

US 1 and Ten-Ten Road Interchange Study

Apex, NC

Prepared for Capital Area Metropolitan Planning Organization
c/o Alex Rickard
The Professional Building, Suite 800
127 West Hargett Street
Raleigh, NC 27601



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Transportation | Land Development | Environmental

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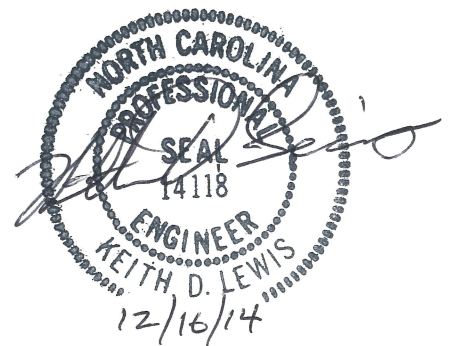


Table of Contents

1.0	Introduction	1
1.1	Study Area	1
2.0	Existing Conditions.....	3
2.1	Existing Roadway and Traffic Conditions.....	3
2.1.1	Existing Roadways.....	3
2.1.2	Existing Traffic.....	3
2.1.3	Base Year (2014) No-Build Capacity Analysis.....	6
2.2	Environmental Features	8
2.3	Accident Evaluation.....	8
3.0	Traffic Forecast.....	11
4.0	Development of Alternatives	12
4.1	Design Year (2040) No-Build.....	16
4.1.1	Design Year (2040) No-Build Planned Roadway Improvements.....	16
4.1.2	Design Year (2040) No-Build Capacity Analysis	16
4.2	CAMPO Metropolitan Transportation Plan Improvements.....	20
4.3	Build Alternative 1 - Improve Existing.....	20
4.3.1	Design Year (2040) Build Alternative 1 – Improve Existing Roadway Improvements	20
4.3.2	Design Year (2040) Build Alternative 1 – Improve Existing Capacity Analysis	21
4.4	Build Alternative 2 - Roundabouts	21
4.4.1	Design Year (2040) Build Alternative 2 – Roundabouts Roadway Improvements	21
4.4.2	Design Year (2040) Build Alternative 2 – Roundabouts Capacity Analysis.....	25
4.5	Build Alternative 3 – Modified Ramps	25
4.5.1	Design Year (2040) Build Alternative 3 – Modified Ramps Roadway Improvements.....	25
4.5.2	Design Year (2040) Build Alternative 3 – Modified Ramps Capacity Analysis	29
5.0	Opinion of Probable Construction Cost	33
6.0	Alternatives Evaluation and Recommendations.....	34
6.1	Impacts of Alternatives	34
6.2	Conclusions and Recommendations	36

Figures

Figure 1-1	Project Study Area	2
Figure 2-1	Base Year (2014) No-Build AM and PM Peak Hour Turning Movement Volumes.....	4
Figure 2-2	Base Year (2014) No-Build Lane Configurations and Traffic Control.....	5
Figure 2-3	Environmental Screening	9
Figure 4-1	Modified DDI Concept	13
Figure 4-2	Proposed Typical Section	14
Figure 4-3	Design Year (2040) No-Build AM and PM Peak Hour Turning Movement Volumes	17
Figure 4-4	Design Year (2040) No-Build Lane Configurations and Traffic Control.....	18
Figure 4-5	Design Year (2040) Build Alternative 1 – Improve Existing Lane Configurations and Traffic Control	22
Figure 4-6	Design Year (2040) Build Alternative 1 – Improve Existing AM and PM Peak Hour Turning Movement Volumes.....	24
Figure 4-7	Design Year (2040) Build Alternative 2 – Roundabouts Lane Configurations and Traffic Control	26
Figure 4-8	Design Year (2040) Build Alternative 2 – Roundabouts AM and PM Peak Hour Turning Movement Volumes.....	28
Figure 4-9	Design Year (2040) Build Alternative 3 – Modified Ramps Lane Configurations and Traffic Control	30
Figure 4-10	Design Year (2040) Build Alternative 3 – Modified Ramps AM and PM Peak Hour Turning Movement Volumes.....	32

Tables

Table 2-1	Level of Service Descriptions for Intersections	6
Table 2-2	Base Year (2014) No-Build Intersection LOS Results	7
Table 2-3	Base Year (2014) No-Build Freeway Ramp LOS Results	7
Table 4-1	Design Year (2040) No-Build Intersection LOS Results	17
Table 4-2	Design Year (2040) No-Build Freeway Ramp LOS Results.....	19
Table 4-3	Design Year (2040) Build Alternative 1 – Improve Existing Intersection LOS Results	23
Table 4-4	Design Year (2040) Build Alternative 1 – Improve Existing Freeway Ramp LOS Results.....	23
Table 4-5	Design Year (2040) Build Alternative 2 – Roundabouts LOS Results	26
Table 4-6	Design Year (2040) Build Alternative 2 – Roundabouts Freeway Ramp LOS Results	27
Table 4-7	Design Year (2040) Build Alternative 3 – Modified Ramps LOS Results.....	31
Table 4-8	Design Year (2040) Build Alternative 3 – Modified Ramps Freeway Ramp LOS Results.....	31
Table 5-1	Opinion of Probable Construction Cost.....	33
Table 6-1	Alternatives Major Impact Comparison	35

Appendices

Appendix A: Conceptual Designs

1.0 INTRODUCTION

Center Street/Ten-Ten Road (SR 1010) is an important arterial facility southwest of Raleigh that connects multiple Raleigh suburbs including Apex, Holly Springs and Garner. Its intersection with US 1 serves as a key interchange along the US 1 corridor as it provides access to residential, commercial, industrial and institutional land uses.

The Capital Area Metropolitan Planning Organization (CAMPO) recognizes the significance of the interchange as well as the existing capacity deficiencies at the ramp intersections and understands the need to plan for improvements at this location. This study examines the existing conditions at this important interchange and evaluates multiple future improvement scenarios.

1.1 STUDY AREA

The scope of the study area for this project includes approximately 3,000 feet along Center Street /Ten-Ten Road as it crosses US 1, including the following intersections:

- Center Street and US 1 Southbound Ramps/ Waterford Green Drive
- Ten-Ten Road and US 1 Northbound Ramps/ Lufkin Road
- Ten-Ten Road and Reliance Avenue

It is expected that some minor right-of-way acquisitions may be required to accommodate the potential improvements; however, the majority of improvement would occur within the existing interchange footprint. The study area, as shown in Figure 1-1, extends to include an area large enough for all potential improvement solutions and includes the interchange ramp lengths.

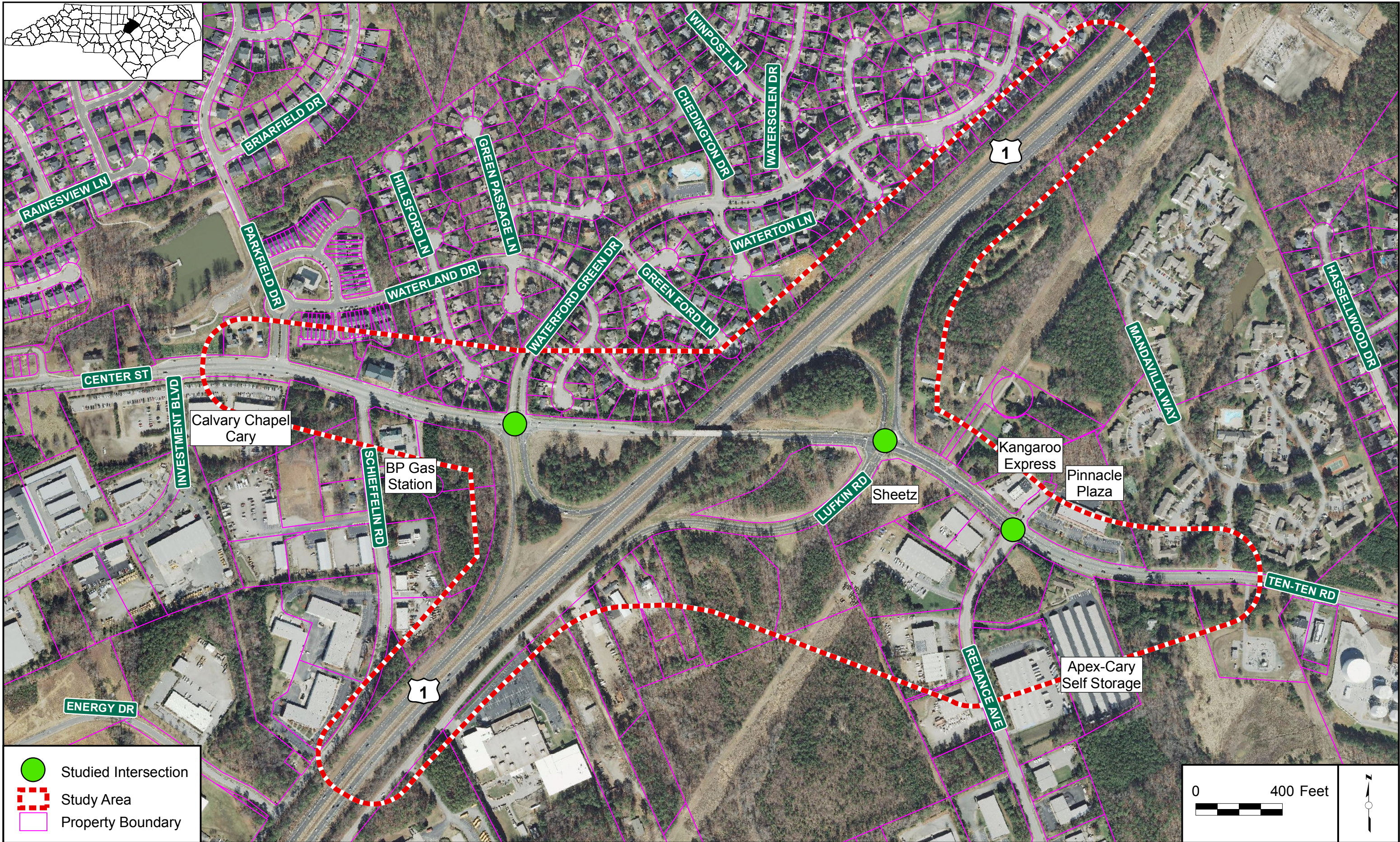


Figure 1-1
Project Study Area

Data Sources: NCDOT; NC One Map; Wake County; Aerial imagery digitization by VHB

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2.0 EXISTING CONDITIONS

2.1 EXISTING ROADWAY AND TRAFFIC CONDITIONS

2.1.1 Existing Roadways

Center Street /Ten-Ten Road (SR 1010) is classified by NCDOT as a Minor Arterial. It provides connectivity to multiple Raleigh suburbs including Apex, Holly Springs and Garner. This roadway is primarily a three-lane roadway in the study area with exclusive turn lanes at intersections, except across the bridge, where it maintains a two-lane typical section as it crosses US 1.

US 1 is classified by NCDOT as a freeway and currently has a four-lane divided typical section. US 1 is a north-south highway along the eastern coastline, stretching from Florida to Maine. Locally, this facility provides access into Raleigh for the suburbs previously mentioned and further south.

2.1.2 Existing Traffic

Traffic turning movement counts were collected at the study area intersection for use in the existing traffic capacity analysis.

According to current NCDOT AADT maps, the 2013 daily volumes vary within the study area; west of the interchange along Ten-Ten Road has a daily volume of 19,000 vehicles per day (vpd) while east of the interchange has a daily volume of 36,000 vpd. Volumes along US 1 vary from 46,000 vpd south of the interchange to 57,000 vpd north of the interchange.

The Base Year (2014) No-Build scenario represents existing roadway conditions present at the time of a field visit in June 2014 and accounts for base year volumes. The volumes used in this analysis scenario were derived from intersection turning movement counts taken in June 2014 and balanced through the network. Figures 2-1 and 2-2 summarize the volumes and lane geometrics, respectively, used in the capacity operations analysis.

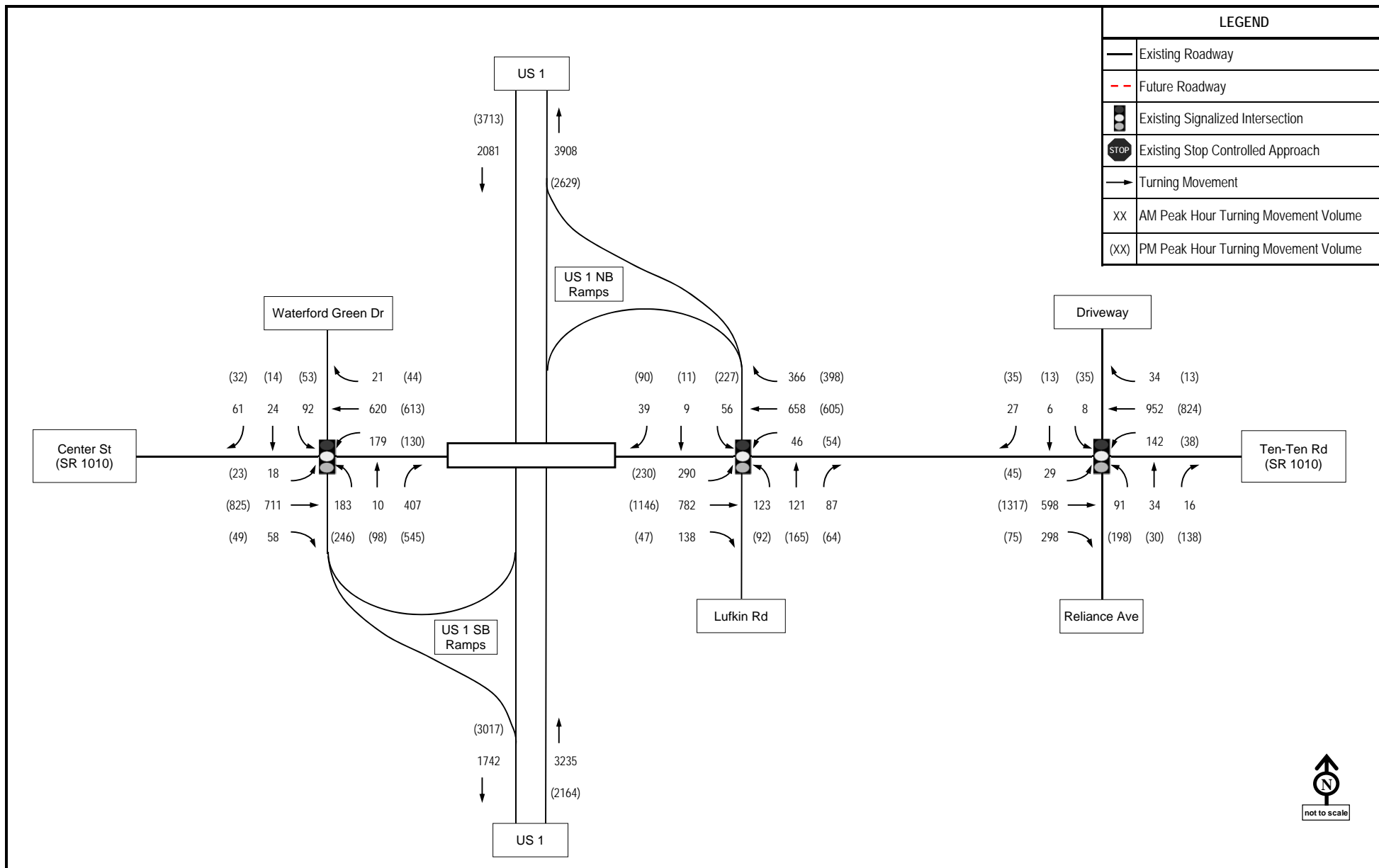


Figure 2-1
Base Year (2014) No-Build AM and PM Peak Hour Turning Movement Volumes

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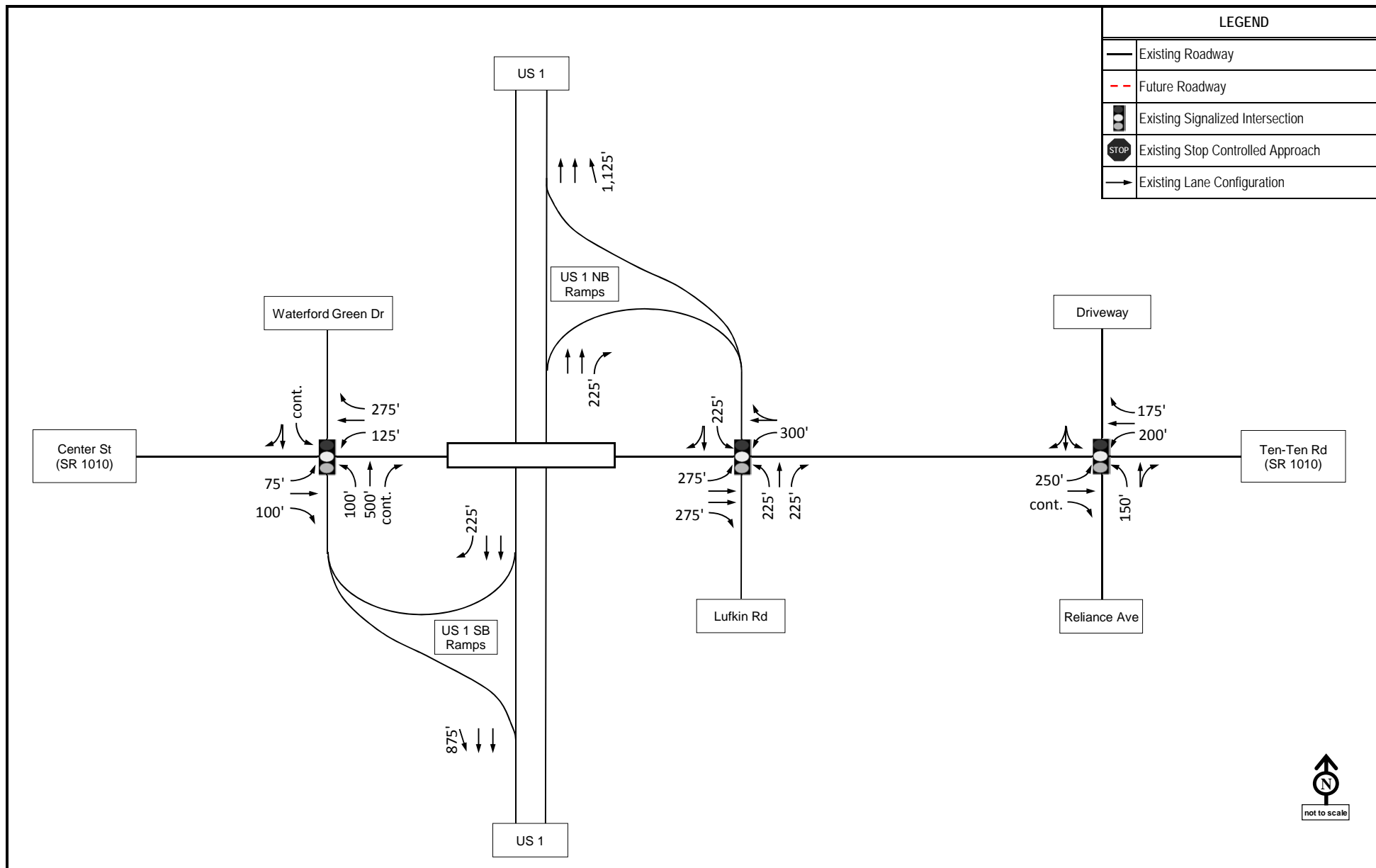


Figure 2-2
Base Year (2014) No-Build Lane Configurations and Traffic Control

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2.1.3 Base Year (2014) No-Build Capacity Analysis

A capacity analysis was performed for the Base Year (2014) No-Build scenario, examining operations at the study intersections. Intersection capacity analyses were conducted for the AM and PM peak hours. Levels of service range from A through F, based on the average control delay experienced by vehicles traveling through the intersection during the peak hour. Control delay represents the portion of total delay attributed to traffic control devices (e.g., signals or stop signs). Table 2-1 provides a general description of the various levels of service categories and delay ranges for the intersection levels of service.

Table 2-1 Level of Service Descriptions for Intersections

Level of Service	Description	Signalized Intersection	Unsignalized Intersection
A	Little or no delay	<= 10 sec.	<= 10 sec.
B	Short traffic delay	10-20 sec.	10-15 sec.
C	Average traffic delay	20-35 sec.	15-25 sec.
D	Long traffic delay	35-55 sec.	25-35 sec.
E	Very long traffic delay	55-80 sec.	35-50 sec.
F	Unacceptable delay	> 80 sec.	> 50 sec.

Intersection capacity analysis was completed using the *Synchro, Version 7* software package, within which signal timings were optimized. Analyzed intersections included the interchange intersections along Center Street/Ten-Ten Road as well as the adjacent Reliance Avenue intersection. The following intersections were analyzed for AM and PM peak hour operations, where applicable.

- Center Street and US 1 Southbound Ramps/ Waterford Green Drive
- Ten-Ten Road and US 1 Northbound Ramps/ Lufkin Road
- Ten-Ten Road and Reliance Avenue

Based on the results of the intersection capacity analysis, two of the three intersections operate acceptably overall under the Base Year (2014) No-Build conditions; however, every intersection has at least one approach operating below LOS D during both of the peak hours. The Ten-Ten Road and US 1 Northbound Ramps/Lufkin Road intersection operates at LOS E during both peak hours under exiting conditions. The Center Street at US 1 Southbound/Waterford Green Drive and Ten-Ten Road at Reliance Avenue signals both operate at LOS D during the PM peak hour indicating that those locations, while currently operating acceptably, are approaching their operational capacity limits. Most of the freeway ramp junctions currently operate at acceptable

levels of service; however, analysis indicates that the US 1 Southbound exit loop (diverge) operates at LOS E during the PM peak hour and anecdotal data supports this reported deficiency. Table 2-2 summarizes the intersection LOS results for the Base Year (2014) No-Build scenario and Table 2-3 summarizes the freeway ramp LOS results for this scenario.

Table 2-2
Base Year (2014) No-Build Intersection LOS Results

Intersection and Approach	Base Year (2014) No-Build	
	AM Peak	PM Peak
Center Street and US 1 Southbound Ramps/Waterford Green Drive	C (34.3 sec)	D (49.9 sec)
Eastbound	C	D
Westbound	A	B
Northbound	E	F
Southbound	E	D
Ten-Ten Road and US 1 Northbound Ramps/Lufkin Road	E (58.7 sec)	E (71.4 sec)
Eastbound	C	D
Westbound	E	F
Northbound	F	F
Southbound	E	F
Ten-Ten Road and Reliance Avenue	B (12.8 sec)	D (42.8 sec)
Eastbound	F	F
Westbound	E	E
Northbound	A	B
Southbound	A	D

Table 2-3
Base Year (2014) No-Build Freeway Ramp LOS Results

Ramp Direction	Junction Type	Base Year (2014) No-Build	
		AM Peak	PM Peak
US 1 Southbound Ramps	Diverge	C	E
	Merge	B	C
US 1 Northbound Ramps	Diverge	D	C
	Merge	D	C

2.2 ENVIRONMENTAL FEATURES

An environmental screening was completed for the project study area utilizing existing GIS resources. This screening analysis indicated very few areas of possible environmental concern, due to the developed character of the area. These data were obtained from a variety of sources including the GIS sources listed below:

- Wake County GIS
- NC Center for Geographic Information and Analysis – NC One Map Geospatial Portal
- NC Department of Cultural Resources – State Historic Preservation Office (NCSHPO)
- NCDOT GIS Unit
- NC Natural Heritage Program (NHP)
- NC Wildlife Resources Commission (WRC)
- US Fish and Wildlife Services (FWS)

As shown in Figure 2-3, there are very few environmental concerns within the study area. There are no USGS designated blue line stream crossings within the study area. The hydrologic features shown include all hydrology mapped by Wake County including pipes and ditches, and do not necessarily represent jurisdictional features that would be subject to mitigation or buffer rules. Additionally, there are no local or nationally recognized historic resources in the project vicinity nor are there any community facilities such as parks, schools, or churches that would be impacted by improvements to this interchange. There are a number of underground storage tanks (USTs) associated with multiple gas stations along the project frontage; however, none of these locations is denoted as leaking or of other notable concern.

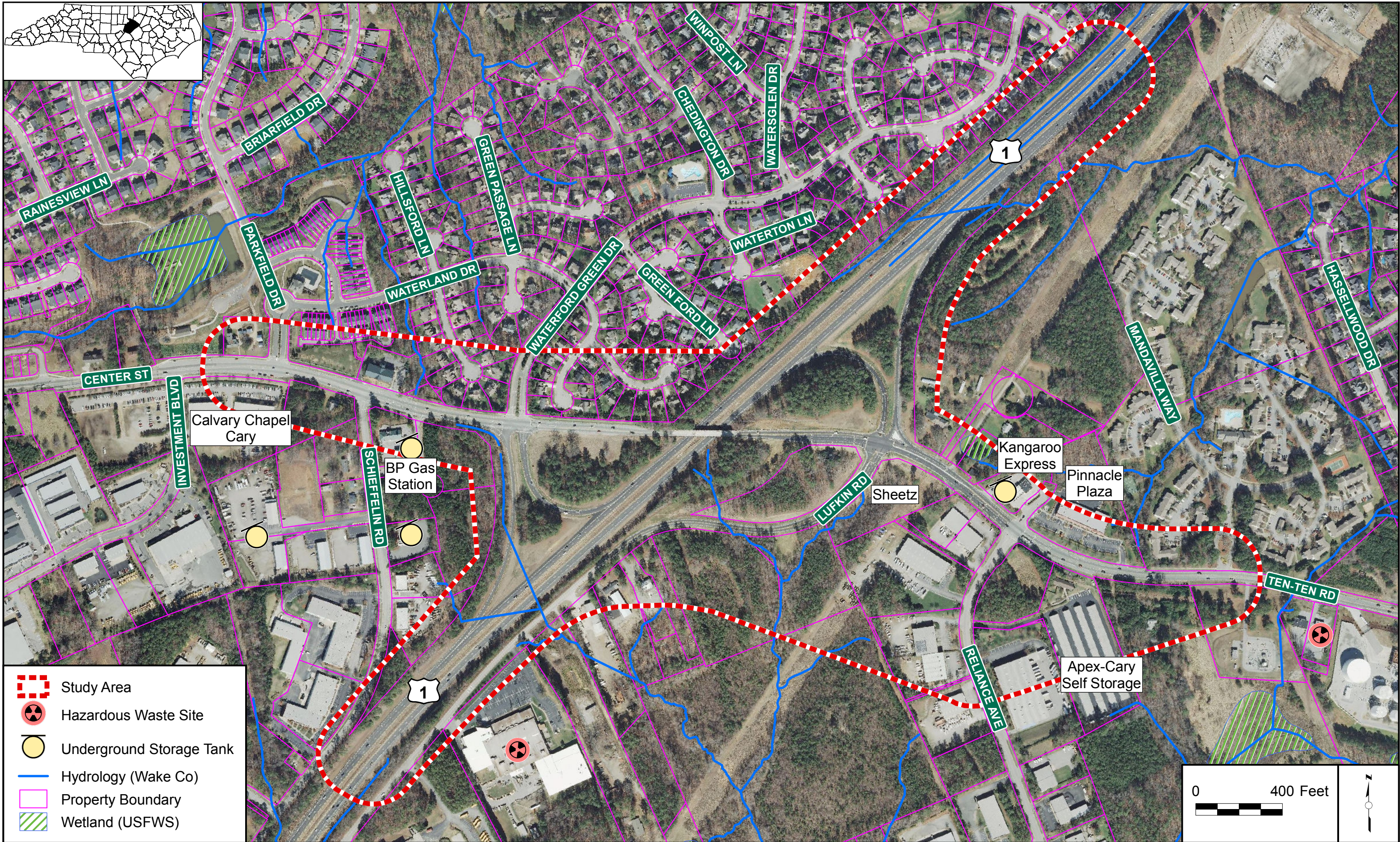
2.3 ACCIDENT EVALUATION

The accident analysis was derived from five years of collision data obtained from the NCDOT Safety Planning Group. The data covered the period from May 1, 2009 to April 30, 2014.

The study intersections were evaluated for crash trends. A crash was considered to occur “at” an intersection if it happened within 150 feet of the intersection. The main types of collisions in the study area were rear-end and left-turn collisions, which are often indicators of general congestion. A summary of trends at each study intersection is below.

Center Street and US 1 Southbound Ramps/Waterford Green Drive

During the five-years of evaluated data, this intersection had a reported 27 crashes. The primary crash type was rear end (18), followed by angle collisions (3). There were no fatalities



**Figure 2-3
Environmental Screening**

Data Sources: NCDOT; NC One Map; Wake County; Aerial imagery digitization by VHB

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reported at this intersection. The high number of rear ends suggest congestion at this intersection as rear ends often occur as cars are braking for a traffic signal.

Ten-Ten Road and US 1 Northbound Ramps/Lufkin Road

During the five-years of evaluated data, this intersection had a reported 25 crashes. The primary crash type was left-turn (8), followed by angle collisions (7) and rear ends (5). There were no fatalities reported at this intersection. The high number of left-turn and angle collisions suggest that drivers may be making unsafe turns or progressions through yellow lights to avoid waiting through another cycle of the traffic signal.

It should be noted that the recently realigned Lufkin Road was offset to the west of this intersection during most of the evaluation time period. The offset Lufkin Road intersection had a reported 13 collisions, with left-turn (4) and rear end (4) being the most prevalent.

Ten-Ten Road and Reliance Avenue

During the five-years of evaluated data, this intersection had a reported 14 crashes. The primary crash type was rear end (6), followed by angle collisions (2) and left-turns (2). There were no fatalities reported at this intersection. As with the US 1 Southbound Ramps intersection, the trend of rear end and left-turn collisions indicates general congestion.

3.0 TRAFFIC FORECAST

The traffic volumes utilized in the existing traffic capacity analysis were derived from intersection turning movement counts taken at the study area intersections in June 2014. Volumes were compared with other recent counts taken in the area and balanced through the network accordingly.

The latest adopted Triangle Regional Model (Version 5.0) was used to project future growth using standard NCDOT Transportation Planning Branch procedures. The average forecasted growth for roadway links within the study area ranged between 1.5% and 2.5% per year. The projected individual growth rates were applied along the Ten-Ten Road corridor and at side streets. Traffic volumes were appropriately balanced between the closely spaced intersections.

The planned improvements at the Center Street and US 1 Southbound Ramps/Waterford Green Drive intersection were incorporated into all of the design year scenarios. The planned widening of Center Street/Ten-Ten Road to a four-lane divided facility and widening of US 1 to a six lane facility were incorporated into the future Build scenarios. In addition, volumes were redirected as necessary to reflect changes in access or to the interchange ramp configurations.

4.0 DEVELOPMENT OF ALTERNATIVES

A number of improvement concepts were considered in the early stages of this project, including conventional widening, a modified diverging diamond concept, roundabout intersections, and many others that would result in substantial impacts to the surrounding residences and businesses. Potential improvements were narrowed to three feasible alternatives that were carried forward for evaluation of traffic operations and environmental impacts.

Modified Diverging Diamond Interchange (DDI)

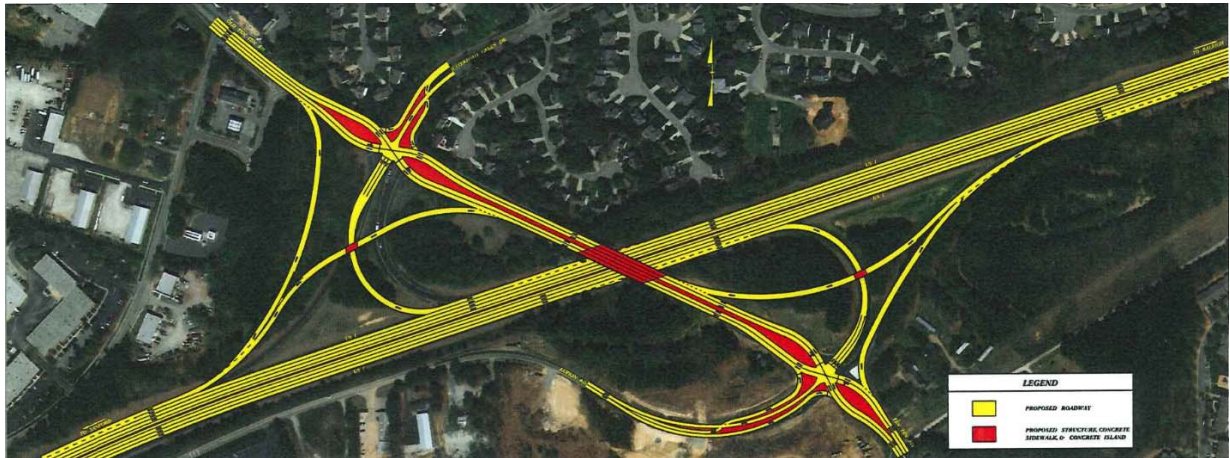
Early in the brainstorming process for improvement concepts, a diverging diamond interchange was considered as an improvement that could be retrofitted into the existing interchange footprint, utilizing the existing bridge over US 1. This innovative interchange concept works best if one of the left-turning movements is high or if the through movements are unbalanced during peak travel periods.

For this location, a modified DDI was considered, however, it was deemed to be not feasible due to poor operations. As shown in Figure 4-1, the typical DDI configuration would be modified to allow for access into and out of existing streets across from the interchange ramps. With a diverging diamond interchange, the movements onto the mainline from the ramps can typically be accommodated via simple yield control, keeping the signal at two-phase operations. Under the current loop configuration, vehicles exiting US 1 would be located on the opposite side of the mainline, requiring both mainline directions to fully stop for the left and right-turns onto Center Street/Ten-Ten Road. The introduction of an inefficient third phase results in poor operations, even with additional widening. The option also has the disadvantage of reduced levels of access to Lufkin Road and Waterford Green Drive, as well as the addition of grade-separated flyovers that would increase project costs relative to the other considered configurations. Given the numerous drawbacks to this concept, it was not carried forward for further study.

Constraints to Alternative Development

There are a several new and planned developments along the frontage of the proposed project that were taken into consideration when developing improvement alternatives. CAMPO and the Town of Apex recognize the importance of supporting these commercial developments and minimizing impact to them. A new Sheetz gas station was recently constructed in the south quadrant of the interchange following the realignment of Lufkin Road. There are also plans to refresh the Kangaroo gas station development on the north side of Ten-Ten Road as well as preliminary plans for a Sonic restaurant along Ten-Ten Road.

Figure 4-1 Modified DDI Concept



**Concept sketch provided by CAMPO 6/11/14*

Additionally, Reliance Avenue provides access into a light industrial park with Motiva Enterprises, a fuel refinery located just east along Ten-Ten Road from the interchange. It was important to consider the accommodation of large trucks and future expansion of these industrial land uses within the context of any potential improvement alternatives.

Typical Section

The proposed typical section for the Center Street/Ten-Ten Road corridor includes a four-lane divided facility; the proposed typical section includes a 16-foot median separating the directions of travel. However, for most of the project length, there is a four-foot concrete island and a 12-foot left-turn lane constituting the median. Each travel direction would have a 12-foot inner lane and a wider, 14-foot outer lane which would accommodate bike traffic. The segment would have 2'-6" curb and gutter along the outside lanes and a 10-foot berm. On one side, a five-foot sidewalk offset from the travel lanes by a three-foot buffer is proposed to accommodate pedestrian demand. This typical section is shown in Figure 4-2.

Design Year Alternatives

This study analyzed various design year scenarios. These scenarios are based on multiple design alternatives and present traffic projections for each condition, as described below. While the Design Year (2040) No-Build scenario does not include the widening projects of Ten-Ten Road/Center Street to a four-lane divided facility and the widening of US 1 to a six lane freeway, the Design Year (2040) Build scenarios assume that those widening projects are in place. It is understood that the developed build alternatives and associated evaluations will be used in the planning process for the widening efforts and incorporated into those projects in the future.

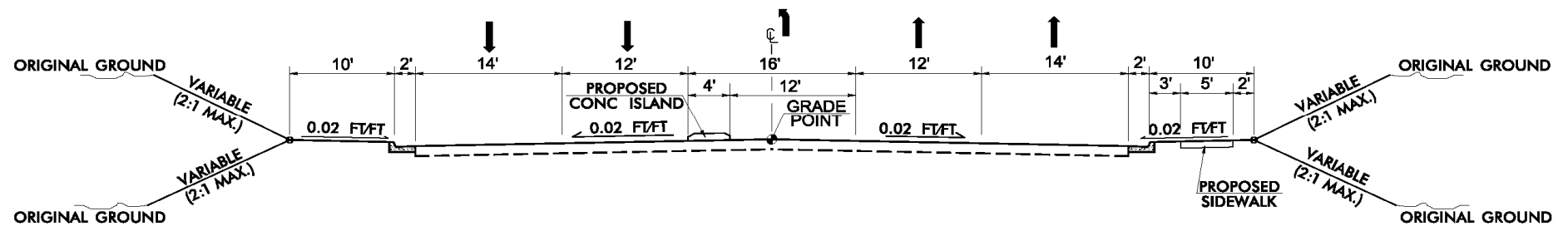
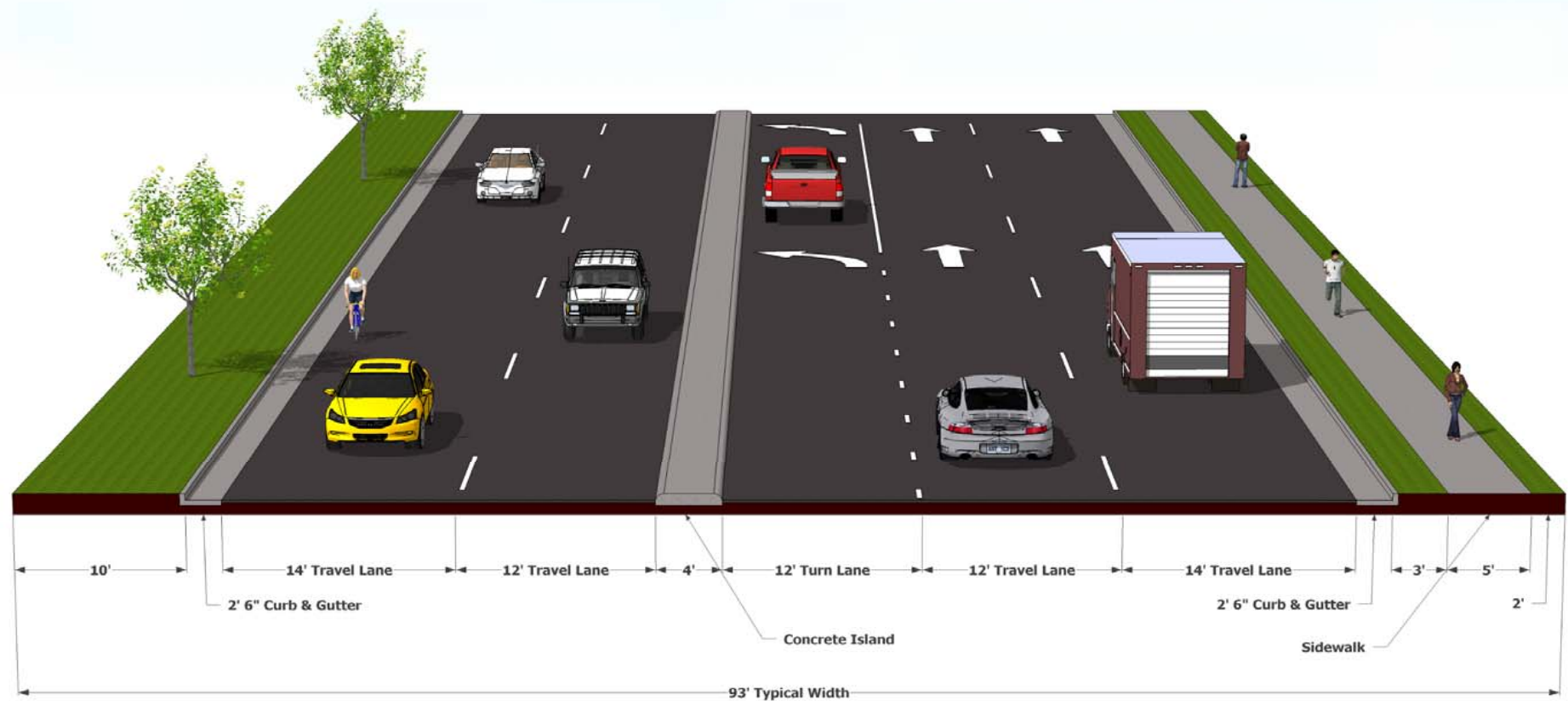


Figure 4-2
Proposed Typical Section - Ten-Ten Road

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- **Design Year (2040) – No-Build:** This scenario projects the traffic conditions at the study interchange including volumes accounting for future growth at the intersections; future roadway conditions excluding the proposed project are reflected including planned improvements at the Center Street and US 1 Southbound Ramps/ Waterford Green Drive intersection.
- **Design Year (2040) Build Alternative 1 – Improve Existing:** This scenario includes the existing Ten-Ten Road as a four-lane facility with a five-lane bridge to accommodate turn lanes, assumes the widening of US 1 to a six-lane section and accounts for projected roadway volumes on the widened facilities. Additionally, this scenario assumes the improvement of the interchange ramp intersections through conventional widening efforts as well as additional widening at the nearby Ten-Ten Road and Reliance Avenue intersection.
- **Design Year (2040) Build Alternative 2 – Roundabouts:** This scenario includes the widening of US 1 to a six-lane section, but would require additional widening beyond the planned four-lane divided section along Ten-Ten Road. It accounts for projected roadway volumes at the study intersections. Additionally, this scenario assumes the improvement of the interchange ramp intersections through conversion to roundabouts as well as additional widening at the Ten-Ten Road and Reliance Avenue intersection.
- **Design Year (2040) Build Alternative 3 – Modified Ramps:** This scenario includes the existing Ten-Ten Road as a four-lane facility with a five-lane bridge to accommodate turn lanes, assumes the widening of US 1 to a six-lane section and accounts for projected roadway volumes on the widened facilities. Additionally, this scenario assumes the improvement of the interchange ramp intersections through widening efforts, various turning movement restrictions and the modification of ramp configurations; it also includes additional widening and signal improvements at the nearby Ten-Ten Road and Reliance Avenue intersection.

A capacity analysis was performed for each of the alternative scenarios, examining operations at the study intersections. Intersection capacity analyses were conducted for the AM and PM peak hours as described in Section 2.1.3. Intersection capacity analysis was completed using the *Synchro, Version 7* software package, within which signal timings were optimized. *Sidra Intersection Version 5.1* was used to analyze the concepts with roundabout geometries.

The following intersections were analyzed for AM and PM peak hour operations:

- Center Street and US 1 Southbound Ramps/ Waterford Green Drive
- Ten-Ten Road and US 1 Northbound Ramps/ Lufkin Road
- Ten-Ten Road and Reliance Avenue

4.1 DESIGN YEAR (2040) NO-BUILD

This scenario projects traffic conditions at the study intersections with the projected volumes along the roadway and the future year geometric improvements at the Center Street and US 1 Southbound Ramps/Waterford Green Drive intersection in place, but without the proposed improvements to the interchange in place.

4.1.1 Design Year (2040) No-Build Planned Roadway Improvements

Geometric improvements accounted for in this scenario include additional turn lanes at the Center Street and US 1 Southbound Ramps/Waterford Green Drive intersection. These improvements are planned as part of a Town of Apex project and are expected to be implemented in the near future. Specifically, the improvements to this intersection include:

- Additional northbound exclusive left-turn lane with 125 feet of storage,
- Northbound right-turn lane with storage lengthened to 100 feet,
- Southbound right-turn lane with continuous storage,
- Southbound left-turn lane with storage lengthened to 200 feet,
- Eastbound right-turn lane with continuous storage, and
- Additional westbound through/right-turn lane beginning approximately 275 feet east of the intersection.

This scenario does not account for the widening of Ten-Ten Road or US 1. These improvements are included in the 2040 CAMPO Metropolitan Transportation Plan (MTP) as long range projects; however, an evaluation of the future year without these projects gives an understanding of the worst case scenario of the future traffic operations. The volumes used in this analysis scenario were derived from the application of growth rates calculated from the Triangle Regional Model Version 5.0. Figures 4-3 and 4-4 summarize the volumes and lane geometrics, respectively, used in the analysis.

4.1.2 Design Year (2040) No-Build Capacity Analysis

Based on the results of the intersection capacity analysis shown in Table 4-1 and the freeway ramp analysis shown in Table 4-2, all intersections are expected to decline significantly in operations due to future travel demand. All intersections are projected to operate at overall LOS F during both peak hours with delays of at least one and one half minutes to over seven minutes per vehicle, with nearly all approaches also operating at LOS F. Additionally, the freeway ramp analysis indicates that all ramp junctions are expected to fail in the future year during the PM peak hour. The No-Build capacity analysis results indicate a clear need for improvement at this interchange to effectively serve future demand.

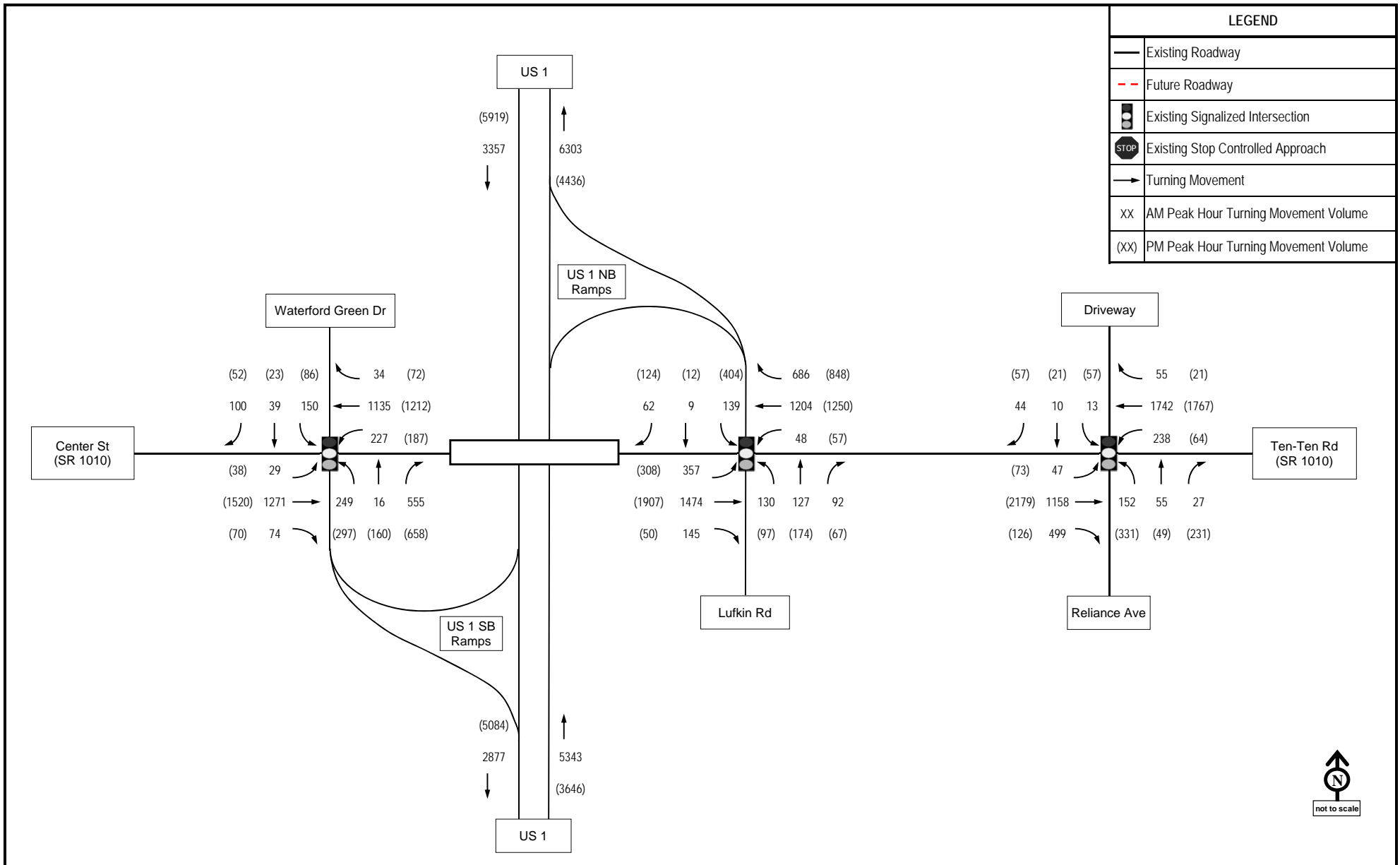


Figure 4-3
Design Year (2040) No-Build
AM and PM Peak Hour Turning Movement Volumes

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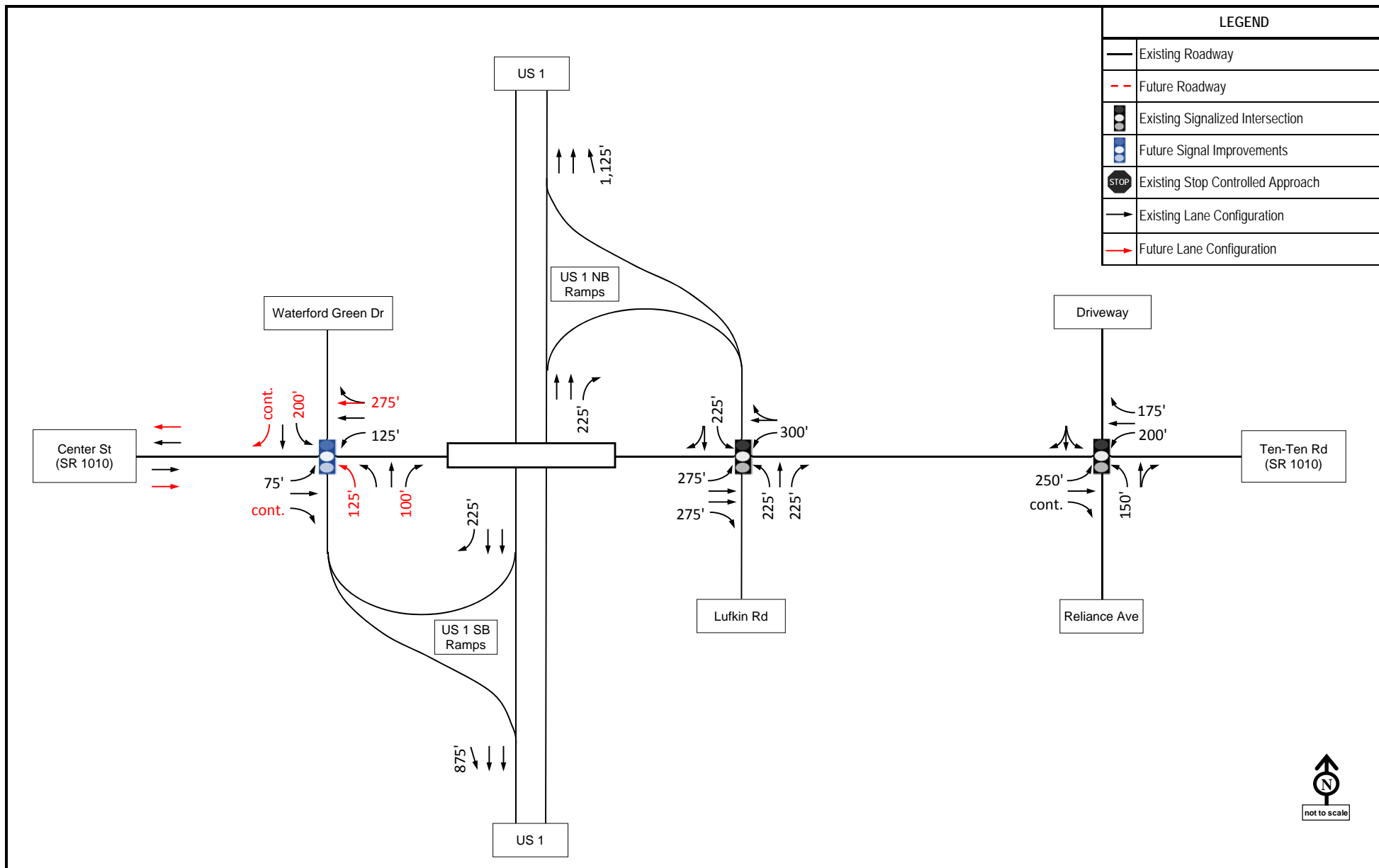


Figure 4-4
Design Year (2040) No-Build Lane Configurations and Traffic Control

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Table 4-1
Design Year (2040) No-Build Intersection LOS Results

Intersection and Approach	Design Year (2040) No-Build	
	AM Peak	PM Peak
Center Street and US 1 Southbound Ramps/Waterford Green Drive	F (98.2 sec)	F (158.2 sec)
Eastbound	F	F
Westbound	B	C
Northbound	F	F
Southbound	F	F
Ten-Ten Road and US 1 Northbound Ramps/Lufkin Road	F (225.3 sec)	F (346.2 sec)
Eastbound	E	F
Westbound	F	F
Northbound	F	F
Southbound	F	F
Ten-Ten Road and Reliance Avenue	F (194.2 sec)	F (442.2 sec)
Eastbound	F	F
Westbound	F	F
Northbound	F	F
Southbound	B	F

Table 4-2
Design Year (2040) No-Build Freeway Ramp LOS Results

Ramp Direction	Junction Type	Design Year (2040) No-Build	
		AM Peak	PM Peak
US 1 Southbound Ramps	Diverge	D	F
	Merge	C	F
US 1 Northbound Ramps	Diverge	F	E
	Merge	F	F

4.2 CAMPO METROPOLITAN TRANSPORTATION PLAN IMPROVEMENTS

As part of the Design Year Build scenarios, several widening improvements are assumed and included in the evaluated geometries for those alternatives. As part of all Build Alternatives, it is assumed that Center Street/Ten-Ten Road is widened to a four-lane divided facility through the project area; the Ten-Ten Road bridge over US 1 is assumed to be replaced with a new, widened bridge accommodating five travel lanes as depicted in the previously described typical section. US 1 is assumed to be widened to a six-lane freeway facility. These improvements are included in the 2040 CAMPO Metropolitan Transportation Plan (MTP) as long range projects and are assumed to be completed by the design year; however, the timing and responsibility of these improvements is not yet determined.

The widening of Center Street/Ten-Ten Road would include improvements at the study intersections in conjunction with the widening, specifically additional and lengthened turn lanes along Center Street/Ten-Ten Road. While the widening of US 1 is assumed, only some improvements to ramps and loops are recommended with these alternatives. The assumed improvements associated with these widening projects are depicted in the future lane geometrics and lane configurations figures as “completed by others.” The Build Alternatives include additional improvements beyond these typical accommodations that would be part of the widening projects, primarily additional ramp and loop improvements and additional turn lanes on Y-lines.

4.3 BUILD ALTERNATIVE 1 - IMPROVE EXISTING

Build Alternative 1 – Improve Existing proposes to upgrade the existing interchange intersections using conventional widening efforts, including signal timing upgrades, additional turning lanes as well as lengthening and widening interchange loops and ramps.

4.3.1 Design Year (2040) Build Alternative 1 – Improve Existing Roadway Improvements

Several existing turn lanes would be lengthened and new turn lanes would be constructed at all three study intersections. Specifically:

Center Street at US 1 Southbound Ramps/Waterford Green Drive

- Lengthen storage of eastbound right-turn lane to 200 feet,
- Additional northbound right-turn lane with 300 feet of storage,
- Lengthen storage of northbound left-turn lane to 200 feet, and
- Additional lane on exit loop, requiring an 800-foot auxiliary lane along US 1.

Ten-Ten Road at US 1 Northbound Ramps/Lufkin Road

- Lengthening of future southbound left-turn lanes on exit loop to 500 feet,
- Westbound free-flowing right-turn lane onto US 1 entry ramp with continuous storage to Reliance Avenue,
- Widened US 1 Northbound entry ramp to allow for 600 feet before the free flow right merges, and
- Lengthening of auxiliary lane along US 1 supporting the future two-lane exit to 800 feet.

Ten-Ten Road at Reliance Avenue

- Additional westbound through/right-turn lane with 250 feet of storage,
- Lengthen storage of northbound left-turn lane to 575 feet, and
- Northbound right-turn lane with 200 feet of storage.

Figure 4-5 illustrates the geometry associated with Build Alternative 1; conceptual designs for this alternative are included as Appendix A.

4.3.2 Design Year (2040) Build Alternative 1 – Improve Existing Capacity Analysis

This scenario represents operations at the study intersections given the design year volumes and accounting for the construction of conventional widening improvements at the study intersections as described previously.

Traffic capacity analysis indicates that the study intersections would all operate acceptably under this scenario; freeway merge/diverge locations would also operate acceptably with the exception of the US 1 Northbound merge junction, operating at LOS E during the AM peak. Table 4-3 summarizes the intersection LOS results, Table 4-4 summarizes the ramp and loop LOS results, and Figure 4-6 illustrates the volumes used in this scenario analysis.

4.4 BUILD ALTERNATIVE 2 - ROUNDABOUTS

Build Alternative 2 – Roundabouts proposes to upgrade the existing interchange intersections to roundabouts and widen Ten-Ten Road to accommodate those roundabouts.

4.4.1 Design Year (2040) Build Alternative 2 – Roundabouts Roadway Improvements

This alternative would require additional widening of Center Street/Ten-Ten Road beyond what is assumed in the MTP, which includes a five-lane bridge. The roundabouts at the interchange ramps would require three circulating lanes as well as numerous right-turn slip lanes to accommodate the projected traffic demand. Improvements at Reliance Avenue are the same as

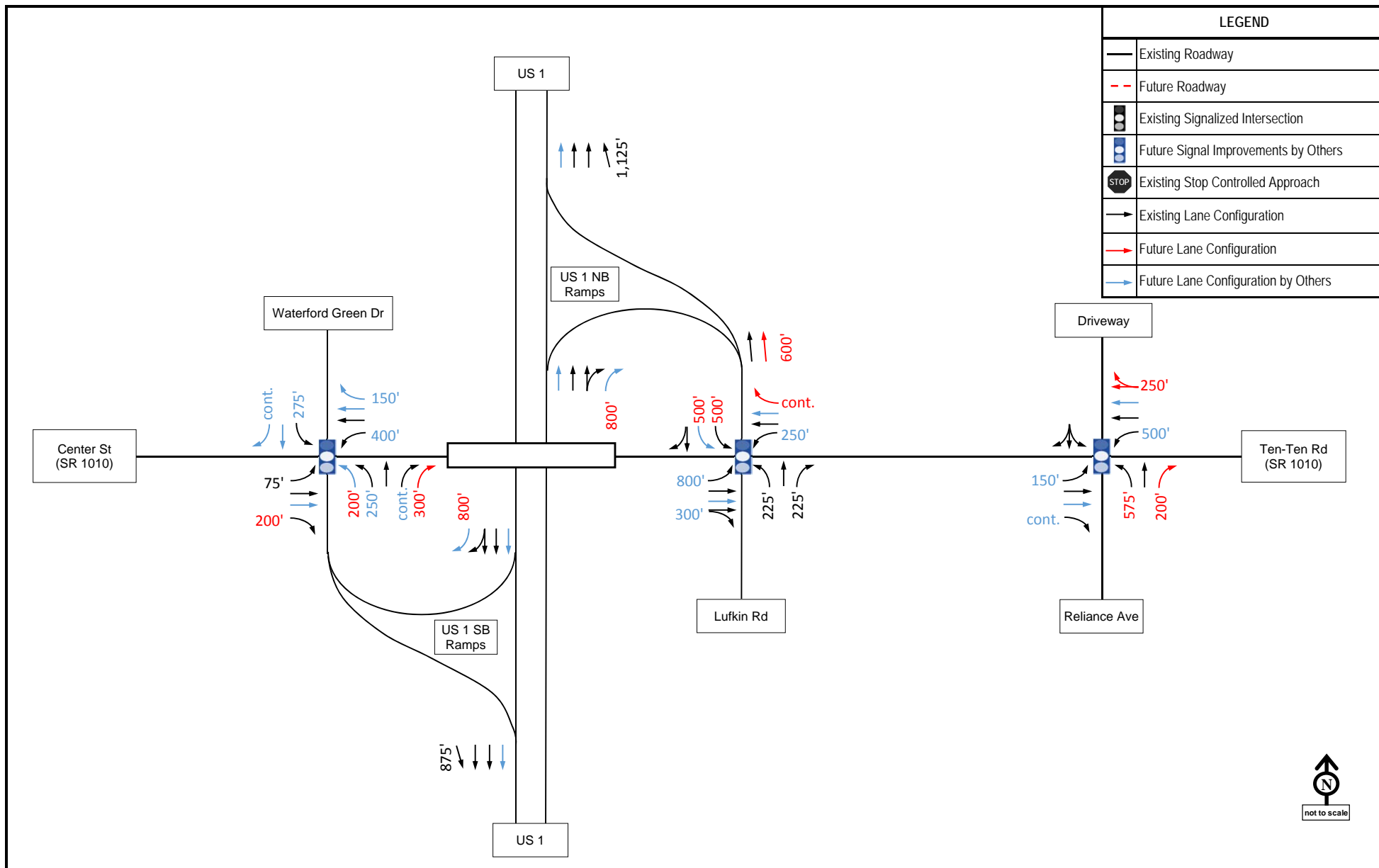


Figure 4-5
Design Year (2040) Build Alternative 1 - Improve Existing
Lane Configurations and Traffic Control

US 1 and Ten-Ten Road
Interchange Study
Apex, NC

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Table 4-3

Design Year (2040) Build Alternative 1 – Improve Existing Intersection LOS Results

Intersection and Approach	Design Year (2040) Build Alternative 1 – Improve Existing	
	AM Peak	PM Peak
Center Street and US 1 Southbound Ramps/Waterford Green Drive	C (27.6 sec)	C (30.0 sec)
Eastbound	C	C
Westbound	B	B
Northbound	D	D
Southbound	D	D
Ten-Ten Road and US 1 Northbound Ramps/Lufkin Road	C (25.9 sec)	C (34.9 sec)
Eastbound	C	C
Westbound	C	C
Northbound	D	E
Southbound	E	E
Ten-Ten Road and Reliance Avenue	B (13.1 sec)	D (41.5 sec)
Eastbound	F	F
Westbound	D	D
Northbound	B	B
Southbound	A	D

Table 4-4

Design Year (2040) Build Alternative 1 – Improve Existing Freeway Ramp LOS Results

Ramp Direction	Junction Type	Design Year (2040) Build Alternative 1 – Improve Existing	
		AM Peak	PM Peak
US 1 Southbound Ramps	Diverge	A	B
	Merge	B	C
US 1 Northbound Ramps	Diverge	B	A
	Merge	E	C

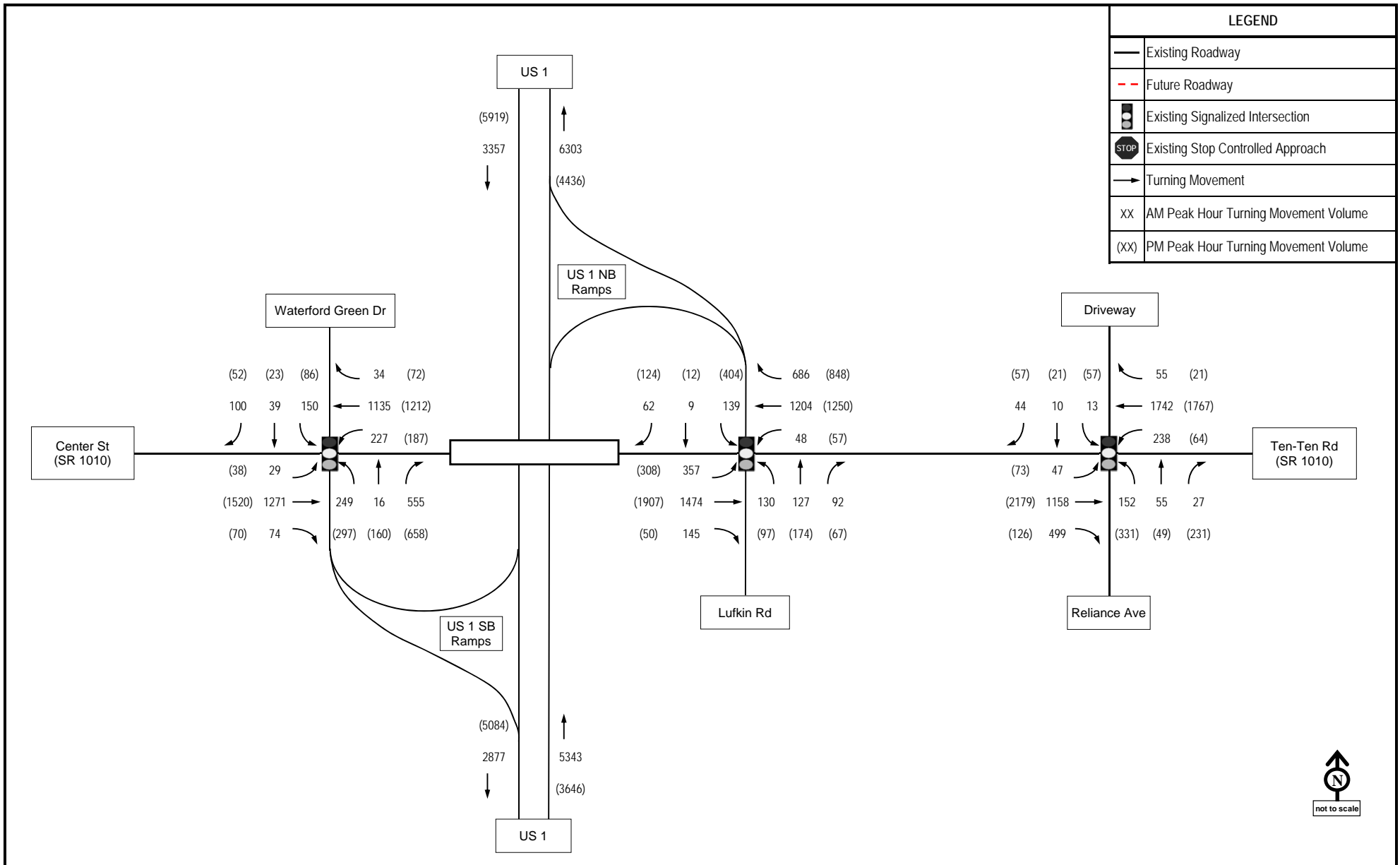


Figure 4-6
Design Year (2040) Build Alternative 1 - Improve Existing
AM and PM Peak Hour Turning Movement Volumes

US 1 and Ten-Ten Road
Interchange Study
Apex, NC

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those recommended in Alternative 1. Figure 4-7 illustrates the geometry associated with Build Alternative 2; conceptual designs for this alternative are included as Appendix A.

4.4.2 Design Year (2040) Build Alternative 2 – Roundabouts Capacity Analysis

This scenario represents operations at the study intersections given the design year volumes and accounting for the construction of roundabouts at the interchange ramp intersections along with the necessary widening to support acceptable traffic operations.

Traffic capacity analysis indicates that most of the intersections would operate acceptably under this scenario, with the exception of the Ten-Ten Road and US 1 Northbound Ramps/Lufkin Road intersection which is projected to still operate at LOS F during the PM peak hour. The freeway ramp junctions are also projected to operate acceptably. However, as mentioned previously, this level of operation would require additional widening of the bridge to accommodate seven lanes. Table 4-5 summarizes the intersection LOS results, Table 4-6 summarizes the freeway ramp LOS results, and Figure 4-8 illustrates the volumes used in this scenario analysis.

4.5 BUILD ALTERNATIVE 3 – MODIFIED RAMPS

Build Alternative 3 – Modified Ramps proposes to upgrade the interchange by altering the existing ramp and loop configuration to address the heaviest movements to and from US 1 and implementing turning movement restrictions to maximize the traffic signal efficiency.

4.5.1 Design Year (2040) Build Alternative 3 – Modified Ramps Roadway Improvements

This scenario represents operations at the study intersections given the design year volumes and accounting for the modification of the existing ramp configurations to switch the US 1 Northbound ramp and loop into the southeast quadrant, removing the existing Northbound off-loop. The existing on-ramp would remain intact. This scenario would also require the realignment of Lufkin Road to intersect Reliance Avenue south of Ten-Ten Road. Other key geometric changes include:

- A free-flow right-turn lane from the US 1 Southbound off-loop onto Ten-Ten Road; this lane would carry across the bridge and through Reliance Avenue before terminating.
- A free-flow right-turn lane from Ten-Ten Road onto the existing US 1 Northbound, requiring a widening of the existing entrance ramp; the free-flow lane would drop prior to merging with US 1 Northbound.
- A new signalized intersection east of Reliance Avenue to facilitate U-turns.

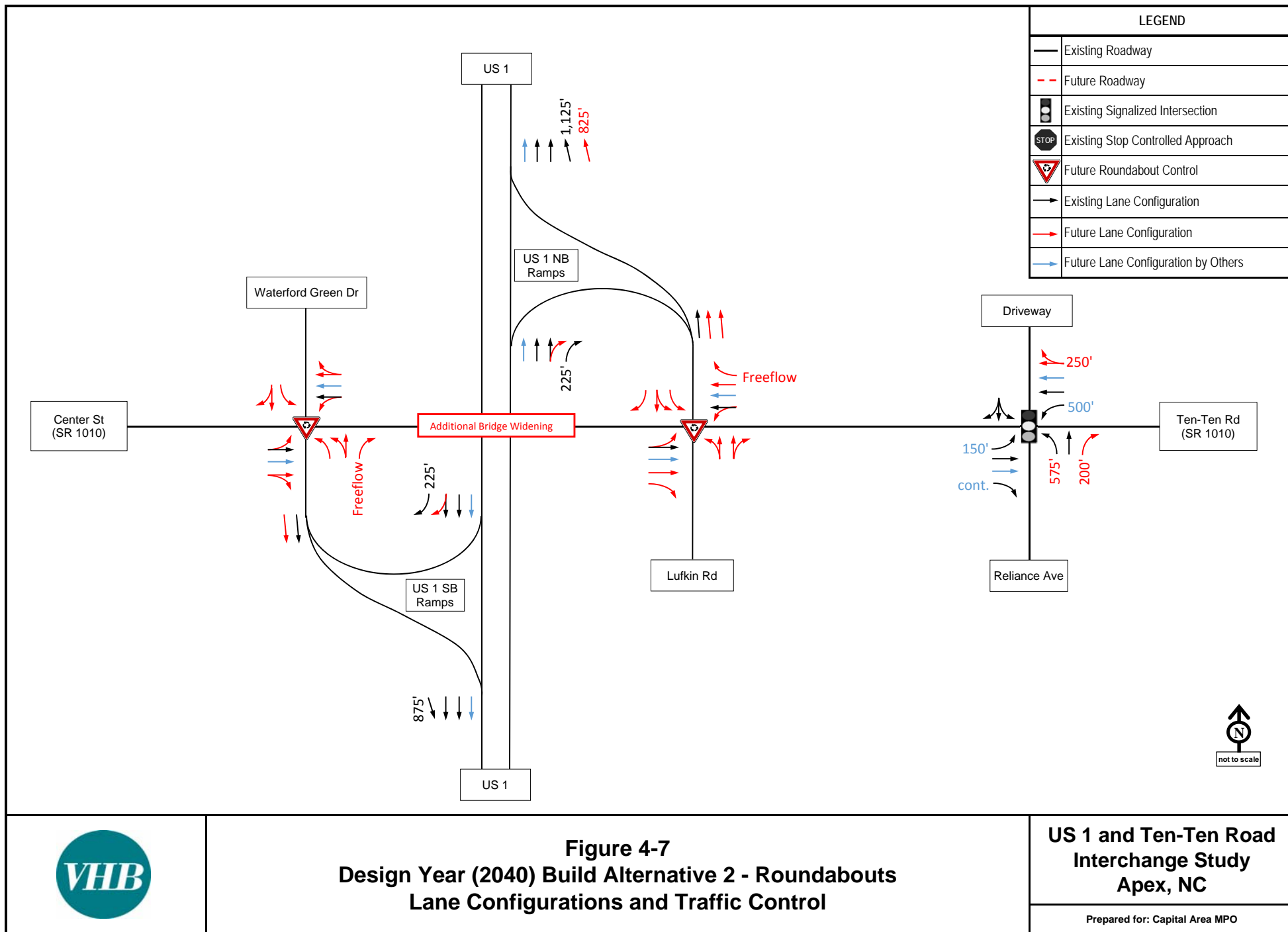


Table 4-5
Design Year (2040) Build Alternative 2 – Roundabouts LOS Results

Intersection and Approach	Design Year (2040) Build Alternative 2 – Roundabouts	
	AM Peak	PM Peak
Center Street and US 1 Southbound Ramps/Waterford Green Drive	B (14.3 sec)	C (22.1 sec)
Eastbound	C	C
Westbound	B	C
Northbound	A	D
Southbound	D	C
Ten-Ten Road and US 1 Northbound Ramps/Lufkin Road	C (20.5 sec)	F (57.9 sec)
Eastbound	C	F
Westbound	B	B
Northbound	F	F
Southbound	B	D
Ten-Ten Road and Reliance Avenue	B (13.1 sec)	D (41.5 sec)
Eastbound	F	F
Westbound	D	D
Northbound	B	B
Southbound	A	D

Table 4-6
Design Year (2040) Build Alternative 2 – Roundabouts Freeway Ramp LOS Results

Ramp Direction	Junction Type	Design Year (2040) Build Alternative 2 – Roundabouts	
		AM Peak	PM Peak
US 1 Southbound Ramps	Diverge	A	B
	Merge	B	C
US 1 Northbound Ramps	Diverge	B	A
	Merge	C	B

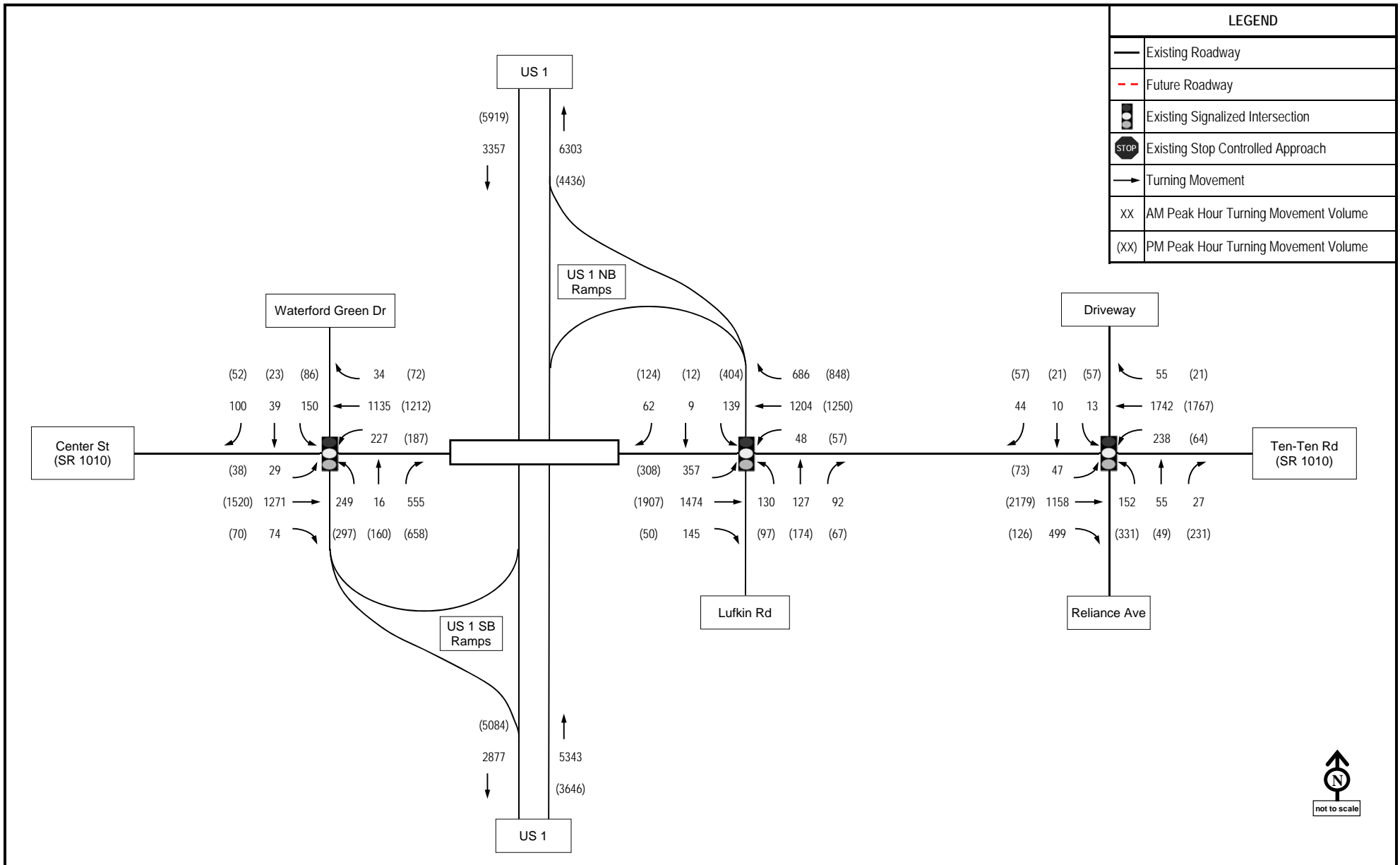


Figure 4-8
Design Year (2040) Build Alternative 2 - Roundabouts
AM and PM Peak Hour Turning Movement Volumes

US 1 and Ten-Ten Road
Interchange Study
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- A new signalized intersection west of US 1 Southbound Ramps/Waterford Green Drive to facilitate U-turns.
- Widening of the US 1 Southbound off-loop to accommodate two exit lanes from US 1.
- Lengthening and addition of several turn lanes to accommodate the turn restrictions.

In addition to geometric improvements, this scenario imposes a number of left-turn restrictions at the study intersections, including:

- No left-turns from Ten-Ten Road onto Reliance Avenue or into the Kangaroo Express; left-turns are directed to signalized downstream U-turn points.
- No left-turns from Center Street/Ten-Ten Road onto US 1 Southbound ramps; left-turns are directed to a signalized downstream U-turn point; Waterford Green Drive has ingress and right-out egress only;

Figure 4-9 illustrates the geometry associated with Build Alternative 3; conceptual designs for this alternative are included as Appendix A.

4.5.2 Design Year (2040) Build Alternative 3 – Modified Ramps Capacity Analysis

This scenario represents operations at the study intersections given the design year volumes and accounting for the modification of the existing ramp configurations.

Traffic capacity analysis indicates that the study intersections and freeway merge/diverge locations would operate acceptably under this scenario.

Table 4-7 summarizes the intersection LOS results, Table 4-8 summarizes the freeway ramp LOS results, and Figure 4-10 illustrates the volumes used in this scenario analysis.

In all Build Alternatives, the US 1 Southbound diverge location is evaluated with two exit lanes from US 1 onto the exit loop and the LOS results reflect that geometry. During review of the developed alternatives, the possibility of a single exit lane was discussed and further analysis indicates that a single lane exit, if necessary, would operate at LOS D; however, the dual exit lane configuration is preferable in order to accommodate potential stacking from the traffic signal and to avoid spillback onto US 1.

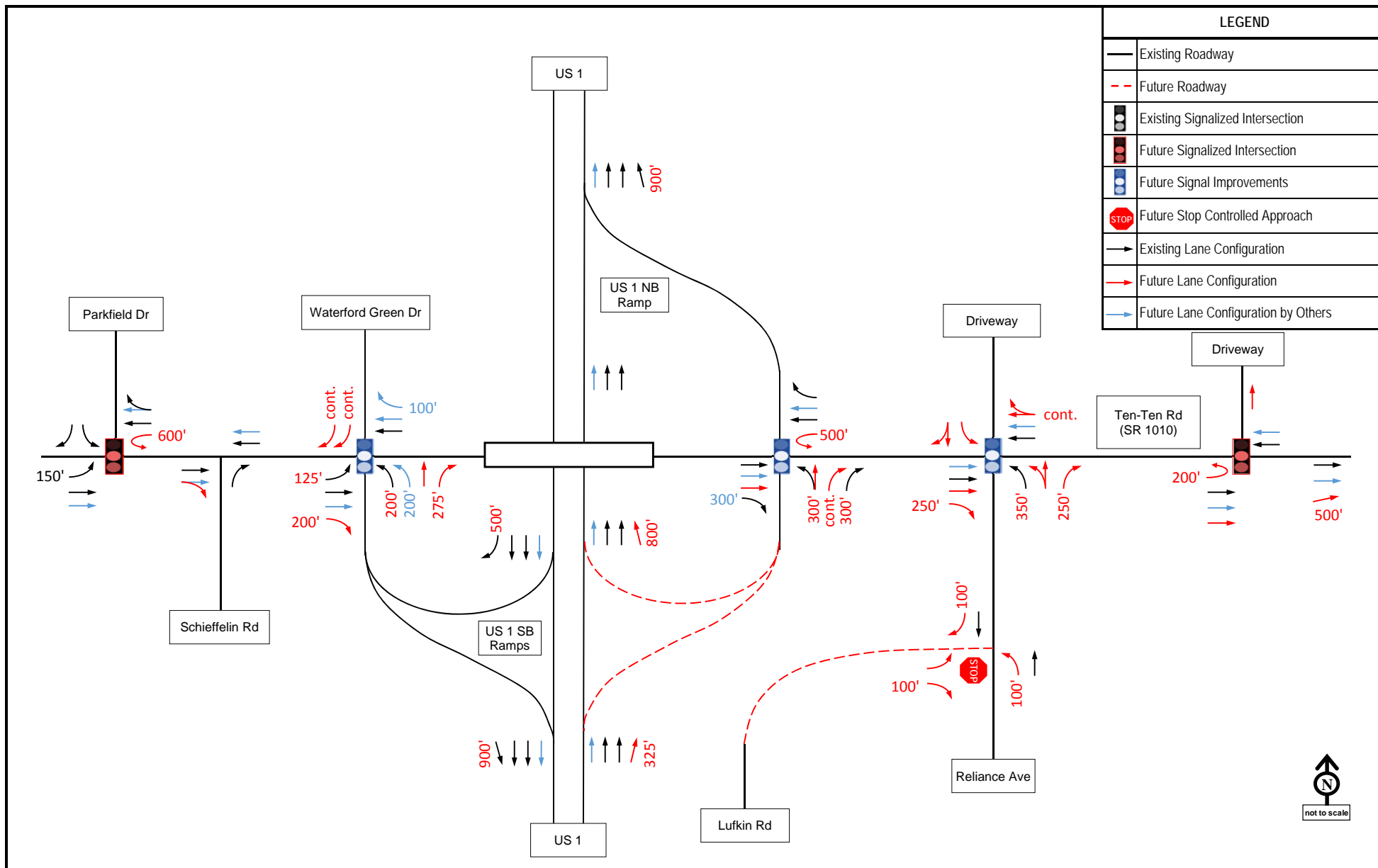


Figure 4-9
Design Year (2040) Build Alternative 3 - Modified Ramps
Lane Configurations and Traffic Control

US 1 and Ten-Ten Road
Interchange Study
Apex, NC

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Table 4-7
Design Year (2040) Build Alternative 3 – Modified Ramps LOS Results

Intersection and Approach	Design Year (2040) Build Alternative 3 – Modified Ramps	
	AM Peak	PM Peak
Center Street and US 1 Southbound Ramps/Waterford Green Drive	B (14.3 sec)	B (13.3 sec)
Eastbound	A	A
Westbound	B	B
Northbound	B	C
Southbound	D	D
Ten-Ten Road and US 1 Northbound Ramps/Lufkin Road	B (12.7 sec)	B (16.3 sec)
Eastbound	B	B
Westbound	B	A
Northbound	E	D
Southbound	-	-
Ten-Ten Road and Reliance Avenue	B (19.5 sec)	C (21.5 sec)
Eastbound	C	D
Westbound	E	E
Northbound	C	B
Southbound	B	B

Table 4-8
Design Year (2040) Build Alternative 3 – Modified Ramps Freeway Ramp LOS Results

Ramp Direction	Junction Type	Design Year (2040) Build Alternative 3 – Modified Ramps	
		AM Peak	PM Peak
US 1 Southbound Ramps	Diverge	B	D
	Merge	B	C
US 1 Northbound Ramps	Diverge	D	B
	Merge	D	C
	Loop Merge	D	B

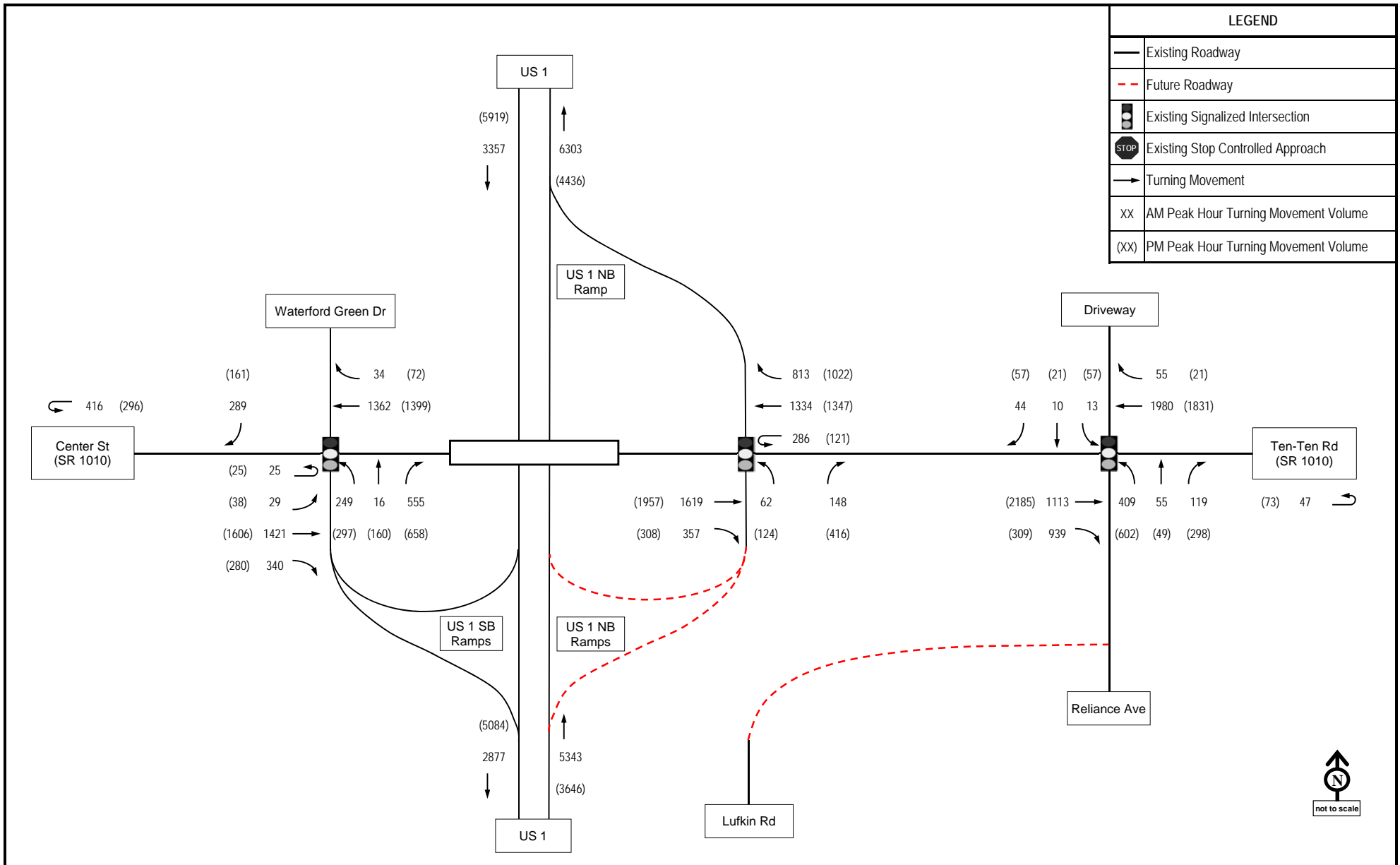


Figure 4-10
Design Year (2040) Build Alternative 3 - Modified Ramps
AM and PM Peak Hour Turning Movement Volumes

US 1 and Ten-Ten Road
Interchange Study
Apex, NC

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5.0 OPINION OF PROBABLE CONSTRUCTION COST

Planning level construction cost estimates were prepared for each of the developed alternatives. These cost estimates include actions related to construction such as earthwork, new pavement and resurfacing, as well as signage and signal upgrades. The cost estimates do not include right-of-way or utility relocation estimates; however, it is likely that these would be comparable to one another across the alternatives.

Table 5-1 summarizes the opinion of probable construction costs.

Table 5-1
Opinion of Probable Construction Cost

Alternative	Estimated Cost
Build Alternative 1 – Improve Existing	\$3,000,000
Build Alternative 2 – Roundabouts	\$7,700,000
Build Alternative 3 – Modified Ramps	\$6,300,000

It should be noted that these cost estimates do not include the construction cost estimates associated with the widening of Center Street/Ten-Ten Road or US 1. As described in Section 4.2, those improvements are in the MTP, however funding and scheduling for the widenings is still undecided. With that in mind, it should be considered that improvements associated with these developed alternatives that go beyond what was assumed to be part of the widening projects may be included within the widening efforts. Specifically, all improvements included in Build Alternative 1 could likely be included in the widening of the two roadways, which would theoretically bring the estimated construction cost of that alternative to zero, as no major intersection geometry changes, additional signals, or major ramp modifications are recommended.

6.0 ALTERNATIVES EVALUATION AND RECOMMENDATIONS

This section details and evaluates the quantitative impacts of the presented alternatives such as stream impacts, relocations and cost estimates. It also includes a discussion comparing the alternatives, resulting in a recommendation.

6.1 IMPACTS OF ALTERNATIVES

Each of the presented alternatives is unique in its associated improvements. Table 6-1 provides a comparison of the quantitative impacts to specific resources for each alternative.

It should be noted that this table indicates that there is no impact to hydrological features, such as streams, except in Build Alternative 3. The GIS data used in this screening is from Wake County and shows all features including pipes, ditches, etc. and does not indicate jurisdictional waters. While the USGS Quadrant maps do not indicate any blue line (assumed perennial) streams within the study area, further field observations and delineations should be completed in later planning phases. In addition, coordination undertaken with the US Army Corps of Engineers and the NC Division of Water Resources should be conducted as necessary to determine the quality of any present waters and the need for any mitigation to those resources.

Additionally, Build Alternative 3 may potentially impact an underground storage tank (UST) associated with the newly constructed Sheetz development. Due to the recent construction of this gas station, the utilized GIS data did not have the exact UST location included. It is likely that the tank location can be avoided during later design stages.

Based on available GIS level information, the developed alternatives would have no impact to any known environmental concerns, any locally or state recognized historic resources, nor would any business or residences require acquisition or relocation.

Table 6-1
Alternatives Major Impact Comparison

Impact/Alternative		Alternative 1 - Improve Existing	Alternative 2 - Roundabouts	Alternative 3 - Modified Ramps
Hydrological Features	Perennial Streams (#/LF)	0	0	0
	Intermittent Streams (#/LF)	0	0	0
	Potential Intermittent Streams* (#/LF)	0 / 0	0 / 0	2 / 364
Relocations	Residences (#)	0	0	0
	Businesses (#)	0	0	0
	Churches (#)	0	0	0
Potential Geoenvironmental Concerns (# of USTs/# of others)		0 / 0	0 / 0	1** / 0
Capacity Analysis Overall (LOS) Results (AM/PM)	Center St and US 1 SB Ramps/Waterford Green Dr	C/C	B/C	B/B
	Ten-Ten Road and US 1 NB Ramps/Lufkin Rd	C/C	C/F	B/B
	Ten-Ten Rd and Reliance Ave	B/D	B/D	B/C
Construction Cost Estimate		\$ 3,000,000	\$ 7,700,000	\$ 6,300,000

* No USGS Blue Line (assumed perennial) stream crossings within project impact areas. The GIS mapping of streams is from Wake County data and shows all hydrological features (pipes, ditches, etc) and does not indicate jurisdictional waters.

** UST associated with newly constructed Sheetz development. Exact tank location can likely be avoided during later design stages.

6.2 CONCLUSIONS AND RECOMMENDATIONS

Based on the data presented in this study, it is recommended that Build Alternative 1 – Improve Existing is considered for implementation to improve future operations at this interchange. The recommendation of this alternative is based on several aspects of the project, including environmental impacts, constructability and cost.

Build Alternative 2 – Roundabouts would require widening of Ten-Ten Road and the bridge to three through lanes in each direction to yield the mostly acceptable levels of traffic operation reported in Table 6-1, but would still leave at least one intersection with unacceptable operations.

Build Alternative 1 – Improve Existing yields acceptable traffic operations with minimal impact to the surrounding environment. Additionally, it is possible that all improvements included with Build Alternative 1 would be incorporated as part of the Center Street/Ten-Ten Road widening and US 1 widening projects, removing the need for a separate interchange improvement project. While Build Alternative 3 – Modified Ramps also results in acceptable traffic operations, the cost of the improvements needed for that alternative is estimated to be more than twice that of Build Alternative 1 and is the only alternative with the potential to impact a UST and hydrologic features.

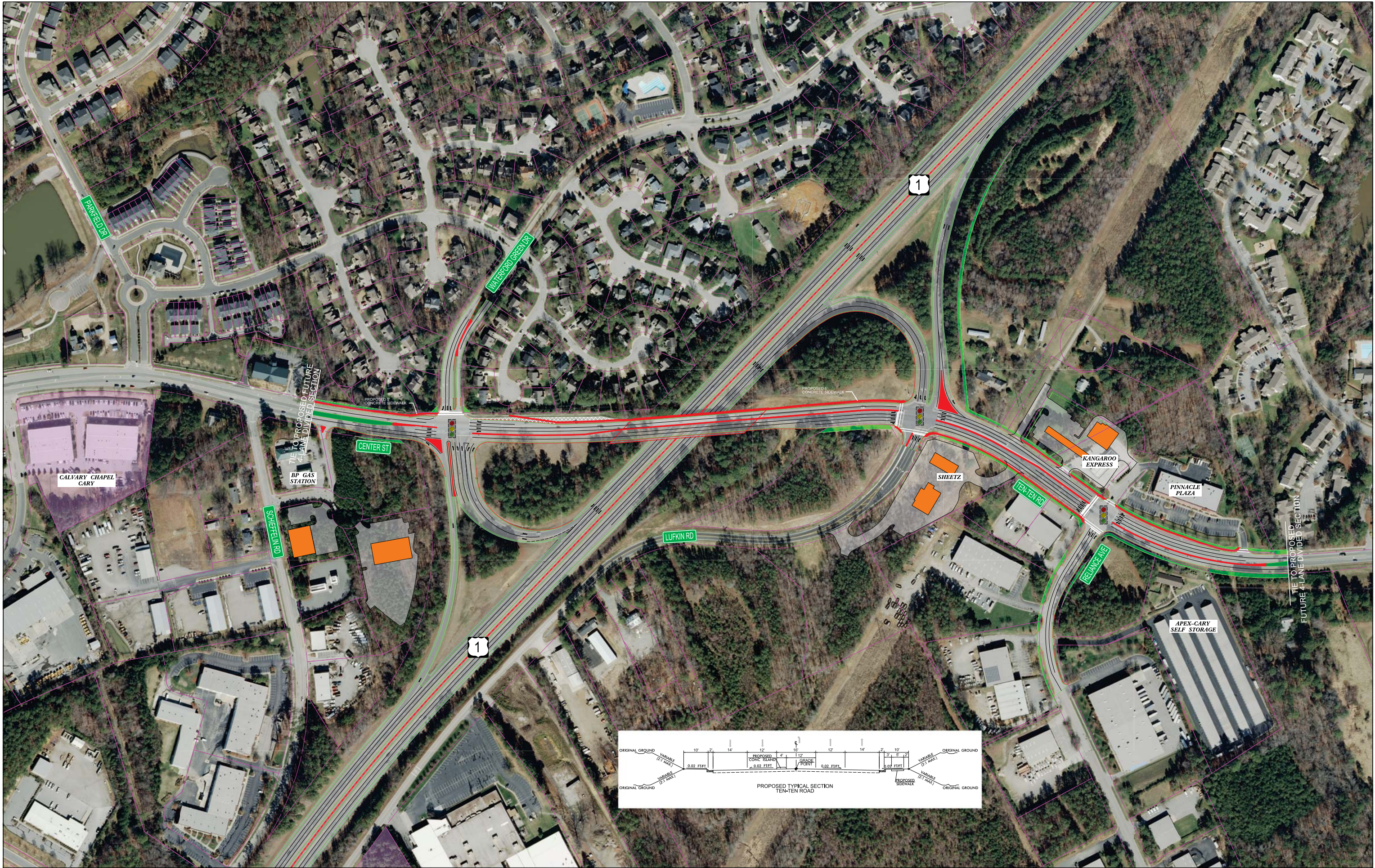
All three alternatives were presented to representatives of CAMPO, the Town of Apex, and NCDOT. After considering the impacts, cost and traffic operations associated with each alternative, Build Alternative 1 – Improve Existing was determined to be the best option for future programming and planning at this interchange location.

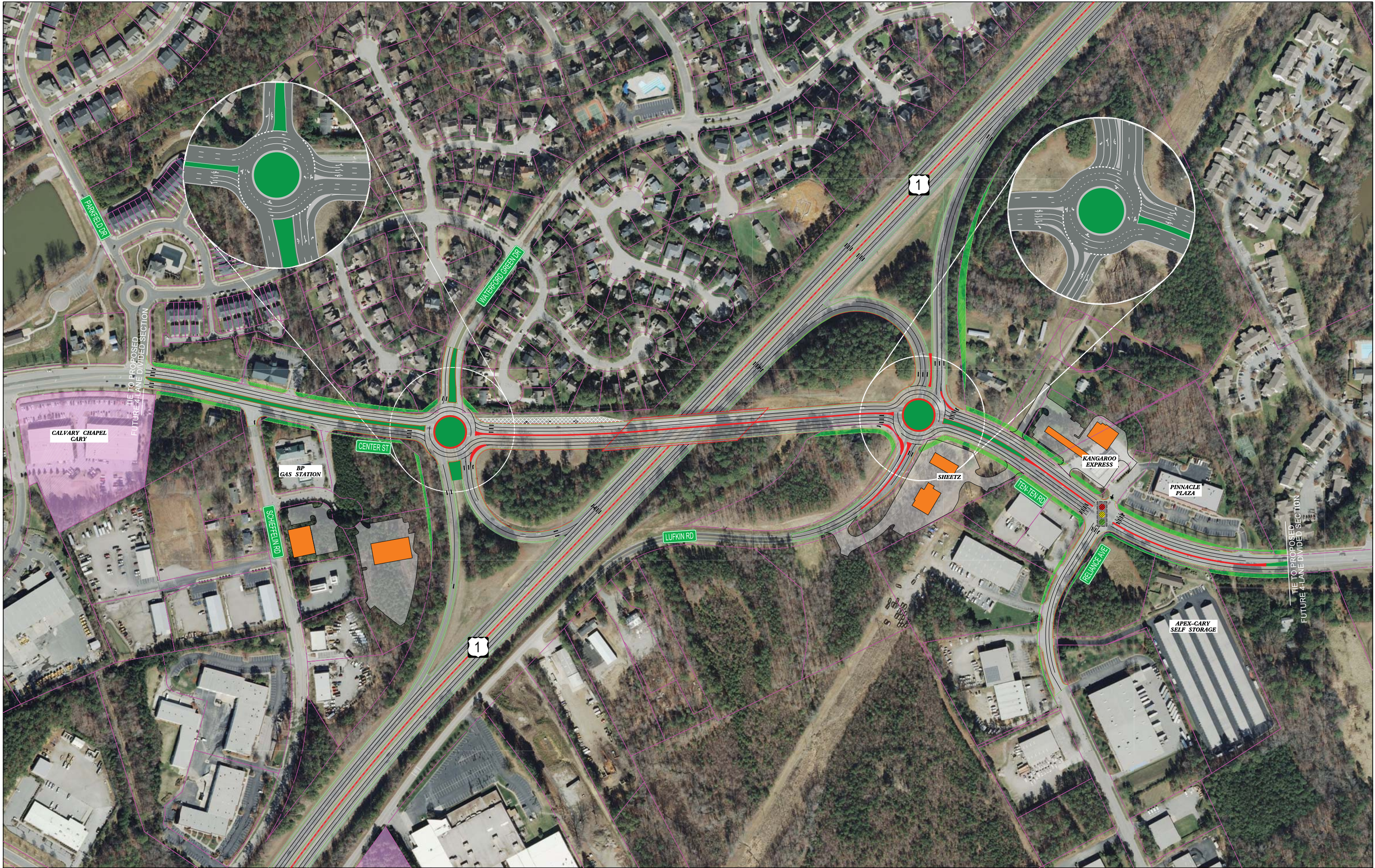
Following the recommendation of Build Alternative 1 – Improve Existing for future programming, a VISSIM simulation was completed for that alternative. This microsimulation can be used to demonstrate to the public or stakeholders a visual traffic simulation of the proposed improvements recommended and the projected flow of traffic through the improved interchange.

APPENDIX

APPENDIX A:

Conceptual Designs





<div><div></div> PROPOSED RIGHT OF WAY</div> <div><div></div> GRASS MEDIAN</div> <div><div></div> FUTURE CONSTRUCTION</div>	<div><div></div> CHURCH PROPERTY</div> <div><div></div> CONCRETE ISLAND</div> <div><div></div> ROADWAY REMOVAL</div>	<div><div></div> NEW TRAFFIC SIGNAL</div> <div><div></div> MODIFIED TRAFFIC SIGNAL</div>	<div>100' 0' 100' 200'</div> <div>50'</div> <div>SCALE</div>	<div></div>	<div>CAMPO US 1 / Ten-Ten Rd Interchange Study July 29, 2014</div>	<div> VHB Engineering NC, P.C. 4000 West Chase Boulevard, Suite 530 Raleigh, North Carolina 27607 NC Lic No. CC3705</div>	<div>Alternative 2 Roundabouts</div>
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