Traveling to Work in Wake:

EXPLORING THE COMMUTER RAIL OPTION

Conducted by:
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NC State University
June 2016

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I. INTRODUCTION

A. PURPOSE OF PROJECT

The study described in this report examined factors associated with development of commuter rail within Wake County, North Carolina, and the surrounding metropolitan area. The study was conducted by the Center for Urban Affairs and Community Services in conjunction with the North Carolina Department of Transportation (NCDOT), Rail Division. This report explores sociodemographic, transportation, and railway characteristics that may impact plans for development of commuter rail in a study area centered on Raleigh and encompassing Wake County, northern Johnston County, and southeastern Durham County. The report does not address the myriad of governmental, political, or regulatory factors surrounding transit but provides basic information that might inform the debate concerning transit alternatives and the feasibility of commuter rail as a means of increasing capacity in and around the Raleigh-Wake County area.

B. COMMUTER RAIL COMPARED TO OTHER RAIL SYSTEMS

Commuter rail is a form of public transit that has shown increasing popularity in the United States in recent years. Commuter rail "…offers the potential for providing attractive, high-quality rapid transit service at a more reasonable cost when compared with other types of urban rail systems, such as light rail or heavy rail" (SEWRPC 1998 n.p.).

Compared with light rail, commuter rail spans a greater distance and serves fewer stations. Trains typically operate every half-hour during peak workday commuting times with runs varying from about one to three hours apart during non-peak service.

Exhibit 1. Characteristics of Commuter Rail.

Typical Vehicles:	Locomotive-Hauled or Self-Propelled Coaches
Train length:	2-8 coaches
Propulsion System	Diesel-Electric, Diesel-Hydraulic, or Diesel-Mechanical
Right-of-Way Requirements:	Existing Main-Line Railway Trackage
Typical Route Length (Miles):	20-50
Average Station Spacing (Miles):	2-5
Boarding Platforms at Stations:	Low
Typical Fare Collection Method(s):	On Board
Maximum / Average Operating Speeds:	79 mph; 30-50 mph
Typical Primary Passenger Market:	Suburbs to Major Urban Centers / Central Business District
Frequency of Service:	30-60 Minutes Peak Period; 1-3 Hours Non-Peak Perios

SEWRPC, 1998. Posted at: http://www.trainweb.org/kenrail/Rail_mode_table.html

Commuter rail trains travel at higher speeds than light rail trains, with top speeds ranging to 79 mph (RTD FasTracks 2016). They utilize electric, diesel-electric, or diesel power and run longer-distance trips, typically twenty to fifty miles in length. Commuter rail usually operates on existing

tracks and, for this reason, trains must be built to main-line railroad standards with respect to both strength and overall size. The decision to pursue commuter rail as a transit alternative is dependent upon a number of factors, including, but not limited to, population characteristics, commuting patterns, infrastructure, and commuter attitudes and preferences.

- The population base must be appropriate to commuter rail in that a large number of commuters in outlying areas travel regularly to one or more central points. The need to increase highway capacity should be well documented based on traffic density.
- Railway infrastructure such as number of existing tracks, number of crossings, right-of-way widths, etc., must be appropriate for the development of commuter rail.
- Finally, commuters must be willing to use the new form of transit; accounting for factors that influence travel mode choice is key to success.

These three broad issues are discussed in the subsequent sections of this report with respect to the Raleigh-Wake County area.

C. EXAMPLES OF SUCCESSFUL COMMUTER RAIL PROJECTS

Several commuter rail lines have been developed in recent years that serve as models for projects in other areas. Three brief case-studies are presented here detailing successful efforts to negotiate and implement commuter rail systems.

1. Tri-Rail

Tri-Rail is a commuter rail system that connects Miami, Fort Lauderdale, and West Palm Beach. Tri-Rail is managed by the South Florida Regional Transportation Authority and owned by the Florida Department of Transportation. The system operates eighteen stations in the Southeast Florida area and serves approximately 14,800 persons per day (Wikipedia Contributors 2015d).

Pompano Tri-Rail Station

Tri-Rail began service in 1989. Though it was originally intended to be temporary while highway construction was underway (Get Cruising n.d.), due to unexpectedly high ridership, it was kept as a permanent line. Tri-Rail used tracks originally built in the 1920s by the Seaboard Air Line Railroad to form the inter-city Seaboard-All Florida Railway, which ran until 1953 (Banner 2013). Seaboard later merged with a rival to form the Seaboard Coast Line Railroad in 1967 (American Rails 2015a). Subsequent mergers led to ownership of the tracks by Seaboard System in 1982 and CSX in 1986. The State originally planned to use tracks owned by the Florida East Coast Railway, but the organization turned down the offer in favor of preserving freight transport (Turnbell 2010). Extensions adding four miles to the original sixty-seven miles of track were constructed (between 1996 and 1998) to Mangonia Park Station and the Miami airport (Federal Transit Administration 2000).

In 2002, "all 70 grade crossings along the CSX tracks from Miami to West Palm Beach [were fitted with] expensive gates, tall concrete curbs or both…making the South Florida Rail Corridor among the first in the country to be 'sealed'" (Turnbell 2002). Additional improvements in the 2000s included increased numbers of trains (from thirty to forty and later to fifty per day), construction of the New River Rail Bridge, and double-tracking between Mangonia Park Station and the Miami Airport (Federal Transit Administration 2000; South Florida Regional Transit Authority 2006).

A serious threat to Tri-Rail arose in 2009 when the Florida Legislature and the three counties slated to fund the railway were unable to provide needed funding. The threat was assuaged when Tri-Rail received funding under the American Recovery and Investment Act of 2009 (Federal Transit Administration 2009).

2. SunRail

The SunRail commuter rail system operates in the Orlando, Florida metropolitan area and is owned by the Florida Department of Transportation. Phase 1 began operation in 2014 and spans thirty-two miles, serving twelve stations. Phase II plans include the addition of five stations. The total route is planned to run 61.5 miles through Central Florida. Trains operate at thirty to seventy-nine miles per hour on average (including time for stops). SunRail cars are wheelchair accessible and provide services such as restrooms, free Wi-Fi, electrical outlets, and room for bicycles.

SunRail Train Leaving Winter Park Station

In 2007, the SunRail line was purchased from CSX Transportation by the State of Florida with additional financing provided by the Federal government and Orlando, Volusia, Osceola, and Seminole counties. The agreement purchased right-of-way and transferred track maintenance and dispatching to the South Florida Regional Transportation Authority. The agreement also arranged for "…unspecified investment in rail freight infrastructure to improve its efficiency statewide, and a $10 million annual payment from CSX in exchange for limited freight transportation on both the South Florida and SunRail lines" (Bogren, 2012:29).

An initial impediment to project implementation arose when the Florida legislature failed to approve the agreement as a result of objections raised by legislators representing areas that would see an increase in freight traffic. A more significant block to the project related to liability that CSX might incur as a result of passenger accidents or injury. Resolution of these concerns was followed by additional liability-related disputes with Amtrak. After an agreement was reached concerning liability and insurance matters, the contract was approved by the Florida legislature and in December of 2009, funding and contractual agreements were finalized to fund both the SunRail system and the South Florida Tri-Rail system. In 2010, Florida set up an escrow account of $173 million to fund building tracks connecting Orlando, Volusia, Osceola, and Seminole counties (Orlando Sentinel 2010). The state of Florida purchased sixty-one miles of track from CSX at a final cost of more than

$615 million (Wikipedia Contributors 2015b). An additional obstacle to proceeding with construction was met with the newly-elected administration in 2010. Florida's new governor froze SunRail contracts and later "…rejected $2.3 billion in federal high-speed rail investment connecting Tampa and Orlando, pointing to predicted cost overruns and concerns about the line's ridership" (Bogren, 2012:30). But by 2011 the project was deemed to be a worthwhile investment and Phase 1 of the SunRail system was approved.

3. Music City Star

The Music City Star commuter rail spans a thirty-two mile route between Nashville and Lebanon, Tennessee. The Star began operation in September of 2006 and is considered to be "…a 'starter' project to demonstrate the effectiveness of commuter rail service to the metro Nashville area" (Wikipedia Contributors 2015c).

Music City Star Car

Negotiations began in 1988 with creation of the Regional Transportation Authority (RTA) of Middle Tennessee, which manages car pools, commuter van pools, regional express bus routes, and the regional rail project for a nine county area. Initial start-up funding of $100,000 was provided by the Tennessee General Assembly and in 2003 legislation was passed to fund ongoing operation through a system of dues based on population of the participating municipality or county. Such a structure supports administrative and overhead costs and allows members to have a voice in RTA initiatives (RTA 2015).

Music City Star funding came from a federal grant for 80 percent of cost. An additional 20 percent was provided by the Tennessee Department of Transportation and local municipalities. RTA upgraded the existing, publicly owned, Nashville and Eastern Railroad short-line tracks.

> Other corridors involved operating over right of way owned by CSX Transportation, which has strict requirements for transit agencies that want to operate commuter trains along its tracks: passenger operations can't compromise safety and must be transparent to freight operations; capacity consumed by passenger operations must be replaced; and CSXT must be compensated for right of way and capacity consumed, and retain no risk of liability for passenger trains. (Cotey 2007:n.p.)

Music City Star service began in 2004 and experienced ups and downs with respect to revenue and shortfalls. The service was almost discontinued in 2009 due to a shortage of funding. After receipt of $4.4 million in state and local funding, later in 2009, the service continued, with support secured until 2011. By the following year, Music City Star ridership increased by 24 percent (Wikipedia Contributors 2015b).

The experiences of these commuter rail projects illustrate the pathway that led to the successful introduction of a new form of transit. Experiences in other cities and states can provide insight into obstacles that commuter rail proponents in Wake County might face.

II. CHARACTERISTICS OF THE STUDY AREA

A. POPULATION AND EMPLOYMENT CHARACTERISTICS

As the state's second most populous county and home to North Carolina's capital city, major colleges and universities and, and a flourishing economic sector, Wake County serves as a desirable residential location and a key employment destination. As of July 2015, Wake County's estimated population was 1,024,198 (US Census Bureau 2015b) and the County's population is expected to increase by 2.2 percent annually through 2019 (NC Office of Budget and Management 2015b).

Two of Wake County's neighbors—Durham and Johnston Counties—have seen similar growth in recent years. Durham County's population increased by around 12.5 percent between 2010 and the estimated 2015 population. Johnston County saw a population increase of 9.9 percent over the same period.

Table 1. Demographic and Labor Characteristics of Study Area Counties.

Characteristic	County		
	Wake	Johnston	Durham
Demographic Characteristics			
➢ 2010 Total Population[1]	900,993	168,878	267,587
➢ July 2015 Population Estimated Population[2]	1,024,198	185,660	300,952
➢ 2014 Projected Population Density (Pop/Square Mile) [1]	1,168.60	227.20	1,010.30
➢ 2019 Projected Total Population[1]	1,085,632	194,968	314,590
➢ 2019 Projected Population Density (Pop/Square Mile) [1]	1,300.0	246.4	1,099.9
➢ Projected Population: Annual Growth Rate: 2014-2019[1]	2.20%	1.60%	1.70%
➢ Projected Population, July 2020[3]	1,105,777	201,861	325,813
➢ Projected Population, July 2025[3]	1,206,166	222,107	353,674
➢ Projected Population, July 2030[3]	1,406,726	242,871	381,361
Economic Characteristics[1]			
➢ 2013 Estimated Working Population, 16+ Years of Age	461,097	76,575	133,966
➢ # Who Worked in State/County of Residence	375,481	36,003	92,293
➢ # Who Worked in State/Outside County of Residence	80,684	39,850	40,163
➢ # Who Worked Outside State of Residence	4,932	722	1,510
➢ % Who Worked in State/County of Residence	81.4%	47.0%	68.9%
➢ % Who Worked in State/Outside County of Residence	17.5%	52.0%	30.0%
➢ % Who Worked Outside State of Residence	1.1%	0.9%	1.1%

Note: Economic data based on information for workers not working at home.
[1] NC Department of Commerce 2015.
[2] US Census of Population Quickfacts
[3] NC Office of State Budget and Management 2015.

The metropolitan area overall has undergone tremendous population growth as well. In 2014, the Raleigh-Durham area ranked as the fifteenth most rapidly growing metropolitan area in the United States (U.S. Census Bureau 2015a). Raleigh is included in both the Raleigh-Cary Metropolitan

Statistical Area (MSA) and the Raleigh-Durham-Chapel Hill Combined Statistical Area (CSA) (City of Raleigh 2015b). [1] As of 2015, The Raleigh-Cary MSA was home to 1,273,568 persons, a 12.7 percent increase over 2010. The Raleigh-Durham-Chapel Hill CSA was home to 2,117,103 persons in 2015, representing a 10.7 percent increase since 2010 (U.S. Census Bureau 2016a).

Municipalities in northern Johnston County also have grown substantially in recent years. Clayton's population increased from 6,973 in 2000 to 17,964 in 2013 (Town of Clayton n.d.) and rose to 19,304 by 2015 (U.S. Census Bureau 2015a).

Along with population increase and growth in the employment sector come the attendant problems of increased traffic and congestion on the area's roadways. Raleigh's Comprehensive Plan assesses the direction of development and traffic in the area as follows:

> By 2035, Raleigh's roadway network is projected to become more congested, with both the amount of time and number of miles spent on the roads increasing. Vehicle miles traveled (VMT) and vehicle hours traveled (VHT) are both projected to increase from 2005 levels by over 50 percent – travel along freeways and other major streets will be most affected. In addition, the total number of trips (AM, PM, and overall) taken on Raleigh's road network is projected to increase by over 50 percent. (City of Raleigh 2015a:62)

Coupled with increasing roadway congestion, the Raleigh metropolitan area is characterized by "sprawl"—a growth pattern in which population spans a large area and moves outward, resulting in a dispersed layout as opposed to a compact, dense layout. Recent research (Ewing and Hamidi 2014) ranking US metropolitan areas and counties on an index of urban sprawl places the Raleigh-Cary MSA at 155 out of 221 metropolitan areas (the 70th percentile) with respect to sprawl. This pattern of growth has left the City highly automobile-dependent and challenged to increase roadway capacity and provide alternate forms of transportation.

Likewise, the Durham-Chapel Hill area ranks as one of the ten most sprawling "medium metro areas"—those with population between 500,000 and one million (Ewing and Hamidi 2014). Sprawling layouts, such as those found in the Raleigh-Durham area, in combination with land-use patterns, lead to increased dependency on the single-occupancy vehicle and exacerbate problems associated with highway congestion: stress, fuel consumption and waste, and CO emissions (APTA 2002; Shapiro et al. 2002; Litman 2015).

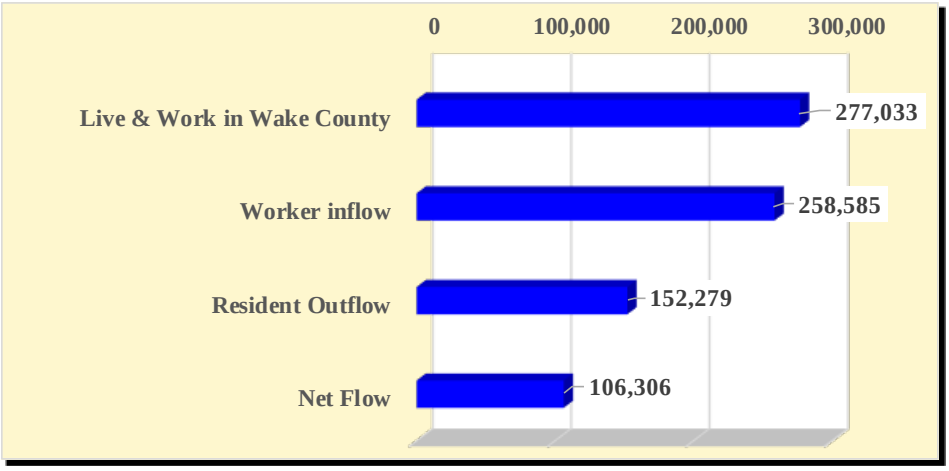
Despite its obvious drawbacks, the sprawling growth pattern lends itself to development of commuter rail as a form of mass transit. In its ability to address the problems of traffic congestion associated with dispersed growth patterns, commuter rail can be viewed as "…a means of managing urban sprawl, stimulating economic development, and reducing the environmental impacts of transportation" (Brock and Souleyrette 2014:1).

[1] *The Raleigh-Cary MSA is comprised of Wake, Johnston, and Franklin counties. The Raleigh-Durham-Chapel Hill CSA is comprised of Harnett, Chatham, Durham, Orange, Person, Vance, Granville, Wake, Johnston, Franklin, and Lee Counties.*

B. HOME-WORK RELATIONSHIPS AND TRAFFIC PATTERNS

Similar to sprawling land-use patterns, local employment patterns are favorable to the potential for commuter rail development. As of 2014, Wake County was the base location for 476,327 workers not working at home, 81.7 percent of whom were employed in various locales within the County itself (NCDOC 2015). Wake County also serves as a key employment destination for workers who reside in other areas—referred to as "inflow." Figure 1 shows worker inflow and "outflow" for primary jobs. In 2014, Wake County inflow from all locations was 258,585. Outflow for that year was 152,279 and the overall "net flow" (inflow minus outflow) was 106,306.

Figure 1. Overall Wake County Inflow/Outflow in 2014 (All Locations).



Source: NCDOC 2014

Table 2. Wake County Worker Inflow and Outflow for Top Ten Counties, Other North Carolina Counties, and Other States: 2014.

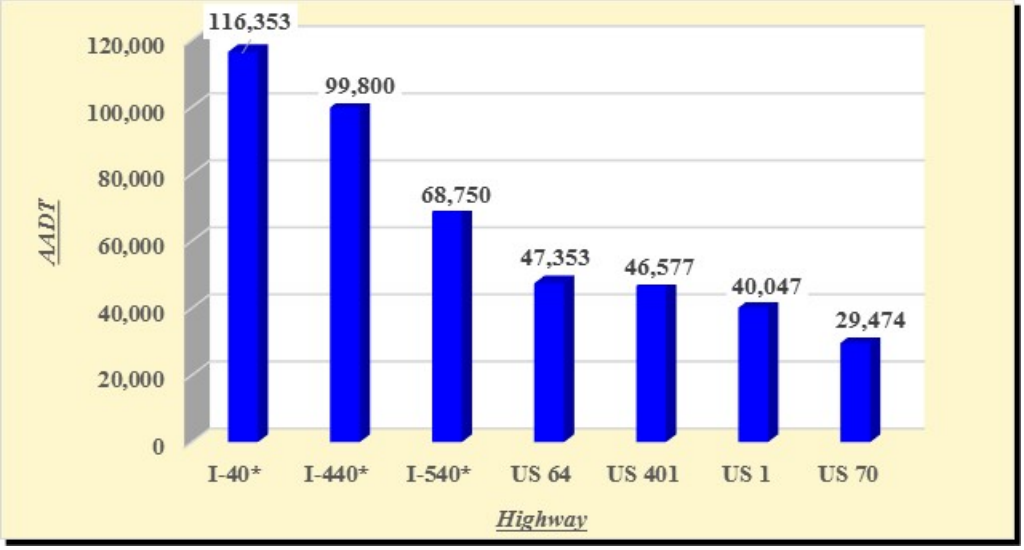
Location	Residents of Location Working in Wake County	Wake County Residents Working Outside Wake County
Johnston County, NC	29,470	5,736
Durham County, NC	26,064	59,589
Mecklenburg County, NC	14,599	17,114
Franklin County, NC	10,532	2,282
Harnett County, NC	10,097	0
Guilford County, NC	9,119	7,914
Cumberland County, NC	8,004	3,385
Orange County, NC	7,855	8,590
Forsyth County, NC	6,415	3,145
Granville County, NC	6,318	0
Other Counties in NC	119,718	37,512
Other States	10,394	7,012
TOTAL	**258,585**	**152,279**

Source: U.S. Census Bureau. 2016b

Table 2 shows similar data for specific Wake County inflow and outflow locations. Inflow and outflow numbers include daily commuters and can also include workers such as salespersons traveling between communities and others who may not hold structured "9 to 5" type jobs. Data shown in Figure 1 and Table 2 portray the extensive level of crossover in employment among workers in and around the Wake County area.

Workers entering and leaving Wake County travel most frequently along several major thoroughfares, including Interstates 40, 440 (Raleigh Beltline), 540 (Wake County Beltline) and 495 east of Knightdale; US 64, running east-west; US 1 and US 401, running north-south; and US 70 east-west. Traffic congestion has become a noteworthy problem along many of these routes in recent years (NCDOT 2014). Figure 2 shows the concentration of traffic along these roadways within Wake County, with the heaviest densities around Raleigh, I-40, and the I-440 Beltline. The Wake County portion of I-40 sees an annual average daily traffic count (AADT)[2] of 116,353.

Figure 2. Average Annual Daily Traffic for Major Wake County Highways: 2013-14.



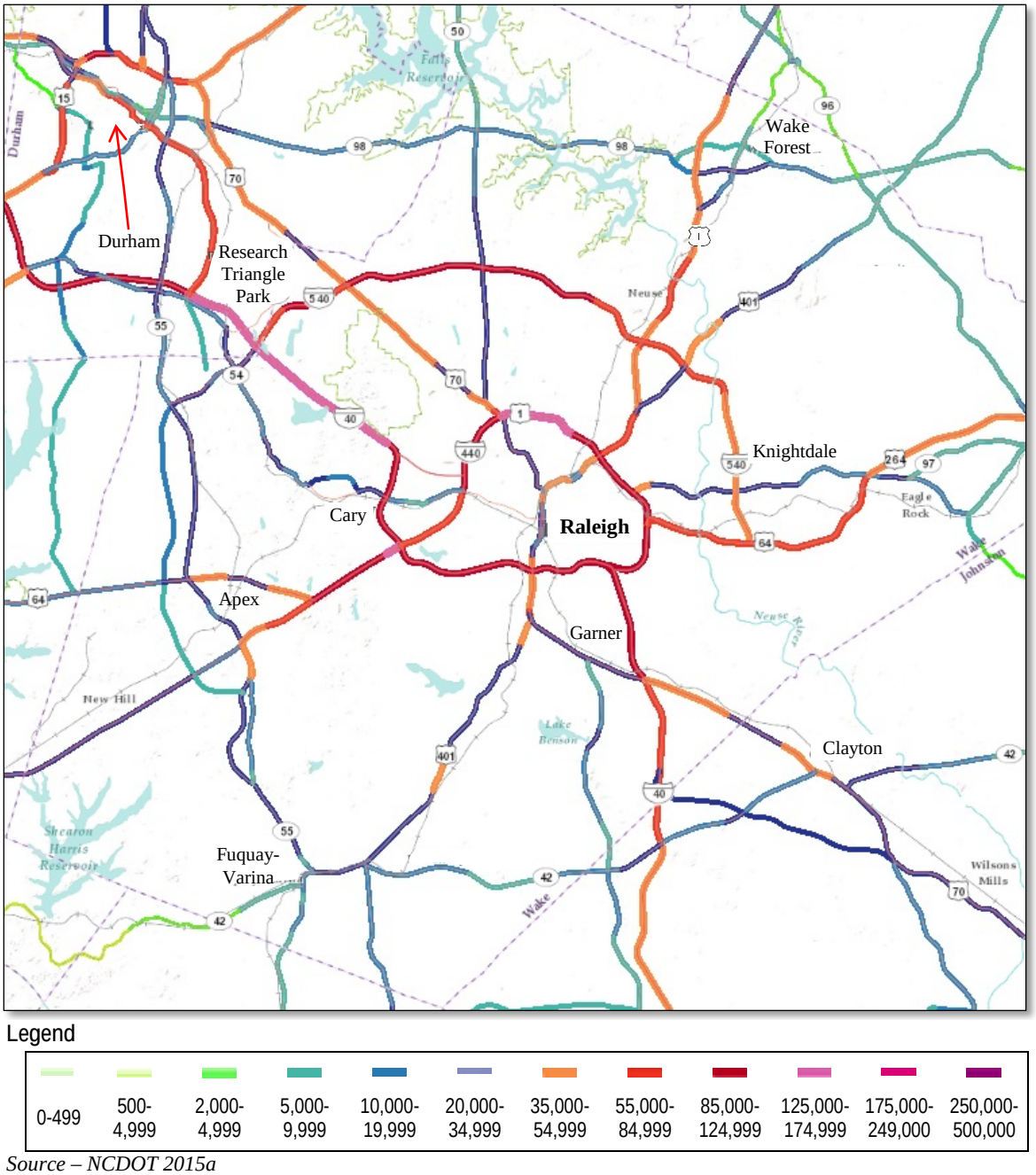
**Interstate values are for 2014. Values for US Highways are for 2013.*
Source: Calculated based on data from NCDOT Traffic Survey Group 2014

The most congested segments of I-40 in Wake County fall between Exits 285 and 287 (Aviation Parkway and Harrison Avenue) with an AADT of 162,000, followed by the segment between Exits 287 and 289 (Harrison Avenue and Wade Avenue) at 157,000 AADT (NCDOT 2014). The most congested segment of the I-440 Beltline falls between Wake Forest Road and Glenwood Avenue, ranging up to 135,000 AADT in 2012 (NCDOT 2015a).

[2] *Annual average daily traffic (AADT) is a measure used primarily in transportation planning and transportation engineering. Traditionally, it is the total volume of vehicle traffic of a highway or road for a year divided by 365 days. AADT is a useful and simple measurement of how busy the road is" (Wikipedia Contributors 2015a).*

Figure 3 presents a graphic representation of AADT along highways in Wake County and the southeastern portion of Durham County.

Figure 3. Average Annual Daily Traffic for Study Area Highways: 2014.



Source – NCDOT 2015a

Congestion along the routes shown in Figures 2 and 3 is largely associated with the high number of single-occupant or private vehicles dominating the roadways. Using I-40 as an example: as of 2003, the private vehicle accounted for 90 percent of the traffic "mode split" on I-40, with transit accounting for

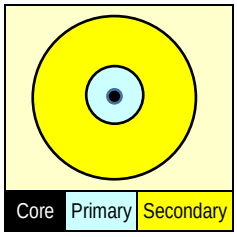
less than 1 percent (NCDOT 2003). Furthermore, the period of congestion is expected to increase over time.

> Note that in the future, average daily traffic volumes increase dramatically. The impact during the peak hour is less pronounced due to the spreading of the peak period. Instead of a peak two-hour period, as is typical under existing conditions, the TRM predicts a future four-hour AM peak period. Peak period spreading occurs when the absolute capacity of the peak hour is exceeded, forcing traffic to begin their trips earlier or later than they normally desire. (NCDOT 2003:19)

Such data predict the inevitable trend of traffic in the metropolitan area in the future and suggest an urgent need for identifying viable alternatives to the single-occupant vehicle in Wake County in general, and on I-40 and other major roadways, in particular.

C. DEFINING COMMUTER RAIL CATCHMENT AREAS

Assessment of the viability of new forms of transit must take into account major factors that will influence the success of these projects. In the case of commuter rail, the area much be characterized by a population adequate to support daily commuting and employment patterns in which workers travel from outer points to common destinations. Communities in which the "trip origin" points occur must be serviced by railways with passenger stops and infrastructure adequate to support the development of commuter rail. Additionally, determining the viability of rail transit for residents in these municipalities must take into account the presence of passenger stations or viable locations for such stations and nearby population "catchment areas"—the region surrounding transit stations from which ridership is drawn.



APTA Catchment Area Classifications

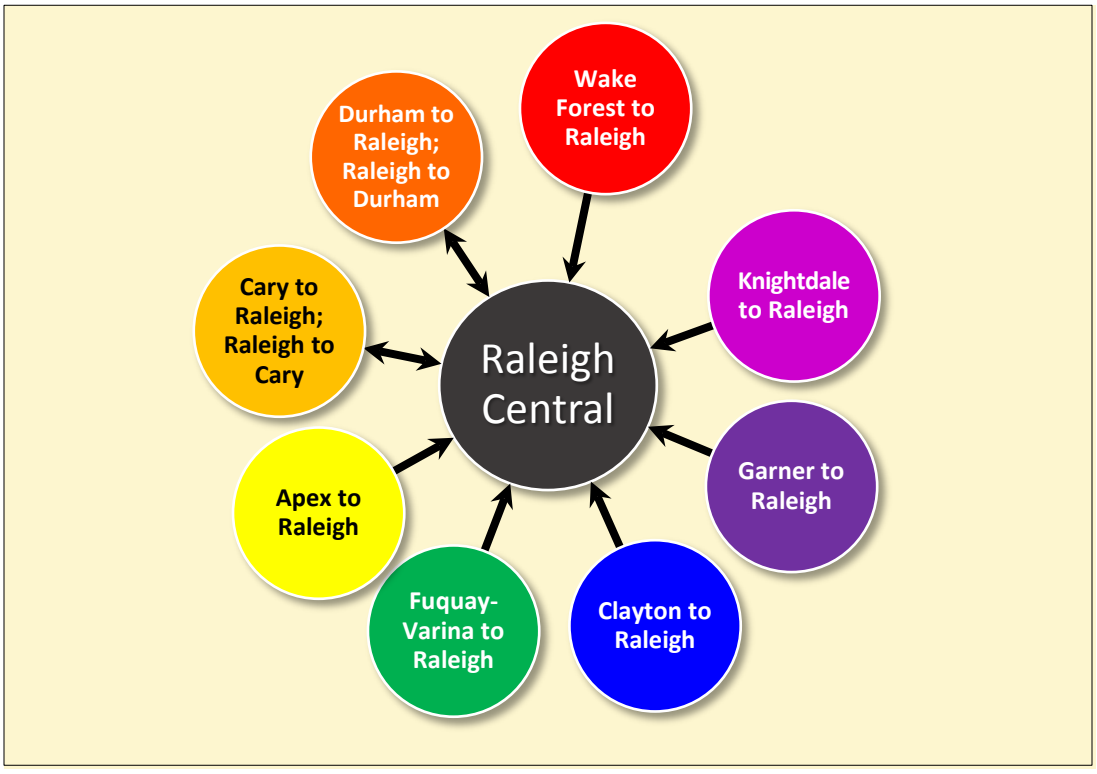
A 2009 study conducted by the American Public Transportation Association (APTA) conceptualizes the transit catchment area in terms of three areas (referred to as "zones in the discussion that follows). The core station zone is the immediate area surrounding the transit stop. This area is typically pedestrian friendly and the spatial and design aspects of the core impact the level of transit use at the stop. The primary catchment zone surrounds the core station area. Similar to the core, riders beginning their transit journeys from the primary zone are usually pedestrians. Ease of access to the primary catchment zone is key in determining transit ridership. The secondary catchment zone is a large space surrounding the primary zone that generates the greatest number of transit trips. Riders whose trips begin in this area reach the station via automobile and other means. The size of the catchment area varies based on the type of transit in question (rail versus bus, etc.). For regional rail, which is similar to but not synonymous with commuter rail (Wikipedia Contributors 2015e), APTA (2009) recommends a catchment area radius of ¼ mile, ½ mile, and five miles for the core, primary, and secondary catchment zones, respectively. Descriptions of potential commuter rail catchment areas in this study are based on this model.

D. IDENTIFYING COMMUTER RAIL CATCHMENT AREAS IN THE WAKE COUNTY AREA

In Wake County and the surrounding area, several locations appear to have promise as potential commuter rail catchment areas. Figure 4 depicts traffic patterns among communities in and near Wake County and illustrates the logic of the discussion that follows. Highway traffic in the smaller communities primarily flows into Raleigh rather than vice versa whereas a significant amount of work traffic flows in both directions between Raleigh, Cary, Research Triangle Park, and Durham. The highest "cross county community flow" occurs between Wake and Durham Counties with about 66,000 commuters traveling this path daily (Jarrett Walker Associates et al. 2015:46). With respect to Wake County alone:

> The highest traveled movements are between the inner Beltway and north Raleigh, north Raleigh and northwest Raleigh, and the inner Beltway and the Cary/Apex areas. There are also substantial volumes traveling between the outer rural areas or smaller municipalities and the more urban Raleigh and Cary districts. (Jarret Walker and Associates et al. 2015:46)

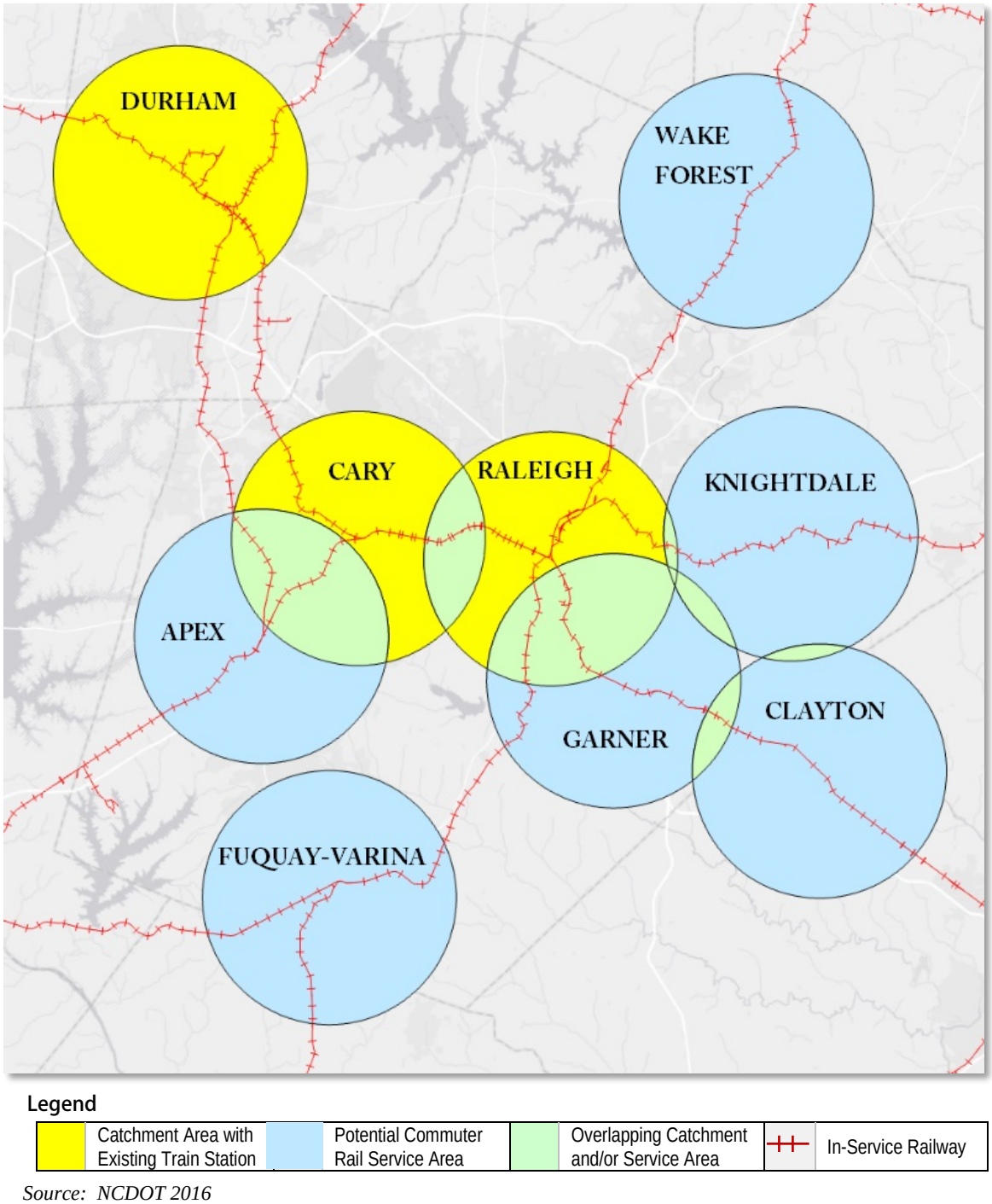
Figure 4. Traffic Flow between Raleigh and Potential Catchment and Service Areas.



The municipalities shown in Figure 4 are linked by several rail lines that run throughout the area. Raleigh serves as a central crossroads and a major hub for railways in the region. Figure 4 depicts these railways and illustrates the relationship among potential catchment or service areas in and near Wake County. Three communities—Raleigh, Cary, and Durham—currently have functioning passenger train stations from which potential commuter rail catchment areas can be clearly

delineated. An additional six communities have railways but no passenger service. Population and travel data suggest that these communities may be suitable for exploration of commuter rail service. Figure 5 shows the location of railways, catchment areas, potential service areas, as well as overlapping catchment and/or service areas.

Figure 5. Catchment Areas, Potential Commuter Rail Service Areas, and In-Service Railways.



Source: NCDOT 2016

The following discussion describes the three catchment areas and the six additional potential service areas shown in Figure 4 with respect to their potential viability for commuter rail.

1. Raleigh Catchment Area

Raleigh, Wake County's major residential population center, attracts residents, visitors, and workers from a wide surrounding area. Raleigh has been ranked as the number one city in the US for jobs, the nation's second best metropolitan area for small business work, and one of four cities leading in economic growth (Dickens 2015) (City of Raleigh 2015c). The city is also ranked as one of the top, mid-sized "American Cities of the Future" by Financial Times (Troyer 2015a)—attracting workers from a variety of locales.

a) Raleigh Home-Work Employment Patterns

Raleigh's estimated 2015 population was 451,066, up 11.6 percent from 2010, with 70.7 percent in the civilian labor force (US Census Bureau 2015b). Like Wake County, Raleigh serves as a key destination for workers in nearby towns and counties.

Table 3 presents data on worker inflow into Raleigh (persons who work in Raleigh but reside elsewhere) from nearby locations. In 2014, Raleigh was home to a total of 323,609 primary jobs. Slightly over a quarter of Raleigh workers (26.4 percent) live and work in Raleigh. The greatest number of inflow jobs—18,491—originate in Cary. Another 12,228 Raleigh jobs are held by workers who reside in Durham. Among the cities shown in Table 3, a total of 238,180 persons work in Raleigh, representing almost three-quarters of Raleigh's total workforce.

Table 3. Raleigh Worker Inflow--Residence of Persons Whose Primary Job is in Raleigh: 2014.

Municipality of Worker Residence	Workers Employed in Raleigh	
	Number	Percent
Raleigh	**85,429**	**26.4%**
Inflow Jobs (238,180; 73.6%)		
➢ Cary	18,491	5.7
➢ Durham	12,228	3.8
➢ Wake Forest	5,344	1.7
➢ Garner	5,174	1.6
➢ Apex	4,986	1.5
➢ Fuquay-Varina	2,452	0.8
➢ Knightdale	2,744	0.8
➢ Clayton	2,559	0.8
➢ Charlotte	6,997	2.2
➢ Morrisville	2,359	0.7
➢ Other Locations*	174,846	54.0
TOTAL	**323,609**	**100.0%**

**In North Carolina and out of state*
Source: U.S. Census Bureau. 2016b

Table 4 shows Raleigh worker outflow to other locations. Around 53 percent of Raleigh residents of working age (n=97,243) are employed outside the city for their primary job. Slightly over 9 percent of Raleigh workers, 17,001, work in Durham and another 15,248, or 8 percent, work in Cary. Data in Tables 3 and 4 clearly demonstrate the extent of employment crossover contributing to traffic flowing to and from Raleigh on workdays. Based on population and employment characteristics, and previously discussed AADT levels, downtown Raleigh may be identified as a location for study as a potential commuter rail catchment area.

Downtown Raleigh – Daytime

Table 4. Raleigh Worker Outflow--Employment Location of Raleigh Residents: 2014.

City	Raleigh Jobs	
	Number of Jobs	Percent of Jobs
Raleigh	**85,429**	**46.8**
Outflow Jobs* (n=97,243)		
➢ Durham	17,001	9.3
➢ Cary	15,248	8.4
➢ Morrisville	3,332	1.8
➢ Chapel Hill	2,435	1.3
➢ Garner	2,279	1.3
➢ Charlotte	6,394	3.5
➢ Apex	1,811	1.0
➢ Wake Forest	1,458	0.8
➢ Other Locations	47,285	25.9
TOTAL	**182,672**	**100.0%**

**Note: Outflow to other study sites (Fuquay-Varina, Knightdale) is less than 1,000.*
Source: U.S. Census Bureau. 2016b

b) Characteristics of Raleigh Union Station

As a major rail hub, Raleigh is connected by rail to other local communities from which work traffic originates. NCRR owns the H-Line between Greensboro and Goldsboro. This line runs from Clayton through Garner and into Raleigh. The CSX S-Line runs from Apex to Cary and from Raleigh to Wake Forest. The CSX S-Line (located on the NCRR H-Line corridor) runs between Cary and Raleigh and the Norfolk Southern NS-Line runs from Fuquay-Varina to from Raleigh.

Raleigh's current Amtrak Station, located southwest of downtown on Cabarrus Street, is scheduled for replacement in 2017. The station cannot accommodate long trains and suffers from overcrowding (City of Raleigh 2015d) and plans are in place to open a new, modern, more accessible station.

Raleigh Union Station

Raleigh Union Station will be located at 510 West Martin Street near the Warehouse District and will operate as a multi-modal facility serving Amtrak trains, city buses, and other forms of transit. The new station will feature 7,500 square feet of space in the passenger waiting area compared with 1,800 square feet in the current station (Railway-Technology.com 2015). The area surrounding the train station will provide an ideal transit location for Raleigh residents who are traveling to Cary, Research Triangle Park, and Durham; a central destination point for workers from other towns; and a transfer point for others traveling through and beyond Raleigh.

c) Land Use Characteristics of Raleigh Union Station Catchment Area

The Union Station catchment area holds potential for attracting transit riders from locales across the metropolitan area. Ongoing development in downtown Raleigh promises neighborhood change and pedestrian friendly features that are compatible with transit use. The following discussion presents information on land use within the Raleigh catchment area. The data shown are based on *Imagine 2040*, a joint initiative of the Capital Area Metropolitan Planning Organization (CAMPO) and the Durham-Chapel Hill-Carrboro Metropolitan Planning Organization (DCHC MPO). Derived from *Imagine 2040*, the term "place type" is used in this report to describe future land use characteristics of areas within the study sites.

The concept of place type was used in *Imagine 2040* because it provides land-use categories that can be generalized across various locales and used to "…describe, measure, and evaluate the built environment" (Noonkester 2013:25). The place type scheme attempts to identify the essence or nature of specific locations and activities and land uses common to them. This strategy simplifies and clarifies the variety of land use categories across the municipalities and counties included in the *Imagine 2040* plan. Characteristics used to identify place types include population size and density, physical and visual features, land-use diversity, travel mode choice, environmental stewardship, and other traits. For this study, place types are preferable to zoning categories not only because they categorize land use similarly across communities but also because place types focus on *future* land use and plans for development. Likewise, the use of place types is beneficial in the study of commuter rail and other forms of transit that are currently unavailable but may be candidates for development in the future.

Imagine 2040 identifies twenty-eight place types (see *Appendix B* for detailed descriptions) across the Triangle region.[3] Table 5 shows detailed place types for the Raleigh Union Station catchment

[3] *The study area for Imagine 2040 includes Wake, Durham, Johnston, Orange, Chatham, Person, Granville, Franklin, Harnett, and Nash Counties and the majority of the cities and towns located in these counties.*

area, indicating the percentage of land in the core, primary, and secondary zones as well as the total Union Station catchment area. Table 6 presents a streamlined version of the table and condenses the Raleigh place types into ten categories based on residential density, typical forms of transit, and primary land uses.[4] Categories in Table 6 were created for this report and are based on groupings of Table 5 place types (numbered sequentially with red line showing grouping separations).

Table 5. Percentage of Raleigh Union Station Catchment Area in Place Type Categories.

Place Type		Catchment Zone / Percentage in Each Place Type			
		Core	Primary	Secondary	Total Catchment
1	Parks and Open Space	2.25	2.57	8.47	8.42
2	Working Farm				
	Rural Living			2.37	2.36
	Large-Lot Residential Neighborhood			2.83	2.81
3	Mobile Home Park			0.46	0.45
	Shade Tree Residential Neighborhood			16.10	15.98
	Small-Lot Residential Neighborhood			16.10	15.97
4	Multi-Family Residential Neighborhood	2.50	3.59	4.96	4.95
	Mixed-Density Residential Neighborhood			4.48	4.45
	Urban Neighborhood	19.38	13.92	2.72	2.82
	High Rise Residential				
5	Rural Crossroads				
	Neighborhood Commercial Center			1.33	1.32
	Suburban Commercial Center			3.40	3.38
	Suburban Hotel			0.22	0.22
6	Suburban Office Center	7.25	2.19	3.22	3.22
	Regional Employment Center			0.38	0.38
7	Light Industrial Center		0.95	5.39	5.35
	Heavy Industrial Center			2.31	2.29
8	Mixed-Use Neighborhood	2.61	9.64	1.99	2.04
	Mixed Use Center			0.95	0.94
	Town Center				
	Transit-Oriented Development				
	Metropolitan Center	61.81	44.35	0.68	1.06
9	Airport				
10	Civic and Institutional	4.21	19.50	14.56	14.57
	Health Care Campus			0.56	0.56
	University Campus		3.30	6.52	6.49

Note: Shaded cell = 0.0%
Source: Calculated based on data from Triangle J. Council of Government 2013

[4] *Percentages shown for place types in the tables that follow were calculated based on data provided by Triangle Council of Government (2013). The "Grouped Place Type" typology was created for this report and adapted from information provided in the original Imagine 2040 Place Type typology.*

The core area surrounding Raleigh Union Station is comprised predominantly of a variety of mixed-use areas including diverse arrays of residential, government, and economic activities. The mixed-use area is typified by walkable streets and a pedestrian-friendly layout.

About 61 percent of the core zone surrounding Raleigh Union Station and about 44 percent of the primary zone classify as metropolitan center—"….the hub of employment, entertainment, civic, and cultural activities, with a mix of housing types and common open space for active living" (Noonkester 2011:B48). This place type is symbolic of the community and attracts visitors from surrounding areas. The metropolitan center is typified by a grid-type street layout, mixed-use planning, and the ability to support a variety of transit modes. Around 19.4 and 13.9 percent of the Raleigh core and primary areas, respectively, are classified as Urban Neighborhood (Table 5), offering walkable streets and supporting a variety of housing types, including detached and multiple-unit buildings.

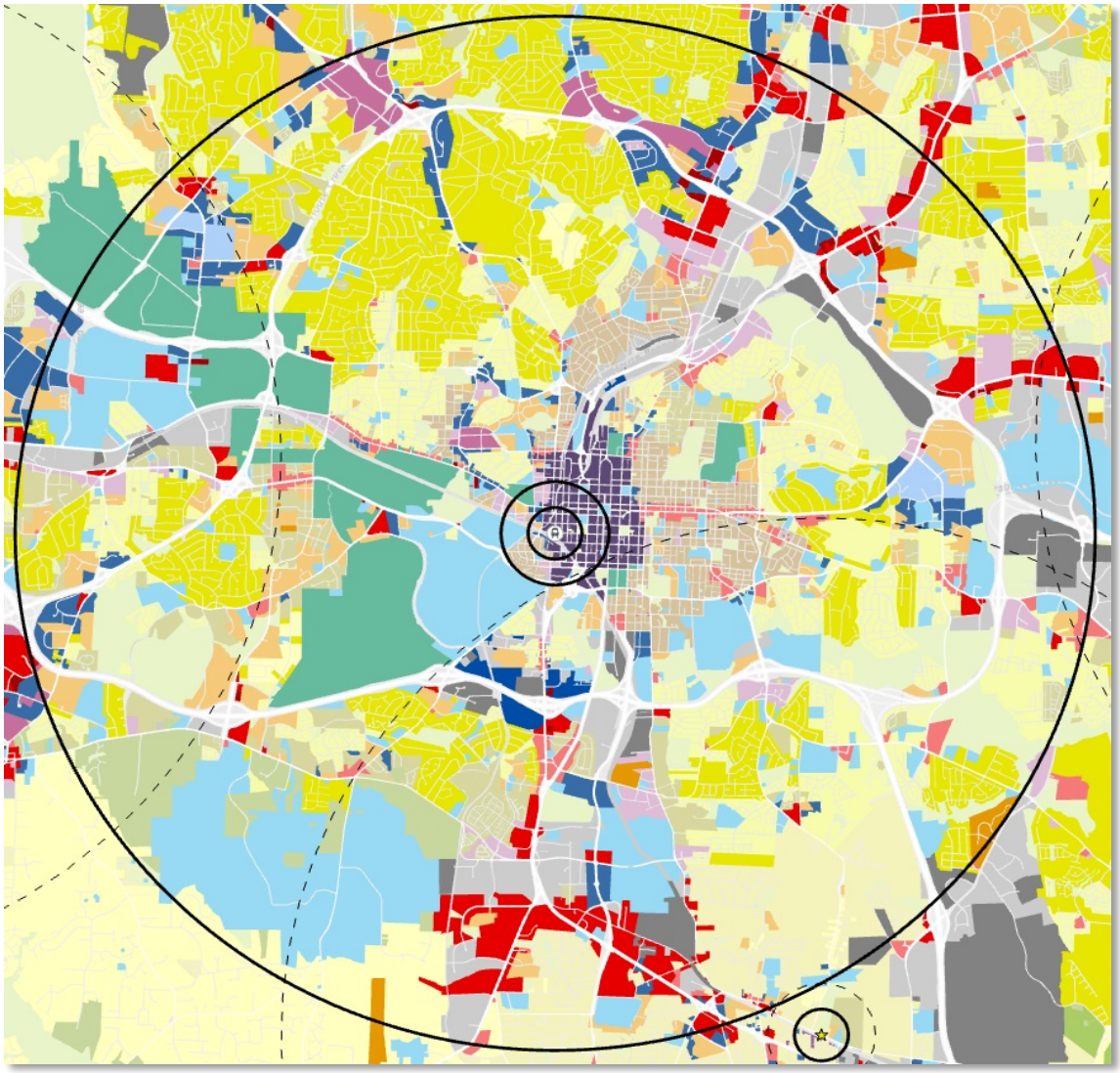
Around 19 percent of both the secondary zone and the total catchment area is classified as shade tree residential neighborhood, characterized by post-World War II detached homes located near urban centers. This place type is typified by curvilinear streets, mature trees, the presence of churches, schools, community buildings, parks.

Table 6. Percentage of Raleigh Union Station Catchment Area in Grouped Place Type Categories.

Place Type		Catchment Zone / Percentage in Each Place Type			
		Core	Primary	Secondary	Total Catchment
1	Parks & Open Space	2.25	2.57	8.47	8.42
2	Predominantly Low Density Residential	0.00	0.00	5.21	5.17
3	Predominantly Mid-Density Residential	0.00	0.00	32.66	32.40
4	Mid-to High-Density Residential	21.88	17.51	12.16	12.21
5	Commercial Centers with Low Density Residential	0.00	0.00	4.95	4.91
6	Rural Crossroads and Commercial, Non-Residential	7.25	2.19	3.60	3.60
7	Heavy and Light Industrial, Non-Residential	0.00	0.95	7.69	7.64
8	Mixed-Use Areas	64.42	53.99	3.62	4.04
9	Airport	0.00	0.00	0.00	0.00
10	Civic-Institutional/ and University & Health Care Campuses	4.21	22.80	21.64	21.61
	TOTAL	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Source: Calculated based on data from Triangle J. Council of Government 2013

Figure 6. Raleigh Union Station Catchment Area Place Types.

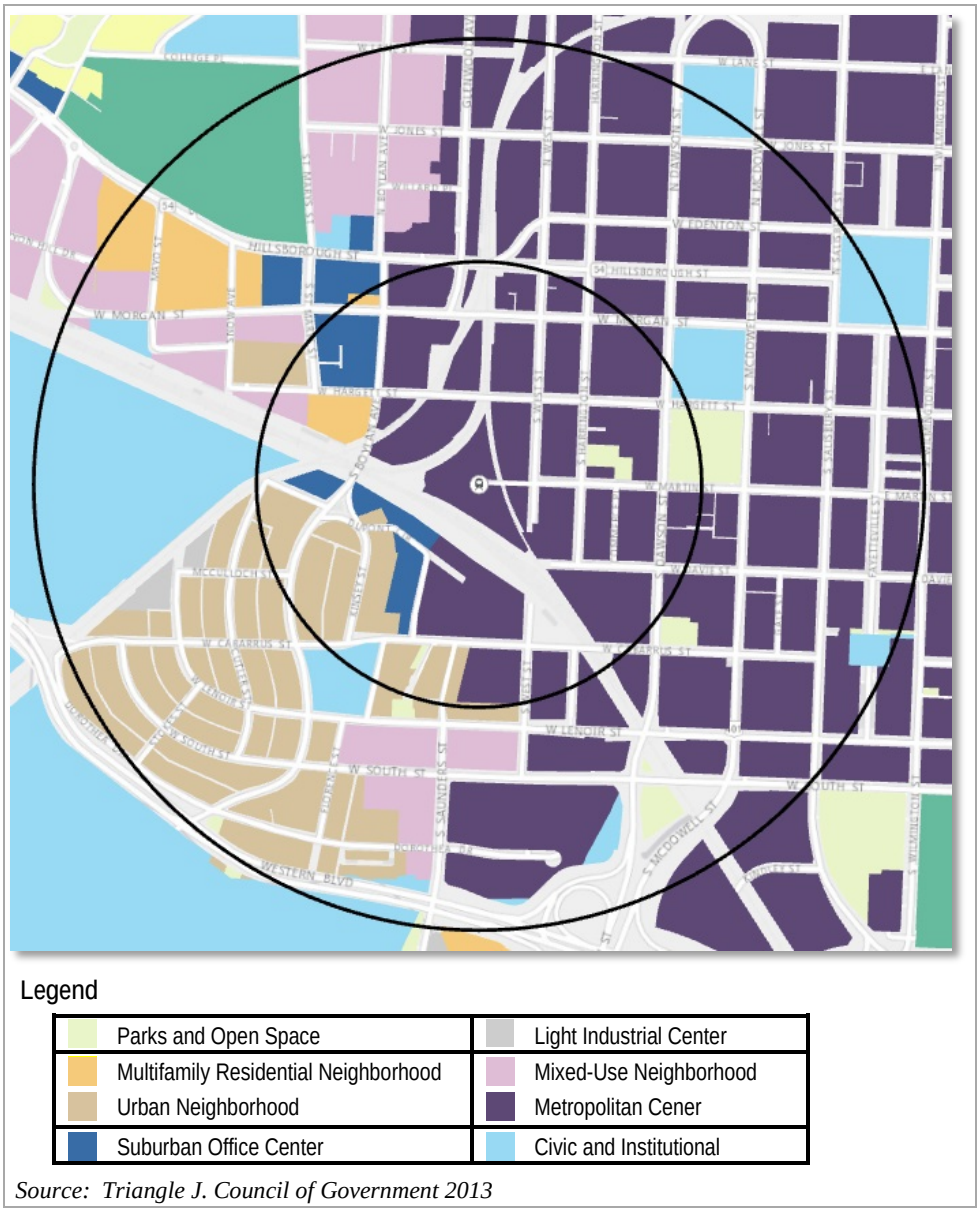


Legend

- Parks and Open Space
- Rural Living
- Large-Lot Residential Neighborhood
- Mobile Home Park
- Shade Tree Residential Neighborhood
- Small Lot Residential Neighborhood
- Multifamily Residential Neighborhood
- Mixed Density Residential Neighborhood
- Urban Neighborhood
- Neighborhood Commercial Center
- Suburban Commercial Center
- Suburban Hotel
- Suburban Office Center
- Regional Employment Center
- Light Industrial Center
- Heavy Industrial Center
- Mixed-Use Neighborhood
- Mixed-Used Center
- Metropolitan Cener
- Civic and Institutional
- Health Care Campus
- University Campus

Source: Triangle J. Council of Government 2013

Figure 7. Raleigh Union Station Core and Primary Catchment Zone Place Types.



Source: Triangle J. Council of Government 2013

2. Cary Catchment Area

Cary is located approximately eight miles due west of Raleigh and ten miles southeast of Research Triangle Park. Cary has experienced extensive growth in recent decades. The town's population tripled between 1990 and 2009 (Town of Cary 2010) and reached an estimated 157,769 in 2015—an 18 percent increase over 2010 (U.S. Census Bureau 2015b). Around 72 percent of Cary's population is in the civilian labor force. Along with residential population increases, Cary has seen significant business expansion over the years and in 2015, the Raleigh-Cary metropolitan area was ranked number two nationwide among "Up-and-Coming Cities for Tech Jobs" (Troyer 2015b).

a) Cary Home-Work Employment Patterns

Growth in the job sector has brought workers into Cary for employment in recent years. Consequently, traffic is significant in and around the Cary area and traffic density along I-40 between Cary, RTP, Raleigh, and Durham is among the highest levels in the Wake County metropolitan area (NCDOT 2015a). In keeping with these numbers, Cary sees a significant level of worker inflow and outflow. Of 78,003 jobs in Cary, only 13,511, or 17.3 percent, are held by Cary residents (Table 7). Around a quarter of Cary primary jobs are held by Raleigh/Durham residents. Likewise, 18,491 Cary residents hold jobs in Raleigh, and another 9,082, in Durham. (See *Appendix A* for detailed information on inflow and outflow.)

Table 7. Cary Worker Inflow and Outflow: 2014.

Commuting Characteristic	Municipality		Number of Primary Jobs	Percent of Primary Jobs
Residence of Workers Employed in Cary	Cary		13,511	17.3
	Other Locations (Inflow)	Raleigh	15,248	19.5
		Durham	4,371	5.6
		Other	44,873	57.5
Total Primary Jobs in Cary			**78,003**	**100.0%**
Work Location of Cary Residents Commuting Elsewhere (Outflow)		Raleigh	18,491	33.1
		Durham	9,082	16.3
		Other	28,263	50.6
Total Outflow Jobs among Cary Residents			**55,836**	**100.0%**

Source: U.S. Census Bureau 2016b

b) Characteristics of Cary Train Station

Cary serves as a rail stop on the routes between Raleigh, Durham, and Apex. The CSX S-line runs from Apex into Cary and the NCRR H-line runs from Durham through Cary, into Raleigh. Cary shows promise as a commuter rail catchment area, not only due to commuting patterns and traffic density on nearby roads but also because the town has an existing train station. The historic Cary station (see http://pwrr.org/nstation/cary.html) was demolished in the 1970's (Amtrak 2015a). The current station, which opened in 1996, is located in the heart of the downtown area. The station is served by eight passenger trains per day. The Cary station provides 130 free parking spaces and offers a waiting room, restrooms, and a ticketing window (Wikipedia Contributors 2015f). The Cary station catchment area includes most of Cary and parts of Morrisville to the west. The eastern portion of Cary's catchment area overlaps with the Raleigh catchment area and the southwestern portion overlaps with the Apex catchment area (see Figure 7).

Cary Amtrak Station

c) Land Use Characteristics of Cary Catchment Area

Table 8 depicts place types for the Cary station catchment area and Table 9 shows the place types grouped into broader categories.

Table 8. Percentage of Cary Station Catchment Area in Place Type Categories.

Place Type		Catchment Zone / Percentage in Each Place Type			
		Core	Primary	Secondary	Total Catchment
1	Parks and Open Space	0.56	3.20	20.05	19.90
2	Working Farm				
	Rural Living			1.57	1.55
	Large-Lot Residential Neighborhood			5.43	5.39
3	Mobile Home Park			0.02	0.02
	Shade Tree Residential Neighborhood		0.40	6.16	6.11
	Small-Lot Residential Neighborhood		3.40	25.45	25.24
4	Multi-Family Residential Neighborhood	3.29	9.04	6.65	6.66
	Mixed-Density Residential Neighborhood			1.98	1.96
	Urban Neighborhood	0.72	47.60	0.64	0.96
	High Rise Residential				
5	Rural Crossroads				
	Neighborhood Commercial Center			1.03	1.02
	Suburban Commercial Center		0.27	3.82	3.79
	Suburban Hotel			0.25	0.25
6	Suburban Office Center		0.27	3.49	3.46
	Regional Employment Center			4.18	4.14
7	Light Industrial Center		5.45	3.12	3.13
	Heavy Industrial Center			1.06	1.05
8	Mixed-Use Neighborhood			1.53	1.52
	Mixed Use Center			1.24	1.23
	Town Center	95.43	24.89	0.20	0.56
	Transit-Oriented Development I				
	Transit-Oriented Development II			0.08	0.07
	Transit-Oriented Development III			0.08	0.08
	Metropolitan Center				
9	Airport			2.73	2.71
10	Civic and Institutional		5.47	5.49	5.48
	Health Care Campus			0.47	0.47
	University Campus			3.27	3.24
	TOTAL	**100%**	**100%**	**100%**	**100%**

Note: Shaded cell = 0.0%
Source: Calculated based on data from Triangle J. Council of Government 2013

Of the twenty-eight individual place types (Table 8), around 95 percent of Cary's core catchment zone is comprised of the town center place type, typified by a variety of housing and commercial establishments as well as community buildings. The largest portion of the primary area is classified as Urban Neighborhood—characterized by moderate- to higher-density housing. A quarter of the secondary zone falls in the small-lot residential neighborhood category, which is comprised of a mix of detached and multi-unit housing with landscaped buffers in between neighborhoods. The secondary zone supports a small percentage of transit-oriented development. Over a quarter of this zone is typified by small-lot development.

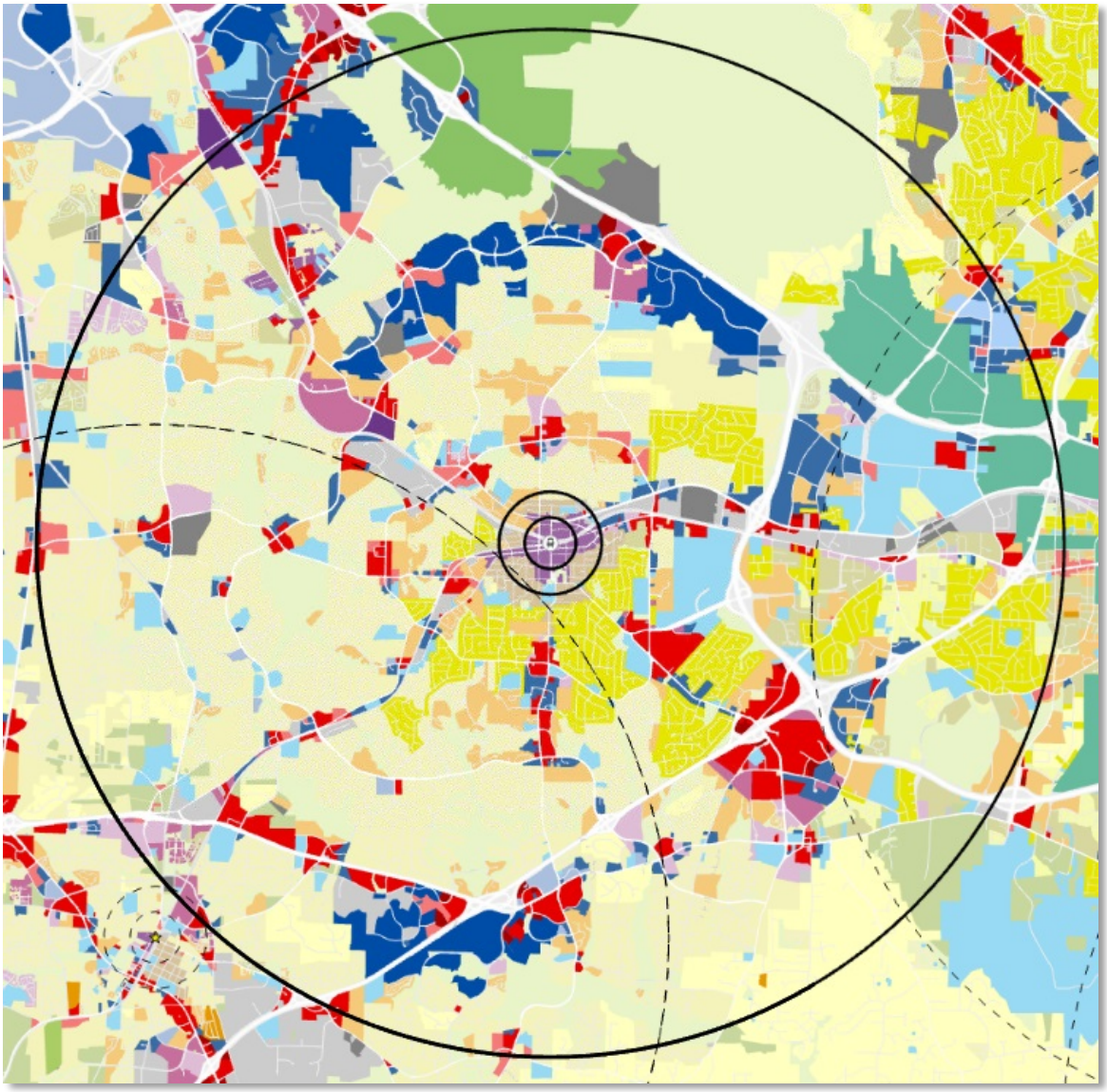
Groupings of place types presented in Table 9 show that the core catchment zone is largely comprised of various types of mixed-use development, which is compatible with transit use. Likewise, over half of the primary zone contains mid-to high-density residential development, providing a larger population base near the train station.

Table 9. Percentage of Cary Station Catchment Area in Grouped Place Type Categories.

Place Type		Catchment Zone / Percentage in Each Place Type			
		Core	Primary	Secondary	Total Catchment
1	Parks & Open Space	0.56	3.20	20.05	19.90
2	Predominantly Low Density Residential	0.00	0.00	7.00	6.94
3	Predominantly Mid-Density Residential	0.00	3.80	31.62	31.37
4	Mid-to High-Density Residential	4.01	56.64	9.27	9.58
5	Commercial Centers with Low Density Residential	0.00	0.27	5.10	5.06
6	Rural Crossroads and Commercial, Non-Residential	0.00	0.27	7.67	7.61
7	Heavy and Light Industrial, Non-Residential	0.00	5.45	4.18	4.18
8	Mixed-Use Areas and Town Center	95.43	24.89	3.13	3.47
9	Airport	0.00	0.00	2.73	2.71
10	Civic-Institutional/ and University & Health Care Campuses	0.00	5.47	9.24	9.19
TOTAL		**100.00%**	**100.00%**	**100.00%**	**100.00%**

Source:Calculated based on data from Triangle J. Council of Government 2013

Figure 8. Cary Station Catchment Area Place Types.



Source: Triangle J. Council of Government 2013

Figure 9. Cary Station Core and Primary Catchment Zone Place Types.

Source: Triangle J. Council of Government 2013

3. Durham Catchment Area

Downtown Durham is located approximately twenty-five miles northwest of Raleigh Union Station. In 2010, Durham's population was 228,418. By 2015 the estimated population was 257,636, representing a 12.8 percent increase (US Census Bureau 2015b). A total of 68.7 percent of Durham's population is in the civilian labor force.

a) Commuting in and Out of Durham

Durham is home to 149,645 primary jobs. About 30 percent of Durham residents also work in Durham (Table 10) and over 100,000 workers from other locations travel into Durham for work. The largest number of inflow workers—17,001 or 11.4 percent—reside in Raleigh. Over 55,000 Durham residents work outside the City.

Table 10. Durham Worker Inflow and Outflow: 2014.

Commuting Characteristic	Municipality		Number of Primary Jobs	Percent of Primary Jobs
Residence of Workers Employed in Durham	Durham		45,139	30.2
	Other Locations (Inflow)	Raleigh	17,001	11.4
		Cary	9,082	6.1
		Other	78,423	52.4
Total Primary Jobs in Durham			**149,645**	**100.0%**
Work Location of Durham Residents Commuting Elsewhere (Outflow)		Raleigh	12,228	22.2
		Cary	4,371	7.9
		Other	38,586	69.9
Total Outflow Jobs among Durham Residents			**55,185**	**100.0%**

Source: U.S. Census Bureau. 2016b

b) Characteristics of Durham Train Station

Durham may represent a viable commuter rail origin and destination point not only due to its employment patterns but also because the city supports a centrally located passenger train station. The Durham Amtrak station, located at 601 West Main Street, is housed in a restored 1897 warehouse in downtown Durham's Bright Leaf National Register Historic District. The station is served by six trains per day with an annual ridership of 83,090 in 2014 (Amtrak 2015b). The CSX S-line runs from Apex to Cary and the CSX SDS-Line runs along the Western edge of RTP, and into Durham. The NCRR H-Line, operated by Norfolk Southern, runs from Cary, along the eastern side of RTP, into Durham.

Durham Amtrak Station

c) Land Use Characteristics of Durham Station Catchment Area

Tables 11 and 12 show detailed and grouped place types for the Durham station catchment area and Figures 10 and 11 contain maps showing place types for the total catchment and the immediate zones surrounding the train station, respectively. Slightly under half of the Durham core zone and over a third of the primary zone are classified as Metropolitan Center. Almost a third of the core and over 10 percent of the primary zone support transit-oriented development, typified by mixed-use properties, higher density development, and pedestrian-friendly streets. Transit-oriented development relieves congestion by "…shifting automobile trips to transit trips and by capturing

some trips on-site between complementary residential and non-residential uses" (Noonkester 2011:B.46). Around a third of the secondary zone is comprised of small-lot residential development. The remainder of this zone is divided among a variety of land uses including residential development, transit oriented development, and parks and open spaces.

Table 11. Percentage of Durham Station Catchment Area in Place Type Categories.

Place Type		Catchment Zone / Percentage in Each Place Type			
		Core	Primary	Secondary	Total Catchment
1	Parks and Open Space	0.12	4.51	10.46	10.40
2	Working Farm			1.56	1.55
	Rural Living			6.23	6.18
	Large-Lot Residential Neighborhood			3.44	3.41
3	Mobile Home Park			0.01	0.01
	Shade Tree Residential Neighborhood				
	Small-Lot Residential Neighborhood		2.02	33.34	33.08
4	Multi-Family Residential Neighborhood		0.14	6.73	6.68
	Mixed-Density Residential Neighborhood			0.69	0.69
	Urban Neighborhood		12.05	9.40	9.40
	High Rise Residential				
5	Rural Crossroads				
	Neighborhood Commercial Center		0.61	1.16	1.16
	Suburban Commercial Center		0.73	3.01	2.99
	Suburban Hotel		0.00	0.11	0.11
6	Suburban Office Center		4.96	1.98	1.99
	Regional Employment Center			1.11	1.10
7	Light Industrial Center			8.75	8.68
	Heavy Industrial Center			0.87	0.86
8	Mixed-Use Neighborhood			0.05	0.05
	Mixed Use Center	15.54	16.87	0.33	0.47
	Town Center				
	Transit-Oriented Development I				
	Transit-Oriented Development II	31.32	8.86	1.57	1.69
	Transit-Oriented Development III		2.34	0.70	0.70
	Metropolitan Center	48.78	36.04	0.04	0.36
9	Airport				
10	Civic and Institutional	4.25	10.34	5.50	5.52
	Health Care Campus			0.24	0.23
	University Campus		0.51	2.70	2.68

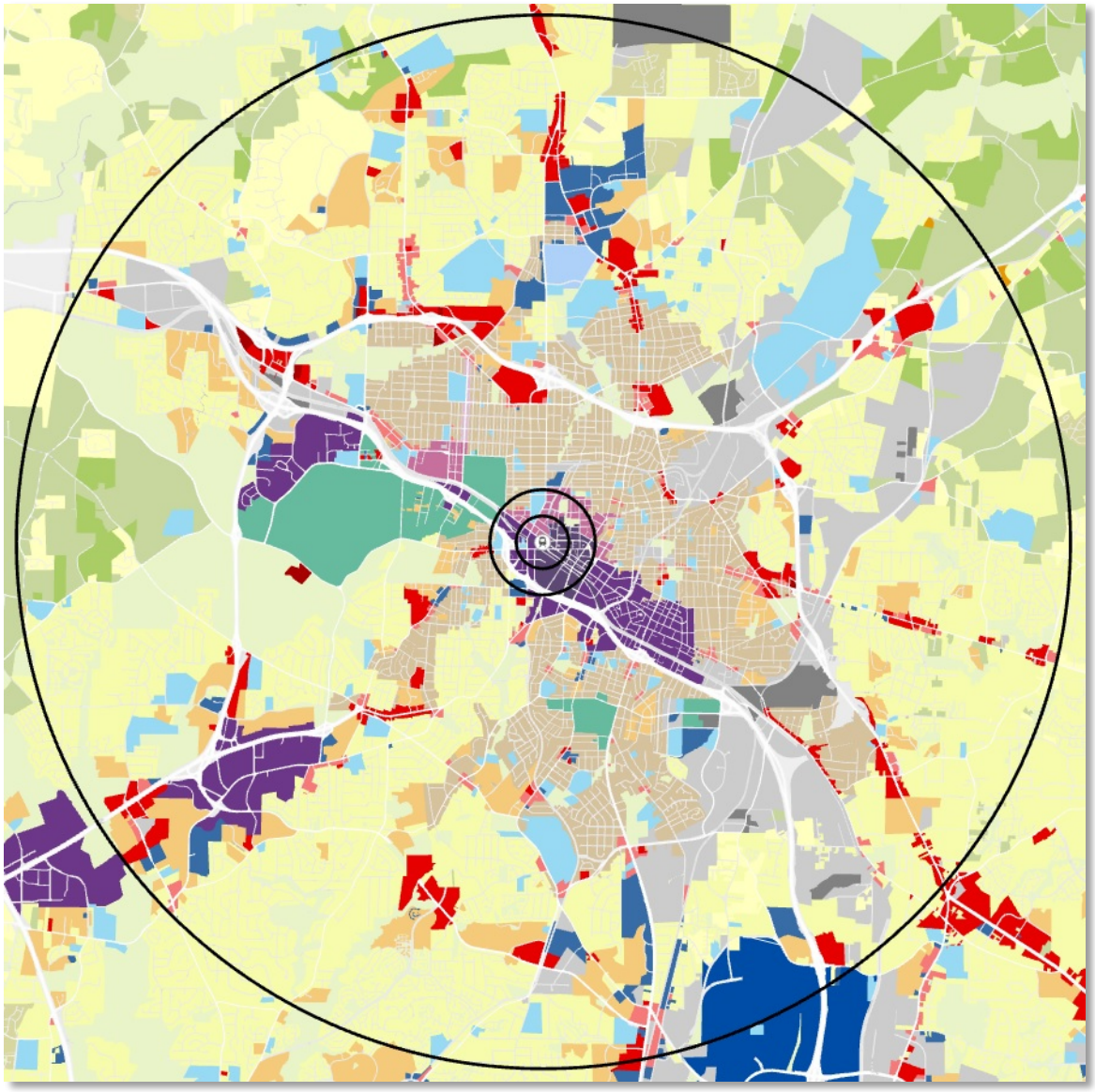
Note: Shaded cell = 0.0%
Source: Calculated based on data provided by Triangle J. Council of Government 2013

Table 12. Percentage of Durham Station Catchment Area in Grouped Place Type Categories.

Place Type		Catchment Zone / Percentage in Each Place Type			
		Core	Primary	Secondary	Total Catchment
1	Parks & Open Space	0.12	4.51	10.46	10.40
2	Predominantly Low Density Residential	0.00	0.00	11.23	11.14
3	Predominantly Mid-Density Residential	0.00	2.02	33.35	33.09
4	Mid-to High-Density Residential	0.00	12.19	16.83	16.77
5	Commercial Centers with Low Density Residential	0.00	1.34	4.29	4.26
6	Commercial, Non-Residential	0.00	4.96	3.09	3.09
7	Industrial, Non-Residential	0.00	0.00	9.62	9.54
8	Mixed-Use Areas	95.64	64.12	2.69	3.27
9	Airport	0.00	0.00	0.00	0.00
10	Civic-Institutional/ University & Health Care Campus	4.25	10.85	8.43	8.44
	TOTAL	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Note: Shaded cell = 0.0%
Source: Calculated based on data provided by Triangle J. Council of Government 2013

Figure 10. Durham Station Catchment Area Place Types.

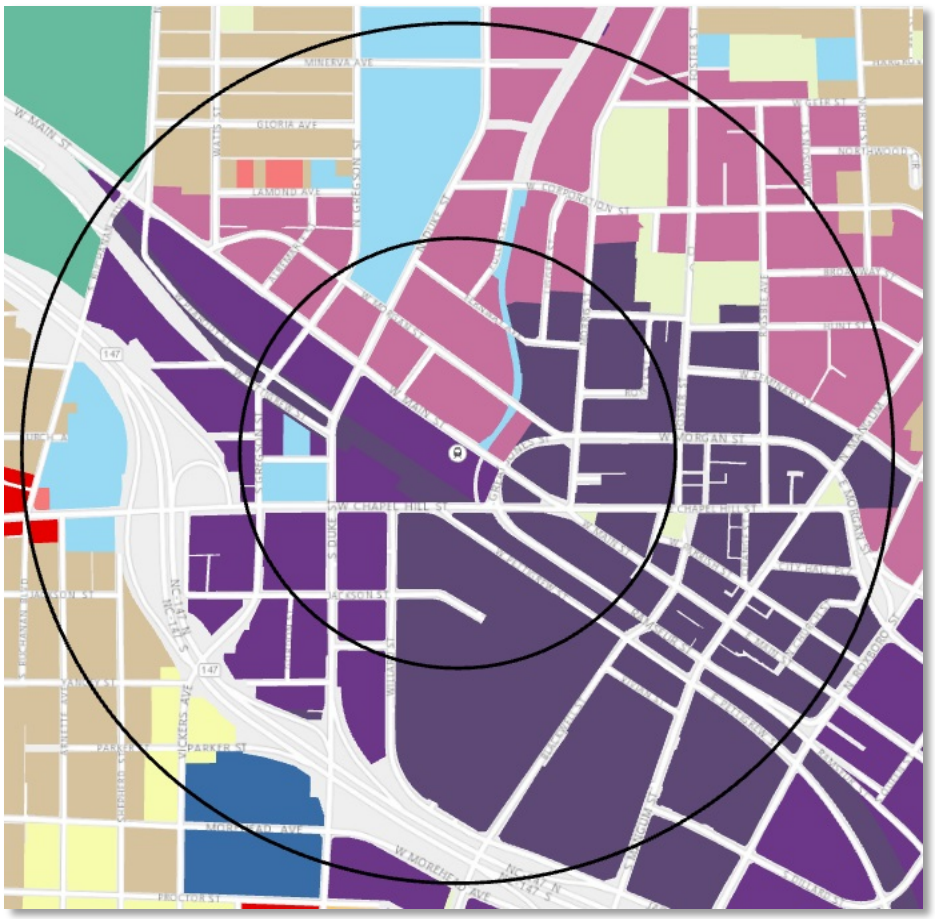


Legend

Parks and Open Space	Neighborhood Commercial Center	Mixed-Use Neighborhood
Working Farm	Suburban Commercial Center	Mixed Used Center
Rural Living	Suburban Hotel	Transit-Oriented Development
Large-Lot Residential Neighborhood	Suburban Office Center	Metropolitan Cener
Mobile Home Park	Regional Employment Center	Civic and Institutional
Small Lot Residential Neighborhood	Light Industrial Center	Health Care Campus
Multifamily Residential Neighborhood	Heavy Industrial Center	University Campus
Mixed Density Residential Neighborhood		
Urban Neighborhood		

Source: Triangle J. Council of Government 2013

Figure 11. Durham Station Core and Primary Catchment Zone Place Types.



4. Research Triangle Park as an Employment Destination

Research Triangle Park (RTP) is comprised of businesses and government organizations that employ large numbers of persons in the Triangle area and beyond. As such, RTP does not serve as a residential catchment area but represents a unique employment destination not only for workers in the study area, but for many others outside the Triangle area. Situated on 7,000 acres in Wake and Durham Counties, RTP is the largest high technology research park in North America and is home to over 170 firms (Durham Convention and Visitor's Bureau 2015). RTP boundaries transverse Morrisville and Cary and Wake County outside the boundaries of a municipality; the largest portion

of RTP—about a quarter—falls within Durham County. The CSX SDS-line borders the western perimeter of RTP and the Norfolk Southern H-line, located on the NCRR corridor, runs along the eastern perimeter. The two lines continue north and converge in downtown Durham.

I-40 West Weekday Peak Hour Traffic

The greatest number of local residents employed in RTP live in Raleigh (5,493), Durham (3,410), and Cary (4,982); almost half of RTP inflow jobs originate in these cities (Table 13). Another 38 percent of RTP inflow jobs originate outside the Raleigh-Durham area and the remainder originate from other Wake, Durham, and Orange County towns. Primary access to RTP is via Interstate 40 running between Raleigh and Durham. AADT in the RTP area is among the highest traffic density rates in the Raleigh-Durham MSA. In 2014 an average of 153,500 vehicles traveled I-40 on work days from Wade Avenue to I-540 access (NCDOT 2014).

> Clearly, the rapid growth in travel demand has outpaced improvements to the region's transportation facilities. Despite large investments in our highway system, congestion is on the rise. Commuters, and sometimes those traveling in the off-peak periods, face delays that were not foreseen at the beginning of the RTP's development.
> These conditions are expected to worsen in the next 25 years. The region's total population is expected to increase by more than 100 percent by 2025. However, capacity is planned to increase by less than 50 percent. Essentially, the pace of growth in the demand for travel will greatly exceed the abilities of the respective cities and the State to provide the necessary roadway capacity (NC DOT 2003:2-2).

RTP represents a viable commuter rail destination in that a large number of Triangle residents commute to RTP each workday along congested highways that are flanked by rail.

Table 13. Research Triangle Park Commuting Inflow from Selected Municipalities: 2014.

County	RTP Job Inflow	
	Number of Inflow Jobs	Percent of Jobs
Raleigh	5,493	19.2
Cary	4,982	17.4
Durham	3,410	11.9
Apex	1,292	4.5
Morrisville	1,015	3.5
Chapel Hill	639	2.2
Holly Springs	569	2.0
Wake Forest	388	1.4
Fuquay-Varina	236	0.8
Other Locations	10,588	37.0
TOTAL	**28,612**	**100.0%**

Source: U.S. Census Bureau 2016b

E. IDENTIFYING POTENTIAL COMMUTER RAIL SERVICE AREAS

The remaining six communities in the study area do not have existing train stations but once hosted operative train stations in their downtown areas. These stations, like many others across the country, closed their passenger service with the advent of highway transportation and the emerging dominance of automobile travel (American-Rails.com 2015b). Despite the lack of passenger stations, based on population and employment patterns, these municipalities may serve as trip origin points, or service areas, for commuter rail transit. The discussion that follows utilizes the location of the historic train stations in the downtown areas as central reference points for delineating potential service areas for future commuter rail stops.[1] The discussion describes the potential service areas lying in the east/northeast, southeast/south, and southwest regions of the study area.

1. Wake Forest Service Area

Wake Forest lies approximately eighteen miles northeast of downtown Raleigh. Wake Forest was home to 30,096 residents in 2010 and 2015 estimates place the population at 36,693 (US Census Bureau 2016a). Seventy percent of residents are in the civilian labor force (US Census Bureau 2015b). In 2014 13,053 residents commuted out of town for work; 7,616 of this group commuted to Raleigh, Cary, Morrisville, or Durham (US Census Bureau 2016b).

The Raleigh-Wake Forest highway corridor is a highly traveled roadway in which traffic density presents a problem. AADT along the US 1-Capital Boulevard corridor averages 18,000 south of Crabtree Boulevard, increases to around 38,000 near Yonkers Road, and ranges as high as 68,000 closer to Wake Forest (NCDOT 2015a). Travel demand is already exceeded along the US 1 corridor north of I-540 and over half of the corridor surpasses the statewide average crash rate (NCDOT 2015d). The drive from downtown Wake Forest to Raleigh Union Station takes an estimated twenty-eight to thirty minutes with no traffic interference. This number increases substantially during peak hours to a maximum of over fifty minutes for morning and evening alike (Google Maps 2016).

The CSX S-Line runs from Raleigh to Wake Forest and north toward Henderson. Wake Forest does not have a functioning passenger train station. The historic train station was located in the downtown area between Front and North White Streets (see http://www.pwrr.org/nstation/wakeforest.html).[2] This location was used to define a potential transit service area for this site.

Table 14 shows grouped place types for the Wake Forest service area (see A*ppendix C* for detailed place types) and Figure 12 at the end of this section depicts the place types graphically. As would be expected, the mid-density and mixed-use areas are concentrated in the core and primary zones of the service area and comprise about 36 percent and 45 percent of these zones, respectively. These

[1] *Wake Forest: Between Front Street and North White Street; Knightdale: Intersection of N. 1st Ave. and Robertson Street; Garner: 204 E. Garner Road; Clayton: Intersection of O'Neill and Front Street; Fuquay-Varina: Depot Street on the eastern side of the Raleigh & Cape Fear Railway; Apex: SE Corner of N. Salem Street and Center Street*

[2] *Links to photographs of historic train stations in this section lead to the website of the Piedmont and Western Railroad Club and Old Rock School Railway Museum: www.pwrr.org*

groupings currently do not include transit-oriented development. The secondary zone contains predominantly low- and mid-density residential areas.

Table 14. Percentage of Wake Forest Service Area in Grouped Place Type Categories.

Place Type		Catchment Zone / Percentage in Each Place Type			
		Core	Primary	Secondary	Total Catchment
1	Parks & Open Space	5.02	6.24	10.35	10.31
2	Predominantly Low Density Residential	0.00	0.00	38.67	38.32
3	Predominantly Mid-Density Residential	0.00	11.89	34.82	34.58
4	Mid-to High-Density Residential	36.61	45.38	2.24	2.62
5	Commercial Centers with Low Density Residential	0.00	0.72	5.25	5.21
6	Commercial, Non-Residential	0.00	0.00	0.63	0.63
7	Industrial, Non-Residential	0.00	0.00	4.29	4.25
8	Mixed-Use Areas and Transit-Oriented Development	27.11	14.62	1.91	2.06
9	Airport	0.00	0.00	0.00	0.00
10	Civic-Institutional/ University & Health Care Campus	31.26	21.16	1.83	2.03
	TOTAL	**100.00**	**100.00**	**100.00**	**100.00**

Source: Calculated based on data from Triangle J. Council of Government 2013

2. Knightdale Service Area

Downtown Knightdale lies approximately seventeen miles east of Raleigh Union Station. Knightdale's estimated 2015 population was 14,256, representing an increase of 25 percent over the 2010 population of 11,401 (U.S. Census Bureau 2016a). In 2014, 5,866 Knightdale residents held primary jobs in other municipalities (US Census Bureau 2016b) (See *Appendix A*). Over half of the outflow jobs (3,219) are in Raleigh or Durham.

Although Knightdale does not have active passenger service, the Norfolk Southern NS-Line, operated by Carolina Coastal Railway, runs from Belhaven on the coast through Knightdale and into Raleigh. Rail service originally came to the Knightdale area in 1904. The Knightdale depot, located at the intersection of North First and Robertson Streets, was constructed in 1905 (see http://www.pwrr.org/nstation/knightdale.html). The town grew and flourished with the advent of rail service, as homes were built for railroad workers. Freight service to Knightdale was discontinued in 1974 (Kropp 1987). The depot building became an antique store and today has been moved and converted to a daycare facility.

Land use in Knightdale is largely typified by mid-density residential development for all three zones of the service area (Table 15 and Figure 13). Less than 10 percent of any zone is devoted to mixed-use and no transit-oriented development zones exist currently. Low-density development comprises about 18 percent of the secondary zone and the total service area.

Table 15. Percentage of Knightdale Service Area in Grouped Place Type Categories.

Place Type		Catchment Zone / Percentage in Each Place Type			
		Core	Primary	Secondary	Total Catchment
1	Parks & Open Space	2.47	10.04	6.08	6.10
2	Predominantly Low Density Residential	0.00	0.16	17.83	17.67
3	Predominantly Mid-Density Residential	77.69	65.05	55.93	56.04
4	Mid-to High-Density Residential	6.29	11.82	3.36	3.43
5	Rural Crossroads and Commercial Centers with Low Density Residential	0.08	1.33	2.80	2.78
6	Commercial, Non-Residential	0.00	0.00	0.14	0.13
7	Industrial, Non-Residential	0.00	0.00	5.06	5.01
8	Mixed-Use Areas and Transit-Oriented Development	8.70	6.54	4.50	4.53
9	Airport	0.00	0.00	0.00	0.00
10	Civic-Institutional/ University & Health Care Campus	4.77	5.05	4.30	4.30
	TOTAL	**100.00**	**100.00**	**100.00**	**100.00**

Source: Calculated based on data from Triangle J. Council of Government 2013

3. Garner Service Area

Garner is located eight miles southeast of downtown Raleigh. Garner's population has increased dramatically in recent years, from 25,765 in 2010, to an estimated 28,053 in 2014 (U.S. Census Bureau 2016a) an 8.9 percent increase. As of 2014, 12,912 Garner residents held primary jobs and among this group, 12,171 worked outside Garner—over half (6,942) in Raleigh, Cary, or Durham (US Census Bureau 2016b). Only 741 of Garner residents (5.7 percent) held jobs in Garner itself.

AADT between Garner and Raleigh via US 70 ranges from approximately 29,000 near Garner to around 48,000 approaching Raleigh (NCDOT n.d.). Travel time between the two cities increases from fourteen minutes with no traffic to as long as twenty-eight minutes during peak hour (Google Maps 2016). Garner does not have an active passenger train service, but the NCRR H-Line, operated by Norfolk-Southern, runs from the coast, through Goldsboro and Selma, into Clayton, Garner, and Raleigh. The historic Garner passenger station (see http://www.pwrr.org/nstation/garner.html) was

located at 204 East Garner Road in downtown Garner and was used to delineate the center point of the service area.

The majority of the Garner service area is typified by mid-density residential development (Table 16 and Figure 14). The core and primary zones are largely comprised of this type development, which includes smaller lot homes that house a higher number of residents per acre. Garner contains a very low percentage of mixed-use neighborhoods or centers and no transit-oriented development.

Table 16. Percentage of Garner Service Area in Grouped Place Type Categories.

Place Type		Catchment Zone / Percentage in Each Place Type			
		Core	Primary	Secondary	Total Catchment
1	Parks & Open Space	13.64	6.23	9.34	9.32
2	Predominantly Low Density Residential	2.87	6.80	13.21	13.14
3	Predominantly Mid-Density Residential	53.01	48.84	46.60	46.63
4	Mid-to High-Density Residential	18.29	20.90	4.79	4.94
5	Rural Crossroads and Commercial Centers with Low Density Residential	0.00	5.68	4.30	4.30
6	Commercial, Non-Residential	1.00	1.18	1.33	1.33
7	Industrial, Non-Residential	1.99	8.40	10.95	10.91
8	Mixed-Use Areas and Transit-Oriented Development	4.43	0.24	1.81	1.80
9	Airport	0.00	0.00	0.00	0.00
10	Civic-Institutional/ University & Health Care Campus	4.77	1.73	7.67	7.62
	TOTAL	**100.00**	**100.00**	**100.00**	**100.00**

Source: Calculated based on data from Triangle J. Council of Government 2013

4. Clayton Service Area

Clayton is located in northern Johnston County approximately sixteen miles from Raleigh via US 70. Clayton was home to 16,116 residents in 2010 and an estimated 19,304 in 2014 (U.S. Census Bureau 2016a). About 69 percent of residents are in the civilian labor force and among 7,820 workers living in Clayton, around 94 percent hold primary jobs out of town (U.S. Census Bureau 2016b). A third of commuters travel to Raleigh and about 16 percent, to other study sites. In 2012 AADT from Clayton to Raleigh ranged from approximately 34,000 near Clayton to over 100,000 on I-40 near Raleigh (NCDOT n.d.). Travel time from Clayton to Raleigh is around twenty-six minutes without traffic but ranges up to forty-five minutes during peak hour (Google Maps 2016).

Although Clayton does not have passenger service currently, the Norfolk-Southern H-Line runs through downtown and passes through Garner, with the nearest Amtrak stop in Raleigh. The historic Clayton train station (see http://www.pwrr.org/nstation/clayton.html), now inoperative, was located at the intersection of O'Neill and Front Streets.

Clayton's core and primary service areas are comprised largely of mid- to high-density residential development whereas the secondary zone contains mostly mid-density housing (Table 17 and Figure 15). Slightly over a fifth of the core is typified by mixed uses. Clayton currently supports no transit-oriented development.

Table 17. Percentage of Clayton Service Area in Grouped Place Type Categories.

Place Type		Catchment Zone / Percentage in Each Place Type			
		Core	Primary	Secondary	Total Catchment
1	Parks & Open Space	0.16	3.48	3.87	3.86
2	Predominantly Low Density Residential	0.00	0.27	21.08	20.91
3	Predominantly Mid-Density Residential	0.00	21.20	58.21	57.86
4	Mid-to High-Density Residential	63.71	53.44	2.17	2.62
5	Rural Crossroads and Commercial Centers with Low Density Residential	2.11	2.75	2.77	2.76
6	Commercial, Non-Residential	4.06	1.20	0.47	0.48
7	Industrial, Non-Residential	0.74	0.73	6.84	6.79
8	Mixed-Use Areas and Transit-Oriented Development	21.71	4.58	0.42	0.49
9	Airport	0.00	0.00	0.00	0.00
10	Civic-Institutional/ University & Health Care Campus	7.51	12.34	4.18	4.23
	TOTAL	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Source: Calculated based on data from Triangle J. Council of Government 2013

5. Fuquay-Varina Service Area

Fuquay-Varina is located twelve miles southeast of Apex and seventeen miles southwest of Raleigh. The town's population in 2010 was 17,994 (US Census Bureau 2015b). The 2015 population was estimated at 23,907 (U.S. Census Bureau 2016b) and is projected to reach 27,679 by 2020 (Fuquay-Varina Economic Development Department 2013).

In 2014, 0nly 6.9 percent of workers were employed in the town itself, with about 26 percent (n=2,452) traveling to Raleigh and around 19 percent (1,752) continuing on to Cary and Durham

(U.S. Census Bureau 2016). The average travel time to work for Fuquay-Varina residents from 2009 through 2013 was 30.2 minutes (U.S. Census Bureau 2010b). The main thoroughfare between Fuquay-Varina and Raleigh is Highway 401. AADT along this route is approximately 31,088 (NCDOT n.d.).

Fuquay-Varina does not have an operational train station currently but two legs of the Norfolk Southern railway—the NS-Line and the VF-Line—converge in the heart of downtown, with Amtrak riders continuing on to the nearest stops in Cary and Raleigh. The historic Fuquay-Varina train depot (see http://www.pwrr.org/nstation/varina.html), once an active stop for travelers between Dunn and Durham (Estes 2014), was located downtown on Depot Street. The Depot Street location was used to identify a possible service area for Fuquay-Varina commuters.

The majority of each of the three service area zones is comprised of mid-density residential development (Table 18 and Figure 16). Over a fifth of the core contains mixed-use areas. Fuquay-Varina currently supports no transit-oriented development.

Table 18. Percentage of Fuquay-Varina Service Area in Grouped Place Type Categories.

Place Type		Service Area Zone / Percentage in Each Place Type			
		Core	Primary	Secondary	Total Catchment
1	Parks & Open Space	5.61	4.29	4.40	4.40
2	Predominantly Low Density Residential	0.00	0.00	20.17	20.00
3	Predominantly Mid-Density Residential	54.27	54.63	62.64	62.57
4	Mid-to High-Density Residential	5.45	24.04	1.14	1.30
5	Rural Crossroads and Commercial Centers with Low Density Residential	0.96	4.86	4.02	4.02
6	Commercial, Non-Residential	4.44	3.15	0.74	0.76
7	Industrial, Non-Residential	4.51	0.02	4.55	4.52
8	Mixed-Use Areas	23.06	4.31	1.39	1.46
9	Airport	0.00	0.00	0.00	0.00
10	Civic-Institutional/ University & Health Care Campus	1.71	4.69	0.94	0.97
	TOTAL	**100.00**	**100.00**	**100.00**	**100.00**

Source: Calculated based on data from Triangle J. Council of Government 2013

6. Apex Service Area

Apex is located in southwest Wake County, approximately fifteen miles from downtown Raleigh and seven miles from downtown Cary. In 2010 the population was 37,540 and the 2105 estimated population is 45,585 (US Census Bureau 2015a). Only 6.7 percent of Apex workers were employed in Apex in 2014 (US Census Bureau 2016b). About 25 percent (4,986) commute to Raleigh and a third (6,758), to points west including Cary, Morrisville, Durham, and Chapel Hill. Based on these destinations alone, almost 12,000 workers leave Apex driving north and northwest on workdays. Apex commuters travel to Raleigh via Highway 64-East. The Apex-Raleigh segment of US 64 west of I-40 sees heavy traffic volumes with 2013 AADT at around 137,000 West of I-40 and 53,000 West of US 1 (NCDOT 2014).

Railways running both northeast and northwest pass through Apex. The CSX S-line runs from Sanford to New Hill into Apex. In the downtown area, the railway splits and the S-Line continues northeastward toward Cary and then progresses north toward RTP. The SDS-Line originates in Apex and runs toward RTP and Durham. Apex does not have a functioning passenger station but the historic Union Depot, listed on the National Register of Historic Places, still stands—located at the southeast Corner of North Salem Street and Center Street. Amtrak trains travel past the depot to the nearest inbound Amtrak stop in Cary. This location was used as the center point for defining a potential service area around Apex. Table 19 and Figure 17 show grouped place types for Apex.

Table 19. Percentage of Apex Service Area in Grouped Place Type Categories.

Place Type		Catchment Zone / Percentage in Each Place Type			
		Core	Primary	Secondary	Total Catchment
1	Parks & Open Space	3.57	10.20	12.32	12.29
2	Predominantly Low Density Residential	0.00	0.49	20.84	20.65
3	Predominantly Mid-Density Residential	33.36	35.17	37.57	37.55
4	Mid-to High-Density Residential	19.72	18.23	5.21	5.33
5	Rural Crossroads and Commercial Centers with Low Density Residential	3.04	8.40	3.91	3.94
6	Commercial, Non-Residential	0.19	1.73	4.78	4.75
7	Industrial, Non-Residential	4.06	0.50	6.97	6.92
8	Mixed-Use Areas	18.80	12.58	5.47	5.55
9	Airport	0.00	0.00	0.00	0.00
10	Civic-Institutional/ University & Health Care Campus	17.26	12.70	2.92	3.02
	TOTAL	**100.00**	**100.00**	**100.00**	**100.00**

Source: Calculated based on data from Triangle J. Council of Government 2013

Slightly over a third of the core zone of the service area is comprised of various types of single-family, mid-density neighborhoods and slightly under a fifth contains multi-family, mixed-density neighborhoods. Around 17 percent of the core is defined by civic and institutional organizations.

Apex is the only potential service area that supports transit oriented development. About two percent of the secondary area is comprised of transit oriented development. This feature is located on the southeast side of the service area, bordering Holly Springs.

Apex Union Depot

F. SUMMARY: KEY FEATURES OF THE STUDY AREA

Tables 20 through 22 summarize key information on commuting and travel time between the major catchment areas and the potential service areas described in the previous discussion. Table 20 compares typical drive times with peak times bewteen Raleigh and the potential service areas. Table 21 reinforces the finding that workers travel among the cities of interest, particularly into Raleigh, Cary, and Durham—the three catchment areas with existing train stations. Table 22 summarizes information on projected land use in the five mile radius surrounding the current train stations or the center points of the potential serivce areas.

Table 20. Travel Time to Raleigh from Study Sites.†

City of Trip Origin	Destination / via (Route)	Travel Time in Minutes		
		Fastest Time*	Peak Hour **	
			Morning	Evening
Cary	Raleigh via I-40	17	18-26	18-35
Durham	Raleigh via NC 147 S. / I-40 E./ Wade Ave./ US 401	30	30-50	35-85
Apex	Raleigh via US 1 N./I-440 W./ Western Blvd./McDowell St.	19	20-40	20-50
Fuquay-Varina	Raleigh via US 401 North	35	35-60	35-55
Clayton	Raleigh via US 70 W. / I-40 W/ US 64 W. / US 401 N.	22	22-35	24-40
Garner	Raleigh via Garner Road / US 40 W. /S. Saunders	14	14-28	14-22
Knightdale	Raleigh via US 64 West / I-440 US 401 South	20	20-40	20-26
Wake Forest	Raleigh via Durham Road / US 1 South/Capital Blvd.	28	30-55	35-60

† *Travel time and AADT based on the location of each core catchment zone or service area*
**Fastest Time: Number of Minutes--No traffic; no specific time of day*
***Peak Hours: Peak Hours:*
Morning: ranges from 8 a.m. to 8:10 a.m.;Evening: ranges from 5 pm to 5:21 p.m.
Morning refers to a.m. trip to desitination. Evening refers to return tip to city of origin.
Information on travel time was calculated from Google Maps (2016).

Table 21. Selected Employment Information on Municipalities in which Catchment Areas and Potential Service Areas are Located: 2014.

City of Residence	Location of Employment					Total Number of Outflow Jobs
	City of Residence	Raleigh	Cary	Durham	Other	
Raleigh		85,429	15,248	17,001	64,994	97,243
Cary		18,491	13,511	9,082	28,263	55,836
Durham		12,228	4,371	45,139	38,586	55,185
Wake Forest	884	5,344	830	1,240	5,639	13,053
Knightdale	190	2,744	436	475	2,211	5,866
Garner	741	5,174	1,037	731	5,229	12,171
Clayton	461	2,559	430	379	3,915	7,283
Fuquay-Varina	642	2,452	1,144	608	4,471	8,675
Apex	1,370	4,986	3,323	2,345	8,279	18,933

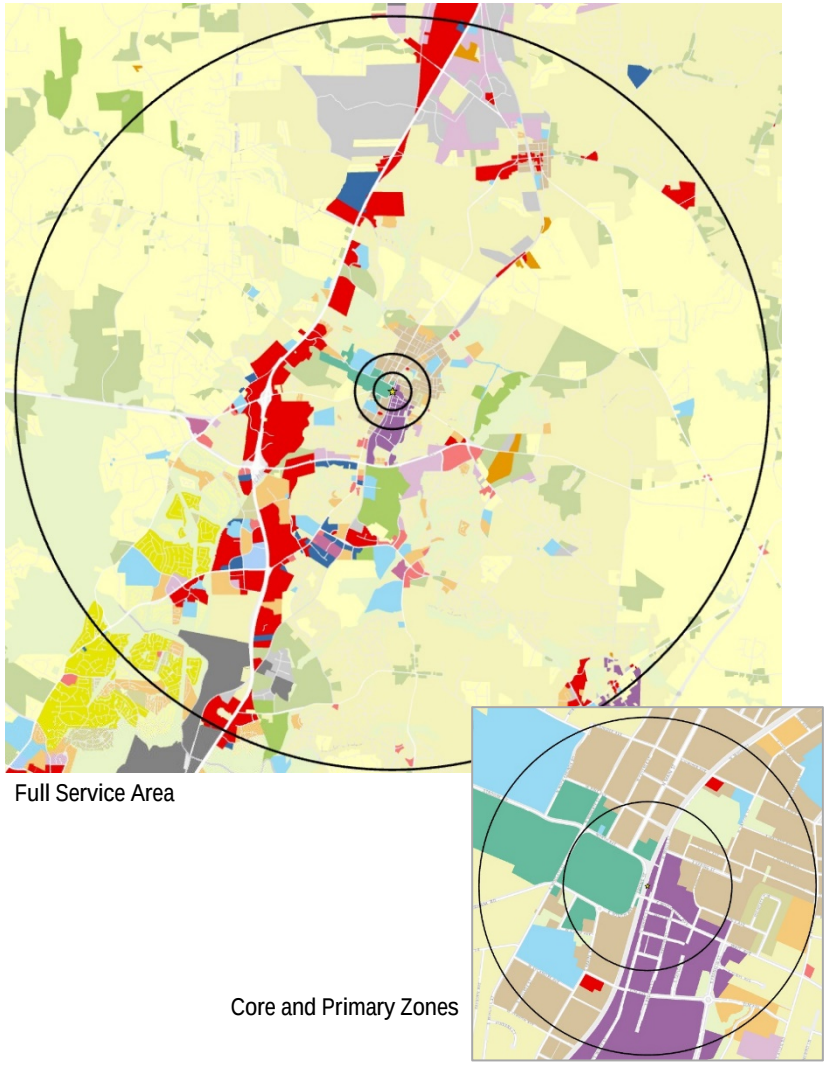
Source: US Census Bureau 2016b

Table 22. Percentage of Total Area in Grouped Place Type Categories for All Commuter Rail Potential Service Areas.

Place Type		Total Service Area / Percentage in Each Place Type					
		Wake Forest	Knightdale	Garner	Clayton	Fuquay-Varina	Apex
1	Parks & Open Space	10.46	6.10	9.32	3.86	4.40	12.29
2	Predominantly Low Density Residential	39.28	17.67	13.14	20.91	20.00	20.65
3	Predominantly Mid-Density Residential	35.48	56.04	46.63	57.86	62.57	37.55
4	Mid-to High-Density Residential	2.64	3.43	4.94	2.62	1.30	5.33
5	Commercial Centers with Low Density Residential	5.33	2.78	4.30	2.76	4.02	3.94
6	Commercial, Non-Residential	0.64	0.13	1.33	0.48	0.76	4.75
7	Industrial, Non-Residential	3.13	5.01	10.91	6.79	4.52	6.92
8	Mixed-Use Areas with Transit-Oriented Development	2.12	4.53	1.80	0.49	1.46	5.55
9	Airport	0.00	0.00	0.00	0.00	0.00	0.00
10	Civic-Institutional/ University & Health Care Campus	0.92	4.30	7.62	4.23	0.97	3.02
	TOTAL	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Source: Based on data from Triangle J. Council of Government: TCV2 Parcel Geodatabase for Place Type & Development Status. Accessed 2/11/2016. http://www.tjcog.org/imagine2040/downloads.aspx

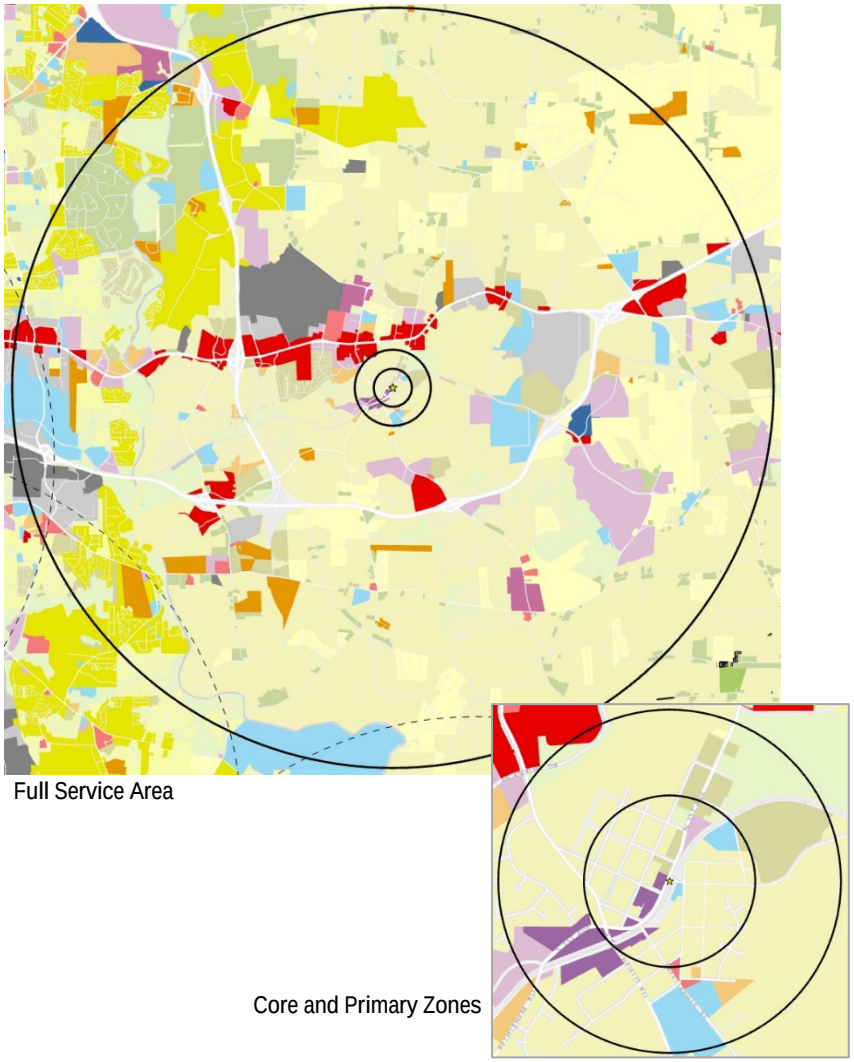
Figure 12. Wake Forest Service Area Place Types.



Full Service Area

Core and Primary Zones

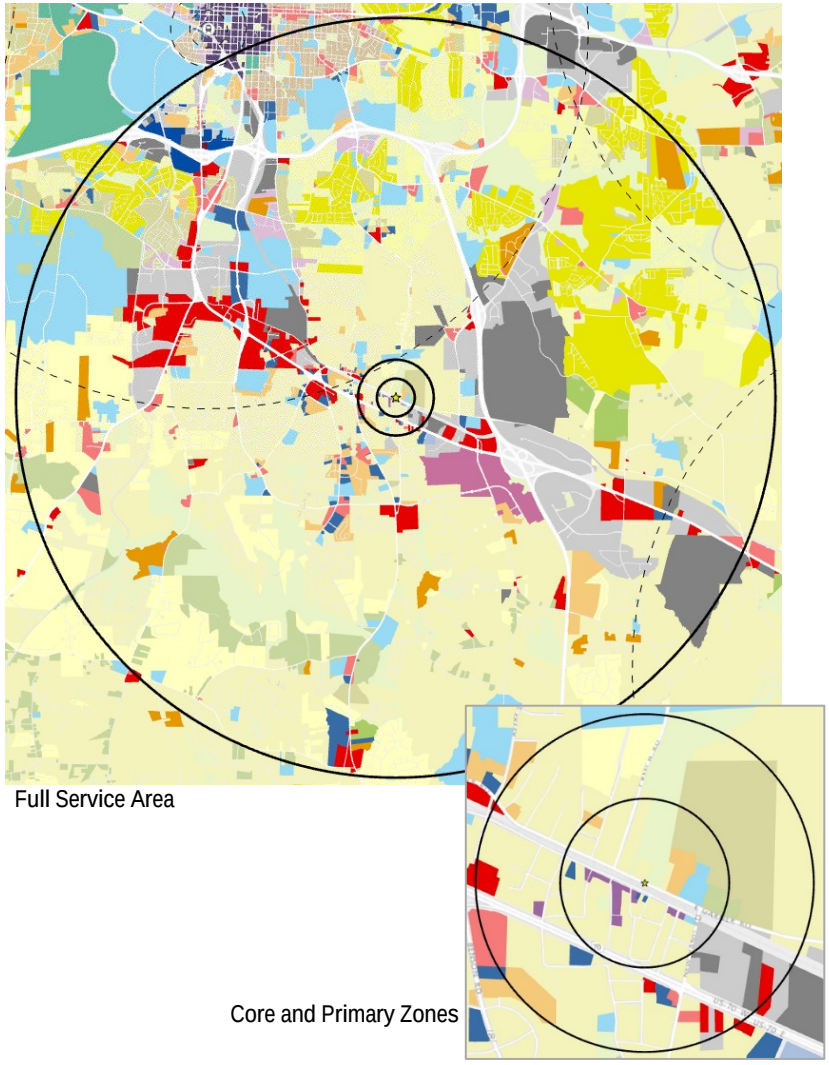
Figure 13. Knightdale Service Area Place Types.



Full Service Area

Core and Primary Zones

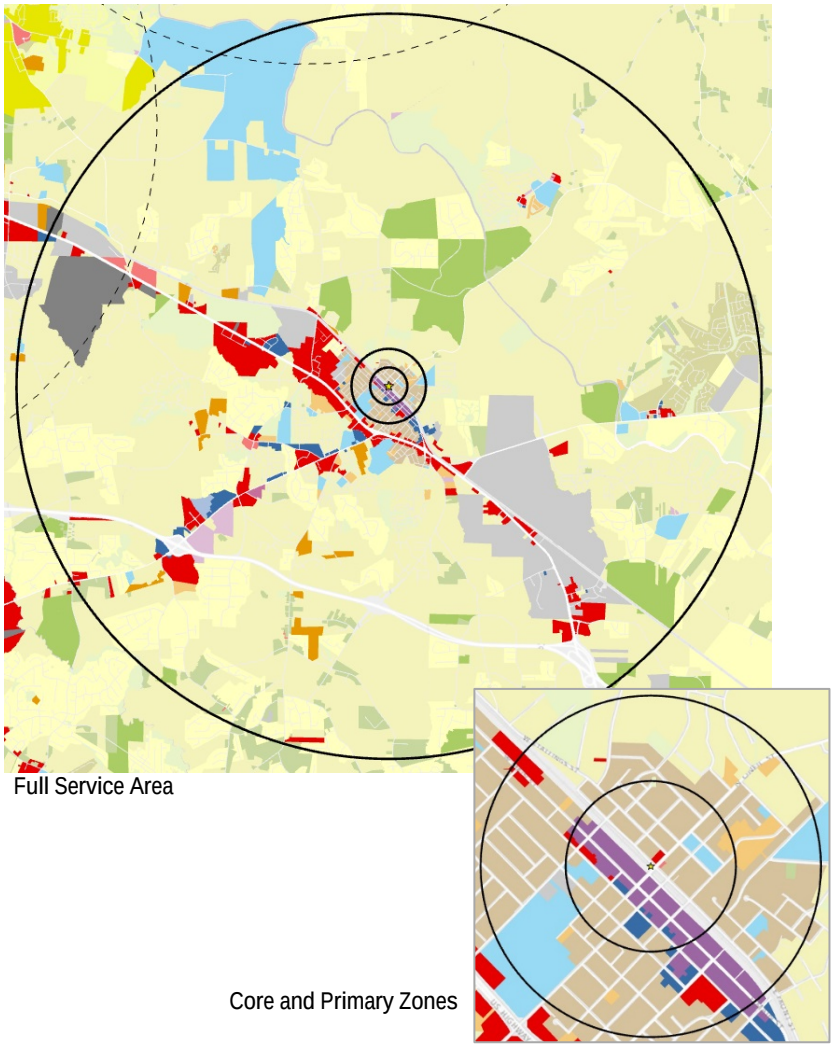
Figure 14. Garner Service Area Place Types.



Full Service Area

Core and Primary Zones

Figure 15. Clayton Service Area Place Types.



Full Service Area

Core and Primary Zones

Figure 16. Fuquay-Varina Service Area Place Types.

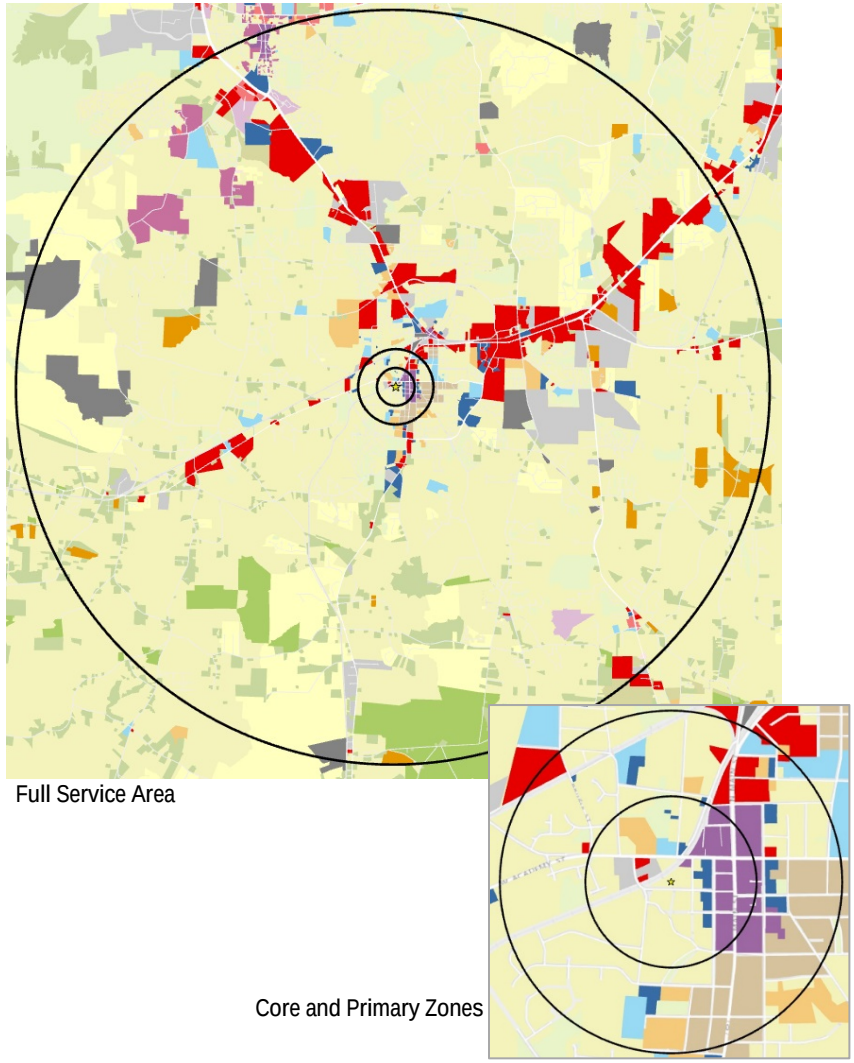
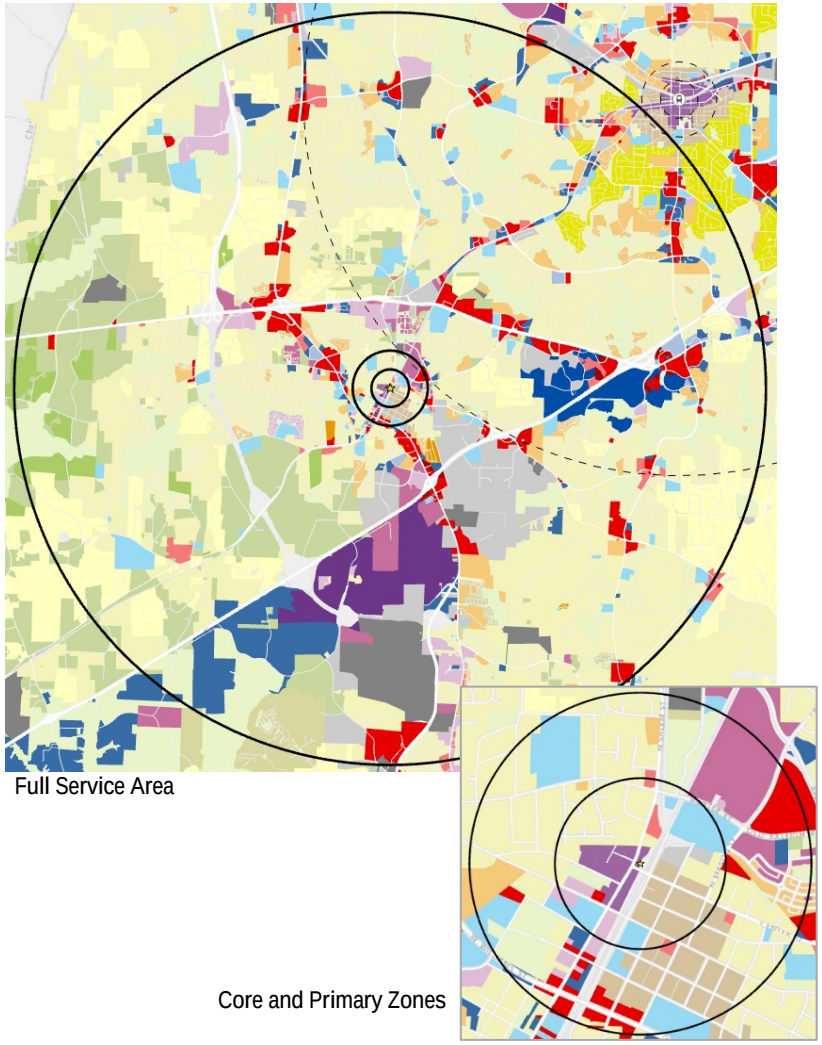


Figure 17. Zoning in Apex Service Area Place Types.



III. Rail Corridors and Infrastructure in the Study Area

A myriad of factors influence the ultimate decision to pursue commuter rail in a given location. In addition to previously discussed factors such as population, employment, and traffic patterns, two other considerations are key: (1) the quality and availability of infrastructure to support commuter rail and (2) the willingness of relevant parties to come to agreement on issues pertaining to the use of existing rail lines. Examples of such issues include the following:

Railroad Track, Wake County

- Assuring that addition of commuter rail will cause no delay in freight traffic.
- Providing protection for pedestrians and vehicles around at-grade crossings.
- Assuring that passenger equipment meets crashworthiness standards set by the Federal Railroad Administration. (HNTB 2008)

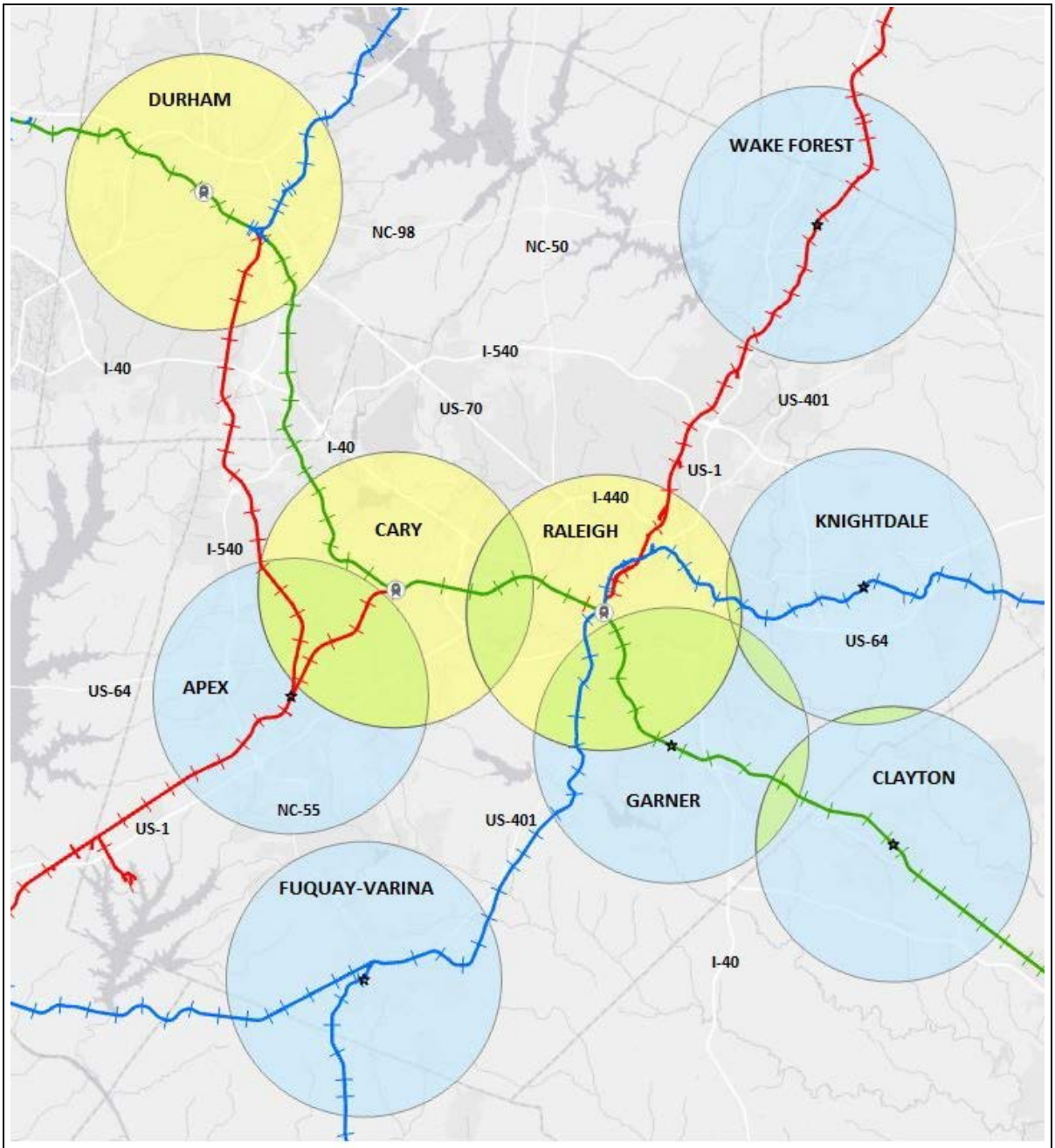
Likewise, the ability of existing rail infrastructure to support commuter rail is of primary concern. Congested highway corridors with nearby railways present potential opportunities for introducing commuter rail but the rail corridors must meet a variety of standards to be adequate to add additional forms of transit. In order to accommodate commuter trains passing freight trains, multiple sets of tracks or sidings are desirable. A siding is a "track adjacent to a main or secondary track for meeting or passing trains" (BNSF Railway 2016:18).

In addition to considerations around tracks and sidings, to account for pedestrian and driver safety, the number of crossings must be limited and the location and design of such crossings may require modification to assure motor vehicle and pedestrian safety. Likewise, right-of-way along the railway must be taken into account in situations in which additional sets of tracks will be added in order to accommodate commuter trains. These considerations will be paramount if commuter rail is introduced in the Wake County area. The following discussion reviews several of these issues with respect to the nine previously discussed study sites.

There are six major corridors that coincide with or encompass the nine catchment and service areas. The quality of infrastructure associated with these corridors will impact the development of commuter rail in the future. In this report, the six rail corridors of interest are labeled as: Wake Forest to Raleigh, Knightdale to Raleigh, Clayton-Garner to Raleigh, Fuquay-Varina to Raleigh, Apex-Cary to Raleigh, and Durham-RTP-Cary to Raleigh.

Figure 9 shows these corridors and the nine study sites and depicts railways owned by North Carolina Railroad (NCRR), Norfolk Southern Railway, and CSX Corporation. The figure also shows major roads that parallel or transverse a similar course as the rail corridors. Roadways shown on the map ("parallel highways") represent the most common routes traveled by commuters in the study sites in the absence of commuter rail.

Figure 18. Catchment and Service Areas, Rail Corridors with Ownership, and Parallel Highways.



Source: NCDOT 2015b

The following discussion details information on the six corridors and relevant aspects of their infrastructure, including length of the corridor, number of main, continuous tracks, number of open

(currently in use) and at-grade crossings, and number and location of sidings. The discussion focuses on passing sidings, which have a functional turnout (switch) at both ends. Information on spurs (dead-end tracks, sometimes used for delivery of freight to businesses) is not included as these tracks would be unusable for commuter rail.

A. WAKE FOREST TO RALEIGH CORRIDOR

The Wake Forest to Raleigh rail corridor begins between Front Street and North White Street in Wake Forest and runs to Raleigh Union Station. The corridor parallels highway US 1 South—a four-lane highway expanding into eight lanes as it reaches the Raleigh city limits.

The Wake Forest-Raleigh rail corridor is approximately 16.9 miles long (Table 23). The majority of the corridor is owned and operated by CSX and has one track. Near Atlantic Avenue in Raleigh, the Norfolk Southern/Carolina Coastal Railway crosses the CSX S-Line from the east. The two lines run roughly parallel southward to the existing station area in downtown Raleigh. Each line has one main track in this area. This corridor includes several tracks for switching and/or storage inside the CSX rail yard in Raleigh. Gaining access to switching/storage tracks would require negotiations between commuter rail and freight companies.

Table 23. Line Aspects of Wake Forest to Raleigh Corridor.

	Line Aspect	Corridor Characteristic / Other Information
TRACKS AND MILEAGE	**Total Miles in Corridor**	16.9
	Number of Continuous Tracks	1
	Miles with 1 Track	16.9
SWITCHING/ STORAGE TRACKS	**Beginning Latitude/Longitude → Ending Latitude /Longitude**	35.799330, -78.632053 → 35.789194, -78.641314
	Beginning Location → Ending Location	South of Capital Boulevard, near Urban Ministries of Wake County → East of Capital Boulevard, West of Semart Drive
	Description	This section includes one main track plus several additional switching/storage tracks leading into and through the CSX yard in Raleigh.
CROSSINGS	**Total Open Crossings**	33
	Total Open At-Grade Crossings	18
	Station to Station Main Highway Route	US 1 South, Capital Blvd

Sources: Number of Tracks and Crossings—NCDOT 2015c
Corridor Length—NCDOT 2016 and Google Maps

There are a total of thirty-three open crossings along the corridor, eighteen of which are at grade. From Wake Forest to the Edgeton rail area near Whitaker Mill Road in Raleigh the right-of-way is a minimum of eighty feet. An additional variable width amount, up to 100 feet, was purchased on the east side. The Wake Forest to Raleigh corridor shows little curvature and few inclines. There are no recorded planned improvements or rail crossings proposed for this corridor currently.

B. KNIGHTDALE TO RALEIGH CORRIDOR

The Knightdale to Raleigh corridor runs approximately 12.46 miles from the intersection of North 1st Avenue and Robertson Street in Knightdale to Raleigh Union Station (Table 24). The corridor parallels US 64 West, a four-lane highway leading into downtown Raleigh. The Knightdale-Raleigh corridor is owned by Norfolk Southern Railroad and operated by Carolina Coastal Railway. The corridor has one continuous track from Knightdale to Raleigh and multiple switching/storage tracks in the Norfolk Southern rail yard between Capital Boulevard and Pershing Road.

There are thirty-three open crossings and fifteen of these crossings are at-grade. The right-of-way over this corridor varies from 50' to 300' centered on the track. There are long sections of only 50' (25' north and 25' south) toward the Raleigh end of the line. The Knightdale to Raleigh track is very curvy, with many inclines, and may require modification to make it feasible for commuter rail.

There are no recorded planned improvements or rail crossings proposed for the Knightdale-Raleigh corridor at the present time. The completion of the southern loop of Interstate 540 may impact rail travel as well as commuter patterns with likely increases in population in this area.

Table 24. Line Aspects of Knightdale to Raleigh Corridor.

	Line Aspect	Corridor Characteristic / Other Information
TRACKS AND MILEAGE	**Total Miles in Corridor**	12.46
	Number of Continuous Tracks	1
	Miles with 1 Track	12.46
SWITCHING/ STORAGE TRACKS	**Beginning Latitude/Longitude → Ending Latitude /Longitude**	35.804304, -78.626719 → 35.7998276, -78.6392224
	Beginning Location → Ending Location	Southeast of Atlantic Avenue and Northeast of Capital Boulevard→ East of Capital Boulevard, West of Semart Drive and Seaboard Avenue
	Description	This section is approximately 0.78 miles long and includes one siding plus several additional main tracks leading into the Norfolk Southern yard in Raleigh. The siding is connected to the main track on both ends.
CROSSINGS	**Total Open Crossings**	33
	Total Open At-Grade Crossings	15
	Station to Station Main Highway Route	US 64 West

Sources: Number of Tracks and Crossings—NCDOT 2015c
Corridor Length—NCDOT 2016 and Google Maps

C. CLAYTON-GARNER TO RALEIGH CORRIDOR

The Clayton-Garner to Raleigh corridor runs from the intersection of O'Neill and Front Street in Clayton, through Garner, to Raleigh Union Station. The corridor is approximately 15.23 miles long (Table 25) and parallels US 70 West—a highway with four-lanes from Selma to Clayton, two lanes

from Clayton to Garner, and four lanes from Garner into Raleigh.

The Clayton-Garner to Raleigh corridor is owned by NCRR and operated by Norfolk Southern Railway. The corridor is one continuous track from Clayton to Raleigh. The right-of-way is generally 200 feet centered on the single main track.

There are four sections of railway with passing sidings along the corridor. The first, located in downtown Clayton, is approximately 0.77 mile long and includes one side track. A second, single track siding, running about 3.56 miles and a third, slightly over a quarter mile, are both located near Garner. The fourth siding, about a third of a mile long, is located in the Norfolk Southern rail yard near Union Station in Raleigh.

There are a total of twenty-eight open crossings along the Clayton-Garner to Raleigh corridor, thirteen of which are at grade. The impending completion of the southern loop of Interstate 540 may lead to changes along this corridor. Detailed assessment of the impact of this project would be required prior to implementation of commuter rail.

D. FUQUAY-VARINA TO RALEIGH CORRIDOR

The Fuquay-Varina to Raleigh corridor runs from Depot Street in Fuquay-Varina to Raleigh Union Station and parallels highway US 401 North into Raleigh (Table 26). US 401 is predominantly a four-lane highway, with several additional stretches of two-lane traffic.

The Fuquay-Varina to Raleigh corridor is approximately 19.5 miles long and is owned and operated by Norfolk Southern Railway. The corridor is a single continuous track from Fuquay-Varina to Raleigh. The right-of-way width is generally 100’ centered on the single main track.

This corridor has one passing siding running about 0.6 mile through the downtown Fuquay-Varina area. The siding is comprised of two tracks to the north of the main track and one track to the south of the main track.

There are thirty-seven open crossings on the Fuquay-Varina to Raleigh corridor, twenty-five of which are at grade. The completion of Interstate 540 will be likely to impact rail transportation in this area. However, no recorded planned improvements or rail crossings are proposed for this corridor at the present time.

Table 25. Line Aspects of Clayton-Garner to Raleigh Corridor.

	Line Aspect	Corridor Characteristic / Other Information
TRACKS AND MILEAGE	**Total Miles in Corridor**	15.23
	Number of Continuous Tracks	1
	Miles with 1 Track	15.23
1ST SIDING	**Beginning Latitude/Longitude → Ending Latitude /Longitude**	35.655444, -78.461072 → 35.663272, -78.470808
	Beginning Location → Ending Location	Between West Front Street and West 1st Street, near North Kildee Street→ East of Old US 70/West Main Street, near West Stallings Street
	Description	This siding is 0.77 mile long and includes one side track.
2ND SIDING	**Beginning Latitude/Longitude → Ending Latitude /Longitude**	35.670888, -78.491537 →35.691057, -78.548788
	Beginning Location → Ending Location	South of Old US Highway 70 West and Harmony St → East of Auburn Knightdale Road and South of East Garner Road intersection
	Description	This section includes a single side track running 3.56 miles
3RD SIDING	**Beginning Latitude/Longitude → Ending Latitude /Longitude**	35.705353, -78.600967→35.706847, -78.604939
	Beginning Location → Ending Location	Within the intersection of East Garner Road, New Rand Road, and East Main Street→ Southeast of Creech Road and East Garner Road and Northeast of East Main Street, near Garner historic train depot
	Description	This section includes a single siding running slightly over a quarter mile (0.2567 mile).
CROSSINGS	**Total Open Crossings**	28
	Total Open At-Grade Crossings	13
	Station to Station Main Highway Route	US 70 West, I-40 West

Sources: Number of Tracks and Crossings—NCDOT 2015c
Corridor Length—NCDOT 2016 and Google Maps

Table 26. Line Aspects of Fuquay-Varina to Raleigh Corridor.

	Line Aspect	Corridor Characteristic / Other Information
TRACKS AND MILEAGE	**Total Miles in Corridor**	19.5
	Number of Continuous Tracks	1
	Miles with 1 Track	19.5
SIDINGS	**Beginning Latitude/Longitude → Ending Latitude /Longitude**	35.592288, -78.792889 → 35.592343, -78.781592
	Beginning Location → Ending Location	Southeast of Broad Street and east of North Ennis Street, near intersection →South of East Broad Street near 1219 North Main Street near Stellata Drive.
	Description	This section runs 0.6 mile and includes multiple sidings ranging from 2 to 3 tracks. The first three sidings parallel the main track, with two tracks south and one north of the main track. A fourth siding begins due north of the intersection of Smithwood Street and North Main Street and runs to the end point due north of the Stellata Drive and North Main Street intersection.
CROSSINGS	**Total Open Crossings**	37
	Total Open At-Grade Crossings	25
	Station to Station Main Highway Route	US 401 North, Wilmington St.

Sources: Number of Tracks and Crossings—NCDOT 2015c
Corridor Length—NCDOT 2016 and Google Maps

E. APEX-CARY TO RALEIGH CORRIDOR

The Apex-Cary to Raleigh corridor runs from the southeast corner of North Salem Street and Center Street in Apex through Cary into downtown Raleigh Union Station. The corridor parallels highway US 1 North and the I-440 Beltline into Raleigh.

The corridor is slightly under fourteen miles long (Table 27). The Apex to Cary portion of the corridor is owned and operated by CSX Corporation. This section is approximately 5.8 miles long and has one track. The Cary to Raleigh portion, owned by NCRR, is 8.2 miles long and has two tracks.

The right-of-way over this corridor is generally 100' centered on the main track, though there are short segments for which CSX owns more right-of-way on one or both sides. Through downtown Apex, the CSX right-of-way is approximately 200'.

The Apex-Cary to Raleigh corridor has twenty-six crossings, twenty of which are at grade. There are no recorded planned improvements or rail crossings proposed for this corridor at the present time.

Table 27. Line Aspects of Apex-Cary to Raleigh Corridor.

	Line Aspect	Corridor Characteristic / Other Information
TRACKS AND MILEAGE	**Total Miles in Corridor**	13.96 Miles
	Maximum Number Continuous Tracks	2
	Minimum Number Continuous Tracks	1
	Miles with 1 Track	5.80
	Miles with 2 Tracks	8.16
1ST SIDING	**Beginning Latitude/Longitude → Ending Latitude /Longitude**	35.734300, -78.848348 → 35.747582, -78.840319
	Beginning Location → Ending Location	406 North Elm Street → Southeast of Spotter Drive, east of Williams Creek.
	Description	The siding includes 1 track running 1.02 miles parallel to the main CSX rail. The siding runs 1.02 miles beginning near 406 North Elm Street and ending Southeast of Spotter Drive, east of Williams Creek.
2ND SIDING	**Beginning Latitude/Longitude → Ending Latitude /Longitude**	35.794419, -78.705413 → 35.794500, -78.691857
	Beginning Location → Ending Location	Intersection of Hillsborough Street and Blue Ridge Road → West of Beryl Road and South of Hillsborough Street/Beryl Road intersection.
	Description	This section includes 1 side tracks running 0.78 mile between the NCRR and CSX main lines.
3RD SIDING	**Beginning Latitude/Longitude → Ending Latitude /Longitude**	35.782222, -78.662846 → 35.777435, -78.649744
	Beginning Location → Ending Location	East of Dunn Avenue and Pullen Road at Pullen Park → North of Dupont Circle, East of South Boylan Avenue, in Raleigh Union Station yard
	Description	This section includes 1-2 side tracks running along the CSX and NCRR lines from the Pullen Park area to the beginning of the Raleigh Union Station yard—approximately 0.9 mile.
CROSSINGS	**Total Open Crossings**	26
	Total Open At-Grade Crossings	20
	Station to Station Main Highway Route	US 1 North, Hillsborough St.

Sources: Number of Tracks and Crossings—NCDOT 2015c
Corridor Length—NCDOT 2016 and Google Maps

F. DURHAM-RTP-CARY TO RALEIGH CORRIDOR

The Durham-RTP-Cary to Raleigh corridor runs from Durham through RTP and Cary to downtown Raleigh. This corridor is a section of the Greensboro to Goldsboro corridor, which is owned by NCRR and operated by Norfolk Southern. The corridor is approximately 26.16 miles long (Table

28) and parallels NC 147 in Durham and proceeds to I-40 East, Chatham Street in Cary, and Hillsborough Street in Raleigh. The Durham section of the corridor begins at 601 West Main Street and runs 8.45 miles to RTP near the intersection of South Miami Boulevard and Chin Page Road. From RTP, the corridor continues 9.55 miles to the Cary train depot at 211 North Academy Street. From Cary, the corridor runs another 8.16 miles into downtown Raleigh to Union Station.

Table 28. Line Aspects of Durham-RTP-Cary to Raleigh Corridor.

	Line Aspect	Corridor Characteristic / Other Information
TRACKS AND MILEAGE	**Total Miles in Corridor**	26.16
	Maximum Number Continuous Tracks	2
	Minimum Number Continuous Tracks	1
	Miles with 1 Track	18.00
	Miles with 2 Tracks	8.16 (Cary to Raleigh)
1ST SIDING PLUS SWITCHING/ STORAGE TRACKS	**Beginning Latitude/Longitude → Ending Latitude /Longitude**	35.985166, -78.891965→ 35.954621, -78.852606
	Beginning Location → Ending Location	Southwest Northeast Peabody and northeast of East Pettigrew Street, near Colfax Street. → Intersection of Glover Road and Angier Avenue
	Description	This section includes a 3.16 mile track with a passing siding that merges into the main track and leads into the Norfolk Southern Railroad yard. There are 4 to 6 switching/storage tracks in the yard between Ellis Road and Cortez Drive.
2ND SIDING	**Beginning Latitude/Longitude → Ending Latitude /Longitude**	35.794419, -78.705413 → 35.794500, -78.691857
	Beginning Location → Ending Location	Intersection of Hillsborough Street and Blue Ridge Road → West of Beryl Road and South of Hillsborough Street/Beryl Road intersection.
	Description	This section includes 1 side tracks running 0.78 mile between the NCRR and CSX main lines.
3RD SIDING	**Beginning Latitude/Longitude → Ending Latitude /Longitude**	35.7822314, -78.6628976 → 35.777252, -78.647686
	Beginning Location → Ending Location	East of Dunn Avenue and Pullen Road at Pullen Park → North of Dupont Circle, East of South Boylan Avenue, in Raleigh Union Station yard
	Description	This section includes 1-2 side tracks running along the CSX and NCRR lines from the Pullen Park area to the beginning of the Raleigh Union Station yard—approximately 0.9 mile.
CROSSINGS	**Total Open Crossings**	46
	Total Open At-Grade Crossings	26
	Station to Station Main Highway Route	NC 147, I-40,Chatham St, Hillsborough St.

Sources: Number of Tracks and Crossings—NCDOT 2015c
Corridor Length—NCDOT 2016 and Google Maps

The corridor has sidings in three locations and up to five switching/storage tracks in the rail yard east of Durham. The general right-of-way width is 200' centered on the single main track. There are a total of forty-six crossings, twenty-six of which are at grade.

Several improvements are currently underway along the Durham-RTP-Cary-Raleigh corridor. These improvements are described briefly below (see http://www.ncdot.gov/projects for more detailed information).

1. Hopson Road Improvements

A Durham/Morrisville Railroad Improvement and Grade Separation project began in 2013 and is scheduled to be completed in 2016. The project involves several components as follow:

- Construction of a new railroad bridge carrying the North Carolina Railroad (NCRR) tracks over Hopson Road in Wake County
- Realigning curves to improve track speeds and reduce travel times between Raleigh and Charlotte
- Constructing a second track between I-40 and McCrimmon Parkway to reduce congestion and conflict between passenger and freight trains
- Removing at-grade crossings at Hopson Road and Church Street in Morrisville
- Extending Church Street to connect to Hopson Road

The addition of a second track will also allow passenger trains to pass slower freight trains, improving service reliability. The construction of the new bridge over Hopson Road will lower the risk of automobile and train collisions, thus improving safety for both automobile and rail passengers, and reducing automobile and train traffic congestion.

2. Morrisville Parkway Improvements

In 2014, construction of a railroad bridge over the Morrisville Parkway between Carpenter and Morrisville. The bridge is planned to provide additional safety features for automobile passengers and to reduce the potential for automobile-train collisions. Construction for this project is planned for the fall of 2016.

The aspects of infrastructure discussed here provide a basic description of local railways and would require extensive assessment if commuter rail were to be implemented. Other factors that will have an effect on rail transportation in the Triangle Area are the consideration of light rail travel as well as transit plans under consideration by local stakeholders. All of the various entities will have to work together to make the vision of commuter rail and other forms of transportation a reality.

IV. TRAVEL MODE CHOICE AND INFLUENCES ON TRANSIT USE

In addition to population factors, commuting and traffic patterns, and the suitability of infrastructure, the success of transit projects, ultimately, depends on human behavior—the willingness to accept and use a new form of transit. Assessing the likelihood that residents in the study area will use commuter rail will be a significant predictor of the feasibility of investing in such a system. Relevant questions include:

- Do commuters view transit in a positive light?
- To what extent do expressed attitudes toward transit reflect likely behavior?
- What personal and extraneous factors impinge upon commuters' travel mode choice?

In studying the probability of success of various forms of transit, researchers have examined a variety of factors, including three discussed below: (1) individual attitudes and preferences; (2) characteristics of residential and work neighborhoods; and (3) the nature of the trip in question. The following discussion presents brief highlights of these key issues as they inform the debate concerning travel mode choice.

A. INDIVIDUAL ATTRIBUTES

Individual attributes such as demographic characteristics can have strong influence on choice of travel mode. Recent research indicates that age plays a key role in attitudes toward transit use. Findings of the 2014 Mobility Attitudes Survey (RSG 2015) demonstrate that suburban adults of the Baby Boomer generation, who came of age dependent on automobile travel, tend to remain dedicated to the automobile. In contrast with their older counterparts, Millennials are much more open to transit use. Study findings also indicate that, unlike age, educational attainment does not appear to have a significant impact on transit use with the exception that students are more likely to use transit than non-students. The study examined other demographic characteristics as well, finding that nonwhite individuals are more likely to use transit as are employed persons.

Research has also examined the impact of attitudes on travel behavior and the extent to which personal preferences for safety and/or comfort override or interact with time and cost factors. A 2006 study (Johansson et al.) examined the impact of concerns about safety, comfort, convenience, the environment, and flexibility on travel mode choice. The researchers found that both time and cost relate to travel mode choice and flexibility and comfort also have an important impact. Safety proved to be less significant in this study, perhaps because the level of risk measured in the study was low. The study also found that environmental attitudes may lead travelers to choose an environmentally friendly travel mode, such as train, over bus. The authors contend that attitudes and personality are key determinants of mode choice and suggest that, although these factors cannot be controlled, when planning for sustainable transportation policies, planners should have an understanding of their potential impact on the success of transit. A later study of attitudes and preferences (Popuri et al. 2011) found that commuters who desire a stress-free commute may be more attracted to transit than automobile travel, which, in metropolitan areas, is likely to be coupled with highway congestion and delays.

B. NEIGHBORHOOD CHARACTERISTICS

1. Neighborhood Demographic Attributes

Other researchers have looked beyond the individual level, focusing on the individual's surroundings. Population characteristics of the neighborhood of residence have been examined with respect to their influence on transit use. Some researchers contend that there is a direct relationship between residential population density and transit use (Ferguson 1997) and research supporting this idea found that transit use increases in areas with population densities over 10,000 persons per square mile (Ross and Dunning 1997). Areas with high population density not only have more highway congestion, but they also typically provide a greater variety of transit alternatives, thus increasing support for transit use. Conversely, mid-size cities or those with lower population density have more difficulty in increasing the number or array of transit services.

Research challenging the residential population density theory has found that *employment* density (employees per acre) is more relevant to transit choice than *population* density. This research finds that change in transit use occurs at around thirteen employees per acre and a notable increase occurs at seventy-five employees per acre (Frank and Pivo 1994).

2. Neighborhood Design

Another body of literature hypothesizes that design of the neighborhood itself, including street and sidewalk layout may encourage or impede the use of transit. Typically, land-use diversity or heterogeneity (e.g., the integration of businesses with residences and services, etc.) is viewed as more "transit friendly" than single use land parcels. Such layouts allow commuters to complete a variety of tasks or errands when approaching or leaving a transit station or stop (see discussion of "trip chaining" below). Other research supports this line of thought, finding that the presence of retail establishments in neighborhoods predicts transit use for both work and non-work trips (Cervero and Kockelman 1997). These studies support the contention that transit use is more likely to be a product of *diversity* than *density*.

In keeping with the diversity theory, the 2014 Mobility Attitudes Survey (RSG 2015) found characteristics of the neighborhood to be the greatest predictor of transit use. Coupled with this finding, the research suggests that many Americans "…would prefer to live in a different type of neighborhood than they do now" (RSG 2015:5) with a preference for mixed-use, walkable, and thus, transit-friendly neighborhoods.

Research conducted by Robert Cervero (2006) points out that, whereas historically, the focus of transit studies has been on attributes of the *residential* neighborhood, the design features of the *destination* point, the workplace neighborhood, may be equally important in promoting the use of transit. Cervero contends that although "….housing has generally been the focus of transit-oriented development, unless the other end of the commute trip—the workplace—is also convenient to transit, transit will continue to struggle in winning over commuters in an environment of increasingly decentralized employment growth" (Cervero 2006:41).

3. Transit Stop Design

More specifically than overall neighborhood design, research has focused on the design of the transit stop itself and the layout of the immediate surrounding area. Transit stop amenities—features that increase transit riders' convenience and/or comfort (Transit Cooperative Research Program (TCRP) 1996)—may impact the overall decision to use transit as well as the choice of a particular transit stop. The presence of transit amenities such as parking, bicycle racks, seating, signage, lighting, and trash receptacles have been studied to assess their impact on the choice of transit over the privately-owned vehicle.

Poorly maintained transit stops or buildings, inadequate sidewalks, damaged seating, or boarded or broken windows may cause riders to view transit as an unsafe alternative. Such factors may actually encourage crime in that the unkempt appearance of facilities leads to the impression that there is no management or security in the area (Loukaitou-Sideris 1999).

Research indicates that the desire for specific amenities may vary based on the location in question. A 1993 study conducted by New Jersey Transit (TCRP 1999) found that inner city bus riders focus on safety, adequate lighting, room for strollers, and lowered steps for boarding. Conversely, suburban riders, who tend to be more affluent, cite the desire for information on arrival time as well as comfort and privacy. This finding may be particularly relevant for the current study in in that riders of commuter rail tend to be workers and as such they require a timely, predictable schedule.

C. THE NATURE OF THE TRIP

Related to both neighborhood design and transit stop design/location, a key factor impacting travel time relates to the nature of the trip itself—whether the traveler prefers to travel directly to and from the destination point or prefers to accommodate "trip chaining"—combining multiple short trips with the commute trip itself. Accounting for trip chaining increases the complexity of examining the time required for commuting trips. Research in Washington, DC found that 44 percent of study subjects made stops during work commutes and members of this group were twice as likely to make such stops during the evening commute as the morning commute (Bhat 2001). Among commuters who stop both to and from work, common trip chaining involved picking up passengers, conducting personal business, or visiting a restaurant. Research (FHA 2001) indicates that trip chaining is increasing over time, with a 21 percent increase for home-to-work trips and a 12 percent increase for trips in both directions noted between 1995 and 2001. This research also notes that workers who chain trips spend approximately fifteen to twenty minutes more in travel than others.

D. COMMUTER RAIL AND TRAVEL MODE CHOICE

Researchers have also examined the impact of time spent in travel and the cost of various transportation modes. In an early study (1973), McDonough examined factors related to commuter rail demand. Findings indicate that "time cost" is an important determinant of commuter rail demand and that minimization of time spent in travel is more important for work trips than non-work trips. She concludes that efforts to decrease rail travel time should be successful when directed toward

peak traffic hours. Likewise, Cervero (2006) found that frequent bus service, employer assistance with fares, and limited parking at the destination point are likely to encourage rail commuting.

More recent research examined a variety of factors, including sociodemographic characteristics, trip characteristics, neighborhood and land use factors, and transit stop characteristics. The authors (Chakour and Eluru 2013:2) contend that:

> …as the distance from the station by active forms of transportation increases, individuals are more likely to select a station first. Young persons, females, car owners, and individuals leaving before 7:30 am have an increased propensity to drive to the commuter train station. The station model indicates that travel time has a significant negative impact on station choice, whereas, presence of parking and increased train frequency encourages use of the stations.

Opportunities for accommodating diverse commuter schedules have been established in existing rail service areas (e.g., New Jersey Transit, Metro-North's Hudson Rail Link) in which commuter rail tickets can be used on bus routes at specific times (Zulig and Phraner 2000). Likewise, commuter rail and buses can provide interchangeable services that increase passenger choice, such as bus coverage of off-peak times. Cooperation of this type may serve to increase public acceptance of commuter rail as a viable transit alternative that functions as one of an array of services to commuters.

> Within the next few years, commuter rail service will be viewed as but one component of an intermodal public transportation system having joint tickets and coordinated schedules. More employers will provide rail commutation tickets rather than parking spaces. Convenient connections will enable customers to originate on a commuter rail line, transfer to an Amtrak intercity train, and finish the trip on a bus or light rail service meeting the train at the destination station. Information for such intermodal travel will be routinely available by telephone or computer web pages. (Zullig and Phraner 2000:6)

> Stephens remembers traveling to Raleigh from Garner on the train. "We could go to Raleigh for about 50 cents," she says. "We'd walk down there to the station. We'd go shopping and come back late in the afternoon. We'd spend the day in Raleigh." Someone in the group remarks "commuter rail," and everyone laughs.
> "Having a railroad as part of your town gave you status," Williams says. "Especially if the train would stop, as opposed to just flying through the town. If it stopped, you were on the map with a depot and that gave you status." (Saylor 2015:n.p.)

In Wake County's past, rail travel was common not only for long distance trips, but for commutes to local towns as well. As a result of the demise of passenger rail use, over 85 percent of North Carolina railroad stations have been demolished since World War II (Turner 2012). Today, dependency on the automobile, and in most instances, the single-occupant vehicle, is the norm for traveling to work in and around Wake County. Slightly over 80 percent of workers drive alone to work and about three-quarters of Durham County residents do likewise (NCDOC 2015). Population, commuting, and traffic density data presented in this report make a strong case for consideration of additional forms of transit in Wake County's future.

The extent to which new forms of transit in general, and commuter rail, in particular, will be accepted in the Raleigh/Wake County area must be carefully studied. Limited research on factors influencing travel mode choice in Wake County has been conducted to date. Within the study area described in this report, neighborhood layout is mixed with respect to its ability to promote transit use. Downtown Raleigh provides an example of a grid-type street pattern that makes walking to transit stops easy and safe (Jarret Walker et al. 2015). Likewise, certain areas of the city provide sidewalks and clearly marked crossing areas, assuring pedestrian safety. Other areas, such as stretches of Capital Boulevard, lack sidewalks and require that pedestrians walk along the highway shoulder to reach transit stops.

Research in the study area further indicates that transit use, though low overall, is much higher in areas that are more walkable, more densely populated, and which provide reliable transit service. One such area is found in communities near NC State University, serviced by the Wolfline, in which over a fifth of workers use transit. Likewise, transit use is higher in areas with high-frequency bus service such as New Bern Avenue and Capital Boulevard, serviced Capital Area Transit (now, GoRaleigh), in which transit use rates are more than 10 percent (Jarret Walker et al. 2015). Such findings, in a broader area with low overall transit use, suggest that ridership can be, and is, influenced by the availability and accessibility of reliable service.

Research on factors that might impact the use and success of commuter rail in particular in the Wake County area have been limited. A survey conducted by North Carolina Department of Transportation (NCDOT 2003) found that, among eleven proposed alternatives for reducing congestion on I-40, commuter rail received top ranking in priority among respondents. Over half (53 percent) rated commuter rail as a high priority and another 25 percent ranked it as a medium priority.

A more recent study (Steer Davies Gleave 2010) focused on the Greensboro to Goldsboro corridor and gathered information on the potential for riding commuter rail. Among locations in the study area described in this report, Cary, Clayton, Durham, and Raleigh were identified as station locations likely to have the greatest number of boardings. The study found that within the identified corridor—Greensboro to Goldsboro—ridership would be dependent upon the level and quality of connecting bus service available to rail riders and that coordination between rail agencies and local transit providers would be key in successful commuter rail implementation.

Such findings hold promise for the public support of commuter rail in the Wake County area. The current move toward walkable spaces and transit-oriented development in Raleigh, along with the multi-modal transit facility, already under construction, are likely to benefit the move toward commuter rail. Likewise, adequate bus service to connect commuters with rail service, lowered transit fares, and workplace incentives (Cervero 2006) will aid any efforts to make commuter rail a viable and desirable option for the Wake County area. Future efforts to assess the feasibility of commuter rail in and around Wake County must account for all relevant factors: current and projected population growth, employment patterns, models and projections of traffic congestion, the quality and suitability of rail infrastructure, ability of neighborhoods to support transit-oriented development, commuter attitudes, and past transit behavior that might predict future use of commuter rail in the region.

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IMAGES

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Dtobias. March 29 2008. Wikimedia Commons. Accessed 2/8/2016.
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"Music City Star" (Page 4)

Brent and MariLynn. Originally posted to Flickr on May 16, 2006 at
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"Downtown Raleigh – Daytime" (Page 14 and Back Cover)

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"I-40 Weekday Peak Hour Traffic" (Page 30)
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"Apex Union Depot" (Page 38)
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"Railroad Track, Wake County." (Page 43)
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"Amtrak Train Departing Raleigh, NC" (Back cover). Willimor, James. March 13, 2014. Accessed 6/3/2016. https://commons.wikimedia.org/wiki/File:Amtrak_train_departing_Raleigh,_NC_(13138801013).jpg

"Amtrak 1755 Approaching Station in Durham" (Back cover). By Ildar Sagdejev (Specious) (Own work). [GFDL (http://www.gnu.org/copyleft/fdl.html) or CC BY-SA 4.0-3.0-2.5-2.0-1.0 (http://creativecommons.org/licenses/by-sa/4.0-3.0-2.5-2.0-1.0)], via Wikimedia Commons. Accessed 7/19/2016. https://commons.wikimedia.org/wiki/File:2008-07-23_Amtrak_1755_approaching_station_in_Durham.jpg

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APPENDIX A

2014 HOME-WORK PATTERNS AMONG THE STUDY SITES

APPENDIX A: SELECTED HOME-WORK INFORMATION ON WAKE COUNTY AND STUDY SITES

Table A-1. Wake County Worker Inflow for the Top Ten Counties: 2014.

County	Total Number of Inflow Jobs	Percent of Inflow Jobs	Percent of All County Jobs
Johnston	29,470	11.4	5.5
Durham	26,064	10.1	4.9
Mecklenburg	14,599	5.6	2.7
Franklin	10,532	4.1	2.0
Harnett	10,097	3.9	1.9
Guilford	9,119	3.5	1.7
Cumberland	8,004	3.1	1.5
Orange	7,855	3.0	1.5
Forsyth	6,415	2.5	1.2
Granville	6,318	2.4	1.2

Table A-2. Raleigh Jobs and Worker Outflow--Employment Location of Raleigh Residents: 2014.

Location of Job among Raleigh Residents	Raleigh Jobs	
	Number of Jobs	Percent of Jobs
Raleigh	**85,429**	**46.8**
Outflow Jobs		
➢ Durham	17,001	9.3
➢ Cary	15,248	8.4
➢ Morrisville	3,332	1.8
➢ Chapel Hill	2,435	1.3
➢ Garner	2,279	1.3
➢ Charlotte	6394	3.5
➢ Apex	1,811	1.0
➢ Wake Forest	1,458	0.8
➢ Other Locations	47,285	25.9
TOTAL	**182,672**	**100.00%**

Table A-3. Raleigh Jobs and Worker Inflow--Residence of Persons Working in Raleigh: 2014.

City	Workers Employed in Raleigh	
	Number	Percent
Raleigh	**85,429**	26.4
Inflow Jobs		
➢ Cary	18,491	5.7
➢ Durham	12,228	3.8
➢ Wake Forest	5,344	1.7
➢ Charlotte	6,997	2.2
➢ Garner	5,174	1.6
➢ Apex	4,986	1.5
➢ Knightdale	2,744	0.9
➢ Fuquay-Varina	2,452	0.8
➢ Clayton	2,559	0.8
➢ Morrisville	2,359	0.7
➢ Rolesville	736	0.2
➢ Selma	302	0.1
➢ Other Locations	173,808	53.7
TOTAL	**323,609**	**100.00%**

Source for all city-based commuting information: US Census Bureau, OnTheMap Application, and LEHD Origin-Destination Employment Statistics. Accessed 4/26/2016. http://onthemap.ces.census.gov/

Table A-4. Cary Jobs and Worker Inflow--Residence of Persons Working in Cary: 2014.

Municipality of Worker Residence	Workers in Town of Residence who are Employed in Cary	
	Number	Percent
Cary	**13,511**	17.3
Inflow Jobs		
➢ Raleigh	15,248	19.6
➢ Durham	4,371	5.6
➢ Apex	3,323	4.3
➢ Morrisville	1,691	2.2
➢ Fuquay-Varina	1,144	1.5
➢ Garner	1,037	1.3
➢ Wake Forest	830	1.1
➢ Clayton	430	0.6
➢ Knightdale	436	0.6
➢ Holly Springs Town	2,025	2.6
➢ Charlotte	2,045	2.6
➢ Other Locations	31,912	40.9
TOTAL	**78,003**	**100.0%**

Table A-5. Cary Jobs and Worker Outflow--Employment Location of Cary Residents: 2014.

Municipality of Worker Residence	Number of Jobs	Percent of Jobs
Cary	**13,511**	**19.5**
Outflow Jobs		
➢ Raleigh	18,491	26.7
➢ Durham	9,082	13.1
➢ Charlotte	2,297	3.3
➢ Morrisville	2,326	3.4
➢ Chapel Hill	2,044	2.9
➢ Apex	1,483	2.1
➢ Greensboro	929	1.3
➢ Garner	576	0.8
➢ Fayetteville	394	0.6
➢ Other Locations	18,214	26.3
TOTAL	**69,347**	**100.0%**

Source for all city-based commuting information: US Census Bureau, OnTheMap Application, and LEHD Origin-Destination Employment Statistics. Accessed 4/26/2016. http://onthemap.ces.census.gov/

Table A-6. Durham Jobs and Worker Inflow--Residence of Persons Working in Durham: 2014.

Municipality of Worker Residence	Workers in Town of Residence who are Employed in Durham	
	Number	Percent
Durham	**45,139**	30.0
Inflow Jobs		
➢ Raleigh	17,001	11.3
➢ Cary	9,082	6.0
➢ Apex	2,345	1.6
➢ Morrisville	2,015	1.3
➢ Chapel Hill	4,116	2.7
➢ Wake Forest	1,240	0.8
➢ Garner	731	0.5
➢ Fuquay-Varina	608	0.4
➢ Knightdale	475	0.3
➢ Clayton	379	0.3
➢ Charlotte	2,257	1.5
➢ Carrboro Town	1,427	1.0
➢ Greensboro	1,238	0.8
➢ Other Locations	61,592	41.4
TOTAL	**149,645**	**100.0%**

Table A-7. Durham Jobs and Worker Outflow--Employment Location of Durham Residents: 2014.

Municipality of Worker Residence	Number of Jobs	Percent of Jobs
Durham	**45,139**	45.0
Outflow Jobs		
➢ Raleigh	12,228	12.2
➢ Chapel Hill	8,584	8.6
➢ Cary	4,371	4.4
➢ Charlotte	2,333	2.3
➢ Greensboro	1,672	1.7
➢ Morrisville	1,470	1.5
➢ Winston-Salem	817	0.8
➢ Apex	616	0.6
➢ Hillsborough	672	0.7
➢ Other Locations	22,422	22.4
TOTAL	**100,324**	**100.0%**

Source for all city-based commuting information: US Census Bureau, OnTheMap Application, and LEHD Origin-Destination Employment Statistics. Accessed 4/26/2016. http://onthemap.ces.census.gov/

Table A-8. Employment Location of Wake Forest Residents: 2014.

City of Job Destination	Wake-Forest Jobs	
	Number of Jobs	Percent of Jobs
Wake-Forest	**884**	6.3
Outflow Jobs		
➢ Raleigh	5,344	38.3
➢ Durham	1,240	8.9
➢ Cary	830	6.0
➢ Knightdale	88	0.6
➢ Garner	125	0.9
➢ Morrisville	202	1.5
➢ Apex	117	0.8
➢ Charlotte	464	3.3
➢ Wilson	123	0.9
➢ Other Locations	4,520	32.4
TOTAL	**13,937**	**100.0%**

Table A-9. Employment Location of Knightdale Residents: 2014.

City of Job Destination	Knightdale Jobs	
	Number of Jobs	Percent of Jobs
Knightdale	**190**	3.1
Outflow Jobs		
➢ Raleigh	2,744	45.3
➢ Durham	475	7.8
➢ Cary	436	7.2
➢ Garner	105	1.7
➢ Morrisville	77	1.3
➢ Apex	75	1.2
➢ Wake Forest	68	1.1
➢ Charlotte	174	2.9
➢ Wilson	39	0.6
➢ Other Locations	1,673	27.6
TOTAL	**6,056**	**100.0%**

Source for all city-based commuting information: US Census Bureau, OnTheMap Application, and LEHD Origin-Destination Employment Statistics. Accessed 4/26/2016. http://onthemap.ces.census.gov/

Table A-10. Employment Location of Garner Residents: 2014.

City of Job Destination	Garner Jobs	
	Number of Jobs	Percent of Jobs
Garner	**741**	5.7
Outflow Jobs		
➢ Raleigh	5,174	40.1
➢ Cary	1,037	8.0
➢ Durham	731	5.7
➢ Apex	215	1.7
➢ Morrisville	165	1.3
➢ Clayton	110	0.9
➢ Chapel Hill	135	1.1
➢ Fuquay-Varina	123	1.0
➢ Smithfield	105	0.8
➢ Wilson	41	0.3
➢ Other Locations	4,335	33.6
TOTAL	**12,912**	**100.0%**

Table A-11. Employment Location of Clayton Residents: 2014.

City of Job Destination	Clayton Jobs	
	Number of Jobs	Percent of Jobs
Clayton	**461**	6.0
Outflow Jobs		
➢ Raleigh	2,559	33.0
➢ Cary	430	5.6
➢ Garner	267	3.5
➢ Durham	379	4.9
➢ Apex	76	1.0
➢ Morrisville	82	1.1
➢ Rocky Mount	67	0.9
➢ Chapel Hill	46	0.6
➢ Fuquay-Varina	52	0.7
➢ Selma	62	0.8
➢ Smithfield	416	5.4
➢ Wilson	102	1.3
➢ Other Locations	2,745	35.5
TOTAL	**7,744**	**100.00%**

Source for all city-based commuting information: US Census Bureau, OnTheMap Application, and LEHD Origin-Destination Employment Statistics. Accessed 4/26/2016. http://onthemap.ces.census.gov/

Table A-12. Employment Location of Fuquay-Varina: 2014.

City of Job Destination	Fuquay-Varina Jobs	
	Number of Jobs	Percent of Jobs
Fuquay-Varina	**642**	6.9
Outflow Jobs		
➢ Raleigh	2,452	26.3
➢ Cary	1,144	12.3
➢ Durham	608	6.5
➢ Apex	305	3.3
➢ Chapel Hill	122	1.3
➢ Morrisville	155	1.7
➢ Garner	146	1.6
➢ Charlotte	429	4.6
➢ Fuquay-Varina	642	6.9
➢ Other Locations	2,672	28.7
TOTAL	**9,317**	**100.0%**

Table A-13. Employment Location of Apex Residents: 2014.

City of Job Destination	Apex Jobs	
	Number of Jobs	Percent of Jobs
Apex	**1,370**	6.8
Outflow Jobs		
➢ Raleigh	4,986	24.6
➢ Cary	3,323	16.4
➢ Durham	2,345	11.6
➢ Chapel Hill	598	3.0
➢ Morrisville	492	2.4
➢ Garner	180	0.9
➢ Charlotte	704	3.5
➢ Fuquay-Varina	156	0.8
➢ Other Locations	6,149	30.3
TOTAL	**20,303**	**100.0%**

Source for all city-based commuting information: US Census Bureau, OnTheMap Application, and LEHD Origin-Destination Employment Statistics. Accessed 4/26/2016. http://onthemap.ces.census.gov/

APPENDIX B

PLACE TYPE DEFINITIONS AND GROUPINGS

Exhibit B1. Selected Characteristics of Place Type Categories.

Place Type[1]	Residential Density per Acre[2]	Typical Transportation Mode(s)	Primary Land Uses	Secondary Land Uses	
Parks And Open Space	NA	Auto, Bicycle, Walking	➢ State Park ➢ Wildlife Refuge ➢ Natural Area ➢ Wildlife Corridor ➢ Greenway	➢ Storm Water Retention/ Detention Area ➢ Community Park ➢ Athletic Fields ➢ Cemetery ➢ Water Dependent Recreation Activities ➢ Community Park	
Working Farm (WF)	0.05-0.10	Auto	➢ Cultivated Farmland ➢ Timber Harvest	➢ Livestock ➢ Woodlands ➢ Single-Family Detached Home ➢ Warehouse/ Storage ➢ Light Industrial (Ancillary to Farm Activities)	
Rural Living (RL)	0.05-0.33	Auto	➢ Single-Family Detached Home	➢ Mobile Home ➢ Hobby Farm ➢ Church ➢ Natural Areas	
Large-Lot, Residential Neighborhood (LLRN)	0.33-1.00	Auto	➢ Single-Family Detached Home	➢ Church ➢ School ➢ Community Center ➢ Pool and Amenities ➢ Natural Areas ➢ Horse Stable	
Shadetree Residential Neighborhood (STRN)	1-4	Auto	➢ Single-Family Detached Home	➢ Duplex ➢ Mobile Home ➢ Church ➢ School ➢ Community Center ➢ Park or Playground ➢ Natural Areas	
Small-Lot, Residential Neighborhood (SLRN)	1-5	Auto	➢ Single-Family Detached Home	➢ Townhome ➢ Duplex ➢ Church ➢ School ➢ Community Center ➢ Pool And Amenities ➢ Natural Areas	
Mobile Home Community (MHP)	6-12	Auto	➢ Single-Wide Mobile Home ➢ Double-Wide Mobile Home	➢ Modular Home ➢ Community Center ➢ Pool and Amenities	
Multi-Family Residential Neighborhood (MFRN)	6.0-16.0	Auto	➢ Apartment ➢ Townhome	➢ Condominium ➢ Senior Housing ➢ Church ➢ Community Center ➢ Pool and Amenities ➢ Natural Areas	
Mixed-Density Residential Neighborhood (MRN)	4-12	Auto/Walking	➢ Single-Family Detached Home ➢ Townhome	➢ Condominium ➢ Apartment ➢ Duplex ➢ Natural Areas ➢ Community Center ➢ Pool And Amenities ➢ School ➢ Church	
Urban Neighborhood (UN)	6-10	Auto	➢ Single-Family Detached Home ➢ Townhome	➢ Duplex ➢ Apartment ➢ Condominium ➢ Church ➢ School ➢ Pocket Parks	

[1] *Source: Noonkester 2011. Building a Regional Framework: Placce Types for Imagine 2040. The Triangle Region Scenario Planning Initiative. Accessed 2/10/2016.* http://www.tjcog.org/imagine2040/downloads.aspx

[2] *D.U.=Dwelling unit per acre*

Exhibit B1. Selected Characteristics of Place Type Categories.

Place Type[1]	Residential Density per Acre[2]	Typical Transportation Mode(s)	Primary Land Uses	Secondary Land Uses	
High-Rise Residential (HRR)	28-100	Auto, Walking, Transit	➢ Apartment	➢ Condominium ➢ Senior Housing ➢ Ground Floor Retail ➢ Pocket Park	
Rural Cross Roads (RCR)	NA	Auto	➢ Gas Station ➢ Sit Down Restaurant	➢ Convenience Store ➢ Hardware Store ➢ Fire Station ➢ Post Office ➢ General Government Center	
Neighborhood Commercial Center (NCC)	10-15	Auto, Walking, Bicycle, Bus	➢ Sit Down Restaurant ➢ Community-Serving Retail ➢ Small Supermarket	➢ Barber Shop Convenience Store ➢ Dry Cleaner ➢ Bank ➢ Farmers Market ➢ Pocket Park	
Suburban Commercial Center (SCC)	NA	Auto	➢ General Commercial Services ➢ Sit Down Or Fast Food Restaurant ➢ Multi-Tenant Commercial	➢ Big Box Commercial ➢ Bank ➢ Hotel ➢ Professional Office ➢ Church ➢ Fire Station ➢ Police Station	
Suburban Hotel (SH)	NA	Auto	➢ Hotel	➢ Motel ➢ Sit-Down Restaurant ➢ Fast-Food Restaurant ➢ Fitness Club ➢ Small Scale Retail ➢ Gas Station	
Suburban Office Center (SOC)	NA	Auto	➢ Multi-Tenant Professional Office ➢ Medical Office ➢ Corporate Office	➢ Call Center ➢ Research and Development ➢ Bank ➢ Copy And Printing Services ➢ Sit Down Or Fast Food Restaurant ➢ Flex Space ➢ General Government Services	
Regional Employment Center (Rec)	NA	Auto, Walking, Transit	➢ Professional Office ➢ Corporate Campus	➢ Research and Development ➢ Government Buildings ➢ Small Retail Uses ➢ Restaurants	

Exhibit B1. Selected Characteristics of Place Type Categories.

Place Type[1]	Residential Density per Acre[2]	Typical Transportation Mode(s)	Primary Land Uses	Secondary Land Uses	
Light Industrial Center (LI)	NA	Auto, Trucks	➢ Light Manufacturing and Assembly ➢ Processing Facilities	➢ Laboratory ➢ Warehouse ➢ Distribution ➢ Small Scale Commercial Uses ➢ Natural Areas	
Heavy Industrial Center (HI)	NA	Auto, Trucks	➢ Factory ➢ Heavy Assembly Plant ➢ Construction Contractor ➢ Regional Warehouse	➢ Regional Distribution And Trucking ➢ Landfill ➢ Small Scale Commercial Uses ➢ Natural Areas	
Mixed - Use Neighborhood (MUN)	4-12	Auto, Walking, Bicycle, Transit (Bus)	➢ Single-Family Detached Home ➢ Condominium ➢ Apartment ➢ Townhome	➢ Sit Down Restaurant ➢ Neighborhood-Serving Commercial ➢ Professional Office ➢ Government Building ➢ Church ➢ School ➢ Pocket Park ➢ Community Park ➢ Natural Areas	
Mixed-Use Center (MUC)	10-30	Auto, Walking, Bicycle, Transit (Bus)	➢ Sit Down Restaurant ➢ Community-Serving Retail ➢ Professional Office ➢ Live/Work/Shop Units ➢ Townhome	➢ Condominium ➢ Apartment ➢ Public Plaza ➢ Movie Theater ➢ Farmers Market ➢ Pocket Park ➢ Day Care ➢ Dry Cleaners	
Town Center (TC)	6-10	Auto, Walking, Bicycle, Transit (Bus)	➢ Townhome ➢ Apartment ➢ Senior Housing ➢ Sit Down Restaurant ➢ Community Facilities	➢ Community-Serving Commercial ➢ Professional Office ➢ Live/Work/Shop Units ➢ Post Office ➢ Day Care ➢ Farmers Market ➢ Pocket Park	

Exhibit B1. Selected Characteristics of Place Type Categories.

Place Type[1]	Residential Density per Acre[2]	Typical Transportation Mode(s)	Primary Land Uses	Secondary Land Uses	
Transit - Oriented Development (TOD)	8-15	Auto, Walking, Bicycle, Transit (Bus, Light Rail, Heavy Rail)	➢ Condominium ➢ Apartment ➢ General Commercial ➢ Live/Work/Shop Units	➢ Government Building ➢ Professional Office ➢ Townhome ➢ Sit Down Restaurant ➢ Church ➢ School ➢ Parking Structure ➢ Public Plaza ➢ Pocket Park	
Metropolitan Center (MC)	10-100	Auto, Walking, Bicycle, Transit (Bus)	➢ Condominium ➢ Apartment ➢ Townhome ➢ Corporate Headquarters ➢ Sit Down Restaurant ➢ Community-Serving Commercial ➢ Professional Office	➢ Live/Work/Shop Units ➢ Museum ➢ Library ➢ Arena/Conference Center ➢ Regional Transportation Hub ➢ Government Buildings ➢ Church ➢ School ➢ Public Plaza ➢ Pocket Park ➢ Parking Deck	
Airport (AIR)	10-30	Auto, Airplanes	➢ Airport Activities (e.g., Commercial Terminal, Control Tower, Freight Facilities, Etc.) ➢ Flight School	➢ Warehouse ➢ Aviation-Related Maintenance and Repair ➢ Shipping ➢ Light Industrial ➢ Heavy Industrial ➢ Professional Office ➢ Hotel ➢ General Commercial ➢ Parking Decks ➢ Surface Parking Lots	
Civic & Institutional Facilities (CIV)	10-30	Auto, Walking	➢ Government Buildings ➢ Library	➢ School ➢ Prison ➢ Public Works Building ➢ Church ➢ Community Center ➢ Water or Wastewater Treatment Plant	
Health Care Campus (HCC)	NA	Auto	➢ Primary Care Buildings ➢ Emergency Services ➢ Research Centers	➢ Birthing Center ➢ Rehabilitation Center ➢ Teaching Facilities ➢ Private Medical Office Buildings ➢ Parking Deck ➢ Surface Parking Lot	
University Campus (UC)	25-100	Auto, Walking, Transit	➢ Academic Buildings ➢ Athletic Buildings ➢ Resident Halls	➢ Recreation Center ➢ Open Space / Public Plazas ➢ Private Research And Development Buildings ➢ Supporting Retail and Restaurants Supporting Retail and Restaurants ➢ Residential Neighborhood ➢ Parking Deck ➢ Surface Parking Lot	

Exhibit B2. Characteristics of Grouped Place Type Categories.

Collapsed Category	Place Types Included in Category	General Characteristics of Collapsed Category		
		Residential Density	Typical Mode(s) of Transportation	Primary Land Uses
Parks and Open Spaces	▪ Parks and Open Space	NA	Auto, Bicycle, Walking	Parks, Greenways, Natural Areas, Wildlife, Recreation, Storm Water
Low-Density Residential	▪ Working Farm ▪ Rural Living Large-Lot Residential	0.05 – 1.00	Auto	Farms, Timber Harvest, Large-lot rural or residential homes, Woodlands
Mid-Density Residential	▪ Shade Tree Residential ▪ Small Lot Residential ▪ Mobile Home Community	1 -12	Auto	Small Lot Single-Family Detached Homes, Multi-Family Units, Mobile Homes
Mid- to High-Density Residential	▪ Multi-Family Residential Neighborhood ▪ Mixed-Density Residential Neighborhood ▪ Urban Neighborhood ▪ High-Rise Residential	6-100	Auto and/or Walking, Transit	Multi-Unit Residences, Single-Family Detached Residences
Commercial with Low Density Residential	▪ Rural Crossroads ▪ Neighborhood Commercial Center ▪ Suburban Commercial Center ▪ Suburban Hotel	0* 10-15	Auto and/or Walking, Bicycle, Bus	Various commercial areas located in rural or suburban locale with little residential development.
Commercial, Non-Residential	▪ Suburban Office Center ▪ Regional Employment Center	0*	Auto	Concentrated employment centers—often located near highways—buffered from residential by landscaped areas. Can include large-scale development.
Industrial, Non- Residential	▪ Light Industrial Center ▪ Heavy Industrial Center	0*	Auto, Trucks	Light Industrial, Heavy Industrial. Supports manufacturing, production, warehousing, assembly/production, storage and/or utilities
Mixed-Use Areas	▪ Mixed - Use Neighborhood ▪ Mixed - Use Center ▪ Town Center ▪ Transit-Oriented Center (I, II, III) ▪ Metro Center	4-100	Auto, Walking, Bicycle, Transit: Bus, Rail** (Light Rail, Heavy Rail)	Single-Family Detached Homes, Multi-Unit Residences, Restaurants, Government Buildings, Live/Work/Shop Areas, Transit-Oriented Development
Airport	▪ Airport	10-30	Auto, Airplanes	Airport and Related Activities
Institutions/ Campuses	▪ Civic and Institutional Facilities ▪ Health Care Campus ▪ University Campus	0* 10-100	Auto and/or Walking and/or Transit	Academic/Residential/Government/ Healthcare Buildings; Prison or Recreation Buildings or Research Centers

** Not Applicable (no residential)*

*** In higher density areas*

Source: Collapsed categories were created for this report based on: Noonkester 2011. Building a Regional Framework: Place Types for Imagine 2040. The Triangle Region Scenario Planning Initiative. Accessed 2/10/2016. http://www.tjcog.org/imagine2040/downloads.aspx

APPENDIX C

SERVICE AREA DETAILED PLACE TYPES

Table C-1. Percentage of Wake Forest Service Area in Place Type Categories.

Place Type		Service Zone / Percentage in Each Place Type			
		Core	Primary	Secondary	Total Service Area
1	Parks and Open Space	6.45	5.81	10.50	10.46
2	Working Farm			1.22	1.21
	Rural Living			6.31	6.25
	Large-Lot Residential Neighborhood			32.12	31.82
3	Mobile Home Park			0.31	0.31
	Shade Tree Residential Neighborhood			1.09	1.08
	Small-Lot Residential Neighborhood		11.42	34.33	34.10
4	Multi-Family Suburban Neighborhood		4.11	1.58	1.59
	Mixed Density Residential Neighborhood		3.19	0.13	0.15
	Urban Neighborhood	38.40	39.13	0.54	0.90
	High Rise Residential				
5	Rural Crossroads				
	Neighborhood Commercial Center			0.51	0.51
	Suburban Commercial Center		0.72	4.86	4.82
	Suburban Hotel				
6	Suburban Office Center			0.65	0.64
	Regional Employment Center				
7	Light Industrial Center			3.16	3.13
	Heavy Industrial Center				
8	Mixed-Use Neighborhood			1.55	1.54
	Mixed Use Center			0.18	0.18
	Town Center	25.26	13.98	0.25	0.40
	Transit-Oriented Development				
	Metropolitan Center				
9	Airport				
10	Civic and Institutional	0.25	9.81	0.47	0.54
	Health Care Campus			0.11	0.11
	University Campus	29.63	11.82	0.12	0.27

Note: Shaded cell=0.00%

Source: Based on data from Triangle J. Council of Government: TCV2 Parcel Geodatabase for Place Type & Development Status. Accessed 2/11/2016. http://www.tjcog.org/imagine2040/downloads.aspx

Table C-2. Percentage of Knightdale Service Area in Place Type Categories.

Place Type		Service Zone / Percentage in Each Place Type			
		Core	Primary	Secondary	Total Service Area
1	Parks and Open Space	2.47	10.04	6.08	6.10
2	Working Farm				
	Rural Living			5.12	5.07
	Large-Lot Residential Neighborhood			12.71	12.60
3	Mobile Home Park			1.83	1.81
	Shade Tree Residential Neighborhood			6.85	6.79
	Small-Lot Suburban Neighborhood	77.69	65.05	47.25	47.44
4	Multi-Family Suburban Neighborhood	0.00	1.17	0.58	0.58
	Mixed-Density Residential Neighborhood	6.29	10.66	2.79	2.85
	Urban Neighborhood				
	High Rise Residential				
5	Rural Crossroads				
	Neighborhood Commercial Center	0.08	0.38	0.46	0.46
	Suburban Commercial Center		0.95	2.34	2.32
	Suburban Hotel				
6	Suburban Office Center			0.14	0.13
	Regional Employment Center				
7	Light Industrial Center			2.92	2.90
	Heavy Industrial Center			2.14	2.12
8	Mixed-Use Neighborhood	2.29	2.14	4.07	4.05
	Mixed Use Center			0.44	0.43
	Town Center	6.41	4.41		0.04
	Transit-Oriented Development I				
	Transit-Oriented Development II				
	Transit-Oriented Development III				
	Metropolitan Center				
9	Airport				
10	Civic and Institutional	4.77	5.05	4.30	4.30
	Health Care Campus				
	University Campus				

Note: Shaded cell=0.00%

Source: Based on data from Triangle J. Council of Government: TCV2 Parcel Geodatabase for Place Type & Development Status. Accessed 2/11/2016. http://www.tjcog.org/imagine2040/downloads.aspx

Table C-3. Percentage of Garner Service Area in Place Type Categories.

Place Type		Service Zone / Percentage in Each Place Type			
		Core	Primary	Secondary	Total Service Area
1	Parks and Open Space	13.64	6.23	9.34	9.32
2	Working Farm			0.62	0.61
	Rural Living	2.87	0.44	3.29	3.27
	Large-Lot Residential Neighborhood		6.35	9.31	9.27
3	Mobile Home Park			1.49	1.48
	Shade Tree Residential Neighborhood			7.92	7.84
	Small-Lot Suburban Neighborhood	53.01	48.84	37.19	37.31
4	Multi-Family Suburban Neighborhood	5.73	3.13	1.97	1.98
	Mixed-Density Residential Neighborhood	12.57	17.76	1.90	2.04
	Urban Neighborhood			0.93	0.92
	High Rise Residential				
5	Rural Crossroads				
	Neighborhood Commercial Center		2.64	1.43	1.43
	Suburban Commercial Center		3.04	2.86	2.86
	Suburban Hotel		0.00	0.01	0.01
6	Suburban Office Center	1.00	1.18	0.99	0.99
	Regional Employment Center			0.35	0.34
7	Light Industrial Center	1.99	6.13	5.93	5.92
	Heavy Industrial Center	0.01	2.27	5.02	4.99
8	Mixed-Use Neighborhood			0.76	0.75
	Mixed Use Center			0.96	0.95
	Town Center	4.43	0.24		0.01
	Transit-Oriented Development I				
	Transit-Oriented Development II				
	Transit-Oriented Development III				
	Metropolitan Center			0.10	0.09
9	Airport				
10	Civic and Institutional	4.77	1.73	7.59	7.54
	Health Care Campus			0.03	0.02
	University Campus			0.05	0.05

Note: Shaded cell=0.00%

Source: Based on data from Triangle J. Council of Government: TCV2 Parcel Geodatabase for Place Type & Development Status. Accessed 2/11/2016. http://www.tjcog.org/imagine2040/downloads.aspx

Table C-4. Percentage of Clayton Service Area in Place Type Categories.

Place Type		Service Zone / Percentage in Each Place Type			
		Core	Primary	Secondary	Total Service Area
1	Parks and Open Space	0.16	3.48	3.87	3.86
2	Working Farm			4.26	4.23
	Rural Living		0.27	2.40	2.39
	Large-Lot Residential Neighborhood			14.41	14.29
3	Mobile Home Park			0.62	0.61
	Shade Tree Residential Neighborhood				
	Small-Lot Suburban Neighborhood		21.20	57.59	57.24
4	Multi-Family Suburban Neighborhood	1.22	4.18	0.35	0.38
	Mixed-Density Residential Neighborhood	0.00	0.00	1.50	1.49
	Urban Neighborhood	62.50	49.27	0.32	0.76
	High Rise Residential				
5	Rural Crossroads				
	Neighborhood Commercial Center	0.14		0.17	0.17
	Suburban Commercial Center	1.97	2.75	2.60	2.60
	Suburban Hotel				
6	Suburban Office Center	4.06	1.20	0.47	0.48
	Regional Employment Center				
7	Light Industrial Center	0.74	0.73	5.39	5.35
	Heavy Industrial Center			1.45	1.44
8	Mixed-Use Neighborhood			0.38	0.38
	Mixed Use Center			0.03	0.03
	Town Center	21.71	4.58		0.07
	Transit-Oriented Development I				
	Transit-Oriented Development II				
	Transit-Oriented Development III				
	Metropolitan Center				
9	Airport				
10	Civic and Institutional	7.51	12.34	4.10	4.16
	Health Care Campus			0.07	0.07
	University Campus				

Note: Shaded cell=0.00%

Source: Based on data from Triangle J. Council of Government: TCV2 Parcel Geodatabase for Place Type & Development Status. Accessed 2/11/2016. http://www.tjcog.org/imagine2040/downloads.aspx

Table C-5. Percentage of Fuquay-Varina Service Area in Place Type Categories.

Place Type		Service Zone / Percentage in Each Place Type			
		Core	Primary	Secondary	Total Service Area
1	Parks and Open Space	5.61	4.29	4.40	4.40
2	Working Farm			3.05	3.02
	Rural Living			6.15	6.10
	Large-Lot Residential Neighborhood			10.97	10.88
3	Mobile Home Park			1.11	1.10
	Shade Tree Residential Neighborhood				
	Small-Lot Suburban Neighborhood	54.27	54.63	61.54	61.48
4	Multi-Family Suburban Neighborhood	5.44	5.14	0.76	0.80
	Mixed-Density Residential Neighborhood			0.29	0.29
	Urban Neighborhood	0.01	18.90	0.09	0.21
	High Rise Residential				
5	Rural Crossroads			0.02	0.02
	Neighborhood Commercial Center			0.14	0.14
	Suburban Commercial Center	0.96	4.86	3.86	3.86
	Suburban Hotel				
6	Suburban Office Center	4.44	3.15	0.74	0.76
	Regional Employment Center				
7	Light Industrial Center	4.51		2.45	2.44
	Heavy Industrial Center		0.02	2.10	2.08
8	Mixed-Use Neighborhood			0.35	0.35
	Mixed Use Center			0.97	0.96
	Town Center	23.06	4.31	0.07	0.15
	Transit-Oriented Development I				
	Transit-Oriented Development II				
	Transit-Oriented Development III				
	Metropolitan Center				
9	Airport				
10	Civic and Institutional	1.71	4.69	0.94	0.97
	Health Care Campus				
	University Campus				

Note: Shaded cell=0.00%

Source: Based on data from Triangle J. Council of Government: TCV2 Parcel Geodatabase for Place Type & Development Status. Accessed 2/11/2016. http://www.tjcog.org/imagine2040/downloads.aspx

Table C-6. Percentage of Apex Service Area in Place Type Categories.

Place Type		Service Zone / Percentage in Each Place Type			
		Core	Primary	Secondary	Total Service Area
1	Parks and Open Space	3.57	10.20	12.32	12.29
2	Working Farm		0.34	1.38	1.37
	Rural Living			10.00	9.91
	Large-Lot Residential Neighborhood		0.15	9.46	9.38
3	Mobile Home Park			0.10	0.10
	Shade Tree Residential Neighborhood			1.28	1.27
	Small-Lot Suburban Neighborhood	33.36	35.17	36.19	36.18
4	Multi-Family Suburban Neighborhood		5.72	3.57	3.58
	Mixed-Density Residential Neighborhood		0.57	1.47	1.46
	Urban Neighborhood	19.72	11.94	0.17	0.30
	High Rise Residential				
5	Rural Crossroads			0.01	0.01
	Neighborhood Commercial Center	2.37	0.64	0.63	0.63
	Suburban Commercial Center	0.68	7.76	3.16	3.19
	Suburban Hotel			0.11	0.11
6	Suburban Office Center	0.19	1.73	3.52	3.50
	Regional Employment Center			1.26	1.25
7	Light Industrial Center	4.06		4.51	4.48
	Heavy Industrial Center		0.50	2.46	2.44
8	Mixed-Use Neighborhood	6.12	1.28	1.96	1.97
	Mixed Use Center		11.29	1.13	1.20
	Town Center	12.69		0.02	0.04
	Transit-Oriented Development I				
	Transit-Oriented Development II			2.36	2.34
	Transit-Oriented Development III				
	Metropolitan Center				
9	Airport				
10	Civic and Institutional	17.26	12.70	2.63	2.73
	Health Care Campus			0.29	0.29
	University Campus				

Note: Shaded cell=0.00%

Source: Based on data from Triangle J. Council of Government: TCV2 Parcel Geodatabase for Place Type & Development Status. Accessed 2/11/2016. http://www.tjcog.org/imagine2040/downloads.aspx

APPENDIX D

DEFINITIONS

DEFINITIONS

AVERAGE DAILY TRAFFIC (ADT)

"The total traffic volume during a given time period, ranging from 2 to 364 consecutive days, divided by the number of days in that time period, and expressed in vpd (vehicles per day)."

(State of Delaware Department of Transportation. *Traffic Summary 2007. Terminology.* http://deldot.gov/information/pubs_forms/manuals/traffic_counts/2007/pdf/27-Terminology.pdf)

ANNUAL AVERAGE DAILY TRAFFIC (AADT)

"Annual average daily traffic, abbreviated AADT, is a measure used primarily in transportation planning and transportation engineering. Traditionally, it is the total volume of vehicle traffic of a highway or road for a year divided by 365 days. AADT is a useful and simple measurement of how busy the road is. Newer advances from traffic data providers are now providing AADT by side of the road, by day of week and by time of day.

One of the most important uses of AADT is for determining funding for the maintenance and improvement of Highways. In the United States the amount of federal funding a state will receive is related to the total traffic measured across its Highway network. Each year on June 15, every state in the United States submits a Highway Performance Monitoring System HPMS report. The HPMS report contains various information regarding the road segments in the state based on a sample (not all of the road segments) of the road segments. In the report, the AADT is converted to Vehicle Miles Traveled (VMT). VMT is the AADT multiplied by the length of the road segment. To determine the amount of traffic a state has, the AADT cannot be summed for all road segments since an AADT is a rate. The VMT is summed and is used as an indicator of the amount of traffic a state has. For federal-funding, formulas are applied to include the VMT and other highway statistics."

(Wikipedia Contributors. 2015a: n.p.)

EMPLOYED

"This category includes all civilians 16 years old and over who either (1) were "at work," that is, those who did any work at all during the reference week as paid employees, worked in their own business or profession, worked on their own farm, or worked 15 hours or more as unpaid workers on a family farm or in a family business; or (2) were "with a job but not at work," that is, those who did not work during the reference week but had jobs or businesses from which they were temporarily absent due to illness, bad weather, industrial dispute, vacation, or other personal reasons. Excluded from the employed are people whose only activity consisted of work around the house or unpaid volunteer work for religious, charitable, and similar organizations; also excluded are all institutionalized people and people on active duty in the United States Armed Forces."

UNEMPLOYED

"All civilians 16 years old and over are classified as unemployed if they (1) were neither "at work" nor "with a job but not at work" during the reference week, and (2) were actively looking for work during the last 4 weeks, and (3) were available to start a job. Also included as unemployed are civilians who did not work at all during the reference week, were waiting to be called back to a job from which they had been laid off, and were available for work except for temporary illness."

CIVILIAN LABOR FORCE

"Consists of people classified as employed or unemployed in accordance with the criteria described above."

LABOR FORCE

"All people classified in the civilian labor force plus members of the U.S. Armed Forces (people on active duty with the United States Army, Air Force, Navy, Marine Corps, or Coast Guard)."

(US Census Bureau.2016. n.p. http://www.census.gov/people/)

DEFINITIONS

OTHER MODES

"Includes walk, bicycle, school bus, airplane, Amtrak, and taxi."

(USDOT-FHA 2001:43.)

PRIVATELY OWNED VEHICLE (POV)

"Motor vehicles owned by or available to the surveyed household. Includes cars, vans, sport utility vehicles, pickup trucks, other trucks, recreational vehicles, motorcycles and other household-based vehicles."

(USDOT-FHA 2001:43.)

PUBLIC TRANSPORTATION

"Includes bus, subway or elevated rail, commuter train, and streetcar or trolley car. "

(USDOT-FHA 2001:43.)

SERVICE AREA

"A measure of access to transit service in terms of population served and area coverage (square miles). The reporting transit agency determines the service area boundaries and population for most transit services using the definitions contained in the Americans with Disabilities Act of 1990 (ADA), i.e. a corridor surrounding the routes ¾ of a mile on either side, or for rail, a series of circles of radius ¾ mile centered on each station. Transit agency reporters are required to submit service area information on the Identification form (B-10). Can be found in: Introduction, B-10, FFA-10, RU-10. "

(Federal Transit Administration 2015: n.p.)

SERVICE AREA — RAIL

"A measure of access to transit service in terms of population served and area coverage (square miles). The reporting transit agency determines the service area boundaries and population for most transit services using the definitions contained in the Americans with Disabilities Act of 1990 (ADA): "Rail. (i) For rail systems, the service area shall consist of a circle with a radius of 3/4 of a mile around each station. (Ii) At end stations and other stations in outlying area, the entity may designate circles with radii of up to 1-1/2 miles as part of its service area, based on local circumstances."
This definition is taken in part from the U. S. Department of Transportation Federal Register, Vol. 56, No. 173, Rules and Regulations, Americans with Disabilities Act of 1990 (ADA). Can be found in: B-10, RU-10"

(National Transit Database: http://www.ntdprogram.gov/ntdprogram/Glossary.htm)

SIDING

"Track adjacent to a main or secondary track for meeting or passing trains "

(BNSF Railway. 2016. "Glossary of Railroad Terminology & Jargon." Accessed 6/26/2016. http://www.bnsf.com/customers/pdf/glossary.pdf)

DEFINITIONS

TRAVEL MODE

"Mode choice is the process where the means of traveling is determined. The means of travel is referred to the travel mode, which may be by private automobile, public transportation, walking, bicycling, or other means. How desirable a travel mode is usually is expressed by utilities. In most travel models, mode choice is applied to travel that has already been estimated, meaning that mode choice is applied to a trip or tour, or group of trips or tours, where the origin and destination are already known."

(Travel Forecasting Resource n.d. Accessed 2/5/2016. http://tfresource.org/Category:Mode_choice)

TRIP CHAINING

"… making stops of 30 minutes or less, such as to drop a child at school, on the way to or from a major destination, such as home or work."

(USDOT-FHA 2001:43.)


EXIT 105 A
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15
501
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BB&T
Marriott
1755
1755
N
C