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10 CFR 50, Appendix E

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Shearon Harris Nuclear Power Plant, Unit 1
Docket No. 50-400
Renewed License No. NPF-63

SUBJECT: Shearon Harris 2022 Evacuation Time Estimate Report

Ladies and Gentlemen:

Pursuant to 10 CFR 50, Appendix E, Section IV, Paragraph 4, Duke Energy Progress, LLC (referred to as Duke Energy) is providing the 2022 Evacuation Time Estimate (ETE) Report for Shearon Harris Nuclear Power Plant, Unit 1 (HNP) to the Nuclear Regulatory Commission (NRC). The HNP 2022 ETE Report is provided in Enclosure 1.

This submittal contains no new regulatory commitments.

Should you have any questions concerning this letter, or require additional information, please contact Lee Grzeck, Fleet Licensing Manager (Acting), at (980) 373-1530.

Sincerely,

M. Christopher Nolan
Vice President, Nuclear Regulatory Affairs, Policy & Emergency Preparedness

Enclosure:

1. Shearon Harris 2022 Evacuation Time Estimate Report

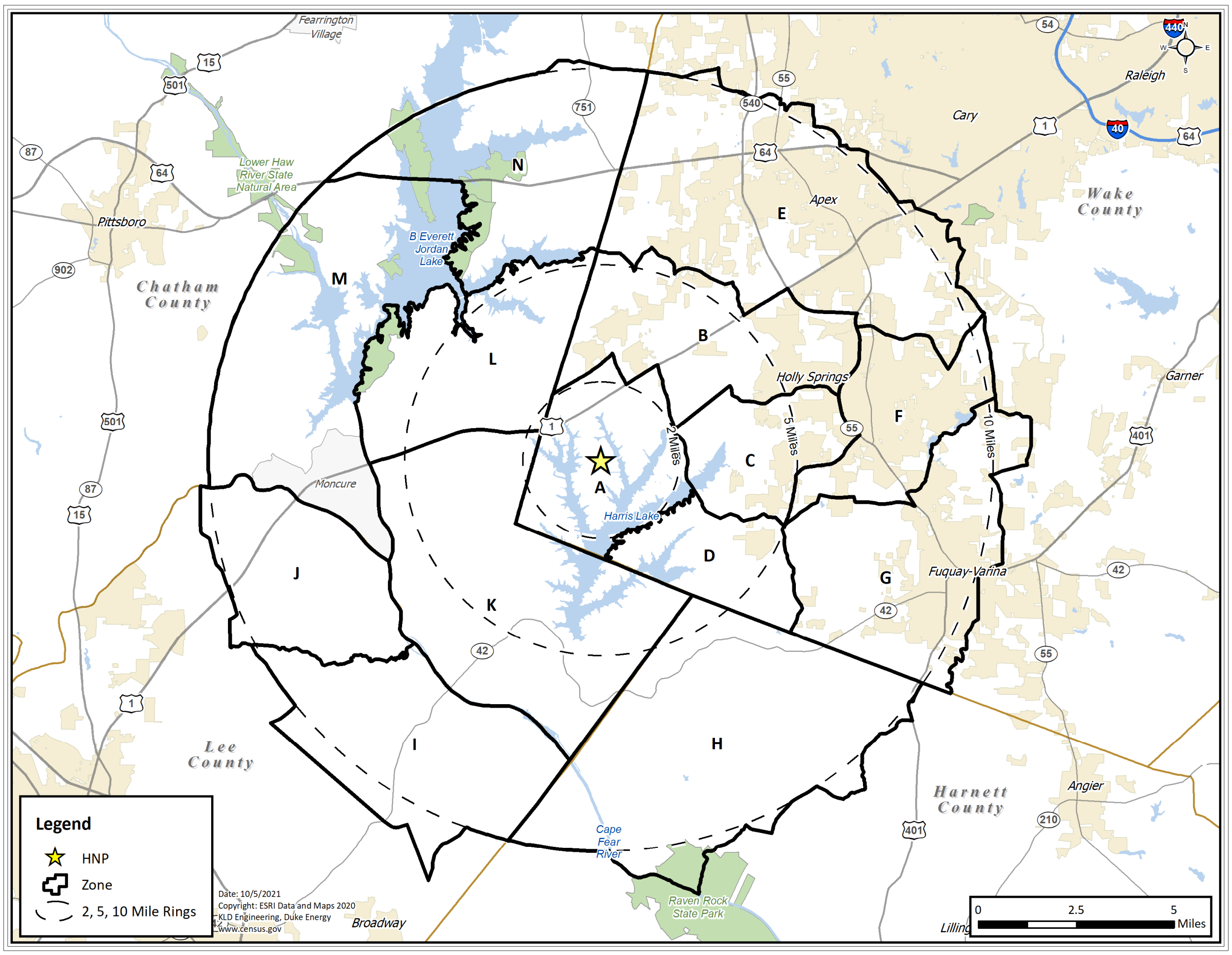
cc:

L. Dudes, Regional Administrator USNRC Region II
J. Zeiler, USNRC Senior Resident Inspector – HNP
A. Hon, NRR Project Manager – HNP

ENCLOSURE 1: Shearon Harris 2022 Evacuation Time Estimate Report

Harris Nuclear Plant

Development of Evacuation Time Estimates



Work performed for Duke Energy, by:

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January 15, 2022 | **Final Report, Rev. 0** | **KLD TR – 1224**

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KLD Engineering, P.C. – Lead Analyst | Date

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KLD Engineering, P.C. – Senior Project Manager | Date

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EXECUTIVE SUMMARY

This report describes the analyses undertaken and the results obtained by a study to develop Evacuation Time Estimates (ETE) for the Harris Nuclear Plant (HNP) located in Wake County, North Carolina. ETE are part of the required planning basis and provide Duke Energy and State and local governments with site-specific information needed for Protective Action decision-making.

In the performance of this effort, guidance is provided by documents published by Federal Governmental agencies. Most important of these are:

- Title 10, Code of Federal Regulations, Appendix E to Part 50 (10CFR50), Emergency Planning and Preparedness for Production and Utilization Facilities, NRC, 2011.
- Emergency Planning and Preparedness for Production and Utilization Facilities, 10CFR50, Appendix E.
- Revision 1 of the Criteria for Development of Evacuation Time Estimate Studies, NUREG/CR-7002, February 2021.
- FEMA, "Radiological Emergency Preparedness Program Manual" (FEMA P-1028), December 2019.
- Development of Evacuation Time Estimates for Nuclear Power Plants, NUREG/CR-6863, January 2005.

Project Activities

This project began in October 2020 and extended over a period of about one year. The major activities performed are briefly described in chronological sequence:

- Conducted a virtual "kick-off" meeting with Duke Energy personnel and emergency management personnel representing state and county governments.
- Accessed the U.S. Census Bureau data files for the year 2020.
- Obtained the estimates of employees who reside outside the EPZ and commute to work within the EPZ from each county.
- Studied Geographic Information Systems (GIS) maps of the area in the vicinity of the HNP, then conducted a detailed field survey of the highway network to observe any roadway changes relative to the previous ETE study done in 2016.
- Updated the analysis network representing the highway system topology and capacities within the Emergency Planning Zone (EPZ), plus a Shadow Region covering the region between the EPZ boundary and approximately 15 miles radially from the plant.
- Updated the EPZ to include the boundaries proposed by Harnett, Chatham, and Wake Counties. These changes in EPZ boundaries are to allow for more specific protective action decisions.

- Conducted a random-sample demographic survey of residents within the EPZ, to gather focused data needed for this ETE study that were not contained within the census database. Leverage the previous survey results to minimize uncertainty in the survey responses.
- The data gathered for the 2016 ETE study were reviewed and updated accordingly by the offsite response organizations (OROs). Special facility data was requested from the OROs at the kickoff meeting. If updated information was not provided and data could not be obtained from online sources, the data gathered in the 2016 ETE study was utilized.
- The traffic demand and trip-generation rates of evacuating vehicles were estimated from the gathered data. The trip generation rates reflect the estimated mobilization time (i.e., the time required by evacuees to prepare for the evacuation trip) computed using the results of the demographic survey of EPZ residents.
- Following federal guidelines, the existing 14 Zones, within the EPZ, are grouped within circular areas or "keyhole" configurations (circles plus radial sectors) that define a total of 37 Evacuation Regions.
- The time-varying external circumstances are represented as Evacuation Scenarios, each described in terms of the following factors: (1) Season (Summer, Winter); (2) Day of Week (Midweek, Weekend); (3) Time of Day (Midday, Evening); and (4) Weather (Good, Rain, Ice). One special event scenario for Fourth of July on Jordan Lake was considered. One roadway impact scenario was considered wherein a single lane was closed on US-1 northbound (from New Hill Holleman Rd to I-40) and US-64 eastbound (from NC-751 to US-1) for the duration of the evacuation.
- Staged evacuation was considered for those regions wherein the 2-mile radius and sectors downwind to 5 miles are evacuated.
- As per NUREG/CR-7002, Rev. 1, the Planning Basis for the calculation of ETE is:
    - A rapidly escalating accident at the HNP that quickly assumes the status of a general emergency wherein evacuation is ordered promptly and no early protective actions have been implemented such that the Advisory to Evacuate (ATE) is virtually coincident with the siren alert.
    - While an unlikely accident scenario, this planning basis will yield ETE, measured as the elapsed time from the ATE until the stated percentage of the population exits the impacted Region that represent "upper bound" estimates. This conservative Planning Basis is applicable for all initiating events.
- If the emergency occurs while schools are in session, the ETE study assumes that the children will be evacuated by bus directly to relocation schools located outside the EPZ. Parents, relatives, and neighbors are advised to not pick up their children at school prior to the arrival of the buses dispatched for that purpose. The ETE for schoolchildren are calculated separately.

- Evacuees who do not have access to a private vehicle will either ride-share with relatives, friends or neighbors, or be evacuated by buses. Those in special facilities will likewise be evacuated with public transit, as needed: bus, minivan, passenger car, wheelchair transport or ambulance, as required. Separate ETE are calculated for the transit-dependent evacuees, for the access and/or functional needs population, and for those evacuated from special facilities.
- Attended "final" meeting with Duke Energy personnel and emergency management personnel representing state and county governments to present results from the study.

Computation of ETE

A total of 518 ETE were computed for the evacuation of the general public. Each ETE quantifies the aggregate evacuation time estimated for the population within one of the 37 Evacuation Regions to evacuate from that Region, under the circumstances defined for one of the 14 Evacuation Scenarios (37 x 14 = 518). Separate ETE are calculated for transit-dependent evacuees, including schoolchildren for applicable scenarios.

Except for Region R03, which is the evacuation of the entire EPZ, only a portion of the people within the EPZ would be advised to evacuate. That is, the Advisory to Evacuate applies only to those people occupying the specified impacted region. It is assumed that 100 percent of the people within the impacted region will evacuate in response to this Advisory. The people occupying the remainder of the EPZ outside the impacted region may be advised to take shelter.

The computation of ETE assumes that 20 percent of the population within the EPZ, but outside the impacted region, will elect to "voluntarily" evacuate. In addition, 20 percent of the population in the Shadow Region will also elect to evacuate. These voluntary evacuees could impede those who are evacuating from within the impacted region. The impedance that could be caused by voluntary evacuees is considered in the computation of ETE for the impacted region.

Staged evacuation is considered wherein those people within the 2-mile region evacuate immediately, while those beyond 2 miles, but within the EPZ, shelter-in-place. Once 90 percent of the 2-mile region is evacuated, those people beyond 2 miles begin to evacuate. As per federal guidance, 20 percent of people beyond 2 miles will evacuate (non-compliance) even though they are advised to shelter-in-place.

The computational procedure is outlined as follows:

- A link-node representation of the highway network is coded. Each link represents a unidirectional length of highway; each node usually represents an intersection or merge point. The capacity of each link is estimated based on the field survey observations and on established traffic engineering procedures.
- The evacuation trips are generated at locations called "zonal centroids" located within the EPZ and Shadow Region. The trip generation rates vary over time reflecting the mobilization process, and from one location (centroid) to another depending on population density and on whether a centroid is within, or outside, the impacted area.

- The evacuation model computes the routing patterns for evacuating vehicles that are compliant with federal guidelines (outbound relative to HNP) and then simulates the traffic flow movements over space and time. This simulation process estimates the rate that traffic flow exits the impacted region.

The ETE statistics provide the elapsed times for 90 percent and 100 percent, respectively, of the population within the impacted region, to evacuate from within the impacted region. These statistics are presented in tabular and graphical formats. The 90th percentile ETE have been identified as the values that should be considered when making protective action decisions because the 100th percentile ETE are prolonged by those relatively few people who take longer to mobilize. This is referred to as the "evacuation tail" in Section 4.0 of NUREG/CR-7002, Rev. 1.

Traffic Management

This study used the comprehensive existing traffic management plan for all counties. Refer to Section 9 and Appendix G.

Selected Results

A compilation of selected information is presented on the following pages in the form of figures and tables extracted from the body of the report; these are described below.

- Table 3-1 presents the estimates of permanent resident population in each Zone based on the 2020 Census data.
- Table 6-1 defines each of the 37 Evacuation Regions in terms of their respective groups of Zones.
- Table 6-2 defines the 14 Evacuation Scenarios.
- Tables 7-1 and 7-2 are compilations of ETE. These data are the times needed to clear the indicated regions of 90 and 100 percent of the population occupying these regions, respectively. These computed ETE include consideration of mobilization time and of estimated voluntary evacuations from other regions within the EPZ and from the Shadow Region.
- Tables 7-3 and 7-4 present ETE for the 2-mile region for un-staged and staged evacuations for the 90th and 100th percentiles, respectively.
- Table 8-2 present ETE for the schools and child care centers in good weather.
- Table 8-5 present ETE for the transit-dependent population in good weather.
- Table 8-8 present ETE for the medical facility population in good weather.
- Figure 6-1 displays a map of the HNP EPZ showing the layout of the 14 Zones that comprise, in aggregate, the EPZ.
- Figure H-8 presents an example of an Evacuation Region (Region R08) to be evacuated under the circumstances defined in Table 6-1. Maps of all Regions are provided in Appendix H.
- Table M-6 compares the ETE results for the proposed EPZ Zone boundary changes.

Conclusions

- General population ETE were computed for 518 unique cases. Table 7-1 and Table 7-2 document these ETE for the 90th and 100th percentiles. The 90th percentile ETE range from 1:20 (hr:min) to 3:45. The 100th percentile ETE range from 5:10 to 5:40.
- Inspection of Table 7-1 and Table 7-2 indicates that the ETE for the 100th percentile are significantly longer than those for the 90th percentile. This is the result of the pronounced congestion within the major population centers (Apex, Holly Springs and Fuquay-Varina) within the EPZ. When the system becomes congested, traffic exits the EPZ at rates somewhat below capacity until some evacuation routes have cleared. As more routes clear, the aggregate rate of egress slows since many vehicles have already left the EPZ. Towards the end of the process, relatively few evacuation routes service the remaining demand. Congestion clears, however, just before the completion of trip generation time. As a result, the 100th percentile ETE is dictated by the time needed to mobilize. See Sections 7.3 through 7.5, and Figures 7-3 through 7-23.
- Inspection of Table 7-3 and Table 7-4 indicates that a staged evacuation provides no benefits to evacuees from within the 2-mile region and unnecessarily delays the evacuation of those beyond 2 miles (compare Regions R02 and R04 through R12 with Regions R28 through R37, respectively, in Table 7-1). See Section 7.6 for additional discussion.
- Comparison of Scenarios 5 (summer, midweek/weekend, evening) and 13 (summer, weekend, evening) in Table 7-1 and Table 7-2 indicates that the special event, Fourth of July on Jordan Lake, has little impact on the 90th percentile ETE (at most 10 minutes) and does not affect the 100th percentile ETE. See Section 7.5 for additional discussion.
- Comparison of Scenarios 1 and 14 in Table 7-1 and Table 7-2 indicates that the roadway closure – one lane northbound on US-1 and one lane eastbound on US-64 – causes at most a 5 minute increase for the 90th percentile ETE and no impact for the 100th percentile ETE. See Section 7.5 for additional discussion.
- The population centers of Apex, Holly Springs and Fuquay-Varina are the most congested areas throughout the evacuation. The last location in the EPZ to exhibit traffic congestion is Fuquay-Varina. All congestion within the EPZ clears by 4 hours and 50 minutes after the Advisory to Evacuate. See Section 7.3 and Figures 7-3 through 7-9.
- Separate ETE were computed for schools and child care centers, medical facilities, transit-dependent persons and access and/or functional needs persons. The average single-wave ETE for schools and child care centers is 1 hour and 15 minutes less than the 90th percentile ETE for the general population; average single-wave ETE for medical facilities is 55 minutes less than the 90th percentile ETE for the general population; average single-wave ETE for transit dependent persons is comparable to the 90th percentile for the general population. The average single-wave ETE for access and/or functional needs persons is comparable (5 minutes longer) than the general population ETE at the 90th percentile. See Section 8.
- Table 8-1 indicates that there are enough vans, wheelchair vans, ambulances and Medevac Helicopters available to evacuate everyone in a single wave; however, there are

not enough buses or wheelchair buses to evacuate special facilities and transit dependent population in a single wave. A second wave is necessary for all ambulatory persons to evacuate. See Section 8.

- A reduction in the base trip generation time of 5 hours reduces the general population ETE at the 90th percentile by 15 minutes. An increase in mobilization time by 1 hour increases the 90th percentile ETE by 30 minutes. See Table M-1.
- The general population ETE is significantly impacted by the increase in voluntary evacuation of vehicles in the Shadow Region (100% shadow evacuation percentages increase 90th percentile ETE by 45 minutes). See Table M-2.
- An increase in permanent resident population (EPZ plus Shadow Region) of 19% or greater results in an increase in the longest 90th percentile ETE of 30 minutes, which meets the federal criterion for performing a fully updated ETE study between decennial Censuses. See Section M.3.
- The proposed EPZ boundaries were used in this study. A sensitivity study was done to ensure that the change in the EPZ boundaries do not result in a significant change to the ETE. The 90th percentile ETE changes by 15 minutes – not a significant change - when comparing against the existing EPZ. See Section M-4.
- An increase in the average household size from 2.85 people per household to 3.11 people per household will result in 8.3% less evacuating vehicles and minimally impacts ETE with a reduction of at most 10 minutes at the 90th percentile. See Section M-5.

Table 3-1. EPZ Permanent Resident Population

Zone	2010 Population[1]	2020 Population
A	134	118
B	1,257	8,573
C	2,086	7,384
D	346	372
E	45,269	67,690
F	22,342	29,041
G	21,463	30,848
H	3,868	4,528
I	963	982
J	1,126	1,323
K	688	714
L	815	717
M	1,753	1,977
N	851	1,303
EPZ TOTAL	**102,961**	**155,570**
EPZ Population Growth (2010-2020):		**51.10%**

[1] The 2010 population shown in the table for Zones A, B, C, D, E, F, H, K, L, and N reflect the new zone boundaries and will therefore not align with the previous ETE study.

Table 6-1. Description of Evacuation Regions

Region	Description	Site PAR Description	Zone													
			A	B	C	D	E	F	G	H	I	J	K	L	M	N
R01	2-Mile Radius	2-Mile Radius	x													
R02	5-Mile Radius	5-Mile Radius	x	x	x	x							x	x		
R03	Full EPZ	10-Mile Radius	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Evacuate 2-Mile Radius and Downwind to 5 Miles																
Region	**Wind Direction From:**	**Site PAR Description**	**Zone**													
			A	B	C	D	E	F	G	H	I	J	K	L	M	N
R04	NNW, N	327° - 010°	x			x							x			
R05	NNE, NE	011° - 056°	x										x			
R06	ENE, E, ESE	057° - 124°	x										x	x		
R07	SE, SSE, S	125° - 191°	x	x										x		
R08	SSW	192° - 214°	x	x												
R09	SW, WSW	215° - 259°	x	x	x											
R10	W	260° - 281°	x		x											
R11	WNW	282° - 304°	x		x	x										
R12	NW	305° - 326°	x			x										
Evacuate 2-Mile Radius and Downwind to the EPZ Boundary																
Region	**Wind Direction From:**	**Site PAR Description**	**Zone**													
			A	B	C	D	E	F	G	H	I	J	K	L	M	N
R13	N	348° - 010°	x			x				x	x		x			
R14	NNE	011° - 034°	x							x	x	x	x			
R15	NE	035° - 056°	x								x	x	x		x	
R16	ENE	057° - 079°	x								x	x	x	x	x	
R17	E	080° - 101°	x									x	x	x	x	
R18	ESE	102° - 124°	x									x	x	x	x	x
R19	SE	125° - 146°	x	x										x	x	x
R20	SSE, S	147° - 191°	x	x			x							x	x	x
R21	SSW	192° - 214°	x	x			x							x		x
R22	SW	215° - 236°	x	x	x		x	x								
R23	WSW	237° - 259°	x	x	x		x	x	x							
R24	W	260° - 281°	x	x	x	x	x	x	x							
R25	WNW	282° - 304°	x		x	x		x	x	x						
R26	NW	305° - 326°	x		x	x			x	x			x			
R27	NNW	327° - 347°	x			x			x	x			x			
Staged Evacuation - 2-Mile Radius Evacuates, then Evacuate Downwind to 5 Miles																
Region	**Wind Direction From:**	**Site PAR Description**	**Zone**													
			A	B	C	D	E	F	G	H	I	J	K	L	M	N
R28	-	5-Mile Radius	x	x	x	x							x	x		
R29	NNW, N	327° - 010°	x			x							x			
R30	NNE, NE	011° - 056°	x										x			
R31	ENE, E, ESE	057° - 124°	x										x	x		
R32	SE, SSE, S	125° - 191°	x	x										x		
R33	SSW	192° - 214°	x	x												
R34	SW, WSW	215° - 259°	x	x	x											
R35	W	260° - 281°	x		x											
R36	WNW	282° - 304°	x		x	x										
R37	NW	305° - 326°	x			x										
Shelter-in-Place until 90% ETE for R01, then Evacuate			Zone(s) Shelter-in-Place							Zone(s) Evacuate						

Table 6-2. Evacuation Scenario Definitions

Scenario	Season[2]	Day of Week	Time of Day	Weather	Special
1	Summer	Midweek	Midday	Good	None
2	Summer	Midweek	Midday	Rain	None
3	Summer	Weekend	Midday	Good	None
4	Summer	Weekend	Midday	Rain	None
5	Summer	Midweek, Weekend	Evening	Good	None
6	Winter	Midweek	Midday	Good	None
7	Winter	Midweek	Midday	Rain	None
8	Winter	Midweek	Midday	Ice	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Rain	None
11	Winter	Weekend	Midday	Ice	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Summer	Midweek, Weekend	Evening	Good	Fourth of July on Jordan Lake
14	Summer	Midweek	Midday	Good	Roadway Impact – Lane Closures on US-1 and US-64

[2] Winter means that school is in session at normal enrollment levels (also applies to spring and autumn). Summer means that school is in session at summer school enrollment levels (lower than normal enrollment).

Table 7-2. Time to Clear the Indicated Area of *90* Percent of the Affected Population

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Ice	Good Weather	Rain	Ice	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region, 5-Mile Region, and EPZ														
R01	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R02	2:30	2:30	2:20	2:25	2:35	2:30	2:30	2:30	2:20	2:25	2:25	2:35	2:35	2:30
R03	3:25	3:35	3:15	3:20	3:10	3:30	3:30	3:45	3:10	3:20	3:35	3:15	3:10	3:30
2-Mile Region and Keyhole to 5 Miles														
R04	2:25	2:25	2:20	2:20	2:25	2:30	2:30	2:30	2:25	2:30	2:30	2:35	2:25	2:25
R05	2:15	2:15	2:15	2:15	2:25	2:20	2:20	2:25	2:25	2:25	2:25	2:30	2:25	2:15
R06	2:20	2:20	2:20	2:20	2:30	2:25	2:25	2:25	2:30	2:30	2:30	2:35	2:20	2:20
R07	2:15	2:15	2:10	2:15	2:20	2:15	2:15	2:20	2:10	2:15	2:15	2:20	2:20	2:20
R08	2:15	2:15	2:10	2:10	2:20	2:15	2:15	2:15	2:10	2:10	2:15	2:20	2:20	2:20
R09	2:30	2:30	2:20	2:20	2:35	2:30	2:30	2:30	2:20	2:20	2:25	2:35	2:35	2:30
R10	2:55	2:55	2:50	2:50	2:50	2:55	2:55	3:00	2:50	2:50	2:55	2:50	2:50	2:55
R11	2:55	2:55	2:50	2:55	2:50	2:55	2:55	3:00	2:50	2:55	2:55	2:50	2:50	2:55
R12	2:05	2:05	2:10	2:10	2:20	2:15	2:15	2:15	2:20	2:20	2:20	2:30	2:20	2:05
2-Mile Region and Keyhole to EPZ Boundary														
R13	2:50	2:50	2:35	2:35	2:40	2:50	2:55	2:55	2:40	2:40	2:40	2:40	2:40	2:50
R14	2:20	2:25	2:15	2:15	2:25	2:25	2:25	2:25	2:15	2:20	2:20	2:30	2:25	2:20
R15	2:20	2:20	2:15	2:15	2:20	2:20	2:20	2:25	2:15	2:20	2:20	2:25	2:15	2:20
R16	2:20	2:20	2:15	2:15	2:20	2:20	2:20	2:25	2:15	2:20	2:20	2:25	2:15	2:20
R17	2:15	2:20	2:15	2:15	2:20	2:20	2:20	2:25	2:15	2:15	2:20	2:20	2:15	2:15
R18	2:20	2:20	2:15	2:15	2:20	2:20	2:25	2:25	2:15	2:20	2:20	2:25	2:10	2:20
R19	2:15	2:20	2:15	2:15	2:20	2:20	2:20	2:20	2:15	2:15	2:20	2:25	2:15	2:20
R20	2:55	2:55	2:40	2:40	2:50	2:55	2:55	3:00	2:45	2:45	2:55	2:55	2:45	2:55
R21	2:55	2:55	2:40	2:40	2:50	2:55	2:55	3:00	2:45	2:45	2:55	2:50	2:45	2:55
R22	3:05	3:05	2:55	3:00	2:55	3:05	3:05	3:20	2:55	3:00	3:10	2:55	2:55	3:10
R23	3:20	3:30	3:15	3:15	3:15	3:20	3:35	3:45	3:10	3:15	3:30	3:10	3:10	3:25
R24	3:20	3:30	3:10	3:20	3:15	3:20	3:35	3:40	3:10	3:20	3:30	3:10	3:15	3:25
R25	3:50	3:55	3:25	3:40	3:25	3:40	3:50	4:10	3:30	3:40	3:55	3:20	3:25	3:50

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Ice	Good Weather	Rain	Ice	Good Weather	Special Event	Roadway Impact
R26	3:30	3:35	3:15	3:25	3:05	3:25	3:40	3:55	3:15	3:30	3:50	3:10	3:05	3:30
R27	3:20	3:30	3:15	3:30	3:05	3:20	3:35	3:55	3:10	3:25	3:40	3:05	3:05	3:20
Staged Evacuation - 2-Mile Region and Keyhole to 5 Miles														
R28	2:45	2:50	2:40	2:45	3:00	2:45	2:55	2:55	2:40	2:50	3:00	3:00	2:55	2:45
R29	2:25	2:25	2:20	2:20	2:25	2:30	2:30	2:30	2:25	2:30	2:30	2:35	2:25	2:25
R30	2:15	2:15	2:15	2:15	2:25	2:20	2:25	2:25	2:25	2:25	2:25	2:30	2:25	2:20
R31	2:20	2:20	2:20	2:20	2:30	2:25	2:25	2:25	2:30	2:30	2:30	2:35	2:20	2:25
R32	2:15	2:15	2:10	2:15	2:20	2:15	2:15	2:20	2:10	2:15	2:15	2:20	2:20	2:20
R33	2:15	2:15	2:10	2:10	2:20	2:15	2:15	2:15	2:10	2:15	2:15	2:20	2:20	2:20
R34	2:45	2:45	2:40	2:40	2:55	2:45	2:45	2:50	2:40	2:40	3:00	2:55	2:55	2:50
R35	3:20	3:25	3:20	3:25	3:20	3:20	3:25	3:30	3:20	3:25	3:30	3:25	3:20	3:20
R36	3:25	3:25	3:20	3:25	3:20	3:25	3:25	3:30	3:20	3:25	3:30	3:20	3:20	3:25
R37	2:05	2:05	2:10	2:10	2:20	2:15	2:15	2:15	2:20	2:20	2:20	2:30	2:20	2:05

Table 7-3. Time to Clear the Indicated Area of *100* Percent of the Affected Population

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Ice	Good Weather	Rain	Ice	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region, 5-Mile Region, and EPZ														
R01	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R02	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R03	5:10	5:15	5:10	5:10	5:10	5:10	5:15	5:40	5:10	5:10	5:30	5:10	5:10	5:10
2-Mile Region and Keyhole to 5 Miles														
R04	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R06	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R07	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R08	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R09	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R10	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R11	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R12	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
2-Mile Region and Keyhole to EPZ Boundary														
R13	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R14	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R15	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R16	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R17	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R18	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R19	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R20	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R21	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R22	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R23	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:20	5:10	5:10	5:10	5:10	5:10	5:10
R24	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:30	5:10	5:10	5:15	5:10	5:10	5:10
R25	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:40	5:10	5:10	5:25	5:10	5:10	5:10

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Ice	Good Weather	Rain	Ice	Good Weather	Special Event	Roadway Impact
R26	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:25	5:10	5:10	5:10	5:10	5:10	5:10
R27	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:25	5:10	5:10	5:10	5:10	5:10	5:10
Staged Evacuation - 2-Mile Region and Keyhole to 5 Miles														
R28	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R29	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R30	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R31	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R32	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R33	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R34	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R35	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R36	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R37	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05

Table 7-4. Time to Clear *90* Percent of the 2-Mile Region within the Indicated Region

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Ice	Good Weather	Rain	Ice	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region and 5-Mile Region														
R01	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R02	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
Un-staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R04	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R05	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R06	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R07	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R08	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R09	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R10	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R11	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R12	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
Staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R28	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R29	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R30	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R31	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R32	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R33	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R34	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R35	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R36	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R37	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20

Table 7-5. Time to Clear *100* Percent of the 2-Mile Region within the Indicated Region

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Ice	Good Weather	Rain	Ice	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region and 5-Mile Region														
R01	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R02	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
Un-staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R04	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R05	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R06	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R07	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R08	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R09	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R10	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R11	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R12	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
Staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R28	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R29	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R30	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R31	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R32	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R33	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R34	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R35	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R36	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R37	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00

Table 8-2. School and Child Care Center Evacuation Time Estimates - Good Weather

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to R.S. (mi.)	Travel Time from EPZ Bdry to H.S. (min)	ETA to R.S. (hr:min)
CHATHAM COUNTY SCHOOLS									
Moncure Elementary School	90	15	4.7	45.0	6	**1:55**	8.4	11	**2:10**
Seaforth High School	90	15	4.7	3.8	74	**3:00**	6.5	9	**3:10**
HARNETT COUNTY SCHOOLS									
Lafayette Elementary School[1]	90	15	0.0	0.0	0	**1:45**	3.9	5	**1:50**
LEE COUNTY SCHOOLS									
Deep River Elementary School[1]	90	15	0.0	0.0	0	**1:45**	8.8	12	**2:00**
WAKE COUNTY SCHOOLS									
Oakview Elementary School	90	15	7.4	8.4	53	**2:40**	24.7	33	**3:15**
Apex Friendship Middle School	90	15	4.9	5.4	54	**2:40**	13.5	18	**3:00**
Apex Friendship High School	90	15	4.9	5.4	54	**2:40**	13.5	18	**3:00**
Thales Academy Holly Springs Pre-K-5	90	15	7.4	8.4	53	**2:40**	24.7	33	**3:15**
Scotts Ridge Elementary School	90	15	4.9	5.6	53	**2:40**	13.5	18	**3:00**
St. Mary Magdalene Catholic School	90	15	4.9	5.2	57	**2:45**	10.6	14	**3:00**
Olive Chapel Elementary School	90	15	3.3	13.0	15	**2:00**	17.4	23	**2:25**
Apex Elementary School	90	15	3.3	4.1	48	**2:35**	14.7	20	**2:55**
Apex Middle School	90	15	2.9	3.2	55	**2:40**	17.1	23	**3:05**
Baucom Elementary School	90	15	3.0	37.9	5	**1:50**	17.3	23	**2:15**
Lufkin Road Middle School	90	15	1.2	12.6	6	**1:55**	17.1	23	**2:20**
Peak Charter Academy	90	15	3.2	36.4	5	**1:50**	15.9	21	**2:15**
Thales Academy Apex K-5	90	15	2.9	30.2	6	**1:55**	14.7	20	**2:15**
Thales Academy Apex JH/HS	90	15	1.4	25.1	3	**1:50**	15.9	21	**2:15**
Apex Senior High School	90	15	0.8	35.2	1	**1:50**	15.9	21	**2:15**
Holly Grove Elementary School	90	15	8.3	8.4	59	**2:45**	13.5	18	**3:05**
Holly Grove Middle School	90	15	8.2	8.4	59	**2:45**	24.9	33	**3:20**
Holly Springs High School	90	15	8.7	8.4	62	**2:50**	13.5	18	**3:10**
Holly Springs Elementary School	90	15	3.7	14.6	15	**2:00**	24.7	33	**2:35**

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to R.S. (mi.)	Travel Time from EPZ Bdry to H.S. (min)	ETA to R.S. (hr:min)
Pine Springs Preparatory Academy	90	15	4.5	5.2	52	**2:40**	13.5	18	**3:00**
Holly Ridge Elementary School	90	15	3.2	13.4	14	**2:00**	13.3	18	**2:20**
Holly Ridge Middle School	90	15	3.2	13.4	14	**2:00**	13.3	18	**2:20**
Buckhorn Creek Elementary School	90	15	3.1	3.8	49	**2:35**	12.8	17	**2:55**
Southern Wake Academy	90	15	3.1	3.9	48	**2:35**	12.8	17	**2:55**
Herbert Akins Road Elementary School	90	15	3.3	37.2	5	**1:50**	27.0	36	**2:30**
Lincoln Heights Elementary School	90	15	1.7	2.8	37	**2:25**	28.9	39	**3:05**
Fuquay-Varina Senior High School	90	15	1.1	3.3	20	**2:05**	13.0	17	**2:25**
Fuquay-Varina Middle School	90	15	0.9	3.4	16	**2:05**	28.4	38	**2:45**
WAKE COUNTY CHILD CARE CENTERS									
Angel's Garden Home Daycare	90	15	3.0	10.0	18	**2:05**	17.3	23	**2:30**
Apex Baptist Church Preschool	90	15	2.7	22.4	7	**1:55**	14.7	20	**2:15**
Apex Peak Schools, Inc.	90	15	2.8	24.0	7	**1:55**	14.7	20	**2:15**
Apex United Methodist Church Preschool	90	15	2.9	3.2	55	**2:40**	14.7	20	**3:00**
AsheBridge Children's Academy of Apex/Cary	90	15	1.9	28.2	4	**1:50**	15.8	21	**2:15**
Bright Start Child Care LLC	90	15	2.9	15.4	11	**2:00**	15.8	21	**2:25**
Children's Choice	90	15	1.8	37.6	3	**1:50**	16.1	21	**2:15**
Children's Lighthouse of Apex	90	15	0.8	23.8	2	**1:50**	15.9	21	**2:15**
Creative Schools of Apex	90	15	0.8	23.8	2	**1:50**	15.9	21	**2:15**
Earth Angel's Day Care Home	90	15	1.8	37.6	3	**1:50**	16.1	22	**2:15**
Eileen's Day Care[1]	90	15	0.0	0.0	0	**1:45**	15.9	21	**2:10**
Everbrook Academy of Apex	90	15	2.9	18.2	10	**1:55**	15.9	21	**2:20**
Goddard School Apex	90	15	2.7	22.4	7	**1:55**	14.7	20	**2:15**
Grace Church Preschool and Summer Camp	90	15	1.5	28.2	3	**1:50**	16.1	21	**2:15**
Growing Years Learning Center	90	15	2.7	22.4	7	**1:55**	14.7	20	**2:15**
Hope Chapel Preschool	90	15	1.4	33.2	3	**1:50**	15.9	21	**2:15**

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to R.S. (mi.)	Travel Time from EPZ Bdry to H.S. (min)	ETA to R.S. (hr:min)
Karen's Kids Home Child Care	90	15	4.9	14.0	21	**2:10**	14.7	20	**2:30**
Kidtowne at Hope Community Church - Apex	90	15	4.5	5.3	51	**2:40**	14.7	20	**3:00**
Kindercare Learning Center	90	15	4.6	13.2	21	**2:10**	15.9	21	**2:35**
Majestic Learning Experience Inc.	90	15	0.9	38.9	1	**1:50**	15.8	21	**2:15**
Montessori Creative Learning School	90	15	3.6	4.5	48	**2:35**	14.7	20	**2:55**
Moravic Family Day Care	90	15	1.0	15.3	4	**1:50**	14.7	20	**2:10**
Nicole Miller's Family Childcare Home	90	15	4.9	14.0	21	**2:10**	14.7	20	**2:30**
Peace Montessori	90	15	3.0	25.3	7	**1:55**	14.7	20	**2:15**
Play Care	90	15	3.2	33.9	6	**1:55**	15.9	21	**2:20**
Primrose School of Apex[1]	90	15	0.0	0.0	0	**1:45**	15.9	21	**2:10**
The Goddard School of Apex (Green Level West)	90	15	1.4	23.6	4	**1:50**	24.2	32	**2:25**
The Learning Experience in Apex	90	15	4.2	17.2	15	**2:00**	15.9	21	**2:25**
Vickie's Day Care Home	90	15	2.7	22.4	7	**1:55**	14.7	20	**2:15**
Woodhaven Weekday Preschool	90	15	4.4	29.6	9	**1:55**	15.0	20	**2:15**
Primrose School at Holly Grove	90	15	9.7	9.5	61	**2:50**	14.7	20	**3:10**
Holly Springs Academy NC	90	15	3.7	15.5	14	**2:00**	13.3	18	**2:20**
Holly Springs KinderCare	90	15	7.4	15.9	28	**2:15**	13.3	18	**2:35**
Holly Springs Learning Center	90	15	4.4	20.7	13	**2:00**	15.0	20	**2:20**
Holly Springs School For Early Education	90	15	4.5	5.2	52	**2:40**	13.5	18	**3:00**
Home Away From Home Childcare	90	15	8.1	8.4	58	**2:45**	14.7	20	**3:05**
Kiddie Academy of Holly Springs	90	15	4.5	5.2	52	**2:40**	13.5	18	**3:00**
Kris' Home Sweet Home Daycare	90	15	4.4	20.7	13	**2:00**	15.0	20	**2:20**
Leaping Froggy	90	15	4.9	5.7	52	**2:40**	13.5	18	**3:00**
Lightbridge Academy	90	15	8.3	8.4	59	**2:45**	14.7	20	**3:05**
Little Dreamers Preschool	90	15	4.5	5.2	52	**2:40**	13.5	18	**3:00**
Loving Hand Day Care	90	15	6.8	6.3	65	**2:50**	13.5	18	**3:10**

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to R.S. (mi.)	Travel Time from EPZ Bdry to H.S. (min)	ETA to R.S. (hr:min)
New School Montessori Center	90	15	2.7	18.0	9	**1:55**	13.4	18	**2:15**
Sisters' Child Care Services	90	15	4.4	20.7	13	**2:00**	15.0	20	**2:20**
Stella Lowery Small Day Care Home	90	15	1.5	14.3	6	**1:55**	13.4	18	**2:15**
Sunrise United Methodist Church Preschool	90	15	2.7	17.1	9	**1:55**	13.3	18	**2:15**
The Clubhouse of Holly Springs	90	15	3.2	13.4	14	**2:00**	13.3	18	**2:20**
The Goddard School of Holly Springs	90	15	3.2	12.1	16	**2:05**	13.3	18	**2:25**
The Learning Experience - Holly Springs	90	15	4.4	20.7	13	**2:00**	15.0	20	**2:20**
A Mother's Love	90	15	2.9	4.7	37	**2:25**	12.8	17	**2:45**
Busy Bee Home Daycare	90	15	1.4	13.9	6	**1:55**	29.7	40	**2:35**
Childcare Network - Fuquay-Varina	90	15	1.1	2.7	25	**2:10**	13.0	17	**2:30**
Fuquay-Varina Baptist Wee Care	90	15	0.8	3.5	14	**2:00**	13.0	17	**2:20**
Fuquay-Varina UMC Preschool Seeds of Faith	90	15	0.8	3.5	14	**2:00**	13.0	17	**2:20**
Little Angels Preparatory	90	15	1.1	2.8	24	**2:10**	13.7	18	**2:30**
Little Miracles	90	15	1.1	2.8	24	**2:10**	13.7	18	**2:30**
Melissa's Sweet Peas Child Care Home	90	15	2.9	4.7	37	**2:25**	12.8	17	**2:45**
My Lil Friends Childcare	90	15	3.1	4.8	39	**2:25**	12.8	17	**2:45**
Ready Or Not Here I Grow	90	15	1.7	5.2	20	**2:05**	12.8	17	**2:25**
Roots To Wings Childcare	90	15	1.1	2.7	25	**2:10**	13.0	17	**2:30**
South Wake Preschool & Academy	90	15	3.1	3.7	50	**2:35**	12.8	17	**2:55**
Unique Creations Child Care Center	90	15	0.8	2.5	19	**2:05**	28.9	39	**2:45**
Unique Creations Child Care Center South Campus	90	15	1.7	2.3	44	**2:30**	28.9	39	**3:10**
Vanessa Bland's Small Day Care Home	90	15	1.7	3.4	30	**2:15**	28.9	39	**2:55**

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to R.S. (mi.)	Travel Time from EPZ Bdry to H.S. (min)	ETA to R.S. (hr:min)
CHATHAM COUNTY CHILD CARE CENTERS									
YMCA After Care Program	90	15	4.7	45.0	6	**1:55**	8.4	11	**2:10**
					Maximum for EPZ:	**3:00**		**Maximum:**	**3:20**
					Average for EPZ:	**2:20**		**Average:**	**2:45**

Note: 1 – Not included in calculation for Maximum and Average ETE values since school/childcare center is in the Shadow Region.

Table 8-5. Transit-Dependent Evacuation Time Estimates - Good Weather

		One-Wave							Two-Wave					
Route Number	Bus Number	Mobilization (min)	Route Length (miles)	Speed (mph)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)	Distance to R. C. (miles)	Travel Time to R. C. (min)	Unload (min)	Driver Rest (min)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)
46	1-3	130	14.3	45.0	19	30	**3:00**	24.2	32	5	10	70	30	**5:30**
47	1 & 2	130	14.3	24.4	35	30	**3:15**	18.8	25	5	10	67	30	**5:35**
43	1-7	130	4.7	10.4	27	30	**3:10**	14.7	20	5	10	33	30	**4:50**
	8-14	150	4.7	18.2	16	30	**3:20**	14.7	20	5	10	33	30	**5:00**
	15-19	170	4.7	25.3	11	30	**3:35**	14.7	20	5	10	33	30	**5:15**
44	1-4	130	20.5	20.8	59	30	**3:40**	13.4	18	5	10	73	30	**6:00**
	5-8	150	20.5	22.7	54	30	**3:55**	13.4	18	5	10	73	31	**6:15**
45	1-5	130	8.3	3.8	132	30	**4:55**	30.7	41	5	10	66	30	**7:30**
	6-9	150	8.3	4.5	110	30	**4:50**	30.7	41	5	10	66	31	**7:25**
40	1 & 2	130	20.2	45.0	27	30	**3:10**	10.0	13	5	10	67	30	**5:15**
48	1	130	6.0	45.0	8	30	**2:50**	10.5	14	5	10	30	30	**4:20**
49	1	130	9.9	45.0	13	30	**2:55**	7.4	10	5	10	36	30	**4:30**
42	1	130	13.0	45.0	17	30	**3:00**	6.5	9	5	10	44	30	**4:40**
						Maximum ETE:	**4:55**						**Maximum ETE:**	**7:30**
						Average ETE:	**3:30**						**Average ETE:**	**5:35**

Table 8-8. Medical Facility Evacuation Time Estimates – Good Weather

Medical Facility	Patient	Mobilization (min)	Loading Rate (min per person)	People	Total Loading Time (min)	Dist. To EPZ Bdry (mi)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
Sanford Health & Rehab	Ambulatory	90	1	31	30	1.9	3	**2:05**
	Wheelchair bound	90	5	63	75	1.9	3	**2:50**
	Bedridden	90	15	2	30	1.9	3	**2:05**
James Rest Home	Ambulatory	90	1	28	28	3.3	7	**2:05**
	Wheelchair bound	90	5	10	50	3.3	4	**2:25**
Brookridge Assisted Living	Ambulatory	90	1	40	30	3.6	38	**2:40**
	Wheelchair bound	90	5	12	60	3.6	5	**2:35**
Rex Rehab & Nursing Center of Apex	Ambulatory	90	1	20	20	2.6	44	**2:35**
	Wheelchair bound	90	5	40	75	2.6	3	**2:50**
	Bedridden	90	15	30	30	2.6	36	**2:40**
Spring Arbor of Apex	Ambulatory	90	1	47	30	2.9	9	**2:10**
	Wheelchair bound	90	5	19	75	2.9	13	**3:00**
Rex Holly Springs Hospital	Ambulatory	90	1	33	30	6.8	50	**2:50**
	Wheelchair bound	90	5	14	70	6.8	93	**4:15**
	Bedridden	90	15	3	30	6.8	61	**3:05**
Fuquay-Varina Homes-Elderly	Ambulatory	90	1	60	30	1.4	48	**2:50**
	Wheelchair bound	90	5	2	10	1.4	27	**2:10**
Kinton Court Home	Ambulatory	90	1	16	16	1.7	44	**2:30**
Windsor Point Continuing Care Retirement Community	Ambulatory	90	1	66	30	1.3	20	**2:20**
	Wheelchair bound	90	5	28	75	1.3	32	**3:20**
	Bedridden	90	15	6	30	1.3	20	**2:20**
							Maximum ETE:	**4:15**
							Average ETE:	**2:40**

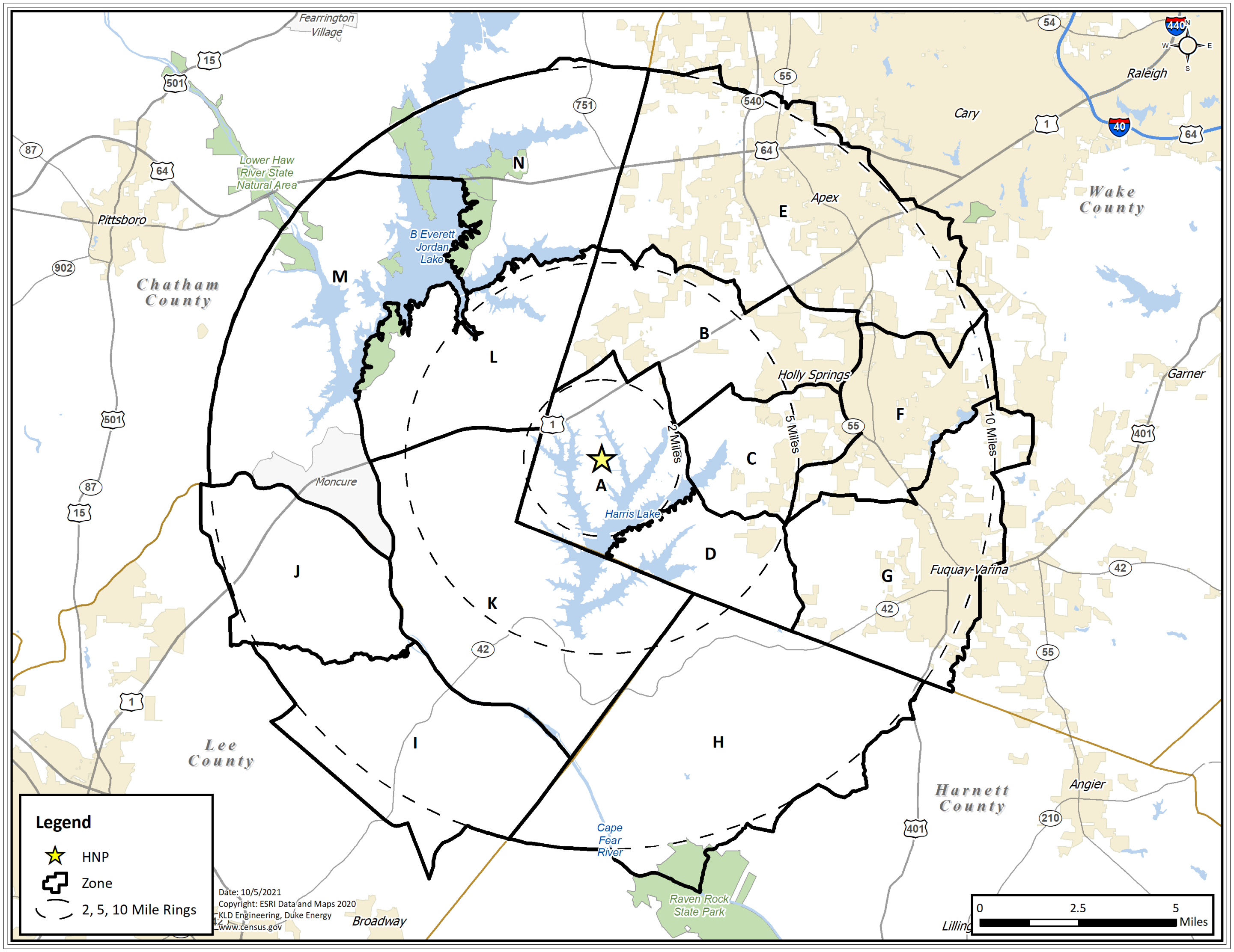


Figure 6-1. HNP EPZ Zones

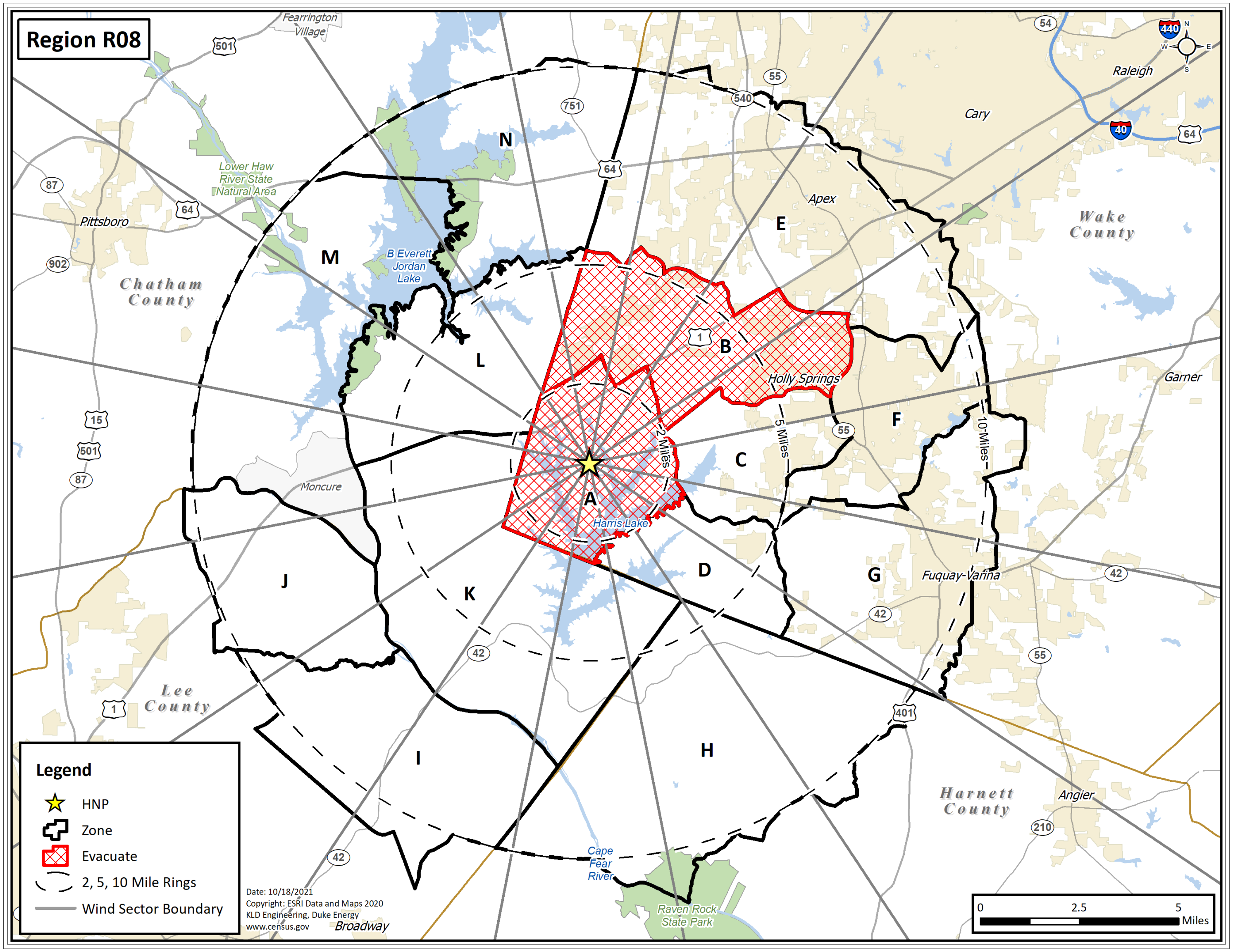


Figure H-8. Region R08

Table M-6. ETE Results for Change in Zone Boundaries

90th Percentile ETE (hr:min)						
	Scenario 1 (Summer, Midweek, Midday, Good Weather)			Scenario 12 (Winter, Midweek, Weekend, Evening, Good Weather)		
Region	**Existing EPZ**	**Proposed EPZ**	**Difference**	**Existing EPZ**	**Proposed EPZ**	**Difference**
2-Mile (R01)	1:20	1:20	0:00	1:55	1:50	-0:05
5-Mile (R02)	2:15	2:30	+0:15	2:20	2:35	+0:15
Full EPZ (R03)	3:25	3:25	0:00	3:15	3:15	0:00
100th Percentile ETE (hr:min)						
	Scenario 1 (Summer, Midweek, Midday, Good Weather)			Scenario 12 (Winter, Midweek, Weekend, Evening, Good Weather)		
Region	**Existing EPZ**	**Proposed EPZ**	**Difference**	**Existing EPZ**	**Proposed EPZ**	**Difference**
2-Mile (R01)	5:00	5:00	0:00	5:00	5:00	0:00
5-Mile (R02)	5:05	5:05	0:00	5:05	5:05	0:00
Full EPZ (R03)	5:10	5:10	0:00	5:10	5:10	0:00

1 INTRODUCTION

This report describes the analyses undertaken and the results obtained by a study to develop Evacuation Time Estimates (ETE) for the Harris Nuclear Plant (HNP), located in Wake County, North Carolina. This ETE study provides Duke Energy and state and local governments with site-specific information needed for Protective Action decision-making.

In the performance of this effort, guidance is provided by documents published by Federal Governmental agencies. Most important of these are:

- Title 10, Code of Federal Regulations, Appendix E to Part 50 (10CFR50), Emergency Planning and Preparedness for Production and Utilization Facilities, NRC, 2011.
- Emergency Planning and Preparedness for Production and Utilization Facilities, 10CFR50, Appendix E.
- Revision 1 of the Criteria for Development of Evacuation Time Estimate Studies, NUREG/CR-7002, February 2021.
- FEMA, "Radiological Emergency Preparedness Program Manual" (FEMA P-1028), December 2019.
- Development of Evacuation Time Estimates for Nuclear Power Plants, NUREG/CR-6863, January 2005.

The work effort reported herein was supported and guided by local stakeholders who contributed suggestions, critiques, and the local knowledge base required. Table 1-1 presents a summary of stakeholders and interactions.

1.1 Overview of the ETE Process

The following outline presents a brief description of the work effort in chronological sequence:

1. Information Gathering:
    a. Defined the scope of work in discussions with representatives from Duke Energy.
    b. Attended meetings with emergency planners from Chatham County Emergency Management, Harnett County Emergency Management, Lee County Office of Emergency Services, Wake County Emergency Management and North Carolina Emergency Management to discuss methodology and project assumptions.
    c. Conducted a detailed field survey of the highway system and of area traffic conditions within the Emergency Planning Zone (EPZ)[1] and Shadow Region.
    d. Obtained demographic data from the 2020 census (see Section 3.1).

[1] All references to Emergency Planning Zone or EPZ refer to the plume exposure pathway proposed EPZ. A sensitivity study is included in Appendix M that documents the changes in ETE when analyzing the existing EPZ.

e. Conducted a random sample telephone survey of EPZ residents.

f. Conducted a data collection effort to identify and describe schools, special facilities, major employers, transportation providers, and other important information.

2. Estimated distributions of Trip Generation times representing the time required by various population groups (permanent residents, employees, and transients) to prepare (mobilize) for the evacuation trip. These estimates are primarily based upon the random sample telephone survey, supplemented by the results from the 2012 survey to reduce uncertainty.

3. Defined Evacuation Scenarios. These scenarios reflect the variation in demand, in trip generation distribution and in highway capacities, associated with different seasons, day of week, time of day and weather conditions.

4. Reviewed the existing traffic management plan to be implemented by local and state police in the event of an incident at the plant. Traffic control is applied at specified Traffic Control Points (TCPs) and Security Road Blocks (SRBs) located within the study area.

5. Updated existing Zone boundaries to reflect evacuation regions proposed by Harnett, Wake and Chatham County. The EPZ is partitioned into 14 Zones along jurisdictional and geographic boundaries. "Regions" are groups of contiguous Zones for which ETE are calculated. The configurations of these Regions reflect wind direction and the radial extent of the impacted area. Each Region, other than those that approximate circular areas, approximates a "key-hole section" within the EPZ as recommended by NUREG/CR-7002, Rev. 1.

6. Estimated demand for transit services for persons at special facilities and for transit-dependent persons at home.

7. Prepared the input streams for the DYNEV II.

   a. Estimated the evacuation traffic demand, based on the available information derived from Census data, and from data provided by local and state agencies, Duke Energy and from the demographic survey.

   b. Applied the procedures specified in the 2016 Highway Capacity Manual (HCM[2]) to the data acquired during the field survey, to estimate the capacity of all highway segments comprising the evacuation routes.

   c. Updated the link-node representation of the evacuation network, which is used as the basis for the computer analysis that calculates the ETE.

   d. Calculated the evacuating traffic demand for each Region and for each Scenario.

   e. Specified selected candidate destinations for each "origin" (location of each "source" where evacuation trips are generated over the mobilization time) to

[2] Highway Capacity Manual (HCM 2016), Transportation Research Board, National Research Council, 2016.

support evacuation travel consistent with outbound movement relative to the location of the HNP.

8. Executed the DYNEV II model to determine optimal evacuation routing and compute ETE for all residents, transients and employees ("general population") with access to private vehicles. Generated a complete set of ETE for all specified Regions and Scenarios.
9. Documented ETE in formats in accordance with NUREG/CR-7002, Rev 1.
10. Calculated the ETE for all transit activities including those for special facilities (schools, childcare centers, and medical facilities), for the transit-dependent population and for the access and/or functional needs population.

1.2 The Harris Nuclear Plant Location

The HNP is located on Lake Harris in New Hill (within Wake County), North Carolina. It is approximately 20 miles southwest of Raleigh, North Carolina. The EPZ consists of parts of Chatham, Harnett, Lee and Wake Counties. A majority of the northwestern portion of the EPZ is made up of B. Everett Jordan Lake. Figure 1-1 displays the area surrounding the HNP. This map identifies the communities in the area and the major roads.

1.3 Preliminary Activities

These activities are described below.

Field Surveys of the Highway Network

In 2020, KLD personnel drove the entire highway system within the EPZ and the Shadow Region which consists of the area between the EPZ boundary and approximately 15 miles radially from the plant. The characteristics of each section of highway were recorded. These characteristics are shown in Table 1-2.

Video and audio recording equipment were used to capture a permanent record of the highway infrastructure. No attempt was made to meticulously measure such attributes as lane width and shoulder width; estimates of these measures based on visual observation and recorded images were considered appropriate for the purpose of estimating the capacity of highway sections. For example, Exhibit 15-7 in the HCM 2016 indicates that a reduction in lane width from 12 feet (the "base" value) to 10 feet can reduce free flow speed (FFS) by 1.1 mph – not a material difference – for two-lane highways. Exhibit 15-46 in the HCM 2016 shows little sensitivity for the estimates of Service Volumes at Level of Service (LOS) E (near capacity), with respect to FFS, for two-lane highways.

The data from the audio and video recordings were used to create detailed geographic information systems (GIS) shapefiles and databases of the roadway characteristics and of the traffic control devices observed during the road survey; this information was referenced while preparing the input stream for the DYNEV II System. Roadway types were assigned based on the following criteria:

- Freeway: limited access highway, 2 or more lanes in each direction, high free flow speeds
- Freeway ramp: ramp on to or off of a limited access highway
- Major arterial: 3 or more lanes in each direction
- Minor arterial: 2 or more lanes in each direction
- Collector: single lane in each direction
- Local roadway: single lane in each direction, local road with low free flow speeds

As documented on page 15-6 of the HCM 2016, the capacity of a two-lane highway is 1,700 passenger cars per hour in one direction. For freeway sections, a value of 2,250 vehicles per hour per lane is assigned, as per Exhibit 12-7 of the HCM 2016. The road survey has identified several segments which are characterized by adverse geometrics on two-lane highways which are reflected in reduced values for both capacity and speed. These estimates are consistent with the service volumes for LOS E presented in HCM Exhibit 15-46. Link capacity is an input to DYNEV II which computes the ETE. Further discussion of roadway capacity is provided in Section 4 of this report.

Traffic signals are either pre-timed (signal timings are fixed over time and do not change with the traffic volume on competing approaches), or are actuated (signal timings vary over time based on the changing traffic volumes on competing approaches). Actuated signals require detectors to provide the traffic data used by the signal controller to adjust the signal timings. These detectors are typically magnetic loops in the roadway, or video cameras mounted on the signal masts and pointed toward the intersection approaches. If detectors were observed on the approaches to a signalized intersection during the road survey, detailed signal timings were not collected as the timings vary with traffic volume. TCPs at locations which have control devices are represented as actuated signals in the DYNEV II system.

If no detectors were observed, the signal control at the intersection was considered pre-timed, and detailed signal timings were gathered for several signal cycles. These signal timings were input to the DYNEV II system used to compute ETE, as per NUREG/CR-7002, Rev. 1 guidance.

Figure 1-2 presents the link-node analysis network that was constructed to model the evacuation roadway network in the EPZ and Shadow Region. The directional arrows on the links and the node numbers have been removed from Figure 1-2 to clarify the figure. The detailed figures provided in Appendix K depict the analysis network with directional arrows shown and node numbers provided. The observations made during the field survey were used to calibrate the analysis network.

<u>Demographic Survey</u>

An online demographic survey was performed to gather information needed for the ETE study. The results from the 2012 telephone survey were also utilized in this study. Appendix F presents the survey instrument, the procedures used and tabulations of data compiled from the survey returns along with discussion validating the use of the survey results in this study.

These data were utilized to develop estimates of vehicle occupancy to estimate the number of evacuating vehicles during an evacuation and to estimate elements of the mobilization process. This database was also referenced to estimate the number of transit-dependent residents.

Computing the Evacuation Time Estimates

The overall study procedure is outlined in Appendix D. Demographic data were obtained from several sources, as detailed later in this report. These data were analyzed and converted into vehicle demand data. The vehicle demand was loaded onto appropriate "source" links of the analysis network using GIS mapping software. The DYNEV II system was then used to compute ETE for all Regions and Scenarios.

Analytical Tools

The DYNEV II System that was employed for this study is comprised of several integrated computer models. One of these is the DYNEV (DYnamic Network EVacuation) macroscopic simulation model, a new version of the IDYNEV model that was developed by KLD under contract with the Federal Emergency Management Agency (FEMA).

DYNEV II consists of four sub-models:

- A macroscopic traffic simulation model (for details, see Appendix C).
- A Trip Distribution (TD), model that assigns a set of candidate destination (D) nodes for each "origin" (O) located within the analysis network, where evacuation trips are "generated" over time. This establishes a set of O-D tables.
- A Dynamic Traffic Assignment (DTA), model which assigns trips to paths of travel (routes) which satisfy the O-D tables, over time. The TD and DTA models are integrated to form the DTRAD (Dynamic Traffic Assignment and Distribution) model, as described in Appendix B.
- A Myopic Traffic Diversion model which diverts traffic to avoid intense, local congestion, if possible.

Another software product developed by KLD, named UNITES (UNIfied Transportation Engineering System) was used to expedite data entry and to automate the production of output tables.

The dynamics of traffic flow over the network are graphically animated using the software product, EVAN (EVacuation ANimator), developed by KLD. EVAN is GIS based, and displays statistics such as LOS, vehicles discharged, average speed, and percent of vehicles evacuated, output by the DYNEV II System. The use of a GIS framework enables the user to zoom in on areas of congestion and query road name, town name and other geographical information.

The procedure for applying the DYNEV II System within the framework of developing ETE is outlined in Appendix D. Appendix A is a glossary of terms.

For the reader interested in an evaluation of the original model, I-DYNEV, the following references are suggested:

- NUREG/CR-4873 – Benchmark Study of the I-DYNEV Evacuation Time Estimate Computer Code
- NUREG/CR-4874 – The Sensitivity of Evacuation Time Estimates to Changes in Input Parameters for the I-DYNEV Computer Code

The evacuation analysis procedures are based upon the need to:

- Route traffic along paths of travel that will expedite their travel from their respective points of origin to points outside the EPZ.
- Restrict movement toward the plant to the extent practicable, and disperse traffic demand so as to avoid focusing demand on a limited number of highways.
- Move traffic in directions that are generally outbound, relative to the location of the plant.

DYNEV II provides a detailed description of traffic operations on the evacuation network. This description enables the analyst to identify bottlenecks and to develop countermeasures that are designed to represent the behavioral responses of evacuees. The effects of these countermeasures may then be tested with the model.

1.4 Comparison with Prior ETE Study

Table 1-3 presents a comparison of the present ETE study with the previous ETE study (KLD TR-869, dated October 26, 2016). The 90th percentile ETE for the full EPZ[3] increases by 30 minutes for a winter midweek midday scenario and by 25 minutes for a summer weekend midday scenario when compared with the 2016 study. The 100th percentile ETE increases by 10 minutes and 30 minutes for the same scenarios, respectively. The major factors contributing to the similarities between the ETE values obtained in this study and those of the previous study are:

- The permanent resident population saw significant increase (18.29%) from the 2016 projected population estimates to the current census data within the EPZ. The increase in permanent resident population results in significantly more evacuating vehicles, which can increase ETE.
- Trip generations times increased by 30 minutes based on data collected from the demographic survey. As a result, vehicles are generated over a longer period of time which can reduce overall congestion but is directly correlated with the increase of the 100th percentile ETE for this site. Since all congestion clears prior to the end of trip generation time, the 100th percentile ETE is dictated by the time needed to mobilize (plus a 10 minute travel time out of the EPZ).
- The number of employees commuting into the EPZ decreased significantly (39.71%) which results in a decrease in vehicular demand that can decrease the 100th percentile ETE. This decrease in quickly mobilizing employees can increase the 90th percentile ETE as it will take longer to reach an evacuation of 90% of the population.
- The permanent resident population in the Shadow Region increased by 22.43%. This population increase results in significantly more vehicles evacuating in the Shadow Region, which reduces the available roadway capacity for EPZ evacuees and can increase ETE.

The various factors that can increase ETE explain why the 90th and 100th percentile ETE for the full EPZ are longer in this study relative to the 2016 ETE study.

[3] It should be noted that due to the change in Zone boundaries, the ETE for the 2- and 5-mile regions (and subsequent keyhole combinations) cannot be compared between the two studies.

Table 1-1. Stakeholder Interaction

<table>
<tr><th>Stakeholder</th><th>Nature of Stakeholder Interaction</th></tr>
<tr><td>Duke Energy</td><td>Attended meetings to define methodology and data requirements. Set up contacts with local government agencies. Reviewed and approved all project assumptions. Attended final meeting where the ETE study results were presented.</td></tr>
<tr><td>Chatham County Emergency Management</td><td rowspan="5">Met to discuss project methodology, key project assumptions and to define data needs. Provided county emergency plans, special facility data and existing traffic management plans. Reviewed and approved all project assumptions. Attended final meeting where the ETE study results were presented.</td></tr>
<tr><td>Harnett County Emergency Management</td></tr>
<tr><td>Lee County Office of Emergency Services</td></tr>
<tr><td>Wake County Emergency Management</td></tr>
<tr><td>North Carolina Emergency Management</td></tr>
</table>

Table 1-2. Highway Characteristics

- Number of lanes
- Lane width
- Shoulder type & width
- Interchange geometries
- Lane channelization & queuing capacity (including turn bays/lanes)
- Geometrics: curves, grades (>4%)
- Posted speed
- Actual free speed
- Abutting land use
- Control devices
- Intersection configuration (including roundabouts where applicable)
- Traffic signal type
- Unusual characteristics: Narrow bridges, sharp curves, poor pavement, flood warning signs, inadequate delineations, toll booths, etc.

Table 1-3. ETE Study Comparisons

Topic	Previous ETE Study	Current ETE Study
Resident Population Basis	ArcGIS software using 2010 US Census blocks and projecting out to 2016 using 2015 population changes published by the US Census; area ratio method used. Population = 131,520	ArcGIS software using 2020 US Census blocks; area ratio method used. Population = 155,570
Resident Population Vehicle Occupancy	2.82 persons/household, 1.39 evacuating vehicles/household yielding: 2.03 persons/vehicle.	2.85 persons/household, 1.40 evacuating vehicles/household yielding: 2.04 persons/vehicle.
Employee Population	Employee estimates based on census work area profile and GIS inflow/outflow analysis. 1.07 employees per vehicle based on telephone survey results. Employees = 15,516	Employee estimates based on census work area profile and GIS inflow/outflow analysis. 1.10 employees per vehicle based on demographic survey results. Employees = 9,354
Transit-Dependent Population	Estimates based upon U.S. Census data and the results of the 2012 telephone survey. Includes households with 0 vehicles and households with 1 or 2 vehicles which are used by a commuter who would not return home and a 50% rideshare percentage. A total of 4,349 people who do not have access to a vehicle, requiring 147 buses to evacuate. An additional 116 access and/or functional needs persons need special transportation to evacuate (85 require a bus, 21 require a wheelchair-accessible vehicle, and 10 require an ambulance).	Estimates based upon U.S. Census data and the results of the 2020 demographic survey. Includes households with 0 vehicles and households with 1 or 2 vehicles which are used by a commuter who would not return home and a 66% rideshare percentage. A total of 1,220 people who do not have access to a vehicle, requiring 46 buses to evacuate. An additional 219 access and/or functional needs persons need special transportation to evacuate (161 require a bus, 44 require a wheelchair-accessible vehicle, and 14 require an ambulance).
Transient Population	Transient estimates based on information provided by each county within the EPZ. Transients = 11,442	Transient estimates based on information provided by each county within the EPZ. Transients = 15,473

Topic	Previous ETE Study	Current ETE Study
Medical Facility Population	Medical facility population based on information provided by each county within the EPZ. Medical Facility Population = 884 Medical Vehicles include 16 Buses, 15 wheelchair buses, 17 wheelchair vans, 27 minivans, 10 cars, and 21 ambulances	Medical facility population based on information provided by each county within the EPZ. Medical Facility Population = 731 Medical Vehicles include 18 Buses, 17 wheelchair buses and 23 ambulances It is assumed small home care facility patients will evacuate in person vehicles of staff.
School and Child Care Center Population	School population based on information provided by each county within the EPZ. Child Care Centers included in these estimates. Total enrollment = 28,601 Buses required = 540	School population based on information provided by each county within the EPZ. Child Care Centers included in these estimates. Total enrollment = 37,383 Buses required = 698
Shadow Population	ArcGIS software using 2010 US Census blocks and projecting out to 2016 using 2015 population changes published by the US Census; area ratio method used. Population = 242,526	ArcGIS software using 2020 US Census blocks; area ratio method used. Population = 251,783
Voluntary evacuation from within EPZ in areas outside region to be evacuated	20% of the population within the EPZ, but not within the Evacuation Region	20% of the population within the EPZ, but not within the Evacuation Region
Shadow Evacuation	20% of people outside of the EPZ within the Shadow Region	20% of people outside of the EPZ within the Shadow Region
Network Size	2,860 links; 1,988 nodes	3,379 links; 2,373 nodes
Roadway Geometric Data	Field surveys conducted in March 2016. Roads and intersections were video archived. Road capacities based on 2010 HCM.	Field surveys conducted in October 2020. Roads and intersections were video archived. Road capacities based on 2016 HCM.
School Evacuation	Direct evacuation to designated Relocation School.	Direct evacuation to designated Relocation School.
Ridesharing	50 percent of transit dependent persons will evacuate with a neighbor or friend.	66 percent of transit dependent persons will evacuate with a neighbor or friend.

Topic	Previous ETE Study	Current ETE Study
Trip Generation for Evacuation	Based on residential telephone survey of specific pre-trip mobilization activities: Residents with commuters returning leave between 30 and 270 minutes. Residents without commuters returning leave between 15 and 225 minutes. Employees and transients leave between 15 and 105 minutes. All times measured from the Advisory to Evacuate.	Based on residential demographic survey of specific pre-trip mobilization activities: Residents with commuters returning leave between 45 and 300 minutes. Residents without commuters returning leave between 30 and 240 minutes. Employees and transients leave between 15 and 105 minutes. All times measured from the Advisory to Evacuate.
Weather	Normal, Rain, or Ice. The capacity and free flow speed of all links in the network are reduced by 10% in the event of rain and 20% for ice.	Normal, Rain, or Ice. The capacity and free flow speed of all links in the network are reduced by 10% in the event of rain and 20% for ice.
Modeling	DYNEV II System – Version 4.0.19.2	DYNEV II System – Version 4.0.20.0
Special Events	Fourth of July on Jordan Lake Special Event Population = 8,962 additional transients	Fourth of July on Jordan Lake Special Event Population = 8,962 additional transients
Evacuation Cases	37 Regions (central sector wind direction and each adjacent sector technique used) and 14 Scenarios producing 518 unique cases.	37 Regions (central sector wind direction and each adjacent sector technique used) and 14 Scenarios producing 518 unique cases.
Evacuation Time Estimates Reporting	ETE reported for 90th and 100th percentile population. Results presented by Region and Scenario.	ETE reported for 90th and 100th percentile population. Results presented by Region and Scenario.
Evacuation Time Estimates for the entire EPZ, 90th percentile	Winter Weekday Midday, Good Weather = 3:00 Summer Weekend, Midday, Good Weather = 2:50	Winter Midweek Midday, Good Weather = 3:30 Summer Weekend, Midday, Good Weather = 3:15
Evacuation Time Estimates for the entire EPZ, 100th percentile	Winter Weekday Midday, Good Weather = 5:00 Summer Weekend, Midday, Good Weather = 4:40	Winter Midweek Midday, Good Weather = 5:10 Summer Weekend, Midday, Good Weather = 5:10

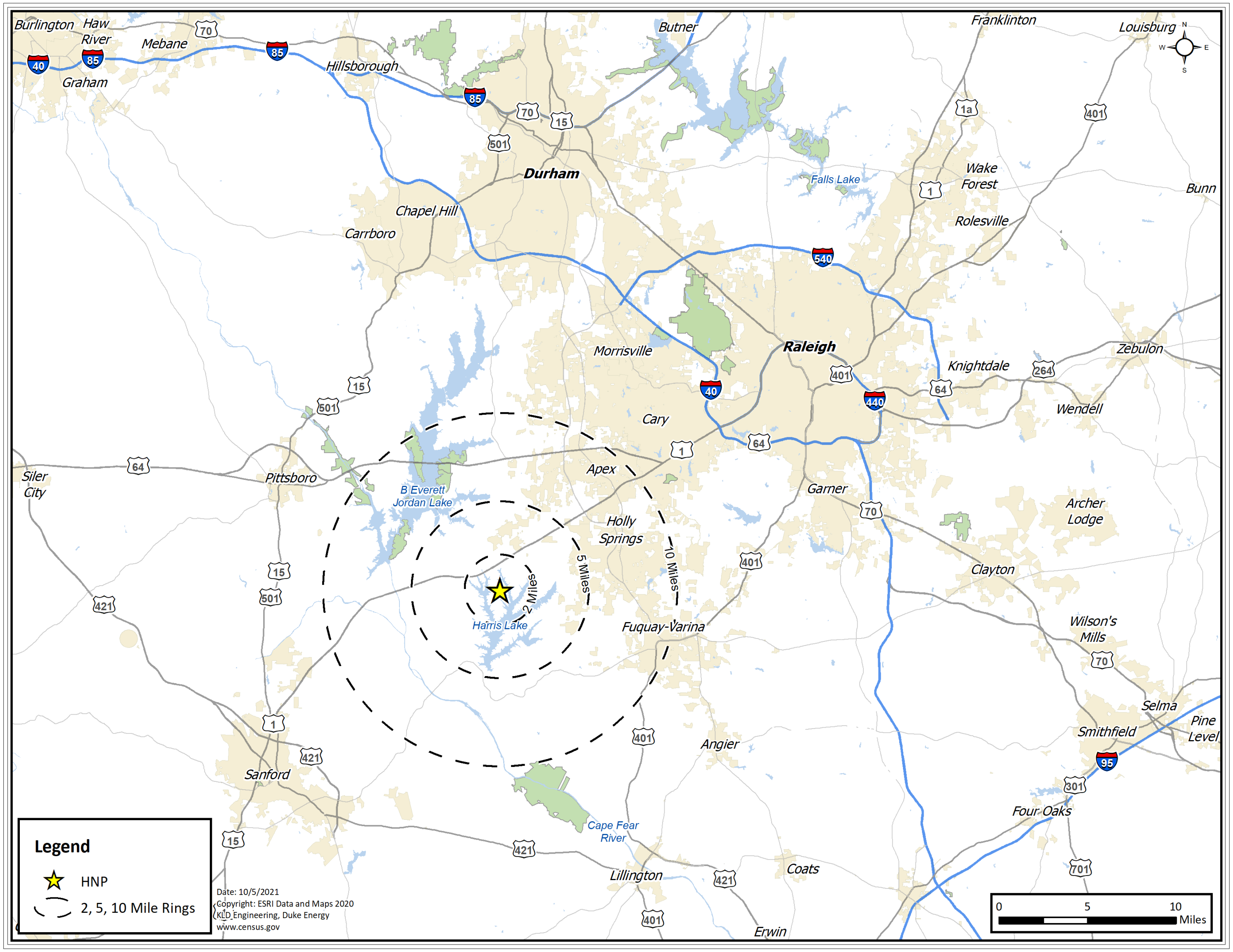


Figure 1-1. HNP Location

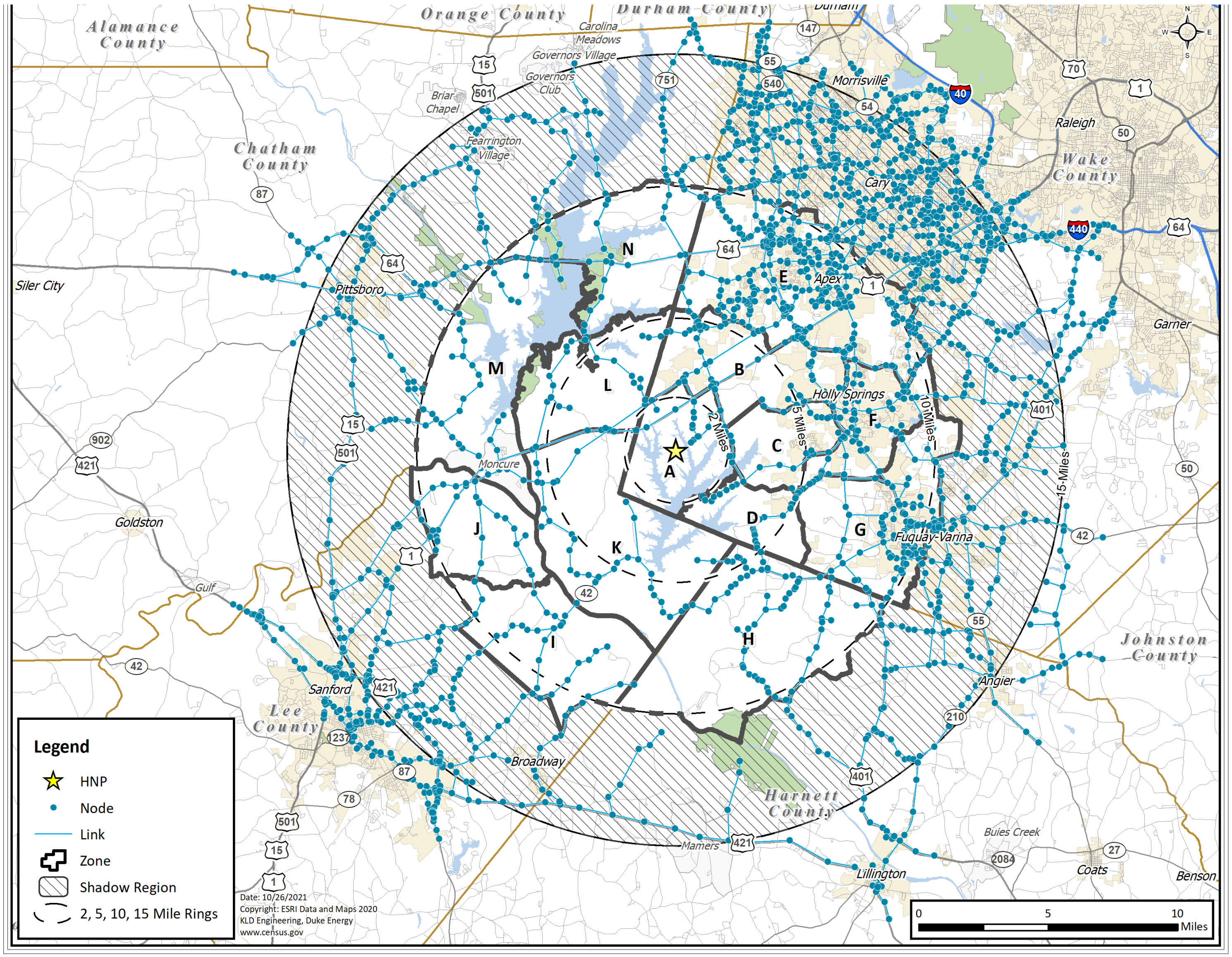


Figure 1-2. HNP Link-Node Analysis Network

2 STUDY ESTIMATES AND ASSUMPTIONS

This section presents the estimates and assumptions utilized in the development of the evacuation time estimates.

2.1 Data Estimate Assumptions

1. The permanent resident population are based on the 2020 U.S. Census population from the Census Bureau website[1]. (See Section 3.1.)
2. Estimates of employees who reside outside the EPZ and commute to work within the EPZ are based upon data provided by each county. For Wake County, the US Census Longitudinal Employer-Household Dynamics from the OnTheMap Census analysis tool[2] is used. (See Section 3.4.)
3. Population estimates at transient and special facilities are based on the data received from the counties within the EPZ, the National Center for Education Statistics website[3], the North Carolina Division of Child Development and Early Education[4] and the previous ETE study, supplemented by internet searches where data was missing.
4. The relationship between permanent resident population and evacuating vehicles is based on Census data and the results of the demographic survey (see Appendix F). Values of 2.85 persons per household and 1.40 evacuating vehicles per household are used for the permanent resident population.
5. Where data was not provided, the average household size is assumed to be the vehicle occupancy rate for transient facilities and the special event. On average, the relationship between persons and vehicles for transients and the special event is as follows:
    a. Parks and other recreational facilities: about 2.85 people per vehicle
    b. Campgrounds: 2.97 people per vehicle
    c. Lodging facilities: 1.16 people per vehicle
    d. Golf Courses: 1.5 people per vehicle
    e. Special event: 2.85 people per vehicle
6. Employee vehicle occupancies are based on the results of the demographic survey; 1.10 employees per vehicle is used in the study. (See Figure F-7.)
7. The maximum bus speed assumed within the EPZ is 45 mph based on North Carolina state laws for buses and average posted speed limits on roadways within the EPZ.

[1] www.census.gov
[2] http://onthemap.ces.census.gov/
[3] https://nces.ed.gov/ccd/schoolsearch/index.asp
[4] https://ncchildcaresearch.dhhs.state.nc.us/search.asp

8. Roadway capacity estimates are based on field surveys performed in 2020 (verified by aerial imagery), and the application of the Highway Capacity Manual 2016.

2.2 Methodological Assumptions

1. The Planning Basis Assumption for the calculation of ETE is a rapidly escalating accident that requires evacuation, and includes the following[5] (as per NRC guidance):
    a. Advisory to Evacuate (ATE) is announced coincident with the siren notification.
    b. Mobilization of the general population will commence within 15 minutes after siren notification.
    c. ETE are measured relative to the ATE.
2. The center-point of the plant is located at the center of the containment building 35.634°N, 78.956° W.
3. The DYNEV II[6] system is used to compute ETE in this study.
4. Evacuees will drive safely, travel radially away from the plant to the extent practicable given the highway network, and obey all control devices and traffic guides. All major evacuation routes are used in the analysis.
5. The proposed EPZ and Zone boundaries are used. See Figure 3-1. A sensitivity study is included in Appendix M to document the impact to ETE due to the proposed changes to Zone boundaries within the EPZ. (See Appendix M.)
6. The Shadow Region extends to 15 miles radially from the plant or approximately 5 miles radially from the EPZ boundary, as per NRC guidance. See Figure 7-2.
7. One hundred percent (100%) of the people within the impacted keyhole will evacuate. Twenty percent (20%) of the population within the Shadow Region and within Zones of the EPZ not advised to evacuate will voluntarily evacuate, as shown in Figure 2-1, as per NRC guidance. Sensitivity studies explore the effect on ETE of increasing the percentage of voluntary evacuees in the Shadow Region (see Appendix M).
8. ETE are presented at the 90th and 100th percentiles, as well as in graphical and tabular format, as per NRC guidance. The percentile ETE is defined as the elapsed time from the Advisory to Evacuate issued to a specific Region of the EPZ, to the time that Region is clear of the indicated percentile of evacuees.

[5] We emphasize that the adoption of this planning basis is <u>not</u> a representation that these events will occur within the indicated time frame. Rather, these assumptions are necessary in order to:
1. Establish a temporal framework for estimating the Trip Generation distribution in the format recommended in Section 2.13 of NUREG/CR-6863.
2. Identify temporal points of reference that uniquely define "Clear Time" and ETE.

It is likely that a longer time will elapse between the various stages of an emergency. See Section 5.1 for more detail.

[6] The models of the I-DYNEV System were recognized as state of the art by the Atomic Safety & Licensing Board (ASLB) in past hearings. (Sources: Atomic Safety & Licensing Board Hearings on Seabrook and Shoreham; Urbanik). The models have continuously been refined and extended since those hearings and were independently validated by a consultant retained by the NRC. The new DYNEV II model incorporates the latest technology in traffic simulation and in dynamic traffic assignment.

9. The ETE also includes consideration of "through" (External-External) trips during the time that such traffic is permitted to enter the evacuated Region. "Normal" traffic flow is assumed to be present within the EPZ at the start of the emergency. See Section 3.10.
10. This study does not assume that roadways are empty at the start of the first time period. Rather, there is a 30-minute initialization period (often referred to as "fill time in traffic simulation) wherein the traffic volumes from the first time period are loaded onto roadways in the study area. The amount of initialization/fill traffic that is on the roadways in the study area at the start of the first time period depends on the scenario and the region being evacuated. See Section 3.11.
11. It is assumed that NC-540 will be available to evacuees as an evacuation route and tolls will be waived.

2.3 Assumptions on Mobilization Times

1. Trip generation time (also known as mobilization time, or the time required by evacuees to prepare for the evacuation) are based upon the results of the demographic survey.
2. One hundred percent (100%) of the Emergency Planning Zone (EPZ) population can be notified within 45 minutes, in accordance with the 2019 Federal Emergency Management Agency (FEMA) Radiological Emergency Preparedness Program Manual.
3. Commuter percentages (and percentage of residents awaiting the return of a commuter) are based on the results of the demographic survey. According to the survey results, 55% of the households in the EPZ have at least 1 commuter (see Section F.3.1.); 57% of those households with commuters will await the return of a commuter before beginning their evacuation trip (see Section F.3.2.). Therefore, 31 percent (55% x 57% = 31%) of EPZ households will await the return of a commuter, prior to beginning their evacuation trip.

2.4 Transit Dependent Assumptions

1. The percentage of transit-dependent people who will rideshare with a neighbor or friend are based on the results of the demographic survey. According to the survey results, two thirds (66%) of the transit-dependent population will rideshare.
2. Transit vehicles are used to transport those without access to private vehicles:
   a. Schools and childcare centers
      i. If schools are in session, buses will evacuate students directly to the designated relocation schools.
      ii. Buses will evacuate children at childcare centers within the EPZ, as needed.
      iii. For the schools that are evacuated via buses, it is assumed no school children will be picked up by their parents prior to the arrival of the buses.
      iv. Schoolchildren, if school is in session, are given priority in assigning transit vehicles.

b. Medical Facilities
    i. Buses, minivans, passenger cars, wheelchair buses, wheelchair vans and ambulances will evacuate patients at medical facilities and at any senior facilities within the EPZ, as needed.
    ii. The percent breakdown of ambulatory, wheelchair bound and bedridden patients for most medical facilities were provided by the counties for each of the medical facilities within the EPZ. For those facilities that the breakdown could not be obtained, data from the previous study is used.
    iii. It is assumed that patients in small home care facilities will evacuate in staff personal vehicles and these people are already included in the census.
c. Transit-dependent permanent residents:
    i. Transit-dependent general population are evacuated to reception centers.
    ii. Access and/or functional needs population may require county assistance (ambulance, bus or wheelchair transport) to evacuate. This is considered separately from the general population ETE, as per NRC guidance.
    iii. Households with 3 or more vehicles were assumed to have no need for transit vehicles.
d. Analysis of the number of required round-trips ("waves") of evacuating transit vehicles is presented.
e. Transport of transit-dependent evacuees from reception centers to congregate care centers is not considered in this study.

3. Transit vehicle capacities:
    a. School buses = 70 students per bus for primary schools/childcare centers and 50 students per bus for middle/high schools
    b. Ambulatory transit-dependent persons and medical facility patients = 30 persons per bus
    c. Minivans = 5 persons
    d. Ambulances = 2 bedridden persons (includes advanced and basic life support)
    e. Wheelchair vans = 4 wheelchair bound persons
    f. Wheelchair buses = 15 wheelchair bound persons

4. Transit vehicles mobilization times:
    a. School and transit buses will arrive at schools and facilities to be evacuated within 90 minutes of the ATE.
    b. Transit dependent buses are mobilized when approximately 80% of residents with no commuters have completed their mobilization at 130 minutes of the ATE.
    c. Vehicles will arrive at hospitals, medical facilities, and senior living facilities to be evacuated within 90 minutes of the ATE.

5. Transit Vehicle loading times:
    a. School buses are loaded in 15 minutes.
    b. Transit Dependent buses require 1 minute of loading time per passenger.
    c. Buses for hospitals and medical facilities require 1 minute of loading time per ambulatory passenger.
    d. Wheelchair transport vehicles require 5 minutes of loading time per passenger.
    e. Ambulances are loaded in 15 minutes per bedridden passenger.

6. It is assumed that drivers for all transit vehicles are available.

2.5 Traffic and Access Control Assumptions

1. Traffic Control Points (TCP) and Security Road Blocks (SRB) as defined in the approved county and state emergency plans are considered in the ETE analysis, as per NRC guidance. See Appendix G.

2. TCP and SRB are assumed to be staffed approximately 120 minutes after the ATE, as per NRC guidance. Earlier activation of SRB locations could delay returning commuters. It is assumed that no through traffic will enter the EPZ after this 120-minute time period.

2.6 Scenarios and Regions

1. A total of 14 "Scenarios" representing different temporal variations (season, time of day, day of week) and weather conditions are considered. Scenarios to be considered are defined in Table 2-1:
    a. Fourth of July on Jordan Lake, located in Zones L, M and N, is considered as the special event (single or multi-day event that attracts a significant population into the EPZ; recommended by NRC guidance) for Scenario 13.
    b. As per NRC guidance, one of the top 5 highest volume roadways must be closed or one lane outbound on a freeway must be closed for a roadway impact scenario. This study considers the closure of one lane northbound on US-1 from just east of the interchange with New Hill Holleman Rd (Exit 89) to the interchange with I-40 (Exit 1A) and one lane eastbound on US-64 from New Hill Olive Chapel Rd/NC-751 to the interchange with US-1 (Exit 404A/B) for the roadway impact scenario – Scenario 14.

2. Two types of adverse weather scenarios are considered. Rain may occur for either winter or summer scenarios; ice occurs in winter scenarios only. It is assumed that the rain or ice begins earlier or at about the same time the evacuation advisory is issued. No weather-related reduction in the number of transients who may be present in the EPZ is assumed. It is assumed that roads are passable and that the appropriate agencies are

clearing/treating the roads as they would normally with ice and the roads are passable albeit at lower speeds and capacities.

3. Adverse weather scenarios affect roadway capacity and the free flow highway speeds. The capacity and free flow speed are reduced by 10% for rain, and 20% for ice, based on recent transportation engineering research. The factors are shown in Table 2-2.
4. It is also assumed that mobilization and loading times for transit vehicles are slightly longer in adverse weather. It is assumed that mobilization times are 10 minutes and 20 minutes longer in rain and ice, respectively. It is assumed that loading times are 5 minutes and 10 minutes longer in rain and ice, respectively. Refer to Table 2-2.
5. Regions are defined by the underlying “keyhole” or circular configurations as specified in Section 1.4 of NUREG/CR-7002, Rev. 1. These Regions, as defined, display irregular boundaries reflecting the geography of the Zones included within these underlying configurations. All 16 cardinal and intercardinal wind direction keyhole configurations are considered. Regions to be considered are defined in Table 6-1. It is assumed that everyone within the group of Zones forming a Region that is issued an ATE will, in fact, respond and evacuate in general accord with the planned routes.
6. Due to the irregular shapes of the Zones, there are instances where a small portion of a Zone (a “sliver”) is within the keyhole and the population within that small portion is low (less than 500 people or 10% of the Zone population, whichever is less). Under those circumstances, the Zone is not included in the Region so as to not evacuate large numbers of people outside of the keyhole for a small number of people that are actually in the keyhole, unless otherwise stated in the PAR document.
7. Staged evacuation is considered as defined in NUREG/CR-7002, Rev. 1 – those people between 2 and 5 miles will shelter-in-place until 90% of the 2-mile region has evacuated, then they will evacuate. See Regions R28 through R35 in Table 6-1.

Table 2-1. Evacuation Scenario Definitions

Scenario	Season[7]	Day of Week	Time of Day	Weather	Special
1	Summer	Midweek	Midday	Good	None
2	Summer	Midweek	Midday	Rain	None
3	Summer	Weekend	Midday	Good	None
4	Summer	Weekend	Midday	Rain	None
5	Summer	Midweek, Weekend	Evening	Good	None
6	Winter	Midweek	Midday	Good	None
7	Winter	Midweek	Midday	Rain	None
8	Winter	Midweek	Midday	Ice	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Rain	None
11	Winter	Weekend	Midday	Ice	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Summer	Midweek, Weekend	Evening	Good	Fourth of July on Jordan Lake (Fireworks Show)
14	Summer	Midweek	Midday	Good	Roadway Impact – Lane Closures on US-1 and US-64

[7] Winter means that school is in session, at normal enrollment levels (also applies to spring and autumn). Summer means that school is in session at summer school enrollment levels (lower than normal enrollment).

Table 2-2. Model Adjustment for Adverse Weather

Scenario	Highway Capacity*	Free Flow Speed*	Mobilization Time for General Population	Mobilization Time for Transit Vehicles	Loading Time for School Buses	Loading Time for Other Transit Vehicles
Rain	90%	90%	No Effect	10-minute increase	5-minute increase	10-minute increase
Ice	80%	80%	No Effect	20-minute increase	10-minute increase	20-minute increase
*Adverse weather capacity and speed values are given as a percentage of good weather conditions. Roads are assumed to be passable.						

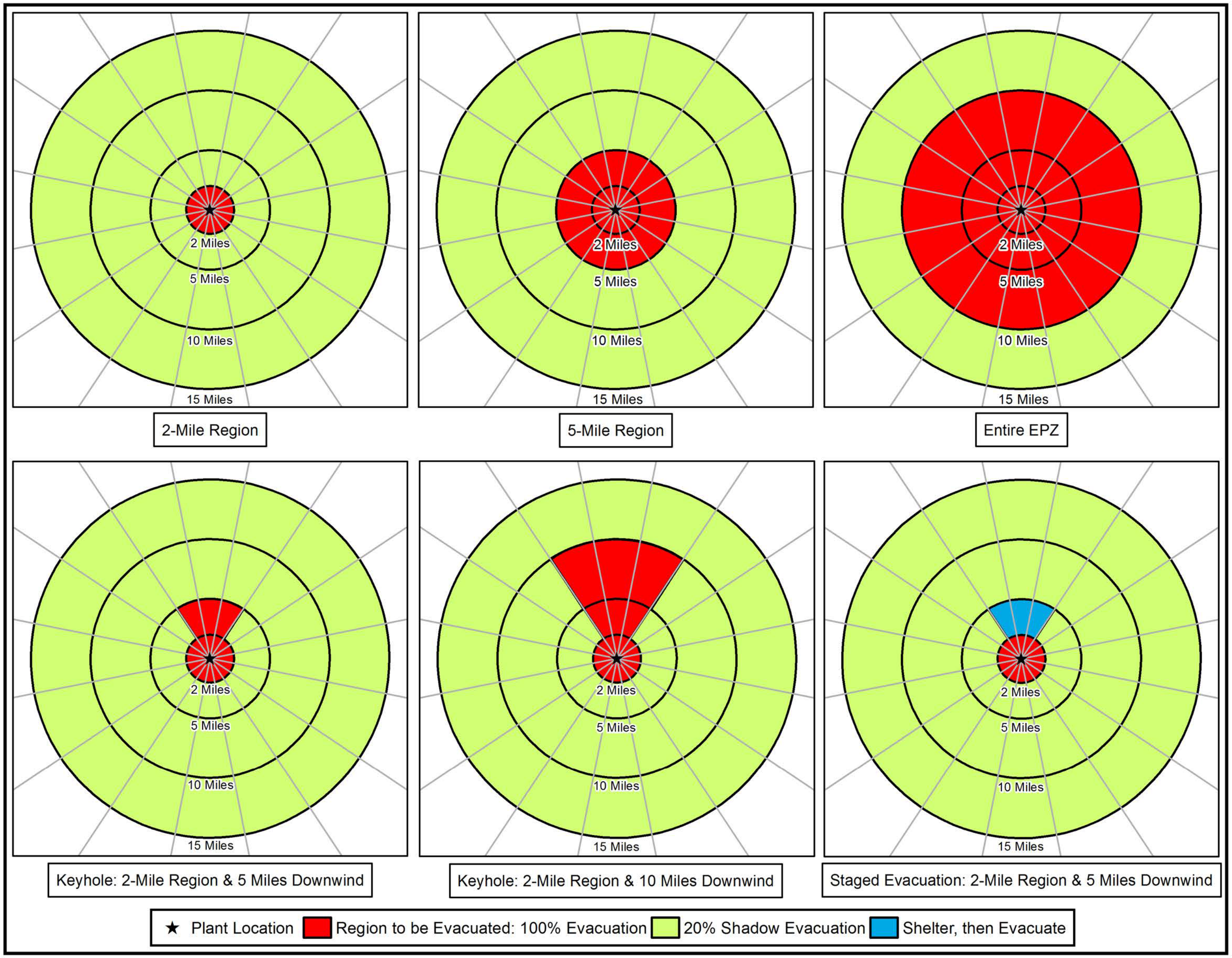


Figure 2-1. Voluntary Evacuation Methodology

3 DEMAND ESTIMATION

The estimates of demand, expressed in terms of people and vehicles, constitute a critical element in developing an evacuation plan. These estimates consist of three components:

1. An estimate of population within the EPZ, stratified into groups (resident, employee, transient).
2. An estimate, for each population group, of mean occupancy per evacuating vehicle. This estimate is used to determine the number of evacuating vehicles.
3. An estimate of potential double-counting of vehicles.

Appendix E presents much of the source material for the population estimates. Our primary source of population data, the 2020 Census, is not adequate for directly estimating some transient groups.

Throughout the year, vacationers and tourists enter the EPZ. These non-residents may dwell within the EPZ for a short period (e.g., a few days or one or two weeks), or may enter and leave within one day. Estimates of the size of these population components must be obtained, so that the associated number of evacuating vehicles can be ascertained.

The potential for double-counting people and vehicles must be addressed. For example:

- A resident who works and shops within the EPZ could be counted as a resident, again as an employee and once again as a shopper.
- A visitor who stays at a hotel and spends time at a park, then goes shopping could be counted three times.

Furthermore, the number of vehicles at a location depends on time of day. For example, motel parking lots may be full at dawn and empty at noon. Similarly, parking lots at area parks, which are full at noon, may be almost empty at dawn. Estimating counts of vehicles by simply adding up the capacities of different types of parking facilities will tend to overestimate the number of transients and can lead to ETE that are too conservative.

Analysis of the population characteristics of the HNP EPZ indicates the need to identify three distinct groups:

- Permanent residents – people who are year round residents of the EPZ.
- Transients – people who reside outside of the EPZ who enter the area for a specific purpose (shopping, recreation) and then leave the area.
- Employees – people who reside outside of the EPZ and commute to work within the EPZ on a daily basis.

Estimates of the population and number of evacuating vehicles for each of the population groups are presented for each Zone and by polar coordinate representation (population rose). The HNP EPZ is subdivided into 14 Zones. The EPZ is shown in Figure 3-1 and reflects the Zone boundary changes for Zones A, B, C, D, E, F, H, K, L, and N.

3.1 Permanent Residents

The primary source for estimating permanent population is the latest U.S. Census data with an availability date of September 16, 2021. The average household size (2.85 persons/household was estimated using the U.S. Census data – See Appendix F, sub-section F.3.1). The number of evacuating vehicles per household (1.40 vehicles/household – See Appendix F, sub-section F.3.2) was adapted from the demographic survey.

The permanent resident population is estimated by cutting the census block polygons by the Zone and EPZ boundaries using GIS software. A ratio of the original area of each census block and the updated area (after cutting) is multiplied by the total block population to estimate the population within the EPZ. This methodology (referred to as the "area ratio method") assumes that the population is evenly distributed across a census block. Table 3-1 provides permanent resident population within the EPZ, by Zone, for 2010 and for 2020 (based on the methodology above). As indicated, the permanent resident population within the EPZ has increased by 51.1% since the 2010 Census.

To estimate the number of vehicles, the year 2020 permanent resident population is divided by the average household size and multiplied by the average number of evacuating vehicles per household. Permanent resident population and vehicle estimates are presented in Table 3-2. Figure 3-2 and Figure 3-3 present the permanent resident population and permanent resident vehicle estimates by sector and distance from HNP. This population "rose" was constructed using GIS software. Note, the 2020 Census includes residents living in group quarters, such as skilled nursing facilities, group homes, etc. These people are transit dependent (will not evacuate in personal vehicles) and are included in the special facility evacuation demand estimates. To avoid double counting vehicles, the vehicle estimates for these people have been removed. The resident vehicles in Table 3-2 and Figure 3-3 have been adjusted accordingly.

It can be argued that this estimate of permanent residents overstates, somewhat, the number of evacuating vehicles, especially during the summer. It is certainly reasonable to assert that some portion of the population would be on vacation during the summer and would travel elsewhere. A rough estimate of this reduction can be obtained as follows:

- Assume 50 percent of all households vacation for a period over the summer.
- Assume these vacations, in aggregate, are uniformly dispersed over 10 weeks, i.e. 10 percent of the population is on vacation during each two-week interval.
- Assume half of these vacationers leave the area.

On this basis, the permanent resident population would be reduced by 5 percent in the summer and by a lesser amount in the off-season. Given the uncertainty in this estimate, we elected to apply no reductions in permanent resident population for the summer scenarios to account for residents who may be out of the area.

3.2 Shadow Population

A portion of the population living outside the evacuation area extending to 15 miles radially from

the HNP may elect to evacuate without having been instructed to do so. This area is called the Shadow Region. Based upon NUREG/CR-7002, Rev. 1 guidance, it is assumed that 20 percent of the permanent resident population, based on U.S. Census Bureau data, in the Shadow Region will elect to evacuate.

Shadow population characteristics (household size, evacuating vehicles per household, mobilization time) are assumed to be the same as those for the EPZ permanent resident population. Table 3-3, Figure 3-4, and Figure 3-5 present estimates of the shadow population and vehicles, by sector. Similar to the EPZ resident vehicle estimates, resident vehicles at group quarters have been removed from the shadow population vehicle demand in Table 3-3 and Figure 3-5.

3.3 Transient Population

Transient population groups are defined as those people (who are not permanent residents, nor commuting employees) who enter the EPZ for a specific purpose (shopping, recreation). Data for transient facilities was provided by the counties within the EPZ, supplemented by the previous ETE study and internet searches where data was missing. Transients may spend less than one day or stay overnight at camping facilities, hotels and motels. The HNP EPZ has a number of areas and facilities that attract transients, including:

- Campgrounds
- Parks
- Community Centers
- Golf Courses
- Lodging Facilities

Jordan Lake State Recreation Area is the primary transient attraction within the EPZ. Jordan Lake is a 46,768-acre lake located in the northwestern portion of the EPZ, occupying parts of Zones L, M, and N. The Jordan Lake State Recreation Area (SRA) consists of 12 separate facilities (11 of which are in the EPZ with Crosswinds Campground and Marina accounting for 2 facilities) that offer camping, fishing, swimming, and boating.

There are nine campgrounds within the EPZ. Chatham County and Harnett County indicated the data from the previous study was still appliable. Data from the previous study was provided by Chatham County, Harnett County, and the offices of the Jordan Lake SRA and included the number of campsites, peak occupancy and the number of vehicles and people per campsite for each facility. These data were used to estimate the number of evacuating vehicles for transients at each of these facilities. A total of 4,180 transients and 1,408 vehicles have been assigned to campgrounds within the EPZ—an average of 2.97 transients per vehicle.

There are numerous parks and community centers within the EPZ. Seven of the facilities are Jordan Lake SRA facilities (Ebenezer Church, Poe's Ridge, Robeson Creek, Seaforth, Visitor's Centers and White Oak). Data for preexisting facilities were confirmed to be still accurate by Chatham, Harnett, and Wake Counties. Data from the previous study was provided by Chatham, Harnett and Wake Counties and the offices of the Jordan Lake SRA and included the number of

transients and vehicles visiting each facility on a peak day. Data for new facilities was provided by the counties as well. The seven Jordan Lake Park facilities attract 3,587 transients and 961 vehicles to the EPZ. In total, 9,939 transients and 3,500 vehicles have been assigned to parks and community centers within the EPZ—an average of 2.84 transients per vehicle.

There are three golf courses within the EPZ. Wake County indicated the data from the previous study was still accurate. Data for the previous study was provided by Wake County and included the number of golfers and vehicles at each facility on a peak day, and the number of golfers that travel from outside the area. A total of 620 transients and 410 vehicles are assigned to golf courses within the EPZ—an average of 1.5 transients per vehicle.

There are ten lodging facilities within the EPZ and they are all in the Wake Count portion of the EPZ. Wake County identified a new lodging facility and indicated the data of the remaining nine facilities from the previous study was still accurate. The estimates of transient vehicle and transients for the new facility were based on the number of rooms and the average household size (2.85). Data from the previous study was provided by Wake County and included the number of rooms, percentage of occupied rooms at peak times, and the number of people and vehicles per room for each facility. These data were used to estimate the number of transients and evacuating vehicles at each of these facilities. A total of 734 transients in 496 vehicles are assigned to lodging facilities in the EPZ—an average of 1.48 transients per vehicle.

Appendix E summarizes the transient data that was collected for the EPZ. Table E-5 presents the number of transients visiting campgrounds, Table E-6 presents the number of transients at parks and community centers, Table E-7 presents the number of transients at golf courses and Table E-8 presents the number of transients at lodging facilities within the EPZ.

Table 3-4 presents transient population and transient vehicle estimates by Zone. Figure 3-6 and Figure 3-7 present these data by sector and distance from the plant. There are a total of 15,473 transients in the EPZ at peak times, evacuating in 5,814 vehicles – an average vehicle occupancy of 2.66 transients per vehicle.

3.4 Employees

The estimate of employees who work within the EPZ is based on the 2018 Workplace Area Characteristic (WAC) data from the OnTheMap Census analysis tool[1] extrapolated to 2020 using the short-term employment projection for the State of North Carolina[2].

The WAC data provides the employee counts by industry sector for each census block within the HNP EPZ. Since not all employees are working at facilities within the EPZ at one time, a maximum shift reduction was applied to each census block. Assuming maximum shift employment occurs Monday through Friday between 9 AM and 5 PM, the following jobs take place outside the typical 9-5 workday:

- Manufacturing – takes place in shifts over 24 hours

[1] http://onthemap.ces.census.gov/ OnTheMap is an interactive map displaying workplace and residential distributions by user-defined geographies at census block level detail. It also reports the work characteristics detail on age, and earnings industry groups.
[2] https://www.nccommerce.com/data-tools-reports/labor-market-data-tools/employment-projections

- Arts, Entertainment, and Recreation – takes place in evenings and on weekends
- Accommodations and Food Services – peaks in the evenings

Therefore, the number of employees working in these 3 industry sectors was subtracted from the total number for each census block to represent the maximum number of employees present in the EPZ at any one time. As per the NUREG/CR-7002, Rev. 1 guidance, employers with 200 or more employees working in a single shift are considered as the major employers. As such, the census blocks with less than 200 employees (during the maximum shift) are not included in this study.

Employees who work within the EPZ fall into two categories:

- Those who live and work in the EPZ
- Those who live outside of the EPZ and commute to jobs within the EPZ.

Those of the first category are already counted as part of the permanent resident population. To avoid double counting, we focus only on those employees commuting from outside the EPZ who will evacuate along with the permanent resident population. The 2018 LEHD (Longitudinal Employer-Household Dynamics) Origin-Destination Employment Statistics (LODES) data[3] from OnTheMap website was then used to estimate the percent of employees that work within the EPZ but live outside. This value, 78.8%, was applied to the maximum shift employee values to compute the number of people commuting into the EPZ to work at peak times.

Plant employment data and percent of employees commuting into the EPZ was provided by Duke Energy and supplemented for the census block in Zone A. As such, the plant employment data is reflected in the Wake County employment subtotal in Table E-4.

To estimate the evacuating employee vehicles, a vehicle occupancy of 1.10 employees per vehicle obtained from the demographic survey (see Section F.3.1) was used for all major employers. Table 3-5 presents employee and vehicle estimates by Zone. Figure 3-8 and Figure 3-9 present these data by sector.

3.5 Medical Facilities

Data were provided by the counties for each of the medical facilities within the EPZ. Table E-3 in Appendix E summarizes the data gathered. Table 3-6 presents the census of medical facilities in the EPZ. A total of 731 persons have been identified as living in, or being treated in, these facilities. Since the average number of patients as these facilities fluctuates often, the capacity, current census and breakdown of ambulatory, wheelchair bound and bedridden patients for each facility were provided by the county emergency management agencies except for two facilities. Average percentage breakdowns from the facilities with data were used for the two facilities wherein data could not be obtained.

The transportation requirements for the medical facility population are also presented in Table

[3] The LODES data is part of the LEHD data products from the U.S. Census Bureau. This dataset provides detailed spatial distributions of workers' employment and residential locations and the relation between the two at the census block level. For detailed information, please refer to this site: https://lehd.ces.census.gov/data/

3-6. As discussed in Section 2.4, it is assumed that patients in small home care facilities will evacuate in staff personal vehicles. The number of ambulance runs is determined by assuming that 2 patients can be accommodated per ambulance trip; the number of wheelchair bus runs assumes 15 wheelchairs per trip, and the number of bus runs estimated assumes 30 ambulatory patients per trip.

3.6 Transit Dependent Population

The 2020 demographic survey (see Appendix F) results were used to estimate the portion of the population requiring transit service:

- Those persons in households that do not have a vehicle available.
- Those persons in households that do have vehicle(s) that would not be available at the time the evacuation is advised.

In the latter group, the vehicle(s) may be used by a commuter(s) who does not return (or is not expected to return) home to evacuate the household.

Table 3-7 presents estimates of transit-dependent people. Note:

- Estimates of persons requiring transit vehicles include schoolchildren. For those evacuation scenarios where children are at school when an evacuation is ordered, separate transportation is provided for the schoolchildren. The actual need for transit vehicles by residents is thereby less than the given estimates. However, estimates of transit vehicles are not reduced when schools are in session.
- It is reasonable and appropriate to consider that many transit-dependent persons will evacuate by ride-sharing with neighbors, friends or family. For example, nearly 80 percent of those who evacuated from Mississauga, Ontario who did not use their own cars, shared a ride with neighbors or friends. Other documents report that approximately 70 percent of transit dependent persons were evacuated via ride sharing. **Based on the results of the demographic survey, two thirds (66%) of the transit-dependent population will rideshare.**

The estimated number of bus trips needed to service transit-dependent persons is based on an estimate of average bus occupancy of 30 persons at the conclusion of the bus run. Transit vehicle seating capacities typically equal or exceed 60 children on average (roughly equivalent to 40 adults). If transit vehicle evacuees are two thirds adults and one third children, then the number of "adult seats" taken by 30 persons is 20 + (2/3 x10) = 27. On this basis, the average load factor anticipated is (27/40) x 100 = 68 percent. Thus, if the actual demand for service exceeds the estimates of Table 3-7 by 50 percent, the demand for service can still be accommodated by the available bus seating capacity.

$$\left[20 + \left(\frac{2}{3} \times 10\right)\right] \div 40 \times 1.5 = 1.00$$

Table 3-7 indicates that transportation must be provided for 1,220 people. Therefore, a total of 41 bus runs are required from a capacity standpoint. In order to service all of the transit dependent population and have at least one bus drive through each of the Zones to pick up

transit dependent people, **46 bus runs** are used in the ETE calculations, see Section 8.1 for further discussion.

To illustrate this estimation procedure, we calculate the number of persons, P, requiring public transit or ride-share, and the number of buses, B, required for the HNP EPZ:

$$P = No. of\ HH \times \sum_{i=0}^{n} \{(\%\ HH\ with\ i\ vehicles) \times [(Average\ HH\ Size) - i]\} \times A^i C^i$$

Where,

A = Percent of households with commuters

C = Percent of households who will not await the return of a commuter

$$P = 54{,}586 \times [0.00 + 0.162 \times (1.93 - 1) \times 0.55 \times 0.43 + 0.573 \times (2.94 - 2) \times (0.55 \times 0.43)^2] = 3{,}589$$

$$B = [(1 - 0.66) \times 3{,}589] \div 30 = (0.34 \times 3{,}589) \div 30 = 41$$

These calculations, based on the 2020 demographic survey results, are explained as follows:

- There were no households with no vehicles, so the term 0.00 represents those who do not have access to a vehicle.
- The members of HH with 1 vehicle away (16.2%), who are at home, equal (1.93-1). The number of HH where the commuter will not return home is equal to (54,586 x 0.162 x 0.93 x 0.55 x 0.43), as 55% of EPZ households have a commuter, 43% of which would not return home in the event of an emergency. The number of persons who will evacuate by public transit or ride-share is equal to the product of these two terms.
- The members of HH with 2 vehicles that are away (57.3%), who are at home, equal (2.94 – 2). The number of HH where neither commuter will return home is equal to 54,586 x 0.573 x 0.94 x $(0.55 \times 0.43)^2$. The number of persons who will evacuate by public transit or ride-share is equal to the product of these two terms (the last term is squared to represent the probability that neither commuter will return).
- Households with 3 or more vehicles are assumed to have no need for transit vehicles.
- The total number of persons requiring public transit is the sum of such people in HH with no vehicles, or with 1 or 2 vehicles that are away from home.

The estimate of transit-dependent population in Table 3-7 far exceeds the number of registered transit-dependent persons in the EPZ as provided by the counties (discussed below in Section 3.9). This is consistent with the findings of NUREG/CR-6953, Volume 2, in that a large majority of the transit-dependent population within the EPZs of U.S. nuclear plants does not register with their local emergency response agency.

3.7 School Population Demand

Table 3-8 presents the school population and transportation requirements for the direct evacuation of all schools and childcare centers within the EPZ for the 2020 to 2021 school year. The column in Table 3-8 entitled "Buses Required" specifies the number of buses required for

each school under the following set of assumptions and estimates:

- No students will be picked up by their parents prior to the arrival of the buses.
- While many high school students commute to school using private automobiles (as discussed in Section 2.4 of NUREG/CR-7002, Rev.1), the estimate of buses required for school evacuation does not consider the use of these private vehicles.
- Bus capacity, expressed in students per bus, is set to 70 for primary schools and childcare centers and 50 for middle and high schools.
- Those staff members who do not accompany the students will evacuate in their private vehicles.
- No allowance is made for student absenteeism, typically 3 percent daily.

Implementation of a process to confirm individual school transportation needs prior to bus dispatch may improve bus utilization. In this way, the number of buses dispatched to the schools will reflect the actual number needed. The need for buses would be reduced by any high school students who have evacuated using private automobiles (if permitted by school authorities). Those buses originally allocated to evacuate schoolchildren that are not needed due to children being picked up by their parents, can be gainfully assigned to service other facilities or those persons who do not have access to private vehicles or to ride-sharing.

Table 10-3 presents a list of the relocation schools for each school in the EPZ. Students will be transported to these schools where they will be subsequently retrieved by their respective families.

3.8 Special Event

Based on discussions with Duke Energy and OROs, Fourth of July fireworks show on Jordan Lake was chosen as the special event (Scenario 13) in accordance with NUREG/CR-7002, Rev.1, because it has the largest transient population. People attending the fireworks show are dispersed between the 12 different Jordan Lake facilities within the EPZ. Utilizing the data from the 2016 ETE study, there are 17,923 transients present for the fireworks show. It is conservatively assumed that none of these people are EPZ residents. As discussed in Assumption 5 in Section 2.1, the average household size (2.85) is assumed to be the vehicle occupancy rate for this event resulting in approximately 6,289 vehicles. Fifty percent (50%) of these transients are already present on Jordan Lake during an average summer weekend (see Table 6-3). Thus, there are an additional 8,962 transients traveling in approximately 3,145 vehicles for the special event. These additional vehicles were loaded onto appropriate roadways in the analysis network at each of the different Jordan Lake facilities. The special event vehicle trips were generated utilizing the same mobilization distributions for transients. Public transportation is not provided for this event and was not considered in the special event analysis.

3.9 Access and/or Functional Needs Population

The county emergency management agencies have a registration for access and/or functional needs persons. The current number of access and/or functional needs people was provided by

the counties. There are an estimated 3 access and/or functional needs people (2 wheelchair-bound and 1 bedridden) within the Chatham County portion of the EPZ; 17 access and/or functional needs people (13 ambulatory, 3 wheelchair-bound and 1 bedridden) within the Harnett County portion of the EPZ; 8 access and/or functional needs people (5 ambulatory, 2 wheelchair-bound and 1 bedridden)[4] within the Lee County portion of the EPZ; and, 191 access and/or functional needs people (143 ambulatory, 37 wheelchair-bound and 11 bedridden) within the Wake County portion of the EPZ. This results in 161 ambulatory persons, 44 wheelchair-bound persons and 14 bedridden persons for a total access and/or functional needs population of 219 people. Table 3-9 shows the total number of people registered for access and/or functional needs by type of need. The table also estimates the number of transportation resources needed to evacuate these people in a timely manner.

Parents are encouraged to register their children with the county if they would need a ride at any time to evacuate. As such, it is assumed that latchkey children, children who are at home while both parents are at work, are included in this data.

3.10 External Traffic

Vehicles will be traveling through the EPZ (external-external trips) at the time of an emergency event. After the Advisory to Evacuate is announced, these through-travelers will also evacuate. These through vehicles are assumed to travel on the major routes traversing the study area – US-1, US-1/US-64, US-401, US-421, and I-40). Emergency management agencies indicated that this traffic will continue to enter the study during the first 120 minutes following the Advisory to Evacuate.

Average Annual Daily Traffic (AADT) data was obtained from the North Carolina Department of Transportation (NCDOT) to estimate the number of vehicles per hour on the aforementioned routes. The AADT was multiplied by the K-Factor, which is the proportion of the AADT on a roadway segment or link during the design hour, resulting in the design hour volume (DHV). The design hour is usually the 30th highest hourly traffic volume of the year, measured in vehicles per hour (vph). The DHV is then multiplied by the D-Factor, which is the proportion of the DHV occurring in the peak direction of travel (also known as the directional split). The resulting values are the directional design hourly volumes (DDHV) and are presented in Table 3-10, for each of the routes considered. The DDHV is then multiplied by 2 hours (Security Road Blocks – SRB – are assumed to be activated at 120 minutes after the advisory to evacuate based upon information provided by emergency management agencies) to estimate the total number of external vehicles loaded on the analysis network. As indicated, there are 24,344 vehicles entering the study area as external-external trips prior to the activation of the SRB and the diversion of this traffic. This number is reduced by 60% for evening scenarios (Scenarios 5 and 12) as discussed in Section 6.

[4] Average breakdown from Table E-3 was used to compute the breakdown of access and/or functional needs people in Lee County.

3.11 Background Traffic

Section 5 discusses the time needed for the people in the EPZ to mobilize and begin their evacuation trips. As shown in Table 5-8, there are 14 time periods during which traffic is loaded on to roadways in the study area to model the mobilization time of people in the EPZ. Note, there is no traffic generated during the 15th time period, as this time period is intended to allow traffic that has already begun evacuating to clear the study area boundaries.

This study does not assume that roadways are empty at the start of Time Period 1. Rather, there is a 50-minute initialization time period (often referred to as "fill time" in traffic simulation) wherein the traffic volumes from Time Period 1 are loaded onto roadways in the study area. The amount of initialization/fill traffic that is on the roadways in the study area at the start of Time Period 1 depends on the scenario and the region being evacuated (see Section 6). There are 4,283 vehicles on the roadways in the study area at the end of fill time for an evacuation of the entire EPZ (Region R03) under Scenario 1 (summer, midweek, midday, good weather) conditions.

3.12 Summary of Demand

A summary of population and vehicle demand is provided in Table 3-11 and Table 3-12, respectively. This summary includes all population groups described in this section. A total of 279,051 people and 144,051 vehicles are considered in this study.

Table 3-1. EPZ Permanent Resident Population

Zone	2010 Population[5]	2020 Population
A	134	118
B	1,257	8,573
C	2,086	7,384
D	346	372
E	45,269	67,690
F	22,342	29,041
G	21,463	30,848
H	3,868	4,528
I	963	982
J	1,126	1,323
K	688	714
L	815	717
M	1,753	1,977
N	851	1,303
EPZ TOTAL	**102,961**	**155,570**
EPZ Population Growth (2010-2020):		**51.10%**

Table 3-2. Permanent Resident Population and Vehicles by Zone

Zone	2020 Population	2020 Resident Vehicles
A	118	57
B	8,573	4,202
C	7,384	3,626
D	372	181
E	67,690	33,151
F	29,041	14,211
G	30,848	15,009
H	4,528	2,217
I	982	480
J	1,323	600
K	714	349
L	717	350
M	1,977	969
N	1,303	638
EPZ TOTAL	**155,570**	**76,040**

[5] The 2010 population shown in the table for Zones A, B, C, D, E, F, H, K, L, and N reflect the new zone boundaries and will therefore not align with the previous ETE study.

Table 3-3. Shadow Population and Vehicles by Sector

Sector	2020 Population	Evacuating Vehicles
N	11,887	5,833
NNE	73,067	35,877
NE	64,002	31,208
ENE	25,287	12,415
E	22,444	10,995
ESE	17,125	8,387
SE	7,140	3,499
SSE	2,335	1,147
S	1,641	805
SSW	3,566	1,738
SW	2,718	1,331
WSW	3,070	1,491
W	1,182	574
WNW	5,676	2,631
NW	3,804	1,828
NNW	6,839	3,355
TOTAL	**251,783**	**123,114**

Table 3-4. Summary of Transients and Transient Vehicles

Zone	Transients	Transient Vehicles
A	401	182
B	359	161
C	0	0
D	224	102
E	1,498	865
F	3,256	1,324
G	816	371
H	998	390
I	0	0
J	0	0
K	440	210
L	338	84
M	2,406	702
N	4,737	1,423
EPZ TOTAL	**15,473**	**5,814**

Table 3-5. Summary of Employees and Employee Vehicles Commuting into the EPZ

Zone	Employees	Employee Vehicles
A	472	429
B	440	400
C	931	847
D	0	0
E	5,015	4,559
F	1,225	1,113
G	1,035	941
H	0	0
I	0	0
J	0	0
K	0	0
L	236	215
M	0	0
N	0	0
EPZ TOTAL	**9,354**	**8,504**

Table 3-6. Medical Facility Transit Demand

Zone	Facility Name	Municipality	Capacity	Current Census	Ambu-latory	Wheel-chair Bound	Bed-ridden	Bus Runs	Wheel-chair Bus Runs	Ambulance Runs
Harnett County										
S.R.	Senter's Memory Care	Fuquay-Varina	50	50	33	14	3	2	1	2
		Harnett County Subtotal:	*50*	*50*	*33*	*14*	*3*	*2*	*1*	*2*
Lee County										
J	Sanford Health & Rehab	Sanford	131	96	31	63	2	2	5	1
		Lee County Subtotal:	*131*	*96*	*31*	*63*	*2*	*2*	*5*	*1*
Wake County										
A	Brown's Family Care Home	New Hill	6	6	6	0	0	Staff Vehicles		
A	James Rest Home	New Hill	40	38	28	10	0	1	1	0
C	Avent Ferry Home	Holly Springs	6	6	6	0	0	Staff Vehicles		
C	Murchison Residential Corp Home	Holly Springs	3	3	3	0	0			
C	Trotter's Bluff	Holly Springs	6	6	6	0	0			
E	Alpha Home Care Service	Apex	6	6	6	0	0			
E	Brookridge Assisted Living	Apex	55	52	40	12	0	2	1	0
E	Kings Group Home for Children	Apex	6	6	6	0	0	Staff Vehicles		
E	Lockley Road Home	Holly Springs	6	6	6	0	0			
E	Mason Street Group Home	Apex	6	6	6	0	0			
E	Rex Rehab & Nursing Center of Apex	Apex	107	90	20	40	30	1	3	15
E	Seagraves Family Care Home	Apex	6	4	4	0	0	Staff Vehicles		
E	Spring Arbor of Apex	Apex	76	66	47	19	0	2	2	0
E	VOCA Olive Home	Apex	6	6	6	0	0	Staff Vehicles		
F	Bass Lake Home	Holly Springs	6	6	6	0	0			
F	Country Lane Group Home	Holly Springs	6	6	6	0	0			
F	Rex Holly Springs Hospital	Holly Springs	50	50	33	14	3	2	1	2

Zone	Facility Name	Municipality	Capacity	Current Census	Ambu-latory	Wheel-chair Bound	Bed-ridden	Bus Runs	Wheel-chair Bus Runs	Ambulance Runs
F	Herbert Reid Home	Holly Springs	4	4	4	0	0	Staff Vehicles		
F	Hickory Avenue Home	Holly Springs	6	6	6	0	0			
F	St. Mark's Manor	Holly Springs	9	9	9	0	0			
G	Avendelle Assisted Living at Southern Oaks	Fuquay-Varina	6	6	4	2	0	Staff Vehicles		
G	Evans-Walston Home	Fuquay-Varina	3	3	3	0	0			
G	Fuquay-Varina Homes-Elderly	Fuquay-Varina	80	62	60	2	0	2	1	0
G	Hope House	Fuquay-Varina	4	4	4	0	0	Staff Vehicles		
G	Kinton Court Home	Fuquay-Varina	16	16	16	0	0	1	0	0
G	Life Skills Independent Care #1	Fuquay-Varina	4	4	4	0	0	Staff Vehicles		
G	Mim's Family Care Home	Holly Springs	6	2	2	0	0			
G	VOCA-Creekway	Fuquay-Varina	6	6	6	0	0			
G	Windsor Point Continuing Care Retirement Community	Fuquay-Varina	100	100	66	28	6	3	2	3
		Wake County Subtotal:	*641*	*585*	*419*	*127*	*39*	*14*	*11*	*20*
		TOTAL:	**822**	**731**	**483**	**204**	**44**	**18**	**17**	**23**

Note: Small home care facilities were assumed to evacuate patients in staff vehicles.

Table 3-7. Transit-Dependent Population Estimates

2020 EPZ Population	Survey Average HH Size with Indicated No. of Vehicles			Estimated No. of Households	Survey Percent HH with Indicated No. of Vehicles			Survey Percent HH with Commuters	Survey Percent HH with Non-Returning Commuters	Total People Requiring Transport	Estimated Ridesharing Percentage	People Requiring Public Transit	Percent Population Requiring Public Transit
	0	1	2		0	1	2						
155,570	0.00	1.93	2.94	54,586	0.00%	16.2%	57.3%	55%	43%	3,589	66%	1,220	0.8%

Table 3-8. School Population Demand Estimates

Zone	School Name	Enroll ment	Buses Required
B	Apex Friendship High School	2,508	51
B	Apex Friendship Middle School	866	18
B	Oakview Elementary School	919	14
B	Thales Academy Holly Springs Pre-K-5	486	7
E	Apex Elementary School	635	10
E	Apex Middle School	1,243	25
E	Apex Senior High School	2,033	41
E	Baucom Elementary School	656	10
E	Lufkin Road Middle School	953	20
E	Olive Chapel Elementary School	996	15
E	Peak Charter Academy	751	11
E	Scotts Ridge Elementary School	849	13
E	St. Mary Magdalene Catholic School	629	9
E	Thales Academy Apex JH/HS	688	14
E	Thales Academy Apex K-5	538	8
F	Holly Grove Elementary School	970	14
F	Holly Grove Middle School	1,645	33
F	Holly Ridge Elementary School	791	12
F	Holly Ridge Middle School	1,112	23
F	Holly Springs Elementary School	808	12
F	Holly Springs High School	2,123	43
F	Pine Springs Preparatory Academy	607	9
G	Buckhorn Creek Elementary School	565	9
G	Fuquay-Varina Middle School	1,018	21
G	Fuquay-Varina Senior High School	2,248	45
G	Herbert Akins Road Elementary School	918	14
G	Lincoln Heights Elementary School	393	6
G	Southern Wake Academy	742	15
M	Moncure Elementary School	300	5
M	Seaforth High School	1,400	28
S.R.	Deep River Elementary School	558	8
S.R.	Lafayette Elementary School	650	10
	School Subtotal:	*31,598*	*573*
Zone	**Childcare Center Name**	**Enroll ment**	**Buses Required**
C	Primrose School at Holly Grove	199	3
E	Angel's Garden Home Daycare	8	1
E	Apex Baptist Church Preschool	174	3
E	Apex Peak Schools, Inc.	60	1
E	Apex United Methodist Church Preschool	78	2

Zone	Childcare Center Name	Enrollment	Buses Required
E	AsheBridge Children's Academy of Apex/Cary	162	3
E	Bright Start Child Care LLC	8	1
E	Children's Choice	8	1
E	Children's Lighthouse of Apex	198	3
E	Creative Schools of Apex	135	2
E	Earth Angel's Day Care Home	8	1
E	Eileen's Day Care	8	1
E	Everbrook Academy of Apex	138	2
E	Goddard School Apex	138	2
E	Grace Church Preschool and Summer Camp	82	2
E	Growing Years Learning Center	130	2
E	Hope Chapel Preschool	75	2
E	Karen's Kids Home Child Care	8	1
E	Kidtowne at Hope Community Church - Apex	156	3
E	Kindercare Learning Center	150	3
E	Lightbridge Academy	195	3
E	Majestic Learning Experience Inc.	6	1
E	Montessori Creative Learning School	62	1
E	Moravic Family Day Care	8	1
E	Nicole Miller's Family Childcare Home	8	1
E	Peace Montessori	45	1
E	Play Care	8	1
E	Primrose School of Apex	185	3
E	The Goddard School of Apex (Green Level West)	153	3
E	The Learning Experience in Apex	178	3
E	Vickie's Day Care Home	8	1
E	Woodhaven Weekday Preschool	102	2
F	Holly Springs Academy NC	122	2
F	Holly Springs KinderCare	199	3
F	Holly Springs Learning Center	199	3
F	Holly Springs School For Early Education	184	3
F	Home Away From Home Childcare	5	1
F	Kiddie Academy of Holly Springs	199	3
F	Kris' Home Sweet Home Daycare	8	1
F	Leaping Froggy	8	1
F	Lightbridge Academy	170	3
F	Little Dreamers Preschool	111	2
F	Loving Hand Day Care	8	1
F	New School Montessori Center	175	3
F	Sisters' Child Care Services	12	1
F	Stella Lowery Small Day Care Home	8	1
F	Sunrise United Methodist Church Preschool	66	1

Zone	Childcare Center Name	Enrollment	Buses Required
F	The Clubhouse of Holly Springs	75	2
F	The Goddard School of Holly Springs	147	3
F	The Learning Experience - Holly Springs	178	3
G	A Mother's Love	5	1
G	Busy Bee Home Daycare	8	1
G	Childcare Network - Fuquay-Varina	163	3
G	Fuquay-Varina Baptist Wee Care	150	3
G	Fuquay-Varina UMC Preschool Seeds of Faith	180	3
G	Herbert Akins Road Elementary School	36	1
G	Lincoln Heights Elementary School	18	1
G	Little Angels Preparatory	49	1
G	Little Miracles	4	1
G	Melissa's Sweet Peas Child Care Home	8	1
G	Montessori Kids Universe - Fuquay Varina	99	2
G	My Lil Friends Childcare	8	1
G	Ready Or Not Here I Grow	142	3
G	Roots To Wings Childcare	8	1
G	South Wake Preschool & Academy	65	1
G	Unique Creations Child Care Center	30	1
G	Unique Creations Child Care Center South Campus	25	1
G	Vanessa Bland's Small Day Care Home	7	1
M	YMCA After Care Program	25	1
	Childcare Center Subtotal:	*5,785*	*125*
	Total:	**37,383**	**698**

Table 3-9. Access and/or Functional Needs Demand Summary

Population Group/Transportation Need	Population	Vehicles deployed
Ambulatory/Buses	161	25
Wheelchair bound/Wheelchair Buses	44	4
Wheelchair bound/Wheelchair Vans		6
Bedridden/Ambulances	14	7
Total:	**219**	**42**

Table 3-10. HNP EPZ External Traffic

Upstream Node	Downstream Node	Road Name	Direction	NCDOT[1] AADT	K-Factor[2]	D-Factor[2]	Hourly Volume	External Traffic
8590	1680	US-1	NB	35,500	0.107	0.5	1,899	3,798
8375	1700	US-1/US-64	SB/WB	35,500	0.107	0.5	1,899	3,798
8222	1817	US-401	NB	10,500	0.116	0.5	609	1,218
8224	224	US-401	SB	10,500	0.116	0.5	609	1,218
8160	1800	US-421	NB	5,500	0.118	0.5	325	650
8230	1815	US-421	SB	5,500	0.118	0.5	325	650
8020	20	I-40	EB	71,500	0.091	0.5	3,253	6,506
8359	359	I-40	WB	71,500	0.091	0.5	3,253	6,506
							TOTAL	**24,344**

[1]NCDOT 2019
[2]HCM 2016

Table 3-11. Summary of Population Demand

Zone	Residents	Transit-Dependent	Transients	Employees	Special Facilities	Schools and Childcare Facilities	Special Event	Shadow Population	External Traffic	Total
A	118	1	401	472	44	0	0	0	0	1,036
B	8,573	67	359	440	0	4,779	0	0	0	14,218
C	7,384	58	0	931	15	199	0	0	0	8,587
D	372	2	224	0	0	0	0	0	0	598
E	67,690	530	1,498	5,015	242	12,653	0	0	0	87,628
F	29,041	228	3,256	1,225	81	9,930	0	0	0	43,761
G	30,848	242	816	1,035	203	6,889	0	0	0	40,033
H	4,528	36	998	0	0	0	0	0	0	5,562
I	982	8	0	0	0	0	0	0	0	990
J	1,323	10	0	0	96	0	0	0	0	1,429
K	714	6	440	0	0	0	0	0	0	1,160
L	717	6	338	236	0	0	750	0	0	2,047
M	1,977	16	2,406	0	0	1,725	3,733	0	0	9,857
N	1,303	10	4,737	0	0	0	4,480	0	0	10,530
Shadow Region	0	0	0	0	50	1,208	0	50,357	0	51,615
Total	**155,570**	**1,220**	**15,473**	**9,354**	**731**	**37,383**	**8,963**	**50,357**	**0**	**279,051**

NOTE: Shadow Population has been reduced to 20%. Refer to Figure 2-1 for additional information.

NOTE: Since the spatial distribution of the access and/or functional needs population is unknown, they are not included in this table.

Table 3-12. Summary of Vehicle Demand

Zone	Residents	Transit-Dependent	Transients	Employees	Special Facilities	Schools and Childcare Facilities	Special Event	Shadow Population	External Traffic	Total
A	57	6	182	429	4	0	0	0	0	678
B	4,202	0	161	400	0	180	0	0	0	4,943
C	3,626	4	0	847	0	6	0	0	0	4,483
D	181	0	102	0	0	0	0	0	0	283
E	33,151	38	865	4,559	37	466	0	0	0	39,116
F	14,211	16	1,324	1,113	8	366	0	0	0	17,038
G	15,009	18	371	941	21	274	0	0	0	16,634
H	2,217	4	390	0	0	0	0	0	0	2,611
I	480	2	0	0	0	0	0	0	0	482
J	600	0	0	0	15	0	0	0	0	615
K	349	0	210	0	0	0	0	0	0	559
L	350	0	84	215	0	0	263	0	0	912
M	969	2	702	0	0	68	1,310	0	0	3,051
N	638	2	1,423	0	0	0	1,572	0	0	3,635
Shadow Region	0	0	0	0	8	36	0	24,623	24,344	49,011
Total	**76,040**	**92**	**5,814**	**8,504**	**93**	**1,396**	**3,145**	**24,623**	**24,344**	**144,051**

NOTE: Buses (including wheelchair buses) represented as two passenger vehicles. Refer to Section 8 for additional information.
NOTE: Shadow Population has been reduced to 20%. Refer to Figure 2-1 for additional information.
NOTE: Since the spatial distribution of the access and/or functional needs population is unknown, they are not included in this table.

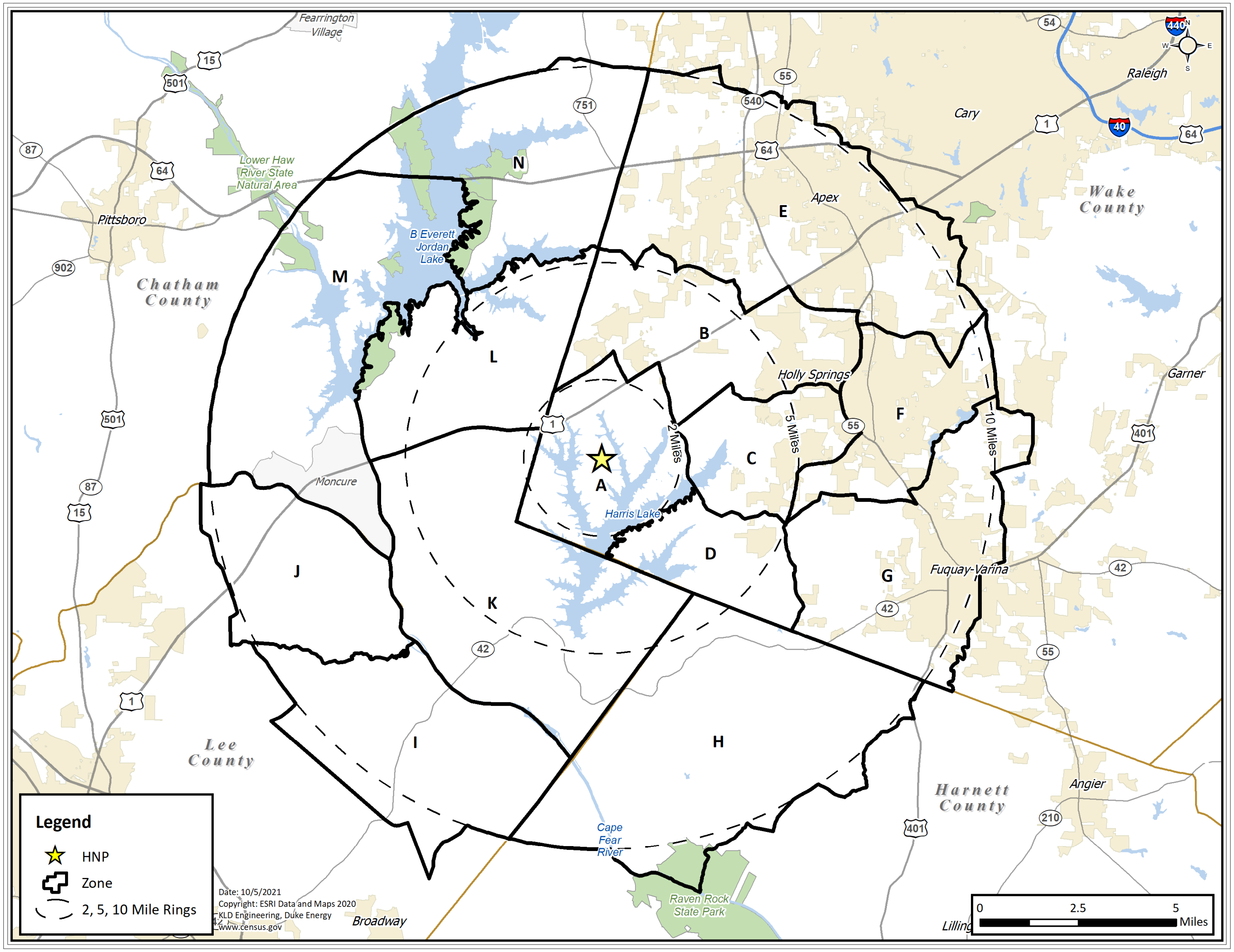
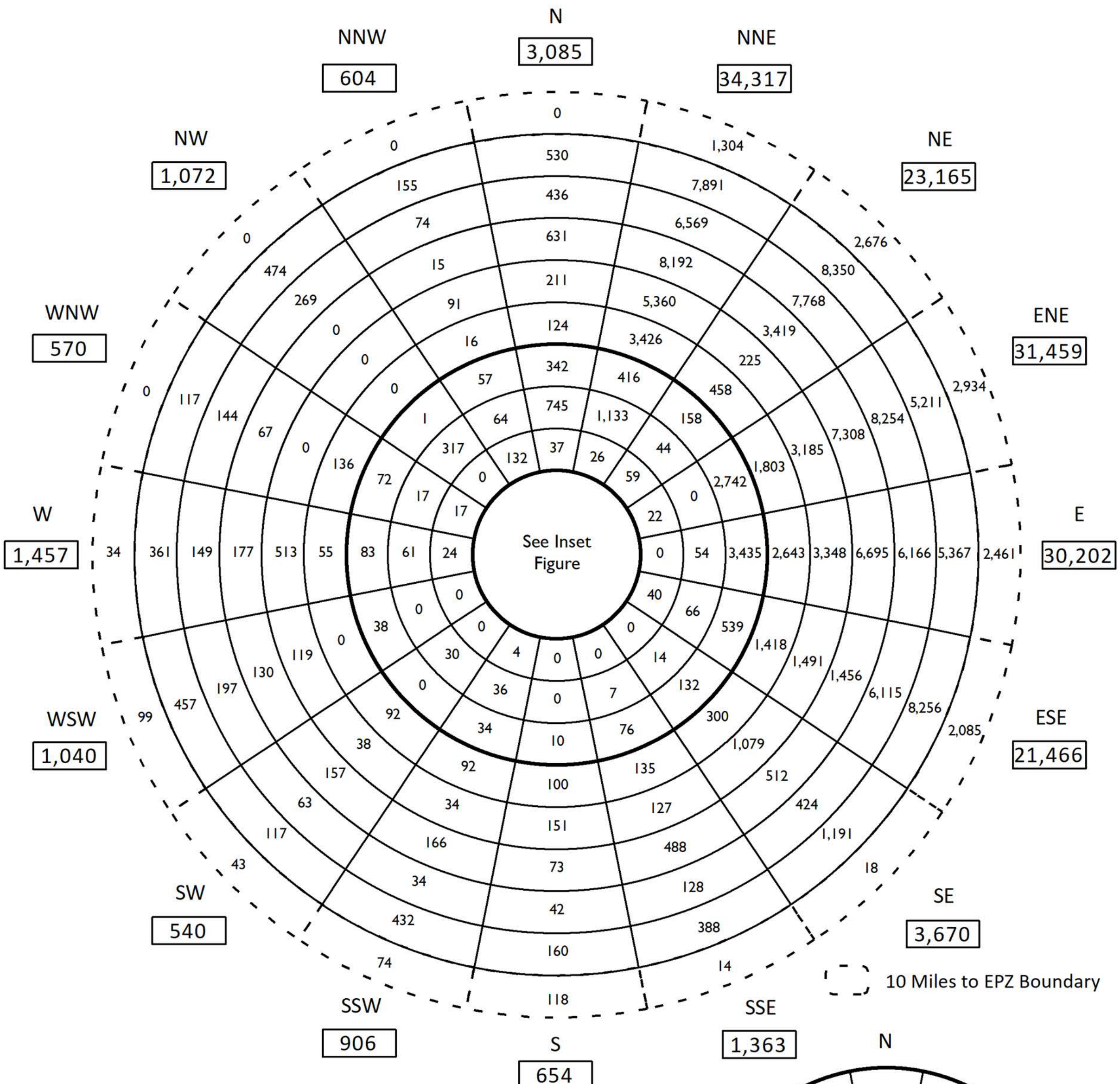


Figure 3-1. HNP EPZ



Resident Population

Miles	Subtotal by Ring	Cumulative Total
0 - 1	0	0
1 - 2	81	81
2 - 3	361	442
3 - 4	2,588	3,030
4 - 5	8,135	11,165
5 - 6	10,798	21,963
6 - 7	15,972	37,935
7 - 8	29,486	67,421
8 - 9	36,832	104,253
9 - 10	39,457	143,710
10 - EPZ	11,860	155,570
	Total:	155,570

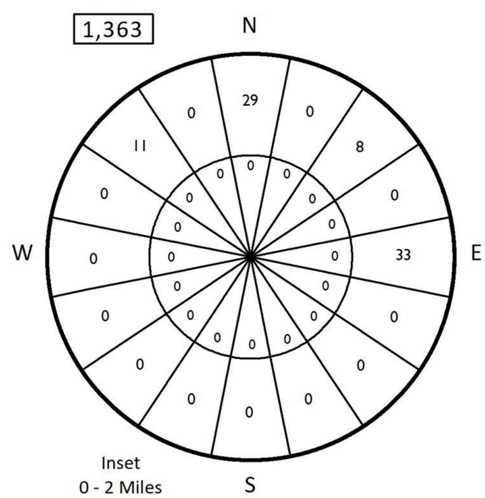
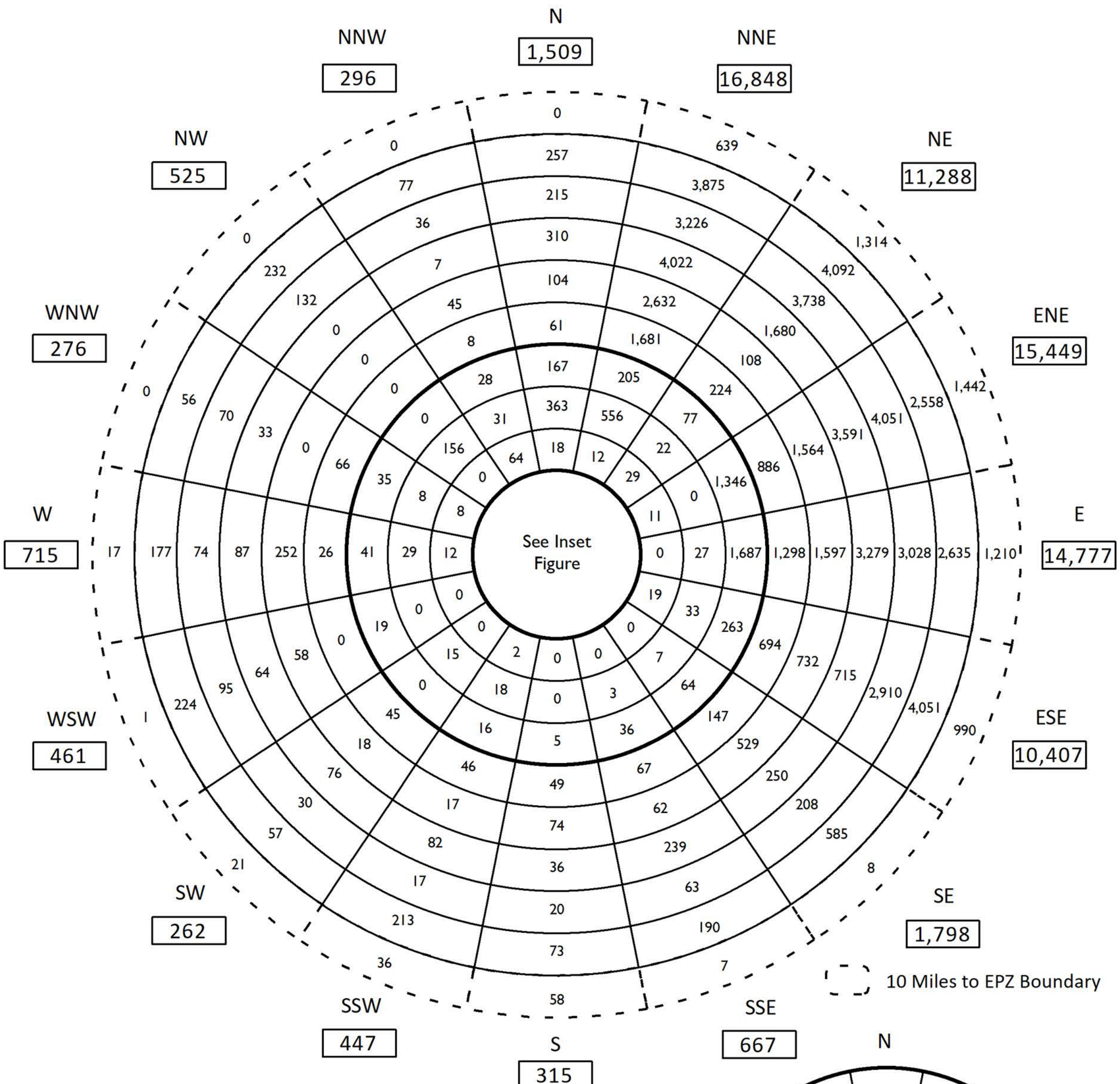


Figure 3-2. Permanent Resident Population by Sector



Resident Vehicles

Miles	Subtotal by Ring	Cumulative Total
0 - 1	0	0
1 - 2	39	39
2 - 3	175	214
3 - 4	1,268	1,482
4 - 5	3,989	5,471
5 - 6	5,298	10,769
6 - 7	7,792	18,561
7 - 8	14,471	33,032
8 - 9	17,913	50,945
9 - 10	19,352	70,297
10 - EPZ	5,743	76,040
	Total:	76,040

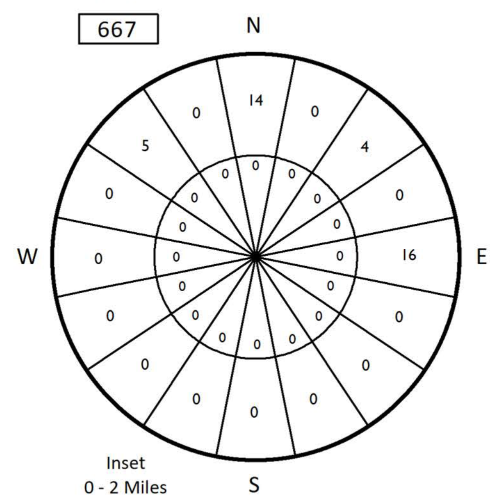
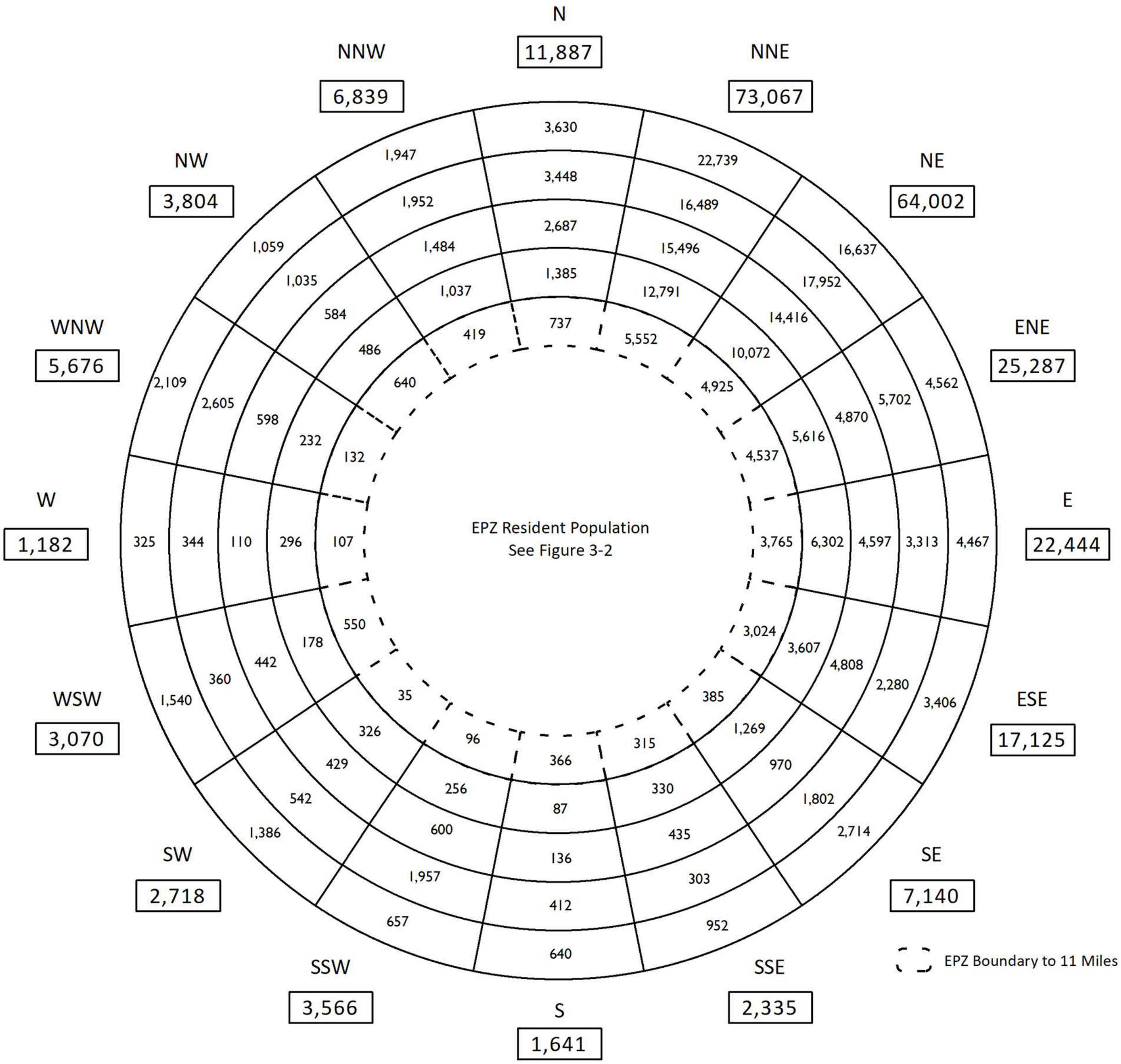


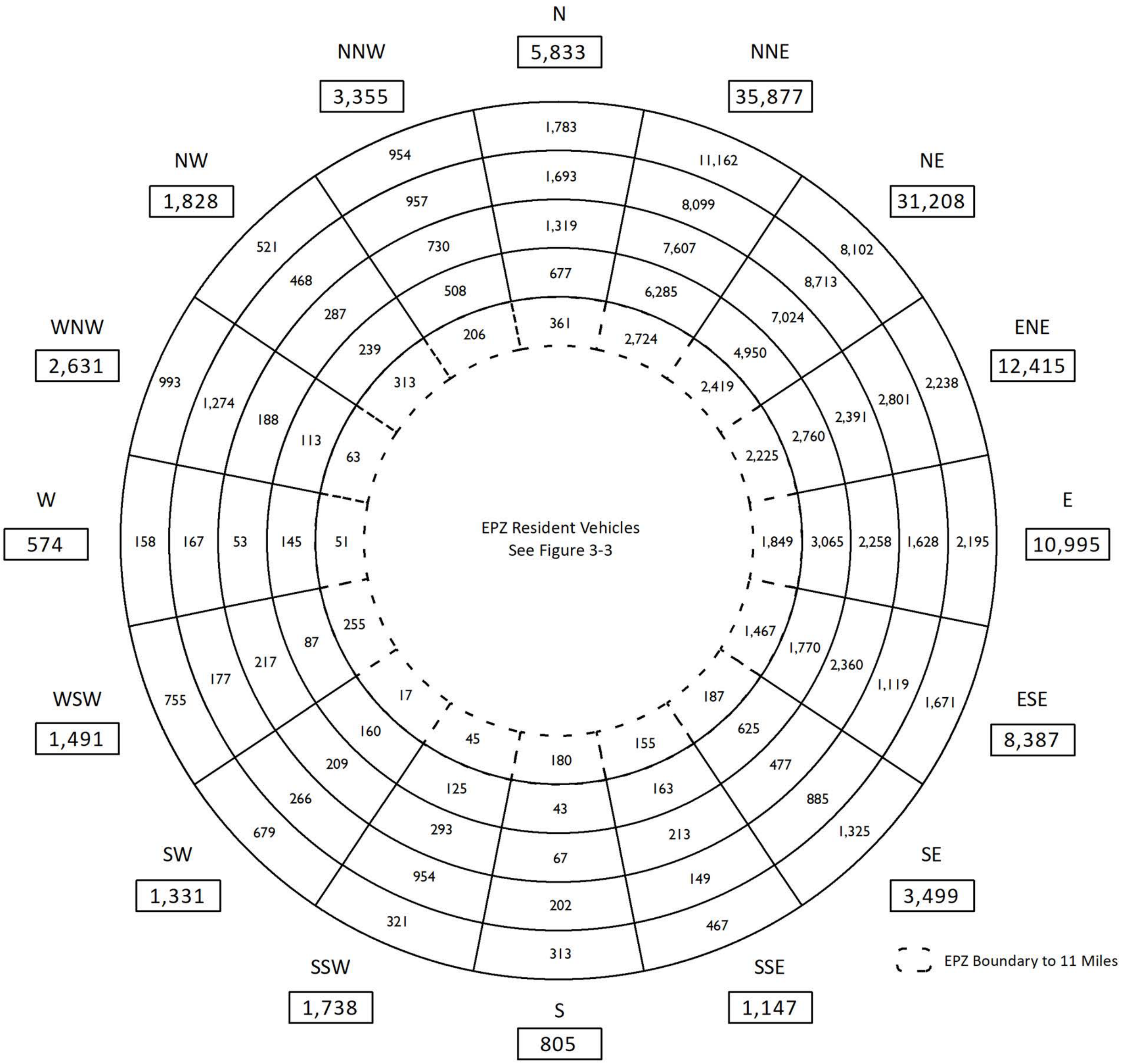
Figure 3-3. Permanent Resident Vehicles by Sector



Shadow Population

Miles	Subtotal by Ring	Cumulative Total
EPZ - 11	25,585	25,585
11 - 12	44,270	69,855
12 - 13	52,662	122,517
13 - 14	60,496	183,013
14 - 15	68,770	251,783
	Total:	251,783

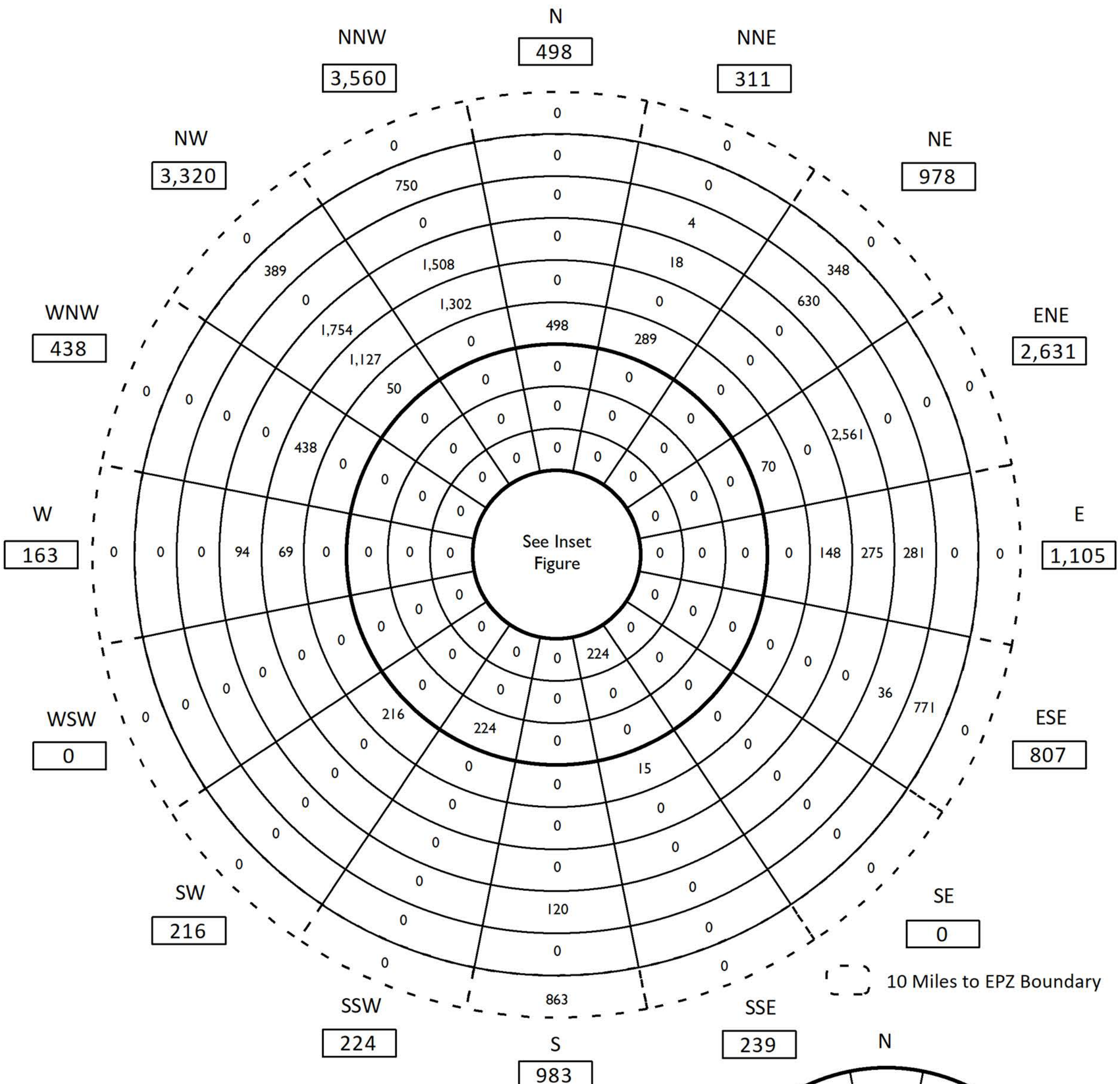
Figure 3-4. Shadow Population by Sector



Shadow Vehicles

Miles	Subtotal by Ring	Cumulative Total
EPZ - 11	12,517	12,517
11 - 12	21,715	34,232
12 - 13	25,693	59,925
13 - 14	29,552	89,477
14 - 15	33,637	123,114
	Total:	123,114

Figure 3-5. Shadow Vehicles by Sector



Transients

Miles	Subtotal by Ring	Cumulative Total
0 - 1	0	0
1 - 2	401	401
2 - 3	224	625
3 - 4	0	625
4 - 5	224	849
5 - 6	1,138	1,987
6 - 7	3,084	5,071
7 - 8	6,210	11,281
8 - 9	1,071	12,352
9 - 10	2,258	14,610
10 - EPZ	863	15,473
	Total:	15,473

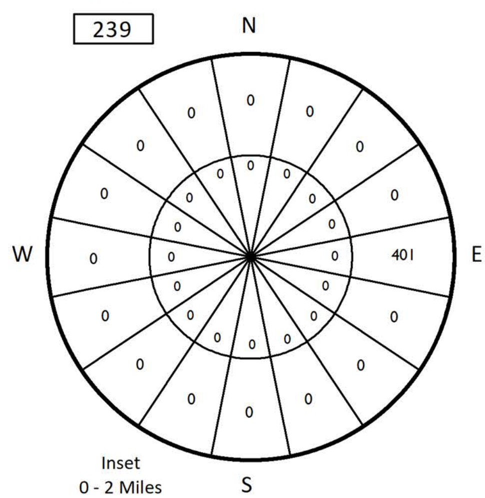
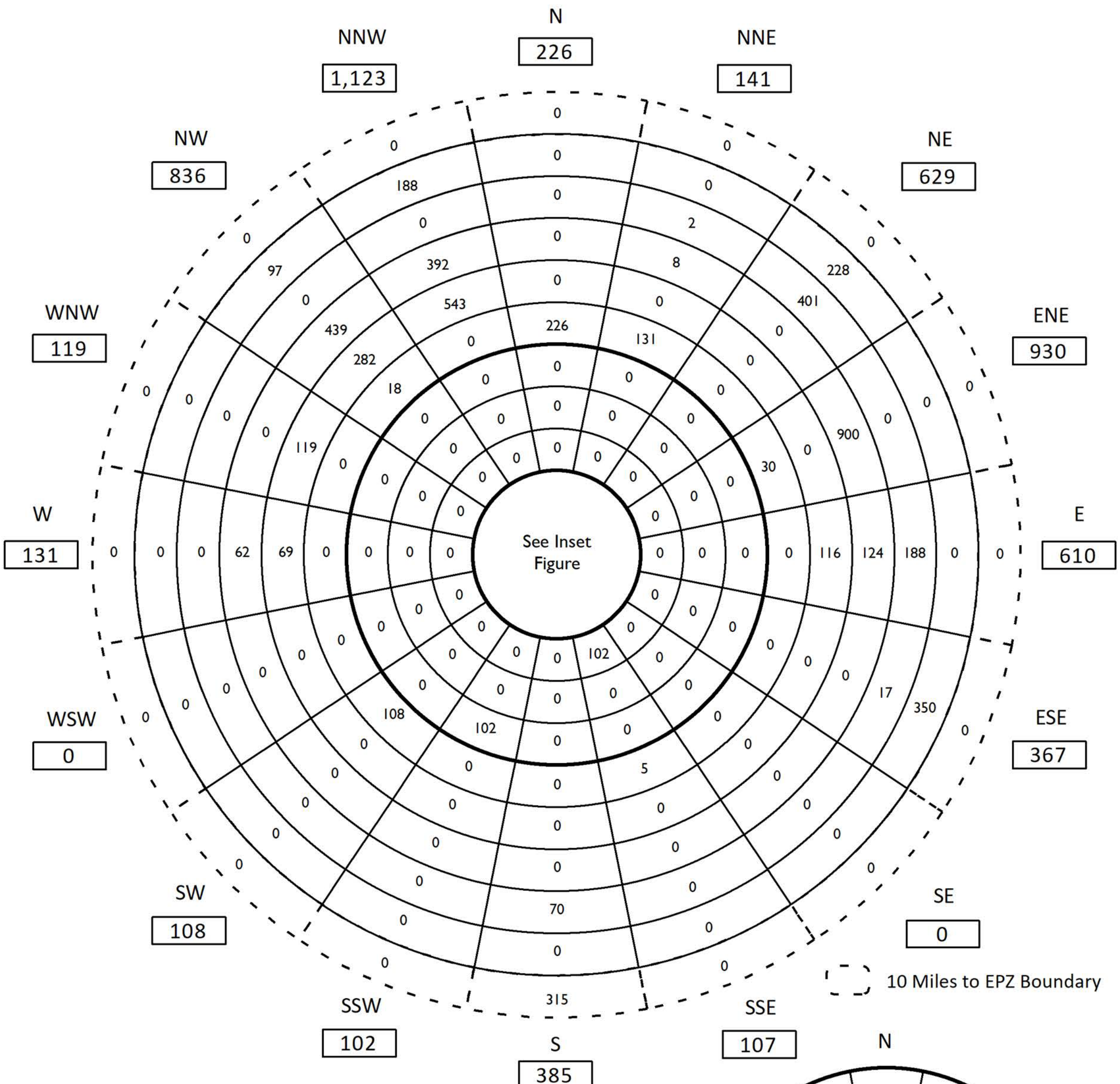


Figure 3-6. Transient Population by Sector



Transient Vehicles

Miles	Subtotal by Ring	Cumulative Total
0 - 1	0	0
1 - 2	182	182
2 - 3	102	284
3 - 4	0	284
4 - 5	102	386
5 - 6	518	904
6 - 7	1,129	2,033
7 - 8	1,925	3,958
8 - 9	678	4,636
9 - 10	863	5,499
10 - EPZ	315	5,814
	Total:	5,814

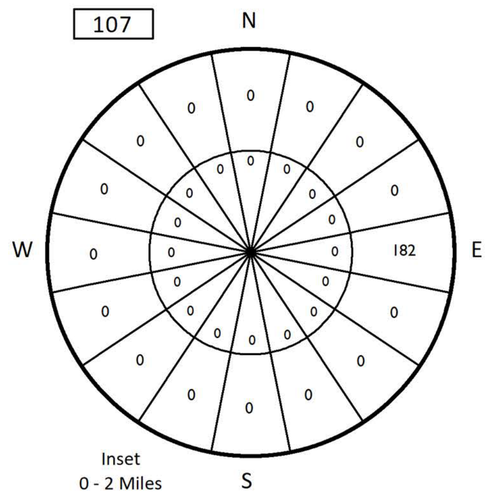
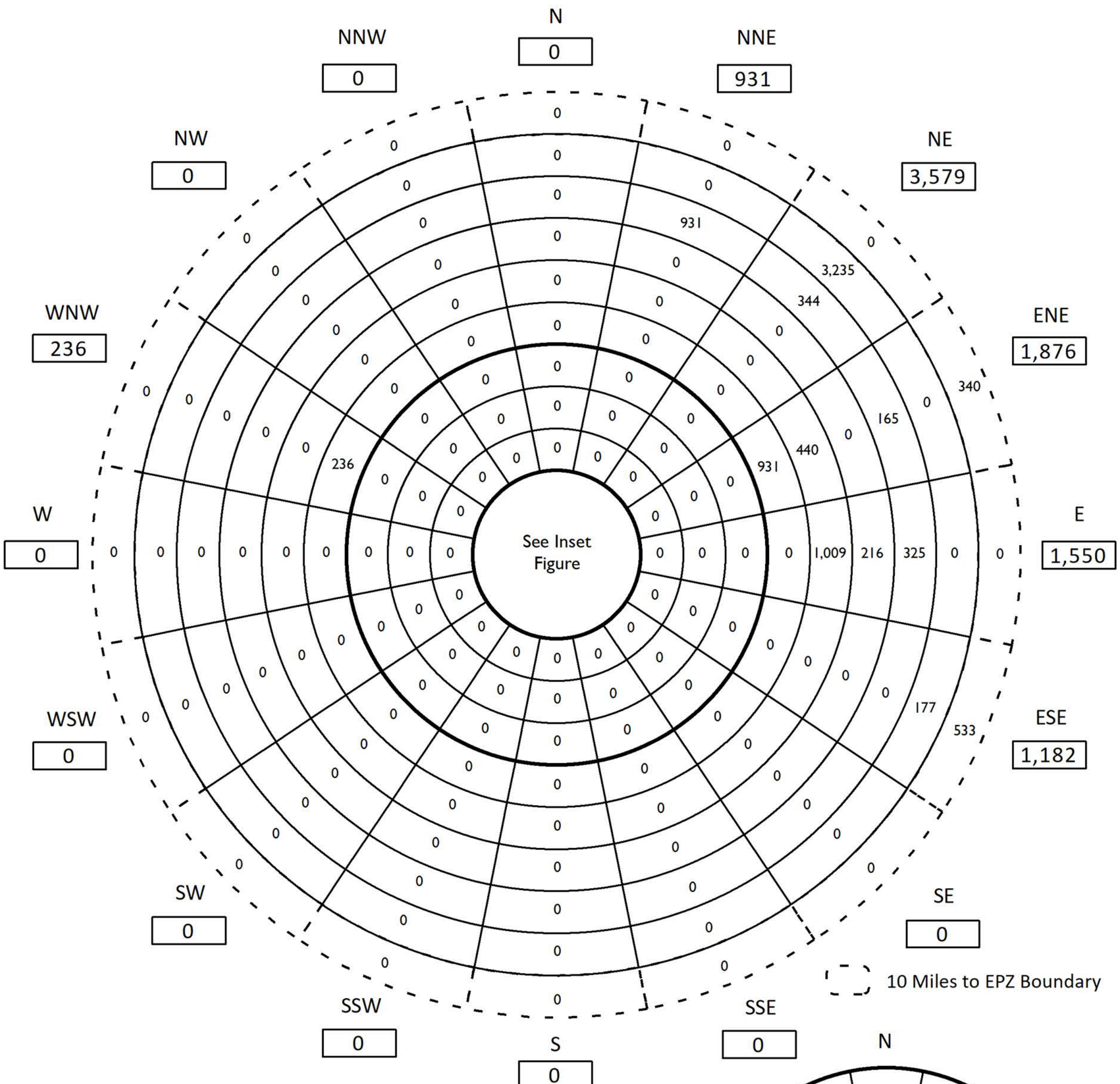


Figure 3-7. Transient Vehicles by Sector



Employees

Miles	Subtotal by Ring	Cumulative Total
0 - 1	472	472
1 - 2	0	472
2 - 3	0	472
3 - 4	0	472
4 - 5	0	472
5 - 6	1,167	1,639
6 - 7	1,449	3,088
7 - 8	216	3,304
8 - 9	1,765	5,069
9 - 10	3,412	8,481
10 - EPZ	873	9,354
	Total:	9,354

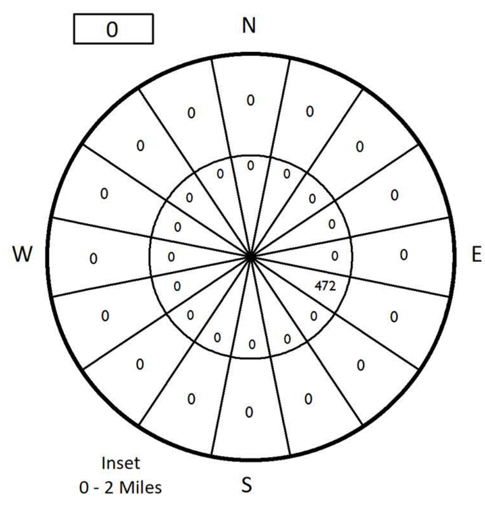
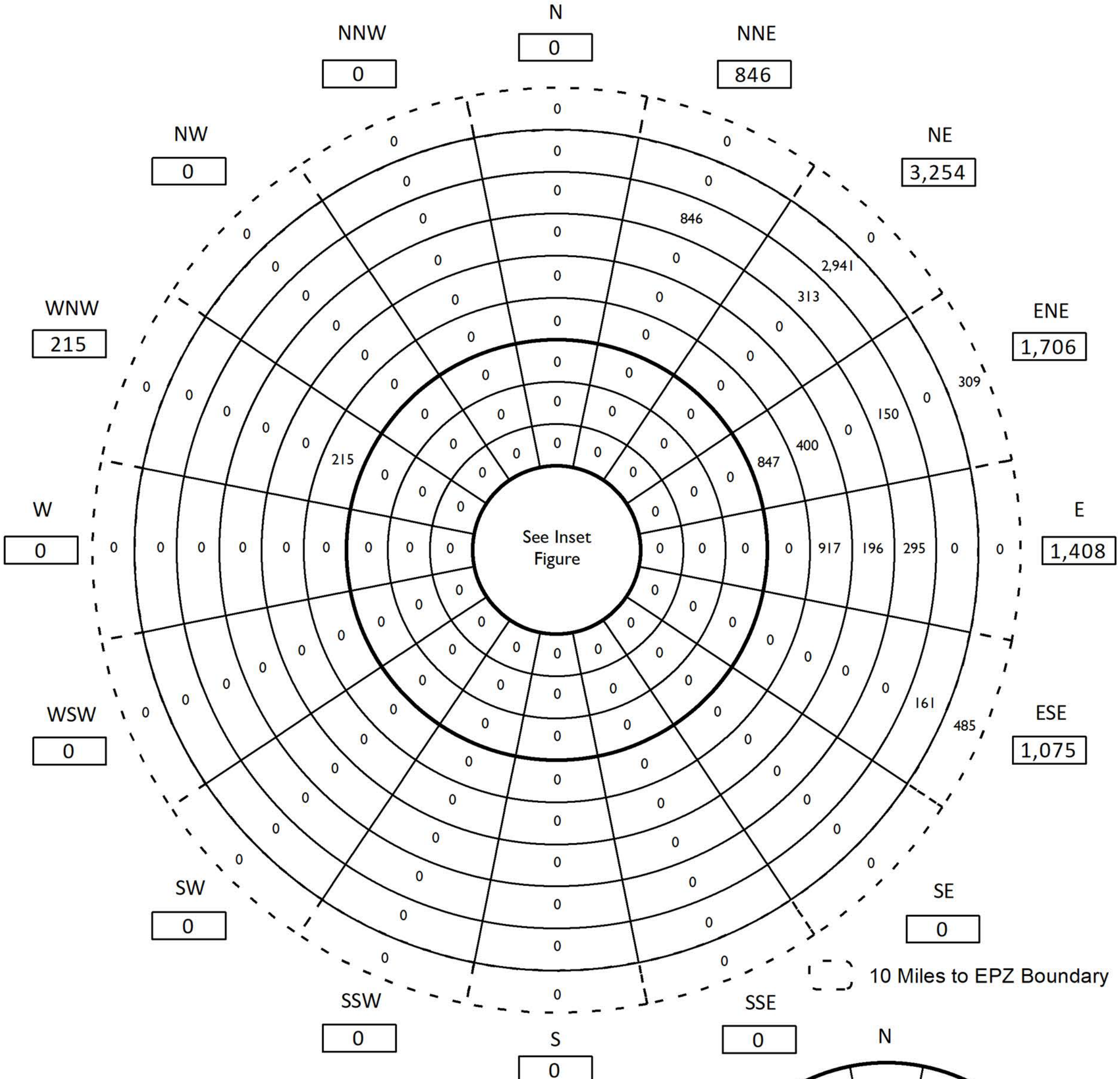


Figure 3-8. Employee Population by Sector



Employee Vehicles

Miles	Subtotal by Ring	Cumulative Total
0 - 1	429	429
1 - 2	0	429
2 - 3	0	429
3 - 4	0	429
4 - 5	0	429
5 - 6	1,062	1,491
6 - 7	1,317	2,808
7 - 8	196	3,004
8 - 9	1,604	4,608
9 - 10	3,102	7,710
10 - EPZ	794	8,504
	Total:	8,504

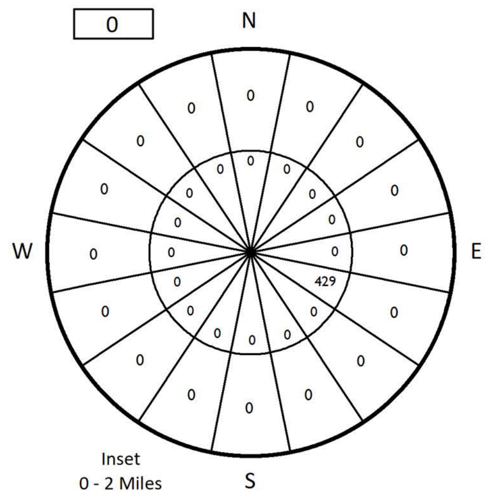


Figure 3-9. Employee Vehicles by Sector

4 ESTIMATION OF HIGHWAY CAPACITY

The ability of the road network to service vehicle demand is a major factor in determining how rapidly an evacuation can be completed. The capacity of a road is defined as the maximum hourly rate at which persons or vehicles can reasonably be expected to traverse a point or uniform section of a lane of roadway during a given time period under prevailing roadway, traffic and control conditions, as stated in the 2016 Highway Capacity Manual (HCM 2016).

In discussing capacity, different operating conditions have been assigned alphabetical designations, A through F, to reflect the range of traffic operational characteristics. These designations have been termed "Levels of Service" (LOS). For example, LOS A connotes free-flow and high-speed operating conditions; LOS F represents a forced flow condition. LOS E describes traffic operating at or near capacity.

Another concept, closely associated with capacity, is "Service Volume" (SV). Service volume is defined as "The maximum hourly rate at which vehicles, bicycles or persons reasonably can be expected to traverse a point or uniform section of a roadway during an hour under specific assumed conditions while maintaining a designated level of service." This definition is similar to that for capacity. The major distinction is that values of SV vary from one LOS to another, while capacity is the service volume at the upper bound of LOS E, only.

Thus, in simple terms, a service volume (SV) is the maximum traffic that can travel on a road and still maintain a certain perceived level of quality to a driver based on the A, B, C, rating system (LOS). Any additional vehicles above the service volume (SV) would drop the rating to a lower letter grade.

This distinction is illustrated in Exhibit 12-37 of the HCM 2016. As indicated there, the SV varies with Free Flow Speed (FFS), and LOS. The SV is calculated by the DYNEV II simulation model, based on the specified link attributes, FFS, capacity, control device and traffic demand.

Other factors also influence capacity. These include, but are not limited to:

- Lane width
- Shoulder width
- Pavement condition
- Horizontal and vertical alignment (curvature and grade)
- Percent truck traffic
- Control device (and timing, if it is a signal)
- Weather conditions (rain, fog, wind speed, ice)

These factors are considered during the road survey and in the capacity estimation process; some factors have greater influence on capacity than others. For example, lane and shoulder width have only a limited influence on Base Free Flow Speed (BFFS[1]) according to Exhibit 15-7 of the HCM. Consequently, lane and shoulder widths at the narrowest points were observed

[1] A very rough estimate of BFFS might be taken as the posted speed limit plus 10 mph (HCM 2016 Page 15-15)

during the road survey and these observations were recorded, but no detailed measurements of lane or shoulder width were taken. Horizontal and vertical alignment can influence both FFS and capacity. The estimated FFS were measured using the survey vehicle's speedometer and observing local traffic, under free flow conditions. Free flow speeds ranged from 15 to 75 mph in the study area. Capacity is estimated from the procedures of the 2016 HCM. For example, HCM Exhibit 7-1(b) shows the sensitivity of Service Volume at the upper bound of LOS D to grade (capacity is the Service Volume at the upper bound of LOS E).

As discussed in Section 2.6, it is necessary to adjust capacity figures to represent the prevailing conditions during inclement weather. Based on limited empirical data, weather conditions such as rain reduce the values of free speed and of highway capacity by approximately 10 percent. Over the last decade new studies have been made on the effects of rain on traffic capacity. These studies indicate a range of effects between 5 and 20 percent depending on wind speed and precipitation rates. As indicated in Section 2.6, we employ a reduction in free speed and in highway capacity of 10 percent and 20 percent for rain and ice, respectively.

Since congestion arising from evacuation may be significant, estimates of roadway capacity must be determined with great care. Because of its importance, a brief discussion of the major factors that influence highway capacity is presented in this section.

Rural highways generally consist of: (1) one or more uniform sections with limited access (driveways, parking areas) characterized by "uninterrupted" flow; and (2) approaches to at-grade intersections where flow can be "interrupted" by a control device or by turning or crossing traffic at the intersection. Due to these differences, separate estimates of capacity must be made for each section. Often, the approach to the intersection is widened by the addition of one or more lanes (turn pockets or turn bays), to compensate for the lower capacity of the approach due to the factors there that can interrupt the flow of traffic. These additional lanes are recorded during the field survey and later entered as input to the DYNEV II system.

4.1 Capacity Estimations on Approaches to Intersections

At-grade intersections are apt to become the first bottleneck locations under local heavy traffic volume conditions. This characteristic reflects the need to allocate access time to the respective competing traffic streams by exerting some form of control. During evacuation, control at critical intersections will often be provided by traffic control personnel assigned for that purpose, whose directions may supersede traffic control devices. See Appendix G for more information.

The per-lane capacity of an approach to a signalized intersection can be expressed (simplistically) in the following form:

$$Q_{cap,m} = \left(\frac{3600}{h_m}\right) \times \left(\frac{G - L}{C}\right)_m = \left(\frac{3600}{h_m}\right) \times P_m$$

where:

$Q_{cap,m}$	=	Capacity of a single lane of traffic on an approach, which executes movement, *m*, upon entering the intersection; vehicles per hour (vph)
h_m	=	Mean queue discharge headway of vehicles on this lane that are executing movement, *m*; seconds per vehicle
G	=	Mean duration of GREEN time servicing vehicles that are executing movement, *m*, for each signal cycle; seconds
L	=	Mean "lost time" for each signal phase servicing movement, *m*; seconds
C	=	Duration of each signal cycle; seconds
P_m	=	Proportion of GREEN time allocated for vehicles executing movement, *m*, from this lane. This value is specified as part of the control treatment.
m	=	The movement executed by vehicles after they enter the intersection: through, left-turn, right-turn, and diagonal.

The turn-movement-specific mean discharge headway h_m, depends in a complex way upon many factors: roadway geometrics, turn percentages, the extent of conflicting traffic streams, the control treatment, and others. A primary factor is the value of "saturation queue discharge headway", h_{sat}, which applies to through vehicles that are not impeded by other conflicting traffic streams. This value, itself, depends upon many factors including motorist behavior. Formally, we can write,

$$h_m = f_m(h_{sat}, F_1, F_2, \dots)$$

where:

h_{sat}	=	Saturation discharge headway for through vehicles; seconds per vehicle
F_1, F_2	=	The various known factors influencing h_m
$f_m(\ )$	=	Complex function relating h_m to the known (or estimated) values of h_{sat}, F_1, F_2, …

The estimation of h_m for specified values of h_{sat}, F_1, F_2, ... is undertaken within the DYNEV II simulation model by a mathematical model[2]. The resulting values for h_m always satisfy the condition:

$$h_m \geq h_{sat}$$

That is, the turn-movement-specific discharge headways are always greater than, or equal to the saturation discharge headway for through vehicles. These headways (or its inverse equivalent, "saturation flow rate"), may be determined by observation or using the procedures of the HCM 2016.

The above discussion is necessarily brief given the scope of this ETE report and the complexity of the subject of intersection capacity. In fact, Chapters 19, 20 and 21 in the HCM 2016 address this topic. The factors, F_1, F_2,…, influencing saturation flow rate are identified in equation (19-8) of the HCM 2016.

The traffic signals within the EPZ and Shadow Region are modeled using representative phasing plans and phase durations obtained as part of the field data collection. Traffic responsive signal installations allow the proportion of green time allocated (P_m) for each approach to each intersection to be determined by the expected traffic volumes on each approach during evacuation circumstances. The amount of green time (G) allocated is subject to maximum and minimum phase duration constraints; 2 seconds of yellow time are indicated for each signal phase and 1 second of all-red time is assigned between signal phases, typically. If a signal is pre-timed, the yellow and all-red times observed during the road survey are used. A lost time (L) of 2.0 seconds is used for each signal phase in the analysis.

4.2 Capacity Estimation along Sections of Highway

The capacity of highway sections -- as distinct from approaches to intersections -- is a function of roadway geometrics, traffic composition (e.g. percent heavy trucks and buses in the traffic stream) and, of course, motorist behavior. There is a fundamental relationship which relates service volume (i.e. the number of vehicles serviced within a uniform highway section in a given time period) to traffic density. The top curve in Figure 4-1 illustrates this relationship.

As indicated, there are two flow regimes: (1) Free Flow (left side of curve); and (2) Forced Flow (right side). In the Free Flow regime, the traffic demand is fully serviced; the service volume increases as demand volume and density increase, until the service volume attains its maximum value, which is the capacity of the highway section. As traffic demand and the resulting highway density increase beyond this "critical" value, the rate at which traffic can be serviced (i.e. the service volume) can actually decline below capacity ("capacity drop"). Therefore, in order to

[2]Lieberman, E., "Determining Lateral Deployment of Traffic on an Approach to an Intersection", McShane, W. & Lieberman, E., "Service Rates of Mixed Traffic on the far Left Lane of an Approach". Both papers appear in Transportation Research Record 772, 1980. Lieberman, E., Xin, W., "Macroscopic Traffic Modeling For Large-Scale Evacuation Planning", presented at the TRB 2012 Annual Meeting, January 22-26, 2012

realistically represent traffic performance during congested conditions (i.e. when demand exceeds capacity), it is necessary to estimate the service volume, V_F, under congested conditions.

The value of V_F can be expressed as:

$$V_F = R \times Capacity$$

where:

R = Reduction factor which is less than unity

We have employed a value of R=0.90. The advisability of such a capacity reduction factor is based upon empirical studies that identified a fall-off in the service flow rate when congestion occurs at "bottlenecks" or "choke points" on a freeway system. Zhang and Levinson[3] describe a research program that collected data from a computer-based surveillance system (loop detectors) installed on the Interstate Highway System, at 27 active bottlenecks in the twin cities metro area in Minnesota over a 7-week period. When flow breakdown occurs, queues are formed which discharge at lower flow rates than the maximum capacity prior to observed breakdown. These queue discharge flow (QDF) rates vary from one location to the next and also vary by day of week and time of day based upon local circumstances. The cited reference presents a mean QDF of 2,016 passenger cars per hour per lane (pcphpl). This figure compares with the nominal capacity estimate of 2,250 pcphpl estimated for the ETE and indicated in Appendix K for freeway links. The ratio of these two numbers is 0.896 which translates into a capacity reduction factor of 0.90.

Since the principal objective of evacuation time estimate analyses is to develop a "realistic" estimate of evacuation times, use of the representative value for this capacity reduction factor (R=0.90) is justified. This factor is applied only when flow breaks down, as determined by the simulation model.

Rural roads, like freeways, are classified as "uninterrupted flow" facilities. (This is in contrast with urban street systems which have closely spaced signalized intersections and are classified as "interrupted flow" facilities.) As such, traffic flow along rural roads is subject to the same effects as freeways in the event traffic demand exceeds the nominal capacity, resulting in queuing and lower QDF rates. As a practical matter, rural roads rarely break down at locations away from intersections. Any breakdowns on rural roads are generally experienced at intersections where other model logic applies, or at lane drops which reduce capacity there. Therefore, the application of a factor of 0.90 is appropriate on rural roads, but rarely, if ever, activated.

The estimated value of capacity is based primarily upon the type of facility and on roadway geometrics. Sections of roadway with adverse geometrics are characterized by lower free-flow speeds and lane capacity. Exhibit 15-46 in the Highway Capacity Manual was referenced to estimate saturation flow rates. The impact of narrow lanes and shoulders on free-flow speed

[3] Lei Zhang and David Levinson, "Some Properties of Flows at Freeway Bottlenecks," Transportation Research Record 1883, 2004.

and on capacity is not material, particularly when flow is predominantly in one direction as is the case during an evacuation.

The procedure used here was to estimate "section" capacity, V_E, based on observations made traveling over each section of the evacuation network, based on the posted speed limits and travel behavior of other motorists and by reference to the 2016 HCM. The DYNEV II simulation model determines for each highway section, represented as a network link, whether its capacity would be limited by the "section-specific" service volume, V_E, or by the intersection-specific capacity. For each link, the model selects the lower value of capacity.

4.3 Application to the Harris Nuclear Plant Study Area

As part of the development of the link-node analysis network for the study area, an estimate of roadway capacity is required. The source material for the capacity estimates presented herein is contained in:

2016 Highway Capacity Manual (HCM)
Transportation Research Board
National Research Council
Washington, D.C.

The highway system in the study area consists primarily of three categories of roads and, of course, intersections:

- Two-Lane roads: Local, State
- Multi-Lane Highways (at-grade)
- Freeways

Each of these classifications will be discussed.

4.3.1 Two-Lane Roads

Ref: HCM Chapter 15

Two lane roads comprise the majority of highways within the EPZ. The per-lane capacity of a two-lane highway is estimated at 1,700 passenger cars per hour (pc/h). This estimate is essentially independent of the directional distribution of traffic volume except that, for extended distances, the two-way capacity will not exceed 3,200 pc/h. The HCM procedures then estimate LOS and Average Travel Speed. The DYNEV II simulation model accepts the specified value of capacity as input and computes average speed based on the time-varying demand: capacity relations.

Based on the field survey and on expected traffic operations associated with evacuation scenarios:

- Most sections of two-lane roads within the EPZ are classified as “Class I”, with "level terrain"; some are “rolling terrain”.
- “Class II” highways are mostly those within urban and suburban centers.

4.3.2 Multi-Lane Highway

Ref: HCM Chapter 12

Exhibit 12-8 of the HCM 2016 presents a set of curves that indicate a per-lane capacity ranging from approximately 1,900 to 2,200 pc/h, for free-speeds of 45 to 60 mph, respectively. Based on observation, the multilane highways outside of urban areas within the EPZ service traffic with free-speeds in this range. The actual time-varying speeds computed by the simulation model reflect the demand: capacity relationship and the impact of control at intersections. A conservative estimate of per-lane capacity of 1,900 pc/h is adopted for this study for multilane highways outside of urban areas, as shown in Appendix K.

4.3.3 Freeways

Ref: HCM Chapters 10, 12, 13, 14

Chapter 10 of the HCM 2016 describes a procedure for integrating the results obtained in Chapters 12, 13 and 14, which compute capacity and LOS for freeway components. Chapter 10 also presents a discussion of simulation models. The DYNEV II simulation model automatically performs this integration process.

Chapter 12 of the HCM 2016 presents procedures for estimating capacity and LOS for "Basic Freeway Segments". Exhibit 12-37 of the HCM 2016 presents capacity vs. free speed estimates, which are provided below.

Free Speed (mph):	55	60	65	70+
Per-Lane Capacity (pc/h):	2,250	2,300	2,350	2,400

The inputs to the simulation model are highway geometrics, free-speeds and capacity based on field observations. The simulation logic calculates actual time-varying speeds based on demand: capacity relationships. A conservative estimate of per-lane capacity of 2,250 pc/h is adopted for this study for freeways, as shown in Appendix K.

Chapter 13 of the HCM 2016 presents procedures for estimating capacity, speed, density and LOS for freeway weaving sections. The simulation model contains logic that relates speed to demand volume: capacity ratio. The value of capacity obtained from the computational procedures detailed in Chapter 13 depends on the "Type" and geometrics of the weaving segment and on the "Volume Ratio" (ratio of weaving volume to total volume).

Chapter 14 of the HCM 2016 presents procedures for estimating capacities of ramps and of "merge" areas. There are three significant factors to the determination of capacity of a ramp-freeway junction: The capacity of the freeway immediately downstream of an on-ramp or immediately upstream of an off-ramp; the capacity of the ramp roadway; and the maximum flow rate entering the ramp influence area. In most cases, the freeway capacity is the controlling factor. Values of this merge area capacity are presented in Exhibit 14-10 of the HCM

2016 and depend on the number of freeway lanes and on the freeway free speed. Ramp capacity is presented in Exhibit 14-12 and is a function of the ramp free flow speed. The DYNEV II simulation model logic simulates the merging operations of the ramp and freeway traffic in accord with the procedures in Chapter 14 of the HCM 2016. If congestion results from an excess of demand relative to capacity, then the model allocates service appropriately to the two entering traffic streams and produces LOS F conditions (The HCM does not address LOS F explicitly).

4.3.4 Intersections

Ref: HCM Chapters 19, 20, 21, 22

Procedures for estimating capacity and LOS for approaches to intersections are presented in Chapter 19 (signalized intersections), Chapters 20, 21 (un-signalized intersections) and Chapter 22 (roundabouts). The complexity of these computations is indicated by the aggregate length of these chapters. The DYNEV II simulation logic is likewise complex.

The simulation model explicitly models intersections: Stop/yield controlled intersections (both 2-way and all-way) and traffic signal controlled intersections. Where intersections are controlled by fixed time controllers, traffic signal timings are set to reflect average (non-evacuation) traffic conditions. Actuated traffic signal settings respond to the time-varying demands of evacuation traffic to adjust the relative capacities of the competing intersection approaches.

The model is also capable of modeling the presence of manned traffic control. At specific locations where it is advisable or where existing plans call for overriding existing traffic control to implement manned control, the model will use actuated signal timings that reflect the presence of traffic guides. At locations where a special traffic control strategy (continuous left-turns, contra-flow lanes) is used, the strategy is modeled explicitly. Where applicable, the location and type of traffic control for nodes in the evacuation network are noted in Appendix K.

4.4 Simulation and Capacity Estimation

Chapter 6 of the HCM is entitled, "HCM and Alternative Analysis Tools." The chapter discusses the use of alternative tools such as simulation modeling to evaluate the operational performance of highway networks. Among the reasons cited in Chapter 6 to consider using simulation as an alternative analysis tool is:

> *"The system under study involves a group of different facilities or travel modes with mutual interactions involving several HCM chapters. Alternative tools are able to analyze these facilities as a single system."*

This statement succinctly describes the analyses required to determine traffic operations across an area encompassing an EPZ operating under evacuation conditions. The model utilized for this study, DYNEV II, is further described in Appendix C. It is essential to recognize that simulation models do not replicate the methodology and procedures of the HCM – they *replace*

these procedures by describing the complex interactions of traffic flow and computing Measures of Effectiveness (MOE) detailing the operational performance of traffic over time and by location. The DYNEV II simulation model includes some HCM 2016 procedures only for the purpose of estimating capacity.

All simulation models must be calibrated properly with field observations that quantify the performance parameters applicable to the analysis network. Two of the most important of these are: (1) Free flow speed (FFS); and (2) saturation headway, h_{sat}. The first of these is estimated by direct observation during the road survey; the second is estimated using the concepts of the HCM 2016, as described earlier. These parameters are listed in Appendix K, for each network link.

4.5 Boundary Conditions

As illustrated in Figure 1-2 and in Appendix K, the link-node analysis network used for this study is finite. The analysis network does extend well beyond the 15-mile radial study area in some locations in order to model intersections with other major evacuation routes beyond the study area. However, the network does have an end at the destination (exit) nodes as discussed in Appendix C. Beyond these destination nodes, there may be signalized intersections or merge points that impact the capacity of the evacuation routes leaving the study area. Rather than neglect these "boundary conditions," this study assumes a 25% reduction in capacity on two-lane roads (Section 4.3.1 above) and multi-lane highways (Section 4.3.2 above). There is no reduction in capacity for freeways due to boundary conditions. The 25% reduction in capacity is based on the prevalence of actuated traffic signals in the study area and the fact that the evacuating traffic volume will be more significant than the competing traffic volume at any downstream signalized intersections, thereby warranting a more significant percentage (75% in this case) of the signal green time.

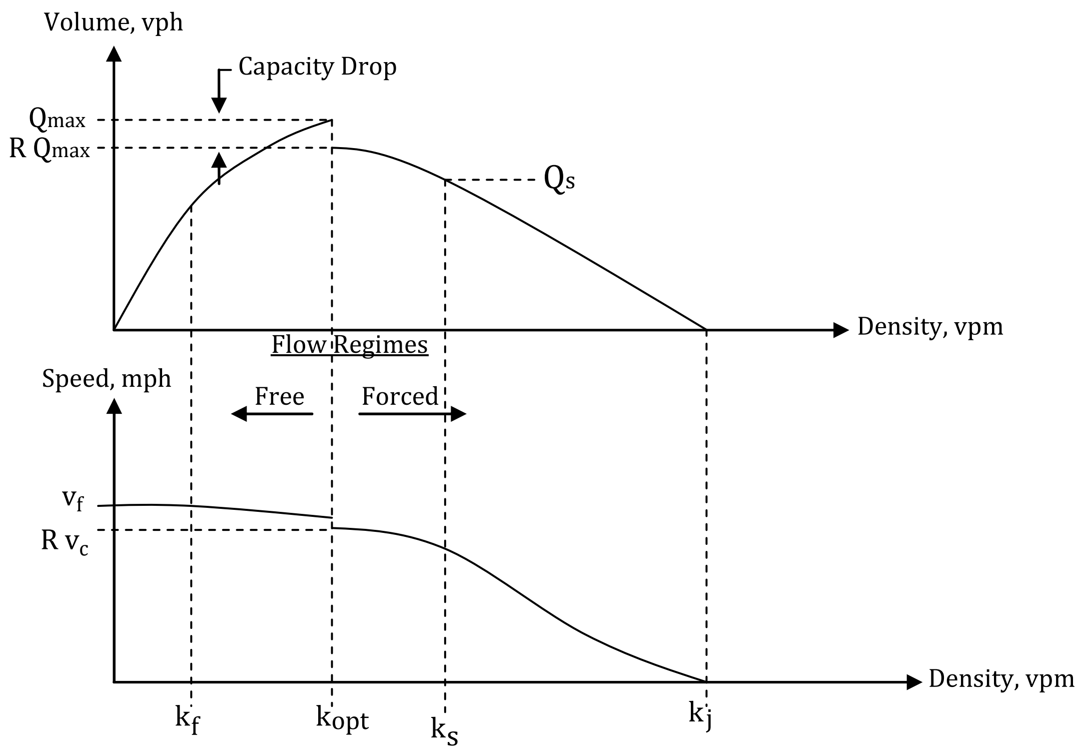


Figure 4-1. Fundamental Diagrams

5 ESTIMATION OF TRIP GENERATION TIME

Federal guidance (see NUREG/CR-7002, Rev. 1) specify that the planner estimate the distributions of elapsed times associated with mobilization activities undertaken by the public to prepare for the evacuation trip. The elapsed time associated with each activity is represented as a statistical distribution reflecting differences between members of the public. The quantification of these activity-based distributions relies largely on the results of the demographic survey. We define the sum of these distributions of elapsed times as the Trip Generation Time Distribution.

5.1 Background

In general, an accident at a nuclear power plant is characterized by the following Emergency Classification Levels (see Section C of Part IV of Appendix E of 10 CFR 50 for details):

1. Unusual Event
2. Alert
3. Site Area Emergency
4. General Emergency

At each level, the Federal guidelines specify a set of Actions to be undertaken by the Licensee and by the State and Local offsite authorities. As a Planning Basis, we will adopt a conservative posture, in accordance with Section 1.2 of NUREG/CR-7002, Rev. 1, that a rapidly escalating accident will be considered in calculating the Trip Generation Time. We will assume:

1. The Advisory to Evacuate will be announced coincident with the siren notification.
2. Mobilization of the general population will commence within 15 minutes after the siren notification.
3. ETE are measured relative to the Advisory to Evacuate.

We emphasize that the adoption of this planning basis is not a representation that these events will occur within the indicated time frame. Rather, these assumptions are necessary in order to:

1. Establish a temporal framework for estimating the Trip Generation distribution in the format recommended in Section 2.13 of NUREG/CR-6863.
2. Identify temporal points of reference that uniquely define "Clear Time" and ETE.

It is likely that a longer time will elapse between the various classes of an emergency. For example, suppose one hour elapses from the siren alert to the Advisory to Evacuate. In this case, it is reasonable to expect some degree of spontaneous evacuation by the public during this one-hour period. As a result, the population within the EPZ will be lower when the Advisory to Evacuate is announced, than at the time of the siren alert. In addition, many will engage in preparation activities to evacuate, in anticipation that an Advisory will be broadcast. Thus, the time needed to complete the mobilization activities and the number of people remaining to evacuate the EPZ after the Advisory to Evacuate, will both be somewhat less than

the estimates presented in this report. Consequently, the ETE presented in this report are higher than the actual evacuation time, if this hypothetical situation were to take place.

The notification process consists of two events:

1. Transmitting information using the alert and notification systems (ANS) available within the EPZ (e.g. sirens, tone alerts, EAS broadcasts, loud speakers).
2. Receiving and correctly interpreting the information that is transmitted.

The population within the EPZ is dispersed over an area of 330 square miles and is engaged in a wide variety of activities. It must be anticipated that some time will elapse between the transmission and receipt of the information advising the public of an accident.

The amount of elapsed time will vary from one individual to the next depending on where that person is, what that person is doing, and related factors. Furthermore, some persons who will be directly involved with the evacuation process may be outside the EPZ at the time the emergency is declared. These people may be commuters, shoppers and other travelers who reside within the EPZ and who will return to join the other household members upon receiving notification of an emergency.

As indicated in Section 2.13 of NUREG/CR-6863, the estimated elapsed times for the receipt of notification can be expressed as a distribution reflecting the different notification times for different people within, and outside, the EPZ. By using time distributions, it is also possible to distinguish between different population groups and different day-of-week and time-of-day scenarios, so that accurate ETE may be computed.

For example, people at home or at work within the EPZ will be notified by siren, and/or tone alert and/or radio (if available). Those well outside the EPZ will be notified by telephone, radio, TV and word-of-mouth, with potentially longer time lags. Furthermore, the spatial distribution of the EPZ population will differ with time of day – families will be united in the evenings but dispersed during the day. In this respect, weekends will differ from weekdays.

As indicated in Section 4.1 of NUREG/CR-7002, Rev. 1, the information required to compute trip generation times is typically obtained from a demographic survey of EPZ residents. Such a survey was conducted in support of this ETE study. Appendix F discusses the survey sampling plan, documents the survey instrument utilized, and provides the survey results. The remaining discussion will focus on the application of the trip generation data obtained from the demographic survey to the development of the ETE documented in this report.

5.2 Fundamental Considerations

The environment leading up to the time that people begin their evacuation trips consists of a sequence of events and activities. Each event (other than the first) occurs at an instant in time and is the outcome of an activity.

Activities are undertaken over a period of time. Activities may be in "series" (i.e., to undertake an activity implies the completion of all preceding events) or may be in parallel (two or more activities may take place over the same period of time). Activities conducted in series are

functionally dependent on the completion of prior activities; activities conducted in parallel are functionally independent of one another. The relevant events associated with the public's preparation for evacuation are:

Event Number	Event Description
1	Notification
2	Awareness of Situation
3	Depart Work
4	Arrive Home
5	Depart on Evacuation Trip

Associated with each sequence of events are one or more activities, as outlined below:

These relationships are shown graphically in Figure 5-1.

- An Event is a 'state' that exists at a point in time (e.g., depart work, arrive home)
- An Activity is a 'process' that takes place over some elapsed time (e.g., prepare to leave work, travel home)

As such, a completed Activity changes the 'state' of an individual (i.e., the activity, 'travel home' changes the state from 'depart work' to 'arrive home'). Therefore, an Activity can be described as an 'Event Sequence'; the elapsed times to perform an event sequence vary from one person to the next and are described as statistical distributions on the following pages.

An employee who lives outside the EPZ will follow sequence (c) of Figure 5-1. A household within the EPZ that has one or more commuters at work, and will await their return before beginning the evacuation trip will follow the first sequence of Figure 5-1(a). A household within the EPZ that has no commuters at work, or that will not await the return of any commuters, will follow the second sequence of Figure 5-1(a), regardless of day of week or time of day.

Households with no commuters on weekends or in the evening/night-time will follow the applicable sequence in Figure 5-1(b). Transients will always follow one of the sequences of Figure 5-1(b). Some transients away from their residence could elect to evacuate immediately without returning to the residence, as indicated in the second sequence.

It is seen from Figure 5-1, that the Trip Generation time (the total elapsed time from Event 1 to Event 5) depends on the scenario and will vary from one household to the next. Furthermore, Event 5 depends, in a complicated way, on the time distributions of all activities preceding that event. That is, to estimate the time distribution of Event 5, we must obtain estimates of the time distributions of all preceding events. For this study, we adopt the conservative posture that all activities will occur in sequence.

In some cases, assuming certain events occur strictly sequential (for instance, commuter returning home before beginning preparation to leave) can result in rather *conservative* (that is, longer) estimates of mobilization times. It is reasonable to expect that at least some parts of these events will overlap for many households, but that assumption is not made in this study.

5.3 Estimated Time Distributions of Activities Preceding Event 5

The time distribution of an event is obtained by "summing" the time distributions of all prior contributing activities. (This "summing" process is quite different than an algebraic sum since it is performed on distributions – not scalar numbers).

Time Distribution No. 1, Notification Process: Activity 1 $\rightarrow$ 2

Federal regulations (10CFR50 Appendix E, Item IV.D.3) stipulate, "[t]he design objective of the prompt public alert and notification system shall be to have the capability to essentially complete the initial alerting and initiate notification of the public within the plume exposure pathway EPZ within about 15 minutes". Furthermore, 2019 Federal Emergency Management Agency (FEMA) Radiological Emergency Preparedness Program Manual Part V Section B.1 Bullet 3 states that "Notification methods will be established to ensure coverage within 45 minutes of essentially 100% of the population".

Given the federal regulations and guidance, and the presence of sirens within the EPZ, it is assumed that 100 percent of the population in the EPZ can be notified within 45 minutes. The assumed distribution for notifying the EPZ population is provided in Table 5-2.

Distribution No. 2, Prepare to Leave Work: Activity 2 $\rightarrow$ 3

It is reasonable to expect that the vast majority of business enterprises within the EPZ will elect to shut down following notification and most employees would leave work quickly. Commuters, who work outside the EPZ could, in all probability, also leave quickly since facilities outside the EPZ would remain open and other personnel would remain. Personnel or farmers responsible for equipment/livestock would require additional time to secure their facility. As discussed in Section F.3.3, the COVID-19 pandemic showed a significant impact on the results of the survey related to commuters. As a result, the results from the 2012 demographic survey ware used for the distributions involving commuters. The distribution of Activity 2 → 3 shown in Table 5-3 reflects data obtained by the 2012 demographic survey. This distribution is also applicable for residents to leave stores, restaurants, parks, and other locations within the EPZ. This distribution is plotted in Figure 5-2.

Distribution No. 3, Travel Home: Activity 3 $\rightarrow$ 4

These data are provided directly by those households which responded to the 2012 demographic survey. This distribution is plotted in Figure 5-2 and listed in Table 5-4.

Distribution No. 4, Prepare to Leave Home: Activity 2, 4 $\rightarrow$ 5

These data are provided directly by those households which responded to the demographic survey. This distribution is plotted in Figure 5-2 and listed in Table 5-5.

5.4 Calculation of Trip Generation Time Distribution

The time distributions for each of the mobilization activities presented herein must be combined to form the appropriate Trip Generation Distributions. As discussed above, this study assumes that the stated events take place in sequence such that all preceding events must be

completed before the current event can occur. For example, if a household awaits the return of a commuter, the work-to-home trip (Activity 3 $\rightarrow$ 4) must precede Activity 4 $\rightarrow$ 5.

To calculate the time distribution of an event that is dependent on two sequential activities, it is necessary to "sum" the distributions associated with these prior activities. The distribution summing algorithm is applied repeatedly as shown to form the required distribution. As an outcome of this procedure, new time distributions are formed; we assign "letter" designations to these intermediate distributions to describe the procedure. Table 5-6 presents the summing procedure to arrive at each designated distribution.

Table 5-7 presents a description of each of the final trip generation distributions achieved after the summing process is completed.

5.4.1 Statistical Outliers

As already mentioned, some portion of the survey respondents answer "don't know" to some questions or choose to not respond to a question. The mobilization activity distributions are based upon actual responses. But, it is the nature of surveys that a few numeric responses are inconsistent with the overall pattern of results. An example would be a case in which for 500 responses, almost all of them estimate less than two hours for a given answer, but 3 say "four hours" and 4 say "six or more hours".

These "outliers" must be considered: are they valid responses, or so atypical that they should be dropped from the sample?

In assessing outliers, there are three alternatives to consider:

1) Some responses with very long times may be valid, but reflect the reality that the respondent really needs to be classified in a different population subgroup, based upon access and/or functional needs;

2) Other responses may be unrealistic (6 hours to return home from commuting distance, or 2 days to prepare the home for departure);

3) Some high values are representative and plausible, and one must not cut them as part of the consideration of outliers.

The issue of course is how to make the decision that a given response or set of responses are to be considered "outliers" for the component mobilization activities, using a method that objectively quantifies the process.

There is considerable statistical literature on the identification and treatment of outliers singly or in groups, much of which assumes the data is normally distributed and some of which uses non-parametric methods to avoid that assumption. The literature cites that limited work has been done directly on outliers in sample survey responses.

In establishing the <u>overall</u> mobilization time/trip generation distributions, the following principles are used:

1) It is recognized that the overall trip generation distributions are conservative estimates, because they assume a household will do the mobilization activities sequentially, with no overlap of activities;

The individual mobilization activities (prepare to leave work, travel home, prepare home) are reviewed for outliers, and then the overall trip generation distributions are created (see Figure 5-1, Table 5-6, Table 5-7);

2) Outliers can be eliminated either because the response reflects a special population (e.g. access and/or functional needs, transit dependent) or lack of realism, because the purpose is to estimate trip generation patterns for personal vehicles;
3) To eliminate outliers,
    a) the mean and standard deviation of the specific activity are estimated from the responses,
    b) the median of the same data is estimated, with its position relative to the mean noted,
    c) the histogram of the data is inspected, and
    d) all values greater than 3 standard deviations are flagged for attention, taking special note of whether there are gaps (categories with zero entries) in the histogram display.

    In general, only flagged values more than 3.5 standard deviations from the mean are allowed to be considered outliers, with gaps in the histogram expected.

    When flagged values are classified as outliers and dropped, steps “a” to “d” are repeated.

4) As a practical matter, even with outliers eliminated by the above, the resultant histogram, viewed as a cumulative distribution, is not a normal distribution. A typical situation that results is shown below in Figure 5-3.
5) In particular, the cumulative distribution differs from the normal distribution in two key aspects, both very important in loading a network to estimate evacuation times:

    - Most of the real data is to the left of the “normal” curve above, indicating that the network loads faster for the first 80-85 percent of the vehicles, potentially causing more (and earlier) congestion than otherwise modeled;
    - The last 10-15 percent of the real data “tails off” slower than the comparable “normal” curve, indicating that there is significant traffic still loading at later times.

    Because these two features are important to preserve, it is the histogram of the data that is used to describe the mobilization activities, not a “normal” curve fit to the data. One could consider other distributions, but using the shape of the *actual* data curve is unambiguous and preserves these important features;

6) With the mobilization activities each modeled according to Steps 1-6, including preserving the features cited in Step 6, the overall (or total) mobilization times are constructed.

This is done by using the data sets and distributions under different scenarios (e.g., commuter returning, no commuter returning in each). In general, these are additive, using weighting based

upon the probability distributions of each element; Figure 5-4 presents the combined trip generation distributions for each population group considered. These distributions are presented on the same time scale. (As discussed earlier, the use of strictly additive activities is a conservative approach, because it makes all activities sequential – preparation for departure follows the return of the commuter, and so forth. In practice, it is reasonable that some of these activities are done in parallel, at least to some extent – for instance, preparation to depart begins by a household member at home while the commuter is still on the road.)

The mobilization distributions that result are used in their tabular/graphical form as direct inputs to later computations that lead to the ETE.

The DYNEV II simulation model is designed to accept varying rates of vehicle trip generation for each origin centroid, expressed in the form of histograms. These histograms, which represent Distributions A, C and D, properly displaced with respect to one another, are tabulated in Table 5-8 (Distribution B, Arrive Home, omitted for clarity).

The final time period (15) is 600 minutes long. This time period is added to allow the analysis network to clear, in the event congestion persists beyond the trip generation period. Note that there are no trips generated during this final time period.

5.4.2 Staged Evacuation Trip Generation

As defined in NUREG/CR-7002, Rev. 1, staged evacuation consists of the following:

1. Zones comprising the 2-mile region are advised to evacuate immediately
2. Zones comprising regions extending from 2 to 5 miles downwind are advised to shelter in-place while the 2-mile region is cleared
3. As vehicles evacuate the 2-mile region, sheltered people from 2 to 5 miles downwind continue preparation for evacuation
4. The population sheltering in the 2-to-5-mile region are advised to begin evacuating when approximately 90 percent of those originally within the 2-mile region evacuate across the 2-mile region boundary
5. Non-compliance with the shelter recommendation is the same as the shadow evacuation percentage of 20 percent

Assumptions

1. The EPZ population in Zones beyond 5 miles will shelter in place, with the exception of the 20 percent non-compliance.
2. The population in the Shadow Region beyond the EPZ boundary, extending to approximately 15 miles radially from the plant, will react as they do for all non-staged evacuation scenarios. That is 20 percent of these households will elect to evacuate with no shelter delay.

3. The transient population will not be expected to stage their evacuation because of the limited sheltering options available to people who may be at parks, on a beach, or at other venues. Also, notifying the transient population of a staged evacuation would prove difficult.
4. Employees will also be assumed to evacuate without first sheltering.

Procedure

1. Trip generation for population groups in the 2-mile region will be as computed based upon the results of the demographic survey and analysis.
2. Trip generation for the population subject to staged evacuation will be formulated as follows:
    a. Identify the 90th percentile evacuation time for the Zones comprising the 2-mile region. This value, T_{Scen}^*, is obtained from simulation results. It will become the time at which the region being sheltered will be told to evacuate for each scenario.
    b. The resultant trip generation curves for staging are then formed as follows:
        i. The non-shelter trip generation curve is followed until a maximum of 20 percent of the total trips are generated (to account for shelter non-compliance).
        ii. No additional trips are generated until time T_{Scen}^*
        iii. Following time T_{Scen}^*, the balance of trips are generated:
            1. by stepping up and then following the non-shelter trip generation curve (if T_{Scen}^* is $\leq$ max trip generation time) or
            2. by stepping up to 100 percent (if T_{Scen}^* is > max trip generation time)
    c. Note: This procedure implies that there may be different staged trip generation distributions for different scenarios, however, that was not the case for this site. NUREG/CR-7002, Rev. 1 uses the statement "approximately 90th percentile" as the time to end staging and begin evacuating. The value of T_{Scen}^* is about 1:30 for all scenarios (see Region R01 in Table 7-1).
    d. Note: Since approximately 90 percent of the 2-mile region (Zone A) is comprised of employees and transients, the T_{Scen}^* value of 1:30 is dictated by the trip generation of these population groups as opposed to the trip generation of residents.
3. Staged trip generation distributions are created for the following population groups:
    a. Residents with returning commuters
    b. Residents without returning commuters

Table 5-8 presents the staged trip generation distributions for both residents with and without returning commuters and employees/transients. At T_{Scen}^*, 20 percent of the resident population (who normally would have completed their mobilization activities for an un-staged evacuation) advised to shelter has nevertheless departed the area. These people do not comply with the

shelter advisory. Also included on the plot are the trip generation distributions for these groups as applied to the regions advised to evacuate immediately.

Since the 90th percentile evacuation time occurs before the end of the trip generation time, after the sheltered region is advised to evacuate, the shelter trip generation distribution rises to meet the balance of the non-staged trip generation distribution. Following time T_{Scen}^*, the balance of staged evacuation trips that are ready to depart are released within 15 minutes. After T_{Scen}^*+15, the remainder of evacuation trips are generated in accordance with the un-staged trip generation distribution.

Table 5-9 provides the trip generation histograms for staged evacuation.

5.4.3 Trip Generation for Waterways and Recreational Areas

The All Federal/State/County Standard Operating Guideline (SOG) for the Waterway and Recreation Area Warning and Evacuation in Support of the Harris Nuclear Plant (August 2020) indicates that if the primary Alert and Notification System (sirens) is operational and operates according to its design specifications, then waterway warning and evacuation activities are not required. The plan further establishes the basic procedures and organizational responsibilities for the **back-up** emergency alert and notification on Harris and Jordan Lakes, the Haw, Deep and Cape Fear Rivers in addition to associated recreational sites, surrounding areas and other facilities within the 10-mile EPZ. Individuals on Jordan Lake, Upper Cape Fear, Deep and Haw Rivers will be notified by the following organizations:

1. Chatham County Sheriff's Office
2. NC Wildlife Resources Commission
3. Moncure Fire Department (back-up only)
4. United States Army Corps of Engineers (USACE) from the B. Everett Jordan Lake and Dam field office
5. North Carolina Parks and Recreation, Jordan Lake
6. NC Highway Patrol - Special Operations/Aviation Unit.

Individuals on Harris Lake will be notified by the following organizations:

1. Wake County Sheriff's Office
2. NC Highway Patrol - Special Operations/Aviation Unit
3. Wake County Parks and Recreation

Individuals on the Lower Cape Fear River will be notified by the following organizations:

1. NC Highway Patrol - Special Operations/Aviation Unit
2. North Carolina Parks and Recreation
3. North Carolina Wildlife Resources Commission (back-up only)
4. Summerville Volunteer Fire Department (back-up only)
5. Northwest Harnett Volunteer Fire Department (back-up only)

As indicated in Table 5-2, this study assumes 100 percent notification in 45 minutes which is consistent with the FEMA REP Manual. Table 5-8 indicates that all transients will have mobilized within 2 hours. It is assumed that this timeframe is sufficient time for boaters, campers and other transients to return to their vehicles or lodging facilities and begin their evacuation trip.

Table 5-1. Event Sequence for Evacuation Activities

Event Sequence	Activity	Distribution
1 → 2	Receive Notification	1
2 → 3	Prepare to Leave Work	2
2,3 → 4	Travel Home	3
2,4 → 5	Prepare to Leave to Evacuate	4
N/A	Snow Clearance	5

Table 5-2. Time Distribution for Notifying the Public

Elapsed Time (Minutes)	Percent of Population Notified
0	0.0%
5	7.1%
10	13.3%
15	26.5%
20	46.9%
25	66.3%
30	86.7%
35	91.8%
40	96.9%
45	100.0%

Table 5-3. Time Distribution for Employees to Prepare to Leave Work

Elapsed Time (Minutes)	Cumulative Percent Employees Leaving Work
0	0.0%
5	42.9%
10	63.7%
15	75.4%
20	79.8%
25	80.6%
30	88.6%
35	89.2%
40	90.0%
45	92.2%
50	92.6%
55	92.6%
60	98.8%
75	99.2%
90	100.0%

NOTE: The survey data was normalized to distribute the "Don't know" response. That is, the sample was reduced in size to include only those households who responded to this question. The underlying assumption is that the distribution of this activity for the "Don't know" responders, if the event takes place, would be the same as those responders who provided estimates.

Table 5-4. Time Distribution for Commuters to Travel Home

Elapsed Time (Minutes)	Cumulative Percent Returning Home
0	0.0%
5	9.0%
10	22.4%
15	34.6%
20	50.8%
25	57.4%
30	78.5%
35	80.9%
40	87.3%
45	94.0%
50	94.8%
55	94.8%
60	98.7%
75	99.8%
90	100.0%

NOTE: The survey data was normalized to distribute the "Don't know" response.

Table 5-5. Time Distribution for Population to Prepare to Leave Home

Elapsed Time (Minutes)	Cumulative Percent Ready to Evacuate
0	0.0%
15	3.2%
30	20.6%
45	35.9%
60	55.5%
75	70.9%
90	75.4%
105	78.6%
120	84.3%
135	93.3%
150	94.8%
165	95.7%
180	97.0%
195	99.1%
210	99.6%
225	100.0%

NOTE: The survey data was normalized to distribute the "Don't know" response

Table 5-6. Mapping Distributions to Events

Apply "Summing" Algorithm To:	Distribution Obtained	Event Defined
Distributions 1 and 2	Distribution A	Event 3
Distributions A and 3	Distribution B	Event 4
Distributions B and 4	Distribution C	Event 5
Distributions 1 and 4	Distribution D	Event 5

Table 5-7. Description of the Distributions

Distribution	Description
A	Time distribution of commuters departing place of work (Event 3). Also applies to employees who work within the EPZ who live outside, and to Transients within the EPZ.
B	Time distribution of commuters arriving home (Event 4).
C	Time distribution of residents with commuters who return home, leaving home to begin the evacuation trip (Event 5).
D	Time distribution of residents without commuters returning home, leaving home to begin the evacuation trip (Event 5).

Table 5-8. Trip Generation Histograms for the EPZ Population for Un-staged Evacuation

Time Period	Duration (Min)	Percent of Total Trips Generated Within Indicated Time Period			
		Employees (Distribution A)	Transients (Distribution A)	Residents with Commuters (Distribution C)	Residents Without Commuters (Distribution D)
1	15	7%	7%	0%	0%
2	15	35%	35%	0%	3%
3	15	34%	34%	1%	9%
4	15	13%	13%	2%	16%
5	15	5%	5%	7%	17%
6	15	4%	4%	11%	16%
7	15	2%	2%	14%	11%
8	15	0%	0%	14%	5%
9	30	0%	0%	21%	11%
10	30	0%	0%	13%	7%
11	30	0%	0%	9%	3%
12	30	0%	0%	4%	2%
13	30	0%	0%	3%	0%
14	30	0%	0%	1%	0%
15	600	0%	0%	0%	0%

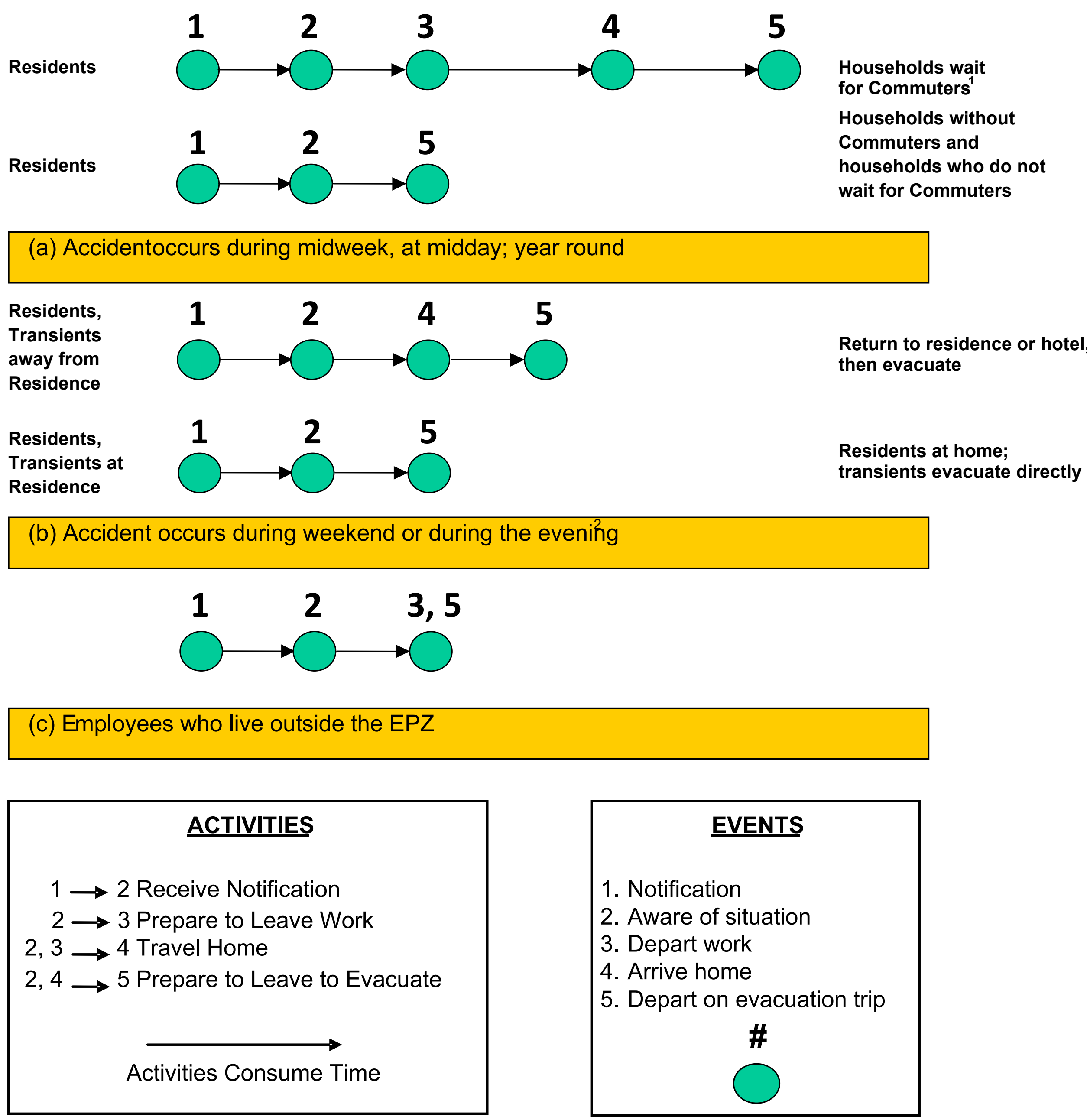
NOTE:

- Shadow vehicles are loaded onto the analysis network (Figure 1-2) using Distribution C for good weather.
- Special event vehicles are loaded using Distribution A.
- Trip generation rates were not changed for ice scenarios.

Table 5-9. Trip Generation Histograms for the EPZ Population for Staged Evacuation

Time Period	Duration (Min)	Percent of Total Trips Generated Within Indicated Time Period*	
		Residents with Commuters (Distribution C)	Residents Without Commuters (Distribution D)
1	15	0%	0%
2	15	0%	1%
3	15	0%	1%
4	15	1%	4%
5	15	1%	3%
6	15	2%	3%
7	15	31%	60%
8	15	14%	5%
9	30	21%	11%
10	30	13%	7%
11	30	9%	3%
12	30	4%	2%
13	30	3%	0%
14	30	1%	0%
15	600	0%	0%

*Trip Generation for Employees and Transients (see Table 5-8) is the same for Un-staged and Staged Evacuation.



[1] Applies for evening and weekends also if commuters are at work.
[2] Applies throughout the year for transients.

Figure 5-1. Events and Activities Preceding the Evacuation Trip

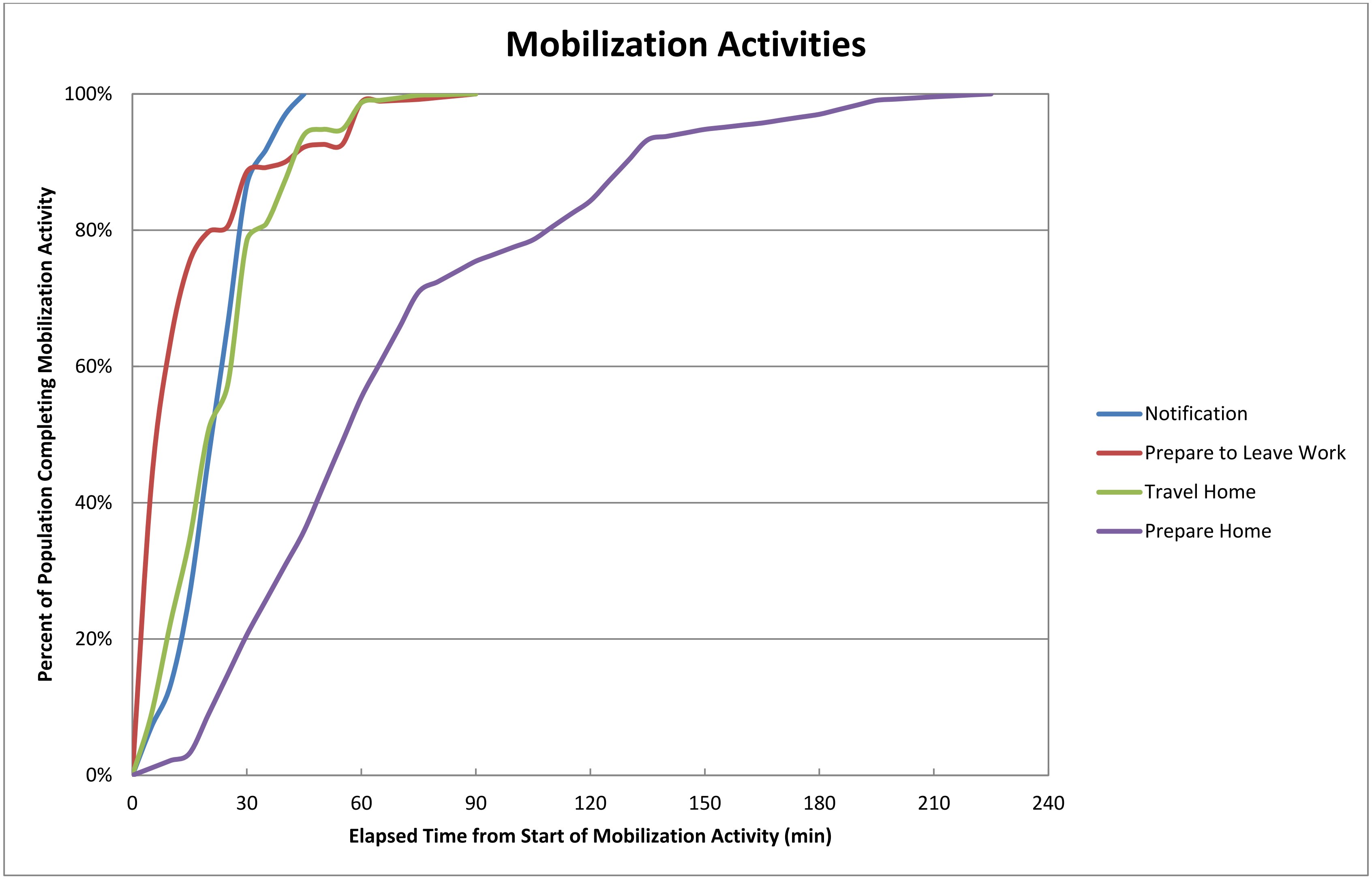


Figure 5-2. Time Distributions for Evacuation Mobilization Activities

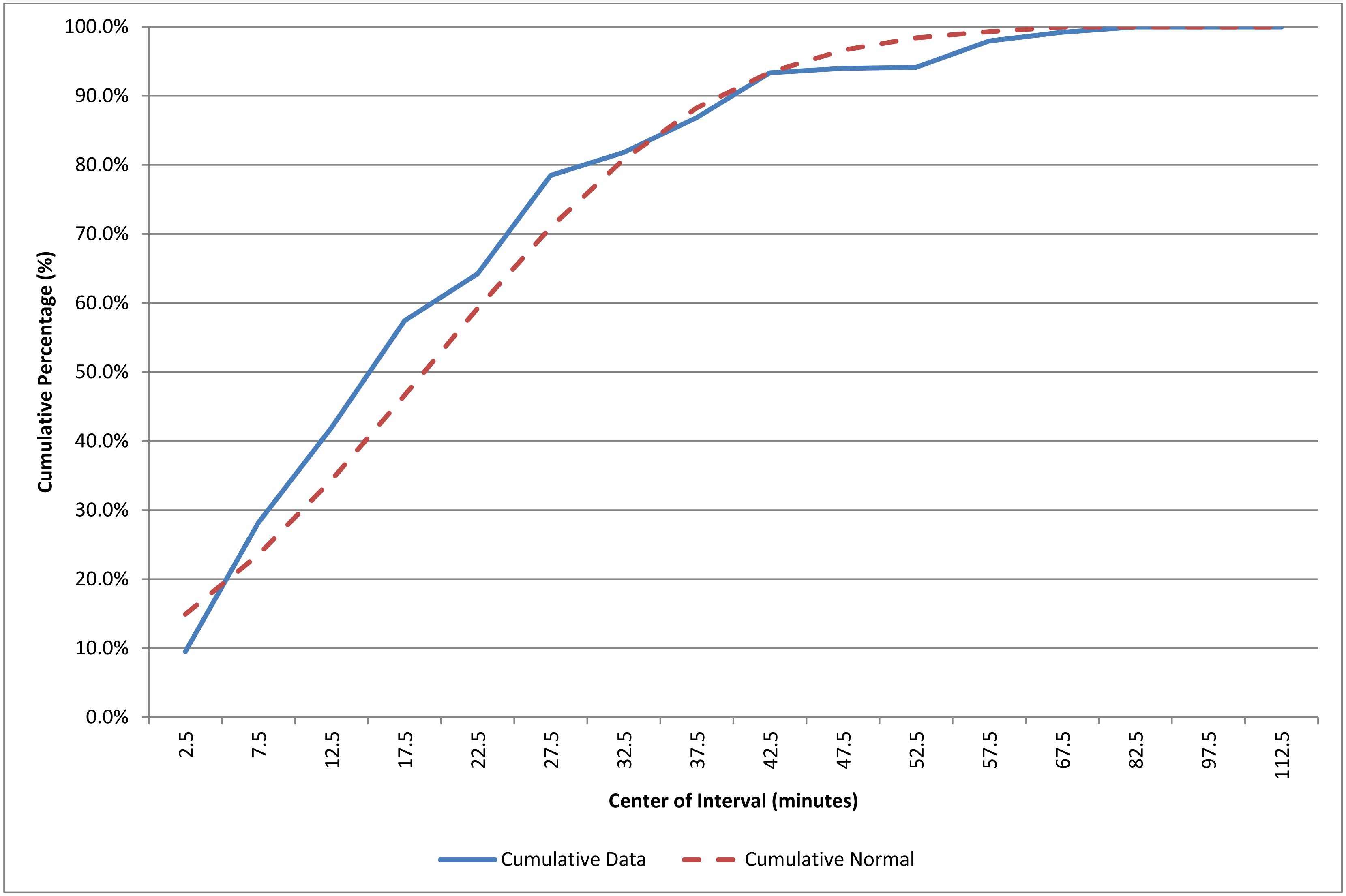


Figure 5-3. Comparison of Data Distribution and Normal Distribution

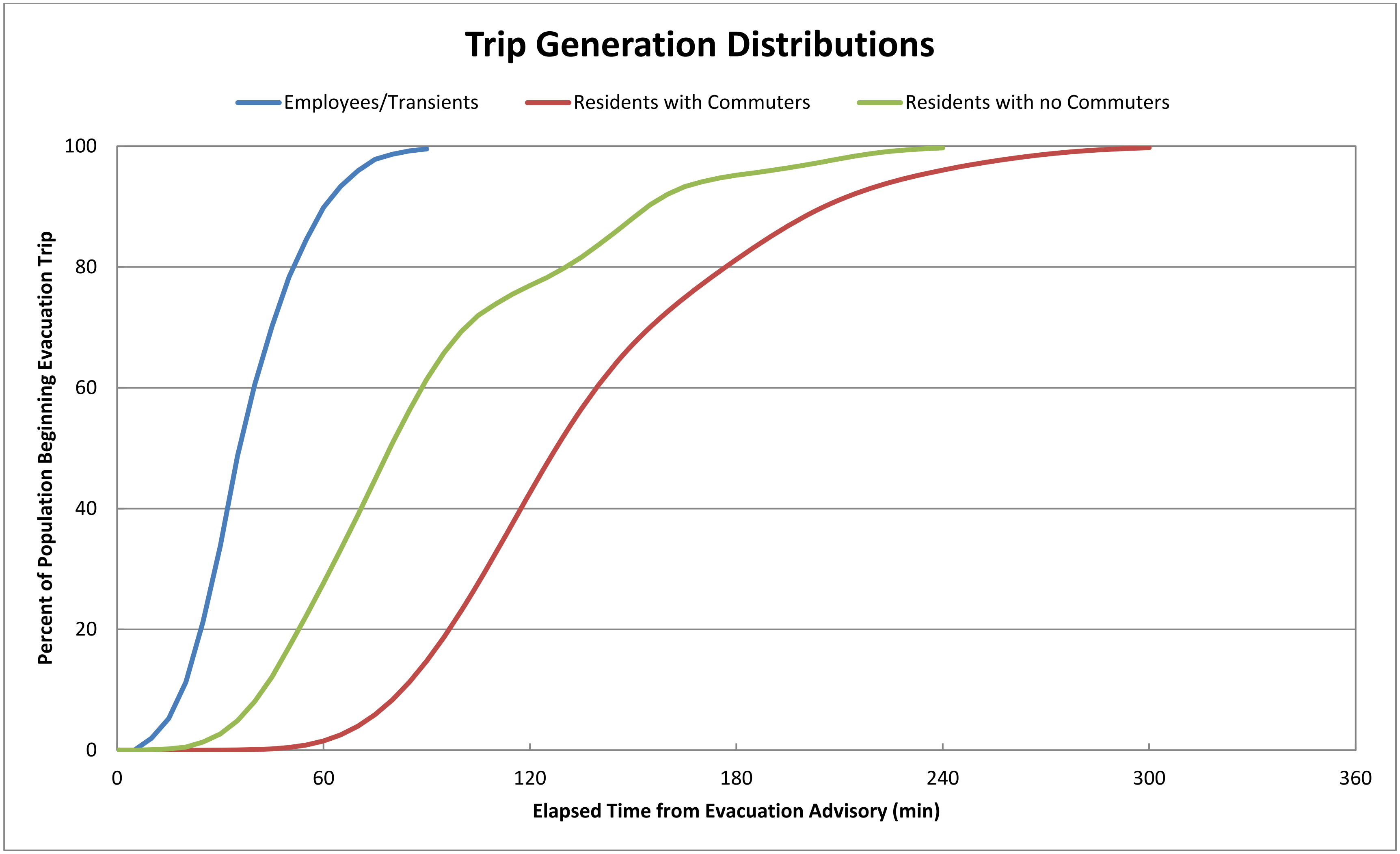


Figure 5-4. Comparison of Trip Generation Distributions

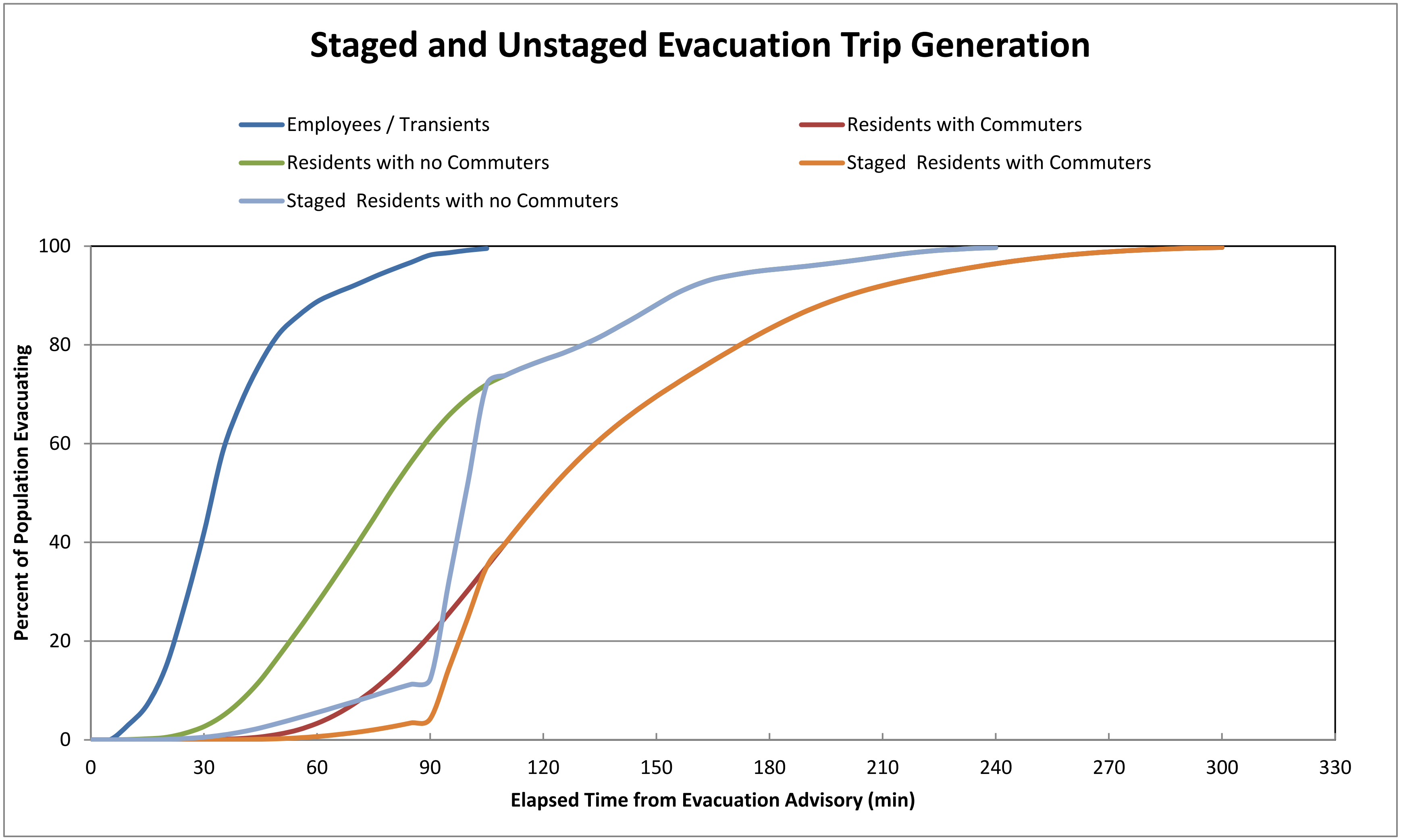


Figure 5-5. Comparison of Staged and Un-staged Trip Generation Distributions in the 2 to 5 Mile Region

6 EVACUATION CASES

An evacuation "case" defines a combination of Evacuation Region and Evacuation Scenario. The definitions of "Region" and "Scenario" are as follows:

Region A grouping of contiguous evacuating Zones that forms either a "keyhole" sector-based area, or a circular area within the EPZ, that must be evacuated in response to a radiological emergency.

Scenario A combination of circumstances, including time of day, day of week, season, and weather conditions. Scenarios define the number of people in each of the affected population groups and their respective mobilization time distributions.

A total of 37 Regions were defined which encompass all the groupings of Zones considered. These Regions are defined in Table 6-1. The Zone configurations are identified in Figure 6-1. Each keyhole sector-based area consists of a central circle centered at the power plant, and three adjoining sectors, each with a central angle of 22.5 degrees, as per NUREG/CR-7002, Rev. 1 guidance. The central sector coincides with the wind direction. These sectors extend to 5 miles from the plant (Regions R04 through R12) or to the EPZ boundary (Regions R13 through R27).

Regions R01, R02 and R03 represent evacuations of circular areas with radii of 2, 5 and 10 miles, respectively. Regions R28 through R37 are identical to Regions R02 and R04 through R12, respectively; however, those Zones between 2 miles and 5 miles are staged until 90% of the 2-mile region (Region R01) has evacuated.

Each Zone that intersects the keyhole is included in the Region; however, there are instances when a small portion (a "sliver") of a Zone is within the keyhole and the population within that small portion is low (500 people or 10% of the Zone population, whichever is less). Under those circumstances, the Zone would not be included in the Region so as to not evacuate large numbers of people outside of the keyhole for a small number of people that are actually in the keyhole. For example, in Region R19, there is a very small area (0.47 square miles) of Zone K within the keyhole. There are 19 people within the small area of Zone K within the keyhole, versus approximately 714 residents living in all of Zone K. Zone K is not included in Region R19 because there are 19 people, or 2.7% of the Zone population, within the keyhole. It would not be prudent to evacuate 714 people that are not within the keyhole because 19 people are within the keyhole.

A total of 14 Scenarios were evaluated for all Regions. Thus, there are a total of 37 x 14 = 518 evacuation cases. Table 6-2 provides a description of all Scenarios.

Each combination of region and scenario implies a specific population to be evacuated. The population and vehicle estimates presented in Section 3 and in Appendix E are peak values. These peak values are adjusted depending on the scenario and region being considered, using scenario and region specific percentages, such that the average population is considered for

each evacuation case. The scenario percentages are presented in Table 6-3, while the regional percentages are provided in Table H-1. The percentages presented in Table 6-3 were determined as follows:

The number of residents with commuters during the week (when workforce is at its peak) is equal to 31%, which is the product of 55% (the number of households with at least one commuter) and 57% (the number of households with a commuter that would await the return of the commuter prior to evacuating). See assumption 3 in Section 2.3. It is estimated for weekend and evening scenarios that 10% of households with returning commuters will have a commuter at work during those times.

Employment is assumed to be at its peak (100%) during the winter, midweek, midday scenarios. Employment is reduced slightly (96%) for summer, midweek, midday scenarios. This is based on the estimation that 50% of the employees commuting into the EPZ will be on vacation for a week during the approximate 12 weeks of summer. It is further estimated that those taking vacation will be uniformly dispersed throughout the summer with approximately 4% of employees vacationing each week. It is further estimated that only 10% of the employees are working in the evenings and during the weekends.

Transient activity is estimated to be at its peak (100%) during summer weekends and less (75%) during the week due to the large number of parks that are at reducing occupancy during the week. As shown in Appendix E, there are many campgrounds and lodging facilities offering overnight accommodations in the EPZ, offset by other transient facilities in which evening use is minimal (parks and community centers); thus, evening transient activity is estimated to be 50% for summer and 20% for winter since fewer facilities are open in the winter than the summer. Transient activity on winter weekends is estimated to be 50% and less (25%) during the week.

As noted in the shadow footnote to Table 6-3, the shadow percentages are computed using a base of 20% (see assumption 7 in Section 2.2); to include the employees within the Shadow Region who may choose to evacuate, the voluntary evacuation is multiplied by a scenario-specific proportion of employees to permanent residents in the Shadow Region. For example, using the values provided in Table 6-4 for Scenario 6, the shadow percentage is computed as follows:

$$20\% \times \left(1 + \frac{8{,}504}{23{,}799 + 52{,}241}\right) = 22\%$$

One special event – Fourth of July on Jordan Lake – was considered as Scenario 13. Thus, the special event traffic is 100% evacuated for Scenario 13, and 0% for all other scenarios.

Based on data provided by county emergency management agencies in 2012, summer school enrollment is approximately 28% of enrollment during the regular school year for midweek, midday scenarios. School is not in session during weekends and evenings, thus no buses for school children are needed under those circumstances. As discussed in Section 7, schools are in

session during the winter season, midweek, midday and 100% of buses will be needed under those circumstances.

Transit buses for the transit-dependent population and medical facility population are set to 100% for all scenarios as it is assumed that the transit-dependent and medical facility population are present in the EPZ at all times.

External traffic is estimated to be reduced by 60% during evening scenarios and is 100% for all other scenarios.

Table 6-1. Description of Evacuation Regions

Region	Description	Site PAR Description	Zone A	B	C	D	E	F	G	H	I	J	K	L	M	N
R01	2-Mile Radius	2-Mile Radius	x													
R02	5-Mile Radius	5-Mile Radius	x	x	x	x							x	x		
R03	Full EPZ	10-Mile Radius	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Evacuate 2-Mile Radius and Downwind to 5 Miles																
Region	**Wind Direction From:**	**Site PAR Description**	**Zone A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**
R04	NNW, N	327° - 010°	x			x							x			
R05	NNE, NE	011° - 056°	x										x			
R06	ENE, E, ESE	057° - 124°	x										x	x		
R07	SE, SSE, S	125° - 191°	x	x										x		
R08	SSW	192° - 214°	x	x												
R09	SW, WSW	215° - 259°	x	x	x											
R10	W	260° - 281°	x		x											
R11	WNW	282° - 304°	x		x	x										
R12	NW	305° - 326°	x			x										
Evacuate 2-Mile Radius and Downwind to the EPZ Boundary																
Region	**Wind Direction From:**	**Site PAR Description**	**Zone A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**
R13	N	348° - 010°	x			x				x	x		x			
R14	NNE	011° - 034°	x							x	x	x	x			
R15	NE	035° - 056°	x								x	x	x		x	
R16	ENE	057° - 079°	x								x	x	x	x	x	
R17	E	080° - 101°	x									x	x	x	x	
R18	ESE	102° - 124°	x									x	x	x	x	x
R19	SE	125° - 146°	x	x										x	x	x
R20	SSE, S	147° - 191°	x	x			x							x	x	x
R21	SSW	192° - 214°	x	x			x							x		x
R22	SW	215° - 236°	x	x	x		x	x								
R23	WSW	237° - 259°	x	x	x		x	x	x							
R24	W	260° - 281°	x	x	x	x	x	x	x							
R25	WNW	282° - 304°	x		x	x		x	x	x						
R26	NW	305° - 326°	x		x	x			x	x			x			
R27	NNW	327° - 347°	x			x			x	x			x			
Staged Evacuation - 2-Mile Radius Evacuates, then Evacuate Downwind to 5 Miles																
Region	**Wind Direction From:**	**Site PAR Description**	**Zone A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**
R28	-	5-Mile Radius	x	x	x	x							x	x		
R29	NNW, N	327° - 010°	x			x							x			
R30	NNE, NE	011° - 056°	x										x			
R31	ENE, E, ESE	057° - 124°	x										x	x		
R32	SE, SSE, S	125° - 191°	x	x										x		
R33	SSW	192° - 214°	x	x												
R34	SW, WSW	215° - 259°	x	x	x											
R35	W	260° - 281°	x		x											
R36	WNW	282° - 304°	x		x	x										
R37	NW	305° - 326°	x			x										

Shelter-in-Place until 90% ETE for R01, then Evacuate | Zone(s) Shelter-in-Place | Zone(s) Evacuate

Table 6-2. Evacuation Scenario Definitions

Scenario	Season[1]	Day of Week	Time of Day	Weather	Special
1	Summer	Midweek	Midday	Good	None
2	Summer	Midweek	Midday	Rain	None
3	Summer	Weekend	Midday	Good	None
4	Summer	Weekend	Midday	Rain	None
5	Summer	Midweek, Weekend	Evening	Good	None
6	Winter	Midweek	Midday	Good	None
7	Winter	Midweek	Midday	Rain	None
8	Winter	Midweek	Midday	Ice	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Rain	None
11	Winter	Weekend	Midday	Ice	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Summer	Midweek, Weekend	Evening	Good	Fourth of July on Jordan Lake
14	Summer	Midweek	Midday	Good	Roadway Impact – Lane Closures on US-1 and US-64

[1] Winter means that school is in session at normal enrollment levels (also applies to spring and autumn). Summer means that school is in session at summer school enrollment levels (lower than normal enrollment).

Table 6-3. Percent of Population Groups Evacuating for Various Scenarios

Scenario	Households With Returning Commuters	Households Without Returning Commuters	Employees	Transients	Shadow	Special Event	Medical Facilities	School Buses	Transit Buses	External Through Traffic
1	31%	69%	96%	75%	22%	0%	100%	28%	100%	100%
2	31%	69%	96%	75%	22%	0%	100%	28%	100%	100%
3	3%	97%	10%	100%	20%	0%	100%	0%	100%	100%
4	3%	97%	10%	100%	20%	0%	100%	0%	100%	100%
5	3%	97%	10%	50%	20%	0%	100%	0%	100%	40%
6	31%	69%	100%	25%	22%	0%	100%	100%	100%	100%
7	31%	69%	100%	25%	22%	0%	100%	100%	100%	100%
8	31%	69%	100%	25%	22%	0%	100%	100%	100%	100%
9	3%	97%	10%	50%	20%	0%	100%	0%	100%	100%
10	3%	97%	10%	50%	20%	0%	100%	0%	100%	100%
11	3%	97%	10%	50%	20%	0%	100%	0%	100%	100%
12	3%	97%	10%	20%	20%	0%	100%	0%	100%	40%
13	3%	97%	10%	50%	20%	100%	100%	0%	100%	40%
14	31%	69%	96%	75%	22%	0%	100%	28%	100%	100%

Resident Households with Commuters....... Households of EPZ residents who await the return of commuters prior to beginning the evacuation trip.
Resident Households with No Commuters . Households of EPZ residents who do not have commuters or will not await the return of commuters prior to beginning the evacuation trip.
Employees.. EPZ employees who live outside the EPZ
Transients .... People who are in the EPZ at the time of an accident for recreational or other (non-employment) purposes.
Shadow .... Residents and employees in the shadow region (outside of the EPZ) who will spontaneously decide to relocate during the evacuation. The basis for the values shown is a 20% relocation of shadow residents along with a proportional percentage of shadow employees.
Special Event .... Additional vehicles in the EPZ due to the identified special event.
Medical, School and Transit Buses .... Vehicle-equivalents present on the road during evacuation servicing schools and transit-dependent people (1 bus is equivalent to 2 passenger vehicles).
External Through Traffic .... Traffic on interstates/freeways and major arterial roads at the start of the evacuation. This traffic is stopped by security road blocks 120 minutes after the evacuation begins.

Table 6-4. Vehicle Estimates by Scenario

Scenario	Households With Returning Commuters	Households Without Returning Commuters	Employees	Transients	Shadow	Special Event	Medical Facilities	School Buses	Transit Buses	External Through Traffic	Total Scenario Vehicles
1	23,799	52,241	8,164	4,361	27,266	-	93	391	92	24,344	140,751
2	23,799	52,241	8,164	4,361	27,266	-	93	391	92	24,344	140,751
3	2,380	73,660	850	5,814	24,898	-	93	-	92	24,344	132,131
4	2,380	73,660	850	5,814	24,898	-	93	-	92	24,344	132,131
5	2,380	73,660	850	2,907	24,898	-	93	-	92	9,738	114,618
6	23,799	52,241	8,504	1,454	27,377	-	93	1,396	92	24,344	139,300
7	23,799	52,241	8,504	1,454	27,377	-	93	1,396	92	24,344	139,300
8	23,799	52,241	8,504	1,454	27,377	-	93	1,396	92	24,344	139,300
9	2,380	73,660	850	2,907	24,898	-	93	-	92	24,344	129,224
10	2,380	73,660	850	2,907	24,898	-	93	-	92	24,344	129,224
11	2,380	73,660	850	2,907	24,898	-	93	-	92	24,344	129,224
12	2,380	73,660	850	1,163	24,898	-	93	-	92	9,738	112,874
13	2,380	73,660	850	2,907	24,898	3,145	93	-	92	9,738	117,763
14	23,799	52,241	8,164	4,361	27,266	-	93	391	92	24,344	140,751

Note: Vehicle estimates are for an evacuation of the entire EPZ (Region R03)

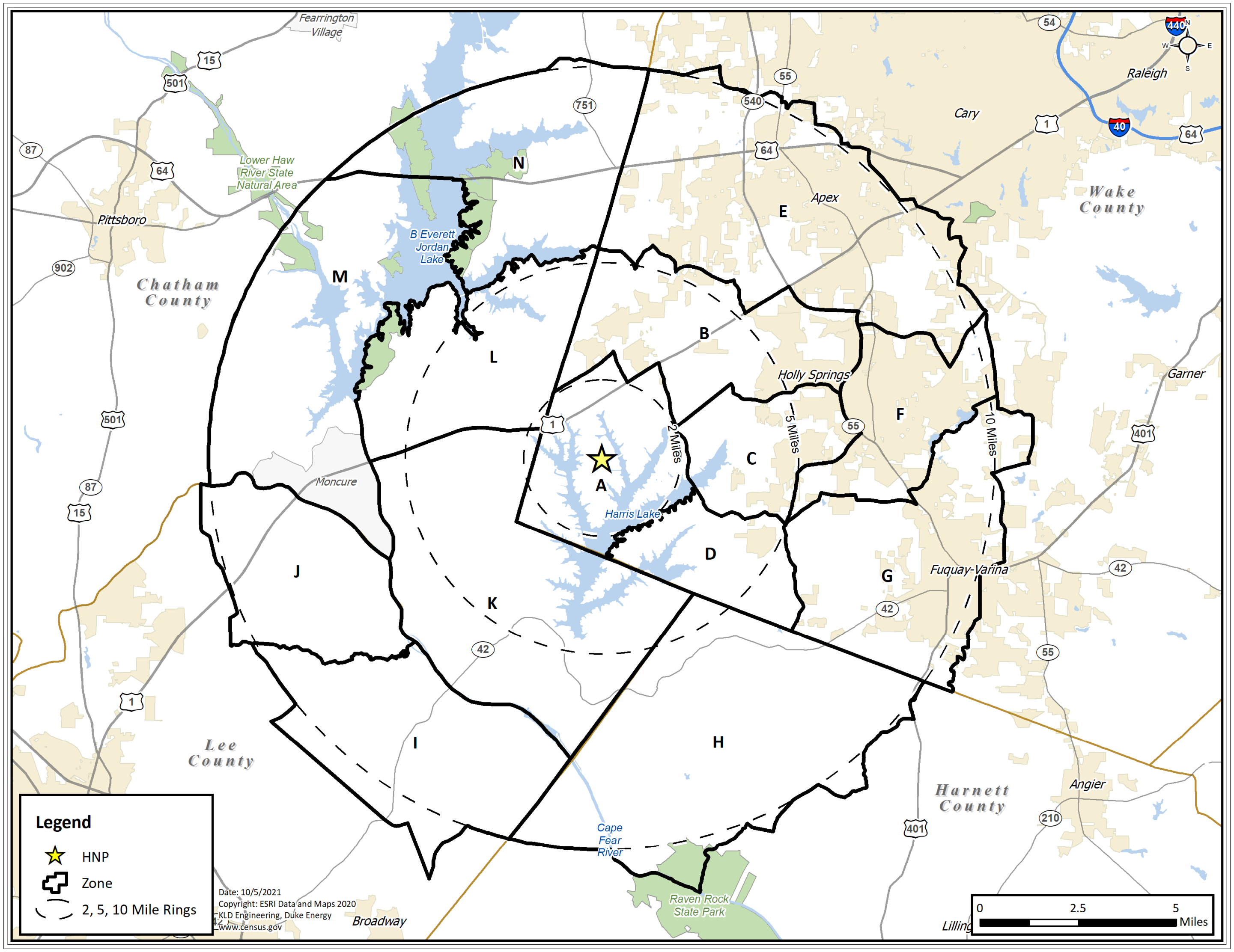


Figure 6-1. HNP EPZ Zones

7 GENERAL POPULATION EVACUATION TIME ESTIMATES (ETE)

This section presents the ETE results of the computer analyses using the DYNEV II System described in Appendices B, C and D. These results cover 37 regions within the HNP EPZ and the 14 Evacuation Scenarios discussed in Section 6.

The ETE for all Evacuation Cases are presented in Table 7-1 and Table 7-2. These tables present the estimated times to clear the indicated population percentages from the Evacuation Regions for all Evacuation Scenarios. The ETE of the 2-Mile region in both staged and un-staged regions are presented in Table 7-3 and Table 7-4. Table 7-5 defines the Evacuation Regions considered. The tabulated values of ETE are obtained from the DYNEV II System outputs which are generated at 5-minute intervals.

7.1 Voluntary Evacuation and Shadow Evacuation

"Voluntary evacuees" are permanent residents within the EPZ in Zones for which an Advisory to Evacuate (ATE) has not been issued, yet who elect to evacuate. "Shadow evacuation" is the voluntary outward movement of some permanent residents from the Shadow Region (outside the EPZ) for whom no protective action recommendation has been issued. Both voluntary and shadow evacuations are assumed to take place over the same time frame as the evacuation from within the impacted Evacuation Region.

The ETE for the HNP EPZ addresses the issue of voluntary evacuees in the manner shown in Figure 7-1. Within the EPZ, 20 percent of permanent residents located in Zones outside of the evacuation region who are not advised to evacuate, are assumed to elect to evacuate. Similarly, it is assumed that 20 percent of those permanent residents in the Shadow Region will choose to leave the area.

Figure 7-2 presents the area identified as the Shadow Region. This region extends radially from the plant to cover a region between the EPZ boundary and approximately 15 miles. The population and number of evacuating vehicles in the Shadow Region were estimated using the same methodology that was used for permanent residents within the EPZ (see Section 3.1). As discussed in Section 3.2, it is estimated that a total of 251,783 people reside in the Shadow Region; 20 percent of them would evacuate. See Table 6-4 for the number of evacuating vehicles from the Shadow Region.

Traffic generated within this Shadow Region (including external-external traffic), traveling away from the HNP, has the potential for impeding evacuating vehicles from within the Evacuation Region. All ETE calculations include this shadow traffic movement.

7.2 Staged Evacuation

As defined in NUREG/CR-7002 Rev.1, staged evacuation consists of the following:

1. Zones comprising the 2 mile region are advised to evacuate immediately.

2. Zones comprising regions extending from 2 to 5 miles downwind are advised to shelter in-place while the 2 mile region is cleared.
3. As vehicles evacuate the 2 mile region, people from 2 to 5 miles downwind continue preparation for evacuation while they shelter.
4. The populations sheltering in the 2 to 5 mile region are advised to begin evacuating when approximately 90 percent of those originally within the 2 mile region evacuate across the 2 mile region boundary.
5. Non-compliance with the shelter recommendation is the same as the shadow evacuation percentage of 20 percent.

See Section 5.4.2 for additional information on staged evacuation.

7.3 Patterns of Traffic Congestion during Evacuation

Figure 7-3 through Figure 7-9 illustrate the patterns of traffic congestion that arise for the case when the entire EPZ (Region R03) is advised to evacuate during the summer, midweek, midday period under good weather conditions (Scenario 1).

Traffic congestion, as the term is used here, is defined as Level of Service (LOS) F. LOS F is defined as follows (HCM 2016, page 5-5):

> The HCM uses LOS F to define operations that have either broken down (i.e., demand exceeds capacity) or have reached a point that most users would consider unsatisfactory, as described by a specified service measure value (or combination of service measure values). However, analysts may be interested in knowing just how bad the LOS F condition is, particularly for planning applications where different alternatives may be compared. Several measures are available for describing individually, or in combination, the severity of a LOS F condition:
>
> • *Demand-to-capacity ratios* describe the extent to which demand exceeds capacity during the analysis period (e.g., by 1%, 15%).
>
> • *Duration of LOS F* describes how long the condition persists (e.g., 15 min, 1 h, 3 h).
>
> • *Spatial extent measures* describe the areas affected by LOS F conditions. They include measures such as the back of queue and the identification of the specific intersection approaches or system elements experiencing LOS F conditions.

All highway "links" which experience LOS F are delineated in these figures by a thick red line; all others are lightly indicated. Congestion develops rapidly around concentrations of population and traffic bottlenecks.

Figure 7-3 displays congestion patterns within the study area at 30 minutes after the ATE. The snapshot shows people beginning to mobilize. There is already significant traffic volume in each of the three major population centers (Apex, Holly Springs, and Fuquay-Varina) in the EPZ, as indicated by the prevalence of colored links. This is to be expected as the population density in

these areas is high. Within the Apex area, there is moderate traffic congestion (LOS D) on SR-55/E Williams St, S Salem St and Old Raleigh Rd. US-1 exhibits LOS F conditions near the intersections with Center St/Ten Ten Rd. Avent Ferry Rd eastbound and SR-55 northbound are operating at LOS F within Holly Springs. SR-55 Bypass experiences moderate traffic congestion as well (LOS D). SR-55 southbound, Judd Pkwy and US-401/N Main St exhibit congestion and LOS F conditions within Fuquay-Varina. NC-42 operates at LOS E leaving the city limits. US-1 is the only roadway showing LOS B conditions within the 2-mile region. Only the eastern portion of Zone C, along Avent Ferry Rd and SR-55, exhibit LOS D or worse in the 5-mile region.

At 1 hour after the ATE, Figure 7-4 indicates that traffic congestion within the study area has intensified. At this time, approximately 11 percent of evacuees have mobilized and approximately 22 percent of vehicles have evacuated the EPZ. The significant congestion in Holly Springs creates a ‘clog in the pipe’ for evacuees attempting to leave the 5-mile region and delays their evacuation. Nearly all of the major evacuation routes servicing the three major population centers within the EPZ are experiencing LOS F conditions. Several roads in the Shadow Region are also operating at LOS F, including Holland Rd, Hilltop Needmore Rd, and US-401 eastbound leaving Fuquay-Varina, Optimist Farm Rd, and Holly Springs Rd eastbound leaving Holly Springs, and US-64/US-1 eastbound leaving Apex. Slight congestion in the 2-mile region remains only on US-1 (LOS B or better). Congestion within the 5-mile region has worsened as traffic backs up on Avent Ferry Rd and New Hill Rd on the eastern and northern boundaries of Zone C, as well as in northwest Holly Springs (near Twelve Oaks) in the eastern portion of Zone B.

At 2 hours after the ATE, as displayed in Figure 7-5, traffic congestion in the study area peaks within significant congestion in Apex, Holly Springs, Fuquay-Varina and within the Shadow Region adjacent to these population centers. At this point, external traffic can no longer enter the EPZ. All routes leaving the three population centers are heavily congested, except for NC-540. The ramps giving access to NC-540 meter the traffic that is able to utilize the roadway. As a result, significant congestion does not develop on NC-540. Many roads in the Shadow Region are operating at LOS F, including US-401 (in both directions), SR-55, E Williams St, Rawls Church Rd, Optimist Farm Rd, Holly Springs Rd, US-1/US-64, and a number of roadways in Cary. These congestion patterns reflect the large number of evacuating vehicles emanating from the three population centers, and the density of shadow evacuees in the outskirts of Raleigh, trying to access the major evacuation routes – US-1, US-64, US-401, I-40, I-440 and I-540 – leaving the area. Slight congestion in the 2-mile region remains only on US-1 (LOS B or better). Congestion within Zone B has somewhat dissipated. Congestion within Zone C along SR-55 and Avent Ferry Rd has worsened in the 5-mile region. Again, the significant congestion beyond the 5-mile region delays the evacuation of those within 5 miles of HNP.

Figure 7-6 displays the congestion patterns at 3 hours after the ATE. At this point, approximately 95 percent of vehicles have mobilized and 84 percent of vehicles have evacuated the EPZ. Traffic congestion in Apex and Holly Springs is dissipating, with only a few routes operating at LOS F. All major evacuation routes in the City of Fuquay-Varina are still operating at LOS F. Pronounced congestion persists within Fuquay-Varina due to the limited capacity of the signalized intersections along US-401 and the pronounced traffic volume on competing approaches to the intersections. Significant congestion also remains in the shadow region east of the EPZ as

evacuees continue to travel away from HNP. It should be noted that all roadways west of Apex, Holly Springs and Fuquay-Varina are operating at LOS A. All congestion has cleared within the 2-mile region and within 5-miles of HNP. Congestion remains on Avent Ferry Rd and NC-55 within the 5-mile region.

Figure 7-7 displays the patterns of congestion at 4 hours after the ATE. At this time, 99 percent of vehicles have mobilized and approximately 97 percent of vehicles have successfully evacuated the study area. Traffic congestion has cleared in Apex and Holy Springs (with the exception of a small section of roadway on Holly Springs Rd. Congestion continues to dissipate in Fuquay-Varina. US-401 north/southbound still exhibits LOS F conditions within the EPZ. In the Shadow Region east of Holly Springs, US-401 north/southbound and several minor roads used to gain access to US-401 (Bells Lake Rd, Ten-Ten Rd, Optimist Farm Rd, and Johnson Pond Rd) are still exhibiting LOS F conditions. A number of roadways (Angier Rd, Atkins Rd, Holland Rd, SR-55, Rawls Church Rd, Purfoy Rd and E Williams St) leaving Fuquay-Varina continue to operate at LOS F. The congestion exhibited within Harnett County is largely due to vehicles evacuating southbound from Wake County.

Figure 7-8 displays the congestion patterns at 4 hours and 30 minutes after the ATE. The last area in the EPZ to exhibit LOS F conditions is along US-401 southbound leaving Fuquay-Varina. Congestion remains in the Shadow Region along US-401 northbound, Optimist Farm Rd and roadways south of Fuquay-Varina. At this time, approximately 99 percent vehicles have mobilized and 99 percent of vehicles have successfully evacuated the area at this time. This congestion clears at about 4 hours and 50 minutes after the ATE.

Congestion patterns at 5 hours and 10 minutes after the ATE, at the 100th percentile ETE, are shown in Figure 7-9. At this time, all evacuees have mobilized and successfully evacuated the area. Congestion continues to remain within the Shadow Region along US-401, Rawls Church Rd, E Williams St, Atkins Rd, Purfoy Rd and SR-55.

7.4 Evacuation Rates

Evacuation is a continuous process, as implied by Figure 7-10 through Figure 7-23. These figures display the rate at which traffic flows out of the indicated areas for the case of an evacuation of the full EPZ (Region R03) under the indicated conditions. One figure is presented for each scenario considered.

As indicated in Figure 7-10, there is typically a long "tail" to these distributions. Vehicles begin to evacuate an area slowly at first, as people respond to the ATE at different rates. Then traffic demand builds rapidly (slopes of curves increase). When the system becomes congested, traffic exits the EPZ at rates somewhat below capacity until some evacuation routes have cleared. As more routes clear, the aggregate rate of egress slows since many vehicles have already left the EPZ. Towards the end of the process, relatively few evacuation routes service the remaining demand.

This decline in aggregate flow rate, towards the end of the process, is characterized by these curves flattening and gradually becoming horizontal. Ideally, it would be desirable to fully

saturate all evacuation routes equally so that all will service traffic near capacity levels and all will clear at the same time. For this ideal situation, all curves would retain the same slope until the end of mobilization time – thus minimizing evacuation time. In reality, this ideal is generally unattainable reflecting the spatial variation in population density, mobilization rates and in highway capacity over the EPZ.

7.5 Evacuation Time Estimate (ETE) Results

Table 7-1 through Table 7-2 present the ETE values for all 37 Evacuation Regions and all 14 Evacuation Scenarios. Table 7-3 through Table 7-4 present the ETE values for the 2-mile region for both staged and un-staged keyhole regions downwind to 5 miles. They are organized as follows:

Table	Contents
7-1	ETE represents the elapsed time required for 90 percent of the population within a Region, to evacuate from that Region. All Scenarios are considered, as well as Staged Evacuation scenarios.
7-2	ETE represents the elapsed time required for 100 percent of the population within a Region, to evacuate from that Region. All Scenarios are considered, as well as Staged Evacuation scenarios.
7-3	ETE represents the elapsed time required for 90 percent of the population within the 2-mile Region, to evacuate from the 2-mile Region with both Concurrent and Staged Evacuations of additional Zones downwind in the keyhole Region.
7-4	ETE represents the elapsed time required for 100 percent of the population within the 2-mile Region, to evacuate from the 2-mile Region with both Concurrent and Staged Evacuations of additional Zones downwind in the keyhole Region.

The animation snapshots described above reflect the ETE statistics for the concurrent (un-staged) evacuation scenarios and regions, which are displayed in Figure 7-3 through Figure 7-9. Nearly all of the traffic congestion is located beyond the 5-mile radius; this is reflected in the ETE statistics:

- The 2-Mile Region (R01) consists of mostly plant employees and transients. There is no congestion within this region, which means that ETE is dictated by mobilization time. As such, the 90th percentile ETE for this region is between 1:20 (hr:min) and 1:35 for all scenarios (except the winter evening scenario) which mimics the rapidly mobilizing employees and transients. During winter evenings, employee and transient population is low (see Section 6) and the more-slowly-mobilizing residents make up a higher percentage of evacuating traffic. As a result, the 90th percentile ETE takes longer to reach and the ETE for this scenario is at most 30 minutes longer when compared to winter non-evening scenarios.

- The 5-Mile Region (R02) has no congestion except for Avent Ferry Rd and SR-55 in Holly Springs, as discussed above. R02 has many more resident vehicles than R01, which increases the mobilization time (see Figure 5-4 – mobilization time is longer for residents than for employees and transients). As a result, the 90th percentile ETE for Region R02 ranges between 2:20 and 2:35 and is dictated by the time to mobilize rather than congestion within the 5-mile region.
- The 90th percentile ETE for Region R03 (full EPZ) are at most 1 hour and 15 minutes longer than the R02, due to the congestion beyond the 5-mile radius. The 90th percentile ETE range between 3:10 and 3:45.
- The 100th percentile ETE for the full EPZ is greater than mobilization time for inclement weather scenarios due to the slower speeds and reduced roadway capacity. The ETE for all other scenarios mimic mobilization time as there are no speed and capacity reductions. The 100th percentile ETE range from 5:10 (mobilization time plus 10 minutes to travel out of the EPZ) to 5:40.

Comparison of Scenarios 5 and 13 in Table 7-1 indicates that the Special Event – Fourth of July fireworks on Jordan Lake – has minimal impact for the 90th (at most 10 minutes) and does not impact 100th percentile ETE. As shown in Figure 7-3 through Figure 7-9 and discussed in Section 7.3, the congestion within the EPZ is predominantly to the north and east of the plant near the major population centers. The additional 3,145 vehicles present for the special event are located west of the plant and predominantly travel north on Beaver Creek Rd and west on US-64 to evacuate the EPZ. There is sufficient capacity on US-64 westbound to service these additional vehicles, which explains why ETE are not affected.

Comparison of Scenarios 1 and 14 in Table 7-1 indicates that the roadway closure – one lane northbound on US-1 from just east of the interchange with New Hill Holleman Rd (Exit 89) to the interchange with I-40 (Exit 1A) and one lane eastbound on US-64 from New Hill Olive Chapel Rd/NC-751 to the interchange with US-1 (Exit 404A/B) – causes at most a 5 minute increase for the 90th percentile ETE and no impact on the 100th percentile ETE for all regions. As shown in Figure 7-3 through Figure 7-9, US-1 northbound operates below capacity (LOS F) in Apex near the periphery of the EPZ. Most of US-64 eastbound is also operating below capacity (LOS F at some signalized intersections). In the roadway impact and non-roadway impact cases, these roadways are operating at well below capacity. Thus, closing a lane does not have an impact. In addition, there are other alternate routes – most notably NC-55 northbound and NC-540 Toll eastbound which have available capacity to compensate for the loss of capacity on US-64 and US-1. Some vehicles reroute onto these roadways as a result of the lane closures on US-1 and US-64, offsetting any substantial increase in ETE. Also, the bottlenecks leaving Fuquay-Varina dictate the ETE for the EPZ, as shown in Figure 7-7 and Figure 7-8, not traffic congestion along US-1 or US-64.

7.6 Staged Evacuation Results

Table 7-3 and Table 7-4 present a comparison of the ETE compiled for the concurrent (un-staged) and staged evacuation studies. Note that Regions R28 through R37 are the same geographic areas

as Regions R02 and R04 through R12, respectively. The times shown in Table 7-3 and Table 7-4 are when the 2-mile region is 90 percent clear and 100 percent clear, respectively.

The objective of a staged evacuation is to show that the ETE for the 2-mile region can be reduced without significantly impacting the region between 2 miles and 5 miles. In all cases, as shown in these tables, the ETE for the 2-mile region is unchanged in the 90th and 100th percentile ETE when a staged evacuation is implemented for all scenarios.

As discussed in Section 7.3, there is no congestion within the 2-mile region and minimal congestion (small portion of Avent Ferry Rd and NC-55) in the 5-mile region. In addition, the congestion beyond 5 miles does not extend upstream to the extent that it penetrates within 2 miles of HNP, so evacuees from within the 2-mile region are not impeded. Therefore, staging the evacuation provides no benefits to evacuees from within the 2-mile region.

To determine the effect of staged evacuation on residents beyond the 2-mile region, the ETE for Regions R02 and R04 through R12 are compared to Regions R28 through R37, respectively, in Table 7-1 and Table 7-2. A comparison of ETE between these similar regions reveals that staging increases the 90th percentile ETE for those in the 2 to 5-mile area by at most 35 minutes (see Table 7-1). Staging has no impact on 100th percentile ETE beyond the 2-mile region.

The increase in the 90th percentile ETE is due to evacuating vehicles, beyond the 2-mile region, sheltering and delaying the start of their evacuation. As shown in Figure 5-5, staging the evacuation causes a significant "spike" (sharp increase) in mobilization (trip-generation rate) of evacuating vehicles.

In summary, the staged evacuation option provides no benefits to evacuees from within the 2-mile region, and adversely impacts some evacuees located beyond 2 miles from the plant.

7.7 Guidance on Using ETE Tables

The user first determines the percentile of population for which the ETE is sought (The NRC guidance calls for the 90th percentile). The applicable value of ETE within the chosen table may then be identified using the following procedure:

1. Identify the applicable **Scenario**:
   - Season
     - Summer
     - Winter (also Autumn and Spring)
   - Day of Week
     - Midweek
     - Weekend
   - Time of Day
     - Midday
     - Evening
   - Weather Condition
     - Good Weather
     - Rain
     - Ice

- Special Event
  - Fourth of July on Jordan Lake
- Roadway Impact – Lane Closure on US-1 and US-64
- Evacuation Staging
  - No, Staged Evacuation is not considered
  - Yes, Staged Evacuation is considered

While these Scenarios are designed, in aggregate, to represent conditions throughout the year, some further clarification is warranted:

- The conditions of a summer evening (either midweek or weekend) and rain are not explicitly identified in the Tables. For these conditions, Scenarios (2) and (4) apply.
- The conditions of a winter evening (either midweek or weekend) and rain are not explicitly identified in the Tables. For these conditions, Scenarios (7) and (10) for rain apply.
- The conditions of a winter evening (either midweek or weekend) and ice are not explicitly identified in the Tables. For these conditions, Scenarios (8) and (11) for ice apply.
- The seasons are defined as follows:
  - Summer assumes school is in session at summer school enrollment levels (lower than normal enrollment).
  - Winter (includes Spring and Autumn) considers that public schools are in session at normal enrollment levels.
- Time of Day: Midday implies the time over which most commuters are at work or are travelling to/from work.

2. With the desired percentile ETE and Scenario identified, now identify **the Evacuation Region:**
   - Determine the projected azimuth direction of the plume (coincident with the wind direction). This direction is expressed in terms of compass orientation – from N, NNE, NE – or in degrees.
   - Determine the distance that the Evacuation Region will extend from the nuclear power plant. The applicable distances and their associated candidate Regions are given below:
     - 2 Miles (Region R01)
     - To 5 Miles (Region R02, R04 through R12)
     - To EPZ Boundary (Regions R03, R13 through R27)
   - Enter Table 7-5 and identify the applicable group of candidate Regions based on the distance that the selected Region extends from the HNP. Select the Evacuation Region identifier in that row, based on the azimuth direction of the plume, from the first column of the Table.
3. Determine the ETE Table based on the percentile selected. Then, for the Scenario identified in Step 1 and the Region identified in Step 2, proceed as follows:
   - The columns of Table 7-1 through Table 7-4 are labeled with the Scenario numbers. Identify the proper column in the selected Table using the Scenario number defined in Step 1.

- Identify the row in this table that provides ETE values for the Region identified in Step 2.
- The unique data cell defined by the column and row so determined contains the desired value of ETE expressed in Hours:Minutes.

Example

It is desired to identify the ETE for the following conditions:

- Sunday, August 10th at 10:00 PM.
- It is raining.
- Wind direction is from the SE.
- Wind speed is such that the distance to be evacuated is judged to be a 2-Mile radius and downwind to 10 miles (to EPZ boundary).
- The desired ETE is that value needed to evacuate 90 percent of the population from within the impacted Region.
- A staged evacuation is not desired.

Table 7-1 is applicable because the 90th percentile ETE is desired. Proceed as follows:

1. Identify the Scenario as summer, weekend, evening and raining. Entering Table 7-1, it is seen that there is no match for these descriptors. However, the clarification given above assigns this combination of circumstances to **Scenario 4**.
2. Enter Table 7-5 and locate the Region described as "Evacuate 2-Mile Radius and Downwind to the EPZ Boundary" for wind direction from SE and read **Region R19** in the first column of that row.
3. Enter Table 7-1 to locate the data cell containing the value of ETE for Scenario 4 and Region R19. This data cell is in column (4) and in the row for Region R19; it contains the ETE value of **2:15**.

Table 7-1. Time to Clear the Indicated Area of *__90__* Percent of the Affected Population

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Ice	Good Weather	Rain	Ice	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region, 5-Mile Region, and EPZ														
R01	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R02	2:30	2:30	2:20	2:25	2:35	2:30	2:30	2:30	2:20	2:25	2:25	2:35	2:35	2:30
R03	3:25	3:35	3:15	3:20	3:10	3:30	3:30	3:45	3:10	3:20	3:35	3:15	3:10	3:30
2-Mile Region and Keyhole to 5 Miles														
R04	2:25	2:25	2:20	2:20	2:25	2:30	2:30	2:30	2:25	2:30	2:30	2:35	2:25	2:25
R05	2:15	2:15	2:15	2:15	2:25	2:20	2:20	2:25	2:25	2:25	2:25	2:30	2:25	2:15
R06	2:20	2:20	2:20	2:20	2:30	2:25	2:25	2:25	2:30	2:30	2:30	2:35	2:20	2:20
R07	2:15	2:15	2:10	2:15	2:20	2:15	2:15	2:20	2:10	2:15	2:15	2:20	2:20	2:20
R08	2:15	2:15	2:10	2:10	2:20	2:15	2:15	2:15	2:10	2:10	2:15	2:20	2:20	2:20
R09	2:30	2:30	2:20	2:20	2:35	2:30	2:30	2:30	2:20	2:20	2:25	2:35	2:35	2:30
R10	2:55	2:55	2:50	2:50	2:50	2:55	2:55	3:00	2:50	2:50	2:55	2:50	2:50	2:55
R11	2:55	2:55	2:50	2:55	2:50	2:55	2:55	3:00	2:50	2:55	2:55	2:50	2:50	2:55
R12	2:05	2:05	2:10	2:10	2:20	2:15	2:15	2:15	2:20	2:20	2:20	2:30	2:20	2:05
2-Mile Region and Keyhole to EPZ Boundary														
R13	2:50	2:50	2:35	2:35	2:40	2:50	2:55	2:55	2:40	2:40	2:40	2:40	2:40	2:50
R14	2:20	2:25	2:15	2:15	2:25	2:25	2:25	2:25	2:15	2:20	2:20	2:30	2:25	2:20
R15	2:20	2:20	2:15	2:15	2:20	2:20	2:20	2:25	2:15	2:20	2:20	2:25	2:15	2:20
R16	2:20	2:20	2:15	2:15	2:20	2:20	2:20	2:25	2:15	2:20	2:20	2:25	2:15	2:20
R17	2:15	2:20	2:15	2:15	2:20	2:20	2:20	2:25	2:15	2:15	2:20	2:20	2:15	2:15
R18	2:20	2:20	2:15	2:15	2:20	2:20	2:25	2:25	2:15	2:20	2:20	2:25	2:10	2:20
R19	2:15	2:20	2:15	2:15	2:20	2:20	2:20	2:20	2:15	2:15	2:20	2:25	2:15	2:20
R20	2:55	2:55	2:40	2:40	2:50	2:55	2:55	3:00	2:45	2:45	2:55	2:55	2:45	2:55
R21	2:55	2:55	2:40	2:40	2:50	2:55	2:55	3:00	2:45	2:45	2:55	2:50	2:45	2:55
R22	3:05	3:05	2:55	3:00	2:55	3:05	3:05	3:20	2:55	3:00	3:10	2:55	2:55	3:10
R23	3:20	3:30	3:15	3:15	3:15	3:20	3:35	3:45	3:10	3:15	3:30	3:10	3:10	3:25
R24	3:20	3:30	3:10	3:20	3:15	3:20	3:35	3:40	3:10	3:20	3:30	3:10	3:15	3:25
R25	3:50	3:55	3:25	3:40	3:25	3:40	3:50	4:10	3:30	3:40	3:55	3:20	3:25	3:50

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Region	**Midday**		**Midday**		**Evening**	**Midday**			**Midday**			**Evening**	**Evening**	**Midday**
	Good Weather	**Rain**	**Good Weather**	**Rain**	**Good Weather**	**Good Weather**	**Rain**	**Ice**	**Good Weather**	**Rain**	**Ice**	**Good Weather**	**Special Event**	**Roadway Impact**
R26	3:30	3:35	3:15	3:25	3:05	3:25	3:40	3:55	3:15	3:30	3:50	3:10	3:05	3:30
R27	3:20	3:30	3:15	3:30	3:05	3:20	3:35	3:55	3:10	3:25	3:40	3:05	3:05	3:20
Staged Evacuation - 2-Mile Region and Keyhole to 5 Miles														
R28	2:45	2:50	2:40	2:45	3:00	2:45	2:55	2:55	2:40	2:50	3:00	3:00	2:55	2:45
R29	2:25	2:25	2:20	2:20	2:25	2:30	2:30	2:30	2:25	2:30	2:30	2:35	2:25	2:25
R30	2:15	2:15	2:15	2:15	2:25	2:20	2:25	2:25	2:25	2:25	2:25	2:30	2:25	2:20
R31	2:20	2:20	2:20	2:20	2:30	2:25	2:25	2:25	2:30	2:30	2:30	2:35	2:20	2:25
R32	2:15	2:15	2:10	2:15	2:20	2:15	2:15	2:20	2:10	2:15	2:15	2:20	2:20	2:20
R33	2:15	2:15	2:10	2:10	2:20	2:15	2:15	2:15	2:10	2:15	2:15	2:20	2:20	2:20
R34	2:45	2:45	2:40	2:40	2:55	2:45	2:45	2:50	2:40	2:40	3:00	2:55	2:55	2:50
R35	3:20	3:25	3:20	3:25	3:20	3:20	3:25	3:30	3:20	3:25	3:30	3:25	3:20	3:20
R36	3:25	3:25	3:20	3:25	3:20	3:25	3:25	3:30	3:20	3:25	3:30	3:20	3:20	3:25
R37	2:05	2:05	2:10	2:10	2:20	2:15	2:15	2:15	2:20	2:20	2:20	2:30	2:20	2:05

Table 7-2. Time to Clear the Indicated Area of *100* Percent of the Affected Population

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Ice	Good Weather	Rain	Ice	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region, 5-Mile Region, and EPZ														
R01	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R02	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R03	5:10	5:15	5:10	5:10	5:10	5:10	5:15	5:40	5:10	5:10	5:30	5:10	5:10	5:10
2-Mile Region and Keyhole to 5 Miles														
R04	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R06	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R07	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R08	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R09	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R10	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R11	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R12	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
2-Mile Region and Keyhole to EPZ Boundary														
R13	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R14	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R15	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R16	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R17	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R18	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R19	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R20	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R21	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R22	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R23	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:20	5:10	5:10	5:10	5:10	5:10	5:10
R24	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:30	5:10	5:10	5:15	5:10	5:10	5:10
R25	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:40	5:10	5:10	5:25	5:10	5:10	5:10

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Ice	Good Weather	Rain	Ice	Good Weather	Special Event	Roadway Impact
R26	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:25	5:10	5:10	5:10	5:10	5:10	5:10
R27	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:25	5:10	5:10	5:10	5:10	5:10	5:10
Staged Evacuation - 2-Mile Region and Keyhole to 5 Miles														
R28	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R29	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R30	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R31	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R32	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R33	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R34	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R35	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R36	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R37	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05

Table 7-3. Time to Clear *90* Percent of the 2-Mile Region within the Indicated Region

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Ice	Good Weather	Rain	Ice	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region and 5-Mile Region														
R01	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R02	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
Un-staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R04	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R05	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R06	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R07	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R08	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R09	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R10	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R11	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R12	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
Staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R28	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R29	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R30	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R31	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R32	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R33	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R34	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R35	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R36	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20
R37	1:20	1:20	1:25	1:25	1:35	1:20	1:20	1:20	1:35	1:35	1:35	1:50	1:35	1:20

Table 7-4. Time to Clear *100* Percent of the 2-Mile Region within the Indicated Region

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Ice	Good Weather	Rain	Ice	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region and 5-Mile Region														
R01	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R02	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
Un-staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R04	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R05	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R06	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R07	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R08	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R09	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R10	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R11	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R12	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
Staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R28	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R29	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R30	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R31	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R32	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R33	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R34	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R35	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R36	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R37	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00

Table 7-5. Description of Evacuation Regions

Region	Description	Site PAR Description	Zone													
			A	B	C	D	E	F	G	H	I	J	K	L	M	N
R01	2-Mile Radius	2-Mile Radius	X													
R02	5-Mile Radius	5-Mile Radius	X	X	X	X							X	X		
R03	Full EPZ	10-Mile Radius	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Evacuate 2-Mile Radius and Downwind to 5 Miles																
Region	**Wind Direction From:**	**Site PAR Description**	**Zone**													
			A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**
R04	NNW, N	327° - 010°	X			X							X			
R05	NNE, NE	011° - 056°	X										X			
R06	ENE, E, ESE	057° - 124°	X										X	X		
R07	SE, SSE, S	125° - 191°	X	X										X		
R08	SSW	192° - 214°	X	X												
R09	SW, WSW	215° - 259°	X	X	X											
R10	Site Specific Region*		X		X											
R11	W, WNW	260° - 304°	X		X	X										
R12	NW	305° - 326°	X			X										
Evacuate 2-Mile Radius and Downwind to the EPZ Boundary																
Region	**Wind Direction From:**	**Site PAR Description**	**Zone**													
			A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**
R13	N	348° - 010°	X			X				X	X		X			
R14	NNE	011° - 034°	X							X	X	X	X			
R15	NE	035° - 056°	X								X	X	X		X	
R16	ENE	057° - 079°	X								X	X	X	X	X	
R17	E	080° - 101°	X									X	X	X	X	
R18	ESE	102° - 124°	X									X	X	X	X	X
R19	SE	125° - 146°	X	X										X	X	X
R20	SSE, S	147° - 191°	X	X			X							X	X	X
R21	SSW	192° - 214°	X	X			X							X		X
R22	SW	215° - 236°	X	X	X		X	X								
R23	WSW	237° - 259°	X	X	X		X	X	X							
R24	W	260° - 281°	X	X	X	X	X	X	X							
R25	WNW	282° - 304°	X		X	X		X	X	X						
R26	NW	305° - 326°	X		X	X			X	X			X			
R27	NNW	327° - 347°	X			X			X	X			X			
Staged Evacuation - 2-Mile Radius Evacuates, then Evacuate Downwind to 5 Miles																
Region	**Wind Direction From:**	**Site PAR Description**	**Zone**													
			A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**
R28	-	5-Mile Radius	X	X	X	X							X	X		
R29	NNW, N	327° - 010°	X			X							X			
R30	NNE, NE	011° - 056°	X										X			
R31	ENE, E, ESE	057° - 124°	X										X	X		
R32	SE, SSE, S	125° - 191°	X	X										X		
R33	SSW	192° - 214°	X	X												
R34	SW, WSW	215° - 259°	X	X	X											
R35	Site Specific Region*		X		X											
R36	W, WNW	260° - 304°	X		X	X										
R37	NW	305° - 326°	X			X										
Shelter-in-Place until 90% ETE for R01, then Evacuate			Zone(s) Shelter-in-Place							Zone(s) Evacuate						

*Region does not follow three-sector keyhole approach and is not used in PAR.

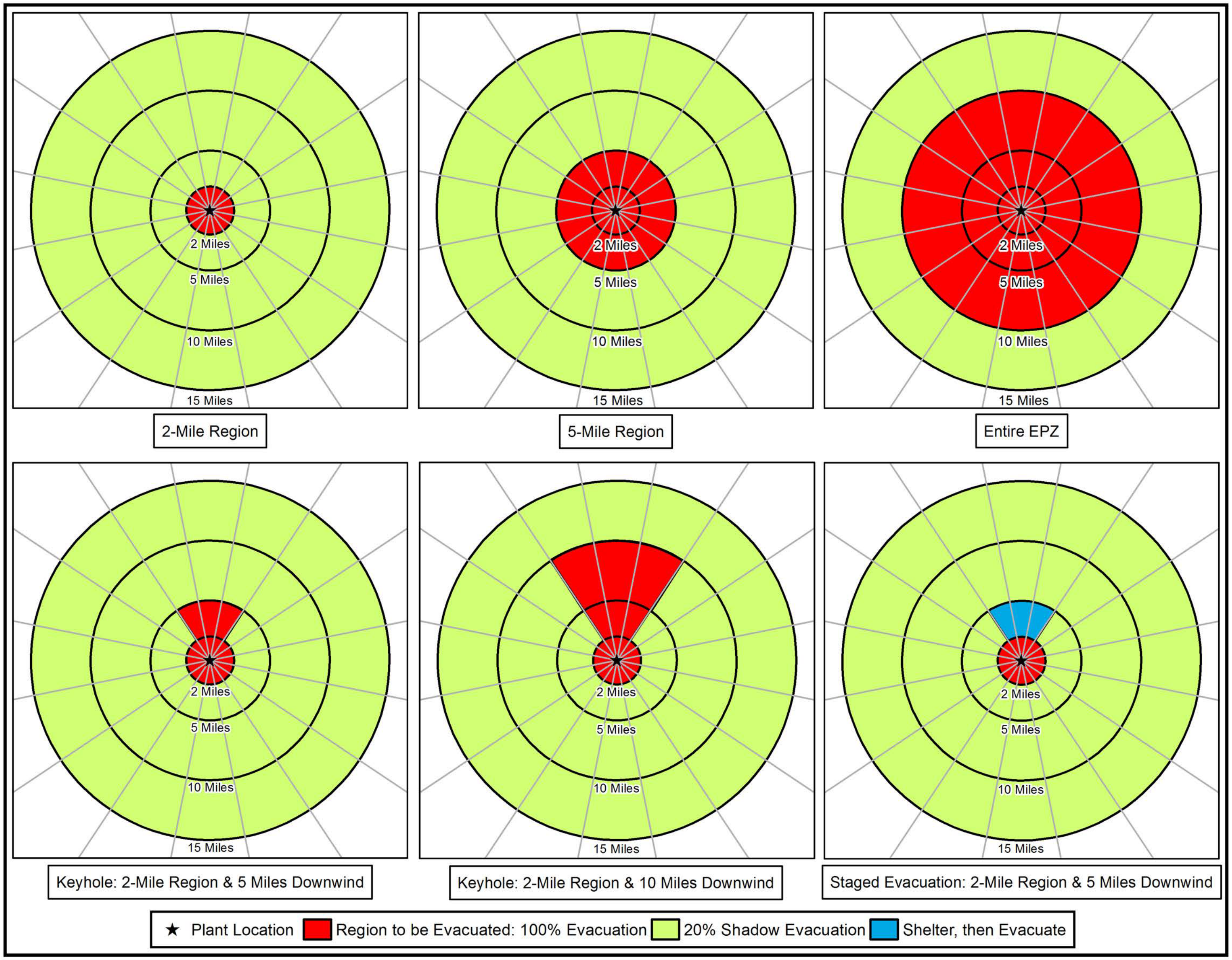


Figure 7-1. Voluntary Evacuation Methodology

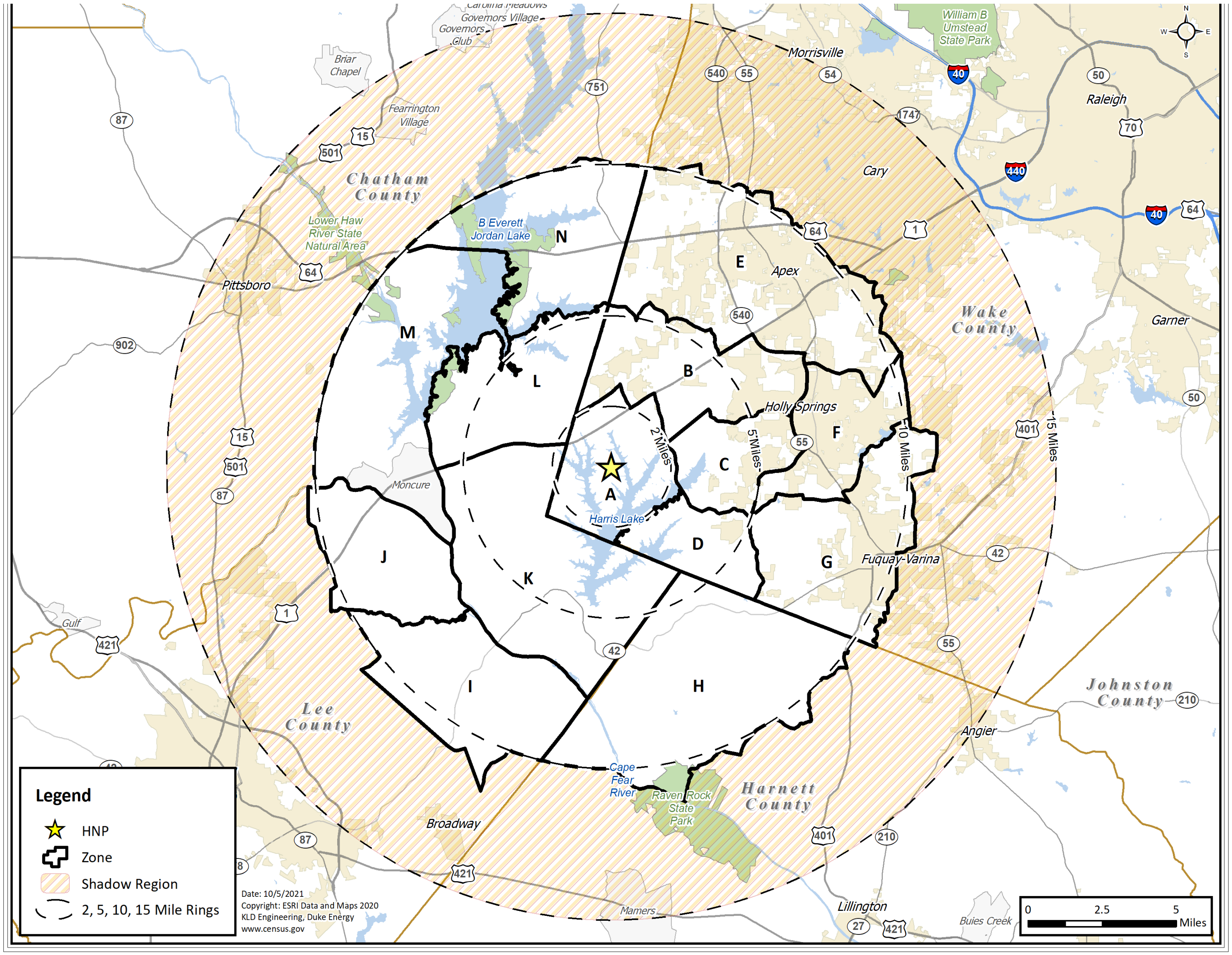


Figure 7-2. HNP Shadow Region

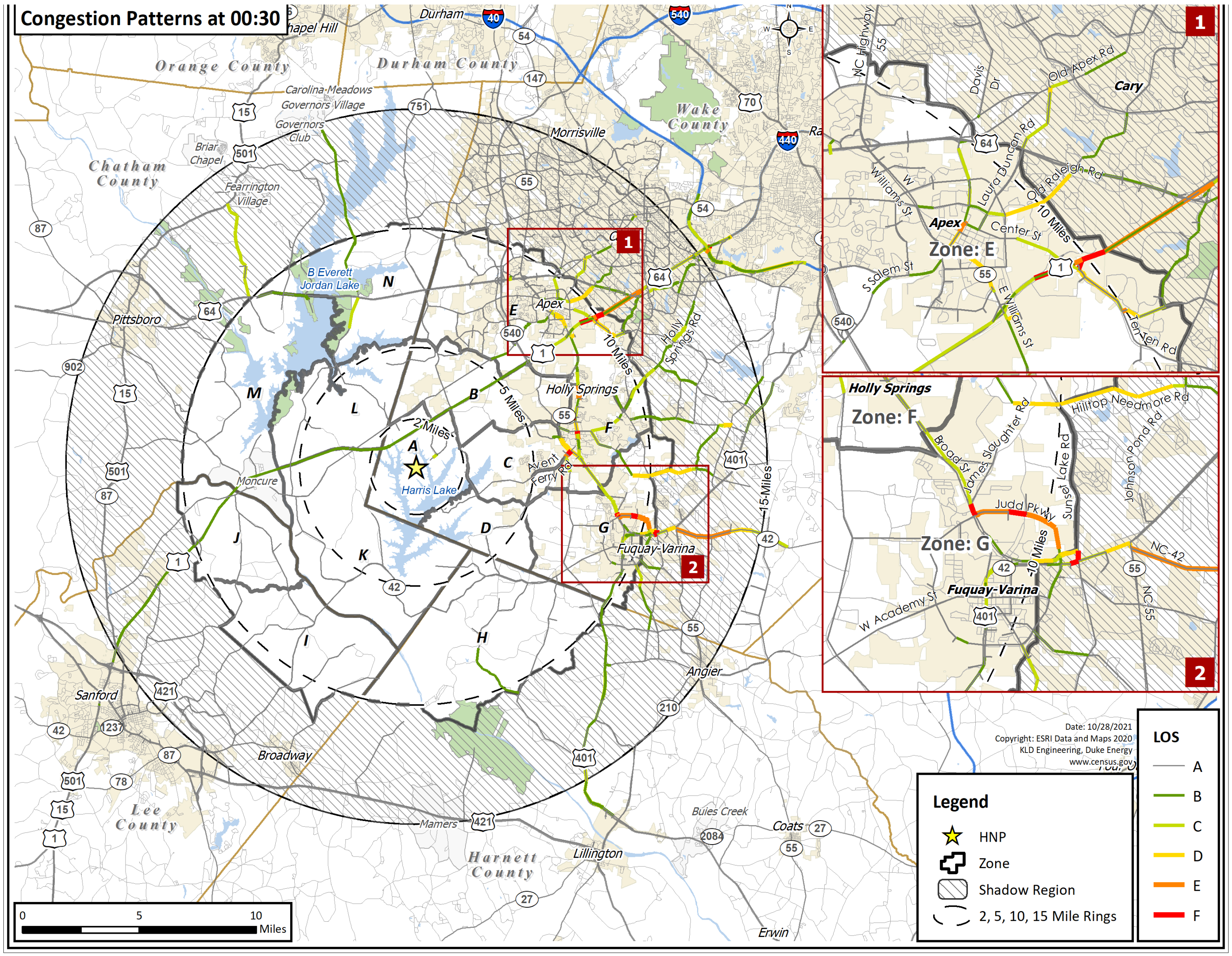


Figure 7-3. Congestion Patterns at 30 Minutes after the Advisory to Evacuate

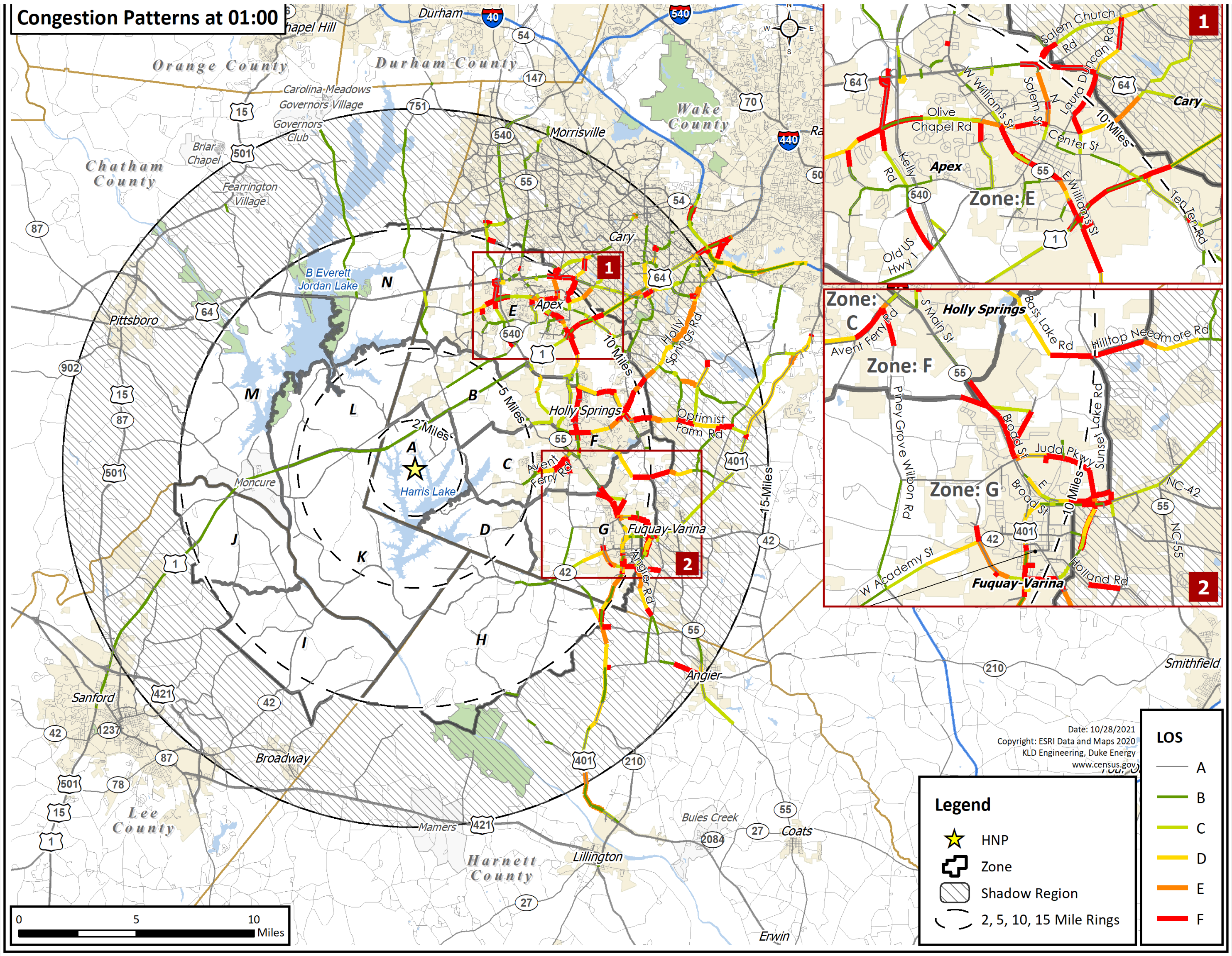


Figure 7-4. Congestion Patterns at 1 Hour after the Advisory to Evacuate

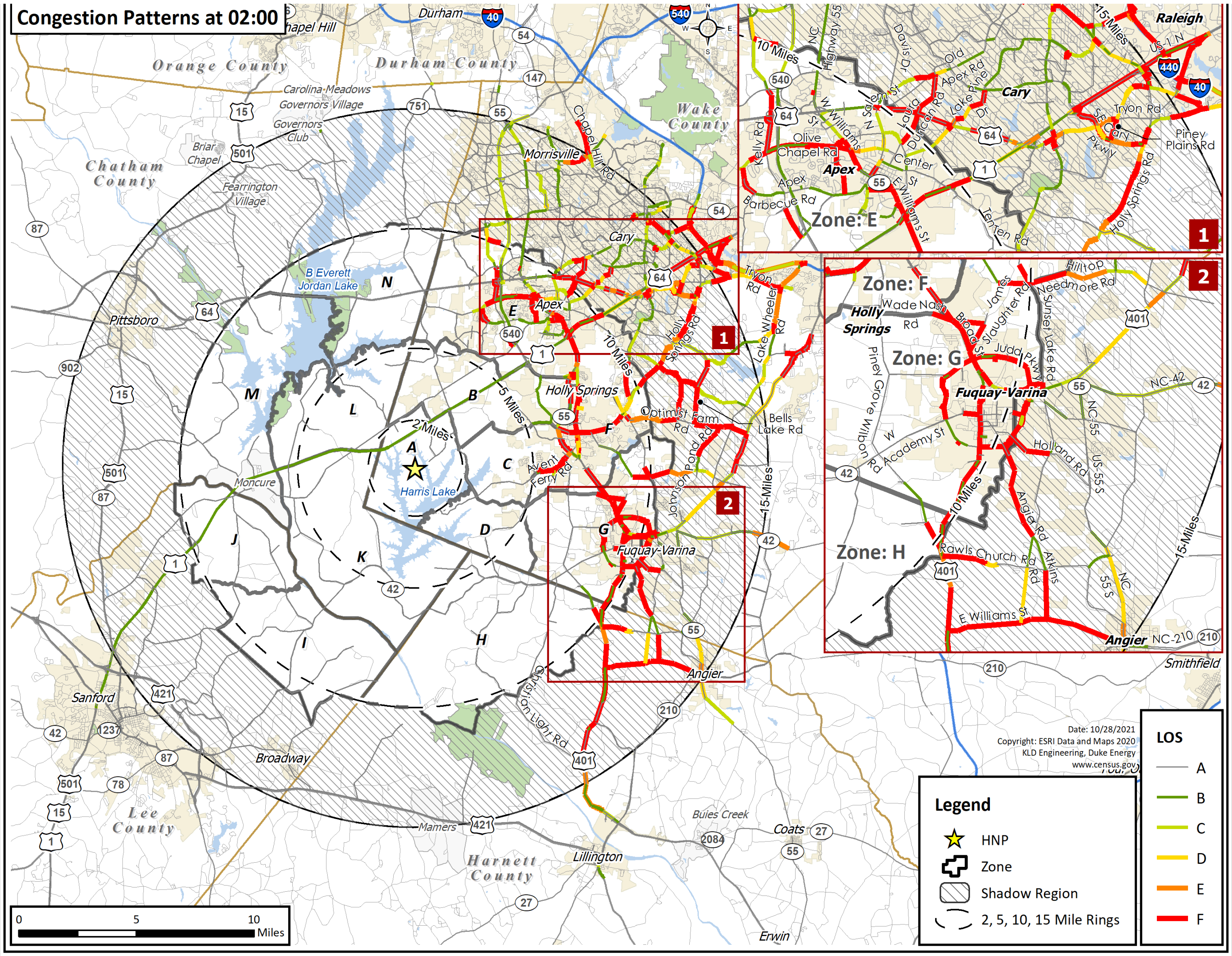


Figure 7-5. Congestion Patterns at 2 Hours after the Advisory to Evacuate

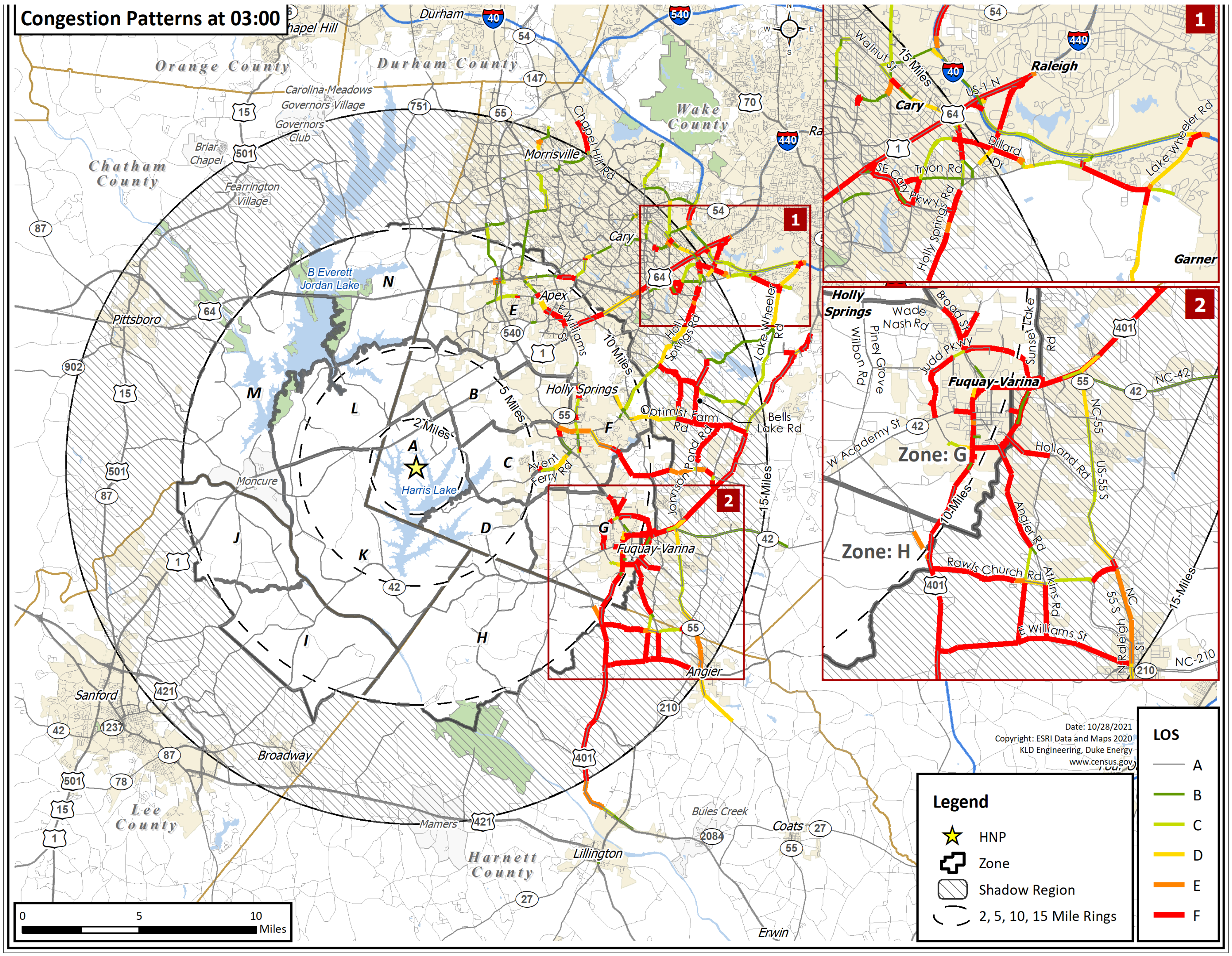


Figure 7-6. Congestion Patterns at 3 Hours after the Advisory to Evacuate

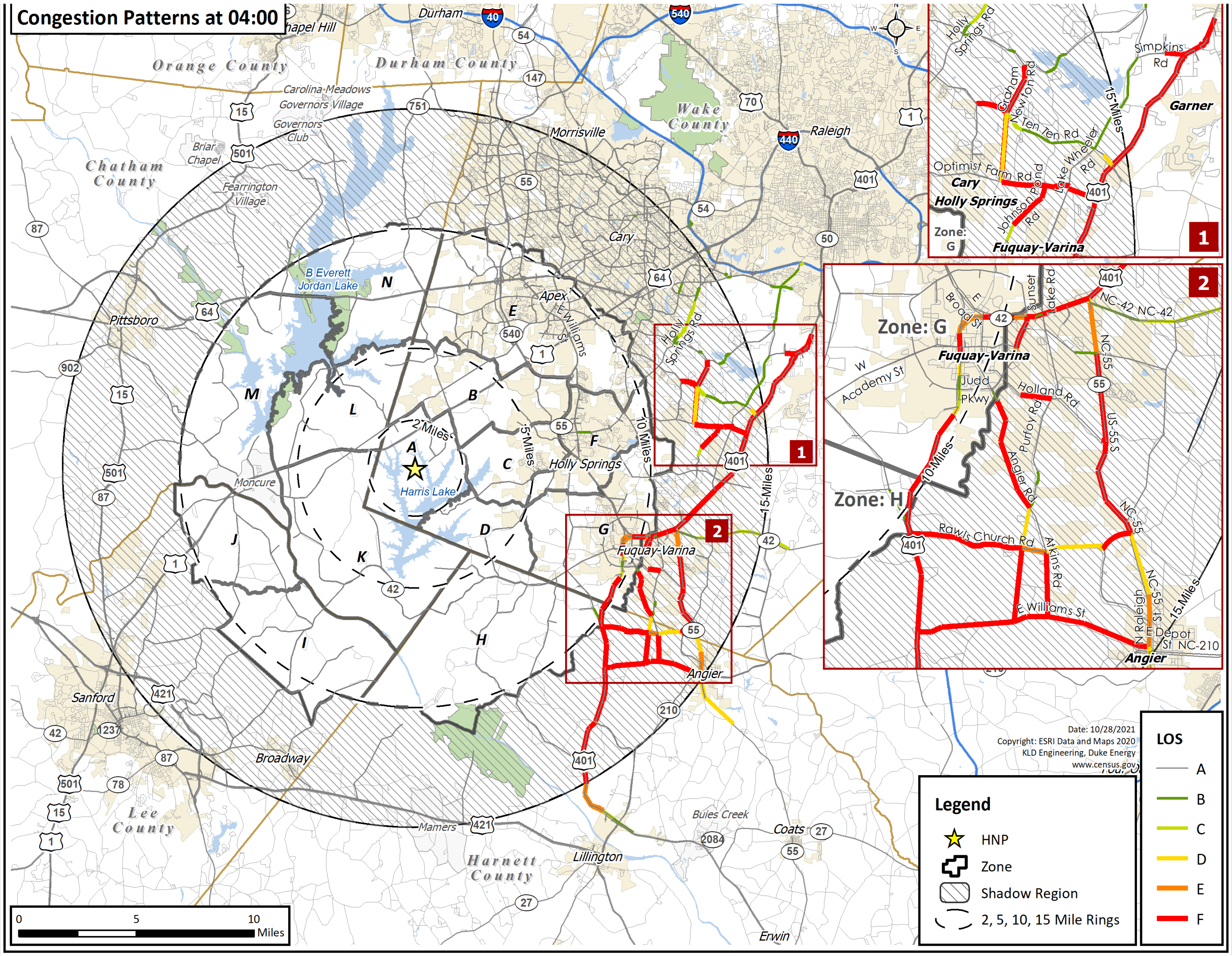


Figure 7-7. Congestion Patterns at 4 Hours after the Advisory to Evacuate

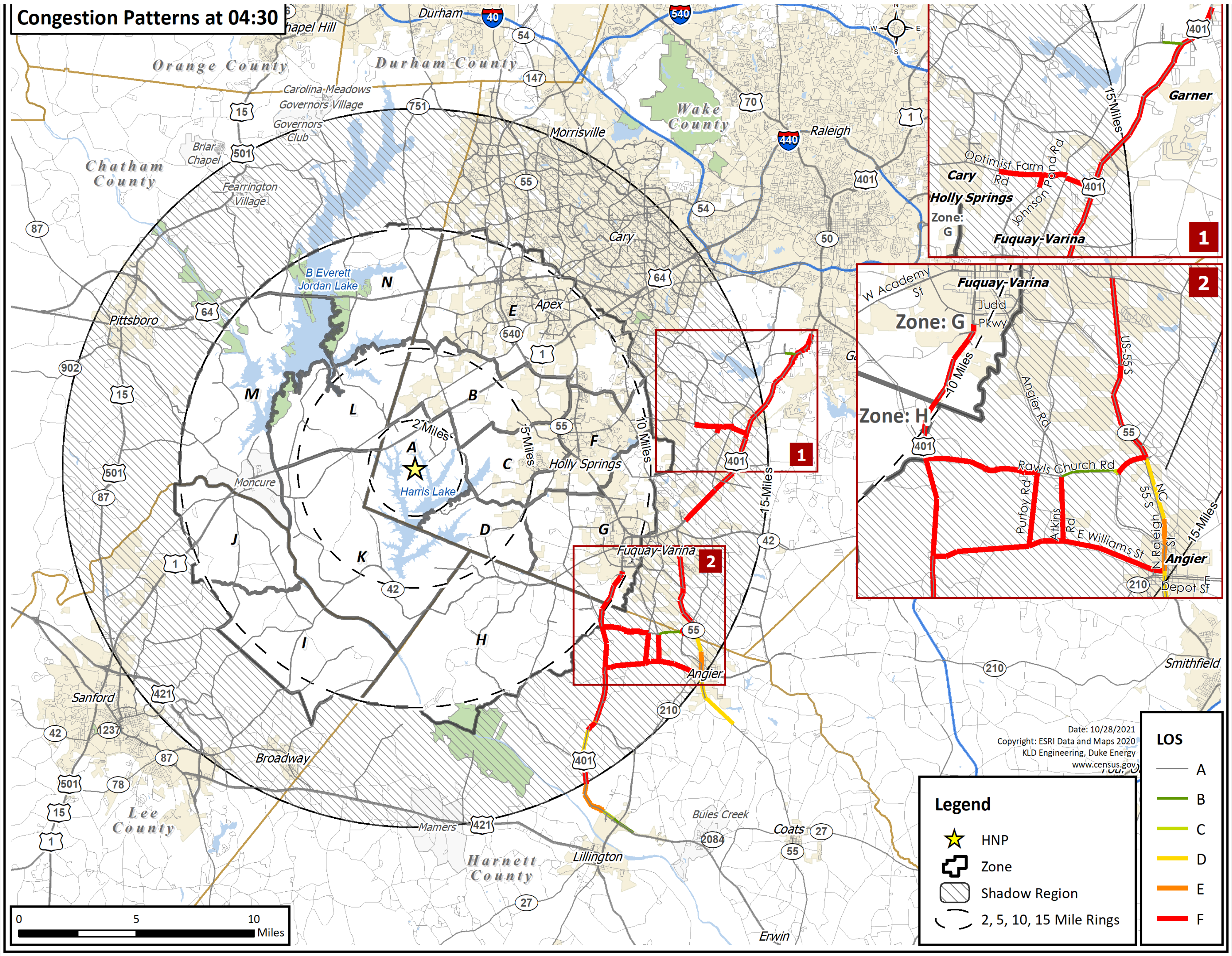


Figure 7-8. Congestion Patterns at 4 Hours 30 Minutes after the Advisory to Evacuate

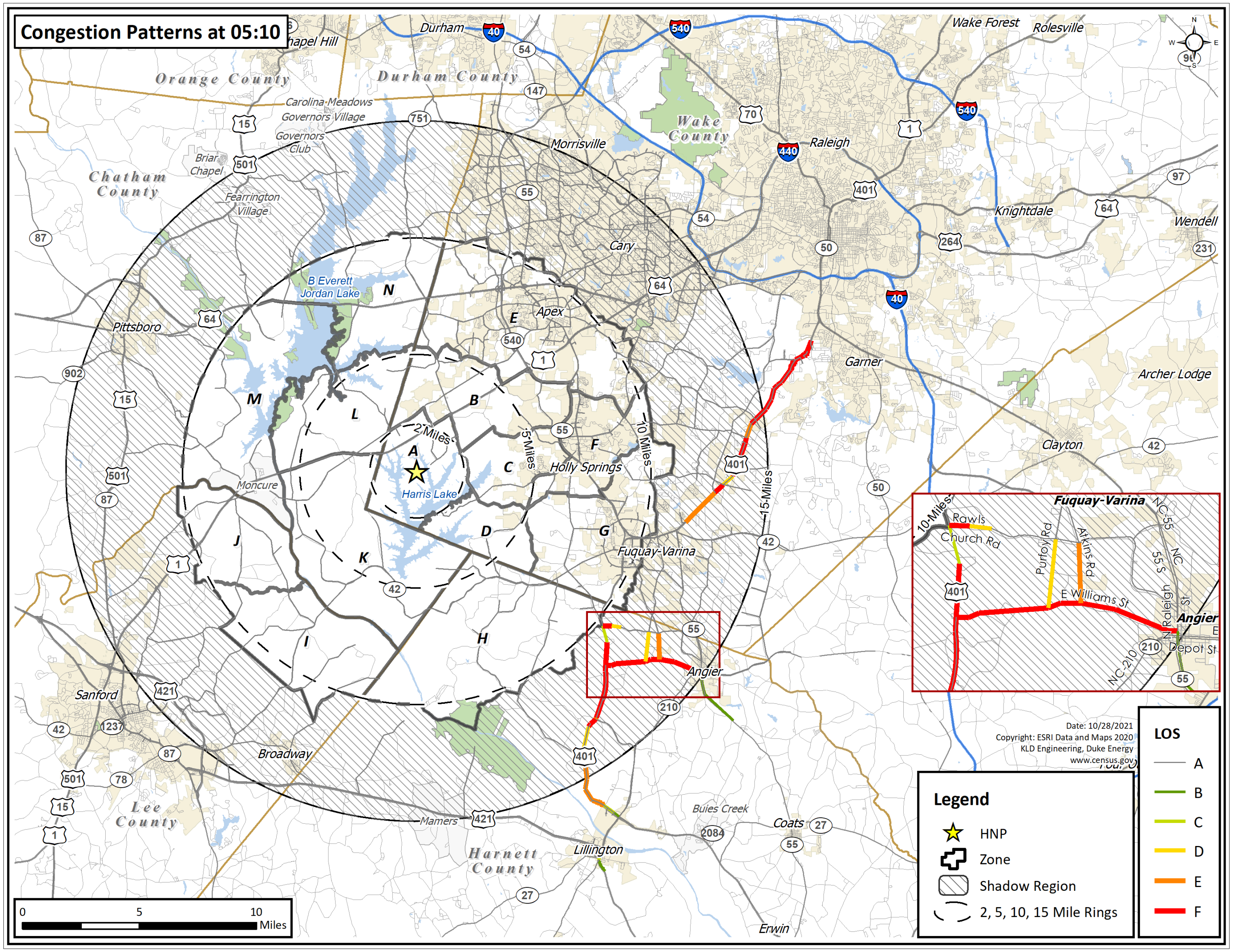


Figure 7-9. Congestion Patterns at 5 Hours 10 Minutes after the Advisory to Evacuate

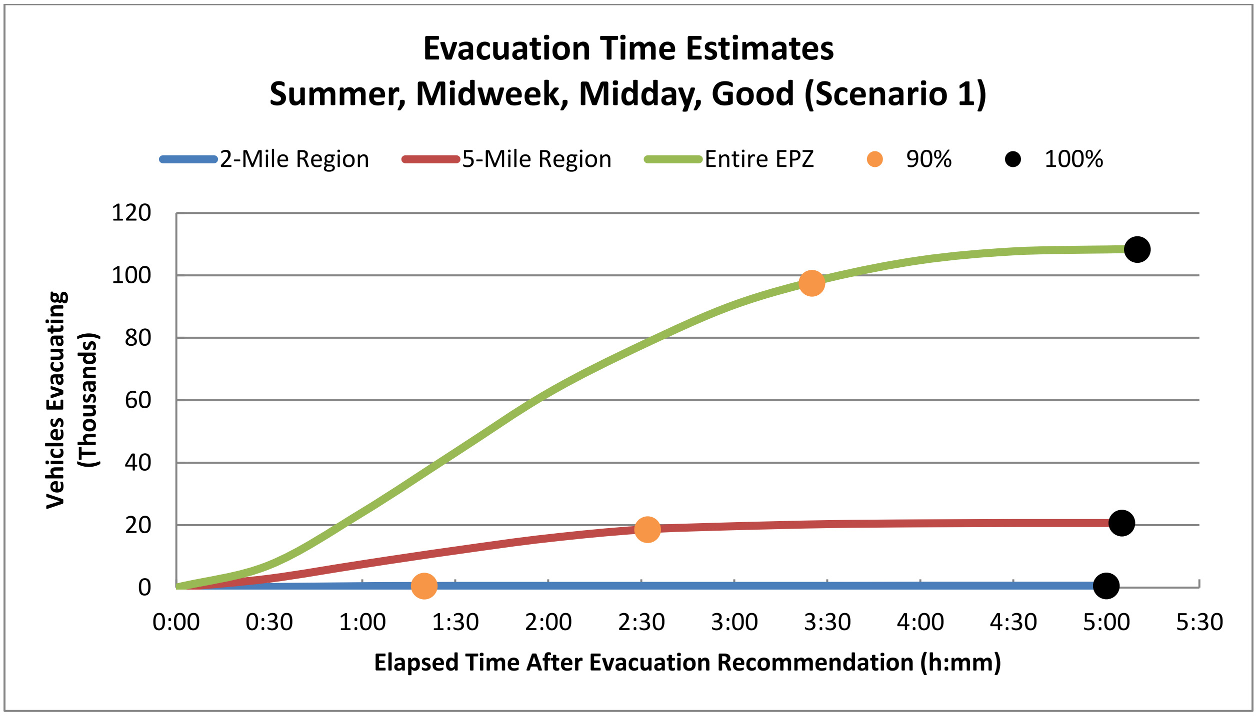


Figure 7-10. Evacuation Time Estimates - Scenario 1 for Region R03

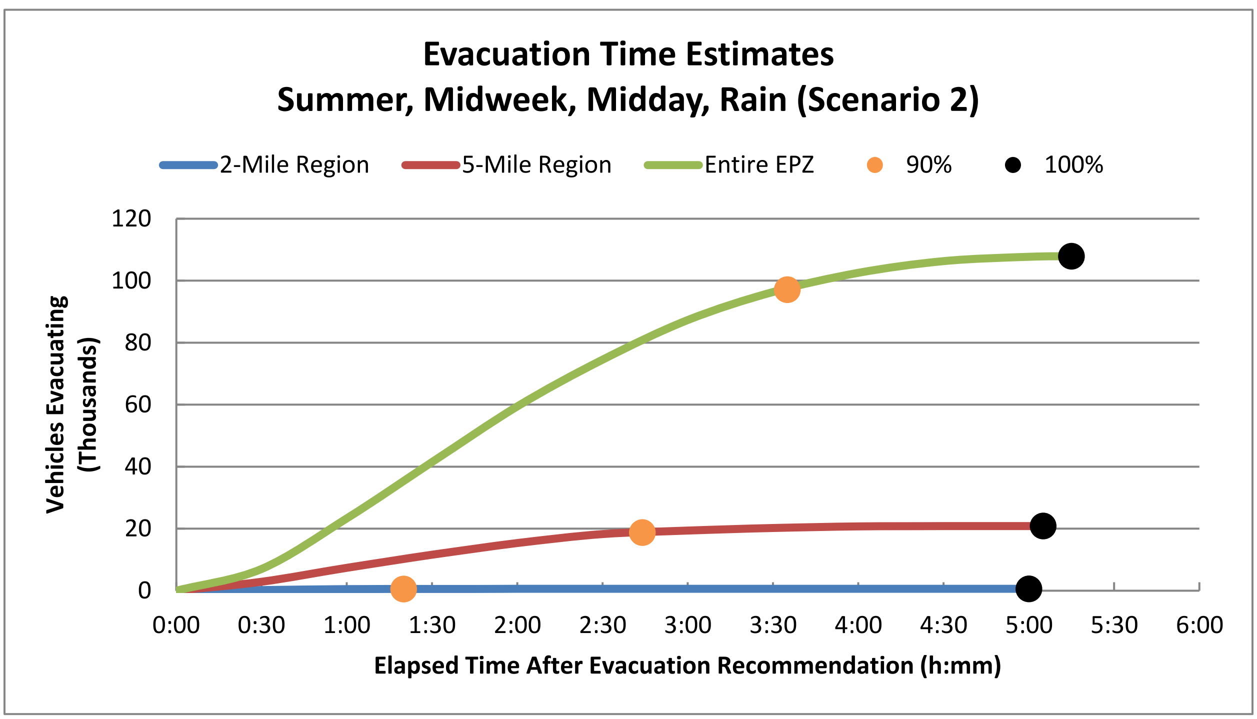


Figure 7-11. Evacuation Time Estimates - Scenario 2 for Region R03

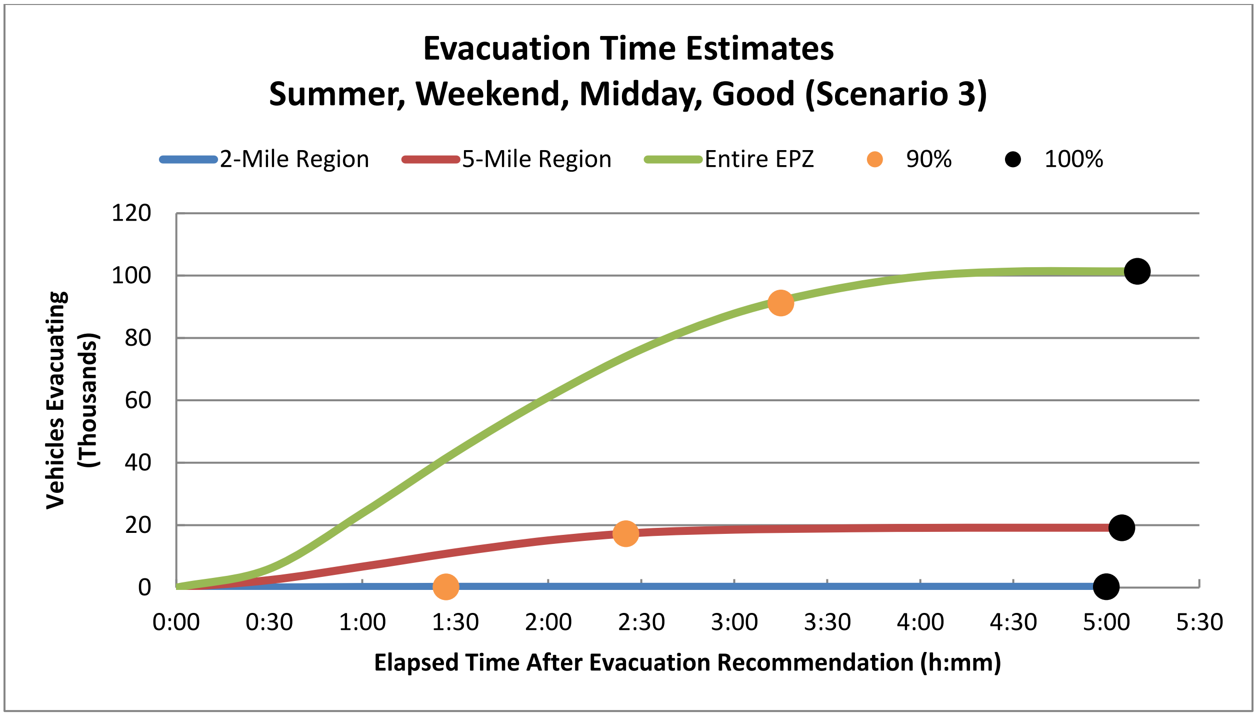


Figure 7-12. Evacuation Time Estimates - Scenario 3 for Region R03

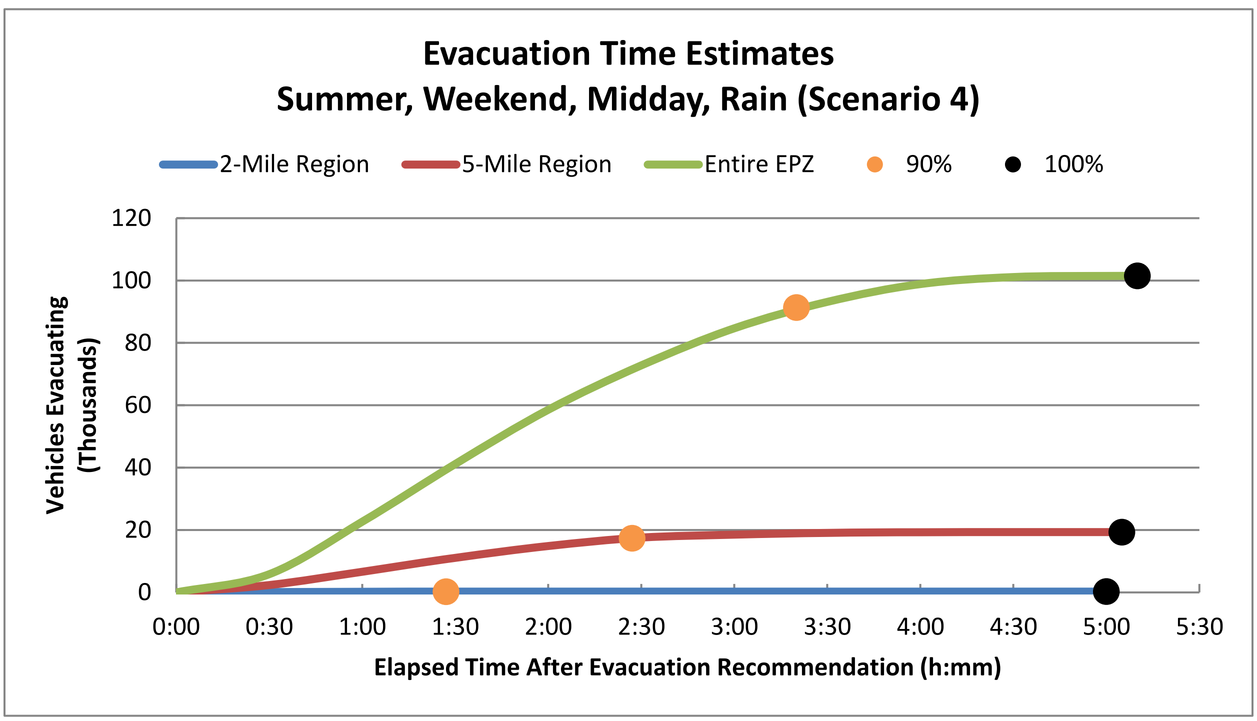


Figure 7-13. Evacuation Time Estimates - Scenario 4 for Region R03

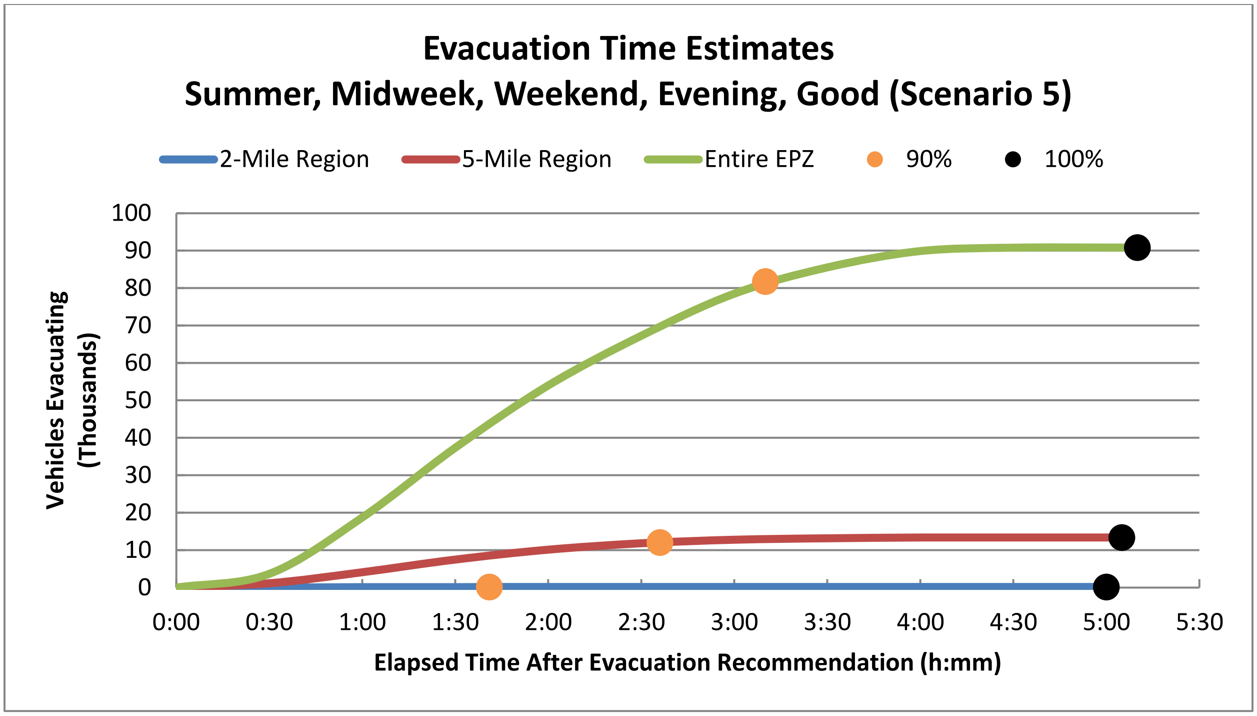


Figure 7-14. Evacuation Time Estimates - Scenario 5 for Region R03

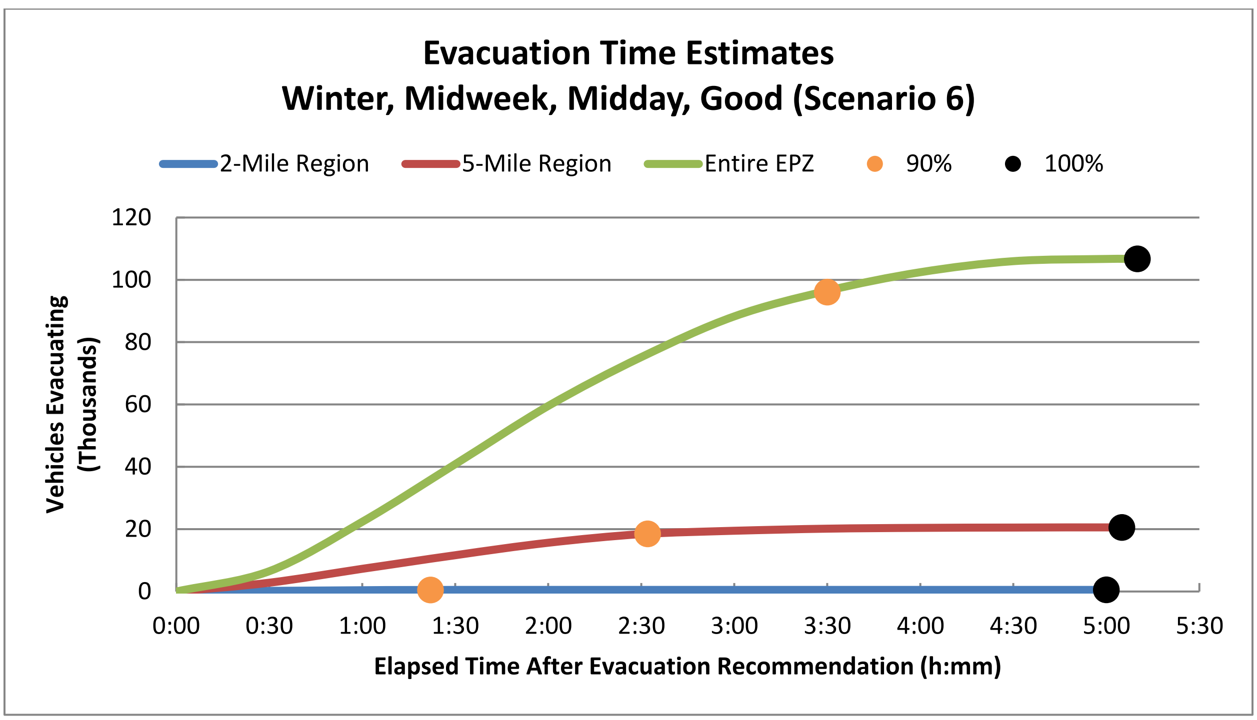


Figure 7-15. Evacuation Time Estimates - Scenario 6 for Region R03

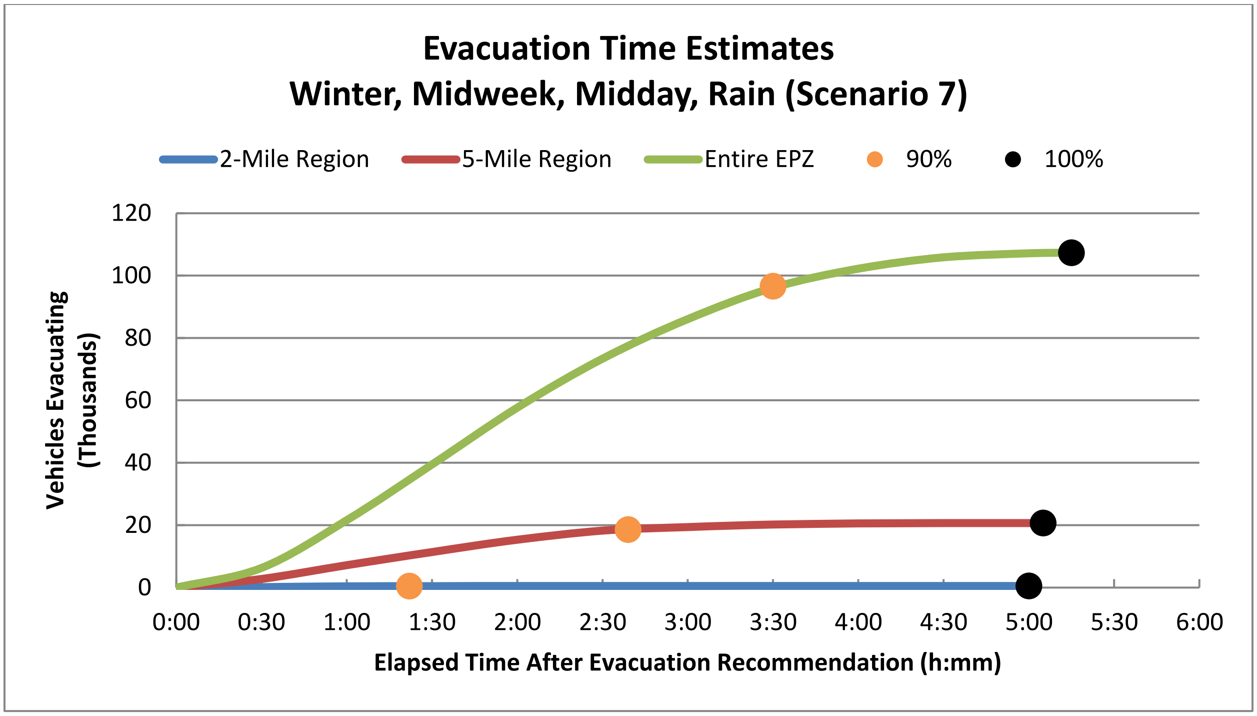


Figure 7-16. Evacuation Time Estimates - Scenario 7 for Region R03

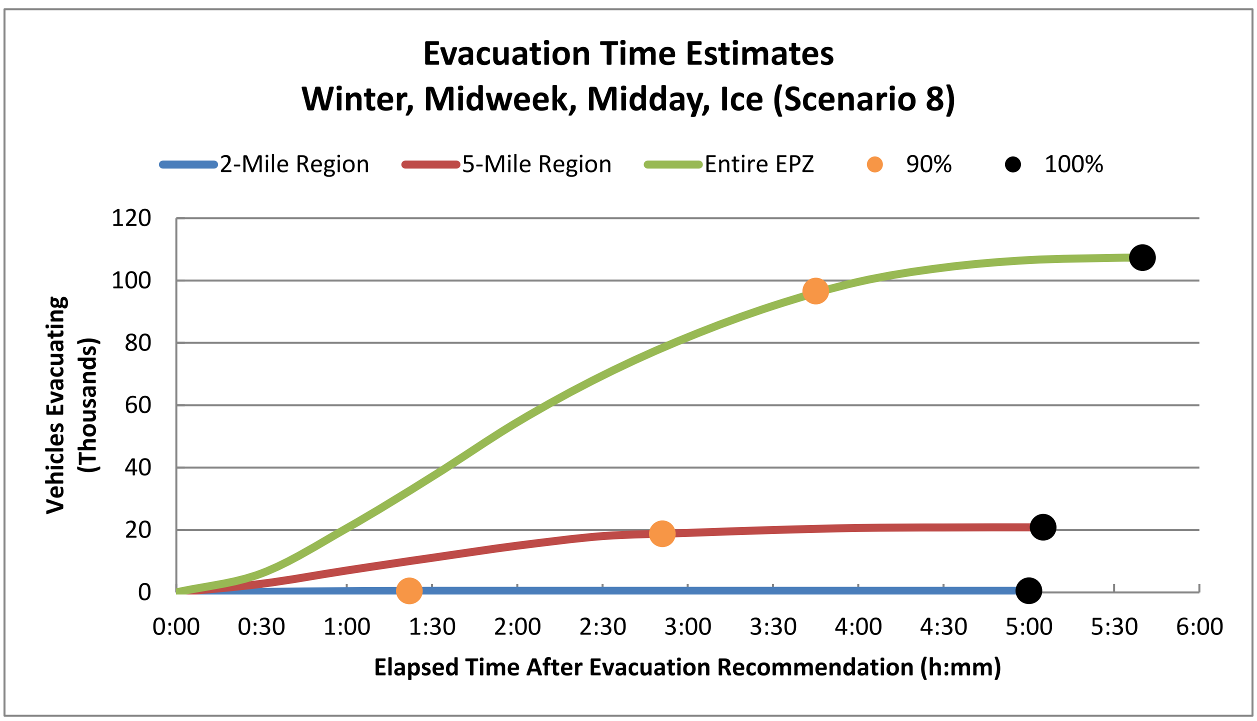


Figure 7-17. Evacuation Time Estimates - Scenario 8 for Region R03

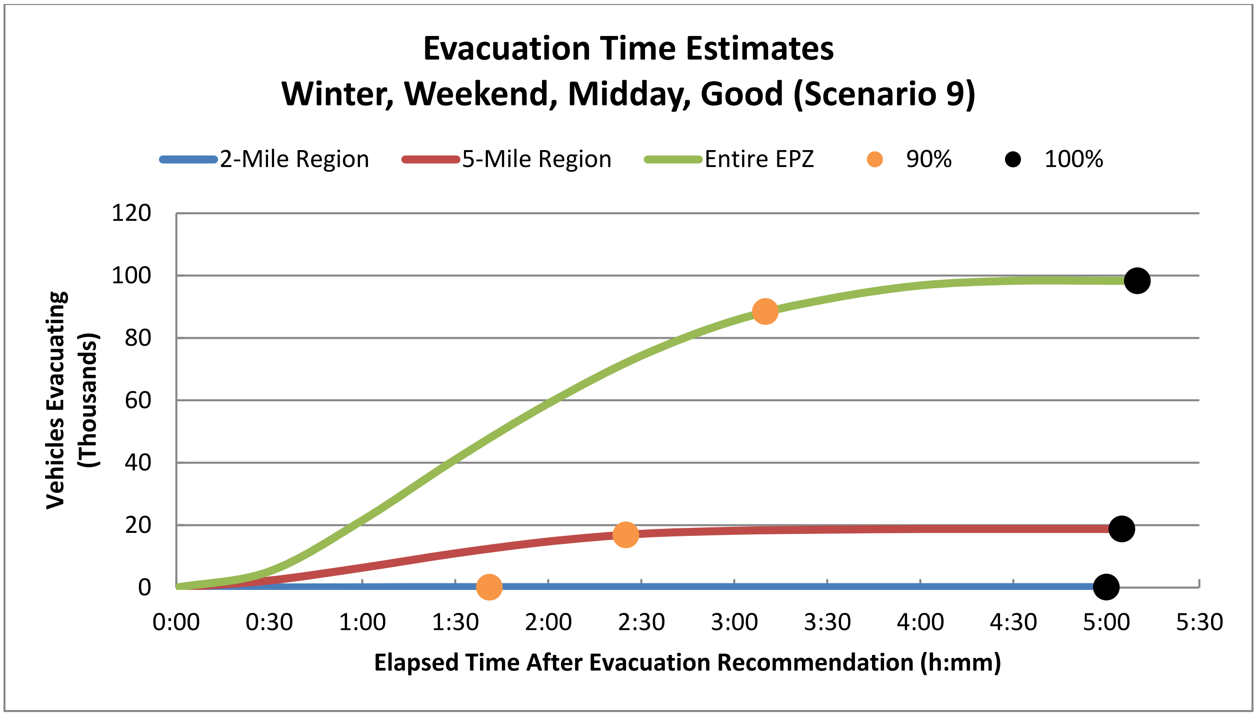


Figure 7-18. Evacuation Time Estimates - Scenario 9 for Region R03

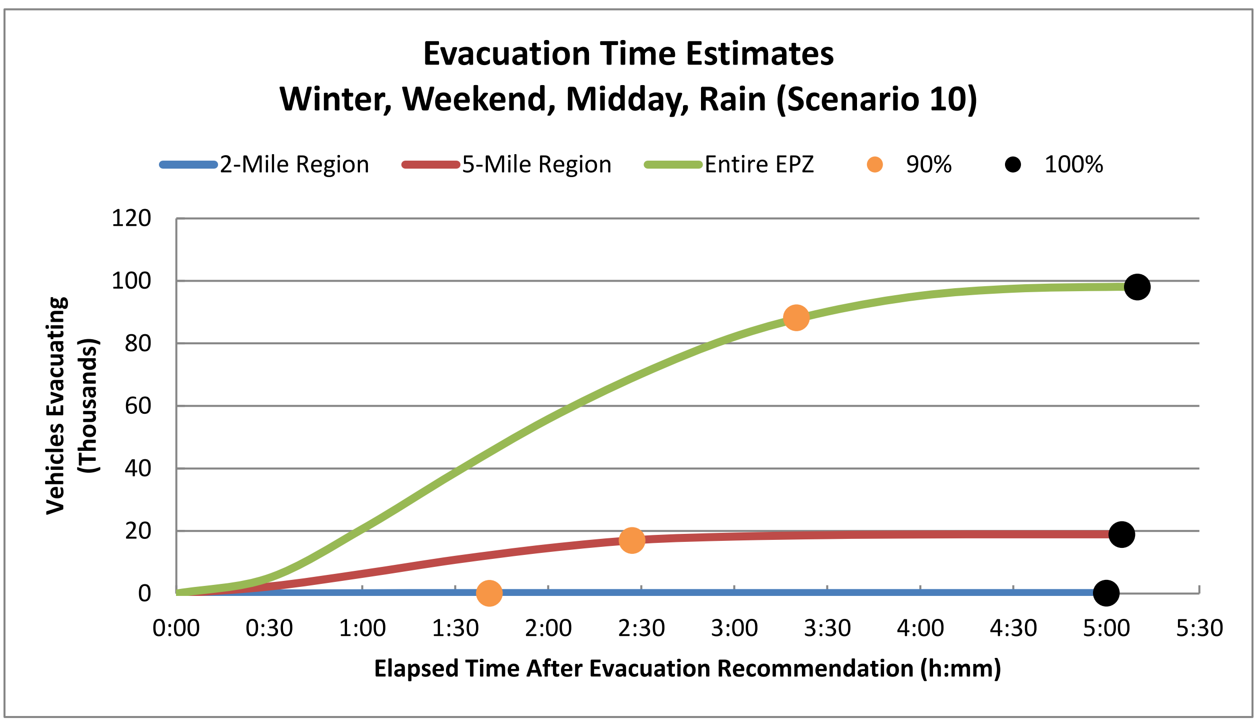


Figure 7-19. Evacuation Time Estimates - Scenario 10 for Region R03

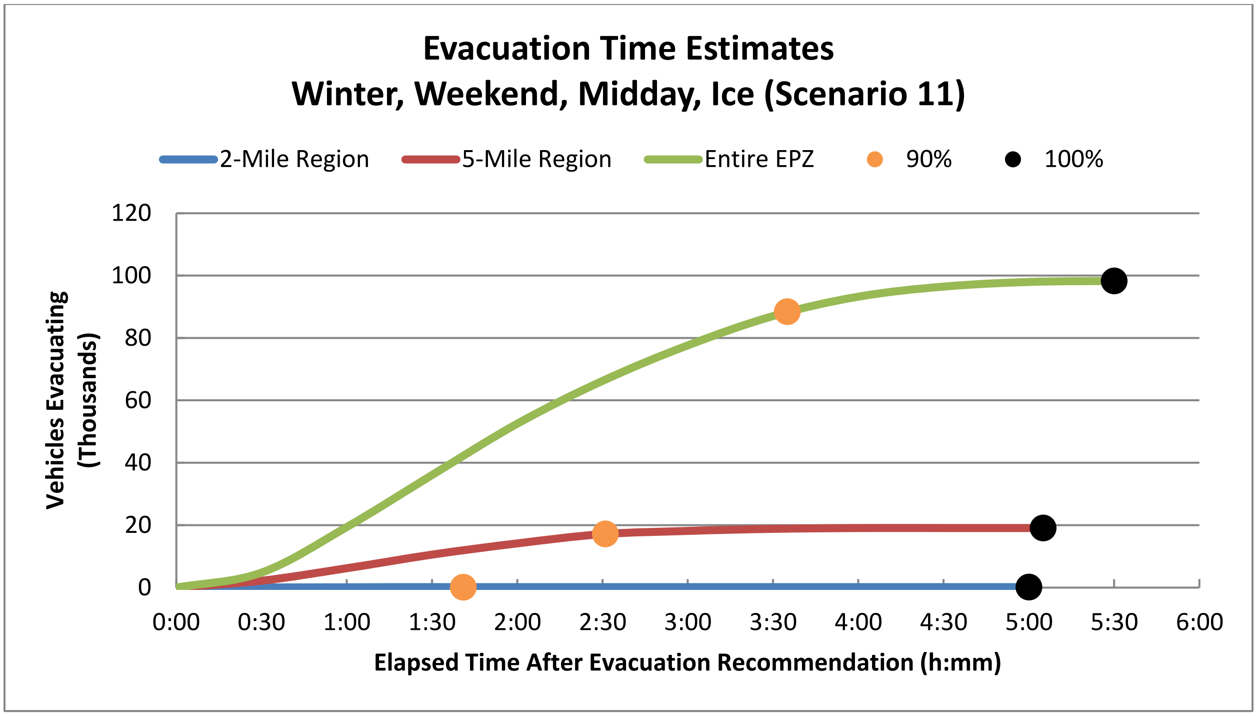


Figure 7-20. Evacuation Time Estimates - Scenario 11 for Region R03

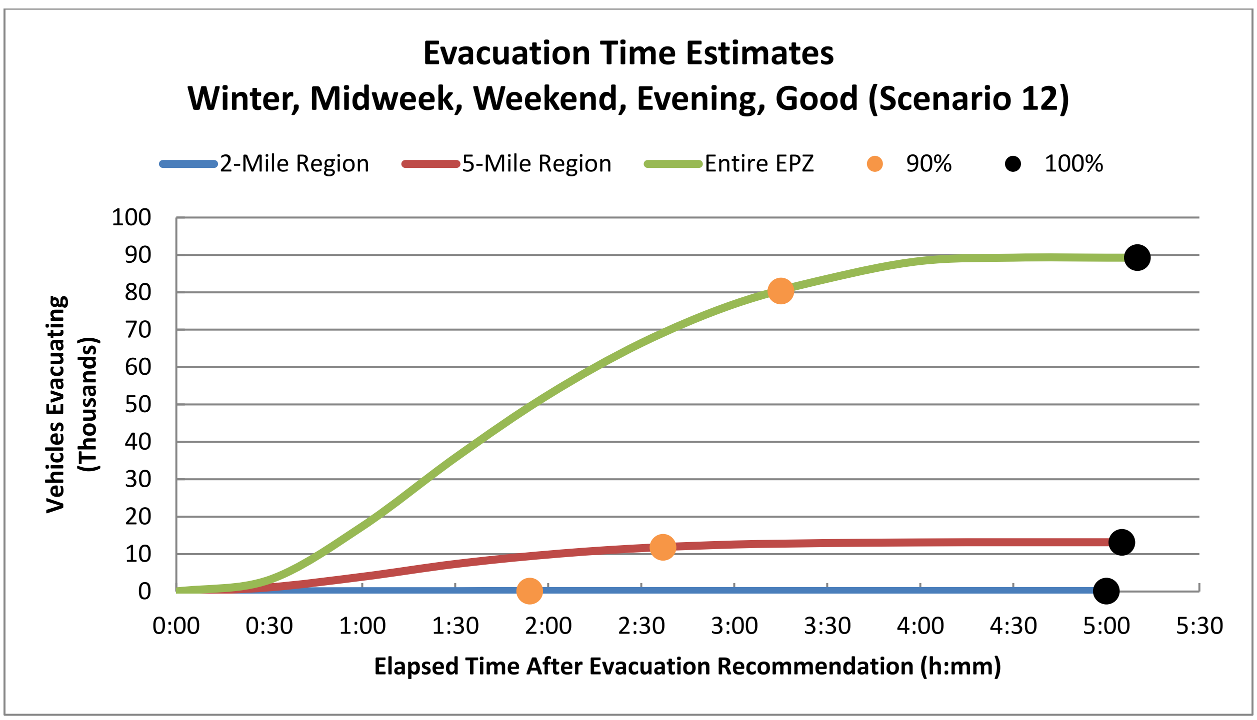


Figure 7-21. Evacuation Time Estimates - Scenario 12 for Region R03

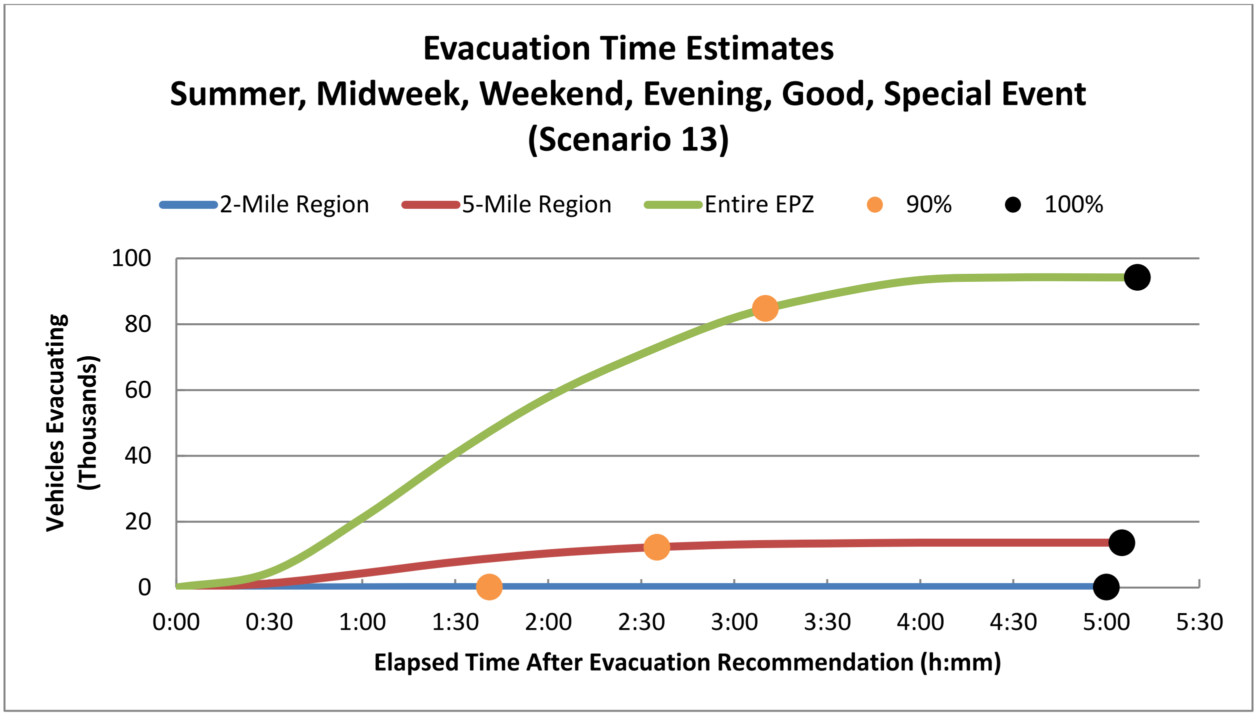


Figure 7-22. Evacuation Time Estimates - Scenario 13 for Region R03

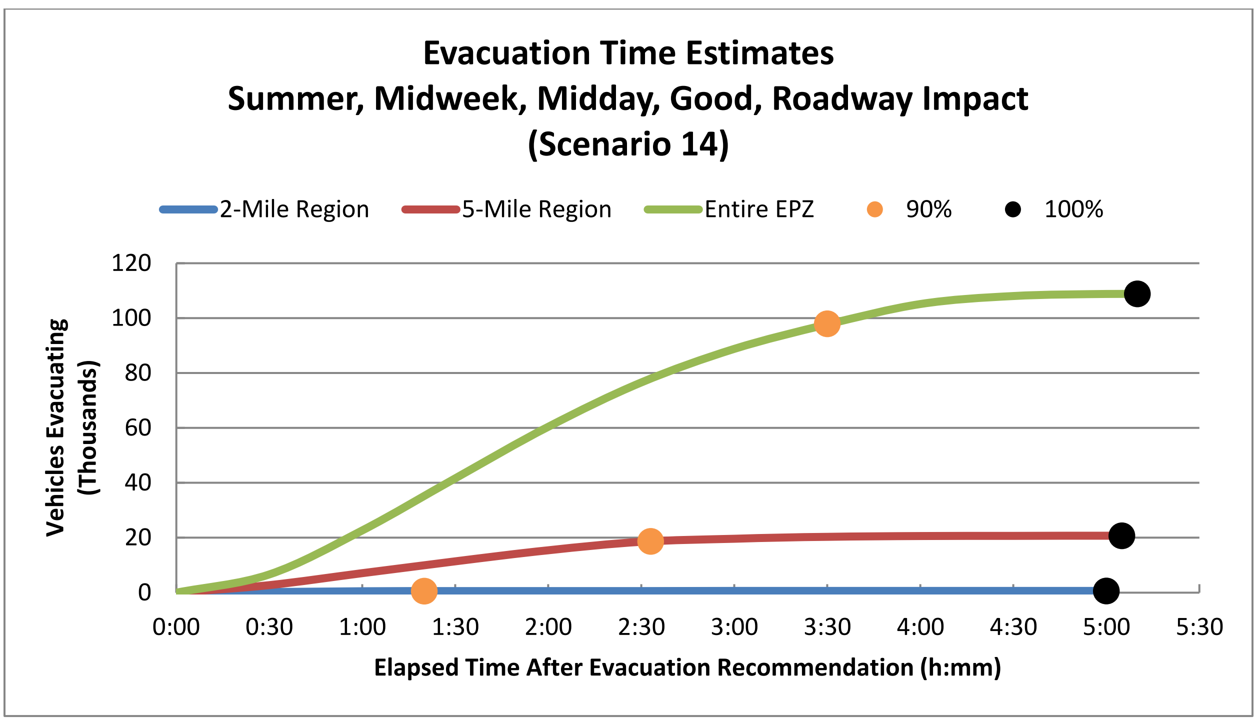


Figure 7-23. Evacuation Time Estimates - Scenario 14 for Region R03

8 TRANSIT-DEPENDENT AND SPECIAL FACILITY EVACUATION TIME ESTIMATES

This section details the analyses applied and the results obtained in the form of evacuation time estimates for transit vehicles (buses, ambulances, and wheelchair transport vehicles). The demand for transit service reflects the needs of three population groups: (1) residents with no vehicles available; (2) residents of special facilities such as schools, childcare centers, and medical facilities; and (3) access and/or functional needs population.

These transit vehicles mix with the general evacuation traffic that is comprised mostly of "passenger cars" (pc's). The presence of each transit vehicle in the evacuating traffic stream is represented within the modeling paradigm described in Appendix D as equivalent to two pc's. This equivalence factor represents the longer size and more sluggish operating characteristics of a transit vehicle, relative to those of a pc.

Transit vehicles must be mobilized in preparation for their respective evacuation missions. Specifically:

- Bus drivers must be alerted
- They must travel to the bus depot
- They must be briefed there and assigned to a route or facility

These activities consume time. As discussed in Item 4 of Section 2.4, it is estimated that school and medical facility bus mobilization times will average approximately 90 minutes extending from the Advisory to Evacuate, to the time when buses first arrive at the facility to be evacuated. The location of bus depots impacts the time to travel from the bus depots to the facilities being evacuated. Locations of bus depots were not identified in this study. Rather, the offsite agencies were asked to factor the location of the depots and the distance to the EPZ into the estimate of mobilization time.

During this mobilization period, other mobilization activities are taking place. One of these is the action taken by parents, neighbors, relatives and friends to pick up children from school or childcare prior to the arrival of buses, so that they may join their families. Virtually all studies of evacuations have concluded that this "bonding" process of uniting families is universally prevalent during emergencies and should be anticipated in the planning process. The current public information disseminated to residents of the HNP EPZ indicates that schoolchildren (includes private schools and childcare centers) will be evacuated to relocation schools where they can be picked up by their parents. As such, it is assumed no school children will be picked up by their parents prior to the arrival of the buses.

As discussed in Section 2, this study assumes a rapidly escalating event at the plant wherein evacuation is ordered promptly and no early protective actions have been implemented. Therefore, children are evacuated to relocation schools. Picking up children at school could add to traffic congestion at the schools, delaying the departure of the buses evacuating schoolchildren, which may have to return in a subsequent "wave" to the EPZ to evacuate the transit-dependent population. This report provides estimates of buses under the assumption

that no children will be picked up by their parents (in accordance with NUREG/CR-7002, Rev. 1), to present an upper bound estimate of buses required.

The procedure for computing transit-dependent ETE is to:

- Estimate demand for transit service (discussed in Section 3)
- Estimate time to perform all transit functions
- Estimate route travel times to the EPZ boundary and to the relocation schools and reception centers

8.1 ETEs for Transit Dependent People

EPZ bus resources are assigned to evacuating schoolchildren (if school is in session at the time of the ATE) as the first priority in the event of an emergency. In the event that the allocation of buses dispatched from the depots to the various facilities and to the bus routes is somewhat inefficient, or if there is a shortfall of available drivers, then there may be a need for some buses to return to the EPZ from the reception center or relocation school after completing their first evacuation trip, to complete a "second wave" of providing transport service to evacuees. For this reason, the ETE for the transit-dependent population will be calculated for both a one wave transit evacuation and for two waves. Of course, if the impacted Evacuation Region is other than R03 (the entire EPZ), then there will likely be ample transit resources relative to demand in the impacted Region and this discussion of a second wave would likely not apply. A list of available transportation resources was provided by each county and is shown in Table 8-1. It is assumed that there are enough drivers available to man all resources listed in Table 8-1.

When school evacuation needs are satisfied, subsequent assignments of buses to service the transit-dependent should be sensitive to their mobilization time. Clearly, the buses should be dispatched after people have completed their mobilization activities and are in a position to board the buses when they arrive at the various routes shown graphically in Table 10-1.

Evacuation Time Estimates for transit trips were developed using both good weather and adverse weather conditions. Figure 8-1 presents the chronology of events relevant to transit operations. The elapsed time for each activity will now be discussed with reference to Figure 8-1.

Activity: Mobilize Drivers (A→B→C)

Mobilization is the elapsed time from the Advisory to Evacuate until the time the buses arrive at the facility to be evacuated. As previously stated, it is assumed drivers would require 90 minutes to be contacted, to travel to the depot, be briefed, and to travel to the transit-dependent facilities for a rapidly escalating radiological emergency with no observable indication before the fact. Mobilization time is slightly longer in adverse weather – 100 minutes when raining, 110 minutes with ice.

Activity: Board Passengers (C→D)

As discussed in Section 2.4, a loading time of 15 minutes (20 minutes for rain and 25 minutes for ice) for school buses is assumed.

For multiple stops along a pick-up route (transit-dependent bus routes) estimation of travel time must allow for the delay associated with stopping and starting at each pick-up point. The time, t, required for a bus to decelerate at a rate, "a", expressed in ft/sec/sec, from a speed, "v", expressed in ft/sec, to a stop, is t = v/a. Assuming the same acceleration rate and final speed following the stop yields a total time, T, to service boarding passengers:

$$T = t + B + t = B + 2t = B + \frac{2v}{a},$$

Where B = Dwell time to service passengers. The total distance, "s" in feet, travelled during the deceleration and acceleration activities is: s = v^2/a. If the bus had not stopped to service passengers, but had continued to travel at speed, v, then its travel time over the distance, s, would be: s/v = v/a. Then the total delay (i.e. pickup time, P) to service passengers is:

$$P = T - \frac{v}{a} = B + \frac{v}{a}$$

Assigning reasonable estimates:

- B = 50 seconds: a generous value for a single passenger, carrying personal items, to board per stop
- v = 25 mph = 37 ft/sec
- a = 4 ft/sec/sec, a moderate average rate

Then, P ≈ 1 minute per stop. Allowing 30 minutes pick-up time per bus run implies 30 stops per run, for good weather. It is assumed that bus acceleration and speed will be less in rain and ice; total loading time is 40 minutes per bus in rain, 50 minutes in ice.

Activity: Travel to EPZ Boundary (D→E)

Evacuation of Schools and Child Care Centers

The transportation resources available were provided by the EPZ county emergency management agencies and are summarized in Table 8-1. Also included in the table are the number of buses needed to evacuate schools and child care centers, medical facilities, transit-dependent population and access and/or functional needs persons (discussed below in Section 8.2). These numbers indicate there are sufficient wheelchair transport (wheelchair buses and vans combined) and ambulance resources available to evacuate everyone in a single wave. There are not enough buses to evacuate in a single wave.

The buses servicing the schools and childcare centers are ready to begin their evacuation trips at 105 minutes after the advisory to evacuate – 90 minutes mobilization time plus 15 minutes loading time – in good weather. The UNITES software discussed in Section 1.3 was used to define bus routes along the most likely path from a school being evacuated to the EPZ boundary, traveling toward the appropriate relocation school. This is done in UNITES by interactively selecting the series of nodes from the school to the EPZ boundary. Each bus route is given an identification number and is written to the DYNEV II input stream. DYNEV computes the route length and outputs the average speed for each 5-minute interval, for each bus route. The specified bus routes are documented in Table 10-2 (refer to the maps of the link-node analysis network in Appendix K for node locations). Data provided by DYNEV during the

appropriate timeframe depending on the mobilization and loading times (i.e., 100 to 105 minutes after the advisory to evacuate for good weather) were used to compute the average speed for each route, as follows:

$$Average\ Speed\ \left(\frac{mi.}{hr}\right) = \left[\frac{\sum_{i=1}^{n} length\ of\ link\ i\ (mi)}{\sum_{i=1}^{n}\left\{Delay\ on\ link\ i\ (min.) + \frac{length\ of\ link\ i\ (mi.)}{current\ speed\ on\ link\ i\ \left(\frac{mi.}{hr.}\right)} \times \frac{60\ min.}{1\ hr.}\right\}}\right] \times \frac{60\ min.}{1\ hr.}$$

The average speed computed (using this methodology) for the buses servicing each of the schools and child care centers in the EPZ is shown in Table 8-2 through Table 8-4, and in Table 8-5 through Table 8-7 for the transit vehicles evacuating transit-dependent persons, which are discussed later. The travel time to the EPZ boundary was computed for each bus using the computed average speed and the distance to the EPZ boundary along the most likely route out of the EPZ. The travel time from the EPZ boundary to the relocation school was computed assuming an average speed of 45 mph, 40 mph, and 35 mph for good weather, rain and ice, respectively. Speeds were reduced in Table 8-2 through Table 8-4 and in Table 8-5 through Table 8-7 to 45 mph (40 mph for rain – 10% decrease – and 35 mph for ice – 20% decrease) for those calculated bus speeds which exceed 45 mph, as the school bus speed limit in North Carolina is 45 mph.

Table 8-2 (good weather), Table 8-3 (rain) and Table 8-4 (ice) present the following evacuation time estimates (rounded up to the nearest 5 minutes) for schools and child care centers in the EPZ: (1) The elapsed time from the Advisory to Evacuate until the bus exits the EPZ; and (2) The elapsed time until the bus reaches the relocation school.

The evacuation time out of the EPZ can be computed as the sum of times associated with Activities A→B→C, C→D, and D→E (For example: 90 min. + 15 + 6 = 1:55, for Moncure Elementary School, in good weather, rounded up to the nearest 5 minutes). The average single wave ETE for schools and childcare centers is 1 hour and 15 minutes less than the 90th percentile ETE for Region R03 for the general population during Scenario 6 conditions (3:30 – 2:15 = 1:10).

The evacuation time to the relocation school is determined by adding the time associated with Activity E→F (discussed below), to this EPZ evacuation time.

Evacuation of Transit-Dependent Population

The buses dispatched from the depots to service the transit-dependent evacuees will be scheduled so that they arrive at their respective routes after their passengers have completed their mobilization. As shown in Figure 5-4 (Residents with no Commuters), approximately 90

percent of the evacuees will complete their mobilization at approximately 130 minutes after the Advisory to Evacuate. As such, mobilization time for the first buses to arrive at each route will be 130 minutes during good weather, 140 minutes in rain and 150 minutes in ice, to account for slower travel speeds and reduced roadway capacity in adverse weather.

It is assumed that the transit-dependent population (and estimate of transit buses) in each Zone is proportional to the Zone population. As such, bus routes were designed by grouping the transit dependent population within Zones as to minimize the number of buses needed, using an occupancy of 30 people per bus. Those routes with multiple buses have been designed such that groups of buses are dispatched using varying headways (20 minutes), as shown in Table 8-5 through Table 8-7. The use of bus headways ensures that those people who take longer to mobilize will be picked up.

Predefined routes or pick up points do not currently exist in the local emergency plans. The routes discussed in Table 10-1 and shown in Figure 10-2 were designed as part of this study to service the major evacuation routes within each Zone. Those buses servicing the transit-dependent evacuees will first travel along these routes, then proceed out of the EPZ. It is assumed that residents will walk to the nearest major roadway and flag down a passing bus, and that they can arrive at the roadway within the 130-minute bus mobilization time (good weather).

As previously discussed, a pickup time of 30 minutes (good weather) is estimated for 30 individual stops to pick up passengers, with an average of one minute of delay associated with each stop. Longer pickup times of 40 minutes and 50 minutes are used for rain and ice, respectively.

The travel distance along the respective pick-up routes within the EPZ is estimated using the UNITES software. Bus travel times within the EPZ are computed using average speeds computed by DYNEV, using the aforementioned methodology that was used for school and child care center evacuation.

Table 8-5 through Table 8-7 present the transit-dependent population evacuation time estimates for each bus route calculated using the above procedures for good weather, rain and ice, respectively.

For example, the ETE for the group of 5 buses servicing the central portion of the EPZ (Old US 1 Hwy and New Hill Olive Chapel Rd spanning Zones A, B, and L) is computed as 130 + 19 + 30 = 3:00 for good weather (rounded up to nearest 5 minutes). Here, 19 minutes is the time to travel 14.3 miles at 45.0 mph, the average speed output by the model for this route starting at 130 minutes. The ETE for a second wave (discussed below) is presented in the event there is a shortfall of available buses or bus drivers.

<u>Activity: Travel to Relocation Schools and Reception Centers (E→F)</u>

The distances from the EPZ boundary to the relocation schools and reception centers are measured using GIS software along the most likely route from the EPZ exit point to the reception center or relocation school. The relocation schools and reception centers are mapped in Figure 10-3. For a one-wave evacuation, this travel time outside the EPZ does not

contribute to the ETE. For a two-wave evacuation, the ETE for buses must be considered separately, since it could exceed the ETE for the general population. Assumed bus speeds of 45 mph, 40 mph, and 35 mph for good weather, rain, and ice, respectively, will be applied for this activity for buses servicing the transit-dependent population.

Activity: Passengers Leave Bus (F→G)

A bus can empty within 5 minutes. The driver takes a 10 minute break.

Activity: Bus Returns to Route for Second Wave Evacuation (G→C)

The buses assigned to return to the EPZ to perform a "second wave" evacuation of transit-dependent evacuees will be those that have already evacuated transit-dependent people who mobilized more quickly. The first wave of transit-dependent people depart the bus, and the bus then returns to the EPZ, travels to its route and proceeds to pick up more transit-dependent evacuees along the route. The travel time back to the EPZ is equal to the travel time to the reception center.

The second-wave ETE for the bus route servicing Zones A, parts of B, and L is computed as follows for good weather:

- Bus arrives at reception center at 3:32 in good weather (3:00 to exit EPZ + 32 minute travel time to reception center).
- Bus discharges passengers (5 minutes) and driver takes a 10-minute rest: 15 minutes.
- Bus returns to EPZ, drives to the start of the route and completes second route: 32 minutes (equal to travel time to reception center) + 19 minutes (equal to travel time to start of route, i.e., 14.3 miles @ 45mph) + 19 minutes (equal to travel time for second route, i.e., 14.3 miles @ 45mph) = 70 minutes
- Bus completes pick-ups along route: 30 minutes.
- Bus exits EPZ at time 3:00 + 0:32 + 0:15 + 1:10 + 0:30 = 5:30 (rounded to nearest 5 minutes) after the Advisory to Evacuate.

The ETE for the completion of the second wave for all transit-dependent bus routes are provided in Table 8-5 through Table 8-7.

The average single wave ETE for the transit-dependent population is the same as the 90th percentile ETE for the evacuation of the general population in the entire EPZ (Region R03) during Scenario 6 conditions (3:30). The average ETE for a two-wave evacuation of transit-dependent people exceeds the ETE for the general population at the 90th percentile by 2 hours and 5 minutes and could impact protective action decision making.

The relocation of transit-dependent evacuees from the reception centers to congregate care centers, if the counties decide to do so, is not considered in this study.

Evacuation of Medical Facilities

The evacuation of these facilities is similar to school evacuation except:

- Buses are assigned on the basis of 30 patients to allow for staff to accompany the

patients.

- Wheelchair buses can accommodate 15 patients.
- Wheelchair vans can accommodate 4 patients.
- Ambulances can accommodate 2 patients.
- Based on feedback from the county emergency management agencies, loading times of 1 minute, 5 minutes, and 15 minutes per patient are used for ambulatory, wheelchair bound, and bedridden patients, respectively.

Using the data provided, these assumptions, and the aforementioned vehicle capacities, Table 3-6 indicates that 16 buses, 16 wheelchair vehicles and 21 ambulances are needed to service all of the medical facilities in the EPZ. As previously discussed, there is a shortfall of buses in the EPZ and two waves will be needed to evacuate the ambulatory population at medical facilities within the EPZ.

As is done for the schools, it is estimated that mobilization time averages 90 minutes in good weather (100 in rain, 110 in ice). Specially trained medical support staff (working their regular shift) will be on site to assist in the evacuation of patients. Additional staff (if needed) could be mobilized over this same 90 minute timeframe.

Table 8-8 through Table 8-10 summarize the ETE for medical facilities within the EPZ for good weather, rain, and ice, respectively. The distances from the medical facilities to the EPZ boundary were estimated using GIS software. Average speeds output by the model for Scenario 6 (Scenario 7 for rain and Scenario 8 for ice) Region 3, capped at 45 mph (40 mph for rain and 35 mph for ice), are used to compute travel time to EPZ boundary. The travel time to the EPZ boundary is computed by dividing the distance to the EPZ boundary by the average travel speed. The ETE is the sum of the mobilization time, total passenger loading time, and travel time out of the EPZ. Concurrent loading on multiple buses, wheelchair buses/vans, and ambulances at capacity is assumed such that the maximum loading times for buses (maximum capacity of 30 times 1 minute per passenger), wheelchair buses (15 times 5), wheelchair vans (4 times 5), and ambulances (2 times 15) are 30, 75, 20 and 30 minutes, respectively. All ETE are rounded to the nearest 5 minutes.

For example, the calculation of ETE for Sanford Health & Rehabilitation with 31 ambulatory residents during good weather is:

ETE: 90 + 30 x 1 + 3 = 123 minutes or 2:05 (rounded up to the nearest 5 minutes.)

It is assumed that the medical facility population is directly evacuated to appropriate host medical facilities outside of the EPZ. Relocation of this population to permanent facilities and/or passing through the reception center before arriving at the host facility are not considered in this analysis.

Average single wave ETE for medical facilities are less than the 90th percentile ETE for the evacuation of the general population from Region R03 during Scenario 6 conditions and will not impact protective action decision making.

A second wave ETE was not computed for each medical facility. Rather, the following representative ETE is provided to estimate the additional time needed for a second wave

evacuation using school buses after the schools have been evacuated. Times and distances are based on facility-wide averages:

- Buses arrive at relocation schools at 2:35 (average travel time to relocation school in Table 8-2)
- Bus discharges passengers 41 minutes (average bus loading time from Table 8-8) and driver takes a 10-minute rest: 51 minutes.
- Bus returns to EPZ and completes second route: 21 minutes to travel back to the EPZ boundary (equal to travel time to reception center in Table 8-2) + 27 minutes to travel back to the facility (average of travel time to EPZ Boundary in Table 8-8) and then back to the EPZ boundary (6 miles @ 45 mph = 8 minutes) = 56 minutes. The average distance to EPZ boundary is approximately 2.9 miles in Table 8-8. Thus 6 miles is the estimated distance to travel from the EPZ boundary to a medical facility and then back to the EPZ boundary.
- Loading Time: 41 minutes (average from Table 8-8).

Bus exits EPZ at time 2:35 + 0:51 + 0:56 + 0:41 = 5:05 (rounded to nearest 5 minutes) after the Advisory to Evacuate.

Thus, the second wave evacuation requires an additional 2 hours and 25 minutes, on average. The average ETE for a two-wave evacuation of medical facilities exceeds the ETE for the general population at the 90th percentile and will impact protective action decision making.

8.2 ETE for Access and/or Functional Needs Population

Table 8-11 summarizes the ETE for access and/or functional needs population. The table is categorized by type of vehicle required and then broken down by weather condition. The table takes into consideration the deployment of multiple vehicles (not filled to capacity) to reduce the number of stops per vehicle. Due to the limitations on driving for access and/or functional needs persons, it assumed they will be picked up from their homes. Furthermore, it is conservatively assumed that ambulatory and wheelchair bound access and/or functional needs households are spaced 3 miles apart and bedridden households are spaced 5 miles apart. Van and bus speeds approximate 20 mph between households and ambulance speeds approximate 30 mph in good weather (10% slower in rain, 20% slower in ice). Mobilization times of 90 minutes were used (100 minutes for rain, and 110 minutes for ice). Loading times of 1 minute per person are assumed for ambulatory people, 5 minutes for wheelchair bound people and 15 minutes per person are assumed for bedridden people. The last HH is assumed to be 5 miles from the EPZ boundary, and the network-wide average speed, capped at 45 mph (40 mph for rain and 35 mph for ice), after the last pickup is used to compute travel time. ETE is computed by summing mobilization time, loading time at first household, travel to subsequent households, loading time at subsequent households, and travel time to EPZ boundary. All ETE are rounded to the nearest 5 minutes.

For example, assuming no more than one access and/or functional needs person per HH implies that 161 ambulatory households need to be serviced. While only 6 buses are needed from a

capacity perspective, if 25 buses are deployed to service these HH, then each would require at most 7 stops. The following outlines the ETE calculations:

1. Assume 25 buses are deployed, each with at most 7 stops, to service a total of 161 HH.
2. The ETE is calculated as follows:
    a. Buses arrive at the first pickup location: 130 minutes
    b. Load HH members at first pickup: 1 minute
    c. Travel to subsequent pickup locations: 6 @ 9 minutes (3 miles @ 20 mph) = 54 minutes
    d. Load HH members at subsequent pickup locations: 6 @ 1 minute = 6 minutes
    e. Travel to EPZ boundary: 24 minutes (5 miles @ 12.5 mph – network wide average speed at this time).

    ETE: 130 + 1 + 54 + 6 + 24 = 3:35 rounded to the nearest 5 minutes

The average ETE for a single wave evacuation of the access and/or functional needs population is approximately 5 minutes longer than the general population ETE at the 90th percentile for an evacuation of the entire EPZ (Region R03), during Scenario 6 conditions. Therefore, the evacuation of transit-dependents could potentially impact protective action decision making.

The following outlines the ETE calculations if a second wave is needed using school buses after the schools have been evacuated (see Table 8-2):

a. School buses arrive at relocation schools: 2:35 on average
b. Unload patients at pick-up point: 5 minutes.
c. Driver takes 10-minute rest: 10 minutes.
d. Travel time back to EPZ: 21 minutes (average time of "Travel Time from EPZ Bdry to Rec. Ctr." From Table 8-2)
e. Travel to first household: 9 minutes (3 miles x 20 mph)
f. Loading time at first household: 1 minute
g. Travel to subsequent pickup locations: 6 @ 9 minutes = 54 minutes
h. Loading time at subsequent households: 6 stops @ 1 minutes = 6 minutes
i. Travel time to EPZ boundary at 5 miles @ 12 mph = 25 minutes

Good Weather ETE: 2:35 + 5 + 10 + 21 + 9 + 1 + 54 + 6 + 25 = 4:50 rounded to the nearest 5 minutes

Rain ETE: 2:55 + 5 + 10 + 21 + 10 + 1 + 60 + 6 + 32 = 5:20 rounded to the nearest 5 minutes

Ice ETE: 3:20 + 5 + 10 + 21 + 11 + 1 + 66 + 6 + 42 = 6:05 rounded to the nearest 5 minutes

Table 8-1. Summary of Transportation Resources

Transportation Resource	Buses	Vans/Minivans	Wheelchair Buses	Wheelchair Vans	Ambulances	Medevac Helicopter
Resources Available						
Harnett County						
Harnett County	300	0	0	0	0	0
Harnett Area Transit System	9	6	0	12	0	0
Anderson Creek Emergency Services	0	0	0	0	3	0
Erwin Fire Rescue	0	0	0	0	2	0
Coats Grove Fire Department	0	0	0	0	2	0
Benhaven Emergency Services	0	0	0	0	3	0
Boone Trail Emergency Services	0	0	0	0	3	0
Buies Creek	0	0	0	0	3	0
Dunn Emergency Services	0	0	0	0	4	0
Harnett EMS (Multiple Staging Locations	0	0	0	2	8	0
Betsy Johnson Hospital	0	0	0	0	0	1
Chatham County						
Chatham Public Schools	93	0	0	0	0	0
CPS Moncure Elementary School	5	0	0	0	0	0
Chatham Transit Network	0	0	1	28	0	0
Chatham County EMS - FirstHealth	0	0	0	0	8	0
UNC Healthcare - Carolina Air Care	0	0	0	0	0	1
Lee County						
Lee County	130	0	0	0	8	0
Central Carolina Hospital (CCH)	0	0	0	1	1	0
County of Lee Transit System (COLTS)	0	0	15	18	0	0
Sanford Health & Rehab	0	0	0	1	0	0
FirstHealth	0	0	0	0	7	0

Transportation Resource	Buses	Vans/Minivans	Wheelchair Buses	Wheelchair Vans	Ambulances	Medevac Helicopter
Wake County						
Wake County Public School System	-	-	-	-	-	-
Wake EMS					45	
Wake County EMS - Apex	-	-	-	-	3	-
Wake County EMS - Fuquay-Varina	-	-	-	-	2	-
Wake County EMS - Holly Springs	-	-	-	-	2	-
Eastern Wake and Cary Area EMS	*merged with Wake County EMS*					
WakeMed Critical Care	*inner hospital transport only*					
Rex Healthcare	*inner hospital transport only*					
Country Lane Group Home	-	1		-	-	-
Creekway Home	-	1		-	-	-
Hickory Avenue Home	-	1		-	-	-
Lockley Road Home	-	1	1	-	-	-
Mim's Family Care Home	-	1	-		-	-
Olive Home	-	1		-	-	-
Seagraves Family Care Home	-	-	1	-	-	-
Windsor Point Continuing Care	1	1	-	-	-	-
TOTAL:	**538**	**13**	**18**	**62**	**104**	**2**
Resources Needed						
Medical Facilities (Table 3-6):	18	0	17	0	23	0
Schools (Table 3-8):	698	0	0	0	0	0
Access and/or Functional Needs (Table 3-9):	25	0	4	6	7	0
Transit-Dependent Population (Table 10-1):	83	0	0	0	0	0
TOTAL TRANSPORTATION NEEDS:	**824**	**0**	**21**	**6**	**30**	**0**

Table 8-2. School and Child Care Center Evacuation Time Estimates - Good Weather

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to R.S. (mi.)	Travel Time from EPZ Bdry to R.S. (min)	ETA to R.S. (hr:min)
CHATHAM COUNTY SCHOOLS									
Moncure Elementary School	90	15	4.7	45.0	6	**1:55**	8.4	11	**2:10**
Seaforth High School	90	15	4.7	3.8	74	**3:00**	6.5	9	**3:10**
HARNETT COUNTY SCHOOLS									
Lafayette Elementary School	90	15	0.0	0.0	0	**1:45**	3.9	5	**1:50**
LEE COUNTY SCHOOLS									
Deep River Elementary School	90	15	0.0	0.0	0	**1:45**	8.8	12	**2:00**
WAKE COUNTY SCHOOLS									
Oakview Elementary School	90	15	7.4	8.4	53	**2:40**	24.7	33	**3:15**
Apex Friendship Middle School	90	15	4.9	5.4	54	**2:40**	13.5	18	**3:00**
Apex Friendship High School	90	15	4.9	5.4	54	**2:40**	13.5	18	**3:00**
Thales Academy Holly Springs Pre-K-5	90	15	7.4	8.4	53	**2:40**	24.7	33	**3:15**
Scotts Ridge Elementary School	90	15	4.9	5.6	53	**2:40**	13.5	18	**3:00**
St. Mary Magdalene Catholic School	90	15	4.9	5.2	57	**2:45**	10.6	14	**3:00**
Olive Chapel Elementary School	90	15	3.3	13.0	15	**2:00**	17.4	23	**2:25**
Apex Elementary School	90	15	3.3	4.1	48	**2:35**	14.7	20	**2:55**
Apex Middle School	90	15	2.9	3.2	55	**2:40**	17.1	23	**3:05**
Baucom Elementary School	90	15	3.0	37.9	5	**1:50**	17.3	23	**2:15**
Lufkin Road Middle School	90	15	1.2	12.6	6	**1:55**	17.1	23	**2:20**
Peak Charter Academy	90	15	3.2	36.4	5	**1:50**	15.9	21	**2:15**
Thales Academy Apex K-5	90	15	2.9	30.2	6	**1:55**	14.7	20	**2:15**
Thales Academy Apex JH/HS	90	15	1.4	25.1	3	**1:50**	15.9	21	**2:15**
Apex Senior High School	90	15	0.8	35.2	1	**1:50**	15.9	21	**2:15**
Holly Grove Elementary School	90	15	8.3	8.4	59	**2:45**	13.5	18	**3:05**
Holly Grove Middle School	90	15	8.2	8.4	59	**2:45**	24.9	33	**3:20**
Holly Springs High School	90	15	8.7	8.4	62	**2:50**	13.5	18	**3:10**

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to R.S. (mi.)	Travel Time from EPZ Bdry to R.S. (min)	ETA to R.S. (hr:min)
Holly Springs Elementary School	90	15	3.7	14.6	15	**2:00**	24.7	33	**2:35**
Pine Springs Preparatory Academy	90	15	4.5	5.2	52	**2:40**	13.5	18	**3:00**
Holly Ridge Elementary School	90	15	3.2	13.4	14	**2:00**	13.3	18	**2:20**
Holly Ridge Middle School	90	15	3.2	13.4	14	**2:00**	13.3	18	**2:20**
Buckhorn Creek Elementary School	90	15	3.1	3.8	49	**2:35**	12.8	17	**2:55**
Southern Wake Academy	90	15	3.1	3.9	48	**2:35**	12.8	17	**2:55**
Herbert Akins Road Elementary School	90	15	3.3	37.2	5	**1:50**	27.0	36	**2:30**
Lincoln Heights Elementary School	90	15	1.7	2.8	37	**2:25**	28.9	39	**3:05**
Fuquay-Varina Senior High School	90	15	1.1	3.3	20	**2:05**	13.0	17	**2:25**
Fuquay-Varina Middle School	90	15	0.9	3.4	16	**2:05**	28.4	38	**2:45**
WAKE COUNTY CHILD CARE CENTERS									
Angel's Garden Home Daycare	90	15	3.0	10.0	18	**2:05**	17.3	23	**2:30**
Apex Baptist Church Preschool	90	15	2.7	22.4	7	**1:55**	14.7	20	**2:15**
Apex Peak Schools, Inc.	90	15	2.8	24.0	7	**1:55**	14.7	20	**2:15**
Apex United Methodist Church Preschool	90	15	2.9	3.2	55	**2:40**	14.7	20	**3:00**
AsheBridge Children's Academy of Apex/Cary	90	15	1.9	28.2	4	**1:50**	15.8	21	**2:15**
Bright Start Child Care LLC	90	15	2.9	15.4	11	**2:00**	15.8	21	**2:25**
Children's Choice	90	15	1.8	37.6	3	**1:50**	16.1	21	**2:15**
Children's Lighthouse of Apex	90	15	0.8	23.8	2	**1:50**	15.9	21	**2:15**
Creative Schools of Apex	90	15	0.8	23.8	2	**1:50**	15.9	21	**2:15**
Earth Angel's Day Care Home	90	15	1.8	37.6	3	**1:50**	16.1	22	**2:15**
Eileen's Day Care	90	15	0.0	0.0	0	**1:45**	15.9	21	**2:10**
Everbrook Academy of Apex	90	15	2.9	18.2	10	**1:55**	15.9	21	**2:20**
Goddard School Apex	90	15	2.7	22.4	7	**1:55**	14.7	20	**2:15**
Grace Church Preschool and Summer Camp	90	15	1.5	28.2	3	**1:50**	16.1	21	**2:15**
Growing Years Learning Center	90	15	2.7	22.4	7	**1:55**	14.7	20	**2:15**
Hope Chapel Preschool	90	15	1.4	33.2	3	**1:50**	15.9	21	**2:15**
Karen's Kids Home Child Care	90	15	4.9	14.0	21	**2:10**	14.7	20	**2:30**

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to R.S. (mi.)	Travel Time from EPZ Bdry to R.S. (min)	ETA to R.S. (hr:min)
Kidtowne at Hope Community Church - Apex	90	15	4.5	5.3	51	**2:40**	14.7	20	**3:00**
Kindercare Learning Center	90	15	4.6	13.2	21	**2:10**	15.9	21	**2:35**
Majestic Learning Experience Inc.	90	15	0.9	38.9	1	**1:50**	15.8	21	**2:15**
Montessori Creative Learning School	90	15	3.6	4.5	48	**2:35**	14.7	20	**2:55**
Moravic Family Day Care	90	15	1.0	15.3	4	**1:50**	14.7	20	**2:10**
Nicole Miller's Family Childcare Home	90	15	4.9	14.0	21	**2:10**	14.7	20	**2:30**
Peace Montessori	90	15	3.0	25.3	7	**1:55**	14.7	20	**2:15**
Play Care	90	15	3.2	33.9	6	**1:55**	15.9	21	**2:20**
Primrose School of Apex	90	15	0.0	0.0	0	**1:45**	15.9	21	**2:10**
The Goddard School of Apex (Green Level West)	90	15	1.4	23.6	4	**1:50**	24.2	32	**2:25**
The Learning Experience in Apex	90	15	4.2	17.2	15	**2:00**	15.9	21	**2:25**
Vickie's Day Care Home	90	15	2.7	22.4	7	**1:55**	14.7	20	**2:15**
Woodhaven Weekday Preschool	90	15	4.4	29.6	9	**1:55**	15.0	20	**2:15**
Primrose School at Holly Grove	90	15	9.7	9.5	61	**2:50**	14.7	20	**3:10**
Holly Springs Academy NC	90	15	3.7	15.5	14	**2:00**	13.3	18	**2:20**
Holly Springs KinderCare	90	15	7.4	15.9	28	**2:15**	13.3	18	**2:35**
Holly Springs Learning Center	90	15	4.4	20.7	13	**2:00**	15.0	20	**2:20**
Holly Springs School For Early Education	90	15	4.5	5.2	52	**2:40**	13.5	18	**3:00**
Home Away From Home Childcare	90	15	8.1	8.4	58	**2:45**	14.7	20	**3:05**
Kiddie Academy of Holly Springs	90	15	4.5	5.2	52	**2:40**	13.5	18	**3:00**
Kris' Home Sweet Home Daycare	90	15	4.4	20.7	13	**2:00**	15.0	20	**2:20**
Leaping Froggy	90	15	4.9	5.7	52	**2:40**	13.5	18	**3:00**
Lightbridge Academy - Apex	90	15	4.6	17.8	16	**2:05**	15.0	20	**2:25**
Lightbridge Academy - Holly Springs	90	15	8.3	8.4	59	**2:45**	14.7	20	**3:05**
Little Dreamers Preschool	90	15	4.5	5.2	52	**2:40**	13.5	18	**3:00**
Loving Hand Day Care	90	15	6.8	6.3	65	**2:50**	13.5	18	**3:10**
New School Montessori Center	90	15	2.7	18.0	9	**1:55**	13.4	18	**2:15**
Sisters' Child Care Services	90	15	4.4	20.7	13	**2:00**	15.0	20	**2:20**

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to R.S. (mi.)	Travel Time from EPZ Bdry to R.S. (min)	ETA to R.S. (hr:min)
Stella Lowery Small Day Care Home	90	15	1.5	14.3	6	**1:55**	13.4	18	**2:15**
Sunrise United Methodist Church Preschool	90	15	2.7	17.1	9	**1:55**	13.3	18	**2:15**
The Clubhouse of Holly Springs	90	15	3.2	13.4	14	**2:00**	13.3	18	**2:20**
The Goddard School of Holly Springs	90	15	3.2	12.1	16	**2:05**	13.3	18	**2:25**
The Learning Experience - Holly Springs	90	15	4.4	20.7	13	**2:00**	15.0	20	**2:20**
A Mother's Love	90	15	2.9	4.7	37	**2:25**	12.8	17	**2:45**
Busy Bee Home Daycare	90	15	1.4	13.9	6	**1:55**	29.7	40	**2:35**
Childcare Network - Fuquay-Varina	90	15	1.1	2.7	25	**2:10**	13.0	17	**2:30**
Fuquay-Varina Baptist Wee Care	90	15	0.8	3.5	14	**2:00**	13.0	17	**2:20**
Fuquay-Varina UMC Preschool Seeds of Faith	90	15	0.8	3.5	14	**2:00**	13.0	17	**2:20**
Little Angels Preparatory	90	15	1.1	2.8	24	**2:10**	13.7	18	**2:30**
Little Miracles	90	15	1.1	2.8	24	**2:10**	13.7	18	**2:30**
Melissa's Sweet Peas Child Care Home	90	15	2.9	4.7	37	**2:25**	12.8	17	**2:45**
Montessori Kids Universe - Fuquay Varina	90	15	0.8	3.9	12	**2:00**	12.8	17	**2:20**
My Lil Friends Childcare	90	15	3.1	4.8	39	**2:25**	12.8	17	**2:45**
Ready Or Not Here I Grow	90	15	1.7	5.2	20	**2:05**	12.8	17	**2:25**
Roots To Wings Childcare	90	15	1.1	2.7	25	**2:10**	13.0	17	**2:30**
South Wake Preschool & Academy	90	15	3.1	3.7	50	**2:35**	12.8	17	**2:55**
Unique Creations Child Care Center	90	15	0.8	2.5	19	**2:05**	28.9	39	**2:45**
Unique Creations Child Care Center South Campus	90	15	1.7	2.3	44	**2:30**	28.9	39	**3:10**
Vanessa Bland's Small Day Care Home	90	15	1.7	3.4	30	**2:15**	28.9	39	**2:55**
CHATHAM COUNTY CHILD CARE CENTERS									
YMCA After Care Program	90	15	4.7	45.0	6	**1:55**	8.4	11	**2:10**
					Maximum for EPZ:	**3:00**		**Maximum:**	**3:20**
					Average for EPZ:	**2:15**		**Average:**	**2:35**

Notes:

1 – Not included in calculation for Maximum and Average ETE values since school/childcare center is in the Shadow Region.

2 – ETE for Herbert Akins Road Elementary School and Lincoln Heights Elementary School includes school children and childcare children.

Table 8-3. School and Child Care Center Evacuation Time Estimates – Rain

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to R. S. (mi.)	Travel Time from EPZ Bdry to R.S. (min)	ETA to R. S. (hr:min)
CHATHAM COUNTY SCHOOLS									
Moncure Elementary School	100	20	4.7	40.0	7	2:10	8.4	13	2:25
Seaforth High School	100	20	4.7	3.3	84	3:25	6.5	10	3:35
HARNETT COUNTY SCHOOLS									
Lafayette Elementary School	100	20	0.0	0.0	0	2:00	3.9	6	2:10
LEE COUNTY SCHOOLS									
Deep River Elementary School	100	20	0.0	0.0	0	2:00	8.8	13	2:15
WAKE COUNTY SCHOOLS									
Oakview Elementary School	100	20	7.4	6.8	66	3:10	24.7	37	3:50
Apex Friendship Middle School	100	20	4.9	6.0	49	2:50	13.5	20	3:10
Apex Friendship High School	100	20	4.9	6.0	49	2:50	13.5	20	3:10
Thales Academy Holly Springs Pre-K-5	100	20	7.4	6.8	66	3:10	24.7	37	3:50
Scotts Ridge Elementary School	100	20	4.9	6.0	49	2:50	13.5	20	3:10
St. Mary Magdalene Catholic School	100	20	4.9	6.4	46	2:50	10.6	16	3:10
Olive Chapel Elementary School	100	20	3.3	12.5	16	2:20	17.4	26	2:50
Apex Elementary School	100	20	3.3	4.7	42	2:45	14.7	22	3:10
Apex Middle School	100	20	2.9	4.3	40	2:40	17.1	26	3:10
Baucom Elementary School	100	20	3.0	31.6	6	2:10	17.3	26	2:40
Lufkin Road Middle School	100	20	1.2	3.7	20	2:20	17.1	26	2:50
Peak Charter Academy	100	20	3.2	23.5	8	2:10	15.9	24	2:35
Thales Academy Apex K-5	100	20	2.9	14.6	12	2:15	14.7	22	2:40
Thales Academy Apex JH/HS	100	20	1.4	16.4	5	2:05	15.9	24	2:30
Apex Senior High School	100	20	0.8	11.4	4	2:05	15.9	24	2:30
Holly Grove Elementary School	100	20	8.3	7.3	68	3:10	13.5	20	3:30
Holly Grove Middle School	100	20	8.2	7.3	67	3:10	24.9	37	3:50
Holly Springs High School	100	20	8.7	8.1	64	3:05	13.5	20	3:25
Holly Springs Elementary School	100	20	3.7	15.9	14	2:15	24.7	37	2:55
Pine Springs Preparatory Academy	100	20	4.5	5.5	49	2:50	13.5	20	3:10

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to R. S. (mi.)	Travel Time from EPZ Bdry to R.S. (min)	ETA to R. S. (hr:min)
Holly Ridge Elementary School	100	20	3.2	15.5	12	**2:15**	13.3	20	**2:35**
Holly Ridge Middle School	100	20	3.2	15.5	12	**2:15**	13.3	20	**2:35**
Buckhorn Creek Elementary School	100	20	3.1	3.8	50	**2:50**	12.8	19	**3:10**
Southern Wake Academy	100	20	3.1	3.5	53	**2:55**	12.8	19	**3:15**
Herbert Akins Road Elementary School	100	20	3.3	31.1	6	**2:10**	27.0	41	**2:55**
Lincoln Heights Elementary School	100	20	1.7	1.8	57	**3:00**	28.9	43	**3:45**
Fuquay-Varina Senior High School	100	20	1.1	2.8	24	**2:25**	13.0	20	**2:45**
Fuquay-Varina Middle School	100	20	0.9	3.1	18	**2:20**	28.4	43	**3:05**
WAKE COUNTY CHILD CARE CENTERS									
Angel's Garden Home Daycare	100	20	3.0	9.8	18	**2:20**	17.3	26	**2:50**
Apex Baptist Church Preschool	100	20	2.7	15.2	11	**2:15**	14.7	22	**2:40**
Apex Peak Schools, Inc.	100	20	2.8	16.4	10	**2:10**	14.7	22	**2:35**
Apex United Methodist Church Preschool	100	20	2.9	4.3	40	**2:40**	14.7	22	**3:05**
AsheBridge Children's Academy of Apex/Cary	100	20	1.9	20.5	5	**2:05**	15.8	24	**2:30**
Bright Start Child Care LLC	100	20	2.9	20.7	8	**2:10**	15.8	24	**2:35**
Children's Choice	100	20	1.8	34.0	3	**2:05**	16.1	24	**2:30**
Children's Lighthouse of Apex	100	20	0.8	12.8	4	**2:05**	15.9	24	**2:30**
Creative Schools of Apex	100	20	0.8	12.8	4	**2:05**	15.9	24	**2:30**
Earth Angel's Day Care Home	100	20	1.8	34.0	3	**2:05**	16.1	24	**2:30**
Eileen's Day Care	100	20	0.0	0.0	0	**2:00**	15.9	24	**2:25**
Everbrook Academy of Apex	100	20	2.9	18.2	10	**2:10**	15.9	24	**2:35**
Goddard School Apex	100	20	2.7	15.2	11	**2:15**	14.7	22	**2:40**
Grace Church Preschool and Summer Camp	100	20	1.5	20.6	4	**2:05**	16.1	24	**2:30**
Growing Years Learning Center	100	20	2.7	15.2	11	**2:15**	14.7	22	**2:40**
Hope Chapel Preschool	100	20	1.4	24.0	4	**2:05**	15.9	24	**2:30**
Karen's Kids Home Child Care	100	20	4.9	15.8	19	**2:20**	14.7	22	**2:45**
Kidtowne at Hope Community Church - Apex	100	20	4.5	5.8	47	**2:50**	14.7	22	**3:15**
Kindercare Learning Center	100	20	4.6	12.3	23	**2:25**	15.9	24	**2:50**
Majestic Learning Experience Inc.	100	20	0.9	35.5	2	**2:05**	15.8	24	**2:30**

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to R. S. (mi.)	Travel Time from EPZ Bdry to R.S. (min)	ETA to R. S. (hr:min)
Montessori Creative Learning School	100	20	3.6	4.7	46	**2:50**	14.7	22	**3:15**
Moravic Family Day Care	100	20	1.0	8.1	7	**2:10**	14.7	22	**2:35**
Nicole Miller's Family Childcare Home	100	20	4.9	15.8	19	**2:20**	14.7	22	**2:45**
Peace Montessori	100	20	3.0	17.4	10	**2:10**	14.7	22	**2:35**
Play Care	100	20	3.2	24.8	8	**2:10**	15.9	24	**2:35**
Primrose School of Apex	100	20	0.0	0.0	0	**2:00**	15.9	24	**2:25**
The Goddard School of Apex (Green Level West)	100	20	1.4	18.9	4	**2:05**	24.2	36	**2:45**
The Learning Experience in Apex	100	20	4.2	14.1	18	**2:20**	15.9	24	**2:45**
Vickie's Day Care Home	100	20	2.7	15.2	11	**2:15**	14.7	22	**2:40**
Woodhaven Weekday Preschool	100	20	4.4	20.2	13	**2:15**	15.0	23	**2:40**
Primrose School at Holly Grove	100	20	9.7	8.1	71	**3:15**	14.7	22	**3:40**
Holly Springs Academy NC	100	20	3.7	13.5	16	**2:20**	13.3	20	**2:40**
Holly Springs KinderCare	100	20	7.4	12.8	35	**2:35**	13.3	20	**2:55**
Holly Springs Learning Center	100	20	4.4	16.8	16	**2:20**	15.0	23	**2:45**
Holly Springs School For Early Education	100	20	4.5	5.5	49	**2:50**	13.5	20	**3:10**
Home Away From Home Childcare	100	20	8.1	7.3	66	**3:10**	14.7	22	**3:35**
Kiddie Academy of Holly Springs	100	20	4.5	5.5	49	**2:50**	13.5	20	**3:10**
Kris' Home Sweet Home Daycare	100	20	4.4	16.8	16	**2:20**	15.0	23	**2:45**
Leaping Froggy	100	20	4.9	5.9	50	**2:50**	13.5	20	**3:10**
Lightbridge Academy - Apex	100	20	4.6	14.1	20	**2:20**	15.0	23	**2:45**
Lightbridge Academy - Holly Springs	100	20	8.3	7.3	68	**3:10**	14.7	22	**3:35**
Little Dreamers Preschool	100	20	4.5	5.5	49	**2:50**	13.5	20	**3:10**
Loving Hand Day Care	100	20	6.8	7.1	57	**3:00**	13.5	20	**3:20**
New School Montessori Center	100	20	2.7	25.0	6	**2:10**	13.4	20	**2:30**
Sisters' Child Care Services	100	20	4.4	16.8	16	**2:20**	15.0	23	**2:45**
Stella Lowery Small Day Care Home	100	20	1.5	21.1	4	**2:05**	13.4	20	**2:25**
Sunrise United Methodist Church Preschool	100	20	2.7	21.8	7	**2:10**	13.3	20	**2:30**
The Clubhouse of Holly Springs	100	20	3.2	15.5	12	**2:15**	13.3	20	**2:35**
The Goddard School of Holly Springs	100	20	3.2	13.0	15	**2:15**	13.3	20	**2:35**

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to R. S. (mi.)	Travel Time from EPZ Bdry to R.S. (min)	ETA to R. S. (hr:min)
The Learning Experience - Holly Springs	100	20	4.4	16.8	16	**2:20**	15.0	23	**2:45**
A Mother's Love	100	20	2.9	3.5	49	**2:50**	12.8	19	**3:10**
Busy Bee Home Daycare	100	20	1.4	19.0	4	**2:05**	29.7	45	**2:50**
Childcare Network - Fuquay-Varina	100	20	1.1	1.9	35	**2:35**	13.0	20	**2:55**
Fuquay-Varina Baptist Wee Care	100	20	0.8	3.1	16	**2:20**	13.0	20	**2:40**
Fuquay-Varina UMC Preschool Seeds of Faith	100	20	0.8	3.1	16	**2:20**	13.0	20	**2:40**
Little Angels Preparatory	100	20	1.1	2.8	24	**2:25**	13.7	21	**2:50**
Little Miracles	100	20	1.1	2.8	24	**2:25**	13.7	21	**2:50**
Melissa's Sweet Peas Child Care Home	100	20	2.9	3.5	49	**2:50**	12.8	19	**3:10**
Montessori Kids Universe - Fuquay Varina	100	20	0.8	3.2	15	**2:15**	12.8	19	**2:35**
My Lil Friends Childcare	100	20	3.1	3.6	52	**2:55**	12.8	19	**3:15**
Ready Or Not Here I Grow	100	20	1.7	3.7	28	**2:30**	12.8	19	**2:50**
Roots To Wings Childcare	100	20	1.1	1.9	35	**2:35**	13.0	20	**2:55**
South Wake Preschool & Academy	100	20	3.1	3.4	54	**2:55**	12.8	19	**3:15**
Unique Creations Child Care Center	100	20	0.8	2.0	24	**2:25**	28.9	43	**3:10**
Unique Creations Child Care Center South Campus	100	20	1.7	1.6	63	**3:05**	28.9	43	**3:50**
Vanessa Bland's Small Day Care Home	100	20	1.7	2.1	50	**2:50**	28.9	43	**3:35**
CHATHAM COUNTY CHILD CARE CENTERS									
YMCA After Care Program	100	20	4.7	40.0	7	**2:10**	8.4	13	**2:25**
Maximum for EPZ:						**3:25**	**Maximum:**		**3:50**
Average for EPZ:						**2:30**	**Average:**		**2:55**

Notes:

1 – Not included in calculation for Maximum and Average ETE values since school/childcare center is in the Shadow Region.

2 – ETE for Herbert Akins Road Elementary School and Lincoln Heights Elementary School includes school children and childcare children.

Table 8-4. School and Child Care Center Evacuation Time Estimates – Ice

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to R. S. (mi.)	Travel Time from EPZ Bdry to R.S. (min)	ETA to R. S. (hr:min)
CHATHAM COUNTY SCHOOLS									
Moncure Elementary School	110	25	4.7	35.0	8	**2:25**	8.4	14	**2:40**
Seaforth High School	110	25	4.7	3.1	90	**3:45**	6.5	11	**4:00**
HARNETT COUNTY SCHOOLS									
Lafayette Elementary School	110	25	0.0	0.0	0	**2:15**	3.9	7	**2:25**
LEE COUNTY SCHOOLS									
Deep River Elementary School	110	25	0.0	0.0	0	**2:15**	8.8	15	**2:30**
WAKE COUNTY SCHOOLS									
Oakview Elementary School	110	25	7.4	7.2	62	**3:20**	24.7	42	**4:05**
Apex Friendship Middle School	110	25	4.9	5.0	59	**3:15**	13.5	23	**3:40**
Apex Friendship High School	110	25	4.9	5.0	59	**3:15**	13.5	23	**3:40**
Thales Academy Holly Springs Pre-K-5	110	25	7.4	7.2	62	**3:20**	24.7	42	**4:05**
Scotts Ridge Elementary School	110	25	4.9	4.9	60	**3:15**	13.5	23	**3:40**
St. Mary Magdalene Catholic School	110	25	4.9	5.1	57	**3:15**	10.6	18	**3:35**
Olive Chapel Elementary School	110	25	3.3	11.4	17	**2:35**	17.4	30	**3:05**
Apex Elementary School	110	25	3.3	3.7	53	**3:10**	14.7	25	**3:35**
Apex Middle School	110	25	2.9	3.2	54	**3:10**	17.1	29	**3:40**
Baucom Elementary School	110	25	3.0	26.5	7	**2:25**	17.3	30	**2:55**
Lufkin Road Middle School	110	25	1.2	2.9	25	**2:40**	17.1	29	**3:10**
Peak Charter Academy	110	25	3.2	5.7	34	**2:50**	15.9	27	**3:20**
Thales Academy Apex K-5	110	25	2.9	4.4	39	**2:55**	14.7	25	**3:20**
Thales Academy Apex JH/HS	110	25	1.4	13.3	6	**2:25**	15.9	27	**2:55**
Apex Senior High School	110	25	0.8	14.8	3	**2:20**	15.9	27	**2:50**
Holly Grove Elementary School	110	25	8.3	6.9	72	**3:30**	13.5	23	**3:55**
Holly Grove Middle School	110	25	8.2	6.9	71	**3:30**	24.9	43	**4:15**
Holly Springs High School	110	25	8.7	7.6	69	**3:25**	13.5	23	**3:50**
Holly Springs Elementary School	110	25	3.7	9.7	23	**2:40**	24.7	42	**3:25**
Pine Springs Preparatory Academy	110	25	4.5	4.9	55	**3:10**	13.5	23	**3:35**

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to R. S. (mi.)	Travel Time from EPZ Bdry to R.S. (min)	ETA to R. S. (hr:min)
Holly Ridge Elementary School	110	25	3.2	10.2	19	**2:35**	13.3	23	**3:00**
Holly Ridge Middle School	110	25	3.2	10.2	19	**2:35**	13.3	23	**3:00**
Buckhorn Creek Elementary School	110	25	3.1	3.1	60	**3:15**	12.8	22	**3:40**
Southern Wake Academy	110	25	3.1	3.1	60	**3:15**	12.8	22	**3:40**
Herbert Akins Road Elementary School	110	25	3.3	29.0	7	**2:25**	27.0	46	**3:15**
Lincoln Heights Elementary School	110	25	1.7	2.0	51	**3:10**	28.9	50	**4:00**
Fuquay-Varina Senior High School	110	25	1.1	2.1	31	**2:50**	13.0	22	**3:15**
Fuquay-Varina Middle School	110	25	0.9	2.6	21	**2:40**	28.4	49	**3:30**
WAKE COUNTY CHILD CARE CENTERS									
Angel's Garden Home Daycare	110	25	3.0	26.7	7	**2:25**	17.3	30	**2:55**
Apex Baptist Church Preschool	110	25	2.7	11.7	14	**2:30**	14.7	25	**2:55**
Apex Peak Schools, Inc.	110	25	2.8	13.3	13	**2:30**	14.7	25	**2:55**
Apex United Methodist Church Preschool	110	25	2.9	3.2	54	**3:10**	14.7	25	**3:35**
AsheBridge Children's Academy of Apex/Cary	110	25	1.9	15.2	7	**2:25**	15.8	27	**2:55**
Bright Start Child Care LLC	110	25	2.9	16.1	11	**2:30**	15.8	27	**3:00**
Children's Choice	110	25	1.8	30.6	4	**2:20**	16.1	28	**2:50**
Children's Lighthouse of Apex	110	25	0.8	14.5	3	**2:20**	15.9	27	**2:50**
Creative Schools of Apex	110	25	0.8	14.5	3	**2:20**	15.9	27	**2:50**
Earth Angel's Day Care Home	110	25	1.8	30.6	4	**2:20**	16.1	28	**2:50**
Eileen's Day Care	110	25	0.0	0.0	0	**2:15**	15.9	27	**2:45**
Everbrook Academy of Apex	110	25	2.9	10.1	17	**2:35**	15.9	27	**3:05**
Goddard School Apex	110	25	2.7	11.7	14	**2:30**	14.7	25	**2:55**
Grace Church Preschool and Summer Camp	110	25	1.5	15.2	6	**2:25**	16.1	28	**2:55**
Growing Years Learning Center	110	25	2.7	11.7	14	**2:30**	14.7	25	**2:55**
Hope Chapel Preschool	110	25	1.4	4.3	19	**2:35**	15.9	27	**3:05**
Karen's Kids Home Child Care	110	25	4.9	15.6	19	**2:35**	14.7	25	**3:00**
Kidtowne at Hope Community Church - Apex	110	25	4.5	4.7	58	**3:15**	14.7	25	**3:40**
Kindercare Learning Center	110	25	4.6	11.4	24	**2:40**	15.9	27	**3:10**
Majestic Learning Experience Inc.	110	25	0.9	32.3	2	**2:20**	15.8	27	**2:50**

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to R. S. (mi.)	Travel Time from EPZ Bdry to R.S. (min)	ETA to R. S. (hr:min)
Montessori Creative Learning School	110	25	3.6	3.7	58	**3:15**	14.7	25	**3:40**
Moravic Family Day Care	110	25	1.0	6.5	9	**2:25**	14.7	25	**2:50**
Nicole Miller's Family Childcare Home	110	25	4.9	15.6	19	**2:35**	14.7	25	**3:00**
Peace Montessori	110	25	3.0	14.4	13	**2:30**	14.7	25	**2:55**
Play Care	110	25	3.2	7.1	27	**2:45**	15.9	27	**3:15**
Primrose School of Apex	110	25	0.0	0.0	0	**2:15**	15.9	27	**2:45**
The Goddard School of Apex (Green Level West)	110	25	1.4	6.7	13	**2:30**	24.2	41	**3:15**
The Learning Experience in Apex	110	25	4.2	7.9	32	**2:50**	15.9	27	**3:20**
Vickie's Day Care Home	110	25	2.7	11.7	14	**2:30**	14.7	25	**2:55**
Woodhaven Weekday Preschool	110	25	4.4	15.2	17	**2:35**	15.0	26	**3:05**
Primrose School at Holly Grove	110	25	9.7	7.6	77	**3:35**	14.7	25	**4:00**
Holly Springs Academy NC	110	25	3.7	11.6	19	**2:35**	13.3	23	**3:00**
Holly Springs KinderCare	110	25	7.4	10.5	42	**3:00**	13.3	23	**3:25**
Holly Springs Learning Center	110	25	4.4	13.5	20	**2:35**	15.0	26	**3:05**
Holly Springs School For Early Education	110	25	4.5	4.9	55	**3:10**	13.5	23	**3:35**
Home Away From Home Childcare	110	25	8.1	6.9	70	**3:25**	14.7	25	**3:50**
Kiddie Academy of Holly Springs	110	25	4.5	4.9	55	**3:10**	13.5	23	**3:35**
Kris' Home Sweet Home Daycare	110	25	4.4	13.5	20	**2:35**	15.0	26	**3:05**
Leaping Froggy	110	25	4.9	5.2	57	**3:15**	13.5	23	**3:40**
Lightbridge Academy - Apex	110	25	4.6	7.9	35	**2:50**	15.0	26	**3:20**
Lightbridge Academy - Holly Springs	110	25	8.3	7.0	71	**3:30**	14.7	25	**3:55**
Little Dreamers Preschool	110	25	4.5	4.9	55	**3:10**	13.5	23	**3:35**
Loving Hand Day Care	110	25	6.8	6.0	68	**3:25**	13.5	23	**3:50**
New School Montessori Center	110	25	2.7	17.3	9	**2:25**	13.4	23	**2:50**
Sisters' Child Care Services	110	25	4.4	13.5	20	**2:35**	15.0	26	**3:05**
Stella Lowery Small Day Care Home	110	25	1.5	13.9	6	**2:25**	13.4	23	**2:50**
Sunrise United Methodist Church Preschool	110	25	2.7	18.7	9	**2:25**	13.3	23	**2:50**
The Clubhouse of Holly Springs	110	25	3.2	10.2	19	**2:35**	13.3	23	**3:00**
The Goddard School of Holly Springs	110	25	3.2	12.0	16	**2:35**	13.3	23	**3:00**

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to R. S. (mi.)	Travel Time from EPZ Bdry to R.S. (min)	ETA to R. S. (hr:min)
The Learning Experience - Holly Springs	110	25	4.4	13.5	20	**2:35**	15.0	26	**3:05**
A Mother's Love	110	25	2.9	3.2	54	**3:10**	12.8	22	**3:35**
Busy Bee Home Daycare	110	25	1.4	16.5	5	**2:20**	29.7	51	**3:15**
Childcare Network - Fuquay-Varina	110	25	1.1	1.8	36	**2:55**	13.0	22	**3:20**
Fuquay-Varina Baptist Wee Care	110	25	0.8	2.6	19	**2:35**	13.0	22	**3:00**
Fuquay-Varina UMC Preschool Seeds of Faith	110	25	0.8	2.6	19	**2:35**	13.0	22	**3:00**
Little Angels Preparatory	110	25	1.1	3.3	20	**2:35**	13.7	23	**3:00**
Little Miracles	110	25	1.1	3.3	20	**2:35**	13.7	23	**3:00**
Melissa's Sweet Peas Child Care Home	110	25	2.9	3.2	54	**3:10**	12.8	22	**3:35**
Montessori Kids Universe - Fuquay Varina	110	25	0.8	2.8	17	**2:35**	12.8	22	**3:00**
My Lil Friends Childcare	110	25	3.1	3.3	57	**3:15**	12.8	22	**3:40**
Ready Or Not Here I Grow	110	25	1.7	3.8	27	**2:45**	12.8	22	**3:10**
Roots To Wings Childcare	110	25	1.1	1.8	36	**2:55**	13.0	22	**3:20**
South Wake Preschool & Academy	110	25	3.1	3.0	63	**3:20**	12.8	22	**3:45**
Unique Creations Child Care Center	110	25	0.8	2.1	23	**2:40**	28.9	50	**3:30**
Unique Creations Child Care Center South Campus	110	25	1.7	1.9	54	**3:10**	28.9	50	**4:00**
Vanessa Bland's Small Day Care Home	110	25	1.7	2.3	44	**3:00**	28.9	50	**3:50**
CHATHAM COUNTY CHILD CARE CENTERS									
YMCA After Care Program	110	25	4.7	35.0	8	**2:25**	8.4	14	**2:40**
					Maximum for EPZ:	**3:45**		**Maximum:**	**4:15**
					Average for EPZ:	**2:50**		**Average:**	**3:20**

Notes:

1 – Not included in calculation for Maximum and Average ETE values since school/childcare center is in the Shadow Region.

2 – ETE for Herbert Akins Road Elementary School and Lincoln Heights Elementary School includes school children and childcare children.

Table 8-5. Transit-Dependent Evacuation Time Estimates - Good Weather

Route Number	Bus Number	One-Wave						Two-Wave						
		Mobilization (min)	Route Length (miles)	Speed (mph)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)	Distance to R. C. (miles)	Travel Time to R. C. (min)	Unload (min)	Driver Rest (min)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)
46	1-3	130	14.3	45.0	19	30	**3:00**	24.2	32	5	10	70	30	**5:30**
47	1 & 2	130	14.3	24.4	35	30	**3:15**	18.8	25	5	10	67	30	**5:35**
43	1-7	130	4.7	10.4	27	30	**3:10**	14.7	20	5	10	33	30	**4:50**
	8-14	150	4.7	18.2	16	30	**3:20**	14.7	20	5	10	33	30	**5:00**
	15-19	170	4.7	25.3	11	30	**3:35**	14.7	20	5	10	33	30	**5:15**
44	1-4	130	20.5	20.8	59	30	**3:40**	13.4	18	5	10	73	30	**6:00**
	5-8	150	20.5	22.7	54	30	**3:55**	13.4	18	5	10	73	31	**6:15**
45	1-5	130	8.3	3.8	132	30	**4:55**	30.7	41	5	10	66	30	**7:30**
	6-9	150	8.3	4.5	110	30	**4:50**	30.7	41	5	10	66	31	**7:25**
40	1 & 2	130	20.2	45.0	27	30	**3:10**	10.0	13	5	10	67	30	**5:15**
48	1	130	6.0	45.0	8	30	**2:50**	10.5	14	5	10	30	30	**4:20**
49	1	130	9.9	45.0	13	30	**2:55**	7.4	10	5	10	36	30	**4:30**
42	1	130	13.0	45.0	17	30	**3:00**	6.5	9	5	10	44	30	**4:40**
						Maximum ETE:	**4:55**						**Maximum ETE:**	**7:30**
						Average ETE:	**3:30**						**Average ETE:**	**5:35**

Table 8-6. Transit-Dependent Evacuation Time Estimates - Rain

Route Number	Bus Number	One-Wave							Two-Wave						
		Mobilization (min)	Route Length (miles)	Speed (mph)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)	Distance to R. C. (miles)	Travel Time to R. C. (min)	Unload (min)	Driver Rest (min)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)
46	1-3	140	14.3	40.0	21	40	**3:25**	24.2	36	5	10	77	40	**6:15**
47	1 & 2	140	14.3	16.6	52	40	**3:55**	18.8	28	5	10	69	40	**6:30**
43	1-7	140	4.7	9.8	29	40	**3:30**	14.7	22	5	10	35	40	**5:25**
	8-14	160	4.7	17.2	16	40	**3:40**	14.7	22	5	10	35	40	**5:35**
	15-19	180	4.7	26.2	11	40	**3:55**	14.7	22	5	10	35	40	**5:50**
44	1-4	140	20.5	17.6	70	40	**4:10**	13.4	20	5	10	78	40	**6:45**
	5-8	160	20.5	21.9	56	40	**4:20**	13.4	20	5	10	84	40	**7:00**
45	1-5	140	8.3	3.5	142	40	**5:25**	30.7	46	5	10	70	40	**8:20**
	6-9	160	8.3	4.6	107	40	**5:10**	30.7	46	5	10	70	40	**8:05**
40	1 & 2	140	20.2	40.0	30	40	**3:30**	10.0	15	5	10	72	40	**5:55**
48	1	140	6.0	40.0	9	40	**3:10**	10.5	16	5	10	33	40	**4:55**
49	1	140	9.9	40.0	15	40	**3:15**	7.4	11	5	10	39	40	**5:00**
42	1	140	13.0	40.0	20	40	**3:20**	6.5	10	5	10	47	40	**5:15**
						Maximum ETE:	**5:25**						**Maximum ETE:**	**8:20**
						Average ETE:	**3:55**						**Average ETE:**	**6:15**

Table 8-7. Transit Dependent Evacuation Time Estimates – Ice

Route Number	Bus Number	One-Wave							Two-Wave					
		Mobilization (min)	Route Length (miles)	Speed (mph)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)	Distance to R. C. (miles)	Travel Time to R. C. (min)	Unload (min)	Driver Rest (min)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)
46	1-3	150	14.3	35.0	25	50	**3:45**	24.2	41	5	10	85	50	**7:00**
47	1 & 2	150	14.3	9.7	89	50	**4:50**	18.8	32	5	10	76	50	**7:45**
43	1-7	150	4.7	8.3	34	50	**3:55**	14.7	25	5	10	39	50	**6:05**
	8-14	170	4.7	12.4	23	50	**4:05**	14.7	25	5	10	39	50	**6:15**
	15-19	190	4.7	19.2	15	50	**4:15**	14.7	25	5	10	39	50	**6:25**
44	1-4	150	20.5	14.9	83	50	**4:45**	13.4	23	5	10	85	50	**7:40**
	5-8	170	20.5	17.7	70	50	**4:50**	13.4	23	5	10	92	50	**7:50**
45	1-5	150	8.3	3.5	144	50	**5:45**	30.7	53	5	10	78	50	**9:05**
	6-9	170	8.3	4.0	125	50	**5:45**	30.7	53	5	10	79	50	**9:05**
40	1 & 2	150	20.2	35.0	35	50	**3:55**	10.0	17	5	10	79	50	**6:40**
48	1	150	6.0	35.0	10	50	**3:30**	10.5	18	5	10	37	50	**5:30**
49	1	150	9.9	35.0	17	50	**3:40**	7.4	13	5	10	43	50	**5:45**
42	1	150	13.0	35.0	22	50	**3:45**	6.5	11	5	10	51	50	**5:55**
						Maximum ETE:	**5:45**						**Maximum ETE:**	**9:05**
						Average ETE:	**4:25**						**Average ETE:**	**7:00**

Table 8-8. Medical Facility Evacuation Time Estimates – Good Weather

Medical Facility	Patient	Mobilization (min)	Loading Rate (min per person)	People	Total Loading Time (min)	Dist. To EPZ Bdry (mi)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
Sanford Health & Rehab	Ambulatory	90	1	31	30	1.9	3	**2:05**
	Wheelchair bound	90	5	63	75	1.9	3	**2:50**
	Bedridden	90	15	2	30	1.9	3	**2:05**
James Rest Home	Ambulatory	90	1	28	28	3.3	7	**2:05**
	Wheelchair bound	90	5	10	50	3.3	4	**2:25**
Brookridge Assisted Living	Ambulatory	90	1	40	30	3.6	38	**2:40**
	Wheelchair bound	90	5	12	60	3.6	5	**2:35**
Rex Rehab & Nursing Center of Apex	Ambulatory	90	1	20	20	2.6	44	**2:35**
	Wheelchair bound	90	5	40	75	2.6	3	**2:50**
	Bedridden	90	15	30	30	2.6	36	**2:40**
Spring Arbor of Apex	Ambulatory	90	1	47	30	2.9	9	**2:10**
	Wheelchair bound	90	5	19	75	2.9	13	**3:00**
Rex Holly Springs Hospital	Ambulatory	90	1	33	30	6.8	50	**2:50**
	Wheelchair bound	90	5	14	70	6.8	93	**4:15**
	Bedridden	90	15	3	30	6.8	61	**3:05**
Fuquay-Varina Homes-Elderly	Ambulatory	90	1	60	30	1.4	48	**2:50**
	Wheelchair bound	90	5	2	10	1.4	27	**2:10**
Kinton Court Home	Ambulatory	90	1	16	16	1.7	44	**2:30**
Windsor Point Continuing Care Retirement Community	Ambulatory	90	1	66	30	1.3	20	**2:20**
	Wheelchair bound	90	5	28	75	1.3	32	**3:20**
	Bedridden	90	15	6	30	1.3	20	**2:20**
							Maximum ETE:	**4:15**
							Average ETE:	**2:40**

Notes:

1 – Small home care facilities are not shown in this table as it is assumed they will evacuate in the personal vehicles of staff and are included in the general population ETE discussed in Section 7.

Table 8-9. Medical Facility Evacuation Time Estimates – Rain

Medical Facility	Patient	Mobilization (min)	Loading Rate (min per person)	People	Total Loading Time (min)	Dist. To EPZ Bdry (mi)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
Sanford Health & Rehab	Ambulatory	100	1	31	30	1.9	3	**2:15**
	Wheelchair bound	100	5	63	75	1.9	3	**3:00**
	Bedridden	100	15	2	30	1.9	3	**2:15**
James Rest Home	Ambulatory	100	1	28	28	3.3	7	**2:15**
	Wheelchair bound	100	5	10	50	3.3	5	**2:35**
Brookridge Assisted Living	Ambulatory	100	1	40	30	3.6	38	**2:50**
	Wheelchair bound	100	5	12	60	3.6	5	**2:45**
Rex Rehab & Nursing Center of Apex	Ambulatory	100	1	20	20	2.6	36	**2:40**
	Wheelchair bound	100	5	40	75	2.6	4	**3:00**
	Bedridden	100	15	30	30	2.6	31	**2:45**
Spring Arbor of Apex	Ambulatory	100	1	47	30	2.9	23	**2:35**
	Wheelchair bound	100	5	19	75	2.9	10	**3:05**
Rex Holly Springs Hospital	Ambulatory	100	1	33	30	6.8	64	**3:15**
	Wheelchair bound	100	5	14	70	6.8	98	**4:30**
	Bedridden	100	15	3	30	6.8	72	**3:25**
Fuquay-Varina Homes-Elderly	Ambulatory	100	1	60	30	1.4	53	**3:05**
	Wheelchair bound	100	5	2	10	1.4	21	**2:15**
Kinton Court Home	Ambulatory	100	1	16	16	1.7	62	**3:00**
Windsor Point Continuing Care Retirement Community	Ambulatory	100	1	66	30	1.3	23	**2:35**
	Wheelchair bound	100	5	28	75	1.3	37	**3:35**
	Bedridden	100	15	6	30	1.3	23	**2:35**
							Maximum ETE:	**4:30**
							Average ETE:	**2:55**

Notes:

1 – Small home care facilities are not shown in this table as it is assumed they will evacuate in the personal vehicles of staff and are included in the general population ETE discussed in Section 7.

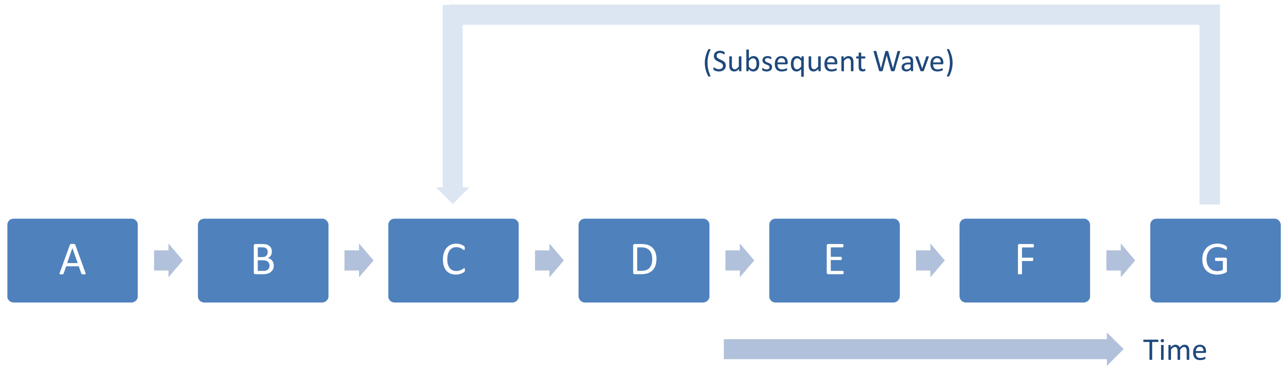
Table 8-10. Medical Facility Evacuation Time Estimates – Ice

Medical Facility	Patient	Mobilization (min)	Loading Rate (min per person)	People	Total Loading Time (min)	Dist. To EPZ Bdry (mi)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
Sanford Health & Rehab	Ambulatory	110	1	31	30	1.9	3	**2:25**
	Wheelchair bound	110	5	63	75	1.9	3	**3:10**
	Bedridden	110	15	2	30	1.9	3	**2:25**
James Rest Home	Ambulatory	110	1	28	28	3.3	9	**2:30**
	Wheelchair bound	110	5	10	50	3.3	6	**2:50**
Brookridge Assisted Living	Ambulatory	110	1	40	30	3.6	52	**3:15**
	Wheelchair bound	110	5	12	60	3.6	6	**3:00**
Rex Rehab & Nursing Center of Apex	Ambulatory	110	1	20	20	2.6	45	**2:55**
	Wheelchair bound	110	5	40	75	2.6	4	**3:10**
	Bedridden	110	15	30	30	2.6	43	**3:05**
Spring Arbor of Apex	Ambulatory	110	1	47	30	2.9	26	**2:50**
	Wheelchair bound	110	5	19	75	2.9	23	**3:30**
Rex Holly Springs Hospital	Ambulatory	110	1	33	30	6.8	65	**3:25**
	Wheelchair bound	110	5	14	70	6.8	106	**4:50**
	Bedridden	110	15	3	30	6.8	73	**3:35**
Fuquay-Varina Homes-Elderly	Ambulatory	110	1	60	30	1.4	44	**3:05**
	Wheelchair bound	110	5	2	10	1.4	29	**2:30**
Kinton Court Home	Ambulatory	110	1	16	16	1.7	54	**3:00**
Windsor Point Continuing Care Retirement Community	Ambulatory	110	1	66	30	1.3	33	**2:55**
	Wheelchair bound	110	5	28	75	1.3	33	**3:40**
	Bedridden	110	15	6	30	1.3	33	**2:55**
							Maximum ETE:	**4:50**
							Average ETE:	**3:05**

Notes:
1 – Small home care facilities are not shown in this table as it is assumed they will evacuate in the personal vehicles of staff and are included in the general population ETE discussed in Section 7.

Table 8-11. Access and/or Functional Needs Population Evacuation Time Estimates

Vehicle Type	People Requiring Vehicle	Vehicles deployed	Stops	Weather Conditions	Mobilization Time (min)	Loading Time at 1st Stop (min)	Travel to Subsequent Stops (min)	Total Loading Time at Subsequent Stops (min)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
Buses	161	15	11	Good	90	1	90	10	0	**3:35**
				Rain	100		100		29	**4:00**
				Snow	110		110		34	**4:25**
Wheelchair Vans	14	4	4	Good	90	5	27	15	21	**2:40**
				Rain	100		30		25	**2:55**
				Snow	110		33		30	**3:15**
Wheelchair Buses	30	6	5	Good	90	5	36	20	22	**2:55**
				Rain	100		40		25	**3:10**
				Snow	110		44		31	**3:30**
Ambulances	14	7	2	Good	90	15	10	15	20	**2:30**
				Rain	100		11		25	**2:50**
				Snow	110		13		30	**3:05**
Maximum ETE:										**4:25**
Average ETE:										**3:15**



Event	
A	Advisory to Evacuate
B	Bus Dispatched from Depot
C	Bus Arrives at Facility/Pick-up Route
D	Bus Departs for Reception Center/Relocation School
E	Bus Exits Region
F	Bus Arrives at Reception Center/Relocation School
G	Bus Available for “Second Wave” Evacuation Service
Activity	
A→B	Driver Mobilization
B→C	Travel to Facility or to Pick-up Route
C→D	Passengers Board the Bus
D→E	Bus Travels Towards Region Boundary
E→F	Bus Travels Towards Reception Center/Relocation School Outside the EPZ
F→G	Passengers Leave Bus; Driver Takes a Break

Figure 8-1. Chronology of Transit Evacuation Operations

9 TRAFFIC MANAGEMENT STRATEGY

This section discusses the suggested traffic control and management strategy that is designed to expedite the movement of evacuating traffic. The resources required to implement this strategy include:

- Personnel with the capabilities of performing the planned control functions of traffic guides (preferably, not necessarily, law enforcement officers).
- The Manual on Uniform Traffic Control Devices (MUTCD) published by the Federal Highway Administration (FHWA) of the U.S.D.O.T. provides guidance for Traffic Control Devices to assist these personnel in the performance of their tasks. All state and most county transportation agencies have access to the MUTCD, which is available on-line: http://mutcd.fhwa.dot.gov which provides access to the official PDF version.
- A written plan that defines all Traffic Control Point (TCP) and Security Road Block (SRB) locations, provides necessary details and is documented in a format that is readily understood by those assigned to perform traffic control.

The functions to be performed in the field are:

1. <u>Facilitate</u> evacuating traffic movements that safely expedite travel out of the EPZ.
2. <u>Discourage</u> traffic movements that move evacuating vehicles in a direction which takes them significantly closer to the power plant, or which interferes with the efficient flow of other evacuees.

The terms "facilitate" and "discourage" are employed rather than "enforce" and "prohibit" to indicate the need for flexibility in performing the traffic control function. There are always legitimate reasons for a driver to prefer a direction other than that indicated. For example:

- A driver may be traveling home from work or from another location, to join other family members prior to evacuating.
- An evacuating driver may be travelling to pick up a relative, or other evacuees.
- The driver may be an emergency worker en route to perform an important activity.

The implementation of a plan <u>must</u> also be flexible enough for the application of sound judgment by the traffic guide.

The traffic management plan is the outcome of the following process:

1. The detailed traffic control tactics discussed in the All County Standard Operating Guideline (SOG) for Traffic Control Point and Security Road Block Operations in Support of the Harris Nuclear Plant, dated January 2019, serve as the basis of the traffic management plan, as per NUREG/CR-7002, Rev. 1. The ETE analysis treated all controlled intersections that are existing SRB or TCP locations in the offsite agency plans as being controlled by actuated signals. Appendix K identifies the number of intersections that were modeled as TCPs.
2. Evacuation simulations were run using DYNEV II to predict traffic congestion during evacuation (see Section 7.3 and Figures 7-3 through 7-9). These simulations help to

identify the best routing and critical intersections that experience pronounced congestion during evacuation. Any critical intersections that would benefit from traffic or access control which are not already identified in the existing offsite plans are examined. No additional TCPs or SRBs were identified as part of this study.

3. Prioritization of TCPs and SRBs. Application of traffic and access control at some TCPs and SRBs will have a more pronounced influence on expediting traffic movements than at other TCPs and SRBs. For example, TCPs controlling traffic originating from areas in close proximity to the power plant could have a more beneficial effect on minimizing potential exposure to radioactivity than those TCPs located far from the power plant. Key locations for manual traffic control (MTC) were analyzed and their impact to ETE was quantified, as per NUREG/CR-7002, Rev. 1. See Appendix G for more detail.

Appendix G documents the existing TMP and list of priority TCPs using the process enumerated above.

9.1 Assumptions

The ETE calculations documented in Sections 7 and 8 assume that the traffic management plan is implemented during evacuation.

The ETE calculations reflect the assumption that all "external-external" trips are interdicted and diverted after 2 hours have elapsed from the Advisory to Evacuate (ATE).

All transit vehicles and other responders entering the EPZ to support the evacuation are assumed to be unhindered by personnel manning TCPs and SRBs.

Study assumption 1 and 2 in section 2.5 discuss TCP and SRB operations.

9.2 Additional Considerations

The use of Intelligent Transportation Systems (ITS) technologies can reduce the manpower and equipment needs, while still facilitating the evacuation process. Dynamic Message Signs (DMS) can be placed within the EPZ to provide information to travelers regarding traffic conditions, route selection, and reception center information. DMS placed outside of the EPZ will warn motorists to avoid using routes that may conflict with the flow of evacuees away from the power plant. Highway Advisory Radio (HAR) can be used to broadcast information to evacuees during egress through their vehicles stereo systems. Automated Travel Information Systems (ATIS) can also be used to provide evacuees with information. Internet websites can provide traffic and evacuation route information before the evacuee begins their trip, while the on board navigation systems (GPS units) and smartphones can be used to provide information during evacuation trip.

There are only several examples of how ITS technologies can benefit the evacuation process. Considerations should be given that ITS technologies can be used to facilitate the evacuation process, and any additional signage placed should consider evacuation needs.

10 EVACUATION ROUTES AND RECEPTION CENTERS

10.1 Evacuation Routes

Evacuation routes are comprised of two distinct components:

- Routing from a Zone being evacuated to the boundary of the Evacuation Region and thence out of the EPZ.
- Routing of transit-dependent evacuees from the EPZ boundary to reception centers.

Evacuees will select routes within the EPZ in such a way as to minimize their exposure to risk. This expectation is met by the DYNEV II model routing traffic away from the location of the plant to the extent practicable. The DTRAD model satisfies this behavior by routing traffic to balance traffic demand relative to the available highway capacity to the extent possible. See Appendices B through D for further discussion. The major evacuation routes for the EPZ are presented in Figure 10-1. These routes will be used by the general population evacuating in private vehicles, and by the transit-dependent population evacuating in buses. Transit-dependent evacuees will be routed to reception centers. General population may evacuate to a reception center or some alternate destination (e.g., lodging facilities, relative's home, campgrounds) outside the EPZ.

The routing of transit-dependent evacuees from the EPZ boundary to reception centers is designed to minimize the amount of travel outside the EPZ, from the points where these routes cross the EPZ boundary. The 9 bus routes shown graphically in Figure 10-2 and described in Table 10-1 were designed by KLD for this ETE study to service the major routes through each Zone. It is assumed that residents will walk to the nearest major roadway and flag down a passing bus, and that they can arrive at the roadway within the 130-minute bus mobilization time (good weather).

The specified bus routes for all the transit-dependent population are documented in Table 10-2 (refer to maps of the link-node analysis network in Appendix K for node locations). Representative routes were developed for all schools and medical facilities within each Zone. It is assumed that all school and medical facility evacuees will be taken to their appropriate reception center and relocation school, respectively. School evacuees will subsequently be picked up by parents or guardians. Transit-dependent evacuees are transported to the nearest reception center for each county. This study does not consider the transport of evacuees from reception centers to congregate care centers if the counties do make the decision to relocate evacuees.

10.2 Reception Centers

Figure 10-3 maps the general population reception centers and relocation schools for evacuees.

Table 10-3 presents a list of the relocation schools for each evacuating school and childcare center in the EPZ. Children will be transported to these relocation schools where they will be subsequently retrieved by their respective families.

Table 10-1. Summary of Transit-Dependent Bus Routes

Route	No. of Buses	Route Description	Zone(s) Serviced	Length (mi.)
46	3	Zones A, B & L: Old US-1 eastbound to New Hill Olive Rd northbound, then out of the EPZ along US-64 WB to NC-540 Toll	A, B & L	14.3
47	2	Zones C & D: Cass Holt Rd eastbound towards Holly Springs, then along Holly Springs New Hill Rd westbound. Exits EPZ along US-1 eastbound to Reception Centers	C & D	14.3
43	19	Zone E: Circulate through Apex, then east out of EPZ to Reception Centers	E	4.7
44	8	Zone F: Circulate through Holly Springs, then northeast out of EPZ to Reception Centers	F	20.5
45	9	Zone G: Circulate through Fuquay-Varina, then south out of EPZ to Reception Centers	G	8.3
40	2	Zones H & K: NC-42 from Fuquay-Varina west out of the EPZ toward Sanford	H & K	20.2
48	1	Zones I & J : Picks up evacuees along Lower Moncure Rd southbound, then out of EPZ towards Sanford	I & J	6.0
49	1	Zone M: Old US-1 in Moncure to Moncure Pittsboro Rd northbound, to Gum Springs Church Rd out of the EPZ towards Pittsboro	M	9.9
42	1	Zone N: US-64 westbound from intersection with Salem St (SR 1011) out of EPZ towards Pittsboro	N	13.0
Total:	46			

Table 10-2. Bus Route Descriptions

Bus Route Number	Description	Nodes Traversed from Route Start to EPZ Boundary
1	Apex Elementary School	1276, 1275, 757, 320, 734, 1274, 1271, 1273, 758, 68, 690, 759, 691, 1583, 692, 601
2	Apex Senior High School	1018, 1450, 120
3	Apex Middle School/Apex Peak Schools, Inc.	319, 320, 734, 1274, 1271, 1273, 758, 68, 690, 759, 691, 1583, 692
4	Baucom Elementary School	694, 1282, 710, 669, 665, 660, 325, 326, 327, 3325, 396, 1578
5	Apex Friendship High School/Apex Friendship Middle School	1695, 3301, 1696, 1697, 287, 290, 1549, 1698, 1699, 1347, 1554, 1715, 1561, 1716, 1719, 1348, 1562, 1563, 1529, 1567, 1530, 1709, 1708, 25, 26, 24, 30, 31, 32, 33, 21, 35, 435, 1264, 3248, 615, 431, 1032, 1573, 1033, 425, 1031, 1253, 424, 226, 1958, 1574, 202
6	Lufkin Road Middle School	447, 60, 692, 601
7	Olive Chapel Elementary School/Kindercare Learning Center/The Learning Experience in Apex	296, 299, 1541, 1542, 1539, 1544, 1726, 434, 1737, 1739, 1543, 1343, 1532, 1531
8	St. Mary Magdalene Catholic School	1010, 291, 1277, 292, 1276, 294, 319, 320, 734, 1274, 1271, 1273, 758, 68, 690, 759, 691, 1583, 692, 601
9	Deep River Elementary School	516, 521, 526, 530, 531, 533
10	Holly Grove Elementary School/Holly Grove Middle School/Holly Springs High School/Home Away From Home Childcare/ Primrose School at Holly Grove	156, 140, 1319, 21, 33, 32, 31, 30, 24, 26, 25, 1566, 1707, 1564, 28, 27, 762, 445, 68, 690, 759, 691, 1583, 692, 601
11	Holly Ridge Elementary School/Holly Ridge Middle School/Holly Springs Learning Center/The Clubhouse of Holly Springs	555, 715, 1629, 716, 52, 790, 520, 522, 524, 525, 1893, 511
12	Holly Springs Elementary School/Sisters' Child Care Services	439, 555, 715, 1629, 716, 52, 790, 520, 522, 524, 525, 1893, 511
13	Southern Wake Academy	431, 1032, 1573, 1033, 1257, 3276, 1254, 1256, 1255, 1258
14	New School Montessori Center	50, 1463, 51, 52, 790, 520, 522, 524, 525, 1893, 511
15	Fuquay-Varina Senior High School	1031, 1253, 424, 226, 1958, 1574, 202
16	Fuquay-Varina Middle School	957, 226, 1958, 1574, 202
17	Lincoln Heights Elementary School	894, 228, 959, 204, 203, 1030, 226, 1958, 1574, 202
18	Moncure Elementary School/YMCA After Care Program	74, 261, 770, 771, 772
19	Herbert Akins Road Elementary School	789, 47, 1462, 1461, 46, 44, 43, 1261
20	Thales Academy Apex K-5	1450, 1018, 585, 1019, 1376, 704, 581, 1220, 60, 692, 601
21	Lafayette Elementary School	212, 735, 3045, 1240, 1241, 1242

Bus Route Number	Description	Nodes Traversed from Route Start to EPZ Boundary
22	Oakview Elementary School/Thales Academy Holly Springs Pre-K-5	1128, 1267, 1268, 1269, 1270, 1266, 33, 21, 35, 438, 3280, 1320, 1321, 439, 775, 32, 31, 30, 24, 26, 25, 1566, 1707, 1564, 28, 27, 762, 445, 68, 690, 759, 691, 1583, 692, 601, 693, 598, 45, 1401, 34, 597, 1111, 40, 355, 1336, 357
24	Unique Creation Child Care Center	203, 1030, 226, 1958, 1574
25	Angel's Garden Home Daycare	3326, 3325, 396, 1578
26	AsheBridge Children's Academy of Apex/Cary	517, 1436, 3344, 454, 717, 459
27	Bright Star Childcare	3340, 1279, 1280, 710, 669, 665, 660, 325, 326, 327, 3325, 396, 1578
28	Buckhorn Creek Elementary School	1497, 147, 38, 615, 431, 1032, 1573, 1033, 1257, 3276, 1254, 1256, 1255, 1258
29	Busy Bee Home Daycare	1099, 1499, 1249
30	Children's Lighthouse of Apex/Creative Schools of Apex	1449, 1450, 120
31	Eileen's Day Care	1012, 3048, 1334
32	Everbrook Academy of Apex	304, 1280, 710, 711, 1281, 670, 671, 123, 122
33	Holly Springs Academy NC	441, 439, 555, 715, 1629, 716, 52, 790, 520, 522, 524
34	Holly Spring KinderCare	32, 775, 439, 555, 715, 1629, 716, 52, 790, 520, 522, 524, 525
35	Karen's Kids Home Child Care/Nicole Miller's Family Childcare Home	1798, 293, 290, 1549, 1698, 1699, 1347, 1554, 1715, 1561, 1716, 1717, 1718, 1560, 582, 1552, 71, 690, 759, 691, 1583, 692, 601
36	Kidtowne at Hope Community Church-Apex	29, 28, 27, 762, 445, 68, 690, 759, 691, 1583, 692, 601
37	Lightbridge Academy – Holly Springs	142, 140, 1319, 21, 33, 32, 31, 30, 24, 26, 25, 1566, 1707, 1564, 28, 27, 762, 445, 68, 690, 759, 691, 1583, 692, 601
38	Majestic Learning Experience Inc.	562, 563, 564
39	Montessori Creative Learning School	702, 294, 319, 320, 734, 1274, 1271, 1273, 758, 68, 690, 759, 691, 1583, 692, 601
40	Bus Route 6 - Zones H & K	872, 873, 874, 875, 3000, 807, 866, 3039, 809, 808, 810, 811, 839, 840, 841, 842
42	Bus Route 9 - Zone N	128, 641, 129, 130, 466, 1024, 1598, 1025, 1849, 135, 620, 655
43	Bus Route 3 - Zone E	315, 314, 306, 299, 303, 3327, 304, 1280, 694, 1993, 1799, 297, 703, 1378, 585, 1018, 1450, 120, 587, 122, 123, 1582, 672, 3239, 126, 326, 325, 660, 665, 669, 710, 1282, 694, 702, 294, 319, 320, 734, 1274, 1271, 1273, 758, 68, 690, 759, 691, 1583, 692, 601
44	Bus Route 4 - Zone F	439, 441, 1036, 1627, 443, 444, 25, 26, 24, 30, 31, 32, 33, 21, 35, 438, 3280, 1320, 1321, 439, 555, 715, 1629, 716, 52, 790, 520, 522, 524, 525, 1893, 511
45	Bus Route 5 - Zone G	957, 958, 1874, 229, 1250, 228, 1504, 957, 226, 1030, 203, 204, 959, 228, 1250, 229, 3271, 1100, 1099, 1499, 1249, 1501, 1502, 1575, 202
46	Bus Route 1 - Zones A, B & L	278, 3038, 632, 436, 282, 283, 235, 239, 241, 243, 3299, 3222, 244, 3047, 245, 246, 249, 251, 128, 433, 1539, 1544, 1726, 434, 1737, 1739, 1543, 1343, 1532, 1531

Bus Route Number	Description	Nodes Traversed from Route Start to EPZ Boundary
47	Bus Route 2 - Zones C & D	1318, 156, 140, 1319, 21, 33, 32
48	Bus Route 7 - Zones I & J	1580, 913, 915, 914, 916, 918, 917, 919
49	Bus Route 8 - Zone M	281, 280, 279, 277, 275
60	James Rest Home	452, 3247, 75, 73, 72, 1557, 1555, 1560, 582, 1552, 71, 690, 759, 691, 1583, 692, 601
61	Unique Creations Child Care Center South Campus	229, 1250, 228, 959, 204, 203, 1030, 226, 1958, 1574
62	Rex Rehab & Nursing Center of Apex	734, 1274, 1271, 1273, 758, 68, 690, 759, 691, 1583, 692, 601
63	Spring Arbor of Apex	304, 1280, 694, 1993, 1799, 297, 298, 1281, 670, 671, 123, 122, 587, 120
64	Peace Montessori	1281, 298, 297, 703, 1378, 585, 1019, 1376, 704, 581, 1220, 60, 692, 601
65	Vanessa Bland's Small Day Care Home	1028, 204, 203, 1030, 226, 1958, 1574
66	Woodhaven Weekday Preschool	517, 1436, 3344, 454, 717, 459
69	Peak Charter Academy	3241, 3239, 672, 1582, 123, 122, 587, 120
71	Fuquay-Varina Homes for the Elderly	206, 3267, 1100, 1099, 1499, 1249, 1501, 1502, 1575, 202
72	Windsor Point Continuing Care Retirement Community	1033, 425, 1031, 1253, 424, 226, 1958, 1574, 202
73	Sanford Health and Rehabilitation	83, 84, 87, 89
77	Brookridge Assisted Living	1276, 294, 319, 320, 734, 1274, 1271, 1273, 758, 68, 690, 759, 691, 1583, 692, 601
78	Ready or Not Here I Grow	1257, 3276, 1254, 1256, 1255, 1258
84	Kinton Court Home	229, 1250, 228, 959, 204, 203, 1030, 226, 1958, 1574, 202
86	Scotts Ridge Elementary School	1322, 1613, 1614, 291, 1277, 292, 1276, 294, 319, 320, 734, 1274, 1271, 1273, 758, 68, 690, 759, 691, 1583, 692, 601
89	Seaforth High School	1605, 1604, 1598, 1025, 1849, 135, 620, 655
91	Vickie's Day Care Home	1019, 1376, 704, 581, 1220, 60, 692, 601
93	Lightbridge Academy - Apex	299, 1541, 1542, 1539, 1544, 1726, 434, 127, 1584, 1593, 126, 3239, 672, 1582, 123, 122, 587, 120
94	Montessori Kids Universe – Fuquay Varina	1262, 1259, 1258, 1263, 202, 1576, 42
99	Stella Lowery Small Day Care Home	520, 522, 524, 525
100	Sunrise United Methodist Church Pre-K	1463, 51, 52, 790, 520, 522, 524, 525
101	Thales Academy Apex JH/HS	670, 671, 123, 122, 587, 120
102	The Goddard School of Apex (Green Level West)	1644, 1643, 1642
103	The Goddard School of Holly Springs/The Learning Experience - Holly Springs	715, 1629, 716, 52, 790, 520, 522, 524, 525
104	Little Miracles	1100, 1099, 1499, 1249

Bus Route Number	Description	Nodes Traversed from Route Start to EPZ Boundary
110	Fuquay-Varina Baptist Wee Care/Fuquay-Varina UMC Preschool Seeds of Faith	957, 226, 1958, 1574, 202
111	Little Angels Preparatory	3271, 1100, 1099, 1499, 1249
112	Childcare Network - Fuquay-Varina/Roots to Wings Childcare	894, 228, 959, 204, 203, 1030, 226, 1958, 1574, 202
113	A Mother's Love/Melissa's Sweet Peas Child Care Home/My Lil Friends Childcare	1032, 1573, 1033, 1257, 3276, 1254, 1256, 1255, 1258, 1263
115	Kris' Home Sweet Home Daycare	555, 715, 1629, 716, 52, 790, 520, 519, 518, 517, 1436, 3344, 454, 717, 459
116	Holly Springs School for Early Education/Kiddie Academy of Holly Springs/ Leaping Froggy/Little Dreamers Preschool/Loving Hand Day Care/Pine Springs Preparatory Academy	443, 444, 29, 28, 27, 762, 445, 68, 690, 759, 691, 1583, 692, 601
118	Grace Church Preschool and Summer Camp	517, 1436, 3344, 454, 717, 459
119	Children's Choice/Earth Angel's Day Care Home	1211, 1063, 728, 727, 1374, 454, 717, 459
120	Apex Baptist Church Preschool/Apex United Methodist Church Preschool/ Goddard School Apex/Growing Years Learning Center	294, 1451, 703, 1378, 585, 1019, 1376, 704, 581, 1220, 60, 692, 601
121	Play Care	682, 1283, 684, 660, 325, 126, 3239, 672, 1582, 123, 122, 587, 120
122	Moravic Family Day Care	1221, 1220, 60, 692, 601
123	Hope Chapel Preschool	301, 1009, 673, 671, 123, 122, 587, 120

Table 10-3. Relocation Schools for Schools and Childcare Centers

School	Relocation School
Apex Friendship High School	Sanderson High School
Apex Friendship Middle School	
Oakview Elementary School	
Thales Academy Holly Springs Pre-K-5	
Apex Elementary School	
Apex Middle School	
Apex Senior High School	
Baucom Elementary School	
Lufkin Road Middle School	
Olive Chapel Elementary School	
Peak Charter Academy	
Scotts Ridge Elementary School	
St. Mary Magdalene Catholic School	
Thales Academy Apex JH/HS	
Thales Academy Apex K-5	
Holly Grove Elementary School	Southeast Raleigh High School
Holly Grove Middle School	
Holly Ridge Elementary School	
Holly Ridge Middle School	
Holly Springs Elementary School	
Holly Springs High School	
Pine Springs Preparatory Academy	
Buckhorn Creek Elementary School	Garner High School
Fuquay-Varina Middle School	
Fuquay-Varina Senior High School	
Herbert Akins Road Elementary School	
Lincoln Heights Elementary School	
Southern Wake Academy	
Moncure Elementary School	Northwood High School
Seaforth High School	

Childcare Center[1]	Relocation School
Angel's Garden Home Daycare	Sanderson High School
Apex Baptist Church Preschool	
Apex Peak Schools, Inc.	
Apex United Methodist Church Preschool	
AsheBridge Children's Academy of Apex/Cary	
Bright Start Child Care LLC	
Children's Choice	
Children's Lighthouse of Apex	
Creative Schools of Apex	
Earth Angel's Day Care Home	
Eileen's Day Care	
Everbrook Academy of Apex	
Goddard School Apex	
Grace Church Preschool and Summer Camp	

[1] Childcare facilities will move children to the relocation school for the Zone where the childcare facility is located.

Childcare Center[1]	Relocation School
Growing Years Learning Center	Sanderson High School
Hope Chapel Preschool	
Karen's Kids Home Child Care	
Kidtowne at Hope Community Church - Apex	
Kindercare Learning Center	
Majestic Learning Experience Inc.	
Montessori Creative Learning School	
Moravic Family Day Care	
Nicole Miller's Family Childcare Home	
Peace Montessori	
Play Care	
Primrose School of Apex	
The Goddard School of Apex (Green Level West)	
The Learning Experience in Apex	
Vickie's Day Care Home	
Woodhaven Weekday Preschool	
Primrose School at Holly Grove	Southeast Raleigh High School
Holly Springs Academy NC	
Holly Springs KinderCare	
Holly Springs Learning Center	
Holly Springs School For Early Education	
Home Away From Home Childcare	
Kiddie Academy of Holly Springs	
Kris' Home Sweet Home Daycare	
Leaping Froggy	
Lightbridge Academy	
Little Dreamers Preschool	
Loving Hand Day Care	
New School Montessori Center	
Sisters' Child Care Services	
Stella Lowery Small Day Care Home	
Sunrise United Methodist Church Preschool	
The Clubhouse of Holly Springs	
The Goddard School of Holly Springs	
The Learning Experience - Holly Springs	
A Mother's Love	Garner High School
Busy Bee Home Daycare	
Childcare Network - Fuquay-Varina	
Fuquay-Varina Baptist Wee Care	
Fuquay-Varina UMC Preschool Seeds of Faith	
Little Angels Preparatory	
Little Miracles	
Melissa's Sweet Peas Child Care Home	
My Lil Friends Childcare	
Ready Or Not Here I Grow	
Roots To Wings Childcare	
South Wake Preschool & Academy	
Unique Creations Child Care Center	

Childcare Center[1]	Relocation School
Unique Creations Child Care Center South Campus	Garner High School
Vanessa Bland's Small Day Care Home	
YMCA After Care Program	Northwood High School

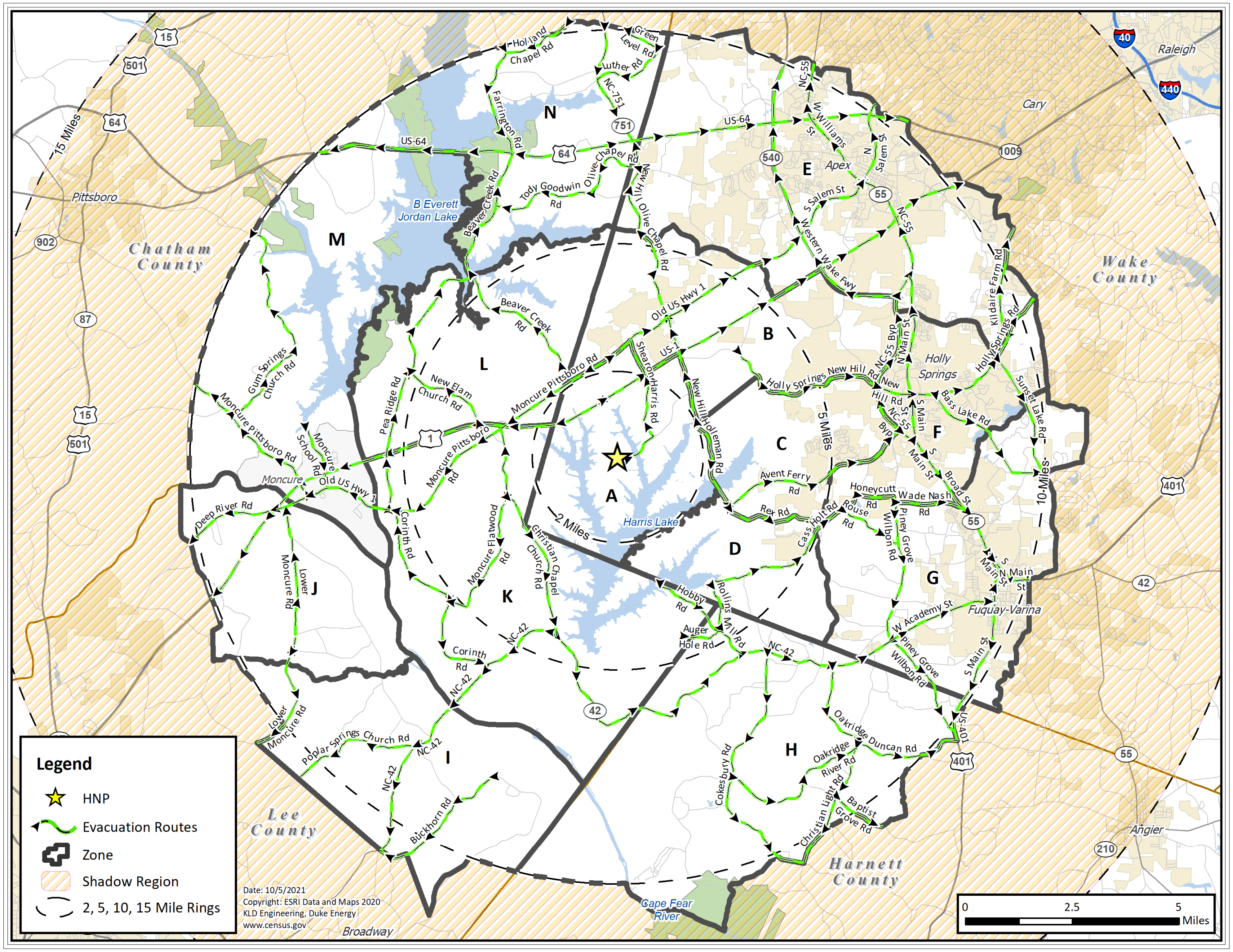


Figure 10-1. Evacuation Routes

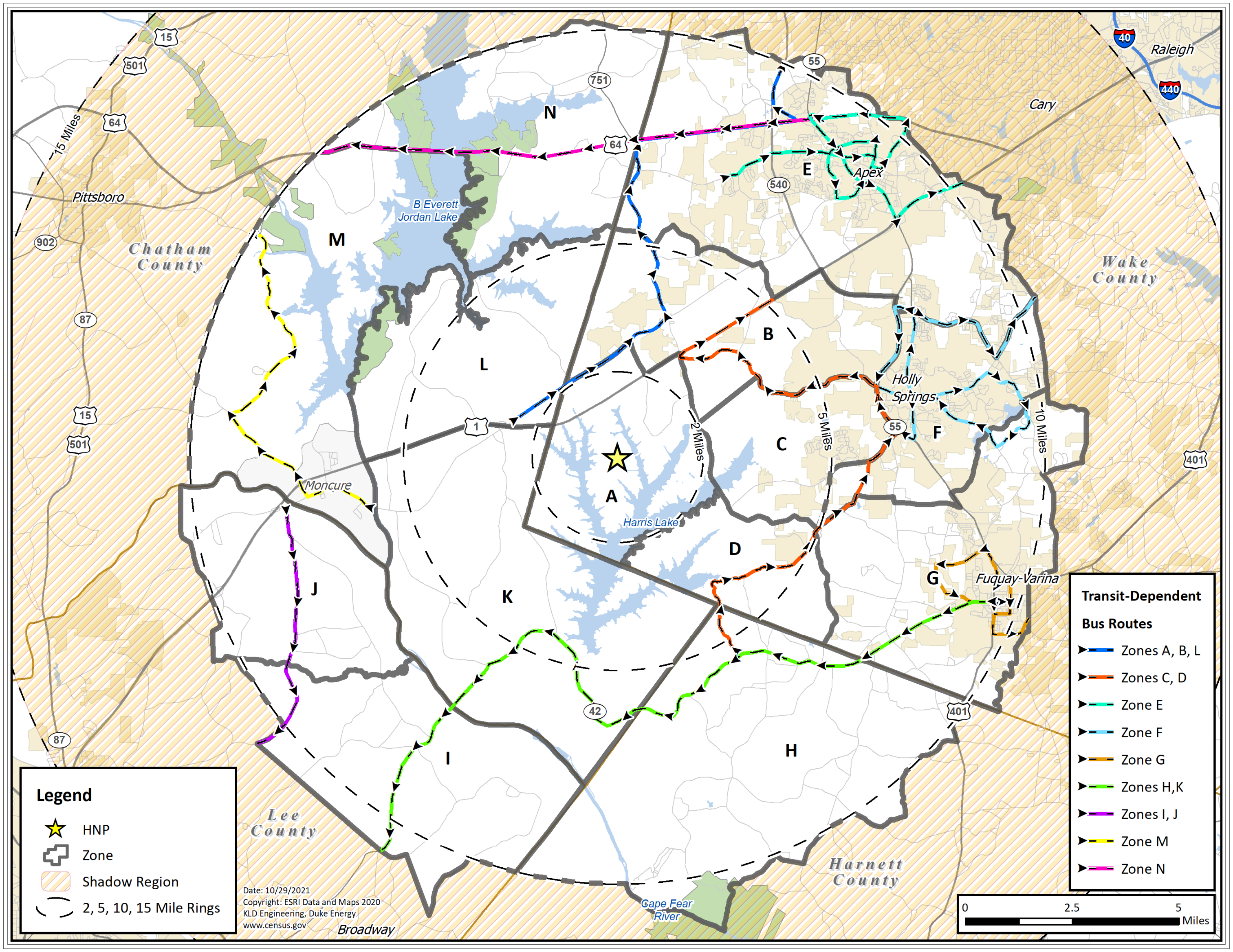


Figure 10-2. Transit-Dependent Bus Routes

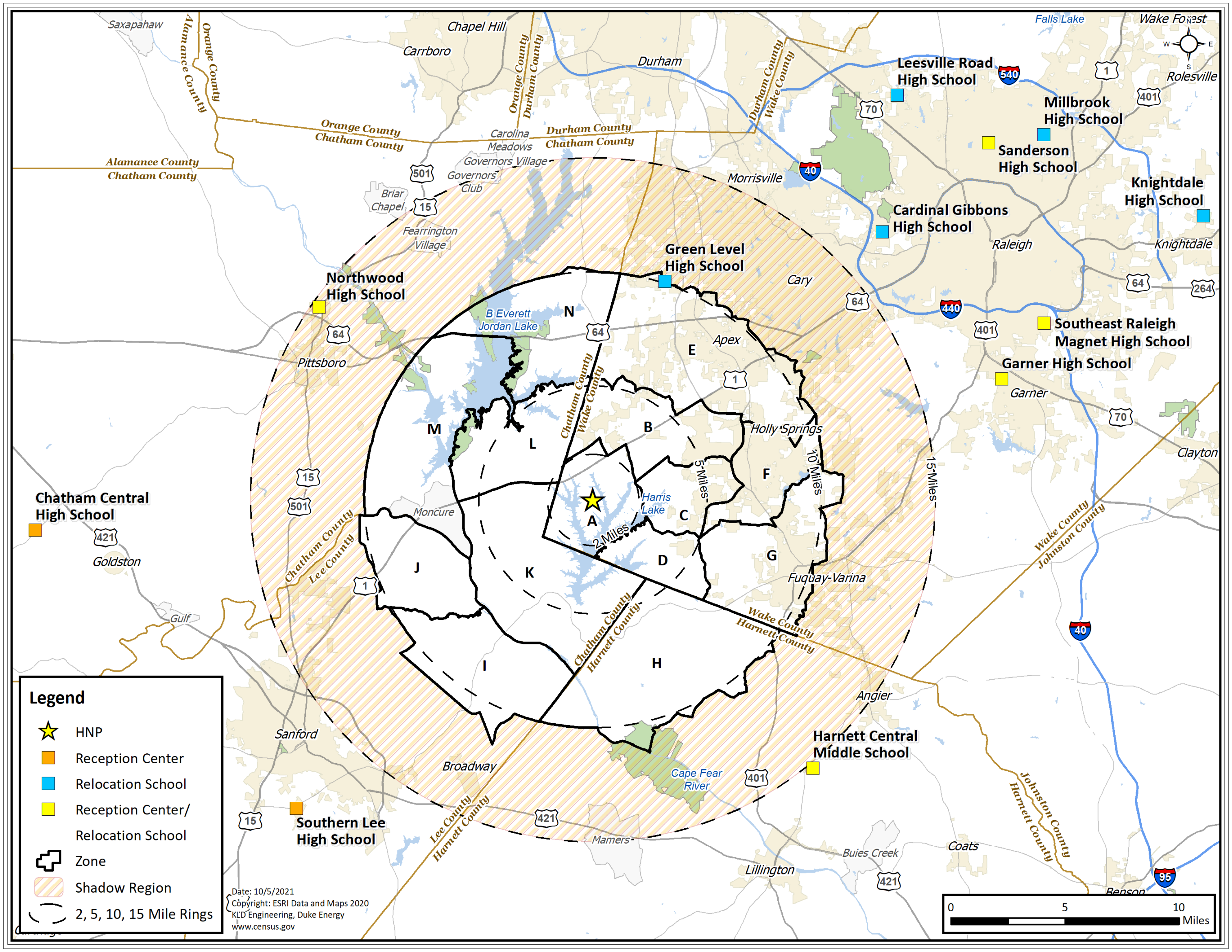


Figure 10-3. General Population Reception Centers and Relocation Schools

APPENDIX A

Glossary of Traffic Engineering Terms

A. GLOSSARY OF TRAFFIC ENGINEERING TERMS

Table A-1. Glossary of Traffic Engineering Terms

Term	Definition
Analysis Network	A graphical representation of the geometric topology of a physical roadway system, which is comprised of directional links and nodes.
Link	A network link represents a specific, one-directional section of roadway. A link has both physical (length, number of lanes, topology, etc.) and operational (turn movement percentages, service rate, free-flow speed) characteristics.
Measures of Effectiveness	Statistics describing traffic operations on a roadway network.
Node	A network node generally represents an intersection of network links. A node has control characteristics, i.e., the allocation of service time to each approach link.
Origin	A location attached to a network link, within the EPZ or Shadow Region, where trips are generated at a specified rate in vehicles per hour (vph). These trips enter the roadway system to travel to their respective destinations.
Prevailing Roadway and Traffic Conditions	Relates to the physical features of the roadway, the nature (e.g., composition) of traffic on the roadway and the ambient conditions (weather, visibility, pavement conditions, etc.).
Service Rate	Maximum rate at which vehicles, executing a specific turn maneuver, can be discharged from a section of roadway at the prevailing conditions, expressed in vehicles per second (vps) or vehicles per hour (vph).
Service Volume	Maximum number of vehicles which can pass over a section of roadway in one direction during a specified time period with operating conditions at a specified Level of Service (The Service Volume at the upper bound of Level of Service, E, equals Capacity). Service Volume is usually expressed as vehicles per hour (vph).
Signal Cycle Length	The total elapsed time to display all signal indications, in sequence. The cycle length is expressed in seconds.
Signal Interval	A single combination of signal indications. The interval duration is expressed in seconds. A signal phase is comprised of a sequence of signal intervals, usually green, yellow, red.

Term	Definition
Signal Phase	A set of signal indications (and intervals) which services a particular combination of traffic movements on selected approaches to the intersection. The phase duration is expressed in seconds.
Traffic (Trip) Assignment	A process of assigning traffic to paths of travel in such a way as to satisfy all trip objectives (i.e., the desire of each vehicle to travel from a specified origin in the network to a specified destination) and to optimize some stated objective or combination of objectives. In general, the objective is stated in terms of minimizing a generalized "cost". For example, "cost" may be expressed in terms of travel time.
Traffic Density	The number of vehicles that occupy one lane of a roadway section of specified length at a point in time, expressed as vehicles per mile (vpm).
Traffic (Trip) Distribution	A process for determining the destinations of all traffic generated at the origins. The result often takes the form of a Trip Table, which is a matrix of origin-destination traffic volumes.
Traffic Simulation	A computer model designed to replicate the real-world operation of vehicles on a roadway network, so as to provide statistics describing traffic performance. These statistics are called Measures of Effectiveness.
Traffic Volume	The number of vehicles that pass over a section of roadway in one direction, expressed in vehicles per hour (vph). Where applicable, traffic volume may be stratified by turn movement.
Travel Mode	Distinguishes between private auto, bus, rail, pedestrian and air travel modes.
Trip Table or Origin-Destination Matrix	A rectangular matrix or table, whose entries contain the number of trips generated at each specified origin, during a specified time period, that are attracted to (and travel toward) each of its specified destinations. These values are expressed in vehicles per hour (vph) or in vehicles.
Turning Capacity	The capacity associated with that component of the traffic stream which executes a specified turn maneuver from an approach at an intersection.

APPENDIX B

DTRAD: Dynamic Traffic Assignment and Distribution Model

B. DYNAMIC TRAFFIC ASSIGNMENT AND DISTRIBUTION MODEL

This section describes the integrated dynamic trip assignment and distribution model named DTRAD (Dynamic Traffic Assignment and Distribution) that is expressly designed for use in analyzing evacuation scenarios. DTRAD employs logit-based path-choice principles and is one of the models of the DYNEV II System. The DTRAD module implements path-based *Dynamic Traffic Assignment* (DTA) so that time dependent Origin-Destination (OD) trips are "assigned" to routes over the network based on prevailing traffic conditions.

To apply the DYNEV II System, the analyst must specify the highway network, link capacity information, the time-varying volume of traffic generated at all origin centroids and, optionally, a set of accessible candidate destination nodes on the periphery of the EPZ for selected origins. DTRAD calculates the optimal dynamic trip distribution (i.e., trip destinations) and the optimal dynamic trip assignment (i.e., trip routing) of the traffic generated at each origin node traveling to its set of candidate destination nodes, so as to minimize evacuee travel "cost."

Overview of Integrated Distribution and Assignment Model

The underlying premise is that the selection of destinations and routes is intrinsically coupled in an evacuation scenario. That is, people in vehicles seek to travel out of an area of potential risk as rapidly as possible by selecting the "best" routes. The model is designed to identify these "best" routes in a manner that realistically distributes vehicles from origins to destinations and routes them over the highway network, in a consistent and optimal manner, reflecting evacuee behavior.

For each origin, a set of "candidate destination nodes" is selected by the software logic and by the analyst to reflect the desire by evacuees to travel away from the power plant and to access major highways. The specific destination nodes within this set that are selected by travelers and the selection of the connecting paths of travel, are both determined by DTRAD. This determination is made by a logit-based path choice model in DTRAD, so as to minimize the trip "cost", as discussed later.

The traffic loading on the network and the consequent operational traffic environment of the network (density, speed, throughput on each link) vary over time as the evacuation takes place. The DTRAD model, which is interfaced with the DYNEV simulation model, executes a succession of "sessions" wherein it computes the optimal routing and selection of destination nodes for the conditions that exist at that time.

Interfacing the DYNEV Simulation Model with DTRAD

The DYNEV II system reflects NRC guidance that evacuees will seek to travel in a general direction away from the location of the hazardous event. An algorithm was developed to support the DTRAD model in dynamically varying the Trip Table (O-D matrix) over time from one DTRAD session to the next. Another algorithm executes a "mapping" from the specified "geometric" network (link-node analysis network) that represents the physical highway system, to a "path" network that represents the vehicle [turn] movements. DTRAD computations are performed on the "path" network: DYNEV simulation model, on the "geometric" network.

DTRAD Description

DTRAD is the DTA module for the DYNEV II System.

When the road network under study is large, multiple routing options are usually available between trip origins and destinations. The problem of loading traffic demands and propagating them over the network links is called Network Loading and is addressed by DYNEV II using macroscopic traffic simulation modeling. Traffic assignment deals with computing the distribution of the traffic over the road network for given O-D demands and is a model of the route choice of the drivers. Travel demand changes significantly over time, and the road network may have time dependent characteristics, e.g., time-varying signal timing or reduced road capacity because of lane closure, or traffic congestion. To consider these time dependencies, DTA procedures are required.

The DTRAD DTA module represents the dynamic route choice behavior of drivers, using the specification of dynamic origin-destination matrices as flow input. Drivers choose their routes through the network based on the travel cost they experience (as determined by the simulation model). This allows traffic to be distributed over the network according to the time-dependent conditions. The modeling principles of DTRAD include:

- It is assumed that drivers not only select the best route (i.e., lowest cost path) but some also select less attractive routes. The algorithm implemented by DTRAD archives several "efficient" routes for each O-D pair from which the drivers choose.
- The choice of one route out of a set of possible routes is an outcome of "discrete choice modeling". Given a set of routes and their generalized costs, the percentages of drivers that choose each route is computed. The most prevalent model for discrete choice modeling is the logit model. DTRAD uses a variant of Path-Size-Logit model (PSL). PSL overcomes the drawback of the traditional multinomial logit model by incorporating an additional deterministic path size correction term to address path overlapping in the random utility expression.
- DTRAD executes the traffic assignment algorithm (TA) on an abstract network representation called "the path network" which is built from the actual physical link-node analysis network. This execution continues until a stable situation is reached: the volumes and travel times on the edges of the path network do not change significantly from one iteration to the next. The criteria for this convergence are defined by the user.
- Travel "cost" plays a crucial role in route choice. In DTRAD, path cost is a linear summation of the generalized cost of each link that comprises the path. The generalized cost for a link, a, is expressed as

$$c_a = \alpha t_a + \beta l_a + \gamma s_a ,$$

  where c_a is the generalized cost for link a, and α , β, and γ are cost coefficients for link travel time, distance, and supplemental cost, respectively. Distance and supplemental costs are defined as invariant properties of the network model, while travel time is a dynamic property dictated by prevailing traffic conditions. The DYNEV simulation model

computes travel times on all edges in the network and DTRAD uses that information to constantly update the costs of paths. The route choice decision model in the next simulation iteration uses these updated values to adjust the route choice behavior. This way, traffic demands are dynamically re-assigned based on time dependent conditions. The interaction between the DTRAD traffic assignment and DYNEV II simulation models is depicted in Figure B-1. Each round of interaction is called a Traffic Assignment Session (TA session). A TA session is composed of multiple iterations, marked as loop B in the figure.

- The supplemental cost is based on the "survival distribution" (a variation of the exponential distribution).The Inverse Survival Function is a "cost" term in DTRAD to represent the potential risk of travel toward the plant:

  $s_a = -\beta \ln(p),\ 0 \leq p \leq l\ ;\ \beta > 0$

  $p = \frac{d_n}{d_0}$

  d_n = Distance of node, n, from the plant
  d_0 =Distance from the plant where there is zero risk
  β = Scaling factor

The value of d_o = 12 miles, the outer distance of the EPZ. Note that the supplemental cost, s_a, of link, a, is (high, low), if its downstream node, n, is (near, far from) the power plant.

Network Equilibrium

In 1952, John Wardrop wrote:

> *Under equilibrium conditions traffic arranges itself in congested networks in such a way that no individual trip-maker can reduce his path costs by switching routes.*

The above statement describes the "User Equilibrium" definition, also called the "Selfish Driver Equilibrium". It is a hypothesis that represents a [hopeful] condition that evolves over time as drivers search out alternative routes to identify those routes that minimize their respective "costs". It has been found that this "equilibrium" objective to minimize costs is largely realized by most drivers who routinely take the same trip over the same network at the same time (i.e., commuters). Effectively, such drivers "learn" which routes are best for them over time. Thus, the traffic environment "settles down" to a near-equilibrium state.

Clearly, since an emergency evacuation is a sudden, unique event, it does not constitute a long-term learning experience which can achieve an equilibrium state. Consequently, DTRAD was not designed as an equilibrium solution, but to represent drivers in a new and unfamiliar situation, who respond in a flexible manner to real-time information (either broadcast or observed) in such a way as to minimize their respective costs of travel.

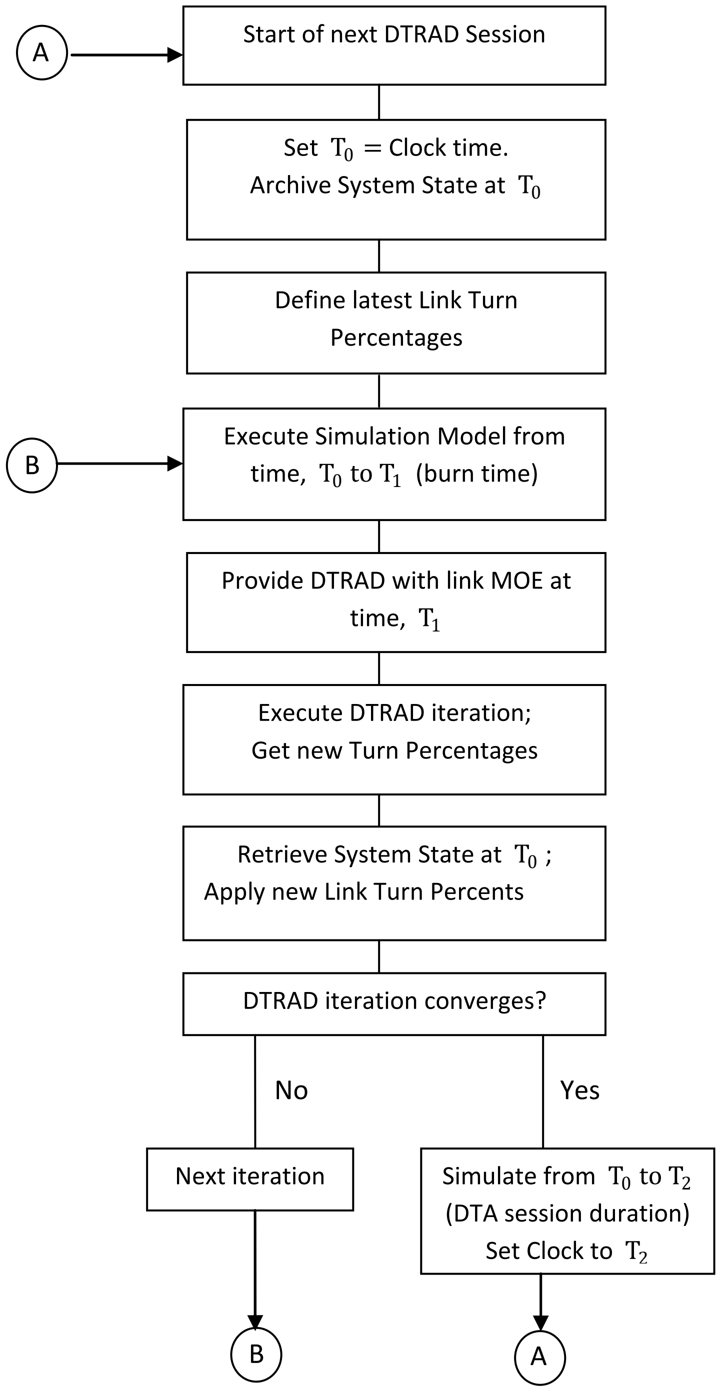


Figure B-1. Flow Diagram of Simulation-DTRAD Interface

APPENDIX C

DYNEV Traffic Simulation Model

C. DYNEV TRAFFIC SIMULATION MODEL

The DYNEV traffic simulation model is a *macroscopic* model that describes the operations of traffic flow in terms of aggregate variables: vehicles, flow rate, mean speed, volume, density, queue length, *on each link*, for each turn movement, during each Time Interval (simulation time step). The model generates trips from "sources" and from Entry Links and introduces them onto the analysis network at rates specified by the analyst based on the mobilization time distributions. The model simulates the movements of all vehicles on all network links over time until the network is empty. At intervals, the model outputs Measures of Effectiveness (MOE) such as those listed in Table C-1.

Model Features Include:

- Explicit consideration is taken of the variation in density over the time step; an iterative procedure is employed to calculate an average density over the simulation time step for the purpose of computing a mean speed for moving vehicles.
- Multiple turn movements can be serviced on one link; a separate algorithm is used to estimate the number of (fractional) lanes assigned to the vehicles performing each turn movement, based, in part, on the turn percentages provided by the dynamic traffic assignment and distribution model (DTRAD) model.
- At any point in time, traffic flow on a link is subdivided into two classifications: queued and moving vehicles. The number of vehicles in each classification is computed. Vehicle spillback, stratified by turn movement for each network link, is explicitly considered and quantified. The propagation of stopping waves from link to link is computed within each time step of the simulation. There is no "vertical stacking" of queues on a link.
- Any link can accommodate "source flow" from zones via side streets and parking facilities that are not explicitly represented. This flow represents the evacuating trips that are generated at the source.
- The relation between the number of vehicles occupying the link and its storage capacity is monitored every time step for every link and for every turn movement. If the available storage capacity on a link is exceeded by the demand for service, then the simulator applies a "metering" rate to the entering traffic from both the upstream feeders and source node to ensure that the available storage capacity is not exceeded.
- A "path network" that represents the specified traffic movements from each network link is constructed by the model; this path network is utilized by the DTRAD model.
- A two-way interface with DTRAD: (1) provides link travel times; (2) receives data that translates into link turn percentages.
- Provides MOE to animation software, EVAN
- Calculates ETE statistics

All traffic simulation models are data-intensive. Table C-2 outlines the necessary input data elements.

To provide an efficient framework for defining these specifications, the physical highway environment is represented as a network. The unidirectional links of the network represent roadway sections: rural, multi-lane, urban streets or freeways. The nodes of the network generally represent intersections or points along a section where a geometric property changes (e.g. a lane drop, change in grade or free flow speed).

Figure C-1 is an example of a small network representation. The freeway is defined by the sequence of links, (20,21), (21,22), and (22,23). Links (8001, 19) and (3, 8011) are Entry and Exit links, respectively. An arterial extends from node 3 to node 19 and is partially subsumed within a grid network. Note that links (21,22) and (17,19) are grade-separated.

C.1 Methodology

C.1.1 The Fundamental Diagram

It is necessary to define the fundamental diagram describing flow-density and speed-density relationships. Rather than "settling for" a triangular representation, a more realistic representation that includes a "capacity drop", (I-R) $Q_{max,}$ at the critical density when flow conditions enter the forced flow regime, is developed and calibrated for each link. This representation, shown in Figure C-2, asserts a constant free speed up to a density, k_f, and then a linear reduction in speed in the range, $k_f \leq k \leq k_c = 45$ vpm, the density at capacity. In the flow-density plane, a quadratic relationship is prescribed in the range, $k_c < k \leq k_s = 95$ vpm which roughly represents the "stop-and-go" condition of severe congestion. The value of flow rate, Q_s, corresponding to k_s, is approximated at $0.7\,RQ_{max}$. A linear relationship between k_s and k_j completes the diagram shown in Figure C-2. Table C-3 is a glossary of terms.

The fundamental diagram is applied to moving traffic on every link. The specified calibration values for each link are: (1) Free speed, v_f ; (2) Capacity, Q_{max} ; (3) Critical density, $k_c = 45$ vpm ; (4) Capacity Drop Factor, R = 0.9 ; (5) Jam density, k_j . Then, $v_c = \frac{Q_{max}}{k_c}$, $k_f = k_c - \frac{(V_f - V_c)\,k_c^2}{Q_{max}}$. Setting $\bar{k} = k - k_c$, then $Q = RQ_{max} - \frac{RQ_{max}}{8333}\bar{k}^2$ for $0 \leq \bar{k} \leq \bar{k}_s = 50$. It can be shown that $Q = (0.98 - 0.0056\,\bar{k})\,RQ_{max}$ for $\bar{k}_s \leq \bar{k} \leq \bar{k}_j$, where $\bar{k}_s = 50$ and $\bar{k}_j = 175$.

C.1.2 The Simulation Model

The simulation model solves a sequence of "unit problems". Each unit problem computes the movement of traffic on a link, for each specified turn movement, over a specified time interval (TI) which serves as the simulation time step for all links. Figure C-3 is a representation of the unit problem in the time-distance plane. Table C-3 is a glossary of terms that are referenced in the following description of the unit problem procedure.

The formulation and the associated logic presented below are designed to solve the unit problem for each sweep over the network (discussed below), for each turn movement serviced on each link that comprises the evacuation network, and for each TI over the duration of the evacuation.

Given = $Q_b, M_b, L, TI, E_0, LN, {}^G/_C, h, L_v, R_0, L_c, E, M$
Compute = O, Q_e, M_e
Define $O = O_Q + O_M + O_E$; $E = E_1 + E_2$

1. For the first sweep, s = 1, of this TI, get initial estimates of mean density, k_0, the R – factor, R_0 and entering traffic, E_0, using the values computed for the final sweep of the prior TI. For each subsequent sweep, $s > 1$, calculate $E = \sum_i P_i\ O_i + S$ where P_i, O_i are the relevant turn percentages from feeder link, i , and its total outflow (possibly metered) over this TI; S is the total source flow (possibly metered) during the current TI.
Set iteration counter, n = 0, $k = k_0$, and $E = E_0$.

2. Calculate $v(k)$ such that $k \leq 130$ using the analytical representations of the fundamental diagram.
Calculate $\text{Cap} = \frac{Q_{max}(TI)}{3600}\left({}^G/_C\right) LN$, in vehicles, this value may be reduced due to metering
Set $R = 1.0$ if ${}^G/_C < 1$ or if $k \leq k_c$; Set $R = 0.9$ only if ${}^G/_C = 1$ and $k > k_c$
Calculate queue length, $L_b = Q_b \frac{L_v}{LN}$

3. Calculate $t_1 = TI - \frac{L}{V}$. If $t_1 \prec 0$, set $t_1 = E_1 = O_E = 0$; Else, $E_1 = E\ \frac{t_1}{TI}$.

4. Then $E_2 = E - E_1$; $t_2 = TI - t_1$

5. If $Q_b \geq \text{Cap}$, then
   $O_Q = \text{Cap}, O_M = O_E = 0$
   If $t_1 > 0$, then
      $Q'_e = Q_b + M_b + E_1 - \text{Cap}$
   Else
      $Q'_e = Q_b - \text{Cap}$
   End if
   Calculate Q_e and M_e using Algorithm A (below)

6. Else $(Q_b \prec \text{Cap})$
   $O_Q = Q_b$, $\text{RCap} = \text{Cap} - O_Q$

7. If $M_b \leq \text{RCap}$, then

8. If $t_1 > 0$, $O_M = M_b, O_E = \min\left(\text{RCap} - M_b, \frac{t_1\ \text{Cap}}{TI}\right) \geq 0$
   $Q'_e = E_1 - O_E$
   If $Q'_e > 0$, then

Calculate Q_e , M_e with Algorithm A

Else

$Q_e = 0$, $M_e = E_2$

End if

Else $(t_1 = 0)$

$O_M = \left(\frac{v(TI)-L_b}{L-L_b}\right) M_b$ and $O_E = 0$

$M_e = M_b - O_M + E$; $Q_e = 0$

End if

9. Else $(M_b > RCap)$

$O_E = 0$

If $t_1 > 0$, then

$O_M = \text{RCap}$, $Q'_e = M_b - O_M + E_1$

Calculate Q_e and M_e using Algorithm A

10. Else $(t_1 = 0)$

$M_d = \left[\left(\frac{v(TI)-L_b}{L-L_b}\right) M_b\right]$

If $M_d > RCap$, *then*

$O_M = \text{RCap}$

$Q'_e = M_d - O_M$

Apply Algorithm A to calculate Q_e and M_e

Else

$O_M = M_d$

$M_e = M_b - O_M + E$ and $Q_e = 0$

End if

End if

End if

End if

11. Calculate a new estimate of average density, $\bar{k}_n = \frac{1}{4}[k_b + 2\,k_m + k_e]$,

where k_b = density at the beginning of the TI

k_e = density at the end of the TI

k_m = density at the mid-point of the TI

All values of density apply only to the moving vehicles.

If $\left|\bar{k}_n - \bar{k}_{n-1}\right| > \in$ and $n < N$

where N = max number of iterations, and ϵ is a convergence criterion, then

12. set $n = n + 1$, and return to step 2 to perform iteration, n, using $k = \bar{k}_n$.

End if

Computation of unit problem is now complete. Check for excessive inflow causing spillback.

13. If $Q_e + M_e > \frac{(L-W)\,LN}{L_v}$, then

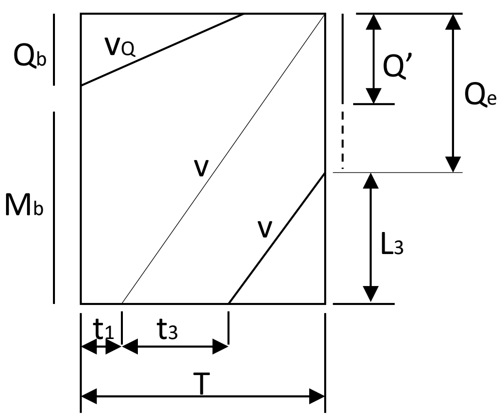
The number of excess vehicles that cause spillback is: $SB = Q_e + M_e - \frac{(L-W) \cdot LN}{L_v}$, where W is the width of the upstream intersection. To prevent spillback, meter the outflow from the feeder approaches and from the source flow, S, during this TI by the amount, SB. That is, set

$$M = 1 - \frac{SB}{(E+S)} \geq 0 \text{, where M is the metering factor (over all movements).}$$

This metering factor is assigned appropriately to all feeder links and to the source flow, to be applied during the next network sweep, discussed later.

Algorithm A

This analysis addresses the flow environment over a TI during which moving vehicles can join a standing or discharging queue. For the case shown, $Q_b \leq Cap$, with $t_1 > 0$ and a queue of length, Q'_e , formed by that portion of M_b and E that reaches the stop-bar within the TI, but could not discharge due to inadequate capacity. That is, $Q_b + M_b + E_1 > Cap$. This queue length, $Q'_e = Q_b + M_b + E_1 - Cap$ can be extended to Q_e by traffic entering the approach during the current TI, traveling at speed, v, and reaching the rear of the queue within the TI. A portion of the entering vehicles, $E_3 = E\,\frac{t_3}{TI}$, will likely join the queue. This analysis calculates t_3 , Q_e and M_e for the input values of L, TI, v, E, t, L_v, LN, Q'_e .



When $t_1 > 0$ and $Q_b \leq Cap$:

Define: $L'_e = Q'_e\,\frac{L_v}{LN}$. From the sketch, $L_3 = v(TI - t_1 - t_3) = L - (Q'_e + E_3)\frac{L_v}{LN}$.

Substituting $E_3 = \frac{t_3}{TI}\,E$ yields: $-vt_3 + \frac{t_3}{TI}\,E\,\frac{L_v}{LN} = L - v(TI - t_1) - L'_e$. Recognizing that the first two terms on the right hand side cancel, solve for t_3 to obtain:

$$t_3 = \frac{L'_e}{\left[v - \frac{E}{TI}\,\frac{L_v}{LN}\right]} \qquad \text{such that} \quad 0 \leq t_3 \leq TI - t_1$$

If the denominator, $\left[v - \frac{E}{TI}\,\frac{L_v}{LN}\right] \leq 0$, set $t_3 = TI - t_1$.

Then, $Q_e = Q'_e + E\,\frac{t_3}{TI}$, $M_e = E\left(1 - \frac{t_1 + t_3}{TI}\right)$

The complete Algorithm A considers all flow scenarios; space limitation precludes its inclusion, here.

C.1.3 Lane Assignment

The “unit problem” is solved for each turn movement on each link. Therefore it is necessary to calculate a value, LN_x , of allocated lanes for each movement, x. If in fact all lanes are specified by, say, arrows painted on the pavement, either as full lanes or as lanes within a turn bay, then the problem is fully defined. If however there remain un-channelized lanes on a link, then an analysis is undertaken to subdivide the number of these physical lanes into turn movement specific virtual lanes, LN_x.

C.2 Implementation

C.2.1 Computational Procedure

The computational procedure for this model is shown in the form of a flow diagram as Figure C-4. As discussed earlier, the simulation model processes traffic flow for each link independently over TI that the analyst specifies; it is usually 60 seconds or longer. The first step is to execute an algorithm to define the sequence in which the network links are processed so that as many links as possible are processed after their feeder links are processed, within the same network sweep. Since a general network will have many closed loops, it is not possible to guarantee that every link processed will have all of its feeder links processed earlier.

The processing then continues as a succession of time steps of duration, TI, until the simulation is completed. Within each time step, the processing performs a series of “sweeps” over all network links; this is necessary to ensure that the traffic flow is synchronous over the entire network. Specifically, the sweep ensures continuity of flow among all the network links; in the context of this model, this means that the values of E, M, and S are all defined for each link such that they represent the synchronous movement of traffic from each link to all of its outbound links. These sweeps also serve to compute the metering rates that control spillback.

Within each sweep, processing solves the “unit problem” for each turn movement on each link. With the turn movement percentages for each link provided by the DTRAD model, an algorithm allocates the number of lanes to each movement serviced on each link. The timing at a signal, if any, applied at the downstream end of the link, is expressed as a G/C ratio, the signal timing needed to define this ratio is an input requirement for the model. The model also has the capability of representing, with macroscopic fidelity, the actions of actuated signals responding to the time-varying competing demands on the approaches to the intersection.

The solution of the unit problem yields the values of the number of vehicles, O, that discharge from the link over the time interval and the number of vehicles that remain on the link at the end of the time interval as stratified by queued and moving vehicles: $Q_e \text{ and } M_e$. The procedure considers each movement separately (multi-piping). After all network links are processed for a given network sweep, the updated consistent values of entering flows, E; metering rates, M; and source flows, S are defined so as to satisfy the “no spillback” condition. The procedure then performs the unit problem solutions for all network links during the following sweep.

Experience has shown that the system converges (i.e. the values of E, M and S "settle down" for all network links) in just two sweeps if the network is entirely under-saturated or in four sweeps in the presence of extensive congestion with link spillback. (The initial sweep over each link uses the final values of E and M, of the prior TI). At the completion of the final sweep for a TI, the procedure computes and stores all measures of effectiveness for each link and turn movement for output purposes. It then prepares for the following time interval by defining the values of Q_b and M_b for the start of the next TI as being those values of Q_e and M_e at the end of the prior TI. In this manner, the simulation model processes the traffic flow over time until the end of the run. Note that there is no space-discretization other than the specification of network links.

C.2.2 Interfacing with Dynamic Traffic Assignment (DTRAD)

The **DYNEV II** system reflects NRC guidance that evacuees will seek to travel in a general direction away from the location of the hazardous event. Thus, an algorithm was developed to identify an appropriate set of destination nodes for each origin based on its location and on the expected direction of travel. This algorithm also supports the DTRAD model in dynamically varying the Trip Table (O-D matrix) over time from one DTRAD session to the next.

Figure B-1 depicts the interaction of the simulation model with the DTRAD model in the **DYNEV II** system. As indicated, **DYNEV II** performs a succession of DTRAD "sessions"; each such session computes the turn link percentages for each link that remain constant for the session duration, $[T_0, T_2]$, specified by the analyst. The end product is the assignment of traffic volumes from each origin to paths connecting it with its destinations in such a way as to minimize the network-wide cost function. The output of the DTRAD model is a set of updated link turn percentages which represent this assignment of traffic.

As indicated in Figure B-1, the simulation model supports the DTRAD session by providing it with operational link MOE that are needed by the path choice model and included in the DTRAD cost function. These MOE represent the operational state of the network at a time, $T_1 \leq T_2$, which lies within the session duration, $[T_0, T_2]$. This "burn time", $T_1 - T_0$, is selected by the analyst. For each DTRAD iteration, the simulation model computes the change in network operations over this burn time using the latest set of link turn percentages computed by the DTRAD model. Upon convergence of the DTRAD iterative procedure, the simulation model accepts the latest turn percentages provided by the Dynamic Traffic Assignment (DTA) model, returns to the origin time, T_0, and executes until it arrives at the end of the DTRAD session duration at time, T_2. At this time the next DTA session is launched and the whole process repeats until the end of the **DYNEV II** run.

Additional details are presented in Appendix B.

Table C-1. Selected Measures of Effectiveness Output by DYNEV II

Measure	Units	Applies To
Vehicles Discharged	Vehicles	Link, Network, Exit Link
Speed	Miles/Hours (mph)	Link, Network
Density	Vehicles/Mile/Lane	Link
Level of Service	LOS	Link
Content	Vehicles	Network
Travel Time	Vehicle-hours	Network
Evacuated Vehicles	Vehicles	Network, Exit Link
Trip Travel Time	Vehicle-minutes/trip	Network
Capacity Utilization	Percent	Exit Link
Attraction	Percent of total evacuating vehicles	Exit Link
Max Queue	Vehicles	Node, Approach
Time of Max Queue	Hours:minutes	Node, Approach
Route Statistics	Length (mi); Mean Speed (mph); Travel Time (min)	Route
Mean Travel Time	Minutes	Evacuation Trips; Network

Table C-2. Input Requirements for the DYNEV II Model

HIGHWAY NETWORK

- Links defined by upstream and downstream node numbers
- Link lengths
- Number of lanes (up to 9) and channelization
- Turn bays (1 to 3 lanes)
- Destination (exit) nodes
- Network topology defined in terms of downstream nodes for each receiving link
- Node Coordinates (X,Y)
- Nuclear Power Plant Coordinates (X,Y)

GENERATED TRAFFIC VOLUMES

- On all entry links and source nodes (origins), by Time Period

TRAFFIC CONTROL SPECIFICATIONS

- Traffic signals: link-specific, turn movement specific
- Signal control treated as fixed time or actuated
- Location of traffic control points (these are represented as actuated signals)
- Stop and Yield signs
- Right-turn-on-red (RTOR)
- Route diversion specifications
- Turn restrictions
- Lane control (e.g. lane closure, movement-specific)

DRIVER'S AND OPERATIONAL CHARACTERISTICS

- Driver's (vehicle-specific) response mechanisms: free-flow speed, discharge headway
- Bus route designation.

DYNAMIC TRAFFIC ASSIGNMENT

- Candidate destination nodes for each origin (optional)
- Duration of DTA sessions
- Duration of simulation "burn time"
- Desired number of destination nodes per origin

INCIDENTS

- Identify and Schedule of closed lanes
- Identify and Schedule of closed links

Table C-3. Glossary

Cap	The maximum number of vehicles, of a particular movement, that can discharge from a link within a time interval.
E	The number of vehicles, of a particular movement, that enter the link over the time interval. The portion, E_{TI}, can reach the stop-bar within the TI.
G/C	The green time: cycle time ratio that services the vehicles of a particular turn movement on a link.
h	The mean queue discharge headway, seconds.
k	Density in vehicles per lane per mile.
$\bar{k}$	The average density of <u>moving</u> vehicles of a particular movement over a TI, on a link.
L	The length of the link in feet.
L_b , L_e	The queue length in feet of a particular movement, at the [beginning, end] of a time interval.
LN	The number of lanes, expressed as a floating point number, allocated to service a particular movement on a link.
L_v	The mean effective length of a queued vehicle including the vehicle spacing, feet.
M	Metering factor (Multiplier): 1.
M_b , M_e	The number of moving vehicles on the link, of a particular movement, that are moving at the [beginning, end] of the time interval. These vehicles are assumed to be of equal spacing, over the length of link upstream of the queue.
O	The total number of vehicles of a particular movement that are discharged from a link over a time interval.
O_Q , O_M , O_E	The components of the vehicles of a particular movement that are discharged from a link within a time interval: vehicles that were Queued at the beginning of the TI; vehicles that were Moving within the link at the beginning of the TI; vehicles that Entered the link during the TI.
P_x	The percentage, expressed as a fraction, of the total flow on the link that executes a particular turn movement, x.

Q_b , Q_e	The number of queued vehicles on the link, of a particular turn movement, at the [beginning, end] of the time interval.
Q_{max}	The maximum flow rate that can be serviced by a link for a particular movement in the absence of a control device. It is specified by the analyst as an estimate of link capacity, based upon a field survey, with reference to the HCM 2016.
R	The factor that is applied to the capacity of a link to represent the "capacity drop" when the flow condition moves into the forced flow regime. The lower capacity at that point is equal to RQ_{max} .
RCap	The remaining capacity available to service vehicles of a particular movement after that queue has been completely serviced, within a time interval, expressed as vehicles.
S_x	Service rate for movement x, vehicles per hour (vph).
t_1	Vehicles of a particular turn movement that enter a link over the first t_1 seconds of a time interval, can reach the stop-bar (in the absence of a queue down-stream) within the same time interval.
TI	The time interval, in seconds, which is used as the simulation time step.
v	The mean speed of travel, in feet per second (fps) or miles per hour (mph), of moving vehicles on the link.
v_Q	The mean speed of the last vehicle in a queue that discharges from the link within the TI. This speed differs from the mean speed of moving vehicles, v.
W	The width of the intersection in feet. This is the difference between the link length which extends from stop-bar to stop-bar and the block length.

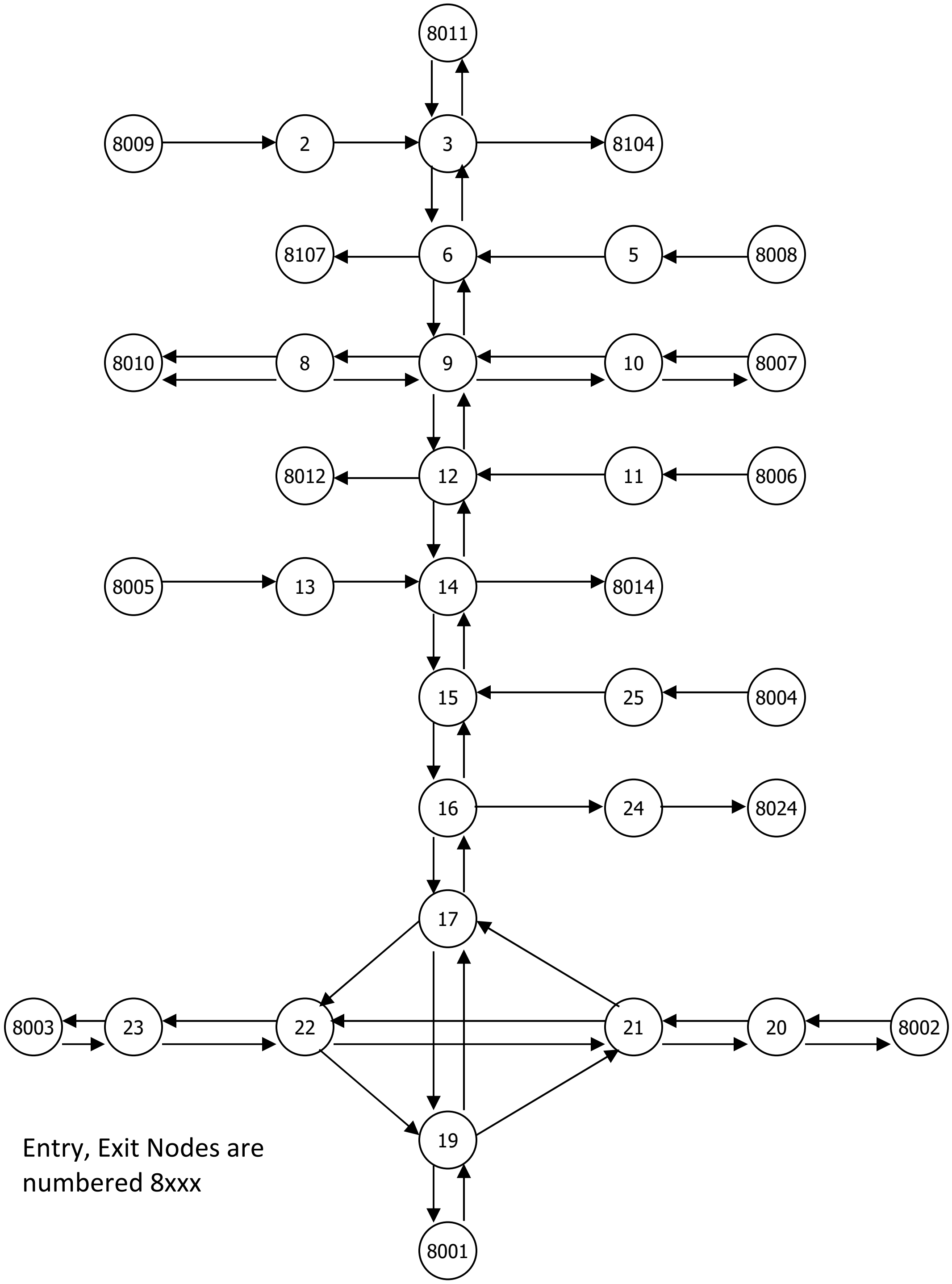


Figure C-1. Representative Analysis Network

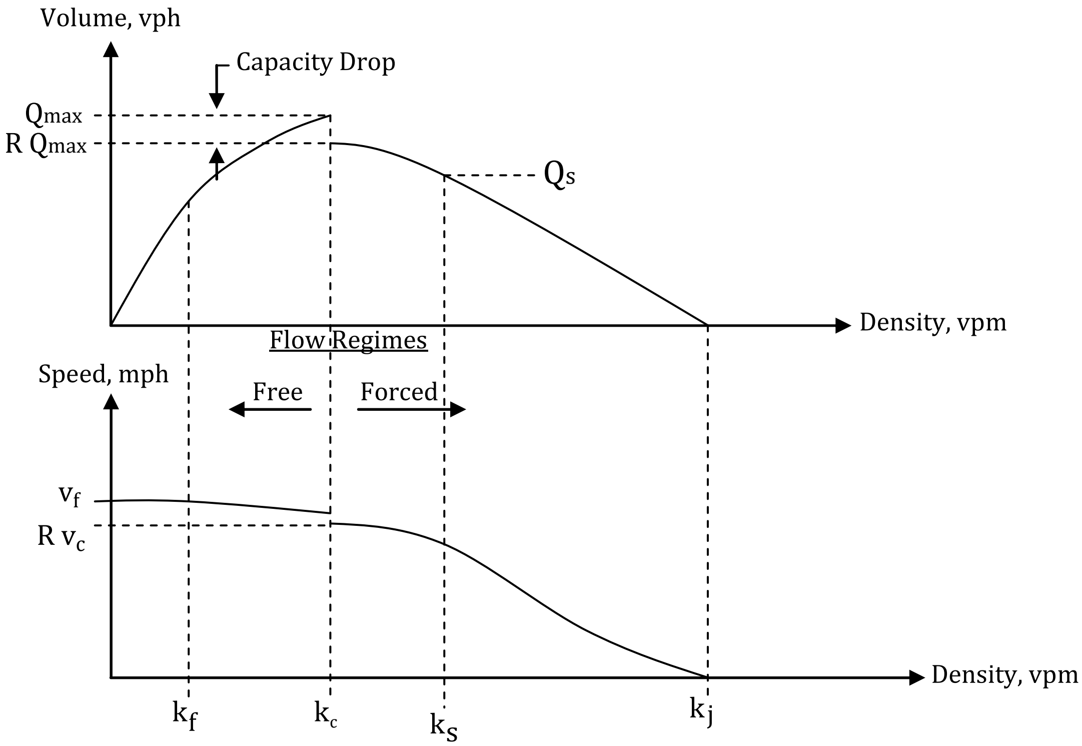


Figure C-2. Fundamental Diagrams

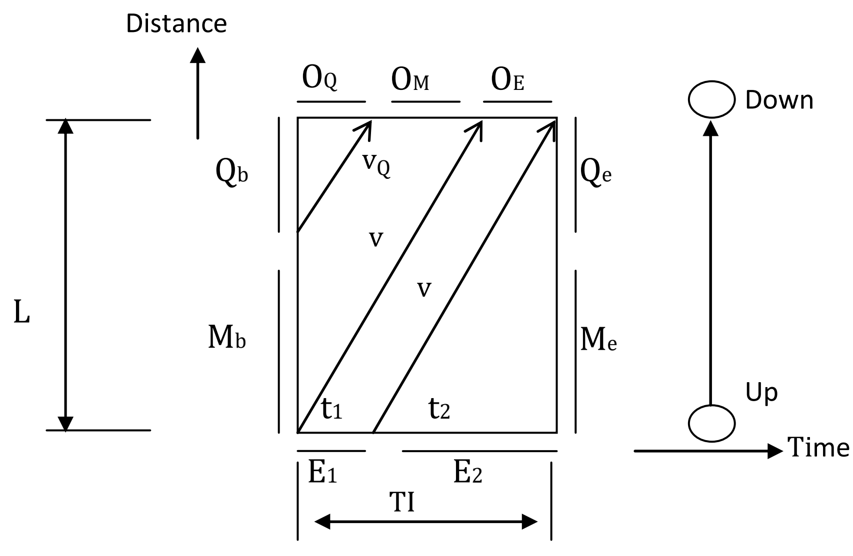


Figure C-3. A UNIT Problem Configuration with $t_1 > 0$

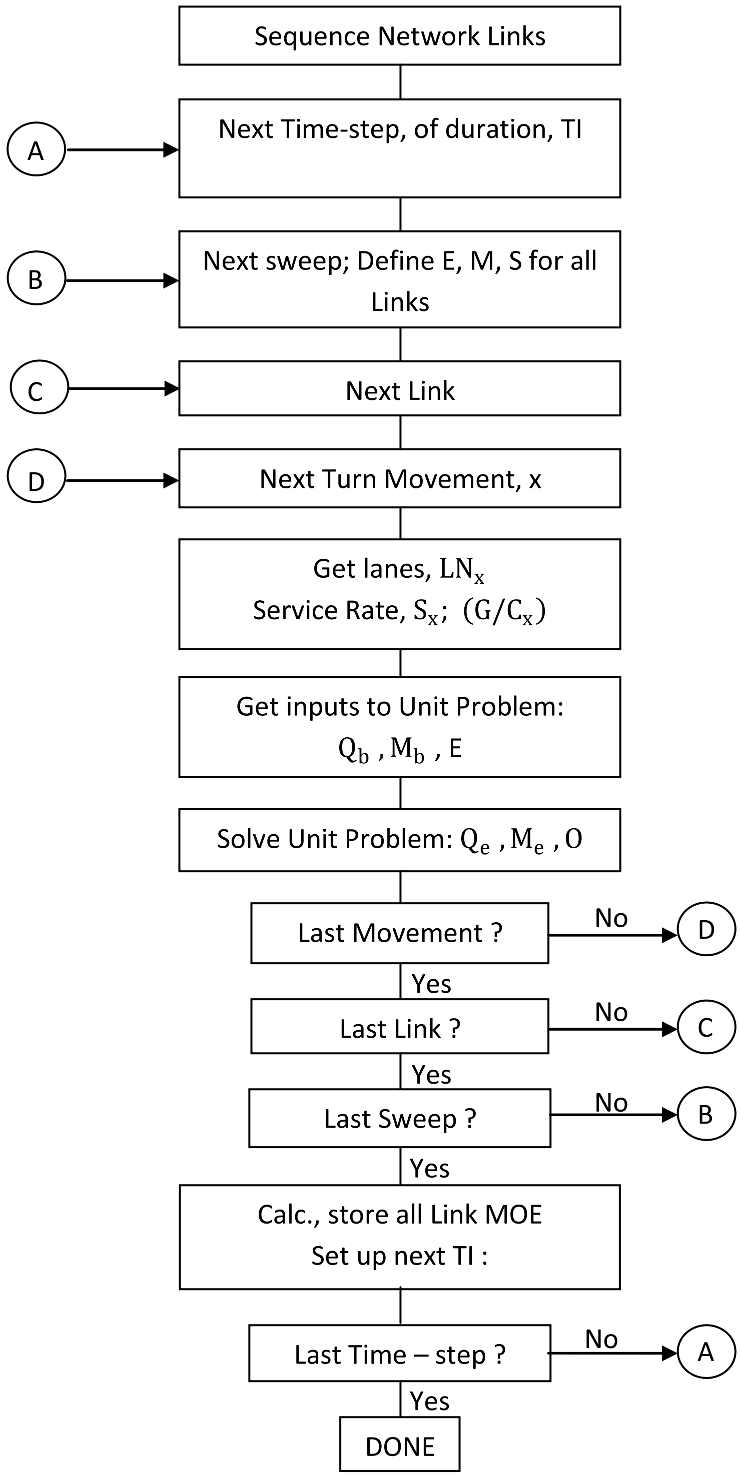


Figure C-4. Flow of Simulation Processing (See Glossary: Table C-3)

APPENDIX D

Detailed Description of Study Procedure

D. DETAILED DESCRIPTION OF STUDY PROCEDURE

This appendix describes the activities that were performed to compute Evacuation Time Estimates (ETE). The individual steps of this effort are represented as a flow diagram in Figure D-1. Each numbered step in the description that follows corresponds to the numbered element in the flow diagram.

Step 1

The first activity was to verify that the EPZ boundary information, provided by Duke Energy, is accurate. Based on discussions with Duke Energy the new, proposed EPZ will be used for this study with a sensitivity study performed on the current EPZ for further analysis. A GIS base map was created with the EPZ and Zone boundaries clearly identified. The base map extends beyond the Shadow Region which extends approximately 15 miles (radially) from the power plant location. The base map incorporates the local roadway topology, a suitable topographic background and the EPZ boundary.

Step 2

2020 Census block population information was obtained in GIS format. This information was used to estimate the resident population within the EPZ and Shadow Region and to define the spatial distribution and demographic characteristics of the population within the study area. Data for employees, transients, schools, and other facilities were obtained from the county emergency management departments, supplemented by internet searches and data from the previous ETE study where new data could not be obtained.

Step 3

A kickoff meeting was conducted with major stakeholders (state and local emergency managers, on-site and off-site utility emergency managers, local and state law enforcement agencies). The purpose of the kickoff meeting was to present an overview of the work effort, identify key agency personnel, and indicate the data requirements for the study. Specific requests for information were presented to county emergency managers. Unique features of the study area were discussed to identify the local concerns that should be addressed by the ETE study.

Step 4

Next, a physical survey of the roadway system in the study area was conducted to determine any changes to the roadway network since the previous study. This survey included consideration of the geometric properties of the highway sections, the channelization of lanes on each section of roadway, whether there are any turn restrictions or special treatment of traffic at intersections, the type and functioning of traffic control devices, gathering signal timings for pre-timed traffic signals, and to make the necessary observations needed to estimate realistic values of roadway capacity. Roadway characteristics were also verified using aerial imagery.

Step 5

A demographic survey of households within the EPZ was conducted to identify household dynamics, trip generation characteristics, and evacuation-related demographic information of the EPZ population. This information was used to determine important study factors including the average number of evacuating vehicles used by each household, and the time required to perform pre-evacuation mobilization activities.

Step 6

A computerized representation of the physical roadway system, called a link-node analysis network, was updated using the most recent UNITES software (see Section 1.3) developed by KLD. Once the updated geometry of the network was completed, the network was calibrated using the information gathered during the road survey (Step 4). Estimates of highway capacity for each link and other link-specific characteristics were introduced to the network description. Traffic signal timings were input accordingly. The link-node analysis network was imported into a GIS map. 2020 Census data were overlaid in the map, and origin centroids where trips would be generated during the evacuation process were assigned to appropriate links.

Step 7

The EPZ is subdivided into 14 Zones. Based on wind direction and speed, Regions (groupings of Zones) that may be advised to evacuate, were developed.

The need for evacuation can occur over a range of time-of-day, day-of-week, seasonal and weather-related conditions. Scenarios were developed to capture the variation in evacuation demand, highway capacity and mobilization time, for different time of day, day of the week, time of year, and weather conditions.

Step 8

The input stream for the DYNEV II model, which integrates the dynamic traffic assignment and distribution model, DTRAD, with the evacuation simulation model, was created for a prototype evacuation case – the evacuation of the entire EPZ for a representative scenario.

Step 9

After creating this input stream, the DYNEV II System was executed on the prototype evacuation case to compute evacuating traffic routing patterns consistent with the appropriate NRC guidelines. DYNEV II contains an extensive suite of data diagnostics which check the completeness and consistency of the input data specified. The analyst reviews all warning and error messages produced by the model and then corrects the database to create an input stream that properly executes to completion.

The model assigns destinations to all origin centroids consistent with a (general) radial evacuation of the EPZ and Shadow Region. The analyst may optionally supplement and/or replace these model-assigned destinations, based on professional judgment, after studying the topology of the analysis highway network. The model produces link and network-wide measures of effectiveness as well as estimates of evacuation time.

Step 10

The results generated by the prototype evacuation case are critically examined. The examination includes observing the animated graphics (using the EVAN software – see Section 1.3) and reviewing the statistics output by the model. This is a labor-intensive activity, requiring the direct participation of skilled engineers who possess the necessary practical experience to interpret the results and to determine the causes of any problems reflected in the results.

Essentially, the approach is to identify those bottlenecks in the network that represent locations where congested conditions are pronounced and to identify the cause of this congestion. This cause can take many forms, either as excess demand due to high rates of trip generation, improper routing, a shortfall of capacity, or as a quantitative flaw in the way the physical system was represented in the input stream. This examination leads to one of two conclusions:

- The results are satisfactory; or
- The input stream must be modified accordingly.

This decision requires, of course, the application of the user's judgment and experience based upon the results obtained in previous applications of the model and a comparison of the results of the latest prototype evacuation case iteration with the previous ones. If the results are satisfactory in the opinion of the user, then the process continues with Step 13. Otherwise, proceed to Step 11.

Step 11

There are many "treatments" available to the user in resolving apparent problems. These treatments range from decisions to reroute the traffic by assigning additional evacuation destinations for one or more sources, imposing turn restrictions where they can produce significant improvements in capacity, changing the control treatment at critical intersections so as to provide improved service for one or more movements, or in prescribing specific treatments for channelizing the flow so as to expedite the movement of traffic along major roadway systems. Such "treatments" take the form of modifications to the original prototype evacuation case input stream. All treatments are designed to improve the representation of evacuation behavior.

Step 12

As noted above, the changes to the input stream must be implemented to reflect the modifications undertaken in Step 11. At the completion of this activity, the process returns to Step 9 where the DYNEV II System is again executed.

Step 13

Evacuation of transit-dependent evacuees and special facilities are included in the evacuation analysis. Fixed routing for transit buses and for school buses, ambulances, and other transit vehicles are introduced into the final prototype evacuation case data set. DYNEV II generates

route-specific speeds over time for use in the estimation of evacuation times for the transit dependent and special facility population groups.

Step 14

The prototype evacuation case was used as the basis for generating all region and scenario-specific evacuation cases to be simulated. This process was automated through the UNITES user interface. For each specific case, the population to be evacuated, the trip generation distributions, the highway capacity and speeds, and other factors are adjusted to produce a customized case-specific data set.

Step 15

All evacuation cases are executed using the DYNEV II System to compute ETE. Once results are available, quality control procedures are used to assure the results are consistent, dynamic routing is reasonable, and traffic congestion/bottlenecks are addressed properly.

Step 16

Once vehicular evacuation results are accepted, average travel speeds for transit and special facility routes are used to compute evacuation time estimates for transit-dependent permanent residents, schools, hospitals, and other special facilities.

Step 17

The simulation results are analyzed, tabulated, and graphed. Traffic management plans are analyzed, and traffic control points are prioritized, if applicable. Additional analysis is conducted to identify the sensitivity of the ETE to changes in some base evacuation conditions and model assumptions. The results are then documented, as required by NUREG/CR-7002, Rev. 1.

Step 18

Following the completion of documentation activities, the ETE criteria checklist (see Appendix N) is completed. An appropriate report reference is provided for each criterion provided in the checklist.

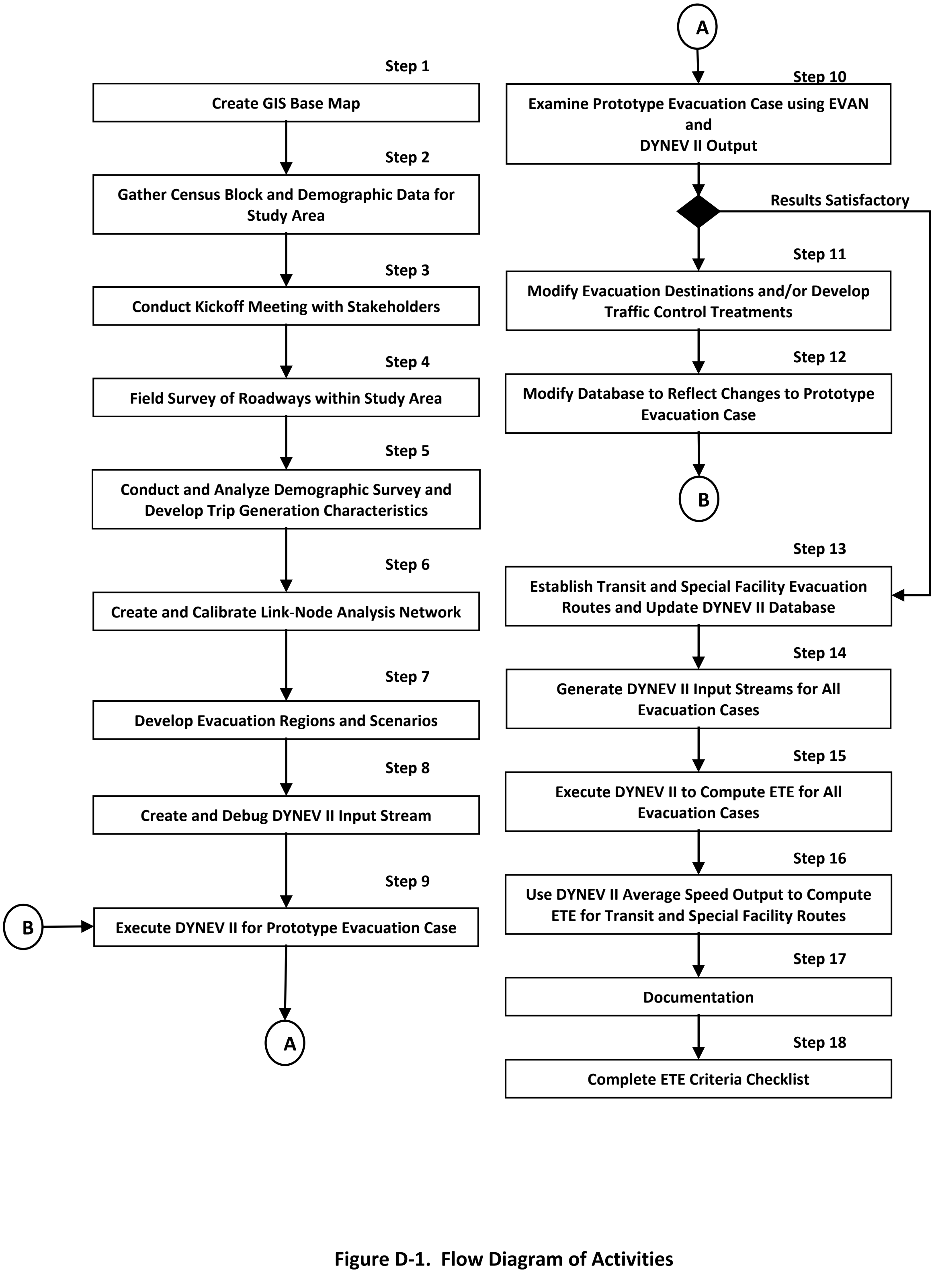


Figure D-1. Flow Diagram of Activities

APPENDIX E

Facility Data

E. FACILITY DATA

The following tables list population information, as of October 2021, for special facilities and transient attractions that are located within the HNP EPZ. Special facilities are defined as schools, childcare centers, and medical care facilities. OnTheMap employment data (see Section 3, sub-section 3.4) is summarized in the table for major employers. Transient population data is included in the tables for campgrounds, parks and community centers, golf courses and lodging facilities.

Each table is grouped by county. The location of the facility is defined by its straight-line distance (miles) and direction (magnetic bearing) from the center point of the plant. Maps of each school, childcare center, medical facility, campground, park, community center, golf course and lodging facility are also provided.

Table E-1. Schools within the Study Area

Zone	Distance (miles)	Direc-tion	School Name	Street Address	Municipality	Enroll-ment
CHATHAM COUNTY						
M	6.8	W	Moncure Elementary School	600 Moncure School Rd	Moncure	300
M	9.0	NW	Seaforth High School	444 Seaforth Rd	Pittsboro	1,400
					Chatham County Subtotal:	*1,700*
HARNETT COUNTY						
S.R.[1]	12.5	SE	Lafayette Elementary School	108 Lafayette School Rd	Fuquay-Varina	650
					Harnett County Subtotal:	*650*
LEE COUNTY						
S.R.[1]	11.1	WSW	Deep River Elementary School	4000 Deep River Rd	Sanford	558
					Lee County Subtotal:	*558*
WAKE COUNTY						
B	5.4	ENE	Oakview Elementary School	11500 Holly Springs Hill Rd	Apex	919
B	5.4	NNE	Apex Friendship Middle School	7701 Humie Olive Rd	Apex	866
B	5.4	NNE	Apex Friendship High School	7801 Humie Olive Rd	Apex	2,508
B	5.9	ENE	Thales Academy Holly Springs Pre-K-5	11244 Holly Springs New Hill Rd	Holly Springs	486
E	7.3	NNE	Scotts Ridge Elementary School	6601 Apex Barbecue Rd	Apex	849
E	7.7	NE	St. Mary Magdalene Catholic School	625 Magdala Pl	Apex	629
E	7.8	NNE	Olive Chapel Elementary School	1751 Olive Chapel Rd	Apex	996
E	8.3	NE	Apex Elementary School	700 Tingen Rd	Apex	635
E	8.8	NE	Apex Middle School	400 E Moore St	Apex	1,243
E	9.2	NE	Baucom Elementary School	400 Hunter St	Apex	656
E	9.3	NE	Lufkin Road Middle School	1002 Lufkin Rd	Apex	953
E	9.4	NNE	Peak Charter Academy	1601 Orchard Villas Ave	Apex	751
E	9.6	NE	Thales Academy Apex K-5	1177 Ambergate St	Apex	538
E	9.8	NE	Thales Academy Apex JH/HS	1300 N Salem St	Apex	688
E	10.1	NE	Apex Senior High School	1501 Laura Duncan Rd	Apex	2,033
F	5.9	E	Holly Grove Elementary School	1451 Avent Ferry Rd	Holly Springs	970
F	6.1	E	Holly Grove Middle School	1401 Avent Ferry Rd	Holly Springs	1,645
F	6.1	E	Holly Springs High School	5329 Cass Holt Rd	Holly Springs	2,123
F	7.4	ENE	Holly Springs Elementary School	401 Holly Springs Rd	Holly Springs	808

[1] S.R. is Shadow Region. As per county plans, these two facilities evacuate due to their close proximity to the EPZ boundary.

Zone	Distance (miles)	Direc-tion	School Name	Street Address	Municipality	Enroll-ment
F	7.4	ENE	Pine Springs Preparatory Academy	220 Rosewood Centre Dr	Holly Springs	607
F	8.0	E	Holly Ridge Elementary School	900 Holly Springs Rd	Holly Springs	791
F	8.0	E	Holly Ridge Middle School	950 Holly Springs Rd	Holly Springs	1,112
G	6.4	E	Buckhorn Creek Elementary School	5651 Honeycutt Rd	Holly Springs	565
G	7.8	E	Southern Wake Academy	5108 Old Powell Rd	Holly Springs	742
G	8.7	E	Herbert Akins Road Elementary School	2255 Herbert Akins Rd	Fuquay-Varina	918
G	8.8	ESE	Lincoln Heights Elementary School	307 Bridge St	Fuquay-Varina	393
G	9.2	ESE	Fuquay-Varina Senior High School	201 Bengal Dr	Fuquay-Varina	2,248
G	9.7	ESE	Fuquay-Varina Middle School	109 N Ennis St	Fuquay-Varina	1,018
					Wake County Subtotal:	*28,690*
					EPZ TOTAL:	**31,598**

Table E-2. Childcare Centers within the EPZ

Zone	Distance (miles)	Direc-tion	Facility Name	Street Address	Municipality	Enroll-ment
CHATHAM COUNTY						
M	6.8	W	YMCA After Care Program	600 Moncure School Rd	Moncure	25
					Chatham County Subtotal:	*25*
WAKE COUNTY						
C	5.7	E	Primrose School at Holly Grove	1530 Avent Ferry Rd	Holly Springs	199
E	6.6	NNE	Nicole Miller's Family Childcare Home	1124 Woodlands Creek Way	Apex	8
E	6.6	NNE	Karen's Kids Home Child Care	1014 Edinburgh Downs Ln	Apex	8
E	7.7	NNE	Kindercare Learning Center	1815 Olive Chapel Rd	Apex	150
E	7.7	NNE	Lightbridge Academy	1075 Newland Ave	Apex	195
E	7.8	ENE	Kidtowne at Hope Community Church - Apex	2080 E Williams St	Apex	156
E	7.9	NNE	The Learning Experience in Apex	560 Evening Star Dr	Apex	178
E	8.4	NE	Bright Start Child Care LLC	1910 White Dogwood Rd	Apex	8
E	8.5	NE	Montessori Creative Learning School	402 Upchurch St	Apex	62
E	8.6	NE	Everbrook Academy of Apex	1001 Olive Chapel Rd	Apex	138
E	8.7	NE	Goddard School Apex	903 Olive Chapel Rd	Apex	138
E	8.7	NE	Growing Years Learning Center	470 W Williams St	Apex	130
E	8.7	NNE	Play Care	1422 Fairfax Woods Dr	Apex	8

Zone	Distance (miles)	Direc-tion	Facility Name	Street Address	Municipality	Enroll-ment
E	8.7	NE	Apex Peak Schools, Inc.	432 E Williams St	Apex	60
E	8.9	NE	Apex Baptist Church Preschool	110 S Salem St	Apex	174
E	8.9	NE	Apex United Methodist Church Preschool	100 S Hughes St	Apex	78
E	9.0	NE	Vickie's Day Care Home	410 E Chatham St	Apex	8
E	9.5	ENE	Earth Angel's Day Care Home	2909 Earth Dr	Apex	8
E	9.5	NNE	Angel's Garden Home Daycare	2204 Walden Creek Dr	Apex	8
E	9.6	NE	Peace Montessori	2190 N Salem Suite 103	Apex	45
E	9.6	NE	Creative Schools of Apex	1201 Old Raleigh Rd	Apex	135
E	9.6	ENE	Children's Choice	7960 Smith Rd	Apex	8
E	9.6	NE	Children's Lighthouse of Apex	2001 Apex Peakway	Apex	198
E	9.7	NE	Moravic Family Day Care	1814 Misty Hollow Ln	Apex	8
E	9.7	ENE	Woodhaven Weekday Preschool	4000 Kildaire Farm Rd	Cary	102
E	9.9	ENE	AsheBridge Children's Academy of Apex/Cary	3901 Kildaire Farm Rd	Apex	162
E	10.1	ENE	Grace Church Preschool and Summer Camp	3725 Kildaire Farm Rd	Cary	82
E	10.1	NE	Eileen's Day Care	902 Wellstone Cir	Apex	8
E	10.2	NE	Hope Chapel Preschool	6175 Old Jenks Rd	Apex	75
E	10.2	ENE	Majestic Learning Experience Inc.	411 Devonhall Ln	Cary	6
E	10.3	NNE	The Goddard School of Apex (Green Level West)	3701 Green Level W Rd	Apex	153
E	10.3	NE	Primrose School of Apex	1710 Laura Duncan Rd	Apex	185
F	6.2	E	Home Away from Home Childcare	416 Cline Falls Dr	Holly Springs	5
F	6.3	ENE	Holly Springs KinderCare	300 Earnie Ln	Holly Springs	199
F	6.6	E	Lightbridge Academy	1840 Ralph Stephens Rd	Holly Springs	170
F	7.0	ENE	Holly Springs Academy NC	116 Quantum Dr	Holly Springs	122
F	7.3	ENE	Kris' Home Sweet Home Daycare	420 Cayman Ave	Holly Springs	8
F	7.3	E	Sisters' Child Care Services	400 Earp St	Holly Springs	12
F	7.4	ENE	Loving Hand Day Care	100 Orvis Dr	Holly Springs	8
F	7.5	ENE	Holly Springs School for Early Education	101 Arobor Creek Dr	Holly Springs	184
F	7.5	ENE	Little Dreamers Preschool	114 Hyannis Dr	Holly Springs	111
F	7.5	ENE	Kiddie Academy of Holly Springs	150 Rosewood Centre Dr	Holly Springs	199
F	7.7	E	The Goddard School of Holly Springs	801 Earp St	Holly Springs	147
F	7.7	ENE	Leaping Froggy	101 Malmedy Dr	Holly Springs	8
F	7.9	ENE	The Learning Experience - Holly Springs	801 Holly Springs Rd	Holly Springs	178
F	8.0	ENE	The Clubhouse of Holly Springs	10308 Holly Springs Rd	Holly Springs	75

Zone	Distance (miles)	Direc-tion	Facility Name	Street Address	Municipality	Enroll-ment
F	8.3	ENE	Holly Springs Learning Center	1180 Holly Springs Rd	Holly Springs	199
F	9.3	ENE	Sunrise United Methodist Church Preschool	5420 Sunset Lake Rd	Holly Springs	66
F	9.6	E	New School Montessori Center	5617 Sunset Lake Rd	Holly Springs	175
F	9.7	ENE	Stella Lowery Small Day Care Home	102 Oakland Dr	Apex	8
G	8.3	E	South Wake Preschool & Academy	2275 N Grassland Dr	Fuquay-Varina	65
G	8.4	ESE	My Lil Friends Childcare	1724 Balfour Downs Cir	Fuquay-Varina	8
G	8.6	E	Herbert Akins Road Elementary School	2255 Herbert Akins Rd	Fuquay-Varina	36
G	8.8	ESE	Lincoln Heights Elementary School	307 Bridge St	Fuquay-Varina	18
G	9.0	ESE	Vanessa Bland's Small Day Care Home	829 Alderleaf Dr	Fuquay-Varina	7
G	9.0	E	Melissa's Sweet Peas Child Care Home	335 Dogwood Creek Pl	Fuquay-Varina	8
G	9.0	ESE	Ready Or Not Here I Grow	201 Powhatan Dr	Fuquay-Varina	142
G	9.0	ESE	Childcare Network - Fuquay-Varina	350 W Jones St	Fuquay-Varina	163
G	9.3	E	A Mother's Love	524 Dogwood Creek Pl	Fuquay-Varina	5
G	9.3	ESE	Roots To Wings Childcare	110 N West St	Fuquay-Varina	8
G	9.4	ESE	Unique Creations Child Care Center	523 N Main St	Fuquay-Varina	30
G	9.5	ESE	Unique Creations Child Care Center South Campus	334 S Main St	Fuquay-Varina	25
G	9.6	ESE	Little Angels Preparatory	724 S Main St	Fuquay-Varina	49
G	9.6	ESE	Fuquay-Varina Baptist Wee Care	301 N Woodrow St	Fuquay-Varina	150
G	9.7	ESE	Fuquay-Varina UMC Preschool Seeds of Faith	100 S Judd Pkwy SE	Fuquay-Varina	180
G	10.0	ESE	Montessori Kids Universe - Fuquay Varina	1200 Galt Ave	Fuquay-Varina	99
G	10.2	ESE	Little Miracles	428 Barn View Ct	Fuquay-Varina	4
G	10.3	ESE	Busy Bee Home Daycare	736 Highwater Pl	Fuquay-Varina	8
					Wake County Subtotal:	*5,760*
					EPZ TOTAL:	**5,785**

Table E-3. Medical Facilities within the Study Area

Zone	Distance (miles)	Direc-tion	Facility Name	Street Address	Municipality	Capa-city	Current Census	Ambula-tory Patients	Wheel-chair Patients	Bed-ridden Patients
HARNETT COUNTY										
S.R.[2]	10.2	SE	Senter's Memory Care	40 Rawls Club Rd	Fuquay-Varina	50	50	33	14	3
					Harnett County Subtotal:	*50*	*50*	*33*	*14*	*3*
LEE COUNTY										
J	10.4	WSW	Sanford Health & Rehab	2702 Farrell Rd	Sanford	131	96	31	63	2
					Lee County Subtotal:	*131*	*96*	*31*	*63*	*2*
WAKE COUNTY										
A	2.3	NE	James Rest Home	8420 James Rest Home Rd	New Hill	40	38	28	10	0
A	2.4	NE	Brown's Family Care Home	8416 James Rest Home Rd	New Hill	6	6	6	0	0
C	4.7	E	Murchison Residential Corp Home	533 Texanna Way	Holly Springs	3	3	3	0	0
C	6.5	E	Trotter's Bluff	912 Avent Ferry Rd	Holly Springs	6	6	6	0	0
C	6.5	E	Avent Ferry Home	904 Avent Ferry Rd	Holly Springs	6	6	6	0	0
E	7.4	NE	Seagraves Family Care Home	1052 Irongate Dr	Apex	6	4	4	0	0
E	7.6	NNE	Kings Group Home for Children	109 Evening Star Dr	Apex	6	6	6	0	0
E	8.0	ENE	Aplha Home Care Service	202 Lindell Dr	Apex	6	6	6	0	0
E	8.4	NE	Brookridge Assisted Living	312 Lynch St	Apex	55	52	40	12	0
E	8.4	NE	Rex Rehab & Nursing Center of Apex	911 S Hughes St	Apex	107	90	20	40	30
E	8.7	NE	Spring Arbor of Apex	901 Spring Arbor Ct	Apex	76	66	47	19	0
E	9.0	NE	VOCA Olive Home	707 Olive St	Apex	6	6	6	0	0
E	9.1	NE	Mason Street Group Home	306 N Mason St	Apex	6	6	6	0	0
E	9.2	ENE	Lockley Road Home	4617 Lockley Rd	Holly Springs	6	6	6	0	0
F	6.6	E	Country Lane Group Home	534 Country Ln	Holly Springs	6	6	6	0	0
F	6.9	E	Rex Holly Springs Hospital	850 S Main St	Holly Springs	50	50	33	14	3
F	7.0	E	Hickory Avenue Home	112 Hickory Ave	Holly Springs	6	6	6	0	0
F	7.8	E	Bass Lake Home	408 Bass Lake Rd	Holly Springs	6	6	6	0	0
F	8.5	ENE	Herbert Reid Home	3733 Heritage Meadows Ln	Holly Springs	4	4	4	0	0
F	8.6	ENE	St. Mark's Manor	3735 Heritage Meadows Ln	Holly Springs	9	9	9	0	0

[2] As per county plan this facility evacuates due to its close proximity to the EPZ boundary.

Zone	Distance (miles)	Direc-tion	Facility Name	Street Address	Municipality	Capa-city	Current Census	Ambula-tory Patients	Wheel-chair Patients	Bed-ridden Patients
G	6.9	SE	Mim's Family Care Home	6337 Mims Rd	Holly Springs	6	2	2	0	0
G	9.0	ESE	Windsor Point Continuing Care Retirement Community	1221 Broad St	Fuquay-Varina	100	100	66	28	6
G	9.3	ESE	Avendelle Assisted Living at Southern Oaks	605 Lawson Cypress Ln #2536	Fuquay-Varina	6	6	4	2	0
G	9.4	ESE	Kinton Court Home	301 Sunset Dr	Fuquay-Varina	16	16	16	0	0
G	9.5	E	Evans-Walston Home	808 Hawks View Ct	Fuquay-Varina	3	3	3	0	0
G	9.8	E	Hope House	821 Brookhannah Ct	Fuquay-Varina	4	4	4	0	0
G	9.8	ESE	Fuquay-Varina Homes-Elderly	1012 S Main St	Fuquay-Varina	80	62	60	2	0
G	9.9	ESE	Life Skills Independent Care #1	800 Perry Howard Rd	Fuquay-Varina	4	4	4	0	0
G	10.2	ESE	VOCA-Creekway	424 Creekway Dr	Fuquay-Varina	6	6	6	0	0
					Wake County Subtotal:	*641*	*585*	*419*	*127*	*39*
					EPZ TOTAL:	**822**	**731**	**483**	**204**	**44**

Table E-4. Major Employers within the EPZ

Zone	Distance (miles)	Direc-tion	Facility Name	Street Address	Municipality	Employees (Max Shift)	Employees Commuting into the EPZ	Employee Vehicles Commuting into the EPZ
CHATHAM COUNTY								
			Various locations throughout the EPZ			300	236	215
					Chatham County Subtotal:	*300*	*236*	*215*
WAKE COUNTY								
			Various locations throughout the EPZ			11,606	9,118	8,289
					Wake County Subtotal:	*11,606*	*9,118*	*8,289*
					EPZ TOTAL[3]:	**11,906**	**9,354**	**8,504**

[3] The major employer locations identified by the Census Bureau are shown in Figure E-6. The locations are represented by circles which increase in size proportional to the number of employees commuting into the EPZ in each Census Block. Note the data indicates there are no major employers in Harnett County or Lee County.

Table E-5. Campgrounds within the EPZ

Zone	Distance (miles)	Direc-tion	Facility Name	Street Address	Municipality	Transients	Vehicles
CHATHAM COUNTY							
K	5.0	SW	Dickens RV Park	2501 Corinth Rd	Moncure	216	108
L	6.2	WNW	New Hope Overlook Campground (Jordan Lake)	339 W H Jones Rd	New Hill	338	84
M	6.9	W	Jordan Dam RV Park & Campground	284 Moncure School Rd	Moncure	44	44
M	6.9	W	Cotten's RV Campground	390 Cotten Acres	Moncure	25	25
M	7.3	NW	Vista Point Campground (Jordan Lake)	3199 N Pea Ridge Rd	Pittsboro	420	105
N	6.7	NNW	Poplar Point Campground (Jordan Lake)	558 Beaver Creek Rd	Apex	1,302	543
N	7.9	NNW	Crosswinds Campground and Marina (Jordan Lake)	389 Farrington Rd	Apex	965	241
N	9.6	NNW	Parker's Creek Campground (Jordan Lake)	Parkers Creek Recreation Rd	Pittsboro	750	188
					Chatham County Subtotal:	*4,060*	*1,338*
HARNETT COUNTY							
H	8.0	S	Camp Agape	1369 Tyler Dewar Ln	Fuquay-Varina	120	70
					Harnett County Subtotal:	*120*	*70*
					EPZ TOTAL:	**4,180**	**1,408**

Table E-6. Parks and Community Centers within the EPZ

Zone	Distance (miles)	Direc-tion	Facility Name	Street Address	Municipality	Transients	Vehicles
CHATHAM COUNTY							
K	4.2	SSW	Harris Lake Boat Launch (Chatham County)	384 Cross Point Rd	New Hill	224	102
M	6.6	WNW	Visitor's Center (Jordan Lake Dam - COE)	2080 Jordan Dam Rd	Moncure	100	35
M	7.3	W	Poe's Ridge Recreation Area (Jordan Lake)	935 Jordan Dam Rd	Moncure	94	62
M	7.7	NW	Seaforth Recreation Area (Jordan Lake)	US Highway 64	NC State Parks	1,334	334
M	9.6	NW	Robeson Creek Recreation Area (Jordan Lake)	Hanks Chapel Rd	NC State Parks	389	97
N	5.4	NW	Beaver Creek Public Fishing Area	3189 State Rd 1008	New Hill	50	18
N	6.3	NW	Ebenezer Church Day Use Area (Jordan Lake)	Ebenezer Rd	NC State Parks	1,127	282
N	7.6	NNW	Visitor's Center (Jordan Lake - State Parks)	280 State Park Rd	Apex	150	53
N	8.0	NNW	White Oak Recreation Area (Jordan Lake)	US Highway 64	NC State Parks	393	98
					Chatham County Subtotal:	*3,861*	*1,081*
HARNETT COUNTY							
H	5.6	SSE	Kidds Place Sporting Clay/Pistol Range	8753 NC-42	Holly Springs	15	5
H	11.0	S	Raven Rock State Park[4]	309 Raven Rock Rd	Lillington	863	315
					Harnett County Subtotal:	*878*	*320*
WAKE COUNTY							
A	2.0	E	Harris Lake County Park	2112 County Park Dr	New Hill	401	182
B	5.1	NNE	Goldstar Soccer Complex	2513 Old US Hwy 1	Wake County	289	131
D	2.0	SSE	Harris Lake Boat Launch	4420 Bartley Holleman Rd	New Hill	224	102
E	5.6	N	American Tobacco Trail	1309 New Hill-Olive Chapel Rd	Apex	498	226
E	7.5	NNE	Kelly Glen Park	1701 Kelly Glen Dr	Apex	2	1
E	7.6	NNE	Kelly Road Park	1609 Kelly Rd	Apex	16	7
E	8.2	NE	Apex Elementary School Park	700 Tingen Rd	Apex	6	3
E	8.5	NE	Jaycee Park	451 NC Hwy 55	Apex	13	6
E	8.5	NE	Sue Helton Park	Matney Ln	Apex	2	1
E	8.5	NE	West Street Park	108 West St	Apex	2	1
E	9.1	NE	Halle Cultural Arts Center	237 N Salem St	Apex	32	15
E	9.1	NE	Claremont Park	801 East Chatham St	Apex	2	1
E	9.3	NE	Apex Community Center	53 Hunter St	Apex	26	12
F	6.8	E	Holly Springs Library & Cultural Center	300 W Ballentine St	Holly Springs	32	15

[4] Only a portion of the park resides in the EPZ, however, the entire facility evacuates as a precautionary measure.

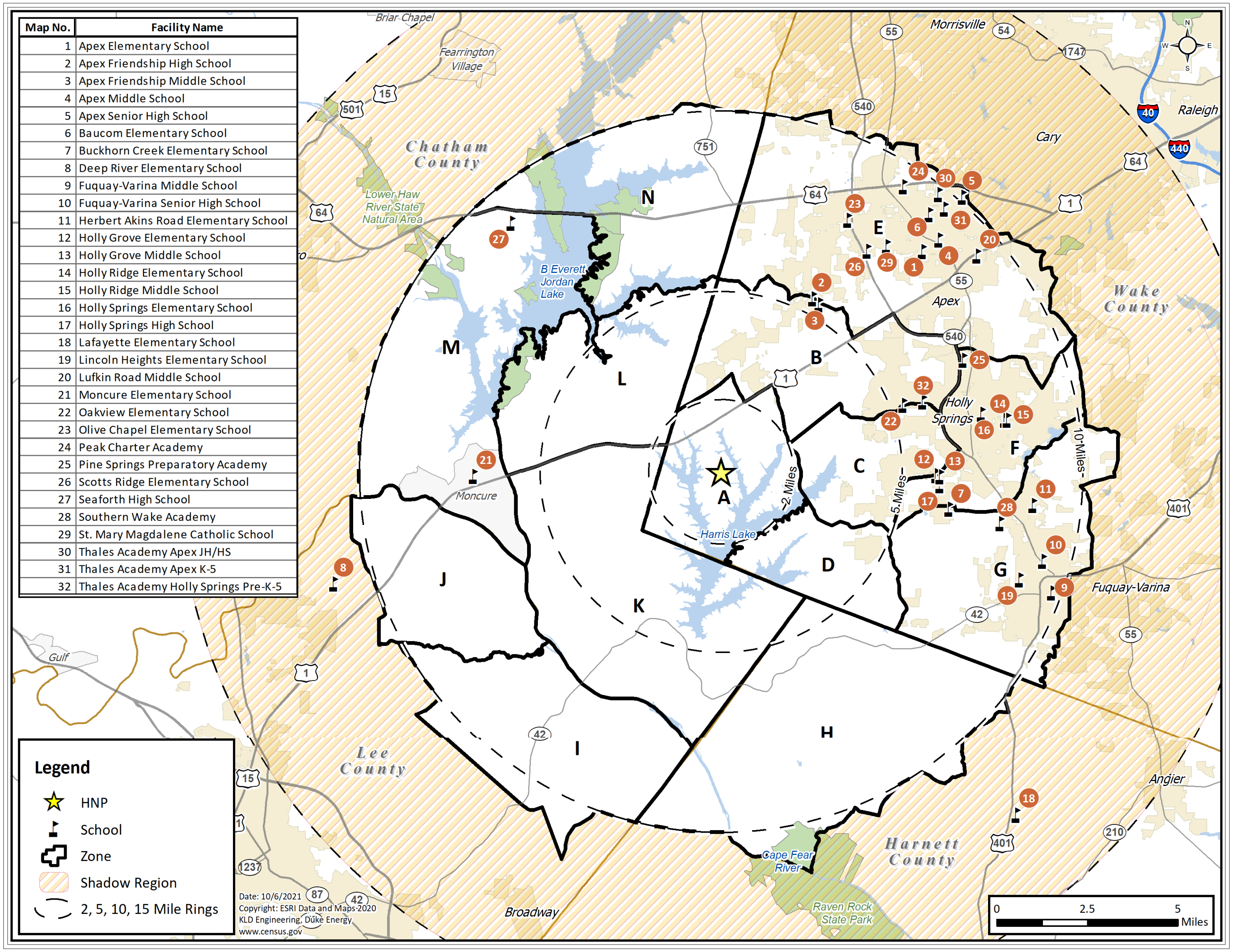
Zone	Distance (miles)	Direc-tion	Facility Name	Street Address	Municipality	Transients	Vehicles
F	7.1	ENE	Ting Park	101 Sportsmanship Way	Holly Springs	1,875	658
F	7.1	ENE	Holly Springs Salamanders	101 Tennis Ct	Holly Springs	678	238
F	7.2	E	W.E. Hunt Community Center & Gym	301 Stinson Ave	Holly Springs	35	15
F	7.3	ENE	Jones Memorial Park	405 School Days Ln	Holly Springs	6	3
F	7.3	E	Parrish Womble Park	1201 Grigsby Ave	Holly Springs	240	109
F	7.5	ENE	Veterans Park	600 Bikram Dr	Holly Springs	2	1
F	8.6	E	Bass Lake Park & Retreat Center	900 Bass Lake Rd	Holly Springs	10	4
G	8.6	E	Herbert Akins School Park	2255 Herbert Akins Rd	Fuquay-Varina	9	4
G	8.6	ESE	Fleming Loop Soccer Complex	301 Fleming Loop Rd	Fuquay-Varina	32	15
G	8.9	ESE	Pine Acres Community Center & Park	402 Mclean St	Fuquay-Varina	4	2
G	9.2	ESE	Action Park	609 Wake Chapel Rd	Fuquay-Varina	296	135
G	9.5	ESE	Kinton Soccer Field	300 W Ransom St	Fuquay-Varina	16	7
G	9.5	ESE	Fuquay Mineral Spring Park	105 Spring St	Fuquay-Varina	2	1
G	9.6	ESE	Library Park	116 South Aiken St	Fuquay-Varina	6	2
G	9.6	ESE	South Park	900 S Main St	Fuquay-Varina	401	182
G	9.6	ESE	Carroll Howard Johnson EE Park	301 Wagstaff Rd	Fuquay-Varina	11	5
G	9.9	ESE	Falcon Park	611 E Academy St	Fuquay-Varina	32	15
					Wake County Subtotal:	*5,200*	*2,099*
					EPZ TOTAL:	**9,939**	**3,500**

Table E-7. Golf Courses within the EPZ

Zone	Distance (miles)	Direc-tion	Facility Name	Street Address	Municipality	Transients	Vehicles
WAKE COUNTY							
B	5.1	ENE	12 Oaks	2008 Green Oaks Pkwy	Holly Springs	70	30
E	9.8	NE	Knights Play Golf Center	2512 Ten-Ten Rd	Apex	288	200
F	8.6	E	Devils Ridge Golf Club	5107 Linksland Dr	Holly Springs	262	180
					Wake County Subtotal:	*620*	*410*
					EPZ TOTAL:	**620**	**410**

Table E-8. Lodging Facilities within the EPZ

Zone	Distance (miles)	Direc-tion	Facility Name	Street Address	Municipality	Transients	Vehicles
WAKE COUNTY							
E	8.5	NE	Quality Inn & Suites Apex/Raleigh NC	1400 E Williams St	Apex	60	52
E	8.6	NE	Comfort Inn Apex	1411 E Williams St	Apex	64	56
E	8.6	NE	Holiday Inn Express	1006 Marco Dr	Apex	26	23
E	8.7	NE	Candlewood Suites	1005 Marco Dr	Apex	76	66
E	8.8	NE	WoodSpring Suites Raleigh Apex	901 Lufkin Road	Apex	113	99
E	8.8	NE	SpringHill Suites Raleigh Apex	1100 Marco Dr	Apex	268	94
E	8.8	NNE	B & B Country Garden Inn	1041 Kelly Rd	Apex	4	2
F	6.7	E	Hampton Inn & Suites Holly Springs	1050 S Main St	Holly Springs	116	101
G	9.5	ESE	Fuquay Mineral Spring Inn and Garden B & B	330 South Main St	Fuquay-Varina	4	2
G	9.8	ESE	Chateau Bellevie	1605 South Main St	Fuquay-Varina	3	1
					Wake County Subtotal:	*734*	*496*
					EPZ TOTAL:	**734**	**496**



Map No.	Facility Name
1	Apex Elementary School
2	Apex Friendship High School
3	Apex Friendship Middle School
4	Apex Middle School
5	Apex Senior High School
6	Baucom Elementary School
7	Buckhorn Creek Elementary School
8	Deep River Elementary School
9	Fuquay-Varina Middle School
10	Fuquay-Varina Senior High School
11	Herbert Akins Road Elementary School
12	Holly Grove Elementary School
13	Holly Grove Middle School
14	Holly Ridge Elementary School
15	Holly Ridge Middle School
16	Holly Springs Elementary School
17	Holly Springs High School
18	Lafayette Elementary School
19	Lincoln Heights Elementary School
20	Lufkin Road Middle School
21	Moncure Elementary School
22	Oakview Elementary School
23	Olive Chapel Elementary School
24	Peak Charter Academy
25	Pine Springs Preparatory Academy
26	Scotts Ridge Elementary School
27	Seaforth High School
28	Southern Wake Academy
29	St. Mary Magdalene Catholic School
30	Thales Academy Apex JH/HS
31	Thales Academy Apex K-5
32	Thales Academy Holly Springs Pre-K-5

Figure E-1. Schools within the EPZ

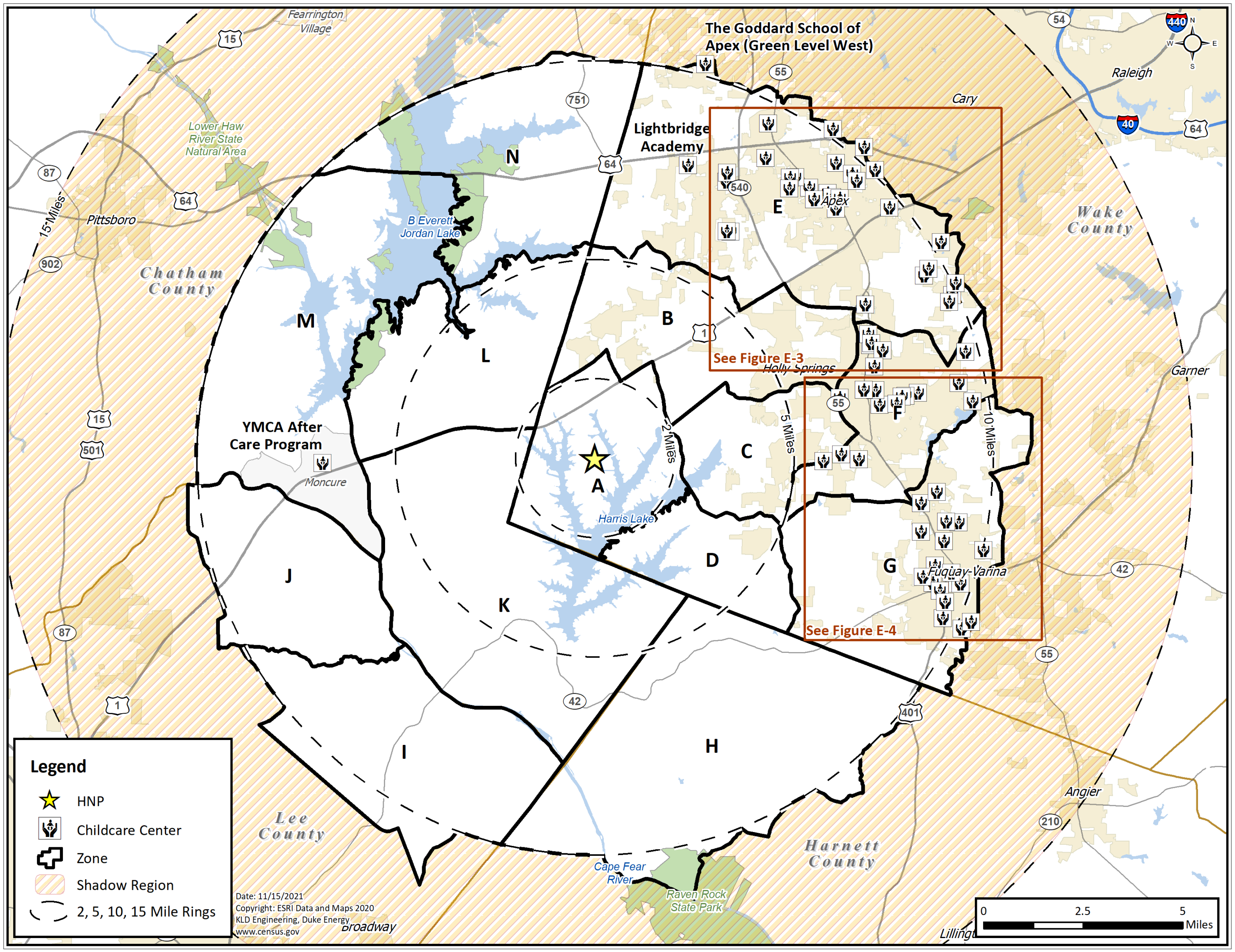
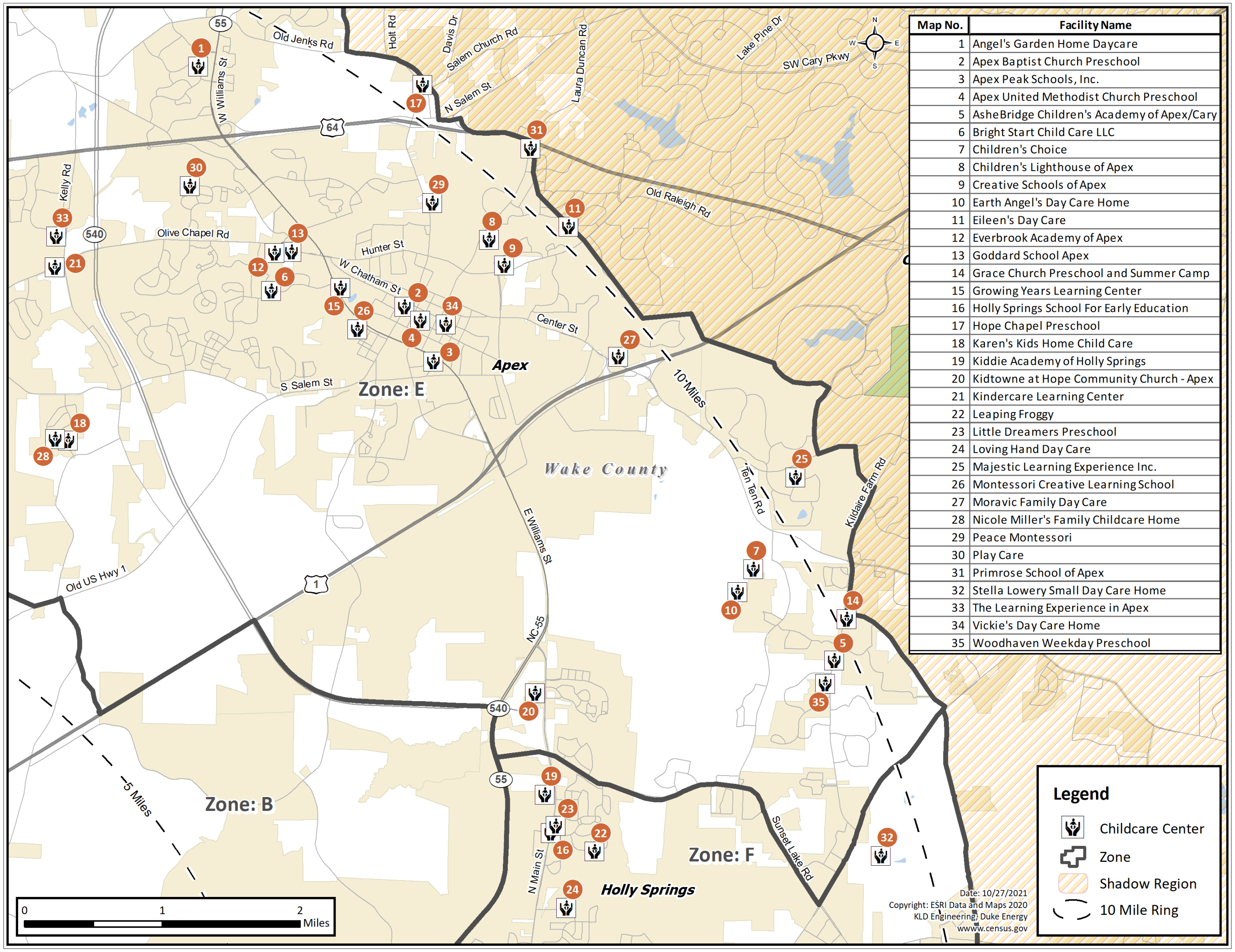
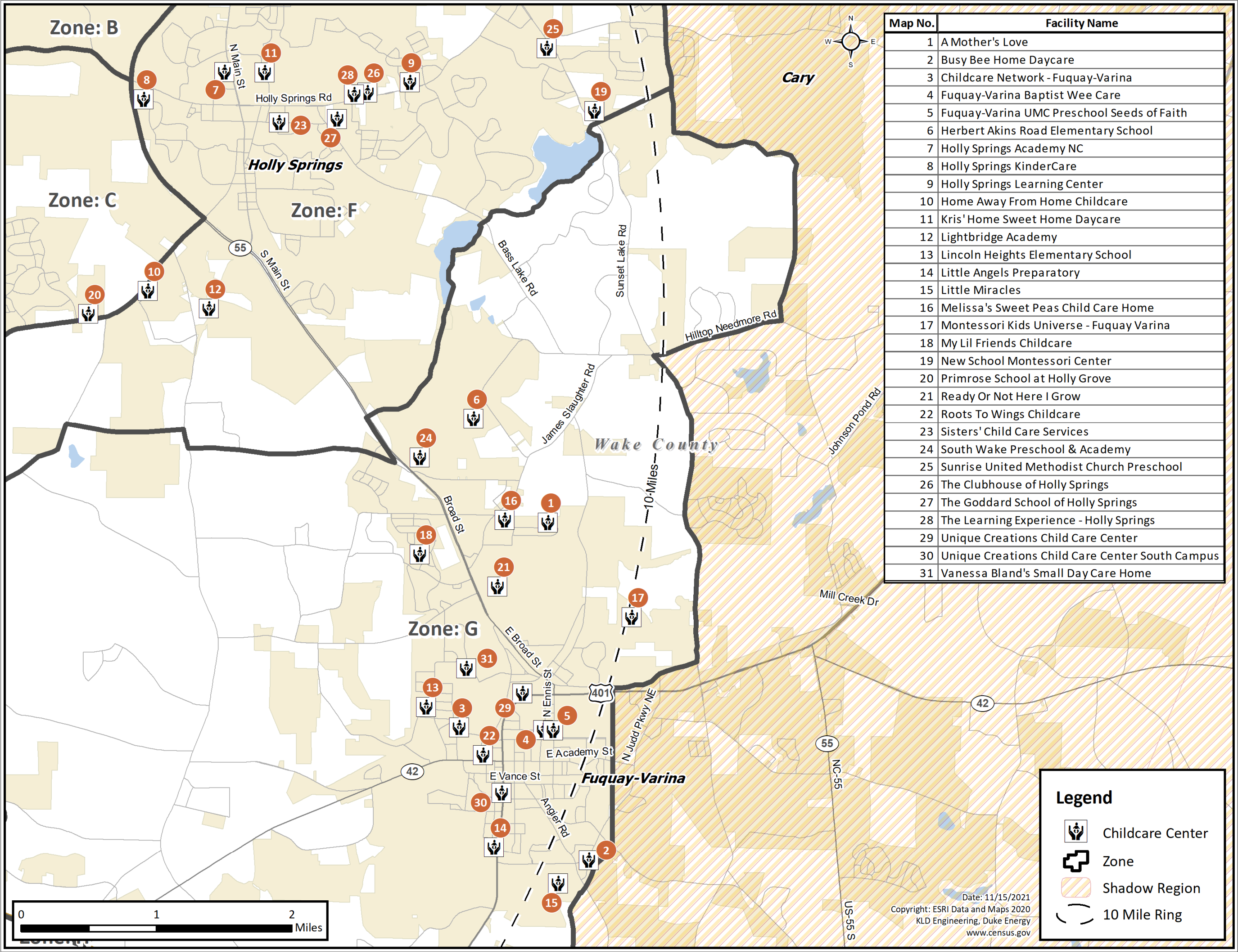


Figure E-2. Overview of Childcare Centers within the EPZ



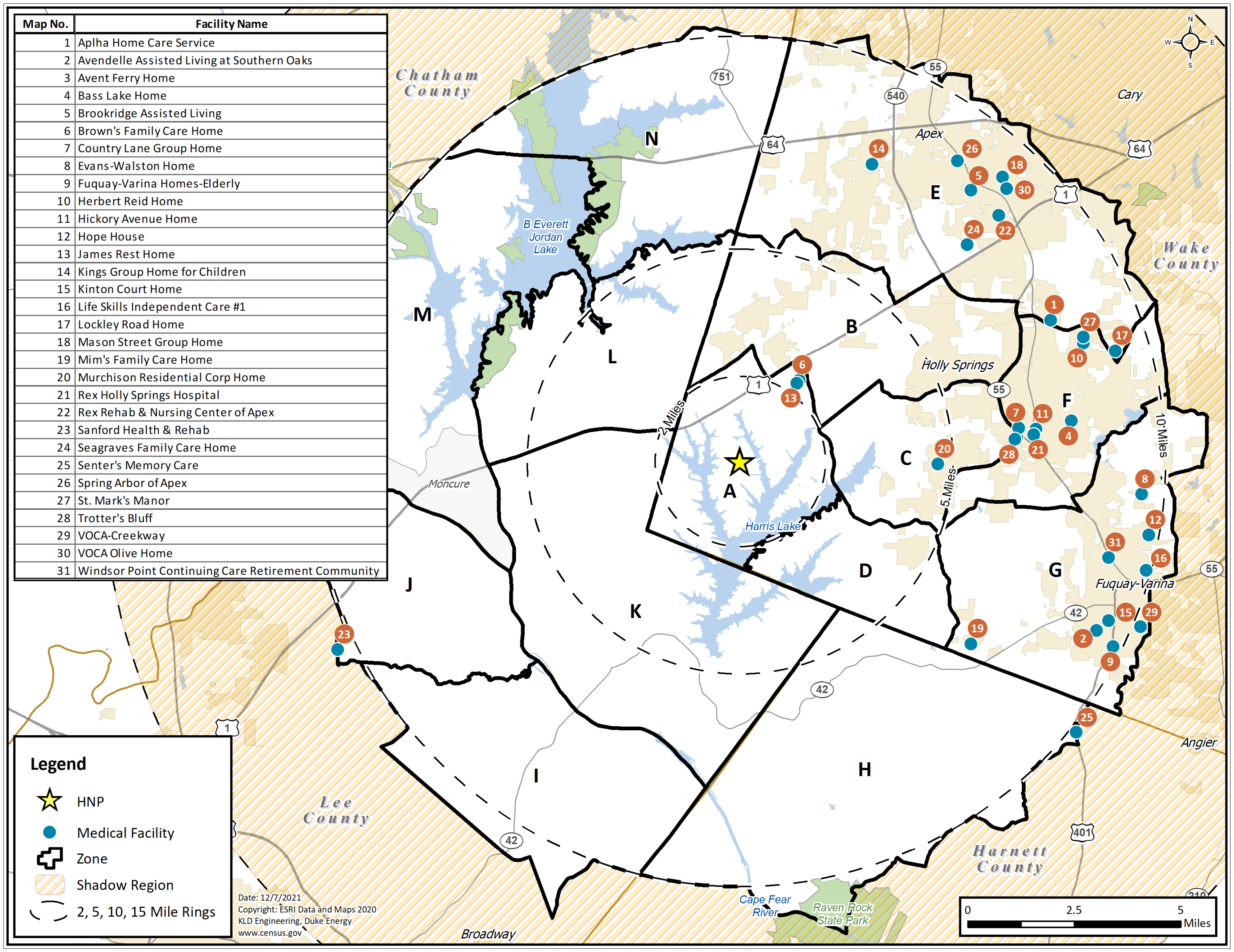
Map No.	Facility Name
1	Angel's Garden Home Daycare
2	Apex Baptist Church Preschool
3	Apex Peak Schools, Inc.
4	Apex United Methodist Church Preschool
5	AsheBridge Children's Academy of Apex/Cary
6	Bright Start Child Care LLC
7	Children's Choice
8	Children's Lighthouse of Apex
9	Creative Schools of Apex
10	Earth Angel's Day Care Home
11	Eileen's Day Care
12	Everbrook Academy of Apex
13	Goddard School Apex
14	Grace Church Preschool and Summer Camp
15	Growing Years Learning Center
16	Holly Springs School For Early Education
17	Hope Chapel Preschool
18	Karen's Kids Home Child Care
19	Kiddie Academy of Holly Springs
20	Kidtowne at Hope Community Church - Apex
21	Kindercare Learning Center
22	Leaping Froggy
23	Little Dreamers Preschool
24	Loving Hand Day Care
25	Majestic Learning Experience Inc.
26	Montessori Creative Learning School
27	Moravic Family Day Care
28	Nicole Miller's Family Childcare Home
29	Peace Montessori
30	Play Care
31	Primrose School of Apex
32	Stella Lowery Small Day Care Home
33	The Learning Experience in Apex
34	Vickie's Day Care Home
35	Woodhaven Weekday Preschool

Figure E-3. Childcare Centers within Zones E and F



Map No.	Facility Name
1	A Mother's Love
2	Busy Bee Home Daycare
3	Childcare Network - Fuquay-Varina
4	Fuquay-Varina Baptist Wee Care
5	Fuquay-Varina UMC Preschool Seeds of Faith
6	Herbert Akins Road Elementary School
7	Holly Springs Academy NC
8	Holly Springs KinderCare
9	Holly Springs Learning Center
10	Home Away From Home Childcare
11	Kris' Home Sweet Home Daycare
12	Lightbridge Academy
13	Lincoln Heights Elementary School
14	Little Angels Preparatory
15	Little Miracles
16	Melissa's Sweet Peas Child Care Home
17	Montessori Kids Universe - Fuquay Varina
18	My Lil Friends Childcare
19	New School Montessori Center
20	Primrose School at Holly Grove
21	Ready Or Not Here I Grow
22	Roots To Wings Childcare
23	Sisters' Child Care Services
24	South Wake Preschool & Academy
25	Sunrise United Methodist Church Preschool
26	The Clubhouse of Holly Springs
27	The Goddard School of Holly Springs
28	The Learning Experience - Holly Springs
29	Unique Creations Child Care Center
30	Unique Creations Child Care Center South Campus
31	Vanessa Bland's Small Day Care Home

Figure E-4. Childcare Centers within Zones C, F and G



Map No.	Facility Name
1	Aplha Home Care Service
2	Avendelle Assisted Living at Southern Oaks
3	Avent Ferry Home
4	Bass Lake Home
5	Brookridge Assisted Living
6	Brown's Family Care Home
7	Country Lane Group Home
8	Evans-Walston Home
9	Fuquay-Varina Homes-Elderly
10	Herbert Reid Home
11	Hickory Avenue Home
12	Hope House
13	James Rest Home
14	Kings Group Home for Children
15	Kinton Court Home
16	Life Skills Independent Care #1
17	Lockley Road Home
18	Mason Street Group Home
19	Mim's Family Care Home
20	Murchison Residential Corp Home
21	Rex Holly Springs Hospital
22	Rex Rehab & Nursing Center of Apex
23	Sanford Health & Rehab
24	Seagraves Family Care Home
25	Senter's Memory Care
26	Spring Arbor of Apex
27	St. Mark's Manor
28	Trotter's Bluff
29	VOCA-Creekway
30	VOCA Olive Home
31	Windsor Point Continuing Care Retirement Community

Figure E-5. Medical Facilities within the EPZ

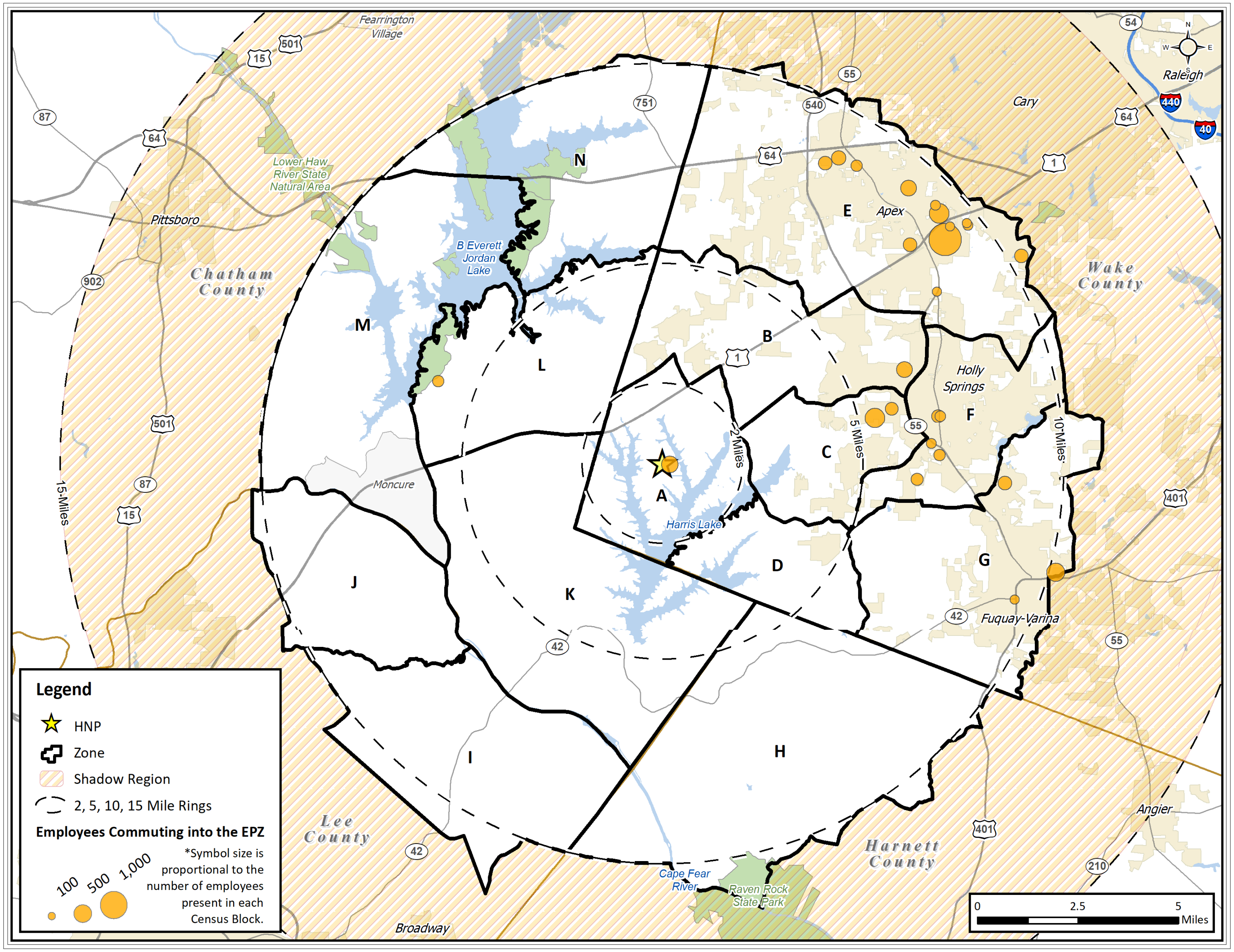


Figure E-6. Major Employers within the EPZ

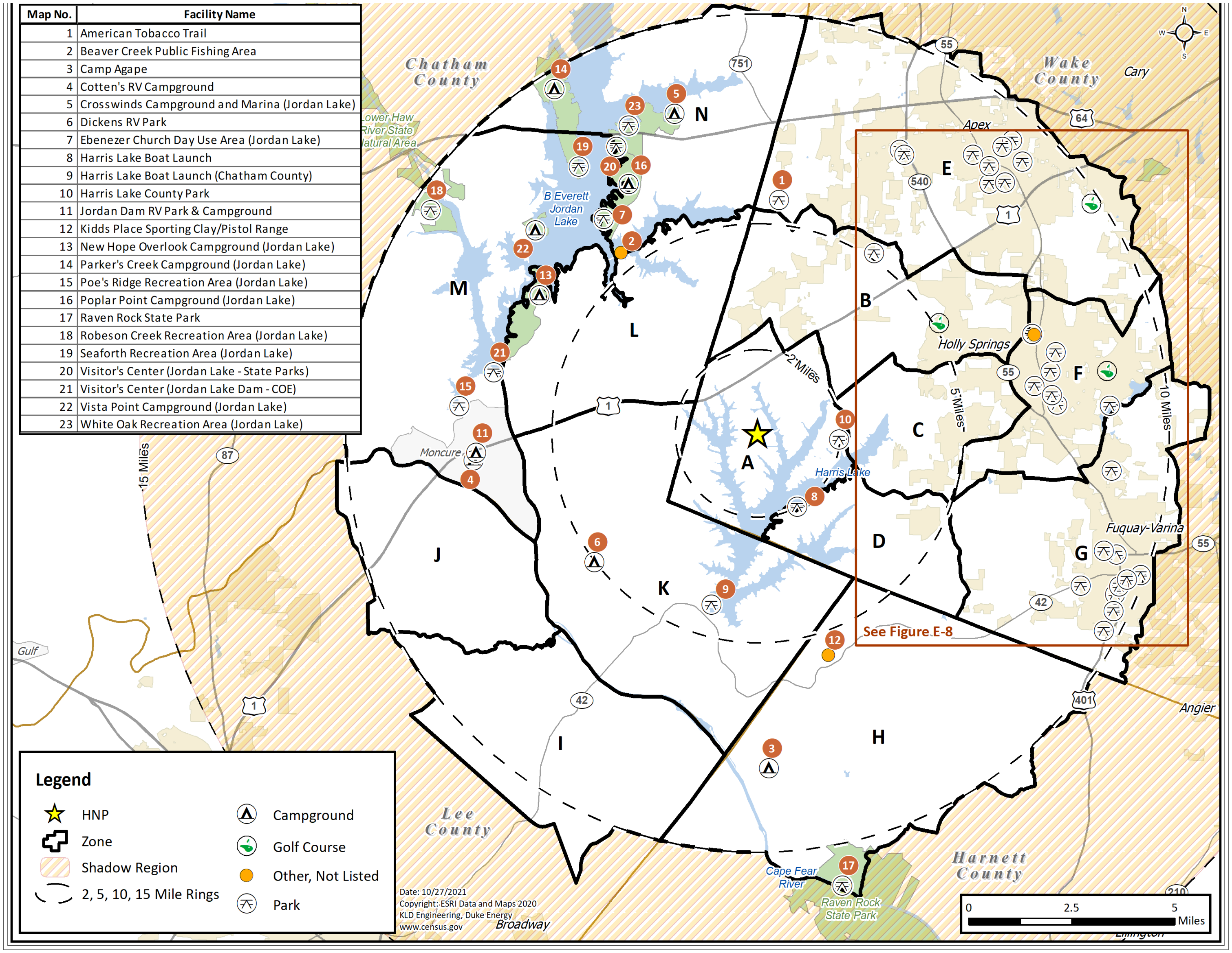
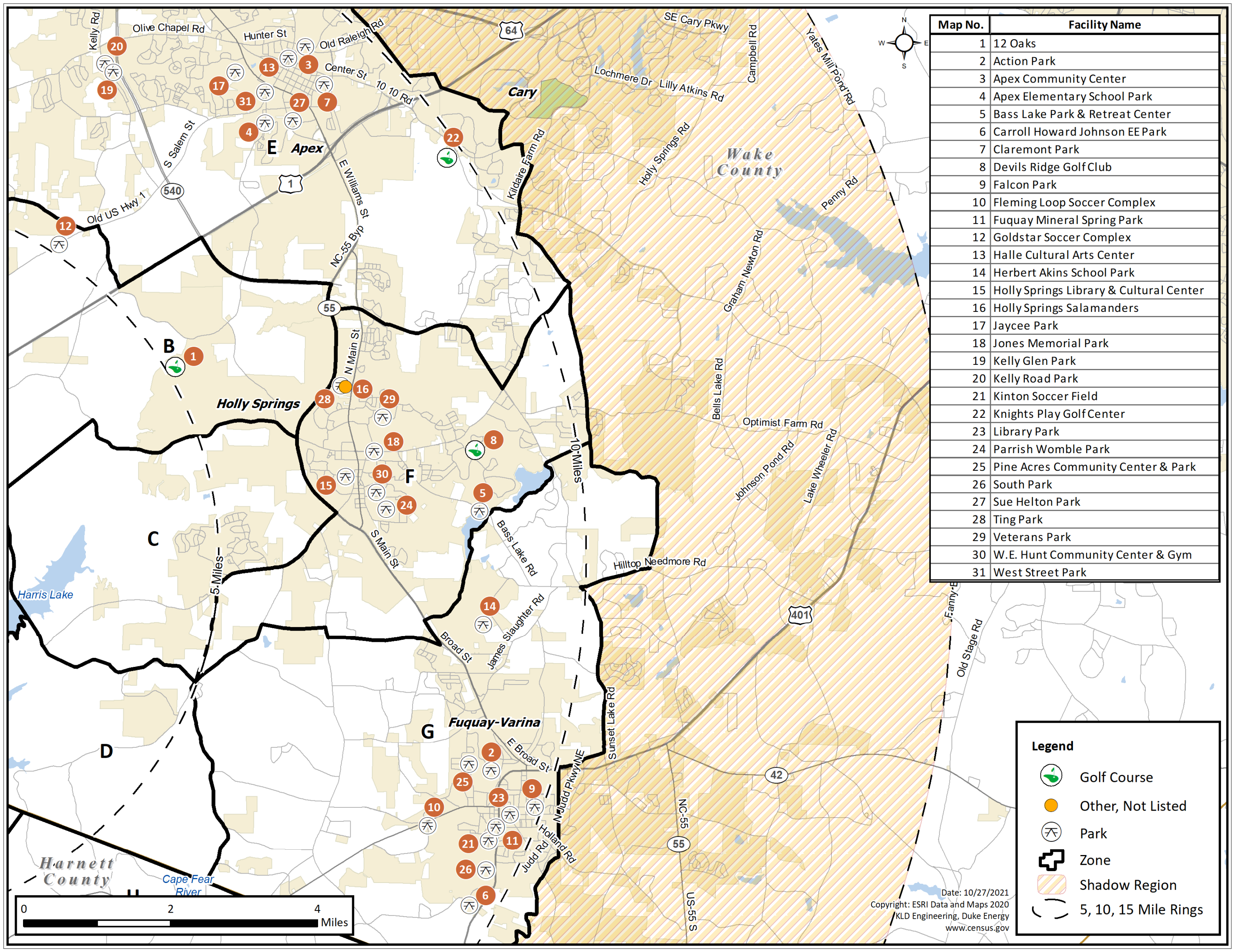


Figure E-7. Recreational Areas within the EPZ



Map No.	Facility Name
1	12 Oaks
2	Action Park
3	Apex Community Center
4	Apex Elementary School Park
5	Bass Lake Park & Retreat Center
6	Carroll Howard Johnson EE Park
7	Claremont Park
8	Devils Ridge Golf Club
9	Falcon Park
10	Fleming Loop Soccer Complex
11	Fuquay Mineral Spring Park
12	Goldstar Soccer Complex
13	Halle Cultural Arts Center
14	Herbert Akins School Park
15	Holly Springs Library & Cultural Center
16	Holly Springs Salamanders
17	Jaycee Park
18	Jones Memorial Park
19	Kelly Glen Park
20	Kelly Road Park
21	Kinton Soccer Field
22	Knights Play Golf Center
23	Library Park
24	Parrish Womble Park
25	Pine Acres Community Center & Park
26	South Park
27	Sue Helton Park
28	Ting Park
29	Veterans Park
30	W.E. Hunt Community Center & Gym
31	West Street Park

Figure E-8. Recreational Areas within Zones B, E, F and G

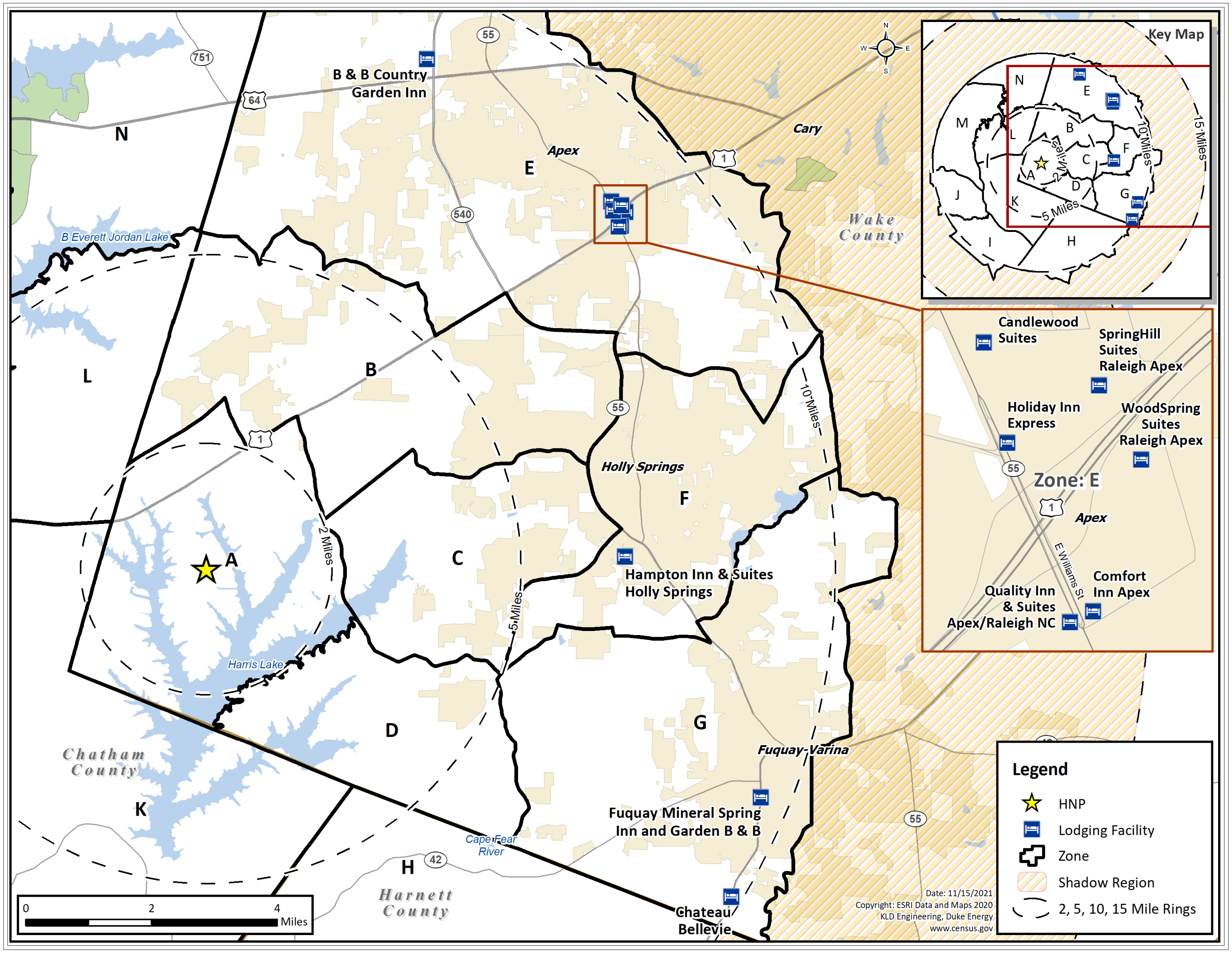


Figure E-9. Lodging Facilities within the EPZ

APPENDIX F

Demographic Survey

F. DEMOGRAPHIC SURVEY

F.1 Introduction

The development of evacuation time estimates for the HNP EPZ requires the identification of travel patterns, car ownership and household size of the population within the EPZ. Demographic information can be obtained from Census data. The use of this data has several limitations when applied to emergency planning. First, the Census data do not encompass the range of information needed to identify the time required for preliminary activities (mobilization) that must be undertaken prior to evacuating the area. Secondly, Census data do not contain attitudinal responses needed from the population of the EPZ and consequently may not accurately represent the anticipated behavioral characteristics of the evacuating populace.

These concerns are addressed by conducting a demographic survey of a representative sample of the EPZ population. The survey is designed to elicit information from the public concerning family demographics and estimates of response times to well defined events. The design of the survey includes a limited number of questions of the form "What would you do if …?" and other questions regarding activities with which the respondent is familiar ("How long does it take you to …?")

F.2 Survey Instrument and Sampling Plan

Attachment A presents the final survey instrument used for the demographic survey. A draft of the instrument was submitted to stakeholders for comment. Comments were received and the survey instrument was modified accordingly, prior to conducting the survey.

Following the completion of the instrument, a sampling plan was developed. Since the demographic survey discussed herein was performed in 2020 and the 2020 Census data had not been released, 2010 Census data was used to develop the sampling plan.

A sample size of approximately 470 **completed** survey forms yields results with a sampling error of ±4.5% at the 95% confidence level. The sample must be drawn from the EPZ population. Consequently, a list of zip codes in the EPZ was developed using GIS software. This list is shown in Table F-1. Along with each zip code, an estimate of the population and number of households in each area was determined by overlaying Census data and the EPZ boundary, again using GIS software. The proportional number of desired completed survey interviews for each area was identified, as shown in Table F-1. Note that the average household size computed in Table F-1 was an estimate for sampling purposes and was not used in the ETE study.

The results of the survey exceeded the sampling plan. A total of 1,235 completed samples were obtained corresponding to a sampling error of ±2.7% at the 95% confidence level based on the 2010 Census data. Table F-1 also shows the number of samples obtained within each zip code.

F.3 Survey Results

The results of the survey fall into two categories. First, the household demographics of the area can be identified. Demographic information includes such factors as household size, automobile ownership, and automobile availability. The distributions of the time to perform certain pre-

evacuation activities are the second category of survey results. These data are processed to develop the trip generation distributions used in the evacuation modeling effort, as discussed in Section 5.

A review of the survey instrument reveals that several questions have a "decline to state" entry for a response. It is accepted practice in conducting surveys of this type to accept the answers of a respondent who offers a decline to state response for a few questions or who refuses to answer a few questions. To address the issue of occasional decline to state responses from a large sample, the practice is to assume that the distribution of these responses is the same as the underlying distribution of the positive responses. In effect, the decline to state responses are ignored and the distributions are based upon the positive data that is acquired.

F.3.1 Household Demographic Results

Household Size

Figure F-1 presents the distribution of household size within the EPZ based on the responses to the demographic survey. The average household contains 3.11 people. The estimated household size from the 2020 Census data is 2.85 people. The difference between the Census data and survey data is 8.3%, which exceeds the sampling error of 4.4%. This issue was discussed with Duke Energy and it was decided that the U.S. Census estimate of 2.85 people per household should be used for this study. This results in a more conservative estimate when determining the number of households and evacuating vehicles.

Automobile Ownership

The average number of automobiles available per household in the EPZ is 2.2. It should be noted that all households in the EPZ have access to an automobile according to the demographic survey. The distribution of automobile ownership is presented in Figure F-2. Figure F-3 and Figure F-4 present the automobile availability by household size.

Ridesharing

Two thirds (66%) of the households surveyed responded that they would share a ride with a neighbor, relative, or friend if a car was not available to them when advised to evacuate in the event of an emergency. Figure F-5 presents this response.

Commuters

Figure F-6 presents the distribution of the number of commuters in each household. Commuters are defined as household members who travel to work or college on a daily basis. The data shows an average of 0.88 commuters in each household in the EPZ, and 55% of households have at least one commuter.

Commuter Travel Modes

Figure F-7 presents the mode of travel that commuters use on a daily basis. The vast majority of commuters use their private automobiles to travel to work or college. The data shows an average of 1.10 commuters per vehicle, assuming 2 people per vehicle – on average – for carpools.

Impact of COVID-19 on Commuters

Figure F-8 presents the distribution of the number of commuters in each household that were temporarily impacted by the COVID-19 pandemic. Sixty-four percent of households indicated someone in their household had a work and/or school commute that was temporarily impacted by the COVID-19 pandemic.

Functional or Transportation Needs

Figure F-9 presents the distribution of the number of individuals with functional or transportation need. The data shows that approximately 6.5 percent of households have functional or transportation needs. Of those with functional or transportation needs, 63% require a bus, 14% require a medical bus/van, 12% require a wheelchair accessible van, and 11% require an ambulance.

F.3.2 Evacuation Response

Several questions were asked to gauge the population's response to an emergency. These are now discussed:

"How many of the vehicles would your household use during an evacuation?" The response is shown in Figure F-10. On average, evacuating households would use 1.40 vehicles.

"Would your family await the return of other family members prior to evacuating the area?" Of the survey participants who responded, 57 percent said they would await the return of other family members before evacuating and 43 percent indicated that they would not await the return of other family members, as shown in Figure **F**-**11**.

"If you had a household pet, would you take your pet with you if you were asked to evacuate the area?" Based on responses from the survey, 67 percent of households have a family pet. Of the households with pets, 22 percent indicated that they would take their pets with them to a shelter, 76 percent indicated that they would take their pets somewhere else and only 2 percent would leave their pet at home, as shown in Figure F-12. Of the households that would evacuate with their pets, 97 percent indicated that they have sufficient room in their vehicle to evacuate with their pet(s)/animal(s).

"What type of pet(s) and/or animal(s) do you have?" Based on responses from the survey, 90 percent of households have a household pet (dog, cat, bird, reptile, or fish), 6% of households have farm animals (horse, chicken, goat, pig, etc.), and 4 percent have other small pets/animals.

"Emergency officials advise you to take shelter at home in an emergency. Would you?" This question is designed to elicit information regarding compliance with instructions to shelter in place. The results indicate that 74 percent of households who are advised to shelter in place would do so; the remaining 26 percent would choose to evacuate the area. Note the baseline ETE study assumes 20 percent of households will not comply with the shelter advisory, as per Section 2.5.2 of NUREG/CR-7002, Rev. 1. Thus, the data obtained above is slightly higher than the federal guidance. A sensitivity study was conducted to estimate the impact of shadow evacuation non-compliance of shelter advisory on ETE – see Table M-2 in Appendix M.

"Emergency officials advise you to take shelter at home now in an emergency and possibly evacuate later while people in other areas are advised to evacuate now. Would you?" This question is designed to elicit information specifically related to the possibility of a staged evacuation. That is, asking a population to shelter in place now and then to evacuate after a specified period of time. Results indicate that 50 percent of households would follow instructions and delay the start of evacuation until so advised, while the other 50 percent would choose to begin evacuating immediately.

"Emergency officials advise you to evacuate due to an emergency. Where would you evacuate to?" This question is designed to elicit information regarding the destination of evacuees in case of an evacuation. Approximately 48% of households indicated that they would evacuate to a friend or relatives' home, 3% to a reception center, 20% to a hotel, motel or campground, 6% to a second or seasonal home, and the remaining 23% answered other/don't know to this question, as shown in Figure F-13.

F.3.3 Time Distribution Results

The survey asked several questions about the amount of time it takes to perform certain pre-evacuation activities. These activities involve actions taken by residents during the course of their day-to-day lives. Thus, the answers fall within the realm of the responder's experience.

The mobilization distributions provided below are the result of having applied the analysis described in Section 5.4.1 on the component activities of the mobilization.

As discussed in Section F.3.1 and shown in Figure F-8, the COVID-19 pandemic had a significant impact on the commuting patterns of those who live in the HNP EPZ. To minimize uncertainty in the trip generation time, data from the 2012 demographic survey will be used for the distributions involving commuters (time to prepare to leave work/college and time to travel home from work/college). For this reason, both the results of this survey, and the results of the 2012 survey for these questions are discussed herein.

"How long does it take the commuter to complete preparation for leaving work/college?" Figure F-14 presents the cumulative distribution for the 2020 and 2012 survey responses. For the 2020 survey, in all cases, the activity is completed within 75 minutes. Approximately 90% can leave within 35 minutes. For the 2012 survey, in all cases, the activity is completed within 90 minutes. Approximately 90% can leave within 30 minutes.

"How long would it take the commuter to travel home?" Figure **F-15** presents the work to home travel time for the EPZ for the 2020 and 2012 survey responses. Approximately 75 percent of commuters can arrive home within 35 minutes of leaving work; all within 75 minutes, according to the 2020 survey. Approximately 80 percent of commuters can arrive home within 30 minutes of leaving work; all within 90 minutes, according to the 2020 survey.

"How long would it take the family to pack clothing, secure the house, and load the car?" Figure F-16 presents the time required to prepare for leaving on an evacuation trip. In many ways this activity mimics a family's preparation for a short holiday or weekend away from home. Hence, the responses represent the experience of the responder in performing similar activities. Approximately 95% of households can be ready to leave home withing 2 hours and 30 minutes; the remaining households require up to an additional one hour and 15 minutes.

"How much time, on average, would it take you to clear 6-8 inches of snow to move the car from the driveway or curb to begin the evacuation trip assuming the roads are passable?" Figure F-17 presents the time required to clear 6-8 inches of snow and begin the evacuation trip. Snow in this area is not common and residents are not used to clearing snow from their driveways so responses to this question varies significantly.

Approximately 75% of households can have their car cleared and the driveway passable within one hour and 15 minutes; the remaining households would require up to an additional 2 hours to begin their evacuation trip, as seen in Figure F-17.

It should be noted that this question was asked for informational purposes only. Since ice was considered and not snow, this distribution was not used in the analysis. Trip generation rates for ice scenarios were not changed from the good weather and rain scenarios for the general population.

F.3.4 Emergency Communications

"At your place of residence, how reliable is your cell phone signal?" This question is designed to elicit information regarding the ability to be notified in case of an evacuation. Approximately 80% of households indicated that they have very reliable signal to receive texts and phone calls, 7% indicated that their signal is reliable for text messages only, 12% indicated that they do not always receive cell communications at their residence, and about one percent indicated that they do not have cell service at their residence, as shown in Figure F-18.

"Emergency management officials in your state may send text messages, similar to AMBER Alerts, with emergency directions for the public during a radiological emergency at the Harris Nuclear Plant. How likely would you be to take action on these directions, if you received the message?" This question is designed to elicit information regarding the likelihood of an individual to take action based on emergency management officials' guidelines. Eighty percent of households indicated that they are highly likely to take action on these directions, about 17% indicated likely, 2% indicated neither likely nor unlikely, 1% indicated unlikely or highly unlikely for them to take action on emergency management officials' directions, as shown in Figure F-19.

"Which of the following emergency communication methods do you think is most likely to alert you at your residence?" This question is designed to elicit information regarding the most efficient way to alert residents within the EPZ. Approximately 74% of households indicated that a text message from emergency officials would be most likely to alert them at their residence, 20% indicated that a siren sounding near their home would be the most likely method, 3% indicated an alert broadcast on the TV, and 3% indicated that a phone call/text message from a family member, friend or neighbor would be the most likely way to alert them at their residence. Note that less than half of a percent (0.5%) indicated that an alert broadcast on radio and information on Twitter or Facebook would be the most likely to alert those at their residence, as shown in Figure F-20.

Table F-1. Harris Demographic Survey Sampling Plan

Zip Code	Population within EPZ (2010)	Households (2010)	Required Sample	Sample Obtained
27312	629	241	3	77
27330	2,100	816	11	12
27502	28,946	10,024	129	479
27505	59	20	0	9
27517	38	13	0	41
27518	4,526	1,480	19	22
27519	138	53	1	32
27523	6,256	2,313	30	80
27526	20,400	7,687	99	85
27539	7,864	2,898	37	30
27540	28,608	9,568	123	209
27559	1,459	584	8	12
27562	1,938	772	10	147
Total	**629**	**241**	**470**	**1,235**
		Average HH Size:	**2.82**	

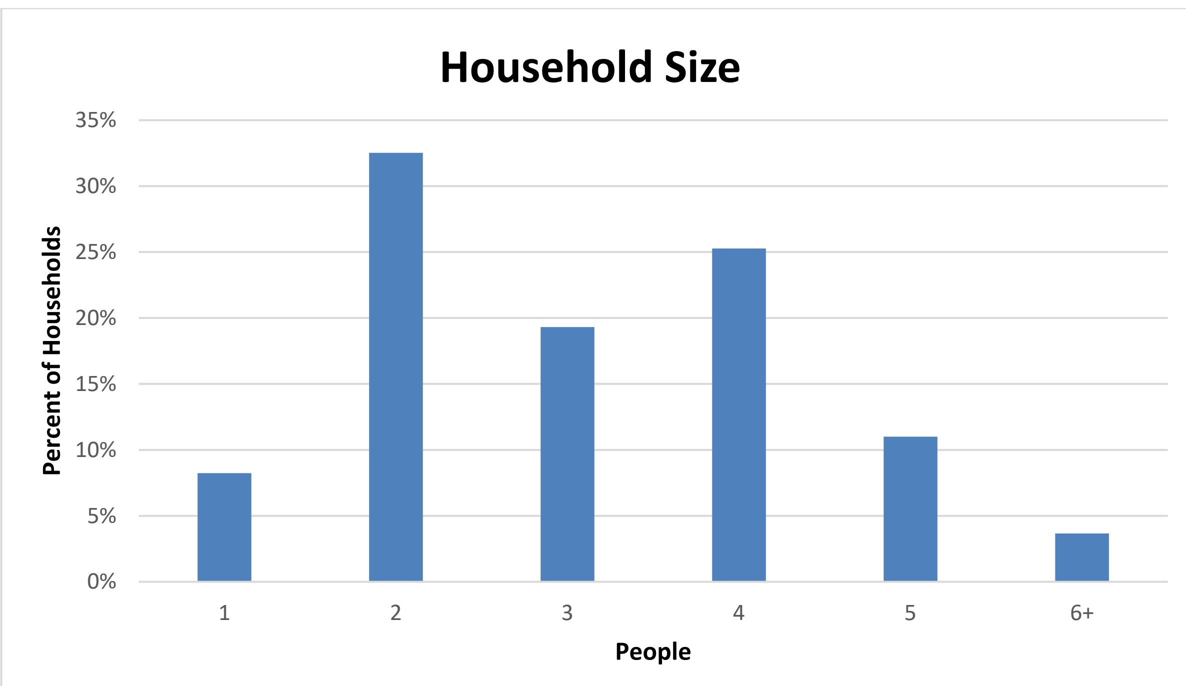


Figure F-1. Household Size in the EPZ

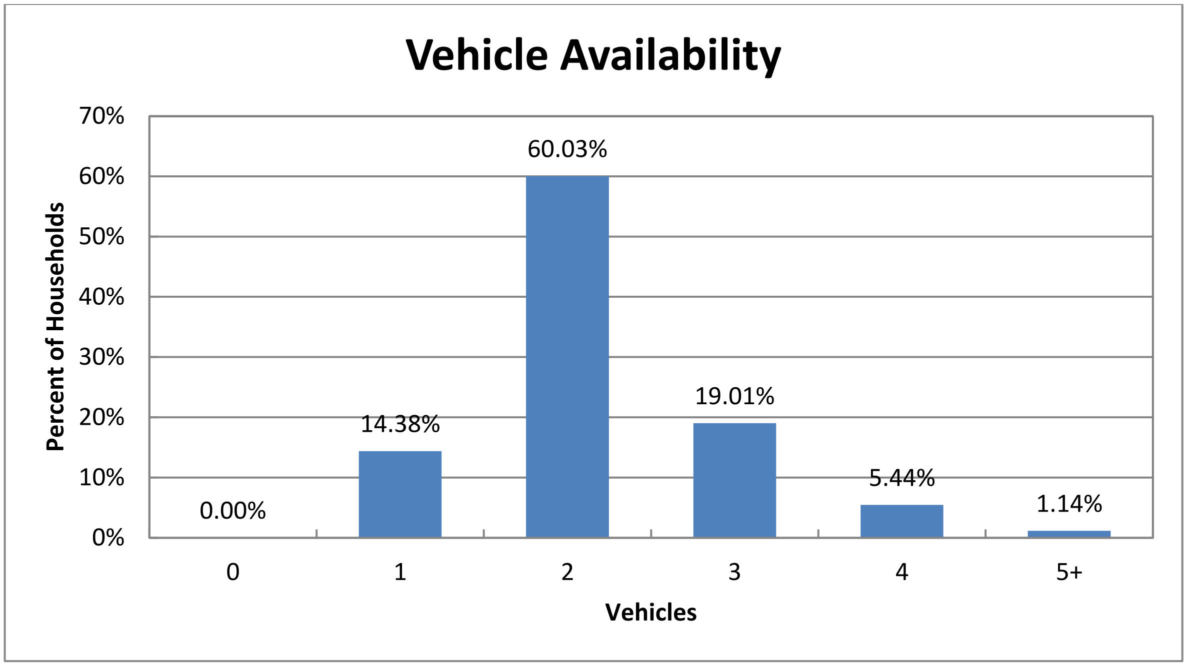


Figure F-2. Household Vehicle Availability

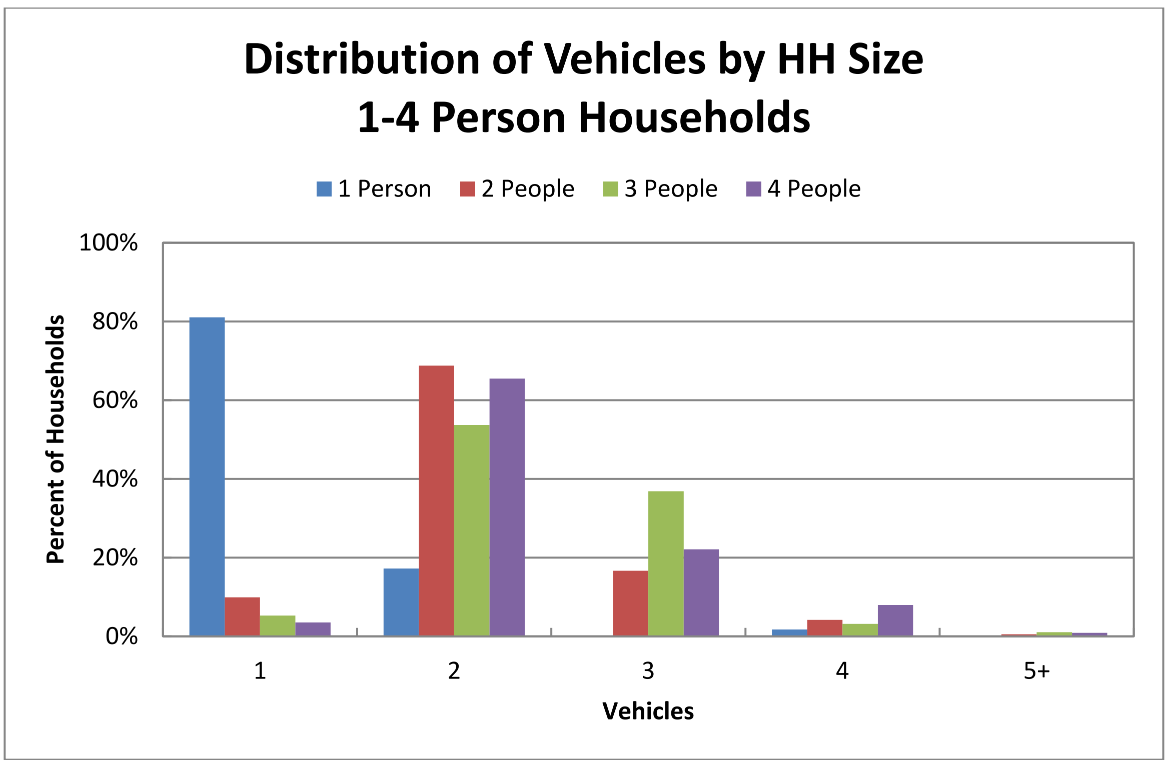


Figure F-3. Vehicle Availability - 1 to 4 Person Households

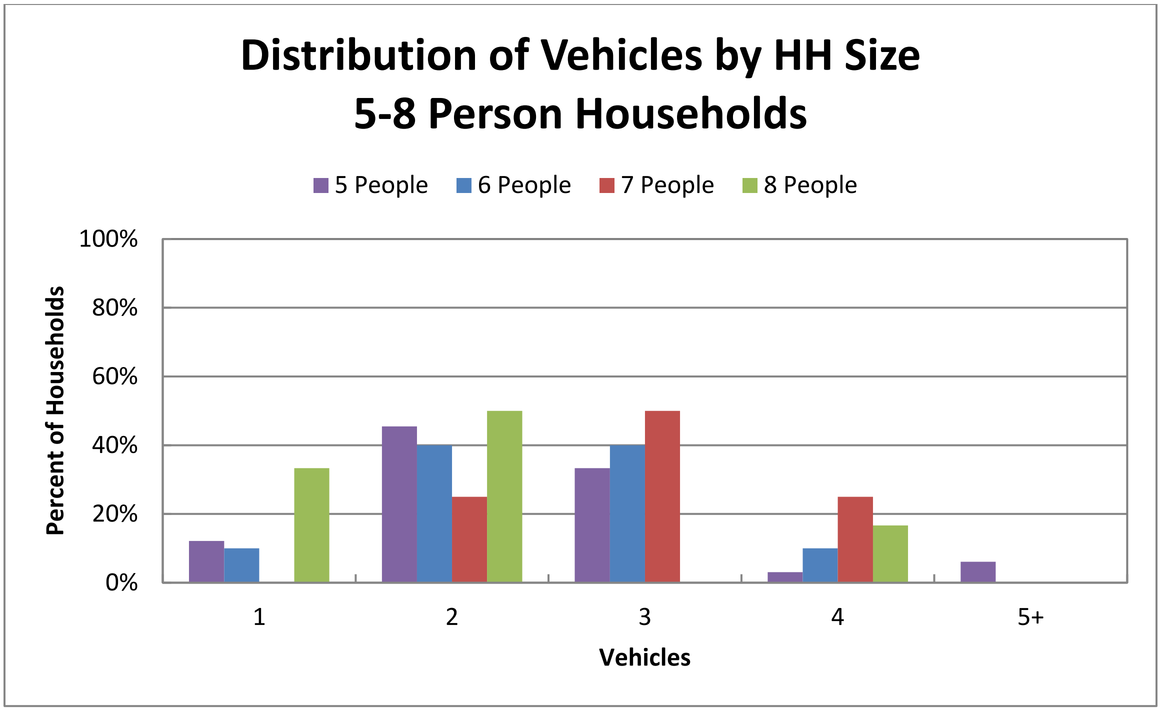


Figure F-4. Vehicle Availability - 5 to 8 Person Households

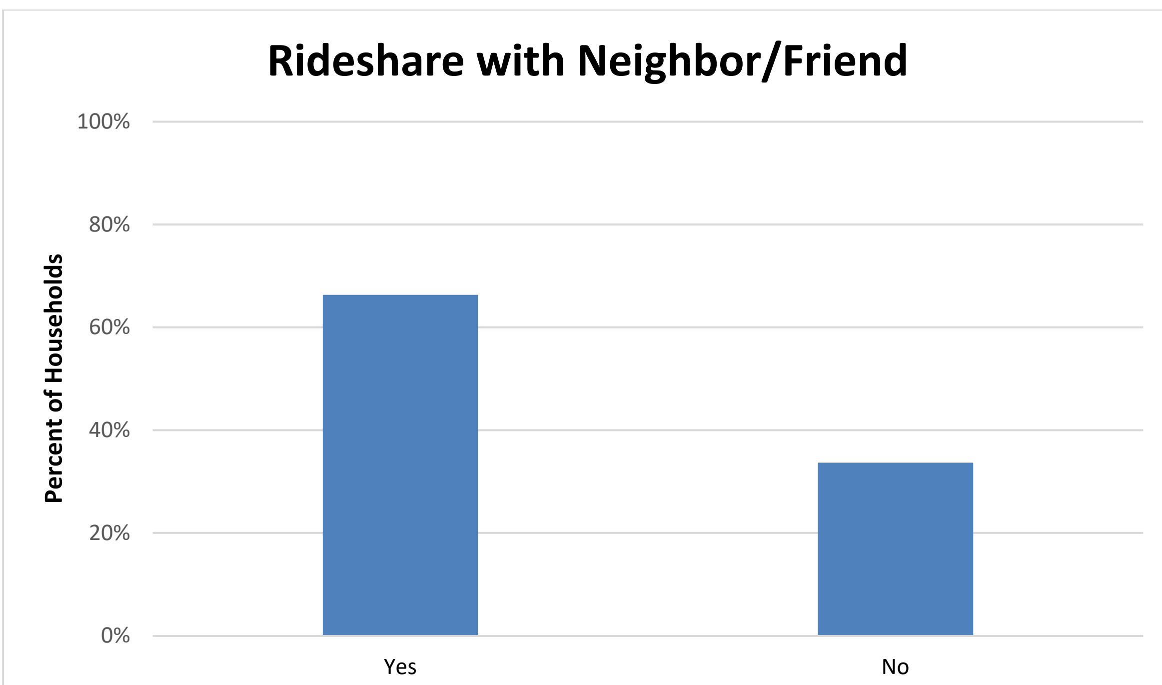


Figure F-5. Household Ridesharing Preference

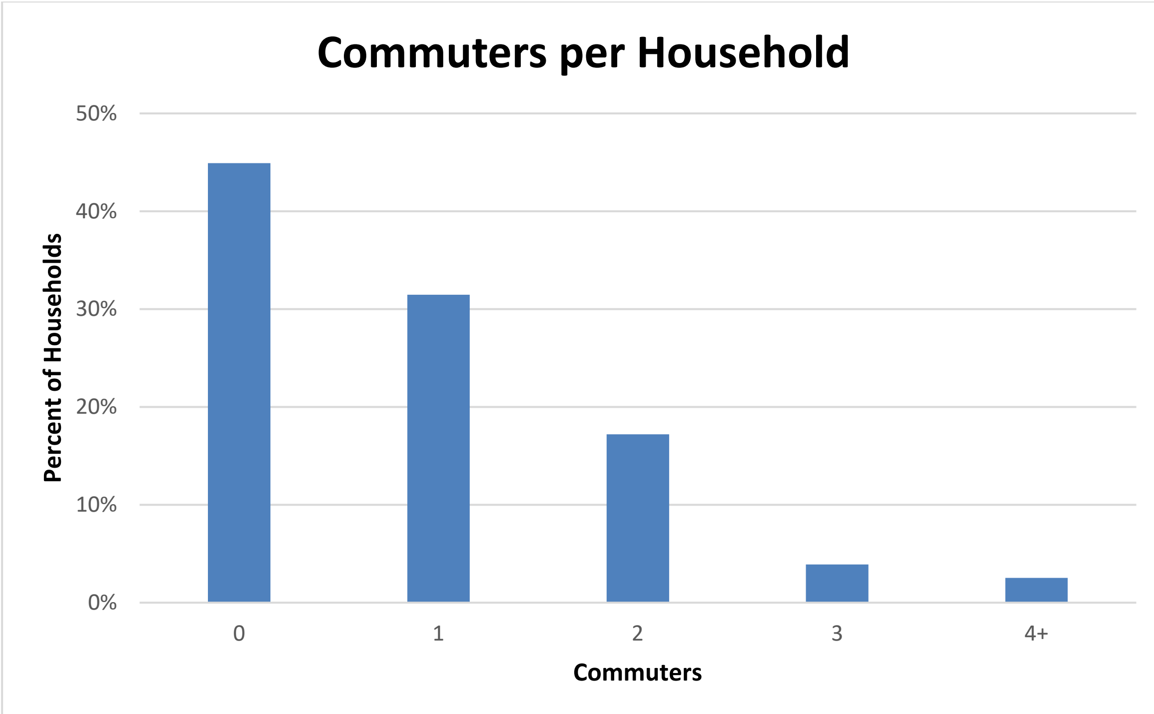


Figure F-6. Commuters per Households in the EPZ

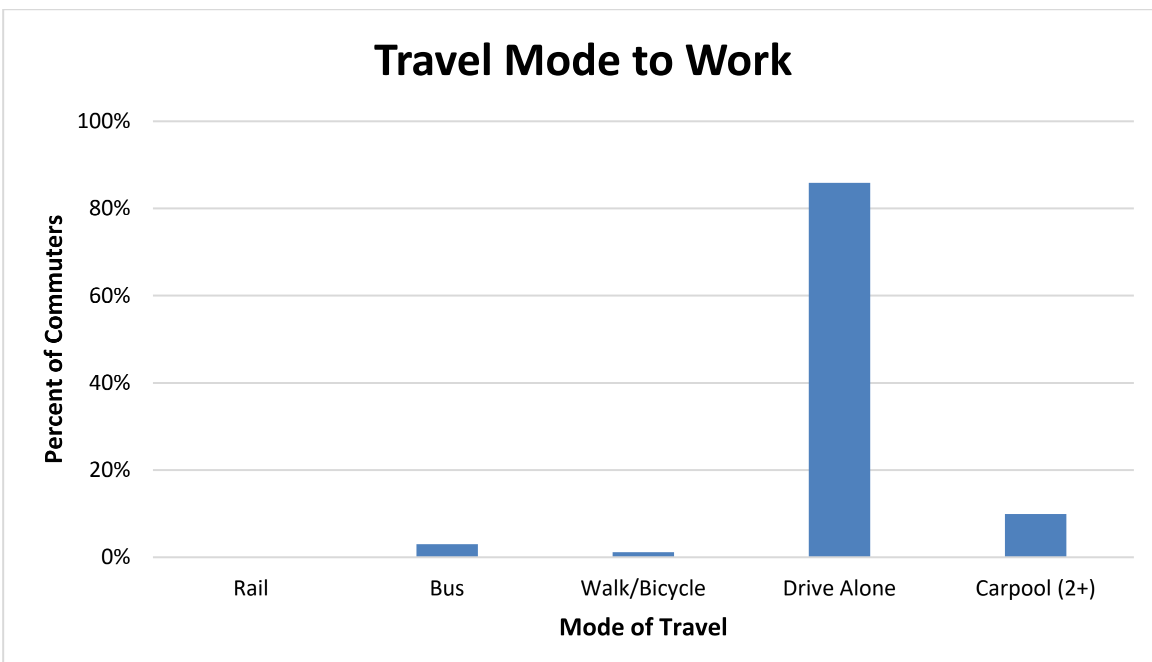


Figure F-7. Modes of Travel in the EPZ

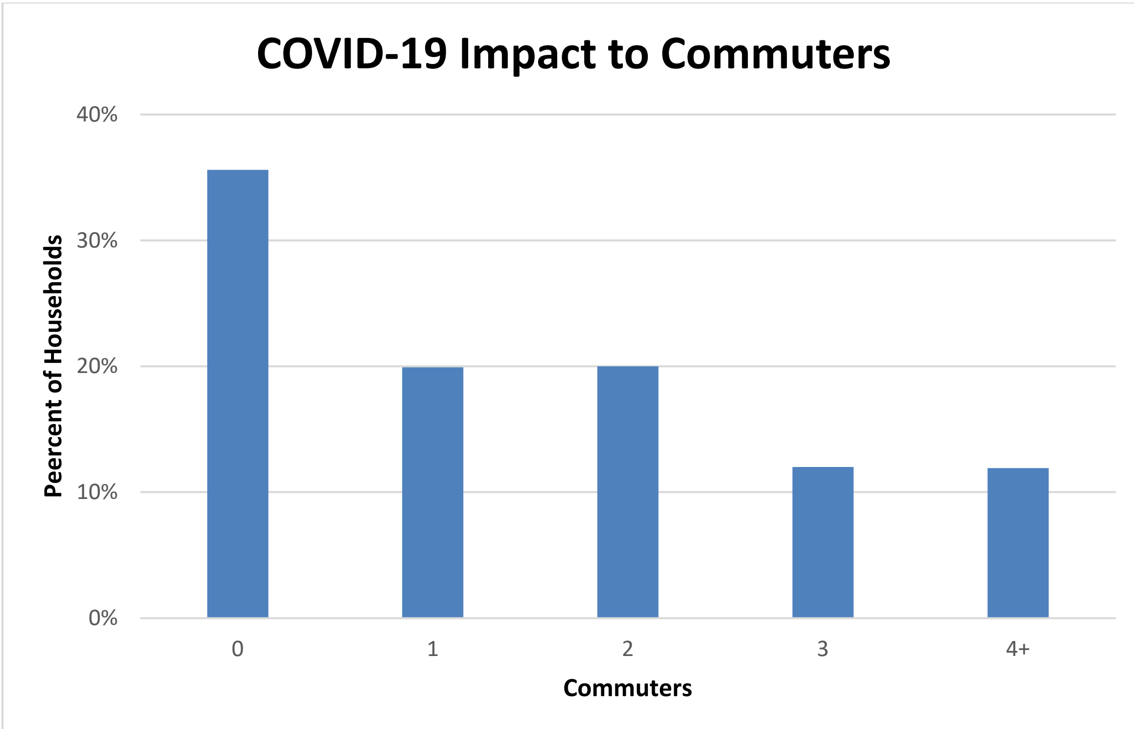


Figure F-8. Impact to Commuters due to the COVID-19 Pandemic

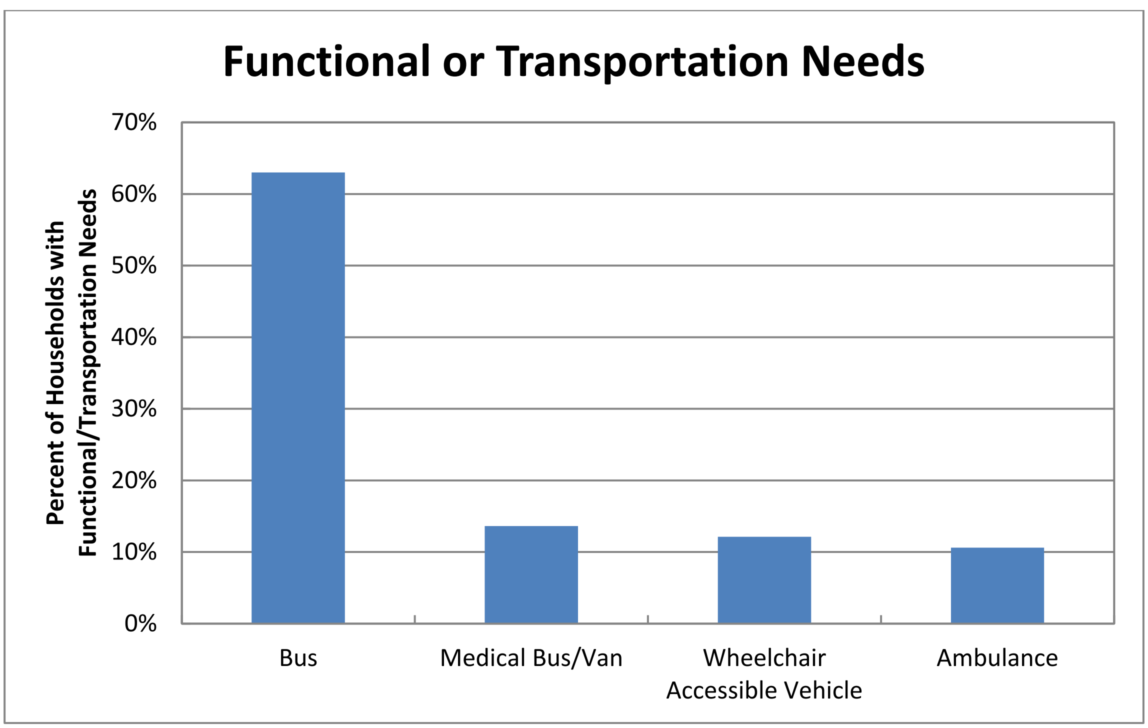


Figure F-9. Households with Functional or Transportation Needs

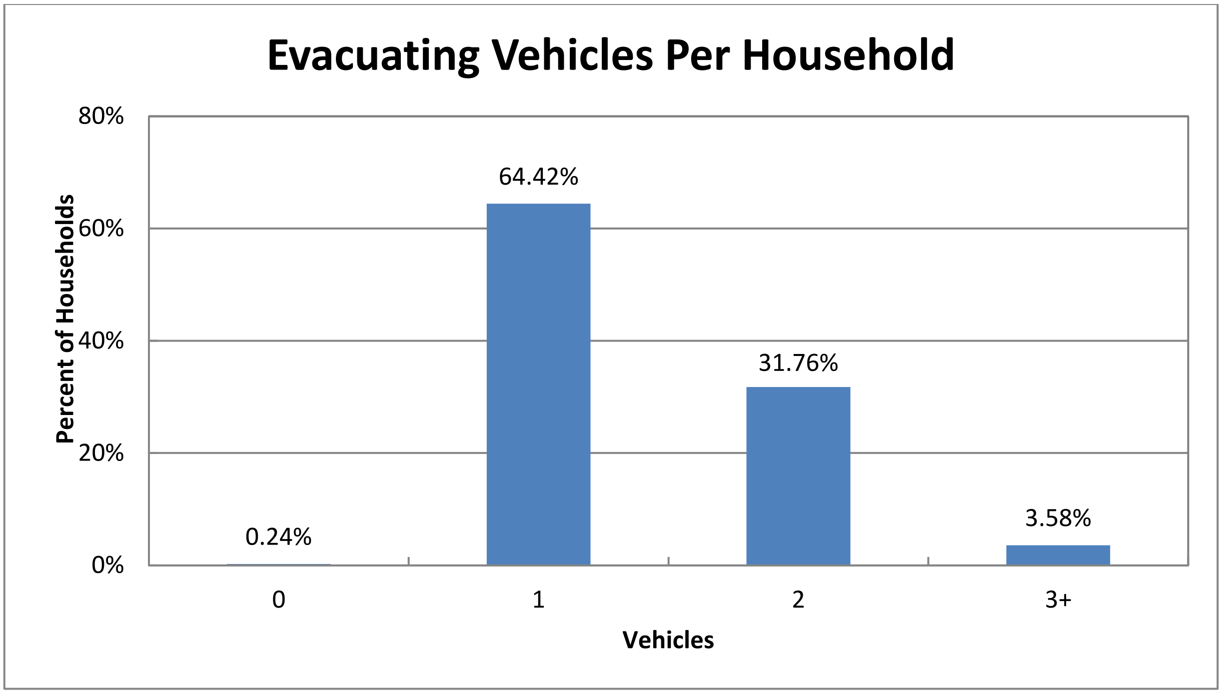


Figure F-10. Number of Vehicles Used for Evacuation

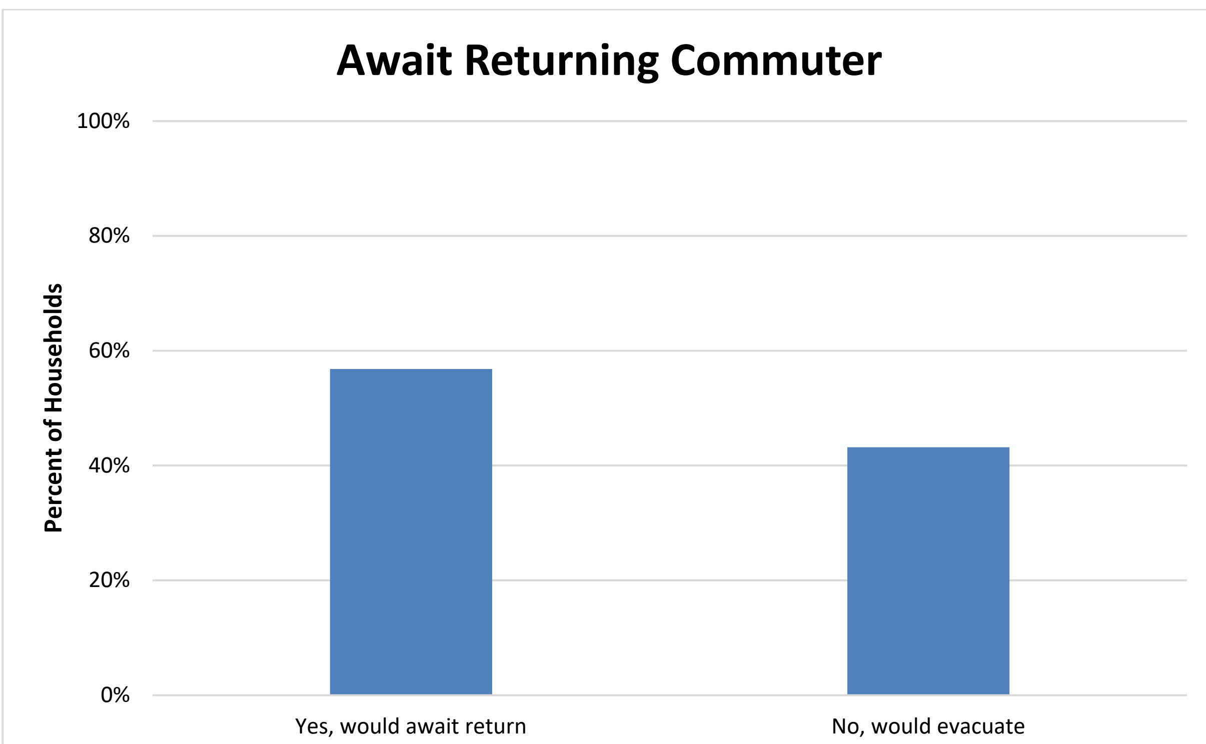


Figure F-11**. Percent of Households that Await Returning Commuter Before Leaving**

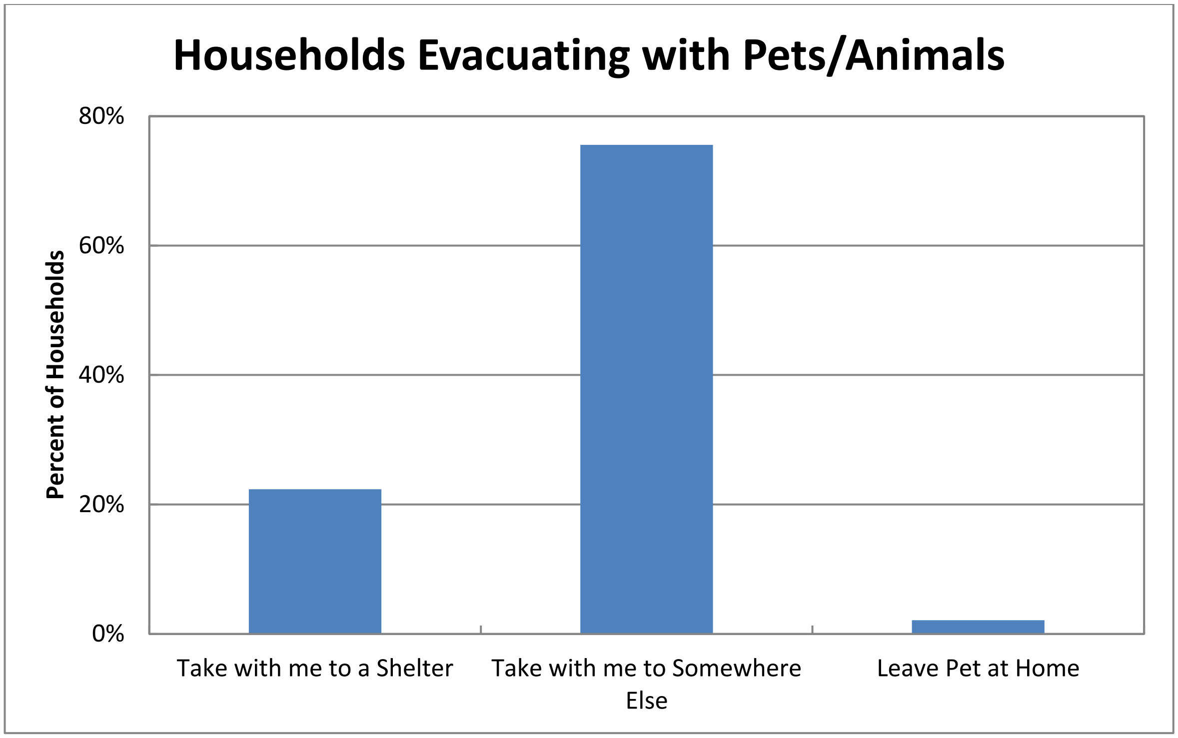


Figure F-12. Households Evacuating with Pets/Animals

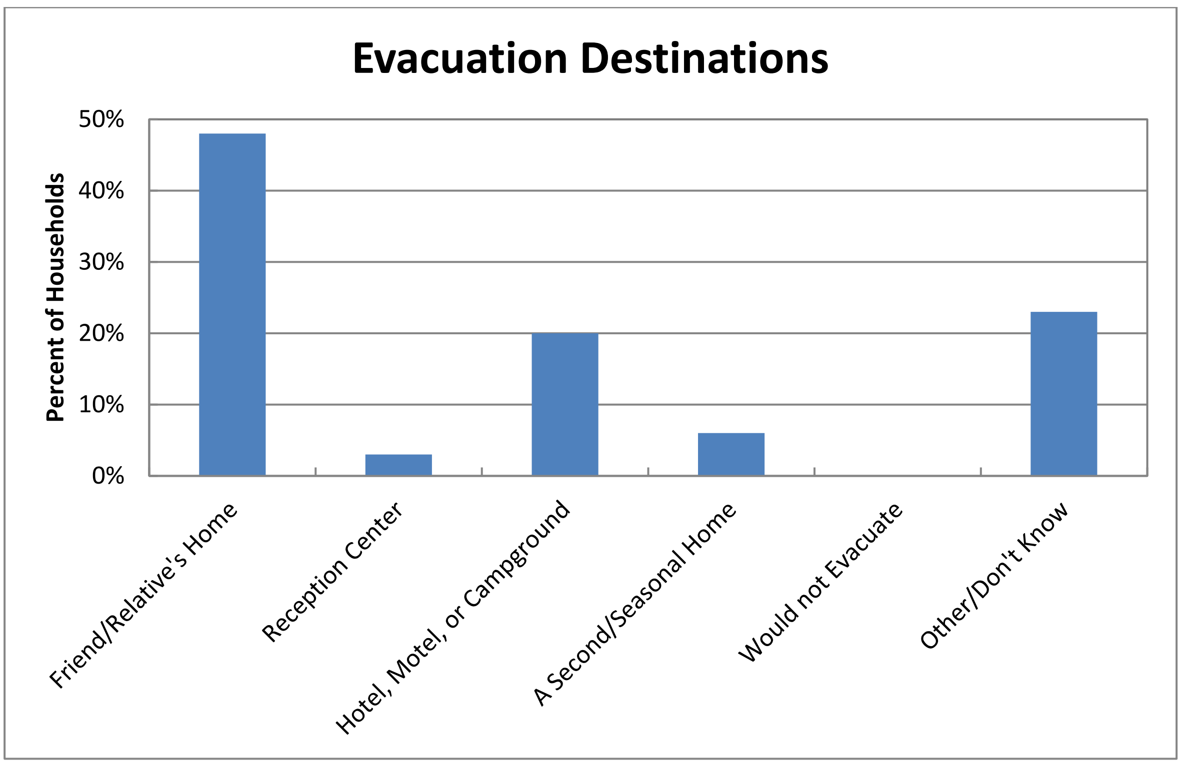


Figure F-13. Study Area Evacuation Destinations

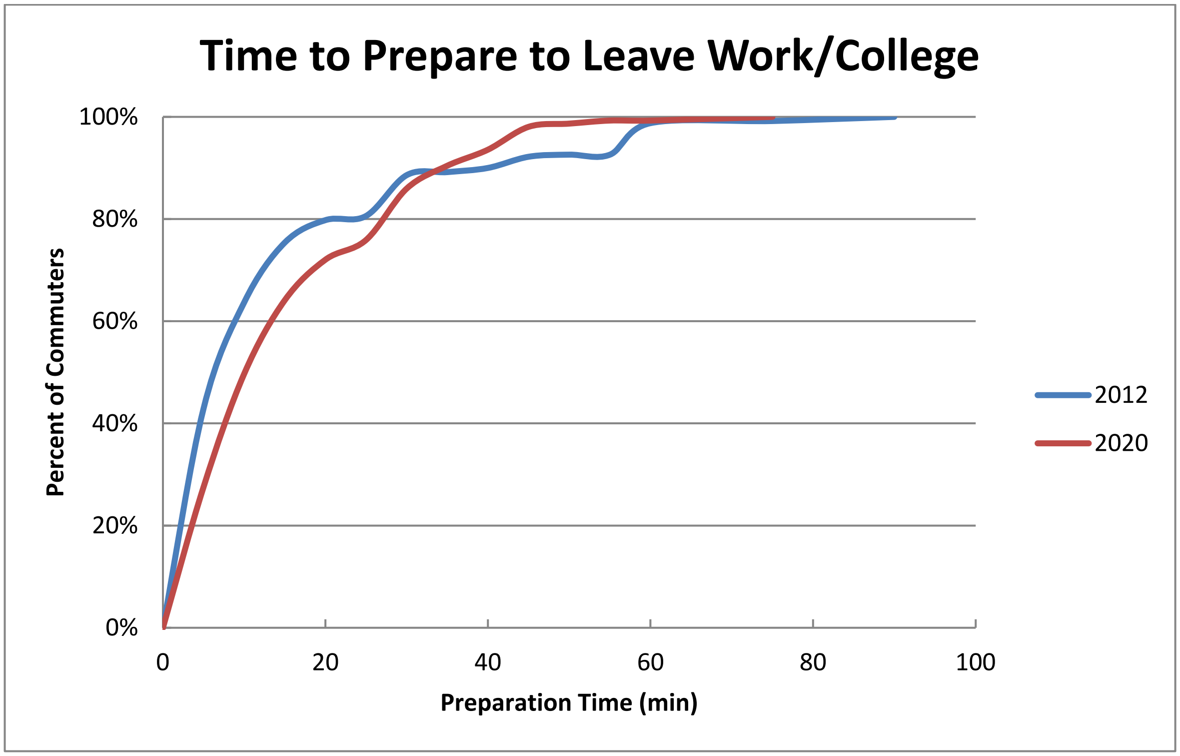


Figure F-14. Time Required to Prepare to Leave Work/College

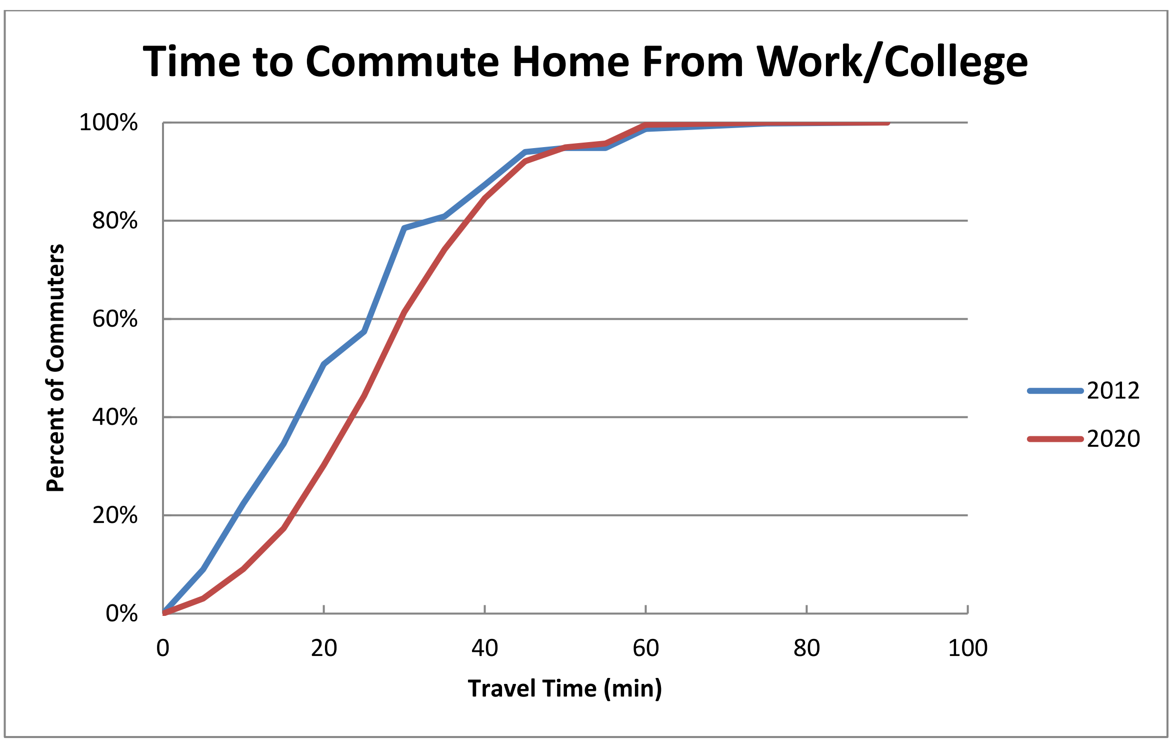


Figure F-15**. Time to Commute Home from Work/College**

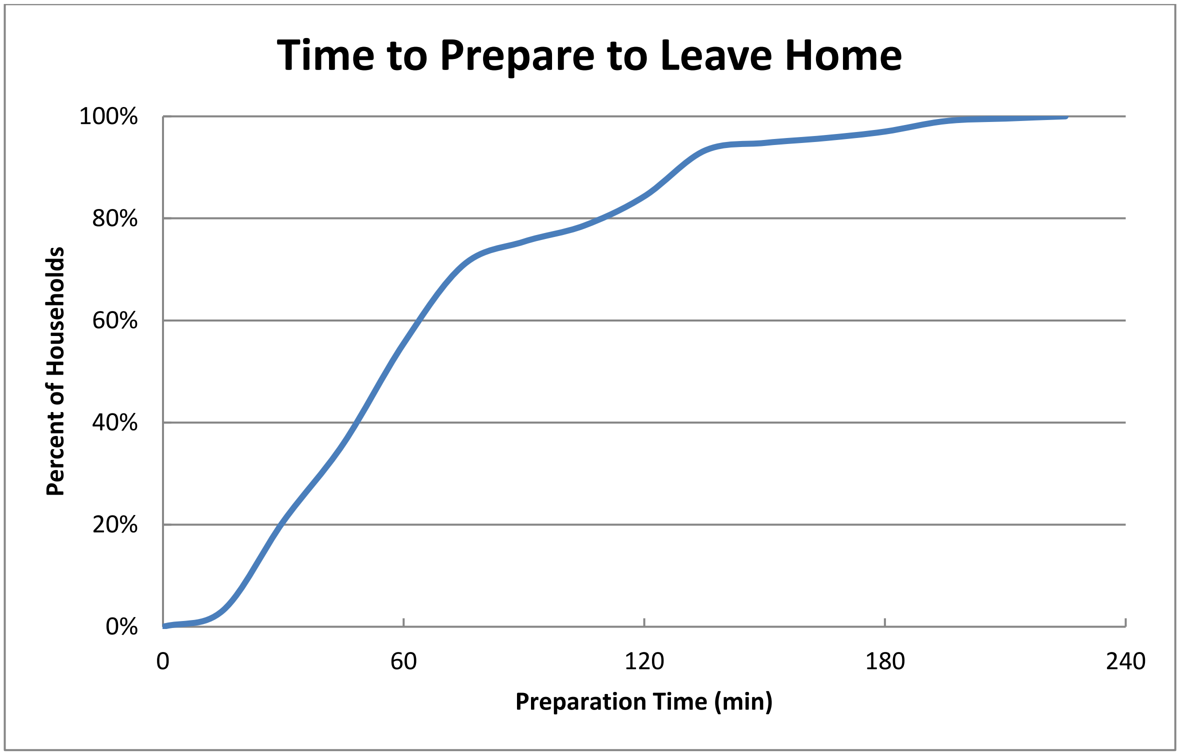


Figure F-16. Time to Prepare Home for Evacuation

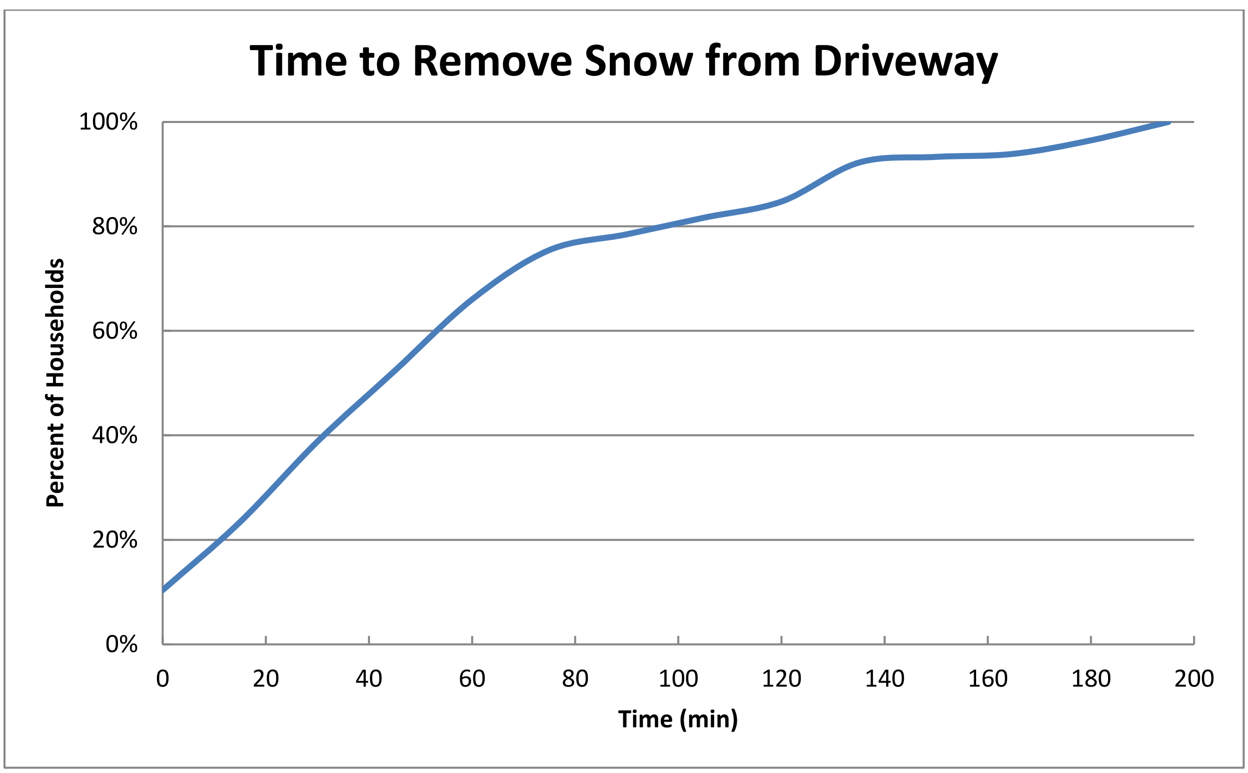


Figure F-17. Time to Remove Snow from Driveway

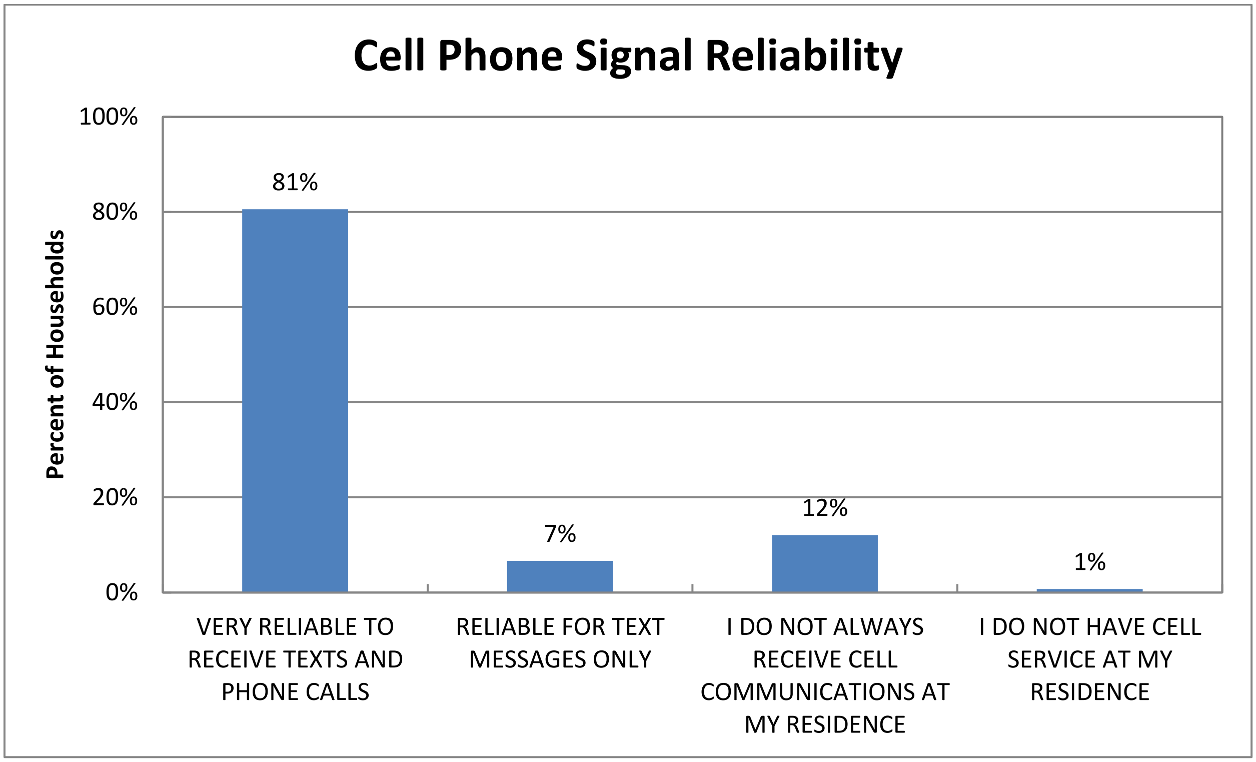


Figure F-18. Cell Phone Signal Reliability

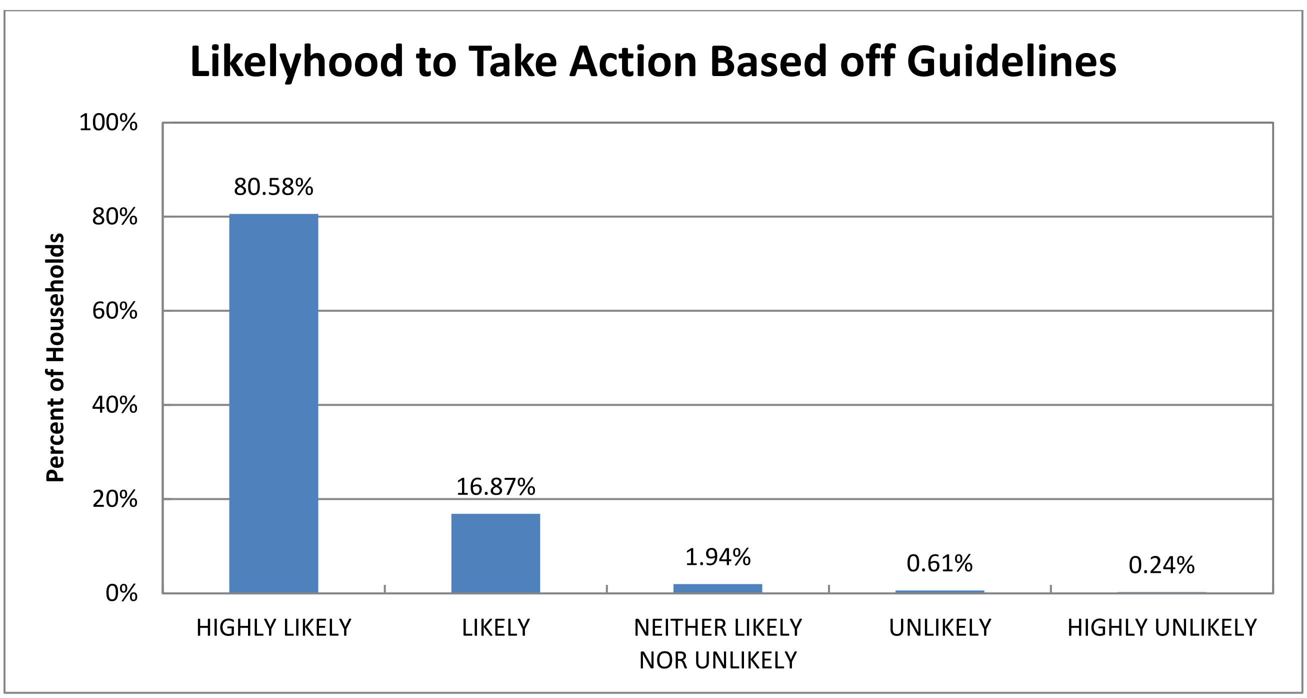


Figure F-19. Likelihood to Take Action Based off Emergency Management Officials Guidelines

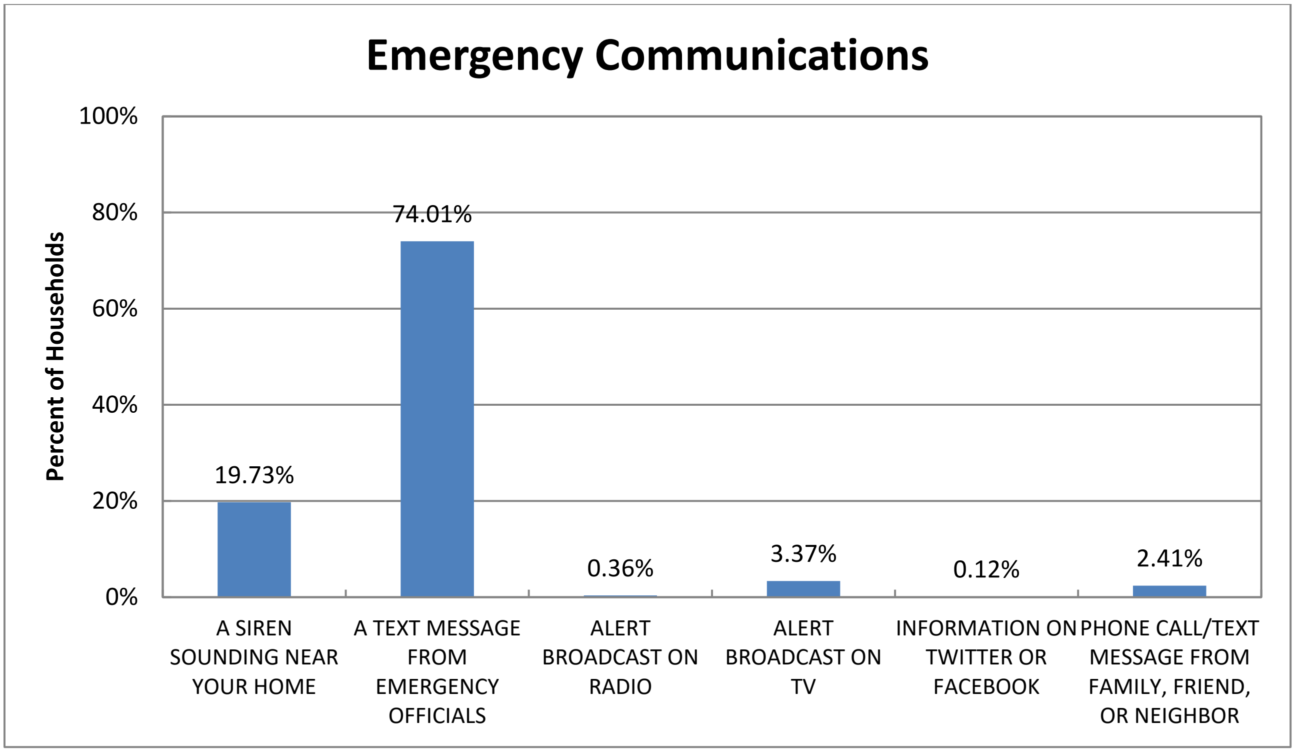


Figure F-20. Emergency Communication Alert

ATTACHMENT A

Demographic Survey Instrument

Harris Nuclear Power Plant Demographic Survey

* Required

Purpose

The purpose of this survey is to identify local behavior during emergency situations. The information gathered in this survey will be shared with the Duke Energy to enhance emergency response plans in your area. Your responses will greatly contribute to local emergency preparedness. **Please only complete one survey per household. Please have the head of the household (18 years or older) complete the survey**. Please do not provide your name or any personal information, and the survey will take less than 5 minutes to complete.

1. 1. What is your gender?

Mark only one oval.

- Male
- Female
- Decline to State
- Other: ____________________

2. 2. What is your home zip code? *

____

3. 3A. In total, how many running cars, or other vehicles are usually available to the household?

Mark only one oval.

- ONE
- TWO
- THREE
- FOUR
- FIVE
- SIX
- SEVEN
- EIGHT
- NINE OR MORE
- ZERO (NONE)
- DECLINE TO STATE

4. 3B. In an emergency, could you get a ride out of the area with a neighbor or friend?

Mark only one oval.

- YES
- NO
- DECLINE TO STATE

5. 4. How many vehicles would your household use during an evacuation?

Mark only one oval.

- ONE
- TWO
- THREE
- FOUR
- FIVE
- SIX
- SEVEN
- EIGHT
- NINE OR MORE
- ZERO (NONE)
- I WOULD EVACUATE BY BICYCLE
- I WOULD EVACUATE BY BUS
- DECLINE TO STATE

6. 5. How many people usually live in this household?

Mark only one oval.

- ONE
- TWO
- THREE
- FOUR
- FIVE SIX
- SEVEN
- EIGHT
- NINE
- TEN
- ELEVEN
- TWELVE
- THIRTEEN
- FOURTEEN
- FIFTEEN
- SIXTEEN
- SEVENTEEN
- EIGHTEEN
- NINETEEN OR MORE
- DECLINE TO STATE

7. 6. How many people in your household have a work and/or school commute that has been temporarily impacted due to the COVID-19 pandemic?

Mark only one oval.

- ZERO
- ONE
- TWO
- THREE
- FOUR OR MORE
- DECLINE TO STATE

8. 7. How many people in the household commute to a job, or to college on a daily basis? *

Mark only one oval.

- ZERO
- ONE
- TWO
- THREE
- FOUR OR MORE
- DECLINE TO STATE

9. 8. Thinking about each commuter, how does each person usually travel to work or college?

Mark only one oval per row.

	Rail	Bus	Walk/Bicycle	Drive Alone	Carpool-2 or more people	Don't know
Commuter 1	⬭	⬭	⬭	⬭	⬭	⬭
Commuter 2	⬭	⬭	⬭	⬭	⬭	⬭
Commuter 3	⬭	⬭	⬭	⬭	⬭	⬭
Commuter 4	⬭	⬭	⬭	⬭	⬭	⬭

10. 9-1. How much time on average, would it take Commuter #1 to travel home from work or college?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MINUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 - 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

11. If Over 2 Hours for Question 9-1, Specify Here

leave blank if your answer for Question 9-1, is under 2 hours.

____

12. 9-2. How much time on average, would it take Commuter #2 to travel home from work or college?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MINUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 - 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

13. If Over 2 Hours for Question 9-2, Specify Here

leave blank if your answer for Question 9-2, is under 2 hours.

____

14. 9-3. How much time on average, would it take Commuter #3 to travel home from work or college?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MINUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 - 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

15. If Over 2 Hours for Question 9-3, Specify Here

leave blank if your answer for Question 9-3, is under 2 hours.

____

16. 9-4. How much time on average, would it take Commuter #4 to travel home from work or college?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MINUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 - 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

17. If Over 2 Hours for Question 9-4, Specify Here

leave blank if your answer for Question 9-4, is under 2 hours.

____

18. 10-1. Approximately how much time would it take Commuter #1 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MINUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 - 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

19. If Over 2 Hours for Question 10-1, Specify Here

leave blank if your answer for Question 10-1, is under 2 hours.

____

20. 10-2. Approximately how much time would it take Commuter #2 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MINUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 - 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

21. If Over 2 Hours for Question 10-2, Specify Here

leave blank if your answer for Question 10-2, is under 2 hours.

____

22. 10-3. Approximately how much time would it take Commuter #3 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MINUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 - 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

23. If Over 2 Hours for Question 10-3, Specify Here

leave blank if your answer for Question 10-3, is under 2 hours.

____

24. 10-4. Approximately how much time would it take Commuter #4 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MINUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 - 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

25. If Over 2 Hours for Question 10-4, Specify Here

leave blank if your answer for Question 10-4, is under 2 hours.

____

26. 11. If you were advised by local authorities to evacuate, how much time would it take the household to pack clothing, medications, secure the house, load the car, and complete preparations prior to evacuating the area?

Mark only one oval.

- LESS THAN 15 MINUTES
- 15-30 MINUTES
- 31-45 MINUTES
- 46 MINUTES - 1 HOUR
- 1 HOUR TO 1 HOUR 15 MINUTES
- 1 HOUR 16 MINUTES TO 1 HOUR 30 MINUTES
- 1 HOUR 31 MINUTES TO 1 HOUR 45 MINUTES
- 1 HOUR 46 MINUTES TO 2 HOURS
- 2 HOURS TO 2 HOURS 15 MINUTES
- 2 HOURS 16 MINUTES TO 2 HOURS 30 MINUTES
- 2 HOURS 31 MINUTES TO 2 HOURS 45 MINUTES
- 2 HOURS 46 MINUTES TO 3 HOURS
- 3 HOURS TO 3 HOURS 15 MINUTES
- 3 HOURS 16 MINUTES TO 3 HOURS 30 MINUTES
- 3 HOURS 31 MINUTES TO 3 HOURS 45 MINUTES
- 3 HOURS 46 MINUTES TO 4 HOURS
- 4 HOURS TO 4 HOURS 15 MINUTES
- 4 HOURS 16 MINUTES TO 4 HOURS 30 MINUTES
- 4 HOURS 31 MINUTES TO 4 HOURS 45 MINUTES
- 4 HOURS 46 MINUTES TO 5 HOURS
- 5 HOURS TO 5 HOURS 30 MINUTES
- 5 HOURS 31 MINUTES TO 6 HOURS
- OVER 6 HOURS
- WILL NOT EVACUATE
- DECLINE TO STATE

27. If Over 6 Hours for Question 11, Specify Here

leave blank if your answer for Question 11, is under 6 hours.

____

28. 12. If there are 6-8 inches of snow on your driveway or curb, would you need to shovel out to evacuate? If yes, how much time, on average, would it take you to clear the 6-8 inches of snow to move the car from the driveway or curb to begin the evacuation trip? Assume the roads are passable.

Mark only one oval.

- LESS THAN 15 MINUTES
- 15-30 MINUTES
- 31-45 MINUTES
- 46 MINUTES – 1 HOUR
- 1 HOUR TO 1 HOUR 15 MINUTES
- 1 HOUR 16 MINUTES TO 1 HOUR 30 MINUTES
- 1 HOUR 31 MINUTES TO 1 HOUR 45 MINUTES
- 1 HOUR 46 MINUTES TO 2 HOURS
- 2 HOURS TO 2 HOURS 15 MINUTES
- 2 HOURS 16 MINUTES TO 2 HOURS 30 MINUTES
- 2 HOURS 31 MINUTES TO 2 HOURS 45 MINUTES
- 2 HOURS 46 MINUTES TO 3 HOURS
- NO, WILL NOT SHOVEL OUT
- OVER 3 HOURS
- DECLINE TO STATE

29. If Over 3 Hours for Question 12, Specify Here

leave blank if your answer for Question 12, is under 3 hours.

____

30. 13. Please specify the number of people in your household who require Functional or Transportation needs in an evacuation:

Mark only one oval per row.

	0	1	2	3	4	More than 4
Bus						
Mediicall Bus/Van						
Wheellchaiirr Accessiiblle Vehiiclle						
Ambullance						
Ottherr						

31. Specify "Other" Transportation Need Below

____

32. 14. Please choose one of the following:

Mark only one oval.

- I would await the return of household members to evacuate together.
- I would evacuate independently and meet other household members later.
- Decline to State

33. 15A. Emergency officials advise you to shelter-in-place in an emergency because you are not in the area of risk. Would you:

Mark only one oval.

- SHELTER-IN-PLACE
- EVACUATE
- DECLINE TO STATE

34. 15B. Emergency officials advise you to shelter-in-place now in an emergency and possibly evacuate later while people in other areas are advised to evacuate now. Would you:

Mark only one oval.

- SHELTER-IN-PLACE
- EVACUATE
- DECLINE TO STATE

35. 15C. Emergency officials advise you to evacuate due to an emergency. Where would you evacuate to?

Mark only one oval.

- A RELATIVE'S OR FRIEND'S HOME
- A RECEPTION CENTER
- A HOTEL, MOTEL OR CAMPGROUND
- A SECOND/SEASONAL HOME
- WOULD NOT EVACUATE
- DON'T KNOW
- OTHER (Specify Below)
- DECLINE TO STATE

36. Fill in OTHER answers for question 15C

____

37. 16A. Do you have any pet(s) and/or animal(s)?

Mark only one oval.

- ⬭ YES
- ⬭ NO
- ⬭ DECLINE TO STATE

38. 16B. What type of pet(s) and/or animal(s) do you have?

Check all that apply.

- ☐ DOG
- ☐ CAT
- ☐ BIRD
- ☐ REPTILE
- ☐ HORSE
- ☐ FISH
- ☐ CHICKEN
- ☐ GOAT
- ☐ PIG
- ☐ OTHER SMALL PETS/ANIMALS (Specify Below)
- ☐ OTHER LARGE PETS/ANIMALS (Specify Below)

Other: ☐ ______________________________

39.

Mark only one oval.

- ⬭ DECLINE TO STATE

40. 16C. What would you do with your pet(s) and/or animal(s) if you had to evacuate?

Mark only one oval.

- TAKE PET WITH ME TO A SHELTER
- TAKE PET WITH ME SOMEWHERE ELSE
- LEAVE PET AT HOME
- DECLINE TO STATE

41. 16D. Do you have sufficient room in your vehicle(s) to evacuate with your pet(s) and/or animal(s)?

Mark only one oval.

- YES
- NO
- DECLINE TO STATE
- Other: ____________________

42. 17A. At your place of residence, how reliable is your cell phone signal?

Mark only one oval.

- VERY RELIABLE TO RECEIVE TEXTS AND PHONE CALLS
- RELIABLE FOR TEXT MESSAGES ONLY
- I DO NOT ALWAYS RECEIVE CELL COMMUNICATIONS AT MY RESIDENCE
- I DO NOT HAVE CELL SERVICE AT MY RESIDENCE

43. 17B. Emergency management officials in your state may send text messages, similar to AMBER Alerts, with emergency directions for the public during a radiological emergency at Harris Nuclear Plant. How likely would you be to take action on these directions, if you received the message?

Mark only one oval.

- HIGHLY LIKELY
- LIKELY
- NEITHER LIKELY NOR UNLIKELY
- UNLIKELY
- HIGHLY UNLIKELY

44. 17C. Which of the following emergency communication methods do you think is most likely to alert you at your residence?

Mark only one oval.

- A SIREN SOUNDING NEAR YOUR HOME
- A TEXT MESSAGE FROM EMERGENCY OFFICIALS
- ALERT BROADCAST ON RADIO
- ALERT BROADCAST ON TV
- INFORMATION ON TWITTER OR FACEBOOK
- PHONE CALL/TEXT MESSAGE FROM FAMILY, FRIEND, OR NEIGHBOR
- OTHER

45. Fill in OTHER answers for question 17C

____

APPENDIX G

Traffic Management Plan

G. TRAFFIC MANAGEMENT PLAN

NUREG/CR-7002, Rev. 1 indicates that the existing traffic control points (TCPs) and security road blocks (SRBs) identified by the offsite agencies should be used in the evacuation simulation modeling. The traffic control and security road block plans for the EPZ are described in the "All County Standard Operating Guideline for Traffic Control Point and Security Road Block Operations in Support of the Harris Nuclear Plant", dated January, 2019.

This traffic management plan (TMP) was reviewed and the TCPs and SRBs were modeled accordingly.

G.1 Traffic Control Points

As discussed in Section 9, traffic control points at intersections (which are controlled) are modeled as actuated signals. If an intersection has a pre-timed signal, stop, or yield control, and the intersection is identified as a traffic control point, the control type was changed to an actuated signal in the DYNEV II system, in accordance with Section 3.3 of NUREG/CR-7002, Rev. 1. TCPs at existing actuated traffic signalized intersections were essentially left alone except where modifications to green time allocation were deemed necessary.

Table K-1 provides the number of nodes with each control type. If the existing control was changed due to the point being a TCP or SRB, the control type is indicated as a TCP/SRB in Table K-1. The TCPs within the study area are mapped as blue dots in Figure G-1 through Figure G-3.

As discussed in Section 3.10, external traffic was considered on the major routes that traverse the study area – US-1, US-1/US-64, US-401, US-421 and I-40 – in this analysis**.** It can be seen in Figure G-1 through Figure G-3 that the majority of TCPs are located along these routes. The generation of these external trips (24,344 vehicles during day conditions, 9,738 vehicles in evening conditions) ceased at 120 minutes after the advisory to evacuate in the simulation to represent the diversion of traffic at these TCP locations.

G.2 Security Road Blocks

The existing SRBs within the study area are mapped as orange/red dots in Figure G-1 through Figure G-3. As shown in Figure G-1, SRBs exist on the periphery of the 2-mile region, 5-mile region, and EPZ boundary. As per the TMP and discussions with the offsite response organizations, it is assumed that SRBs will be established within 120 minutes of the advisory to evacuate to discourage through travelers from entering these areas.

G.3 Analysis of Key TCP and SRB Locations

As discussed in Section 5.2 of NUREG/CR-7002, Rev. 1, manual traffic control (MTC) at intersections could benefit from ETE analysis. The TCP and SRB locations contained within the traffic management plan were analyzed to determine key locations where MTC would be most useful and can be readily implemented. As previously mentioned, signalized intersections that were actuated based on field data collection were essentially left as actuated traffic signals in the

model, with modifications to green time allocation as needed. Other controlled intersections (pre-timed signals, stop signs and yield signs) were changed to actuated traffic signals to represent the MTC that would be implemented according to the traffic management plan.

Table G-1 shows a list of the controlled intersections that were identified as TCPs or SRBs in the TMP that were not previously actuated signals, including the type of control that currently exists at each location. To determine the impact of MTC at these locations, a summer, midweek, midday, good weather scenario (Scenario 1) evacuation of the entire EPZ (Region R03) was simulated wherein these intersections were left as is (without MTC). The results were compared to the results presented in Section 7. Although localized congestion worsened, the ETE changed by 5 minutes (not a significant change) at both the 90th and 100th percentile when MTC was not present at these intersections. The remaining TCPs and SRBs were left as actuated signals in the model and, therefore, had no impact to ETE.

As shown in Figure 7-3 through Figure 7-9 the southern and western portion of the EPZ experience very little traffic congestion. As such, the TCPs and SRBs in the southern and western portion of the EPZ do very little to help the ETE. The northern and eastern portion of the EPZ experiences significant traffic congestion. Heavy traffic flows exist in both the north-south and east direction as vehicles evacuate the area. When heavy traffic persists in competing directions, MTC provides little to no benefit since both approaches need equal amounts of green time. As a result, the TCPs and SRBs in the northern and eastern portion of the EPZ do very little to help the ETE as well.

In addition, traffic congestion clears prior to the completion of trip generation. The 100th percentile ETE is dictated by mobilization. As such, the impact of MTC at TCPs and SRBs will have little to no impact on the 100th percentile ETE.

Table G-1. List of Key TCP/SRB Locations

TCP/SRB	UNITES Node #	TCP or SRB	Previous Control
A-01	452	TCP	Stop Control
A-03	436	TCP	Stop Control
B-01	235	SRB	Stop Control
C-02	278	SRB	Stop Control
C-02-1	143	TCP	Yield Control
C-03	462	SRB	Stop Control
C-04	742	SRB	Stop Control
C-06	797	SRB	Stop Control
C-07-1	797	TCP	Stop Control
C-08-1	807	TCP	Stop Control
C-10	1655	SRB	Stop Control
C-12	494	SRB	Stop Control
H-08	215	TCP	Stop Control
L-03-1	808	TCP	Stop Control
L-05-1	806	TCP	Stop Control
L-06-1	903	TCP	Stop Control
L-08-1	852	TCP	Stop Control
W-01	1696	SRB	Stop Control
W-02	235	SRB	Stop Control
W-08	1134	SRB	Stop Control
W-26	525	SRB	Stop Control

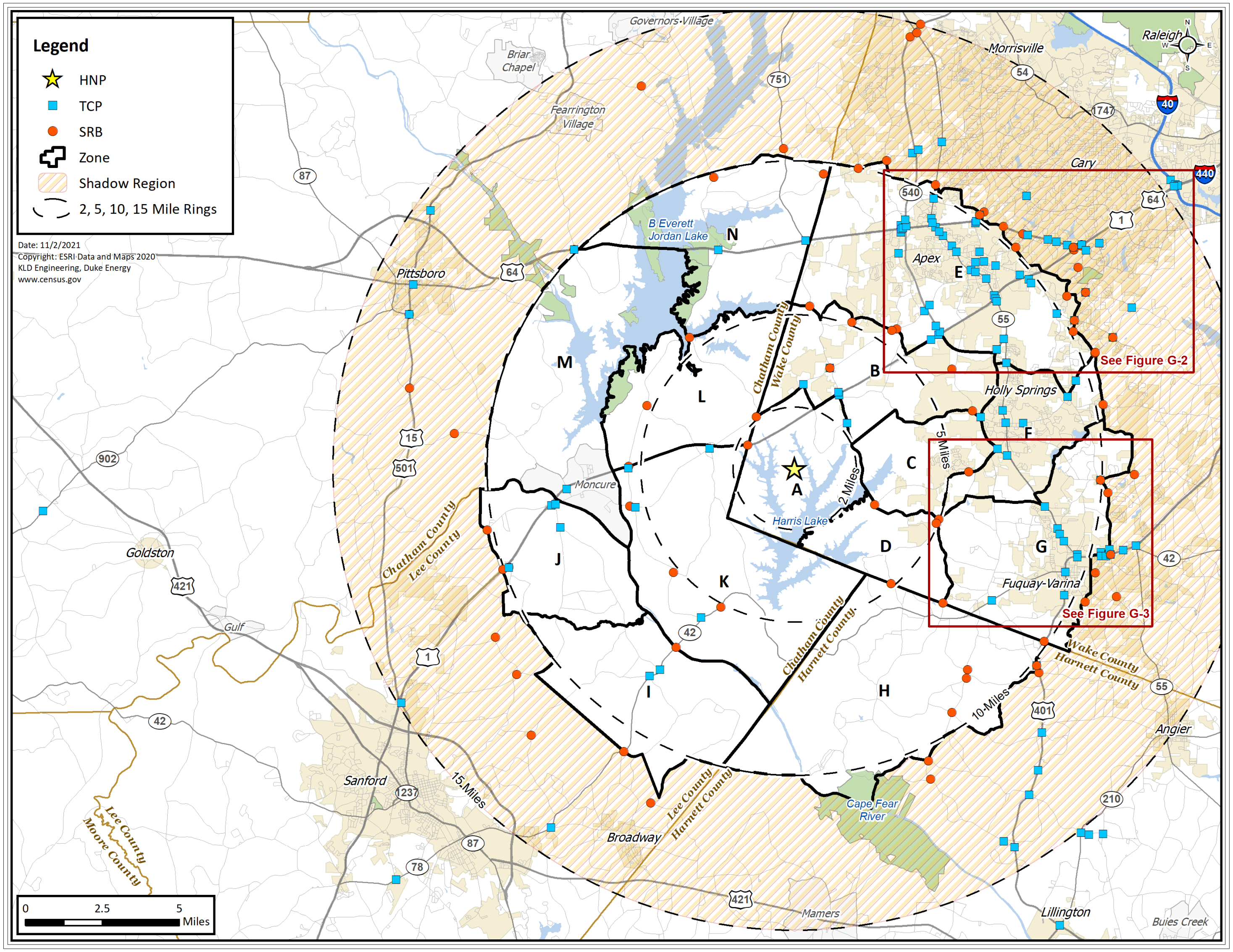


Figure G-1. Overview of Traffic Control Points and Security Road Blocks for the HNP Site

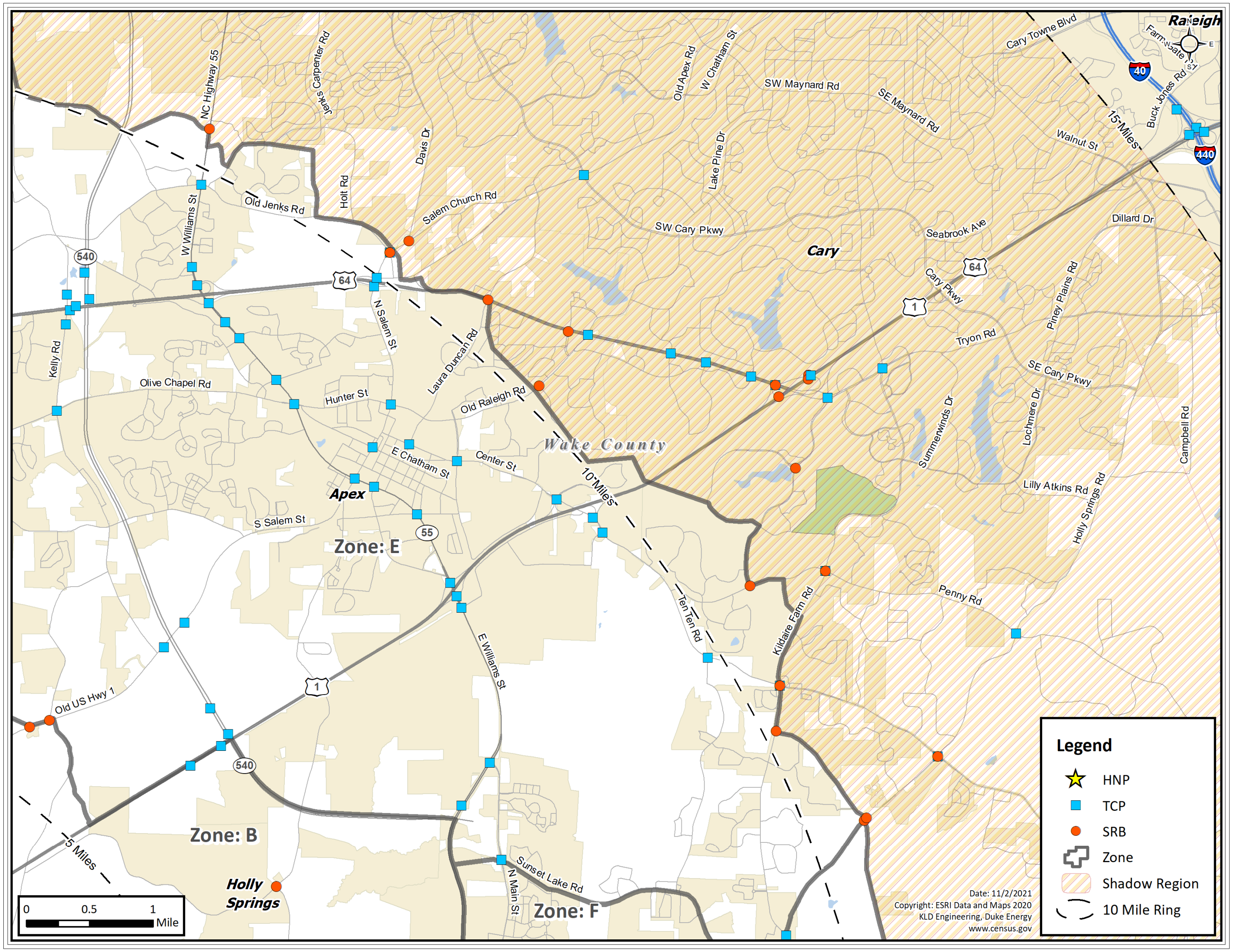


Figure G-2. Traffic Control Points and Security Road Blocks within Zones B, E and Cary in the Shadow Region

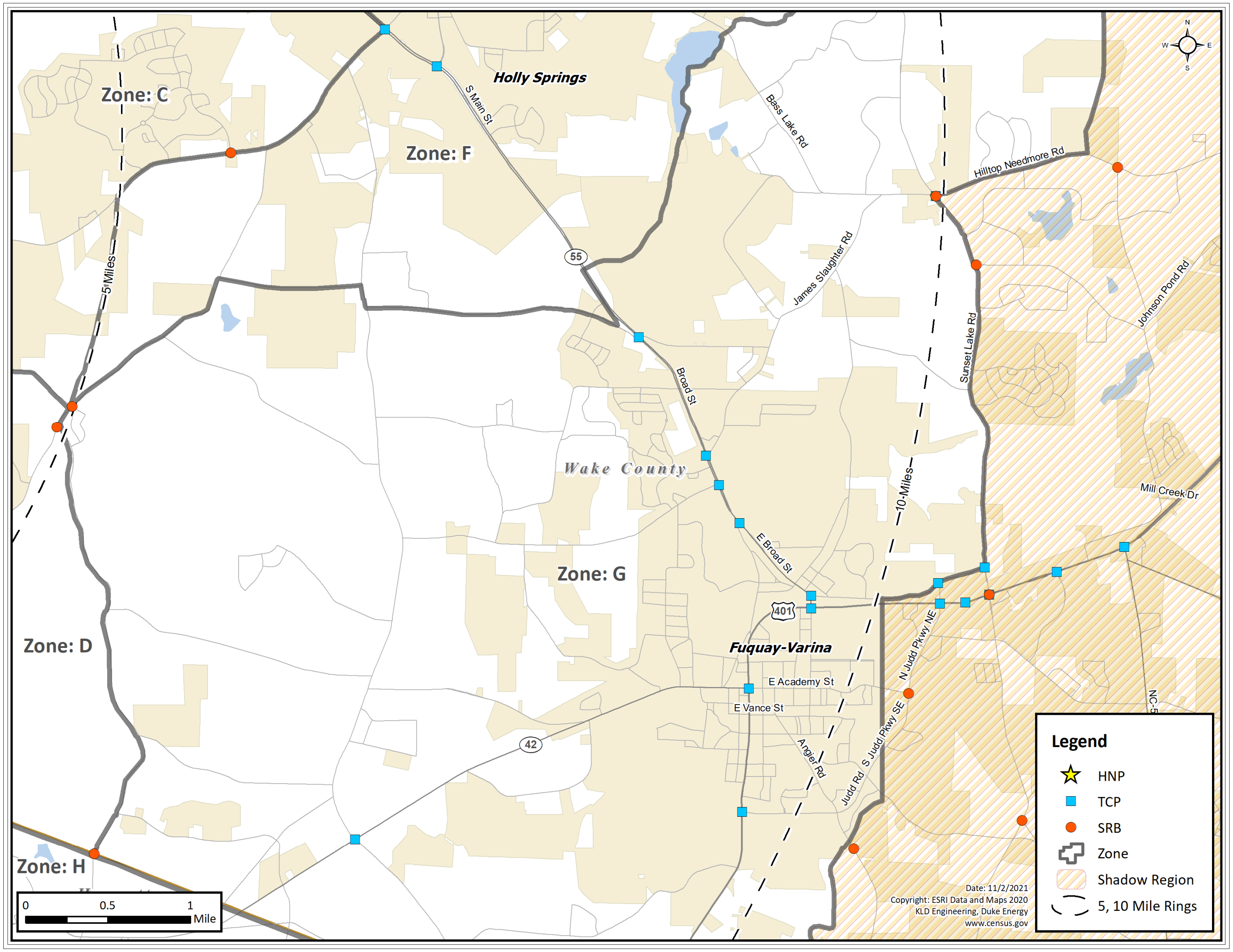


Figure G-3. Traffic Control Points and Security Road Blocks within Zones F, G and Fuquay-Varina in the Shadow Region

APPENDIX H

Evacuation Regions

H EVACUATION REGIONS

This appendix presents the evacuation percentages for each Evacuation Region (Table H-1) and maps of all Evacuation Regions (Figure H-1 through Figure H-37). The percentages presented in Table H-1 are based on the methodology discussed in assumption 7 of Section 2.2 and shown in Figure 2-1.

Note the baseline ETE study assumes 20 percent of households will not comply with the shelter advisory, as per Section 2.5.2 of NUREG/CR-7002, Rev 1.

Table H-1. Percent of Zone Population Evacuating for Each Region

Region	Description	Site PAR Description	Zone													
			A	B	C	D	E	F	G	H	I	J	K	L	M	N
R01	2-Mile Radius	2-Mile Radius	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R02	5-Mile Radius	5-Mile Radius	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	100%	100%	20%	20%
R03	Full EPZ	10-Mile Radius	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Evacuate 2-Mile Radius and Downwind to 5 Miles																
Region	**Wind Direction From:**	**Site PAR Description**	**Zone**													
			A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**
R04	NNW, N	327° - 010°	100%	20%	20%	100%	20%	20%	20%	20%	20%	20%	100%	20%	20%	20%
R05	NNE, NE	011° - 056°	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	100%	20%	20%	20%
R06	ENE, E, ESE	057° - 124°	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	100%	100%	20%	20%
R07	SE, SSE, S	125° - 191°	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	100%	20%	20%
R08	SSW	192° - 214°	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R09	SW, WSW	215° - 259°	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R10	W	260° - 281°	100%	20%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R11	WNW	282° - 304°	100%	20%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R12	NW	305° - 326°	100%	20%	20%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Evacuate 2-Mile Radius and Downwind to the EPZ Boundary																
Region	**Wind Direction From:**	**Site PAR Description**	**Zone**													
			A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**
R13	N	348° - 010°	100%	20%	20%	100%	20%	20%	20%	100%	100%	20%	100%	20%	20%	20%
R14	NNE	011° - 034°	100%	20%	20%	20%	20%	20%	20%	100%	100%	100%	100%	20%	20%	20%
R15	NE	035° - 056°	100%	20%	20%	20%	20%	20%	20%	20%	100%	100%	100%	20%	100%	20%
R16	ENE	057° - 079°	100%	20%	20%	20%	20%	20%	20%	20%	100%	100%	100%	100%	100%	20%
R17	E	080° - 101°	100%	20%	20%	20%	20%	20%	20%	20%	20%	100%	100%	100%	100%	20%
R18	ESE	102° - 124°	100%	20%	20%	20%	20%	20%	20%	20%	20%	100%	100%	100%	100%	100%
R19	SE	125° - 146°	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	100%	100%	100%
R20	SSE, S	147° - 191°	100%	100%	20%	20%	100%	20%	20%	20%	20%	20%	20%	100%	100%	100%
R21	SSW	192° - 214°	100%	100%	20%	20%	100%	20%	20%	20%	20%	20%	20%	100%	20%	100%
R22	SW	215° - 236°	100%	100%	100%	20%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%
R23	WSW	237° - 259°	100%	100%	100%	20%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%
R24	W	260° - 281°	100%	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%
R25	WNW	282° - 304°	100%	20%	100%	100%	20%	100%	100%	100%	20%	20%	20%	20%	20%	20%
R26	NW	305° - 326°	100%	20%	100%	100%	20%	20%	100%	100%	20%	20%	100%	20%	20%	20%
R27	NNW	327° - 347°	100%	20%	20%	100%	20%	20%	100%	100%	20%	20%	100%	20%	20%	20%

Staged Evacuation - 2-Mile Radius Evacuates, then Evacuate Downwind to 5 Miles																
Region	Wind Direction From:	Site PAR Description	Zone													
			A	B	C	D	E	F	G	H	I	J	K	L	M	N
R28	-	5-Mile Radius	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	100%	100%	20%	20%
R29	NNW, N	327° - 010°	100%	20%	20%	100%	20%	20%	20%	20%	20%	20%	100%	20%	20%	20%
R30	NNE, NE	011° - 056°	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	100%	20%	20%	20%
R31	ENE, E, ESE	057° - 124°	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	100%	100%	20%	20%
R32	SE, SSE, S	125° - 191°	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	100%	20%	20%
R33	SSW	192° - 214°	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R34	SW, WSW	215° - 259°	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R35	W	260° - 281°	100%	20%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R36	WNW	282° - 304°	100%	20%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R37	NW	305° - 326°	100%	20%	20%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Shelter-in-Place until 90% ETE for R01, then Evacuate			Zone(s) Shelter-in-Place							Zone(s) Evacuate						

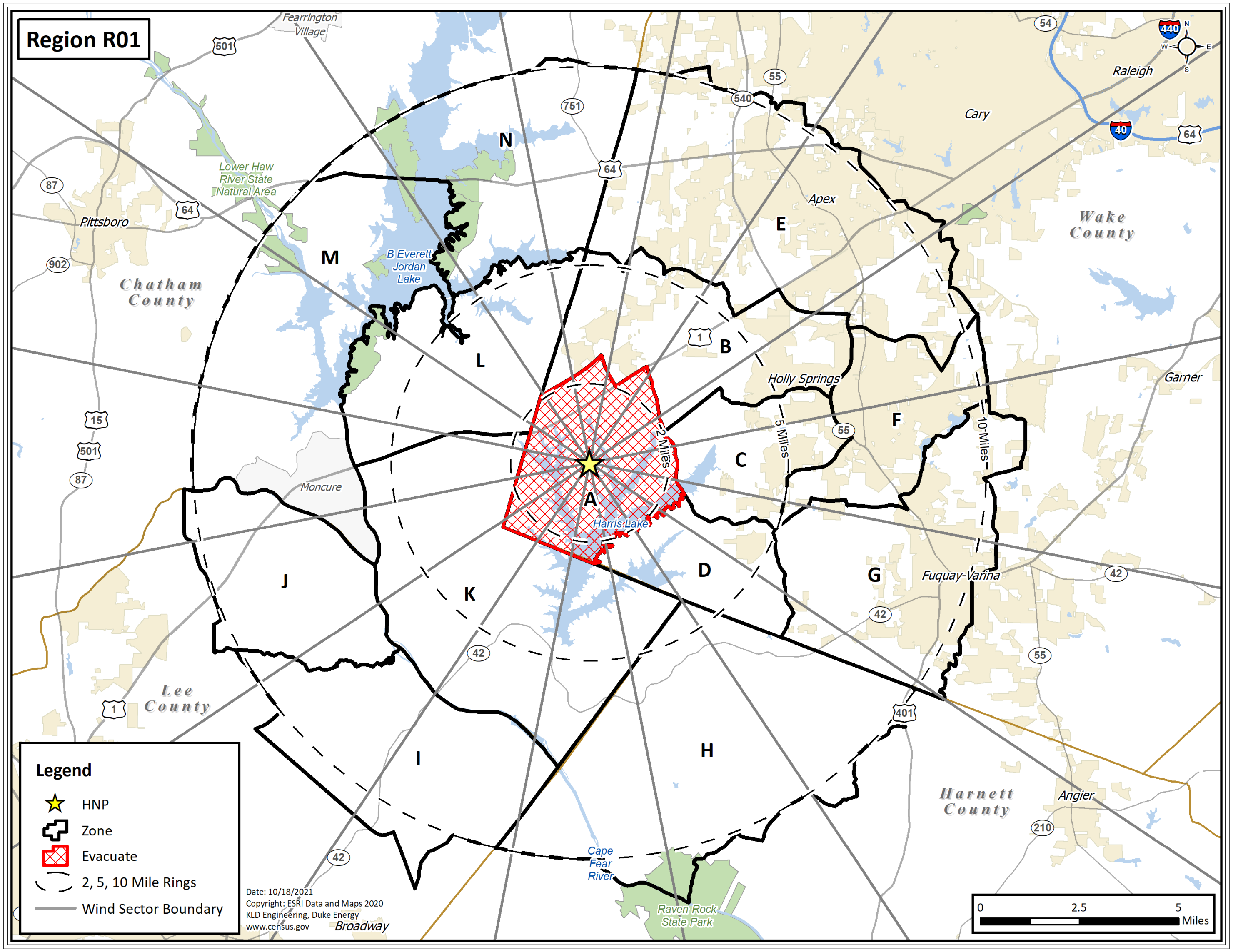


Figure H-1. Region R01

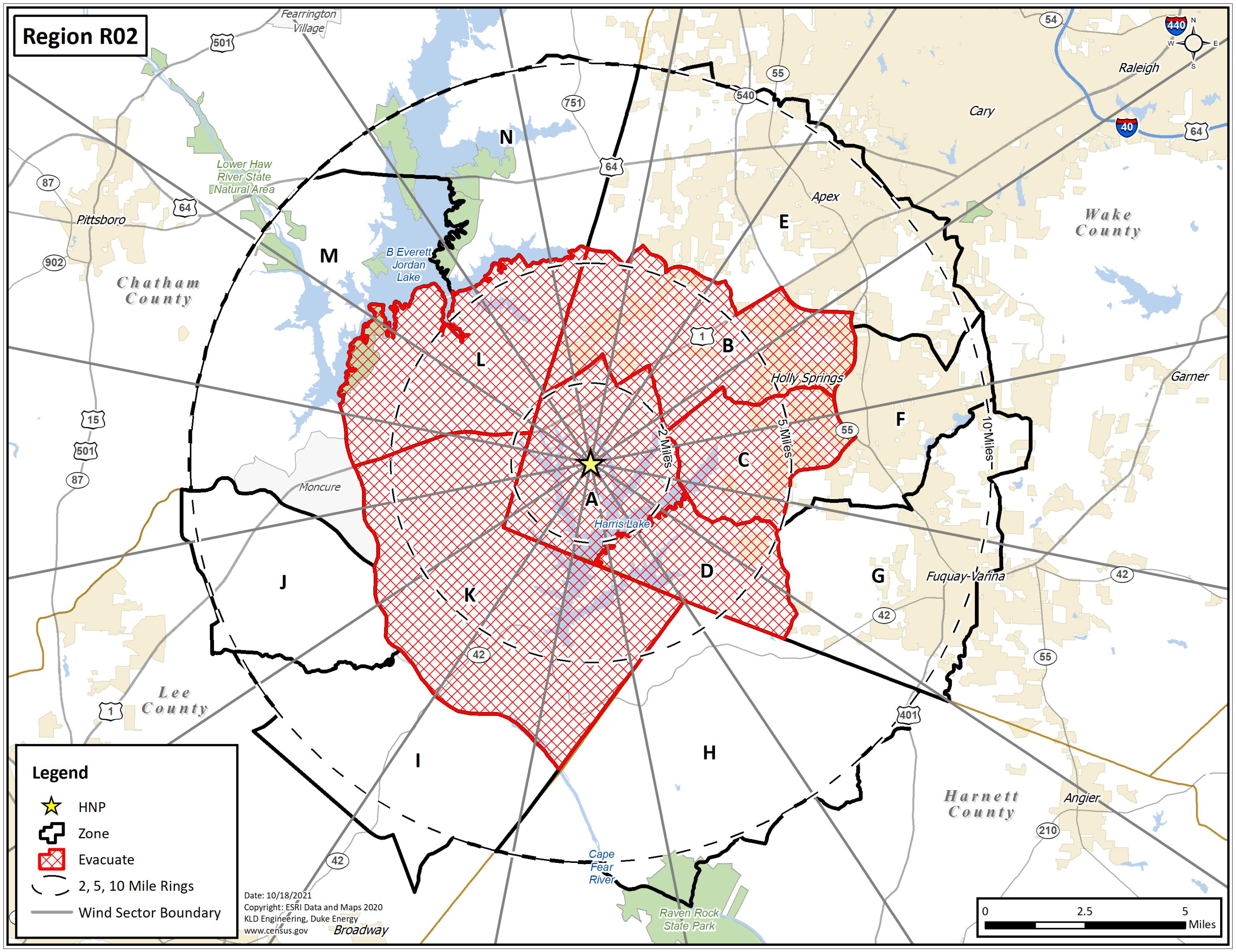


Figure H-2. Region R02

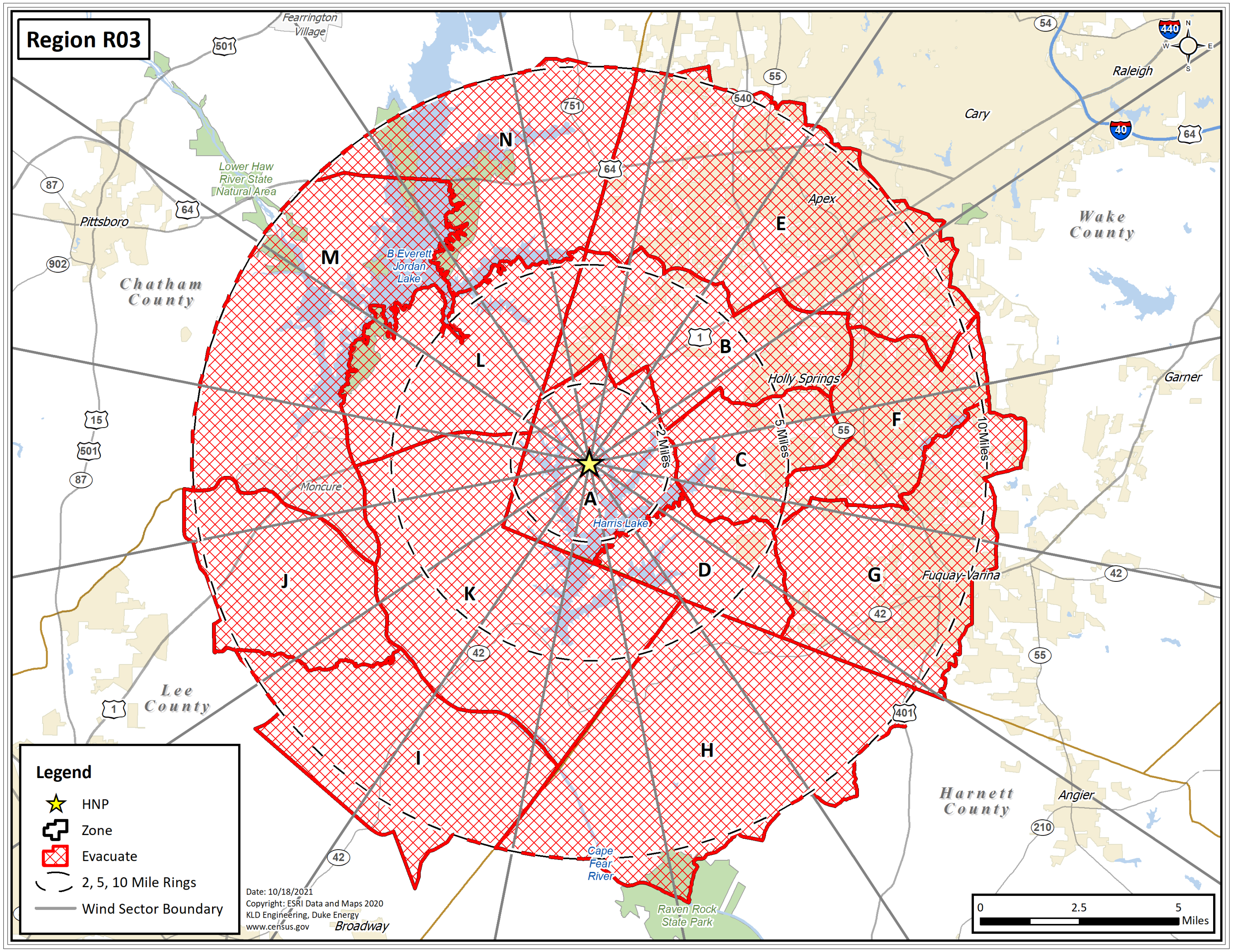


Figure H-3. Region R03

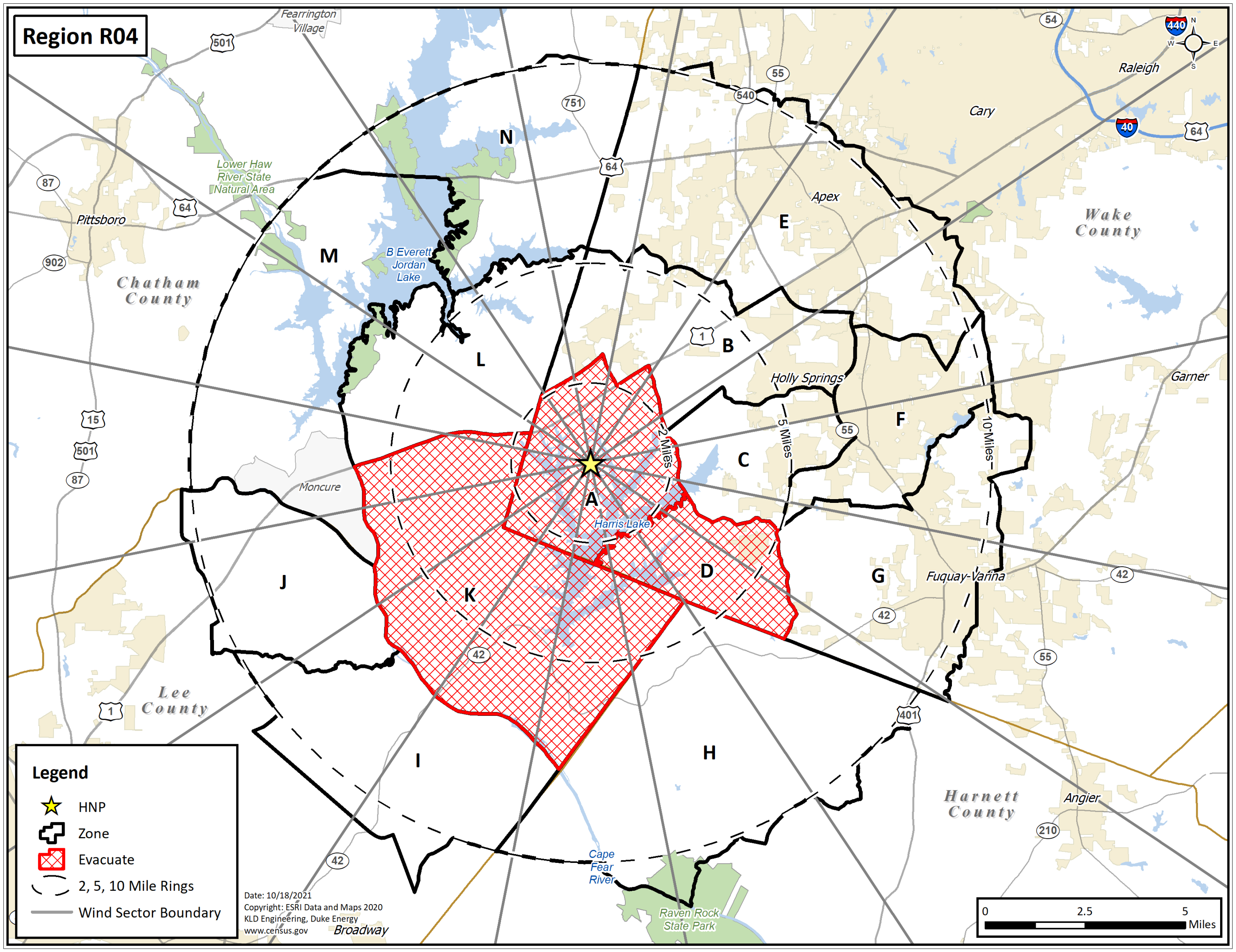


Figure H-4. Region R04

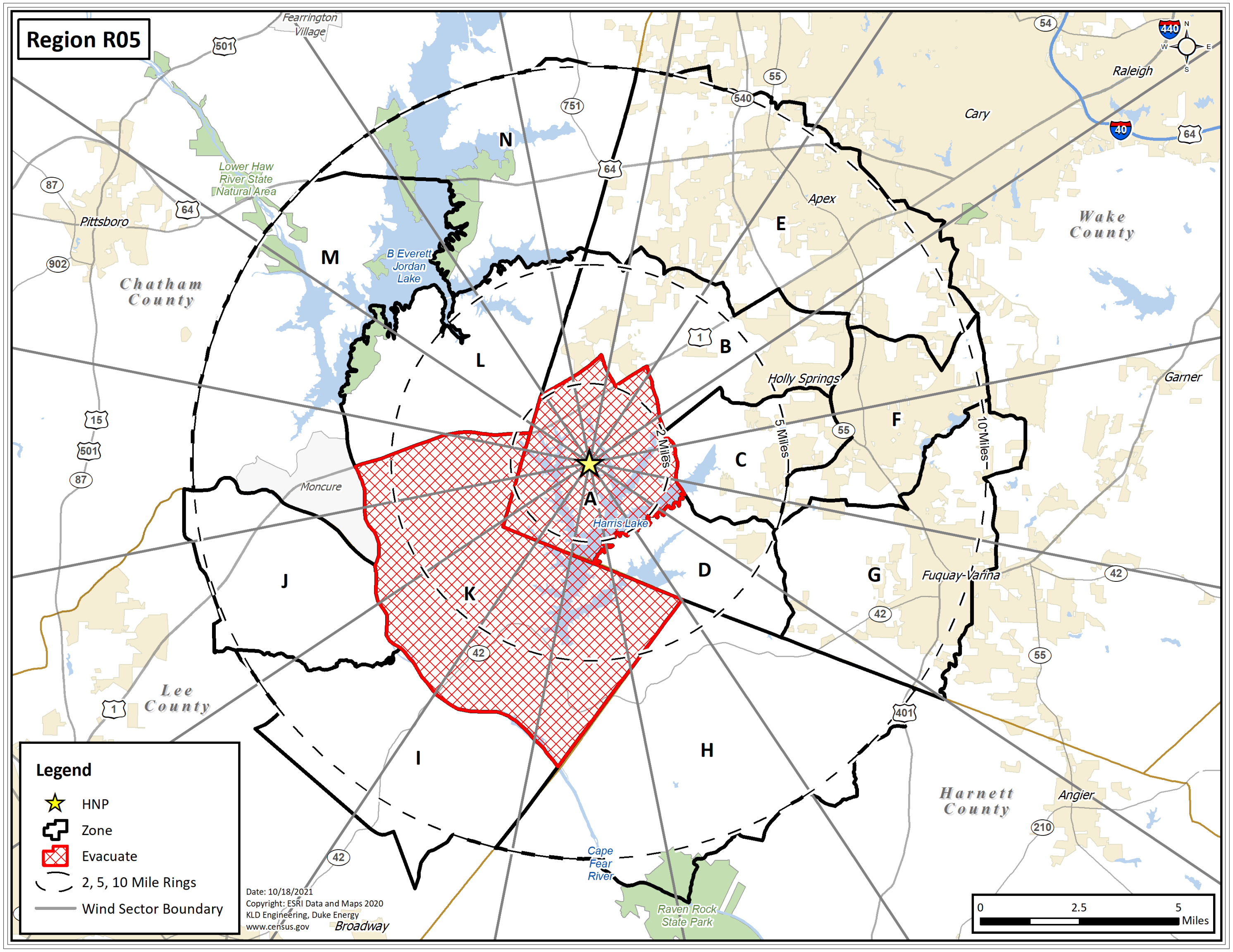


Figure H-5. Region R05

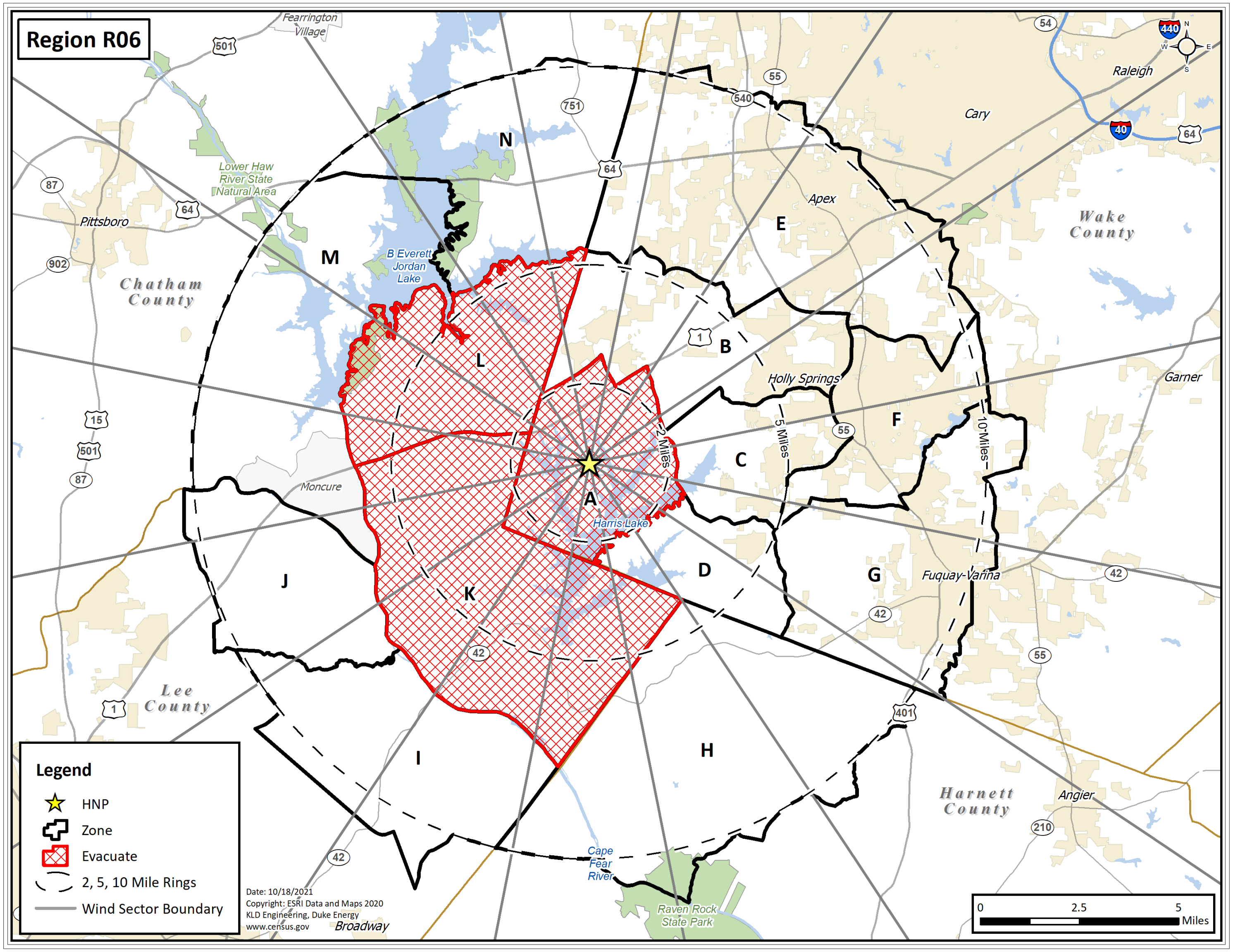


Figure H-6. Region R06

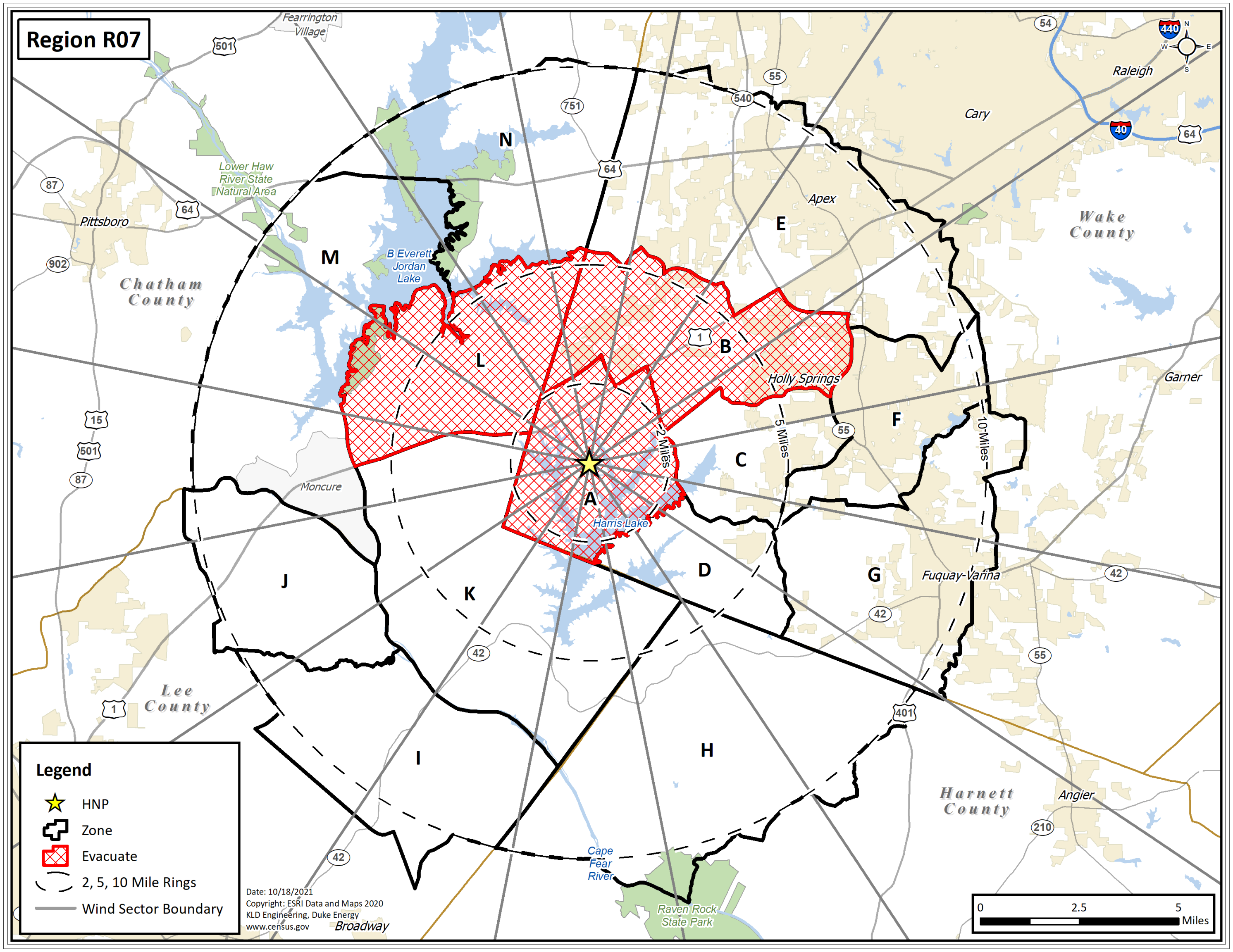


Figure H-7. Region R07

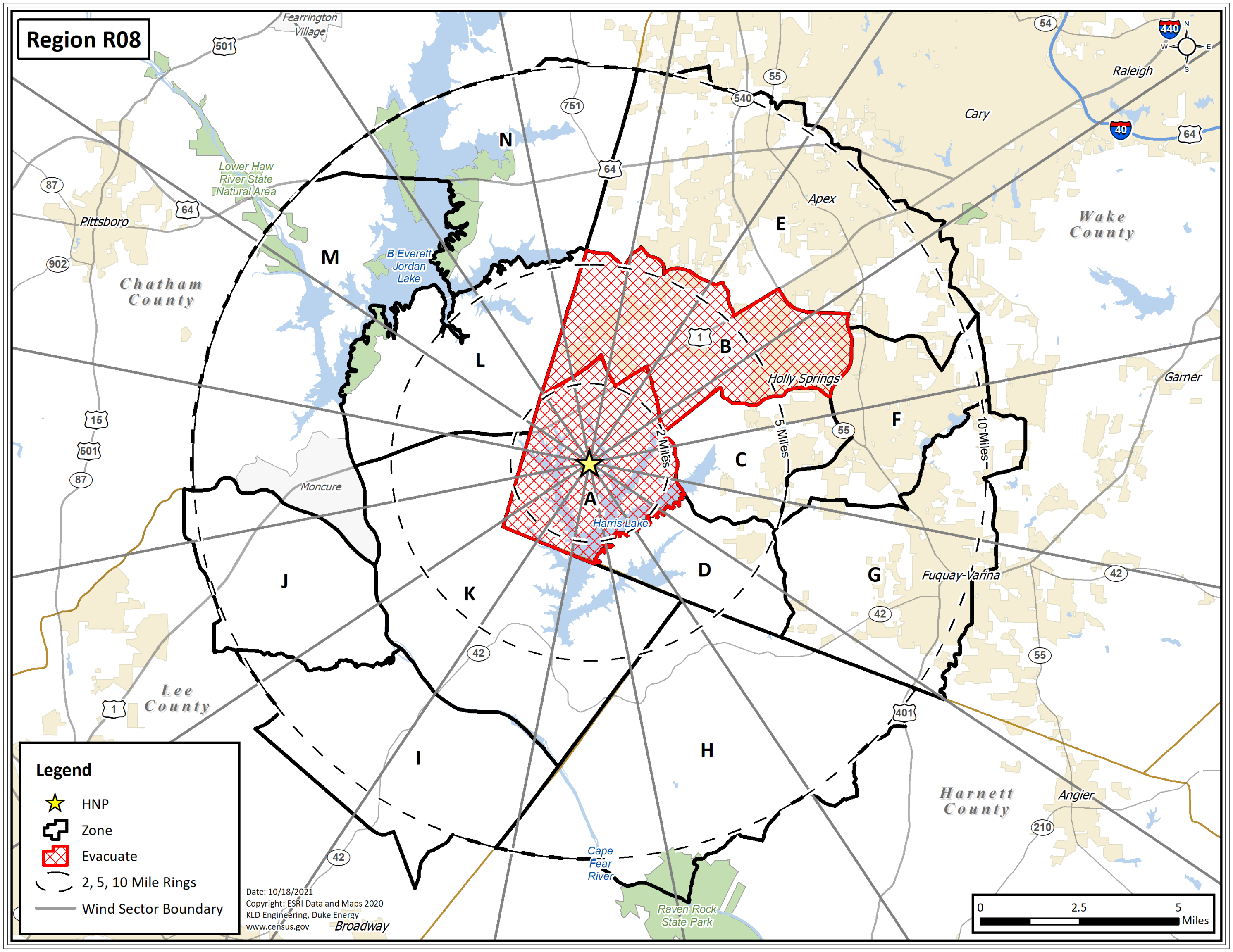


Figure H-8. Region R08

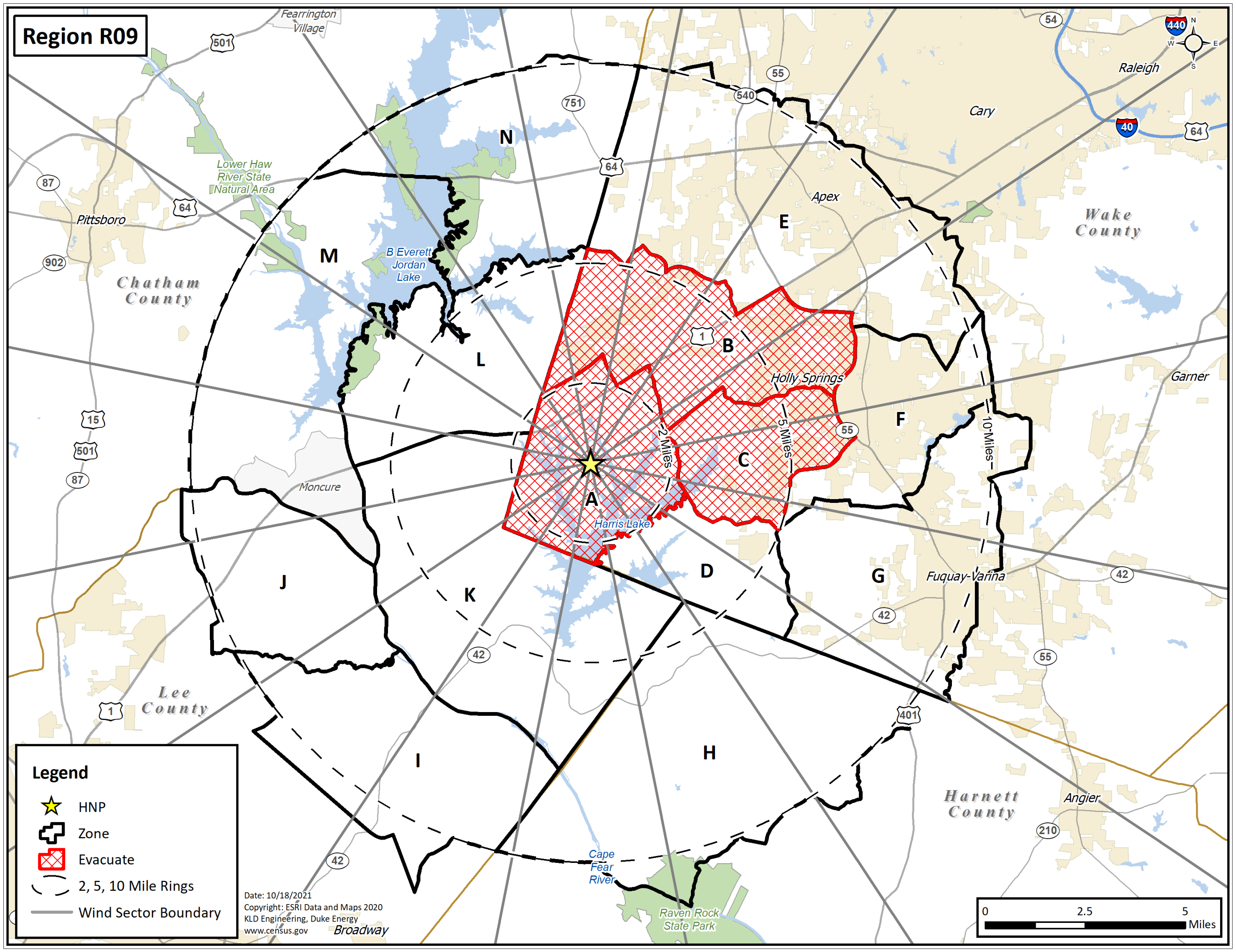


Figure H-9. Region R09

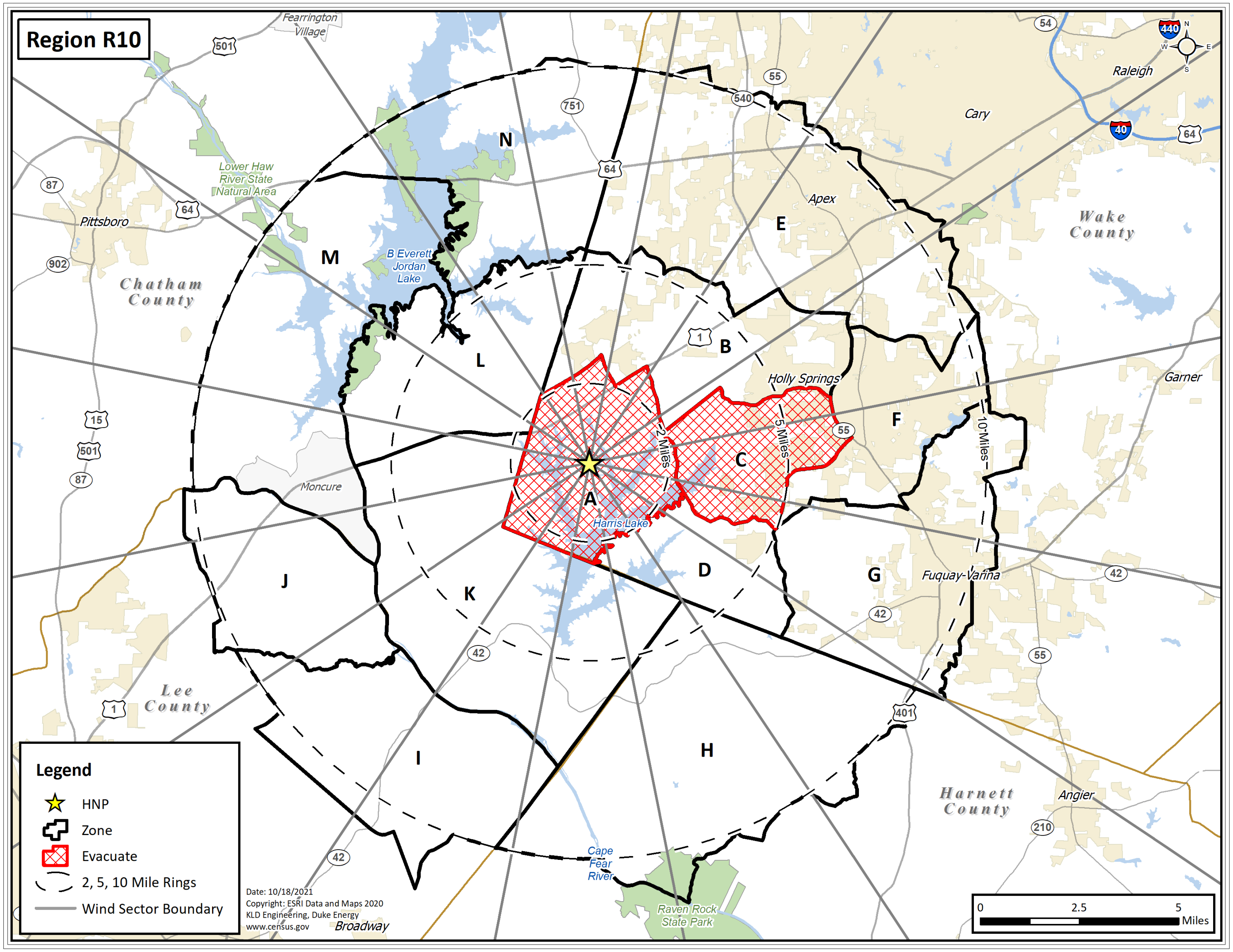


Figure H-10. Region R10

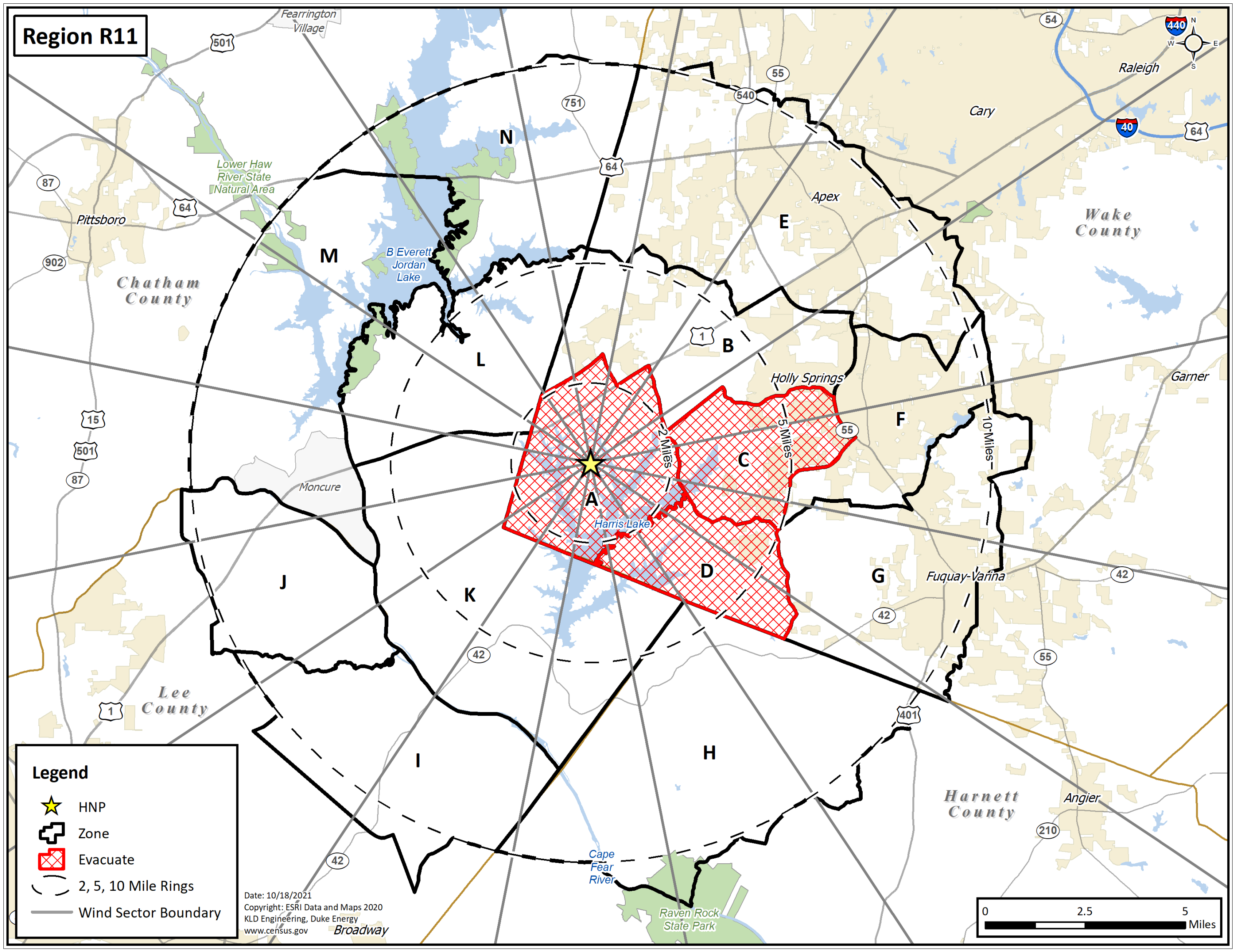


Figure H-11. Region R11

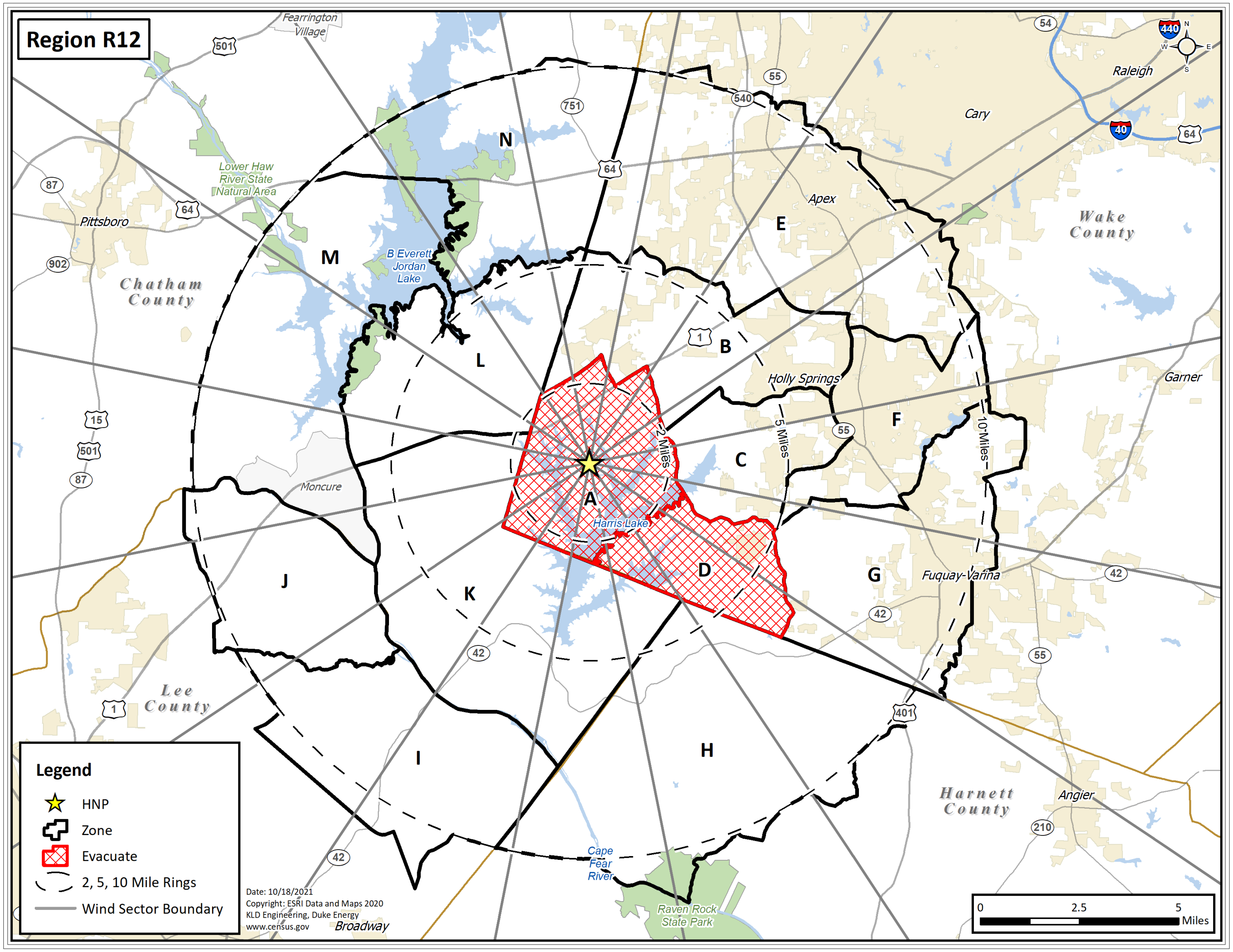


Figure H-12. Region R12

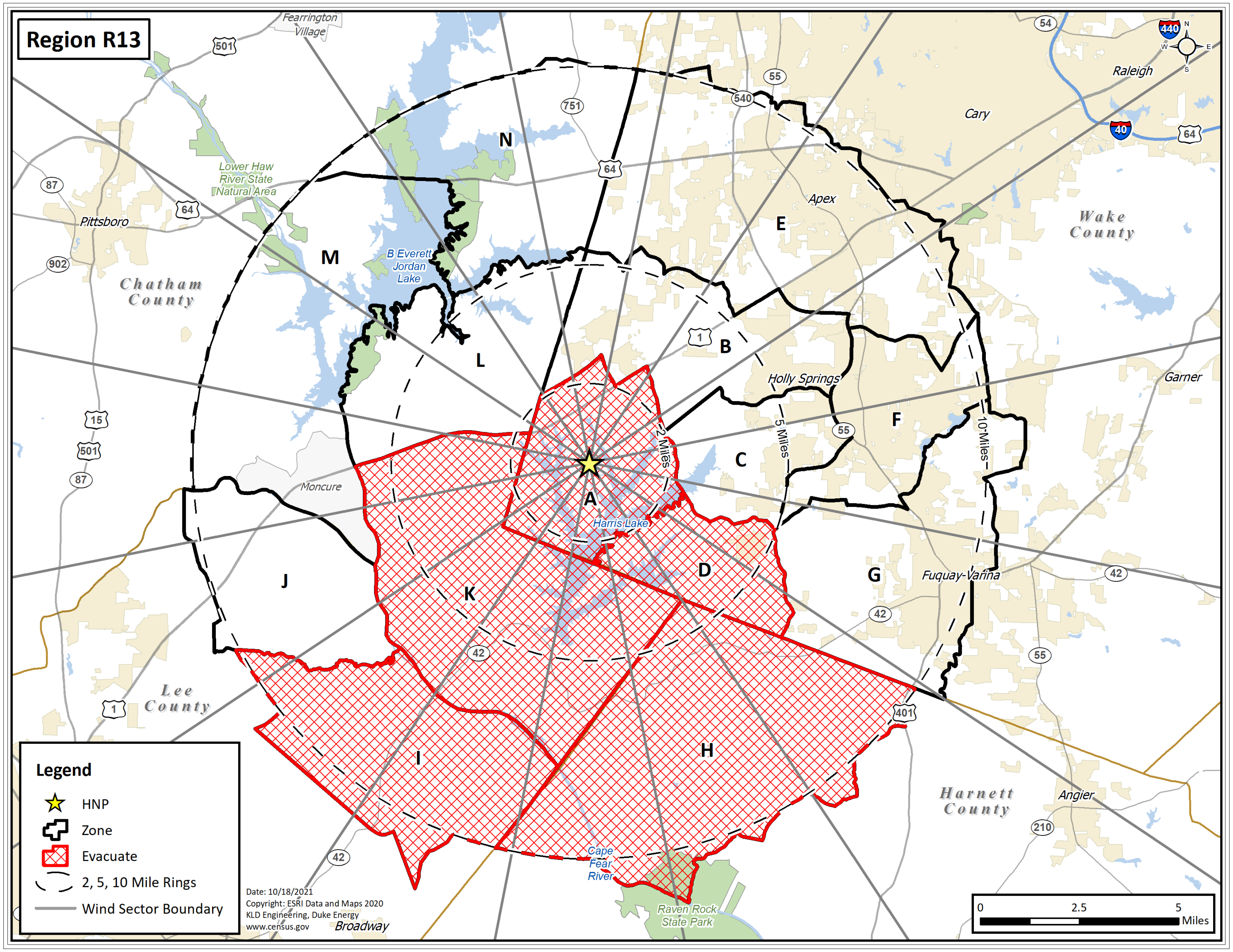


Figure H-13. Region R13

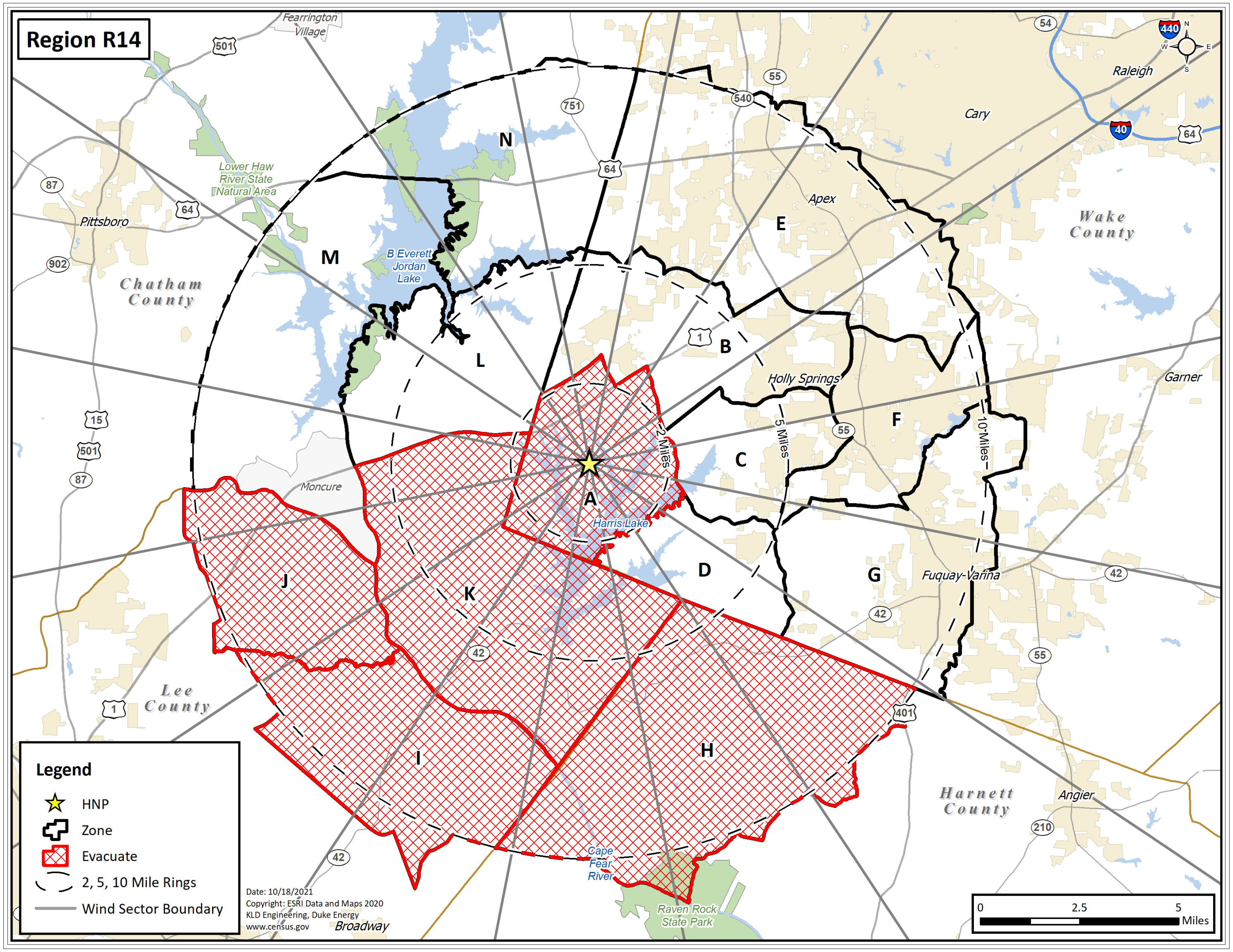


Figure H-14. Region R14

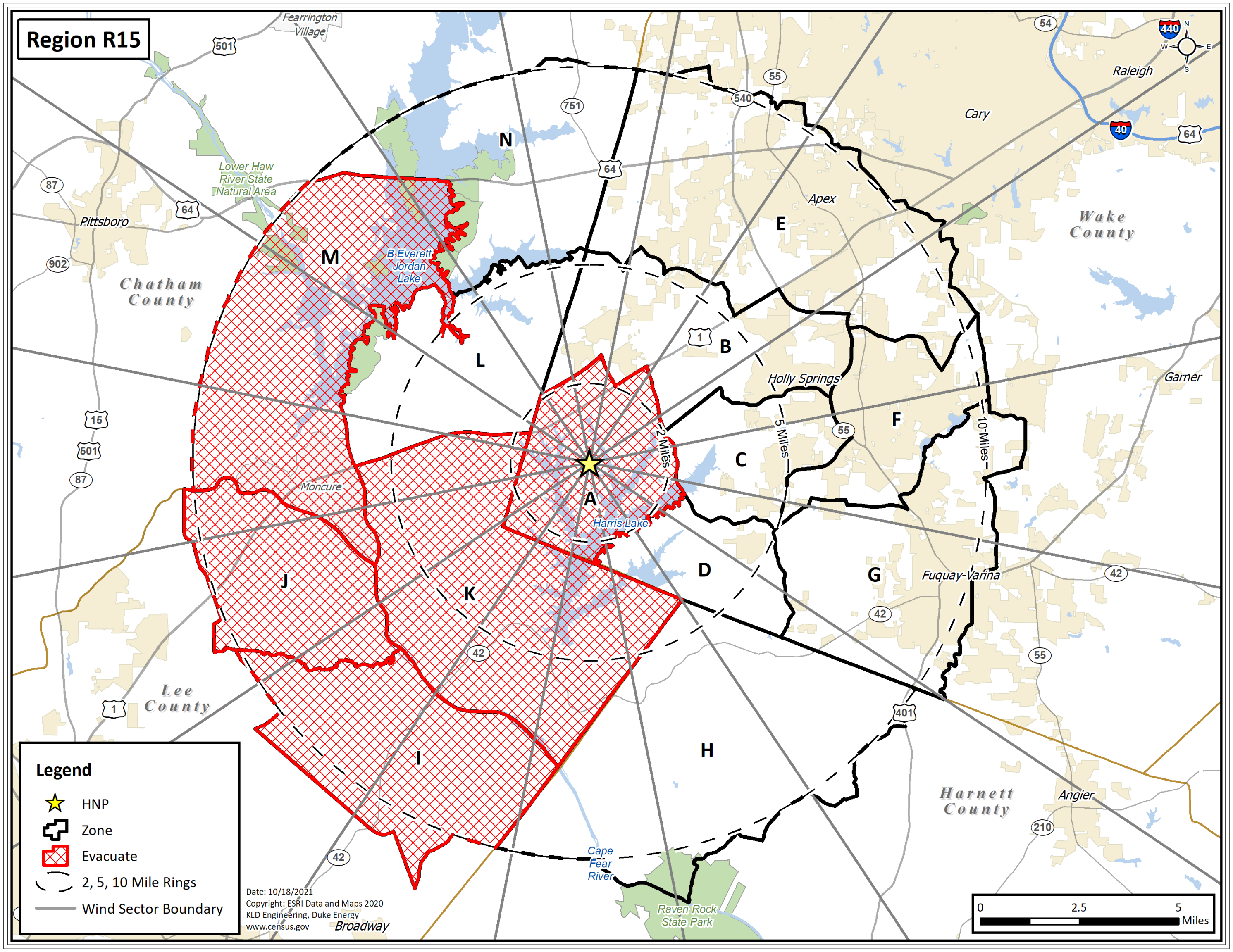


Figure H-15. Region R15

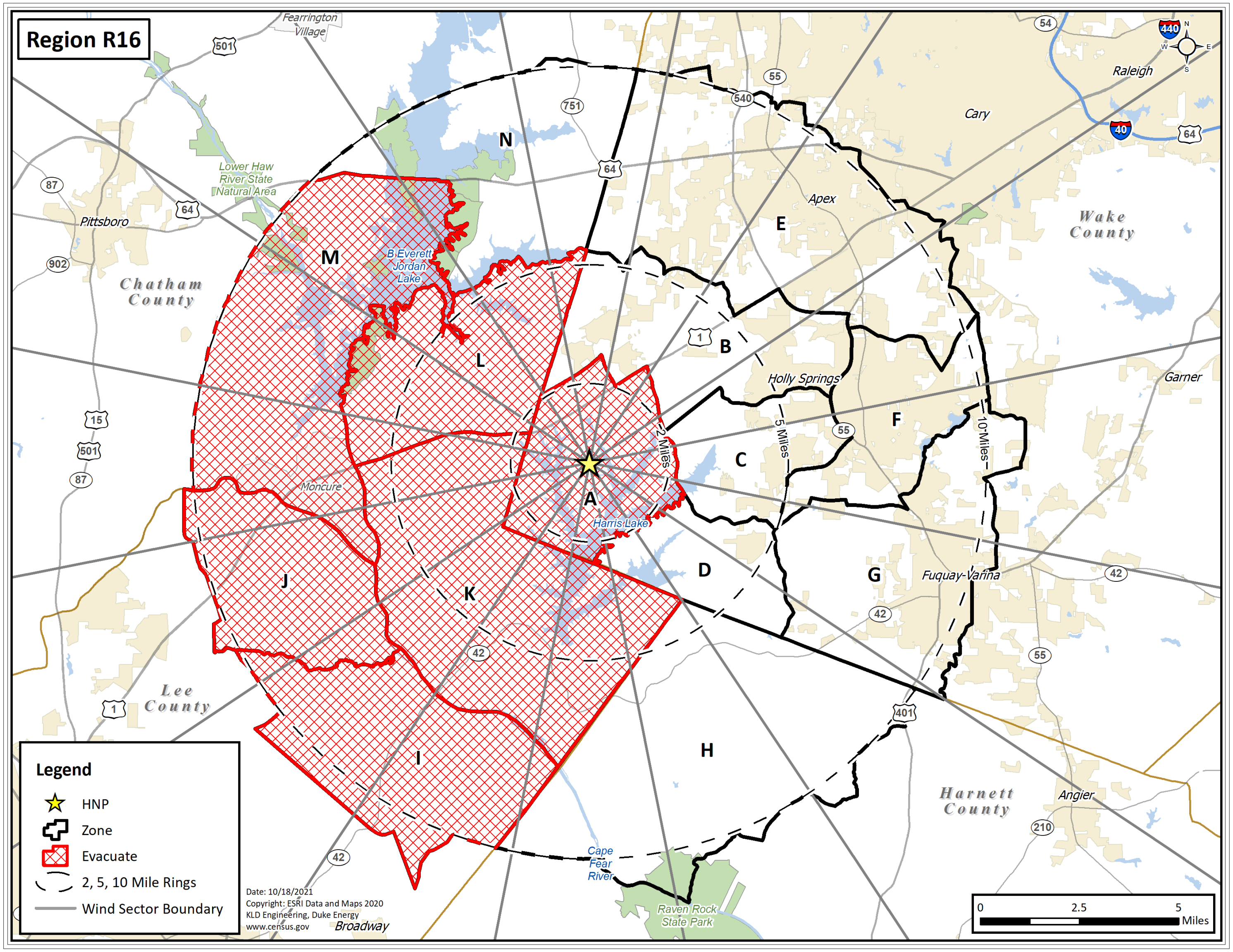


Figure H-16. Region R16

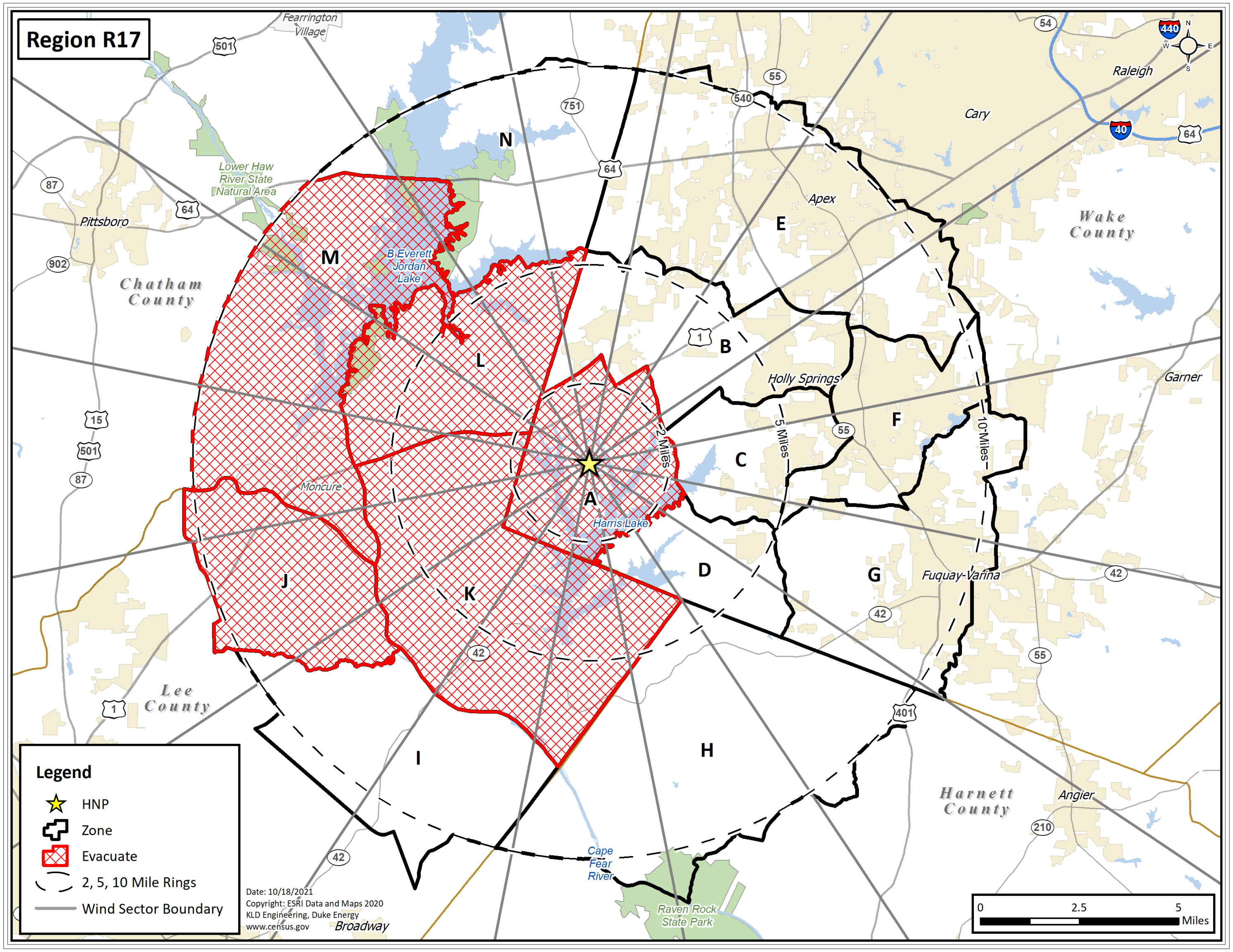


Figure H-17. Region R17

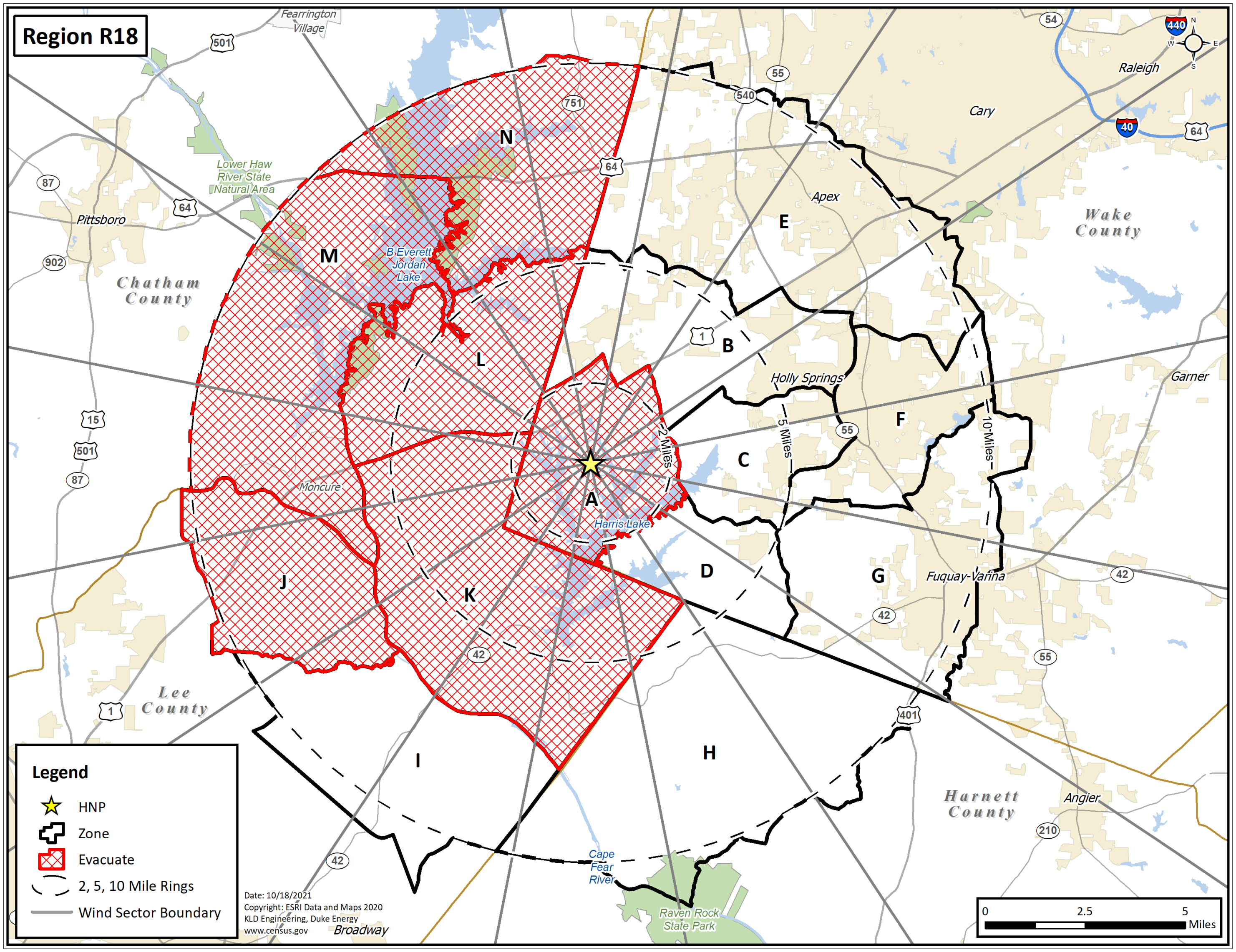


Figure H-18. Region R18

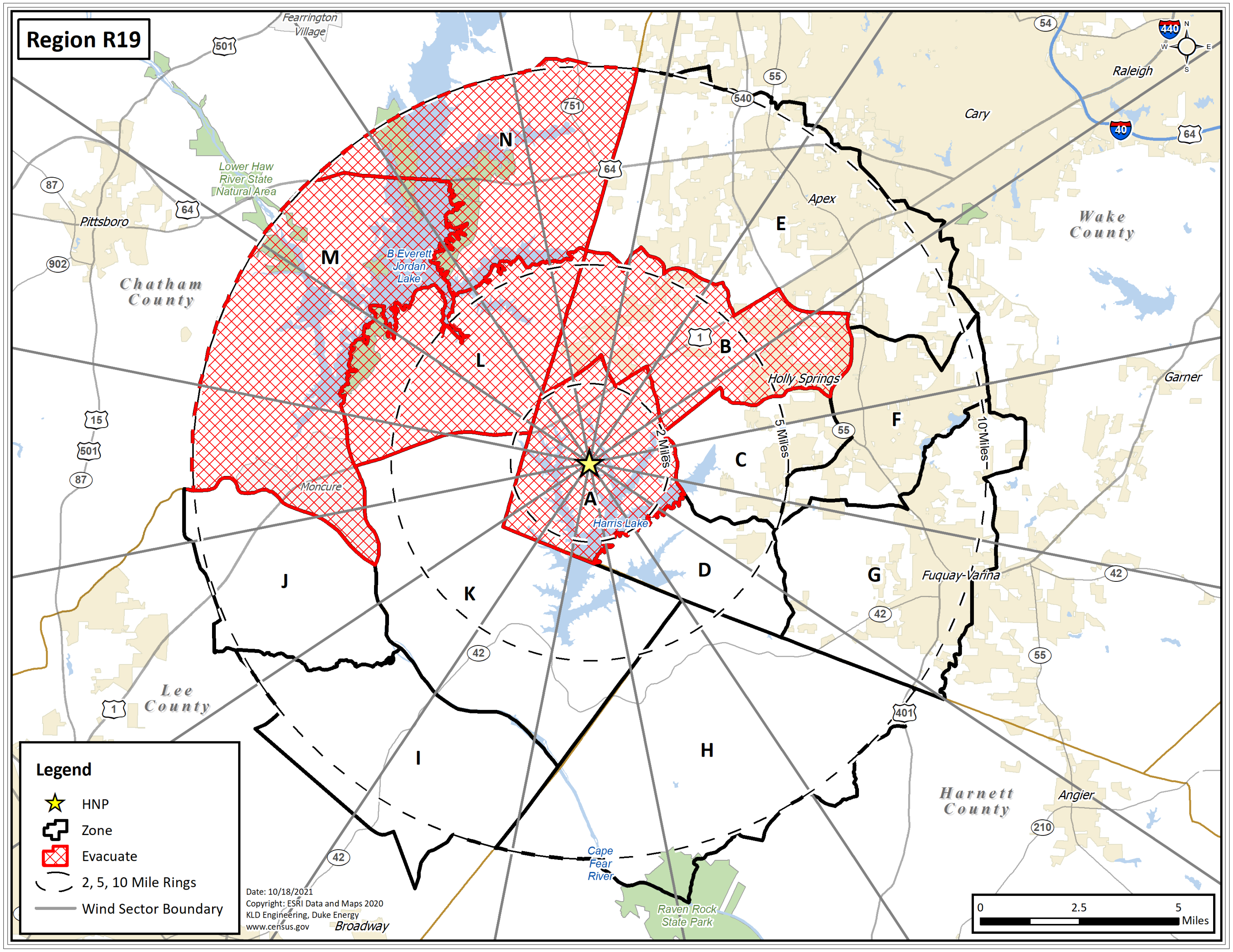


Figure H-19. Region R19

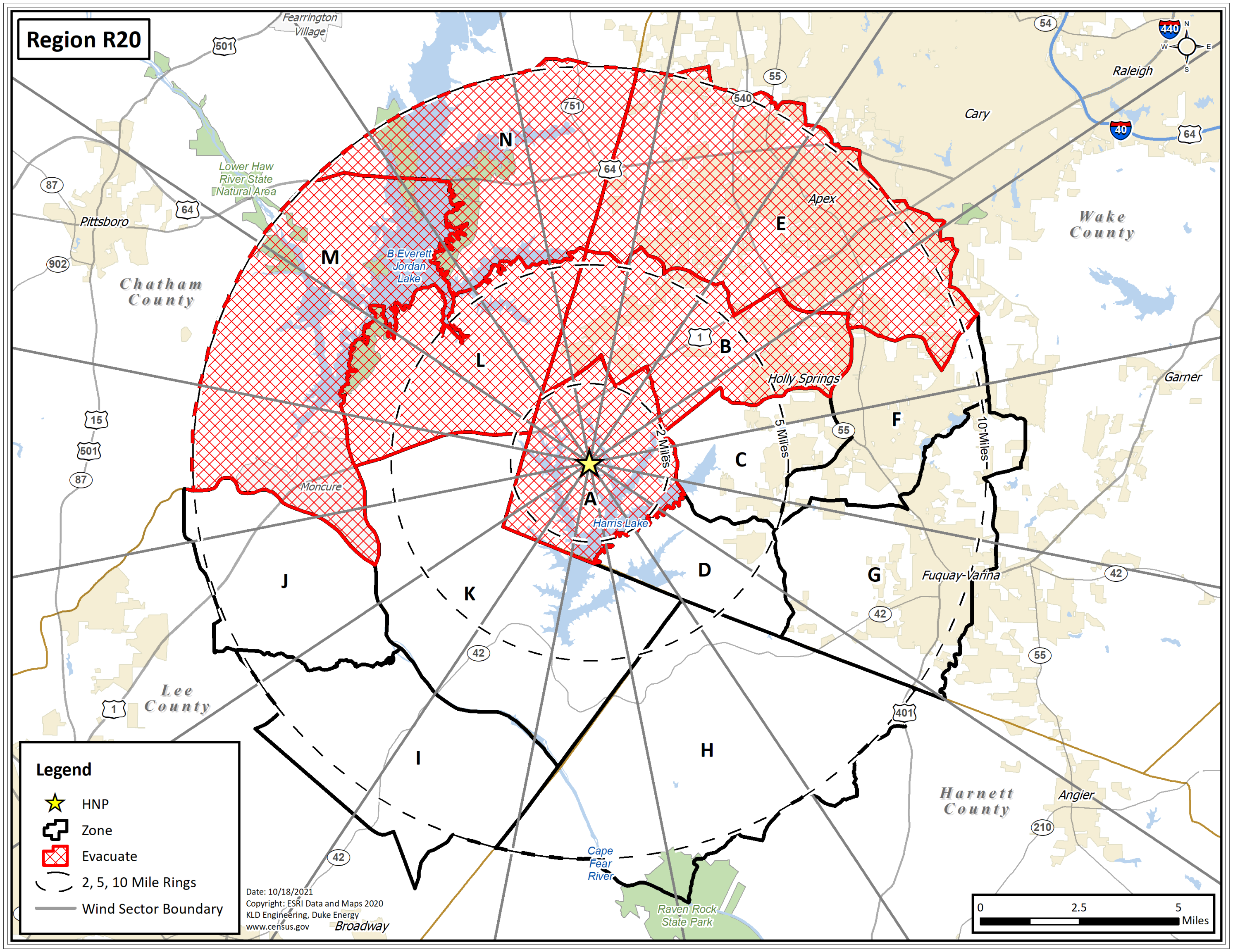


Figure H-20. Region R20

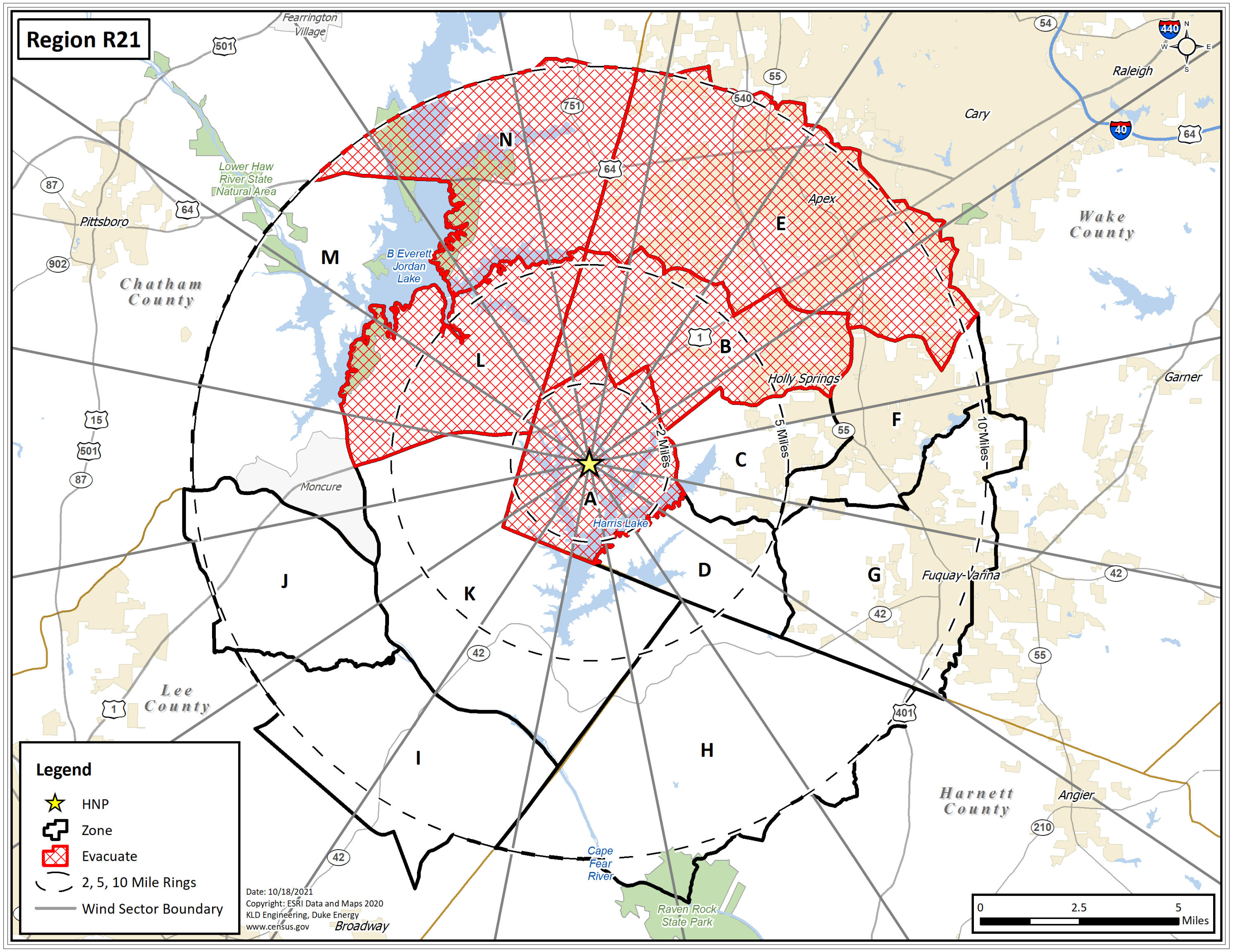


Figure H-21. Region R21

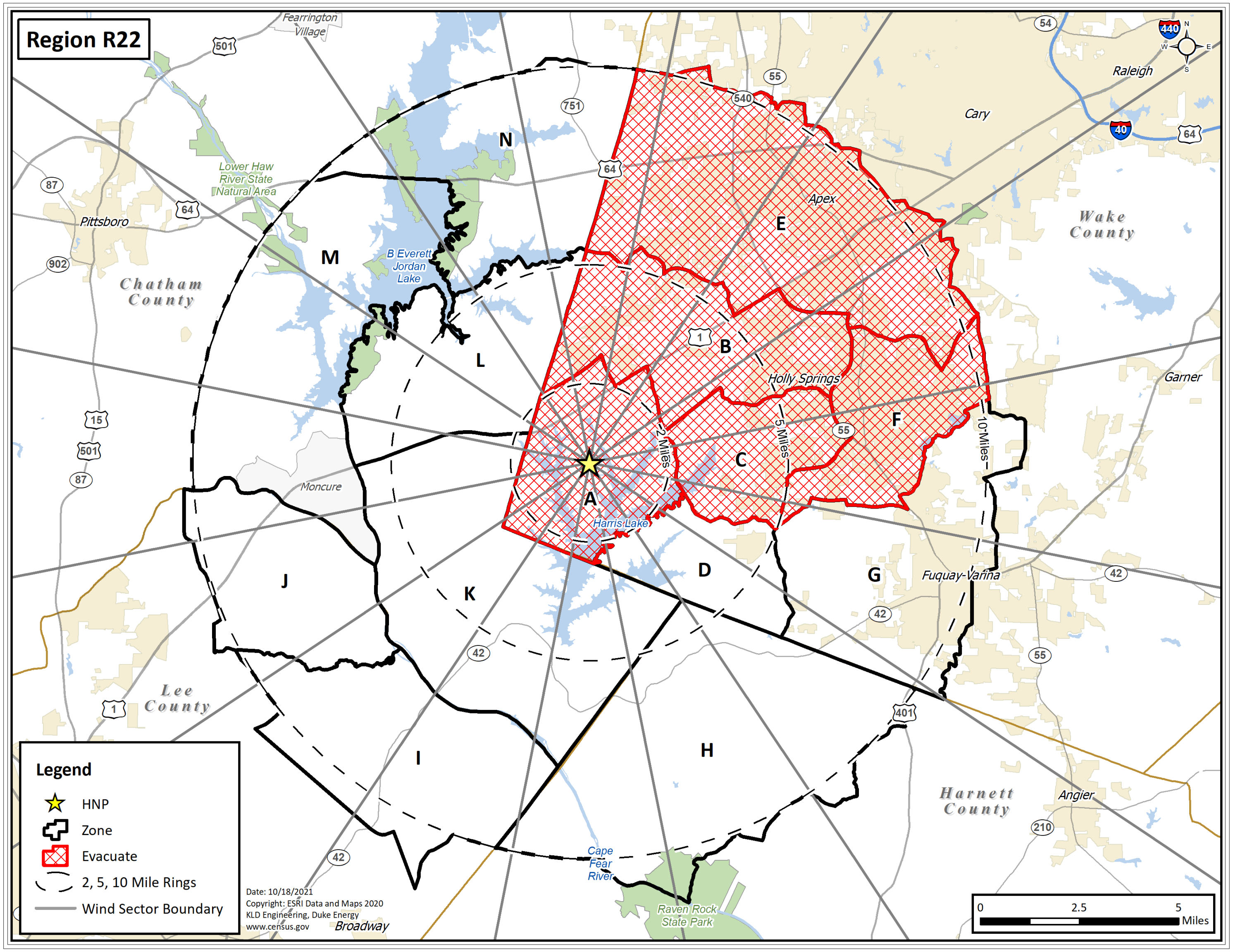


Figure H-22. Region R22

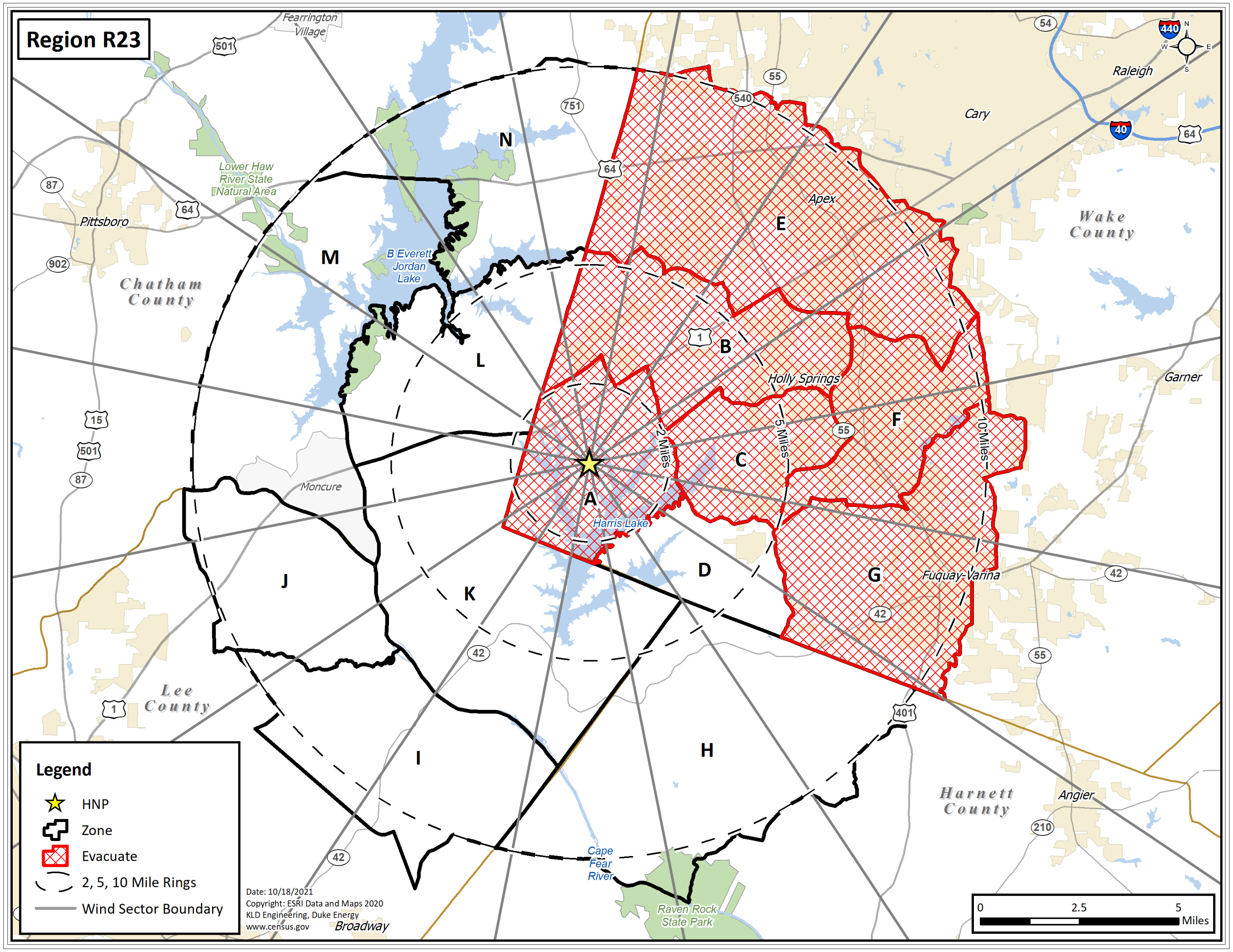


Figure H-23. Region R23

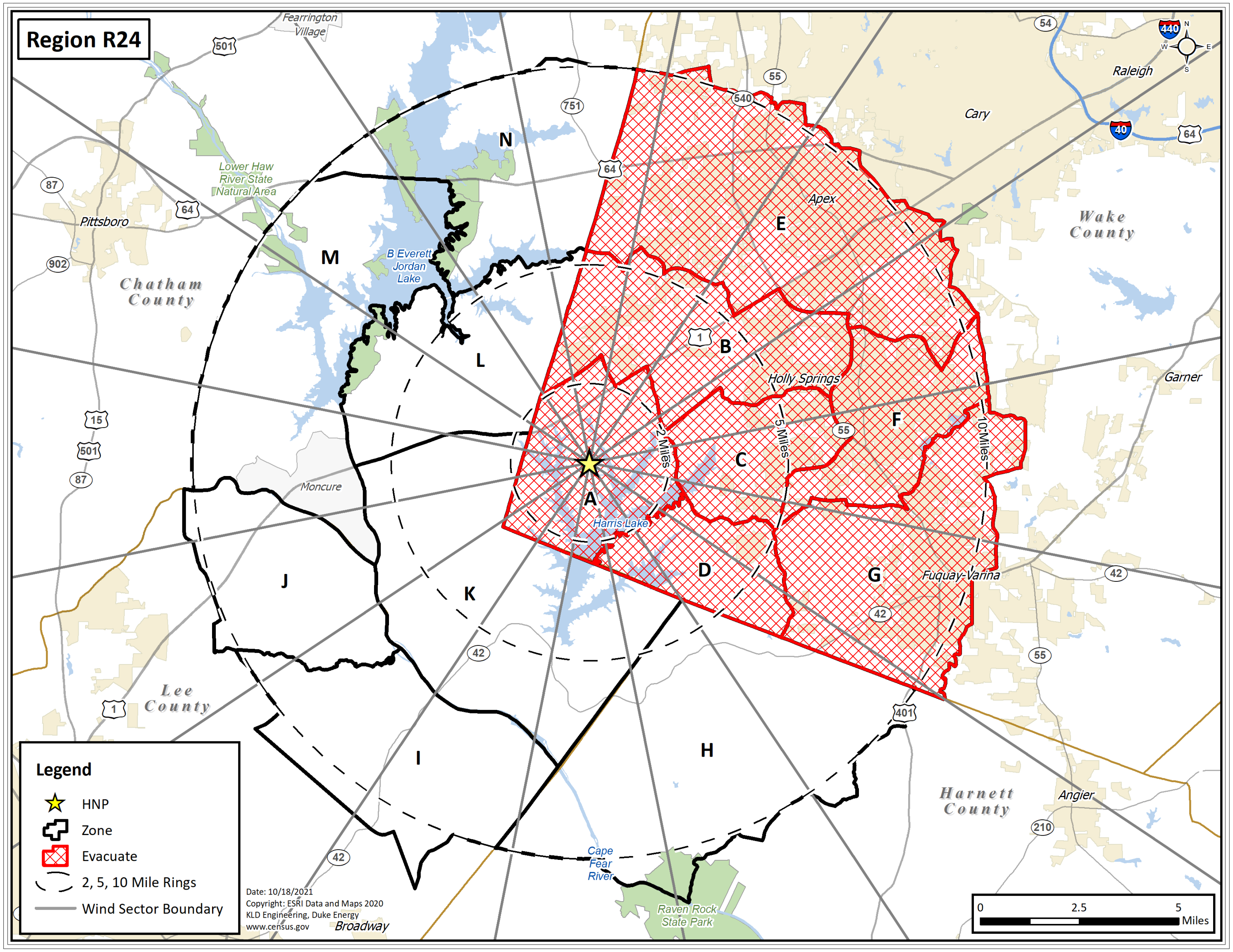


Figure H-24. Region R24

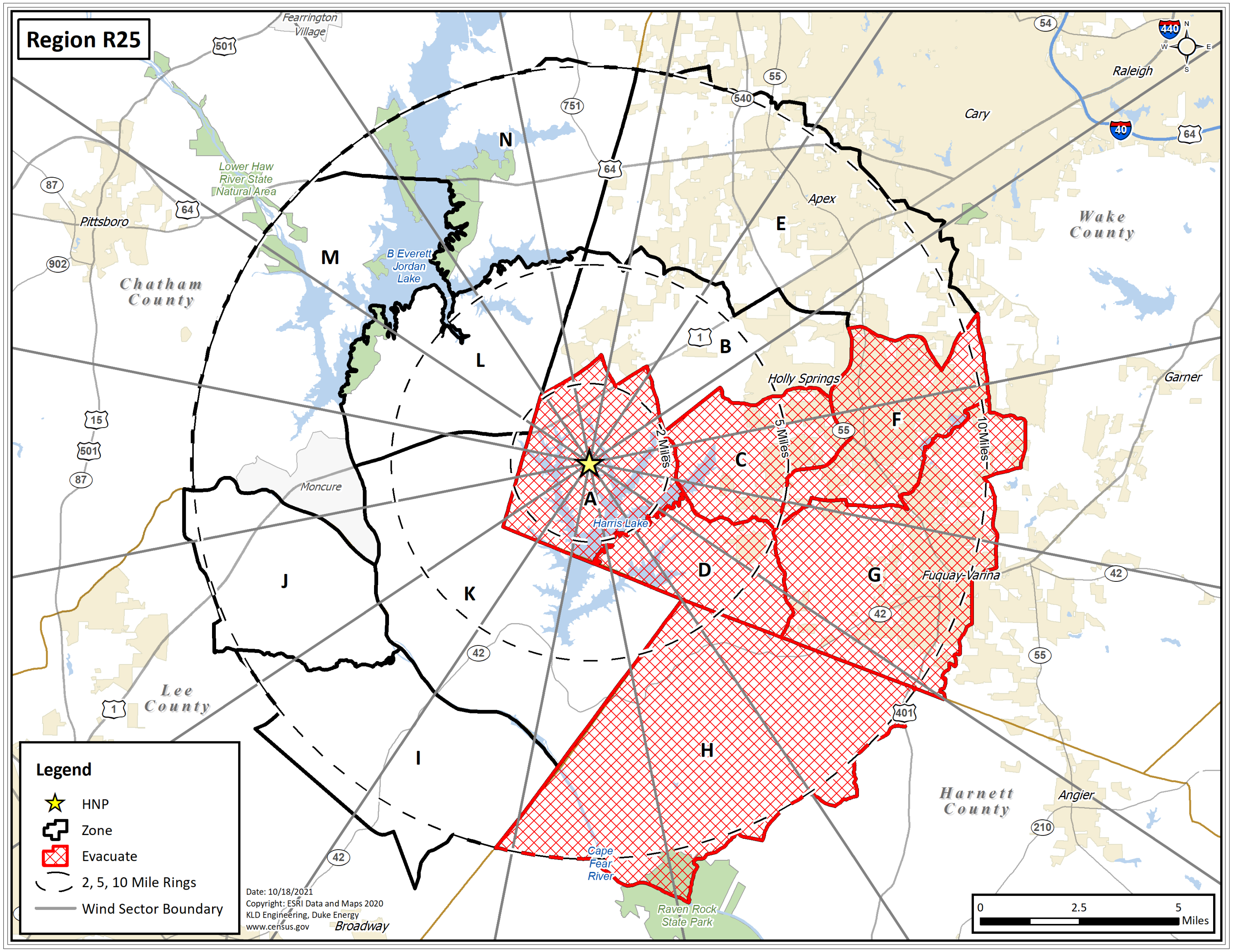


Figure H-25. Region R25

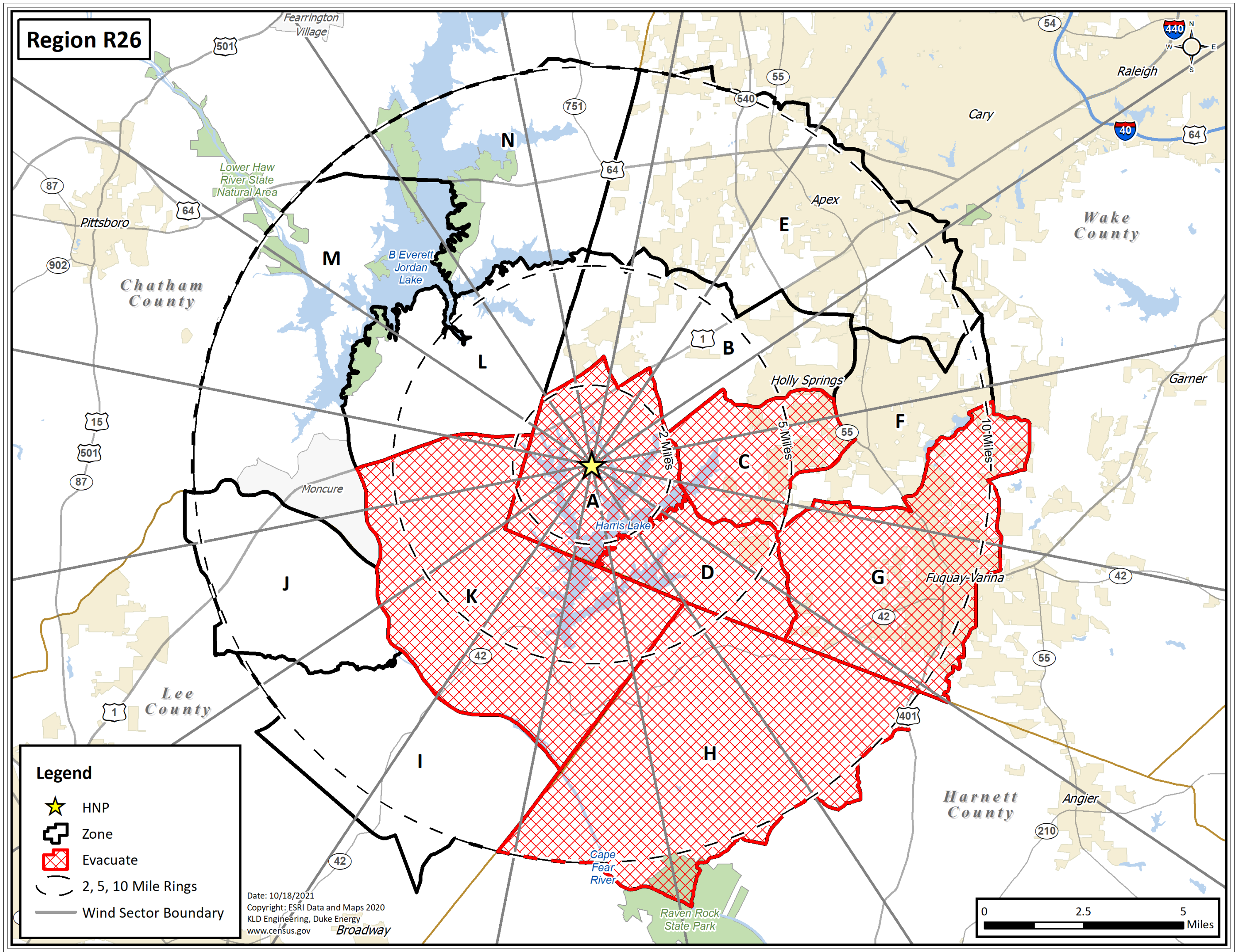


Figure H-26. Region R26

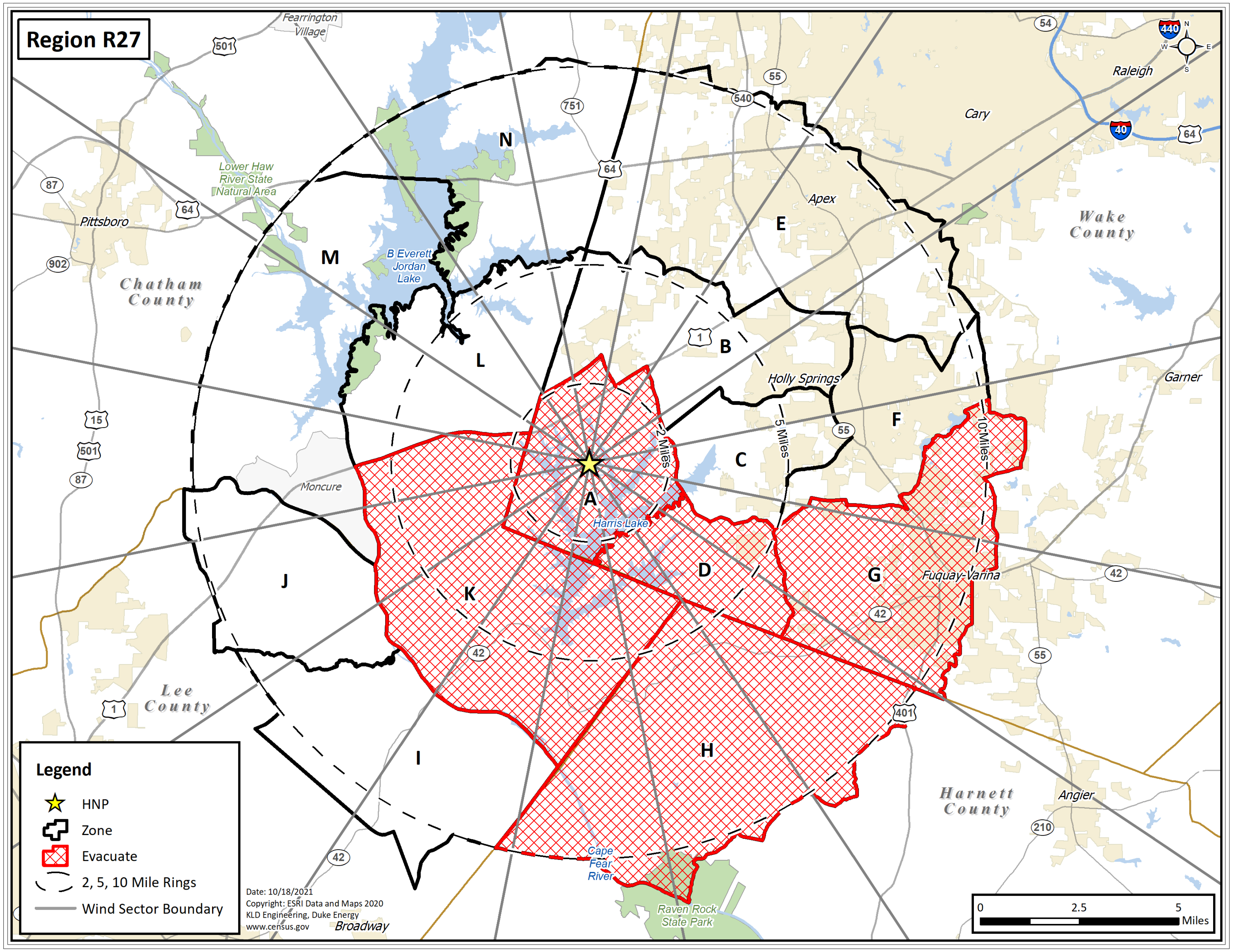


Figure H-27. Region R27

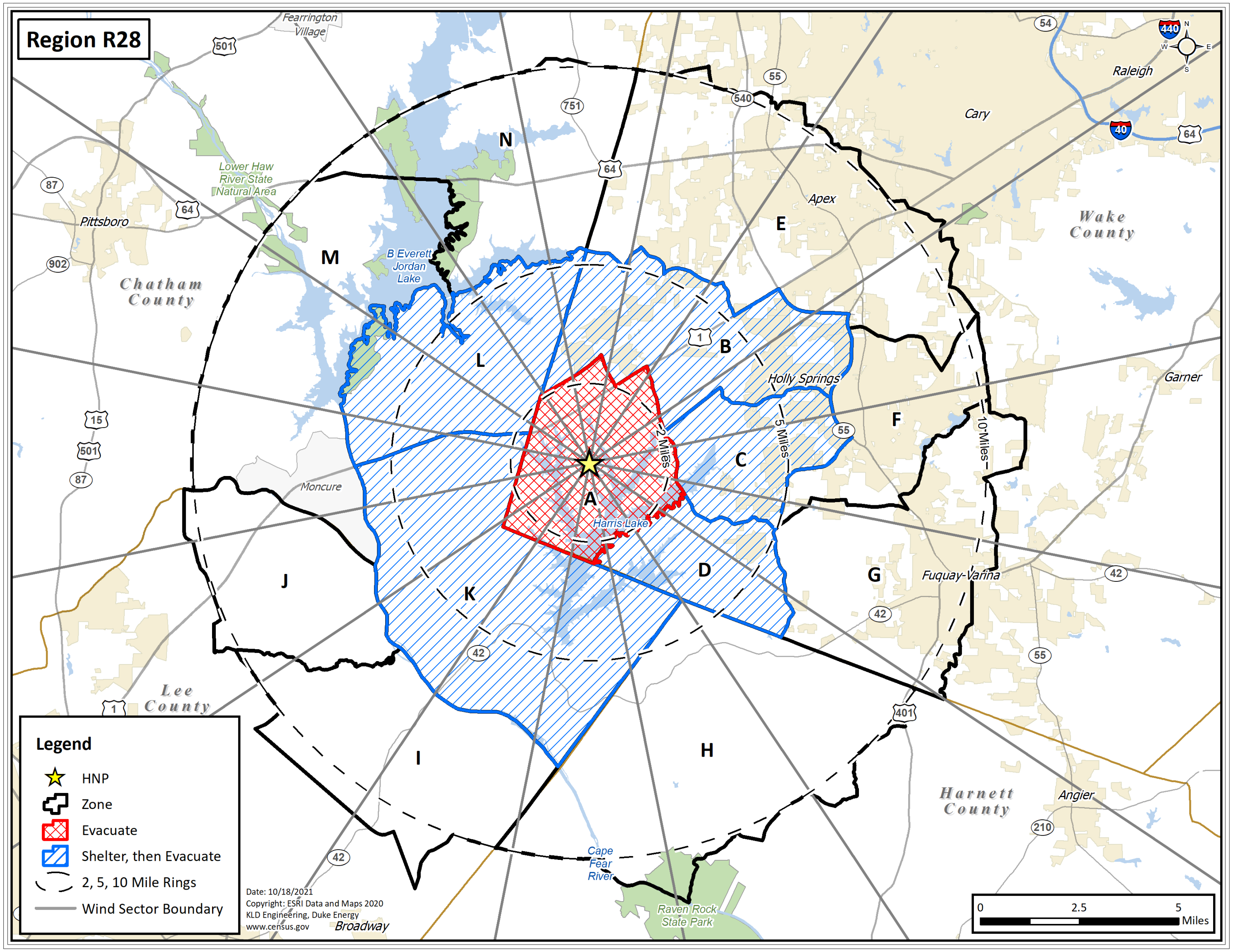


Figure H-28. Region R28

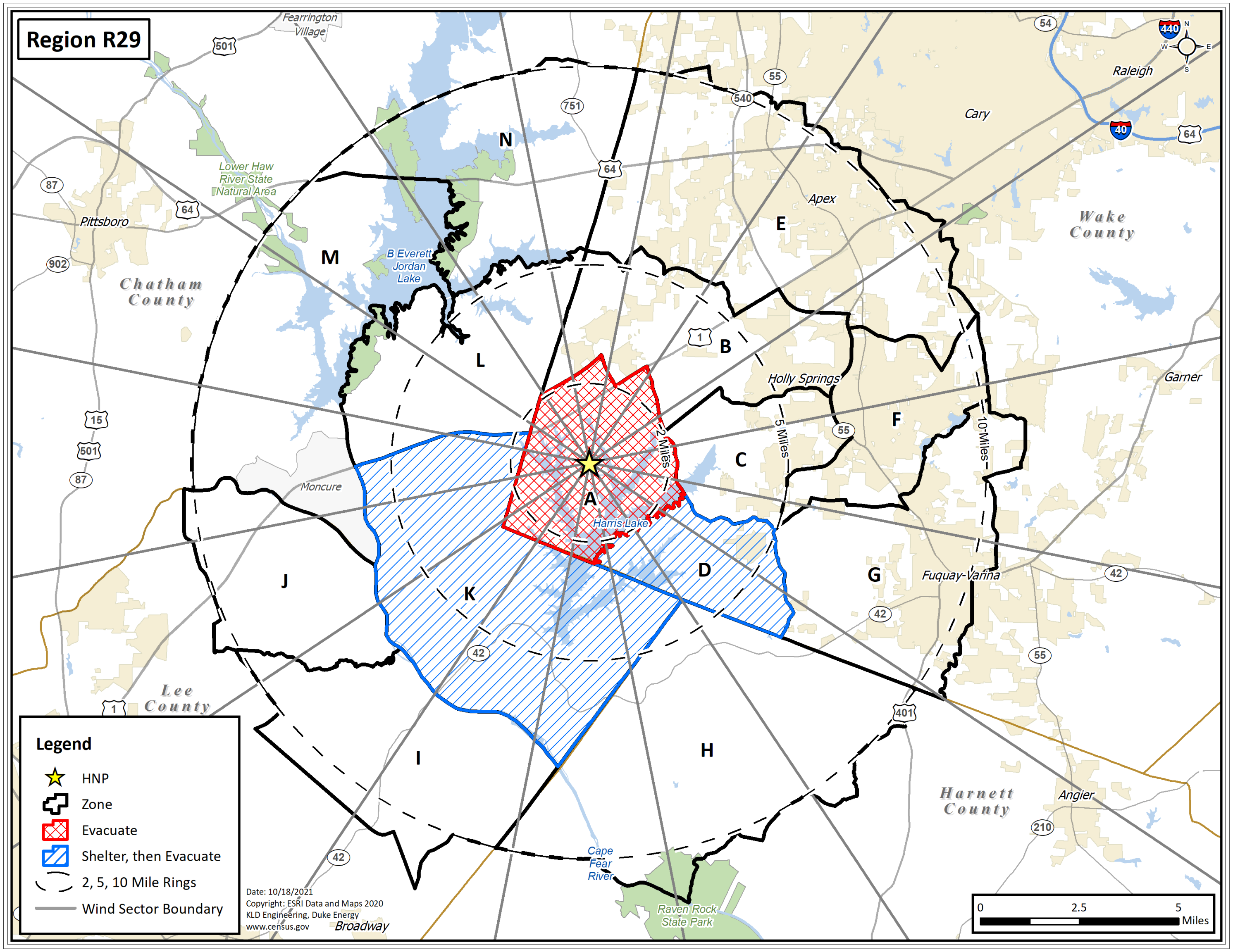


Figure H-29. Region R29

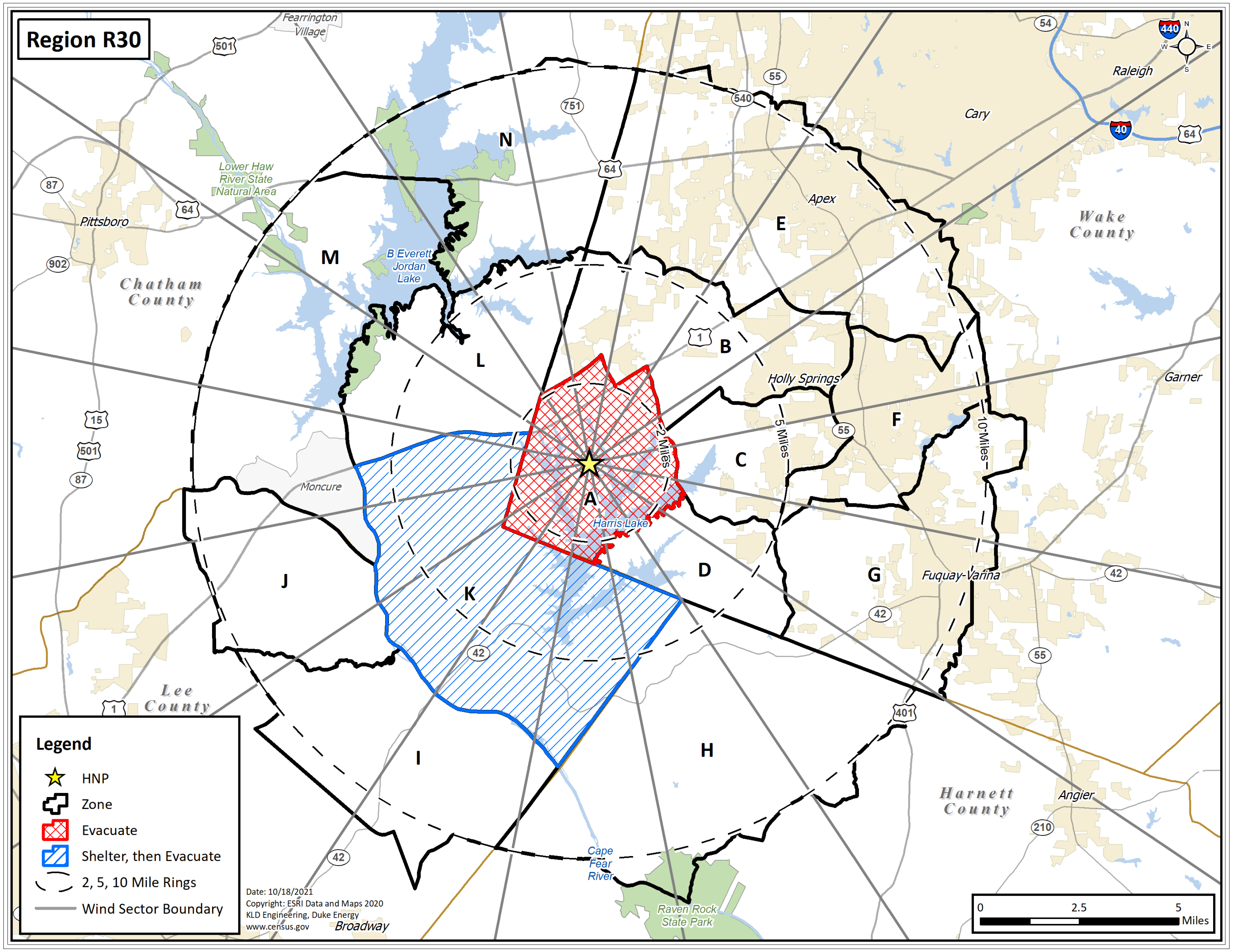


Figure H-30. Region R30

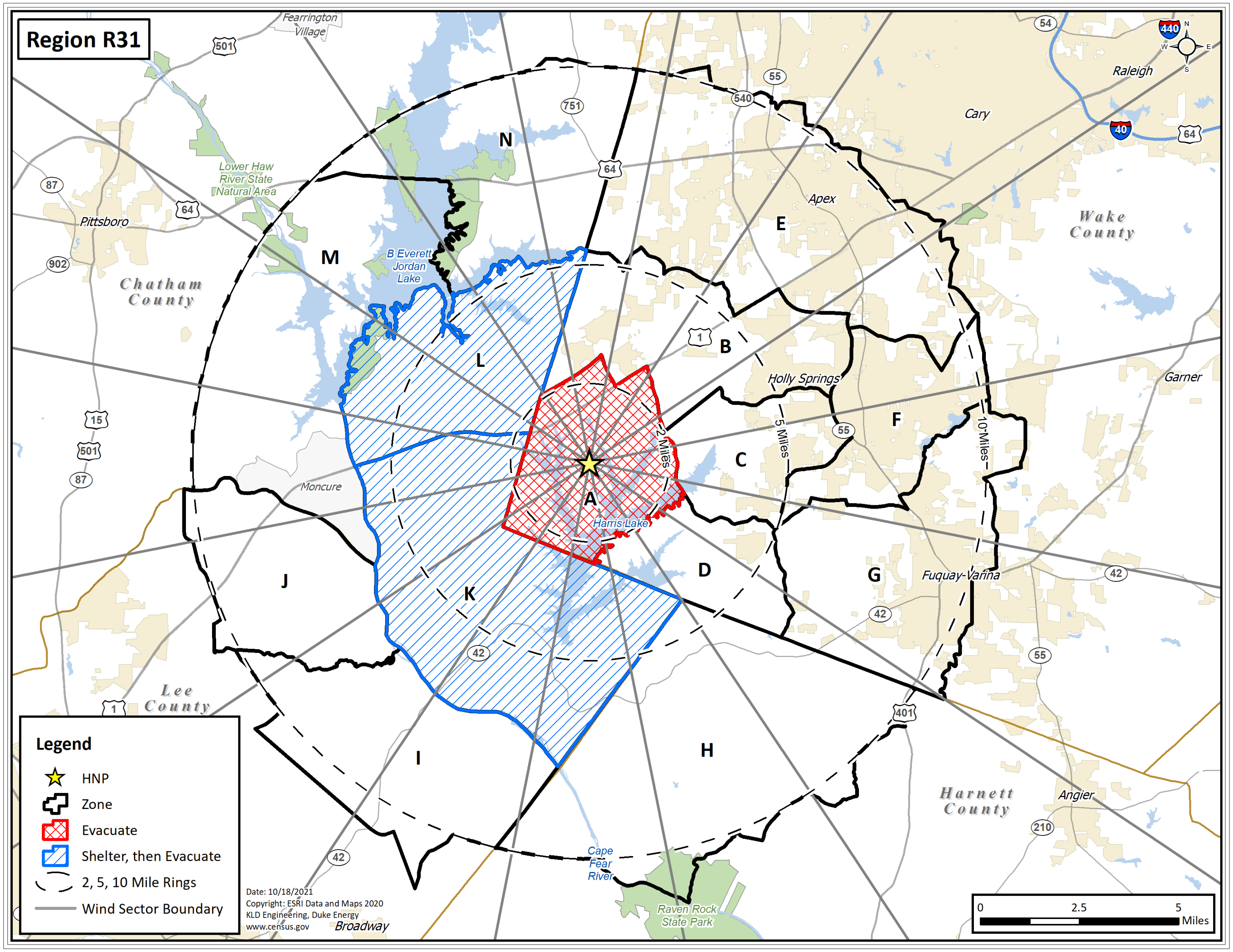


Figure H-31. Region R31

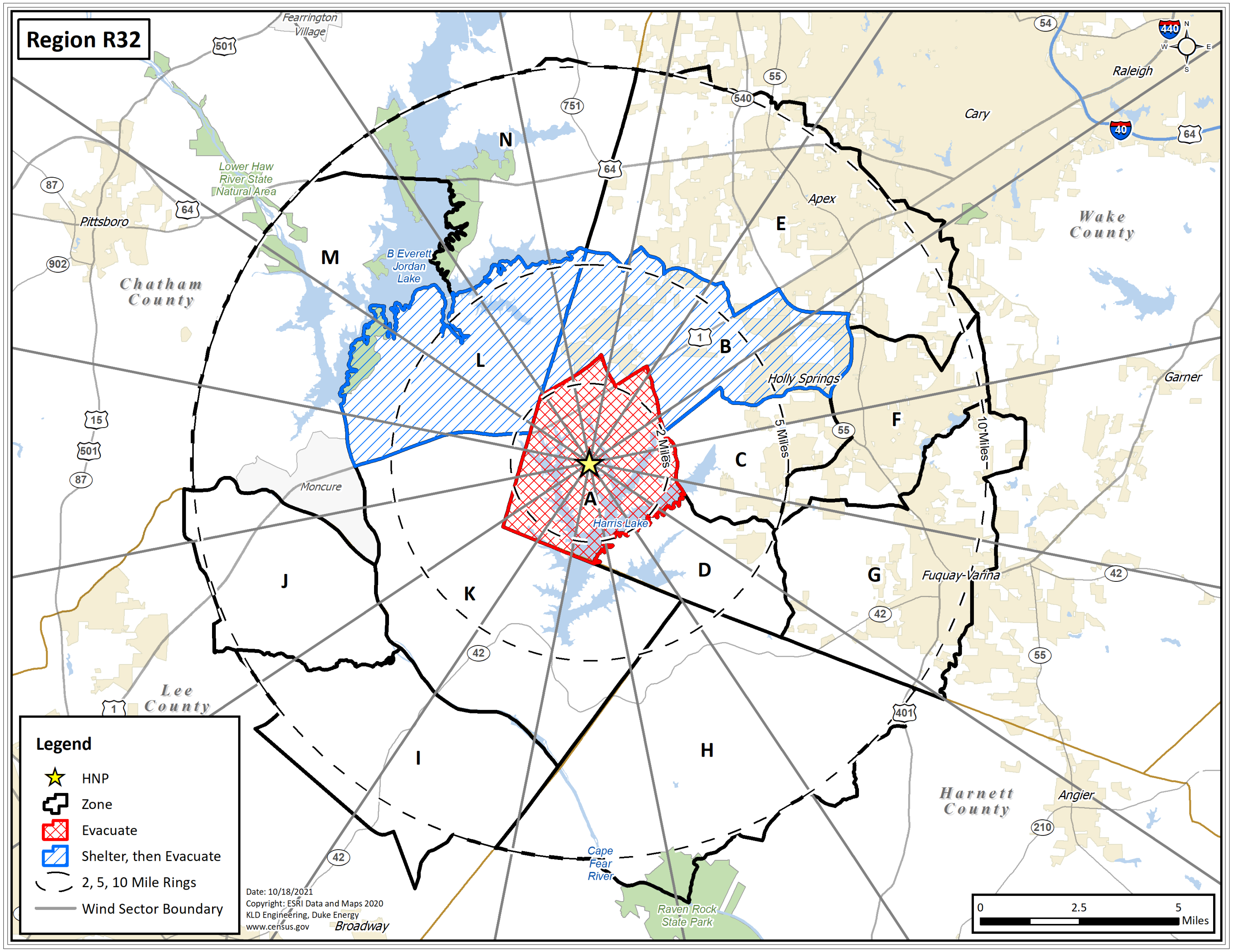


Figure H-32. Region R32

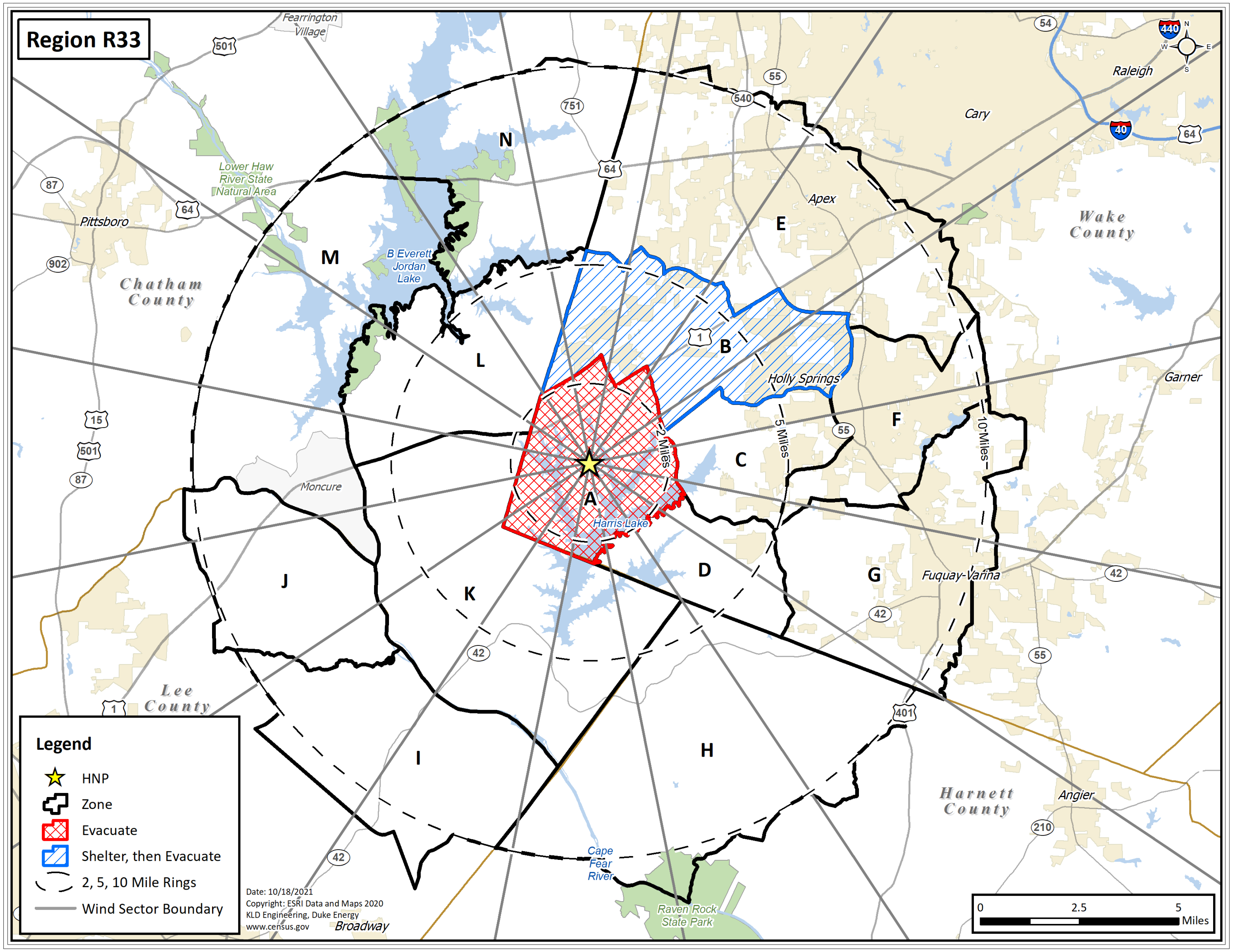


Figure H-33. Region R33

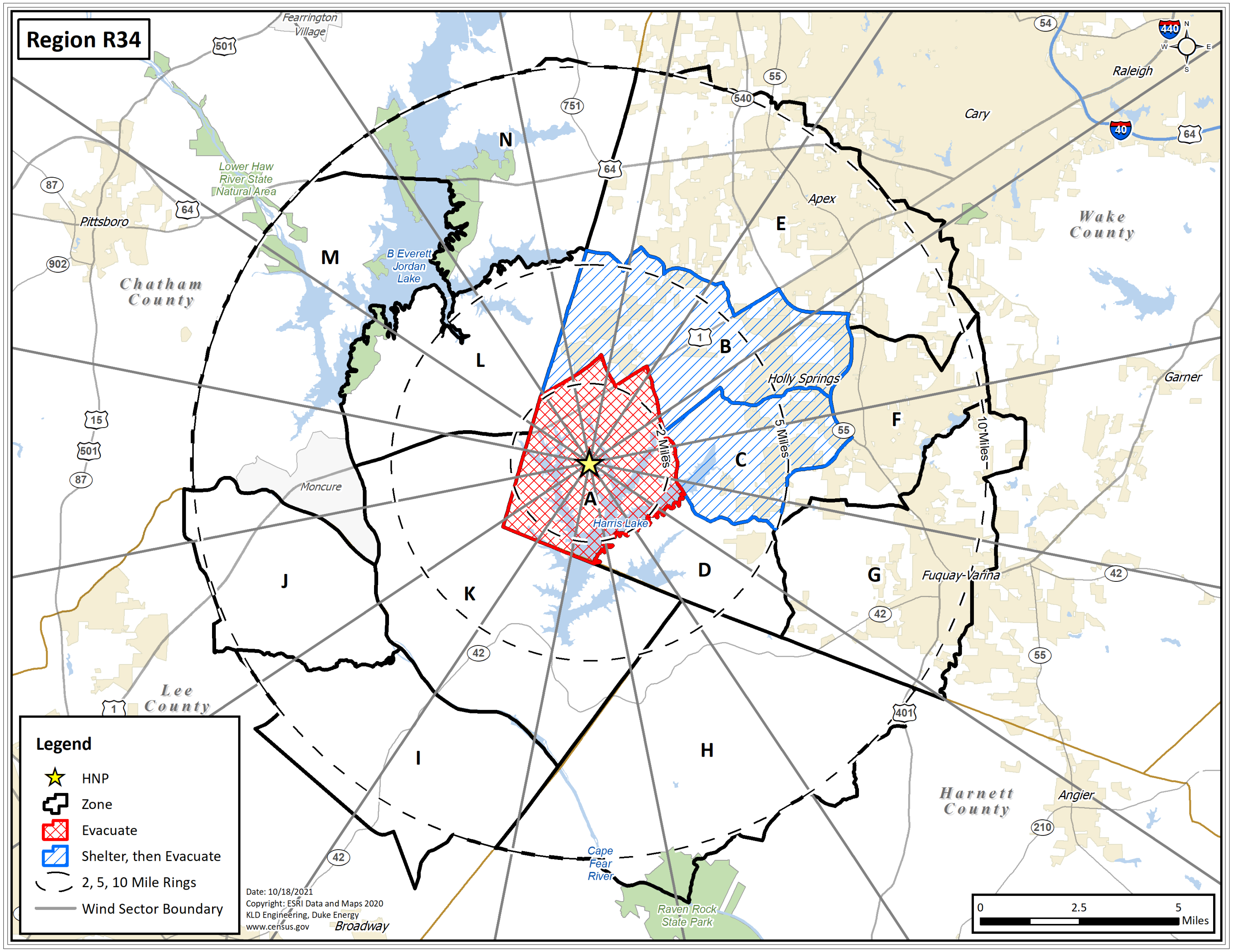


Figure H-34. Region R34

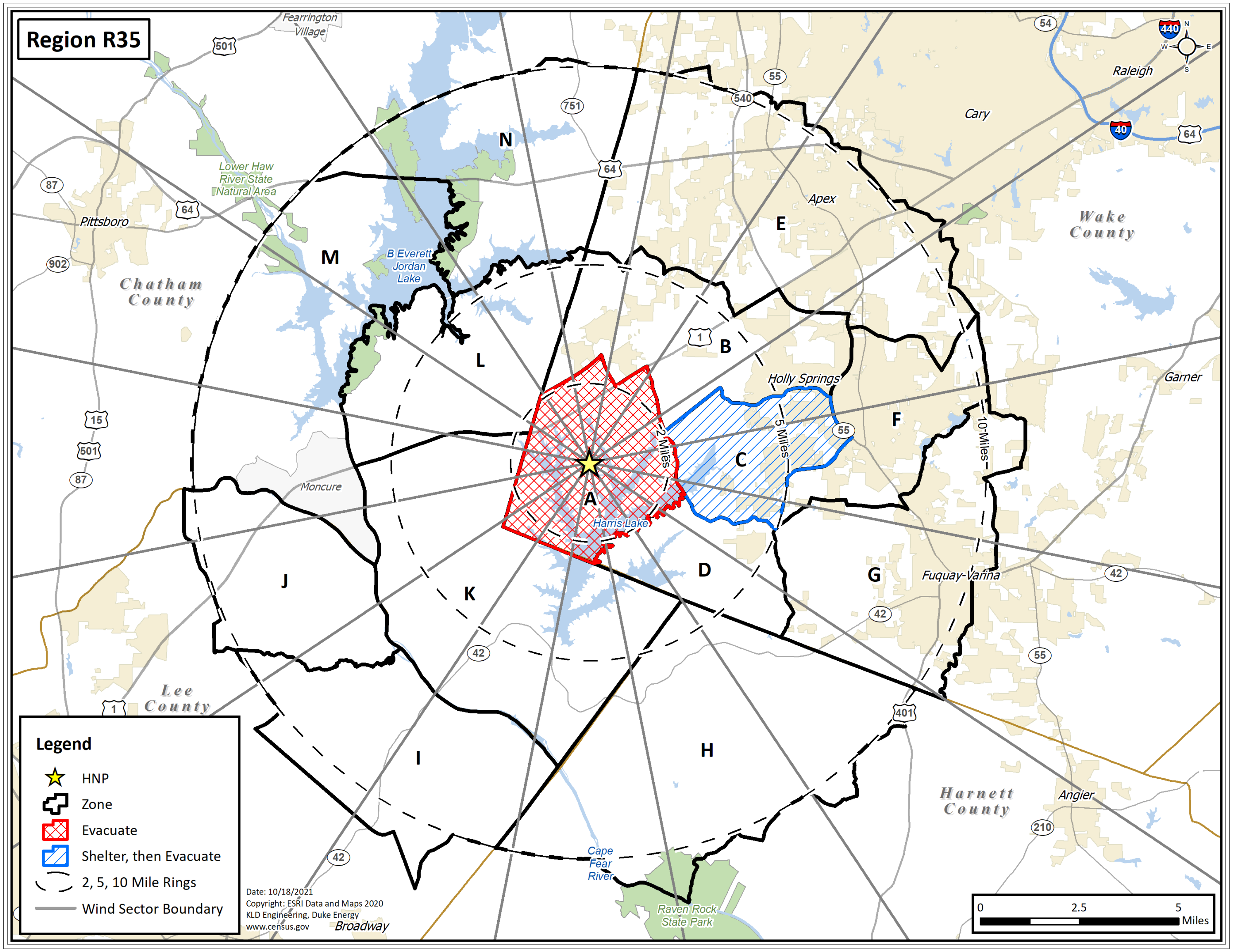


Figure H-35. Region R35

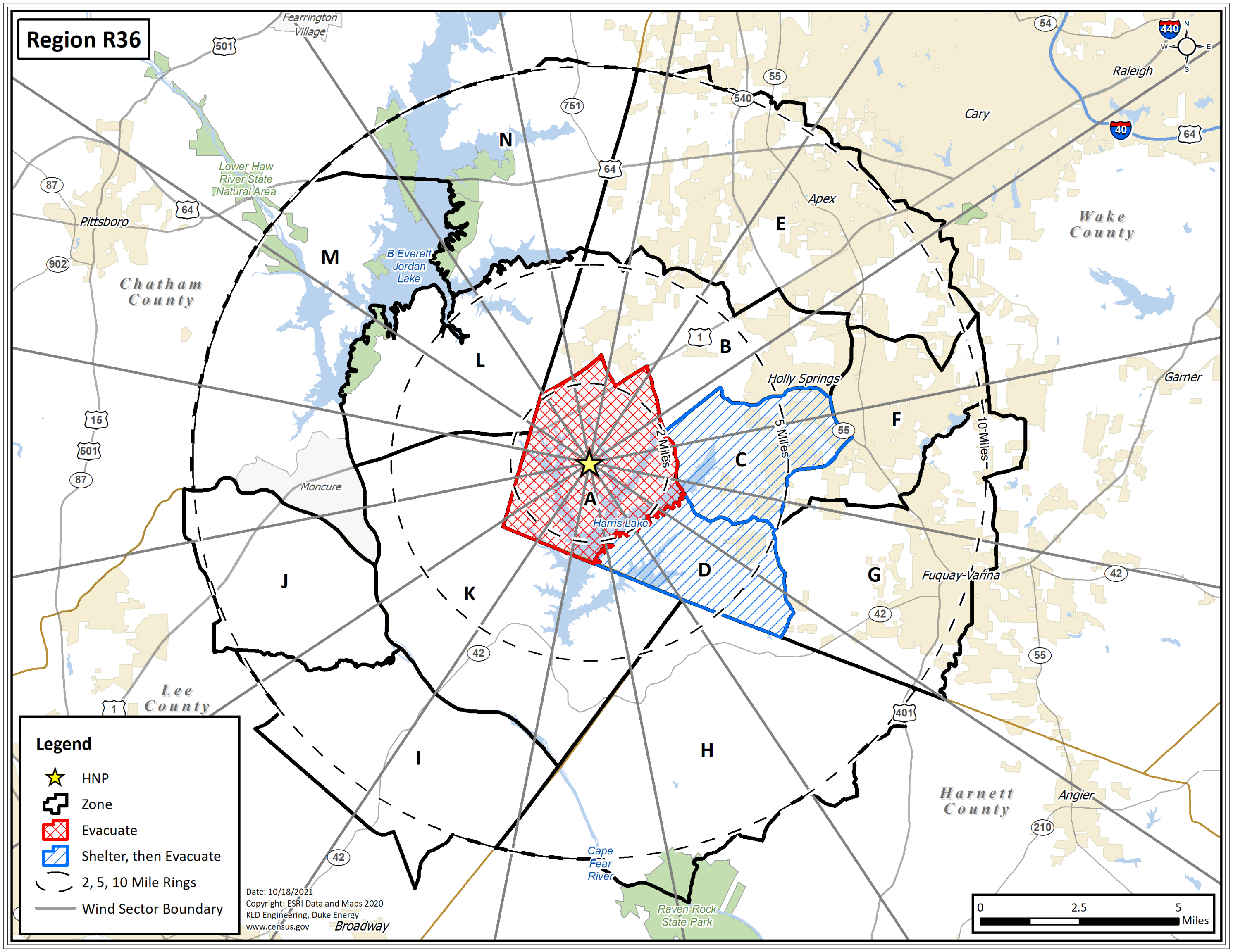


Figure H-36. Region R36

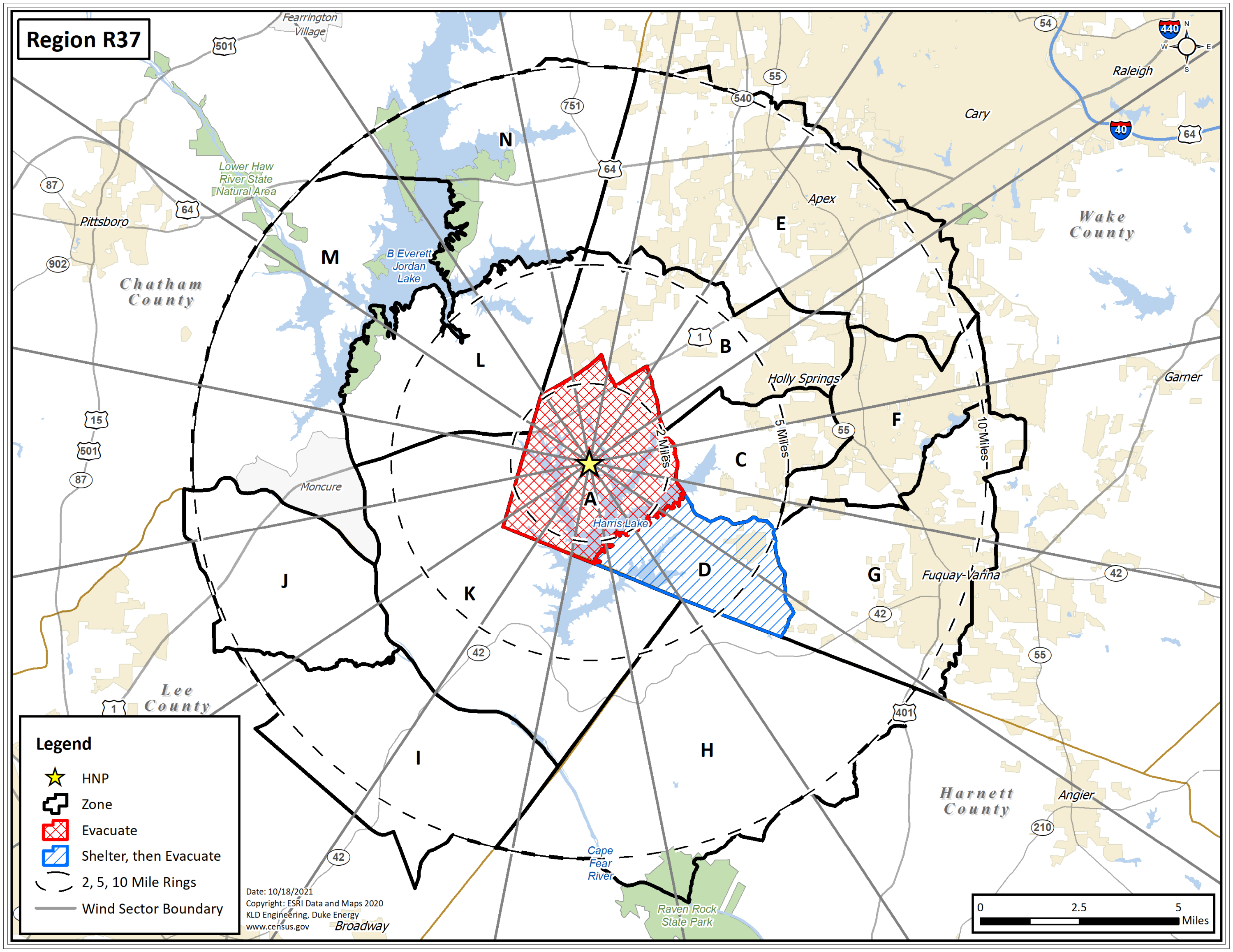


Figure H-37. Region R37

APPENDIX J

Representative Inputs to and Outputs from the DYNEV II System

J. REPRESENTATIVE INPUTS TO AND OUTPUTS FROM THE DYNEV II SYSTEM

This appendix presents data input to and output from the DYNEV II System.

Table J-1 provides source (vehicle loading) and destination information for several roadway segments (links) in the analysis network. In total, there are a total of 2,866 source links (origins) in the model. The source links are shown as centroid points in Figure J-1. On average, evacuees travel a straight-line distance of 6.04 miles to exit the network.

Table J-2 provides network–wide statistics (average travel time, average delay time[1], average speed and number of vehicles) for an evacuation of the entire EPZ (Region R03) for each scenario. Scenarios 7 and 8, and Scenarios 9 and 10, which are rain and ice scenarios, exhibit slower average speeds, higher delays, and longer average travel times than good weather scenarios.

Table J-3 provides statistics (average speed and travel time) for the major evacuation routes – NC-540 Toll, US-64, US-1, NC-42, NC-55 and US-401 – for an evacuation of the entire EPZ (Region R03) under Scenario 1 conditions. As discussed in Section 7.3 and shown in Figures 7-3 through 7-9, major roadways to the northeast, east, and southeast are congested for the majority of the evacuation. As such, the average speeds are comparably slower (and travel times longer) on the major roadways traveling in these directions than other major evacuation routes.

Table J-4 provides the number of vehicles discharged and the cumulative percent of total vehicles discharged for each link exiting the analysis network, for an evacuation of the entire EPZ (Region R03) under Scenario 1 conditions. Refer to the figures in Appendix K for a map showing the geographic location of each link.

Figure J-2 through Figure J-15 plot the trip generation time versus the ETE for each of the 14 Scenarios considered. The distance between the trip generation and ETE curves is the travel time. Plots of trip generation versus ETE are indicative of the level of traffic congestion during evacuation. For low population density sites, the curves are close together, indicating short travel times and minimal traffic congestion. For higher population density sites, the curves are farther apart indicating longer travel times and the presence of traffic congestion. As seen in Figure J-2 through Figure J-15, the curves are spatially separated as a result of the traffic congestion in the EPZ, specifically in the population centers of Apex, Holly Springs and Fuquay-Varina, which was discussed in detail in Section 7.3.

[1] Computed as the difference of the average travel time and the average ideal travel time under free flow conditions.

Table J-1. Sample Simulation Model Input

Link Number	Upstream Node	Downstream Node	Vehicles Entering Network on this Link	Directional Preference	Destination Nodes	Destination Capacity
737	452	3247	20	NE	8290	9,000
					8359	6,750
					8020	6,750
1142	711	1281	28	NE	8359	6,750
					8020	6,750
					8375	4,500
265	147	38	173	E	8392	1,700
					8101	1,700
					8989	1,700
2999	3135	3134	346	E	8392	1,700
					8101	1,700
					8989	1,700
3076	3211	3210	14	W	8190	2,850
					8137	3,810
					8590	4,500
559	343	329	86	N	8020	6,750
					8430	4,275
					8667	2,850
982	614	613	83	NW	8190	2,850
1455	960	962	8	SE	8392	1,700
					8101	1,700
1923	1299	491	33	NW	8190	2,850
2447	1676	1673	54	N	8290	9,000
					8667	2,850
					8276	1,275

Table J-2. Selected Model Outputs for the Evacuation of the Entire EPZ (Region R03)

Scenario	1	2	3	4	5	6	7
Network-Wide Average Travel Time (Min/Veh-Mi)	3.1	3.6	3.1	3.6	3.1	3.1	3.7
Network-Wide Average Delay Time (Min/Veh-Mi)	1.9	2.3	1.8	2.3	1.8	1.9	2.4
Network-Wide Average Speed (mph)	19.1	16.9	19.6	16.8	19.5	19.1	16.4
Total Vehicles Exiting Network	146,653	147,245	137,408	137,964	117,622	144,992	145,757
Scenario	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Network-Wide Average Travel Time (Min/Veh-Mi)	4.4	3.0	3.5	4.3	3.1	3.0	3.2
Network-Wide Average Delay Time (Min/Veh-Mi)	3.1	1.8	2.3	3.0	1.9	1.8	1.9
Network-Wide Average Speed (mph)	13.6	19.9	17.0	14.0	19.2	19.7	18.7
Total Vehicles Exiting Network	146,387	134,300	134,926	135,140	115,731	121,001	146,798

Table J-3. Average Speed (mph) and Travel Time (min) for Major Evacuation Routes (Region R03, Scenario 1)

		Elapsed Time (hours)											
		1		2		3		4		5		6	
Route Name	Length (miles)	Speed (mph)	Travel Time (min)	Speed	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed	Travel Time
NC-540 Toll Northbound	8.5	71.6	7.1	70.6	7.2	71.4	7.1	71.5	7.1	71.7	7.1	71.7	7.1
US-64 Eastbound	8.9	52.4	10.2	54.3	9.8	54.7	9.7	54.1	9.8	54.6	9.7	60.8	8.7
US-64 Westbound	8.0	58.2	8.3	58.4	8.2	58.6	8.2	58.8	8.2	60.0	8.0	60.0	8.0
US-1 Northbound	9.4	24.6	23.0	25.6	22.1	47.9	11.8	73.1	7.8	73.1	7.7	73.1	7.7
US-1 Southbound	11.3	73.8	9.1	74.3	9.1	75.0	9.0	75.0	9.0	75.0	9.0	75.0	9.0
NC-42 Westbound	6.9	52.2	7.9	52.4	7.9	52.4	7.9	52.5	7.9	54.4	7.6	54.4	7.6
NC-55 Northbound	9.2	17.0	32.5	4.8	115.0	22.3	24.8	43.5	12.7	46.1	12.0	50.8	10.9
US-401 Northbound	12.4	26.4	28.1	7.3	101.1	2.8	264.3	4.4	168.3	4.8	154.1	31.6	23.4
US-401 Southbound	8.1	38.4	12.7	4.3	113.4	3.5	138.5	5.5	87.8	13.5	35.9	48.5	10.0

Table J-4. Simulation Model Outputs at Network Exit Links for Region R03, Scenario 1

Network Exit Link	Elapsed Time (hours)					
	1	2	3	4	5	6
	Cumulative Vehicles Discharged by the Indicated Time					
	Cumulative Percent of Vehicles Discharged by the Indicated Time Interval					
27	4,017	8,449	12,788	15,502	15,874	15,879
	17%	12%	12%	12%	11%	11%
211	25	127	200	228	235	235
	0%	0%	0%	0%	0%	0%
248	395	771	968	1,051	1,071	1,071
	2%	1%	1%	1%	1%	1%
322	434	1,074	1,510	1,690	1,736	1,737
	2%	2%	1%	1%	1%	1%
378	1,563	4,130	6,681	9,209	11,739	14,282
	7%	6%	6%	7%	8%	10%
947	1,961	4,567	5,868	6,009	6,042	6,042
	8%	7%	5%	5%	4%	4%
1214	571	1,174	1,497	1,662	1,681	1,681
	2%	2%	1%	1%	1%	1%
1251	29	169	270	312	320	320
	0%	0%	0%	0%	0%	0%
1484	267	1,087	2,068	3,281	4,468	5,133
	1%	2%	2%	3%	3%	4%
1910	1,109	7,838	13,418	15,544	15,759	15,763
	5%	12%	12%	12%	11%	11%
1999	211	1,286	2,436	2,984	3,078	3,079
	1%	2%	2%	2%	2%	2%
2356	492	2,704	4,679	5,537	5,724	5,726
	2%	4%	4%	4%	4%	4%
2521	601	1,515	1,923	2,041	2,076	2,076
	3%	2%	2%	2%	1%	1%
2593	437	1,097	1,463	1,592	1,617	1,617
	2%	2%	1%	1%	1%	1%
2617	846	1,974	3,151	4,517	5,816	6,748
	4%	3%	3%	3%	4%	5%
2679	264	992	1,711	2,136	2,540	3,178
	1%	1%	2%	2%	2%	2%
2714	289	1,344	2,002	2,284	2,355	2,355
	1%	2%	2%	2%	2%	2%

Network Exit Link	Elapsed Time (hours)					
	1	2	3	4	5	6
	Cumulative Vehicles Discharged by the Indicated Time					
	Cumulative Percent of Vehicles Discharged by the Indicated Time Interval					
2755	300	1,590	2,622	3,021	3,137	3,139
	1%	2%	2%	2%	2%	2%
2788	843	1,941	3,141	3,993	4,942	4,949
	4%	3%	3%	3%	4%	3%
2869	319	1,787	3,619	4,977	5,282	5,287
	1%	3%	3%	4%	4%	4%
2873	5,112	11,584	16,699	19,574	20,248	20,261
	21%	17%	16%	15%	14%	14%
2875	3,093	7,197	11,344	15,168	15,683	15,690
	13%	11%	11%	12%	11%	11%
2919	400	2,506	5,131	5,883	6,095	6,100
	2%	4%	5%	4%	4%	4%
2923	38	701	1,440	1,727	1,801	1,802
	0%	1%	1%	1%	1%	1%
3328	183	534	946	1,416	1,918	2,206
	1%	1%	1%	1%	1%	2%

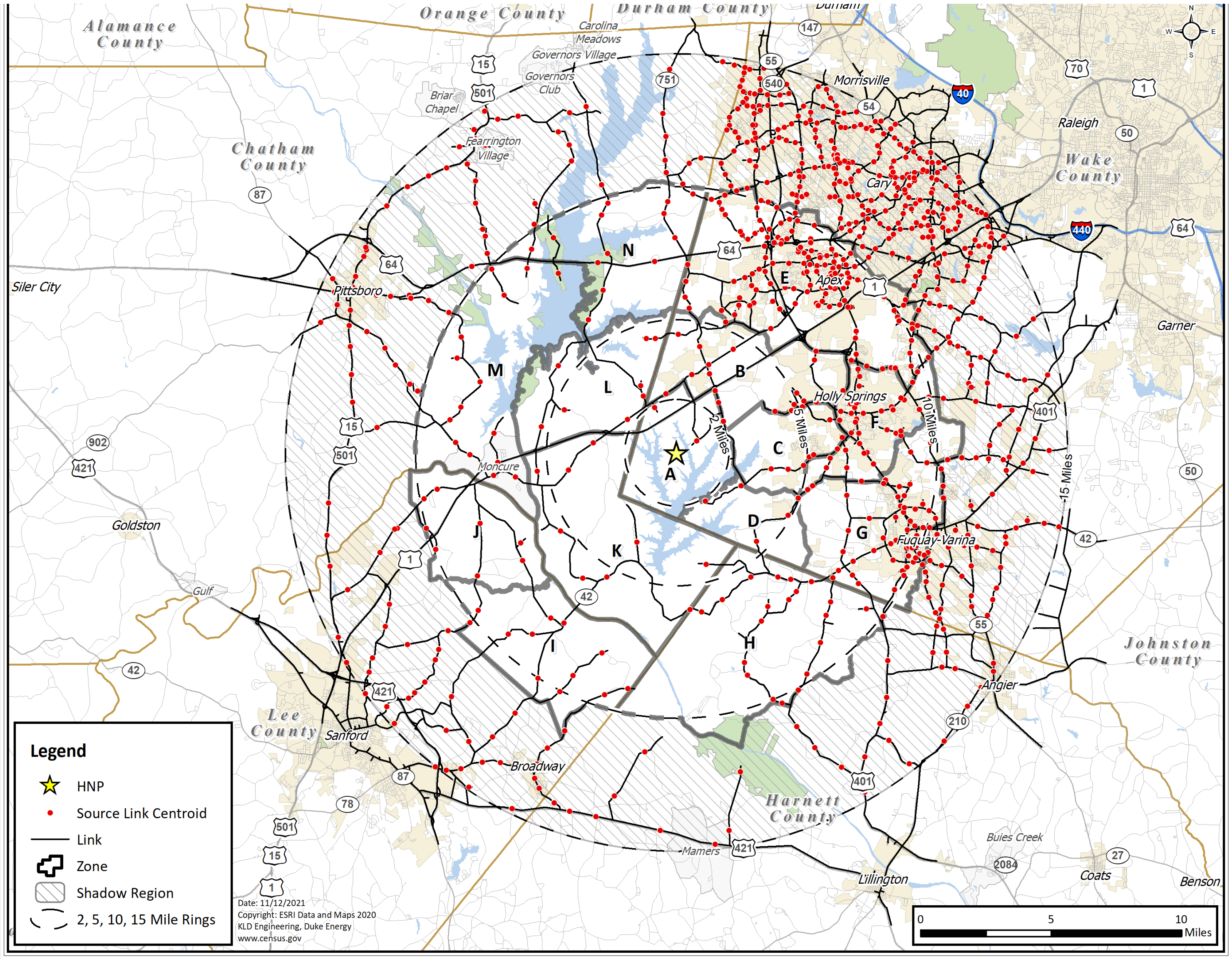


Figure J-1. Network Sources/Origins

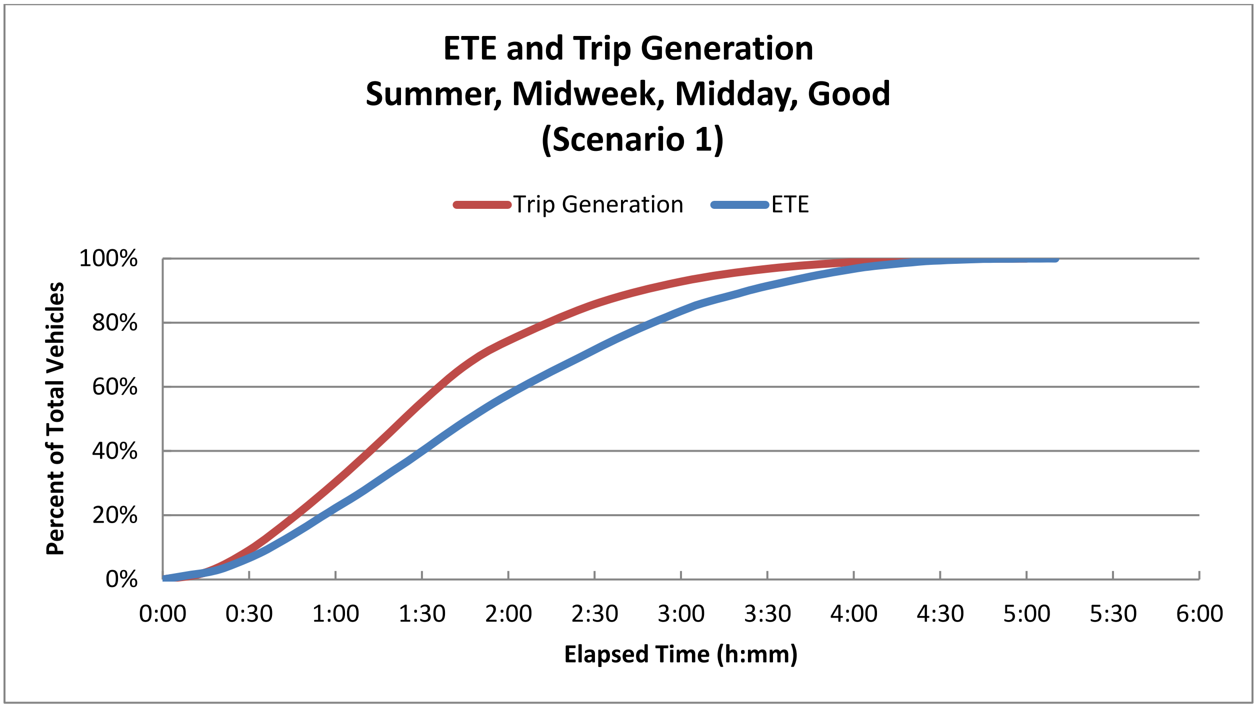


Figure J-2. ETE and Trip Generation: Summer, Midweek, Midday, Good Weather (Scenario 1)

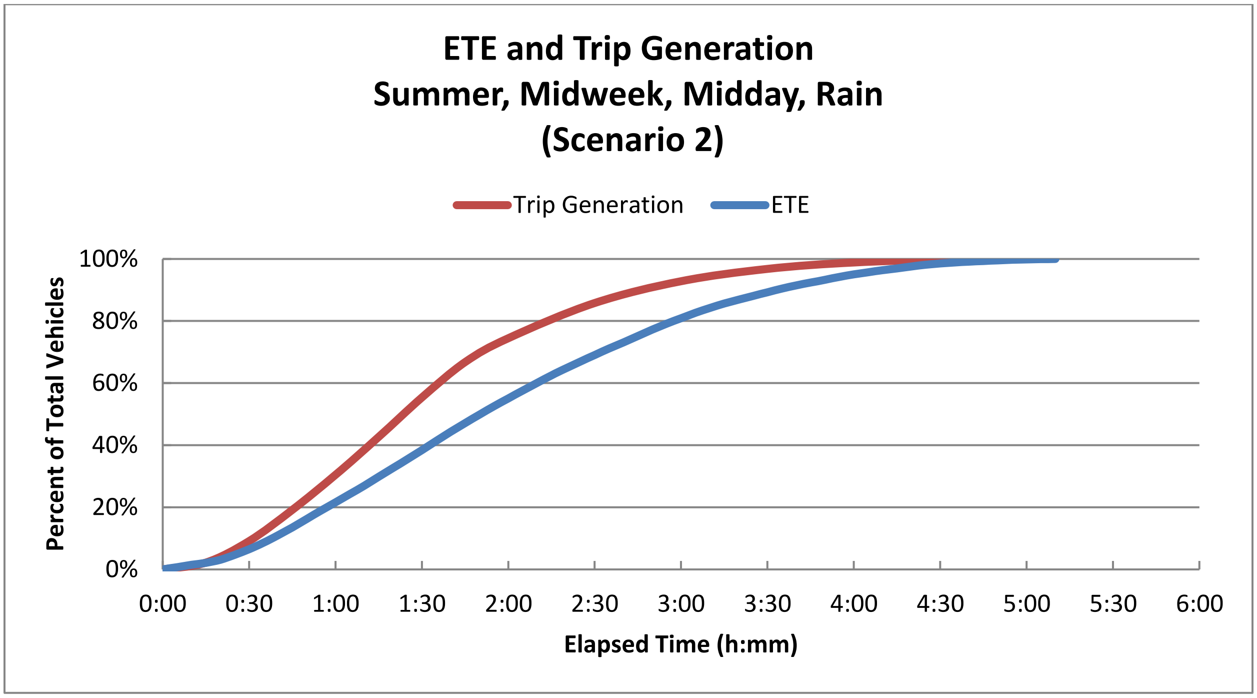


Figure J-3. ETE and Trip Generation: Summer, Midweek, Midday, Rain (Scenario 2)

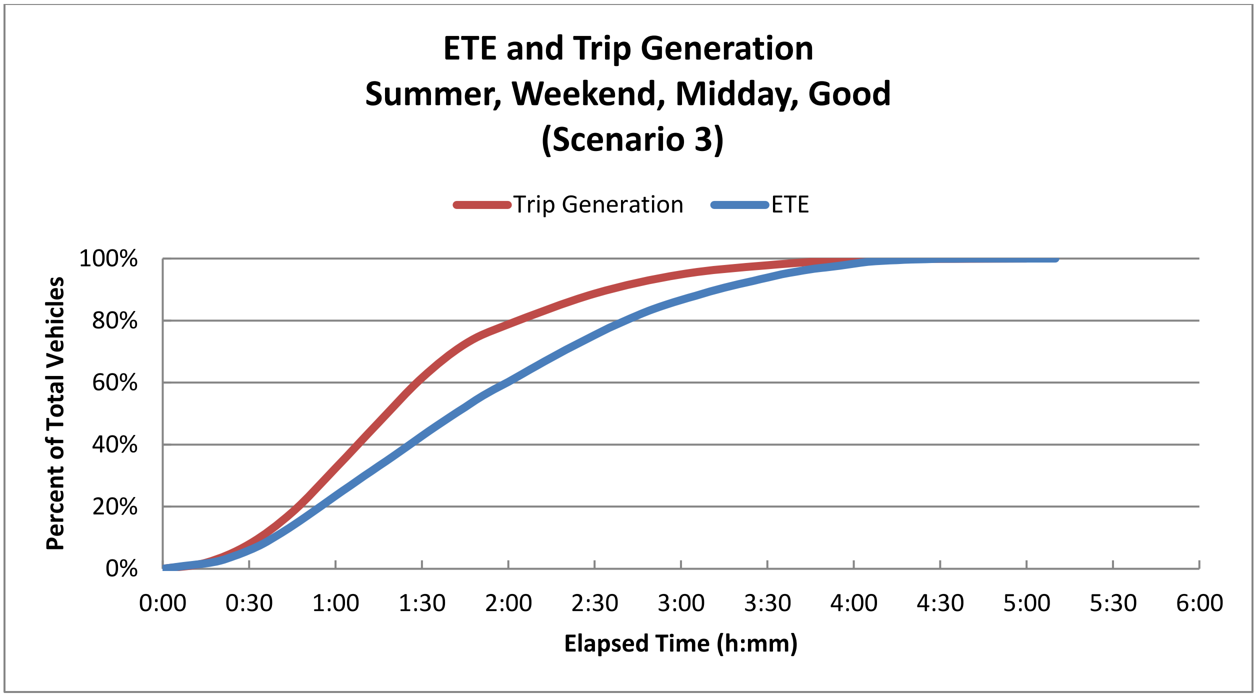


Figure J-4. ETE and Trip Generation: Summer, Weekend, Midday, Good Weather (Scenario 3)

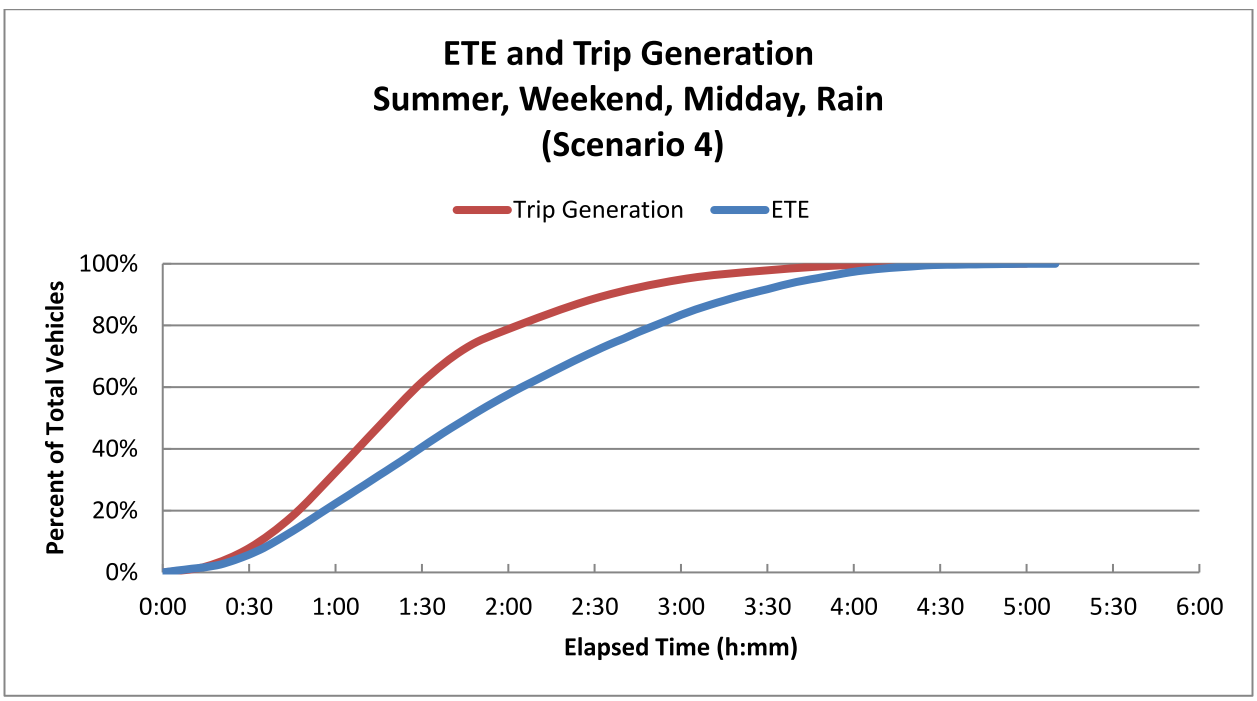


Figure J-5. ETE and Trip Generation: Summer, Weekend, Midday, Rain (Scenario 4)

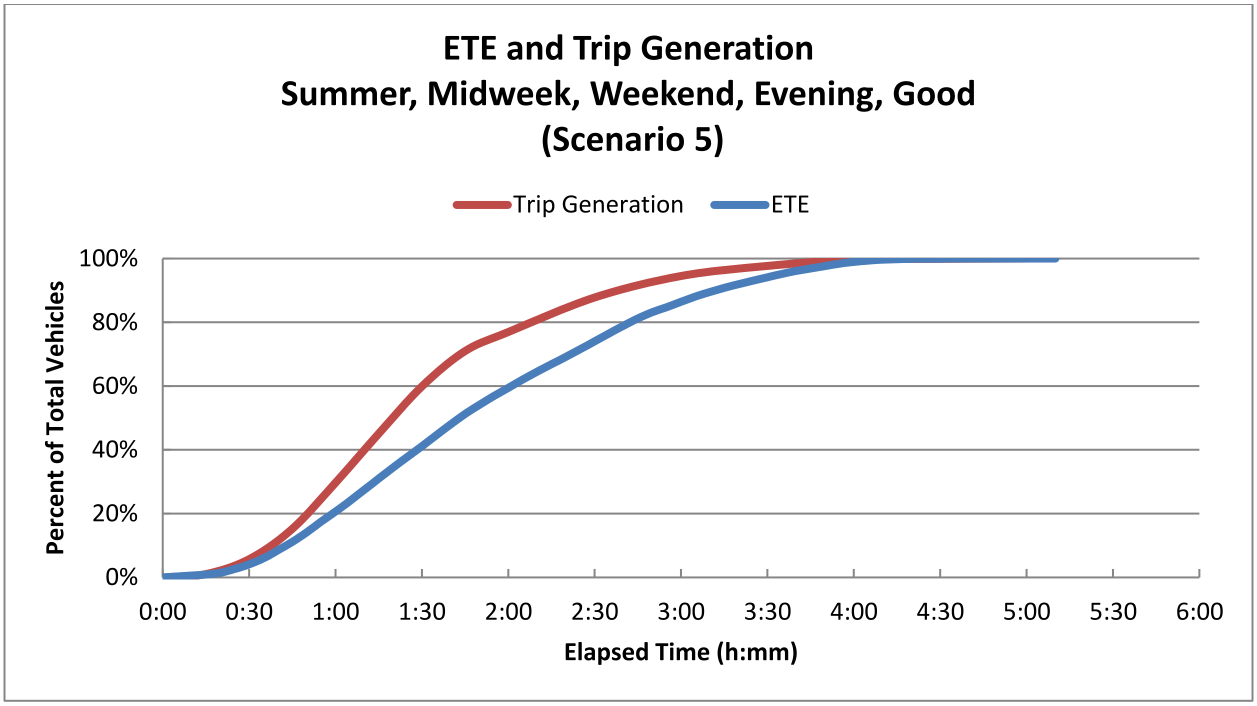


Figure J-6. ETE and Trip Generation: Summer, Midweek, Weekend, Evening, Good Weather (Scenario 5)

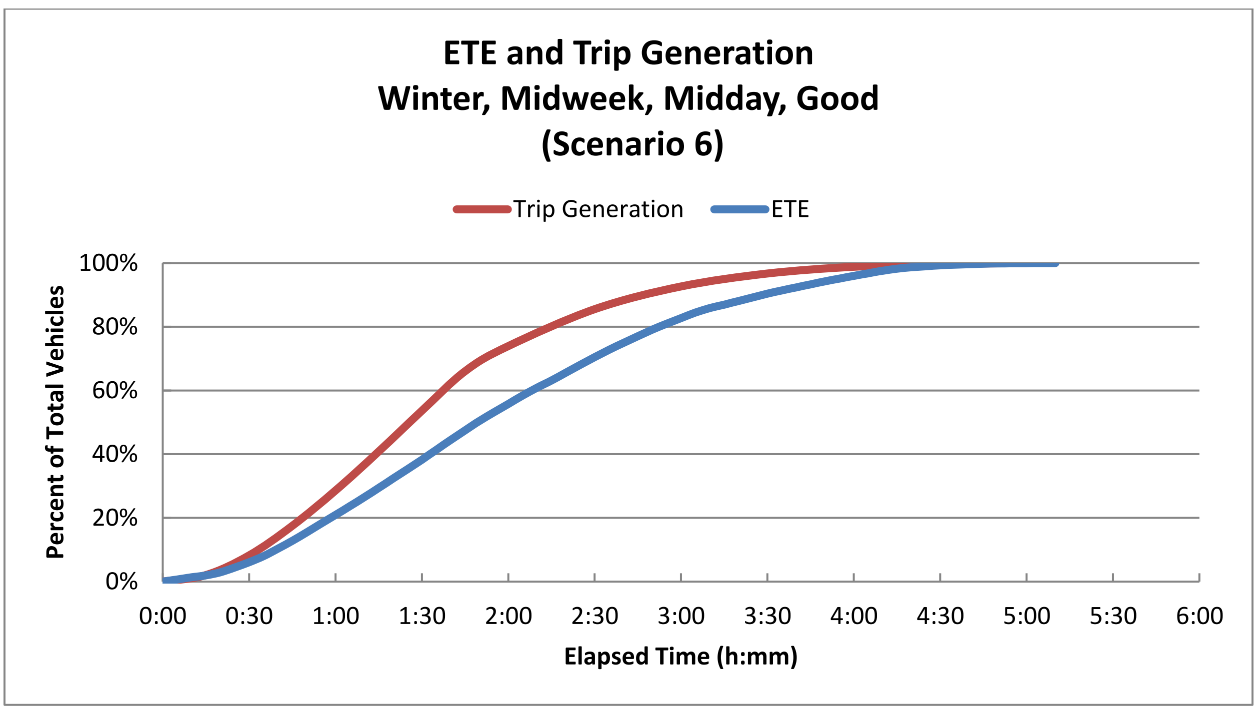


Figure J-7. ETE and Trip Generation: Winter, Midweek, Midday, Good Weather (Scenario 6)

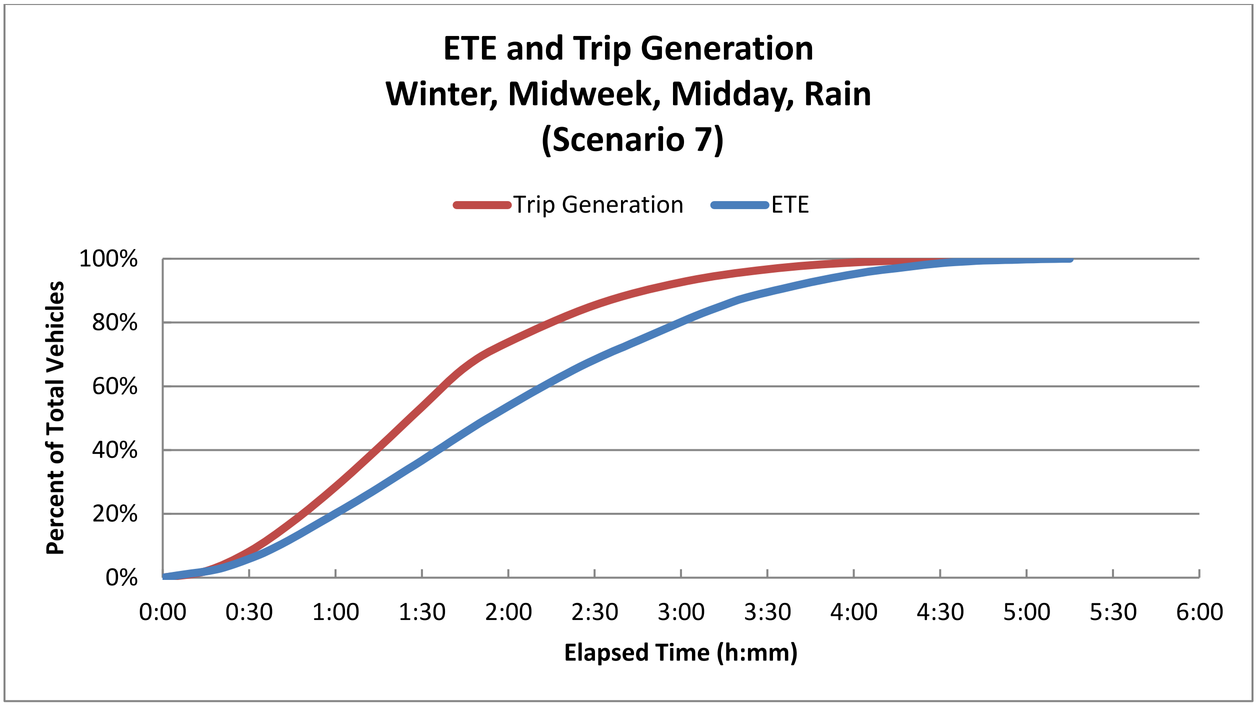


Figure J-8. ETE and Trip Generation: Winter, Midweek, Midday, Rain (Scenario 7)

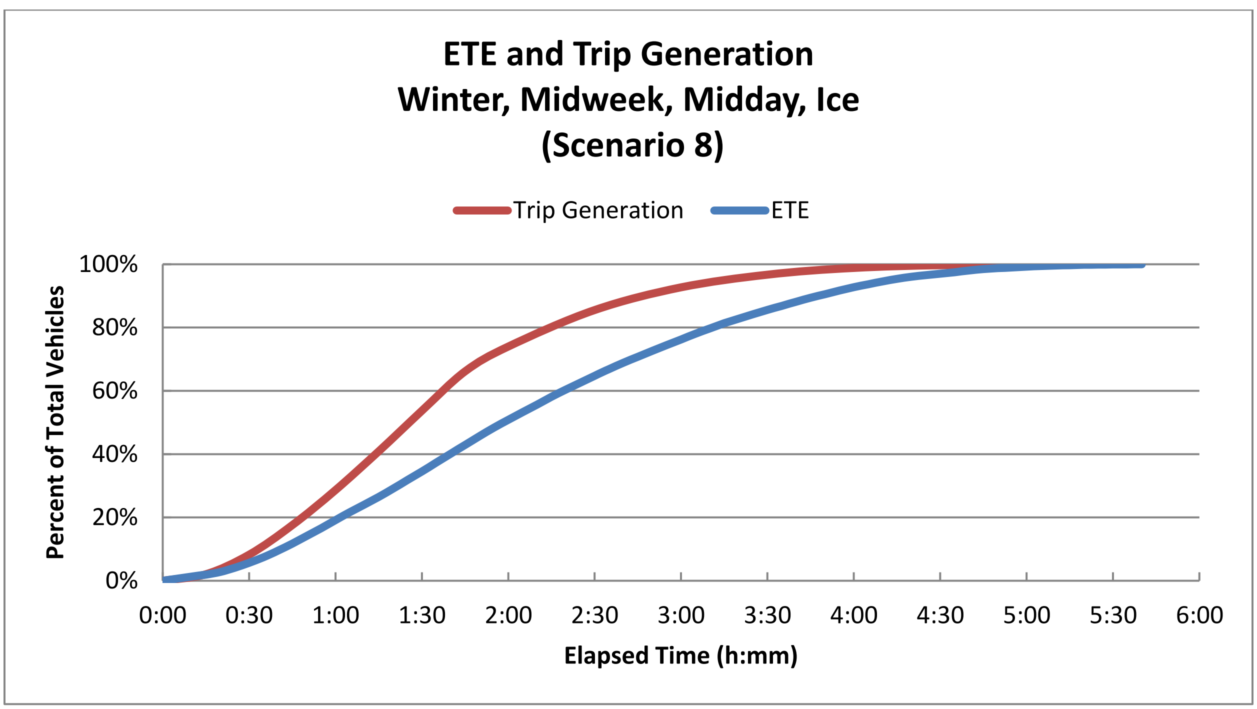


Figure J-9. ETE and Trip Generation: Winter, Midweek, Midday, Ice (Scenario 8)

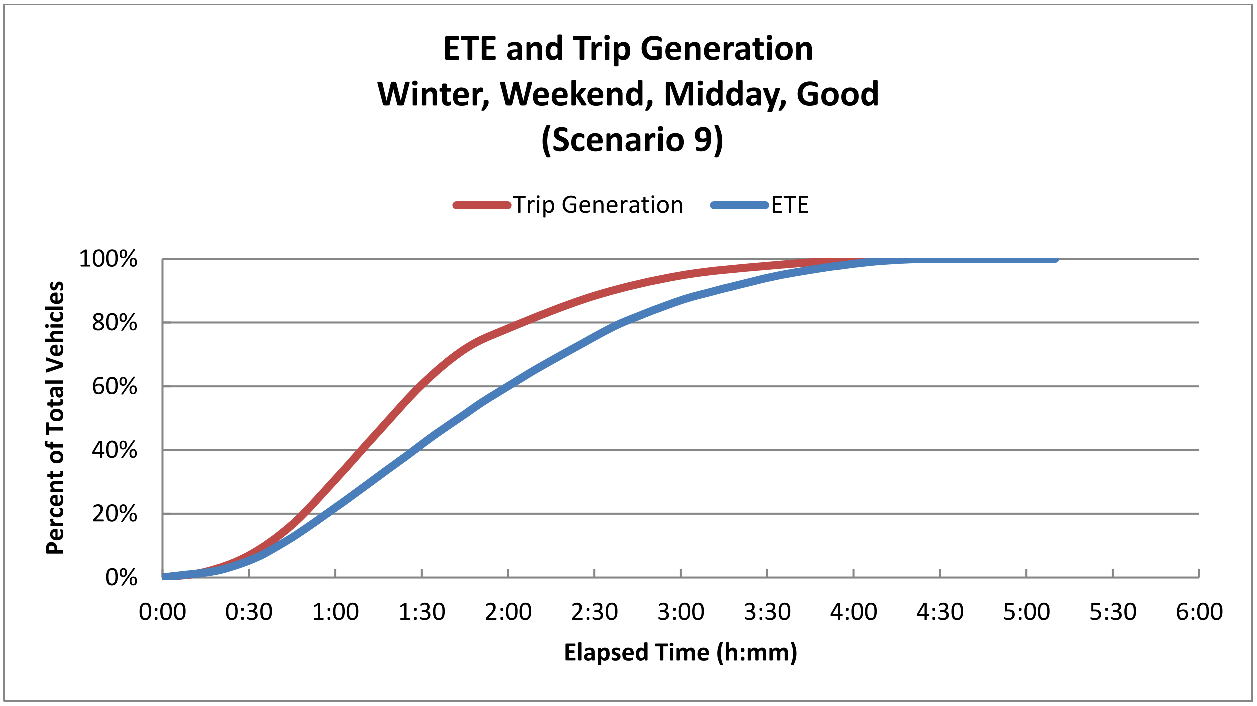


Figure J-10. ETE and Trip Generation: Winter, Weekend, Midday, Good Weather (Scenario 9)

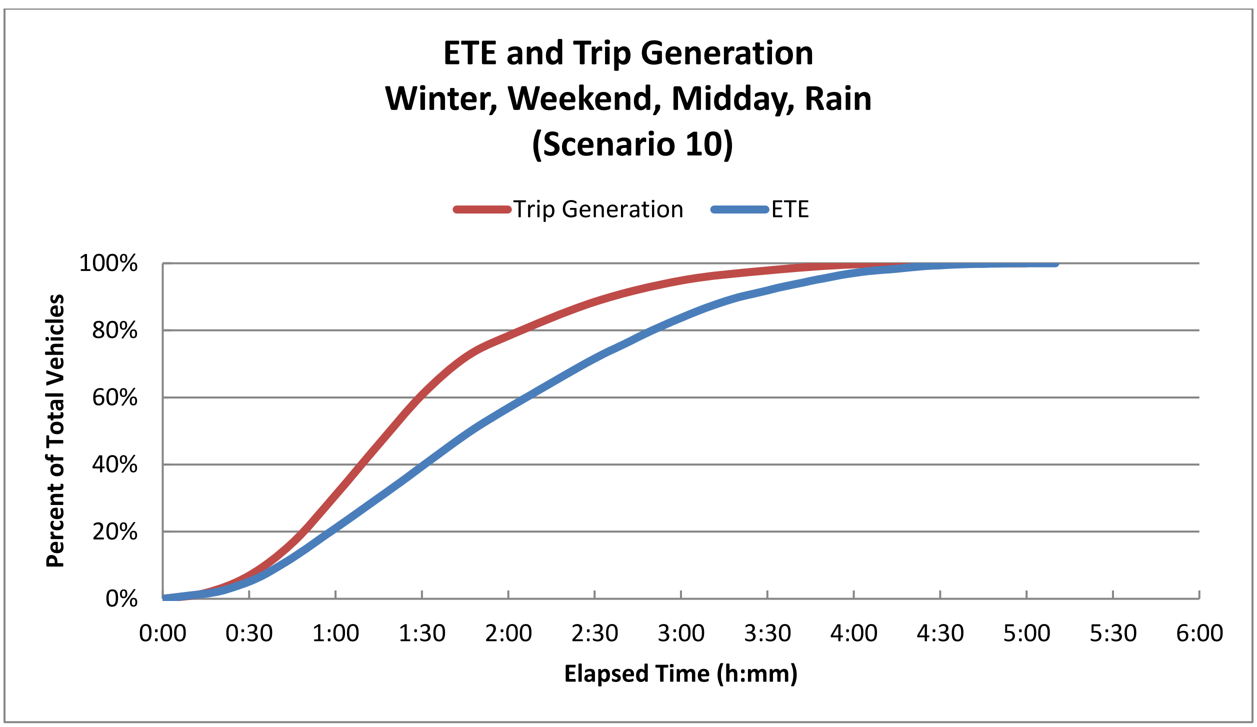


Figure J-11. ETE and Trip Generation: Winter, Weekend, Midday, Rain (Scenario 10)

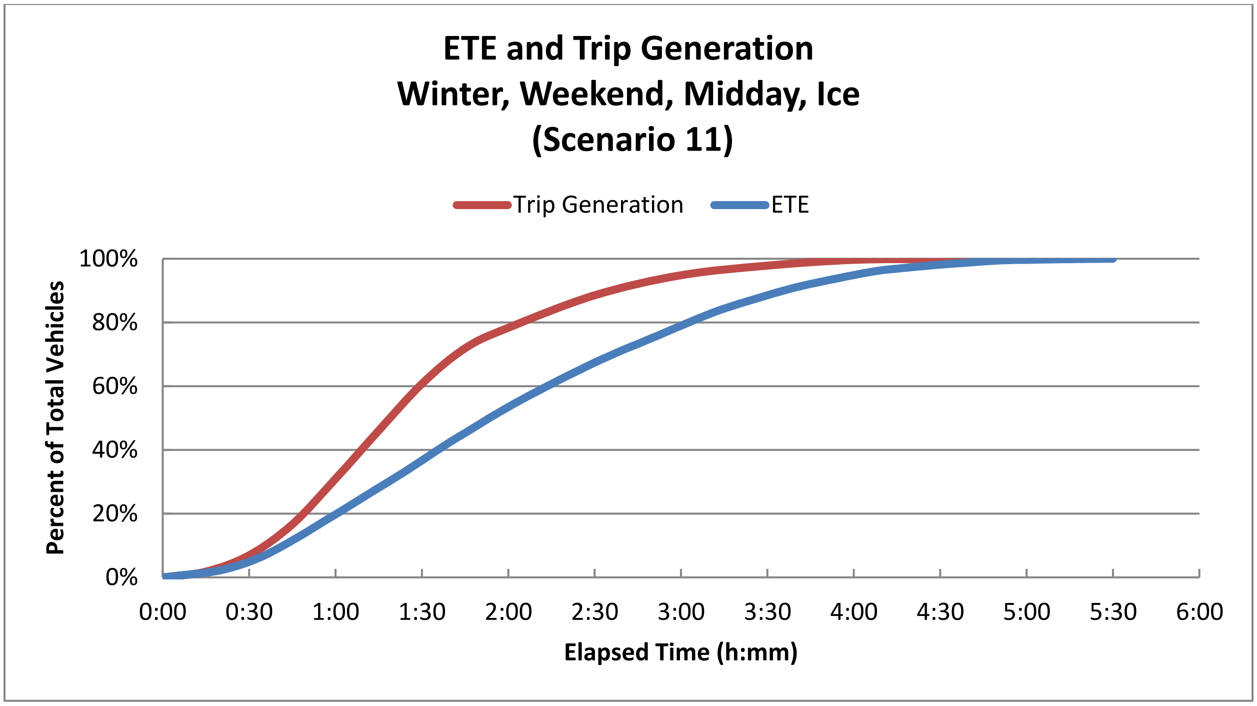


Figure J-12. ETE and Trip Generation: Winter, Weekend, Midday, Ice (Scenario 11)

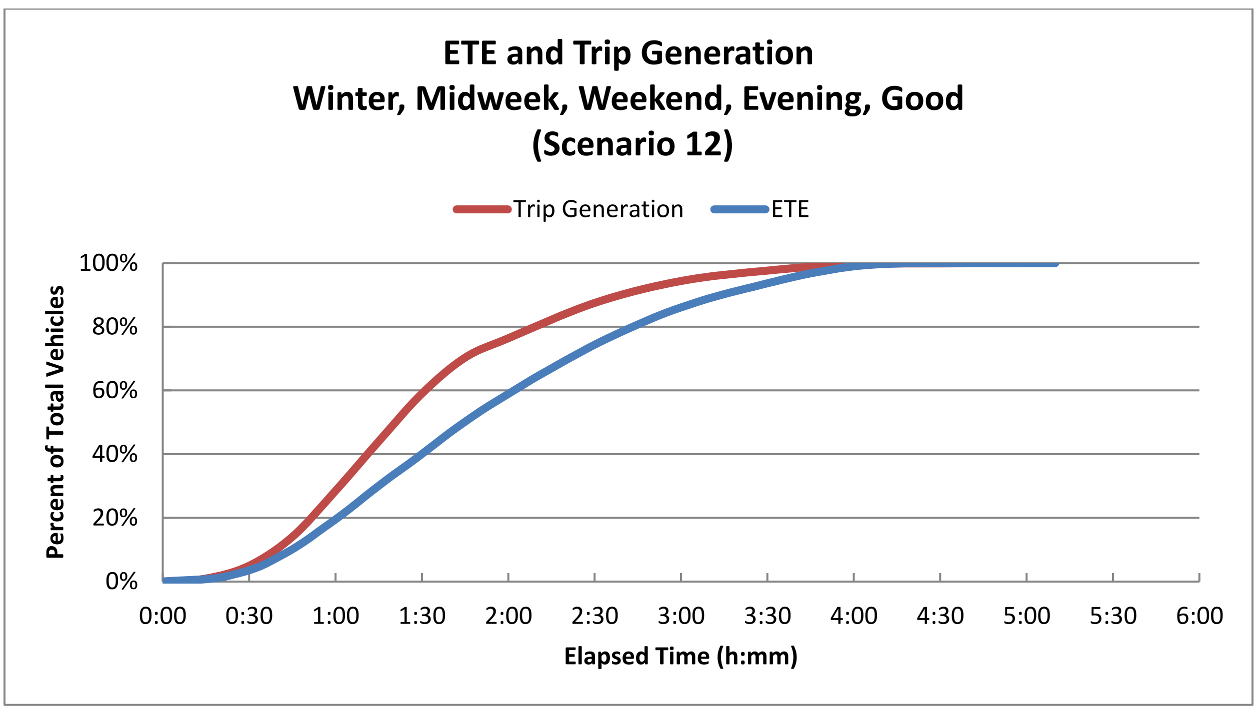


Figure J-13. ETE and Trip Generation: Winter, Midweek, Weekend, Evening, Good Weather (Scenario 12)

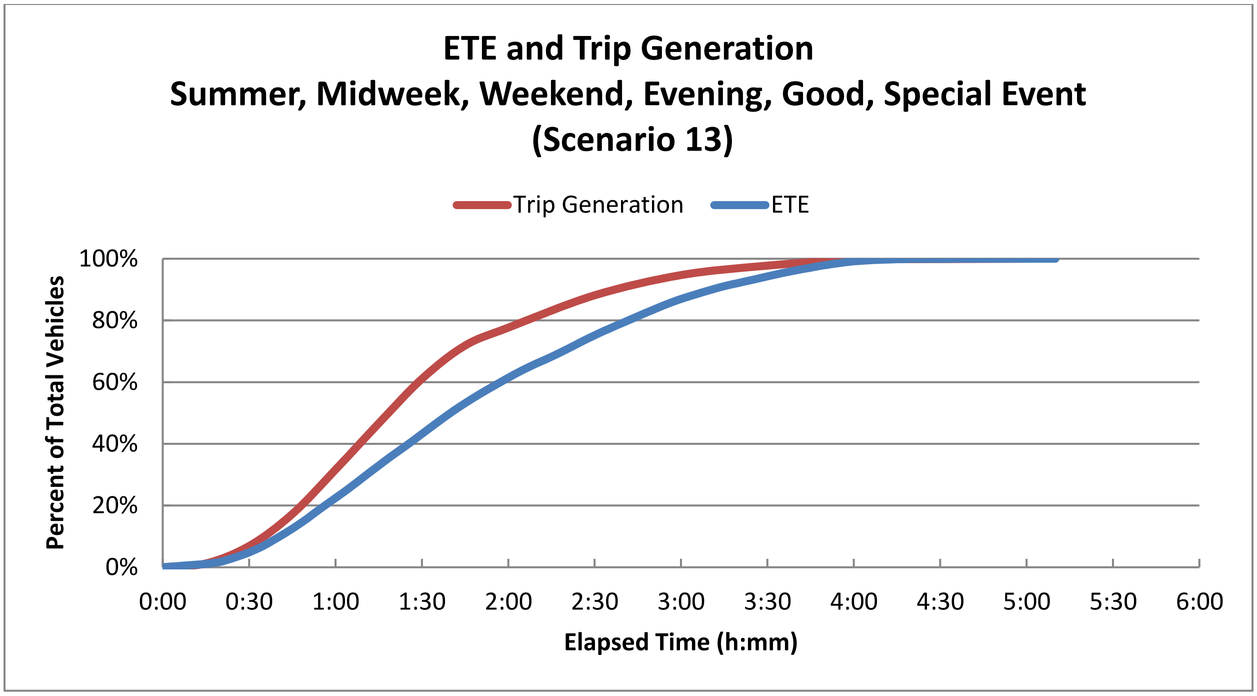


Figure J-14. ETE and Trip Generation: Summer, Midweek, Weekend, Evening, Good Weather, Special Event (Scenario 13)

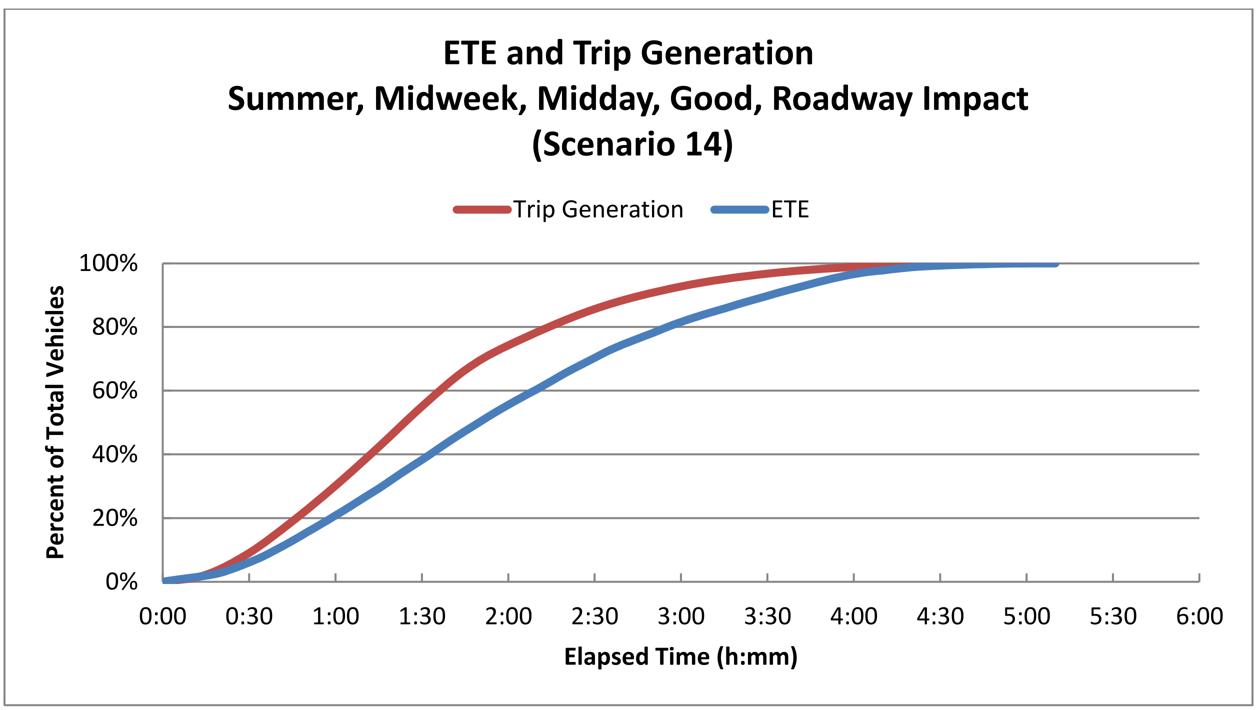


Figure J-15. ETE and Trip Generation: Summer, Midweek, Midday, Good Weather, Roadway Impact (Scenario 14)

APPENDIX K

Evacuation Roadway Network

K. EVACUATION ROADWAY NETWORK

As discussed in Section 1.3, a link-node analysis network was constructed to model the roadway network within the study area. Figure K-1 provides an overview of the link-node analysis network. The figure has been divided up into 112 more detailed figures (Figure K-2 through Figure K-113) which show each of the links and nodes in the network.

The analysis network was calibrated using the observations made during the field surveys conducted in October 2020.

Table K-1 summarizes the number of nodes by the type of control (stop sign, yield sign, pre-timed signal, actuated signal, traffic control point [TCP] or security road block [SRB], uncontrolled).

Table K-1. Summary of Nodes by the Type of Control

Control Type	Number of Nodes
Uncontrolled	1,771
Pretimed	1
Actuated	263
Stop	162
TCP/SRB	161
Yield	15
Total:	**2,373**

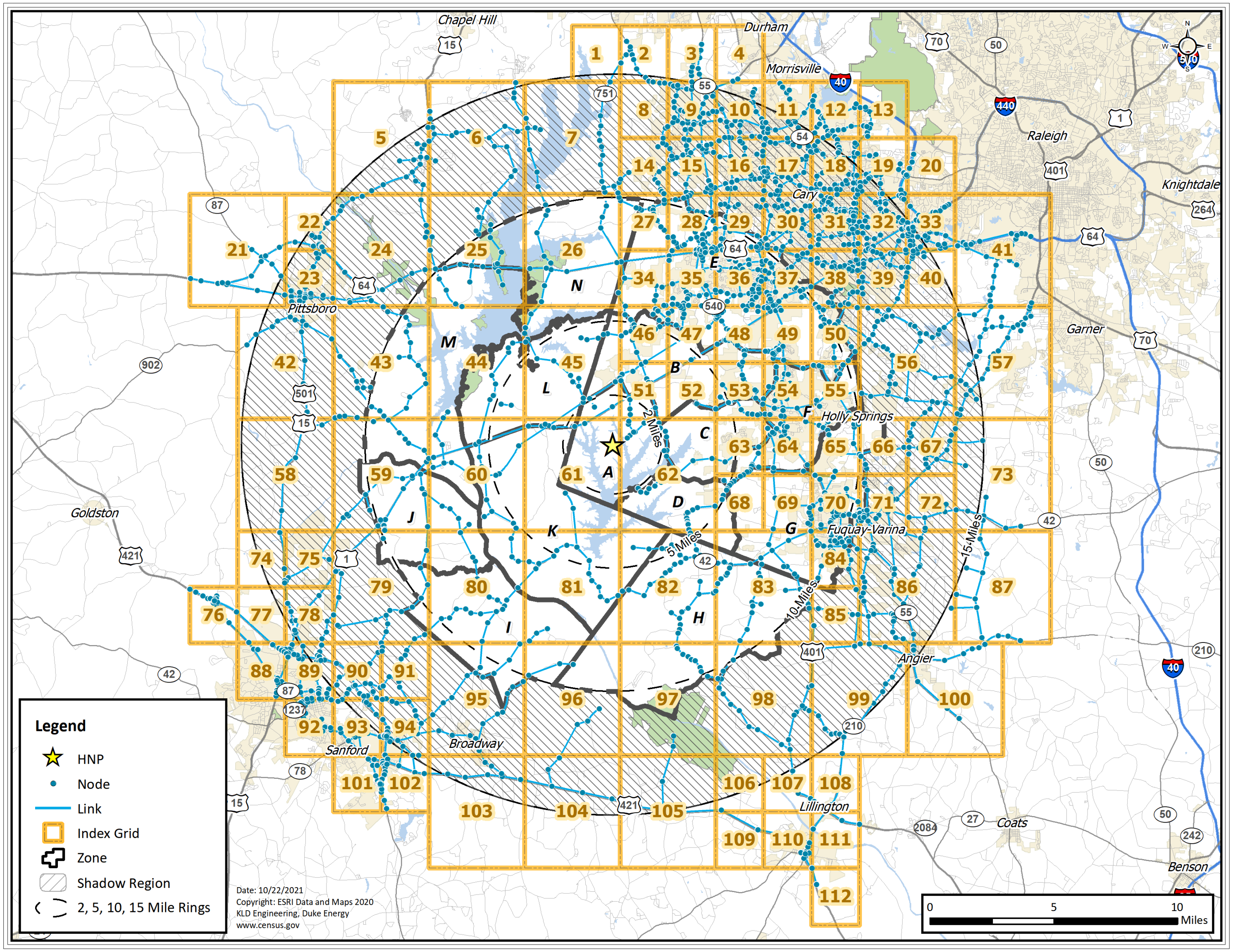


Figure K-1. Harris Link-Node Analysis Network

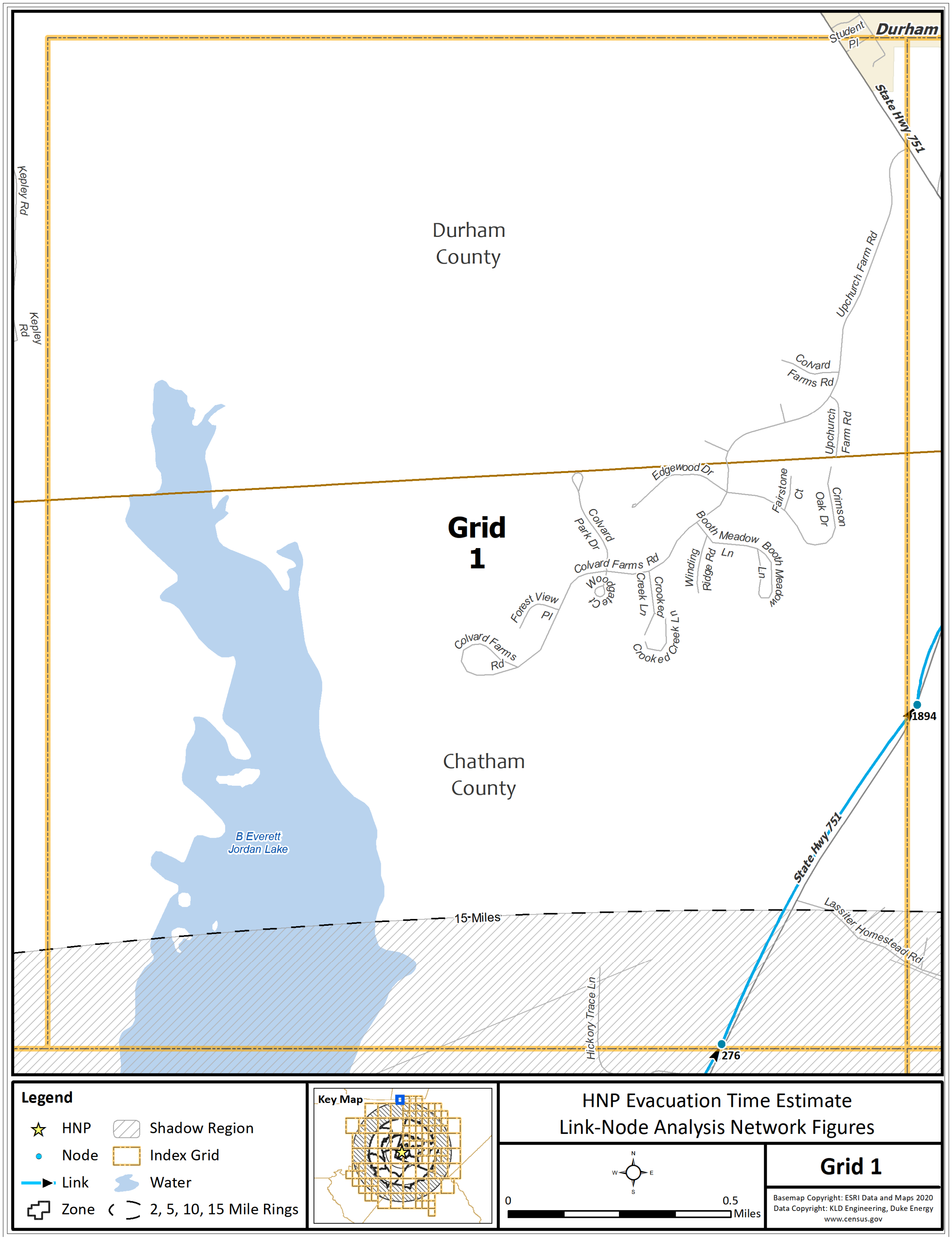


Figure K-2. Link-Node Analysis Network – Grid 1

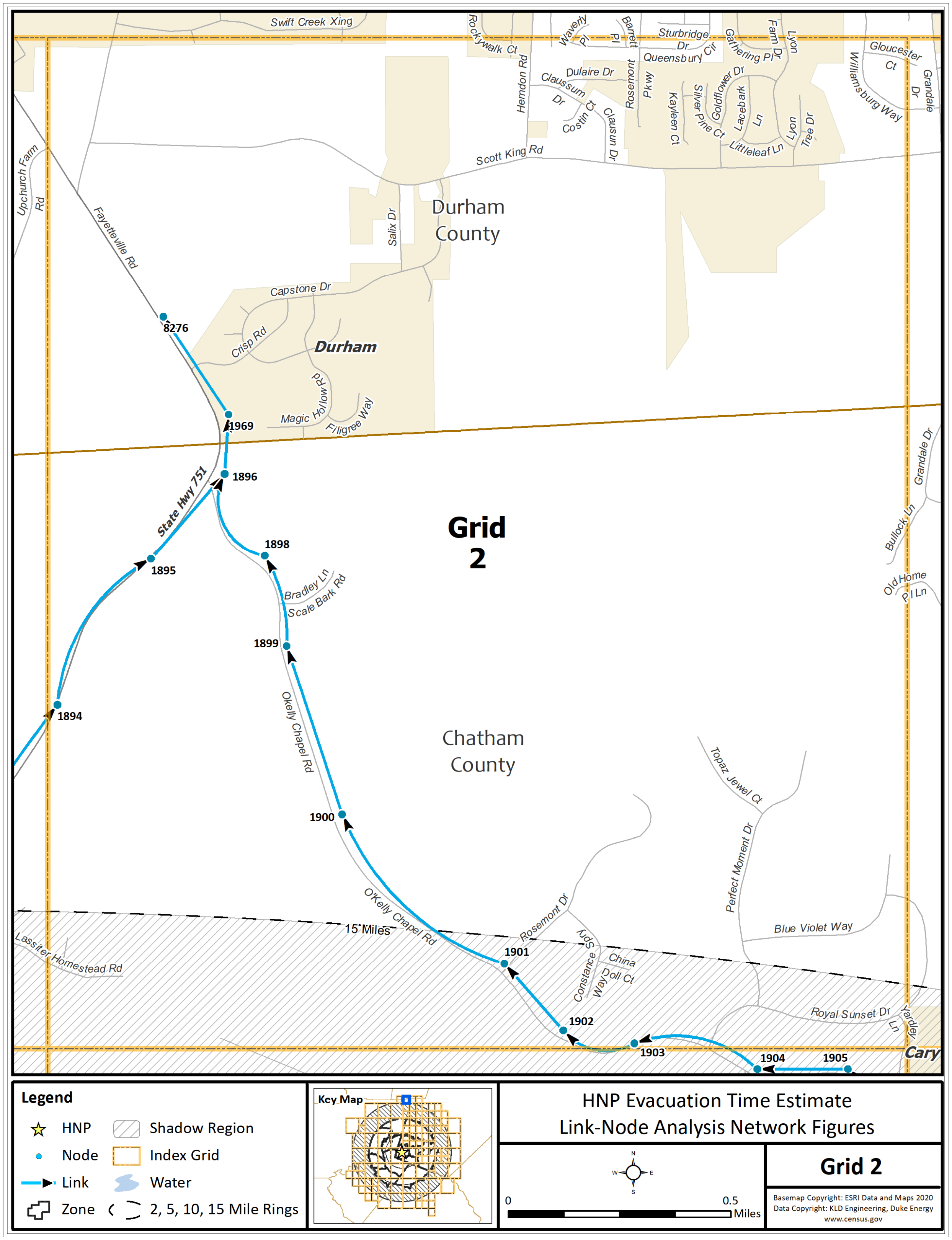


Figure K-3. Link-Node Analysis Network – Grid 2

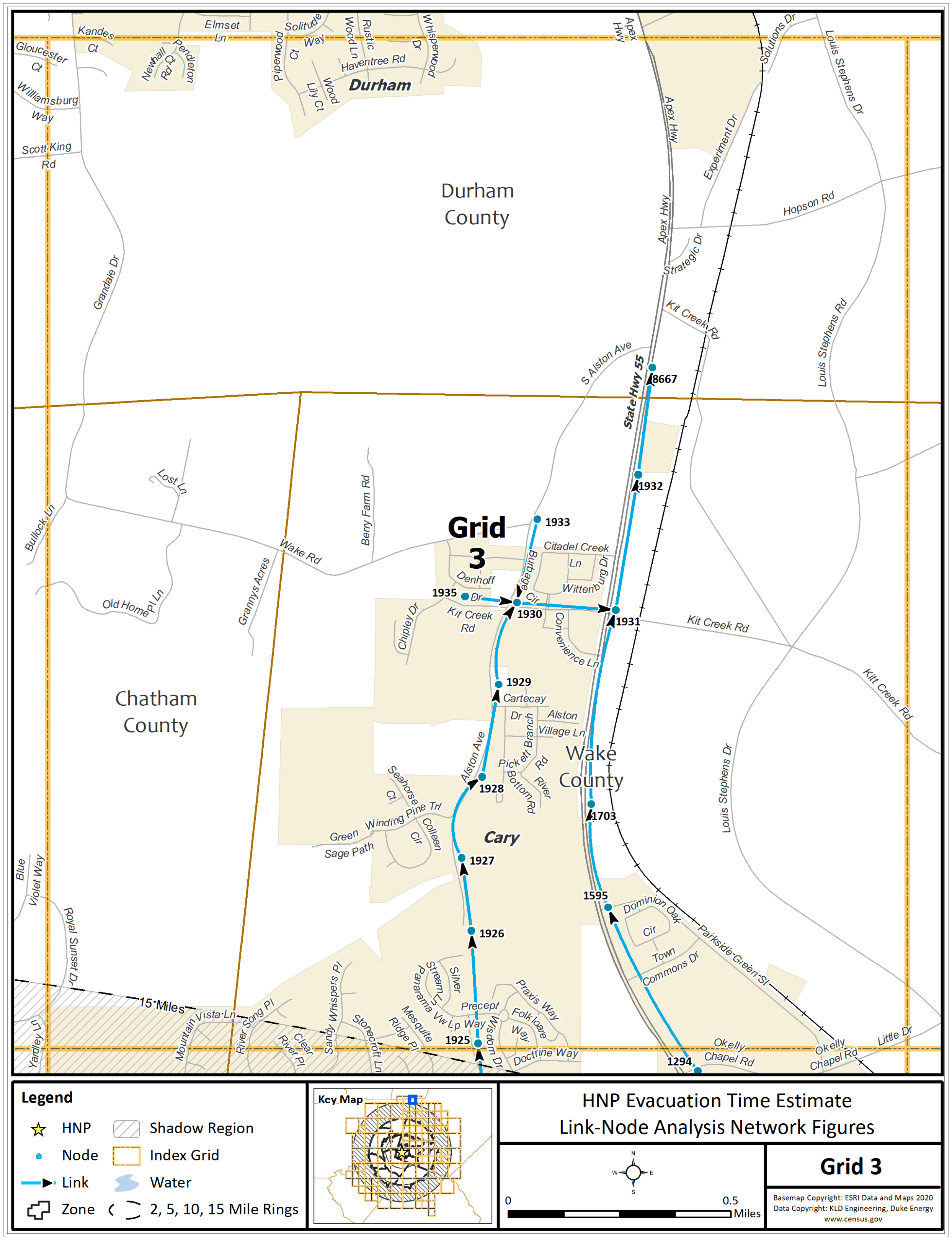


Figure K-4. Link-Node Analysis Network – Grid 3

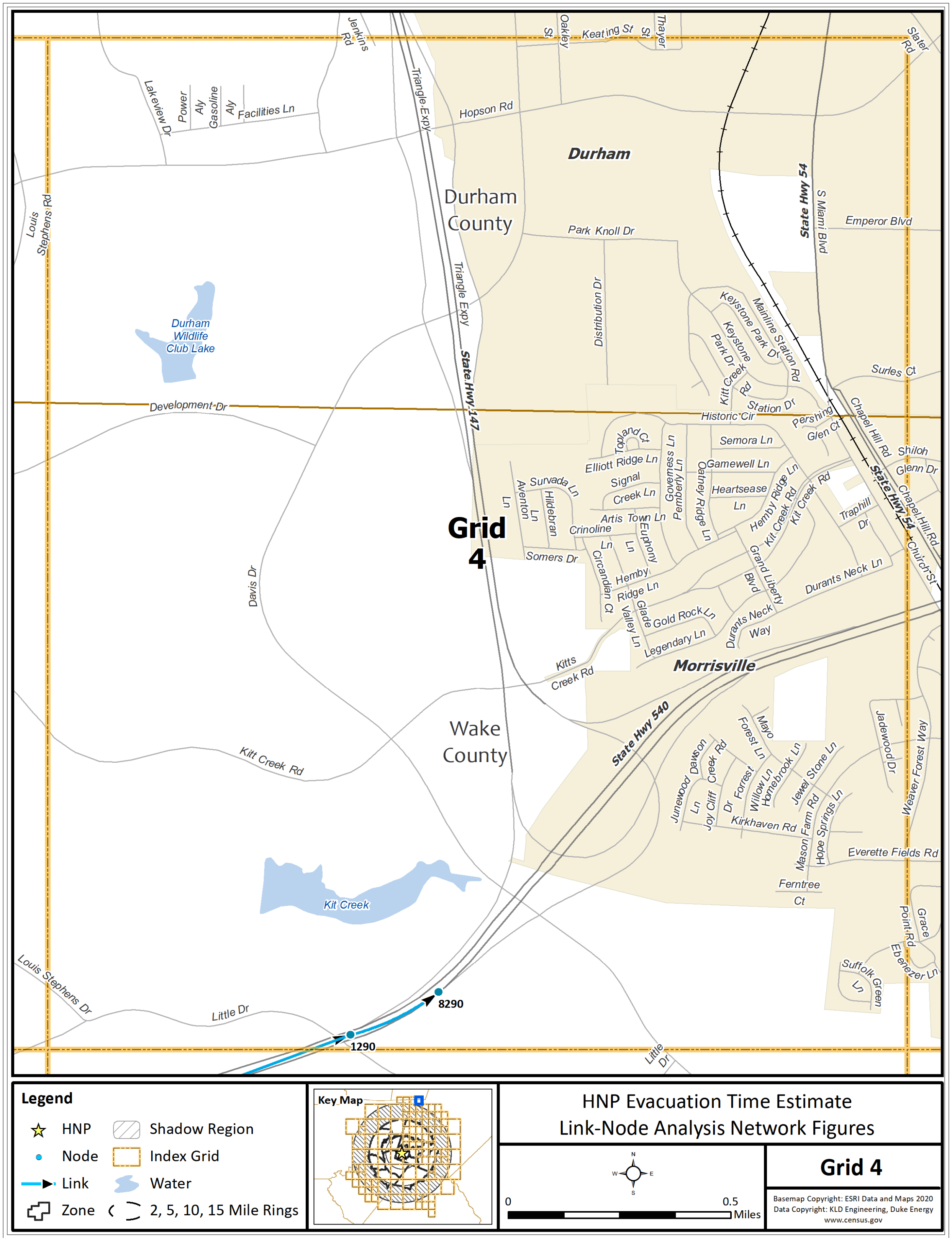


Figure K-5. Link-Node Analysis Network – Grid 4

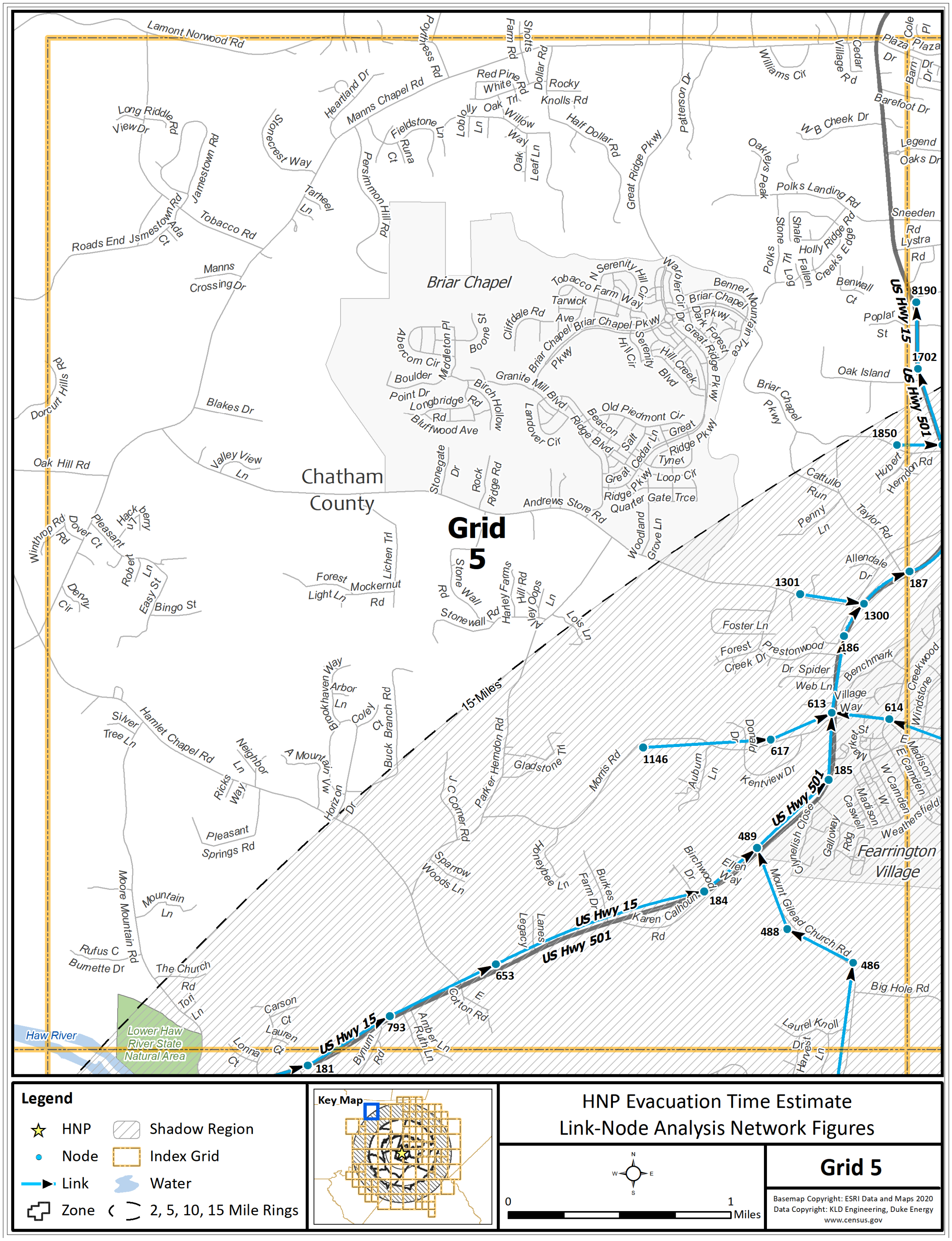


Figure K-6. Link-Node Analysis Network – Grid 5

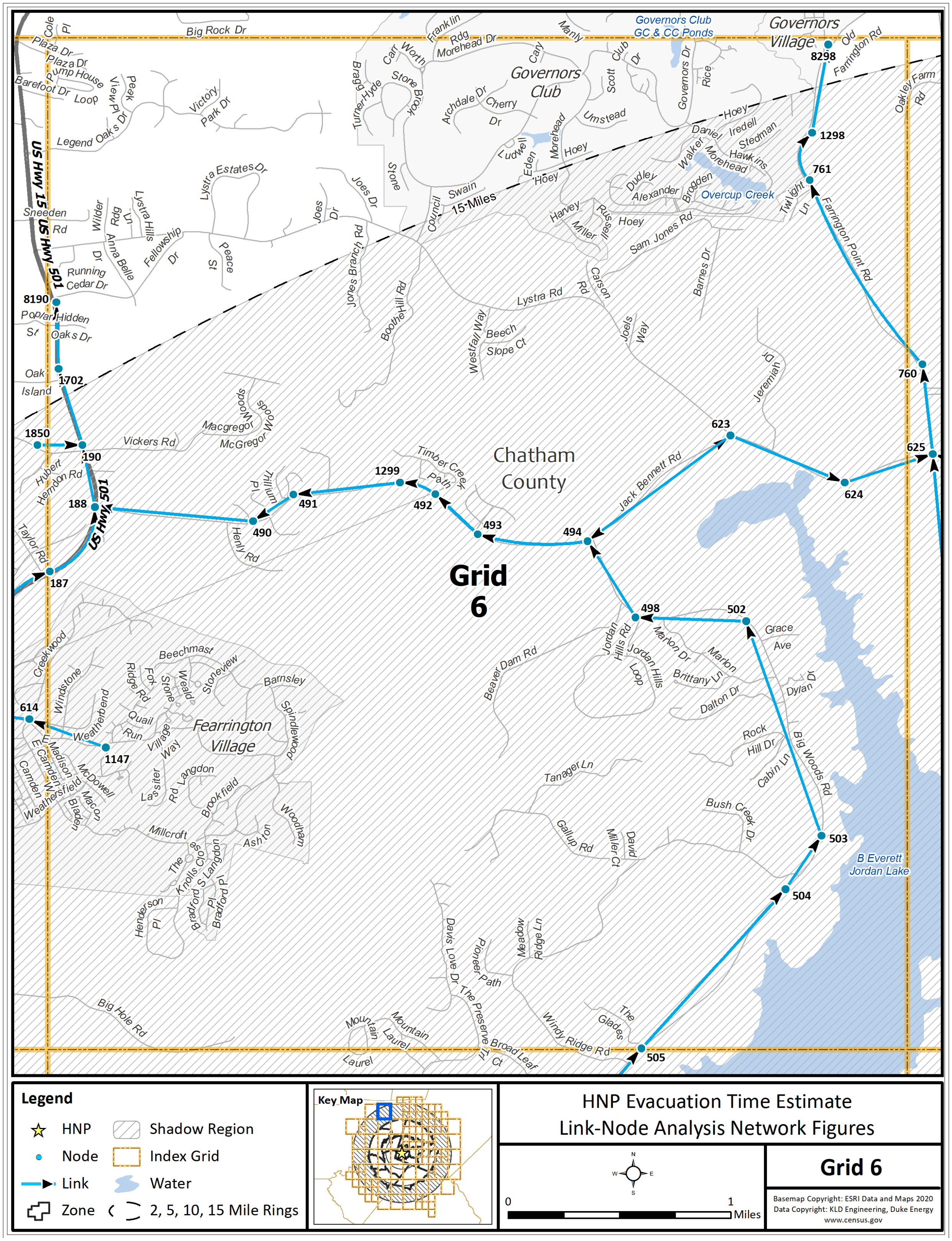


Figure K-7. Link-Node Analysis Network – Grid 6

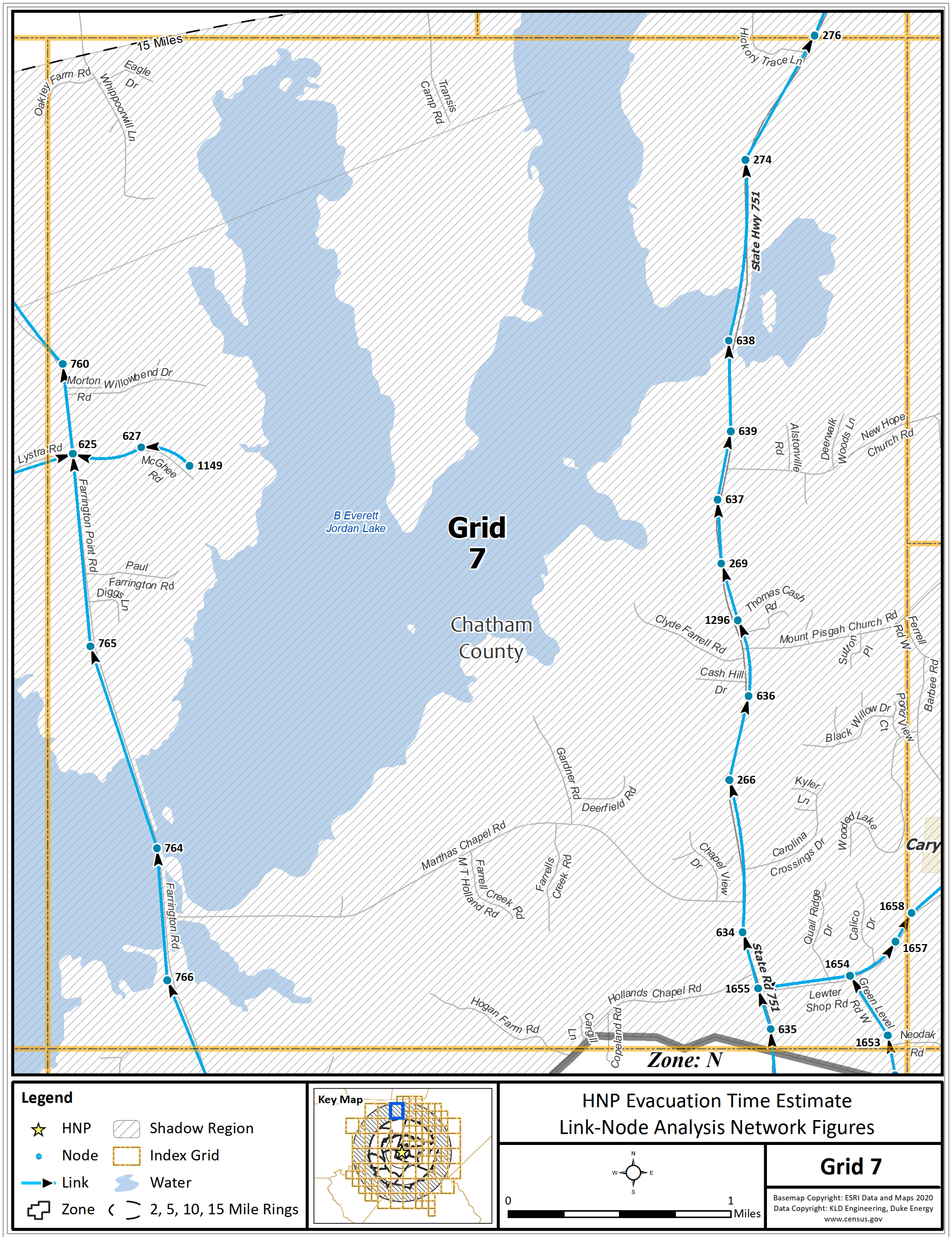


Figure K-8. Link-Node Analysis Network – Grid 7

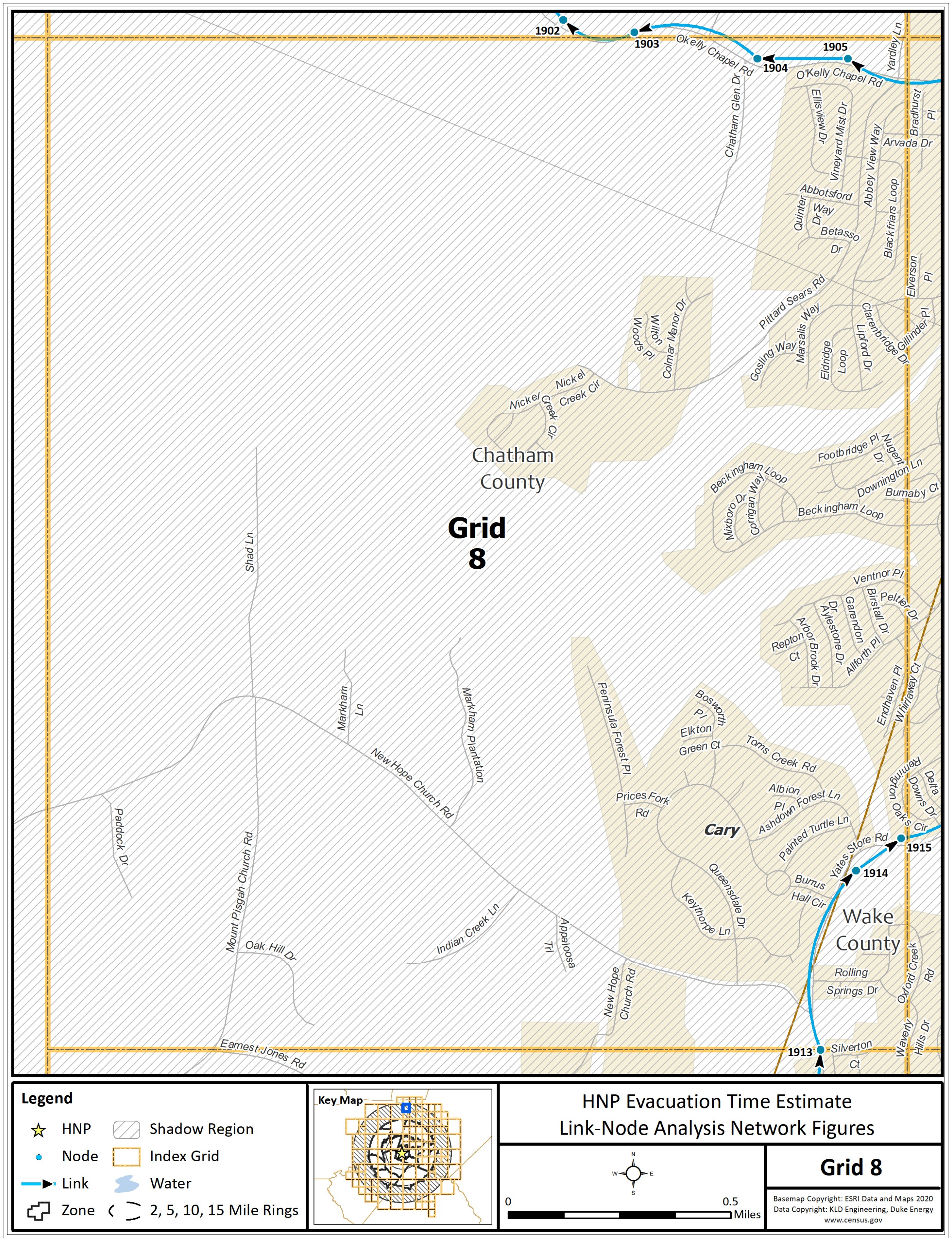


Figure K-9. Link-Node Analysis Network – Grid 8

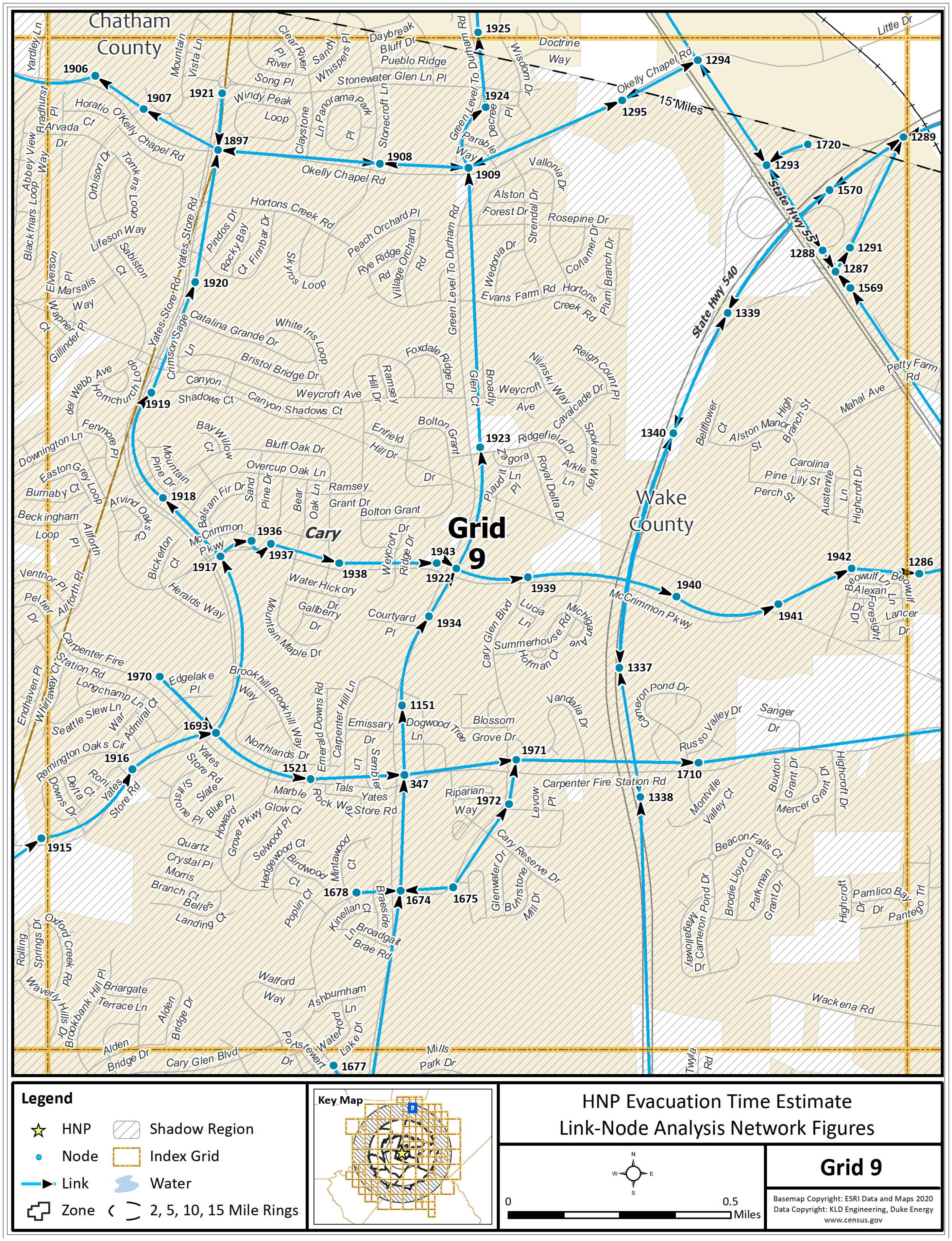


Figure K-10. Link-Node Analysis Network – Grid 9

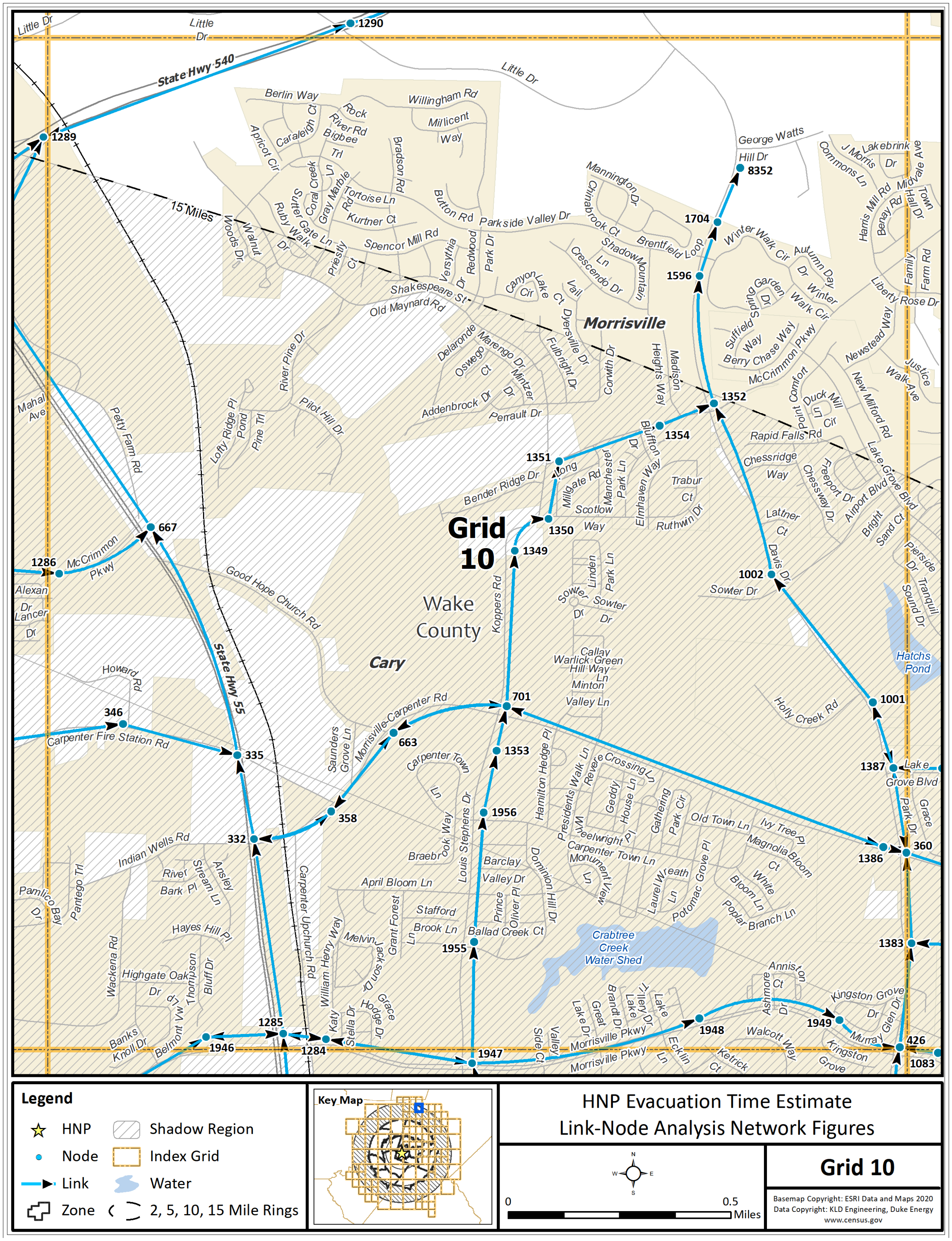


Figure K-11. Link-Node Analysis Network – Grid 10

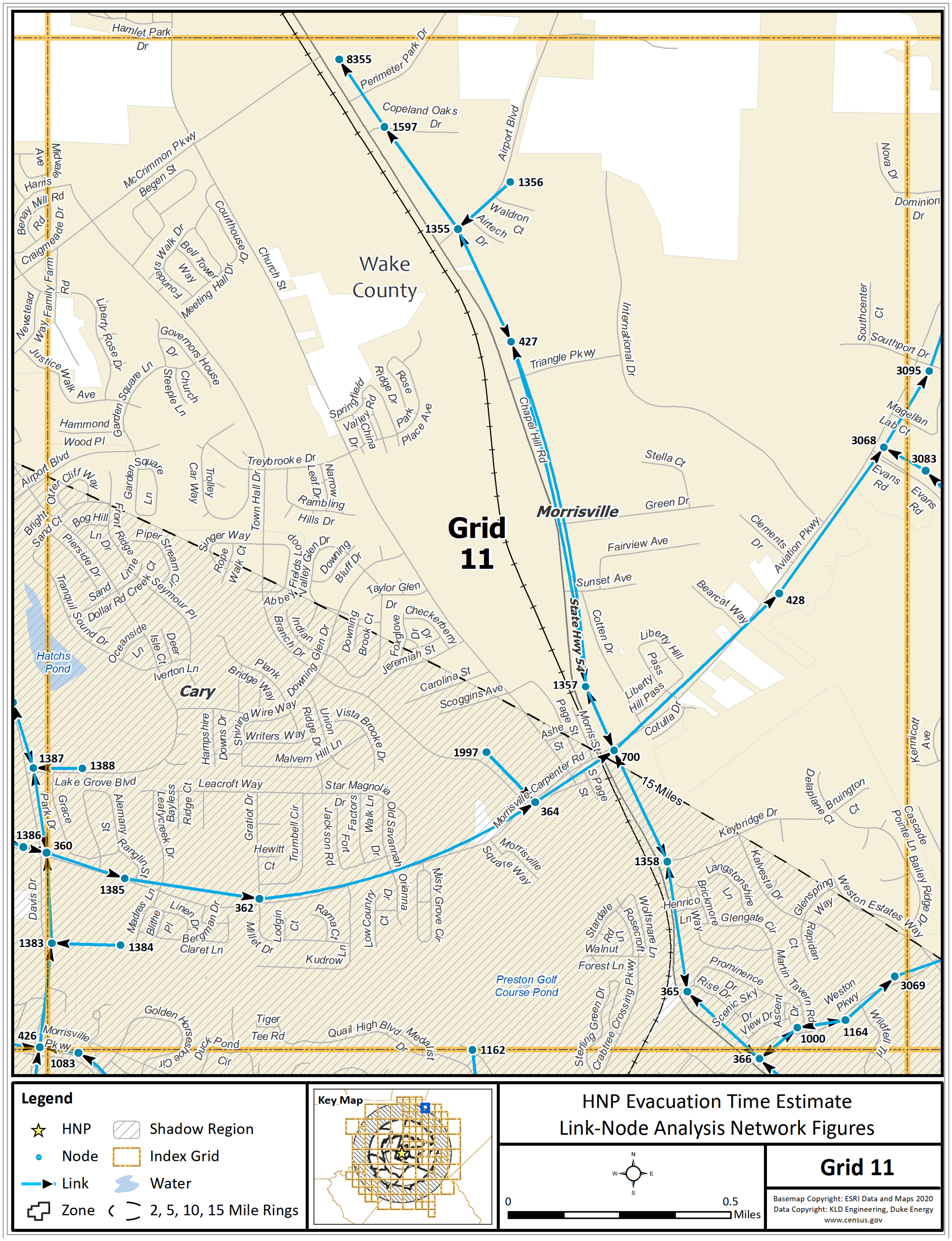


Figure K-12. Link-Node Analysis Network – Grid 11

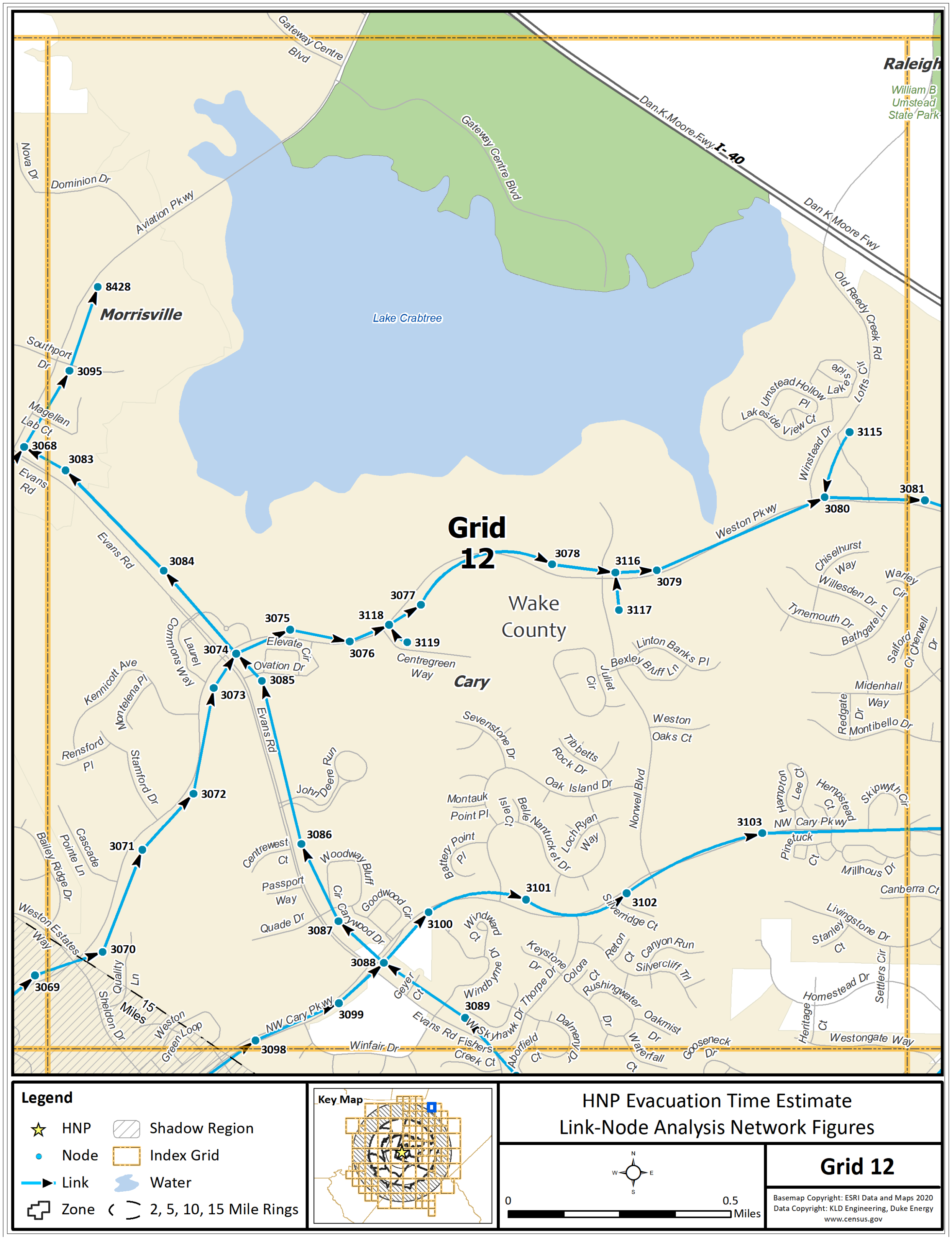


Figure K-13. Link-Node Analysis Network – Grid 12

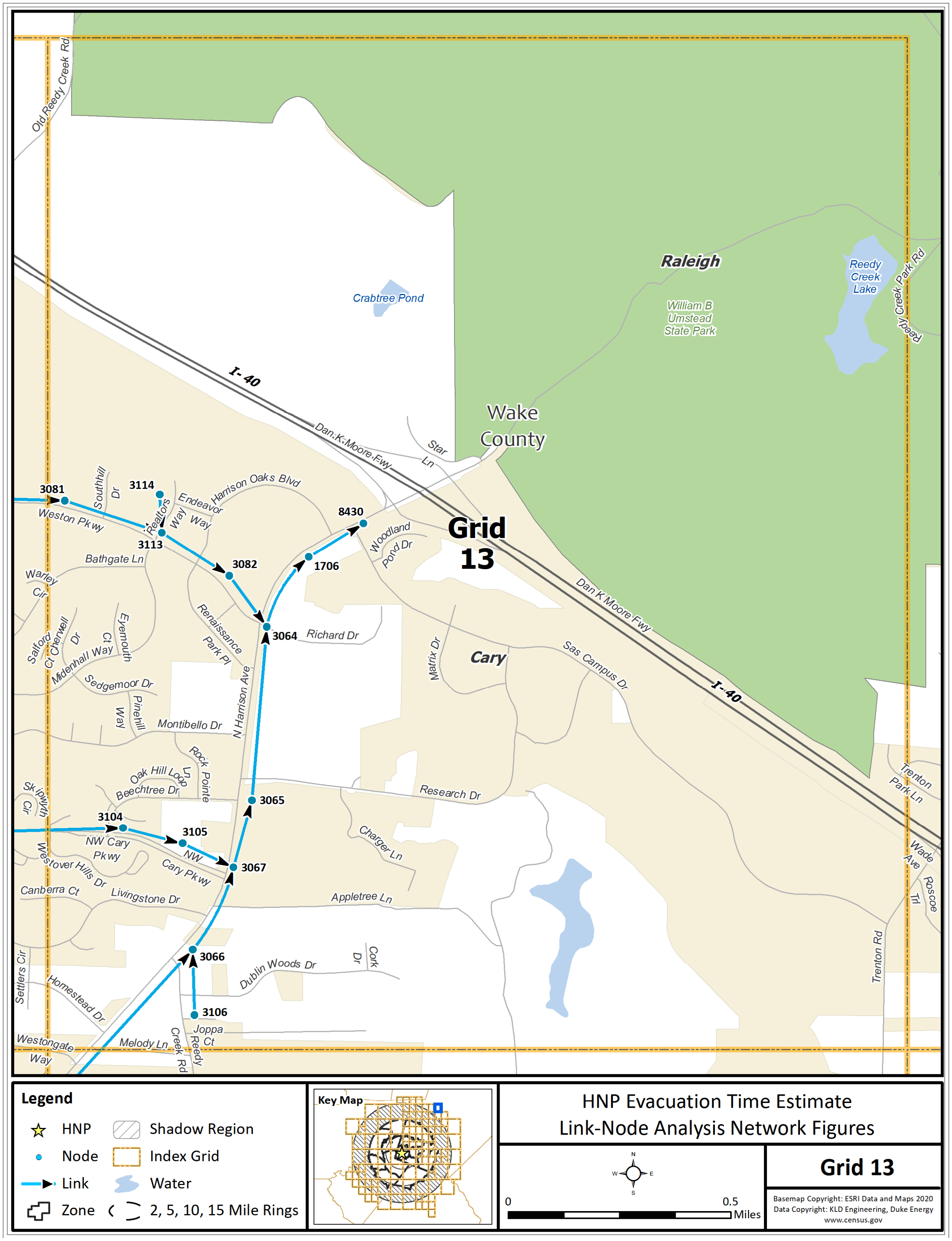


Figure K-14. Link-Node Analysis Network – Grid 13

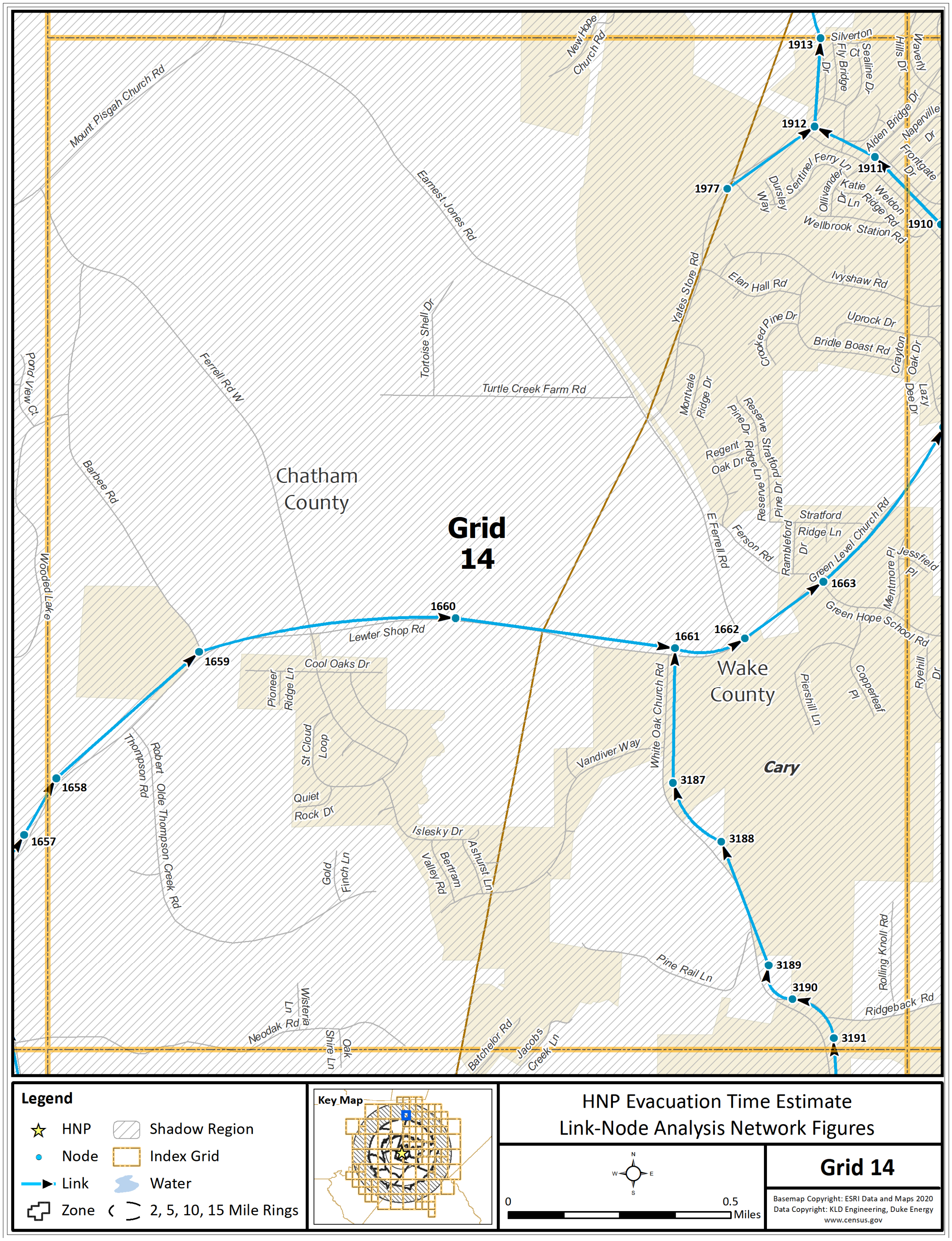


Figure K-15. Link-Node Analysis Network – Grid 14

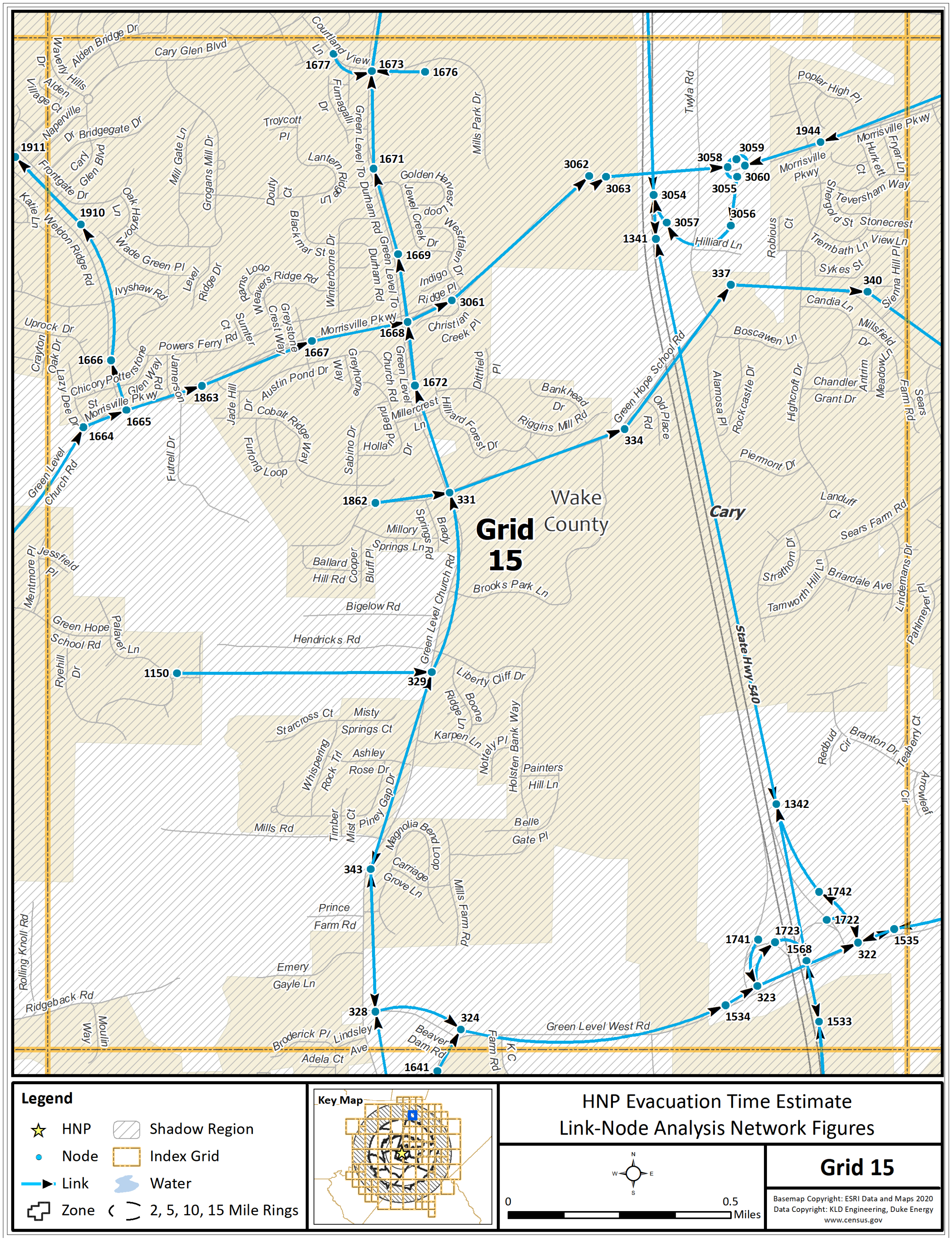


Figure K-16. Link-Node Analysis Network – Grid 15

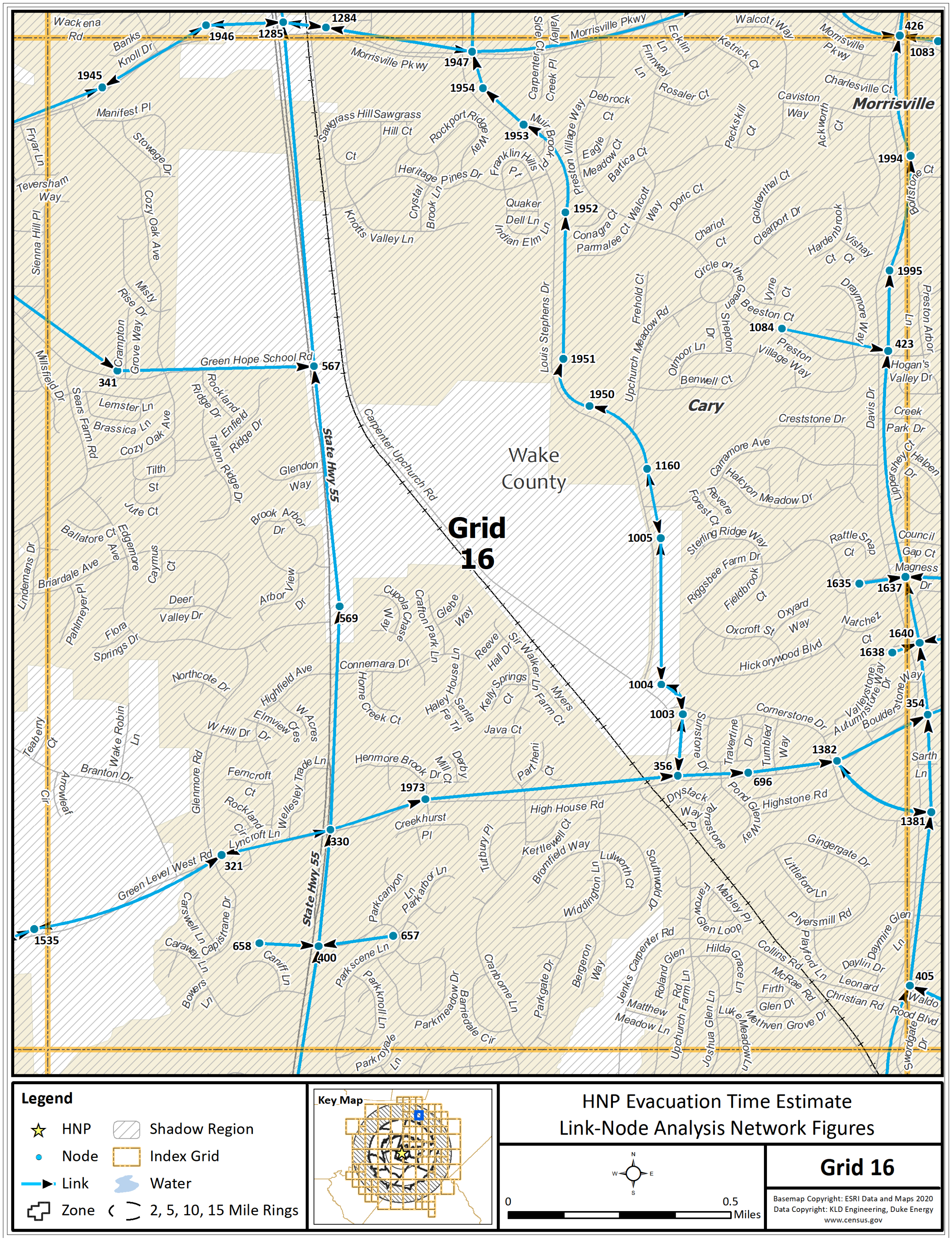
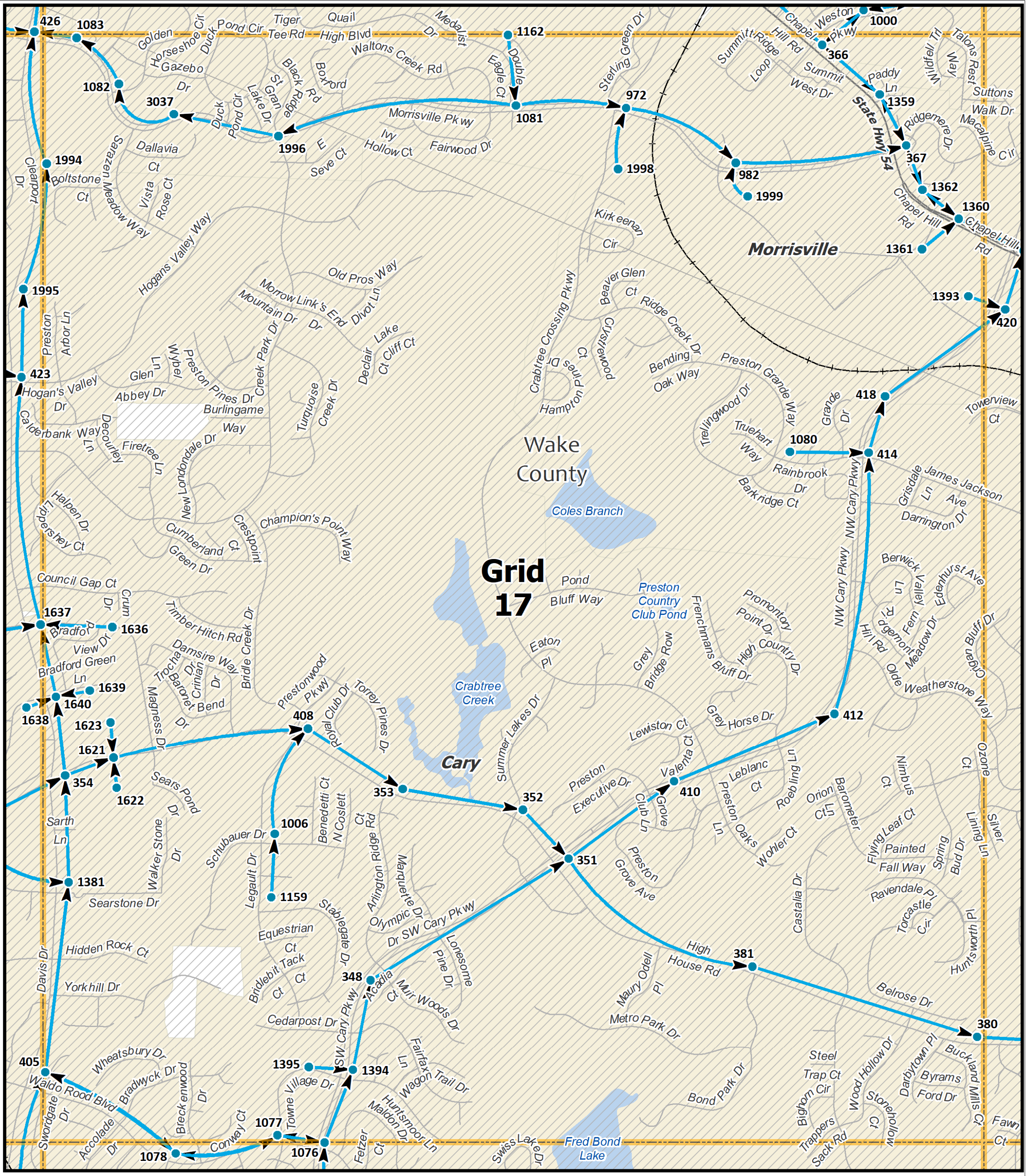
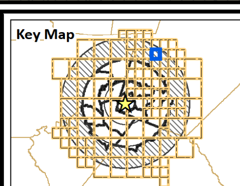


Figure K-17. Link-Node Analysis Network – Grid 16





HNP Evacuation Time Estimate
Link-Node Analysis Network Figures

Grid 17

0 0.5 Miles

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Figure K-18. Link-Node Analysis Network – Grid 17

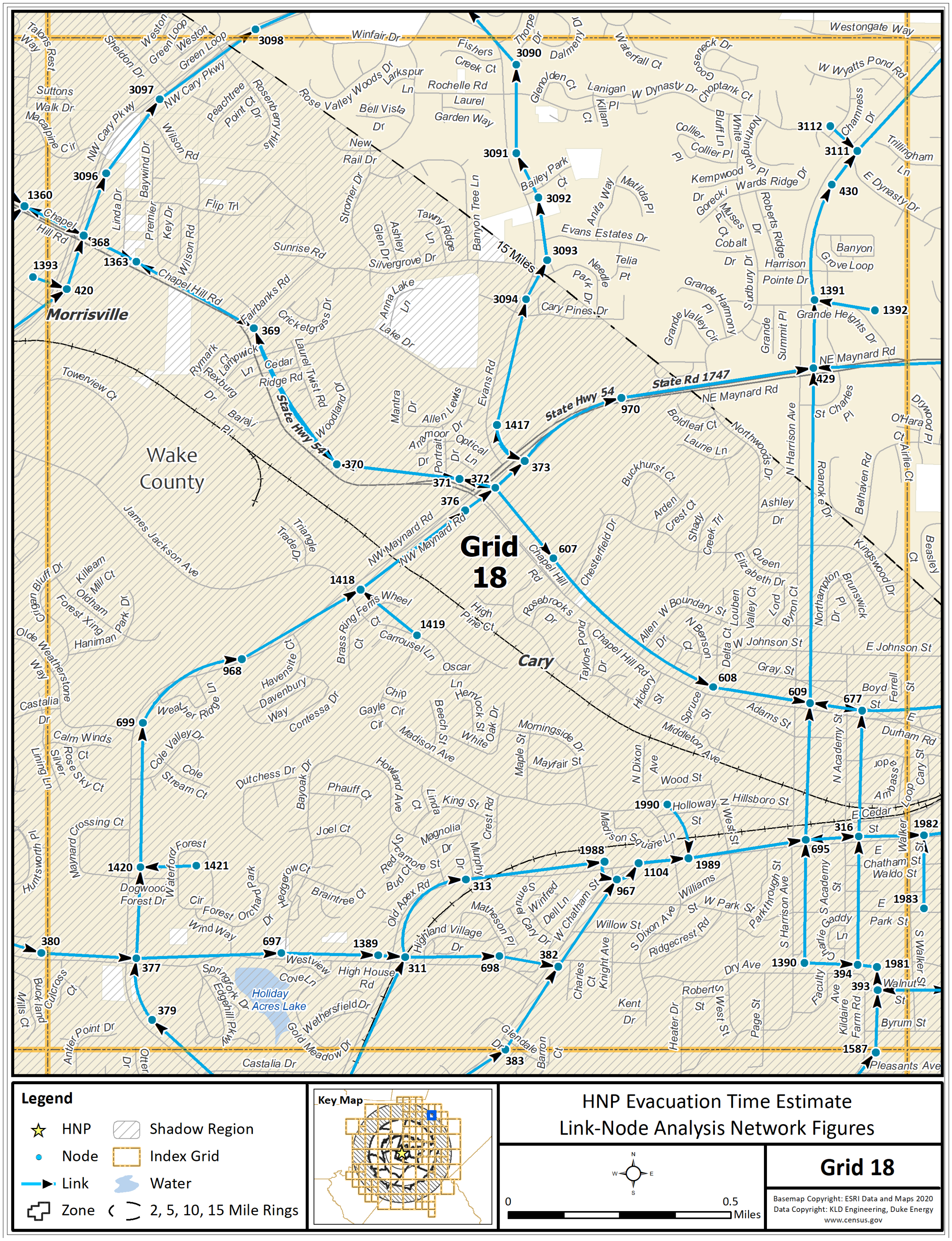


Figure K-19. Link-Node Analysis Network – Grid 18

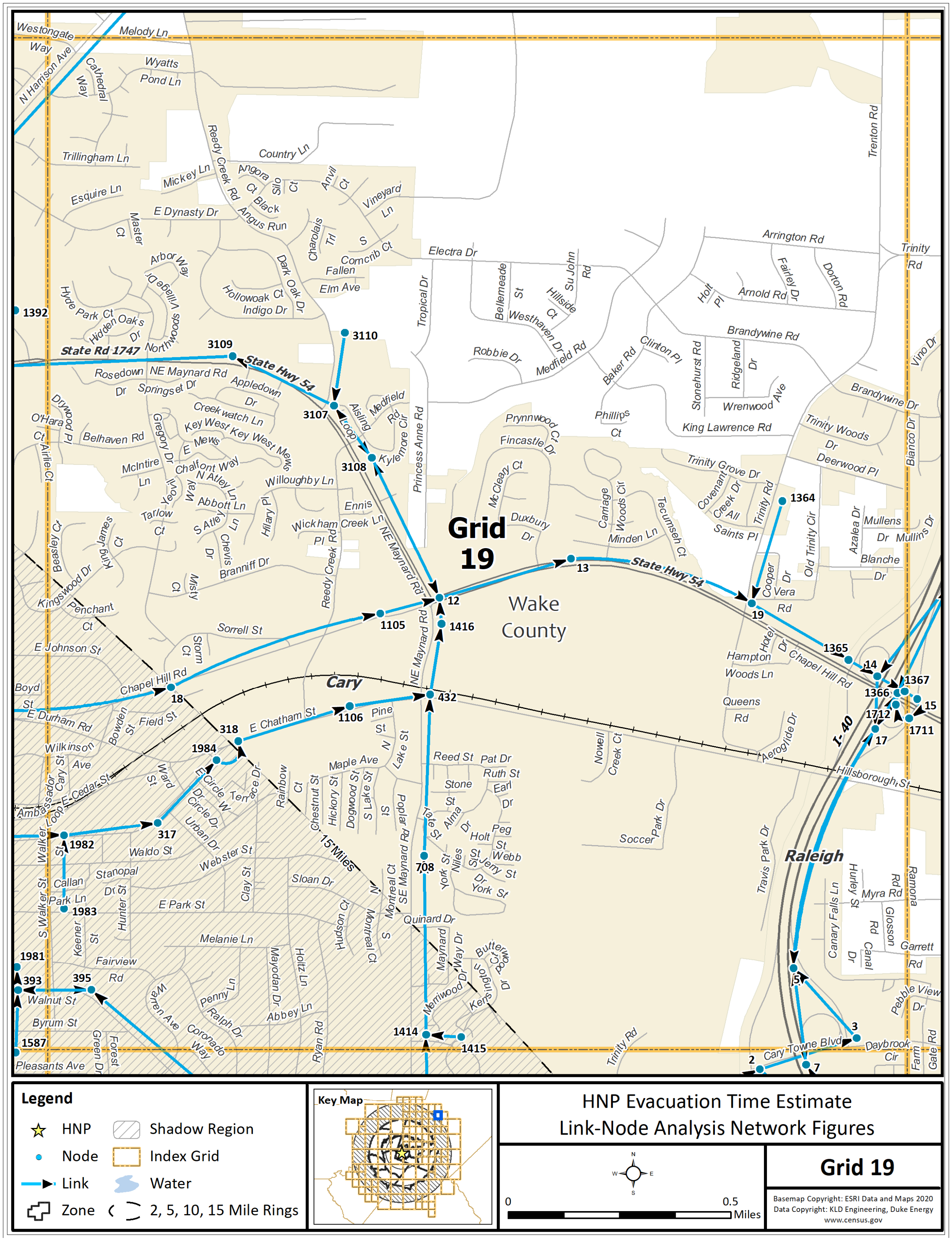


Figure K-20. Link-Node Analysis Network – Grid 19

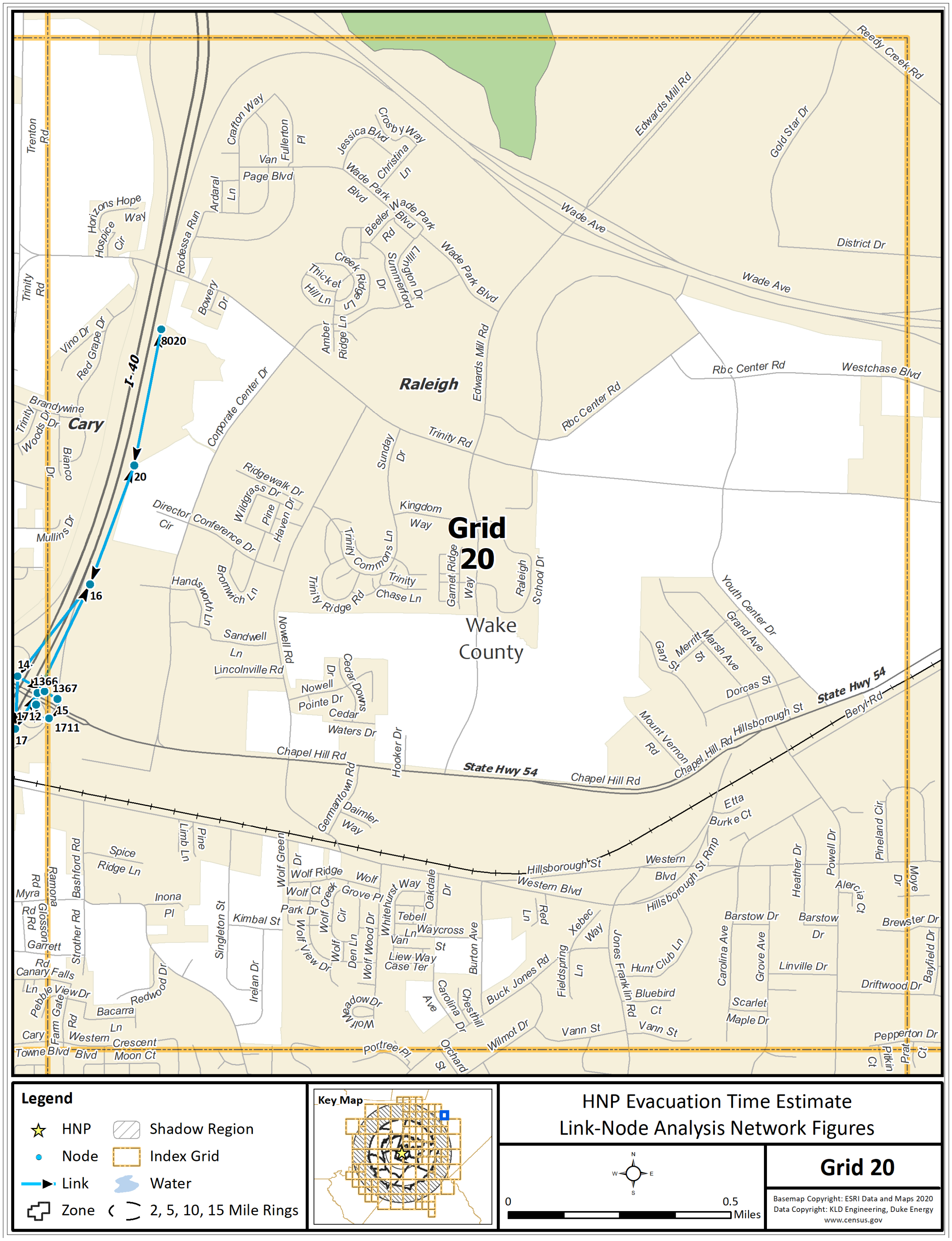


Figure K-21. Link-Node Analysis Network – Grid 20

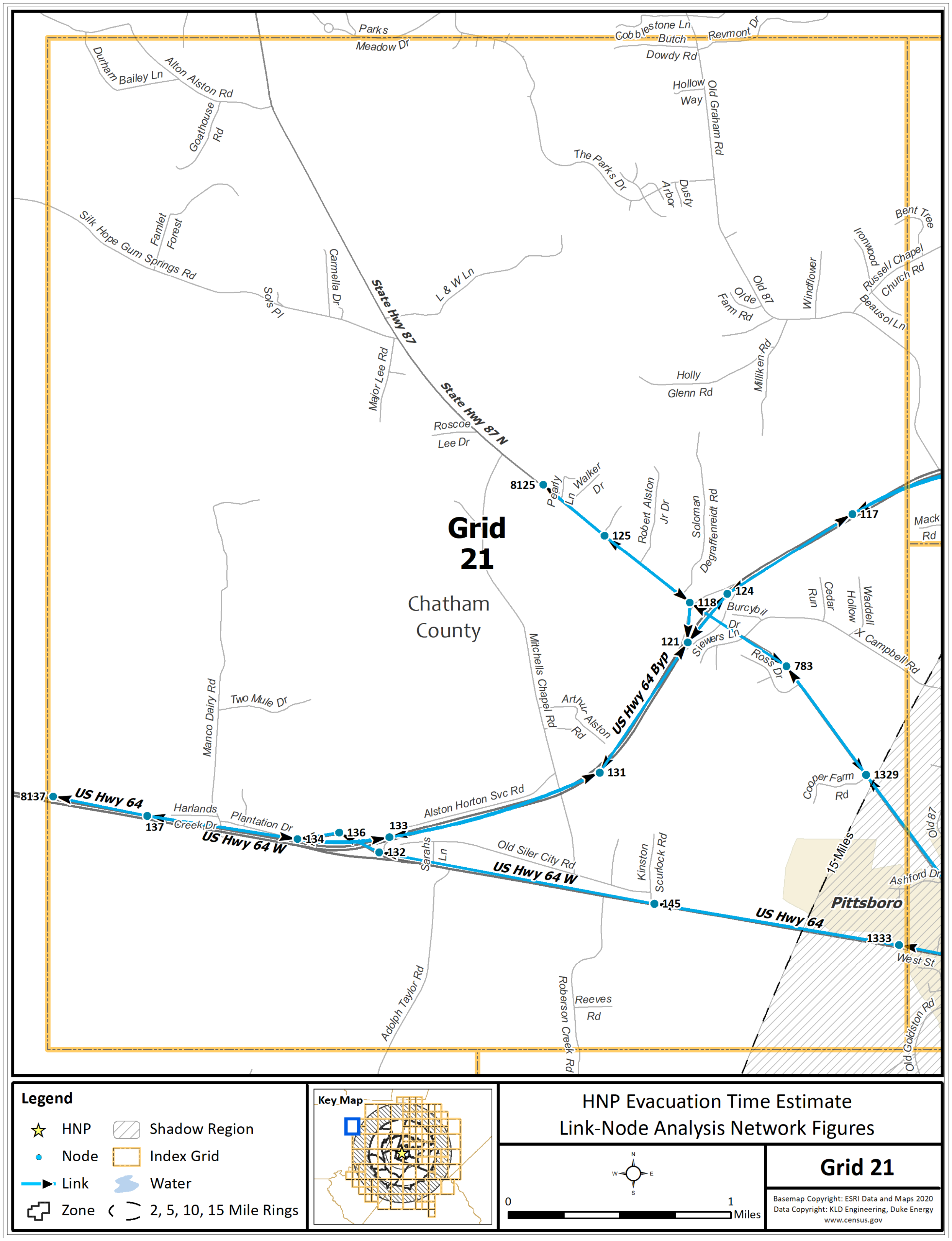


Figure K-22. Link-Node Analysis Network – Grid 21

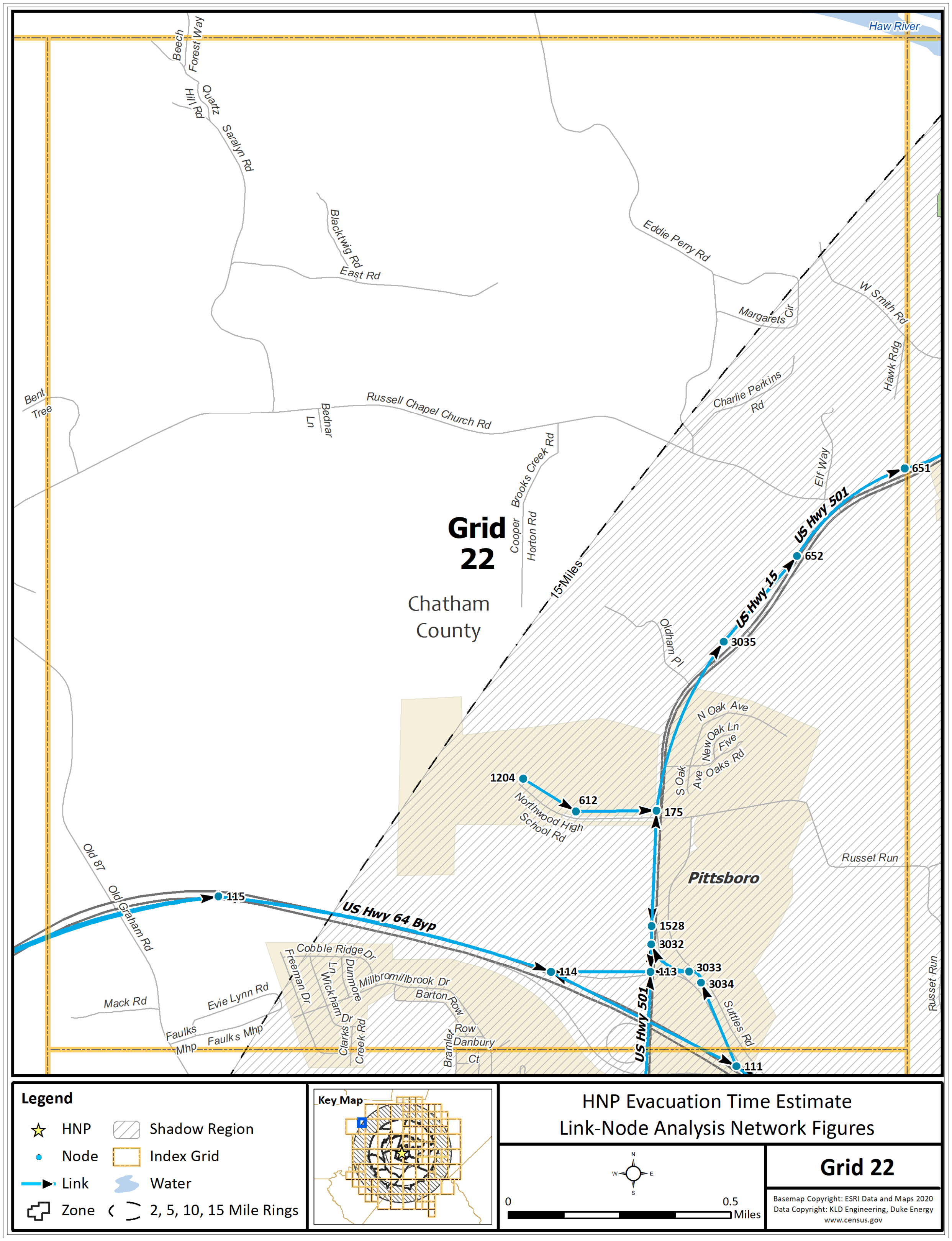


Figure K-23. Link-Node Analysis Network – Grid 22

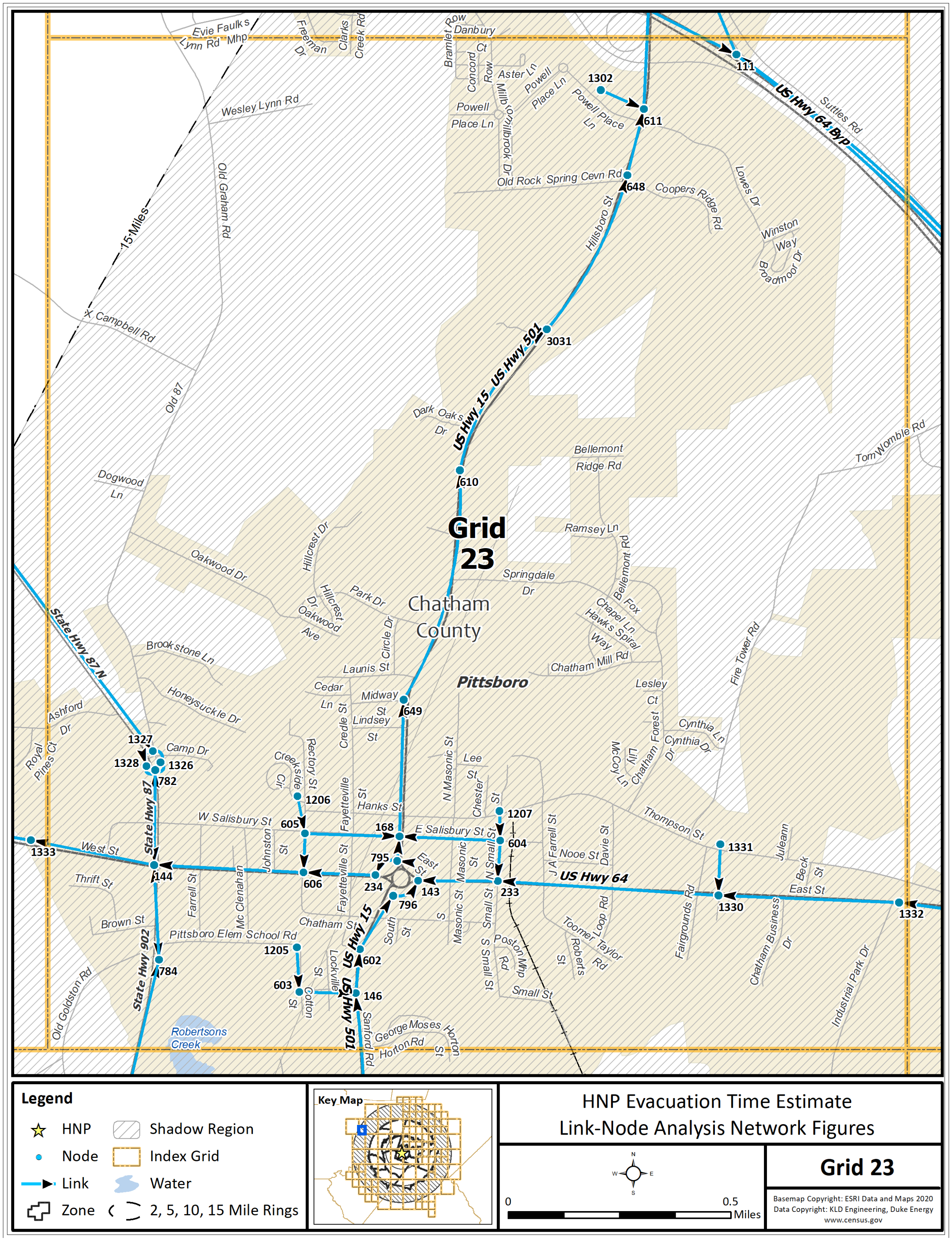


Figure K-24. Link-Node Analysis Network – Grid 23

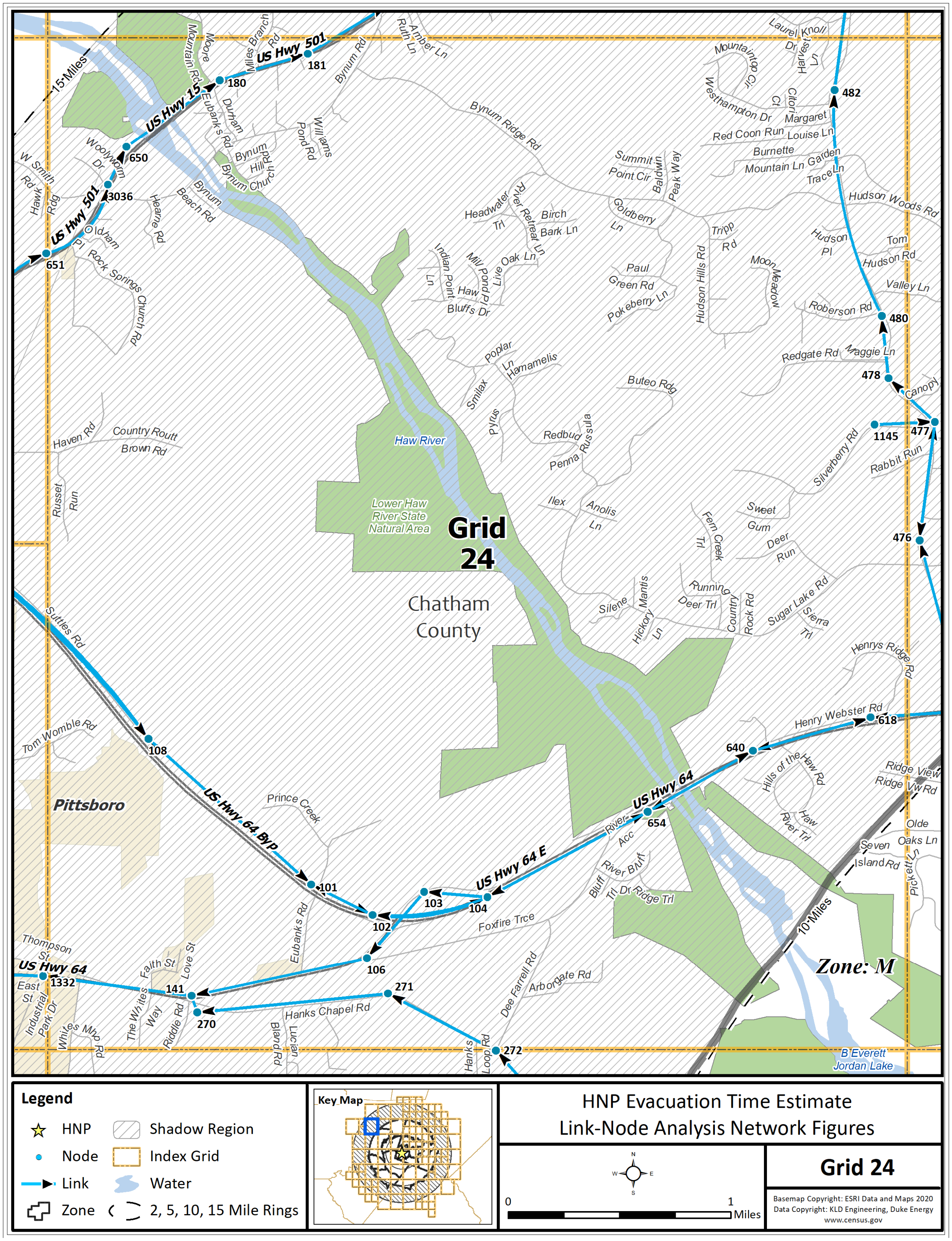


Figure K-25. Link-Node Analysis Network – Grid 24

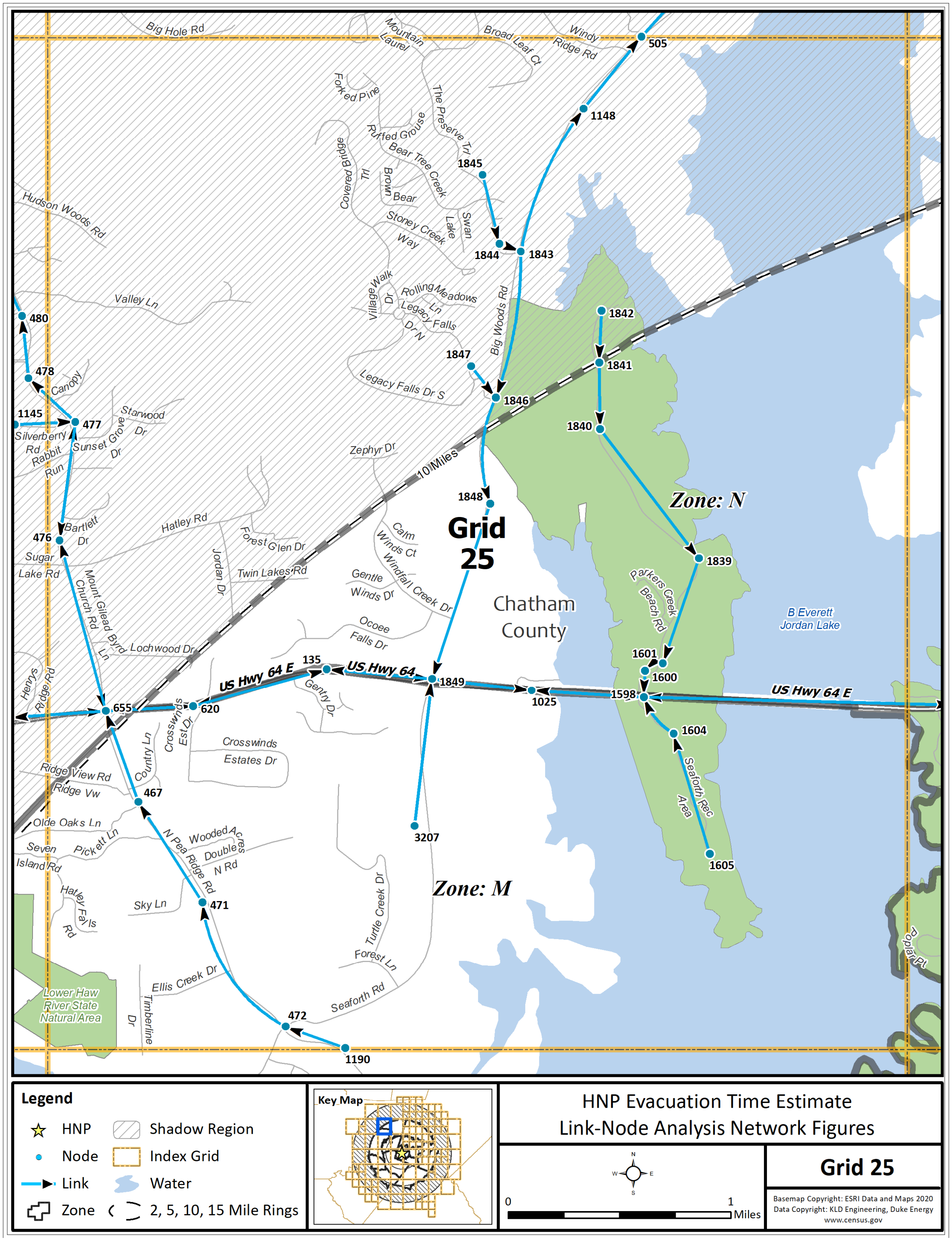


Figure K-26. Link-Node Analysis Network – Grid 25

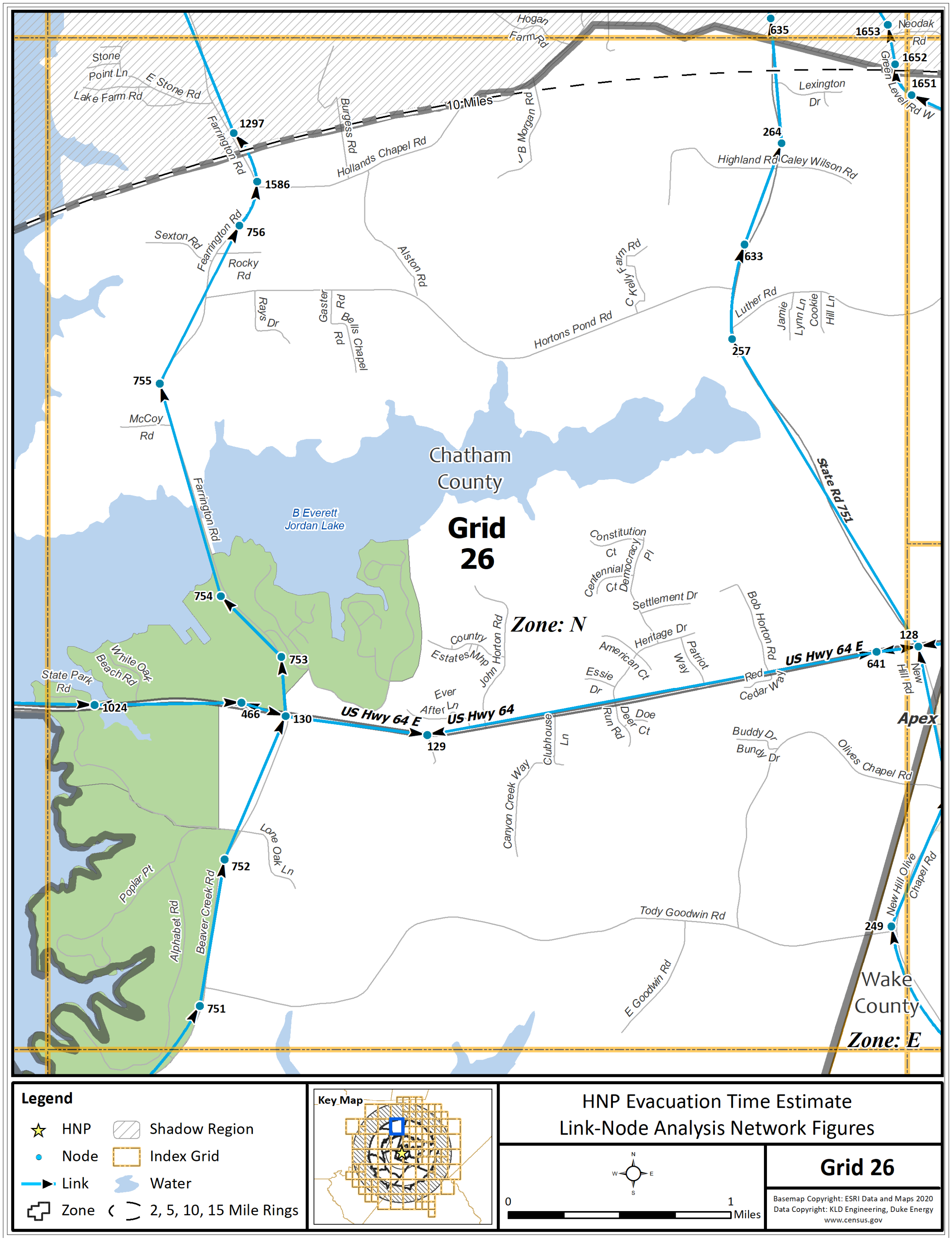


Figure K-27. Link-Node Analysis Network – Grid 26

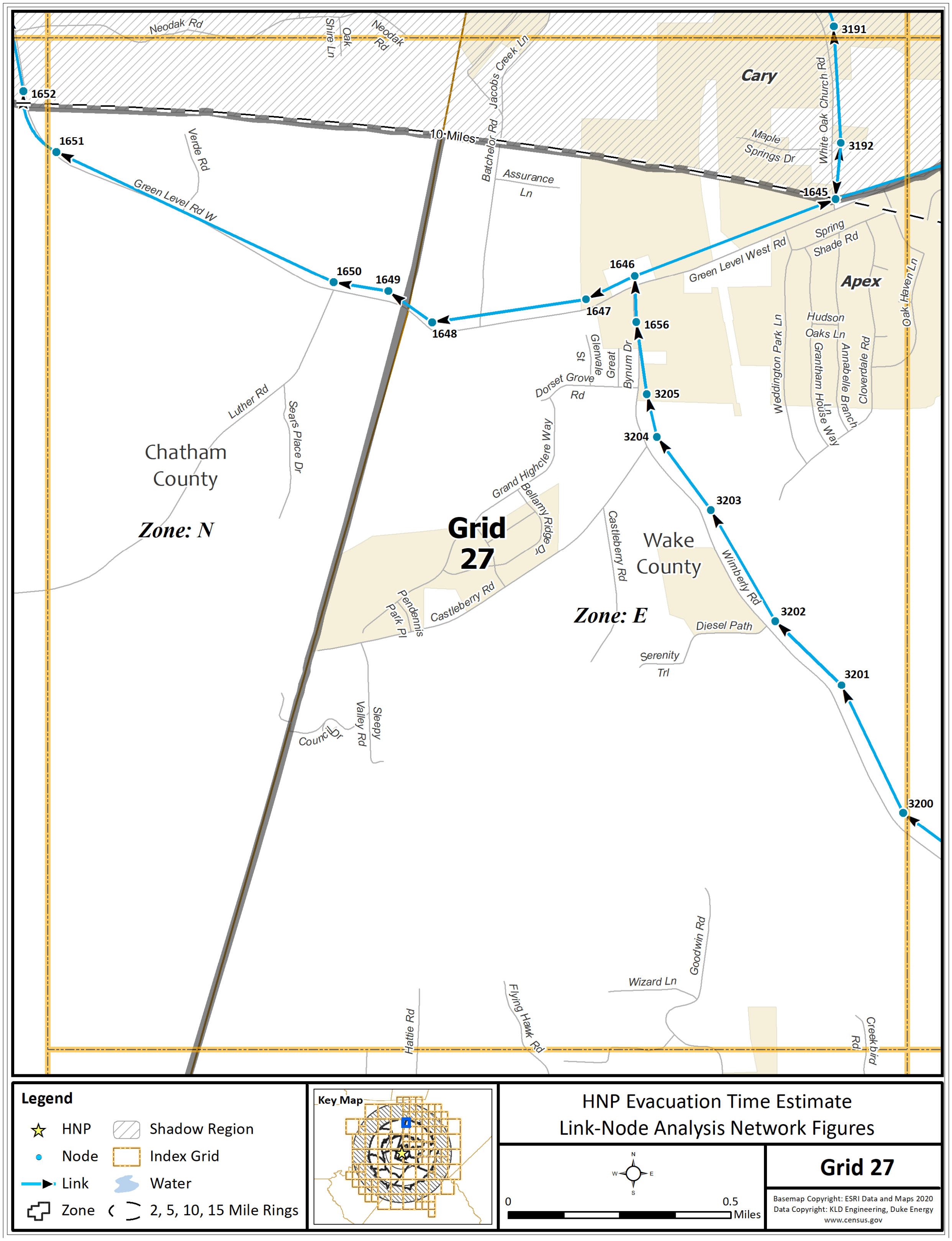


Figure K-28. Link-Node Analysis Network – Grid 27

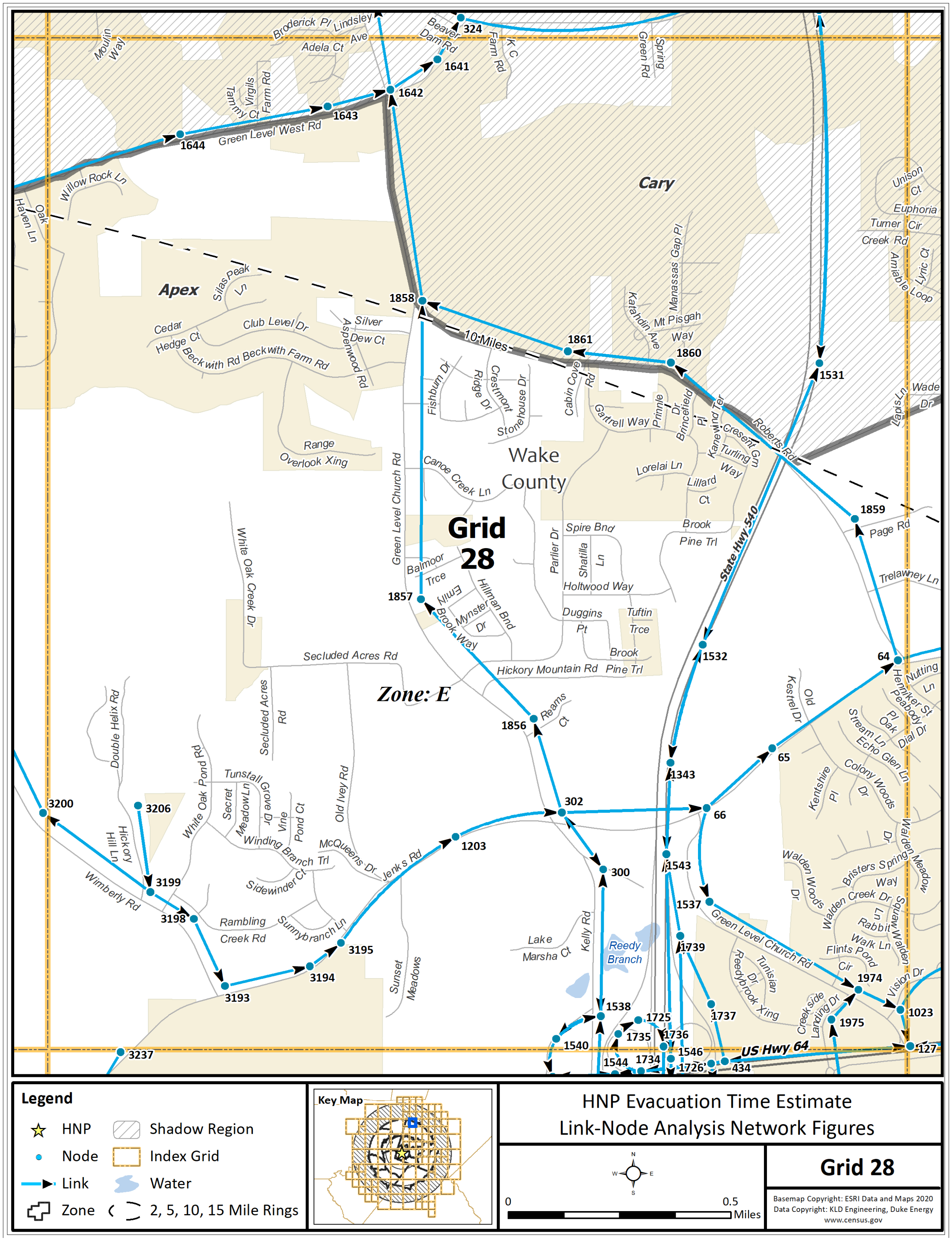


Figure K-29. Link-Node Analysis Network – Grid 28

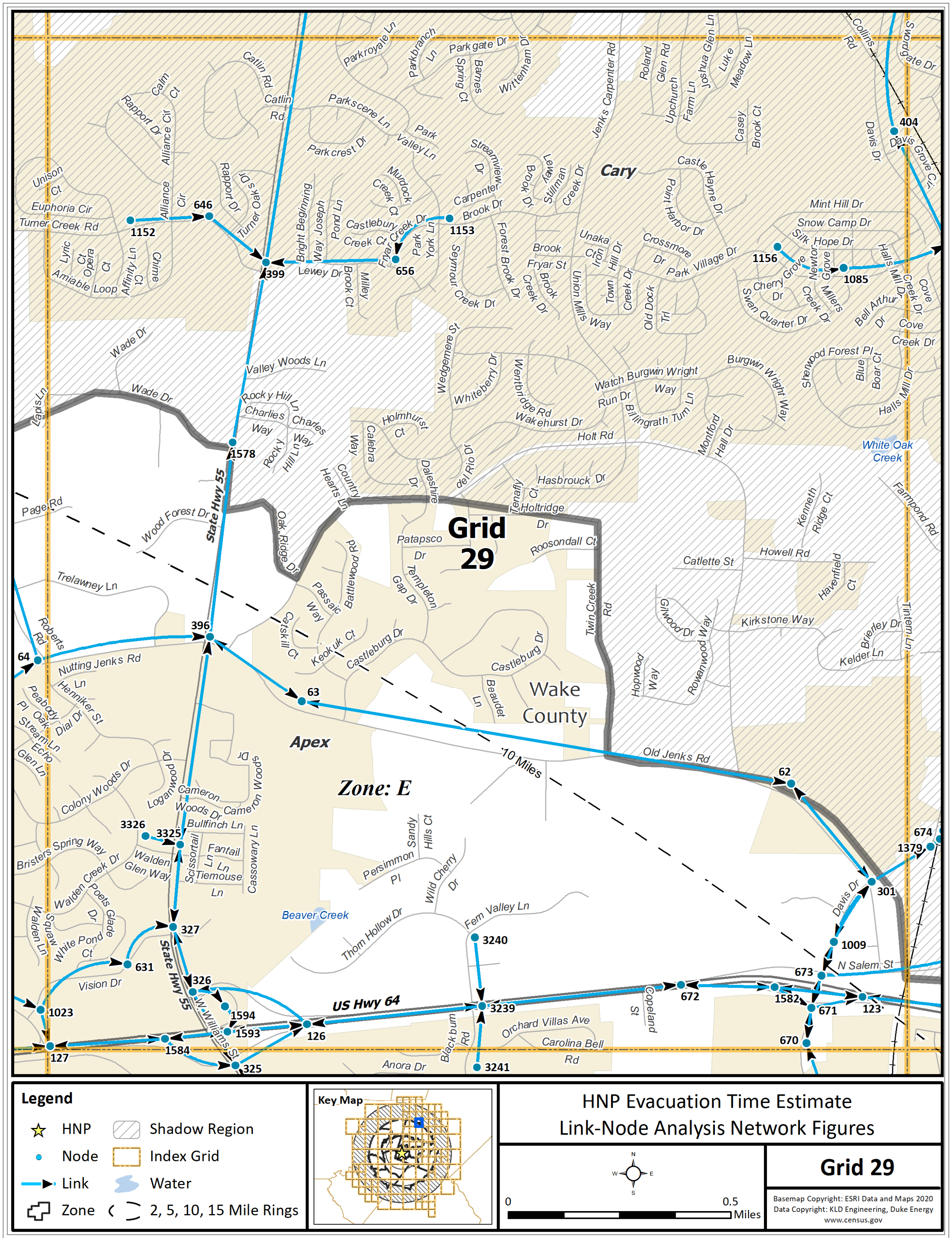


Figure K-30. Link-Node Analysis Network – Grid 29

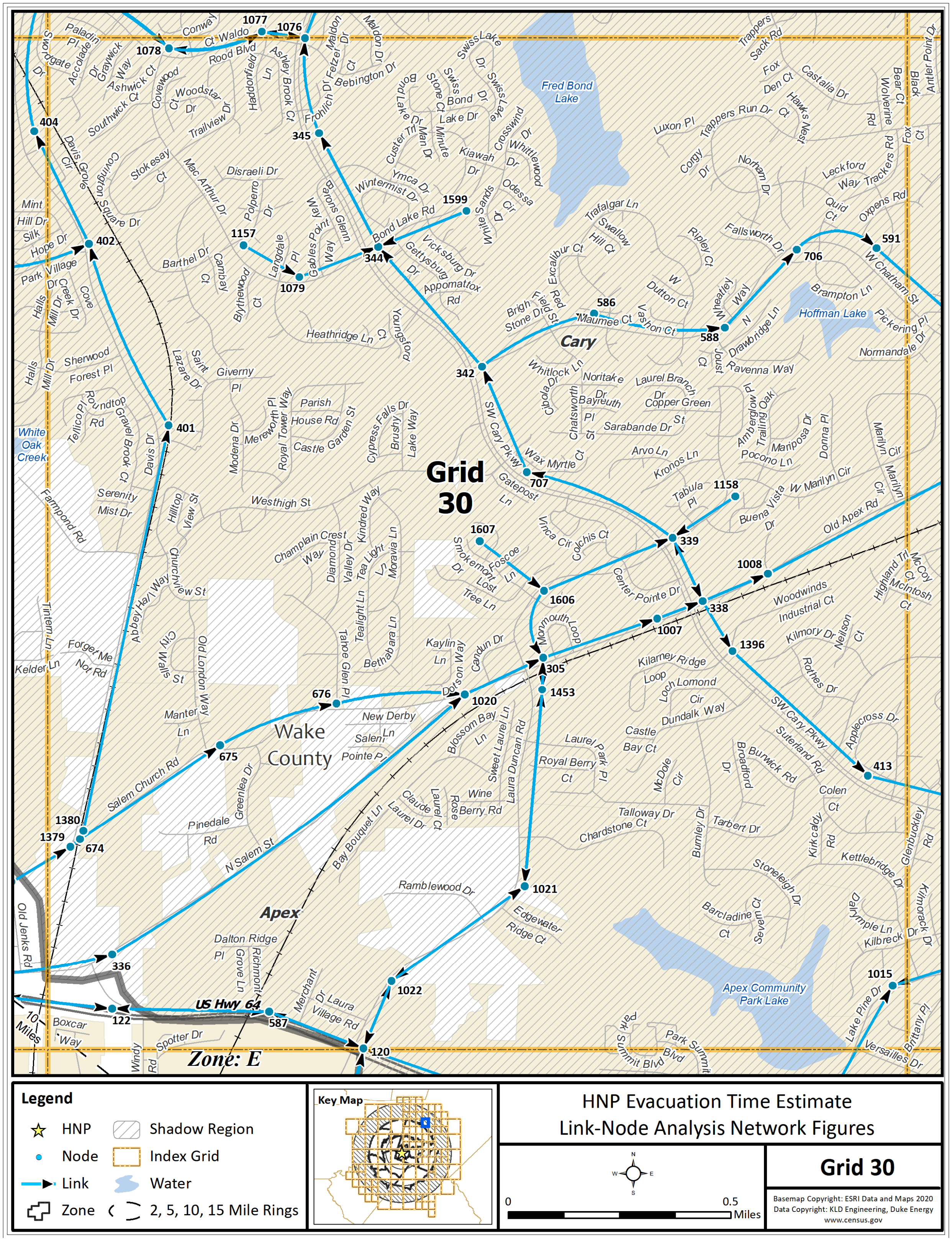


Figure K-31. Link-Node Analysis Network – Grid 30

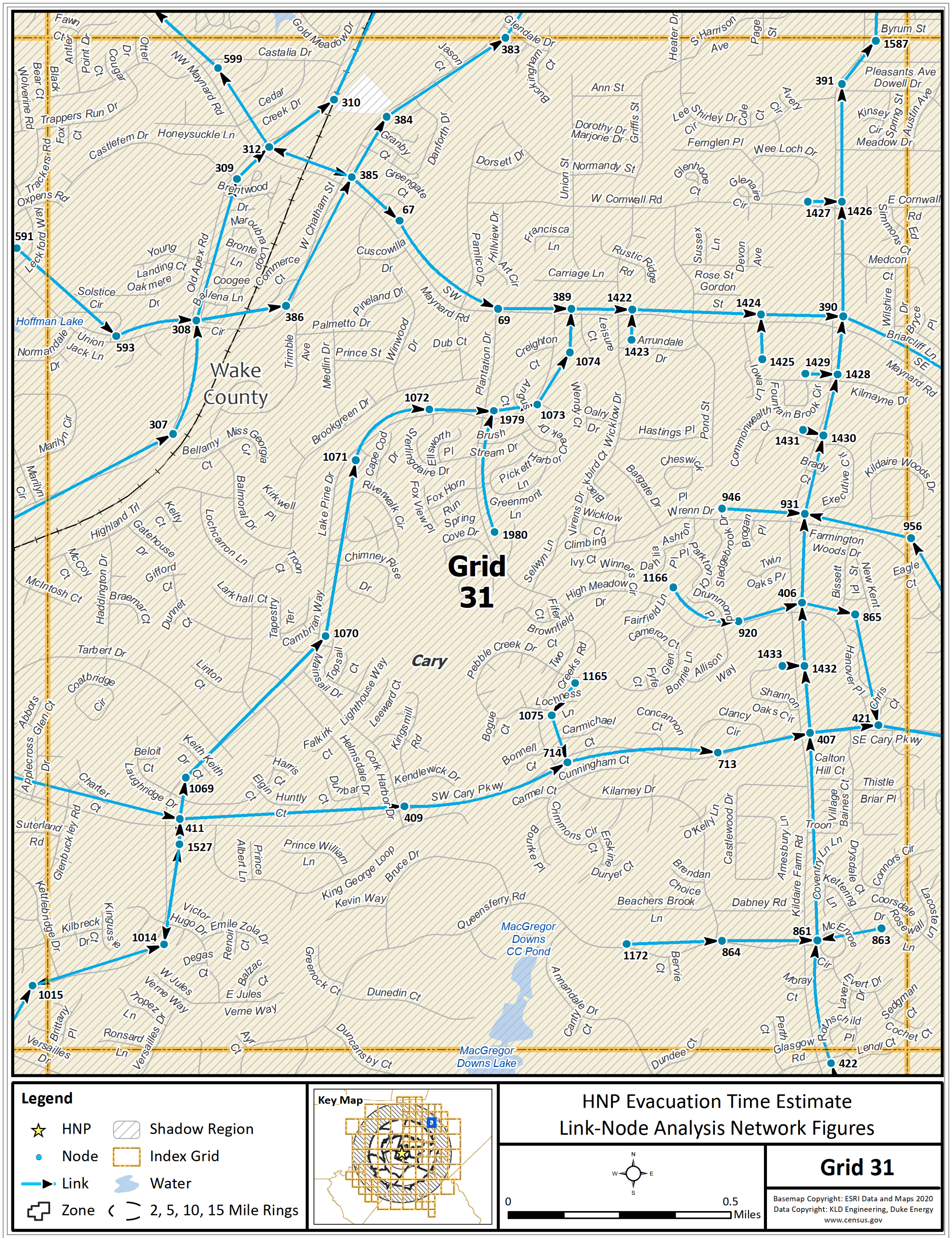


Figure K-32. Link-Node Analysis Network – Grid 31

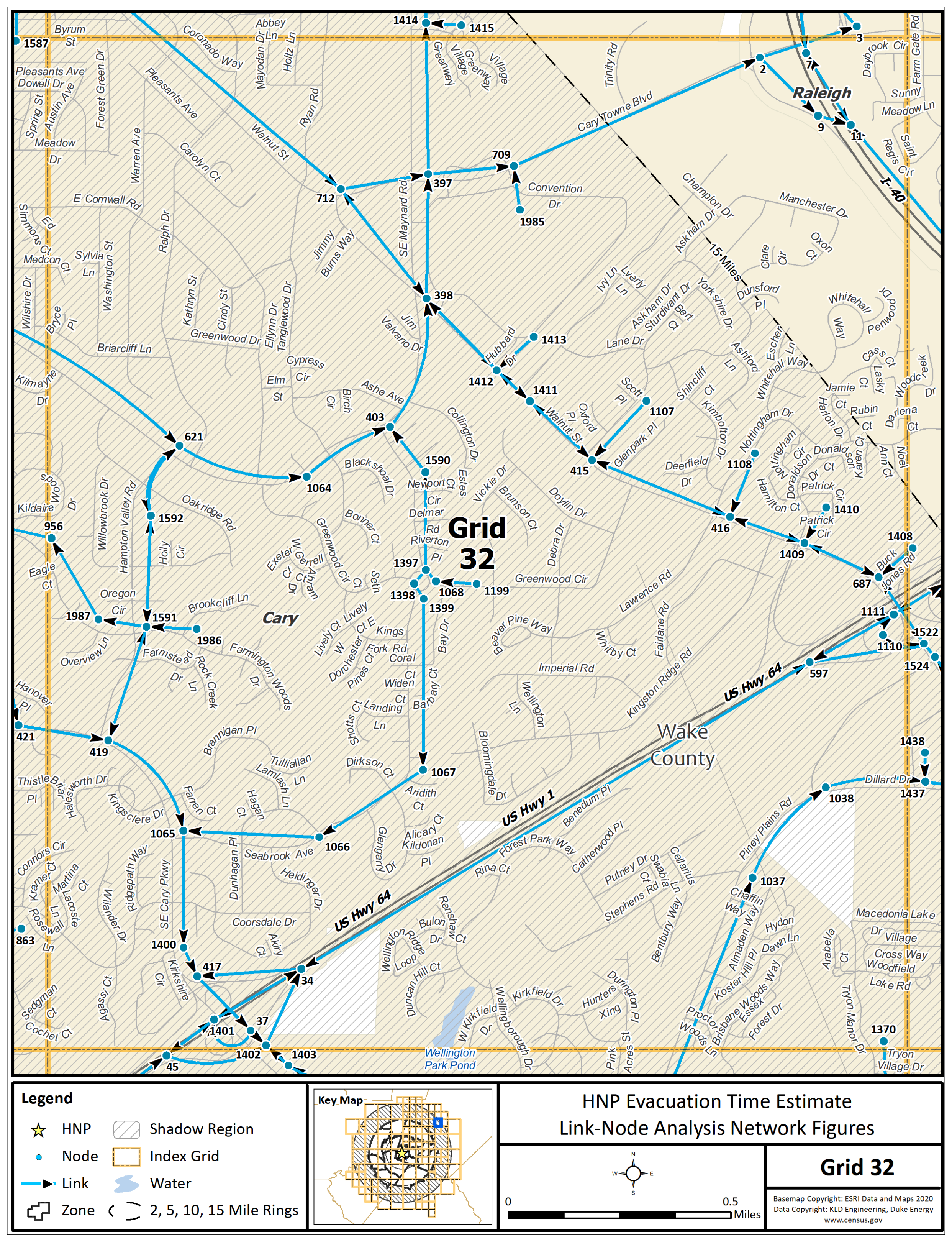


Figure K-33. Link-Node Analysis Network – Grid 32

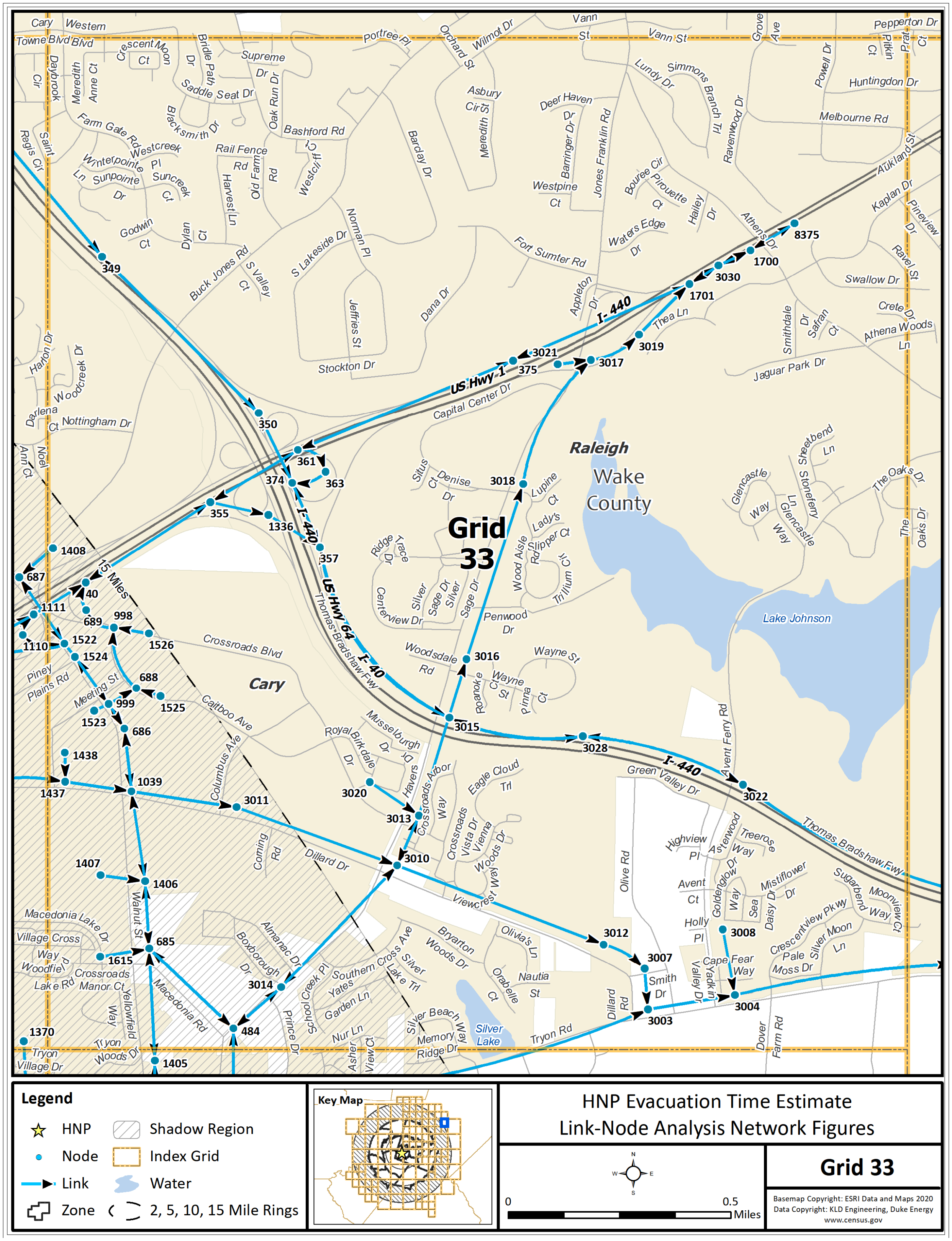


Figure K-34. Link-Node Analysis Network – Grid 33

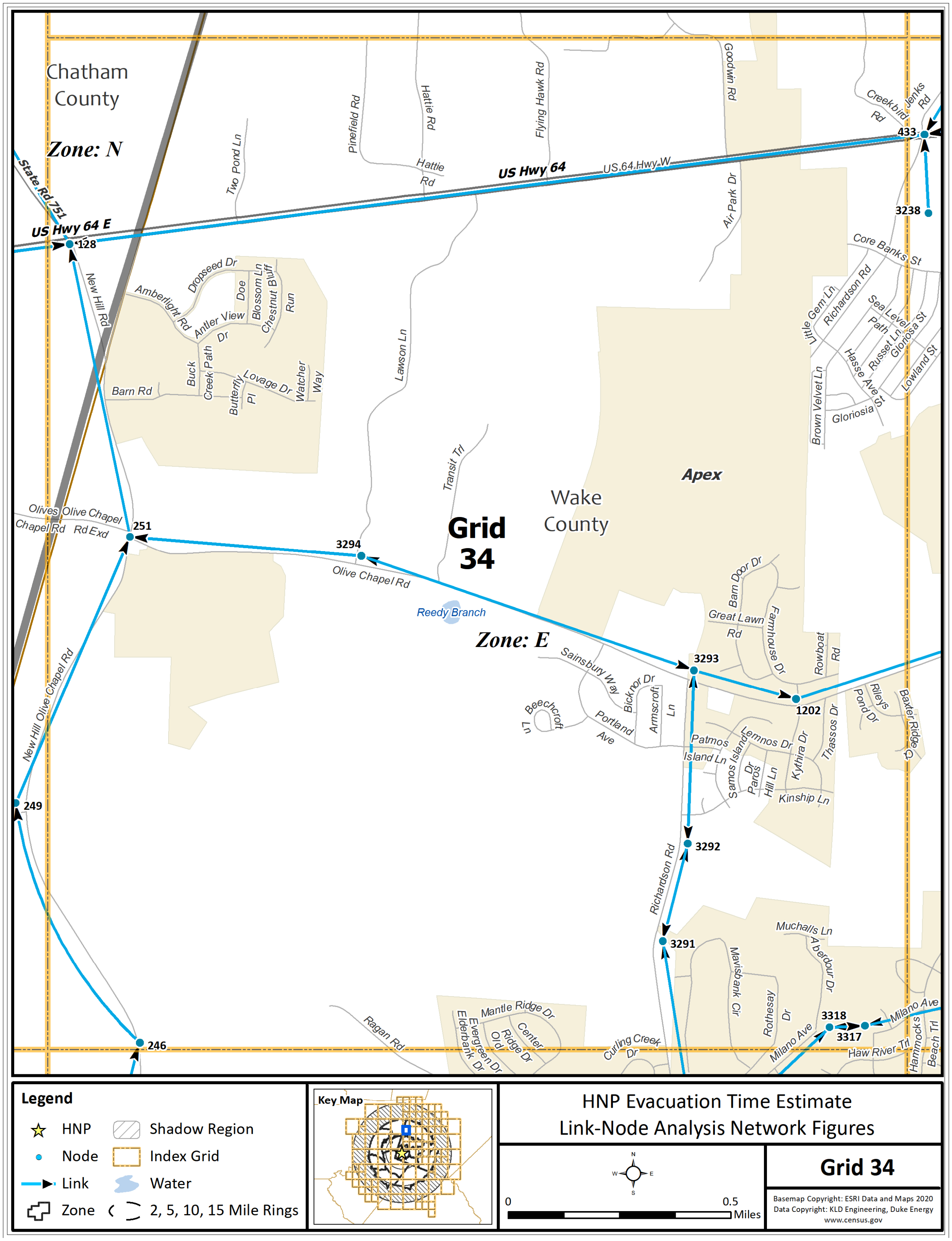


Figure K-35. Link-Node Analysis Network – Grid 34

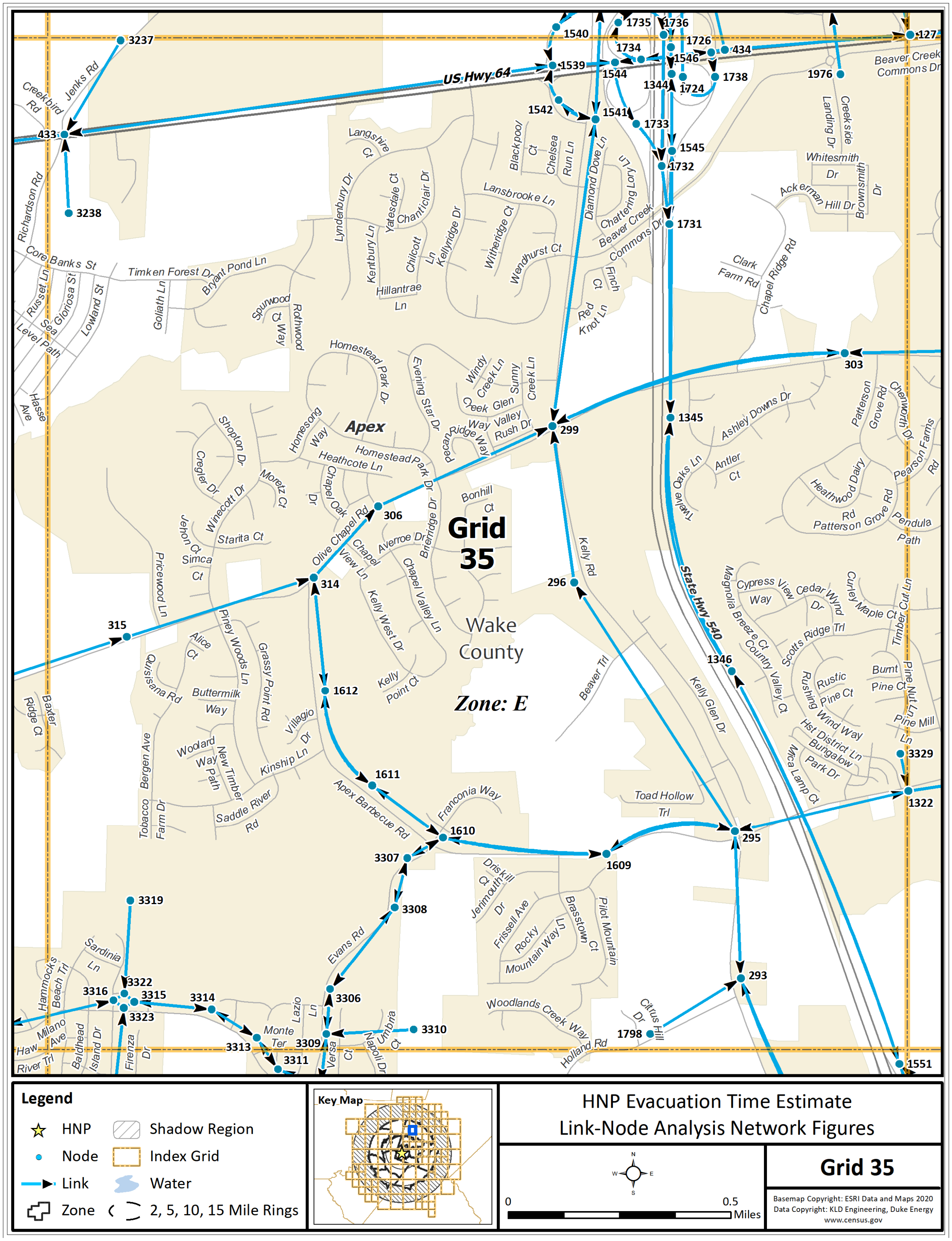


Figure K-36. Link-Node Analysis Network – Grid 35

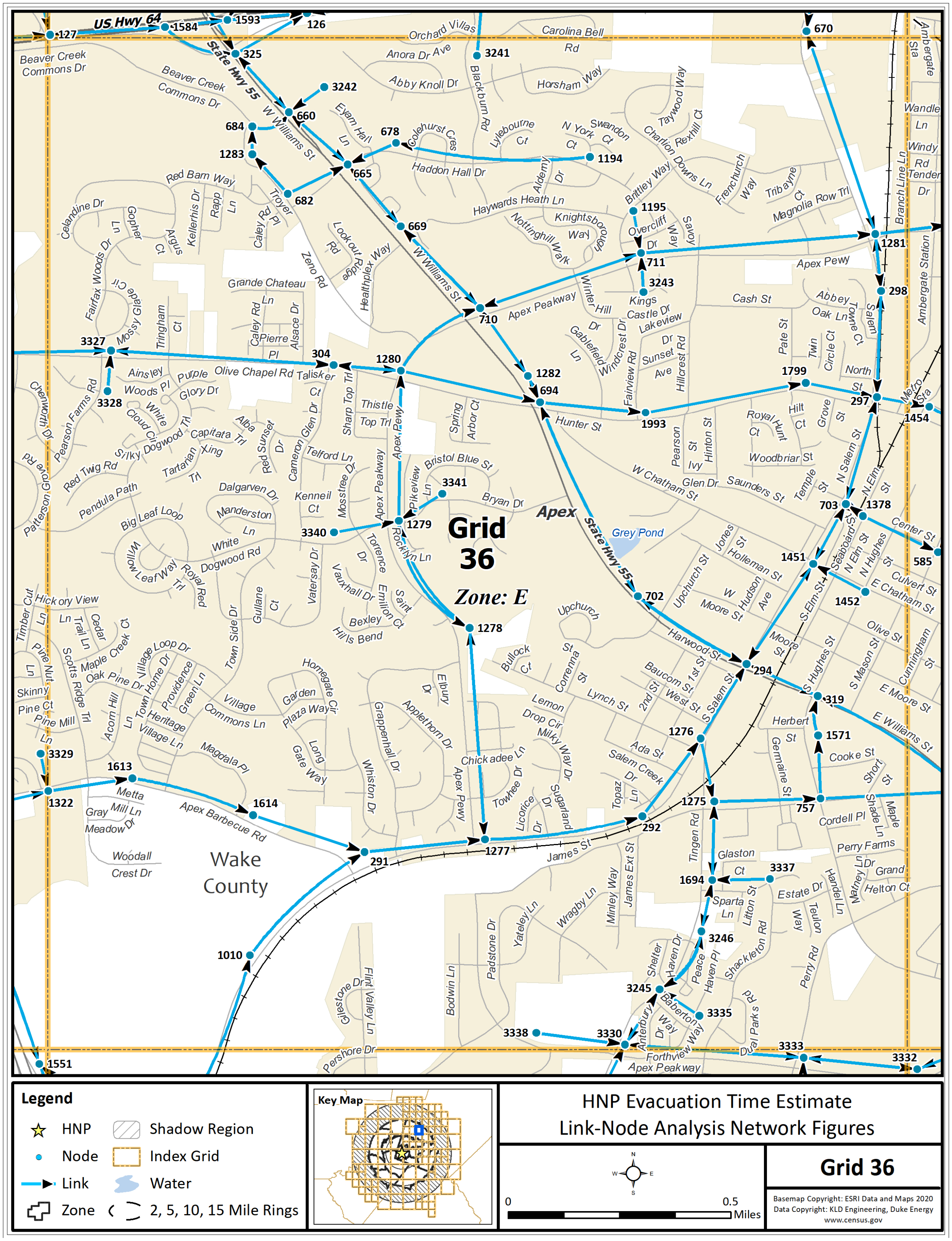


Figure K-37. Link-Node Analysis Network – Grid 36

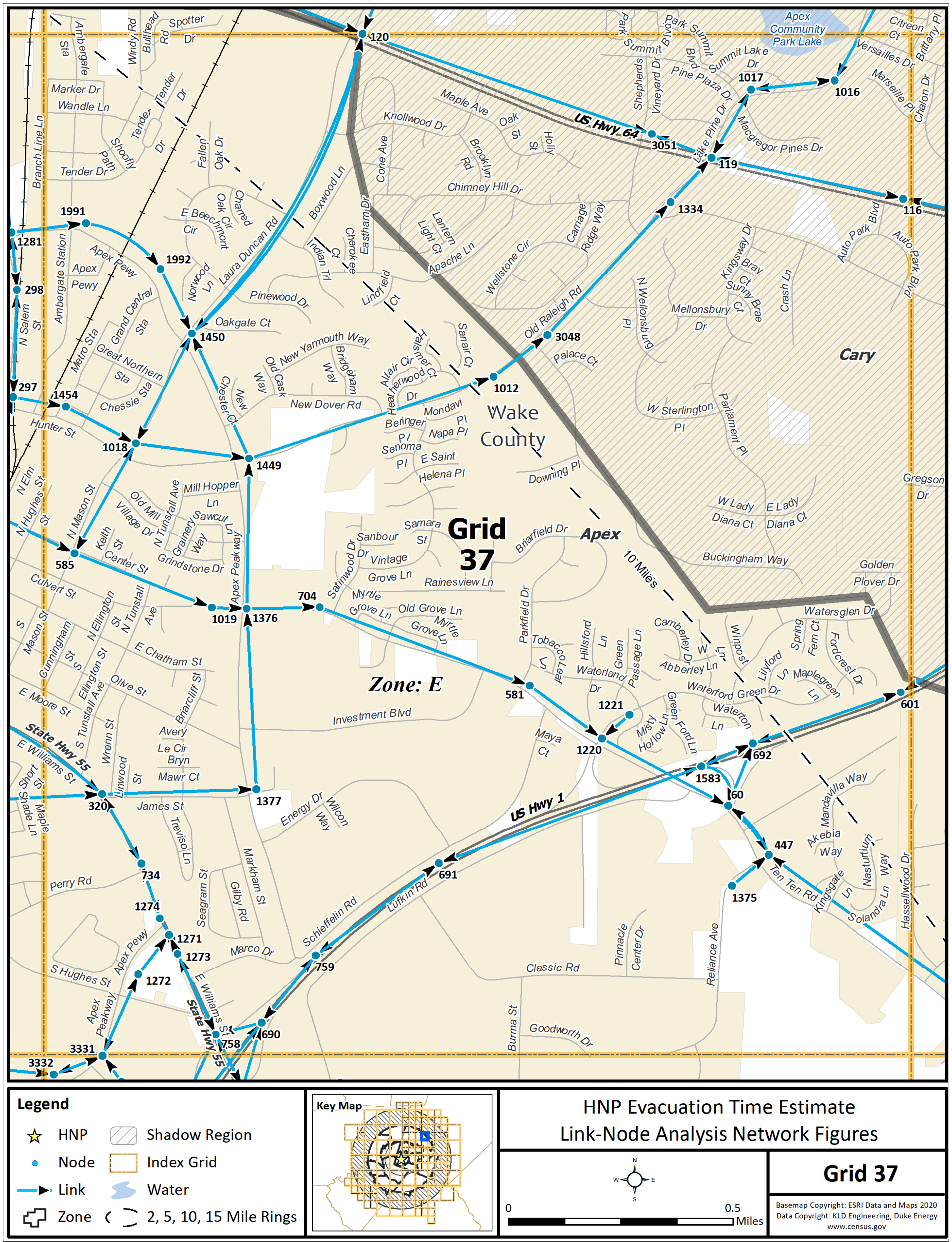


Figure K-38. Link-Node Analysis Network – Grid 37

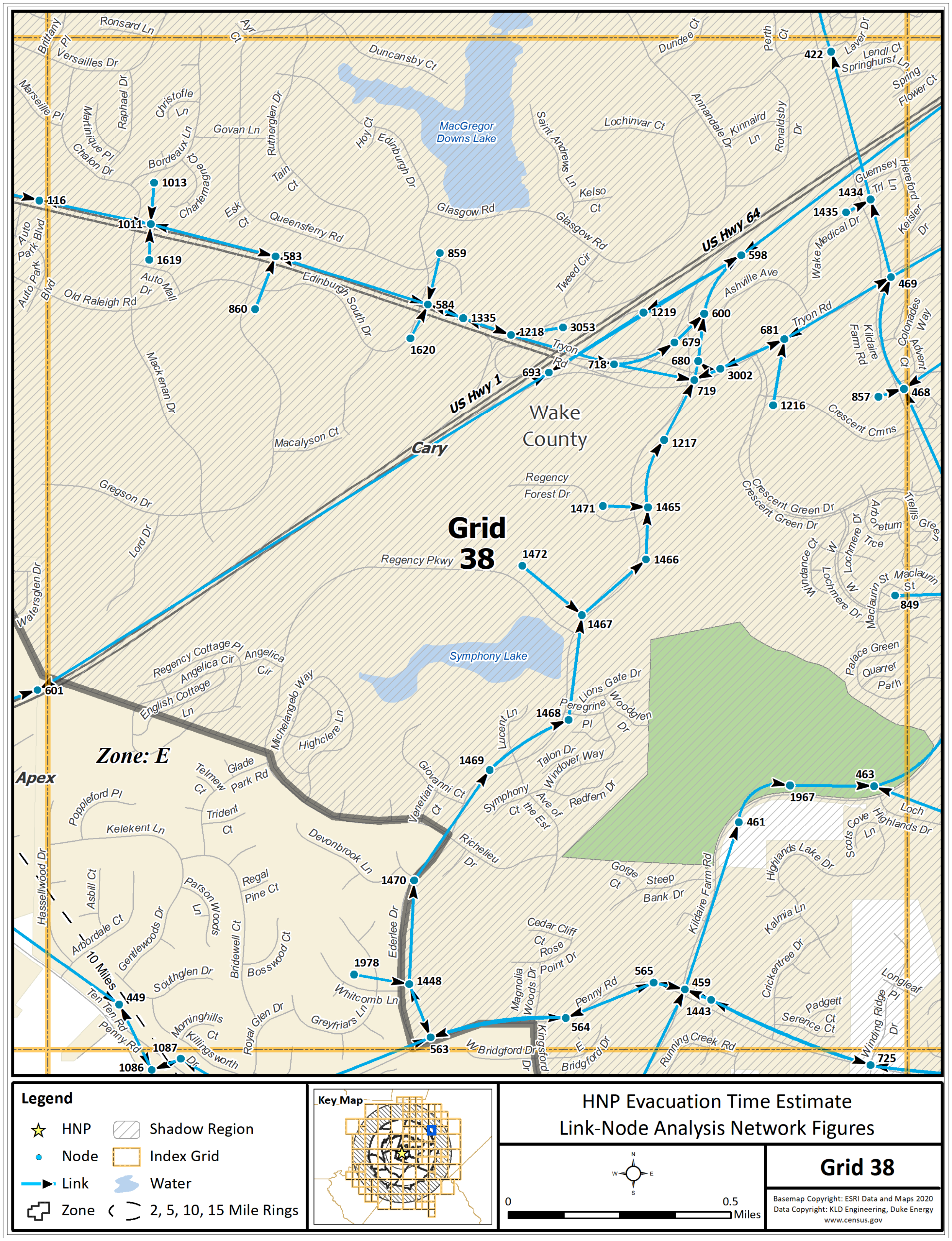


Figure K-39. Link-Node Analysis Network – Grid 38

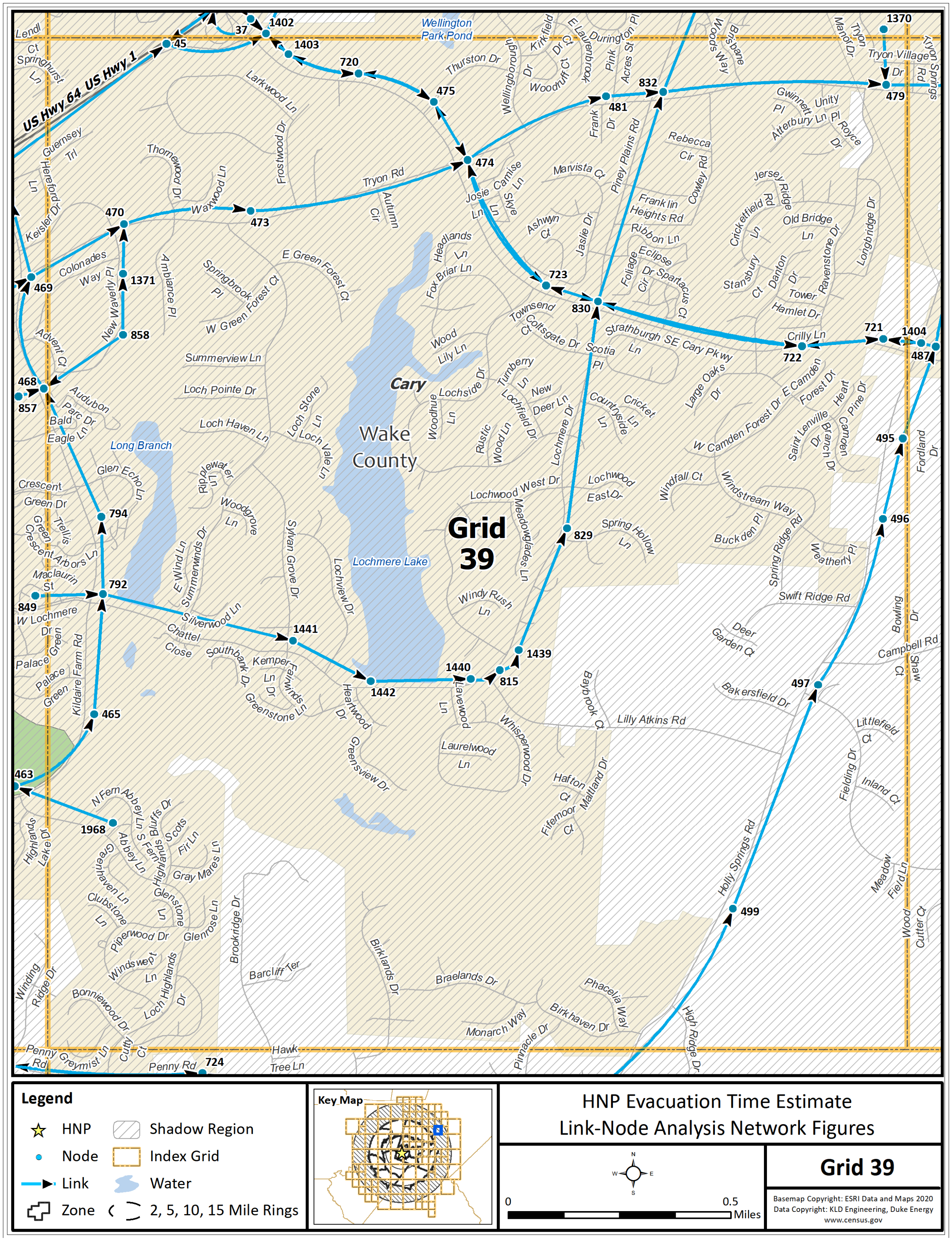


Figure K-40. Link-Node Analysis Network – Grid 39

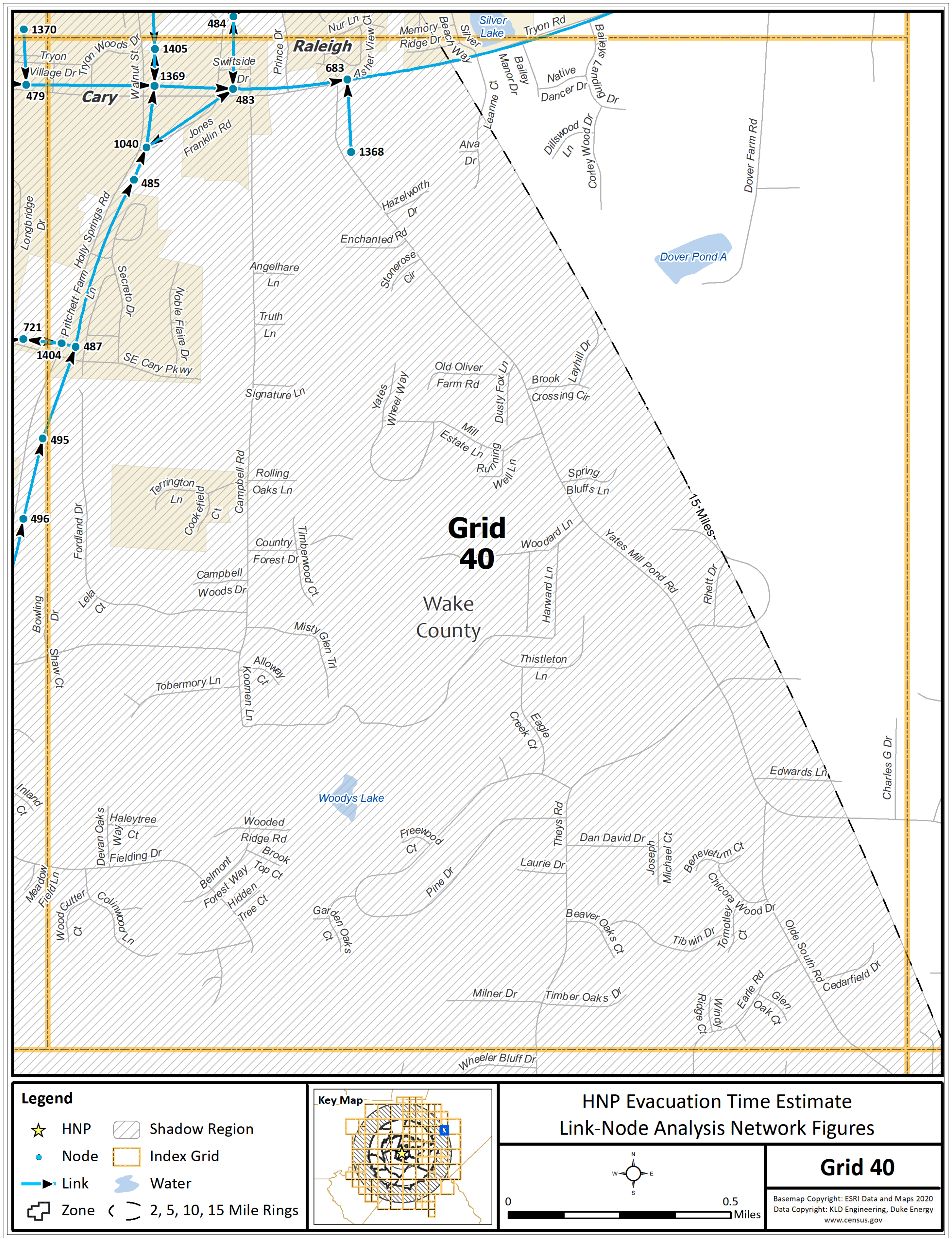


Figure K-41. Link-Node Analysis Network – Grid 40

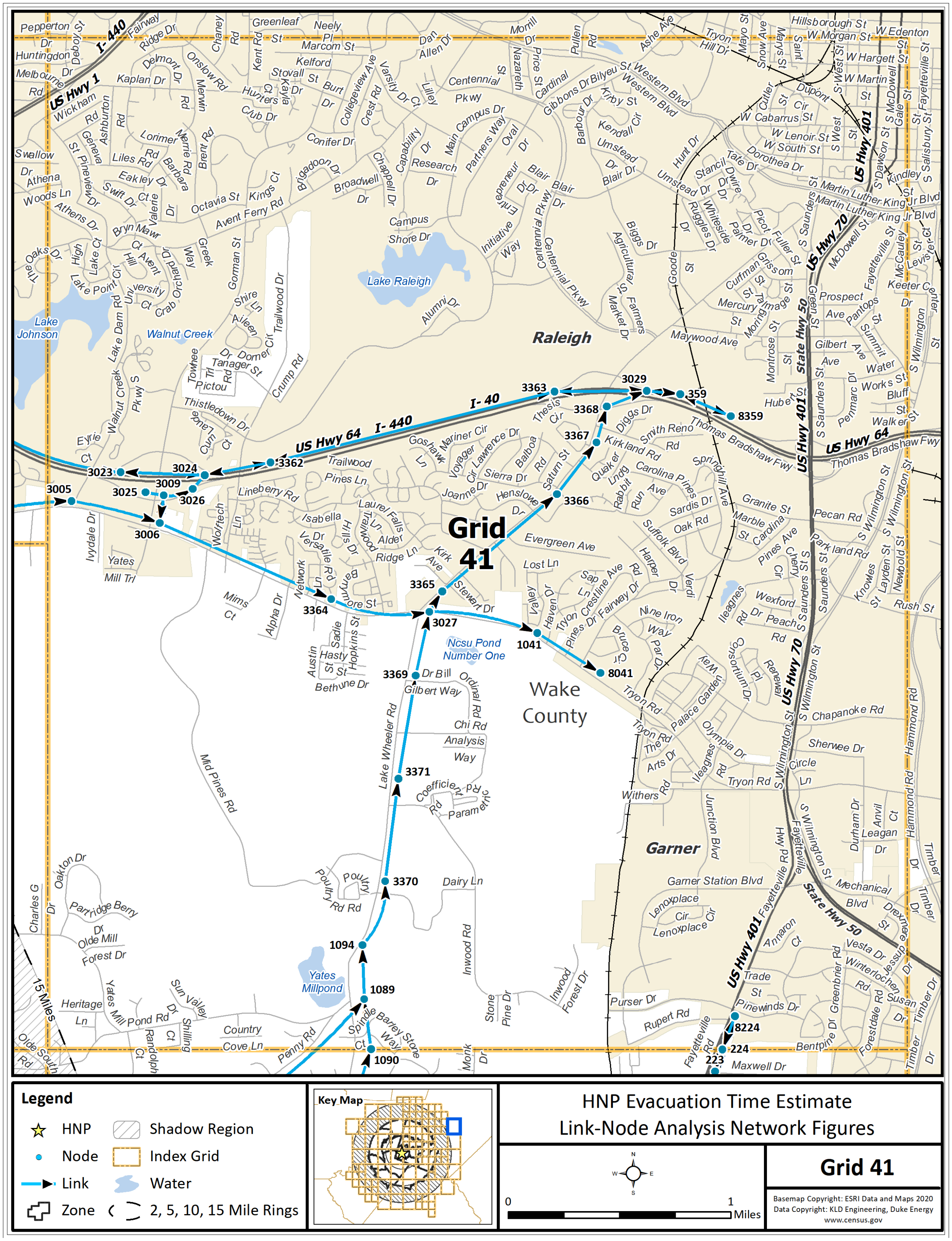


Figure K-42. Link-Node Analysis Network – Grid 41

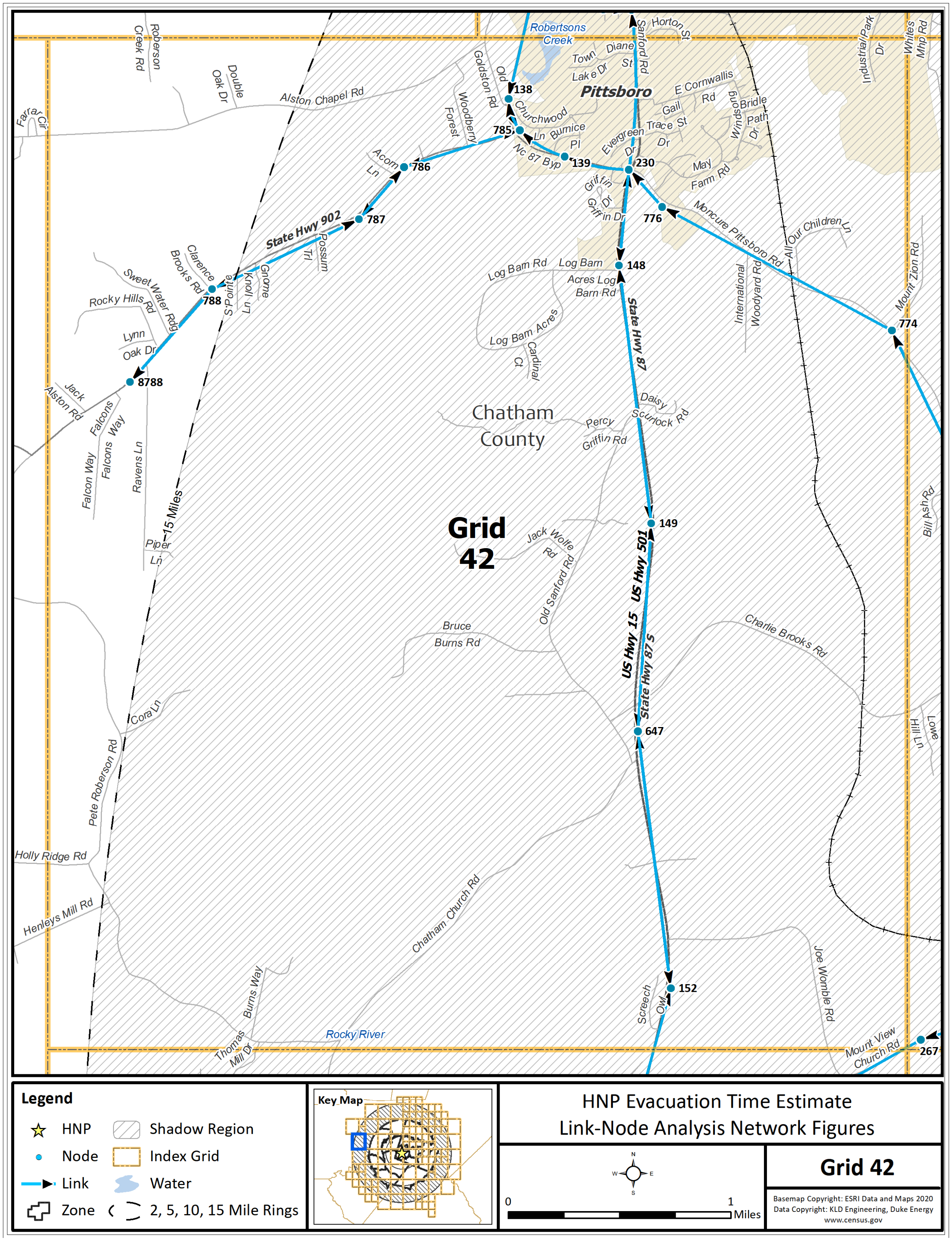


Figure K-43. Link-Node Analysis Network – Grid 42

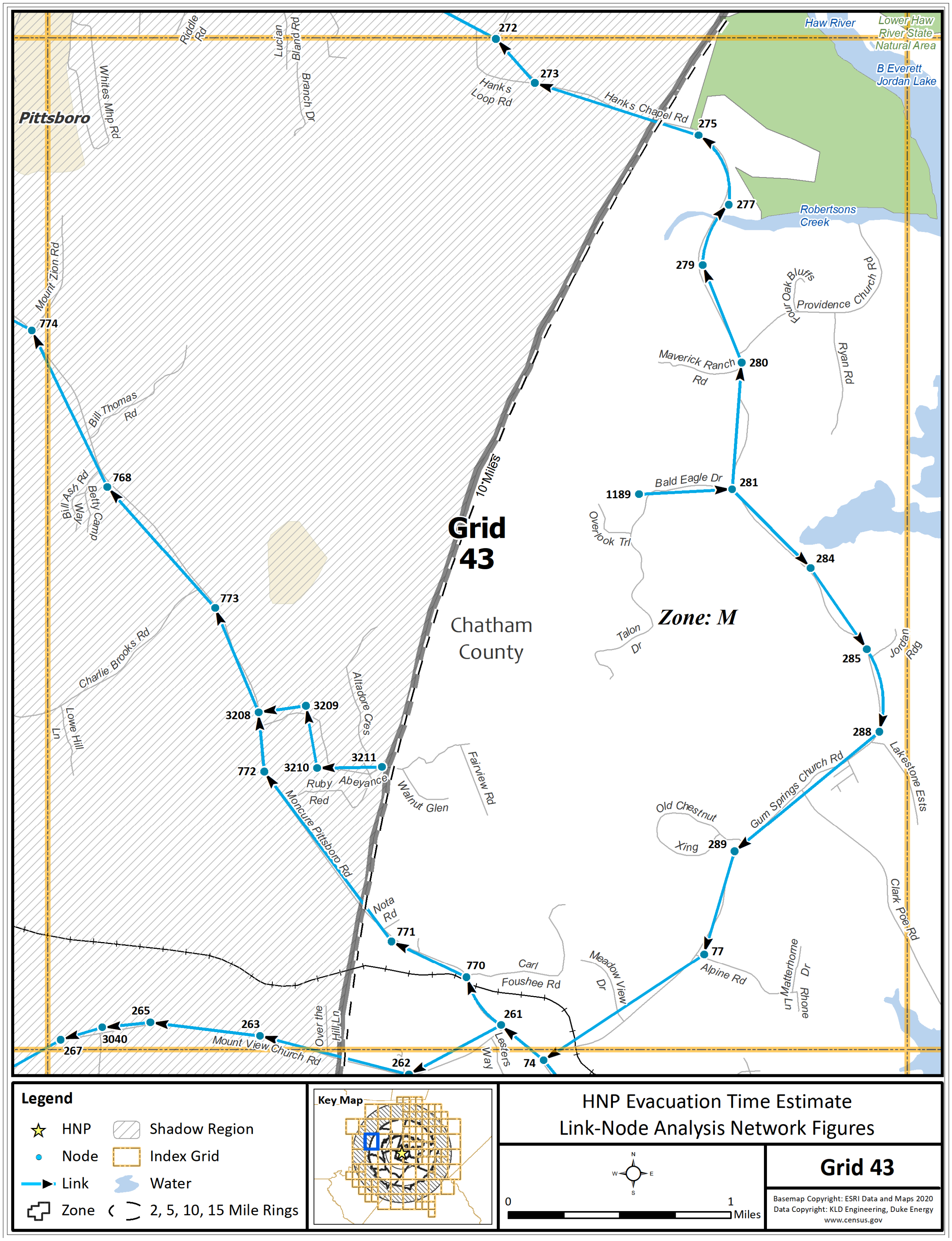
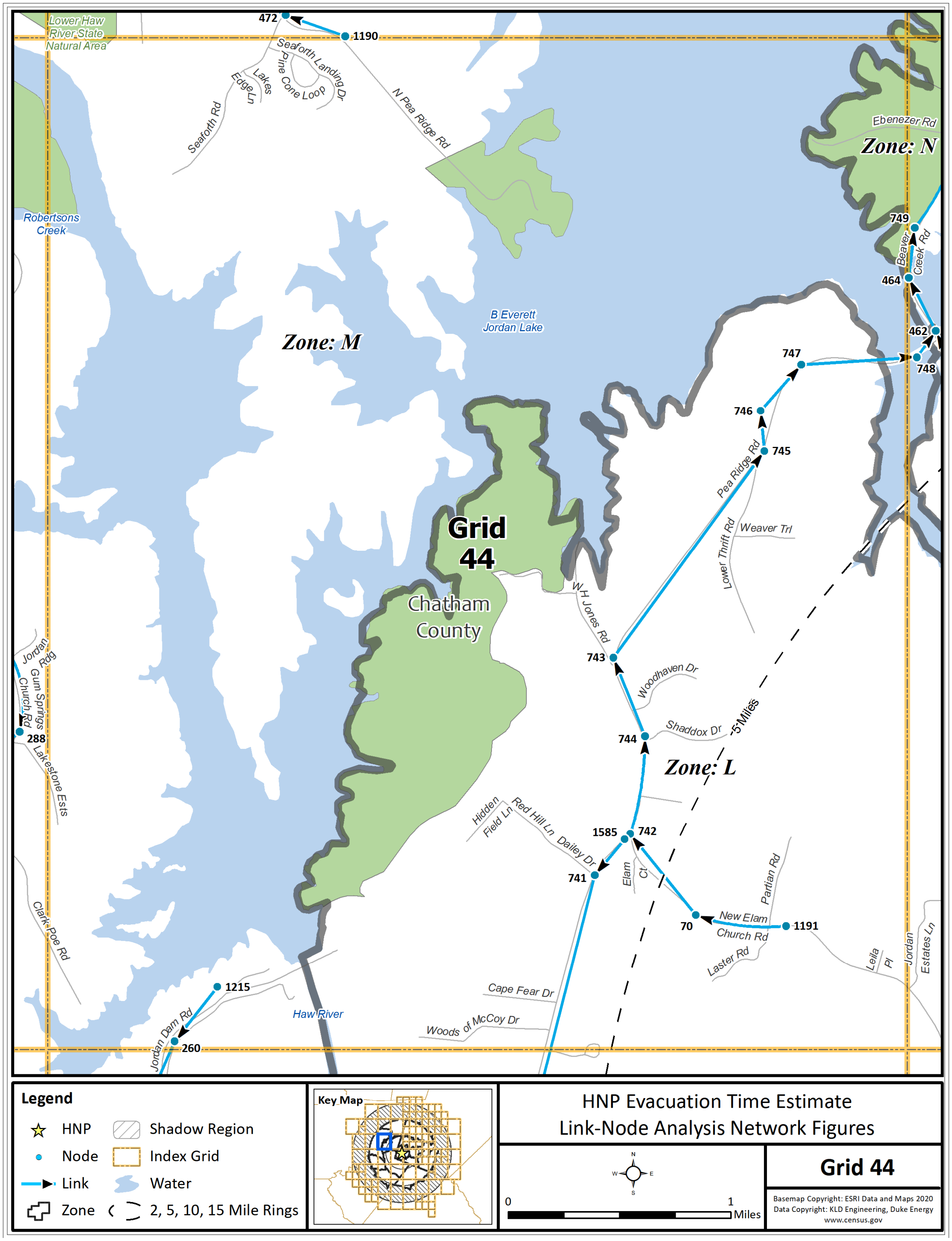


Figure K-44. Link-Node Analysis Network – Grid 43



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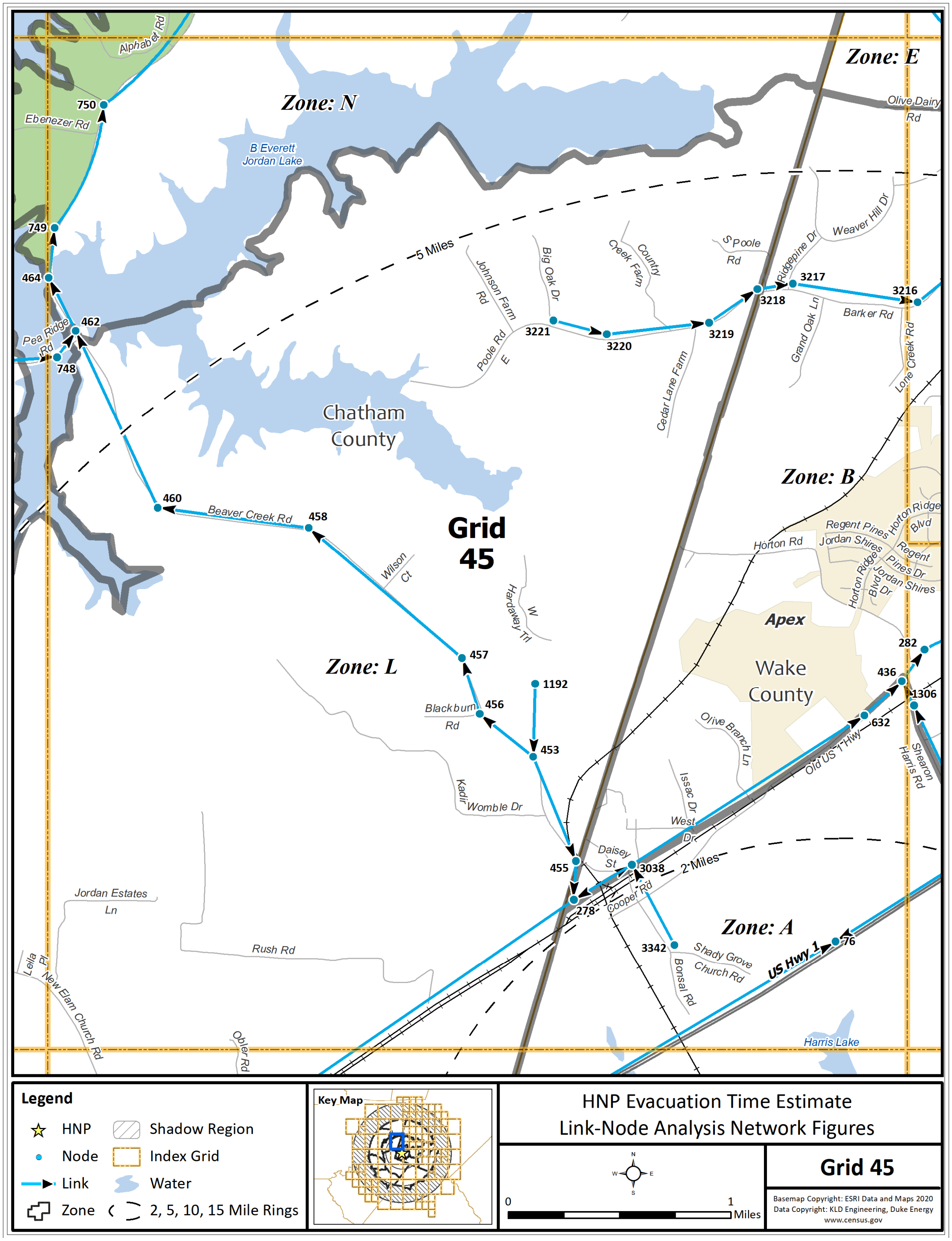


Figure K-46. Link-Node Analysis Network – Grid 45

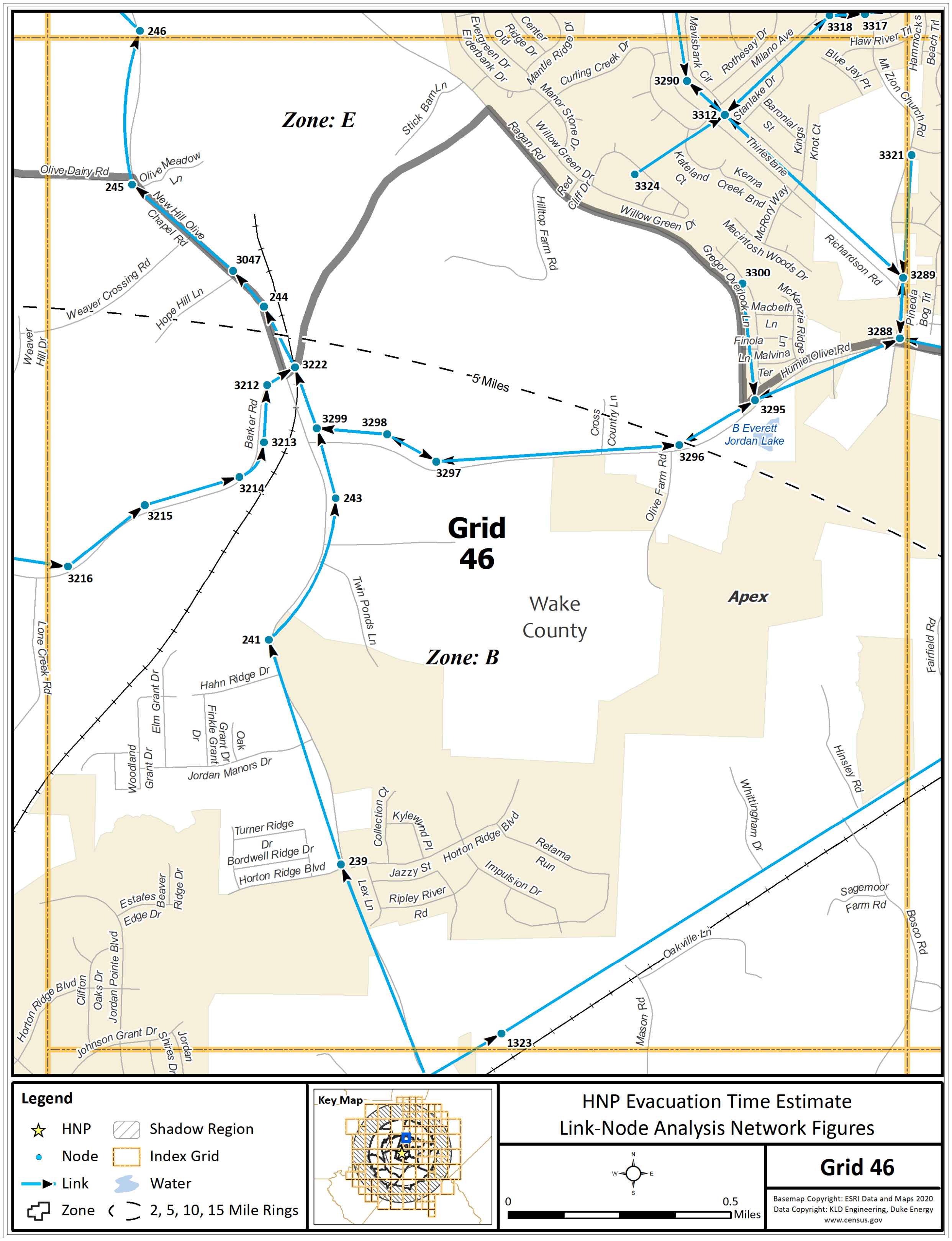
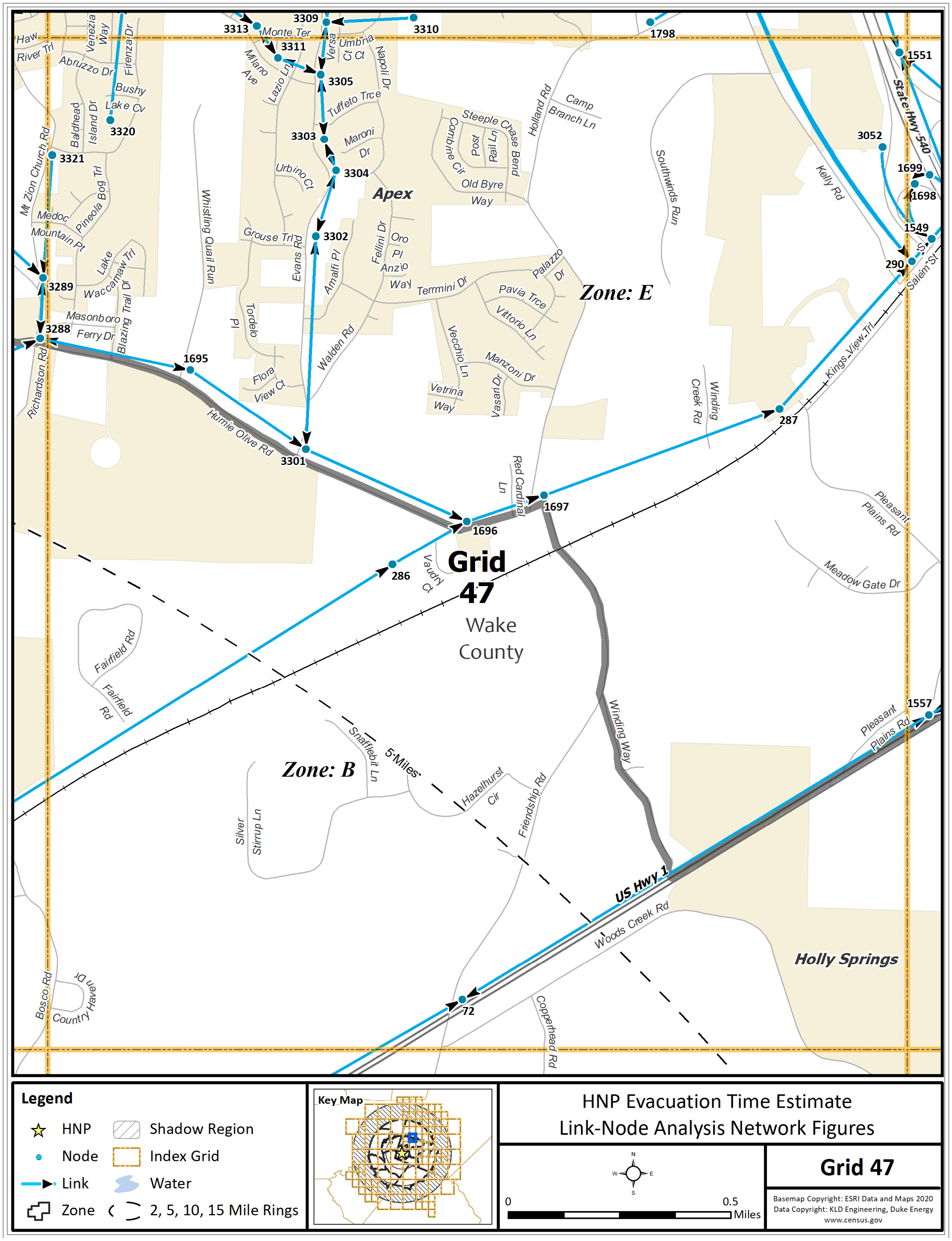


Figure K-47. Link-Node Analysis Network – Grid 46



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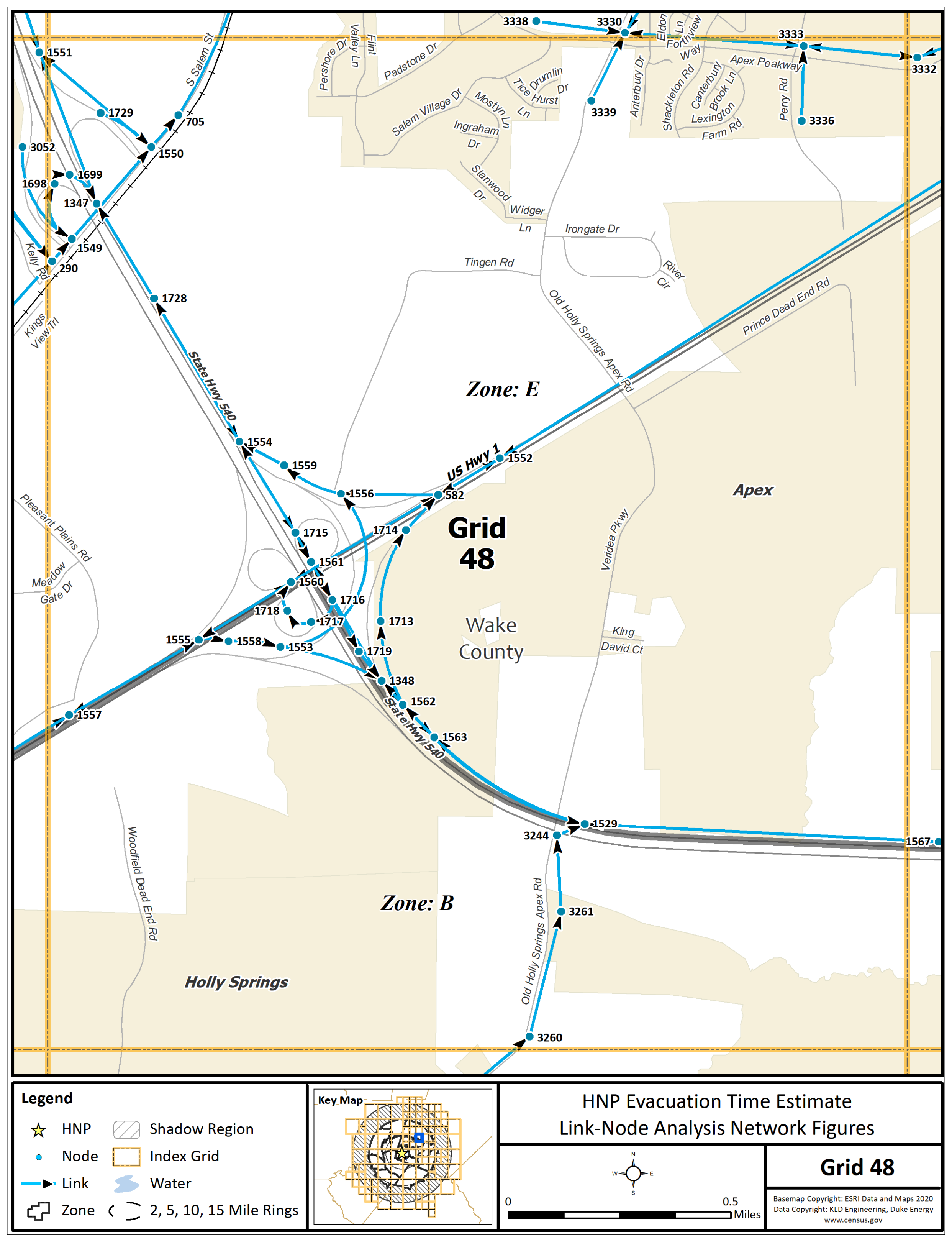


Figure K-49. Link-Node Analysis Network – Grid 48

Figure K-50. Link-Node Analysis Network – Grid 49

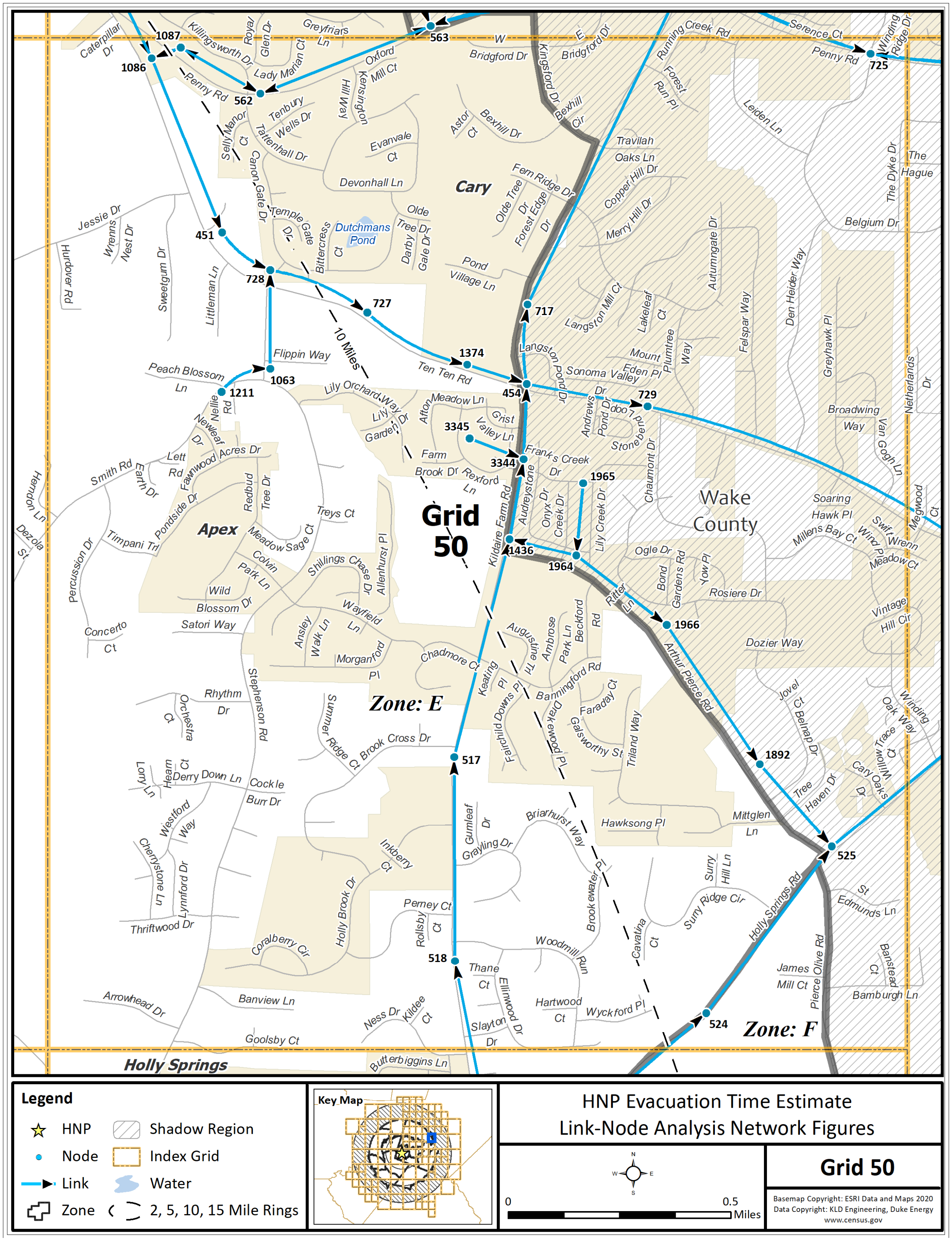


Figure K-51. Link-Node Analysis Network – Grid 50

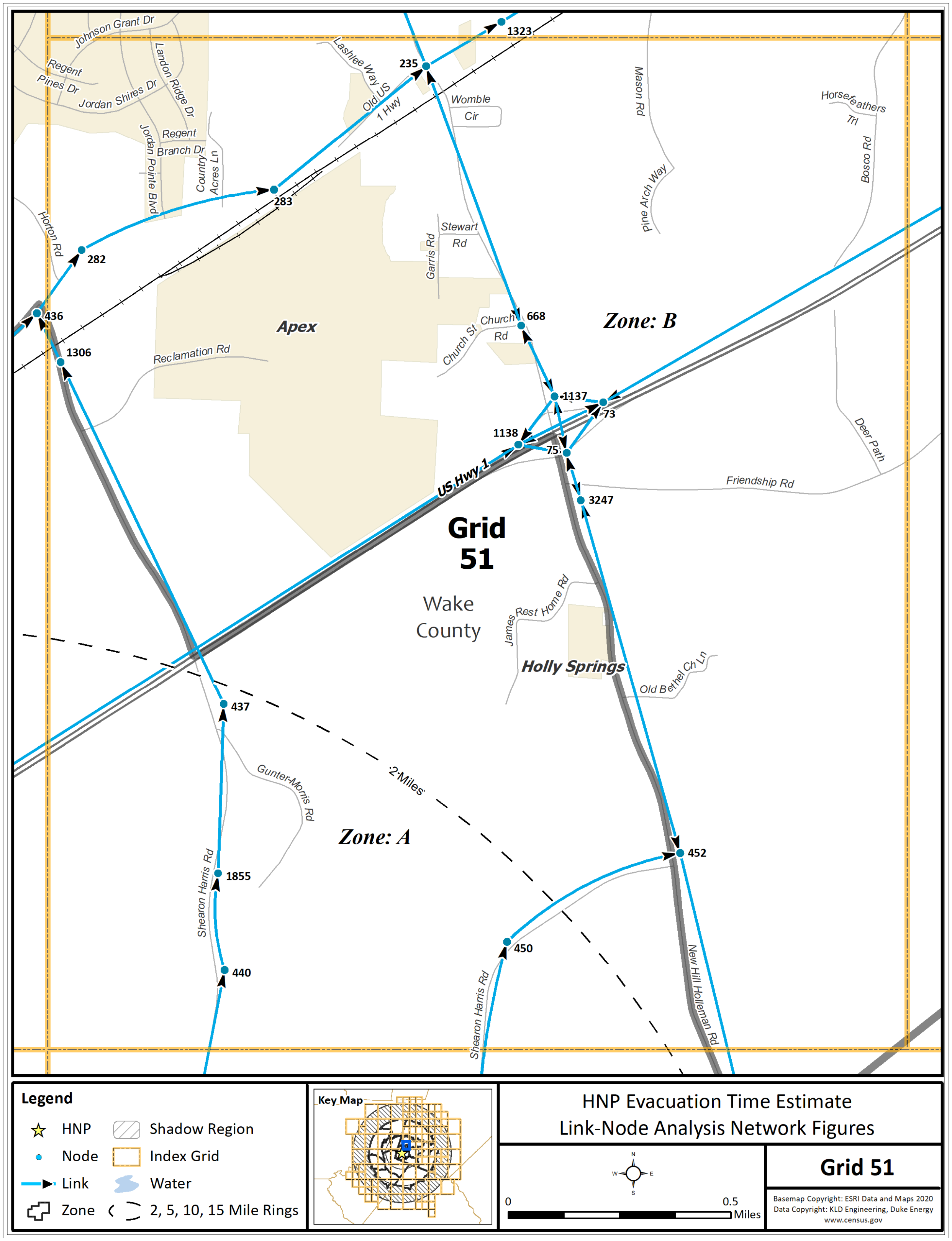


Figure K-52. Link-Node Analysis Network – Grid 51

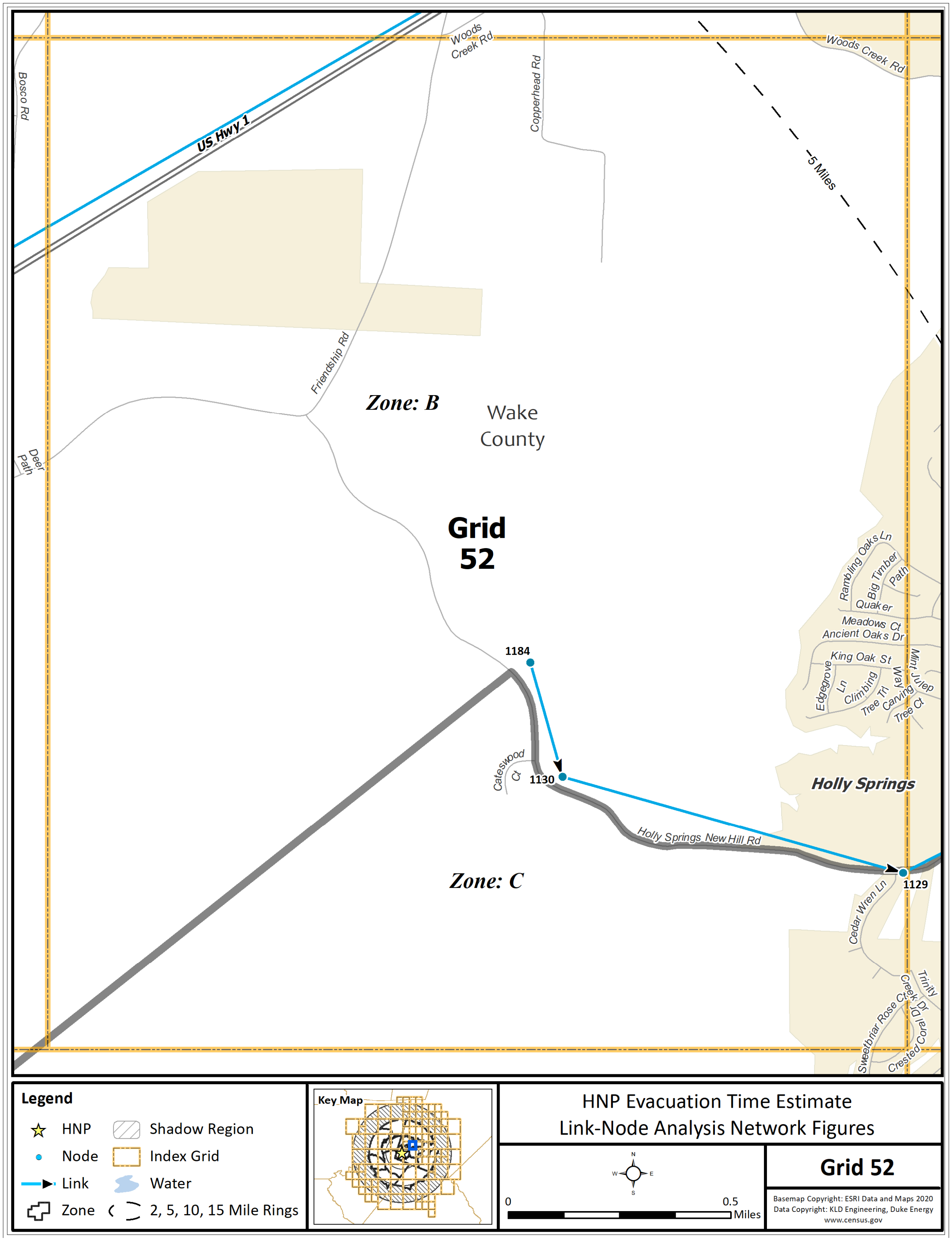


Figure K-53. Link-Node Analysis Network – Grid 52

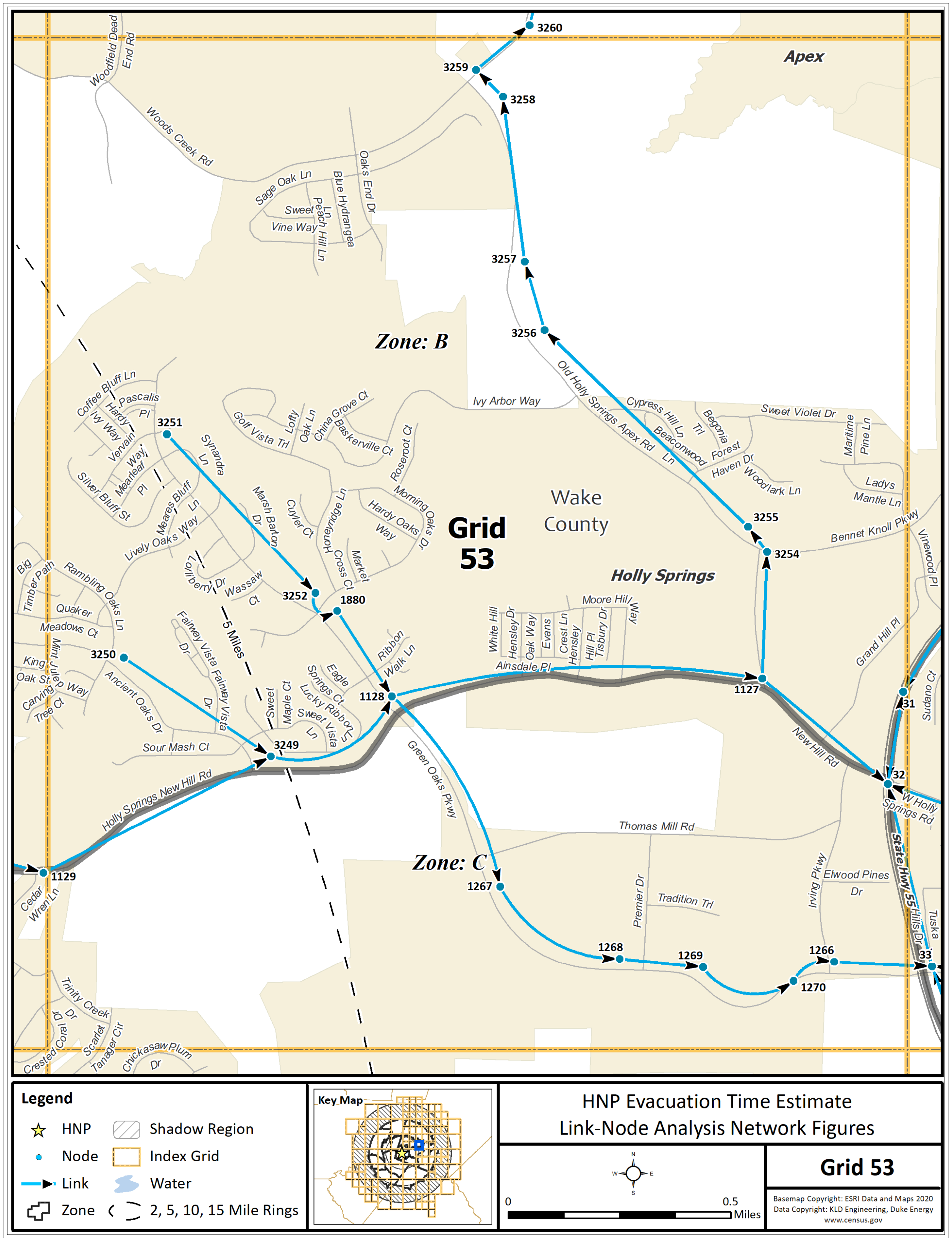


Figure K-54. Link-Node Analysis Network – Grid 53

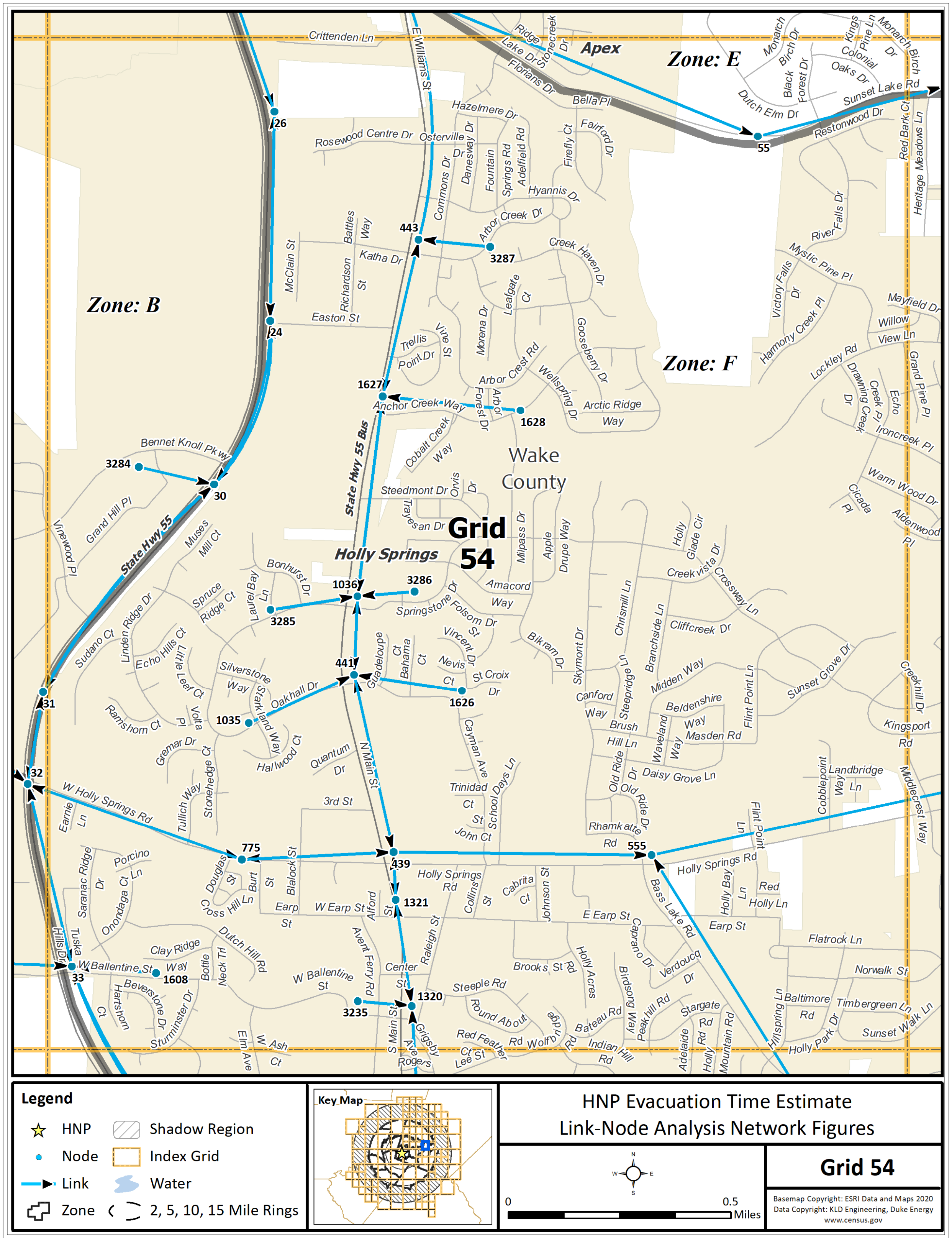


Figure K-55. Link-Node Analysis Network – Grid 54

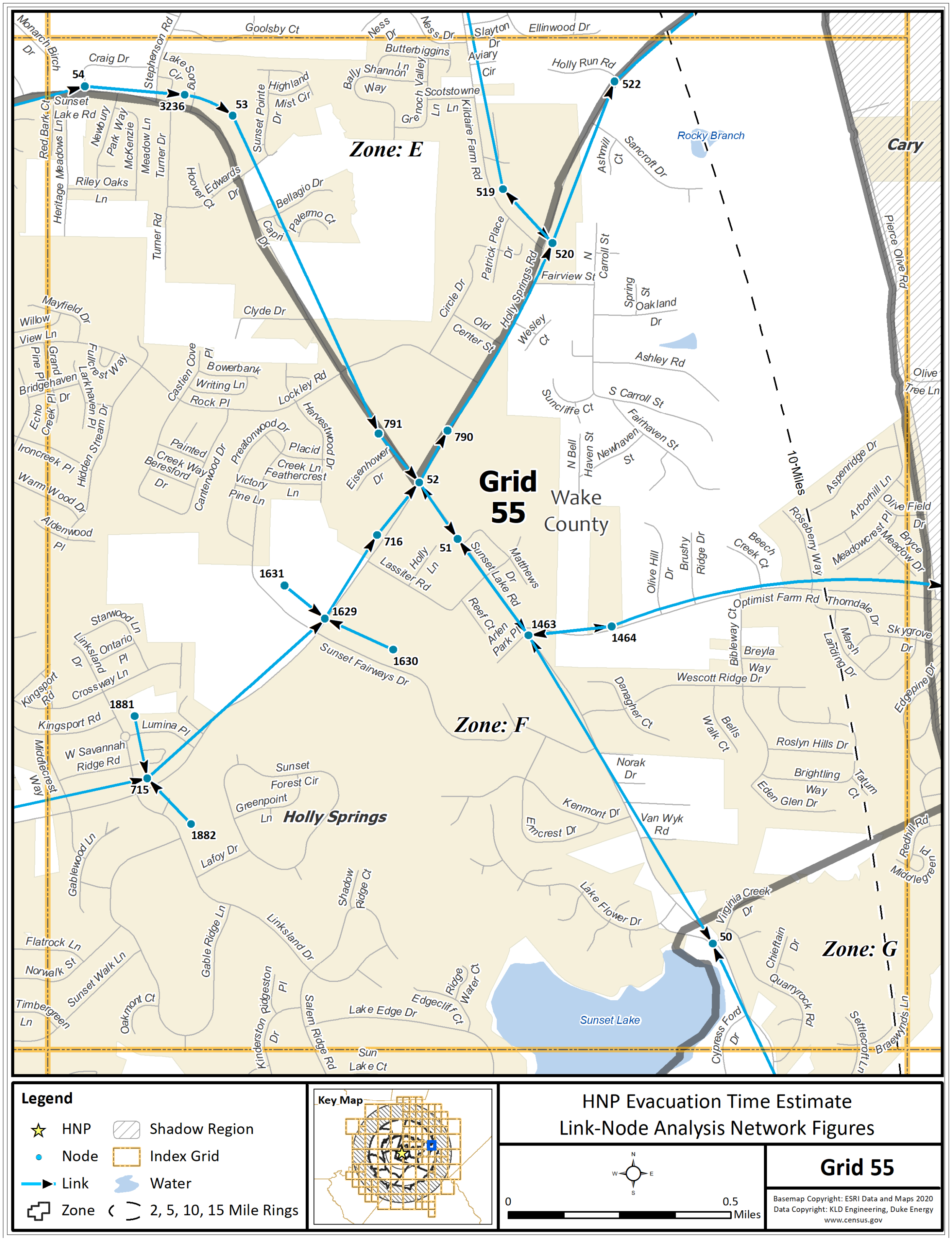


Figure K-56. Link-Node Analysis Network – Grid 55

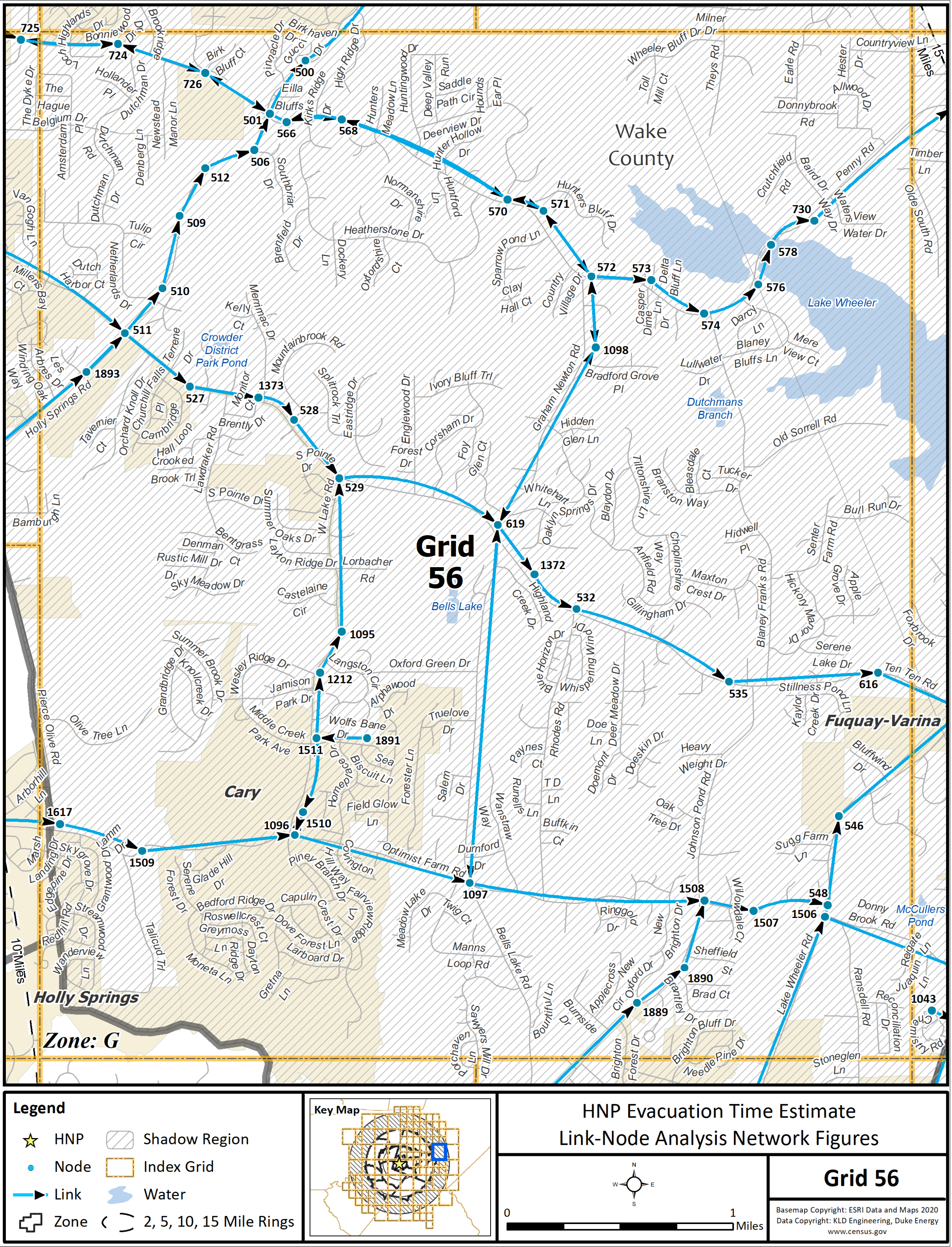


Figure K-57. Link-Node Analysis Network – Grid 56

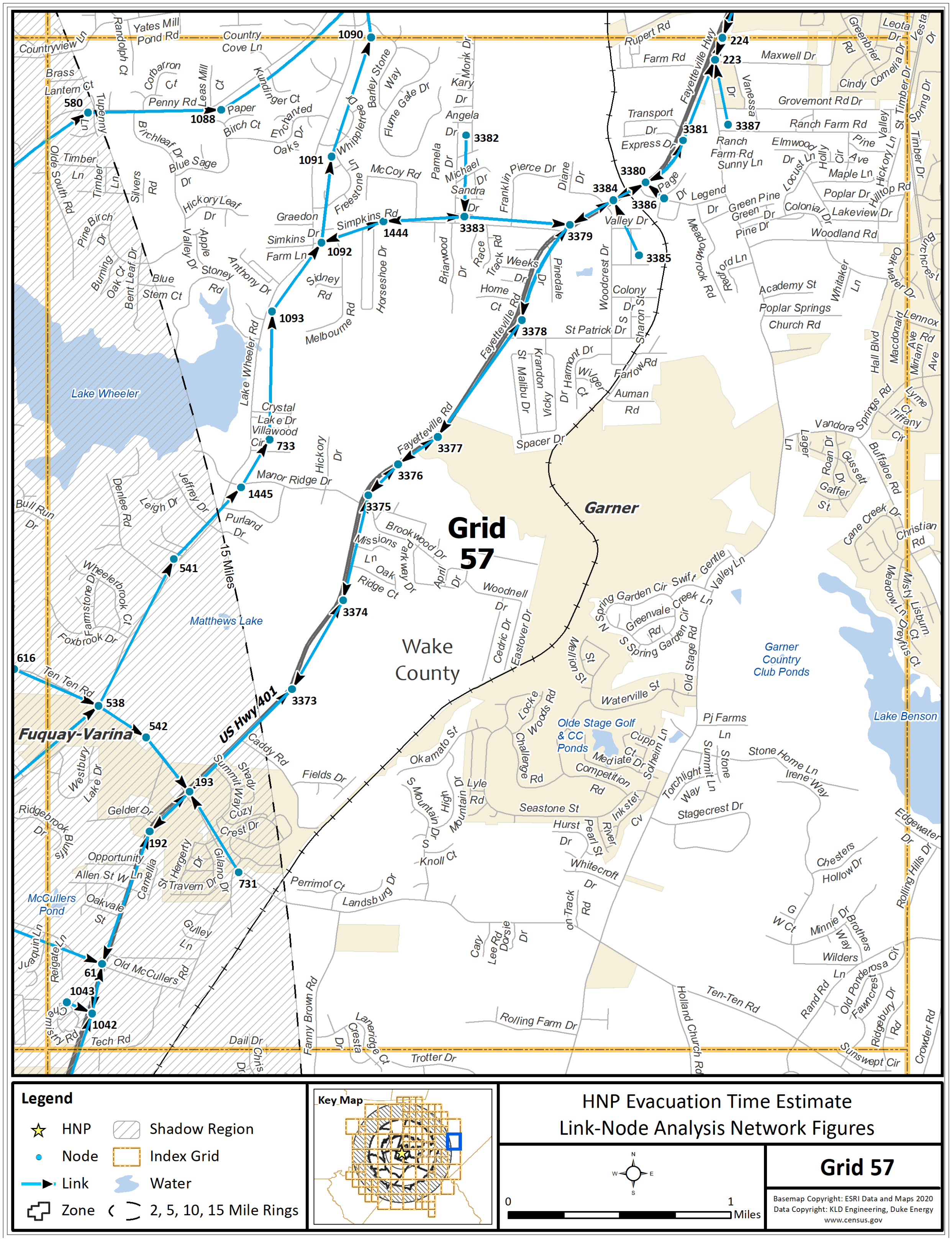
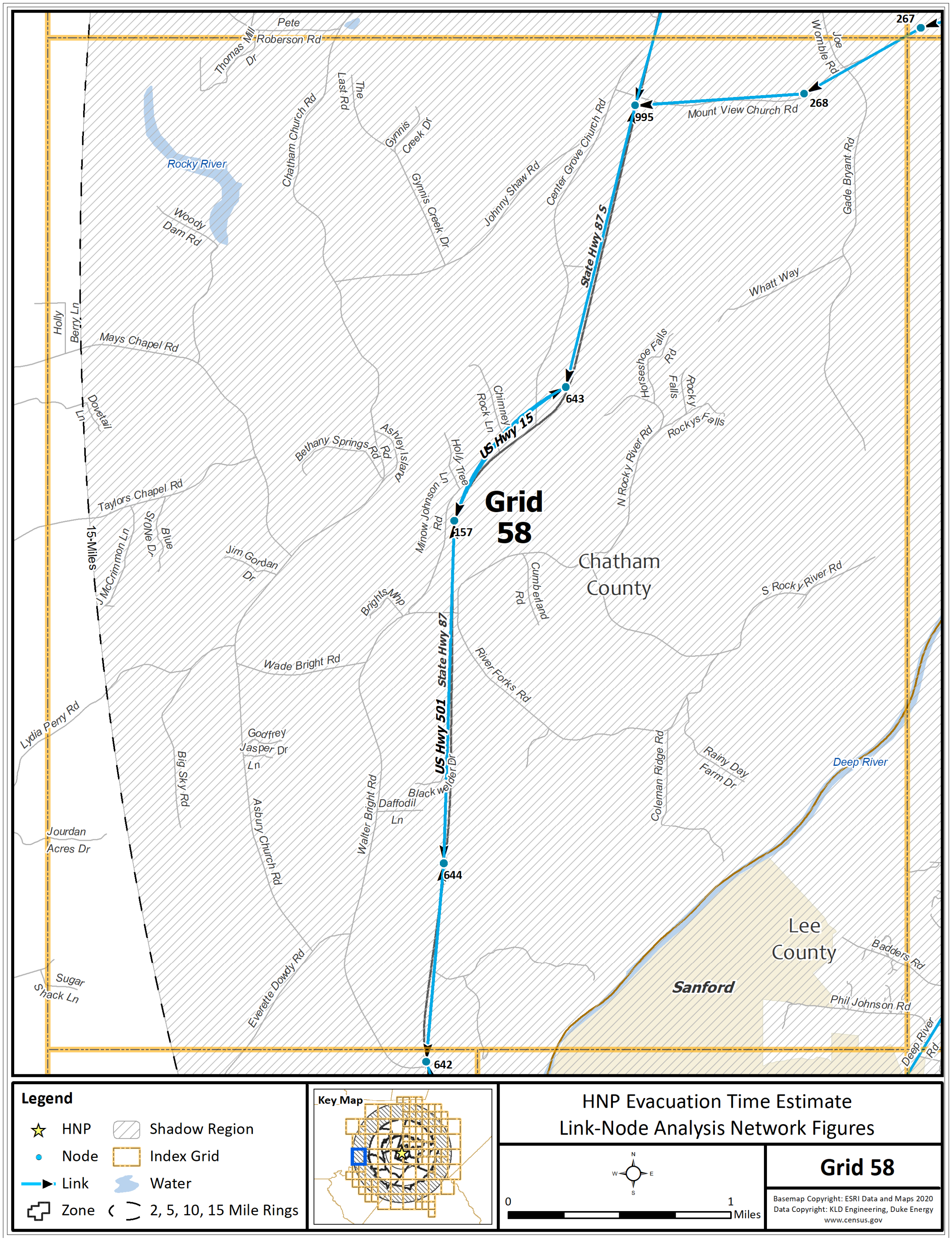


Figure K-58. Link-Node Analysis Network – Grid 57



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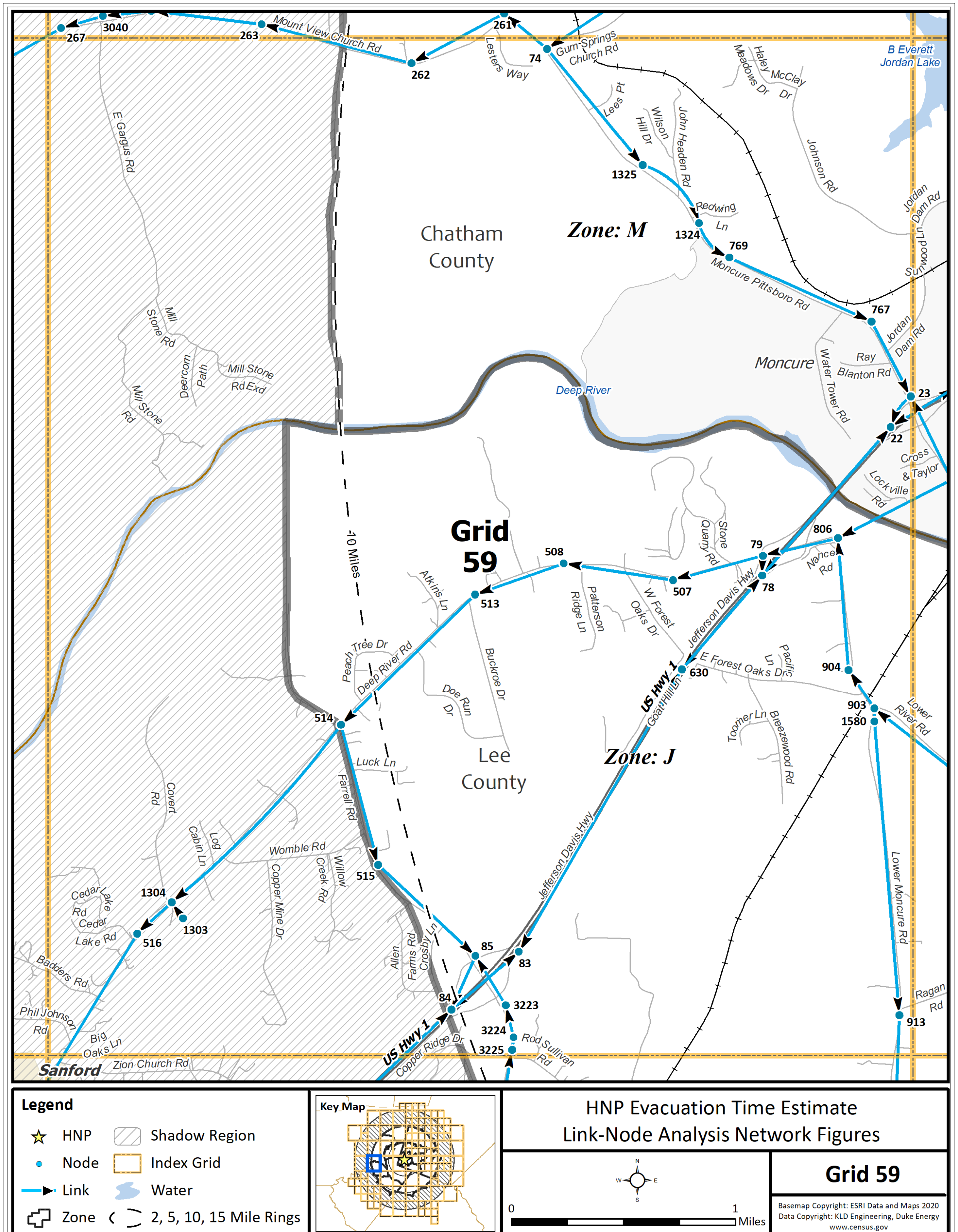

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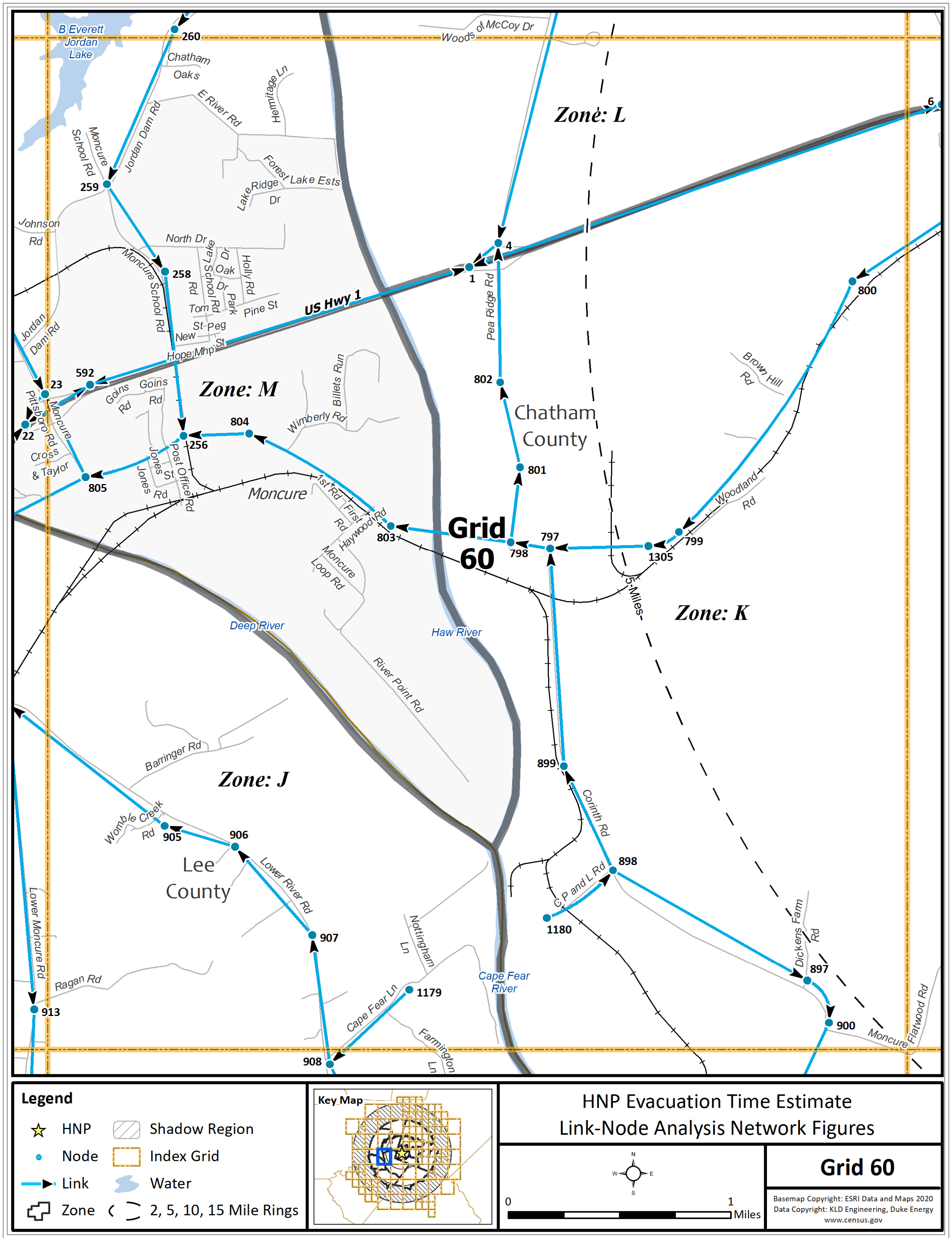

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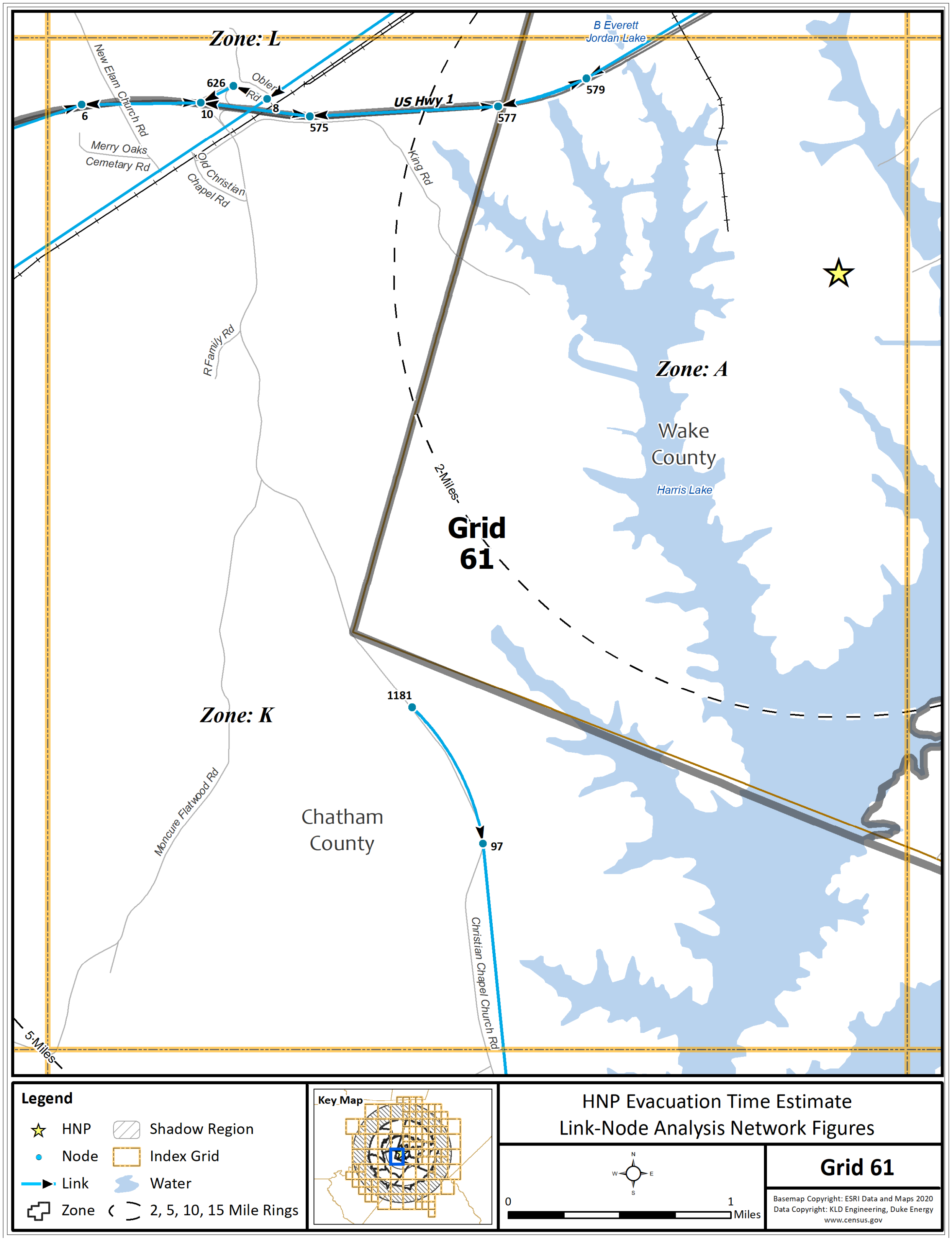

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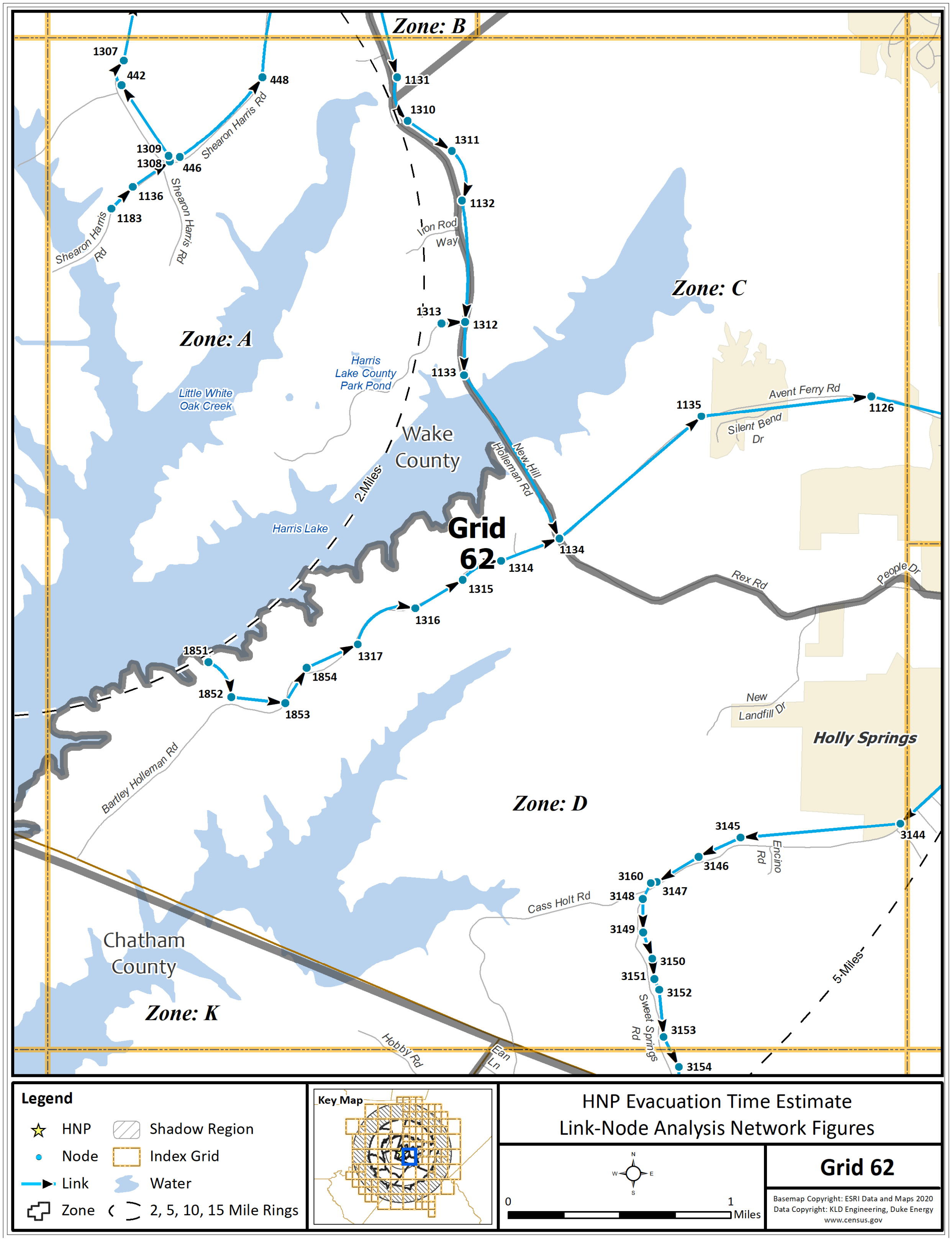

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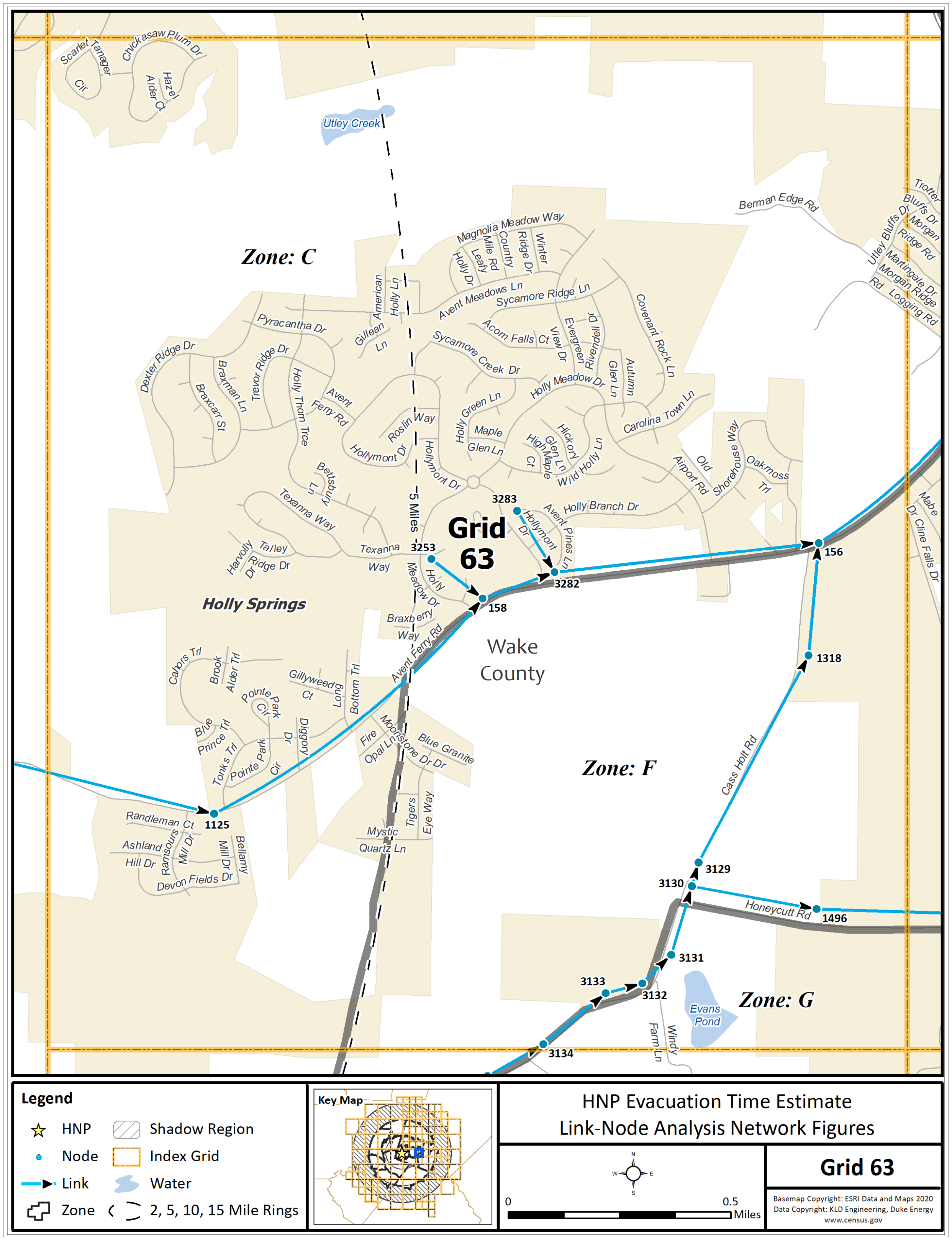

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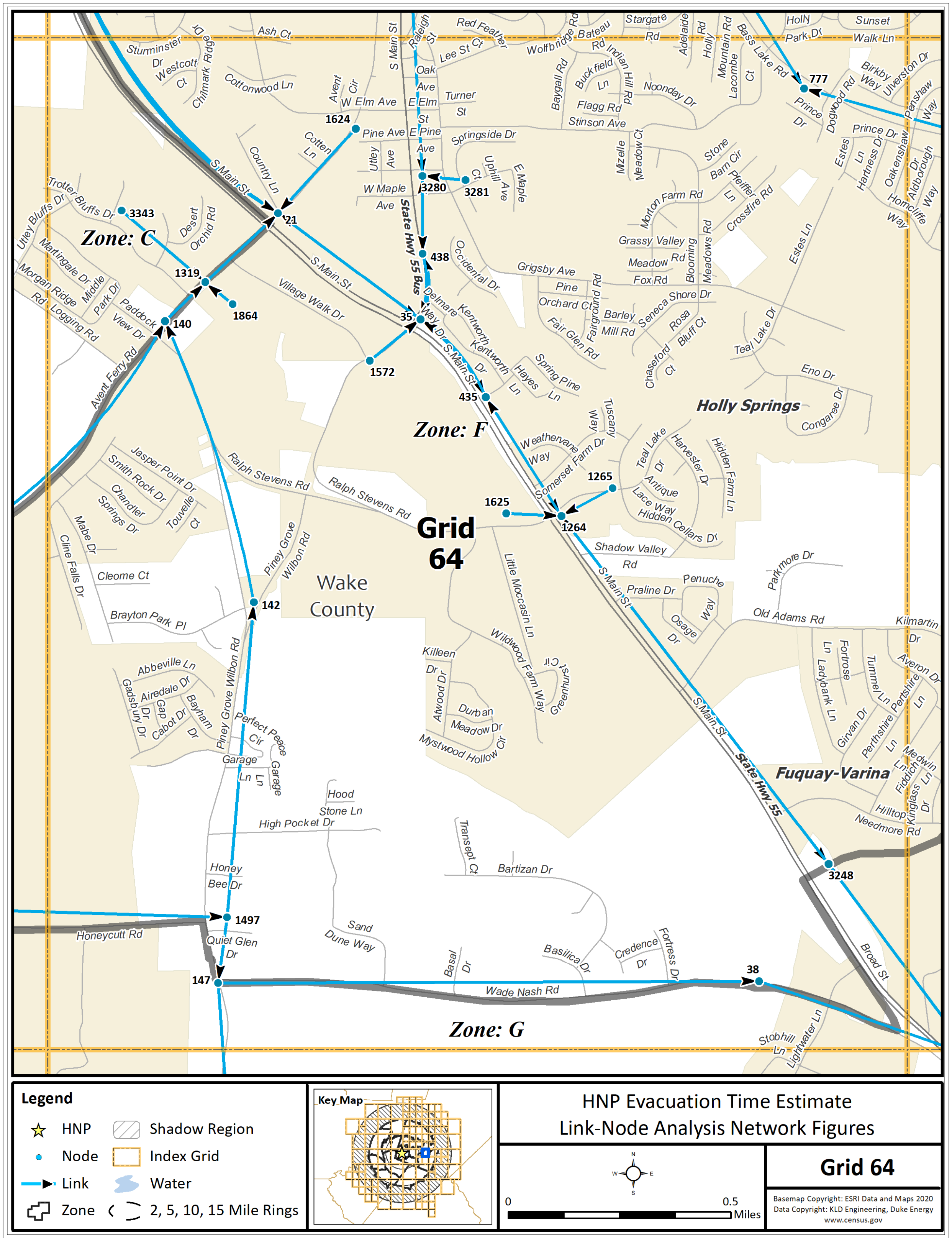

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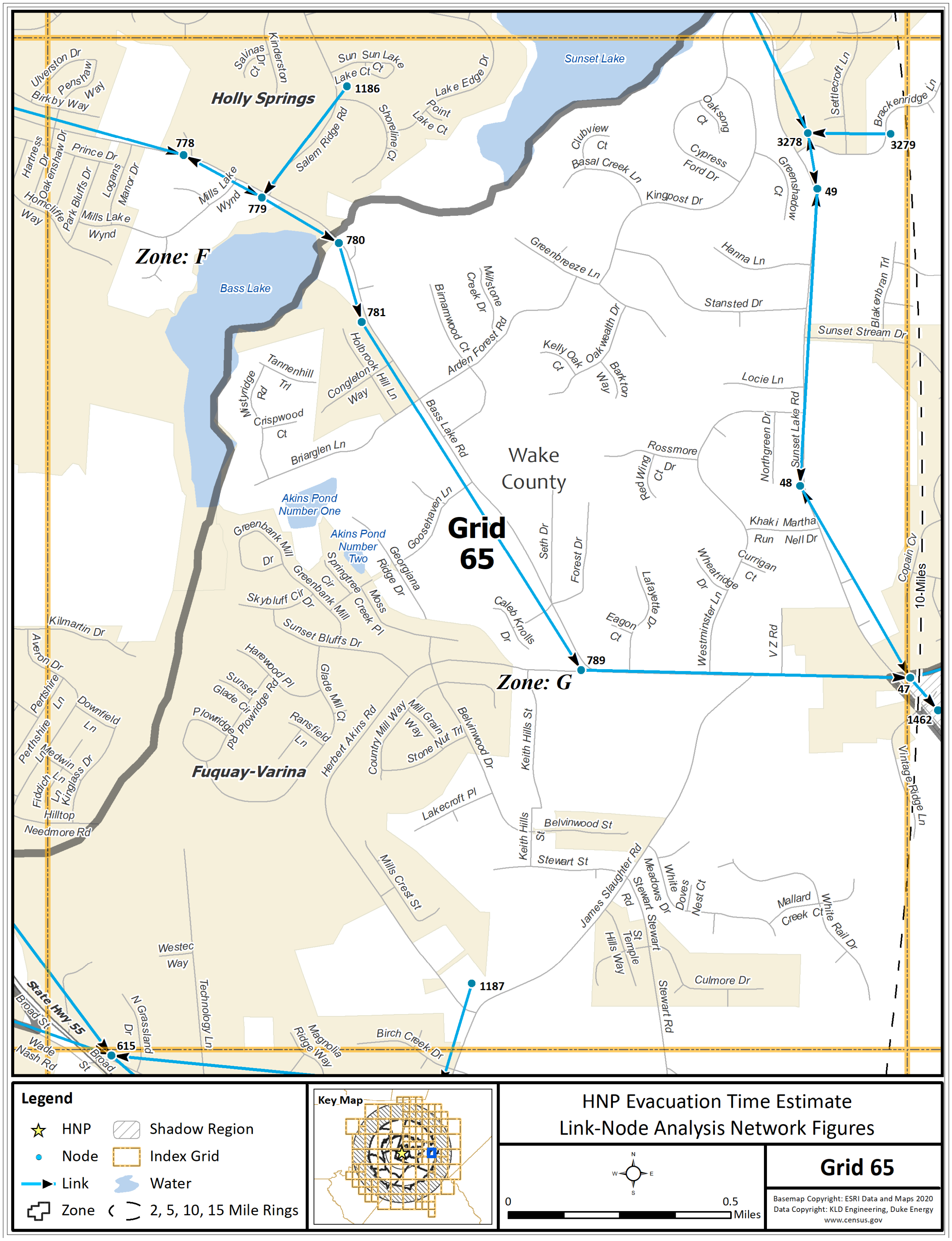

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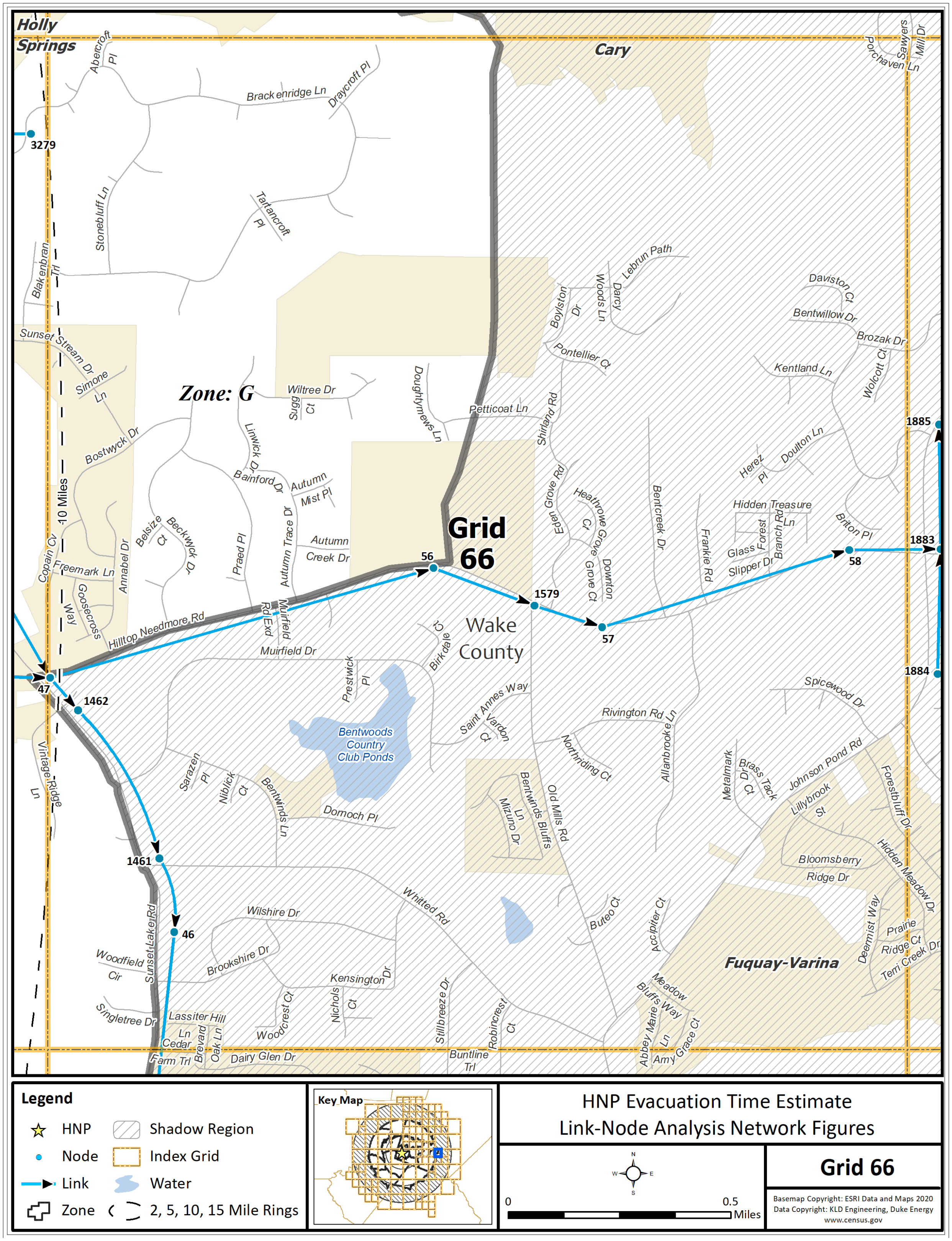

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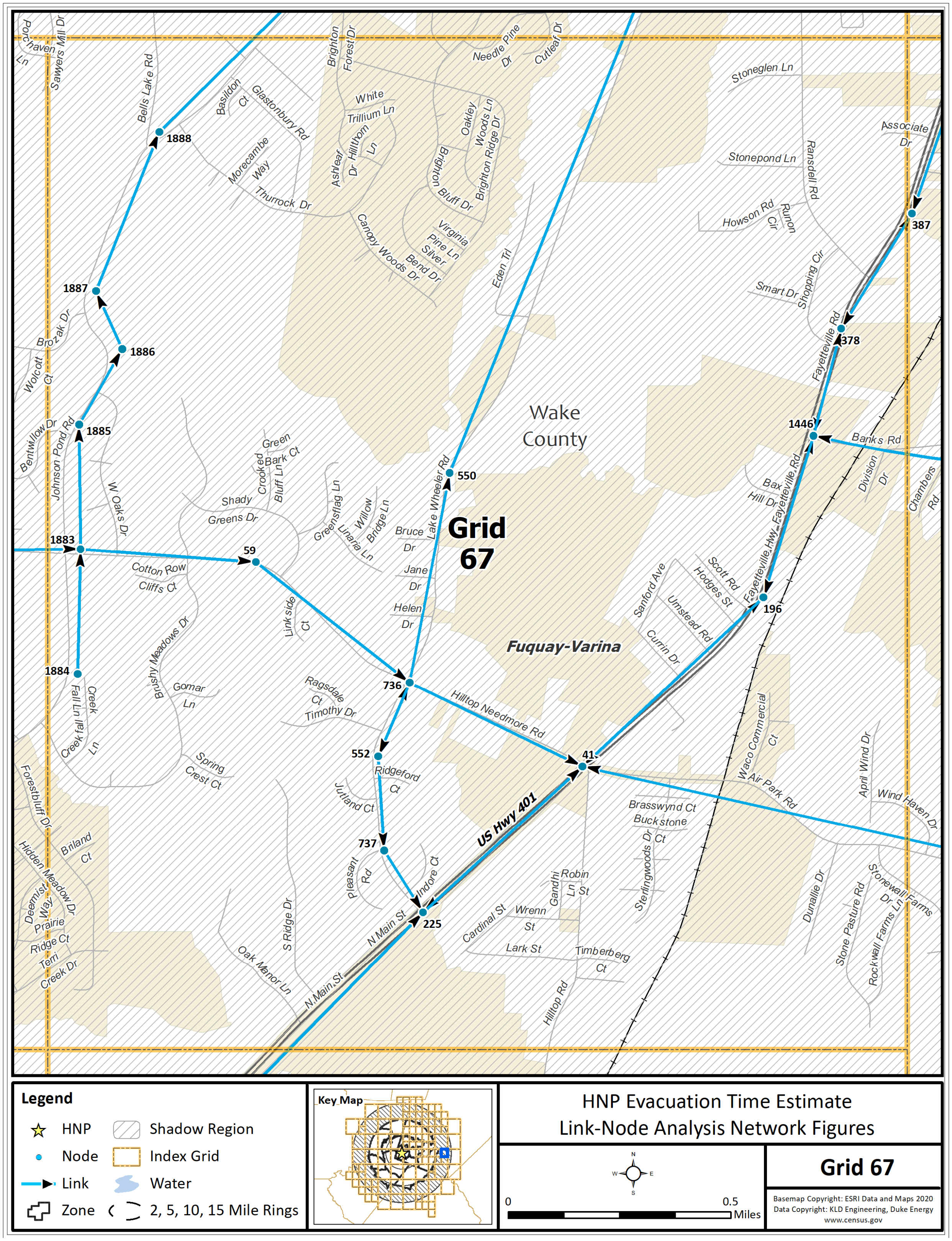

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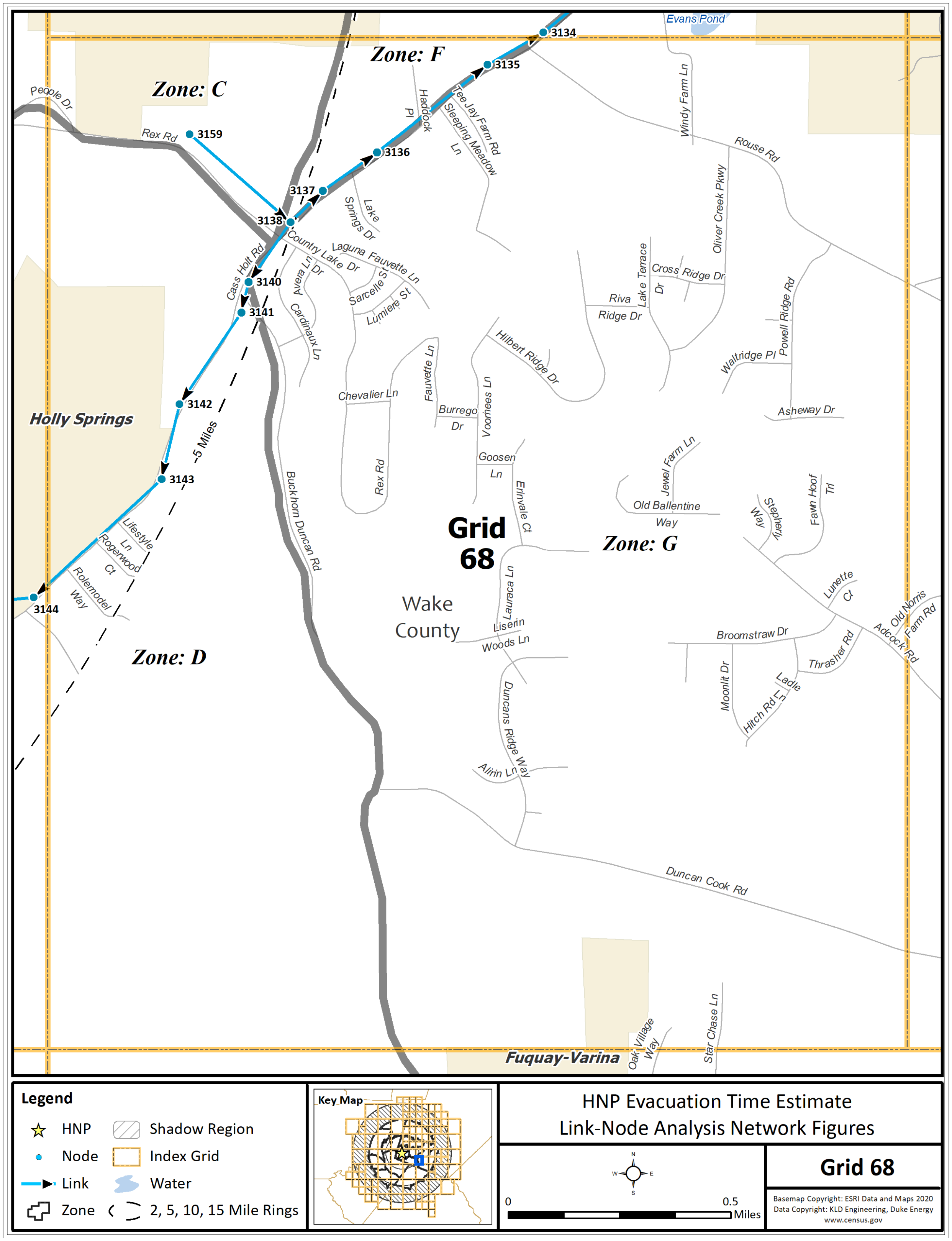

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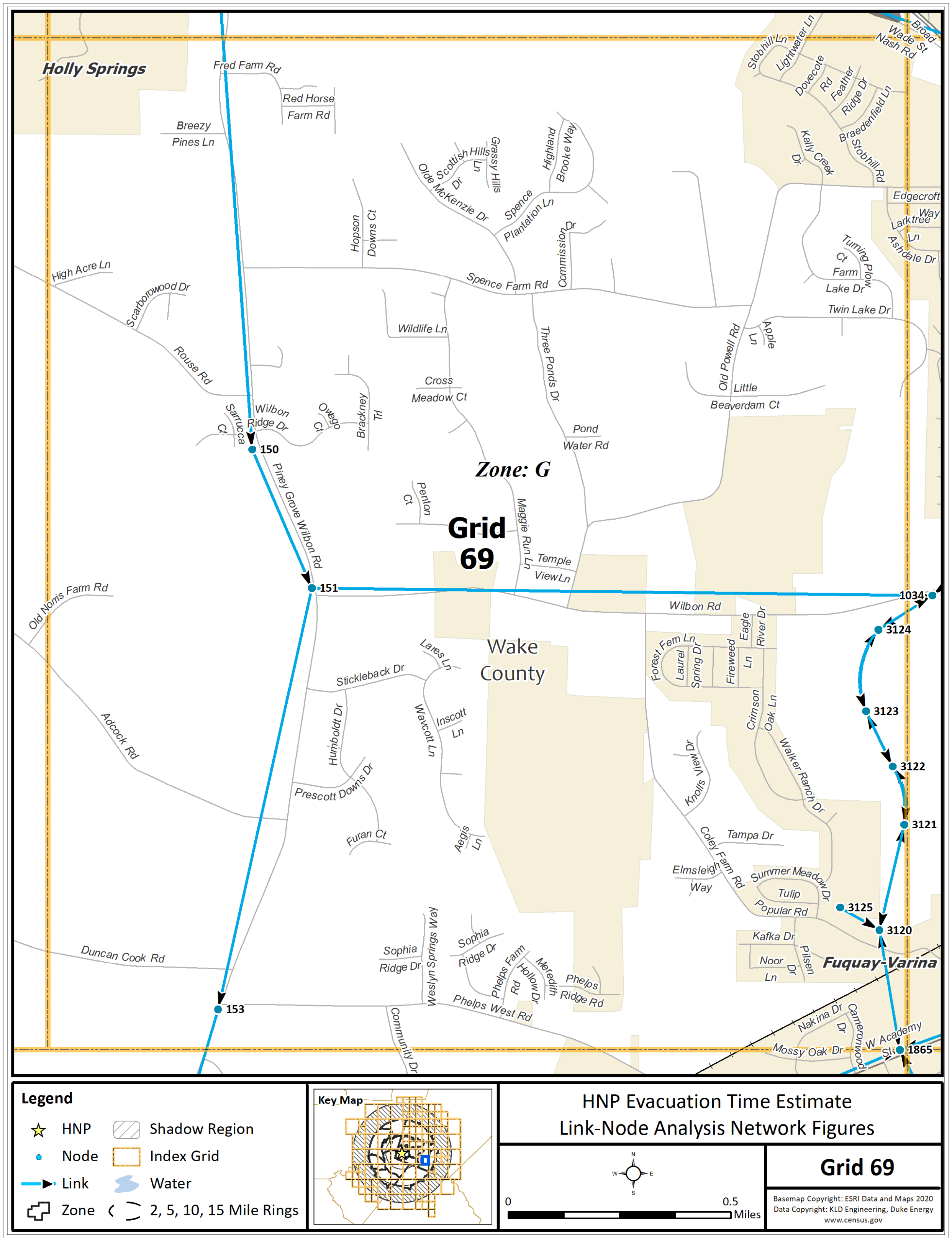

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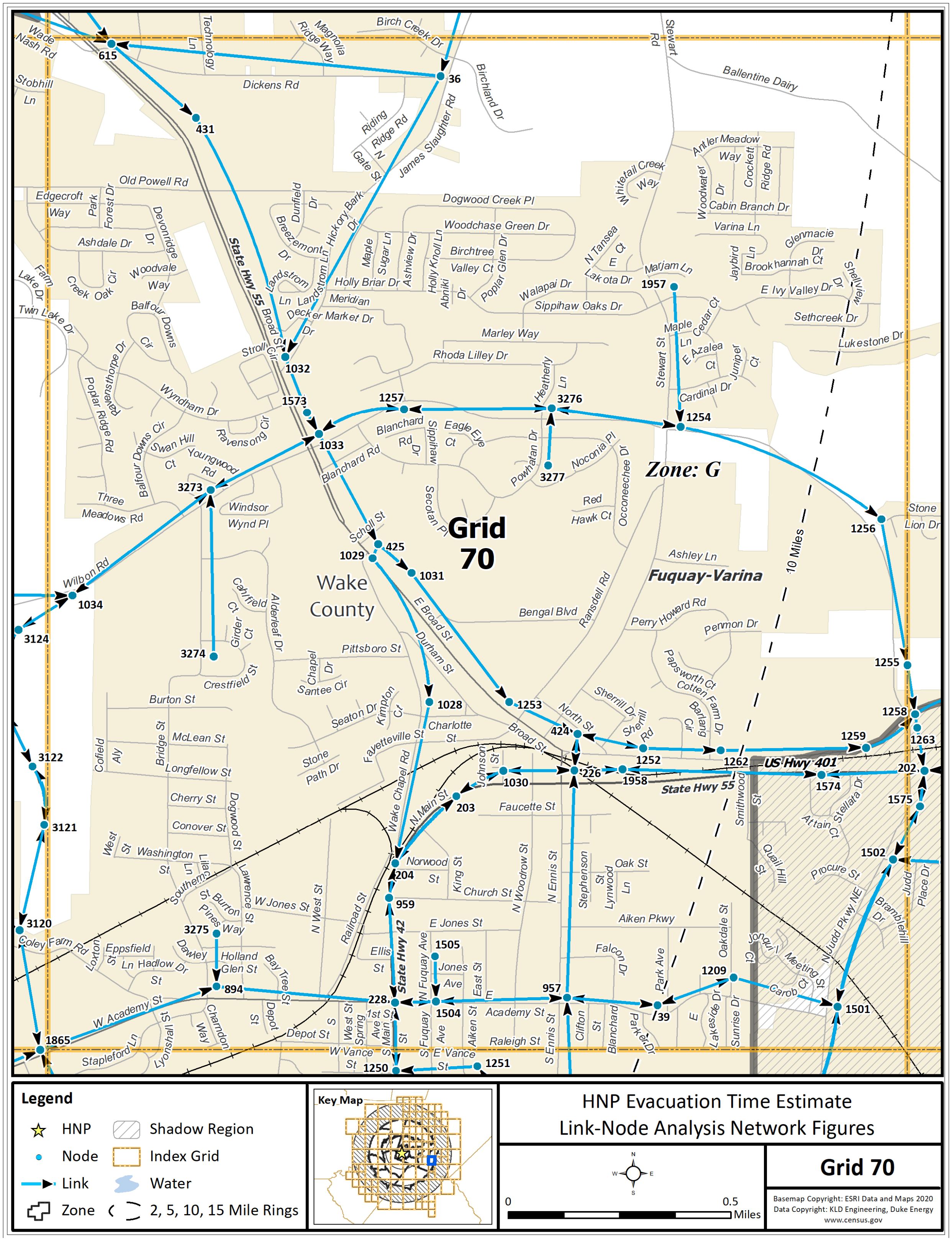

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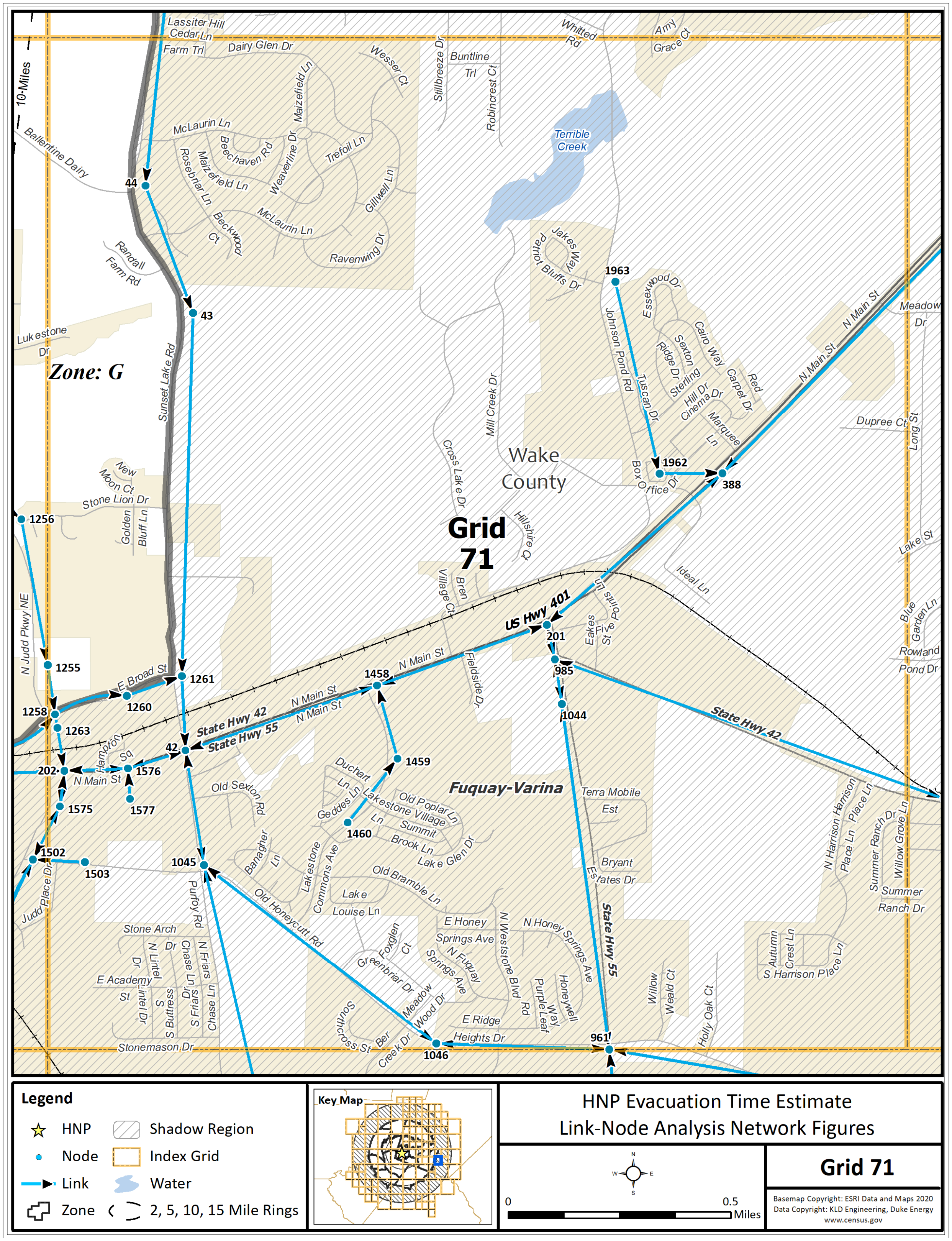

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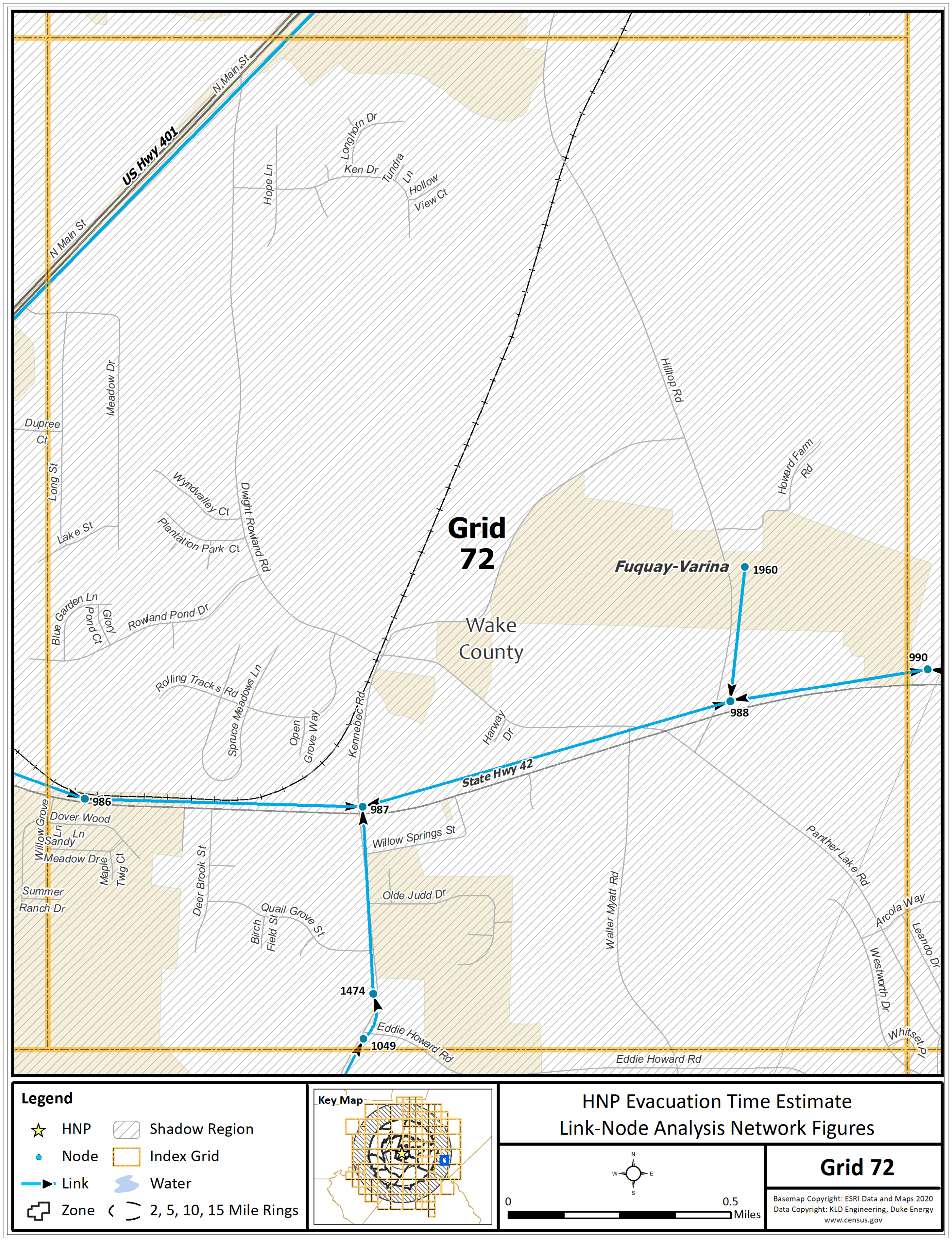

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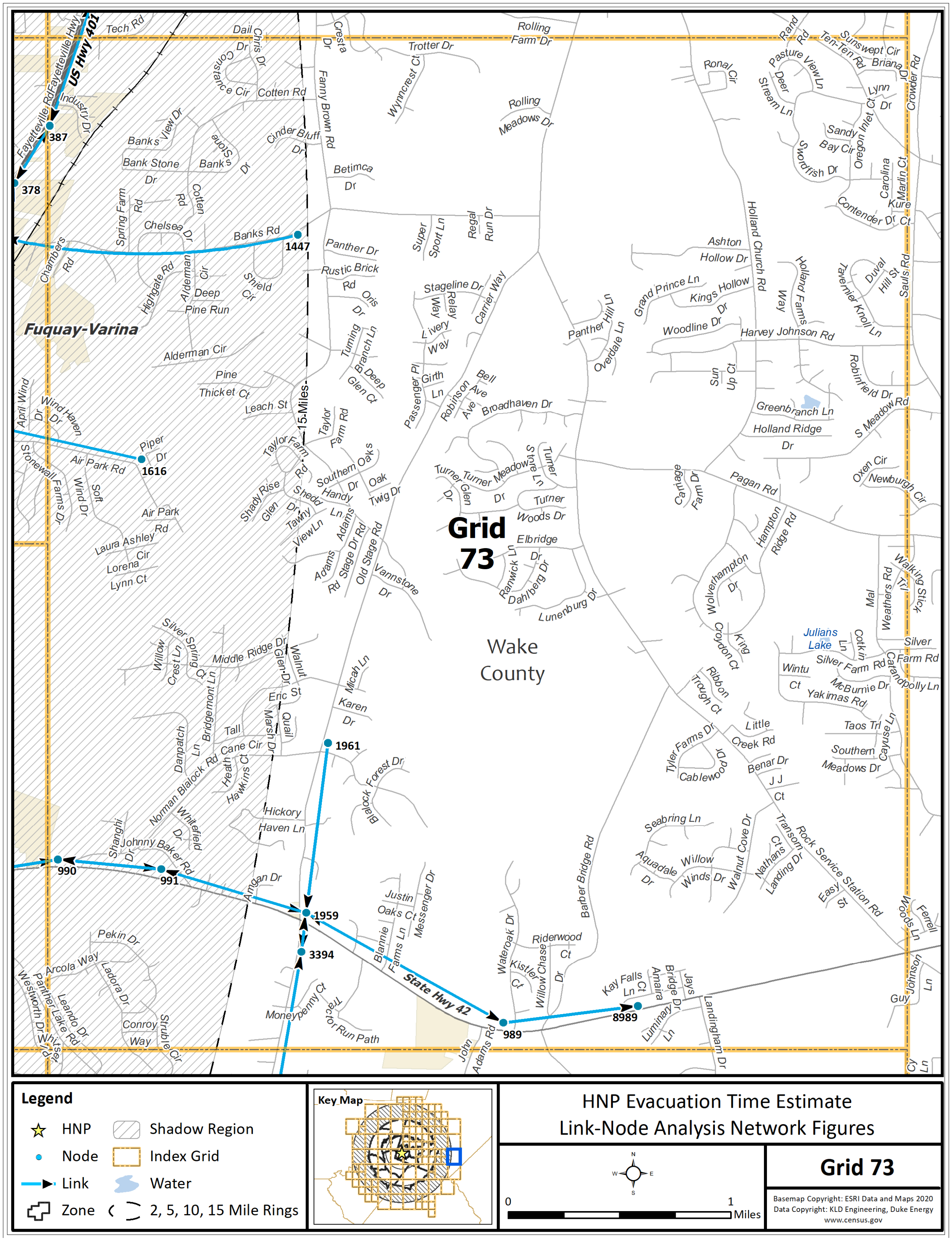

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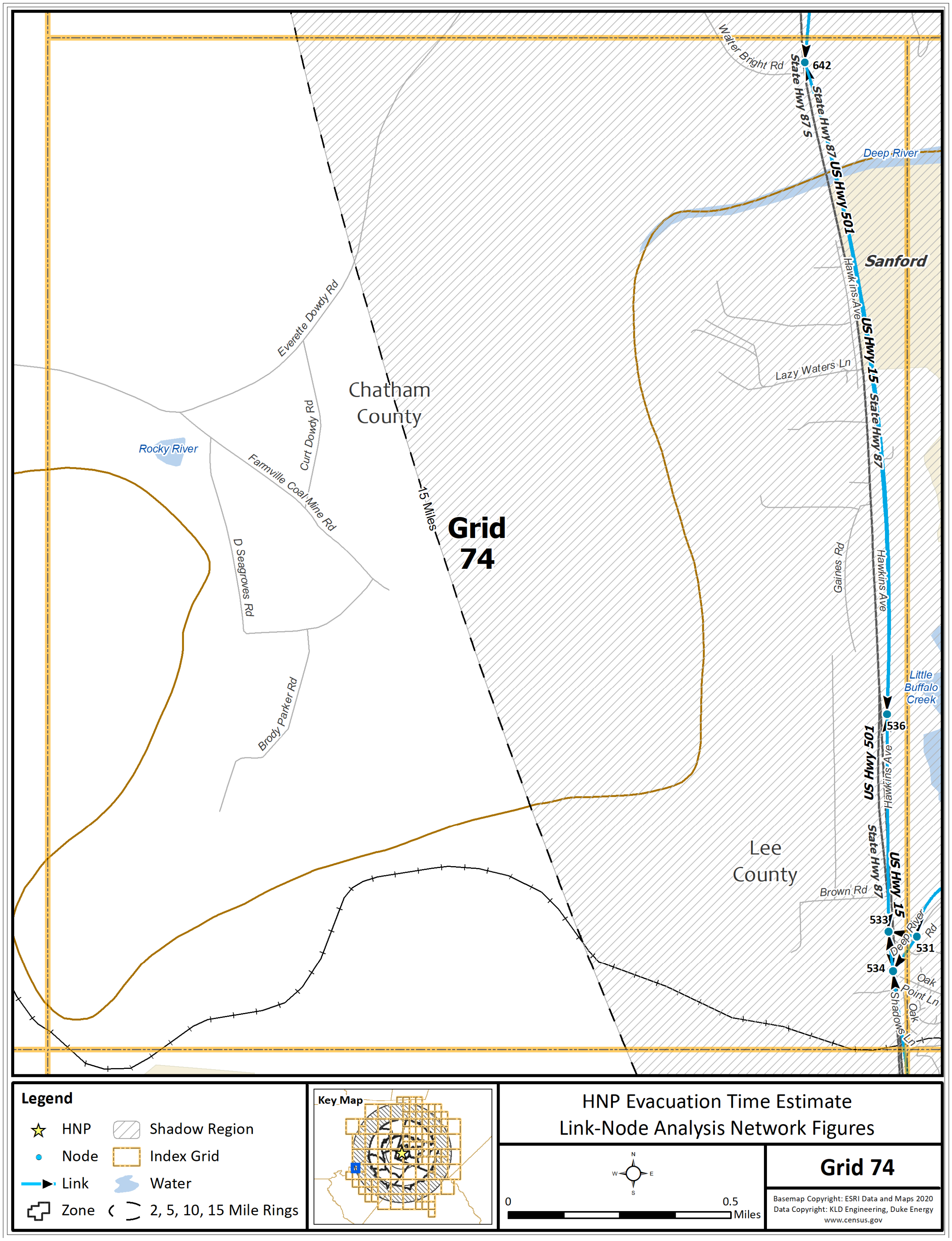

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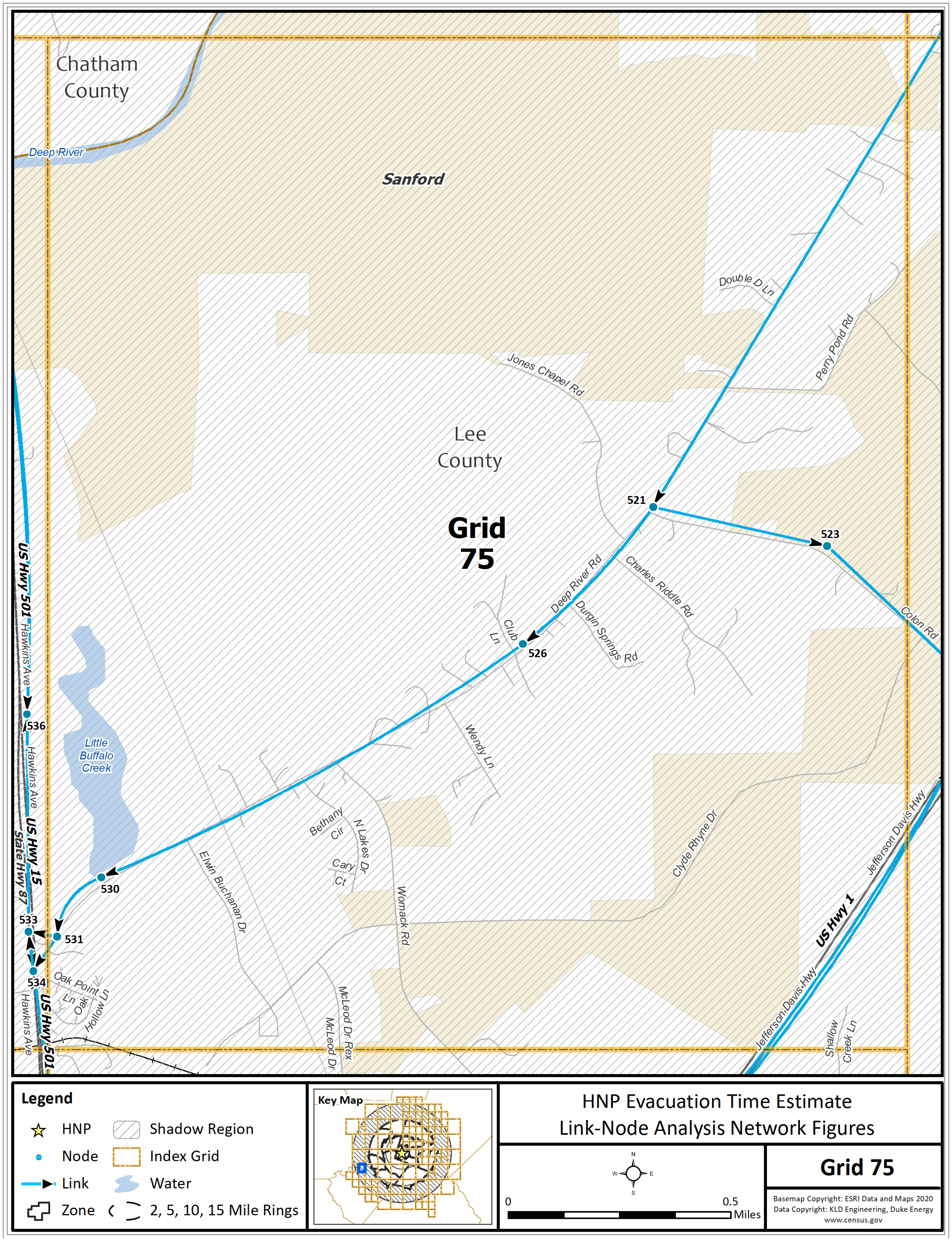

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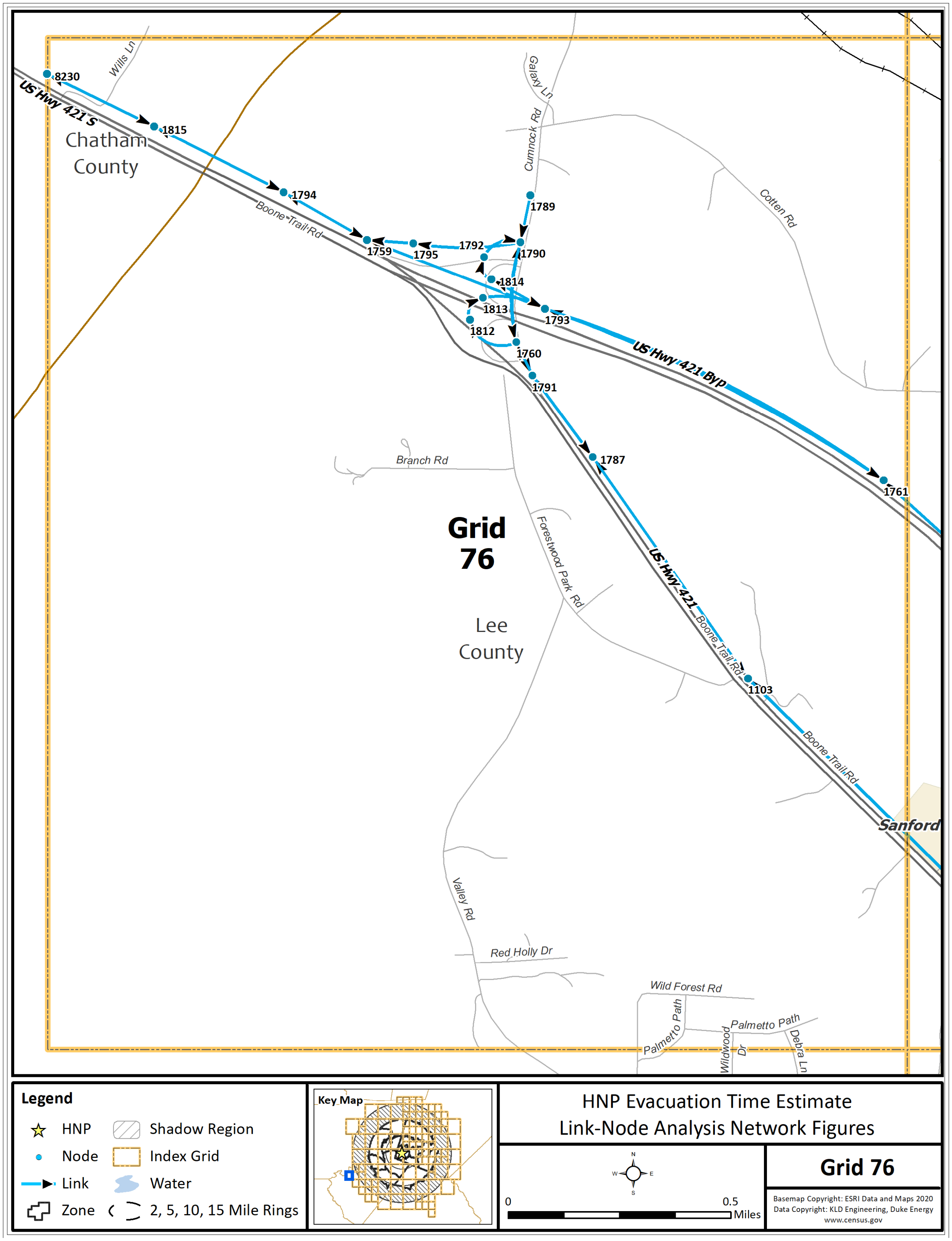

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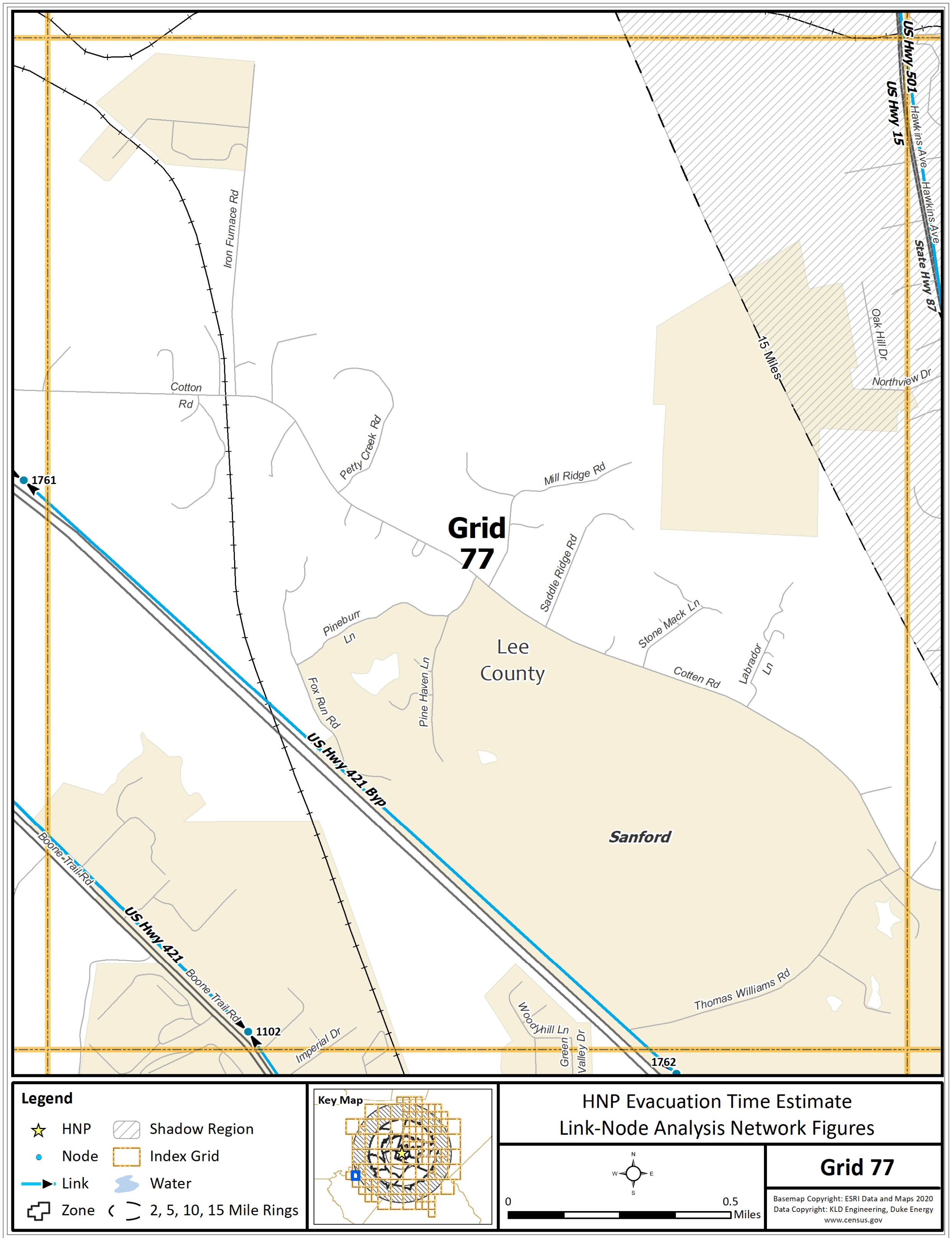

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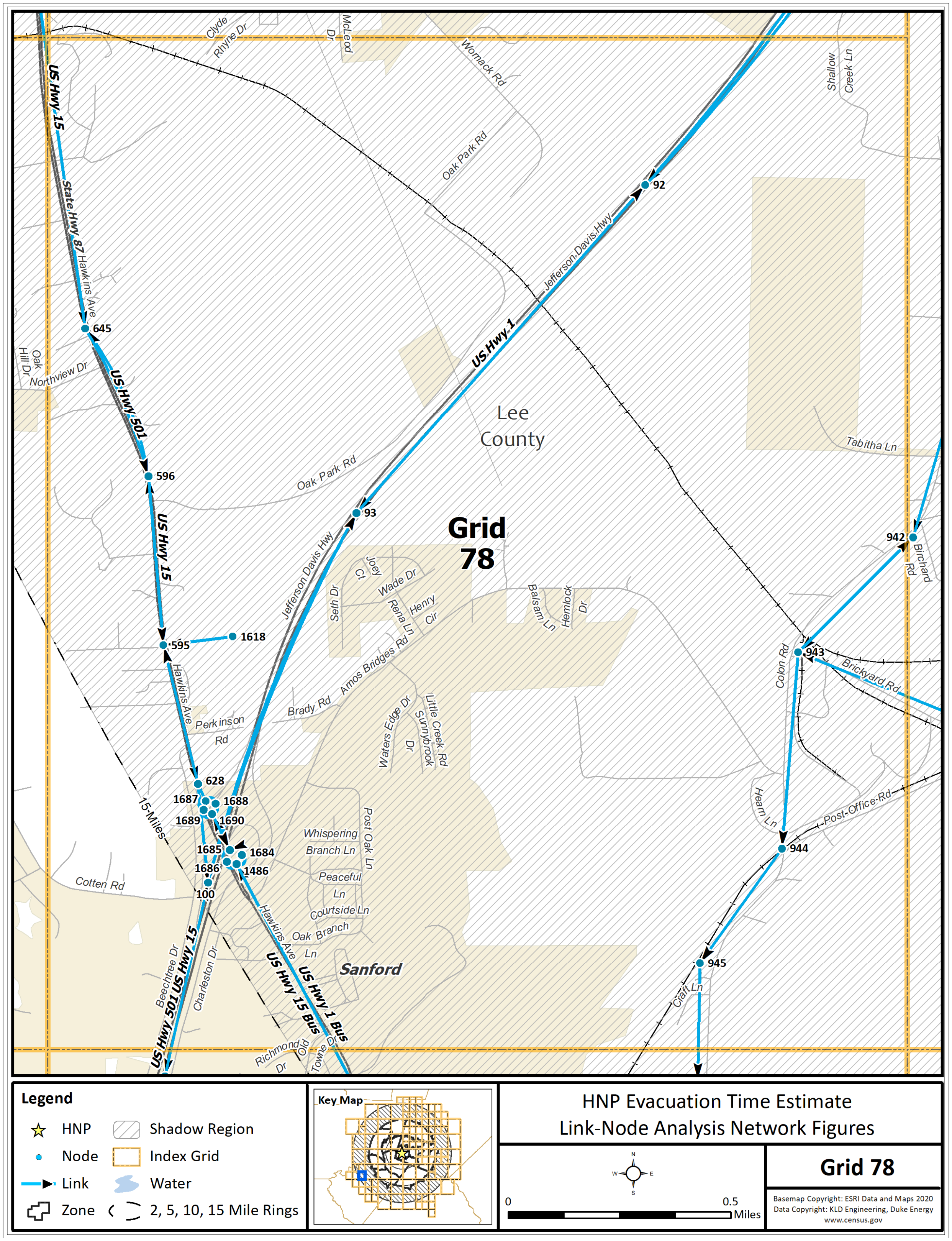

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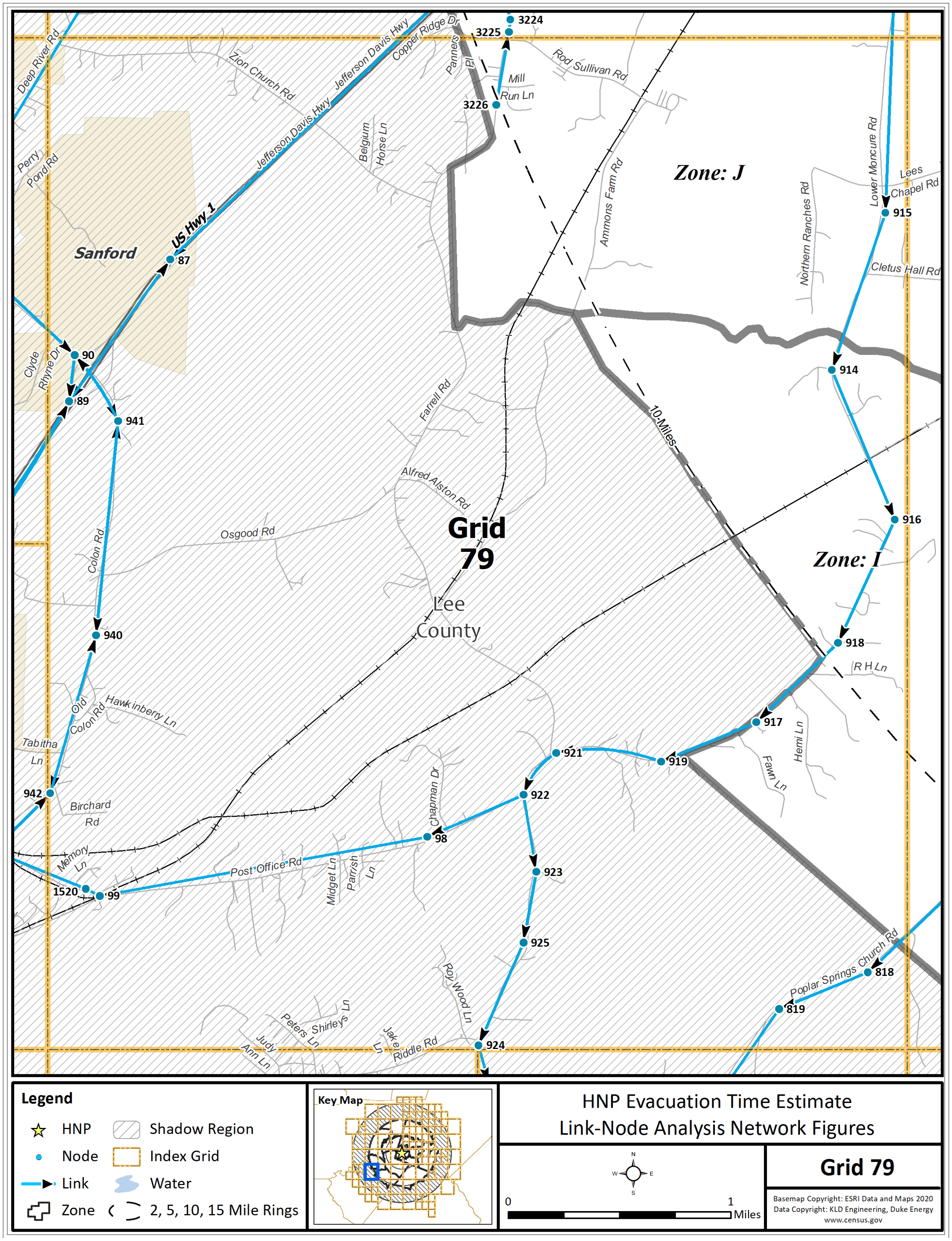

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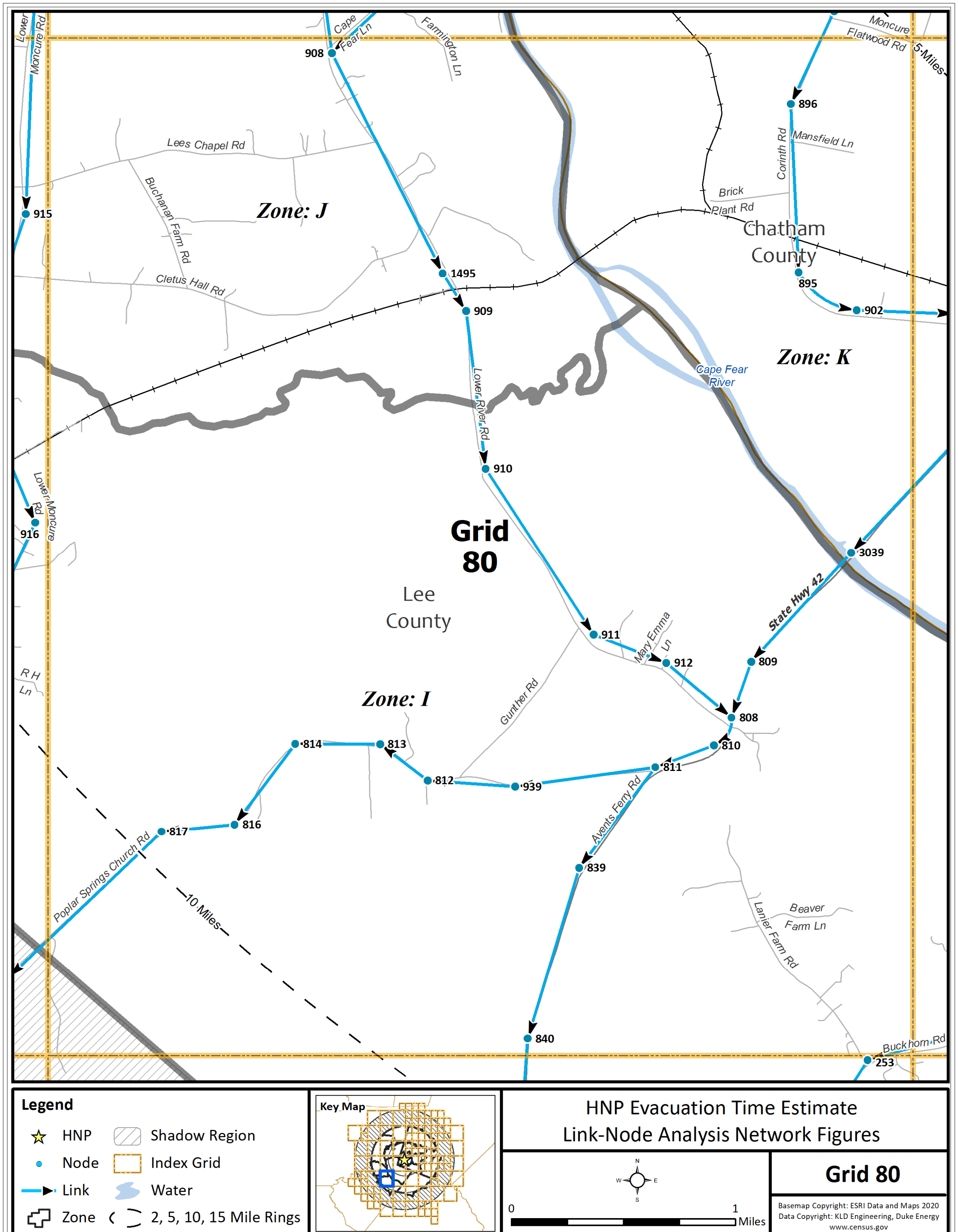
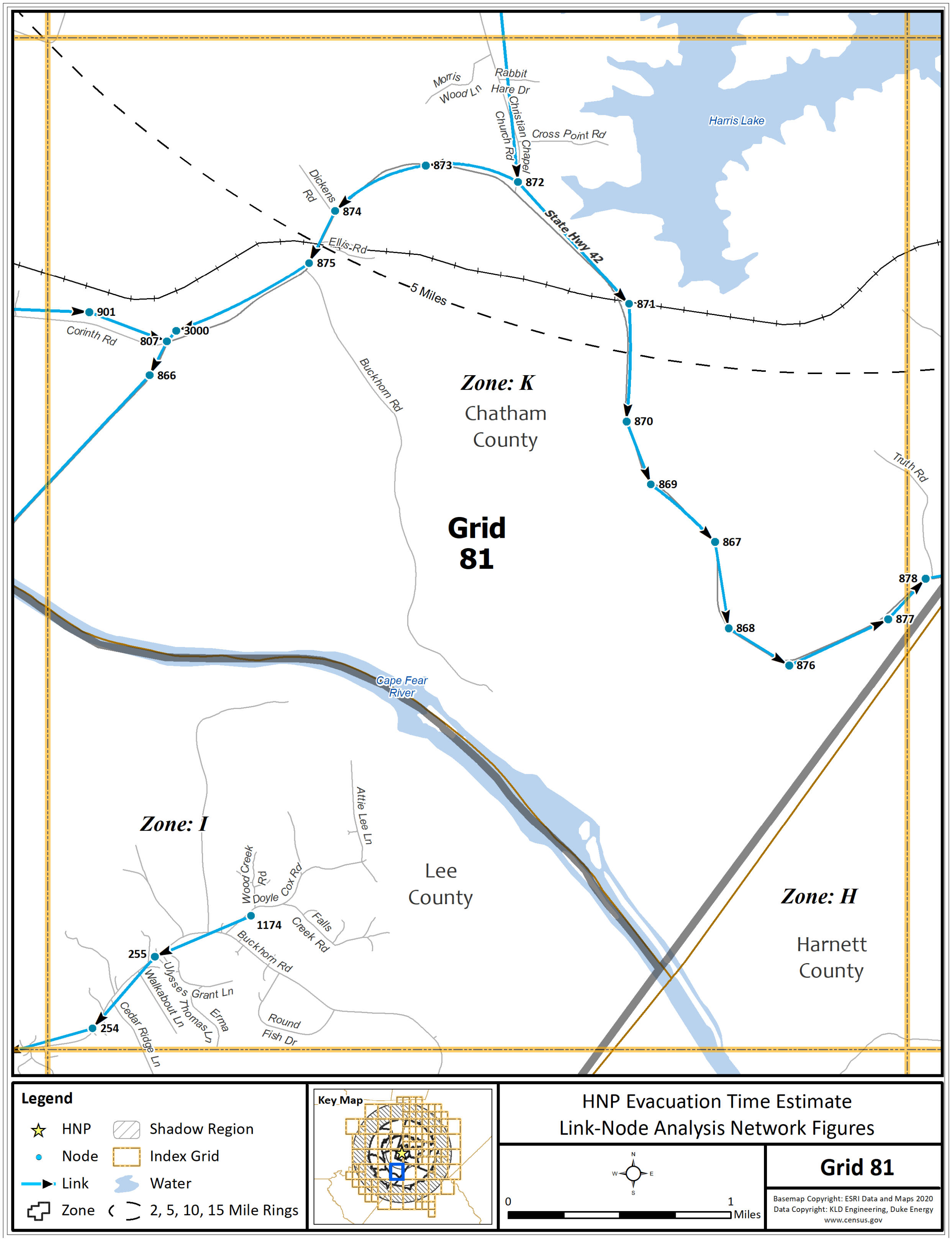


Figure K-81. Link-Node Analysis Network – Grid 80



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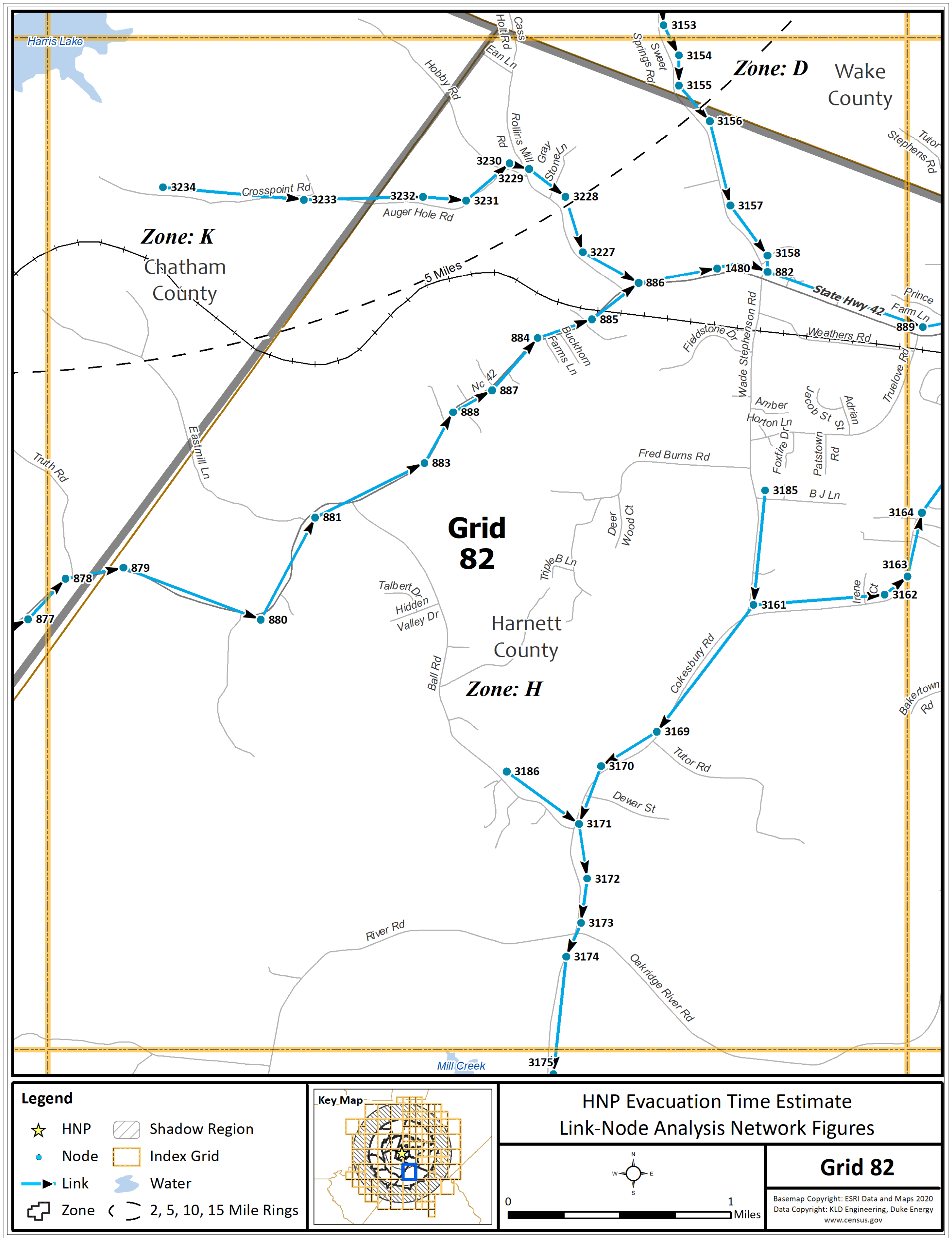

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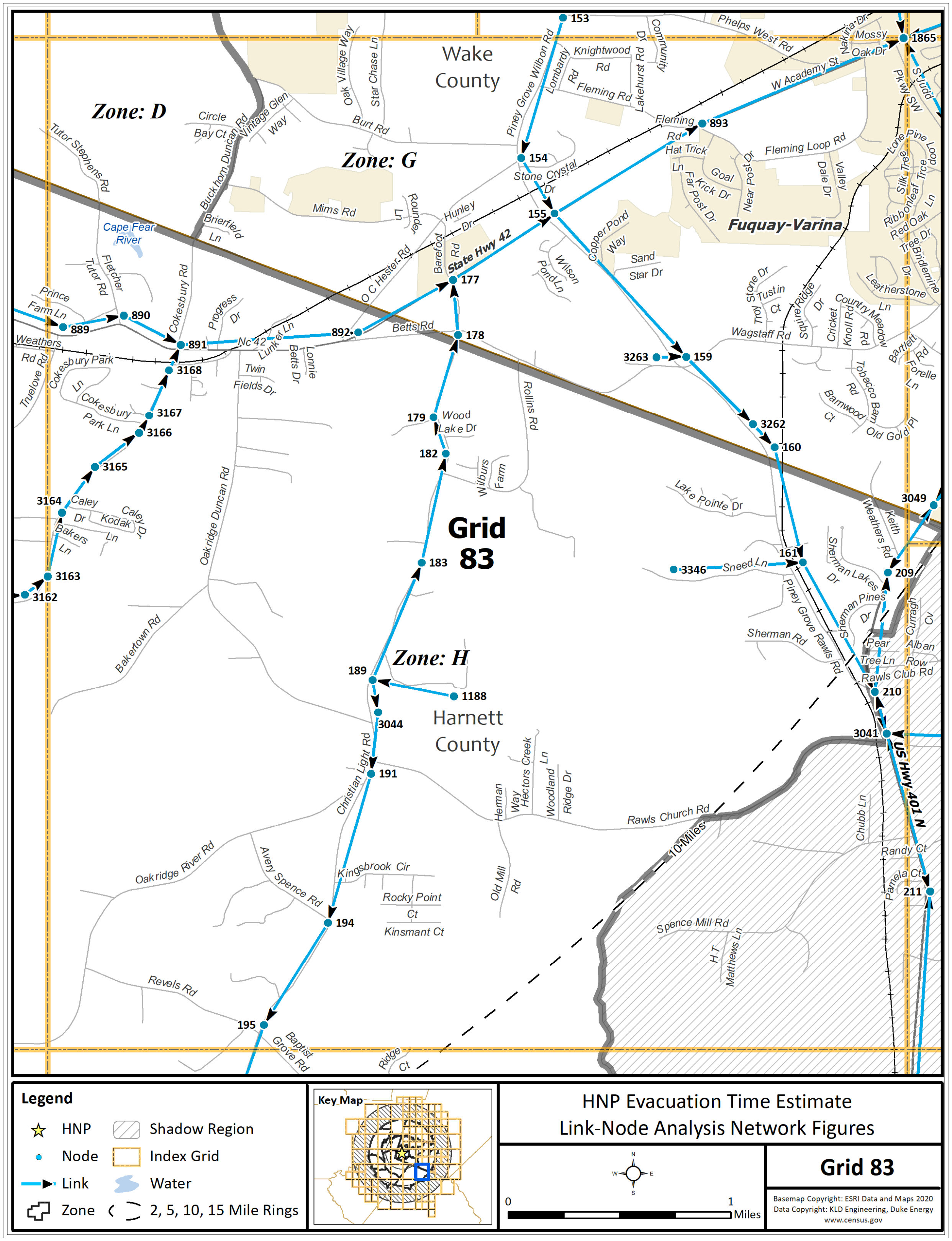

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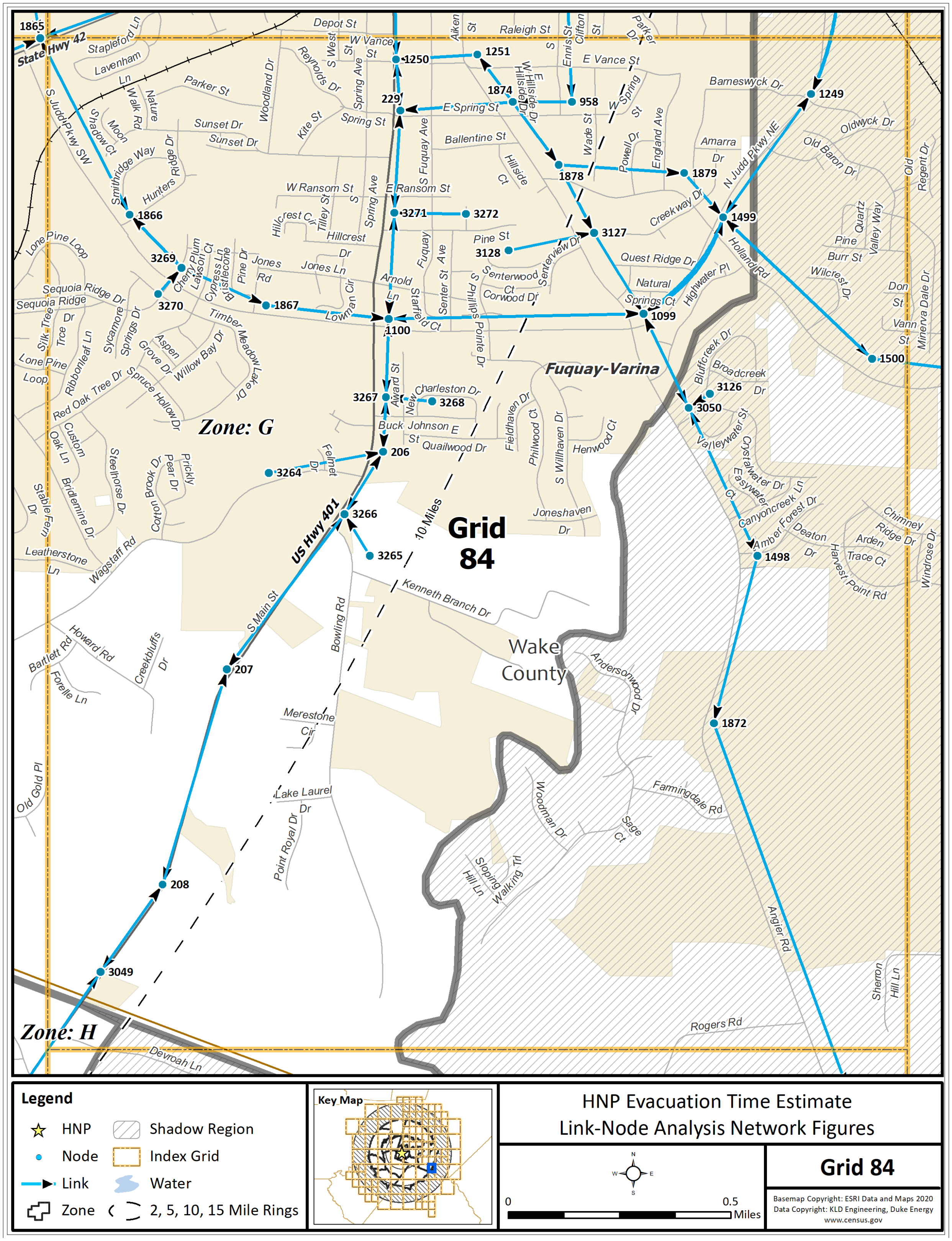


Figure K-85. Link-Node Analysis Network – Grid 84

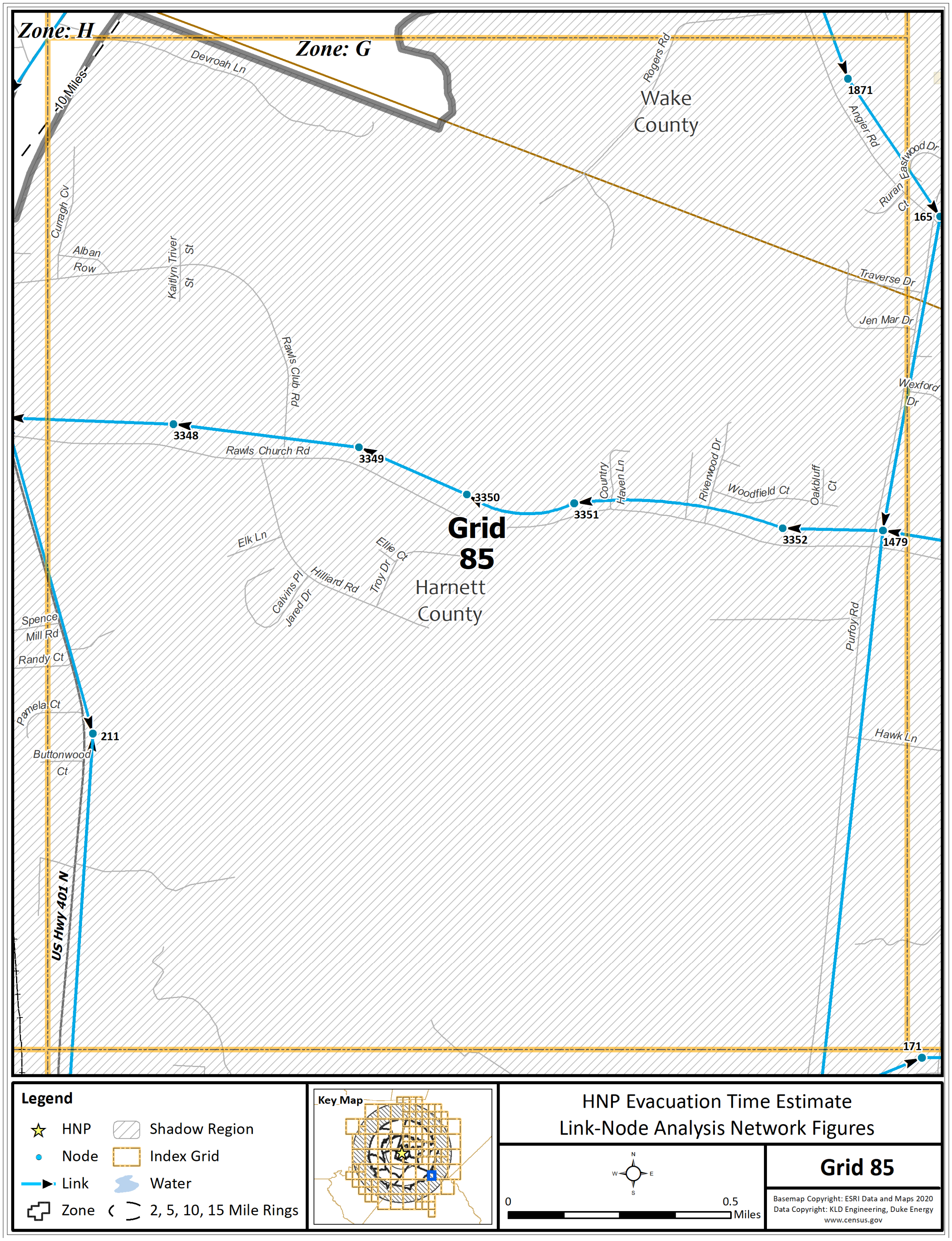
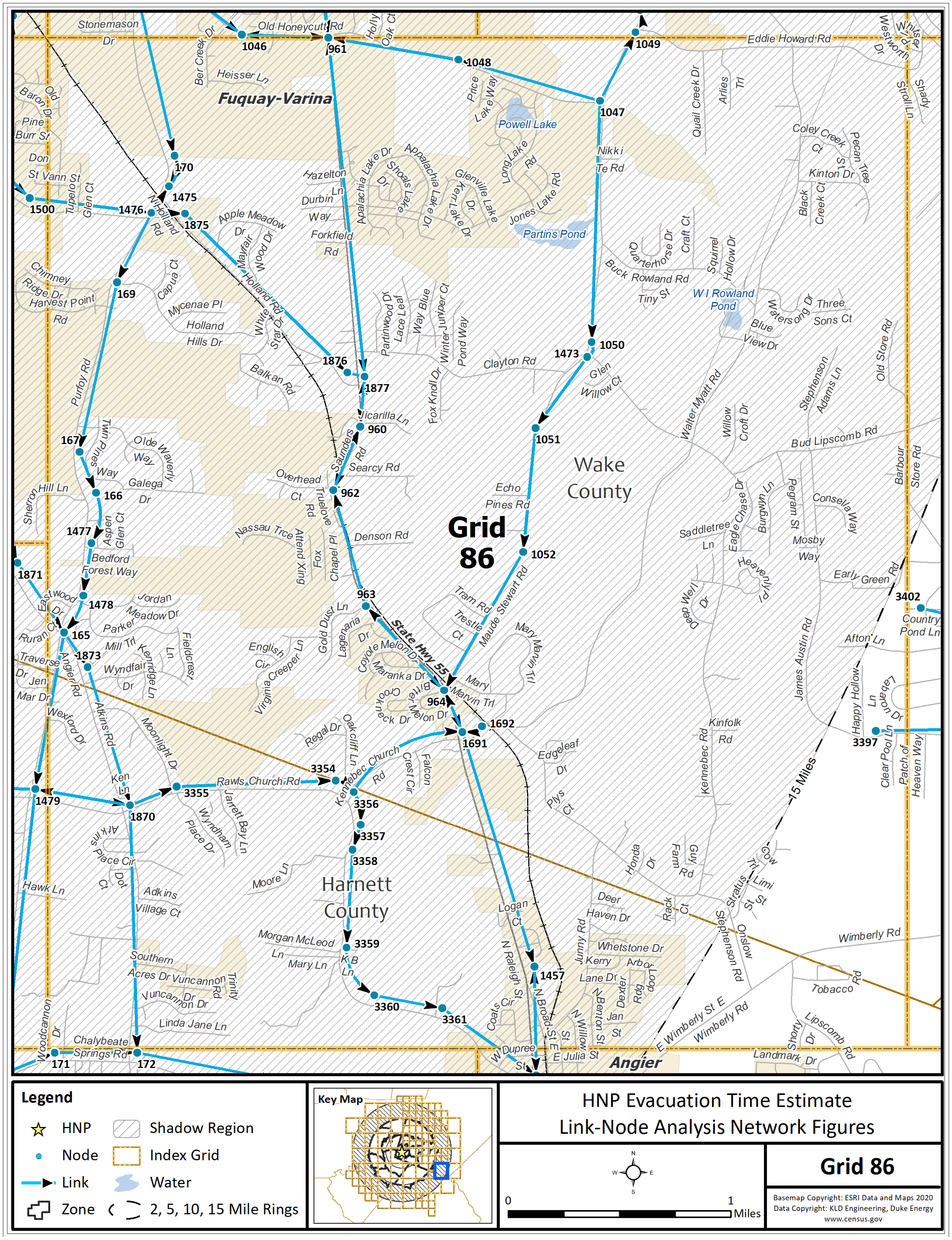


Figure K-86. Link-Node Analysis Network – Grid 85



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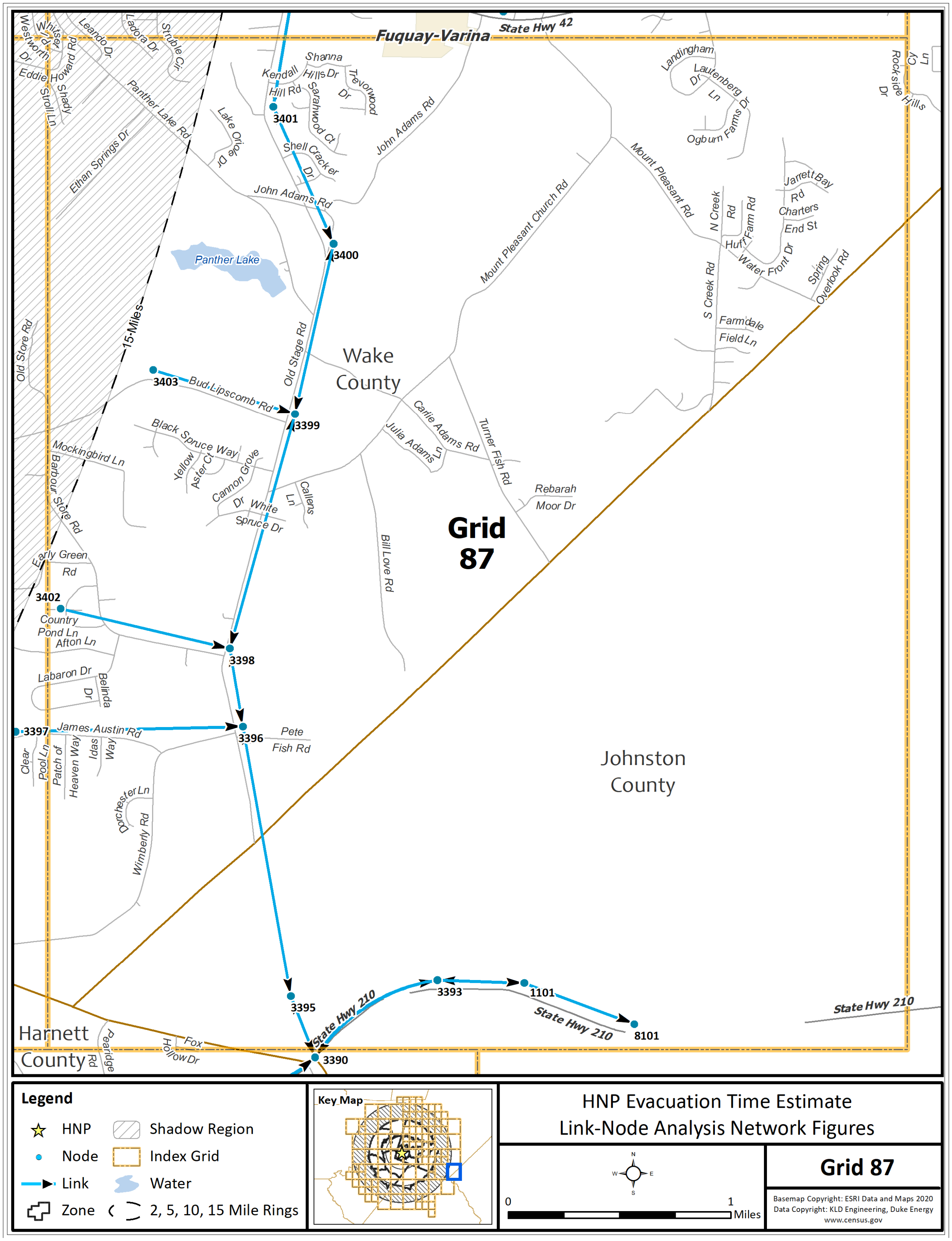


Figure K-88. Link-Node Analysis Network – Grid 87

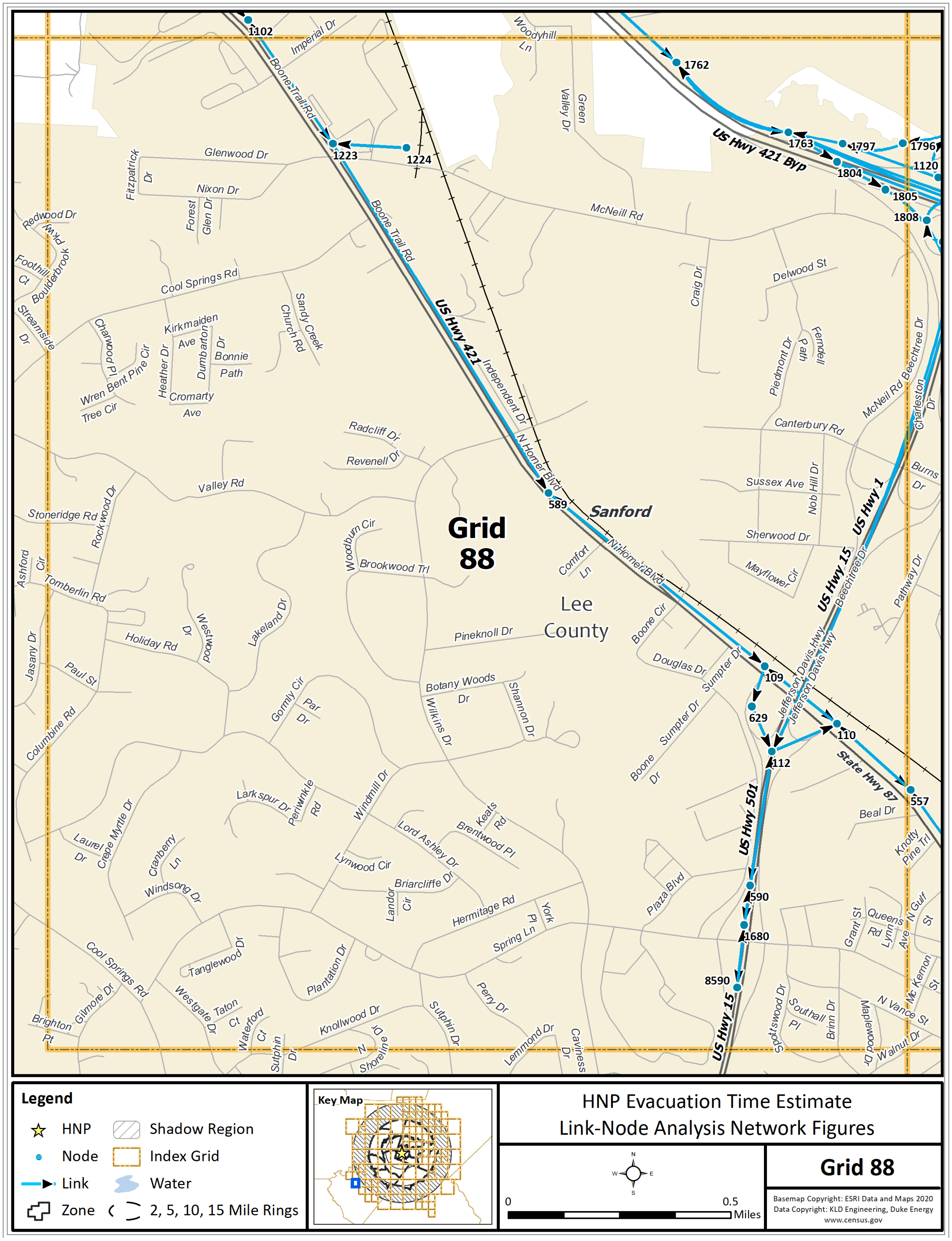


Figure K-89. Link-Node Analysis Network – Grid 88

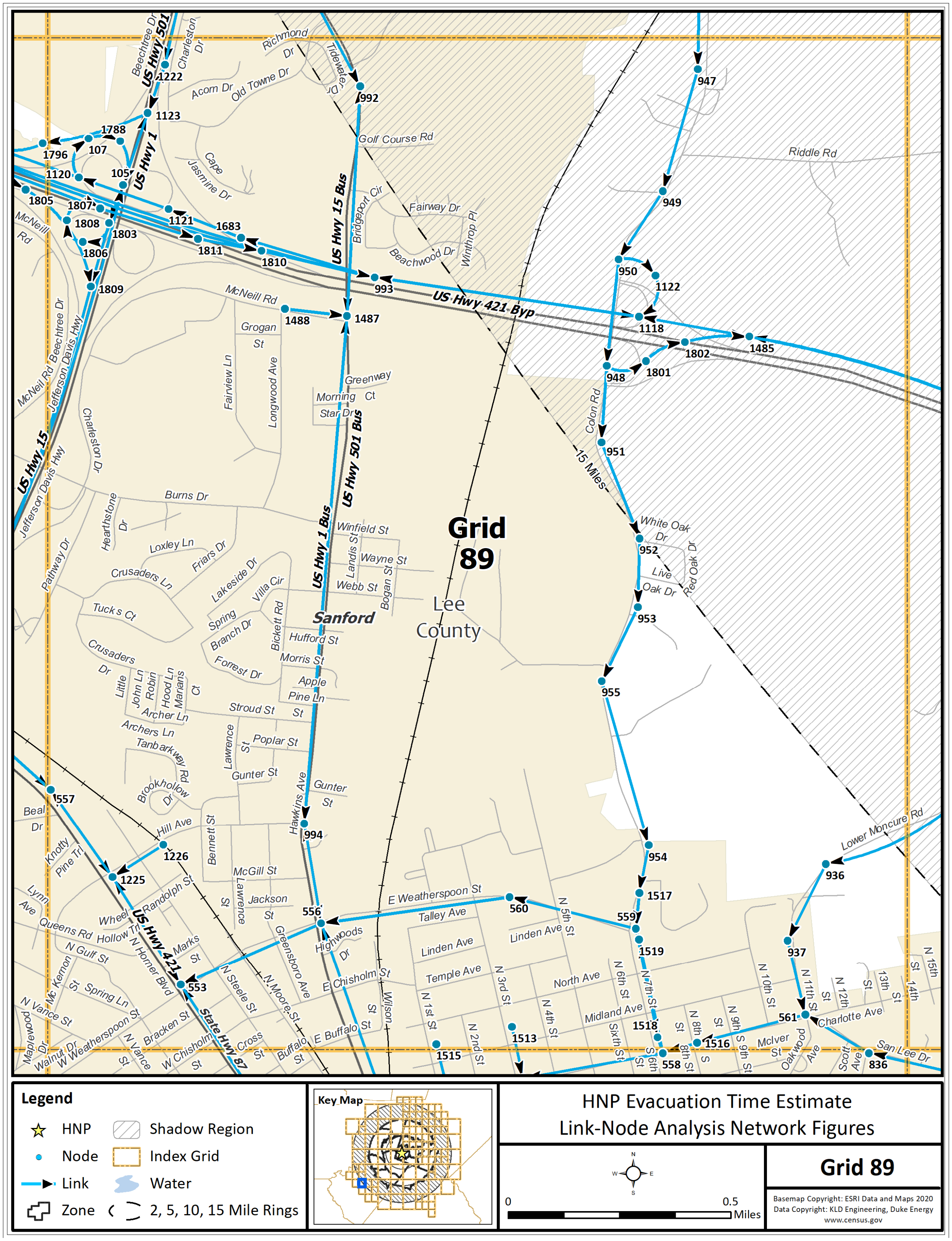
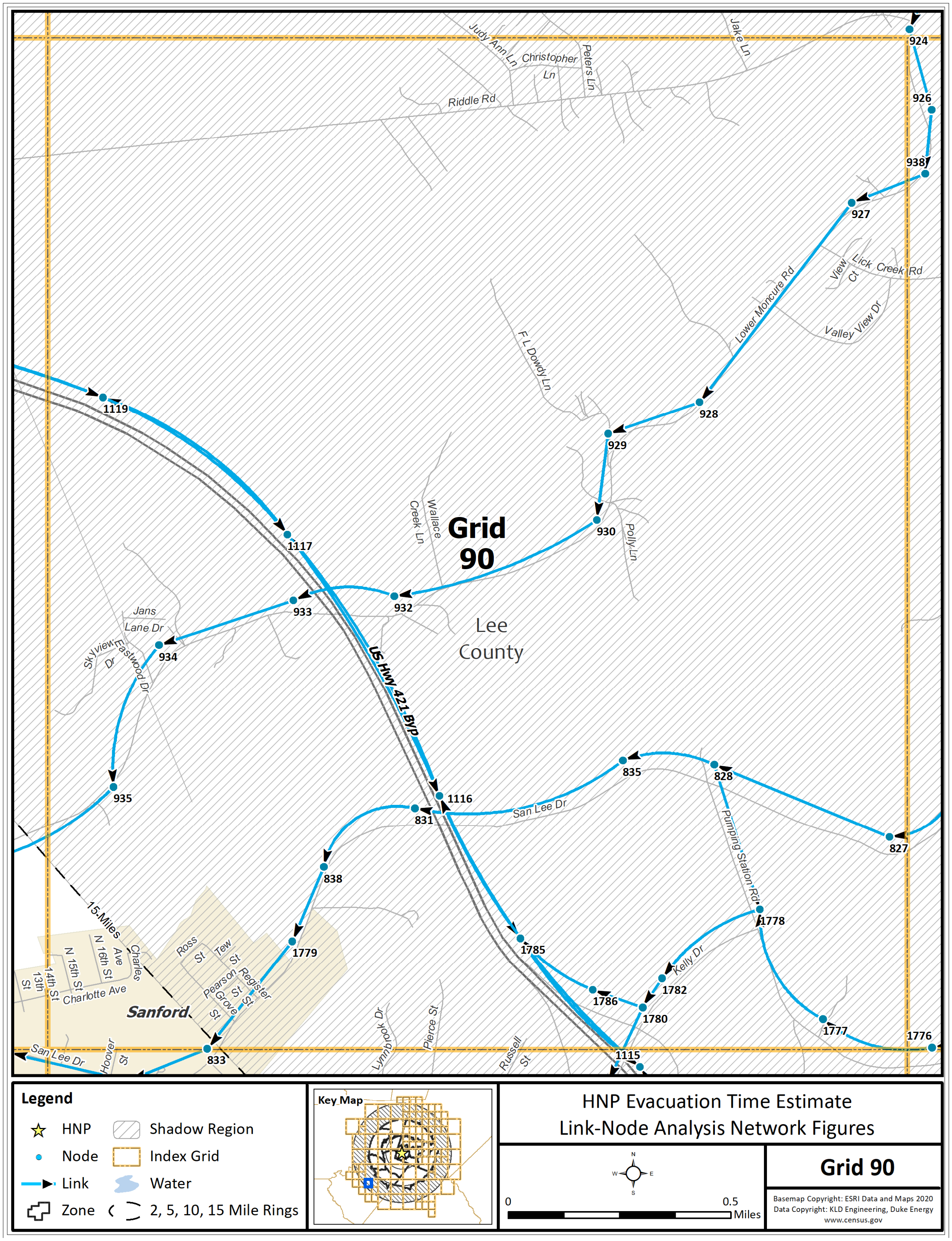


Figure K-90. Link-Node Analysis Network – Grid 89



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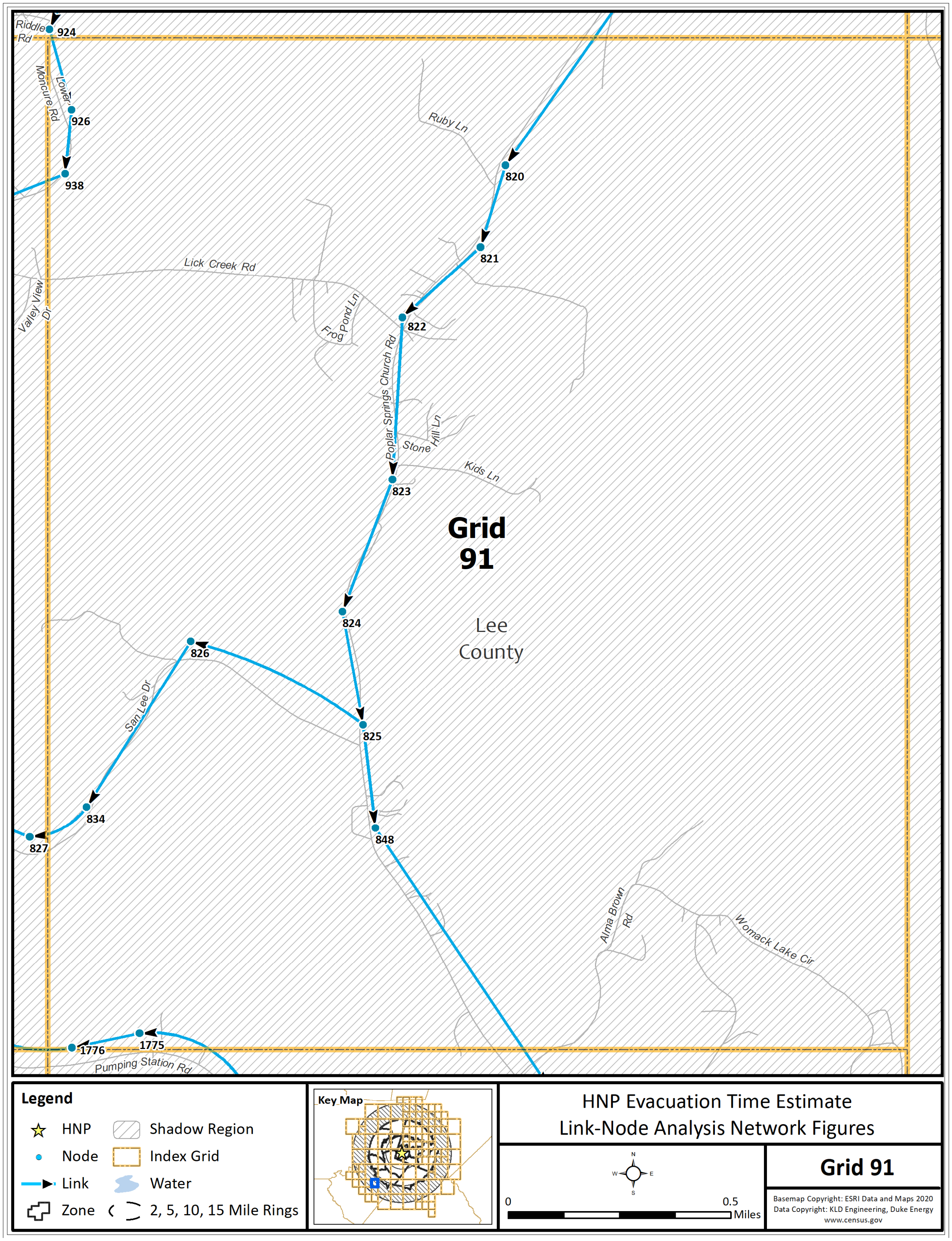

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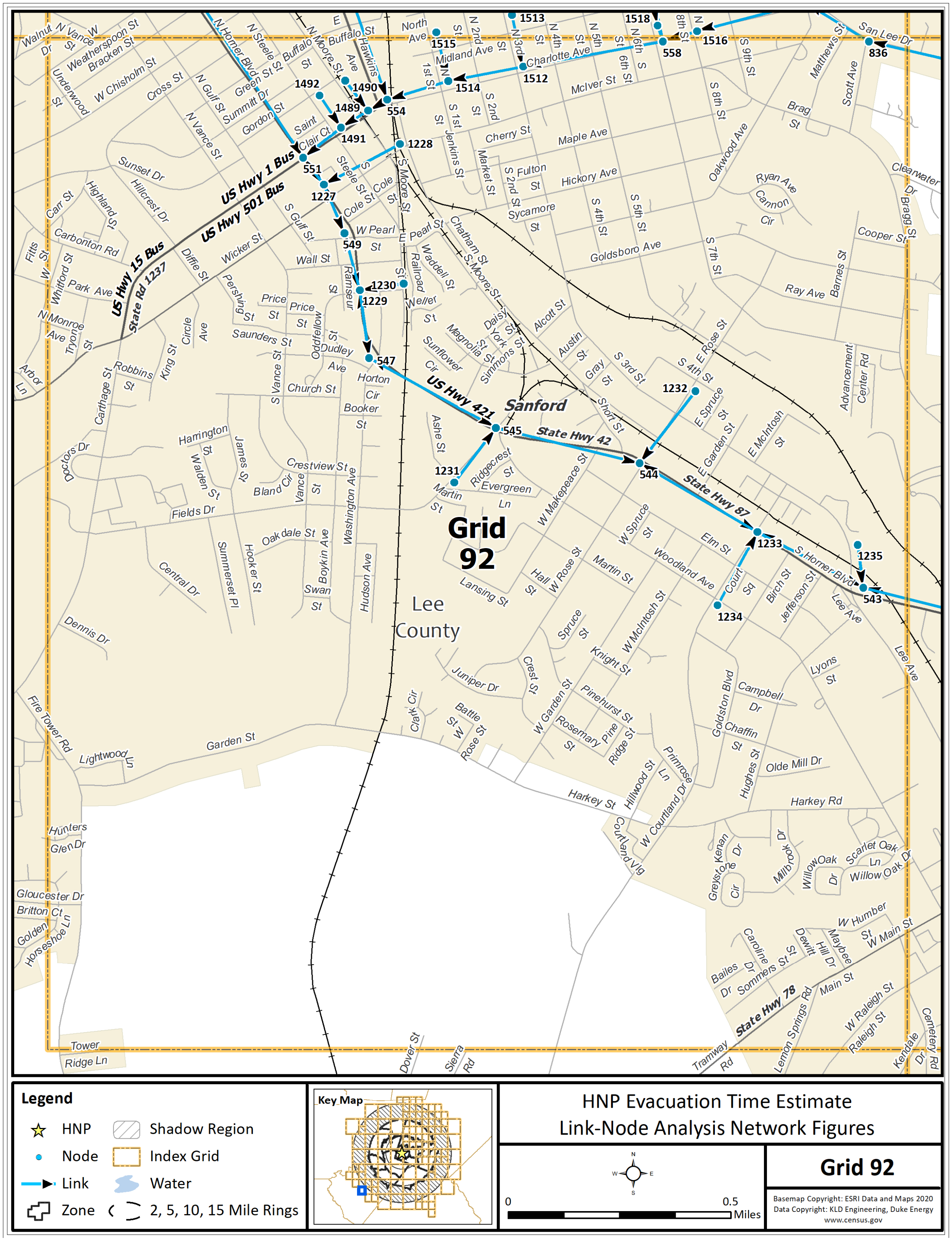

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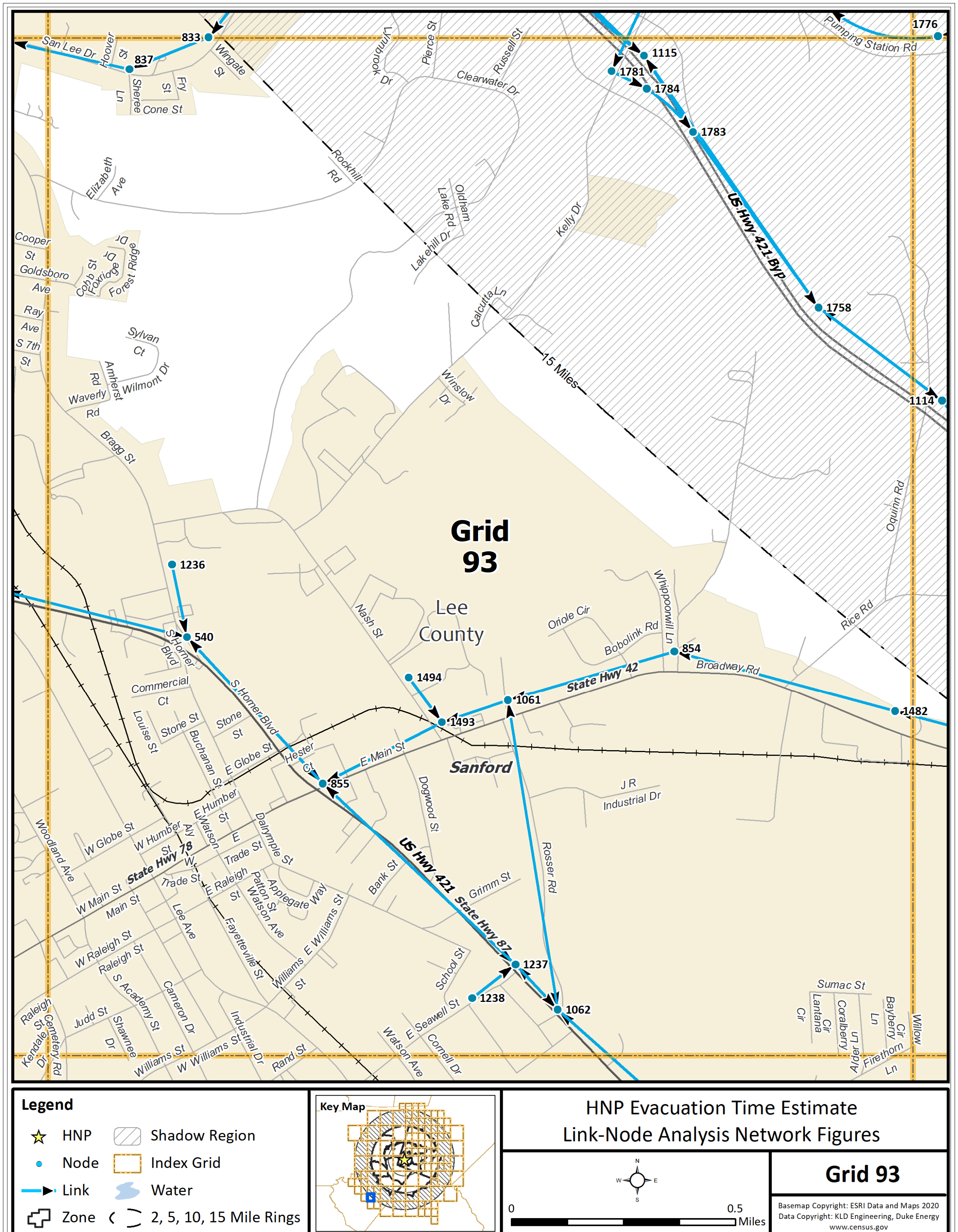

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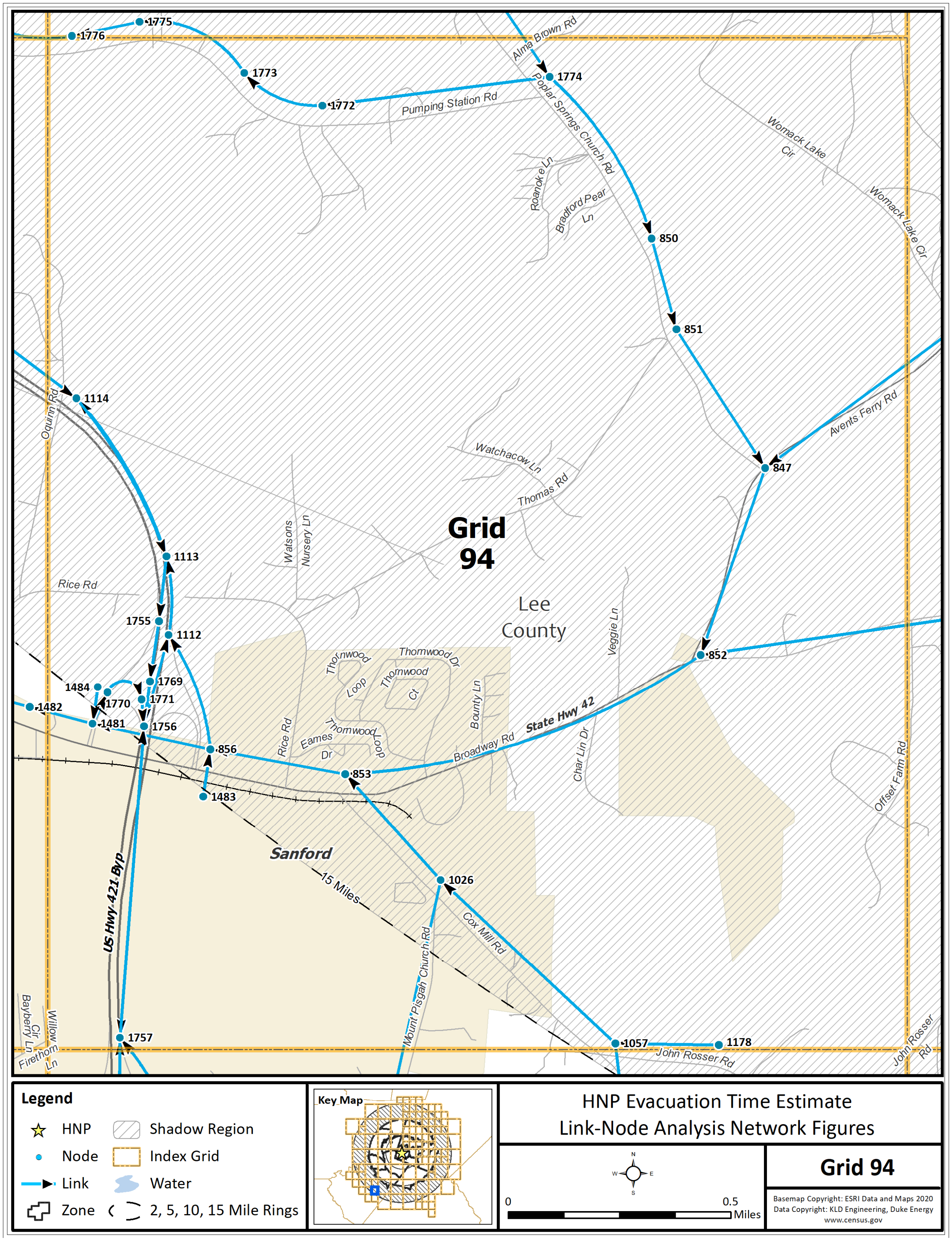
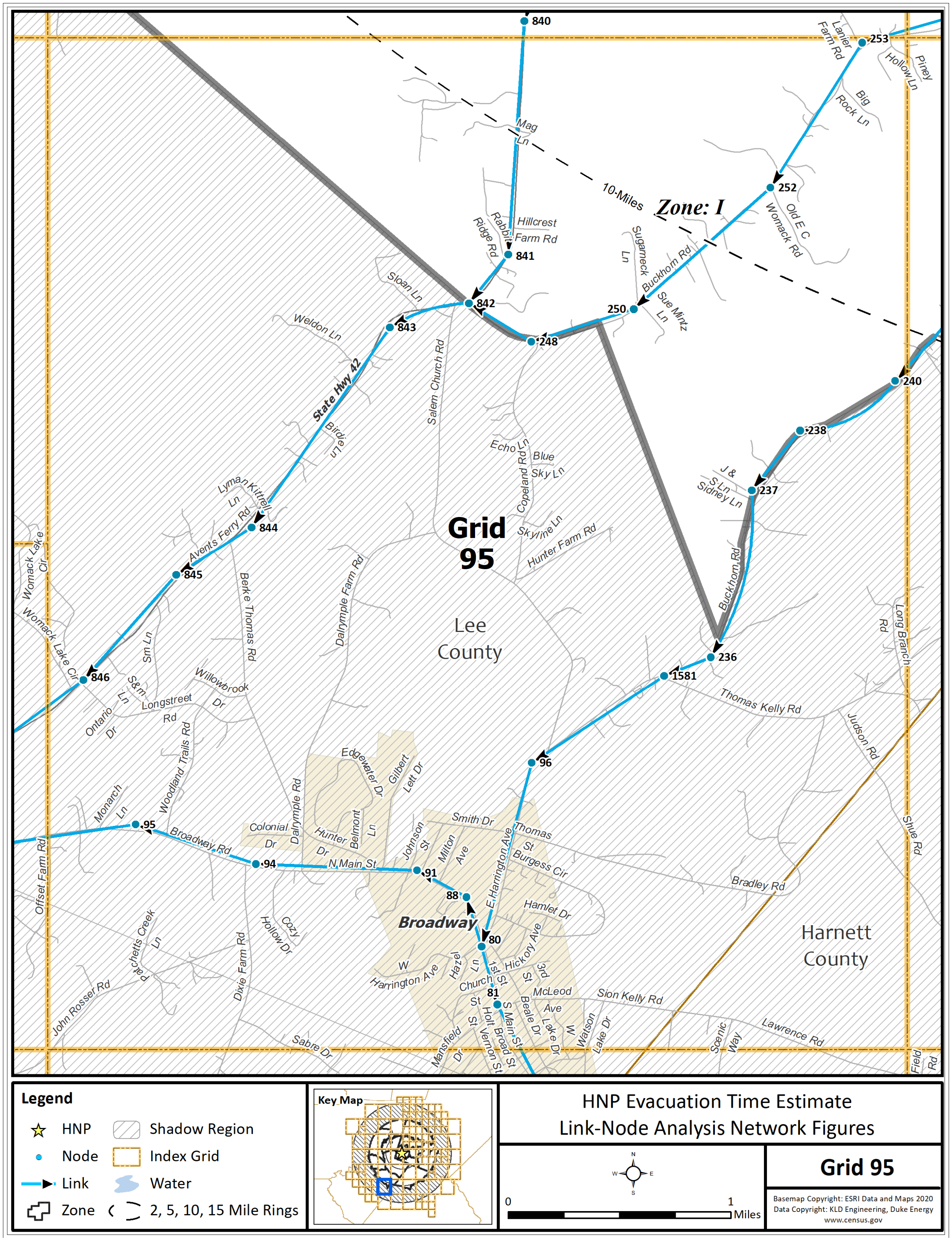


Figure K-95. Link-Node Analysis Network – Grid 94



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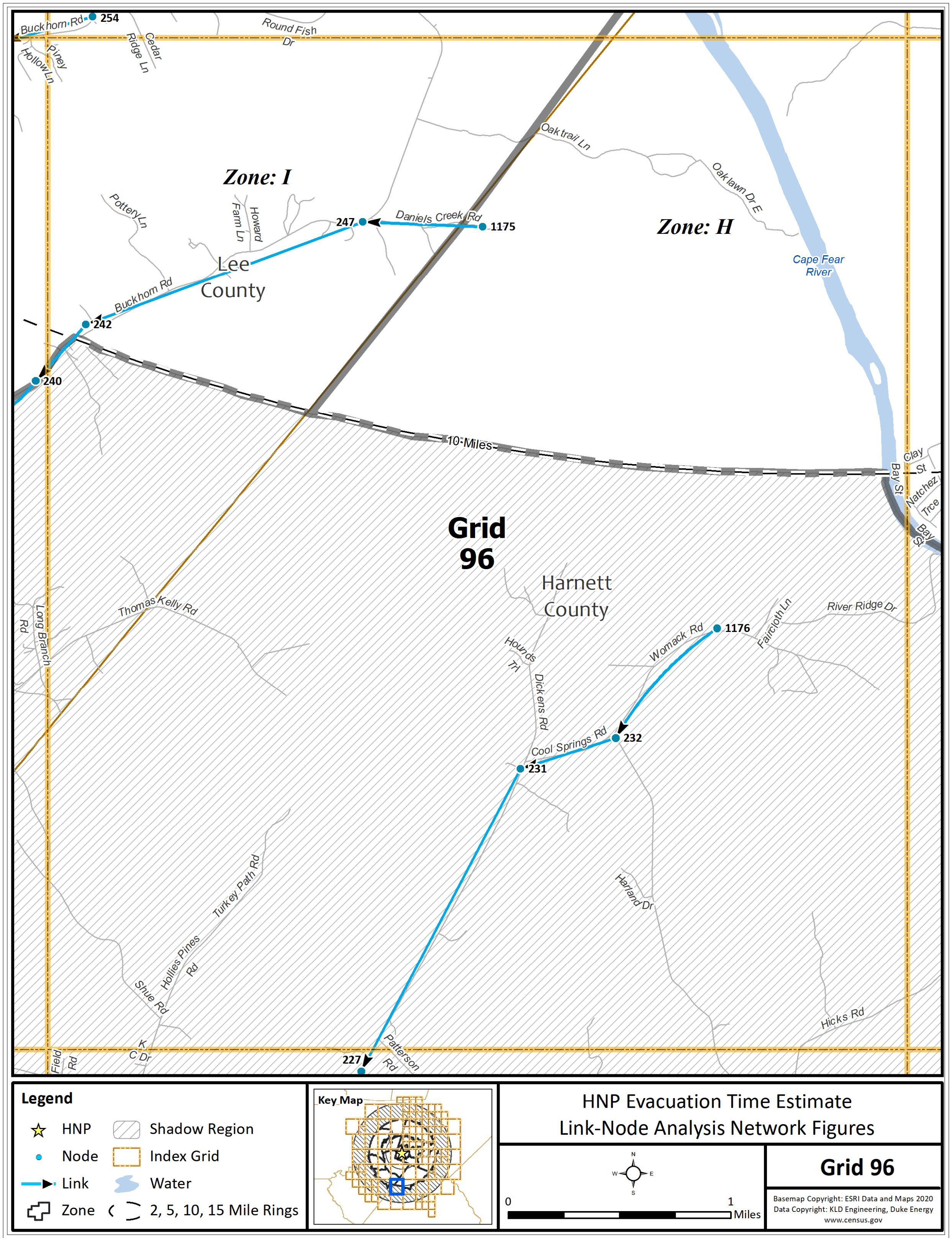

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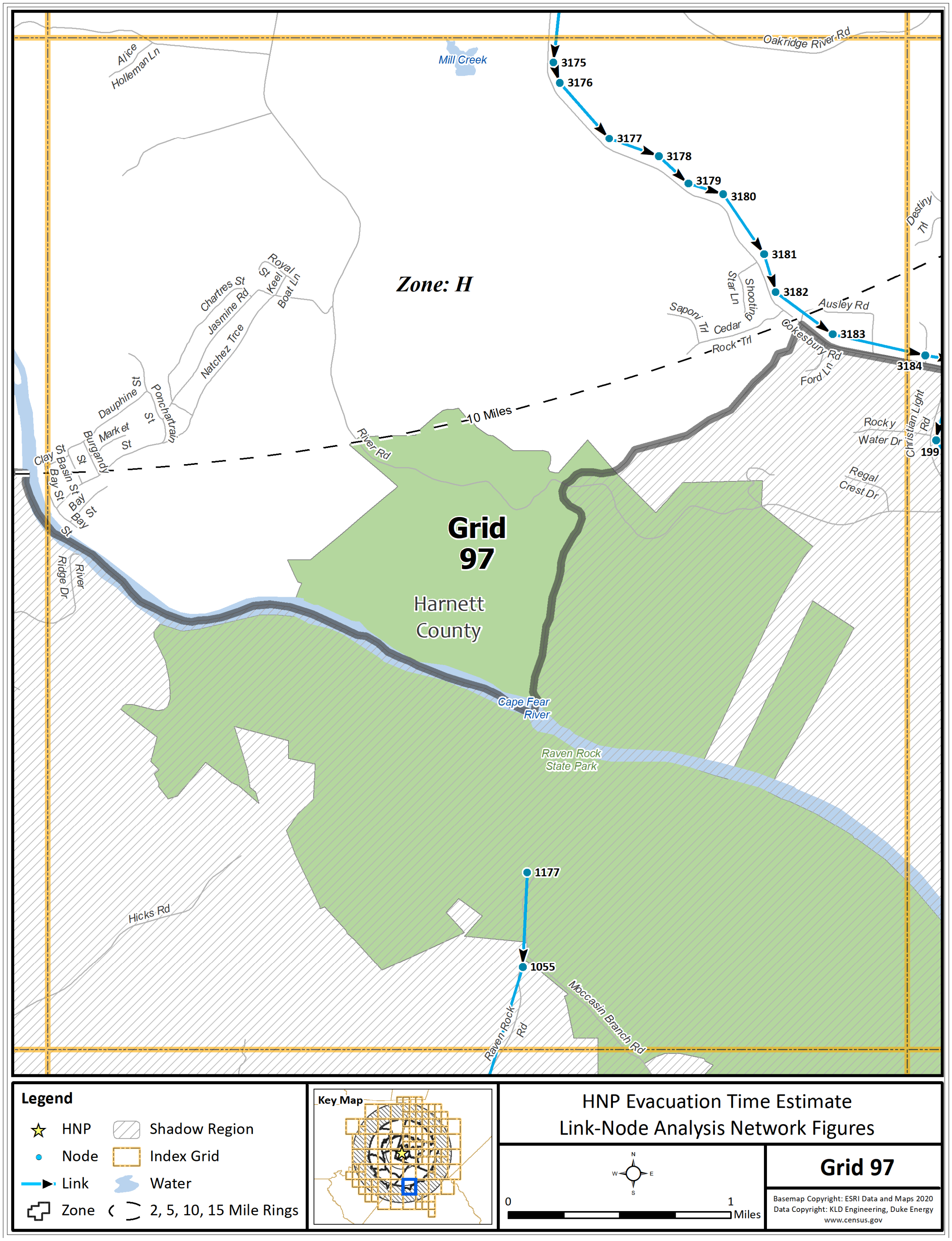

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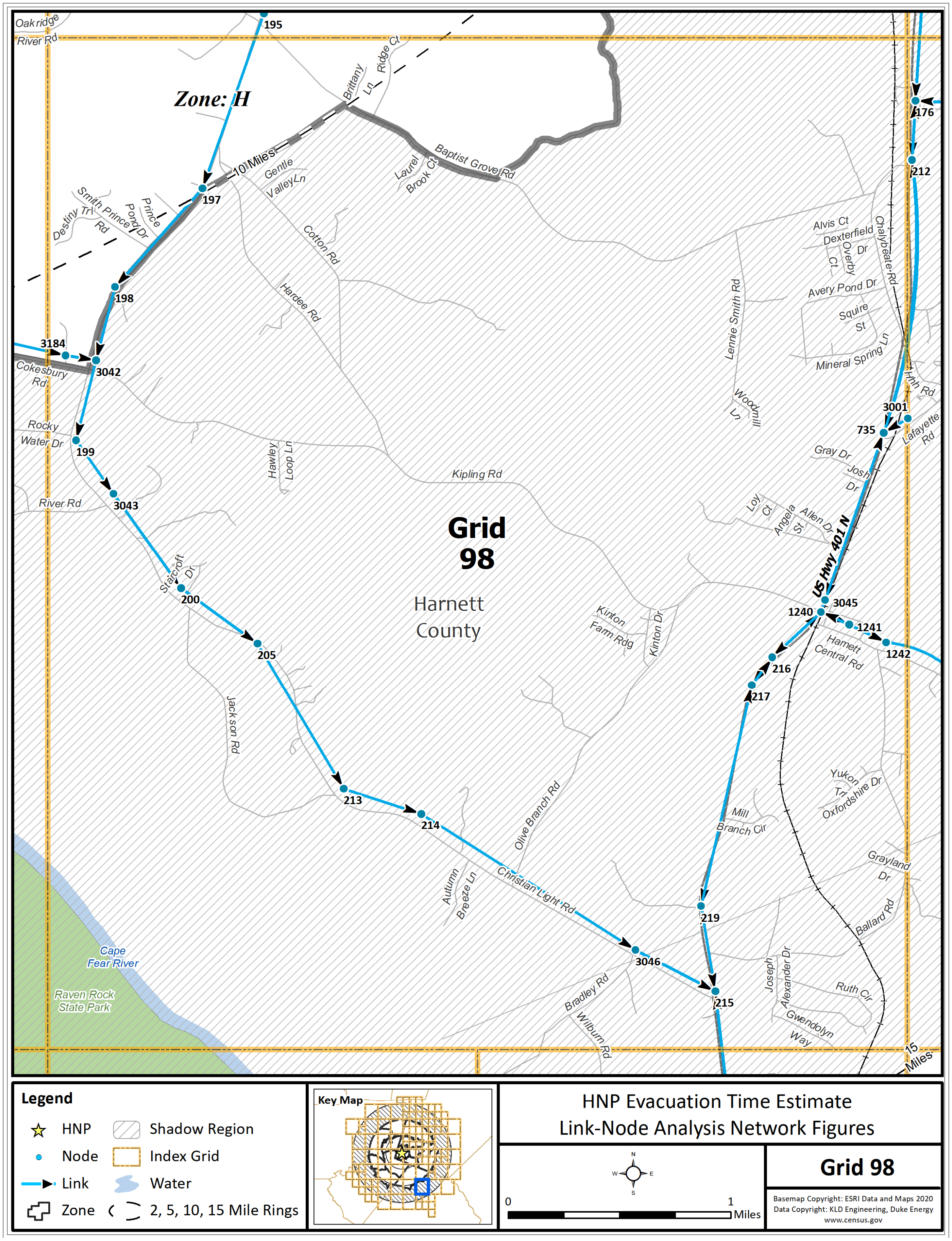

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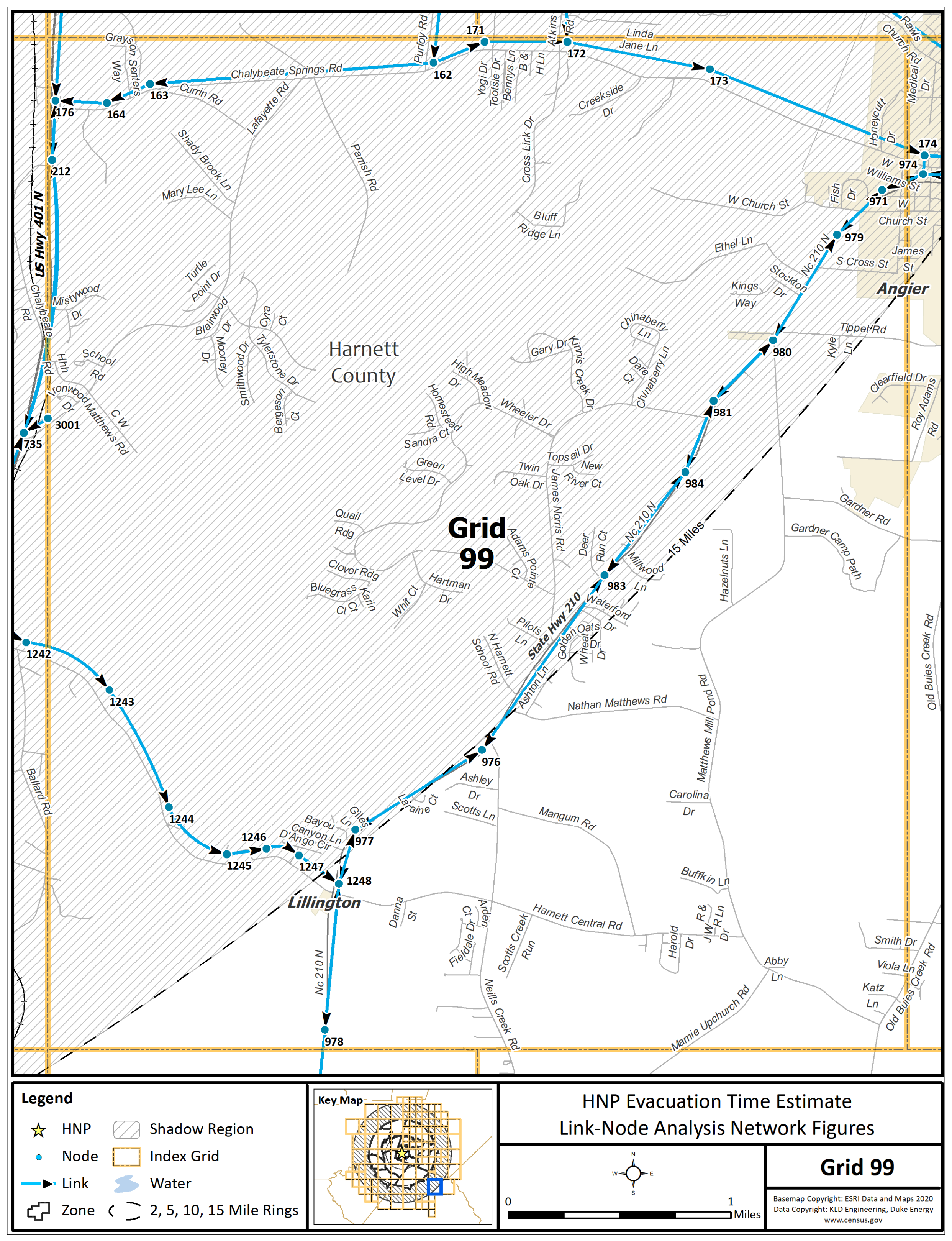
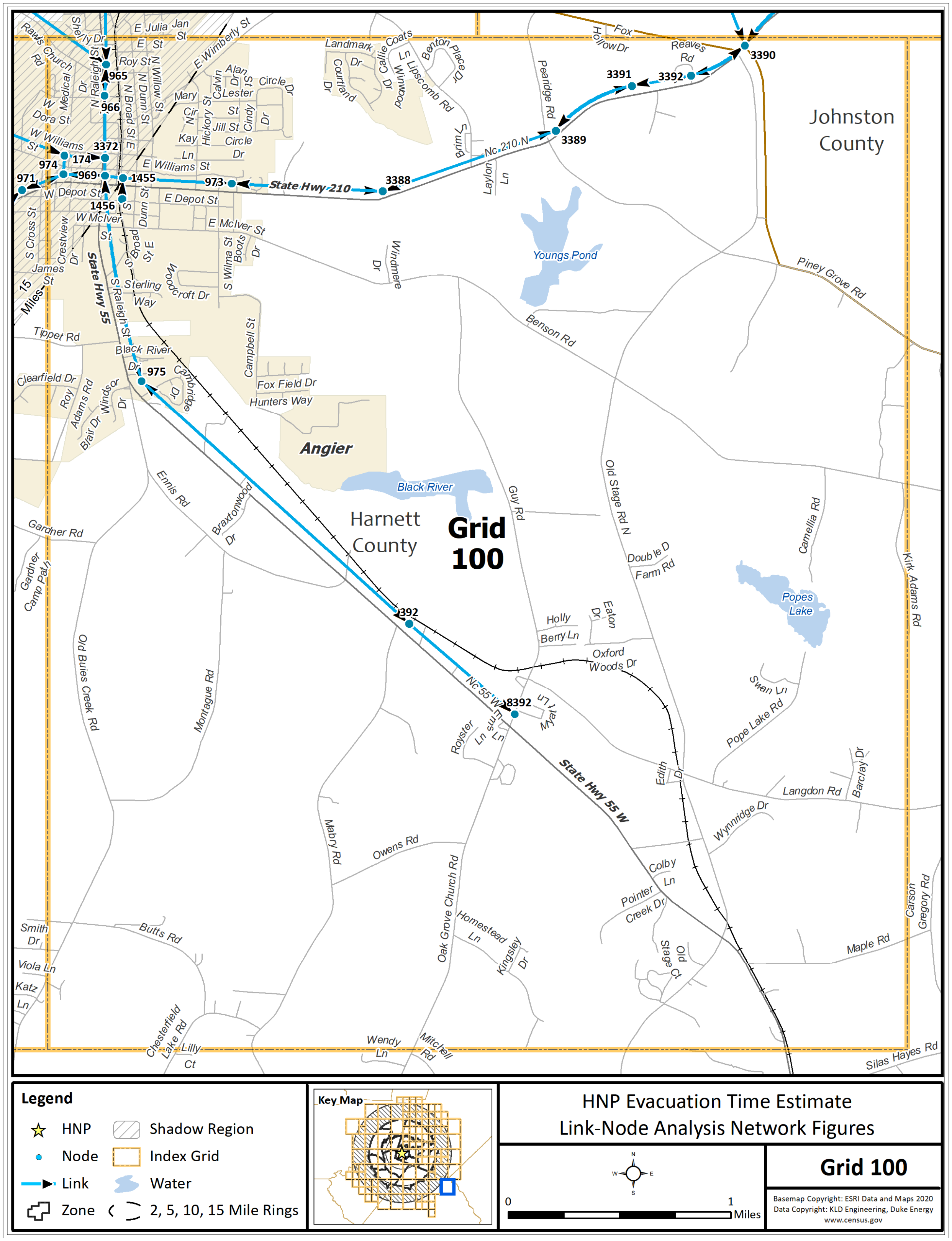


Figure K-100. Link-Node Analysis Network – Grid 99



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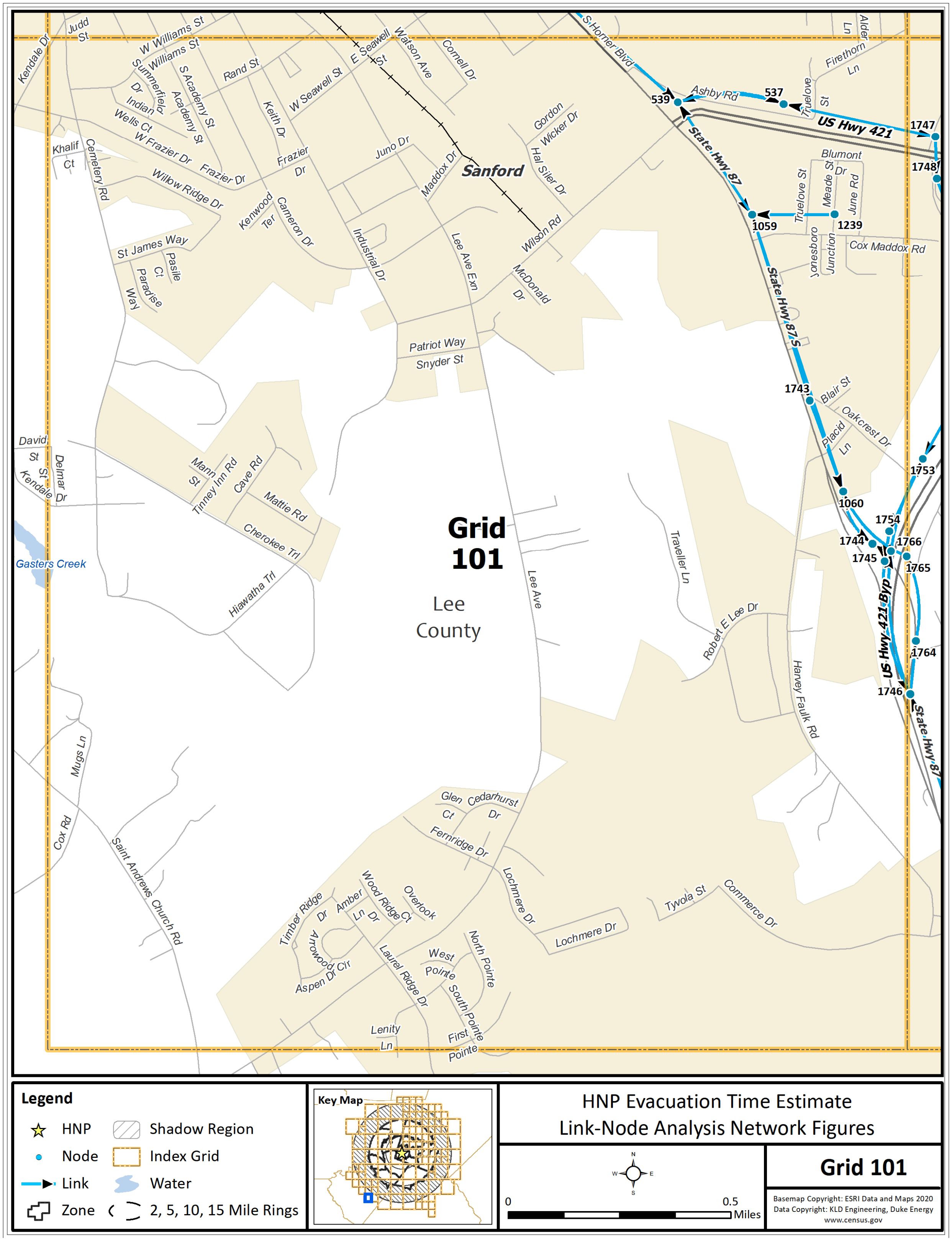
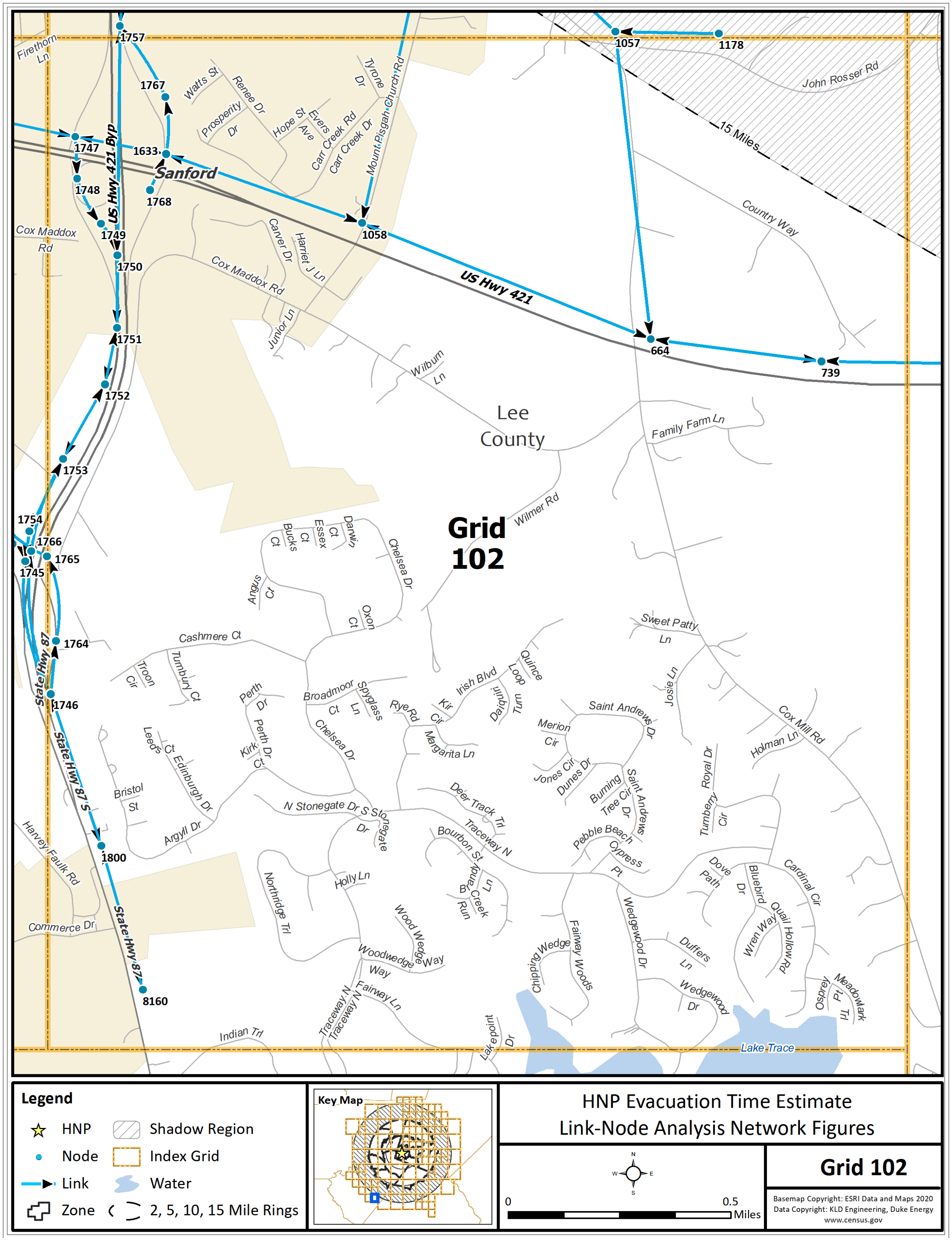


Figure K-102. Link-Node Analysis Network – Grid 101



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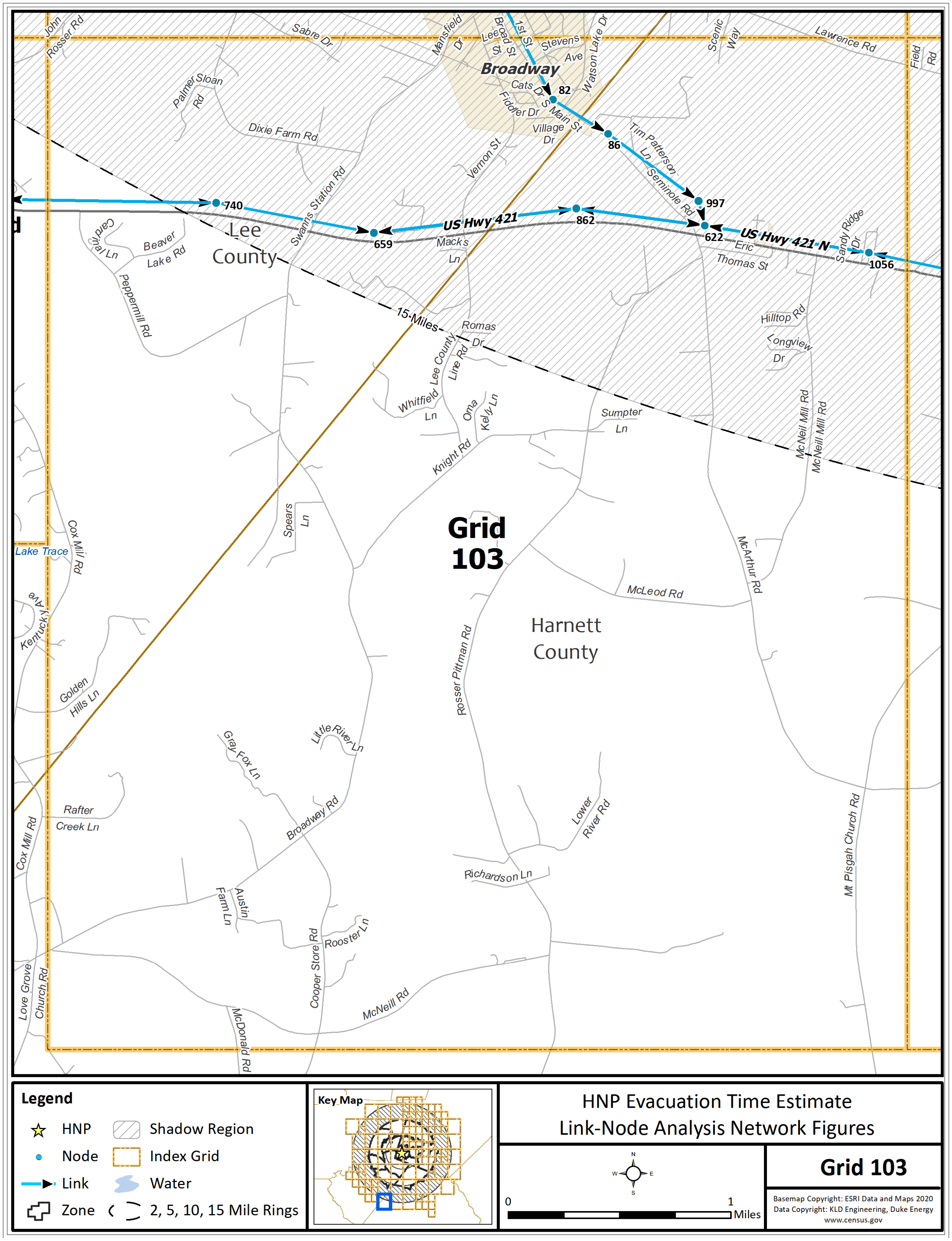
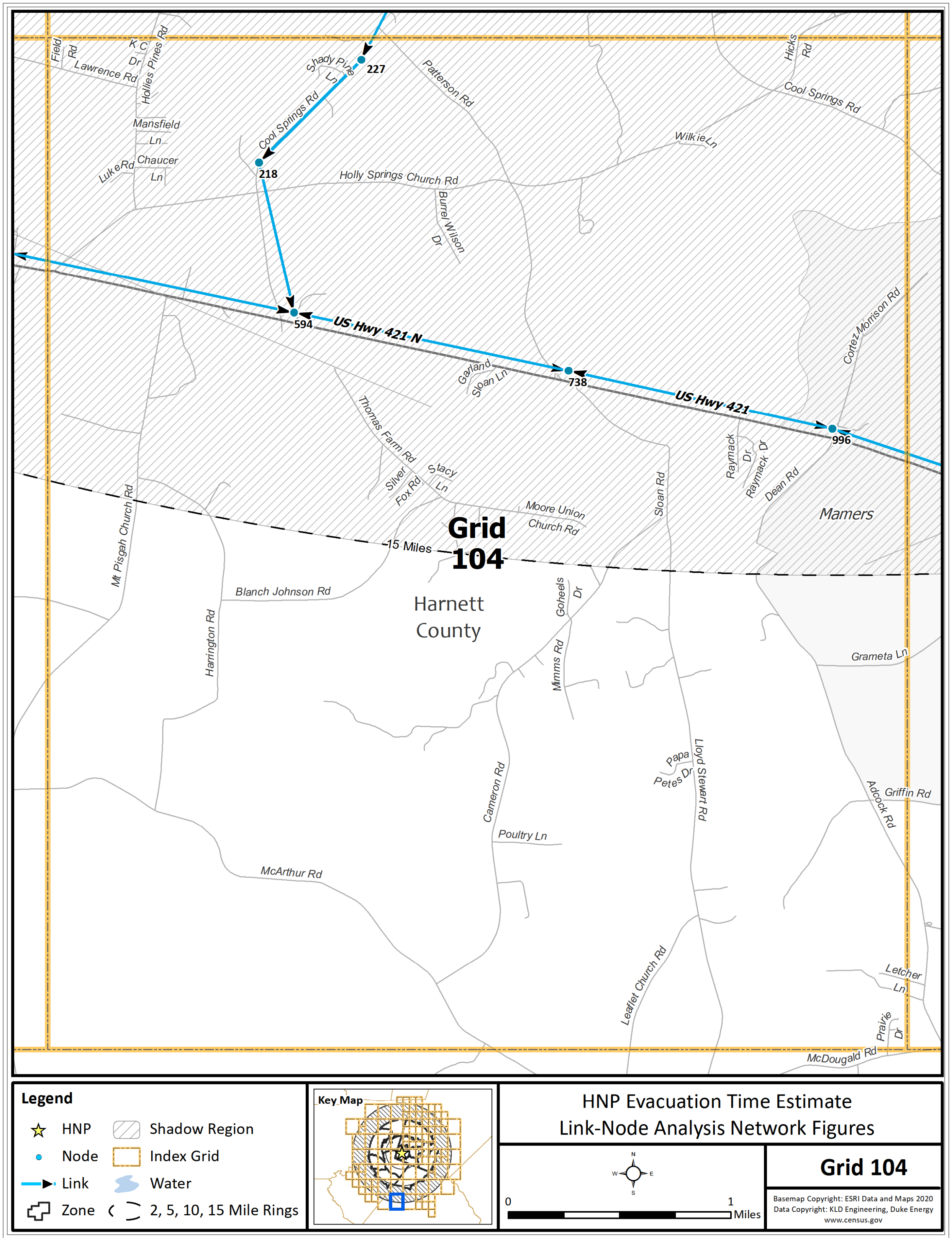


Figure K-104. Link-Node Analysis Network – Grid 103



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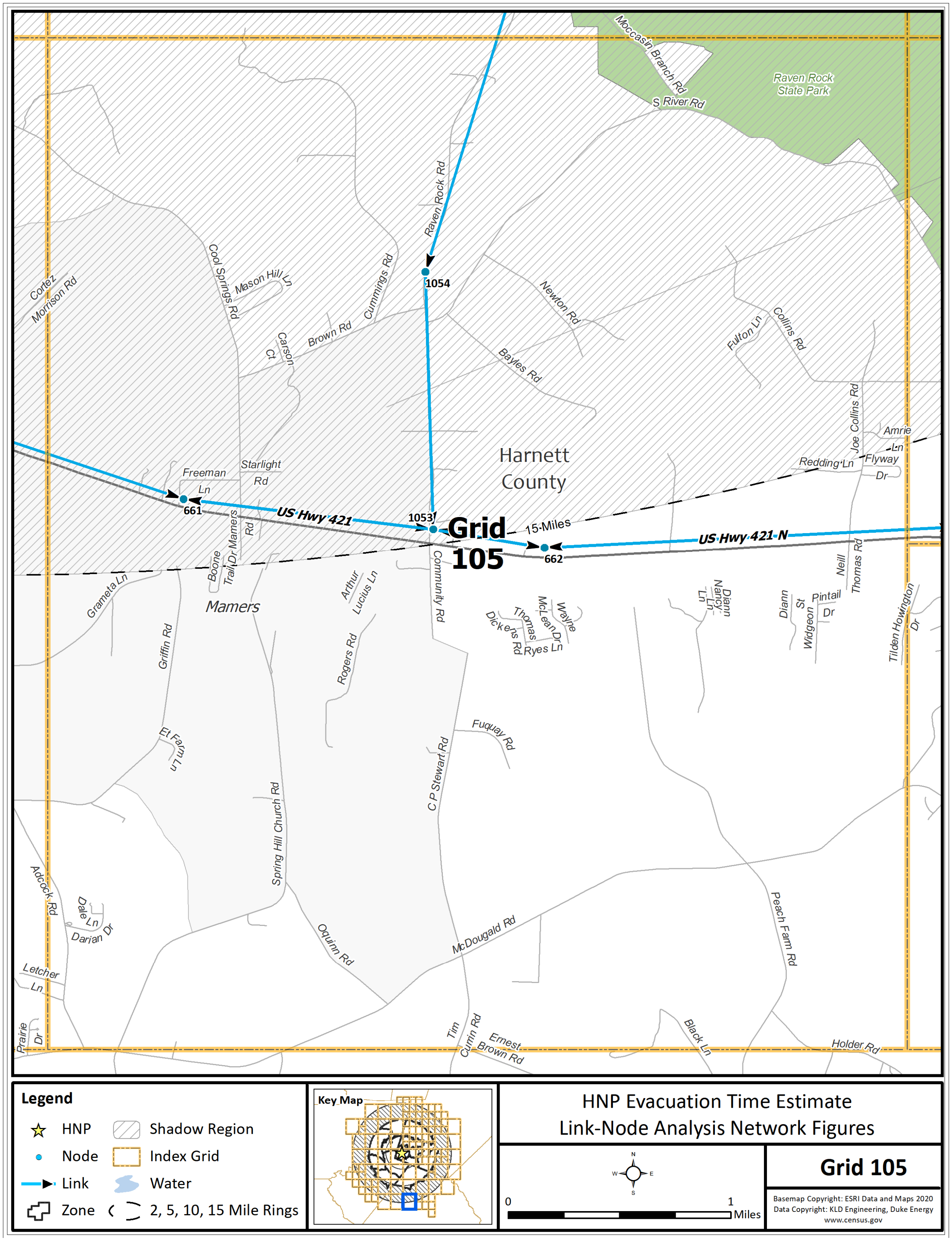

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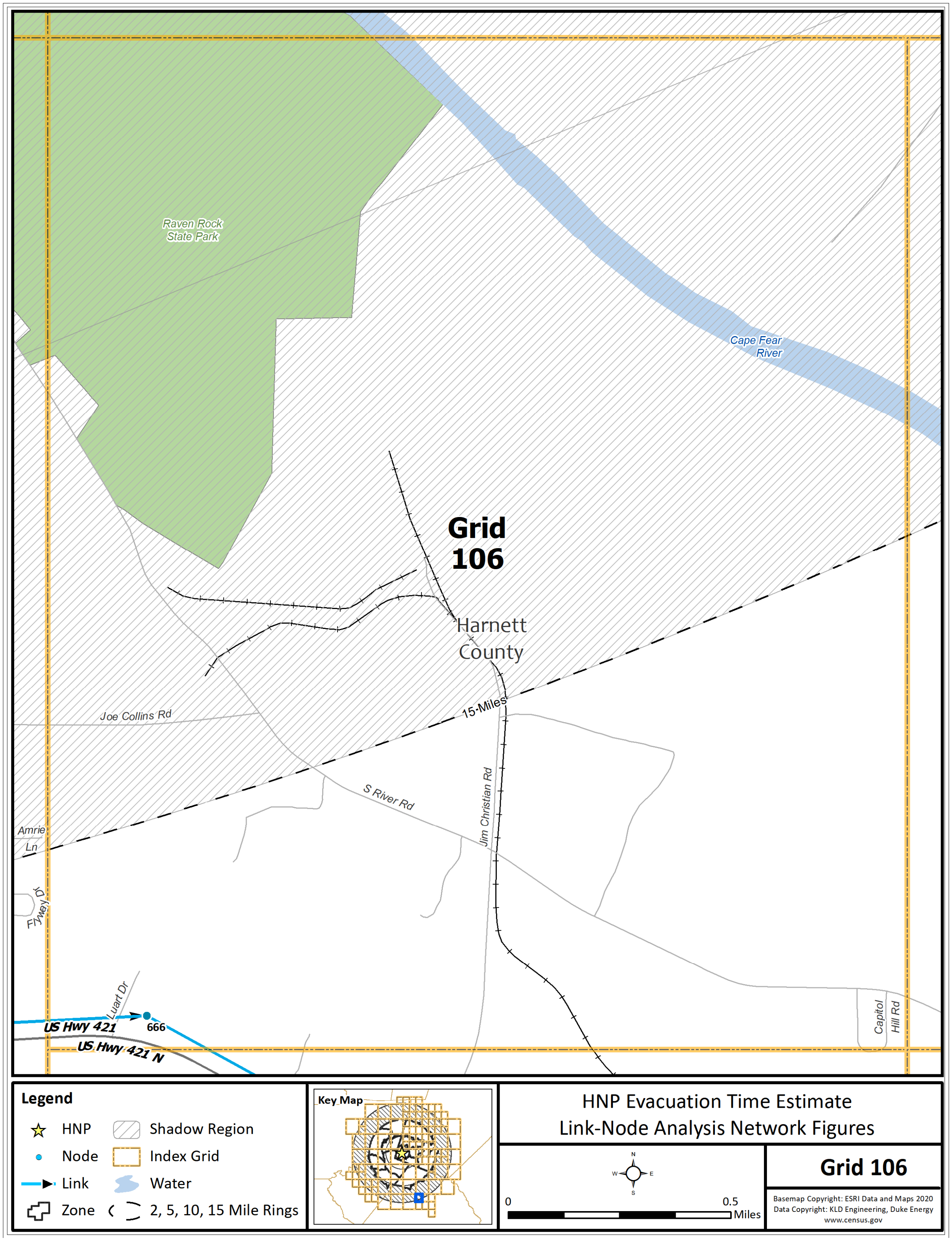

Figure K-107. Link-Node Analysis Network – Grid 106

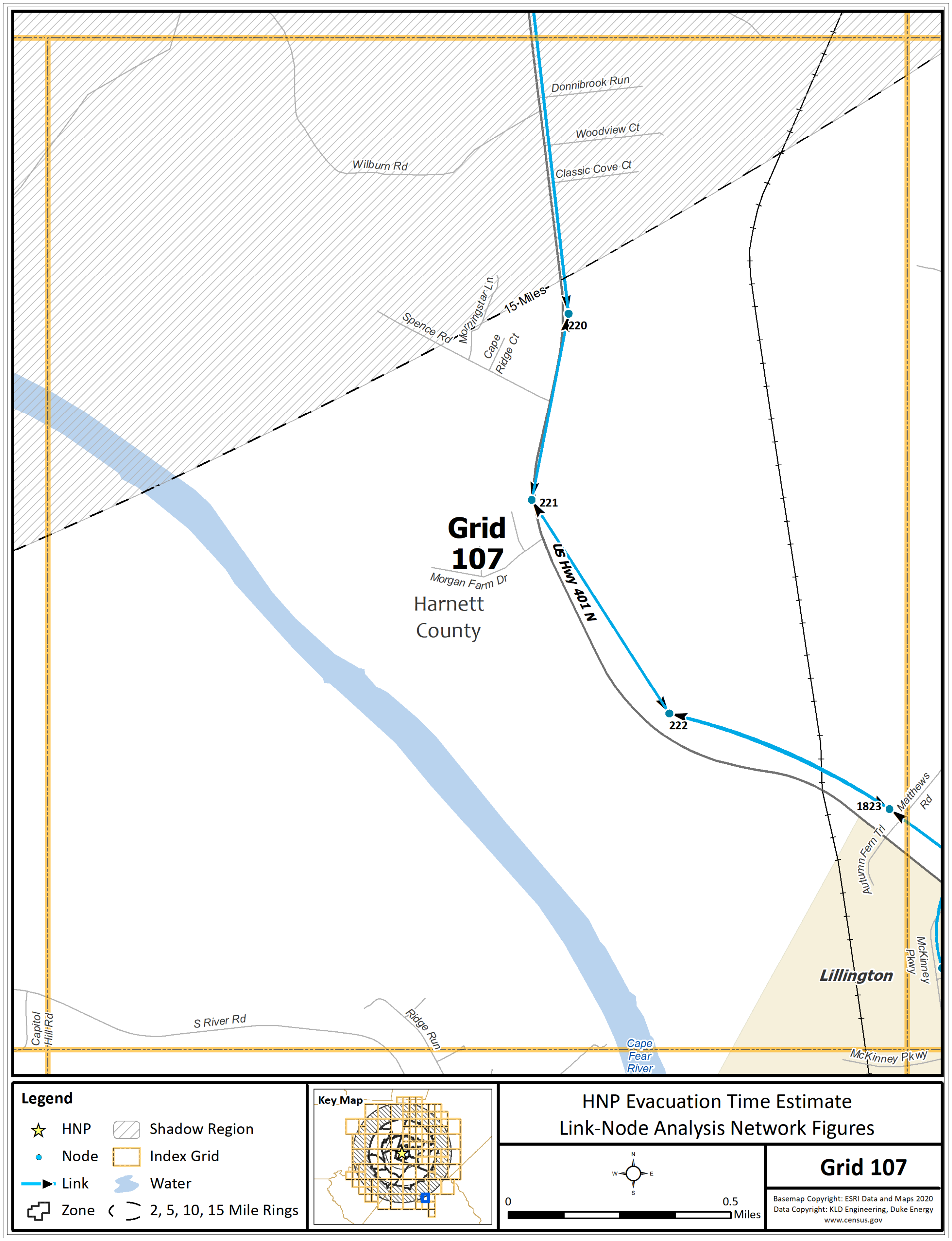

Figure K-108. Link-Node Analysis Network – Grid 107

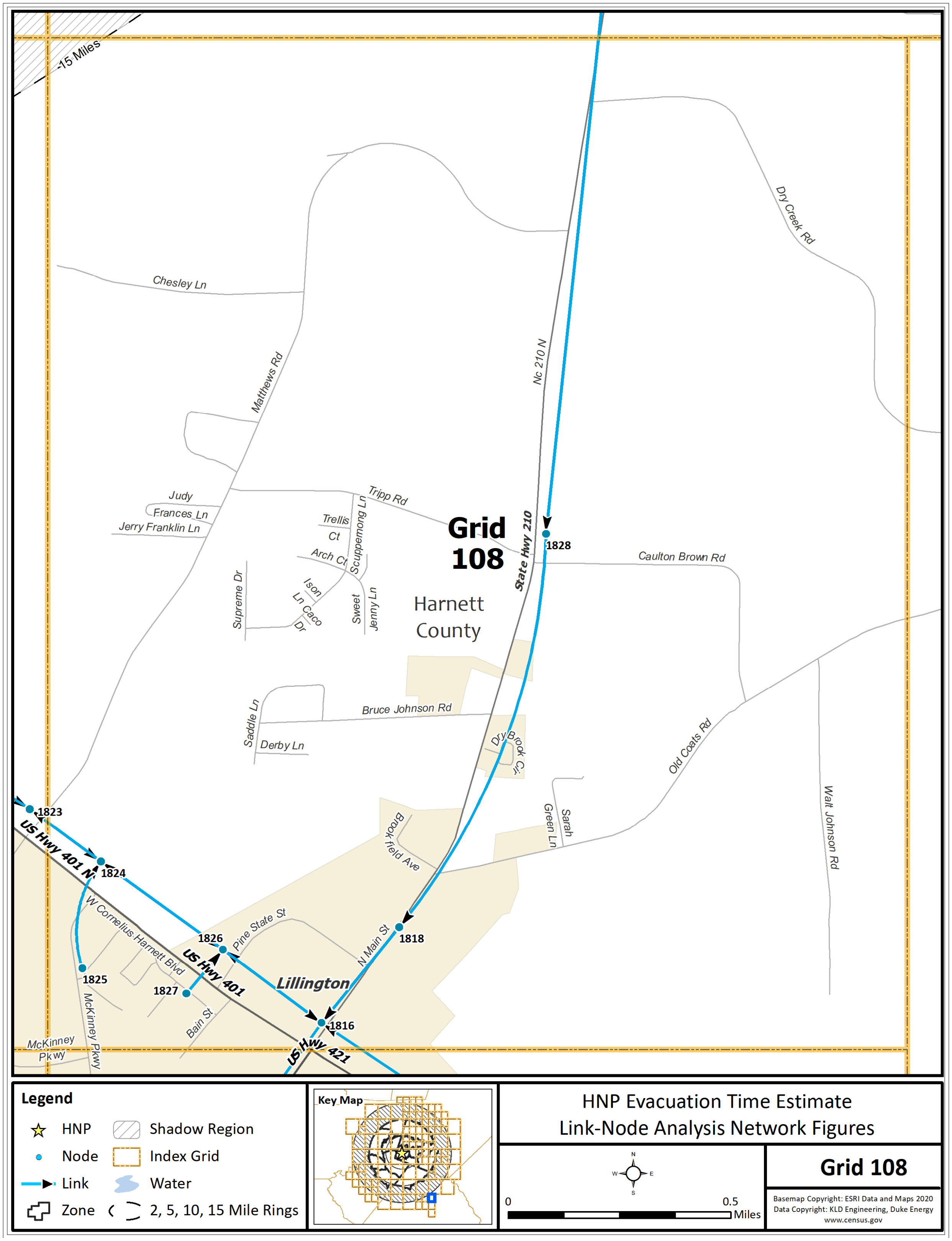

Figure K-109. Link-Node Analysis Network – Grid 108

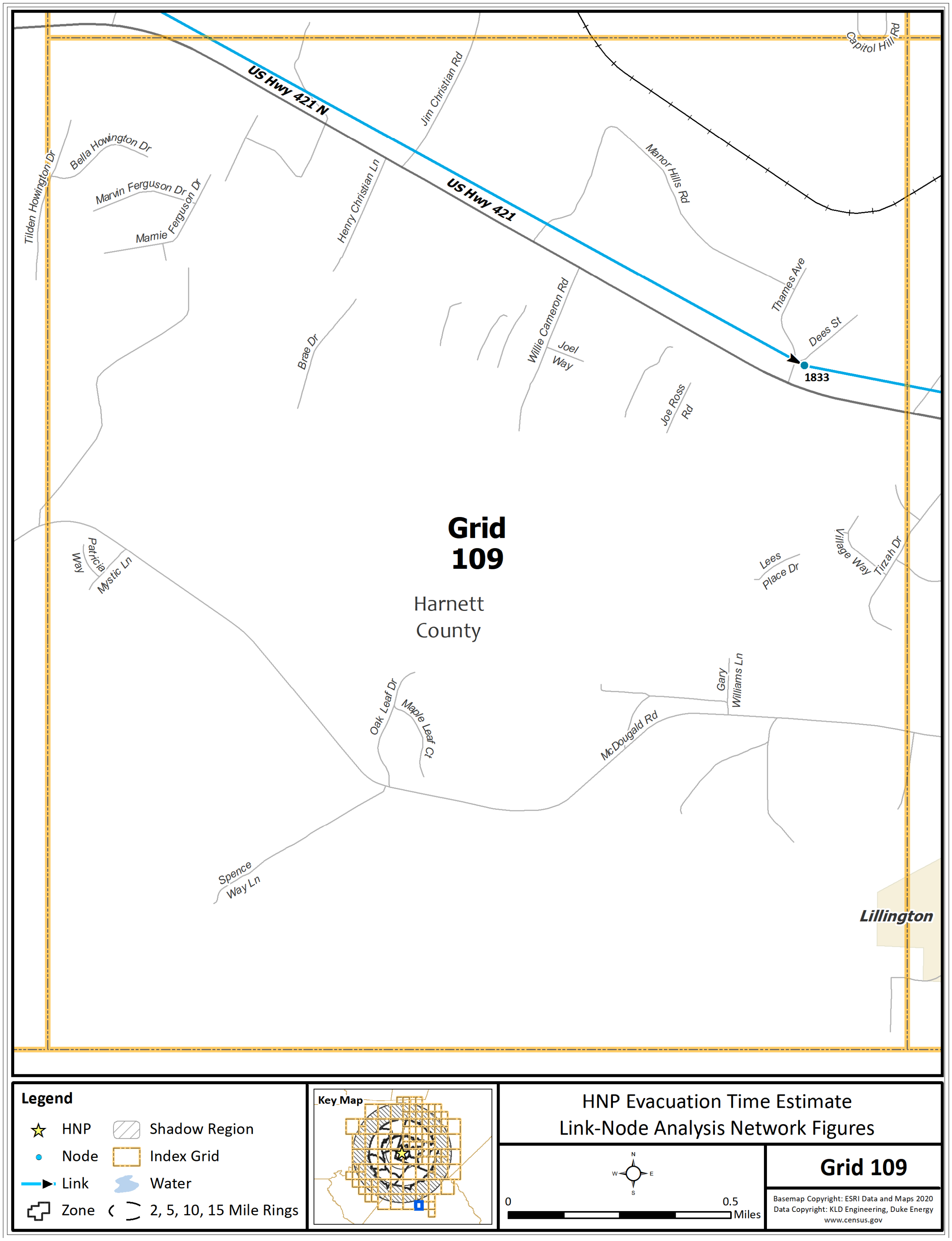

Figure K-110. Link-Node Analysis Network – Grid 109

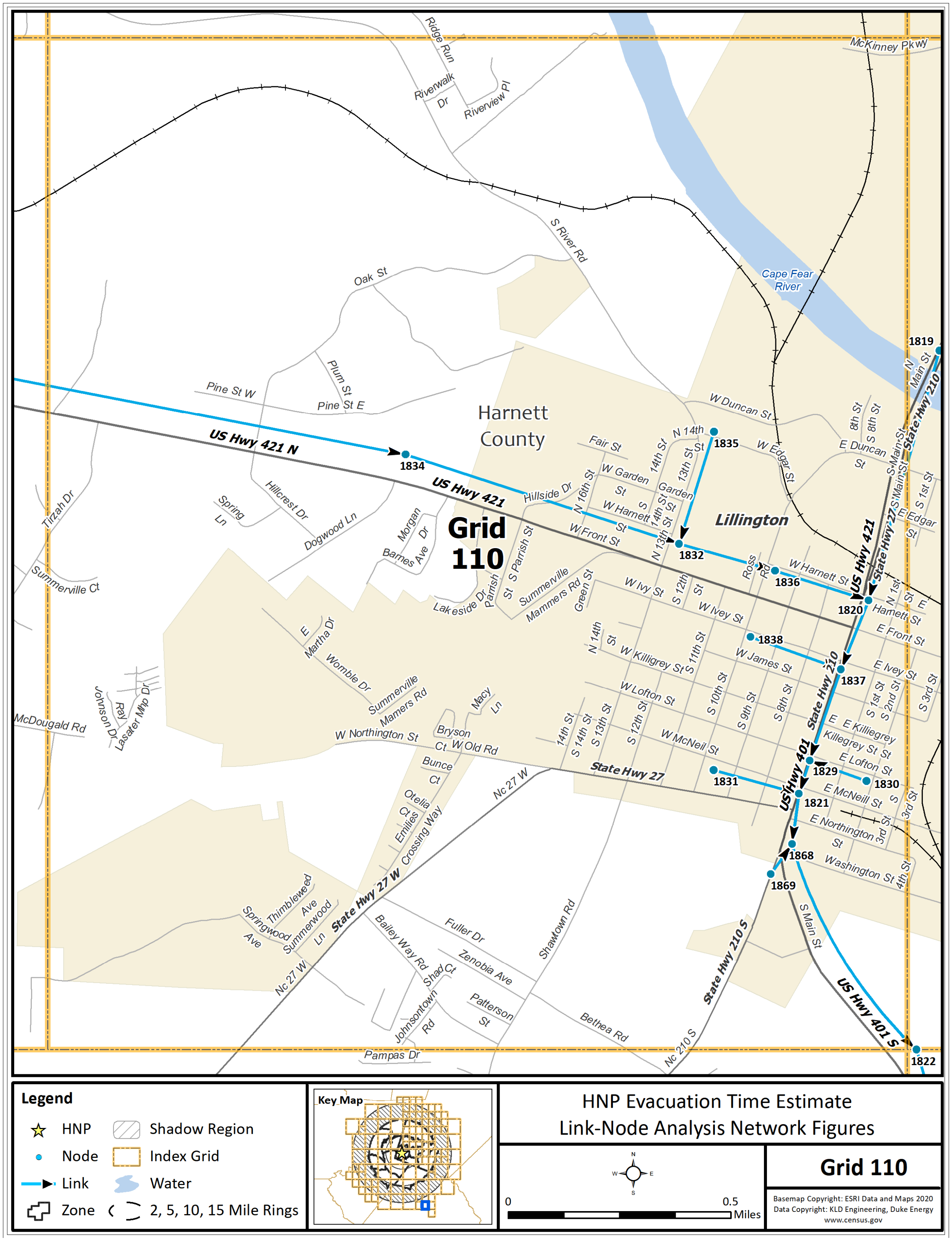

Figure K-111. Link-Node Analysis Network – Grid 110

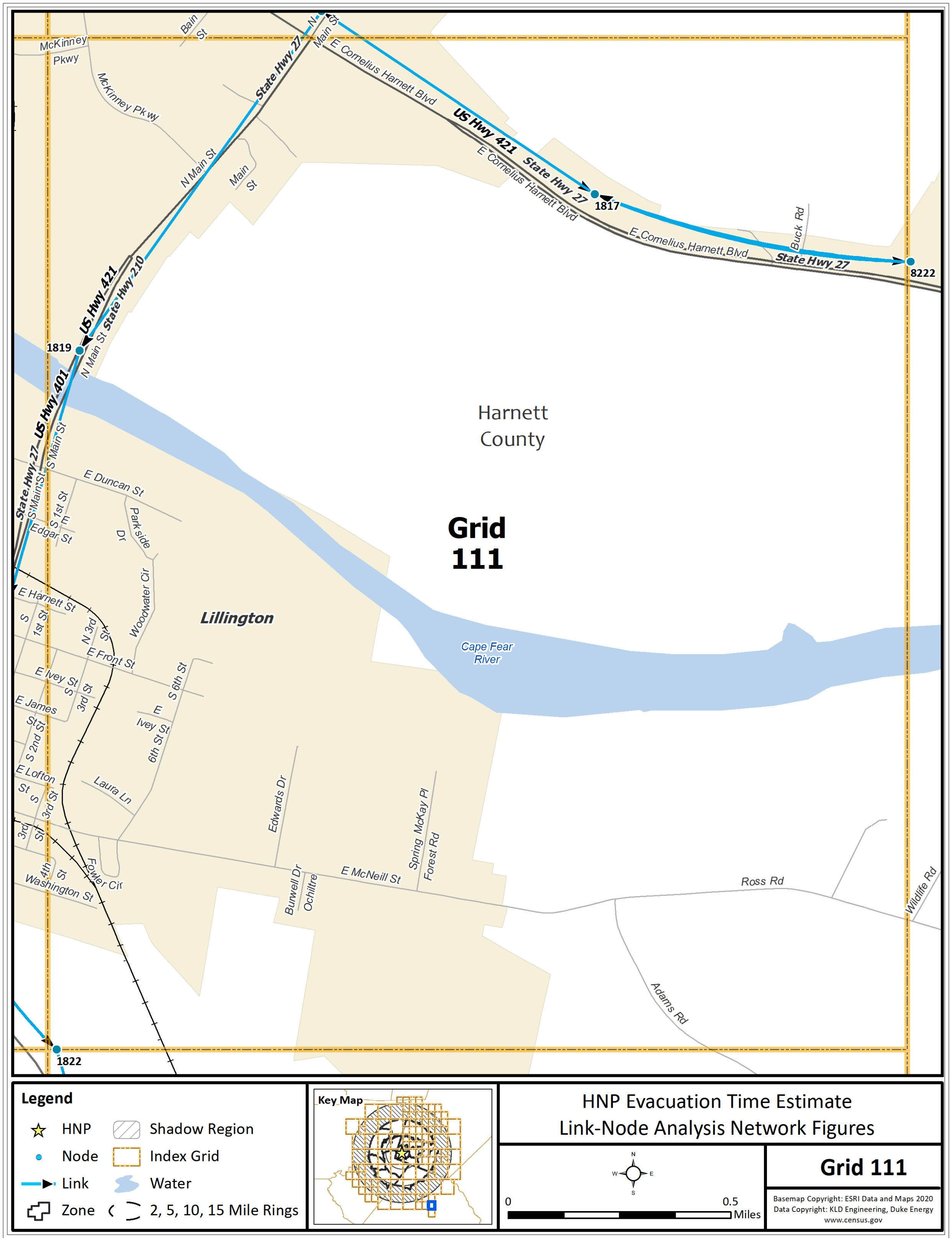

Figure K-112. Link-Node Analysis Network – Grid 111

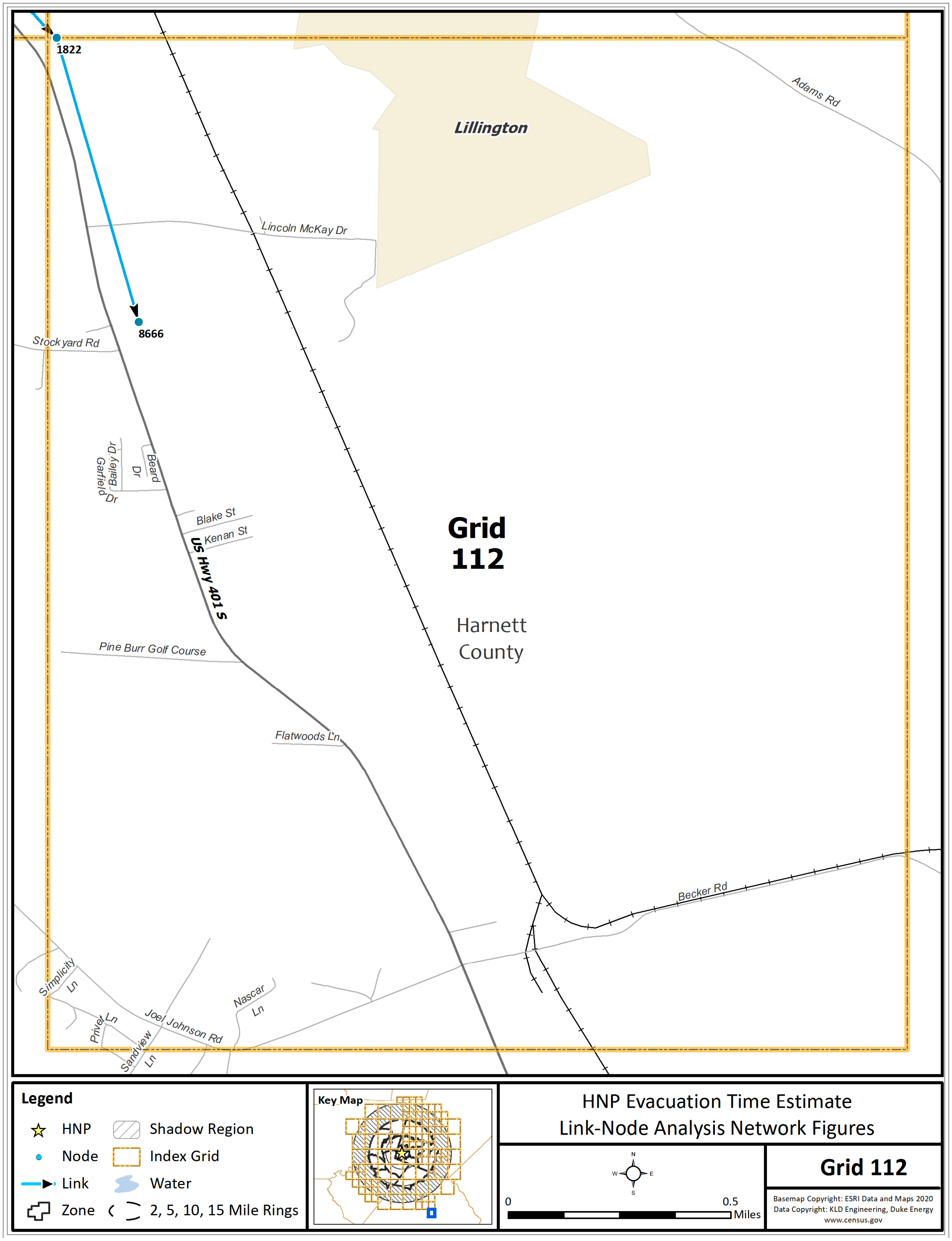

Figure K-113. Link-Node Analysis Network – Grid 112

APPENDIX L

Zone Boundaries

L. ZONE BOUNDARIES

Zone A

County: Wake

Zone A includes the community of Bonsal southeast of Old US Hwy. 1. Within this portion of Zone A is the Shearon Harris Nuclear Power Plant, and the central portion of the Shearon Harris Lake. The northern border of Zone A is Old US Hwy. 1 to Shearon Harris to US Hwy. 1 (Claude E. Pope Memorial Hwy.) to New Hill Holleman Rd. The eastern border is New Hill Holleman Rd. from US Hwy. 1 (Claude E. Pope Memorial Hwy.) to the eastern shore of Shearon Harris Lake. The eastern border is the eastern lake shore south to the Wake/ Chatham county line. The southern and western zone border is the Wake/Chatham county line to Christian Chapel Church Rd. north to Old US Hwy. 1.

Zone B

County: Wake

This portion of Zone B includes the town of New Hill, and the community of Friendship. Within the boundaries of Zone B is US Hwy. 1 (Claude E. Pope Memorial Hwy.) and the subdivisions of Weaver Crossing, New Hill Estate, Sears Plantation and Jordan Pointe. The northern border of Zone B is Olive Dairy Rd. south to New Hill Olive Chapel Rd., then extends on a line north to Ragan Rd. and south to Humie Olive Rd. until it meets Old US Hwy. 1. The northern border then is Friendship Rd. to Winding Way and to US Hwy. 1 to NC 540/Western Wake Hwy to N Carolina Bypass 55. The eastern border is NC Carolina Bypass 55 to Holly Springs New Hill Rd. The southern border is a line the extends from Holly Springs New Hill Rd to New Hill Holleman Rd., then New Hill Holleman Rd northwest to US Hwy. 1 (Claude E. Pope Memorial Hwy.) to Shearon Harris Rd. and then to Old US Hwy. 1. The western border is the Wake/Chatham county line from Old US Hwy. 1 north to Olive Dairy Rd.

Zone C

County: Wake

Zone C includes the community north of Holleman's Crossroads. Within the boundaries of Zone C are the northeast portion of the Shearon Harris Lake, White Oak Creek, Utley Creek, and the western portion of the Club at Twelve Oaks. The northern border of Zone C is a line that extends northeast from New Hill Holleman Rd. to Holly Springs New Hill Rd. to New Hill Rd. The eastern border is N Carolina Bypass 55. The southern border is Avent Ferry Rd. to a line that extends from just north of Moonstone Dr to the intersection of Rex Rd. and Cass Holt Rd. then follows Rex Rd., and the western border is New Hill Holleman Rd.

Zone D	<u>County:</u> Wake

Zone D includes the community south of Holleman's Crossroads, Vintage Point, and the areas along Cass Holt Rd. south of Rex Rd. Within the boundaries of Zone D is the Shearon Harris Lake. The northern border of Zone D is New Hill Holleman Rd. and Rex Rd. between the Shearon Harris Lake and Cass Holt Rd. The eastern border is Buckhorn Duncan Rd. south to the Wake/Harnett county line. The southern border is the Wake/Harnett county line west from Buckhorn Duncan Rd. across Tutor Stephens Rd., Sweet Springs Rd., and Cass Holt Rd. to the Shearon Harris Lake. The western border is Shearon Harris Lake.

Zone E	<u>County:</u> Wake

Zone E includes the town of Apex, the community of Friendship, and the areas surrounding US Hwy. 1, NC Hwy. 55 and Olive Chapel Rd. The northern border of Zone E is an arc southeast 10 miles from the Shearon Harris Nuclear Power Plant that includes parts of (from west to east) Green Level Rd., Roberts Rd., Wade Drive, NC Hwy. 55, Oak Ridge Drive, Holt Rd., Twin Creek Rd., Old Jenks Rd., US Hwy. 64 West, Buckingham Way, Regency Parkway, Ederlee Drive, Penny Rd., Kingsford Drive, Kildaire Farms Rd. and Arthur Pierce Rd. The eastern zone border is Holly Springs Rd. from Arthur Pierce Rd. south to Sunset Lake Rd. The southern border includes parts of (from east to west) Sunset Lake Rd., Old Smithfield Rd., NC Hwy. 55 Bypass, NC 540/Western Wake Hwy., US Hwy. 1/Claude E. Pope Memorial Hwy., Winding Way, Friendship Rd., Old US Hwy. 1, Humie Olive Rd. and Ragan Rd. The southern border then is a line that extends to the intersection of New Hill Olive Chapel Rd. and Baker Rd. to New Hill Olive Chapel Rd. to a line that extends to the Wake/Chatham county line. The western border is the Wake/Chatham county line from Olive Dairy Rd. north to just north of Green Level Rd.

Zone F	<u>County:</u> Wake

This zone includes the city of Holly Springs and the community of Feltonville. Within the boundaries of the zone are the Devil's Ridge Golf Club, Bass Lake and Sunset Lake. The northern border of the zone begins with Old Smithfield Rd. to Sunset Lake Rd. to Holly Springs Rd. The eastern border is Pierce-Olive Rd. extended south past Optimist Farm Rd. The eastern border is then a line drawn from Redhill Rd. to the eastern shore of Sunset Lake and Bass Lake to Basal Creek south to NC Hwy. 55 (N. Broad Street). The southern border is NC Hwy. 55 (Broad Street) south to Wade Nash Rd. to Piney Grove Wilbon Rd. to Honeycutt Rd. to the Rex Rd. and Cass Holt Rd. intersection. The western border is an arc 5 miles from the Shearon Harris Nuclear Power Plant extending from the Rex Rd. and Cass Holt Rd. intersection to Avent Ferry Rd. The western border then follows Avent Ferry Rd. to N Carolina Bypass 55 to the intersection with Old Smithfield Rd.

Zone G County: Wake

Zone G includes the town of Fuquay-Varina and the community of Wilbon. Within the boundaries of Zone G is Fuquay-Varina High School. The northern border of Zone G is Cass Holt Rd. from the Rex Rd. intersection north to Honeycutt Rd. to Piney Grove Wilbon Rd. to Wade Nash Rd. to NC Hwy. 55 (N. Broad St.). The northern border then is Basal Creek to the eastern shores of Bass Lake and Sunset Lake and then extends on a line from the northern end of Sunset Lake west to Redhill Rd. The eastern border is a line south from Redhill Rd. to Middle Creek, then it is Middle Creek east to a point north of Petticoat Lane and then it is a line from Middle Creek south across Petticoat Lane to Hilltop Needmore Rd. The eastern border is then Hilltop Needmore Rd. west to Sunset Lake Rd. to E. Broad St. then across US Hwy. 401 (N. Main St.) to Smithwood St. The eastern border is then a line south from Smithwood St. across E. Academy St. and S. Judd Parkway SE to Kenneth Creek, which is the border south to the Wake/Harnett county line. The southern border is the Wake/Harnett county line west crossing US Hwy. 401 (S. Main St.) and extending from US Hwy. 401 (S. Main St.) to Buckhorn Duncan Rd. The western border of the zone is Buckhorn Duncan Rd. to Cass Holt Rd.

Zone H County: Harnett

Zone H includes the communities of Duncan and Cokesbury. Within the boundaries of Zone H are the northern portions of Raven Rock State Park and Camp Agape. The northern border of Zone H is the Harnett/Wake county line from the Harnett/Lee county line to Hus Hwy 401. The eastern border is US Hwy. 401 (S. Main St.) from the Harnett/Wake county line south to Rawls Church Rd. to Hector Creek and to Baptist Grove Rd. From the intersection of Baptist Grove Rd. and Brittany Lane, the eastern border extends on a line southwest to Christian Light Rd. The eastern border is then Christian Light Rd. to Cokesbury Rd. to its intersection with Ausley Rd. From that intersection the eastern border is a line southwest to Avents Creek north of River Rd., then is Avents Creek south to the Cape Fear River. The southern border is the Cape Fear River northwest to a point west of Clay St. and then extends on a line that follows an arc 10 miles from the Shearon Harris Nuclear Power Plant, crossing Daniels Creek, to the Harnett/Lee county line. The western border is the Harnett/Lee county line north to the Harnett/Chatham/Wake county line.

Zone I   County: Lee

Zone I includes the areas east of Osgood (crossroads of Osgood Rd. and Farrell Rd.) and north of Broadway. Within the boundaries of Zone I are Roberts Creek, Hughes Creek, Lick Creek, Bush Creek, Fall Creek and Stony Creek. The northern border of Zone I begins where Hughes Creek crosses Ammons Farm Rd. and is Hughes creek to Lick Creek to the Cape Fear River. The northern border is the Cape Fear River to the Lee/Harnett county line. The eastern border is the Lee/Harnett county line south to a point south of Daniel's Creek Rd., where the eastern border then extends on a line west to Buckhorn Rd. The southern and western border is Buckhorn Rd. south to a point north of Thomas Kelly Rd., where it then becomes a line northwest across Fall Creek to another section of Buckhorn Rd. The southern and western border is Buckhorn Rd. to its intersection with NC 42 (Avents Ferry Rd.). From NC 42 (Avents Ferry Rd.) the border extends on a line northwest to Lower Moncure Rd., and then extends on another line to Hughes Creek.

Zone J   County: Lee

Zone J includes the community of Blacknel (crossroads of Lower Moncure Rd., Lower River Rd. and East Forest Oaks Dr.). Within the boundaries of Zone J is the Raleigh Executive Jetport. The northern border of Zone J is the Deep River, and the eastern border is the Cape Fear River south to Lick Creek. The southern border is Lick Creek to Hughes Creek, and to Farrell Rd. The western border is Farrell Rd. extended north to the Deep River.

Zone K   County: Chatham

Zone K includes the town of Merry Oaks and the communities of Brickhaven and Corinth. Within the boundaries of Zone K is the southern portion of Harris Lake. The northern border of Zone K is US Hwy. 1 from the Haw River to the Chatham/Wake county line. The eastern border is the Chatham/Harnett county line south to the Cape Fear River. The southern border is the Cape Fear River to the Haw River to US Hwy. 1.

Zone L   County: Chatham

Zone L includes the areas west of New Hill and north of Moncure. Within the boundaries of Zone L are the B. Everett Jordan Lake and the Jordan Lake State Recreation Area. The northern border of Zone L is the southern border of Jordan Lake to the Chatham/Wake County Line. The eastern border is the Chatham/Wake county line south to US Hwy. 1 (Claude E. Pope Memorial Hwy.). The southern border is US Hwy. 1 (Claude E. Pope Memorial Hwy.) to the Haw River. The western border is the Haw River to the eastern shore of Jordan Lake.

Zone M <u>County:</u> Chatham

Zone M includes the community of Moncure and the areas south of Griffin's Crossroads. Within the boundaries of Zone M are the B. Everett Jordan Lake and the Jordan Lake State Recreation Area. The northern border of Zone M is US Hwy. 64 from North Pea Ridge Rd. to the eastern shore of Jordan Lake. The eastern border is the eastern shore of Jordan Lake, including the Beaver Creek Rd. bridge, south to the Haw River and then to the Haw River and Deep River confluence. The southern border is the Deep River west to Rocky Branch Creek, and the western border is an arc 10 miles from the Shearon Harris Nuclear Power Plant between the Deep River and US Hwy. 64 that crosses Mt. View Church Rd., Moncure Pittsboro Rd., Roberson Creek, Hanks Chapel Rd., and Ridge View Rd. to US Hwy. 64.

Zone N <u>County:</u> Chatham

Zone N includes the town of Bells and the communities of Seaforth and Wilsonville. Within the boundaries of Zone N are the Jordan Lake State Recreation Area and the B. Everett Jordan Lake. The northern border of Zone N is an arc 10 miles from the Shearon Harris Nuclear Power Plant between US Hwy. 64 and the Chatham/Wake county line that crosses Windfall Creek Dr., Big Woods Rd., Jordan Lake, Farrington Rd., and NC Hwy. 751. The eastern border is the Chatham/Wake county line south to the southern border of Beaver Creek. The southern border is the eastern border of Jordan Lake north to US Hwy. 64.

APPENDIX M

Evacuation Sensitivity Studies

M. EVACUATION SENSITIVITY STUDIES

This appendix presents the results of a series of sensitivity analyses. These analyses are designed to identify the sensitivity of the Evacuation Time Estimate (ETE) to changes in some base evacuation conditions.

M.1 Effect of Changes in Trip Generation Times

A sensitivity study was performed to determine whether changes in the estimated trip generation time have an effect on the ETE for the entire Emergency Planning Zone (EPZ). Specifically, if the tail of the mobilization distribution were truncated (i.e., if those who responded most slowly to the Advisory to Evacuate (ATE) could be persuaded to respond much more rapidly) or if the tail were elongated (i.e. spreading out the departure of evacuees to limit the demand during peak times), how would the ETE be affected? The case considered was Scenario 1, Region 3; a summer, midweek, midday, with good weather evacuation of the entire EPZ. Table M-1 presents the results of this study.

If evacuees mobilize one hour quicker, the 90th percentile is reduced by 15 minutes, and the 100th percentile is reduced by 20 minutes. An increase in mobilization time by 1 hour increases the 90th percentile ETE by 30 minutes and the 100th percentile ETE by 1 hour.

As discussed in Section 7.3, traffic congestion persists within the EPZ for about 4 hours and 50 minutes due to the large population centers (Apex, Holly Springs and Fuquay-Varina) in the EPZ. As such, congestion dictates the 100th percentile ETE until 5 hours after the ATE. After this time, trip generation, (plus a 10-minute travel time to the EPZ boundary), dictates the 100th percentile ETE.

M.2 Effect of Changes in the Number of People in the Shadow Region Who Relocate

A sensitivity study was conducted to determine the effect on ETE due to changes in the percentage of people who decide to relocate from the Shadow Region. The case considered was Scenario 1, Region 3; a summer, midweek, midday, with good weather evacuation for the entire EPZ. The movement of people in the Shadow Region has the potential to impede vehicles evacuating from an Evacuation Region within the EPZ. Refer to Sections 3.2 and 7.1 for additional information on population within the Shadow Region.

Table M-2 presents the ETE for each of the cases considered. The results show that a reduction and/or elimination of the shadow evacuation (0%) decreases the 90th ETE by 10 minutes – not a significant change – and does not impact the 100th percentile ETE since it is dictated by trip generation time. Tripling the shadow evacuation (60%) increases the ETE by 10 minutes and 55 minutes for the 90th percentile and 100th percentile ETE, respectively. A full evacuation (100%) of the shadow population results in an increase of ETE by 45 minutes at the 90th percentile and 2 hours (significant changes) at the 100th percentile.

Note, the demographic survey results presented in Appendix F indicate that 26 percent of households would elect to evacuate if advised to shelter, which differs from the assumption of 20

percent non-compliance as suggested in NUREG/CR-7002, Rev 1. A sensitivity study was considered using a 26 percent shadow evacuation and the 90th and 100th percentile ETEs were minimally affected – 25 minutes at the 100th percentile and no impact at the 90th percentile.

Reducing the shadow evacuation has little impact on ETE because the traffic congestion in the major population centers within the EPZ is significant and trip generation dictates the ETE. Increasing the shadow evacuation, however, does have a significant impact on ETE because the additional vehicles using roadways outside the EPZ reduces the available roadway capacity for EPZ evacuees thereby exacerbating the traffic congestion in the major population centers within the EPZ.

M.3 Effect of Changes in EPZ Resident Population

A sensitivity study was conducted to determine the effect on ETE due to changes in the permanent resident population within the study area (EPZ plus Shadow Region). As population in the study area changes over time, the time required to evacuate the public may increase, decrease, or remain the same. Since the ETE is related to the demand to capacity ratio present within the study area, changes in population will cause the demand side of the equation to change and could impact ETE.

As per the NRC's response to the Emergency Planning Frequently Asked Question (EPFAQ) 2013-001, the ETE population sensitivity study must be conducted to determine what percentage increase in permanent resident population causes an increase in the 90th percentile ETE of 25% or 30 minutes, whichever is less. The sensitivity study must use the scenario with the longest 90th percentile ETE (excluding the roadway impact scenario and the special event scenario if it is a 1 day per year special event).

Thus, the sensitivity study was conducted using the following planning assumptions:

1. The percent change in population within the study area was increased up to 20%. Changes in population were applied to permanent residents only (as per federal guidance), in both the EPZ and the Shadow Region.
2. The transportation infrastructure remained fixed (as presented in Appendix K); the presence of future proposed roadway changes and/or highway capacity improvements were not considered.
3. The study was performed for the 2-Mile Region (R01), the 5-Mile Region (R02) and the entire EPZ (R03).
4. The scenario (excluding roadway impact and special event) which yielded the highest 90th percentile ETE values was selected as the case to be considered in this sensitivity study (Scenario 8 – Winter, Midweek, Midday, Icy Condition).

Table M-3 presents the results of the sensitivity study. Section IV of Appendix E to 10 CFR Part 50, and NUREG/CR-7002, Rev 1, Section 5.4, require licensees to provide an updated ETE analysis to the NRC when a population increase within the EPZ causes the longest 90th percentile ETE values (for the 2-Mile Region, 5-Mile Region or entire EPZ) to increase by 25% or 30 minutes, whichever is less. The base ETE value for the 2-Mile Region (R01) is less than 2

hours; R01 criterion for updating is 20 minutes (1:20 multiplied by 25%). Base ETE value for the 5-Mile Region (R02) and entire EPZ (R03) is greater than 2 hours; 25 percent of the base ETE is always equal or greater than 30 minutes. Therefore 30 minutes is the lesser and is the criterion for updating ETE.

Those percent population changes which result in a 90^{th} percentile ETE change greater than or equal to 30 minutes are highlighted in red in Table M-3 – a 19% or greater increase in the full EPZ population. Duke Energy will have to estimate the EPZ population on an annual basis. If the study area population increases by 19% or more, an updated ETE analysis will be needed.

M.4 Changes in Emergency Planning Zone

As requested by Duke Energy, this ETE results contained within the study were computed based on the proposed EPZ changes in Wake, Chatham, and Harnett County. A majority of the Zones (A, B, C, D, E, F, H, K, L, and N) in these counties have borders that separate neighborhoods or developed properties, and/or overlap counties. When making protective action decisions, the neighborhoods contained in these Zones are tied to the same decision (i.e., Shelter-in-Place, Evacuation). If each county/neighborhood/developed property has a distinct Zone, different protective actions could be considered for each. The need becomes more evident with a hostile action-based event where the response to the event may require a more specific protective action (i.e., go inside/stay inside) close to the nuclear site. Figure M-1 shows the existing EPZ overlaid with the proposed EPZ.

Section B of the December 2019 FEMA Radiological Emergency Preparedness (REP) Program Manual outlines the process for making changes to the EPZ boundary:

> If an ORO wants to change the boundary of an existing EPZ, the proposal must be submitted to the FEMA Regional Administrator or designee, usually the RAC [Regional Assistance Committee] Chair. The proposal shall include, but not be limited to:
>
> - Action by appropriate ORO officials desiring the change to the boundary (i.e., resolution by elected official, etc.).
> - Description of the change to the boundary.
> - Discussion of the population affected by the change.
> - Effect that the change has on evacuation routes or ETEs.
> - Maps showing the existing EPZ boundary and proposed new boundary.
>
> FEMA and the RAC will review the request on its merits. After the regional review, the request and RAC recommendation will be forwarded to FEMA Headquarters for final action.
>
> If the EPZ boundary change is approved, the approval is contingent on the ORO submitting for review the appropriate changes to their plans/procedures, maps of the EPZ, public information material, and impact that the addition or subtraction of population from the EPZ has on the ETEs. The information would include changes to the geographical boundary descriptions and the ANS, including additional sirens or other means for public notification.

> Any modifications to any ANS must be consistent with Part V of the RPM [REP Program Manual].

According to NRC's Title 10 of the Code of Federal Regulations Part 50.54(q),

> The licensee may make changes to its emergency plan without NRC approval only if the licensee performs and retains an analysis demonstrating that the changes do not reduce the effectiveness of the plan and the plan, as changed, continues to meet the requirements in appendix E to this part and, for nuclear power reactor licensees, the planning standards of § 50.47(b).
>
> The changes to a licensee's emergency plan that reduce the effectiveness of the plan as defined in paragraph (q)(1)(iv) of this section may not be implemented without prior approval by the NRC. A licensee desiring to make such a change after February 21, 2012 shall submit an application for an amendment to its license. In addition to the filing requirements of §§ 50.90 and 50.91, the request must include all emergency plan pages affected by that change and must be accompanied by a forwarding letter identifying the change, the reason for the change, and the basis for concluding that the licensee's emergency plan, as revised, will continue to meet the requirements in appendix E to this part and, for nuclear power reactor licensees, the planning standards of § 50.47(b).

M.4.1 Methodology

The changes to the boundaries of Zones A, B, C, D, E, F, H, K, L and N changes the population and vehicles evacuating from each of these Zones. The population for all other Zones in the EPZ is not impacted. Since the changes to the boundaries of these Zones is internal to the EPZ only, the total population of the EPZ as a whole is not impacted as well. Table M-4 and Table M-5 compare the evacuating population demand and evacuating vehicle estimates, respectively, by Zone for the existing and proposed EPZs.

The link-node analysis that was used as port of this study was used as-is for this sensitivity study except for exit links (links that cross the boundary of each region which are used to track when the evacuated area has been cleared) that had to be revised due to the proposed boundary changes. The change in exit links was introduced into the input streams for the DYNEV-II modeling system. Evacuation simulations were then run and the ETE predicted by these simulations were compared with the ETE of the proposed EPZ (presented in Section 7) to quantify the change in ETE caused by the change in the Zone boundaries.

Two different scenarios (temporal variations) and three different regions (wind strength/ direction) were considered to bound the potential impact of the boundary changes, on the ETE:

- Scenario 1 – summer, midweek, midday with good weather was chosen because it represents the scenario with the largest number of evacuating vehicles (see Table 6-4).
- Scenario 12 – winter, midweek, weekend, evening with good weather was also chosen because it represents the scenario with the lowest number of evacuating vehicles (see Table 6-4).

- Regions R01, R02 and R03 were considered as they represent the evacuation radii emphasized in the federal guidance – 2 miles, 5 miles and full EPZ (approximately 10 miles), respectively.

Table M-6 presents the ETE results for the Zone boundary changes (Proposed EPZ – used as the EPZ for this study), the ETE results that were calculated as part of this sensitivity study (Existing EPZ), and the difference in ETE caused by the change in Zone boundaries. As shown in Table M-6, the 90th percentile ETE for the 2-mile region was unchanged and reduced by 5 minutes for Scenarios 1 and 6, respectively – not a significant change. This is a result of the 2-mile region slightly reducing in size, but in areas that are sparsely populated. As a result, there is little to no impact on the ETE for this region. The 90th percentile ETE for the 5-mile region (R02) is slightly impacted with an increase in ETE of 15 minutes for both scenarios. Even though the size of this region reduces slightly with the proposed Zone boundary changes, the increase in ETE is a direct result of the expansion of Zone B to include more of Holly Springs. As shown in Figure 7-3 through 7-8, Holly Springs is one of the most congested areas in the network and the last area to clear in the 5-mile region. The addition of this piece of Zone B includes the congestion in Holly Springs in the 5-mile region and, therefore, increases the ETE. The ETE for the 90th percentile remained the same for the full EPZ (Region R03) for both scenarios considered since the outer boundary of the EPZ did not change.

The 100th percentile ETE for all regions and scenarios considered were not impacted by the change in Zone boundaries. As discussed in Section 7, the 100th percentile ETE is dictated by trip generation times, not congestion. As a result, regardless of the boundaries of the zones, the 100th percentile ETE will always be approximately 5 hours for good weather scenarios.

M.4.2 Conclusions

The FEMA REP Program Manual indicates that a proposal to change an existing EPZ boundary should include a discussion of the population affected by the change, as well an estimate of the effect of the EPZ change on ETE. The EPZ population (all population groups) does not change as a result of the proposed EPZ change since all proposed changes are internal to the EPZ. The distribution of the population between Zones within the EPZ, however, is changed. Slight changes (15 minutes at most) are seen at the 90th percentile for subsets of Zones. The 100th percentile ETE remains unchanged.

As discussed in Section 5.4 of NUREG/CR-7002, Rev 1, the NRC considers an increase of 25% or 30 minutes (whichever is less) to be a ‘significant change’ in ETE. Since 15 minutes does not meet either of those thresholds (25% of 2 hours and 15 minutes is 34 minutes and 25% of 2 hours and 20 minutes is 35 minutes), the increase in ETE that is a result of the change in Zone boundaries does not represent a significant change in ETE.

M.5 Changes in Average Household Size

As discussed in Appendix F, the average household size obtained from the survey results was 3.11 people per household. The difference between the Census data (2.85 people per

household) and survey data is 8.3%, which exceeds the sampling error of 4.4%. Upon discussions with Duke Energy, it was decided that the estimated household size from the 2020 Census data would be used in the study. A sensitivity study was performed to determine how sensitive the ETE is to changes in the average household size. It should be noted that only resident and shadow vehicles were changed for this sensitivity study. The case considered was Scenario 1, Region 3; a summer, midweek, midday, with good weather evacuation of the 2-mile region, 5-mile region, and entire EPZ. Table M-7 presents the results of this study.

Increasing the average household size (decreasing the total number of people and evacuating vehicles) by 8.3% has little impact on ETE (decreasing the 90th percentile ETE by 10 minutes at most) because the traffic congestion in the major population centers within the EPZ is significant and trip generation dictates the ETE. The 100th percentile ETE remains dictated by trip generation time.

Table M-1. Evacuation Time Estimates for Trip Generation Sensitivity Study

Trip Generation Time	Evacuation Time Estimate for Entire EPZ	
	90th Percentile	100th Percentile
4 Hours	3:10	4:50
5 Hours (Base)	3:25	5:10
6 Hours	3:55	6:10

Table M-2. Evacuation Time Estimates for Shadow Sensitivity Study

Percent Shadow Evacuation	Evacuating Shadow Vehicles[1]	Evacuation Time Estimate for Entire EPZ	
		90th Percentile	100th Percentile
0	0	3:15	5:10
20 (base)	27,266	3:25	5:10
26 (survey)	35,446	3:25	5:35
40	54,533	3:25	5:35
60	81,799	3:35	6:05
80	109,066	3:45	6:20
100	136,332	4:10	7:10

[1] The Evacuating Shadow Vehicles, in Table M-2, represent the residents and employees who will spontaneously decide to relocate during the evacuation. The basis, for the base values shown, is a 20% relocation of shadow residents along with a proportional percentage of shadow employees. See Section 6 for further discussion.

Table M-3. ETE Variation with Population Change

EPZ and 20% Shadow Resident Population	Base	Population Change		
		18%	19%	20%
	205,927	242,994	245,053	247,112
ETE for 90th Percentile				
Region	Base	Population Change		
		18%	19%	20%
2-MILE	1:20	1:20	1:20	1:20
5-MILE	2:30	2:40	2:40	2:40
FULL EPZ	3:45	4:10	**4:15**	**4:20**
ETE for 100th Percentile				
Region	Base	Population Change		
		18%	19%	20%
2-MILE	5:00	5:00	5:00	5:00
5-MILE	5:10	5:10	5:10	5:10
FULL EPZ	5:40	6:20	6:20	6:40

Table M-4. Evacuation Population Demand for the Existing and Proposed EPZs

Zone	Residents	Transit-Dependent	Transients	Employees	Special Facilities	Schools and Childcare Facilities	Special Event	Shadow Population	External Traffic	Total
Existing EPZ										
A	132	2	401	472	44	0	0	0	0	1,051
B	3,273	50	289	0	0	3,374	0	0	0	6,986
C	6,945	106	70	0	3	0	0	0	0	7,124
D	539	8	224	0	0	0	0	0	0	771
E	67,752	1,032	1,498	5,015	242	12,653	0	0	0	88,192
F	34,797	530	3,256	2,596	43	11,534	0	0	0	52,756
G	30,848	470	816	1,035	203	6,889	0	0	0	40,261
H	4,361	66	998	0	0	0	0	0	0	5,425
I	982	15	0	0	0	0	0	0	0	997
J	1,323	20	0	0	96	0	0	0	0	1,439
K	714	11	440	0	0	0	0	0	0	1,165
L	877	13	2,967	236	0	0	2,243	0	0	6,336
M	1,977	30	2,406	0	0	1,725	3,733	0	0	9,871
N	1,050	16	2,108	0	0	0	2,987	0	0	6,161
Shadow Region	0	0	0	0	50	1,208	0	50,357	0	51,615
EPZ TOTAL	**155,570**	**2,369**	**15,473**	**9,354**	**681**	**37,383**	**8,963**	**50,357**	**0**	**280,150**
Proposed EPZ										
A	118	2	401	472	44	0	0	0	0	1,037
B	8,573	131	359	440	0	4,779	0	0	0	14,282
C	7,384	112	0	931	15	199	0	0	0	8,641
D	372	6	224	0	0	0	0	0	0	602
E	67,690	1,030	1,498	5,015	242	12,653	0	0	0	88,128
F	29,041	442	3,256	1,225	31	9,930	0	0	0	43,925
G	30,848	470	816	1,035	203	6,889	0	0	0	40,261

Zone	Residents	Transit-Dependent	Transients	Employees	Special Facilities	Schools and Childcare Facilities	Special Event	Shadow Population	External Traffic	Total
H	4,528	69	998	0	0	0	0	0	0	5,595
I	982	15	0	0	0	0	0	0	0	997
J	1,323	20	0	0	96	0	0	0	0	1,439
K	714	11	440	0	0	0	0	0	0	1,165
L	717	11	338	236	0	0	750	0	0	2,052
M	1,977	30	2,406	0	0	1,725	3,733	0	0	9,871
N	1,303	20	4,737	0	0	0	4,480	0	0	10,540
Shadow Region	0	0	0	0	50	1,208	0	50,357	0	51,615
EPZ TOTAL	**155,570**	**2,369**	**15,473**	**9,354**	**681**	**37,383**	**8,963**	**50,357**	**0**	**280,150**

NOTE: Shadow Population has been reduced to 20%. Refer to Figure 2-1 for additional information.

Table M-5. Evacuating Vehicle Demand for the Existing and Proposed EPZs

Zone	Residents	Transit-Dependent	Transients	Employees	Special Facilities	Schools and Childcare Facilities	Special Event	Shadow Population	External Traffic	Total
Existing EPZ										
A	64	10	182	429	6	0	0	0	0	691
B	1,600	0	131	0	0	138	0	0	0	1,869
C	3,409	8	30	0	2	0	0	0	0	3,449
D	262	0	102	0	0	0	0	0	0	364
E	33,181	70	865	4,559	49	466	0	0	0	39,190
F	17,038	30	1,324	2,360	14	414	0	0	0	21,180
G	15,009	32	371	941	33	274	0	0	0	16,660
H	2,136	6	390	0	0	0	0	0	0	2,532
I	480	4	0	0	0	0	0	0	0	484
J	600	0	0	0	15	0	0	0	0	615
K	349	2	210	0	0	0	0	0	0	561
L	430	0	980	215	0	0	787	0	0	2,412
M	969	2	702	0	0	68	1,310	0	0	3,051
N	513	2	527	0	0	0	1,048	0	0	2,090
Shadow Region	0	0	0	0	8	36	0	24,623	24,344	49,011
EPZ TOTAL	**76,040**	**166**	**5,814**	**8,504**	**127**	**1,396**	**3,145**	**24,623**	**24,344**	**144,159**
Proposed EPZ										
A	57	10	182	429	6	0	0	0	0	684
B	4,202	0	161	400	0	180	0	0	0	4,943
C	3,626	8	0	847	6	6	0	0	0	4,493
D	181	0	102	0	0	0	0	0	0	283
E	33,151	70	865	4,559	49	466	0	0	0	39,160
F	14,211	30	1,324	1,113	10	366	0	0	0	17,054
G	15,009	32	371	941	33	274	0	0	0	16,660

Zone	Residents	Transit-Dependent	Transients	Employees	Special Facilities	Schools and Childcare Facilities	Special Event	Shadow Population	External Traffic	Total
H	2,217	6	390	0	0	0	0	0	0	2,613
I	480	4	0	0	0	0	0	0	0	484
J	600	0	0	0	15	0	0	0	0	615
K	349	2	210	0	0	0	0	0	0	561
L	350	0	84	215	0	0	263	0	0	912
M	969	2	702	0	0	68	1,310	0	0	3,051
N	638	2	1,423	0	0	0	1,572	0	0	3,635
Shadow Region	0	0	0	0	8	36	0	24,623	24,344	49,011
EPZ TOTAL	**76,040**	**166**	**5,814**	**8,504**	**127**	**1,396**	**3,145**	**24,623**	**24,344**	**144,159**

NOTE: Buses (including wheelchair buses) represented as two passenger vehicles. Refer to Section 8 for additional information.

NOTE: Shadow Population has been reduced to 20%. Refer to Figure 2-1 for additional information.

NOTE: Transit Dependent Buses are assumed to collect transient dependent people from multiple zones as discussed in Section 3.

Table M-6. ETE Results for Change in Zone Boundaries

90th Percentile ETE (hr:min)						
	Scenario 1 (Summer, Midweek, Midday, Good Weather)			Scenario 12 (Winter, Midweek, Weekend, Evening, Good Weather)		
Region	**Existing EPZ**	**Proposed EPZ**	**Difference**	**Existing EPZ**	**Proposed EPZ**	**Difference**
2-Mile (R01)	1:20	1:20	0:00	1:55	1:50	-0:05
5-Mile (R02)	2:15	2:30	+0:15	2:20	2:35	+0:15
Full EPZ (R03)	3:25	3:25	0:00	3:15	3:15	0:00
100th Percentile ETE (hr:min)						
	Scenario 1 (Summer, Midweek, Midday, Good Weather)			**Scenario 12 (Winter, Midweek, Weekend, Evening, Good Weather)**		
Region	**Existing EPZ**	**Proposed EPZ**	**Difference**	**Existing EPZ**	**Proposed EPZ**	**Difference**
2-Mile (R01)	5:00	5:00	0:00	5:00	5:00	0:00
5-Mile (R02)	5:05	5:05	0:00	5:05	5:05	0:00
Full EPZ (R03)	5:10	5:10	0:00	5:10	5:10	0:00

Table M-7. ETE Results for Change in Average Household Size

EPZ and 20% Shadow Resident Population	Base (Average HH Size of 2.85 people per household) 205,927	Average HH Size of 3.11 people per household 188,711
ETE for 90th Percentile		
2-MILE	1:20	1:15
5-MILE	2:30	2:25
FULL EPZ	3:25	3:15
ETE for 100th Percentile		
2-MILE	5:00	5:00
5-MILE	5:05	5:05
FULL EPZ	5:10	5:10

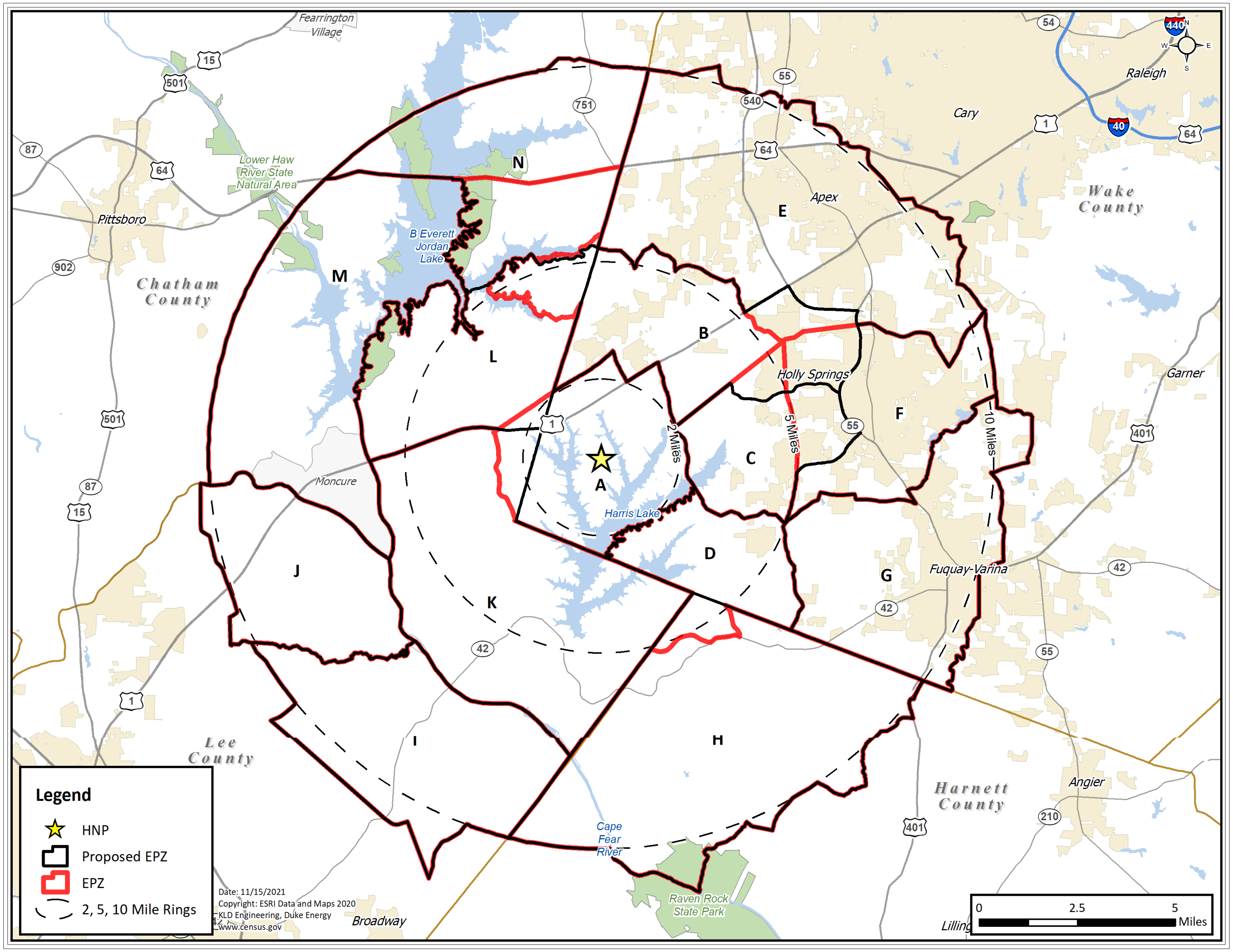

Figure M-1. Existing and Proposed HNP EPZ

APPENDIX N

ETE Criteria Checklist

N. ETE CRITERIA CHECKLIST

Table N-1. ETE Review Criteria Checklist

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
1.0 Introduction		
a. The emergency planning zone (EPZ) and surrounding area is described.	Yes	Section 1
b. A map is included that identifies primary features of the site including major roadways, significant topographical features, boundaries of counties, and population centers within the EPZ.	Yes	Figures 1-1, 3-1, 6-1
c. A comparison of the current and previous ETE is provided including information similar to that identified in Table 1-1, "ETE Comparison."	Yes	Table 1-3
1.1 Approach		
a. The general approach is described in the report as outlined in Section 1.1, "Approach."	Yes	Section 1.1, Section 1.3, Appendix D, Table 1-1,
1.2 Assumptions		
a. Assumptions consistent with Table 1-2, "General Assumptions," of NUREG/CR-7002 are provided and include the basis to support use.	Yes	Section 2
1.3 Scenario Development		
a. The scenarios in Table 1-3, "Evacuation Scenarios," are developed for the ETE analysis. A reason is provided for use of other scenarios or for not evaluating specific scenarios.	Yes	Section 6, Table 6-2

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
1.4 Evacuation Planning Areas		
a. A map of the EPZ with emergency response planning areas (ERPAs) is included.	Yes	Figure 3-1, Figure 6-1
1.4.1 Keyhole Evacuation		
a. A table similar to Table 1-4 "Evacuation Areas for a Keyhole Evacuation", is provided identifying the ERPAs considered for each ETE calculation by downwind direction.	Yes	Table 6-1, Table 7-5, Table H-1
1.4.2 Staged Evacuation		
a. The approach used in development of a staged evacuation is discussed.	Yes	Section 7.2
b. A table similar to Table 1-5, "Evacuation Areas for a Staged Evacuation," is provided for staged evacuations identifying the ERPAs considered for each ETE calculation by downwind direction.	Yes	Table 7-3, Table 7-4
2.0 Demand Estimation		
a. Demand estimation is developed for the four population groups (permanent residents of the EPZ, transients, special facilities, and schools).	Yes	Section 3
2.1 Permanent Residents and Transient Population		
a. The U.S. Census is the source of the population values, or another credible source is provided.	Yes	Section 3.1
b. The availability date of the census data is provided.	Yes	Section 3.1
c. Population values are adjusted as necessary for growth to reflect population estimates to the year of the ETE.	Yes	N/A - 2020 used as the base year of the analysis

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
d. A sector diagram, similar to Figure 2-1, "Population by Sector," is included showing the population distribution for permanent residents.	Yes	Figure 3-2
2.1.1 Permanent Residents with Vehicles		
a. The persons per vehicle value is between 1 and 3 or justification is provided for other values.	Yes	Section 3.1
2.1.2 Transient Population		
a. A list of facilities that attract transient populations is included, and peak and average attendance for these facilities is listed. The source of information used to develop attendance values is provided.	Yes	Section 3.3, Table E-5 through Table E-8
b. Major employers are listed.	Yes	Section 3.4, Table E-4
c. The average population during the season is used, itemized and totaled for each scenario.	Yes	Table 3-4, Table 3-5 and Appendix E itemize the peak transient population and employee estimates. These estimates are multiplied by the scenario specific percentages provided in Table 6-3 to estimate average transient population by scenario – see Table 6-4.
d. The percentage of permanent residents assumed to be at facilities is estimated.	Yes	Section 3.3 and Section 3.4
e. The number of people per vehicle is provided. Numbers may vary by scenario, and if so, reasons for the variation are discussed.	Yes	Section 3.3 and Section 3.4

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
f. A sector diagram is included, similar to Figure 2-1, “Population by Sector”, is included showing the population distribution for the transient population.	Yes	Figure 3-6 (transients) and Figure 3-8 (employees)
2.2 Transit Dependent Permanent Residents		
a. The methodology (e.g., surveys, registration programs) used to determine the number of transit dependent residents is discussed.	Yes	Section 3.6
b. The State and local evacuation plans for transit dependent residents are used in the analysis.	Yes	Section 8.1
c. The methodology used to determine the number of people with disabilities and those with access and functional needs who may need assistance and do not reside in special facilities is provided. Data from local/county registration programs are used in the estimate.	Yes	Section 3.9
d. Capacities are provided for all types of transportation resources. Bus seating capacity of 50 percent is used or justification is provided for higher values.	Yes	Item 3 of Section 2.4
e. An estimate of the transit dependent population is provided.	Yes	Section 3.6, Table 3-7, Table 3-9
f. A summary table showing the total number of buses, ambulances, or other transport assumed available to support evacuation is provided. The quantification of resources is detailed enough to ensure that double counting has not occurred.	Yes	Table 3-9, Table 8-1

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
2.3 Special Facility Residents		
a. Special facilities, including the type of facility, location, and average population, are listed. Special facility staff is included in the total special facility population.	Yes	Table E-3 lists all medical facilities by facility name, location, and average population. Staff estimates were not provided.
b. The method of obtaining special facility data is discussed.	Yes	Section 3.5
c. An estimate of the number and capacity of vehicles assumed available to support the evacuation of the facility is provided.	Yes	Table 3-6
d. The logistics for mobilizing specially trained staff (e.g., medical support or security support for prisons, jails, and other correctional facilities) are discussed when appropriate.	Yes	Section 8.1 – under Evacuation of Medical Facilities
2.4 Schools		
a. A list of schools including name, location, student population, and transportation resources required to support the evacuation, is provided. The source of this information should be identified.	Yes	Table 3-8, Table E-1, Section 3.7
b. Transportation resources for elementary and middle schools are based on 100 percent of the school capacity.	Yes	Section 3.7
c. The estimate of high school students who will use personal vehicle to evacuate is provided and a basis for the values used is given.	Yes	Section 3.7
d. The need for return trips is identified.	Yes	Section 8.1

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
2.5 Other Demand Estimate Considerations		
2.5.1 Special Events		
a. A complete list of special events is provided including information on the population, estimated duration, and season of the event.	Yes	Section 3.8
b. The special event that encompasses the peak transient population is analyzed in the ETE.	Yes	Section 3.8
c. The percentage of permanent residents attending the event is estimated.	Yes	Section 3.8
2.5.2 Shadow Evacuation		
a. A shadow evacuation of 20 percent is included consistent with the approach outlined in Section 2.5.2, "Shadow Evacuation".	Yes	Item 7 of Section 2.2, Figure 2-1 and Figure 7-1, Section 3.2
b. Population estimates for the shadow evacuation in the shadow region beyond the EPZ are provided by sector.	Yes	Section 3.2, Table 3-3, Figure 3-4
c. The loading of the shadow evacuation onto the roadway network is consistent with the trip generation time generated for the permanent resident population.	Yes	Section 5 – Table 5-8 (footnote)
2.5.3 Background and Pass Through Traffic		
a. The volume of background traffic and pass-through traffic is based on the average daytime traffic. Values may be reduced for nighttime scenarios.	Yes	Section 3.10 and Section 3.11

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
b. The method of reducing background and pass-through traffic is described.	Yes	Section 2.2 – Assumptions 9 and 10 Section 2.5 Section 3.10 and Section 3.11 Table 6-3 – External Through Traffic footnote
c. Pass-through traffic is assumed to have stopped entering the EPZ about two (2) hours after the initial notification.	Yes	Section 2.5
2.6 Summary of Demand Estimation		
a. A summary table is provided that identifies the total populations and total vehicles used in the analysis for permanent residents, transients, transit dependent residents, special facilities, schools, shadow population, and pass-through demand in each scenario.	Yes	Table 3-11, Table 3-12, and Table 6-4
3.0 Roadway Capacity		
a. The method(s) used to assess roadway capacity is discussed.	Yes	Section 4
3.1 Roadway Characteristics		
a. The process for gathering roadway characteristic data is described including the types of information gathered and how it is used in the analysis.	Yes	Section 1.3, Appendix D
b. Legible maps are provided that identify nodes and links of the modeled roadway network similar to Figure A-1, "Roadway Network Identifying Nodes and Links," and Figure A-2, "Grid Map Showing Detailed Nodes and Links."	Yes	Appendix K

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
3.2 Model Approach		
a. The approach used to calculate the roadway capacity for the transportation network is described in detail, and the description identifies factors that are expressly used in the modeling.	Yes	Section 4
b. Route assignment follows expected evacuation routes and traffic volumes.	Yes	Appendix B and Appendix C
c. A basis is provided for static route choices if used to assign evacuation routes.	N/A	Static route choices are not used to assign evacuation routes. Dynamic traffic assignment is used.
d. Dynamic traffic assignment models are described including calibration of the route assignment.	Yes	Appendix B and Appendix C
3.3 Intersection Control		
a. A list that includes the total numbers of intersections modeled that are unsignalized, signalized, or manned by response personnel is provided.	Yes	Table K-1
b. The use of signal cycle timing, including adjustments for manned traffic control, is discussed.	Yes	Section 4, Appendix G
3.4 Adverse Weather		
a. The adverse weather conditions are identified.	Yes	Assumption 2 and 3 of Section 2.6
b. The speed and capacity reduction factors identified in Table 3-1, "Weather Capacity Factors," are used or a basis is provided for other values, as applicable to the model.	Yes	Table 2-2
c. The calibration and adjustment of driver behavior models for adverse weather conditions are described, if applicable.	N/A	Driver behavior is not adjusted for adverse weather conditions.

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
d. The effect of adverse weather on mobilization is considered and assumptions for snow removal on streets and driveways are identified, when applicable.	Yes	Table 2-2; snow is not considered for this site.
4.0 Development of Evacuation Times		
4.1 Traffic Simulation Models		
a. General information about the traffic simulation model used in the analysis is provided.	Yes	Section 1.3, Table 1-3, Appendix B, Appendix C
b. If a traffic simulation model is not used to perform the ETE calculation, sufficient detail is provided to validate the analytical approach used.	N/A	Not applicable since a traffic simulation model was used.
4.2 Traffic Simulation Model Input		
a. Traffic simulation model assumptions and a representative set of model inputs are provided.	Yes	Section 2, Appendix J
b. The number of origin nodes and method for distributing vehicles among the origin nodes are described.	Yes	Appendix J, Appendix C
c. A glossary of terms is provided for the key performance measures and parameters used in the analysis.	Yes	Appendix A
4.3 Trip Generation Time		
a. The process used to develop trip generation times is identified.	Yes	Section 5
b. When surveys are used, the scope of the survey, area of the survey, number of participants, and statistical relevance are provided.	Yes	Appendix F
c. Data used to develop trip generation times are summarized.	Yes	Appendix F, Section 5

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
d. The trip generation time for each population group is developed from site-specific information.	Yes	Section 5
e. The methods used to reduce uncertainty when developing trip generation times are discussed, if applicable.	Yes	Appendix F
4.3.1 Permanent Residents and Transient Population		
a. Permanent residents are assumed to evacuate from their homes but are not assumed to be at home at all times. Trip generation time includes the assumption that a percentage of residents will need to return home before evacuating.	Yes	Section 5 discusses trip generation for households with and without returning commuters. Table 6-3 presents the percentage of households with returning commuters and the percentage of households either without returning commuters or with no commuters. Appendix F presents the percent households who will await the return of commuters. Section 2.3, Assumption 3
b. The trip generation time accounts for the time and method to notify transients at various locations.	Yes	Section 5
c. The trip generation time accounts for transients potentially returning to hotels before evacuating.	Yes	Section 5, Figure 5-1
d. The effect of public transportation resources used during special events where a large number of transients are expected is considered.	Yes	Section 3.8

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
4.3.2 Transit Dependent Permanent Residents		
a. If available, existing and approved plans and bus routes are used in the ETE analysis.	N/A	Established bus routes do not exist. Section 8.1 under Evacuation of Transit-Dependent Population
b. The means of evacuating ambulatory and non-ambulatory residents are discussed.	Yes	Section 8.1 under Evacuation of Transit-Dependent Population, Section 8.2
c. Logistical details, such as the time to obtain buses, brief drivers and initiate the bus route are used in the analysis.	Yes	Section 8.1, Figure 8-1
d. The estimated time for transit dependent residents to prepare and then travel to a bus pickup point, including the expected means of travel to the pickup point, is described.	Yes	Section 8.1 under Evacuation of Transit-Dependent Population
e. The number of bus stops and time needed to load passengers are discussed.	Yes	Section 8.1, Table 8-5 though Table 8-7
f. A map of bus routes is included.	Yes	Figure 10-2
g. The trip generation time for non-ambulatory persons including the time to mobilize ambulances or special vehicles, time to drive to the home of residents, time to load, and time to drive out of the EPZ, is provided.	Yes	Section 8.2
h. Information is provided to support analysis of return trips, if necessary.	Yes	Section 8.1 and 8.2
4.3.3 Special Facilities		
a. Information on evacuation logistics and mobilization times is provided.	Yes	Section 2.4, Section 8.1, Table 8-8 through Table 8-10

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
b. The logistics of evacuating wheelchair and bed bound residents are discussed.	Yes	Section 8.1, Table 8-8 through Table 8-10
c. Time for loading of residents is provided.	Yes	Section 2.4, Section 8.1, Table 8-8 through Table 8-10
d. Information is provided that indicates whether the evacuation can be completed in a single trip or if additional trips are needed.	Yes	Section 8.1
e. Discussion is provided on whether special facility residents are expected to pass through the reception center before being evacuated to their final destination.	Yes	Section 8.1
f. Supporting information is provided to quantify the time elements for each trip, including destinations if return trips are needed.	Yes	Section 8.1
4.3.4 Schools		
a. Information on evacuation logistics and mobilization times is provided.	Yes	Section 2.4, Section 8.1, Table 8-2 through Table 8-4
b. Time for loading of students is provided.	Yes	Section 2.4, Section 8.1, Table 8-2 through Table 8-4
c. Information is provided that indicates whether the evacuation can be completed in a single trip or if additional trips are needed.	Yes	Section 8.1
d. If used, reception centers should be identified. A discussion is provided on whether students are expected to pass through the reception center before being evacuated to their final destination.	Yes	Section 8.1, Table 10-3

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
e. Supporting information is provided to quantify the time elements for each trip, including destinations if return trips are needed.	Yes	Section 8.1, Table 8-2 through Table 8-4
4.4 Stochastic Model Runs		
a. The number of simulation runs needed to produce average results is discussed.	N/A	DYNEV does not rely on simulation averages or random seeds for statistical confidence. For DYNEV/DTRAD, it is a meso-scopic simulation and uses dynamic traffic assignment model to obtain the "average" (stable) network work flow distribution. This is different from microscopic simulation, which is monte-carlo random sampling by nature relying on different seeds to establish statistical confidence. Refer to Appendix B for more details
b. If one run of a single random seed is used to produce each ETE result, the report includes a sensitivity study on the 90 percent and 100 percent ETE using 10 different random seeds for evacuation of the full EPZ under Summer, Midweek, Daytime, Normal Weather conditions.	N/A	
4.5 Model Boundaries		
a. The method used to establish the simulation model boundaries is discussed.	Yes	Section 4.5
b. Significant capacity reductions or population centers that may influence the ETE and that are located beyond the evacuation area or shadow region are identified and included in the model, if needed.	Yes	Section 4.5

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
4.6 Traffic Simulation Model Output		
a. A discussion of whether the traffic simulation model used must be in equilibration prior to calculating the ETE is provided.	Yes	Appendix B
b. The minimum following model outputs for evacuation of the entire EPZ are provided to support review: 1. Evacuee average travel distance and time. 2. Evacuee average delay time. 3. Number of vehicles arriving at each destination node. 4. Total number and percentage of evacuee vehicles not exiting the EPZ. 5. A plot that provides both the mobilization curve and evacuation curve identifying the cumulative percentage of evacuees who have mobilized and exited the EPZ. 6. Average speed for each major evacuation route that exits the EPZ.	Yes	1. Appendix J, Table J-2 2. Table J-2 3. Table J-4 4. None and 0%. 100 percent ETE is based on the time the last vehicle exits the evacuation zone 5. Figures J-2 through J-15 (one plot for each scenario considered) 6. Table J-3
c. Color coded roadway maps are provided for various times (e.g., at 2, 4, 6 hrs.) during a full EPZ evacuation scenario, identifying areas where congestion exists.	Yes	Figure 7-3 through Figure 7-9
4.7 Evacuation Time Estimates for the General Public		
a. The ETE includes the time to evacuate 90 percent and 100 percent of the total permanent resident and transient population.	Yes	Table 7-1 and Table 7-2
b. Termination criteria for the 100 percent ETE are discussed, if not based on the time the last vehicle exits the evacuation zone.	N/A	100 percent ETE is based on the time the last vehicle exits the evacuation zone.

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
c. The ETE for 100 percent of the general public includes all members of the general public. Any reductions or truncated data is explained.	Yes	Section 5.4.1 – truncating survey data to eliminate statistical outliers Table 7-2 – 100^{th} percentile ETE for general population
d. Tables are provided for the 90 and 100 percent ETEs similar to Table 4-3, "ETEs for a Staged Evacuation," and Table 4-4, "ETEs for a Keyhole Evacuation."	Yes	Table 7-3 and Table 7-4
e. ETEs are provided for the 100 percent evacuation of special facilities, transit dependent, and school populations.	Yes	Section 8
5.0 Other Considerations		
5.1 Development of Traffic Control Plans		
a. Information that responsible authorities have approved the traffic control plan used in the analysis are discussed.	Yes	Section 9, Appendix G
b. Adjustments or additions to the traffic control plan that affect the ETE is provided.	Yes	Section 9, Appendix G
5.2 Enhancements in Evacuation Time		
a. The results of assessments for enhancing evacuations are provided.	Yes	Appendix M
5.3 State and Local Review		
a. A list of agencies contacted is provided and the extent of interaction with these agencies is discussed.	Yes	Table 1-1

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
b. Information is provided on any unresolved issues that may affect the ETE.	Yes	Results of the ETE study were formally presented to state and local agencies at the final project meeting. Comments on the draft report were provided and were addressed in the final report. There are no unresolved issues.
5.4 Reviews and Updates		
a. The criteria for when an updated ETE analysis is required to be performed and submitted to the NRC is discussed.	Yes	Appendix M, Section M.3
5.4.1 Extreme Conditions		
a. The updated ETE analysis reflects the impact of EPZ conditions not adequately reflected in the scenario variations.	N/A	This ETE is being updated as a result of the availability of US Census Bureau decennial census data.
5.5 Reception Centers and Congregate Care Center		
a. A map of congregate care centers and reception centers is provided.	Yes	Figure 10-3