	B	12.4	B	12.2	B
UrgentCare (Northbound) & Nifong	18.8	C	29.2	D	18.8	C	15.2	C	15.4	C	15.2	C
Phillips66 (Southbound) & Nifong	19.3	C	30.2	D	20.6	C	11.8	B	12.1	B	11.8	B
Monterey (Northbound) & Nifong	37.7	E	351.6	F	90.7	F	66.9	E	66.9	E	66.9	E
Monterey (Southbound) & Nifong	121.2	F	1678.4	F	347.5	F	58.7	E	58.7	E	58.7	E
Santiago (Southbound) & Nifong	44.7	E	816.9	F	103.6	F	103.6	F	103.6	F	103.6	F
Baurichter (Southbound) & Nifong	50.7	F	244.0	F	70.9	F	70.9	F	70.9	F	70.9	F

Table VIII-7: HCM2010 Performance – AM Peak Hour
*(*Roundabout LOS uses HCM thresholds for unsignalized intersections)*

Intersection or Approach	PM Peak Hour											
	2017 Existing		2040 No-Build		5-Lane		5-Lane + 3/4		5-Lane + Median		5-Lane + Roundabouts	
	Delay (s)	LOS	Delay (s)	LOS	Delay (s)	LOS	Delay (s)	LOS	Delay (s)	LOS	Delay (s)	LOS
Providence & Nifong - Signal	45.9	D	82.3	F	82.2	F	82.2	F	82.2	F	82.2	F
Bethel & Nifong - Signal	47.2	D	73.7	E	14.9	B	14.9	B	14.9	B	21.2 *	C
Forum & Nifong - Signal	33.4	C	57.9	E	40.2	D	40.2	D	40.2	D	40.2 *	E
Aurora & Nifong - Signal	-	-	13.0	B	5.8	A	5.8	A	5.8	A	12.9	B
Monterey & Nifong - Signal	-	-	-	-	-	-	23.8	C	27.2	C	23.8	C
Bank Drive (Northbound) & Nifong	20.2	C	40.2	E	20.6	C	15.9	C	18.7	C	15.9	C
Gerbes Drive (Southbound) & Nifong	23.9	C	61.3	F	47.0	E	29.3	D	31.0	D	29.3	D
UrgentCare (Northbound) & Nifong	17.7	C	27.4	D	16.1	C	14.9	B	15.0	C	14.9	B
Phillips66 (Southbound) & Nifong	35.7	E	112.9	F	77.2	F	18.9	C	19.7	C	18.9	C
Monterey (Northbound) & Nifong	81.8	F	4721.0	F	1024.1	F	46.0	D	44.1	D	46.0	D
Monterey (Southbound) & Nifong	370.7	F	6433.4	F	1957.0	F	46.4	D	44.5	D	46.4	D
Santiago (Southbound) & Nifong	42.3	E	653.3	F	155.3	F	155.3	F	155.3	F	155.3	F
Baurichter (Southbound) & Nifong	122.8	F	1105.4	F	430.1	F	430.1	F	430.1	F	430.1	F

Table VIII-8: HCM2010 Performance – PM Peak Hour
*(*Roundabout LOS uses HCM thresholds for unsignalized intersections)*

Performance of two approaches at stop-controlled intersections (Santiago & Baurichter/Stonebridge with Nifong) under all alternatives examined have an unacceptable LOS of F. The southbound approach at Santiago Drive is expected to operate with a delay of 155.3 seconds during the 2040 PM peak. Considering that the southbound volume is only 15 vehicles for

the 2040 PM peak, and that motorists can access the signalized intersections of Bethel and Monterey from Diego Court or Granada Boulevard, this level of service for the southbound approach may be acceptable with no plans to mitigate it.

The performance of the stop-controlled southbound approach at Baurichter/Stone Bridge and Nifong is expected to be a LOS F during the morning and evening peak periods. This approach is projected to carry 98 vehicles in the 2040 PM peak period. Motorists at this intersection have no other access beyond the single approach along Nifong Boulevard. Possible plans to mitigate this congestion include making the Stone Bridge intersection ¾ access and forcing exiting left turning motorists to make a right turn and proceed west to Forum to a possible U-turn lane. Other improvements may include a Green-Tee signalized intersection or a full 4-leg signalized intersection with Baurichter.

Complete HCM2010 reports for all alternative build options are available in ***Appendix C***.

D. Providence Congestion

Congestion at the intersection of Providence Road and Nifong Boulevard is largely unchanged between the 2040 No-build and all of the alternative options studied. It is expected to continue to act as a bottleneck on the eastern portion of the study area in the forecasted design year. The traffic signal constrains the free flow of traffic and congestion spills back to the east towards Buttonwood Drive. However, the queues are not as long when compared to the 2040 No-build, due to the addition of a second westbound through lane past Monterey in the 5-Lane typical section. This additional lane results in a more balanced lane usage for the westbound Nifong approach at Providence.

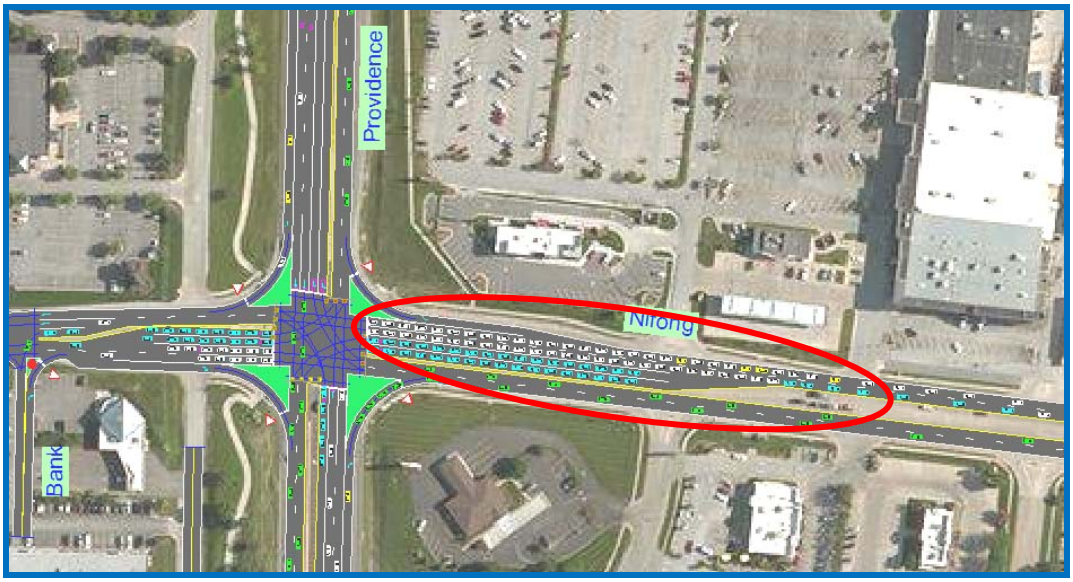


Figure VIII-1: Westbound Congestion at Providence

E. Bethel Congestion

The intersection of Bethel Street and Nifong Boulevard is expected to see improvement on all legs when comparing the signalized 5-Lane build options to the 2040 No-build scenario. The eastbound congestion during the morning peak hour is anticipated to be drastically reduced, with the queue extending west, just beyond the auxiliary right turn lane, not making it beyond Bailey Drive. During the afternoon peak hour, the queues are moderate and clear with each cycle of the signal, never extending beyond the Mixed-Use commercial drive to the east.

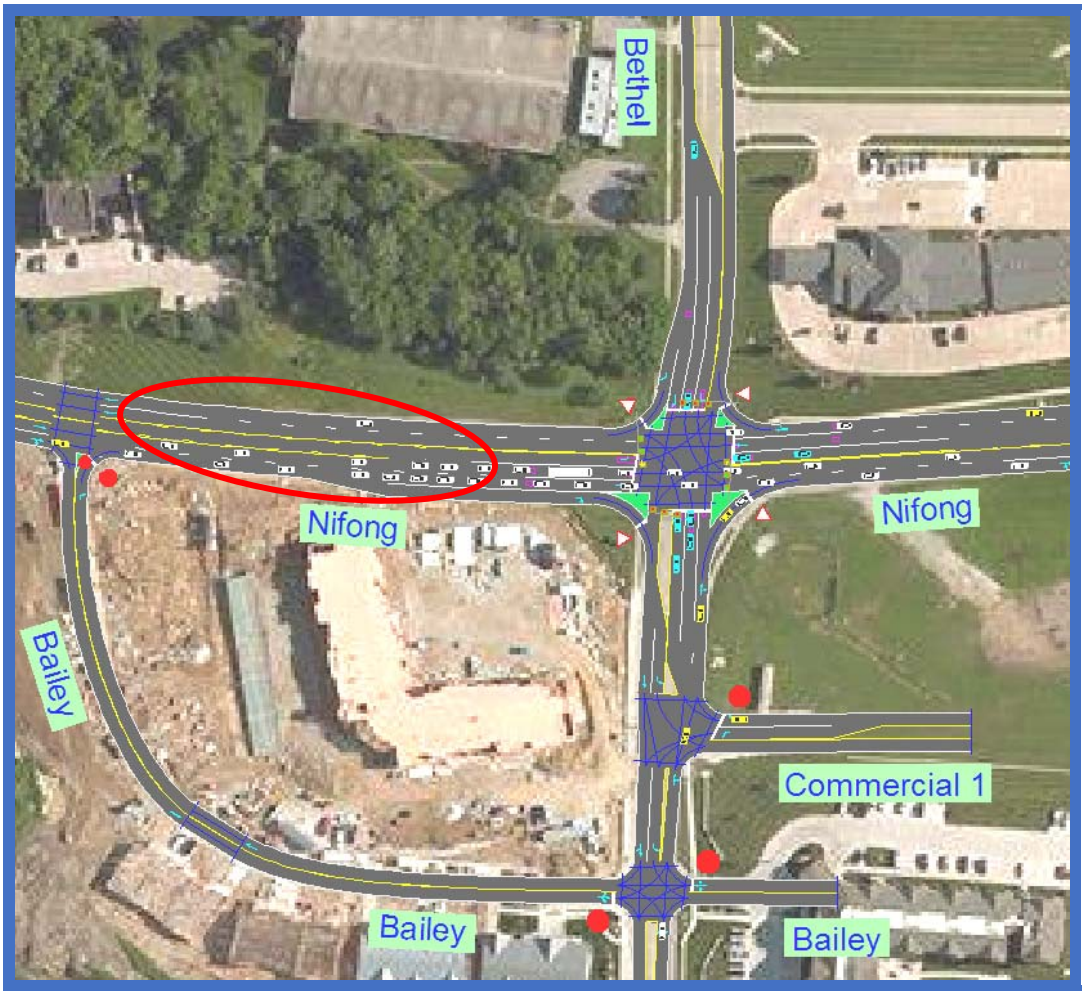


Figure VIII-2: Eastbound AM Congestion at Bethel

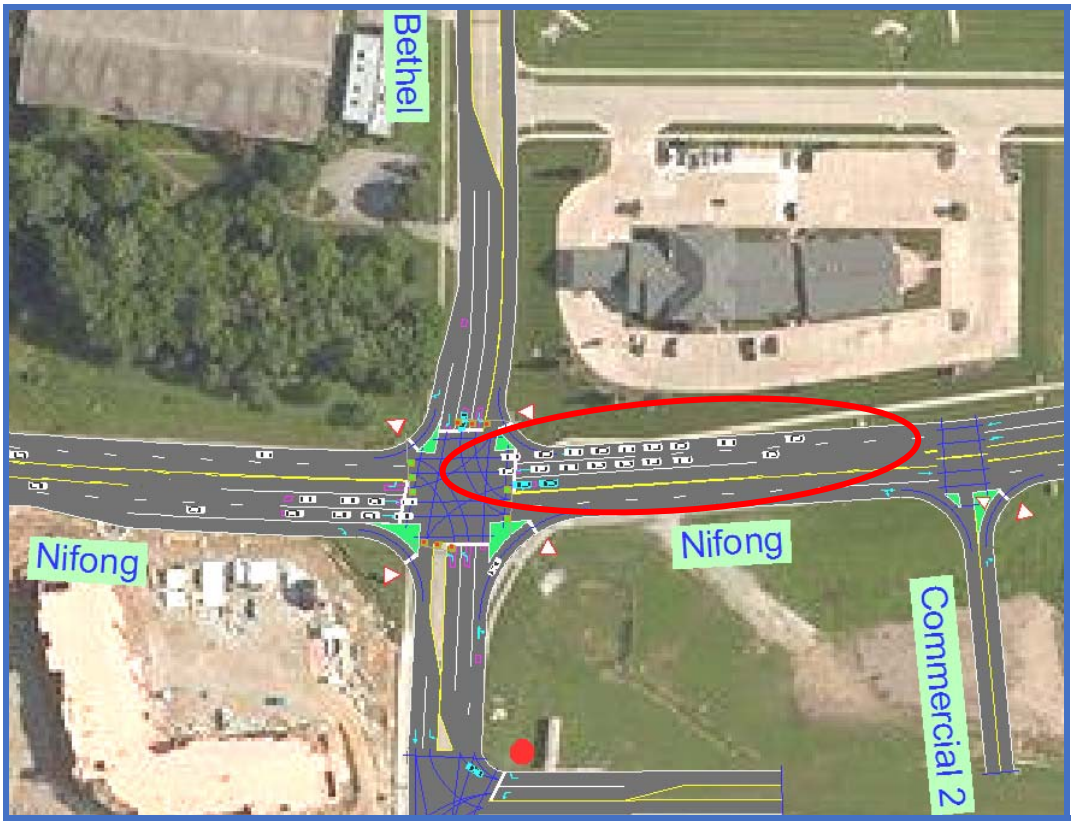


Figure VIII-3: Westbound PM Congestion at Bethel

Queues for the 5-lane roundabout option were unacceptable for both morning and afternoon peak periods. During the morning period, traffic is unable to enter the roundabout due to a high circulating flow and therefore backs up to the south beyond the Gentry middle school drives. During the afternoon period, the southbound leg of Bethel is unable to enter the roundabout due to the heavy westbound flow of traffic along Nifong, which results in queues extending north along Bethel past Diego Court. Right turn bypass lanes would be expected to have minimal performance impact due to the heavy through volumes along Nifong having a high circulating flow conflicting with the entering flow at Bethel.

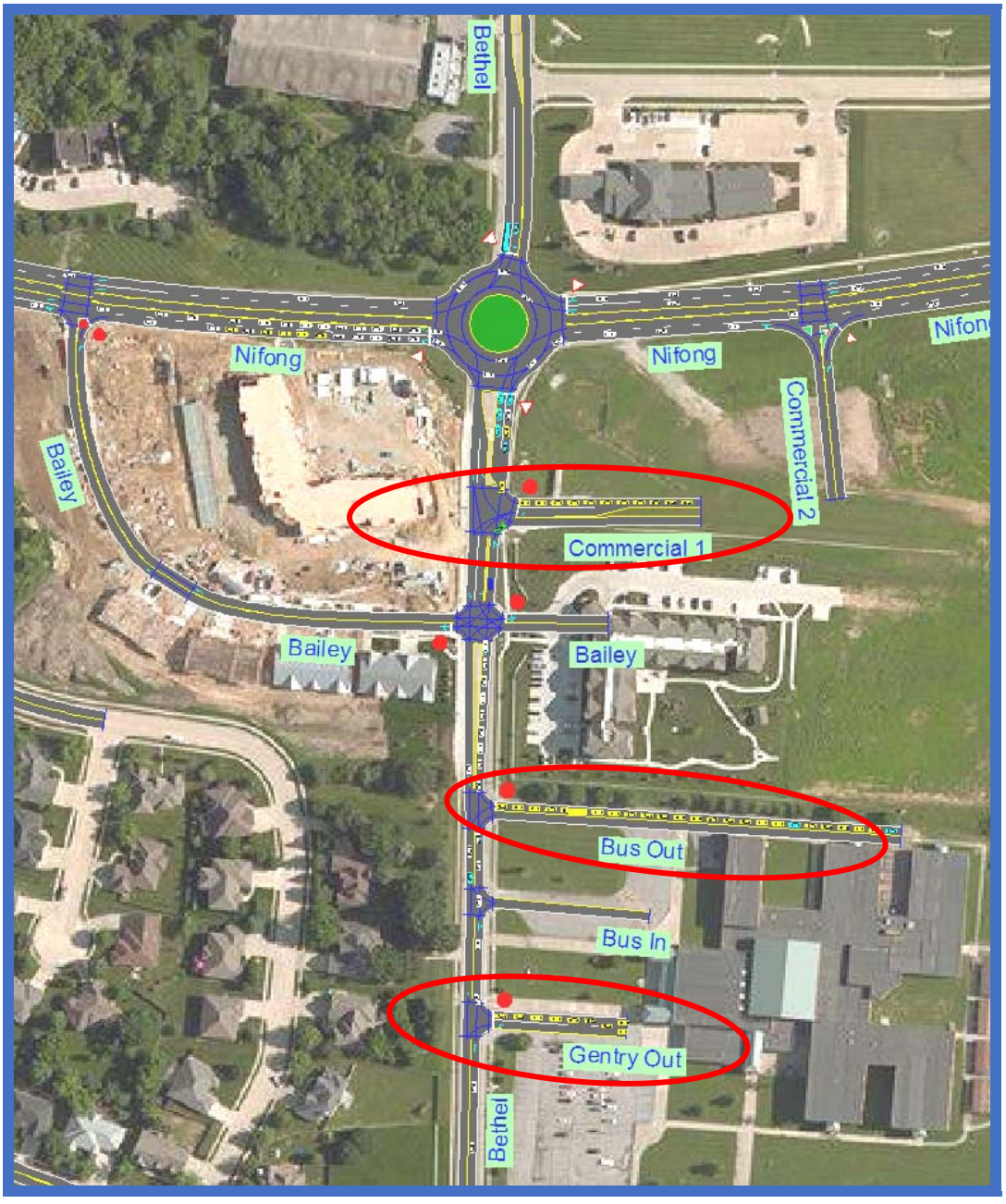


Figure VIII-4: AM Congestion at Bethel – Roundabout alternative

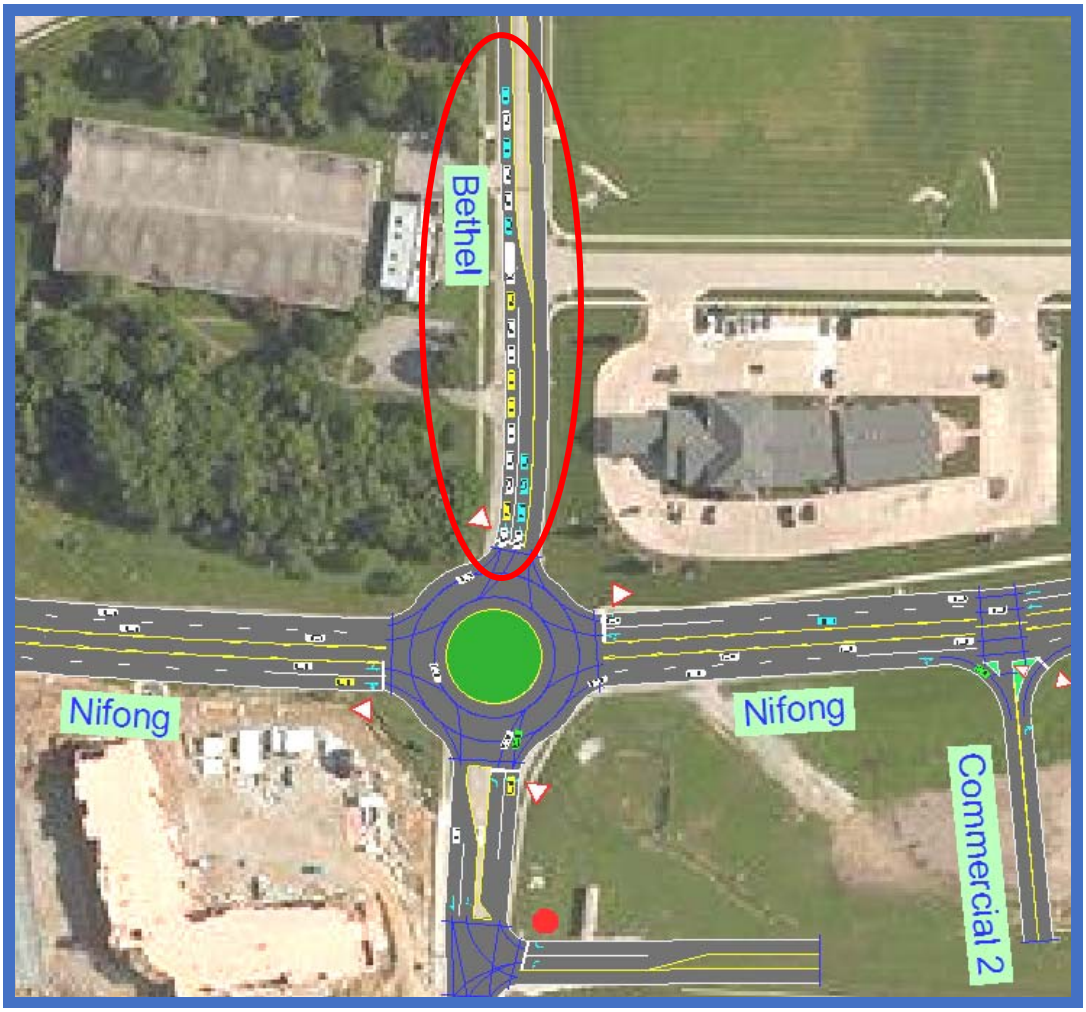


Figure VIII-5: PM Congestion at Bethel – Roundabout alternative

F. Forum Congestion

The intersection of Forum Boulevard and Nifong Boulevard experiences much improved conditions compared to the extreme congestion of the 2040 No-build. Eastbound queues during the morning peak are not expected to reach the Walgreens drive. During the afternoon peak period, westbound Nifong Boulevard traffic is not expected to queue beyond the west Hospital drive.

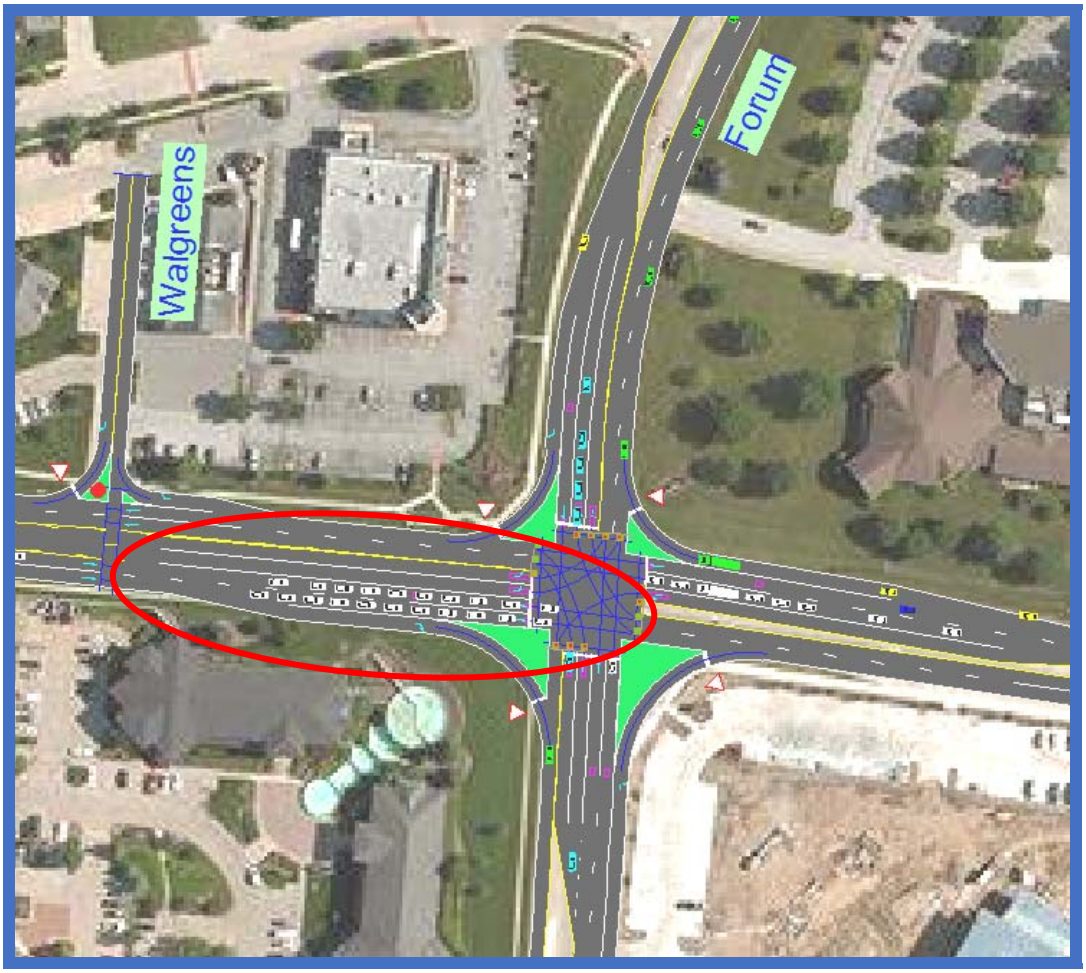


Figure VIII-6: AM Congestion at Forum – 5-Lane alternative

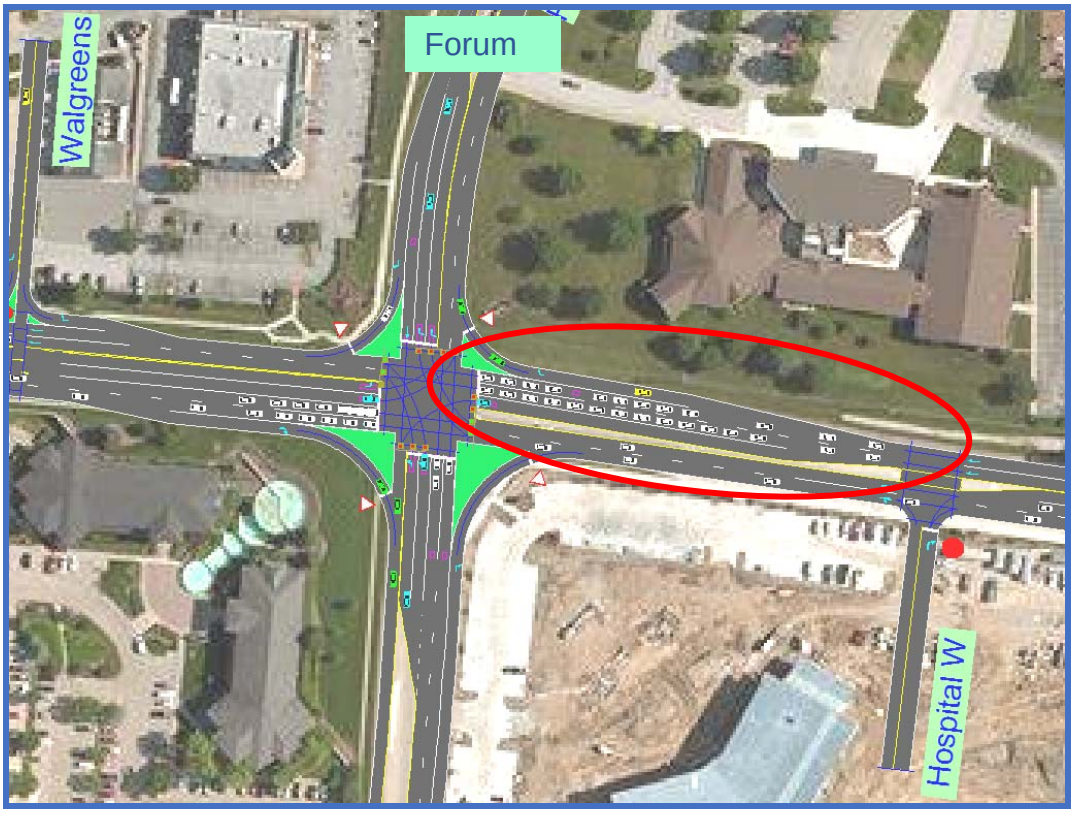


Figure VIII-7: PM Congestion at Forum – 5-Lane alternative

A 5-lane roundabout option at Forum is expected to produce unacceptably long queues for both morning and afternoon peak periods. During the morning period, northbound traffic is unable to enter the roundabout due to a high circulating flow and therefore backs up to the south beyond the hospital drives. During the afternoon period, the southbound leg of Forum is unable to enter the roundabout due to the heavy westbound flow of traffic along Nifong, which results in queues extending north along Forum past Diego Court. Right turn bypass lanes would be expected to have minimal performance impact due to the heavy through volumes along Nifong having a high circulating flow conflicting with the entering flow at Forum.

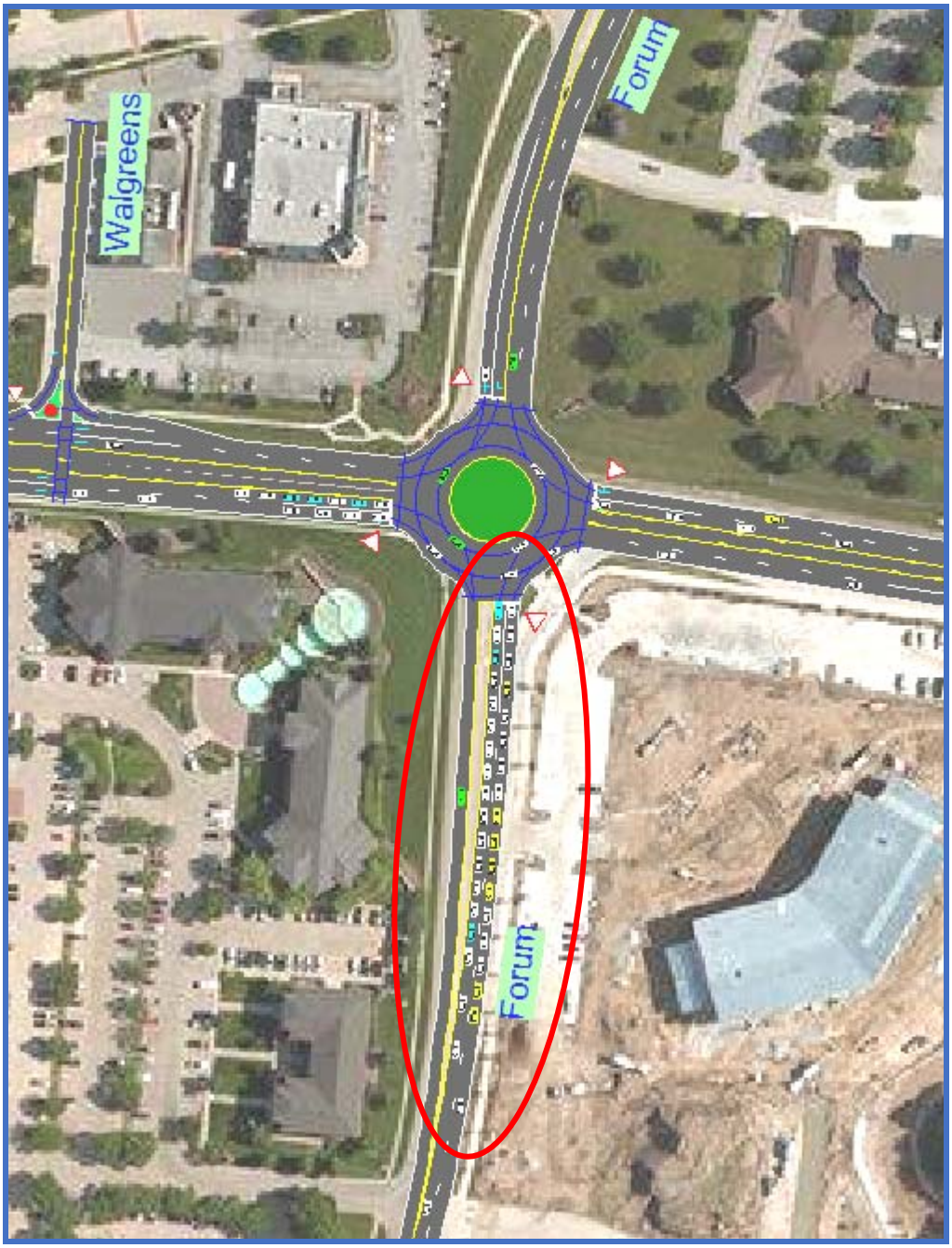


Figure VIII-7: AM Congestion at Forum – Roundabout alternative

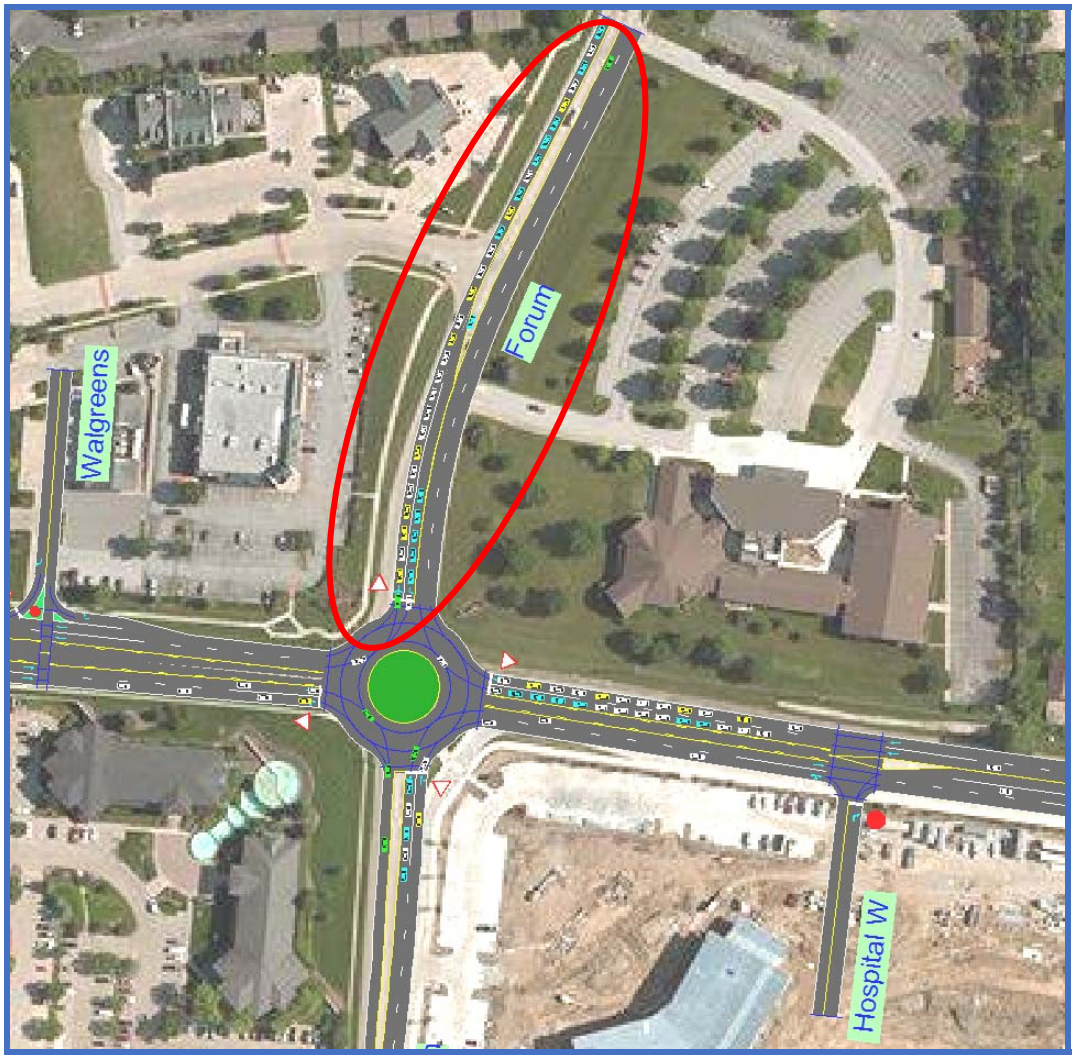


Figure VIII-8: PM Congestion at Forum – Roundabout alternative

G. Commercial Drives & Monterey Congestion

Performance at the commercial drives along Nifong Boulevard, between Monterey and Providence are much improved during the morning and afternoon peak periods with the 5-lane ¾ access management alternative. Motorists are able to find an acceptable gap when exiting the drive while making a right turn onto Nifong Boulevard. Two-stage left turns out of the drives are eliminated and redirected to the signal at Monterey. Queue lengths observed in a typical simulation during the AM and PM peak hours are short, with typically one or two vehicles waiting to exit the commercial drives. Monterey is expected to see queues remain in the short auxiliary turn bays and clear with every cycle of the new signal. For simplicity, traffic analysis of both the ¾ alternative and the median

alternative was analyzed as all drives configured with the same level of access management. Further analysis could be conducted with some as ¾ access and some as right-in right-out. One such example could be configuring the Bank drive as a right-in right-out, which would allow for a longer eastbound left turn storage bay for Nifong Boulevard at Providence Road and could include a u-turn at Monterey to provide westbound Nifong traffic access to the Bank.

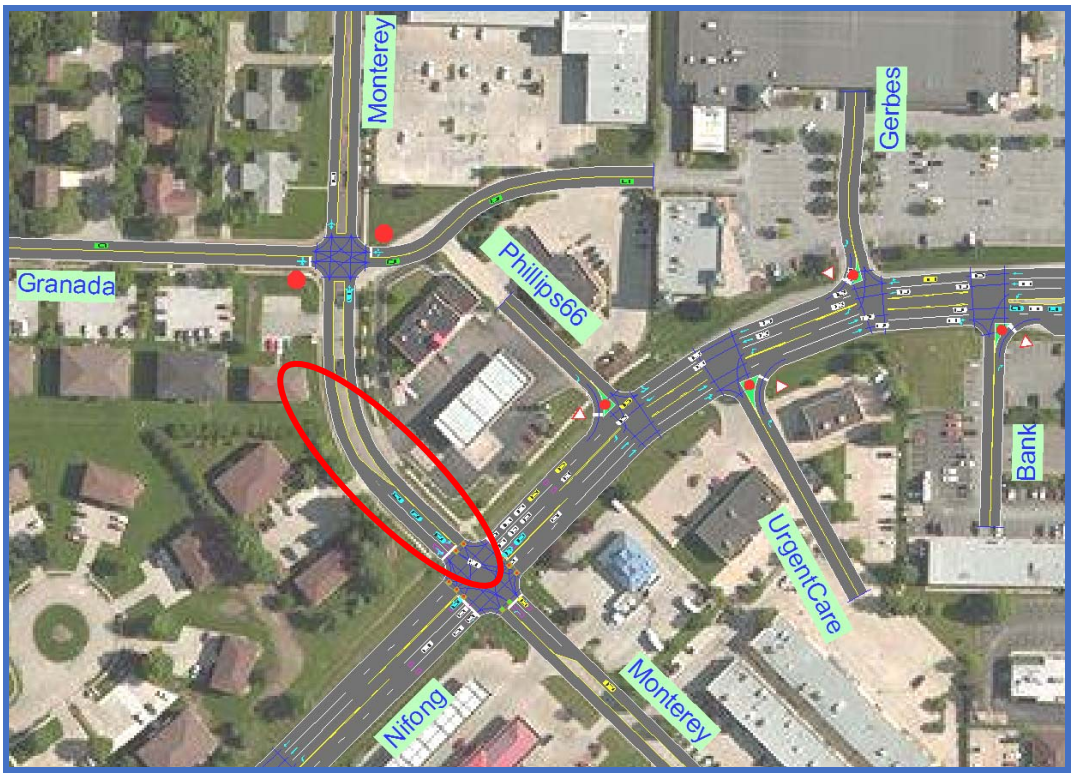


Figure VIII-9: Typical congestion at commercial drives & Monterey

IX. SAFETY ANALYSIS

A. Crashes by Location

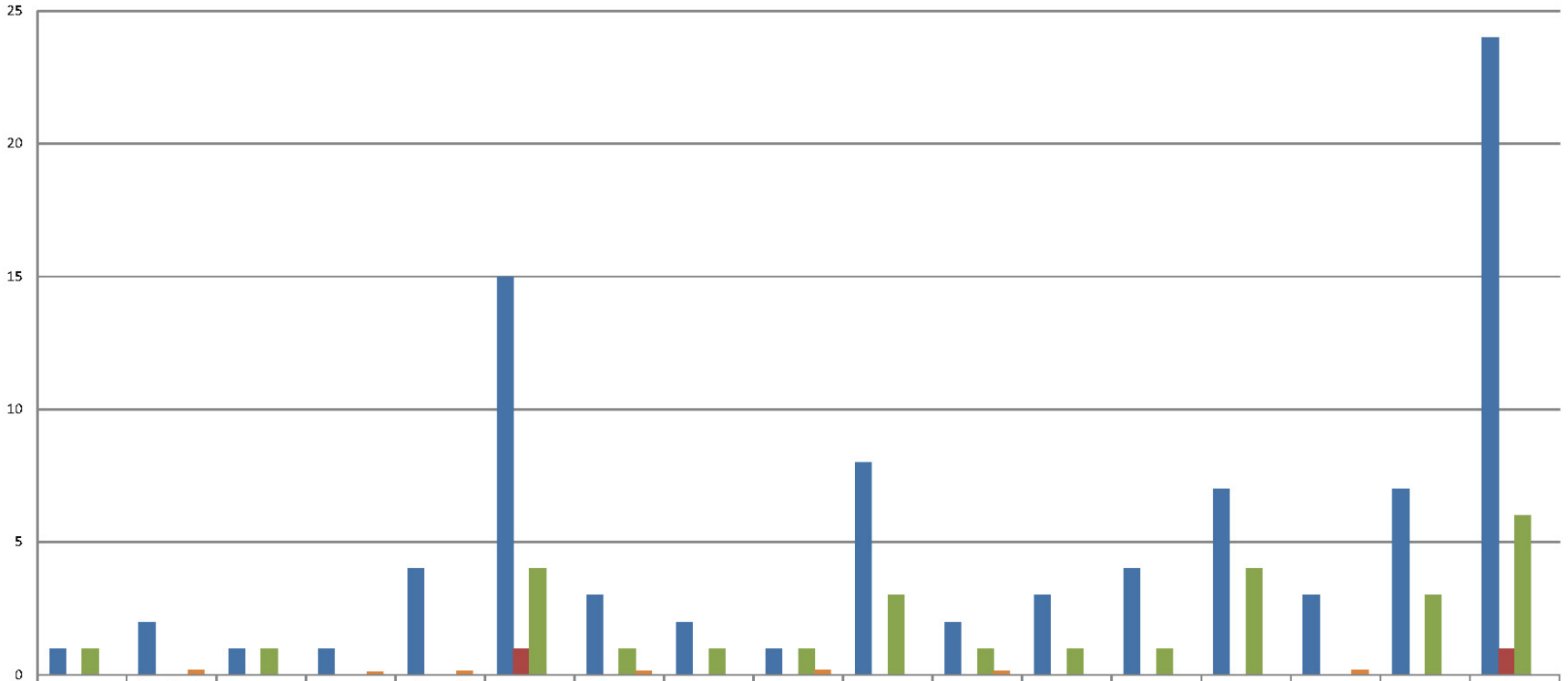
A crash analysis was conducted along Nifong Boulevard from Sinclair Road to Providence Road using crash data provided by the City of Columbia, Missouri. The data shown spans the years 2012 through 2016, and both intersections and segments were analyzed. For the purposes of the analyses, crashes that occurred within the proximity of 0.02 miles from the log mile station are associated with intersection-related crashes and the sections of Nifong Boulevard between the intersections are analyzed as segment analyses. Crashes occurring on side roads are not included in the analysis but are discussed in the intersection and roadway segment summary.

The log mile stations for each year included in the study years are listed below:

2012-2016 Log Mile Station	Reference Point
0.512	Sinclair Road
0.942	Woodtrail on the Green
1.012	Glen Eagle Drive
1.191	Willowcreek Lane
1.314	Club Village Drive
1.364	Westrail Court
1.503	Forum Boulevard
1.665	Barrington Drive
1.833	Baurichter Drive
2.009	Bethel Street
2.165	Santiago Drive
2.330	Peachtree Drive
2.395	Monterey Drive
2.573	Outer Road
2.599-2.610 0.000-0.011	Providence Road (MO Route 163)

Table IX-1: Log Mile vs. Reference Point

From a review of the available summarized crash data it appears that the large volume of traffic is the basis for a majority of these crashes. A review of all detailed crash reports could provide more circumstantial details but generally as the AADT increases so do the number of crashes.



	Glen Eagle Drive	Glen Eagle Drive to Willowcreek Lane	Willowcreek Lane	Willowcreek Lane to Club Village Drive	Westrail Court to Forum Boulevard	Forum Boulevard	Forum Boulevard to Barrington Drive	Barrington Drive	Baurichter Drive to Bethel Street	Bethel Street	Bethel Street to Santiago Drive	Santiago Drive	Peachtree Drive	Monterey Drive	Monterey Drive to Outer Road	Outer Road	Providence Road
Total Crashes (2012-2016)	1	2	1	1	4	15	3	2	1	8	2	3	4	7	3	7	24
Diablilng Injury	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Minor Injury	1	0	1	0	0	4	1	1	1	3	1	1	1	4	0	3	6
Segment Length		0.179		0.123	0.139		0.162		0.176		0.156				0.178		

Figure IX-1: Total Crashes by Location (Segments and Intersections) 2012-2016

B. Crashes by Type

The most common type of crash was rear end which accounted for 46.6% of the total crashes followed by turning (16.9%) which includes right turn, right turn-right angle, left turn, and left turn-right angle; head on (12.5%); right angle (11.4%); u-turn (3.4%); out of control (3.4%); passing (2.3%); fixed object (1.1%); parking/parked car (1.1%); and sideswipe (1.1%).

Rear end collisions were the highest occurring crash type for eleven of the seventeen intersections/segments analyzed including two of the three signalized intersections (Forum Boulevard and Providence Road). At the signalized intersection of Bethel Street, rear end and head on crashes tied for the predominate type of crashes.

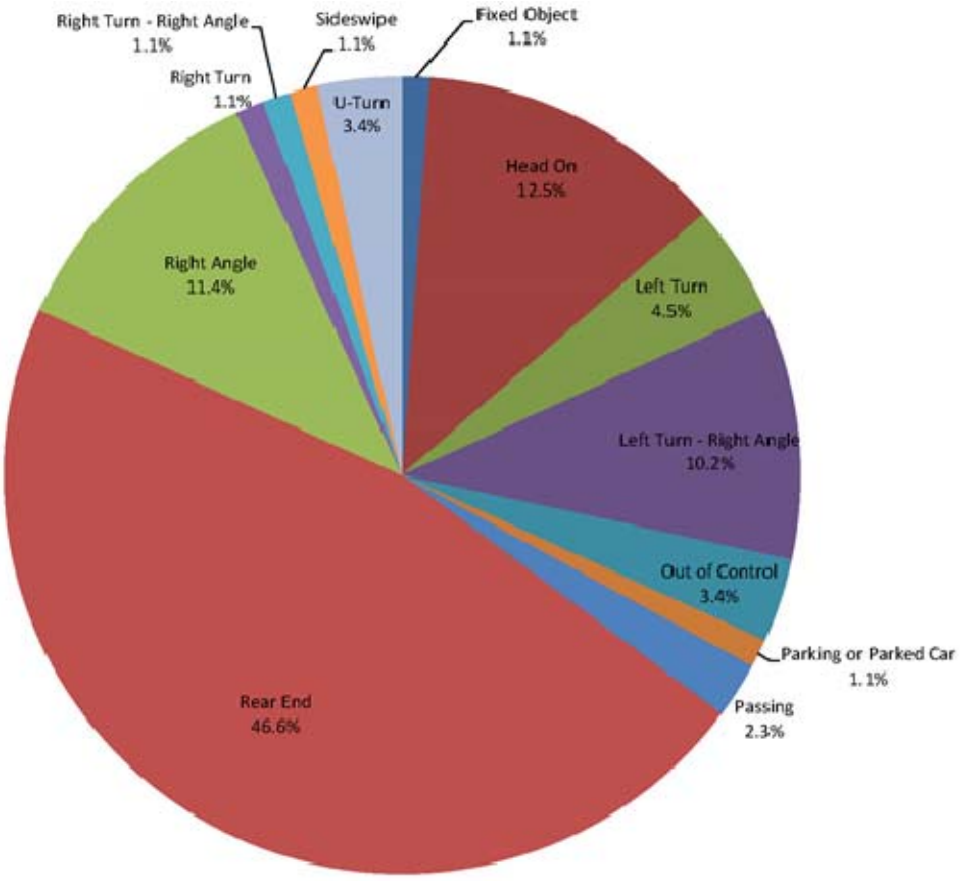


Figure IX-2: Total Crashes by Type (Segments and Intersections) 2012-2016

C. Crash Severity Analysis

The crash data categorized the crashes by the following severity levels:

- Disabling Injury
- Minor Injury
- Property Damage Only

Of the 88 total crashes in the study area, 30 crashes or 34.1% involved injuries (disabling or minor); 2 crashes or 6.7% involved disabling injuries. There were no fatal crashes in the study period. Figure 4 depicts crashes by type with the severity of the crash.

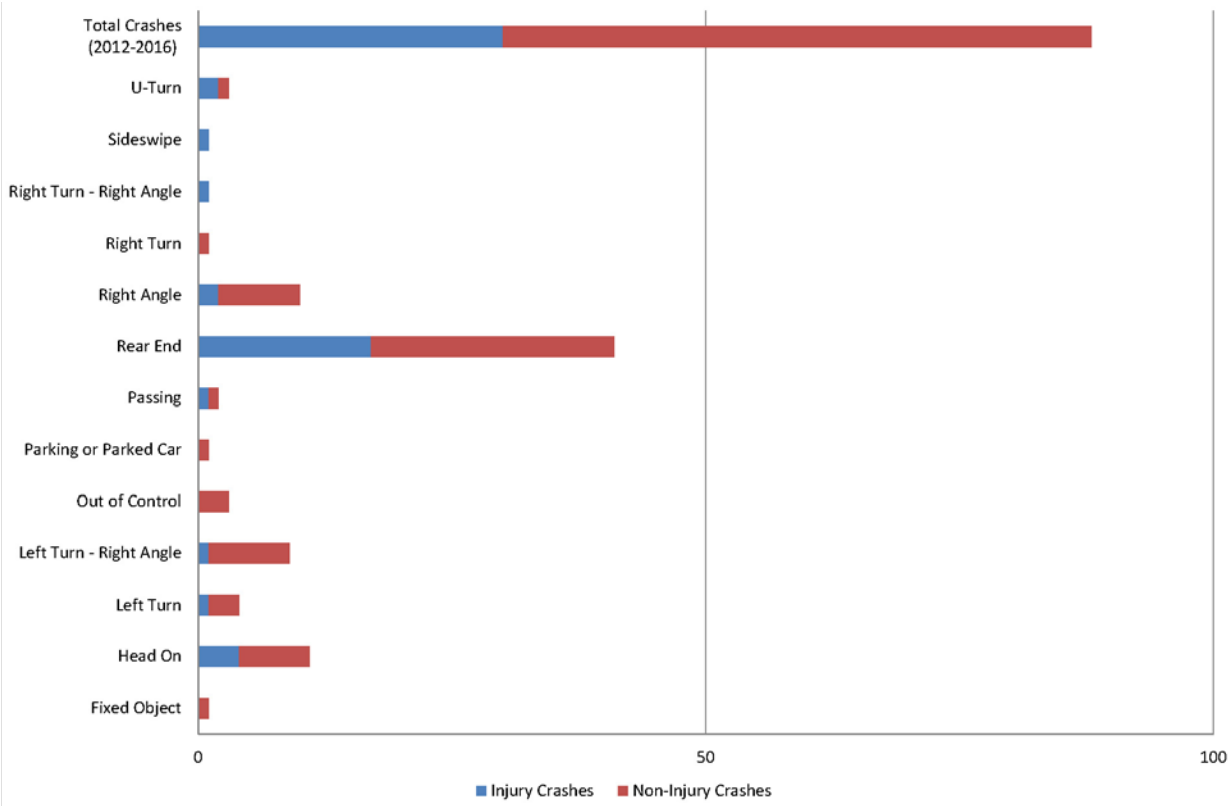


Figure IX-3: Crashes by Type with Severity (Segments and Intersections) 2012-2016

D. Roadway Surface Condition Analysis

Table IX-2 summarizes the distribution of the 88 total crashes by the roadway surface condition at the time of the crash. As shown, 88.6% of all crashes occurred on a dry roadway surface. With 11.4% of crashes occurring on wet, ice, or unknown pavement conditions; the general findings of this crash analysis suggest that wet pavement was not a significant cause for crashes within the study area.

Table 2 - Total Crashes by Roadway Surface Condition and Injury Severity
Nifong Boulevard between Sinclair Road and Providence Road (2012-2016)

Roadway Surface	No. of Crashes	Frequency	Total Injury Crashes	Injury		PD
				Disabling	Minor	
Dry	78	88.6%	26	1	25	52
Wet	8	9.1%	4	1	3	4
Ice	1	1.1%	0	0	0	0
Unknown	1	1.1%	0	0	0	0
Total Crashes (2012-2016)	**88**	**100%**	**30**	**2**	**28**	**56**

Table IX-2: Total Crashes by Roadway Surface Condition and Injury Severity (Segments and Intersections) 2012-2016

E. Roadway Lighting Conditions Analysis

Table IX-3 summarizes the distribution of crash data by lighting condition. As shown in the table, 69.3% of the crashes occurred in daylight conditions, 6.8% of the crashes occurred during night hours with no street lights on or unknown lighting conditions, and 23.9% occurred during night hours with street lights on. The majority of the study limit along Nifong Boulevard is unlit. With only 6.8% of crashes occurring during darkness without street light on, findings of this crash analysis suggest that lighting conditions may not be a significant contributing factor to crashes.

Table 3 - Total Crashes by Roadway Lighting Condition and Injury Severity Nifong Boulevard between Sinclair Road and Providence Road (2012-2016)						
				Injury		
Lighting Condition	No. of Crashes	Frequency	Total Injury Crashes	Disabling	Minor	PD
Daylight	61	69.3%	17	1	16	44
Dark w/ Street Lights Off	4	4.5%	2	0	2	2
Dark w/ Street Lights On	21	23.9%	10	1	9	11
Dark - Unknown	2	2.3%	1	0	1	1
Total Crashes (2012-2016)	**88**	**100%**	**30**	**2**	**28**	**58**

Table IX-3: Total Crashes by Roadway Lighting Condition and Injury Severity (Segments and Intersections) 2012-2016

F. Time of Day and Day of Week Analysis

The crash data was also analyzed based on the time of day and day of week (weekday or weekend) the crashes occurred. The majority of crashes were recorded during the daytime. In addition, it is noted that the pattern of the weekday peak traffic periods coincides with approximately half of the crashes recorded. The crash data for time of day and day of week is shown in Table 4.

During the weekday period, the percentage of crashes in general coincides with the peak traffic periods and extends approximately 1 hour after peak traffic periods. Based on weekday traffic data collected for the traffic studies, the crashes generally follow the pattern of observed traffic volumes using Nifong Boulevard. Those patterns show weekday peak traffic periods are from 7:15 a.m. to 8:15 a.m. and from 4:45 p.m. to 5:45 p.m. Traffic volumes then decrease after 7:00 p.m.

The weekend time of day crash pattern shows that the highest percentage of crashes occurred in the period between 11:00 a.m. and 8:00 p.m. These patterns represent what would generally be expected with the number of crashes increasing as traffic volumes increase.

Table 4 - Total Crashes by Time of Day and Day of Week
Nifong Boulevard between Sinclair Road and Providence Road (2012-2016)

Time of Day	Weekend	Weekday	Total	% of day of week total*		% of Total**	
				Weekend	Weekday	Weekend	Weekday
12:00-12:59 a.m.	2	2	4	9.1%	3.0%	2.3%	2.3%
1:00-1:59 a.m.	1	1	2	4.5%	1.5%	1.1%	1.1%
2:00-2:59 a.m.	0	0	0	0.0%	0.0%	0.0%	0.0%
3:00-3:59 a.m.	0	0	0	0.0%	0.0%	0.0%	0.0%
4:00-4:59 a.m.	0	0	0	0.0%	0.0%	0.0%	0.0%
5:00-5:59 a.m.	0	0	0	0.0%	0.0%	0.0%	0.0%
6:00-6:59 a.m.	0	0	0	0.0%	0.0%	0.0%	0.0%
7:00-7:59 a.m.	0	1	1	0.0%	1.5%	0.0%	1.1%
8:00-8:59 a.m.	0	8	8	0.0%	12.1%	0.0%	9.1%
9:00-9:59 a.m.	0	3	3	0.0%	4.5%	0.0%	3.4%
10:00-10:59 a.m.	0	2	2	0.0%	3.0%	0.0%	2.3%
11:00 -11:59 a.m.	2	4	6	9.1%	6.1%	2.3%	4.5%
12:00-12:59 p.m.	2	4	6	9.1%	6.1%	2.3%	4.5%
1:00-1:59 p.m.	3	4	7	13.6%	6.1%	3.4%	4.5%
2:00-2:59 p.m.	2	1	3	9.1%	1.5%	2.3%	1.1%
3:00-3:59 p.m.	1	5	6	4.5%	7.6%	1.1%	5.7%
4:00-4:59 p.m.	0	4	4	0.0%	6.1%	0.0%	4.5%
5:00-5:59 p.m.	2	14	16	9.1%	21.2%	2.3%	15.9%
6:00-6:59 p.m.	2	4	6	9.1%	6.1%	2.3%	4.5%
7:00-7:59 p.m.	2	2	4	9.1%	3.0%	2.3%	2.3%
8:00-8:59 p.m.	0	3	3	0.0%	4.5%	0.0%	3.4%
9:00-9:59 p.m.	1	2	3	4.5%	3.0%	1.1%	2.3%
10:00-10:59 p.m.	1	1	2	4.5%	1.5%	1.1%	1.1%
11:00 p.m.-11:59 a.m.	1	1	2	4.5%	1.5%	1.1%	1.1%
Total Crashes (2012-2016)	22	66	88	100%	100%	25%	75%

*This percentage is the total crashes for either the weekend or weekday time period divided by the total crashes for that period.

**This percentage is the total crashes for either the weekend or weekday time period divided by the total crashes for all days of the week.

0 - 3 percent
3.1 - 6 percent
6.1 - 8 percent
> 8 percent

Table IX-4: Total Crashes by Time of Day and Day of Week (Segments and Intersections) 2012-2016

Complete intersection and segment crash analysis data are available in ***Appendix E***.

X. CORRIDOR RECOMMENDATIONS

A. Access Management of Commercial Drives

In planning, designing, and managing access, critical consideration must be given to arterial and collector streets, as these streets serve both mobility and access functions. To the extent possible, it is best to manage driveways so that access is provided to and from the roadway with the lower functional classification as these roadways typically have lower traffic volumes and speeds. This helps to reduce the frequency of conflicts, which minimizes both the opportunity for crashes and the severity of those crashes, should they occur.

According to the Columbia Area Transportation Study Organization (CATSO) 2025 Roadway Plan, *"Uncontrolled driveway access for commercial land uses significantly reduces the capacity of an arterial to carry traffic. Depending upon the number of turning movements, number of travel lanes and the arterial traffic volumes, a driveway permitted access to an arterial street will reduce roadway capacity by up to 25%. The movement function of the arterial is quickly degraded to that of a collector street… Although access to abutting property generally is permitted from arterial streets in the Columbia area, less permissive driveway regulations are needed to control the turning movements into and out of the properties in order to minimize the interference with traffic on the arterial streets"*.

In general, the number and types of conflict points (i.e., the number of locations where the travel paths of two different vehicles may cross) at the intersection of a driveway and a public road influence the safety of motorists, bicyclists, and pedestrians. It is desirable to minimize the number of conflict points created with existing and future driveways since more conflict points increase the risk of a crash occurring. For example, a crash due to crossing maneuvers (created by motorists turning across the roadway or making left turns) can lead to more severe crashes then merging or diverging conflicts because of the angle and speed differentials between the vehicles. As the angle and speed differentials increases, crash severity can also increase.

By reducing the access of the commercial drives to Nifong Boulevard, between Monterey Drive and Providence Road, from full access to ¾ access, the potential vehicle and bicycle crossing conflict points are reduced from 12 to 3 and merging conflicts are reduced from 5 to 3. Pedestrian crossing conflict points at the sidewalk are reduced from 6 to 4.

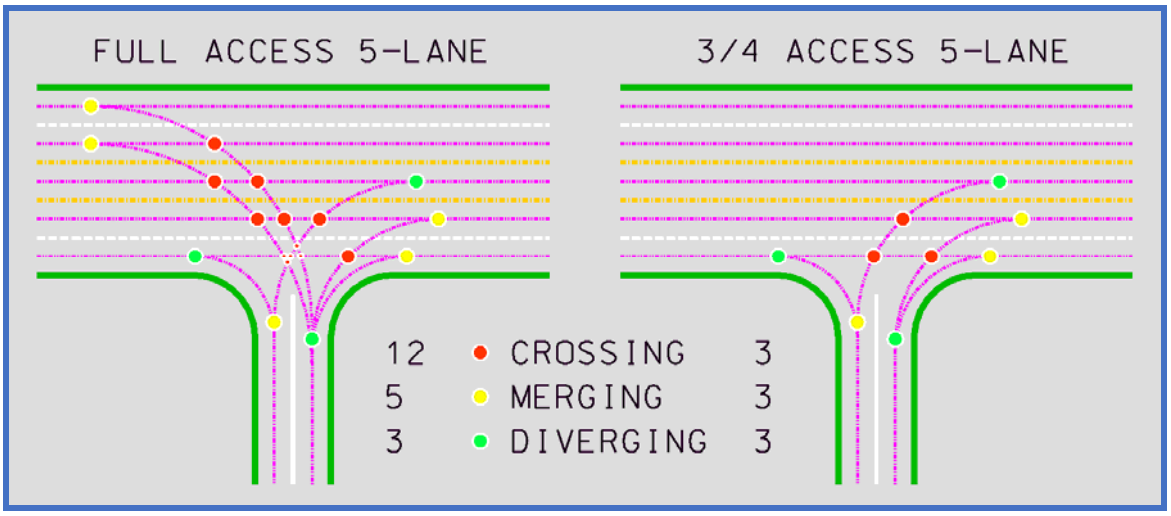


Figure X-1: Vehicle & Bicycle conflict points of full access & ¾ access 5-Lane sections

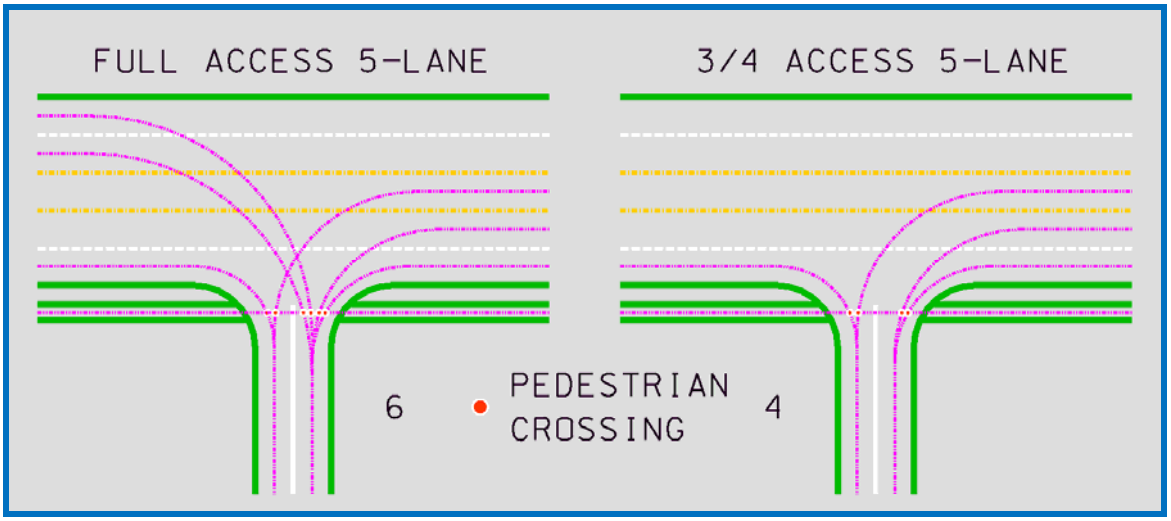


Figure X-2: Pedestrian conflict points of full access & ¾ access 5-Lane sections

B. Access Management of West Outer Road

The intersection of the West Outer Road (Providence/163) with Nifong Boulevard is currently only allowed eastbound access by way of a raised median that restricts westbound movements. Further access control of this intersection is recommended based on the eastbound queues along Nifong Boulevard extending beyond the West Outer Road tie in point. According to the AASHTO Policy on Geometric Design of Highways and Streets, driveways and intersections should not be located within the upstream or downstream functional area of an intersection. AASHTO defines the upstream functional area of an intersection as a variable distance, influenced by: distance traveled during perception-reaction time, deceleration distance while the driver maneuvers to a stop, and the amount of queuing at the intersection.

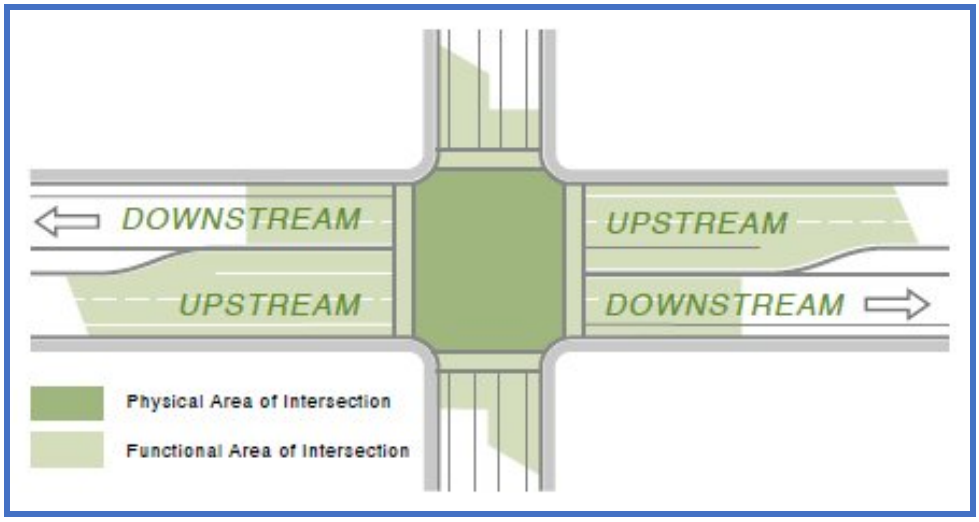


Figure X-3: AASHTO intersection areas

Therefore, it is recommended that access from the West Outer Road to Nifong Boulevard be reduced to only eastbound right-in turns from Nifong Boulevard to southbound West Outer road, and northbound right-out turns to the southbound right turn lane for Providence Road. This would be accomplished by way of a physical raised median between the Eastbound through lanes and the right turn lane along Nifong Boulevard, as seen in ***Figure X-4***. This reduction in access would eliminate conflicts with outer road motorists wanting to cross multiple lanes of traffic to gain access to the eastbound left turn lanes or through lanes.

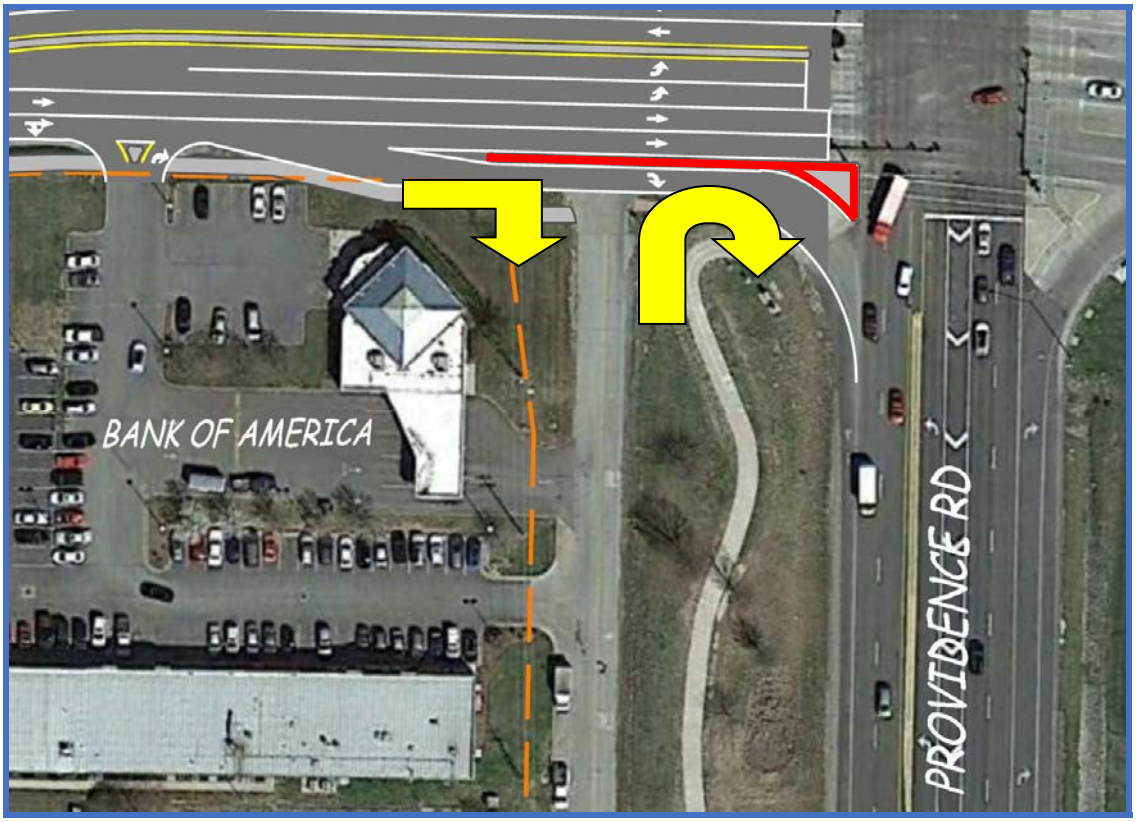


Figure X-4: West Outer Road right turn restriction

C. Monterey Intersection & Signalization

Signalizing the intersection of Monterey Drive with Nifong Boulevard is recommended as part of the improvements analyzed with the 5-Lane plus ¾ access and 5-Lane plus center-median alternative options, as previously described in ***Section VII***. Intersection improvements should include the following:

- Permissive+Protected flashing yellow operation for left turns
- Minimum eastbound and westbound auxiliary left turn storage of 100'
- Minimum northbound auxiliary left turn storage of 75'
- Minimum southbound auxiliary left turn storage of 100'

D. Bethel Improvements

As part of the 5-Lane plus ¾ access alternative option, the following improvements to the intersection of Bethel Street and Nifong Boulevard are recommended:

- Permissive+Protected flashing yellow operation for left turns

- Northbound dual left turns with a minimum storage of 140'
- Southbound dual left turns with a minimum storage of 200'
- Eastbound left turn minimum storage of 150'
- Eastbound right turn minimum storage of 225'
- Westbound left turn minimum storage of 200'
- Gap Acceptance Right turn islands at all corners of the intersection (Australian style)

E. Forum Improvements

As part of the 5-Lane plus ¾ access alternative option, the following improvements to the intersection of Forum Boulevard and Nifong Boulevard are recommended:

- Permissive+Protected flashing yellow operation for left turns
- Northbound dual left turns with a minimum storage of 140'
- Southbound dual left turns with a minimum storage of 240'
- Southbound right turn with a minimum storage of 180'
- Eastbound dual left turns with a minimum storage of 300'
- Eastbound right turn with a minimum storage of 200'
- Westbound left turn with a minimum storage of 300'
- Westbound right turn with a minimum storage of 200'
- Gap Acceptance Right turn islands at all corners of the intersection (Australian style)

XI. CONCLUSIONS

The alternative that provides the greatest traffic performance improvement over the 2040 No-build condition is the 5-Lane alternative with ¾ drive access between Monterey and Providence. However, the 5-Lane with center median between Monterey and Providence will also satisfy the current and future 2040 traffic needs of this study area, but with additional restricted access management of the commercial drives. Moreover, the center median alternative has an even greater reduction in vehicle and pedestrian conflict points which yields additional safety improvements. It is possible that the best solution for the corridor may include a mix of a center median and ¾ drive access once further detailed design takes into consideration any engineering constraints, and input from the appropriate governing agencies and interested parties.