Magnolia Avenue / Rutledge Pike / Asheville Highway Interchange Study Technical Memorandum #7 ICE Stage I – Scoping Analysis

Knoxville, Knox County, TN

Executive Summary

Three options are proposed for consideration based on this Intersection Control Evaluation (ICE) Stage I Scoping Analysis:

1. Multilane roundabout (worst traffic operations, best safety characteristics, middle cost)
2. Traffic signal (middle traffic operations, worst safety characteristics, lowest cost by a considerable margin)
3. Quadrant roadway (best traffic operations, middle safety characteristics, middle cost, may not fit with the desired context of the surrounding urban neighborhood)

For
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April 27, 2020

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1.0 MAGNOLIA AVENUE / RUTLEDGE PIKE / ASHEVILLE HIGHWAY ICE

The purpose of the *Magnolia Avenue / Rutledge Pike / Asheville Highway Interchange Study* is to examine transportation system improvements that improve mobility and connectivity at this interchange within the Burlington area of East Knoxville. All transportation modes are considered including motor-vehicle, pedestrian, bicycle, and transit. The goal of the study is to propose an improvement option that complements and connects the surrounding urban neighborhood. The existing interchange of Magnolia Avenue (State Route 1, SR 1), Asheville Highway (SR 168) and Rutledge Pike (SR 1) is out of context with its urban surroundings. It bisects the Burlington neighborhood, making it difficult for both motorists and pedestrians to cross between the south and north sides of Magnolia Avenue (SR 1) / Asheville Highway (SR 168). The existing interchange does not provide a direct connection from Rutledge Pike (SR 1) southbound (from I-40) towards Asheville Highway (SR 168) eastbound. Figure 1 provides a location map on aerial photography of the study area.

Intersection Control Evaluation (ICE) methodology was used to determine viable traffic control improvement options for the existing Magnolia Avenue (SR 1) / Rutledge Pike (SR 1) / Asheville Highway (SR 168) Interchange. ICE is a data-driven, performance-based framework and approach used to objectively screen options and identify an optimal geometric and control solution for an intersection.

There are dozens of conventional and innovative intersection types and variations proven to work in the United States. With so many choices, it is important to use a consistent process to assess what options best meet project need and purpose. Utilizing ICE policies and procedures to evaluate and select the geometry and control for an intersection offers many potential benefits to road agencies and the traveling public, including:

- Implementation of safer, more balanced and more cost-effective solutions.
- Consistent documentation that improves the transparency of transportation decisions.
- Increased awareness of innovative intersection solutions and emphasis on objective performance metrics for consistent comparisons.
- The opportunity to consolidate and streamline existing intersection-related policies and procedures, including access or encroachment approvals, new traffic signal requests, and impact studies for development.

A growing number of transportation agencies are developing and adopting ICE policies. TDOT does not currently have an ICE policy but is developing one. Although there are differences among these ICE policies, they are consistent in emphasizing transparency, flexibility, and adaptability.

The ICE process is typically conducted in two stages:

- A "Stage I – Scoping" step to determine the short list of all possible options that merit further consideration and analysis because they meet project needs and are practical to pursue.
- A "Stage II – Alternative Selection" step to determine the preferred option based on more detailed evaluations conducted during typical preliminary engineering activities.

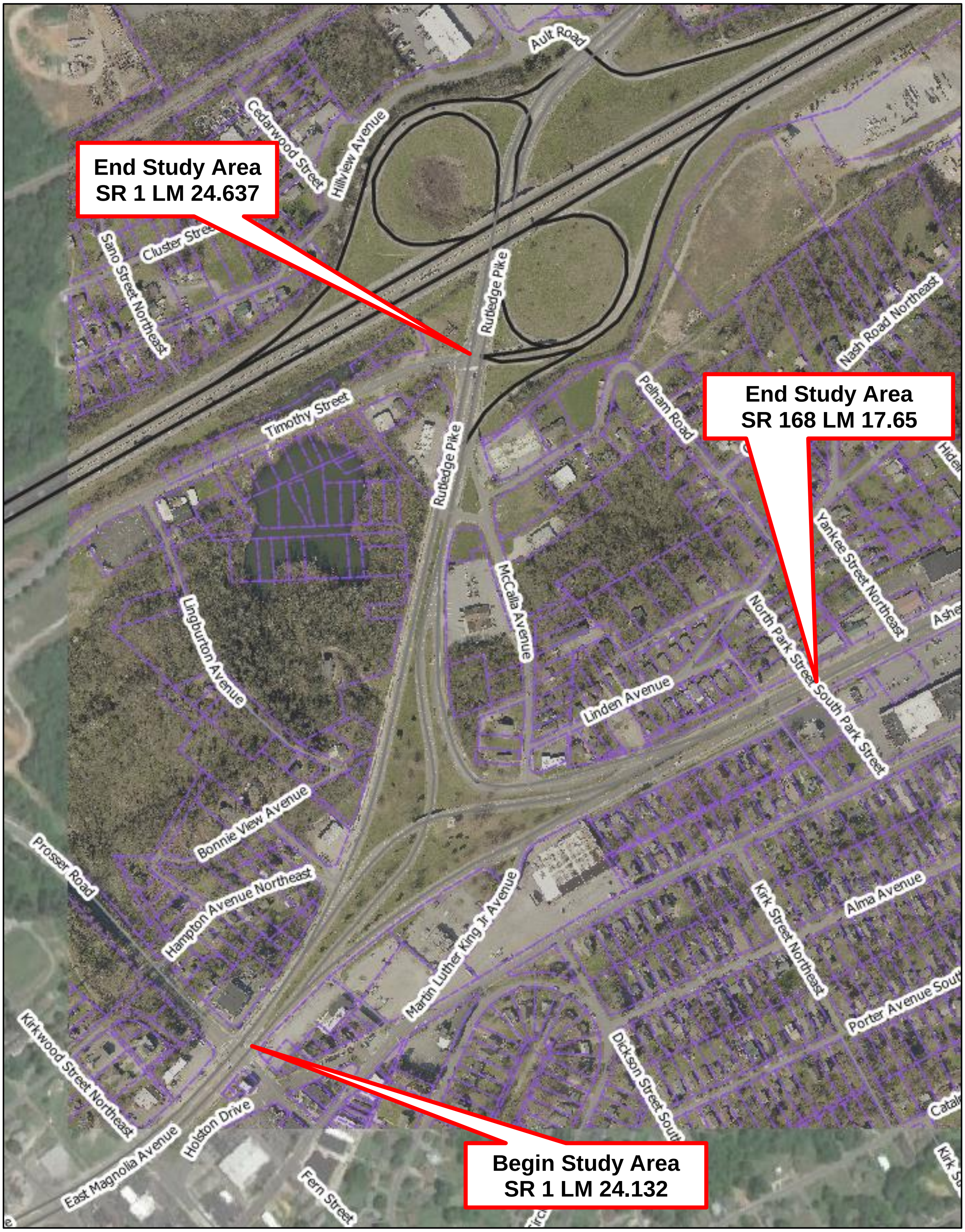

FIGURE 1: LOCATION MAP WITH AERIAL IMAGERY

This memorandum provides an ICE Stage I Scoping Analysis for the *Magnolia Avenue / Rutledge Pike / Asheville Highway Interchange Study*. Table 1 summarizes all intersection / interchange control options considered. Based on past public engagement activities, the following are criteria that should be met in a transportation system improvement (listed in no particular order):

1. Improve access, or do not exclude future improved access, into the Burlington commercial district. This eliminates options that do not allow for a fourth leg into the Burlington district to be incorporated into the preferred option.
2. Provide a more direct connection from Rutledge Pike (SR 1) southbound to Asheville Highway (SR 168) eastbound. Motorists must currently either make a U-turn at Prosser Road or cut through a residential neighborhood along McCalla Avenue, Linden Avenue, and Park Street to make this traffic movement.
3. Support local business activities. This eliminates options that require long segments of full access control or options that would require the acquisition of large amounts of right-of-way.
4. Support multimodal transportation options including transit, walking, and biking. This eliminates options that would require large footprints, eliminate pedestrian crossing opportunities, or promote high vehicular speeds. This eliminates interchange options.
5. The transportation improvement should fit the context of the urban neighborhood. This eliminates options that do not support dense development patterns and a walkable community.

As seen in Table 1, three options are proposed for consideration based on this Stage I Scoping Analysis:

1. Multilane roundabout
2. Traffic signal
3. Quadrant roadway

2.0 CAP-X TRAFFIC ANALYSIS

These three options plus a two-way stop option were carried forward into the Federal Highway Administration's (FHWA's) Capacity Analysis for Planning of Junctions (CAP-X) traffic screening tool. The CAP-X Tool was developed to provide practitioners with a means of evaluating the anticipated operational performance of innovative intersection control strategies within a single tool. The CAP-X Tool uses a critical lane volume analysis to determine the volume to capacity ratio (v/c) for a variety of intersection control strategies and also provides an assessment of the pedestrian and bicycle accommodations for the selected intersection types. A v/c less than 1 means an option is viable and a candidate for ICE Stage II Alternative Selection Analysis. The Stage II analysis will include a more detailed traffic and geometric design analysis.

Based on the input parameters, the CAP-X tool is able to generate a list of intersection types, ranked by v/c and given a multimodal score based on pedestrian and bicycle accommodations. Practitioners can choose to directly use turning volumes as input into the spreadsheet or grow the volumes based on a user specified volume growth percentage. For this *Magnolia Avenue / Rutledge Pike / Asheville Highway Interchange Study* Design Year 2045 AM and PM traffic volumes were utilized so that an option that functions through the design year is selected. The CAP-X output results are summarized in Table 2 and Table 3.

TABLE 1: STAGE I ICE SELECTION

ID #	44321.00
Project Location:	Magnolia @ Rutledge
Existing Control:	New Intersection or Other
Prepared by:	JHS
Date:	3/11/2020

Note: Up to 5 alternatives may be selected and evaluated; Use this ICE Stage 1 to screen 5 or fewer alternatives to evaluate in Stage 2

Answer "Yes" or "No" to each policy question for each control type to identify which alternatives should be evaluated in the Stage 2 Decision Record; enter justification in the rightmost column

	Intersection Alternative (see "Intersections" tab for detailed description of intersection/interchange type)	1. Does alternative address the project need in a balanced manner and in scale with the project?	2. Does alternative improve safety performance in terms of reducing severe crashes?	3. Does alternative incorporate safety, convenience and accessibility for pedestrians and/or bicyclists?	4. Does alternative improve (or preserve) traffic operations (congestion, delay, reliability, etc.)?	5. Does alternative appear feasible given the site characteristics, constrains & location context?	6. Does alternative appear feasible with respect to other project factors?	7. Overall feasible alternative (select alternative for further evaluation in Stage 2)?	**Screening Decision Justification:**
Unsignalized Intersections	Conventional (Minor Stop)	Yes	Yes	Yes	No	Yes	Yes	No	Traffic volumes too heavy.
	Conventional (All-Way Stop)	Yes	Yes	Yes	No	No	No	No	No stop signs on 4-lane highway.
	Mini Roundabout	No	Yes	Yes	No	No	No	No	
	Single Lane Roundabout	No	Yes	Yes	No	No	No	No	4-lane highways.
	Multilane Roundabout	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
	RCUT (stop control)	No	Yes	Yes	Yes	No	No	No	Community wants full movements.
	RIRO w/down stream U-Turn	No	No	No	No	No	No	No	Median too narow.
	High-T (unsignalized)	No	No	No	No	No	No	No	Does not apply.
	Offset-T Intersections	No	No	No	No	No	No	No	Does not apply.
	Diamond Interch (Stop Control)	No	No	No	No	No	No	No	Does not apply.
	Diamond Interch (RAB Control)	No	No	No	No	No	No	No	Does not apply.
	No LT Lane Improvements No RT Lane Improvements	No	No	No	No	No	No	No	Does not apply.
	Other unsignalized (provide description):	No	No	No	No	No	No	No	Does not apply.
Signalized Intersections	Traffic Signal	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
	Median U-Turn (Indirect Left)	No	No	No	No	No	No	No	Median too narrow.
	RCUT (signalized)	No	No	No	No	No	No	No	Community wants full movements.
	Displaced Left Turn (CFI)	No	No	No	No	No	No	No	Access to properties prohibits.
	Continuous Green-T	No	No	No	No	No	No	No	Community wants 4th leg to Burlington.
	Jughandle	No	No	No	No	No	No	No	ROW not available on south side.
	Quadrant Roadway	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NW quadrant should be investigated. ROW Prohibits other quadrants.
	Diamond Interch (Signal Control)	No	No	No	No	No	No	No	No interchange.
	Diverging Diamond	No	No	No	No	No	No	No	No interchange.
	Single Point Interchange	No	No	No	No	No	No	No	No interchange.
	No LT Lane Improvements No RT Lane Improvements	No	No	No	No	No	No	No	Does not apply.
	Other Signalized (provide description):	No	No	No	No	No	No	No	Does not apply.

☐ = Intersection type selected for more detailed analysis in Stage 2 Alternative Selection Decision Record

TABLE 2: FHWA CAP-X STAGE I SCREENING 2045 AM

Capacity Analysis for Planning of Junctions

Dynamic Results Summary

TYPE OF INTERSECTION	Overall V/C Ratio	V/C Ranking	Pedestrian Accommodations	Bicycle Accommodations
Quadrant Roadway N-W	0.42	1	Good	Good
2 X 2 Roundabout	0.46	2	Good	Good
3 X 3 Roundabout	0.46	2	Fair	Good
Traffic Signal	0.48	4	Good	Fair
Two-Way Stop Control E-W	4.17	5	Fair	Fair
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Use the "yes/no" drop-down menus in Step 2 (Base and Alt Selection) to exclude intersection types from summary rankings, if they are not applicable.

Note: Projected traffic data inputs are described in Technical Memorandum #4, Traffic Data and Projection Summary (approved by TDOT on March 25, 2020).

TABLE 3: FHWA CAP-X STAGE I SCREENING 2045 PM

Capacity Analysis for Planning of Junctions

Dynamic Results Summary

TYPE OF INTERSECTION	Overall V/C Ratio	V/C Ranking	Pedestrian Accommodations	Bicycle Accommodations
Quadrant Roadway N-W	0.46	1	Good	Good
3 X 3 Roundabout	0.48	2	Fair	Good
Traffic Signal	0.48	3	Good	Fair
2 X 2 Roundabout	0.48	4	Good	Good
Two-Way Stop Control E-W	6.66	5	Fair	Fair
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Use the "yes/no" drop-down menus in Step 2 (Base and Alt Selection) to exclude intersection types from summary rankings, if they are not applicable.

Note: Projected traffic data inputs are described in Technical Memorandum #4, Traffic Data and Projection Summary (approved by TDOT on March 25, 2020).

For additional data points, the options were also carried forward into the Virginia Department of Transportation's Junction Screening Tool (VJuST). This tool helps to identify innovative intersection and interchange configurations that have the potential for reducing congestion and improving safety. Congestion results are based on user inputs such as turning movement volumes, number of lanes and lane configurations, while safety results are based on conflict points. Results from the tool are not meant to replicate results obtained from more detailed traffic operations, safety and design analyses.

This tool is most applicable at isolated intersections or interchanges and does not account for the influence of adjacent intersections on traffic patterns; however, the results may be indicative of how an intersection or interchange within a corridor might operate. This tool was used in the *Magnolia Avenue / Rutledge Pike / Asheville Highway Interchange Study* as a supplement to CAP-X and because the Tennessee Department of Transportation does not have a similar tool.

One benefit of VJust over CAP-X is the inclusion of a Stage I safety ranking, based upon conflict points for each intersection option. A second benefit of VJuST is it also quantifies pedestrian accommodation. It reflects the potential to accommodate pedestrians by taking into consideration the relative impact of safety, wayfinding and delay. It is a qualitative metric not dependent on vehicular volumes, pedestrian volumes, or number of lanes and is relative to conventional intersections. It is therefore limited in its results and should be understood as only applicable as an initial screening tool. The VJuST output results are summarized in Table 4 and Table 5.

TABLE 4: VDOT STAGE I SCREENING 2045 AM

VDOT Junction Screening Tool

Results Worksheet

General Information	
Project Title:	Magnolia Avenue
EW Facility:	Magnolia Avenue / Asheville Hwy.
NS Facility:	Rutledge Pike / New Connector
Date:	April 9, 2020

Volumes (veh/hr)	U-Turn / Left	Through	Right
Eastbound	260	243	10
Westbound	26	430	153
Northbound	36	43	42
Southbound	65	65	393

General Instructions: All intersection and interchange configurations have a default assumption of one exclusive lane per movement. No results shall be interpreted until the user has verified the lane configurations on each worksheet.

Intersection Results

		Congestion	Pedestrian	Safety	Notes
Type	**Dir**	**Maximum V/C**	**Accommodation Compared to Conventional**	**Weighted Total Conflict Points**	
Conventional	-	0.50		48	
Quadrant Roadway	N-W	0.46		40	
Roundabout	-	0.47		8	
Two-Way Stop Control	-	1.13		48	

Information

Congestion	The maximum v/c ratio represents the worst v/c of all zones that make up an intersection.
Pedestrian	Compares the potential of each design to accommodate pedestrians based on safety, wayfinding, and delay. Potential is qualitatively defined as better (+), similar (blank cell), or worse (-) than a conventional intersection or traditional diamond interchange.
Safety	Weighted Total = (2 x Crossing Conflicts) + Merging Conflicts + Diverging Conflicts

Note: Projected traffic data inputs are described in Technical Memorandum #4, Traffic Data and Projection Summary (approved by TDOT on March 25, 2020).

TABLE 5: VDOT STAGE I SCREENING 2045 PM

VDOT Junction Screening Tool

Results Worksheet

General Information	
Project Title:	Magnolia Avenue
EW Facility:	Magnolia Avenue / Asheville Hwy.
NS Facility:	Rutledge Pike / New Connector
Date:	April 9, 2020

Volumes (veh/hr)	U-Turn / Left	Through	Right
Eastbound	497	525	9
Westbound	47	450	170
Northbound	18	26	157
Southbound	36	117	224

General Instructions: All intersection and interchange configurations have a default assumption of one exclusive lane per movement. No results shall be interpreted until the user has verified the lane configurations on each worksheet.

Intersection Results

		Congestion	Pedestrian	Safety	Notes
Type	Dir	Maximum V/C	Accommodation Compared to Conventional	Weighted Total Conflict Points	
Conventional	-	0.52		48	
Quadrant Roadway	N-W	0.51		40	
Roundabout	-	0.68		8	
Two-Way Stop Control	-	N/A*		48	

Information

Congestion	The maximum v/c ratio represents the worst v/c of all zones that make up an intersection.
Pedestrian	Compares the potential of each design to accommodate pedestrians based on safety, wayfinding, and delay. Potential is qualitatively defined as better (+), similar (blank cell), or worse (-) than a conventional intersection or traditional diamond interchange.
Safety	Weighted Total = (2 x Crossing Conflicts) + Merging Conflicts + Diverging Conflicts

Note: Projected traffic data inputs are described in Technical Memorandum #4, Traffic Data and Projection Summary (approved by TDOT on March 25, 2020).

3.0 SUMMARY

Table 6 summarizes the ICE Stage I – Scoping Analysis results. The quadrant roadway, traffic signal, and roundabout options are all viable options to carry forward to an ICE Stage II – Alternative Selection Analysis. Brief discussions of each option follow.

TABLE 6: ICE STAGE I SCOPING RESULTS

Option	2045 AM				2045 PM				2045	
	CAP-X		VJuST		CAP-X		VJuST		Average	Average
	v/c	Rank	v/c	Rank	v/c	Rank	v/c	Rank	v/c	Rank
Quadrant Roadway	0.42	1	0.46	1	0.46	1	0.51	1	0.46	1
Traffic Signal	0.48	3	0.5	3	0.48	2	0.52	2	0.50	2
Roundabout	0.46	2	0.47	2	0.48	2	0.68	3	0.52	3
Two-Way Stop	4.17	4	1.13	4	6.66	4	n/a	4	3.99	4

<u>Quadrant Roadway</u>

A quadrant roadway is:

- Intersection design with one main intersection and two secondary intersections that are linked by a connector road in any quadrant of the intersection
- Left-turn vehicles from all four legs of the main intersection use the secondary intersections and connector road, instead of the main intersection, to complete left-turn movements
- Secondary intersections are typically signalized
- When all three intersections are signalized, traffic signals are timed to operate together

Quadrant roadways improve efficiency by minimizing the signal phases at subject intersections. They improve safety by reducing conflict points. Of the three viable options to carry forward to an ICE Stage II Alternative Selection Analysis, a quadrant roadway is expected to have the best traffic operations, 2nd best safety characteristics and 2nd highest cost. However, it would have a large footprint that would require considerable right-of-way. A double-left turn lane would be expected from Magnolia Avenue (SR 1) eastbound onto the quadrant roadway and from the quadrant roadway onto Rutledge Pike (SR 1) northbound. The quadrant roadway would have a 25-mph design speed (maximum) and would introduce three new signalized intersections to the network. Figure 2 provides a single-line sketch of a quadrant roadway.

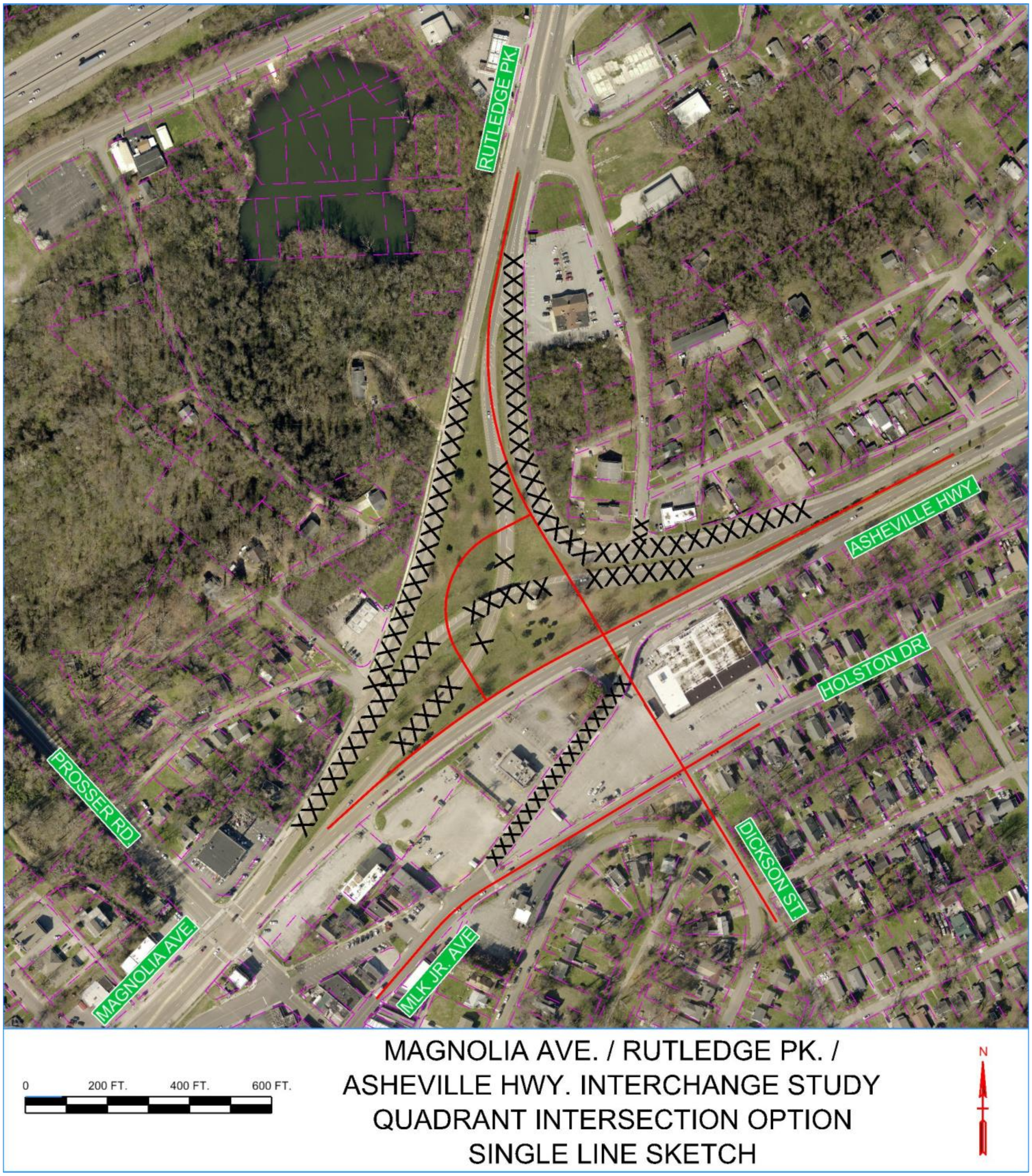

FIGURE 2: QUADRANT ROADWAY SINGLE-LINE SKETCH

Traffic Signal

A traffic signal would construct a standard intersection under signal control. Of the three viable options to carry forward to an ICE Stage II Alternative Selection Analysis, a signalized intersection is expected to have the 2nd best traffic operations, worst safety characteristics and lowest cost (by a considerable margin). It would have the smallest footprint. It would introduce one new traffic signal to the network. A double-left turn lane would be expected from Magnolia Avenue (SR 1) eastbound onto Rutledge Pike (SR 1). Figure 3 Provides a single-line sketch of a signalized intersection's geometry.

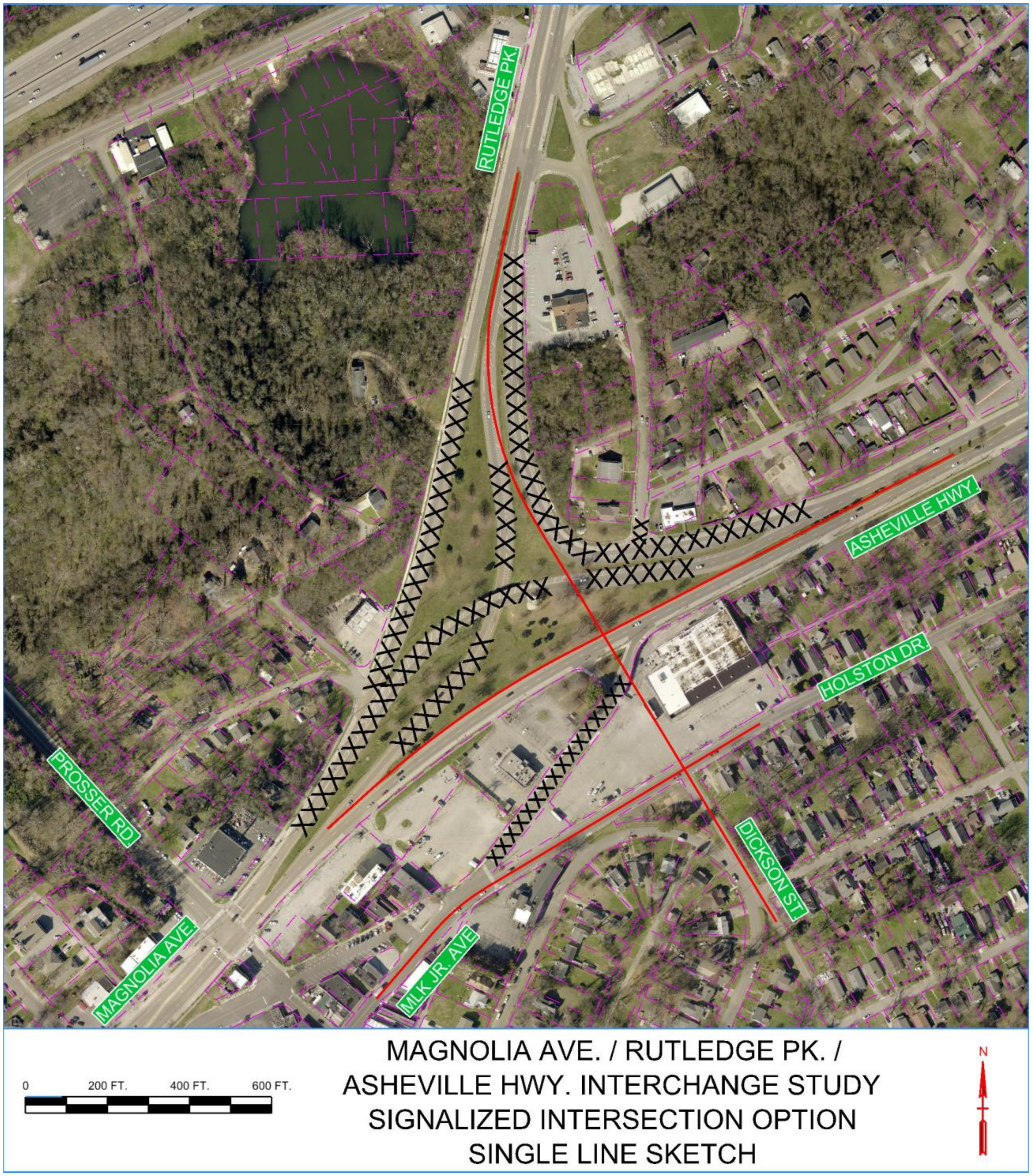

FIGURE 3: TRAFFIC SIGNAL SINGLE-LINE SKETCH

Roundabout

A roundabout is:

- A circular, unsignalized intersection where all traffic moves counterclockwise around a central island
- Traffic entering the roundabout slows down and yields to traffic already inside the roundabout
- Roundabouts can be designed with one or more circulating lanes
- Design options allow for right turns to be channelized to bypass the circulating lanes

Of the three viable options to carry forward to an ICE Stage II Alternative Selection Analysis, a roundabout is expected to have the 3rd best traffic operations, best safety characteristics and highest cost. However, since a multi-lane roundabout would be required, it would have a relatively large footprint. VJuST predicts a multilane roundabout would have similar pedestrian characteristics as a traditional signalized intersection. However, experience demonstrates that multilane roundabouts at high traffic-volume intersections can pose challenges for pedestrians to cross, especially those with visual disabilities. The roundabout's circulatory roadway design could be complex with three entry legs that have multiple approach lanes and one entry leg with a single approach lane. Figure 4 provides a single-line sketch of a roundabout.

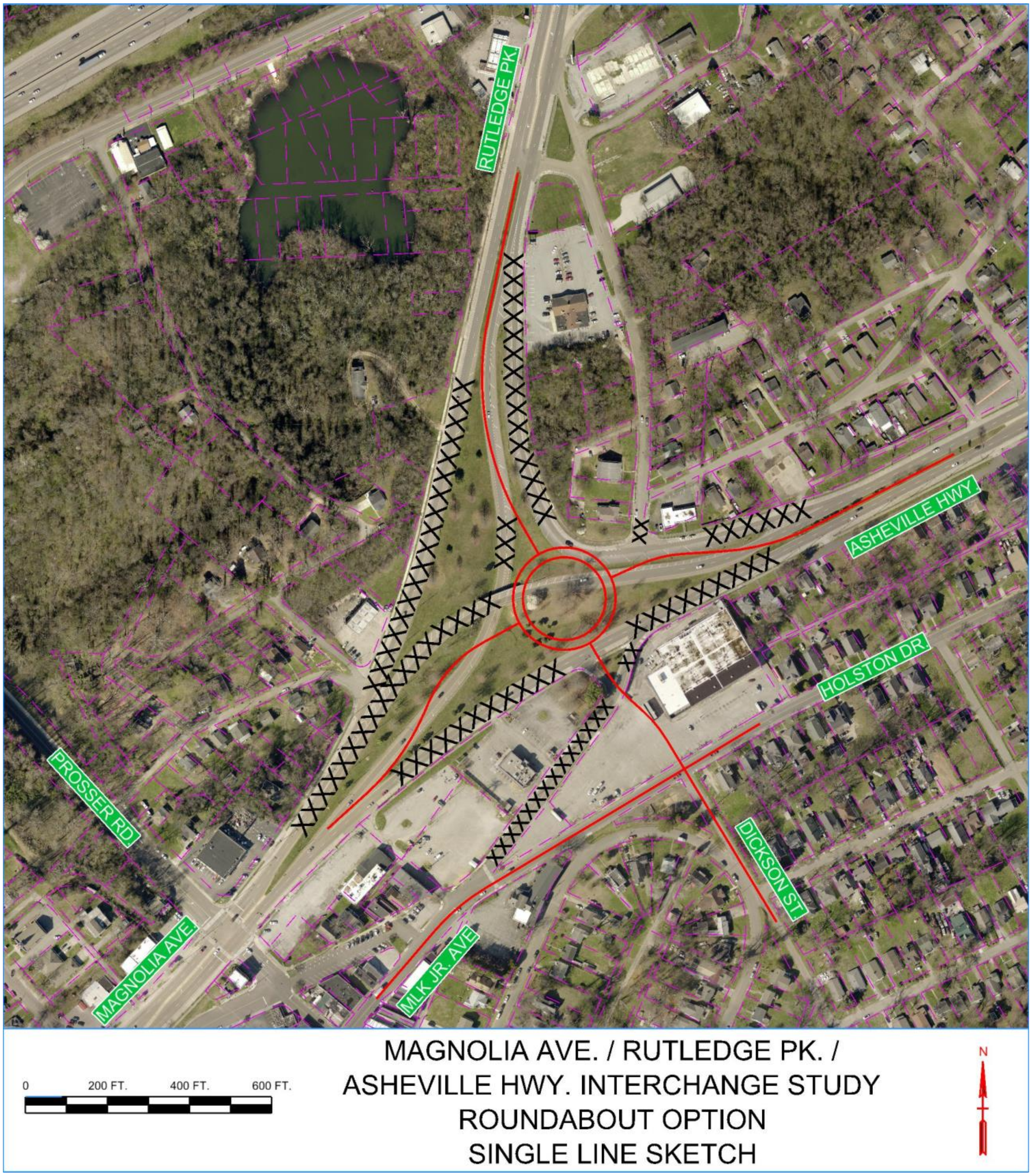

FIGURE 4: ROUNDABOUT SINGLE-LINE SKETCH

3.1 NEXT STEP

The next step is to determine, in coordination with the City of Knoxville, the option(s) to carry forward to an ICE Stage II – Alternative Selection Analysis, which will include more detailed traffic analysis and conceptual design of options.