

Mr. Tim Crockett. P.E.
Crockett Engineering
2608 North Stadium Drive
Columbia, MO 65202

Dear Mr. Crockett:

As requested, CBB has completed a traffic impact study pertaining to the proposed residential development, known as The Brooks Phase 2, in Columbia, Missouri. The subject property is located north of Highway WW between Roseta Avenue and Rolling Hills Road. The location of the site in relation to the surrounding road system is depicted in **Figure 1**.

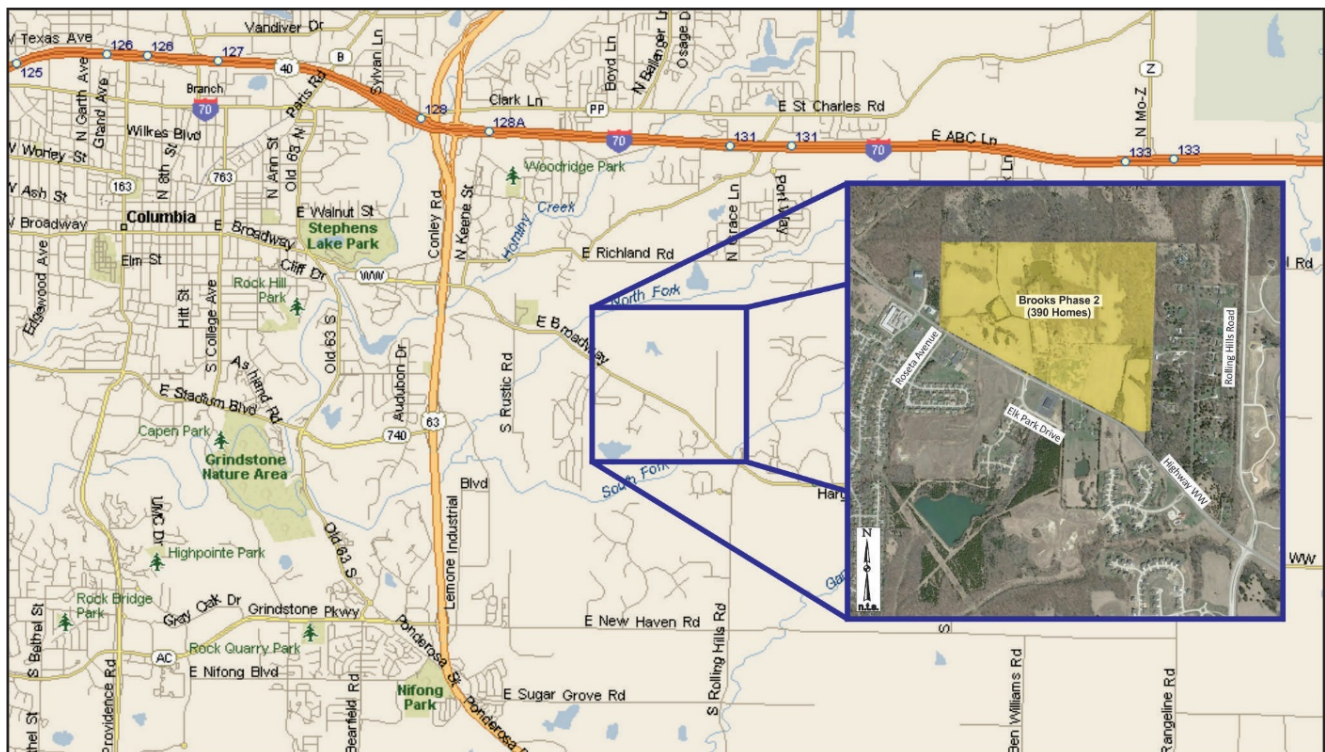


Figure 1: Project Location Map

Based on the site plan provided at the commencement of the study, the proposed development would consist of approximately 390 single family homes. Access to the proposed subdivision would be provided via two new roads on Highway WW; one opposite Elk Park Drive and one opposite Roseta Avenue. A schematic of the concept plan provided is shown in **Figure 2**.



Figure 2: The Brooks Phase 2 Concept Plan (Provided by Crockett Engineering)

As part of the project, a collector road would be built through the proposed subdivision from Highway WW, opposite Elk Park Drive, to the north where it would tie into the east/west collector road, Hoylake Drive, currently under construction through the new subdivision to the



northeast of the proposed site, The Brooks Phase I. This would provide a collector road between Highway WW and Rolling Hills Road.

The purpose of this study was to determine the number of additional trips that would be generated by the proposed development, evaluate the impact on the operating conditions for the adjacent roadways, and determine the ability of motorists to safely enter and exit the site. If necessary, roadway improvements (lane additions and/or traffic control modifications) are recommended to mitigate the impact of the development and to accommodate the additional traffic. The focus of this study was the AM and PM peak hours of a typical weekday.

CBB discussed the scope of work for this traffic study with the Missouri Department of Transportation (MoDOT) and the City of Columbia at the commencement of the traffic study process. CBB also provided MoDOT and the City a Technical Memo summarizing the proposed site trip generation and directional distribution estimates, as well as the 20-year background traffic growth assumptions and gained their consensus on the assumptions prior to completing the traffic analyses.

As requested by MoDOT and the City, the following intersections were included in the study:

- Highway WW and El Chaparral Avenue;
- Highway WW and Roseta Avenue;
- Highway WW and Elk Park Drive;
- Highway WW and Rolling Hills Road; and
- Rolling Hills Road and east/west collector road.

As requested by MoDOT and the City, the following analysis scenarios were considered:

- 2016 Base Conditions (2016 existing traffic volumes plus The Brooks Phase 1);
- 2016 Build Conditions;
 - 2016 Base plus proposed Brooks Phase 2 development
- 2036 No-Build Conditions;
 - 2016 Base plus 20 years background growth and future adjacent developments
- 2036 Build Conditions; and
 - 2036 No-Build plus proposed Brooks Phase 2 development

The following report presents the methodology and findings relative to the Base, 2016 Build, and Design Year conditions.



EXISTING CONDITIONS

Area Roadway System: **Highway WW** (East Broadway) is a minor arterial roadway that runs primarily east-west through the study area. Highway WW is owned and maintained by MoDOT. Within the study area, Highway WW provides two travel lanes, one in each direction. The posted speed limit adjacent to the site is 45 miles per hour (mph); to the east of the site, the posted speed increases to 55 mph. No sidewalks are provided along Highway WW through the study area. Paved shoulders are provided to the east of Cedar Grove Boulevard/Stone Mountain Parkway.

Rolling Hills Road is a collector road that runs north-south. Within the study area, Rolling Hills Road provides two travel lanes, one in each direction. The posted speed limit is 45 mph. Sidewalks are provided along the east side of the roadway north of Highway WW and along both sides of the roadway south of Highway WW.

Elk Park Drive is a local road that runs north-south at the intersection with Highway WW and curves to the east south of Highway WW. Elk Park Drive provides two travel lanes, one in each direction. The posted speed limit is 30 mph. Sidewalks are provided along the west side of the roadway south of Highway WW and along the north side of the east-west section.

Roseta Avenue is a local road that runs north-south. Roseta Avenue provides two travel lanes, one in each direction. The posted speed limit is 20 mph. Sidewalks are not provided along the roadway.

El Chaparral Avenue is a local road that runs north-south. El Chaparral Avenue provides two travel lanes, one in each direction. The posted speed limit is 20 mph. Sidewalks are not provided along the roadway.

The intersection of Highway WW and Rolling Hills Road is controlled by a roundabout. The eastbound and westbound approaches consist of one entering lane, and the northbound and southbound approaches consist of two entering lanes. Pedestrian crosswalks are provided within the roundabout.

The three-legged intersection of Highway WW and Elk Park Drive is controlled by a side-street stop. There is a traffic signal at the intersection, but it is currently non-operational (dark). It is our understanding that the traffic signal would be turned on when the traffic volumes meet warrants for a traffic signal. The eastbound approach consists of one left-turn lane and one through lane, the westbound approach consists of a through lane and a right-turn lane, and the northbound approach consists of one left-turn lane and one right-turn lane. **Figure 3** provides an aerial view of the intersection.



Figure 3: Highway WW at Elk Park Drive

The three-legged intersection of Highway WW and Roseta Avenue is controlled by a side-street stop. The eastbound, westbound, and northbound approaches consist of one lane each. **Figure 4** provides an aerial view of the intersection.



Figure 4: Highway WW at Roseta Avenue

The intersection of Highway WW and El Chaparral Avenue is controlled by a side-street stop. The eastbound, westbound, and southbound approaches consist of one lane each. The northbound approach consists of one left-turn lane and one right-turn lane. **Figure 5** provides an aerial view of the intersection.



Figure 5: Highway WW at El Chaparral Avenue

Existing Traffic Volumes: In order to establish existing traffic conditions, manual peak period traffic counts were conducted at the following intersections within the study area:

- Highway WW and El Chaparral Avenue;
- Highway WW and Roseta Avenue;
- Highway WW and Elk Park Drive; and
- Highway WW and Rolling Hills Road.

These counts were conducted from 7:00 to 9:00 a.m. and from 4:00 to 6:00 p.m. the first week of December 2016. Both the University of Columbia and the Columbia public school academic calendars were reviewed to ensure that the data was collected during normal school operations. These counts were supplemented with traffic counts collected by CBB in May 2014 along Rolling Hills Road, north of Highway WW. Based on the counts, the weekday AM peak hour occurred from 7:15 to 8:15 a.m. while the weekday PM peak hour occurred from 4:45 to



5:45 p.m. The existing weekday AM and PM peak hour traffic volumes are summarized in **Exhibit 1**.

Given the traffic characteristics in the area and the anticipated trip generation for the proposed development, the weekday AM and PM peak periods would represent a “worst-case scenario” with regards to the traffic impact. If traffic operations are acceptable during these peak periods, it can be reasoned that conditions would be acceptable throughout the remainder of the day.

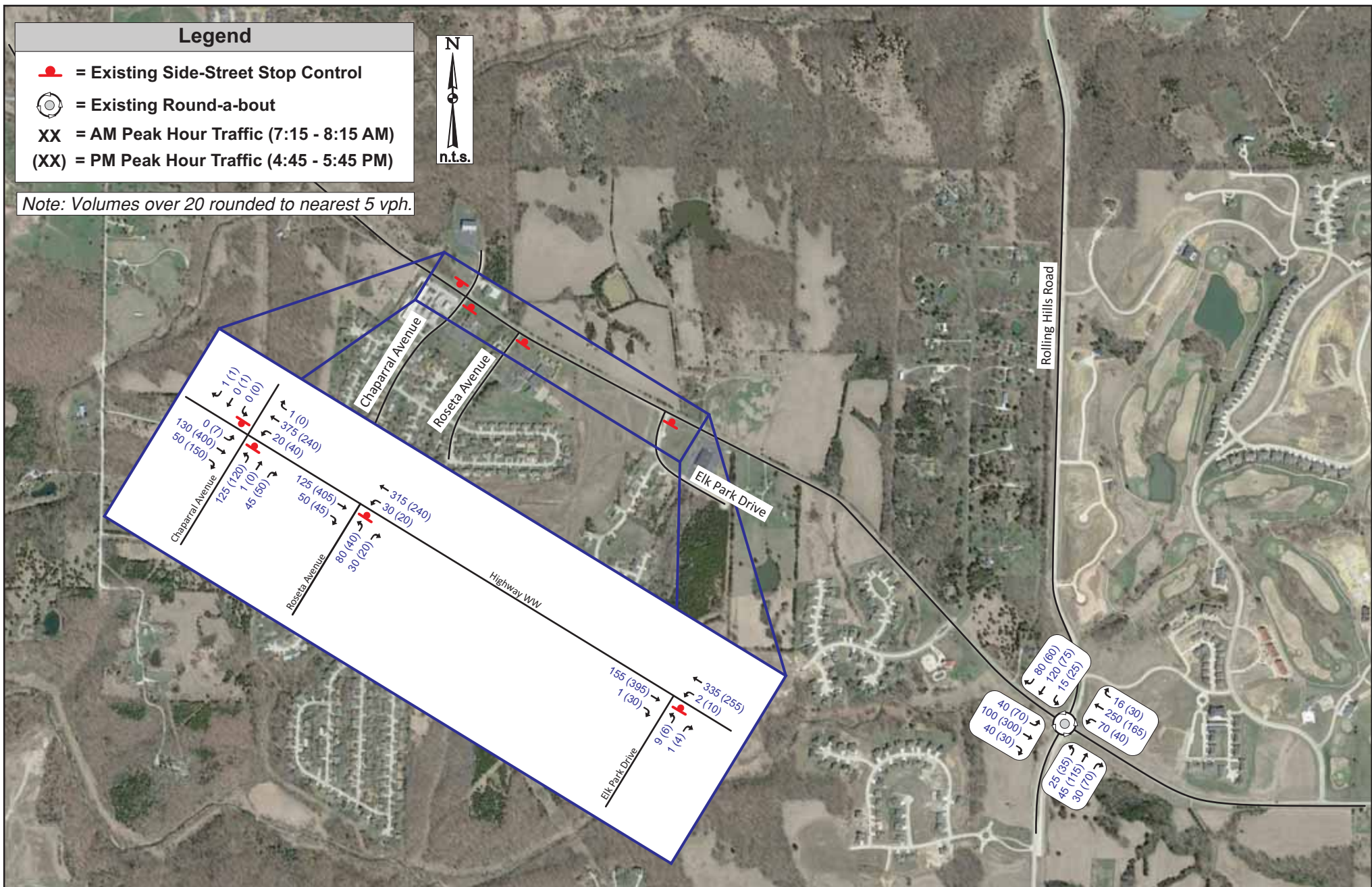


Exhibit 1: Existing Traffic Volumes

APPROVED DEVELOPMENT – THE BROOKS PHASE 1

CBB previously completed a Traffic Impact Study in June 2014 for The Brooks Phase I residential development off Rolling Hills Road just northeast of the site. The Brooks Phase 1 consists of 83 single-family homes. The project is currently under construction, but there are no homes built to date. As detailed in the June 2014 Traffic Impact Study, the trips associated with The Brooks Phase 1 are shown in **Figure 6**. These trips were assigned assuming the provision of a collector street through the Brooks Phase 2 development. The Brooks Phase 1 trips (Figure 6) were added to the existing traffic volumes (Exhibit 1) to develop the 2016 Base, or 2016 No Build, traffic volumes shown in **Exhibit 2**.

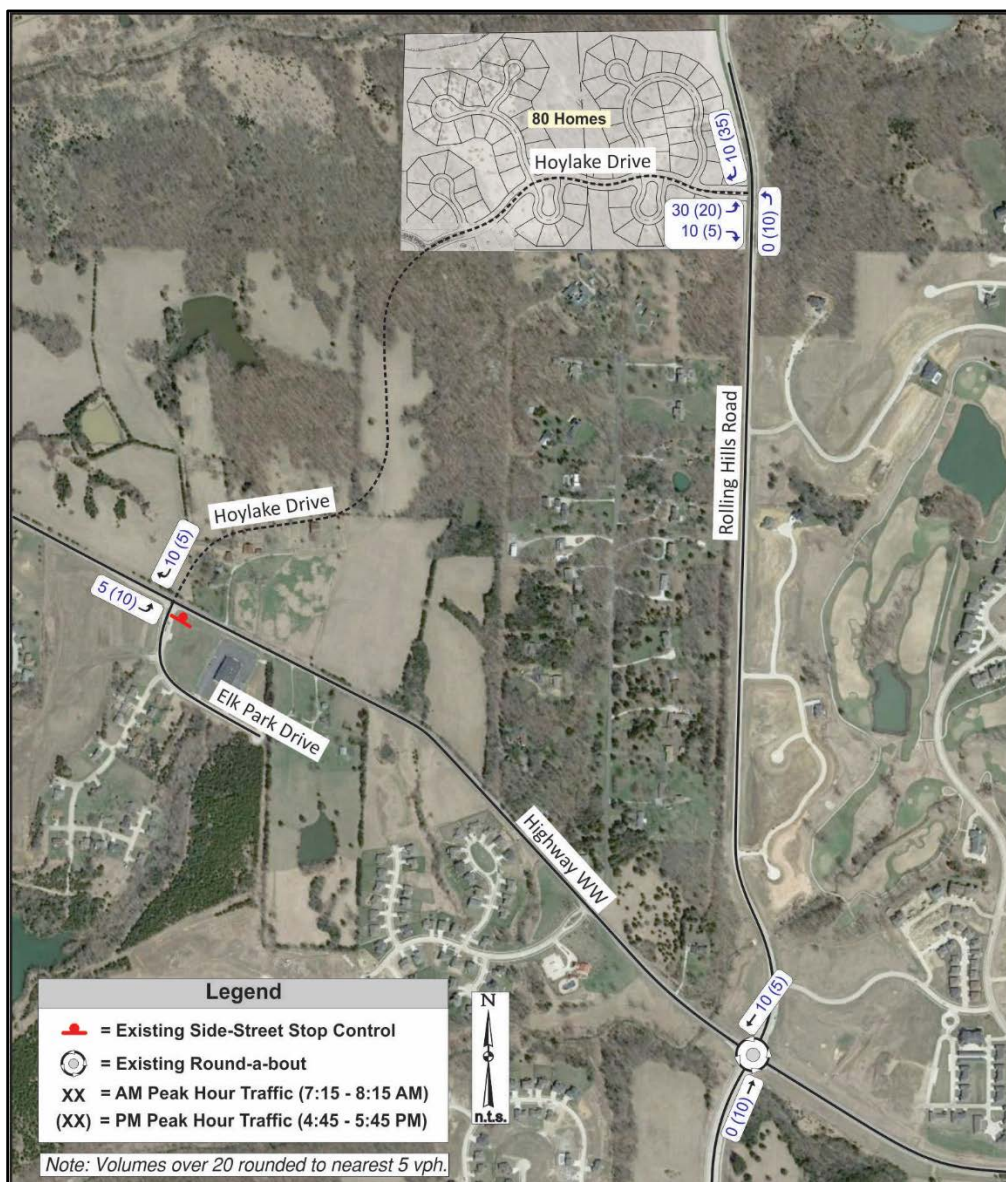


Figure 6: The Brooks Phase 1 Site Trips (from CBB June 2014 Traffic Impact Study)

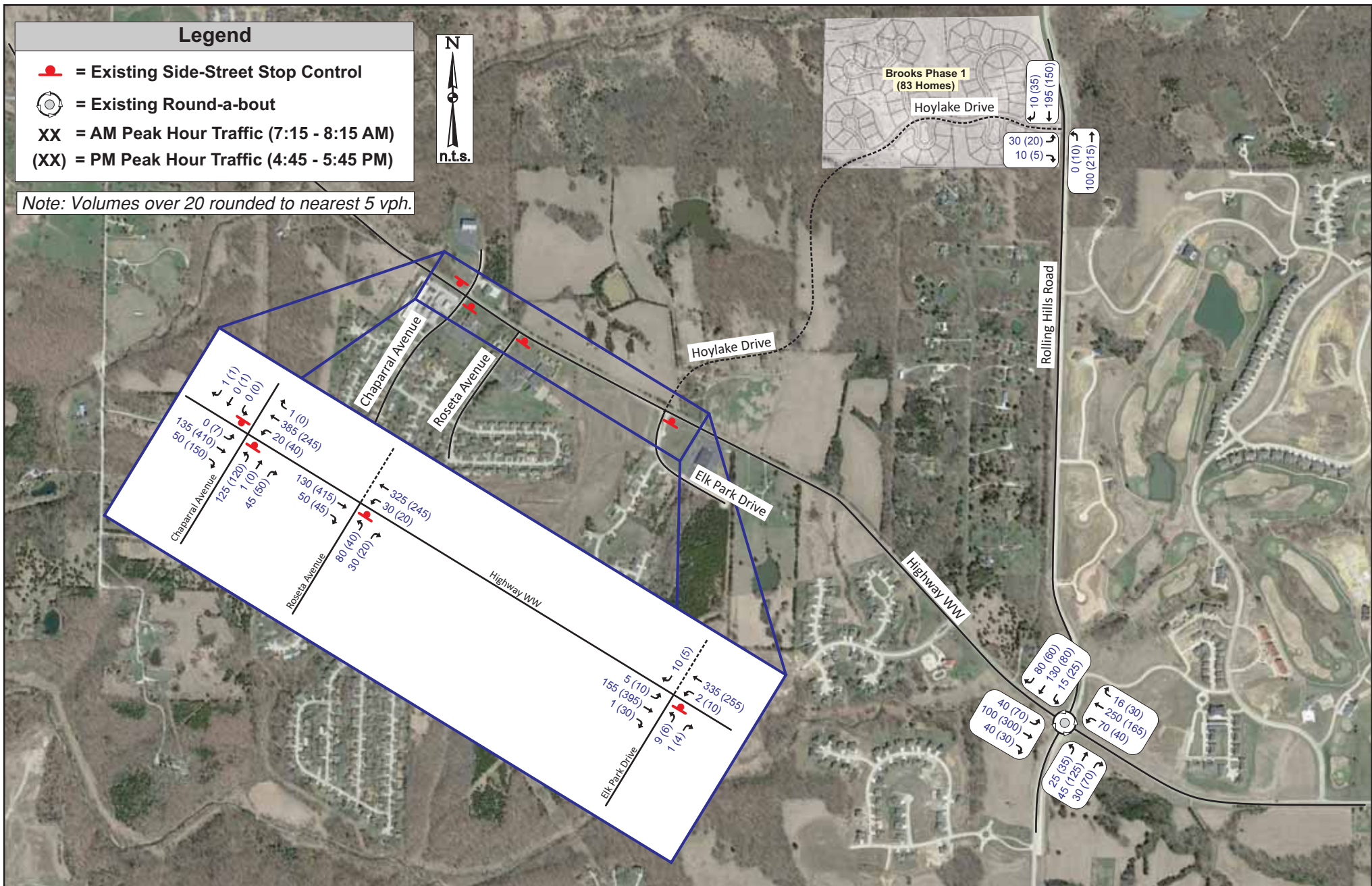


Exhibit 2: 2016 No-Build Traffic Volumes



PROPOSED SITE

Once the base traffic volumes within the study area were established, we then considered the traffic associated with the proposed Brooks Phase 2 development.

Proposed Land Use: Based upon the concept plan provided by Crockett Engineering Consultants, previously shown in Figure 2, a single-family residential development is proposed north of Highway WW near Elk Park Drive. The site would consist of approximately 390 single family homes.

Site Access: As shown on the concept plan, access to the proposed subdivision would be provided via two new roads on Highway WW; one opposite Elk Park Drive which would be an extension of Hoylake Drive from The Brooks Phase 1 development through The Brooks Phase 2 development and one opposite Roseta Avenue, named Sunningdale Drive.

As part of the project, the existing Hoylake Drive collector road currently under construction through The Brooks Phase I site would be extended through the proposed subdivision and tie into Highway WW, opposite Elk Park Drive. This would provide a collector road between Highway WW and Rolling Hills Road.

Intersection Sight Distance: The sight distance for the proposed site drive opposite Roseta Avenue was compared to the guidelines found in *A Policy on Geometric Design of Highways and Streets* published by the American Association of State Highway and Transportation Officials (AASHTO), commonly referred to as the Green Book. Adequate sight distance is necessary at intersections to allow drivers to perceive potentially conflicting vehicles and allow those motorists sufficient time to adjust their speed to avoid a collision or make a choice of when to cross or enter the mainline traffic flow. All drivers approaching or stopped at the intersection should have an unobstructed view of the entire intersection so that potential collisions can be avoided.

The Green Book's guidelines for minimum safe sight distance for entrances reflect the design speed of the major road and the gap time required for a vehicle on the minor road to enter or cross the major road. The intersection sight distance is computed according to the following formula:

$$ISD = 1.47 * \text{Design Speed (mph)} * \text{Design Gap (sec)}$$

A design speed of 50 mph (45 mph posted + 5 mph) was used for Highway WW. The minimum design gap time for a passenger car is typically assumed to be 7.5 seconds plus 0.5 seconds for each additional lane crossing. Based on these criteria, the recommended Intersection Sight Distance on Highway WW is 555 feet.

When measuring sight distance, the driver's eye for the side street vehicle is typically assumed to be 14.5 feet back from the edge of pavement. **Figure 7** depicts the sight distance for the proposed site drive opposite Roseta Avenue at Highway WW assuming the driver's eye is located close to 14.5 feet from the edge of Highway WW. Given the existing ditch and vegetation, and the fact that the proposed street is not constructed yet, it was not possible to measure the sight distance exactly 14.5 feet from the edge of pavement. However, it is apparent from the photos in Figure 7, that the existing vegetation along the north side of Highway WW, east and west of Roseta Avenue, will need to be removed to achieve adequate sight distance.



Looking East (~14.5 feet back)



Looking West (~14.5 feet back)

Figure 7: Sight Distance for Proposed Drive Opposite Roseta Avenue – 14.5 feet Back from Highway WW

The sight distance for the proposed site drive opposite Roseta Avenue was measured in the field assuming the driver's eye is located closer to the edge of Highway WW (to account for the removal of the existing vegetation). The intersection sight distance to the east was measured in the field at 800 feet, while the intersection sight distance to the west was measured in the field at 670 feet, both of which exceed the required 555 feet. However, as the design progresses, the area within the sight distance triangle must be cleared of any vegetation that would obstruct the sight distance.

Furthermore, careful consideration should be given to sight distance obstructions when planning any future aesthetics enhancements, such as berms, fencing and landscaping for the proposed Brooks Phase 2 development to ensure that these improvements do not obstruct the view of entering and exiting traffic at the proposed entrances onto Highway WW. It is generally recommended that all improvements higher than 3.5 feet above the elevation of the nearest pavement edge be held back at least 20 feet from the traveled roadway.



Trip Generation: As a primary step in this analysis, forecasts were prepared to estimate the amount of traffic that the proposed development would generate during the weekday AM and PM peak periods. These forecasts were based upon information provided in the latest edition of the *Trip Generation Manual*. Estimates for the proposed development were based upon Land Use: 210 – Single-Family Detached Housing.

The data provided for Peak Hour of the Adjacent Street was used for the traditional weekday AM and PM peak hour forecasts. Based on this data, the trip generation forecast for the proposed Brooks Phase 2 development is shown in **Table 1**. As shown, the proposed Brooks Phase 2 development would generate a total of 285 trips during the weekday AM peak hour and 355 trips during the weekday PM peak hour.

Table 1: Trip Estimate – The Brooks Phase 2

ITE Code	Land Use	Unit	ADT (VPD)	Weekday AM Peak Hour			Weekday PM Peak Hour		
				In	Out	Total	In	Out	Total
210	Single-Family Homes	390 Homes	3,675	70	215	285	225	130	355
The Brooks Phase 2 Total Trips			3,675	70	215	285	225	130	355

Trip Distribution: The site-generated trips for the proposed development were then assigned into and out of the site based upon an estimated directional distribution. Based upon the existing travel patterns in the area, it is anticipated that the distribution of site-generated trips for The Brooks Phase 2 development would be as follows:

- To/from the north on Rolling Hills Road 35%
- To/from the south on Rolling Hills Road 10%
- To/from the east on Highway WW 3%
- To/from the west on Highway WW 52%

The site-generated traffic volumes for the weekday AM and PM peak hour are shown in **Exhibit 3**.

2016 Build Traffic Volumes (2016 No Build plus Brooks Phase 2): The assigned traffic volumes resulting from the trip distribution for the proposed Brooks Phase 2 development were added to the 2016 No Build traffic volumes to determine the total volumes in the forecasted scenario. The forecasted, 2016 Build, traffic volumes for the AM and PM peak hours are shown in **Exhibit 4**.

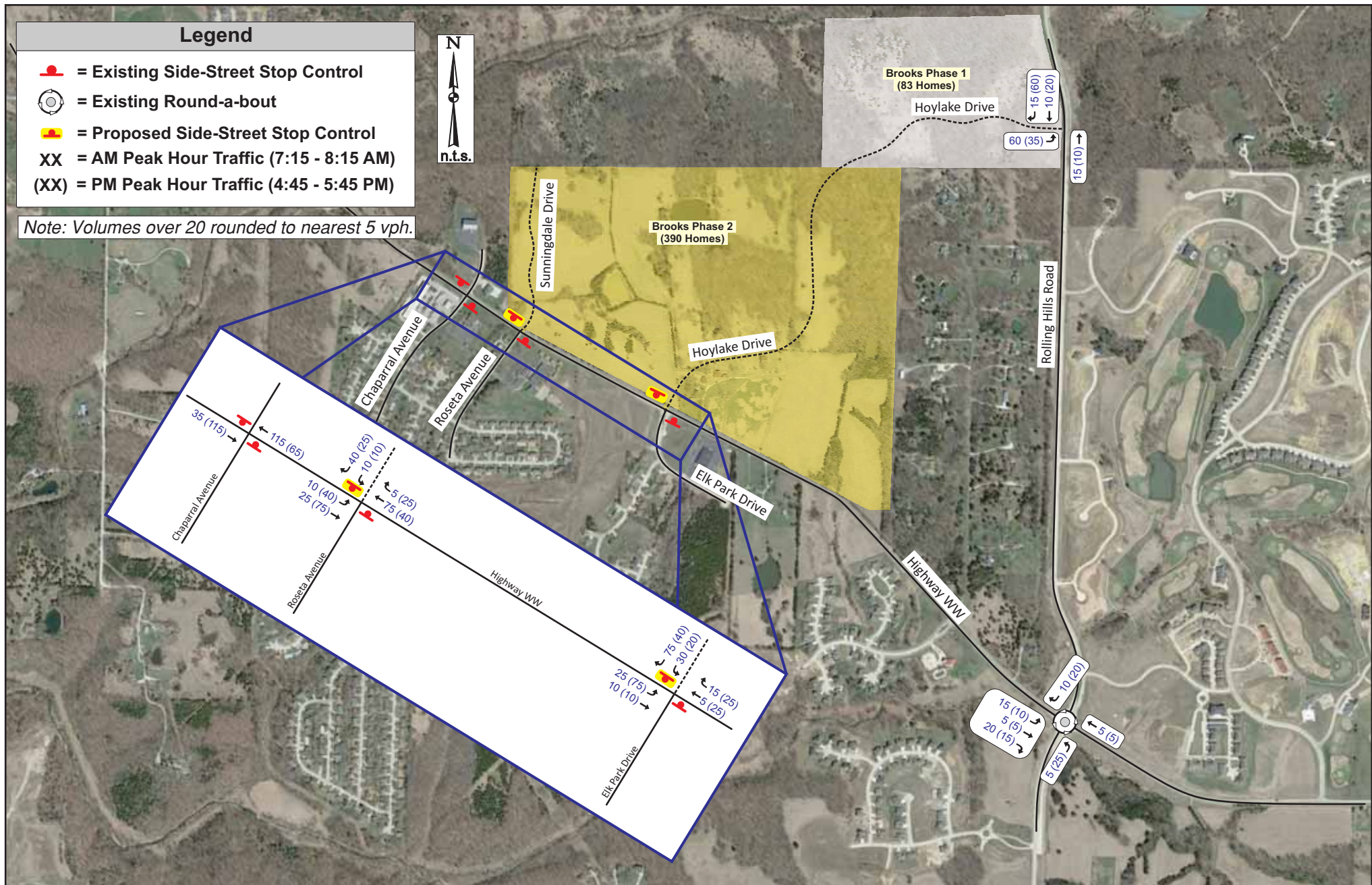


Exhibit 3: Site-Generated Trips - The Brooks Phase 2

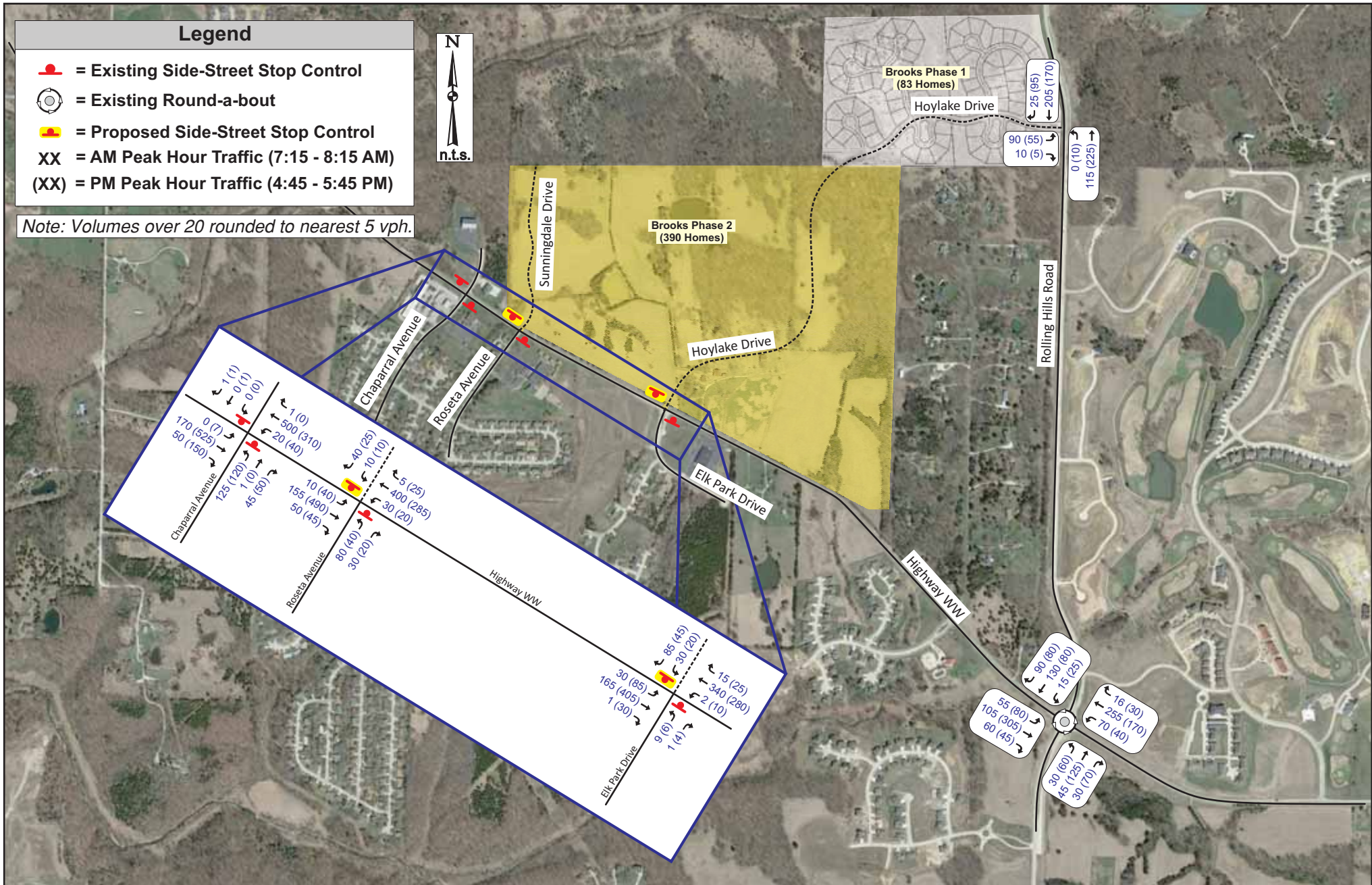


Exhibit 4: 2016 Build Traffic Volumes



2016 TRAFFIC ANALYSIS

Study Procedures: The 2016 No Build and 2016 Build operating conditions were analyzed using SYNCHRO 8, a macro-level analytical traffic flow model. SIDRA was used to analyze the roundabout intersections. SYNCHRO and SIDRA are based on study procedures outlined in the *Highway Capacity Manual*, published by the Transportation Research Board. This manual, which is used universally by traffic engineers to measure roadway capacity, establishes six levels of traffic service: Level A ("Free Flow"), to Level F ("Fully Saturated"). 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 considered acceptable for peak period conditions in urban and suburban areas.

The thresholds that define level 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 then 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.

Level of service is directly related to control delay. At signalized intersections, the level of service criteria differ from that at unsignalized intersections primarily because different transportation facilities create different driver expectations. The expectation is that a signalized intersection is designed to carry higher traffic volumes, and consequently may experience greater delay than an unsignalized intersection. **Table 2** summarizes the thresholds used in the analysis for signalized and unsignalized intersections.

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



2016 Build Auxiliary Turn Lane Needs: The need for separate westbound right-turn lanes and eastbound left-turn lanes on Highway WW were evaluated using MoDOT's Access Management Guidelines (AMG). These guidelines consider auxiliary lanes an asset in promoting safety and improved traffic flow at relatively high conflict locations. Separate turn lanes are intended to remove turning vehicles from the through lanes to reduce the potential number of rear-end collisions at intersections. The MoDOT method provides volume guidelines for the consideration of separate turn lanes by comparing the total advancing volume (which includes all turning traffic) to the number of right and left-turns during the design hour with respect to a given major road speed.

Utilizing MoDOT's AMG *Right-Turn Lane Guideline for Two-lane Roadway* nomograph, separate right-turn lanes are not warranted on Highway WW at either site drive. Utilizing MoDOT's AMG *Left-Turn Lane Guideline for Two-lane Roadway (45 mph)* nomograph, separate left-turn lanes are warranted on Highway WW at both the west drive opposite Roseta Avenue, Sunningdale Drive, and the main drive opposite Elk Park Drive, Hoylake Drive.

2016 Build Signal Warrant Analysis: As mentioned previously, traffic signal equipment is present at the intersection of Highway WW and Elk Park Drive; however, the traffic signal is non-operational (dark). It is our understanding that the traffic signal would be turned on when the traffic volumes meet warrants for a traffic signal. Thus, the need for a traffic signal at Highway WW and Elk Park Drive was evaluated using criteria outlined in the *Manual on Uniform Traffic Control Devices* (MUTCD), published by the Federal Highway Administration, United States Department of Transportation. Part Four of the MUTCD provides eight different warrants for signalization that are based on hourly traffic volumes, traffic operations, pedestrian volumes or accident experience. The Manual further states that a traffic signal should not be installed unless one or more warrants are satisfied, an engineering study indicates that the installation will improve the overall safety and/or operation of the intersection, and that a traffic signal will not seriously disrupt progressive traffic flow.

Warrant 1 has two conditions, "A" and "B". Condition "A" (Minimum Vehicular Volume) is intended for application where a large volume of intersecting traffic is the principal reason to consider a signal. Condition "B" (Interruption of Continuous Traffic) is intended for application where traffic volumes on a major street are so heavy that traffic on the minor intersecting street suffers excessive delay or conflict in entering or crossing the major street. The minimum volume requirements are shown in **Figure 8**.

Reduced warrants are applicable at locations where the speed of the major street exceeds 40 mph. In this case the posted speed on Highway WW is 45 mph, so the traffic volumes in the 70% column of the table shown in Figure 8 may be used.

Table 4C-1. Warrant 1, Eight-Hour Vehicular Volume									
Condition A—Minimum Vehicular Volume									
Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
Major Street	Minor Street	100% ^a	80% ^b	70% ^c	56% ^d	100% ^a	80% ^b	70% ^c	56% ^d
1	1	500	400	350	280	150	120	105	84
2 or more	1	600	480	420	336	150	120	105	84
2 or more	2 or more	600	480	420	336	200	160	140	112
1	2 or more	500	400	350	280	200	160	140	112

Condition B—Interruption of Continuous Traffic									
Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
Major Street	Minor Street	100% ^a	80% ^b	70% ^c	56% ^d	100% ^a	80% ^b	70% ^c	56% ^d
1	1	750	600	525	420	75	60	53	42
2 or more	1	900	720	630	504	75	60	53	42
2 or more	2 or more	900	720	630	504	100	80	70	56
1	2 or more	750	600	525	420	100	80	70	56

^a Basic minimum hourly volume
^b Used for combination of Conditions A and B after adequate trial of other remedial measures
^c May be used when the major-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000

Figure 8: MUTCD Warrant 1, Eight Hour Vehicular Volume

Using the 70% reduced warrant thresholds, Warrant 1A (Minimum Vehicular Volume) requires hourly approach volumes of at least 350 vehicles per hour (vph) on the major street for any eight hours of a typical day. During this same period, the volume of traffic entering from the minor street must exceed 105 vph (assuming a single lane approach). Warrant 1B requires approach volumes of at least 525 vph on the major street with a minimum of 53 vph on the minor street. The major street volume includes both directions, while the minor street volume includes only the heavier side-street approach. Elk Park Drive consists of a two lane approach (a left-turn lane and a shared through/right-turn lane). Likewise, the proposed subdivision street was assumed to consist of a two lane approach (a left-turn lane and a shared through/right-turn lane). Thus, the right-turn movements would commonly be reduced from the traffic analysis since they have a separate lane to get around any vehicles waiting to turn left. Thus, only the left-turn volume, in a single lane, was considered for the 2016 Build traffic signal warrant analysis since the through volume would be very low, effectively allowing for a separate right-turn lane.

In the absence of eight-hour traffic counts, the 8th highest hourly volumes are commonly estimated as 55% of peak hour traffic. As indicated by the 2016 Build traffic volumes (Exhibit 4), the total approach volume on Highway WW is forecasted at 835 vph during the weekday PM peak hour, while the approach volume on the side street (discounting the right-turn volume) is forecasted at 20 vph. At 55% of the peak hour, the 8th highest hourly volume is estimated to be approximately 460 vph on Highway WW and 11 vph on the side street



approach. As a result, the 2016 Build traffic volumes would not even satisfy one hour of the required eight hours. Thus, a traffic signal at Highway WW and Elk Park Drive is not warranted in the 2016 Build conditions.

2016 Operating Conditions: The study intersections were evaluated using the methodologies described above. The recommended eastbound left-turn lanes on Highway WW at both Sunningdale Drive, opposite Roseta Avenue, and Hoylake Drive, opposite Elk Park Drive, are reflected in the Build analyses. Hoylake Drive was assumed to have two lanes exiting (a left-turn lane and a shared through/right-turn lane) and one lane entering. Sunningdale Drive was assumed to have one lane exiting and one lane entering. **Table 3** summarizes the results of this analysis, which reflects the 2016 No Build and Build operating conditions and average delays during the AM and PM peak hours.

The 2016 No Build operating conditions reflect the anticipated operating conditions upon the full build-out of The Brooks Phase 1 development. As shown in **Table 3**, all of the study intersections and individual approaches operate at desirable levels of service (i.e., LOS C or better) during the peak hours with the exception of the northbound approach of El Chaparral Avenue at Highway WW which operates at LOS D during the PM peak hour.

The study intersections were re-evaluated for the 2016 Build conditions using the same methodologies. This analysis includes the full build-out of The Brooks Phase 2 development. As shown in **Table 3**, all of the study intersections and individual approaches are forecasted to operate at acceptable levels of service (i.e. LOS D or better) in the 2016 Build conditions with the exception of the northbound approach of El Chaparral Avenue at Highway WW which is forecasted to operate at LOS E during the PM peak hour.

As mentioned previously, a traffic signal at Highway WW and Elk Park Drive is not warranted in the 2016 Build conditions, and given the favorable level of service forecasted for the intersection, it is not recommended that the traffic signal be turned on until such time that the side street volume merits signalization.



Table 3: 2016 Capacity Analysis Summary

Intersection/Movement	AM Peak Hour		PM Peak Hour	
	2016 No Build Conditions	2016 Build Conditions	2016 No Build Conditions	2016 Build Conditions
Highway WW and Chaparral Avenue (Side-Street STOP)				
Eastbound Highway WW Approach	A (<1.0)	A (<1.0)	A (<1.0)	A (<1.0)
Westbound Highway WW Approach	A (<1.0)	A (<1.0)	A (1.7)	A (1.6)
Northbound Chaparral Ave Approach	C (16.7)	C (22.2)	D (27.8)	E (48.4)
Southbound Fire Station Approach	B (10.7)	B (11.7)	B (15.0)	C (17.6)
Highway WW and Roseta Avenue/Proposed Sunningdale Drive (Side-Street STOP)				
Eastbound Highway WW Approach	A (<1.0)	A (<1.0)	A (<1.0)	A (<1.0)
Westbound Highway WW Approach	A (<1.0)	A (<1.0)	A (<1.0)	A (<1.0)
Northbound Roseta Ave Approach	B (13.8)	C (20.3)	C (15.5)	D (25.0)
Southbound Sunningdale Drive Approach		B (12.7)		B (14.6)
Highway WW and Elk Park Drive/Proposed Hoylake Drive (Side-Street STOP)				
Eastbound Highway WW Left-Turn	A (8.0)	A (8.2)	A (7.8)	A (8.2)
Westbound Highway WW Left-Turn	A (7.6)	A (7.6)	A (8.3)	A (8.3)
Northbound Elk Park Drive Approach	B (13.1)	C (16.8)	B (14.3)	C (18.9)
Southbound Hoylake Drive Approach	B (10.4)	B (12.3)	A (9.8)	B (14.4)
Highway WW and Rolling Hills Road (Roundabout)				
Eastbound Highway WW Approach	A (6.0)	A (6.5)	A (8.8)	A (7.6)
Westbound Highway WW Approach	A (7.4)	A (7.7)	A (6.8)	A (7.2)
Northbound Rolling Hills Road Approach	A (4.6)	A (4.7)	A (8.3)	A (7.2)
Southbound Rolling Hills Road Approach	A (8.2)	A (8.6)	A (5.9)	A (6.5)
Overall	A (7.0)	A (7.3)	A (7.8)	A (7.2)
Rolling Hills Road and Hoylake Drive (Side-Street STOP)				
Eastbound Hoylake Drive Approach	B (10.5)	B (11.6)	B (11.1)	B (12.6)
Northbound Rolling Hills Road Approach	A (<1.0)	A (<1.0)	A (<1.0)	A (<1.0)
Southbound Rolling Hills Road Approach	A (<1.0)	A (<1.0)	A (<1.0)	A (<1.0)

X (XX.X) - Level of Service (Vehicular delay in seconds per vehicle)

20-YEAR DESIGN HORIZON

Based on prior discussions with the City of Columbia, it is likely that the vacant tracts to the north (referred to as the North Tract), west (referred to as the El Chaparral Tract) and south (referred to as the Elk Park Tract) of the subject site will develop within the next 20 years. These tracts are depicted in **Figure 9**. As such, the 20 year conditions considered these future development areas along with the build-out of the approved Brooks Phase 1 development and the proposed Brooks Phase 2 development.



Figure 9: Adjacent Tracts Assumed to Develop by 2036



2036 No Build Traffic Volumes: A series of volume assignments were estimated to determine the 20-year No Build traffic volumes. As a first step, the existing traffic volumes were increased by an annual growth rate of 1.5% to account for 20 years of background growth as depicted in the Appendix in **Exhibit A-1**.

Next, the trips associated with the North Tract, El Chaparral Tract, and Elk Park Tract were estimated and assigned to the roadways. Based on a review of the vacant tracts developable land area, it was estimated that the adjacent tracts would develop as follows:

The North Tract

- 85 single-family homes

El Chaparral Tract

- 40 single-family homes

Elk Park Tract

- Residential (*noted in orange in Figure 9*)
 - 120 single-family homes
- Neighborhood Commercial (*noted in yellow in Figure 9*)
 - 55,000 ft² of neighborhood commercial space

Traffic forecasts for the North Tract, El Chaparral Tract, and Elk Park Tract were developed using data provided in the *Trip Generation Manual* as depicted in **Table 4**.

Table 4: Trip Generation Estimate – Adjacent Tracts

ITE Code	Land Use	Unit	ADT (VPD)	Weekday AM Peak Hour			Weekday PM Peak Hour		
				In	Out	Total	In	Out	Total
North Tract									
210	Single-Family Homes	85 Homes	905	20	50	70	55	35	90
El Chaparral Tract									
210	Single-Family Homes	40 Homes	450	10	30	40	30	15	45
Elk Park Residential Tract									
210	Single-Family Homes	120 Homes	1,240	25	70	95	80	45	125
Elk Park Commercial Tract									
820	Neighborhood Retail	55,000 ft²	4,605	65	40	105	195	205	400

*the numbers in the table have been rounded to the nearest 5

As shown in the table, the North Tract is estimated to generate a total of 70 trips during the weekday AM peak hour and 90 trips during the weekday PM peak hour. The El Chaparral Tract



is estimated to generate a total of 40 trips during the weekday AM peak hour and 45 trips during the weekday PM peak hour. The Elk Park residential tract is estimated to generate a total of 95 trips during the weekday AM peak hour and 125 trips during the weekday PM peak hour. The Elk Park commercial tract is estimated to generate a total of 105 trips during the weekday AM peak hour and 400 trips during the weekday PM peak hour.

The anticipated distribution of site generated traffic for the adjacent residential tracts was consistent with that assumed for the Brooks Phase 1 and 2 developments. The anticipated distribution of site generated traffic for the adjacent commercial tract was assumed to be more uniform to the surrounding residential areas. The North Tract, El Chaparral Tract, and Elk Park Tract site-generated traffic volumes for the weekday AM and PM peak hour are shown in **Exhibit A-2**.

The North Tract, El Chaparral Tract, and Elk Park Tract site-generated traffic volumes (Exhibit A-2) were then added to the Exhibit A-1 volumes to determine the total volumes in the 20 Year No Build scenario. The 2036 No Build traffic volumes for the AM and PM peak hours are shown in **Exhibit 5**.

2036 No Build Signal Warrant Analysis: The need for a traffic signal at Highway WW and Elk Park Drive was re-evaluated using the same criteria as before for the 2036 No Builds conditions.

As mentioned previously, using the 70% reduced warrant thresholds, Warrant 1A requires hourly approach volumes of at least 350 vph on the major street for any eight hours of a typical day. During this same period, the volume of traffic entering from the minor street must exceed 105 vph (assuming a single lane approach). Warrant 1B requires approach volumes of at least 525 vph on the major street with a minimum of 53 vph on the minor street (assuming one lane) and 70 vph on the minor street (assuming two lanes). The major street volume includes both directions, while the minor street volume includes only the heavier side-street approach.

Elk Park Drive consists of a two lane approach (a left-turn lane and a shared through/right-turn lane). Likewise, the proposed subdivision street would consist of a two lane approach (a left-turn lane and a shared through/right-turn lane). The signal warrant analysis considered two alternatives; only the left-turn volume in a single lane and the total approach volume in two lanes.

In the absence of eight-hour traffic counts, the 8th highest hourly volumes are commonly estimated as 55% of peak hour traffic. As indicated by the 2036 No Build traffic volumes (Exhibit 5), the total approach volume on Highway WW is forecasted at 1,145 vph during the weekday PM peak hour, while the approach volume on the side street is forecasted at 90 vph in a single lane or 265 vph in two lanes. At 55% of the peak hour, the 8th highest hourly volume is estimated to be approximately 630 vph on Highway WW and 50 vph in a single lane or 145 vph in two lanes on the side street approach.

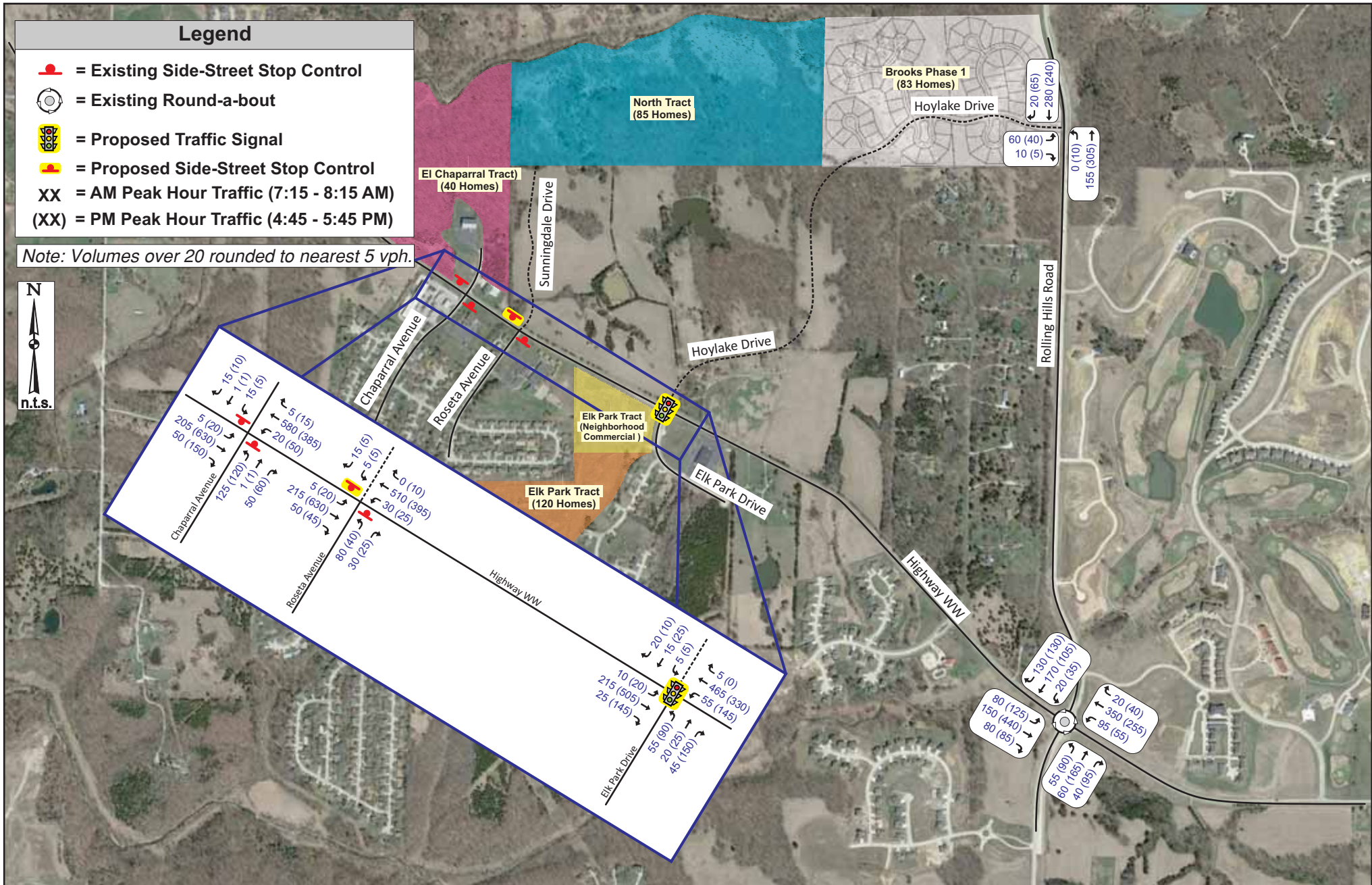


Exhibit 5: 2036 No-Build Traffic Volumes



As a result, the 2036 No Build traffic volumes would satisfy both Warrant 1A and 1B for the required eight hours. Thus, the traffic signal at Highway WW and Elk Park Drive will be necessary to accommodate the 2036 No Build traffic volumes, and specifically the development of the Elk Park Tract.

2036 Build Traffic Volumes: The proposed Brooks Phase 2 site trips (Exhibit 3) were added to the 2036 No Build traffic volumes (Exhibit 5) to determine the total volumes in the 2036 Build scenario. The 2036 Build traffic volumes for the AM and PM peak hours are shown in **Exhibit 6**.

2036 Build Auxiliary Turn Lane Needs: The need for separate westbound right-turn lanes on Highway WW were re-evaluated using MoDOT's Access Management Guidelines (AMG). Utilizing MoDOT's AMG *Right-Turn Lane Guideline for Two-lane Roadway* nomograph, separate right-turn lanes are not warranted on Highway WW at either site drive in the 20 year build conditions.

2036 Traffic Analysis: The study intersections were re-evaluated using the methodologies previously described. **Table 5** summarizes the results of this analysis, which reflects the 2036 No Build and 2036 Build operating conditions and average delays during the AM and PM peak hours. The recommended eastbound left-turn lanes on Highway WW at both Sunningdale Drive, opposite Roseta Avenue, and Hoylake Drive, opposite Elk Park Drive, are reflected in the Build analyses. Hoylake Drive was assumed to have two lanes exiting (a left-turn lane and a shared through/right-turn lane) and one lane entering. Sunningdale Drive was assumed to have one lane exiting and one lane entering.

In addition, based on the signal warrant analysis for the 2036 No Build conditions, it was assumed that the traffic signal at the Highway WW and Elk Park Drive intersection would be operational in the 20-year conditions. It is recommended that the Highway WW and Elk Park Drive/side-street left-turn movements operate under protected-plus-permissive control. It was assumed that the signal would operate free (actuated-uncoordinated).

The 2036 No Build operating conditions reflect the anticipated operating conditions 20 years into the future based on the assumptions described previously. As shown in **Table 5**, all of the study intersections and individual approaches are forecasted to operate at acceptable levels of service (i.e., LOS D or better) during the peak hours with the exception of the northbound approach of El Chaparral Avenue at Highway WW which is forecasted to operate at LOS F during the PM peak hour and the northbound approach of Roseta Avenue at Highway WW which is forecasted to operate at LOS E during the PM peak hour.

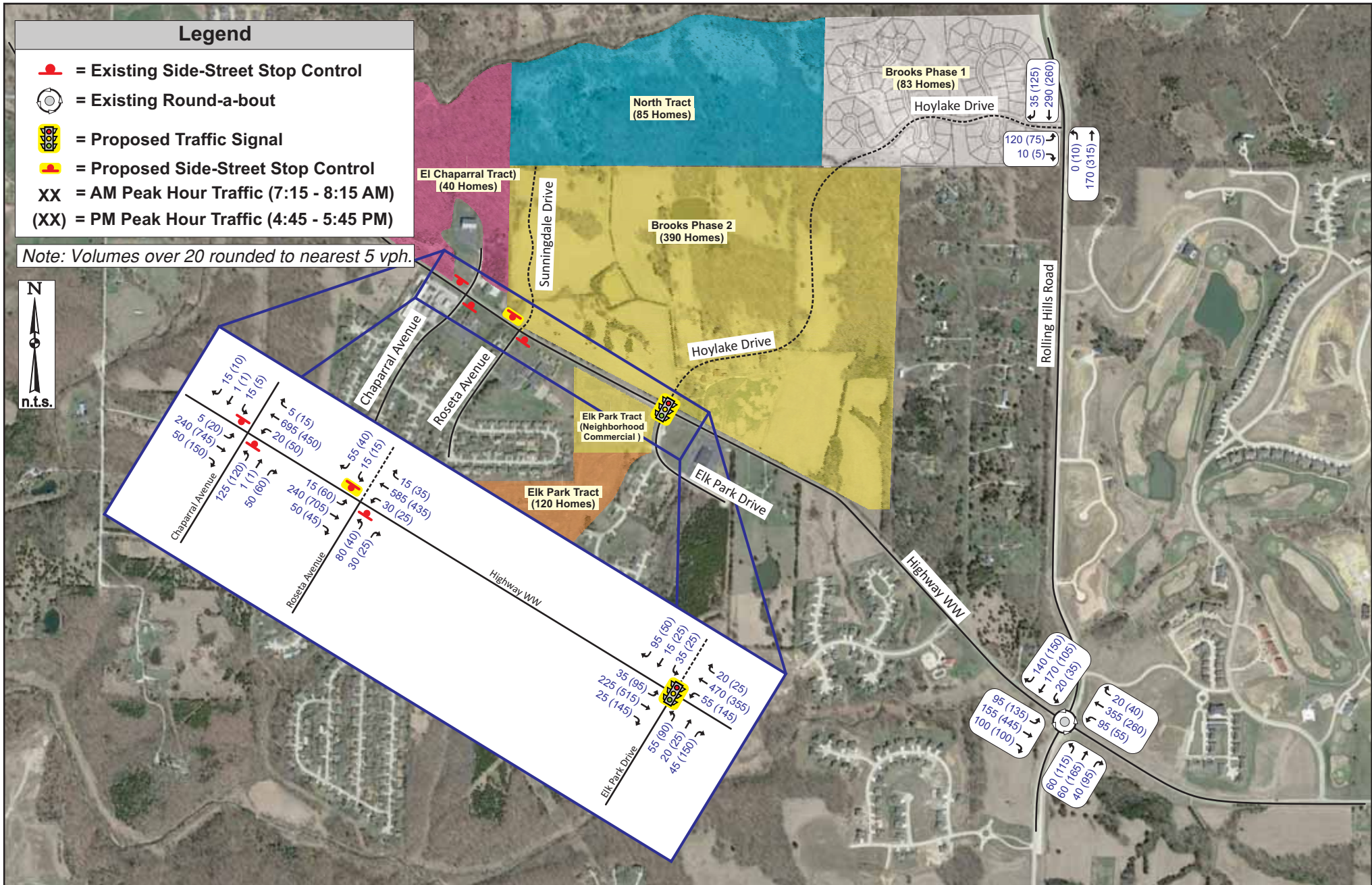


Exhibit 6: 2036 Build Traffic Volumes



Table 5: 2036 Capacity Analysis Summary

Intersection/Movement	AM Peak Hour		PM Peak Hour	
	2036 No Build Conditions	2036 Build Conditions	2036 No Build Conditions	2036 Build Conditions
Highway WW and Chaparral Avenue (Side-Street STOP)				
Eastbound Highway WW Approach	A (<1.0)	A (<1.0)	A (<1.0)	A (<1.0)
Westbound Highway WW Approach	A (<1.0)	A (<1.0)	A (1.9)	A (2.1)
Northbound Chaparral Ave Approach	D (33.2)	F (56.8)	F (135.4)	F (>200)
Southbound Fire Station Approach	C (19.3)	C (23.7)	C (24.6)	D (32.4)
Highway WW and Roseta Avenue/Proposed Sunningdale Drive (Side-Street STOP)				
Eastbound Highway WW Approach	A (<1.0)	A (<1.0)	A (<1.0)	A (<1.0)
Westbound Highway WW Approach	A (<1.0)	A (<1.0)	A (<1.0)	A (<1.0)
Northbound Roseta Ave Approach	C (24.9)	E (43.8)	E (35.4)	F (69.7)
Southbound Sunningdale Drive Approach	B (14.4)	C (17.6)	C (17.0)	D (25.5)
Highway WW and Elk Park Drive/Proposed Hoylake Drive (Signalized)				
Eastbound Highway WW Approach	B (13.5)	B (13.7)	B (19.9)	B (19.5)
Westbound Highway WW Approach	B (14.3)	C (20.1)	B (13.1)	B (17.5)
Northbound Elk Park Drive Approach	B (12.8)	B (14.6)	B (13.2)	B (14.1)
Southbound Hoylake Drive Approach	B (16.1)	B (12.3)	C (23.0)	B (17.1)
Overall	B (14.0)	B (16.8)	B (16.5)	B (17.8)
Highway WW and Rolling Hills Road (Roundabout)				
Eastbound Highway WW Approach	A (8.6)	A (9.4)	C (18.1)	C (20.1)
Westbound Highway WW Approach	B (10.8)	B (11.3)	B (10.6)	B (11.2)
Northbound Rolling Hills Road Approach	A (5.4)	A (5.6)	B (13.6)	B (13.9)
Southbound Rolling Hills Road Approach	B (13.9)	B (14.7)	A (9.3)	B (10.4)
Overall	B (10.4)	B (10.9)	B (14.0)	C (15.2)
Rolling Hills Road and Hoylake Drive (Side-Street STOP)				
Eastbound Hoylake Drive Approach	B (12.4)	B (14.3)	B (13.9)	C (16.3)
Northbound Rolling Hills Road Approach	A (<1.0)	A (<1.0)	A (<1.0)	A (<1.0)
Southbound Rolling Hills Road Approach	A (<1.0)	A (<1.0)	A (<1.0)	A (<1.0)

X (XX.X) - Level of Service (Vehicular delay in seconds per vehicle)



The 2036 No Build operating conditions reflect the anticipated operating conditions 20 years into the future based on the assumptions described previously. As shown in **Table 5**, all of the study intersections and individual approaches operate at acceptable levels of service (i.e., LOS D or better) during the peak hours with the exception of the northbound approach of El Chaparral Avenue at Highway WW which is forecasted to operate at LOS F during the PM peak hour and the northbound approach of Roseta Avenue at Highway WW which is forecasted to operate at LOS E during the PM peak hour.

This poor level of service for the northbound approaches of El Chaparral Avenue and Roseta Avenue at Highway WW is attributed to the heavier traffic volumes on Highway WW during the PM peak hour. Separate left- and right-turn lanes are provided on El Chaparral Avenue to accommodate traffic turning onto Highway WW. Consequently, there are not any further improvements, short of a traffic signal and/or roundabout that would lessen the delay for motorists desiring to turn left from El Chaparral Avenue and Roseta Avenue onto Highway WW. Although not desirable, it is not unusual for motorists on the side streets to incur longer delays during the peak hours.

The study intersections were re-evaluated for the 2036 Build conditions using the same methodologies. This analysis includes the full build-out of The Brooks Phase 2 development on top of the 20 Year No build conditions. As shown in **Table 5**, all of the study intersections and individual approaches are forecasted to continuing operating at acceptable levels of service (i.e. LOS D or better) with the exception of the northbound approach of El Chaparral Avenue at Highway WW which is forecasted to operate at LOS F during the AM and PM peak hours and the northbound approach of Roseta Avenue at Highway WW which is forecasted to operate at LOS E during the AM peak hour and LOS F during the PM peak hour.

As stated previously, this poor level of service for the northbound approaches of El Chaparral Avenue and Roseta Avenue at Highway WW is attributed to the heavier traffic volumes on Highway WW during the peak hours. Any additional traffic along Highway WW will lessen the available gaps for left-turn traffic from the side streets and result in a decline in the level of service for the side-street approaches as depicted in the table. Again, in order to provide improved operations for the northbound approaches of El Chaparral Avenue and Roseta Avenue at Highway WW, a traffic signal and/or roundabout may be necessary in the future.

CATSO ROADWAY PLAN

The proposed residential development was evaluated to determine if the proposed site plan provides an appropriate internal roadway network considering future developments and the City's CATSO Roadway Plan. Both Highway WW and Rolling Hills Road are designated as Minor Arterials in the CATSO Major Roadway Plan Map (August 2010) as depicted in **Figure 10**. Additionally, a Major Collector Road is identified in the vicinity of development area that would provide access between Rolling Hills Road and Highway WW.

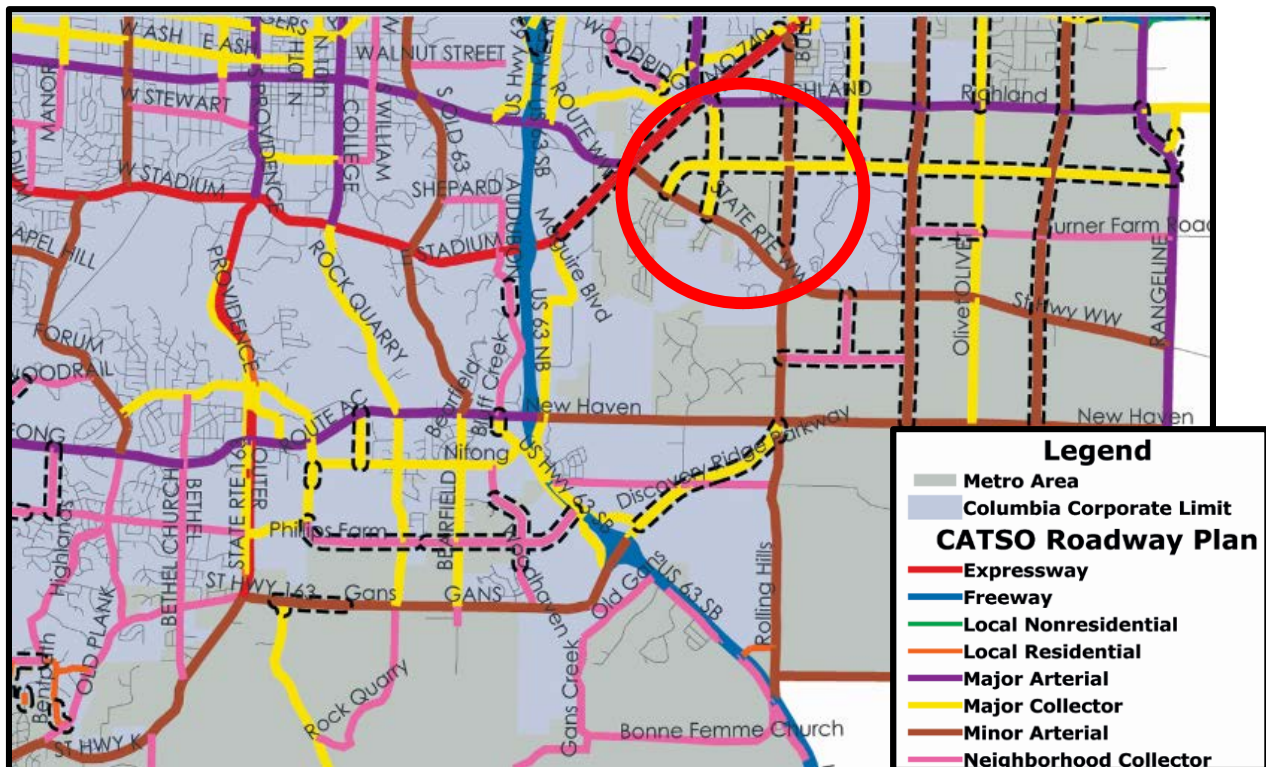


Figure 10: CATSO Major Roadway Plan Map (August 2010)

The collector road connecting Rolling Hills Road to Highway WW was added by the City to the Major Roadway Plan to provide a future roadway to ensure both access and circulation to support development. Although a collector road is also depicted from Highway WW to Richland Road, the presence of the North Fork of Grindstone Creek limits a future northern connection from Richland Road to this area.

As part of The Brooks Phase 1 development, Hoylake Drive is being constructed to collector standards from Rolling Hills Road to the west edge of the property. As part of The Brooks Phase 2 development, it is anticipated that this collector road would be continued The Brooks Phase 1 south through The Brooks Phase 2, connecting to Highway WW opposite Elk Park Drive. This collector road would adequately serve both the planned and future residential areas north of

Highway WW and west of Rolling Hills Road. **Figure 11** depicts the estimated average daily traffic (ADT) on the internal subdivision streets between Rolling Hills Road and Highway WW. The ADT forecasts are based on the previously assumed adjacent future developments. As shown, the estimated ADT on Hoylake Drive serving the residential area is 2,450 vehicles per day (vpd) which is within the City's Neighborhood Collector volume range of 1,500 to 3,500 vpd. It is recommended that this main road be designed to the City's Neighborhood Collector standards and that direct access to homes from this collector road be minimized.

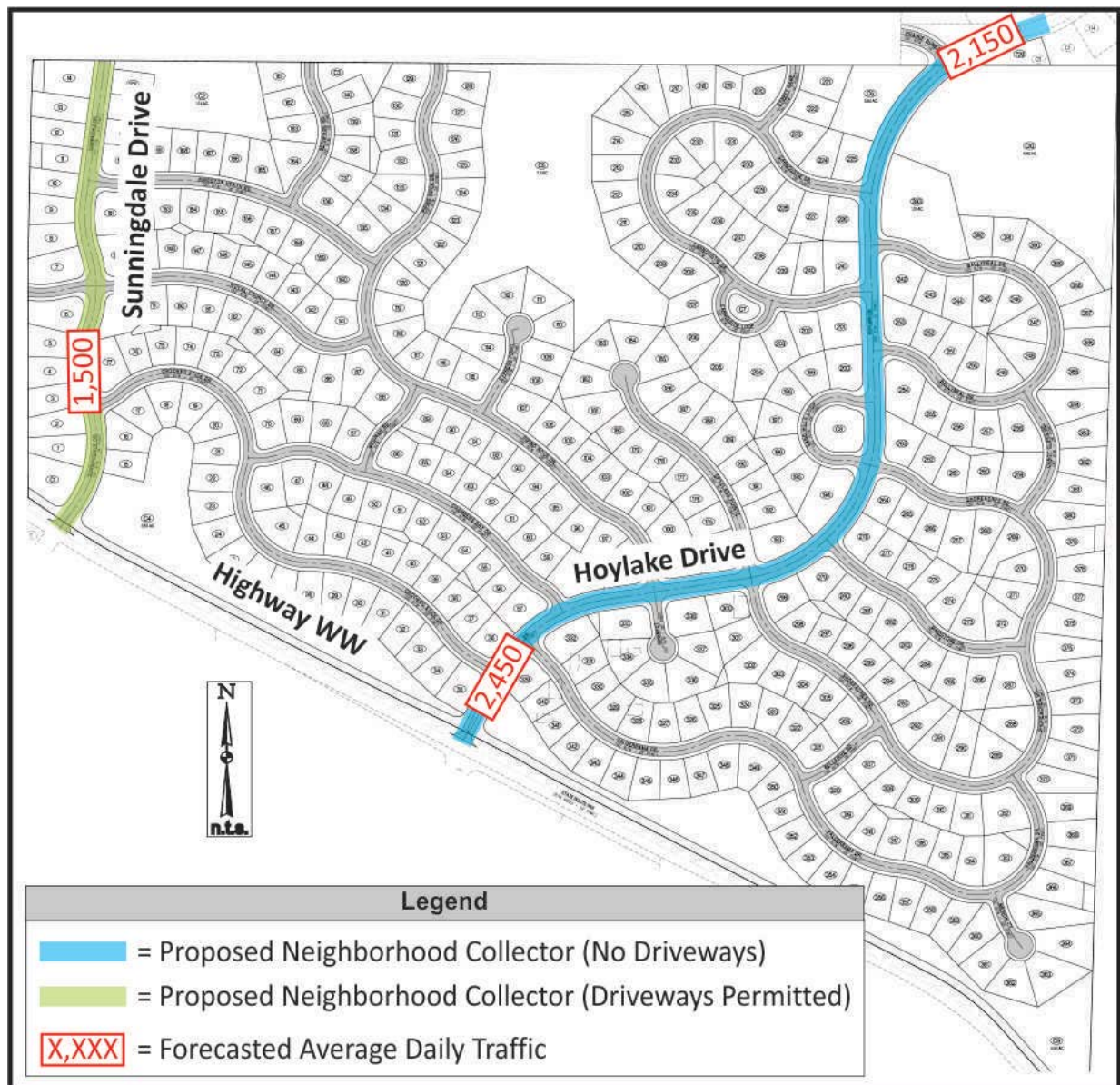


Figure 11: Average Daily Traffic Volumes on Primary Brooks Phase 2 Streets



The estimated ADT on Sunningdale Drive serving The Brooks Phase 2 residential area, opposite Roseta Avenue, is 1,500 vpd which is also within the City's Neighborhood Collector volume range of 1,500 to 3,500 vpd. Given the much lower traffic volumes forecasted, it is recommended that Sunningdale Drive also be designed to the City's Neighborhood Collector standards, though driveways could be permitted.

The estimated ADT on Hoylake Drive near Rolling Hills Road is 2,150 vpd which is consistent with the planned Neighborhood Collector currently under construction in conjunction with The Brooks Phase 1.

While it was assumed that the North Tract development area would develop in a manner consistent with The Brooks Phases 1 and 2, the ADT estimates were re-evaluated assuming the North Tract developed according to the maximum zoning allowed. The North Tract consists of 69 acres zoned for up to 4 units per acre for a total of up to 276 units. While it is very unlikely that the North Tract would develop with this many units due to the existing topography and surrounding subdivision characteristics, **Figure 12** depicts the estimated ADT on the internal subdivision streets between Rolling Hills Road and Highway WW if the North Tract developed with 276 units instead of the previously assumed 85 units.

As shown, the estimated ADT on Hoylake Drive would increase to is 3,110 vpd which is still within the City's Neighborhood Collector volume range of 1,500 to 3,500 vpd and would still adequately serve the North Tract as a Neighborhood Collector.

The estimated ADT on Sunningdale Drive would increase to 1,910 vpd which would also still be on the lower volume range for a Neighborhood Collector and would function acceptably as a Neighborhood Collector with driveways.

The estimated ADT on Hoylake Drive near Rolling Hills Road would increase to 2,700 vpd which is still consistent with the planned Neighborhood Collector currently under construction in conjunction with The Brooks Phase 1.



Figure 12: Average Daily Traffic Volumes on Primary Brooks Phase 2 Streets – Max Build Out of the North Tract

Thus, the proposed roadways within The Brooks Phase 2 development would adequately serve the proposed subdivision, in addition to the future development of the North Tract. The proposed extension of Hoylake Drive as a Neighborhood Collector through The Brooks Phase 2 would achieve the desired outcome of providing a 'Collector Road' between Highway WW and Rolling Hills Road to serve the entire residential development area between the creek and Highway WW.

Prior alignments of this 'Collector Road' have looked at tying into Highway WW at Elk Park Drive and at El Chaparral Avenue. Given the planned traffic signal at Elk Park Drive, it would be



advantageous to focus the residential traffic to Elk Park Drive to gain access to Highway WW via the currently planned traffic signal.

Furthermore, it is our opinion that the collector road, as proposed opposite Elk Park Drive, would lessen the likelihood of cut-thru traffic through the subdivision which is often a major concern of residents. If a more direct collector road is providing from Highway WW, near El Chaparral Avenue, to Rolling Hills Road it may become an attractive cut-thru route since the travel distance would be cut in half by using the collector road versus using Highway WW to Rolling Hills Road (i.e. it would be approximately one mile using the cut-thru road versus two miles by staying on Highway WW and Rolling Hills Road).

In addition, given the existing barriers of the creek to the north and west, Rolling Hills Road to the east and Highway WW to the south, the proposed Neighborhood Collector, Hoylake Drive, would only serve a relatively small residential development area and could be adequately accommodated with the proposed roadways. Additionally, although the CATSO model showed this collector road (Hoylake Drive) extending to the east of Rolling Hills Road, a collector road was not built through the adjacent Hawthorne development further supporting the fact that a 'straight' connection from Highway WW to Rolling Hills Road is not necessary.

In summary, the proposed residential development plan provides an appropriate internal roadway network considering future developments and the City's CATSO Roadway Plan.



SUMMARY

CBB completed the preceding study to address the traffic impacts associated with the proposed residential development, known as The Brooks Phase 2, in Columbia, Missouri. The subject property is located north of Highway WW between Roseta Avenue and Rolling Hills Road.

The Brooks Phase 2 development would consist of approximately 390 single family homes. In conjunction with the proposed development, the existing Hoylake Drive collector road currently under construction through The Brooks Phase I site would be extended through the proposed subdivision and tie into Highway WW, opposite Elk Park Drive. This would provide a collector road between Highway WW and Rolling Hills Road. Access to the proposed Brooks Phase 2 development would be provided via two new roads on Highway WW; one opposite Elk Park Drive (the extension of Hoylake Drive) and one opposite Roseta Avenue (Sunningdale Drive).

The following improvements should be considered to better accommodate the proposed Brooks Phase 2 residential development (2016 Build):

- Construct a separate eastbound left-turn lane on Highway WW at Hoylake Drive (main site drive);
- Construct a separate eastbound left-turn lane on Highway WW at Sunningdale Drive (west site drive);
- Provide two lanes exiting (a left-turn lane and a shared through/right-turn lane) for the southbound approach of Hoylake Drive at Highway WW;
- Clear the existing vegetation along the north side of Highway WW to ensure that the area within the sight distance triangles for the proposed site drives is clear of any vegetation that would obstruct the sight distance;
- It is recommended that Hoylake Drive through The Brooks Phase 2 development be designed to the City's Neighborhood Collector standards and that direct access to homes from this collector road be minimized; and
- It is recommended that Sunningdale Drive through The Brooks Phase 2 development be designed to the City's Neighborhood Collector standards and that direct access to homes from this collector road be allowed.

The following additional improvements should be considered to better accommodate the 20 Year forecasted conditions (2036 Build):

- Turn on the traffic signal at the Highway WW at Elk Park Drive/Hoylake Drive intersection (would require signal modifications to accommodate the north leg);



- In order to provide improved operations for the northbound approaches of El Chaparral Avenue and Roseta Avenue at Highway WW, a traffic signal and/or roundabout may be necessary in the future.

We trust that this traffic study adequately describes the forecasted traffic conditions that should be expected in the vicinity of the proposed Brooks Phase 2 residential development. If additional information is desired, please feel free to contact me at 314-449-9572 or swhite@cbbtraffic.com.

Sincerely,

Shawn Lerai White, P.E., PTOE
Associate - Senior Traffic Engineer



APPENDIX

EXHIBITS A-1 THRU A-2

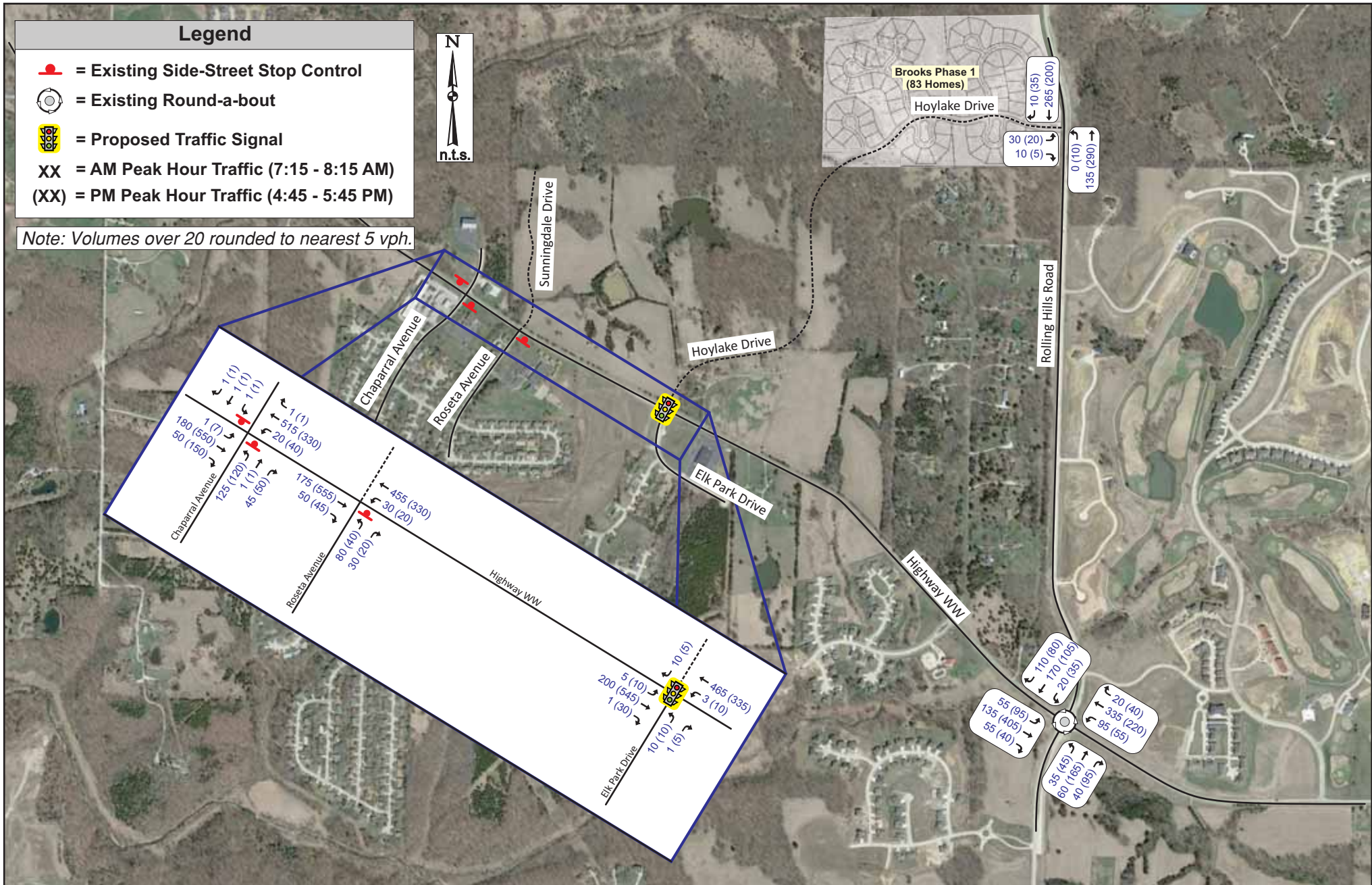


Exhibit A-1: Background Traffic Growth (annual rate of 1.5%)

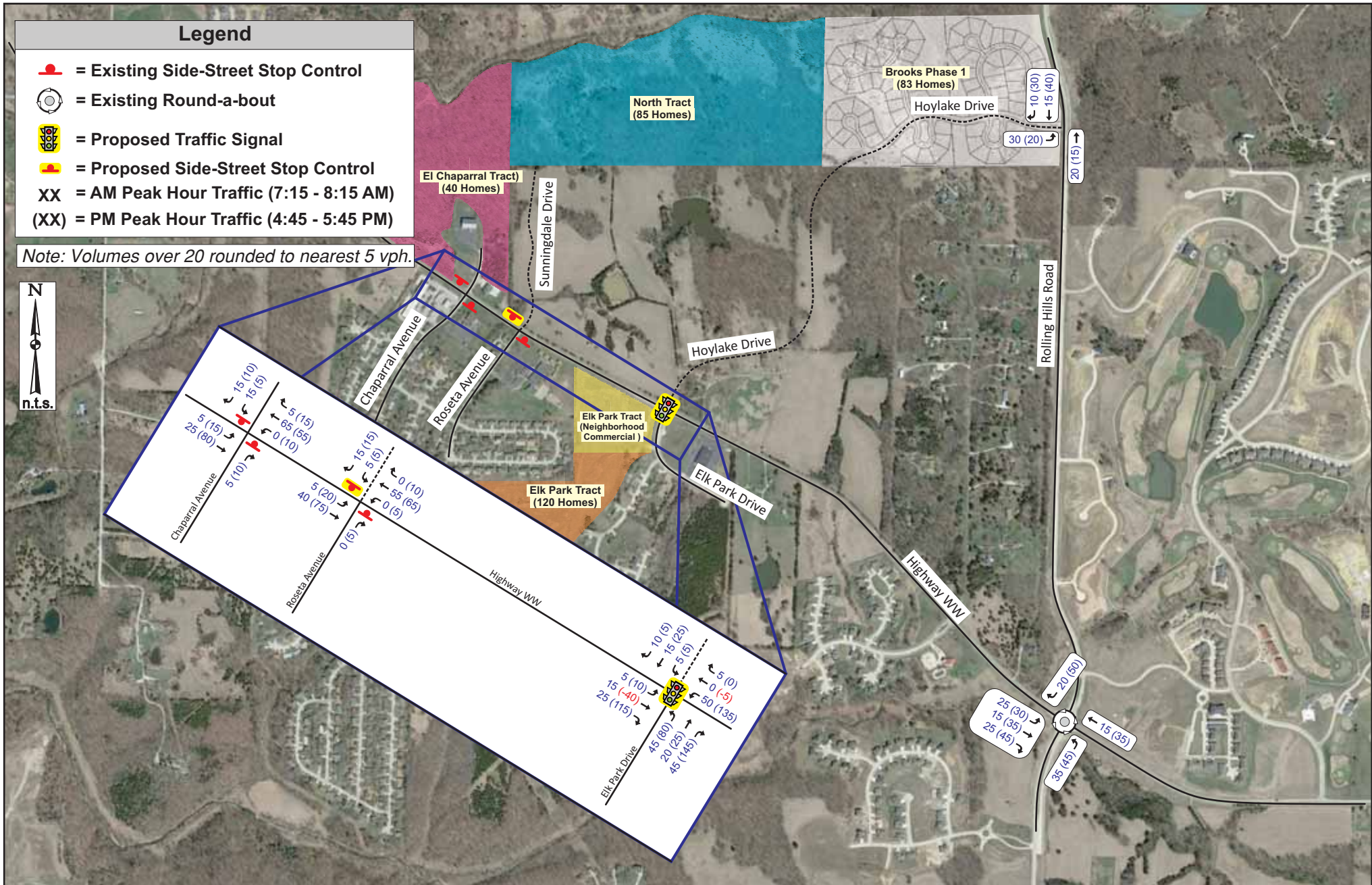


Exhibit A-2: Potential Adjacent Developments - Site Trips