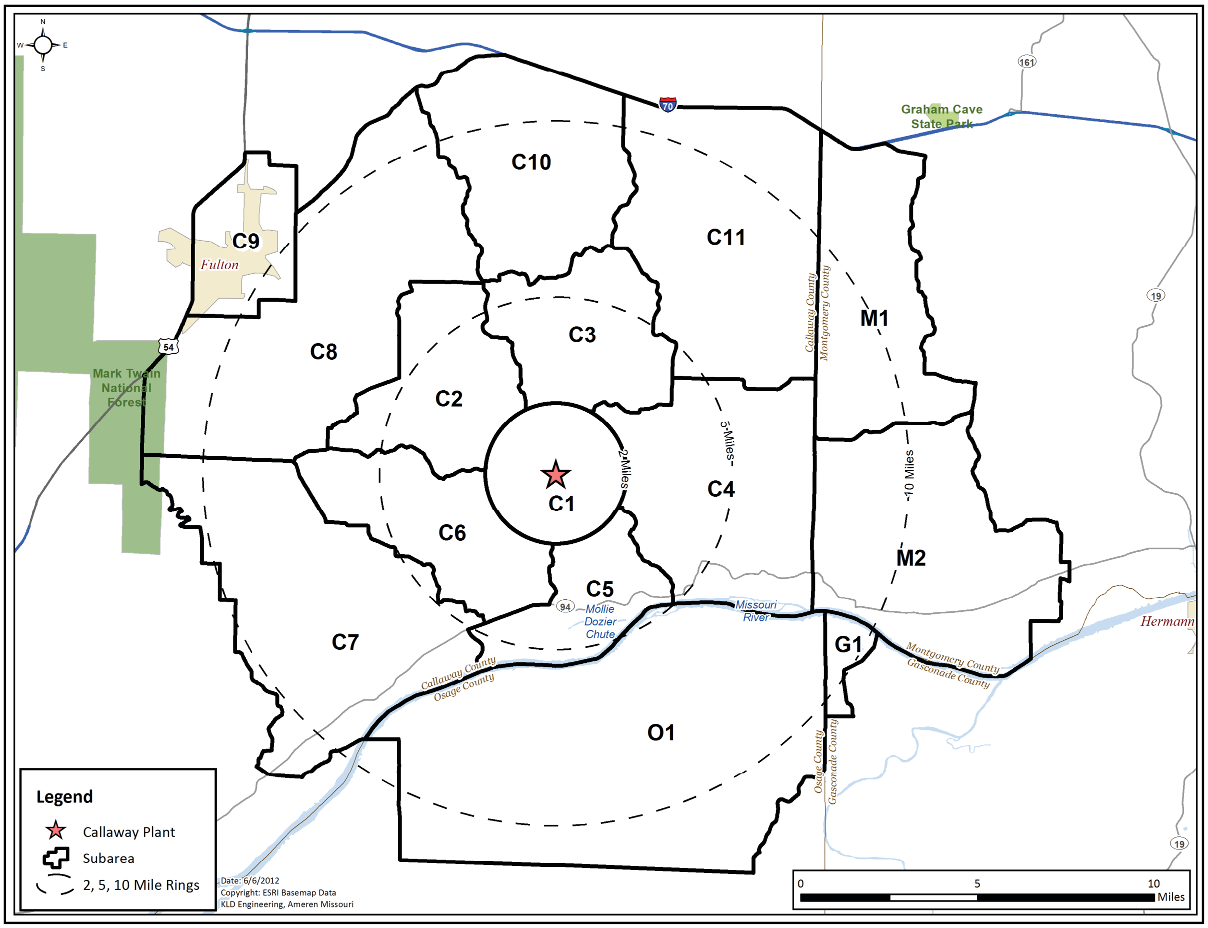
Enclosure
to ULNRC-05881

KLD ENGINEERING, P.C.

Callaway Plant

Development of Evacuation Time Estimates



Work performed for Ameren Missouri, by:

KLD Engineering, P.C.
43 Corporate Drive
Hauppauge, NY 11788
mailto:kweinisch@kldcompanies.com

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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 Callaway Plant located in Reform, MO. ETE are part of the required planning basis and provide Ameren Missouri 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:

- Criteria for Development of Evacuation Time Estimate Studies, NUREG/CR-7002, December 2011.
- Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants, NUREG-0654/FEMA-REP-1, Rev. 1, November 1980.
- Development of Evacuation Time Estimates for Nuclear Power Plants, NUREG/CR-6863, January 2005.
- 10CFR50, Appendix E – “Emergency Planning and Preparedness for Production and Utilization Facilities”

Overview of Project Activities

This project began in July, 2011 and extended over a period of 7 months. The major activities performed are briefly described in chronological sequence:

- Attended “kick-off” meetings with Ameren Missouri personnel and emergency management personnel representing county governments.
- Accessed U.S. Census Bureau data files for the year 2010. Studied Geographical Information Systems (GIS) maps of the area in the vicinity of the Callaway Plant, then conducted a detailed field survey of the highway network.
- Synthesized this information to create an 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.
- Designed and sponsored a telephone survey of residents within the EPZ to gather focused data needed for this ETE study that were not contained within the census database. The survey instrument was reviewed and modified by the licensee and offsite response organization (ORO) personnel prior to the survey.
- Data collection forms (provided to the OROs at the kickoff meeting) were returned with data pertaining to employment, transients, and special facilities in each county. Telephone calls to specific facilities supplemented the data provided.
- The traffic demand and trip-generation rates of evacuating vehicles were estimated

from the gathered data. The trip generation rates reflected the estimated mobilization time (i.e., the time required by evacuees to prepare for the evacuation trip) computed using the results of the telephone survey of EPZ residents.

- Following federal guidelines, the EPZ is subdivided into 15 subareas. These subareas are then grouped within circular areas or "keyhole" configurations (circles plus radial sectors) that define a total of 28 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, Snow). One special event scenario involving construction of new nuclear generating facilities at the Callaway Plant site was considered. One roadway impact scenario was considered wherein a single lane was closed on Interstate 70 for the duration of the evacuation.
- Staged evacuation was considered for those regions wherein the 2 mile radius and sectors downwind to 5 miles were evacuated.
- As per NUREG/CR-7002, the Planning Basis for the calculation of ETE is:
  - A rapidly escalating accident at the Callaway Plant that quickly assumes the status of General Emergency such that the Advisory to Evacuate is virtually coincident with the siren alert, and no early protective actions have been implemented.
  - While an unlikely accident scenario, this planning basis will yield ETE, measured as the elapsed time from the Advisory to Evacuate until the a 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 reception centers 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 provided as specified in the county evacuation plans. Those in special facilities will likewise be evacuated with public transit, as needed: bus, van, or ambulance, as required. Separate ETE are calculated for the transit-dependent evacuees, for homebound special needs population, and for those evacuated from special facilities.

Computation of ETE

A total of 392 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 28 Evacuation Regions to evacuate from that Region, under the circumstances defined for one of the 14

Evacuation Scenarios (28 x 14 = 392). 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% of the population within the EPZ but outside the impacted region will elect to "voluntarily" evacuate. In addition, 20% 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% of the 2-mile region is evacuated, those people beyond 2 miles begin to evacuate. As per federal guidance, 20% 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 the location of the plant), and then simulate 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 value 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.

The use of a public outreach (information) program to emphasize the need for evacuees to minimize the time needed to prepare to evacuate (secure the home, assemble needed clothes, medicines, etc.) should also be considered.

Traffic Management

This study references the comprehensive traffic management plans provided by Callaway, Gasconade, Montgomery and Osage Counties, and identifies critical intersections.

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.

- Figure 6-1 displays a map of the Callaway Plant EPZ showing the layout of the 15 subareas that comprise, in aggregate, the EPZ.
- Table 3-1 presents the estimates of permanent resident population in each subarea based on the 2010 Census data.
- Table 6-1 defines each of the 28 Evacuation Regions in terms of their respective groups of subarea.
- Table 6-2 lists the 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 8-7 presents ETE for the schoolchildren in good weather.
- Table 8-11 presents ETE for the transit-dependent population in good weather.
- 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.

Conclusions

- General population ETE were computed for 392 unique cases – a combination of 28 unique Evacuation Regions and 14 unique Evacuation Scenarios. Table 7-1 and Table 7-2 document these ETE for the 90th and 100th percentiles. These ETE range from 1:15 (hr:min) to 2:55 at the 90th percentile.
- 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 congestion 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. See Figures 7-6 through 7-19.
- 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 R09 with Regions R28, and R22 through R27, respectively, in Tables 7-1 and 7-2). See Section 7.6 for additional discussion.

- Comparison of Scenarios 6 (winter, midweek, midday, good) and 13 (winter, midweek, midday, good) in Table 7-2 indicates that the special event does not materially affect the ETE. See Section 7.5 for additional discussion.
- Comparison of Scenarios 1 and 14 in Table 7-1 indicates that the roadway closure – one lane on I-70 – does not affect the ETE.
- Fulton is the most congested area during an evacuation and the last location in the EPZ to exhibit traffic congestion is US-54 northbound, just north of Fulton. All congestion within the EPZ clears by 1 hour and 45 minutes after the Advisory to Evacuate. See Section 7.3 and Figures 7-3 through 7-8.
- Separate ETE were computed for schools, medical facilities, transit-dependent persons, homebound special needs persons and correctional facilities. The average single-wave ETE for these facilities are within a similar range as the general population ETE at the 90^{th} percentile. See Section 8.
- Table 8-5 indicates that there is enough transportation available to evacuate special facilities in a single wave; however, the transit-dependent population requires a second wave evacuation. The second-wave ETE for exceeds the general population ETE at the 90^{th} percentile. See Sections 8.4 and 8.5.
- The general population ETE at the 90^{th} percentile is relatively insensitive to reductions in the base trip generation time of 4 hours due to the lack of traffic congestion throughout the majority of the EPZ. See Table M-1.
- The general population ETE is insensitive to the voluntary evacuation of vehicles in the Shadow Region. See Table M-2.
- Population changes between ±30% do not result in ETE changes which meet the criteria for updating ETE between decennial Censuses. See Section M.3.
- A sensitivity study was conducted to determine the effect on ETE from the potential construction of two large new units, Units 2 and 3 at the Callaway Plant site, and two proposed roadways (to assist in traffic generated by an increase of construction workers at the new units). Because the existing roadway network has sufficient reserve capacity, the proposed roadways have little effect on ETE. See Section M.4.

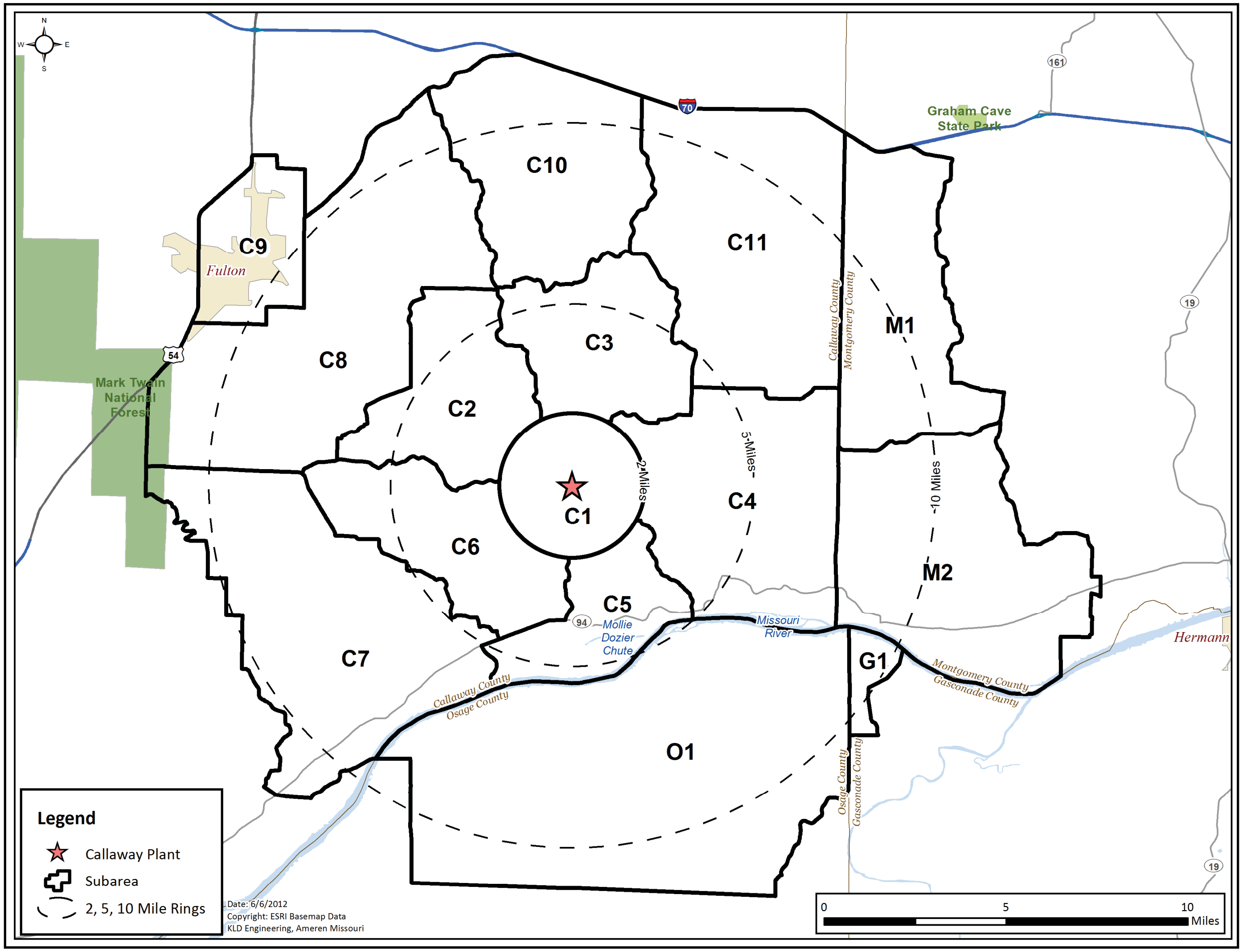

Figure 6-1. EPZ Subareas

Table 3-1. EPZ Permanent Resident Population

Subarea	2000 Population	2010 Population
C1	78	90
C2	363	363
C3	339	441
C4	322	264
C5	72	86
C6	451	492
C7	1,279	1,406
C8	2,462	2,493
C9	11,723	12,112
C10	417	544
C11	258	239
G1	102	107
M1	209	181
M2	555	496
O1	996	859
TOTAL	**19,626**	**20,173**
EPZ Population Growth:		**2.79%**

Table 6-1. Description of Evacuation Regions

Region	Description	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	G1	M1	M2	O1
Basic Regions																
		Subarea														
Region	**Description**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**G1**	**M1**	**M2**	**O1**
R01	2-Mile Radius	X														
R02	5-Mile Radius	X	X	X	X	X	X									
R03	Full EPZ	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Evacuate 2-Mile Radius and Downwind to 5 Miles																
		Subarea														
Region	**Wind Direction From:**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**G1**	**M1**	**M2**	**O1**
R04	N, NNE, NE	X				X	X									
R05	ENE, E, ESE,	X	X				X									
R06	SE, SSE, S	X	X	X												
R07	SSW, SW, WSW	X		X	X											
R08	W	X			X											
R09	WNW, NW, NNW	X			X	X										
Evacuate 5-Mile Radius and Downwind to the EPZ Boundary																
		Subarea														
Region	**Wind Direction From:**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**G1**	**M1**	**M2**	**O1**
R10	N	X	X	X	X	X	X									X
R11	NNE, NE	X	X	X	X	X	X	X								X
R12	ENE	X	X	X	X	X	X	X	X							
R13	E, ESE	X	X	X	X	X	X	X	X	X						
R14	SE, SSE	X	X	X	X	X	X		X	X	X					
R15	S	X	X	X	X	X	X		X		X	X				
R16	SSW, SW	X	X	X	X	X	X				X	X		X		
R17	WSW	X	X	X	X	X	X					X		X	X	
R18	W	X	X	X	X	X	X					X	X	X	X	
R19	WNW	X	X	X	X	X	X						X	X	X	X
R20	NW	X	X	X	X	X	X						X		X	X
R21	NNW	X	X	X	X	X	X						X			X
Staged Evacuation - 2-Mile Radius Evacuates, then Evacuate Downwind to 5 Miles																
		Subarea														
Region	**Wind Direction From:**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**G1**	**M1**	**M2**	**O1**
R22	N, NNE, NE	X				X	X									
R23	ENE, E, ESE	X	X				X									
R24	SE, SSE, S	X	X	X												
R25	SSW, SW, WSW	X		X	X											
R26	W	X			X											
R27	WNW, NW, NNW	X			X	X										
R28	No Wind	X	X	X	X	X	X									

Key

Subarea(s) Evacuate	Subarea(s) Shelter-in-Place	Shelter-in-Place until 90% ETE for R01, then 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	Snow	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Rain	None
11	Winter	Weekend	Midday	Snow	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Winter	Midweek	Midday	Good	Construction of new units at the Callaway site
14	Summer	Midweek	Midday	Good	Roadway Impact – Lane Closure on I-70 Outbound

[1] Winter assumes that school is in session (also applies to spring and autumn). Summer assumes that school is not in session.

Table 7-1. Time to Clear the Indicated Area of *90* Percent of the Affected Population

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Midday		Midday		Evening	Midday			Midday			Evening	Midday	Midday
Region	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Construction of New Unit	Roadway Impact
Entire 2-Mile Region, 5-Mile Region, and EPZ														
R01	1:15	1:15	1:25	1:25	1:25	1:15	1:15	1:25	1:25	1:25	2:15	1:25	1:10	1:15
R02	1:55	1:55	1:45	1:45	1:45	1:55	1:55	2:50	1:45	1:45	2:55	1:45	1:30	1:55
R03	2:00	2:05	2:00	2:00	1:55	2:05	2:05	2:35	2:00	2:00	2:30	1:55	2:00	2:10
2-Mile Region and Keyhole to 5 Miles														
R04	1:45	1:45	1:40	1:40	1:40	1:45	1:45	2:35	1:40	1:40	2:50	1:40	1:25	1:45
R05	1:45	1:50	1:45	1:45	1:45	1:45	1:45	2:45	1:45	1:45	2:55	1:45	1:25	1:45
R06	1:45	1:45	1:45	1:45	1:45	1:45	1:45	2:40	1:45	1:45	2:50	1:45	1:20	1:45
R07	1:45	1:45	1:45	1:45	1:45	1:40	1:45	2:30	1:45	1:45	2:50	1:45	1:20	1:45
R08	1:35	1:35	1:40	1:40	1:40	1:35	1:35	2:05	1:40	1:40	2:40	1:40	1:15	1:35
R09	1:35	1:40	1:35	1:40	1:35	1:35	1:40	2:15	1:35	1:40	2:40	1:35	1:15	1:35
5-Mile Region and Keyhole to EPZ Boundary														
R10	2:00	2:00	1:45	1:45	1:45	2:00	2:00	2:55	1:45	1:45	2:55	1:45	1:35	2:00
R11	2:00	2:00	1:45	1:45	1:45	2:00	2:00	3:00	1:45	1:45	2:55	1:45	1:45	2:00
R12	2:00	2:00	1:50	1:50	1:50	2:00	2:00	2:45	1:55	1:55	2:40	1:55	1:50	2:00
R13	2:00	2:00	1:50	1:55	1:50	2:00	2:05	2:55	1:55	1:55	2:45	1:50	1:55	2:00
R14	2:00	2:00	1:55	1:55	1:55	2:00	2:00	2:25	1:55	1:55	2:25	1:55	1:55	2:05
R15	2:00	2:00	1:55	2:00	1:55	2:00	2:00	2:10	2:00	2:00	2:10	2:00	1:55	2:00
R16	2:00	2:00	2:00	2:00	2:00	2:00	2:00	2:10	2:00	2:00	2:15	2:00	1:55	2:00
R17	2:00	2:00	2:00	2:00	2:00	2:00	2:00	2:10	2:00	2:00	2:10	2:00	1:55	2:00
R18	2:00	2:00	2:00	2:00	2:00	2:00	2:00	2:10	2:00	2:00	2:10	2:00	1:55	2:00
R19	2:00	2:00	1:55	2:00	1:55	2:00	2:00	2:10	1:55	2:00	2:10	1:55	1:55	2:00
R20	2:00	2:00	1:45	1:50	1:45	2:00	2:00	3:00	1:45	1:50	2:55	1:45	1:40	2:00
R21	2:00	2:00	1:45	1:45	1:45	2:00	2:00	2:55	1:45	1:45	2:55	1:45	1:35	2:00
Staged Evacuation - 2-Mile Region and Keyhole to 5 Miles														
R22	1:45	1:45	1:45	1:45	1:45	1:45	1:45	2:35	1:45	1:45	2:50	1:45	1:30	1:45
R23	1:50	1:50	1:45	1:45	1:45	1:45	1:50	2:45	1:45	1:45	2:55	1:45	1:35	1:50
R24	1:45	1:50	1:45	1:50	1:45	1:45	1:45	2:40	1:45	1:50	2:55	1:45	1:35	1:45
R25	1:50	1:50	1:50	1:50	1:50	1:50	1:50	2:35	1:50	1:50	2:55	1:50	1:30	1:50
R26	1:45	1:45	1:45	1:50	1:45	1:45	1:45	2:05	1:45	1:50	2:50	1:45	1:20	1:45
R27	1:45	1:45	1:45	1:50	1:45	1:45	1:45	2:15	1:45	1:50	2:50	1:45	1:25	1:45
R28	1:55	1:55	1:50	1:50	1:50	1:55	1:55	2:50	1:50	1:50	2:55	1:50	1:40	1:55

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

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Midday		Midday		Evening	Midday			Midday			Evening	Midday	Midday
Region	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Construction of New Unit	Roadway Impact
Entire 2-Mile Region, 5-Mile Region, and EPZ														
R01	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R02	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
R03	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:15
2-Mile Region and Keyhole to 5 Miles														
R04	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
R05	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
R06	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
R07	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
R08	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
R09	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
5-Mile Region and Keyhole to EPZ Boundary														
R10	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:10
R11	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:10
R12	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:10
R13	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:10
R14	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:10
R15	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:10
R16	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:10
R17	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:10
R18	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:10
R19	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:10
R20	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:10
R21	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:10
Staged Evacuation - 2-Mile Region and Keyhole to 5 Miles														
R22	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
R23	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
R24	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
R25	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
R26	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
R27	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
R28	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05

Table 7-3. Time to Clear *__90__* Percent of the 2-Mile Region

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek	Midweek
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Region	Midday				Midday				Evening			Midday		
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Construction of New Unit	Roadway Impact
Entire 2-Mile Region and 5-Mile Region														
R01	1:15	1:15	1:25	1:25	1:25	1:15	1:15	1:25	1:25	1:25	2:15	1:25	1:10	1:15
R02	1:15	1:15	1:25	1:25	1:25	1:15	1:15	1:25	1:25	1:25	2:15	1:30	1:10	1:15
2-Mile Region and Keyhole to 5 Miles														
R04	1:15	1:15	1:25	1:25	1:25	1:15	1:15	1:25	1:25	1:25	2:15	1:25	1:25	1:15
R05	1:15	1:15	1:25	1:25	1:25	1:15	1:15	1:25	1:25	1:25	2:15	1:25	1:25	1:15
R06	1:15	1:15	1:30	1:30	1:30	1:15	1:15	1:25	1:30	1:30	2:15	1:30	1:20	1:15
R07	1:15	1:15	1:30	1:30	1:30	1:15	1:15	1:25	1:30	1:30	2:15	1:30	1:20	1:15
R08	1:15	1:15	1:30	1:30	1:30	1:15	1:15	1:25	1:30	1:30	2:15	1:30	1:20	1:15
R09	1:15	1:15	1:30	1:30	1:30	1:15	1:15	1:25	1:30	1:30	2:15	1:30	1:20	1:15
Staged Evacuation - 2-Mile Region and Keyhole to 5 Miles														
R22	1:15	1:15	1:25	1:25	1:25	1:15	1:15	1:25	1:25	1:25	2:15	1:25	1:20	1:15
R23	1:15	1:15	1:25	1:25	1:25	1:15	1:15	1:25	1:25	1:25	2:15	1:25	1:20	1:15
R24	1:15	1:15	1:25	1:25	1:25	1:15	1:15	1:25	1:25	1:25	2:15	1:25	1:20	1:15
R25	1:15	1:15	1:25	1:25	1:25	1:15	1:15	1:25	1:25	1:25	2:15	1:25	1:20	1:15
R26	1:15	1:15	1:25	1:25	1:25	1:15	1:15	1:25	1:25	1:25	2:15	1:25	1:20	1:15
R27	1:15	1:15	1:25	1:25	1:25	1:15	1:15	1:25	1:25	1:25	2:15	1:25	1:20	1:15
R28	1:15	1:15	1:25	1:25	1:25	1:15	1:15	1:25	1:25	1:25	2:15	1:25	1:20	1:15

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

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Region	Midday		Midday		Evening	Midday			Midday			Evening	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Construction of New Unit	Roadway Impact
Entire 2-Mile Region and 5-Mile Region														
R01	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R02	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
2-Mile Region and Keyhole to 5 Miles														
R04	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R05	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R06	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R07	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R08	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R09	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
Staged Evacuation - 2-Mile Region and Keyhole to 5 Miles														
R22	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R23	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R24	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R25	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R26	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R27	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R28	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00

Table 8-7. School Evacuation Time Estimates – Good Weather

School	Driver Mobilization Time	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.C. (mi.)	Travel Time from EPZ Bdry to R.C. (min)	ETE to R.C. (hr:min)
CALLAWAY COUNTY SCHOOLS									
Bartley Elementary School	90	15	1.5	40.8	3	**1:50**	22.6	31	**2:20**
Bush Elementary School	90	15	2.4	31.3	5	**1:50**	22.6	31	**2:25**
Fulton High School	90	15	1.6	43.5	3	**1:50**	26.1	35	**2:25**
Fulton Middle School	90	15	2.1	35.6	4	**1:50**	22.6	31	**2:20**
Kingdom Christian Academy	90	15	2.1	34.9	4	**1:50**	22.6	31	**2:20**
McIntire Elementary School	90	15	1.0	45.0	2	**1:50**	22.6	31	**2:20**
Missouri School for the Deaf	90	15	1.7	31.1	4	**1:50**	22.6	31	**2:20**
South Callaway Elementary School	90	15	6.0	45.0	8	**1:55**	17.7	24	**2:20**
South Callaway High School	90	15	6.0	45.0	8	**1:55**	17.7	24	**2:20**
South Callaway Middle School	90	15	6.0	45.0	8	**1:55**	17.7	24	**2:20**
St. Peter Catholic School	90	15	3.0	33.3	6	**1:55**	26.1	35	**2:30**
Westminster College	90	15	1.1	45.0	2	**1:50**	22.6	31	**2:20**
William Woods University	90	15	3.0	36.3	5	**1:50**	26.1	35	**2:25**
OSAGE COUNTY SCHOOLS									
Osage County Chamois R-1 School District	30	5	9.1	45.0	13	**0:50**	30.0	40	**1:30**
					Maximum for EPZ:	**1:55**		**Maximum:**	**2:30**
					Average for EPZ:	**1:50**		**Average:**	**2:20**

Table 8-11. Transit-Dependent Evacuation Time Estimates – Good Weather

Route Number	Bus Number	One-Wave						Two-Wave						
		Mobilization	Length (miles)	Speed (mph)	Route Travel Time	Pickup Time	ETE	Dist. EPZ Bdry to R.C. (miles)	Travel Time to Rec. Ctr	Unload	Driver Rest	Route Travel Time	Pickup Time	ETE
1	1	90	14.0	45.0	19	30	**2:20**	17.7	24	5	10	42	30	**4:10**
	2	110	14.0	45.0	19	30	**2:40**	17.7	24	5	10	42	30	**4:30**
2	1	90	12.5	40.6	18	30	**2:20**	22.6	30	5	10	48	30	**4:25**
	2	110	12.5	40.3	19	30	**2:40**	22.6	30	5	10	49	30	**4:45**
3	1	90	11.2	42.7	16	30	**2:20**	26.1	35	5	10	50	30	**4:30**
	2	110	11.2	42.5	16	30	**2:40**	26.1	35	5	10	51	30	**4:50**
4	1	90	4.8	30.8	9	30	**2:10**	26.1	35	5	10	44	30	**4:15**
	2	110	4.8	31.7	9	30	**2:30**	26.1	35	5	10	44	30	**4:35**
5	1	90	10.0	45.0	13	30	**2:15**	11.0	15	5	10	31	30	**3:45**
	2	110	10.0	45.0	13	30	**2:35**	11.0	15	5	10	28	31	**4:05**
						Maximum ETE:	**2:40**						**Maximum ETE:**	**4:50**
						Average ETE:	**2:30**						**Average ETE:**	**4:25**

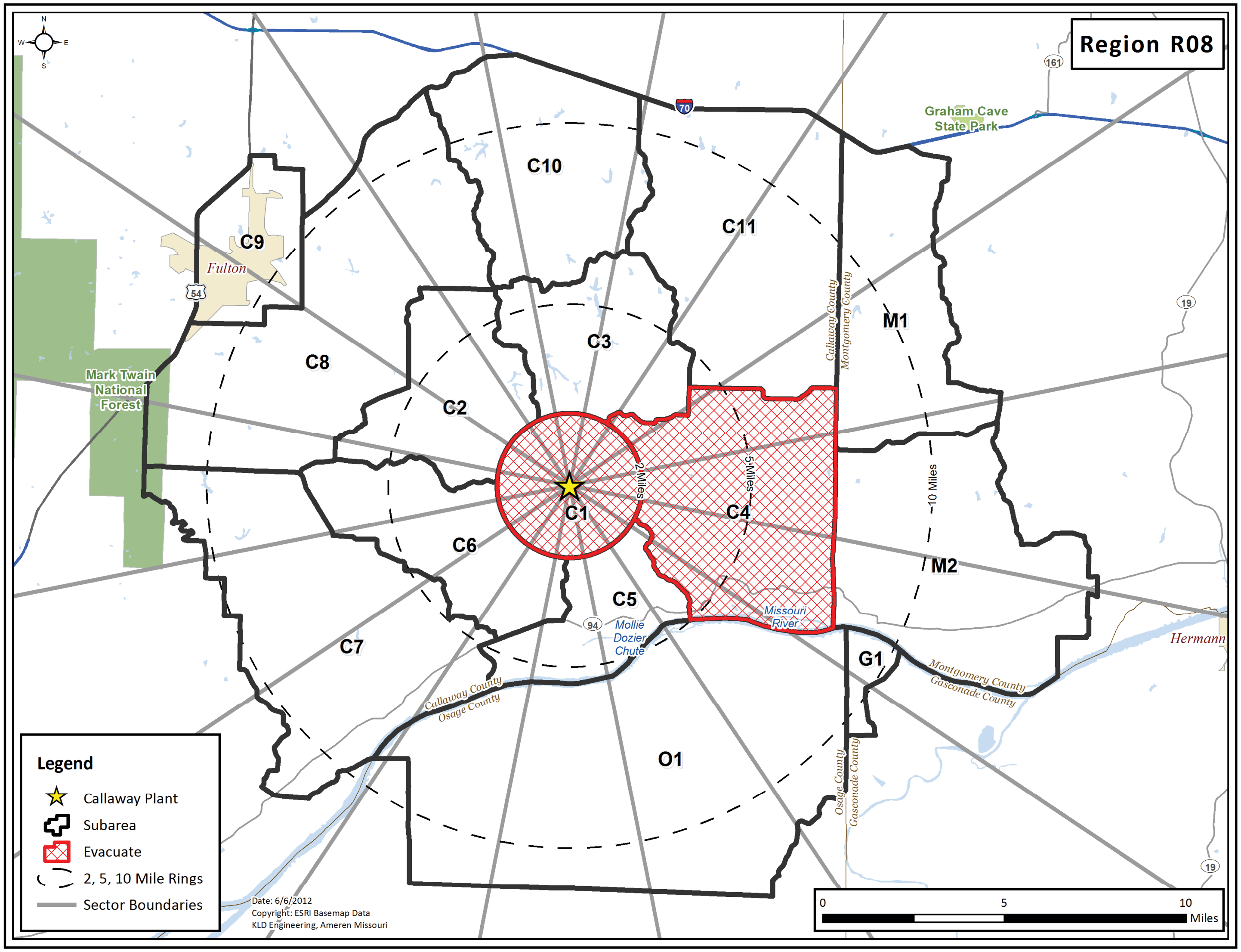

Figure H-8. Region R08

1 INTRODUCTION

This report describes the analyses undertaken and the results obtained by a study to develop Evacuation Time Estimates (ETE) for the Callaway Plant, located 10 miles southeast of Fulton, MO. ETE provide 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 Government agencies. Most important of these are:

- Criteria for Development of Evacuation Time Estimate Studies, NUREG/CR-7002, December 2011.
- Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants, NUREG 0654/FEMA REP 1, Rev. 1, November 1980.
- Analysis of Techniques for Estimating Evacuation Times for Emergency Planning Zones, NUREG/CR 1745, November 1980.
- 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.

Table 1-1. Stakeholder Interaction

Stakeholder	Nature of Stakeholder Interaction
Ameren emergency planning personnel	Meetings to define data requirements and set up contacts with local government agencies
Callaway, Gasconade, Montgomery, and Osage County Emergency Management Departments (EMD)	Obtain existing traffic management plans and special facility data
Missouri State Emergency Management Department	Obtain County Implementing Procedures and Radiological Emergency Response Plans

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 Ameren Missouri.
    b. Attended meetings with emergency planners from Callaway Plant, Callaway

County EMD, Gasconade County EMD, Montgomery County EMD, and Osage County EMD to identify issues to be addressed and resources available.

c. Conducted a detailed field survey of the highway system and of area traffic conditions within the Emergency Planning Zone (EPZ) and Shadow Region.

d. Obtained demographic data from census, state and local agencies.

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.

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 (TCP) located within the EPZ.

5. Used existing subareas to define Evacuation Regions. The EPZ is partitioned into 15 subareas along jurisdictional and geographic boundaries. "Regions" are groups of contiguous subareas 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.

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 system.

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

    b. Applied the procedures specified in the 2010 Highway Capacity Manual (HCM[1]) to the data acquired during the field survey, to estimate the capacity of all highway segments comprising the evacuation routes.

    c. Developed the link-node representation of the evacuation network, which is

[1] Highway Capacity Manual (HCM 2010), Transportation Research Board, National Research Council, 2010.

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

8. Executed the DYNEV II model to provide the estimates of evacuation routing and 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.

10. Calculated the ETE for all transit activities including those for special facilities (schools, medical facilities, etc.), for the transit-dependent population and for homebound special needs population.

1.2 The Callaway Plant Location

The Callaway Plant is about 5 miles north of the Missouri River and 10 miles southeast of Fulton. The site is approximately 25 miles northeast of Jefferson City, 30 miles southeast of Columbia, and 80 miles west of St. Louis. The EPZ consists of parts of Callaway, Gasconade, Montgomery, and Osage Counties in Missouri. Figure 1-1 displays the area surrounding the Callaway Plant. This map identifies the cities in the area and the major roads.

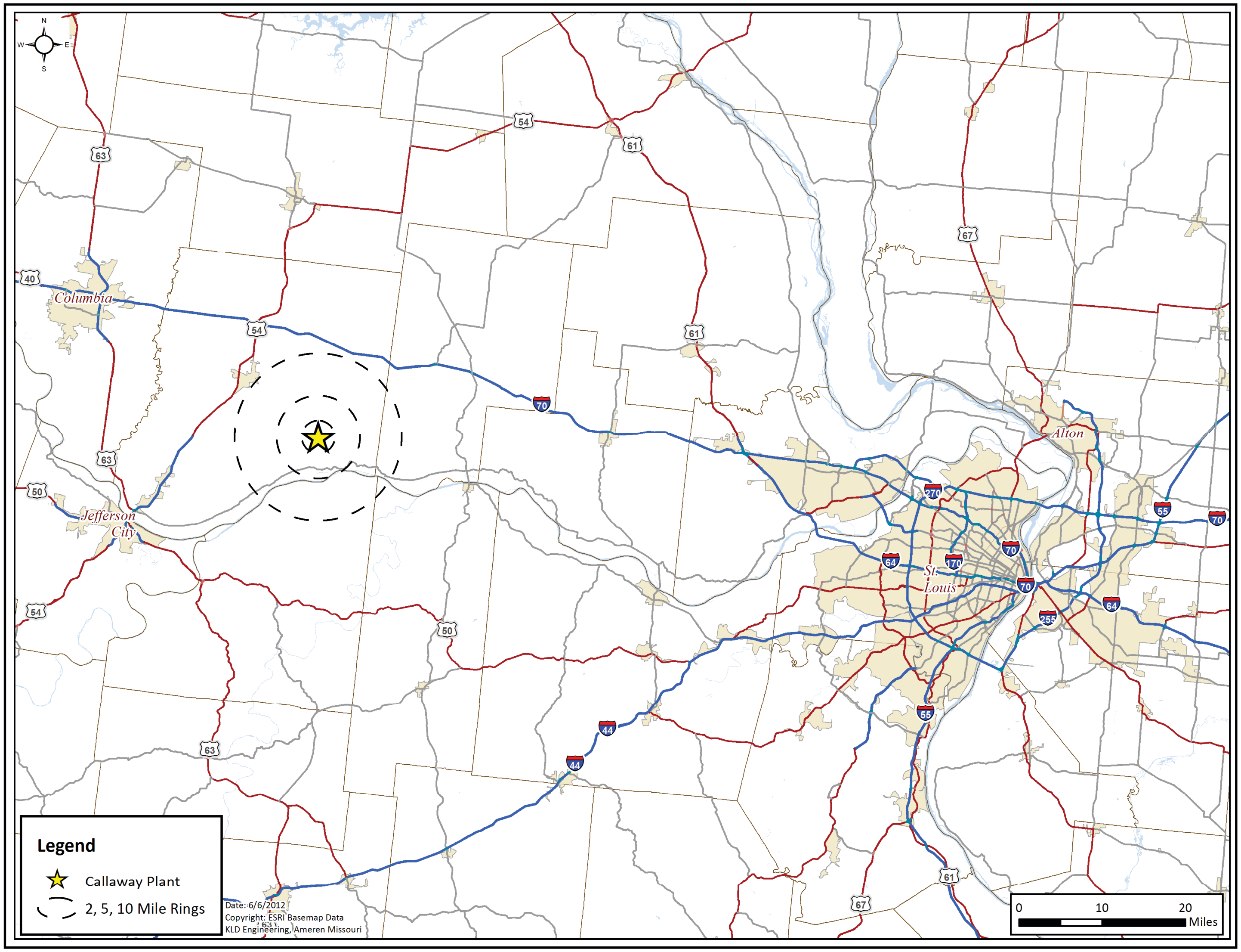

Figure 1-1. Callaway Plant Location

1.3 Preliminary Activities

These activities are described below.

Field Surveys of the Highway Network

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:

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.

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 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 15-30 in the HCM 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 geographical 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.

As documented on page 15-5 of the HCM 2010, the capacity of a two-lane highway is 1700 passenger cars per hour in one direction. For freeway sections, a value of 2250 vehicles per hour per lane is assigned, as per Exhibit 11-17 of the HCM 2010. 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 15-30. These links may be identified by reviewing Appendix K. 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 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>Telephone Survey</u>

A telephone survey was undertaken to gather information needed for the evacuation study. Appendix F presents the survey instrument, the procedures used and tabulations of data compiled from the survey returns.

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.

<u>Developing the Evacuation Time Estimates</u>

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.

<u>Analytical Tools</u>

The DYNEV II System that was employed for this study is comprised of several integrated computer models. One of these is the DYNEV (<u>DY</u>namic <u>N</u>etwork <u>EV</u>acuation) macroscopic simulation model, a new version of the IDYNEV model that was developed by KLD under contract with the Federal Emergency Management Agency (FEMA).

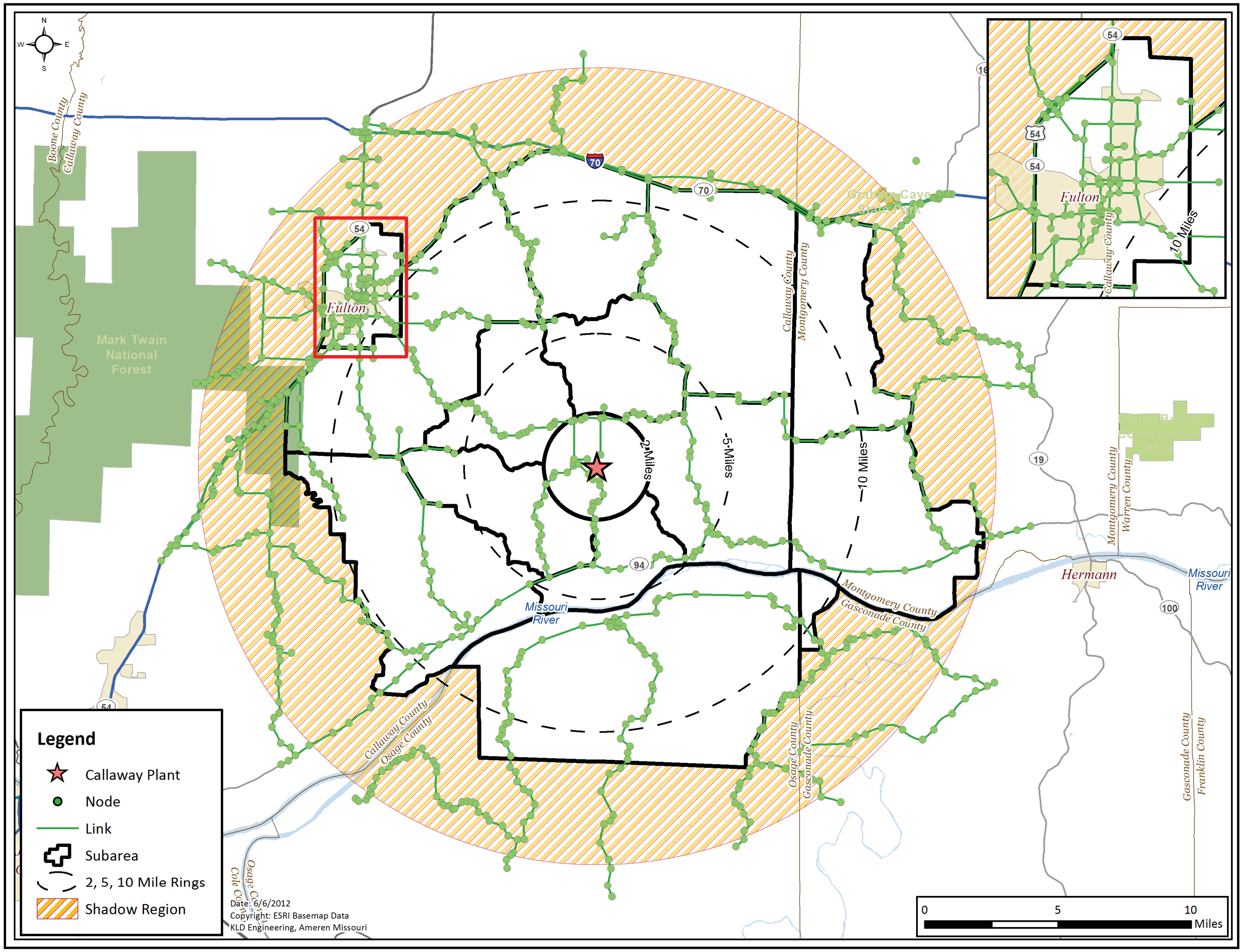

Figure 1-2. Callaway Plant Link-Node Analysis Network

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 Callaway 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 2009 study. The major factors contributing to the differences between the ETE values obtained in this study and those of the previous study can be summarized as follows:

- Vehicle occupancy and trip-generation rates are based on the results of a telephone survey of EPZ residents.
- Voluntary and shadow evacuations are considered.
- The highway representation is far more detailed.
- Dynamic evacuation modeling.

Table 1-3. ETE Study Comparisons

Topic	Previous ETE Study	Current ETE Study
Resident Population Basis	2008 US Census Data; Population = 20,028	ArcGIS Software using 2010 US Census blocks; area ratio method used. Population = 20,173
Resident Population Vehicle Occupancy	Used 1.470 vehicles available per occupied housing unit, based on the most conservative vehicle availability factor in the 4-county region.	2.40 persons/household, 1.35 evacuating vehicles/household yielding: 1.78 persons/vehicle.
Employee Population	For the worker populations, 1.3 persons per vehicle is assumed for evacuating temporary workers (construction and outage workers), and 1.0 person per evacuating vehicle is assumed for regular plant workers.	Data was provided by offsite agencies and supplemented by data gathered in phone calls to major employers. 1.09 employees per vehicle based on telephone survey results.
Voluntary evacuation from within EPZ in areas outside region to be evacuated	Not considered.	20% of the population within the EPZ, but not within the Evacuation Region (see Figure 2-1).
Shadow Evacuation	Not considered.	20% of people outside of the EPZ within the Shadow Region (see Figure 7-2).
Network Size	Major evacuation routes considered.	1,086 links; 918 nodes.
Roadway Geometric Data	The location, types, and capacities of the local roadways were examined.	Field surveys conducted in July, 2011. Roads and intersections are video archived and capacities are based on 2010 HCM.

Topic	Previous ETE Study	Current ETE Study
School Evacuation	Direct evacuation to designated Reception Center.	Direct evacuation to designated Reception Center.
Transit- Dependent Population	The traffic demand for this population group is already accounted for in the factoring of the general population statistics to calculate the traffic demand estimate.	Transit-Dependent population estimated using population estimates and results of telephone survey.
Ridesharing	It is assumed that many of these people would be able to ride with friends or family who do own autos.	50 percent of transit-dependent persons will evacuate with a neighbor or friend.
Trip Generation for Evacuation	Assumed mobilization time of 60 minutes for general population, 65 minutes for plant worker families, and 15 minutes for transients.	Based on residential telephone survey of specific pre-trip mobilization activities: Residents with commuters returning leave between 40 and 220 minutes. Residents without commuters returning leave within 200 minutes. Employees and transients leave within 100 minutes. All times measured from the Advisory to Evacuate.
Weather	Adverse conditions considered.	Normal, Rain, or Snow. The capacity and free flow speed of all links in the network are reduced by 10% in the event of rain and 20% for snow.
Computational Modeling	Static calculations.	DYNEV II System – Version 4.0.0.0
Special Events	Not considered.	Construction of a new unit at the Callaway Plant site.
Evacuation Cases	15 Subareas plus 2-mile, 5-mile, and 10-mile rings.	28 Regions (central sector wind direction and each adjacent sector technique used) and 14 Scenarios producing 392 unique cases.
Evacuation Time Estimates Reporting ETE for the entire EPZ, 100^{th} percentile	General value for 20 population groups. Normal Conditions: 3:50 Adverse conditions: 4:33	ETE reported for 90^{th} and 100^{th} percentile population. Results presented by Region and Scenario. Winter, Midweek, Midday: 4:10 Winter, Midweek, Midday, Rain: 4:10

2 STUDY ESTIMATES AND ASSUMPTIONS

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

2.1 Data Estimates

1. Population estimates are based upon Census 2010 data.
2. Estimates of employees who reside outside the EPZ and commute to work within the EPZ are based upon data obtained from surveys of major employers in the EPZ.
3. Population estimates at special facilities are based on available data from county emergency management offices and from phone calls to specific facilities.
4. Roadway capacity estimates are based on field surveys and the application of the Highway Capacity Manual 2010.
5. Population mobilization times are based on a statistical analysis of data acquired from a random sample telephone survey of EPZ residents (see Section 5 and Appendix F).
6. The relationship between resident population and evacuating vehicles is developed from the telephone survey. Average values of 2.40 persons per household and 1.35 evacuating vehicles per household are used. The relationship between persons and vehicles for special facilities is as follows:
    a. Employees: 1.09 employees per vehicle (telephone survey results) for all major employers.
    b. Parks: Vehicle occupancy varies based upon data gathered from local transient facilities.
    c. Special Event Scenario: The construction of new units at the Callaway Plant site is considered with an estimated vehicle occupancy of 1.09 employees per vehicle, derived from the telephone survey.

2.2 Study Methodological Assumptions

1. ETE are presented for the evacuation of the 90th and 100th percentiles of population for each Region and for each Scenario. 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. A Region is defined as a group of subareas that is issued an Advisory to Evacuate. A scenario is a combination of circumstances, including time of day, day of week, season, and weather conditions.
2. The ETE are computed and presented in tabular format and graphically, in a format compliant with NUREG/CR-7002.
3. Evacuation movements (paths of travel) are generally outbound relative to the plant to the extent permitted by the highway network. All major evacuation routes are used in the analysis.
4. Regions are defined by the underlying “keyhole” or circular configurations as specified in Section 1.4 of NUREG/CR-7002. These Regions, as defined, display irregular boundaries reflecting the geography of the subareas included within these underlying configurations.
5. As indicated in Figure 2-2 of NUREG/CR-7002, 100% of people within the impacted “keyhole” evacuate. 20% of those people within the EPZ, not within the impacted keyhole, will voluntarily evacuate. 20% of those people within the Shadow Region will voluntarily evacuate. See Figure 2-1 for a graphical representation of these evacuation percentages. Sensitivity studies explore the effect on ETE of increasing the percentage of voluntary evacuees in the Shadow Region (see Appendix M).
6. A total of 14 “Scenarios” representing different temporal variations (season, time of day, day of week) and weather conditions are considered. These Scenarios are outlined in Table 2-1.
7. Scenario 14 considers the closure of a single lane on Interstate-70 for the entirety of the analysis network. The lane closure is in the direction away from the plant: one lane in the eastbound direction west of the Missouri Z interchange and one lane in the westbound direction east of the Missouri Z interchange.
8. 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[1]). 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. There are two correctional facilities within the EPZ – The Fulton Reception and Diagnostic Center and the Callaway County Jail. Both of these facilities will shelter in place in the event of an evacuation in accordance with state and county plans.

[1] Urbanik, T., et. al. Benchmark Study of the I-DYNEV Evacuation Time Estimate Computer Code, NUREG/CR-4873, Nuclear Regulatory Commission, June, 1988.

Table 2-1. 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	Snow	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Rain	None
11	Winter	Weekend	Midday	Snow	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Winter	Midweek	Midday	Good	Construction new units at the Callaway site
14	Summer	Midweek	Midday	Good	Roadway Impact – Lane Closure on I-70

[2] Winter assumes that school is in session (also applies to spring and autumn). Summer assumes that school is not in session.

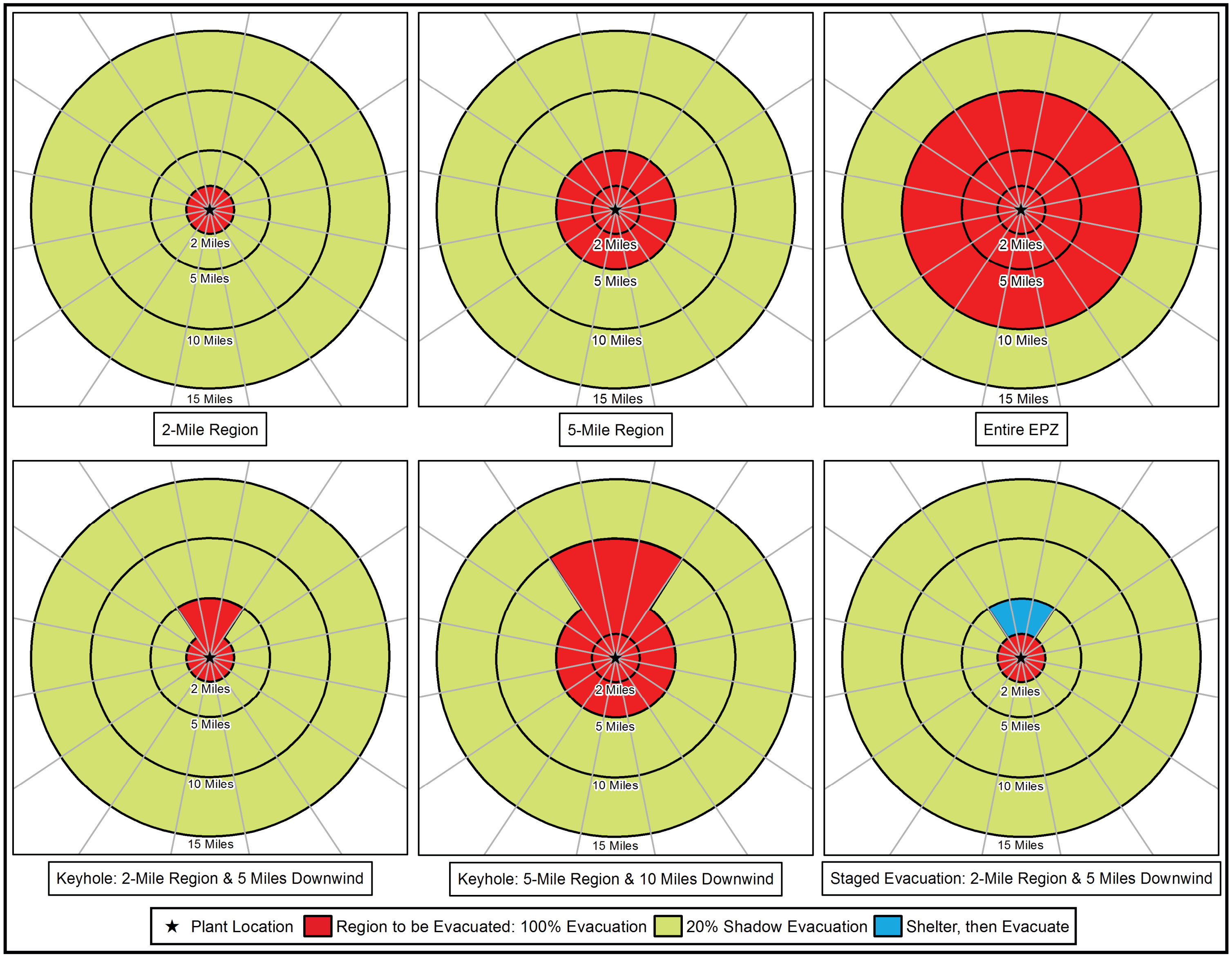

Figure 2-1. Voluntary Evacuation Methodology

2.3 Study Assumptions

1. The Planning Basis Assumption for the calculation of ETE is a rapidly escalating accident that requires evacuation, and includes the following:
    a. Advisory to Evacuate 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 Advisory to Evacuate.
2. It is assumed that everyone within the group of subareas forming a Region that is issued an Advisory to Evacuate will, in fact, respond and evacuate in general accord with the planned routes.
3. 60 percent of the households in the EPZ have at least 1 commuter; 48 percent of those households with commuters will await the return of a commuter before beginning their evacuation trip, based on the telephone survey results. Therefore 29 percent (60% x 48% = 29%) of EPZ households will await the return of a commuter, prior to beginning their evacuation trip.
4. The ETE will also include 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.
5. Access Control Points (ACP) will be staffed within approximately 120 minutes following the siren notifications, to divert traffic attempting to enter the EPZ. Earlier activation of ACP locations could delay returning commuters. It is assumed that no through traffic will enter the EPZ after this 120 minute time period.
6. Traffic Control Points (TCP) within the EPZ will be staffed over time, beginning at the Advisory to Evacuate. Their number and location will depend on the Region to be evacuated and resources available. The objectives of these TCP are:
    a. Facilitate the movements of all (mostly evacuating) vehicles at the location.
    b. Discourage inadvertent vehicle movements towards the plant.
    c. Provide assurance and guidance to any traveler who is unsure of the appropriate actions or routing.
    d. Act as local surveillance and communications center.
    e. Provide information to the emergency operations center (EOC) as needed, based on direct observation or on information provided by travelers.

    In calculating ETE, it is assumed that evacuees will drive safely, travel in directions identified in the plan, and obey all control devices and traffic guides.

7. Buses will be used to transport those without access to private vehicles:
    a. If schools are in session, transport (buses) will evacuate students directly to the designated reception centers.
    b. It is assumed parents will pick up children at day care centers prior to evacuation.
    c. Buses, wheelchair vans and ambulances will evacuate patients at medical facilities and at any senior facilities within the EPZ, as needed.
    d. Transit-dependent general population will be evacuated to reception centers.
    e. Schoolchildren, if school is in session, are given priority in assigning transit vehicles.
    f. Bus mobilization time is considered in ETE calculations.
    g. Analysis of the number of required round-trips ("waves") of evacuating transit vehicles is presented.
8. Provisions are made for evacuating the transit-dependent portion of the general population to reception centers by bus, based on the assumption that some of these people will ride-share with family, neighbors, and friends, thus reducing the demand for buses. We assume that the percentage of people who rideshare is 50 percent. This assumption is based upon reported experience for other emergencies[3], and on guidance in Section 2.2 of NUREG/CR-7002.
9. Two types of adverse weather scenarios are considered. Rain may occur for either winter or summer scenarios; snow occurs in winter scenarios only. It is assumed that the rain or snow 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 plowing the roads as they would normally when snowing.

    Adverse weather scenarios affect roadway capacity and the free flow highway speeds. The factors applied for the ETE study are based on recent research on the effects of weather on roadway operations[4]; the factors are shown in Table 2-2.

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[3] Institute for Environmental Studies, University of Toronto, THE MISSISSAUGA EVACUATION FINAL REPORT, June 1981. The report indicates that 6,600 people of a transit-dependent population of 8,600 people shared rides with other residents; a ride share rate of 76% (Page 5-10).

[4] Agarwal, M. et. Al. Impacts of Weather on Urban Freeway Traffic Flow Characteristics and Facility Capacity, Proceedings of the 2005 Mid-Continent Transportation Research Symposium, August, 2005. The results of this paper are included as Exhibit 10-15 in the HCM 2010.

10. School buses used to transport students are assumed to transport 70 students per bus for elementary schools and 50 students per bus for middle and high schools, based on discussions with county offices of emergency management. Transit buses used to transport the transit-dependent general population are assumed to transport 30 people per bus.

Table 2-2. Model Adjustment for Adverse Weather

Scenario	Highway Capacity*	Free Flow Speed*	Mobilization Time for General Population
Rain	90%	90%	No Effect
Snow	80%	80%	Clear driveway before leaving home (Source: Telephone Survey)
*Adverse weather capacity and speed values are given as a percentage of good weather conditions. Roads are assumed to be passable.			

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 2010 Census, however, 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 Callaway Plant 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 businesses 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 subarea and by polar coordinate representation (population rose). The Callaway EPZ is subdivided into 15 subareas. The EPZ is shown in Figure 3-1.

3.1 Permanent Residents

The primary source for estimating permanent population is the latest U.S. Census data. The average household size (2.40 persons/household – See Figure F-1) and the number of evacuating vehicles per household (1.35 vehicles/household – See Figure F-8) were adapted from the telephone survey results.

Population estimates are based upon Census 2010 data. Table 3-1 provides the permanent resident population within the EPZ, by subarea.

The year 2010 permanent resident population is divided by the average household size and then multiplied by the average number of evacuating vehicles per household in order to estimate number of vehicles. In Subarea C9, an additional step was taken to remove resident vehicles associated with the Fulton Reception and Diagnostic Center, a correctional facility that does not evacuate, and to alter the vehicle numbers for the two higher education facilities as described in Section 3.6. 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 the Callaway Plant. This "rose" was constructed using GIS software.

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 two-week 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.

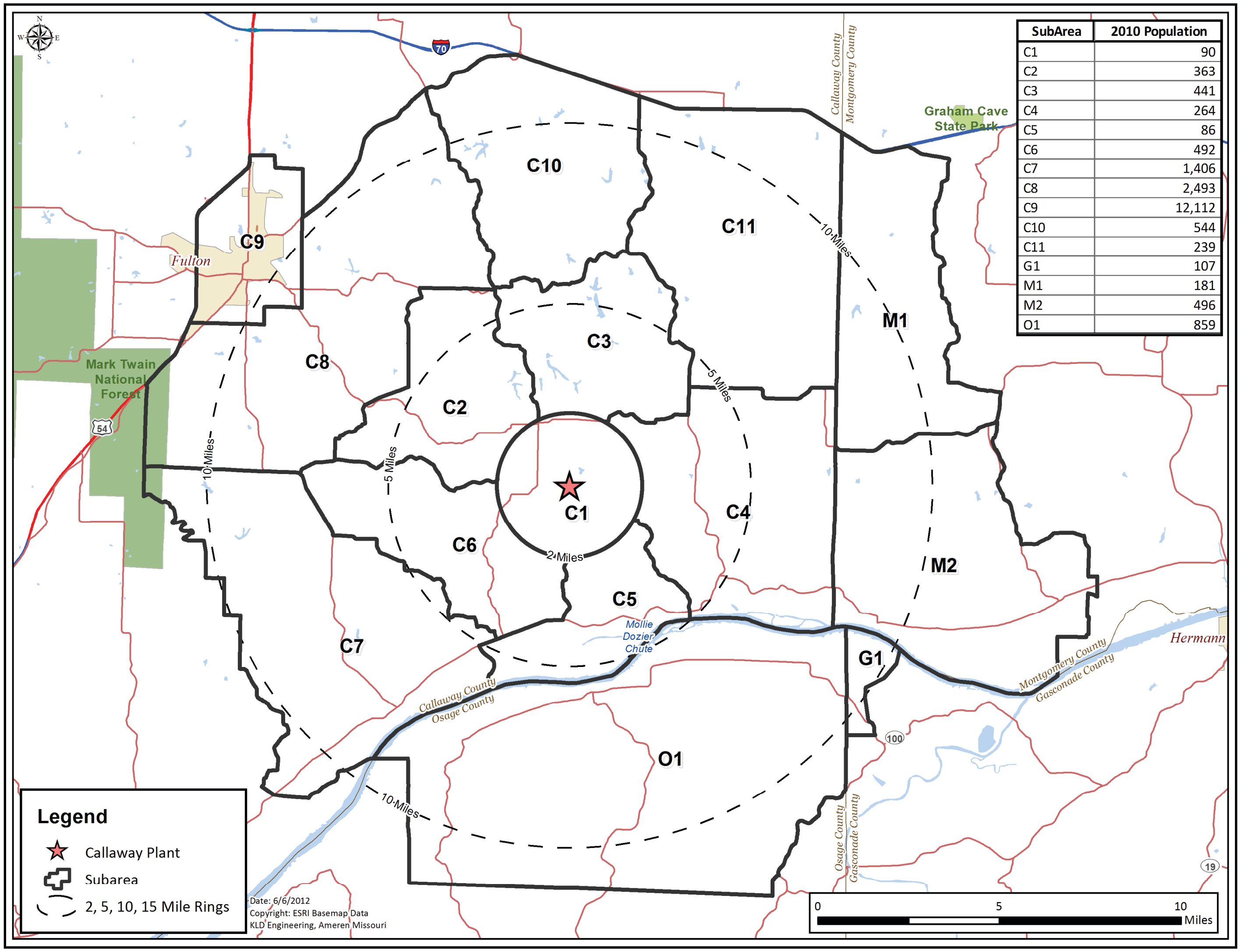


Figure 3-1. Callaway Plant EPZ

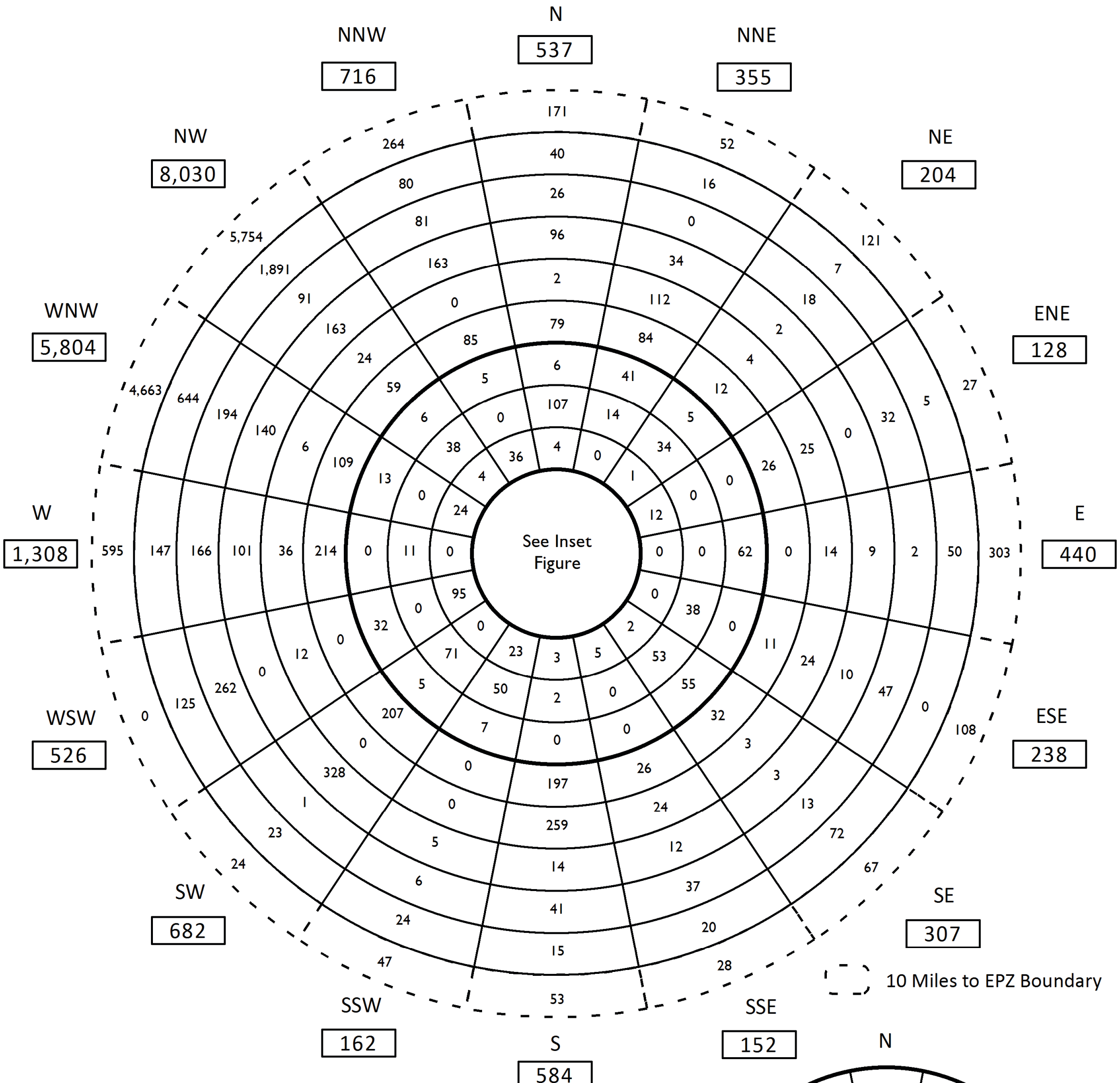
Table 3-1. EPZ Permanent Resident Population

Subarea	2000 Population	2010 Population
C1	78	90
C2	363	363
C3	339	441
C4	322	264
C5	72	86
C6	451	492
C7	1,279	1,406
C8	2,462	2,493
C9	11,723	12,112
C10	417	544
C11	258	239
G1	102	107
M1	209	181
M2	555	496
O1	996	859
TOTAL	**19,626**	**20,173**
EPZ Population Growth:		**2.79%**

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

Subarea	2010 Population	2010 Vehicles
C1	90	50
C2	363	202
C3	441	249
C4	264	151
C5	86	49
C6	492	276
C7	1,406	792
C8	2,493	1,395
C9	12,112	6,396*
C10	544	304
C11	239	135
G1	107	60
M1	181	104
M2	496	279
O1	859	487
TOTAL	**20,173**	**10,929**

*Altered based on correctional and higher education facilities located in Subarea C9.



Resident Population

Miles	Subtotal by Ring	Cumulative Total
0 - 1	0	0
1 - 2	90	90
2 - 3	209	299
3 - 4	418	717
4 - 5	237	954
5 - 6	1,141	2,095
6 - 7	545	2,640
7 - 8	1,080	3,720
8 - 9	1,017	4,737
9 - 10	3,159	7,896
10 - EPZ	12,277	20,173
	Total:	20,173

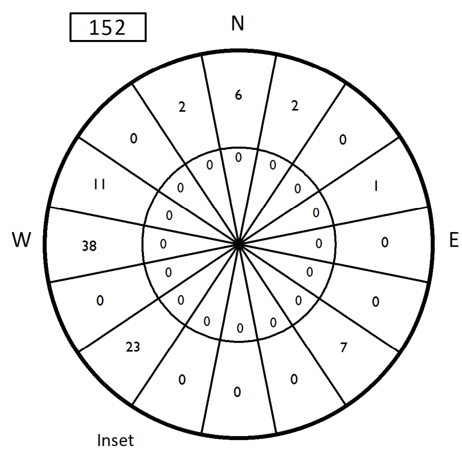
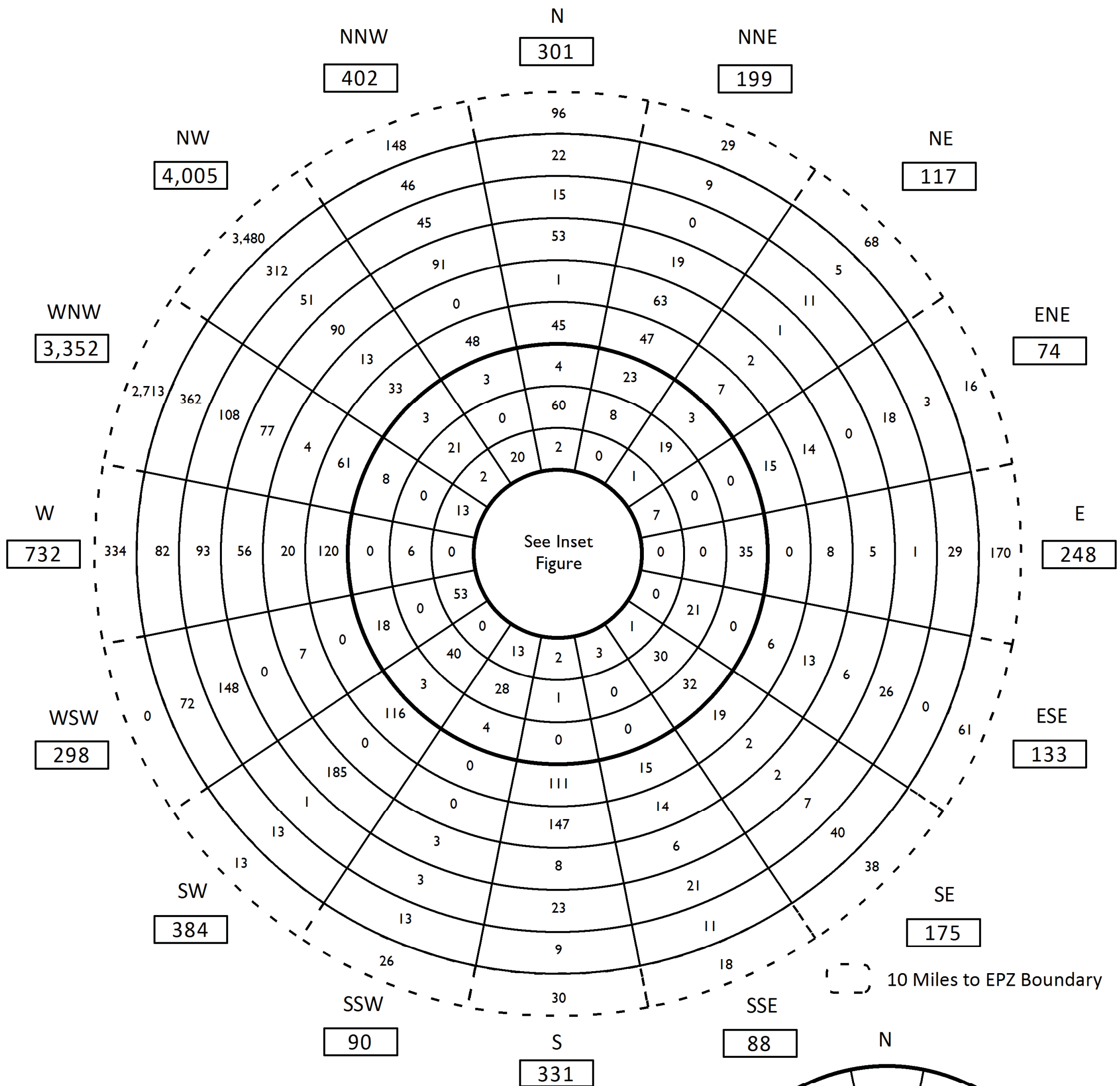


Figure 3-2. Permanent Resident Population by Sector



Resident Vehicles

Miles	Subtotal by Ring	Cumulative Total
0 - 1	0	0
1 - 2	50	50
2 - 3	117	167
3 - 4	234	401
4 - 5	136	537
5 - 6	643	1,180
6 - 7	308	1,488
7 - 8	602	2,090
8 - 9	571	2,661
9 - 10	1,028	3,689
10 - EPZ	7,240	10,929
	Total:	10,929

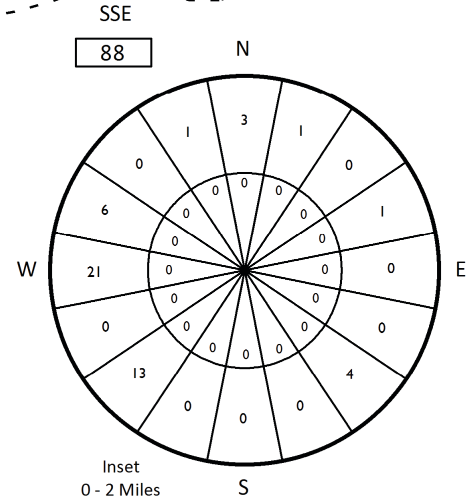


Figure 3-3. Permanent Resident Vehicles by Sector

3.2 Shadow Population

A proportion of the population living outside the evacuation area extending to 15 miles radially from the Callaway Plant (in the Shadow Region) may elect to evacuate without having been instructed to do so. Based upon NUREG/CR-7002 guidance, it is assumed that 20 percent of the permanent resident population, based on U.S. Census Bureau data, in this Shadow Region will elect to evacuate.

Shadow population characteristics (household size, evacuation vehicles per household, mobilization time) are assumed to be the same as that for the EPZ permanent resident population. Table 3-3 presents estimates of the shadow population and vehicles, by sector.

Table 3-3. Shadow Population and Vehicles by Sector

Sector	Population	Vehicles
N	197	113
NNE	125	71
NE	156	89
ENE	181	105
E	135	77
ESE	265	149
SE	282	162
SSE	109	64
S	186	107
SSW	356	200
SW	373	209
WSW	505	282
W	663	373
WNW	1,868	1,054
NW	967	543
NNW	333	186
TOTAL	**6,701**	**3,784**

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). Transients may spend less than one day or stay overnight at camping facilities, hotels and motels. The Callaway Plant EPZ has a number of areas and facilities that attract transients, including:

- Lodging Facilities
- Boat Ramps

- Campgrounds
- Golf Courses
- Hunting/Fishing

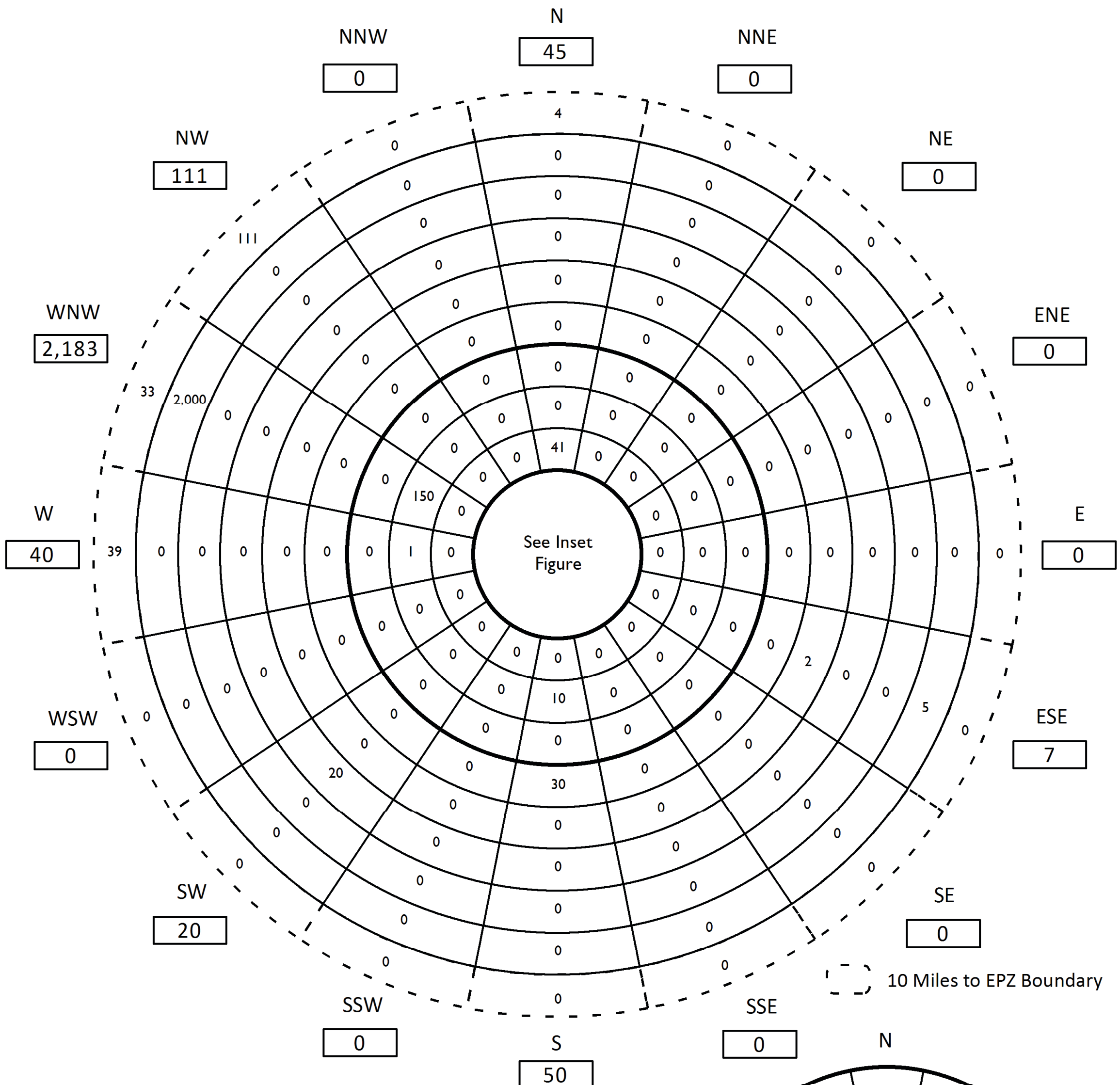
Surveys of transient facilities within the EPZ were conducted to determine the number of transients and vehicle occupancy for each type of transient attraction. A total of 144 transients in 71 vehicles are assigned to lodging facilities within the EPZ. A total of 2,251 transients in 825 vehicles are assigned to recreational areas within the EPZ. Thus, a total of 2,395 transients and 896 vehicles evacuate from transient attractions within the EPZ at peak times. Some facilities did not provide transient or vehicle occupancy data. For those facilities, the use of an observed parking lot capacity combined with aerial imagery and representative occupancy averages were applied to estimate peak occupancy.

Appendix E summarizes the transient data that was estimated for the EPZ. Table E-4 presents the number of transients visiting recreational areas, while Table E-5 presents the number of transients at lodging facilities within the EPZ.

Table 3-4 presents transient population and transient vehicle estimates by subarea. Figure 3-4 and Figure 3-5 present these data by sector and distance from the plant.

Table 3-4. Summary of Transients and Transient Vehicles

Subarea	Transients	Transient Vehicles
C1	10	4
C2	151	76
C3	41	15
C4	2	2
C5	0	0
C6	10	4
C7	20	12
C8	2,039	698
C9	144	71
C10	4	2
C11	0	0
G1	0	0
M1	0	0
M2	5	5
O1	30	30
TOTAL	**2,456**	**919**



Transients

Miles	Subtotal by Ring	Cumulative Total
0 - 1	0	0
1 - 2	10	10
2 - 3	41	51
3 - 4	161	212
4 - 5	0	212
5 - 6	30	242
6 - 7	2	244
7 - 8	20	264
8 - 9	0	264
9 - 10	2,005	2,269
10 - EPZ	187	2,456
	Total:	2,456

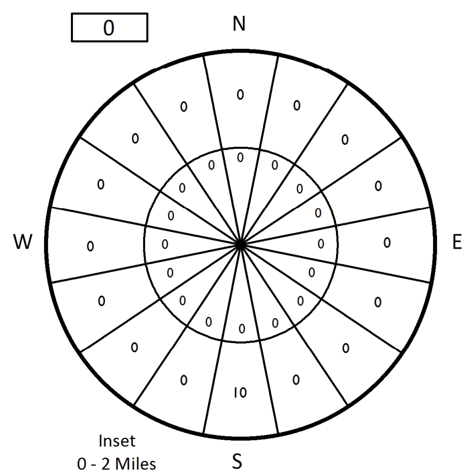
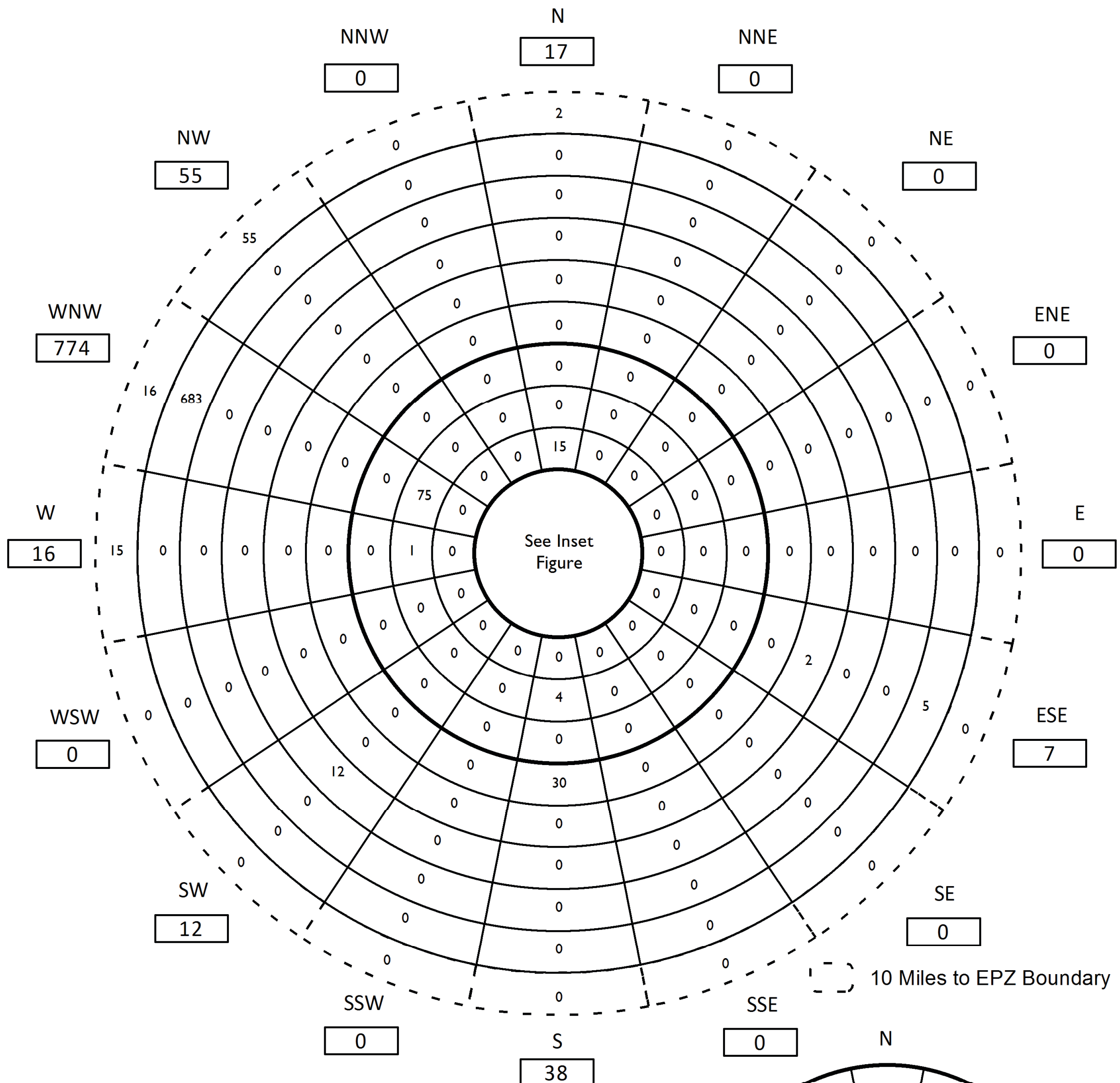


Figure 3-4. Transient Population by Sector



Transient Vehicles

Miles	Subtotal by Ring	Cumulative Total
0 - 1	0	0
1 - 2	4	4
2 - 3	15	19
3 - 4	80	99
4 - 5	0	99
5 - 6	30	129
6 - 7	2	131
7 - 8	12	143
8 - 9	0	143
9 - 10	688	831
10 - EPZ	88	919
	Total:	919

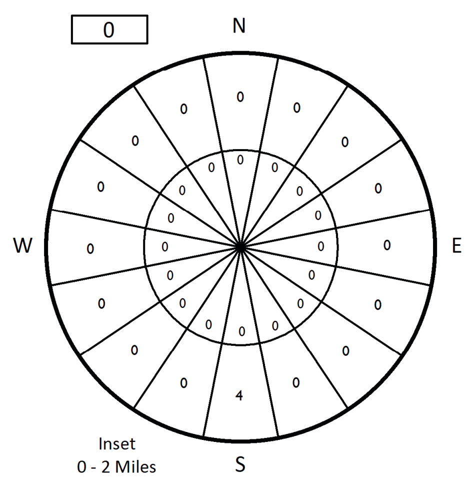


Figure 3-5. Transient Vehicles by Sector

3.4 Employees

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.

Year 2009 Longitudinal Employer-Household Dynamics[1] Origin-Destination Employment Statistics provided by the U.S. Census Bureau was used to estimate the number of employees commuting into the EPZ for those employers who did not provide data.

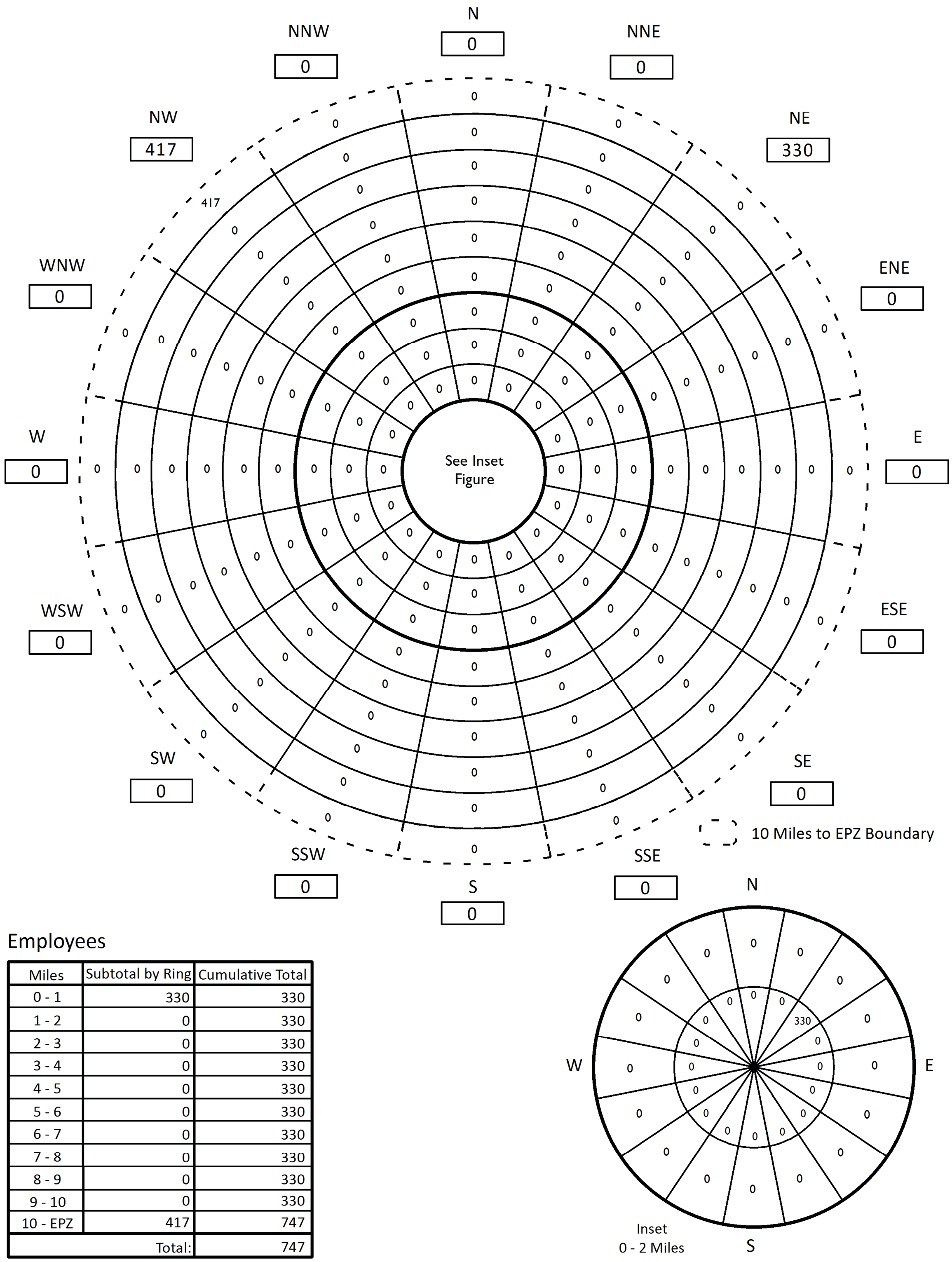
In Table E-3, the number of employees (max shift) is multiplied by the percent Non-EPZ factor to determine the number of employees who are not residents of the EPZ. A vehicle occupancy of 1.09 employees per vehicle obtained from the telephone survey (See Figure F-7) was used to determine the number of evacuating employee vehicles for all major employers. The numbers for plant employees and employee vehicles (the only major employer in Subarea C1) were obtained directly from the plant.

Table 3-5 presents non-EPZ Resident employee and vehicle estimates by subarea. Figure 3-6 and Figure 3-7 present these data by sector.

[1] U.S. Census Bureau, OnTheMap Application and LEHD Origin-Destination Employment Statistics (Beginning of Quarter Employment, 2nd Quarter of 2009). Analysis Generation Date: 9/22/2011

Table 3-5. Summary of Non-EPZ Resident Employees and Employee Vehicles

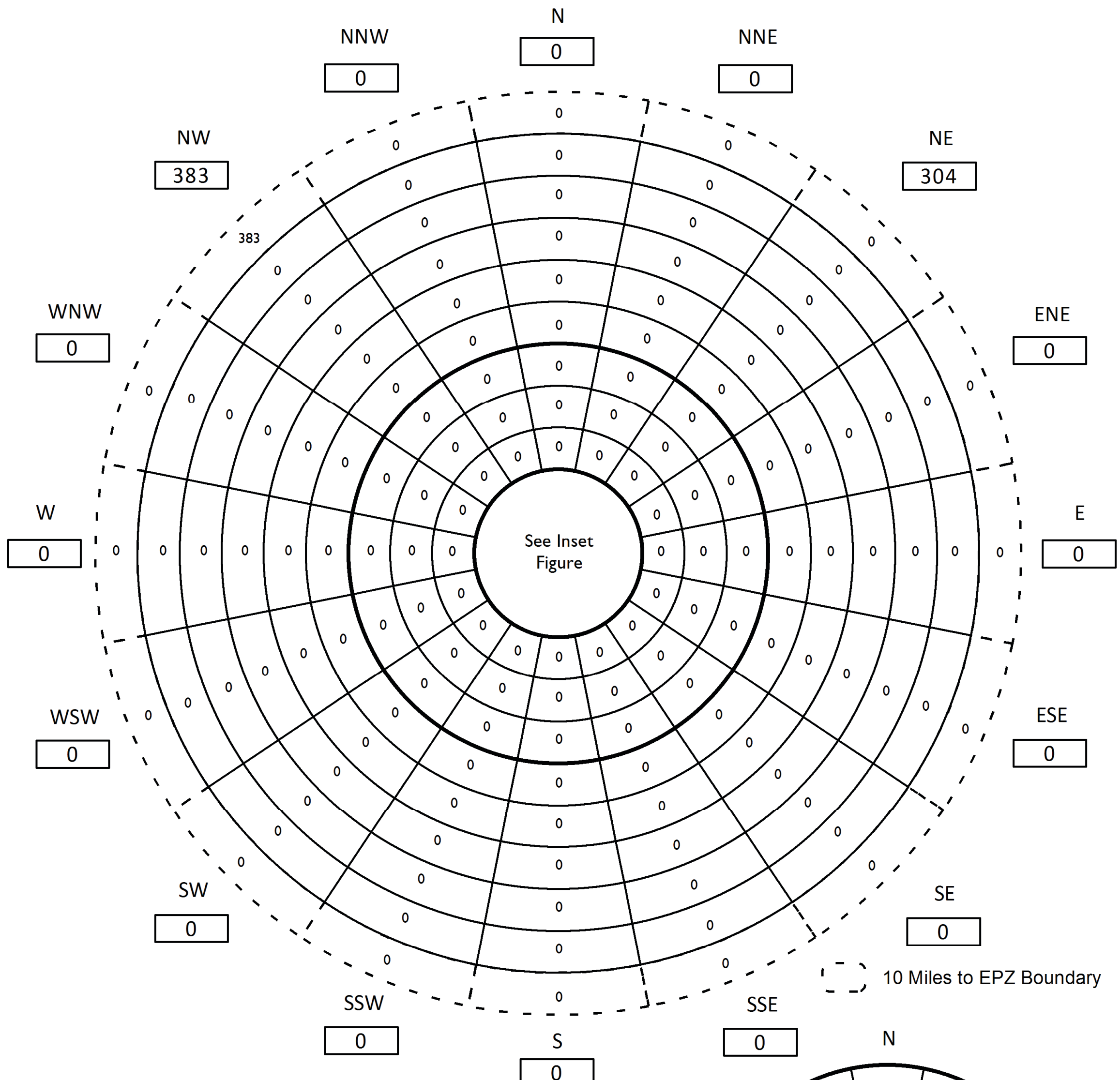
Subarea	Employees	Employee Vehicles
C1	330	304
C2	0	0
C3	0	0
C4	0	0
C5	0	0
C6	0	0
C7	0	0
C8	0	0
C9	417	383
C10	0	0
C11	0	0
G1	0	0
M1	0	0
M2	0	0
O1	0	0
TOTAL	**747**	**687**

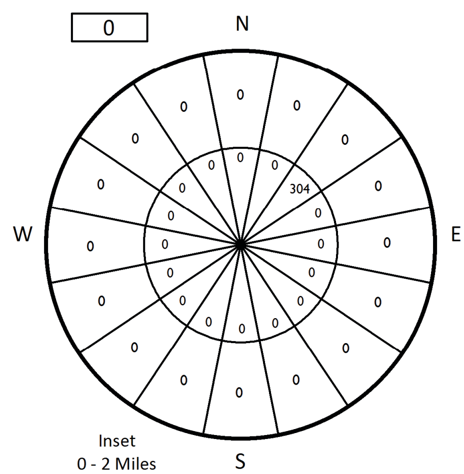


Employees

Miles	Subtotal by Ring	Cumulative Total
0 - 1	330	330
1 - 2	0	330
2 - 3	0	330
3 - 4	0	330
4 - 5	0	330
5 - 6	0	330
6 - 7	0	330
7 - 8	0	330
8 - 9	0	330
9 - 10	0	330
10 - EPZ	417	747
	Total:	747

Figure 3-6. Employee Population by Sector





Employee Vehicles

Miles	Subtotal by Ring	Cumulative Total
0 - 1	304	304
1 - 2	0	304
2 - 3	0	304
3 - 4	0	304
4 - 5	0	304
5 - 6	0	304
6 - 7	0	304
7 - 8	0	304
8 - 9	0	304
9 - 10	0	304
10 - EPZ	383	687
	Total:	687

Figure 3-7. Employee Vehicles by Sector

3.5 Medical Facilities

Data were provided by the counties for each of the medical facilities within the EPZ. Chapter 8 details the evacuation of medical facilities and their patients. The number and type of evacuating vehicles that need to be provided depend on the patients' state of health. It is estimated that buses can transport up to 30 people; wheelchair vans, up to 4 people; wheelchair buses up to 15 people; and ambulances, up to 2 people.

3.6 Colleges and Universities

There are two higher education facilities in the Callaway EPZ: Westminster College and William Woods University. To estimate the demand for these facilities, it was assumed that all students without personal vehicles on campus would need to be provided transportation assistance from the county, and that all students with personal vehicles would evacuate with a ratio of one person per vehicle. The percentage of students without personal vehicles on campus was determined from the US News College and World Reports website. The percentage of students without personal vehicles is 23% for Westminster College[2] and 10% for William Woods University.[3] The resulting number of students who would need transportation is 265 (23% of 1,151 total enrollment) for Westminster College and 223 (10% of 2,226 total enrollment) for William Woods University.

[2] (2011). U.S. News & World Reports LP. "Westminster College," <http://colleges.usnews.rankingsandreviews.com/best-colleges/westminster-college-3681> (November 21, 2011).

[3] (2001). U.S. News & World Reports LP. "William Woods University," <http://colleges.usnews.rankingsandreviews.com/best-colleges/william-woods-2525> (November 21, 2011).

3.7 Total Demand in Addition to Permanent Population

Vehicles will be traveling through the EPZ (external-external trips) at the time of an accident. 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 EPZ – Interstate 70 and US Highway 54. It is assumed that this traffic will continue to enter the EPZ during the first 120 minutes following the Advisory to Evacuate.

Average Annual Daily Traffic (AADT) data was obtained from Federal Highway Administration 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 3-6, for each of the routes considered. The DDHV is then multiplied by 2 hours (access control points – ACP – are assumed to be activated at 120 minutes after the advisory to evacuate) to estimate the total number of external vehicles loaded on the analysis network. As indicated, there are 9,064 vehicles entering the EPZ as external-external trips prior to the activation of the ACP and the diversion of this traffic. This number is scaled down to an estimated 40% (3,626 vehicles) for evening scenarios (Scenarios 5 and 12) as discussed in Section 6.

Table 3-6. Callaway Plant EPZ External Traffic

Up Node	Dn Node	Road Name	Direction	HPMS[1] AADT	K-Factor[2]	D-Factor[2]	Hourly Volume	External Traffic
8005	5	I-70	EB	29,468	0.107	0.5	1,577	3,154
8800	800	I-70	WB	29,468	0.107	0.5	1,577	3,154
8073	756	US 54	NB	11,880	0.116	0.5	689	1,378
8028	28	US 54	SB	11,880	0.116	0.5	689	1,378
							TOTAL	**9,064**

[1] Highway Performance Monitoring System (HPMS), Federal Highway Administration (FHWA), Washington, D.C., 2011

[2] HCM 2010

3.8 Special Event

Based on discussion with Ameren Missouri and the offsite agencies, the special event considered is the construction of new nuclear generating facilities at the Callaway Plant site during the peak construction year - 2023. The Ameren Missouri Combined Operating License Application (COLA) estimates the number of construction workers at that time to be 2,765 evacuating in an estimated 2,469 vehicles. A population annual exponential growth rate was obtained from 2000 and 2010 populations, and then applied to the resident and shadow population to project the population in the year 2023. Table 3-7 shows the population growth for each Subarea and the Shadow Region for the future construction year.

An additional sensitivity study was conducted to determine the effect on ETE from the construction of two large new units and two proposed roadways (to assist in traffic generated by an increase of workers at the new units). The details and results of this study are discussed in Section M.4 of Appendix M.

Table 3-7. Population Growth for Construction Scenario

Subarea	2000 Population	2010 Population	Growth Rate to Construction Year	2023 Population	2010 - 2023 Population Change
C1	78	90	120%	108	18
C2	363	363	100%	363	0
C3	339	441	141%	621	180
C4	322	264	77%	204	-60
C5	72	86	126%	108	22
C6	451	492	112%	551	59
C7	1,279	1,406	113%	1,590	184
C8	2,462	2,493	102%	2,534	41
C9	11,723	12,112	104%	12,637	525
C10	417	544	141%	769	225
C11	258	239	91%	216	-23
G1	102	107	106%	114	7
M1	209	181	83%	150	-31
M2	555	496	86%	429	-67
O1	996	859	83%	709	-150
EPZ	**19,626**	**20,173**	**-**	**21,103**	**930**
Shadow	**-**	**6,701**	**106%**	**7,083**	**382**
TOTAL		**26,874**		**28,186**	**1,312**

Note: Growth rate for the shadow region is assumed to be the average of the subarea growth rates

3.9 Summary of Demand

A summary of population and vehicle demand is summarized in

Table 3-8 and Table 3-9, respectively. This summary includes all population groups described in this section. Additional population groups – transit-dependent, special facility and school population – are described in greater detail in Section 8. A total of 30,778 people and 22,618 vehicles are considered in this study.

Table 3-8. Summary of Population Demand

Subarea	Residents	Transit-Dependent	Transients	Employees	Special Facilities	Schools	Shadow Population	External Traffic	Total
C1	90	2	10	330	0	0	0	0	432
C2	363	6	151	0	0	0	0	0	520
C3	441	7	41	0	0	0	0	0	489
C4	264	4	2	0	0	0	0	0	270
C5	86	1	0	0	0	0	0	0	87
C6	492	8	10	0	0	0	0	0	510
C7	1,406	24	20	0	0	864	0	0	2,314
C8	2,493	42	2,039	0	0	0	0	0	4,574
C9	12,112	207	144	417	17	4,620	0	0	17,517
C10	544	9	4	0	0	0	0	0	557
C11	239	4	0	0	0	0	0	0	243
G1	107	2	0	0	0	0	0	0	109
M1	181	3	0	0	0	0	0	0	184
M2	496	8	5	0	0	0	0	0	509
O1	859	15	30	0	0	219	0	0	1,173
Shadow	0	0	0	0	0	0	1,340	0	1,340
Total	**20,173**	**342**	**2,456**	**747**	**17**	**5,703**	**1,340**	**0**	**30,778**

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

Table 3-9. Summary of Vehicle Demand

Subarea	Residents	Transit-Dependent	Transients	Employees	Special Facilities	Schools	Shadow Population	External Traffic	Total
C1	50	4	4	304	0	0	0	0	362
C2	202	8	76	0	0	0	0	0	286
C3	249	0	15	0	0	0	0	0	264
C4	151	0	2	0	0	0	0	0	153
C5	49	0	0	0	0	0	0	0	49
C6	276	0	4	0	0	0	0	0	280
C7	792	0	12	0	0	36	0	0	840
C8	1,395	4	698	0	0	0	0	0	2,097
C9	6,396	4	71	383	4	184	0	0	7,042
C10	304	0	2	0	0	0	0	0	306
C11	135	0	0	0	0	0	0	0	135
G1	60	0	0	0	0	0	0	0	60
M1	104	0	0	0	0	0	0	0	104
M2	279	0	5	0	0	0	0	0	284
O1	487	4	30	0	0	14	0	0	535
Shadow	0	0	0	0	0	0	757	9,064	9,821
Total	**10,929**	**24**	**919**	**687**	**4**	**234**	**757**	**9,064**	**22,618**

NOTE: Buses represented as two passenger vehicles. Refer to Section 8 for additional information.

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 2010 Highway Capacity Manual (HCM 2010).

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.

This distinction is illustrated in Exhibit 11-17 of the HCM 2010. 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
- Percent truck traffic
- Control device (and timing, if it is a signal)
- Weather conditions (rain, snow, 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 during the road survey and these observations were recorded, but no detailed measurements of lane or shoulder width were taken. The estimated FFS were measured using the survey vehicle’s speedometer and observing local traffic, under free flow conditions.

As discussed in Section 2.3, it is necessary to adjust capacity figures to represent the prevailing conditions during inclement weather. Based on limited empirical data, weather conditions such

[1] A very rough estimate of BFFS might be taken as the posted speed limit plus 10 mph (HCM 2010 Page 15-15)

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 2.3, we employ a reduction in free speed and in highway capacity of 10 percent and 20 percent for rain and snow, 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. The existing traffic management plans documented in the county emergency plans are extensive and were adopted without change.

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,

$$h_m = f_m(h_{sat}, F, F_2, \ldots)$$

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 2010.

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[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

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 18, 19 and 20 in the HCM 2010 address this topic. The factors, F_1, F_2,…, influencing saturation flow rate are identified in equation (18-5) of the HCM 2010.

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 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 15-30 in the Highway Capacity Manual was referenced to estimate saturation flow rates. The impact of narrow lanes and shoulders on free-flow speed 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 2010 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.

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

4.3 Application to the Callaway 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:

2010 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 1700 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 3200 pc/h. The HCM procedures then estimate Level of Service (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 14

Exhibit 14-2 of the HCM 2010 presents a set of curves that indicate a per-lane capacity ranging from approximately 1900 to 2200 pc/h, for free-speeds of 45 to 60 mph, respectively. Based on observation, the multi-lane 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 1900 pc/h is adopted for this study for multi-lane highways outside of urban areas, as shown in Appendix K.

4.3.3 Freeways

Ref: HCM Chapters 10, 11, 12, 13

Chapter 10 of the HCM 2010 describes a procedure for integrating the results obtained in Chapters 11, 12 and 13, 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 11 of the HCM 2010 presents procedures for estimating capacity and LOS for "Basic Freeway Segments". Exhibit 11-17 of the HCM 2010 presents capacity vs. free speed estimates, which are provided below.

Free Speed (mph):	55	60	65	70+
Per-Lane Capacity (pc/h):	2250	2300	2350	2400

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.

Chapter 12 of the HCM 2010 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 12 depends on the "Type" and geometrics of the weaving segment and on the "Volume Ratio" (ratio of weaving volume to total volume).

Chapter 13 of the HCM 2010 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 13-8 of the HCM 2010, and depend on the number of freeway lanes and on the freeway free speed. Ramp capacity is presented in Exhibit 13-10 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 13 of the HCM 2010. 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 18, 19, 20, 21

Procedures for estimating capacity and LOS for approaches to intersections are presented in Chapter 18 (signalized intersections), Chapters 19, 20 (un-signalized intersections) and Chapter 21 (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 invoking several procedural chapters of the HCM. 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 2010 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 2010, as described earlier. These parameters are listed in Appendix K, for each network link.

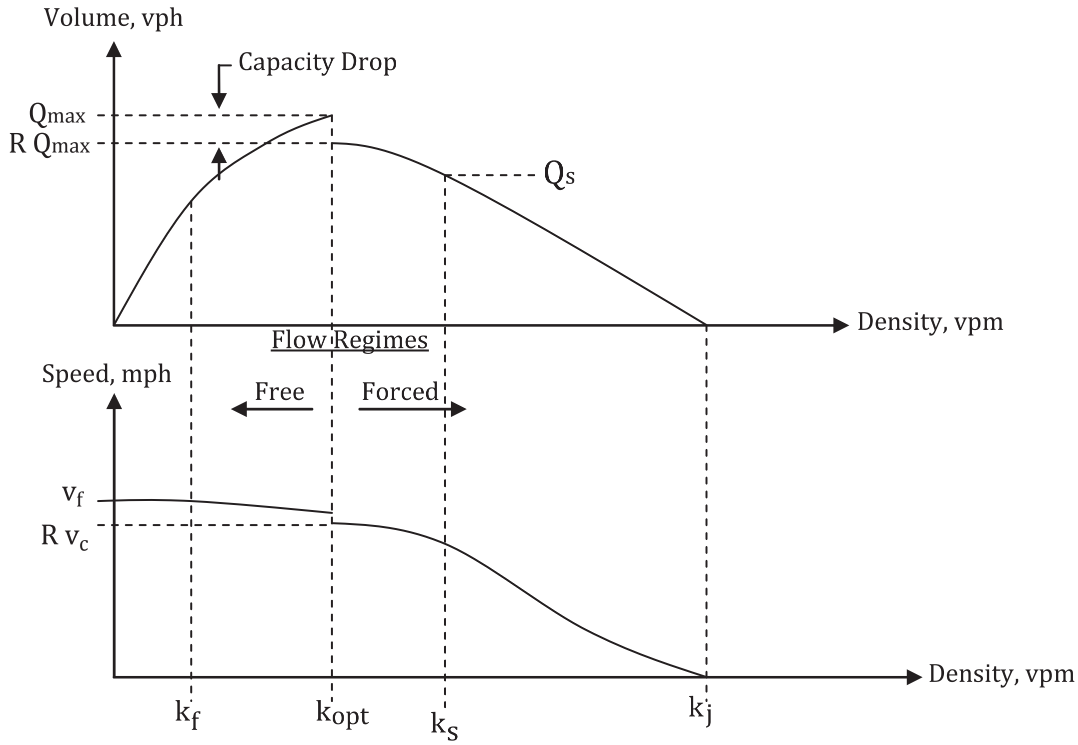


Figure 4-1. Fundamental Diagrams

5 ESTIMATION OF TRIP GENERATION TIME

Federal Government guidelines (see NUREG CR-7002) 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 telephone 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 Action Levels (see Appendix 1 of NUREG 0654 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 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, 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 emergency notification.
2. Mobilization of the general population will commence up to 10 minutes after the alert 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 notification systems available within the EPZ (e.g. sirens, tone alerts, EAS broadcasts, loud speakers and REVERSE911).
2. Receiving and correctly interpreting the information that is transmitted.

The population within the EPZ is dispersed over an area of approximately 420 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, the information required to compute trip generation times is typically obtained from a telephone survey of EPZ residents. Such a survey was conducted in support of this ETE study. Appendix F presents the survey sampling plan, survey instrument, and raw survey results. It is important to note that the shape and duration of the evacuation trip mobilization distribution is important at sites where traffic congestion is not expected to cause the evacuation time estimate to extend in time well beyond the trip generation period. The remaining discussion will focus on the application of the trip generation data obtained from the telephone 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:

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

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)

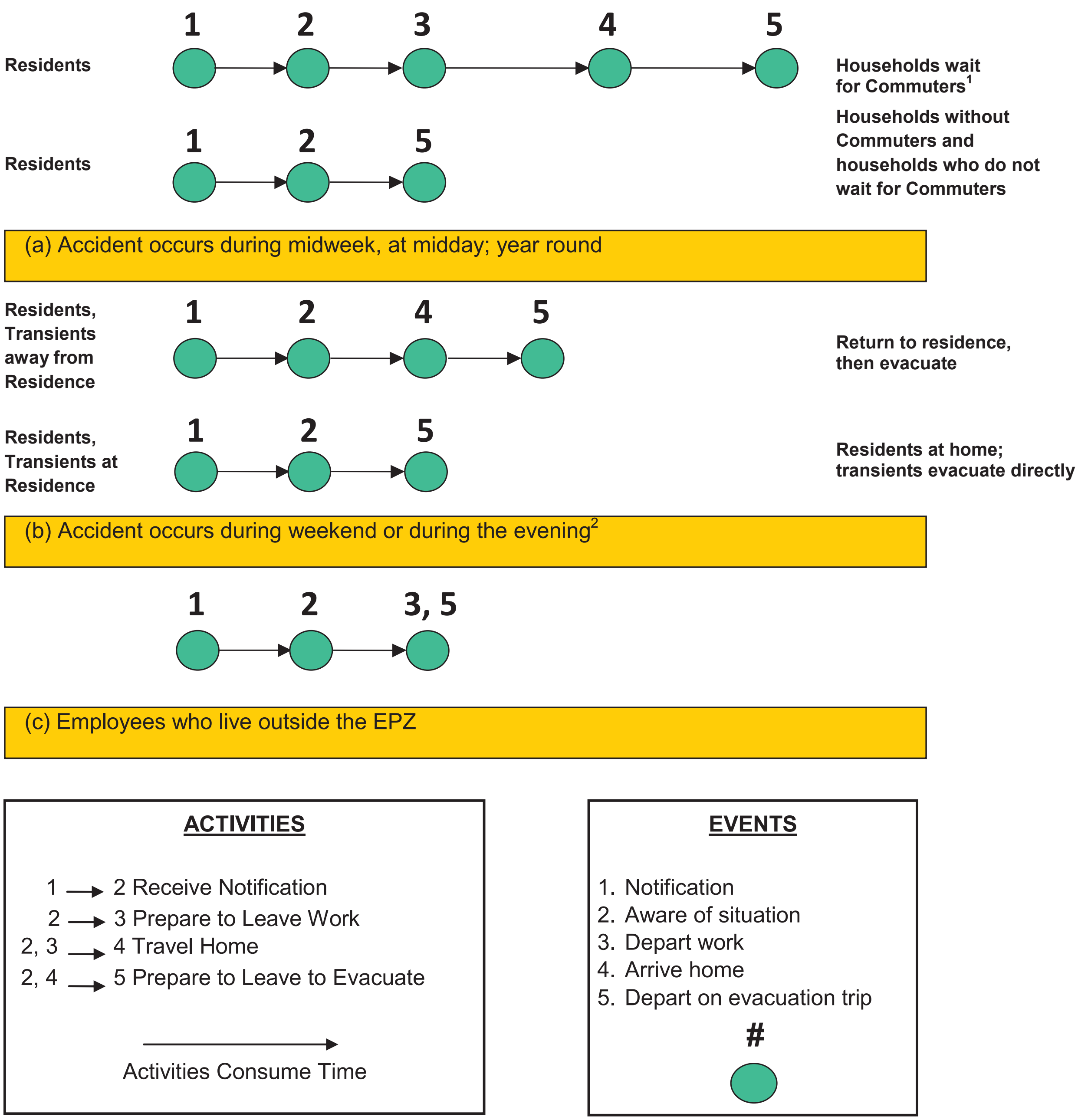
As such, a completed Activity changes the 'state' of an individual (e.g. the activity, 'travel home' changes the state from 'depart work' to 'arrive home'). Therefore, an Activity can be described as an 'Event Sequence'; the elapsed times to perform an event sequence vary from one person to the next 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 (i.e. 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, or removing snow only after the 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.



[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

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

It is assumed (based on the presence of sirens within the EPZ) that 87 percent of those within the EPZ will be aware of the accident within 30 minutes with the remainder notified within the following 15 minutes. The notification distribution is given below:

Table 5-2. Time Distribution for Notifying the Public

Elapsed Time (Minutes)	Percent of Population Notified
0	0%
5	7%
10	13%
15	27%
20	47%
25	66%
30	87%
35	92%
40	97%
45	100%

Distribution No. 2, Prepare to Leave Work: Activity 2 → 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. The distribution of Activity 2 → 3 shown in Table 5-3 reflects data obtained by the telephone survey. This distribution is plotted in Figure 5-2.

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

Elapsed Time (Minutes)	Cumulative Percent Employees Leaving work
0	0%
5	47%
10	67%
15	77%
20	82%
25	82%
30	92%
35	93%
40	93%
45	95%
50	95%
55	95%
60	100%

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.

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

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

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

Elapsed Time (Minutes)	Cumulative Percent Returning Home
0	0
5	17%
10	35%
15	49%
20	62%
25	69%
30	84%
35	86%
40	89%
45	94%
50	94%
55	95%
60	98%
75	99%
90	100%

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

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

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

Table 5-5. Time Distribution for Population to Prepare to Evacuate

Elapsed Time (Minutes)	Cumulative Percent Ready to Evacuate
0	0%
15	20%
30	64%
45	69%
60	86%
75	91%
90	93%
105	93%
120	97%
135	99%
150	99%
165	99%
180	100%

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

Distribution No. 5, Snow Clearance Time Distribution

Inclement weather scenarios involving snowfall must address the time lags associated with snow clearance. It is assumed that snow equipment is mobilized and deployed during the snowfall to maintain passable roads. The general consensus is that the snow-plowing efforts are generally successful for all but the most extreme blizzards when the rate of snow accumulation exceeds that of snow clearance over a period of many hours.

Consequently, it is reasonable to assume that the highway system will remain passable – albeit at a lower capacity – under the vast majority of snow conditions. Nevertheless, for the vehicles to gain access to the highway system, it may be necessary for driveways and employee parking lots to be cleared to the extent needed to permit vehicles to gain access to the roadways. These clearance activities take time; this time must be incorporated into the trip generation time distributions. These data are provided by those households which responded to the telephone survey. This distribution is plotted in Figure 5-2 and listed in Table 5-6.

Table 5-6. Time Distribution for Population to Clear 6"-8" of Snow

Elapsed Time (Minutes)	Cumulative Percent Ready to Evacuate
0	47%
15	54%
30	69%
45	73%
60	83%
75	85%
90	87%
105	88%
120	95%
135	97%
150	97%
165	97%
180	100%

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

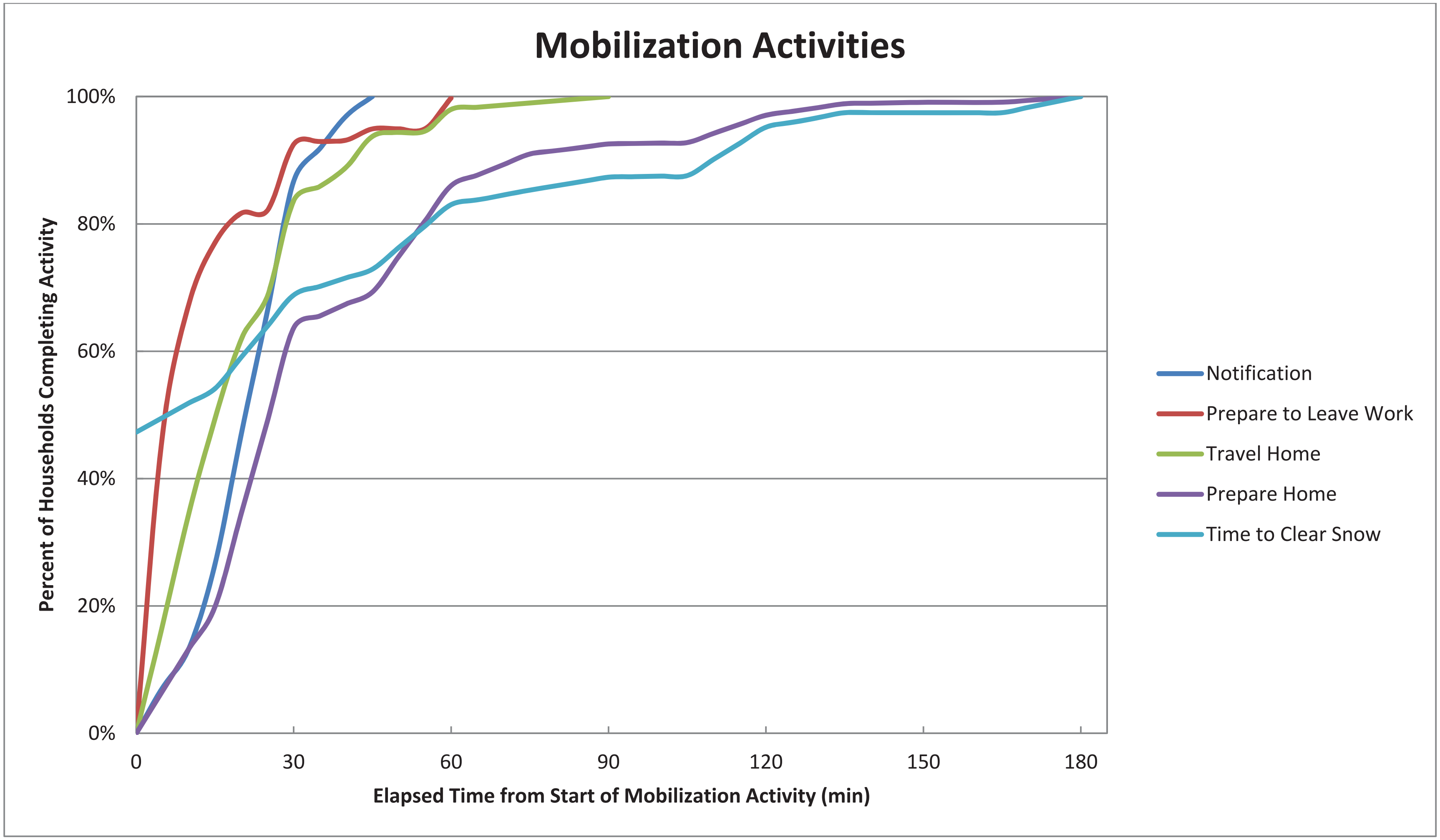


Figure 5-2. Evacuation Mobilization Activities

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 5-7 presents the summing procedure to arrive at each designated distribution.

Table 5-7. 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
Distributions C and 5	Distribution E	Event 5
Distributions D and 5	Distribution F	Event 5

Table 5-8 presents a description of each of the final trip generation distributions achieved after the summing process is completed.

Table 5-8. 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).
E	Time distribution of residents with commuters who return home, leaving home to begin the evacuation trip, after snow clearance activities (Event 5).
F	Time distribution of residents with no commuters returning home, leaving to begin the evacuation trip, after snow clearance activities (Event 5).

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 alternates 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 special 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 nonparametric methods to avoid that assumption. The literature cites that limited work has been done directly on outliers in sample survey responses.

In establishing the overall 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;

2) The individual mobilization activities (prepare to leave work, travel home, prepare home, clear snow) are reviewed for outliers, and then the overall trip generation distributions are created (see Figure 5-1, Table 5-7, Table 5-8);

3) Outliers can be eliminated either because the response reflects a special population (e.g. special needs, transit dependent) or lack of realism, because the purpose is to estimate trip generation patterns for personal vehicles;

4) 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 3.5 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 4 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.

5) 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.

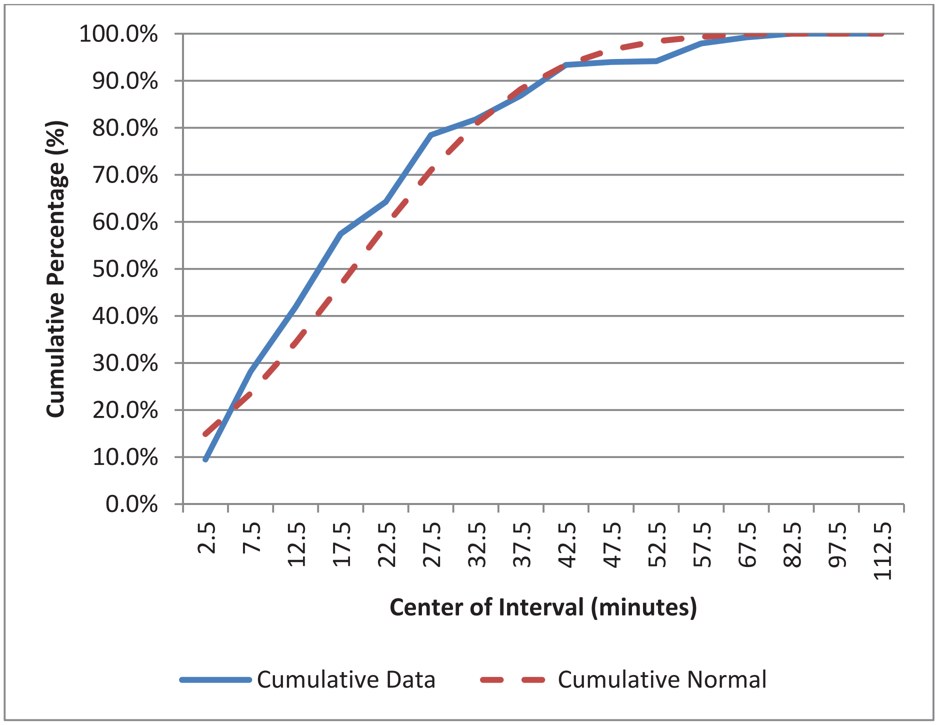


Figure 5-3. Comparison of Data Distribution and Normal Distribution

6) 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% of the vehicles, potentially causing more (and earlier) congestion than otherwise modeled;
   - The last 10-15% 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, <u>not</u> 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;

7) 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, no snow or snow 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 designated A, C, D, E and F. 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; snow clearance follows the preparation for departure, 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, D, E and F, properly displaced with respect to one another, are tabulated in Table 5-9 (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, staged evacuation consists of the following:

1. Subareas comprising the 2 mile region are advised to evacuate immediately
2. Subareas comprising regions extending from 2 to 5 miles downwind are advised to shelter in-place while the two 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% 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%

<u>Assumptions</u>

1. The EPZ population in subareas beyond 5 miles will react as does the population in the 2 to 5 mile region; that is they will first shelter, then evacuate after the 90th percentile ETE for the 2 mile region
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% 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, 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.

<u>Procedure</u>

1. Trip generation for population groups in the 2 mile region will be as computed based upon the results of the telephone 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 subareas comprising the two mile region. This value, T_{Scen}^{*}, obtained from simulation results is scenario-specific. 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% 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% (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. NUREG/CR-7002 uses the statement "approximately 90th percentile" as the time to end staging and begin evacuating. The value of T_{Scen}^* is 1:25 for non-snow, 1:25 for snow-weekday, and 2:15 for snow-weekend scenarios. The reason for the time difference between snow-weekday and snow-weekend scenarios is that 85% of the vehicles within the 2-mile region are those of the employees at the Callaway Plant. This population group mobilizes faster (100% have mobilized within 60 minutes) than the general population and will therefore evacuate in a shorter amount of time. While this has no impact on the 100th percentile evacuation time, the 90th percentile evacuation time during a weekday snow scenario is almost an hour shorter than during a weekend snow scenario when employee vehicles only account for 38% of all vehicles within the 2-mile region.

3. Staged trip generation distributions are created for the following population groups:
   a. Residents with returning commuters
   b. Residents without returning commuters
   c. Residents with returning commuters and snow conditions
   d. Residents without returning commuters and snow conditions

Figure 5-5 presents the staged trip generation distributions for both residents with and without returning commuters; the 90th percentile two-mile evacuation time is 80 minutes for rain and good weather, 90 minutes for snow weekday scenarios and 155 minutes for snow weekend scenarios. At the 90th percentile evacuation time, approximately 8-18% of the population 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 period, 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 5-10 provides the trip generation for staged evacuation.

Table 5-9. Trip Generation Histograms for the EPZ Population for Unstaged 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)	Residents With Commuters Snow (Distribution E)	Residents Without Commuters Snow (Distribution F)
1	20	16%	16%	0%	3%	0%	2%
2	20	55%	55%	2%	26%	1%	13%
3	20	21%	21%	14%	35%	8%	22%
4	20	5%	5%	25%	17%	14%	17%
5	20	3%	3%	22%	9%	17%	13%
6	20	0%	0%	16%	3%	15%	8%
7	20	0%	0%	8%	3%	11%	6%
8	20	0%	0%	6%	3%	9%	6%
9	20	0%	0%	3%	0%	7%	5%
10	20	0%	0%	2%	1%	6%	3%
11	20	0%	0%	1%	0%	4%	2%
12	20	0%	0%	1%	0%	3%	1%
13	60	0%	0%	0%	0%	4%	2%
14	60	0%	0%	0%	0%	1%	0%
15	600	0%	0%	0%	0%	0%	0%

NOTE: Shadow vehicles are loaded onto the analysis network (Figure 1-2) using Distributions C and E for good weather and snow, respectively.. Special event vehicles are loaded using Distribution A

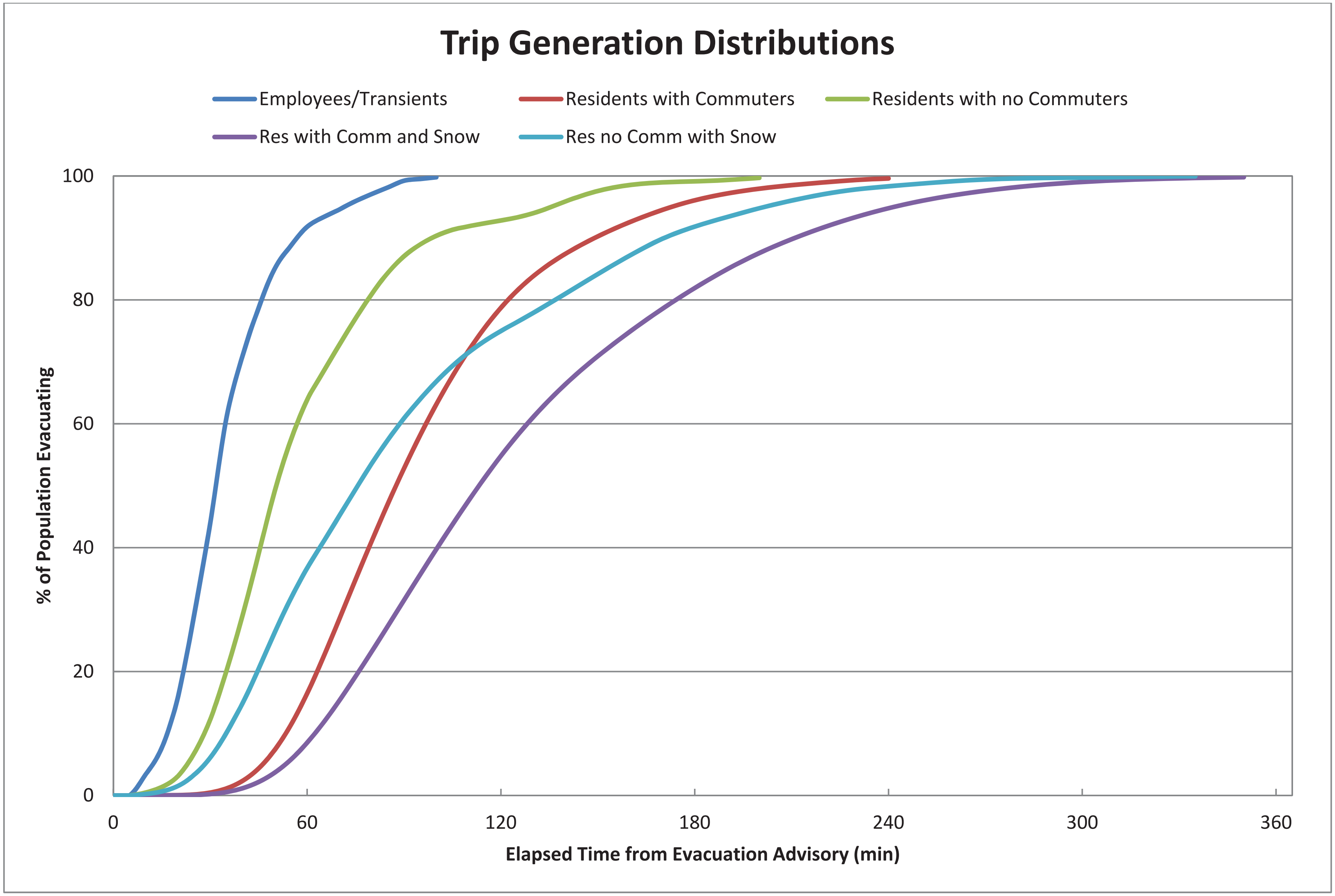


Figure 5-4. Comparison of Trip Generation Distributions

Table 5-10. 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)	Residents With Commuters Weekday-Snow (Distribution E)	Residents Without Commuters Weekday-Snow (Distribution F)	Residents With Commuters Weekend-Snow (Distribution E)	Residents Without Commuters Weekend-Snow (Distribution F)
1	20	0%	1%	0%	0%	0%	0%
2	20	0%	5%	0%	3%	0%	3%
3	20	3%	7%	2%	4%	2%	4%
4	20	5%	3%	3%	4%	3%	4%
5	20	55%	74%	35%	56%	3%	2%
6	20	16%	3%	15%	8%	3%	2%
7	20	8%	3%	11%	6%	21%	24%
8	20	6%	3%	9%	6%	43%	48%
9	20	3%	0%	7%	5%	7%	5%
10	20	2%	1%	6%	3%	6%	3%
11	20	1%	0%	4%	2%	4%	2%
12	20	1%	0%	3%	1%	3%	1%
13	60	0%	0%	4%	2%	4%	2%
14	60	0%	0%	1%	0%	1%	0%
15	600	0%	0%	0%	0%	0%	0%

*Trip Generation for Employees and Transients (see Table 5-9) is the same for Un-staged and Staged Evacuation.

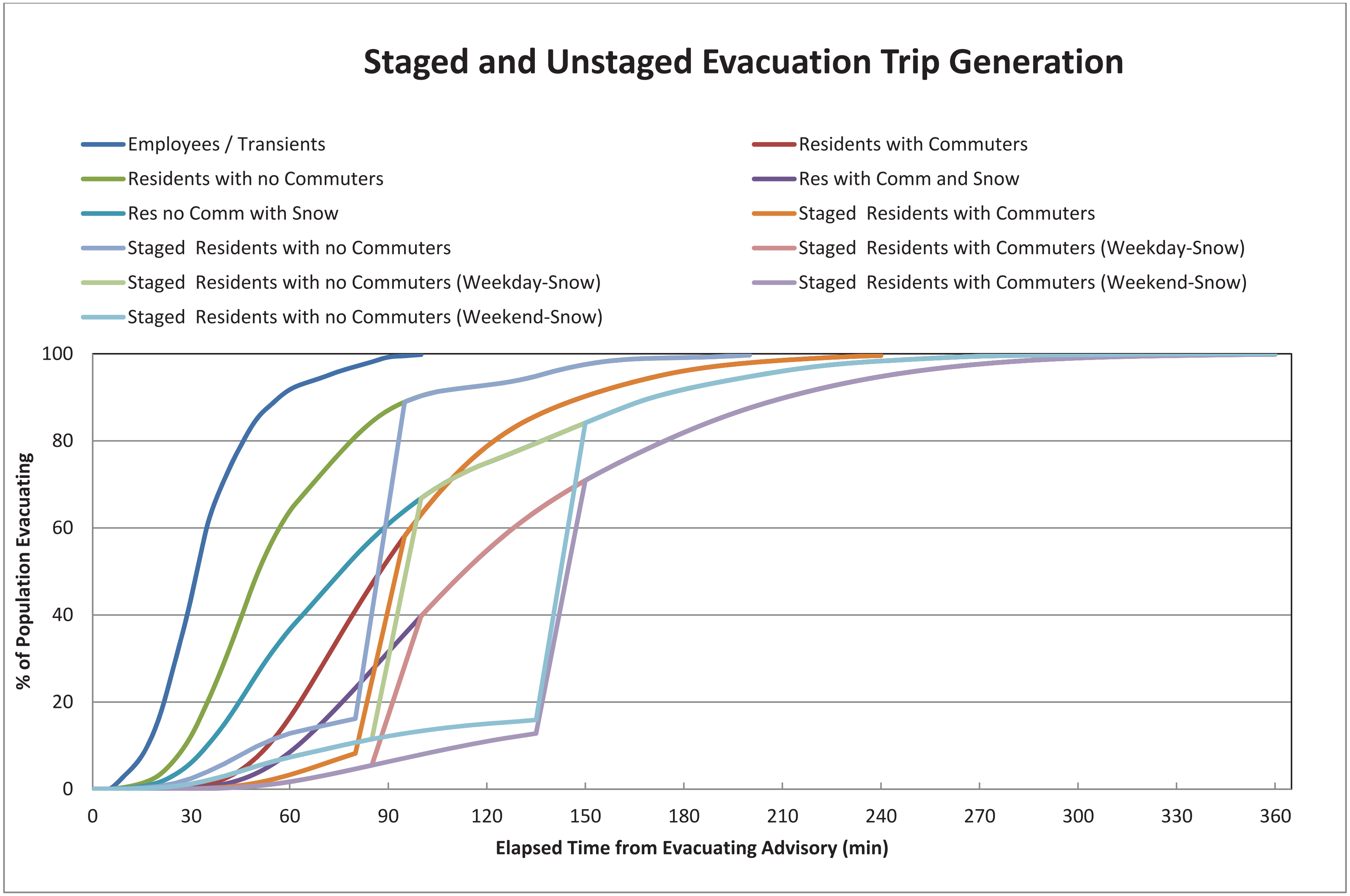


Figure 5-5. Comparison of Staged and Unstaged Trip Generation Distributions in the 2 to 5 Mile Region

6 DEMAND ESTIMATION FOR EVACUATION SCENARIOS

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 subareas 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 28 Regions were defined which encompass all the groupings of subareas considered. These Regions are defined in Table 6-1. The subarea 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 guidance. The central sector coincides with the wind direction. These sectors extend to 5 miles from the plant (Regions R04 through R09) or to the EPZ boundary (Regions R10 through R21). Regions R01, R02 and R03 represent evacuations of circular areas with radii of 2, 5 and 10 miles, respectively. Regions R22 through R28 are identical to Regions R04 through R09 and R02, respectively; however, those subareas between 2 miles and 5 miles are staged until 90% of the 2-mile region (Region R01) has evacuated.

A total of 14 Scenarios were evaluated for all Regions. Thus, there are a total of 28 x 14 = 392 evacuation cases. Table 6-2 is a description of all Scenarios.

Each combination of region and scenario implies a specific population to be evacuated. Table 6-3 presents the percentage of each population group estimated to evacuate for each scenario. Table 6-4 presents the vehicle counts for each scenario for an evacuation of Region R03 – the entire EPZ.

The vehicle estimates presented in Section 3 are peak values. These peak values are adjusted depending on the scenario and region being considered, using scenario and region specific percentages; 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 the product of 60% (the number of households with at least one commuter) and 48% (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 commuters will have a commuter at work during those times.

Employment is estimated to be at its peak 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.

The recreational areas in the EPZ (shown in Appendix E, Table E-4) are predominantly outdoors and will be frequented more often during the summer than the winter. Transient activity is estimated to be at its peak (100%) during summer weekends, 35% during the week, and 10% during the evening. For the winter, transient activity is estimated to be less, 5% during the week and 12% on the weekend.

As noted in the shadow footnote to Table 6-3, the shadow percentages are computed using a base of 20% (see assumption 5 in Section 2.2); to include the employees within the shadow region, all of whom are expected 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 1, the shadow percentage is computed as follows:

$$20\% \times \left(1 + \frac{660}{3{,}266 + 8{,}062}\right) = 21\%$$

One special event – future construction (year 2023) of new nuclear generating facilities at the Callaway Plant site – was considered as Scenario 13. Thus, the special event traffic is 100% evacuated for Scenario 13, and 0% for all other scenarios.

It is estimated that summer school enrollment is approximately 10% of enrollment during the regular school year for summer, midweek, midday scenarios. School is not in session during weekends and evening, 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 are set to 100% for all scenarios as it is assumed that the transit-dependent population is present in the EPZ for all scenarios.

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	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	G1	M1	M2	O1
Basic Regions																
		Subarea														
R01	2-Mile Radius	X														
R02	5-Mile Radius	X	X	X	X	X	X									
R03	Full EPZ	X	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:**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**G1**	**M1**	**M2**	**O1**
R04	N, NNE, NE	X				X	X									
R05	ENE, E, ESE,	X	X				X									
R06	SE, SSE, S	X	X	X												
R07	SSW, SW, WSW	X		X	X											
R08	W	X			X											
R09	WNW, NW, NNW	X			X	X										
Evacuate 5-Mile Radius and Downwind to the EPZ Boundary																
Region	**Wind Direction From:**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**G1**	**M1**	**M2**	**O1**
R10	N	X	X	X	X	X	X									X
R11	NNE, NE	X	X	X	X	X	X	X								X
R12	ENE	X	X	X	X	X	X	X	X							
R13	E, ESE	X	X	X	X	X	X	X	X	X						
R14	SE, SSE	X	X	X	X	X	X		X	X	X					
R15	S	X	X	X	X	X	X		X		X	X				
R16	SSW, SW	X	X	X	X	X	X				X	X		X		
R17	WSW	X	X	X	X	X	X					X		X	X	
R18	W	X	X	X	X	X	X					X	X	X	X	
R19	WNW	X	X	X	X	X	X						X	X	X	X
R20	NW	X	X	X	X	X	X						X		X	X
R21	NNW	X	X	X	X	X	X						X			X
Staged Evacuation - 2-Mile Radius Evacuates, then Evacuate Downwind to 5 Miles																
Region	**Wind Direction From:**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**G1**	**M1**	**M2**	**O1**
R22	N, NNE, NE	X				X	X									
R23	ENE, E, ESE	X	X				X									
R24	SE, SSE, S	X	X	X												
R25	SSW, SW, WSW	X		X	X											
R26	W	X			X											
R27	WNW, NW, NNW	X			X	X										
R28	No Wind	X	X	X	X	X	X									

Key

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

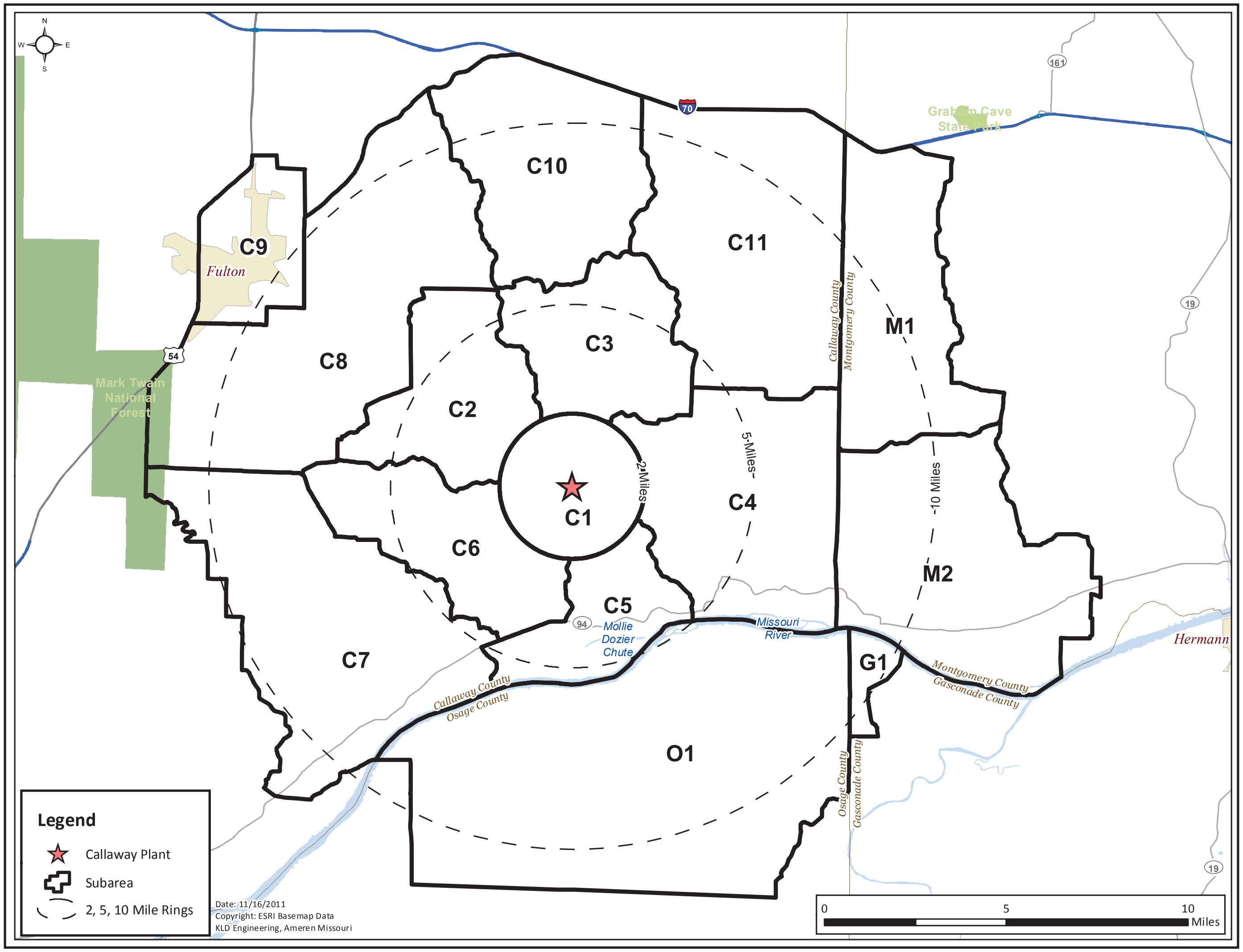


Figure 6-1. Callaway Plant EPZ Subareas

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	Snow	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Rain	None
11	Winter	Weekend	Midday	Snow	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Winter	Midweek	Midday	Good	Construction of new units at the Callaway Plant site
14	Summer	Midweek	Midday	Good	Roadway Impact – Lane Closure on I-70 Outbound

[1] Winter means that school is in session (also applies to spring and autumn). Summer means that school is not in session.

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	School Buses	Transit Buses	External Through Traffic
1	29%	71%	96%	35%	21%	0%	10%	100%	100%
2	29%	71%	96%	35%	21%	0%	10%	100%	100%
3	10%	90%	10%	100%	20%	0%	0%	100%	100%
4	10%	90%	10%	100%	20%	0%	0%	100%	100%
5	10%	90%	10%	10%	20%	0%	0%	100%	40%
6	29%	71%	100%	5%	21%	0%	100%	100%	100%
7	29%	71%	100%	5%	21%	0%	100%	100%	100%
8	29%	71%	100%	5%	21%	0%	100%	100%	100%
9	29%	71%	10%	12%	20%	0%	0%	100%	100%
10	10%	90%	10%	12%	20%	0%	0%	100%	100%
11	10%	90%	10%	12%	20%	0%	0%	100%	100%
12	10%	90%	10%	5%	20%	0%	0%	100%	40%
13	29%	71%	100%	5%	21%	100%	100%	100%	100%
14	29%	71%	96%	35%	21%	0%	10%	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.
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 access control approximately 2 hours 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	School Buses	Transit Buses	External Through Traffic	Total Scenario Vehicles
1	3,151	7,778	660	322	803	0	23	24	9,064	21,817
2	3,151	7,778	660	322	803	0	23	24	9,064	21,817
3	315	10,614	69	919	762	0	0	24	9,064	21,744
4	315	10,614	69	919	762	0	0	24	9,064	21,744
5	315	10,614	69	92	762	0	0	24	3,626	15,500
6	3,151	7,778	687	46	804	0	234	24	9,064	21,787
7	3,151	7,778	687	46	804	0	234	24	9,064	21,787
8	3,151	7,778	687	46	804	0	234	24	9,064	21,787
9	315	10,614	69	111	762	0	0	24	9,064	20,956
10	315	10,614	69	111	762	0	0	24	9,064	20,956
11	315	10,614	69	111	762	0	0	24	9,064	20,956
12	315	10,614	69	46	762	0	0	24	3,626	15,455
13	3,290	8,145	687	46	847	2,469	234	24	9,064	24,805
14	3,151	7,778	660	322	803	0	23	24	9,064	21,817

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

7 GENERAL POPULATION EVACUATION TIME ESTIMATES (ETE)

This section presents the current ETE results of the computer analyses using the DYNEV II System described in Appendices B, C and D. These results cover 28 regions within the Callaway Plant 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 people within the EPZ in subareas for which an Advisory to Evacuate has not been issued, yet who elect to evacuate. "Shadow evacuation" is the voluntary outward movement of some people 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 Callaway Plant EPZ addresses the issue of voluntary evacuees in the manner shown in Figure 7-1. Within the EPZ, 20 percent of people located in subareas 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 people 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 6,701 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, traveling away from the Callaway Plant location, has a 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, staged evacuation consists of the following:

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

2. Subareas comprising regions extending from 2 to 5 miles downwind are advised to shelter in-place while the two 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 population sheltering in the 2 to 5 mile region is advised to evacuate when approximately 90% of the 2 mile region evacuating traffic crosses the 2 mile region boundary.
5. Non-compliance with the shelter recommendation is the same as the shadow evacuation percentage of 20%.

See Section 5.4.2 for additional information on staged evacuation.

7.3 Patterns of Traffic Congestion during Evacuation

Figure 7-3 through Figure 7-5 illustrate the patterns of traffic congestion that arise for the case when the entire EPZ (Region R03) is advised to evacuate during the winter, midweek, midday period under good weather conditions (Scenario 6).

Traffic congestion, as the term is used here, is defined as Level of Service (LOS) F. LOS F is defined as follows (HCM 2010, page 5-5):

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

At 30 minutes after the Advisory to Evacuate (ATE), congestion develops rapidly around concentrations of population and traffic bottlenecks as seen in Figure 7-3. Roads displaying LOS E or lower are Bluff Street heading north out of Fulton, and US-54 just south of the interchange with the I-70 westbound ramps. It is expected that roadways in and around Fulton have the most pronounced traffic congestion because the majority of both population (60% of the EPZ) and special facilities are located in this area. There is minor congestion on County Road 459 due to plant workers evacuating south, on I-70 due to external traffic, and on a small section of Route 94 westbound just south of Mokane.

At 1 hour after the ATE, Figure 7-4 displays fully-developed congestion within the population center of Fulton, and north of Fulton to the junction of US-54 and I-70. Congestion has intensified along US-54 heading north to I-70 and Bluff Street in downtown Fulton. Additional congestion has developed in downtown Fulton as more vehicles begin their evacuation trips. All congestion has cleared within a 5 mile radius of the plant, and minor congestion persists on Route 94 and I-70.

At 1 hour and 45 minutes after the ATE, Figure 7-5 shows that major congestion within the EPZ has subsided. Only minor congestion exists along Business-54, Bluff St and US-54 exiting Fulton, and along I-70 eastbound. The only roadway exhibiting LOS F is US-54 just south of the intersection with the I-70 westbound freeway ramps. This portion of US-54 has 2 lanes with an estimated free-flow speed of 50 mph; however, the vehicle demand is greater than the roadway capacity due to the large number of vehicles exiting Fulton attempting to access I-70, and the lack of a traffic control point at this intersection.

At 2 hours and 20 minutes after the ATE, Figure 7-6 shows the entire network finally clear of all congestion. Vehicles will still be present in the network until 4 hours and 10 minutes after the ATE due to the mobilization time, but not enough to cause any LOS lower than “A”.

7.4 Evacuation Rates

Evacuation is a continuous process, as implied by Figure 7-7 through Figure 7-20. These figures indicate 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 7-7 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 – 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 28 Evacuation Regions and all 14 Evacuation Scenarios. Table 7-3 through Table 7-4 present the ETE values for 2-Mile region for both staged and un-staged 5-Mile regions. 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 that Region with both Concurrent and Staged Evacuations.
7-4	ETE represents the elapsed time required for 100 percent of the population within the 2-mile Region, to evacuate from that Region with both Concurrent and Staged Evacuations.

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 7-6. Most of the congestion is located in subarea C9 which is beyond the 5-mile area; this is reflected in the ETE statistics:

- The 90th percentile ETE for Region R01 generally ranges from 1:15 to 1:25 (higher for weekend snow case)
- The 90th percentile ETE for all other regions generally range between 1:15 and 2:10 (higher for snow cases).

The 100th percentile ETE for all Regions and Scenarios mirror the trip generation times. This fact implies that the congestion within the EPZ dissipates prior to the end of mobilization, as displayed in Figure 7-5 and discussed in Section 7.3.

Comparison of Scenarios 1 and 13 in Table 7-1 indicates that the Special Event – future construction of new nuclear generating facilities at the Callaway Plant site – has little impact on the ETE for the 90th percentile. The additional 2,469 vehicles for construction workers at the plant increases congestion slightly on roadways surrounding the plant, but congestion quickly dissipates as vehicles are dispersed throughout the network. For most regions, the 90th percentile ETE for Scenario 13 is slightly shorter than Scenario 6 because the many added construction worker vehicles in Scenario 13 mobilize at a faster rate than the general population, bringing down the overall average ETE.

The Special Event scenario occurs during good weather as this is the most probable weather condition throughout the year. Any ETE increases for rain or snow can be estimated by comparing effects between Scenarios 6, 7, and 8 and applying any differences to Scenario 13. Note that there is no significant time increase for rain and about a 30 minute increase for snow at the 90th percentile.

Comparison of Scenarios 1 and 14 in Table 7-1 indicates that the roadway closure – one lane on I-70 – does not significantly impact ETE because there is no significant congestion on the mainline of I-70. However, the ramps to I-70, especially US 54, do experience congestion. Thus, the mainline is under-utilized and removing a lane does not impact ETE.

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 R22 through R28 are the same geographic areas as Regions R04 through R09 and R02, respectively.

To determine whether the staged evacuation strategy is worthy of consideration, one must show that the ETE for the 2 Mile region can be reduced without significantly affecting the region between 2 miles and 5 miles. In all cases, as shown in Table 7-3 and Table 7-4, the ETE for the 2 mile region is relatively unchanged when a staged evacuation is implemented. The reason for this is that there is no significant congestion in the 5-mile area. Staging the evacuation to attempt to reduce congestion within the 5-mile area provides no benefits to evacuees from within the 2-mile region and unnecessarily delays the evacuation of those beyond 2 miles.

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
     - Snow
   - Special Event

    - Future Construction of new nuclear generating facilities at the Callaway Plant Site
    - Road Closure (One lane on I-70 is closed, as explained in Section 2.2)
- 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 snow are not explicitly identified in the Tables. For these conditions, Scenarios (8) and (11) for snow apply.
- The seasons are defined as follows:
    - Summer assumes that public schools are not in session.
    - Winter (includes Spring and Autumn) considers that public schools are in session.
- 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 the N, NNE, NE, etc.
    - 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 R09)
        - to EPZ Boundary (Regions R03, R10 through R21)
    - Enter Table 7-5 and identify the applicable group of candidate Regions based on the distance that the selected Region extends from the Callaway Plant. 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 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 4:00 AM.
- It is raining.
- Wind direction is from the southwest (SW).
- Wind speed is such that the distance to be evacuated is judged to be a 5-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 5-Mile Radius and Downwind to the EPZ Boundary” for wind direction from the SW and read Region R16 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 R16. This data cell is in column (4) and in the row for Region R16; it contains the ETE value of 2:00.

Table 7-1. Time to Clear the Indicated Area of *90* Percent of the Affected Population

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Midday		Midday		Evening	Midday			Midday			Evening	Midday	Midday
Region	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Construction of New Unit	Roadway Impact
Entire 2-Mile Region, 5-Mile Region, and EPZ														
R01	1:15	1:15	1:25	1:25	1:25	1:15	1:15	1:25	1:25	1:25	2:15	1:25	1:10	1:15
R02	1:55	1:55	1:45	1:45	1:45	1:55	1:55	2:50	1:45	1:45	2:55	1:45	1:30	1:55
R03	2:00	2:05	2:00	2:00	1:55	2:05	2:05	2:35	2:00	2:00	2:30	1:55	2:00	2:10
2-Mile Region and Keyhole to 5 Miles														
R04	1:45	1:45	1:40	1:40	1:40	1:45	1:45	2:35	1:40	1:40	2:50	1:40	1:25	1:45
R05	1:45	1:50	1:45	1:45	1:45	1:45	1:45	2:45	1:45	1:45	2:55	1:45	1:25	1:45
R06	1:45	1:45	1:45	1:45	1:45	1:45	1:45	2:40	1:45	1:45	2:50	1:45	1:20	1:45
R07	1:45	1:45	1:45	1:45	1:45	1:40	1:45	2:30	1:45	1:45	2:50	1:45	1:20	1:45
R08	1:35	1:35	1:40	1:40	1:40	1:35	1:35	2:05	1:40	1:40	2:40	1:40	1:15	1:35
R09	1:35	1:40	1:35	1:40	1:35	1:35	1:40	2:15	1:35	1:40	2:40	1:35	1:15	1:35
5-Mile Region and Keyhole to EPZ Boundary														
R10	2:00	2:00	1:45	1:45	1:45	2:00	2:00	2:55	1:45	1:45	2:55	1:45	1:35	2:00
R11	2:00	2:00	1:45	1:45	1:45	2:00	2:00	3:00	1:45	1:45	2:55	1:45	1:45	2:00
R12	2:00	2:00	1:50	1:50	1:50	2:00	2:00	2:45	1:55	1:55	2:40	1:55	1:50	2:00
R13	2:00	2:00	1:50	1:55	1:50	2:00	2:05	2:55	1:55	1:55	2:45	1:50	1:55	2:00
R14	2:00	2:00	1:55	1:55	1:55	2:00	2:00	2:25	1:55	1:55	2:25	1:55	1:55	2:05
R15	2:00	2:00	1:55	2:00	1:55	2:00	2:00	2:10	2:00	2:00	2:10	2:00	1:55	2:00
R16	2:00	2:00	2:00	2:00	2:00	2:00	2:00	2:10	2:00	2:00	2:15	2:00	1:55	2:00
R17	2:00	2:00	2:00	2:00	2:00	2:00	2:00	2:10	2:00	2:00	2:10	2:00	1:55	2:00
R18	2:00	2:00	2:00	2:00	2:00	2:00	2:00	2:10	2:00	2:00	2:10	2:00	1:55	2:00
R19	2:00	2:00	1:55	2:00	1:55	2:00	2:00	2:10	1:55	2:00	2:10	1:55	1:55	2:00
R20	2:00	2:00	1:45	1:50	1:45	2:00	2:00	3:00	1:45	1:50	2:55	1:45	1:40	2:00
R21	2:00	2:00	1:45	1:45	1:45	2:00	2:00	2:55	1:45	1:45	2:55	1:45	1:35	2:00
Staged Evacuation - 2-Mile Region and Keyhole to 5 Miles														
R22	1:45	1:45	1:45	1:45	1:45	1:45	1:45	2:35	1:45	1:45	2:50	1:45	1:30	1:45
R23	1:50	1:50	1:45	1:45	1:45	1:45	1:50	2:45	1:45	1:45	2:55	1:45	1:35	1:50
R24	1:45	1:50	1:45	1:50	1:45	1:45	1:45	2:40	1:45	1:50	2:55	1:45	1:35	1:45
R25	1:50	1:50	1:50	1:50	1:50	1:50	1:50	2:35	1:50	1:50	2:55	1:50	1:30	1:50
R26	1:45	1:45	1:45	1:50	1:45	1:45	1:45	2:05	1:45	1:50	2:50	1:45	1:20	1:45
R27	1:45	1:45	1:45	1:50	1:45	1:45	1:45	2:15	1:45	1:50	2:50	1:45	1:25	1:45
R28	1:55	1:55	1:50	1:50	1:50	1:55	1:55	2:50	1:50	1:50	2:55	1:50	1:40	1:55

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

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Midday		Midday		Evening	Midday			Midday			Evening	Midday	Midday
Region	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Construction of New Unit	Roadway Impact
Entire 2-Mile Region, 5-Mile Region, and EPZ														
R01	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R02	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
R03	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:15
2-Mile Region and Keyhole to 5 Miles														
R04	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
R05	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
R06	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
R07	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
R08	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
R09	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
5-Mile Region and Keyhole to EPZ Boundary														
R10	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:10
R11	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:10
R12	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:10
R13	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:10
R14	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:10
R15	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:10
R16	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:10
R17	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:10
R18	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:10
R19	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:10
R20	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:10
R21	4:10	4:10	4:10	4:10	4:10	4:10	4:10	6:10	4:10	4:10	6:10	4:10	4:10	4:10
Staged Evacuation - 2-Mile Region and Keyhole to 5 Miles														
R22	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
R23	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
R24	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
R25	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
R26	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
R27	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05
R28	4:05	4:05	4:05	4:05	4:05	4:05	4:05	6:05	4:05	4:05	6:05	4:05	4:05	4:05

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

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Region	Midday				Midday				Evening			Midday		
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Construction of New Unit	Roadway Impact
Entire 2-Mile Region and 5-Mile Region														
R01	1:15	1:15	1:25	1:25	1:25	1:15	1:15	1:25	1:25	1:25	2:15	1:25	1:10	1:15
R02	1:15	1:15	1:25	1:25	1:25	1:15	1:15	1:25	1:25	1:25	2:15	1:30	1:25	1:15
2-Mile Region and Keyhole to 5 Miles														
R04	1:15	1:15	1:25	1:25	1:25	1:15	1:15	1:25	1:25	1:25	2:15	1:25	1:25	1:15
R05	1:15	1:15	1:25	1:25	1:25	1:15	1:15	1:25	1:25	1:25	2:15	1:25	1:25	1:15
R06	1:15	1:15	1:30	1:30	1:30	1:15	1:15	1:25	1:30	1:30	2:15	1:30	1:20	1:15
R07	1:15	1:15	1:30	1:30	1:30	1:15	1:15	1:25	1:30	1:30	2:15	1:30	1:20	1:15
R08	1:15	1:15	1:30	1:30	1:30	1:15	1:15	1:25	1:30	1:30	2:15	1:30	1:20	1:15
R09	1:15	1:15	1:30	1:30	1:30	1:15	1:15	1:25	1:30	1:30	2:15	1:30	1:20	1:15
Staged Evacuation - 2-Mile Region and Keyhole to 5 Miles														
R22	1:15	1:15	1:25	1:25	1:25	1:15	1:15	1:25	1:25	1:25	2:15	1:25	1:20	1:15
R23	1:15	1:15	1:25	1:25	1:25	1:15	1:15	1:25	1:25	1:25	2:15	1:25	1:20	1:15
R24	1:15	1:15	1:25	1:25	1:25	1:15	1:15	1:25	1:25	1:25	2:15	1:25	1:20	1:15
R25	1:15	1:15	1:25	1:25	1:25	1:15	1:15	1:25	1:25	1:25	2:15	1:25	1:20	1:15
R26	1:15	1:15	1:25	1:25	1:25	1:15	1:15	1:25	1:25	1:25	2:15	1:25	1:20	1:15
R27	1:15	1:15	1:25	1:25	1:25	1:15	1:15	1:25	1:25	1:25	2:15	1:25	1:20	1:15
R28	1:15	1:15	1:25	1:25	1:25	1:15	1:15	1:25	1:25	1:25	2:15	1:25	1:20	1:15

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

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Region	Midday		Midday		Evening	Midday			Midday			Evening	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Construction of New Unit	Roadway Impact
Entire 2-Mile Region and 5-Mile Region														
R01	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R02	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
2-Mile Region and Keyhole to 5 Miles														
R04	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R05	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R06	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R07	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R08	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R09	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
Staged Evacuation - 2-Mile Region and Keyhole to 5 Miles														
R22	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R23	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R24	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R25	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R26	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R27	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00
R28	4:00	4:00	4:00	4:00	4:00	4:00	4:00	6:00	4:00	4:00	6:00	4:00	4:00	4:00

Table 7-5. Description of Evacuation Regions

Region	Description	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	G1	M1	M2	O1
Basic Regions																
		Subarea														
Region	**Description**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**G1**	**M1**	**M2**	**O1**
R01	2-Mile Radius	X														
R02	5-Mile Radius	X	X	X	X	X	X									
R03	Full EPZ	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Evacuate 2-Mile Radius and Downwind to 5 Miles																
		Subarea														
Region	**Wind Direction From:**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**G1**	**M1**	**M2**	**O1**
R04	N, NNE, NE	X				X	X									
R05	ENE, E, ESE,	X	X				X									
R06	SE, SSE, S	X	X	X												
R07	SSW, SW, WSW	X		X	X											
R08	W	X			X											
R09	WNW, NW, NNW	X			X	X										
Evacuate 5-Mile Radius and Downwind to the EPZ Boundary																
		Subarea														
Region	**Wind Direction From:**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**G1**	**M1**	**M2**	**O1**
R10	N	X	X	X	X	X	X									X
R11	NNE, NE	X	X	X	X	X	X	X								X
R12	ENE	X	X	X	X	X	X	X	X							
R13	E, ESE	X	X	X	X	X	X	X	X	X						
R14	SE, SSE	X	X	X	X	X	X		X	X	X					
R15	S	X	X	X	X	X	X		X		X	X				
R16	SSW, SW	X	X	X	X	X	X				X	X		X		
R17	WSW	X	X	X	X	X	X					X		X	X	
R18	W	X	X	X	X	X	X					X	X	X	X	
R19	WNW	X	X	X	X	X	X						X	X	X	X
R20	NW	X	X	X	X	X	X						X		X	X
R21	NNW	X	X	X	X	X	X						X			X
Staged Evacuation - 2-Mile Radius Evacuates, then Evacuate Downwind to 5 Miles																
		Subarea														
Region	**Wind Direction From:**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**G1**	**M1**	**M2**	**O1**
R22	N, NNE, NE	X				X	X									
R23	ENE, E, ESE	X	X				X									
R24	SE, SSE, S	X	X	X												
R25	SSW, SW, WSW	X		X	X											
R26	W	X			X											
R27	WNW, NW, NNW	X			X	X										
R28	No Wind	X	X	X	X	X	X									

Key

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

Figure 7-1. Voluntary Evacuation Methodology

Enclosure
to ULNRC-05881

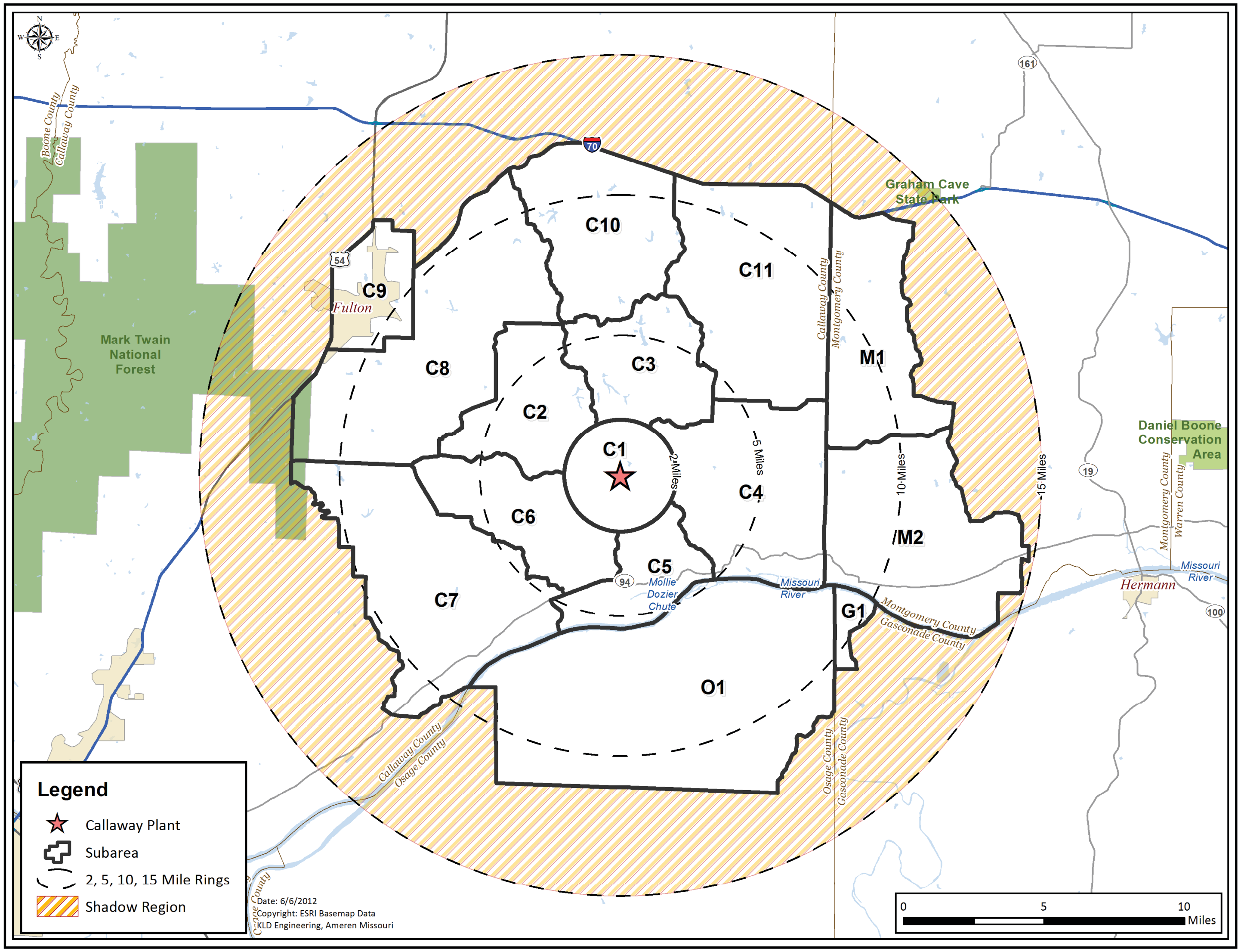


Figure 7-2. Callaway Plant Shadow Region

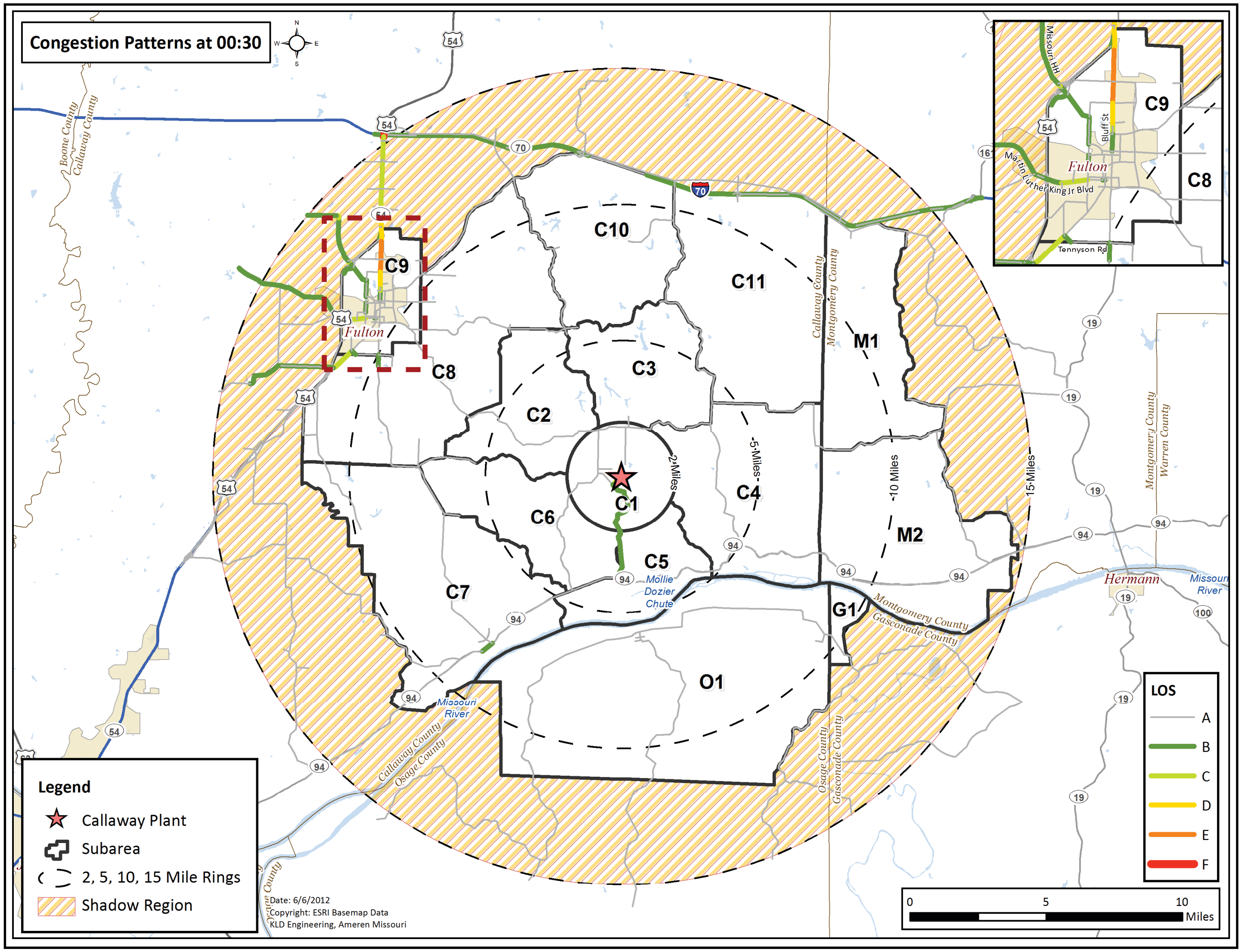


Figure 7-3. Congestion Patterns at 30 Minutes after the Advisory to Evacuate

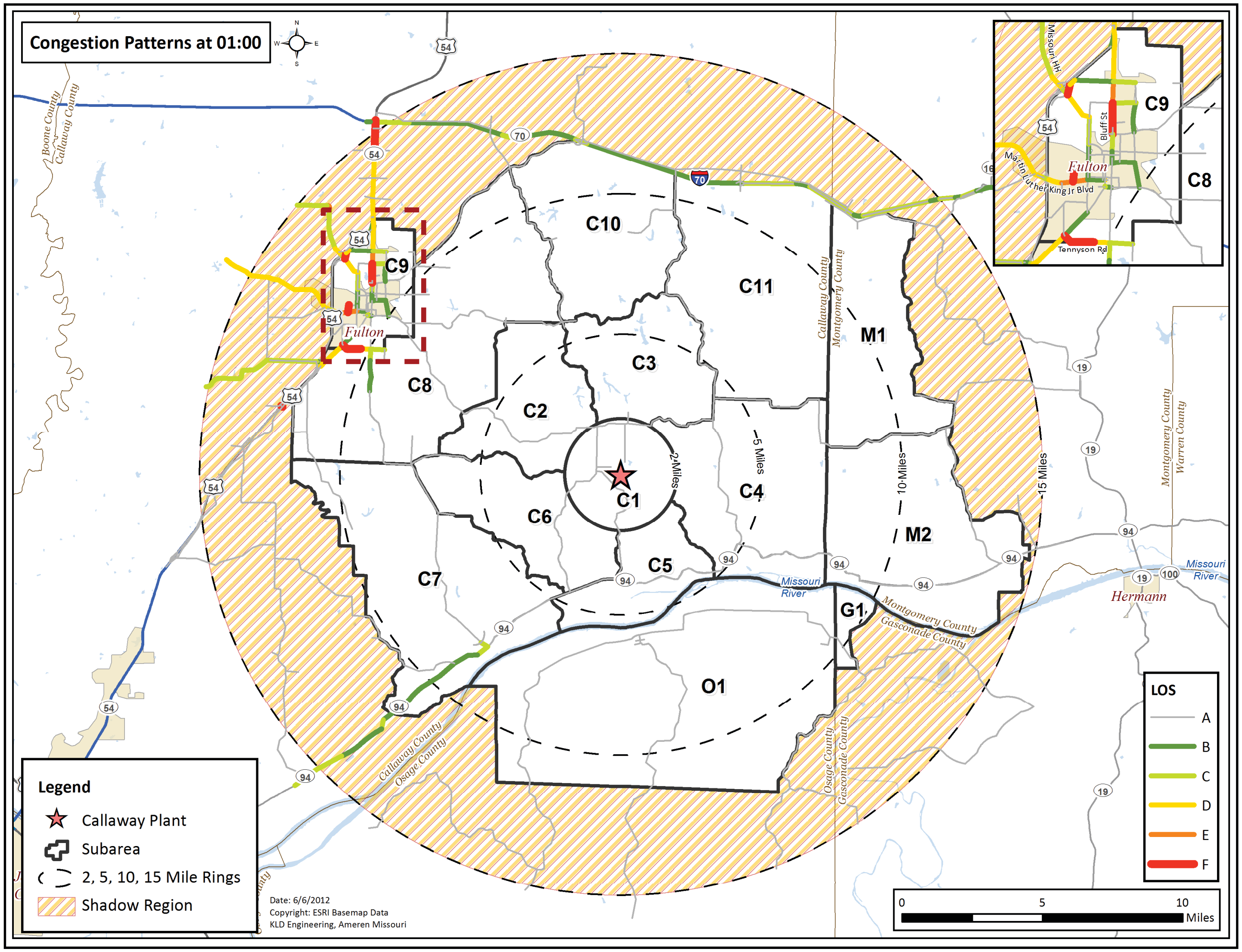


Figure 7-4. Congestion Patterns at 1 Hour after the Advisory to Evacuate

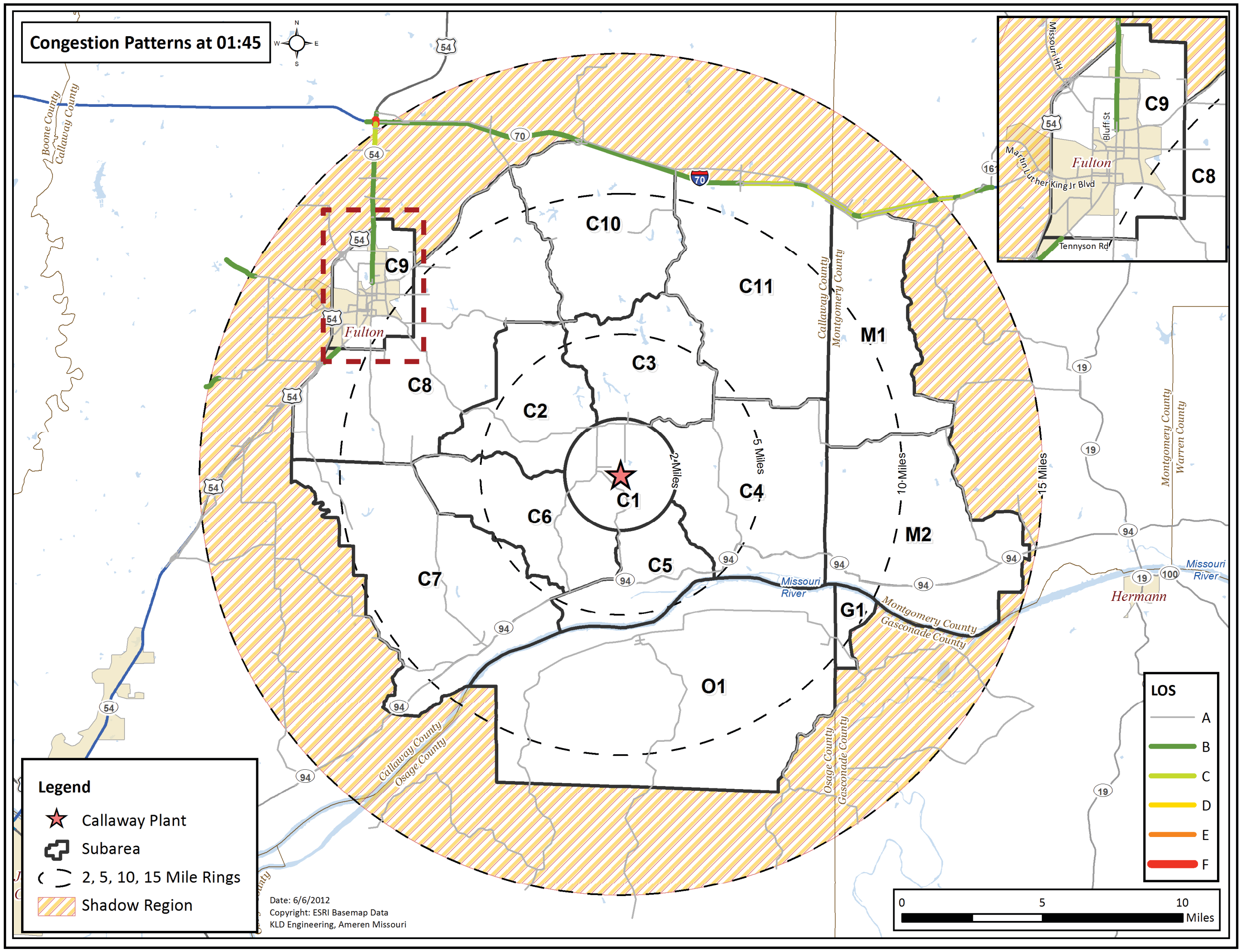


Figure 7-5. Congestion Patterns at 1 Hour and 45 Minutes after the Advisory to Evacuate

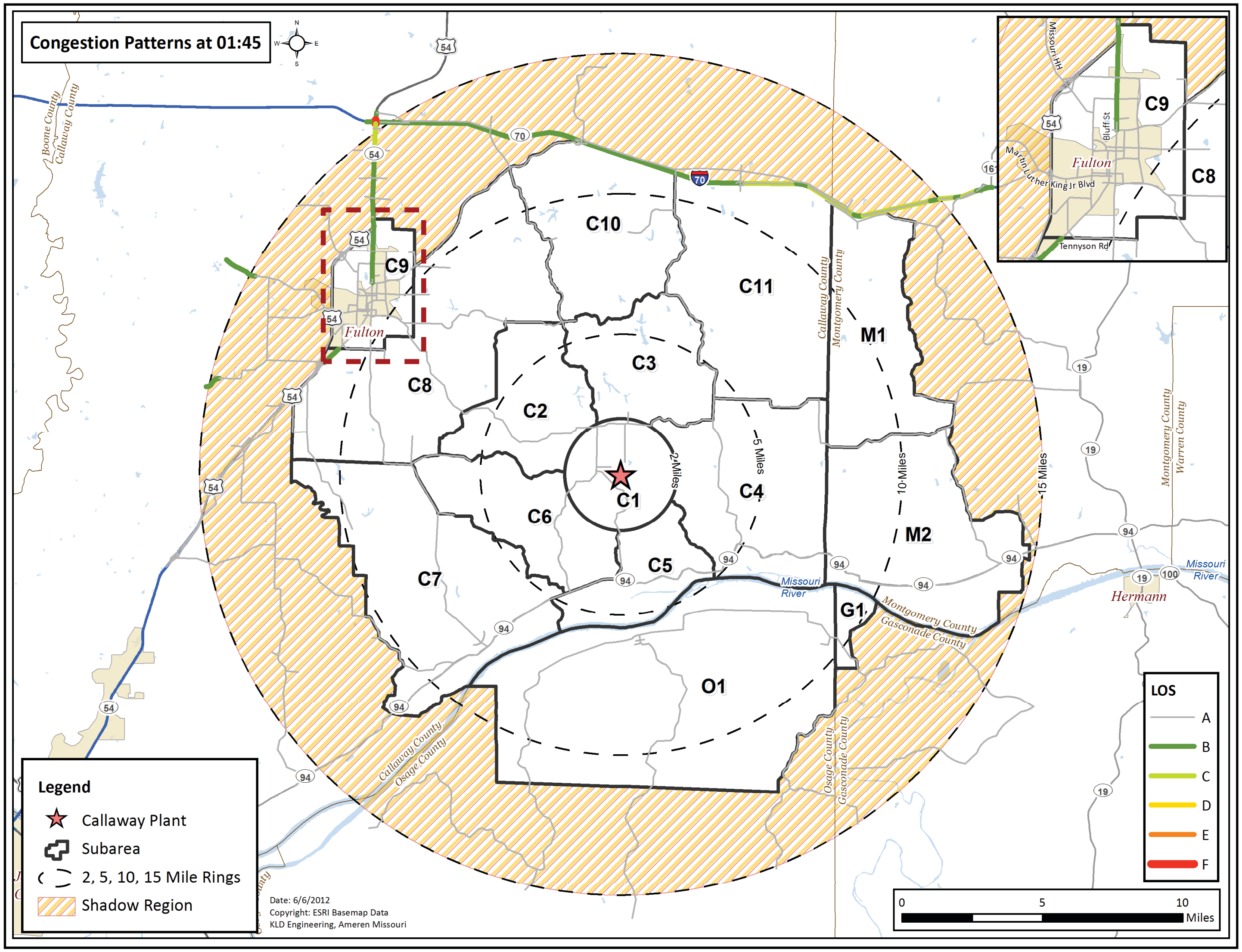


Figure 7-6. Congestion Patterns at 2 Hours and 20 Minutes after the Advisory to Evacuate

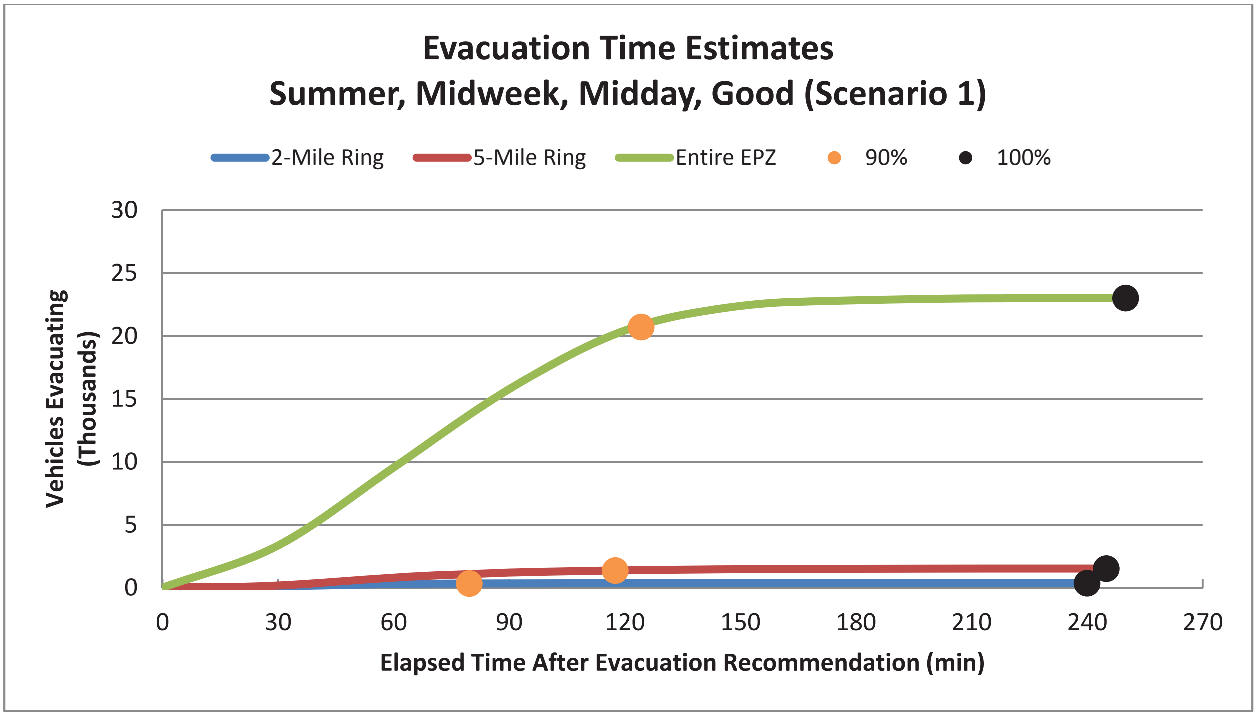


Figure 7-7. Evacuation Time Estimates – Scenario 1 for Region R03

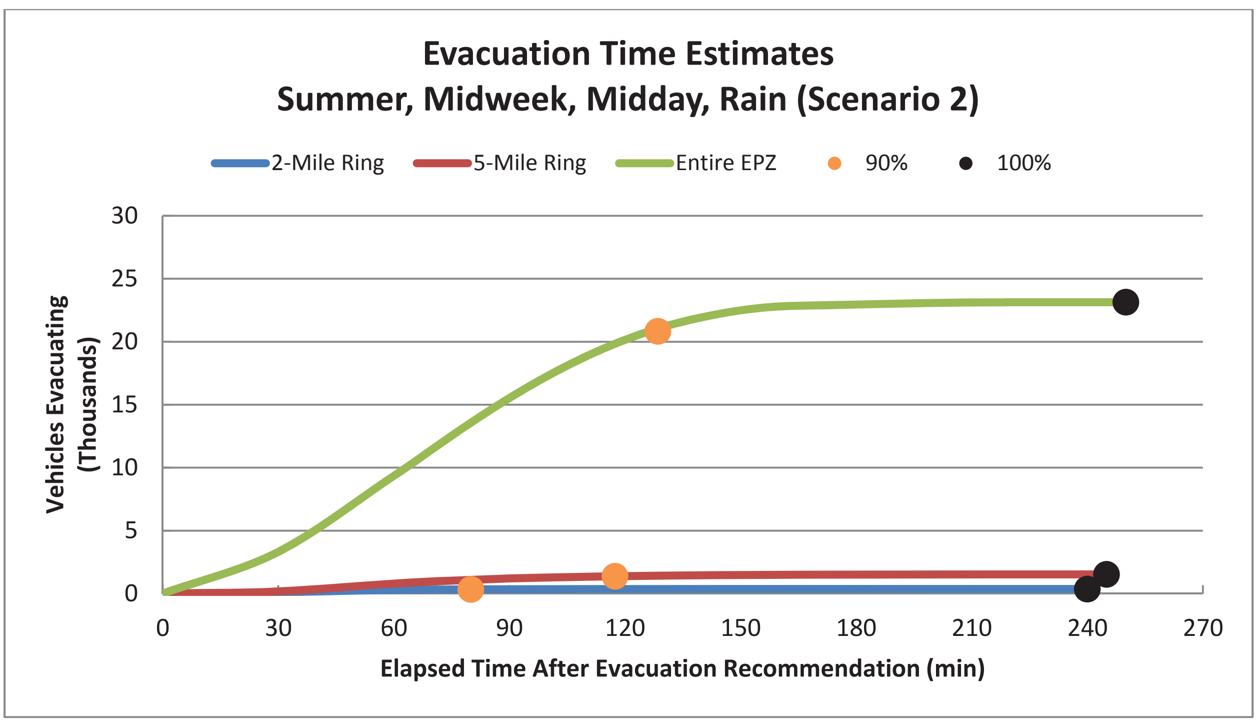


Figure 7-8. Evacuation Time Estimates – Scenario 2 for Region R03

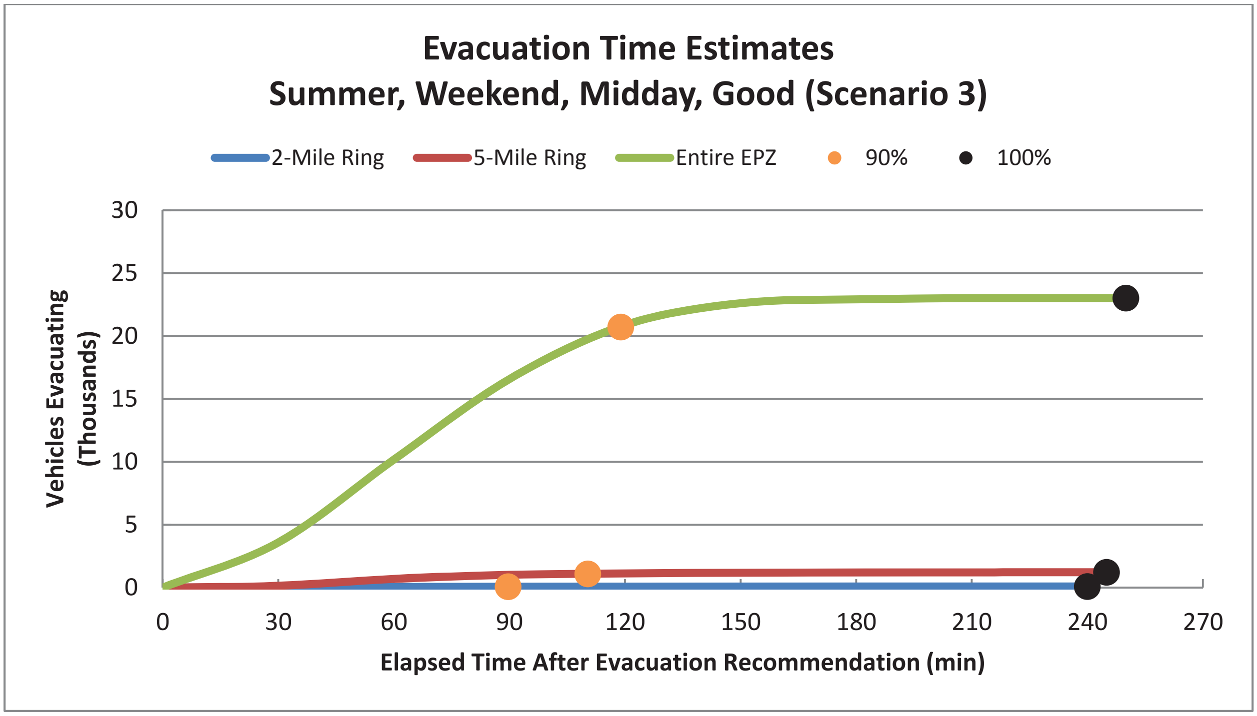


Figure 7-9. Evacuation Time Estimates – Scenario 3 for Region R03

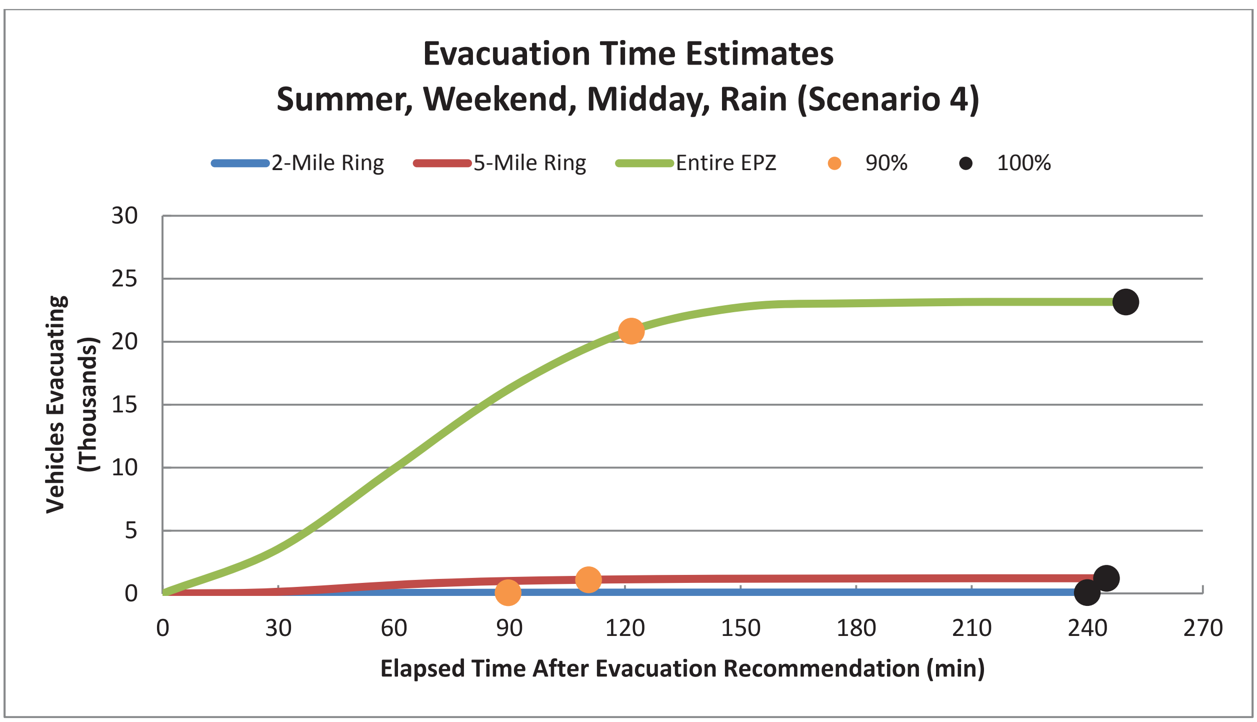


Figure 7-10. Evacuation Time Estimates – Scenario 4 for Region R03

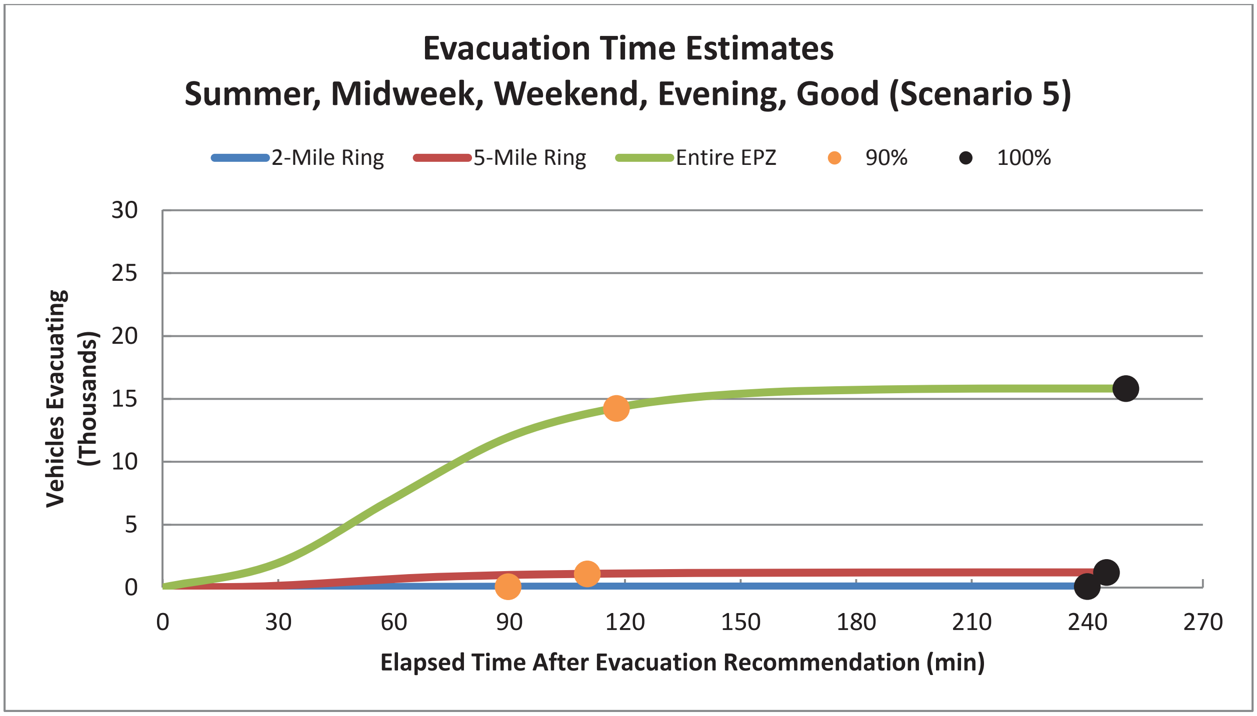


Figure 7-11. Evacuation Time Estimates – Scenario 5 for Region R03

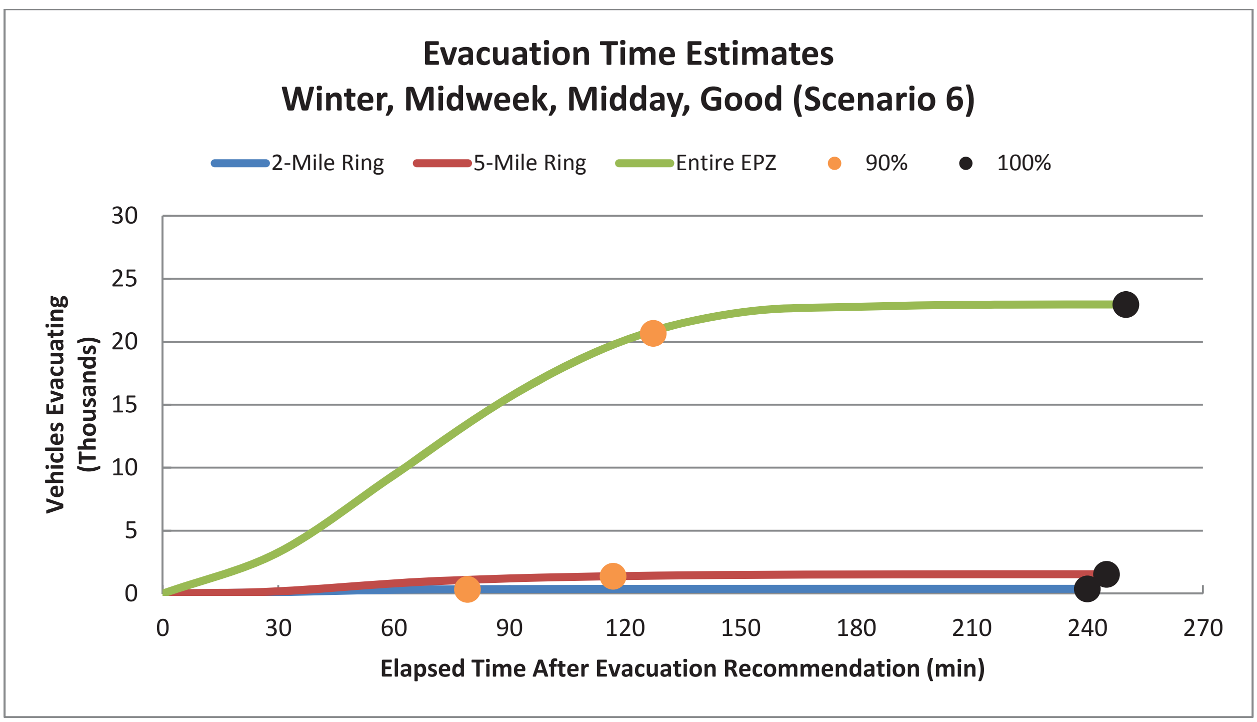


Figure 7-12. Evacuation Time Estimates – Scenario 6 for Region R03

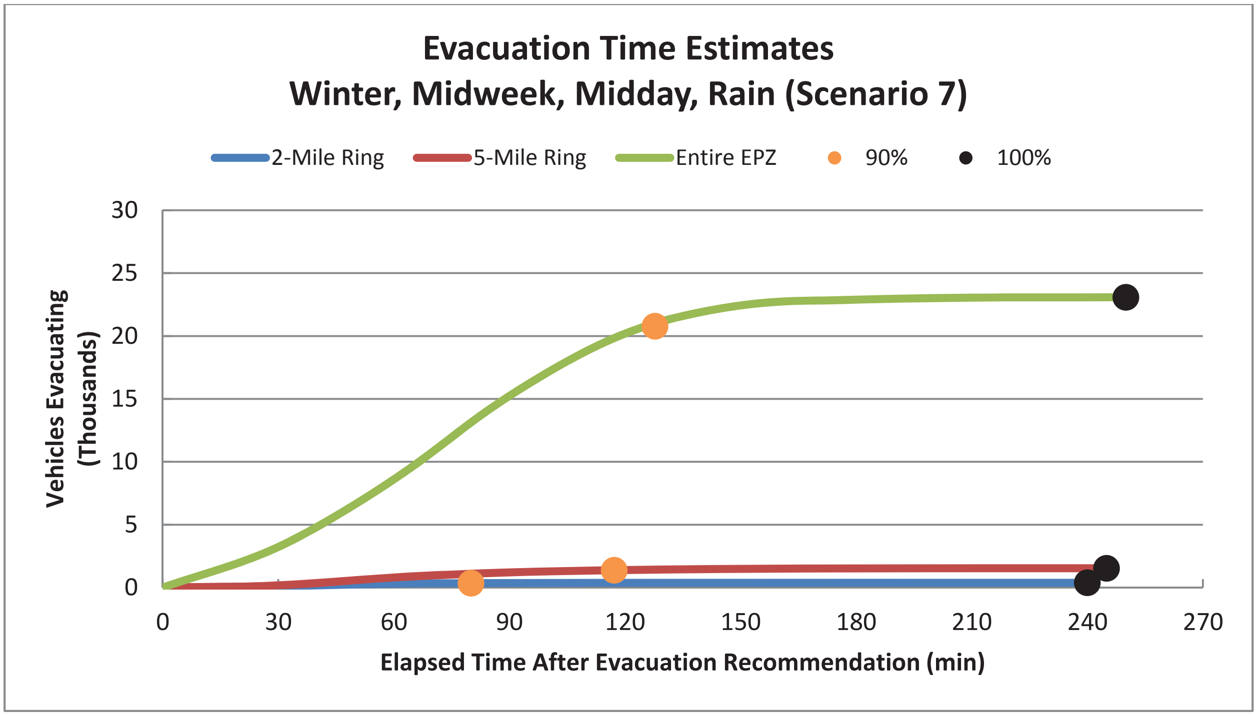


Figure 7-13. Evacuation Time Estimates – Scenario 7 for Region R03

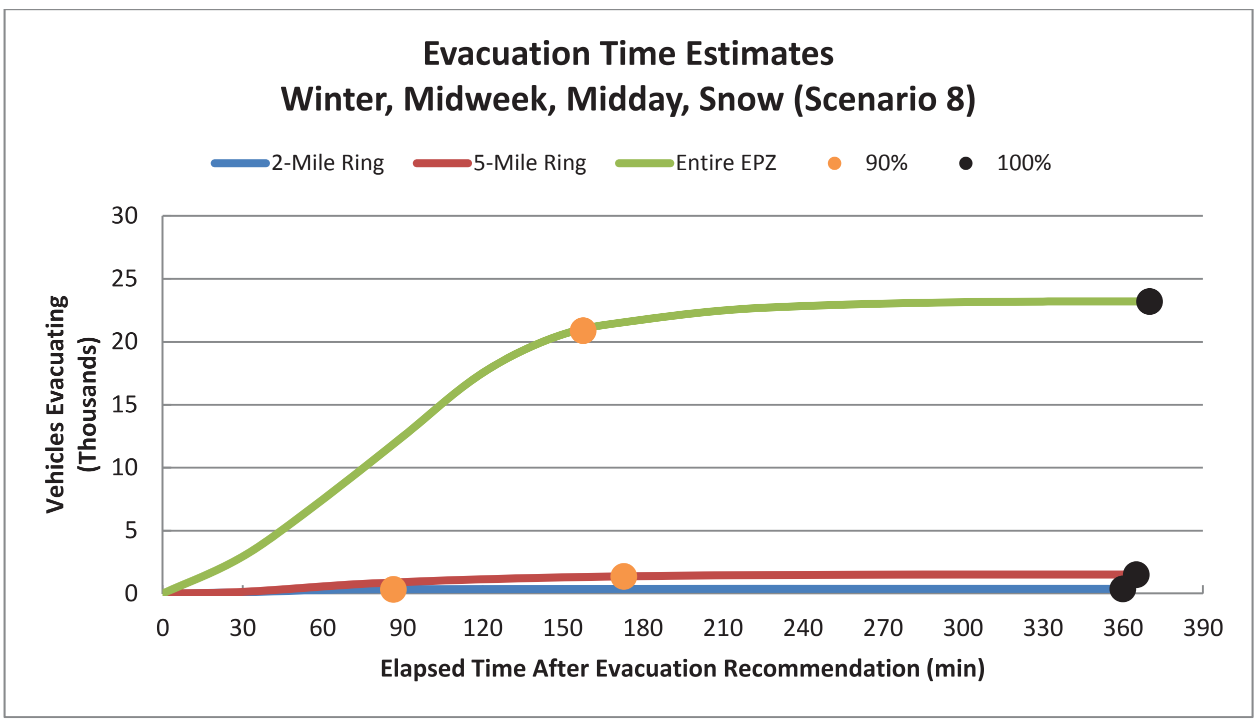


Figure 7-14. Evacuation Time Estimates – Scenario 8 for Region R03

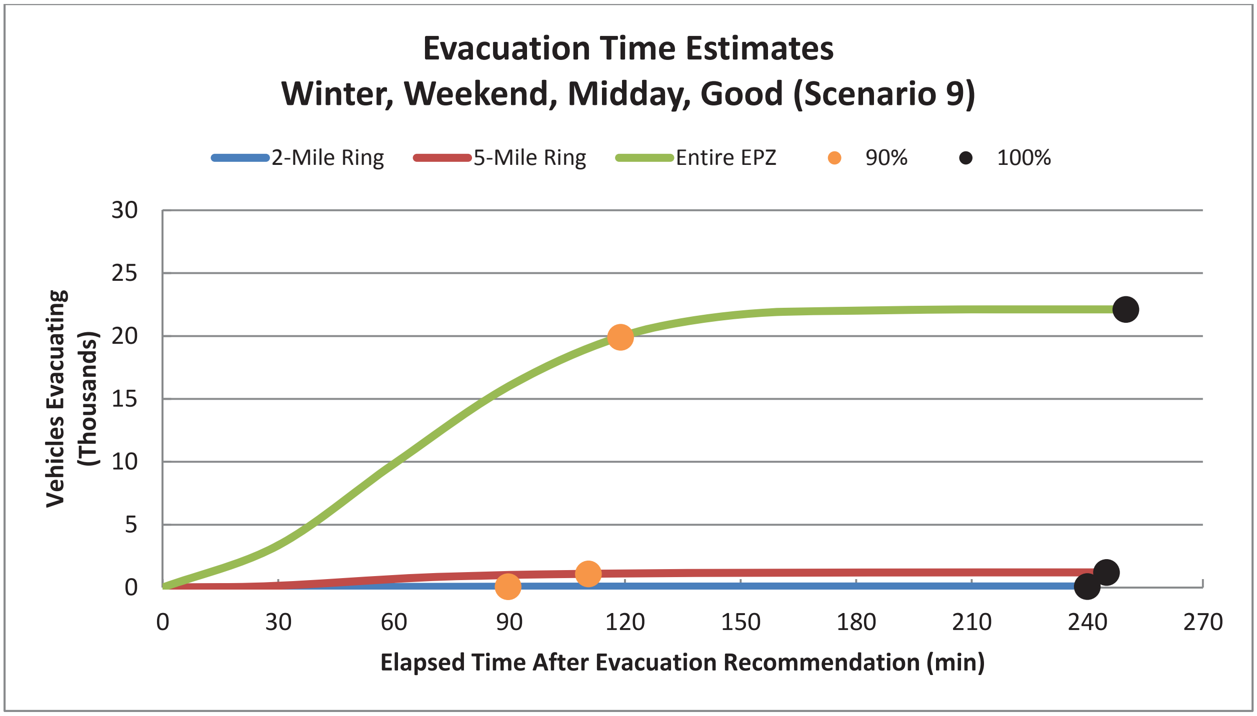


Figure 7-15. Evacuation Time Estimates – Scenario 9 for Region R03

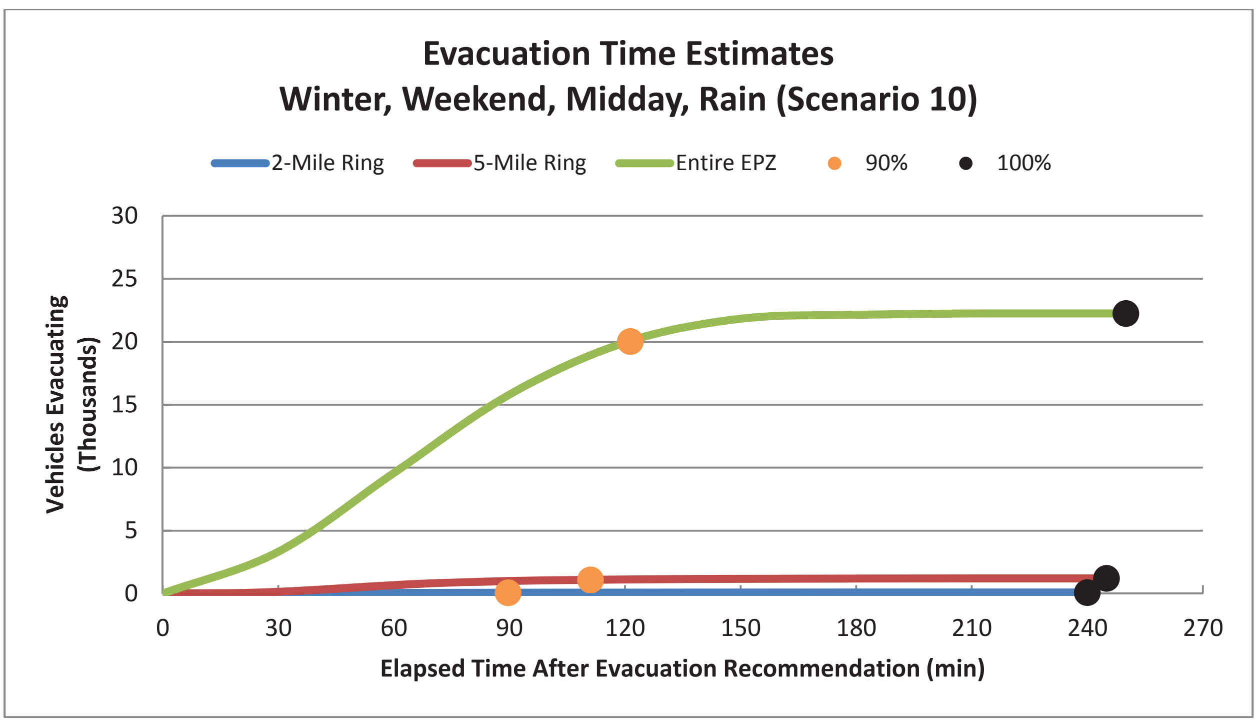


Figure 7-16. Evacuation Time Estimates – Scenario 10 for Region R03

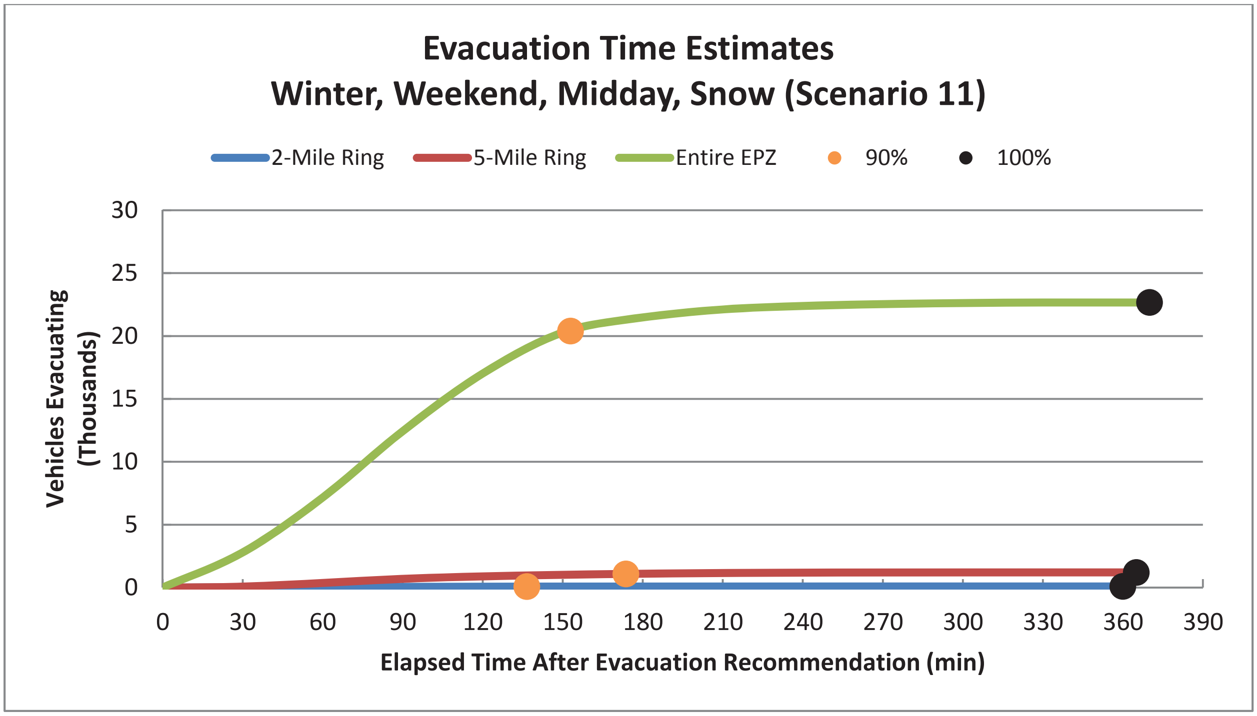


Figure 7-17. Evacuation Time Estimates – Scenario 11 for Region R03

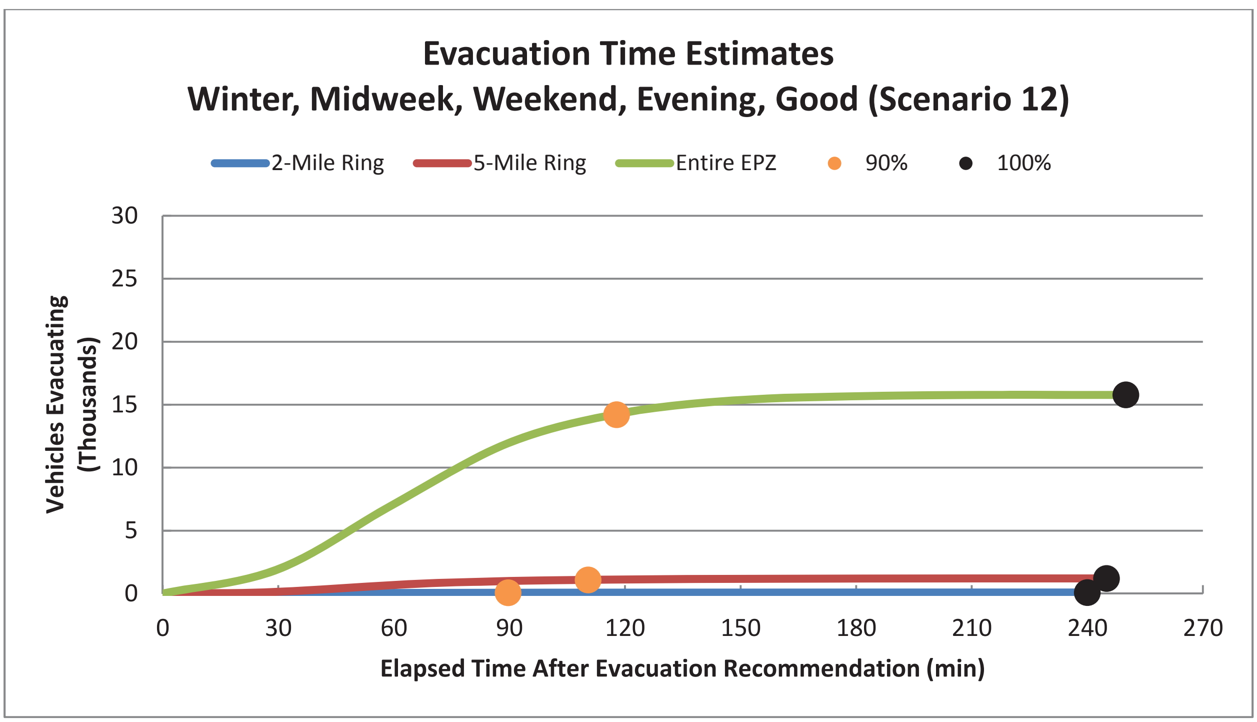


Figure 7-18. Evacuation Time Estimates – Scenario 12 for Region R03

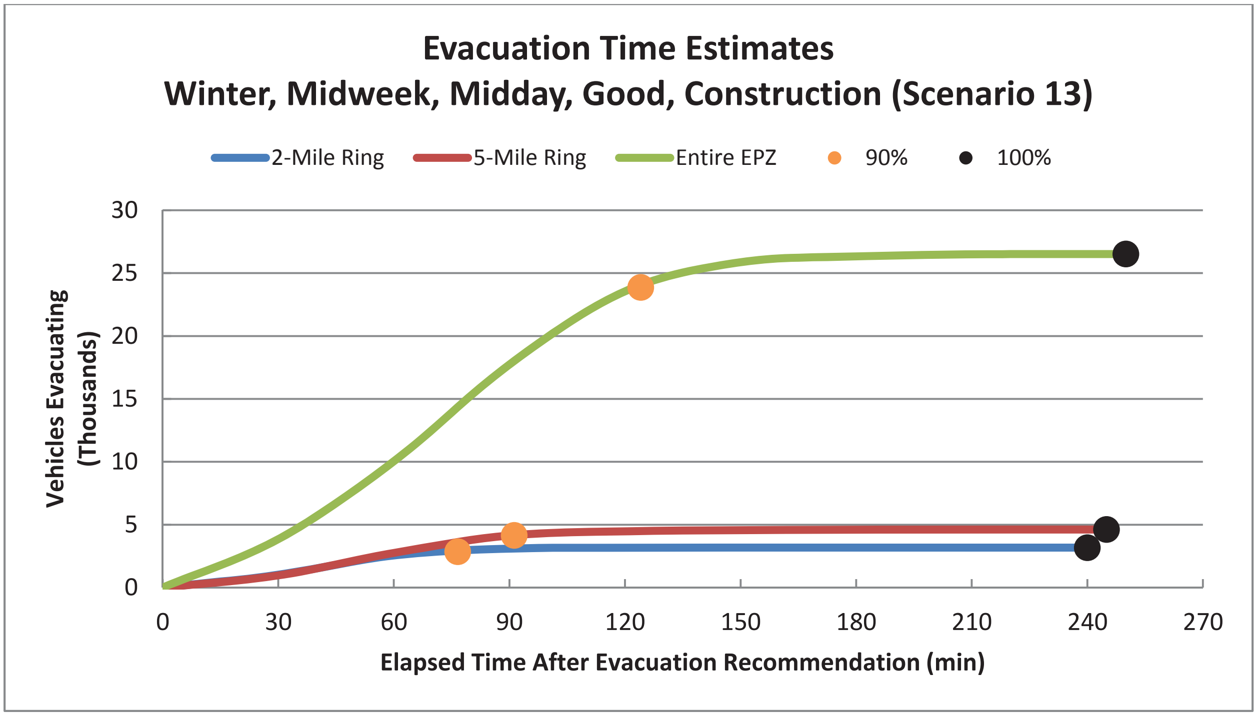


Figure 7-19. Evacuation Time Estimates – Scenario 13 for Region R03

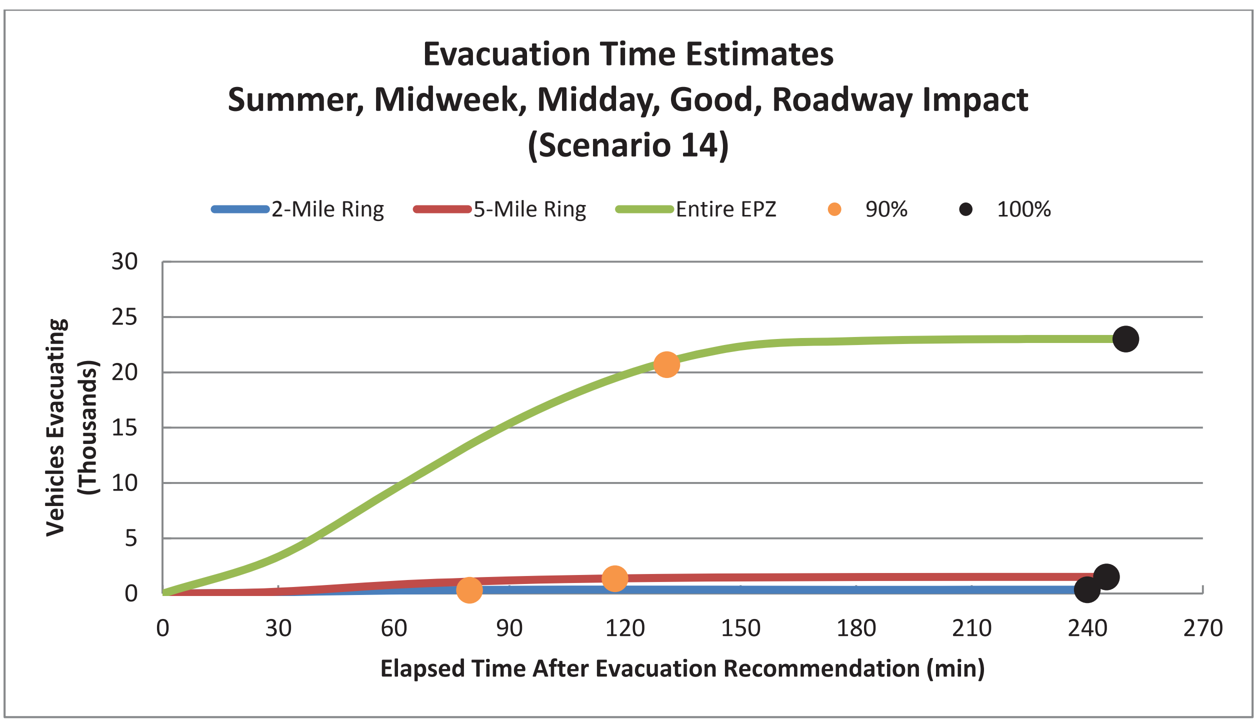


Figure 7-20. Evacuation Time Estimates – Scenario 14 for Region R03

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. 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, medical facilities, and (3) homebound special 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. Based discussion with offsite agencies, it is estimated that bus mobilization time will average approximately 90 minutes (30 minutes for Osage County) extending from the Advisory to Evacuate, to the time when buses first arrive at the facility to be evacuated.

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 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 Callaway Plant EPZ indicates that in the event of an emergency, schoolchildren will be evacuated to their school's specific reception center where they can be picked up by their parents. As discussed in Section 2, this study assumes a fast breaking general emergency. Therefore, children are evacuated to reception centers. 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), to present an upper bound estimate of buses required. It is assumed that children at day-care centers are picked up by parents or guardians and that the time to perform this activity is included in the trip generation times discussed in Section 5.

The procedure for computing transit-dependent ETE is to:

- Estimate demand for transit service

- Estimate time to perform all transit functions
- Estimate route travel times to the EPZ boundary and to the school reception centers

8.1 Transit Dependent People Demand Estimate

The telephone 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 8-1 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. **We will adopt a conservative estimate that 50 percent of transit dependent persons will ride share, in accordance with NUREG/CR-7002.**

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 (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 8-1 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 8-1 indicates that transportation must be provided for 296 people. Therefore, a total of 10 bus runs are required to transport this population to reception centers.

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 Callaway Plant 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

$$P = 8{,}405 \times [0.0241 \times 1.33 + 0.1891 \times (1.54 - 1) \times 0.60 \times 0.52 + 0.4185 \times (2.43 - 2) \times (0.60 \times 0.52)^2] = 684$$

$$B = (0.5 \times P) \div 30 = 12$$

These calculations are explained as follows:

- All members (1.33 avg.) of households (HH) with no vehicles (2.41%) will evacuate by public transit or ride-share. The term 8,405 (number of households) x 1.33 x 0.0241, accounts for these people.
- The members of HH with 1 vehicle away (18.91%), who are at home, equal (1.54-1). The number of HH where the commuter will not return home is equal to (8,405 x 0.1891 x 0.60 x 0.52), as 60% of EPZ households have a commuter, 52% 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 (41.85%), who are at home, equal (2.43 – 2). The number of HH where neither commuter will return home is equal to 8,405 x 0.4185 x $(0.60 \times 0.52)^2$. 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 8-1 far exceeds the number of registered transit-dependent persons in the EPZ as provided by the counties (discussed below in Section 8.5). 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.

8.2 School Population – Transit Demand

Table 8-2 presents the school population and transportation requirements for the direct evacuation of all schools within the EPZ for the 2011-2012 school year. This information was provided by the local county emergency management agencies. The column in Table 8-2 entitled "Bus Runs 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), the estimate of buses required for school evacuation do not consider the use of these private vehicles.
- Bus capacity, expressed in students per bus, is set to 70 for primary schools 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.

It is recommended that the counties in the EPZ introduce procedures whereby the schools are contacted prior to the dispatch of buses from the depot (approximately one hour after the Advisory to Evacuate), to ascertain the current estimate of students to be evacuated. In this way, the number of buses dispatched to the schools will reflect the actual number needed. 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 8-3 presents a list of the school reception centers for each school in the EPZ. Students will be transported to these centers where they will be subsequently retrieved by their respective families.

8.3 Special Facility Demand

Table 8-4 presents the census of special facilities in the EPZ. Approximately 17 people have been identified as living in, or being treated in, these facilities that will evacuate. The capacity and current census for each facility were provided by the county emergency management agencies and from the facilities themselves. This data is presented in Table 8-4.

The transportation requirements for the special facility population are also presented in Table 8-4. 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.

8.4 Evacuation Time Estimates 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 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.

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 pick-up points.

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. It is assumed that for a rapidly escalating radiological emergency with no observable indication before the fact, drivers would likely require 90 minutes to be contacted, to travel to the depot, be briefed, and to travel to the transit-dependent facilities. Mobilization time is slightly longer in adverse weather – 100 minutes when raining, 110 minutes when snowing (30, 35 and 40 minutes respectively for Osage County).

Activity: Board Passengers (C→D)

Based on discussions with offsite agencies, a loading time of 15 minutes (20 minutes for rain and 25 minutes for snow) for school buses is used.

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; total loading time is 40 minutes per bus in rain, 50 minutes in snow. Then

<u>Activity: Travel to EPZ Boundary (D→E)</u>

<u>*School Evacuation*</u>

Transportation resources available were provided by the EPZ county emergency management agencies and are summarized in Table 8-5. Also included in the table are the number of buses needed to evacuate schools, medical facilities, transit-dependent population, and homebound special needs (discussed below in Section 8.5). The current transportation needs exceed the resources available, so a second wave evacuation, where some buses return into the EPZ to pick up the remainder of evacuees, will be considered.

The buses servicing the schools are ready to begin their evacuation trips at 105 minutes after the advisory to evacuate – 90 minutes mobilization time plus 15 minutes loading time (30 minutes and 5 minutes respectively for Osage County) – 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 school reception center. 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 8-6 (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:

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

The average speed computed (using this methodology) for the buses servicing each of the schools in the EPZ is shown in Table 8-7 through Table 8-9 for school evacuation, and in Table 8-11 through Table 8-13 for the transit vehicles evacuating transit-dependent persons, which are discussed later. To comply with state bus speed regulations, the computed speeds are restricted to 45 mph, 40 mph, and 35 mph for good weather, rain and snow, respectively. 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 Reception Center was computed assuming an average speed of 45 mph, 40 mph, and 35 mph for good weather, rain and snow, respectively.

Table 8-7 (good weather), Table 8-8 (rain) and Table 8-9 (snow) present the following evacuation time estimates (rounded up to the nearest 5 minutes) for schools 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 School Reception Center. 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 + 3 = 1:50 rounded to the nearest 5 minutes for Bartley Elementary School, with good weather). The evacuation time to the School Reception Center 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), 90 percent of the evacuees will complete their mobilization when the buses will begin their routes, approximately 90 minutes after the Advisory to Evacuate.

Five separate routes have been identified to service the transit-dependent evacuees throughout the entire EPZ. These routes (shown graphically in Figure 8-2 and described in Table 8-10) were designed by KLD to service the major routes through each subarea and then proceed to the nearest reception center. It is assumed that residents will walk to and congregate at the nearest major road to be picked up. Each route has one bus that departs at 90 minutes after the ATE and a second but that departs at 110 minutes after the ATE, except for Route #2 which has two buses sent at each time period. Table 8-11 (good weather), Table 8-12 (rain) and Table 8-13 (snow) show the ETE breakdown for each step in the transit-dependent evacuation process, including a second wave evacuation. The residents taking longer to mobilize would either be picked up by the later bus on the route or be serviced by a second wave evacuation.

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 snow, 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 evacuation, where they are restricted to 45 mph, 40 mph, and 35 mph for good weather, rain and snow, respectively.

Table 8-11 through Table 8-13 present the transit-dependent population evacuation time estimates for each bus route calculated using the above procedures for good weather, rain and snow, respectively.

For example, the ETE for the Bus Route 4 is computed as 90 + 9 + 30 = 2:10 for good weather (rounded to nearest 5 minutes). Here, 9 minutes is the time to travel 4.8 miles at 30.8 mph, the average speed output by the model for this route at 90 minutes. The ETE for a second wave (discussed below) is presented due to the shortfall of available buses (see Table 8-5), as previously discussed.

Activity: Travel to Reception Centers (E→F)

The distances from the EPZ boundary to the reception centers are measured using GIS software along the most likely route from the EPZ exit point to the reception center. The reception centers are mapped in Figure 10-1. 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 public. Assumed bus speeds of 45 mph, 40 mph, and 35 mph for good weather, rain, and snow, 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 Subarea C-9 (route number 4) is computed as follows for good weather:

- Bus arrives at reception center at 2:45 in good weather (2:10 to exit EPZ + 35 minute travel time to reception center).
- Bus discharges passengers (5 minutes) and driver takes a 10-minute rest: 15 minutes.
- Bus returns to EPZ and completes second route: 35 minutes (equal to travel time to reception center) + 9 minutes (4.8 miles @ 33 mph) = 44 minutes
- Bus completes pick-ups along route: 30 minutes.
- Bus exits EPZ at time 2:10 + 0:35 + 0:15 + 0:44 + 0:30 = 4:15 (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 8-11 through Table 8-13.

The average ETE for a one-wave and two-wave evacuation of transit-dependent people both exceed the ETE for the general population at the 90th percentile.

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 Persons from Special Facilities

The bus operations for this group are similar to those for school evacuation except:

- Buses are assigned on the basis of 30 patients to allow for staff to accompany the patients.
- The passenger loading time will be longer at approximately one minute per patient to account for the time to move patients from inside the facility to the vehicles.

Table 8-4 indicates that only 2 bus runs are needed to service all of the special facilities in the EPZ. According to Table 8-5 the counties can collectively provide 120 buses, 6 vans, 3 wheelchair accessible buses, 7 wheelchair accessible vans and 12 ambulances. There are not enough buses for a single wave evacuation of all schools, transit-dependent and special facility populations. As such, second-wave ETE are provided for special facilities.

As is done for the schools, it is estimated that mobilization time averages 90 minutes. 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.

Based on the locations of the medical facilities in Figure E-2, it is estimated that buses will have to travel 1 mile on average to leave the EPZ for facilities that do not shelter in place. Assuming an average speed of 35 mph, the travel time out of the EPZ is approximately 2 minutes.

The ETE for buses evacuating ambulatory patients at medical facilities is the sum of the mobilization time, total passenger loading time, and travel time out of the EPZ. For example, the calculation of ETE for Callaway Community Hospital with 8 ambulatory residents is:

ETE: 90 + 8 x 1 + 2 = 100 min. or 1:40.

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

8.5 Special Needs Population

The county emergency management agencies have a combined registration for transit-dependent and homebound special needs persons. Based on data provided by the counties, there are an estimated 26 homebound special needs people within the Callaway County portion of the EPZ and 5 people within the Osage County portion of the EPZ who require transportation assistance to evacuate. Out of the 31 total special needs persons there are 19 ambulatory persons, 11 wheelchair-bound persons and 1 bedridden person.

<u>ETE for Homebound Special Needs Persons</u>

<u>*Wheel-Chair Buses*</u>

Section 8.3 identifies a wheelchair bus capacity of 15 wheelchairs per trip. As discussed above, there are 11 homebound special needs persons within the EPZ requiring a wheelchair bus. While only 1 wheelchair bus is needed from a capacity perspective, if 2 buses were deployed they would need to make a maximum of 6 stops (assuming 1 person per HH). It is conservatively assumed that the households are spaced 3 miles apart, and that van speeds approximate 20 mph between households in good weather (10% slower in rain, 20% slower in snow). The last HH is assumed to be 5 miles from the EPZ boundary, and the speed of 45 mph after the last pickup is used to compute travel time. All ETE are rounded to the nearest 5 minutes.

a. Assumed mobilization time for wheelchair bus resources to arrive at first household: 1:30 (1:40 in rain; 1:50 in snow)
b. Loading time at first household: 5 minutes
c. Travel to subsequent households: 5 @ 9 minutes (3 miles @ 20 mph, 18 mph in rain; 16 mph in snow) = 45 minutes (50 minutes in rain; 56 minutes in snow)
d. Loading time at subsequent households: 5 @ 5 minutes = 25 minutes
e. Travel time to EPZ boundary at 2:45 (3:00-rain; 3:15 – snow): 5 miles @ 45 mph (40 mph – rain; 35 mph - snow) = 7 minutes (8 minutes – rain; 9 minutes - snow)

ETE: 1:30 + 5 + 45 + 25 + 7 = 2:55

Rain ETE: 1:40 + 5 + 50 + 25 + 8 = 3:10

Snow ETE: 1:50 + 5 + 56 + 25 + 9 = 3:25

<u>*Buses*</u>

Assuming no more than one special needs person per HH implies that 19 households need to be serviced. While only 1 bus is needed from a capacity perspective, if 4 buses are deployed to service these special needs HH, then each would require 5 stops maximum. Because there are insufficient buses available, buses evacuating schools will return to the EPZ to service homebound special needs persons requiring bus transportation. The following outlines the ETE calculations:

1. Assume 4 buses are deployed, each with about 5 stops, to service a total of 19 HH.
2. The ETE is calculated as follows:
    a. Buses arrive at the first pickup location: 3:04 (2:21 average time for buses to arrive at reception centers, 5 minutes to unload, 10 minute driver rest, and 28 minutes to travel back to the EPZ for good weather).
    b. Load HH members at first pickup: 2 minutes
    c. Travel to subsequent pickup locations: 4 @ 9 minutes = 36 minutes
    d. Load HH members at subsequent pickup locations: 4 @ 2 minutes = 8 minutes
    e. Travel to EPZ boundary: 7 minutes.

ETE: 3:04 + 2 + 36 + 8 + 7 = 4:00

Rain ETE: 3:28 + 2 + 40 + 8 + 8 = 4:25

Snow ETE: 3:52 + 2 + 45 + 8 + 9 = 4:55

The estimated travel time between pickups is based on a distance of 3 miles @ 20 mph = 9 minutes (speeds are 10% and 20% lower for rain and snow, respectively). If planned properly, the pickup locations for each bus run should be clustered within the same general area. The estimated travel time to the EPZ boundary is based on a distance of 5 miles @ 45 mph = 7 minutes (assumed maximum bus speed). It is assumed that mobilization time to first pickup is 10 minutes longer in rain and 20 minutes longer in snow. All ETE are rounded to the nearest 5 minutes.

Assuming all HH members (avg. HH size equals 2.40 persons – Figure F-1) travel with the disabled person yields 5 x 2.40 = 12 persons per bus. From the perspective of bus capacity, fewer buses could be deployed. For example, 2 buses, each servicing about 10 HH could accommodate 2.40 x 10 = 24 people each, but the additional 5 stops would add 5 × (9 + 2) = 55 minutes to the ETE.

Ambulances

It is estimated that 1 ambulance will be needed to evacuate the 1 homebound bed-ridden person within the EPZ.

As discussed above, there are 12 ambulances available within the EPZ and only 1 is required to evacuate a homebound bedridden patient within the EPZ (see Table 8-5).

Ambulance mobilization time and loading time are assumed to be 15 minutes per patient and has an estimated distance of 5 miles to the EPZ boundary after the stop. It is conservatively assumed that the ambulance will travel at 30 mph. Mobilization time is 5 minutes longer and travel speed is 10% less in rain – 27 mph, and an additional 5 minutes longer and 10% less in snow – 24 mph. All ETE are rounded to the nearest 5 minutes.

The ETE are computed as follows:

a. Ambulance arrives at first household: 30 minutes
b. Loading time at first household: 15 minutes

c. Ambulance travels to second household: 5 miles @ 30 mph = 10 minutes
d. Loading time at second household: 15 minutes
e. Travel time to EPZ boundary: 5 miles @ 45 mph = 7 minutes (40 mph, 8 minutes – rain; 35, 9 minutes - snow)

ETE: 30 + 15 + 7 = 0:55

Rain ETE: 40 + 15 + 8 = 1:05

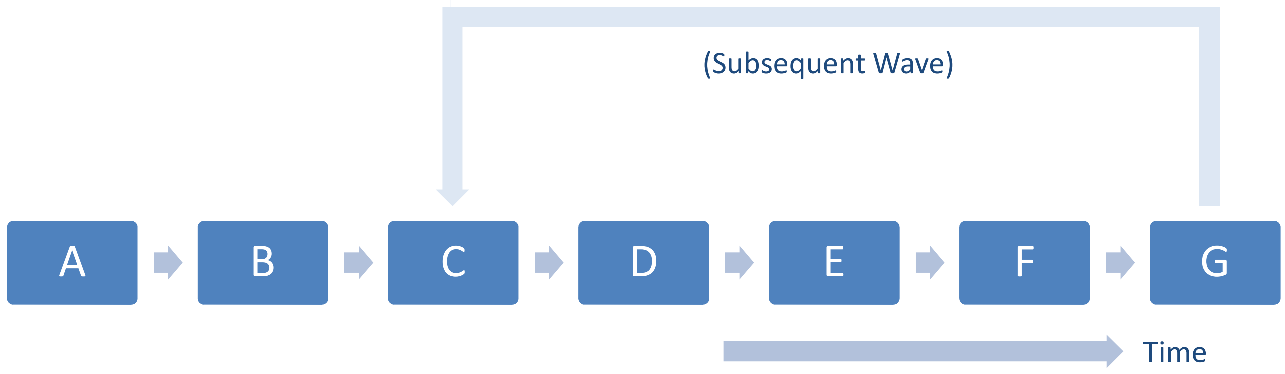
Snow ETE: 50 + 15 + 9 = 1:15

8.6 Correctional Facilities

As detailed in Table E-9, there are two correctional facilities within the EPZ – The Fulton Reception and Diagnostic Center and the Callaway County Jail. Both of these facilities will shelter in place in the event of an evacuation, as per state plans (2010 Missouri Nuclear Accident Plan, Section III.A.16).

8.7 Other Special Facilities

Missouri Girls Town, a residential treatment facility for girls, has its own transportation resources and is treated as a part of the permanent residential population.



	Event
A	Advisory to Evacuate
B	Bus Dispatched from Depot
C	Bus Arrives at Facility/Pick-up Route
D	Bus Departs for Reception Center
E	Bus Exits Region
F	Bus Arrives at Reception Center/Host Facility
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 Outside the EPZ
F→G	Passengers Leave Bus; Driver Takes a Break

Figure 8-1. Chronology of Transit Evacuation Operations

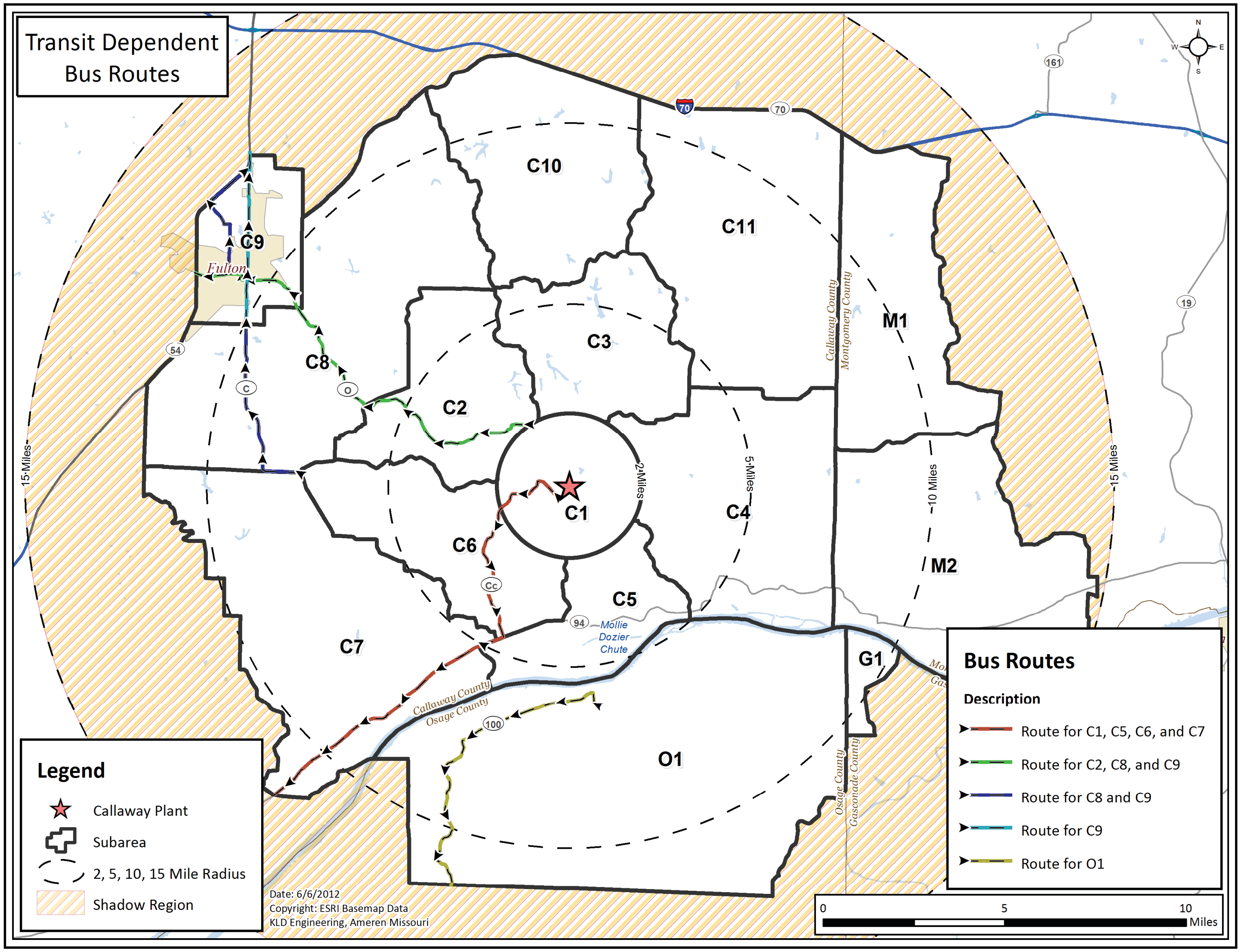


Figure 8-2. Transit-Dependent Bus Routes

Table 8-1. Transit-Dependent Population Estimates

2010 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						
20,173	1.33	1.54	2.43	8,405	2.41%	18.91%	41.85%	60%	52%	684	50%	342	1.7%

Table 8-2. School Population Demand Estimates

Subarea	School Name	Enrollment	Bus Runs Required
C7	South Callaway Elementary School	864[2]	18
C7	South Callaway High School		
C7	South Callaway Middle School		
C9	Bartley Elementary School	282	5
C9	Bush Elementary School	370	6
C9	Fulton High School	2,129	43
C9	Fulton Middle School	580	12
C9	Kingdom Christian Academy	174	4
C9	McIntire Elementary School	389	6
C9	Missouri School For the Deaf	80	2
C9	St. Peter Catholic School	128	3
C9	Westminster College[1]	265	6
C9	William Woods University[1]	223	5
O1	Osage County Chamois R-1 School District	219	7
	TOTAL:	**5,703**	**117**

[1]Enrollment number reflects only the students requiring bus evacuation.

[2]Enrollment number is grouped because data was given for the South Callaway R-II school district as a whole.

Table 8-3. School Reception Centers

School	Reception Center
Osage County Chamois R-1 School District	Lincoln University
South Callaway Elementary School	
South Callaway High School	
South Callaway Middle School	
Bartley Elementary School	
Bush Elementary School	University of Missouri
Fulton High School	
Fulton Middle School	
Kingdom Christian Academy	
McIntire Elementary School	
Missouri School For the Deaf	
St. Peter Catholic School	
Westminster College	
William Woods University	

Table 8-4. Special Facility Transit Demand

Subarea	Facility Name	Municipality	Cap-acity	Current Census	Ambu-latory	Wheel-chair Bound	Bed-ridden	Bus Runs	Wheel-chair Bus Runs	Ambulance Runs
C7	Riverview Nursing Center	Mokane	Shelter in Place							
C9	Ashbury Heights Independent Living	Fulton	Shelter in Place							
C9	Bristol Manor	Fulton	Shelter in Place							
C9	Callaway Community Hospital	Fulton	39	8	8	0	0	1	0	0
C9	Churchill Terrace	Fulton	44	9	9	0	0	1	0	0
C9	Fulton Nursing & Rehab	Fulton	Shelter in Place							
C9	Fulton State Hospital	Fulton	Shelter in Place							
		TOTAL:	**83**	**17**	**17**	**0**	**0**	**2**	**0**	**0**

Table 8-5. Summary of Transportation Resources

Transportation Resource	Buses	Vans	Wheelchair Buses	Wheelchair Vans	Ambulances
Resources Available					
Callaway County Ambulance District	-	-	-	-	4
Churchill Terrace	-	-	-	1	-
First Student Transportation	10	-	-	-	-
Fulton School District	32	-	2	-	-
Holts Summit	-	-	-	-	1
Jim Wright, Chamois	5	-	-	-	-
Montgomery County	-	-	-	3	3
North Callaway R-I Schools	25	-	-	-	-
Osage R-I School District	2	3	-	-	-
R-I School District, Hermann	13	-	-	-	-
Riverview Nursing Center	-	-	-	1	-
Rudroff Bus Company Linn	24	-	-	-	-
SERVE	-	-	-	2	-
South Callaway R-II School District	21	-	1	-	-
Swartz Bus Co.	8	-	-	-	-
University of Missouri Hospital	-	-	-	-	4
Westminster College	6	-	-	-	-
William Woods University	4	3	-	-	-
TOTAL:	**150**	**6**	**3**	**7**	**12**
Resources Needed					
Schools (Table 8-2):	117	-	-	-	-
Medical Facilities (Table 8-4):	3	-	-	-	-
Transit-Dependent Population (Table 8-10):	12	-	-	-	-
Homebound Special Needs (Section 8.5):	1	-	1	1	1
Correctional Facilities (Section 8.6):	-	-	-	-	-
TOTAL TRANSPORTATION NEEDS:	**133**	**0**	**1**	**1**	**1**

Table 8-6. Bus Route Descriptions

Bus Route Number	Description	Nodes Traversed from Route Start to EPZ Boundary
1	Osage County Chamois R-1 School District	938, 618, 788, 551, 550, 549, 548, 547, 546, 545, 544, 543, 542, 541, 540, 539, 538, 537, 536, 535, 534, 533, 532, 531
2	South Callaway High School, South Callaway Middle School, and South Callaway Elementary School	428, 429, 430, 431, 185, 186, 187, 188, 189, 190, 197, 191, 192
4	Fulton High School	399, 400, 48, 40, 45
5	McIntire Elementary School	397, 398, 58, 57, 56, 59
6	Bush Elementary School	780, 982, 779, 776, 865, 387, 388, 813, 394, 395, 396, 397, 398, 58, 57, 56, 59
7	Bartley Elementary School	402, 403, 404, 405, 963, 66, 441, 65, 64, 67
8	St. Peter Catholic School	780, 384, 385, 386, 809, 399, 400, 48, 40, 45
9	William Woods University	810, 386, 809, 399, 400, 48, 40, 45
10	Kingdom Christian Academy	388, 813, 394, 395, 396, 397, 398, 58, 57, 56, 59
11	Fulton Middle School	779, 776, 386, 809, 399, 400, 48, 40, 45
12	Westminster College	397, 398, 58, 57, 56, 59
13	Missouri School for the Deaf	863, 815, 813, 394, 395, 396, 397, 398, 58, 57, 56, 59
14	Transit-Dependent Bus Route #3	420, 817, 419, 418, 417, 416, 415, 414, 413, 409, 408, 407, 406, 390, 967, 966, 394, 395, 396, 985, 979, 765, 766, 767, 768, 832, 769, 770, 890
15	Transit-Dependent Bus Route #2	348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 232, 393, 392, 391, 390, 967, 966, 394, 395, 396, 397, 398, 58, 57, 56, 59
16	Transit-Dependent Bus Route #5	617, 678, 618, 788, 551, 552, 553, 911, 554, 555, 556, 557, 910, 558, 559, 560, 561, 562, 563, 564, 565
17	Transit-Dependent Bus Route #1	703, 688, 687, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 335, 331, 332, 333, 334, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 197, 191
18	Transit-Dependent Bus Route #4	408, 407, 406, 390, 815, 813, 388, 387, 865, 776, 386, 809, 399, 400, 48, 40, 45

Table 8-7. School Evacuation Time Estimates - Good Weather

School	Driver Mobilization Time	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.C. (mi.)	Travel Time from EPZ Bdry to R.C. (min)	ETE to R.C. (hr:min)
CALLAWAY COUNTY SCHOOLS									
Bartley Elementary School	90	15	1.5	40.8	3	**1:50**	22.6	31	**2:20**
Bush Elementary School	90	15	2.4	31.3	5	**1:50**	22.6	31	**2:25**
Fulton High School	90	15	1.6	43.5	3	**1:50**	26.1	35	**2:25**
Fulton Middle School	90	15	2.1	35.6	4	**1:50**	22.6	31	**2:20**
Kingdom Christian Academy	90	15	2.1	34.9	4	**1:50**	22.6	31	**2:20**
McIntire Elementary School	90	15	1.0	45.0	2	**1:50**	22.6	31	**2:20**
Missouri School for the Deaf	90	15	1.7	31.1	4	**1:50**	22.6	31	**2:20**
South Callaway Elementary School	90	15	6.0	45.0	8	**1:55**	17.7	24	**2:20**
South Callaway High School	90	15	6.0	45.0	8	**1:55**	17.7	24	**2:20**
South Callaway Middle School	90	15	6.0	45.0	8	**1:55**	17.7	24	**2:20**
St. Peter Catholic School	90	15	3.0	33.3	6	**1:55**	26.1	35	**2:30**
Westminster College	90	15	1.1	45.0	2	**1:50**	22.6	31	**2:20**
William Woods University	90	15	3.0	36.3	5	**1:50**	26.1	35	**2:25**
OSAGE COUNTY SCHOOLS									
Osage County Chamois R-1 School District	30	5	9.1	45.0	13	**0:50**	30.0	40	**1:30**
					Maximum for EPZ:	**1:55**		**Maximum:**	**2:30**
					Average for EPZ:	**1:50**		**Average:**	**2:20**

Table 8-8. School Evacuation Time Estimates – Rain

School	Driver Mobilization Time	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.C. (mi.)	Travel Time from EPZ Bdry to R.C. (min)	ETE to R.C. (hr:min)
CALLAWAY COUNTY SCHOOLS									
Bartley Elementary School	100	20	1.5	37.0	3	**2:05**	22.6	34	**2:40**
Bush Elementary School	100	20	2.4	29.2	6	**2:10**	22.6	34	**2:40**
Fulton High School	100	20	1.6	40.0	3	**2:05**	26.1	40	**2:45**
Fulton Middle School	100	20	2.1	33.2	4	**2:05**	22.6	34	**2:40**
Kingdom Christian Academy	100	20	2.1	32.3	4	**2:05**	22.6	34	**2:40**
McIntire Elementary School	100	20	1.0	40.0	2	**2:05**	22.6	34	**2:40**
Missouri School for the Deaf	100	20	1.7	29.3	4	**2:05**	22.6	34	**2:40**
South Callaway Elementary School	100	20	6.0	40.0	9	**2:10**	17.7	27	**2:40**
South Callaway High School	100	20	6.0	40.0	9	**2:10**	17.7	27	**2:40**
South Callaway Middle School	100	20	6.0	40.0	9	**2:10**	17.7	27	**2:40**
St. Peter Catholic School	100	20	3.0	31.3	6	**2:10**	26.1	40	**2:50**
Westminster College	100	20	1.1	40.0	2	**2:05**	22.6	34	**2:40**
William Woods University	100	20	3.0	34.1	6	**2:10**	26.1	40	**2:50**
OSAGE COUNTY SCHOOLS									
Osage County Chamois R-1 School District	35	10	9.1	40.0	13	**1:00**	30.0	45	**1:45**
					Maximum for EPZ:	**2:10**		**Maximum:**	**2:50**
					Average for EPZ:	**2:05**		**Average:**	**2:40**

Table 8-9. School Evacuation Time Estimates – Snow

School	Driver Mobilization Time	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.C. (mi.)	Travel Time from EPZ Bdry to R.C. (min)	ETE to R.C. (hr:min)
CALLAWAY COUNTY SCHOOLS									
Bartley Elementary School	110	25	1.5	32.9	3	**2:20**	22.6	39	**3:00**
Bush Elementary School	110	25	2.4	26.3	6	**2:25**	22.6	39	**3:00**
Fulton High School	110	25	1.6	35.0	3	**2:20**	26.1	45	**3:05**
Fulton Middle School	110	25	2.1	29.9	5	**2:20**	22.6	39	**3:00**
Kingdom Christian Academy	110	25	2.1	28.8	5	**2:20**	22.6	39	**3:00**
McIntire Elementary School	110	25	1.0	35.0	2	**2:20**	22.6	39	**3:00**
Missouri School for the Deaf	110	25	1.7	26.2	4	**2:20**	22.6	39	**3:00**
South Callaway Elementary School	110	25	6.0	35.0	11	**2:30**	17.7	31	**3:00**
South Callaway High School	110	25	6.0	35.0	11	**2:30**	17.7	31	**3:00**
South Callaway Middle School	110	25	6.0	35.0	11	**2:30**	17.7	31	**3:00**
St. Peter Catholic School	110	25	3.0	28.0	7	**2:25**	26.1	45	**3:10**
Westminster College	110	25	1.1	35.0	2	**2:20**	22.6	39	**3:00**
William Woods University	110	25	3.0	30.6	6	**2:25**	26.1	45	**3:10**
OSAGE COUNTY SCHOOLS									
Osage County Chamois R-1 School District	40	15	9.1	35.0	13	**1:15**	30.0	52	**2:05**
					Maximum for EPZ:	**2:30**		**Maximum:**	**3:10**
					Average for EPZ:	**2:20**		**Average:**	**3:00**

Table 8-10. Summary of Transit-Dependent Bus Routes

Route	No. of Buses	Route Description	Length (mi.)
1	2	Servicing Subareas C1, C5, C6, and C7 along Missouri CC to State Rt. 94 to Lincoln University	14.0
2	4	Servicing Subareas C2, C8, and C9 along Missouri O to University of Missouri	12.5
3	2	Servicing Subareas C8 and C9 along State Highway C to University of Missouri	11.2
4	2	Servicing Subarea C9 along State Rd C to BUS 54 to University of Missouri	4.8
5	2	Servicing Subareas O1 and G1 along State Rt. 100 to Hermann Middle School	10.0

Table 8-11. Transit-Dependent Evacuation Time Estimates - Good Weather

		One-Wave							Two-Wave					
Route Number	Bus Group Number	Mobilization	Route Length (miles)	Speed (mph)	Route Travel Time	Pickup Time	ETE	Dist. EPZ Bdry to R.C. (miles)	Travel Time to Rec. Ctr	Unload	Driver Rest	Route Travel Time	Pickup Time	ETE
1	1	90	14.0	45.0	19	30	2:20	17.7	24	5	10	42	30	4:10
	2	110	14.0	45.0	19	30	2:40	17.7	24	5	10	42	30	4:30
2	1	90	12.5	40.6	18	30	2:20	22.6	30	5	10	48	30	4:25
	2	110	12.5	40.3	19	30	2:40	22.6	30	5	10	49	30	4:45
3	1	90	11.2	42.7	16	30	2:20	26.1	35	5	10	50	30	4:30
	2	110	11.2	42.5	16	30	2:40	26.1	35	5	10	51	30	4:50
4	1	90	4.8	30.8	9	30	2:10	26.1	35	5	10	44	30	4:15
	2	110	4.8	31.7	9	30	2:30	26.1	35	5	10	44	30	4:35
5	1	90	10.0	45.0	13	30	2:15	11.0	15	5	10	31	30	3:45
	2	110	10.0	45.0	13	30	2:35	11.0	15	5	10	28	30	4:05
						Maximum ETE:	2:40						Maximum ETE:	4:50
						Average ETE:	2:30						Average ETE:	4:25

Table 8-12. Transit-Dependent Evacuation Time Estimates – Rain

Route Number	Bus Group Number	One-Wave: Mobilization	One-Wave: Route Length (miles)	One-Wave: Speed (mph)	One-Wave: Route Travel Time	One-Wave: Pickup Time	One-Wave: ETE	Two-Wave: Dist. EPZ Bdry to R.C. (miles)	Two-Wave: Travel Time to Rec. Ctr	Two-Wave: Unload	Two-Wave: Driver Rest	Two-Wave: Route Travel Time	Two-Wave: Pickup Time	Two-Wave: ETE
1	1	100	14.0	40.0	21	40	**2:45**	17.7	27	5	10	48	40	**4:55**
	2	120	14.0	40.0	21	40	**3:05**	17.7	27	5	10	48	40	**5:15**
2	1	100	12.5	36.9	20	40	**2:45**	22.6	34	5	10	54	40	**5:05**
	2	120	12.5	37.0	20	40	**3:05**	22.6	34	5	10	53	40	**5:25**
3	1	100	11.2	39.1	17	40	**2:40**	26.1	39	5	10	57	40	**5:10**
	2	120	11.2	39.0	17	40	**3:00**	26.1	39	5	10	56	40	**5:30**
4	1	100	4.8	28.8	10	40	**2:35**	26.1	39	5	10	49	40	**4:55**
	2	120	4.8	28.5	10	40	**2:55**	26.1	39	5	10	48	40	**5:15**
5	1	100	10.0	40.0	15	40	**2:35**	11.0	17	5	10	32	40	**4:20**
	2	120	10.0	40.0	15	40	**2:55**	11.0	17	5	10	32	40	**4:40**
						Maximum ETE:	**3:05**						**Maximum ETE:**	**5:30**
						Average ETE:	**2:50**						**Average ETE:**	**5:05**

Table 8-13. Transit Dependent Evacuation Time Estimates – Snow

Route Number	Bus Group Number	One-Wave							Two-Wave					
		Mobilization	Route Length (miles)	Speed (mph)	Route Travel Time	Pickup Time	ETE	Dist. EPZ Bdry to R.C. (miles)	Travel Time to Rec. Ctr	Unload	Driver Rest	Route Travel Time	Pickup Time	ETE
1	1	110	14.0	35.0	24	50	**3:05**	17.7	30	5	10	54	50	**5:35**
	2	130	14.0	35.0	24	50	**3:25**	17.7	30	5	10	54	50	**5:55**
2	1	110	12.5	32.5	23	50	**3:05**	22.6	39	5	10	62	50	**5:50**
	2	130	12.5	32.6	23	50	**3:25**	22.6	39	5	10	61	50	**6:10**
3	1	110	11.2	34.6	19	50	**3:00**	26.1	45	5	10	64	50	**5:55**
	2	130	11.2	34.5	19	50	**3:20**	26.1	45	5	10	64	50	**6:15**
4	1	110	4.8	25.9	11	50	**2:55**	26.1	45	5	10	55	50	**5:40**
	2	130	4.8	25.9	11	50	**3:15**	26.1	45	5	10	56	50	**6:00**
5	1	110	10.0	35.0	17	50	**3:00**	11.0	19	5	10	36	50	**5:00**
	2	130	10.0	35.0	17	50	**3:20**	11.0	19	5	10	36	50	**5:20**
						Maximum ETE:	**3:25**						**Maximum ETE:**	**6:15**
						Average ETE:	**3:15**						**Average ETE:**	**5:50**

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).
- Traffic Control Devices to assist these personnel in the performance of their tasks. These devices should comply with the guidance of the Manual of Uniform Traffic Control Devices (MUTCD) published by the Federal Highway Administration (FHWA) of the U.S.D.O.T. 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 plan that defines all 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.

We employ the terms "facilitate" and "discourage" 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 existing TCPs and ACPs identified by the offsite agencies in their existing emergency plans serve as the basis of the traffic management plan, as per NUREG/CR-7002.
2. Computer analysis of the evacuation traffic flow environment.

   This analysis identifies the best routing and those critical intersections that experience pronounced congestion. Any critical intersections that are not identified in the existing offsite plans are suggested as additional TCPs and ACPs
3. A field survey of the highway network within 15 miles of the power plant.
4. Consultation with emergency management and law enforcement personnel.

   Trained personnel who are experienced in controlling traffic and are aware of the likely evacuation traffic patterns should review the control tactics at the suggested additional TCPs and ACPs.
5. Prioritization of TCPs and ACPs.

   Application of traffic and access control at some TCPs and ACPs will have a more pronounced influence on expediting traffic movements than at other TCPs and ACPs. 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. These priorities should be assigned by state/county emergency management representatives and by law enforcement personnel.

It is recommended that the control tactics identified in Appendix G be reviewed by the state and county emergency planners, and local and state police. Specifically the number and locations of the suggested TCPs and ACPs should be reviewed in detail, and the indicated resource requirements should be reconciled with current assets.

The use of Intelligent Transportation Systems (ITS) technologies can reduce 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 can also be placed outside of the EPZ to 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 en route through their vehicle stereo systems. Automated Traveler 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 his trip, while on board navigation systems (GPS units), cell phones, and pagers can be used to provide information en route. These are only several examples of how ITS technologies can benefit the evacuation process. Consideration should be given that ITS technologies be used to facilitate the evacuation process, and any additional signage placed should consider evacuation needs.

The ETE analysis treated all controlled intersections that are existing TCP locations in the offsite agency plans as being controlled by actuated signals.

Chapters 2N and 5G, and Part 6 of the 2009 MUTCD are particularly relevant and should be reviewed during emergency response training.

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

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

Study Assumptions 5 and 6 in Section 2.3 discuss ACP and TCP staffing schedules and operations.

10 EVACUATION ROUTES

Evacuation routes are comprised of two distinct components:

- Routing from a subarea 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 so as to balance traffic demand relative to the available highway capacity to the extent possible. See Appendices B through D for further discussion.

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.

Figure 10-1 is a map showing the general population and school reception centers for evacuees. The major evacuation routes for the EPZ are presented in Figure 10-2.

It is assumed that all school evacuees will be taken to the appropriate reception center and subsequently picked up by parents or guardians. Transit-dependent evacuees are transported to the nearest reception center for each county.

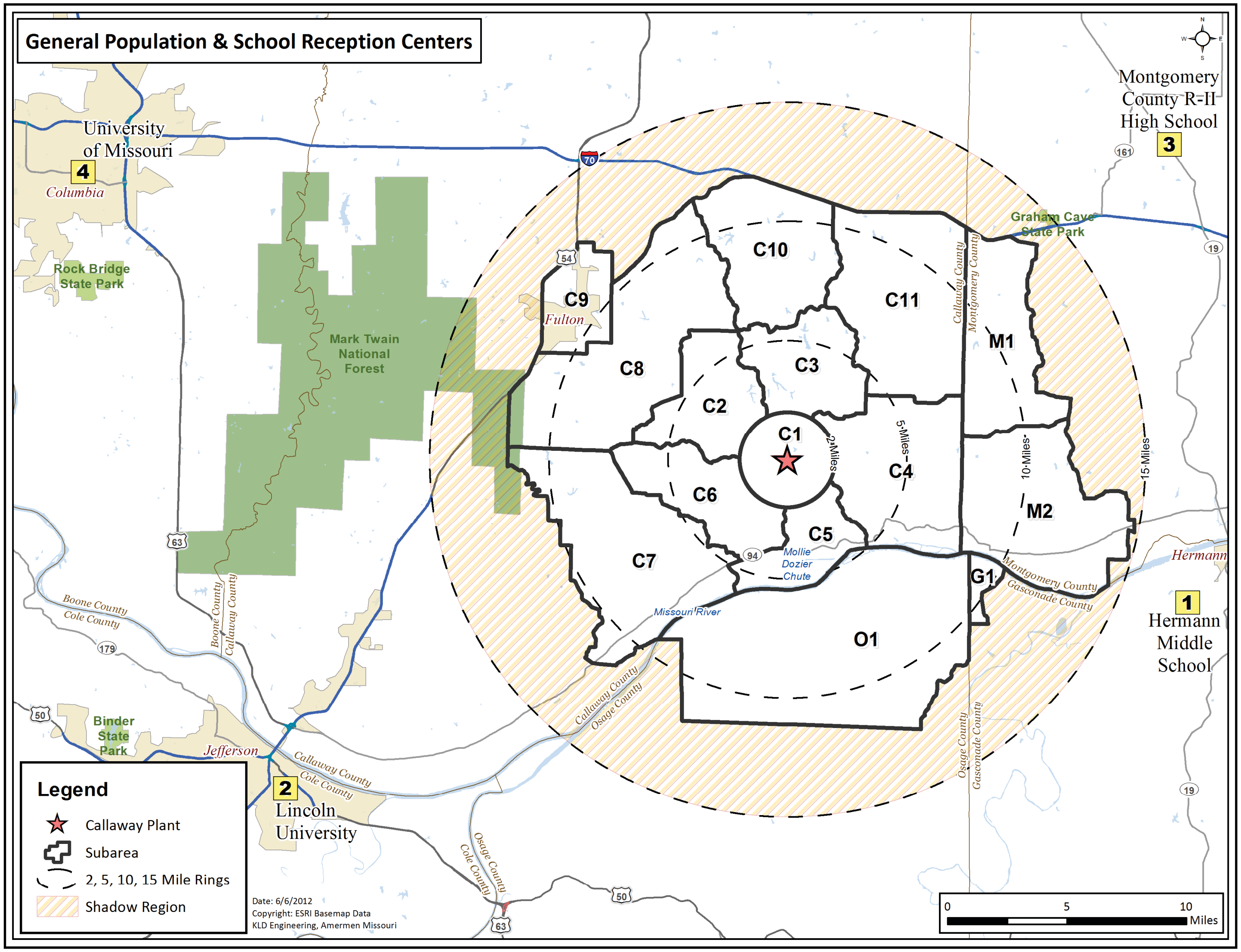


Figure 10-1. General Population and School Reception Centers

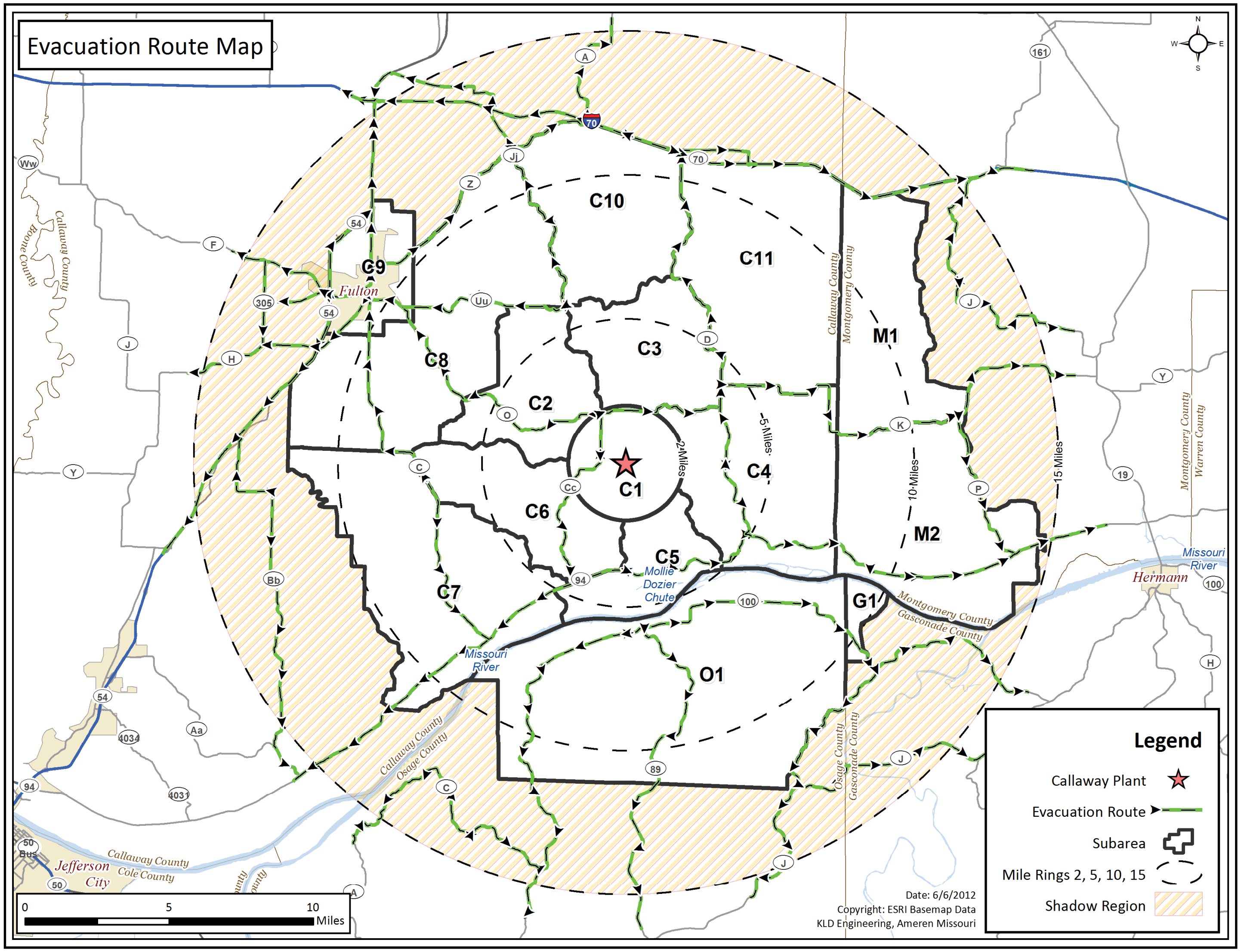


Figure 10-2. Evacuation Route Map

11 SURVEILLANCE OF EVACUATION OPERATIONS

There is a need for surveillance of traffic operations during the evacuation. There is also a need to clear any blockage of roadways arising from accidents or vehicle disablement. Surveillance can take several forms.

1. Traffic control personnel, located at Traffic Control and Access Control points, provide fixed-point surveillance.
2. Ground patrols may be undertaken along well-defined paths to ensure coverage of those highways that serve as major evacuation routes.
3. Aerial surveillance of evacuation operations may also be conducted using helicopter or fixed-wing aircraft, if available.
4. Cellular phone calls (if cellular coverage exists) from motorists may also provide direct field reports of road blockages.

These concurrent surveillance procedures are designed to provide coverage of the entire EPZ as well as the area around its periphery. It is the responsibility of the Counties to support an emergency response system that can receive messages from the field and be in a position to respond to any reported problems in a timely manner. This coverage should quickly identify, and expedite the response to any blockage caused by a disabled vehicle.

Tow Vehicles

In a low-speed traffic environment, any vehicle disablement is likely to arise due to a low-speed collision, mechanical failure or the exhaustion of its fuel supply. In any case, the disabled vehicle can be pushed onto the shoulder, thereby restoring traffic flow. Past experience in other emergencies indicates that evacuees who are leaving an area often perform activities such as pushing a disabled vehicle to the side of the road without prompting.

While the need for tow vehicles is expected to be low under the circumstances described above, it is still prudent to be prepared for such a need. Consideration should be given that tow trucks with a supply of gasoline be deployed at strategic locations within, or just outside, the EPZ. These locations should be selected so that:

- They permit access to key, heavily loaded, evacuation routes.
- Responding tow trucks would most likely travel counter-flow relative to evacuating traffic.

Consideration should also be given that the state and local emergency management agencies encourage gas stations to remain open during the evacuation.

12 CONFIRMATION TIME

It is necessary to confirm that the evacuation process is effective in the sense that the public is complying with the Advisory to Evacuate. Callaway County is currently in the process of acquiring a new vendor for the use of reverse 911. Confirming evacuation would take an estimated 30 minutes using the reverse 911 method. While this method is not yet available, we suggest using this temporary approach.

The procedure we suggest employs a stratified random sample and a telephone survey. The size of the sample is dependent on the expected number of households that do not comply with the Advisory to Evacuate. We believe it is reasonable to assume, for the purpose of estimating sample size that at least 80 percent of the population within the EPZ will comply with the Advisory to Evacuate. On this basis, an analysis could be undertaken (see Table 12-1) to yield an estimated sample size of approximately 300.

The confirmation process should start at about 2½ hours after the Advisory to Evacuate, which is when approximately 90 percent of evacuees have completed their mobilization activities (see Table 5-9). At this time, virtually all evacuees will have departed on their respective trips and the local telephone system will be largely free of traffic.

As indicated in Table 12-1, approximately 7½ person hours are needed to complete the telephone survey. If six people are assigned to this task, each dialing a different set of telephone exchanges (e.g., each person can be assigned a different set of subareas), then the confirmation process will extend over a timeframe of about 75 minutes. Thus, the confirmation should be completed before the evacuated area is cleared. Of course, fewer people would be needed for this survey if the Evacuation Region were only a portion of the EPZ. Use of modern automated computer controlled dialing equipment can significantly reduce the manpower requirements and the time required to undertake this type of confirmation survey.

If this method is indeed used by the offsite agencies, consideration should be given to maintain a list of telephone numbers within the EPZ in the Emergency Operations Center (EOC) at all times. Such a list could be purchased from vendors and should be periodically updated. As indicated above, the confirmation process should not begin until 2½ hours after the Advisory to Evacuate, to ensure that households have had enough time to mobilize. This 2½-hour timeframe will enable telephone operators to arrive at their workplace, obtain a call list and prepare to make the necessary phone calls.

Should the number of telephone responses (i.e., people still at home) exceed 20 percent, then the telephone survey should be repeated after an hour's interval until the confirmation process is completed.

Other techniques should also be considered. After traffic volumes decline, the personnel manning TCPs can be redeployed to travel through residential areas to observe and to confirm evacuation activities.

Table 12-1. Estimated Number of Telephone Calls Required for Confirmation of Evacuation

Problem Definition

Estimate number of phone calls, n, needed to ascertain the proportion, F of households that have not evacuated.

Reference: Burstein, H., Attribute Sampling, McGraw Hill, 1971

Given:

- No. of households plus other facilities, N, within the EPZ (est.) = 8,500
- Est. proportion, F, of households that will not evacuate = 0.20
- Allowable error margin, e: 0.05
- Confidence level, α: 0.95 (implies A = 1.96)

Applying Table 10 of cited reference,

$$p = F + e = 0.25; \;\; q = 1 - p = 0.75$$

$$n = \frac{A^2 pq + e}{e^2} = 308$$

Finite population correction:

$$n_F = \frac{nN}{n + N - 1} = 297$$

Thus, some 300 telephone calls will confirm that approximately 20 percent of the population has not evacuated. If only 10 percent of the population does not comply with the Advisory to Evacuate, then the required sample size, n_F = 211.

Est. Person Hours to complete 300 telephone calls

Assume:

- Time to dial using touch tone (random selection of listed numbers): 30 seconds
- Time for 6 rings (no answer): 36 seconds
- Time for 4 rings plus short conversation: 60 sec.
- Interval between calls: 20 sec.

Person Hours:

$$\frac{300[30 + 0.8(36) + 0.2(60) + 20]}{3600} = 7.6$$

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 DYNEVII 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 nodeswithin 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 DYNEVII 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 D-TRAD 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 TA algorithm 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 = 15 miles, the outer distance of the shadow region. 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.

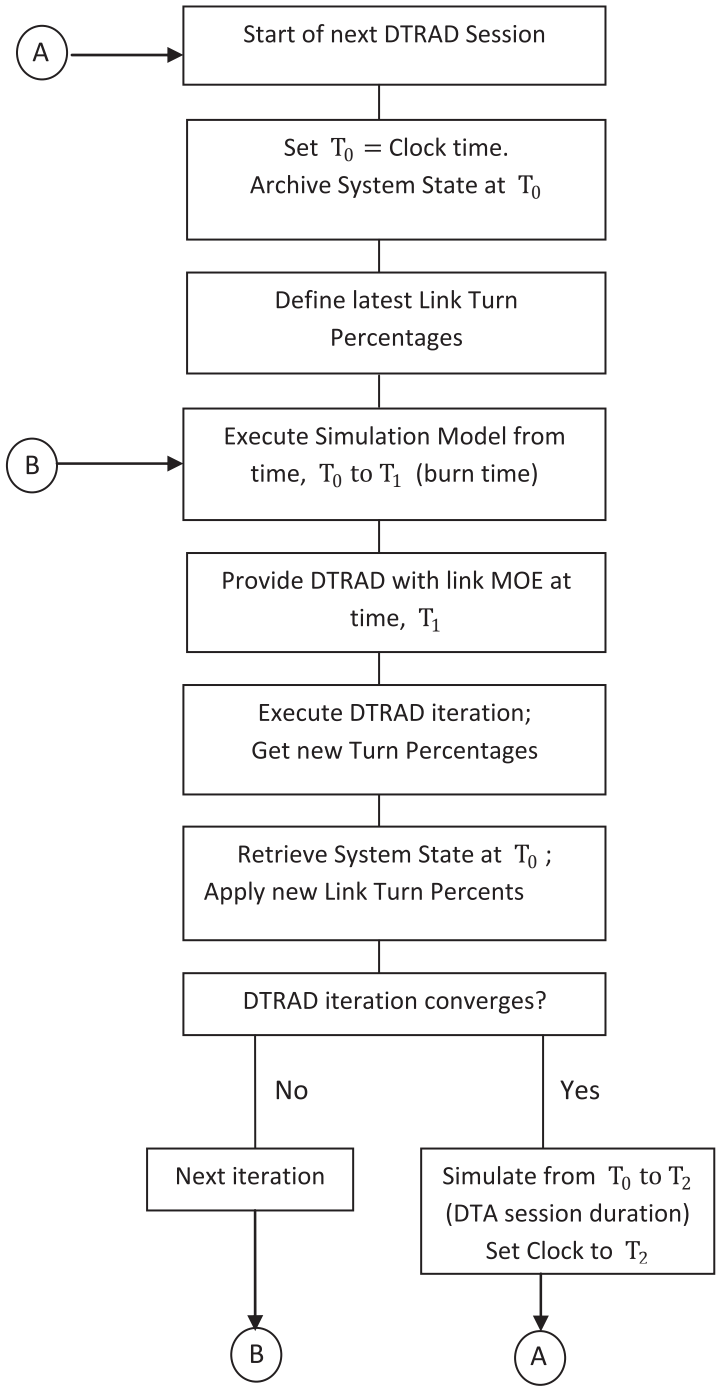


Figure B-1. Flow Diagram of Simulation-DTRAD Interface

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 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.

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 6) 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

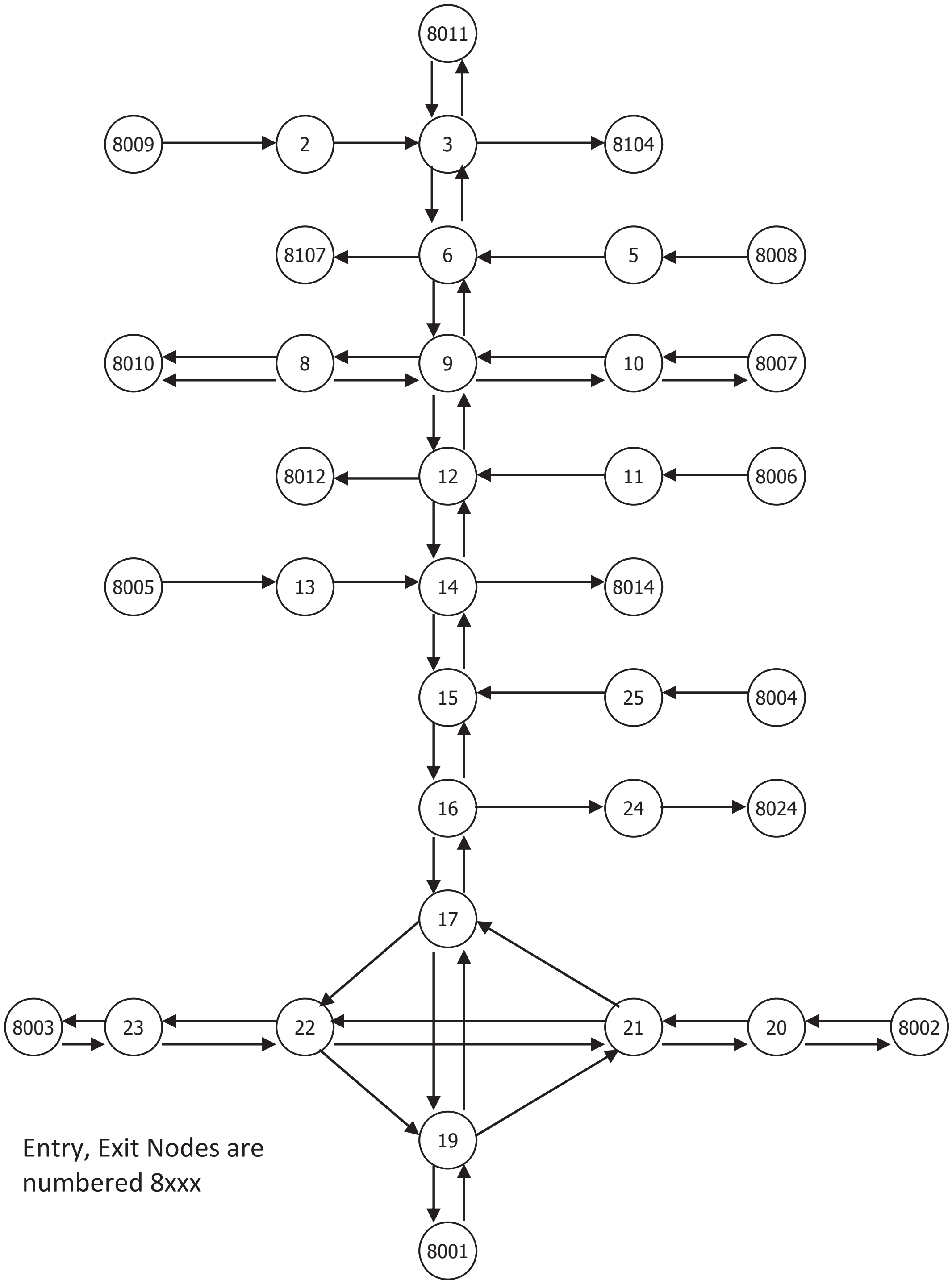


Figure C-1. Representative Analysis Network

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 <u>moving</u> 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 $Q = \left(0.98 - 0.0056\,\bar{k}\right) RQ_{max}$ 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.

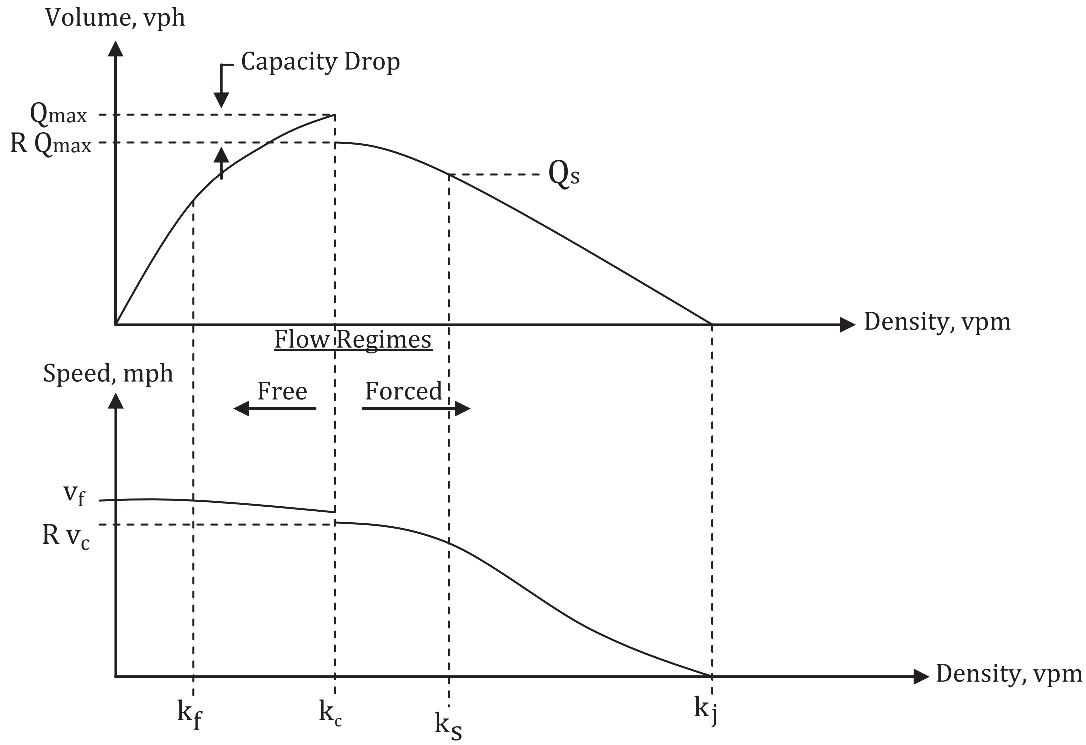


Figure C-2. Fundamental Diagrams

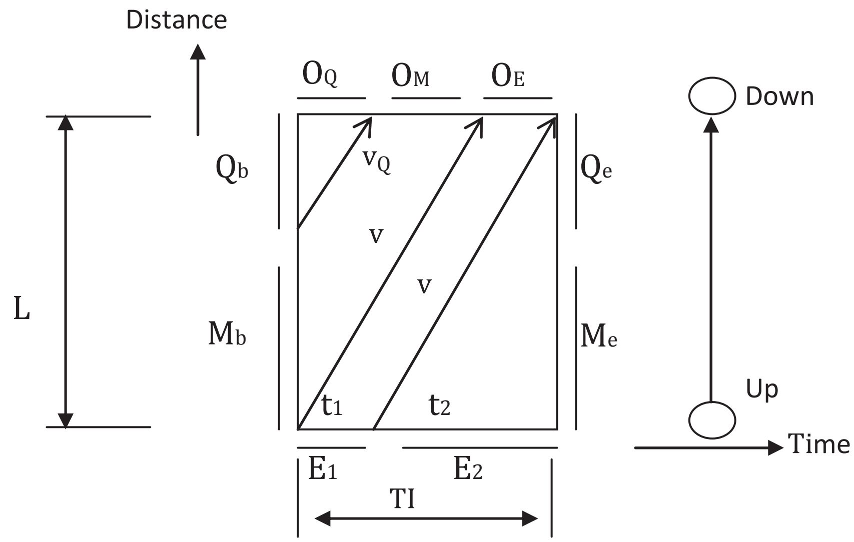


Figure C-3. A UNIT Problem Configuration with $t_1 > 0$

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.
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.

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 $t_1 < 0$, 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 $(Q_b < \text{Cap})$
   $O_Q = Q_b$, $\text{RCap} = \text{Cap} - O_Q$

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

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

$Q'_e = E_1 - O_E$

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

$O_M = RCap$, $Q'_e = M_b - O_M + E_1$

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*

$O_M = RCap$

$Q'_e = M_d - O_M$

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 <u>moving</u> vehicles.

If $\left|\bar{k}_n - \bar{k}_{n-1}\right| > \epsilon$ 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

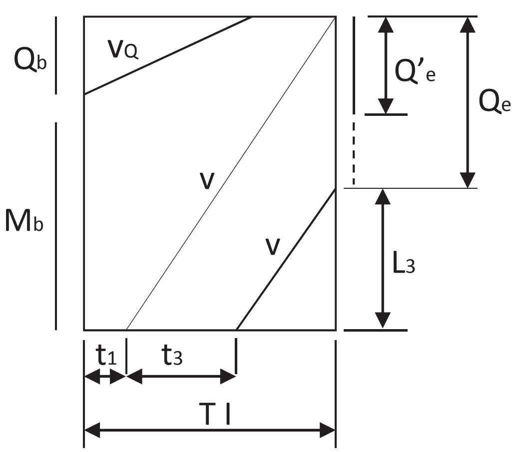
The number of excess vehicles that cause spillback is: $SB = Q_e + M_e - \frac{(L-W) \cdot LN}{L_v}$, where W is the width of the upstream intersection. To prevent spillback, meter the outflow from the feeder approaches and from the source flow, S, during this TI by the amount, SB. That is, set

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

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:

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

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

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

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 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.

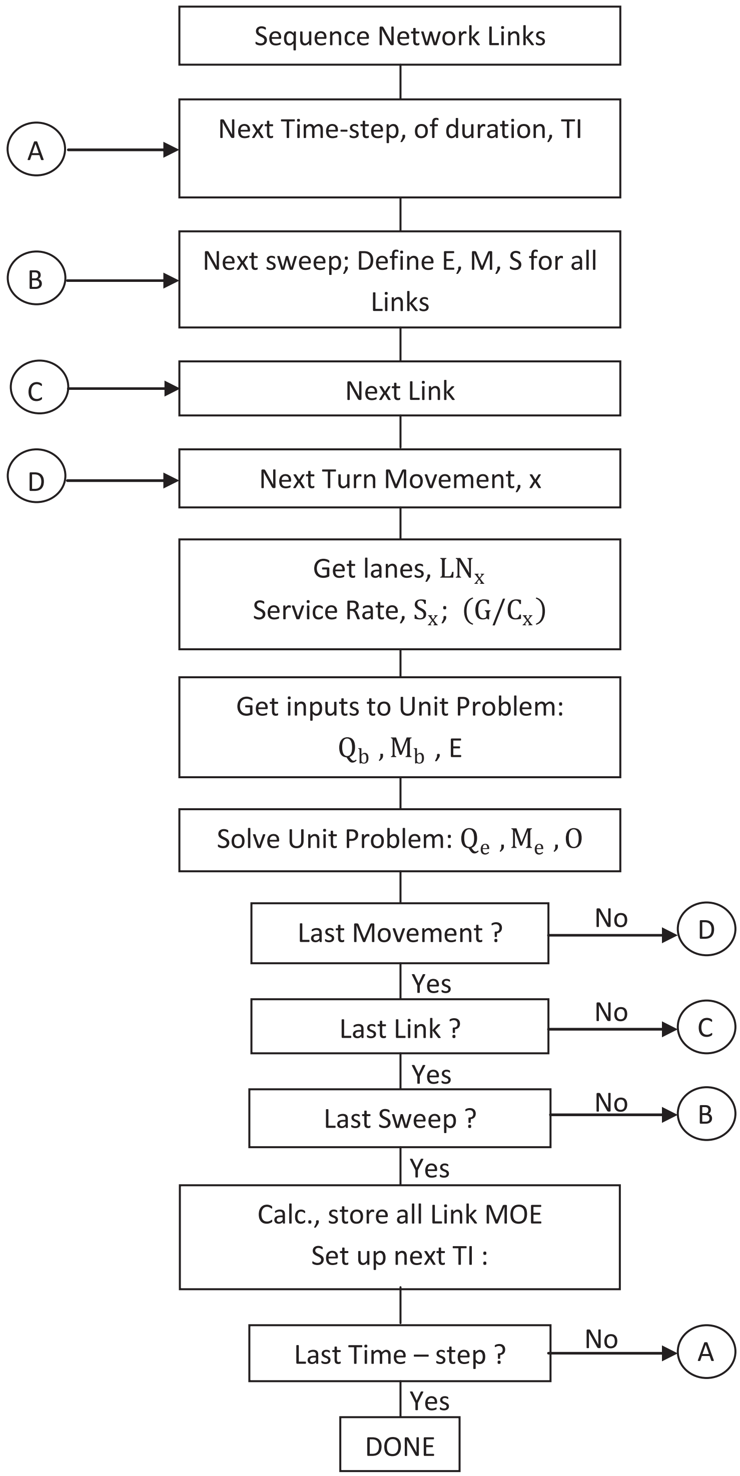


Figure C-4. Flow of Simulation Processing (See Glossary: Table C-3)

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 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.

APPENDIX D

Detailed Description of Study Procedure

D. DETAILED DESCRIPTION OF STUDY PROCEDURE

This appendix describes the activities that were performed to compute 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 obtain EPZ boundary information and create a GIS base map. 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 and subarea boundaries.

Step 2

2010 Census block 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. Employee data were estimated using the U.S. Census Bureau's Longitudinal Employer-Household Dynamics interactive website[1], and from phone calls to major employers. Transient data were obtained from local/state emergency management agencies and from phone calls to transient attractions. Information concerning schools, medical and other types of special facilities within the EPZ was obtained from county and municipal sources, augmented by telephone contacts with the identified facilities.

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 local 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 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.

[1] http://lehdmap.did.census.gov/

Step 5

A telephone 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 developed using the UNITES software developed by KLD. Once the 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. 2010 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 15 subareas. Based on wind direction and speed, Regions (groupings of subarea) 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 which operates on data produced by DYNEV II) 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 were available, quality control procedures were used to assure the results were consistent, dynamic routing was reasonable, and traffic congestion/bottlenecks were addressed properly.

Step 16

Once vehicular evacuation results are accepted, average travel speeds for transit and special facility routes were 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. The results were then documented, as required by NUREG/CR-7002.

Step 18

Following the completion of documentation activities, the ETE criteria checklist was completed. An appropriate report reference is provided for each criterion provided in the checklist.

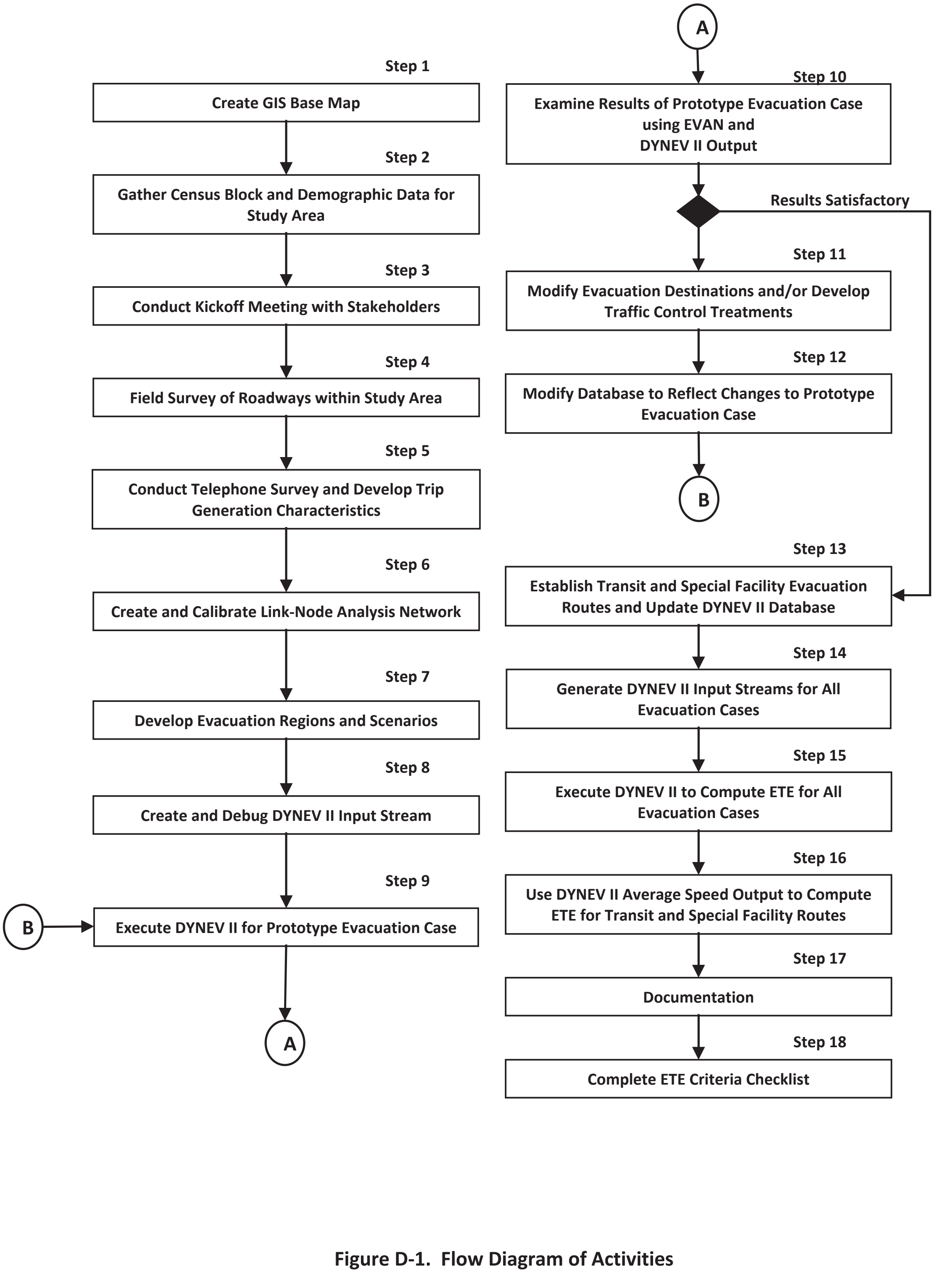


Figure D-1. Flow Diagram of Activities

APPENDIX E

Special Facility Data

E. SPECIAL FACILITY DATA

The following tables list population information, as of November 2011, for special facilities that are located within the Callaway Plant EPZ. Special facilities are defined as schools, hospitals and other medical care facilities, and correctional facilities. Transient population data is included in the tables for recreational areas and lodging facilities. Employment data is included in the tables for major employers. 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 special facility, recreational area, lodging facility, and major employer are also provided.

Table E-1. Schools within the EPZ

Subarea	Distance (miles)	Dire-ction	School Name	Street Address	Municipality	Phone	Enroll-ment	Staff
CALLAWAY COUNTY								
C7	7.9	SW	South Callaway Elementary School	10135 State Rd C	Mokane	(573) 676-5226	864	40
C7	7.9	SW	South Callaway High School	10135 State Rd C	Mokane	(573) 676-5227		102
C7	7.8	SW	South Callaway Middle School	10135 State Rd C	Mokane	(573) 676-5228		67
C9	10.8	WNW	Bartley Elementary School	603 S Business 54	Fulton	(573) 642-5365	282	35
C9	10.5	NW	Bush Elementary School	908 Wood St	Fulton	(573) 642-2877	370	50
C9	11.7	NW	Fulton High School	1 Hornet Dr	Fulton	(573) 642-2023	2,129	399
C9	10.9	NW	Fulton Middle School	403 East 10th St	Fulton	(573) 642-7221	580	65
C9	10.6	NW	Kingdom Christian Academy	650 East 8th St	Fulton	(573) 642-2117	174	21
C9	11.4	WNW	McIntire Elementary School	706 Hickman Ave	Fulton	(573) 590-8500	389	55
C9	10.5	NW	Missouri School For the Deaf	505 East 5th St	Fulton	(573) 592-4000	80	160
C9	10.8	NW	St. Peter Catholic School	700 State Road Z	Fulton	(573) 642-2839	128	24
C9	11.3	WNW	Westminster College[1]	501 Westminster Ave	Fulton	(573) 642-3361	265	80
C9	11.3	NW	William Woods University[1]	University Ave	Fulton	(800) 995-3199	223	215
						Callaway County Subtotals:	*5,484*	*1,313*
OSAGE COUNTY								
O1	6.2	S	Osage County Chamois R-1 School District	614 Poplar St	Chamois	(573) 763-5393	219	50
						Osage County Subtotals:	*219*	*50*
						TOTAL:	**5,703**	**1,363**

[1]Enrollment number reflects only the students requiring bus evacuation.

Table E-2. Medical Facilities within the EPZ

Subarea	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Phone	Cap-acity	Current Census	Ambul-atory Patients	Wheel-chair Patients	Bed-ridden Patients
CALLAWAY COUNTY											
C7	7.8	SW	Riverview Nursing Center	10303 State Road C	Mokane	(573) 676-3136	60	Shelter in Place			
C9	11.0	WNW	Ashbury Heights Independent Living	704 West Chestnut St	Fulton	(573) 642-2015	12	Shelter in Place			
C9	11.2	WNW	Bristol Manor	750 Sign Painter Rd	Fulton	(573) 642-7557	12	Shelter in Place			
C9	11.4	WNW	Callaway Community Hospital	10 North Hospital Dr	Fulton	(573) 642-3376	39	8	8	0	0
C9	11.4	WNW	Churchill Terrace	120 Hospital Dr	Fulton	(573) 826-4179	44	9	9	0	0
C9	11.2	NW	Fulton Nursing & Rehab	1510 North Bluff St	Fulton	(573) 642-0202	100	Shelter in Place			
C9	10.3	NW	Fulton State Hospital	600 East 5th St	Fulton	(573) 592-4100	281	Shelter in Place			
Callaway County Subtotals:							*548*	*17*	*17*	*0*	*0*
TOTAL:							**548**	**17**	**17**	**0**	**0**

Table E-3. Major Employers within the EPZ

Subarea	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Phone	Employees (max shift)	% Non-EPZ	Employees (Non EPZ)
CALLAWAY COUNTY									
C1	0.0	N/A	Callaway Plant	County Rd 459	Reform	N/A	770	43%	330
C9	12.4	NW	Dollar General	1990 North Bluff Street	Fulton	(573) 592-3500	350	65%	228
C9	12.1	NW	Harbison-Walker Refractories	111 W Saint Eunice Rd	Fulton	(573) 642-6667	56	46%	26
C9	11.9	NW	Kingdom Projects Inc.	2611 North Bluff Street	Fulton	(573) 642-7333	120	40%	48
C9	11.1	NW	Ovid-Bell Press	1201 Bluff St	Fulton	(573) 642-2256	118	35%	41
C9	11.3	NW	Walmart Supercenter	1701 North Bluff Street	Fulton	(573) 642-6877	161	46%	74
Callaway County Subtotals:							*1,575*	-	*747*
TOTAL:							**1,575**	**-**	**747**

Table E-4. Recreational Areas within the EPZ

Subarea	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Phone	Transients	Vehicles
CALLAWAY COUNTY								
C1	1.3	S	Reform Conservation Area	County Rd 459	Reform	N/A	10	4
C2	3.1	W	Hams Prairie Access	County Rd 449	Auxvasse	(573) 884-6861	1	1
C2	3.1	WNW	Harmony Hills Youth Camp	8033 State Rd O	Fulton	(573) 642-3864	150	75
C3	2.5	N	Wildwood RV Park	Wildwood Estates Dr	Reform	N/A	41	15
C4	6.8	ESE	Tate Island CA	N/A	Portland	(573) 884-6861	2	2
C6	3.7	S	KATY Trail	Route 94	Portland	N/A	10	4
C7	7.9	SW	High Hopes Hunting Sports Club	440 Fulton Rd	Mokane	(573) 291-5191	20	12
C8	9.6	WNW	Callaway Raceway Inc	7419 County Rd 405	Fulton	(573) 592-7795	1,500	500
C8	11.0	W	Hidden Oaks RV Park and Campground, LLC	4855 Hidden Oaks	Fulton	(573) 592-8834	39	15
C8	9.2	WNW	Kingdom of Callaway County Fair	7217 State Rd C	Fulton	(573) 220-2752	500	183
C9	10.6	NW	Fulton Country Club	701 East 10th St	Fulton	(573) 642-3005	0	0
C10	10.4	N	Moores Mill Access	County Rd 139	Calwood	(573) 884-6861	4	2
						Callaway County Subtotals:	*2,277*	*813*
MONTGOMERY COUNTY								
M2	9.5	ESE	Grand Bluffs CA	Bluffton Rd	Fulton	(573) 884-6861	5	5
						Montgomery County Subtotals:	*5*	*5*
OSAGE COUNTY								
O1	5.6	S	Chamois Access	Highway 100	Chamois	(573) 884-6861	30	30
						Osage County Subtotals:	*30*	*30*
						TOTAL:	**2,312**	**848**

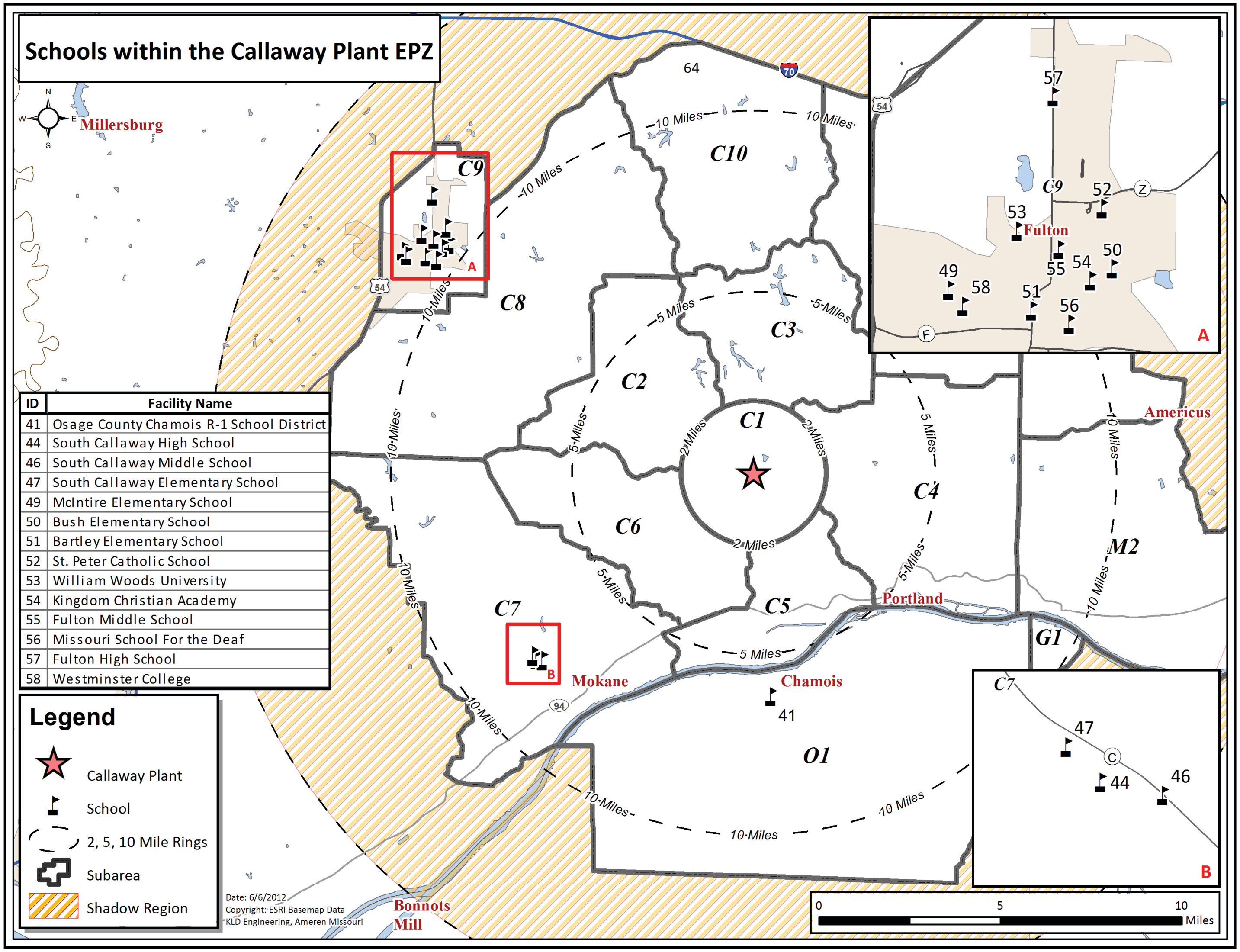
[1]Facility reported having all local residents, resulting in no transients or transient vehicles.

Table E-5. Lodging Facilities within the EPZ

Subarea	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Phone	Transients	Vehicles
CALLAWAY COUNTY								
C9	12.5	NW	Holiday Inn Express Fulton Hotel	2205 Cardinal Dr	Fulton	(573) 642-2600	111	55
C9	11.1	WNW	Loganberry Inn	310 West Seventh St	Fulton	(573) 642-9229	4	2
C9	10.8	WNW	Travelier Motel	600 South Business 54	Fulton	(573) 642-3332	10	5
C9	11.8	WNW	Westwoods Motel	422 Gaylord Dr	Fulton	(573) 642-5991	19	9
						Callaway County Subtotals:	*144*	*71*
						TOTAL:	**144**	**71**

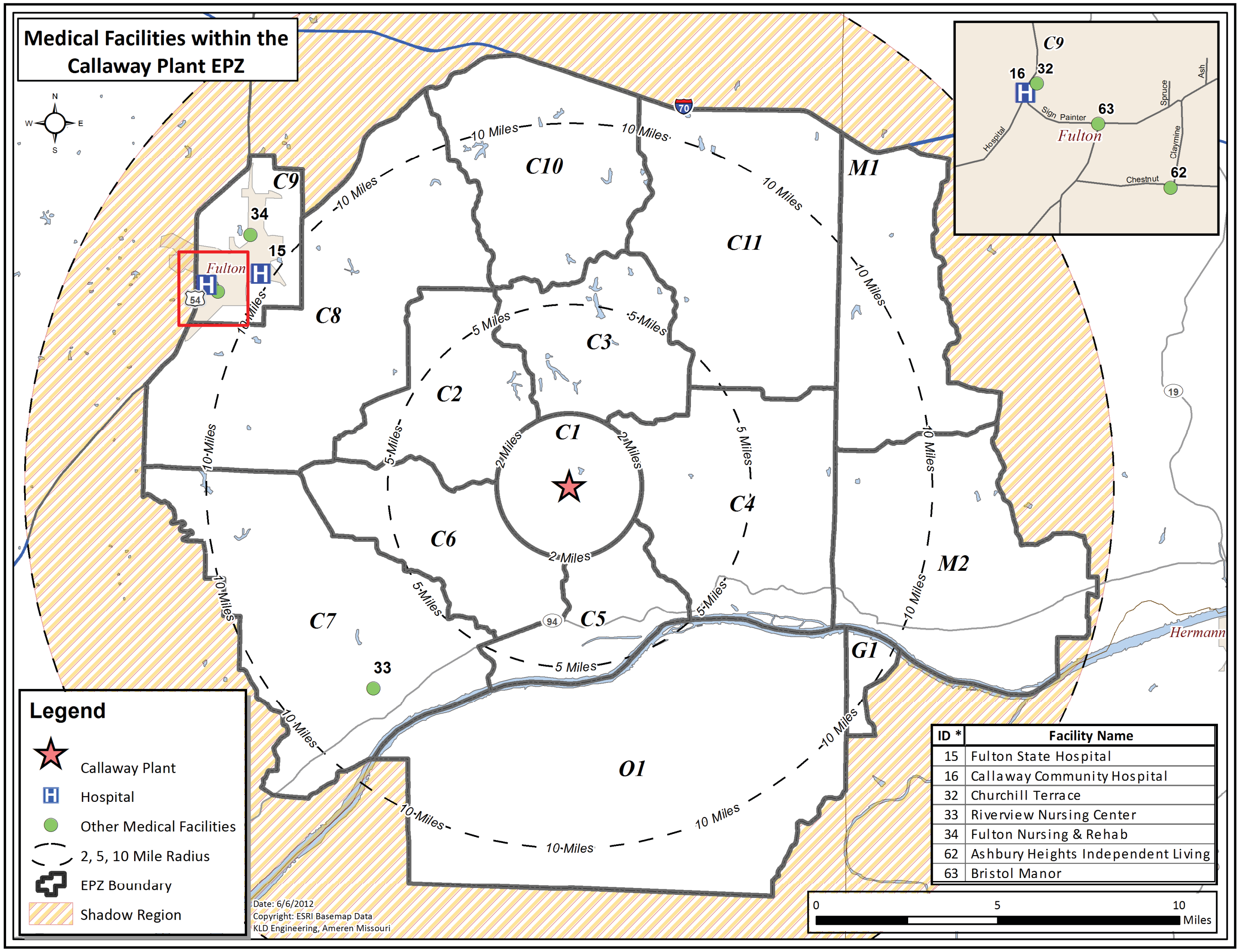
Table E-6. Correctional Facilities within the EPZ

Subarea	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Phone	Cap-acity
CALLAWAY COUNTY							
C9	9.9	NW	Fulton Reception and Diagnostic Center	1393 Missouri O	Fulton	(573) 592-4040	1,346
C9	9.9	NW	Callaway County Jail	1201 Missouri O	Fulton	(573) 592-2400	109
						Callaway County Subtotals:	*1,455*
						TOTAL:	**1,455**



ID	Facility Name
41	Osage County Chamois R-1 School District
44	South Callaway High School
46	South Callaway Middle School
47	South Callaway Elementary School
49	McIntire Elementary School
50	Bush Elementary School
51	Bartley Elementary School
52	St. Peter Catholic School
53	William Woods University
54	Kingdom Christian Academy
55	Fulton Middle School
56	Missouri School For the Deaf
57	Fulton High School
58	Westminster College

Figure E-1. Schools within the EPZ



ID *	Facility Name
15	Fulton State Hospital
16	Callaway Community Hospital
32	Churchill Terrace
33	Riverview Nursing Center
34	Fulton Nursing & Rehab
62	Ashbury Heights Independent Living
63	Bristol Manor

Figure E-2. Medical Facilities within the EPZ

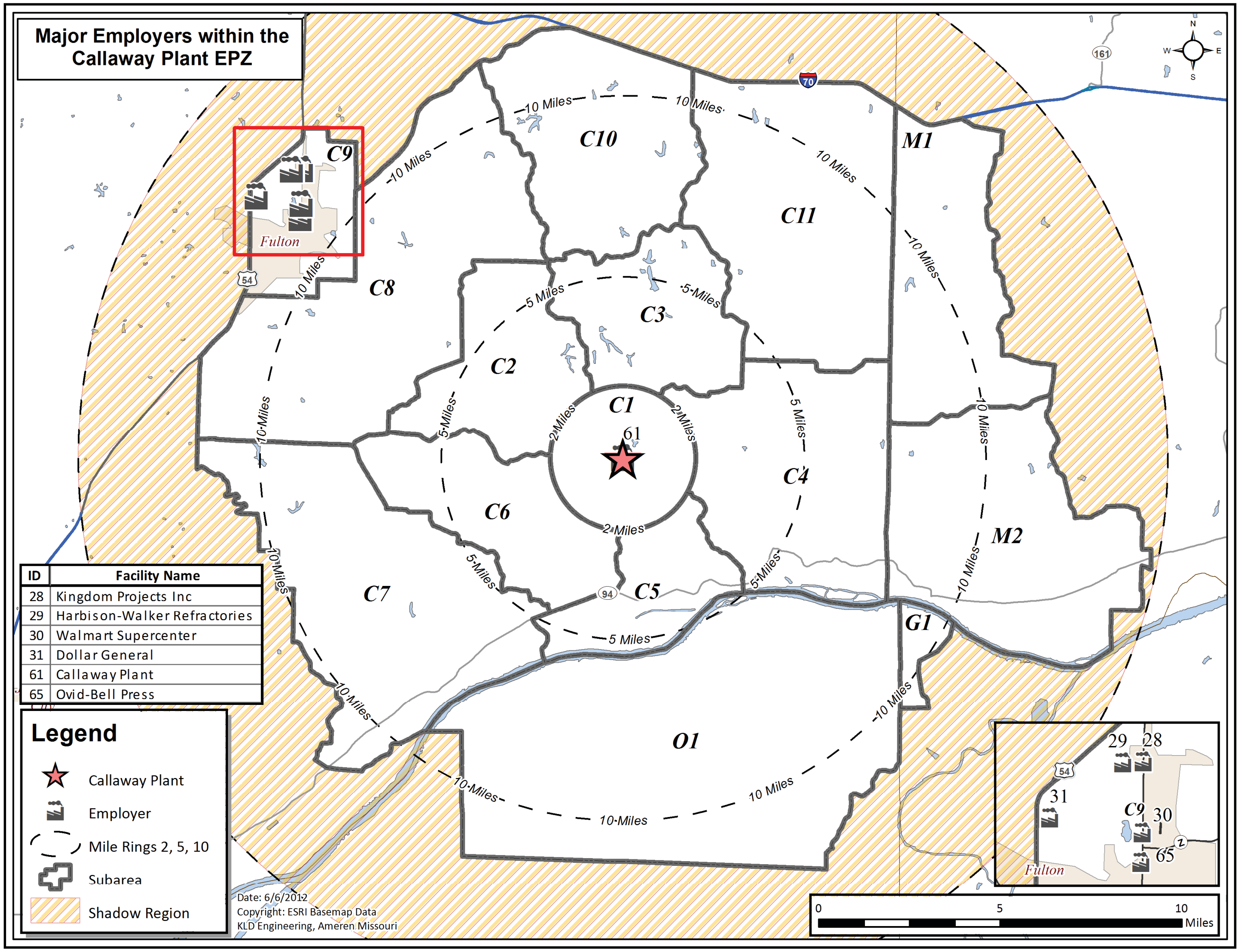


Figure E-3. Major Employers within the EPZ

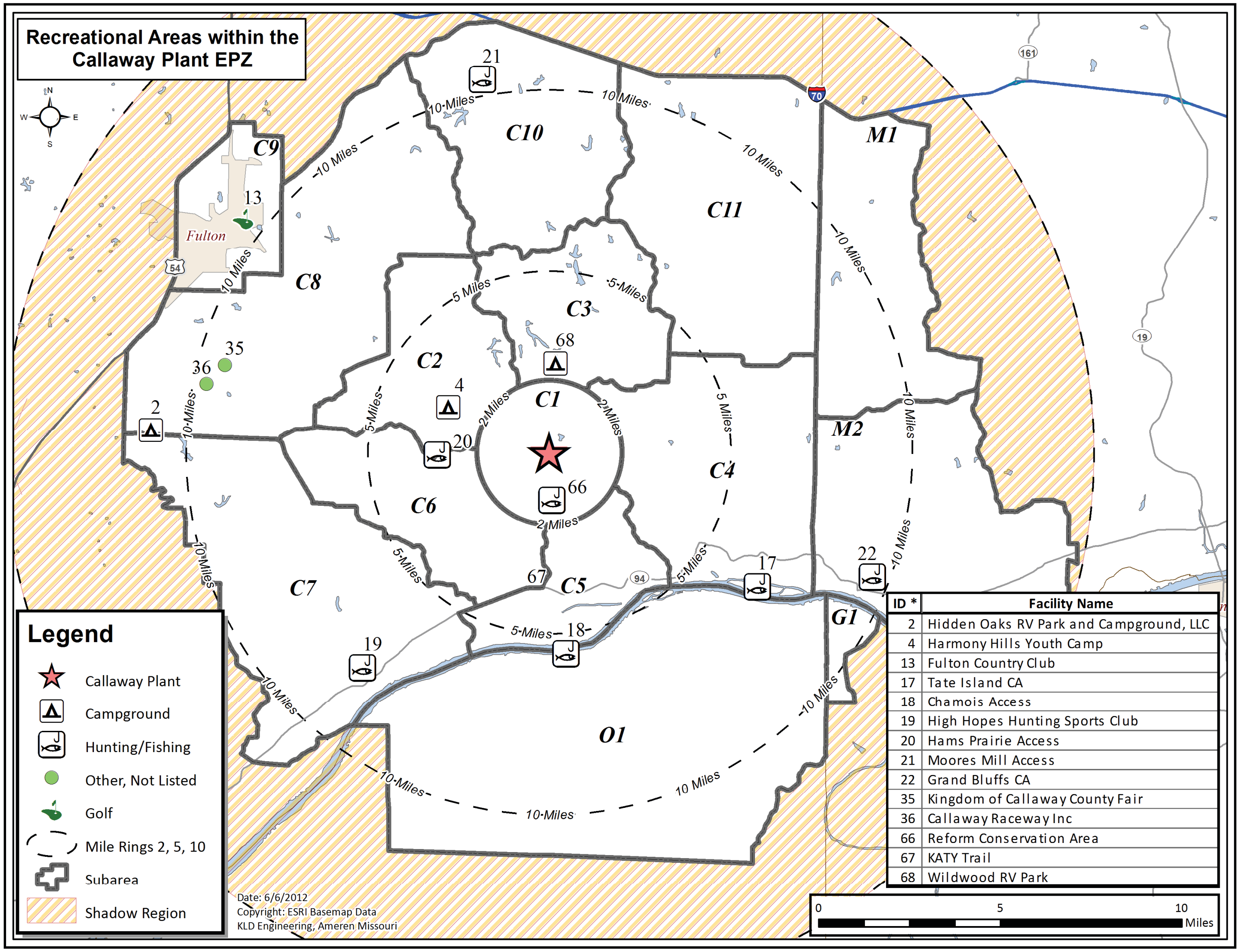
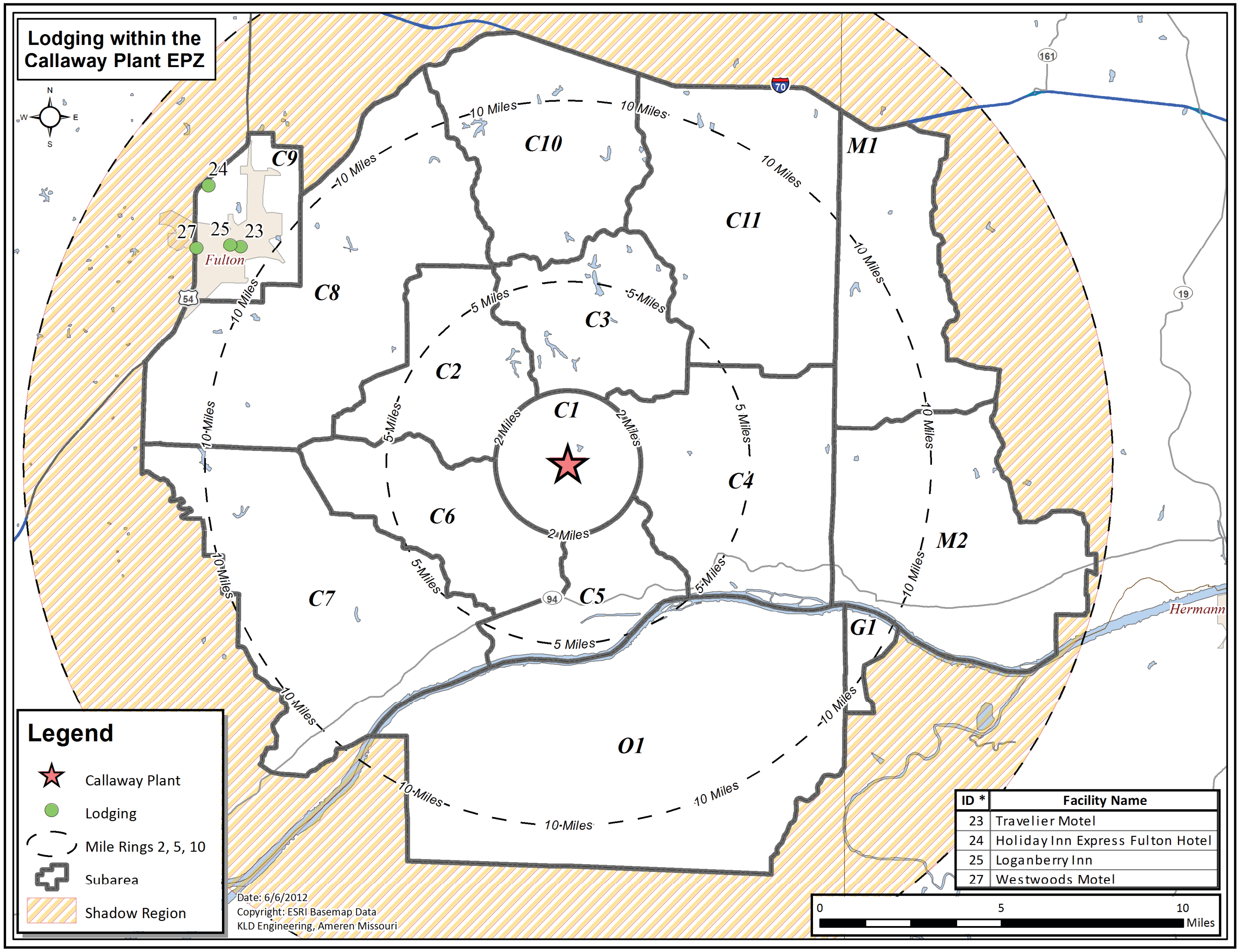
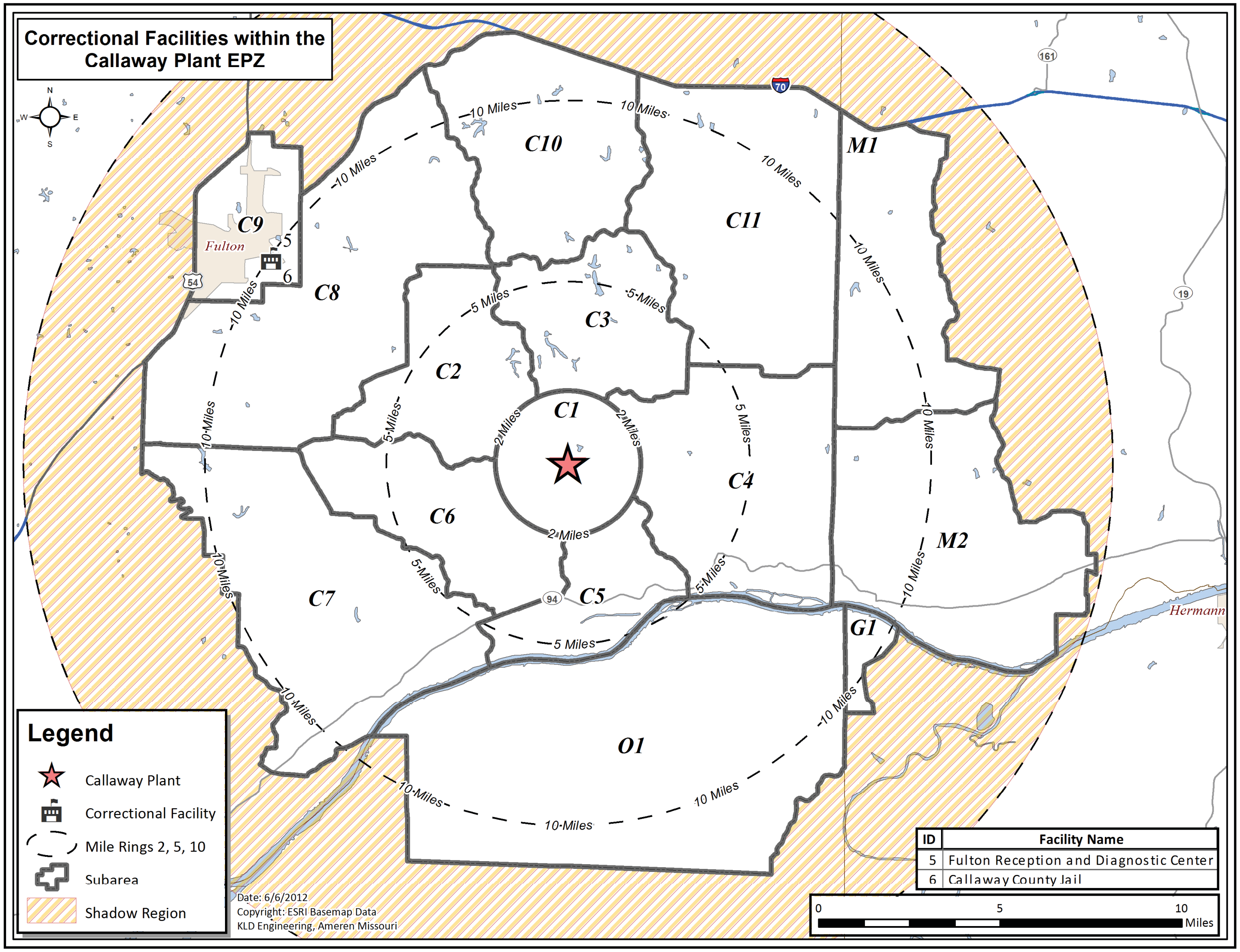


Figure E-4. Recreational Areas within the EPZ



ID *	Facility Name
23	Travelier Motel
24	Holiday Inn Express Fulton Hotel
25	Loganberry Inn
27	Westwoods Motel

Figure E-5. Lodging Facilities within the EPZ



ID	Facility Name
5	Fulton Reception and Diagnostic Center
6	Callaway County Jail

Figure E-6. Correctional Facilities within the EPZ

APPENDIX F

Telephone Survey

F. TELEPHONE SURVEY

F.1 Introduction

The development of evacuation time estimates for the EPZ of the Callaway Plant 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 telephone 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 in this study. 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. A sample size of approximately 500 **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.

The completed survey adhered to the sampling plan.

Table F-1. Callaway Plant EPZ Telephone Survey Sampling Plan

Zip Code	Population within EPZ (2010)	Households	Required Sample
63363	17	8	1
65080	41	15	1
65041	62	20	1
63361	101	51	4
65061	134	57	4
65067	390	169	12
65077	510	225	16
65069	510	223	16
63388	552	239	17
65024	832	338	24
65059	1,155	443	31
65251	15,869	5,238	373
Total	**20,173**	**7,026**	**500**
	Avg HH Size:	**2.87**	

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 “don’t know” (DK) or “refused” entry for a response. It is accepted practice in conducting surveys of this type to accept the answers of a respondent who offers a DK response for a few questions or who refuses to answer a few questions. To address the issue of occasional DK/refused 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 DK/refused 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. The average household determined from the telephone survey contains 2.40 people, which is the number used for analysis in this report. The estimated household size (2.87 persons) used to determine the survey sample (Table F-1) was drawn from Census data. The estimation of 2.87 people per household is an overestimation because the census includes the Callaway County Jail, Westminster College, William Woods University and several other facilities that are not homes. When census blocks with household sizes of over 15 are ignored (8 blocks total), the adjusted average household size becomes 2.41, which is consistent with the telephone survey results.

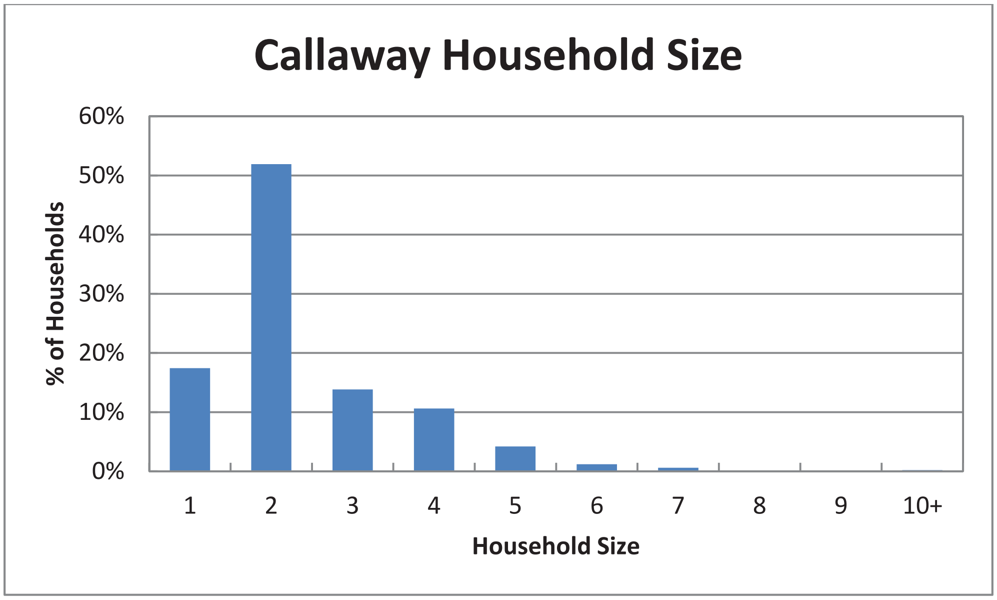


Figure F-1. Household Size in the EPZ

Automobile Ownership

The average number of automobiles available per household in the EPZ is 1.35. It should be noted that approximately 2.4 percent of households do not have access to an automobile. 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. Note that the majority of households without access to a car are single person households. As expected, nearly all households of 2 or more people have access to at least one vehicle.

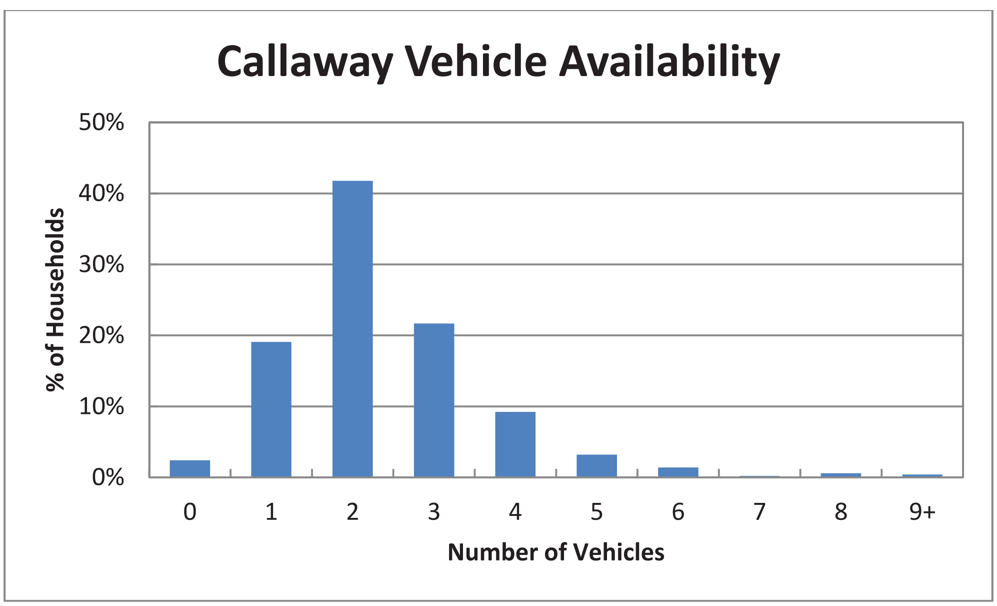


Figure F-2. Household Vehicle Availability

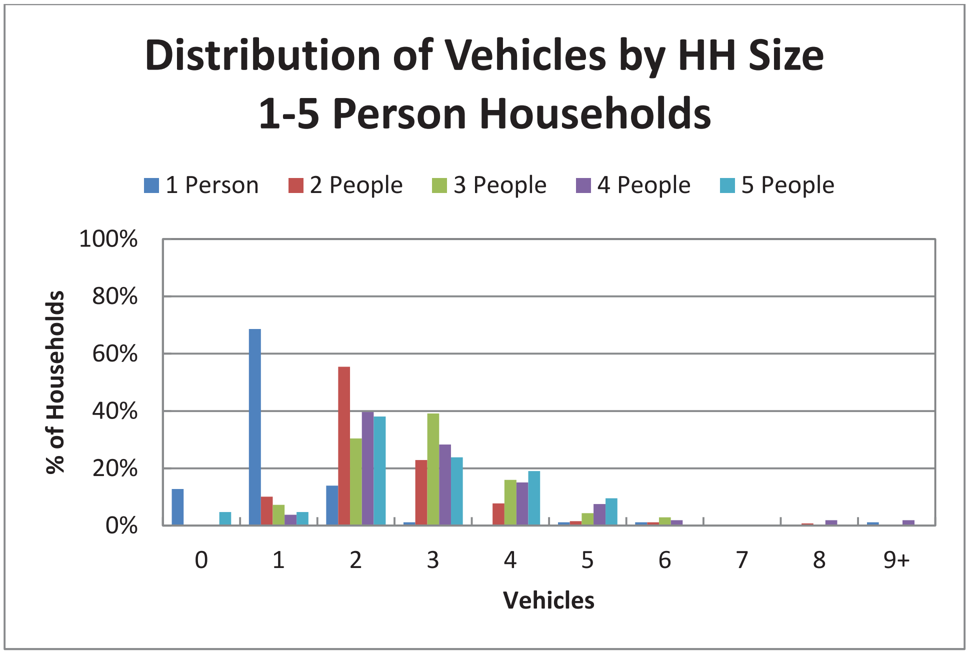


Figure F-3. Vehicle Availability - 1 to 5 Person Households

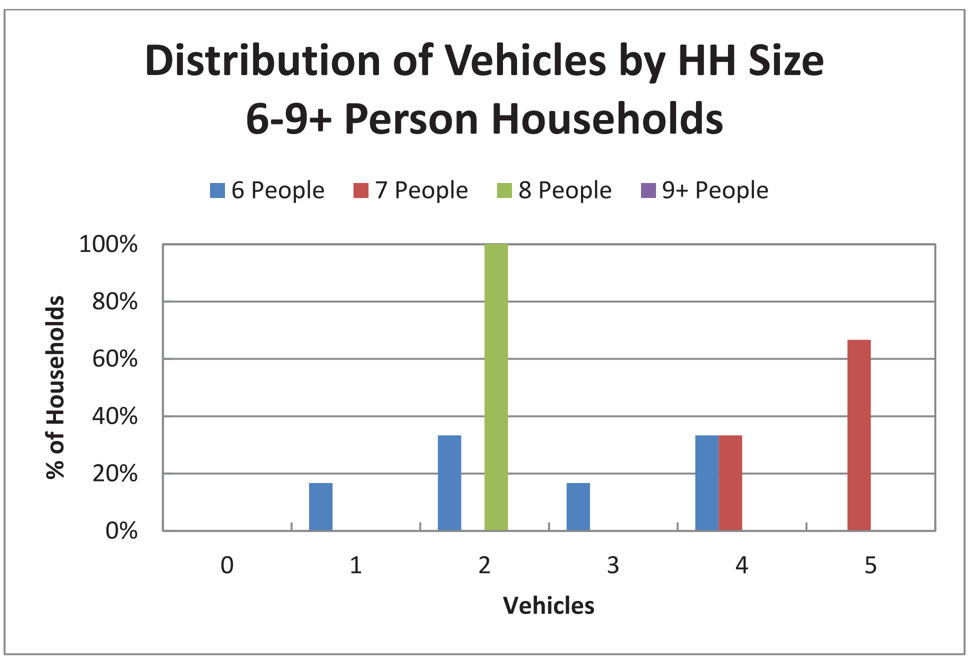


Figure F-4. Vehicle Availability - 6 to 9+ Person Households

Ridesharing

The ten households surveyed (who do not own a vehicle) responded that they would share a ride with a neighbor, relative, or friend if a car was not available to them when asked to evacuate. Figure F-5 presents this response.

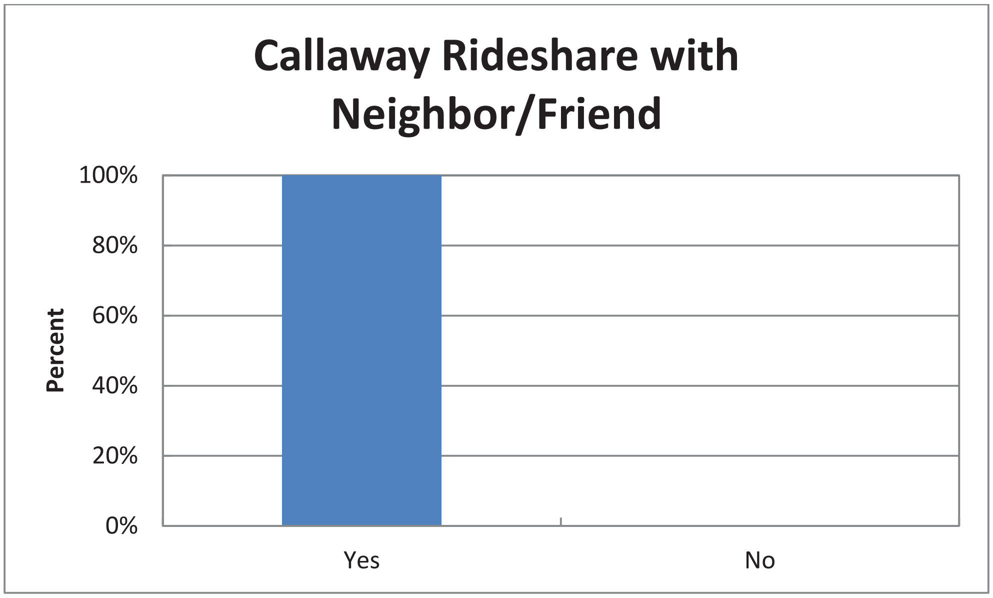


Figure F-5. Household Ridesharing Preference

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 1.02 commuters in each household in the EPZ, and 60 percent of households have at least one commuter.

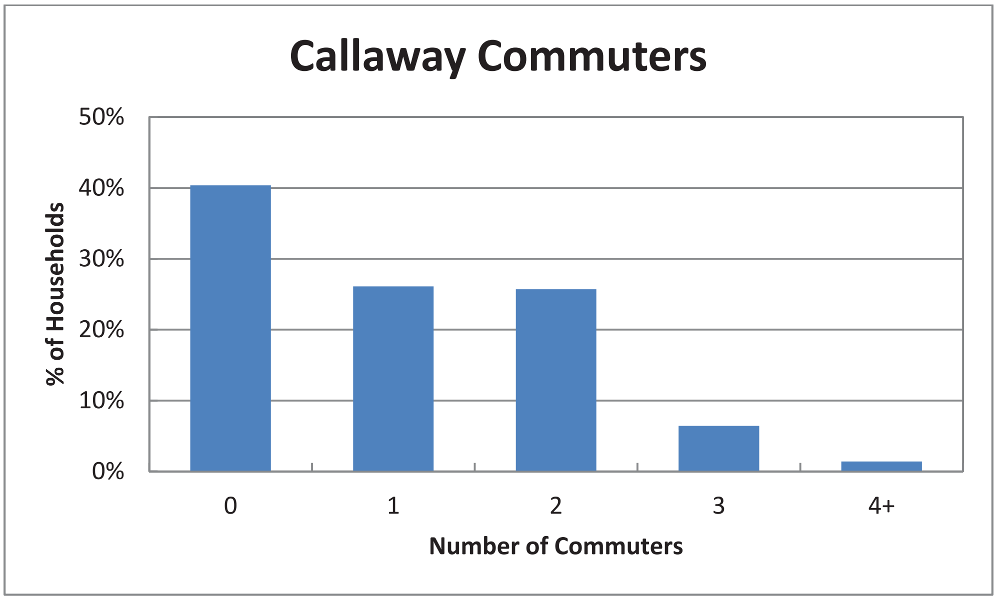


Figure F-6. Commuters in Households in the EPZ

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. The data shows an average of 1.09 employees per vehicle, assuming 2 people per vehicle – on average – for carpools.

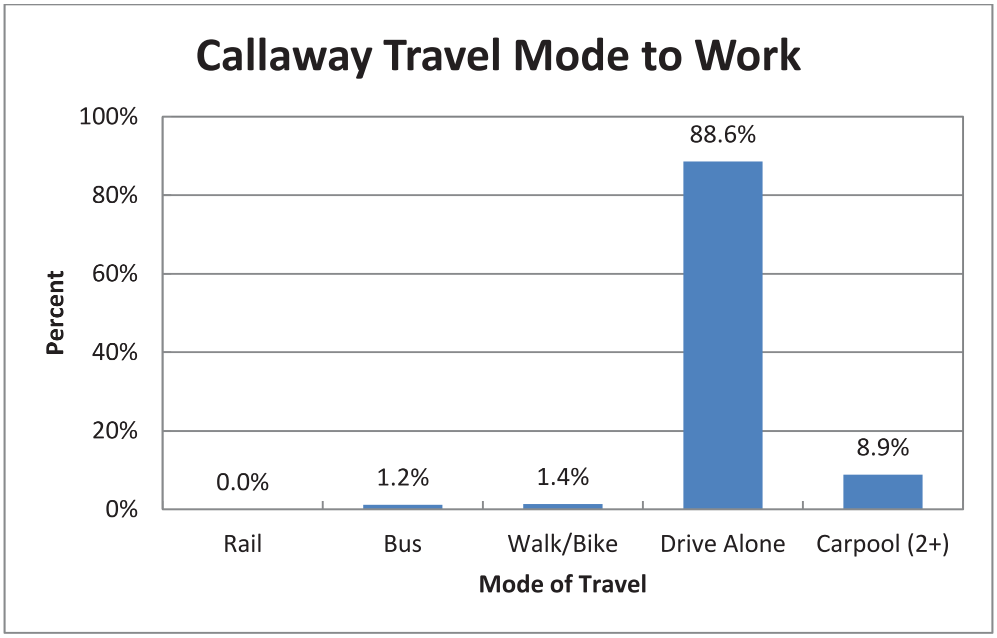


Figure F-7. Modes of Travel in the EPZ

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-8. On average, evacuating households would use 1.35 vehicles.

"Would your family await the return of other family members prior to evacuating the area?" Of the survey participants who responded, 48 percent said they would await the return of other family members before evacuating and 52 percent indicated that they would not await the return of other family members.

"If you had a household pet, would you take your pet with you if you were asked to evacuate the area?" As shown in Figure F-9, 15 percent of households do not have a family pet. Of the households with pets, 84 percent of them indicated that they would take their pets.

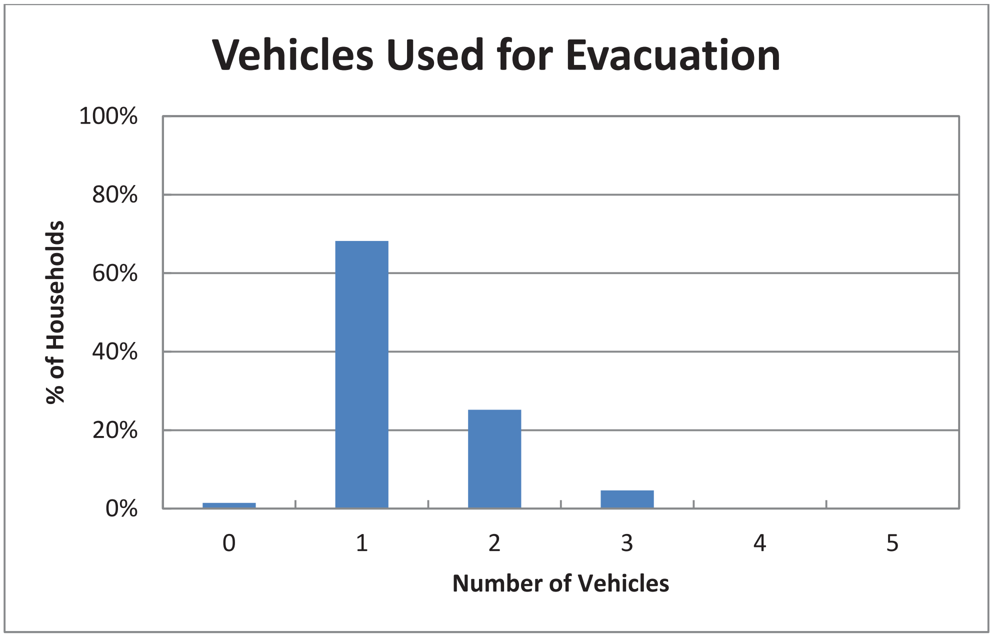


Figure F-8. Number of Vehicles Used for Evacuation

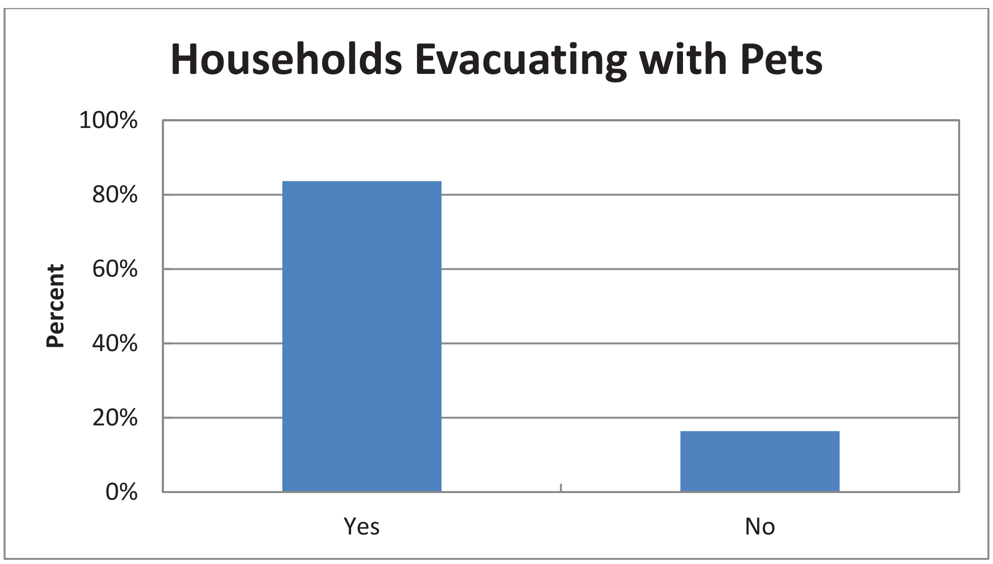


Figure F-9. Percent of Households Evacuating with Pets

"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 90 percent of households who are advised to shelter in place would do so; the remaining 10 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. A sensitivity study was conducted to determine the effect of changes in the percentage of people who elect to evacuate, if advised to shelter (see 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 77 percent of households would follow instructions and delay the start of evacuation until so advised, while the balance of 23 percent would choose to begin evacuating immediately. Thus, the NRC recommendation of 20% non-compliance during a staged evacuation is valid.

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.

"How long does it take the commuter to complete preparation for leaving work?" Figure F-10 presents the cumulative distribution; in all cases, the activity is completed by about 60 minutes. Eighty-two percent can leave within 20 minutes.

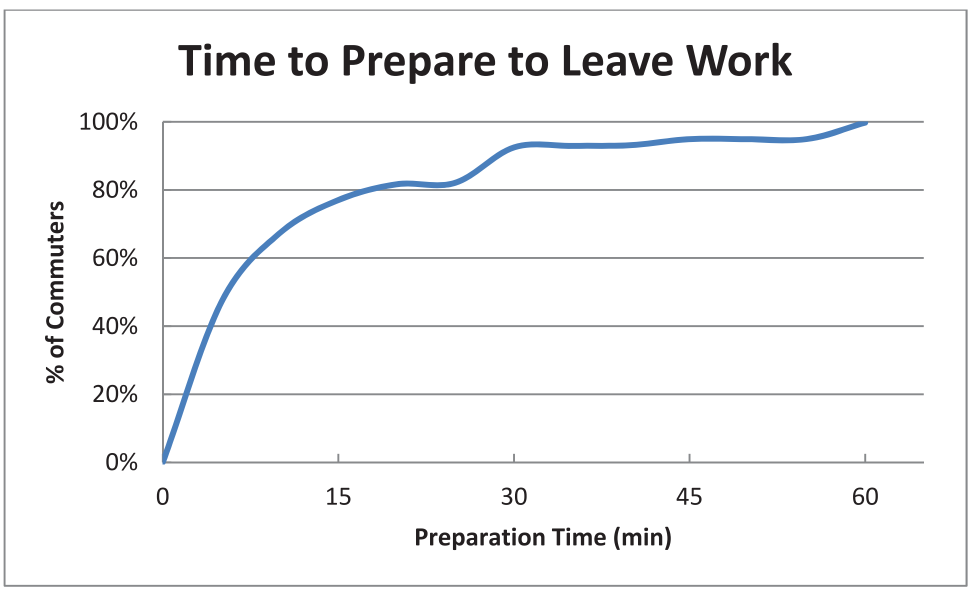


Figure F-10. Time Required to Prepare to Leave Work/School

"How long would it take the commuter to travel home?" Figure F-11 presents the work to home travel time for the EPZ. About 84 percent of commuters can arrive home within about 30 minutes of leaving work; the activity is completed by about 90 minutes.

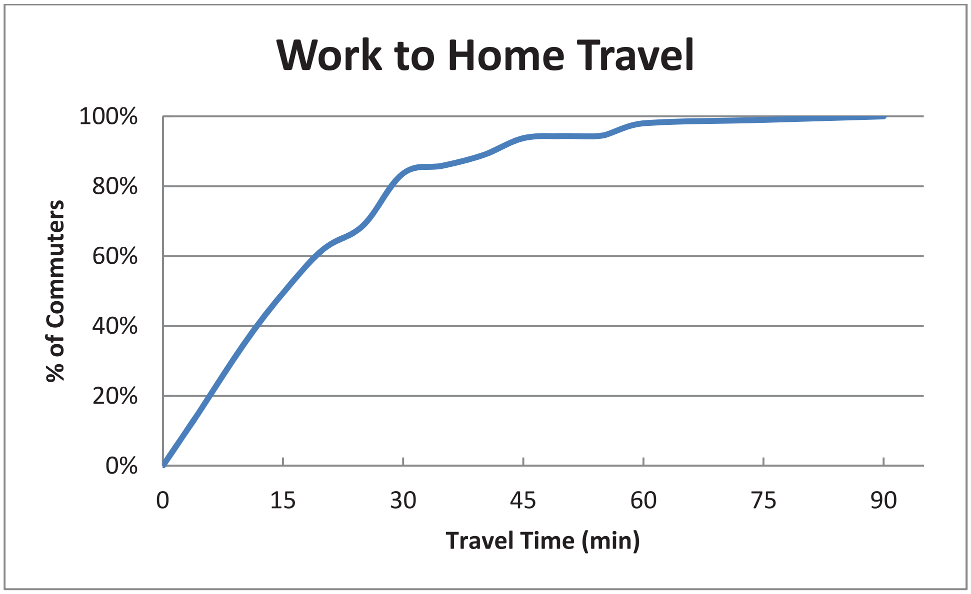


Figure F-11. Work to Home Travel Time

"How long would it take the family to pack clothing, secure the house, and load the car?" Figure F-12 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.

The distribution shown in Figure F-12 has a long "tail." About 86 percent of households can be ready to leave home within 60 minutes; the remaining households require up to an additional two hours.

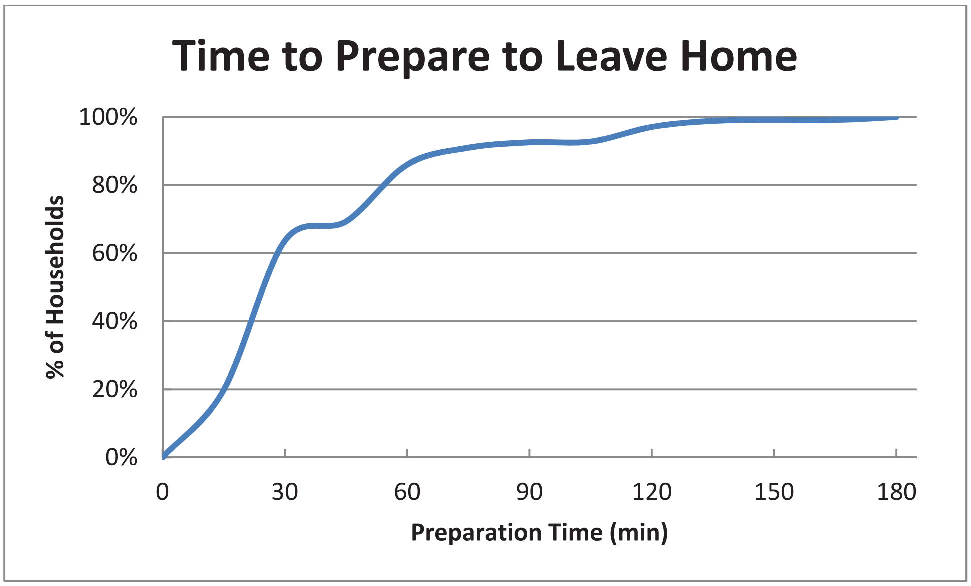


Figure F-12. Time to Prepare Home for Evacuation

"How long would it take you to clear 6 to 8 inches of snow from your driveway?" During adverse, snowy weather conditions, an additional activity must be performed before residents can depart on the evacuation trip. Although snow scenarios assume that the roads and highways have been plowed and are passable (albeit at lower speeds and capacities), it may be necessary to clear a private driveway prior to leaving the home so that the vehicle can access the street. Figure F-13 presents the time distribution for removing 6 to 8 inches of snow from a driveway. The time distribution for clearing the driveway has a long tail; about 83 percent of driveways are passable within 60 minutes. The last driveway is cleared three hours after the start of this activity. Note that those respondents (47%) who answered that they would not take time to clear their driveway were assumed to be ready immediately at the start of this activity. Essentially they would drive through the snow on the driveway to access the roadway and begin their evacuation trip.

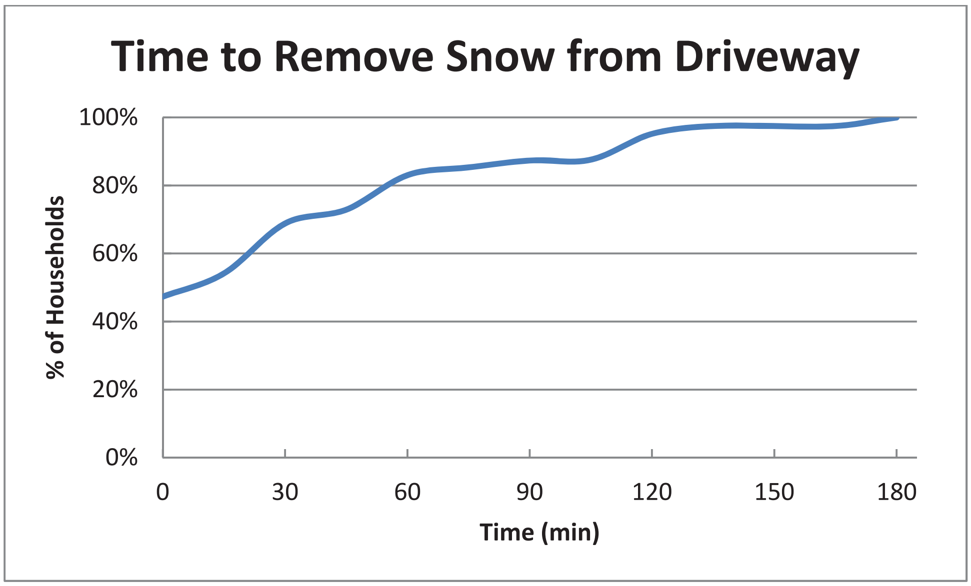


Figure F-13. Time to Clear Driveway of 6"-8" of Snow

F.4 Conclusions

The telephone survey provides valuable, relevant data associated with the EPZ population, which have been used to quantify demographics specific to the EPZ, and "mobilization time" which can influence evacuation time estimates.

ATTACHMENT A

Telephone Survey Instrument

Telephone Survey Instrument

Hello, my name is ___________ and I'm working for First Market Research on a survey for local county emergency management agencies to identify local behavior during emergency situations. This information will be used for emergency planning and will be shared with local officials to enhance emergency response plans in your area for all hazards; emergency planning for some hazards may require evacuation. Your responses will greatly contribute to local emergency preparedness. I will not ask for your name and the survey shall take no more than 10 minutes to complete.

COL. 1	Unused
COL. 2	Unused
COL. 3	Unused
COL. 4	Unused
COL. 5	Unused
Sex	COL. 8
	1 Male
	2 Female

INTERVIEWER: ASK TO SPEAK TO THE HEAD OF HOUSEHOLD OR THE SPOUSE OF THE HEAD OF HOUSEHOLD. (Terminate call if not a residence.)

DO NOT ASK:

1A.	Record area code. To Be Determined	COL. 9-11	
1B.	Record exchange number. To Be Determined	COL. 12-14	
2.	What is your home zip code?	COL. 15-19	
3A.	In total, how many running cars, or other running vehicles are usually available to the household? (DO NOT READ ANSWERS)	COL. 20	SKIP TO
		1 ONE	Q. 4
		2 TWO	Q. 4
		3 THREE	Q. 4
		4 FOUR	Q. 4
		5 FIVE	Q. 4
		6 SIX	Q. 4
		7 SEVEN	Q. 4
		8 EIGHT	Q. 4
		9 NINE OR MORE	Q. 4
		0 ZERO (NONE)	Q. 3B
		X DON'T KNOW/REFUSED	Q. 3B
3B.	In an emergency, could you get a ride out of the area with a neighbor or friend?	COL. 21	
		1 YES	
		2 NO	
		X DON'T KNOW/REFUSED	
4.	How many people usually live in this household? (DO NOT READ ANSWERS)	COL. 22	COL. 23
		1 ONE	0 TEN
		2 TWO	1 ELEVEN
		3 THREE	2 TWELVE
		4 FOUR	3 THIRTEEN
		5 FIVE	4 FOURTEEN
		6 SIX	5 FIFTEEN

	7 SEVEN	6 SIXTEEN
	8 EIGHT	7 SEVENTEEN
	9 NINE	8 EIGHTEEN
		9 NINETEEN OR MORE
		X DON'T KNOW/REFUSED

5. How many adults in the household commute to a job, or to college on a daily basis?	COL. 24	SKIP TO
	0 ZERO	Q. 9
	1 ONE	Q. 6
	2 TWO	Q. 6
	3 THREE	Q. 6
	4 FOUR OR MORE	Q. 6
	5 DON'T KNOW/REFUSED	Q. 9

INTERVIEWER: For each person identified in Question 5, ask Questions 6, 7, and 8.

6. Thinking about commuter #1, how does that person usually travel to work or college? (REPEAT QUESTION FOR EACH COMMUTER)

	Commuter #1	Commuter #2	Commuter #3	Commuter #4
	COL. 25	COL. 26	COL. 27	COL. 28
Rail	1	1	1	1
Bus	2	2	2	2
Walk/Bicycle	3	3	3	3
Drive Alone	4	4	4	4
Carpool-2 or more people	5	5	5	5
Don't know/Refused	6	6	6	6

7. How much time on average, would it take Commuter #1 to travel home from work or college? (REPEAT QUESTION FOR EACH COMMUTER) (DO NOT READ ANSWERS)

COMMUTER #1		COMMUTER #2	
COL. 29	COL. 30	COL. 31	COL. 32
1 5 MINUTES OR LESS	1 46-50 MINUTES	1 5 MINUTES OR LESS	1 46-50 MINUTES
2 6-10 MINUTES	2 51-55 MINUTES	2 6-10 MINUTES	2 51-55 MINUTES
3 11-15 MINUTES	3 56 – 1 HOUR	3 11-15 MINUTES	3 56 – 1 HOUR
4 16-20 MINUTES	4 OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES	4 16-20 MINUTES	4 OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
5 21-25 MINUTES	5 BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES	5 21-25 MINUTES	5 BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
6 26-30 MINUTES	6 BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES	6 26-30 MINUTES	6 BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES

7	31-35 MINUTES	7	BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS	7	31-35 MINUTES	7	BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
8	36-40 MINUTES	8	OVER 2 HOURS (SPECIFY _______)	8	36-40 MINUTES	8	OVER 2 HOURS (SPECIFY _______)
9	41-45 MINUTES	9		9	41-45 MINUTES	9	
		0				0	
		X	DON'T KNOW /REFUSED			X	DON'T KNOW /REFUSED

COMMUTER #3				COMMUTER #4			
COL. 33		COL. 34		COL. 35		COL. 36	
1	5 MINUTES OR LESS	1	46-50 MINUTES	1	5 MINUTES OR LESS	1	46-50 MINUTES
2	6-10 MINUTES	2	51-55 MINUTES	2	6-10 MINUTES	2	51-55 MINUTES
3	11-15 MINUTES	3	56 – 1 HOUR	3	11-15 MINUTES	3	56 – 1 HOUR
4	16-20 MINUTES	4	OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES	4	16-20 MINUTES	4	OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
5	21-25 MINUTES	5	BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES	5	21-25 MINUTES	5	BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
6	26-30 MINUTES	6	BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES	6	26-30 MINUTES	6	BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
7	31-35 MINUTES	7	BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS	7	31-35 MINUTES	7	BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
8	36-40 MINUTES	8	OVER 2 HOURS (SPECIFY _______)	8	36-40 MINUTES	8	OVER 2 HOURS (SPECIFY _______)
9	41-45 MINUTES	9		9	41-45 MINUTES	9	
		0				0	
		X	DON'T KNOW /REFUSED			X	DON'T KNOW /REFUSED

8. Approximately how much time does it take Commuter #1 to complete preparation for leaving work or college prior to starting the trip home? (REPEAT QUESTION FOR EACH COMMUTER) (DO NOT READ ANSWERS)

COMMUTER #1				COMMUTER #2			
COL. 37		COL. 38		COL. 39		COL. 40	
1	5 MINUTES OR LESS	1	46-50 MINUTES	1	5 MINUTES OR LESS	1	46-50 MINUTES
2	6-10 MINUTES	2	51-55 MINUTES	2	6-10 MINUTES	2	51-55 MINUTES
3	11-15 MINUTES	3	56 – 1 HOUR	3	11-15 MINUTES	3	56 – 1 HOUR
4	16-20 MINUTES	4	OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES	4	16-20 MINUTES	4	OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
5	21-25 MINUTES	5	BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES	5	21-25 MINUTES	5	BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
6	26-30 MINUTES	6	BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES	6	26-30 MINUTES	6	BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
7	31-35 MINUTES	7	BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS	7	31-35 MINUTES	7	BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
8	36-40 MINUTES	8	OVER 2 HOURS (SPECIFY _______)	8	36-40 MINUTES	8	OVER 2 HOURS (SPECIFY _______)
9	41-45 MINUTES	9		9	41-45 MINUTES	9	
		0				0	

		X	DON'T KNOW /REFUSED
		X	DON'T KNOW /REFUSED

COMMUTER #3

COL. 41		COL. 42	
1	5 MINUTES OR LESS	1	46-50 MINUTES
2	6-10 MINUTES	2	51-55 MINUTES
3	11-15 MINUTES	3	56 – 1 HOUR
4	16-20 MINUTES	4	OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
5	21-25 MINUTES	5	BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
6	26-30 MINUTES	6	BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
7	31-35 MINUTES	7	BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
8	36-40 MINUTES	8	OVER 2 HOURS (SPECIFY _______)
9	41-45 MINUTES	9	
		0	
		X	DON'T KNOW /REFUSED

COMMUTER #4

COL. 43		COL. 44	
1	5 MINUTES OR LESS	1	46-50 MINUTES
2	6-10 MINUTES	2	51-55 MINUTES
3	11-15 MINUTES	3	56 – 1 HOUR
4	16-20 MINUTES	4	OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
5	21-25 MINUTES	5	BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
6	26-30 MINUTES	6	BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
7	31-35 MINUTES	7	BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
8	36-40 MINUTES	8	OVER 2 HOURS (SPECIFY _______)
9	41-45 MINUTES	9	
		0	
		X	DON'T KNOW /REFUSED

9. 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? (DO NOT READ ANSWERS)

COL. 45		COL. 46	
1	LESS THAN 15 MINUTES	1	3 HOURS TO 3 HOURS 15 MINUTES
2	15-30 MINUTES	2	3 HOURS 16 MINUTES TO 3 HOURS 30 MINUTES
3	31-45 MINUTES	3	3 HOURS 31 MINUTES TO 3 HOURS 45 MINUTES
4	46 MINUTES – 1 HOUR	4	3 HOURS 46 MINUTES TO 4 HOURS
5	1 HOUR TO 1 HOUR 15 MINUTES	5	4 HOURS TO 4 HOURS 15 MINUTES
6	1 HOUR 16 MINUTES TO 1 HOUR 30 MINUTES	6	4 HOURS 16 MINUTES TO 4 HOURS 30 MINUTES
7	1 HOUR 31 MINUTES TO 1 HOUR 45 MINUTES	7	4 HOURS 31 MINUTES TO 4 HOURS 45 MINUTES
8	1 HOUR 46 MINUTES TO 2 HOURS	8	4 HOURS 46 MINUTES TO 5 HOURS
9	2 HOURS TO 2 HOURS 15 MINUTES	9	5 HOURS TO 5 HOURS 30 MINUTES
0	2 HOURS 16 MINUTES TO 2 HOURS 30 MINUTES	0	5 HOURS 31 MINUTES TO 6 HOURS
X	2 HOURS 31 MINUTES TO 2 HOURS 45 MINUTES	X	OVER 6 HOURS (SPECIFY ________)
Y	2 HOURS 46 MINUTES TO 3 HOURS		

COL. 47

1 DON'T KNOW/REFUSED

10. If there is 6-8" 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" of snow to move the car from the driveway or curb to begin the evacuation trip? Assume the roads are passable. (DO NOT READ RESPONSES)

COL. 48

1 LESS THAN 15 MINUTES
2 15-30 MINUTES
3 31-45 MINUTES
4 46 MINUTES – 1 HOUR
5 1 HOUR TO 1 HOUR 15 MINUTES
6 1 HOUR 16 MINUTES TO 1 HOUR 30 MINUTES
7 1 HOUR 31 MINUTES TO 1 HOUR 45 MINUTES
8 1 HOUR 46 MINUTES TO 2 HOURS
9 2 HOURS TO 2 HOURS 15 MINUTES
0 2 HOURS 16 MINUTES TO 2 HOURS 30 MINUTES
X 2 HOURS 31 MINUTES TO 2 HOURS 45 MINUTES
Y 2 HOURS 46 MINUTES TO 3 HOURS
Z NO, WILL NOT SHOVEL OUT

COL. 49

1 OVER 3 HOURS (SPECIFY ________)
2 DON'T KNOW/REFUSED

11. Please choose one of the following (READ ANSWERS):

A. I would await the return of household commuters to evacuate together.

B. I would evacuate independently and meet other household members later.

COL. 50

1 A
2 B
X DON'T KNOW/REFUSED

12. How many vehicles would your household use during an evacuation? (DO NOT READ ANSWERS)

COL. 51

1 ONE
2 TWO
3 THREE
4 FOUR
5 FIVE
6 SIX
7 SEVEN
8 EIGHT
9 NINE OR MORE
0 ZERO (NONE)
X DON'T KNOW/REFUSED

13A.	Emergency officials advise you to take shelter at home in an emergency. Would you: (READ ANSWERS) A. SHELTER; or B. EVACUATE	COL. 52 1 A 2 B X DON'T KNOW/REFUSED
13B.	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: (READ ANSWERS) A. SHELTER; or B. EVACUATE	COL. 53 1 A 2 B X DON'T KNOW/REFUSED
14.	If you have a household pet, would you take your pet with you if you were asked to evacuate the area? (READ ANSWERS)	COL. 54 1 DON'T HAVE A PET 2 YES 3 NO X DON'T KNOW/REFUSED

Thank you very much. ________________________________

(TELEPHONE NUMBER CALLED)

IF REQUESTED:

For additional information, contact your County Emergency Management Agency during normal business hours.

County	EMA Phone
Callaway	(573) 592-2480
Gasconade	(573) 486-3621
Montgomery	(573) 564-2283
Osage	(573) 897-3561 (Ext. 220)

APPENDIX G

Traffic Management Plan

G. TRAFFIC MANAGEMENT PLAN

NUREG/CR-7002 indicates that the existing TCPs and ACPs identified by the offsite agencies should be used in the evacuation simulation modeling. The traffic and access control plans for the EPZ were provided by each county.

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. Table K-2 provides the control type and node number for those nodes which are controlled. If the existing control was changed due to the point being a TCP, the control type is indicated as “TCP-Actuated” in Table K-2.

As discussed in Section 7.3, the animation of evacuation traffic conditions indicates several critical intersections which could be bottlenecks during evacuation. These critical intersections were cross-checked with the EPZ county traffic management plans. All of the intersections, except two –US 54 and the two access ramps to I-70 in Callaway County – were identified as TCPs in the county plans. As these are the last congested intersections to clear, it is recommended that the county consider these intersections as additional TCPs.

Figure G-1 maps the TCPs identified in the county emergency plans. Theses TCPs would be manned during evacuation by traffic guides who would direct evacuees in the proper direction and facilitate the flow of traffic through the intersection**s**.

Vehicles traveling on US-54 (County Rd 201) northbound must cross two high volume intersections with the I-70 ramps before exiting the study area to the north. It is recommended that the off-ramps at Exit 148 be barricaded to prohibit vehicles from exiting I-70, mitigating congestion on US-54. Two police officers at each intersection would direct all vehicles traveling northbound on US-54 to either continue north on US-54 or access I-70. The officers stationed at the northern intersection would direct all US-54 southbound traffic onto I-70 westbound to reduce conflicts with northbound traveling vehicles. Figure G-2 through Figure G-5 provide schematics for these proposed TCPs.

G.2 Access Control Points

It is assumed that ACPs will be established within 2 hours of the advisory to evacuate to discourage through travelers from using major through routes which traverse the EPZ. As discussed in Section 3.7, external traffic was only considered on two routes which traverse the EPZ – Interstate-70 and US 54 in this analysis. The generation of these external trips ceased at 2 hours after the advisory to evacuate in the simulation.

According to the counties’ emergency plans, the access control points in Callaway and

Montgomery are listed in their respective emergency operations centers, and will be manned after the advisory to evacuate has been given. It is recommended that ACPs on each border of the EPZ along the two aforementioned routes be the top priority in assigning manpower and equipment as they are the major routes traversing the EPZ, which will typically carry the highest volume of through traffic.

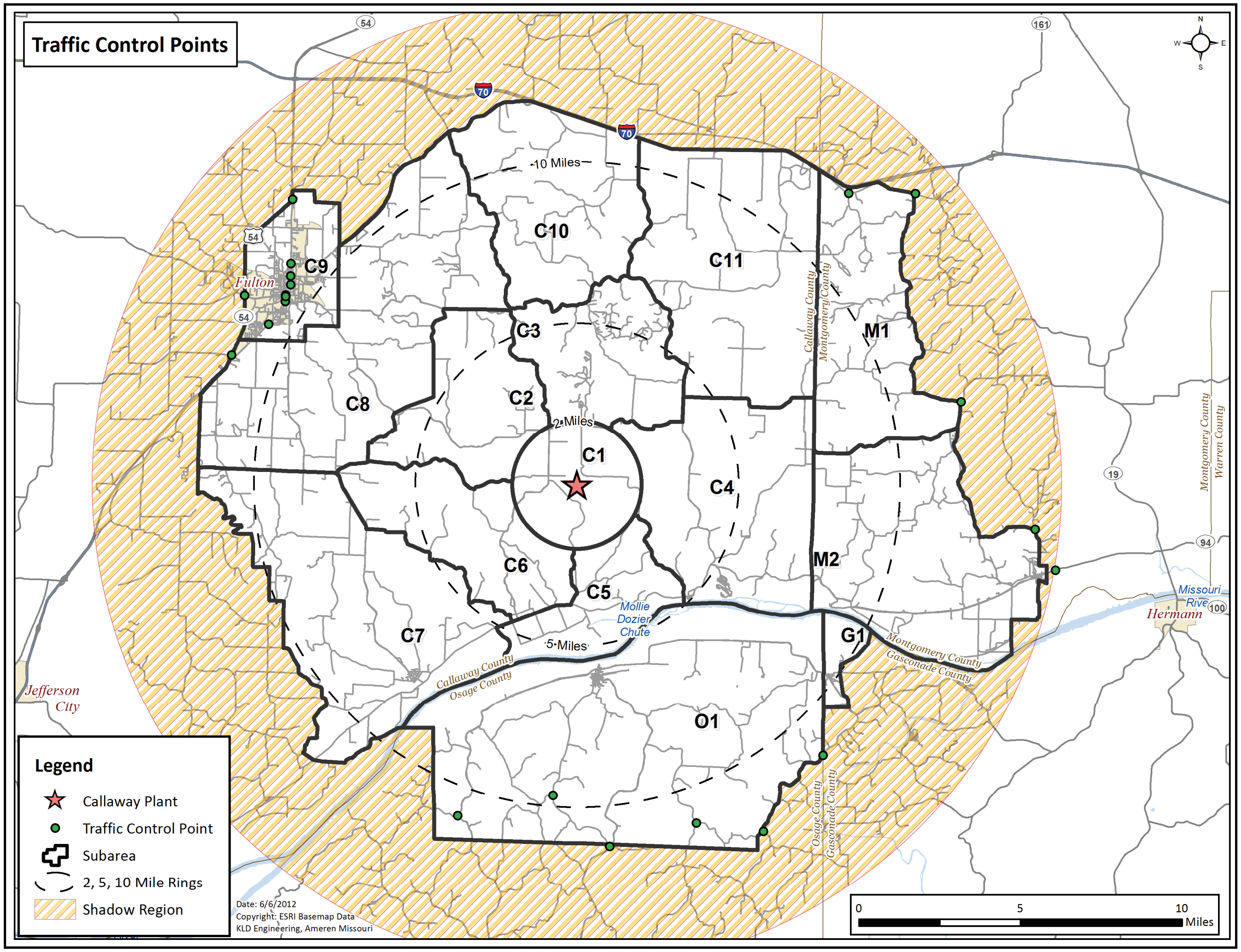
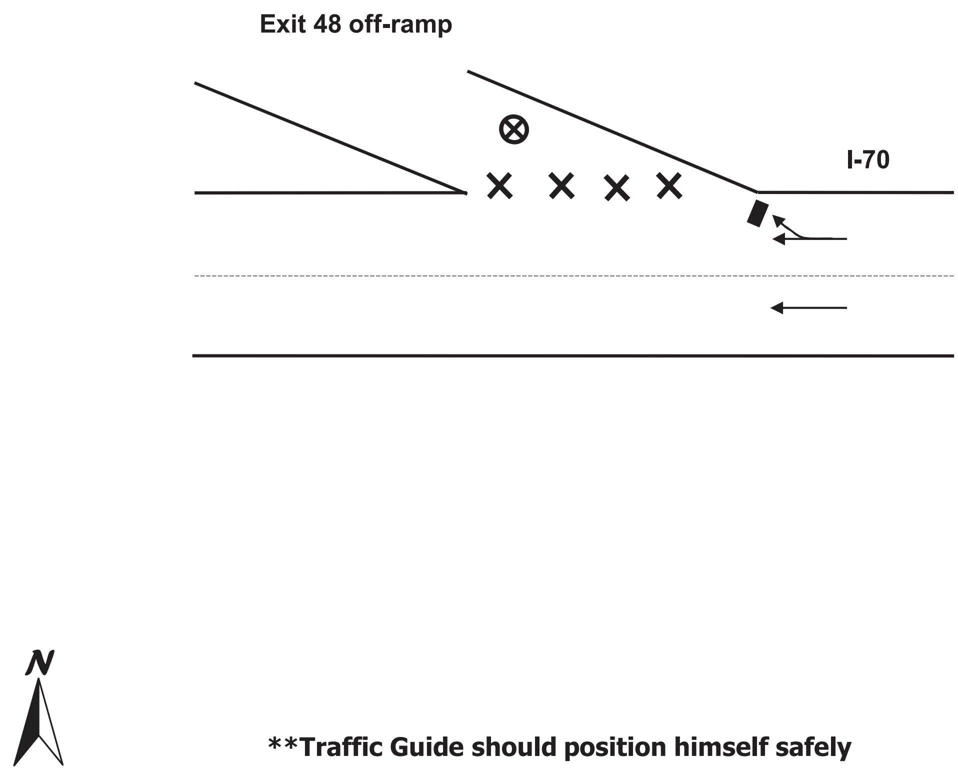


Figure G-1. Traffic Control Points for the Callaway Plant

TCP

MUNICIPALITY: Kingdom City
LOCATION: I-70 Westbound Exit 48
ID: 1
SUBAREA: Shadow Region



Key

- MOVEMENT FACILITATED
- MOVEMENT DISCOURAGED/DIVERTED
- TRAFFIC GUIDE
- STOP SIGN
- TRAFFIC BARRICADE (2 ft, 3 ft)
  - 2 PER LANE (LOCAL ROADS AND RAMPS)
  - 4 PER LANE (FREEWAY AND RAMPS)
- TRAFFIC SIGNAL
- TRAFFIC CONES SPACED TO DISCOURAGE TRAFFIC BUT ALLOW PASSAGE (3 PER LANE): 8 ft

ACTIONS TO BE TAKEN

1. Discourage westbound traffic on I-70 onto Exit 48

MANPOWER/EQUIPMENT ESTIMATE

4 Traffic Barricades

LOCATION PRIORITY

1

****Traffic Guide should position himself safely**

Figure G-2. Schematic of the TCP at I-70 Westbound Exit 48

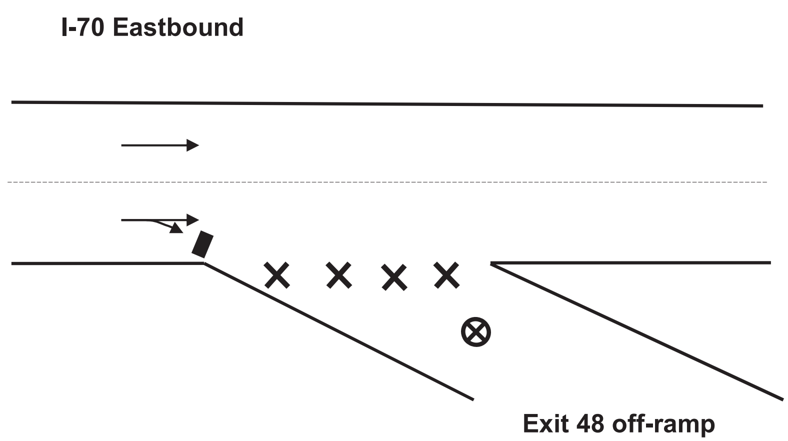
TCP

MUNICIPALITY: Kingdom City

LOCATION: I-70 Westbound Exit 48

ID: 2

SUBAREA: Shadow Region



Key

- MOVEMENT FACILITATED
- MOVEMENT DISCOURAGED/DIVERTED
- TRAFFIC GUIDE
- STOP SIGN
- TRAFFIC BARRICADE (2 ft, 3 ft)
  - 2 PER LANE (LOCAL ROADS AND RAMPS)
  - 4 PER LANE (FREEWAY AND RAMPS)
- TRAFFIC SIGNAL
- TRAFFIC CONES SPACED TO DISCOURAGE TRAFFIC BUT ALLOW PASSAGE (3 PER LANE): 8 ft

ACTIONS TO BE TAKEN

1. Discourage eastbound traffic on I-70 onto Exit 48

MANPOWER/EQUIPMENT ESTIMATE

4 Traffic Barricades

LOCATION PRIORITY

1

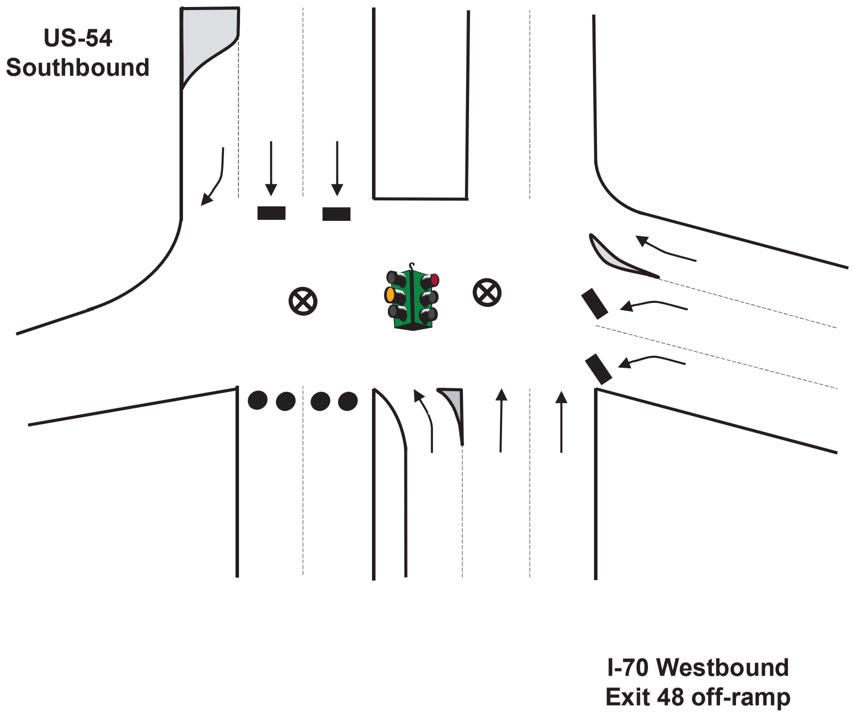
N

**Traffic Guide should position himself safely

Figure G-3. Schematic of the TCP at I-70 Eastbound Exit 48

TCP

MUNICIPALITY: Kingdom City
LOCATION: I-70 Westbound ramps and US-54
ID: 3
SUBAREA: Shadow Region



Key

- MOVEMENT FACILITATED
- MOVEMENT DISCOURAGED/DIVERTED
- TRAFFIC GUIDE
- STOP SIGN
- TRAFFIC BARRICADE (2 ft, 3 ft)
  - 2 PER LANE (LOCAL ROADS AND RAMPS)
  - 4 PER LANE (FREEWAY AND RAMPS)
- TRAFFIC SIGNAL
- TRAFFIC CONES SPACED TO DISCOURAGE TRAFFIC BUT ALLOW PASSAGE (3 PER LANE): 8 ft

ACTIONS TO BE TAKEN

1. Discourage traffic on US-54 Southbound
2. Give priority to traffic flowing on US-54 NB

MANPOWER/EQUIPMENT ESTIMATE

2 Traffic Guides
6 Traffic Cones

LOCATION PRIORITY

1

N

**Traffic Guide should position himself safely

Figure G-4. Schematic of the TCP at I-70 Westbound Ramps and US-54

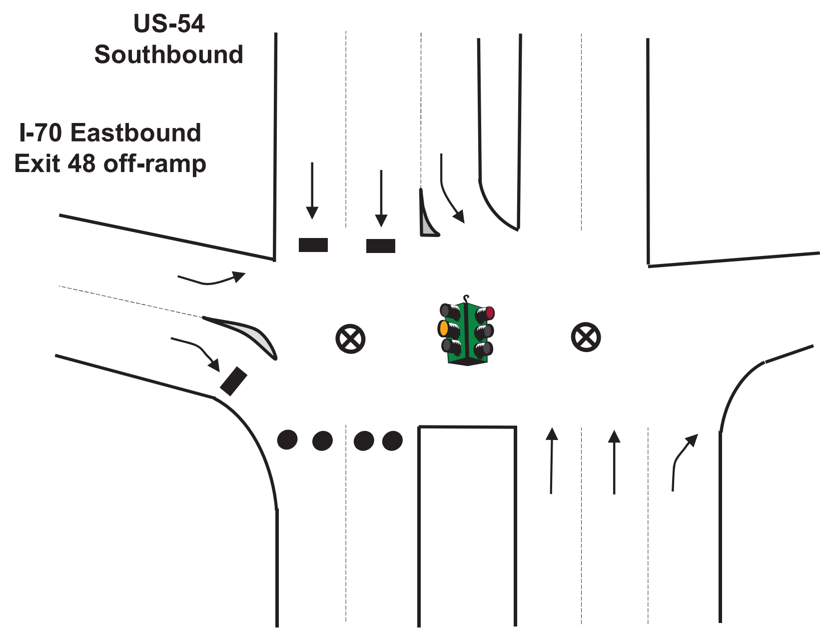
TCP

MUNICIPALITY: Kingdom City

LOCATION: I-70 Eastbound ramps and US-54

ID: 3

SUBAREA: Shadow Region



Key

- → MOVEMENT FACILITATED
- MOVEMENT DISCOURAGED/DIVERTED
- ⊗ TRAFFIC GUIDE
- STOP SIGN
- ✕ TRAFFIC BARRICADE 2 ft 3 ft
  - 2 PER LANE (LOCAL ROADS AND RAMPS)
  - 4 PER LANE (FREEWAY AND RAMPS)
- TRAFFIC SIGNAL
- ●● TRAFFIC CONES SPACED TO DISCOURAGE TRAFFIC BUT ALLOW PASSAGE (3 PER LANE): ●● ● 8 ft

ACTIONS TO BE TAKEN

1. Discourage traffic on US-54 Southbound
2. Give priority to traffic flowing on US-54 NB

MANPOWER/EQUIPMENT ESTIMATE

2 Traffic Guides
6 Traffic Cones

LOCATION PRIORITY

1

N

****Traffic Guide should position himself safely**

Figure G-5. Schematic of the TCP at I-70 Eastbound Ramps and US-54

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. The percentages presented in Table H-1 are based on the methodology discussed in assumption 5 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. As discussed in Appendix F, the data obtained in response to the telephone survey question on sheltering is used in the shadow evacuation sensitivity study documented in Appendix M.

Table H-1. Percent of Subarea Population Evacuating for Each Region

Basic Regions																
		Subarea														
Region	Description	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	G1	M1	M2	O1
R01	2-Mile Radius	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R02	5-Mile Radius	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R03	Full EPZ	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Evacuate 2-Mile Radius and Downwind to 5 Miles																
		Subarea														
Region	Wind Direction From:	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	G1	M1	M2	O1
R04	N, NNE, NE	100%	20%	20%	20%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R05	ENE, E, ESE,	100%	100%	20%	20%	20%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R06	SE, SSE, S	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R07	SSW, SW, WSW	100%	20%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R08	W	100%	20%	20%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R09	WNW, NW, NNW	100%	20%	20%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Evacuate 5-Mile Radius and Downwind to the EPZ Boundary																
		Subarea														
Region	Wind Direction From:	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	G1	M1	M2	O1
R10	N	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	100%
R11	NNE, NE	100%	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	100%
R12	ENE	100%	100%	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%
R13	E, ESE	100%	100%	100%	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%
R14	SE, SSE	100%	100%	100%	100%	100%	100%	20%	100%	100%	100%	20%	20%	20%	20%	20%
R15	S	100%	100%	100%	100%	100%	100%	20%	100%	20%	100%	100%	20%	20%	20%	20%
R16	SSW, SW	100%	100%	100%	100%	100%	100%	20%	20%	20%	100%	100%	20%	100%	20%	20%
R17	WSW	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	100%	20%	100%	100%	20%
R18	W	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	100%	100%	100%	100%	20%
R19	WNW	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	100%	100%	100%	100%
R20	NW	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	100%	20%	100%	100%
R21	NNW	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	100%	20%	20%	100%

Staged Evacuation - 2-Mile Radius Evacuates, then Evacuate Downwind to 5 Miles																
Region	Wind Direction From:	Subarea														
		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	G1	M1	M2	O1
R22	N, NNE, NE	100%	20%	20%	20%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R23	ENE, E, ESE	100%	100%	20%	20%	20%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R24	SE, SSE, S	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R25	SSW, SW, WSW	100%	20%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R26	W	100%	20%	20%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R27	WNW, NW, NNW	100%	20%	20%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R28	None	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%

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

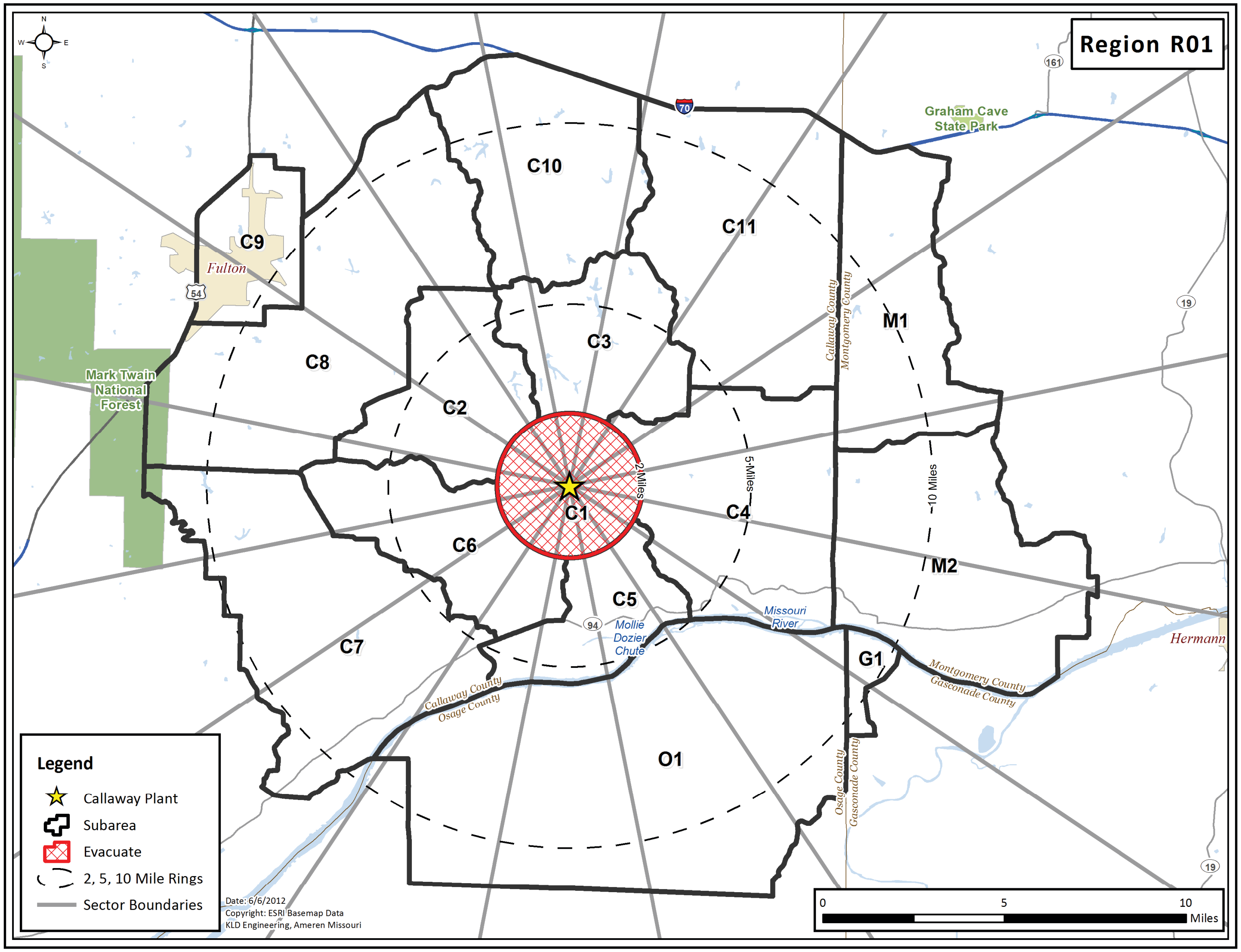


Figure H-1 Region R01

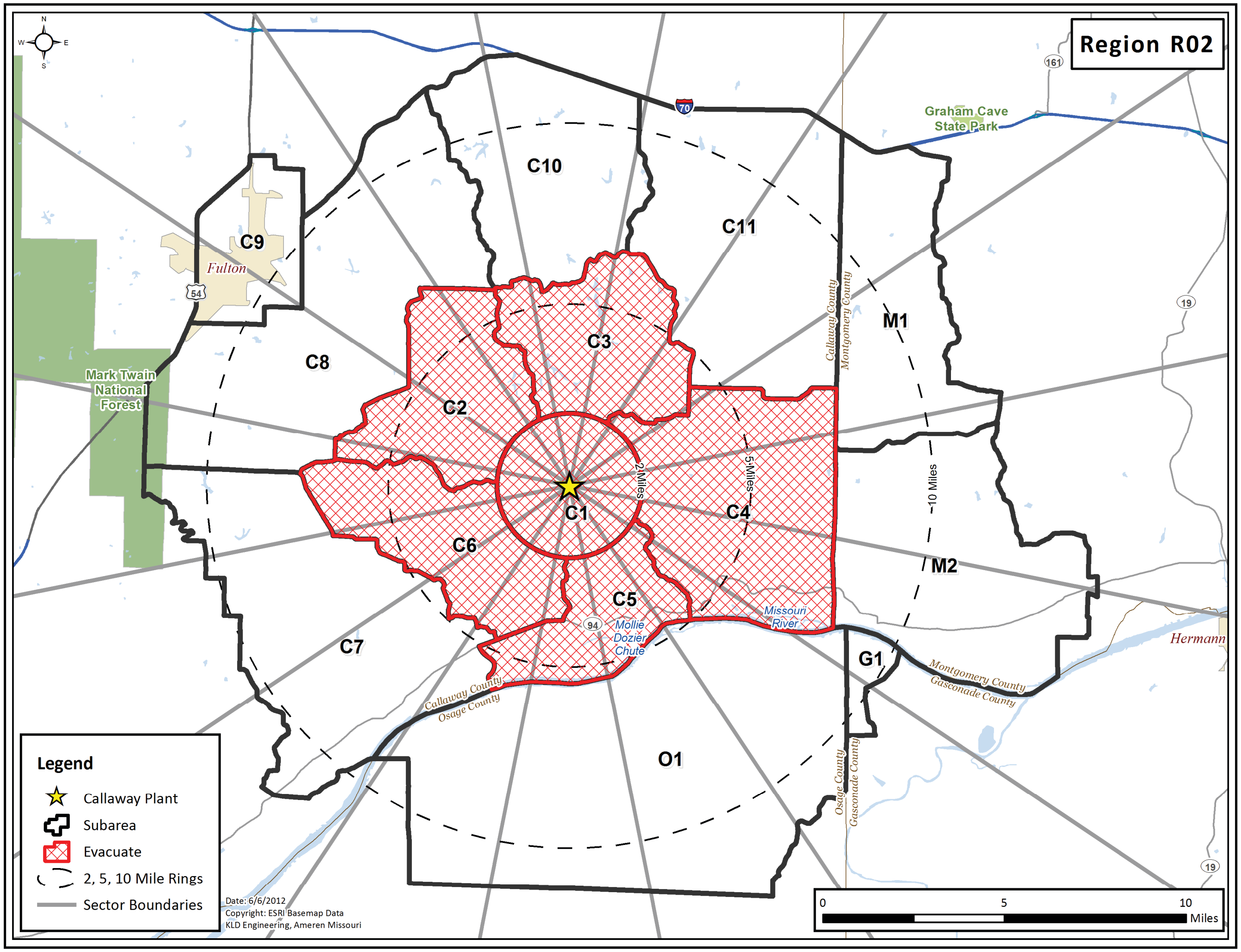


Figure H-2 Region R02

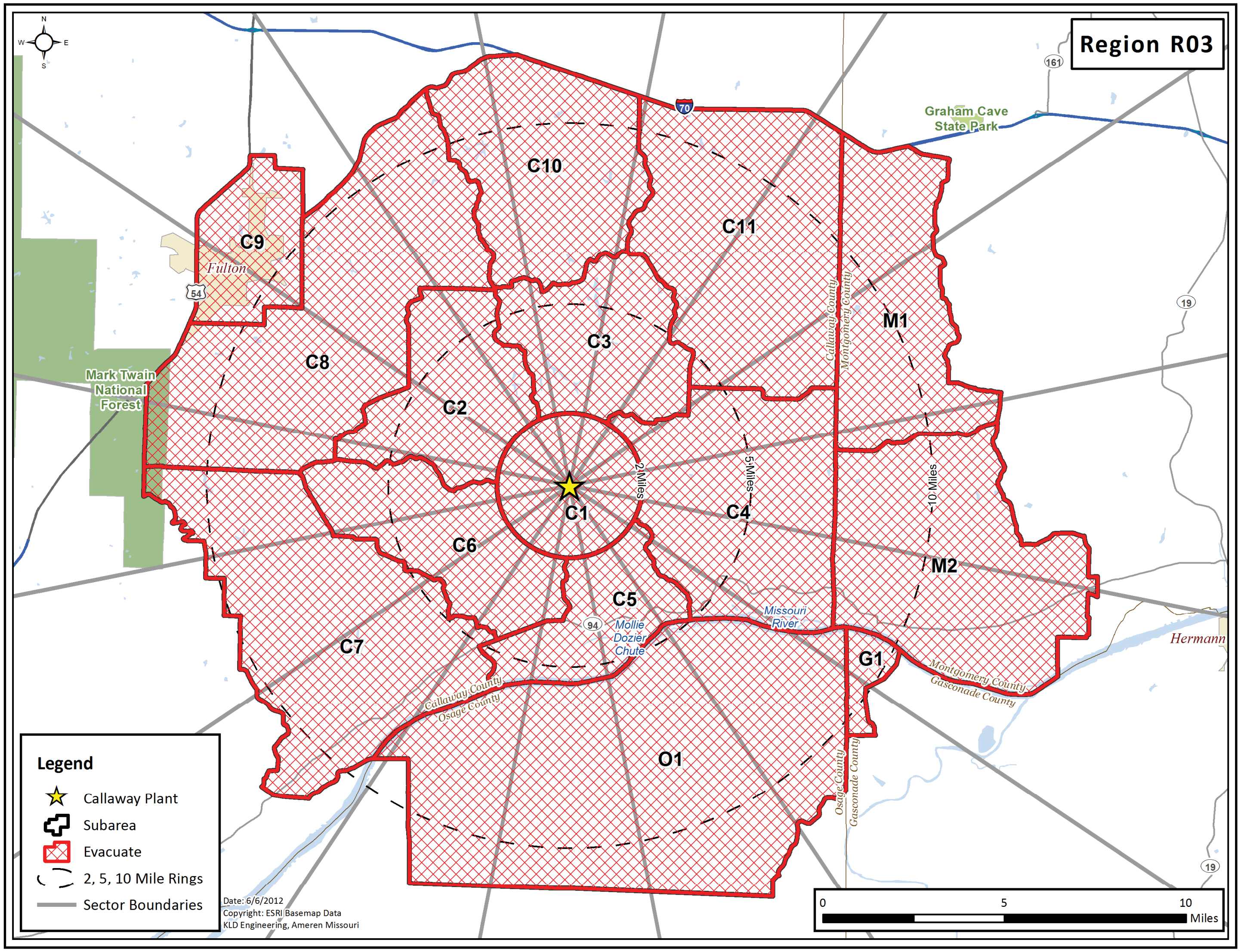


Figure H-3 Region R03

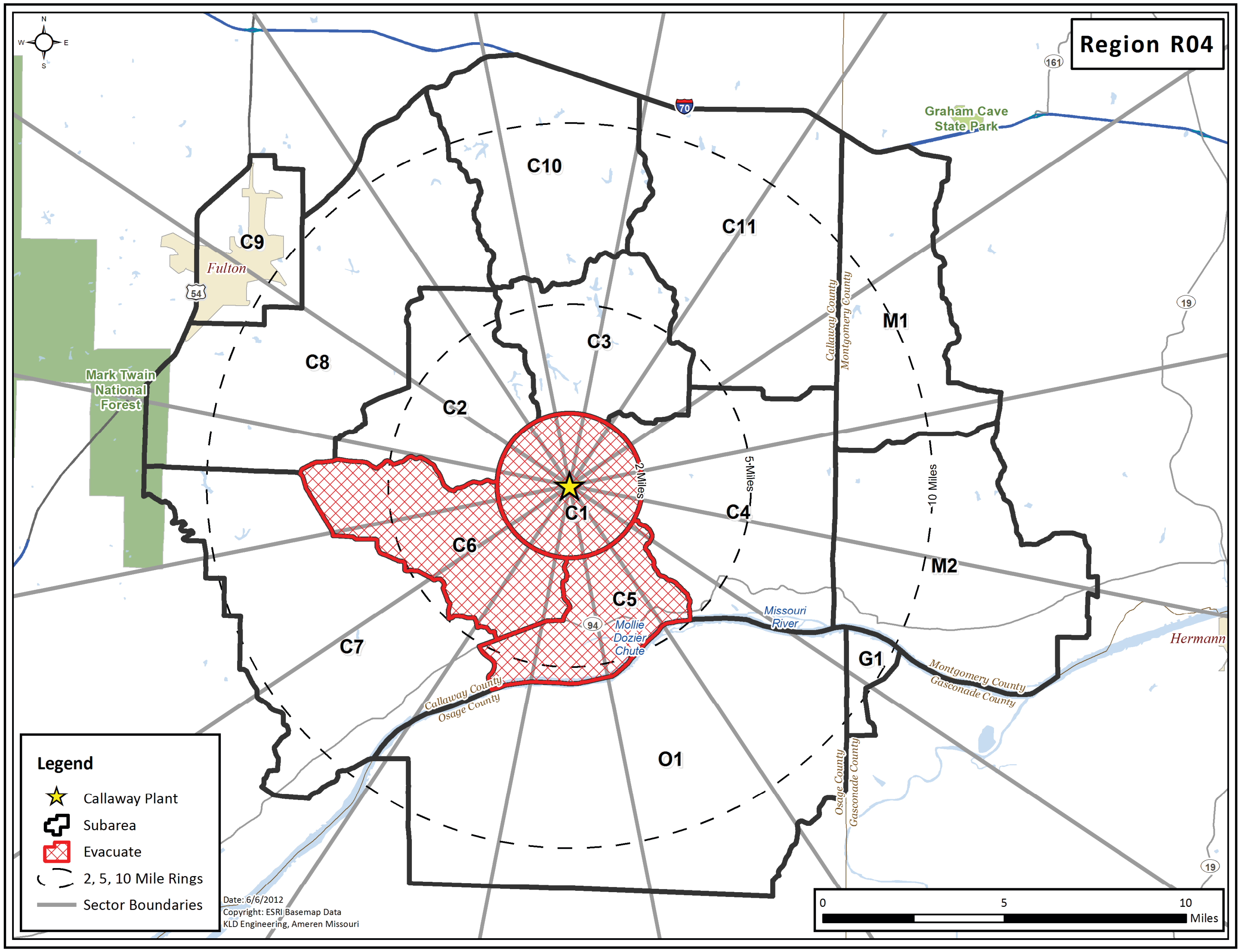


Figure H-4 Region R04

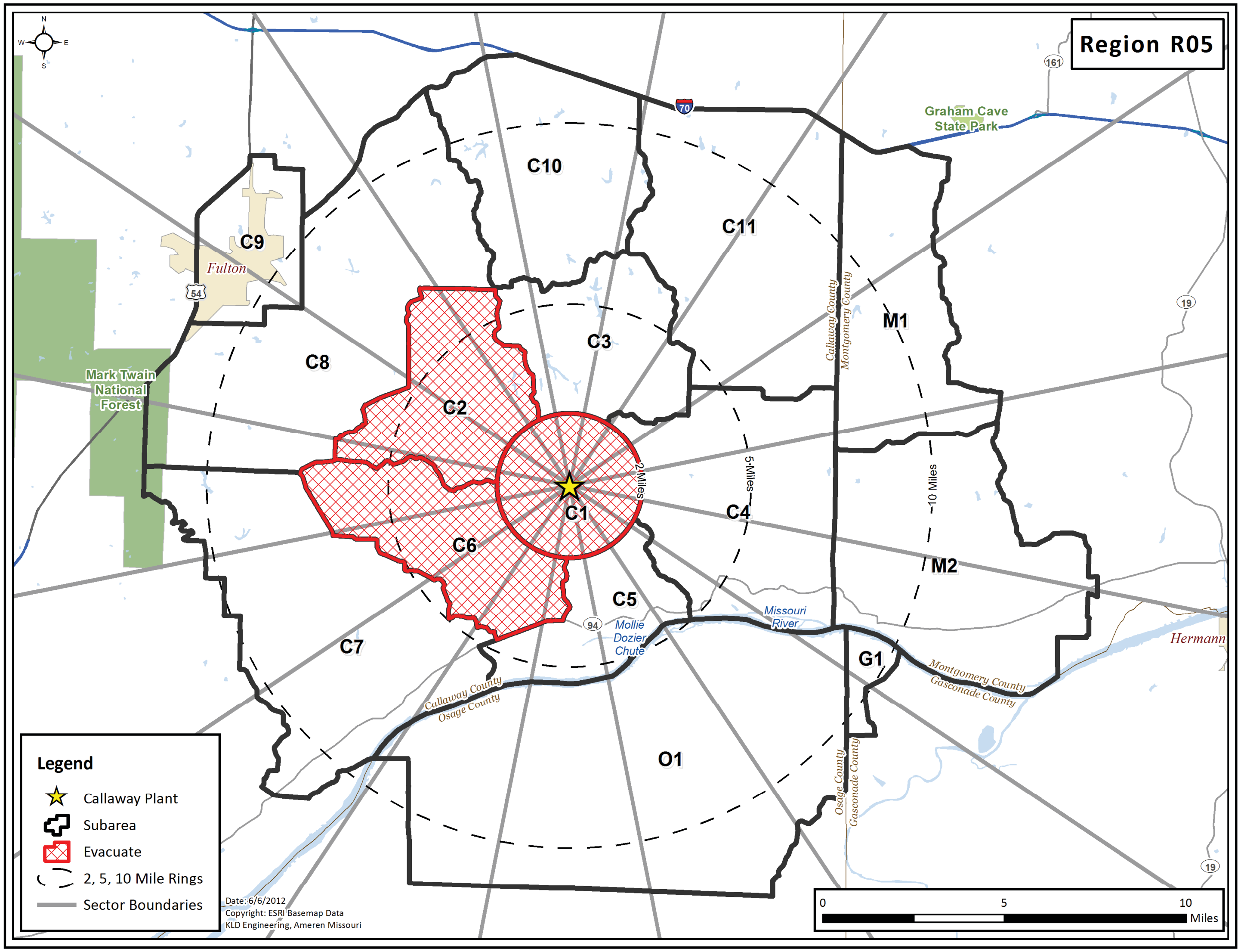


Figure H-5 Region R05

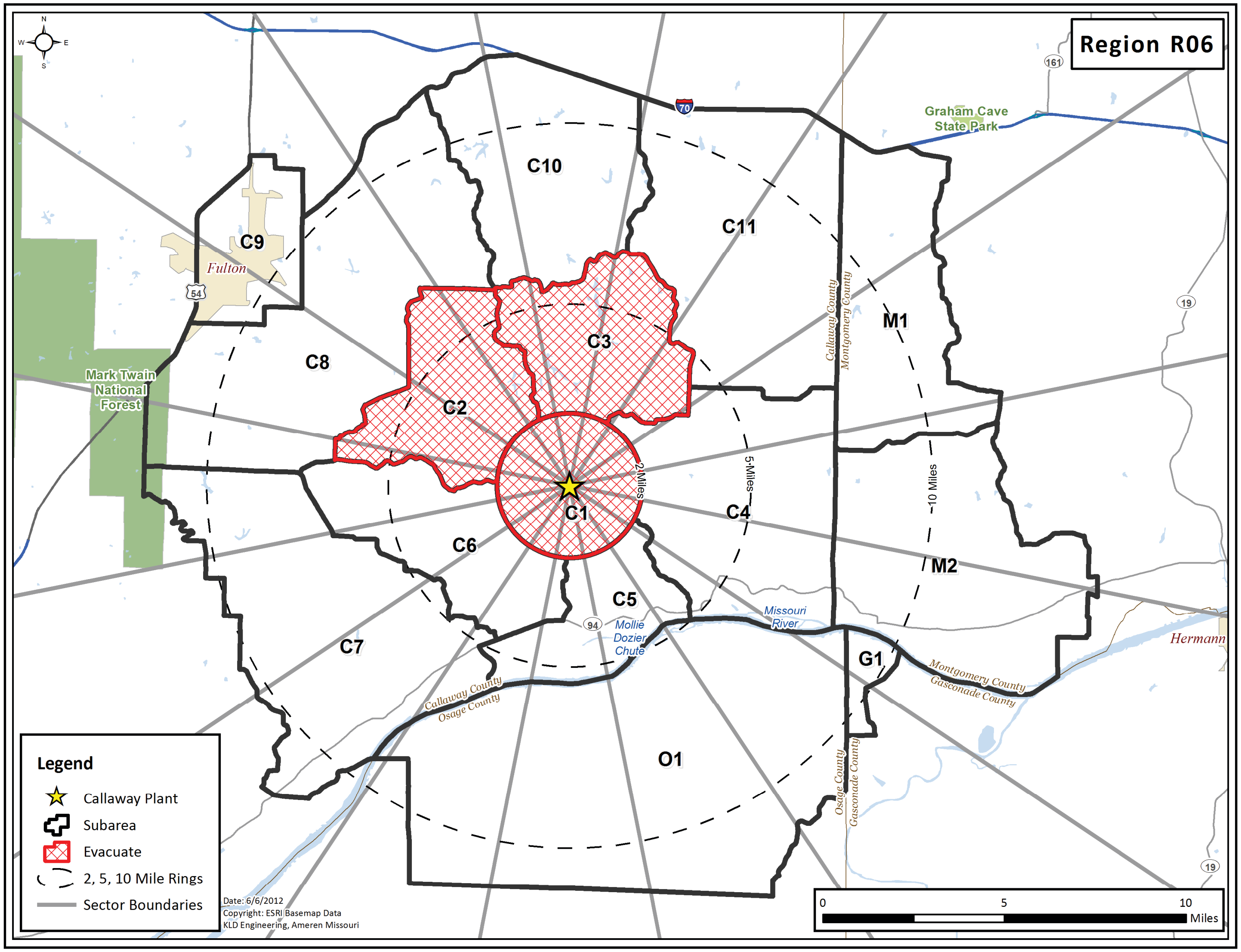


Figure H-6 Region R06

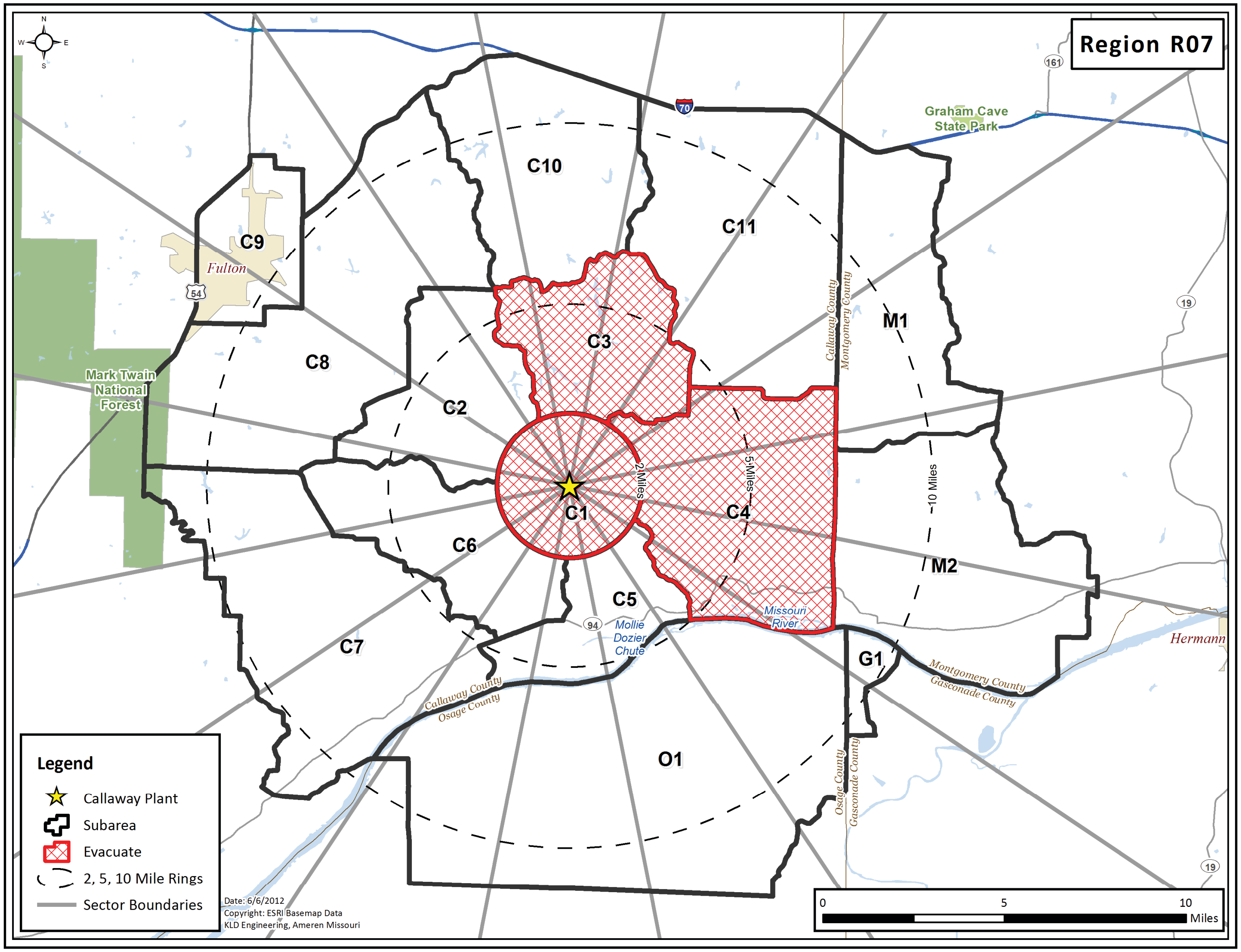


Figure H-7 Region R07

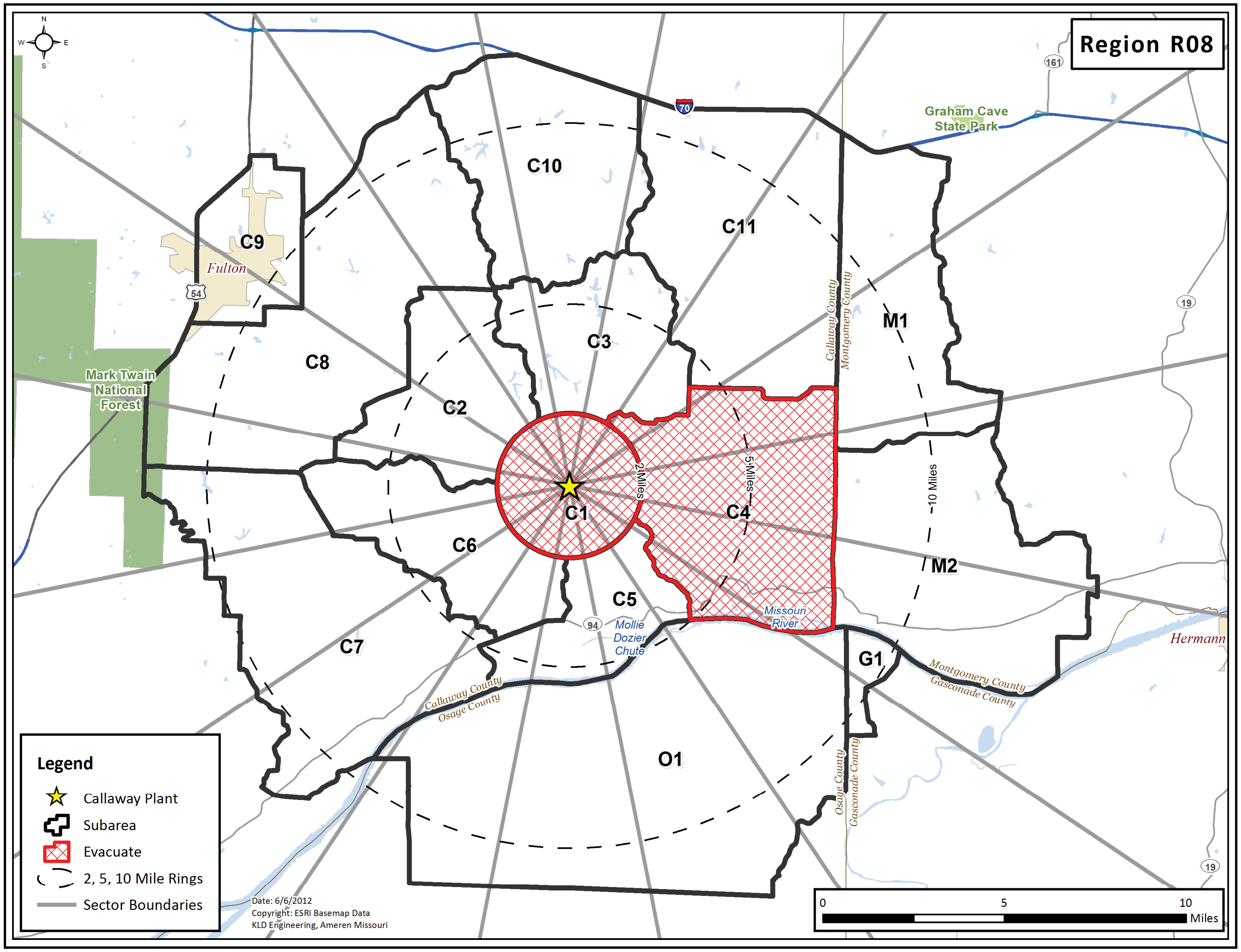


Figure H-8 Region R08

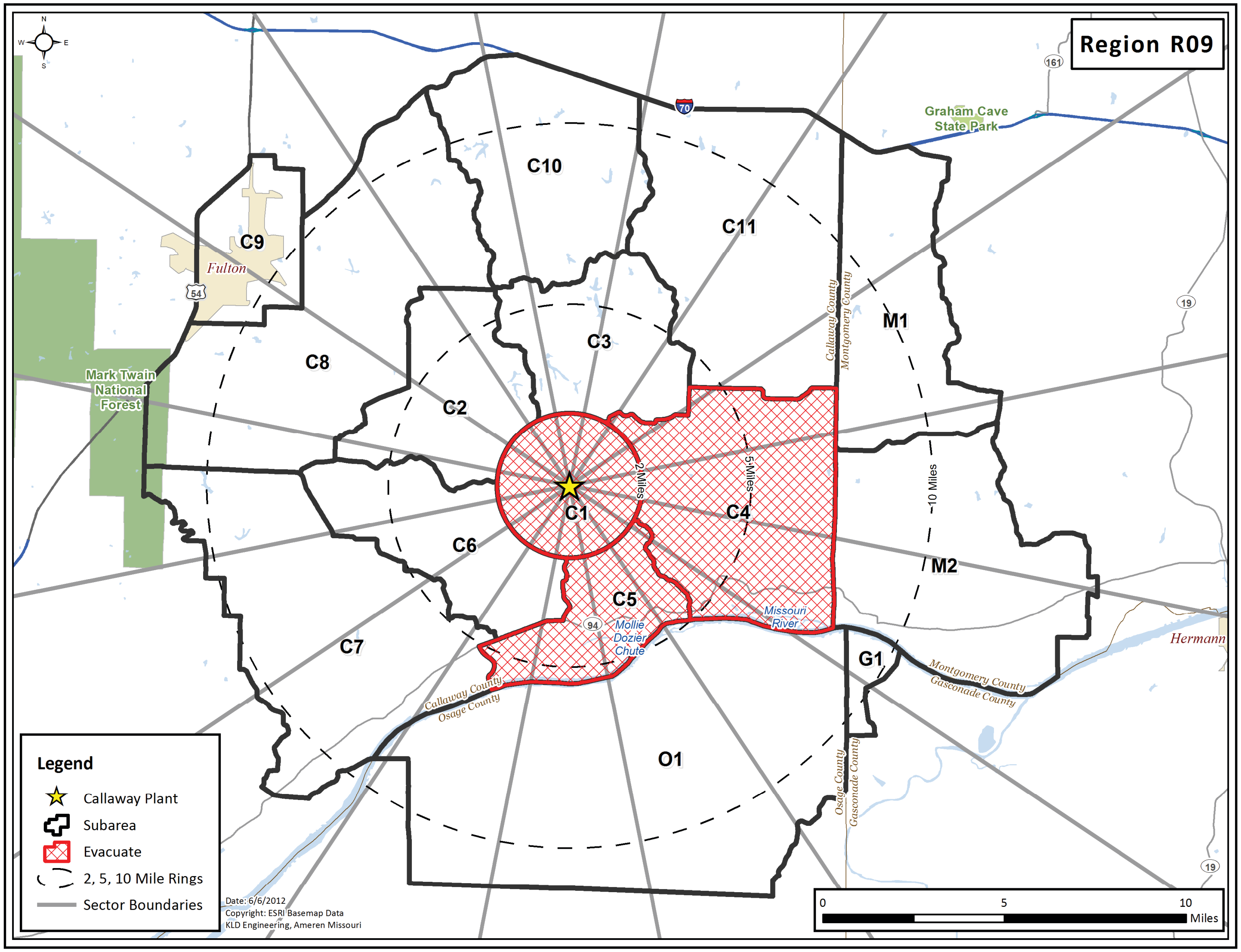


Figure H-9 Region R09

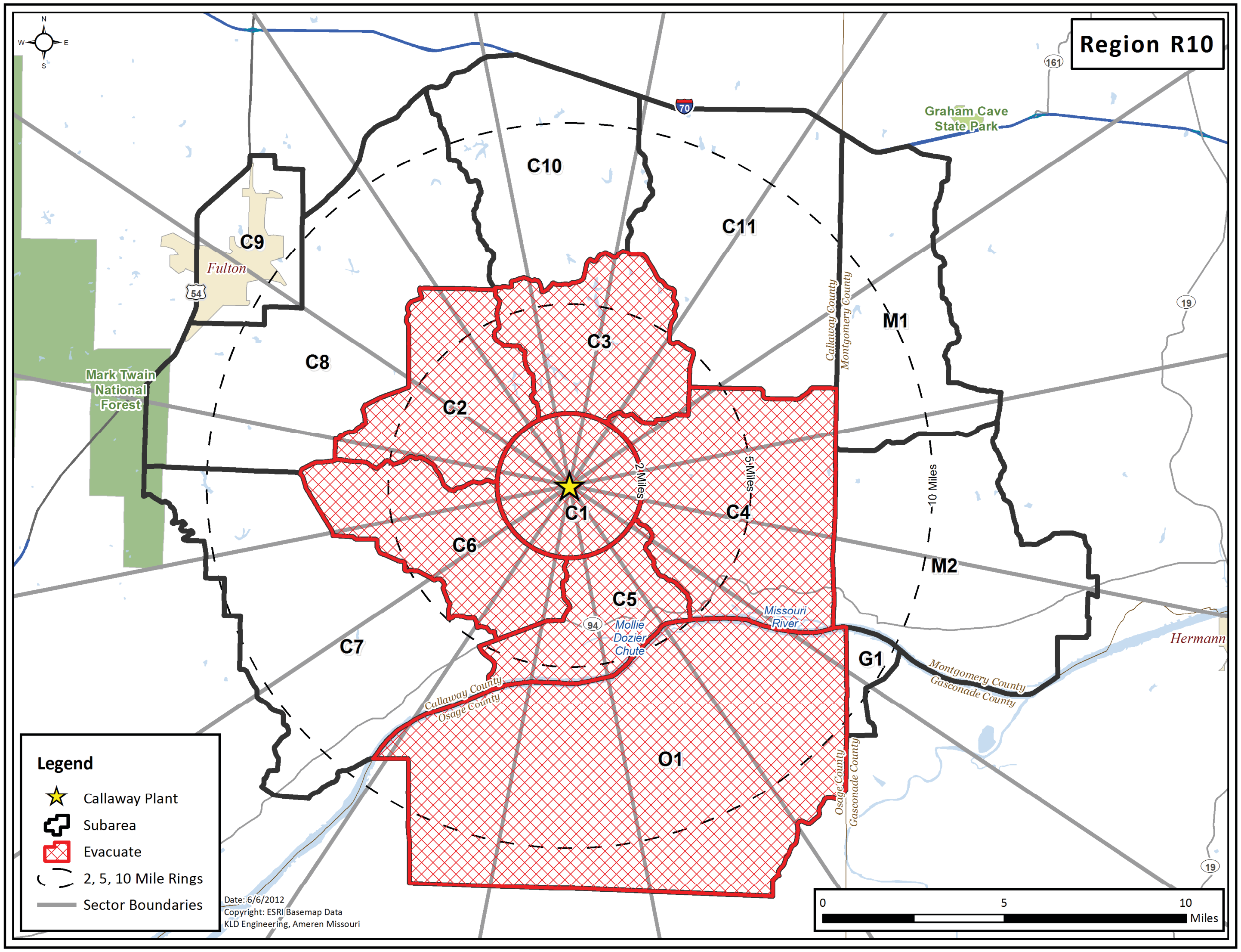


Figure H-10 Region R10

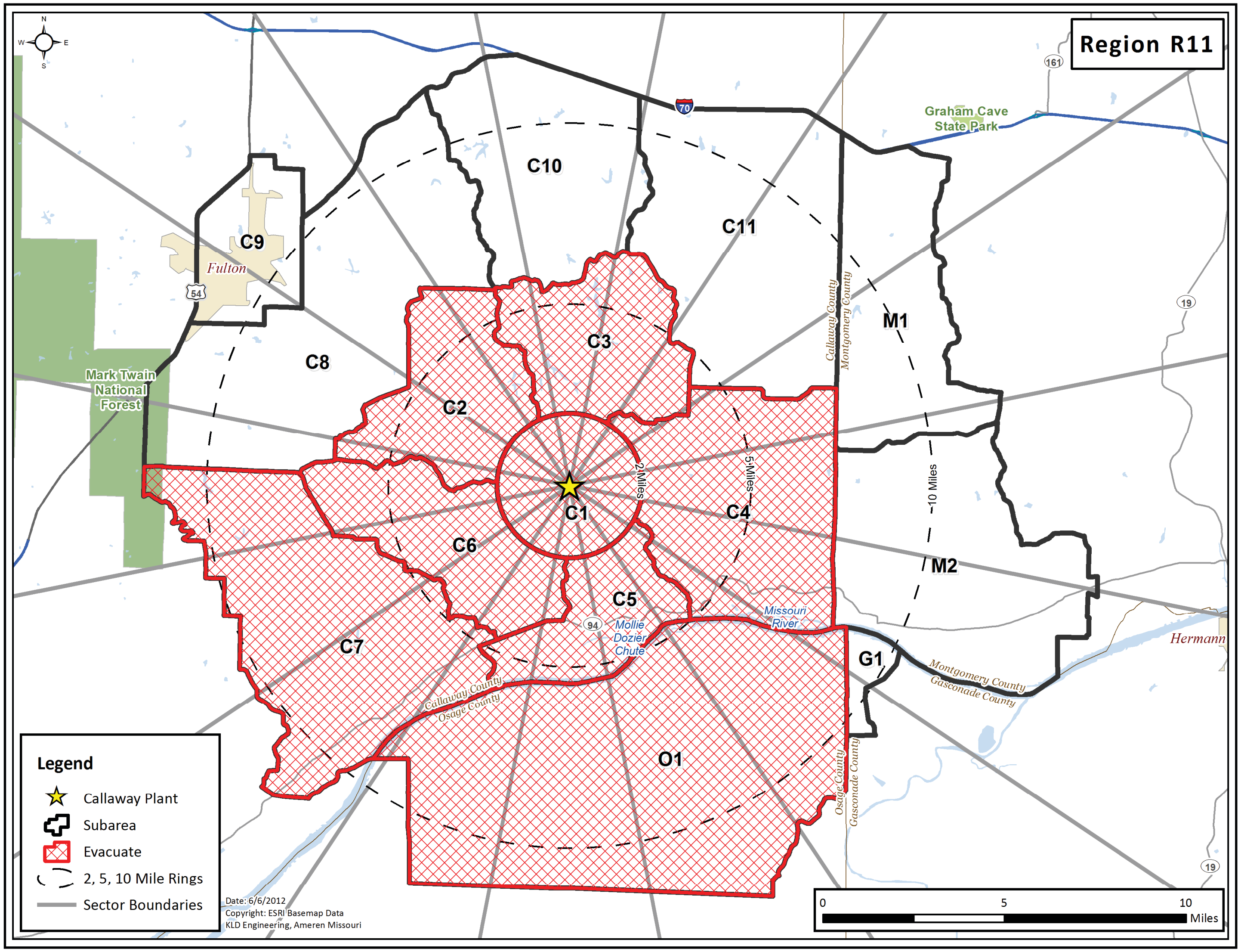


Figure H-11 Region R11

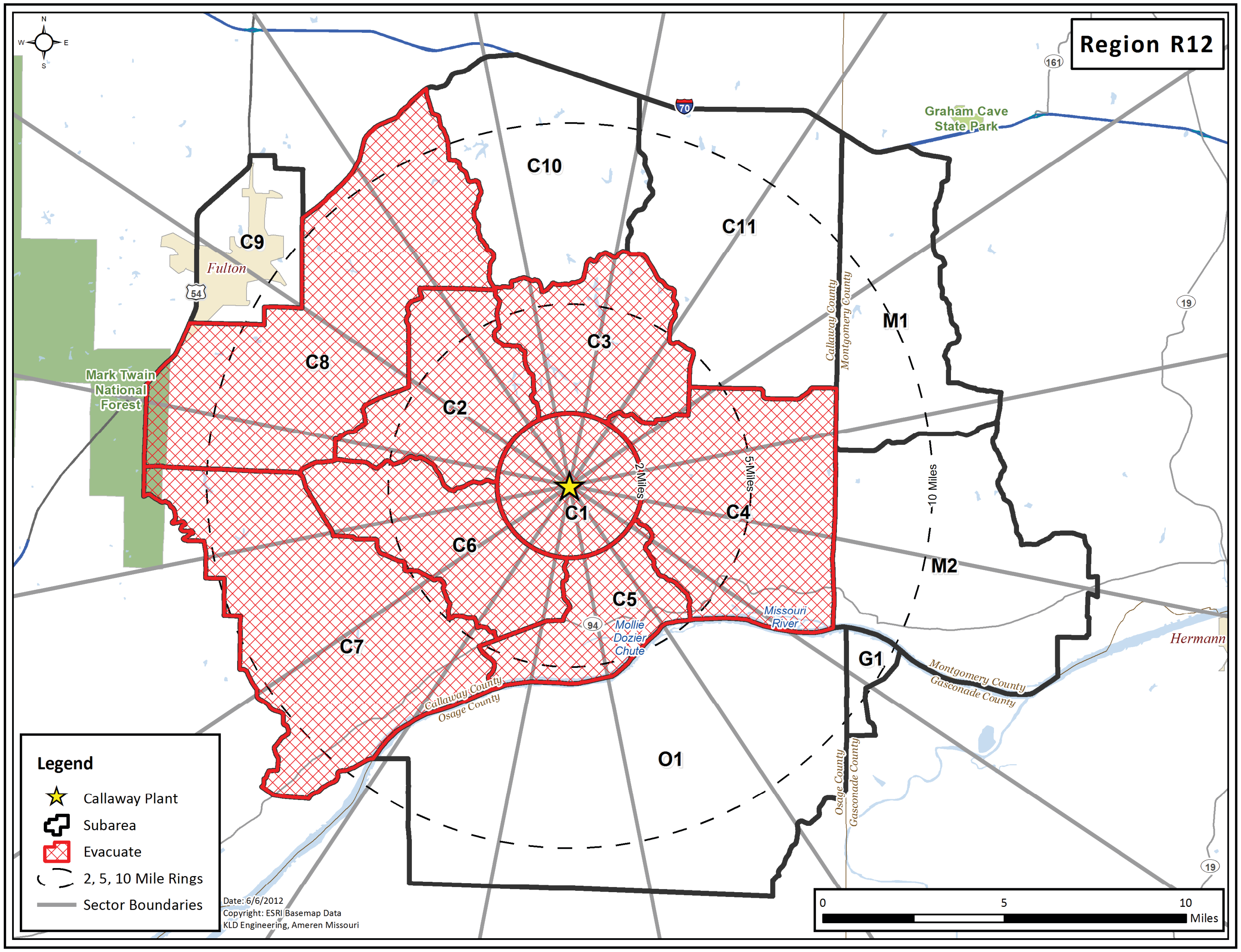


Figure H-12 Region R12

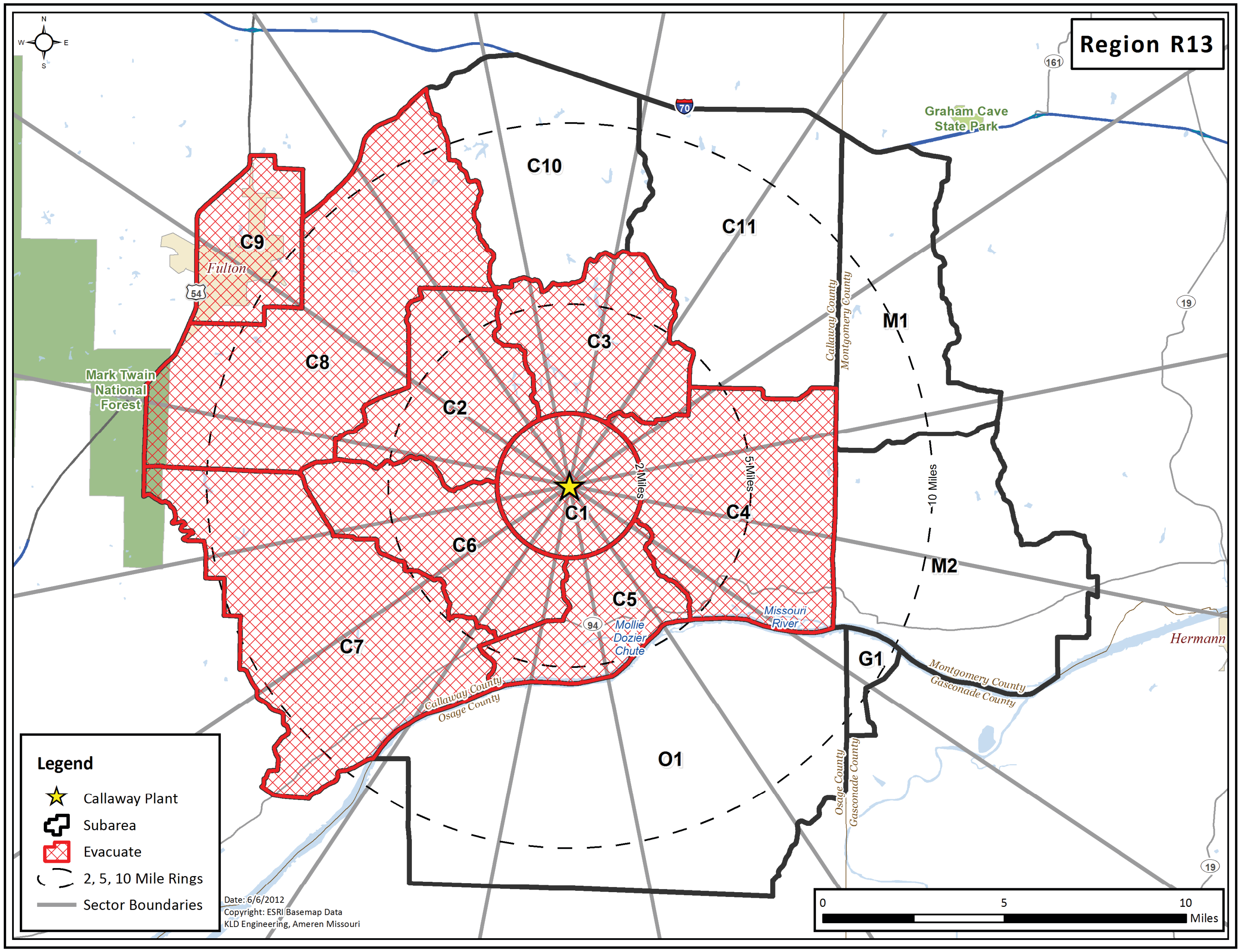


Figure H-13 Region R13

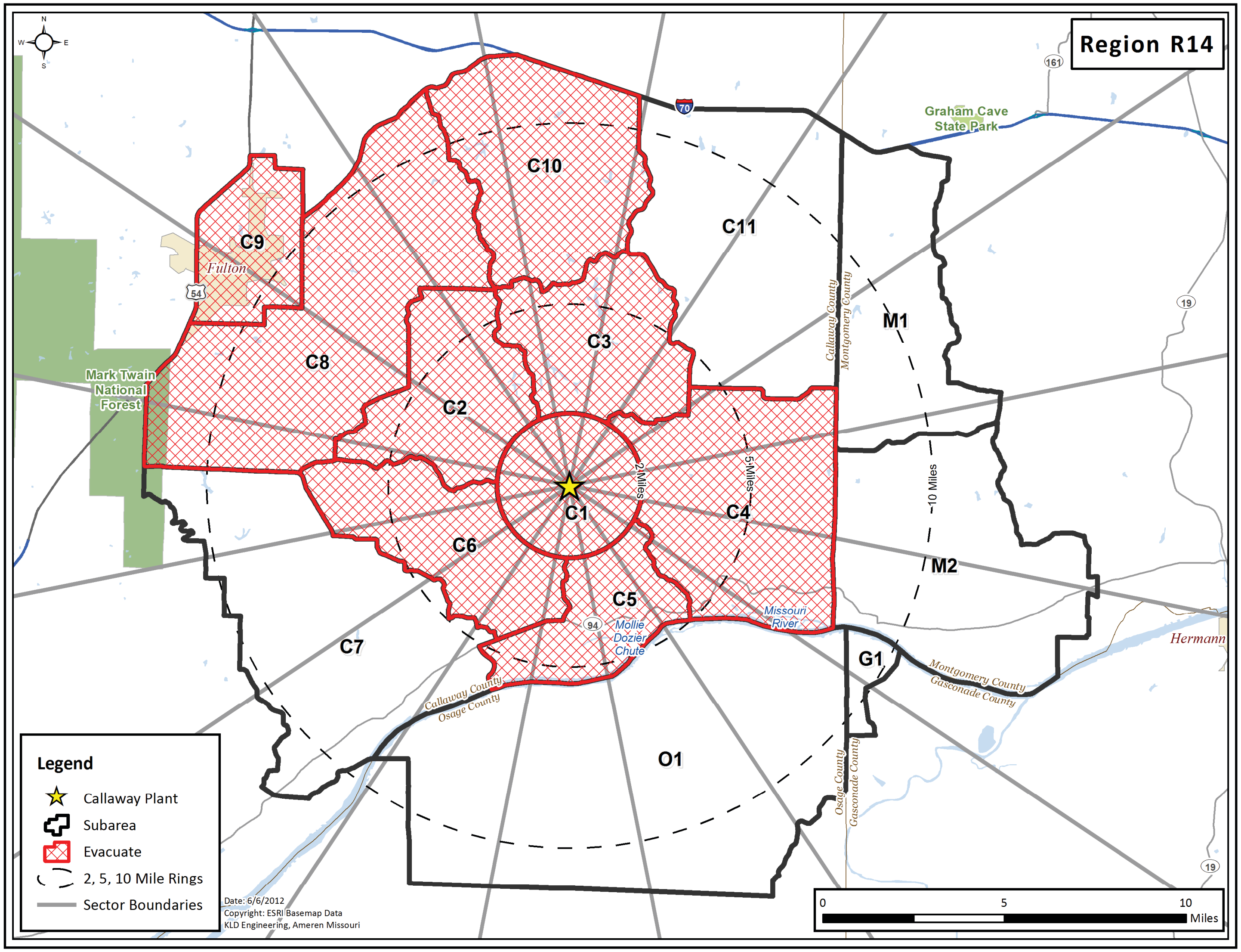


Figure H-14 Region R14

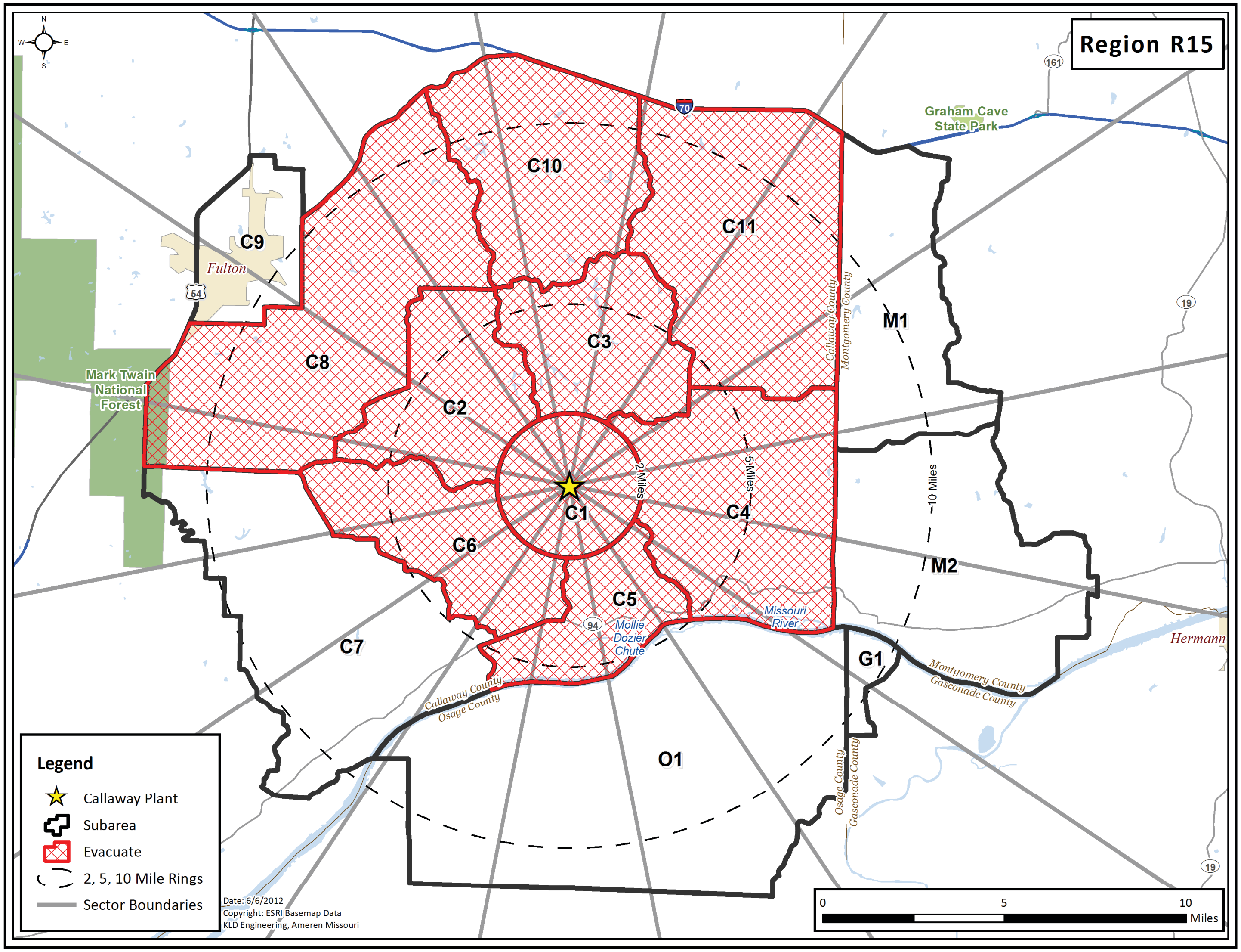


Figure H-15 Region R15

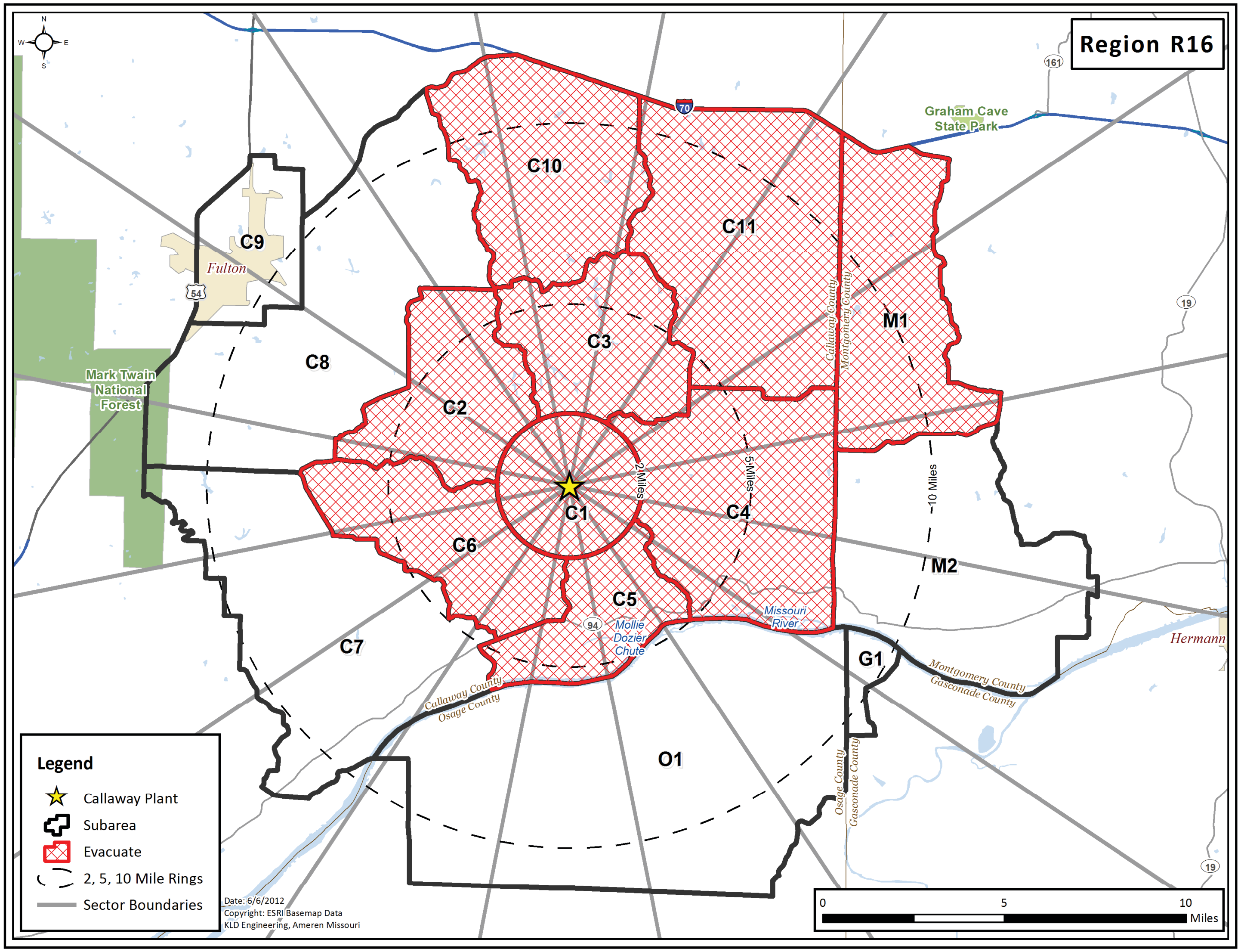


Figure H-16 Region R16

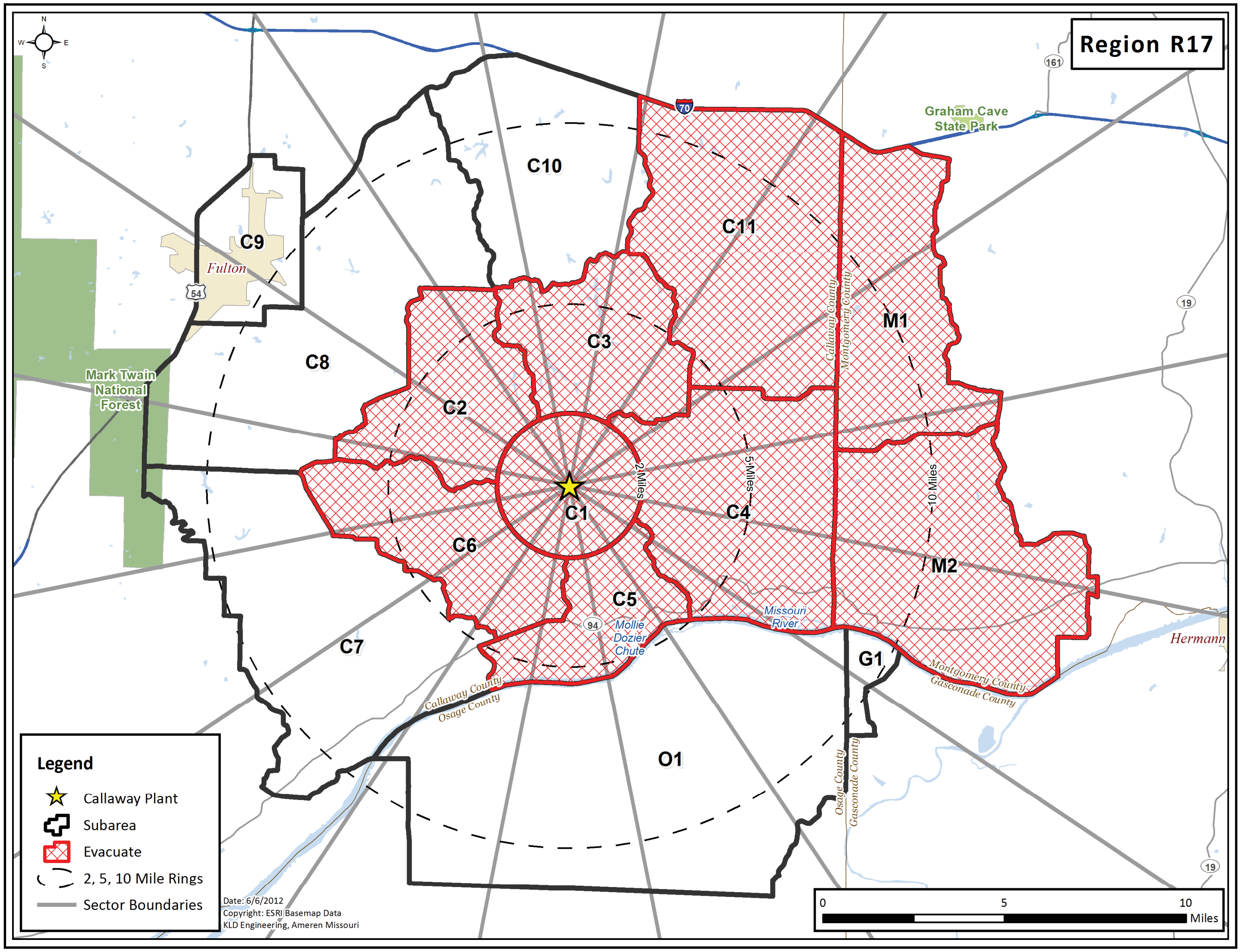


Figure H-17 Region R17

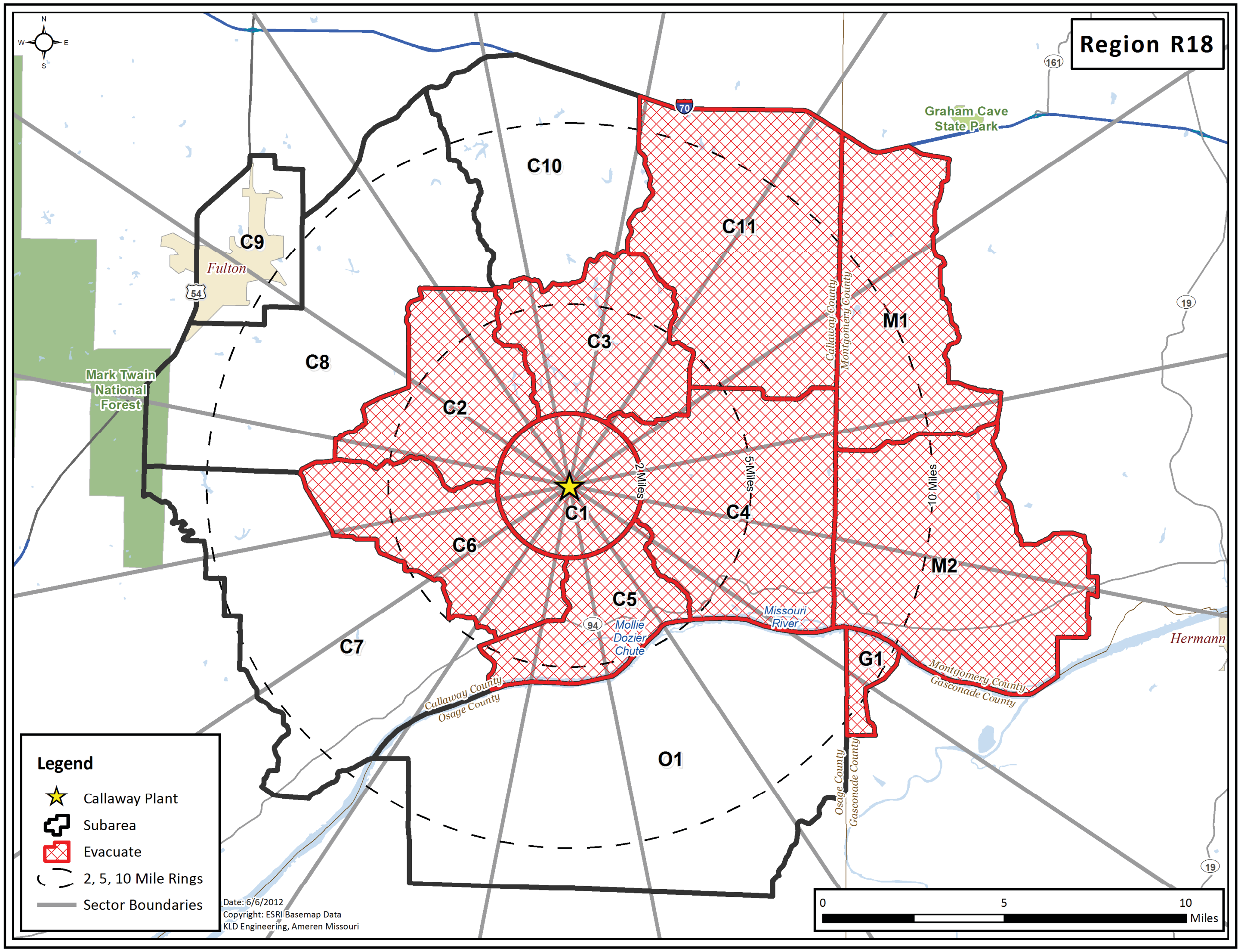


Figure H-18 Region R18

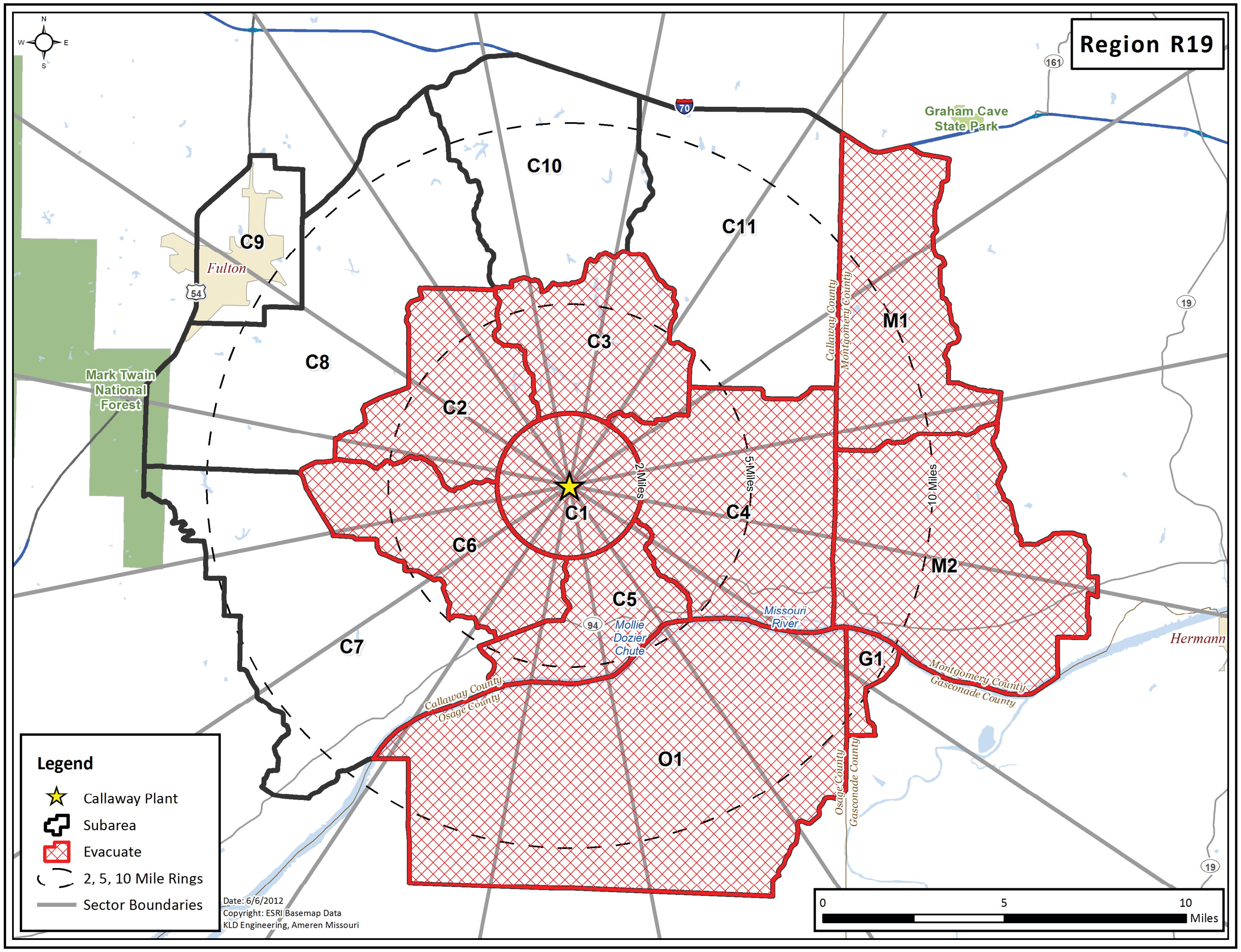


Figure H-19 Region R19

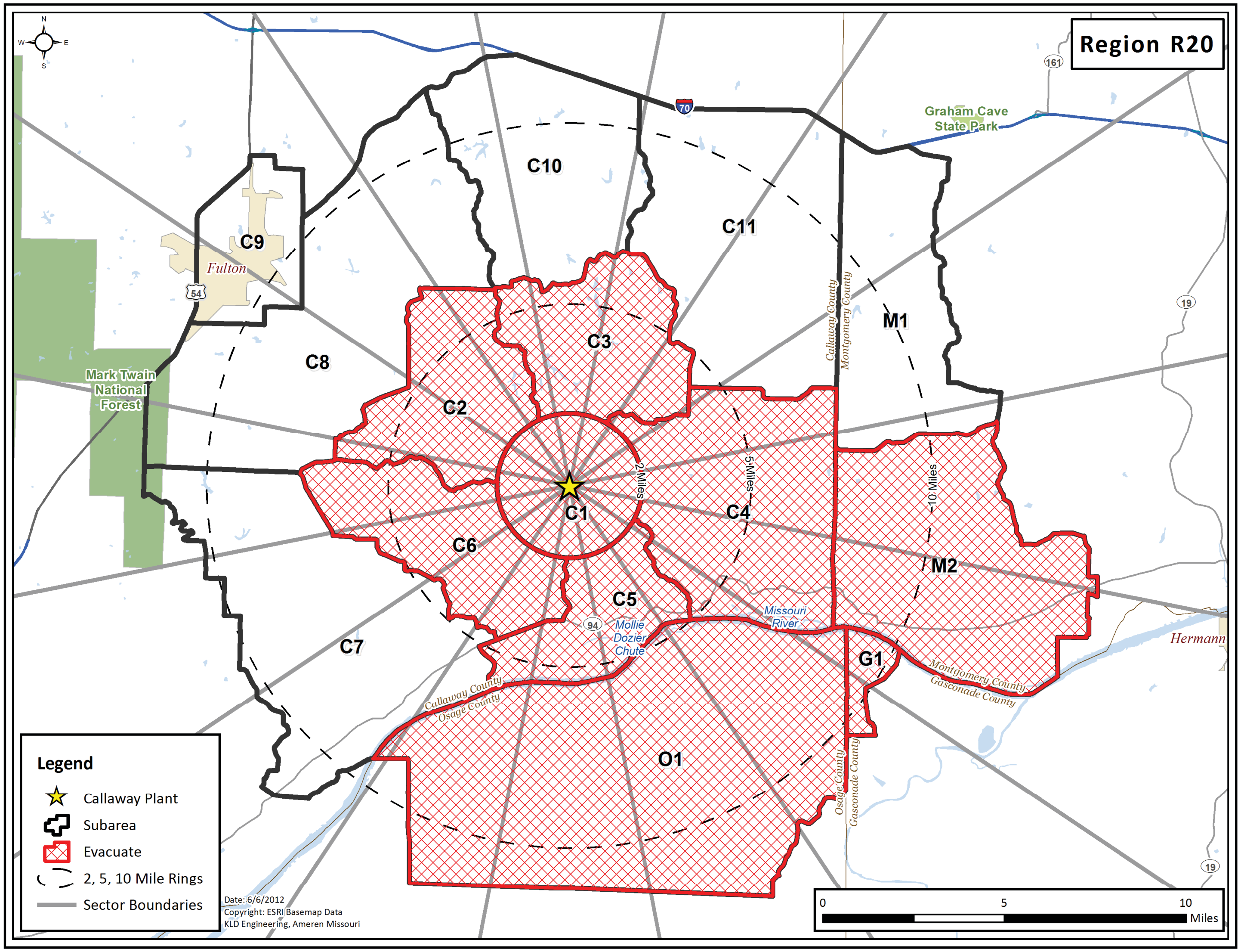


Figure H-20 Region R20

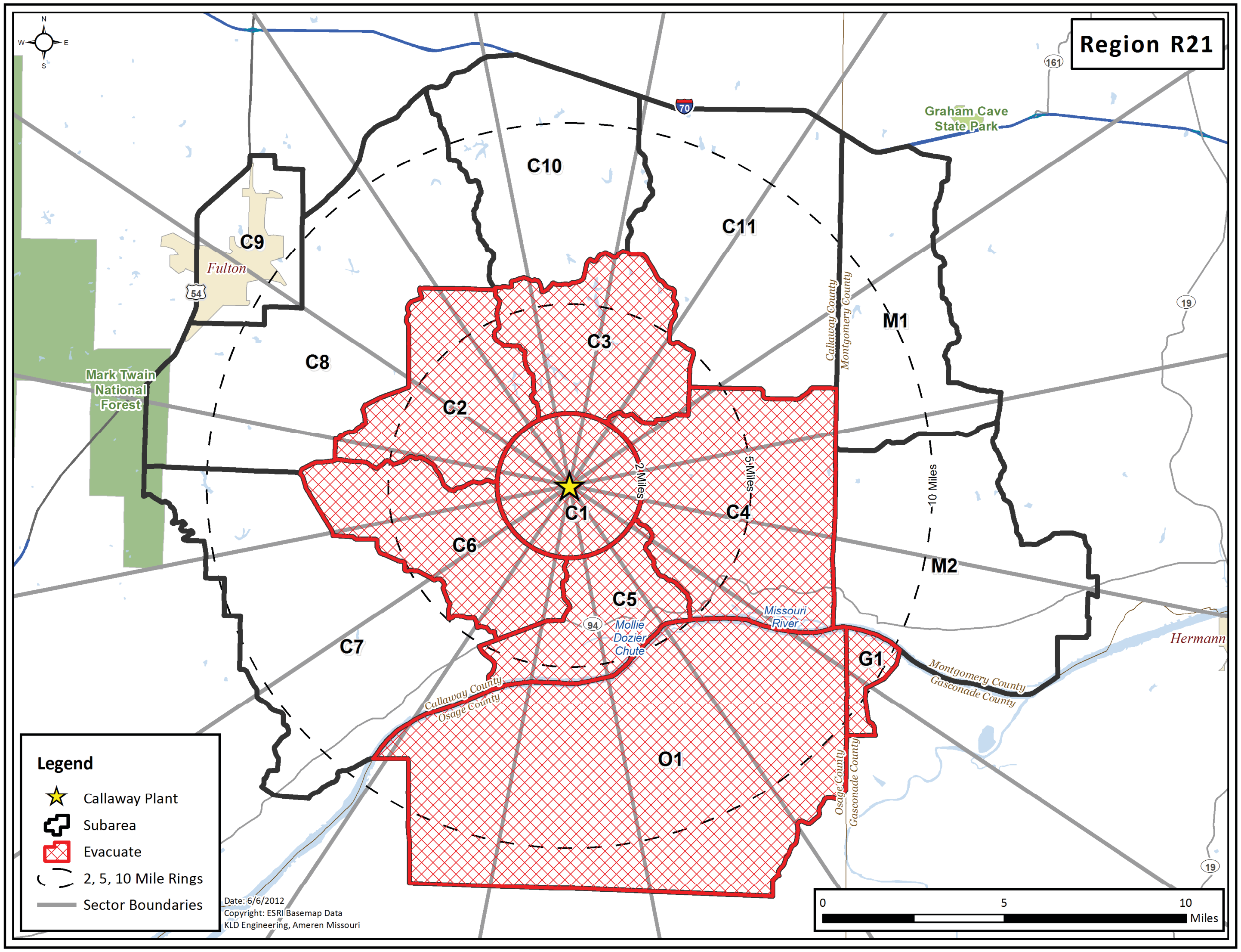


Figure H-21 Region R21

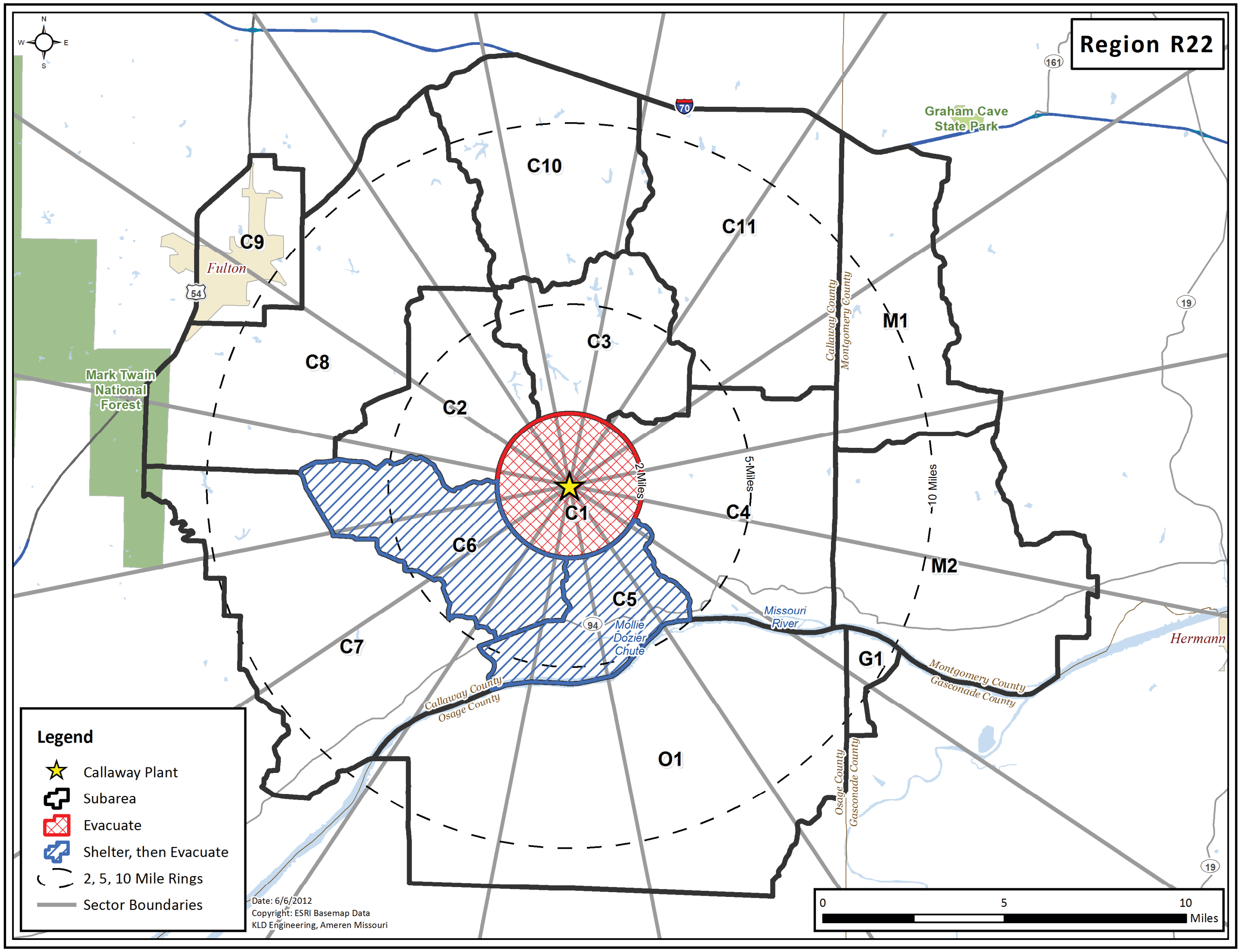


Figure H-22 Region R22

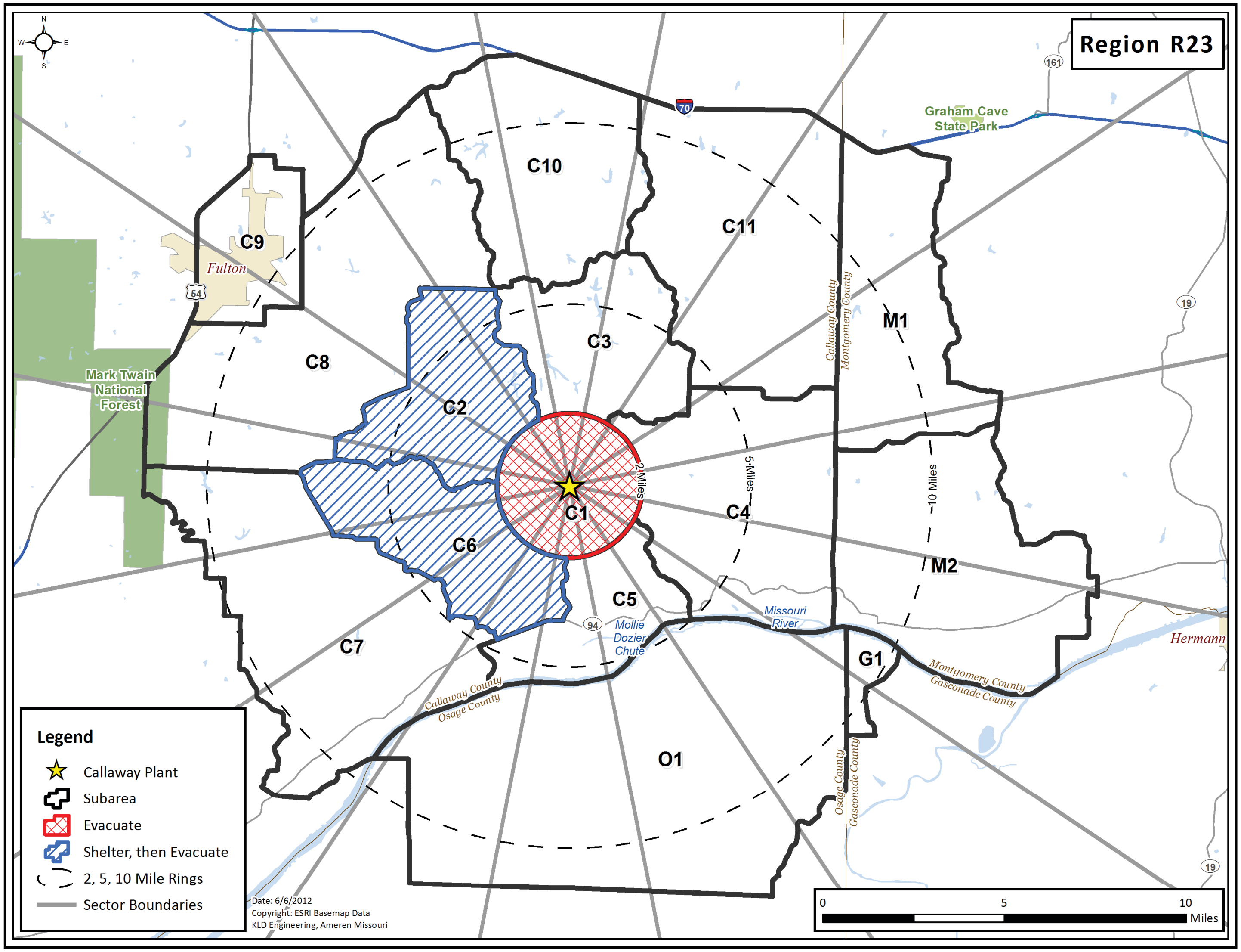


Figure H-23 Region R23

Enclosure
to ULNRC-05881

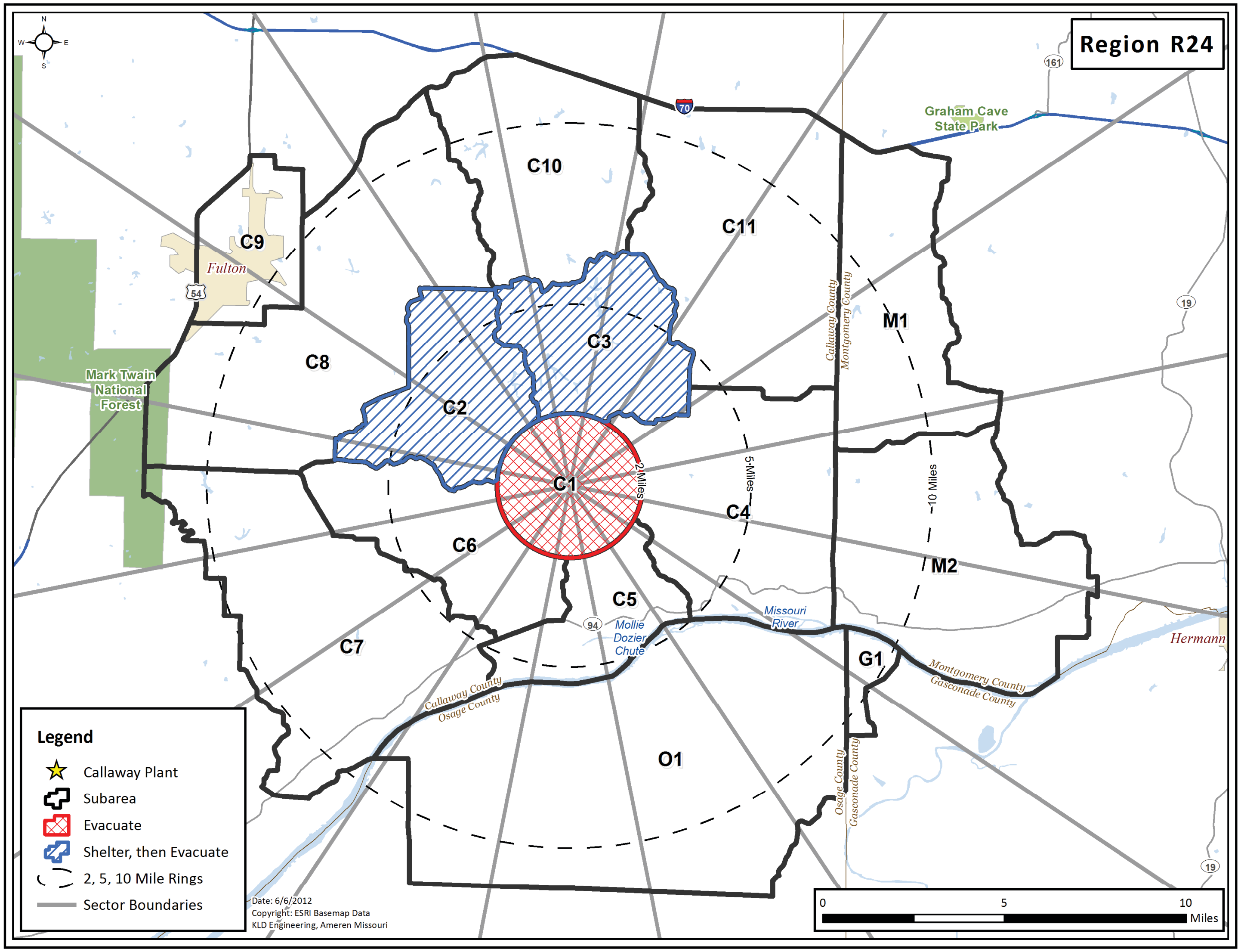


Figure H-24 Region R24

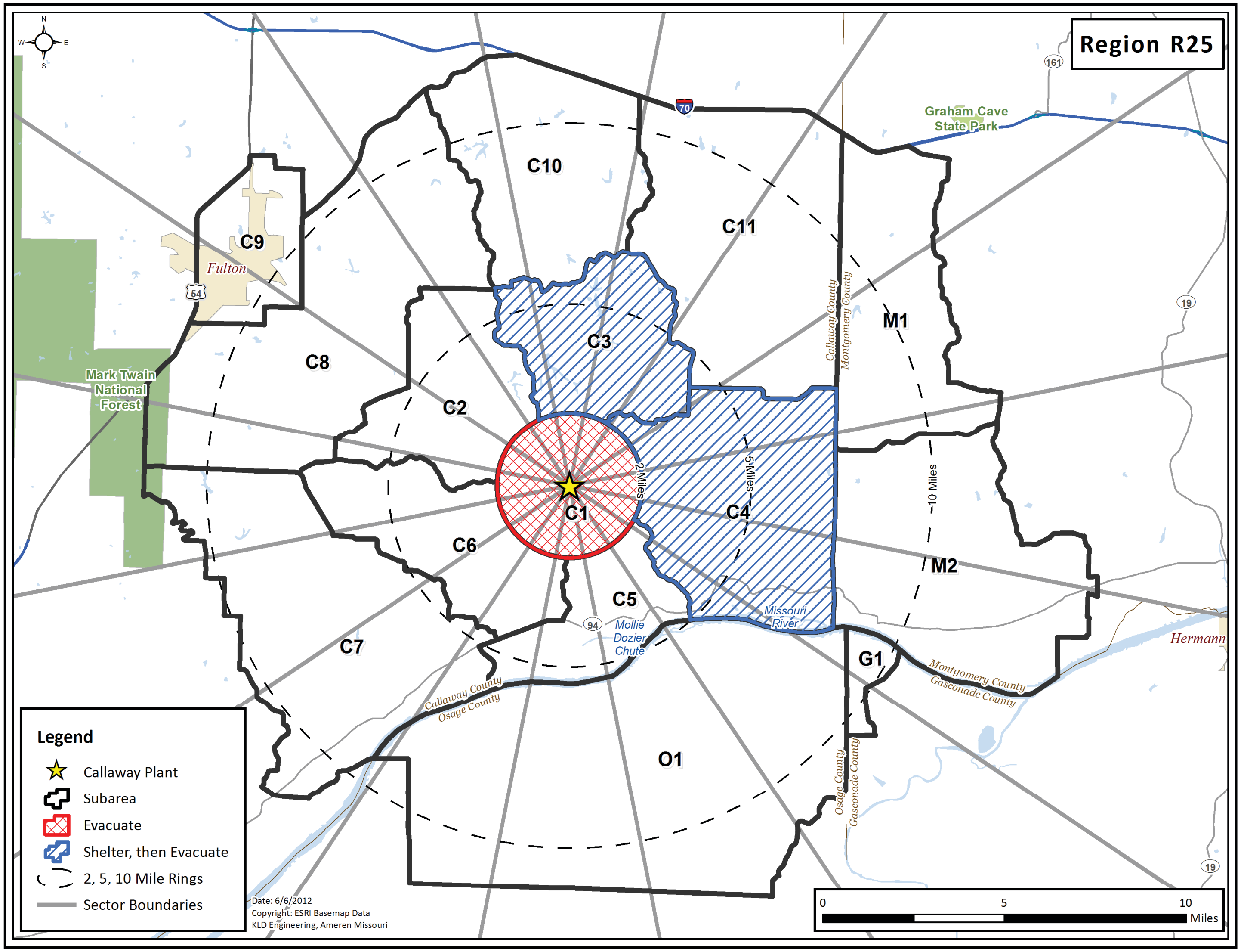


Figure H-25 Region R25

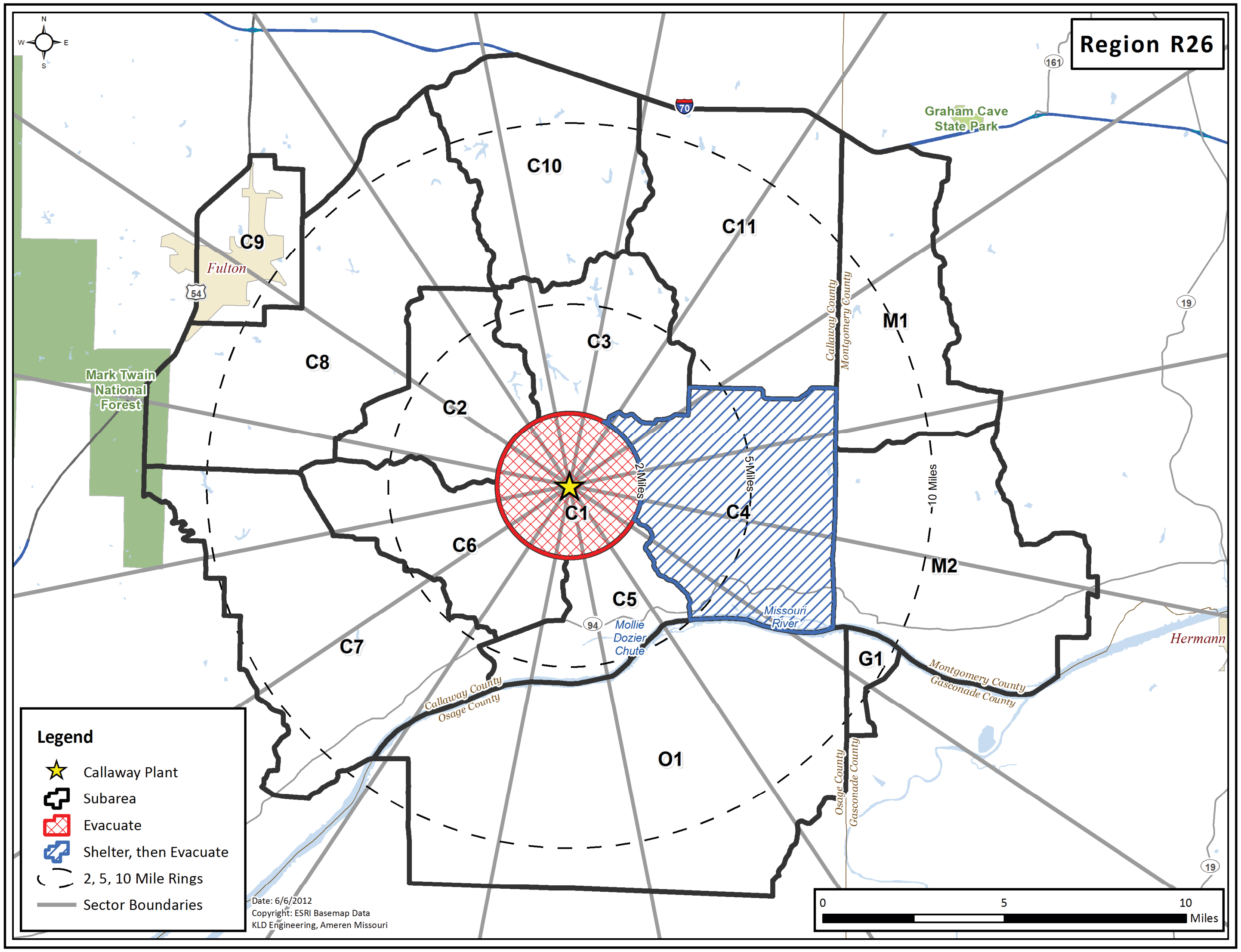


Figure H-26 Region R26

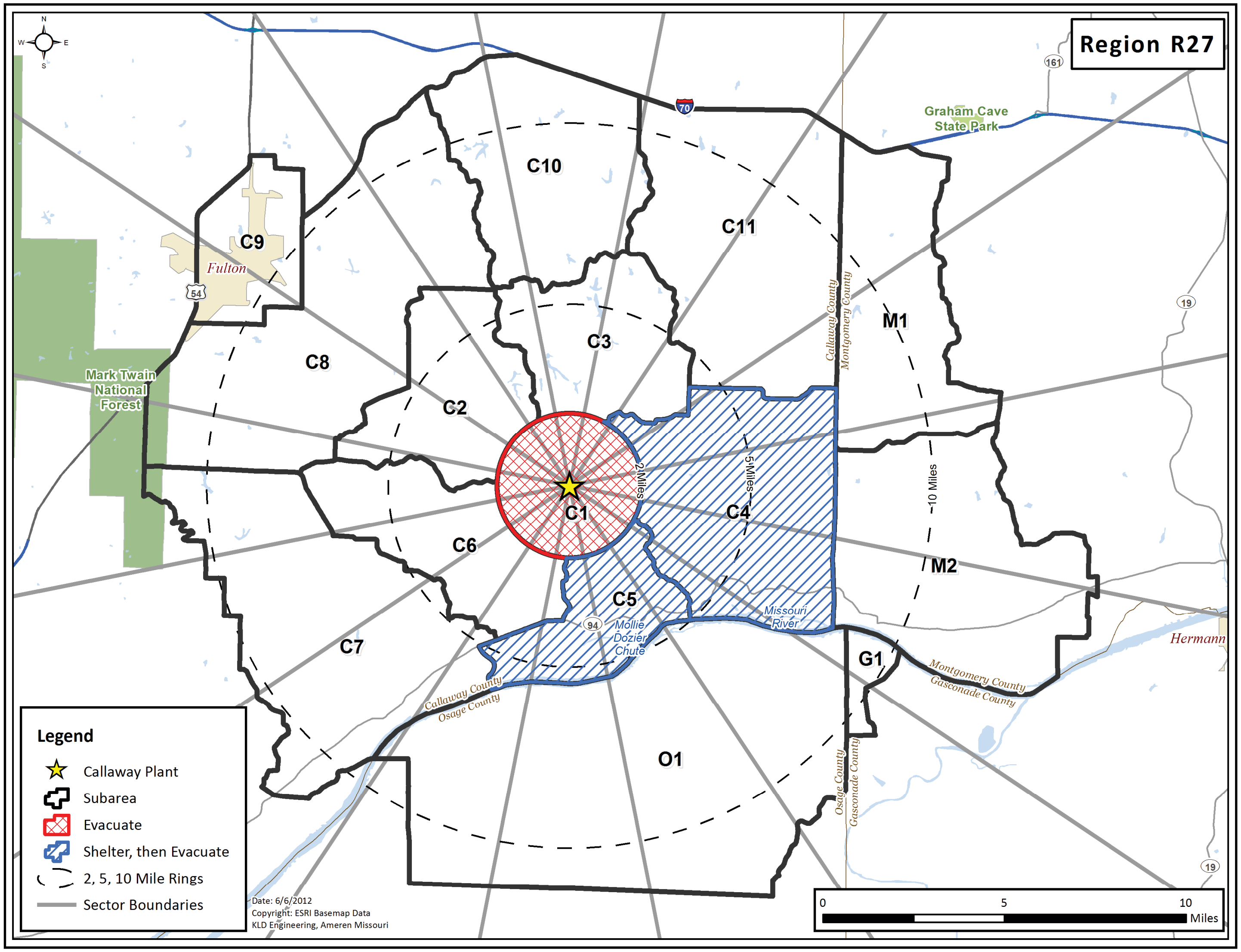


Figure H-27 Region R27

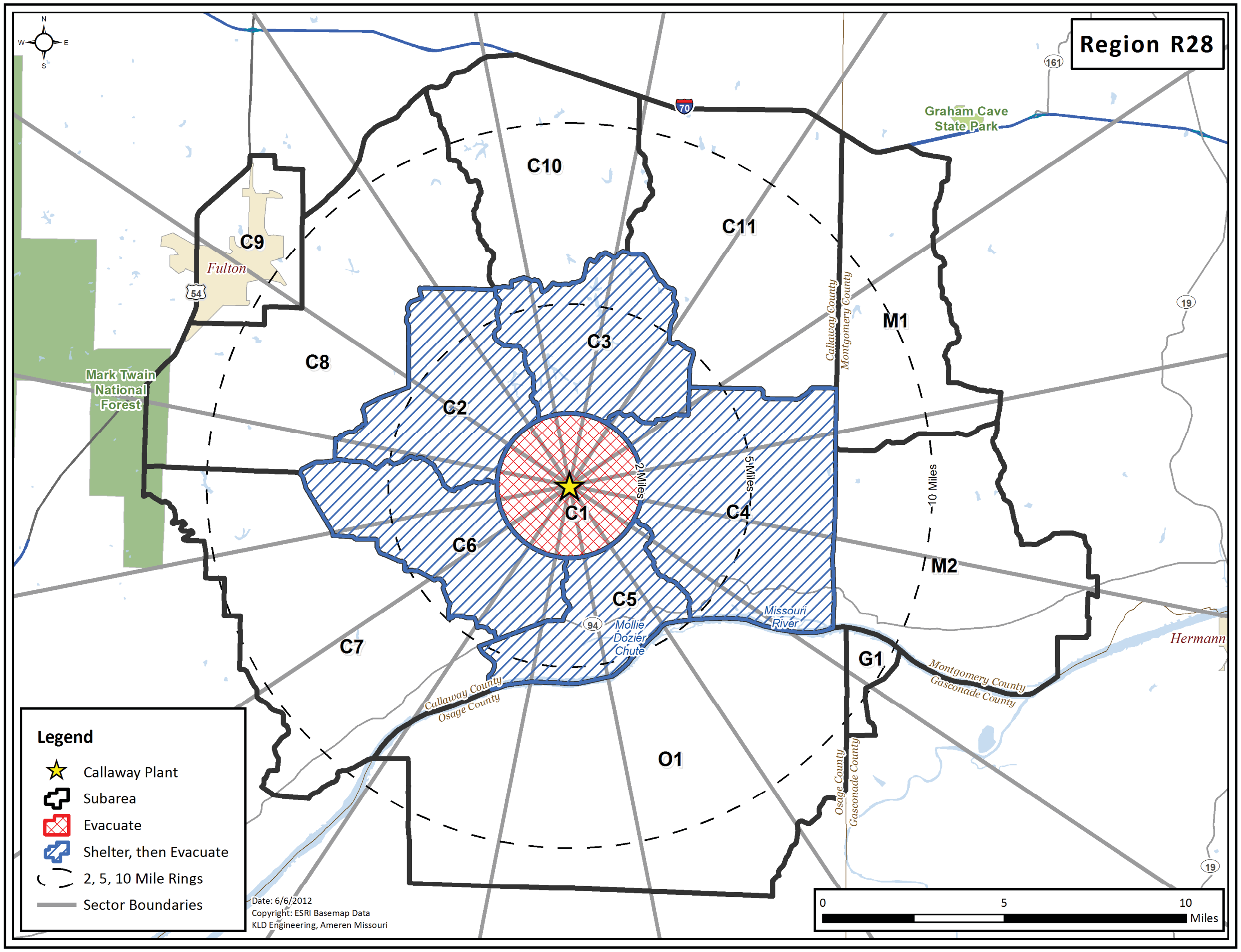


Figure H-28 Region R28

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 the volume and queues for the ten highest volume signalized intersections in the study area. Refer to Table K-2 and the figures in Appendix K for a map showing the geographic location of each intersection.

Table J-2 provides source (vehicle loading) and destination information for several roadway segments (links) in the analysis network. Refer to Table K-1 and the figures in Appendix K for a map showing the geographic location of each link.

Table J-3 provides network–wide statistics (average travel time, average speed and number of vehicles) for an evacuation of the entire EPZ (Region R03) for each scenario. As expected, Scenarios 8 and 11, which are snow scenarios, exhibit the slowest average speed and longest average travel times.

Table J-4 provides statistics (average speed and travel time) for the major evacuation routes – Interstate-70 and US-54 – for an evacuation of the entire EPZ (Region R03) under Scenario 1 conditions.

Table J-5 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 Table K-1 and the figures in Appendix K for a map showing the geographic location of each link.

Figure J-1 through Figure J-14 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-1 through Figure J-14, the curves are close together as a result of limited traffic congestion in the EPZ, which was discussed in detail in Section 7.3.

Table J-1. Characteristics of the Ten Highest Volume Signalized Intersections

Node	Location	Intersection Control	Approach (Up Node)	Total Volume (Veh)	Max. Turn Queue (Veh)
31	US 54 & I-70 EB on-ramp	Actuated	30	1,436	0
			32	5,496	17
			5	0	0
			TOTAL	6,932	-
32	US 54 & Gold Rd	Actuated	31	1,438	0
			33	5,489	51
			803	0	0
			804	4	0
			TOTAL	6,931	-
30	US 54 & I-70 EB off-ramp	Actuated	31	4,449	30
			28	1,510	0
			29	0	0
			TOTAL	5,959	-
399	US 54 BUS & Industrial Dr	Actuated	809	2,062	90
			806	491	11
			TOTAL	2,553	-
809	US 54 BUS & Douglas Blvd	Actuated	386	1,815	6
			808	0	0
			807	95	0
			399	9	0
			TOTAL	1,919	-
386	US 54 BUS & Missouri Z	Actuated	385	424	0
			776	1,220	0
			810	136	0
			809	32	0
			TOTAL	1,812	-
396	Westminster Ave & W 4th St & Martin Luther King Jr Blvd	Actuated	395	1,043	0
			985	634	0
			818	106	0
			TOTAL	1,783	-
776	US 54 BUS & E 10th St	Actuated	865	989	0
			386	55	0
			779	74	0
			TOTAL	1,118	-
387	US 54 BUS & Buff St & E 8th St	Actuated	865	30	0
			388	14	0
			811	626	0
			815	377	0
			TOTAL	1,047	-
394	US 54 BUS & 4th St	Actuated	813	361	0
			966	408	0
			816	9	0
			TOTAL	778	-

Table J-2. Sample Simulation Model Input

Link Number	Vehicles Entering Network on this Link	Directional Preference	Destination Nodes	Destination Capacity
74	0	NW	8073	4500
328	9	E	8300	1698
			8725	1698
428	3	W	8005	4500
			8028	4530
			8073	4500
495	396	W	8005	4500
			8775	1698
			8073	4500
595	14	SW	8488	1698
689	14	S	8589	1698
817	326	NW	8028	4530
			8005	4500
			8775	1698
963	20	NW	8775	1698
			8028	4530
			8005	4500
851	3	W	8440	1698

Table J-3. Selected Model Outputs for the Evacuation of the Entire EPZ (Region R03)

Scenario	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Network-Wide Average Travel Time (Min/Veh-Mi)	1	1.12	1.08	1.22	1.08	0.99	1.17	1.24	1.01	1.14	1.58	1.08	1.19	1.12
Network-Wide Average Speed (mph)	59.86	53.36	55.79	49.31	55.48	60.7	51.26	48.56	59.48	52.79	37.86	55.68	50.56	53.55
Total Vehicles Exiting Network	23897	24059	23894	24067	16508	23832	23991	24118	22973	23136	23554	16464	27467	23897

Table J-4. Average Speed (mph) and Travel Time (min) for Major Evacuation Routes (Region R03, Scenario 1)

		Elapsed Time (hours)							
		1		2		3		4	
Route	Length (miles)	Speed (mph)	Travel Time (min)	Speed	Travel Time	Speed	Travel Time	Speed	Travel Time
I-70 EB	13.25	71.7	11.1	73.5	10.8	70.3	11.3	75	10.6
I-70 WB	13.25	75	10.6	75	10.6	72	11	75	10.6
US-54 WB	7.99	73.3	6.5	73.3	6.5	68	7.1	74.1	6.5
US-54 EB	7.99	73.5	6.5	73.8	6.5	74.3	6.5	74.4	6.4

Table J-5. Simulation Model Outputs at Network Exit Links for Region R03, Scenario 1

EPZ Exit Link	Elapsed Time (hours)				
	1	2	3	4	5
	Vehicles Discharged During the Indicated Time Interval				
	Cumulative Percent of Vehicles Discharged During the Indicated Time Interval				
1	454	1038	1148	1161	1161
	5.01%	4.97%	4.83%	4.84%	4.84%
4	2486	5285	6122	6161	6163
	27.42%	25.33%	25.75%	25.70%	25.70%
58	889	1897	2264	2297	2298
	9.81%	9.09%	9.52%	9.58%	9.58%
133	986	2252	2584	2603	2604
	10.88%	10.79%	10.87%	10.86%	10.86%
192	71	192	219	222	222
	0.78%	0.92%	0.92%	0.93%	0.93%
279	652	1600	1797	1830	1832
	7.19%	7.67%	7.56%	7.63%	7.64%
358	208	495	559	563	563
	2.29%	2.37%	2.35%	2.35%	2.35%
522	550	1298	1472	1500	1500
	6.07%	6.22%	6.19%	6.26%	6.25%
575	7	34	40	40	40
	0.08%	0.16%	0.17%	0.17%	0.17%
675	25	88	105	106	106
	0.28%	0.42%	0.44%	0.44%	0.44%
677	51	129	146	147	147
	0.56%	0.62%	0.61%	0.61%	0.61%
678	79	227	263	265	265
	0.87%	1.09%	1.11%	1.11%	1.10%
709	20	65	75	76	76
	0.22%	0.31%	0.32%	0.32%	0.32%
795	24	91	109	111	111
	0.26%	0.44%	0.46%	0.46%	0.46%
858	1844	4585	5144	5146	5146
	20.34%	21.97%	21.64%	21.46%	21.46%
964	592	1238	1328	1341	1342
	6.53%	5.93%	5.59%	5.59%	5.60%
968	119	310	351	356	356
	1.31%	1.49%	1.48%	1.48%	1.48%
973	1	17	20	21	21
	0.01%	0.08%	0.08%	0.09%	0.09%
977	8	25	29	29	29
	0.09%	0.12%	0.12%	0.12%	0.12%

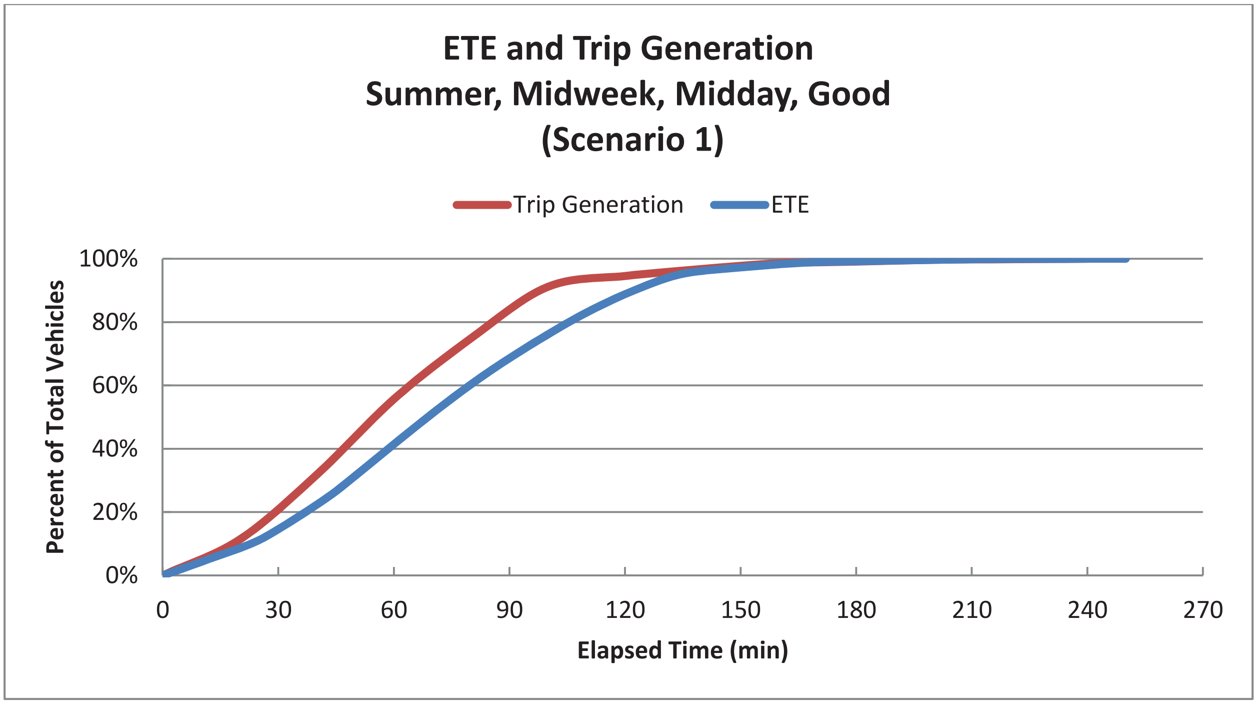


Figure J-1. ETE and Trip Generation: Summer, Midweek, Midday, Good Weather (Scenario 1)

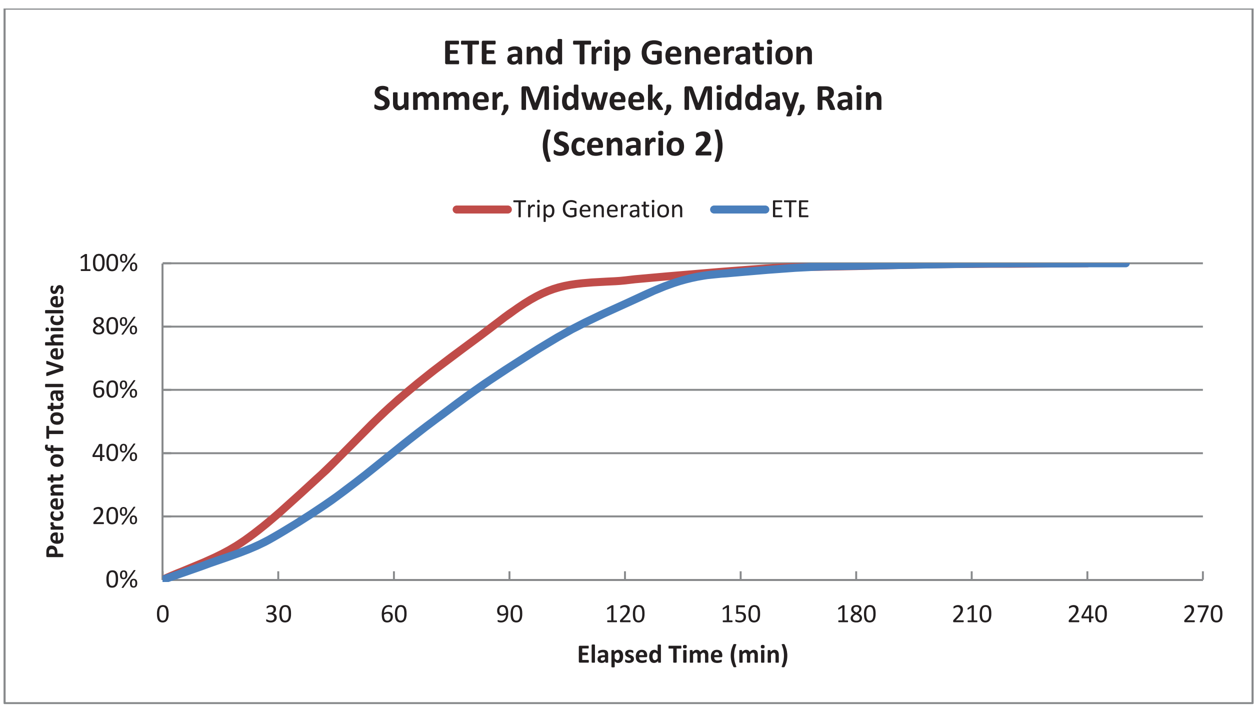


Figure J-2. ETE and Trip Generation: Summer, Midweek, Midday, Rain (Scenario 2)

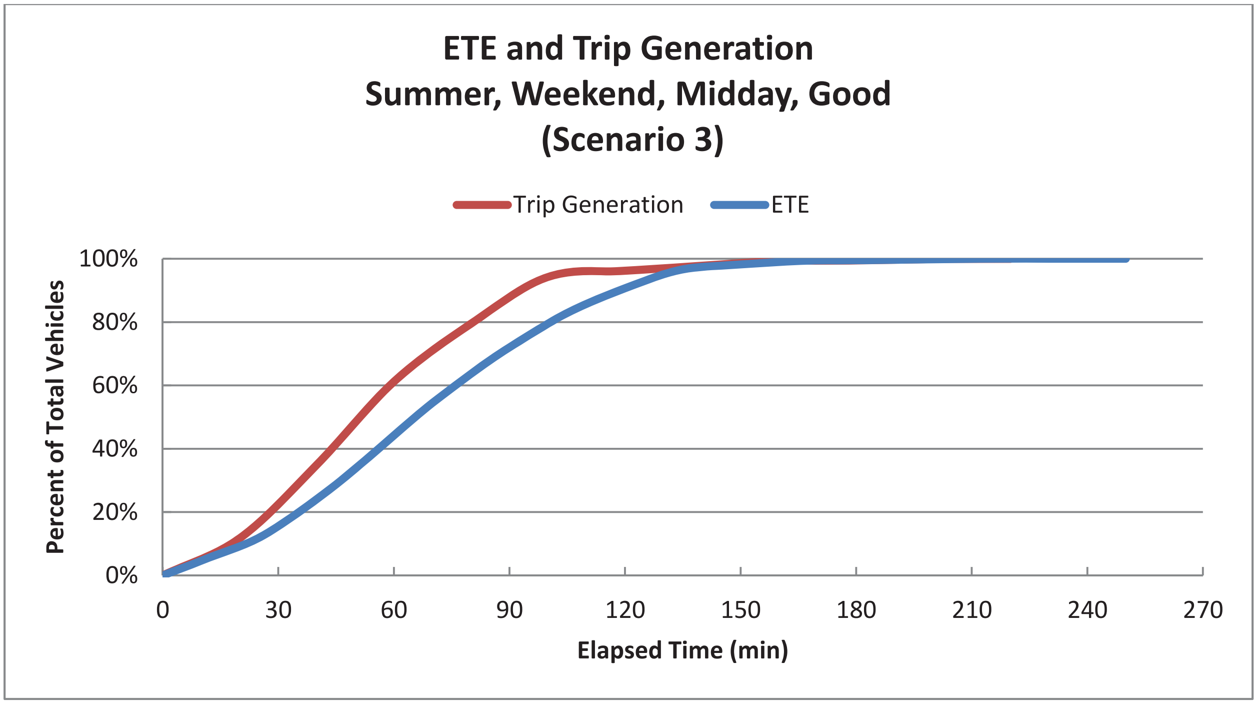


Figure J-3. ETE and Trip Generation: Summer, Weekend, Midday, Good Weather (Scenario 3)

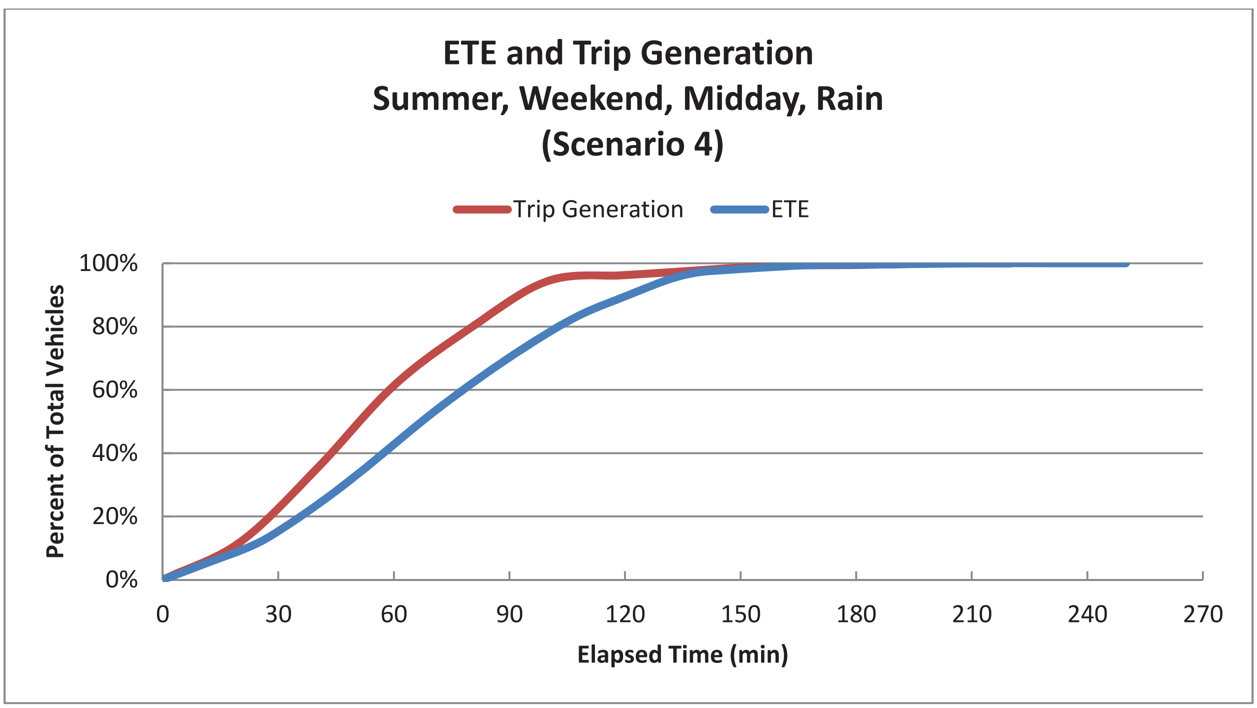


Figure J-4. ETE and Trip Generation: Summer, Weekend, Midday, Rain (Scenario 4)

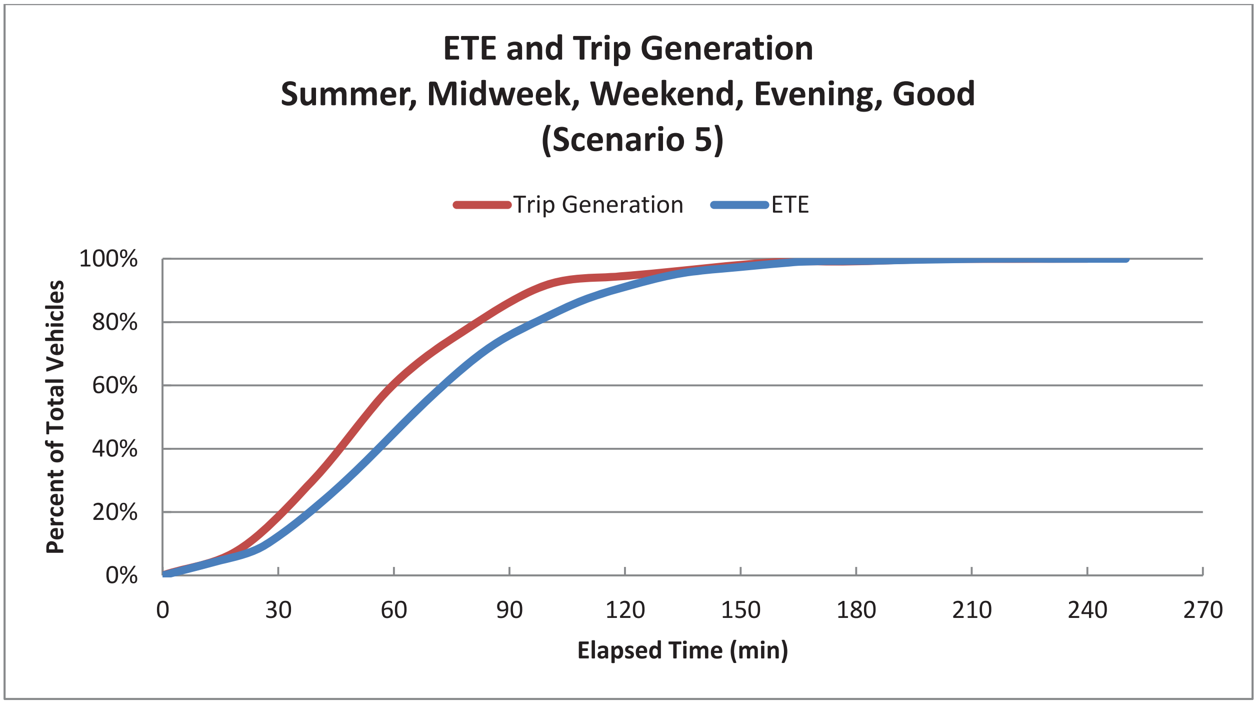


Figure J-5. ETE and Trip Generation: Summer, Midweek, Weekend, Evening, Good Weather (Scenario 5)

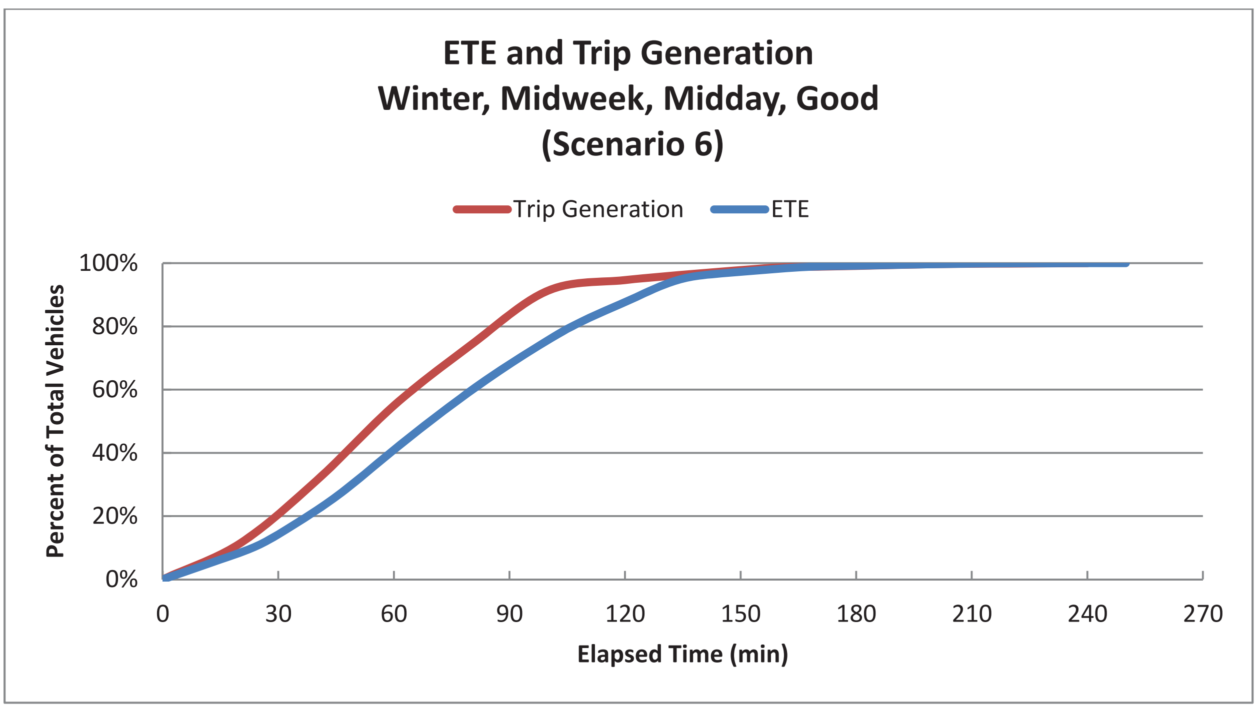


Figure J-6. ETE and Trip Generation: Winter, Midweek, Midday, Good Weather (Scenario 6)

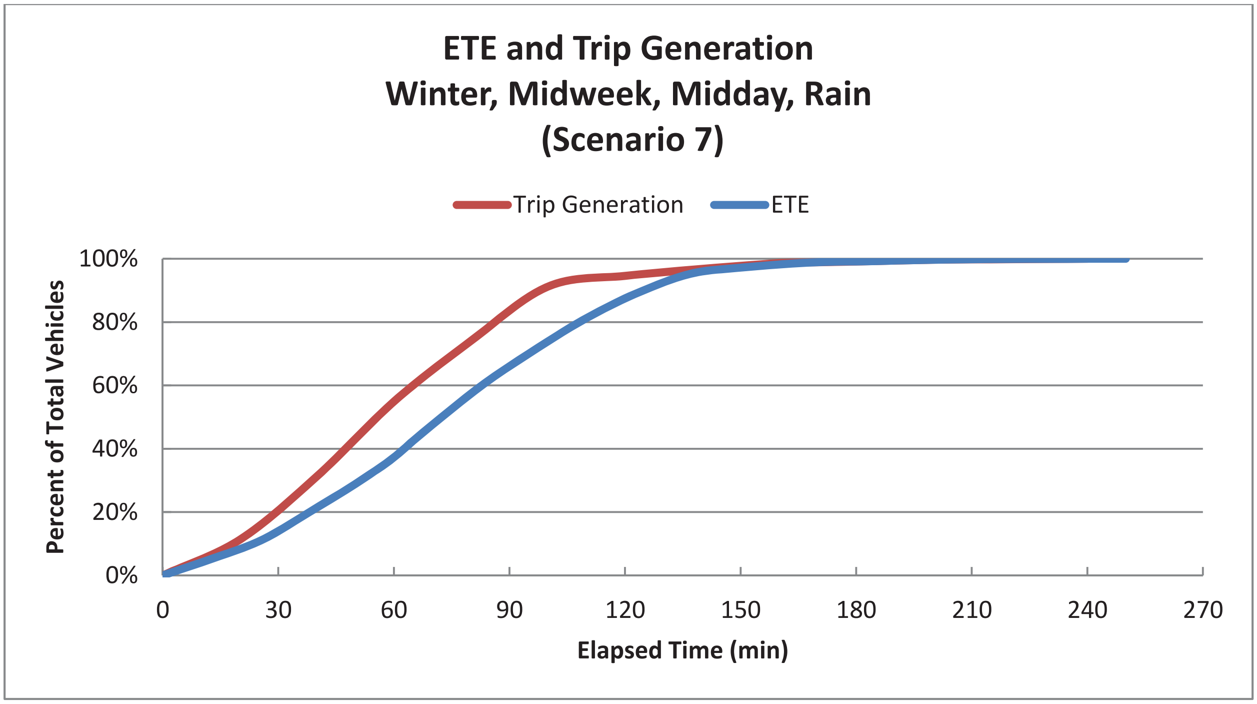


Figure J-7. ETE and Trip Generation: Winter, Midweek, Midday, Rain (Scenario 7)

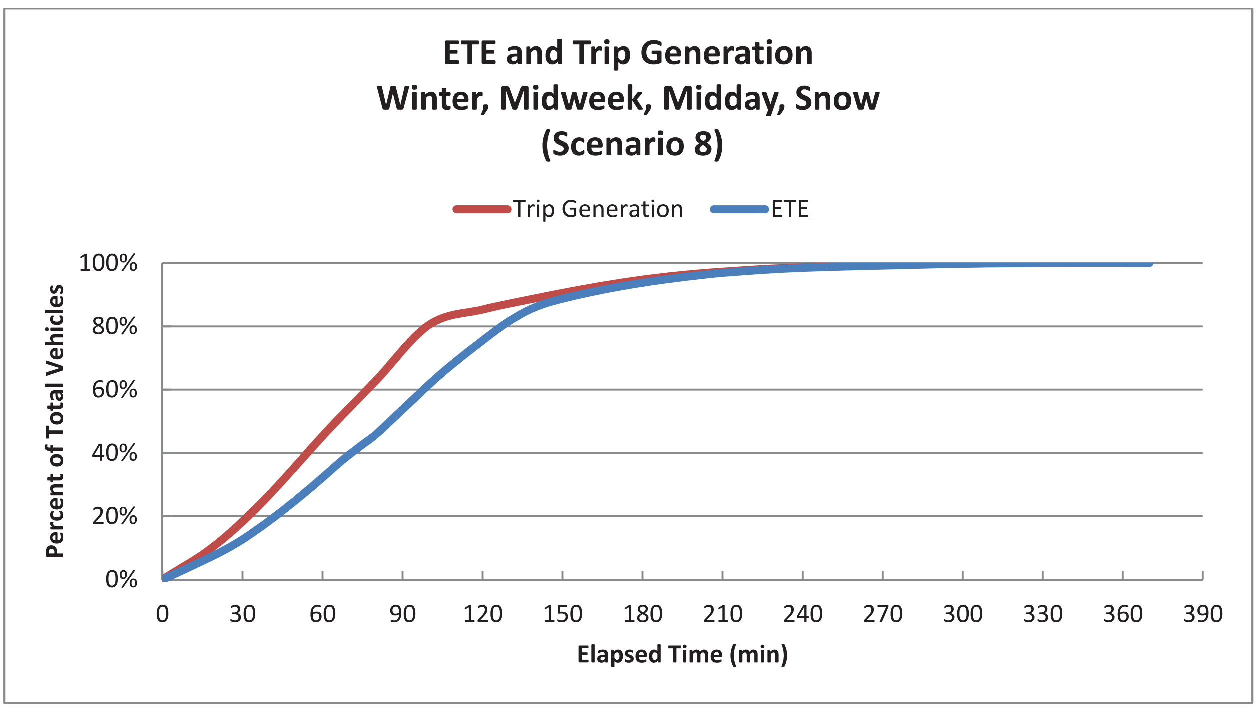


Figure J-8. ETE and Trip Generation: Winter, Midweek, Midday, Snow (Scenario 8)

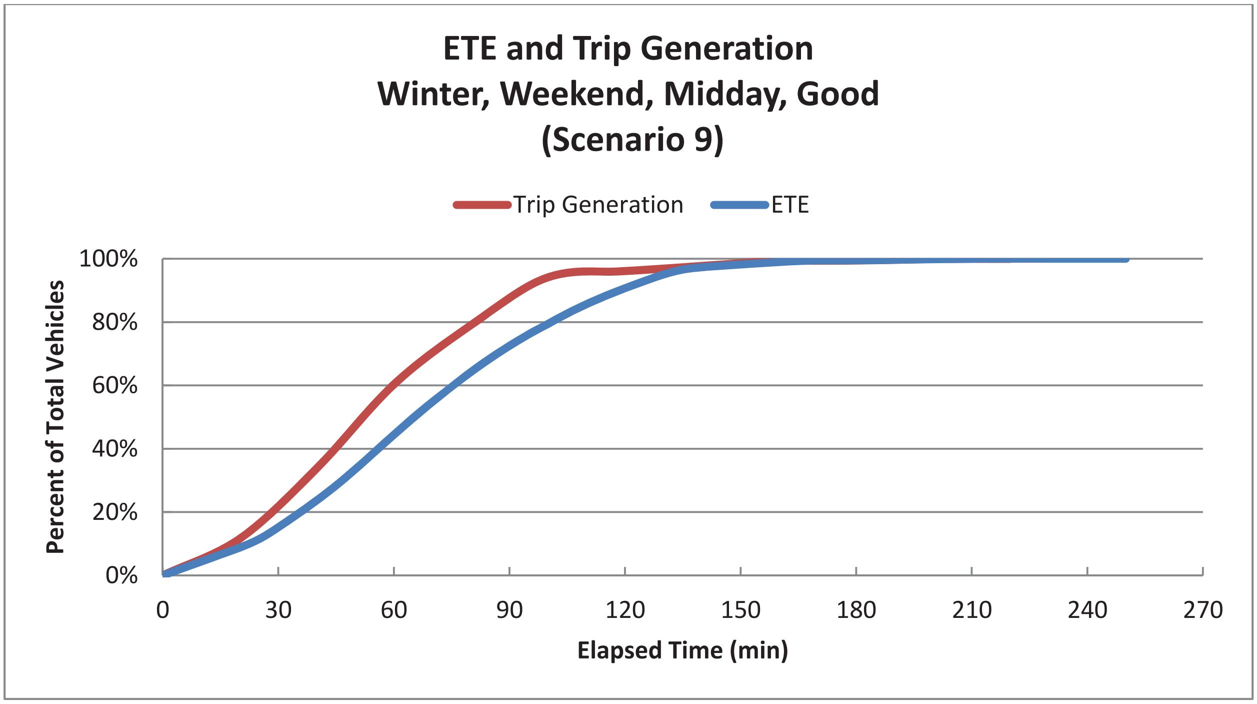


Figure J-9. ETE and Trip Generation: Winter, Weekend, Midday, Good Weather (Scenario 9)

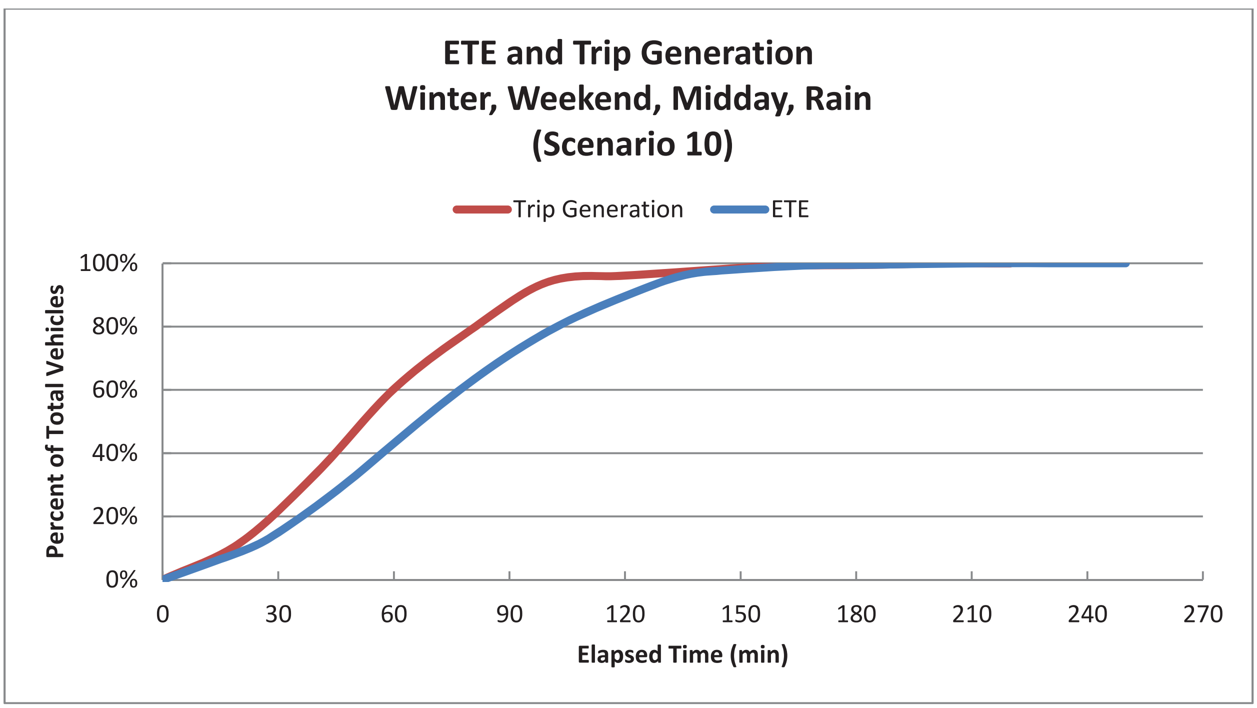


Figure J-10. ETE and Trip Generation: Winter, Weekend, Midday, Rain (Scenario 10)

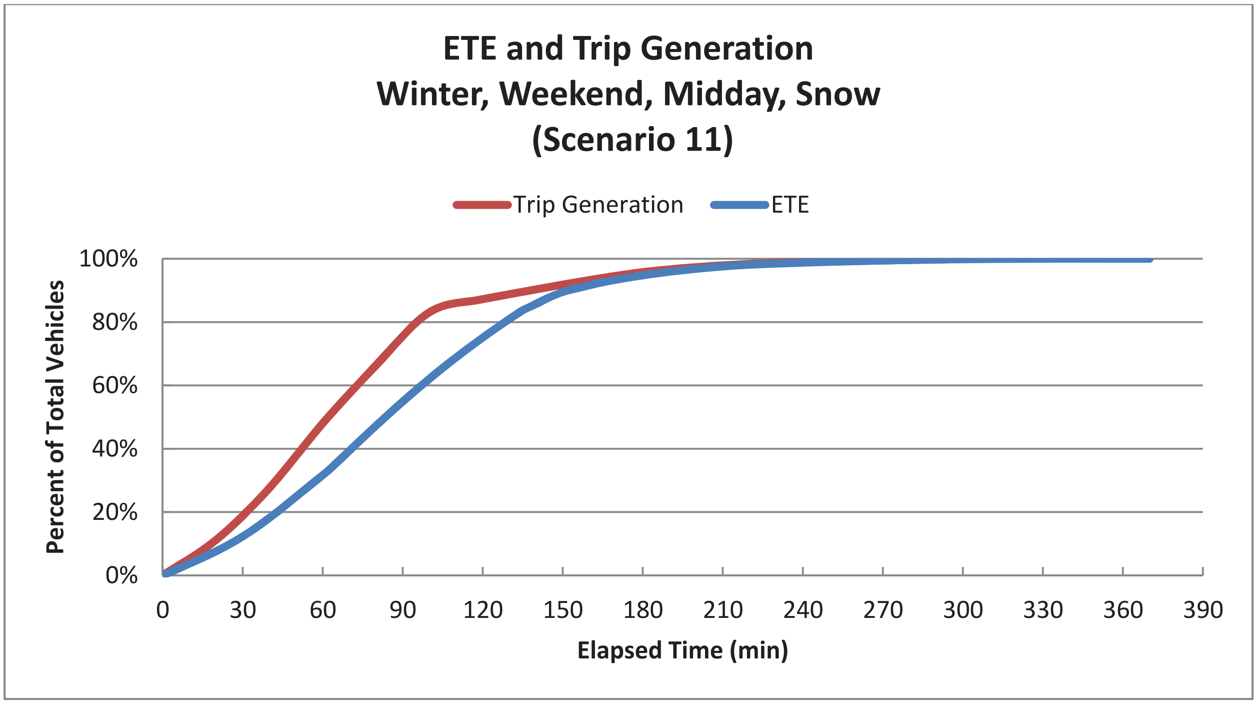


Figure J-11. ETE and Trip Generation: Winter, Weekend, Midday, Snow (Scenario 11)

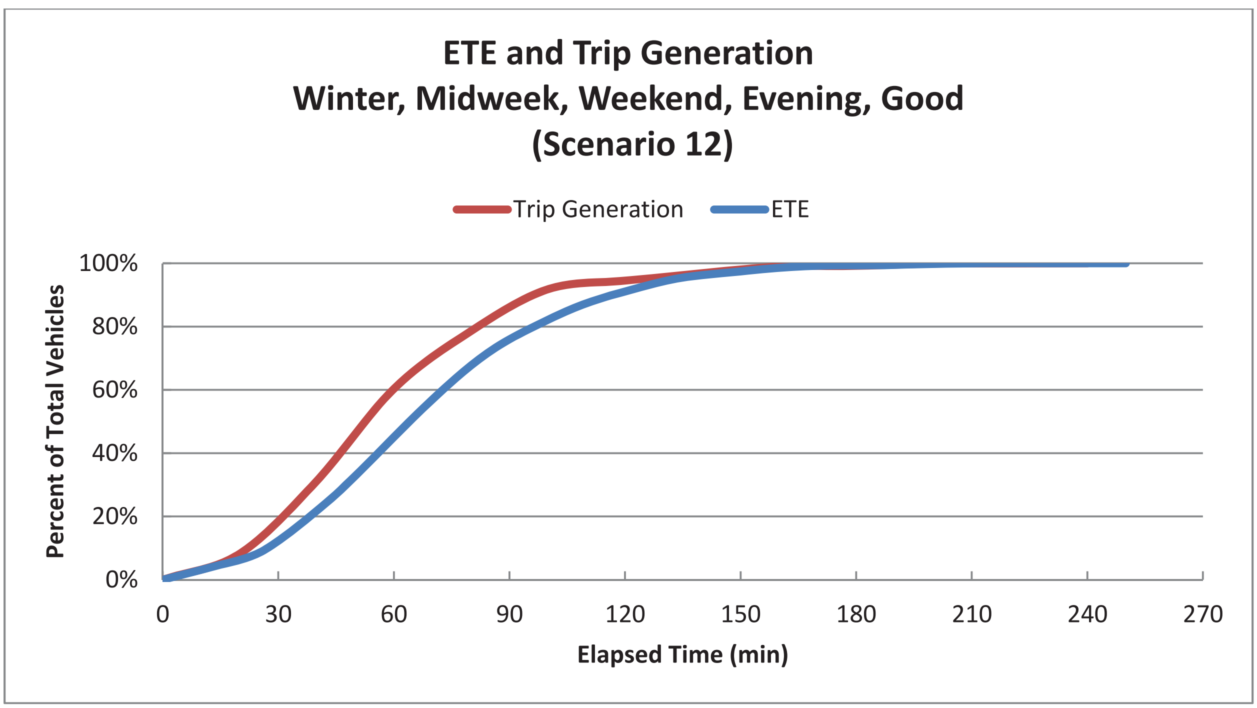


Figure J-12. ETE and Trip Generation: Winter, Midweek, Weekend, Evening, Good Weather (Scenario 12)

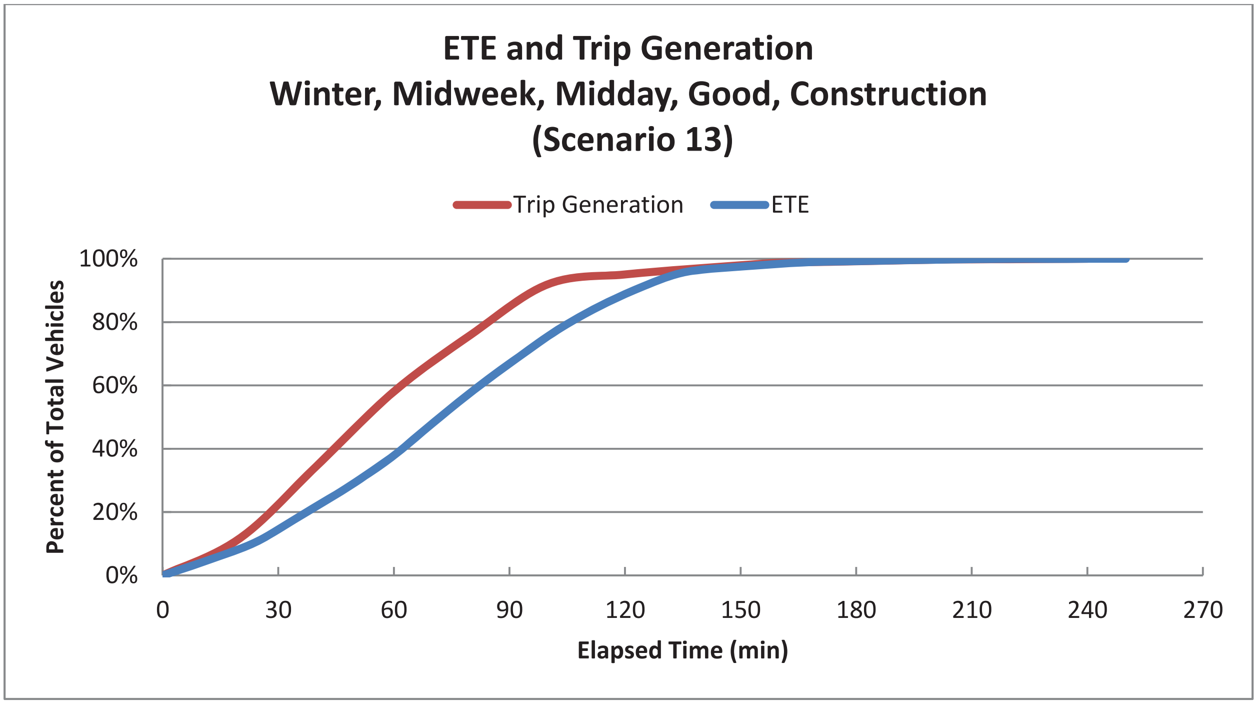


Figure J-13. ETE and Trip Generation: Summer, Weekend, Evening, Good Weather, Special Event (Scenario 13)

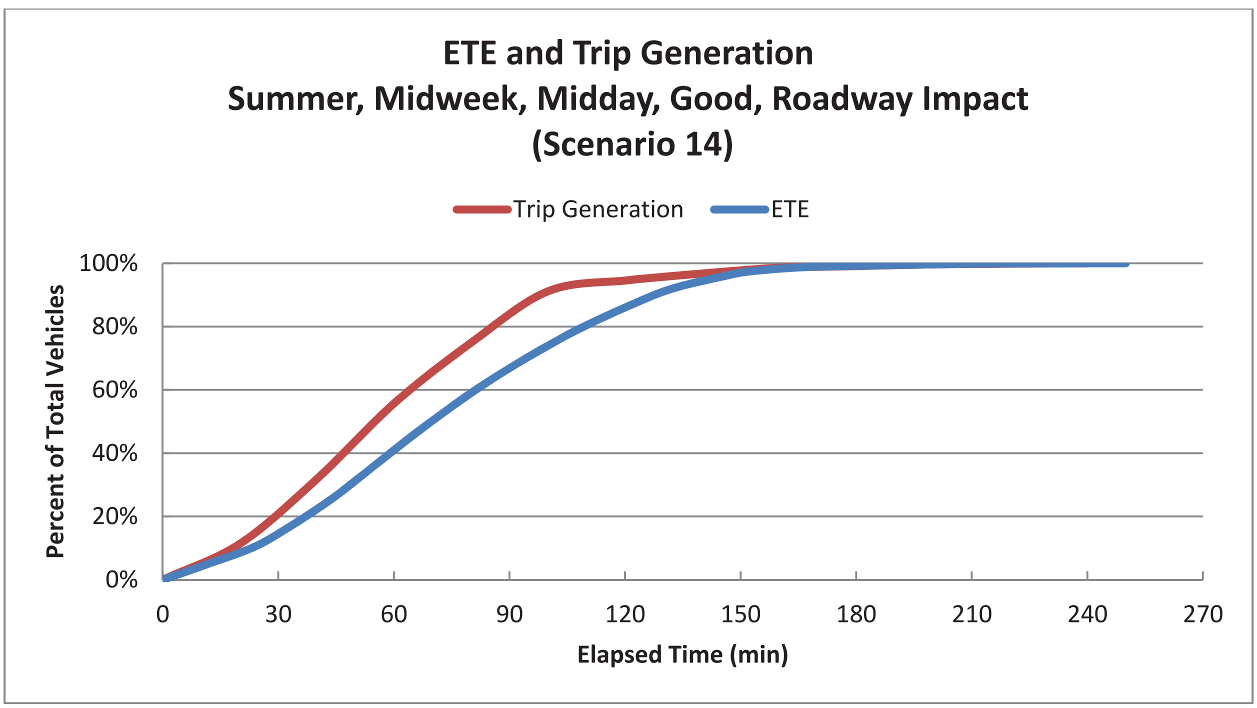


Figure J-14. ETE and Trip Generation: Summer, Midweek, Midday, Good Weather, Roadway Impact (Scenario 14)

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 41 more detailed figures (Figure K-2 through Figure K-42) which show each of the links and nodes in the network.

The analysis network was calibrated using the observations made during the field survey conducted in July, 2011. Table K-1 lists the characteristics of each roadway section modeled in the ETE analysis. Each link is identified by its road name and the upstream and downstream node numbers. The geographic location of each link can be observed by referencing the grid map number provided in Table K-1. The roadway type identified in Table K-1 is 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 roadways: single lane in each direction, local roads with low free flow speeds

The term, "No. of Lanes" in Table K-1 identifies the number of lanes that extend throughout the length of the link. Many links have additional lanes on the immediate approach to an intersection (turn pockets); these have been recorded and entered into the input stream for the DYNEV II System.

As discussed in Section 1.3, lane width and shoulder width were not physically measured during the road survey. Rather, estimates of these measures were based on visual observations and recorded images.

Table K-2 identifies each node in the network that is controlled and the type of control (stop sign, yield sign, pre-timed signal, actuated signal, traffic control point) at that node. Uncontrolled nodes are not included in Table K-2.

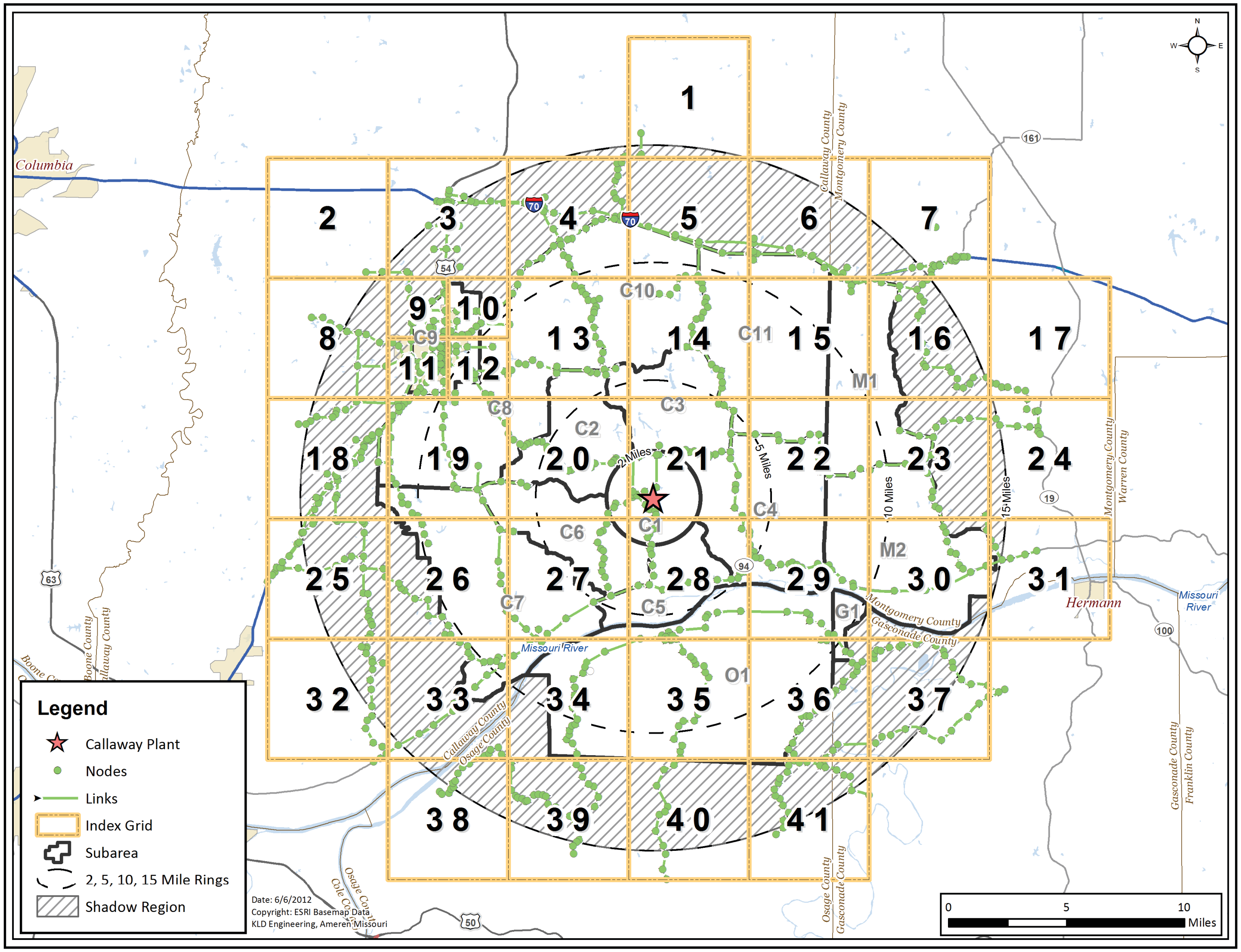


Figure K-1 Callaway Link-Node Analysis Network

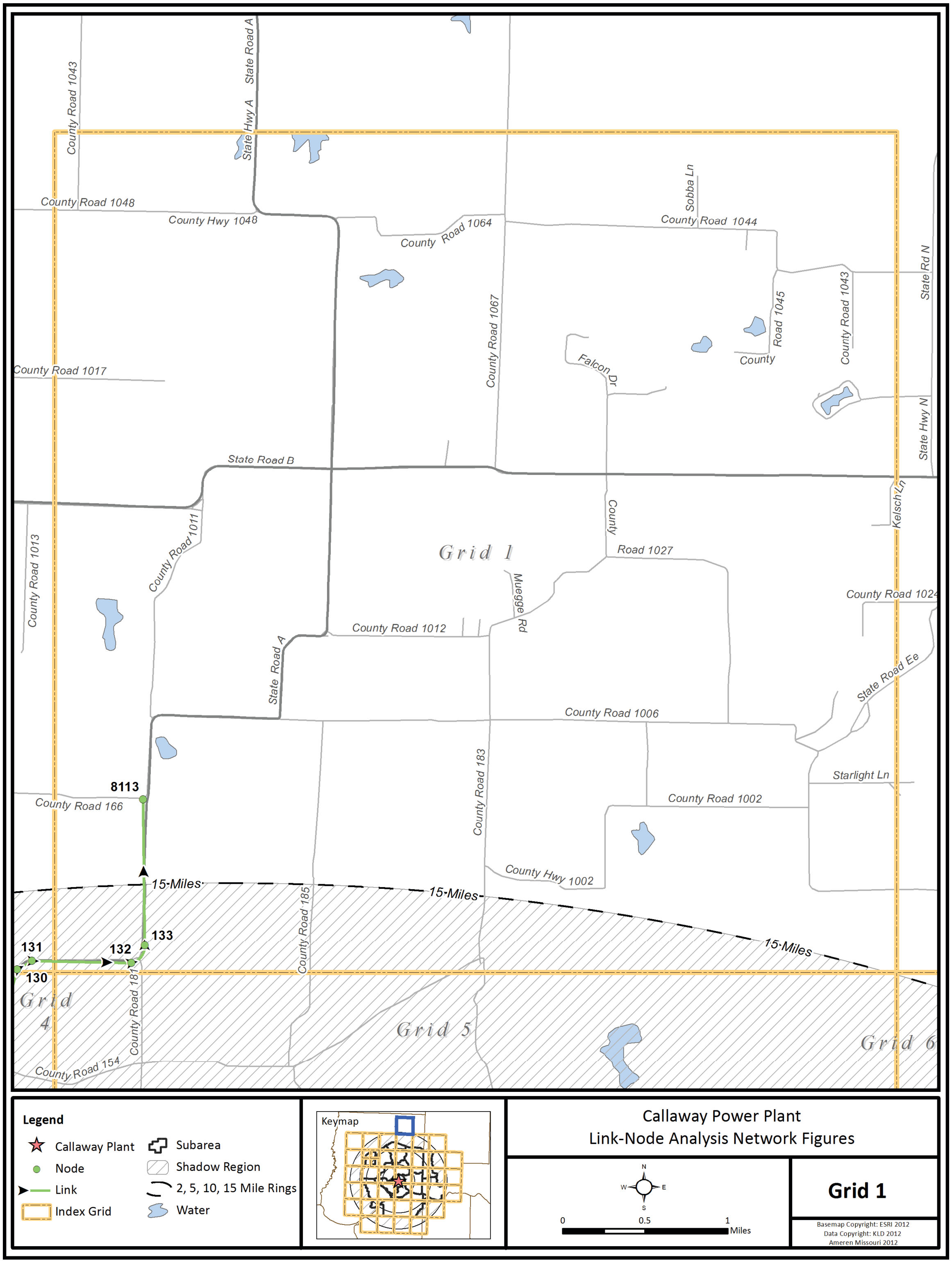


Figure K-2 Link-Node Analysis Network – Grid 1

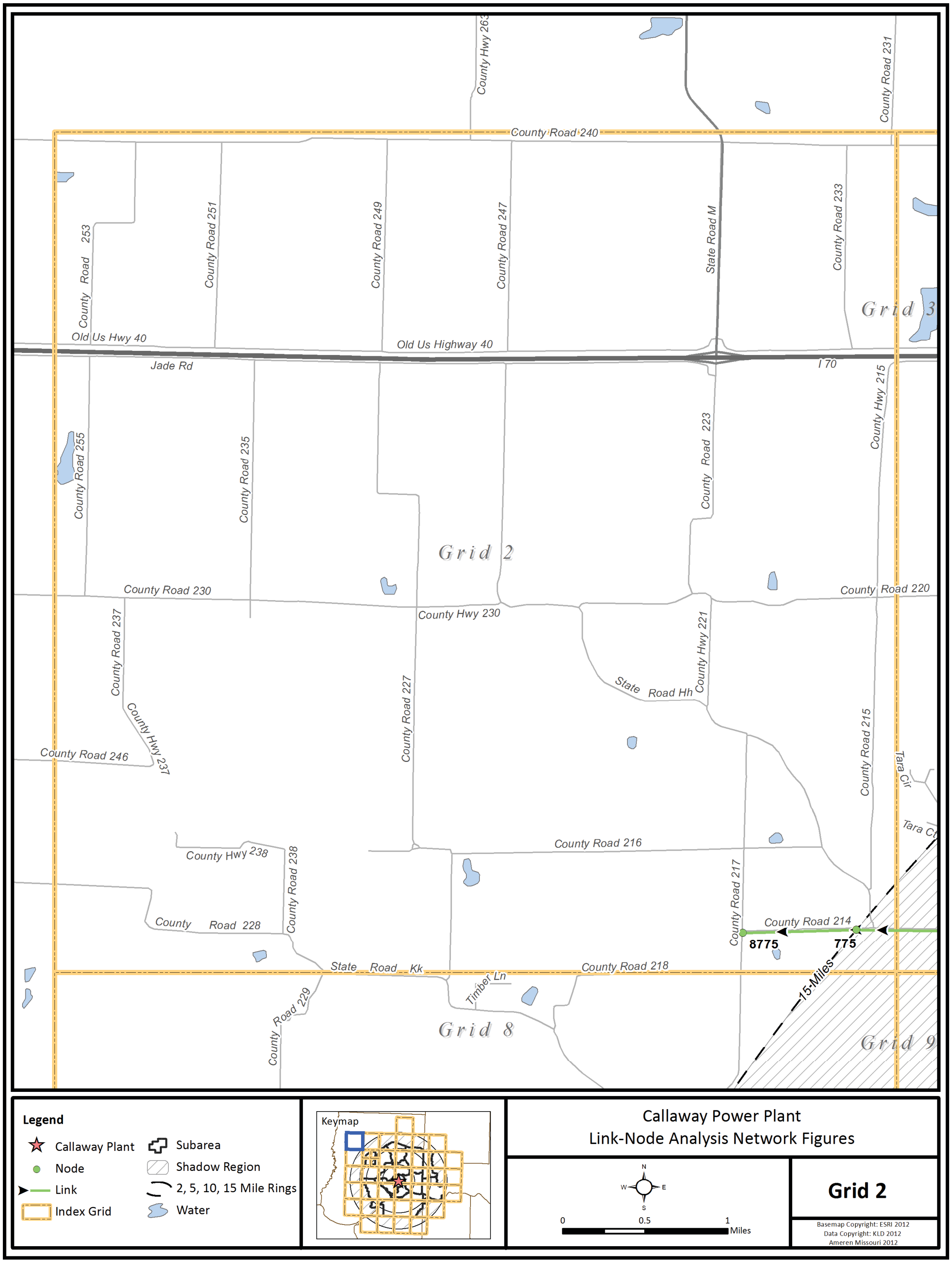


Figure K-3 Link-Node Analysis Network – Grid 2

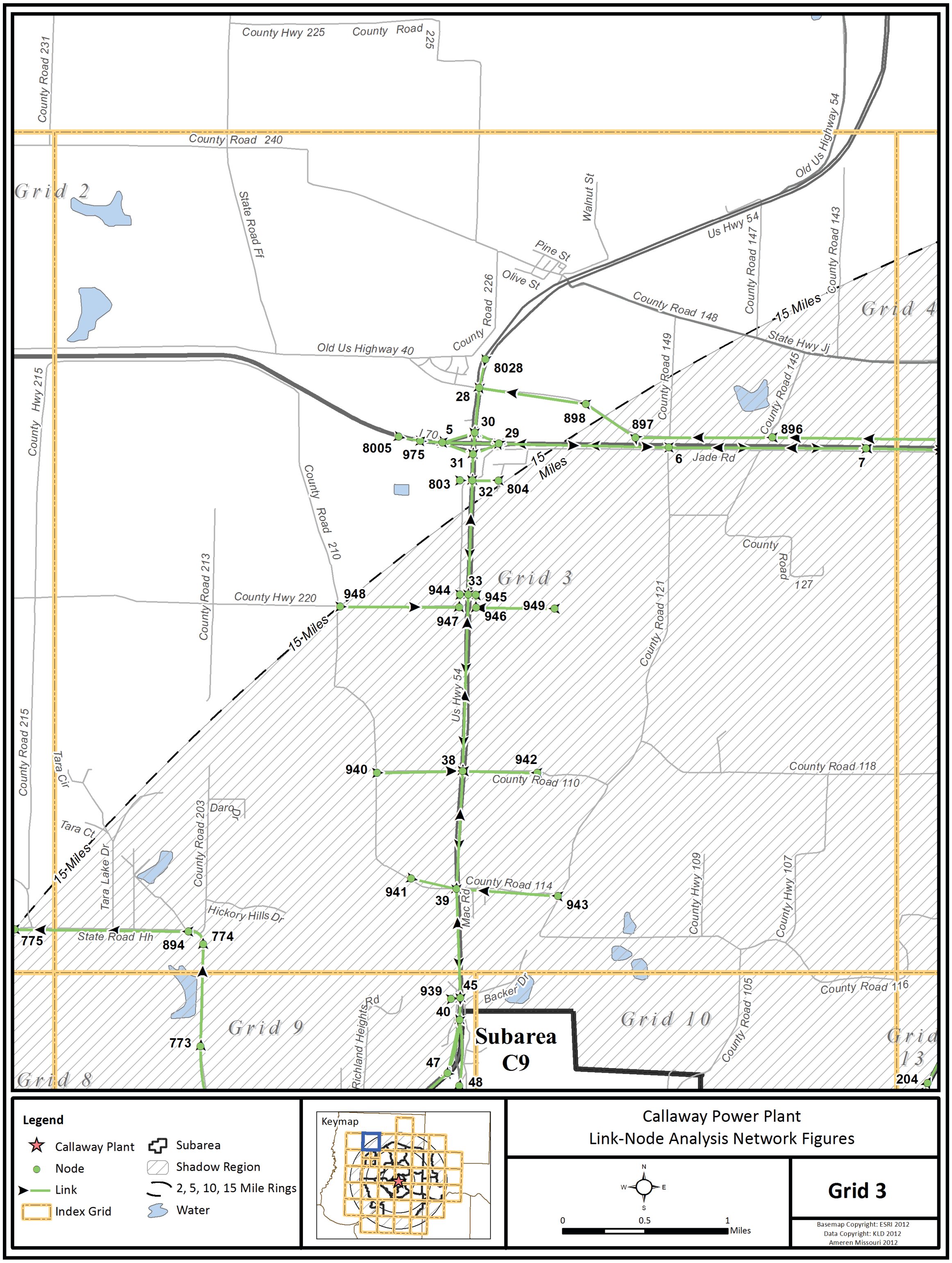


Figure K-4 Link-Node Analysis Network – Grid 3

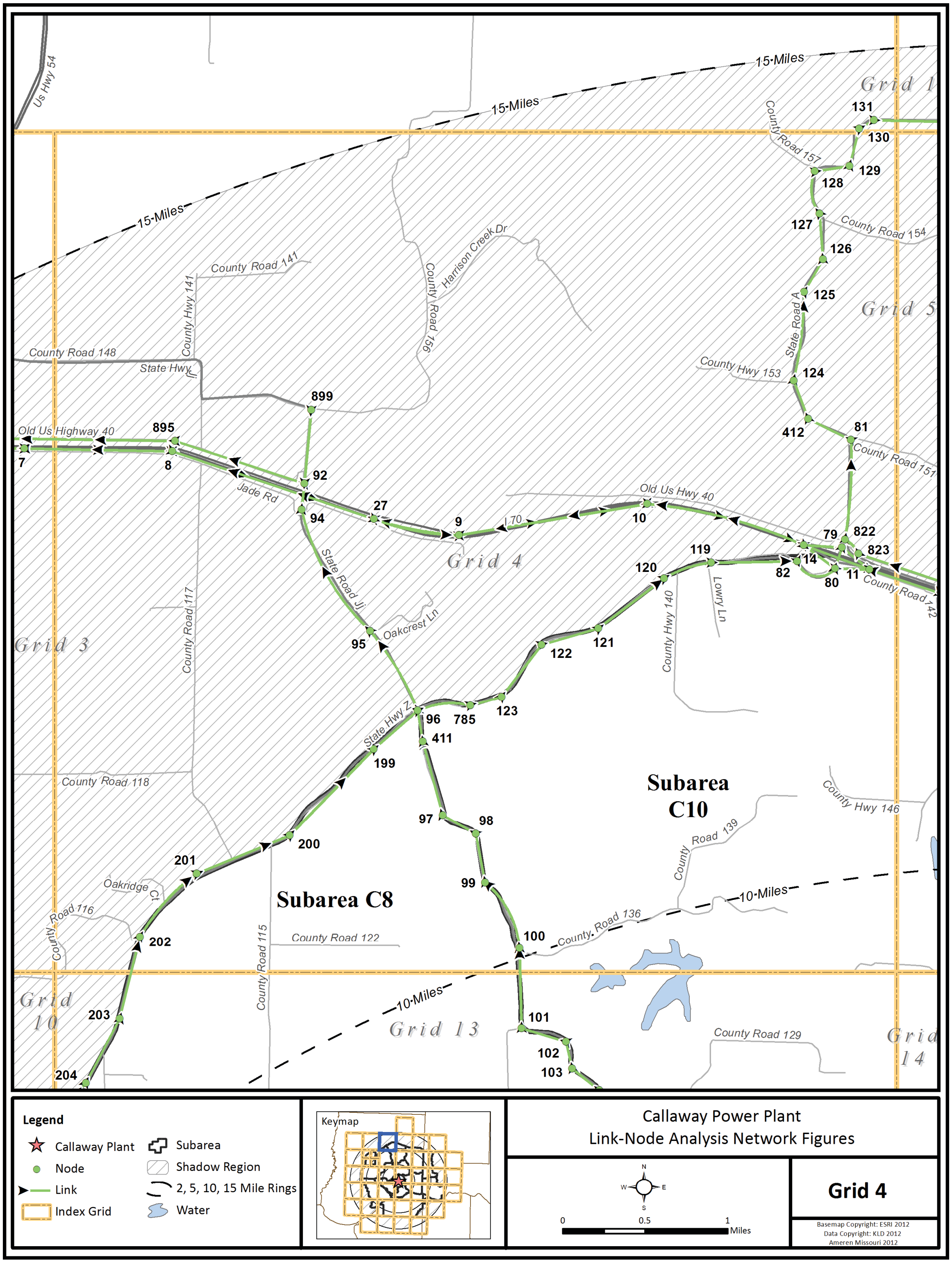


Figure K-5 Link-Node Analysis Network – Grid 4

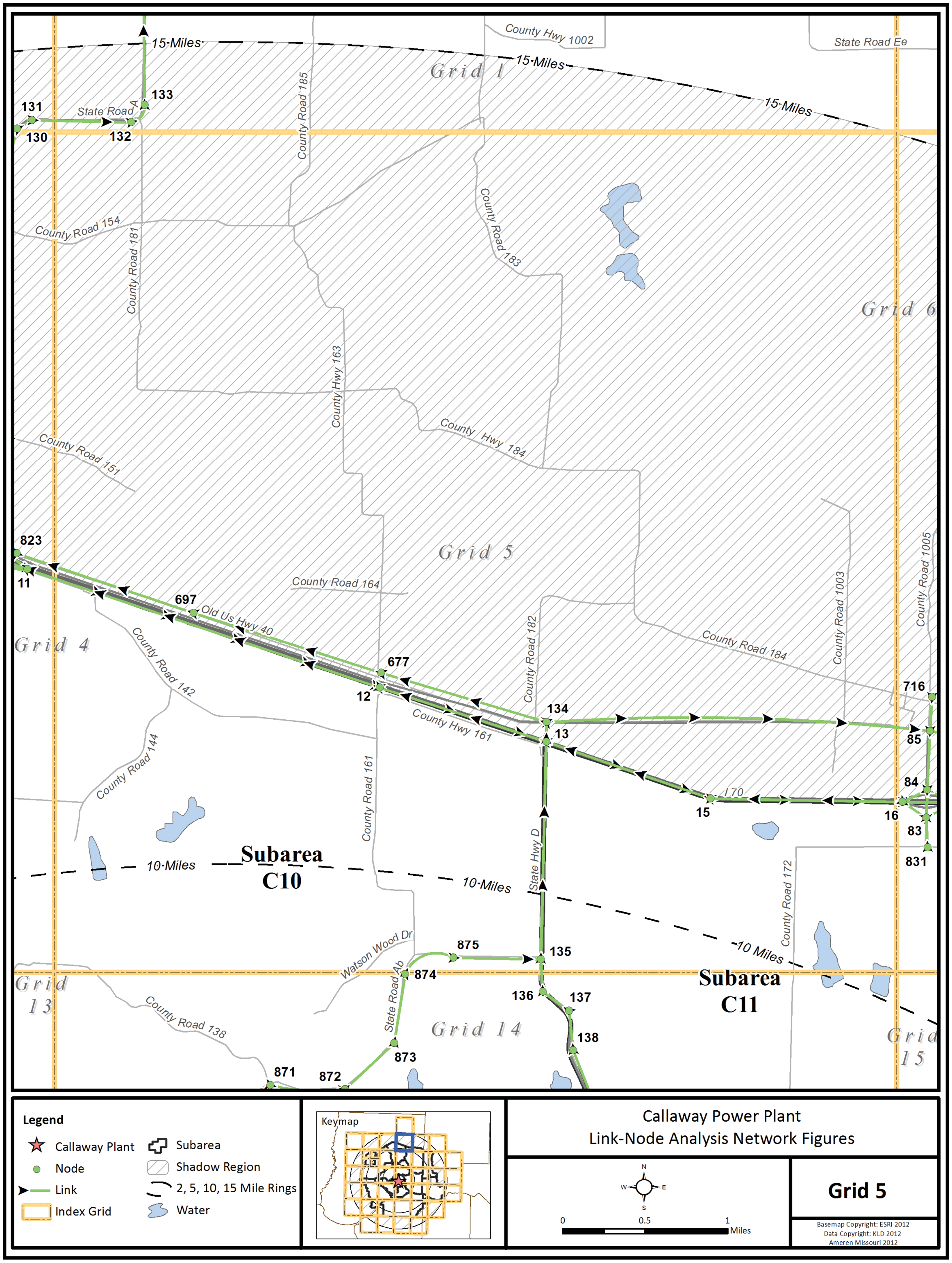


Figure K-6 Link-Node Analysis Network – Grid 5

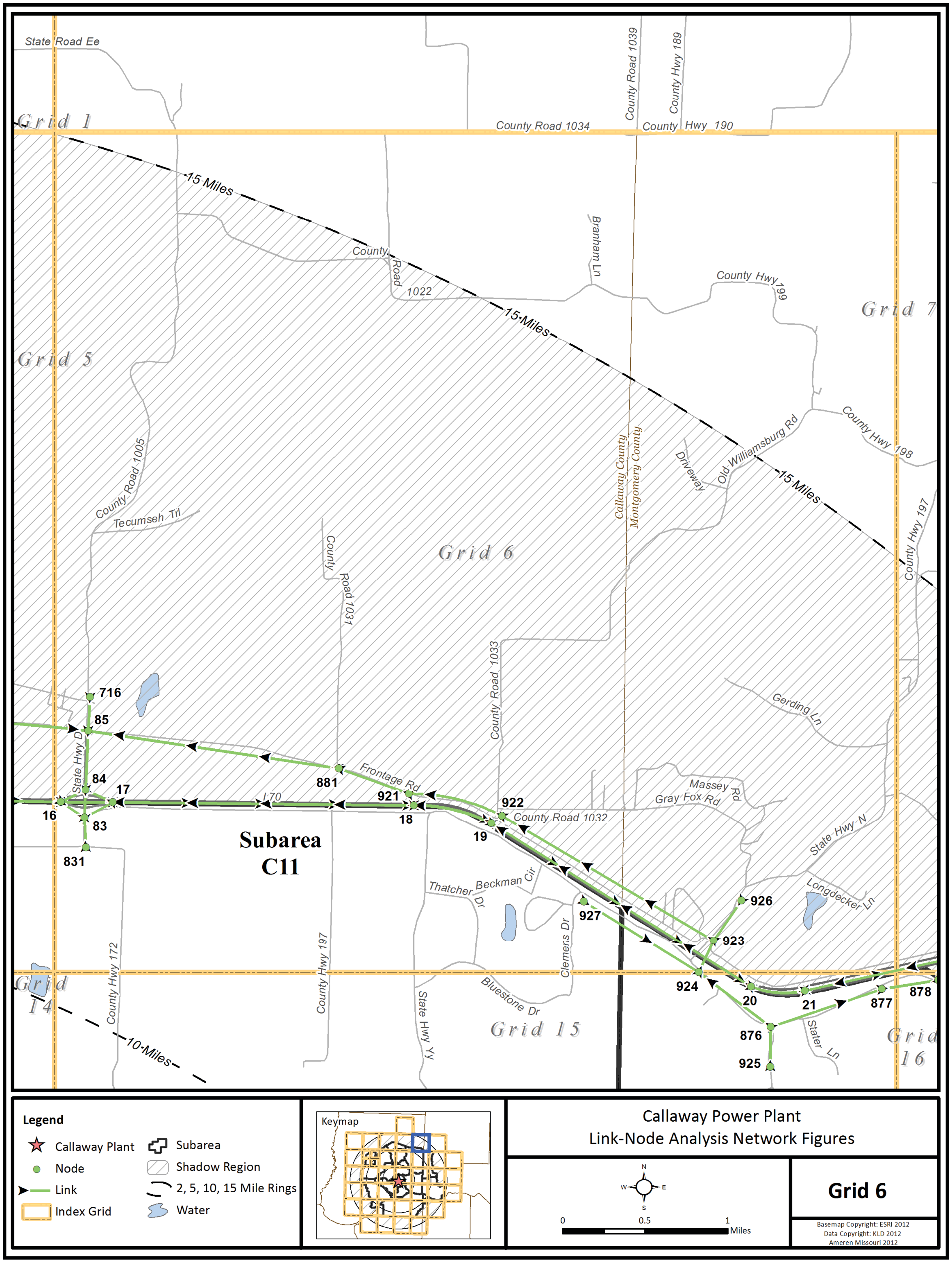


Figure K-7 Link-Node Analysis Network – Grid 6

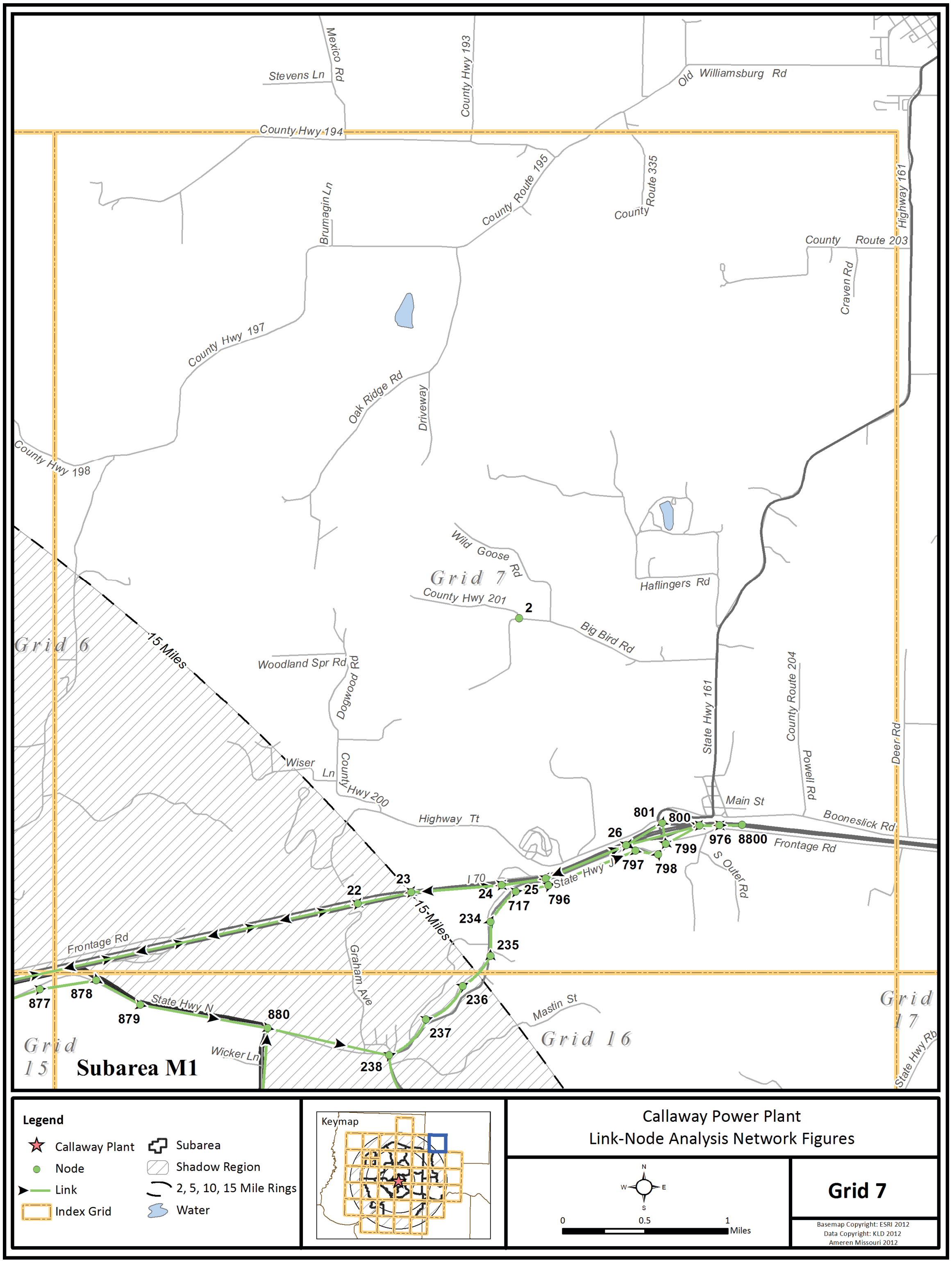


Figure K-8 Link-Node Analysis Network – Grid 7

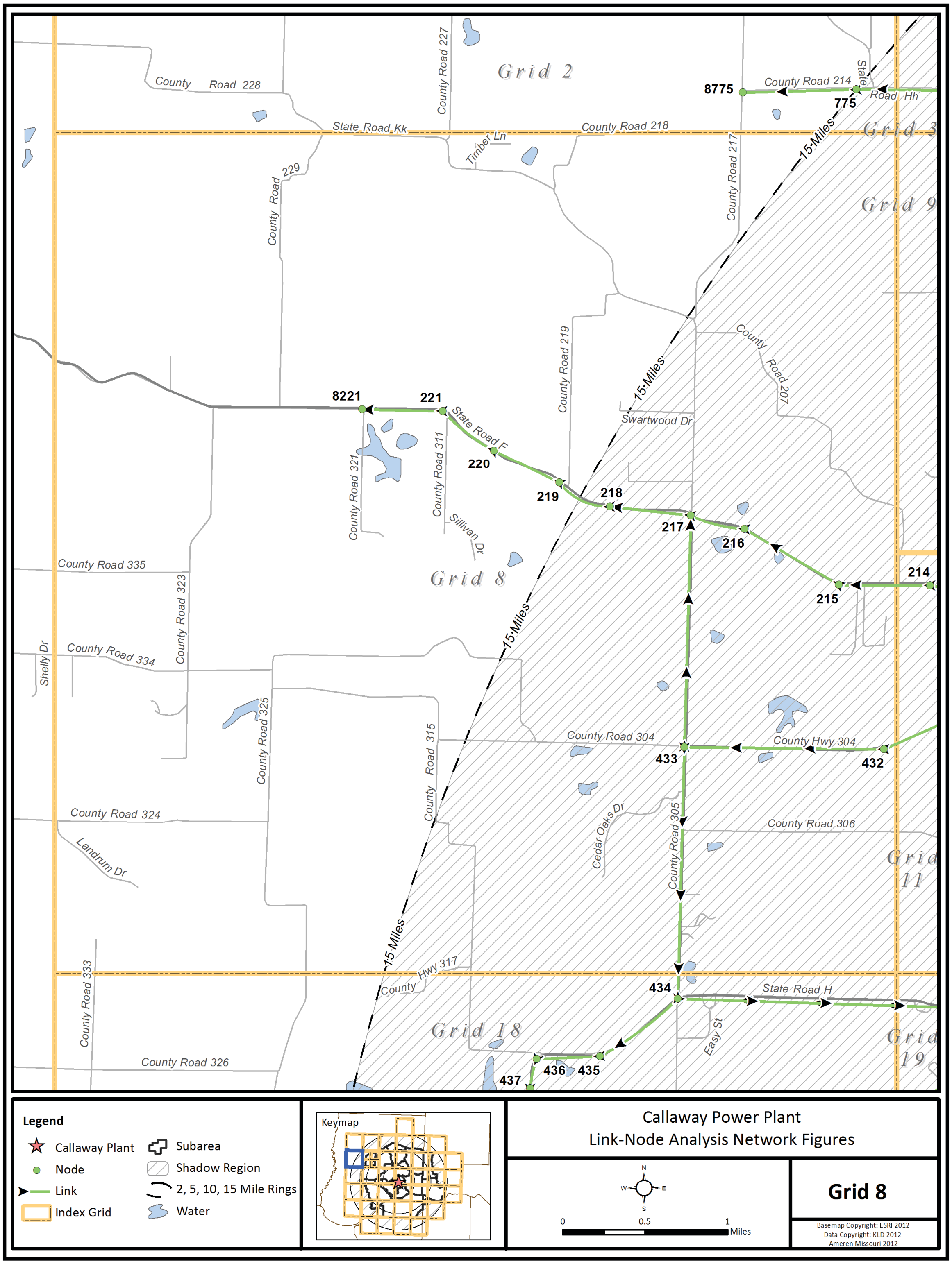


Figure K-9 Link-Node Analysis Network – Grid 8

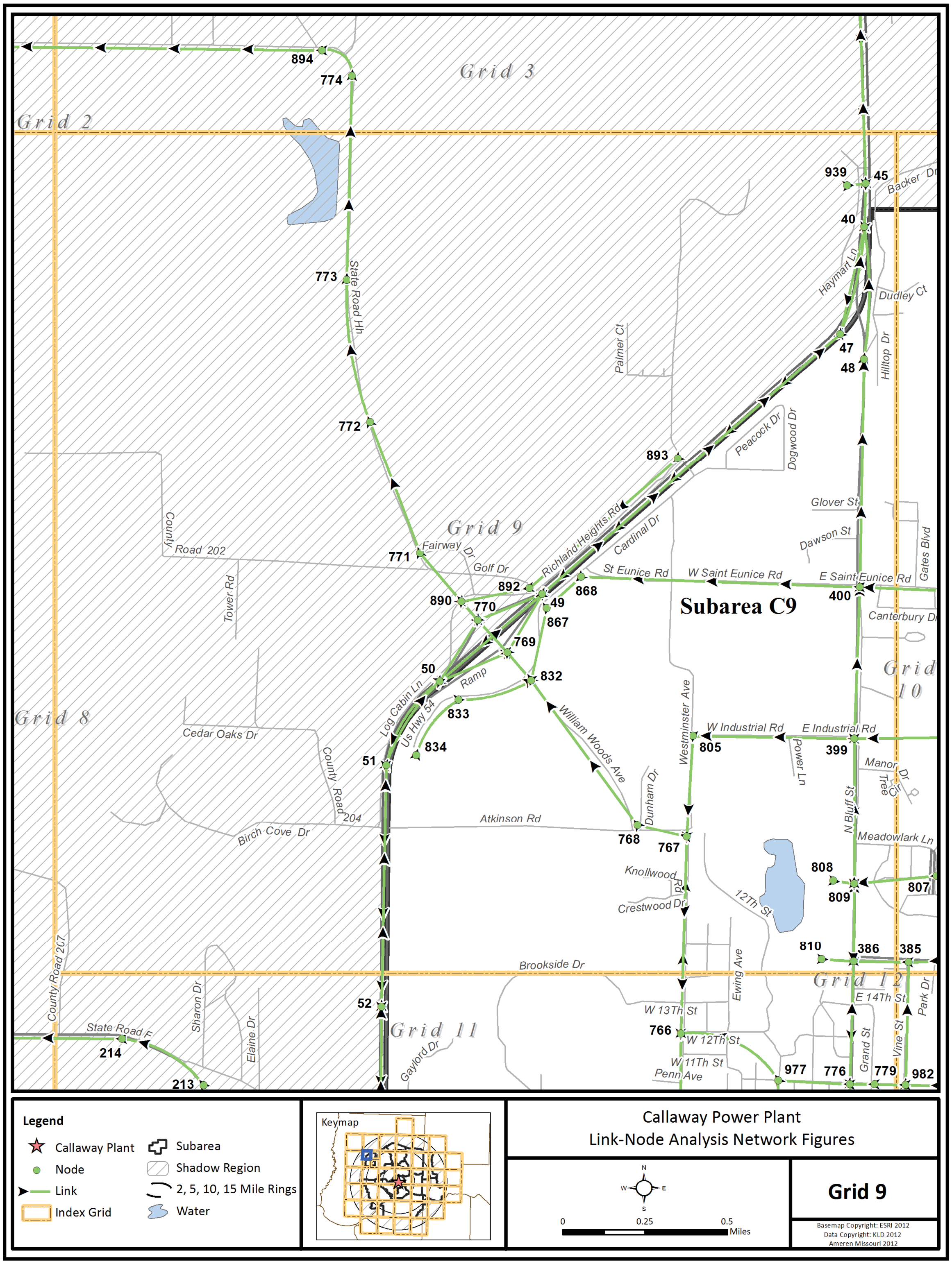


Figure K-10 Link-Node Analysis Network – Grid 9

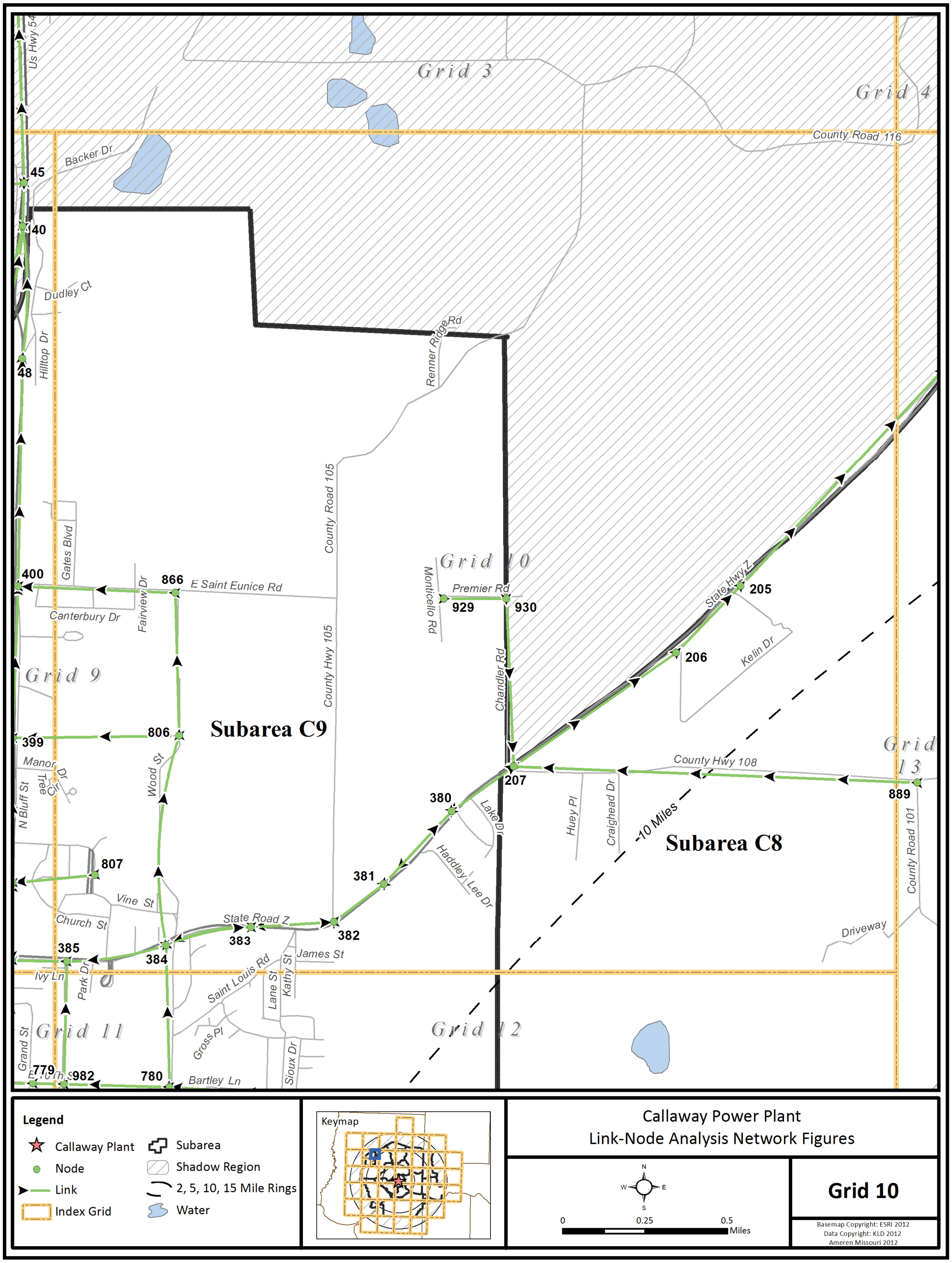


Figure K-11 Link-Node Analysis Network – Grid 10

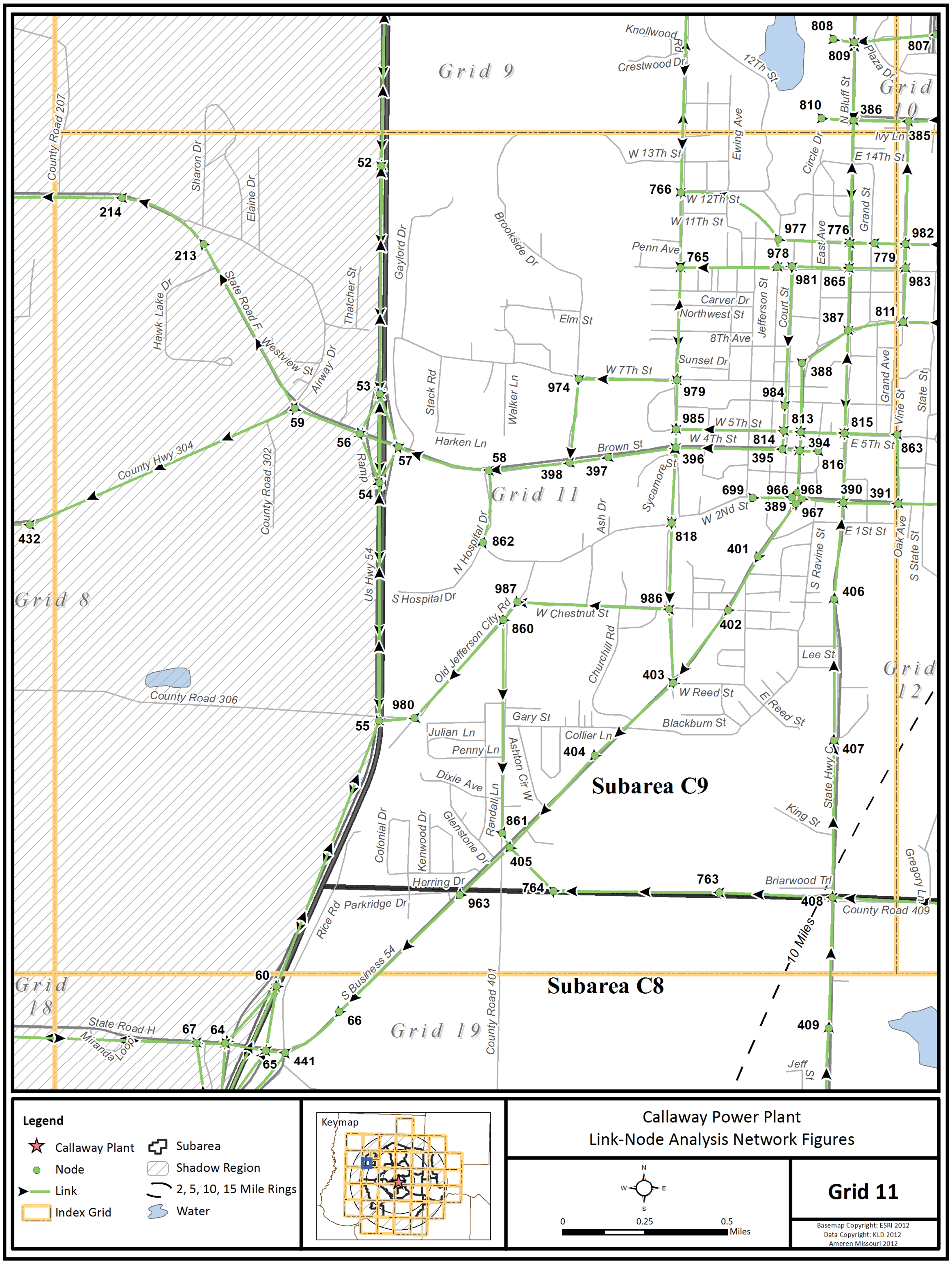


Figure K-12 Link-Node Analysis Network – Grid 11

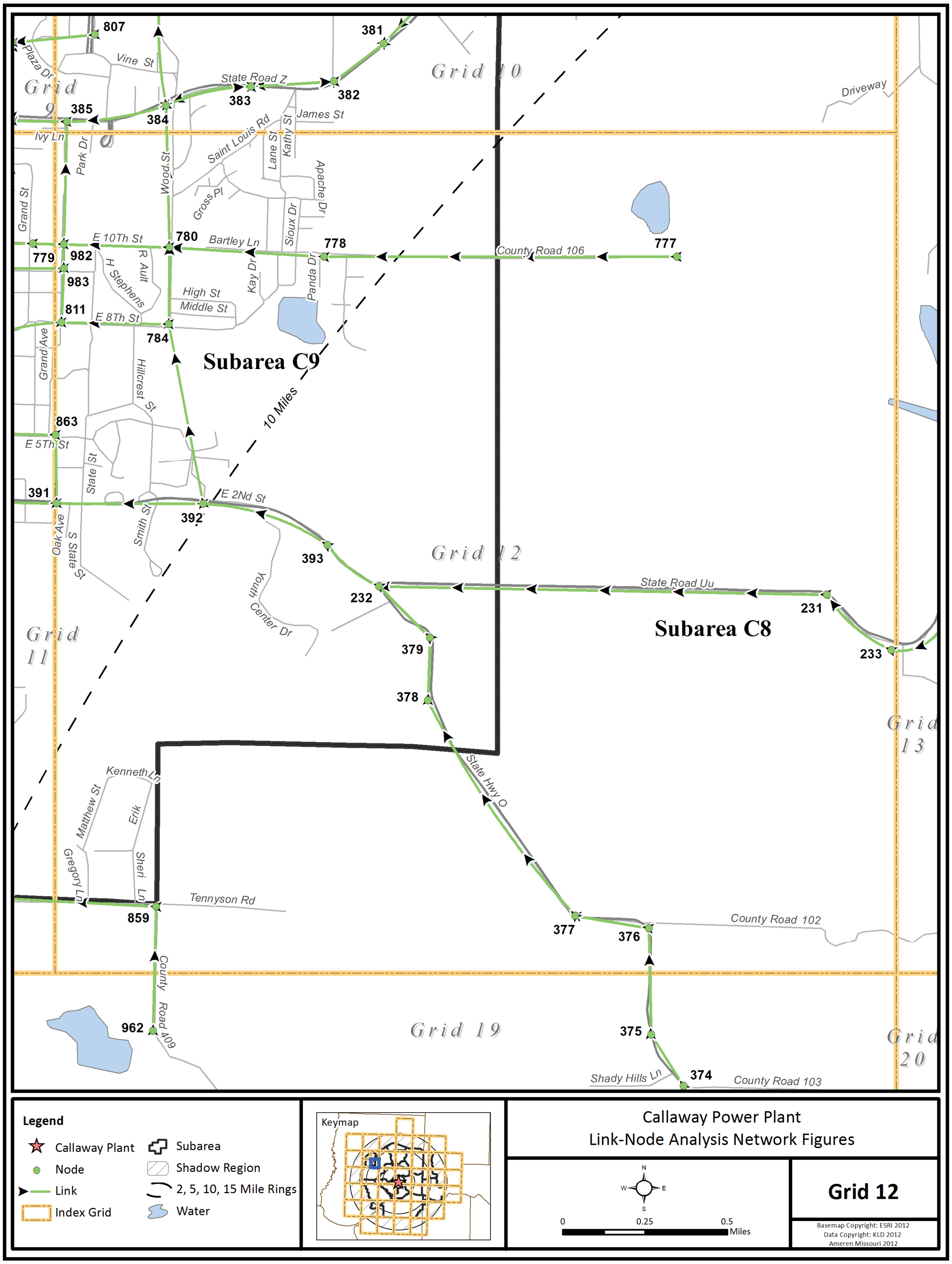


Figure K-13 Link-Node Analysis Network – Grid 12

Enclosure
to ULNRC-05881

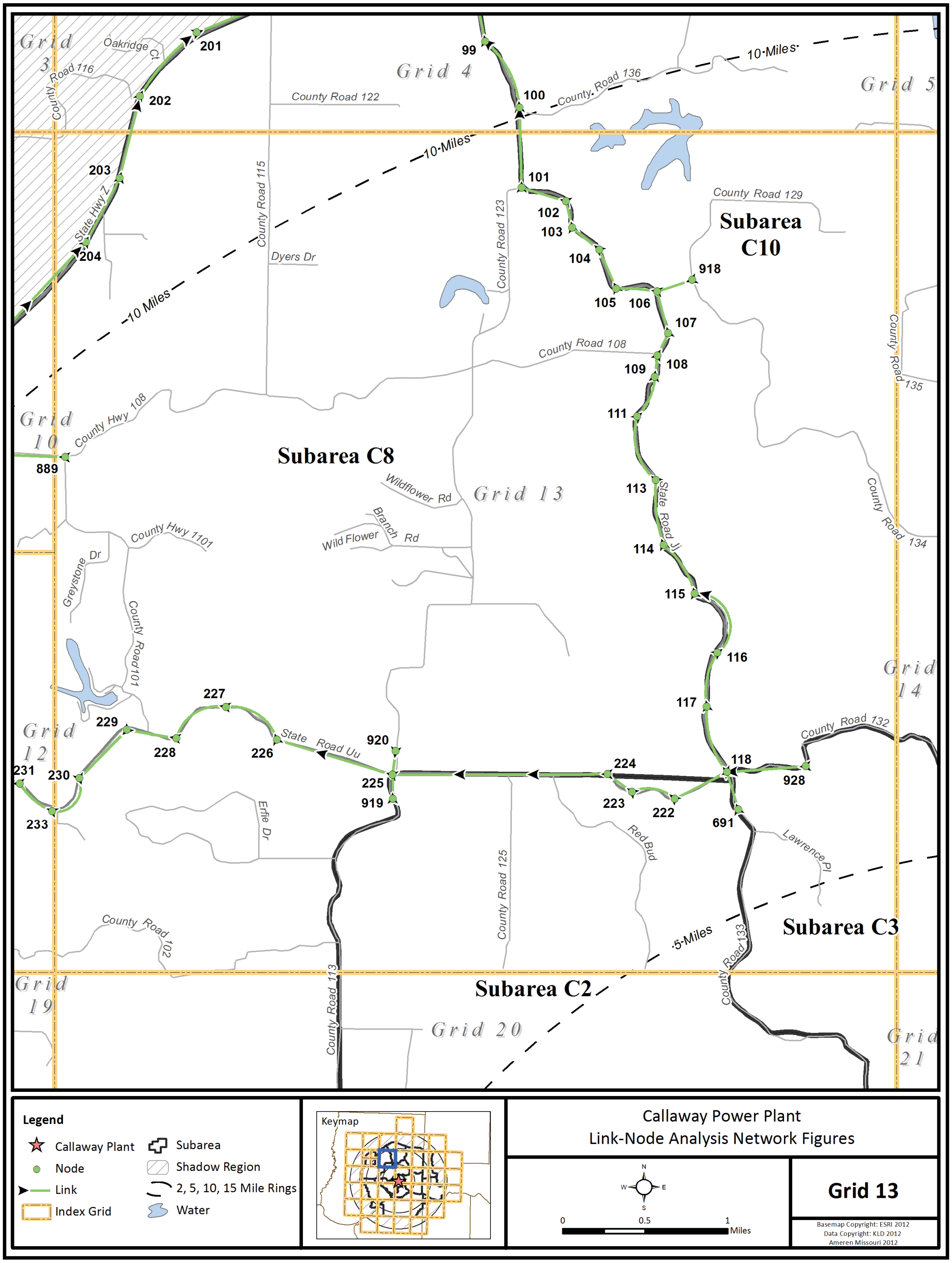


Figure K-14 Link-Node Analysis Network – Grid 13

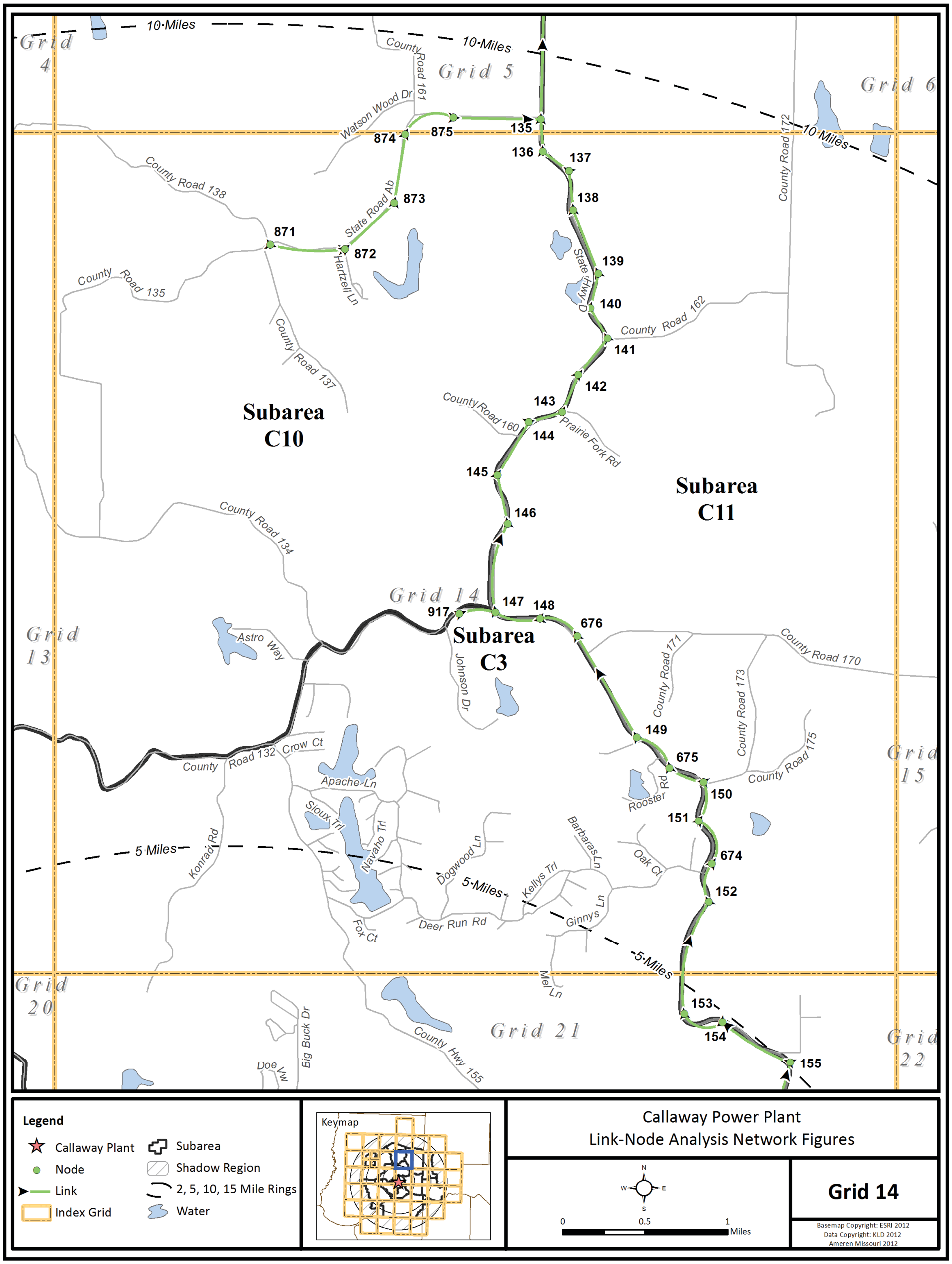


Figure K-15 Link-Node Analysis Network – Grid 14

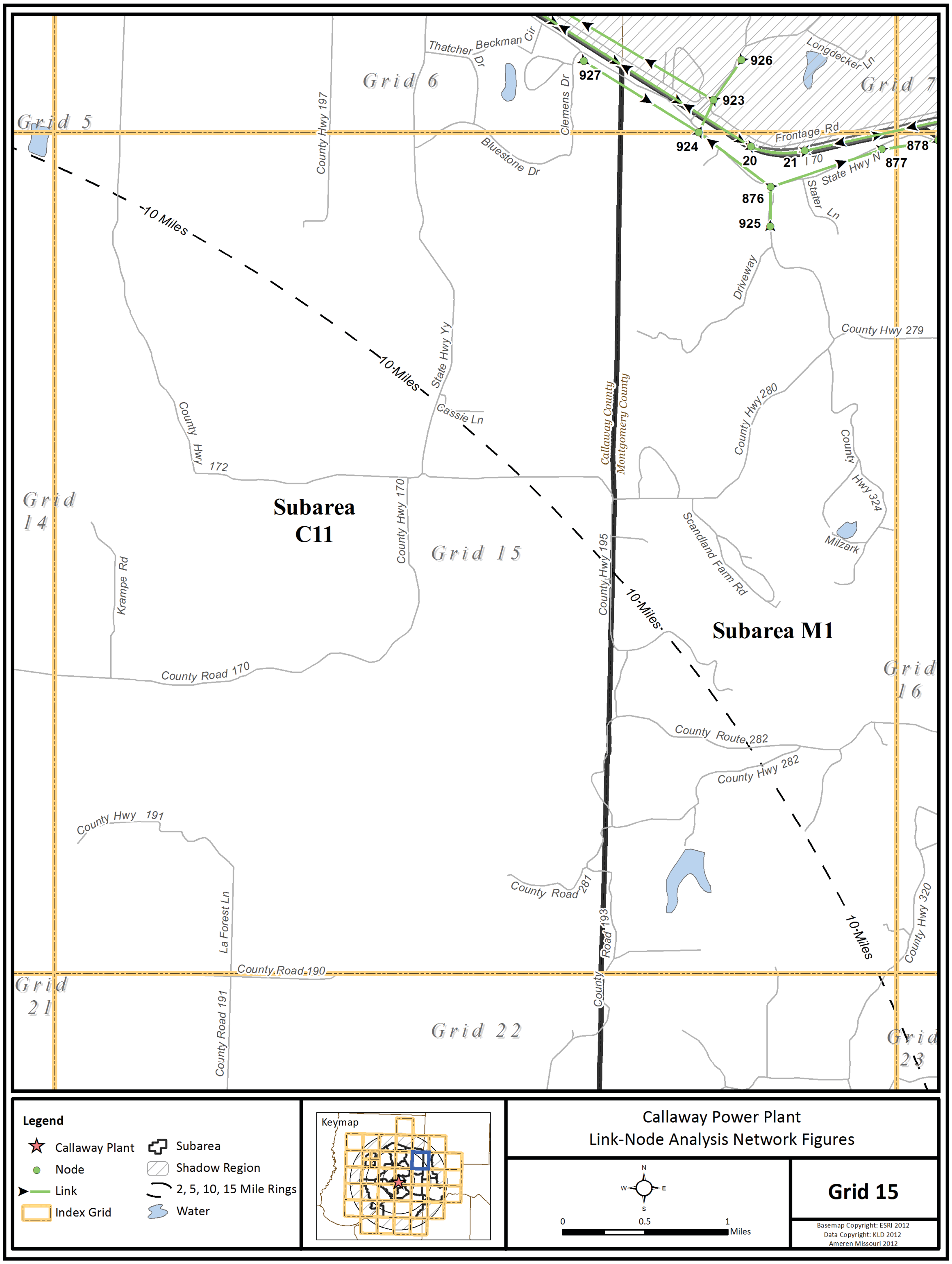


Figure K-16 Link-Node Analysis Network – Grid 15

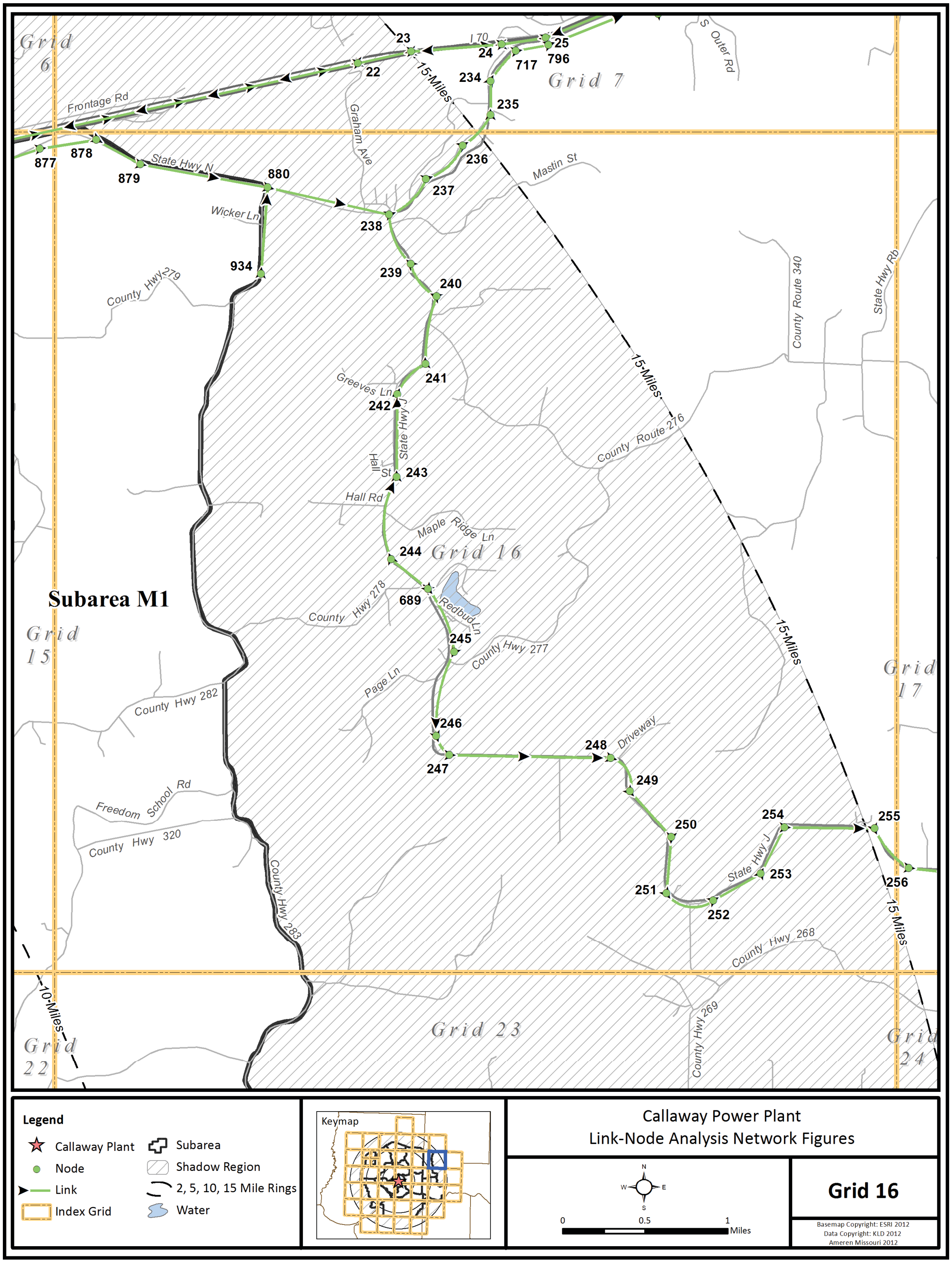


Figure K-17 Link-Node Analysis Network – Grid 16

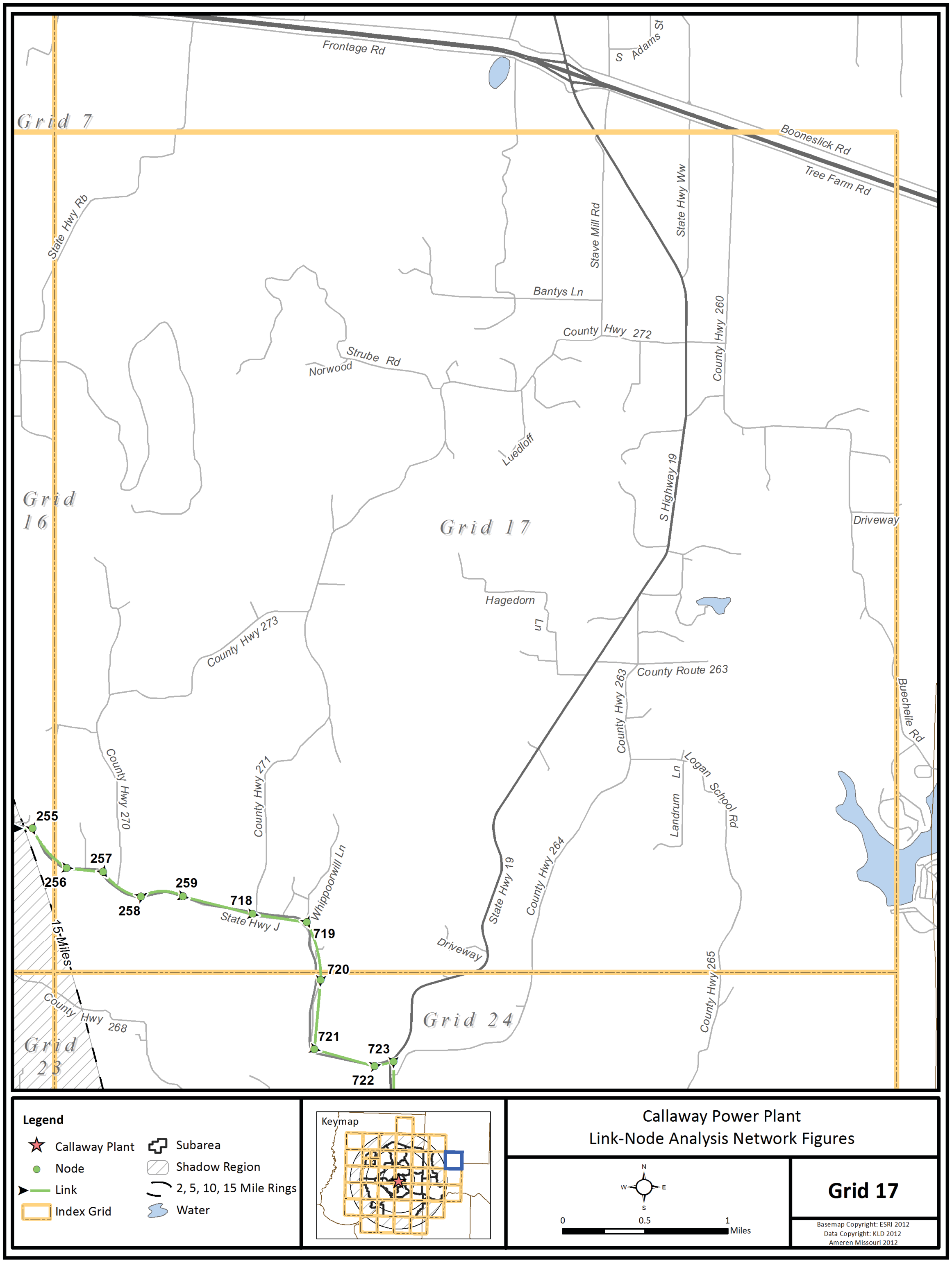


Figure K-18 Link-Node Analysis Network – Grid 17

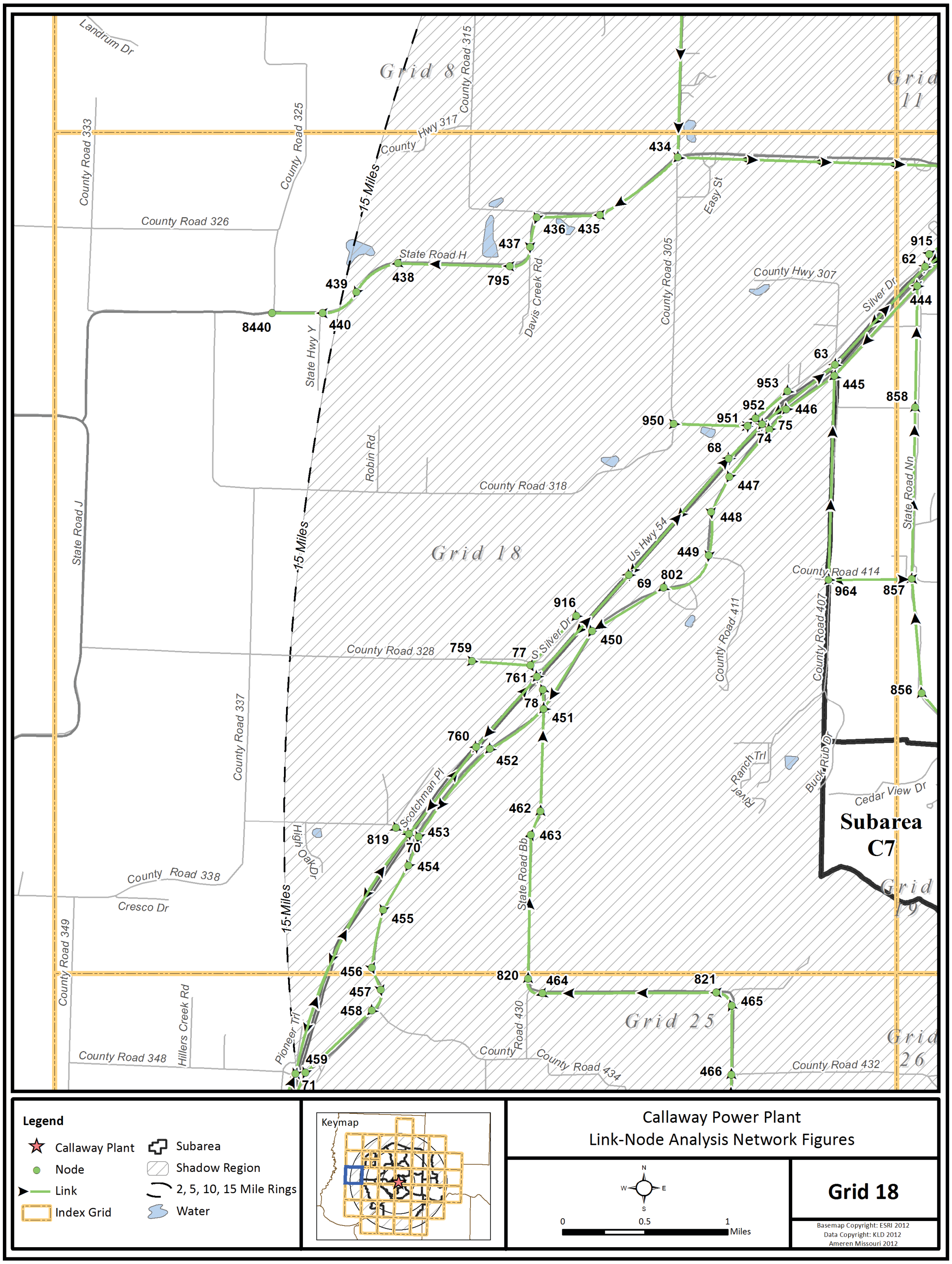


Figure K-19 Link-Node Analysis Network – Grid 18

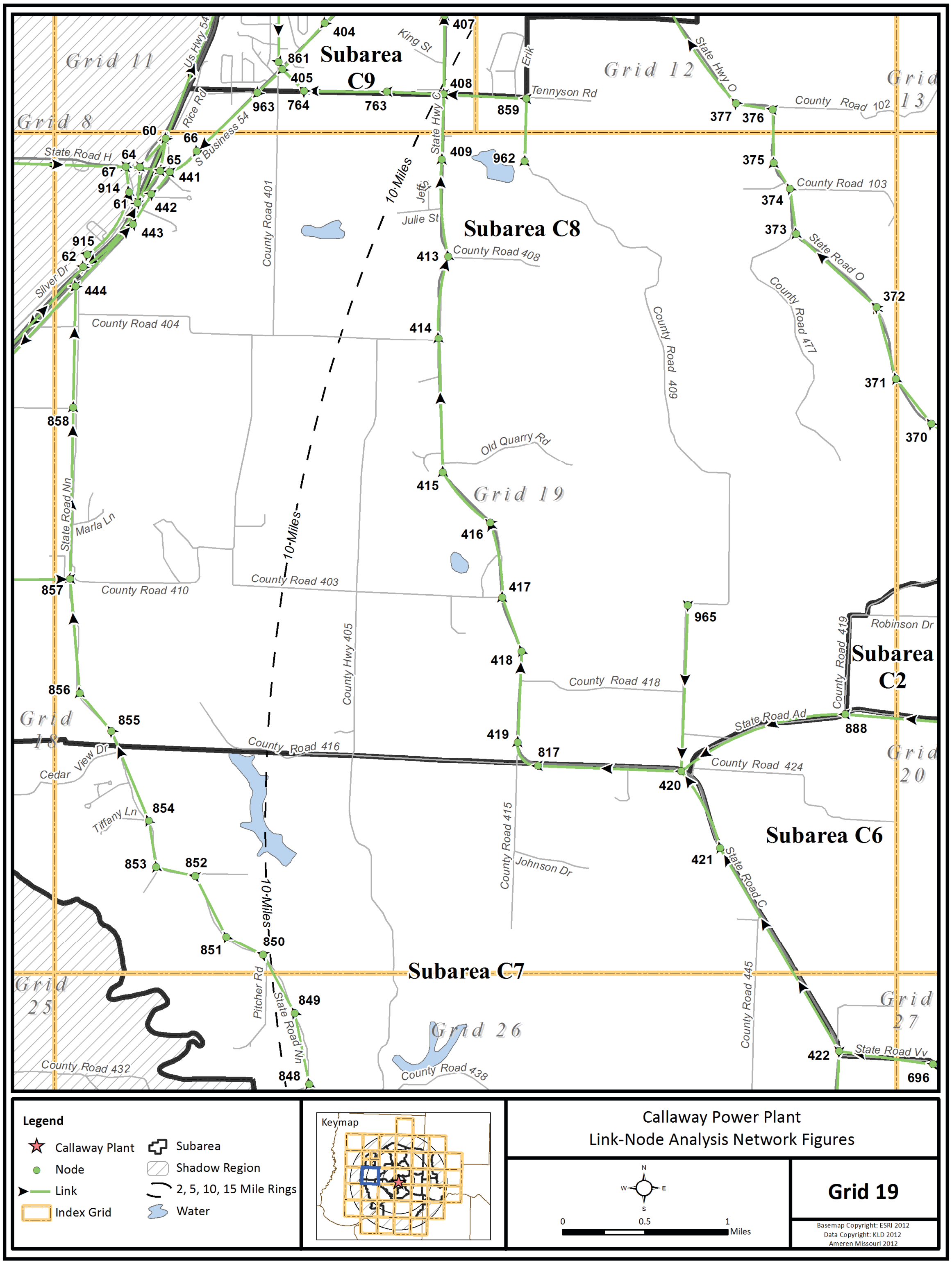


Figure K-20 Link-Node Analysis Network – Grid 19

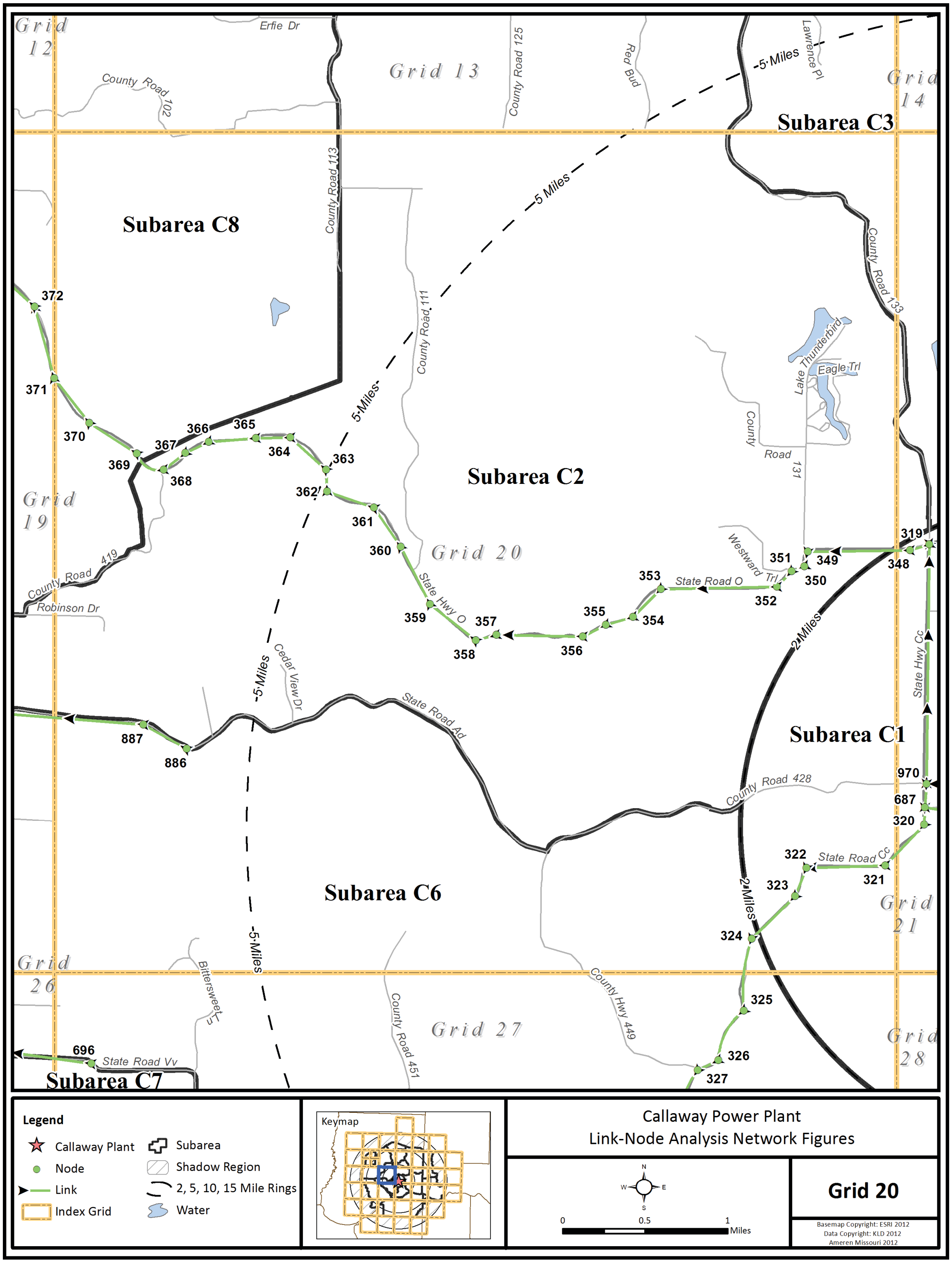


Figure K-21 Link-Node Analysis Network – Grid 20

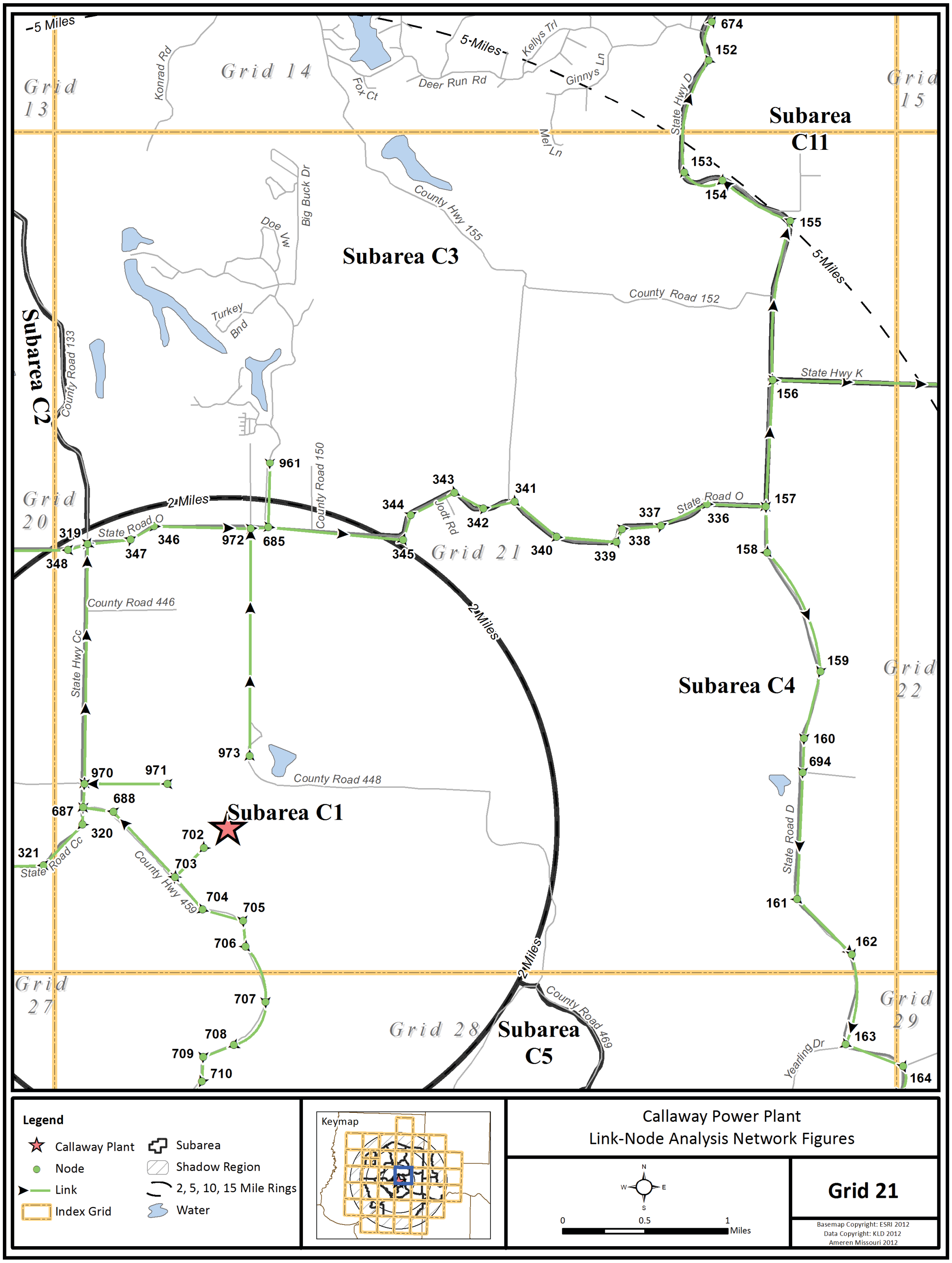


Figure K-22 Link-Node Analysis Network – Grid 21

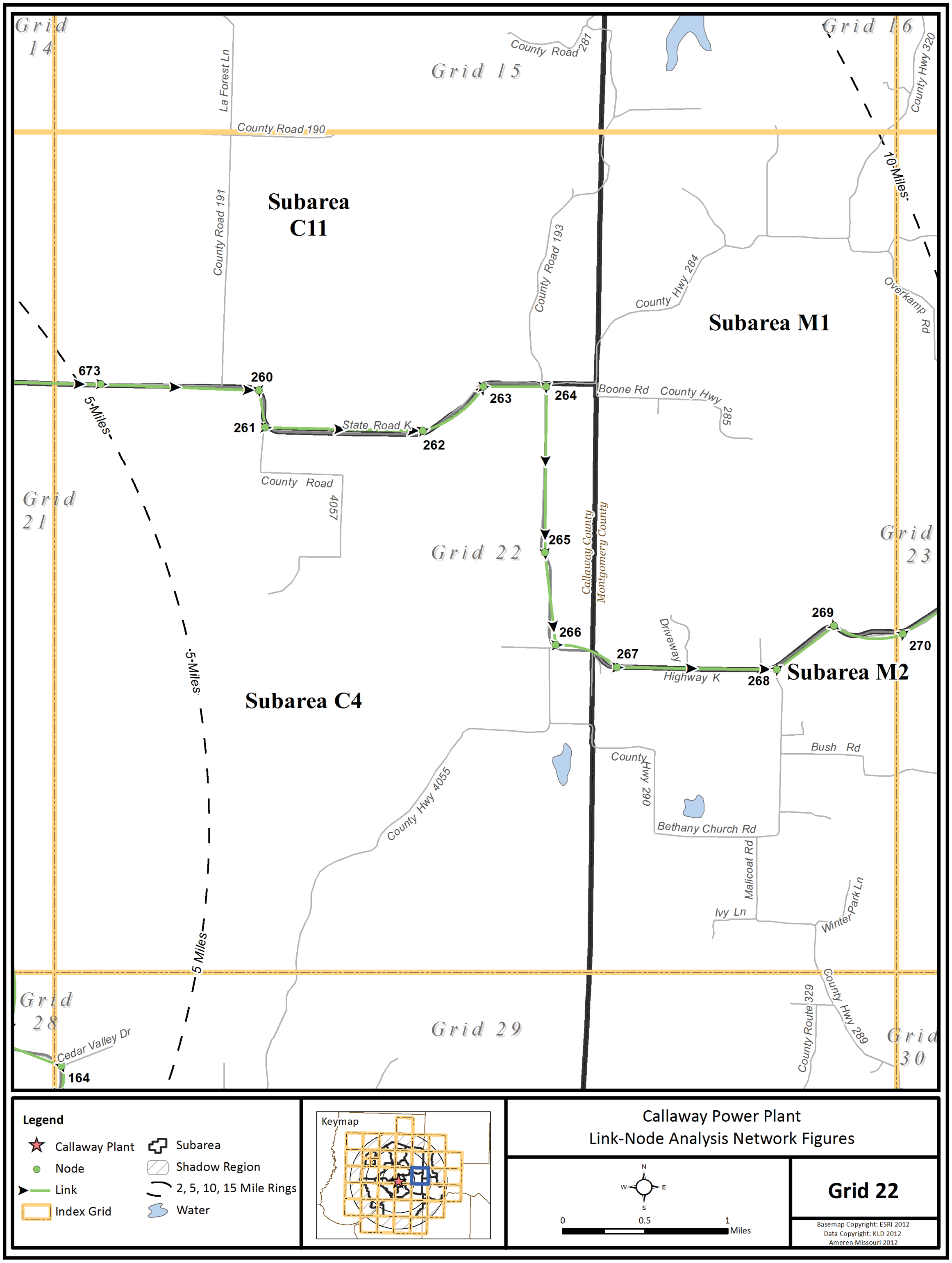


Figure K-23Link-Node Analysis Network – Grid 22

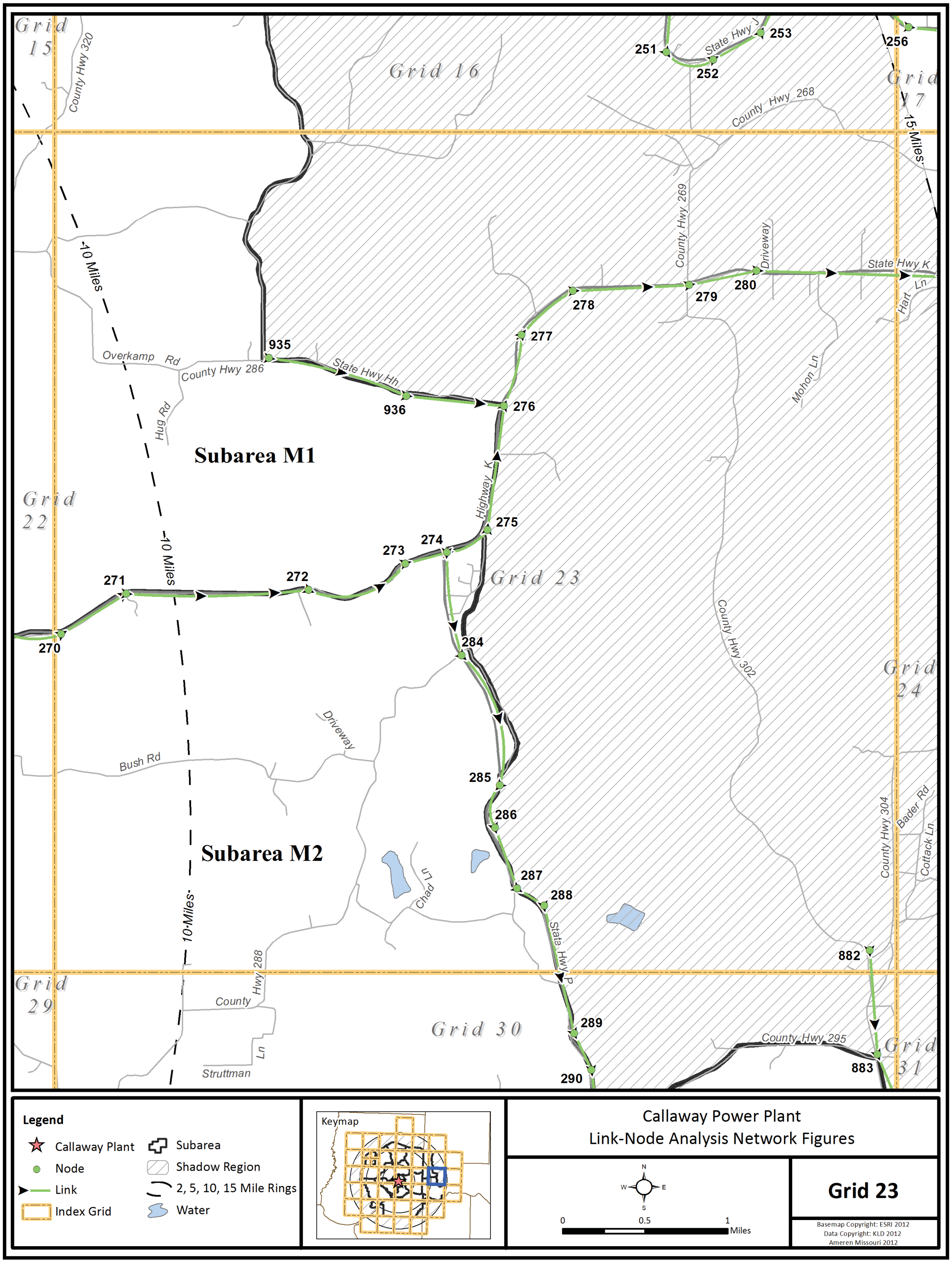


Figure K-24 Link-Node Analysis Network – Grid 23

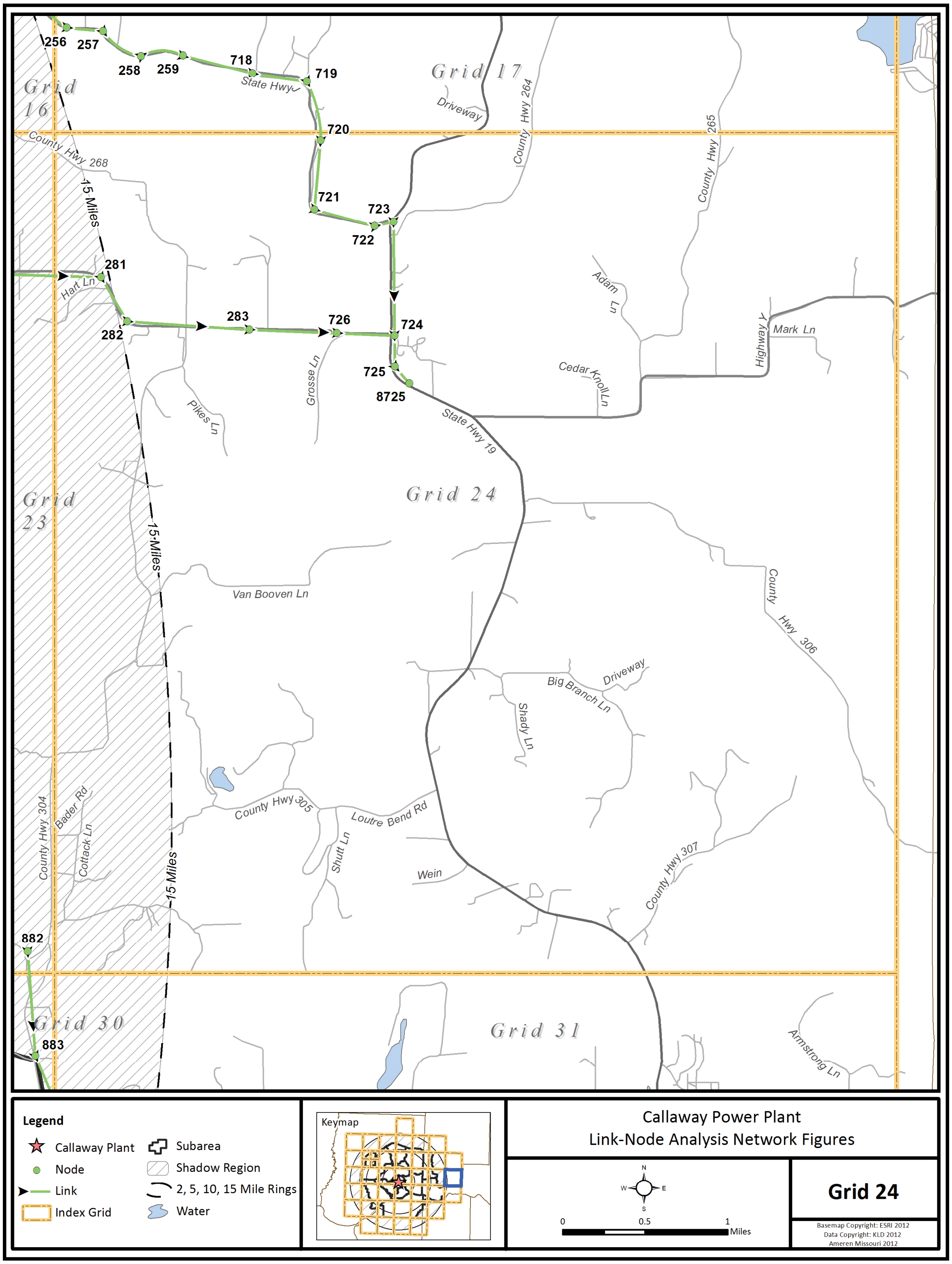


Figure K-25 Link-Node Analysis Network – Grid 24

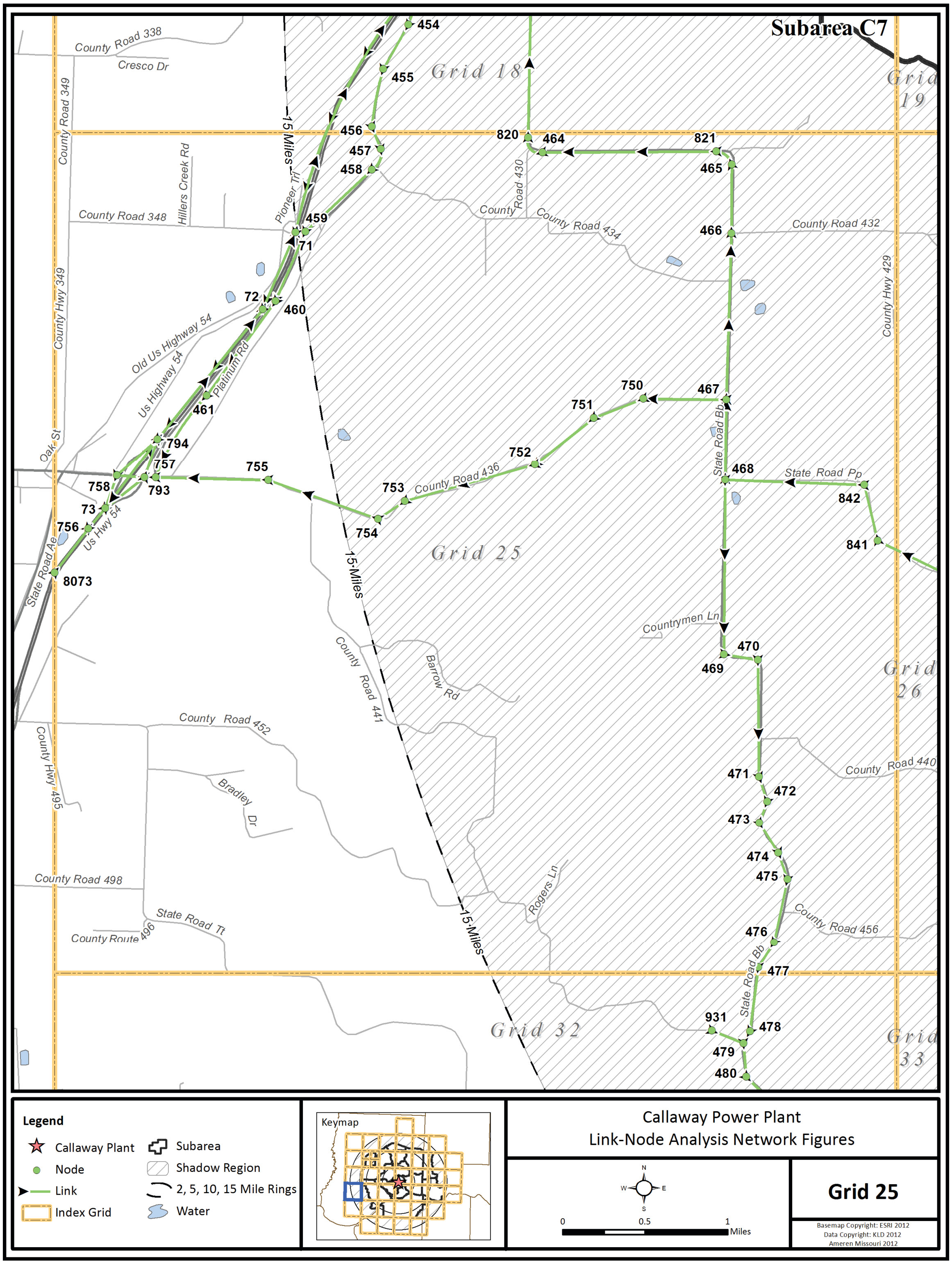


Figure K-26 Link-Node Analysis Network – Grid 25

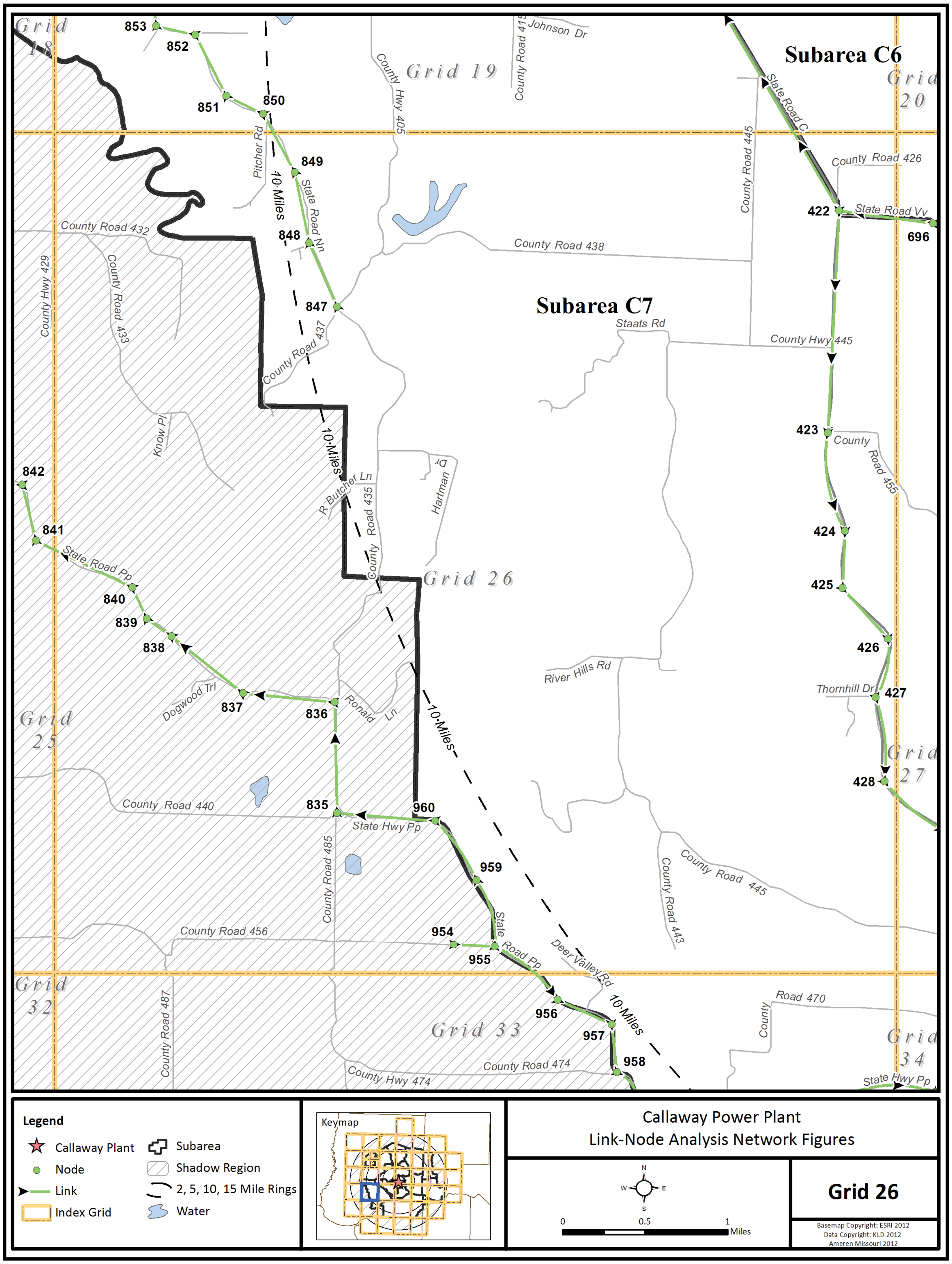


Figure K-27 Link-Node Analysis Network – Grid 26

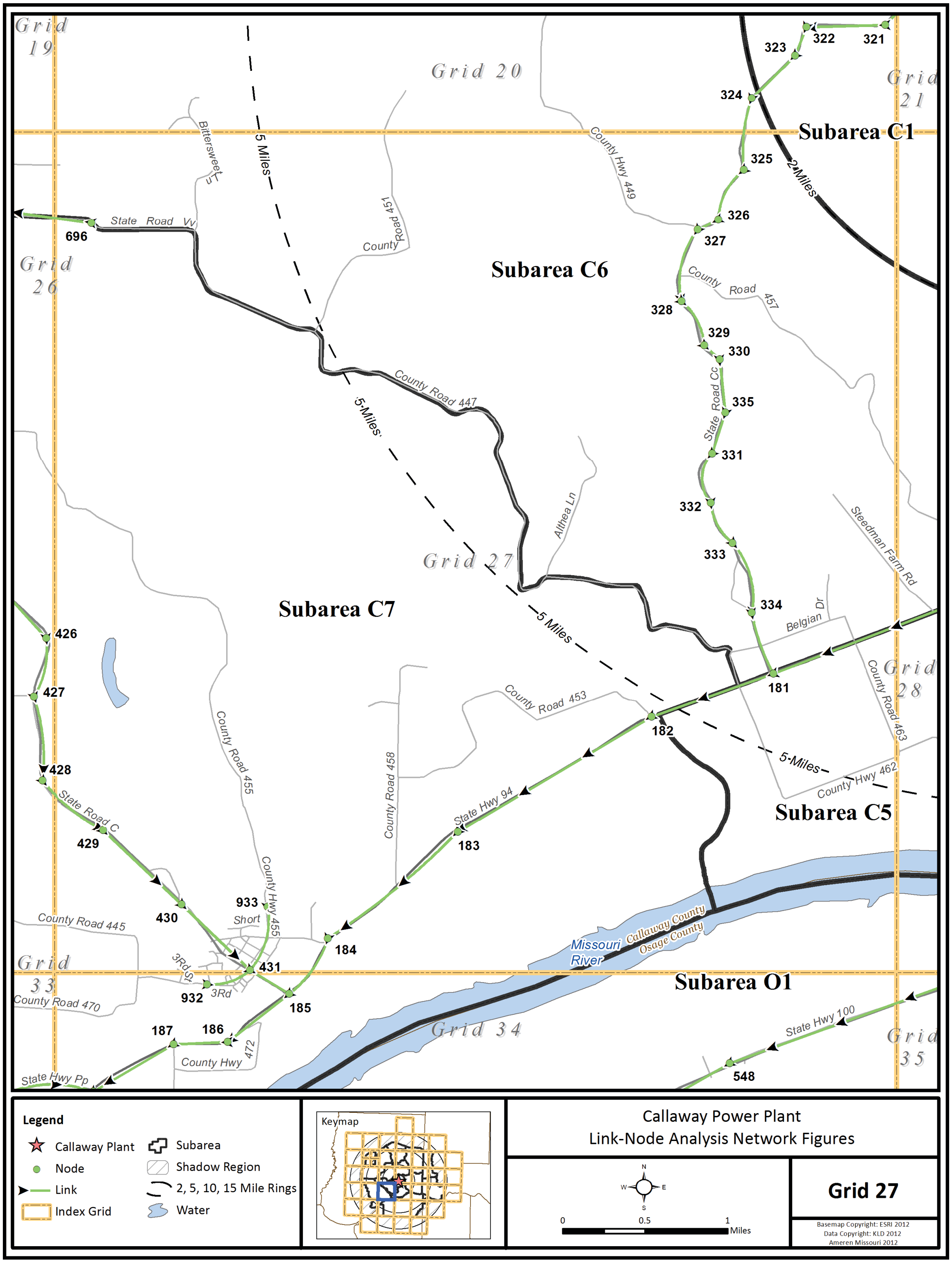


Figure K-28 Link-Node Analysis Network – Grid 27

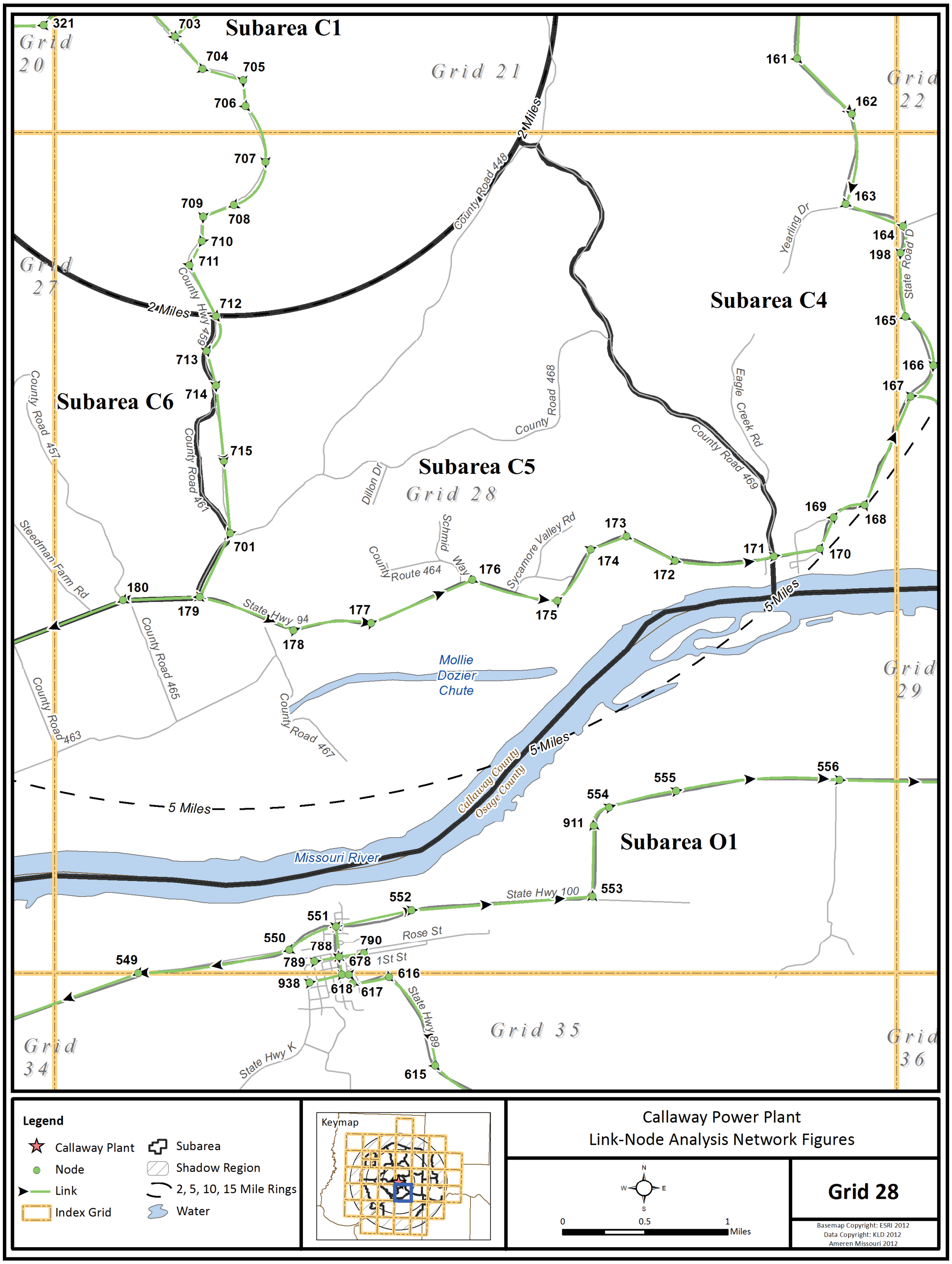


Figure K-29 Link-Node Analysis Network – Grid 28

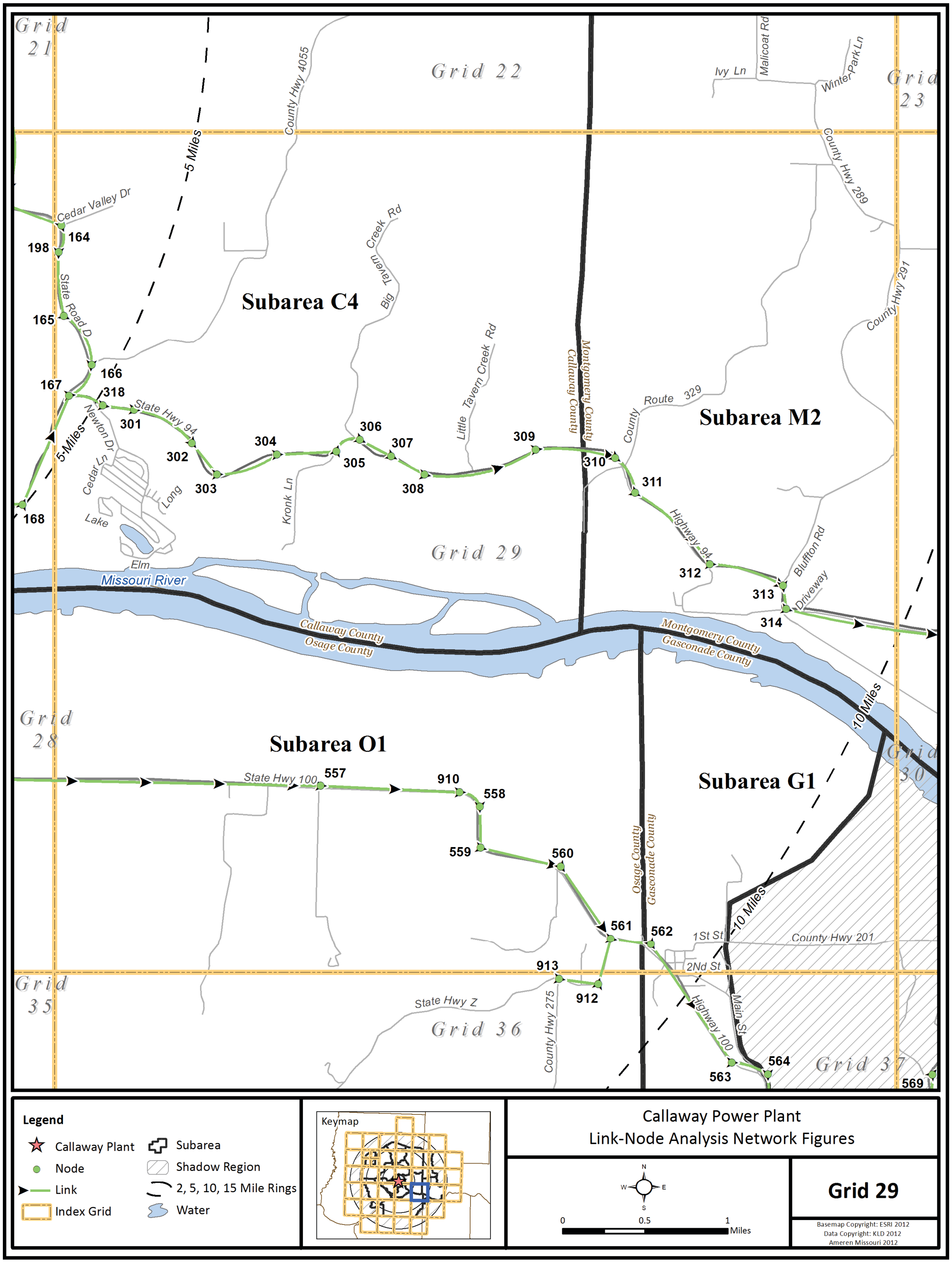


Figure K-30 Link-Node Analysis Network – Grid 29

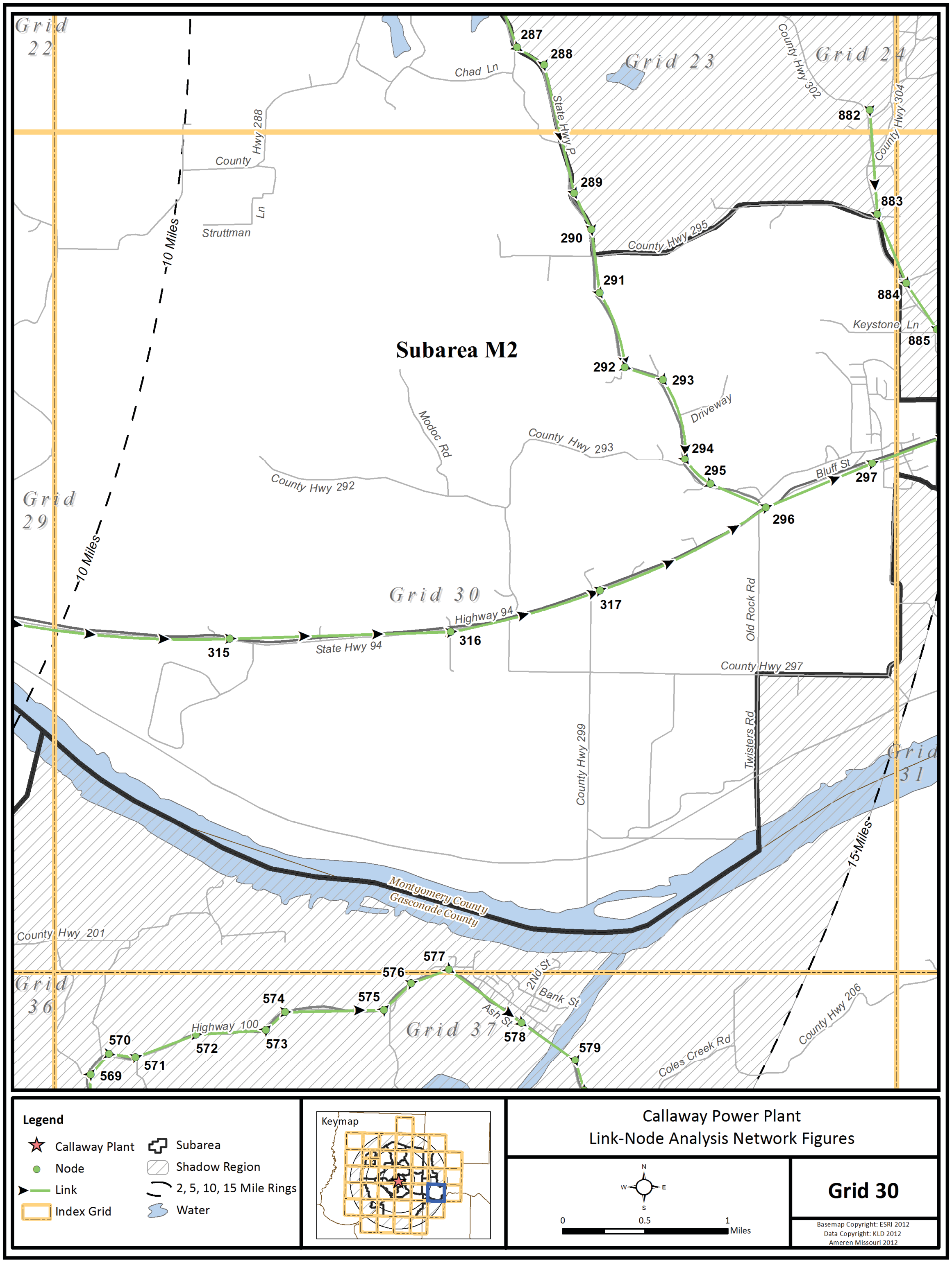


Figure K-31 Link-Node Analysis Network – Grid 30

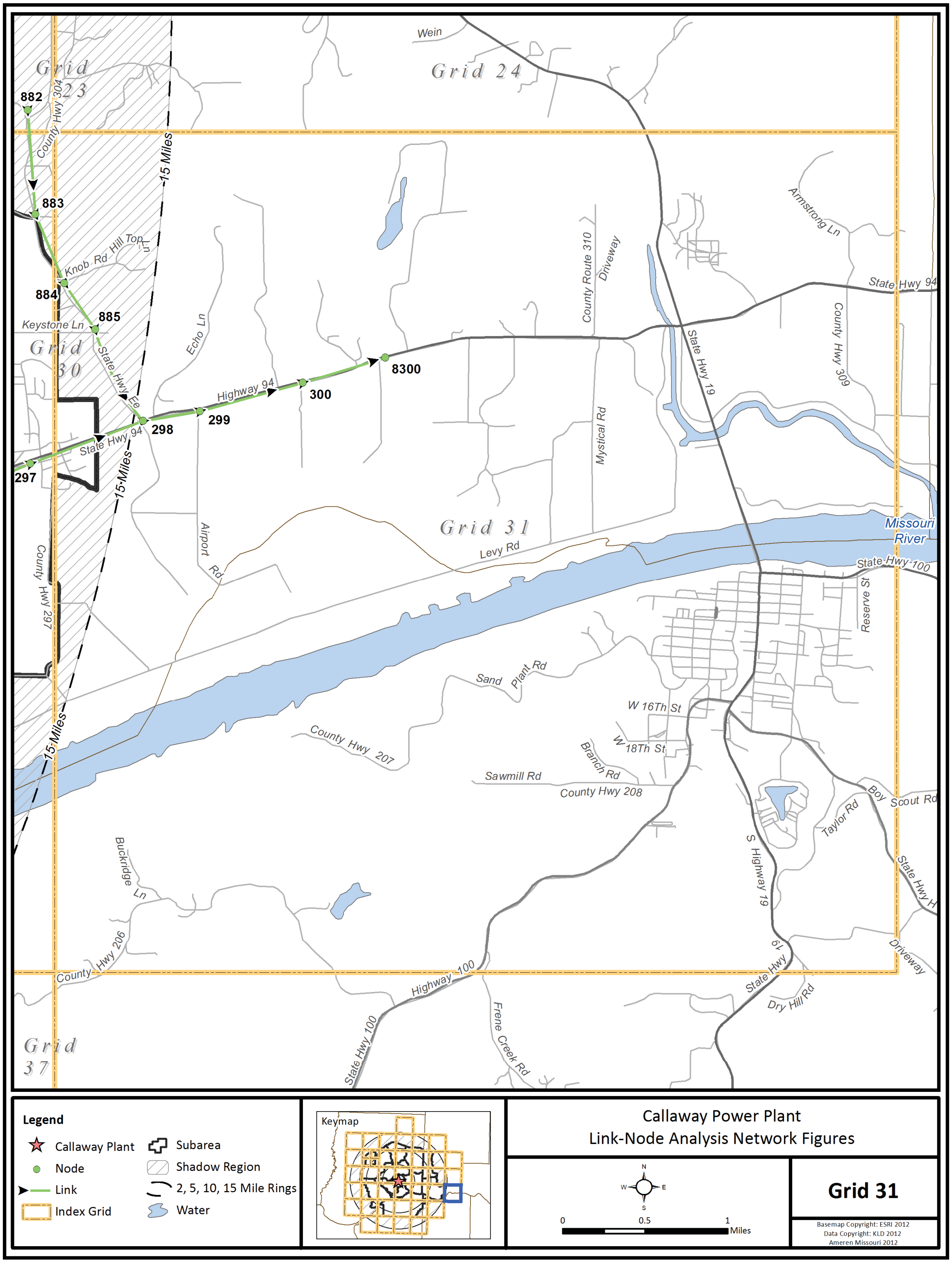


Figure K-32 Link-Node Analysis Network – Grid 31

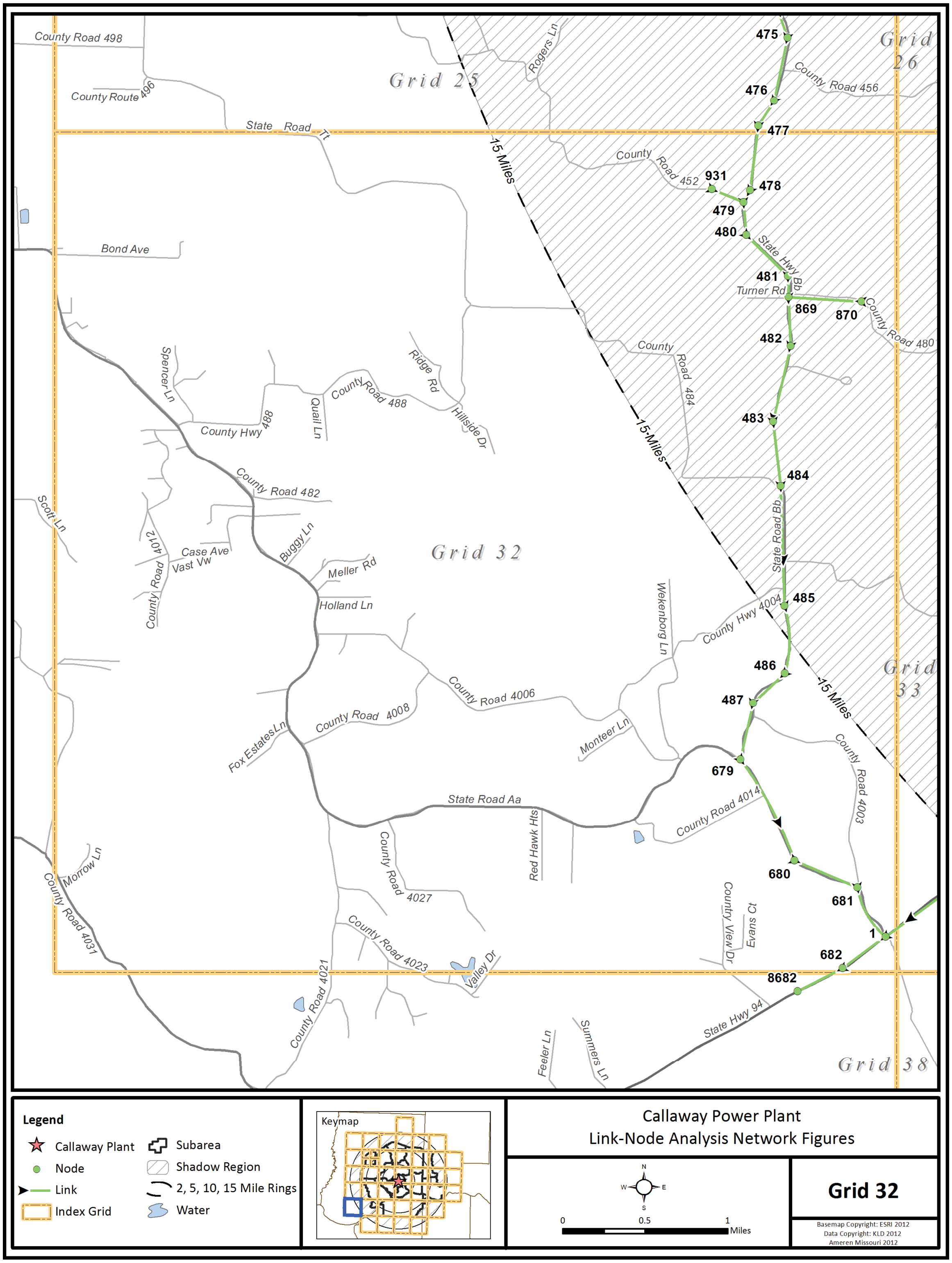


Figure K-33 Link-Node Analysis Network – Grid 32

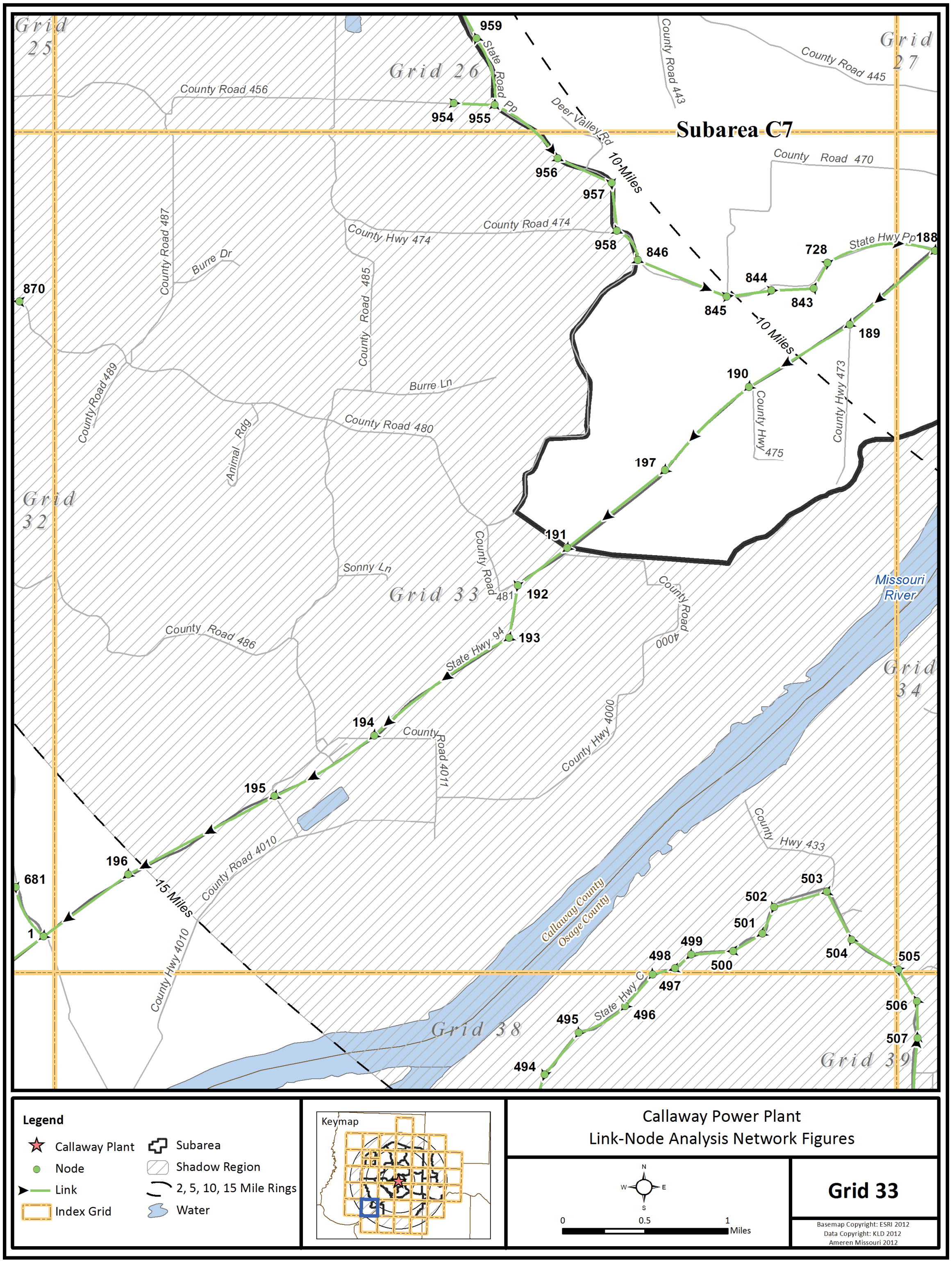


Figure K-34 Link-Node Analysis Network – Grid 33

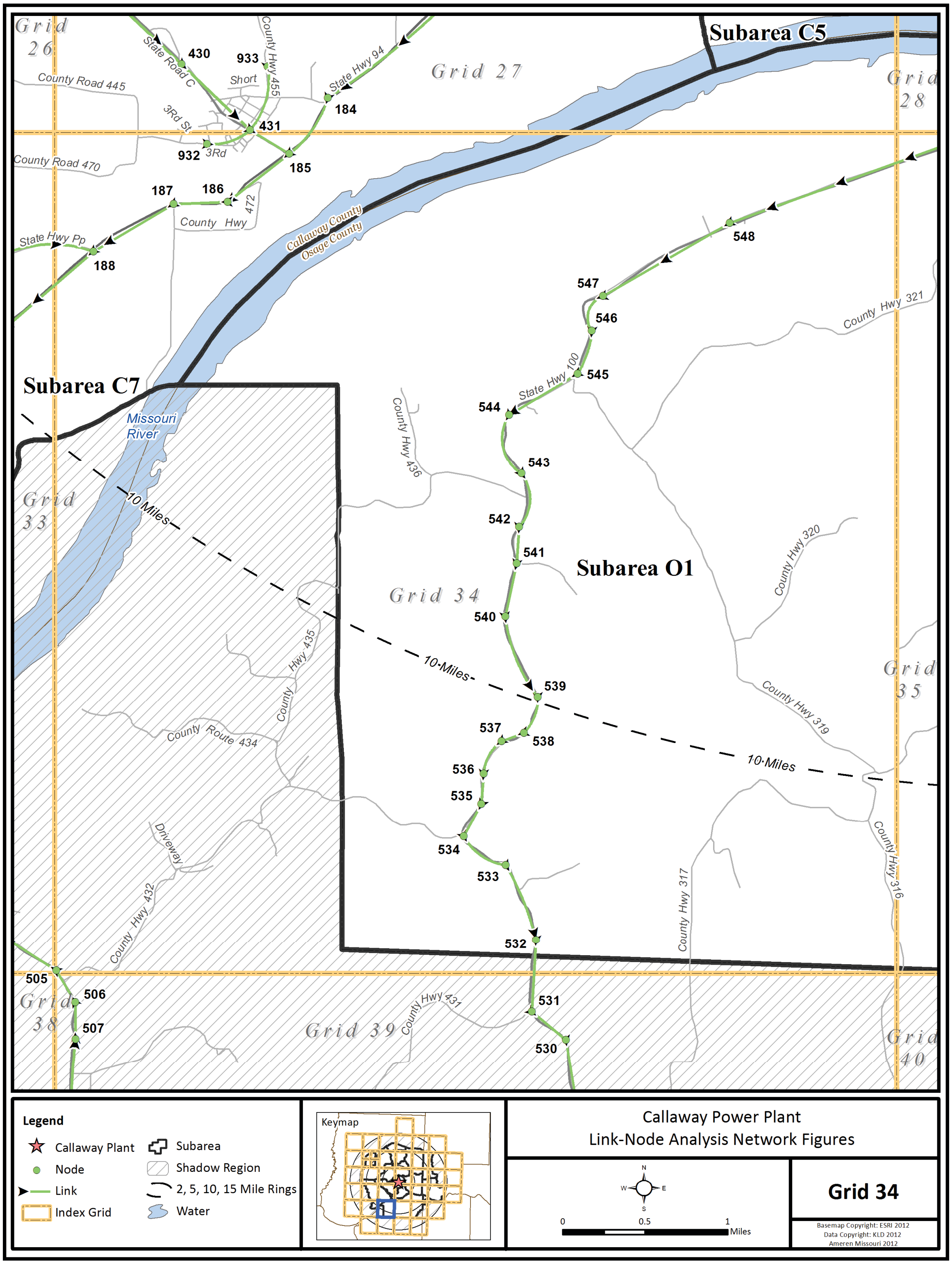


Figure K-35 Link-Node Analysis Network – Grid 34

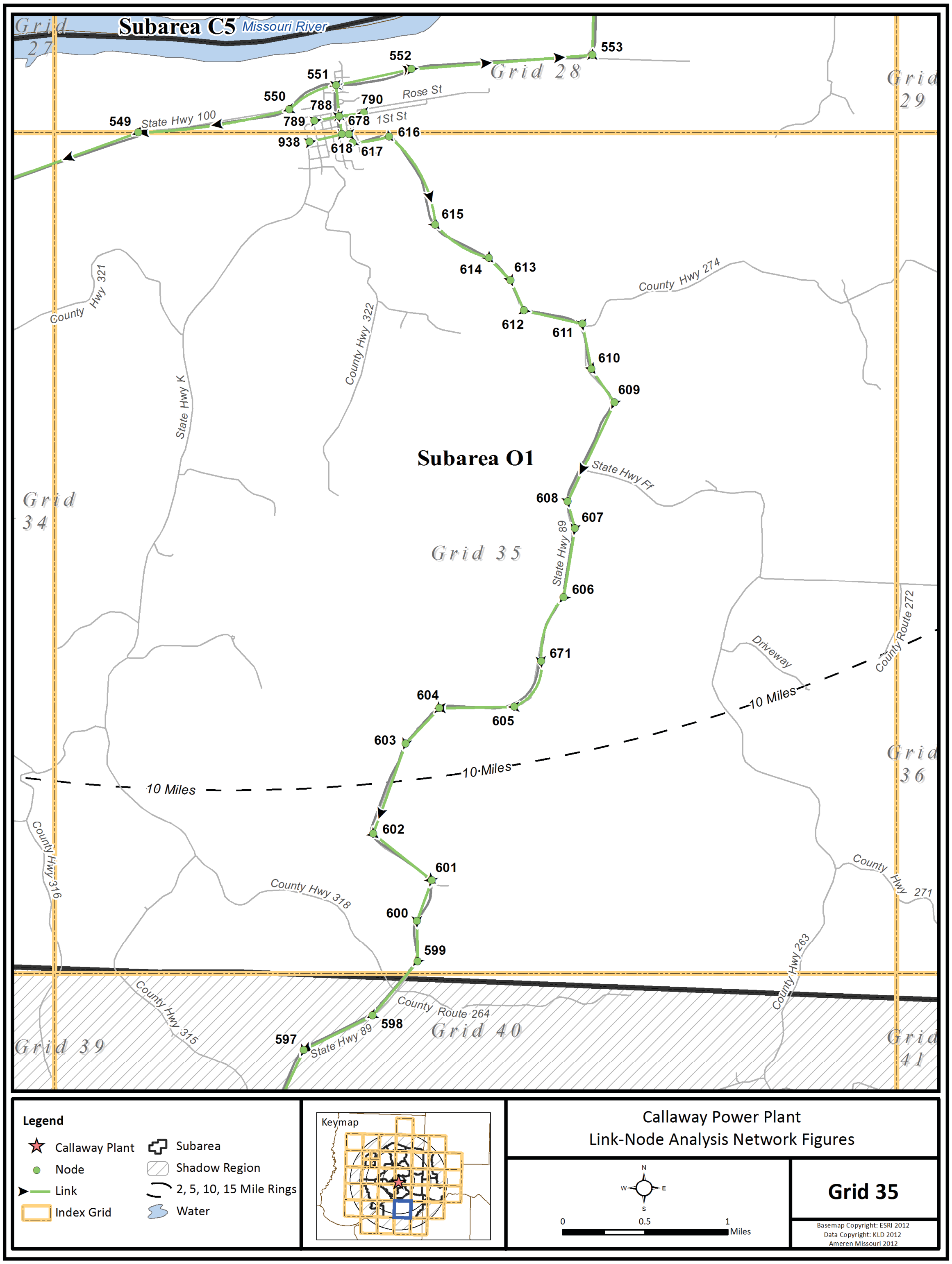


Figure K-36 Link-Node Analysis Network – Grid 35

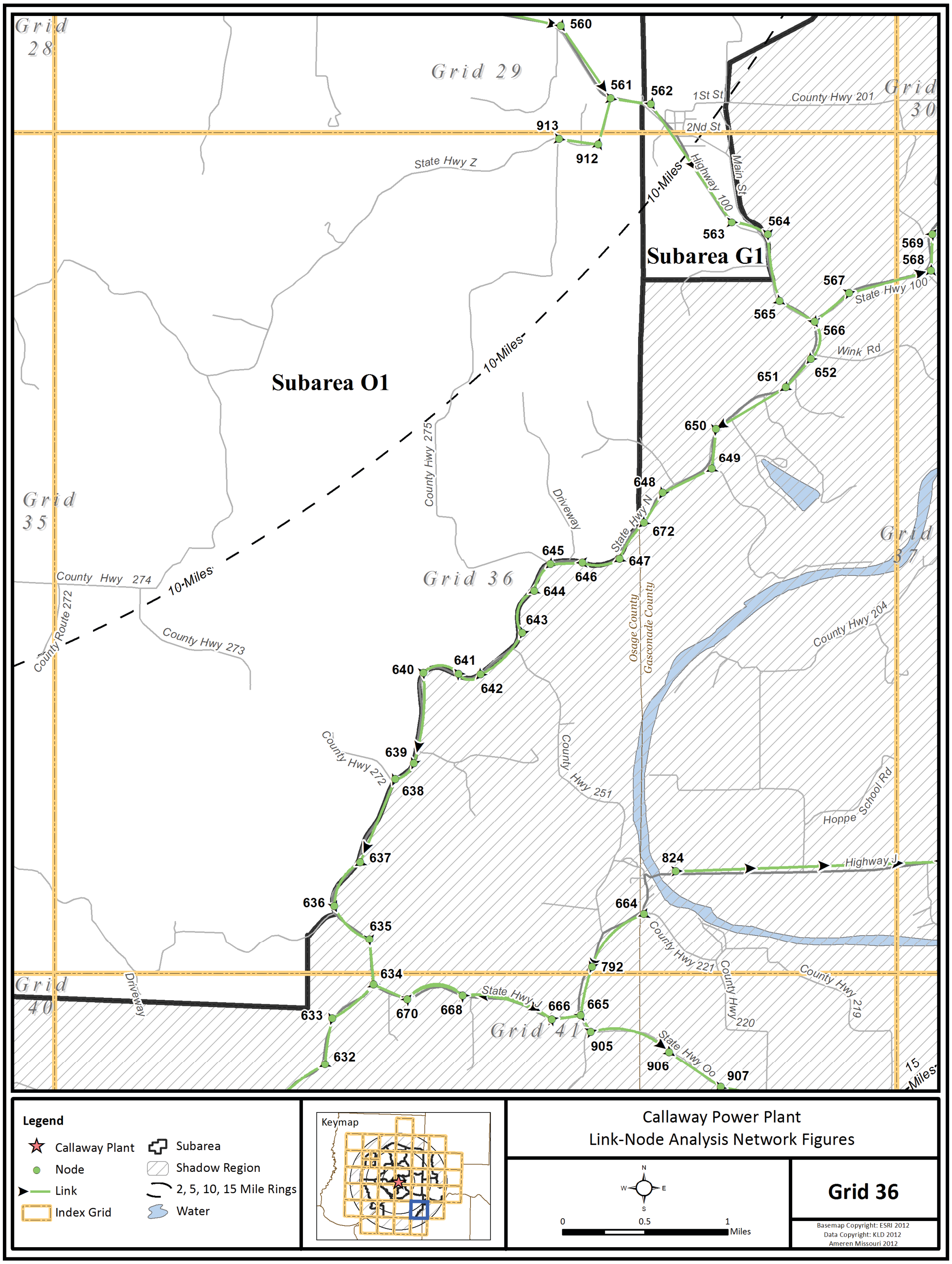


Figure K-37 Link-Node Analysis Network – Grid 36

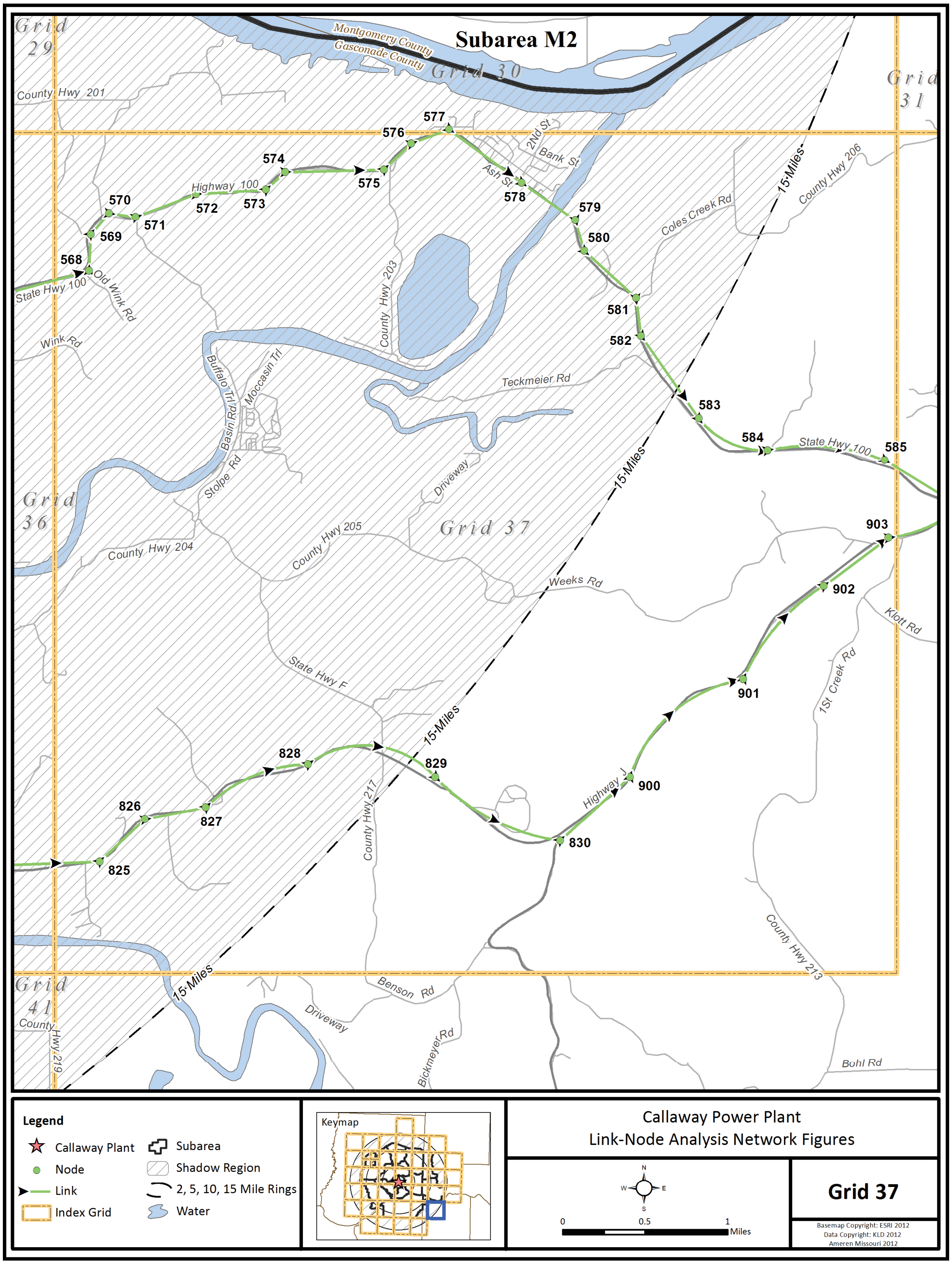


Figure K-38 Link-Node Analysis Network – Grid 37

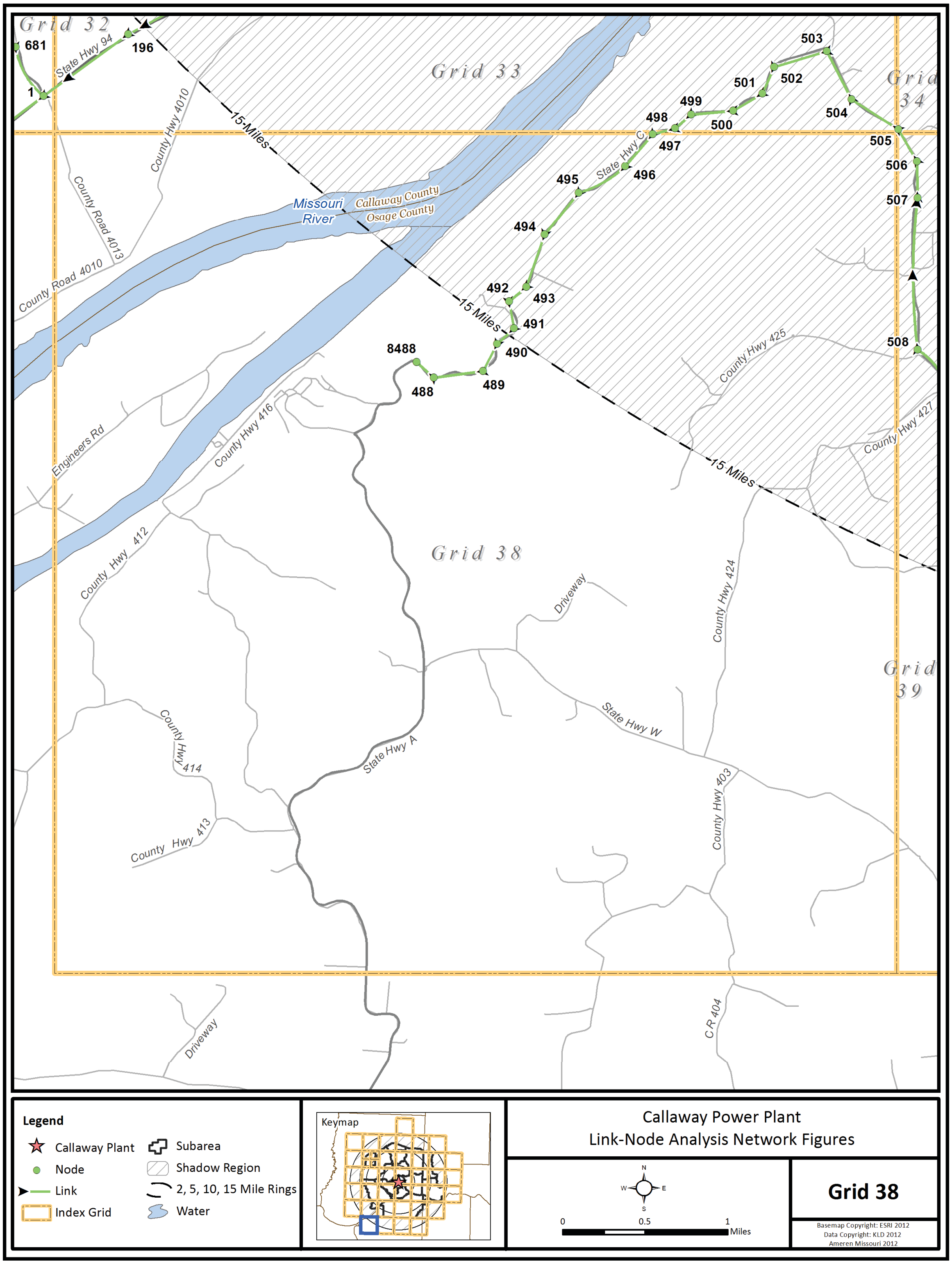


Figure K-39 Link-Node Analysis Network – Grid 38

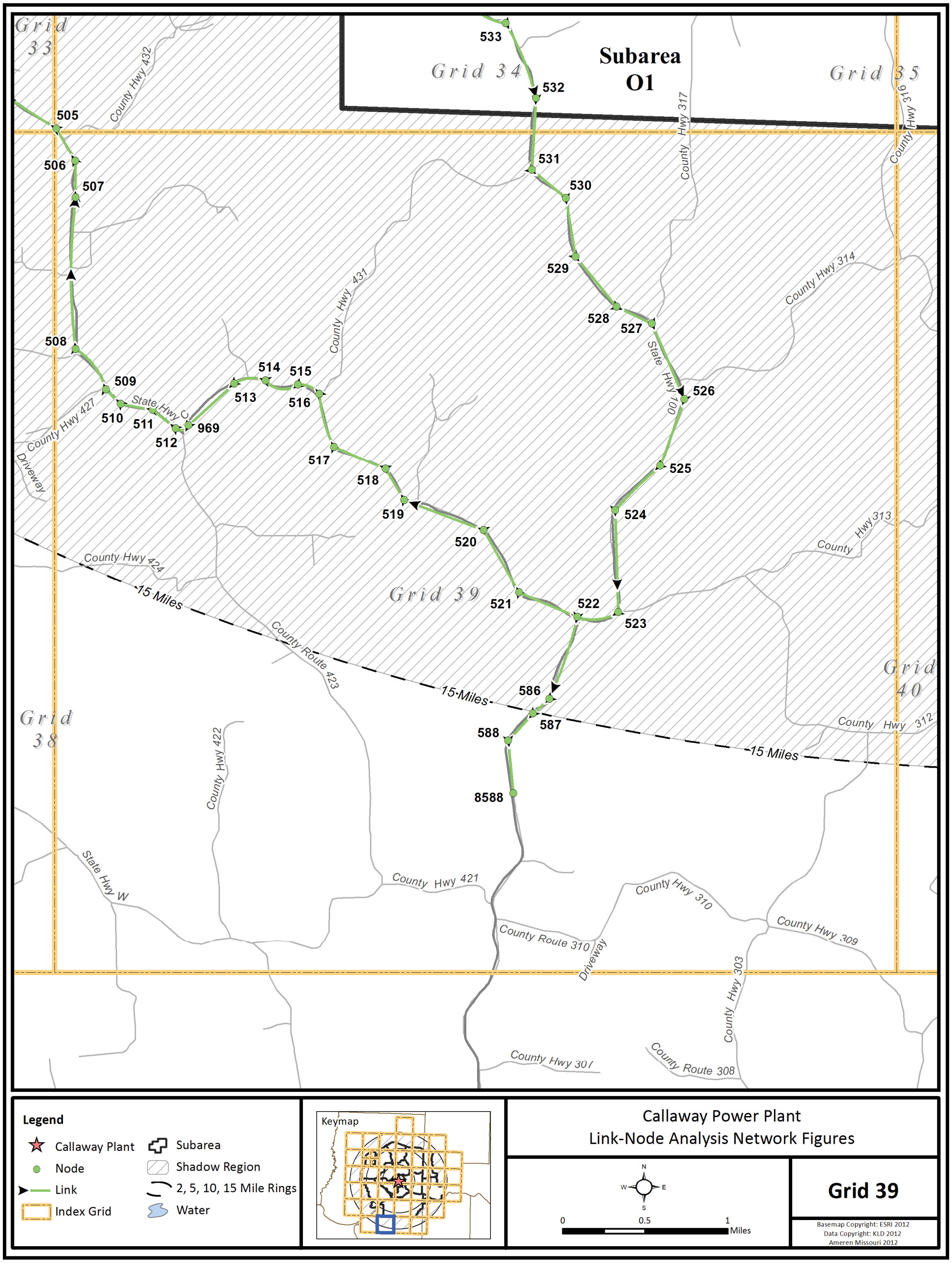


Figure K-40 Link-Node Analysis Network – Grid 39

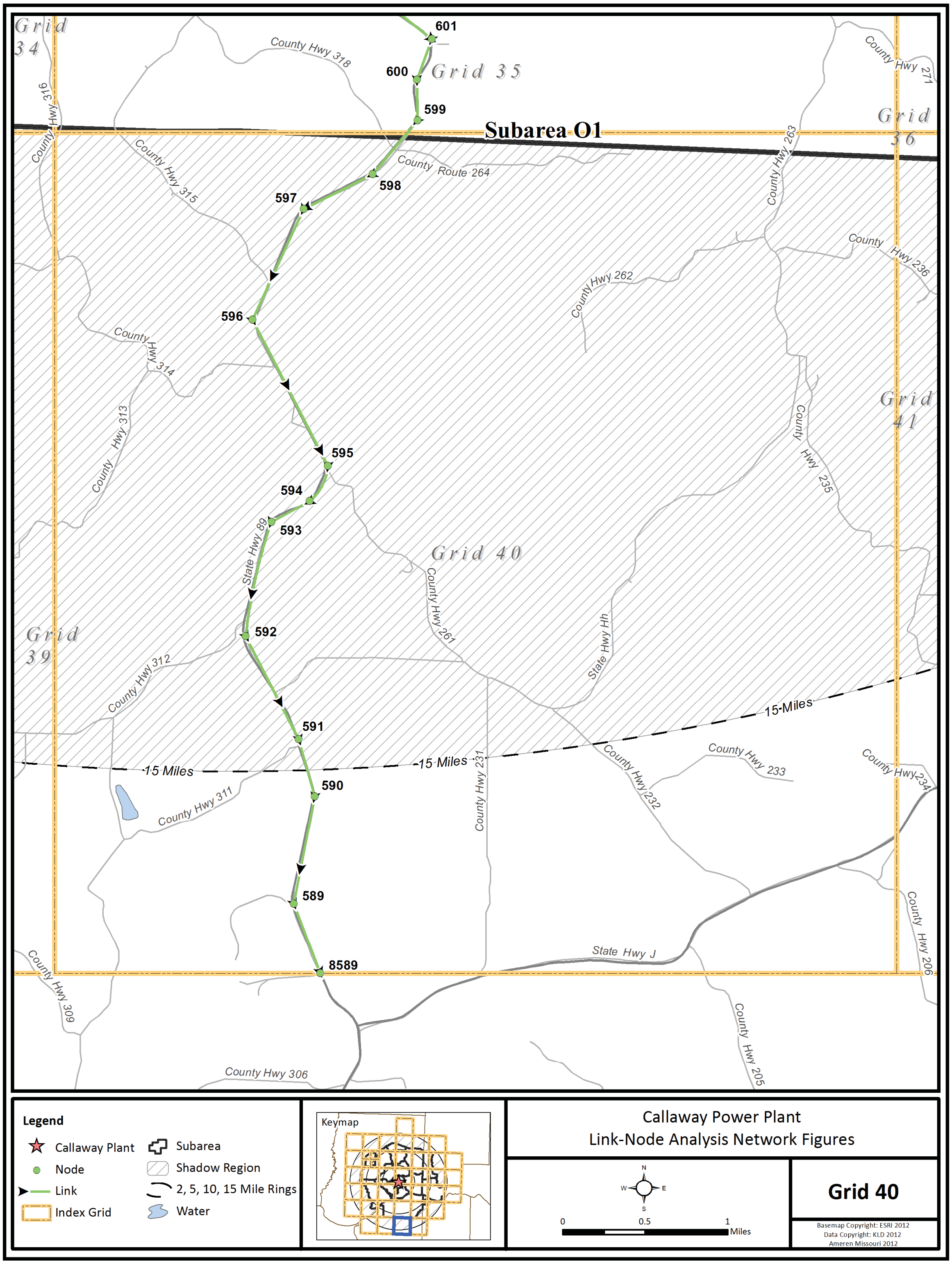


Figure K-41 Link-Node Analysis Network – Grid 40

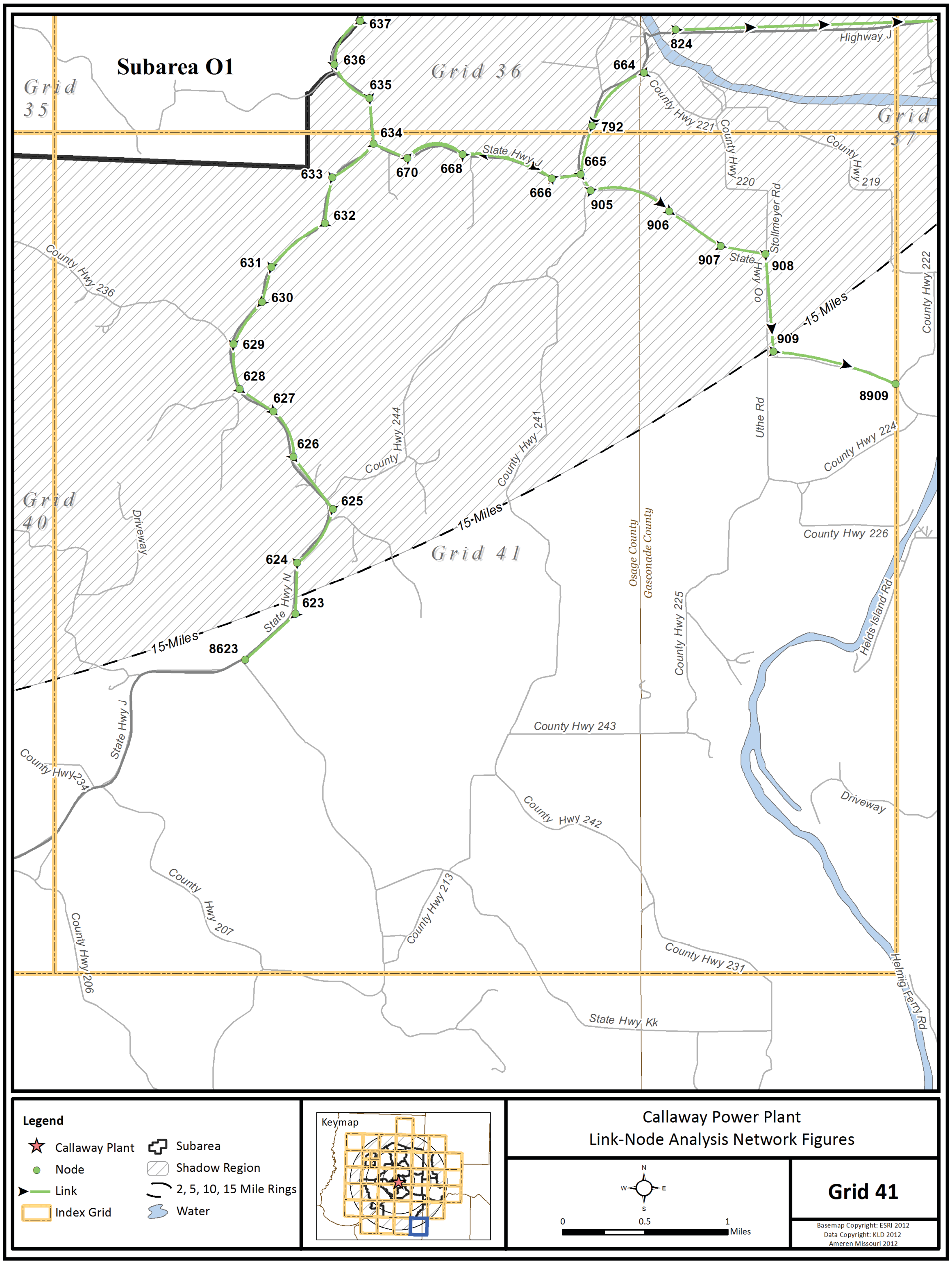


Figure K-42 Link-Node Analysis Network – Grid 41

Table K-1. Evacuation Roadway Network Characteristics

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
1	1	682	SR 94	COLLECTOR	1725	1	10	0	1700	60	32
2	5	29	I-70	FREEWAY	1809	2	12	10	2250	75	3
3	5	31	I-70 OFF-RAMP TO US-54	FREEWAY RAMP	1056	1	12	4	1750	45	3
4	5	975	I-70	FREEWAY	711	2	12	10	2250	75	3
5	6	7	I-70	FREEWAY	6321	2	12	10	2250	75	3
6	6	29	I-70	FREEWAY	5461	2	12	10	2250	75	3
7	7	6	I-70	FREEWAY	6321	2	12	10	2250	75	3
8	7	8	I-70	FREEWAY	4751	2	12	10	2250	75	4
9	8	7	I-70	FREEWAY	4751	2	12	10	2250	75	4
10	8	27	I-70	FREEWAY	6820	2	12	10	2250	75	4
11	9	10	I-70	FREEWAY	6121	2	12	10	2250	75	4
12	9	27	I-70	FREEWAY	2782	2	12	10	2250	75	4
13	10	9	I-70	FREEWAY	6121	2	12	10	2250	75	4
14	10	14	I-70	FREEWAY	5211	2	12	10	2250	75	4
15	11	12	I-70	FREEWAY	11919	2	12	10	2250	75	5
16	11	14	I-70	FREEWAY	2246	2	12	10	2250	75	4
17	11	79	I-70 OFF-RAMP TO MISSOURI A	FREEWAY RAMP	1129	1	12	4	1700	45	4

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
18	12	11	I-70	FREEWAY	11919	2	12	10	2250	75	5
19	12	13	I-70	FREEWAY	5614	2	12	10	2250	75	5
20	13	12	I-70	FREEWAY	5614	2	12	10	2250	75	5
21	13	15	I-70	FREEWAY	5580	2	12	10	2250	75	5
22	14	10	I-70	FREEWAY	5212	2	12	10	2250	75	4
23	14	11	I-70	FREEWAY	2246	2	12	10	2250	75	4
24	14	80	I-70 OFF-RAMP TO MISSOURI A	FREEWAY RAMP	1253	1	12	4	1700	45	4
25	15	13	I-70	FREEWAY	5580	2	12	10	2250	75	5
26	15	16	I-70	FREEWAY	6159	2	12	10	2250	75	5
27	16	15	I-70	FREEWAY	6159	2	12	10	2250	75	5
28	16	17	I-70	FREEWAY	1664	2	12	10	2250	75	6
29	16	83	I-70 OFF-RAMP TO MISSOURI D	FREEWAY RAMP	917	1	12	4	1700	45	6
30	17	16	I-70	FREEWAY	1664	2	12	10	2250	75	6
31	17	18	I-70	FREEWAY	9662	2	12	10	2250	75	6
32	17	84	I-70 OFF-RAMP TO MISSOURI D	FREEWAY RAMP	955	1	12	4	1700	45	6
33	18	17	I-70	FREEWAY	9662	2	12	10	2250	75	6
34	18	19	I-70	FREEWAY	2575	2	12	10	2250	75	6
35	19	18	I-70	FREEWAY	2569	2	12	10	2250	75	6

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
36	19	20	I-70	FREEWAY	9850	2	12	10	2250	75	6
37	20	19	I-70	FREEWAY	9850	2	12	10	2250	75	6
38	20	21	I-70	FREEWAY	1754	2	12	10	2250	75	15
39	21	20	I-70	FREEWAY	1752	2	12	10	2250	75	15
40	21	22	I-70	FREEWAY	12966	2	12	10	2250	75	7
41	22	21	I-70	FREEWAY	12966	2	12	10	2250	75	7
42	22	23	I-70	FREEWAY	1756	2	12	10	2250	75	7
43	23	22	I-70	FREEWAY	1756	2	12	10	2250	75	7
44	23	24	I-70	FREEWAY	2906	2	12	10	2250	75	7
45	24	23	I-70	FREEWAY	2906	2	12	10	2250	75	7
46	24	25	I-70	FREEWAY	1426	2	12	10	2250	75	7
47	25	24	I-70	FREEWAY	1426	2	12	10	2250	75	7
48	25	26	I-70	FREEWAY	2798	2	12	10	2250	75	7
49	26	25	I-70	FREEWAY	2798	2	12	10	2250	75	7
50	26	800	I-70	FREEWAY	2433	2	12	10	2250	75	7
51	27	8	I-70	FREEWAY	6820	2	12	10	2250	75	4
52	27	9	I-70	FREEWAY	2788	2	12	10	2250	75	4
53	28	30	US-54	FREEWAY	1443	2	12	10	1750	50	3
54	29	5	I-70	FREEWAY	1809	2	12	10	2250	75	3
55	29	6	I-70	FREEWAY	5461	2	12	10	2250	75	3

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
56	29	30	I-70 OFF-RAMP TO US-54	FREEWAY RAMP	850	1	12	4	1750	45	3
57	30	5	I-70 ON-RAMP FROM US-54	FREEWAY RAMP	1082	1	12	4	1700	45	3
58	30	28	US-54	FREEWAY	1443	2	12	10	1900	50	3
59	30	31	US-54	FREEWAY	694	2	12	10	1750	50	3
60	31	29	I-70 ON-RAMP FROM US-54	FREEWAY RAMP	890	1	12	4	1700	45	3
61	31	30	US-54	FREEWAY	694	2	12	10	1750	50	3
62	31	32	US-54	FREEWAY	837	2	12	10	1750	50	3
63	32	31	US-54	FREEWAY	837	2	12	10	1750	50	3
64	32	33	US-54	FREEWAY	3666	2	12	10	1900	70	3
65	33	32	US-54	FREEWAY	3666	2	12	10	1750	70	3
66	33	38	US-54	FREEWAY	5677	2	12	10	1900	75	3
67	38	33	US-54	FREEWAY	5677	2	12	10	1900	75	3
68	38	39	US-54	FREEWAY	3799	2	12	10	1900	75	3
69	39	38	US-54	FREEWAY	3799	2	12	10	1900	75	3
70	39	45	US-54	FREEWAY	3501	2	12	10	1900	75	3
71	40	45	US-54	FREEWAY	700	2	12	10	1900	75	9
72	40	47	US-54	FREEWAY	1761	2	12	10	2250	65	9
73	45	39	US-54	FREEWAY	3501	2	12	10	1900	75	3

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
74	45	40	US-54	FREEWAY	700	2	12	10	1900	75	9
75	47	40	US-54	FREEWAY	1766	2	12	10	2250	65	9
76	47	49	US-54	FREEWAY	6349	2	12	10	2250	75	9
77	48	40	US-54 BUS	FREEWAY RAMP	2131	1	12	8	1700	50	9
78	49	47	US-54	FREEWAY	6349	2	12	10	2250	75	9
79	49	50	US-54	FREEWAY	2162	2	12	10	2250	75	9
80	49	770	US-54 OFF-RAMP TO MISSOURI HH	FREEWAY RAMP	1113	1	12	4	1700	45	9
81	50	49	US-54	FREEWAY	2162	2	12	10	2250	75	9
82	50	51	US-54	FREEWAY	1623	2	12	10	2250	75	9
83	50	769	US-54 OFF-RAMP TO MISSOURI HH	FREEWAY RAMP	1182	1	12	4	1700	45	9
84	51	50	US-54	FREEWAY	1606	2	12	10	2250	75	9
85	51	52	US-54	FREEWAY	3882	2	12	10	2250	75	9
86	52	51	US-54	FREEWAY	3882	2	12	10	2250	75	9
87	52	53	US-54	FREEWAY	3661	2	12	10	2250	75	11
88	53	52	US-54	FREEWAY	3661	2	12	10	2250	75	11
89	53	54	US-54	FREEWAY	1424	2	12	10	2250	65	11
90	53	56	US-54 OFF-RAMP TO MLK JR BLVD	FREEWAY RAMP	712	1	12	4	1700	45	11

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
91	54	53	US-54	FREEWAY	1424	2	12	10	2250	75	11
92	54	55	US-54	FREEWAY	3825	2	12	10	2250	75	11
93	54	57	US-54 OFF-RAMP TO MLK JR BLVD	FREEWAY RAMP	650	1	12	4	1700	45	11
94	55	54	US-54	FREEWAY	3825	2	12	10	2250	75	11
95	55	60	US-54	FREEWAY	4561	2	12	10	2250	75	11
96	56	54	US-54 ON-RAMP FROM MLK JR BLVD	FREEWAY RAMP	849	1	12	4	1700	45	11
97	56	57	MLK JR BLVD	COLLECTOR	653	1	12	10	1700	55	11
98	56	59	MLK JR BLVD	COLLECTOR	1120	1	10	8	1700	60	11
99	57	53	US-54 ON-RAMP FROM MLK JR BLVD	FREEWAY RAMP	900	1	12	4	1700	45	11
100	57	56	MLK JR BLVD	COLLECTOR	653	1	12	10	1700	55	11
101	58	57	MLK JR BLVD	COLLECTOR	1509	1	12	10	1700	55	11
102	59	56	MLK JR BLVD	COLLECTOR	1120	1	10	8	1700	60	11
103	59	213	MISSOURI F	COLLECTOR	3014	1	10	8	1700	60	11
104	59	432	CO RD 304	COLLECTOR	4646	1	10	0	1700	45	11
105	60	55	US-54	FREEWAY	4561	2	12	10	2250	75	11
106	60	61	US-54	FREEWAY	2253	2	12	10	2250	75	19
107	60	64	US-54 OFF-RAMP TO MISSOURI H	FREEWAY RAMP	1228	1	12	4	1700	45	19

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
108	61	60	US-54	FREEWAY	2253	2	12	10	2250	75	19
109	61	62	US-54	FREEWAY	2722	2	12	10	2250	75	19
110	61	65	US-54 OFF-RAMP TO MISSOURI H	FREEWAY RAMP	1266	1	12	4	1700	45	19
111	62	61	US-54	FREEWAY	2728	2	12	10	2250	75	19
112	62	63	US-54	FREEWAY	4262	2	12	10	2250	75	18
113	63	62	US-54	FREEWAY	4262	2	12	10	2250	75	18
114	63	74	US-54	FREEWAY	3023	2	12	10	1900	75	18
115	64	61	US-54 ON-RAMP FROM MISSOURI H	FREEWAY RAMP	1153	1	12	4	1700	45	19
116	64	65	MISSOURI H	COLLECTOR	660	1	12	4	1700	55	19
117	64	67	MISSOURI H	COLLECTOR	460	1	12	4	1700	45	19
118	65	60	US-54 ON-RAMP FROM MISSOURI H	FREEWAY RAMP	1046	1	12	4	1700	45	19
119	65	64	MISSOURI H	COLLECTOR	660	1	12	4	1700	55	19
120	66	441	US-54 BUS	COLLECTOR	1096	1	12	4	1700	40	19
121	67	64	MISSOURI H	COLLECTOR	460	1	12	4	1700	45	19
122	67	434	MISSOURI H	COLLECTOR	9300	1	10	0	1700	50	18
123	68	69	US-54	FREEWAY	4916	2	12	10	1900	75	18
124	68	74	US-54	FREEWAY	1540	2	12	10	1900	75	18
125	69	68	US-54	FREEWAY	4916	2	12	10	1900	75	18

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
126	69	761	US-54	FREEWAY	4402	2	12	10	1900	75	18
127	70	71	US-54	FREEWAY	8586	2	12	10	1900	75	18
128	70	760	US-54	FREEWAY	3526	2	12	10	1900	75	18
129	71	70	US-54	FREEWAY	8581	2	12	10	1900	75	18
130	71	72	US-54	FREEWAY	2677	2	12	10	2250	75	25
131	72	71	US-54	FREEWAY	2677	2	12	10	2250	75	25
132	72	794	US-54	FREEWAY	5359	2	12	10	2250	75	25
133	73	756	US-54	FREEWAY	838	2	12	10	2250	75	25
134	73	793	US-54 OFF-RAMP TO CO RD 436	FREEWAY RAMP	1607	1	12	4	1700	45	25
135	73	794	US-54	FREEWAY	2801	2	12	10	2250	75	25
136	74	63	US-54	FREEWAY	3023	2	12	10	1900	75	18
137	74	68	US-54	FREEWAY	1540	2	12	10	1900	75	18
138	75	74	COUNTY RD 318	COLLECTOR	285	1	10	0	1575	35	18
139	75	447	OLD US HWY 54	COLLECTOR	1980	1	10	0	1700	55	18
140	77	761	CO ROAD 328	COLLECTOR	415	1	12	4	1575	35	18
141	78	761	STATE HWY BB	COLLECTOR	461	1	12	4	1575	35	18
142	79	14	I-70 ON-RAMP FROM MISSOURI A	FREEWAY RAMP	1227	1	12	4	1700	45	4
143	79	822	MISSOURI A	COLLECTOR	276	1	10	0	1700	65	4

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
144	80	11	I-70 ON-RAMP FROM MISSOURI A	FREEWAY RAMP	1104	1	12	4	1700	45	4
145	80	79	MISSOURI A	COLLECTOR	712	1	12	4	1700	65	4
146	81	412	MISSOURI A	COLLECTOR	1525	1	10	0	1700	45	4
147	82	80	MISSOURI Z	COLLECTOR	1439	1	10	2	1700	55	4
148	83	17	I-70 ON-RAMP FROM MISSOURI D	FREEWAY RAMP	1034	1	12	4	1700	45	6
149	83	84	MISSOURI D	COLLECTOR	898	1	12	4	1700	45	6
150	84	16	I-70 ON-RAMP FROM MISSOURI D	FREEWAY RAMP	884	1	12	4	1700	45	6
151	84	83	MISSOURI D	COLLECTOR	898	1	12	4	1700	55	6
152	85	84	MISSOURI D	COLLECTOR	1892	1	11	0	1700	50	6
153	92	895	OLD US 40	COLLECTOR	4377	1	10	0	1700	50	4
154	94	92	COUNTY RD 159	COLLECTOR	847	1	12	4	1700	45	4
155	95	94	MISSOURI JJ	COLLECTOR	4522	1	10	0	1700	55	4
156	96	95	MISSOURI JJ	COLLECTOR	2997	1	10	0	1700	55	4
157	96	785	MISSOURI Z	COLLECTOR	1726	1	10	0	1700	45	4
158	97	411	MISSOURI JJ	COLLECTOR	2444	1	10	0	1700	50	4
159	98	97	MISSOURI JJ	COLLECTOR	1222	1	10	0	1700	45	4
160	99	98	MISSOURI JJ	COLLECTOR	1592	1	10	0	1700	45	4
161	100	99	MISSOURI JJ	COLLECTOR	2448	1	10	0	1700	50	4

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
162	101	100	MISSOURI JJ	COLLECTOR	2562	1	10	0	1700	50	13
163	102	101	MISSOURI JJ	COLLECTOR	1493	1	10	0	1700	45	13
164	103	102	MISSOURI JJ	COLLECTOR	887	1	10	0	1700	45	13
165	104	103	MISSOURI JJ	COLLECTOR	1111	1	10	0	1700	45	13
166	105	104	MISSOURI JJ	COLLECTOR	1360	1	10	0	1700	45	13
167	106	105	MISSOURI JJ	COLLECTOR	1319	1	10	0	1700	45	13
168	107	106	MISSOURI JJ	COLLECTOR	1383	1	10	0	1700	45	13
169	108	107	MISSOURI JJ	COLLECTOR	802	1	10	0	1700	45	13
170	109	108	MISSOURI JJ	COLLECTOR	695	1	10	0	1700	45	13
171	111	109	MISSOURI JJ	COLLECTOR	1412	1	10	0	1700	45	13
172	113	111	MISSOURI JJ	COLLECTOR	2229	1	10	0	1700	45	13
173	114	113	MISSOURI JJ	COLLECTOR	2116	1	10	0	1700	45	13
174	115	114	MISSOURI JJ	COLLECTOR	1876	1	10	0	1700	45	13
175	116	115	MISSOURI JJ	COLLECTOR	2598	1	10	0	1700	40	13
176	117	116	MISSOURI JJ	COLLECTOR	1794	1	10	0	1700	55	13
177	118	117	MISSOURI JJ	COLLECTOR	2246	1	10	0	1700	55	13
178	118	222	MISSOURI UU	COLLECTOR	1883	1	10	0	1700	45	13
179	119	82	MISSOURI Z	COLLECTOR	2757	1	10	0	1700	55	4
180	120	119	MISSOURI Z	COLLECTOR	1609	1	10	0	1700	55	4
181	121	120	MISSOURI Z	COLLECTOR	2646	1	10	0	1700	55	4

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
182	122	121	MISSOURI Z	COLLECTOR	1898	1	10	0	1700	55	4
183	123	122	MISSOURI Z	COLLECTOR	2105	1	10	0	1700	55	4
184	124	125	MISSOURI A	COLLECTOR	2861	1	10	0	1700	45	4
185	125	126	MISSOURI A	COLLECTOR	1214	1	10	0	1700	50	4
186	126	127	MISSOURI A	COLLECTOR	1492	1	10	0	1700	50	4
187	127	128	MISSOURI A	COLLECTOR	1411	1	10	0	1700	45	4
188	128	129	MISSOURI A	COLLECTOR	1120	1	10	0	1700	40	4
189	129	130	MISSOURI A	COLLECTOR	1227	1	10	0	1700	45	4
190	130	131	MISSOURI A	COLLECTOR	548	1	10	0	1575	35	0
191	131	132	MISSOURI A	COLLECTOR	3187	1	10	0	1700	50	1
192	132	133	MISSOURI A	COLLECTOR	740	1	10	0	1575	35	1
193	134	85	OLD U.S. 40	COLLECTOR	12316	1	10	0	1700	55	5
194	134	677	OLD U.S. 40	COLLECTOR	5535	1	10	0	1700	45	5
195	135	134	MISSOURI D	COLLECTOR	7633	1	10	0	1700	55	5
196	136	135	MISSOURI D	COLLECTOR	1037	1	10	0	1700	45	14
197	137	136	MISSOURI D	COLLECTOR	1042	1	10	0	1700	45	14
198	138	137	MISSOURI D	COLLECTOR	1270	1	10	0	1700	45	14
199	139	138	MISSOURI D	COLLECTOR	2194	1	10	0	1700	45	14
200	140	139	MISSOURI D	COLLECTOR	1130	1	10	0	1700	45	14
201	141	140	MISSOURI D	COLLECTOR	1117	1	10	0	1700	45	14

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
202	142	141	MISSOURI D	COLLECTOR	1497	1	10	0	1700	45	14
203	143	142	MISSOURI D	COLLECTOR	1304	1	10	0	1700	45	14
204	144	143	MISSOURI D	COLLECTOR	1116	1	10	0	1700	45	14
205	145	144	MISSOURI D	COLLECTOR	1988	1	10	0	1700	45	14
206	146	145	MISSOURI D	COLLECTOR	1588	1	10	0	1700	45	14
207	147	146	MISSOURI D	COLLECTOR	2933	1	10	0	1700	45	14
208	148	147	MISSOURI D	COLLECTOR	1483	1	10	0	1700	45	14
209	149	676	MISSOURI D	COLLECTOR	3772	1	10	0	1700	45	14
210	150	675	MISSOURI D	COLLECTOR	1191	1	10	0	1700	45	14
211	151	150	MISSOURI D	COLLECTOR	1293	1	10	0	1700	45	14
212	152	674	MISSOURI D	COLLECTOR	1302	1	10	0	1700	45	14
213	153	152	MISSOURI D	COLLECTOR	3761	1	10	0	1700	45	14
214	154	153	MISSOURI D	COLLECTOR	1409	1	10	0	1700	45	21
215	155	154	MISSOURI D	COLLECTOR	2538	1	10	0	1700	45	21
216	156	155	MISSOURI D	COLLECTOR	5170	1	10	0	1700	45	21
217	156	673	MISSOURI K	COLLECTOR	5448	1	11	0	1700	55	21
218	157	156	MISSOURI D	COLLECTOR	4083	1	10	0	1700	55	21
219	157	158	MISSOURI D	COLLECTOR	1470	1	10	0	1700	45	21
220	158	159	MISSOURI D	COLLECTOR	4245	1	10	0	1700	45	21
221	159	160	MISSOURI D	COLLECTOR	2222	1	10	0	1700	45	21

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
222	160	694	MISSOURI D	COLLECTOR	1089	1	10	0	1700	45	21
223	161	162	MISSOURI D	COLLECTOR	2492	1	10	0	1700	45	21
224	162	163	MISSOURI D	COLLECTOR	2938	1	10	0	1700	45	28
225	163	164	MISSOURI D	COLLECTOR	1979	1	10	0	1700	45	28
226	164	198	MISSOURI D	COLLECTOR	895	1	10	0	1700	45	29
227	165	166	MISSOURI D	COLLECTOR	1888	1	10	0	1700	45	29
228	166	167	MISSOURI D	COLLECTOR	1290	1	10	0	1700	45	29
229	167	318	SR 94	COLLECTOR	1162	1	10	0	1700	45	29
230	168	167	SR 94	COLLECTOR	3802	1	10	0	1700	50	28
231	169	168	SR 94	COLLECTOR	1118	1	10	0	1575	40	28
232	170	169	SR 94	COLLECTOR	1107	1	10	0	1575	40	28
233	171	170	SR 94	COLLECTOR	1492	1	10	0	1575	50	28
234	172	171	SR 94	COLLECTOR	3196	1	10	0	1575	60	28
235	173	172	SR 94	COLLECTOR	1735	1	10	0	1700	60	28
236	174	173	SR 94	COLLECTOR	1229	1	10	0	1700	50	28
237	175	174	SR 94	COLLECTOR	1972	1	10	0	1700	50	28
238	176	175	SR 94	COLLECTOR	2825	1	10	0	1700	45	28
239	177	176	SR 94	COLLECTOR	3525	1	10	0	1700	45	28
240	178	177	SR 94	COLLECTOR	2523	1	10	0	1700	45	28
241	179	178	SR 94	COLLECTOR	3199	1	10	0	1700	45	28

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
242	179	180	SR 94	COLLECTOR	2463	1	10	0	1700	45	28
243	180	181	SR 94	COLLECTOR	6583	1	10	0	1700	45	27
244	181	182	SR 94	COLLECTOR	4147	1	10	0	1700	60	27
245	182	183	SR 94	COLLECTOR	7229	1	10	0	1700	60	27
246	183	184	SR 94	COLLECTOR	5399	1	10	0	1700	60	27
247	184	185	SR 94	COLLECTOR	2204	1	12	0	1700	50	27
248	185	186	SR 94	COLLECTOR	2505	1	10	0	1575	45	34
249	186	187	SR 94	COLLECTOR	1740	1	10	0	1700	60	34
250	187	188	SR 94	COLLECTOR	2987	1	10	0	1700	60	34
251	188	189	SR 94	COLLECTOR	3618	1	10	0	1700	60	33
252	189	190	SR 94	COLLECTOR	3809	1	10	0	1700	60	33
253	190	197	SR 94	COLLECTOR	3812	1	10	0	1700	60	33
254	191	192	SR 94	COLLECTOR	1984	1	10	0	1700	60	33
255	192	193	SR 94	COLLECTOR	1697	1	10	0	1700	60	33
256	193	194	SR 94	COLLECTOR	5360	1	10	0	1700	60	33
257	194	195	SR 94	COLLECTOR	3750	1	10	0	1700	55	33
258	195	196	SR 94	COLLECTOR	5336	1	10	0	1700	60	33
259	196	1	SR 94	COLLECTOR	3352	1	10	0	1700	60	33
260	197	191	SR 94	COLLECTOR	4009	1	10	0	1700	60	33
261	198	165	MISSOURI D	COLLECTOR	2052	1	10	0	1700	45	29

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
262	199	96	MISSOURI Z	COLLECTOR	1885	1	10	0	1700	45	4
263	200	199	MISSOURI Z	COLLECTOR	3857	1	10	0	1700	55	4
264	201	200	MISSOURI Z	COLLECTOR	3226	1	10	0	1700	55	4
265	202	201	MISSOURI Z	COLLECTOR	2748	1	10	0	1700	55	4
266	203	202	MISSOURI Z	COLLECTOR	2711	1	10	0	1700	55	13
267	204	203	MISSOURI Z	COLLECTOR	2330	1	10	0	1700	55	13
268	205	204	MISSOURI Z	COLLECTOR	5126	1	10	0	1700	55	10
269	206	205	MISSOURI Z	COLLECTOR	1486	1	10	0	1700	55	10
270	207	206	MISSOURI Z	COLLECTOR	3179	1	10	0	1700	55	10
271	207	380	MISSOURI Z	COLLECTOR	1227	1	10	0	1700	55	10
272	213	214	MISSOURI F	COLLECTOR	1539	1	10	0	1700	60	11
273	214	215	MISSOURI F	COLLECTOR	2931	1	10	0	1700	60	8
274	215	216	MISSOURI F	COLLECTOR	3513	1	10	0	1700	60	8
275	216	217	MISSOURI F	COLLECTOR	1784	1	10	0	1700	60	8
276	217	218	MISSOURI F	COLLECTOR	2609	1	10	0	1700	60	8
277	218	219	MISSOURI F	COLLECTOR	1853	1	10	0	1700	60	8
278	219	220	MISSOURI F	COLLECTOR	2339	1	10	0	1700	60	8
279	220	221	MISSOURI F	COLLECTOR	2088	1	10	0	1700	60	8
280	222	223	MISSOURI UU	COLLECTOR	1456	1	10	0	1700	40	13
281	223	224	MISSOURI UU	COLLECTOR	971	1	10	0	1700	45	13

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
282	224	225	MISSOURI UU	COLLECTOR	6896	1	10	0	1700	50	13
283	225	226	MISSOURI UU	COLLECTOR	3866	1	10	0	1700	50	13
284	226	227	MISSOURI UU	COLLECTOR	2085	1	10	0	1700	40	13
285	227	228	MISSOURI UU	COLLECTOR	2031	1	10	0	1700	40	13
286	228	229	MISSOURI UU	COLLECTOR	1613	1	10	0	1700	45	13
287	229	230	MISSOURI UU	COLLECTOR	2177	1	10	0	1700	50	13
288	230	233	MISSOURI UU	COLLECTOR	1623	1	10	0	1700	45	13
289	231	232	MISSOURI UU	COLLECTOR	7181	1	10	0	1700	55	12
290	232	393	MISSOURI O	COLLECTOR	1068	1	10	0	1700	40	12
291	233	231	MISSOURI UU	COLLECTOR	1380	1	10	0	1700	45	12
292	234	717	MISSOURI J	COLLECTOR	1266	1	8	0	1575	35	7
293	235	234	MISSOURI J	COLLECTOR	1093	1	8	0	1700	45	7
294	236	235	MISSOURI J	COLLECTOR	1338	1	8	0	1700	45	16
295	237	236	MISSOURI J	COLLECTOR	1627	1	8	0	1700	45	16
296	238	237	MISSOURI J	COLLECTOR	1678	1	8	0	1700	40	16
297	239	238	MISSOURI J	COLLECTOR	1771	1	8	0	1700	45	16
298	240	239	MISSOURI J	COLLECTOR	1353	1	8	0	1700	45	16
299	241	240	MISSOURI J	COLLECTOR	2206	1	8	0	1700	45	16
300	242	241	MISSOURI J	COLLECTOR	1352	1	8	0	1700	45	16
301	243	242	MISSOURI J	COLLECTOR	2674	1	8	0	1700	45	16

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
302	244	243	MISSOURI J	COLLECTOR	2729	1	8	0	1700	45	16
303	245	246	MISSOURI J	COLLECTOR	2796	1	8	0	1700	40	16
304	246	247	MISSOURI J	COLLECTOR	737	1	8	0	1575	35	16
305	247	248	MISSOURI J	COLLECTOR	5186	1	8	0	1700	45	16
306	248	249	MISSOURI J	COLLECTOR	1350	1	8	0	1575	35	16
307	249	250	MISSOURI J	COLLECTOR	1991	1	8	0	1700	45	16
308	250	251	MISSOURI J	COLLECTOR	1801	1	8	0	1700	45	16
309	251	252	MISSOURI J	COLLECTOR	1654	1	8	0	1575	35	16
310	252	253	MISSOURI J	COLLECTOR	1747	1	8	0	1700	45	16
311	253	254	MISSOURI J	COLLECTOR	1668	1	8	0	1700	45	16
312	254	255	MISSOURI J	COLLECTOR	2889	1	8	0	1700	45	16
313	255	256	MISSOURI J	COLLECTOR	1691	1	8	0	1700	45	16
314	256	257	MISSOURI J	COLLECTOR	1178	1	8	0	1700	45	17
315	257	258	MISSOURI J	COLLECTOR	1479	1	8	0	1700	40	17
316	258	259	MISSOURI J	COLLECTOR	1395	1	8	0	1700	45	17
317	259	718	MISSOURI J	COLLECTOR	2303	1	8	0	1700	45	17
318	260	261	MISSOURI K	COLLECTOR	1196	1	11	0	1700	40	22
319	261	262	MISSOURI K	COLLECTOR	5061	1	11	0	1700	50	22
320	262	263	MISSOURI K	COLLECTOR	2442	1	11	0	1700	50	22
321	263	264	MISSOURI K	COLLECTOR	2016	1	11	0	1700	50	22

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
322	264	265	MISSOURI K	COLLECTOR	5328	1	11	0	1700	50	22
323	265	266	MISSOURI K	COLLECTOR	2986	1	11	0	1700	50	22
324	266	267	MISSOURI K	COLLECTOR	2132	1	11	0	1700	50	22
325	267	268	MISSOURI K	COLLECTOR	5132	1	11	0	1700	50	22
326	268	269	MISSOURI K	COLLECTOR	2301	1	11	0	1700	50	22
327	269	270	MISSOURI K	COLLECTOR	2292	1	11	0	1700	50	22
328	270	271	MISSOURI K	COLLECTOR	2457	1	11	0	1700	50	23
329	271	272	MISSOURI K	COLLECTOR	5861	1	11	0	1700	50	23
330	272	273	MISSOURI K	COLLECTOR	3433	1	11	0	1700	50	23
331	273	274	MISSOURI K	COLLECTOR	1389	1	11	0	1700	50	23
332	274	275	MISSOURI K	COLLECTOR	1516	1	11	0	1700	50	23
333	274	284	MISSOURI P	COLLECTOR	3345	1	9	0	1700	55	23
334	275	276	MISSOURI K	COLLECTOR	4029	1	11	0	1750	50	23
335	276	277	MISSOURI K	COLLECTOR	2365	1	11	0	1700	50	23
336	277	278	MISSOURI K	COLLECTOR	2171	1	11	0	1700	50	23
337	278	279	MISSOURI K	COLLECTOR	3733	1	11	0	1700	50	23
338	279	280	MISSOURI K	COLLECTOR	2217	1	11	0	1700	50	23
339	280	281	MISSOURI K	COLLECTOR	5975	1	11	0	1700	50	23
340	281	282	MISSOURI K	COLLECTOR	1639	1	11	0	1700	50	24
341	282	283	MISSOURI K	COLLECTOR	3926	1	11	0	1700	50	24

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
342	283	726	MISSOURI K	COLLECTOR	2813	1	11	0	1700	50	24
343	284	285	MISSOURI P	COLLECTOR	4529	1	9	0	1700	55	23
344	285	286	MISSOURI P	COLLECTOR	1457	1	9	0	1700	55	23
345	286	287	MISSOURI P	COLLECTOR	2059	1	9	0	1700	55	23
346	287	288	MISSOURI P	COLLECTOR	1032	1	9	0	1700	45	23
347	288	289	MISSOURI P	COLLECTOR	4228	1	9	0	1700	55	23
348	289	290	MISSOURI P	COLLECTOR	1295	1	9	0	1700	55	30
349	290	291	MISSOURI P	COLLECTOR	2051	1	9	0	1700	40	30
350	291	292	MISSOURI P	COLLECTOR	2544	1	9	0	1700	40	30
351	292	293	MISSOURI P	COLLECTOR	1285	1	9	0	1700	40	30
352	293	294	MISSOURI P	COLLECTOR	2677	1	9	0	1700	40	30
353	294	295	MISSOURI P	COLLECTOR	1157	1	9	0	1700	40	30
354	295	296	MISSOURI P	COLLECTOR	1936	1	9	0	1700	40	30
355	296	297	SR 94	COLLECTOR	3693	1	10	0	1700	60	30
356	297	298	SR 94	COLLECTOR	3865	1	10	0	1750	60	31
357	298	299	SR 94	COLLECTOR	1850	1	10	0	1700	55	31
358	299	300	SR 94	COLLECTOR	3426	1	10	0	1700	55	31
359	301	302	SR 94	COLLECTOR	2195	1	10	0	1700	45	29
360	302	303	SR 94	COLLECTOR	1290	1	10	0	1700	45	29
361	303	304	SR 94	COLLECTOR	2045	1	10	0	1700	45	29

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
362	304	305	SR 94	COLLECTOR	1919	1	10	0	1700	45	29
363	305	306	SR 94	COLLECTOR	926	1	10	0	1700	45	29
364	306	307	SR 94	COLLECTOR	1143	1	10	0	1700	45	29
365	307	308	SR 94	COLLECTOR	1216	1	10	0	1700	45	29
366	308	309	SR 94	COLLECTOR	3725	1	10	0	1700	45	29
367	309	310	SR 94	COLLECTOR	2587	1	10	0	1700	50	29
368	310	311	SR 94	COLLECTOR	1319	1	10	0	1700	50	29
369	311	312	SR 94	COLLECTOR	3342	1	10	0	1700	50	29
370	312	313	SR 94	COLLECTOR	2463	1	10	0	1700	45	29
371	313	314	SR 94	LOCAL ROADWAY	755	1	10	0	1350	30	29
372	314	315	SR 94	COLLECTOR	9232	1	10	0	1700	60	30
373	315	316	SR 94	COLLECTOR	7082	1	10	0	1700	60	30
374	316	317	SR 94	COLLECTOR	4978	1	10	0	1700	60	30
375	317	296	SR 94	COLLECTOR	5963	1	10	0	1700	60	30
376	318	301	SR 94	COLLECTOR	1006	1	10	0	1700	45	29
377	319	347	MISSOURI O	COLLECTOR	1387	1	10	0	1700	45	21
378	319	348	MISSOURI O	LOCAL ROADWAY	652	1	10	0	1350	30	21
379	320	321	MISSOURI CC	COLLECTOR	1816	1	10	0	1700	45	21

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
380	321	322	MISSOURI CC	COLLECTOR	2531	1	10	0	1700	45	20
381	322	323	MISSOURI CC	COLLECTOR	983	1	10	0	1700	45	20
382	323	324	MISSOURI CC	COLLECTOR	1951	1	10	0	1700	45	20
383	324	325	MISSOURI CC	COLLECTOR	2333	1	10	0	1700	45	27
384	325	326	MISSOURI CC	COLLECTOR	1842	1	10	0	1700	45	27
385	326	327	MISSOURI CC	COLLECTOR	733	1	10	0	1700	40	27
386	327	328	MISSOURI CC	COLLECTOR	2427	1	10	0	1700	45	27
387	328	329	MISSOURI CC	COLLECTOR	1629	1	10	0	1700	45	27
388	329	330	MISSOURI CC	COLLECTOR	677	1	10	0	1700	45	27
389	330	335	MISSOURI CC	COLLECTOR	1715	1	10	0	1700	45	27
390	331	332	MISSOURI CC	COLLECTOR	1717	1	10	0	1700	45	27
391	332	333	MISSOURI CC	COLLECTOR	1504	1	10	0	1700	45	27
392	333	334	MISSOURI CC	COLLECTOR	2385	1	10	0	1700	45	27
393	334	181	MISSOURI CC	COLLECTOR	2078	1	10	0	1700	45	27
394	335	331	MISSOURI CC	COLLECTOR	1371	1	10	0	1700	45	27
395	336	157	MISSOURI O	COLLECTOR	1887	1	10	0	1700	45	21
396	337	336	MISSOURI O	COLLECTOR	1635	1	10	0	1700	45	21
397	338	337	MISSOURI O	COLLECTOR	1259	1	10	0	1700	45	21
398	339	338	MISSOURI O	COLLECTOR	448	1	10	0	1700	40	21
399	340	339	MISSOURI O	COLLECTOR	1924	1	10	0	1700	45	21

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
400	341	340	MISSOURI O	COLLECTOR	1753	1	10	0	1700	45	21
401	342	341	MISSOURI O	COLLECTOR	1026	1	10	0	1700	40	21
402	343	342	MISSOURI O	COLLECTOR	1057	1	10	0	1700	45	21
403	344	343	MISSOURI O	COLLECTOR	1570	1	10	0	1700	45	21
404	345	344	MISSOURI O	COLLECTOR	828	1	10	0	1700	45	21
405	346	972	MISSOURI O	COLLECTOR	3099	1	10	0	1700	55	21
406	347	346	MISSOURI O	COLLECTOR	867	1	10	0	1700	45	21
407	348	349	MISSOURI O	LOCAL ROADWAY	3276	1	10	0	1350	30	20
408	349	350	MISSOURI O	LOCAL ROADWAY	478	1	10	0	1350	30	20
409	350	351	MISSOURI O	COLLECTOR	442	1	10	0	1700	45	20
410	351	352	MISSOURI O	COLLECTOR	680	1	10	0	1700	45	20
411	352	353	MISSOURI O	COLLECTOR	3720	1	10	0	1700	50	20
412	353	354	MISSOURI O	COLLECTOR	1266	1	10	0	1700	45	20
413	354	355	MISSOURI O	COLLECTOR	912	1	10	0	1700	45	20
414	355	356	MISSOURI O	COLLECTOR	826	1	10	0	1700	45	20
415	356	357	MISSOURI O	COLLECTOR	2775	1	10	0	1700	45	20
416	357	358	MISSOURI O	COLLECTOR	686	1	10	0	1575	35	20
417	358	359	MISSOURI O	COLLECTOR	1873	1	10	0	1700	45	20

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
418	359	360	MISSOURI O	COLLECTOR	2066	1	10	0	1700	50	20
419	360	361	MISSOURI O	COLLECTOR	1520	1	10	0	1700	45	20
420	361	362	MISSOURI O	COLLECTOR	1590	1	10	0	1700	45	20
421	362	363	MISSOURI O	COLLECTOR	700	1	10	0	1700	45	20
422	363	364	MISSOURI O	COLLECTOR	1547	1	10	0	1575	35	20
423	364	365	MISSOURI O	COLLECTOR	1110	1	10	0	1700	45	20
424	365	366	MISSOURI O	COLLECTOR	1510	1	10	0	1700	45	20
425	366	367	MISSOURI O	COLLECTOR	833	1	10	0	1700	45	20
426	367	368	MISSOURI O	COLLECTOR	882	1	10	0	1700	45	20
427	368	369	MISSOURI O	COLLECTOR	1086	1	10	0	1575	35	20
428	369	370	MISSOURI O	COLLECTOR	1813	1	10	0	1700	45	20
429	370	371	MISSOURI O	COLLECTOR	1823	1	10	0	1700	45	20
430	371	372	MISSOURI O	COLLECTOR	2392	1	10	0	1700	45	19
431	372	373	MISSOURI O	COLLECTOR	3485	1	10	0	1700	50	19
432	373	374	MISSOURI O	COLLECTOR	1463	1	10	0	1700	45	19
433	374	375	MISSOURI O	COLLECTOR	974	1	10	0	1700	45	19
434	375	376	MISSOURI O	COLLECTOR	1719	1	10	0	1700	45	19
435	376	377	MISSOURI O	COLLECTOR	1197	1	10	0	1700	45	12
436	377	378	MISSOURI O	COLLECTOR	4199	1	10	0	1700	45	12
437	378	379	MISSOURI O	COLLECTOR	1002	1	10	0	1700	45	12

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
438	379	232	MISSOURI O	COLLECTOR	1163	1	10	0	1700	45	12
439	380	207	MISSOURI Z	COLLECTOR	1227	1	10	0	1700	55	10
440	380	381	MISSOURI Z	COLLECTOR	1598	1	10	0	1700	45	10
441	381	380	MISSOURI Z	COLLECTOR	1598	1	10	0	1700	45	10
442	381	382	MISSOURI Z	COLLECTOR	1005	1	10	0	1700	45	10
443	382	381	MISSOURI Z	COLLECTOR	1005	1	10	0	1700	45	10
444	382	383	MISSOURI Z	COLLECTOR	1331	1	10	0	1700	45	10
445	383	382	MISSOURI Z	COLLECTOR	1331	1	10	0	1700	45	10
446	383	384	MISSOURI Z	COLLECTOR	1410	1	10	0	1700	40	10
447	384	383	MISSOURI Z	COLLECTOR	1406	1	10	0	1700	40	10
448	384	385	MISSOURI Z	COLLECTOR	1617	1	10	0	1575	35	10
449	384	806	WOOD ST	COLLECTOR	3411	1	10	4	1575	35	10
450	385	386	MISSOURI Z	COLLECTOR	883	1	10	0	1750	35	9
451	386	776	US-54 BUS	COLLECTOR	1969	1	10	0	1750	35	11
452	386	809	BUS 54	COLLECTOR	1255	1	12	4	1750	40	9
453	387	388	US-54 BUS	LOCAL ROADWAY	902	1	12	0	1125	25	11
454	387	815	BLUFF ST	LOCAL ROADWAY	1650	1	12	0	1350	30	11
455	387	865	US-54 BUS	COLLECTOR	1001	1	10	0	1575	35	11

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
456	388	387	US-54 BUS	LOCAL ROADWAY	902	1	12	0	1750	25	11
457	388	813	US-54 BUS	LOCAL ROADWAY	1112	1	12	0	1750	25	11
458	389	401	US-54 BUS	COLLECTOR	1041	1	10	0	1575	35	11
459	389	967	US-54 BUS TRAFFIC CIRCLE TO STATE RD C	LOCAL ROADWAY	128	1	12	4	1125	25	11
460	390	815	BLUFF ST	LOCAL ROADWAY	1113	1	12	0	1125	25	11
461	390	967	STATE RD C	LOCAL ROADWAY	668	1	12	4	1125	25	11
462	391	390	MISSOURI O	COLLECTOR	882	1	12	0	1575	35	11
463	391	863	OAK ST	COLLECTOR	1111	1	12	4	1575	35	12
464	392	391	MISSOURI O	COLLECTOR	2350	1	10	0	1700	40	12
465	392	784	WOOD ST	COLLECTOR	2946	1	10	4	1575	35	12
466	393	392	MISSOURI O	COLLECTOR	2124	1	10	0	1700	40	12
467	394	395	W 4TH ST	LOCAL ROADWAY	278	1	10	0	1125	25	11
468	394	813	US-54 BUS	LOCAL ROADWAY	300	1	12	0	1750	25	11
469	394	966	US-54 BUS	LOCAL ROADWAY	669	1	10	4	1125	25	11

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
470	395	396	W 4TH ST	COLLECTOR	1714	1	10	0	1750	35	11
471	396	397	MLK JR BLVD	COLLECTOR	1092	1	12	10	1575	40	11
472	396	818	WESTMINSTER AVE	COLLECTOR	1210	1	12	0	1575	35	11
473	396	985	WESTMINSTER AVE	COLLECTOR	296	1	10	0	1700	45	11
474	397	398	MLK JR BLVD	COLLECTOR	625	1	12	10	1575	55	11
475	398	58	MLK JR BLVD	COLLECTOR	1299	1	12	10	1700	55	11
476	399	400	US-54 BUS	COLLECTOR	2428	1	12	6	1700	40	9
477	399	805	INDUSTRIAL DR	COLLECTOR	2591	1	12	4	1700	40	9
478	399	809	US-54 BUS	COLLECTOR	2329	1	12	4	1750	40	9
479	400	48	US-54 BUS	COLLECTOR	3660	1	12	6	1700	45	9
480	400	868	W ST EUNICE RD	COLLECTOR	4472	1	10	0	1575	35	9
481	401	402	US-54 BUS	COLLECTOR	989	1	10	0	1700	40	11
482	402	403	US-54 BUS	COLLECTOR	1458	1	10	0	1700	40	11
483	403	404	US-54 BUS	COLLECTOR	1715	1	10	0	1700	40	11
484	404	405	US-54 BUS	COLLECTOR	2010	1	10	0	1700	40	11
485	405	963	US-54 BUS	COLLECTOR	1105	1	10	0	1700	40	11
486	406	390	STATE RD C	COLLECTOR	1557	1	10	0	1575	35	11
487	407	406	STATE RD C	COLLECTOR	2268	1	10	0	1575	35	11
488	408	407	STATE RD C	COLLECTOR	2519	1	10	0	1575	35	11
489	408	763	TYNNYSON RD	COLLECTOR	1818	1	10	0	1700	45	11

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
490	409	408	STATE RD C	COLLECTOR	2098	1	10	0	1575	35	11
491	411	96	MISSOURI JJ	COLLECTOR	1003	1	10	0	1700	45	4
492	412	124	MISSOURI A	COLLECTOR	1313	1	10	0	1700	45	4
493	413	409	STATE HWY C	COLLECTOR	3122	1	10	0	1700	55	19
494	414	413	STATE HWY C	COLLECTOR	2666	1	10	0	1700	60	19
495	415	414	STATE HWY C	COLLECTOR	4309	1	10	0	1700	60	19
496	416	415	STATE HWY C	COLLECTOR	2229	1	10	0	1700	60	19
497	417	416	STATE HWY C	COLLECTOR	2453	1	10	0	1700	60	19
498	418	417	STATE HWY C	COLLECTOR	1821	1	10	0	1700	60	19
499	419	418	STATE HWY C	COLLECTOR	2926	1	10	0	1700	60	19
500	420	817	STATE HWY C	COLLECTOR	4599	1	10	0	1700	60	19
501	421	420	STATE HWY C	COLLECTOR	2780	1	10	0	1700	60	19
502	422	421	STATE HWY C	COLLECTOR	7564	1	10	0	1700	55	19
503	422	423	STATE HWY C	COLLECTOR	7143	1	10	0	1700	60	26
504	423	424	STATE HWY C	COLLECTOR	3272	1	10	0	1700	60	26
505	424	425	STATE HWY C	COLLECTOR	1826	1	10	0	1700	60	26
506	425	426	STATE HWY C	COLLECTOR	2184	1	10	0	1700	60	26
507	426	427	STATE HWY C	COLLECTOR	1953	1	10	0	1700	60	26
508	427	428	STATE HWY C	COLLECTOR	2725	1	10	0	1700	60	26
509	428	429	STATE HWY C	COLLECTOR	2526	1	10	0	1700	55	27

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
510	429	430	STATE HWY C	COLLECTOR	3474	1	10	0	1700	55	27
511	430	431	STATE HWY C	COLLECTOR	3038	1	10	0	1700	40	27
512	431	185	FULTON AVE	LOCAL ROADWAY	1472	1	12	4	1350	30	34
513	432	433	CO RD 304	COLLECTOR	6402	1	10	0	1700	45	8
514	433	217	CO ROUTE 305	COLLECTOR	7431	1	10	0	1700	50	8
515	433	434	CO ROUTE 305	COLLECTOR	8076	1	10	0	1700	50	8
516	434	67	MISSOURI H	COLLECTOR	9300	1	10	0	1700	50	18
517	434	435	MISSOURI H	COLLECTOR	3109	1	10	0	1700	50	18
518	435	436	MISSOURI H	COLLECTOR	2031	1	10	0	1700	50	18
519	436	437	MISSOURI H	COLLECTOR	968	1	10	0	1700	50	18
520	437	795	MISSOURI H	COLLECTOR	1019	1	10	0	1700	50	18
521	438	439	MISSOURI H	COLLECTOR	1667	1	10	0	1700	50	18
522	439	440	MISSOURI H	COLLECTOR	1335	1	10	0	1700	50	18
523	441	65	US-54 BUS	COLLECTOR	311	1	12	4	1700	55	19
524	442	441	STATE HWY NN	COLLECTOR	927	1	10	0	1700	45	19
525	443	442	STATE HWY NN	COLLECTOR	1139	1	10	0	1700	50	19
526	444	443	STATE HWY NN	COLLECTOR	2705	1	10	0	1700	50	19
527	444	445	OLD US HWY 54	COLLECTOR	3929	1	10	0	1700	55	18
528	445	446	OLD US HWY 54	COLLECTOR	1882	1	10	0	1700	55	18

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
529	446	75	OLD US HWY 54	COLLECTOR	842	1	10	0	1700	55	18
530	447	448	OLD US HWY 54	COLLECTOR	1272	1	10	0	1700	55	18
531	448	449	OLD US HWY 54	COLLECTOR	1395	1	10	0	1700	55	18
532	449	802	OLD US HWY 54	COLLECTOR	1975	1	10	0	1700	55	18
533	450	451	OLD US HWY 54	COLLECTOR	2941	1	10	0	1700	55	18
534	451	78	STATE HWY BB	COLLECTOR	624	1	12	4	1700	45	18
535	451	452	OLD US HWY 54	COLLECTOR	2154	1	10	0	1700	55	18
536	452	453	OLD US HWY 54	COLLECTOR	3644	1	10	0	1700	55	18
537	453	70	ACCESS RD	COLLECTOR	322	1	10	0	1575	35	18
538	453	454	OLD US HWY 54	COLLECTOR	978	1	10	0	1700	55	18
539	454	455	OLD US HWY 54	COLLECTOR	1635	1	10	0	1700	55	18
540	455	456	OLD US HWY 54	COLLECTOR	1887	1	10	0	1700	55	18
541	456	457	OLD US HWY 54	COLLECTOR	766	1	10	0	1700	55	25
542	457	458	OLD US HWY 54	COLLECTOR	760	1	10	0	1700	55	25
543	458	459	OLD US HWY 54	COLLECTOR	2917	1	10	0	1700	55	25
544	459	460	PLATINUM RD	COLLECTOR	2418	1	10	0	1700	55	25
545	460	461	PLATINUM RD	COLLECTOR	3758	1	10	0	1700	55	25
546	461	757	PLATINUM RD	COLLECTOR	3118	1	10	0	1700	55	25
547	462	451	STATE HWY BB	COLLECTOR	3272	1	10	0	1700	55	18
548	463	462	STATE HWY BB	COLLECTOR	836	1	10	0	1700	55	18

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
549	464	820	STATE HWY BB	COLLECTOR	803	1	10	0	1575	35	25
550	465	821	STATE HWY BB	COLLECTOR	677	1	10	0	1575	35	25
551	466	465	STATE HWY BB	COLLECTOR	2219	1	10	0	1700	55	25
552	467	466	STATE HWY BB	COLLECTOR	5331	1	10	0	1700	55	25
553	467	750	CO RD 436	LOCAL ROADWAY	2660	1	10	0	1350	30	25
554	468	467	STATE HWY BB	COLLECTOR	2577	1	10	0	1700	55	25
555	468	469	STATE HWY BB	COLLECTOR	5598	1	10	0	1700	45	25
556	469	470	STATE HWY BB	COLLECTOR	1106	1	10	0	1575	35	25
557	470	471	STATE HWY BB	COLLECTOR	3764	1	10	0	1700	45	25
558	471	472	STATE HWY BB	COLLECTOR	835	1	10	0	1700	45	25
559	472	473	STATE HWY BB	COLLECTOR	725	1	10	0	1700	40	25
560	473	474	STATE HWY BB	COLLECTOR	1136	1	10	0	1700	40	25
561	474	475	STATE HWY BB	COLLECTOR	905	1	10	0	1700	45	25
562	475	476	STATE HWY BB	COLLECTOR	2070	1	10	0	1700	45	25
563	476	477	STATE HWY BB	COLLECTOR	951	1	10	0	1700	45	25
564	477	478	STATE HWY BB	COLLECTOR	2072	1	10	0	1700	45	32
565	478	479	STATE HWY BB	COLLECTOR	441	1	10	0	1700	40	32
566	479	480	STATE HWY BB	COLLECTOR	1073	1	10	0	1700	45	32
567	480	481	STATE HWY BB	COLLECTOR	1879	1	10	0	1700	45	32

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
568	481	869	STATE HWY BB	COLLECTOR	672	1	10	0	1700	45	32
569	482	483	STATE HWY BB	COLLECTOR	2482	1	10	0	1700	45	32
570	483	484	STATE HWY BB	COLLECTOR	2101	1	10	0	1700	45	32
571	484	485	STATE HWY BB	COLLECTOR	3844	1	10	0	1700	45	32
572	485	486	STATE HWY BB	COLLECTOR	2183	1	10	0	1700	45	32
573	486	487	STATE HWY BB	COLLECTOR	1399	1	10	0	1700	45	32
574	487	679	STATE HWY BB	COLLECTOR	1854	1	10	0	1700	45	32
575	489	488	MISSOURI C	COLLECTOR	1589	1	10	0	1700	55	38
576	490	489	MISSOURI C	COLLECTOR	981	1	10	0	1700	55	38
577	491	490	MISSOURI C	COLLECTOR	736	1	10	0	1700	55	38
578	492	491	MISSOURI C	COLLECTOR	881	1	10	0	1700	55	38
579	493	492	MISSOURI C	COLLECTOR	725	1	10	0	1700	55	38
580	494	493	MISSOURI C	COLLECTOR	1774	1	10	0	1700	55	38
581	495	494	MISSOURI C	COLLECTOR	1738	1	10	0	1700	55	38
582	496	495	MISSOURI C	COLLECTOR	1724	1	10	0	1700	55	38
583	497	496	MISSOURI C	COLLECTOR	1352	1	10	0	1700	55	38
584	498	497	MISSOURI C	COLLECTOR	739	1	10	0	1700	55	33
585	499	498	MISSOURI C	COLLECTOR	684	1	10	0	1700	55	33
586	500	499	MISSOURI C	COLLECTOR	1353	1	10	0	1700	55	33
587	501	500	MISSOURI C	COLLECTOR	1096	1	10	0	1700	55	33

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
588	502	501	MISSOURI C	COLLECTOR	923	1	10	0	1700	55	33
589	503	502	MISSOURI C	COLLECTOR	1769	1	10	0	1700	55	33
590	504	503	MISSOURI C	COLLECTOR	1731	1	10	0	1700	55	33
591	505	504	MISSOURI C	COLLECTOR	1785	1	10	0	1700	55	33
592	506	505	MISSOURI C	COLLECTOR	1183	1	10	0	1700	55	39
593	507	506	MISSOURI C	COLLECTOR	1175	1	10	0	1700	55	39
594	508	507	MISSOURI C	COLLECTOR	4884	1	10	0	1700	55	39
595	509	508	MISSOURI C	COLLECTOR	1640	1	10	0	1700	55	39
596	510	509	MISSOURI C	COLLECTOR	669	1	10	0	1700	55	39
597	511	510	MISSOURI C	COLLECTOR	1039	1	10	0	1700	40	39
598	512	511	MISSOURI C	COLLECTOR	942	1	10	0	1700	40	39
599	513	969	MISSOURI C	COLLECTOR	1987	1	10	0	1700	45	39
600	514	513	MISSOURI C	COLLECTOR	1034	1	10	0	1700	55	39
601	515	514	MISSOURI C	COLLECTOR	1138	1	10	0	1700	55	39
602	516	515	MISSOURI C	COLLECTOR	769	1	10	0	1700	55	39
603	517	516	MISSOURI C	COLLECTOR	1779	1	10	0	1700	55	39
604	518	517	MISSOURI C	COLLECTOR	1804	1	10	0	1700	55	39
605	519	518	MISSOURI C	COLLECTOR	1167	1	10	0	1700	55	39
606	520	519	MISSOURI C	COLLECTOR	2719	1	10	0	1700	55	39
607	521	520	MISSOURI C	COLLECTOR	2303	1	10	0	1700	55	39

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
608	522	521	MISSOURI C	COLLECTOR	2029	1	10	0	1700	55	39
609	522	586	SR 100	COLLECTOR	2770	1	10	0	1700	50	39
610	523	522	SR 100	COLLECTOR	1356	1	10	0	1700	45	39
611	524	523	SR 100	COLLECTOR	3278	1	10	0	1700	50	39
612	525	524	SR 100	COLLECTOR	2031	1	10	0	1700	50	39
613	526	525	SR 100	COLLECTOR	2292	1	10	0	1700	50	39
614	527	526	SR 100	COLLECTOR	2640	1	10	0	1700	50	39
615	528	527	SR 100	COLLECTOR	1259	1	10	0	1700	50	39
616	529	528	SR 100	COLLECTOR	2067	1	10	0	1700	50	39
617	530	529	SR 100	COLLECTOR	1913	1	10	0	1700	50	39
618	531	530	SR 100	COLLECTOR	1423	1	10	0	1700	50	39
619	532	531	SR 100	COLLECTOR	2297	1	10	0	1700	50	39
620	533	532	SR 100	COLLECTOR	2602	1	10	0	1700	50	34
621	534	533	SR 100	COLLECTOR	1685	1	10	0	1700	50	34
622	535	534	SR 100	COLLECTOR	1181	1	10	0	1700	50	34
623	536	535	SR 100	COLLECTOR	967	1	10	0	1700	50	34
624	537	536	SR 100	COLLECTOR	1221	1	10	0	1700	50	34
625	538	537	SR 100	COLLECTOR	762	1	10	0	1700	50	34
626	539	538	SR 100	COLLECTOR	1266	1	10	0	1700	50	34
627	540	539	SR 100	COLLECTOR	2809	1	10	0	1700	50	34

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
628	541	540	SR 100	COLLECTOR	1734	1	10	0	1700	50	34
629	542	541	SR 100	COLLECTOR	1179	1	10	0	1700	50	34
630	543	542	SR 100	COLLECTOR	1841	1	10	0	1700	50	34
631	544	543	SR 100	COLLECTOR	2108	1	10	0	1700	50	34
632	545	544	SR 100	COLLECTOR	2560	1	10	0	1700	50	34
633	546	545	SR 100	COLLECTOR	1469	1	10	0	1700	50	34
634	547	546	SR 100	COLLECTOR	1318	1	10	0	1575	35	34
635	548	547	SR 100	COLLECTOR	4685	1	10	0	1700	55	34
636	549	548	SR 100	COLLECTOR	8540	1	10	0	1700	55	34
637	550	549	SR 100	COLLECTOR	4918	1	10	0	1700	55	28
638	551	550	SR 100	COLLECTOR	1705	1	10	0	1575	35	28
639	551	552	SR 100	COLLECTOR	2475	1	10	0	1575	35	28
640	551	788	SR 89	LOCAL ROADWAY	998	1	12	4	1125	25	28
641	552	553	SR 100	COLLECTOR	5820	1	10	0	1700	50	28
642	553	911	SR 100	COLLECTOR	2258	1	10	0	1700	50	28
643	554	555	SR 100	COLLECTOR	2221	1	10	0	1700	50	28
644	555	556	SR 100	COLLECTOR	5266	1	10	0	1700	50	28
645	556	557	SR 100	COLLECTOR	10362	1	10	0	1700	50	29
646	557	910	SR 100	COLLECTOR	4468	1	10	0	1700	50	29

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
647	558	559	SR 100	COLLECTOR	1330	1	10	0	1700	50	29
648	559	560	SR 100	COLLECTOR	2646	1	10	0	1700	50	29
649	560	561	SR 100	COLLECTOR	2814	1	10	0	1700	50	29
650	561	562	SR 100	COLLECTOR	1303	1	10	0	1700	45	29
651	562	563	SR 100	COLLECTOR	4601	1	10	0	1700	45	36
652	563	564	SR 100	COLLECTOR	1238	1	10	0	1700	50	36
653	564	565	SR 100	COLLECTOR	2169	1	10	0	1700	50	36
654	565	566	SR 100	COLLECTOR	1312	1	10	0	1700	50	36
655	566	567	SR 100	COLLECTOR	1430	1	10	0	1700	45	36
656	566	652	MISSOURI N	COLLECTOR	1296	1	10	0	1700	45	36
657	567	568	SR 100	COLLECTOR	2725	1	10	0	1700	45	36
658	568	569	SR 100	COLLECTOR	1158	1	10	0	1700	45	37
659	569	570	SR 100	COLLECTOR	902	1	10	0	1700	45	37
660	570	571	SR 100	COLLECTOR	866	1	10	0	1700	45	37
661	571	572	SR 100	COLLECTOR	2066	1	10	0	1700	45	37
662	572	573	SR 100	COLLECTOR	2244	1	10	0	1700	45	37
663	573	574	SR 100	COLLECTOR	842	1	10	0	1700	45	37
664	574	575	SR 100	COLLECTOR	3170	1	10	0	1700	45	37
665	575	576	SR 100	COLLECTOR	1215	1	10	0	1700	45	37
666	576	577	SR 100	COLLECTOR	1296	1	10	0	1700	45	37

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
667	577	578	SR 100	COLLECTOR	2886	1	10	0	1700	55	37
668	578	579	SR 100	COLLECTOR	2098	1	10	0	1700	55	37
669	579	580	SR 100	COLLECTOR	1022	1	10	0	1700	45	37
670	580	581	SR 100	COLLECTOR	2251	1	10	0	1700	55	37
671	581	582	SR 100	COLLECTOR	1217	1	10	0	1700	55	37
672	582	583	SR 100	COLLECTOR	3236	1	10	0	1700	55	37
673	583	584	SR 100	COLLECTOR	2505	1	10	0	1700	50	37
674	584	585	SR 100	COLLECTOR	3818	1	10	0	1700	55	37
675	585	904	SR 100	COLLECTOR	2867	1	10	0	1700	55	0
676	586	587	SR 100	COLLECTOR	708	1	10	0	1700	50	39
677	587	588	SR 100	COLLECTOR	1181	1	10	0	1700	50	39
678	590	589	SR 89	COLLECTOR	3508	1	11	0	1700	50	40
679	591	590	SR 89	COLLECTOR	1902	1	11	0	1700	50	40
680	592	591	SR 89	COLLECTOR	3723	1	11	0	1700	50	40
681	593	592	SR 89	COLLECTOR	3769	1	11	0	1700	50	40
682	594	593	SR 89	COLLECTOR	1395	1	11	0	1700	50	40
683	595	594	SR 89	COLLECTOR	1305	1	11	0	1700	50	40
684	596	595	SR 89	COLLECTOR	5290	1	11	0	1700	50	40
685	597	596	SR 89	COLLECTOR	3917	1	11	0	1700	50	40
686	598	597	SR 89	COLLECTOR	2469	1	11	0	1700	50	40

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
687	599	598	SR 89	COLLECTOR	2243	1	11	0	1700	50	40
688	600	599	SR 89	COLLECTOR	1307	1	11	0	1700	50	35
689	601	600	SR 89	COLLECTOR	1388	1	11	0	1700	50	35
690	602	601	SR 89	COLLECTOR	2400	1	11	0	1700	50	35
691	603	602	SR 89	COLLECTOR	3079	1	11	0	1700	50	35
692	604	603	SR 89	COLLECTOR	1561	1	11	0	1700	50	35
693	605	604	SR 89	COLLECTOR	2410	1	11	0	1700	50	35
694	606	671	SR 89	COLLECTOR	2219	1	11	0	1700	50	35
695	607	606	SR 89	COLLECTOR	2246	1	11	0	1700	50	35
696	608	607	SR 89	COLLECTOR	903	1	11	0	1700	50	35
697	609	608	SR 89	COLLECTOR	3518	1	11	0	1700	50	35
698	610	609	SR 89	COLLECTOR	1304	1	11	0	1700	50	35
699	611	610	SR 89	COLLECTOR	1479	1	11	0	1700	50	35
700	612	611	SR 89	COLLECTOR	1923	1	11	0	1700	50	35
701	613	612	SR 89	COLLECTOR	1053	1	11	0	1700	50	35
702	614	613	SR 89	COLLECTOR	1002	1	11	0	1700	50	35
703	615	614	SR 89	COLLECTOR	2043	1	11	0	1700	50	35
704	616	615	SR 89	COLLECTOR	3280	1	11	0	1575	35	35
705	617	616	SR 89	LOCAL ROADWAY	1179	1	11	0	1350	30	35

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
706	617	678	SR 89	LOCAL ROADWAY	305	1	12	4	1125	25	35
707	618	678	SR 89	LOCAL ROADWAY	221	1	12	4	1125	25	35
708	618	788	SR 89	LOCAL ROADWAY	584	1	12	4	1125	25	28
709	624	623	MISSOURI N	COLLECTOR	1643	1	10	0	1700	45	41
710	625	624	MISSOURI N	COLLECTOR	2105	1	10	0	1700	45	41
711	626	625	MISSOURI N	COLLECTOR	2097	1	10	0	1700	45	41
712	627	626	MISSOURI N	COLLECTOR	1644	1	10	0	1700	45	41
713	628	627	MISSOURI N	COLLECTOR	1292	1	10	0	1700	45	41
714	629	628	MISSOURI N	COLLECTOR	1468	1	10	0	1700	45	41
715	630	629	MISSOURI N	COLLECTOR	1643	1	10	0	1700	45	41
716	631	630	MISSOURI N	COLLECTOR	1151	1	10	0	1700	45	41
717	632	631	MISSOURI N	COLLECTOR	2243	1	10	0	1700	45	41
718	633	632	MISSOURI N	COLLECTOR	1496	1	10	0	1700	45	41
719	634	633	MISSOURI N	COLLECTOR	1717	1	10	0	1700	45	41
720	634	670	MISSOURI J	COLLECTOR	1176	1	10	0	1700	50	41
721	635	634	MISSOURI N	COLLECTOR	1466	1	10	0	1700	45	36
722	636	635	MISSOURI N	COLLECTOR	1598	1	10	0	1700	45	36
723	637	636	MISSOURI N	COLLECTOR	1684	1	10	0	1700	45	36

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
724	638	637	MISSOURI N	COLLECTOR	2901	1	10	0	1700	45	36
725	639	638	MISSOURI N	COLLECTOR	813	1	10	0	1700	45	36
726	640	639	MISSOURI N	COLLECTOR	2933	1	10	0	1700	45	36
727	641	640	MISSOURI N	COLLECTOR	1241	1	10	0	1700	45	36
728	642	641	MISSOURI N	COLLECTOR	809	1	10	0	1700	45	36
729	643	642	MISSOURI N	COLLECTOR	1903	1	10	0	1700	45	36
730	644	643	MISSOURI N	COLLECTOR	1555	1	10	0	1700	45	36
731	645	644	MISSOURI N	COLLECTOR	1022	1	10	0	1700	45	36
732	646	645	MISSOURI N	COLLECTOR	1038	1	10	0	1700	45	36
733	647	646	MISSOURI N	COLLECTOR	1231	1	10	0	1700	45	36
734	648	672	MISSOURI N	COLLECTOR	1125	1	10	0	1700	45	36
735	649	648	MISSOURI N	COLLECTOR	1766	1	10	0	1700	45	36
736	650	649	MISSOURI N	COLLECTOR	1302	1	10	0	1700	45	36
737	651	650	MISSOURI N	COLLECTOR	2613	1	10	0	1700	45	36
738	652	651	MISSOURI N	COLLECTOR	1212	1	10	0	1700	45	36
739	664	792	MISSOURI J	COLLECTOR	2461	1	10	0	1700	45	36
740	665	666	MISSOURI J	COLLECTOR	934	1	10	0	1700	45	41
741	665	905	MISSOURI OO	COLLECTOR	618	1	10	0	1700	50	41
742	666	665	MISSOURI J	COLLECTOR	933	1	10	0	1700	45	41
743	666	668	MISSOURI J	COLLECTOR	3007	1	10	0	1700	50	41

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
744	668	666	MISSOURI J	COLLECTOR	3027	1	10	0	1700	50	41
745	668	670	MISSOURI J	COLLECTOR	1987	1	10	0	1700	50	41
746	670	634	MISSOURI J	COLLECTOR	1176	1	10	0	1700	50	41
747	670	668	MISSOURI J	COLLECTOR	1957	1	10	0	1700	50	41
748	671	605	SR 89	COLLECTOR	1799	1	11	0	1700	50	35
749	672	647	MISSOURI N	COLLECTOR	1405	1	10	0	1700	45	36
750	673	260	MISSOURI K	COLLECTOR	5084	1	11	0	1700	55	22
751	674	151	MISSOURI D	COLLECTOR	1589	1	10	0	1700	45	14
752	675	149	MISSOURI D	COLLECTOR	1502	1	10	0	1700	45	14
753	676	148	MISSOURI D	COLLECTOR	1392	1	10	0	1700	45	14
754	677	697	OLD U.S. 40	COLLECTOR	6315	1	10	0	1700	45	5
755	678	617	SR 89	LOCAL ROADWAY	305	1	12	4	1125	25	35
756	678	618	SR 89	LOCAL ROADWAY	221	1	12	4	1125	25	35
757	679	680	STATE HWY AA	COLLECTOR	3687	1	10	0	1700	55	32
758	680	681	STATE HWY AA	COLLECTOR	2204	1	10	0	1700	55	32
759	681	1	STATE HWY AA	COLLECTOR	1844	1	10	0	1700	40	32
760	685	345	MISSOURI O	COLLECTOR	4340	1	10	0	1700	55	21
761	687	320	MISSOURI CC	COLLECTOR	556	1	10	0	1700	45	21

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
762	687	970	MISSOURI CC	COLLECTOR	760	1	10	0	1700	60	21
763	688	687	COUNTY RD 459	LOCAL ROADWAY	983	1	10	0	1350	30	21
764	689	244	MISSOURI J	COLLECTOR	1511	1	8	0	1700	45	16
765	689	245	MISSOURI J	COLLECTOR	2209	1	8	0	1700	45	16
766	691	118	COUNTY RD 133	COLLECTOR	1254	1	10	0	1700	40	13
767	694	161	MISSOURI D	COLLECTOR	4073	1	10	0	1700	45	21
768	696	422	STATE RD VV	COLLECTOR	3045	1	10	0	1700	45	26
769	697	823	OLD U.S. 40	COLLECTOR	5991	1	10	0	1700	45	5
770	699	968	E 2ND ST	LOCAL ROADWAY	630	1	10	4	1350	30	11
771	701	179	COUNTY RD 459	LOCAL ROADWAY	2261	1	10	0	1350	30	28
772	702	703	PLANT ACCESS RD	COLLECTOR	1320	1	10	0	1350	30	21
773	703	688	COUNTY RD 459	LOCAL ROADWAY	2881	1	10	0	1350	30	21
774	703	704	COUNTY RD 459	LOCAL ROADWAY	1370	1	10	0	1350	30	21
775	704	705	COUNTY RD 459	LOCAL ROADWAY	1344	1	10	0	1350	30	21
776	705	706	COUNTY RD 459	LOCAL ROADWAY	833	1	10	0	1350	30	21

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
777	706	707	COUNTY RD 459	LOCAL ROADWAY	1934	1	10	0	1350	30	21
778	707	708	COUNTY RD 459	LOCAL ROADWAY	1831	1	10	0	1350	30	28
779	708	709	COUNTY RD 459	LOCAL ROADWAY	1049	1	10	0	1350	30	28
780	709	710	COUNTY RD 459	LOCAL ROADWAY	787	1	10	0	1350	30	28
781	710	711	COUNTY RD 459	LOCAL ROADWAY	864	1	10	0	1350	30	28
782	711	712	COUNTY RD 459	LOCAL ROADWAY	1843	1	10	0	1350	30	28
783	712	713	COUNTY RD 459	LOCAL ROADWAY	1311	1	10	0	1350	30	28
784	713	714	COUNTY RD 459	LOCAL ROADWAY	1143	1	10	0	1350	30	28
785	714	715	COUNTY RD 459	LOCAL ROADWAY	2454	1	10	0	1350	30	28
786	715	701	COUNTY RD 459	LOCAL ROADWAY	2330	1	10	0	1350	30	28
787	716	85	COUNTY RD 1005	COLLECTOR	1086	1	10	0	1700	45	6
788	717	796	MISSOURI J	COLLECTOR	1069	1	12	0	1700	40	7
789	718	719	MISSOURI J	COLLECTOR	1764	1	8	0	1700	45	17

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
790	719	720	MISSOURI J	COLLECTOR	1948	1	8	0	1700	45	17
791	720	721	MISSOURI J	COLLECTOR	2227	1	8	0	1700	45	24
792	721	722	MISSOURI J	COLLECTOR	2000	1	8	0	1700	45	24
793	722	723	MISSOURI J	COLLECTOR	628	1	10	0	1700	45	24
794	723	724	SR 19	COLLECTOR	3641	1	10	2	1700	45	24
795	724	725	SR 19	COLLECTOR	1009	1	10	2	1700	50	24
796	726	724	MISSOURI K	COLLECTOR	1852	1	11	0	1700	50	24
797	728	188	STATE RD PP	COLLECTOR	3582	1	10	0	1575	35	33
798	750	751	CO RD 436	LOCAL ROADWAY	1708	1	10	0	1350	30	25
799	751	752	CO RD 436	LOCAL ROADWAY	2410	1	10	0	1350	30	25
800	752	753	CO RD 436	LOCAL ROADWAY	4342	1	10	0	1350	30	25
801	753	754	CO RD 436	LOCAL ROADWAY	1029	1	10	0	1350	30	25
802	754	755	CO RD 436	LOCAL ROADWAY	3731	1	10	0	1350	30	25
803	755	757	CO RD 436	LOCAL ROADWAY	3616	1	10	0	1350	30	25
804	756	73	US-54	FREEWAY	838	2	12	10	2250	75	25
805	757	793	CO RD 436	COLLECTOR	367	1	12	4	1700	45	25

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
806	758	73	US-54 ON-RAMP FROM CO RD 436	FREEWAY RAMP	1134	1	12	4	1700	45	25
807	759	77	CO ROAD 328	COLLECTOR	1884	1	10	0	1700	45	18
808	760	70	US-54	FREEWAY	3526	2	12	10	1900	75	18
809	760	761	US-54	FREEWAY	2982	2	12	10	1900	75	18
810	761	69	US-54	FREEWAY	4402	2	12	10	1900	75	18
811	761	760	US-54	FREEWAY	2982	2	12	10	1900	75	18
812	763	764	TYNNYSON RD	COLLECTOR	2659	1	10	0	1700	45	11
813	764	405	TYNNYSON RD	COLLECTOR	988	1	10	0	1700	40	11
814	765	766	WESTMINSTER AVE	COLLECTOR	1205	1	10	0	1700	45	11
815	765	979	WESTMINSTER AVE	COLLECTOR	1803	1	10	0	1700	45	11
816	766	765	WESTMINSTER AVE	COLLECTOR	1205	1	10	0	1700	45	11
817	766	767	WESTMINSTER AVE	COLLECTOR	3170	1	10	0	1700	45	9
818	767	766	WESTMINSTER AVE	COLLECTOR	3170	1	10	0	1700	45	9
819	767	768	WILLIAM WOODS AVE	COLLECTOR	809	1	10	0	1700	45	9
820	768	832	WILLIAM WOODS AVE	COLLECTOR	2884	1	10	0	1700	45	9
821	769	49	US-54 ON-RAMP FROM MISSOURI HH	FREEWAY RAMP	1092	1	12	4	1700	50	9
822	769	770	MISSOURI HH	COLLECTOR	704	1	12	4	1700	45	9
823	770	50	US-54 ON-RAMP FROM MISSOURI HH	FREEWAY RAMP	1160	1	12	4	1700	50	9

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
824	770	769	MISSOURI HH	COLLECTOR	704	1	12	4	1700	45	9
825	770	890	MISSOURI HH	COLLECTOR	398	1	12	4	1700	45	9
826	771	772	MISSOURI HH	COLLECTOR	2252	1	10	0	1700	55	9
827	772	773	MISSOURI HH	COLLECTOR	2329	1	10	0	1700	55	9
828	773	774	MISSOURI HH	COLLECTOR	3269	1	10	0	1700	55	9
829	774	894	MISSOURI HH	COLLECTOR	702	1	10	0	1575	35	3
830	776	386	US-54 BUS	COLLECTOR	1970	1	10	0	1750	35	11
831	776	865	US-54 BUS	COLLECTOR	400	1	10	0	1575	35	11
832	776	977	E 10TH ST	COLLECTOR	1148	1	12	4	1575	35	11
833	777	778	BARTLEY LN	COLLECTOR	5658	1	12	0	1575	35	12
834	778	780	BARTLEY LN	COLLECTOR	2484	1	12	0	1575	35	12
835	779	776	E 10TH ST	COLLECTOR	398	1	10	0	1750	35	11
836	780	384	WOOD ST	COLLECTOR	2274	1	10	4	1575	35	12
837	780	982	E 10TH ST	COLLECTOR	1696	1	10	0	1575	35	12
838	784	780	WOOD ST	COLLECTOR	1233	1	10	4	1575	35	12
839	784	811	E 8TH ST	LOCAL ROADWAY	1722	1	10	0	1350	30	12
840	785	123	MISSOURI Z	COLLECTOR	1032	1	10	0	1700	55	4
841	788	551	SR 89	LOCAL ROADWAY	998	1	12	4	1125	25	28

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
842	788	618	SR 89	LOCAL ROADWAY	584	1	12	4	1125	25	28
843	789	788	2ND ST	LOCAL ROADWAY	798	1	12	4	1125	25	28
844	790	788	2ND ST	LOCAL ROADWAY	802	1	12	4	1125	25	28
845	792	665	MISSOURI J	COLLECTOR	1597	1	10	0	1700	45	41
846	793	758	MISSOURI J	COLLECTOR	884	1	12	4	1700	45	25
847	793	794	US-54 ON-RAMP FROM CO RD 436	FREEWAY RAMP	1309	1	12	4	1700	45	25
848	794	72	US-54	FREEWAY	5359	2	12	10	2250	75	25
849	794	73	US-54	FREEWAY	2801	2	12	10	2250	75	25
850	794	758	US-54 OFF-RAMP TO CO RD 436	FREEWAY RAMP	1754	1	12	4	1700	45	25
851	795	438	MISSOURI H	COLLECTOR	3592	1	10	0	1700	50	18
852	796	797	MISSOURI J	COLLECTOR	3002	1	12	0	1700	40	7
853	797	798	MISSOURI J	COLLECTOR	740	1	12	0	1700	40	7
854	798	799	MISSOURI J	COLLECTOR	427	1	12	0	1700	40	7
855	799	800	I-70 ON-RAMP FROM MISSOURI J	FREEWAY RAMP	1228	1	12	4	1700	45	7
856	799	801	MISSOURI J	COLLECTOR	680	1	12	0	1700	40	7
857	800	26	I-70	FREEWAY	2433	2	12	10	2250	75	7

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
858	800	976	I-70	FREEWAY	642	2	12	10	2250	75	7
859	801	26	I-70 ON-RAMP FROM MISSOURI J	FREEWAY RAMP	1365	1	12	4	1700	45	7
860	802	450	OLD US HWY 54	COLLECTOR	2685	1	10	0	1700	55	18
861	803	32	GOLD RD	COLLECTOR	391	1	12	4	1750	35	3
862	804	32	GOLD RD	COLLECTOR	849	1	12	4	1750	35	3
863	805	767	WESTMINSTER AVE	COLLECTOR	1620	1	12	4	1700	40	9
864	806	399	INDUSTRIAL DR	COLLECTOR	2670	1	10	0	1750	35	10
865	806	866	WOOD ST	COLLECTOR	2291	1	10	4	1575	35	10
866	807	809	DOUGLAS BLVD	COLLECTOR	1325	1	10	0	1750	35	9
867	808	809	WALLMART DRIVEWAY	LOCAL ROADWAY	337	1	10	0	1750	25	9
868	809	386	US-54 BUS	COLLECTOR	1255	1	12	4	1750	40	9
869	809	399	US-54 BUS	COLLECTOR	2329	1	12	4	1750	40	9
870	810	386	UNIVERSITY AVE	LOCAL ROADWAY	511	1	12	4	1750	30	9
871	811	387	ST LOUIS AVE	LOCAL ROADWAY	896	1	10	0	1750	25	11
872	811	983	VINE ST	COLLECTOR	867	1	12	4	1575	35	12
873	813	388	US-54 BUS	LOCAL ROADWAY	1112	1	12	0	1125	25	11

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
874	813	394	US-54 BUS	LOCAL ROADWAY	300	1	12	0	1750	25	11
875	813	814	W 5TH ST	COLLECTOR	274	1	12	4	1575	35	11
876	814	395	COURT ST	COLLECTOR	302	1	12	4	1575	35	11
877	814	985	W 5TH ST	COLLECTOR	1728	1	12	4	1575	35	11
878	815	387	BLUFF ST	LOCAL ROADWAY	1650	1	12	0	1750	30	11
879	815	390	BLUFF ST	LOCAL ROADWAY	1113	1	12	0	1125	25	11
880	815	813	E 5TH ST	LOCAL ROADWAY	702	1	12	0	1750	25	11
881	816	394	E 4TH ST	LOCAL ROADWAY	297	1	12	2	1750	25	11
882	817	419	STATE HWY C	COLLECTOR	1107	1	10	0	1700	40	19
883	818	396	WESTMINSTER AVE	LOCAL ROADWAY	1210	1	10	0	1750	30	11
884	818	986	S WESTMINSTER DR	COLLECTOR	1387	1	12	0	1575	35	11
885	819	70	ACCESS RD	COLLECTOR	463	1	10	0	1575	35	18
886	820	463	STATE HWY BB	COLLECTOR	4607	1	10	0	1700	55	18
887	821	464	STATE HWY BB	COLLECTOR	5575	1	10	0	1700	55	25
888	822	81	MISSOURI A	COLLECTOR	3205	1	10	0	1700	55	4
889	823	822	OLD U.S. 40	COLLECTOR	637	1	10	0	1700	45	4

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
890	824	825	MISSOURI J	COLLECTOR	8529	1	10	0	1700	55	36
891	825	826	MISSOURI J	COLLECTOR	1992	1	10	0	1700	50	37
892	826	827	MISSOURI J	COLLECTOR	1991	1	10	0	1700	50	37
893	827	828	MISSOURI J	COLLECTOR	3625	1	10	0	1700	50	37
894	828	829	MISSOURI J	COLLECTOR	4455	1	10	0	1700	50	37
895	829	830	MISSOURI J	COLLECTOR	4565	1	10	0	1700	50	37
896	830	900	MISSOURI J	COLLECTOR	3037	1	10	0	1700	50	37
897	831	83	MISSOURI D	COLLECTOR	962	1	10	1	1700	45	6
898	832	769	WILLIAM WOODS AVE	COLLECTOR	587	1	10	0	1700	45	9
899	833	832	CARDINAL DR	LOCAL ROADWAY	1217	1	12	0	1350	30	9
900	834	833	CARDINAL DR	LOCAL ROADWAY	1134	1	12	0	1350	30	9
901	835	836	STATE RD PP	COLLECTOR	3549	1	10	0	1700	50	26
902	836	837	STATE RD PP	COLLECTOR	2947	1	10	0	1700	50	26
903	837	838	STATE RD PP	COLLECTOR	2933	1	10	0	1700	50	26
904	838	839	STATE RD PP	COLLECTOR	977	1	10	0	1700	50	26
905	839	840	STATE RD PP	COLLECTOR	1102	1	10	0	1700	50	26
906	840	841	STATE RD PP	COLLECTOR	3434	1	10	0	1700	50	26
907	841	842	STATE RD PP	COLLECTOR	1847	1	10	0	1700	50	25

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
908	842	468	STATE RD PP	COLLECTOR	4457	1	10	0	1700	50	25
909	843	728	STATE RD PP	COLLECTOR	928	1	10	0	1700	50	33
910	844	843	STATE RD PP	COLLECTOR	1360	1	10	0	1700	50	33
911	845	844	STATE RD PP	COLLECTOR	1442	1	10	0	1700	50	33
912	846	845	STATE RD PP	COLLECTOR	3081	1	10	0	1700	50	33
913	847	848	STATE HWY NN	COLLECTOR	2223	1	10	0	1700	50	26
914	848	849	STATE HWY NN	COLLECTOR	2319	1	10	0	1700	50	26
915	849	850	STATE HWY NN	COLLECTOR	2137	1	10	0	1700	50	26
916	850	851	STATE HWY NN	COLLECTOR	1308	1	10	0	1700	45	19
917	851	852	STATE HWY NN	COLLECTOR	2194	1	10	0	1700	45	19
918	852	853	STATE HWY NN	COLLECTOR	1286	1	10	0	1700	45	19
919	853	854	STATE HWY NN	COLLECTOR	1507	1	10	0	1700	45	19
920	854	855	STATE HWY NN	COLLECTOR	3114	1	10	0	1700	50	19
921	855	856	STATE HWY NN	COLLECTOR	1593	1	10	0	1700	50	19
922	856	857	STATE HWY NN	COLLECTOR	3670	1	10	0	1700	55	19
923	857	858	STATE HWY NN	COLLECTOR	5509	1	10	0	1700	55	19
924	857	964	CO ROUTE 414	COLLECTOR	2675	1	10	0	1575	35	18
925	858	444	STATE HWY NN	COLLECTOR	3903	1	10	0	1700	50	19
926	859	408	TYNNYSON RD	COLLECTOR	2654	1	10	0	1700	45	12
927	860	861	COTE SANS DESSEIN RD	COLLECTOR	3428	1	10	0	1575	35	11

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
928	860	980	OLD JEFFERSON CITY RD	COLLECTOR	2127	1	12	0	1575	35	11
929	861	405	COTE SANS DESSEIN RD	COLLECTOR	257	1	10	0	1575	35	11
930	862	58	N HOSPITAL DR	LOCAL ROADWAY	1165	1	10	0	1350	30	11
931	863	815	E 5TH ST	LOCAL ROADWAY	849	1	12	0	1125	25	11
932	865	387	US-54 BUS	COLLECTOR	1001	1	10	0	1750	35	11
933	865	776	US-54 BUS	COLLECTOR	400	1	10	0	1750	35	11
934	865	981	E 9TH ST	COLLECTOR	922	1	10	0	1575	35	11
935	866	400	E ST EUNICE RD	COLLECTOR	2523	1	10	0	1575	35	10
936	867	832	CARDINAL DR	COLLECTOR	1187	1	10	0	1700	40	9
937	868	867	CARDINAL DR	COLLECTOR	743	1	10	0	1700	40	9
938	869	482	STATE HWY BB	COLLECTOR	1574	1	10	0	1700	45	32
939	870	869	CO RD 480	COLLECTOR	2347	1	10	0	1700	45	32
940	871	872	MISSOURI AB	COLLECTOR	2411	1	10	0	1700	50	14
941	872	873	MISSOURI AB	COLLECTOR	2170	1	10	0	1700	50	14
942	873	874	MISSOURI AB	COLLECTOR	2230	1	10	0	1700	50	14
943	874	875	MISSOURI AB	COLLECTOR	1826	1	10	0	1575	35	5
944	875	135	MISSOURI AB	COLLECTOR	2806	1	10	0	1700	50	5
945	876	877	MISSOURI N	COLLECTOR	3762	1	10	0	1700	50	15

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
946	876	924	MISSOURI N	COLLECTOR	2897	1	10	0	1700	50	15
947	877	878	MISSOURI N	COLLECTOR	1834	1	10	0	1700	50	16
948	878	879	MISSOURI N	COLLECTOR	1613	1	10	0	1700	50	16
949	879	880	MISSOURI N	COLLECTOR	4152	1	10	0	1700	50	16
950	880	238	MISSOURI N	COLLECTOR	3992	1	10	0	1700	45	16
951	881	85	OLD U.S. 40	COLLECTOR	8126	1	10	4	1700	45	6
952	882	883	STATE HWY EE	COLLECTOR	3338	1	9	0	1700	50	30
953	883	884	STATE HWY EE	COLLECTOR	2406	1	9	0	1700	50	30
954	884	885	STATE HWY EE	COLLECTOR	1780	1	9	0	1700	50	31
955	885	298	STATE HWY EE	COLLECTOR	3350	1	9	0	1750	50	31
956	886	887	STATE HWY AD	COLLECTOR	1592	1	10	0	1700	50	20
957	887	888	STATE HWY AD	COLLECTOR	4504	1	10	0	1700	50	20
958	888	420	STATE HWY AD	COLLECTOR	5668	1	10	0	1700	50	19
959	889	207	COUNTY RD 106	COLLECTOR	6478	1	10	0	1700	50	10
960	890	770	MISSOURI HH	COLLECTOR	398	1	12	4	1700	45	9
961	890	771	MISSOURI HH	COLLECTOR	1021	1	10	0	1700	45	9
962	892	890	RICHLAND HEIGHTS RD	COLLECTOR	1111	1	10	0	1700	40	9
963	893	892	RICHLAND HEIGHTS RD	COLLECTOR	3164	1	10	0	1700	50	9
964	894	775	MISSOURI HH	COLLECTOR	5567	1	10	0	1700	55	3
965	895	896	OLD US 40	COLLECTOR	7834	1	10	0	1700	50	3

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
966	896	897	OLD US 40	COLLECTOR	4393	1	10	0	1700	50	3
967	897	898	OLD US 40	COLLECTOR	1924	1	10	0	1700	50	3
968	898	28	OLD US 40	COLLECTOR	3463	1	10	0	1700	50	3
969	899	92	CO RD 159	COLLECTOR	2374	1	10	0	1700	50	4
970	900	901	MISSOURI J	COLLECTOR	5022	1	10	0	1700	50	37
971	901	902	MISSOURI J	COLLECTOR	3992	1	10	0	1700	50	37
972	902	903	MISSOURI J	COLLECTOR	2597	1	10	0	1700	50	37
973	903	904	MISSOURI J	COLLECTOR	2550	1	10	0	1700	50	0
974	905	906	MISSOURI OO	COLLECTOR	2719	1	10	0	1700	55	41
975	906	907	MISSOURI OO	COLLECTOR	2000	1	10	0	1700	55	41
976	907	908	MISSOURI OO	COLLECTOR	1456	1	10	0	1700	55	41
977	908	909	MISSOURI OO	COLLECTOR	3138	1	10	0	1700	55	41
978	910	558	SR 100	COLLECTOR	843	1	10	0	1700	45	29
979	911	554	SR 100	COLLECTOR	858	1	10	0	1700	45	28
980	912	561	MISSOURI Z	COLLECTOR	1523	1	10	0	1700	50	29
981	913	912	MISSOURI Z	COLLECTOR	1278	1	10	0	1700	50	36
982	914	67	SILVER DR	COLLECTOR	820	1	10	0	1700	45	19
983	915	914	SILVER DR	COLLECTOR	2458	1	10	0	1700	45	19
984	916	77	CO ROAD 328	COLLECTOR	2154	1	10	0	1700	45	18
985	917	147	COUNTY RD 134	COLLECTOR	1181	1	10	0	1575	35	14

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
986	918	106	COUNTY RD 134	COLLECTOR	1192	1	10	0	1575	35	13
987	919	225	COUNTY RD 113	COLLECTOR	777	1	10	0	1575	35	13
988	920	225	COUNTY RD 113	COLLECTOR	764	1	10	0	1575	35	13
989	921	881	OLD U.S. 40	COLLECTOR	2399	1	10	4	1700	45	6
990	922	921	OLD U.S. 40	COLLECTOR	3085	1	10	4	1700	45	6
991	923	922	OLD U.S. 40	COLLECTOR	7882	1	10	4	1700	45	6
992	924	923	MISSOURI N	COLLECTOR	1141	1	10	0	1700	40	6
993	925	876	COUNTY RD 280	COLLECTOR	1284	1	10	0	1700	35	15
994	926	923	MISSOURI N	COLLECTOR	1564	1	10	0	1700	40	6
995	927	924	MICAH RD	COLLECTOR	4330	1	10	0	1575	35	6
996	928	118	COUNTY RD 132	COLLECTOR	2529	1	10	0	1575	35	13
997	929	930	PREMIER RD	LOCAL ROADWAY	1004	1	10	4	1575	30	10
998	930	207	CHANDLER RD	COLLECTOR	2688	1	10	0	1575	35	10
999	931	479	COUNTY RD 452	COLLECTOR	1097	1	10	0	1575	35	32
1000	932	431	W 3RD ST	LOCAL ROADWAY	1484	1	12	4	1350	30	34
1001	933	431	BROAD ST	LOCAL ROADWAY	2167	1	12	4	1350	30	27
1002	934	880	COUNTY RD 278	COLLECTOR	2786	1	10	0	1750	35	16
1003	935	936	MISSOURI HH	COLLECTOR	4577	1	10	0	1700	55	23

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
1004	936	276	MISSOURI HH	COLLECTOR	3154	1	10	0	1750	55	23
1005	938	618	W 3RD ST	COLLECTOR	1065	1	10	0	1575	35	35
1006	939	45	HAYMART LN	COLLECTOR	298	1	12	0	1575	30	9
1007	940	38	COUNTY RD 209	COLLECTOR	2745	1	10	0	1575	35	3
1008	941	39	COUNTY RD 210	COLLECTOR	1491	1	10	0	1575	35	3
1009	942	38	COUNTY RD 110	COLLECTOR	2405	1	10	0	1575	35	3
1010	943	39	COUNTY RD 114	COLLECTOR	3261	1	10	0	1575	35	3
1011	944	33	COUNTY RD 220	COLLECTOR	264	1	10	0	1575	35	3
1012	945	33	COUNTY RD 220	COLLECTOR	249	1	10	0	1575	35	3
1013	946	945	COUNTY RD 220	COLLECTOR	415	1	10	0	1575	35	3
1014	947	944	COUNTY RD 220	COLLECTOR	406	1	10	0	1575	35	3
1015	948	947	COUNTY RD 220	COLLECTOR	3817	1	10	0	1575	35	3
1016	949	946	COUNTY RD 220	COLLECTOR	2520	1	10	0	1575	35	3
1017	950	951	COUNTY RD 318	COLLECTOR	2374	1	10	0	1575	35	18
1018	951	952	COUNTY RD 318	COLLECTOR	356	1	10	0	1575	35	18
1019	952	74	COUNTY RD 318	COLLECTOR	283	1	10	0	1575	35	18
1020	953	952	SILVER DR	COLLECTOR	1348	1	10	0	1575	35	18
1021	954	955	COUNTY RD 456	COLLECTOR	1312	1	10	0	1575	35	26
1022	955	956	STATE RD PP	COLLECTOR	2680	1	10	0	1700	50	26
1023	955	959	STATE RD PP	COLLECTOR	2251	1	10	0	1700	50	26

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
1024	956	957	STATE RD PP	COLLECTOR	1899	1	10	0	1700	50	33
1025	957	958	STATE RD PP	COLLECTOR	1552	1	10	0	1700	50	33
1026	958	846	STATE RD PP	COLLECTOR	1203	1	10	0	1700	50	33
1027	959	960	STATE RD PP	COLLECTOR	2329	1	10	0	1700	50	26
1028	960	835	STATE RD PP	COLLECTOR	3155	1	10	0	1700	50	26
1029	961	685	WILDWOOD ESTATES DR	COLLECTOR	2068	1	10	0	1575	35	21
1030	962	859	COUNTY RD 409	COLLECTOR	2009	1	10	0	1575	35	12
1031	963	66	US-54 BUS	COLLECTOR	2695	1	10	0	1700	40	11
1032	964	445	CO ROUTE 407	COLLECTOR	6552	1	10	0	1575	35	18
1033	964	857	CO ROUTE 414	COLLECTOR	2675	1	10	0	1575	35	18
1034	965	420	COUNTY RD 409	COLLECTOR	5322	1	10	0	1575	35	19
1035	966	394	US-54 BUS	LOCAL ROADWAY	669	1	10	4	1750	25	11
1036	966	968	US-54 BUS TRAFFIC CIRCLE TO E 2ND ST	LOCAL ROADWAY	126	1	12	4	1125	25	11
1037	967	966	STATE RD C TRAFFIC CIRCLE TO US-54 BUS	LOCAL ROADWAY	117	1	12	4	1125	25	11
1038	968	389	E 2ND ST TRAFFIC CIRCLE TO US-54 BUS	LOCAL ROADWAY	118	1	12	4	1125	25	11
1039	969	512	MISSOURI C	COLLECTOR	483	1	10	0	1125	25	39
1040	970	319	MISSOURI CC	COLLECTOR	7691	1	10	0	1700	60	21

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
1041	970	687	MISSOURI CC	COLLECTOR	760	1	10	0	1700	60	21
1042	971	970	COUNTY RD 428	MINOR ARTERIAL	2657	1	12	0	1700	40	21
1043	972	685	MISSOURI O	COLLECTOR	569	1	10	0	1700	55	21
1044	973	972	COUNTY RD 448	COLLECTOR	7299	1	12	0	1700	40	21
1045	974	398	HICKMAN AVE	COLLECTOR	1355	1	12	0	1700	40	11
1046	975	5	I-70	FREEWAY	711	2	12	10	2250	75	3
1047	976	800	I-70	FREEWAY	643	2	12	10	2250	75	7
1048	977	766	W 12TH ST	COLLECTOR	1814	1	12	4	1575	35	11
1049	978	765	E 9TH ST	COLLECTOR	1553	1	10	0	1575	35	11
1050	978	977	NICHOLS ST	COLLECTOR	441	1	12	4	1575	35	11
1051	979	765	WESTMINSTER AVE	COLLECTOR	1803	1	10	0	1700	45	11
1052	979	974	W 7TH STREET	COLLECTOR	1575	1	12	4	1700	40	11
1053	979	985	WESTMINSTER AVE	COLLECTOR	789	1	10	0	1750	45	11
1054	980	55	CO ROUTE 306	COLLECTOR	571	1	12	0	1575	35	11
1055	981	978	E 9TH ST	COLLECTOR	235	1	10	0	1575	35	11
1056	981	984	COURT ST	COLLECTOR	2236	1	12	4	1575	35	11
1057	982	385	VINE ST	COLLECTOR	1963	1	12	4	1575	35	12
1058	982	779	E 10TH ST	COLLECTOR	495	1	10	0	1575	35	11
1059	983	865	E 9TH ST	COLLECTOR	898	1	12	4	1575	35	11

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
1060	983	982	VINE ST	COLLECTOR	388	1	12	4	1575	35	12
1061	984	814	COURT ST	COLLECTOR	404	1	12	4	1575	35	11
1062	985	396	WESTMINSTER AVE	COLLECTOR	296	1	10	0	1750	45	11
1063	985	979	WESTMINSTER AVE	COLLECTOR	789	1	10	0	1700	45	11
1064	986	403	S WESTMINSTER DR	COLLECTOR	1181	1	12	0	1575	35	11
1065	986	987	W CHESTNUT ST	COLLECTOR	2441	1	12	0	1575	35	11
1066	987	860	OLD JEFFERSON CITY RD	COLLECTOR	362	1	12	0	1575	35	11
1067	8005	975	I-70	FREEWAY	701	2	12	10	2250	75	3
1068	8028	28	US-54	MINOR ARTERIAL	934	2	12	10	1900	55	3
1069	8073	756	US-54	FREEWAY	1778	2	12	10	2250	75	25
Exit Link	28	8028	US-54	MINOR ARTERIAL	934	2	12	10	1900	55	3
Exit Link	133	8113	MISSOURI A	COLLECTOR	4706	1	10	0	1700	50	1
Exit Link	221	8221	MISSOURI F	COLLECTOR	2581	1	10	0	1700	60	8
Exit Link	300	8300	SR 94	COLLECTOR	2768	1	10	0	1700	55	31
Exit Link	440	8440	MISSOURI H	COLLECTOR	1626	1	10	0	1700	50	18
Exit	488	8488	MISSOURI C	COLLECTOR	744	1	10	0	1700	55	38

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft)	No. of Lanes	Lane Width (ft)	Shoulder Width (ft)	Saturation Flow Rate	Free Flow Speed (mph)	Grid Map Number
Link											
Exit Link	588	8588	SR 100	COLLECTOR	1697	1	10	0	1700	30	39
Exit Link	589	8589	SR 89	COLLECTOR	2399	1	11	0	1700	50	40
Exit Link	623	8623	MISSOURI N	COLLECTOR	2188	1	10	0	1700	45	41
Exit Link	682	8682	SR 94	COLLECTOR	1621	1	10	0	1700	60	0
Exit Link	725	8725	SR 19	COLLECTOR	705	1	10	2	1700	50	24
Exit Link	756	8073	US-54	FREEWAY	1778	2	12	10	2250	75	25
Exit Link	775	8775	MISSOURI HH	COLLECTOR	3647	1	10	0	1700	55	2
Exit Link	904	8585	MISSOURI J	COLLECTOR	1505	1	10	0	1700	50	0
Exit Link	909	8909	MISSOURI OO	COLLECTOR	4064	1	10	0	1700	55	41
Exit Link	975	8005	I-70	FREEWAY	701	2	12	10	2250	75	3
Exit Link	976	8800	I-70	FREEWAY	726	2	12	10	2250	75	7

Table K-2. Nodes in the Link-Node Analysis Network which are Controlled

Node	X Coordinate (ft)	Y Coordinate (ft)	Control Type	Grid Map Number
1	1785578	1009355	Stop	32
28	1799545	1134965	Stop	3
30	1799399	1133529	Actuated	3
31	1799350	1132837	Actuated	3
32	1799321	1132001	Actuated	3
33	1799193	1128337	Stop	3
38	1799013	1122663	Stop	3
39	1798819	1118869	Stop	3
40	1798916	1114671	TCP - Actuated	9
45	1798937	1115370	Stop	9
55	1791132	1093239	Stop	11
56	1790825	1097851	TCP - Actuated	11
57	1791442	1097640	TCP - Actuated	11
58	1792896	1097260	Stop	11
64	1788667	1088071	Stop	19
65	1789317	1087953	Stop	19
67	1788208	1088082	Stop	19
70	1770294	1066666	Stop	18
74	1781623	1079816	Stop	18
79	1838175	1129846	Stop	4
80	1837954	1129168	Stop	4
83	1867884	1121167	Stop	6
84	1867921	1122064	Stop	6
85	1868005	1123954	Stop	6
96	1824575	1124599	Stop	4
106	1832254	1111063	Stop	13
118	1834495	1095636	Stop	13
134	1855707	1124232	Stop	5
135	1855523	1116601	Stop	5

Node	X Coordinate (ft)	Y Coordinate (ft)	Control Type	Grid Map Number
147	1854069	1100771	Stop	14
157	1862743	1077141	Stop	21
167	1867387	1053715	Stop	29
179	1844583	1047264	Stop	28
181	1835982	1044791	Stop	27
185	1820453	1034503	Stop	34
188	1814171	1031372	Stop	34
207	1806792	1106003	Stop	10
217	1779332	1103880	Stop	8
225	1823763	1095551	Stop	13
232	1804632	1095400	Stop	12
238	1904659	1113536	Stop	16
276	1908339	1080392	TCP - Actuated	23
296	1916743	1050108	Stop	30
298	1923765	1052900	TCP - Actuated	31
319	1840987	1075948	Stop	21
384	1801217	1103121	Stop	10
385	1799626	1102859	Stop	10
386	1798743	1102876	Actuated	9
387	1798656	1099507	Actuated	11
390	1798579	1096745	Stop	11
394	1797879	1097577	Actuated	11
395	1797602	1097598	Stop	11
396	1795888	1097628	Actuated	11
398	1794189	1097383	Stop	11
399	1798757	1106460	Actuated	9
400	1798843	1108887	Stop	9
403	1795850	1093854	Stop	11
405	1793232	1091207	Stop	11
408	1798406	1090409	Stop	11

Node	X Coordinate (ft)	Y Coordinate (ft)	Control Type	Grid Map Number
420	1806025	1068677	Stop	19
422	1811092	1059684	Stop	26
431	1819195	1035267	Stop	27
433	1779127	1096452	Stop	8
434	1778913	1088379	Stop	18
441	1789627	1087917	Stop	19
444	1786599	1084255	Stop	19
445	1783934	1081368	Stop	18
451	1774611	1070671	Stop	18
468	1780442	1051034	Stop	25
479	1781020	1032940	Stop	32
551	1848953	1036701	Stop	28
561	1884761	1036276	Stop	29
618	1849147	1035131	Yield	35
634	1877162	1007822	Stop	41
665	1883803	1006844	Stop	41
679	1780925	1015034	Stop	32
685	1846787	1076485	Stop	21
687	1840843	1067497	Stop	21
703	1843787	1065253	Stop	21
723	1931803	1086319	Stop	24
724	1931833	1082678	Stop	24
757	1762172	1051108	Stop	25
758	1760925	1051177	Stop	25
761	1774398	1071714	Stop	18
765	1795968	1100514	Stop	11
766	1795971	1101719	Stop	11
767	1796067	1104888	Stop	9
769	1793189	1107838	Stop	9
770	1792716	1108359	Stop	9

Node	X Coordinate (ft)	Y Coordinate (ft)	Control Type	Grid Map Number
776	1798682	1100908	Actuated	11
779	1799080	1100904	Stop	11
780	1801271	1100847	Stop	12
788	1849051	1035707	Stop	28
793	1761806	1051108	Stop	25
805	1796167	1106505	Stop	9
809	1798754	1104131	Actuated	9
813	1797897	1097877	Actuated	11
814	1797624	1097899	Stop	11
815	1798598	1097858	Stop	11
822	1838275	1130102	Stop	4
832	1793571	1107392	Stop	9
857	1786424	1074845	Stop	19
859	1801056	1090267	Stop	12
860	1793126	1094862	Stop	11
863	1799446	1097837	Yield	12
865	1798677	1100508	Stop	11
866	1801364	1108783	Stop	10
869	1782464	1029886	Stop	32
876	1889895	1114441	TCP - Actuated	15
880	1900764	1114409	TCP - Actuated	16
890	1792453	1108658	Stop	9
904	1922993	1023166	Stop	N/A
955	1800042	1036046	Stop	26
964	1783749	1074819	Stop	18
966	1797851	1096909	Yield	11
967	1797914	1096810	Yield	11
968	1797755	1096827	Yield	11
970	1840891	1068256	Stop	21
972	1846218	1076440	Stop	21

Node	X Coordinate (ft)	Y Coordinate (ft)	Control Type	Grid Map Number
977	1797536	1100969	Stop	11
979	1795911	1098712	Stop	11
981	1797756	1100536	Stop	11
982	1799575	1100897	Stop	12
983	1799575	1100509	Stop	12
984	1797638	1098303	Stop	11
985	1795896	1097923	Stop	11
986	1795787	1095033	Stop	11
987	1793349	1095148	Stop	11

[1]Coordinates are in the North American Datum of 1983 Missouri Central State Plane Zone

APPENDIX L

Subarea Boundaries

L. SUBAREA BOUNDARIES

Subarea C1	County: Callaway Defined as the area within the following boundary: The area within a two mile radius of the Callaway Plant.
Subarea C2	County: Callaway Defined as the area within the following boundary: The area bounded by Route UU on the north; Route AD and County Road 428 on the south; County Roads 111 and 419 on the west; and County Road 133 on the east.
Subarea C3	County: Callaway Defined as the area within the following boundary: The area bounded by County Roads 132 and 134 on the north; Route O on the south; Route D on the east; and County Road 133 on the west.
Subarea C4	County: Callaway Defined as the area within the following boundary: The area bounded by Routes O and K on the north; the Missouri River on the south; the Montgomery County line on the east; and County Roads 469 and 448 on the west.
Subarea C5	County: Callaway Defined as the area within the following boundary: The area bounded by County Roads 469 and 448 on the east; County Road 459, Highway 94 and Auxvasse Creek on the west; the Missouri River on the south, and two miles from the plant on the north.
Subarea C6	County: Callaway Defined as the area within the following boundary: The area bounded by Route AD and County Road 428 on the north; Highway 94 on the south; County Road 459 on the east; and Routes C, VV, and County Road 447 on the west.
Subarea C7	County: Callaway Defined as the area within the following boundary: The area south of Hams Prairie bounded on the north by Route C from Hams Prairie extended directly west to the Middle River; by Routes C, VV and County Road 447 on the east; the Middle River on the west; and the Missouri River on the south.

Subarea C8 County: Callaway

Defined as the area within the following boundary: The area southeast of Fulton bounded by Route JJ, Route UU, County Roads 111 and 419, and Route AD on the east, Route C from Hams Prairie extended directly west to the Middle River on the south; and Route NN, Fulton city limits and Route Z on the west and north. This does not include the City of Fulton.

Subarea C9 County: Callaway

Defined as the area within the following boundary: The City of Fulton

Subarea C10 County: Callaway

Defined as the area within the following boundary: The area bounded by Route Z and I-70 on the north, County roads 132 and 134 on the south, Route D on the east; and Route JJ on the west.

Subarea C11 County: Callaway

Defined as the area within the following boundary: The area bounded by I-70 on the north; Route K on the south, the Montgomery County line on the east; and Route D on the west.

Subarea G1 County: Gasconade

Defined as the area within the following boundary: The area south of the Missouri River, east of the Osage County line, and northwest of Shawnee Creek, including Morrison

Subarea M1 County: Montgomery

Defined as the area within the following boundary: The area south of I-70, North of Route K, east of the Callaway County line, and west of County Roads 278 (Graveyard Hill Road) and 283 (Mill Pond Road) and Routes HH and K

Subarea M2 County: Montgomery

Defined as the area within the following boundary: The area south of Route K to the Missouri River between the Callaway County line and Route P, County Road 295 (Warden's Branch Road) and Route EE, including Rhineland.

Subarea O1 County: Osage

Defined as the area within the following boundary: The area east of St. Aubert, west of Route N, and within five miles of the Missouri River.

NOTE: Descriptions taken from the State of Missouri Emergency Management Agency Nuclear Accident Plan, January 2010

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 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 EPZ. Specifically, if the tail of the mobilization distribution were truncated (i.e., if those who responded most slowly to the Advisory to Evacuate, could be persuaded to respond much more rapidly), how would the ETE be affected? The case considered was Scenario 6, Region 3; a winter, midweek, midday, good weather evacuation of the entire EPZ. Table M-1 presents the results of this study.

Table M-1. Evacuation Time Estimates for Trip Generation Sensitivity Study

Trip Generation Period	Evacuation Time Estimate for Entire EPZ	
	90th Percentile	100th Percentile
2 Hours 30 Minutes	1:50	2:45
3 Hours 30 Minutes	1:50	3:35
4 Hours (Base)	2:05	4:10

As discussed in Section 7.3, traffic congestion exists within the EPZ for about 2 hours. The ETE for the 100th percentile closely mirror the values for the time the last evacuation trip is generated. In contrast, the 90th percentile ETE is very insensitive to truncating the tail of the mobilization distribution. Therefore, the results confirm the importance of accurately estimating the trip generation (mobilization) times. The results also indicate that programs to educate the public and encourage them toward faster responses for a radiological emergency, translates into shorter ETE at the 100th Percentile. The results also justify the guidance to employ the [stable] 90th percentile ETE for protective action recommendation (PAR) decision-making.

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 of changes in the percentage of people who decide to relocate from the Shadow Region. The case considered was Scenario 6, Region 3; a winter, midweek, midday, 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 Section 7.1 for additional information on population within the shadow region.

Table M-2 presents the evacuation time estimates for each of the cases considered. The results show that the ETE is insensitive to shadow evacuation. Tripling the shadow percentage does not affect the ETE at either Percentile. Reducing the shadow evacuation percentage to ten percent, reflecting the telephone survey results presented in Appendix F, or to zero percent has no effect on ETE.

Table M-2. Evacuation Time Estimates for Shadow Sensitivity Study

Percent Shadow Evacuation	Evacuating Shadow Vehicles	Evacuation Time Estimate for Entire EPZ	
		90th Percentile	100th Percentile
0	0	2:05	4:10
10	401	2:05	4:10
20 (Base)	804	2:05	4:10
60	2,408	2:05	4:10

M.3 Effect of Changes in EPZ Resident Population

A sensitivity study was conducted to determine the effect on ETE of changes in the resident population within the EPZ. As population in the EPZ 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 EPZ, changes in population will cause the demand side of the equation to change. The sensitivity study was conducted using the following planning assumptions:

1. The change in population within the EPZ was treated parametrically. The percent population change was varied between ±30%. Changes in population were applied to permanent residents only (as per federal guidance), in both the EPZ area and the Shadow Region.
2. The transportation infrastructure remained fixed; the presence of new roads 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 good weather scenario which yielded the highest ETE values was selected as the case to be considered in this sensitivity study (Scenario 1).

Table M-3 presents the results of the sensitivity study. Section IV of Appendix E to 10 CFR Part 50, and NUREG/CR-7002, Section 5.4, require licensees to provide an updated ETE analysis to the NRC when a population increase within the EPZ causes ETE values (for the 2-Mile Region, 5-Mile Region or entire EPZ) to increase by 25 percent or 30 minutes, whichever is less. Note that the ETE values for the 90th and 100th percentiles do not change significantly over the range of population changes considered. The existing highway network has sufficient reserve capacity to accommodate a reasonable population increase. Reducing population has no effect because the ETE values reflect the trip generation distribution, which is essentially independent of population.

Table M-3. ETE Variation with Population Change

EPZ Population	Base	Population Change			Base	Population Change		
		10%	20%	30%		-10%	-20%	-30%
	20,173	22,190	24,208	26,225	20,173	18,156	16,138	14,121
ETE for 90th Percentile								
Region	**Base**	**Population Change**			**Base**	**Population Change**		
		10%	**20%**	**30%**		**-10%**	**-20%**	**-30%**
2-Mile	1:15	1:15	1:15	1:15	1:15	1:10	1:10	1:10
5-Mile	1:55	1:55	1:55	1:55	1:55	1:50	1:50	1:50
Full EPZ	2:00	2:05	2:05	2:05	2:00	2:00	2:00	2:00
ETE for 100th Percentile								
Region	**Base**	**Population Change**			**Base**	**Population Change**		
		10%	**20%**	**30%**		**-10%**	**-20%**	**-30%**
2-Mile	4:00	4:00	4:00	4:00	4:00	4:00	4:00	4:00
5-Mile	4:05	4:05	4:05	4:05	4:05	4:05	4:05	4:05
Full EPZ	4:10	4:10	4:10	4:10	4:10	4:10	4:10	4:10

M.4 New Units and Proposed Roadways Sensitivity Analysis

A sensitivity study was conducted to determine the effect on ETE from the potential construction of two large new units, Units 2 and 3 at the Callaway Plant site, and two proposed roadways (to assist in traffic generated by an increase of construction workers at the new units). A total of six cases are considered. Three sets of roadway configurations are considered:

1. A no build scenario using only the existing infrastructure,
2. A proposed roadway connecting the plant to US-54 to the west, and
3. Both the proposed roadway to the west and an additional roadway connecting the plant to I-70, to the north.

The proposed roadways are considered as one-lane limited-access highways with an estimated free-flow speed of 60 mph. Their approximate locations are shown in Figure M-1:

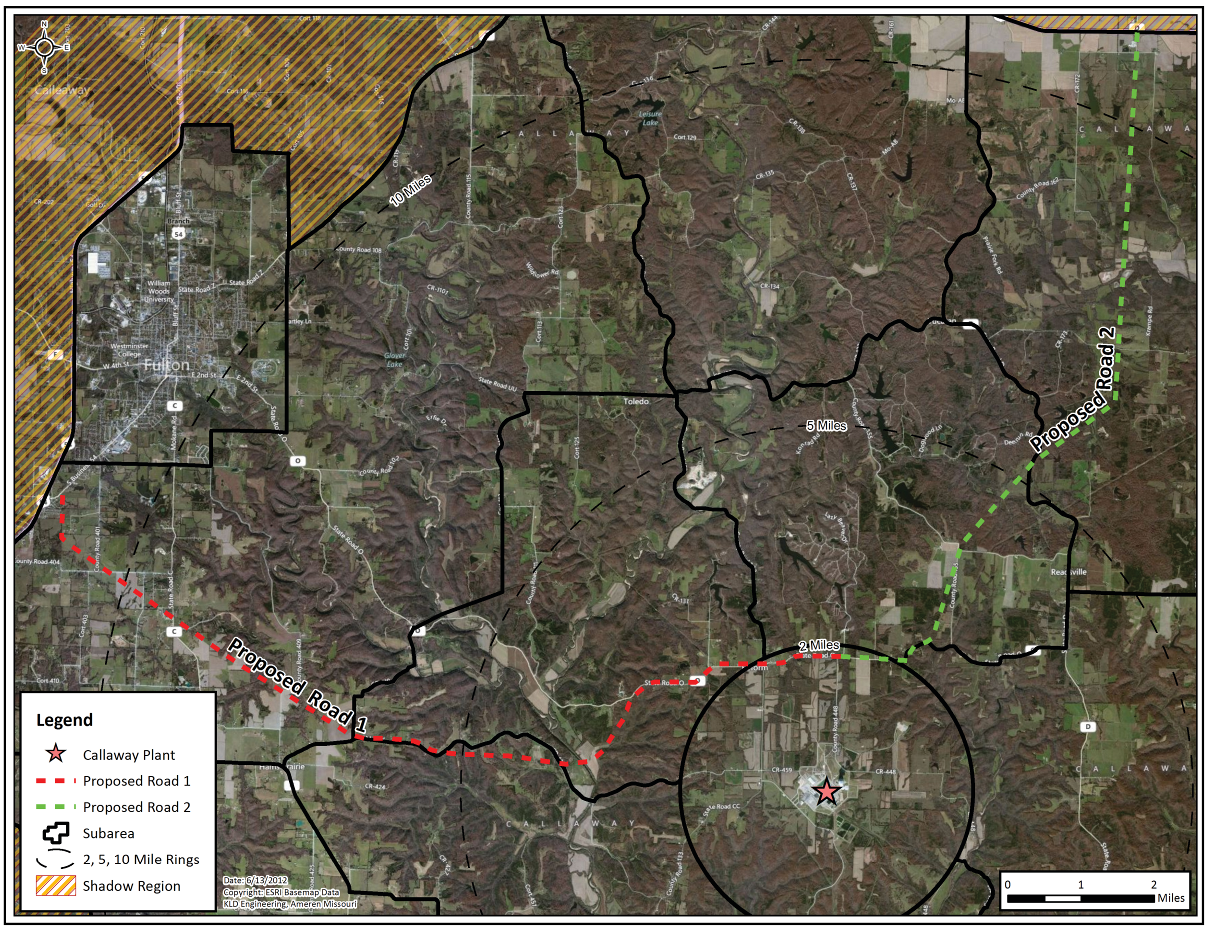


Figure M-1. Proposed Roadways 1 and 2.

For each set of roadway scenarios, two cases are considered:

1. 2,469 vehicles are added to the network representing vehicles used by workers constructing the proposed Unit 2.
2. 2,469 vehicles are added to the network, representing vehicles used by workers constructing the proposed Unit 3, and an additional 737 vehicles representing the vehicles used by plant workers at the operational Unit 2.

All sensitivity studies are assumed to occur in in the year 2023, as described in Chapter 3, Section 3.6. They are also assumed to occur during good weather so they can be compared to the "No Build" Scenario (Scenario 13 in Chapter 7). The same number of construction worker vehicles was used for the proposed Units 2 and 3, as they are assumed to be constructed in series.

Table M-4 summarizes the ETE for the 2-Mile, 5-Mile and Full EPZ Regions for the base case as well as the two sensitivity cases. In each case, Unit 3 construction increased the 90th percentile 2-mile Region ETE by 20 minutes and the 5-Mile Region by 5 minutes due to the increased number of vehicles from the plant workers at the operational Unit 2. Because the existing roadway network has sufficient reserve capacity, the proposed roadways have little effect on 100th percentile ETE.

Table M-4. Construction Scenarios Sensitivity Analysis

Roadway Scenario	Region	Construction of Unit 2		Construction of Unit 3 & Unit 2 Operational	
		90th Percentile ETE	100th Percentile ETE	90th Percentile ETE	100th Percentile ETE
No Build	2-Mile Region	1:20	4:00	1:40	4:00
	5-Mile Region	1:40	4:05	1:50	4:05
	Full EPZ	2:00	4:10	2:05	4:10
Proposed Road 1	2-Mile Region	1:20	4:00	1:40	4:00
	5-Mile Region	1:30	4:05	1:50	4:05
	Full EPZ	2:00	4:10	2:05	4:10
Proposed Road 1 and Road 2	2-Mile Region	1:20	4:00	1:40	4:00
	5-Mile Region	1:30	4:05	1:50	4:05
	Full EPZ	2:00	4:10	2:05	4:10

APPENDIX N

ETE Criteria Checklist

N. ETE CRITERIA CHECKLIST

Table N-1. ETE Review Criteria Checklist

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
1.0 Introduction		
a. The emergency planning zone (EPZ) and surrounding area should be described.	Yes	Section 1
b. A map should be included that identifies primary features of the site, including major roadways, significant topographical features, boundaries of counties, and population centers within the EPZ.	Yes	Figure 1-1
c. A comparison of the current and previous ETE should be provided and includes similar information as identified in Table 1-1, “ETE Comparison,” of NUREG/CR-7002.	Yes	Table 1-3
1.1 Approach		
a. A discussion of the approach and level of detail obtained during the field survey of the roadway network should be provided.	Yes	Section 1.3
b. Sources of demographic data for schools, special facilities, large employers, and special events should be identified.	Yes	Section 2.1 Section 3
c. Discussion should be presented on use of traffic control plans in the analysis.	Yes	Section 1.3, Section 2.2, Section 9, Appendix G
d. Traffic simulation models used for the analyses should be identified by name and version.	Yes	Section 1.3, Table 1-3, Appendix B, Appendix C

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
e. Methods used to address data uncertainties should be described.	Yes	Section 3 – avoid double counting Section 5, Appendix F – 4.5% sampling error at 95% confidence interval for telephone survey
1.2 Assumptions		
a. The planning basis for the ETE includes the assumption that the evacuation should be ordered promptly and no early protective actions have been implemented.	Yes	Section 2.3 – Assumption 1 Section 5.1
b. Assumptions consistent with Table 1-2, "General Assumptions," of NUREG/CR-7002 should be provided and include the basis to support their use.	Yes	Sections 2.2, 2.3
1.3 Scenario Development		
a. The ten scenarios in Table 1-3, Evacuation Scenarios, should be developed for the ETE analysis, or a reason should be provided for use of other scenarios.	Yes	Tables 2-1, 6-2
1.3.1 Staged Evacuation		
a. A discussion should be provided on the approach used in development of a staged evacuation.	Yes	Sections 5.4.2, 7.2
1.4 Evacuation Planning Areas		
a. A map of EPZ with emergency response planning areas (ERPAs) should be included.	Yes	Figure 6-1
b. A table should be provided identifying the ERPAs considered for each ETE calculation by downwind direction in each sector.	Yes	Table 6-1, Table 7-5

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
c. A table similar to Table 1-4, “Evacuation Areas for a Staged Evacuation Keyhole,” of NUREG/CR-7002 should be provided and includes the complete evacuation of the 2, 5, and 10 mile areas and for the 2 mile area/5 mile keyhole evacuations.	Yes	Table 7-5
2.0 Demand Estimation		
a. Demand estimation should be developed for the four population groups, including permanent residents of the EPZ, transients, special facilities, and schools.	Yes	Permanent residents, employees, transients – Section 3, Appendix E Special facilities, schools – Section 8, Appendix E
2.1 Permanent Residents and Transient Population		
a. The US Census should be the source of the population values, or another credible source should be provided.	Yes	Section 3.1
b. Population values should be adjusted as necessary for growth to reflect population estimates to the year of the ETE.	Yes	2010 used as the base year for analysis. No growth of population necessary.
c. A sector diagram should be included, similar to Figure 2-1, “Population by Sector,” of NUREG/CR-7002, showing the population distribution for permanent residents.	Yes	Figure 3-2
2.1.1 Permanent Residents with Vehicles		
a. The persons per vehicle value should be between 1 and 2 or justification should be provided for other values.	Yes	1.78 persons per vehicle – Table 1-3
b. Major employers should be listed.	Yes	Appendix E – Table E-3

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
2.1.2 Transient Population		
a. A list of facilities which attract transient populations should be included, and peak and average attendance for these facilities should be listed. The source of information used to develop attendance values should be provided.	Yes	Sections 3.3, 3.4, Appendix E
b. The average population during the season should be used, itemized and totaled for each scenario.	Yes	Tables 3-4, 3-5 and Appendix E itemize the transient population and employee estimates. These estimates are multiplied by the scenario specific percentages provided in Table 6-3 to estimate transient population by scenario.
c. The percent of permanent residents assumed to be at facilities should be estimated.	Yes	Sections 3.3, 3.4
d. The number of people per vehicle should be provided. Numbers may vary by scenario, and if so, discussion on why values vary should be provided.	Yes	Sections 3.3, 3.4, Section 6
e. A sector diagram should be included, similar to Figure 2-1 of NUREG/CR-7002, showing the population distribution for the transient population.	Yes	Figure 3-6 – transients Figure 3-8 – employees
2.2 Transit Dependent Permanent Residents		
a. The methodology used to determine the number of transit dependent residents should be discussed.	Yes	Section 8.1, Table 8-1
b. Transportation resources needed to evacuate this group should be quantified.	Yes	Section 8.1, Tables 8-5, 8-10
c. The county/local evacuation plans for transit dependent residents should be used in the analysis.	Yes	Sections 8.1, 8.4

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
d. 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 should be provided. Data from local/county registration programs should be used in the estimate, but should not be the only set of data.	Yes	Section 8.5
e. Capacities should be provided for all types of transportation resources. Bus seating capacity of 50% should be used or justification should be provided for higher values.	Yes	Section 2.3 – Assumption 10 Sections 3.5, 8.1, 8.2, 8.3
f. An estimate of this population should be provided and information should be provided that the existing registration programs were used in developing the estimate.	Yes	Table 8-1 – transit dependents Section 8.4 – special needs
g. A summary table of the total number of buses, ambulances, or other transport needed to support evacuation should be provided and the quantification of resources should be detailed enough to assure double counting has not occurred.	Yes	Section 8.4 – page 8-6 Table 8-5, Section 8.3
2.3 Special Facility Residents		
a. A list of special facilities, including the type of facility, location, and average population should be provided. Special facility staff should be included in the total special facility population.	Yes	Appendix E, Tables E-2, E-6 – list facilities, type, location, and population
b. A discussion should be provided on how special facility data was obtained.	Yes	Sections 8.2, 8.3
c. The number of wheelchair and bed-bound individuals should be provided.	Yes	Section 3.5

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
d. An estimate of the number and capacity of vehicles needed to support the evacuation of the facility should be provided.	Yes	Section 8.3 Table 8-4
e. The logistics for mobilizing specially trained staff (e.g., medical support or security support for prisons, jails, and other correctional facilities) should be discussed when appropriate.	Yes	Section 8.4, 8.6, 8.7
2.4 Schools		
a. A list of schools including name, location, student population, and transportation resources required to support the evacuation, should be provided. The source of this information should be provided.	Yes	Table 8-2 Section 8.2
b. Transportation resources for elementary and middle schools should be based on 100% of the school capacity.	Yes	Table 8-2
c. The estimate of high school students who will use their personal vehicle to evacuate should be provided and a basis for the values used should be discussed.	Yes	Section 8.2
d. The need for return trips should be identified if necessary.	Yes	There are sufficient resources to evacuate schools in a single wave. However, Section 8.3 and Figure 8-1 discuss the potential for a multiple wave evacuation

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
2.5.1 Special Events		
a. A complete list of special events should be provided and includes 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 should be analyzed in the ETE.	Yes	Section 3.8
c. The percent of permanent residents attending the event should be estimated.	Yes	Section 3.8
2.5.2 Shadow Evacuation		
a. A shadow evacuation of 20 percent should be included for areas outside the evacuation area extending to 15 miles from the NPP.	Yes	Section 2.2 – Assumption 5 Figure 2-1 Section 3.2
b. Population estimates for the shadow evacuation in the 10 to 15 mile area beyond the EPZ are provided by sector.	Yes	Section 3.2 Figure 3-4 Table 3-3
c. The loading of the shadow evacuation onto the roadway network should be consistent with the trip generation time generated for the permanent resident population.	Yes	Section 5 – Table 5-9

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
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 3.7 Table 3-6 Section 6 Table 6-3
b. Pass through traffic is assumed to have stopped entering the EPZ about two hours after the initial notification.	Yes	Section 2.3 – Assumption 5 Section 3.7
2.6 Summary of Demand Estimation		
a. A summary table should be provided that identifies the total populations and total vehicles used in analysis for permanent residents, transients, transit dependent residents, special facilities, schools, shadow population, and pass-through demand used in each scenario.	Yes	Tables 3-8, 3-9
3.0 Roadway Capacity		
a. The method(s) used to assess roadway capacity should be discussed.	Yes	Section 4
3.1 Roadway Characteristics		
a. A field survey of key routes within the EPZ has been conducted.	Yes	Section 1.3
b. Information should be provided describing the extent of the survey, and types of information gathered and used in the analysis.	Yes	Section 1.3

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
c. A table similar to that in Appendix A, “Roadway Characteristics,” of NUREG/CR-7002 should be provided.	Yes	Appendix K, Table K-1
d. Calculations for a representative roadway segment should be provided.	Yes	Section 4
e. A legible map of the roadway system that identifies node numbers and segments used to develop the ETE should be provided and should be similar to Figure 3-1, “Roadway Network Identifying Nodes and Segments,” of NUREG/CR-7002.	Yes	Appendix K, Figures K-1 through K-42 present the entire link-node analysis network at a scale suitable to identify all links and nodes
3.2 Capacity Analysis		
a. The approach used to calculate the roadway capacity for the transportation network should be described in detail and identifies factors that should be expressly used in the modeling.	Yes	Section 4
b. The capacity analysis identifies where field information should be used in the ETE calculation.	Yes	Section 1.3, Section 4
3.3 Intersection Control		
a. A list of intersections should be provided that includes the total number of intersections modeled that are unsignalized, signalized, or manned by response personnel.	Yes	Appendix K, Table K-2
b. Characteristics for the 10 highest volume intersections within the EPZ are provided including the location, signal cycle length, and turn lane queue capacity.	Yes	Table J-1
c. Discussion should be provided on how signal cycle time is used in the calculations.	Yes	Section 4.1, Appendix C.

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
3.4 Adverse Weather		
a. The adverse weather condition should be identified and the effects of adverse weather on mobilization time should be considered.	Yes	Table 2-1, Section 2.3 – Assumption 9 Mobilization time – Table 2-2, Section 5.3 (page 5-10)
b. The speed and capacity reduction factors identified in Table 3-1, "Weather Capacity Factors," of NUREG/CR-7002 should be used or a basis should be provided for other values.	Yes	Table 2-2 – based on HCM 2010. The factors provided in Table 3-1 of NUREG/CR-7002 are from HCM 2000.
c. The study identifies assumptions for snow removal on streets and driveways, when applicable.	Yes	Section 5.3 – page 5-10 Appendix F – Section F.3.3
4.0 Development of Evacuation Times		
4.1 Trip Generation Time		
a. The process used to develop trip generation times should be identified.	Yes	Section 5
b. When telephone surveys are used, the scope of the survey, area of survey, number of participants, and statistical relevance should be provided.	Yes	Appendix F
c. Data obtained from telephone surveys should be summarized.	Yes	Appendix F
d. The trip generation time for each population group should be developed from site specific information.	Yes	Section 5, Appendix F

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
4.1.1 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 prior to 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.
b. Discussion should be provided on the time and method used to notify transients. The trip generation time discusses any difficulties notifying persons in hard to reach areas such as on lakes or in campgrounds.	Yes	Section 5.4.3
c. The trip generation time accounts for transients potentially returning to hotels prior to evacuating.	Yes	Section 5, Figure 5-1
d. Effect of public transportation resources used during special events where a large number of transients should be expected should be considered.	Yes	Section 3.7
e. The trip generation time for the transient population should be integrated and loaded onto the transportation network with the general public.	Yes	Section 5, Table 5-9

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
4.1.2 Transit Dependent Residents		
a. If available, existing plans and bus routes should be used in the ETE analysis. If new plans should be developed with the ETE, they have been agreed upon by the responsible authorities.	Yes	Section 8.3 – page 8-7. Pre-established bus routes do not exist. Basic bus routes were developed for the ETE analysis – see Figure 8-2, Table 8-10.
b. Discussion should be included on the means of evacuating ambulatory and non-ambulatory residents.	Yes	Section 8.4
c. The number, location, and availability of buses, and other resources needed to support the demand estimation should be provided.	Yes	Section 8.4
d. Logistical details, such as the time to obtain buses, brief drivers, and initiate the bus route should be provided.	Yes	Section 8.4, Figure 8-1
e. Discussion should identify the time estimated for transit dependent residents to prepare and travel to a bus pickup point, and describes the expected means of travel to the pickup point.	Yes	Section 8.3
f. The number of bus stops and time needed to load passengers should be discussed.	Yes	Section 8.3
g. A map of bus routes should be included.	Yes	Figure 8-2
h. The trip generation time for non-ambulatory persons includes the time to mobilize ambulances or special vehicles, time to drive to the home of residents, loading time, and time to drive out of the EPZ should be provided.	Yes	Section 8.4

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
i. Information should be provided to supports analysis of return trips, if necessary.	Yes	Sections 8.3, 8.4 Figure 8-1 Tables 8-9 through 8-11
4.1.3 Special Facilities		
a. Information on evacuation logistics and mobilization times should be provided.	Yes	Section 8-4
b. Discussion should be provided on the inbound and outbound speeds.	Yes	Sections 8.4
c. The number of wheelchair and bed-bounds individuals should be provided, and the logistics of evacuating these residents should be discussed.	Yes	Table 8-4
d. Time for loading of residents should be provided	Yes	Section 8.4
e. Information should be provided that indicates whether the evacuation can be completed in a single trip or if additional trips should be needed.	Yes	Section 8.4, Table 8-5
f. If return trips should be needed, the destination of vehicles should be provided.	Yes	Section 8.4
g. Discussion should be provided on whether special facility residents are expected to pass through the reception center prior to being evacuated to their final destination.	Yes	Section 8.4
h. Supporting information should be provided to quantify the time elements for the return trips.	Yes	Section 8.4

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
4.1.4 Schools		
a. Information on evacuation logistics and mobilization time should be provided.	Yes	Section 8.4
b. Discussion should be provided on the inbound and outbound speeds.	Yes	School bus routes are presented in Table 8-6. School bus speeds are presented in Tables 8-7 (good weather), 8-8 (rain), and 8-9 (snow or ice if applicable). Outbound speeds are defined as the minimum of the evacuation route speed and the State school bus speed limit. Inbound speeds are limited to the State school bus speed limit.
c. Time for loading of students should be provided.	Yes	Tables 8-7 through 8-9, Discussion in Section 8.4
d. Information should be provided that indicates whether the evacuation can be completed in a single trip or if additional trips are needed.	Yes	Section 8.4 – page 8-8
e. If return trips are needed, the destination of school buses should be provided.	Yes	Return trips are not needed
f. If used, reception centers should be identified. Discussion should be provided on whether students are expected to pass through the reception center prior to being evacuated to their final destination.	Yes	Table 8-3. Students are evacuated to receiving schools where they will be picked up by parents or guardians.

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
g. Supporting information should be provided to quantify the time elements for the return trips.	Yes	Return trips are not needed. Tables 8-7 and 8-9 provide time needed to arrive at care center, which could be used to compute a second wave evacuation if necessary
4.2 ETE Modeling		
a. General information about the model should be provided and demonstrates its use in ETE studies.	Yes	DYNEV II (Ver. 4.0.0.0). Section 1.3, Table 1-3, Appendix B, Appendix C.
b. If a traffic simulation model is not used to conduct the ETE calculation, sufficient detail should be provided to validate the analytical approach used. All criteria elements should have been met, as appropriate.	No	Not applicable as a traffic simulation model was used.
4.2.1 Traffic Simulation Model Input		
a. Traffic simulation model assumptions and a representative set of model inputs should be provided.	Yes	Appendices B and C describe the simulation model assumptions and algorithms Table J-2
b. A glossary of terms should be provided for the key performance measures and parameters used in the analysis.	Yes	Appendix A Tables C-1, C-2

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
4.2.2 Traffic Simulation Model Output		
a. A discussion regarding whether the traffic simulation model used must be in equilibration prior to calculating the ETE should be provided.	Yes	Appendix B
b. The minimum following model outputs should be provided to support review: 1. Total volume and percent by hour at each EPZ exit node. 2. Network wide average travel time. 3. Longest queue length for the 10 intersections with the highest traffic volume. 4. Total vehicles exiting the network. 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. Table J-5. 2. Table J-3. 3. Table J-1. 4. Table J-3. 5. Figures J-1 through J-14 (one plot for each scenario considered). 6. Table J-4. Network wide average speed also provided in Table J-3.
c. Color coded roadway maps should be provided for various times (i.e., at 2, 4, 6 hrs., etc.) during a full EPZ evacuation scenario, identifying areas where long queues exist including level of service (LOS) "E" and LOS "F" conditions, if they occur.	Yes	Figures 7-3 through 7-6
4.3 Evacuation Time Estimates for the General Public		
a. The ETE should include the time to evacuate 90% and 100% of the total permanent resident and transient population	Yes	Tables 7-1, 7-2

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
b. The ETE for 100% of the general public should include all members of the general public. Any reductions or truncated data should be explained.	Yes	Section 5.4 – truncating survey data to eliminate statistical outliers Table 7-2 – 100^{th} percentile ETE for general public
c. Tables should be provided for the 90 and 100 percent ETEs similar to Table 4-3, "ETEs for Staged Evacuation Keyhole," of NUREG/CR-7002.	Yes	Tables 7-3, 7-4
d. ETEs should be provided for the 100 percent evacuation of special facilities, transit dependent, and school populations.	Yes	Section 8.4 Tables 8-7 through 8-9 Tables 8-11 through 8-13
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 should be provided.	Yes	Section 9, Appendix G
b. A discussion of adjustments or additions to the traffic control plan that affect the ETE should be provided.	Yes	Appendix G
5.2 Enhancements in Evacuation Time		
a. The results of assessments for improvement of evacuation time should be provided.	Yes	Appendix M
b. A statement or discussion regarding presentation of enhancements to local authorities should be provided.	Yes	Results of the ETE study were formally presented to local authorities at the final project meeting. Recommended enhancements were discussed.
5.3 State and Local Review		

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
a. A list of agencies contacted and the extent of interaction with these agencies should be discussed.	Yes	Table 1-1
b. Information should be provided on any unresolved issues that may affect the ETE.	Yes	No issues were determined after review with the offsite agencies
5.4 Reviews and Updates		
a. A discussion of when an updated ETE analysis is required to be performed and submitted to the NRC.	Yes	Appendix M, Section M.3
5.5 Reception Centers and Congregate Care Center		
a. A map of congregate care centers and reception centers should be provided.	Yes	Figure 10-1
b. If return trips are required, assumptions used to estimate return times for buses should be provided.	Yes	Section 8.3 discusses a multi-wave evacuation procedure. Figure 8-1
c. It should be clearly stated if it is assumed that passengers are left at the reception center and are taken by separate buses to the congregate care center.	Yes	Section 2.3 – Assumption 7h Section 10

Technical Reviewer ______________________________ Date ________________________

Supervisory Review ______________________________ Date ________________________