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) schoolchildren; 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 on discussion with the offsite agencies, it is estimated that school bus mobilization time will average approximately 90 minutes extending from the Advisory to Evacuate, to the time when school 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 CGS EPZ indicates that schoolchildren will be evacuated to a safe location at emergency action levels of Site Area Emergency or higher, and that parents should listen to KONA (610 AM or 105.3 FM) to find out where to pick up their schoolchildren. As discussed in Section 2, this study assumes a fast breaking general emergency. Therefore, children are evacuated to assistance 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 assistance 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 210 people. Therefore, a total of **7 bus runs** are required to transport this population to assistance 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 CGS 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

$$P = 1{,}498 \times [0.04 \times 2.44 + 0.21 \times (2.35 - 1) \times 0.66 \times 0.55 + 0.45 \times (3.33 - 2) \times (0.66 \times 0.55)^2] = 1{,}498 \times 0.279 = 419$$

$$B = (0.5 \times P) \div 30 = 7$$

These calculations are explained as follows:

- All members (2.44 avg.) of households (HH) with no vehicles (4%) will evacuate by public transit or ride-share. The term 1,498 (number of households) x 0.04 x 2.44, accounts for these people.
- The members of HH with 1 vehicle away (21%), who are at home, equal (2.35-1). The number of HH where the commuter will not return home is equal to (1,498 x 0.21 x 1.35 x 0.66 x 0.55), as 66% of EPZ households have a commuter, 55% 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 (45%), who are at home, equal (3.33 – 2). The number of HH where neither commuter will return home is equal to 1,498 x 0.45 x 1.33 x $(0.66 \times 0.55)^2$. 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 is comparable to the number of registered transit-dependent persons in the EPZ as provided by the counties (discussed below in Section 8.4).

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 county emergency management agencies. The columns in Table 8-2 entitled "Buses Required" and "Vans Required" specify the number of buses and vans 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.
- Bus capacity, expressed in students per bus, is set to 70 for primary schools and 50 for middle and high schools.
- Students at Country Haven Academy[1] will be evacuated in a van owned by the facility
- 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 identifies the assistance center each school in the EPZ will be evacuated to. Students will be transported to these centers where they will be subsequently retrieved by their respective families.

8.3 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 assistance 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.

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[1] Country Haven Academy is currently closed. It is unclear whether or not it will reopen. It has been included in the analysis in the event that the school reopens.

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.

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.

Activity: Travel to EPZ Boundary (D→E)

School Evacuation

Transportation resources available were provided by the EPZ county emergency management agencies and are summarized in Table 8-4. Also included in the table are the number of buses needed to evacuate schools, the transit-dependent population, and the homebound special needs (discussed below in Section 8.4) These numbers indicate there are sufficient resources available to evacuate everyone in a single wave.

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 – 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 assistance 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 8-5 (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 8-6 through Table 8-8 for school evacuation, and in Table 8-10 through Table 8-12 for the transit vehicles evacuating transit-dependent persons, which are discussed later. The travel time to the EPZ boundary was computed for each bus using the computed average speed and the distance to the EPZ boundary along the most likely route out of the EPZ. The travel time from the EPZ boundary to the assistance center was computed assuming an average speed of 45 mph, 40 mph, and 35 mph for good weather, rain and snow, respectively. Speeds were reduced in Table 8-6 through Table 8-8 and in Table 8-10 through Table 8-12 to 45 mph (40 mph for rain – 10% decrease – and 35 mph for snow – 20% decrease) for those calculated bus speeds which exceed 45 mph, as Washington State law states no person shall drive a vehicle on a highway at a speed greater than is reasonable.

Table 8-6 (good weather), Table 8-7 (rain) and Table 8-8 (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 assistance 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 + 9 = 1:55 for Country Haven Academy, with good weather). The ETE for school children is comparable to the 90th percentile ETE for the general population (Table 7-1) for an evacuation of the entire EPZ (Region R03) under Scenario 6 conditions. The evacuation time to the assistance 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), 85 percent of the evacuees will complete their mobilization when the buses will begin their routes, approximately 90 minutes after the Advisory to Evacuate (100 minutes in rain and 110 minutes in snow). Sections 1 and 2 combined have a higher transit-dependent population than Sections 3B and 3C (Table 3-7). As such, four buses were assigned to Route 5 servicing Sections 1 and 2 versus three buses for Route 6 servicing Sections 3A and 3B (Table 8-9). The start of service on the third and fourth buses on Route 5 and the final bus on Route 3 are separated by a 20 minute headway from the earlier buses, as shown in Table 8-10 through Table 8-12. The use of headways provides more robust transit services and account for those residents who may require more time to mobilize.

Those buses servicing the transit-dependent evacuees will first travel along their pick-up routes, then proceed out of the EPZ. The county emergency plans do not define bus routes or stops to service the transit-dependent population. The 2 bus routes shown graphically in Figure 8-2 and described in Table 8-9 were designed by KLD to service the major routes through each populated Section of the EPZ. It is assumed that residents will walk to major evacuation routes and flag down a bus, and that they can arrive at the routes within the 90 minute bus mobilization time (good weather).

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

Table 8-10 through Table 8-12 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 first 2 buses on bus route 5 (servicing Sections 1 and 2) is computed as 90 + 33 + 30 = 2:35 for good weather (rounded up to nearest 5 minutes). Here, 33 minutes is the time to travel 24.7 miles at 45.00 mph, the average speed output by the model for this route at 90 minutes. The ETE for a second wave (discussed below) is presented in the event there is a shortfall of available buses or bus drivers, as previously discussed.

Activity: Travel to Assistance Centers (E→F)

The distances from the EPZ boundary to the assistance centers are measured using GIS software along the most likely route from the EPZ exit point to the assistance center. The assistance 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 population. 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 (if needed) 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 assistance center.

The second-wave ETE for the first 2 buses servicing bus route 5 (servicing Sections 1 and 2) is computed as follows for good weather:

- Bus arrives at assistance center at 2:47 in good weather (2:35 to exit EPZ + 12 minute travel time to assistance center)
- Bus discharges passengers (5 minutes) and driver takes a 10-minute rest: 15 minutes
- Bus returns to EPZ and completes second route: 12 minutes (equal to travel time to assistance center) + 33 minutes (24.7 miles @ 45 mph) = 45 minutes
- Bus completes pick-ups along route: 30 minutes
- Bus exits EPZ at time 2:35 + 0:12 + 0:15 + 0:45 + 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 8-10 through Table 8-12. The average ETE for a single-wave and a two-wave evacuation of transit-dependent people exceeds the ETE for the general population at the 90th percentile. The ETE could be reduced by dispatching buses earlier, but that may not be feasible as evacuees need time to mobilize and time is needed to mobilize buses and bus drivers.

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

8.4 Special Needs Population

The county emergency management agencies have a combined registration for transit-dependent and homebound special needs persons. Page 6 of the 2011 public information reads, "Telephone your county emergency management office today if you are elderly, handicapped or without a car. Your county emergency management director will put you on a list that shows who needs special assistance during an evacuation." Based on data provided by the counties, there are an estimated 192 homebound special needs people within the Benton County portion of the EPZ and 2 people within the Franklin County portion of the EPZ who require transportation assistance to evacuate. Details on the number of ambulatory, wheelchair-bound and bedridden people were not available. It is assumed that with assistance, all homebound special needs people can be evacuated on buses.

ETE for Homebound Special Needs Persons

Table 8-13 and Table 8-14 summarize the ETE for homebound special needs people for a one wave and two wave evacuation, respectively. The tables are broken down by weather condition. The table takes into consideration the deployment of multiple vehicles to reduce the number of stops per vehicle. It is conservatively assumed that special needs households are spaced 3 miles apart, and that bus speeds approximate 20 mph between households in good weather (10% slower in rain, 20% slower in snow). Mobilization times of 90 minutes are used (100 minutes for rain, and 110 minutes for snow). Loading time is conservatively assumed to be 5 minutes per household due to the limited mobility of some special needs persons. The last HH is assumed to be 5 miles from the EPZ boundary, and the network-wide average speed, capped at 45 mph (40 mph for rain and 35 mph for snow), after the last pickup is used to compute travel time out of the EPZ. The ETE is computed by summing mobilization time, loading time at first household, travel time to subsequent households, loading time at subsequent households, and travel time to EPZ boundary. All ETE are rounded to the nearest 5 minutes.

For example, assuming no more than one special needs person per HH implies that 194 ambulatory households need to be serviced. While only 7 buses are needed from a capacity perspective, if 15 buses are deployed to service these special needs HH, then each would require about 13 stops. The following outlines the ETE calculations:

1. Assume 15 buses are deployed, each with about 13 stops, to service a total of 194 HH.
2. The ETE is calculated as follows:
    a. Buses arrive at the first pickup location: 90 minutes
    b. Load HH members at first pickup: 5 minutes
    c. Travel to subsequent pickup locations: 12 @ 9 minutes (3 miles @ 20mph) = 108 minutes

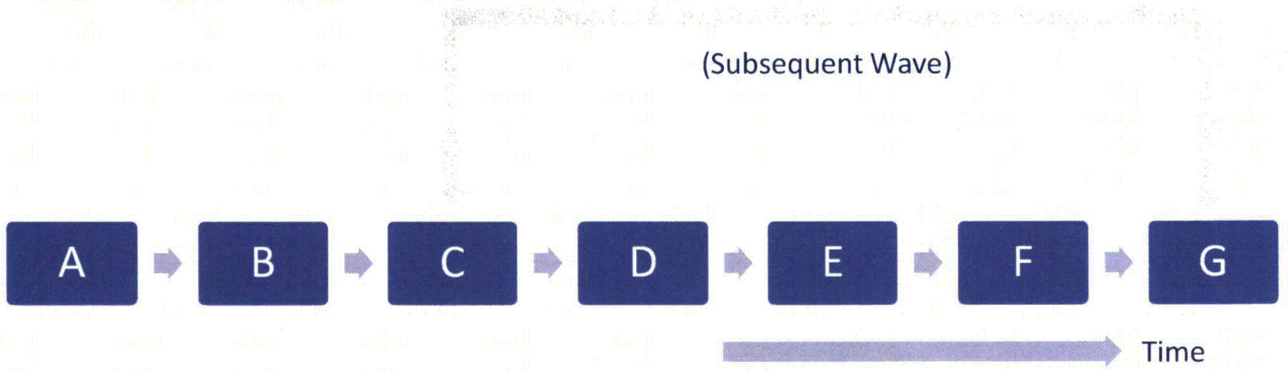
d. Load HH members at subsequent pickup locations: 12 @ 5 minutes = 60 minutes
e. Travel to EPZ boundary: 7 minutes (5 miles at 45 mph).

ETE: 90 + 5 + 108 + 60 + 7 = 4:30 rounded to the nearest 5 minutes

The following outlines the ETE calculations in the event a second wave is needed using school buses after the schools have been evacuated (good weather):

a. Buses arrive at assistance center (A.C.) after evacuating schoolchildren (avg. ETE to A.C. from Table 8-6): 2:10
b. Unload students at assistance center: 5 minutes.
c. Driver takes 10 minute rest: 10 minutes.
d. Travel time back to first household in EPZ: 14 minutes (average time of "Travel Time from EPZ Bdry to A.C." from Table 8-6)
e. Loading time at first household: 5 minutes
f. Bus travels to subsequent households: 12 @ 9 minutes (3 miles @ 20 mph) = 108 minutes
g. Loading time at subsequent households: 12 stops @ 5 minutes = 60 minutes
h. Travel time to EPZ boundary at 5:35: 5 miles @ 45 mph = 7 minutes

ETE: 2:10 + 5 + 10 + 14 + 5 + 108 + 60 + 7 = 5:40 rounded to the nearest 5 minutes



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

Figure 8-1. Chronology of Transit Evacuation Operations

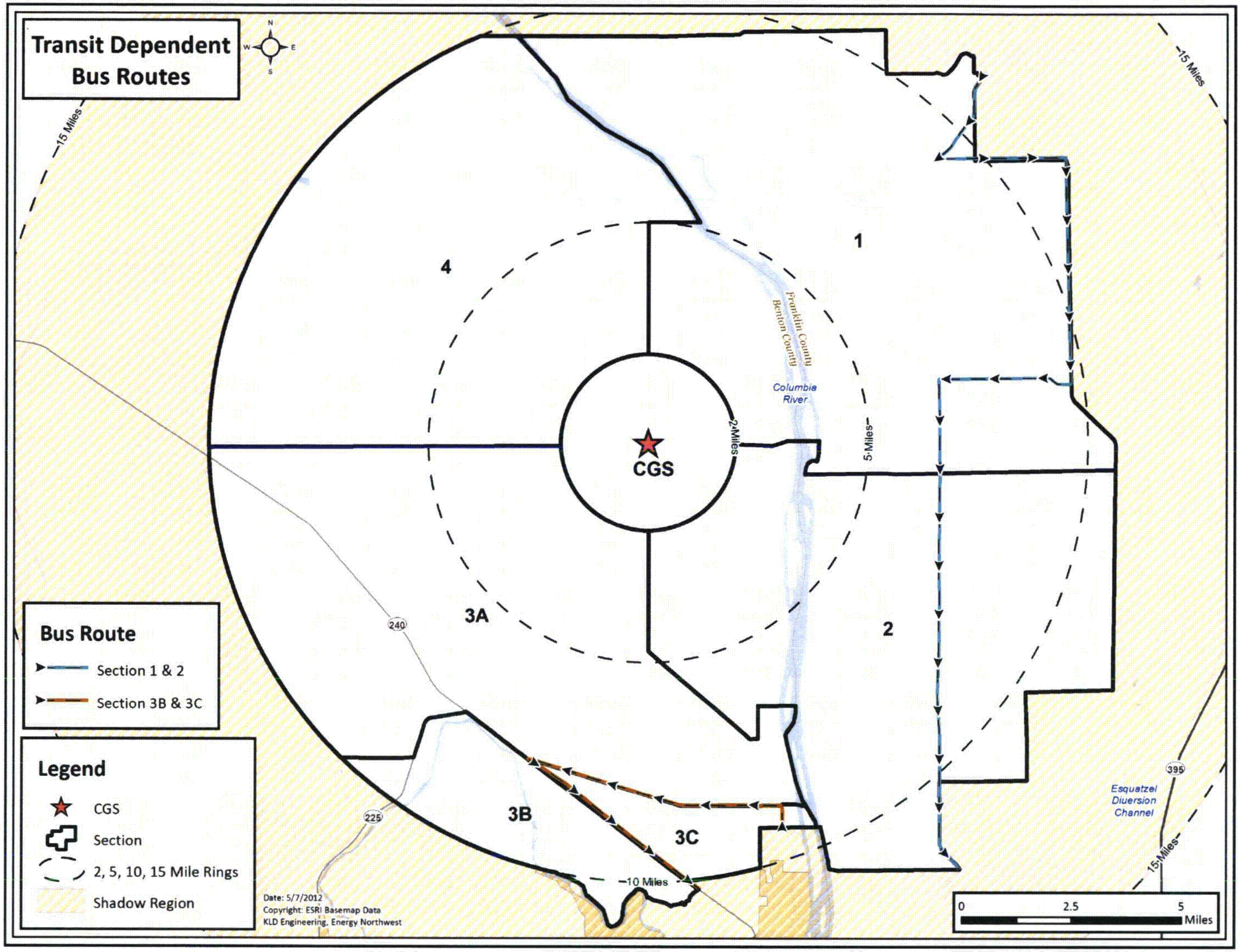


Figure 8-2. Transit-Dependent Bus Routes

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						
4,688	2.44	2.35	3.33	1,498	4%	21%	45%	66%	55%	419	50%	210	4.5%

Table 8-2. School Population Demand Estimates

Section	School Name	Enrollment	Buses Required	Vans Required
2	Big River Country School	13	1	-
2	Country Christian Center	25	1	-
2	Country Haven Academy	6	-	1
2	Edwin Markham Elementary School	280	4	-
	TOTAL:	**324**	**6**	**1**

Table 8-3. School Assistance Centers

School	Assistance Center
Big River Country School	Columbia Basin College
Country Christian Center	Columbia Basin College
Country Haven Academy	Columbia Basin College
Edwin Markham Elementary School	Columbia Basin College

Table 8-4. Summary of Transportation Resources

Transportation Provider	Buses	Vans	Ambulances
Resources Available			
Ben Franklin Transit - MAA	3	-	-
Richland School District - MAA	4	-	-
Kennewick School District - MAA	3	-	-
Pasco School District	67	-	-
Benton County	-	-	4
Country Haven Academy	-	1	-
Country Christian Academy	1	1	-
Big River Country School	-	1	-
TOTAL:	**78**	**3**	**4**
Resources Needed			
Schools (Table 8-2):	6	1	-
Transit-Dependent Population (Table 8-9):	7	-	-
Homebound Special Needs (Section 8.4):	15	-	-
TOTAL TRANSPORTATION NEEDS:	**28**	**1**	**0**

Table 8-5. Bus Route Descriptions

Bus Route Number	Description	Nodes Traversed from Route Start to EPZ Boundary
1	Country Christian Center	212, 140, 142
2	Country Haven Academy, Edwin Markham Elementary School	352, 212, 353, 296, 201
3	Big River County School	141, 212, 353, 296, 201
5	Transit Dependent Bus Route for Section 1 & 2	297, 352, 212, 353, 296, 201
6	Transit Dependent Bus Route for Section 3B & 3C	267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 278

Table 8-6. School Evacuation Time Estimates - Good Weather

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi.)	Average Speed (mph)	Travel Time to EPZ Bdry (min.)	ETE (hr:min)	Dist. EPZ Bdry to A.C. (mi.)	Travel Time from EPZ Bdry to A.C. (min)	ETE to A.C. (hr:min)
FRANKLIN COUNTY SCHOOLS									
Country Haven Academy[2]	90	15	6.4	45.00	9	1:55	8.6	12	2:10
Country Christian Center	90	15	3.2	45.00	5	1:50	13.6	19	2:10
Edwin Markham Elementary School	90	15	7.2	45.00	10	1:55	8.6	12	2:10
Big River County School	90	15	6.1	45.00	9	1:55	8.6	12	2:10
					Maximum for EPZ:	**1:55**		**Maximum:**	**2:10**
					Average for EPZ:	**1:55**		**Average:**	**2:10**

Table 8-7. School Evacuation Time Estimates - Rain

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi.)	Average Speed (mph)	Travel Time to EPZ Bdry (min.)	ETE (hr:min)	Dist. EPZ Bdry to A.C. (mi.)	Travel Time from EPZ Bdry to A.C. (min)	ETE to A.C. (hr:min)
FRANKLIN COUNTY SCHOOLS									
Country Haven Academy[2]	100	20	6.4	40.00	10	2:10	8.6	13	2:25
Country Christian Center	100	20	3.2	40.00	5	2:05	13.6	21	2:30
Edwin Markham Elementary School	100	20	7.2	40.00	11	2:15	8.6	13	2:25
Big River County School	100	20	6.1	40.00	10	2:10	8.6	13	2:25
					Maximum for EPZ:	**2:15**		**Maximum:**	**2:30**
					Average for EPZ:	**2:10**		**Average:**	**2:30**

[2] Country Haven Academy is currently closed. It is unclear whether or not it will reopen. It has been included in the analysis in the event the school reopens.

Table 8-8. School Evacuation Time Estimates - Snow

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi.)	Average Speed (mph)	Travel Time to EPZ Bdry (min.)	ETE (hr:min)	Dist. EPZ Bdry to A.C. (mi.)	Travel Time from EPZ Bdry to A.C. (min)	ETE to A.C. (hr:min)
FRANKLIN COUNTY SCHOOLS									
Country Haven Academy[3]	110	25	6.4	35.00	11	**2:30**	8.6	15	**2:45**
Country Christian Center	110	25	3.2	35.00	6	**2:25**	13.6	24	**2:45**
Edwin Markham Elementary School	110	25	7.2	35.00	13	**2:30**	8.6	15	**2:45**
Big River County School	110	25	6.1	35.00	11	**2:30**	8.6	15	**2:45**
					Maximum for EPZ:	**2:30**		**Maximum:**	**2:45**
					Average for EPZ:	**2:30**		**Average:**	**2:45**

[3] Country Haven Academy is currently closed. It is unclear whether or not it will reopen. It has been included in the analysis in the event the school reopens.

Table 8-9. Summary of Transit-Dependent Bus Routes

Route	No. of Buses	Route Description	Length (mi.)
5	4	Sections 1& 2: Starting at the northern boundary of Section 1 - southbound on Rd 170 - left onto W Klamath Rd eastbound - right onto Glade North Rd southbound - left onto Ringold Rd westbound - left onto Taylor Flats Rd southbound to EPZ boundary.	24.7
6	3	Sections 3B & 3C: Starting at the southern boundary of Section 3C - northbound on George Washington Way - left onto Horn Rapids Rd westbound - left onto SH 240 southbound to EPZ boundary	11.3
Total:	7		

Table 8-10. Transit-Dependent Evacuation Time Estimates - Good Weather

		One-Wave						Two-Wave						
Route Number	Bus Number	Mobiliza-tion (min)	Route Length (miles)	Speed (mph)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)	Distance to A. C. (miles)	Travel Time to A. C. (min)	Unload (min)	Driver Rest (min)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)
5	1 & 2	90	24.7	45.00	33	30	2:35	8.7	12	5	10	45	30	4:15
	3 & 4	110	24.7	45.00	33	30	2:55	8.7	12	5	10	45	30	4:35
6	1 & 2	90	11.3	45.00	15	30	2:20	18.2	24	5	10	39	30	4:05
	3	110	11.3	45.00	15	30	2:40	18.2	24	5	10	39	30	4:25
						Maximum ETE:	2:55						Maximum ETE:	4:35
						Average ETE:	2:40						Average ETE:	4:20

Table 8-11. Transit-Dependent Evacuation Time Estimates - Rain

		One-Wave							Two-Wave					
Route Number	Bus Number	Mobiliza-tion (min)	Route Length (miles)	Speed (mph)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)	Distance to A. C. (miles)	Travel Time to A. C. (min)	Unload (min)	Driver Rest (min)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)
5	1 & 2	100	24.7	39.50	38	40	3:00	8.7	13	5	10	50	40	5:00
	3 & 4	120	24.7	40.00	37	40	3:20	8.7	13	5	10	50	40	5:20
6	1 & 2	100	11.3	40.00	17	40	2:40	18.2	27	5	10	44	40	4:45
	3	120	11.3	40.00	17	40	3:00	18.2	27	5	10	44	40	5:05
						Maximum ETE:	**3:20**						**Maximum ETE:**	**5:20**
						Average ETE:	**3:00**						**Average ETE:**	**5:05**

Table 8-12. Transit Dependent Evacuation Time Estimates - Snow

		One-Wave							Two-Wave					
Route Number	Bus Number	Mobiliza-tion (min)	Route Length (miles)	Speed (mph)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)	Distance to A. C. (miles)	Travel Time to A. C. (min)	Unload (min)	Driver Rest (min)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)
5	1 & 2	110	24.7	35.00	42	50	3:25	8.7	15	5	10	71	50	5:55
	3 & 4	130	24.7	35.00	42	50	3:45	8.7	15	5	10	57	50	6:00
6	1 & 2	110	11.3	35.00	19	50	3:00	18.2	31	5	10	51	50	5:30
	3	130	11.3	35.00	19	50	3:20	18.2	31	5	10	51	50	5:50
						Maximum ETE:	**3:45**						**Maximum ETE:**	**6:00**
						Average ETE:	**3:25**						**Average ETE:**	**5:50**

Table 8-13. Homebound Special Needs Population Evacuation Time Estimates – One Wave

One Wave										
Vehicle Type	People Requiring Vehicle	Vehicles deployed	Stops	Weather Conditions	Mobilization Time (min)	Loading Time at 1st Stop (min)	Travel to Subsequent Stops (min)	Total Loading Time at Subsequent Stops (min)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
Buses	194	15	13	Normal	90	5	108	60	7	**4:30**
				Rain	100		120		8	**4:55**
				Snow	110		132		9	**5:20**

Table 8-14. Homebound Special Needs Population Evacuation Time Estimates – Two Wave

Two Wave													
Vehicle Type	People Requiring Vehicle	Vehicles deployed	Stops	Weather Conditions	One Wave ETE[4] (hr:min)	Unload Students (min)	Driver Rest (min)	Travel Time Back to EPZ[5] (min)	Loading Time at 1st Stop (min)	Travel to Subsequent Stops (min)	Total Loading Time at Subsequent Stops (min)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
Buses	194	15	13	Normal	2:10	5	10	14	5	108	60	7	**5:40**
				Rain	2:30	5	10	15		120		8	**6:15**
				Snow	2:45	5	10	17		132		9	**6:35**

[4] Average ETE to Assistance Center from Table 8-6 through Table 8-8, respectively

[5] Average of travel time from EPZ boundary to Assistance Center from Table 8-6 through Table 8-8, respectively

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.

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

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

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

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

1. The 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 (see Figures 7-3 through 7-6).

   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. The existing TCPs and ACPs, and how they were applied in this study, are discussed in Appendix G.

4. 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. As shown in Figures 7-3 through 7-6, traffic congestion is concentrated in Richland. Those existing TCPs and ACPs in Richland, especially along State Highway 240, Stevens Dr, and George Washington Way, should be considered top priority when assigning personnel and equipment for traffic and access control.

The critical intersections identified as a result of this study are already identified as traffic and access control point in the existing county traffic management plans. Therefore, no changes to traffic and access control are suggested as a result of this study.

The use of Intelligent Transportation Systems (ITS) technologies (if available) 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 assistance 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 or ACP 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 section 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 assistance 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 assistance 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 presents maps showing the general population assistance 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 assistance center and subsequently picked up by parents or guardians. Transit-dependent evacuees are transported to the nearest assistance center for each county. This study does not consider the transport of evacuees from assistance centers to congregate care centers, if the counties do make the decision to relocate evacuees.

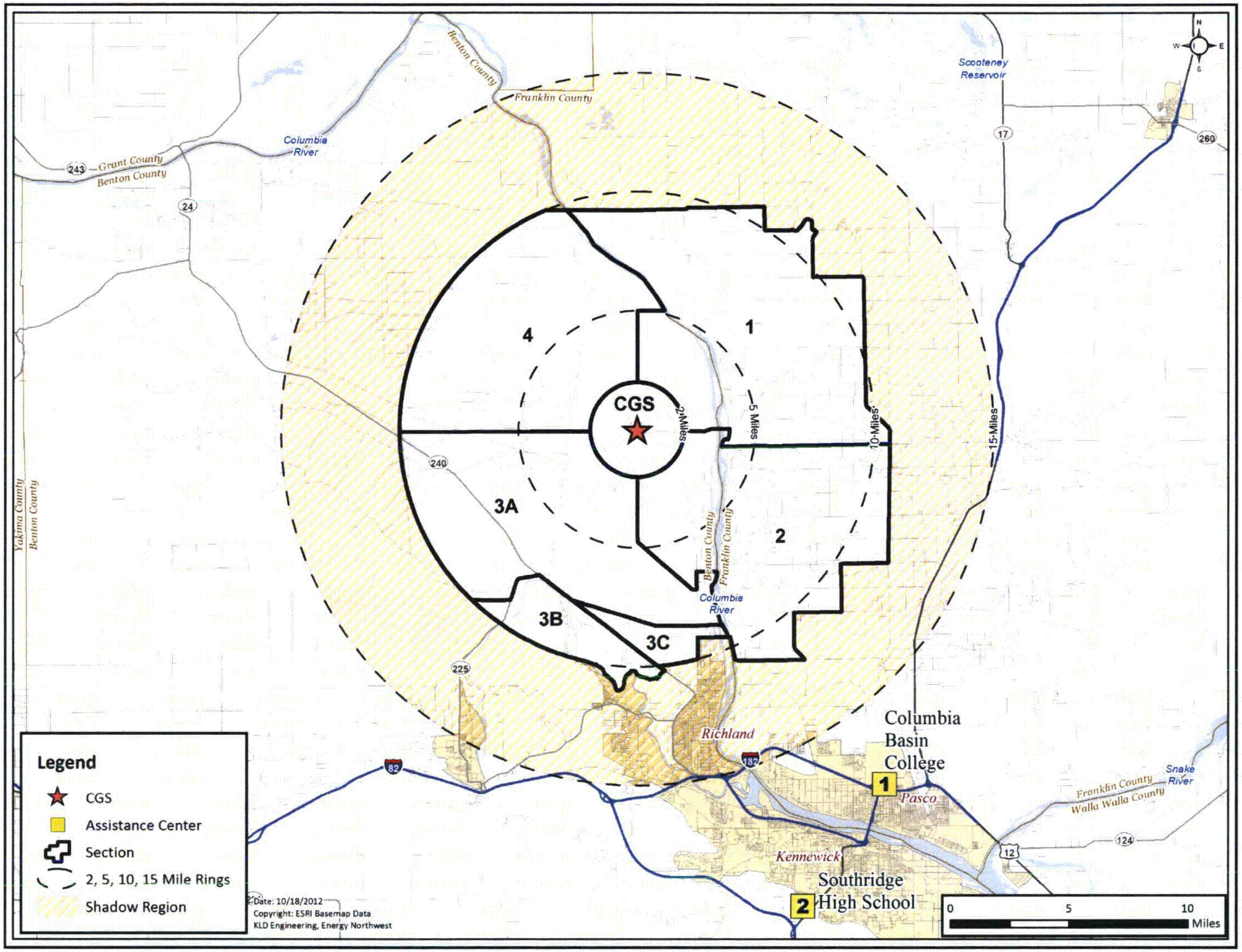


Figure 10-1. General Population Assistance Centers

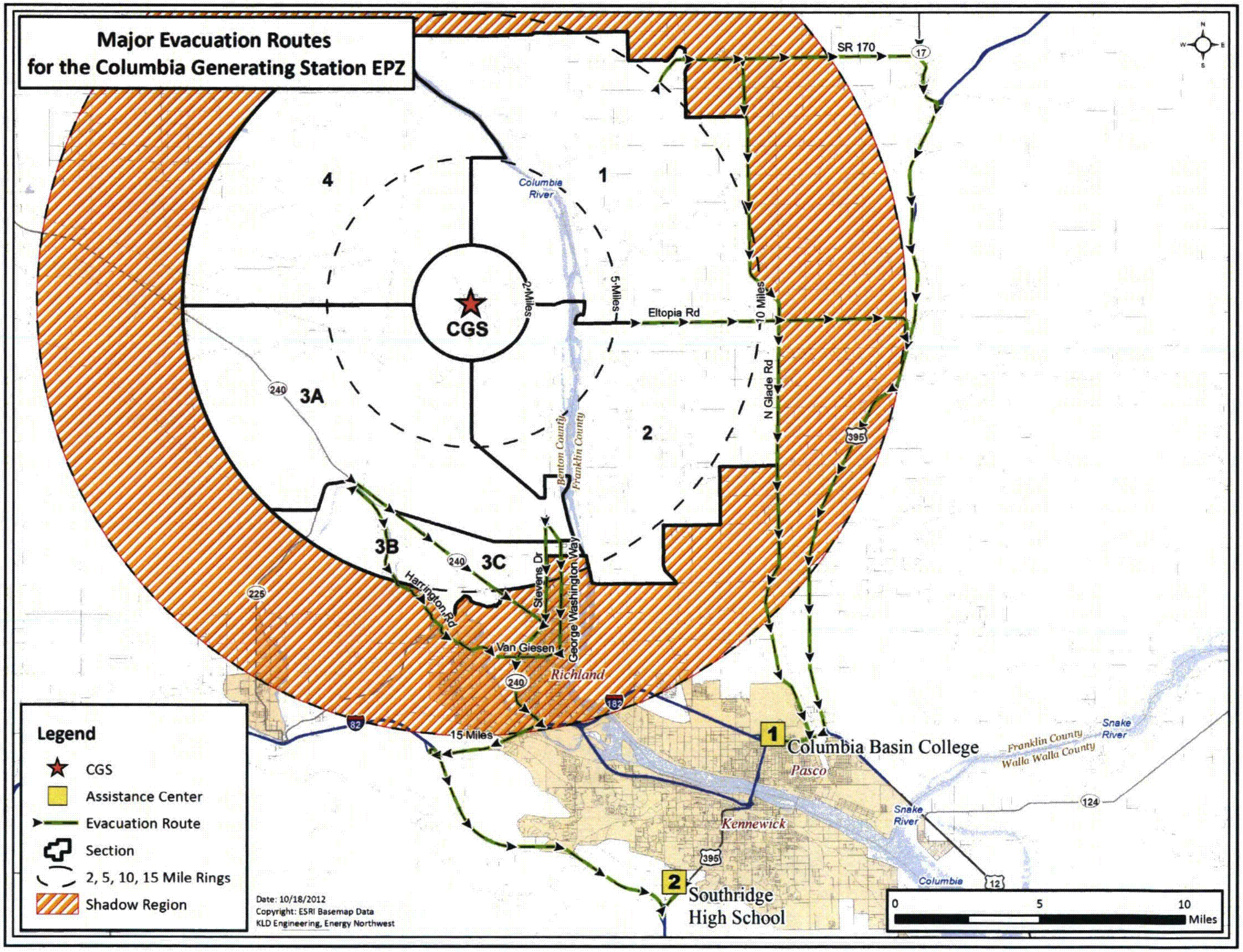


Figure 10-2. Evacuation Route Map

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 county 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. Section 4h of the Plan Overview – ESF-10.C: Franklin County Radiological Emergency Response: Energy Northwest indicates that "[l]aw enforcement officers may patrol designated areas to confirm that people have evacuated or taken shelter." Section IV of the Plan Overview of the Benton County Emergency Response Plan also indicates that law enforcement may patrol designated areas to confirm evacuation.

This method of confirmation would require significant manpower. Police cars would be dispatched to populated residential areas to observe whether or not homes are vacant. There are approximately 550 roadway miles in the CGS EPZ. Assuming a police cruiser would travel at 20mph down each road, confirmation of evacuation would take about 28 hours. Assigning 7 police officers to this task would reduce the confirmation time to 4 hours. If a smaller portion of the EPZ were evacuated, there would be less roadway miles to cover and the confirmation time would be reduced. Also, if additional police officers were available, the confirmation time would be reduced.

Should there be insufficient manpower to confirm evacuation using this method, the following alternative or complementary approach is suggested.

The suggested procedure 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. 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 260.

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 6½ 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 sections), then the confirmation process will extend over a timeframe of about 65 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 or other technologies (e.g., reverse 911 or equivalent if available) 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 EOC at all times. Such a list could be purchased from vendors and could 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.

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.) = 1,500
- 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,

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

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

Finite population correction:

$$n_F = \frac{nN}{n + N - 1} = 256$$

Thus, some 260 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 = 189.

Est. Person Hours to complete 260 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:

$$\frac{260[30 + 0.8(36) + 0.2(60) + 20]}{3600} = 6.6$$

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 nodes within this set that are selected by travelers and the selection of the connecting paths of travel, are both determined by DTRAD. This determination is made by a logit-based path choice model in DTRAD, so as to minimize the trip "cost", as discussed later.

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

Interfacing the DYNEV Simulation Model with DTRAD

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

DTRAD Description

DTRAD is the DTA module for the DYNEV II System.

When the road network under study is large, multiple routing options are usually available between trip origins and destinations. The problem of loading traffic demands and propagating them over the network links is called Network Loading and is addressed by 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:

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

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

  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.

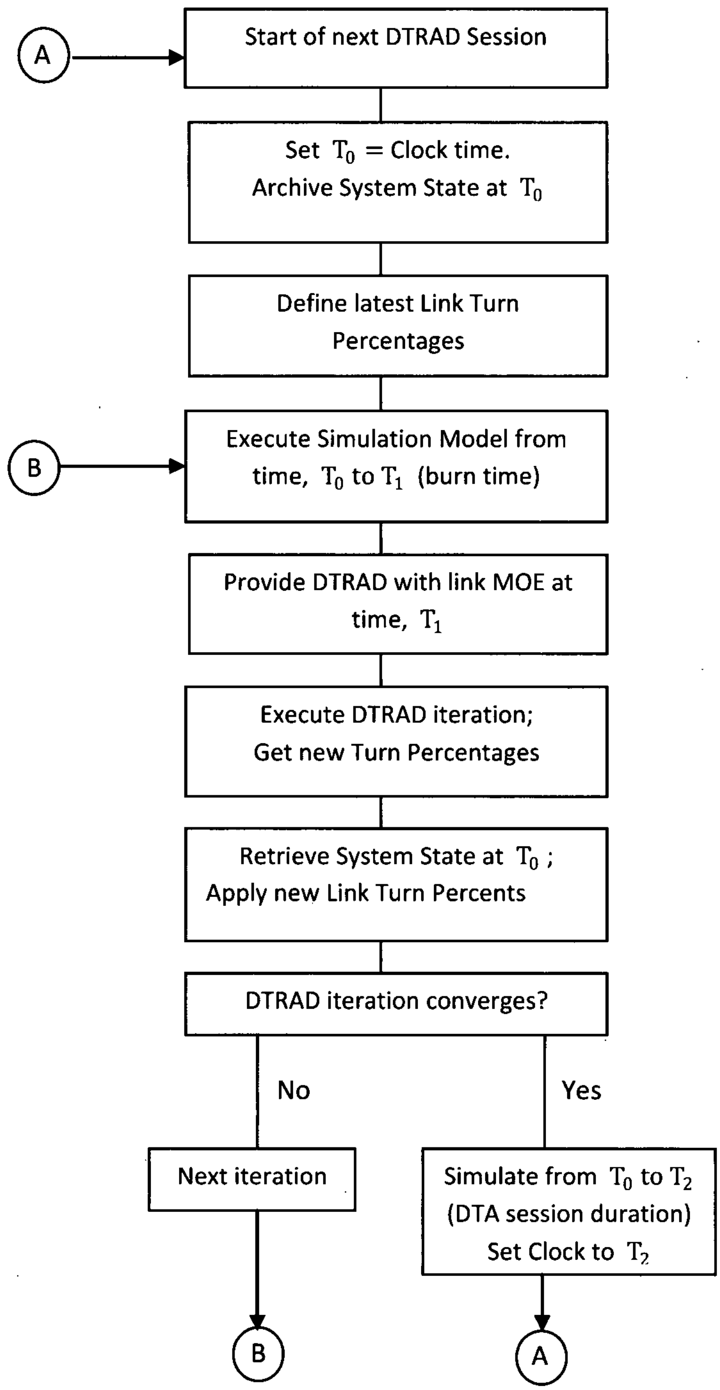


Figure B-1. Flow Diagram of Simulation-DTRAD Interface

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

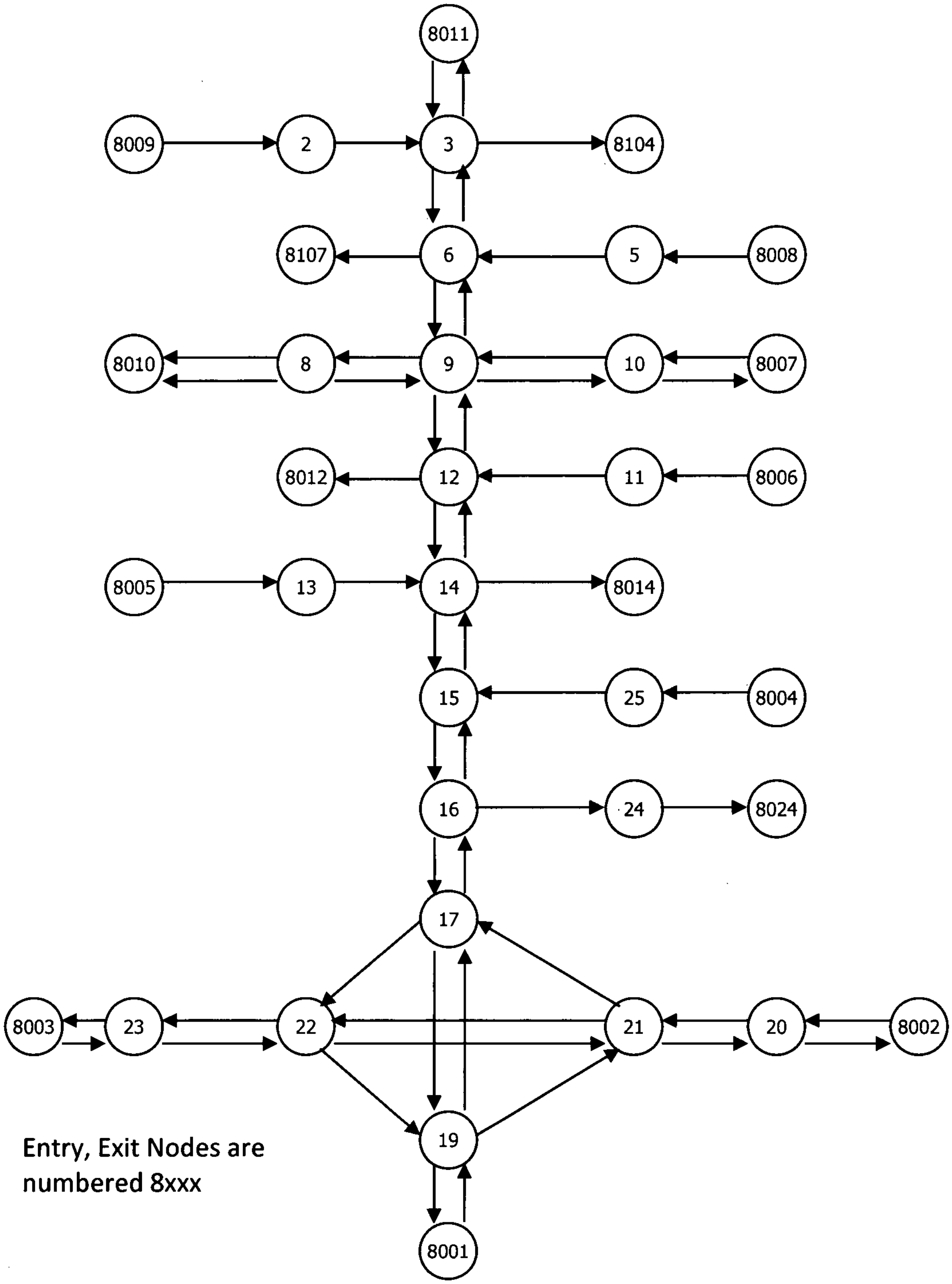


Figure C-1. Representative Analysis Network

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, $k_f \leq k \leq k_c = 45 \text{ vpm}$, the density at capacity. In the flow-density plane, a quadratic relationship is prescribed in the range, $k_c < k \leq k_s = 95 \text{ vpm}$ 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, $k_c = 45 \text{ vpm}$; (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.

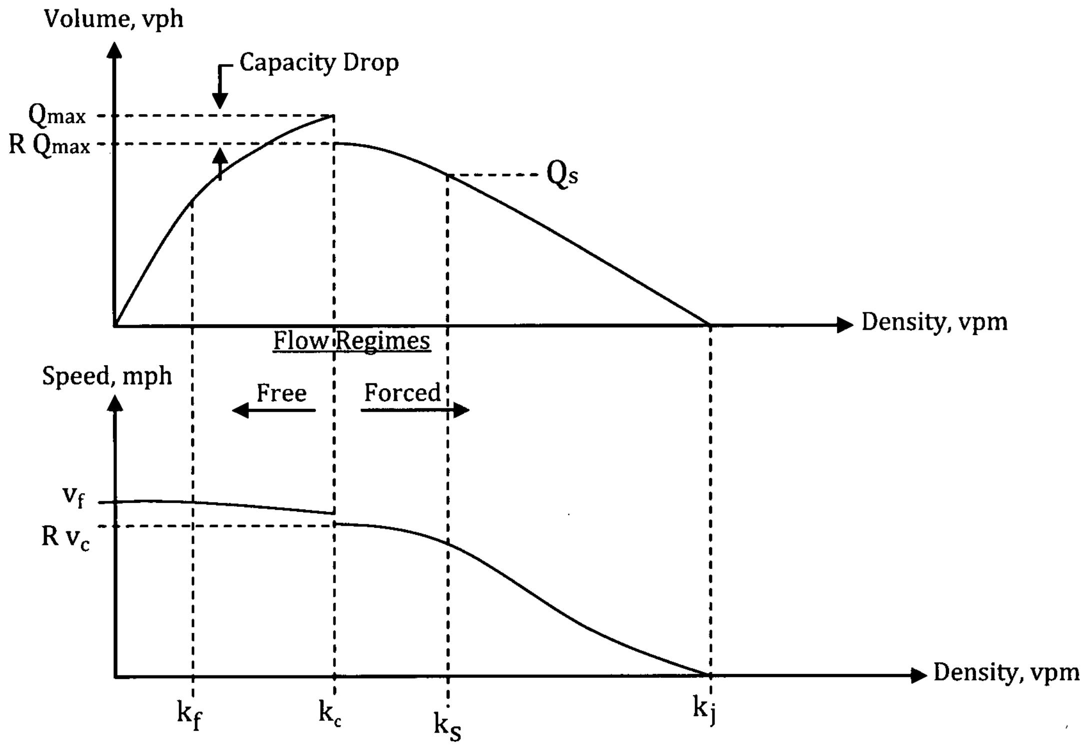


Figure C-2. Fundamental Diagrams

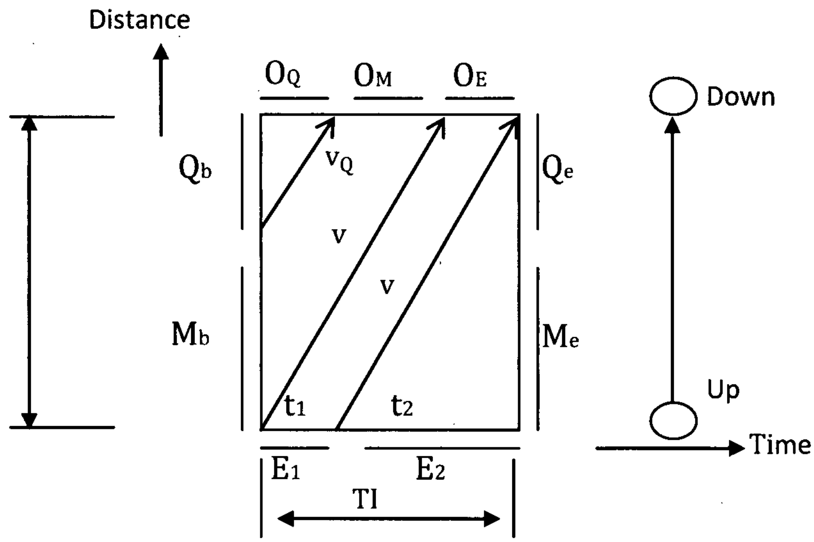


Figure C-3. A UNIT Problem Configuration with $t_1 > 0$

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 <u>moving</u> 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 $k \le 130$ using the analytical representations of the fundamental diagram.
   Calculate $\text{Cap} = \frac{Q_{max}(TI)}{3600} ({}^{G}/_{C})\, LN$, in vehicles, this value may be reduced due to metering
   Set $R = 1.0$ if ${}^{G}/_{C} < 1$ or if $k \le k_c$; 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 $Q_b \ge \text{Cap}$, 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 $M_b \le \text{RCap}$, 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 $|\bar{k}_n - \bar{k}_{n-1}| > \epsilon$ 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

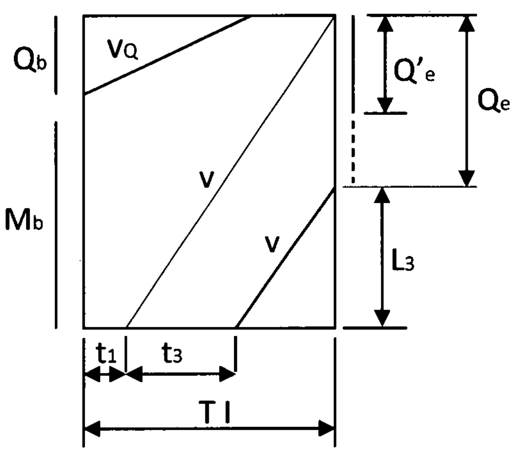
The number of excess vehicles that cause spillback is: $SB = Q_e + M_e - \frac{(L-W) \cdot LN}{L_v}$, where W is the width of the upstream intersection. To prevent spillback, meter the outflow from the feeder approaches and from the source flow, S, during this TI by the amount, SB. That is, set

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

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.

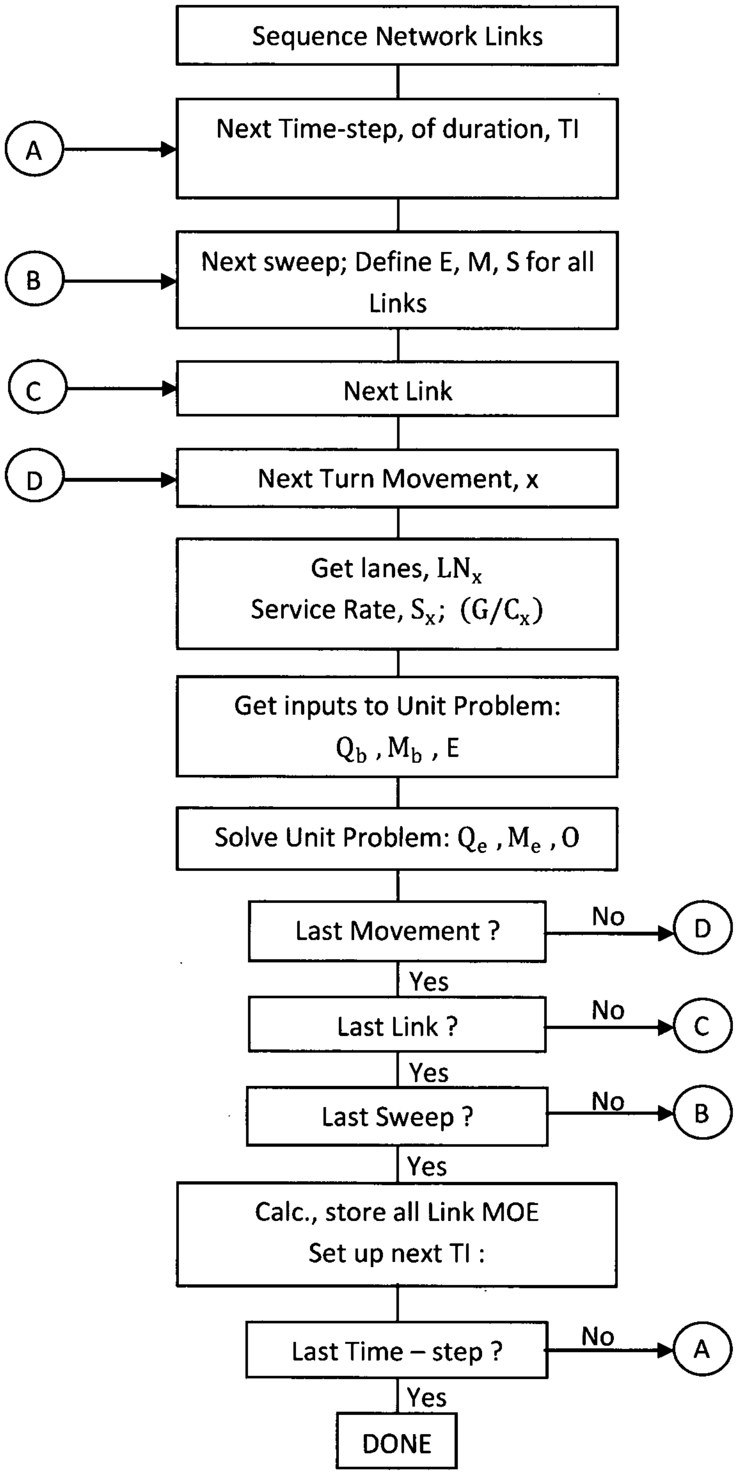


Figure C-4. Flow of Simulation Processing (See Glossary: Table C-3)

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, $[\mathrm{T}_0, \mathrm{T}_2]$, 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, $\mathrm{T}_1 \leq \mathrm{T}_2$, which lies within the session duration, $[\mathrm{T}_0, \mathrm{T}_2]$. This "burn time", $\mathrm{T}_1 - \mathrm{T}_0$, 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 Evacuation Time Estimates. 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 Section 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 data provided by the counties 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 within the EPZ was obtained from the counties.

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.

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 7 Sections. Based on wind direction and speed, Regions (groupings of Sections) 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 (see Appendix N) was completed. An appropriate report reference is provided for each criterion provided in the checklist.

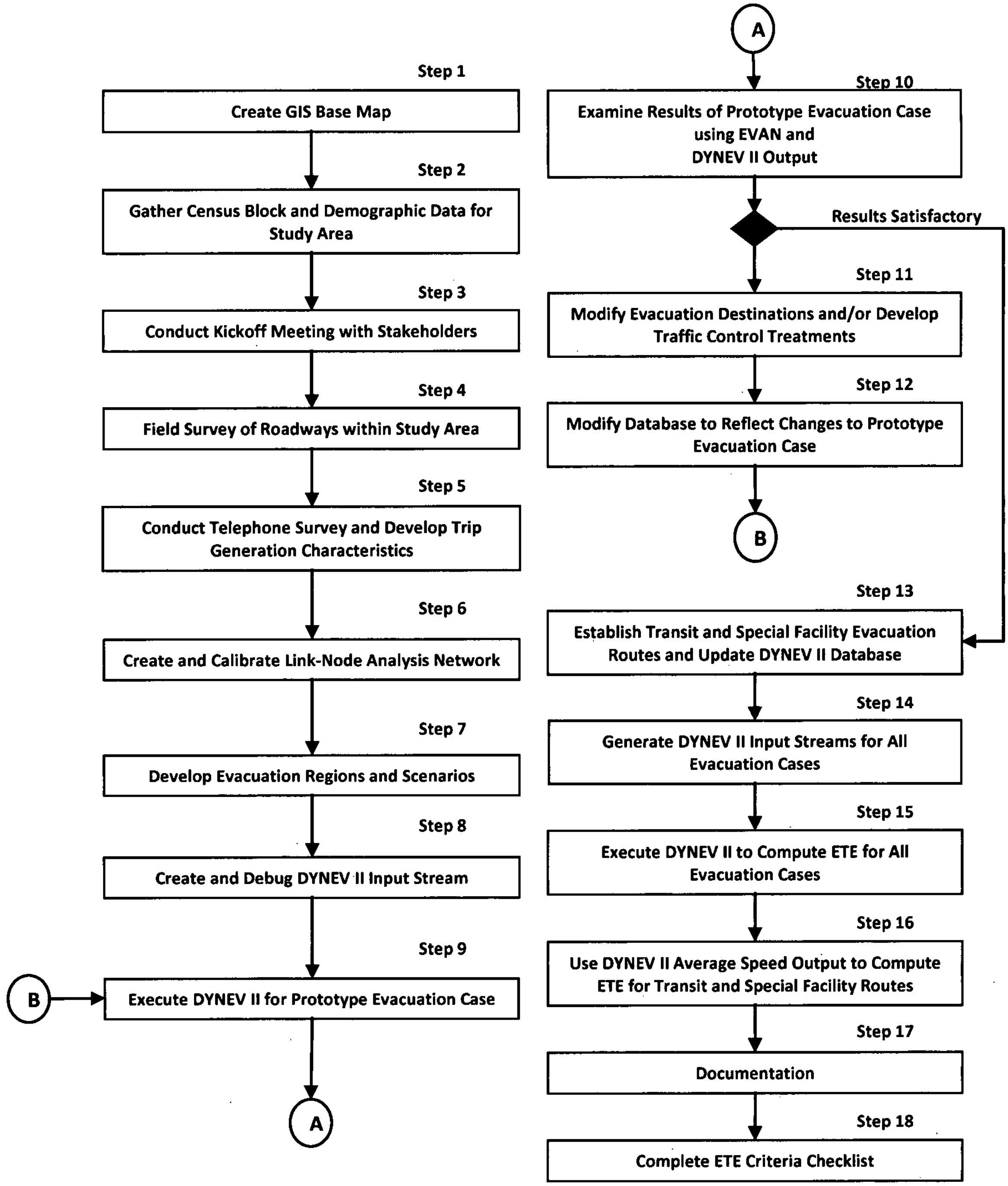


Figure D-1. Flow Diagram of Activities

APPENDIX E

Special Facility Data

E. SPECIAL FACILITY DATA

The following tables list population information, as of February 2012, for schools, major employers, and recreational areas that are located within the CGS EPZ. Transient population data is included in the table for recreational areas. Employment data is included in the table for major employers. Each table is grouped by county. Information that was not available is indicated as N/A in the tables. The location of the facility is defined by its straight-line distance (miles) and direction (magnetic bearing) from the center point of the plant. Maps of each school, major employer, and recreational area are also provided.

Table E-1. Schools within the EPZ

Section	Distance (miles)	Dire-ction	School Name	Street Address	Municipality	Phone	Enroll-ment	Staff
FRANKLIN COUNTY, WA								
2	7.4	SE	Big River Country School	620 Cottonwood Dr	Pasco	509-266-4962	13	2
2	9.2	SE	Country Christian Center	5500 West Sagemoor Rd	Pasco	509-266-4231	25	6
2	6.9	SE	Country Haven Academy[1]	791 Country Haven Loop	Pasco	509-266-4422	6	4
2	7.1	ESE	Edwin Markham Elementary School	4031 Elm Rd	Pasco	509-543-6790	280	26
						Franklin County Subtotal:	*324*	*38*
						TOTAL:	**324**	**38**

[1] Country Haven Academy is currently closed. It is unclear whether or not it will reopen. It has been included in the event the school reopens.

Table E-2. Major Employers within the EPZ

Section	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Phone	Employees (max shift)	% Non-EPZ	Employees (Non EPZ)
BENTON COUNTY, WA									
CGS	0.0	-	Columbia Generating Station	76 N Power Plant Loop	Richland	509-372-5000	611	97%	593
3A	7.6	SSE	300 Area MSA - Hanford Site	N/A	Richland	N/A	1,462	97%	1,418
3A	8.2	S	HAMMER - Mission Support Alliance	2890 Horn Rapids Rd	Richland	509-372-3143	425	97%	412
3A	7.6	SSE	LIGO	127124 N Rt 10	Richland	509-372-8248	90	97%	87
3A	8.8	SSE	Washington Closure Hanford LLC	3650 George Washington Way	Richland	N/A	70	97%	68
3A	8.6	SSE	Washington Closure Hanford LLC	600 Horn Rapids Rd	Richland	N/A	105	97%	102
3C	9.0	SSE	Areva NP Richland	2104 Battelle Blvd	Richland	509-375-8100	557	97%	540
3C	8.5	SSE	Areva NP Richland	2101 Horn Rapids Rd	Richland	509-375-8101	595	97%	577
3C	8.8	SSE	Battelle MJ Berman J2-33	3400 George Washington Way	Richland	509-371-1807	192	97%	186
3C	8.8	SSE	Battelle MJ Berman J2-33	3475 George Washington Way	Richland	509-371-1807	161	97%	156
3C	8.6	SSE	Battelle MJ Berman J2-33	700 Horn Rapids Rd	Richland	509-371-1807	303	97%	294
3C	8.6	SSE	Battelle MJ Berman J2-33	622 Horn Rapids Rd	Richland	509-371-1807	259	97%	251
3C	8.6	SSE	Battelle MJ Berman J2-33	696 Horn Rapids Rd	Richland	509-371-1807	151	97%	146
3C	8.8	SSE	Battelle MJ Berman J2-33	3350 George Washington Way	Richland	509-371-1807	372	97%	361
3C	9.1	SSE	Battelle MJ Berman J2-33	3190 George Washington Way	Richland	509-371-1807	76	97%	74
3C	9.1	SSE	Battelle MJ Berman J2-33	3180 George Washington Way	Richland	509-371-1807	79	97%	77
3C	9.1	SSE	Battelle MJ Berman J2-33	3170 George Washington Way	Richland	509-371-1807	82	97%	80
3C	9.2	SSE	Battelle MJ Berman J2-33	3160 George Washington Way	Richland	509-371-1807	84	97%	81
3C	9.1	SSE	Battelle MJ Berman J2-33	900 Battelle Blvd	Richland	509-371-1807	51	97%	49

Section	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Phone	Employees (max shift)	% Non-EPZ	Employees (Non EPZ)
3C	8.8	SSE	Battelle MJ Berman J2-33	3345 Q Ave	Richland	509-371-1807	443	97%	430
3C	9.2	SSE	Battelle MJ Berman J2-33	622 Battelle Blvd	Richland	509-371-1807	544	97%	528
3C	8.9	SSE	Battelle MJ Berman J2-33	3230 Q Ave	Richland	509-371-1807	377	97%	366
3C	8.9	SSE	Battelle MJ Berman J2-33	3015 Q Ave	Richland	509-371-1807	287	97%	278
3C	9.0	SSE	Fairway Group I LLC	1038 Battelle Blvd	Richland	N/A	65	97%	63
3C	9.1	S	Ferguson Enterprises Inc.	2501 Battelle Blvd	Richland	509-375-3164	55	97%	53
3C	9.0	SSE	Permafix Northwest	2025 Battelle Blvd	Richland	509-375-5160	104	97%	101
3C	9.1	SSE	Port of Benton	3250 Port of Benton Blvd	Richland	509-375-3060	60	97%	58
3C	9.3	SSE	Port of Benton	1001 Batelle Blvd	Richland	509-375-3060	70	97%	68
3C	9.3	SSE	Port of Benton Building	3100 George Washington Way	Richland	509-375-3060	70	97%	68
3C	8.9	SSE	SAIC	3215 Richardson Rd	Richland	509-372-7700	50	97%	49
						Benton County Subtotal:	*7,850*	*-*	*7,614*
						TOTAL:	**7,850**	**-**	**7,614**

Note: Due to the fact that reliable migratory employment data is unavailable, it was not included in this section. A sensitivity study was conducted to see the effect of the migratory worker population on ETE; see Section M.5.

Table E-3. Recreational Areas within the EPZ

Section	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Phone	Transients	Vehicles
BENTON COUNTY, WA								
3B	7.9	SW	Horn Rapids County Park Day Use	Horn Rd	Richland	509-531-7016	500	160
3B	7.9	SW	Horn Rapids County Park Horse Area	Horn Rd	Richland	509-967-2582	150	48
3B	7.9	SW	Horn Rapids County Park Overnight Seasonal	Horn Rd	Richland	509-531-7016	120	38
3B	10.0	S	Horn Rapids Golf Club	2800 Clubhouse Lane	Richland	509-375-4714	25	6
3B	9.8	SW	Rattlesnake Mountain Shooting Area	98204 N SR 225	Benton City	509-588-4770	300	96
3C	10.8	SSE	Babe Ruth Ball Diamonds	N/A	Richland	N/A	500	160
3C	8.4	S	Horn Rapids ORV Park Boat Race Area	3323 Twin Bridges Rd	Richland	509-496-2958	2,000	639
3C	8.4	S	Horn Rapids ORV Park Go Carts	3323 Twin Bridges Rd	Richland	509-496-2958	200	64
3C	8.0	S	Horn Rapids ORV Park Motocross	3323 Twin Bridges Rd	Richland	509-496-2958	1,500	479
3C	8.4	S	Horn Rapids ORV Park Overnight	3323 Twin Bridges Rd	Richland	509-531-7016	1,000	319
3C	8.4	S	Horn Rapids ORV Park RC Airport	3323 Twin Bridges Rd	Richland	509-496-2958	50	16
3C	10.0	S	Horn Rapids RV Resort	2640 Kingsgate Way	Richland	509-375-9913	704	675
						Benton County Subtotal:	*7,049*	*2,700*
FRANKLIN COUNTY, WA								
1	4.5	NE	Ringold Fishing Area	N/A	N/A	N/A	1,000	319
1	8.1	NNW	Wahluke Hunting Area	N/A	N/A	N/A	500	160
2	8.6	SSE	Columbia and Yakima River Areas	N/A	Pasco	N/A	1,000	319
						Franklin County Subtotal:	*2,500*	*798*
						TOTAL:	**9,549**	**3,498**

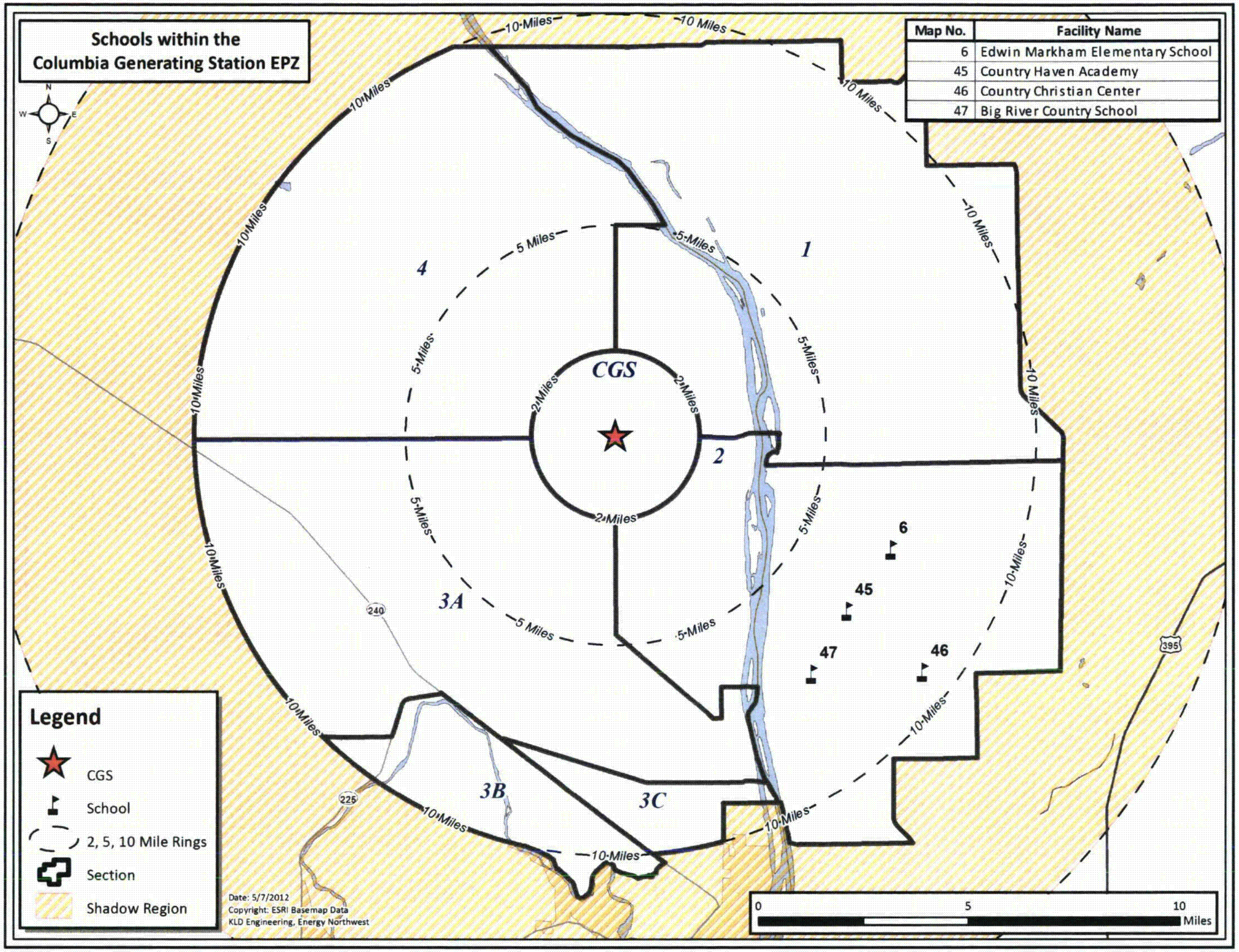


Figure E-1. Schools within the EPZ

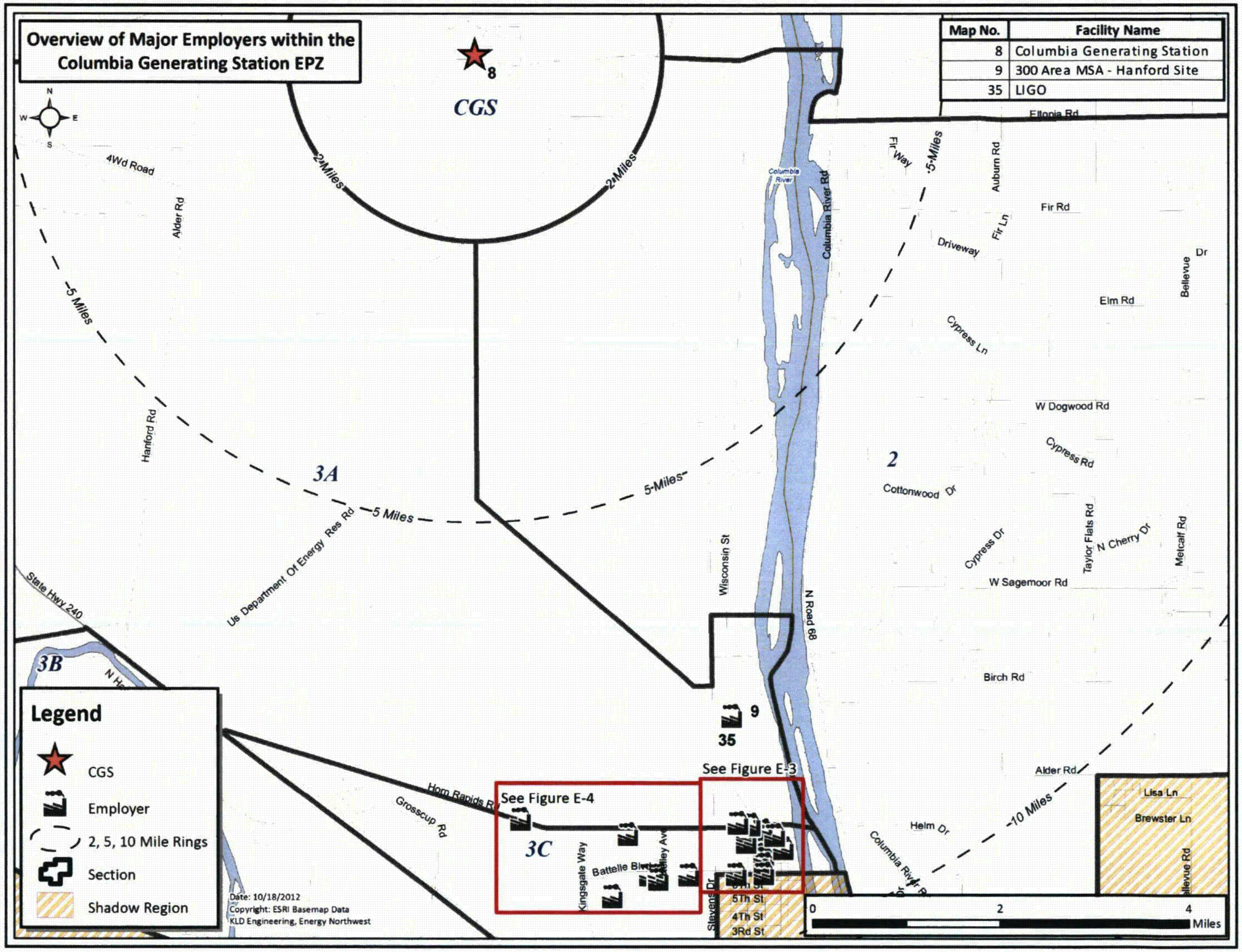
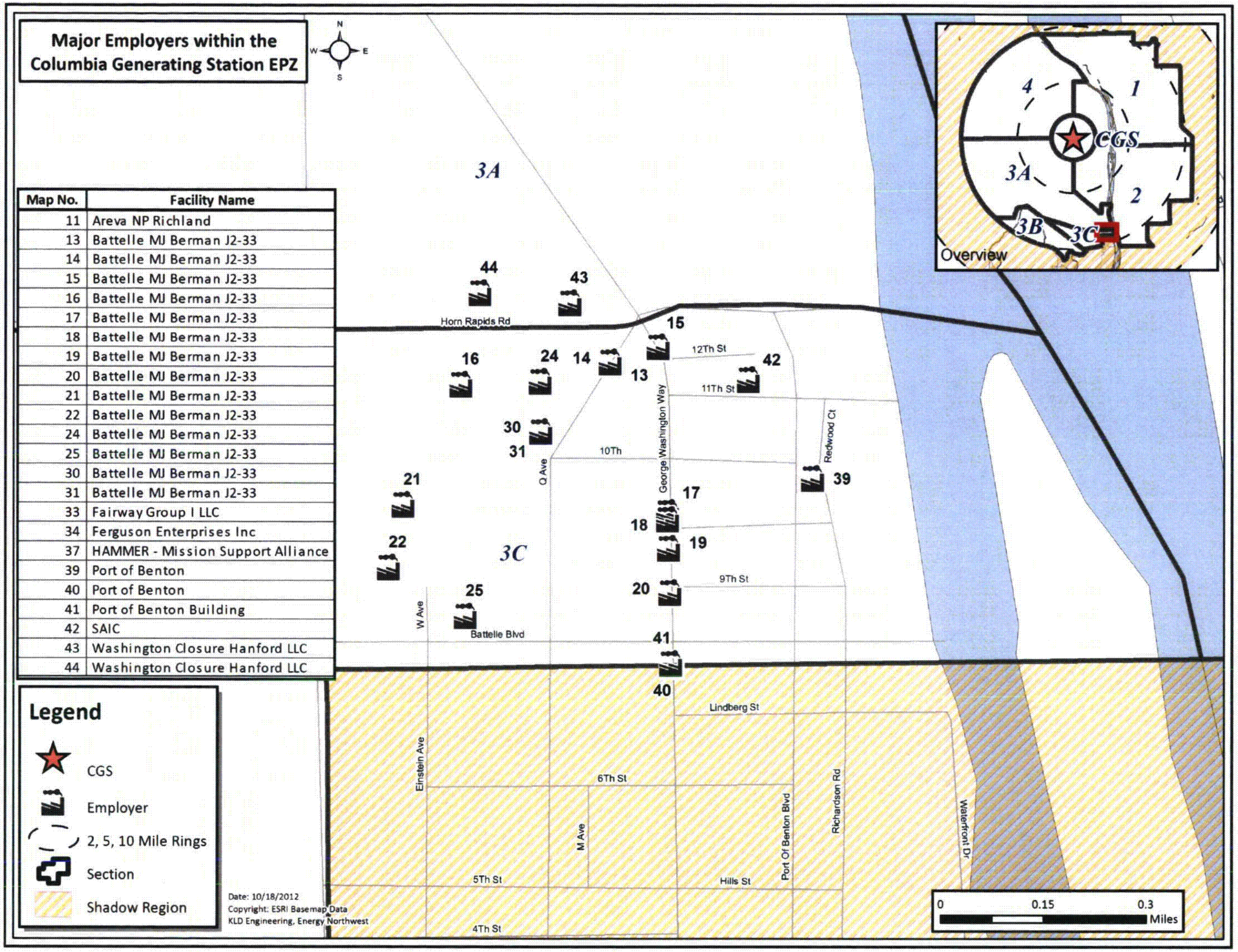


Figure E-2. Major Employer Overview



Map No.	Facility Name
11	Areva NP Richland
13	Battelle MJ Berman J2-33
14	Battelle MJ Berman J2-33
15	Battelle MJ Berman J2-33
16	Battelle MJ Berman J2-33
17	Battelle MJ Berman J2-33
18	Battelle MJ Berman J2-33
19	Battelle MJ Berman J2-33
20	Battelle MJ Berman J2-33
21	Battelle MJ Berman J2-33
22	Battelle MJ Berman J2-33
24	Battelle MJ Berman J2-33
25	Battelle MJ Berman J2-33
30	Battelle MJ Berman J2-33
31	Battelle MJ Berman J2-33
33	Fairway Group I LLC
34	Ferguson Enterprises Inc
37	HAMMER - Mission Support Alliance
39	Port of Benton
40	Port of Benton
41	Port of Benton Building
42	SAIC
43	Washington Closure Hanford LLC
44	Washington Closure Hanford LLC

Figure E-3. Major Employers

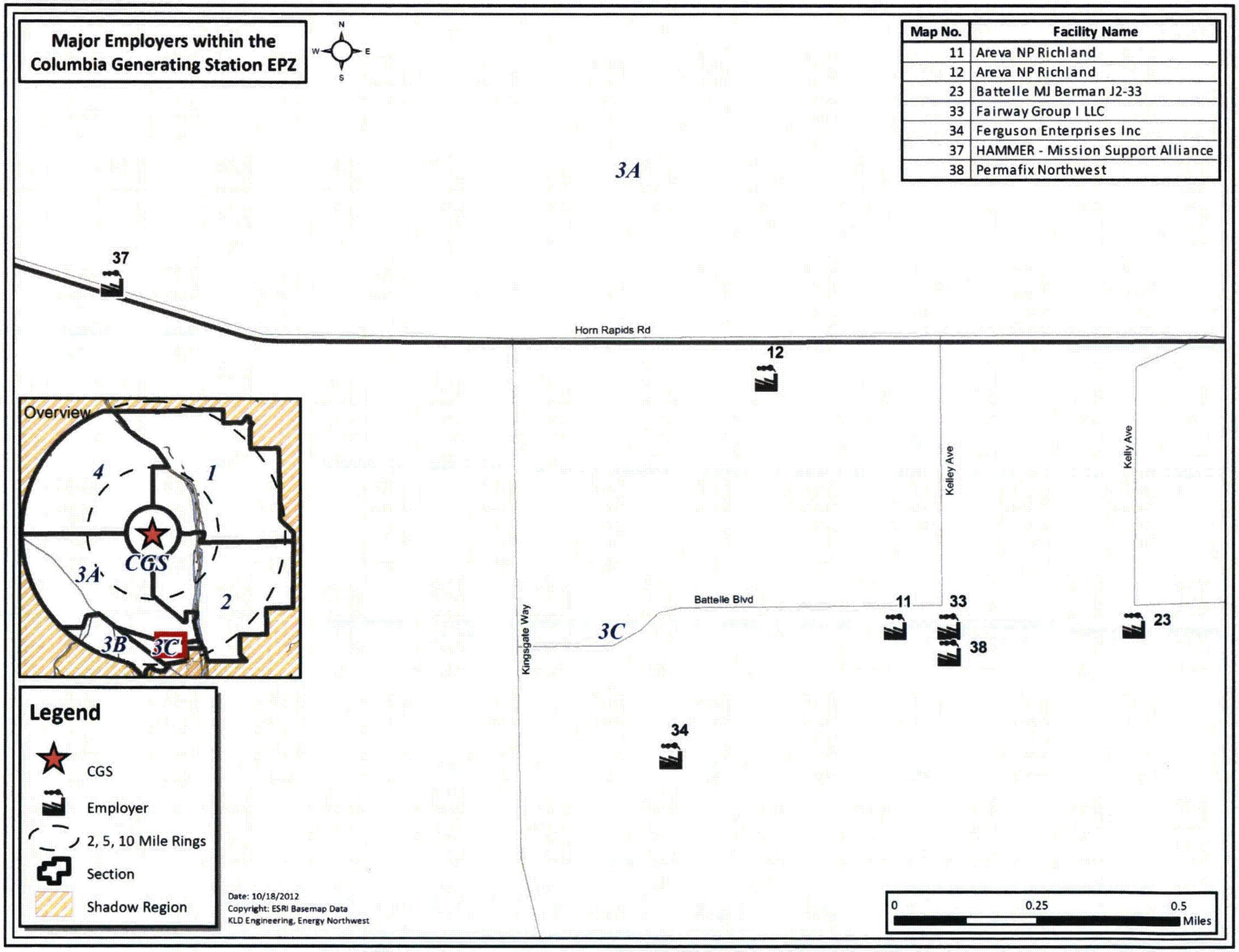


Figure E-4. Major Employers within the EPZ

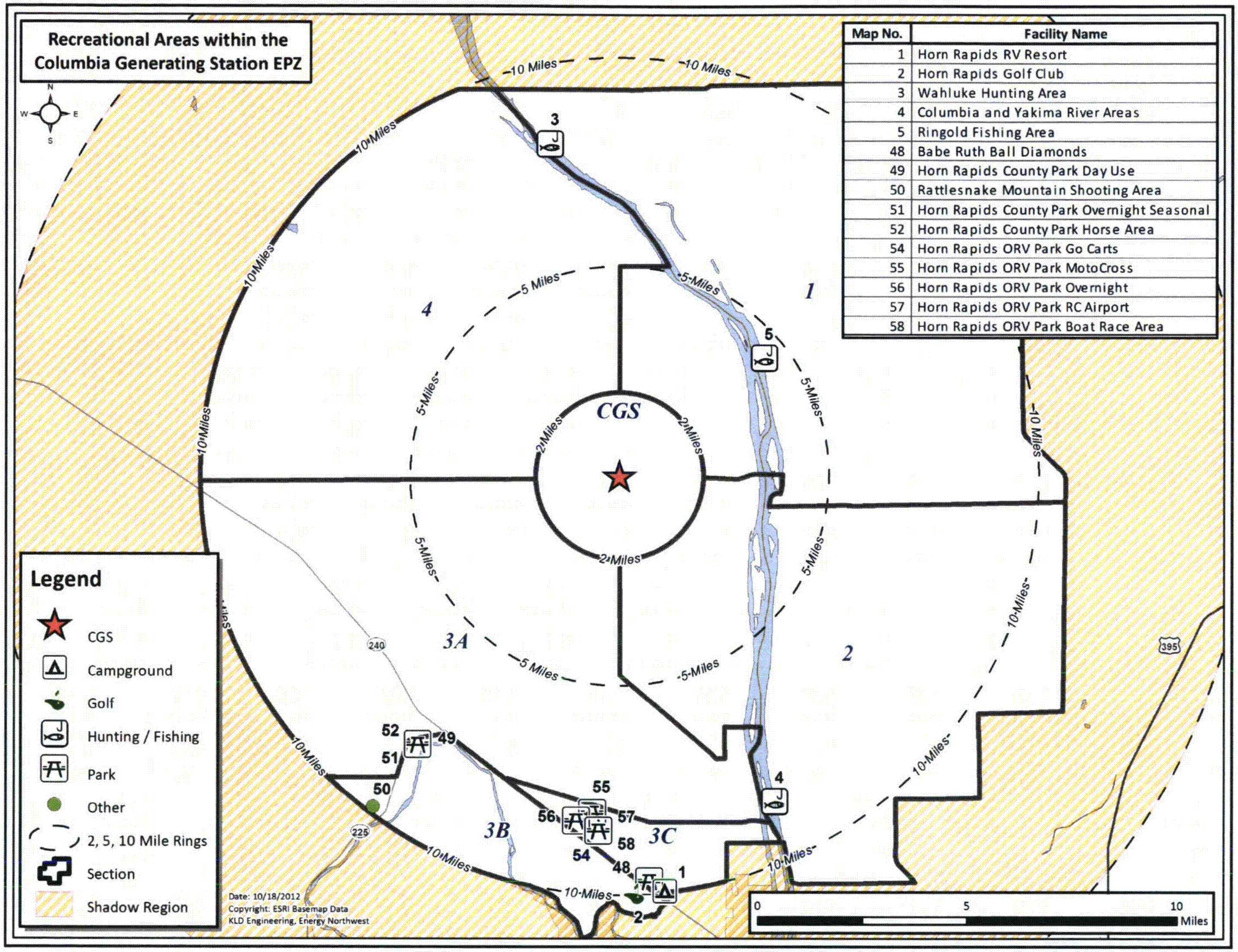


Figure E-5. Recreational Areas within the EPZ

APPENDIX F

Telephone Survey

F. TELEPHONE SURVEY

F.1 Introduction

The development of evacuation time estimates for the EPZ of the CGS 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. Note that the average household size computed in Table F-1 was an estimate for sampling purposes and was not used in the ETE study.

Due to the sparse population of the zip codes within the EPZ, the area which was sampled was expanded (within the zip codes identified) so that an appropriate sample could be gathered. The telephone survey typically has a 10% response rate. Thus, the survey requires at least 10 times as many households (5,000) as samples (500). The over-sampling was computed in proportion to the entire zip code population. The approach is justified on the basis that the area outside of the EPZ has similar land-use and housing characteristics as does the EPZ. The completed survey adhered to the over-sampling plan. The survey was also conducted in Spanish (specifically Central and South American dialects) to account for the significant Spanish speaking population within the EPZ.

Table F-1. Columbia Telephone Survey Sampling Plan

ZIP	Zip Population 2010	EPZ Population 2010	Zip Code Households	Households in EPZ	Required Sample	Over Sampling in Zip Code due to Sparse Population
99301	69,416	1,731	21,171	526	164	234
99320	10,465	1	3,750	1	0	41
99330	1,386	306	440	95	30	5
99343	3,614	689	943	195	61	10
99344	17,698	0	4,969	0	0	55
99353	13,882	633	4,940	254	79	54
99354	21,929	1,328	9,115	534	166	101
Total	**138,407**	**4,688**	**45,337**	**1,605**	**500**	**500**
Avg HH Size:				**3.05**		

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

<u>Household Size</u>

Figure F-1 presents the distribution of household size within the EPZ. The average household contains 3.13 people. The estimated household size (3.05 persons) used to determine the survey sample (Table F-1) was drawn from Census data. The close agreement (well within the sampling error bounds) between the average household size obtained from the survey and from the Census is an indication of the reliability of the survey.

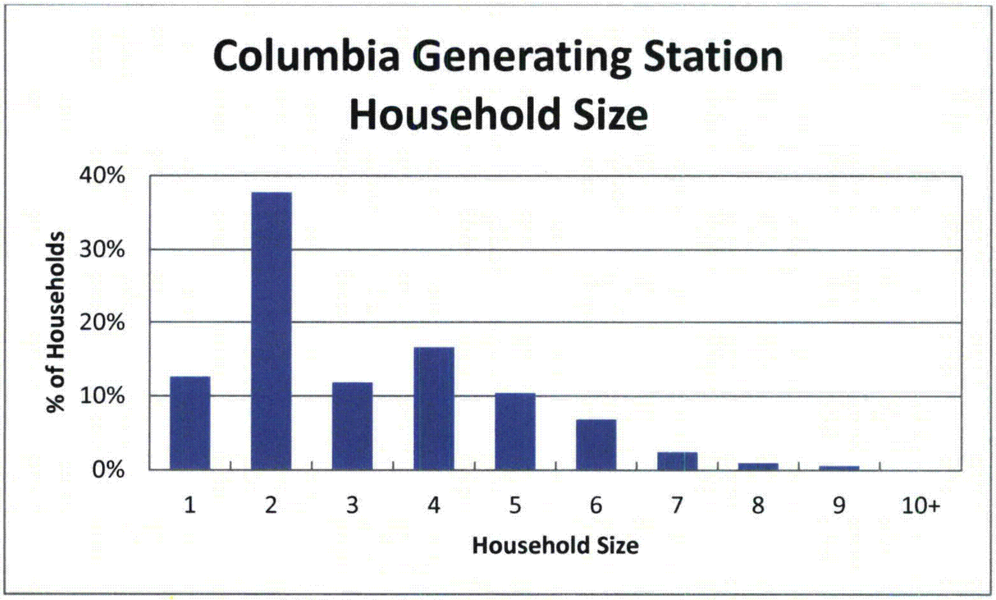


Figure F-1. Household Size in the EPZ

Automobile Ownership

The average number of automobiles available per household in the EPZ is 2.18. It should be noted that approximately 3.6 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.

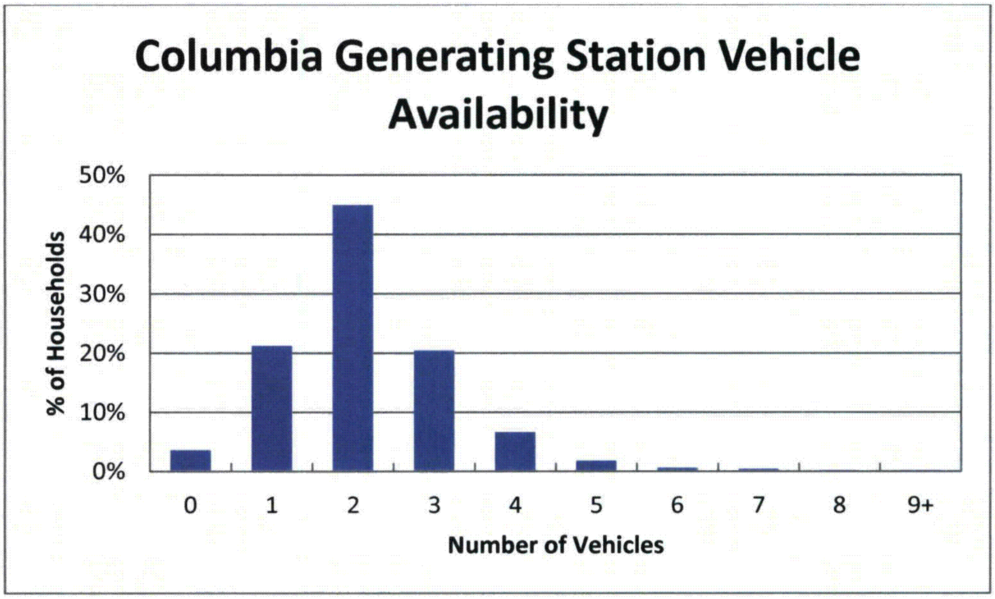


Figure F-2. Household Vehicle Availability

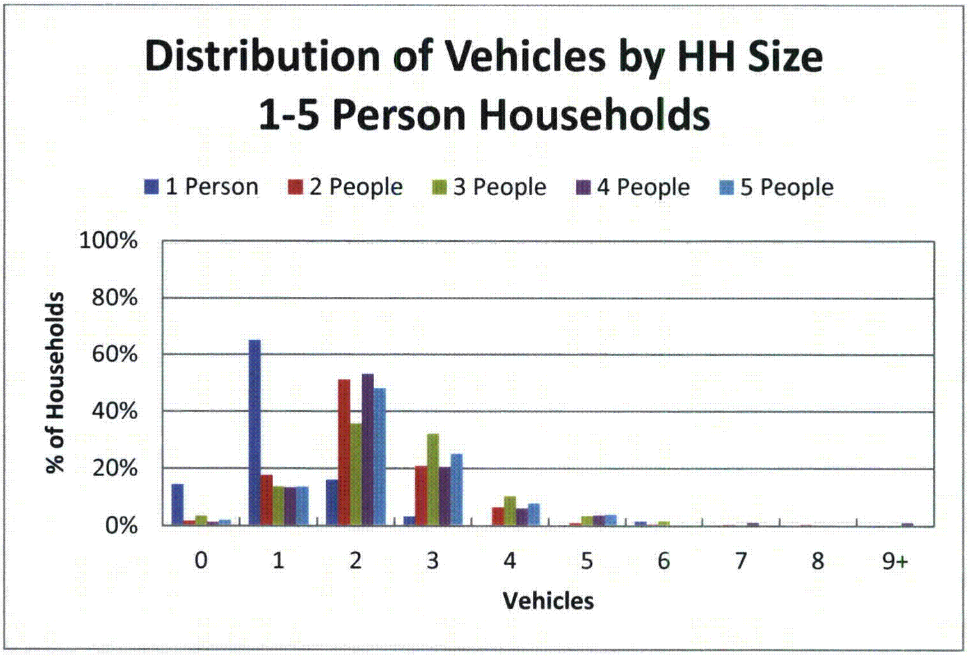


Figure F-3. Vehicle Availability - 1 to 5 Person Households

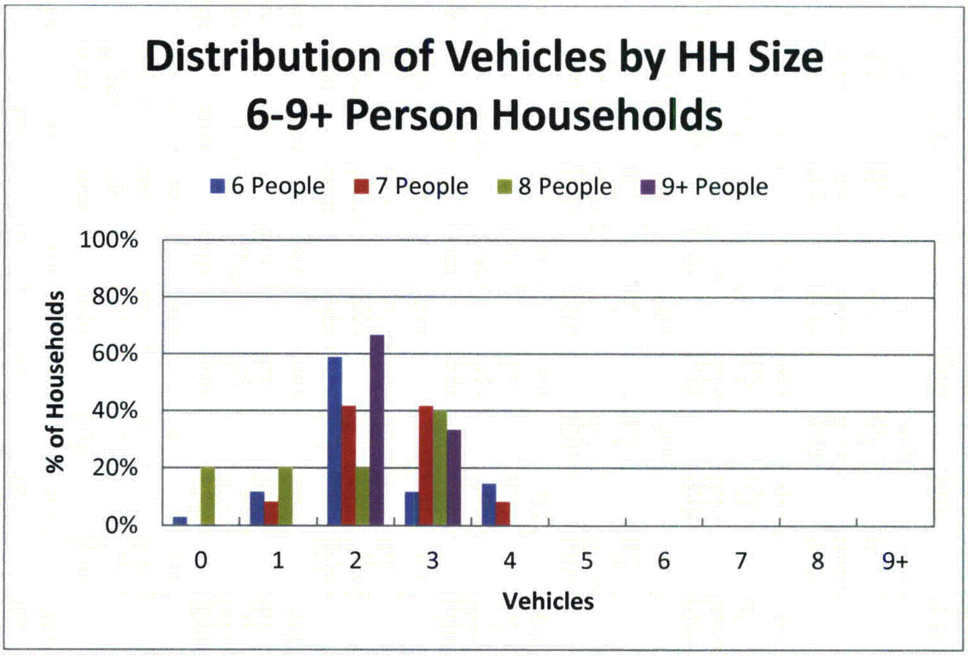


Figure F-4. Vehicle Availability - 6 to 9+ Person Households

Ridesharing

The overwhelming proportion (94%) of the 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 advised to evacuate in the event of an emergency. Figure F-5 presents this response. Note, however, that only those households with no access to a vehicle – 16 total out of the sample size of 500 – answered this question. Thus, the results are not statistically significant. As such, the NRC recommendation of 50% ridesharing is used throughout this study.

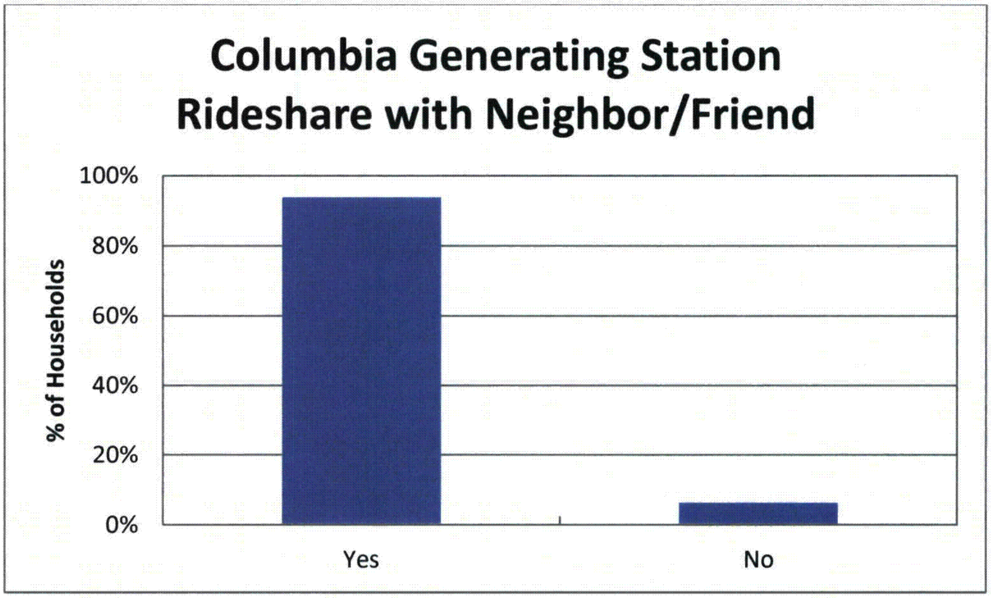


Figure F-5. Household Ridesharing Preference

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 1.15 commuters in each household in the EPZ, and 66% of households have at least one commuter.

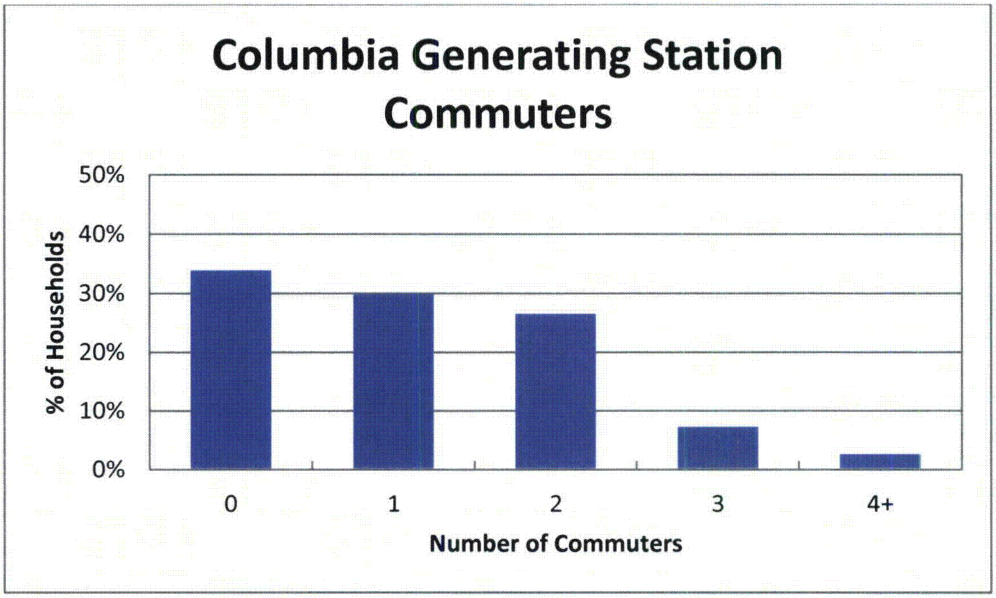


Figure F-6. Commuters in Households in the EPZ

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 1.19 employees per vehicle, assuming 2 people per vehicle – on average – for carpools.

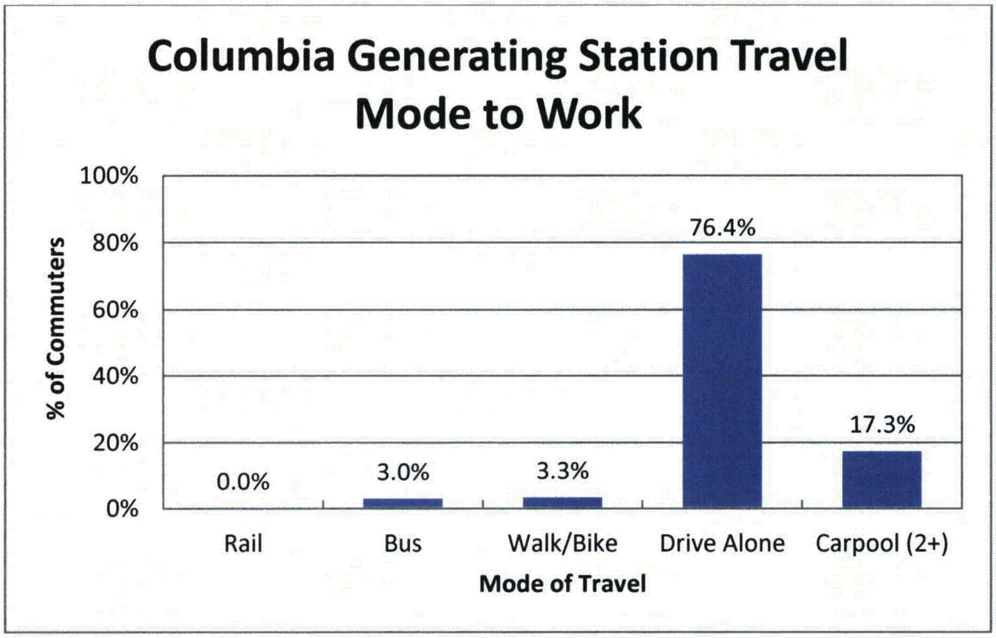


Figure F-7. Modes of Travel in the EPZ

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 1.32 vehicles.

"Would your family await the return of other family members prior to evacuating the area?" Of the survey participants who responded, 45 percent said they would await the return of other family members before evacuating and 55 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?" Based on the responses to the survey, 76 percent of households have a family pet. Of the households with pets, 81 percent of them indicated that they would take their pets with them, as shown in Figure F-9.

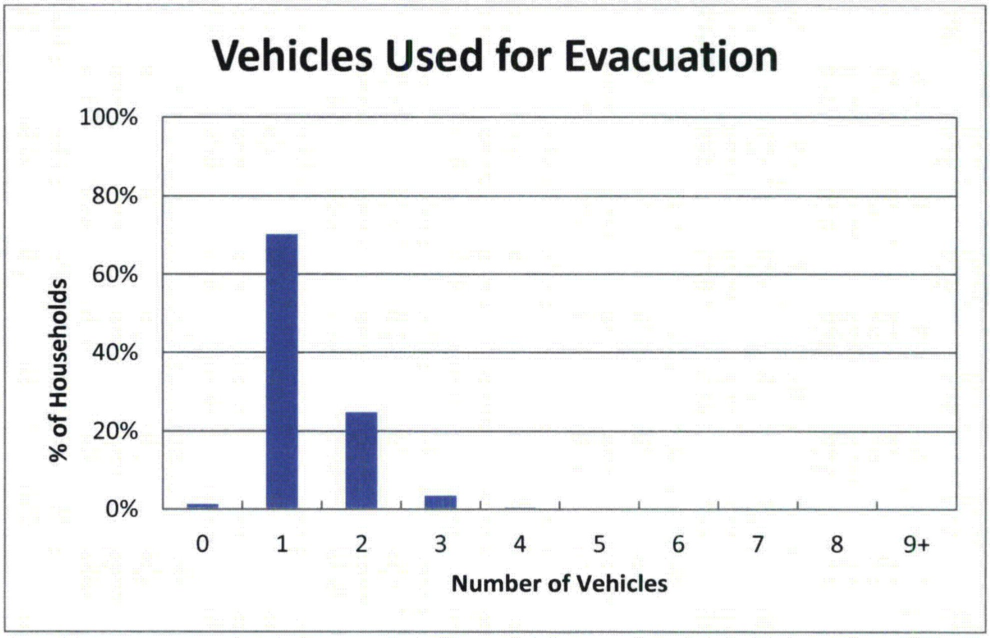


Figure F-8. Number of Vehicles Used for Evacuation

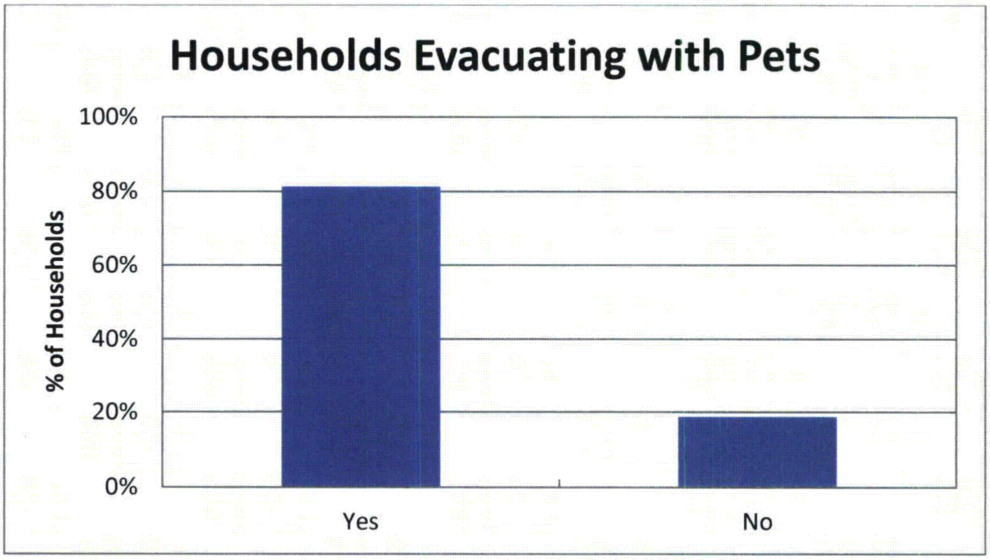


Figure F-9. Households Evacuating with Pets

"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 80 percent of households who are advised to shelter in place would do so; the remaining 20 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. Thus, the data obtained above is in agreement with the federal guidance.

"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 72 percent of households would follow instructions and delay the start of evacuation until so advised, while the balance of 28 percent would choose to begin evacuating immediately.

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 90 minutes. Ninety percent can leave within 30 minutes.

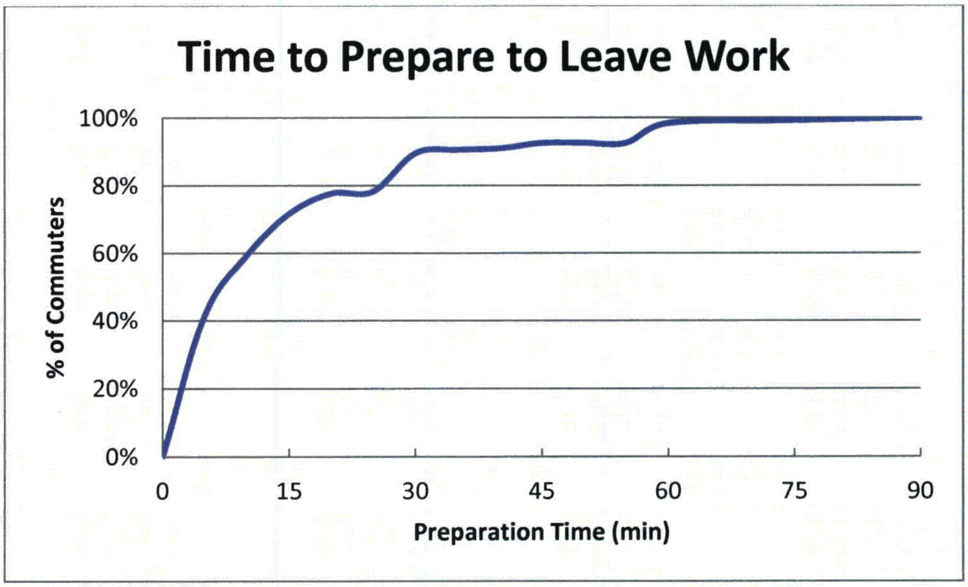


Figure F-10. Time Required to Prepare to Leave Work/School

"How long would it take the commuter to travel home?" Figure F-11 presents the work to home travel time for the EPZ. In all cases, the activity is completed by 90 minutes. About 90 percent of commuters can arrive home within 40 minutes of leaving work.

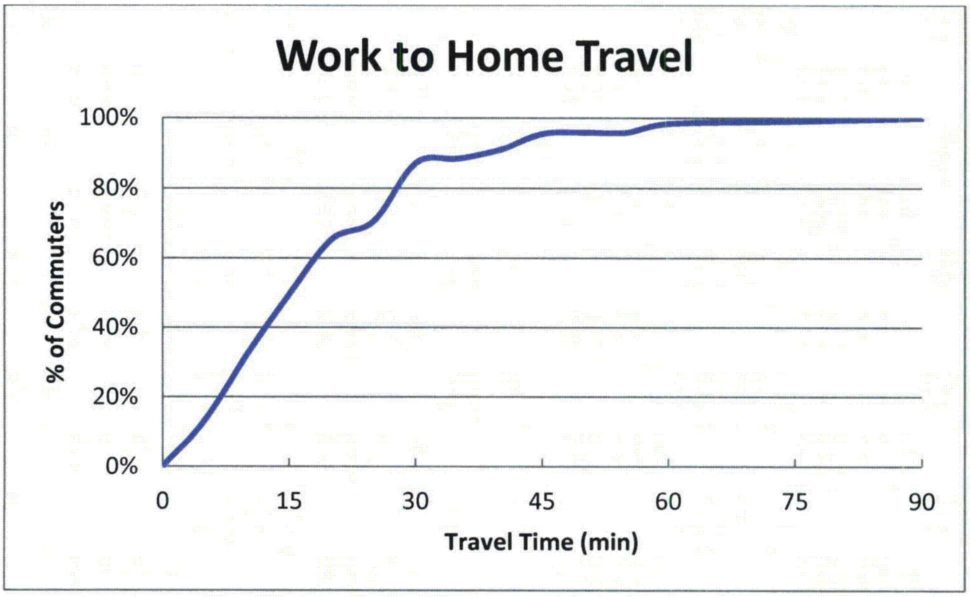


Figure F-11. Work to Home Travel Time

"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 90 percent of households can be ready to leave home within 90 minutes; the remaining households require up to an additional 1 hour and 45 minutes.

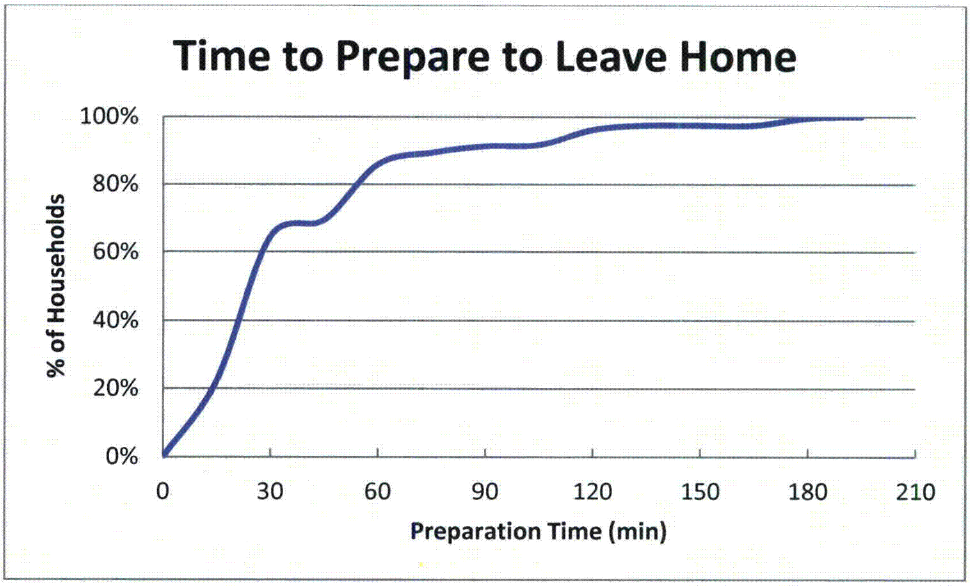


Figure F-12. Time to Prepare Home for Evacuation

"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 85 percent of driveways are passable within 30 minutes. The last driveway is cleared two hours and fifteen minutes after the start of this activity. Note that those respondents (47.5%) 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.

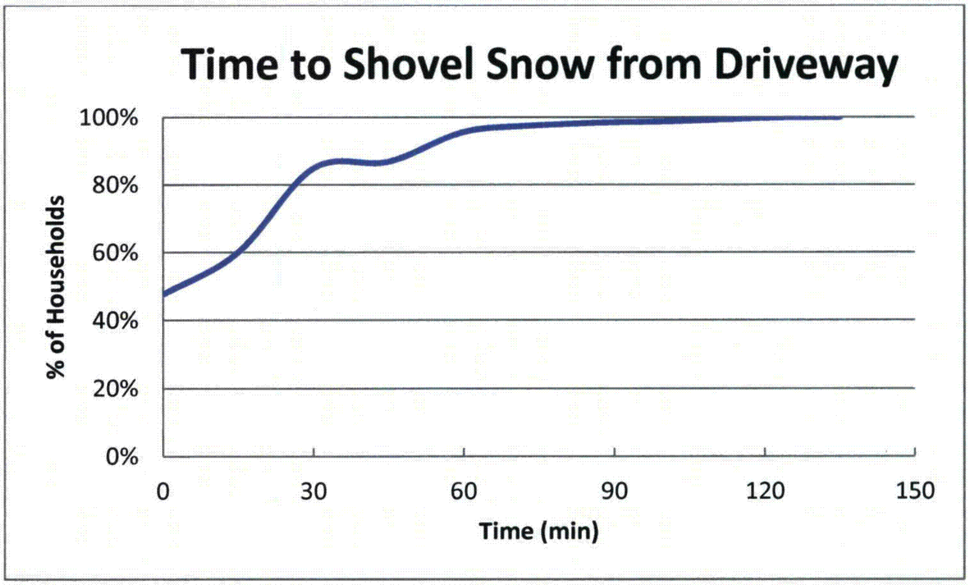


Figure F-13. Time to Clear Driveway of 6"-8" of Snow

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 on a survey for your county emergency management agency 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 or any personal information, and the survey will take less 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 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 COL. 25	Commuter #2 COL. 26	Commuter #3 COL. 27	Commuter #4 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				COMMUTER #4			
COL. 41		COL. 42		COL. 43		COL. 44	
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

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, <u>on average</u>, 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	<u>COL. 52</u> 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	<u>COL. 53</u> 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)	<u>COL. 54</u> 1 DON'T HAVE A PET 2 YES 3 NO X DON'T KNOW/REFUSED

Thank you very much. ________________________________

(TELEPHONE NUMBER CALLED)

<u>IF REQUESTED:</u>

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

County	EMA Phone
Benton	(509) 628-2600
Franklin	(509) 545-3546

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.

These plans were reviewed and the TCPs and ACPs were modeled accordingly.

G.1 Traffic Control Points

As discussed in Section 9, traffic control points at intersections (which are controlled) are modeled as actuated signals. If an intersection has a pre-timed signal, stop, or yield control, and the intersection is identified as a traffic control point, the control type was changed to an actuated signal in the DYNEV II system. 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 "Traffic Control Point" in Table K-2.

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 considered on three routes which traverse the study area – US-395, I-82, and I-182 – in this analysis. The generation of the external trips on US-395 ceased at 2 hours after the advisory to evacuate in the simulation due to the ACPs.

Figure G-1 maps the ACPs identified in the county emergency plans. These ACPS are concentrated on roadways giving access to the EPZ. Theses ACPs would be manned during evacuation by traffic guides who would direct evacuees in the proper direction away from CGS and facilitate the flow of traffic through the intersections.

This study did not identify any additional intersections that should be identified as TCPs or ACPs. However, as discussed in Section 7.3 and shown in Figures 7-3 through 7-5, there is pronounced traffic congestion in Richland south of the EPZ. The offsite agencies could consider establishing ACPs along I-82 and I-182 to stop the flow of traffic through Richland during an evacuation so that the full capacity of the roadways is available to evacuees. This will not affect ETE as the ramps to these interstates are the bottlenecks, not the main thoroughfare on the interstates.

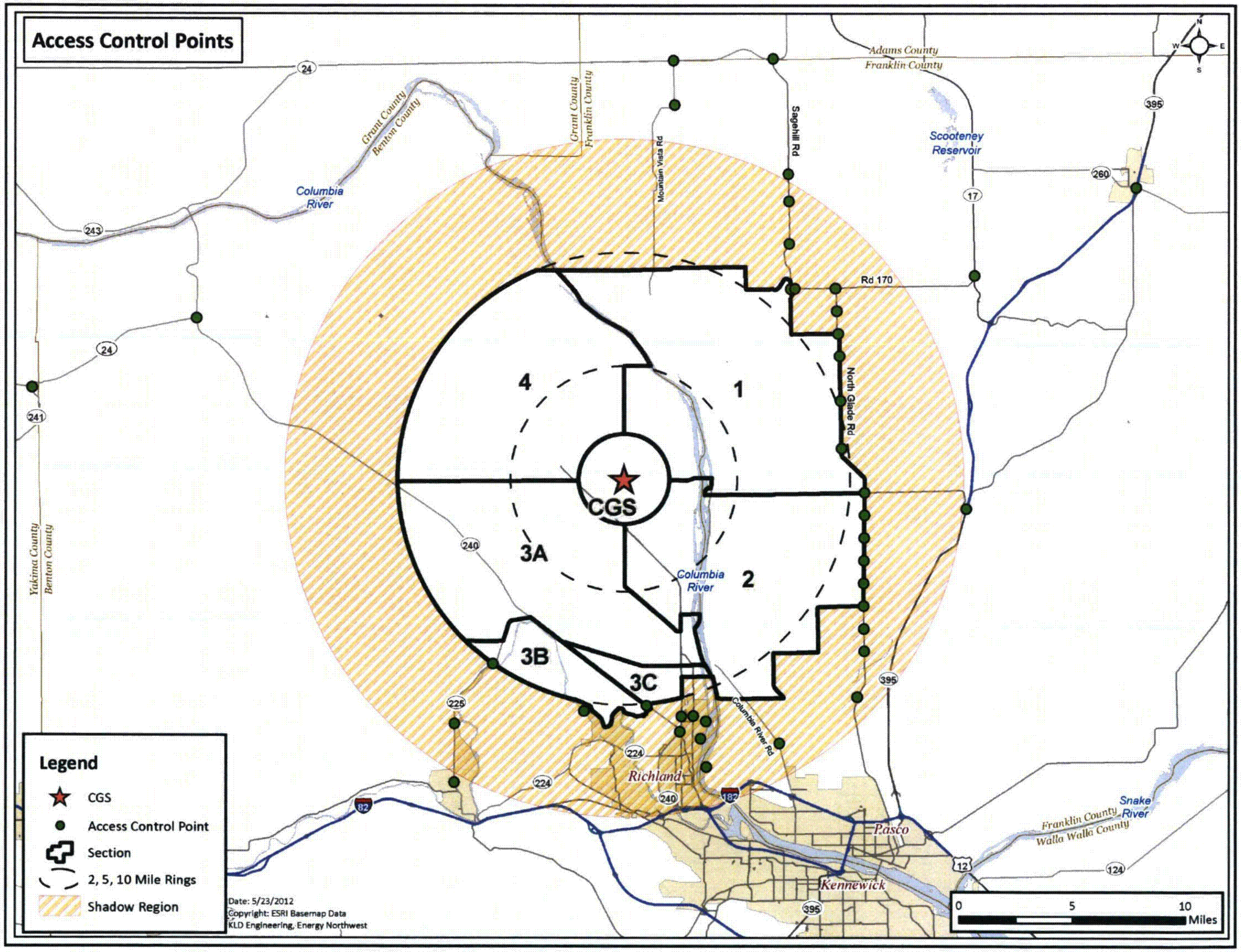


Figure G-1. Access Control Points for the Columbia Generating Station

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.

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

Region	Description	Section						
		CGS	1	2	3A	3B	3C	4
R01	2-Mile Radius	100%	20%	20%	20%	20%	20%	20%
R02	5-Mile Radius	100%	100%	100%	100%	20%	20%	100%
R03	Full EPZ	100%	100%	100%	100%	100%	100%	100%
Evacuate 2-Mile Radius and Downwind to 5 Miles								
Region	Wind Direction From:	Section						
		CGS	1	2	3A	3B	3C	4
R04	SSE, S, SSW	100%	100%	20%	20%	20%	20%	100%
R05	SW, WSW	100%	100%	20%	20%	20%	20%	20%
R06	W, WNW	100%	100%	100%	20%	20%	20%	20%
R07	NW	100%	20%	100%	20%	20%	20%	20%
R08	NNW, N, NNE	100%	20%	100%	100%	20%	20%	20%
R09	NE	100%	20%	20%	100%	20%	20%	20%
R10	ENE, E, ESE	100%	20%	20%	100%	20%	20%	100%
R11	SE	100%	20%	20%	20%	20%	20%	100%
Evacuate 2-Mile Radius and Downwind to the EPZ Boundary								
Region	Wind Direction From:	Section						
		CGS	1	2	3A	3B	3C	4
N/A	SSE, S, SSW	Refer to Region R04						
N/A	SW, WSW	Refer to Region R05						
N/A	W, WNW	Refer to Region R06						
N/A	NW	Refer to Region R07						
R12	NNW, N	100%	20%	100%	100%	100%	100%	20%
R13	NNE, NE, ENE	100%	20%	20%	100%	100%	100%	20%
R14	E, ESE	100%	20%	20%	100%	100%	100%	100%
N/A	SE	Refer to Region R11						
Staged Evacuation - 2-Mile Radius Evacuates, then Evacuate Downwind to 5 Miles								
Region	Wind Direction From:	Section						
		CGS	1	2	3A	3B	3C	4
R15	SSE, S, SSW	100%	100%	20%	20%	20%	20%	100%
R16	SW	100%	100%	20%	20%	20%	20%	20%
R17	WSW, W, WNW	100%	100%	100%	20%	20%	20%	20%
R18	NW	100%	20%	100%	20%	20%	20%	20%
R19	NNW, N, NNE	100%	20%	100%	100%	20%	20%	20%
R20	NE	100%	20%	20%	100%	20%	20%	20%
R21	ENE, E, ESE	100%	20%	20%	100%	20%	20%	100%
R22	SE	100%	20%	20%	20%	20%	20%	100%
Shelter-in-Place until 90% ETE for R01, then Evacuate		Section(s) Shelter-in-Place			Section(s) Evacuate			

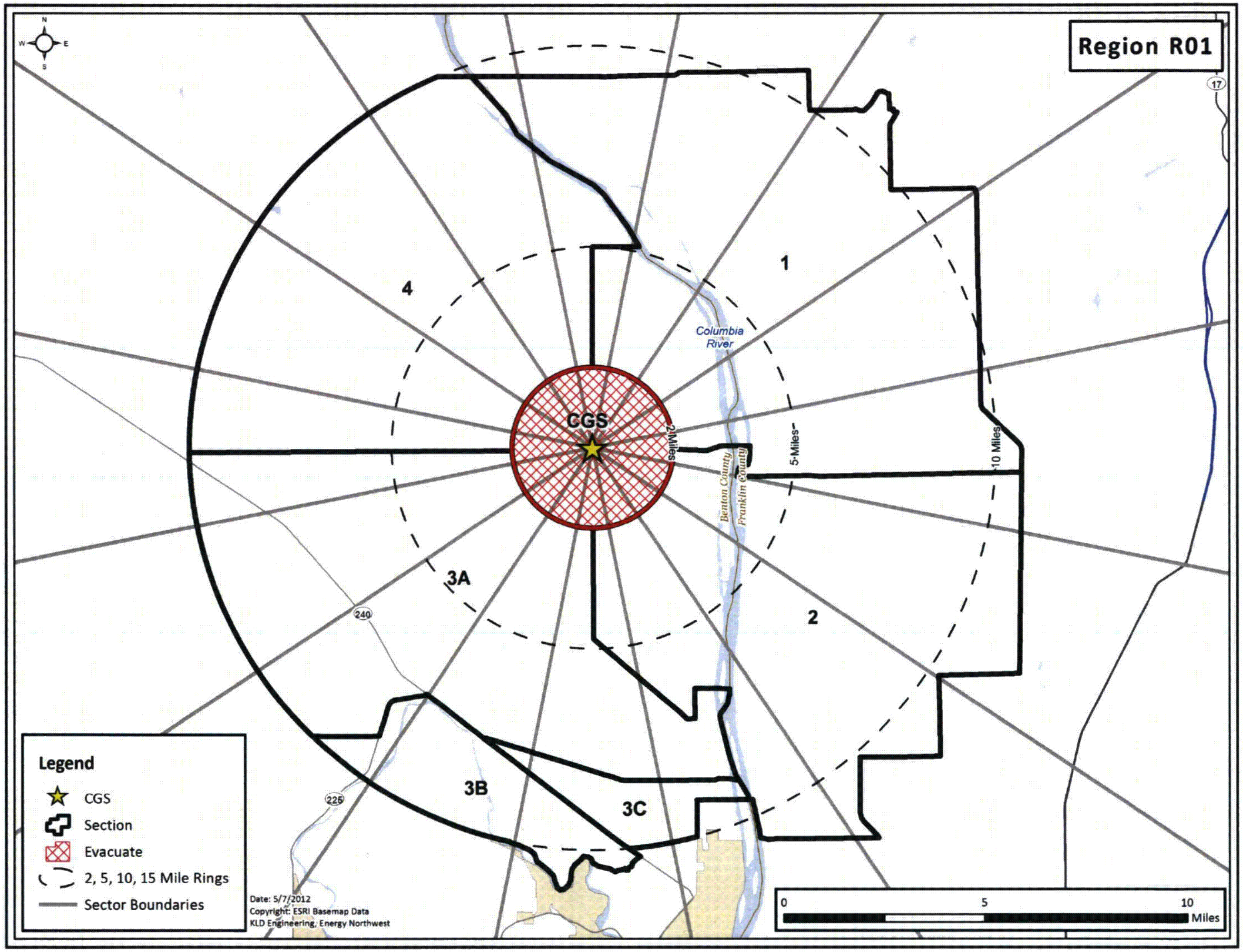


Figure H-1. Region R01

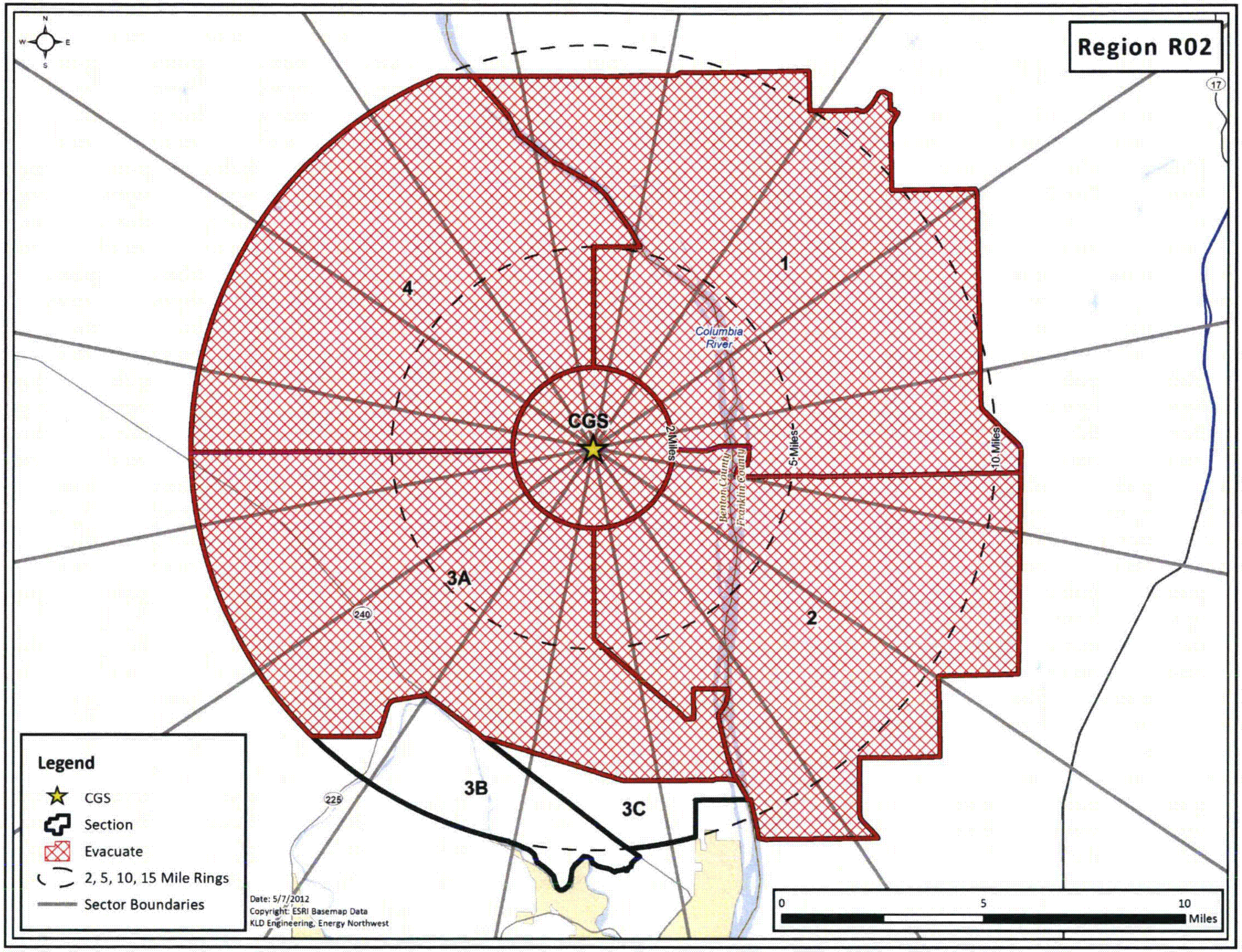


Figure H-2. Region R02

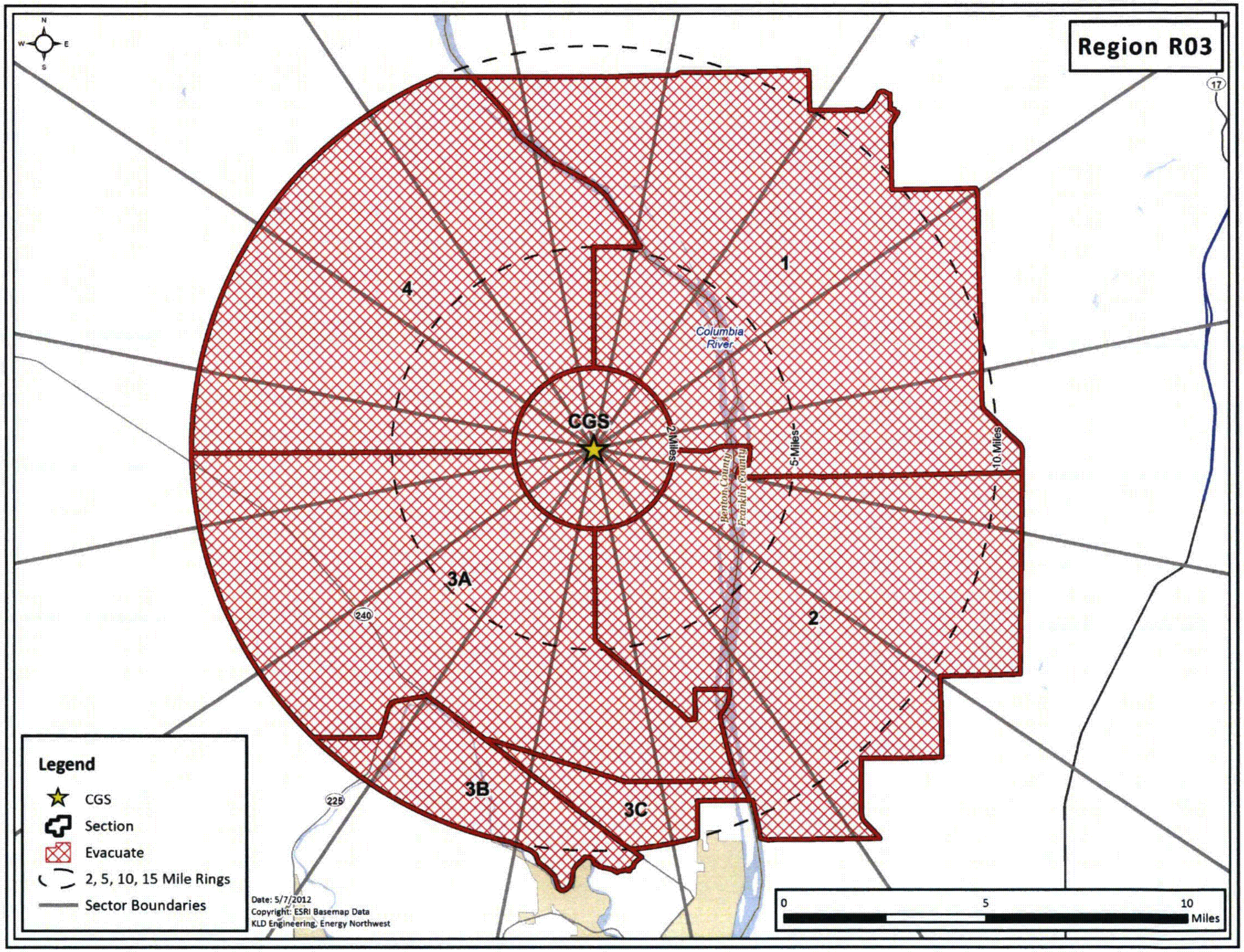


Figure H-3. Region R03

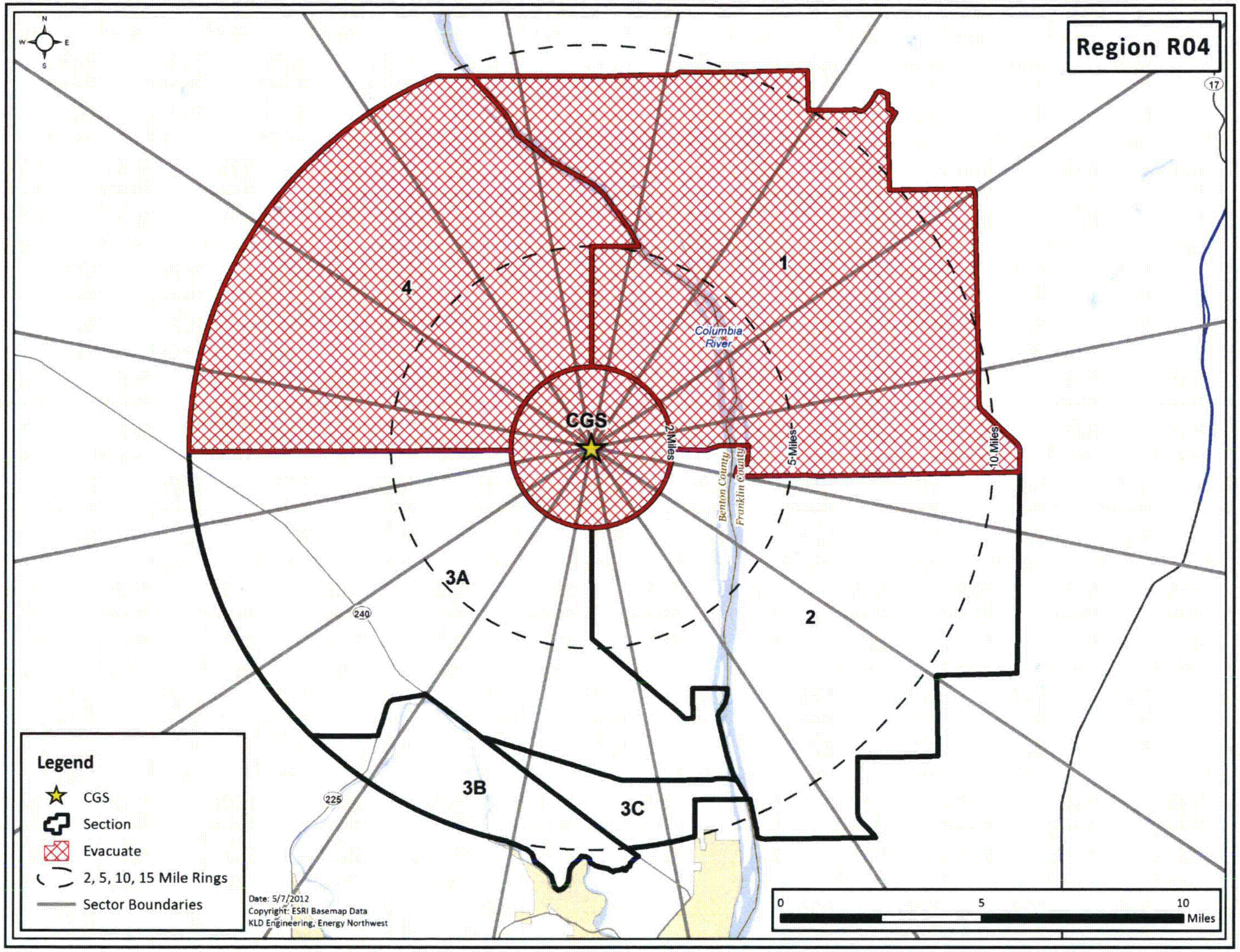


Figure H-4. Region R04

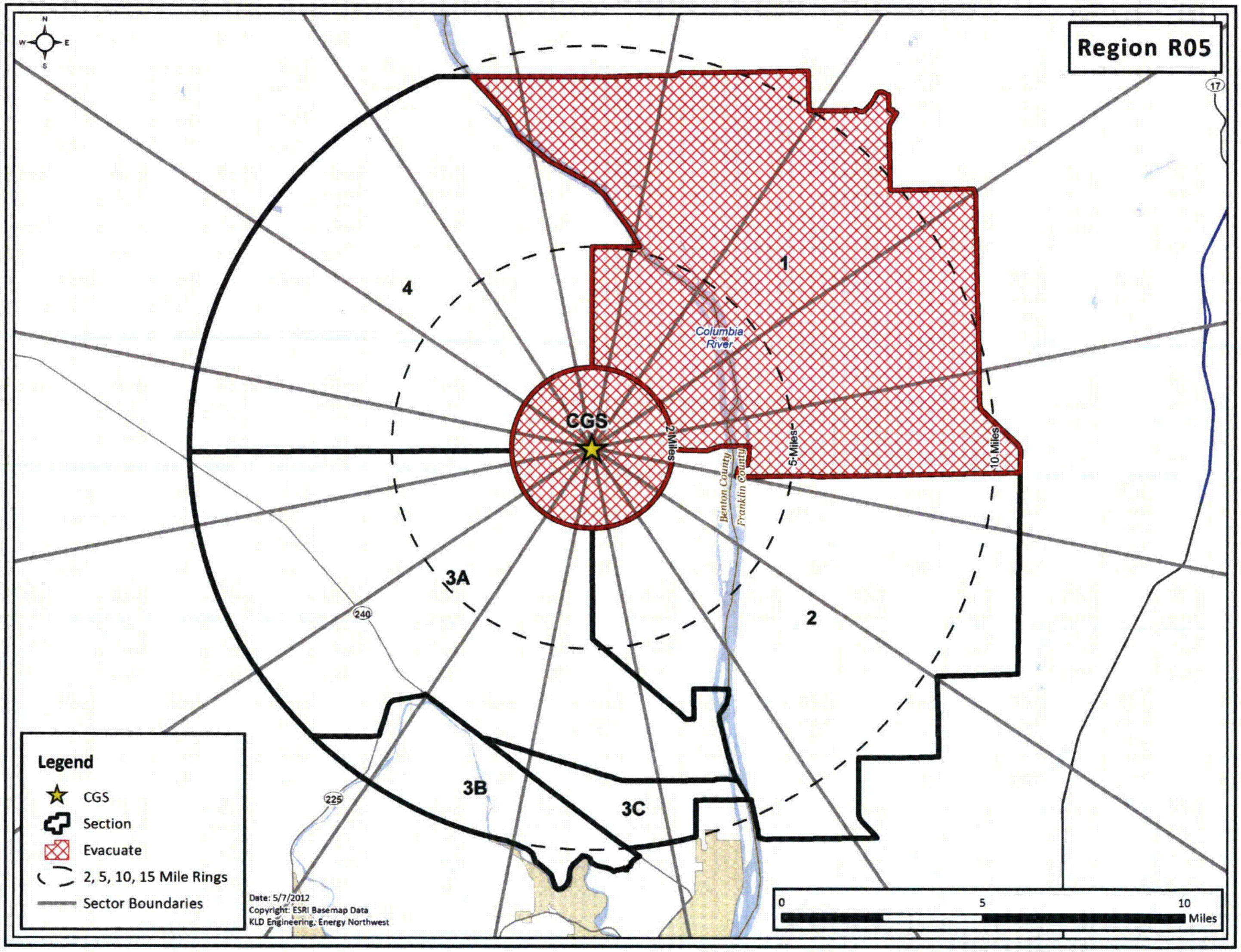


Figure H-5. Region R05

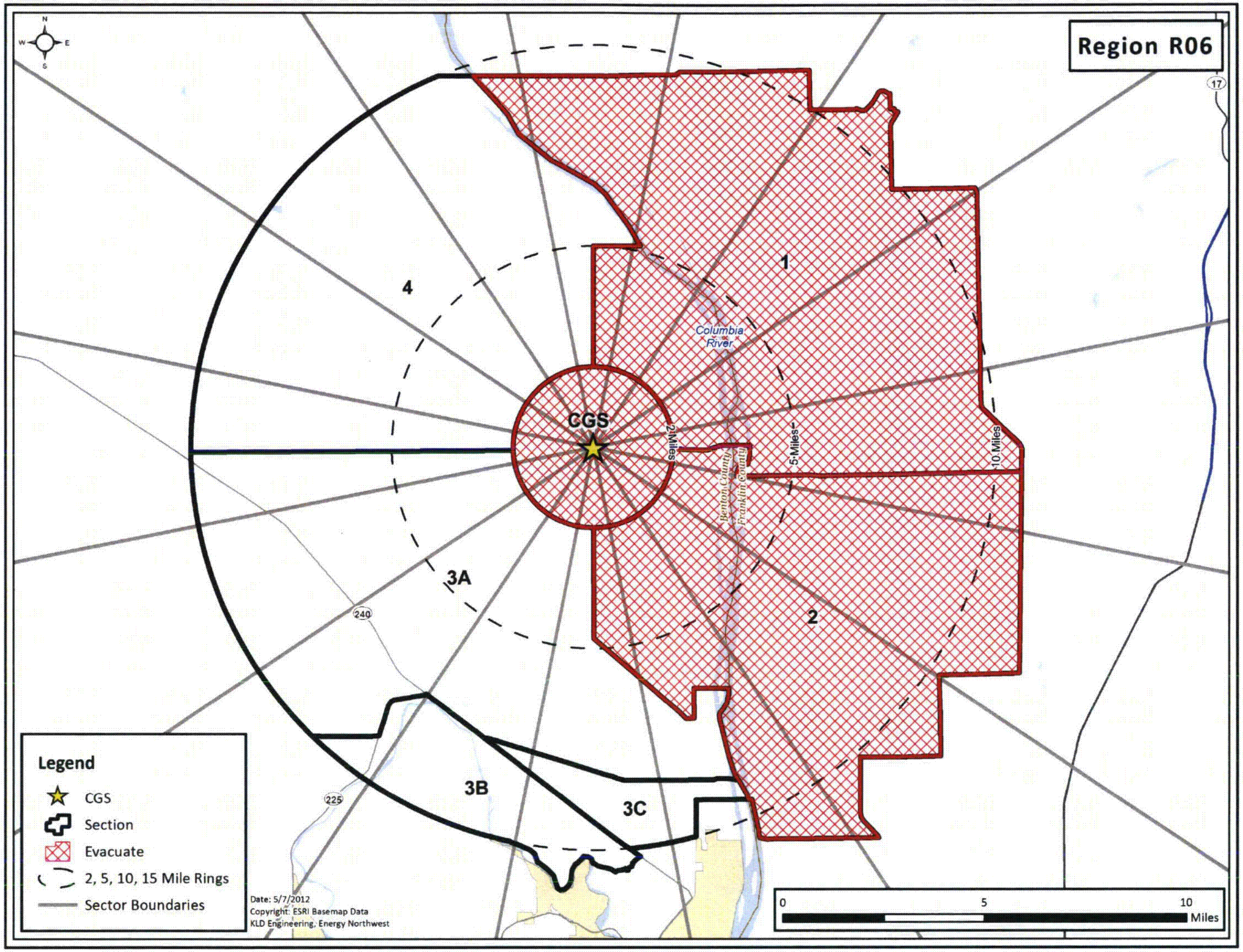


Figure H-6. Region R06

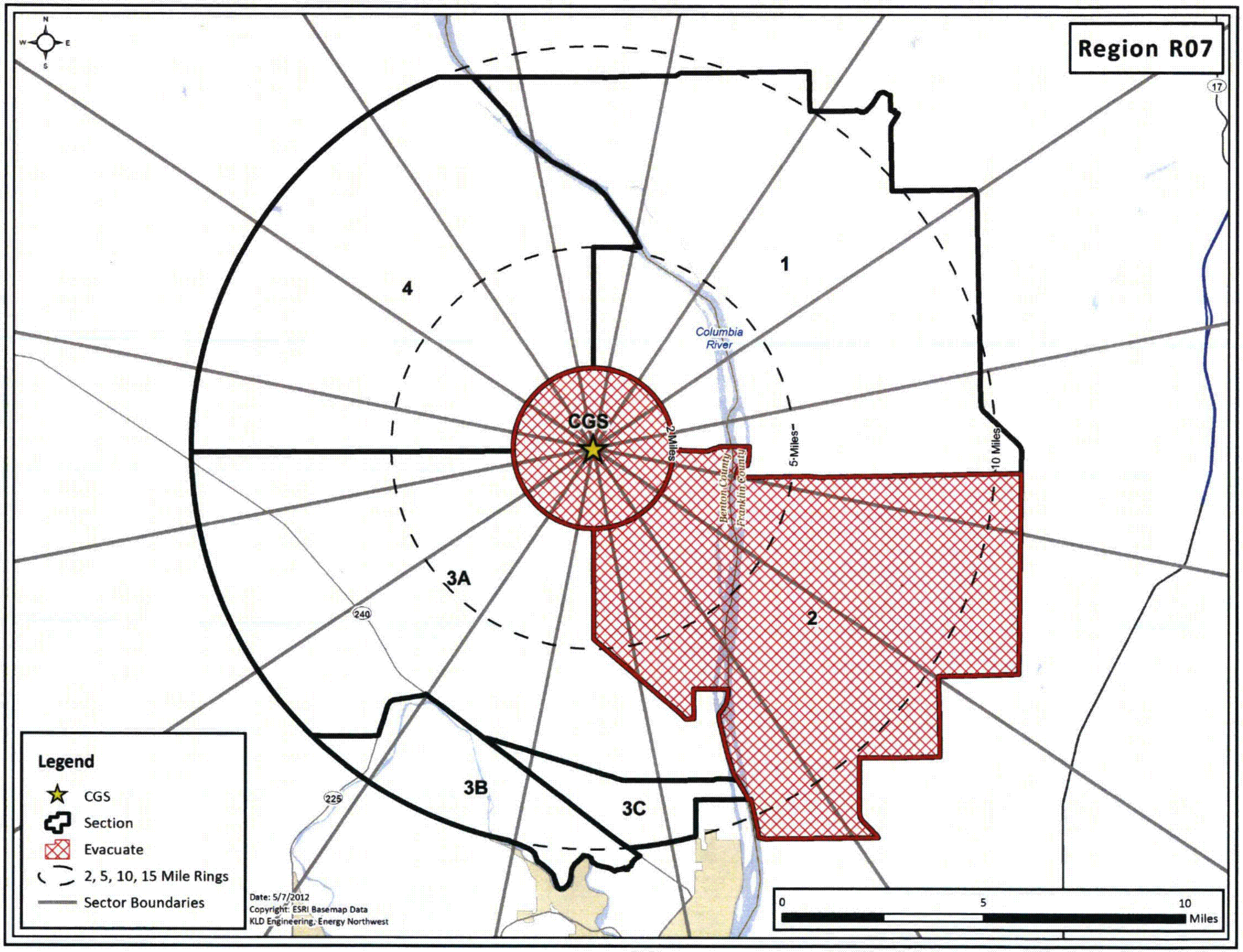


Figure H-7. Region R07

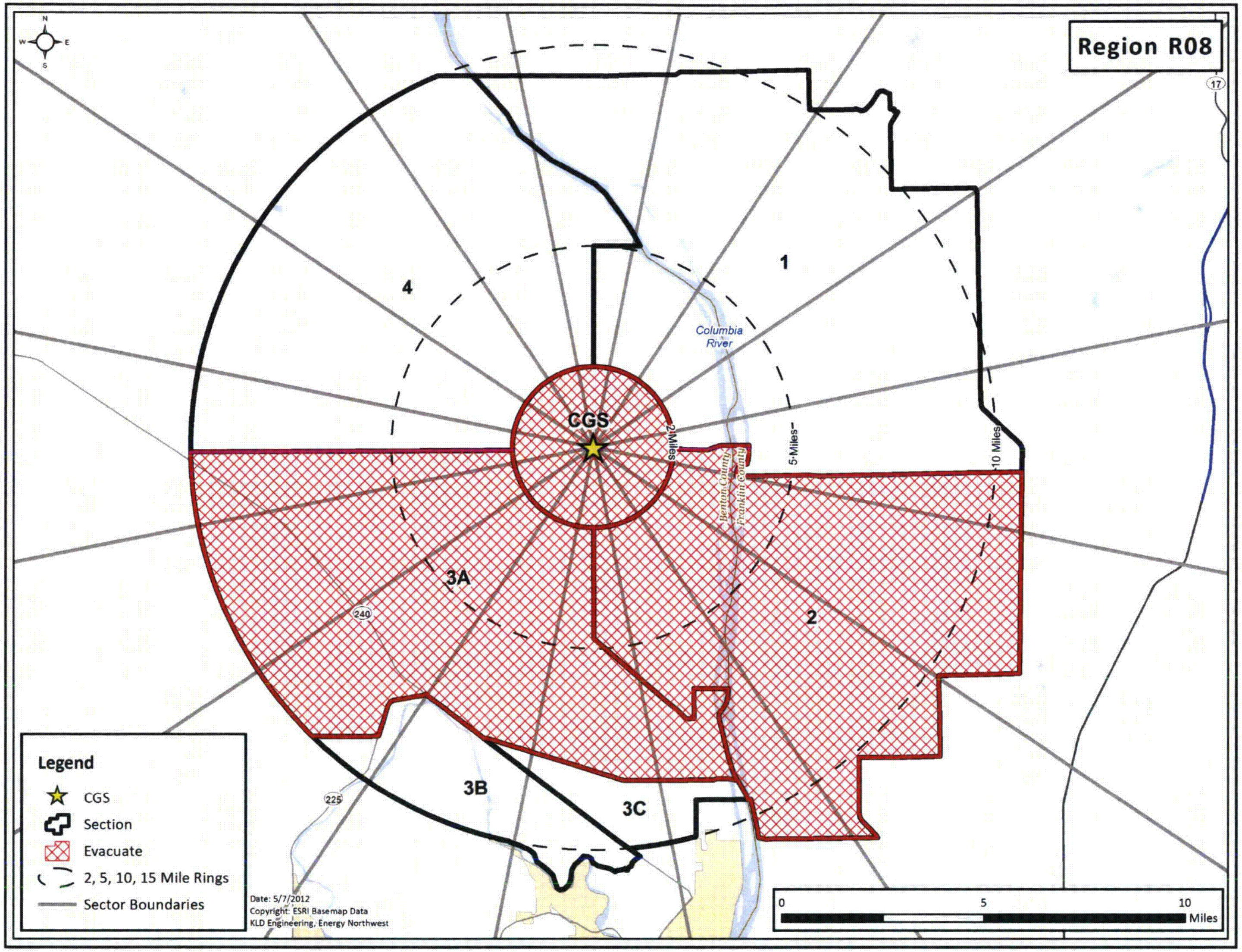


Figure H-8. Region R08

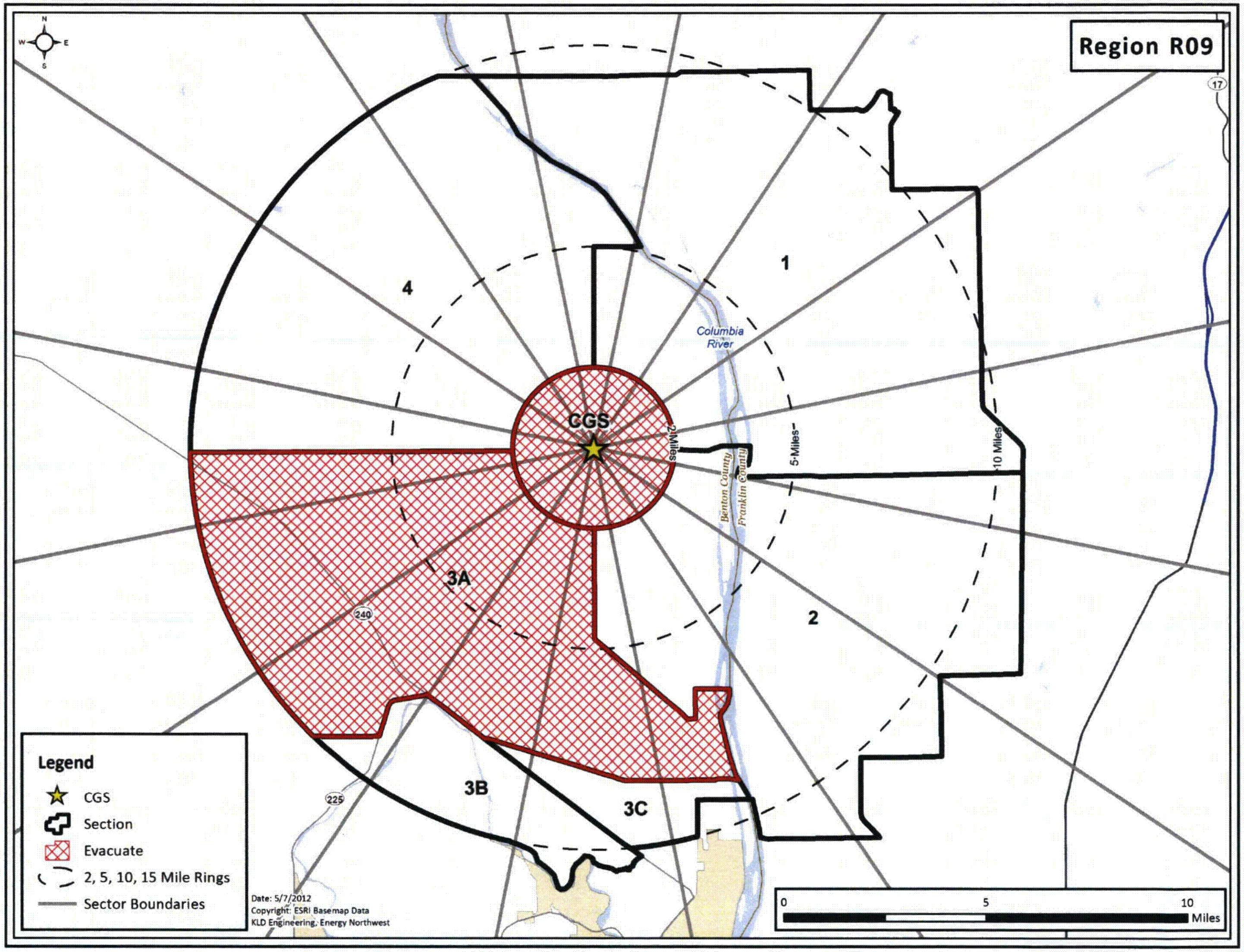


Figure H-9. Region R09

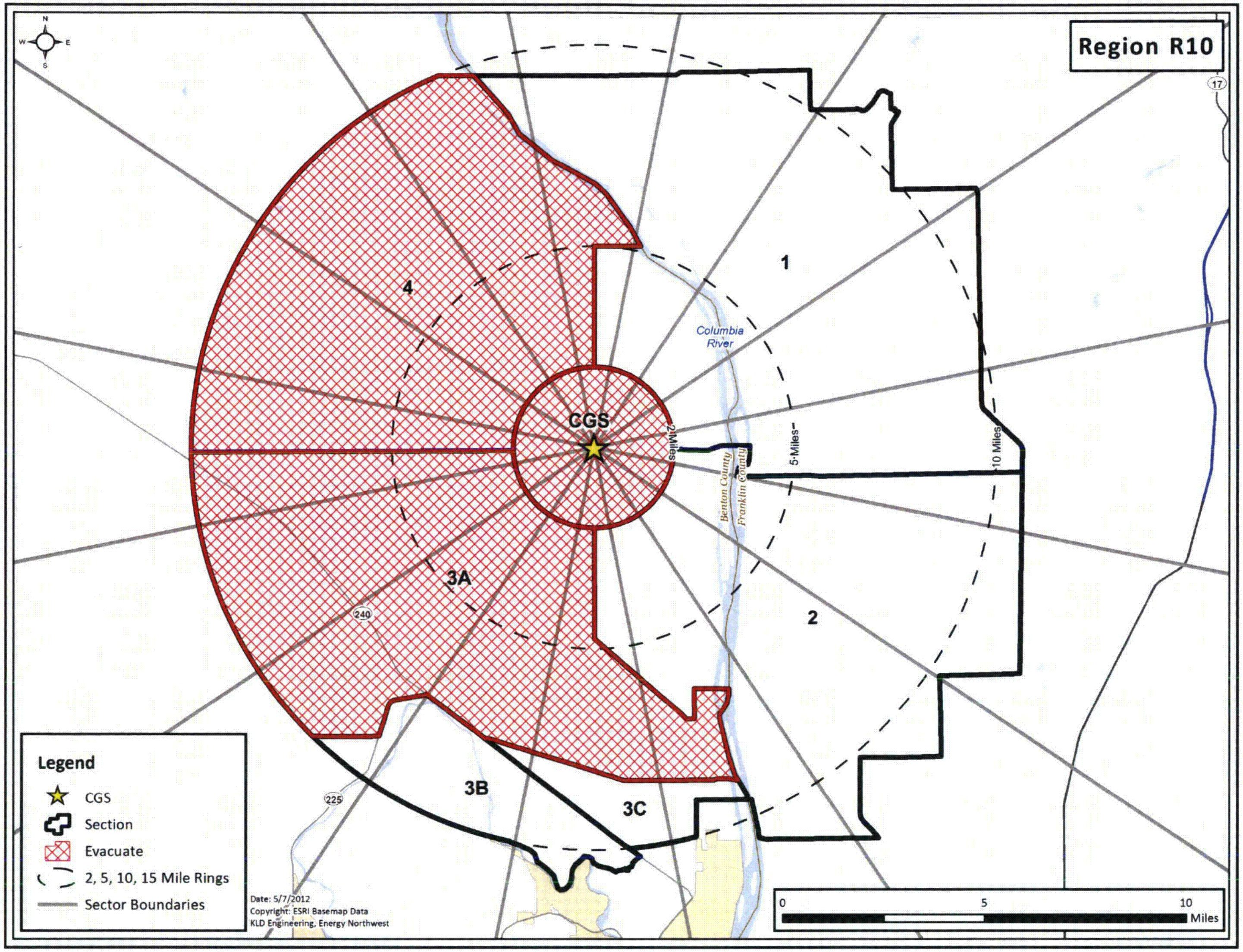


Figure H-10. Region R10

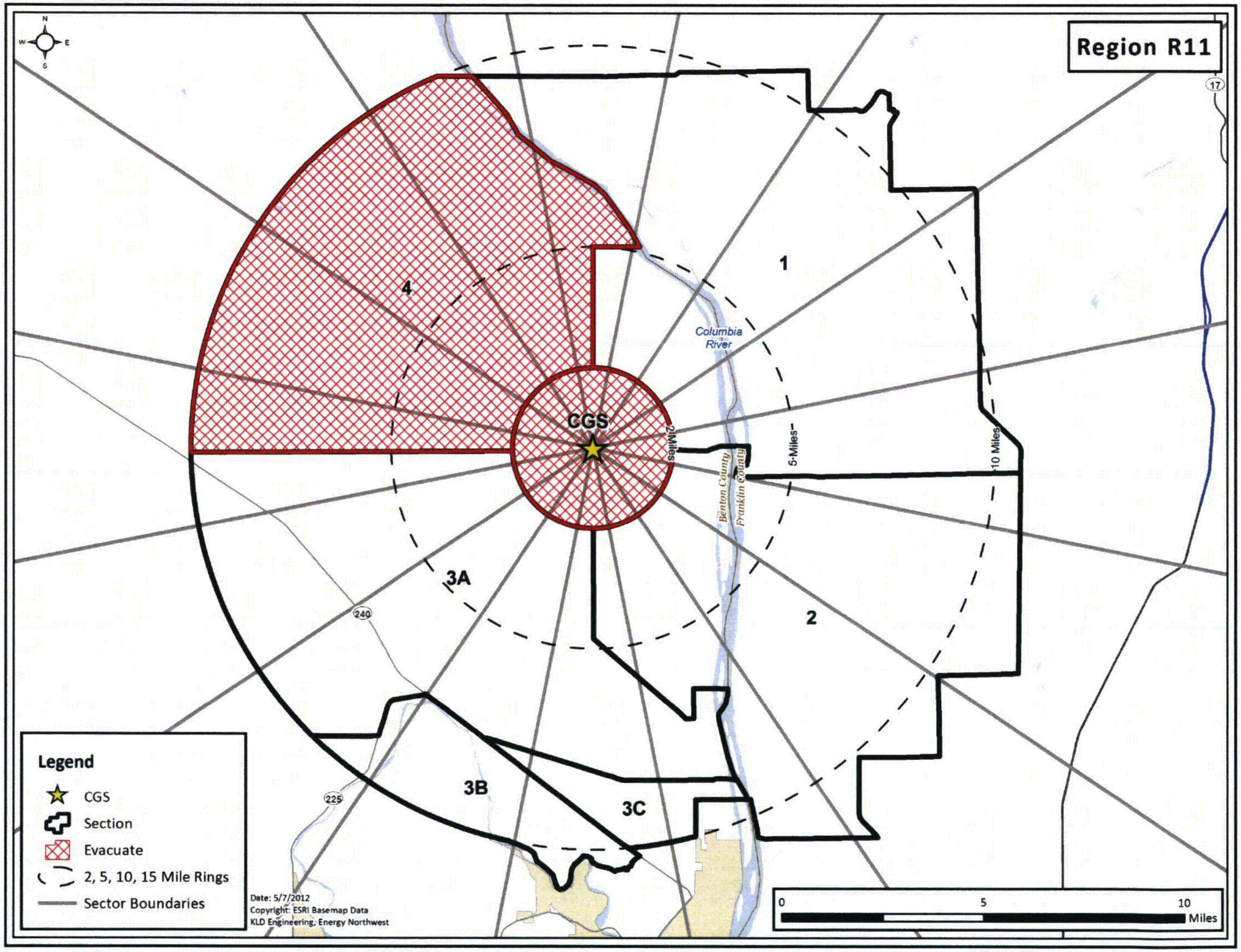


Figure H-11. Region R11

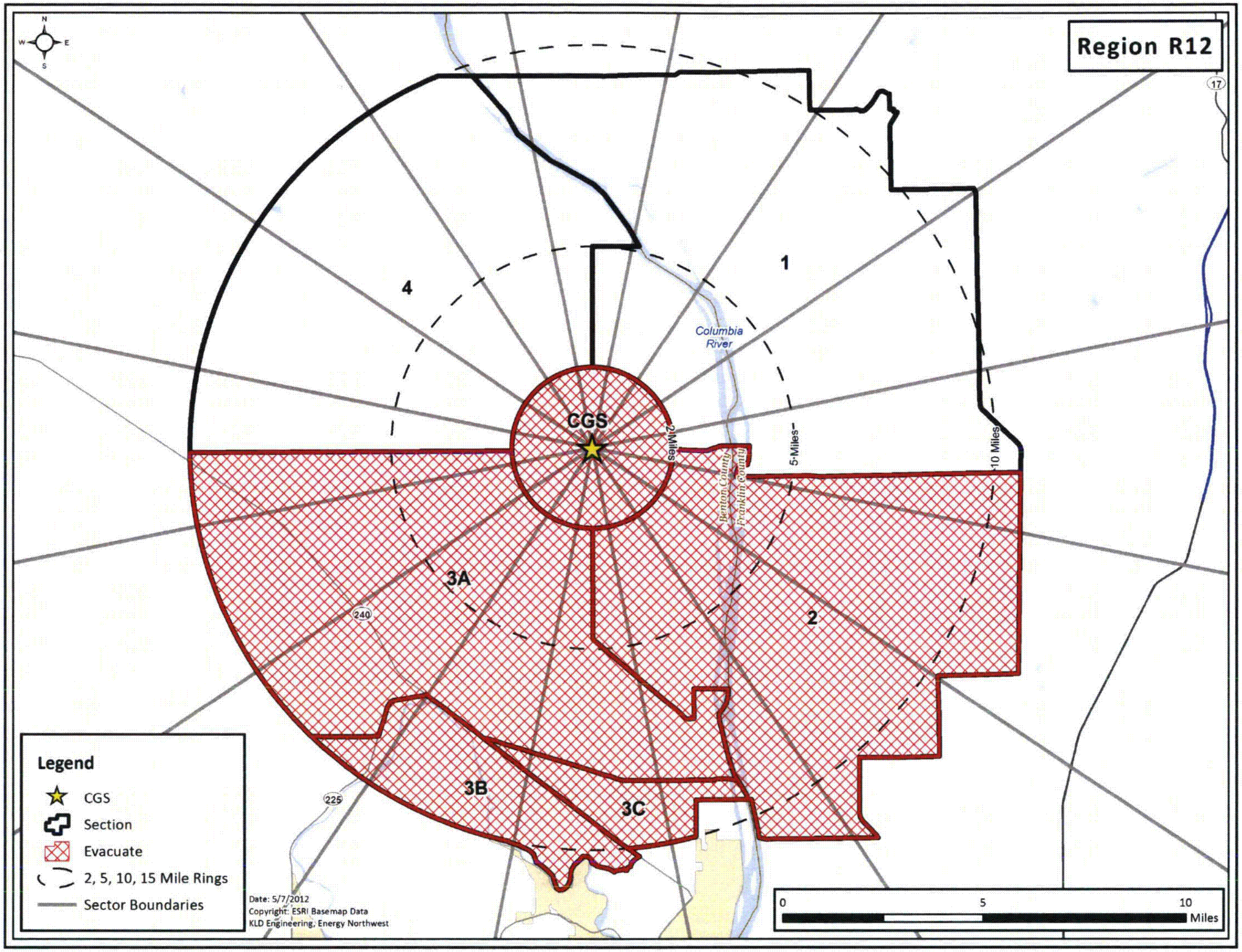


Figure H-12. Region R12

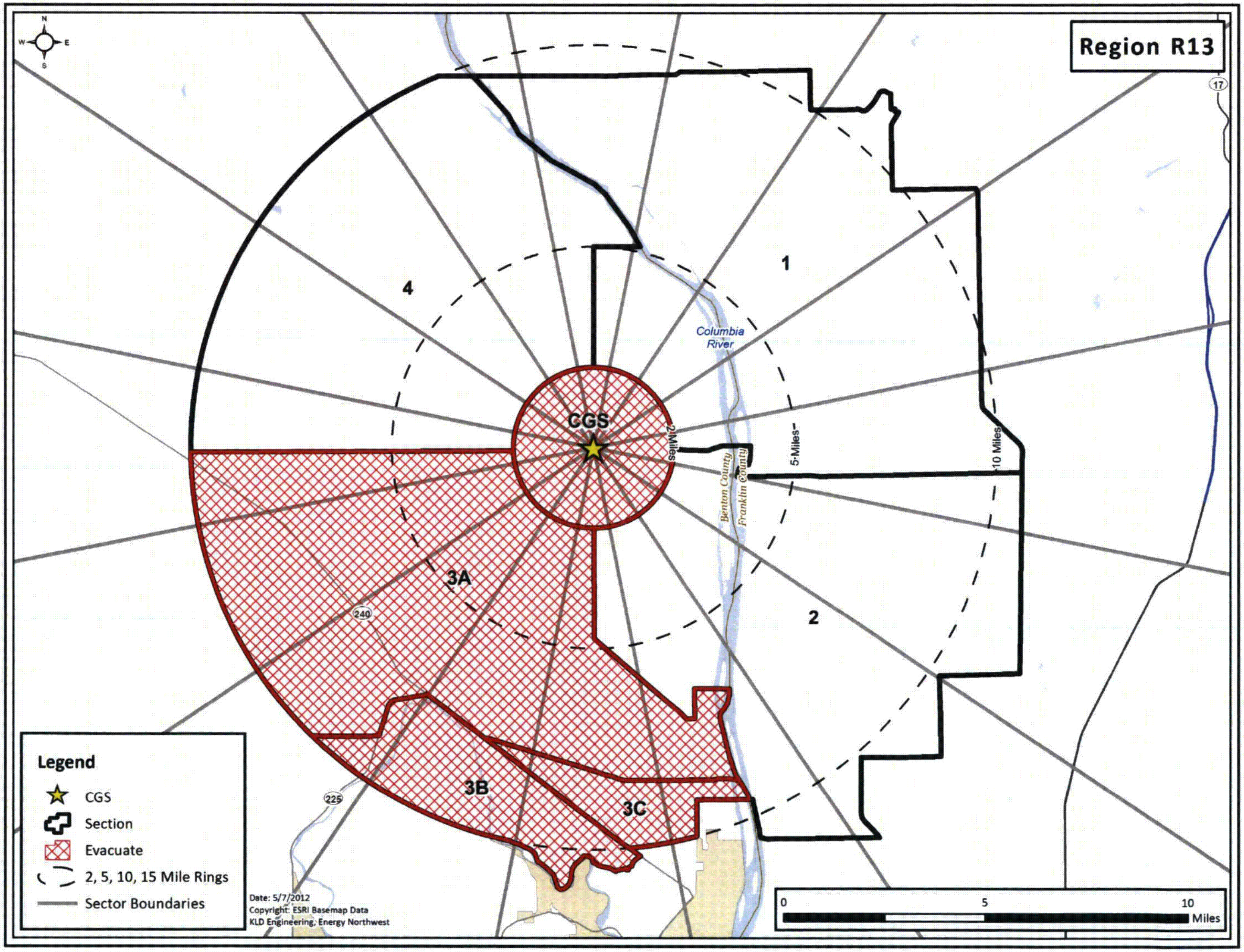


Figure H-13. Region R13

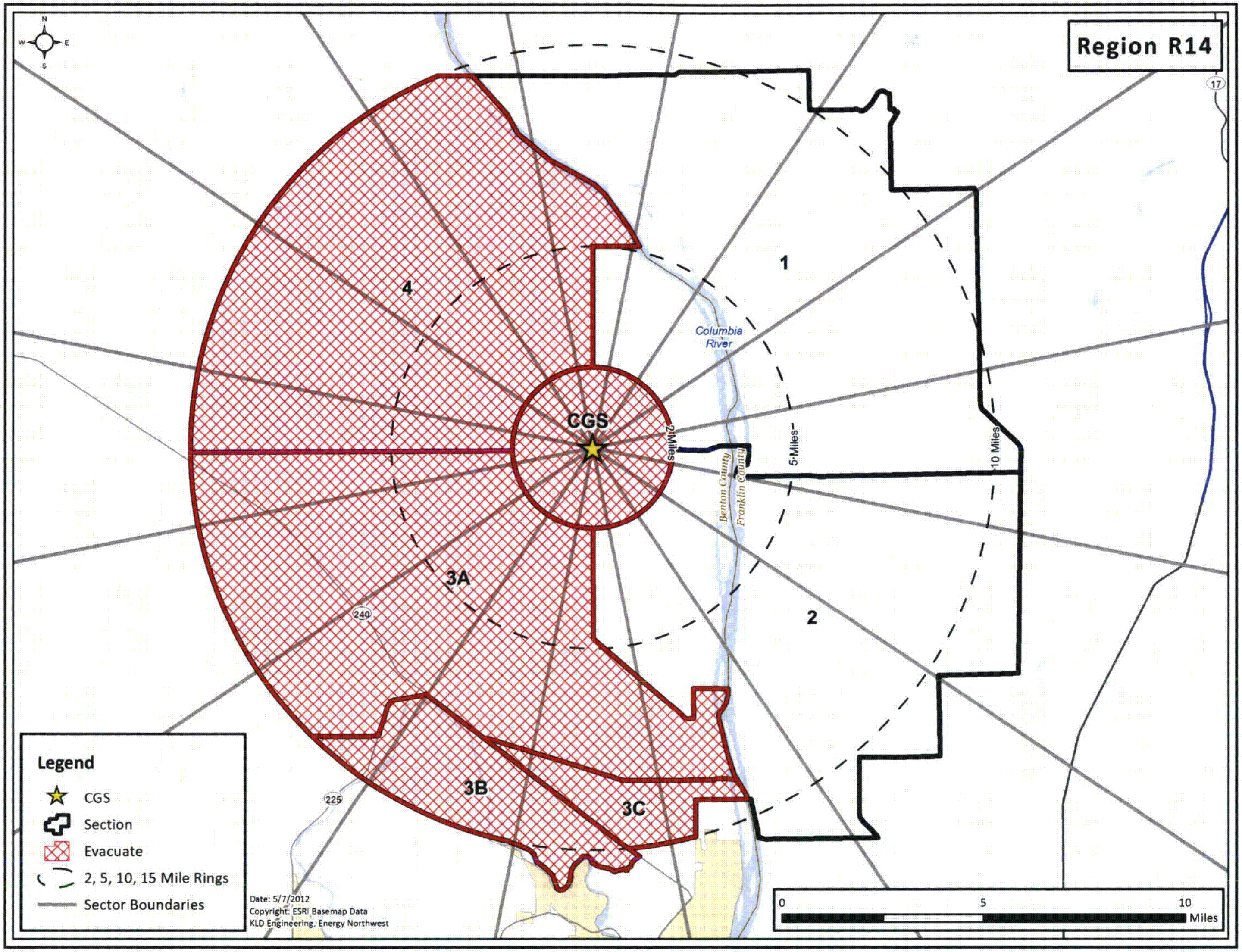


Figure H-14. Region R14

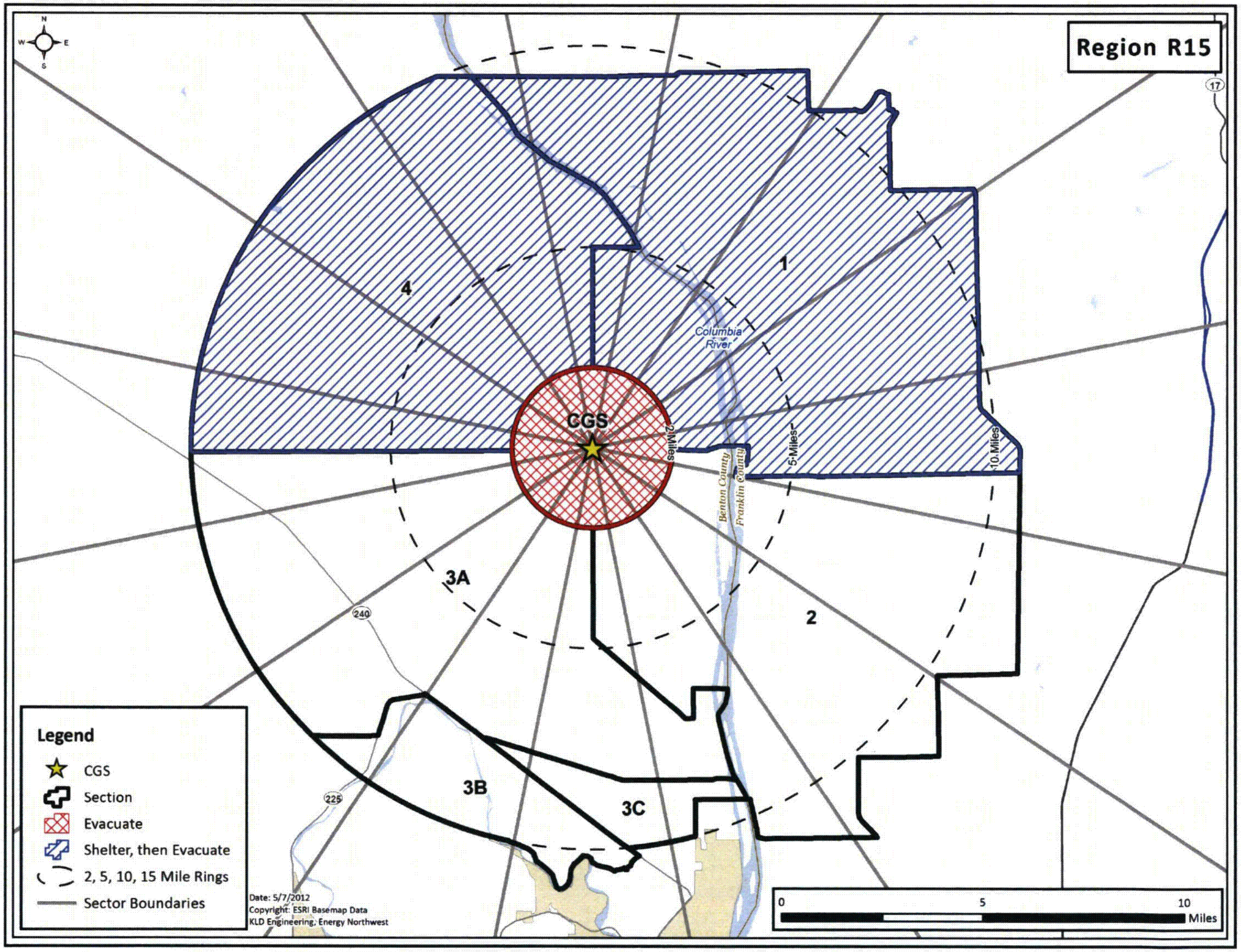


Figure H-15. Region R15

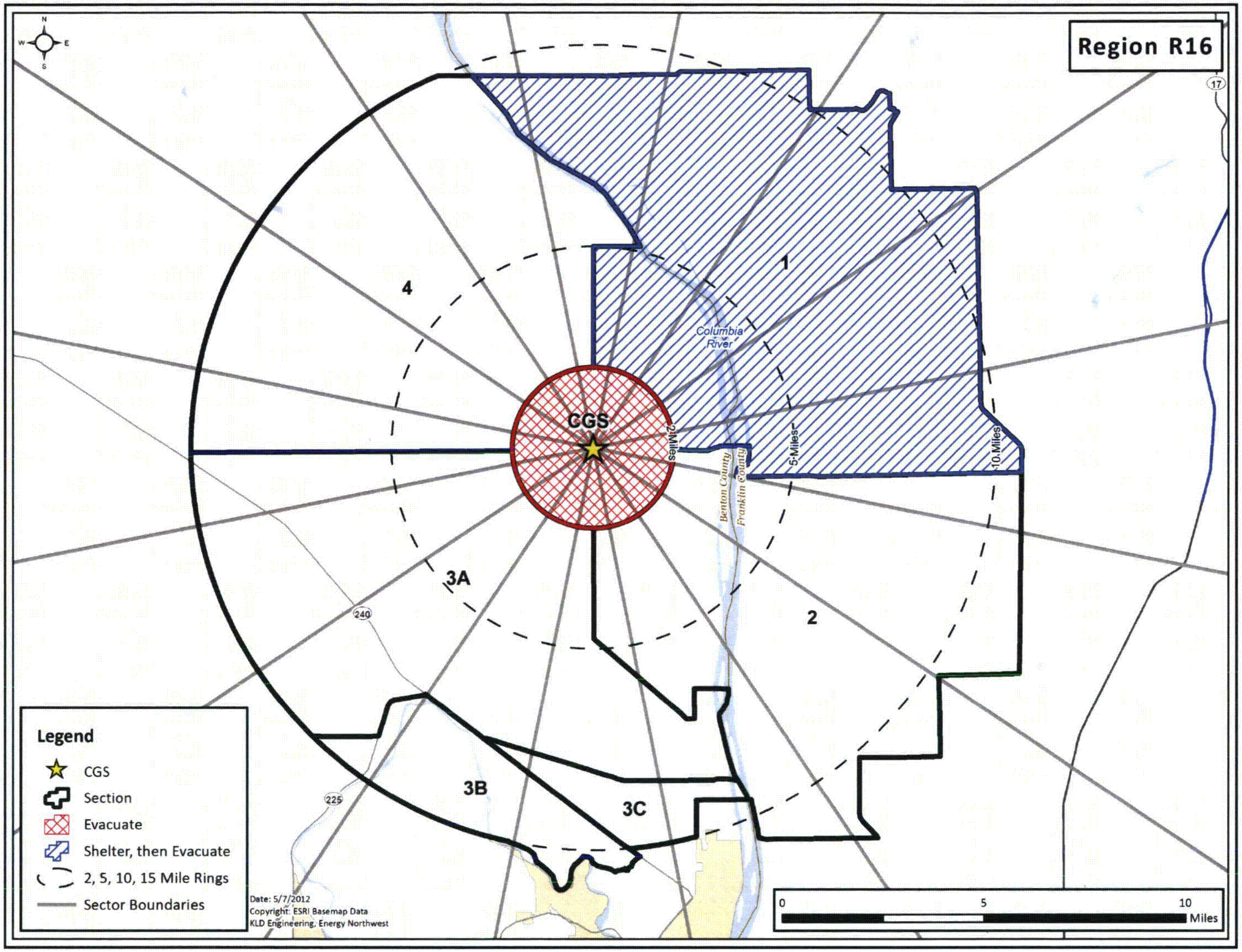


Figure H-16. Region R16

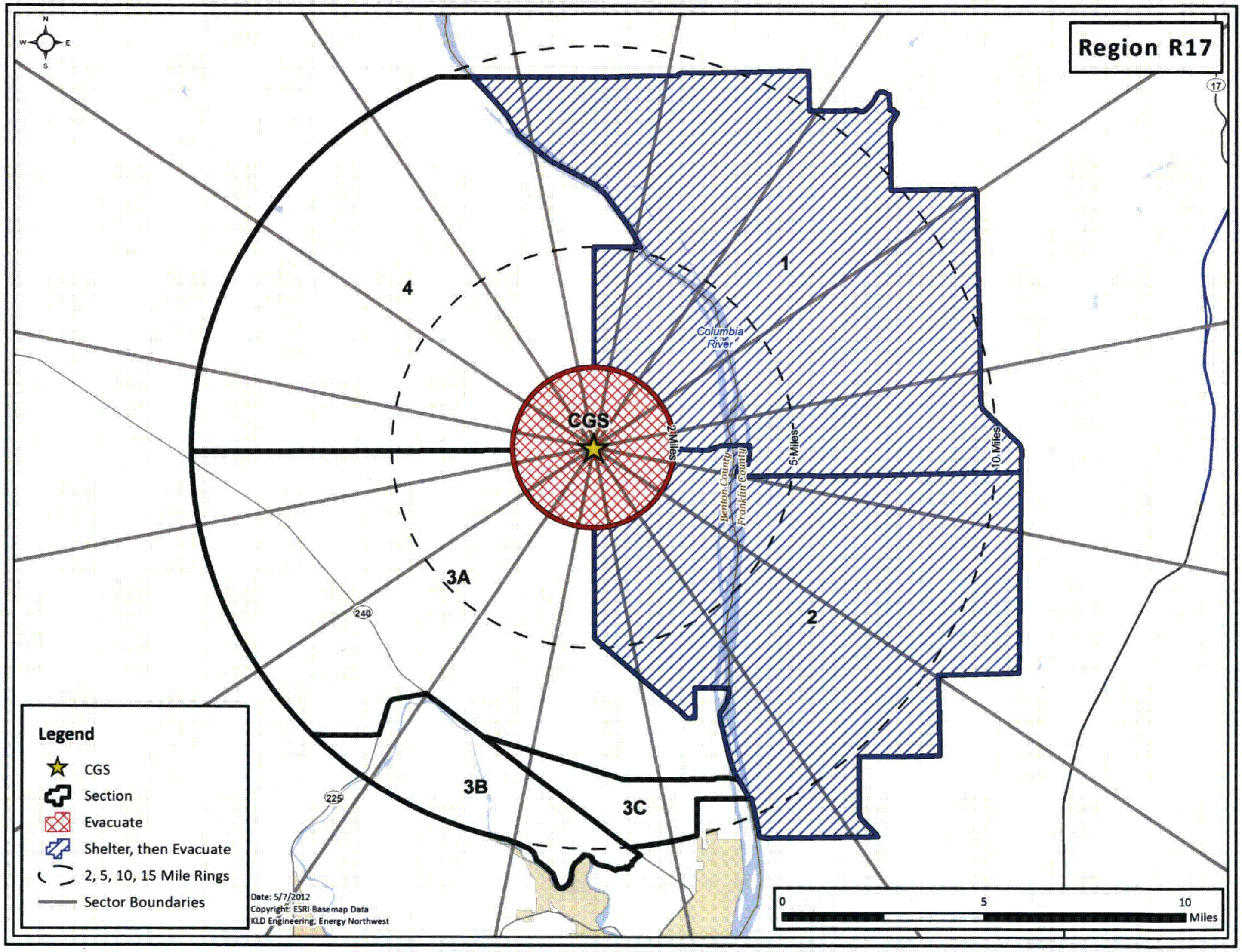


Figure H-17. Region R17

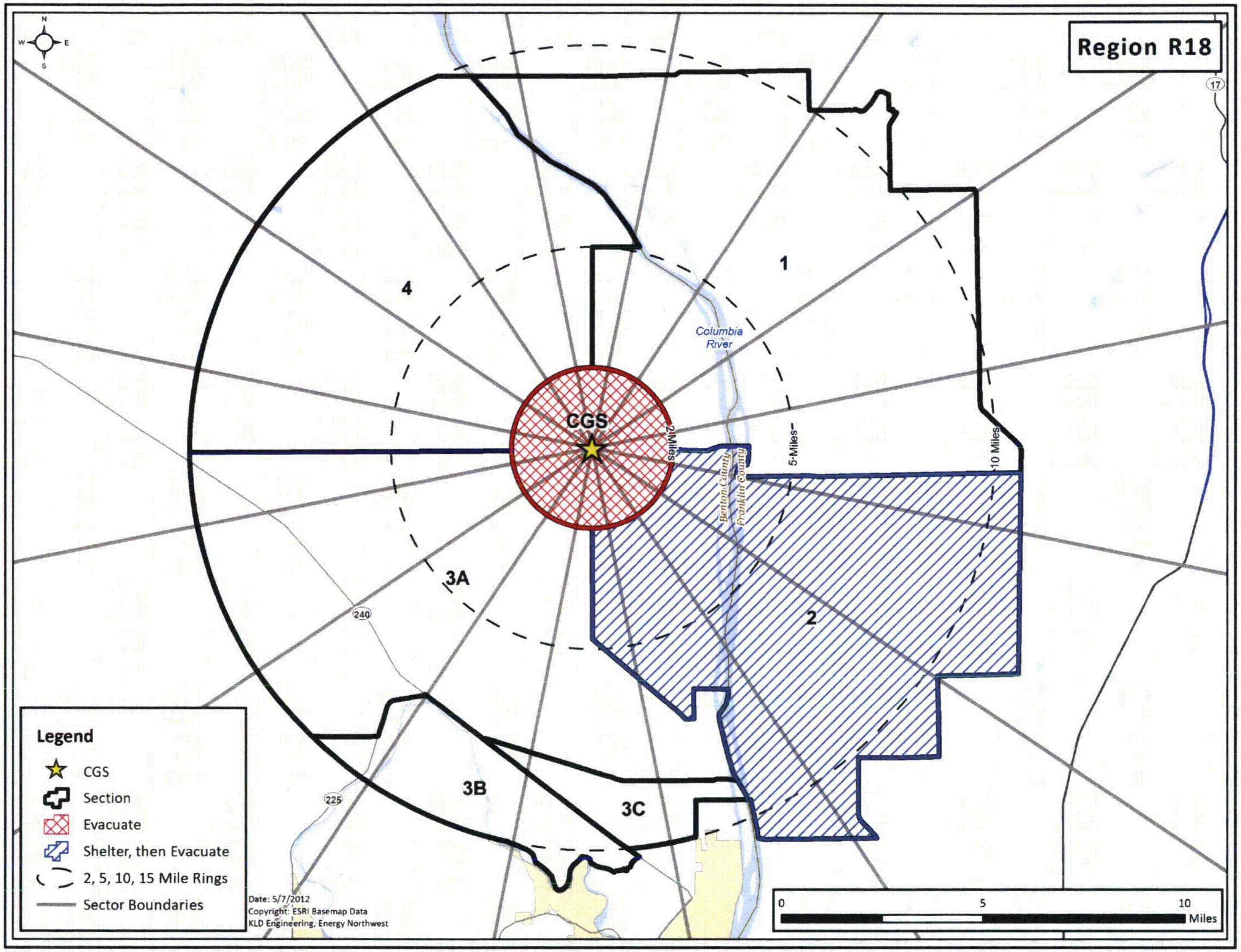


Figure H-18. Region R18

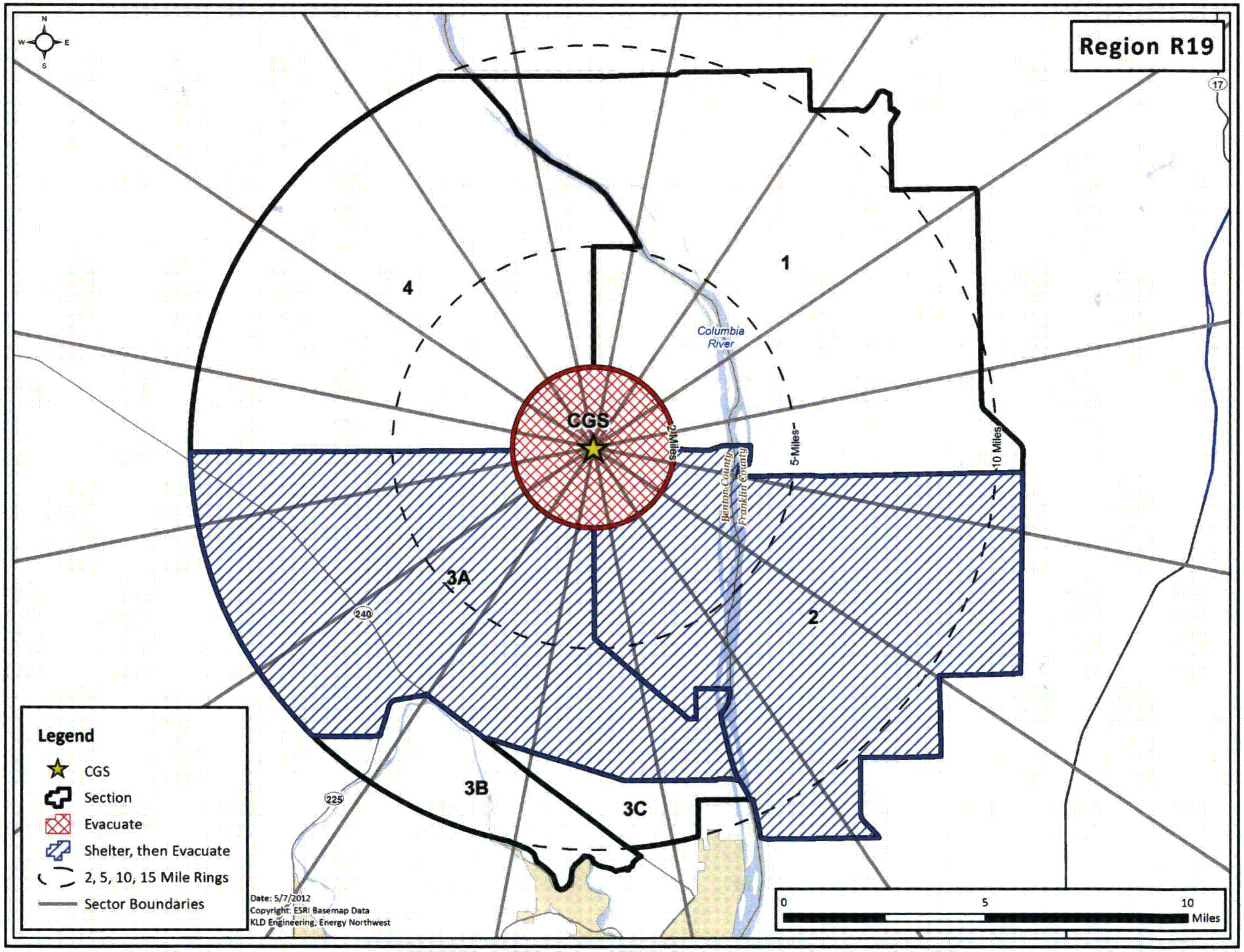


Figure H-19. Region R19

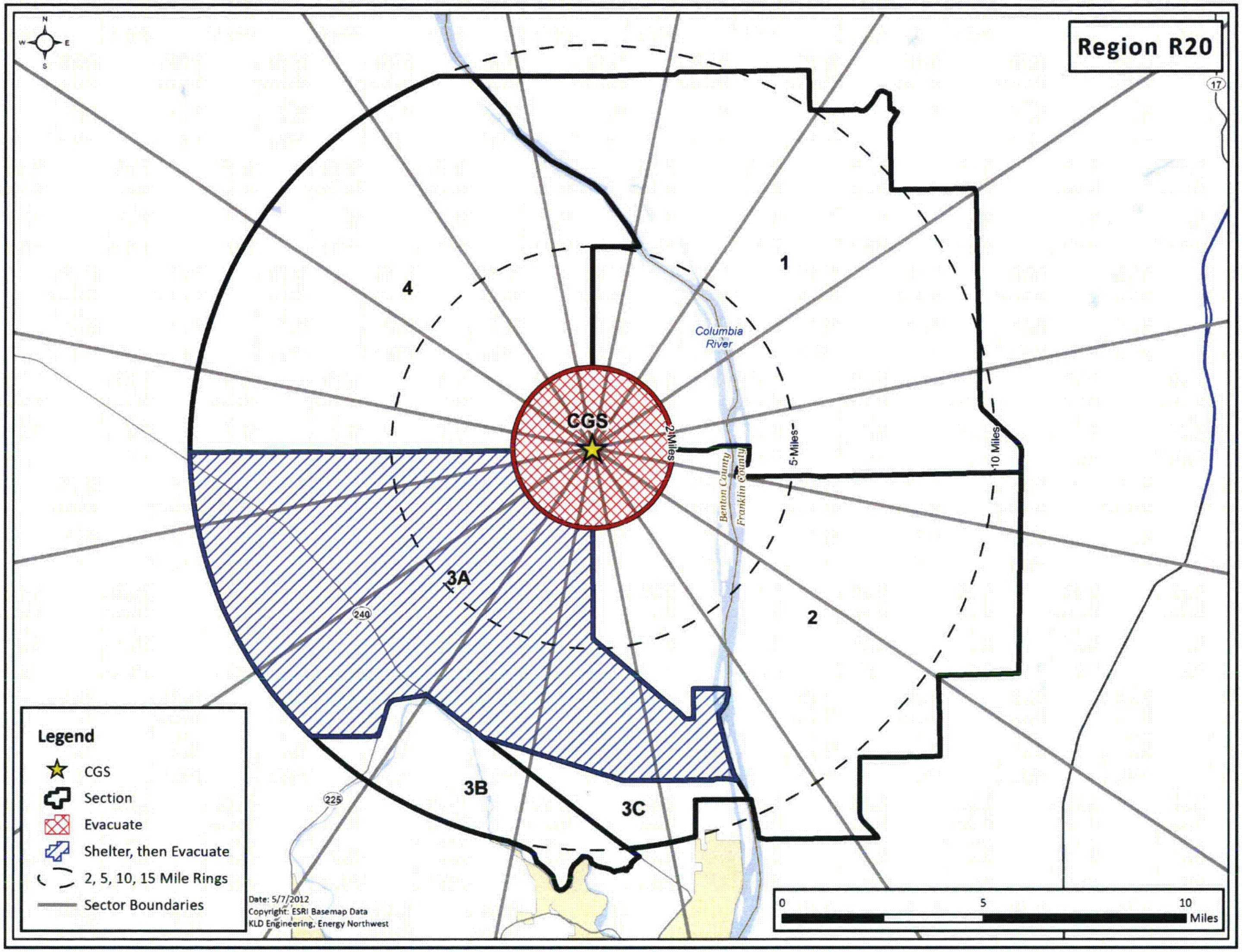


Figure H-20. Region R20

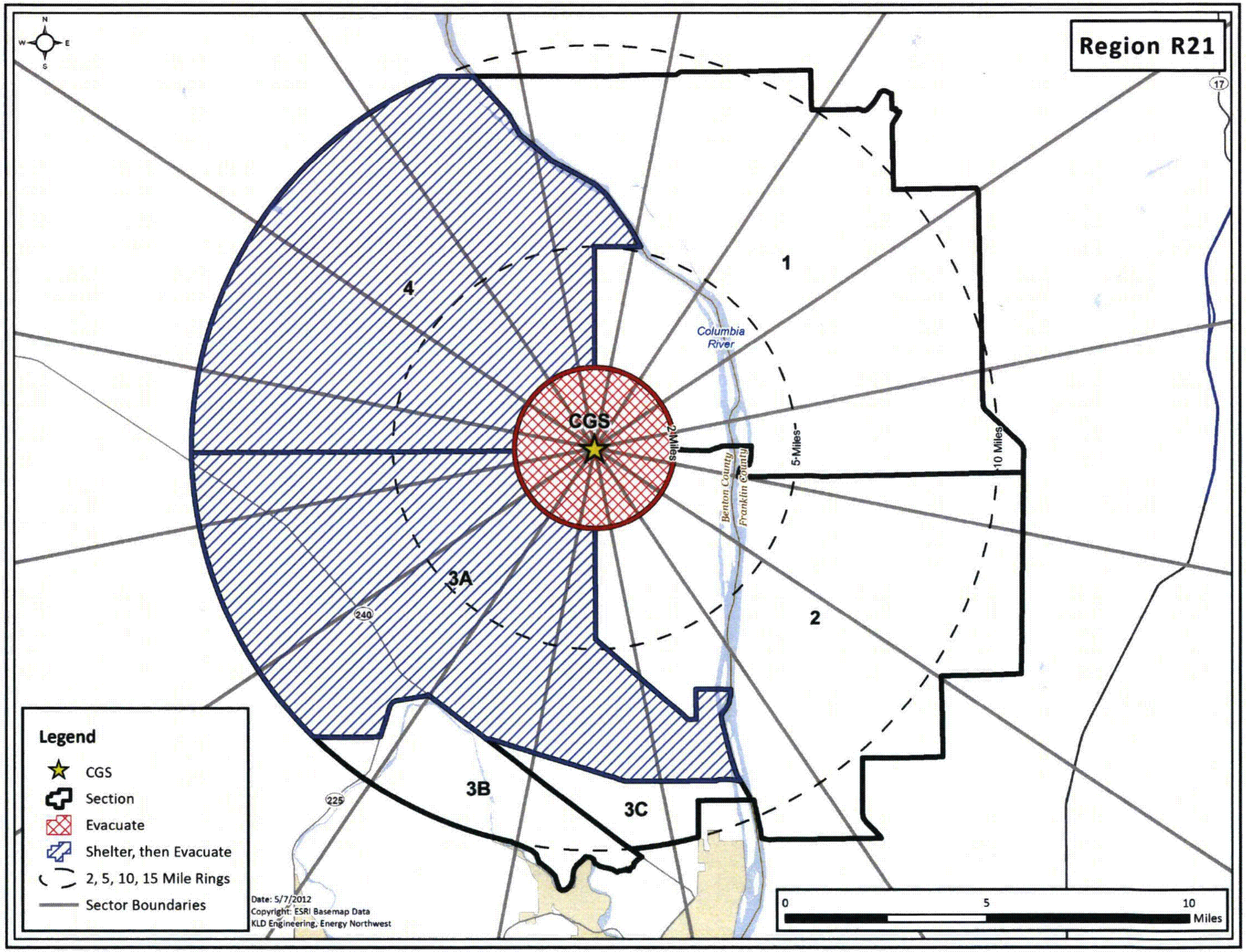


Figure H-21. Region R21

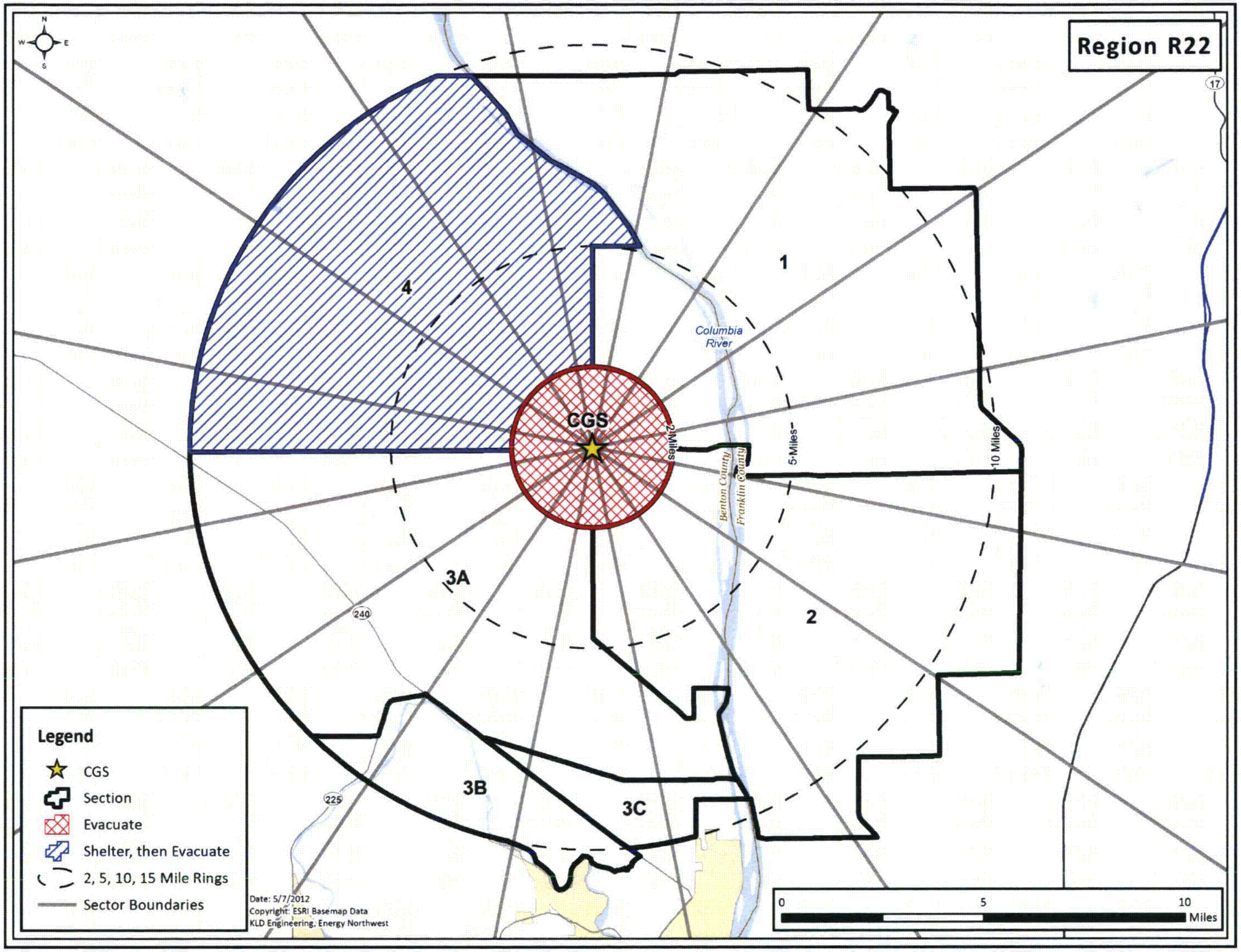


Figure H-22. Region R22