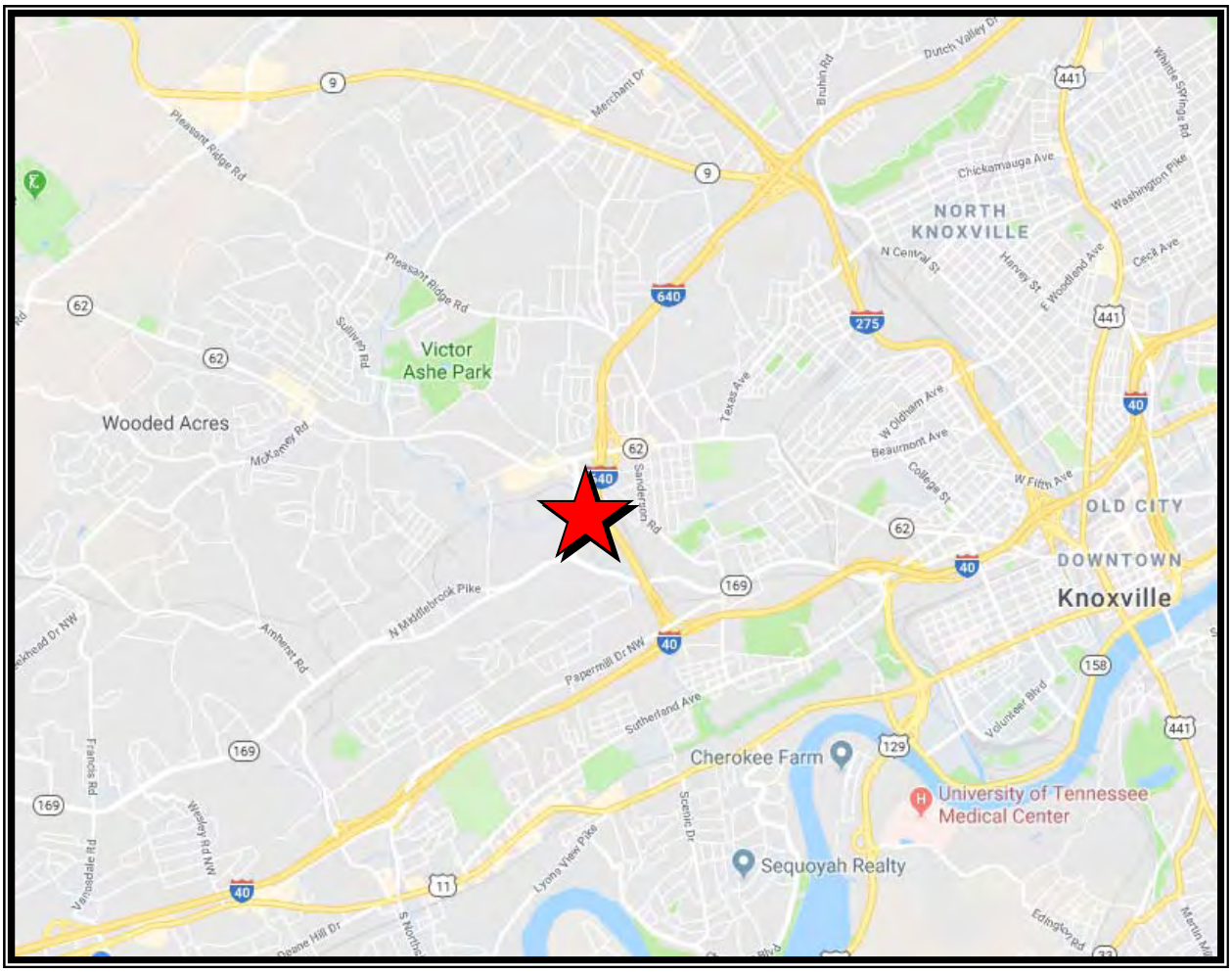

TRANSPORTATION IMPACT STUDY

HISTORIC MIDDLEBROOK

KNOXVILLE, TENNESSEE

-Prepared For-

Fiser, Inc.
132 Sherlake Lane
Knoxville, TN 37922

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REGISTERED ENGINEER
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STATE OF TENNESSEE
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Revised April 2019

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EXECUTIVE SUMMARY

Preface:

Fiser, Inc. is proposing to construct an office/warehouse development adjacent to Ed Shouse Drive in Knoxville, TN. This proposed office/warehouse development is named "Historic Middlebrook". Historic Middlebrook will consist of an initial phase of 40,000 square feet of office/warehouse building space and a future phase which will contain an additional 180,000 square feet of office/warehouse building space. This development will be bounded by Interstate 640, Middlebrook Pike, and Ed Shouse Drive on 25.6 acres and located to the west of downtown Knoxville. The purpose of this study is to determine and evaluate the potential impacts of the proposed office/warehouse development on the adjacent transportation system. The study includes a review of the operating characteristics of the existing transportation system that will provide access to the proposed development site. Recommendations and mitigation measures will be analyzed and offered where traffic operations have been projected to be below traffic engineering standards.

Study Results:

The findings of this study include the following:

- When the initial and future phase is fully built-out, the proposed development with 10 buildings containing a total of 220,000 square feet of office/warehouse space is expected to generate approximately 439 trips on an average weekday. 78 of these trips are estimated to occur during the AM peak hour of traffic and 83 trips in the PM peak hour of traffic at full build-out. Full build-out of both phases is expected to occur by the year 2025.
- The proposed development driveway at the intersection with Ed Shouse Drive is projected to operate adequately for vehicular traffic in both the initial phase in the year 2020 and the future phase in the year 2025 with respect to road capacity. This development is expected to generate a relatively high percentage of heavy truck traffic and these large vehicles will interact with existing high traffic volumes, high speeds, and relatively steep road grades on Ed Shouse Drive. Several auxiliary lanes are recommended to be constructed to mitigate the potential impacts of the truck traffic generated by the proposed office/warehouse development. The proposed intersection was also analyzed to determine if traffic signal warrants might possibly be met for potential signalization of the intersection. Based on the projected volumes in the year 2025, the proposed intersection will not meet warrants for signalization.

Recommendations:

The following recommendations are offered based on the study analyses. Figure 9 on page 58 illustrates most of these recommendations:

- It is recommended that the trees located in the median on Ed Shouse Drive be removed in between the CSX Railroad overpass all the way to the new median opening proposed for the Historic Middlebrook development.
- A separate northbound right turn entering lane is not required but the radius at this corner be a minimum of 50 feet but preferably larger.
- The new median opening on Ed Shouse Drive for the Historic Middlebrook Driveway should be constructed with a triangular-shaped depressed grass island that outlines the intended paths with adequate dimensions for vehicles up to the size of a WB-67 tractor-trailer truck. The depressed grass island should have minimal vertical grade changes in the interior of the island. It is recommended that in advance of this new median opening, No U-Turn Signs (R3-4) be installed facing northbound and southbound traffic on Ed Shouse Drive.


R3-4

- A southbound left turn entering median lane should be constructed with a bay taper of 220 feet and a storage length of 290 feet. The lane should be marked as shown in TDOT Standard Drawing T-M-4 with a white lane line, dotted white lane line, and white left turn arrows. The end of this left turn lane should be marked with a 24" white stop bar in advance of the northbound thru lanes of Ed Shouse Drive. This will provide guidance to left turning motorists as to the proper stopping point in the median opening when waiting for a suitable gap in the oncoming northbound thru traffic on Ed Shouse Drive. A Do Not Enter Sign (R5-1) sign should be installed at the end of this lane in the median and facing the westbound left turn lane of the Historic Middlebrook Driveway to warn motorists to not enter the southbound left turn entering lane.

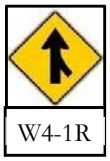
R5-1

- A southbound left turn exiting median acceleration lane should be constructed with an ending bay taper of 144 feet. The designer should maximize the available storage/acceleration lane length to fit in between the proposed intersection and the existing median opening located to the south for KUB. The lane should be striped as shown in TDOT Standard Drawing T-M-6 for parallel acceleration lanes. A Merge Sign (W4-1L) should be installed in the triangular-shaped depressed median


W4-1L

grass island at the proposed intersection in advance of the median acceleration lane for southbound thru motorists on Ed Shouse Drive.

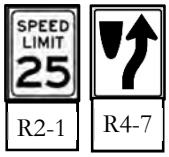
- A westbound right turn exiting acceleration lane should be constructed with an ending bay taper of 144 feet. The designer should maximize the available storage/acceleration lane length to fit in between the proposed intersection and the existing railroad overpass located to the north on Ed Shouse Drive. The lane should be striped as shown in TDOT Standard Drawing T-M-6 for parallel acceleration lanes. A triangular-shaped depressed grass island should be constructed on the east side at the intersection of Ed Shouse Drive at the proposed Historic Middlebrook Driveway that separates westbound left and right turns. The depressed grass island should have minimal vertical grade changes in the interior of the island. A Merge Sign (W4-1R) should be installed in the triangular-shaped depressed island in advance of the acceleration lane for northbound thru motorists on Ed Shouse Drive. It is also recommended that a white lane reduction arrow be installed in this lane to notify motorists of the requirement to merge and to also notify northbound thru motorists that this lane does not continue on Ed Shouse Drive past the CSX Railroad overpass.



- The westbound left turn lane of the Historic Middlebrook Driveway should be constructed with a Stop Sign (R1-1) and a 24" white stop bar. The stop bar should be located outside the vehicle path of where heavy truck traffic will be turning left into the development. A No Outlet Sign (W14-2aR) should be installed at the top of the Stop Sign (R1-1) post. A Speed Limit 25 (mph) Sign (R2-1) and a Keep Right Sign (R4-7) should be installed for vehicles entering the development. A Double Arrow Sign (W12-1) should be installed at the east approach end of the depressed grass island for vehicles leaving the development traveling westbound towards Ed Shouse Drive. Left and right white turn arrows should be installed on the pavement in advance of the depressed grass island for vehicles traveling westbound towards Ed Shouse Drive.

R1-1

W14-2aR



R2-1 R4-7


W12-1

- Two Do Not Enter Signs (R5-1) should be installed on the northbound lanes of Ed Shouse Drive just to the south of the proposed intersection and facing north. One should be placed on the east outside shoulder and one in the existing depressed grass median.

R5-1

- Two Wrong Way Signs (R5-1a) should be installed on the northbound lanes of Ed Shouse Drive further to the south of the Do Not Enter Signs (R5-1) and facing north. One should be placed on the east outside shoulder and one in the existing depressed grass median. Two Wrong Way Signs (R5-1a) should also be installed on the southbound lanes of Ed Shouse Drive just to the north of the proposed intersection and facing south. One should be placed on the west outside shoulder and one in the existing depressed grass median.

R5-1a

- The existing median opening that is proposed to be closed on Ed Shouse Drive should have the pavement fully removed, median edges striped, be re-graded for proper drainage, and the area seeded.
- Consideration should be given to installing Truck Crossing Signs (W8-6) in advance of the proposed intersection for both directions on Ed Shouse Drive.

W8-6

DESCRIPTION OF EXISTING CONDITIONS

- **STUDY AREA:**

The proposed new office/warehouse development is to be located adjacent and to the east of Ed Shouse Drive as shown on a map in Figure 1. The proposed development is expected to be constructed in two phases on approximately 25.6 acres. The development property will be subdivided out of an existing parent property parcel of 58.7 acres. The initial phase will involve constructing a new driveway to tie into Ed Shouse Drive and 2 – 40,000 square foot office/warehouse buildings. At this stage of planning, the future phase is expected to include an additional 8 office/warehouse buildings with 180,000 square feet of building space. To identify the transportation impacts associated with both phases of the proposed office/warehouse development, the following roadway and proposed intersection were analyzed where the greatest impact is expected:

- Ed Shouse Drive
- Intersection of Ed Shouse Drive at proposed Historic Middlebrook Driveway

Near this study area, there are several commercial and industrial businesses located to the north and south. The largest existing development adjacent to the proposed site is the Knoxville Utilities Board (KUB). This facility is located on the northwest corner of Ed Shouse Drive at Middlebrook Pike (SR 169) and is the main operation center for KUB. KUB is the main provider of electrical, gas, water, and wastewater services in Knoxville and Knox County.

The property for the proposed development is currently unoccupied and a large majority of it is covered in woods. The parent tract of 58.4 acres will be subdivided into 2 parcels and is crossed by Third Creek on the southwestern portion of the property. The northern portion will contain the office/warehouse development on 25.6 acres. The southern portion of the subdivided property will remain undeveloped. Located on the southern tract is Middlebrook, a historic house that was built around 1845 and is listed on the National Register of Historic Places. The southern tract will retain access to Middlebrook Pike (SR 169) at the intersection with Lonas Drive. The proposed site for the Historic Middlebrook office/warehouse development will be bounded by Interstate 640 to the east, Ed Shouse Drive to the west, CSX Railroad to the north, and the subdivided property to the south that fronts Middlebrook Pike (SR 169).

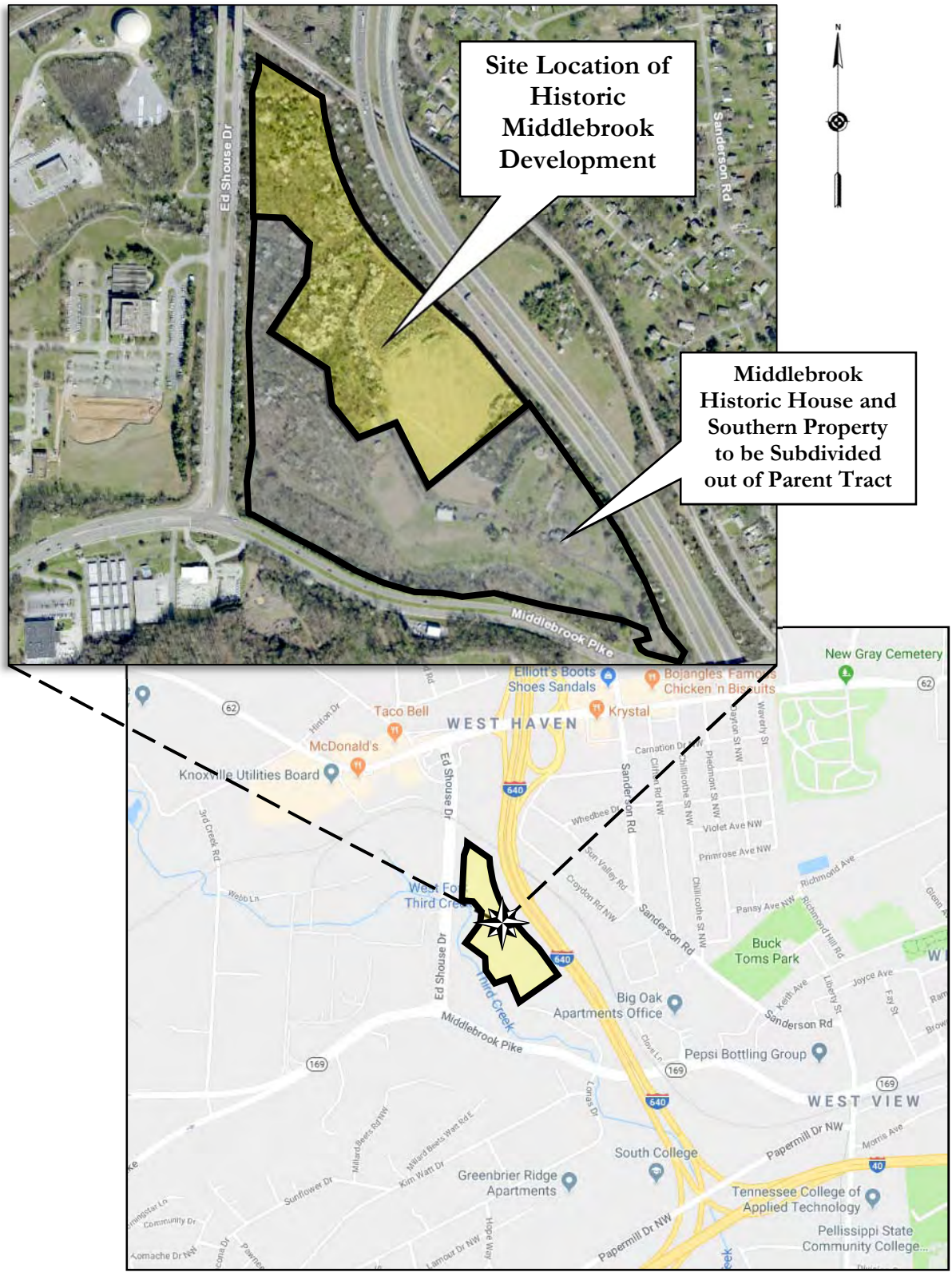


Figure 1
Location Map

- **EXISTING ROADWAYS:**

Table 1 shows the characteristics of the key existing roadway included in the study:

TABLE 1
STUDY CORRIDOR CHARACTERISTICS

NAME	CLASSIFICATION [1]	SPEED LIMIT	LANES	ROAD WIDTH [2]	TRANSIT [3]	MEDIAN WIDTH	PEDESTRIAN FACILITIES	BICYCLE FACILITIES
Ed Shouse Drive	Major Arterial	50 mph	4 lane divided	115 feet	Route 90 (no existing bus stops)	38.5 feet (grassed)	No sidewalks	No bike lanes

[1] 2018 Major Road Plan by Knoxville/Knox County Metropolitan Planning Commission
[2] Edge of curb to edge of curb or edge of pavements near project site
[3] According to Knoxville Area Transit System Map

Ed Shouse Drive traverses in a general north-south direction and will provide the sole road access for the proposed development. It is a major arterial and is an important and well-traveled link between Middlebrook Pike (SR 169) and Western Avenue (SR 62) in west Knoxville. The road is approximately 3,350 feet in length and has a straight horizontal alignment with a large vertical sag curve roughly midway in its length as it crosses over Third Creek. Ed Shouse Drive adjacent to the project site consists of a 4-lane divided roadway section with a 38.5-foot grass median, approximately 150 feet of public right-of-way, and a couple of median openings.

Ed Shouse Drive has streetlights along its entire length and a large majority of the road is lined with guardrails on both northbound and southbound outside shoulder edges. The shoulders are paved and are approximately 12 feet in width. In 2003, this road was renamed from Forty-Fourth Street to Ed Shouse Drive.

Currently, there are only a handful of road and driveway access points along Ed Shouse Drive. Randy Tyree Street and Falconite Way intersect Ed Shouse Drive on the north side just south of Western Avenue (SR 62). Falconite Way is a single access drive for a United Rentals business. Just to the south of Western Avenue (SR 62), CVS Pharmacy has a driveway connection on the west side that only allows travel on the southbound lanes of Ed Shouse Drive. Other road connections to Ed Shouse Drive include 2 driveways that are located roughly half-way along Ed Shouse Drive. These 2 driveways provide access to Knoxville Utilities Board (KUB) facilities on the west side of Ed Shouse Drive and are located near each other. The northernmost KUB driveway provides access to a sanitary sewer pump station and this driveway only has access to the southbound lanes of Ed Shouse Drive (no median

opening). The southernmost KUB driveway is one of the main access points for KUB employees. This driveway is gated and only KUB employees can enter or exit. This driveway has access to both northbound and southbound lanes of Ed Shouse Drive via a median opening.

KUB Driveway at Ed Shouse Drive

Figure 2 shows the lane configurations of Ed Shouse Drive and the location where the traffic count was conducted, adjacent to the proposed location of the driveway connection for the development. Figure 2 shows the posted speed limit on Ed Shouse Drive along with the distances between the proposed development driveway to Western Avenue (SR 62) and Middlebrook Pike (SR 169) to the north and south respectively. The pages following Figure 2 give an overview of the site study area with photographs.

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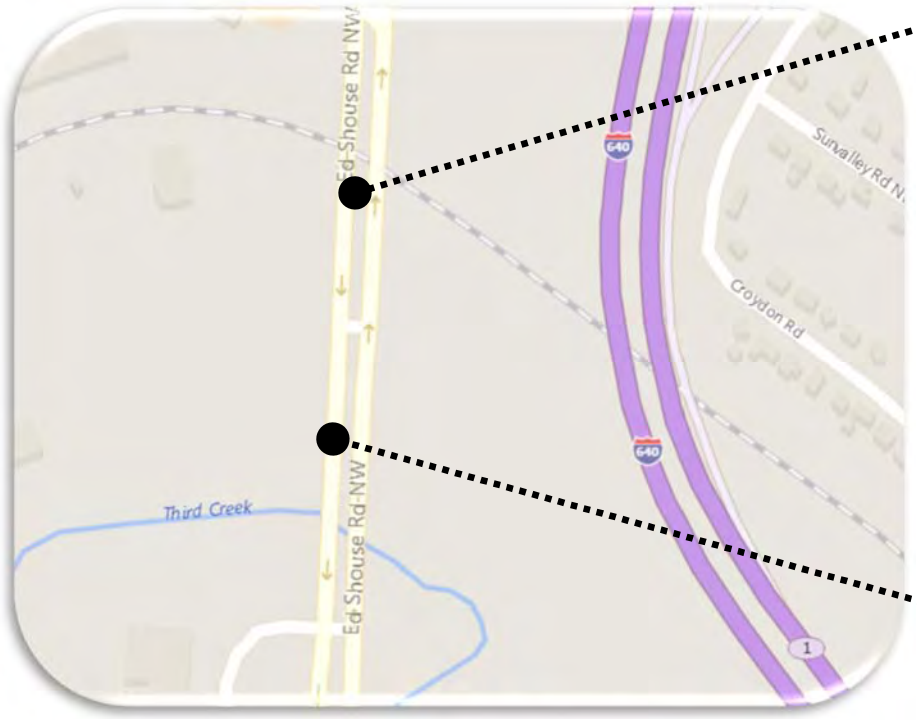
FIGURE 2

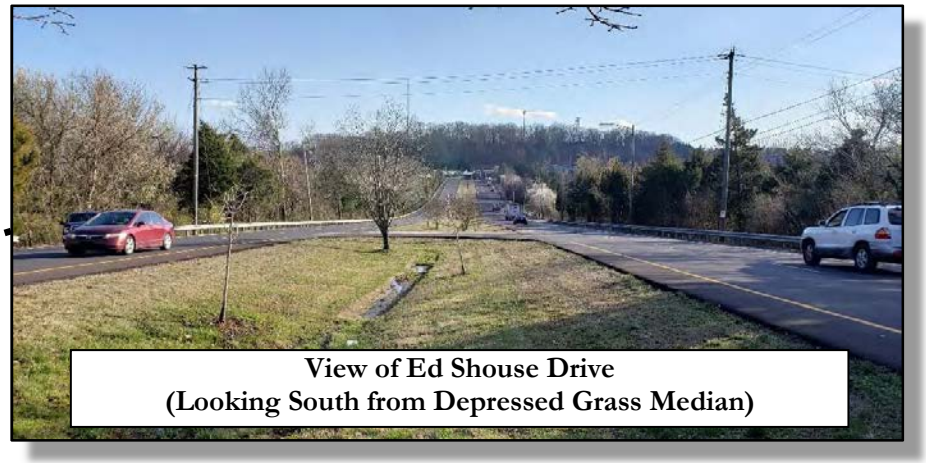
Historic Middlebrook

Traffic Count Location & Existing Lane Configurations

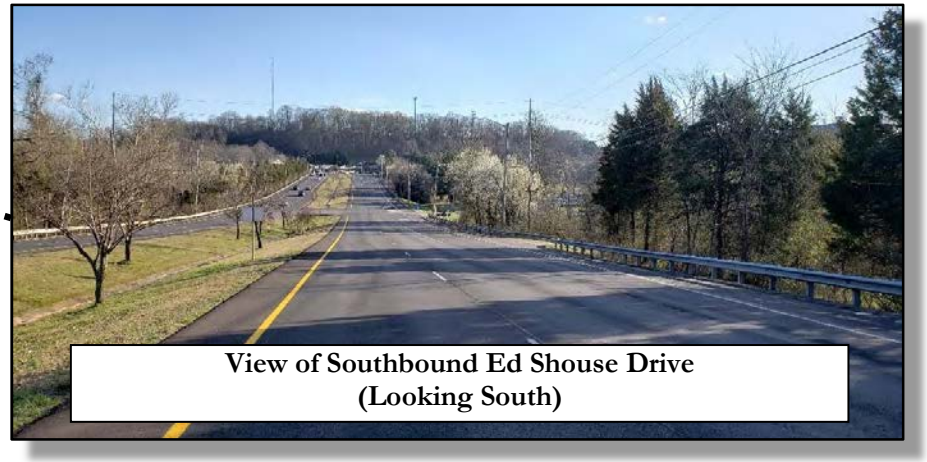
PHOTO EXHIBITS



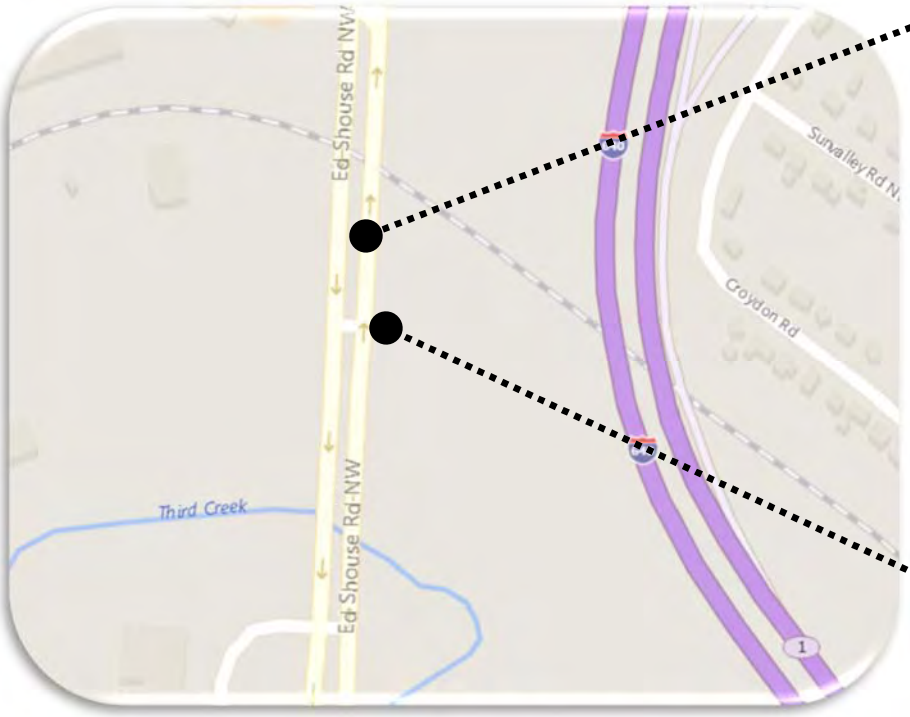
Ed Shouse Drive



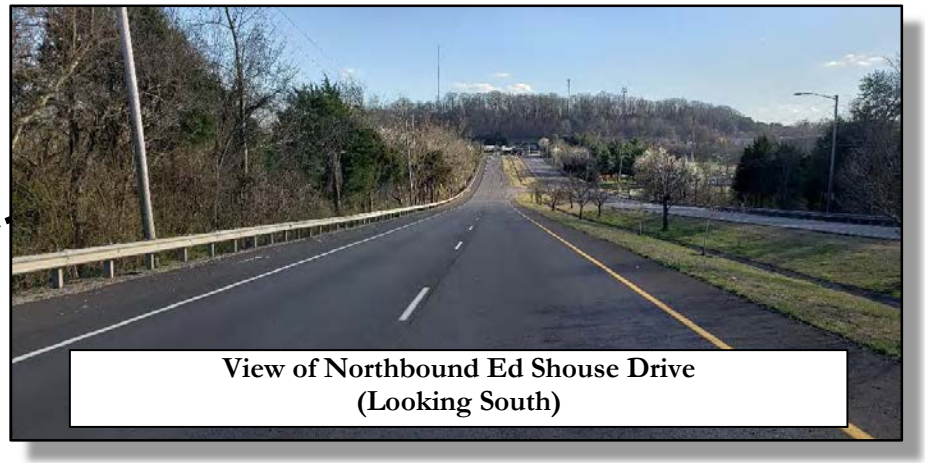
View of Ed Shouse Drive
(Looking South from Depressed Grass Median)



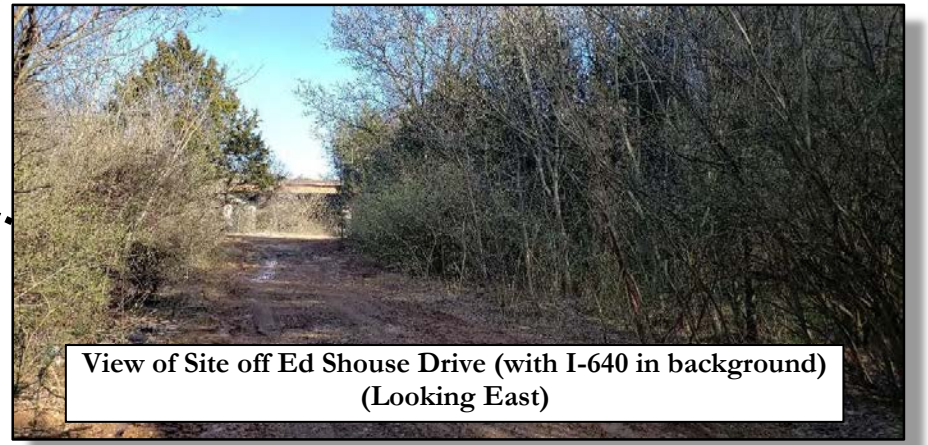
View of Southbound Ed Shouse Drive
(Looking South)



Ed Shouse Drive



View of Northbound Ed Shouse Drive (Looking South)



View of Site off Ed Shouse Drive (with I-640 in background) (Looking East)

- **EXISTING TRANSPORTATION VOLUMES PER MODE:**

There is one permanent vehicular traffic count location adjacent to this project site on Ed Shouse Drive. This count at this location is conducted by the Tennessee Department of Transportation (TDOT) on a yearly basis. The count data is the following:

- Average Daily Traffic (ADT) on Ed Shouse Drive was reported by TDOT at 22,028 vehicles per day in 2017. From 2007 – 2017, this count station has indicated a -1.1% average annual growth rate. The researched historical traffic count data for this report can be viewed in Appendix A.

Bicycle facilities (lanes) and pedestrian sidewalks are not currently available within the project site study area along Ed Shouse Drive.

- Bicycle and pedestrian volumes are unknown. No bicyclists were observed but two pedestrians were observed on Ed Shouse Drive during the traffic counts.

- **ON-STREET PARKING:**

On-street parking is not allowed on Ed Shouse Drive. Along the shoulders, No Parking Signs (R7-2) are posted at regular intervals.

- **TRANSIT SERVICES:**

The City of Knoxville has a network of public transit opportunities offered by Knoxville Area Transit (KAT). Bus service is available in this area of Knoxville but currently there are not any bus stops on Ed Shouse Drive. This KAT service is Route 90 "Crosstown Connector". This route operates on weekdays and weekends and the route map is included in Appendix B. The closest public transit KAT bus stop location on this route is located at the corner of Western Avenue (SR 62) at Randy Tyree Street. Other transit services include the East Tennessee Human Resource Agency (ETHRA) and the Community Action Committee (CAC) which provides transportation services when requested along with private taxis, and ride-sharing opportunities (Uber, etc.).

PROJECT DESCRIPTION

- **LOCATION AND SITE PLAN:**

The proposed plan layout given by GBS Engineering is shown in Figure 3. As can be seen in the figure, one roadway for the office/warehouse development will tie into Ed Shouse Drive. The development is expected to be constructed in 2 phases. The initial phase will involve constructing the new driveway to tie into Ed Shouse Drive and will construct 2 – 40,000 square foot office/warehouse buildings. At this point, the future phase is expected to include an additional 8 office/warehouse buildings that will include 180,000 square feet of building space. The future phase will contain 4 buildings of 20,000 square feet each and 4 buildings of 25,000 square feet each. In total, the initial and future phase is expected to contain 10 office/warehouse buildings that will have 220,000 square feet of office/warehouse space on 25.6 acres. The developer expects that most of the square footage of the office/warehouse buildings will be dedicated to warehouse space.

The proposed plan for the initial phase includes 80 automobile parking spaces in multiple lots. The two buildings in the initial phase include truck loading dock areas and will be designed to handle heavy trucks up to a WB-67 tractor-trailer truck. Figure 3a shows the proposed layout for the initial phase. The plan for the future additional phase shown in Figure 3b also includes areas for automobile parking. The parking lots for the future phase will provide approximately 350 automobile parking spaces. The eight buildings in the future phase will also include truck loading dock areas.

The actual schedule for completion of this office/warehouse development is dependent on economic factors and construction timelines. This project is also contingent on permitting, design, and other issues. However, for the purposes of this study, it was assumed that the total construction build-out of the development and full occupancy of the initial phase will occur within the next 18 months (late 2020). The future phase is expected to be built and occupied within the next 6 years (2025).

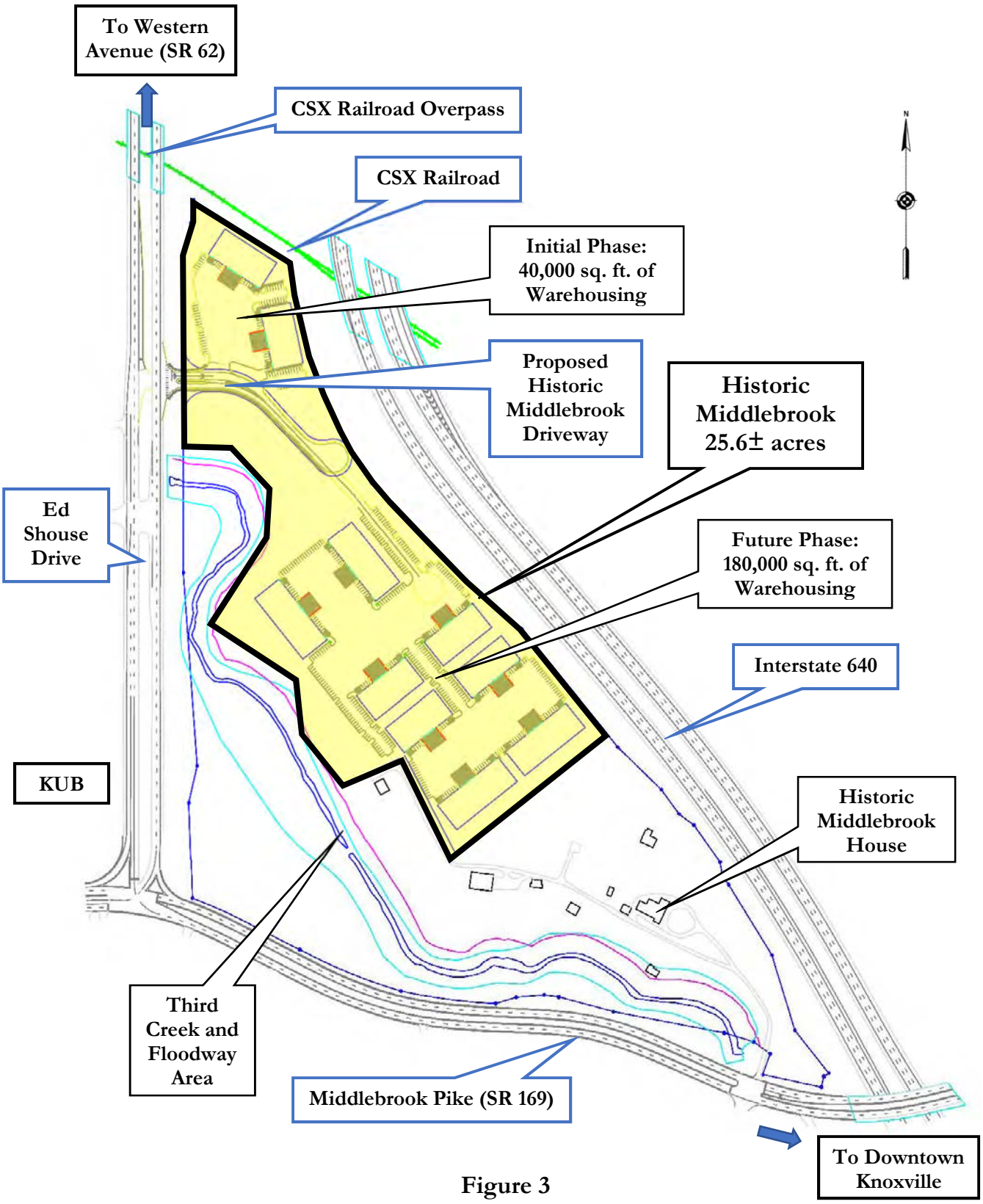


Figure 3

Proposed Plan Layout
Historic Middlebrook

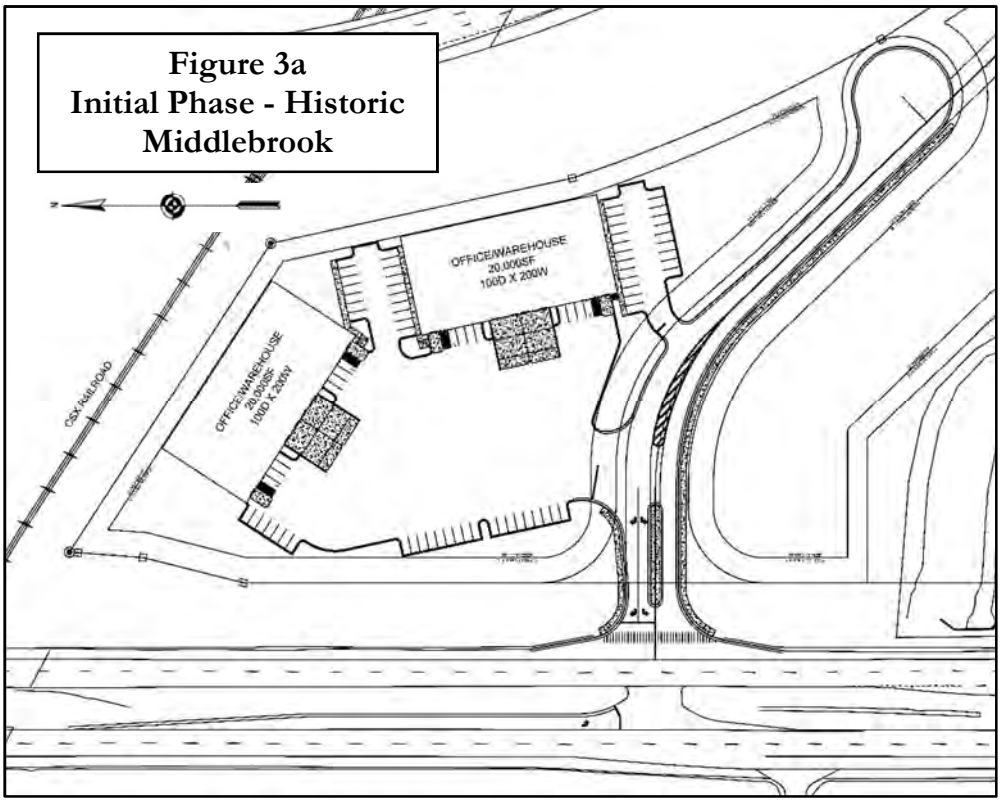


Figure 3a
Initial Phase - Historic
Middlebrook
OFFICE/WAREHOUSE
20,000SF
100D X 200W
OFFICE/WAREHOUSE
20,000SF
100D X 200W
CSX RAILROAD

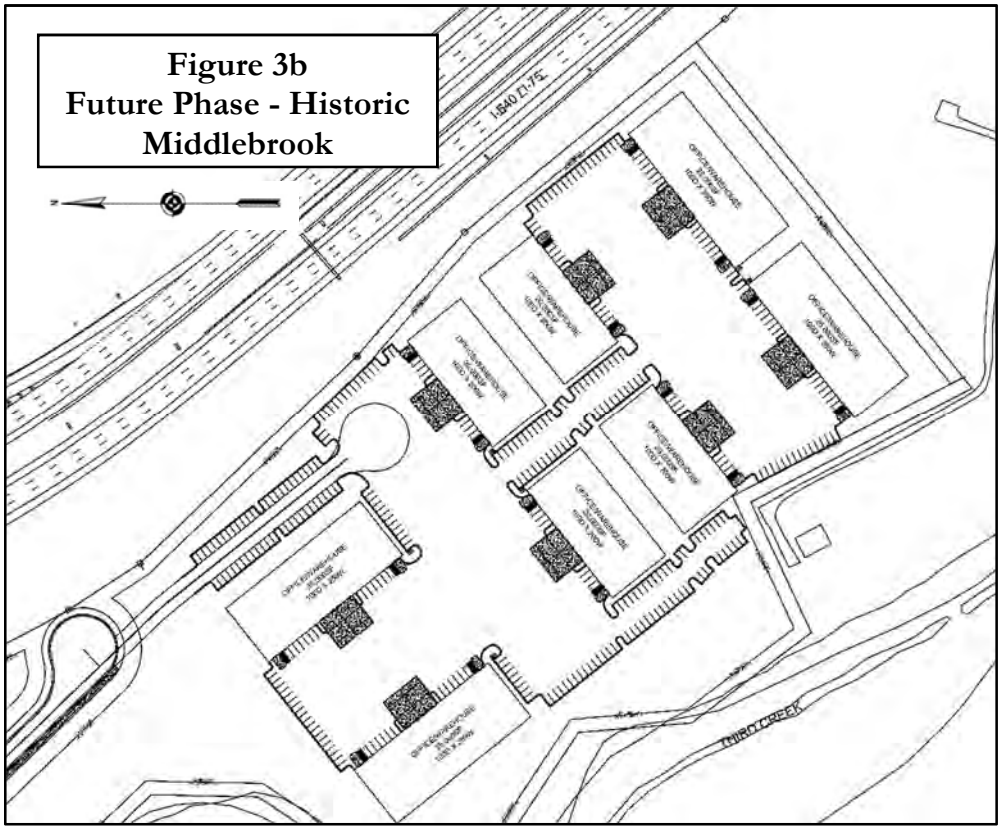


Figure 3b
Future Phase - Historic
Middlebrook

▪ PROPOSED USES AND ZONING REQUIREMENTS:

The proposed office/warehouse development is expected to be constructed with a single roadway that will provide vehicular access to Ed Shouse Drive.

The parent property tract is within the City of Knoxville and is zoned for several usages: General Agricultural District (A-1), General Commercial Park District (C-6), and Floodway District (F-1). The current zoning map is provided in Appendix C. The parent property tract will be subdivided to separate the existing A-1 and C-6 zoning districts. The proposed office/warehouse development will be located on the north side of the property tract and within the C-6 zone. The A-1 district to the south contains the historic Middlebrook home and several outbuildings. The parent property tract is bisected by Third Creek which is contained within the F-1 zoning district. The F-1 zoning district is used to delineate flood waters for a 500-year flood frequency. The existing adjacent surrounding land uses are the following:

- The land to the east of the proposed development consists of Interstate 640. The property immediately on the other side and to the east of Interstate 640 is zoned General Agricultural District (A-1) and consists of single-family homes.
- The property to the north of the proposed development is zoned in the Highway and Arterial Commercial District (C-4). A CSX railroad line separates this Highway and Arterial Commercial District (C-4) property from the proposed development property. This property to the north is adjacent to and south of Western Avenue (SR 62) and is occupied by a United Rentals business.
- The proposed development is bounded by Ed Shouse Drive to the west. On the opposite side of Ed Shouse Drive, and to the west of the development property, the property contains the KUB facilities and is zoned in the General Industrial District (I-3).
- After the parent property tract subdivision, the proposed development will be adjacent and to the north of the historic Middlebrook house and property located in the General Agricultural District (A-1).

The General Commercial Park District (C-6) allows for a variety of land uses within the commercial/light industry realm and is used to cluster commercial activities with an orderly development design.

▪ ON-SITE CIRCULATION:

The total length of the new internal road that will be constructed for the initial phase and tie into Ed Shouse Drive will be approximately 640 feet. The internal roadway for the development will be paved, include 2.5-foot concrete curb and gutters with lane widths of 13 feet for a total 26-foot pavement width. The concept plans for the Historic Middlebrook Driveway show 2 exiting lanes at Ed Shouse Drive to separate westbound left and right turn movements. A five-foot sidewalk will be provided along the internal road. The new internal road in the initial phase will terminate at a cul-de-sac and will be a public roadway. The construction of the future phase of the development will build a private driveway an additional 475 feet to provide access to the additional office/warehouse buildings constructed further into the property.

▪ VEHICLE ACCESS AND CIRCULATION:

The design plans show a new median southbound left turn lane on Ed Shouse Drive. To provide this left turn lane, an existing median opening on Ed Shouse Drive is proposed to be closed and a new median opening will be constructed further to the south to allow for traffic to enter and exit at the Historic Middlebrook Driveway. The existing median opening that is proposed to be closed on Ed Shouse Drive is approximately 400 feet to the south of a CSX Railroad line overpass and the new median opening for Historic Middlebrook will be an additional 340 feet further to the south of the overpass.

In addition to WB-67 tractor-trailer trucks, the proposed internal road will also provide access to passenger cars, service, delivery, maintenance, and fire protection vehicles. To accommodate the large size of WB-67 tractor-trailer trucks, it is expected that smaller vehicles entering and exiting the development will not experience any difficulties with access. The development will need to ensure that there are appropriate road directional signs and pavement markings to reduce the possibility of larger and smaller vehicle movements having unsafe interactions.

TRAFFIC ANALYSIS OF EXISTING AND PROJECTED CONDITIONS

▪ EXISTING TRAFFIC CONDITIONS

Traffic counts were conducted on Ed Shouse Drive adjacent to the proposed driveway connection for the development as directed by Knoxville-Knox County Planning. These counts tabulated the existing northbound and southbound traffic on Ed Shouse Drive.

The traffic counts on Ed Shouse Drive were obtained on Tuesday, March 5th, 2019, for a total of 8 hours. The counts were conducted during the morning, mid-day, and afternoon peak periods. Local schools were in session when the traffic counts were conducted. Based on the traffic volumes tabulated, the AM peak hour of traffic was observed from 7:30 – 8:30 am. The PM peak hour of traffic was observed from 4:30 – 5:30 pm. There was a noticeable directional pattern of traffic heading northbound and southbound on Ed Shouse Drive during different times of the day. On Ed Shouse Drive in the morning, most of the traffic was observed headed southbound towards Middlebrook Pike (SR 169) and in the afternoon, the reversed occurred with most of the traffic observed headed northbound to Western Avenue (SR 62).

The manual tabulated traffic counts can be reviewed in Appendix D. In Figure 4, the volumes shown are from the existing traffic counts during the AM and PM peak hours observed on Ed Shouse Drive. Overall, the vehicular traffic volumes on Ed Shouse Drive were quite large. Several school buses and KAT buses were observed during the traffic counts. Most of the traffic observed during the traffic count was typical passenger vehicles but there was a relatively high percentage of heavy truck traffic. Most of this heavy truck traffic consisted of interstate truck semi-trailers. Appendix D also shows the percentage of heavy trucks observed during the traffic counts.

A few motorists were observed performing u-turn maneuvers at the median opening just south of the railroad overpass on Ed Shouse Drive. The traffic count observations on Ed Shouse Drive also noted some brief northbound back-ups from the signalized intersection of Western Avenue (SR 62) at Ed Shouse Drive during the afternoon. One of these back-ups was just after 3:30 pm when a large volume of KUB employees left work. These back-ups extended past the Ed Shouse Drive bridge over the railroad. The back-up queues primarily formed in the outside lane of Ed Shouse Drive for vehicles waiting to turn right onto Western Avenue (SR 62). The outside lane is preferred by motorists due to the entrances to Interstate 640 being located on the right side just to the east of this signalized intersection.

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FIGURE 4

Historic Middlebrook

2019 Peak Hour Traffic Volumes - EXISTING TRAFFIC CONDITIONS

▪ OPENING YEAR TRAFFIC CONDITIONS (WITHOUT PROJECT):

Opening year traffic volume estimates represent the potential future road volumes the study area is subject to without the proposed project being developed (no-build option). As previously stated, the build-out and full occupancy for the initial phase of this office/warehouse development was assumed to be within the next 18 months (by late 2020). The future phase of the development was estimated to be fully built and occupied by the year 2025.

Traffic growth on Ed Shouse Drive has shown overall negative growth over the past 10 years according to the TDOT count station (historical traffic data is shown in Appendix A). From 2007 thru 2017, the average annual growth rate was calculated to be -1.1%. Currently, there are no known upcoming developments adjacent or nearby to the proposed site on Ed Shouse Drive that would indicate large future increased traffic volumes in the study area in the next few years.

Since this area is in an established area of Knoxville, for this study, a 1% annual growth rate was used to consider any future development in the area and potential rising traffic volumes. The results of this growth rate applied to the existing traffic volumes can be seen in Figure 5a for the year 2020 and Figure 5b for the year 2025. Figures 5a and 5b show the projected opening year traffic volumes during the AM and PM peak hours on Ed Shouse Drive based on an assumed annual growth rate of 1%. The volumes that are shown in Figures 5a and 5b have been calculated to potentially exist on Ed Shouse Drive in the year 2020 and 2025 even without the proposed office/warehouse project being constructed and developed.

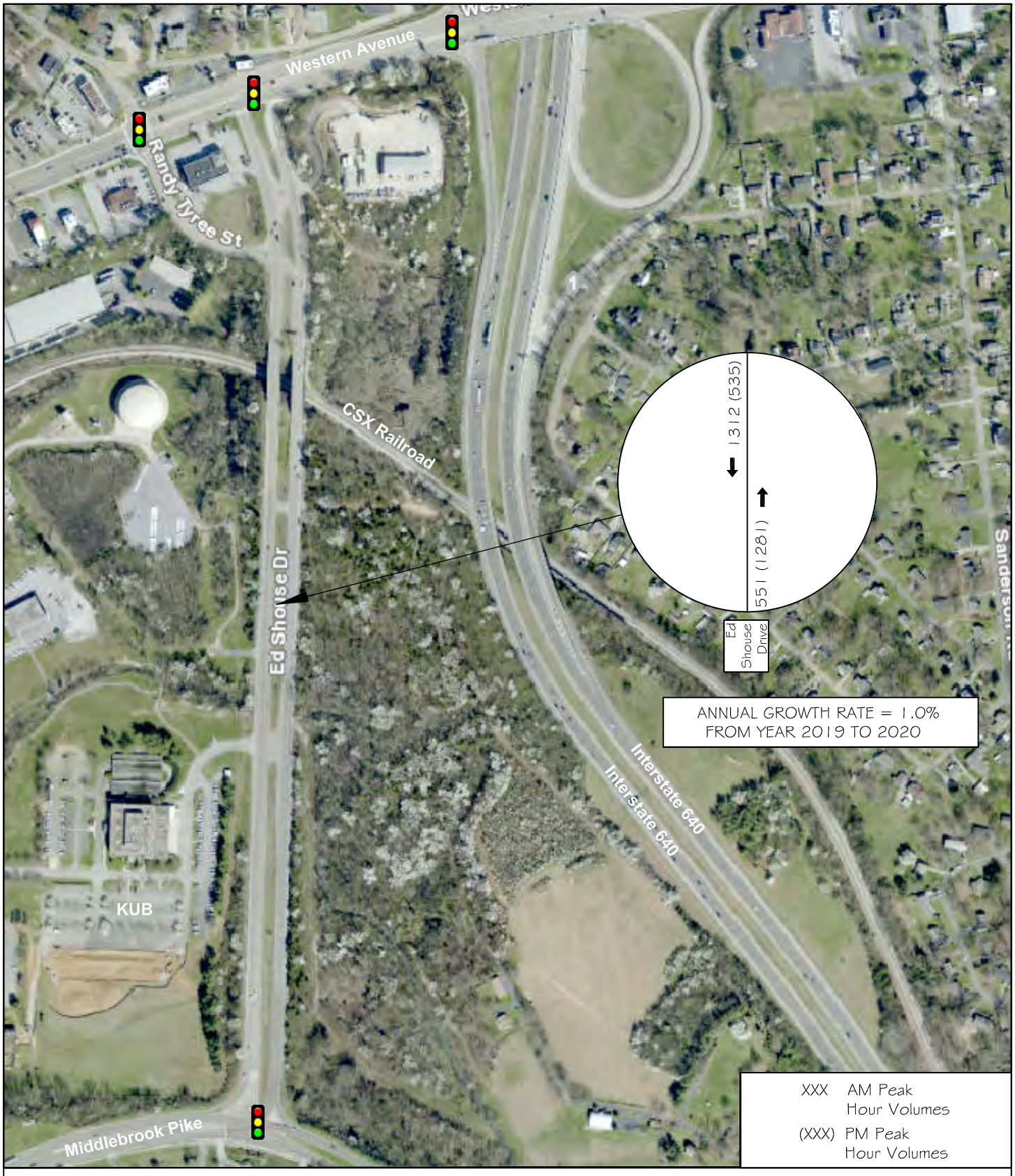

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FIGURE 5a

Historic Middlebrook

2020 Peak Hour Traffic Volumes - OPENING YEAR TRAFFIC (WITHOUT PROJECT)

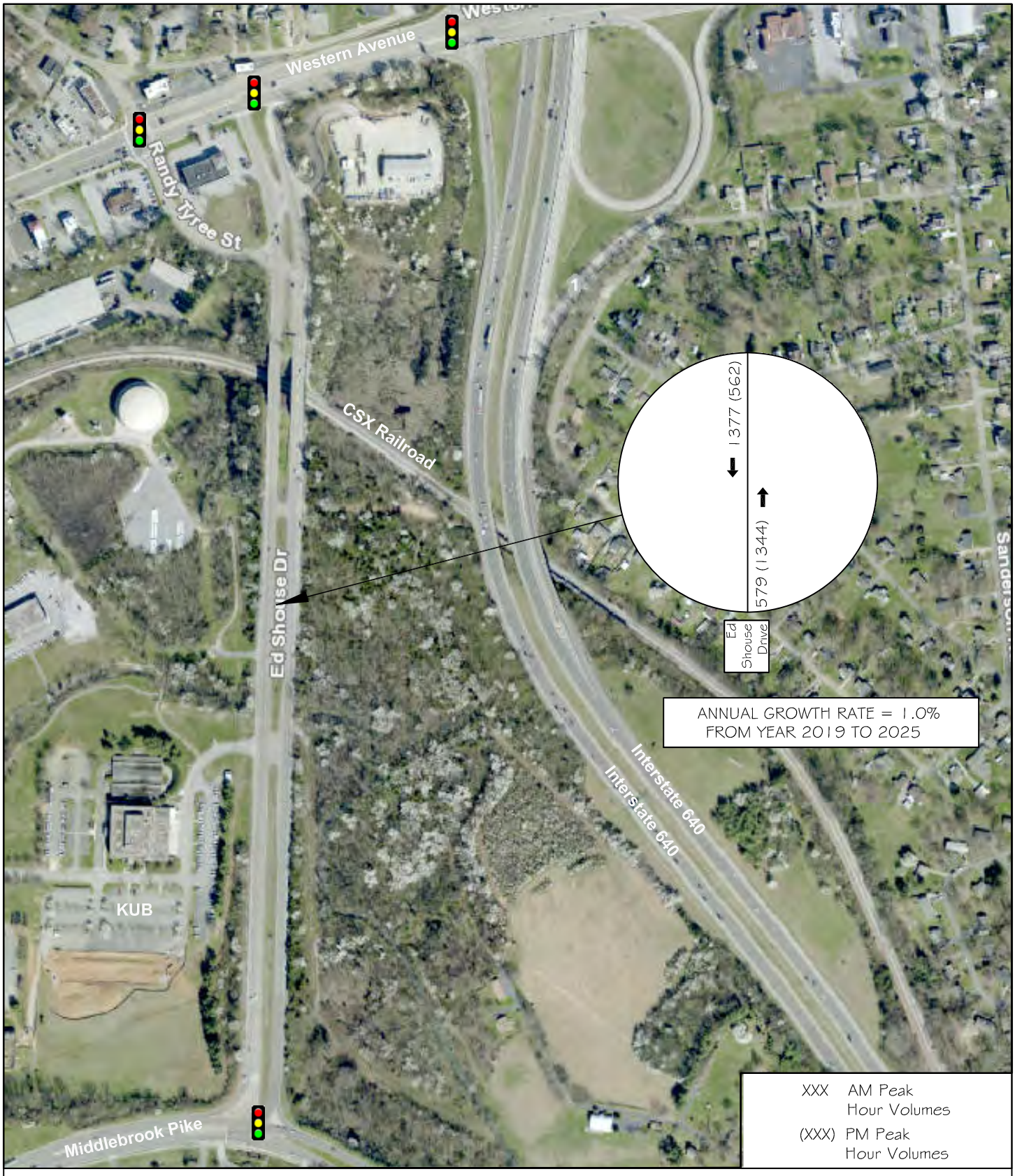

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FIGURE 5b

Historic Middlebrook

2025 Peak Hour Traffic Volumes - OPENING YEAR TRAFFIC (WITHOUT PROJECT)

▪ TRIP GENERATION

The estimated amount of traffic that will be generated by the proposed office/warehouse development was calculated based upon rates and equations for peak hour trips provided by Trip Generation Manual, 10th Edition, a publication of the Institute of Transportation Engineers (ITE). A generated trip is a single or one-direction vehicle movement that is either entering or exiting the study site. The Trip Generation Manual is the traditional and most popular resource for determining trip generation rates when traffic impact studies are produced. The Manual lists and includes data for a variety of land uses and correlates trips generated based on different variables such as dwelling units, square footage, etc. The data from ITE for the proposed land use is shown in Appendix E.

The description for Land Use #150, Warehousing, in the ITE Trip Generation Manual states that the trip generation data for this land use includes office and maintenance areas in the square footage. A summary of the calculated trip generation is presented in Table 2 for the initial phase of the Historic Middlebrook development with 40,000 square feet of office/warehouse space:

TABLE 2
TRIP GENERATION FOR HISTORIC MIDDLEBROOK
Initial Phase

ITE LAND USE CODE	LAND USE DESCRIPTION	UNITS	GENERATED DAILY TRAFFIC	GENERATED TRAFFIC AM PEAK HOUR			GENERATED TRAFFIC PM PEAK HOUR		
				ENTER	EXIT	TOTAL	ENTER	EXIT	TOTAL
				77%	23%		27%	73%	
#150	Warehousing	40,000 sq. ft.	109	24	7	31	9	24	33
Total New Volume Site Trips			**109**	**24**	**7**	**31**	**9**	**24**	**33**

ITE Trip Generation Manual, 10th Edition

In the initial phase, with 2 buildings containing a total of 40,000 square feet of office/warehousing space, it is estimated that 24 vehicles will enter and 7 will exit, for a total of 31 generated trips during the AM Peak Hour in the year 2020. Similarly, it is estimated that 9 vehicles will enter and 24 will exit, for a total of 33 generated trips during the PM Peak Hour in the year 2020. The calculated trips generated for an average weekday could be expected to be approximately 109 vehicles for the proposed development in the year 2020.

A summary of the total calculated trip generation for the year 2025 that includes the initial phase of 40,000 square feet of office/warehouse space and the future phase with an additional 180,000 square feet of office/warehouse space is presented in Table 3:

TABLE 3
TRIP GENERATION FOR HISTORIC MIDDLEBROOK
Initial & Future Phase

ITE LAND USE CODE	LAND USE DESCRIPTION	UNITS	GENERATED DAILY TRAFFIC	GENERATED TRAFFIC AM PEAK HOUR			GENERATED TRAFFIC PM PEAK HOUR		
				ENTER	EXIT	TOTAL	ENTER	EXIT	TOTAL
#150	Initial Phase Warehousing	40,000 sq. ft.	109	77%	23%		27%	73%	
				24	7	31	9	24	33
#150	Future Phase Warehousing	180,000 sq. ft.	330	77%	23%		27%	73%	
				36	11	47	14	36	50
Total New Volume Site Trips			**439**	**60**	**18**	**78**	**23**	**60**	**83**

ITE Trip Generation Manual, 10th Edition

In both phases, with a total of 220,000 square feet of office/warehousing, it is estimated that 60 vehicles will enter and 18 will exit, for a total of 78 generated trips during the AM Peak Hour in the year 2025. Similarly, it is estimated that 23 vehicles will enter and 60 will exit, for a total of 83 generated trips during the PM Peak Hour in the year 2025. The calculated trips generated for an average weekday could be expected to be approximately 439 vehicles for the entire development in the year 2025.

Pass-by trips are trips that are assumed to already be occurring on the adjacent street that enter a site. These trips are an intermediate stop between an existing origin and destination without a route diversion. Office/warehouse developments typically do not attract any measurable number of pass-by trips. Thus, no pass-by trip reductions were made for this study. Also, internal trip reductions can be calculated when there are two or more land uses that have interactions without utilizing the adjacent external road system. This proposed development is for a single land use and therefore no internal trip reductions were made either.

▪ TRUCK TRIP GENERATION

As previously shown in Tables 2 and 3, it is projected that relatively low amounts of overall traffic will be generated by this proposed development. However, it is expected that it will generate a relatively high percentage of heavy truck traffic as compared to other land uses. The trip generation and introduction of vehicles consisting of high percentages of heavy truck traffic could affect traffic operations and reduce safety on Ed Shouse Drive.

In general, all types of vehicles are accounted for in the trip generation rates provided in the ITE Trip Generation Manual, but it does not distinguish or provide a tabulation or percentage of heavy truck trips in the data. In most cases, transportation impact studies are usually concentrated and associated with passenger type vehicles to determine the level of impact a development has on an adjacent transportation system.

The distribution and amount of heavy truck traffic in the traffic stream that will be generated by the proposed Historic Middlebrook office/warehouse development is unknown and partly speculative at this point. A review of research on this subject identified the most appropriate means to estimate the percentage of heavy truck traffic for warehousing is based on a report entitled, Truck Trip Generation Study. This study was conducted by the City of Fontana, California in August 2003. The purpose of the Truck Trip Generation Study by the City of Fontana was "to evaluate the vehicle trip generation characteristics of several land use categories that typically generate significant volumes of truck traffic." The truck trip generation study utilized data from sampling and analysis of land uses in the Fontana, CA area that generates large amounts of heavy truck traffic. These land uses included warehousing, industrial developments, truck sales, and truck stops. This publication follows the same procedures and reporting as presented in the ITE Trip Generation Manual.

The Truck Trip Generation Study was based on data collected in a specific area and the report suggests that it may not be directly applicable to other areas. However, absent any other relevant and more local information, it is considered for use in this study for Historic Middlebrook. Online research for truck traffic trip generation resulted in many other traffic unrelated studies referencing this City of Fontana study. The City of Fontana Truck Trip Generation Study also provides calculations for trip generation trip rates for land uses with heavy truck traffic. Utilizing the trip rates for light warehousing (buildings < 100,000 square feet) from the Fontana, CA study for the Historic Middlebrook development calculated fewer overall trips than compared to the ITE trip generation rates. Therefore, to achieve a more

conservative estimate for this study, the ITE trip generation rates were used, which resulted in a higher number of generated trips.

The City of Fontana Truck Trip Generation Study data for light warehousing vehicle mix is shown in Appendix F. The data from that study indicated a vehicle mix of 80% passenger vehicles and 20% heavy trucks for the light warehousing land use. This vehicle mix will be assumed for this study. For example, with total daily trips calculated to be 439 vehicles in the year 2025 conditions, it is assumed that 351 of these will be passenger vehicles (primarily for employee trips) and 88 will be heavy trucks hauling material to and from the warehouses. The following tables provide an estimation of heavy trucks and passenger car vehicles in the projected conditions using this vehicle mix assumption.

TABLE 4
TRIP GENERATION - ASSUMED VEHICLE TYPE BREAKDOWN
Initial Phase

VEHICLE TYPE	GENERATED DAILY TRAFFIC	GENERATED TRAFFIC AM PEAK HOUR			GENERATED TRAFFIC PM PEAK HOUR		
		ENTER	EXIT	TOTAL	ENTER	EXIT	TOTAL
All Vehicles	109	24	7	31	9	24	33
Passenger Car (Employee) Trips (80%)	87	19	6	25	7	19	26
Heavy Truck Trips (20%)	22	5	1	6	2	5	7

TABLE 5
TRIP GENERATION - ASSUMED VEHICLE TYPE BREAKDOWN
Initial & Future Phase

VEHICLE TYPE	GENERATED DAILY TRAFFIC	GENERATED TRAFFIC AM PEAK HOUR			GENERATED TRAFFIC PM PEAK HOUR		
		ENTER	EXIT	TOTAL	ENTER	EXIT	TOTAL
All Vehicles	439	60	18	78	23	60	83
Passenger Car (Employee) Trips (80%)	351	48	14	62	18	48	66
Heavy Truck Trips (20%)	88	12	4	16	5	12	17

▪ TRIP DISTRIBUTION AND ASSIGNMENT

The proposed office/warehouse development includes the addition of a new driveway connection to tie into the east side of Ed Shouse Drive. This road connection is proposed to be built approximately 730 feet south of the CSX Railroad overpass and 435 feet to the north of the KUB driveway on Ed Shouse Drive. The details of the proposed Historic Middlebrook Driveway will be discussed further later in the report.

Figure 6 shows the projected distribution for traffic entering/exiting the Historic Middlebrook office/warehouse development during the future AM and PM peak hour at the proposed intersection of Ed Shouse Drive at the Historic Middlebrook Driveway. The percentages that are shown pertain to the trips projected to be generated by the proposed office/warehouse development and calculated from the ITE Trip Generation Manual. These percentages were assumed based on the location of the development and the expectation of traffic movements by the developer.

One of the large advantages of this office/warehouse development being constructed adjacent to Ed Shouse Drive is its proximity to Interstate 640. Interstate 640 provides convenient access to Interstate 40 and 75 for further travel and Interstate 640 access is readily available just to the northeast of the development site off Western Avenue (SR 62). There is also a large industrial and commercial base to the south along Middlebrook Pike (SR 169). At this point, the developer does not believe that the level of attraction to the existing developments on Middlebrook Pike (SR 169) will be significant, and thus most of the trips for the Historic Middlebrook development are assumed to travel to and from the north to Western Avenue (SR 62) to access Interstate 640. As shown in Figure 6, it is assumed that in the AM and PM peak hours, 80% of all vehicles (passenger cars and trucks) will travel to and from the north and 20% will travel to and from the south.

Figures 7a and 7b show the traffic assignment of the computed trips that will be generated by the proposed development (from Tables 2 and 3) in the year 2020 and 2025 for the initial phase and future phase respectively. The computed trips are applied to the various intersection movements based on the assumed distribution of trips shown in Figure 6.

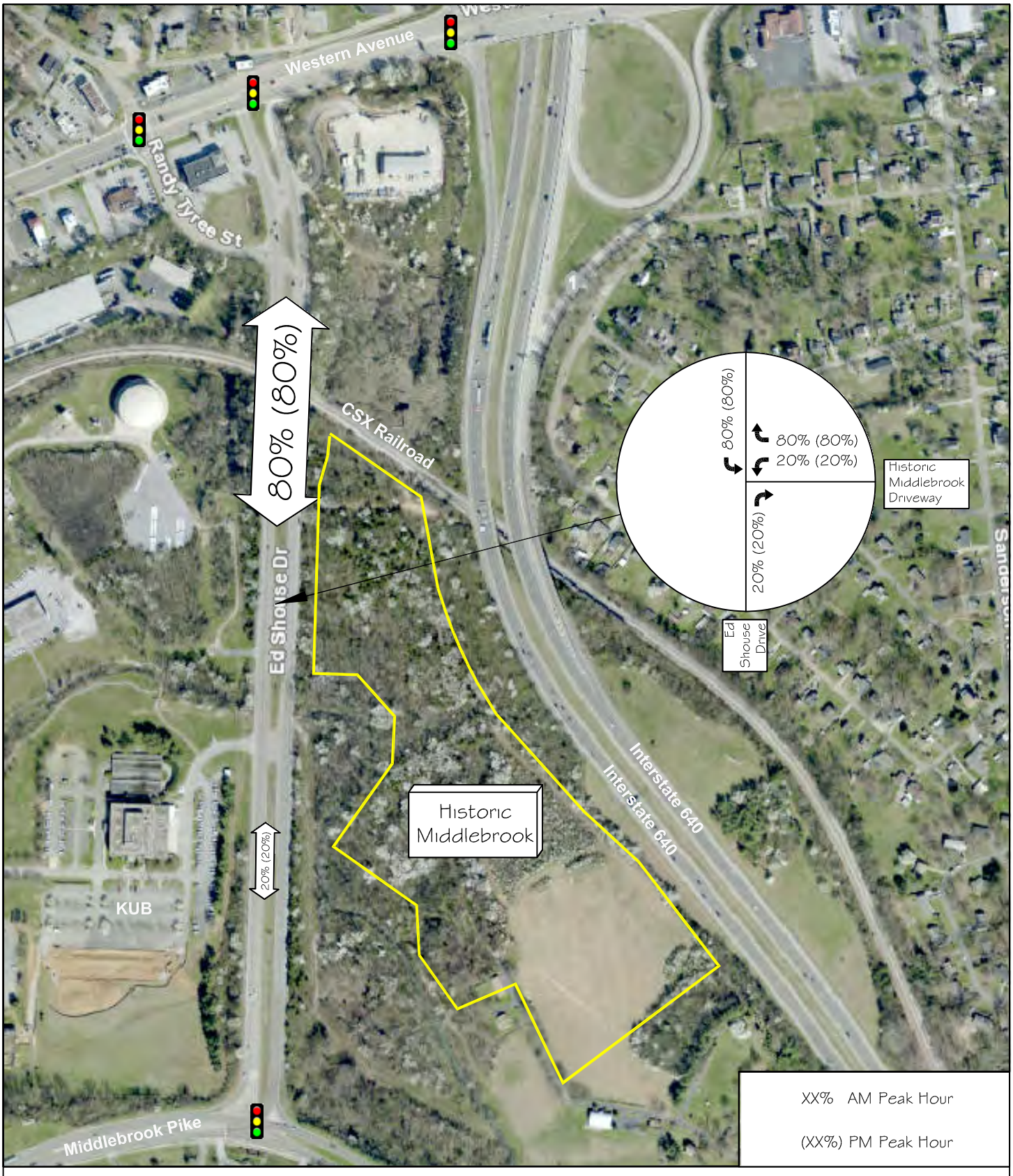

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FIGURE 6

Historic Middlebrook

Directional Distribution of Generated Traffic during AM and PM Peak Hour

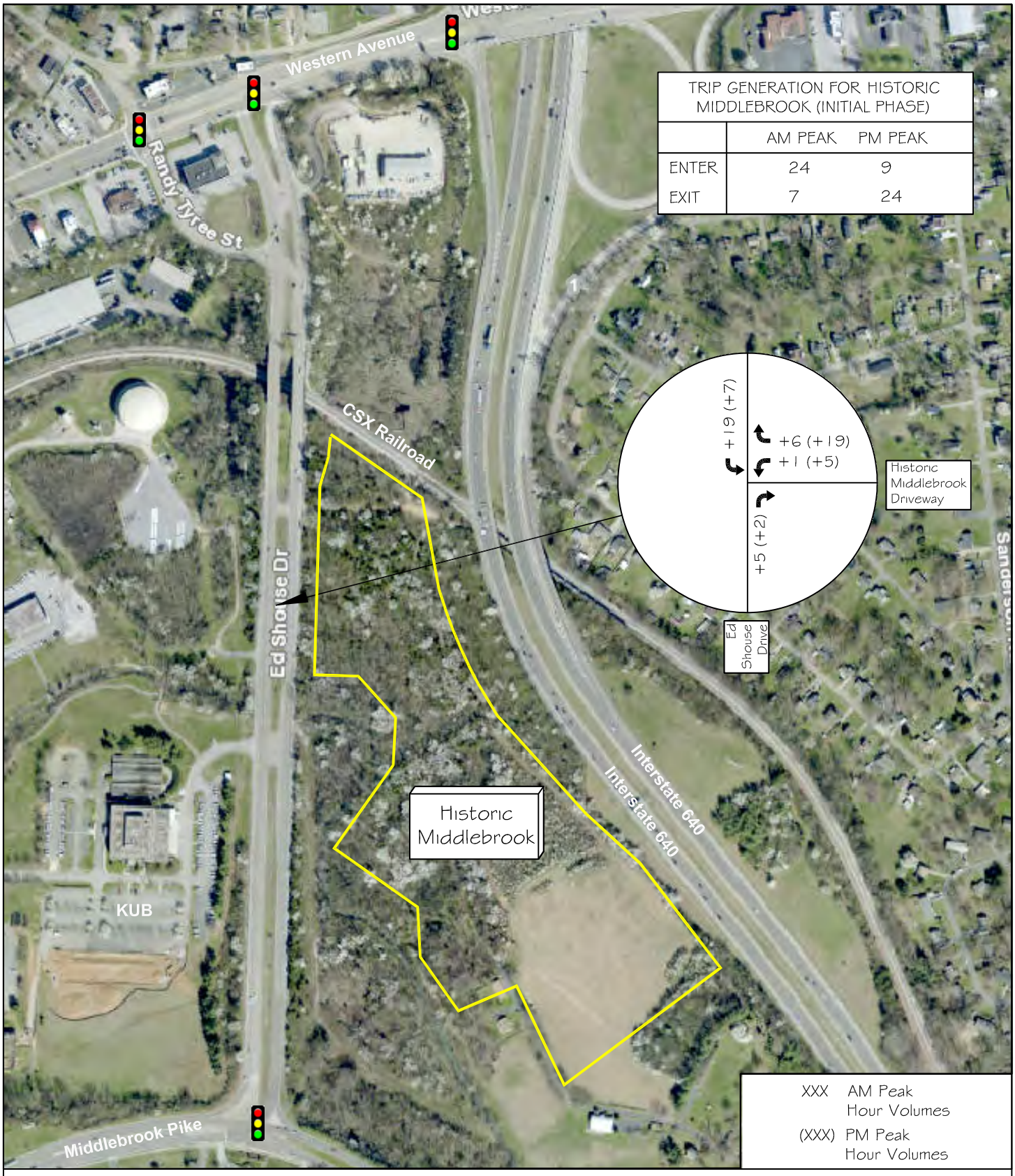

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FIGURE 7a

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Traffic Assignment of Generated Traffic during AM and PM Peak Hour in 2020 (Initial Phase)

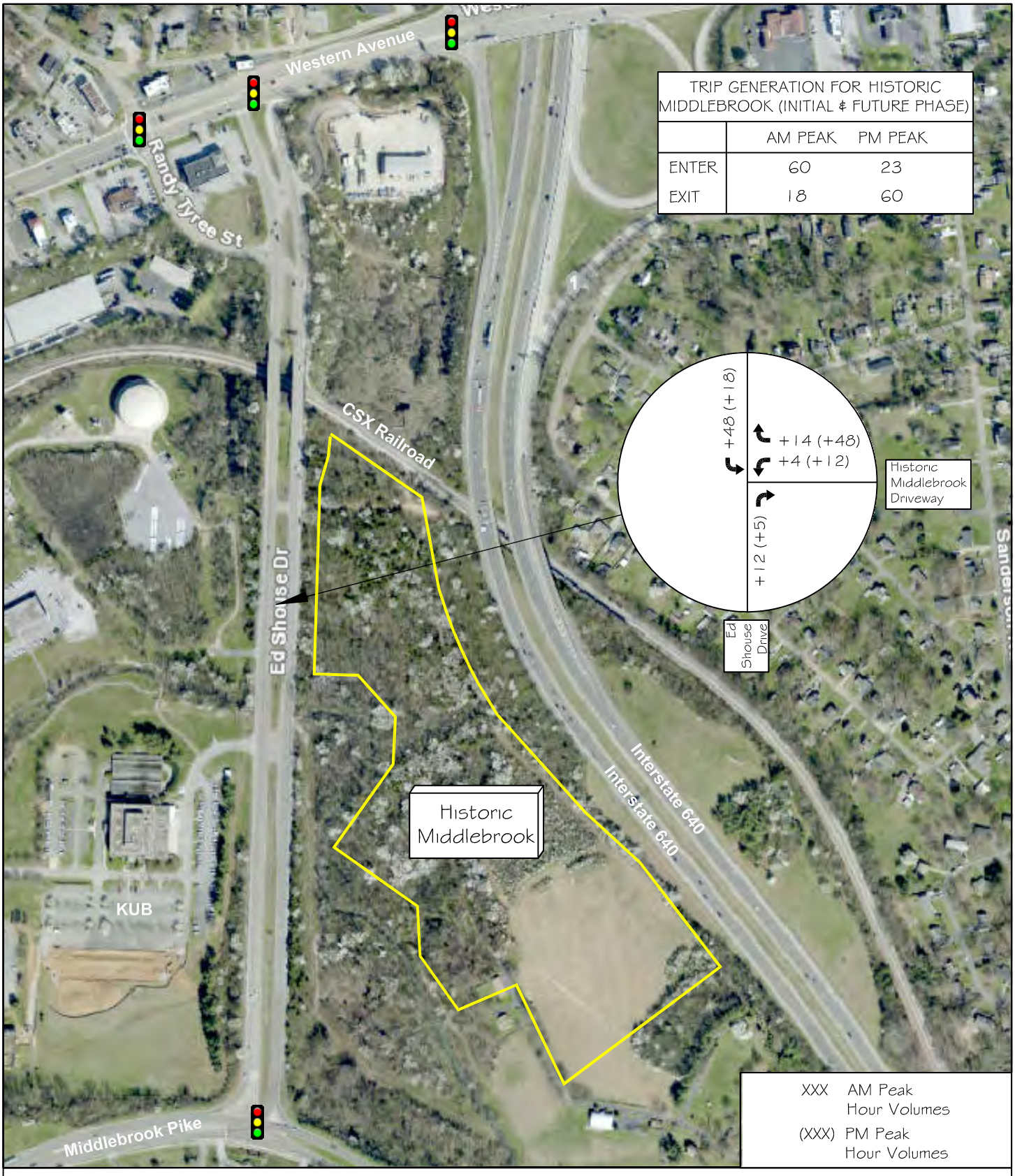

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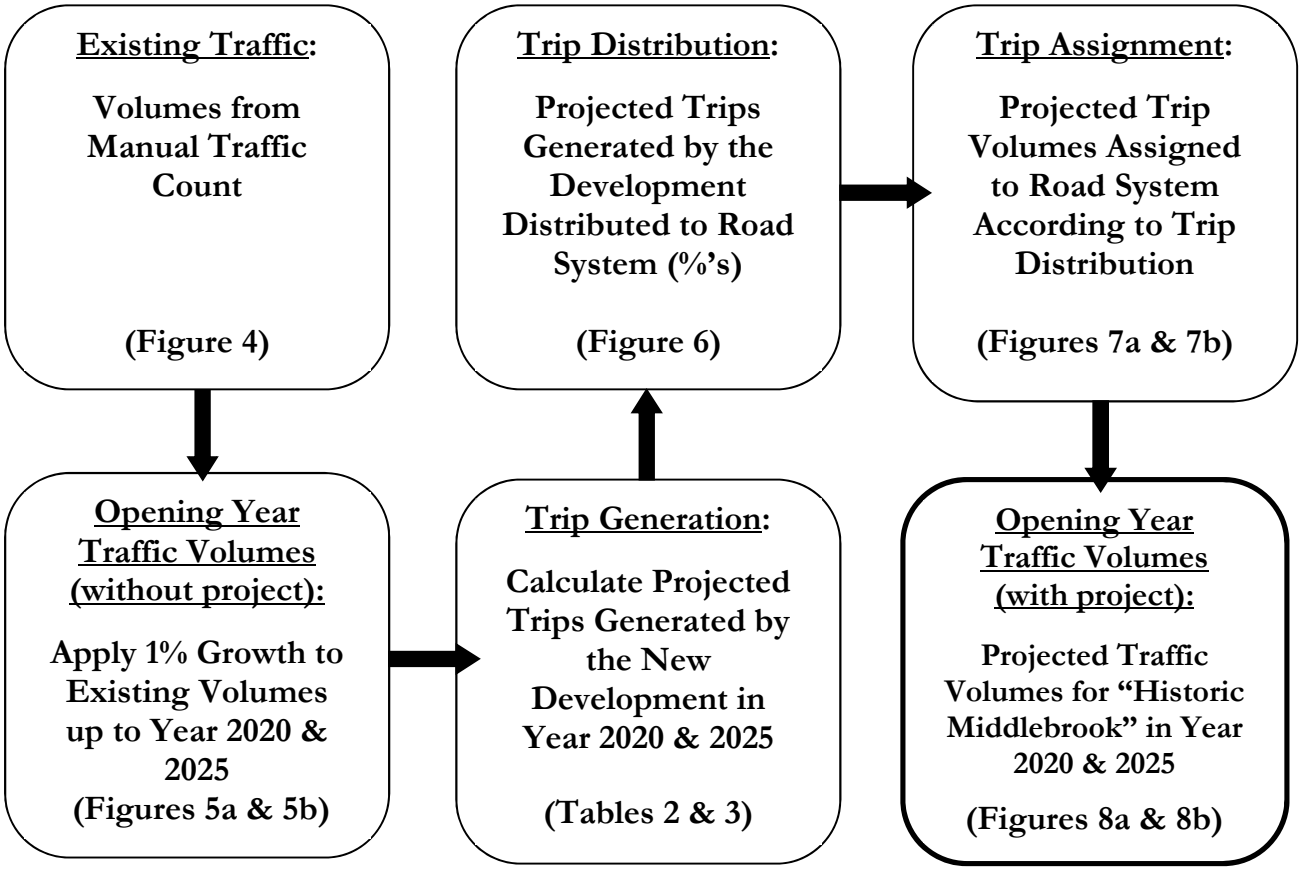
FIGURE 7b

Historic Middlebrook

Traffic Assignment of Generated Traffic during AM and PM Peak Hour in 2025 (Initial & Future Phase)

▪ OPENING YEAR TRAFFIC CONDITIONS (WITH PROJECT)

Overall, several additive steps were taken to estimate the total opening year projected traffic volumes at the intersection of Ed Shouse Drive at the proposed Historic Middlebrook Driveway when the development is fully constructed and occupied in the year 2020 for the initial phase and 2025 for the addition of the future phase. The steps are illustrated below for clarity:



To calculate the total future projected traffic volumes at the studied intersection, the calculated peak hour traffic (from ITE Trip Generation) generated by the new proposed office/warehouse development was added to the opening year traffic on Ed Shouse Drive (shown in Figures 5a & 5b) in accordance with the predicted directional distributions and assignments (shown in Figures 6, 7a, & 7b). This procedure was necessary to obtain the total projected traffic volumes at the time the development is fully built-out for the initial phase in the year 2020 and for the year 2025 when the future phase is added to the development. Figures 8a and 8b show the projected AM and PM peak hour volumes at the studied intersection for the year 2020 and 2025 respectively.

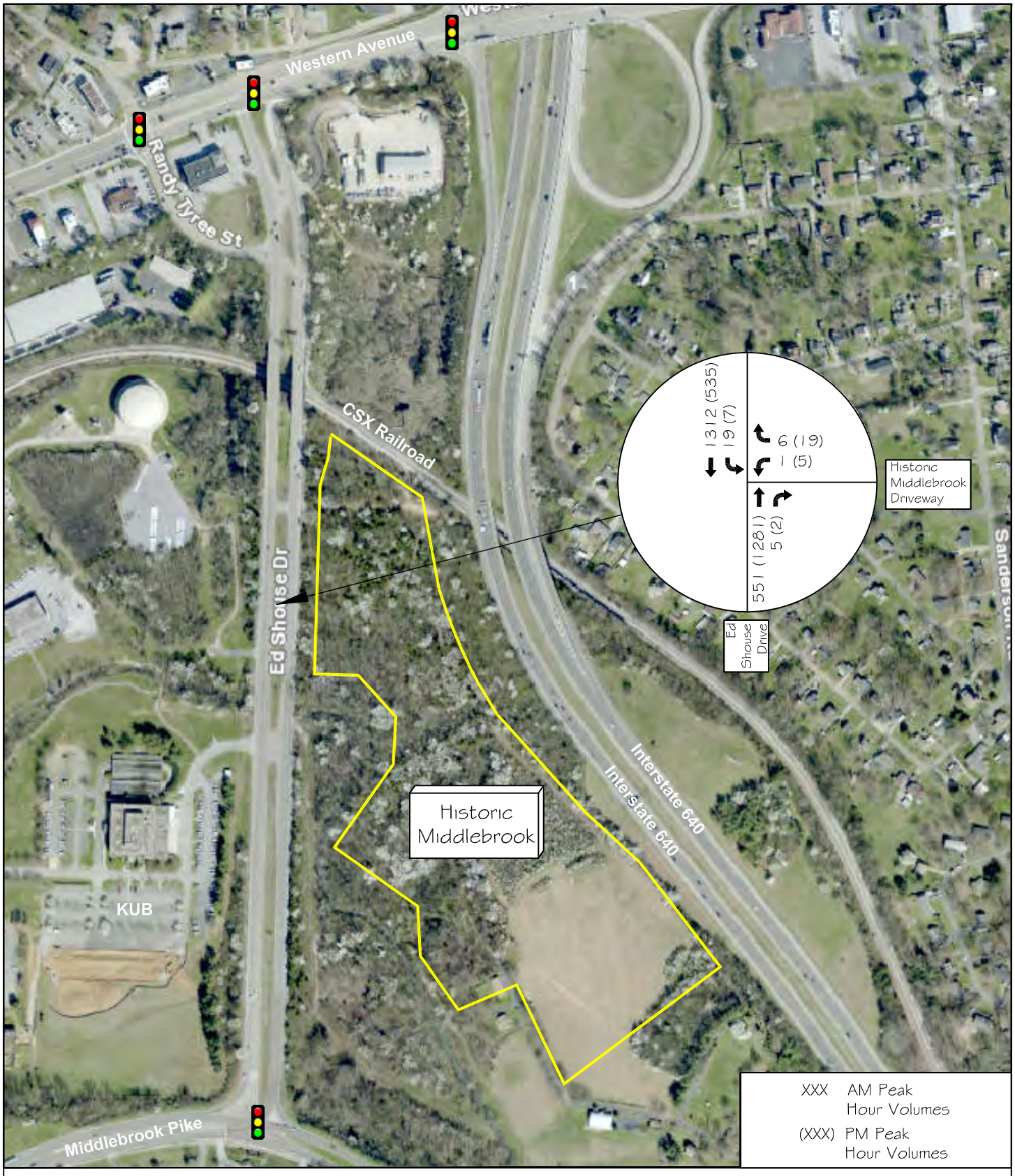


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FIGURE 8a

Historic Middlebrook

2020 Peak Hour Traffic Volumes - OPENING YEAR TRAFFIC (WITH PROJECT)

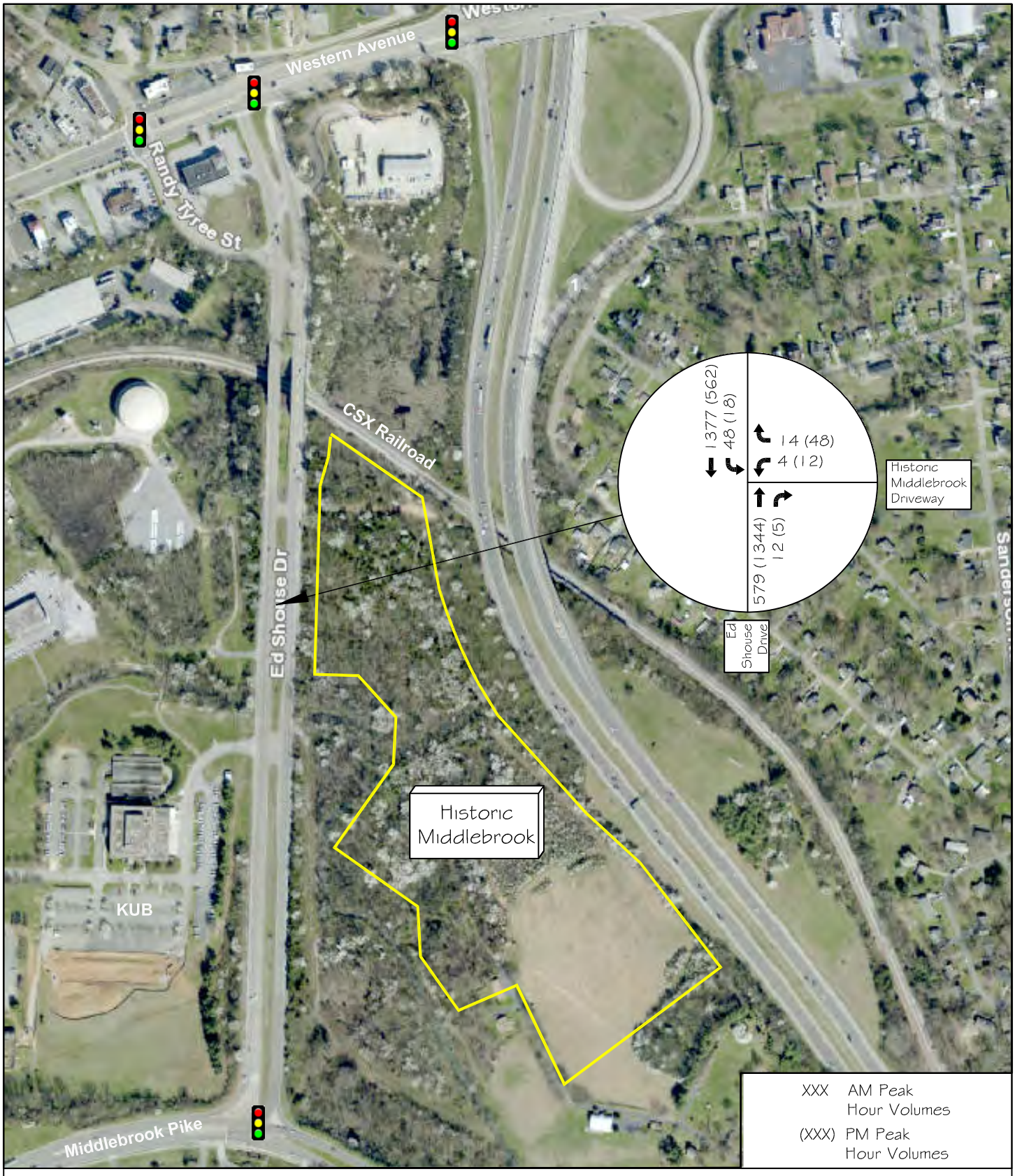

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FIGURE 8b

Historic Middlebrook

2025 Peak Hour Traffic Volumes - OPENING YEAR TRAFFIC (WITH PROJECT)

Capacity analyses were undertaken to determine the projected Level of Service (LOS) for the studied intersection with respect to vehicular traffic in the year 2020 and 2025. The capacity analyses were calculated by following the methods outlined in the Highway Capacity Manual and using Synchro Traffic Software (Version 8). LOS is a qualitative measurement developed by the transportation profession of how well an intersection or roadway performs based on a driver's perception. LOS designations include LOS A through LOS F. The designation of LOS A signifies a roadway or intersection operating at best, while LOS F signifies road operations at the worst. This grading system provides a reliable straightforward means to communicate road operations to the public. The Highway Capacity Manual (HCM) lists level of service criteria for unsignalized intersections and signalized intersections.

(Source: FDOT)

For unsignalized intersections, Level of Service is measured in terms of delay (in seconds). This measure is an attempt to quantify delay that includes travel time, driver discomfort, and fuel consumption. The LOS for a two-way stop (or yield) controlled intersection is defined by the delay for each minor approach and major street left-turn movement. Table 6 lists the level of service criteria for unsignalized intersections.

From the capacity calculations, the results from the projected peak hour vehicular traffic can be seen in Tables 7 and 8 for the intersection in the year 2020 and 2025 respectively. The intersection in the tables is shown with a LOS designation, delay (in seconds), and v/c ratio (volume/capacity) for the AM and PM peak hours. A v/c ratio of 1 would indicate that the traffic volumes are at the roadway capacity. The assumed percentage of 20% heavy truck traffic is included in the analysis. Appendix G includes the worksheets from the capacity analyses for the projected peak hour vehicular traffic in the year 2020 and 2025.

TABLE 6

LEVEL OF SERVICE AND DELAY FOR UNSIGNALIZED INTERSECTIONS

LEVEL OF SERVICE	DESCRIPTION	DELAY RANGE (seconds/vehicle)
A	Little or no delay	≤ 10
B	Short Traffic Delays	>10 and ≤15
C	Average Traffic Delays	>15 and ≤25
D	Long Traffic Delays	>25 and ≤35
E	Very Long Traffic Delays	>35 and ≤50
F	Extreme Traffic Delays	>50

Source: Highway Capacity Manual

TABLE 7

2020 PEAK HOUR LEVEL OF SERVICE & DELAY - OPENING YEAR (WITH INITIAL PHASE OF PROJECT)

INTERSECTION	TRAFFIC CONTROL	APPROACH	AM PEAK			PM PEAK		
			LOS	DELAY (seconds)	V/C	LOS	DELAY (seconds)	V/C
Ed Shouse Drive at Historic Middlebrook Driveway	Unsignalized	Westbound Left	C	20.4	0.000	D	33.8	0.040
		Westbound Right	B	10.7	0.010	C	16.6	0.060
		Southbound Left	A	9.3	0.020	A	14.5	0.020

Note: All analyses were calculated in Synchro 8 software and reported with HCM 2000 methodology for intersections

TABLE 8

2025 PEAK HOUR LEVEL OF SERVICE & DELAY - OPENING YEAR (WITH INITIAL AND FUTURE PHASE OF PROJECT)

INTERSECTION	TRAFFIC CONTROL	APPROACH	AM PEAK			PM PEAK		
			LOS	DELAY (seconds)	V/C	LOS	DELAY (seconds)	V/C
Ed Shouse Drive at Historic Middlebrook Driveway	Unsignalized	Westbound Left	C	23.2	0.020	E	39.6	0.110
		Westbound Right	B	10.9	0.020	C	18.9	0.170
		Southbound Left	A	9.7	0.060	C	15.6	0.060

Note: All analyses were calculated in Synchro 8 software and reported with HCM 2000 methodology for intersections

As can be seen in Tables 7 and 8, the studied intersection is shown to operate at good levels during the projected AM and PM peak hours except for westbound left turns which are calculated to operate at LOS D and LOS E in the PM peak hour in the year 2020 and 2025 respectively. This is attributable to the large amounts of thru traffic on Ed Shouse Drive.

The level of service calculations for the intersection assume that there is space available for at least one westbound left turn vehicle to cross the northbound lanes, temporarily pause mid-way in the median, and wait for an acceptable gap in the southbound traffic to allow for fully completing the turn. The existing median width on Ed Shouse Drive is sufficiently wide enough to allow a passenger sized vehicle to pause mid-way and wait for gaps in southbound traffic. However, without modifications, this median refuge will not be available for heavy trucks due to their length being longer than the existing median width provided on Ed Shouse Drive. Reevaluating the calculations with the assumption that there is not adequate median width for at least one heavy truck to pause in the center median refuge, the results show higher delays since westbound left turning heavy trucks would need to find gaps in traffic in both the northbound and southbound directions simultaneously. This issue will be discussed later in the report in the "Conclusions and Recommendations" where recommendations will be offered to allow both passenger cars and heavy trucks to use the median as a refuge when needed.

For the capacity analysis, it is assumed that the peak hour of trips generated by the development (including heavy truck traffic) will coincide with the non-development related peak hour of traffic on Ed Shouse Drive. This may or may not occur since warehousing is a land use which could produce traffic volume peaks at non-traditional peak hours especially as it relates to heavy truck traffic. It is not known at this point whether the peak movement of traffic to and from this development will occur earlier or later than the traditional peak hours of traffic of Ed Shouse Drive. The ITE Trip Generation Manual states that the sites surveyed for their research showed overall highest volumes from 11:30 am – 12:30 pm and 3:00 – 4:00 pm for the Warehousing (#150) land use. Nonetheless, this study assumes that the adjacent street and the development peak traffic will occur within the same peak AM and PM hours and this will result in a conservative analysis.

▪ POTENTIAL SAFETY ISSUES

The study area was investigated for potential existing and future safety issues. Several features in the study area were identified and are discussed in the following pages.

☛ SPOT SPEED STUDY

A spot speed study was conducted on Ed Shouse Drive to sample and tabulate the existing vehicle speeds along the road in the vicinity of the proposed development. The equipment used for the speed study was a Bushnell Speedster III Radar Speed Gun. The vehicles that were tabulated for the spot speed study were both the northbound and southbound motorists along Ed Shouse Drive near the proposed location of the Historic Middlebrook development.

As expected, the results of the study indicate that most of the traffic along Ed Shouse Drive travels at a higher speed than the posted speed limit. The posted speed limit on Ed Shouse Drive is 50 mph. The results of the spot speed study indicate that the observed 85th percentile speed was 56.7 mph for northbound traffic and 55.0 mph for southbound traffic. The spot speed field observations are provided in Appendix H.

☛ EVALUATION OF TURN LANE THRESHOLDS

The intersection of Ed Shouse Drive at the proposed Historic Middlebrook Driveway was evaluated for the need for separate turn lanes for entering vehicles into the development in the year 2020 and 2025. The standard design policy that was used for these turn lane evaluations is based on "Knox County's Access Control and Driveway Design Policy". This design policy by Knox County relates vehicle volume thresholds based on prevailing speeds for two-lane and four-lane roadways. Using these criteria, a determination was made whether turn lanes are warranted for this development.

Based on the projected traffic volumes at the intersection of Ed Shouse Drive at the proposed Historic Middlebrook Driveway and according to "Knox County's Access Control and Driveway Design Policy", a separate left (southbound) turn lane is warranted on Ed Shouse Drive for entering vehicles in the year 2020 and 2025. However, a separate right (northbound) turn lane is not warranted on Ed Shouse Drive in the year 2020 or 2025. The Knox County turn lane policy worksheets are in Appendix I and the results that are shown in the Appendix are based on the projected volumes during the AM and PM peak hour volumes at the

intersection in the year 2020 and 2025. The speed classification that was chosen for this evaluation was based on the spot speed study on Ed Shouse Drive that showed the 85th percentile speed was 56.7 mph for northbound traffic and 55.0 mph for southbound traffic. Therefore, this study evaluation used the Knox County classification for speeds of 56 mph and greater with the calculated projected volumes.

EVALUATION OF SIGHT DISTANCE

Based on the observed 85th percentile speed limit of nearly 57 miles per hour on Ed Shouse Drive and standard policy of requiring 10 feet of sight distance per 1 mph of speed, the required intersection sight distance would be 570 feet looking each direction at the intersection on Ed Shouse Drive from the proposed Historic Middlebrook Driveway.

Based on the proposed location of the Historic Middlebrook Driveway situated on the east side of Ed Shouse Drive and based on visual observation, there is more than 570 feet of sight distance available looking towards the south. However, sight distance looking towards the north is marginal and could not be verified strictly by visual observation. There are several trees located in the existing grass median of Ed Shouse Drive which potentially restricts sight distance. This sight restriction would be worsened during the growing season. The geometry of Ed Shouse Drive also restricts the length of this sight distance.

Due to the potential for a significant amount of heavy truck traffic being generated by the development, there is concern whether the available sight distance is sufficient for heavy trucks with slower acceleration rates than standard passenger vehicles. This subject will be discussed in the following section of the report.

View of Sight Distance on Ed Shouse Drive
Looking North from Approximate Location of the Proposed Historic Middlebrook Driveway

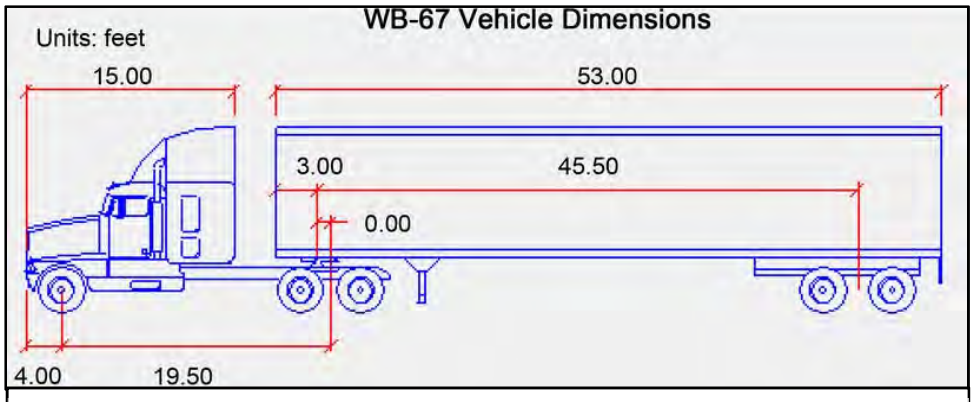
View of Sight Distance on Ed Shouse Drive
Looking South from Approximate Location of the Proposed Historic Middlebrook Driveway

CONCLUSIONS AND RECOMMENDATIONS

The following is an overview of conclusions and recommendations to minimize the traffic impacts of the proposed development on the surrounding road system while attempting to achieve an acceptable level of traffic flow and safety.

In addition to presenting calculations to determine the potential vehicular delays at the proposed intersection, there are other issues that need to be addressed for this type of development. This development will be composed of warehousing and is expected to generate a significant amount of heavy truck traffic. When this potential exists, the analysis requires, and the design should reflect the effects of heavy trucks on the transportation system. Heavy trucks have a large effect on traffic conditions due to their size, acceleration, and deceleration characteristics.

This development is being designed to handle heavy trucks up to WB-67 tractor-trailer trucks. These trucks have 5 axles with a 53-foot trailer and usually have a typical overall length of 73.5 feet with the tractor length included. These trucks are the typical sized trucks seen on the interstate system and have a minimum design turning radius of 45 feet. To accommodate heavy trucks for this development, this report discusses median spacing, sight distance, and auxiliary lanes in the following pages.

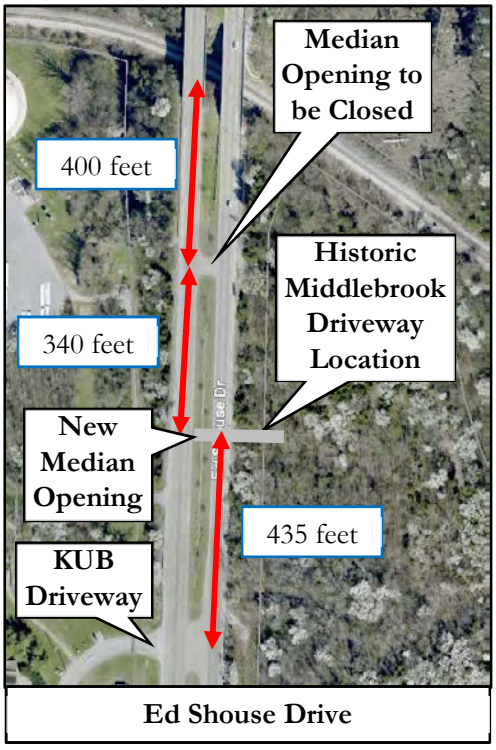


WB – 67 Design Vehicle

1) Median Spacing:

Ed Shouse Drive is a 4-lane divided highway with a depressed grass median. The grass median is just less than 40 feet in width and the center of the median is lined with concrete drainage ditches and tree landscaping. As part of constructing the Historic Middlebrook Driveway at Ed Shouse Drive, the developer is proposing to close an existing median opening and construct a new median opening to allow for full traffic movements at the proposed driveway.

The existing median opening proposed to be closed on Ed Shouse Drive is located approximately 400 feet to the south of the CSX Railroad overpass. A new median opening will be constructed on Ed Shouse Drive at the new Historic Middlebrook Driveway and will be approximately 340 feet to the south of the existing median opening. It will also be approximately 435 feet to the north of the existing median opening that is provided for the main KUB driveway.



According to TDOT's Roadway Design Guidelines in Section 2-140.0, TDOT lists desirable median opening spacings for rural and urban locations. For this location in an urban environment on Ed Shouse Drive, it states that the desirable spacing is 660 feet. However, it also states that a range of 440 feet to 880 feet is acceptable. Based on a TDOT minimum median spacing of 440 feet, the proposed location of the new median opening on Ed Shouse Drive will be 5 feet below the minimum at 435 feet. It is not expected that this spacing shortfall of 5 feet will create a safety issue.

2) Sight Distance:

Based on the observed 85th percentile speed limit of nearly 57 miles per hour on Ed Shouse Drive and a standard policy of requiring 10 feet of sight distance per 1 mph of speed, the required intersection sight distance would be 570 feet looking north and south on Ed Shouse Drive at the intersection with the proposed Historic Middlebrook Driveway. As stated earlier, it appears that this distance is available looking to the south on Ed Shouse Drive from the proposed location of the Historic Middlebrook Driveway but is potentially not available looking towards the north due to vegetation (trees) in the median and the geometrics of Ed Shouse Drive.

Existing Vegetation in Median on Ed Shouse Drive

Since a large amount of heavy truck traffic will utilize this intersection and due to Ed Shouse Drive being a 4-lane divided highway, sight distances will need to be discussed further. In TDOT Standard Drawing, RD01-SD-5, guidelines are established for intersection sight distances for 4-lane divided highways. Sight distance requirements for 4-lane divided highways are greater for left turn and crossing maneuvers due to the longer travel distances required to traverse the additional lanes and median. The TDOT standard drawing offers sight distance requirements based on the width of the median, vehicle types, and design speeds. Based on a median width of 38.5 feet, a design speed of 55 mph, and semi-trailer vehicles; this intersection would require a sight distance of 1,220 feet according to the tables in the TDOT guidelines.

With the appropriate clearing of vegetation to the south of the proposed intersection location and along the east side of Ed Shouse Drive, a sight distance of 1,220 feet is achievable looking to the south. However, this sight distance length is not available to the north. The TDOT guidelines provide shorter sight distance lengths for left-turning vehicles if vehicles can pause mid-way in the median when the median is sufficiently wide enough to contain the length of the vehicle (plus a minimum of 6 feet). For this location, this is not available for any vehicles larger than passenger sized vehicles. The median width on Ed Shouse Drive is 38.5 feet but a WB-67 design vehicle for this development with a length of 73.5 feet is nearly double the available length. Since a

WB-67 tractor-trailer would not be able to pause mid-way to complete a southbound left turn towards Middlebrook Pike (SR 169) because of the insufficient median width, the full sight distance requirement of 1,220 feet looking towards the north would need to be available. A southbound left turn entering median lane is recommended as remediation to this sight distance inadequacy and details of this lane are discussed in the following sections. Nonetheless, it is recommended that the trees located in the median on Ed Shouse Drive be removed in between the CSX Railroad overpass all the way to the new median opening proposed for the Historic Middlebrook development if possible. It is not known if these trees are a part of a City of Knoxville landscaping or beautification initiative that could make permission to remove difficult, but it should be strongly considered due to the limits the vegetation will pose on sight distances looking to the north from the new proposed Historic Middlebrook Driveway at Ed Shouse Drive.

The sight distance from the Historic Middlebrook Driveway in both directions on Ed Shouse Drive will need to be maintained in the future and must not be impacted by future landscaping, existing vegetation, or road signage. The site designer should ensure that this intersection is given the maximum amount of sight distance as possible to provide clear unobstructed views.

3) <u>Northbound Right Turn Entering Lane:</u>

As discussed earlier in the report in the "Evaluation of Turn Lane Thresholds", the proposed Historic Middlebrook Driveway was evaluated, and it was estimated that a separate right turn lane for northbound entering vehicles would not be required. This is due to the low projected northbound right turns at the intersection. It is recommended that the radius at this corner be a minimum of 50 feet but preferably larger.

4) Southbound Left Turn Entering Median Lane:

As discussed earlier in the report in the "Evaluation of Turn Lane Thresholds", the proposed Historic Middlebrook Driveway was evaluated, and it was estimated that a separate left turn lane for southbound entering vehicles would be required. Since the development is proposing to close the existing median opening on Ed Shouse Drive and constructing a new median opening further to the south for the new driveway; the concept site design already showed the addition of a left turn lane for southbound entering left turns into the development.

The concept design plan for the development shows a southbound left turn being constructed in the divided grass median area with 270 feet of storage and a 240-foot bay taper length for a total length of 510 feet. This total length of 510 feet is close to the maximum available because of the CSX Railroad overpass located to the north on Ed Shouse Drive.

TDOT's Roadway Design Guidelines provides guidance for the design of turning lanes at intersections and is based on AASHTO's *A Policy on Geometric Design of Highways and Streets* (Green Book). The TDOT guidelines (Table 2-3, pg. 2-38) states that for a design speed of 55 mph; the deceleration length needed for a stop condition for grades less than 3% would be 485 feet. However, the proposed location of the southbound left turn lane on Ed Shouse Drive has an existing downgrade of 5%. Adjustment of the deceleration length based on a steeper grade of 5% is offered in the Green Book (6th Edition, Table 10-4) and this adjustment results in a total length of 655 feet (1.35 x 485 feet). In the TDOT guidelines it states that it is preferable to provide the entire deceleration length for vehicles entering turning lanes; however, it also states that providing the entire deceleration length in urban locations is not normally feasible. Providing a total deceleration length of 655 feet at this location will not be possible due to the constraints of the CSX Railroad overpass to the north on Ed Shouse Drive.

The deceleration length to allow for a vehicle to come to a complete stop in a turn lane can be summarized as the sum of the bay taper plus the storage length of a turn lane. Bay tapers lengths are given in the TDOT guidelines by the formula:

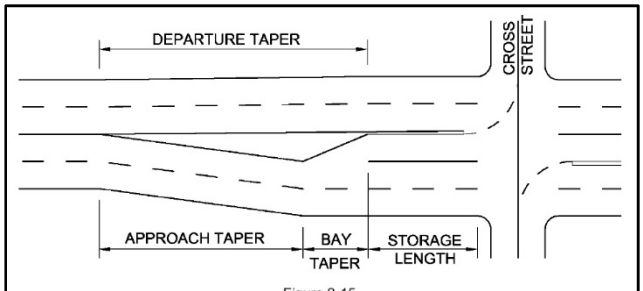


Figure 2-15
Turning Lane Terminology

$$L = W*S/3$$

Where, W = width of offset (lane) in feet

S = design speed in miles per hour

For an observed 85th percentile speed of 55 mph, left turn lane width of 12 feet; the bay taper length calculates to be 220 feet for a left turn lane at this location. If the full deceleration length of 655 feet was provided at this location for southbound left turns, this would result in a storage length of 435 feet (655 feet – 220 feet) based on the preferable standards.

With the physical constraints that would not allow for a storage length of 435 feet for this turn lane, other TDOT guidelines were used to establish a storage length for the turn lane. TDOT Roadway Design Guidelines (Figure 2-17, pg. 2-42) provides a chart to determine the storage length of left turn lanes on 4-lane highways at unsignalized intersections based on level grades and vehicle volumes. Based on the projected left turn traffic volumes at the intersection in the year 2025, the chart recommends a storage length of 100 feet for the southbound left turn lane on Ed Shouse Drive without considering the road grade. The guidelines also provide a means to calculate longer storage lengths based on the percentage of heavy truck traffic in the turning volume. As discussed earlier, it is assumed 20% of traffic generated by the development will be heavy truck traffic. Based on this percentage, Table 2-5 in the guidelines recommends adding an additional 25 feet to the 100 feet from Figure 2-17 for a total storage length of 125 feet for the southbound left turn lane on Ed Shouse Drive. This calculated length is less than the proposed storage length of 270 feet shown on the concept plans for the Historic Middlebrook development.

Thus, based on the above calculations, the concept plans showing 270 feet of storage with a 240-foot taper length (total of 510 feet) is recommended to be revised slightly.

It is recommended that the taper length is reduced to 220 feet and the extra 20 feet of distance be added to the storage length. This would result in a 220-foot taper with 290 feet of storage length with an overall length of 510 feet. While the desirable deceleration length of 655 feet is not provided, it is deemed acceptable due to the physical constraints on Ed Shouse Drive and this development existing in an urban environment.

The southbound left turn entering median lane will need to have pavement markings applied as shown in TDOT Standard Drawing T-M-4 to delineate the lane. For this turn lane, with a storage length greater than 200 feet, three white left turn arrows will need to be applied to the lane with a solid white line delineating the turn lane. It is also recommended that a dotted white line be applied to the pavement thru the length of the bay taper as shown in the TDOT standard drawing.

It is also recommended that the new median opening for the new intersection on Ed Shouse Drive is designed similar to the median opening at the intersection of Ed Shouse Drive at Falconite Way. Falconite Way is a road/driveway that provides access to a United Rentals business. This intersection is located to the north of the project site and just south of the signalized intersection of Ed Shouse Drive at Western Avenue (SR 62). The median opening at Falconite Way separates left turning movements in the median with a triangular-shaped depressed island. It is recommended that the new median opening for Historic Middlebrook be constructed in a similar manner to help separate the left turning movements at the intersection and restrict thru motorists on Ed Shouse Drive from attempting u-turn maneuvers.

Ed Shouse Drive at Falconite Way

It is recommended that the new median opening be constructed with a depressed grass island in a triangular shape that outlines the intended paths in the median for the left turn movements at the intersection. The lane pavement and markings will need to be laid out to accommodate vehicles up to a WB-67 truck. The new median opening width and left turn lanes will require radii suitable for WB-67 trucks to traverse without wheels off-tracking into the grass island or median.

The southbound left turn entering lane should be constructed with a 24" white stop bar at the end and in advance of the northbound lanes of Ed Shouse Drive. The southbound left turn entering lane should also have a Do Not Enter Sign (R5-1) facing the exiting westbound left turn lane at the Historic Middlebrook Driveway. It is also recommended that in advance of this new median opening, No U-Turn Signs (R3-4) be installed facing northbound and southbound traffic on Ed Shouse Drive.

5) <u>Southbound Left Turn Exiting Median Acceleration Lane:</u>

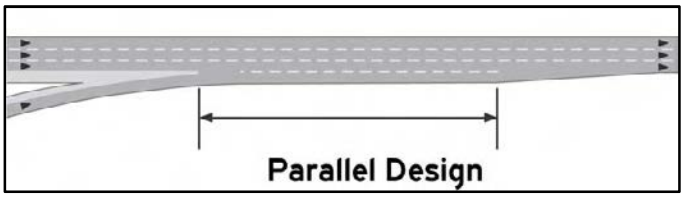
Due to the limited sight distance available looking to the north from the proposed Historic Middlebrook Driveway and the insufficient width of the existing median for heavy trucks on Ed Shouse Drive, it is recommended that a left turn exiting acceleration lane be provided in the median of Ed Shouse Drive. Providing an acceleration lane will allow westbound left turn vehicles to cross the northbound 2 lanes of traffic of Ed Shouse Drive, accelerate for a distance, and merge into the southbound traffic stream. Vehicles could merge at higher speeds, reduce westbound left turn delays at the intersection, reducing the potential for right angle traffic crashes. With high volumes on Ed Shouse Drive and limited gaps in traffic flow, this lane will allow for heavy trucks to cross the northbound lanes of Ed Shouse Drive with a sufficient median refuge area to complete left turn movements without waiting for suitable gaps in the northbound and southbound traffic flows simultaneously.

The centerline distance in between the new median opening at the proposed Historic Middlebrook Driveway and the existing median opening to the south at the KUB driveway is approximately 435 feet. The actual available distance in between the two median openings is only 350 feet when the widths of the median openings themselves are included.

Median acceleration lanes are not specifically detailed in Knox County or City of Knoxville design guidelines. For auxiliary lanes, Knox County states that 'left-turn acceleration lanes may be permitted when a need based on safety and capacity considerations has been documented in a traffic access and traffic impact study report and the provision of a lane has been recommended as an appropriate mitigating measure."

TDOT also does not provide specific design policies for median acceleration lanes but is assumed to follow general guidelines for acceleration lanes based on the AASHTO Green Book. The AASHTO Green Book offers tables to determine acceleration lane lengths based on design speeds and grades. For a highway design speed of 55 mph, a 5% downgrade (with a reduction of 0.525), assuming an initial speed of 15 mph for left turning vehicles entering the median acceleration lane; the desirable acceleration lane length is calculated to be 472.50 feet. This distance does not include a bay taper length. Assuming an acceleration lane design with a 12:1 bay taper length and a 12' acceleration

lane width, the overall taper length would be 144 feet. With an available length of only 350 feet, this would leave the theoretical remaining length in between the two median openings to be 206 feet (350 feet - 144 feet) for a full-width storage/acceleration lane. However, once vehicle turning radii are considered in the design, it is expected that the full-width storage/acceleration lane length will be less than 206 feet. The designer should maximize the available storage/acceleration lane length to fit in between the proposed intersection and the existing median opening located to the south for KUB.



It is recommended that the left turn median acceleration lane be constructed with a parallel design. While the physical constraints do not allow for a fully optimized acceleration lane length, providing the maximum possible length will be beneficial. A median acceleration lane will provide a mid-way refuge, will allow some distance for vehicles to reach speeds close to thru vehicle speeds, and merge into the traffic stream heading southbound on Ed Shouse Drive.

Road signage is recommended to be installed on Ed Shouse Drive to provide proper warning to southbound thru traffic. A Merge Sign (W4-1L) for southbound thru motorists should be installed in advance of the southbound median acceleration lane on the east side of Ed Shouse Drive in the median's new depressed triangular island. The sign should be installed where it will not interfere with the view of traffic entering the roadway and should be installed with a break-away post design.

6) Westbound Right Turn Exiting Acceleration Lane:

It is recommended that a right turn exiting acceleration lane be provided for vehicles heading north towards Western Avenue (SR 62). It is projected that most of the traffic generated by the development will exit to the north including a high percentage of heavy trucks. The proposed entrance for Historic Middlebrook will be located on Ed Shouse Drive where the road towards the north has a 5% upgrade. Without an acceleration lane, this grade would provide a significant challenge for heavy trucks to find acceptable gaps in northbound traffic, while starting from a stop and accelerating uphill towards Western Avenue (SR 62). The distance between the proposed Historic Middlebrook Driveway and Western Avenue (SR 62) is approximately 1,700 feet.

The AASHTO Green Book offers tables to determine acceleration lane lengths based on design speeds and grades. For a highway speed of 55 mph, a 5% upgrade (with a factor increase of 1.8), and assuming an initial speed of 15 mph for right turning vehicles entering the acceleration lane; the desirable acceleration lane length is calculated to be 1,620 feet. This distance does not include a bay taper length.

The CSX Railroad overpass on Ed Shouse Drive is approximately 600 feet to the north from the proposed Historic Middlebrook Driveway. Assuming an acceleration lane design with a 12:1 bay taper length and a 12' acceleration lane width, the overall taper length would be 144 feet. With an available length of only 600 feet, this would leave a remaining length of approximately 456 feet (600 feet - 144 feet) for a full-width storage/acceleration lane. However, once vehicle turning radii are considered in the design, it is expected that the full-width storage/acceleration lane length will be less than 456 feet. The designer should maximize the available storage/acceleration lane length to fit in between the proposed intersection and the existing railroad overpass located to the north on Ed Shouse Drive.

It is recommended that the right turn acceleration lane be constructed with a parallel design. While the physical constraints do not allow for a fully optimized acceleration lane length, providing the maximum possible length will be beneficial. An acceleration lane will allow some distance for vehicles to reach speeds closer to thru speeds and merge into the traffic stream heading northbound on Ed Shouse Drive. It is not expected that exiting merging vehicles from the development will need to reach the 85th percentile speed of nearly 55 mph since northbound thru motorists on Ed Shouse

Drive are most likely decelerating as they approach the influence of the signalized intersection at Western Avenue (SR 62). The observed back-ups on Ed Shouse Drive from the signalized intersection at Western Avenue (SR 62) during the afternoon may cause brief blocking of exiting vehicles out of the development on the acceleration lane, but these impacts would be temporary in nature.

It is recommended that the intersection of Ed Shouse Drive at the proposed Historic Middlebrook Driveway be constructed with a depressed grass island that separates the exiting westbound left turn lane and right turn lane. This island should be marked as shown in TDOT Standard Drawing T-M-3. The westbound right turn lane should be provided a large enough radius for vehicles to have an initial speed that would allow for the largest merging downstream speed as possible. Providing too small of a radius could cause truck drivers seeing the impending 5% road grade and attempt to enter the curve at speeds high enough to cause roll-over crashes.

Installation of road signage is recommended to provide proper warning to northbound thru traffic on Ed Shouse Drive. A Merge Sign (W4-1R) should be installed in advance of the acceleration lane on the east side of Ed Shouse Drive in the new depressed triangular island at the intersection for northbound thru motorists. The sign should also be installed where it will not interfere with the view of traffic entering the roadway with a break-away post design.

To avoid northbound thru motorists mistaking the right turn acceleration lane as an additional through lane towards Western Avenue (SR 62), it is recommended that a white pavement marking lane line be applied with a broken white line in the tapered section as shown in TDOT Standard Drawing T-M-6 for parallel acceleration lanes. It is also recommended that a white lane reduction arrow be installed in this acceleration lane to notify motorists of the requirement to merge, also notifying to northbound thru motorists that this lane does not continue on Ed Shouse Drive past the CSX Railroad overpass.

7) Traffic Signalization:

This proposed intersection was examined with the projected 2025 traffic volumes with respect to traffic signal warrants.

The Manual on Uniform Traffic Control Devices – 2009 Edition (MUTCD) presents 9 different warrants that have been developed by the traffic engineering profession to determine whether a traffic signal is warranted. These warrants cover a broad range of minimum elements required to indicate whether a traffic signal is justified for any particular location. These elements consist of traffic volumes, pedestrian volumes, crash history, and other factors. The MUTCD explicitly states that a traffic control signal should not be installed unless one or more of the signal warrants in the manual are met. However, the satisfaction of a warrant does not entirely in itself justify the need for a traffic signal. Sometimes further engineering studies and judgments also need to be applied before justifying the need for the installation of a traffic signal. These further studies are a very important step in ensuring that installation of a traffic signal will not actually bring about degradations in safety and efficiencies.

The MUTCD defines 9 different warrants, two of which are potentially applicable to this intersection at this time and are explained below:

- Warrant 1, Eight-Hour Vehicular Volume:

Warrant 1 is comprised of 2 conditions – A and B. The Minimum Vehicular Volume, Condition A, is intended for application where the volume of intersecting traffic is the principal reason for consideration of signal installation. The Interruption of Continuous Traffic, Condition B, is intended for application at locations where Condition A is not satisfied and where the traffic volume on a major street is so heavy that traffic on a minor intersecting street suffers excessive delay or conflict in entering or crossing the major street.

- Warrant 2, Four-Hour Vehicular Volume:

The Four-Hour Vehicular Volume signal warrant conditions are intended to be applied where the volume of intersecting traffic is the principal reason to consider installing a traffic control signal.

The intersection of Ed Shouse Drive at the proposed Historic Middlebrook Pike Driveway was evaluated for possible justification for a traffic signal based on the MUTCD Warrants listed above and the projected 2025 traffic count volumes. The Historic Middlebrook Driveway was used as the minor side street for the warrant analysis and Ed Shouse Drive was the major street. The analysis shows that this intersection does not meet Warrant 1 or 2 in the projected 2025 conditions. The results of the traffic signal warrant assessment at this proposed intersection for the projected volumes of 2025 are in Appendix J.

8) Projected Queue Length Analysis:

As part of the analysis of the intersection, the projected queue lengths were calculated. To estimate the projected queue length, SimTraffic (Version 8) software was employed. SimTraffic performs micro-simulation and animation of vehicular traffic and calculates various vehicle parameters such as intersection vehicle queue lengths. Based on the projected volumes during the AM and PM peak hours, the maximum queue lengths were calculated. The calculated queue results were based on averaging the outcome obtained during 10 traffic simulations. The queue results from the SimTraffic software are in Appendix K.

The results shown in the Appendix indicate that the maximum queue length for the southbound left turn was calculated to be 95 feet and the maximum for the westbound left turn lane was calculated to be 69 feet during the projected peak hours in the year 2025. The proposed storage length of the southbound left turn lane is 290 feet and the queues formed by the generated traffic should be contained well within the designed storage lane length. The westbound left turn lane at the Historic Middlebrook Driveway is recommended to have a minimum storage length of 75 feet. With separate westbound left and right turn lanes being proposed for the development at this intersection, this minimum length should be readily attainable.

9) **<u>Historic Middlebrook Internal Development</u>**: The layout plan shows a single roadway being constructed for the development as shown in Figure 3.

- It is recommended that a Speed Limit 25 (mph) Sign (R2-1) be posted on the proposed Historic Middlebrook Driveway just to the east of the intersection of Ed Shouse Drive for vehicles traveling into the development. For all internal intersections, the sight distance must meet AASHTO guidelines for a 25-mph speed limit.

- A Stop Sign (R1-1) and a 24" white stop bar should be installed at the westbound exiting left turn lane at Ed Shouse Drive. The stop bar should be located outside the path of where heavy truck traffic will be turning left into the development.

- A Double Arrow Sign (W12-1) should be installed at the approach end of the depressed island for vehicles exiting westbound out of the development towards Ed Shouse Drive. This will notify drivers that they are permitted to travel to either side of the island based on their direction of travel either to the north or south. Left and right white turn arrows should be applied on the pavement in advance of the depressed grass island for vehicles traveling westbound towards Ed Shouse Drive.

- Sight distance at the new internal intersections and parking lots must not be impacted by new signage, future landscaping, or parked vehicles. For a posted 15 mph speed limit for the internal development, the internal intersection sight distance requirement is 150 feet. The design engineer should ensure that these sight distance lengths are met.

- All road grade and intersection elements internally and externally should be designed to AASHTO, TDOT, and City of Knoxville Engineering specifications and guidelines to ensure proper operation.

- The sidewalks that are proposed for the development should have appropriate ADA compliant curbed ramps at the intersection corners.

10) Summary of Recommendations:

A summary of the major recommendations for the Historic Middlebrook Development are provided in the following list and a rough intersection concept plan showing many of these recommendations is shown in Figure 9.

- It is recommended that the trees located in the median on Ed Shouse Drive be removed in between the CSX Railroad overpass all the way to the new median opening proposed for the Historic Middlebrook development.

- A separate northbound right turn entering lane is not required but the radius at this corner be a minimum of 50 feet but preferably larger.

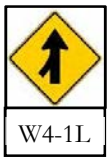
- The new median opening on Ed Shouse Drive for the Historic Middlebrook Driveway should be constructed with a triangular-shaped depressed grass island that outlines the intended paths with adequate dimensions for vehicles up to the size of a WB-67 tractor-trailer truck. The depressed grass island should have minimal vertical grade changes in the interior of the island. It is recommended that in advance of this new median opening, No U-Turn Signs (R3-4) be installed facing northbound and southbound traffic on Ed Shouse Drive. Appendix L includes truck turning templates that show the design paths for trucks entering and exiting the development.


R3-4

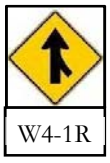
- A southbound left turn entering median lane should be constructed with a bay taper of 220 feet and a storage length of 290 feet. The lane should be marked as shown in TDOT Standard Drawing T-M-4 with a white lane line, dotted white lane line, and white left turn arrows. The end of this left turn lane should be marked with a 24" white stop bar in advance of the northbound thru lanes of Ed Shouse Drive. This will provide guidance to left turning motorists as to the proper stopping point in the median opening when waiting for a suitable gap in the oncoming northbound thru traffic on Ed Shouse Drive. A Do Not Enter Sign (R5-1) sign should be installed at the end of this lane in the median and facing the westbound left turn lane of the Historic Middlebrook Driveway to warn motorists to not enter the southbound left turn entering lane.

R5-1

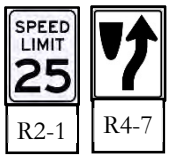
- A southbound left turn exiting median acceleration lane should be constructed with an ending bay taper of 144 feet. The designer should maximize the available storage/acceleration lane length to fit in between the proposed intersection and the existing median opening located to the south for KUB. The lane should be striped as shown in TDOT Standard Drawing T-M-6 for parallel acceleration lanes. A Merge Sign (W4-1L) should be installed in the triangular-shaped depressed median grass island at the proposed intersection in advance of the median acceleration lane for southbound thru motorists on Ed Shouse Drive.



- A westbound right turn exiting acceleration lane should be constructed with an ending bay taper of 144 feet. The designer should maximize the available storage/acceleration lane length to fit in between the proposed intersection and the existing railroad overpass located to the north on Ed Shouse Drive. The lane should be striped as shown in TDOT Standard Drawing T-M-6 for parallel acceleration lanes. A triangular-shaped depressed grass island should be constructed on the east side at the intersection of Ed Shouse Drive at the proposed Historic Middlebrook Driveway that separates westbound left and right turns. The depressed grass island should have minimal vertical grade changes in the interior of the island. A Merge Sign (W4-1R) should be installed in the triangular-shaped depressed island in advance of the acceleration lane for northbound thru motorists on Ed Shouse Drive. It is also recommended that a white lane reduction arrow be installed in this lane to notify motorists of the requirement to merge and to also notify northbound thru motorists that this lane does not continue on Ed Shouse Drive past the CSX Railroad overpass.



- The westbound left turn lane of the Historic Middlebrook Driveway should be constructed with a Stop Sign (R1-1) and a 24" white stop bar. The stop bar should be located outside the vehicle path of where heavy truck traffic will be turning left into the development. A No Outlet Sign (W14-2aR) should be installed at the top of the Stop Sign (R1-1) post. A Speed Limit 25 (mph) Sign (R2-1) and a Keep Right Sign (R4-7) should be installed for vehicles entering the development. A Double Arrow Sign (W12-1) should be installed at the east approach



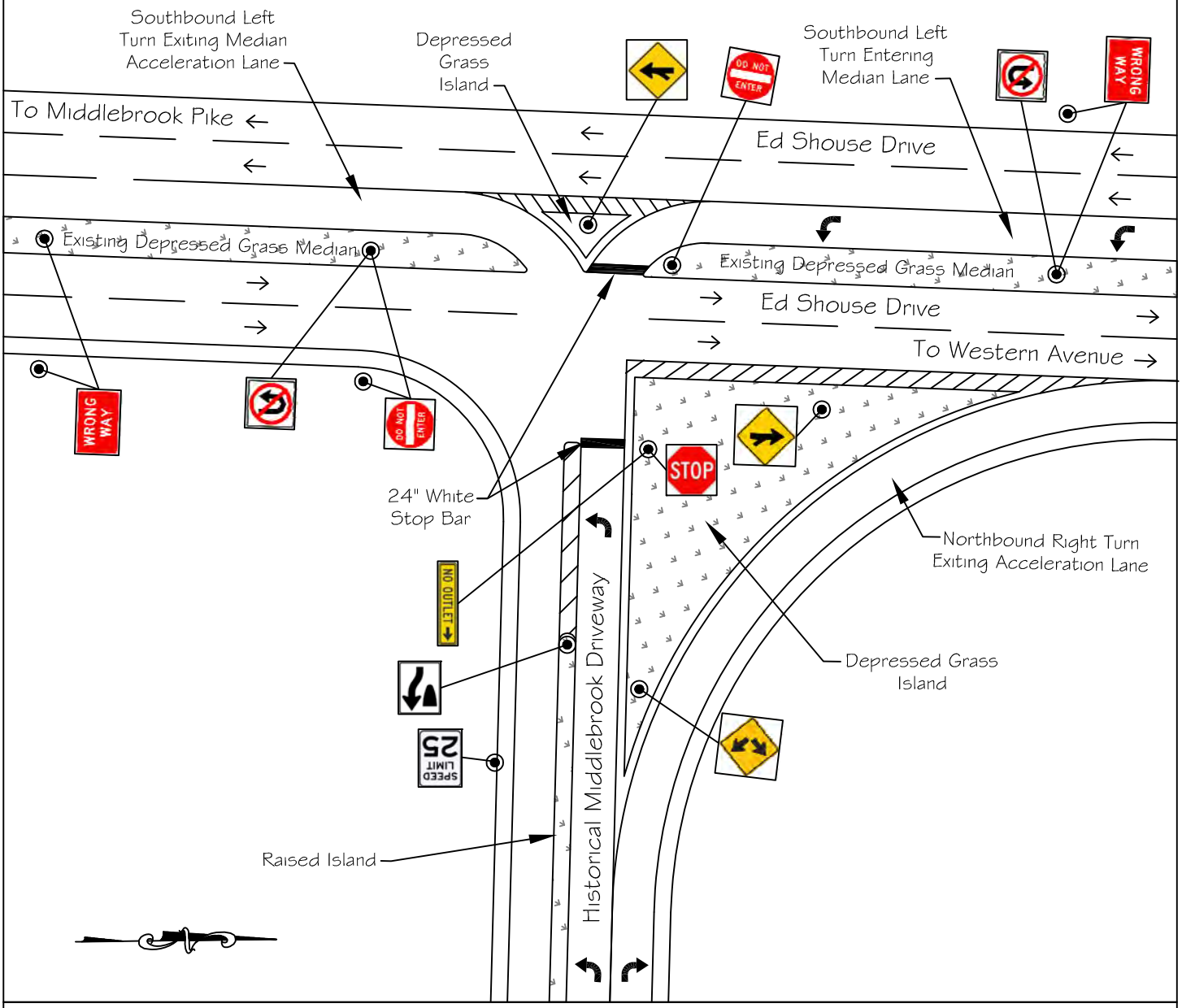
end of the depressed grass island for vehicles leaving the development traveling westbound towards Ed Shouse Drive. Left and right white turn arrows should be installed on the pavement in advance of the depressed grass island for vehicles traveling westbound towards Ed Shouse Drive.

- Two Do Not Enter Signs (R5-1) should be installed on the northbound lanes of Ed Shouse Drive just to the south of the proposed intersection and facing north. One should be placed on the east outside shoulder and one in the existing depressed grass median.

- Two Wrong Way Signs (R5-1a) should be installed on the northbound lanes of Ed Shouse Drive further to the south of the Do Not Enter Signs (R5-1) and facing north. One should be placed on the east outside shoulder and one in the existing depressed grass median. Two Wrong Way Signs (R5-1a) should also be installed on the southbound lanes of Ed Shouse Drive just to the north of the proposed intersection and facing south. One should be placed on the west outside shoulder and one in the existing depressed grass median.

- The existing median opening that is proposed to be closed on Ed Shouse Drive should have the pavement fully removed, median edges striped, be re-graded for proper drainage, and the area seeded.

- Consideration should be given to installing Truck Crossing Signs (W8-6) in advance of the proposed intersection for both directions on Ed Shouse Drive.



AJAX ENGINEERING
11812 Black Road
Knoxville, TN 37932
Phone: (865) 556-0042
Email: ajaxengineering@gmail.com

NOT TO SCALE

FIGURE 9

Intersection Concept Plan

Ed Shouse Drive at Historic Middlebrook Driveway

APPENDIX A

HISTORICAL TRAFFIC COUNT DATA

Historical Traffic Counts

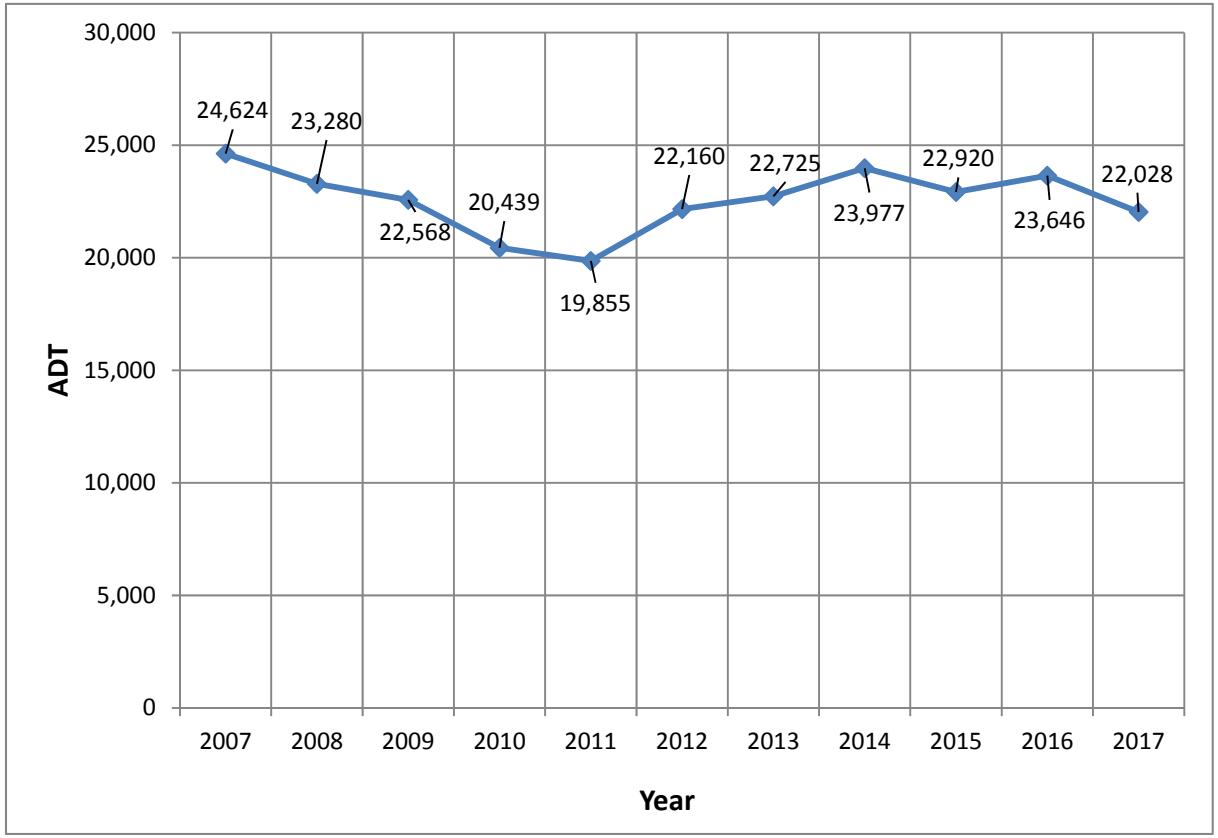
Organization: TDOT

Station ID #: 000349

Location: Ed Shouse Drive - between SR 169 and SR 62

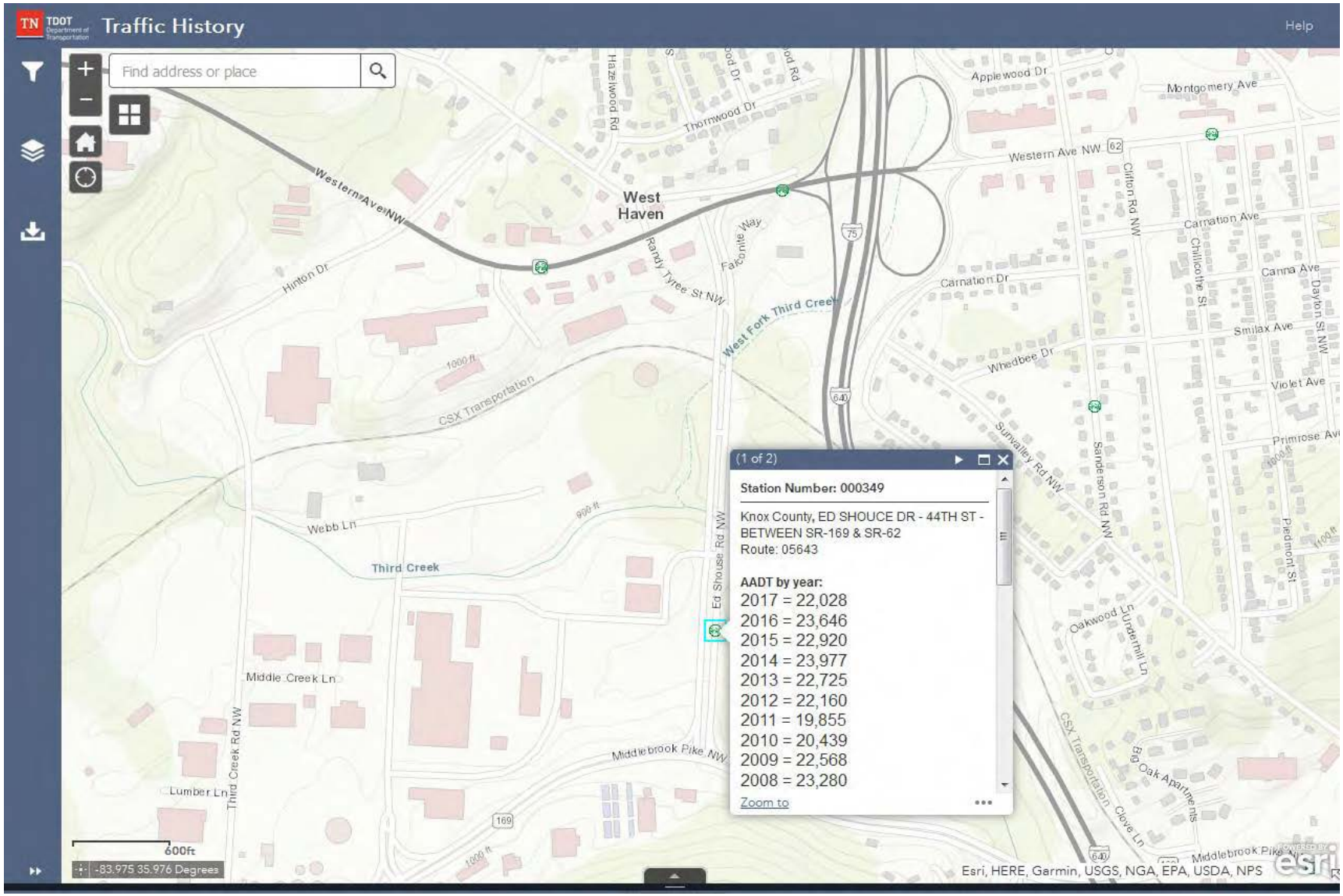
YEAR	ADT
2007	24,624
2008	23,280
2009	22,568
2010	20,439
2011	19,855
2012	22,160
2013	22,725
2014	23,977
2015	22,920
2016	23,646
2017	22,028

Trendline



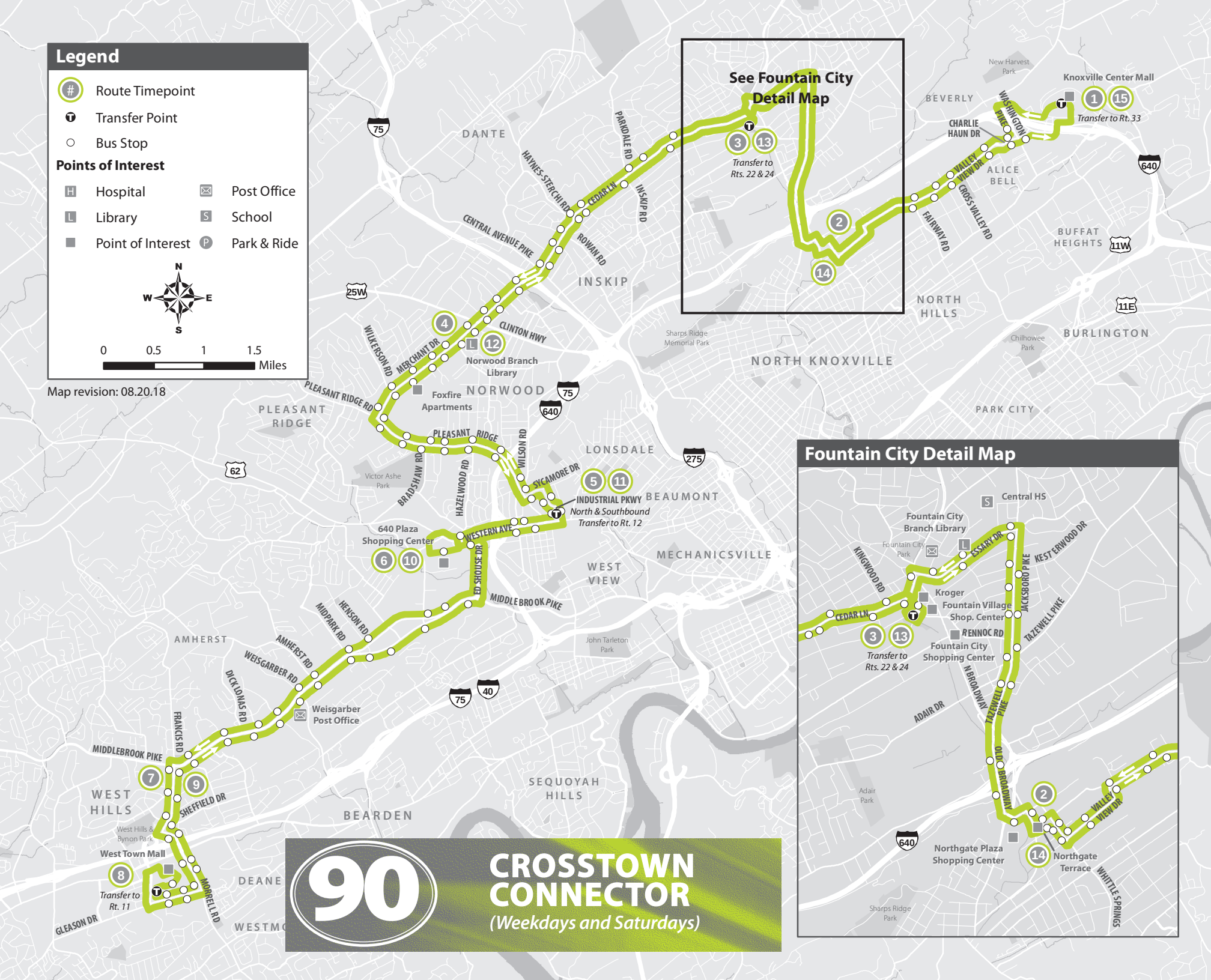
2007 - 2017 Growth Rate = -10.5%

Average Annual Growth Rate = -1.1%


TN TDOT Department of Transportation
Traffic History
Help
Find address or place
Western Ave NW
West Haven
Hazelwood Rd
Thornwood Dr
Applewood Dr
Montgomery Ave
Western Ave NW
62
Clifton Rd NW
Carnation Ave
Chillicothe St
Canna Ave
Dayton St NW
Smilax Ave
Violet Ave
Primrose Ave
Piedmont St
Carnation Dr
Whedbee Dr
Sunvalley Rd NW
Sanderson Rd NW
Oakwood Ln
Underhill Ln
Hinton Dr
Randy Tyree St NW
Falconite Way
West Fork Third Creek
75
640
1000 ft
CSX Transportation
Webb Ln
900 ft
Third Creek
Ed Shouse Rd NW
Middle Creek Ln
Third Creek Rd NW
Middlebrook Pike NW
Lumber Ln
169
CSX Transportation
Clove Ln
Big Oak Apartments
Middlebrook Pike NW
600ft
-83.975 35.976 Degrees
Esri, HERE, Garmin, USGS, NGA, EPA, USDA, NPS
(1 of 2)
Station Number: 000349
Knox County, ED SHOUCE DR - 44TH ST - BETWEEN SR-169 & SR-62
Route: 05643
AADT by year:
2017 = 22,028
2016 = 23,646
2015 = 22,920
2014 = 23,977
2013 = 22,725
2012 = 22,160
2011 = 19,855
2010 = 20,439
2009 = 22,568
2008 = 23,280
Zoom to

APPENDIX B

KNOXVILLE AREA TRANSIT MAP AND INFORMATION


Legend
Route Timepoint
Transfer Point
Bus Stop
Points of Interest
Hospital
Library
Point of Interest
Post Office
School
Park & Ride
N
W
E
S
0
0.5
1
1.5
Miles
Map revision: 08.20.18
See Fountain City Detail Map
Transfer to Rts. 22 & 24
Knoxville Center Mall
Transfer to Rt. 33
Norwood Branch Library
Foxfire Apartments
Victor Ashe Park
640 Plaza Shopping Center
INDUSTRIAL PKWY
North & Southbound
Transfer to Rt. 12
Weisgarber Post Office
West Town Mall
Transfer to Rt. 11
Fountain City Detail Map
Central HS
Fountain City Branch Library
Fountain City Park
Kroger
Fountain Village Shop. Center
Fountain City Shopping Center
Transfer to Rts. 22 & 24
Northgate Plaza Shopping Center
Northgate Terrace
Adair Park
Sharps Ridge Memorial Park
Sharps Ridge Park
Chilhowee Park
John Tarleton Park
New Harvest Park
DANTE
INSKIP
NORWOOD
PLEASANT RIDGE
LONSDALE
BEAUMONT
MECHANICSVILLE
WEST VIEW
NORTH KNOXVILLE
BEVERLY
ALICE BELL
BUFFAT HEIGHTS
NORTH HILLS
BURLINGTON
PARK CITY
AMHERST
WEST HILLS
BEARDEN
SEQUOYAH HILLS
DEANE
WESTMORELAND
CENTRAL AVENUE PIKE
CLINTON HWY
PLEASANT RIDGE RD
MIDDLEBROOK PIKE
KINGSTON PIKE
CEDAR LN
ESSARY DR
KINGWOOD RD
KESTERWOOD DR
JACKSBORO PIKE
TAZEWELL PIKE
RENNOC RD
N BROADWAY
OLD BROADWAY
ADAIR DR
VALLEY VIEW DR
WHITTLE SPRINGS
90
CROSSTOWN CONNECTOR
(Weekdays and Saturdays)

90 CROSSTOWN CONNECTOR

(Weekdays and Saturdays)

kat KNOXVILLE AREA TRANSIT

SERVES:

- 640 Plaza
- Fountain City Branch Library
- Knoxville Center Mall
- Knox Road/Kroger
- Northgate Shopping Center
- Northgate Terrace
- Norwood Branch Library
- West Town Mall

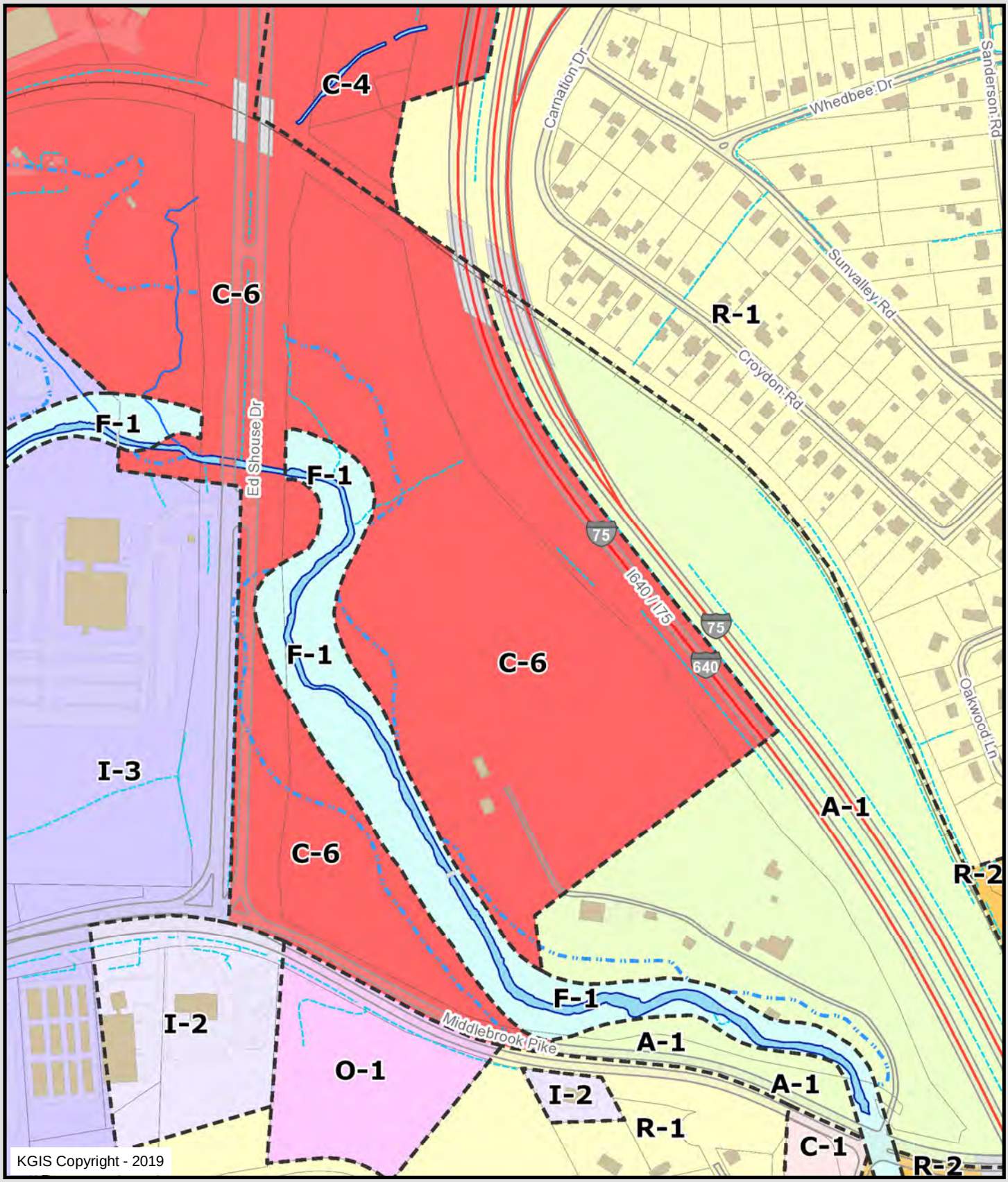
Information Updated: August 20, 2018

	Going toward West Town Mall							Going toward Knoxville Center Mall							
	T Transfer to:		Rts. 22 & 24		Rt. 12			Rt. 11			Rt. 12		Rts. 22 & 24		Rt. 33
	Knoxville Center Mall	Northgate Terrace	Fountain City Superstop	Merchants at Marguerite	Industrial Parkway	I-640 Plaza	Middlebrook at Vanosdale	West Town Mall	Vanosdale at Middlebrook	I-640 Plaza	Industrial Parkway	Merchants at Marguerite	Fountain City Superstop	Northgate Terrace	Knoxville Center Mall
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WEEKDAY SCHEDULE															
A.M.								6:01	6:06	6:22	6:28	6:37	7:05	7:11	7:25
			6:05	6:15	6:25	6:36	6:43	7:01	7:06	7:22	7:28	7:37	8:05	8:11	8:25
	6:30	6:45	7:05	7:15	7:25	7:36	7:43	8:01	8:06	8:22	8:28	8:37	9:05	9:11	9:25
	7:30	7:45	8:05	8:15	8:25	8:36	8:43	9:01	9:06	9:22	9:28	9:37	10:05	10:11	10:25
	8:30	8:45	9:05	9:15	9:25	9:36	9:43	10:01	10:06	10:22	10:28	10:37	11:05	11:11	11:25
	9:30	9:45	10:05	10:15	10:25	10:36	10:43	11:01	11:06	11:22	11:28	11:37	**12:05**	**12:11**	**12:25**
	10:30	10:45	11:05	11:15	11:25	11:36	11:43	**12:01**	**12:06**	**12:22**	**12:28**	**12:37**	**1:05**	**1:11**	**1:25**
	11:30	11:45	**12:05**	**12:15**	**12:25**	**12:36**	**12:43**	**1:01**	**1:06**	**1:22**	**1:28**	**1:37**	**2:05**	**2:11**	**2:25**
P.M.	**12:30**	**12:45**	**1:05**	**1:15**	**1:25**	**1:36**	**1:43**	**2:01**	**2:06**	**2:22**	**2:28**	**2:37**	**3:05**	**3:11**	**3:25**
	1:30	**1:45**	**2:05**	**2:15**	**2:25**	**2:36**	**2:43**	**3:01**	**3:06**	**3:22**	**3:28**	**3:37**	**4:05**	**4:11**	**4:25**
	2:30	**2:45**	**3:05**	**3:15**	**3:25**	**3:36**	**3:43**	**4:01**	**4:06**	**4:22**	**4:28**	**4:37**	**5:05**	**5:11**	**5:25**
	3:30	**3:45**	**4:05**	**4:15**	**4:25**	**4:36**	**4:43**	**5:01**	**5:06**	**5:22**	**5:28**	**5:37**	**6:05**	**6:11**	**6:25**
	4:30	**4:45**	**5:05**	**5:15**	**5:25**	**5:36**	**5:43**	**6:01**	**6:06**	**6:22**	**6:28**	**6:37**	**7:05**	**7:11**	**7:25**
	5:30	**5:45**	**6:05**	**6:15**	**6:25**	**6:36**	**6:43**	**7:01**	**7:06**	**7:22**	**7:28**	**7:37**	**8:15**	**8:21**	**8:35**
	6:30	**6:45**	**7:05**	**7:15**	**7:25**	**7:36**	**7:43**	**7:59**	*To Garage*						
	7:30	**7:45**	**8:05**	**8:15**	**8:25**	**8:36**	**8:43**	**8:59**	*To Garage*						
SATURDAY SCHEDULE															
A.M.								7:31	7:36	7:52	7:58	8:07	8:35	8:41	8:55
	7:00	7:15	7:35	7:45	7:55	8:06	8:13	8:31	8:36	8:52	8:58	9:07	9:35	9:41	9:55
	8:00	8:15	8:35	8:45	8:55	9:06	9:13	9:31	9:36	9:52	9:58	10:07	10:35	10:41	10:55
	9:00	9:15	9:35	9:45	9:55	10:06	10:13	10:31	10:36	10:52	10:58	11:07	11:35	11:41	11:55
	10:00	10:15	10:35	10:45	10:55	11:06	11:13	11:31	11:36	11:52	11:58	**12:07**	**12:35**	**12:41**	**12:55**
	11:00	11:15	11:35	11:45	11:55	**12:06**	**12:13**	**12:31**	**12:36**	**12:52**	**12:58**	**1:07**	**1:35**	**1:41**	**1:55**
P.M.	**12:00**	**12:15**	**12:35**	**12:45**	**12:55**	**1:06**	**1:13**	**1:31**	**1:36**	**1:52**	**1:58**	**2:07**	**2:35**	**2:41**	**2:55**
	1:00	**1:15**	**1:35**	**1:45**	**1:55**	**2:06**	**2:13**	**2:31**	**2:36**	**2:52**	**2:58**	**3:07**	**3:35**	**3:41**	**3:55**
	2:00	**2:15**	**2:35**	**2:45**	**2:55**	**3:06**	**3:13**	**3:31**	**3:36**	**3:52**	**3:58**	**4:07**	**4:35**	**4:41**	**4:55**
	3:00	**3:15**	**3:35**	**3:45**	**3:55**	**4:06**	**4:13**	**4:31**	**4:36**	**4:52**	**4:58**	**5:07**	**5:35**	**5:41**	**5:55**
	4:00	**4:15**	**4:35**	**4:45**	**4:55**	**5:06**	**5:13**	**5:31**	**5:36**	**5:52**	**5:58**	**6:07**	**6:35**	**6:41**	**6:55**
	5:00	**5:15**	**5:35**	**5:45**	**5:55**	**6:06**	**6:13**	**6:31**	**6:36**	**6:52**	**6:58**	**7:07**	**7:35**	**7:41**	**7:55**
	6:00	**6:15**	**6:35**	**6:45**	**6:55**	**7:06**	**7:13**	**7:31**	**7:36**	**7:52**	**7:58**	**8:07**	**8:35**	**8:41**	**8:55**
	7:00	**7:15**	**7:35**	**7:45**	**7:55**	**8:06**	**8:13**	**8:31**	*To Garage*						

Need help reading this schedule?
Need other general information on how to ride?
Click here to Download the General Schedule Information pdf available from katbus.com

APPENDIX C

ZONING MAP



Historic Middlebrook

Zoning Map - 2.25.19

Knoxville - Knox County - KUB Geographic Information System

Printed: 2/25/2019 at 3:05:20 PM

0 200 400 800

ft

APPENDIX D

MANUAL TRAFFIC COUNT DATA

TRAFFIC COUNT DATA

Major Street: Ed Shouse Drive (SB - NB)
Minor Street: n/a
Traffic Control: n/a

3/5/2019 (Thursday)
Sunny /Cold
Conducted by: Ajax Engineering

All Vehicles

TIME BEGIN	Ed Shouse Drive SOUTHBOUND THRU	Ed Shouse Drive NORTHBOUND THRU	VEHICLE TOTAL	PEAK HOUR
7:00 AM	239	93	332	
7:15 AM	301	93	394	
7:30 AM	**330**	**137**	**467**	**7:30 AM - 8:30 AM**
7:45 AM	**364**	**116**	**480**	
8:00 AM	**336**	**144**	**480**	
8:15 AM	**269**	**149**	**418**	
8:30 AM	252	121	373	
8:45 AM	232	119	351	
TOTAL	2323	972	3295	
11:00 AM	107	158	265	
11:15 AM	129	156	285	
11:30 AM	138	176	314	
11:45 AM	129	161	290	
12:00 PM	135	195	330	
12:15 PM	154	163	317	
12:30 PM	148	172	320	
12:45 PM	150	145	295	
TOTAL	1090	1326	2416	
2:00 PM	136	142	278	
2:15 PM	150	183	333	
2:30 PM	139	211	350	
2:45 PM	143	179	322	
3:00 PM	126	227	353	
3:15 PM	121	172	293	
3:30 PM	141	311	452	
3:45 PM	132	269	401	
4:00 PM	139	242	381	
4:15 PM	125	265	390	
4:30 PM	**127**	**304**	**431**	**4:30 PM - 5:30 PM**
4:45 PM	**133**	**286**	**419**	
5:00 PM	**125**	**357**	**482**	
5:15 PM	**145**	**321**	**466**	
5:30 PM	134	246	380	
5:45 PM	117	195	312	
TOTAL	1565	3195	4760	

2019 AM Peak Hour **7:30 AM - 8:30 AM**

TIME BEGIN	Ed Shouse Drive SOUTHBOUND THRU	Ed Shouse Drive NORTHBOUND THRU
7:30 AM	330	137
7:45 AM	364	116
8:00 AM	336	144
8:15 AM	269	149
TOTAL	1299	546
PHF	0.89	0.92

2019 PM Peak Hour **4:30 PM - 5:30 PM**

TIME BEGIN	Ed Shouse Drive SOUTHBOUND THRU	Ed Shouse Drive NORTHBOUND THRU
4:30 PM	127	304
4:45 PM	133	286
5:00 PM	125	357
5:15 PM	145	321
TOTAL	530	1268
PHF	0.91	0.89

TRAFFIC COUNT DATA

Major Street: Ed Shouse Drive (SB - NB) 3/5/2019 (Thursday)
Minor Street: n/a Sunny /Cold
Traffic Control: n/a Conducted by: Ajax Engineering

Heavy Trucks Only

TIME BEGIN	Ed Shouse Drive SOUTHBOUND THRU	Ed Shouse Drive NORTHBOUND THRU	VEHICLE TOTAL	PEAK HOUR
7:00 AM	14	16	30	
7:15 AM	13	16	29	
7:30 AM	**16**	**16**	**32**	**7:30 AM - 8:30 AM**
7:45 AM	**18**	**11**	**29**	
8:00 AM	**11**	**11**	**22**	
8:15 AM	**18**	**18**	**36**	
8:30 AM	13	18	31	
8:45 AM	19	18	37	
TOTAL	122	124	246	
11:00 AM	12	16	28	
11:15 AM	19	16	35	
11:30 AM	18	19	37	
11:45 AM	13	13	26	
12:00 PM	15	19	34	
12:15 PM	12	16	28	
12:30 PM	14	8	22	
12:45 PM	11	8	19	
TOTAL	114	115	229	
2:00 PM	8	12	20	
2:15 PM	12	14	26	
2:30 PM	13	16	29	
2:45 PM	17	11	28	
3:00 PM	16	9	25	
3:15 PM	17	11	28	
3:30 PM	18	10	28	
3:45 PM	11	13	24	
4:00 PM	9	14	23	
4:15 PM	15	9	24	
4:30 PM	**8**	**10**	**18**	**4:30 PM - 5:30 PM**
4:45 PM	**10**	**12**	**22**	
5:00 PM	**10**	**5**	**15**	
5:15 PM	**5**	**14**	**19**	
5:30 PM	12	10	22	
5:45 PM	11	6	17	
TOTAL	142	123	265	

2019 AM Peak Hour **7:30 AM - 8:30 AM**

TIME BEGIN	Ed Shouse Drive SOUTHBOUND THRU	Ed Shouse Drive NORTHBOUND THRU
7:30 AM	16	16
7:45 AM	18	11
8:00 AM	11	11
8:15 AM	18	18
TOTAL	63	56
TRUCK %	4.8%	10.3%

2019 PM Peak Hour **4:30 PM - 5:30 PM**

TIME BEGIN	Ed Shouse Drive SOUTHBOUND THRU	Ed Shouse Drive NORTHBOUND THRU
4:30 PM	8	10
4:45 PM	10	12
5:00 PM	10	5
5:15 PM	5	14
TOTAL	33	41
TRUCK %	6.2%	3.2%

APPENDIX E

ITE TRIP GENERATION RATES

Land Use: 150
Warehousing

Description

A warehouse is primarily devoted to the storage of materials, but it may also include office and maintenance areas. High-cube transload and short-term storage warehouse (Land Use 154), high-cube fulfillment center warehouse (Land Use 155), high-cube parcel hub warehouse (Land Use 156), and high-cube cold storage warehouse (Land Use 157) are related uses.

Additional Data

Time-of-day distribution data for this land use are presented in Appendix A. For the 13 general urban/suburban sites with data, the overall highest vehicle volumes during the AM and PM on a weekday were counted between 11:30 a.m. and 12:30 p.m. and 3:00 and 4:00 p.m., respectively.

The sites were surveyed in the 1980s, the 1990s, the 2000s, and the 2010s in California, Connecticut, Minnesota, New Jersey, New York, Ohio, Oregon, Pennsylvania, and Texas.

Source Numbers

184, 331, 406, 411, 443, 579, 583, 596, 598, 611, 619, 642, 752, 869, 875, 876, 914, 940

Warehousing
(150)

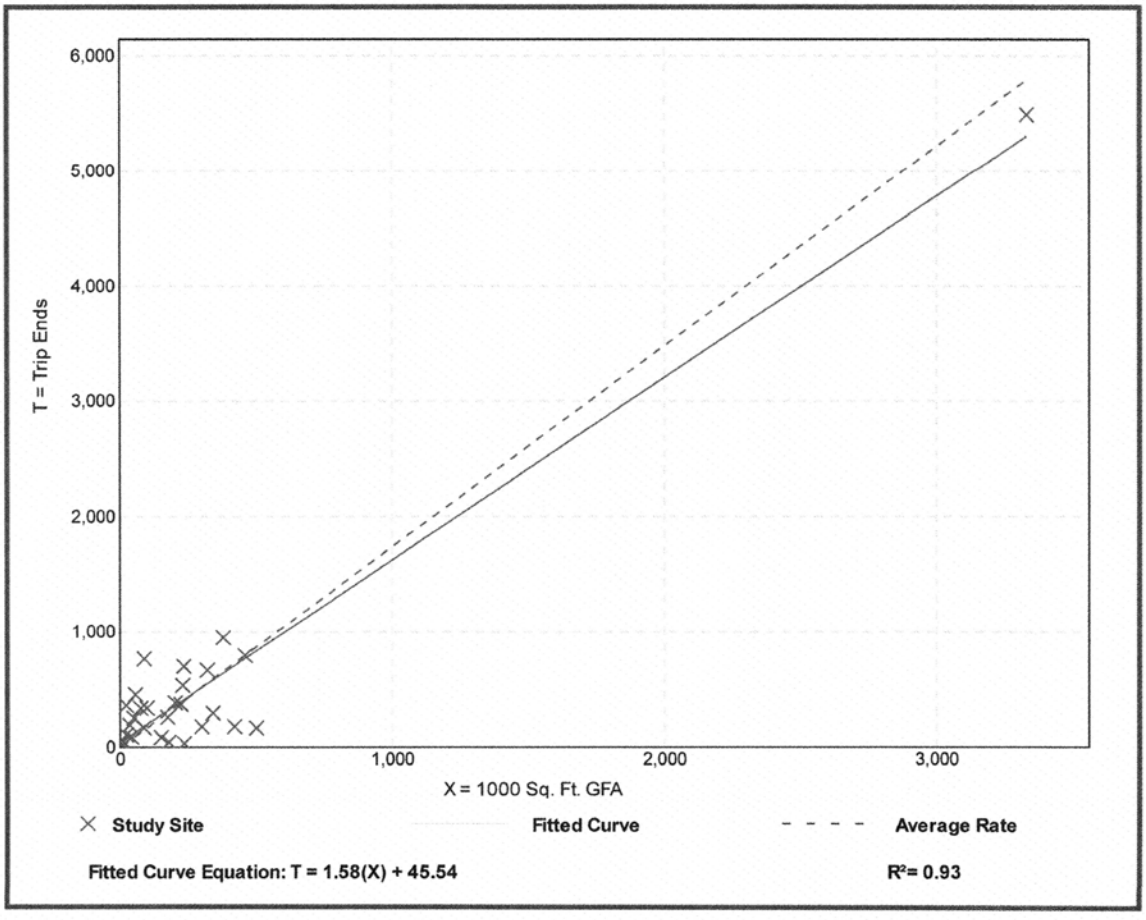
Vehicle Trip Ends vs: 1000 Sq. Ft. GFA
On a: Weekday

Setting/Location: General Urban/Suburban
Number of Studies: 29
1000 Sq. Ft. GFA: 285
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
1.74	0.15 - 16.93	1.55

Data Plot and Equation



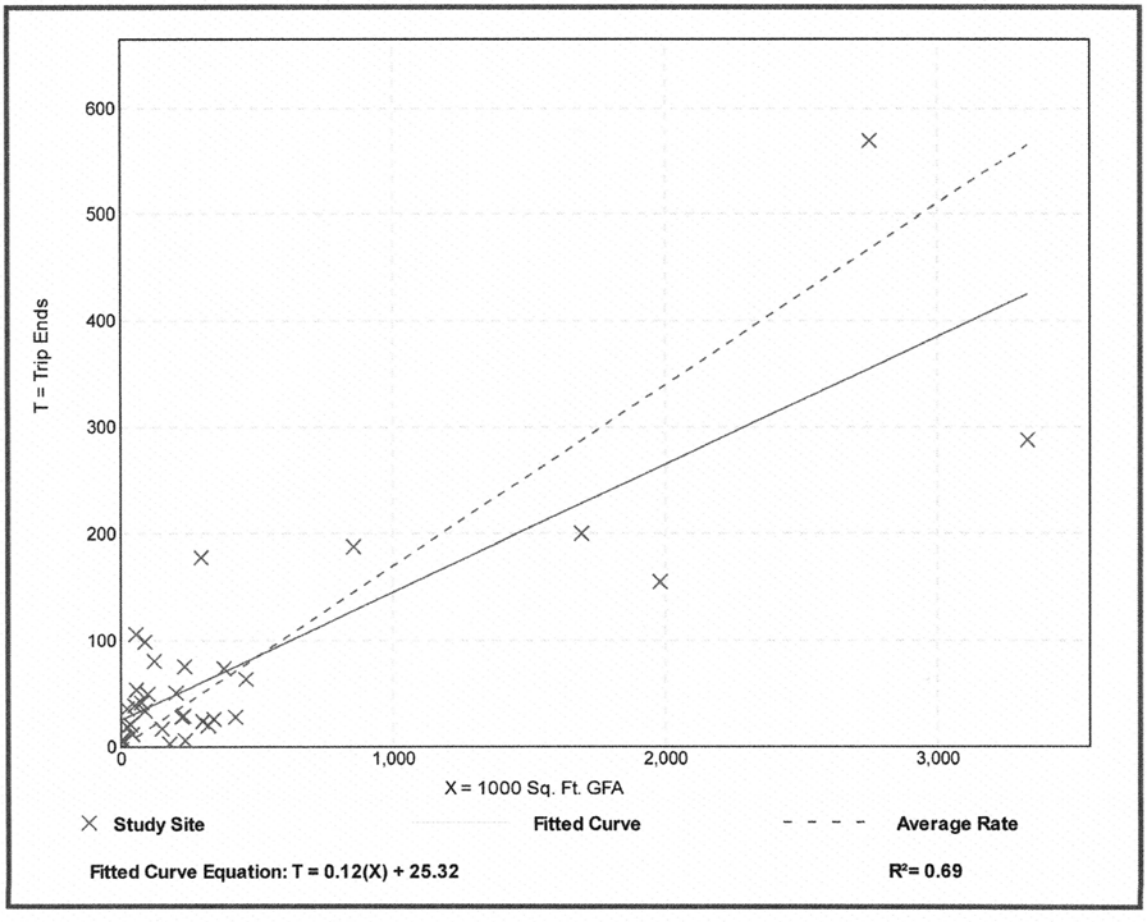
Warehousing
(150)

Vehicle Trip Ends vs: **1000 Sq. Ft. GFA**
On a: **Weekday,**
Peak Hour of Adjacent Street Traffic,
One Hour Between 7 and 9 a.m.
Setting/Location: **General Urban/Suburban**
Number of Studies: 34
1000 Sq. Ft. GFA: 451
Directional Distribution: 77% entering, 23% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
0.17	0.02 - 1.93	0.20

Data Plot and Equation



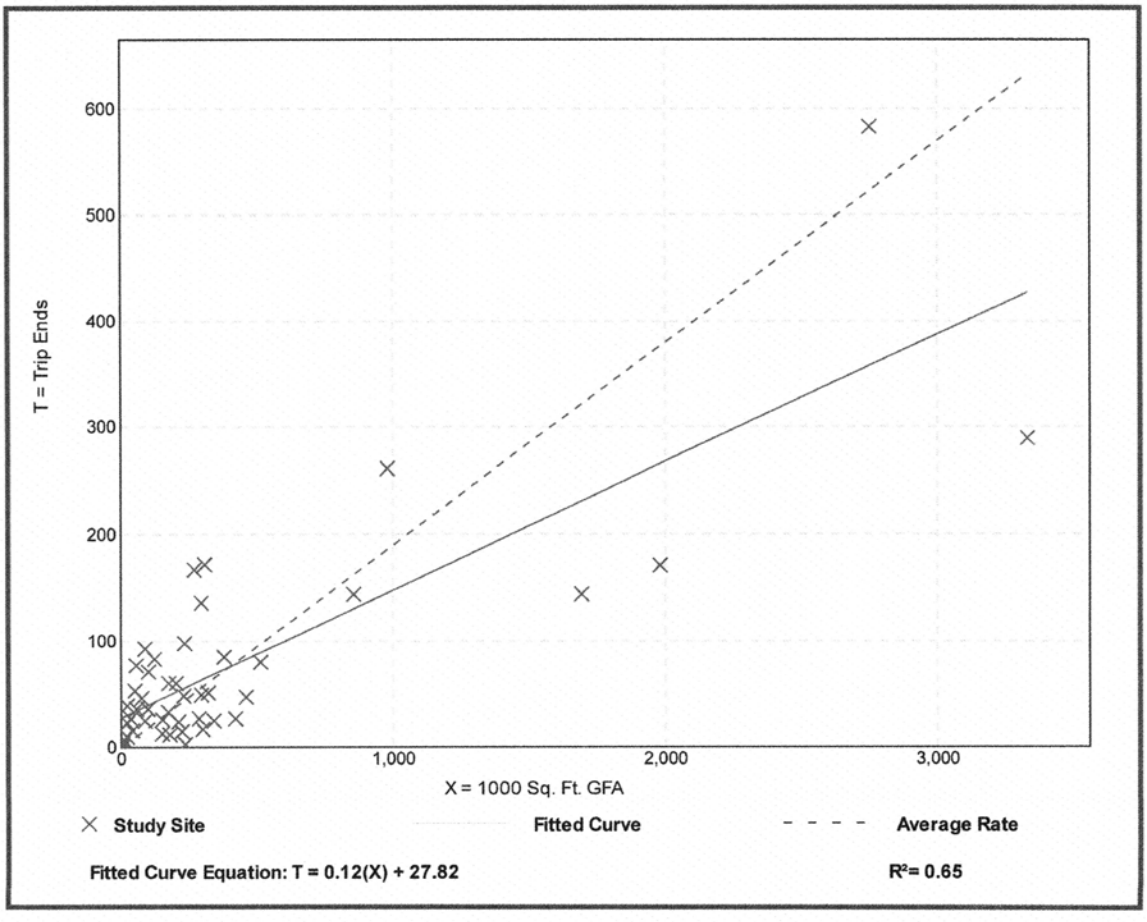
Warehousing
(150)

Vehicle Trip Ends vs: **1000 Sq. Ft. GFA**
On a: **Weekday,**
Peak Hour of Adjacent Street Traffic,
One Hour Between 4 and 6 p.m.
Setting/Location: **General Urban/Suburban**
Number of Studies: 47
1000 Sq. Ft. GFA: 400
Directional Distribution: 27% entering, 73% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
0.19	0.01 - 1.80	0.18

Data Plot and Equation



TRIP GENERATION FOR HISTORIC MIDDLEBROOK
Initial Phase

ITE LAND USE CODE	LAND USE DESCRIPTION	UNITS	GENERATED DAILY TRAFFIC	GENERATED TRAFFIC AM PEAK HOUR			GENERATED TRAFFIC PM PEAK HOUR		
				ENTER	EXIT	TOTAL	ENTER	EXIT	TOTAL
				77%	**23%**		**27%**	**73%**	
#150	Warehousing	40,000 sq. ft.	109	24	7	31	9	24	33
Total New Volume Site Trips			**109**	**24**	**7**	**31**	**9**	**24**	**33**

ITE Trip Generation Manual, 10th Edition

TRIP GENERATION FOR HISTORIC MIDDLEBROOK
40,000 sq. ft. Warehousing - INITIAL PHASE

X = 1000 sq. ft. GFA

Weekday:

Fitted Curve Equation: T = 1.58(X) + 45.54

T = 1.58 * 40 + 45.54
T = 109 trips

Peak Hour of Adjacent Traffic between 7 and 9 am:

Fitted Curve Equation: T = 0.12(X) + 25.32

T = 0.12 * 40 + 25.32
T = 31 trips

Peak Hour of Adjacent Traffic between 4 and 6 pm:

Fitted Curve Equation: T = 0.12(X) + 27.82

T = 0.12 * 40 + 27.82
T = 33 trips

TRIP GENERATION FOR HISTORIC MIDDLEBROOK
Initial & Future Phase

ITE LAND USE CODE	LAND USE DESCRIPTION	UNITS	GENERATED DAILY TRAFFIC	GENERATED TRAFFIC AM PEAK HOUR			GENERATED TRAFFIC PM PEAK HOUR		
				ENTER	EXIT	TOTAL	ENTER	EXIT	TOTAL
#150	Initial Phase Warehousing	40,000 sq. ft.	109	**77%**	**23%**		**27%**	**73%**	
				24	7	31	9	24	33
#150	Future Phase Warehousing	180,000 sq. ft.	330	**77%**	**23%**		**27%**	**73%**	
				36	11	47	14	36	50
Total New Volume Site Trips			**439**	**60**	**18**	**78**	**23**	**60**	**83**

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TRIP GENERATION FOR HISTORIC MIDDLEBROOK
180,000 sq. ft. Warehousing - FUTURE PHASE

X = 1000 sq. ft. GFA

Weekday:

Fitted Curve Equation: T = 1.58(X) + 45.54

T = 1.58 * 180 + 45.54
T = 330 trips

Peak Hour of Adjacent Traffic between 7 and 9 am:

Fitted Curve Equation: T = 0.12(X) + 25.32

T = 0.12 * 180 + 25.32
T = 47 trips

Peak Hour of Adjacent Traffic between 4 and 6 pm:

Fitted Curve Equation: T = 0.12(X) + 27.82

T = 0.12 * 180 + 27.82
T = 50 trips

TRIP GENERATION - ASSUMED VEHICLE TYPE BREAKDOWN
Initial Phase

VEHICLE TYPE	GENERATED DAILY TRAFFIC	GENERATED TRAFFIC AM PEAK HOUR			GENERATED TRAFFIC PM PEAK HOUR		
		ENTER	EXIT	TOTAL	ENTER	EXIT	TOTAL
All Vehicles	109	24	7	31	9	24	33
Passenger Car (Employee) Trips (80%)	87	19	6	25	7	19	26
Heavy Truck Trips (20%)	22	5	1	6	2	5	7

TRIP GENERATION - ASSUMED VEHICLE TYPE BREAKDOWN
Initial & Future Phase

VEHICLE TYPE	GENERATED DAILY TRAFFIC	GENERATED TRAFFIC AM PEAK HOUR			GENERATED TRAFFIC PM PEAK HOUR		
		ENTER	EXIT	TOTAL	ENTER	EXIT	TOTAL
All Vehicles	439	60	18	78	23	60	83
Passenger Car (Employee) Trips (80%)	351	48	14	62	18	48	66
Heavy Truck Trips (20%)	88	12	4	16	5	12	17

APPENDIX F

CITY OF FONTANA, CA TRUCK TRIP GENERATION STUDY EXCERPT

VEHICLE MIX AND ENTER/EXIT SPLITS BY LAND USE CATEGORY

Classification: Light Warehouse

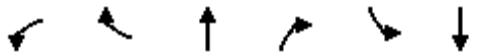
	Recommended Large Truck Mix (%)							
	Lge 2 Ax	3 Axle	4+ Axle	Total				
	24.7	20.6	54.6	100.0				
	Pass Veh	Lge 2 Ax	3 Axle	4+ Axle	Total			
	80.3	5.2	4.5	10.0	100.0			
	Site Entering & Exiting							
	a.m.				p.m.			
	Total Enter	Total Exit	Large Truck Enter	Large Truck Exit	Total Enter	Total Exit	Large Truck Enter	Large Truck Exit
Split	73.97	26.03	62.07	37.93	23.81	76.19	45.45	54.55
	Street Entering & Exiting							
	a.m.				p.m.			
	Total Enter	Total Exit	Large Truck Enter	Large Truck Exit	Total Enter	Total Exit	Large Truck Enter	Large Truck Exit
Split	73.77	26.23	65.22	34.78	20.00	80.00	31.58	68.42

Light Warehouse (<100,000 sq. ft.)

% Mix of Passenger Vehicles and Heavy Trucks:
~80% Passenger Vehicles
~20% Heavy Trucks

APPENDIX G

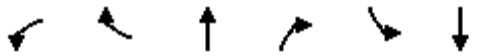
CAPACITY ANALYSES – HCM WORKSHEETS (SYNCHRO 8)



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	1	6	551	5	19	1312
Sign Control	Stop		Free			Free
Grade	2%		5%			-5%
Peak Hour Factor	0.90	0.90	0.92	0.90	0.90	0.89
Hourly flow rate (vph)	1	7	599	6	21	1474
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type			Raised			Raised
Median storage veh)			1			1
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	1381	302			604	
vC1, stage 1 conf vol	602					
vC2, stage 2 conf vol	779					
vCu, unblocked vol	1381	302			604	
tC, single (s)	7.2	7.3			4.5	
tC, 2 stage (s)	6.2					
tF (s)	3.7	3.5			2.4	
p0 queue free %	100	99			98	
cM capacity (veh/h)	235	643			856	

Direction, Lane #	WB 1	WB 2	NB 1	NB 2	SB 1	SB 2	SB 3
Volume Total	1	7	399	205	21	737	737
Volume Left	1	0	0	0	21	0	0
Volume Right	0	7	0	6	0	0	0
cSH	235	643	1700	1700	856	1700	1700
Volume to Capacity	0.00	0.01	0.23	0.12	0.02	0.43	0.43
Queue Length 95th (ft)	0	1	0	0	2	0	0
Control Delay (s)	20.4	10.7	0.0	0.0	9.3	0.0	0.0
Lane LOS	C	B			A		
Approach Delay (s)	12.0		0.0		0.1		
Approach LOS	B						

Intersection Summary			
Average Delay	0.1		
Intersection Capacity Utilization	46.3%	ICU Level of Service	A
Analysis Period (min)	15		



Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	5	19	1281	2	7	535
Sign Control	Stop		Free			Free
Grade	2%		5%			-5%
Peak Hour Factor	0.90	0.90	0.89	0.90	0.90	0.91
Hourly flow rate (vph)	6	21	1439	2	8	588
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type			Raised			Raised
Median storage veh)			1			1
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	1750	721			1442	
vC1, stage 1 conf vol	1440					
vC2, stage 2 conf vol	310					
vCu, unblocked vol	1750	721			1442	
tC, single (s)	7.2	7.3			4.5	
tC, 2 stage (s)	6.2					
tF (s)	3.7	3.5			2.4	
p0 queue free %	96	94			98	
cM capacity (veh/h)	130	332			385	

Direction, Lane #	WB 1	WB 2	NB 1	NB 2	SB 1	SB 2	SB 3
Volume Total	6	21	960	482	8	294	294
Volume Left	6	0	0	0	8	0	0
Volume Right	0	21	0	2	0	0	0
cSH	130	332	1700	1700	385	1700	1700
Volume to Capacity	0.04	0.06	0.56	0.28	0.02	0.17	0.17
Queue Length 95th (ft)	3	5	0	0	2	0	0
Control Delay (s)	33.8	16.6	0.0	0.0	14.5	0.0	0.0
Lane LOS	D	C			B		
Approach Delay (s)	20.2		0.0		0.2		
Approach LOS	C						

Intersection Summary			
Average Delay	0.3		
Intersection Capacity Utilization	45.5%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	4	14	579	12	48	1377
Sign Control	Stop		Free			Free
Grade	2%		5%			-5%
Peak Hour Factor	0.90	0.90	0.92	0.90	0.90	0.89
Hourly flow rate (vph)	4	16	629	13	53	1547
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type			Raised			Raised
Median storage veh)			1			1
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	1516	321			643	
vC1, stage 1 conf vol	636					
vC2, stage 2 conf vol	880					
vCu, unblocked vol	1516	321			643	
tC, single (s)	7.2	7.3			4.5	
tC, 2 stage (s)	6.2					
tF (s)	3.7	3.5			2.4	
p0 queue free %	98	98			94	
cM capacity (veh/h)	202	624			826	

Direction, Lane #	WB 1	WB 2	NB 1	NB 2	SB 1	SB 2	SB 3
Volume Total	4	16	420	223	53	774	774
Volume Left	4	0	0	0	53	0	0
Volume Right	0	16	0	13	0	0	0
cSH	202	624	1700	1700	826	1700	1700
Volume to Capacity	0.02	0.02	0.25	0.13	0.06	0.46	0.46
Queue Length 95th (ft)	2	2	0	0	5	0	0
Control Delay (s)	23.2	10.9	0.0	0.0	9.7	0.0	0.0
Lane LOS	C	B			A		
Approach Delay (s)	13.7		0.0		0.3		
Approach LOS	B						

Intersection Summary			
Average Delay	0.3		
Intersection Capacity Utilization	48.1%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	12	48	1344	5	18	562
Sign Control	Stop		Free			Free
Grade	2%		5%			-5%
Peak Hour Factor	0.90	0.90	0.89	0.90	0.90	0.91
Hourly flow rate (vph)	13	53	1510	6	20	618
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type			Raised			Raised
Median storage veh)			1			1
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	1862	758			1516	
vC1, stage 1 conf vol	1513					
vC2, stage 2 conf vol	349					
vCu, unblocked vol	1862	758			1516	
tC, single (s)	7.2	7.3			4.5	
tC, 2 stage (s)	6.2					
tF (s)	3.7	3.5			2.4	
p0 queue free %	89	83			94	
cM capacity (veh/h)	117	313			358	

Direction, Lane #	WB 1	WB 2	NB 1	NB 2	SB 1	SB 2	SB 3
Volume Total	13	53	1007	509	20	309	309
Volume Left	13	0	0	0	20	0	0
Volume Right	0	53	0	6	0	0	0
cSH	117	313	1700	1700	358	1700	1700
Volume to Capacity	0.11	0.17	0.59	0.30	0.06	0.18	0.18
Queue Length 95th (ft)	9	15	0	0	4	0	0
Control Delay (s)	39.6	18.9	0.0	0.0	15.6	0.0	0.0
Lane LOS	E	C			C		
Approach Delay (s)	23.0		0.0		0.5		
Approach LOS	C						

Intersection Summary			
Average Delay	0.8		
Intersection Capacity Utilization	47.3%	ICU Level of Service	A
Analysis Period (min)	15		

APPENDIX H

SPOT SPEED STUDY

SPOT SPEED STUDY

Location: Ed Shouse Drive
Posted Speed Limit: 50 mph
Equipment: Bushnell Speedster III Radar Speed Gun
Direction: Northbound

Date: 2/27/2019
Weather: Sunny/Mild
Time: 2:30 PM
Pavement Conditions: Dry

Vehicle #	Speed (mph)
1	51
2	46
3	57
4	49
5	50
6	59
7	50
8	51
9	47
10	45
11	47
12	54
13	48
14	53
15	49
16	48
17	42
18	46
19	43
20	51
21	48
22	48
23	50
24	52
25	53

Vehicle #	Speed (mph)
26	52
27	53
28	50
29	60
30	57
31	64
32	55
33	45
34	60
35	55
36	53
37	45
38	56
39	47
40	53
41	58
42	56
43	51
44	49
45	48
46	60
47	51
48	51
49	50
50	46

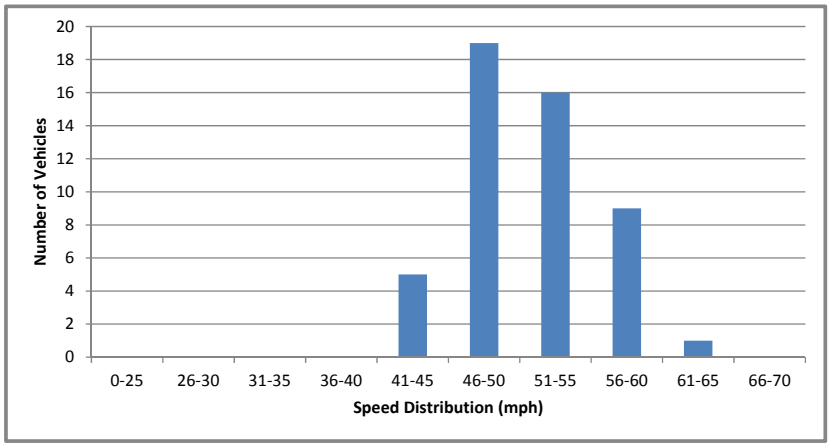
Sample Size Requirements (*ITE Manual of Transportation Engineering Studies*)

$N = (S * K/E)^2$

where:
- N = minimum number of measured speeds
- S = estimated sample standard deviation (mph)
- K = constant corresponding to desired confidence level
- E = permitted error in the average speed estimate (mph)

S = 5 mph (Table 3-2, page 38)
K = 2.58 (Confidence level of 99% - Table 3-3, page 38)
E = 2 mph assumed error range

Therefore, N = 42 observations needed



Average speed = 51.2 mph
50th percentile speed = 51.0 mph
85th percentile speed = 56.7 mph

SPOT SPEED STUDY

Location: Ed Shouse Drive
Posted Speed Limit: 50 mph
Equipment: Bushnell Speedster III Radar Speed Gun
Direction: Southbound

Date: 2/27/2019
Weather: Sunny/Mild
Time: 2:30 PM
Pavement Conditions: Dry

Vehicle #	Speed (mph)
1	48
2	44
3	52
4	45
5	43
6	54
7	55
8	52
9	50
10	52
11	53
12	48
13	47
14	52
15	48
16	49
17	50
18	64
19	53
20	55
21	58
22	53
23	56
24	52
25	50

Vehicle #	Speed (mph)
26	52
27	54
28	55
29	59
30	54
31	58
32	47
33	50
34	47
35	55
36	58
37	52
38	51
39	54
40	52
41	51
42	55
43	57
44	53
45	54
46	53
47	53
48	48
49	49
50	53

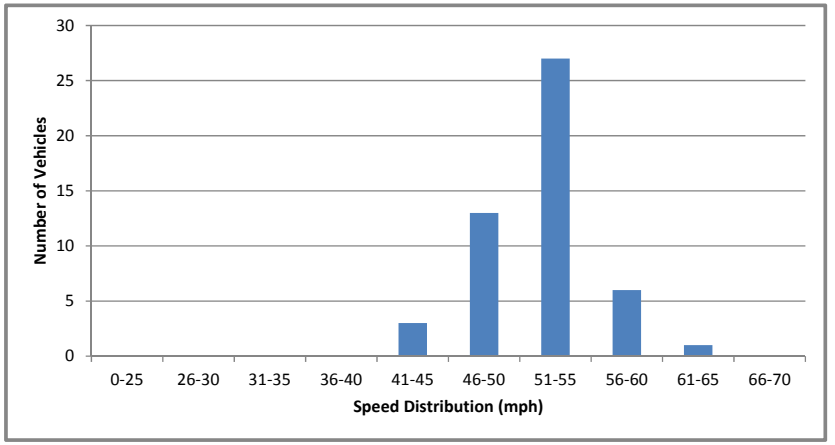
Sample Size Requirements (*ITE Manual of Transportation Engineering Studies*)

$N = (S * K/E)^2$

where:
- N = minimum number of measured speeds
- S = estimated sample standard deviation (mph)
- K = constant corresponding to desired confidence level
- E = permitted error in the average speed estimate (mph)

S = 5 mph (Table 3-2, page 38)
K = 2.58 (Confidence level of 99% - Table 3-3, page 38)
E = 2 mph assumed error range

Therefore, N = 42 observations needed



Average speed = 52.1 mph
50th percentile speed = 52.0 mph
85th percentile speed = 55.0 mph

APPENDIX I

KNOX COUNTY TURN LANE VOLUME THRESHOLD WORKSHEETS

TABLE 7A

LEFT-TURN LANE VOLUME THRESHOLDS FOR TWO-LANE ROADWAYS WITH A PREVAILING SPEED OF 56 MPH OR OVER

(If the left-turn volume exceeds the table value a left -turn lane is needed)

OPPOSING VOLUME	THROUGH VOLUME PLUS RIGHT-TURN VOLUME *					
	100 - 149	150 - 199	200 - 249	250 - 299	300 - 349	350 - 399
100 - 149	150	75	60	45	35	30
150 - 199	110	65	55	40	35	30
200 - 249	85	60	50	35	30	30
250 - 299	70	55	45	35	30	30
300 - 349	60	50	40	30	25	25
350 - 399	55	45	35	30	325	25
400 - 449	50	40	30	25	20	20
450 - 499	45	35	30	25	20	20
500 - 549	40	30	25	20	20	20
550 - 599	40	25	20	20	20	20
600 - 649	35	20	20	20	20	15
650 - 699	35	20	20	20	15	15
700 - 749	30	20	20	15	15	15
750 or More	30	20	15	15	15	15

OPPOSING VOLUME	THROUGH VOLUME PLUS RIGHT-TURN VOLUME *					
	350 - 399	400 - 449	450 - 499	500 - 549	550 - 599	=/ >600
100 - 149	30	25	25	20	20	20
150 - 199	30	25	25	20	20	20
200 - 249	30	25	25	20	20	
250 - 299	30	25	25	20	20	15
300 - 349	25	25	20	20	15	15
350 - 399	25	25		20	15	15
400 - 449	20	20		15	15	15
450 - 499	20	20		15	15	15
500 - 549	20	20		15	15	15
550 - 599	20	15		15	15	15
600 - 649	15	15		15	15	15
650 - 699	15	15		15	15	15
700 - 749	15	15		15	15	15
750 or More	15	15	15	15	15	15

(1312/2) * 1.05 = 689

(556/2) * 1.05 = 292

Ed Shouse Drive at Proposed Historic Middlebrook Driveway

2020 Projected AM Left Turns = 19

Turn Lane Warranted

* Or through volume only if a right-turn lane exists.

TABLE 7B

RIGHT-TURN LANE VOLUME THRESHOLDS FOR TWO-LANE ROADWAYS WITH A PREVAILING SPEED OF 56 MPH OR OVER

RIGHT-TURN VOLUME	THROUGH VOLUME PLUS LEFT-TURN VOLUME *					
	< 100	100 - 199	200 - 249	250 - 299	300 - 349	350 - 399
Fewer Than 25 25 - 49 50 - 99						
100 - 149 150 - 199					Yes	Yes Yes
200 - 249 250 - 299				Yes Yes	Yes Yes	Yes Yes
300 - 349 350 - 399	Yes			Yes Yes	Yes Yes	Yes Yes
400 - 449 450 - 499	Yes Yes	Yes	Yes	Yes Yes	Yes Yes	Yes Yes
500 - 549 550 - 599	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
600 or More	Yes	Yes	Yes	Yes	Yes	Yes

(551/2) * 1.05 = 290

Ed Shouse Drive at Proposed Historic Middlebrook Driveway

2020 Projected AM Right Turns = 5

Turn Lane NOT Warranted

RIGHT-TURN VOLUME	THROUGH VOLUME PLUS LEFT-TURN VOLUME *					
	350 - 399	400 - 449	450 - 499	500 - 549	550 - 600	+ / > 600
Fewer Than 25 25 - 49 50 - 99		Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
100 - 149 150 - 199	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
200 - 249 250 - 299	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
300 - 349 350 - 399	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
400 - 449 450 - 499	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
500 - 549 550 - 599	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
600 or More	Yes	Yes	Yes	Yes	Yes	Yes

* Or through volume only if a left-turn lane exists.

TABLE 7A

LEFT-TURN LANE VOLUME THRESHOLDS FOR TWO-LANE ROADWAYS WITH A PREVAILING SPEED OF 56 MPH OR OVER

(If the left-turn volume exceeds the table value a left -turn lane is needed)

(535/2) * 1.05 = 281

OPPOSING VOLUME	THROUGH VOLUME PLUS RIGHT-TURN VOLUME *					
	100 - 149	150 - 199	200 - 249	250 - 299	300 - 349	350 - 399
100 - 149	150	75	60	45	35	30
150 - 199	110		55	40	35	30
200 - 249	85		50	35	30	30
250 - 299	70		45	35	30	30
300 - 349	60		40	30	25	25
350 - 399	55		35	30	325	25
400 - 449	50		30	25	20	20
450 - 499	45		30	25	20	20
500 - 549	40		25	20	20	20
550 - 599	40	25	20	20	20	20
600 - 649	35	20	20	20	20	15
650 - 699	35	20	20	20	15	15
700 - 749	30	20	20	15	15	15
750 or More	30	20	15	15	15	15

Ed Shouse Drive at Proposed Historic Middlebrook Driveway

2020 Projected PM Left Turns = 7

Turn Lane NOT Warranted

(1283/2) * 1.05 = 674

OPPOSING VOLUME	THROUGH VOLUME PLUS RIGHT-TURN VOLUME *					
	350 - 399	400 - 449	450 - 499	500 - 549	550 - 599	=/ >600
100 - 149	30	25	25	20	20	20
150 - 199	30	25	25	20	20	20
200 - 249	30	25	25	20	20	15
250 - 299	30	25	25	20	20	15
300 - 349	25	25	20	20	15	15
350 - 399	25	25	20	20	15	15
400 - 449	20	20	20	15	15	15
450 - 499	20	20	20	15	15	15
500 - 549	20	20	15	15	15	15
550 - 599	20	15	15	15	15	15
600 - 649	15	15	15	15	15	15
650 - 699	15	15	15	15	15	15
700 - 749	15	15	15	15	15	15
750 or More	15	15	15	15	15	15

* Or through volume only if a right-turn lane exists.

TABLE 7B

RIGHT-TURN LANE VOLUME THRESHOLDS FOR TWO-LANE ROADWAYS WITH A PREVAILING SPEED OF 56 MPH OR OVER

RIGHT-TURN VOLUME	THROUGH VOLUME PLUS LEFT-TURN VOLUME *					
	< 100	100 - 199	200 - 249	250 - 299	300 - 349	350 - 399
Fewer Than 25 25 - 49 50 - 99						
100 - 149 150 - 199					Yes	Yes Yes
200 - 249 250 - 299			Yes	Yes Yes	Yes Yes	Yes Yes
300 - 349 350 - 399	Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
400 - 449 450 - 499	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
500 - 549 550 - 599	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
600 or More	Yes	Yes	Yes	Yes	Yes	Yes

(1281/2) * 1.05 = 673

RIGHT-TURN VOLUME	THROUGH VOLUME PLUS LEFT-TURN VOLUME					
	350 - 399	400 - 449	450 - 499	500 - 549	550 - 600	+ / > 600
Fewer Than 25 25 - 49 50 - 99			Yes	Yes Yes	Yes Yes	Yes Yes
100 - 149 150 - 199	Yes Yes			Yes Yes	Yes Yes	Yes Yes
200 - 249 250 - 299	Yes Yes			Yes Yes	Yes Yes	Yes Yes
300 - 349 350 - 399	Yes Yes			Yes Yes	Yes Yes	Yes Yes
400 - 449 450 - 499	Yes Yes	Yes	Yes	Yes Yes	Yes Yes	Yes Yes
500 - 549 550 - 599	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
600 or More	Yes	Yes	Yes	Yes	Yes	Yes

Ed Shouse Drive at Proposed Historic Middlebrook Driveway

2020 Projected PM Right Turns = 2

Turn Lane NOT Warranted

* Or through volume only if a left-turn lane exists.

TABLE 7A

LEFT-TURN LANE VOLUME THRESHOLDS FOR TWO-LANE ROADWAYS WITH A PREVAILING SPEED OF 56 MPH OR OVER

(If the left-turn volume exceeds the table value a left -turn lane is needed)

OPPOSING VOLUME	THROUGH VOLUME PLUS RIGHT-TURN VOLUME *					
	100 - 149	150 - 199	200 - 249	250 - 299	300 - 349	350 - 399
100 - 149 150 - 199	150 110	75 65	60 55	45 40	35 35	30 30
200 - 249 250 - 299	85 70	60 55	50 45	35 35	30 30	30 30
300 - 349 350 - 399	60 55	50 45	40 35	30 30	25 325	25 25
400 - 449 450 - 499	50 45	40 35	30 30	25 25	20 20	20 20
500 - 549 550 - 599	40 40	30 25	25 20	20 20	20 20	20 20
600 - 649 650 - 699	35 35	20 20	20 20	20 20	20 15	15 15
700 - 749 750 or More	30 30	20 20	20 15	15 15	15 15	15 15

OPPOSING VOLUME	THROUGH VOLUME PLUS RIGHT-TURN VOLUME *					
	350 - 399	400 - 449	450 - 499	500 - 549	550 - 599	=/ >600
100 - 149 150 - 199	30 30	25 25	25 25	20 20	20 20	20 20
200 - 249 250 - 299	30 30	25 25	25 25	20 20	20 20	15 15
300 - 349 350 - 399	25 25	25 25	20 20	20 20	15 15	15 15
400 - 449 450 - 499	20 20	20 20	15 15	15 15	15 15	15 15
500 - 549 550 - 599	20 20	20 15	15 15	15 15	15 15	15 15
600 - 649 650 - 699	15 15	15 15	15 15	15 15	15 15	15 15
700 - 749 750 or More	15 15	15 15	15 15	15 15	15 15	15 15

(1377/2) * 1.05 = 723

(591/2) * 1.05 = 311

Ed Shouse Drive at Proposed Historic Middlebrook Driveway

2025 Projected AM Left Turns = 48

Turn Lane Warranted

* Or through volume only if a right-turn lane exists.

TABLE 7B

RIGHT-TURN LANE VOLUME THRESHOLDS FOR TWO-LANE ROADWAYS WITH A PREVAILING SPEED OF 56 MPH OR OVER

(579/2) * 1.05 = 304

RIGHT-TURN VOLUME	THROUGH VOLUME PLUS LEFT-TURN VOLUME *					
	< 100	100 - 199	200 - 249	250 - 299	300 - 349	350 - 399
Fewer Than 25 25 - 49 50 - 99						
100 - 149 150 - 199					Yes	Yes Yes
200 - 249 250 - 299				Yes Yes	Yes Yes	Yes Yes
300 - 349 350 - 399	Yes			Yes Yes	Yes Yes	Yes Yes
400 - 449 450 - 499	Yes Yes	Yes	Yes	Yes Yes	Yes Yes	Yes Yes
500 - 549 550 - 599	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
600 or More	Yes	Yes	Yes	Yes	Yes	Yes

Ed Shouse Drive at Proposed Historic Middlebrook Driveway

2025 Projected AM Right Turns = 12

Turn Lane NOT Warranted

RIGHT-TURN VOLUME	THROUGH VOLUME PLUS LEFT-TURN VOLUME *					
	350 - 399	400 - 449	450 - 499	500 - 549	550 - 600	+ / > 600
Fewer Than 25 25 - 49 50 - 99		Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
100 - 149 150 - 199	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
200 - 249 250 - 299	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
300 - 349 350 - 399	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
400 - 449 450 - 499	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
500 - 549 550 - 599	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
600 or More	Yes	Yes	Yes	Yes	Yes	Yes

* Or through volume only if a left-turn lane exists.

TABLE 7A

LEFT-TURN LANE VOLUME THRESHOLDS FOR TWO-LANE ROADWAYS WITH A PREVAILING SPEED OF 56 MPH OR OVER

(If the left-turn volume exceeds the table value a left -turn lane is needed)

(562/2) * 1.05 = 296

OPPOSING VOLUME	THROUGH VOLUME PLUS RIGHT-TURN VOLUME *					
	100 - 149	150 - 199	200 - 249	250 - 299	300 - 349	350 - 399
100 - 149	150	75	60	45	35	30
150 - 199	110	65	55	40	35	30
200 - 249	85	60	50	35	30	30
250 - 299	70	55	45	35	30	30
300 - 349	60	50	40	30	25	25
350 - 399	55	45	35	30	325	25
400 - 449	50	40	30	25	20	20
450 - 499	45	35	30	25	20	20
500 - 549	40	30	25	20	20	20
550 - 599	40	30	20	20	20	20
600 - 649	35	20	20	20	20	15
650 - 699	35	20	20	20	15	15
700 - 749	30	20	20	15	15	15
750 or More	30	20	15	15	15	15

Ed Shouse Drive at Proposed Historic Middlebrook Driveway

2025 Projected PM Left Turns = 18

Turn Lane Warranted

(1349/2) * 1.05 = 709

OPPOSING VOLUME	THROUGH VOLUME PLUS RIGHT-TURN VOLUME *					
	350 - 399	400 - 449	450 - 499	500 - 549	550 - 599	=/ >600
100 - 149	30	25	25	20	20	20
150 - 199	30	25	25	20	20	20
200 - 249	30	25	25	20	20	15
250 - 299	30	25	25	20	20	15
300 - 349	25	25	20	20	15	15
350 - 399	25	25	20	20	15	15
400 - 449	20	20	20	15	15	15
450 - 499	20	20	20	15	15	15
500 - 549	20	20	15	15	15	15
550 - 599	20	15	15	15	15	15
600 - 649	15	15	15	15	15	15
650 - 699	15	15	15	15	15	15
700 - 749	15	15	15	15	15	15
750 or More	15	15	15	15	15	15

* Or through volume only if a right-turn lane exists.

TABLE 7B

RIGHT-TURN LANE VOLUME THRESHOLDS FOR TWO-LANE ROADWAYS WITH A PREVAILING SPEED OF 56 MPH OR OVER

RIGHT-TURN VOLUME	THROUGH VOLUME PLUS LEFT-TURN VOLUME *					
	< 100	100 - 199	200 - 249	250 - 299	300 - 349	350 - 399
Fewer Than 25 25 - 49 50 - 99						
100 - 149 150 - 199					Yes	Yes Yes
200 - 249 250 - 299			Yes	Yes Yes	Yes Yes	Yes Yes
300 - 349 350 - 399	Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
400 - 449 450 - 499	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
500 - 549 550 - 599	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
600 or More	Yes	Yes	Yes	Yes	Yes	Yes

(1344/2) * 1.05 = 706

RIGHT-TURN VOLUME	THROUGH VOLUME PLUS LEFT-TURN VOLUME					
	350 - 399	400 - 449	450 - 499	500 - 549	550 - 600	+ / > 600
Fewer Than 25 25 - 49 50 - 99			Yes	Yes Yes	Yes Yes	Yes Yes
100 - 149 150 - 199	Yes Yes			Yes Yes	Yes Yes	Yes Yes
200 - 249 250 - 299	Yes Yes			Yes Yes	Yes Yes	Yes Yes
300 - 349 350 - 399	Yes Yes			Yes Yes	Yes Yes	Yes Yes
400 - 449 450 - 499	Yes Yes	Yes	Yes	Yes Yes	Yes Yes	Yes Yes
500 - 549 550 - 599	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
600 or More	Yes	Yes	Yes	Yes	Yes	Yes

Ed Shouse Drive at Proposed Historic Middlebrook Driveway

2025 Projected PM Right Turns = 5

Turn Lane NOT Warranted

* Or through volume only if a left-turn lane exists.

APPENDIX J

TRAFFIC SIGNALIZATION WARRANTS

TRAFFIC SIGNAL WARRANTS

PROJECTED FUTURE VOLUMES

	Ed Shouse Drive		Driveway		Ed Shouse Drive		
TIME	SOUTHBOUND		WESTBOUND		NORTHBOUND		
BEGIN	LT	THRU	LT	RT	THRU	RT	
7:00 AM		239			93		Existing Volumes
7:15 AM		301			93		Existing Volumes
7:30 AM		330			137		Existing Volumes
7:45 AM		364			116		Existing Volumes
Sum		1234			439		Sum
Growth		74.04			26.34		Growth Rate of 1.0% for 6 years
7-8 am		1308			465		Existing Volumes in Future
Year 2025	49	1308	4	15	465	12	Volumes in Year 2025
							7-8 am
8:00 AM		336			144		
8:15 AM		269			149		
8:30 AM		252			121		
8:45 AM		232			119		
Sum		1089			533		
Growth		65.34			31.98		
8-9 am		1154			565		
Year 2025	15	1154	1	4	565	4	Volumes in Year 2025
							8-9 am
11:00 AM		107			158		
11:15 AM		129			156		
11:30 AM		138			176		
11:45 AM		129			161		
Sum		503			651		
Growth		30.18			39.06		
11am-12 pm		533			690		
Year 2025	9	533	2	9	690	2	Volumes in Year 2025
							11am-12 pm
12:00 PM		135			195		
12:15 PM		154			163		
12:30 PM		148			172		
12:45 PM		150			145		
Sum		587			675		
Growth		35.22			40.5		
12-1 pm		622			716		
Year 2025	12	622	3	12	716	3	Volumes in Year 2025
							12-1 pm
2:00 PM		136			142		
2:15 PM		150			183		
2:30 PM		139			211		
2:45 PM		143			179		
Sum		568			715		
Growth		34.08			42.9		
2-3 pm		602			758		
Year 2025	6	602	4	17	758	2	Volumes in Year 2025
							2-3 pm
3:00 PM		126			227		
3:15 PM		121			172		
3:30 PM		141			311		
3:45 PM		132			269		
Sum		520			979		
Growth		31.2			58.74		
3-4 pm		551			1038		
Year 2025	8	551	5	21	1038	2	Volumes in Year 2025
							3-4 pm
4:00 PM		139			242		
4:15 PM		125			265		
4:30 PM		127			304		
4:45 PM		133			286		
Sum		524			1097		
Growth		31.44			65.82		
4-5 pm		555			1163		
Year 2025	9	555	6	24	1163	2	Volumes in Year 2025
							4-5 pm
5:00 PM		125			357		
5:15 PM		145			321		
5:30 PM		134			246		
5:45 PM		117			195		
Sum		521			1119		
Growth		31.26			67.14		
5-6 pm		552			1186		
Year 2025	18	552	12	49	1186	5	Volumes in Year 2025
							5-6 pm

Assumed Growth Rate (%)=	1.0%
Number of years =	6
	Year 2025

Note:
The entering and exiting traffic volumes are estimated based on trip generation of the entire development, based on assumed amounts of entering and exiting traffic, assumed percentages of directional traffic, and the assumed percentage of trips based on time of day (from NCHRP Report 365)

Entire Development: 439 Daily Trips Generated

Entering and Exiting Assumptions %'s:		Directional Distribution Assumptions:	
77% Entering	AM Hours	80% from North	20% from South
23% Exiting		20% to South	80% to North
50% Entering	Mid-Day Hours	80% from North	20% from South
50% Exiting		20% to South	80% to North
27% Entering	PM Hours	80% from North	20% from South
73% Exiting		20% to South	80% to North

NCHRP Report 365 - Table 41
Urban Size = 500,000 - 999,999
Knoxville Urban Size (2014) = 857,585

Time of Day	Percentage of Trips	
7-8 am	18.00%	Note: The orginal value shown in the NCHRP Report gives a value of
8-9 am	5.42%	7.52% for the 7-8 am period. However, to match the projected generated
		traffic volumes, this percentage was increased to 18%
11 am-Noon	4.95%	
Noon-1 pm	6.64%	
2-3 pm	6.56%	
3-4 pm	8.28%	
4-5 pm	9.31%	Note: The orginal value shown in the NCHRP Report gives a value of
5-6 pm	19.00%	9.52% for the 5-6 pm period. However, to match the projected generated
	78.16%	traffic volumes, this percentage was increased to 19%

For example, 7-8 AM for WB Left Turns:
Volume = 737 Daily Trips * 25% Exiting * 30% Trips from East * 7.42% Trips (at 7-8 AM)
Volume = 737 x .25 x .3 x .0742
Volume = 4 Trips

This spreadsheet is used to estimate the future project hourly volumes to determine if a intersection will meet traffic signal warrants.

Traffic Signal Warrant Analysis

Project Name	**Historic Middlebrook**
Project/File #	**1904**
Scenario	**2025 - Projected Traffic Volumes**

Intersection Information	
Major Street Name	Ed Shouse Drive
North/South or East/West	N/S
Speed Limit > 40 mph	Yes
# of Approach Lanes	2 or more
% of Right Turn Traffic to Include	100%
Minor Street Name	Driveway
# of Approach Lanes	1
% of Right Turn Traffic to Include	100%
Isolated Community < 10,000 pop	No

Additional Warrants to Consider	
Warrant 3, Peak Hour (A - Volume and Delay)	No
All-Way Stop Warrant	No

Traffic Signal Warrant Analysis

Ed Shouse Drive (Major Street) Volume

Northbound Volume by Hour				
Time	Left Turns	Through	Right Turns	Peds/Bikes
12 - 1 AM				
1 - 2 AM				
2 - 3 AM				
3 - 4 AM				
4 - 5 AM				
5 - 6 AM				
6 - 7 AM				
7 - 8 AM		465	12	
8 - 9 AM		565	4	
9 - 10 AM				
10 - 11 AM				
11 - 12 PM		690	2	
12 - 1 PM		716	3	
1 - 2 PM				
2 - 3 PM		758	2	
3 - 4 PM		1038	2	
4 - 5 PM		1163	2	
5 - 6 PM		1186	5	
6 - 7 PM				
7 - 8 PM				
8 - 9 PM				
9 - 10 PM				
10 - 11 PM				
11 - 12 AM				
Total Vehicles (unadjusted)			6,613	0

Southbound Volume by Hour				
Time	Left Turns	Through	Right Turns	Peds/Bikes
12 - 1 AM				
1 - 2 AM				
2 - 3 AM				
3 - 4 AM				
4 - 5 AM				
5 - 6 AM				
6 - 7 AM				
7 - 8 AM	49	1,308		
8 - 9 AM	15	1154		
9 - 10 AM				
10 - 11 AM				
11 - 12 PM	9	533		
12 - 1 PM	12	622		
1 - 2 PM				
2 - 3 PM	6	602		
3 - 4 PM	8	551		
4 - 5 PM	9	555		
5 - 6 PM	18	552		
6 - 7 PM				
7 - 8 PM				
8 - 9 PM				
9 - 10 PM				
10 - 11 PM				
11 - 12 AM				
Total Vehicles (unadjusted)			6,003	0

Driveway (Minor Street) Volume

Eastbound Volume by Hour				
Time	Left Turns	Through	Right Turns	Peds/Bikes
12 - 1 AM				
1 - 2 AM				
2 - 3 AM				
3 - 4 AM				
4 - 5 AM				
5 - 6 AM				
6 - 7 AM				
7 - 8 AM				
8 - 9 AM				
9 - 10 AM				
10 - 11 AM				
11 - 12 PM				
12 - 1 PM				
1 - 2 PM				
2 - 3 PM				
3 - 4 PM				
4 - 5 PM				
5 - 6 PM				
6 - 7 PM				
7 - 8 PM				
8 - 9 PM				
9 - 10 PM				
10 - 11 PM				
11 - 12 AM				
Total Vehicles (unadjusted)			0	0

Westbound Volume by Hour				
Time	Left Turns	Through	Right Turns	Peds/Bikes
12 - 1 AM				
1 - 2 AM				
2 - 3 AM				
3 - 4 AM				
4 - 5 AM				
5 - 6 AM				
6 - 7 AM				
7 - 8 AM	4		15	
8 - 9 AM	1		4	
9 - 10 AM				
10 - 11 AM				
11 - 12 PM	2		9	
12 - 1 PM	3		12	
1 - 2 PM				
2 - 3 PM	4		17	
3 - 4 PM	5		21	
4 - 5 PM	6		24	
5 - 6 PM	12		49	
6 - 7 PM				
7 - 8 PM				
8 - 9 PM				
9 - 10 PM				
10 - 11 PM				
11 - 12 AM				
Total Vehicles (unadjusted)			188	0

Traffic Signal Warrant Analysis

Warrants 1 - 3 (Volume Warrants)

Project Name	Historic Middlebrook
Project/File #	1904
Scenario	2025 - Projected Traffic Volumes

Intersection Information			
Major Street (N/S Road)	Ed Shouse Drive	Minor Street (E/W Road)	Driveway
Analyzed with	2 or more approach lanes	Analyzed with	1 Approach Lane
Total Approach Volume	12616 vehicles	Total Approach Volume	188 vehicles
Total Ped/Bike Volume	0 crossings	Total Ped/Bike Volume	0 crossings
Right turn reduction of	0 percent applied	Right turn reduction of	0 percent applied

Reduction applied to warrant thresholds due to high speed on Ed Shouse Drive

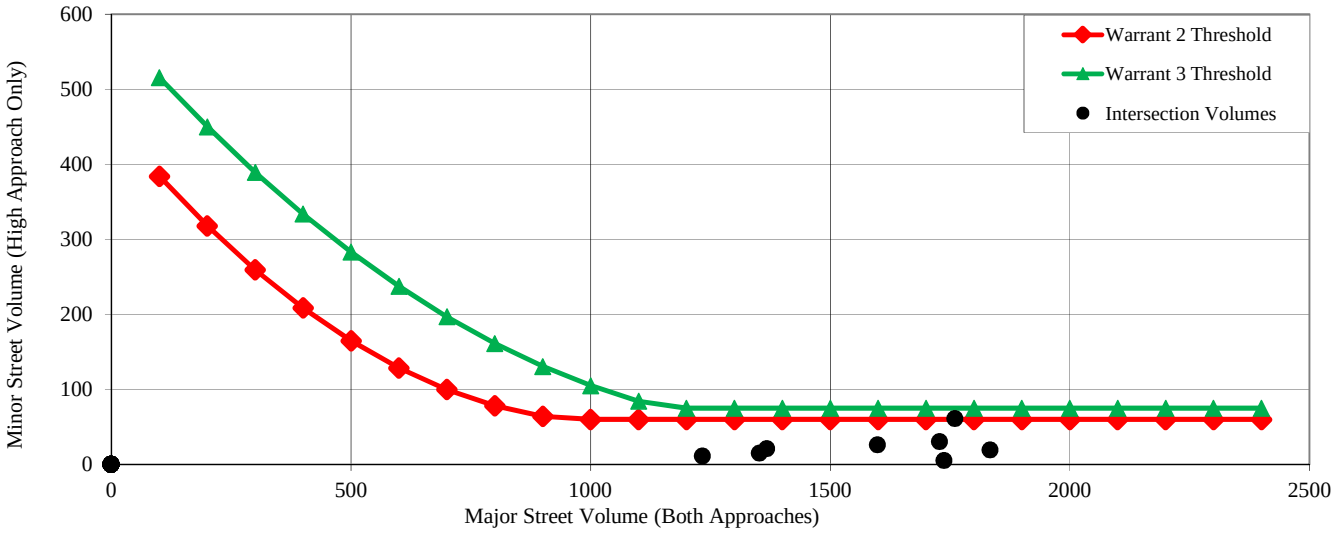
Warrant 1, Eight Hour Vehicular Volume			
	Condition A	**Condition B**	**Condition A+B***
Condition Satisfied?	**Not satisfied**	**Not satisfied**	**Not satisfied**
Required values reached for	0 hours	1 hour	0 (Cond. A) & 1 (Cond. B)
Criteria - Major Street (veh/hr)	420	630	336 (Cond. A) & 504 (Cond. B)
Criteria - Minor Street (veh/hr)	105	53	84 (Cond. A) & 42 (Cond. B)

* Should be applied only after an adequate trail of other alternatives that could cause less delay and inconvenience to traffic has failed to solve the traffic problems.

Warrant 2, Four Hour Vehicular Volume	
Condition Satisfied?	**Not satisfied**
Required values reached for	1 hour
Criteria	See Figure Below

Warrant 3, Peak Hour Vehicular Volume		
	Condition A	**Condition B**
Condition Satisfied?	**Not Examined**	**Not Satisfied**
Required values reached for		0 hours
Criteria - Total Approach Volume (veh in one hour)		See Figure Below
Criteria - Minor Street High Side Volume (veh in one hour)		
Criteria - Minor Street High Side Delay (veh-hrs)		

Figure 4C-2 (Warrant 2 - 70% Factor) & Figure 4C-4 (Warrant 3 - 70% Factor)



APPENDIX K

SIMTRAFFIC QUEUE LENGTH CALCULATIONS

Intersection: 10: Ed Shouse Drive & Historic Middlebrook Driveway

Movement	WB	NB	SB
Directions Served	L	T	L
Maximum Queue (ft)	47	10	95
Average Queue (ft)	4	0	25
95th Queue (ft)	28	7	73
Link Distance (ft)	227	305	
Upstream Blk Time (%)			
Queuing Penalty (veh)			
Storage Bay Dist (ft)			250
Storage Blk Time (%)			
Queuing Penalty (veh)			

Network Summary

Network wide Queuing Penalty: 0

Intersection: 10: Ed Shouse Drive & Historic Middlebrook Driveway

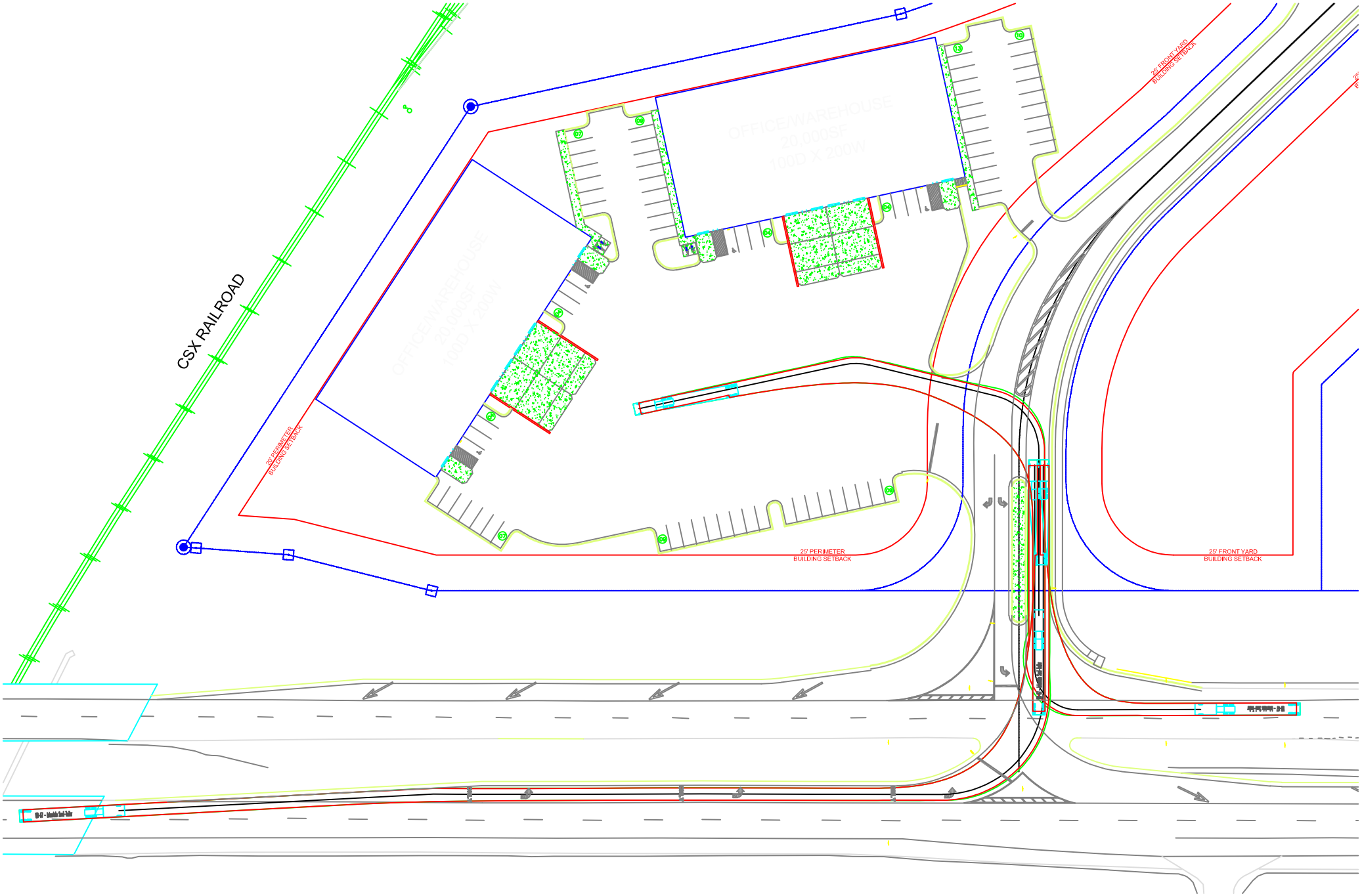
Movement	WB	NB	NB	SB
Directions Served	L	T	TR	L
Maximum Queue (ft)	69	6	2	86
Average Queue (ft)	13	0	0	17
95th Queue (ft)	45	4	2	62
Link Distance (ft)	227	305	305	
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)				250
Storage Blk Time (%)				
Queuing Penalty (veh)				

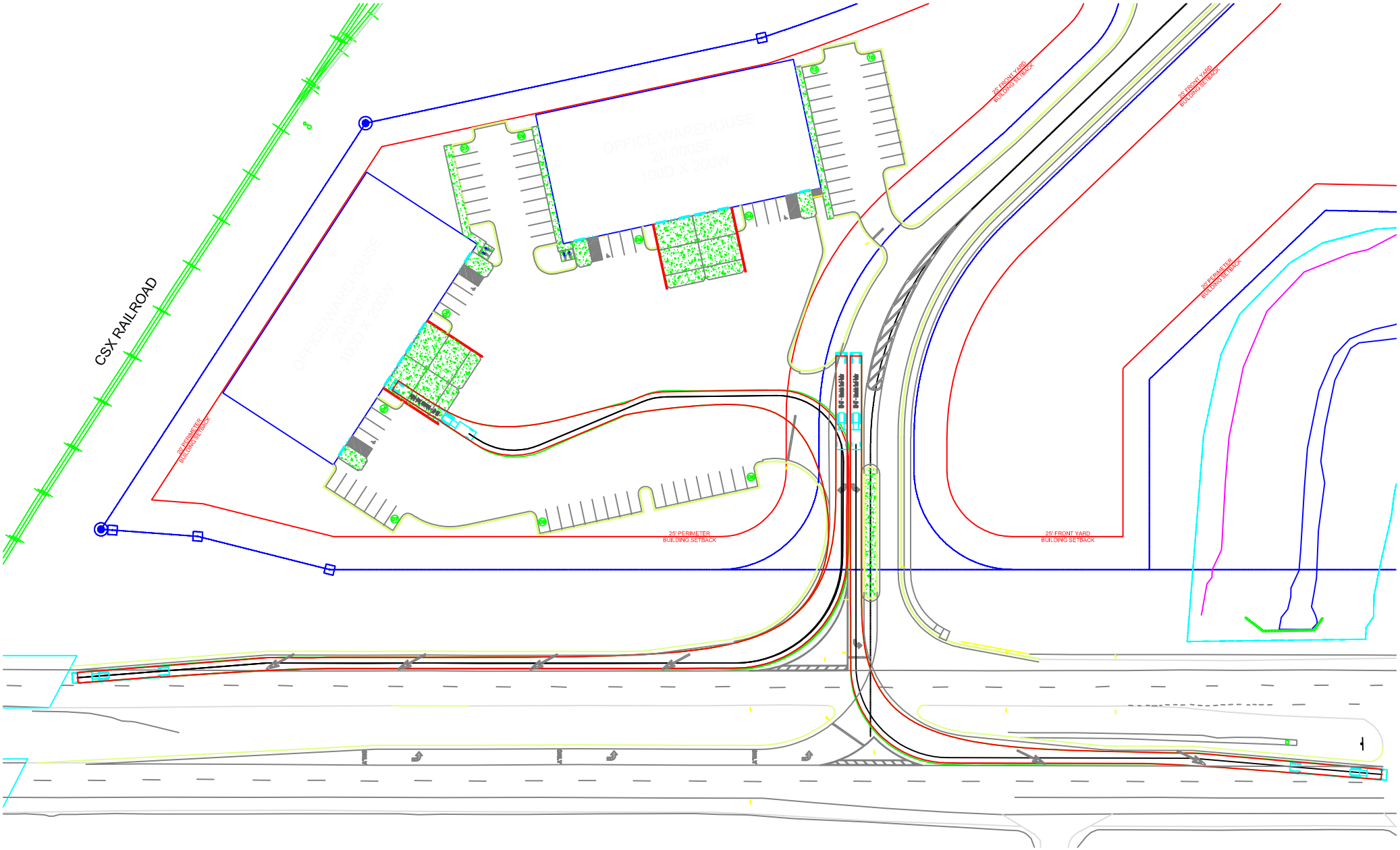
Network Summary

Network wide Queuing Penalty: 0

APPENDIX L

TRUCK TURNING TEMPLATES


CSX RAILROAD
OFFICE/WAREHOUSE
20,000SF
100D X 200W
OFFICE/WAREHOUSE
20,000SF
100D X 200W
25' PERIMETER
BUILDING SETBACK
25' PERIMETER
BUILDING SETBACK
25' FRONT YARD
BUILDING SETBACK
25' FRONT YARD
BUILDING SETBACK


CSX RAILROAD
OFFICE/WAREHOUSE
20,000SF
100D X 200W
OFFICE/WAREHOUSE
20,000SF
100D X 200W
25' PERIMETER
BUILDING SETBACK
25' FRONT YARD
BUILDING SETBACK
25' FRONT YARD
BUILDING SETBACK
25' PERIMETER
BUILDING SETBACK
25' PERIMETER
BUILDING SETBACK
25' FRONT YARD
BUILDING SETBACK

AJAX ENGINEERING
CIVIL ENGINEERING / TRAFFIC ENGINEERING

11812 Black Road
Knoxville, Tennessee 37932
Phone (865) 556-0042
ajaxengineering@gmail.com

April 22, 2019

PROJECT NAME: Historic Middlebrook

TO: Knoxville-Knox County Planning
City of Knoxville Engineering Department

SUBJECT: TIS Comment Response Document for Historic Middlebrook Traffic Impact Study Review (3-SC-19-C) Review Comments dated April 17, 2019

Dear Knoxville-Knox County Planning and City of Knoxville Engineering Department staff:

The following comment response document is submitted to address comments dated April 17, 2019.

1. **Reviewer Comment: Please reorder the pages. The first page of the Executive Summary was before the Table of Contents.**

   Response: The pages have been reordered. The first page of the Executive Summary was moved to its correct position behind the Table of Contents.

2. **Reviewer Comment: On page 17 first paragraph, indicates that a future phase will extend the roadway. It was the understanding of the review team that a driveway or easement would be extended into the property, but not necessarily the public roadway.**

   Response: On page 17 first paragraph, the wording has been changed to state that the initial phase of construction will build a public roadway that will terminate at a cul-de-sac and the future phase will build a private driveway further into the property for access to additional office/warehouse buildings.

3. **<u>Reviewer Comment</u>: On page 38, the report indicates that sight distance could not be evaluated to the north because of the trees. The sight distance needs to be evaluated in order to validate adequate sight distance for this entrance to Ed Shouse.**

<u>Response</u>: A request has been made to the owner for him to employ a registered land surveyor to take intersection sight distance measurements for the proposed intersection on Ed Shouse Drive. Due to the holiday and short turn-around time, these measurements will not be able to be made in time to include in this response letter. A copy of the email that was sent to the owner requesting sight distance measurements is attached to the end of this response letter. The owner is working on this request.

4. **<u>Reviewer Comment</u>: On page 41 second paragraph, please mention that TDOT minimum median spacing is 440 ft, especially considering the new proposed median opening will be 435 ft north of the KUB driveway. Please discuss whether or not this creates a safety issue.**

<u>Response</u>: On page 41 third paragraph, the report stated that the TDOT minimum spacing for a median opening is 440 feet. The median spacing shortfall has been clarified and the discussion has included a statement that this is not expected to create a safety issue.

5. **<u>Reviewer Comment</u>: On page 54, the first bullet indicates a recommended posted speed of 15 mph. The minimum speed limit within the City of Knoxville (by City ordinance) is 25 mph. For internal intersections, the sight distance must meet AASHTO guidelines for a 25 mph road, which it looks like it meets. Please state that requirement and revise the recommendation. Also, change this speed limit on page 56.**

<u>Response</u>: On page 54 the first bullet, the recommended speed limit has been changed to 25-mph and stated that the sight distance for internal intersections must meet AASHTO guidelines for a 25-mph speed limit. This speed limit change has also been made on page 3, page 56, and Figure 9 (page 58).

6. **<u>Reviewer Comment</u>: On page 55 third bullet point, please make sure a turning template is provided in the Appendix for exiting trucks (largest accessing site) making a left-turn & right-turn movement.**

<u>Response</u>: On page 55 third bullet point, a statement has been added that turning templates for entering and exiting trucks is shown in Appendix L.

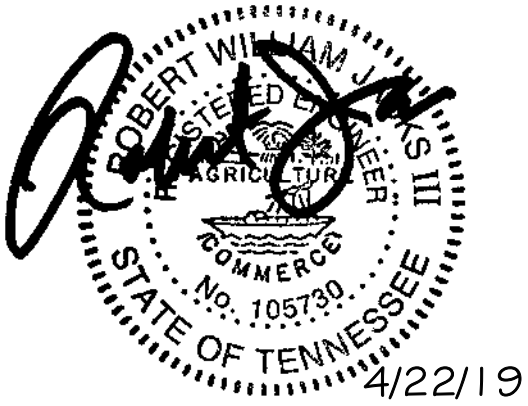
In addition to the requested revisions, other changes in the report include the following:

- Updated Title Page
- Updated Table of Contents
- Updated Page Footers
- Added Appendix L (Truck Turning Templates)

If you have any questions or further comments, please feel free to contact me at any time. I look forward to your review and approval.

Sincerely,

Ajax Engineering, LLC
Robert W. Jacks, P.E.



ajaxengineering@gmail.com

From: ajaxengineering@gmail.com
Sent: Thursday, April 18, 2019 9:51 AM
To: 'David Fiser'
Cc: 'Mark Bialik'
Subject: Request for Surveying - Historic Middlebrook

David,

As part of the Knoxville - Knox County Planning review of the Traffic Impact Study for Historic Middlebrook, they are requesting that a sight distance measurement be made at the proposed intersection at Ed Shouse Drive. Mark told me that you use Cannon & Cannon for your land surveying work. I would like to request that you ask them to perform these sight distance measurements looking from the proposed driveway as requested in the Historic Middlebrook Traffic Impact Study Review (3-SC-19-C) letter. If you have any questions about this request, please let me know. If you could let me know when they will be able to make these measurements and the results of their measurements, I would appreciate it.

Thank you,

Robert

Ajax Engineering, LLC
11812 Black Road
Knoxville, TN 37932
Phone: (865) 556-0042
www.ajaxengineeringllc.com

AJAX ENGINEERING
CIVIL ENGINEERING / TRAFFIC ENGINEERING
11812 Black Road
Knoxville, Tennessee 37932
Phone (865) 556-0042
ajaxengineering@gmail.com

MEMO

TO: Ms. Tarren Barrett, Transportation Engineer
Knoxville-Knox County Planning

FROM: Robert Jacks, PE
Ajax Engineering, LLC

DATE: 5/6/19

SUBJECT: Historic Middlebrook Traffic Impact Study (3-SC-19-C)
Additional Intersection Sight Distance Discussion

In your TIS Comment Response Document for the Historic Middlebrook Traffic Impact Study dated 4/17/19, you requested that the sight distance be evaluated for the proposed entrance at Ed Shouse Drive to ensure that adequate sight distance is available.

In my response letter dated 4/22/19, I stated that a "request has been made to the owner for him to employ a registered land surveyor to take intersection sight distance measurements for the proposed intersection on Ed Shouse Drive. Due to the holiday and short turn-around time, these measurements will not be able to be made in time to include in this response letter."

After sending you the response letter, the owner of the project employed Cannon & Cannon, Inc. to make sight distance measurements at the location of the proposed entrance for Historic Middlebrook on Ed Shouse Drive. The following is directly quoted from an email from Alan Childers, PE with Cannon & Cannon, Inc. and dated 4/29/19:

"-Looking left from the future site driveway – 805 feet was measured at which point some overhanging trees from the side of the road create an obstruction. These trees could be easily cut-back. If they were cut-back to clear the obstruction, the sight distance was measured to be 1487 feet.

-Looking right from the future site driveway – 751 feet was measured until the vertical curve at a bridge block the sight distance. The surveyors were of the opinion that the trees in the median could have some limbs trimmed up from the bottom and the sight distance could be fully cleared."

In addition, a follow up email to Mr. Childers confirmed that the Cannon & Cannon land surveyors made these measurements from the location of the proposed entrance to Historic Middlebrook 15 feet from the edge of roadway with a drivers' height and height of object at 3.5 feet.

Based on this information, and as listed in the original recommendation listed in the traffic impact study, the sight distance for the proposed intersection of Historic Middlebrook at Ed Shouse Drive should be adequate once trees and tree branches are removed.

If you need any further information or clarification, please let me know. Please attach this memo to the revised TIS for Historic Middlebrook for inclusion in the record.

Thank you,

Ajax Engineering, LLC
Robert W. Jacks, P.E.