

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STATE TRANSPORTATION IMPROVEMENT PROGRAM (STIP) PROJECTS R-2721, R-2828, & R-2829



**First Tier Alternative Concepts Screening & Traffic
Reassessment**

FINAL

December 12, 2017

Submitted to:

North Carolina Department of Transportation
Raleigh, North Carolina

Federal Highway Administration
Raleigh, North Carolina

Submitted for:

North Carolina Department of Transportation
Raleigh, North Carolina

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1. INTRODUCTION

The North Carolina Turnpike Authority (NCTA) contracted HNTB North Carolina, P.C. (HNTB) to provide future traffic data to be used in the first-tier screening of alternative concepts in the *Alternatives Development and Analysis Report* for the Complete 540 Triangle Expressway Southeast Extension project. The first purpose of this memo is to revisit the original *Southeast Extension - First Tier Screening Traffic Memorandum* (HNTB, 2011) to determine if the findings of the original memo, based on 2035 traffic and socioeconomic data, are still valid when using the updated information on 2040 traffic and socioeconomic data. This memo reevaluates the preliminary alternative concepts from the 2011 First Tier Screening Memo in the Complete 540 DEIS using Triangle Regional Model (TRM) Version 5 (V5) data and No-Build indirect and cumulative effects (ICE) socioeconomic (SE) data. This effort consists of utilizing Measures of Effectiveness (MOEs) to screen project alternatives using the updated information. The second purpose of this memo is to determine if using the socioeconomic data on population and employment derived in the Quantitative Indirect and Cumulative Effects Technical Memorandum 4 to develop a conservative No-Build Scenario would have a substantial effect on the screening decisions. The third purpose of this memo is to determine if additional project-level traffic forecasting, specifically a 2040 future year no-build scenario, would have the potential to change project decisions and therefore be necessary.

This is a screening scenario based on the Quantitative ICE, and is not intended to represent the most likely scenario, but rather the most conservative, reasonable assessment of the maximum potential of the Complete 540 to induce changes to traffic and population growth. The Quantitative ICE noted that area planners did not believe the project would cause notable changes in overall population growth but may have some effect on the location of development. Detailed information on the ICE land use scenarios and the methodology used to develop them can be found in the Complete 540 Quantitative ICE Memos 1 (Section 2) and 4 (Section 3).

As mentioned before, this memo utilized the TRM V5. The original memo used TRM V4. The current version (TRM V5) differs from the previous version of the TRM in the following ways:

- TRM V5 roadway and transit networks represent the fiscally-constrained 2040 Capital Area Metropolitan Planning Organization (CAMPO) Metropolitan Transportation Plan (MTP) instead of the fiscally-constrained 2035 CAMPO Long Range Transportation Plan (LRTP).
- TRM V5 socioeconomic data has a horizon year of 2040 instead of 2035.
- TRM V5 has an expanded geographic coverage and roadway network coverage in the outer counties of the model.

The two primary purposes of the project are improving mobility and reducing congestion on the road network in the project study area. Data analyzed as quantitative MOEs for meeting these purposes include vehicle miles traveled (VMT), vehicle hours traveled (VHT), congested VMT, congested VHT, congested miles of roadway, average speed, and travel times between representative origins and destinations. The data were examined at a region-wide level and within the project traffic study area for 10 different preliminary alternative concepts. The traffic study area is shown in **Figure 1**.

2. ALTERNATIVE CONCEPTS EVALUATION

The Triangle Regional Model, Version 5 (TRM), the Triangle Region's officially approved travel demand model, was the source of information used to compare the alternative concepts. The TRM was adopted in February 2016 after being developed by the Triangle Regional Model Service Bureau, which is housed

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at the Institute for Transportation Research and Education. The TRM was calibrated to exceed Federal Highway Administration (FHWA) model calibration standards¹ using observed base-year data, before being adopted by the North Carolina Department of Transportation (NCDOT), local Metropolitan Planning Organizations (MPOs), and Triangle Transit. The aforementioned MOE data were produced for 2040 project design year. For the purposes of this technical memorandum, the following alternative concepts were analyzed:

- No-Build ICE: This alternative concept includes all projects in the fiscally-constrained Capital Area MPO 2040 MTP roadway and transit networks, except Complete 540. Socio-economic data developed as part of the Complete 540 Quantitative Indirect and Cumulative Effects study was used in place of the official socio-economic data for this alternative only.
- No-Build: This alternative concept includes all projects in the fiscally-constrained Capital Area MPO MTP roadway and transit networks, except the Southeast Extension.
- New Location Highway²: This alternative concept consists of the official fiscally-constrained MTP roadway and transit networks with the Complete 540 as a toll facility.
- Hybrid 1: This alternative concept includes all projects in the fiscally-constrained MTP roadway and transit networks except the eastern section (I-40 to US 64/264) of Complete 540. In place of the eastern section, I-440 (I-40 to US 1) and US 64/264 (I-440 to I-540) would be widened to 10 lanes.
- Hybrid 2: This alternative concept includes all projects in the fiscally-constrained MTP roadway and transit networks except the southern section (NC 55 to I-40) of Complete 540. In place of the southern section, NC 55 (NC 540 to NC 42) and NC 42 (NC 55 to I-40) would be upgraded to six-lane controlled access facilities with service roads.
- Hybrid 3: This alternative concept includes all projects in the fiscally-constrained MTP roadway and transit networks except the southern section of Complete 540. In place of the southern section, Jessie Drive (NC 540 to Ten Ten Road) and Ten Ten Road (Jessie Drive to I-40, including a new location facility east of NC 50) would be upgraded to six-lane controlled access facilities with service roads.
- Improve Existing 1²: This alternative concept includes all projects in the fiscally- constrained MTP roadway and transit networks except Complete 540. In place of Complete 540, I-40 (US 70 to US 1/64), I-440 (I-40 to US 1), and US 64/264 (I-440 to I-540) would be all widened to 12 lanes.
- Improve Existing 2 – Freeway²: This alternative concept includes all projects in the fiscally-constrained MTP roadway and transit networks except Complete 540. In place of Complete 540, NC 55 (NC 540 to NC 42) and NC 42 (NC 55 to I-40) would be upgraded to six-lane controlled access facilities with service roads. I-440 (I-40 to US 1) and US 64/264 (I-440 to I-540) are widened to 12 lanes.
- Improve Existing 2 – Arterial²: This alternative concept includes all projects in the fiscally-constrained MTP roadway and transit networks except Complete 540. In place of Complete 540, NC 55 (NC 540 to NC 42) and NC 42 (NC 55 to I-40) would be widened to six-lane arterials. I-440 (I-40 to US 1) and US 64/264 (I-440 to I-540) are widened to 12 lanes.
- Improve Existing 3 – Freeway²: This alternative concept includes all projects in the fiscally-constrained MTP roadway and transit networks except Complete 540. In place of Complete 540,

¹ FHWA Travel Model Improvement Program, *Model Validation and Reasonableness Checking Manual*, 2nd Edition (2013)

² The alternative names used in the original 2011 memo were changed to match that of the *Complete 540 Alternatives Development and Analysis Report* (2014). The “Build” alternative is now referred to as “New Location Highway”. “Upgrade Existing” alternatives are now referred to as “Improve Existing”.

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Jessie Drive (NC 540 to Ten Ten Road) and Ten Ten Road (Jessie Drive to I-40, including a new location facility east of NC 50) would be upgraded to six-lane controlled access facilities with service roads. I-440 (I-40 to US 1) and US 64/264 (I-440 to I-540) are widened to 12 lanes.

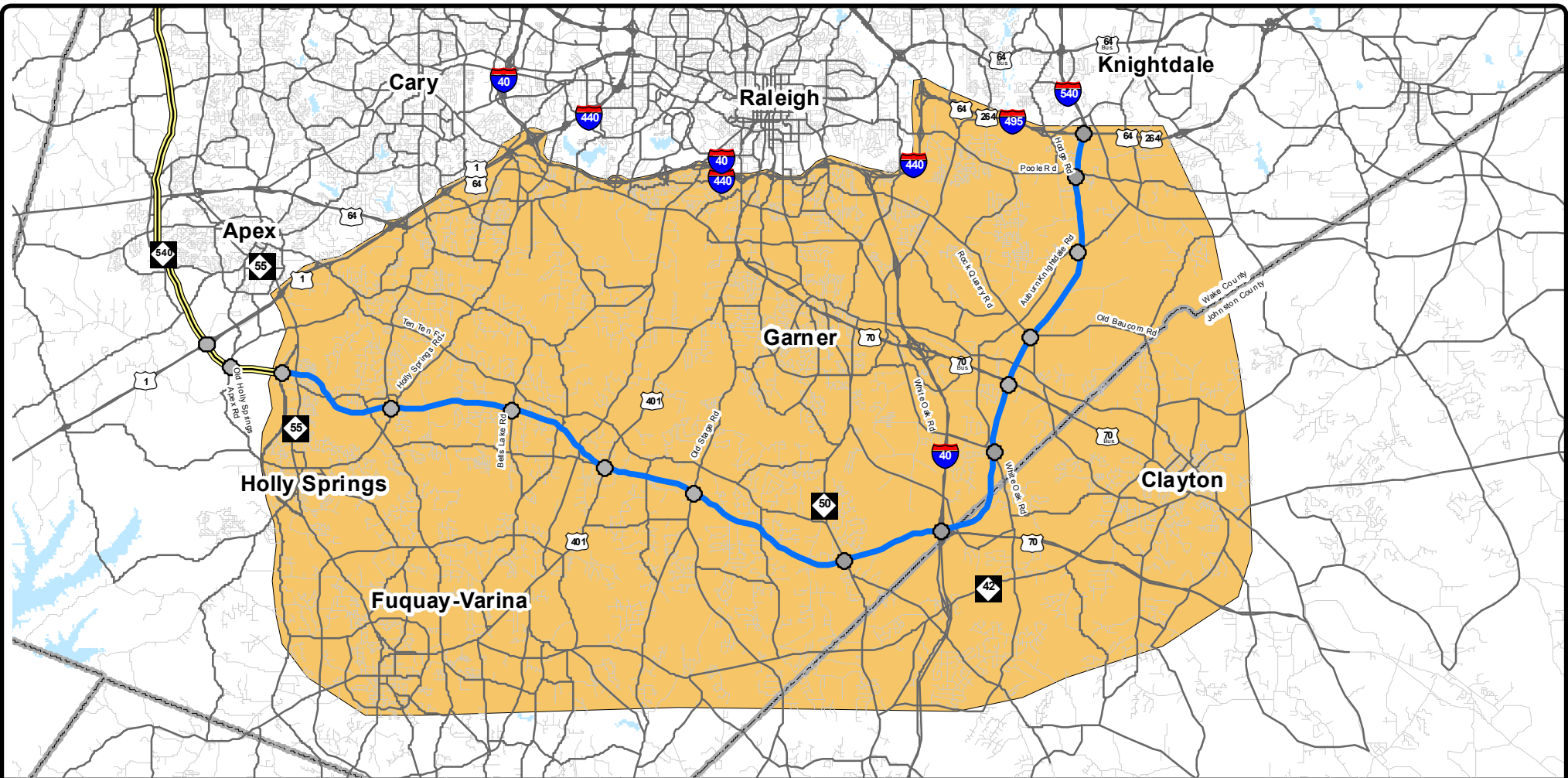
- **Improve Existing 3 – Arterial²:** This alternative concept includes all projects in the fiscally-constrained MTP roadway and transit networks except Complete 540. In place of Complete 540, Jessie Drive (NC 540 to Ten Ten Road) and Ten Ten Road (Jessie Drive to I-40, including a new location facility east of NC 50) would be upgraded to six-lane arterials. I-440 (I-40 to US 1) and US 64/264 (I-440 to I-540) are widened to 12 lanes.
- **Mass Transit:** This alternative concept utilizes transit improvements within the traffic study area in attempts to alleviate congestion. Those transit modes included in the TRM (bus, express bus, and light rail) were considered in this analysis. Other modes of transit were not considered due to limited capital investment potential.
- **Travel Demand Management (TDM):** This alternative concept consists of methods that aim to reduce congestion during the peak time periods. Some options considered in this alternative, such as ridesharing or telecommuting, take vehicles off the road completely during the peak work commute periods. Other options, such as staggered work hours, do not take vehicles off the road but attempt to decrease the number of vehicles during the peak periods.
- **Transportation System Management (TSM):** This alternative concept involves minor improvements (signal timing, ramp meters, variable message signs, etc.) meant to maximize the efficiency of traffic flow on existing facilities TSM improvements are typically limited to freeway/expressway and major arterial facilities.

Additional descriptions of the alternative concepts can be found in the *Complete 540 Alternatives Development and Analysis Report (Lochner, 2014)* for the project.

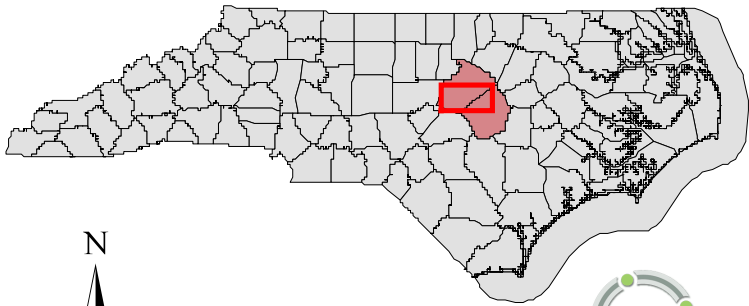
All new-location facilities included in the alternative concepts were modeled as toll facilities. In addition, the portions of existing roadways that were upgraded to controlled-access facilities were also modeled as toll facilities. Because current law requires a free alternative route, “non-toll” service roads were added to the model network to provide a parallel free alternative and address businesses and communities whose access points onto the roadway network were altered. All facilities without control of access were modeled as “non-toll” due to the inability to toll a facility without controlled-access. Improvements to existing controlled-access facilities, e.g. I-40/I-440, were not considered to be tolled in the future for this analysis.

A traffic study area, shown in **Figure 1**, that differs from the original project study area was created for the 2011 First Tier Screening Traffic Memo and was also utilized for this memorandum. The traffic study area generally coincides with the project study area except the traffic study area was expanded to include I-40/I-440 to the north and US 1/64 to the west. This was done to better capture the effects that the various alternative concepts would have on more of the Triangle area’s roadway network.

Specific travel origins and destinations for typical commuters in the traffic study area were selected based on employment center locations and more densely populated residential land uses within the traffic study area. The travel times analyzed in this study were calculated using the travel time forecast by TRM for trips between Traffic Analysis Zones (TAZs) for each selected location best representing the center of its activity.



Complete 540 First Tier Screening Traffic Study Area



Legend	
	Traffic Study Area
	Triangle Expressway
	Complete 540
	Interchanges
	Major Roads
	Counties

STIP: R-2721, R-2828, R-2829	WBS: 37673.1.TA2, 35516.1.TA2, 35517.1.TA1
COUNTY: Wake/Johnston	DIVISION: 5/4
DATE: December 2017	
PREPARED BY:	HNTB North Carolina, P.C. 343 E. Six Forks Rd, Suite 200 Raleigh, NC 27609
LOCATION:	NC 55 Bypass (Holly Springs) to I-495 / US 64 Bypass / US 264 (Knightdale)
PROJECT: Complete 540 Triangle Expressway Southeast Extension	Figure 1

3. CONCLUSIONS

Alternatives Analysis and Screening

The various MOEs described in Sections 4.0 through 7.0 demonstrate that all alternative concepts provide some benefit to the region and traffic study area in improving mobility and reducing congestion, the two purposes of the Complete 540 project, when compared to the No-Build ICE alternative.

All MOEs analyzed showed that Complete 540 would have a greater impact in the traffic study area than the entire region, based on the No-Build ICE Alternative. The New Location Highway Alternative showed positive impacts in all MOEs that were examined. The New Location Highway Alternative outperformed the No-Build ICE Alternative in all PM Peak MOEs as well as the daily average speed MOE both regionally and within the traffic study area.

MOE comparisons between the No-Build and No-Build ICE alternatives showed minimal differences, particularly from a regional standpoint. All MOE comparisons for the PM Peak saw maximum variances of slightly more than three percent regionally and less than six percent within the traffic study area. While the No-Build ICE alternative performs slightly better than the No-Build alternative in terms of MOEs, simply assuming the No-Build ICE land uses occur would not provide the needed increased mobility and congestion relief that the New Location Highway alternative produces. Therefore, the New Location Highway alternative continues to be the preferred alternative concept to meet the primary project purposes.

Table 2.7 of the *Complete 540 Alternatives Development and Analysis Report (Lochner, 2014)* summarizes the results of the quantitative analysis of project purpose MOEs, based on 2035 traffic information. For each of the two primary project purpose elements (improve mobility and reduce congestion), the table highlights those Alternative Concepts that received no quartile rankings below 3. In other words, these Alternative Concepts performed above the median value for each metric and would therefore have the largest potential for improvement relative to that element of the project purpose. These Alternative Concepts were considered to meet that element of the project purpose. That report found that only the New Location Highway and Hybrid 3 alternatives would meet both primary project purposes. Mass Transit, TDM, and TSM alternative MOEs could not be determined using the TRM and, therefore, were not included in the quartile rankings. The rationale behind excluding those alternatives is discussed in Section 7.1.

The Lochner 2014 approach was used for this revised first tier screening. The updated summary quartile rankings can be found in **Table 1**. Three Alternative Concepts quantitatively met the purpose element of improving mobility: New Location Highway, Improve Existing 3 – Freeway, and Hybrid 1. Two Alternative Concepts met the purpose element of reducing congestion: New Location Highway and Hybrid 3. Only one Alternative Concept met both project purpose elements: New Location Highway. Additionally, the New Location Highway alternative would satisfy the additionally identified desirable outcome of improving system linkage in the regional transportation network, as defined in the Lochner 2014 report.

Based on this reassessment of the first-tier screening using 2040 traffic information, only the New Location Highway Alternative Concept warrants being carried forward. Therefore, the prior conclusions relative to Alternative Concepts in the first-tier screening for the project are supported. All subsequent screening decisions and conclusions relative to alternatives for the project were based on factors other than traffic.

Mass Transit, TDM, and TSM

Each of these alternatives was reconsidered using a methodology consistent with their evaluation in the original Tier 1 Alternative Concepts Screening, updated to reflect currently available planning assumptions. The conclusions from the reconsiderations are presented here. Section 7 of this document explains the methodology and the MOE results for Mass Transit, Travel Demand Management, and Traffic Systems Management that support these conclusions.

The Mass Transit alternative would require changes in the travel behavior of Wake County residents to experience the same MOE improvements produced by the New Location Highway alternative. Although Mass Transit can complement other transportation improvements, the travel demand in the traffic study area exceeds the ability for Mass Transit alone to provide service levels that would match the VHT benefits provided by the New Location Highway alternative.

The TDM alternative involves improvements options such as telecommuting or ridesharing. TDM can complement transportation improvements; however, TDM alone cannot be implemented on a scale necessary to match the VHT benefits provided by the New Location Highway alternative.

The TSM alternative involves minor improvements (signal timing, ramp meters, variable message signs, incident management) meant to maximize the efficiency of traffic flow on highway or larger arterial facilities. Although TSM can complement other transportation improvements, the travel demand in the traffic study area exceeds the ability for TSM alone to provide service levels that would match the VHT benefits provided by the New Location Highway alternative due to the limited amount of TSM-amenable facilities within the traffic study area.

In summary, Mass Transit, TDM, and TSM are not feasible alternatives to meet the project's purpose and need.

Project-Level Traffic Forecast

The No-Build and No-Build ICE MOE comparisons (in Sections 4, 5, 6, and 7) quantitatively assess and compare the degree of potential influence the MPO adopted 2040 SE data and 2040 ICE SE data have on No-Build traffic conditions using the travel demand model assignment output. Resulting travel demand model MOEs for the No-Build ICE alternative concept and the No-Build alternative concept are included in Tables 2 – 8 and in Appendix A.

As explained in Section 2, both of these alternative No-Build concepts utilize the same fiscally constrained roadway and transit networks and future projects. The difference between the alternative concepts is the No-Build alternative concept utilizes the MPO adopted 2040 SE data, and the No-Build ICE alternative concept utilizes the 2040 ICE SE data that was developed as part of the Complete 540 Quantitative ICE study.

As described in the Complete 540 Quantitative ICE study (*ICE Tech Memo 1, Section 2*), the MPO adopted SE data was determined to represent a Build scenario from the perspective of the Complete 540 project. The ICE SE data developed as part of the Complete 540 quantitative ICE study represents a conservative No-Build scenario from the perspective of the Complete 540 project.

The No-Build ICE alternative concept is considered to be a conservative No-Build scenario because it reduces the population and employment projections from the CAMPO adopted total using a research-

based approach. While area planners have stated that they anticipated similar growth would occur with or without the project, reducing population and employment totals for the ICE No-Build maximizes the estimate of potential growth that could be attributed to the project. From a forecasted traffic conditions perspective based on travel demand model output, this methodology of developing and utilizing No-Build ICE SE data unique from the MPO adopted ICE SE data results in the maximum potential effect and change in future No-Build traffic conditions compared to the other alternatives. The results of these comparisons are reported quantitatively in Tables 2-8 and in Appendix A.

Additionally, a project level traffic forecast for the for the New Location Highway Alternative was completed in October 2016. Details of the analysis development are detailed in **Appendix G** of the *Complete 540 Project Level Traffic Forecast*. In general, a FYNB (future year no-build) traffic forecast scenario is provided in a project-level traffic forecast, in conjunction with a FYB (future year build) traffic forecast scenario, to help assess the long-term effect a transportation project would have on area traffic conditions. In this case, the FYNB was evaluated using the ICE No-Build alternative.

As part of the quantitative ICE study, and documented in Sections 5 and 7 of ICE Memo 4, the long-term effect of Complete 540 on area traffic conditions has been quantitatively assessed utilizing a three-tier approach. The results showed that the levels of traffic and patterns of congestion in the project study area (based on comparing the New Location Highway alternative to the ICE No-Build alternative) differed insignificantly from the original comparison with the No-Build alternative.

Based on that assessment, additional project-level traffic forecasting or development of a 2040 FYNB project-level traffic forecast utilizing adopted or ICE SE data do not have the potential to change traffic forecasts used to support the project decisions, and therefore the project-level traffic forecast was not updated.

Table 1: Summary of MOE Quartile Rankings

Alternative Concept	Improve Mobility MOEs			Reduce Congestion MOEs		
	Average Speed - PM	Travel Time from RTP – PM	Travel Time from Brier Creek - PM	Average Daily VHT	Congested VMT – PM	Congested VHT - PM
New Location Highway	4	4	4	4	4	4
Hybrid 1	4	4	3	4	1	4
Hybrid 2	1	1	2	2	2	1
Hybrid 3	3	2	4	3	3	3
Improve Existing 1	1	1	1	1	1	1
Improve Existing 2 - Arterial	1	2	1	1	3	2
Improve Existing 2 - Freeway	2	1	1	1	2	1
Improve Existing 3 - Arterial	2	3	2	2	4	2
Improve Existing 3 - Freeway	3	3	3	3	1	3

4. VEHICLE MILES TRAVELED & VEHICLE HOURS TRAVELED ANALYSIS

As previously mentioned, the TRM was the main tool used to generate, analyze, and calculate the 2040 traffic data used to evaluate MOEs for improving mobility and reducing congestion. Complete TRM model runs were conducted for each alternative concept.

The following sections explain the methodology used to calculate each MOE data set and the results of the calculations.

4.1 Average Daily Vehicle Miles Traveled (VMT) & Vehicle Hours Traveled (VHT)

The VMT and VHT for each modeled alternative concept were extracted from the loaded TRM highway networks. VMT & VHT were calculated for both region-wide model traffic assignment and within the project traffic study area, for comparison purposes, for daily traffic flows. The region-wide totals account for every roadway modeled in the TRM, while the traffic study area only incorporates roadways from the TRM that fall within the traffic study area boundary. VHT provides an MOE for comparing the alternative concepts' ability to meet the project purpose of reducing traffic congestion. The results are shown in **Table 2**.

Table 2: 2040 Average Daily VMT & VHT Comparisons

Alternative Concept	Region Wide				Traffic Study Area			
	VMT (miles)	VHT (hours)	VMT Change	VHT Change	VMT (miles)	VHT (hours)	VMT Change	VHT Change
No-Build ICE	86,544,796	2,233,114	-	-	17,504,053	460,415	-	-
No-Build	87,365,432	2,268,263	0.95%	1.57%	17,835,660	476,120	1.89%	3.41%
New Location Hwy	87,872,949	2,243,677	1.53%	0.47%	18,393,282	458,973	5.08%	-0.31%
Hybrid 1	87,718,470	2,247,585	1.36%	0.65%	18,293,381	462,890	4.51%	0.54%
Hybrid 2	87,712,234	2,259,040	1.35%	1.16%	18,215,294	470,198	4.06%	2.12%
Hybrid 3	87,733,689	2,252,000	1.37%	0.85%	18,249,365	464,976	4.26%	0.99%
Improve 1	87,573,781	2,258,260	1.19%	1.13%	18,110,262	471,818	3.46%	2.48%
Improve 2 - Arterial	87,636,892	2,256,163	1.26%	1.03%	18,194,564	470,774	3.94%	2.25%
Improve 2 - Freeway	87,738,288	2,255,353	1.38%	1.00%	18,319,959	470,947	4.66%	2.29%
Improve 3 - Arterial	87,631,444	2,253,996	1.26%	0.94%	18,197,949	469,187	3.96%	1.91%
Improve 3 - Freeway	87,750,979	2,248,985	1.39%	0.71%	18,354,113	465,979	4.86%	1.21%

4.2 Average Daily Congested Vehicle Miles Traveled & Vehicle Hours Traveled

Daily congested VMT and VHT were identified as a MOE for comparing each alternative concept's ability to meet the project purpose of reducing congestion. The congested VMT and VHT data were extracted from the loaded TRM highway networks. Roadways with daily volume over capacity (VOC) ratios of greater than 0.80 were considered to be "congested" and were included in the data set developed for each alternative concept. A VOC ratio of 0.80 or greater was chosen as the threshold because it typically equals a Highway Capacity Manual Level of Service (LOS) of D or worse. Average daily congested VMT & VHT were calculated region-wide and within the project traffic study area, for comparison purposes. The results are shown in **Table 3**.

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Table 3: 2040 Average Daily Congested VMT & VHT Comparisons

Alternative Concept	Region Wide				Traffic Study Area			
	VMT (miles)	VHT (hours)	VMT Change	VHT Change	VMT (miles)	VHT (hours)	VMT Change	VHT Change
No-Build ICE	25,215,556	623,454	-	-	6,013,710	142,872	-	-
No-Build	26,449,065	658,209	4.89%	5.57%	6,813,758	163,956	13.30%	14.76%
New Location Hwy	24,995,659	611,707	-0.87%	-1.88%	5,288,158	121,783	-12.06%	-14.76%
Hybrid 1	25,359,370	622,598	0.57%	-0.14%	5,745,867	132,742	-4.45%	-7.09%
Hybrid 2	25,718,459	635,163	1.99%	1.88%	5,907,005	139,894	-1.77%	-2.08%
Hybrid 3	25,485,809	626,477	1.07%	0.48%	5,730,014	134,023	-4.72%	-6.19%
Improve 1	24,414,661	616,852	-3.18%	-1.06%	4,832,551	126,278	-19.64%	-11.61%
Improve 2 - Arterial	24,341,520	613,202	-3.47%	-1.64%	4,717,985	122,243	-21.55%	-14.44%
Improve 2 - Freeway	24,379,310	613,219	-3.32%	-1.64%	4,730,520	122,158	-21.34%	-14.50%
Improve 3 - Arterial	24,268,203	610,445	-3.76%	-2.09%	4,661,106	120,543	-22.49%	-15.63%
Improve 3 - Freeway	24,240,860	607,622	-3.87%	-2.54%	4,533,326	115,862	-24.62%	-18.91%

4.3 PM Peak Congested Vehicle Miles Traveled & Vehicle Hours Traveled

While daily congested VMT and VHT statistics provide useful MOE for comparison between alternative concepts, the PM peak period conditions were also examined to further evaluate impacts on reducing congestion. The PM peak period in the TRM assigns traffic on network roadways from 3:00 PM to 7:00 PM. The 2040 PM peak highway assignments from the TRM for each alternative were used to calculate totals for both region-wide and within the traffic study area. Roadways need only a PM Peak VOC of 0.80 or higher compared to that of a daily VOC above 0.80. The results are shown in **Table 4**.

Table 4: 2040 Average PM Peak Congested VMT & VHT Comparisons

Alternative Concept	Region Wide				Traffic Study Area			
	VMT (miles)	VHT (hours)	VMT Change	VHT Change	VMT (miles)	VHT (hours)	VMT Change	VHT Change
No-Build ICE	13,738,032	408,111	-	-	3,471,245	108,220	-	-
No-Build	14,021,753	421,672	2.07%	3.32%	3,591,552	114,428	3.47%	5.74%
New Location Hwy	13,717,015	397,827	-0.15%	-2.52%	3,399,985	97,211	-2.05%	-10.17%
Hybrid 1	13,762,707	402,516	0.18%	-1.37%	3,495,492	102,034	0.70%	-5.72%
Hybrid 2	13,889,335	411,230	1.10%	0.76%	3,485,348	106,278	0.41%	-1.79%
Hybrid 3	13,840,981	406,240	0.75%	-0.46%	3,460,243	102,615	-0.32%	-5.18%
Improve 1	13,872,427	412,125	0.98%	0.98%	3,514,280	108,815	1.24%	0.55%
Improve 2 - Arterial	13,780,064	408,178	0.31%	0.02%	3,442,158	105,686	-0.84%	-2.34%
Improve 2 - Freeway	13,790,904	407,828	0.38%	-0.07%	3,468,444	105,921	-0.08%	-2.12%
Improve 3 - Arterial	13,762,436	406,608	0.18%	-0.37%	3,424,467	104,322	-1.35%	-3.60%
Improve 3 - Freeway	13,787,091	403,936	0.36%	-1.02%	3,494,992	103,466	0.68%	-4.39%

5. AVERAGE SPEED ANALYSIS

Average network speed is a useful MOE in evaluating and comparing the ability of alternative concepts to meet the project purpose of improving mobility. The TRM was used to calculate the average 2040 speeds for each alternative concept. The average daily and average PM peak speeds were calculated by dividing the VMT totals by the VHT totals.

5.1 Average Daily Speed

2040 average daily speeds were calculated using TRM output. The results for all model alternative concepts are shown in **Table 5**.

Table 5: 2040 Average Daily Speed Comparisons

Alternative Concept	Region Wide		Traffic Study Area	
	Speed (MPH)	Speed Change	Speed (MPH)	Speed Change
No-Build ICE	38.8	-	38.0	-
No-Build	38.5	-0.62%	37.5	-1.47%
New Location Hwy	39.2	1.06%	40.1	5.41%
Hybrid 1	39.0	0.70%	39.5	3.95%
Hybrid 2	38.8	0.19%	38.7	1.90%
Hybrid 3	39.0	0.52%	39.2	3.24%
Improve 1	38.8	0.06%	38.4	0.96%
Improve 2 - Arterial	38.8	0.23%	38.6	1.66%
Improve 2 - Freeway	38.9	0.38%	38.9	2.32%
Improve 3 - Arterial	38.9	0.32%	38.8	2.02%
Improve 3 - Freeway	39.0	0.68%	39.4	3.60%

5.2 Average PM Peak Speed

2040 PM peak average speeds were calculated using the TRM outputs. The PM peak average speeds are the PM peak VMT divided by the PM peak VHT. The results for all alternative concepts are shown in **Table 6**.

Table 6: 2040 Average PM Peak Speed Comparisons

Alternative Concept	Region Wide		Traffic Study Area	
	Speed	Speed Change	Speed	Speed Change
No-Build ICE	35.4	-	33.7	-
No-Build	35.1	-0.83%	33.1	-1.90%
New Location Hwy	35.9	1.61%	36.4	7.93%
Hybrid 1	35.8	1.10%	35.6	5.67%
Hybrid 2	35.5	0.28%	34.6	2.70%
Hybrid 3	35.6	0.78%	35.3	4.65%
Improve 1	35.4	0.12%	34.2	1.37%
Improve 2 - Arterial	35.5	0.37%	34.5	2.40%
Improve 2 - Freeway	35.6	0.52%	34.8	3.05%
Improve 3 - Arterial	35.6	0.51%	34.7	2.95%
Improve 3 - Freeway	35.7	0.98%	35.4	4.85%

6. CONGESTED ROADWAY MILEAGE

6.1 Daily Congested Roadway Mileage

The total daily congested roadway lane mileage, another MOE for evaluating reduction in congestion, was determined using the TRM. Model runs were used to calculate roadways in the highway network with a daily VOC above 0.80. The results are shown below in **Table 7**.

Table 7: 2040 Daily Congested Roadway Lane Mileage

Alternative Concept	Region Wide		Study Area	
	Lane Mileage	Change	Lane Mileage	Change
No-Build ICE	564.6	-	115.9	-
No-Build	589.9	4.48%	130.9	12.94%
New Location Hwy	562.6	-0.35%	102.8	-11.30%
Hybrid 1	571.6	1.24%	110.5	-4.66%
Hybrid 2	573.4	1.56%	110.2	-4.92%
Hybrid 3	571.1	1.15%	109.8	-5.26%
Improve 1	555.7	-1.58%	98.7	-14.84%
Improve 2 - Arterial	553.4	-1.98%	95.6	-17.52%
Improve 2 - Freeway	555.7	-1.58%	95.6	-17.52%
Improve 3 - Arterial	554.4	-1.81%	95.4	-17.69%
Improve 3 - Freeway	555.5	-1.61%	93.4	-19.41%

6.2 PM Peak Congested Roadway Lane Mileage

The total PM peak congested roadway lane mileage was determined using the TRM. Model runs were used to calculate roadways in the highway network with a PM peak VOC above 0.80. The PM peak totals were much higher than the daily totals. The results are show below in **Table 8**.

Table 8: 2040 PM Peak Congested Roadway Lane Mileage

Alternative Concept	Region Wide		Study Area	
	Lane Mileage	% Change	Lane Mileage	% Change
No-Build ICE	1,350.1	-	315.9	-
No-Build	1,384.7	2.56%	328.1	3.86%
New Location Hwy	1,339.1	-0.81%	307.4	-2.69%
Hybrid 1	1,348.3	-0.13%	315.7	-0.06%
Hybrid 2	1,355.1	0.37%	305.8	-3.20%
Hybrid 3	1,344.5	-0.41%	300.6	-4.84%
Improve 1	1,358.4	0.61%	311.4	-1.42%
Improve 2 - Arterial	1,345.7	-0.33%	301.6	-4.53%
Improve 2 - Freeway	1,342.5	-0.56%	300.8	-4.78%
Improve 3 - Arterial	1,345.2	-0.36%	302.8	-4.15%
Improve 3 - Freeway	1,337.3	-0.95%	301.3	-4.62%

7. MASS TRANSIT, TRAVEL DEMAND MANAGEMENT, AND TRAFFIC SYSTEMS MANAGEMENT ANALYSIS

The following sections provide explanations on the methodology used to analyze the MOEs for Mass Transit, Travel Demand Management, and Traffic Systems Management as well as the MOE results.

7.1 Mass Transit

Model runs were not done for the mass transit alternative for all the MOEs. A detailed transit study would be needed to assess transit routes and service characteristics required by the TRM. Instead, requirements to improve the existing transit system in the Triangle needed to meet the New Location Highway alternative VHT reduction (compared to the No-Build ICE alternative) were estimated using the following assumptions.

- According to the 2040 No-Build ICE TRM run, the average work trip in 2040 is projected to be 12 miles in length and take 28 minutes. The TRM only calculates these values on a region-wide basis.
- The average bus can accommodate 50 passengers.³
- The average light rail train can accommodate 150 passengers.⁴
- A vehicle occupancy rate of one (1.0) persons per vehicle was used to conservatively calculate the maximum equivalent transit capacity needed (total daily number of buses and light rail trains).
- The bus or light rail equivalents were converted to private vehicle trips by first converting the VHT differences between the New Location Highway alternative and No-Build ICE alternative to minutes. The total minutes were then divided by 28, the average time for a work trip. The resulting totals were then divided by 50 for buses and 150 light rail trains, the average capacity of both, to estimate the number of fully loaded bus or light rail trains required to remove the same amount of private vehicle trips from the roadway network that would equal the VHT benefits provided by the New Location Highway alternative.

GoTriangle, the Triangle's regional transit provider, currently has 14 regional and 10 express transit routes region-wide that run more than 500 buses daily. Only four of those routes (60 buses daily) enter the traffic study area. The buses rarely are used at full-capacity.

It should be noted that the effect of the number-of-buses estimate on the MOE used in this analysis is very favorable to transit because it does not take into account the likelihood that the added buses themselves in the numbers necessary to achieve the proposed improvements would contribute to congestion and delay in the traffic study area. In addition, In-vehicle travel time for bus travelers will not be lower than for private auto travel.

Taking these assumptions into account, for the traffic study area VHT changes to equal that of the New Location Highway alternative when compared to the No-Build ICE alternative, the following mass transit improvements would be required for each MOE:

2040 Average Daily VHT - Nearly 100 additional buses (at maximum capacity) or over 30 additional full light rail trains (at maximum capacity) would be needed on a daily basis to equal the 1,442 less VHT produced by the New Location Highway alternative when compared to the No-Build ICE alternative. These basic analyses also imply that the transit capacity provided is at full loading – in reality, additional bus/train capacity would be required to provide adequate service for these demand estimates. This

³ Patrick McDonough, GoTriangle, Personal Communication, December 12, 2017, HNTB North Carolina, P.C.

⁴ Patrick McDonough, GoTriangle, Personal Communication, December 12, 2017, HNTB North Carolina, P.C.

would require a minimum increase of over 100 percent in buses run compared to the current service. Triangle Transit currently has no light rail service and providing service would entail a project comparable in scope to Complete 540 itself.

2040 Average Daily Congested VHT - The traffic study area would require approximately 900 additional buses or 300 light rail trains, both at maximum capacity, on a daily basis to equal the 21,089 less VHT produced by the New Location Highway alternative when compared to the No-Build ICE alternative. Triangle Transit currently has no light rail service

2040 Average PM Peak Congested VHT - The traffic study area would require nearly 500 additional buses and over 150 light rail trains, both at maximum capacity during the PM Peak period to equal the 11,009 less VHT produced by the New Location Highway alternative when compared to the No-Build ICE alternative.

2040 Average Daily Speed - Additional mass transit could potentially improve average daily speeds in the traffic study area, by removing some number of cars from the road. The number of buses required to achieve the performance of the New Location Highway alternative would be similar to that required to achieve VHT improvements. However, a substantially higher percentage of buses could potentially decrease speeds on the major arterial facilities in the highway network, due to their slower acceleration/deceleration characteristics and increased amount of stops along arterial facilities.

2040 Average PM Peak Speed - Additional mass transit could potentially improve average PM Peak speeds in the traffic study area, by removing some number of cars from the road. The number of buses required to achieve the performance of the New Location Highway alternative would be similar to that required to achieve VHT improvements. However, a substantially higher percentage of buses could potentially decrease speeds on the major arterial facilities in the highway network, due to their slower acceleration/deceleration characteristics and increased amount of stops along arterial facilities.

2040 Daily Congested Roadway Mileage - Additional mass transit could potentially improve daily congested roadway mileage in the traffic study area, by removing some number of cars from the road. The number of buses required to achieve the performance of the New Location Highway alternative would be similar to that required to achieve VHT and Speed improvements. However, a substantially higher percentage of buses could potentially decrease speeds on the major arterial facilities in the highway network, due to their slower acceleration/deceleration characteristics and increased amount of stops along arterial facilities.

2040 PM Peak Congested Roadway Mileage - Additional mass transit could potentially improve PM Peak congested roadway mileage in the traffic study area, by removing some number of cars from the road. The number of buses required to achieve the performance of the New Location Highway alternative would be similar to that required to achieve VHT and Speed improvements. However, a substantially higher percentage of buses could potentially decrease speeds on the major arterial facilities in the highway network, due to their slower acceleration/deceleration characteristics and increased amount of stops along arterial facilities.

The Mass Transit alternative would require changes in the travel behaviors of Wake County residents to experience the same MOE improvements produced by the New Location Highway alternative. The average Daily Congested VHT MOE would require approximately 45,000 workers in the traffic study area (22 percent) to shift to a daily mass transit option to equal the VHT benefits of the New Location Highway alternative. The average PM Peak Congested VHT MOE would require approximately 24,000 workers in the traffic study area (12 percent) to shift to a daily mass transit option to equal the VHT

benefits of the New Location Highway alternative.

Total daily passenger boardings for all transit providers serving Wake County saw an increase of less than one percent from 2012 (54,825 daily boardings) to 2015 (55,029 daily boardings). The latest American Community Survey data showed that in 2016 only 1.3 percent of Wake County residents use transit as a mode to commute to and from their place of employment.

The traffic study area also has minimal planned mass transit improvement in the future. The CAMPO 2040 MTP and recent Wake County Transit Plan (2016) show planned improvements of a peak-period commuter rail service from Garner to Durham and peak-period only bus routes from downtown Raleigh to Holly Springs and Fuquay-Varina.

The data presented above show that although Mass Transit can complement other transportation improvements, the travel demand in the traffic study area exceeds the ability for Mass Transit alone to provide service levels that would match the VHT benefits provided by the New Location Highway alternative.

7.2 Travel Demand Management

Travel Demand Management (TDM) was also not specifically modeled in the TRM. TDM improvements include options such as telecommuting or ridesharing. TDM is included for all the modeled alternatives at a fixed rate reflecting TDM usage in the model base year. However, the TRM is not able to forecast TDM response to new initiatives in the future. The TRM is designed to address roadway and transit projects, while TDM improvements are primarily policy-based programs that cannot explicitly be captured as inputs to the TRM. Similar to the mass transit alternative methodology outlined above, the 2040 work trip attributes, along with projected employment totals in each TAZ, were used to calculate the threshold needed to meet the New Location Highway Alternative VHT reduction compared to the No-Build ICE alternative. The 2040 traffic study area employment projection is 207,000^{4,5}. According to the TRM, the average work trip for the 2040 No-Build ICE alternative is projected to be 12 miles in length and take 28 minutes. The TRM only calculates these values on a region-wide basis.

There are several barriers to achieving large telecommuting or ridesharing results. For example, many types of jobs, such as industrial or medical, could not be performed via telecommuting. Studies also show that those who telecommute often make many trips throughout the day that would not normally be made if they worked in an office⁶.

The latest American Community Survey data showed that in 2016 already 8.1 percent of Wake County residents carpool to work and 8.5 percent work from home, both forms of TDM. The current levels of TDM usage is already accounted for in TRM runs for all of the highway alternative MOEs.

Taking these assumptions into account, for the traffic study area VHT changes to equal that of the New Location Highway alternative, the following TDM improvements would be required for each MOE:

2040 Average Daily VHT - 3,100 workers in the traffic study area would need to shift to TDM daily to equal the VHT reductions achieved by the New Location Highway alternative. These employment estimates were calculated by converting the New Location Highway alternative concept VHT reductions to total travel minutes and then dividing them by 28, the average time for a 2040 work trip.

⁵ 2040 Triangle Regional Model Socioeconomic Data

⁶ Travel Demand Management: An Analysis of the Effectiveness of TDM Plans in Reducing Traffic and Parking in the Minneapolis-St. Paul Region (2010); Spack Consulting

2040 Average Daily Congested VHT - The traffic study area would require the use of TDM by over 45,000 employees daily to equal the VHT reductions achieved by the New Location Highway alternative. These employment estimates were calculated by converting the New Location Highway alternative concept VHT reductions to total travel minutes and then dividing them by 28, the average time for a 2040 work trip.

2040 Average PM Peak Congested VHT - The traffic study area would require nearly 24,000 employees to use TDM during the PM peak to equal the VHT reductions achieved by the New Location Highway alternative. These employment estimates were calculated by converting the New Location Highway alternative concept VHT reductions to total travel minutes and then dividing them by 28, the average time for a 2040 work trip.

2040 Average Daily Speed - TDM could potentially improve average daily speeds in the traffic study area, by removing some number of cars from the road. The number of employees required to use TDM to achieve the performance of the New Location Highway alternative would be similar to that required to achieve VHT improvements. However, a substantially higher percentage of buses could potentially decrease speeds on the major arterial facilities in the highway network, due to their slower acceleration/deceleration characteristics and increased amount of stops along arterial facilities.

2040 Average PM Peak Speed - TDM could potentially improve average PM Peak speeds in the traffic study area, by removing some number of cars from the road. The number of employees required to use TDM to achieve the performance of the New Location Highway alternative would be similar to that required to achieve VHT improvements. However, a substantially higher percentage of buses could potentially decrease speeds on the major arterial facilities in the highway network, due to their slower acceleration/deceleration characteristics and increased amount of stops along arterial facilities.

2040 Daily Congested Roadway Mileage - TDM could provide improvements to the congested roadway network in the traffic study area. However, these improvements would likely be very minor when compared to the construction of the New Location Highway alternative considering the percent of workers that would need to shift to TDM (please see the conclusions to the TDM discussion below).

2040 PM Peak Congested Roadway Mileage - As discussed above with the daily congested roadway mileage MOE, TDM could provide improvements to the congested roadway network in the traffic study area. However, these improvements would likely be very minor when compared to the construction of the New Location Highway alternative considering the percent of workers that would need to shift to TDM.

TDM can serve to complement transportation improvements; however, TDM alone cannot be implemented on a scale necessary to match the VHT benefits provided by the New Location Highway alternative. More than 16 percent of Wake County residents already use TDM. An additional 21 percent and 12 percent of traffic study area employees would need to shift to TDM to provide the same VHT benefits for the New Location Highway alternative for the Daily Congested VHT and PM Peak Congested VHT, respectively.

7.3 Traffic Systems Management

Traffic Systems Management (TSM) was also estimated without a specific TRM model run. TSM involves minor improvements (signal timing, ramp meters, variable message signs, incident management)

meant to maximize the efficiency of traffic flow on highway or larger arterial facilities. Because these improvements are localized and can be very specific to changing traffic conditions, they cannot be modeled at a “macro” level in a regional travel demand model. TSM improvements are better measured for specific locations in microscopic traffic simulation programs or through deterministic Highway Capacity Manual (HCM) techniques. Specific TSM studies⁷ conducted in similar areas to that of the Complete 540 study area show that TSM improvements, on average, can increase the speeds on the improved facilities by 2 to 3 percent in areas similar in size to the Research Triangle. A study done specifically to study ramp metering feasibility in the Research Triangle showed that this TSM measure increased peak hour travel time only on the freeway facilities with the ramp metering by ten percent in Atlanta, Georgia and Arlington, Virginia in current conditions⁸. The TRM modeled network in the No-Build ICE scenario was used to identify miles of facilities amenable to TSM improvement. It should be noted that TSM improvements are designed for congested periods and will have little to no impact on daily totals.

Taking these assumptions into account, TSM could possibly have the following MOEs:

2040 Average Daily VHT - Approximately 43 percent of traffic study area VHT occur on TSM-amenable facilities⁹. TSM alternative concepts would also not feasibly be able to reduce daily VHT impacts on a similar scale as the New Location Highway alternative. In order to match the New Location Highway alternative benefits, the TSM alternative would need to reduce VHT on TSM-amenable facilities by 600 VHT. This would require an increase of speeds on TSM-amenable facilities by approximately 3 percent.

2040 Average Daily Congested VHT - TSM alternative concepts would also not feasibly be able to reduce daily congested VHT impacts on a similar scale as the New Location Highway alternative. In order to match the New Location Highway alternative benefits, the TSM alternative would need to reduce VHT on TSM-amenable facilities by 11,000 VHT. This would require an increase of speeds on TSM-amenable facilities by approximately 34 percent.

2040 Average PM Peak Congested VHT - TSM alternative concepts would also not feasibly reduce congested PM peak VHT impacts on a similar scale as the New Location Highway alternative. In order to match the New Location Highway alternative benefits, the TSM alternative would need to reduce VHT on TSM-amenable facilities by 4,600 VHT. This would require an increase of speeds on TSM-amenable facilities by approximately 58 percent.

2040 Average Daily Speed - While TSM could improve average daily speeds on freeways/expressways and major arterials, these facilities only account for 26 percent of traffic study area roadway facilities in the 2040 TRM. The average daily speed on TSM-amenable facilities would need to be increased by 14 percent for the No-Build ICE alternative speeds to equal the daily speeds of the New Location Highway alternative.¹⁰

2040 Average PM Peak Speed - While TSM could improve average PM Peak speeds on

⁷ New Mississippi River Bridge Traffic Analysis Report (2004); HNTB

⁸ M-0446 Ramp Metering Feasibility Study for Durham and Wake Counties (2013); Atkins

⁹ Triangle Regional Model V5 2040 No-Build ICE model run output.

¹⁰ The required speed increases were calculated by using the New Location Highway alternative speed as a target speed. The overall VMT was divided by the target speed in order to calculate a target VHT. The target VHT was then split into TSM-amenable and Non-TSM-amenable. The target speed on TSM-amenable facilities was then calculated by dividing TSM-amenable VMT by TSM-amenable target VHT. Finally, the percentage in speed change was calculated by dividing the TSM-amenable target speed by the overall traffic study area speed from the No-Build ICE alternative.

freeways/expressways and major arterials, these facilities only account for 26 percent of traffic study area roadway facilities in the 2040 TRM. The average PM Peak speed on TSM-amenable facilities would need to be increased by 19 percent for the No-Build ICE alternative speeds to equal the PM peak speeds of the New Location Highway alternative¹⁰.

2040 Daily Congested Roadway Mileage - TSM could provide improvements to the daily congested roadway network in the traffic study area, but TSM is designed to improve congested time periods. Approximately 80 percent of the daily congested roadway mileage occurs on TSM-amenable facilities. Approximately 34 percent of the daily congested TSM-amenable facilities have a VOC between 0.8 and 0.9. Roughly one-third of those facilities would then need to experience an approximate daily roadway capacity increase of ten percent due to TSM in order to match the benefits provided by the New Location Highway alternative from a daily perspective.

2040 PM Peak Congested Roadway Mileage - TSM could provide improvements to the PM Peak congested roadway network in the traffic study area. Approximately 65 percent of the PM Peak congested roadway mileage occurs on TSM-amenable facilities. Approximately 25 percent of the PM Peak congested TSM-amenable facilities have a VOC between 0.8 and 0.9. Roughly twenty percent of those facilities would then need to experience an approximate PM Peak roadway capacity increase of ten percent due to TSM in order to match the benefits provided by the New Location Highway alternative from a PM Peak perspective.

The MOE evaluations presented above show that, although TSM can complement other transportation improvements, the travel demand in the traffic study area exceeds the ability for TSM alone to provide service levels that would match the VHT benefits provided by the New Location Highway alternative due to the limited amount (26 percent) of TSM-amenable facilities within the traffic study area. The studies state that TSM improvements can improve peak travel time and speeds by up to ten percent only on the TSM-amenable facilities in current conditions. Nearly all of the MOE changes needed to equal the benefits of the New Location Highway exceed that percentage.

8. TRAVEL TIME ANALYSIS

Travel time for average individual trips between representative origins and destinations is a useful MOE for evaluating how alternative concepts meet the project purpose of improving mobility in the traffic study area. The TRM was used to calculate 2040 travel times for the AM and PM peak periods between the origins and destinations listed below. These origins and destinations include employment centers and the more densely populated residential land uses within the region and traffic study area and as such were selected because they have high concentrations of population and employment. The following origins and destinations were also studied in the 2011 study and are shown in **Figure 2**.

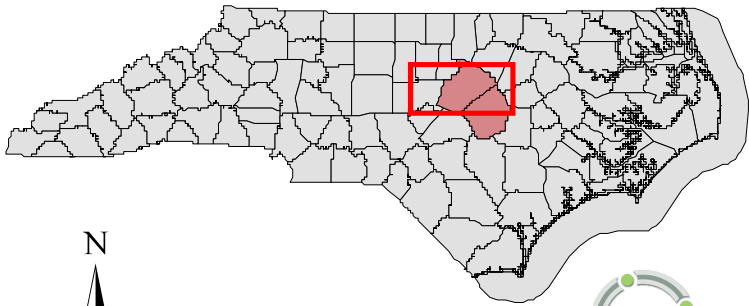
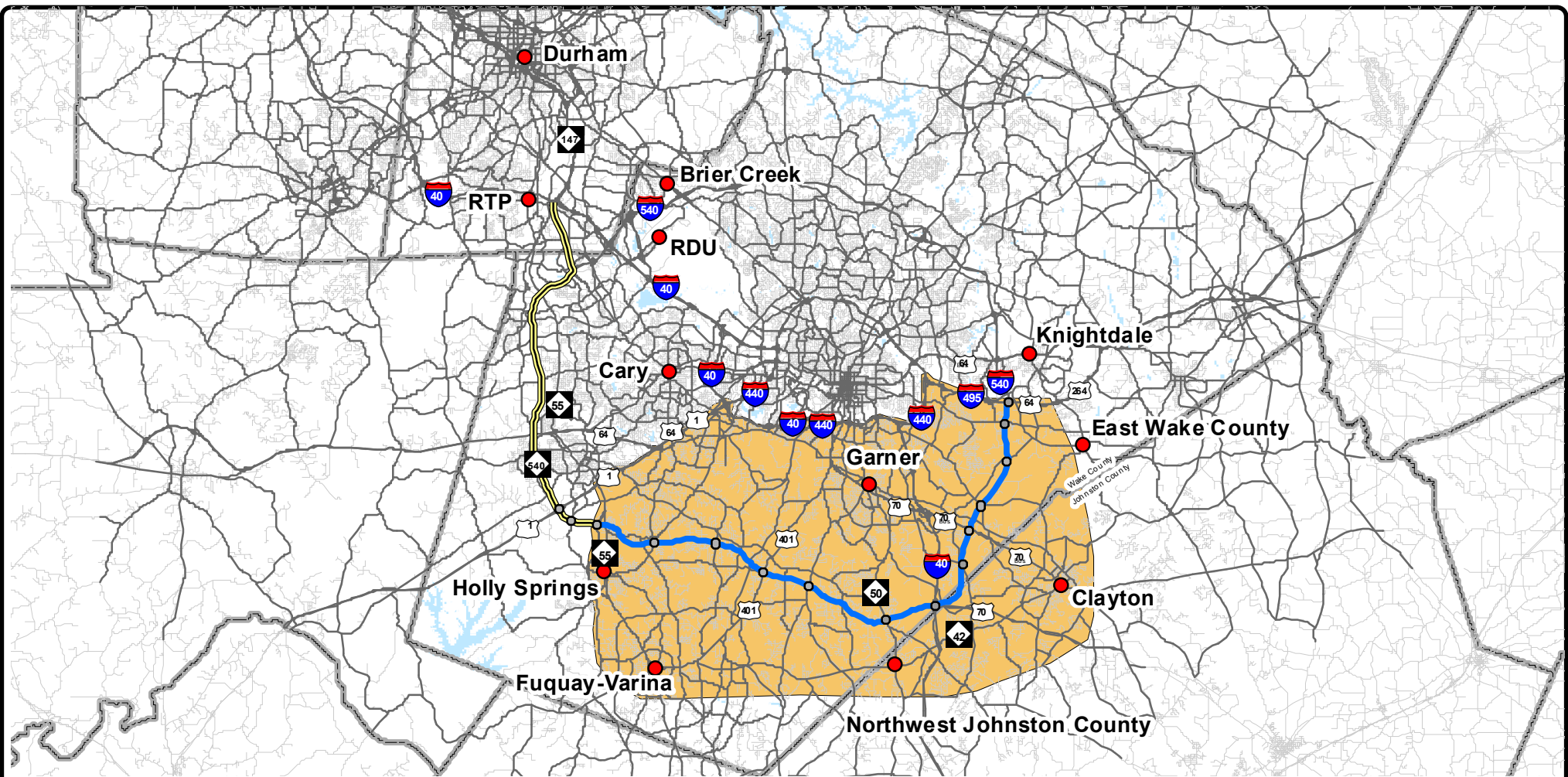
- Holly Springs (Main Street & Holly Springs Road) - Within Traffic Study Area
- Fuquay-Varina (US 401 & Ennis Street) - Within Traffic Study Area
- Garner (Garner Road & Vandora Springs Road) - Within Traffic Study Area
- Clayton (US 70 Business & NC 42) - Within Traffic Study Area
- Knightdale (US 64 Business & Smithfield Road) - Outside of Traffic Study Area
- Eastern Wake County (Smithfield Road & Grasshopper Road) - Outside of Traffic Study Area
- Northwestern Johnston County (NC 50 & NC 42) - Within Traffic Study Area

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- Research Triangle Park (NC 55 & NC 54) - Outside of Traffic Study Area
- RDU Airport (Airport Boulevard & International Drive) - Outside of Traffic Study Area
- Brier Creek (US 70 & Brier Creek Parkway) - Outside of Traffic Study Area
- Durham (Chapel Hill Street & Mangum Street) - Outside of Traffic Study Area
- Cary (Academy Street & Chatham Street) - Outside of Traffic Study Area

Not all pairs of origins and destinations traverse the study area, but they are included to provide a regional picture of the project's effect on typical travel demand over the entire region. Some of the pairs of origins and destinations will naturally be more affected by the project than others. Trip pairs, particularly in northwestern Wake County and Durham County, experience little to no travel time effects regardless of which alternative is analyzed. Trips pairs of greater length and that traverse the study area usually experience the greatest travel time differences between the different alternatives.

The complete results of the travel time calculations can be found in *Appendix A*. The tables represent minutes of travel for a representative trip in the given time period. The alternative concepts each had some degree of positive impact on the travel times when compared to those of the No-Build ICE alternative. The New Location Highway alternative provided the largest travel time reductions over the No-Build alternative for long-distance trips that traverse the traffic study area and for southern and eastern Wake County by providing a high-speed regional mobility connection. For instance, the PM peak travel time for a trip from Durham to northwestern Johnston County is reduced by 15 minutes in the New Location Highway alternative compared to the No-Build ICE. Another example is that the PM peak travel time from Holly Springs to eastern Wake County drops by 23 minutes with the New Location Highway alternative in place. However, some travel times experienced little change, particularly for a trip with both an origin and a destination in the western part of the traffic study.



Complete 540 First Tier Screening Travel Time Locations

Legend	
	Traffic Study Area
	Triangle Expressway
	Complete 540
	Travel Time Locations
	Major Roads
	Counties

STIP: R-2721, R-2828, R-2829	WBS: 37673.1.TA2, 35516.1.TA2, 35517.1.TA1
COUNTY: Wake/Johnston	DIVISION: 5/4
DATE: December 2017	
PREPARED BY:	HNTB North Carolina, P.C. 343 E. Six Forks Rd, Suite 200 Raleigh, NC 27609
LOCATION:	NC 55 Bypass (Holly Springs) to I-495 / US 64 Bypass / US 264 (Knightdale)
PROJECT: Complete 540 Triangle Expressway Southeast Extension	Figure 2

APPENDIX A

Travel Time Calculations

2040 Alternatives Analysis AM Travel Times

Origin: Holly Springs (Main St. & Holly Springs Rd.)

Destination	Alternatives										
	No-Build ICE	No-Build	New Location Highway	Hybrid 1	Hybrid 2	Hybrid 3	Improve Existing 1	Improve Existing 2A	Improve Existing 2F	Improve Existing 3A	Improve Existing 3F
Fuquay-Varina	7.0	7.0	7.0	7.0	7.1	7.0	7.0	7.0	7.1	7.0	7.0
Garner	29.6	29.7	23.2	23.3	29.5	26.1	29.7	29.6	29.4	28.8	26.1
Clayton	37.2	37.9	23.5	23.5	30.7	29.5	38.4	33.7	31.0	34.4	29.5
Knightdale	40.5	40.5	30.2	40.8	40.1	36.3	40.1	40.0	40.0	40.1	40.1
E Wake County	42.4	42.3	29.0	35.8	41.3	35.1	41.7	41.7	41.6	41.8	41.7
NW John. Co.	25.1	25.2	18.1	18.1	20.1	24.6	25.3	22.6	20.1	25.1	24.6
RTP	32.8	32.8	33.4	33.8	32.8	33.0	32.6	32.7	32.7	32.4	32.7
RDU	33.0	33.1	33.5	33.9	33.0	33.1	32.9	32.9	32.9	32.6	32.8
Brier Creek	33.5	33.6	34.0	34.3	33.5	33.6	33.3	33.4	33.4	33.1	33.3
Durham	42.9	43.0	43.5	43.9	42.9	43.1	42.9	42.9	42.9	42.6	42.8
Cary	26.1	26.2	26.7	26.9	26.1	26.3	26.0	26.1	26.1	262	26.2

2040 Alternatives Analysis PM Travel Times

Origin: Holly Springs (Main St. & Holly Springs Rd.)

Destination	Alternatives										
	No-Build ICE	No-Build	New Location Highway	Hybrid 1	Hybrid 2	Hybrid 3	Improve Existing 1	Improve Existing 2A	Improve Existing 2F	Improve Existing 3A	Improve Existing 3F
Fuquay-Varina	17.9	19.0	15.3	15.5	19.0	17.2	18.3	18.3	18.6	17.7	16.8
Garner	34.3	35.4	25.3	25.4	34.0	32.3	34.5	33.7	33.5	33.2	31.9
Clayton	51.8	54.0	32.5	32.5	45.6	45.6	51.7	46.6	45.2	47.7	44.6
Knightdale	61.2	63.5	39.0	50.9	57.7	52.1	59.3	58.7	58.6	57.9	56.8
E Wake County	59.4	61.8	36.0	45.6	54.7	49.2	58.9	57.9	57.7	57.4	56.0
NW John. Co.	41.1	43.6	26.8	26.9	35.1	37.7	41.8	35.6	34.3	39.0	36.9
RTP	21.3	21.3	21.2	21.3	21.3	21.4	21.3	21.3	21.3	21.4	21.4
RDU	23.7	23.7	23.5	23.5	23.7	23.7	23.7	23.6	23.7	23.7	23.7
Brier Creek	24.8	25.0	24.5	24.6	24.9	24.9	24.8	24.8	24.7	24.8	24.8
Durham	30.9	31.0	30.8	30.9	30.9	31.0	30.9	30.9	30.9	31.0	31.0
Cary	18.2	18.3	17.6	17.7	18.2	17.7	18.4	18.3	18.3	17.9	17.8

2040 Alternatives Analysis AM Travel Times

Origin: Fuquay-Varina (US 401 & Ennis St.)

Alternatives

Destination	No-Build ICE	No-Build	New Location Highway	Hybrid 1	Hybrid 2	Hybrid 3	Improve Existing 1	Improve Existing 2A	Improve Existing 2F	Improve Existing 3A	Improve Existing 3F
Holly Springs	15.9	16.5	14.0	14.2	16.7	15.3	16.3	16.1	16.4	15.7	15.0
Garner	27.0	27.2	26.9	27.0	25.5	26.3	27.2	26.2	25.5	26.5	26.4
Clayton	30.7	31.3	27.3	27.3	23.9	29.4	31.9	26.7	24.2	30.0	29.6
Knightdale	45.8	46.3	34.0	44.6	35.8	36.5	45.9	45.1	44.4	45.4	45.0
E Wake County	43.4	43.8	32.9	39.6	34.6	35.3	43.6	39.5	37.0	42.8	41.9
NW John. Co.	18.6	18.6	18.6	18.6	13.4	18.4	18.7	15.6	13.4	18.6	18.4
RTP	48.3	48.9	46.6	47.2	49.0	47.6	48.3	48.2	48.6	47.5	47.1
RDU	48.5	49.2	46.7	47.3	49.2	47.7	48.5	48.4	48.8	47.7	47.2
Brier Creek	49.0	49.7	47.2	47.7	49.7	48.2	49.0	48.9	49.3	48.1	47.7
Durham	58.4	59.1	56.7	57.3	59.1	57.7	58.5	58.4	58.8	57.6	57.2
Cary	40.3	41.3	39.0	39.1	41.1	39.7	40.6	40.7	40.9	40.4	39.4

2040 Alternatives Analysis PM Travel Times

Origin: Fuquay-Varina (US 401 & Ennis St.)

Alternatives

Destination	No-Build ICE	No-Build	New Location Highway	Hybrid 1	Hybrid 2	Hybrid 3	Improve Existing 1	Improve Existing 2A	Improve Existing 2F	Improve Existing 3A	Improve Existing 3F
Holly Springs	8.1	8.2	8.1	8.1	8.3	8.1	8.2	8.2	8.3	8.2	8.1
Garner	23.5	23.8	22.7	22.8	22.7	23.3	23.7	23.2	22.5	23.4	23.2
Clayton	36.1	37.8	30.4	30.4	27.0	34.0	36.7	28.7	48.4	34.9	33.9
Knightdale	53.9	55.6	36.9	48.8	39.0	43.1	52.7	50.3	48.4	52.2	51.9
E Wake County	48.6	50.2	33.9	43.5	36.1	40.2	48.1	42.9	41.1	47.6	47.3
NW John. Co.	24.9	26.3	21.5	21.5	16.4	23.2	25.3	17.7	16.0	23.7	22.8
RTP	28.5	28.6	28.4	28.3	28.8	28.6	28.6	28.6	28.8	28.6	28.6
RDU	30.9	31.0	30.6	30.6	31.2	30.9	30.9	30.9	31.2	31.0	30.9
Brier Creek	32.0	32.3	31.7	31.6	32.4	32.1	32.0	32.0	32.2	32.1	32.0
Durham	38.1	38.3	37.9	37.9	38.4	38.2	38.2	38.2	38.4	38.3	38.2
Cary	25.7	25.8	25.3	25.4	25.7	25.6	25.9	25.8	25.7	25.8	25.6

2040 Alternatives Analysis AM Travel Times

Origin: Garner (Garner Rd. & Vandora Springs Rd.)

Destination	Alternatives										
	No-Build ICE	No-Build	New Location Highway	Hybrid 1	Hybrid 2	Hybrid 3	Improve Existing 1	Improve Existing 2A	Improve Existing 2F	Improve Existing 3A	Improve Existing 3F
Holly Springs	31.5	32.4	23.1	23.2	31.4	29.6	31.7	31.3	31.1	30.8	29.1
Fuquay-Varina	21.8	22.0	21.4	21.4	21.0	21.6	21.9	21.4	20.8	21.8	21.6
Clayton	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1
Knightdale	22.7	23.2	16.6	21.8	16.7	16.7	22.4	22.3	22.3	22.2	21.8
E Wake County	18.3	18.4	15.5	17.9	15.5	15.5	18.1	18.1	18.1	18.0	17.9
NW John. Co.	12.3	12.3	12.2	12.2	12.2	12.3	12.3	12.2	11.9	12.2	12.2
RTP	40.0	40.8	37.9	38.2	40.2	39.4	40.0	39.8	39.9	39.5	39.0
RDU	36.3	37.0	34.3	34.6	36.4	35.7	36.2	36.1	36.2	35.7	35.2
Brier Creek	38.5	39.3	36.6	36.8	38.7	38.0	38.5	38.4	38.4	38.0	37.5
Durham	49.0	49.7	47.0	47.2	49.1	48.4	49.0	48.9	48.9	48.5	48.0
Cary	29.1	29.8	27.4	27.7	29.4	28.5	28.9	28.7	28.9	28.6	27.9

2040 Alternatives Analysis PM Travel Times

Origin: Garner (Garner Rd. & Vandora Springs Rd.)

Destination	Alternatives										
	No-Build ICE	No-Build	New Location Highway	Hybrid 1	Hybrid 2	Hybrid 3	Improve Existing 1	Improve Existing 2A	Improve Existing 2F	Improve Existing 3A	Improve Existing 3F
Holly Springs	31.3	31.5	24.6	24.9	31.4	27.9	31.5	31.4	31.2	30.5	27.9
Fuquay-Varina	29.0	29.4	28.6	28.9	27.9	28.3	29.3	28.3	27.7	28.5	28.4
Clayton	19.7	20.7	19.4	19.7	19.8	19.8	19.2	18.9	18.9	19.1	19.1
Knightdale	31.8	33.2	25.7	31.5	26.0	25.9	30.0	29.9	29.8	29.9	29.8
E Wake County	26.5	27.8	22.8	26.8	23.1	23.0	26.0	25.9	25.9	26.0	26.0
NW John. Co.	22.6	24.5	20.5	21.1	22.1	20.3	23.1	21.6	21.4	20.3	19.9
RTP	26.8	26.8	26.7	26.8	26.7	26.6	26.7	26.6	26.7	26.7	26.6
RDU	23.1	23.1	23.0	23.0	23.0	22.9	22.9	22.9	22.9	22.9	22.9
Brier Creek	26.7	26.8	26.5	26.6	26.7	26.5	26.5	26.5	26.5	26.5	22.9
Durham	34.1	34.1	34.0	34.1	34.0	33.9	34.0	34.0	34.0	34.0	33.9
Cary	17.7	17.7	17.6	17.7	17.6	17.4	17.7	17.6	17.6	17.6	17.5

2040 Alternatives Analysis AM Travel Times

Origin: Clayton (US 70 Business & NC 42)

Destination	Alternatives										
	No-Build ICE	No-Build	New Location Highway	Hybrid 1	Hybrid 2	Hybrid 3	Improve Existing 1	Improve Existing 2A	Improve Existing 2F	Improve Existing 3A	Improve Existing 3F
Holly Springs	46.0	48.5	28.6	28.3	41.2	40.3	47.0	42.8	40.8	43.0	39.3
Fuquay-Varina	32.1	33.6	27.5	27.1	24.8	31.0	32.8	27.0	24.7	31.7	30.9
Garner	17.6	18.4	17.9	18.0	18.1	17.9	17.3	17.4	17.4	17.4	17.4
Knightdale	23.8	24.6	16.8	24.2	16.9	16.9	24.4	24.4	24.4	24.3	24.1
E Wake County	13.5	13.7	13.3	13.5	13.3	13.3	13.5	13.6	13.6	13.5	13.5
NW John. Co.	10.2	10.3	10.2	10.3	9.8	10.2	10.4	10.3	9.9	10.3	10.3
RTP	55.3	57.1	51.8	51.9	55.1	54.6	54.4	54.2	54.2	53.9	53.0
RDU	51.7	53.4	48.4	49.4	50.6	50.2	50.4	50.5	50.5	50.2	49.2
Brier Creek	53.9	55.7	44.1	51.6	45.8	45.4	52.7	52.8	52.7	52.4	51.5
Durham	64.3	66.1	59.6	62.0	61.4	61.0	63.2	63.3	63.2	62.9	62.0
Cary	44.4	46.2	41.5	42.5	44.8	43.9	43.1	43.1	43.1	43.0	41.9

2040 Alternatives Analysis PM Travel Times

Origin: Clayton (US 70 Business & NC 42)

Destination	Alternatives										
	No-Build ICE	No-Build	New Location Highway	Hybrid 1	Hybrid 2	Hybrid 3	Improve Existing 1	Improve Existing 2A	Improve Existing 2F	Improve Existing 3A	Improve Existing 3F
Holly Springs	39.9	40.8	24.9	24.8	34.6	31.6	41.5	37.1	35.2	36.3	31.4
Fuquay-Varina	33.7	34.5	29.1	29.0	26.4	31.8	35.2	29.0	27.0	32.8	31.8
Garner	12.5	12.6	12.7	12.6	12.7	12.7	12.6	12.6	12.6	12.6	12.6
Knightdale	23.9	24.3	19.5	24.3	19.3	19.3	23.8	23.8	23.8	23.8	23.9
E Wake County	14.8	15.2	13.6	15.0	13.5	13.6	14.6	14.6	14.6	14.6	14.7
NW John. Co.	12.7	13.3	11.1	11.4	11.4	11.2	13.9	12.0	12.0	11.9	11.6
RTP	35.4	35.4	35.5	35.4	35.5	35.4	35.0	35.0	35.0	35.1	35.0
RDU	31.7	31.7	31.8	31.7	31.8	31.7	31.3	31.3	31.3	31.3	31.3
Brier Creek	35.3	35.5	32.5	35.3	32.4	32.4	34.9	34.9	34.9	34.9	34.8
Durham	42.7	42.8	42.8	42.8	42.9	42.7	42.4	42.4	42.3	42.4	42.3
Cary	26.3	26.4	26.4	26.4	26.4	26.3	26.0	26.0	26.0	26.0	25.9

2040 Alternatives Analysis AM Travel Times

Origin: Knightdale (US 64 Business & Smithfield Rd.)

Destination	Alternatives										
	No-Build ICE	No-Build	New Location Highway	Hybrid 1	Hybrid 2	Hybrid 3	Improve Existing 1	Improve Existing 2A	Improve Existing 2F	Improve Existing 3A	Improve Existing 3F
Holly Springs	51.6	53.1	34.7	45.4	51.6	46.7	48.7	48.6	48.5	48.1	47.3
Fuquay-Varina	47.4	48.7	33.6	44.2	35.1	38.7	46.0	45.5	43.1	45.9	45.7
Garner	27.7	28.7	22.5	27.7	22.6	22.5	25.8	25.8	25.8	25.8	58.8
Clayton	21.9	22.1	17.7	22.1	17.7	17.6	21.8	21.9	21.9	21.9	21.9
E Wake County	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.4
NW John. Co.	30.4	31.2	20.3	30.5	20.2	20.2	28.7	28.7	28.4	28.8	28.9
RTP	43.4	44.9	43.5	43.2	45.3	44.8	43.4	43.3	43.3	43.2	42.7
RDU	39.0	40.5	39.1	38.9	40.8	40.4	38.9	38.9	38.8	38.7	38.2
Brier Creek	34.2	35.6	34.4	34.1	36.0	35.6	34.1	34.1	34.1	34.0	33.5
Durham	49.6	51.2	49.9	49.6	51.7	51.2	49.7	49.7	49.7	49.6	49.0
Cary	43.1	44.9	41.8	40.7	44.4	43.5	40.0	40.0	40.1	39.9	39.3

2040 Alternatives Analysis PM Travel Times

Origin: Knightdale (US 64 Business & Smithfield Rd.)

Destination	Alternatives										
	No-Build ICE	No-Build	New Location Highway	Hybrid 1	Hybrid 2	Hybrid 3	Improve Existing 1	Improve Existing 2A	Improve Existing 2F	Improve Existing 3A	Improve Existing 3F
Holly Springs	47.6	47.7	32.8	46.5	47.0	39.7	47.0	47.0	46.9	46.9	46.6
Fuquay-Varina	52.1	52.7	37.0	50.6	41.6	40.1	52.5	51.5	50.8	51.6	51.1
Garner	27.6	28.6	18.0	26.5	18.2	18.1	28.4	28.3	28.3	28.1	27.8
Clayton	26.1	26.8	19.6	26.1	19.7	19.8	26.6	26.5	26.5	26.5	26.3
E Wake County	11.5	11.9	9.5	11.6	9.7	9.6	11.9	11.9	11.9	11.9	11.7
NW John. Co.	38.0	39.2	23.8	36.7	26.6	24.8	39.6	37.8	37.7	37.6	37.1
RTP	29.0	29.0	29.1	29.0	29.1	29.1	29.0	29.0	29.0	29.0	29.0
RDU	25.9	25.9	26.0	25.9	26.0	26.0	25.8	25.8	25.8	25.8	25.8
Brier Creek	22.1	22.1	22.2	22.1	22.2	22.2	22.1	22.1	22.1	22.1	22.1
Durham	34.3	34.4	34.5	34.4	34.5	34.4	34.4	34.4	34.4	34.4	34.4
Cary	26.0	26.2	25.6	26.1	25.7	25.6	25.8	25.8	25.8	25.8	25.7

2040 Alternatives Analysis AM Travel Times

Origin: Eastern Wake County (Smithfield Rd. & Grasshopper Rd.)

Destination	Alternatives										
	No-Build ICE	No-Build	New Location Highway	Hybrid 1	Hybrid 2	Hybrid 3	Improve Existing 1	Improve Existing 2A	Improve Existing 2F	Improve Existing 3A	Improve Existing 3F
Holly Springs	53.1	55.0	32.9	41.6	49.6	44.8	52.8	52.3	51.9	51.7	50.1
Fuquay-Varina	43.4	44.6	31.8	40.4	33.2	36.9	43.0	40.1	37.8	42.7	42.5
Garner	23.7	24.6	20.6	24.0	20.6	20.6	23.1	23.1	23.1	23.2	23.2
Clayton	13.6	13.8	13.1	13.7	13.0	13.1	13.5	13.5	13.5	13.5	13.6
Knightdale	10.5	11.1	9.0	10.7	9.1	9.0	10.9	10.9	10.9	10.9	10.7
NW John. Co.	23.4	23.7	18.4	23.6	18.2	18.4	23.4	23.4	23.0	23.4	23.5
RTP	51.9	54.0	48.9	51.9	50.8	50.4	52.4	52.3	52.1	52.0	51.4
RDU	47.5	49.5	44.6	47.5	46.4	45.9	47.8	47.8	47.7	47.6	46.9
Brier Creek	42.6	44.7	39.9	42.8	41.6	41.1	43.1	43.1	42.9	42.9	42.2
Durham	58.1	60.3	55.4	58.3	57.2	56.7	58.7	58.7	58.5	58.4	57.7
Cary	46.3	48.8	44.1	45.1	46.8	45.9	44.9	45.0	44.9	44.8	44.0

2040 Alternatives Analysis PM Travel Times

Origin: Eastern Wake County (Smithfield Rd. & Grasshopper Rd.)

Destination	Alternatives										
	No-Build ICE	No-Build	New Location Highway	Hybrid 1	Hybrid 2	Hybrid 3	Improve Existing 1	Improve Existing 2A	Improve Existing 2F	Improve Existing 3A	Improve Existing 3F
Holly Springs	49.4	49.4	30.9	28.6	46.5	37.6	48.2	48.3	48.2	48.1	45.2
Fuquay-Varina	47.5	48.5	35.1	42.7	39.4	38.0	48.4	42.8	40.8	46.7	45.7
Garner	20.2	20.4	16.1	19.5	16.1	16.0	20.2	20.2	20.1	20.1	19.9
Clayton	14.6	14.8	13.9	14.5	13.9	13.9	14.6	14.6	14.6	14.6	14.6
Knightdale	9.0	9.1	9.0	9.2	9.0	9.0	9.2	9.2	9.2	9.2	9.2
NW John. Co.	26.5	27.3	21.9	25.1	24.4	22.8	27.7	25.9	25.8	25.7	25.4
RTP	34.9	35.0	34.5	35.0	34.5	34.5	35.0	35.0	35.0	35.0	35.0
RDU	31.8	31.9	31.3	31.9	31.3	31.3	31.8	31.8	31.8	31.8	31.8
Brier Creek	28.0	28.1	27.6	28.1	27.6	27.6	28.1	28.1	28.1	28.1	28.1
Durham	40.2	40.3	39.9	40.4	39.8	39.8	40.3	40.3	40.3	40.3	40.3
Cary	27.8	27.9	27.3	27.6	27.3	27.2	27.1	27.1	27.0	27.0	26.9

2040 Alternatives Analysis AM Travel Times
Origin: Northwestern Johnston County (NC 50 & NC 42)

Destination	Alternatives										
	No-Build ICE	No-Build	New Location Highway	Hybrid 1	Hybrid 2	Hybrid 3	Improve Existing 1	Improve Existing 2A	Improve Existing 2F	Improve Existing 3A	Improve Existing 3F
Holly Springs	35.8	38.2	23.1	23.1	31.4	33.5	36.8	32.5	30.9	34.8	33.0
Fuquay-Varina	21.9	23.3	19.9	19.9	15.0	20.9	22.5	16.8	14.7	21.4	20.6
Garner	20.8	22.2	19.0	19.4	20.1	18.9	21.7	20.4	19.9	18.9	18.5
Clayton	12.1	12.7	10.7	10.8	1.6	11.0	13.1	11.1	10.8	11.4	11.2
Knightdale	33.5	35.3	20.4	30.7	22.4	21.8	35.0	33.0	32.7	32.7	31.9
E Wake Co.	24.9	25.5	19.2	23.6	21.2	20.6	25.9	23.9	23.6	24.1	23.9
RTP	58.1	60.4	46.4	46.7	57.0	55.7	58.0	56.0	55.7	55.3	54.1
RDU	54.4	56.7	46.5	46.8	53.3	52.0	54.3	52.3	52.0	51.6	50.3
Brier Creek	56.6	59.0	47.0	47.2	51.3	50.3	56.5	54.6	54.2	53.8	52.6
Durham	67.1	69.4	56.5	56.8	66.0	64.7	67.1	65.0	64.7	64.3	63.1
Cary	47.2	49.5	39.1	39.2	46.2	44.8	46.9	44.9	44.6	44.4	43.0

2040 Alternatives Analysis PM Travel Times
Origin: Northwestern Johnston County (NC 50 & NC 42)

Destination	Alternatives										
	No-Build ICE	No-Build	New Location Highway	Hybrid 1	Hybrid 2	Hybrid 3	Improve Existing 1	Improve Existing 2A	Improve Existing 2F	Improve Existing 3A	Improve Existing 3F
Holly Springs	27.2	27.5	19.6	19.6	23.2	26.4	27.6	25.1	23.2	27.2	26.3
Fuquay-Varina	21.0	21.2	20.6	20.6	15.0	20.6	21.3	17.0	15.0	21.0	20.5
Garner	13.7	13.8	13.7	13.7	13.7	13.6	13.8	13.8	13.6	13.6	13.6
Clayton	11.2	11.5	10.8	11.1	10.5	10.8	11.4	11.0	10.8	11.2	11.2
Knightdale	34.0	35.2	22.4	34.4	22.6	22.6	32.9	32.6	32.4	32.8	32.7
E Wake Co.	25.6	26.2	19.5	25.7	19.6	19.8	25.5	25.2	25.0	25.3	25.4
RTP	36.2	36.4	32.4	32.3	36.1	36.1	35.8	35.6	35.3	35.7	35.5
RDU	32.5	32.7	32.2	32.3	32.4	32.4	32.1	31.9	31.6	32.0	31.8
Brier Creek	36.1	36.4	35.4	35.6	35.7	35.7	35.7	35.5	35.2	35.5	35.3
Durham	43.6	43.8	41.9	41.9	43.5	43.4	43.1	42.9	42.6	43.0	42.9
Cary	27.2	27.3	26.8	26.9	27.0	26.9	26.8	26.6	26.3	26.6	26.4

2040 Alternatives Analysis AM Travel Times

Origin: Research Triangle Park (NC 55 & NC 54)

Destination	Alternatives										
	No-Build ICE	No-Build	New Location Highway	Hybrid 1	Hybrid 2	Hybrid 3	Improve Existing 1	Improve Existing 2A	Improve Existing 2F	Improve Existing 3A	Improve Existing 3F
Holly Springs	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5
Fuquay-Varina	25.2	25.2	25.3	25.3	25.3	25.3	25.3	25.2	25.3	25.3	25.3
Garner	23.2	23.2	23.2	23.2	23.2	23.1	23.2	23.2	23.2	23.2	23.2
Clayton	32.2	32.2	32.2	32.2	32.2	32.2	32.3	32.3	32.3	32.3	32.2
Knightdale	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9
E Wake Co.	32.1	32.1	32.0	32.0	32.0	32.0	31.9	31.9	31.9	32.0	31.9
NW John. Co.	31.8	31.8	30.7	30.7	31.7	31.8	31.8	31.7	31.4	31.8	31.7
RDU	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Brier Creek	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8
Durham	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8
Cary	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3

2040 Alternatives Analysis PM Travel Times

Origin: Research Triangle Park (NC 55 & NC 54)

Destination	Alternatives										
	No-Build ICE	No-Build	New Location Highway	Hybrid 1	Hybrid 2	Hybrid 3	Improve Existing 1	Improve Existing 2A	Improve Existing 2F	Improve Existing 3A	Improve Existing 3F
Holly Springs	36.3	36.6	37.1	37.7	36.7	36.6	36.6	36.7	36.7	36.2	36.5
Fuquay-Varina	53.6	54.8	51.8	52.4	55.1	52.6	54.1	54.4	54.7	53.3	52.6
Garner	46.8	48.0	43.9	44.0	47.1	45.9	46.8	46.4	46.4	46.1	45.3
Clayton	66.0	68.2	60.0	60.7	66.4	65.3	65.5	64.8	64.8	64.8	64.0
Knightdale	53.7	56.1	54.2	52.6	56.3	55.4	53.3	53.2	53.2	52.8	52.8
E Wake Co.	63.4	66.4	60.3	62.4	62.6	61.6	63.9	63.7	63.8	63.3	63.2
NW John. Co.	69.3	71.8	60.0	55.1	68.7	65.1	69.4	67.3	67.0	66.2	64.8
RDU	12.8	12.9	12.8	12.7	12.9	12.9	13.0	12.9	12.9	12.9	12.9
Brier Creek	17.3	17.5	17.2	17.1	17.5	17.3	17.3	17.3	17.3	17.3	17.2
Durham	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
Cary	21.2	21.3	21.0	20.9	21.2	21.2	21.7	21.6	21.6	21.6	21.6

2040 Alternatives Analysis AM Travel Times

Origin: Raleigh-Durham Airport (Airport Blvd. & International Dr.)

Destination	Alternatives										
	No-Build ICE	No-Build	New Location Highway	Hybrid 1	Hybrid 2	Hybrid 3	Improve Existing 1	Improve Existing 2A	Improve Existing 2F	Improve Existing 3A	Improve Existing 3F
Holly Springs	21.8	21.9	21.8	21.8	21.9	21.9	21.9	21.9	21.9	21.9	21.9
Fuquay-Varina	27.6	27.6	27.6	27.6	27.7	27.6	27.6	27.6	27.6	27.7	27.7
Garner	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7
Clayton	30.7	30.8	30.7	30.8	30.7	30.7	30.8	30.8	30.8	30.8	30.7
Knightdale	24.4	24.4	24.5	24.4	24.5	24.5	24.4	24.4	24.4	24.4	24.4
E Wake Co.	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8
NW John. Co.	30.3	30.4	30.3	30.3	30.2	30.3	30.3	30.3	30.3	29.9	30.3
RTP	11.6	11.7	11.6	11.6	11.7	11.7	11.7	11.7	11.7	11.7	11.7
Brier Creek	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
Durham	20.6	20.7	20.6	20.6	20.6	20.6	20.8	20.7	20.7	20.7	20.7
Cary	12.8	12.9	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8

2040 Alternatives Analysis PM Travel Times

Origin: Raleigh-Durham Airport (Airport Blvd. & International Dr.)

Destination	Alternatives										
	No-Build ICE	No-Build	New Location Highway	Hybrid 1	Hybrid 2	Hybrid 3	Improve Existing 1	Improve Existing 2A	Improve Existing 2F	Improve Existing 3A	Improve Existing 3F
Holly Springs	36.5	36.7	37.2	37.7	36.8	36.3	36.6	36.8	36.7	36.2	36.4
Fuquay-Varina	53.8	54.9	51.9	52.4	55.2	52.5	54.2	54.5	54.8	53.3	52.6
Garner	42.7	43.9	39.9	40.2	43.0	41.8	42.6	42.3	42.2	41.9	41.2
Clayton	61.9	64.1	56.5	59.4	58.5	57.9	61.3	60.6	60.7	60.6	59.8
Knightdale	46.0	48.3	46.6	45.1	48.5	47.7	45.6	45.4	45.5	45.1	45.2
E Wake Co.	55.7	58.6	52.6	54.9	54.7	53.9	56.2	56.0	56.1	55.6	55.6
NW John. Co.	65.2	67.7	54.3	55.1	64.6	61.0	65.2	63.2	62.9	62.0	60.7
RTP	11.9	11.9	11.9	11.9	12.0	11.9	11.9	11.9	11.9	11.9	11.9
Brier Creek	9.6	9.7	9.6	9.6	9.7	9.7	9.6	9.6	9.6	9.6	9.6
Durham	19.0	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1
Cary	17.1	17.2	17.0	17.0	17.1	17.0	17.5	17.5	17.5	17.4	17.5

2040 Alternatives Analysis AM Travel Times

Origin: Brier Creek (US 70 & Brier Creek Pkwy.)

Alternatives

Destination	No-Build ICE	No-Build	New Location Highway	Hybrid 1	Hybrid 2	Hybrid 3	Improve Existing 1	Improve Existing 2A	Improve Existing 2F	Improve Existing 3A	Improve Existing 3F
Holly Springs	22.7	22.8	22.7	22.7	22.8	22.8	22.7	22.7	22.7	22.7	22.7
Fuquay-Varina	28.5	28.6	28.5	28.5	28.6	28.5	28.5	28.5	28.5	28.5	28.5
Garner	24.9	25.0	24.8	24.8	24.9	24.8	24.9	24.9	24.9	24.8	24.8
Clayton	33.9	34.0	30.1	33.9	30.0	30.1	33.9	33.9	33.9	33.9	33.9
Knightdale	19.6	19.6	19.7	19.6	19.7	19.7	19.6	19.6	19.6	19.6	19.6
E Wake Co.	25.0	25.1	25.0	25.1	25.0	25.0	25.0	25.0	25.0	25.0	25.1
NW John. Co.	33.5	33.6	32.7	33.4	32.5	32.6	33.5	33.4	33.0	33.4	33.4
RTP	14.5	14.6	14.4	14.4	14.6	14.6	14.6	14.6	14.6	14.6	14.5
RDU	9.7	9.7	9.8	9.8	9.7	9.8	9.8	9.8	9.8	9.8	9.8
Durham	16.0	16.1	16.1	16.0	16.2	16.1	16.1	16.1	16.1	16.1	16.1
Cary	15.9	16.1	15.9	15.9	16.1	16.0	16.0	16.0	16.0	15.9	15.9

2040 Alternatives Analysis PM Travel Times

Origin: Brier Creek (US 70 & Brier Creek Pkwy.)

Alternatives

Destination	No-Build ICE	No-Build	New Location Highway	Hybrid 1	Hybrid 2	Hybrid 3	Improve Existing 1	Improve Existing 2A	Improve Existing 2F	Improve Existing 3A	Improve Existing 3F
Holly Springs	36.6	36.8	37.3	37.9	36.9	36.5	36.8	37.0	36.9	36.4	36.6
Fuquay-Varina	53.9	55.1	52.0	52.6	55.3	52.7	54.3	54.7	54.9	53.5	52.7
Garner	45.6	46.8	42.8	43.0	45.9	44.7	45.5	45.2	45.1	44.8	44.0
Clayton	64.7	66.9	52.3	60.8	54.2	53.5	64.2	63.6	63.6	63.5	62.7
Knightdale	41.7	43.9	42.4	40.9	44.1	43.4	41.4	41.2	41.3	40.8	41.0
E Wake Co.	51.4	54.2	48.4	50.7	50.4	49.6	51.9	51.8	51.9	51.4	51.3
NW John. Co.	68.1	70.6	54.5	55.2	61.0	58.6	68.1	66.1	65.7	64.9	63.6
RTP	12.7	12.7	12.8	12.8	12.7	12.7	12.8	12.7	12.7	12.7	12.7
RDU	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
Durham	13.0	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1
Cary	20.0	20.0	19.9	19.9	20.0	19.9	20.4	20.4	20.4	20.3	20.4

2040 Alternatives Analysis AM Travel Times

Origin: Durham (Chapel Hill St. & Mangum St.)

Destination	Alternatives										
	No-Build ICE	No-Build	New Location Highway	Hybrid 1	Hybrid 2	Hybrid 3	Improve Existing 1	Improve Existing 2A	Improve Existing 2F	Improve Existing 3A	Improve Existing 3F
Holly Springs	27.4	27.5	27.5	27.5	27.4	27.4	27.4	27.4	27.4	27.4	27.4
Fuquay-Varina	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2
Garner	31.1	31.1	31.0	31.0	31.0	31.0	31.1	31.1	31.0	31.1	31.0
Clayton	40.1	40.1	40.0	40.1	40.1	40.0	40.1	40.1	40.1	40.1	40.1
Knightdale	30.7	30.7	30.8	30.7	30.8	30.8	30.7	30.7	30.7	30.7	30.7
E Wake Co.	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1	36.1
NW John. Co.	39.7	39.7	38.7	38.7	39.6	39.7	39.6	39.6	39.6	39.2	39.6
RTP	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4
RDU	17.9	17.9	17.8	17.9	17.8	17.8	17.8	17.8	17.8	17.8	17.8
Brier Creek	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2
Cary	22.1	22.2	22.1	22.1	22.2	22.1	22.2	22.2	22.2	22.1	22.2

2040 Alternatives Analysis PM Travel Times

Origin: Durham (Chapel Hill St. & Mangum St.)

Destination	Alternatives										
	No-Build ICE	No-Build	New Location Highway	Hybrid 1	Hybrid 2	Hybrid 3	Improve Existing 1	Improve Existing 2A	Improve Existing 2F	Improve Existing 3A	Improve Existing 3F
Holly Springs	47.9	48.2	48.8	49.4	48.2	47.8	48.3	48.4	48.4	47.9	48.1
Fuquay-Varina	65.2	66.5	63.5	64.1	66.7	64.1	65.8	66.2	66.4	65.0	64.2
Garner	57.9	59.1	55.1	55.3	58.2	57.1	58.0	57.6	57.5	57.3	56.5
Clayton	77.1	79.3	70.7	72.3	72.7	72.0	76.7	76.0	76.0	76.0	75.2
Knightdale	60.1	62.4	60.8	59.3	62.6	61.9	60.0	59.8	59.9	59.5	59.4
E Wake Co.	69.8	72.7	66.9	69.1	68.9	68.1	70.6	70.4	70.5	70.0	69.8
NW John. Co.	80.4	82.9	65.9	66.8	79.5	76.2	80.5	78.5	78.2	77.3	76.0
RTP	14.7	14.7	14.8	14.8	14.7	14.7	14.8	14.8	14.8	14.8	14.8
RDU	24.0	24.1	24.0	24.0	24.0	24.0	24.1	24.1	24.1	24.1	24.1
Brier Creek	18.7	18.8	18.7	18.7	18.8	18.8	18.9	18.9	18.8	18.9	18.7
Cary	32.3	32.4	32.2	32.2	32.2	32.3	32.8	32.8	32.8	32.8	32.8

2040 Alternatives Analysis AM Travel Times

Origin: Cary (Academy St. & Chatham St.)

Alternatives

Destination	No-Build ICE	No-Build	New Location Highway	Hybrid 1	Hybrid 2	Hybrid 3	Improve Existing 1	Improve Existing 2A	Improve Existing 2F	Improve Existing 3A	Improve Existing 3F
Holly Springs	16.3	16.3	16.0	16.0	16.3	15.9	16.4	16.4	16.4	16.1	15.9
Fuquay-Varina	22.4	22.4	22.2	22.3	22.5	22.3	22.5	22.5	22.5	22.4	22.3
Garner	15.1	15.1	15.1	15.1	15.1	15.0	15.1	15.1	15.1	15.1	15.1
Clayton	24.1	24.1	24.1	24.2	24.1	24.1	24.2	24.2	24.2	24.2	24.1
Knightdale	22.2	22.2	22.1	22.3	22.1	22.1	22.2	22.2	22.2	22.2	22.2
E Wake Co.	24.0	24.0	23.9	24.0	23.9	23.9	23.8	23.8	23.8	23.8	23.8
NW John. Co.	23.7	23.7	23.7	23.7	23.6	23.7	23.7	23.6	23.3	23.6	23.6
RTP	18.9	18.9	18.7	18.6	18.9	18.9	19.2	19.2	19.2	19.1	19.1
RDU	15.2	15.2	15.1	15.0	15.1	15.1	15.4	15.4	15.4	15.4	15.4
Brier Creek	17.4	17.4	17.3	17.3	17.4	17.4	17.7	17.7	17.7	17.7	17.6
Durham	27.8	27.9	27.7	27.7	27.8	27.8	28.2	28.2	28.2	28.2	28.1

2040 Alternatives Analysis PM Travel Times

Origin: Cary (Academy St. & Chatham St.)

Alternatives

Destination	No-Build ICE	No-Build	New Location Highway	Hybrid 1	Hybrid 2	Hybrid 3	Improve Existing 1	Improve Existing 2A	Improve Existing 2F	Improve Existing 3A	Improve Existing 3F
Holly Springs	28.2	28.3	28.5	29.0	28.0	28.0	28.0	28.1	28.0	28.2	28.1
Fuquay-Varina	44.0	45.1	42.0	42.5	44.8	43.1	44.2	44.4	44.4	43.9	42.9
Garner	33.7	34.9	31.1	31.4	34.0	32.9	33.3	32.9	32.8	32.6	31.8
Clayton	53.0	55.0	49.7	50.6	53.3	52.3	52.0	51.3	51.3	51.3	50.4
Knightdale	52.5	54.4	49.4	49.3	53.0	51.9	49.5	49.2	49.1	49.0	48.3
E Wake Co.	55.8	58.6	51.7	53.2	55.3	54.3	53.9	53.4	53.4	53.3	52.4
NW John. Co.	54.9	56.9	44.7	45.3	54.1	50.4	55.0	53.6	53.4	51.7	49.5
RTP	17.3	17.3	17.2	17.2	17.3	17.3	17.4	17.4	17.4	17.4	17.3
RDU	13.6	13.6	13.6	13.2	13.6	13.6	13.7	13.7	13.7	13.6	13.6
Brier Creek	17.2	17.4	17.1	17.1	17.3	17.2	17.2	17.2	17.2	17.2	17.1
Durham	24.6	24.7	24.6	24.6	24.7	24.6	24.7	24.7	24.7	24.7	24.6