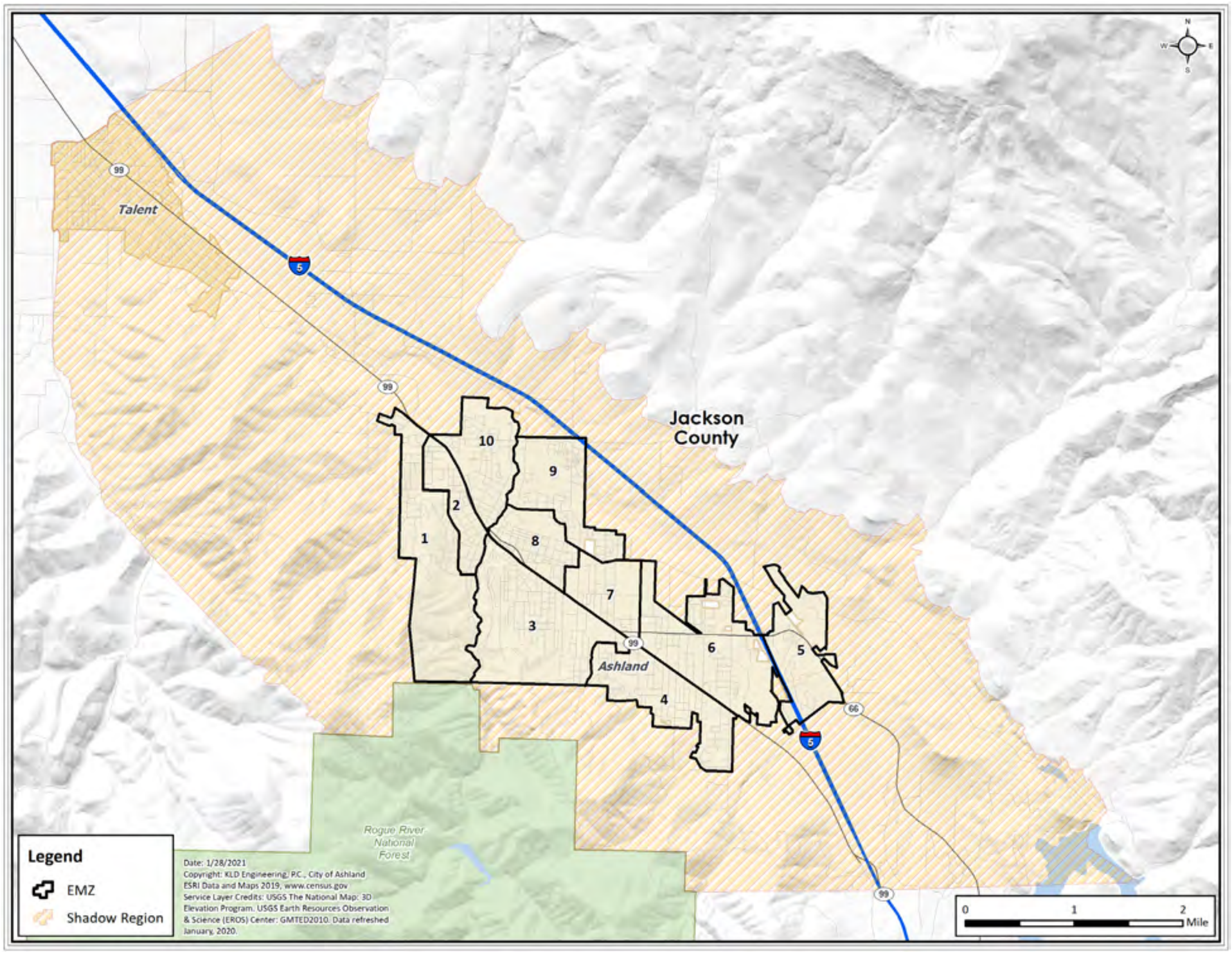
KLD ENGINEERING, P.C.

City of Ashland

Evacuation Time Estimate Study



Date: 1/28/2021
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation Program. USGS Earth Resources Observation & Science (EROS) Center: GMTED2010. Data refreshed January, 2020.

Work performed for the City of Ashland, by:

KLD Engineering, P.C.
1601 Veterans Memorial Highway, Suite 340
Islandia, NY 11749
e-mail: kweinisch@kldcompanies.com

April 2021 **Final Report, Rev. 0** **KLD TR – 1217**

Table of Contents

Note: Appendix I intentionally skipped

List of Figures

List of Tables

EXECUTIVE SUMMARY

Wildfires, and the impacts thereof, are a critical issue facing the world. Increased temperatures, drought, unusually low humidity, and increased winds contribute to the increase in frequency and severity of wildfires. Of the numerous concerns surrounding wildfire emergencies, one of the most critical is the availability of transportation services and facilities. Under normal circumstances, the transportation system provides capacity for evacuation (of both those who can evacuate independently as well as those who need transportation assistance) and allows for emergency responders to enter an area at risk. During a wildfire, however, the transportation system can become inadequate due to unsafe roadway conditions, abandoned vehicles blocking the roadway, and/or congestion. As a result, the risk to public health and the environment – and the potential for loss of life – increases.

The City of Ashland is a small mountain town of about 6 square miles that has a very unique linear design as it rests in three mountain ranges – the Cascades to the east, the coastal range to the west, and the Siskiyous to the south. The City is located 15 miles north of the California border and is home to over 20,000 residents. Due to its topography, the City has limited ingress/egress routes. Highway 99, Highway 66, and Interstate-5 are the major roadways servicing the City.

As such, there is an urgent need to identify areas and populations most vulnerable to fire and to develop a plan for evacuations in the City of Ashland. This study analysed traffic conditions and evacuation times for a variety of evacuation scenarios of the City of Ashland. Alternative emergency management strategies that could be used in response to an evacuation of the City were also examined. This study, and the results contained within this report, will further inform the City's emergency planning and protective action decision making.

A traffic/evacuation simulation model (Dynamic Evacuation Simulation Model, or DYNEV-II) is used to compute evacuation time estimates (ETE) using the procedure shown in Figure ES-1. The supply and demand are input to DYNEV-II. The supply input to DYNEV-II is in the form of a link-node analysis network – a computerized replica of the roadway system within the study area (see Appendix H). The link-node analysis network is calibrated to include roadway characteristics such as free speed (speed that drivers are comfortable traveling at in the lack of traffic congestion), number of lanes, type of traffic control (signal, stop sign, manned), etc. that were collected during a field survey in July 2020. The demand input to DYNEV-II includes people that could be living, working or recreating in the area who may need to be evacuated during an emergency. Resident population was obtained from the 2010 US Census and was projected to the year 2020. Employee and tourist data were obtained from the the US Census Longitudinal Employer-Household Dynamics and from local stakeholders, supplemented by internet searches. Special facilities that may need to be evacuated include schools, preschools, and medical facilities. Lastly, external traffic are vehicles that have their origin and destination outside of Ashland but travel through the city on their route thereby potentially delaying evacuating vehicles from within the city.

The two main outputs of the DYNEV-II model are ETE for general population (evacuees with personal vehicles) and route-specific evacuation speeds, which are used to compute the ETE for special facilities (schools and medical facilities) and the transit-dependent population. These times are critical for developing an effective plan to protect the health and safety of the public.

City officials have divided the City of Ashland into 10 Emergency Management Zones (EMZs). The boundaries of the EMZs follow political or geographical boundaries, which helps the City communicate evacuation orders to the public. Given the large wilderness areas surrounding the City of Ashland, it is highly unlikely that a wildfire would only impact Ashland. Rather, neighbouring communities which are also along the ridgelines of these wilderness areas are likely to evacuate at the same time. The vehicles evacuating from these neighbouring communities could delay egress from Ashland; this phenomenon is referred to as a “shadow evacuation.” Figure 3-2 shows the EMZs that comprise the City of Ashland, as well as the shadow evacuation region surrounding the City and encompassing the neighbouring city of Talent.

The general population ETE are presented in Tables 7-1 and 7-2. These data are the times needed to clear the indicated regions (individual EMZs or groupings of EMZs) of 90 and 100 percent of the population occupying these regions, respectively. For definitions of scenarios (demand changes due to temporal variations) and regions (area to be evacuated varies by wildfire situation), see Section 6 and Appendix G, respectively. The 100th percentile ETE is defined as the time when the last evacuation vehicle crosses the boundary of the regions shown in Appendix G. These computed ETE include consideration of mobilization time (how long it takes people to prepare to evacuate prior to actually getting in their vehicle and driving out of the area) and of estimated voluntary evacuations from areas outside of the area given the evacuation order.

Critical findings of the study include:

- The 100th percentile ETE for the evacuation of individual EMZs are entirely dictated by the time needed to mobilize rather than by traffic congestion. All traffic congestion clears prior to the completion of mobilization for all regions. As such, it is recommended that the 90th percentile is used when making protective action decisions. (See Section 7.4). It is highly unlikely that an individual EMZ would be evacuated for a wildfire. It is more likely that an individual EMZ would be evacuated for a smaller event such as a gas leak or a HAZMAT spill. Thus, the ETE for individual EMZs presented in this study can be used for hazards other than wildfire.
- The 90th percentile ETE ranges between 1 hour and 20 minutes and 3 hours and 10 minutes. Evacuations involving multiple EMZs have longer ETE than evacuations of individual EMZs. See Table 7-1.
- Several access impaired neighborhoods have been identified and are shown in Table 8-7. These areas have high wildfire risk, high population densities, and limited means of egress. These neighborhoods would require early notification during an approaching wildfire as they may have difficulty evacuating if a fire were present.
- Transportation resources available were provided by city emergency management representatives. Table 9-1 summarizes the information received. Also included in the table are the number of buses needed to evacuate schools, medical facilities and transit-dependent population. These numbers indicate there are not sufficient resources

available to evacuate everyone in a single wave. (See Section 9). There are two ways to handle this shortfall of transportation resources: (1) the same vehicles are used multiple times; passengers are picked up and dropped off outside of the area at risk. The vehicle then returns to the City to pick up additional passengers. (2) Memorandums of Understanding (MOUs) or Mutual Aid Agreements are established with neighboring cities or with the State to provide additional transportation resources to assist with evacuation.

- One traffic control point (TCP) was recommended as a result of the findings of this study: at the intersection of OR-99 and Crowson Rd. This ETE was modeled explicitly in the ETE simulations (See Section 10).
- Congestion within the ETE exists within the EMZs for just over 3 hours and 30 minutes. As such, if the time to mobilize is less than 3 hours and 40 minutes, congestion dictates the 100th percentile ETE. If the time to mobilize is longer than 3 hours and 40 minutes, the 100th percentile is dictated by the trip generation time. See Section J.1.
- The Shadow Region was defined as the area beyond the EMZ including the City of Talent to the north, Emigrant Lake to the south and the surrounding ridgelines. All of these areas are sparsely populated areas. Therefore, changes in the percentage of people that decide to voluntarily evacuate beyond the city limits will have little to no impact (at most 10 minutes) on an evacuation of the City of Ashland.
- If the evacuation demand could be reduced – by limiting to one evacuating vehicle per household, for example – the 90th percentile ETE decreases by 30 minutes.
- The entire City takes 4 hours, on average, if the city can evacuate in either direction.
    - For an evacuation case wherein a wildfire is in the north forcing evacuees southbound, the 90th percentile ETE increases by 3 hours and 25 minutes at most. See Section J.4.
    - For an evacuation case wherein a wildfire is in the south forcing evacuees northbound, the 90th percentile ETE increases by 2 hours and 35 minutes at most. See Section J.4.
- Several roadway improvement projects were tested to determine their impact on ETE (See Section J.5):
    - The addition of a bridge to reconnect E Nevada St over Bear Creek decreases the 90th percentile ETE by 10 minutes.
    - The addition of ramps to I-5 along N Mountain Ave decreases the 90th percentile ETE by 10 minutes.
    - If both the bridge and I-5 Freeway Ramps were implemented, the 90th percentile ETE decreases by 15 minutes.
    - If OR-99 northbound was widened to 2 lanes from Helman St to Jackson Rd (where it currently widens to 2 lanes), the 90th percentile ETE decreases by 20 minutes.

  - If S Valley View Rd was widened to 2 lanes between OR-99 and I-5, the 90th percentile ETE remains the same.
  - If there were an additional lane on both OR-99 NB and S Valley View Rd, the 90th percentile ETE decreases by 25 minutes.
  - If all of the above were implemented (bridge on E Nevada St, additional ramps at N Mountain Rd, and additional lanes on OR-99 and S Valley View Rd), the 90th percentile ETE decreases by 25 minutes.

The City of Ashland should consider revising their emergency plans to incorporate the lessons learned from this study. Once revised, the new procedures developed should be practiced through exercises and drills. Lessons learned from these exercises and drills should then be used to improve the emergency plans further. Emergency planning is an iterative process.

City residents and visitors should be informed, through public outreach, of the emergency plan contents, including how they will be notified, which evacuation routes to use, what to do if they need transportation assistance, how long it might take to evacuate, and what would happen if critical evacuation routes were unavailable. Citizen participation in evacuation drills is recommended. Education is key in protecting public health and safety.

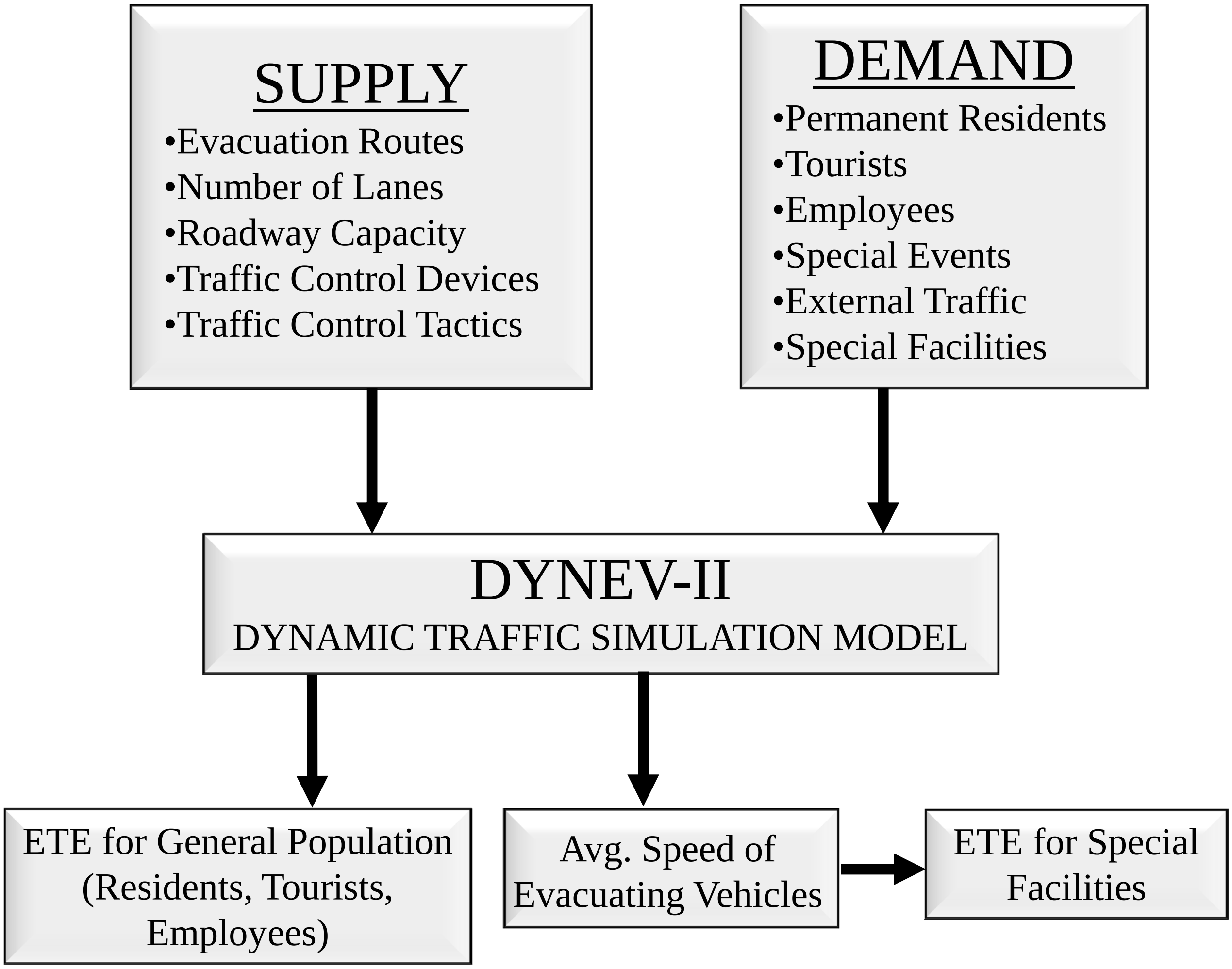


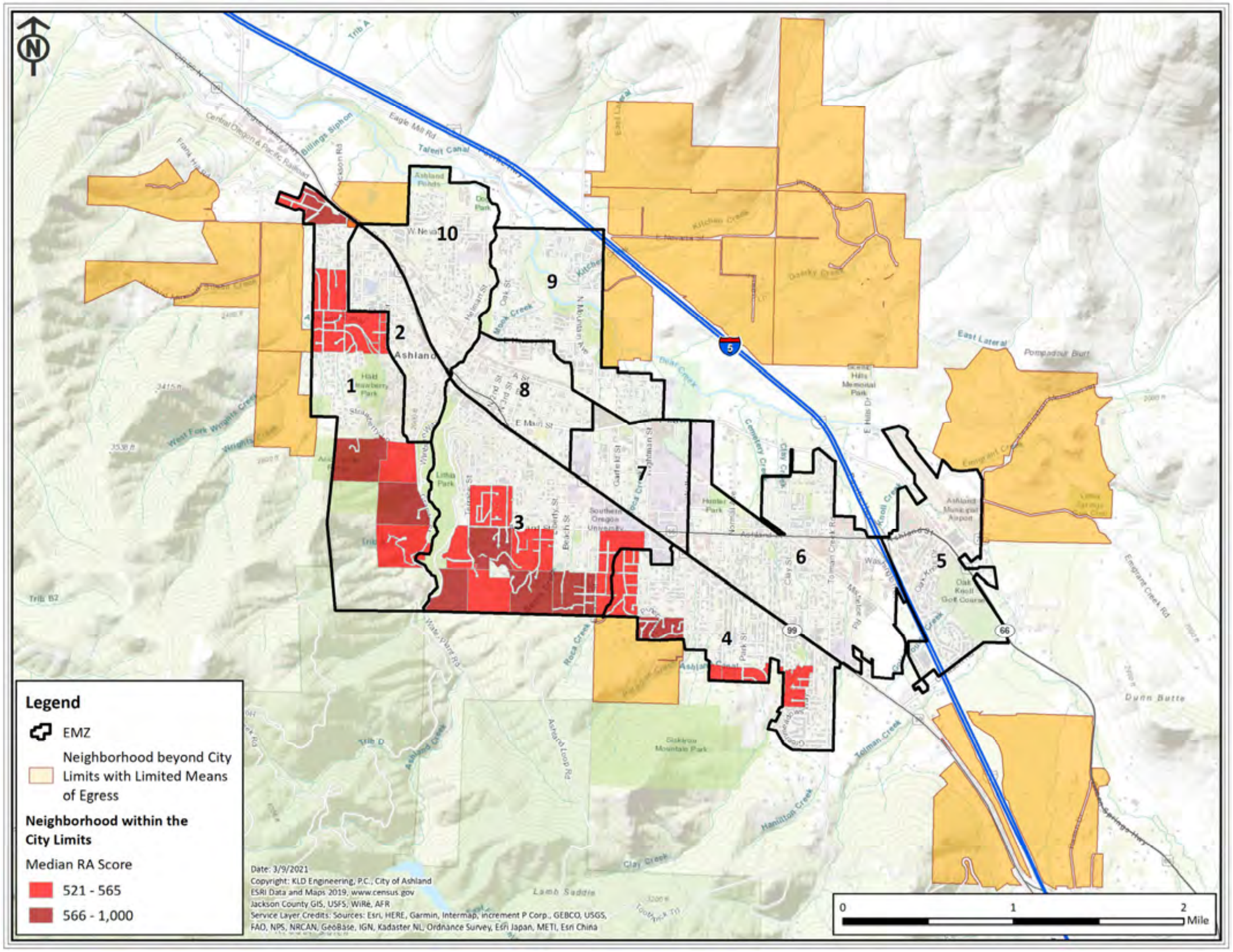
Figure ES-1. ETE Methodology

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

	Summer			Fall		
	Midweek	Weekend	Midweek Weekend	Midweek	Weekend	Midweek Weekend
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Region	**Midday**	**Midday**	**Evening**	**Midday**	**Midday**	**Evening**
R01 – EMZ 1	1:55	1:45	1:40	1:55	1:45	1:40
R02 – EMZ 2	1:55	1:50	1:45	1:55	1:50	1:45
R03 – EMZ 3	1:40	1:50	1:45	1:35	1:50	1:45
R04 – EMZ 4	2:00	1:55	1:55	2:00	1:55	1:55
R05 – EMZ 5	1:30	1:25	1:20	1:30	1:30	1:20
R06 – EMZ 6	1:50	1:50	1:50	1:45	1:50	1:50
R07 – EMZ 7	1:50	1:50	1:50	1:50	1:50	1:50
R08 – EMZ 8	1:50	1:55	1:50	1:50	1:55	1:50
R09 – EMZ 9	1:55	1:50	1:50	1:55	1:50	1:50
R10 – EMZ 10	1:55	1:55	1:55	1:55	1:55	1:55
R11 - Western Ashland	1:50	1:50	1:45	1:35	1:50	1:45
R12 - Eastern Ashland	1:50	1:50	1:50	1:55	1:50	1:50
R13 - Northern Ashland	2:00	1:55	1:50	2:00	1:55	1:50
R14 - Central Ashland	1:45	1:50	1:45	2:30	1:50	1:45
R15 - Southern Ashland	2:05	1:55	1:55	2:45	1:55	1:55
R16 - Northern and Central Ashland	1:55	1:50	1:50	2:30	1:50	1:50
R17 - Southern and Central Ashland	1:55	1:50	1:50	1:50	1:50	1:50
R18 - All EMZs	2:35	2:25	2:15	3:10	2:25	2:20

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

	Summer			Fall		
	Midweek	Weekend	Midweek Weekend	Midweek	Weekend	Midweek Weekend
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Region	**Midday**	**Midday**	**Evening**	**Midday**	**Midday**	**Evening**
R01 – EMZ 1	4:00	4:00	4:00	4:00	4:00	4:00
R02 – EMZ 2	4:00	4:00	4:00	4:00	4:00	4:00
R03 – EMZ 3	4:00	4:00	4:00	4:00	4:00	4:00
R04 – EMZ 4	4:00	4:00	4:00	4:00	4:00	4:00
R05 – EMZ 5	4:00	4:00	4:00	4:00	4:00	4:00
R06 – EMZ 6	4:00	4:00	4:00	4:00	4:00	4:00
R07 – EMZ 7	4:00	4:00	4:00	4:00	4:00	4:00
R08 – EMZ 8	4:00	4:00	4:00	4:00	4:00	4:00
R09 – EMZ 9	4:00	4:00	4:00	4:00	4:00	4:00
R10 – EMZ 10	4:00	4:00	4:00	4:00	4:00	4:00
R11 - Western Ashland	4:00	4:00	4:00	4:00	4:00	4:00
R12 - Eastern Ashland	4:00	4:00	4:00	4:00	4:00	4:00
R13 - Northern Ashland	4:00	4:00	4:00	4:00	4:00	4:00
R14 - Central Ashland	4:00	4:00	4:00	4:00	4:00	4:00
R15 - Southern Ashland	4:00	4:00	4:00	4:00	4:00	4:00
R16 - Northern and Central Ashland	4:00	4:00	4:00	4:00	4:00	4:00
R17 - Southern and Central Ashland	4:00	4:00	4:00	4:00	4:00	4:00
R18 - All EMZs	4:00	4:00	4:00	4:00	4:00	4:00



Date: 3/9/2021
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Jackson County GIS, USFS, WiRé, AFR
Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China

Figure 8-7. Combined Access Impaired Neighborhoods

Table 9-1. Summary of Transportation Needs

Transportation Resource	Buses	Wheelchair Buses	Ambulances
Resources Available			
Ashland School District	19	0	0
Ashland Fire & Rescue	0	0	2
Jackson County Fire District	0	0	2-4*
TOTAL:	**19**	**0**	**2**
Resources Needed			
Medical Facilities (Table 3-7):	6	6	32
Schools (Table 3-9):	75	0	0
Transit-Dependent Population (Table 11-1):	4	0	0
TOTAL TRANSPORTATION NEEDS:	**85**	**6**	**32**

***Note: 2-4 Ambulances can be made available from Jackson County Fire Department in the case that more are needed.**

1 INTRODUCTION

This section provides an introduction of the study and an overview of the process used to compute the evacuation time estimates (ETE) for the City of Ashland, including preliminary activities of the project.

This study analyzed traffic conditions and evacuation times for a variety of evacuation scenarios of the City of Ashland. Alternative emergency management strategies that could be used in response to an evacuation of the City of Ashland were also examined. This study, and the results contained within this report, will further inform the City of Ashland's emergency planning and protective action decision making.

In the performance of this effort, guidance is provided by documents published by Federal and State Governmental agencies. The nuclear industry is highly regulated and offers a number of resources for developing evacuation studies. Very few such documents exist for wildfire hazards. While the hazard is different, much of the concepts of evacuation (warning time, smaller/isolated communities, lower density roadway networks, etc.) are appliable. As such, most of the references used in this study have been published by the US Nuclear Regulatory Commission (NRC). Most important of these are:

- Title 10, Code of Federal Regulations, Appendix E to Part 50 (10CFR50), Emergency Planning and Preparedness for Production and Utilization Facilities, NRC, 2011.
- Criteria for Development of Evacuation Time Estimate Studies, NUREG/CR-7002, November 2011.
- Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants, NUREG 0654/FEMA REP 1, Rev. 1, November 1980.
- Analysis of Techniques for Estimating Evacuation Times for Emergency Planning Zones, NUREG/CR 1745, November 1980.

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

1.1 Overview of the ETE Process

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

1. Information Gathering:
    a. Defined the scope of work in discussions with representatives from the City of Ashland.
    b. Attended meetings with local stakeholders to define methodology.

    c. Conducted a detailed field survey of the highway system and of area traffic conditions within the Emergency Management Zones (EMZs) and Shadow Region[1].
    d. Obtained demographic data from the 2010 Census. Projected the 2010 Census data to the year 2020 (see Section 3.1).
    e. Estimated the number of non-EMZ employees using data obtained from the US Census Longitudinal Employer-Household Dynamics from the OnTheMap Census analysis tool (see Section 3.4).
    f. Conducted a random sample demographic survey of EMZ residents.
    g. Obtained data (to the extent available) to update the database of schools, colleges, medical facilities, tourist attractions, recreational facilities, and transportation resources available. Majority of this data was provided by the City supplemented with internet searches.

2. Estimated distribution of trip generation times representing the time required by various population groups (permanent residents, employees, and tourists) to prepare for the evacuation trip (mobilize) and updated where necessary. These estimates were based upon the demographic survey results and notification time calculation (see Section 5 and Appendix F).
3. Defined Evacuation Scenarios. These scenarios reflect the variation in demand associated with different seasons, day of week, and time of day. The scenarios selected were bound by the normal wildfire season.
4. Created Evacuation Regions. "Regions" are individual or groups of EMZs for which ETE are calculated. The configurations of these Regions reflect evacuation of each EMZ and a combination of EMZs (see Appendix G).
5. Estimated demand for transit services for persons at special facilities and for transit-dependent persons.
6. Identified and mapped access impaired neighborhoods in and around the City of Ashland wherein there are medium to high population densities, high wildfire risk, and limited means of egress.
7. Prepared the input streams for the DYNEV II system which computes ETE (see Appendices B and C).
    a. Estimated the evacuation traffic demand, based on the available information derived from Census data, from data provided by local agencies, and from the demographic survey.
    b. Created the link-node representation of the evacuation network, which was

---

[1] An evacuation in the shadow region occurs when residents voluntarily evacuate from areas beyond the area officially given the evacuation order. This phenomenon can cause unwanted congestion and increase clearance times for people in the areas of actual risk.

used as the basis for the computer analysis that calculates the ETE.

   c. Applied the procedures specified in the 2016 Highway Capacity Manual (HCM[2]) to the data acquired during the field survey, to estimate the capacity of all highway segments comprising the evacuation routes.
   d. Calculated the evacuating traffic demand for each Region and for each Scenario.
   e. Specified selected candidate destinations for each “origin” (location of each “source” where evacuation trips are generated over the mobilization time) to support evacuation travel consistent with outbound movement relative to the location of the wildfire.

8. Executed the DYNEV II model to determine optimal evacuation routing and compute ETE for all residents, tourists and employees (“general population”) with access to private vehicles. Generated a complete set of ETE for all specified Regions and Scenarios.
9. Identified Traffic Control Points (TCP) and Access Control Points (ACP) within the study area. See Section 10.
10. Calculated the ETE for all transit activities including those for special facilities (schools and medical facilities) and for the transit-dependent population.
11. Documented ETE results.
12. Considered two additional cases to represent bounding conditions for possible wildfire scenarios:
    a. A case wherein the fire is originating from the north and traveling southbound toward the City of Ashland. In this case, all evacuees are forced to evacuate to the south.
    b. A case wherein the fire is originating from the south and traveling northbound toward the City of Ashland. In this case, all evacuees are forced to evacuate to the north.
13. Tested what-if scenarios to evaluate alternative management strategies that could be used in response to wildfire situations.

1.2 Location of the Study Area

The City of Ashland is located in Jackson County, Oregon, approximately 14 miles southeast of Medford, OR. Figure 1-1 displays the area surrounding the EMZs. This map identifies the major roadways and Shadow Region as well.

---

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

1.3 Preliminary Activities

These activities are described below.

Field Surveys of the Highway Network

KLD personnel drove the entire highway system within the EMZ and the Shadow Region. The Shadow Region considered for the City of Ashland ETE was defined as the area beyond the EMZ including the City of Talent. The Shadow Region is bounded by the northern city limit of Talent to the north, the ridge line and the United States Forest Service (USFS) border to the west, a horizontal line connecting the USFS border to Emigrant Lake to the south, and the ridge line to the east, shown in Figure 1-1. The characteristics of each section of highway were recorded. These characteristics are shown in Table 1-2.

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

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

As documented on page 15-6 of the HCM 2016, the capacity of a two-lane highway is 1700 passenger cars per hour in one direction. For freeway sections, a value of 2250 vehicles per hour per lane is assigned, as per Exhibit 12-37 of the HCM 2016. The road survey has identified several segments which are characterized by adverse geometrics (steep hills and tight curves with no shoulders) on two-lane highways which are reflected in reduced values for both capacity and speed. These estimates are consistent with the service volumes for LOS E presented in HCM Exhibit 15-46. These links may be identified by reviewing Appendix H. Link capacity is an input to DYNEV II which computes the ETE. Further discussion of roadway capacity is provided in Section 4 of this report.

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

If no detectors were observed, the signal control at the intersection was considered pre-timed, and detailed signal timings were gathered for several signal cycles. These signal timings were input to the DYNEV II system used to compute ETE.

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

Demographic Survey

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

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

Computing the Evacuation Time Estimates

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

Analytical Tools

The DYNEV II System[3] that was employed for this study is comprised of several integrated computer models. One of these is the DYNEV (DYnamic Network EVacuation) macroscopic simulation model, a new version of the IDYNEV model that was developed by KLD under contract with the Federal Emergency Management Agency (FEMA).

DYNEV II consists of four sub-models:

- A macroscopic traffic simulation model (for details, see Appendix C).

---

[3] The models of the IDYNEV System were recognized as state of the art by the Atomic Safety & Licensing Board (ASLB) in past hearings. (Sources: Atomic Safety & Licensing Board Hearings on Seabrook and Shoreham; Urbanik). The models have continuously been refined and extended since those hearings and were independently validated by a consultant retained by the NRC. The new DYNEV II model incorporates the latest technology in traffic simulation and in dynamic traffic assignment. (Urbanik, T., et. al. Benchmark Study of the I-DYNEV Evacuation Time Estimate Computer Code, NUREG/CR-4873, Nuclear Regulatory Commission, June, 1988.)

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

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

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

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

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

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

The evacuation analysis procedures are based upon the need to:

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

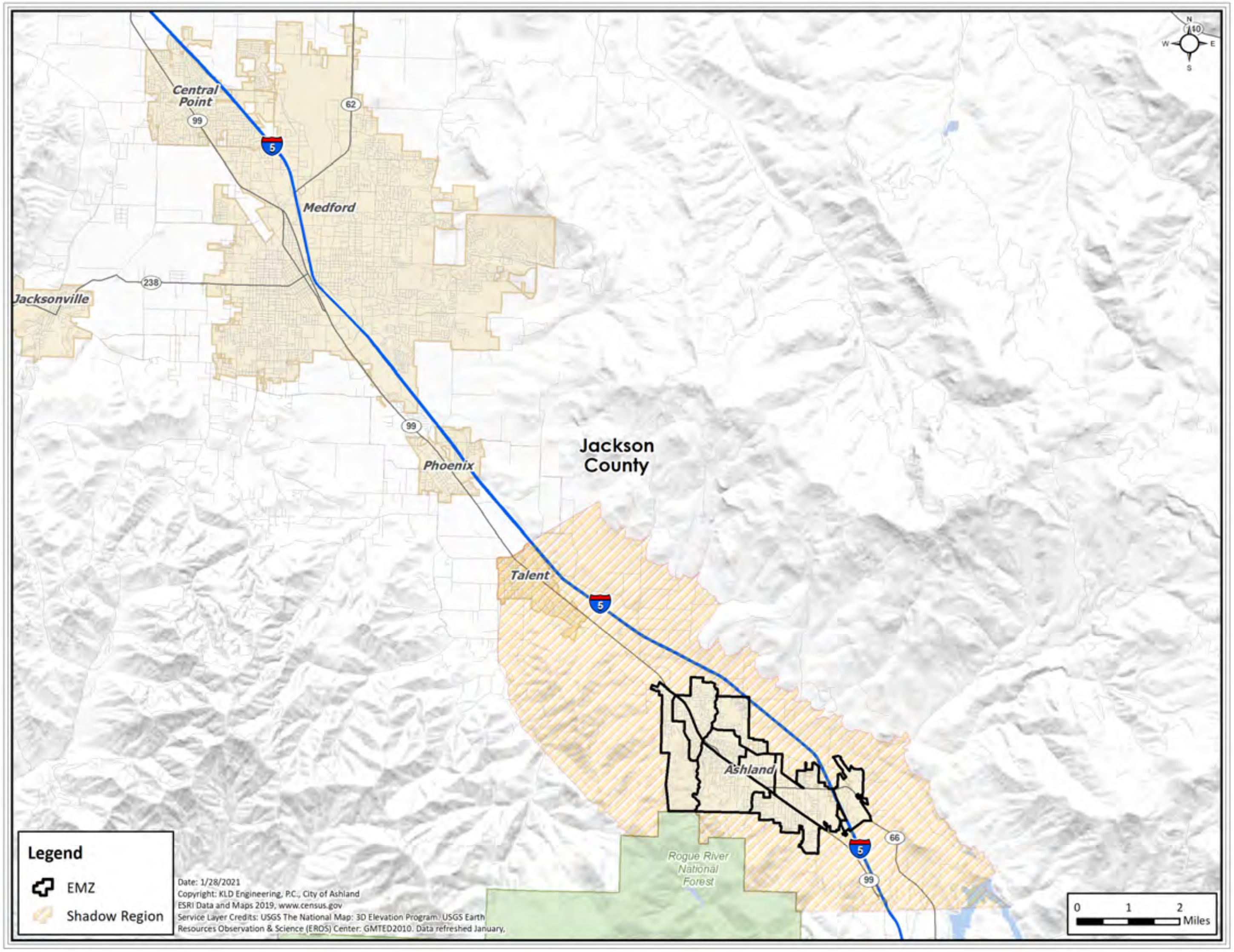
DYNEV II provides a detailed description of traffic operations on the evacuation network. This description enables the analyst to identify bottlenecks and to develop countermeasures that are designed to represent the behavioral responses of evacuees. The effects of these countermeasures may then be tested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

Table 1-1. Stakeholder Interaction

Stakeholder	Nature of Stakeholder Interaction
City of Ashland Police Department	Attended meetings and engaged in correspondence to define methodology and data requirements. Assisted in data collection. Reviewed and discussed all study assumptions.
City of Ashland Fire Department	
City of Ashland Chamber of Commerce	
Southern Oregon University (SOU)	Attended kick off meeting. Provided SOU data.

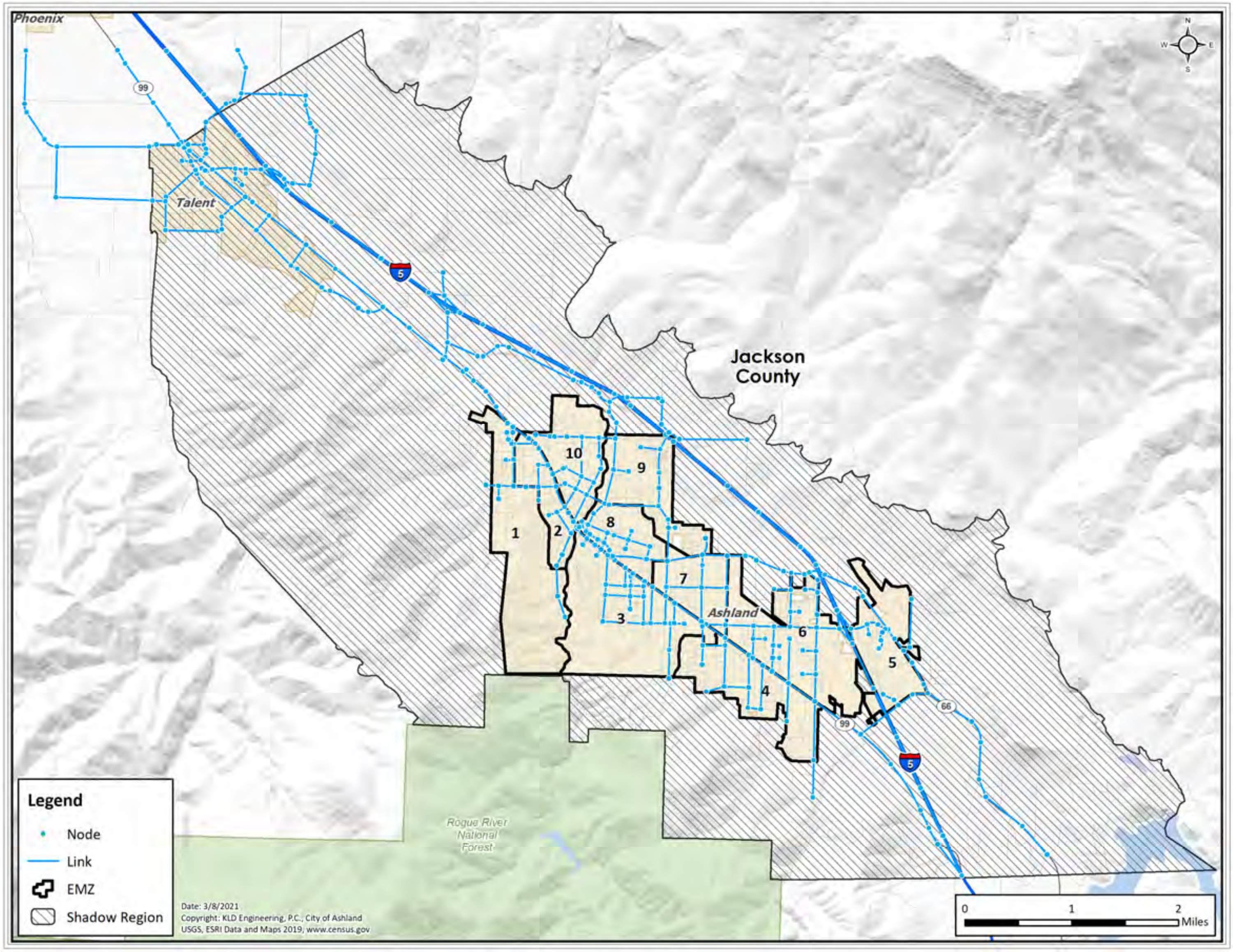
Table 1-2. Highway Characteristics

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



Date: 1/28/2021
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation Program. USGS Earth Resources Observation & Science (EROS) Center: GMTED2010. Data refreshed January,

Figure 1-1. Study Area Location



Date: 3/8/2021
Copyright: KLD Engineering, P.C., City of Ashland
USGS, ESRI Data and Maps 2019, www.census.gov

Figure 1-2. Study Area Link-Node Analysis Network

2 STUDY ESTIMATES AND ASSUMPTIONS

This section discusses the data estimates and project assumptions utilized in this study. These assumptions were discussed with representatives from the City of Ashland Police Department. An assumptions memorandum documenting all the project assumptions was reviewed and approved by stakeholders from the City of Ashland prior to their use in this study.

2.1 Data Estimates

1. The estimate of permanent resident population was based upon the 2010 U.S. Census population data from the Census Bureau website[1] extrapolated to November 2020 using annual growth rates that were computed from the 2019 Census population estimates (see Section 3.1).
2. Estimates of employees who reside outside the EMZ and commute to work within the EMZ were based upon data obtained from the US Census Longitudinal Employer-Household Dynamics from the OnTheMap Census analysis tool[2].
3. Population estimates at tourist and special facilities were based on the data received from the City of Ashland Police Department and internet searches (see Sections 3.1.2, 3.3, 3.5 and 3.7).
4. Evacuee mobilization times were based on a statistical analysis of data acquired from a random sample demographic survey of the EMZ residents conducted in August 2020 (documented in Section 5 and Appendix F).
5. The relationship between permanent resident population and evacuating vehicles was extracted from the demographic survey. Average values of 2.23 persons per household (Figure F-1) and 1.43 evacuating vehicles per household (Figure F-10) were used for permanent resident population. The relationship between persons and vehicles for other population groups in the EMZs is as follows:
    a. Employees: 1.06 employees per vehicle (demographic survey results) for all major employers.
    b. Tourists Population Data (Vehicle Occupancy Average is 2.29 tourists per vehicle; see Section 3.3 and Appendix E for additional information):
        i. Lodging Facilities: Operate at maximum capacity during peak times and have an average vehicle occupancy of 2.23 persons per vehicle.
        ii. Other tourist facilities: Vehicle occupancy varies between 1.00 and 3.57 persons per vehicle.
        iii. It was assumed that parking lots are full at peak times, and if no data was provided, it was assumed that the vehicle occupancy rate is equal to the average household size, 2.23 persons per vehicle.
6. Roadway capacity estimates were based on field surveys performed in July 2020 and the application of the Highway Capacity Manual 2016.

---

[1] www.census.gov

[2] http://onthemap.ces.census.gov/

2.2 Study Methodological Assumptions

1. A total of 6 "Scenarios" representing different temporal variations (season, time of day, day of week) and conditions were considered. These Scenarios are outlined in Table 2-1.
2. Three different wildfire events were considered. The first wildfire evacuation scenario allows evacuees to travel in any direction. The second wildfire event forces all evacuees to evacuate towards the south due to a fire originating in the north and traveling southbound towards the City of Ashland. The third event forces all evacuees to evacuate towards the north due to a fire originating in the south and moving northbound towards the City of Ashland.
3. Several sensitivity studies were conducted to determine the elasticity of the evacuation time estimates based on the notification time distribution.
4. The notification time distribution (the time required for evacuees to receive notification of an evacuation) is based on the results of the demographic survey. See Section 5.3 for the notification distribution that is used in this study.
5. The Shadow Region was defined as the area beyond the EMZ including the City of Talent. The Shadow Region is bounded by the northern city limit of Talent to the north, the ridge line and the United States Forest Service (USFS) border to the west, a horizontal line connecting the USFS border to Emigrant Lake to the south, and the ridge line to the east, see Figure 3-2.
6. The DYNEV II System was used to compute ETE in this study.
7. Evacuees will drive safely, travel away from the wildfire to the extent practicable given the highway network, and obey all control devices and traffic guides.
8. Evacuation movements (paths of travel) are generally outbound relative to the wildfire to the extent permitted by the highway network. All major evacuation routes were used in the analysis.

2.3 Study Assumptions

1. The Planning Basis Assumption for the calculation of ETE is a rapidly escalating hazard that requires immediate evacuation, and includes the following:
    a. Advisory to evacuate is announced coincident with local emergency alerts (NIXLE Citizen Alert, social media, local news and similar communication systems).
    b. Mobilization of the general population will commence within 15 minutes after the emergency alerts.
    c. ETE are measured relative to the advisory to evacuate.
2. One hundred percent (100%) of the people told to evacuate, will do so.
3. Approximately six percent (6%) of the population within the Shadow Region and within the EMZ not advised to evacuate will voluntarily evacuate based on the results of the demographic survey performed within the EMZ.
4. Buses will be used to transport those without access to private vehicles:
    a. Schools and childcare facilities[3]

---

[3] Elementary, Middle, and High schools were considered Schools. Anything pre-elementary level was considered a childcare facility.

        i. It was assumed that parents will pick up children at childcare facilities (pre-elementary schools) prior to evacuation.
        ii. School bus demand was computed for all schools based on enrollment for emergency planning purposes regardless of whether or not parents will pick up school children prior to evacuating. This will result in a more conservative estimate of buses and evacuating vehicles.
        iii. Schoolchildren, if school is in session, are given priority in assigning transit vehicles.
    b. Medical Facilities
        i. Buses, wheelchair transport vehicles and ambulance will be used to evacuate patients at medical facilities.
    c. Transit dependent permanent residents:
        i. Transit dependent general population will be evacuated by bus.
        ii. Homebound special needs population are included in the transit dependent population and will be evacuated by bus.
        iii. Households with 3 or more vehicles were assumed to have no need for transit vehicles.

5. Transit vehicle capacities and maximum speed limits:
    a. School buses – the study assumed 60 students per bus for elementary school students, 40 students per bus for middle school and high school students.
    b. Ambulatory transit-dependent persons, included college students, and medical facility patients = 30 people per bus.
    c. Basic Life Support (BLS) (ambulances) = 2 persons.
    d. Wheelchair transport vehicles – the study assumed 15 persons per wheelchair bus and 4 persons per wheelchair van.
    e. The maximum bus speed assumed is 55 miles per hour, based on the 2019 Oregon Pupil Transportation Manual[4].
6. It is assumed all transit vehicles will arrive at the facilities to be evacuated within 90 minutes of the advisory to evacuate.
7. Transit Vehicle loading times:
    a. School buses will be loaded in 15 minutes.
    b. Transit Dependent buses will require 1 minute of loading time per passenger.
    c. Buses for medical facilities will require 1 minute of loading time per ambulatory passenger.
    d. Wheelchair transport vehicles for medical facilities will require 5 minutes of loading time per passenger.
    e. Ambulances for medical facilities will require 30 minutes per bedridden passenger.
8. The percent breakdown of ambulatory (50%), wheelchair using (25%) and bedridden patients (25%) was applied to total populations provided at Asante Ashland Community

---

[4] https://www.oregon.gov/ode/schools-and-districts/ptf/Documents/OPTM%202018%20Draft%20Final.pdf

Hospital, Linda Vista Nursing & Rehab Center and Ashland Surgery Center, accounting for rounding errors.

9. It was assumed that drivers for all transit vehicles identified in Table 9-1 are available.
10. Approximately eighty-eight percent (88%) of transit-dependent population will rideshare with a neighbor or friend, based on the demographic survey results.
11. Vehicles will be traveling through the study area (external-external trips) at the start of a wildfire. After the advisory to evacuate is announced, these pass-through travelers will also evacuate. External traffic vehicles will utilize Pacific Highway (I-5) to pass through the area. Dynamic and variable message signs will be strategically positioned outside of the hazard area at logical diversion points to attempt to divert traffic away from these routes. As such, it was assumed this pass-through (external) traffic will diminish over time with all external traffic flow stopping at 2 hours after the advisory to evacuate.
12. Access control will be implemented on I-5 during an emergency in Ashland. The access control will be implemented over the course of 2 hours to allow police to mobilize personnel and equipment to block the roadways and to allow time for commuters to return home and unite with family (see Section 3.8).
13. Traffic Control Points (TCP) were considered in this analysis. TCPs were considered at locations that benefit the evacuation during the analysis period. Their number and location will depend on the Region to be evacuated and resources available. The objectives of these TCPs are:
    a. Facilitate the movements of all (mostly evacuating) vehicles at the location.
    b. Discourage inadvertent vehicle movements towards the wildfire.
    c. Provide assurance and guidance to any traveler who is unsure of the appropriate actions or routing.
    d. Act as local surveillance and communications center.
    e. Provide information to the county and other emergency workers as needed, based on direct observation or on information provided by evacuees.
14. External Traffic was estimated to be reduced by 60% during evening scenarios (Scenario 3 and 6).
15. This study does not assume that roadways are empty at the start of the first time period. Rather, there is a 30-minute initialization period (often referred to as “fill time in traffic simulation) wherein the traffic volumes from the first time period were loaded onto roadways in the study area. The amount of initialization/fill traffic that is on the roadways in the study area at the start of the first time period depends on the scenario and the region being evacuated.
16. Based on the results of the demographic survey, 36 percent of the households in the EMZ have at least 1 commuter; 39 percent of those households will await the return of household members before beginning their evacuation trip, based on the demographic survey results. Therefore, 14 percent (36% x 39% = 14%) of households will await the return of household members, prior to beginning their evacuation trip.

Table 2-1. Evacuation Scenario Definitions

Scenarios	Season[5]	Day of Week	Time of Day
1	Summer	Midweek	Midday
2	Summer	Weekend	Midday
3	Summer	Midweek, Weekend	Evening
4	Fall	Midweek	Midday
5	Fall	Weekend	Midday
6	Fall	Midweek, Weekend	Evening

---

[5] Fall means that school is in session at normal enrollment levels. Summer means that school is in session at summer school enrollment levels (lower than normal enrollment).

3 DEMAND ESTIMATION

This section discusses the estimates of demand, expressed in terms of people and vehicles, which constitute a critical element in developing an evacuation plan. This section also documents these sources of data, as well as the methodology used to extract relevant data from these sources. These estimates consist of three components:

1. An estimate of population within the Emergency Management Zones (EMZ), stratified into groups (e.g., resident, employee, tourists, special facilities, etc.).
2. An estimate, for each population group, of mean occupancy per evacuating vehicle. This estimate is used to determine the number of evacuating vehicles.
3. An estimate of potential double-counting of vehicles.

Appendix E presents much of the source material for the population estimates. Our primary source of population data, the 2010 Census, however, is not adequate for directly estimating some tourists.

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

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

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

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

Analysis of the population characteristics of the study area indicates the need to identify three distinct groups:

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

Estimates of the population and number of evacuating vehicles for each of the population groups are presented for each EMZ. The EMZ boundaries are shown in Figure 3-1.

3.1 Permanent Residents

The primary source for estimating permanent population is the latest U.S. Census data. The U.S. Census Bureau conducts a physical census of the permanent resident population in the U.S. every ten years. The last census began on April 1, 2010 with data from the census being published on April 1, 2011. In the years between the decennial censuses, the Census Bureau works with state and local agencies to provide annual population estimates at the state and local levels. These estimates are done using data on deaths, births and migration. This annual data gathering process and analysis is extensive. As such, population estimates are a year behind – 2019 data are released in 2020[1].

This study is based on 2010 Census population data from the Census Bureau website[2] extrapolated to 2020 using annual growth rates computed from the 2019 Census population estimates as outlined in the methodology below.

The Census Bureau QuickFacts[3] website provides annual population estimates for each state, county, and municipality[4] in the United States. As discussed above, Census population estimates are a year behind. Thus, the most recent population estimates available for the counties and municipalities are for the time period from April 1, 2010 to July 1, 2019. The population change and annual growth rate for each county and municipality in the study area (the EMZ plus Shadow Region) are provided in Table 3-1 and Table 3-2, respectively. Figure 3-2 shows the county and municipality boundaries identified by the Census Bureau.

The permanent resident population, as per the 2010 Census, for the EMZ and the Shadow Region was projected to 2020 using the compound growth formula (Equation 1). In the compound growth formula, g is the annual growth rate and X is the number of years projected forward from Year 2010. The compound growth formula can be solved for g as shown in Equation 2.

Equation 1

$$(Compound\ Growth\ for\ X\ years): Population\ 201X\ =\ Population\ 2010\ (1\ +\ g)^{\ x}$$

Equation 2

$$(Solving\ for\ the\ annual\ growth\ rate): g =\ (Population\ 201X\ \div\ Population\ 2010)^{1/x} - 1$$

The 2010 and 2019 population data provided in Table 3-1 and Table 3-2 were used in Equation 2 to compute the annual growth rate for each county and municipality in the study area using X = 9.25 (9 years and 3 months from April 1, 2010 to July 1, 2019). The computed annual growth rate for each county and municipality is summarized in the final column of Table 3-1 and Table 3-2, respectively.

---

[1] The schedule for release of Census data is provided on the Census website: https://www.census.gov/programs-surveys/popest/about/schedule.html

[2] www.census.gov

[3] https://www.census.gov/quickfacts/fact/table/US/PST045218

[4] https://www.census.gov/data/datasets/time-series/demo/popest/2010s-total-cities-and-towns.html

The most detailed data should always be used when forecasting population. In terms of detailed data, municipal data is the finest level of detail, then county data, and state data. The municipality growth rate was used first and if that was not available or applicable within the study area, then the county growth rate was used. County growth rates are available for the entire study area and were used (in the absence of municipal data) as they are the finest level of detail available for the entire study area. Thus, state data was not used.

The Census Bureau does not provide population data specific to the boundaries of the study area. As such, the county or municipality population was used to compute the annual growth rate. Then, the appropriate municipality or county growth rate was applied only to those Census blocks located within the study area. All other blocks outside of the study area were not considered as part of the EMZ or Shadow Region population, even if they are located within one of the municipalities or counties that intersect the study area.

The appropriate annual growth rate was applied to each Census block in the study area depending on which county or municipality the block is located within. The population was extrapolated to November 1, 2020 using Equation 1 with X = 10.58 (10 years and 7 months from the April 1, 2010 Census date to November 1, 2020), as the base year for this study.

The permanent resident population is estimated by cutting the census block polygons by the EMZ boundaries. A ratio of the original area of each census block and the updated area (after cutting) is multiplied by the total block population to estimate what the population is within the EMZ. This methodology (referred to as the "area ratio method") assumes that the population is evenly distributed across a census block. Table 3-3 provides the permanent resident population within the EMZ for 2010 (based on the most recent U.S. Census) and for 2020 (based on the methodology above). As indicated, the permanent resident population within the EMZ has increased by approximately 6.83% since the 2010 Census.

The 2020 extrapolated permanent resident population is divided by the average household size and then multiplied by the average number of evacuating vehicles per household to estimate number of vehicles. The average household size (2.23 persons/household) was estimated using the demographic survey results (see Appendix F, sub-section F.3.1). The number of evacuating vehicles per household (1.43 vehicles/household – See Appendix F, sub-section F.3.2) was also adapted from the demographic survey results. Permanent resident population and vehicle estimates are presented in Table 3-4.

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

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

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

3.1.1 Special Facilities

Three medical facilities are located within the EMZ (see Table E-2). These facilities have permanent residents that are included in the Census; however, these facilities are transit dependent (will not evacuate in personal vehicles) and are addressed below in Section 3.5. As such, these residents are included in the resident population, but no personal evacuating vehicles are considered. The vehicles in Table 3-4 have been adjusted accordingly.

3.1.2 University Students

Southern Oregon University (SOU) is the only university in the EMZ. Upon examination for Census blocks in the vicinity of these campuses, it does not appear the resident students were captured in the Census. As such, no modifications to residents or resident vehicles were made to account for this university.

Based on the data provided by the City of Ashland, some students will evacuate in private vehicles while other students either rideshare with a fellow classmate or need transportation assistance (a bus) to evacuate. The campuses are broken down as follows.

- According to the city, the total enrollment of SOU is 5,000.
- According to the National Application Center database[5], 83% of students live off campus and 17% of students live on campus. Sixty (60%) of students who live on campus own personal vehicles. Therefore, 4,150 (5,000 x 83%) students live off campus, 850 (5,000 x 17%) students live on campus, and 510 (850 x 60%) on campus students own personal vehicles. In other words, 510 personal vehicles will be used by students living on campus during an evacuation.
- Based on the demographic survey results, the commuter vehicle occupancy is 1.06 persons per vehicle (see Appendix F, subsection F.3.1). Thus, the number of commuter vehicles used by off-campus students is 3,915 (4,150 ÷ 1.06).
- The demographic survey results indicate 88% of the transit-dependent people will rideshare with a neighbor or friend (see Appendix F, subsection F.3.1). Apply this ratio to the 340 (850 – 510) on-campus students with no personal vehicles, resulting in 299 (340 x 88%) students who will rideshare to evacuate. In summary, the total number of on-campus students evacuated by personal vehicles is 809 (510 + 299). This leaves 41 (850 – 809) on-campus students who are transit dependent and need buses to evacuate.

---

[5] https://www.nationalapplicationcenter.com/gotocollege/campustour/undergraduate/4790/Southern_Oregon_University/Southern_Oregon_University5.html

- Using the capacity of 30 people per bus (see Section 2.3, Assumption 5), SOU needs 2 (41 ÷ 30 = 2, rounded up) transit-dependent buses or 4 passage car equivalent (pce's) vehicles (1 bus is equivalent to 2 passenger vehicles).
- In summary, 4,959 (809 + 4,150) commuter/ridesharing students will be evacuated in 4,425 (510 + 3,915) private vehicles, and 41 transit-dependent students will be evacuated in 2 buses.

3.2 Shadow Population

A portion of the population living outside the evacuation area, including the City of Talent, may elect to evacuate without having been instructed to do so. Based on the demographic survey, it is assumed that 6 percent of the permanent resident population, based on U.S. Census Bureau data, in this Shadow Region will elect to evacuate.

Shadow population characteristics (household size, evacuating vehicles per household, mobilization time) are assumed to be the same as that of the permanent resident population. There are 10,099 permanent residents and 6,490 vehicles in the Shadow Region.

3.3 Tourist Population

Tourist population groups are defined as those people (who are not permanent residents, nor commuting employees) who enter the EMZ for a specific purpose (shopping, recreation). Tourists may spend less than one day or stay overnight at hotels and motels. Data was provided by the City of Ashland for the majority of these facilities. For facilities wherein no data was provided or data was not available at that time, parking lot spaces were used to estimate facility capacities, see Section 2.1, Assumption 5b. Vehicle occupancy rates vary by facility from 1.00 persons per vehicle to 3.57 persons per vehicle. The EMZ has a number of areas and facilities that attract tourists, including:

- Golf Courses
- Hiking Trails
- Lodging Facilities
- Theatres

There is one golf course within the EMZ. According to the city, both the average daily peak attendance and parking capacity of this facility are 50. Therefore, an average of 1.00 person per vehicle is assigned to this facility.

There are four hiking trails within the EMZ. The average number of daily hikers and parking capacity for each hiking trail was provided by the city. There are limited parking spots for Oredson Todd Woods and Acid Castle Boulders Access Point. It is assumed the hikers go hiking in pairs (2.00 persons per vehicles) and their vehicles are parked in the nearby areas when the parking spaces are fully occupied. A total of 1,435 tourists in 558 vehicles (an average of 2.57 persons per vehicle) are assigned to the hiking trails in the EMZ.

There are fourteen lodging facilities within the EMZ. The average daily capacity for each lodging facility was provided by the city. Assumed the tourists travel as groups of family member, the average household size (2.23 persons/household) was used to estimate the tourist vehicles. A total of 1,690 tourists in 758 vehicles (an average of 2.23 persons per vehicle) are assigned to the lodging facilities in the EMZ.

According to the city, a theatre festival – Oregon Shakespeare Festival runs from February to October each year. The average daily peak attendance is 2,500, and 21% of the visitors are residents living within the EMZ. The remaining 1,975 (2,500 x 79%) visitors live outside of the EMZ. Assuming these visitors attend the festival with family members, the average household size (2.23 persons/household) was used to estimate the vehicles for the festival. Thus, 1,975 tourists in 886 vehicles (an average of 2.23 persons per vehicle) are assigned to the theatre.

Appendix E summarizes the tourist data that was estimated for the EMZ. Table E-4 presents the number of tourists visiting recreational facilities and lodging facilities within the EMZ.

In total, there are 5,150 tourists evacuating in 2,252 vehicles (an average of 2.29 tourists per vehicle) in the study area. Table 3-5 presents tourist population and vehicle estimates in the study area.

3.4 Employees

Employees who work within the EMZ fall into two categories:

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

Those of the first category are already counted as part of the permanent resident population. To avoid double counting, we focus only on those employees commuting from outside the EMZ who will evacuate along with the permanent resident population.

Data obtained from the US Census Longitudinal Employer-Household Dynamics from the OnTheMap Census analysis tool[6] were used to estimate the number of employees commuting into the EMZ. The latest Workplace Area Characteristic data available (2017), was also obtained from this website and was used to determine the number of employees by Census Block within the EMZ.

Since not all employees are working at facilities within the EMZ at one time, a maximum shift reduction was applied. The Work Area Profile Report, also output by the OnTheMap Application, breaks down jobs within the EMZ by industry sector. Assuming maximum shift employment occurs Monday through Friday between 9 AM and 5 PM, the following jobs take place outside the typical 9-5 workday:

- Manufacturing – 5.7% of jobs; takes place in shifts over 24 hours
- Arts, Entertainment, and Recreation – 9.1% of jobs; takes place in evenings and on weekends

---

[6] http://onthemap.ces.census.gov/

- Accommodations and Food Services – 26.2% of jobs; peaks in the evenings

The maximum shift in the EMZ is about 59.0% (100% - 5.7% - 9.1% - 26.2% = 59.0%). This value was applied to the total employment in 2017 to represent the maximum number of employees present in the EMZ at any one time. The Inflow/Outflow Report was then used to calculate the percent of employees that work within the EMZ but live outside. This value, 66.8%, was applied to the maximum shift employee values to compute the number of people commuting into the EMZ to work at peak times. Table E-3 in Appendix E summarizes the number of employees commuting into the EMZ during the peak shift.

In Table 3-6, a vehicle occupancy of 1.06 employees per vehicle obtained from the demographic survey (See Appendix F, sub-section F.3.1, “Commuter Travel Modes”) was used to determine the number of evacuating employee vehicles for all major employers. Table 3-6 presents employee and vehicle estimates by EMZ.

3.5 Medical Facilities

The data for the three medical facilities was provided by the city. Table E-2 in Appendix E summarizes the data gathered. Table 3-7 presents the current census and transportation requirement of medical facilities in the EMZ. As shown in these tables, 250 people have been identified as living in, or being treated in, these facilities. Since the average number of patients at medical facilities fluctuate daily, a percent breakdown of ambulatory, wheelchair using, and bedridden patients was used to estimate the number of each type of patient (see Section 2.3, Assumption 8). The estimated breakdown for the three facilities consists of about 50% ambulatory, 25% wheelchair using, and 25% bedridden patients, accounting for rounding errors. The number of ambulances is determined by assuming that 2 patients can be accommodated per ambulance trip; the number of wheelchair buses assumes 15 wheelchairs per trip, and the number of buses estimated assumes 30 ambulatory patients per trip (see Section 2.3, Assumption 5).

3.6 Transit Dependent Population

The demographic survey results were used to estimate the portion of the population requiring transit service:

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

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

Table 3-8 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[7] 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. The results from the demographic survey indicate approximately 88 percent is appropriate for this area. As such, 88 percent ride-sharing was utilized to estimate the transit dependent population within the EMZ.

The estimated number of bus trips needed to service transit-dependent persons is based on an estimate of average bus occupancy of 30 persons at the conclusion of the bus run. Transit vehicle seating capacities typically equal or exceed 60 children on average (roughly equivalent to 40 adults). If transit vehicle evacuees are two thirds adults and one third children, then the number of "adult seats" taken by 30 persons is 20 + (2/3 x10) = 27. On this basis, the average load factor anticipated is (27/40) x 100 = 68 percent. Thus, if the actual demand for service exceeds the estimates of Table 3-8 by 50 percent, the demand for service can still be accommodated by the available bus seating capacity.

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

Table 3-8 indicates that transportation must be provided for 94 people. Therefore, a total of **4 buses** are required to transport this population outside of the EMZ.

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 EMZ:

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

Where,

A = Percent of households with commuters

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

$$P = 9{,}618 \times [1.50\ \times 0.0068 + 0.3530 \times (1.76 - 1) \times 0.3586 \times 0.6131 + 0.4426 \times (2.56 - 2) \times (0.3582 \times 0.6131)^2] = 780$$

$$B = ((1 - 0.88) \times P) \div 30 = 4$$

---

[7] 1979 Mississauga Train Derailment

These calculations are explained as follows:

- Number of households is computed by dividing the EMZ population (21,449) by the average household size (2.23) and equates to 9,618.
- All members (1.50 avg.) of households (HH) with no vehicles (0.68%) will evacuate by public transit or ride-share. The term 9,618 (number of households) x 1.50 x 0.0068, accounts for these people.
- The members of HH with 1 vehicle (35.30%) away, who are at home, equal (1.76-1). The number of HH where the commuter will not return home is equal to (9,618 x 0.76 x 0.3530 x 0.3582 x 0.6131), as 35.82% of EMZ households have a commuter, 61.31% 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 (44.26%) that are away, who are at home, equal (2.56 – 2). The number of HH where neither commuter will return home is equal to 9,618 x 0.4426 x 0.56 x $(0.3582 \times 0.6131)^2$. 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 1 or 2 vehicles that are away from home and households with no vehicles.

It is assumed that homeless people and those with access and functional needs who may also need assistance and do not reside in medical facilities are included in these calculations. Data was not provided on the homeless population or those with access and functional needs.

KLD designed bus routes to service the transit dependent population in each EMZ. These routes are shown in Figure 11-2 and described in Table 11-1. These routes were designed by grouping EMZs into clusters to minimize the number of buses needed. For example, using a weighted distribution, there are 5 people in EMZ 1, 8 people in EMZ 2, and 9 people in EMZ 10 that would need transportation assistance to evacuate. Since these EMZs border one another, a single bus could be used to gather all of these people. Assuming a bus capacity of 30 people, as discussed above, only one bus is needed to evacuate these three EMZs, rather than using one bus for each EMZ. This grouping of EMZs should be considered when looking at the summary of vehicle demand by EMZ at the end of this section.

3.7 School Population Demand

Table 3-9 presents the school population and transportation requirements for the direct evacuation of all schools within the EMZ. This information was provided by the City of Ashland supplemented by internet searches for schools in which no data was provided. The column in Table 3-9 entitled "Buses Required" specifies the number of buses required for each school under the following set of assumptions and estimates:

- No students will be picked up by their parents prior to the arrival of the buses.

- The estimate of buses required for school evacuation does not consider the use of private vehicles by students.
- Bus capacity, expressed in students per bus, was assumed to be 40 for High School and Middle School buses, and 60 for Elementary School and childcare facility buses.
- 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.

The City of Ashland may consider procedures whereby the schools are contacted prior to the dispatch of buses from the depot 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. The need for buses would be reduced by any high school students who have evacuated using private automobiles (if permitted by school authorities). Those buses originally allocated to evacuate schoolchildren that are not needed due to children being picked up by their parents, can be gainfully assigned to service other facilities or those persons who do not have access to private vehicles or to ride-sharing.

3.8 External Traffic

Vehicles will be traveling through the study area (external-external trips) at the time of an event. After the Advisory to Evacuate is announced, these through-travelers will also evacuate. These through vehicles are assumed to travel on the major route traversing the study area – Interstate 5. It is likely dynamic and variable message signs will be strategically positioned outside of the study area at logical diversion points to attempt to divert traffic away from the area at risk. As such, it is assumed this external traffic will diminish over 120 minutes following the Advisory to Evacuate.

Average Annual Daily Traffic (AADT) data was obtained from Oregon Department of Transportation (ODOT) to estimate the number of vehicles per hour on the aforementioned routes. The AADT was multiplied by the K-Factor, which is the proportion of the AADT on a roadway segment or link during the design hour, resulting in the Design Hour Volume (DHV). The design hour is usually the 30th highest hourly traffic volume of the year, measured in vehicles per hour (vph). The DHV is then multiplied by the D-Factor, which is the proportion of the DHV occurring in the peak direction of travel (also known as the directional split).

The resulting values are the directional design hourly volumes (DDHV) and are presented in Table 3-10, for each of the routes considered. The DDHV is then multiplied by 2 hours (dynamic messaging signs are assumed to be activated within the 120 minutes of the ATE; no vehicles have diverted during this time) to estimate the total number of external vehicles loaded on the analysis network. As indicated in Table 3-10, there are 8,412 vehicles entering the study area as external-external trips prior to any diversion of traffic. This number is reduced by 60% for evening scenarios (Scenarios 3 and 6) as discussed in Section 6.

3.9 Background Traffic

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

In traffic simulations, the network is initially empty. Thus, for this study, the network needs to be filled (to represent a routine travel conditions just prior to an evacuation order) so that system performance can be assessed under a more realistic set of conditions. As such, there is a 30-minute initialization time period (often referred to as “fill time” in traffic simulation) wherein a portion of the traffic volumes from Time Period 1 are loaded onto roadways in the study area. The amount of initialization/fill traffic that is on the roadways in the study area at the start of Time Period 1 depends on the scenario and the region being evacuated (see Section 6). There are 1,578 vehicles on the roadways in the study area at the end of fill time for an evacuation of all the EMZ (Region R18) under Scenario 1 (summer, midweek, midday, normal) conditions.

3.10 Summary of Demand

A summary of population and vehicle demand is provided in Table 3-11 and Table 3-12, respectively. This summary includes all population groups described in this section. A total of 47,674 people and 37,654 vehicles are considered in this study.

Table 3-1. County Population Change and Annual Growth Rate from April 1, 2010 to July 1, 2019

County	2010 Population	2019 Population	Percent Change	Annual Growth Rate
Jackson	203,204	220,944	8.73%	0.91%

Table 3-2. Municipality Population Change and Annual Growth Rate from April 1, 2010 to July 1, 2019

Municipality	2010 Population	2019 Population	Percent Change	Annual Growth Rate
Jackson County, OR				
EMZ				
Ashland	20,076	21,281	6.00%	0.63%
Shadow Region				
Talent	6,059	6,608	9.06%	0.94%

Table 3-3. EMZ Permanent Resident Population

EMZ	2010 Population	2020 Extrapolated Population
1	1,170	1,252
2	1,665	1,777
3	3,283	3,506
4	2,653	2,835
5	593	636
6	3,307	3,531
7	1,973	2,110
8	1,397	1,489
9	2,115	2,257
10	1,922	2,056
TOTAL	**20,078**	**21,449**
Population Growth (2010-2020):		**6.83%**
Shadow	9,164	10,099
STUDY AREA TOTAL	**29,242**	**31,548**

Table 3-4. Permanent Resident Population and Vehicles by EMZ

EMZ	2020 Extrapolated Population	2020 Resident Vehicles
1	1,252	803
2	1,777	1,074
3	3,506	2,243
4	2,835	1,813
5	636	409
6	3,531	2,266
7	2,110	1,354
8	1,489	953
9	2,257	1,445
10	2,056	1,306
TOTAL	**21,449**	**13,666**
Shadow	10,099	6,490
STUDY AREA TOTAL	**31,548**	**20,156**

Table 3-5. Summary of Tourists and Tourist Vehicles

EMZ	Tourists	Tourist Vehicles
1	1,000	280
2	75	133[8]
3	2,205	420[8]
4	180	90
5	732	355
6	328	147
7	266	119
8	0	475[8]
9	180	150
10	184	83
TOTAL	**5,150**	**2,252**

---

[8] There is limited parking capacity at Oregon Shakespeare Festival in EMZ 3. According to the city, the vehicles for the festival are parked at multiple places near the theatre in EMZs (2, 3 and 8).

Table 3-6. Summary of Employees and Employee Vehicles Commuting into the EMZ

EMZ	Employees	Employee Vehicles
1	74	70
2	100	94
3	627	593
4	0	0
5	181	171
6	475	448
7	86	81
8	599	565
9	54	51
10	106	100
TOTAL	**2,302**	**2,173**

Table 3-7. Medical Facilities Transit Demand Estimates

EMZ	Facility Name	Capacity	Current Census	Ambulatory Patients	Wheel-chair Bound Patients	Bed-ridden Patients	Buses	Wheel- chair Buses	Ambulances
2	Asante Ashland Community Hospital	125	125	63	31	31	3	3	16
10	Ashland Surgery Center	25	25	13	6	6	1	1	3
2	Linda Vista Nursing & Rehab Center	100	100	50	25	25	2	2	13
	TOTAL:	**250**	**250**	**126**	**62**	**62**	**6**	**6**	**32**

Table 3-8. Transit-Dependent Population Estimates

Projected 2020 EPZ Population	Survey Average HH Size with Indicated No. of Vehicles			Estimated No. of Households	Survey Percent HH with Indicated No. of Vehicles			Survey Percent HH with Commuters	Survey Percent HH with Non-Returning Commuters	Total People Requiring Transport	Estimated Ridesharing Percentage	People Requiring Public Transit	Percent Population Requiring Public Transit
	0	1	2		0	1	2						
21,449	1.50	1.76	2.56	9,618	0.68%	35.30%	44.26%	35.82%	61.31%	780	88%	94	0.4%

Table 3-9. School and Preschool/Daycare Population Demand Estimates

EMZ	School Name	Enrollment	Buses Required
10	Helman Elementary School	360	6
7	Ashland High School	1,000	25
6	Walker Elementary School	340	6
6	Ashland Middle School	900	23
6	John Muir Elementary School	270	5
6	Bellview Elementary School	460	8
3	Southern Oregon University	5,000	2
	TOTAL:	**8,330**	**75**
2	Oregon Child Development	213	4
3	Reflective Hearts Childcare	10	1
6	Stone Soup Playschool	10	1
3	Pea Pod Village	10	1
2	Children's World	10	1
4	Memory Lane Preschool	20	1
7	Head Start	20	1
4	Rain and Shine Preschool	20	1
	PRESCHOOL/DAYCARE TOTAL:	**313**	**11**

Table 3-10. Study Area External Traffic Demand

Upstream Node	Downstream Node	Road Name	Direction	ODOT[1] AADT	K-Factor[2]	D-Factor[2]	Hourly Volume	External Traffic
8001	291	I-5	NB	39,300	0.107	0.5	2,103	4,206
8002	31	I-5	SB	39,300	0.107	0.5	2,103	4,206
							TOTAL:	**8,412**

1 https://www.oregon.gov/ODOT/DATA/Pages/Traffic-Counting.aspx

2 HCM 2016

Table 3-11. Summary of Population Demand

EMZ	Residents	Transit-Dependent	Tourists	Employees	Medical Facilities	Schools	On Campus University Students	Off Campus University Students	External Traffic	Total
1	1,252	5	1,000	74	0	0	0	0	0	2,331
2	1,777	8	75	100	225	0	0	0	0	2,185
3	3,506	15	2,205	627	0	0	850	4,150	0	11,353
4	2,835	15	180	0	0	0	0	0	0	3,030
5	636	3	732	181	0	0	0	0	0	1,552
6	3,531	13	328	475	0	1,970	0	0	0	6,317
7	2,110	9	266	86	0	1,000	0	0	0	3,471
8	1,489	7	0	599	0	0	0	0	0	2,095
9	2,257	10	180	54	0	0	0	0	0	2,501
10	2,056	9	184	106	25	360	0	0	0	2,740
Shadow	10,099	0	0	0	0	0	0	0	0	10,099
Total	**31,548**	**94**	**5,150**	**2,302**	**250**	**3,330**	**850**	**4,150**	**0**	**47,674**

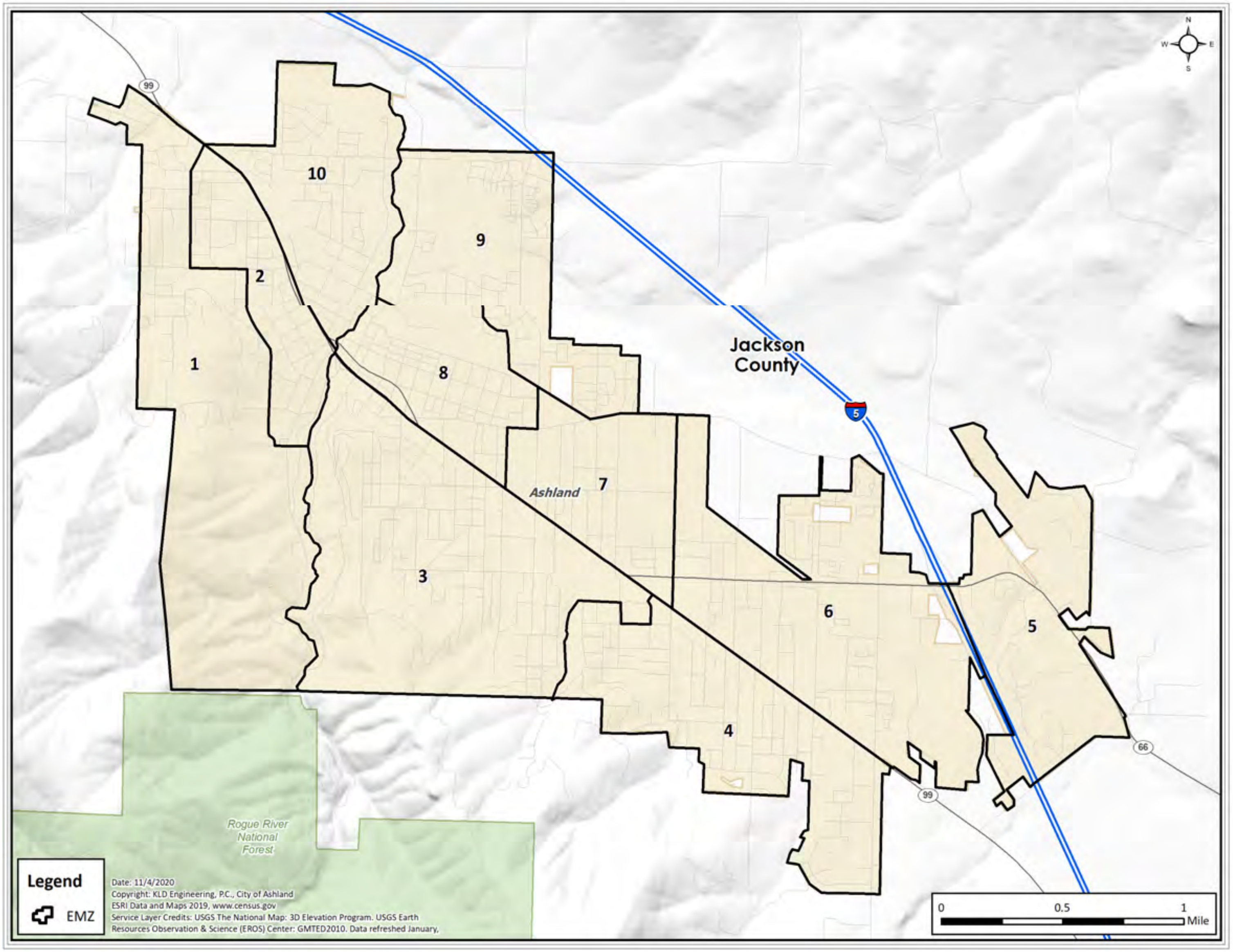
Table 3-12. Summary of Vehicle Demand

EMZ	Residents	Transit-Dependent[9] [10]	Tourists	Employees	Medical Facilities[9]	School Buses[9]	On Campus University Students	Off Campus University Students	External Traffic	Total
1	803	2	280	70	0	0	0	0	0	1,155
2	1,074	0	133	94	49	10	0	0	0	1,360
3	2,243	2	420	593	0	8	510	3,915	0	7,691
4	1,813	0	90	0	0	4	0	0	0	1,907
5	409	2	355	171	0	0	0	0	0	937
6	2,266	0	147	448	0	86	0	0	0	2,947
7	1,354	2	119	81	0	52	0	0	0	1,608
8	953	0	475	565	0	0	0	0	0	1,993
9	1,445	0	150	51	0	0	0	0	0	1,646
10	1,306	0	83	100	7	12	0	0	0	1,508
Shadow	6,490	0	0	0	0	0	0	0	8,412	14,902
Total	**20,156**	**8**	**2,252**	**2,173**	**56**	**172**	**510**	**3,915**	**8,412**	**37,654**

---

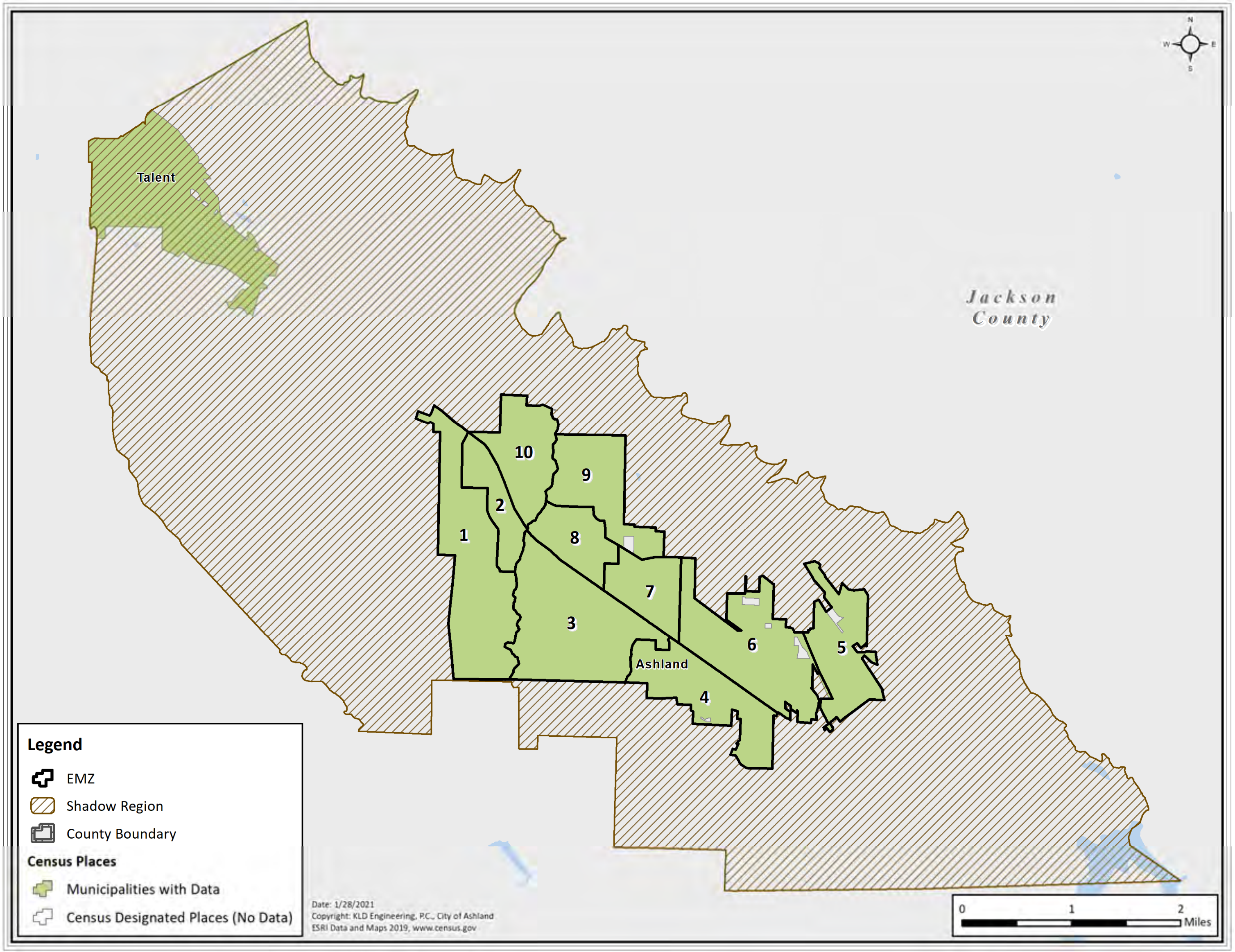
[9] One bus is equivalent to 2 pce's. As such, buses for transit dependent persons, ambulatory and wheelchair using medical facility patients, schools and colleges are doubled in the simulation.

[10] Transit dependent buses for EMZs 2 and 10 are included with EMZ 1. Transit dependent buses for EMZ 4 is included with EMZ 3. Transit dependent buses for EMZ 6 is included with EMZ 5. Transit dependent buses for EMZs 8 and 9 are included with EMZ 7.



Date: 11/4/2020
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation Program. USGS Earth Resources Observation & Science (EROS) Center: GMTED2010. Data refreshed January,

Figure 3-1. EMZ Boundaries



Date: 1/28/2021
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov

Figure 3-2. Census Boundaries within the Study Area

4 ESTIMATION OF HIGHWAY CAPACITY

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

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

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

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

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

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

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

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

---

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

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

The amount of traffic that can flow on a roadway is effectively governed by vehicle speed and spacing. The faster that vehicles can travel when closely spaced, the higher the amount of flow.

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

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

4.1 Capacity Estimations on Approaches to Intersections

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

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

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

where:

$Q_{cap,m}$ = Capacity of a single lane of traffic on an approach, which executes movement, m, upon entering the intersection; vehicles per hour (vph)

h_m = Mean queue discharge headway of vehicles on this lane that are executing movement, m; seconds per vehicle

G = Mean duration of GREEN time servicing vehicles that are executing movement, m, for each signal cycle; seconds

L = Mean "lost time" for each signal phase servicing movement, m; seconds

C = Duration of each signal cycle; seconds

P_m = Proportion of GREEN time allocated for vehicles executing movement, m, from this lane. This value is specified as part of the control treatment.

m = The movement executed by vehicles after they enter the intersection: through, left-turn, right-turn, and diagonal.

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

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

where:

h_{sat} = Saturation discharge headway for through vehicles; seconds per vehicle

F_1, F_2 = The various known factors influencing h_m

$f_m(\ )$ = Complex function relating h_m to the known (or estimated) values of h_{sat}, F_1, F_2, …

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

$$h_m \geq h_{sat}$$

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

---

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

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

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

4.2 Capacity Estimation along Sections of Highway

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

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

The value of V_F can be expressed as:

$$V_F = R \times Capacity$$

where:

R = Reduction factor which is less than unity

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

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

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

The estimated value of capacity is based primarily upon the type of facility and on roadway geometrics. Sections of roadway with adverse geometrics are characterized by lower free-flow speeds and lane capacity. Exhibit 15-46 in the Highway Capacity Manual was referenced to estimate saturation flow rates. The impact of narrow lanes and shoulders on free-flow speed and on capacity is not material, particularly when flow is predominantly in one direction as is the case during an evacuation.

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

---

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

4.3 Application to the City of Ashland Study Area

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

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

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

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

Each of these classifications will be discussed.

4.3.1 Two-Lane Roads

Ref: HCM Chapter 15

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

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

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

4.3.2 Multi-Lane Highway

Ref: HCM Chapter 12

Exhibit 12-8 of the HCM 2016 presents a set of curves that indicate a per-lane capacity ranging from approximately 1,900 to 2,300 pc/h, for free-speeds of 45 to 70 mph, respectively. Based on observation, the multi-lane highways outside of urban areas within the study area service traffic with free-speeds in this range. The actual time-varying speeds computed by the simulation model reflect the demand and capacity relationship and the impact of control at intersections. A conservative estimate of per-lane capacity of 1,900 pc/h is adopted for this study for multi-lane highways outside of urban areas, as shown in Appendix H.

4.3.3 Freeways

Ref: HCM Chapters 10, 12, 13, 14

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

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

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

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

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

Chapter 14 of the HCM 2016 presents procedures for estimating capacities of ramps and of "merge" areas. There are three significant factors to the determination of capacity of a ramp-freeway junction: The capacity of the freeway immediately downstream of an on-ramp or immediately upstream of an off-ramp; the capacity of the ramp roadway; and the maximum flow rate entering the ramp influence area. In most cases, the freeway capacity is the controlling factor. Values of this merge area capacity are presented in Exhibit 14-10 of the HCM 2016 and depend on the number of freeway lanes and on the freeway free speed. Ramp capacity is presented in Exhibit 14-12 and is a function of the ramp's FFS. The DYNEV II simulation model logic simulates the merging operations of the ramp and freeway traffic in accord with the procedures in Chapter 14 of the HCM 2016. If congestion results from an excess of demand relative to capacity, then the model allocates service appropriately to the two entering traffic streams and produces LOS F conditions (The HCM does not address LOS F explicitly).

4.3.4 Intersections

Ref: HCM Chapters 19, 20, 21, 22

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

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

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

4.4 Simulation and Capacity Estimation

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

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

This statement succinctly describes the analyses required to determine traffic operations across an area encompassing a study area operating under evacuation conditions. The model utilized for this study, DYNEV II, is further described in Appendix C. It is essential to recognize that simulation models do not replicate the methodology and procedures of the HCM – they *replace* these procedures by describing the complex interactions of traffic flow and computing Measures of Effectiveness (MOE) detailing the operational performance of traffic over time and by location. The DYNEV II simulation model includes some HCM 2016 procedures only for the purpose of estimating capacity.

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

It is important to note that simulation represents a mathematical representation of an assumed set of conditions using the best available knowledge and understanding of traffic flow and available inputs. Simulation should not be assumed to be a prediction of what will happen under any event because a real evacuation can be impacted by an infinite number of things – many of which will differ from these test cases – and many others cannot be taken into account with the tools available.

4.5 Boundary Conditions

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

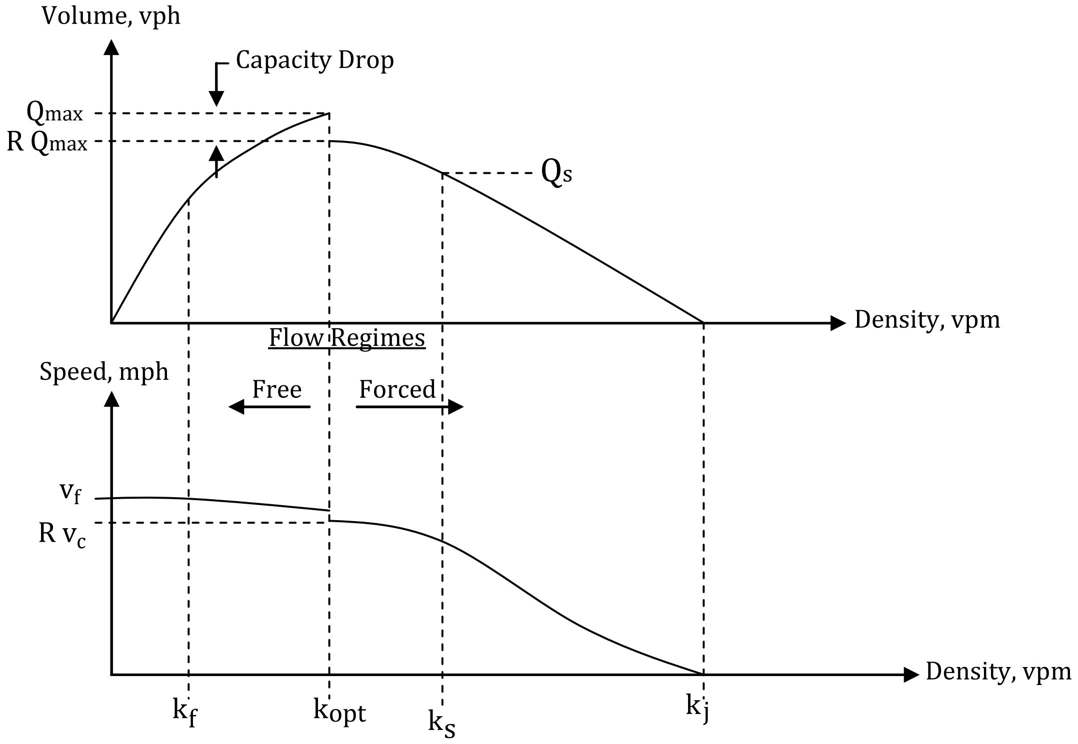


Figure 4-1. Fundamental Diagrams

5 ESTIMATION OF TRIP GENERATION TIME

It is general practice for planners to estimate the distributions of elapsed times associated with mobilization activities undertaken by the public to prepare for the evacuation trip. The elapsed time associated with each activity is represented as a statistical distribution reflecting differences between members of the public. The quantification of these activity-based distributions relies largely on the results of the demographic survey. We define the <u>sum</u> of these distributions of elapsed times as the Trip Generation Time Distribution. This section documents how the trip generation time distributions were estimated.

5.1 Background

In general, during a wildfire emergency, priorities are given to life safety, preservation of property and resource conservation. To ensure life safety, depending on the severity, wind speed and direction of the wildfire, emergency officials may issue warnings that include evacuation.

As a <u>Planning Basis</u>, we will adopt a conservative posture, a rapidly escalating wildfire situation, wherein evacuation is required, ordered promptly and no early protective actions have been implemented when calculating the Trip Generation Time. In these analyses, we have assumed:

1. The advisory to evacuate will be announced coincident with local emergency alerts (e.g. emergency alert systems (EAS) broadcasts, sirens, social media, local news, door-to-door and with alike communication systems).
2. Mobilization of the general population will commence within 15 minutes after emergency alerts.
3. ETE are measured relative to the advisory to evacuate.

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

1. Establish a temporal framework for estimating the Trip Generation distribution
2. Identify temporal points of reference that uniquely define "Clear Time" and ETE.

The notification process consists of two events:

1. <u>Transmitting</u> information using the alert and notification systems mentioned above.
2. <u>Receiving</u> and correctly <u>interpreting</u> the information that is transmitted.

The population within the Emergency Management Zone (EMZ) is dispersed over an area of approximately 6.7 square miles and is engaged in a wide variety of activities. It must be anticipated that some time will elapse between the transmission and receipt of the information advising the public of an event.

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

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

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

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

5.2 Fundamental Considerations

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

Activities are undertaken over a period of time. Activities may be in "series" (i.e. to undertake an activity implies the completion of all preceding events) or may be in parallel (two or more activities may take place over the same period of time). Activities conducted in series are functionally dependent on the completion of prior activities; activities conducted in parallel are functionally independent of one another. The relevant events associated with the public's preparation for evacuation are:

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

Associated with each sequence of events are one or more activities, as outlined in Table 5-1.

These relationships are shown graphically in Figure 5-1.

- An Event is a ‘state’ that exists at a point in time (e.g., depart work, arrive home)

- An Activity is a ‘process’ that takes place over some elapsed time (e.g., prepare to leave work, travel home)

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

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

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

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

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

5.3 Estimated Time Distributions of Activities Preceding Event 5

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

Time Distribution No. 1, Notification Process: Activity 1 → 2

A demographic survey of Ashland residents was conducted to study evacuation behavior of the population within the EMZ. The survey results were used to create the notification time distribution. The survey asked specific questions about notifying neighbors and friends during an emergency using various methods like phone calls, text messages, social media, and in person conversation. Since the survey was statistically significant at the 99% confidence level, it can be assumed that the population within the EMZ will behave similarly to the survey respondents.

The City of Ashland uses emergency alert systems such as NIXLE and Citizen Alert to push notifications to the population opted-in to the service.

Given the presence of the existing emergency alert systems and the responses to the demographic survey regarding notification of friends and neighbors, it was assumed that about 63% of the EMZ population can be notified within 5 minutes of an emergency, about 95% of the EMZ population can be notified within 15 minutes, and 100% of the EMZ population can be notified within 45 minutes. The distribution of Activity 1 → 2 shown in Table **5**-**2** reflects data obtained by the demographic survey and the above assumptions.

Given the uncertainty in some critical assumptions, several sensitivity studies were conducted as part of this work effort to determine the elasticity of the evacuation time estimates to those assumptions, see Appendix J.

Distribution No. 2, Prepare to Leave Work: Activity 2 → 3

It is reasonable to expect that the vast majority of business enterprises within the EMZ will elect to shut down following notification and most employees would leave work quickly. Commuters, who work outside the EMZ could, in all probability, also leave quickly since facilities outside the EMZ would remain open and other personnel would remain. Personnel or farmers responsible for equipment/livestock would require additional time to secure their facility. The distribution of Activity 2 → 3 shown in Table 5-3 reflects data obtained by the demographic survey. This distribution is also applicable for residents to leave stores, restaurants, parks and other locations within the EMZ. This distribution is plotted in Figure 5-2.

Distribution No. 3, Travel Home: Activity 3 → 4

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

Distribution No. 4, Prepare to Leave Home: Activity 2, 4 → 5

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

5.4 Calculation of Trip Generation Time Distribution

The time distributions for each of the mobilization activities presented herein must be combined to form the appropriate Trip Generation Distributions. As discussed above, this study assumes that the stated events take place in sequence such that all preceding events must be completed before the current event can occur. For example, if a household awaits the return of a commuter, the work-to-home trip (Activity 3 → 4) must precede Activity 4 → 5.

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

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

5.4.1 Statistical Outliers

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

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

In assessing outliers, there are three alternates to consider:

> 1) Some responses with very long times may be valid, but reflect the reality that the respondent really needs to be classified in a different population subgroup, based upon special needs;
>
> 2) Other responses may be unrealistic (6 hours to return home from commuting distance, or 2 days to prepare the home for departure);
>
> 3) Some high values are representative and plausible, and one must not cut them as part of the consideration of outliers.

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

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

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

1) It is recognized that the overall trip generation distributions are <u>conservative</u> estimates, because they assume a household will do the mobilization activities sequentially, with no overlap of activities;
2) The individual mobilization <u>activities</u> (receive notification, prepare to leave work, travel home, prepare home) are reviewed for outliers, and <u>then</u> the overall trip generation distributions are created (see Figure 5-1, Table 5-6, Table 5-7);
3) Outliers can be eliminated either because the response reflects a special population (e.g.

special needs, transit dependent) or lack of realism, because the purpose is to estimate trip generation patterns for personal vehicles;

4) To eliminate outliers,
    a) the mean and standard deviation of the specific activity are estimated from the responses,
    b) the median of the same data is estimated, with its position relative to the mean noted,
    c) the histogram of the data is inspected, and
    d) all values greater than 3.5 standard deviations are flagged for attention, taking special note of whether there are gaps (categories with zero entries) in the histogram display.

    In general, only flagged values more than 4 standard deviations[1] from the mean are allowed to be considered outliers, with gaps in the histogram expected.

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

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

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

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

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

This is done by using the data sets and distributions under different scenarios (e.g. commuter returning, no commuter returning in each). In general, these are additive, using weighting based upon the probability distributions of each element; Figure 5-4 presents the combined trip generation distributions designated A, C, and D. These distributions are presented on the same time scale. (As discussed earlier, the use of strictly additive activities is a conservative approach, because it makes all activities sequential – preparation for departure follows the return of the

---

[1] This rule was followed for all truncation analyses except the time distribution for notification. The truncation for the notification distribution used 8 standard deviations as the responses that fell within 8 standard deviations did not appear to be statistical outliers. Only those data points that fell beyond 8 standard deviations from the mean were considered outliers. Basically, more data points were included in the distribution (rather than eliminated as outliers).

commuter. In practice, it is reasonable that some of these activities are done in parallel, at least to some extent – for instance, preparation to depart begins by a household member at home while the commuter is still on the road.)

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

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

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

Table 5-1. Event Sequence for Evacuation Activities

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

Table 5-2. Time Distribution for Notifying the Public

Elapsed Time (Minutes)	Cumulative Percent Notified
0	0.0%
5	62.8%
10	84.5%
15	94.5%
20	97.3%
25	98.0%
30	99.2%
35	99.8%
40	99.9%
45	100.0%

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

Elapsed Time (Minutes)	Cumulative Percent Employees Leaving Work
0	0%
5	35%
10	61%
15	77%
20	84%
25	87%
30	92%
35	94%
40	94%
45	96%
50	96%
55	97%
60	100%

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

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

Elapsed Time (Minutes)	Cumulative Percent Returning Home
0	0%
5	16%
10	41%
15	56%
20	69%
25	82%
30	92%
35	95%
40	97%
45	98%
50	99%
55	99%
60	100%

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

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

Elapsed Time (Minutes)	Cumulative Percent Ready to Evacuate
0	0%
15	7%
30	38%
45	56%
60	76%
75	84%
90	87%
105	89%
120	93%
135	97%
150	98%
165	98%
180	99%
195	100%

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

Table 5-6. Mapping Distributions to Events

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

Table 5-7. Description of the Distributions

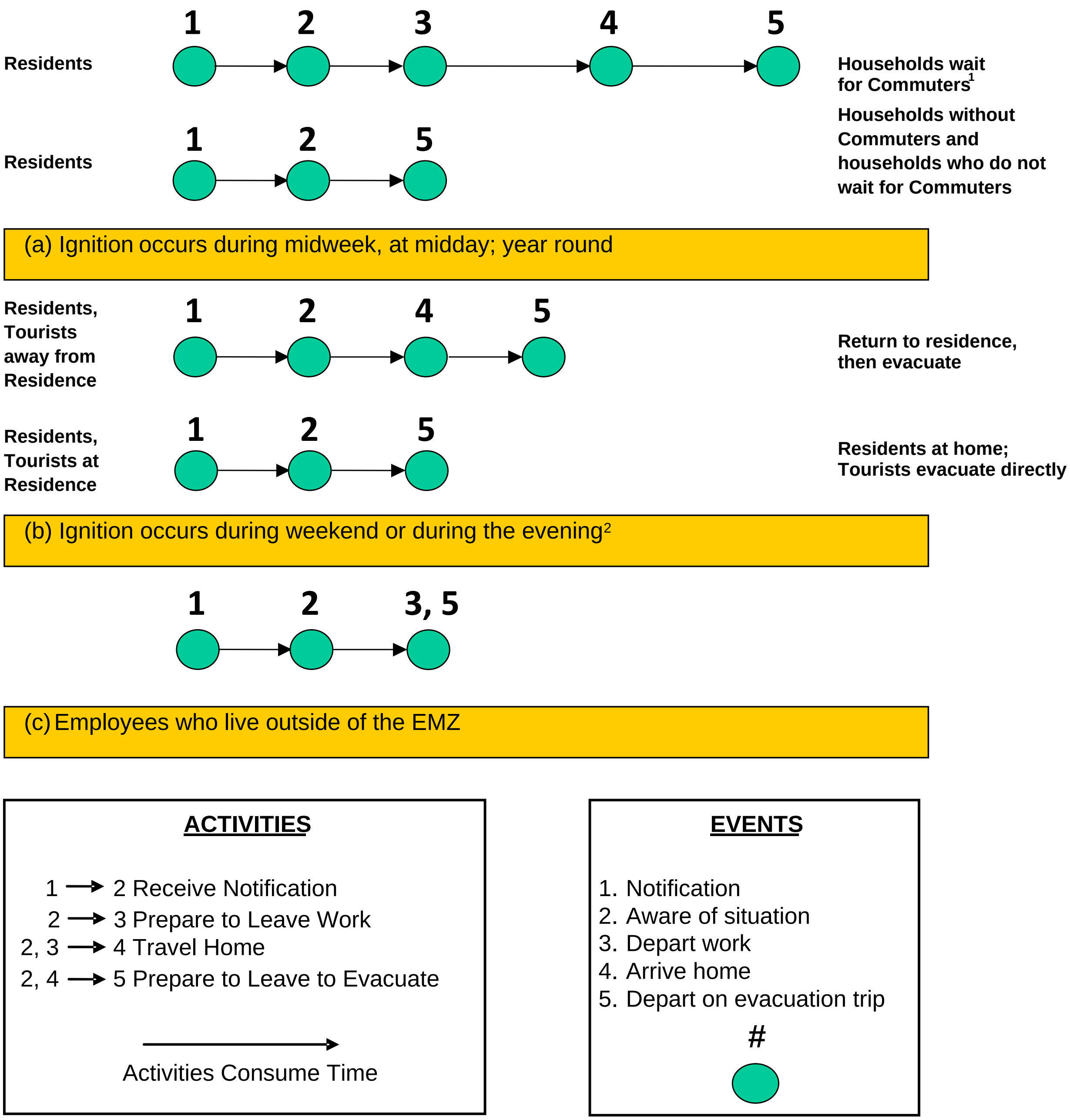
Distribution	Description
A	Time distribution of commuters departing place of work (Event 3). Also applies to employees who work within the EMZ who live outside, and to Tourists within the EMZ.
B	Time distribution of commuters arriving home (Event 4).
C	Time distribution of residents with commuters who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

Table 5-8. Trip Generation Histograms for the EMZ Population

Time Period	Duration (Min)	Percent of Total Trips Generated Within Indicated Time Period			
		Employees (Distribution A)	Tourists (Distribution B)	Residents with Commuters (Distribution C)	Residents Without Commuters (Distribution D)
1	15	46%	46%	0%	3%
2	15	36%	36%	1%	19%
3	15	11%	11%	7%	24%
4	15	3%	3%	16%	20%
5	15	4%	4%	19%	13%
6	15	0%	0%	18%	6%
7	15	0%	0%	13%	3%
8	15	0%	0%	8%	3%
9	15	0%	0%	4%	4%
10	15	0%	0%	4%	2%
11	15	0%	0%	4%	1%
12	15	0%	0%	2%	0%
13	30	0%	0%	2%	2%
14	30	0%	0%	2%	0%
15	600	0%	0%	0%	0%

NOTE:

- Shadow vehicles are loaded onto the analysis network (Figure 1-2) using Distribution C.



[1] Applies for evening and weekends also if commuters are at work.

[2] Applies throughout the year for tourists.

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

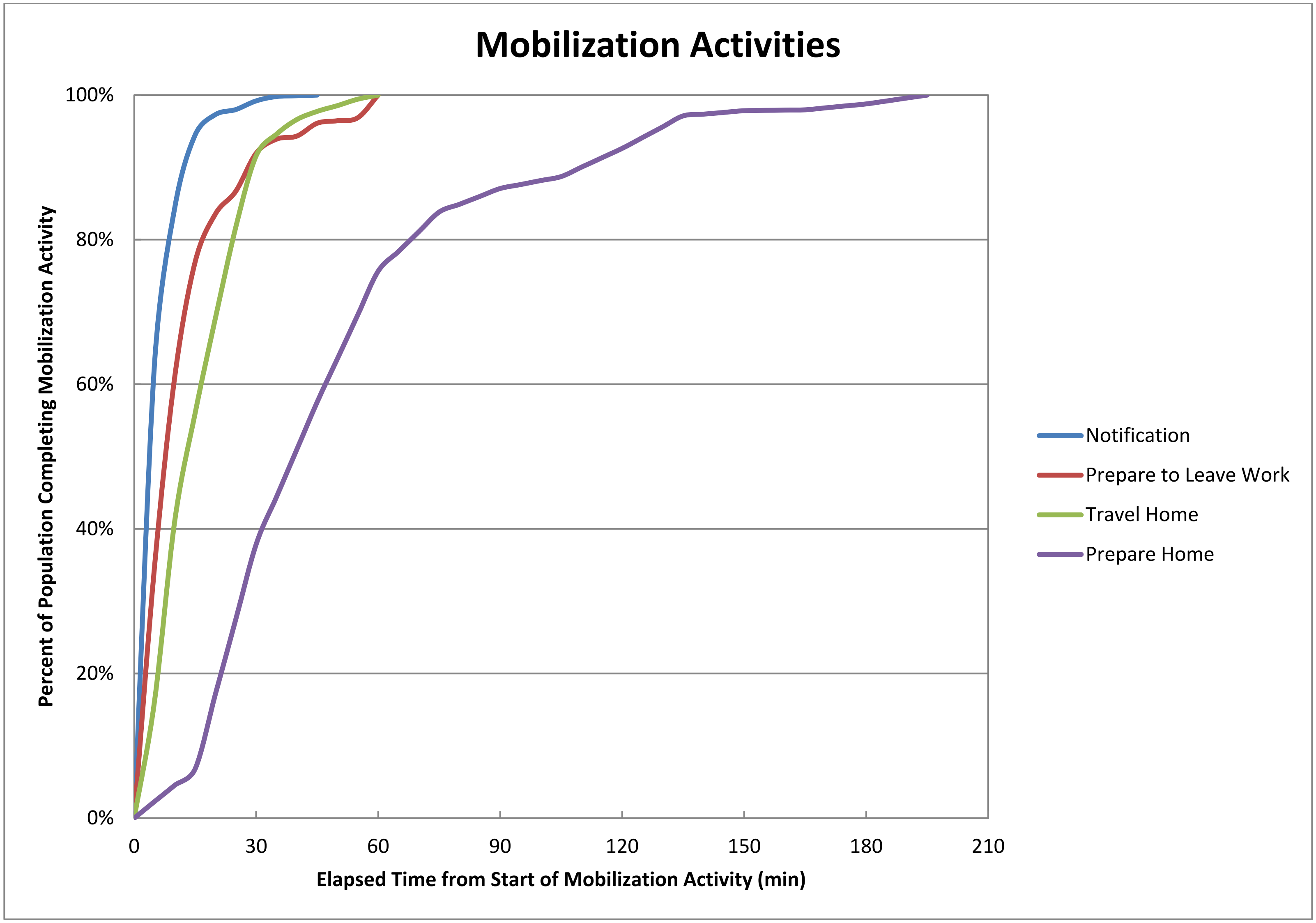


Figure 5-2. Evacuation Mobilization Activities

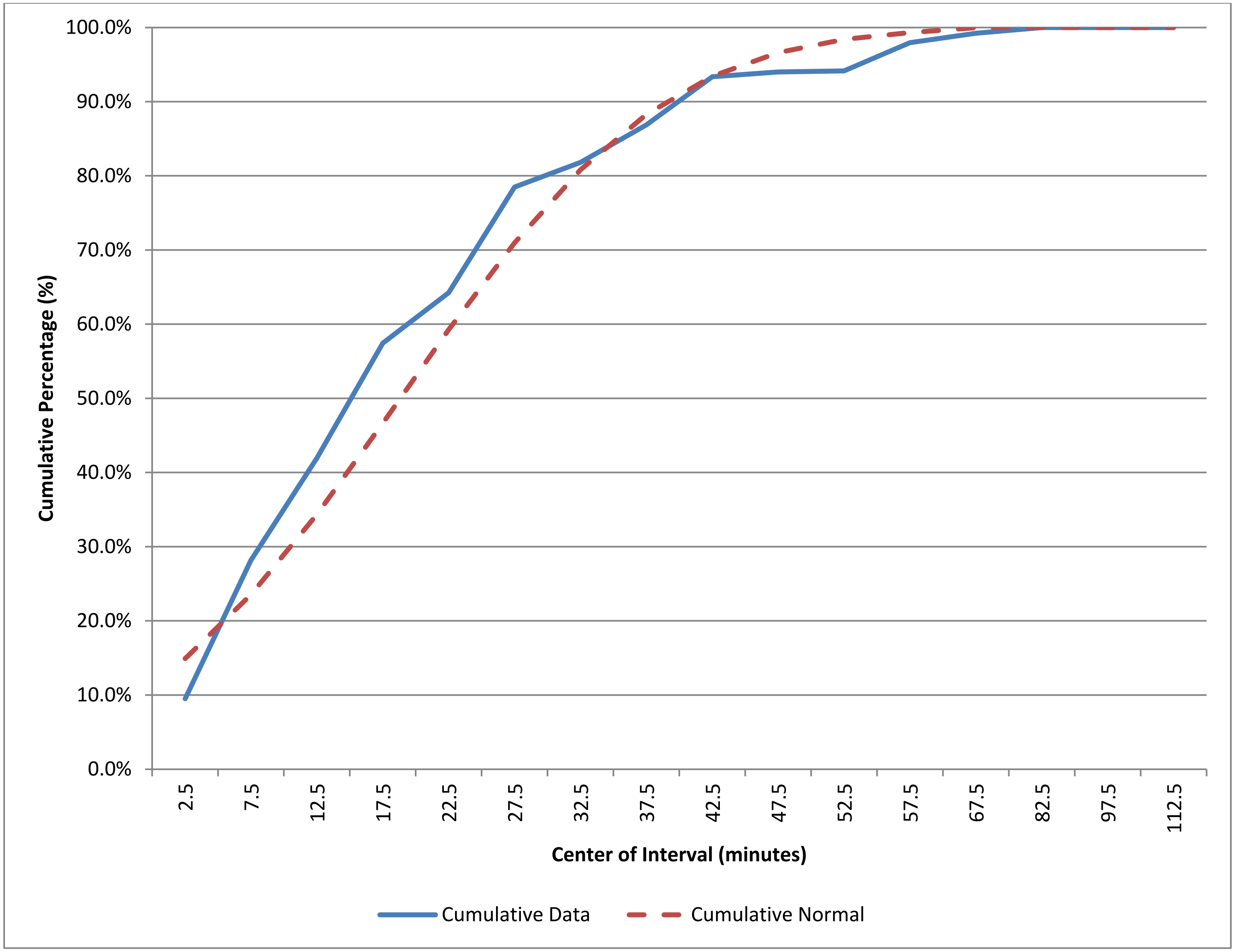


Figure 5-3. Comparison of Data Distribution and Normal Distribution

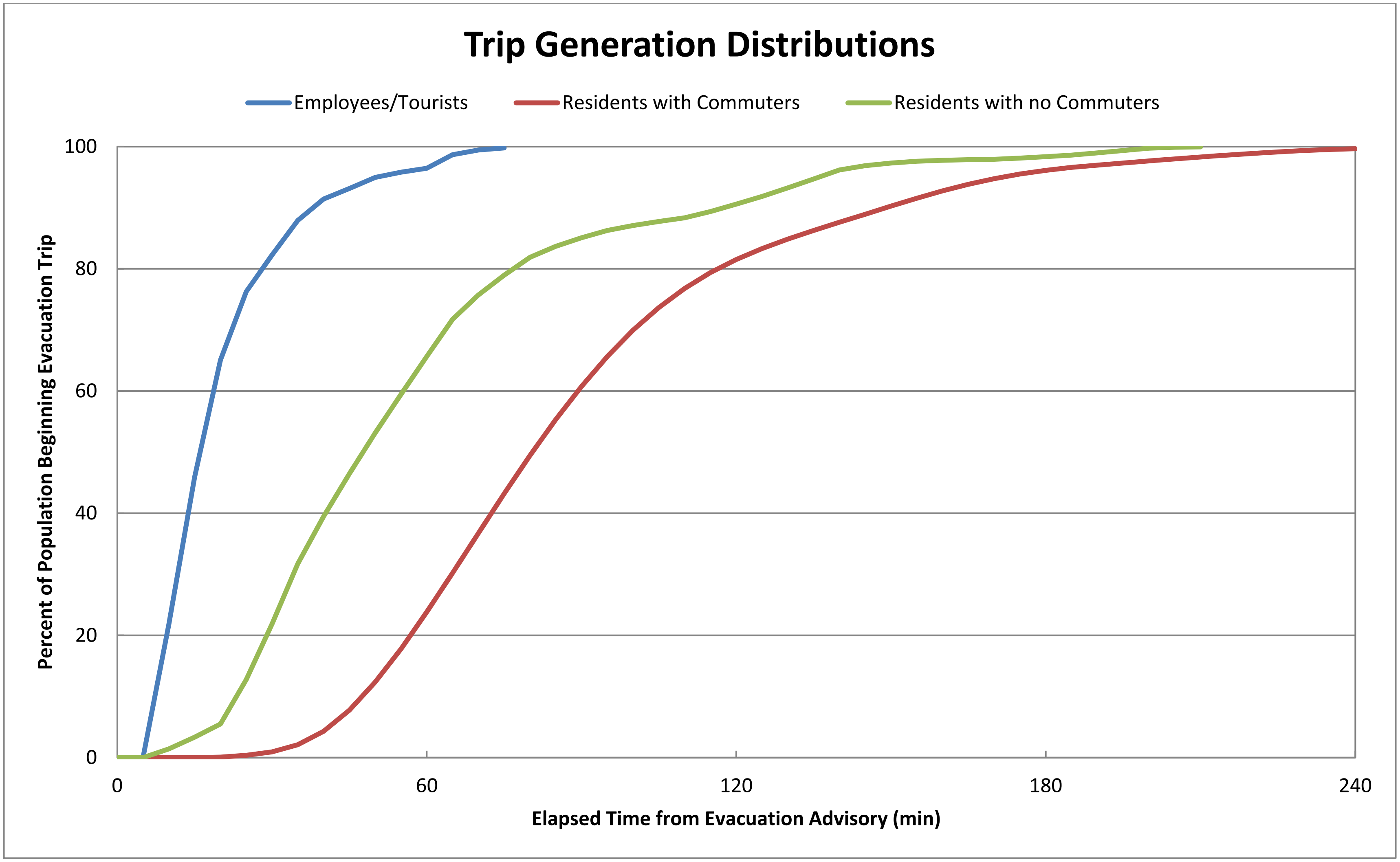


Figure 5-4. Comparison of Trip Generation Distributions

6 EVACUATION CASES

This section discusses the spatial and temporal variations in evacuation situations. The regions outlined in the study were created based on various geometric areas that would be evacuated in response to a wildfire emergency. The scenarios outlined in the study were created based on the various temporal changes that affect the number of vehicles evacuating during a wildfire emergency. This section provides an overview of all the possible evacuation cases that were studied. An evacuation "case" defines a combination of Evacuation Region and Evacuation Scenario. For this specific study, the definitions of "Region" and "Scenario" are as follows:

Region	A grouping of evacuating EMZ, or an individual EMZ, that must be evacuated in response to a wildfire emergency.
Scenario	A combination of circumstances, including time of day, day of week, and season. Scenarios define the number of people in each of the affected population groups and their respective mobilization time distributions.

A total of 18 Regions were defined which encompass all the groupings of EMZ considered. These Regions are defined in Table 6-1 by showing which EMZ evacuates for each Region. EMZs marked with a red "X" evacuate for that given Region. The EMZ boundaries are identified in Figure 6-1. The EMZ boundaries were provided by the City of Ashland.

Regions R01 through R10 represent evacuations of each individual EMZ by itself. Regions R11 through R17 are evacuations of combinations of EMZ based on the origin of a potential wildfire and prevailing winds. Lastly, Region R18 is the evacuation of all EMZs at once.

A total of 6 Scenarios were evaluated for all Regions. Thus, there are a total of 108 (18 x 6 = 108) evacuation cases. Table 6-2 is a description of all Scenarios.

Each combination of Region and Scenario implies a specific population to be evacuated. The population group and the vehicle estimates presented in Section 3 and in Appendix E are peak values. These peak values are adjusted depending on the scenario and region being considered, using Scenario and Region-specific percentages, such that the average population is considered for each evacuation case. The Scenario percentages are presented in Table 6-3, while the Region percentages are provided in Table G-1.

Table 6-4 presents the vehicle counts for each scenario for an evacuation of Region R18 – all EMZs. Based on the scenario percentages in Table 6-3. The percentages presented in Table 6-3 were determined as follows:

The number of residents with commuters during the week (when workforce is at its peak) is equal to the product of 36% (the number of households with at least one commuter) and 39% (the number of households with a commuter that would await the return of the commuter prior to evacuating) – 14 percent. See assumption 16 in Section 2.3. It is estimated for weekend and evening scenarios that 10% of households with returning commuters will have a commuter at work during those times.

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

Tourist activity is estimated to be at its peak (100%) during evenings due to the high number of lodging facilities in the area. During the daytime, summer weekdays and weekends have slightly more tourists (55% and 70%, respectively) than during fall weekdays and weekend (50% and 65%, respectively) since the golf course and hiking trails peak during the summer season and on weekends.

As noted in the shadow footnote to Table 6-3, the shadow percentages are computed using a base of 6% (see assumption 3 in Section 2.3); to include the employees within the shadow region who may choose to evacuate, the voluntary evacuation is multiplied by a scenario-specific proportion of employees to permanent residents in the shadow region. For example, using the values provided in Table 6-4 for Scenario 1, the shadow percentage is computed as follows:

$$6\% \times \left(1 + \frac{2{,}086}{1{,}921 + 11{,}745}\right) = 7\%$$

As discussed in Section 7, schools are in session during the fall season, midweek, midday and 100% of buses will be needed under those circumstances. In addition, 100% of on and off campus students at Southern Oregon University are assumed to be present in the fall, with only the on campus students being present on weekends and evenings. It is estimated that summer school/commuter college enrollment is approximately 10% of enrollment during the regular school year for summer scenarios. School is not in session during weekends and evenings, thus no buses for school children are needed under those circumstances.

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

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

Table 6-1. Description of Evacuation Regions

Region	Description	Emergency Management Zone (EMZ)									
		1	2	3	4	5	6	7	8	9	10
R01	EMZ1	X									
R02	EMZ2		X								
R03	EMZ3			X							
R04	EMZ4				X						
R05	EMZ5					X					
R06	EMZ6						X				
R07	EMZ7							X			
R08	EMZ8								X		
R09	EMZ9									X	
R10	EMZ10										X
R11	Western Ashland - EMZ1, EMZ2, EMZ3, EMZ4	X	X	X	X						
R12	Eastern Ashland - EMZ5, EMZ6, EMZ7, EMZ8, EMZ9, EMZ10					X	X	X	X	X	X
R13	Northern Ashland - EMZ1, EMZ2, EMZ10	X	X								X
R14	Central Ashland - EMZ3, EMZ7, EMZ8, EMZ9			X				X	X	X	
R15	Southern Ashland - EMZ4, EMZ5, EMZ6				X	X	X				
R16	Northern and Central Ashland - EMZ1, EMZ2, EMZ3, EMZ7, EMZ8, EMZ9, EMZ10	X	X	X				X	X	X	X
R17	Southern and Central Ashland - EMZ3, EMZ4, EMZ5, EMZ6, EMZ7, EMZ8, EMZ9			X	X	X	X	X	X	X	
R18	All EMZ	X	X	X	X	X	X	X	X	X	X
EMZ(s) Shelter-in-Place						EMZ(s) Evacuate					

Table 6-2. Evacuation Scenario Definitions

Scenario	Season	Day of Week	Time of Day
1	Summer	Midweek	Midday
2	Summer	Weekend	Midday
3	Summer	Midweek, Weekend	Evening
4	Fall	Midweek	Midday
5	Fall	Weekend	Midday
6	Fall	Midweek, Weekend	Evening

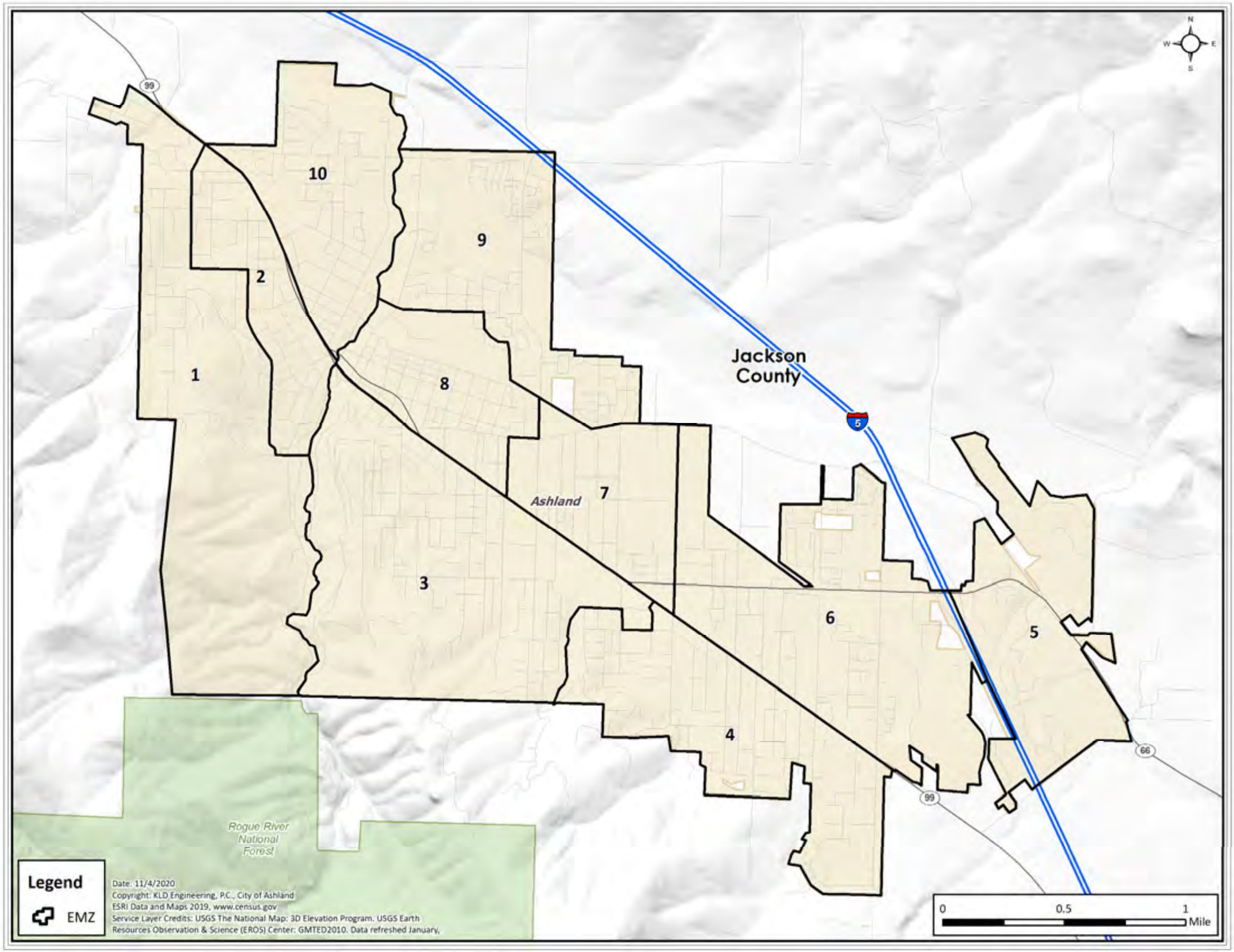
Table 6-3. Percent of Population Groups Evacuating for Various Scenarios

Scenario	Households With Returning Commuters	Households Without Returning Commuters	Employees	Tourists	Shadow	Medical Vehicles	On Campus Vehicles	Off Campus Vehicles	School/College Buses	Transit Buses	External Through Traffic
1	14%	86%	96%	55%	7%	100%	10%	10%	10%	100%	100%
2	1%	99%	10%	70%	6%	100%	0%	0%	0%	100%	100%
3	1%	99%	10%	100%	6%	100%	0%	0%	0%	100%	40%
4	14%	86%	100%	50%	7%	100%	100%	100%	100%	100%	100%
5	1%	99%	10%	65%	6%	100%	100%	0%	0%	100%	100%
6	1%	99%	10%	100%	6%	100%	100%	0%	0%	100%	40%

Resident Households with Commuters	**Households of EMZ residents who await the return of commuters prior to beginning the evacuation trip.**
Resident Households with No Commuters	**Households of EMZ residents who do not have commuters or will not await the return of commuters prior to beginning the evacuation trip.**
Employees	**Employees who live outside the EMZ but work within.**
Tourists	**People who are in the EMZ at the time of an event for recreational or other (non-employment) purposes.**
Shadow	**Residents and employees in the shadow region (outside of the EMZ) who will spontaneously decide to relocate during the evacuation. The basis for the values shown is a 6% relocation of shadow residents along with a proportional percentage of shadow employees.**
On Campus Vehicles	**Students who reside on campus within the EMZ that will evacuate using a private vehicle.**
Off Campus Vehicles	**Students who reside off campus within the EMZ that will evacuate using a private vehicle.**
Medical, School and Transit Buses	**Vehicle-equivalents present on the road during evacuation servicing medical facilities, schools and transit-dependent people (1 bus is equivalent to 2 passenger vehicles).**
External Through Traffic	**Traffic on interstates and major arterial roads at the start of the evacuation. This traffic is stopped by access control approximately 2 hours after the evacuation begins.**

Table 6-4. Vehicle Estimates by Scenario

Scenarios	Residents with Commuters	Residents without Commuters	Employees	Tourists	Shadow	Medical Vehicles	On Campus Vehicles	Off Campus Vehicles	School Buses	Transit Buses	External Traffic	Total Scenario Vehicles
1	1,921	11,745	2,086	1,239	449	56	51	392	17	8	8,412	26,376
2	192	13,473	217	1,576	396	56	-	-	-	8	8,412	24,330
3	192	13,473	217	2,252	396	56	-	-	-	8	3,365	19,959
4	1,921	11,745	2,173	1,126	451	56	510	3,915	172	8	8,412	30,489
5	192	13,473	217	1,464	396	56	-	-	-	8	8,412	24,218
6	192	13,473	217	2,252	396	56	-	-	-	8	3,365	19,959



Date: 11/4/2020
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation Program. USGS Earth Resources Observation & Science (EROS) Center: GMTED2010. Data refreshed January,

Figure 6-1. **EMZ Boundaries**

7 GENERAL POPULATION EVACUATION TIME ESTIMATES (ETE)

This section presents the ETE results of the computer analyses using the DYNEV II System described in Appendices B, C and D. These results cover 18 Evacuation Regions and the 6 Evacuation Scenarios discussed in Section 6.

The ETE for all Evacuation Cases are presented in Table 7-1 and Table 7-2. These tables present the estimated times to clear the indicated population percentages from the Evacuation Regions for all Evacuation Scenarios. Table 6-1 and Table G-1 defines the Evacuation Regions considered. The tabulated values of ETE are obtained from the DYNEV II System outputs which are generated at 5-minute intervals.

7.1 Voluntary Evacuation and Shadow Evacuation

"Voluntary evacuees" are people within the EMZ for which an Advisory to Evacuate has not been issued, yet who elect to evacuate. "Shadow evacuation" is the voluntary outward movement of some people from the Shadow Region for whom no evacuation order has been issued. Both voluntary and shadow evacuations are assumed to take place over the same time frame as the evacuation from within the impacted Evacuation Region.

Within the EMZ, 6 percent of permanent residents located outside of the evacuation region who are not advised to evacuate, are assumed to elect to evacuate. Similarly, it is assumed that 6 percent of those people in the Shadow Region will choose to leave the area.

Figure 7-1 presents the area identified as the Shadow Region. The Shadow Region was defined as the area beyond the EMZ including the City of Talent. The Shadow Region is bounded by the northern city limit of Talent to the north, the ridge line and the United States Forest Service (USFS) border to the west, a horizontal line connecting the USFS border to Emigrant Lake to the south, and the ridge line to the east. The population and number of evacuating vehicles in the Shadow Region were estimated using the same methodology that was used for permanent residents within the EMZ (see Section 3.1). As discussed in Section 3.2, it is estimated that a total of 10,099 people reside in the Shadow Region; 6 percent of them would evacuate. See Table 6-4 for the number of evacuating vehicles from the Shadow Region.

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

7.2 Patterns of Traffic Congestion during Evacuation

Figure 7-2 through Figure 7-7 illustrate the patterns of traffic congestion that arise for the case when all ten EMZs (Region R18) are advised to evacuate during a summer, midweek, midday period (Scenario 4).

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

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

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

Figure 7-2 displays the congestion patterns in the study area at just 30 minutes after the advisory to evacuate. Severe congestion has already developed on major evacuation routes, such as Siskiyou Blvd (OR-99) and Ashland St (OR-66), and many of the local roadways within the City of Ashland. The on ramps to I-5 have limited capacity and, as a result, meter traffic getting onto the interstate. For this reason, I-5 experiences little congestion. At this time, approximately 41% of vehicles have begun their evacuation trip and 15% of evacuating vehicles have successfully evacuated the area.

At one hour after the evacuation advisory, the City of Ashland experiences peak congestion, as shown in Figure 7-3. Much of the city experiences gridlock as the number of evacuating vehicles attempting to access OR-99 exceeds its capacity. It is important to note that traffic is moving, it is just moving slowly. Side streets experience congestion as they compete for green time at signalized intersections and look for acceptable gaps at stop and yield signs along OR-99. Ashland Road (OR-66) exhibits LOS F conditions in both east bound and west bound directions between I-5 and OR-99. East bound traffic along OR-66 exhibits LOS D conditions where there is access to I-5 provided by Freeway Ramps while west bound traffic continues to exhibit LOS F conditions from I-5 to where it meets Siskiyou Blvd (OR-99). Oak St leaving EMZ 9 is also significantly congested. I-5 continues to exhibit LOS B conditions due limited capacity ramps that meter the traffic entering the highway. At this time, approximately 72% of vehicles have begun their evacuation trip and approximately 28% of evacuating vehicles have successfully evacuated the area.

At two hours after the advisory to evacuate, as shown in Figure 7-4, congestion has dissipated along OR-66 between OR-99 and I-5, as well as along E Main St, but remains quite heavy along many of the roadways within EMZ 2, EMZ 3, EMZ 4, EMZ 9 and EMZ 10. OR-99 and OR-66 remain severely congested as vehicles continue utilizes these roadways to access I-5. The I-5 southbound freeway ramp from OR-99 continues to be a significant bottleneck causing traffic to back up all the way into the EMZ. At this time, all external traffic is assumed to be diverted. Oak St is still congested leaving the EMZ. Ninety-three percent (93%) of vehicles have begun their evacuation trip and 58% of evacuating vehicles have successfully evacuated out of the EMZs.

Congestion in the EMZ has dissipated quite a bit at three hours after the evacuation advisory, as shown in Figure 7-5. At this time, congestion has cleared along E Main St. Oak St is now operating at LOS C within EMZ 9. Congestion within downtown Ashland now only remains on a small section of Oak St and OR-99. Severe congestion, however, remains on OR-99 for most of the EMZ. Congestion persists on Crowson Rd eastbound due to the stop controlled intersection with OR-66. At this time, approximately 98% have mobilized, and 87% of evacuating vehicles have successfully evacuated the EMZs.

At 3 hours and 30 minutes after the advisory to evacuate, almost all congestion within the City of Ashland has dissipated, as shown in Figure 7-6. At this time, the only congestion remains at the intersection of University Way and OR-99 (due to the large number of commuting student at SOU and the stop controlled right turn only at this intersection) and Clay St southbound at the intersection with OR-66 (again due to a high demand and stop controlled intersection). OR-99 is operating at LOS C or better. OR-66 is operating at LOS D or better. The rest of the EMZ is clear of congestion. At this time, nearly all vehicles (99.8%) have mobilized, and 99% of evacuating vehicles have successfully evacuated the EMZs.

At four hours after the advisory to evacuate, all evacuees have mobilized and successfully evacuated the EMZ as no congestion remains within the EMZ, as shown in Figure 7-6.

7.3 Evacuation Rates

Evacuation is a continuous process, as implied by Figure 7-8 through Figure 7-13. These figures indicate the rate at which traffic flows out of the indicated areas for the case of an evacuation of all EMZs (Region R18) under the indicated conditions. One figure is presented for each scenario considered.

The distance between the trip generation and ETE curves is the travel time. Plots of trip generation versus ETE are indicative of the level of traffic congestion during evacuation. The evacuation population mobilize over four hours as discussed in Section 5. This disperses evacuees over a lengthy period of time, thus, as seen in Figure 7-8 through Figure 7-13, the maximum travel time experienced is approximately 85 minutes.

As indicated in these figures, there is typically a long "tail" to these distributions due to mobilization and not congestion. Vehicles begin to evacuate an area slowly at first, as people respond to the ATE at different rates. Then traffic demand builds rapidly (slopes of curves increase). As more routes clear, the aggregate rate of egress slows since many vehicles have already left the EMZs. Towards the end of the process, relatively few evacuation routes service the remaining demand.

This decline in aggregate flow rate, towards the end of the process, is characterized by these curves flattening and gradually becoming horizontal. Ideally, it would be desirable to fully saturate all evacuation routes equally so that all will service traffic near capacity levels and all will clear at the same time. For this ideal situation, all curves would retain the same slope until the end – thus minimizing evacuation time. In reality, this ideal is generally unattainable reflecting the spatial variation in population density, mobilization rates and in highway capacity over the study area.

7.4 Evacuation Time Estimate (ETE) Results

Table 7-1 and Table 7-2 present the ETE values for all 18 Evacuation Regions and all 6 Evacuation Scenarios.

Table	Contents
7-1	ETE represents the elapsed time required for 90 percent of the population within a Region, to evacuate from that Region. All Scenarios are considered.
7-2	ETE represents the elapsed time required for 100 percent of the population within a Region, to evacuate from that Region. All Scenarios are considered.

The animation snapshots described above reflect the ETE statistics for evacuation scenarios and regions, which are displayed in Figure 7-2 through Figure 7-7. Majority of the congestion is located on major evacuation routes, OR-66 and OR-99 that serve a majority of the evacuating population.

The 100th percentile ETE is 4:00 (Hours:Minutes) for all regions and scenarios. Since the trip generation time is 4 hours, an ETE of 4:00 implies that traffic congestion clears within the EMZs prior to the completion of mobilization time. A factor that significantly effects mobilization times are how quickly the public can be notified of an evacuation. This study assumed notification time of 45 minutes (see Section 5). If the evacuating population can be notified more quickly, this will truncate mobilization times and could reduce the 100th percentile ETE. Similarly, if it takes longer to notify the evacuation population, the 100th percentile ETE will be longer and will likely be equal to the longer trip mobilization time. Appendix J discusses how sensitive the ETE are to changes in mobilization time.

The 90th percentile ETE ranges between 1:20 (Hours:Minutes) and 3:10 (Hours:Minutes) for all regions and scenarios.

When the EMZs evacuate alone, the ETE is 1 hour and 55 minutes, on average. EMZ 4 (Region R04) has the longest ETE when comparing against other EMZ-only evacuations (Regions R01 through R10), specifically for midweek, midday scenarios. This is due to an anomaly caused by the composition of demand for this region. As shown in Table 3-11, this EMZ has the third highest number of residents and the second lowest number of employees and tourists combined. As discussed in Section 5, residents awaiting the return of a commuter have the longest mobilization times and employees/tourists have the shortest. Since this EMZ has the third most 'slowest mobilizers' and the second least 'fastest mobilizers', it actually takes longer to reach the 90th percentile ETE. As a result, EMZ 4 has the longest 90th percentile ETE despite having a moderate amount of total evacuating vehicles.

Alternatively, EMZ 5 has the shortest ETE when comparing against Regions R01 through R10. This EMZ has the lowest total number of evacuating vehicles, and has more tourists (fast mobilizers) than residents (slow mobilizers).

When looking at Regions R11 through R18, regions wherein EMZs evacuate together, Scenario 4 has the longest ETE, specifically for Regions wherein EMZ 3 and EMZ 7, and/or EMZ 4, evacuate. This is directly caused by the large number of commuting students evacuating from SOU.

7.5 Guidance on Using ETE Tables

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

1. Identify the applicable **Scenario**:
   - Season
     - Summer
     - Fall
   - Day of Week
     - Midweek
     - Weekend
   - Time of Day
     - Midday
     - Evening

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

   - The seasons are defined as follows:
     - Summer assumes that public schools are not in session.
     - Fall considers that public schools are in session.
   - Time of Day: Midday implies the time over which most commuters are at work or are travelling to/from work.
2. With the desired percentile ETE and Scenario identified, now identify the **Evacuation Region**:
   - Determine which EMZ or combination of EMZs need to evacuate from Table 6-1:

    - Individual EMZs (R01 through R10)
    - Groupings/Combinations of EMZs (Region R11 through R18)
3. Determine the **ETE Table** based on the **percentile** selected**.** Then, for the **Scenario** identified in Step 1 and the **Region** identified in Step 2, proceed as follows:
    - The columns of Table 7-1 and Table 7-2 are labeled with the Scenario numbers. Identify the proper column in the selected Table using the Scenario number defined in Step 1.
    - Identify the row in this table that provides ETE values for the Region identified in Step 2.
    - The unique data cell defined by the column and row so determined contains the desired value of ETE expressed in Hours:Minutes.

<u>Example</u>

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

- Wednesday, October 14th at 12:00 PM.
- It is sunny.
- The wildfire threatens northern Ashland only.
- The desired ETE is that value needed to evacuate 90 percent of the population from within the impacted Region.

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

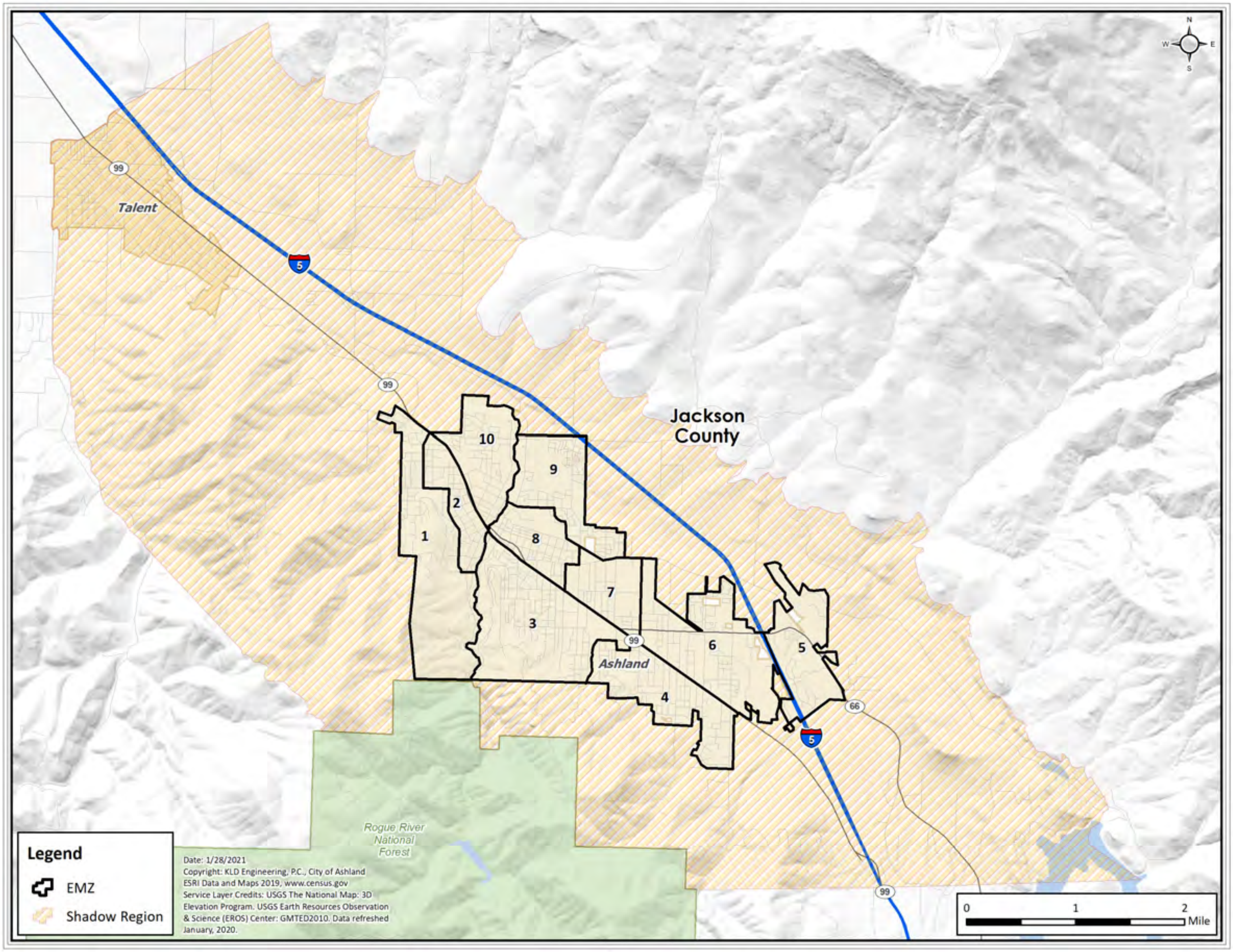
1. Identify the Scenario as fall, midweek, midday conditions. Entering Table 7-1, it is seen that this combination of circumstances describes Scenario 4.
2. In Table 6-1, locate the Region that has northern Ashland only, Region R13.
3. In Table 7-1, locate the data cell containing the value of ETE for Scenario 4 and Region R13. This data cell is in column (4) and in the row for Region R13; it contains the ETE value of 2:00.

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

	Summer			Fall		
	Midweek	Weekend	Midweek Weekend	Midweek	Weekend	Midweek Weekend
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Region	**Midday**	**Midday**	**Evening**	**Midday**	**Midday**	**Evening**
R01 – EMZ 1	1:55	1:45	1:40	1:55	1:45	1:40
R02 – EMZ 2	1:55	1:50	1:45	1:55	1:50	1:45
R03 – EMZ 3	1:40	1:50	1:45	1:35	1:50	1:45
R04 – EMZ 4	2:00	1:55	1:55	2:00	1:55	1:55
R05 – EMZ 5	1:30	1:25	1:20	1:30	1:30	1:20
R06 – EMZ 6	1:50	1:50	1:50	1:45	1:50	1:50
R07 – EMZ 7	1:50	1:50	1:50	1:50	1:50	1:50
R08 – EMZ 8	1:50	1:55	1:50	1:50	1:55	1:50
R09 – EMZ 9	1:55	1:50	1:50	1:55	1:50	1:50
R10 – EMZ 10	1:55	1:55	1:55	1:55	1:55	1:55
R11 - Western Ashland	1:50	1:50	1:45	1:35	1:50	1:45
R12 - Eastern Ashland	1:50	1:50	1:50	1:55	1:50	1:50
R13 - Northern Ashland	2:00	1:55	1:50	2:00	1:55	1:50
R14 - Central Ashland	1:45	1:50	1:45	2:30	1:50	1:45
R15 - Southern Ashland	2:05	1:55	1:55	2:45	1:55	1:55
R16 - Northern and Central Ashland	1:55	1:50	1:50	2:30	1:50	1:50
R17 - Southern and Central Ashland	1:55	1:50	1:50	1:50	1:50	1:50
R18 - All EMZs	2:35	2:25	2:15	3:10	2:25	2:20

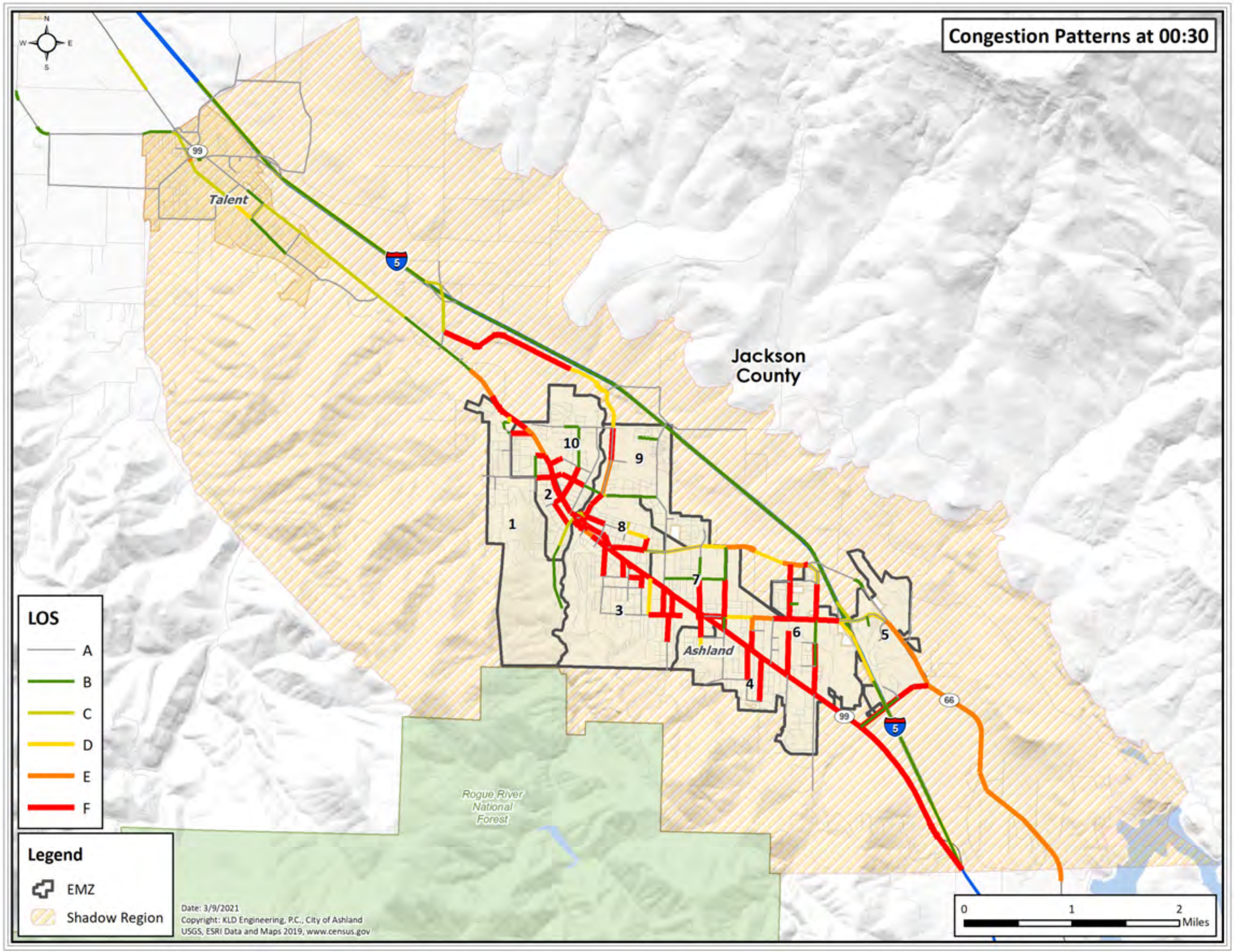
Table 7-2. Time to Clear the Indicated Area of ***100*** Percent of the Affected Population

	Summer			Fall		
	Midweek	Weekend	Midweek Weekend	Midweek	Weekend	Midweek Weekend
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Region	**Midday**	**Midday**	**Evening**	**Midday**	**Midday**	**Evening**
R01 – EMZ 1	4:00	4:00	4:00	4:00	4:00	4:00
R02 – EMZ 2	4:00	4:00	4:00	4:00	4:00	4:00
R03 – EMZ 3	4:00	4:00	4:00	4:00	4:00	4:00
R04 – EMZ 4	4:00	4:00	4:00	4:00	4:00	4:00
R05 – EMZ 5	4:00	4:00	4:00	4:00	4:00	4:00
R06 – EMZ 6	4:00	4:00	4:00	4:00	4:00	4:00
R07 – EMZ 7	4:00	4:00	4:00	4:00	4:00	4:00
R08 – EMZ 8	4:00	4:00	4:00	4:00	4:00	4:00
R09 – EMZ 9	4:00	4:00	4:00	4:00	4:00	4:00
R10 – EMZ 10	4:00	4:00	4:00	4:00	4:00	4:00
R11 - Western Ashland	4:00	4:00	4:00	4:00	4:00	4:00
R12 - Eastern Ashland	4:00	4:00	4:00	4:00	4:00	4:00
R13 - Northern Ashland	4:00	4:00	4:00	4:00	4:00	4:00
R14 - Central Ashland	4:00	4:00	4:00	4:00	4:00	4:00
R15 - Southern Ashland	4:00	4:00	4:00	4:00	4:00	4:00
R16 - Northern and Central Ashland	4:00	4:00	4:00	4:00	4:00	4:00
R17 - Southern and Central Ashland	4:00	4:00	4:00	4:00	4:00	4:00
R18 - All EMZs	4:00	4:00	4:00	4:00	4:00	4:00



Date: 1/28/2021
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation Program. USGS Earth Resources Observation & Science (EROS) Center: GMTED2010. Data refreshed January, 2020.

Figure 7-1. Study Area Shadow Region



Date: 3/9/2021
Copyright: KLD Engineering, P.C., City of Ashland
USGS, ESRI Data and Maps 2019, www.census.gov

Figure 7-2. Congestion Patterns at 30 Minutes after the Advisory to Evacuate

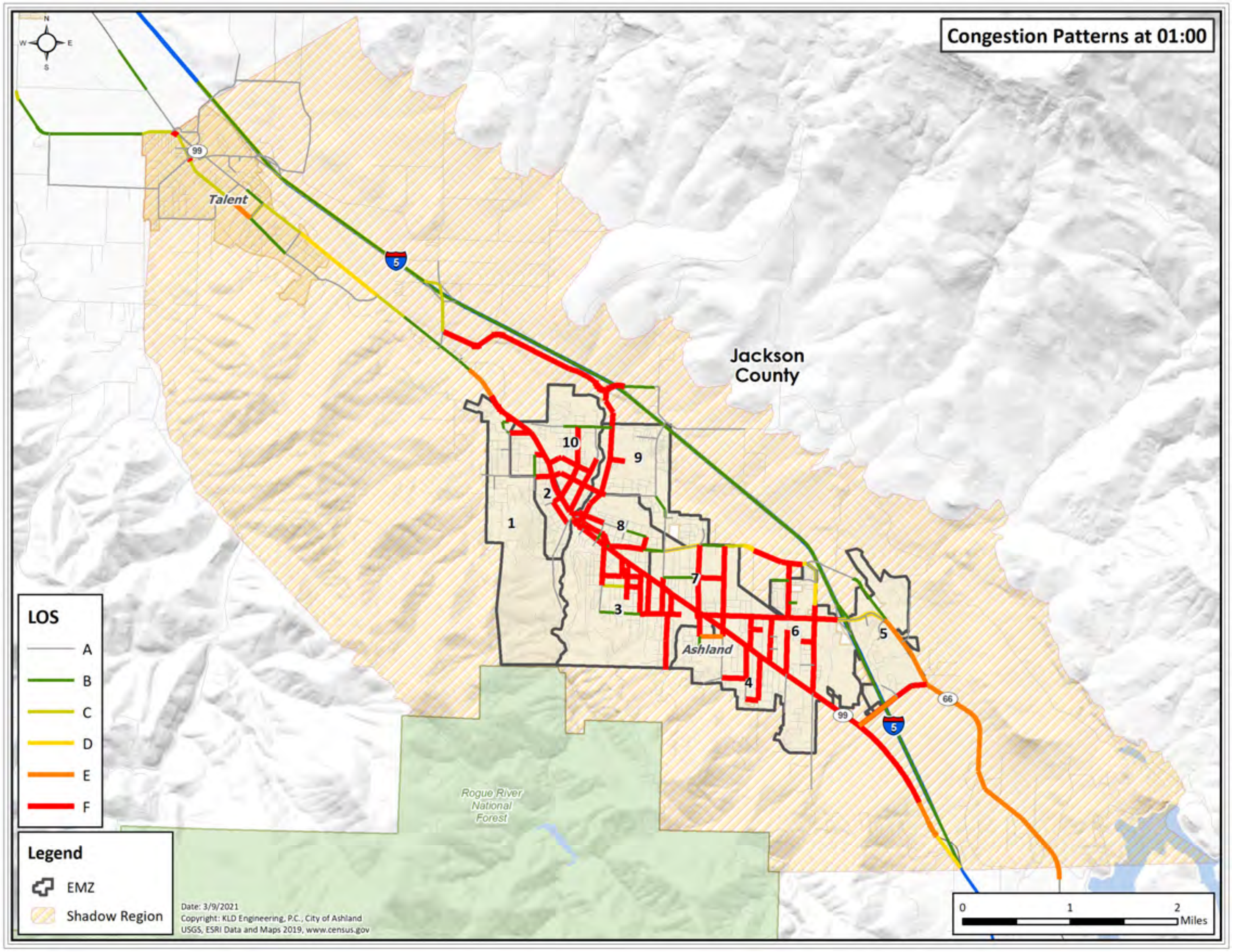


Figure 7-3. Congestion Patterns at 1 Hour after the Advisory to Evacuate

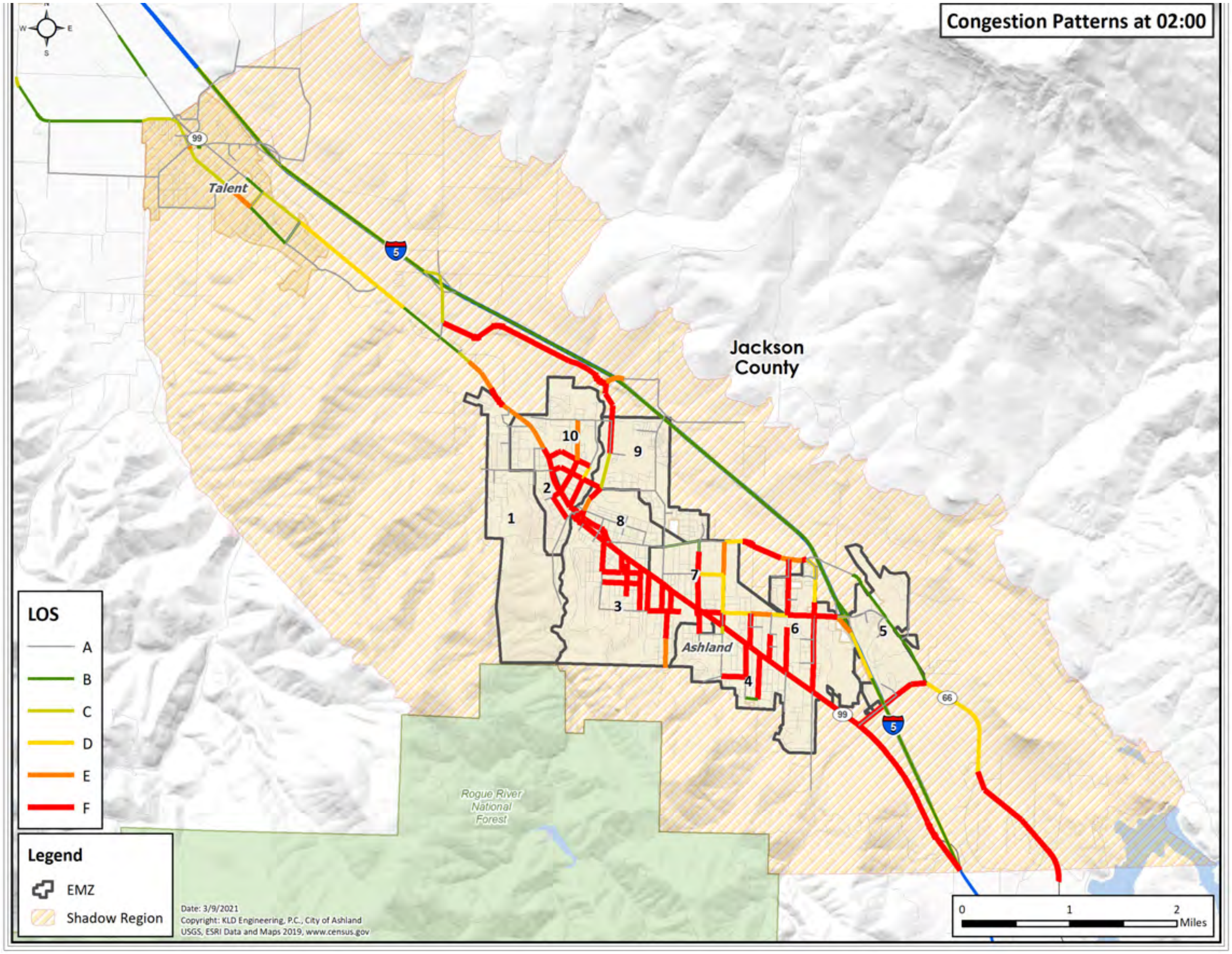
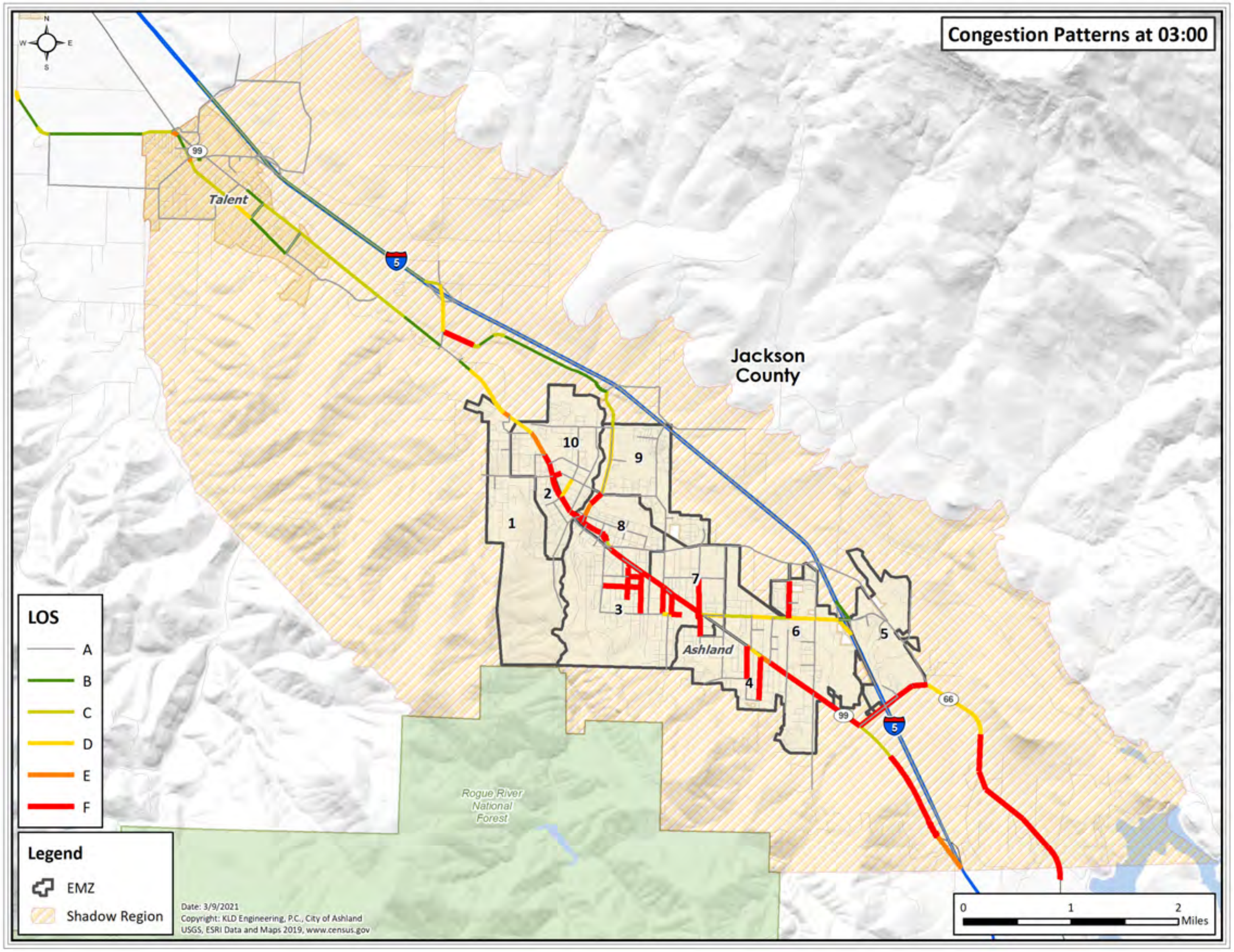
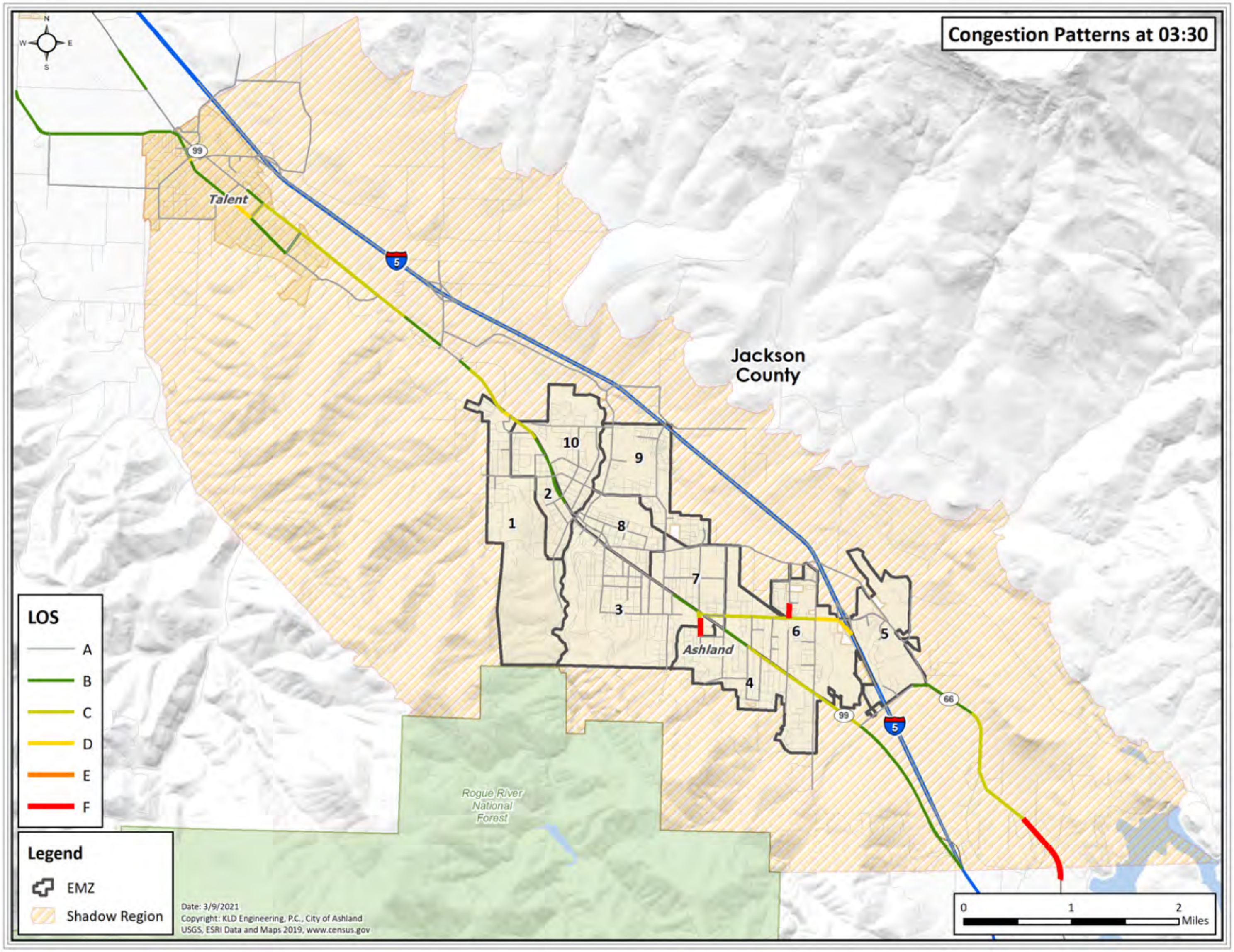


Figure 7-4. Congestion Patterns at 2 Hours after the Advisory to Evacuate



Date: 3/9/2021
Copyright: KLD Engineering, P.C., City of Ashland
USGS, ESRI Data and Maps 2019, www.census.gov

Figure 7-5. Congestion Patterns at 3 Hours after the Advisory to Evacuate



Date: 3/9/2021
Copyright: KLD Engineering, P.C., City of Ashland
USGS, ESRI Data and Maps 2019, www.census.gov

Figure 7-6. Congestion Patterns at 3 Hours and 30 Minutes after the Advisory to Evacuate

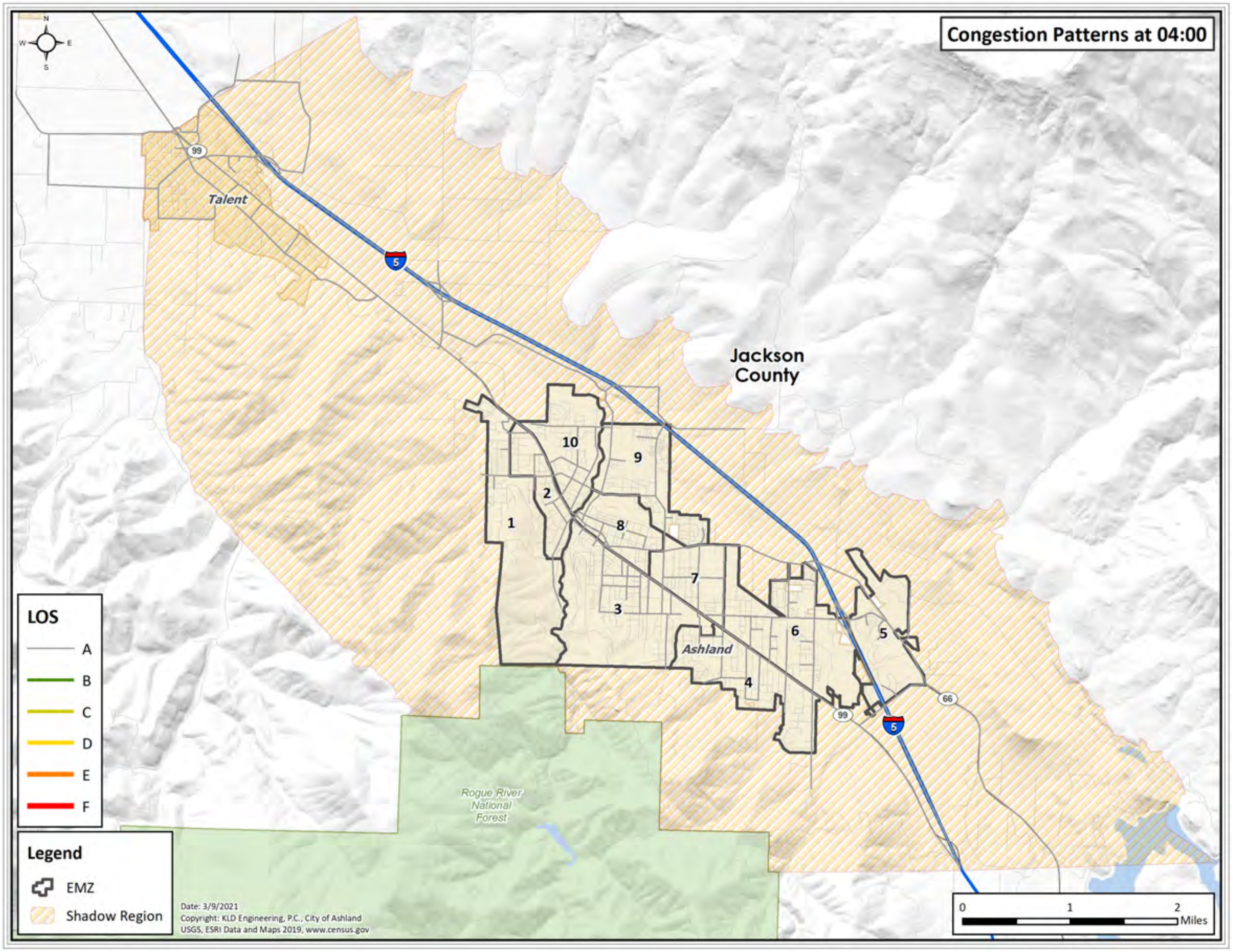


Figure 7-7. Congestion Patterns at 4 Hours after the Advisory to Evacuate

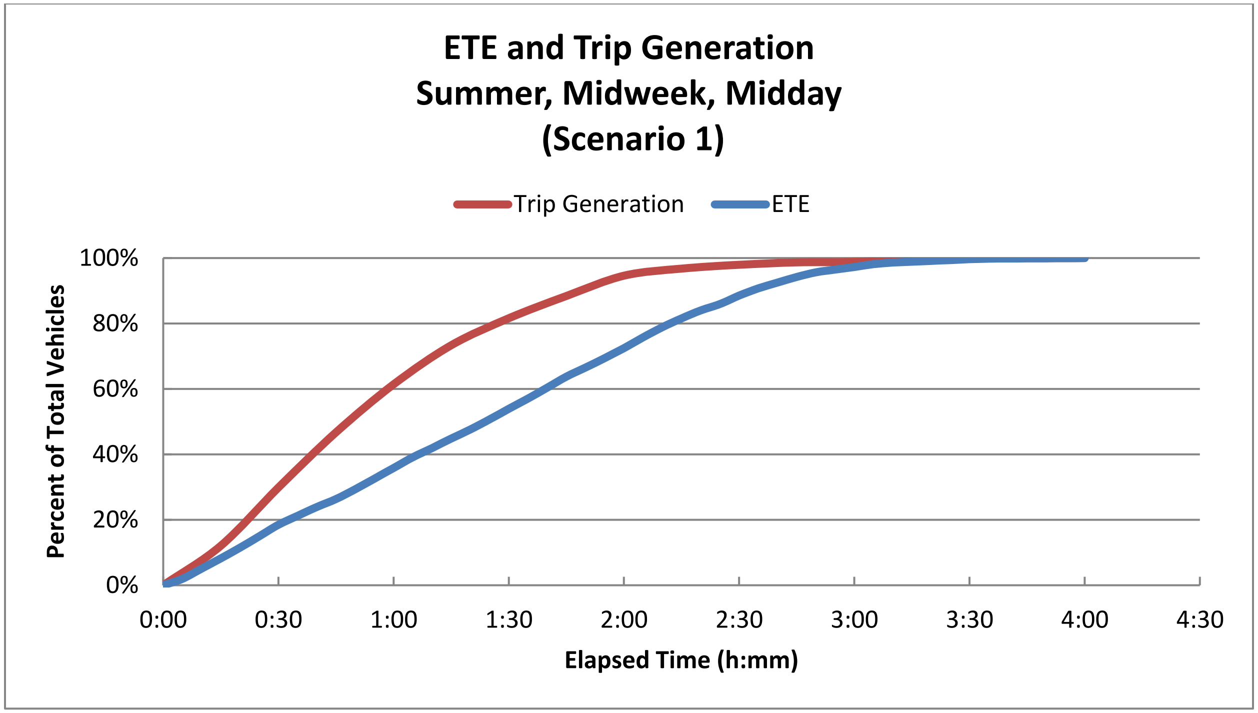


Figure 7-8. Evacuation Time Estimates - Scenario 1 for Region R18

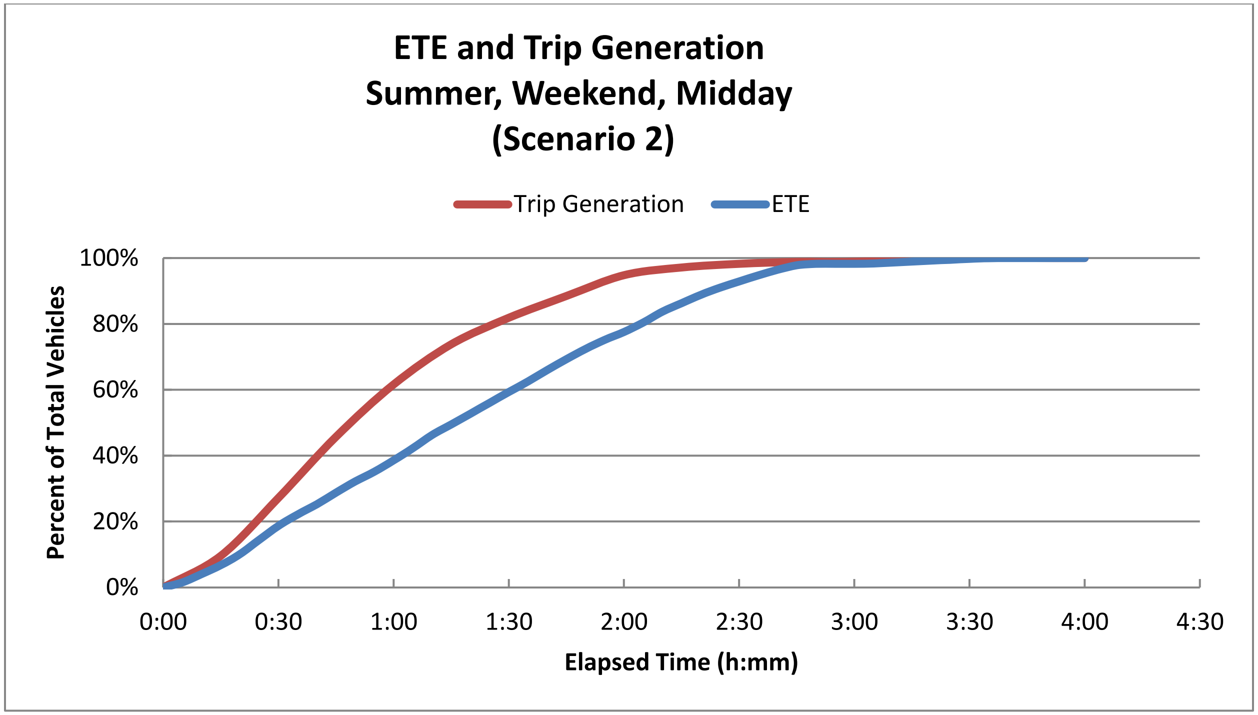


Figure 7-9. Evacuation Time Estimates - Scenario 2 for Region R18

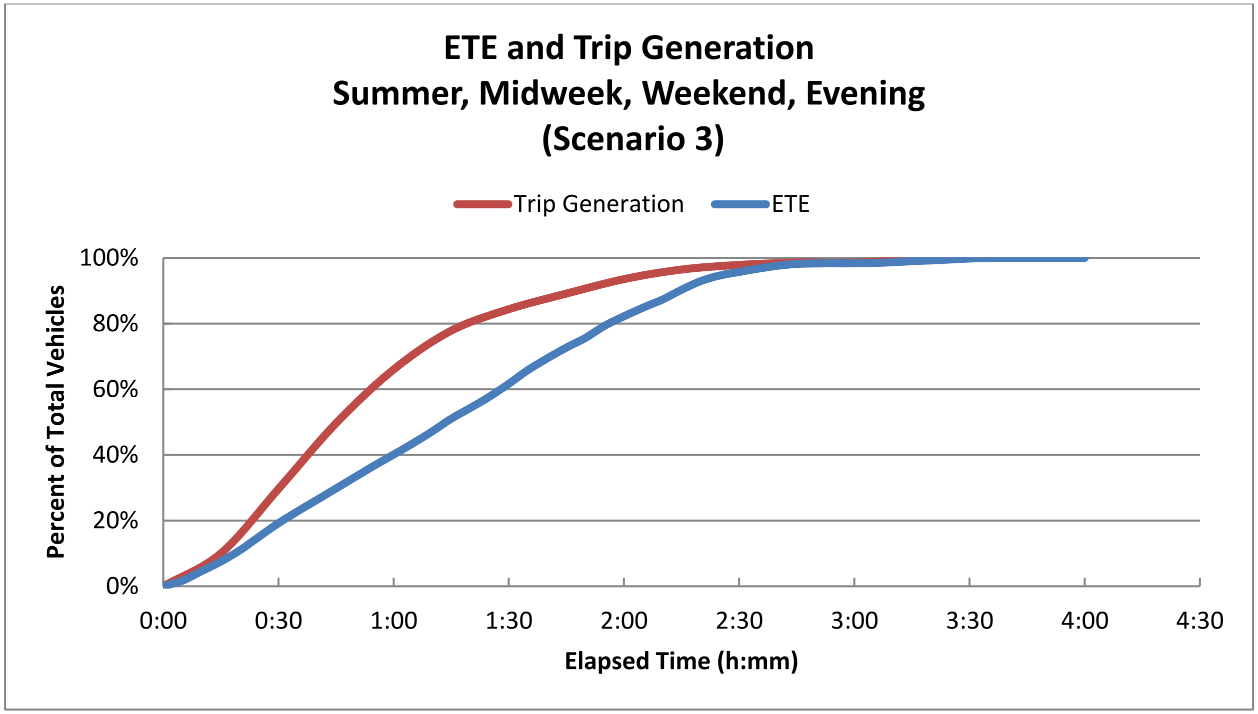


Figure 7-10. Evacuation Time Estimates - Scenario 3 for Region R18

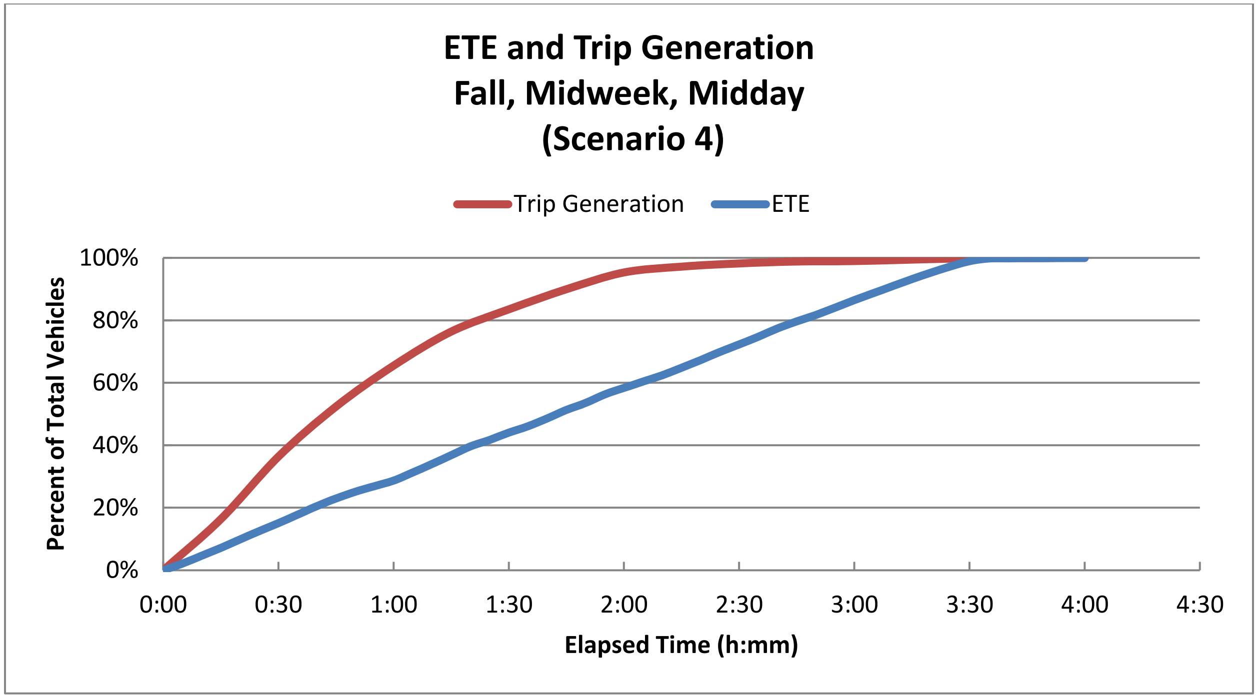


Figure 7-11. Evacuation Time Estimates - Scenario 4 for Region R18

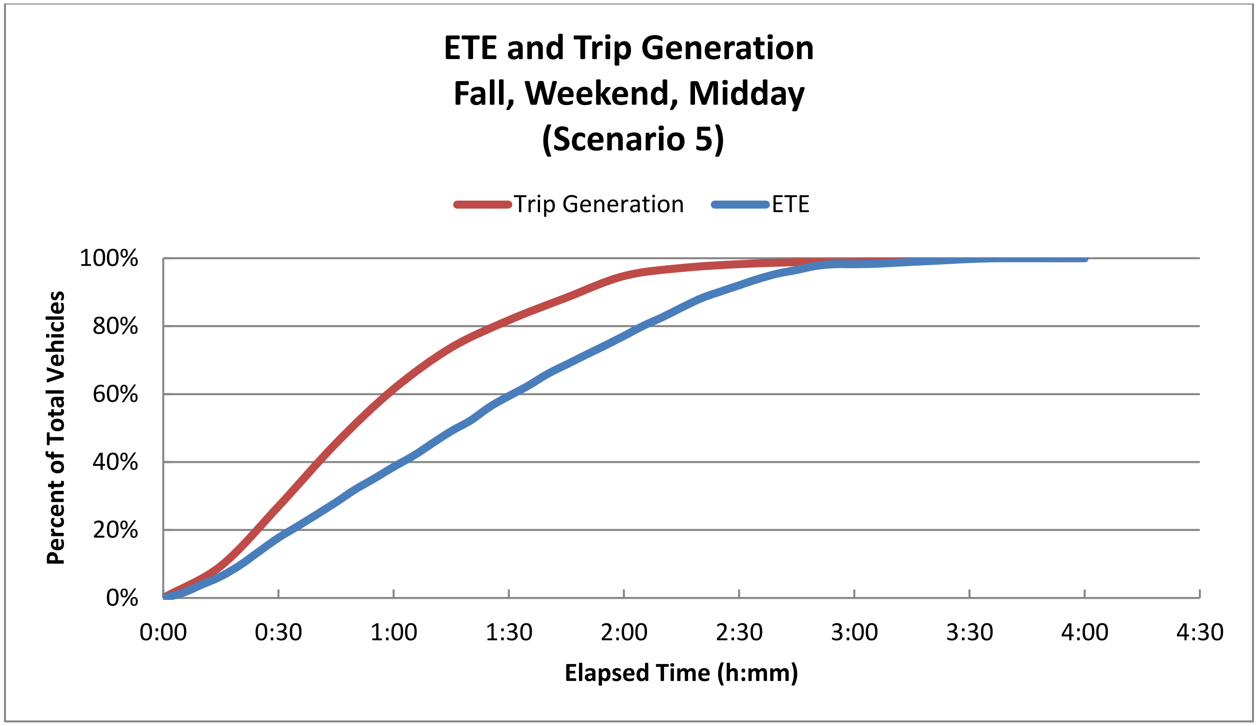


Figure 7-12. Evacuation Time Estimates - Scenario 5 for Region R18

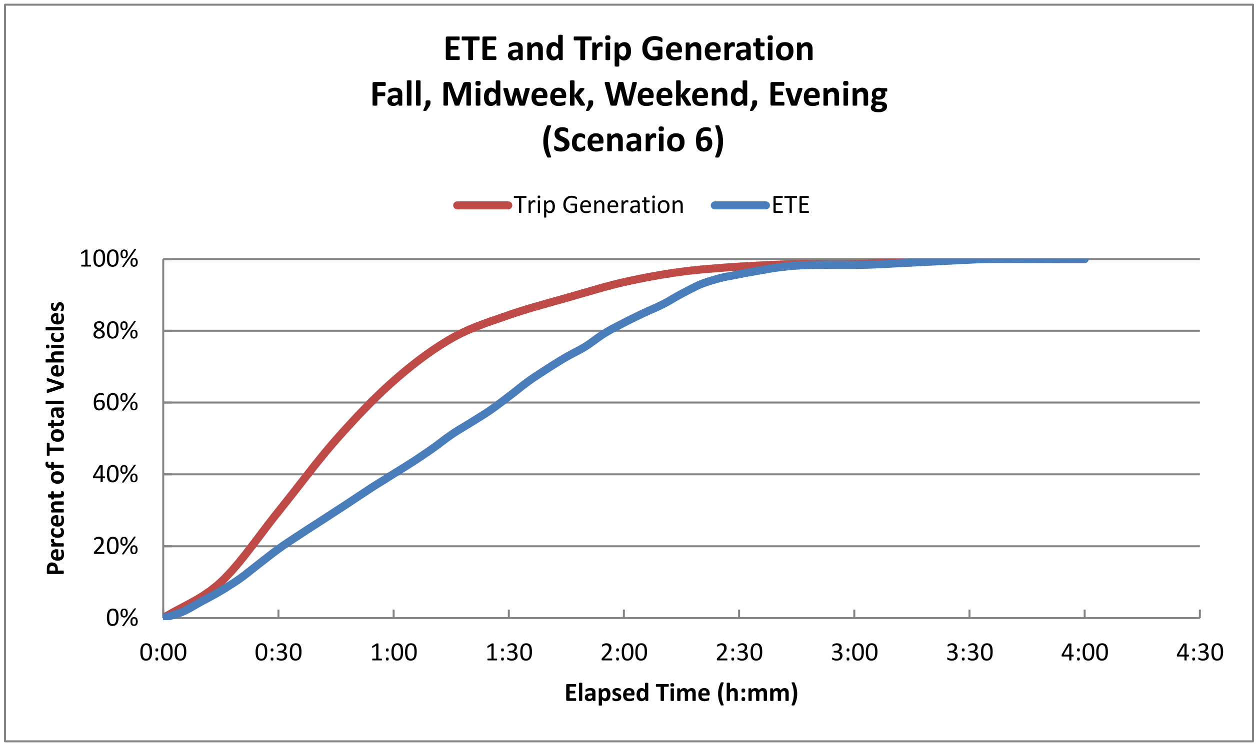


Figure 7-13. **Evacuation Time Estimates - Scenario 6 for Region R18**

8 ACCESS IMPAIRED NEIGHBORHOODS

This section details the analyses of access impaired neighborhoods within and in proximity to the City of Ashland. Access impaired neighborhoods are areas that could have difficulty evacuating during a wildfire emergency due to limited or narrow evacuation routes, traffic bottlenecks, extremely low traffic flow, etc. These neighborhoods are at a higher risk during an evacuation and should be given special consideration when planning for emergencies that require evacuation.

In June 2020, Ashland Fire and Rescue (AFR) teamed with The Wildfire Research Center (WiRē) to perform a Rapid Wildfire Risk Assessment (RA) of the properties within the City of Ashland[1]. The RA considered a number of risk factors associated with wildfires, including access (address posting, ingress/egress, driveway width, and driveway length), background conditions (distance to dangerous topography, slope, and parcel exposure), defensible space (defensible space and other combustibles), and home ignition potential (roof, siding, and attachments). The RA was conducted at the parcel level for properties within the City of Ashland. As such, the analysis does not include those properties and neighborhoods just outside of the city limits that could be considered access impaired. The following approach was used to determine the access impaired neighborhoods within and in proximity to the City of Ashland.

8.1 Data Sources

The following datasets were used to determine which neighborhoods are access impaired:

Inside the city limits

In 2018, AFR collected RA data for the 6,799 parcels within the city limits. The data collected by the AFR was assessed for 31 wildfire-vulnerability related attributes.

Outside the city limits

- Address points for Jackson County from the Oregon GIS Portal[2]. These address points represent the actual locations of structures and/or parcels.
- Tax lots (aka parcels) for Jackson County from the Oregon GIS Portal[3]. The tax lot data includes property type and vacancy information which was used to select the resident address points. The tax lot was also used to determine neighborhood boundaries.
- ESRI street network was used for network analysis in GIS to calculate the approximate driving distance for each neighborhood. This data was used to help identify which areas have limited ingress/egress routes.

---

[1] The Wildfire Research Center Memorandum, dated June 29, 2020, subject titled "Rapid Wildfire Risk Assessment Data Scoring".

[2] https://gis.jacksoncounty.org/datasets/address-point

[3] https://gis.jacksoncounty.org/datasets/tax-lots?geometry=-127.983%2C41.783%2C-117.530%2C43.201

- Wildfire risk dataset from Oregon Explorer Natural Resources Digital Library[4]. Data layers – *Wildfire Risk to People and Property*[5] and *Estimated Housing Density*[6] – were used to select the neighborhoods with relatively high wildfire risks and high density residential areas.

8.2 Analysis

The following methodology was used to determine which neighborhoods are access impaired within and in proximity to the City of Ashland:

Inside the city limits

1. Each RA attribute was assigned a weighting factor and an overall risk rating based on the adjusted WiRē's scoring approach[7]. Table 1 shows the overall risk rating was used to categorize each parcel.
2. For this analysis, any parcels categorized as "Very High" or "Extreme" were considered to be access impaired. The results of the RA are displayed in Figure 8-1, represented by parcel centroids. As shown in the figure, the majority of the access impaired neighborhoods within the city limits are along the ridgeline to the south of the city.

Outside the city limits

1. *Neighborhoods with low population densities were eliminated.* Tax lots define the boundaries of residential areas; however, some tax lots, especially those in urban area are too small to be used as neighborhoods. Therefore, the tax lots were first aggregated to map books, which have a more reasonable scale to be considered as neighborhoods, as shown in Figure 8-2. For example, the size of the map book in an urban area is generally smaller than the size of a map book in a suburban or rural area. Next, these aggregated tax lots (neighborhoods) were then superimposed with the *Estimated Housing Density* layer. The neighborhoods in low density residential areas were eliminated, as shown in Figure 8-3. At the end of this step, 144 neighborhoods remained.
2. *Neighborhoods with low wildfire risks were removed.* The 144 neighborhoods with medium to high housing densities were superimposed with the *Wildfire Risk to People and Property* data, as shown in Figure 8-4. The neighborhoods in low wildfire risk areas were removed from the analysis. At the end of this step, 141 neighborhoods remained.
3. *Identified the neighborhoods with limited means of egress.* First, the resident address points were aggregated to one central point per neighborhood, as shown in Figure 8-5. This representative point represents the "origin" of the neighborhood for the network analysis in GIS. A network analysis was performed using the ESRI street data to determine the amount of roadway miles that could be driven from each origin (neighborhood) within 10 minutes[8]. Then a statistical analysis was performed on the resulting roadway mileage for each neighborhood from the network

---

[4] https://tools.oregonexplorer.info/OE_HtmlViewer/index.html?viewer=wildfireplanning#

[5] *Wildfire Risk to People and Property* is the product of the likelihood and consequence of wildfire on housing unit density (Where People Live) and US Forest Service (USFS) private inholdings. This dataset considers the likelihood of fire (likelihood of burning), the susceptibility of assets to wildfire of different intensities, and the likelihood of those intensities.

[6] *Estimated Housing Density* is from the Oakridge National Laboratory LandScan™ population data and was obtained from the 2013 West Wide Wildfire Risk Assessment. It was developed by integrating high-resolution nighttime lights imagery and local spatial data to identify population distributions. At approximately 1 km resolution, LandScan™ represents an ambient population (an average over 24 hours). Housing densities range from less than 1 housing unit per 40 acres, up to more than 3 housing units per acre. Areas that are outside of urban cores and adjacent to and within wildland vegetation are of primary concern in wildfire management.

[7] For detailed information of the methodology, please refer to the WiRē Memorandum.

[8] The average drive time to exit the city and its surrounding residential areas under normal conditions is within 10 minutes. As such, 10 minutes was chosen as the threshold for the network analysis.

analysis. The mean and standard deviation were computed from the data. Based on the empirical rule, almost all observed data falls within three standard deviations from the mean for a normal distribution. Using this rule as our basis, we looked at those neighborhoods that fell beyond 1, 2, and 3 standard deviations from the mean. All of the data fell within 3 standard deviations. All but 2 neighborhoods fell within 2 standard deviations. Lastly, all but 16 neighborhoods fell within 1 standard deviation. (Meaning 16 neighborhoods fall beyond 1 standard deviation from the mean.) These 16 'outlier' neighborhoods have less roadway milage within a 10 minute driving time than the remaining 125 neighborhoods. So, in comparison to the rest of the neighborhoods in the analysis, these 16 neighborhoods are considered to have limited means of egress. Among the 16 access impaired neighborhoods, 11 of them are outside of the city limits.

4. *The neighborhood boundaries from Step 3 were refined.* Large portions of uninhabited areas (based on aerial imagery and resident address points) were removed from the boundaries of the 11 neighborhoods. Figure 8-6 shows the 11 neighborhoods, with refined boundaries, that were selected as access impaired neighborhoods outside of the city limits.

Figure 8-7 shows the results of both the inner and outer city limits access impaired neighborhood analysis. The RA results have been aggregated into map books, to be consistent with the outer city limits analysis, The median overall risk score has been assigned to map books that contain multiple scores.

8.3 ETE Results, Safe Refuge Areas, and Evacuation Signage

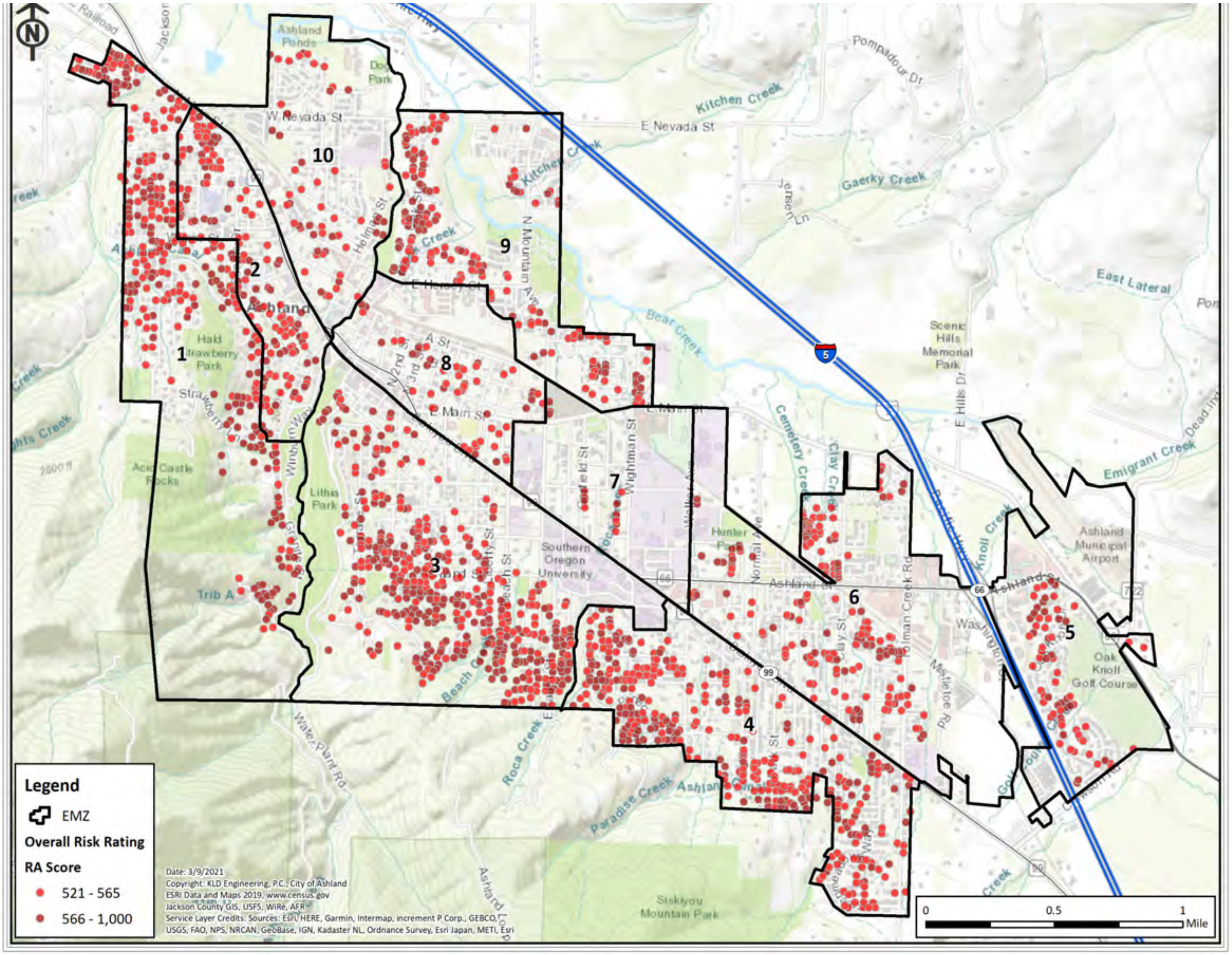
Under a fall weekday, midday scenario for an evacuation of all EMZs (worst case scenario), it takes all of these areas 3 hours and 30 minutes to clear of congestion, as shown in Figure 7-6. These areas can be fully evacuated in 4 hours. Depending on the wildfire situation at hand, these neighborhoods may require early notification to have sufficient time to evacuate before their safety is at risk.

Given the extent of the area considered as access impaired, no safe refuge areas large enough to safely hold this many people, in a centralized location, could be identified.

Consideration should be given regarding placement of evacuation signage, in accordance with the MUTCD (see Section 11.3), along Frank Hill Rd, Ashland Mine Rd, Granite St, Ashland Loop Rd, Morton St, Terrace St, Elkader St, Highwood Dr, Pinecrest Terrace, Timberlake Dr, Emigrant Creek Rd, and E Nevada St to guide evacuees out of these neighborhoods.

Table 1. Overall Risk Rating

Risk Level	Minimum Score	Maximum Score
Low	30	320
Moderate	321	425
High	426	520
Very High	521	565
Extreme	566	1,000



Date: 3/9/2021
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Jackson County GIS, USFS, WiRe, AFR
Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri

Figure 8-1. Access Impaired Neighborhoods with the City Limits

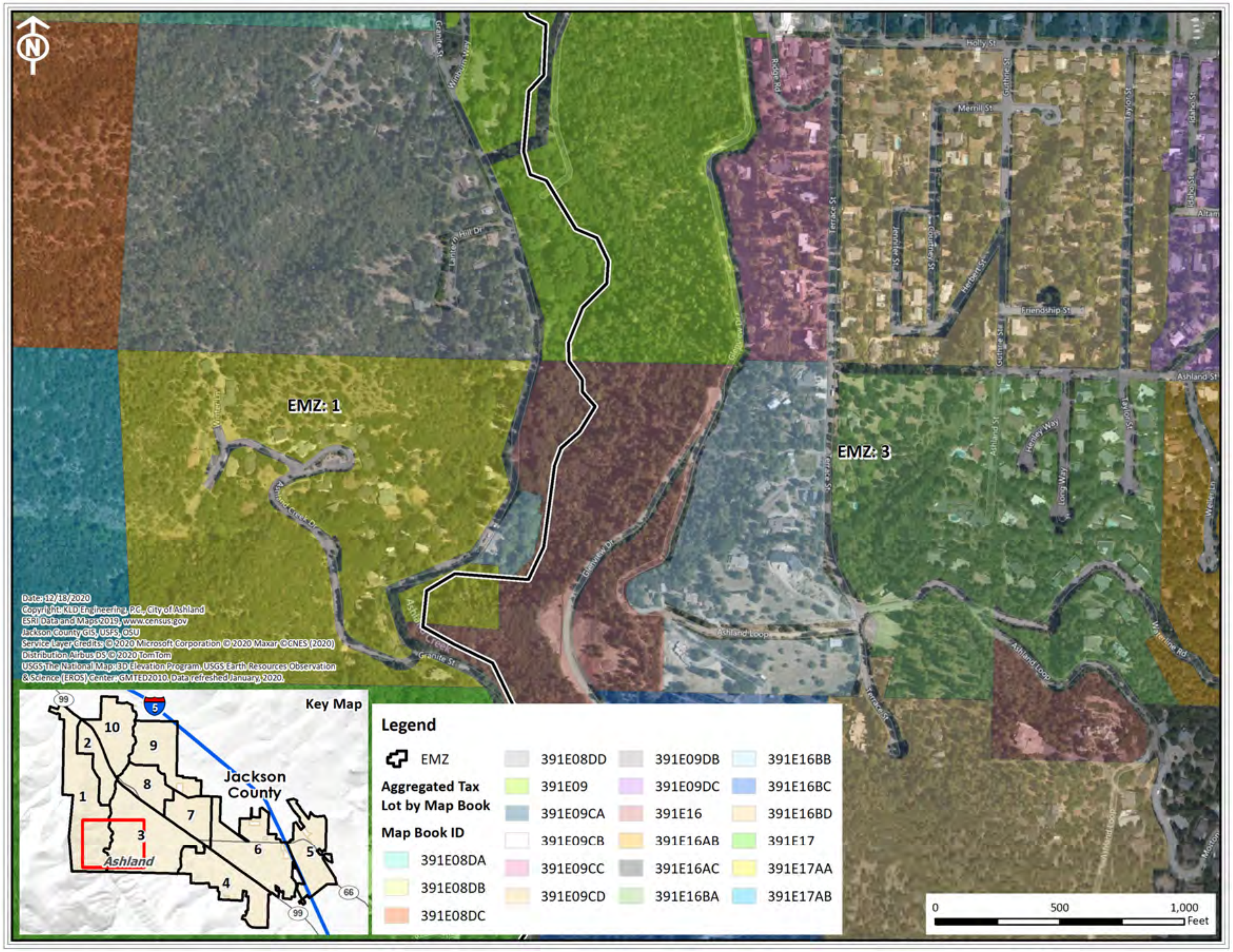
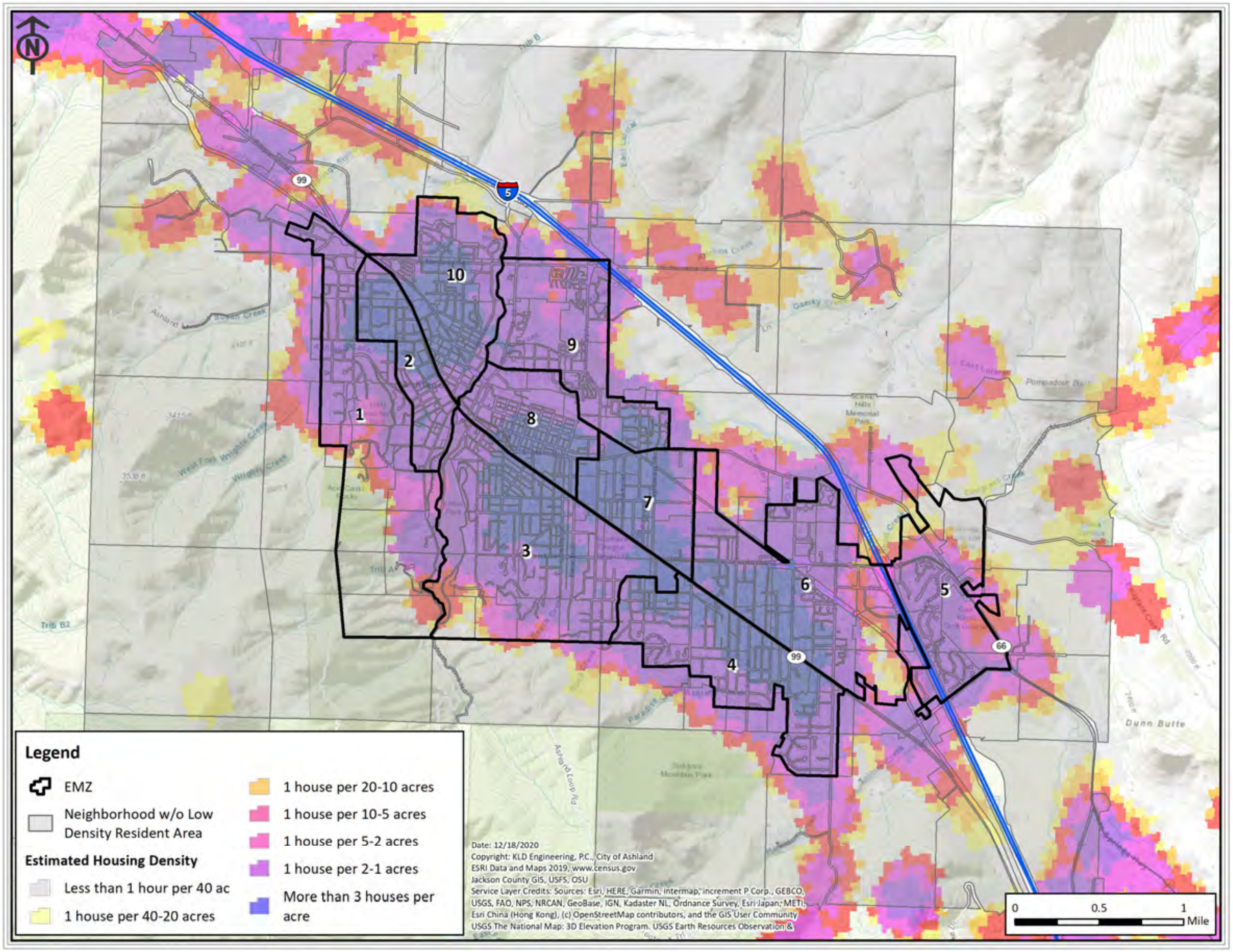
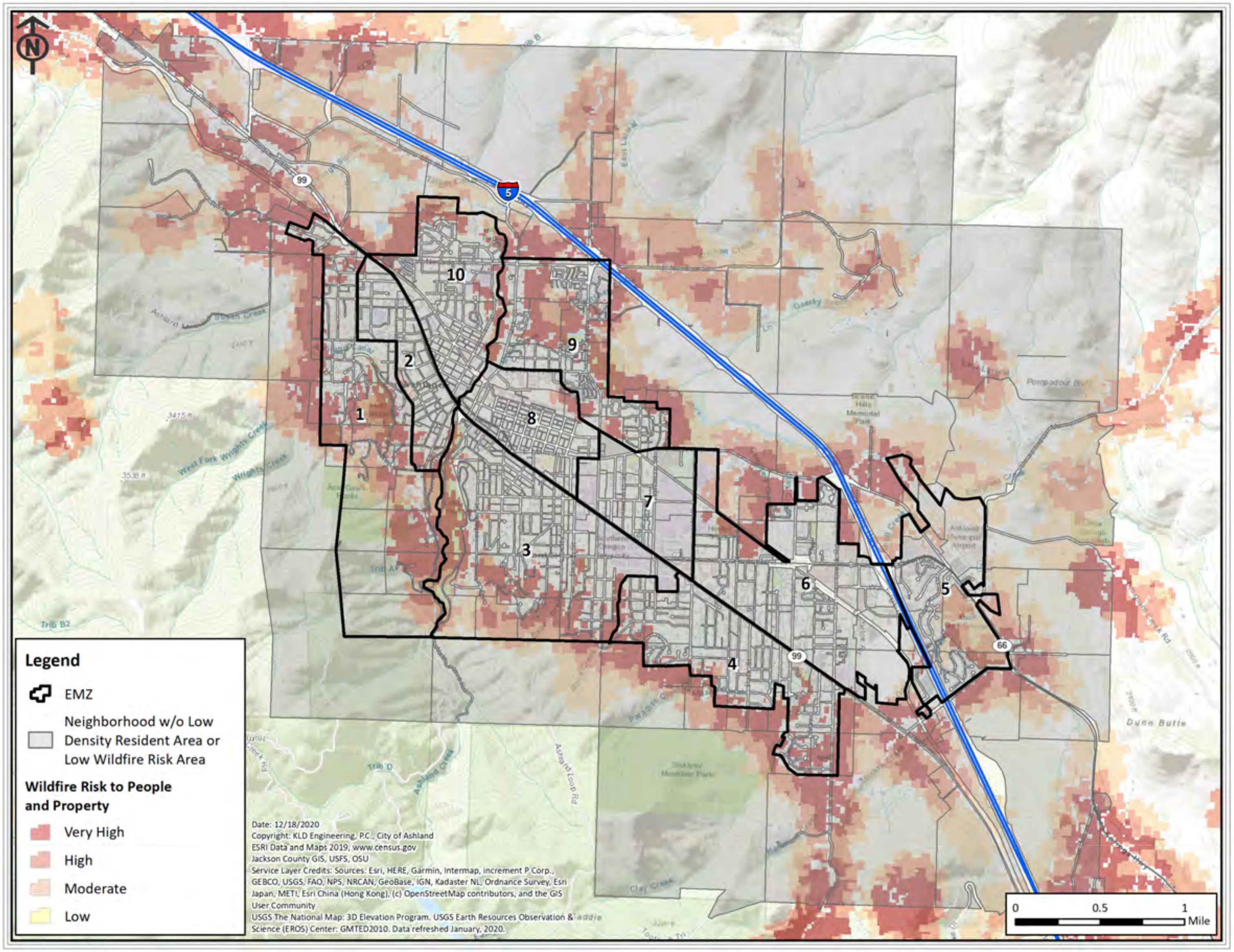


Figure 8-2. Aggregated Tax Lots



Date: 12/18/2020
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Jackson County GIS, USFS, OSU
Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
USGS The National Map: 3D Elevation Program. USGS Earth Resources Observation &

Figure 8-3. Neighborhoods without Low Density Resident Areas



Date: 12/18/2020
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Jackson County GIS, USFS, OSU
Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
USGS The National Map: 3D Elevation Program. USGS Earth Resources Observation & Science (EROS) Center: GMTED2010. Data refreshed January, 2020.

Figure 8-4. Neighborhoods without Low Density Resident Areas and Moderate to Very High Wildfire Risk to People and Property

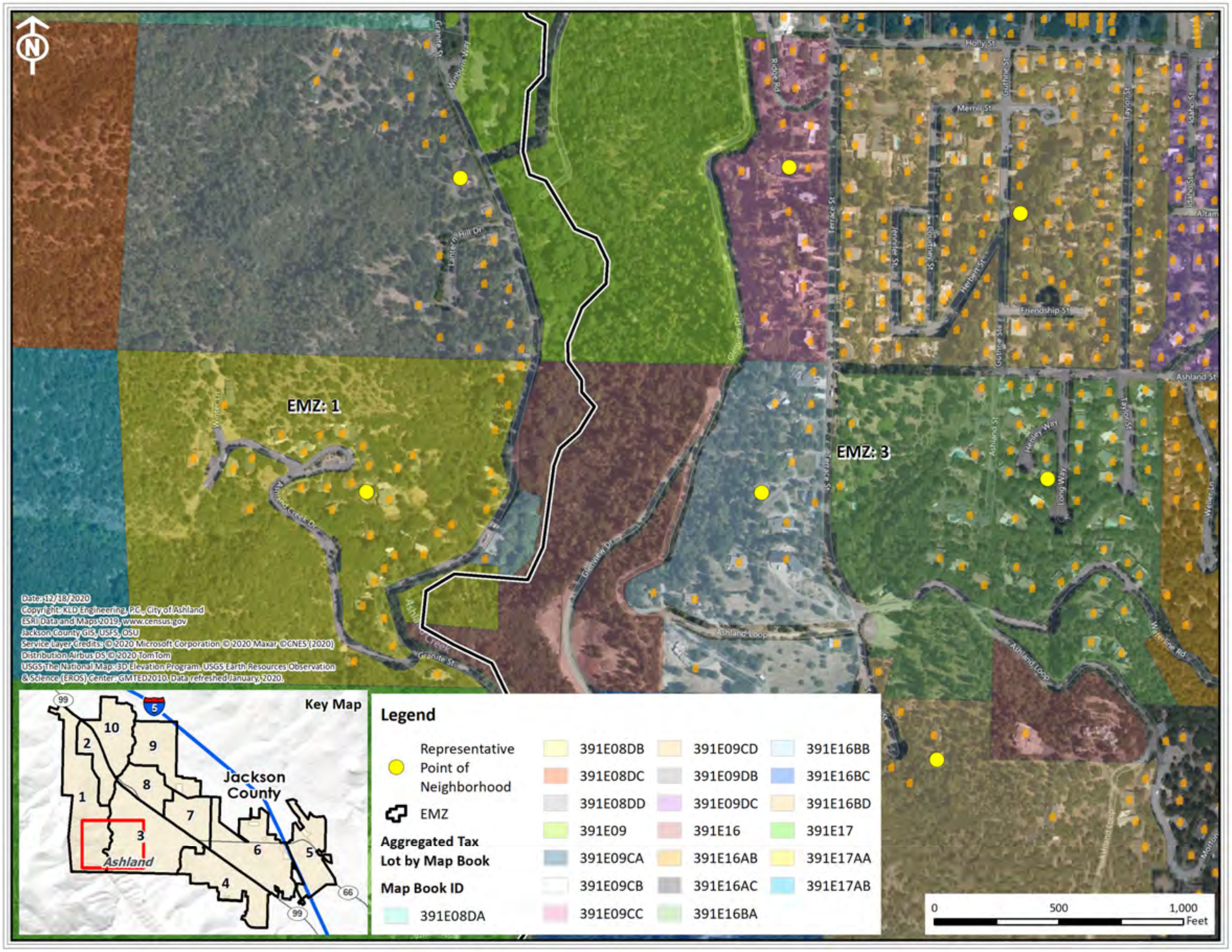
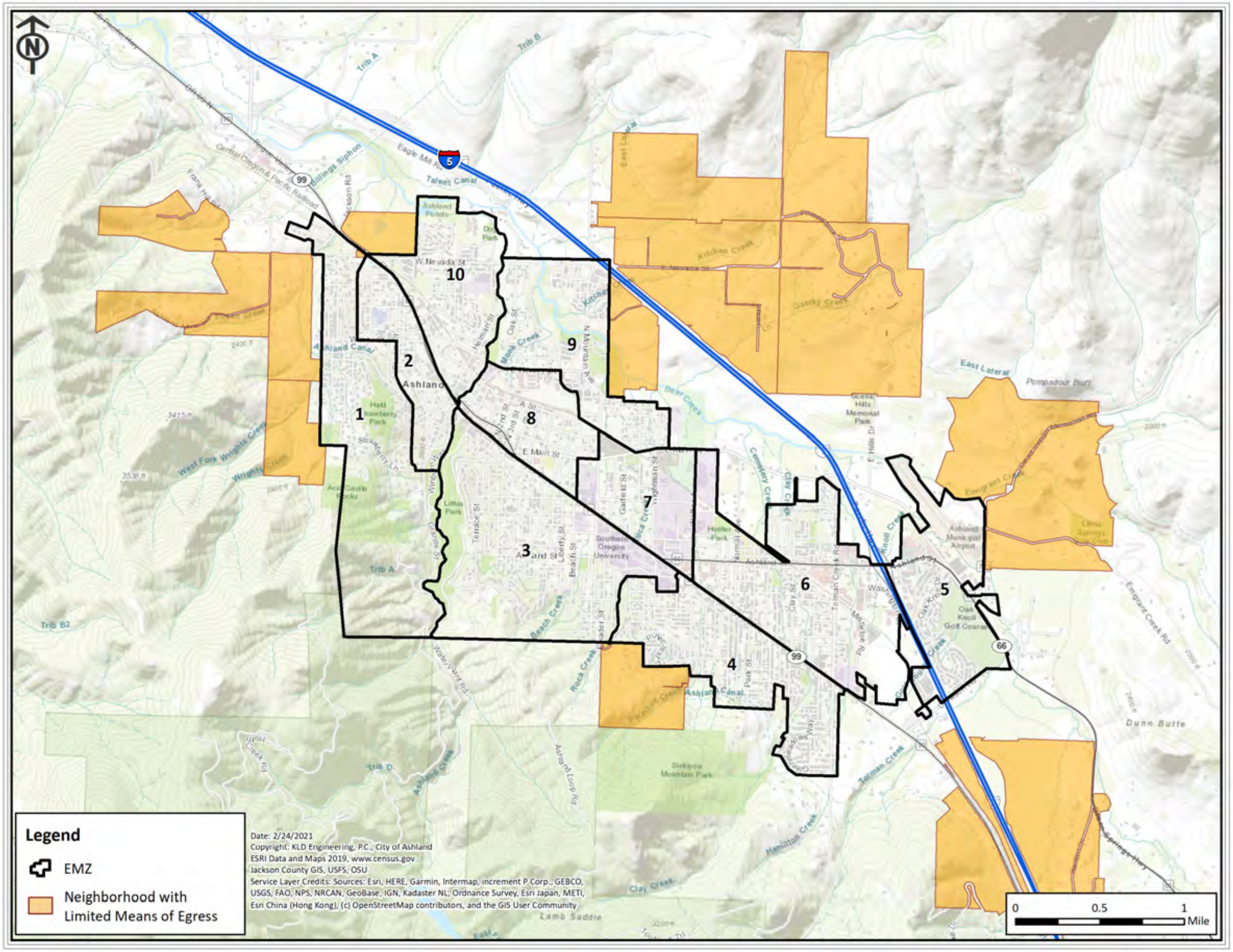
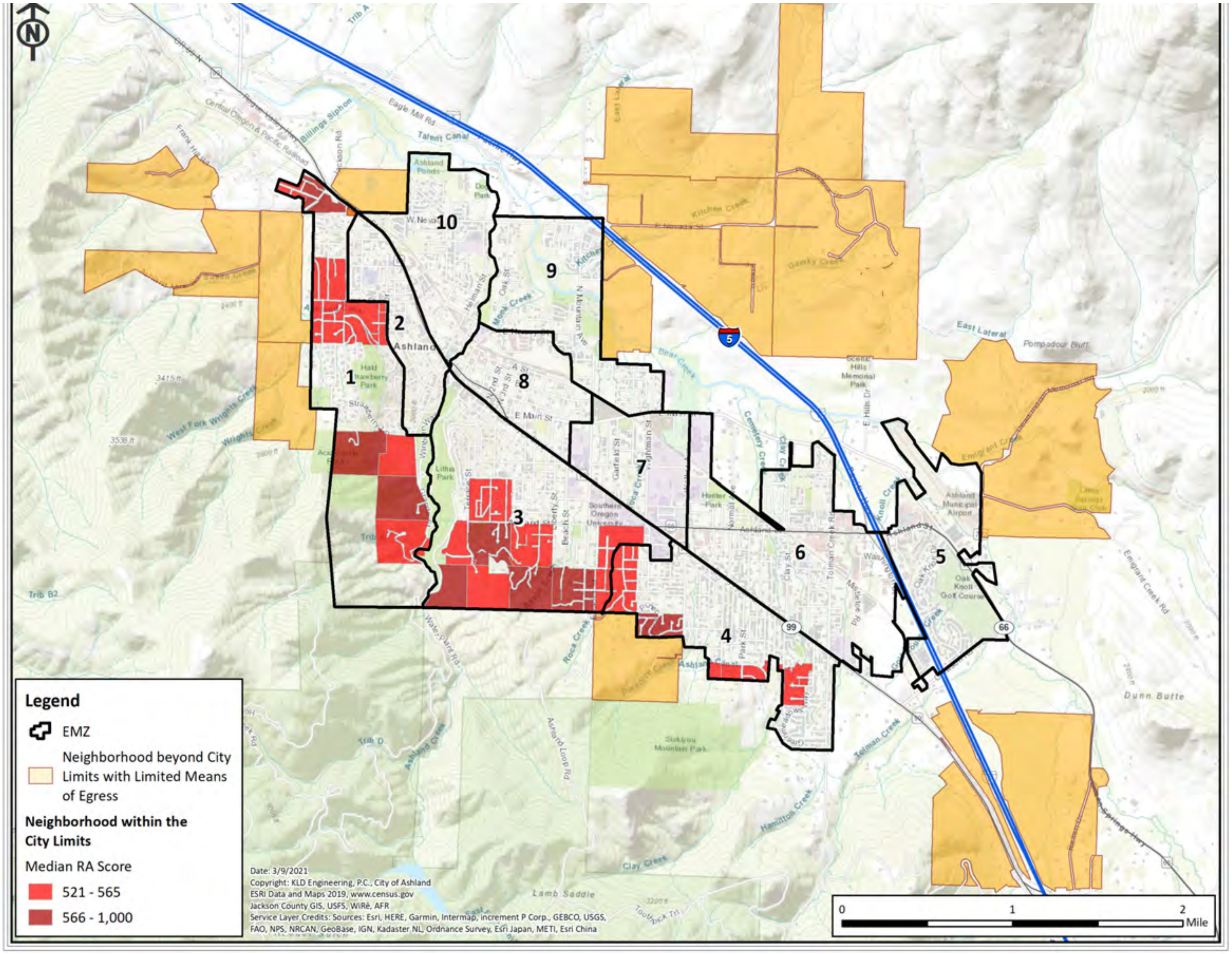


Figure 8-5. Resident Address Points



Date: 2/24/2021
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Jackson County GIS, USFS, OSU
Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Figure 8-6. Access Impaired Neighborhoods outside of the City Limits



Date: 3/9/2021
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Jackson County GIS, USFS, WiRė, AFR
Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China

Figure 8-7. Combined Access Impaired Neighborhoods

9 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 two population groups:

- residents with no vehicles available; and
- residents of special facilities such as schools and medical facilities.

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. It is estimated that bus mobilization time will average approximately 90 minutes extending from the advisory to evacuate to the time when buses first arrive schools, medical facilities, and transit dependent bus routes. See assumption 6 in Section 2.3.

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. As discussed in Section 2, this study assumes a rapidly escalating wildfire. However, local stakeholders have indicated that children will likely be picked up by parents or guardians prior to an evacuation. Emergency plans for the schools could not be obtained. It is generally safer if all students are loaded onto buses and evacuated so that all students can be accounted for; when parents pick up students, it can be a logistical nightmare especially during a high pressure situation. In addition, if buses are kept close to the school, or are on site, it is possible that buses will be loaded and evacuated before many parents even arrive. Since preschools and daycare facilities often do not have their own buses and generally low enrollments, it is more feasible and safer if parents pick up these children prior to evacuating. As such, it is assumed that children at preschool and daycare facilities are picked up by parents or guardians prior to evacuation and that the time to perform this activity is included in the trip generation times discussed in Section 5. This report provides estimates of buses under the assumption that no children will be picked up by their parents, to present an upper bound estimate of buses required.

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 out of the area at risk.

9.1 ETEs for Transit Dependent People

As discussed in Section 11, there are 4 bus routes designed to service the transit dependent people residing in the EMZs. During an emergency, buses will need to be dispatched to help those who need transportation assistance. These routes were used as representative routes to gather this population. It is likely that during an actual evacuation, people will call the City of Ashland Police Department and a bus will be dispatched and travel directly to the houses of those who need assistance. If there is a shortfall of transportation resources, buses should return to the EMZs after getting their initial passengers to safety.

When school evacuation needs are satisfied, subsequent assignments of buses to service the transit-dependent population 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 along the bus transit route.

Figure 9-1 presents the chronology of events relevant to transit operations. The elapsed time for each activity will now be discussed with reference to Figure 9-1.

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 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/route for schools, medical facilities, and transit dependent individuals.

Activity: Board Passengers (C→D)

A loading time of 15 minutes for school buses is used. Loading times of 1 minute, 5 minutes, and 30 minutes per patient are assumed for ambulatory patients, wheelchair using patients, and bedridden patients, respectively.

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.

Activity: Travel to EMZ Boundaries (D→E)

Transportation resources available were provided by the city emergency management personnel. Table 9-1 summarizes the information received. Also included in the table are the number of buses needed to evacuate schools, medical facilities, and transit-dependent population. **These numbers indicate there are not sufficient resources available to evacuate everyone in a single wave.**

School Evacuation

The buses servicing the schools are ready to begin their evacuation trips at 75 minutes after the advisory to evacuate – 90 minutes mobilization time plus 15 minutes loading time. 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 evacuation boundary. This is done in UNITES by interactively selecting the series of nodes from the school to the EMZ 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 11-2 (refer to the maps of the link-node analysis network in Appendix H for node locations). Data provided by DYNEV during the appropriate timeframe depending on the mobilization and loading times (i.e., 90 minutes after the advisory to evacuate) were used to compute the average speed for each route, as follows:

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

The average speed computed (using this methodology) for the buses servicing each of the schools in the EMZs are shown in the ETE tables for each facility. The travel time to the boundary of the

EMZ was computed for each bus using the computed average speed and the distance to the boundary along the most likely route out. The maximum bus speed limit within the study area was assumed to be 55 mph.

Table 9-2 presents the evacuation time estimates (rounded up to the nearest 5 minutes) for schools in the EMZs. The evacuation time out of the EMZs can be computed as the sum of time associated with Activities A→B→C, C→D, and D→E (For example: 90 min. + 15 + 45 = 2:30 for Helman Elementary School).

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 5-8 (Residents Without Commuters), approximately 85% of all evacuees will complete their mobilization when the buses begin their routes at 90 minutes after the evacuation advisory.

Those buses servicing the transit-dependent evacuees will first travel through the EMZs, then proceed out of the area at risk. It is assumed that residents will walk to and congregate along the roadways these routes traverse or will be picked up directly from their home, and that they can arrive at the routes within 90 minutes after the evacuation advisory.

As previously discussed, a pickup time of 30 minutes is estimated for 30 individual stops to pick up passengers, with an average of one minute of delay associated with each stop.

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

Table 9-3 present the transit-dependent population evacuation time estimates for each bus route calculated using the above procedures. ETE are rounded up to the nearest 5 minutes.

For example, the ETE for the bus on the route servicing EMZ 1, EMZ 2 and EMZ 10 is computed as 90 + 35 + 30 = 2:35. Here, 35 minutes is the time to travel 5.9 miles at 15.0 mph, the average speed output by the model for this route at 90 minutes.

Evacuation of Medical Facilities

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

- Buses are assigned on the basis of 30 patients to allow for staff to accompany the patients.
- Basic Life Support (BLS) (ambulances) can hold 2 patient per ambulance.
- Wheelchair transport vehicles can accommodate 15 patients per wheelchair bus

Table 3-7 indicates that 6 bus runs, 6 wheelchair bus runs, and 32 ambulance runs are needed to service the 3 medical facilities within the EMZs.

It is estimated that mobilization time averages 90 minutes. Specially trained medical support staff (working their regular shift) will be on site to assist in the evacuation of patients.

Table 9-4 summarize the ETE for medical facilities within the EMZs for normal. The distance from each medical facility to the boundary of the EMZs was measured using GIS software and is provided in Table 9-4 (Dist. to EMZ Bdry). Average speeds output by the DYNEV model for Scenario 4 Region R18, capped at 55 mph, are used to compute travel time out of the area at risk. The travel time out of the area at risk (Travel Time to Safety) is computed by dividing the travel distance by the average travel speed. The ETE is the sum of the mobilization time, total passenger loading time, and travel time to safety. Concurrent loading on multiple buses, wheelchair buses, and ambulances at capacity is assumed. All ETE are rounded to the nearest 5 minutes. For example, the calculation of ETE for Asante Ashland Community Hospital's ambulatory patients are:

ETE: 90 + 30 + 5 = 125 min. or 2:05.

Table 9-1. Summary of Transportation Needs and Resources

Transportation Resource	Buses	Wheelchair Buses	Ambulances
Resources Available			
Ashland School District	19	0	0
Ashland Fire & Rescue	0	0	2
Jackson County Fire District	0	0	2-4*
TOTAL:	**19**	**0**	**2**
Resources Needed			
Medical Facilities (Table 3-7):	6	6	32
Schools (Table 3-9):	75	0	0
Transit-Dependent Population (Table 11-1):	4	0	0
TOTAL TRANSPORTATION NEEDS:	**85**	**6**	**32**

*Note: 2-4 Ambulances can be made available from Jackson County Fire Department in the case that more are needed.

Table 9-2. School Evacuation Time Estimates

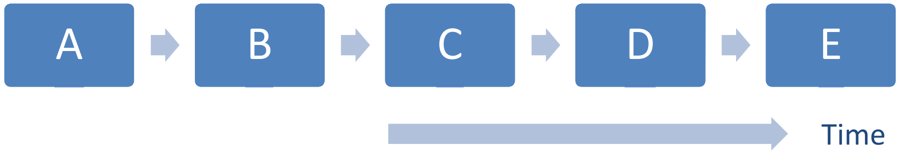
School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To Safety (mi)	Average Speed (mph)	Travel Time to Safety (min)	ETE (hr:min)
City of Ashland, OR						
Helman Elementary School	90	15	2.8	3.7	45	**2:30**
Ashland High School	90	15	3.2	2.6	74	**3:00**
Walker Elementary School	90	15	4.0	10.4	24	**2:10**
Ashland Middle School	90	15	5.3	11.1	29	**2:15**
John Muir Elementary School	90	15	0.3	10.1	2	**1:50**
Bellview Elementary School	90	15	6.9	21.1	20	**2:05**
Southern Oregon University	90	15	6.1	12.1	30	**2:15**
					Maximum ETE:	**3:00**
					Average ETE:	**2:20**

Table 9-3. Transit-Dependent Evacuation Time Estimates

Bus Route Number	Bus Route	Number of Buses	Mobilization (min)	Route Length (miles)	Speed (mph)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)
1	**Servicing EMZ 1, EMZ 2 and EMZ 10**	1	90	5.88	10.1	35	30	**2:35**
2	**Servicing EMZ 3 and EMZ 4**	1	90	3.98	4.8	50	30	**2:50**
3	**Servicing EMZ 5 and EMZ 6**	1	90	4.26	10.1	26	30	**2:30**
4	**Servicing EMZ 7, EMZ 8 and EMZ 9**	1	90	3.82	5.2	45	30	**2:45**
							Maximum ETE:	**2:50**
							Average ETE:	**2:40**

Table 9-4. Special Facility Evacuation Time Estimates

Medical Facility	Patient	Mobilization (min)	Loading Rate (min per person)	People	Max Loading Time (min)	Dist. To EMZ Bdry (mi)	Speed (mph)	Travel Time to Safety (min)	ETE (hr:min)
Asante Ashland Community Hospital	Ambulatory	90	1	63	30	2.3	26.6	5	**2:05**
	Wheelchair Using	90	5	31	75	2.3	29.8	5	**2:50**
	Bedridden	90	30	31	60	2.3	22.4	6	**2:40**
Ashland Surgery Center	Ambulatory	90	1	13	13	2.0	20.7	6	**1:50**
	Wheelchair Using	90	5	6	30	2.0	38.3	3	**2:05**
	Bedridden	90	30	6	60	2.0	38.2	3	**2:35**
Linda Vista Nursing Home & Rehab Center	Ambulatory	90	1	50	30	2.1	38.3	3	**2:05**
	Wheelchair Using	90	5	25	75	2.1	38.2	3	**2:50**
	Bedridden	90	30	25	60	2.1	38.2	3	**2:35**
								Maximum ETE:	**2:50**
								Average ETE:	**2:25**



Event	
A	Advisory to Evacuate
B	Bus Dispatched from Depot
C	Bus Arrives at Facility/Transit Dependent Person’s Home
D	Bus Departs Facility/Transit Dependent Person’s Home
E	Bus Exits Area at Risk

Activity	
A→B	Driver Mobilization
B→C	Travel to Facility or Transit Dependent Person’s Home
C→D	Passengers Board the Bus
D→E	Bus Travels Toward At-Risk Area Boundary

Figure 9-1. Chronology of Transit Evacuation Operations

10 TRAFFIC MANAGEMENT STRATEGY

This section discusses the suggested Traffic Management Plan (TMP) 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).
- Guidance is provided by 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 written plan that defines all Traffic Control Point (TCP) and Access Control Point (ACP) 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. Facilitate evacuating traffic movements that safely expedite travel out of the area at risk.
2. Discourage traffic movements that move evacuating vehicles in a direction which takes them significantly closer to the area of risk, 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.

ACPs are established during the evacuation to stop the flow of external traffic through the study area. Doing so reserves the capacity on major through routes for evacuees rather than the traffic that is passing through the area.

The implementation of a TMP must also be flexible enough for the application of sound judgment by the traffic guide.

The TMP for this study is the outcome of the following process:

1. Evacuation simulations were run using DYNEV II to predict traffic congestion during evacuation (see Section 7.2 and Figures 7-2 through 7-7).
2. These simulations help to identify the best routing and critical intersections that experience pronounced congestion during evacuation. Any critical intersections that would benefit from traffic or access control are suggested as TCPs. One TCP was

identified which would benefit the evacuation: the intersection of OR-99 and Crowson Rd. While the overall ETE remained the same with the placement of this TCP, localized congestion decreased. As a result, this location is recommended as a TCP.

3. Prioritization of TCPs and ACPs.
    a. 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 wildfire could have a more beneficial effect on minimizing potential exposure to threat than those TCPs located far from the wildfire. These priorities should be assigned by city emergency management representatives and by law enforcement personnel.

10.1 Assumptions

The ETE calculations documented in Sections 7 and 9 assume that the recommended TMP is implemented during evacuation.

The ETE calculations reflect the assumption that all “external-external” trips are interdicted and diverted after 2 hours have elapsed from the Advisory to Evacuate (ATE) to discourage through travelers from using major through routes that traverse the study area. Dynamic and variable message signs should be strategically positioned outside of the study area at logical diversion points to attempt to divert traffic away from the area of risk. As such, it is assumed pass-through traffic that traverses the study area will diminish over the 2-hour period.

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

The ETE analysis treated the controlled intersection that is recommended as a TCP location as being controlled by an actuated signal. In Appendix H, Table H-2 identifies those intersections that were modeled as TCPs.

Study assumptions 12 and 13 in Section 2.3 discuss additional TCP and ACP operational assumptions.

10.2 Additional Considerations

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

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

11 EVACUATION ROUTES AND EVACUATION SIGNAGE

This section documents major evacuation routes within the study area, possible bus routes, and suggestions on evacuation signage based on current traffic engineering standards.

11.1 Evacuation Routes

Evacuation routes are responsible for transporting EMZ evacuees and transit dependent evacuees (schools, medical facilities, and residents who do not own or have access to a private vehicle) to safety.

Evacuees will select routes within the EMZ 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 wildfire 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 major evacuation routes for the study area are presented in Figure 11-1. These routes will be used by the general population evacuating in private vehicles and by the transit-dependent population evacuating in buses. Transit-dependent evacuees will be routed to safety, outside of the evacuation area. The general population may evacuate to some alternate destination (e.g., lodging facilities, relative's home, campgrounds) outside the EMZ.

The 4 representative bus routes shown graphically in Figure 11-2 and described in Table 11-1 were designed by KLD to service the transit dependent population in each EMZ. This does not imply that these exact routes would be used in an emergency. It is assumed that residents will walk to and congregate along the existing evacuation routes to flag down a bus.

The specified bus routes for all the transit-dependent population are documented in Table 11-2 (refer to the maps of the link-node analysis network in Appendix H for node locations). This study does not consider the transport of evacuees from the boundary of the evacuation region to reception centers or congregate care centers.

Schools and medical facilities were routed along the most likely path from the facility being evacuated to the boundary of the evacuation region. A single route was used for facilities that would use a similar path for evacuation.

The City of Ashland should consider identifying safe shelter locations within the EMZ in an event that an evacuation is not feasible (i.e. the fire is moving faster than an evacuation would take). When a wildfire threat is perceived, emergency officials need to make a protective action decision to either evacuate or shelter (at a safe refuge location) the population in imminent danger. Safe refuge areas (i.e. hardened structures, safe open areas, water bodies) should be predetermined and locally known in the case of an emergency.

See Section 3.6 for more information on the transit dependent population and Section 9 for transit dependent ETE calculations.

11.2 Evacuation Signage

Locations of evacuation signs installed along the routes shown in Figure 11-1 for "straight-ahead" confirmation should be in accordance with Part 2, Chapter 2N, Section 2N.03 of the 2009 MUTCD[1]. These signs should display a blue circular symbol on a white square sign with a white directional arrow and a white legend "EVACUATION ROUTE" within the blue circular symbol, as shown in Figure 11-3. A straight, vertical arrow pointing upward to indicate that evacuees should continue their travel along that route should be placed on I-5, OR-66, and OR-99. These evacuation signs should be installed at one-mile spacing along major evacuation routes.

Other signing may be placed on the approaches to major intersections to indicate the direction of evacuation travel through the intersection. The MUTCD states that these signs should be installed 150 to 300 feet in advance of the intersection and should indicate the turn direction required to follow the evacuation route. These signs should display a straight horizontal arrow pointing to the left or right, or a bent arrow pointing to the left or right, depending on the geometrics of the approach and of the intersection, to indicate the appropriate turn movement through the intersection needed to follow the recommended evacuation route. A through movement will be shown as described in the previous paragraph.

Such directional signing may also be placed at the exits of special facilities to guide evacuees toward or along recommended evacuation routes. These facilities include schools, medical facilities, and major recreational areas, as specified in Appendix E.

Part 2, Chapter 2N of the 2009 MUTCD presents guidelines for implementing emergency management signs. It states that "emergency management signs shall not permanently displace any of the standard signs that are normally applicable." While this report does not specify the precise locations of every recommended road sign, the installation of every evacuation route sign must comply with the guidance provided in the MUTCD.

---

[1] Manual on Uniform Traffic Control Devices for Streets and Highways, 2009 Edition, US Department of Transportation, Federal Highway Administration

Table 11-1. Summary of Transit-Dependent Bus Routes

Route	No. of Buses	Route Description	Length (mi.)
1	1	Transit Dependent Bus Route servicing EMZ 1, EMZ 2, and EMZ 10	5.88
2	1	Transit Dependent Bus Route servicing EMZ 3 and EMZ 4	3.98
3	1	Transit Dependent Bus Route servicing EMZ 5 and EMZ 6	4.26
4	1	Transit Dependent Bus Route servicing EMZ 7, EMZ 8, and EMZ 9	3.82
Total:	4		

Table 11-2. Bus Route Description

Bus Route Number	Description	Nodes Traversed from Route Start to EPZ Boundary
1	Walker Elementary School	124, 108, 110, 113, 323, 9, 7, 8
2	Helman Elementary School	161, 162, 261, 50, 51, 52, 159, 53, 54, 55
4	Ashland High School	127, 41, 233, 42, 237, 240, 43, 44, 148, 238, 45, 227, 46, 254, 47, 241, 48, 49, 50, 51, 52, 159, 53, 54, 55
6	John Muir Outdoor School	124, 108, 110, 113, 323, 9, 7, 8
7	Bellview Elementary School	40, 308, 307, 9, 7, 8
9	Ashland Surgery Center	51, 52, 159, 53, 54, 55
10	Linda Vista Nursing and Rehab Center	51, 52, 159, 53, 54, 55
11	Oregon Child Development	215, 48, 49, 50, 51, 52, 159, 53, 54, 55
12	Reflective Hearts Childcare	133, 143, 134, 148, 238, 45, 227, 46, 254, 47, 241, 48, 49, 50, 51, 52, 159, 53, 54, 55
13	Stone Soup Playschool	114, 311, 312, 113, 323, 9, 7, 8
14	Pea Pod Village	143, 134, 148, 238, 45, 227, 46, 254, 47, 241, 48, 49, 50, 51, 52, 159, 53, 54, 55
15	Childrens World	233, 42, 237, 240, 43, 44, 148, 238, 45, 227, 46, 254, 47, 241, 48, 49, 50, 51, 52, 159, 53, 54, 55
16	Memory Lane Preschool	109, 108, 110, 113, 323, 9, 7, 8
17	Head Start	108, 110, 113, 323, 9, 7, 8
18	Rain and Shine Preschool	267, 111, 275, 315, 110, 113, 323, 9, 7, 8

Bus Route Number	Description	Nodes Traversed from Route Start to EPZ Boundary
3	Transit Dependent Bus Route for EMZ 1, EMZ 2, and EMZ 10	290, 284, 283, 149, 150, 49, 50, 51, 52, 159, 53, 54, 55
20	Transit Dependent Bus Route for EMZ 3 and EMZ 4	268, 135, 235, 234, 41, 339, 123, 70, 108, 110, 113, 323, 9, 7, 8
23	Transit Dependent Bus Route for EMZ 5 and EMZ 6	275, 315, 110, 113, 323, 9, 7, 8
26	Transit Dependent Bus Route for EMZ 7, EMZ 8, and EMZ 9	226, 224, 225, 144, 147, 145, 122, 121, 146, 49, 50, 51, 52, 159, 53, 54, 55
8	Asante Ashland Community Hospital	119, 51, 52, 159, 53, 54, 55
5	Ashland Middle School	124, 108, 110, 113, 323, 9, 7, 8
27	TD Zone 10	281, 282, 161, 162, 261, 50, 51, 52, 159, 53, 54, 55
28	Southern Oregon University	123, 70, 108, 110, 113, 323, 9, 7, 8

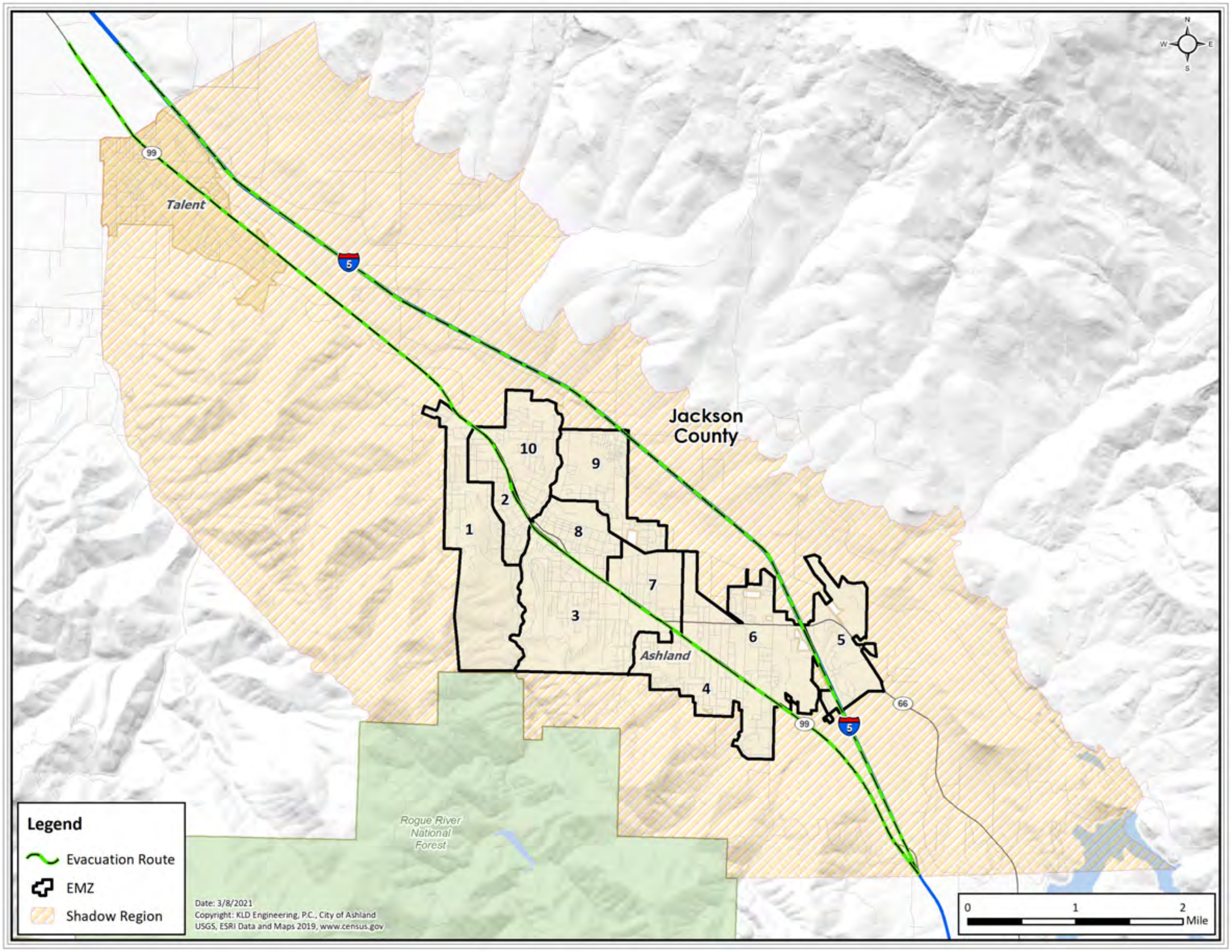
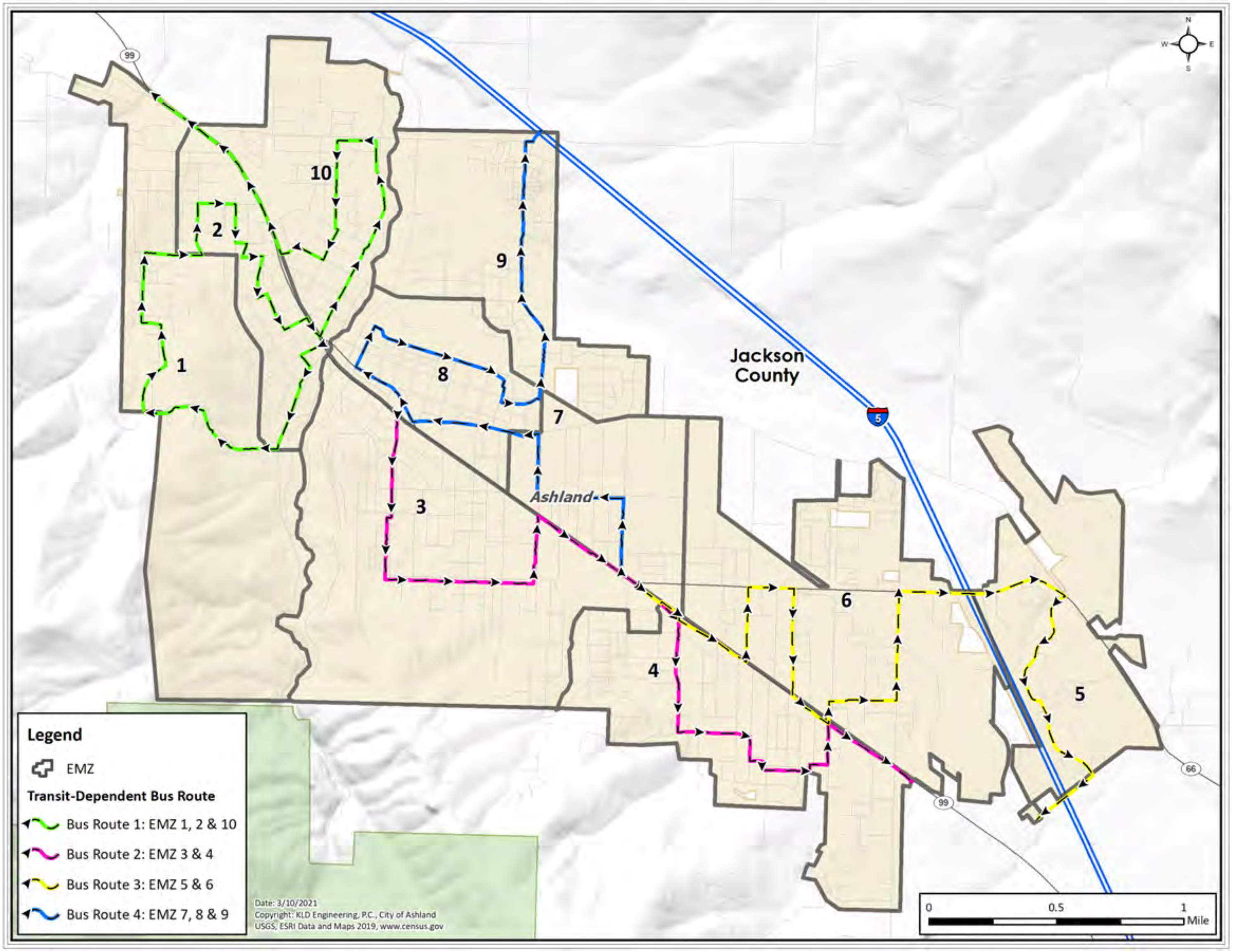


Figure 11-1. Evacuation Route Map



Date: 3/10/2021
Copyright: KLD Engineering, P.C., City of Ashland
USGS, ESRI Data and Maps 2019, www.census.gov

Figure 11-2. Transit-Dependent Bus Routes Servicing the EMZ

Figure 11-3. Evacuation Route Sign Example

APPENDIX A

Glossary of Traffic Engineering Terms

A. GLOSSARY OF TRAFFIC ENGINEERING TERMS

This appendix provides a glossary of traffic engineering terms that are used throughout this report.

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 EMZ 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.

Term	Definition
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.
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 (MOE).
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.

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

To apply the DYNEV II System, the analyst must specify the highway network, link capacity information, the time-varying volume of traffic generated at all origin centroids and, optionally, a set of accessible candidate destination nodes on the periphery of the EMZ 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 wildfire 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 evacuation behavior wherein evacuees will seek to travel in a general direction away from the location of the hazardous event. An algorithm was developed to support the DTRAD model in dynamically varying the Trip Table (O-D matrix) over time from one DTRAD session to the next. Another algorithm executes a "mapping" from the specified "geometric" network (link-node analysis network) that represents the physical highway system, to a "path" network that represents the vehicle [turn] movements. DTRAD computations are performed on the "path" network: DYNEV simulation model, on the "geometric" network.

DTRAD Description

DTRAD is the DTA module for the DYNEV II System.

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

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

- It is assumed that drivers not only select the best route (i.e., lowest cost path) but some also select less attractive routes. The algorithm implemented by DTRAD archives several “efficient” routes for each O-D pair from which the drivers choose.
- The choice of one route out of a set of possible routes is an outcome of “discrete choice modeling”. Given a set of routes and their generalized costs, the percentages of drivers that choose each route is computed. The most prevalent model for discrete choice modeling is the logit model. DTRAD uses a variant of Path-Size-Logit model (PSL). PSL overcomes the drawback of the traditional multinomial logit model by incorporating an additional deterministic path size correction term to address path overlapping in the random utility expression.
- DTRAD executes the Traffic Assignment (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 wildfire:

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

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

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

A d_o was chosen such that the EMZs are within the area at risk. Note that the supplemental cost, s_a, of link, a, is (high, low), if its downstream node, n, is (near, far from) the wildfire.

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.

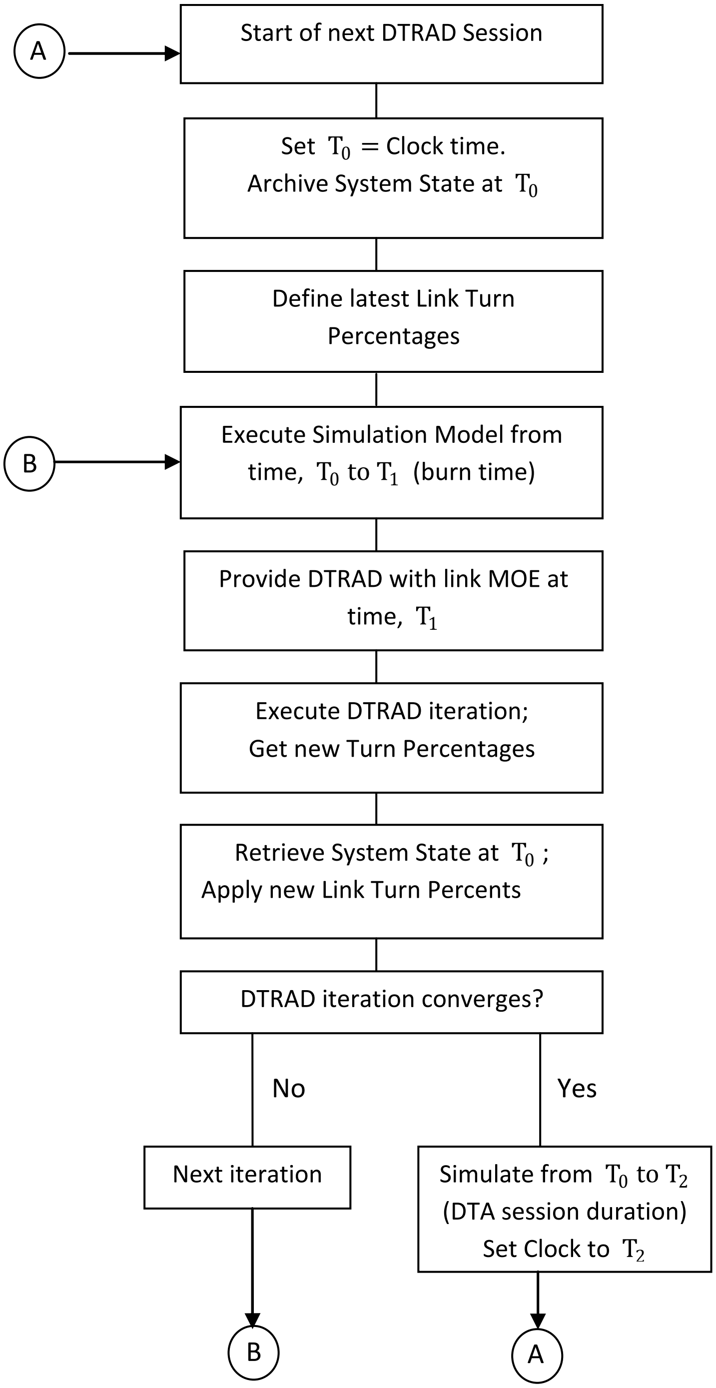


Figure B-1. Flow Diagram of Simulation-DTRAD Interface

APPENDIX C

DYNEV Traffic Simulation Model

C. DYNEV TRAFFIC SIMULATION MODEL

This appendix describes the 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.

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 moving traffic on every link. The specified calibration values for each link are: (1) Free speed, v_f ; (2) Capacity, Q_{max} ; (3) Critical density, $k_c = 45 \text{ vpm}$; (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.

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

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

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

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

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

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

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

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

7.      If $M_b \leq RCap$, 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 moving vehicles.

If $|\bar{k}_n - \bar{k}_{n-1}| > \in$ and $n < N$
    where $N = \max$ number of iterations, and $\epsilon$ 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 $\mathrm{Q_e + M_e > \frac{(L-W)\,LN}{L_v}}$, then

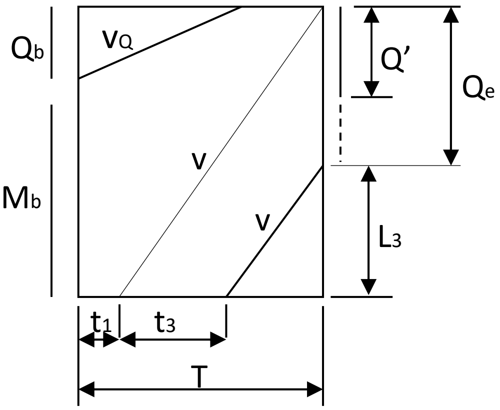
The number of excess vehicles that cause spillback is: $\mathrm{SB = Q_e + M_e - \frac{(L-W)\cdot LN}{L_v}}$, where W is the width of the upstream intersection. To prevent spillback, meter the outflow from the feeder approaches and from the source flow, S, during this TI by the amount, SB. That is, set

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

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, $\mathrm{Q_b \leq Cap, with\ t_1 > 0}$ and a queue of length, $\mathrm{Q'_e}$, formed by that portion of $\mathrm{M_b}$ and E that reaches the stop-bar within the TI, but could not discharge due to inadequate capacity. That is, $\mathrm{Q_b + M_b + E_1} > Cap$. This queue length, $\mathrm{Q'_e = Q_b + M_b + E_1 - Cap}$ can be extended to $\mathrm{Q_e}$ 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, $\mathrm{E_3 = E\,\frac{t_3}{TI}}$, will likely join the queue. This analysis calculates $\mathrm{t_3}$, $\mathrm{Q_e}$ and $\mathrm{M_e}$ for the input values of L, TI, v, E, t, $\mathrm{L_v}$, LN, $\mathrm{Q'_e}$.



When $\mathrm{t_1 > 0}$ and $\mathrm{Q_b \leq Cap}$:

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

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

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

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

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

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, $\mathrm{LN_x}$, 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, $\mathrm{LN_x}$.

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: $\mathrm{Q_e}$ and $\mathrm{M_e}$. 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 $\mathrm{Q_b}$ and $\mathrm{M_b}$ for the start of the next TI as being those values of $\mathrm{Q_e}$ and $\mathrm{M_e}$ at the end of the prior TI. In this manner, the simulation model processes the traffic flow over time until the end of the run. Note that there is no space-discretization other than the specification of network links.

C.2.2 Interfacing with Dynamic Traffic Assignment (DTRAD)

The **DYNEV II** system reflects evacuation behavior wherein 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 Dynamic Traffic Assignment (DTA) model, returns to the origin time, $\mathrm{T_0}$, and executes until it arrives at the end of the DTRAD session duration at time, $\mathrm{T_2}$. At this time the next DTA session is launched and the whole process repeats until the end of the **DYNEV II** run.

Additional details are presented in Appendix B.

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

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

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

HIGHWAY NETWORK

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

GENERATED TRAFFIC VOLUMES

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

TRAFFIC CONTROL SPECIFICATIONS

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

DRIVER'S AND OPERATIONAL CHARACTERISTICS

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

DYNAMIC TRAFFIC ASSIGNMENT

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

INCIDENTS

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

Table C-3. Glossary

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

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

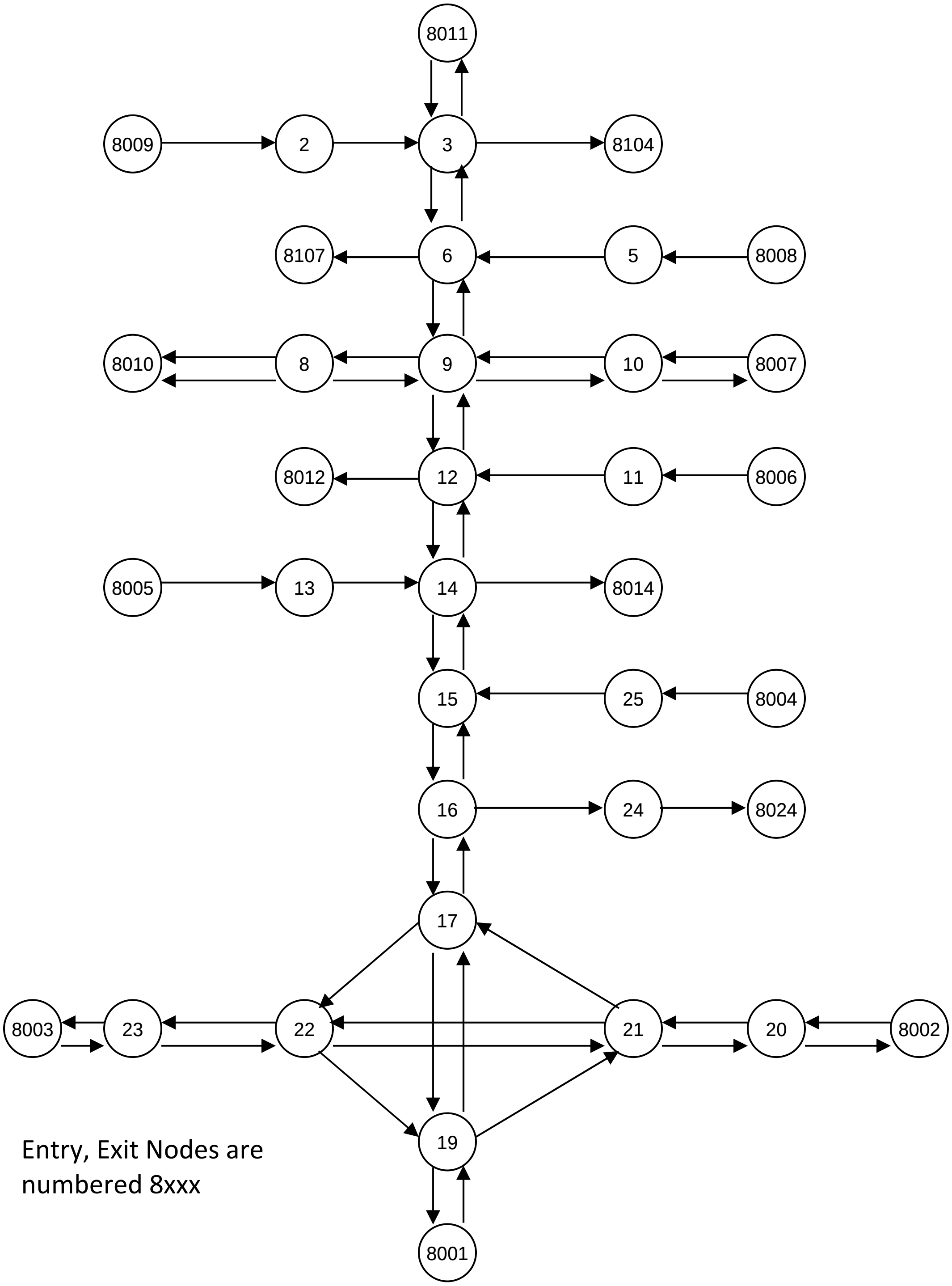


Figure C-1. Representative Analysis Network

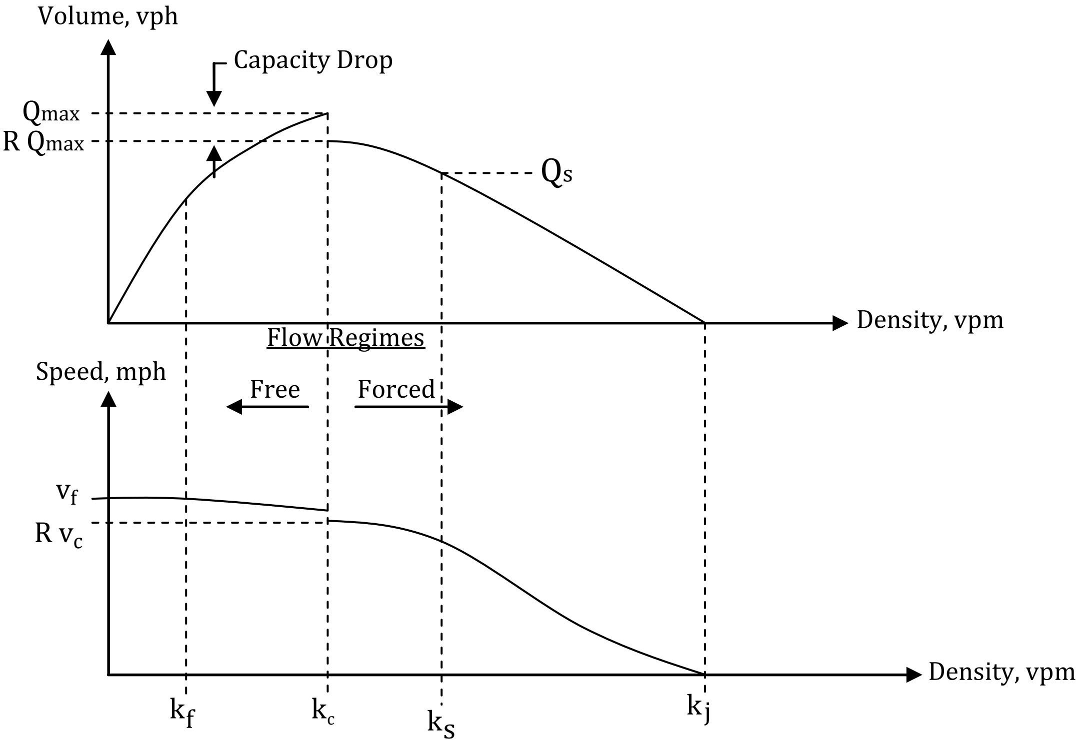


Figure C-2. Fundamental Diagrams

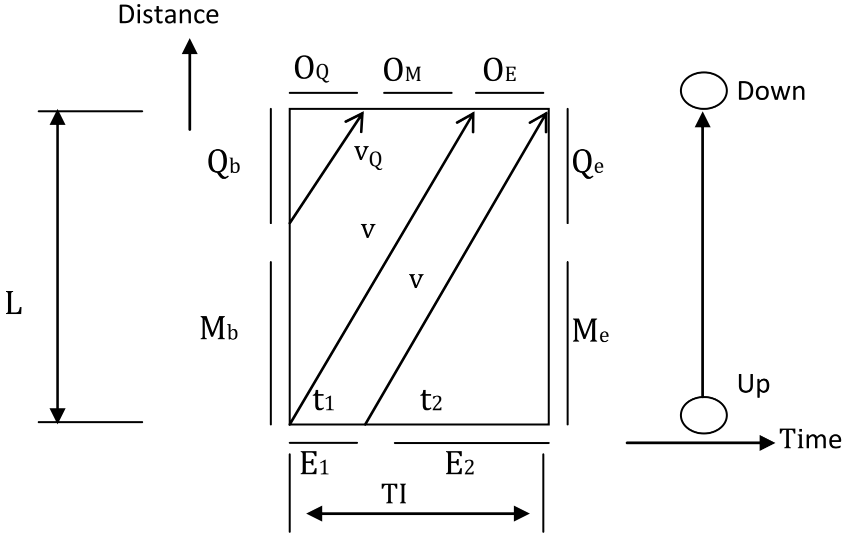


Figure C-3. A UNIT Problem Configuration with $t_1 > 0$

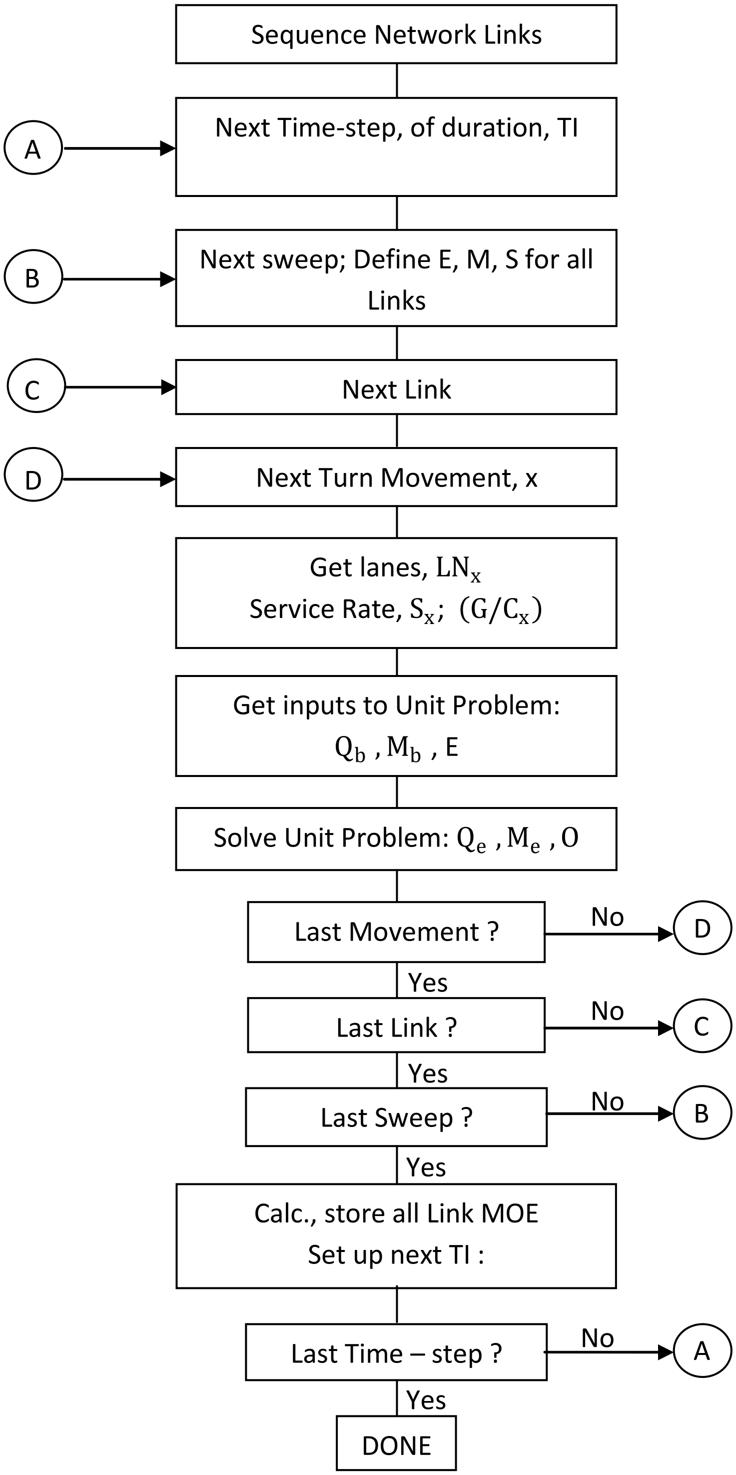


Figure C-4. Flow of Simulation Processing (See Glossary: Table C-3)

APPENDIX D

Detailed Description of Study Procedure

D. DETAILED DESCRIPTION OF STUDY PROCEDURE

This appendix describes the activities that were performed to compute the 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 EMZ information and create a GIS base map. The base map extends beyond the EMZ into the Shadow Region. The EMZ and Shadow Region generally run northwest to southeast. The study area is situated on OR-99 and is bounded mostly by I-5 to the northeast and Siskiyou Mountain Park to the southwest. The base map incorporates the local roadway topology, a suitable topographic background and the EMZ boundaries.

Step 2

2010 Census block information was obtained in GIS format. This information was used to estimate the resident population within the EMZ and the Shadow Region and to define the spatial distribution and demographic characteristics of the population within the study area. Employee data were estimated using the U.S. Census Longitudinal Employer-Household Dynamics from the OnTheMap Census analysis tool[1]. Tourist information, schools, medical and other types of special facilities data were provided by the City of Ashland supplemented with internet searches.

Step 3

A kickoff meeting was conducted with major stakeholders (city emergency managers, Southern Oregon University, and transportation and county transit managers). 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 the city. Unique features of the study area were discussed to identify the local concerns that should be addressed by the ETE study.

Step 4

Next, a physical survey of the roadway system in the study area was conducted to determine the geometric properties of the highway sections, the channelization of lanes on each section of roadway, whether there are any turn restrictions or special treatment of traffic at intersections, the type and functioning of traffic control devices, gathering signal timings for pre-timed traffic signals, and to make the necessary observations needed to estimate realistic values of roadway capacity.

---

[1] https://onthemap.ces.census.gov/

Step 5

A demographic survey of households within the EMZ was conducted to identify household dynamics, trip generation characteristics, and evacuation-related demographic information of the EMZ 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. Census data was overlaid in the map, and origin centroids where trips would be generated during the evacuation process were assigned to appropriate links.

Step 7

Regions (groupings of EMZ) that may be advised to evacuate, were developed.

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

Step 8

Access impaired neighborhoods were identified and classified based on specific criteria. First, neighborhoods with low population densities were eliminated. Then, neighborhoods with low wildfire risks were removed. Next, Neighborhoods with limited means of egress were selected. Last, neighborhood boundaries were refined to eliminate large uninhabited areas. Once access impaired neighborhoods were identified, recommendations were made for safe refuge areas as well as evacuation signage for these neighborhoods.

Step 9

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 EMZ for a representative scenario.

Step 10

After creating this input stream, the DYNEV II System was executed on the prototype evacuation case to compute evacuating traffic routing patterns. 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 EMZ and Shadow Region, away from the hazard. 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 11

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 14. Otherwise, proceed to Step 12.

Step 12

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 13

As noted above, the changes to the input stream must be implemented to reflect the modifications undertaken in Step 12. At the completion of this activity, the process returns to Step 10 where the DYNEV II System is again executed.

Step 14

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 15

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 16

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 17

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 18

Several ETE sensitivity studies were conducted to consider the impact on ETE based on “what if” scenarios. These scenarios include direction of wildfire approach and changes to mobilization time, number of evacuating vehicles per household, number of vehicles evacuating from the shadow region, and potential implementation of traffic management plans by the City of Ashland. These scenarios were then compared to the baseline ETE to test if certain tactics could be used to reduce evacuation time.

Step 19

The simulation results are analyzed, tabulated and graphed. The results were then documented.

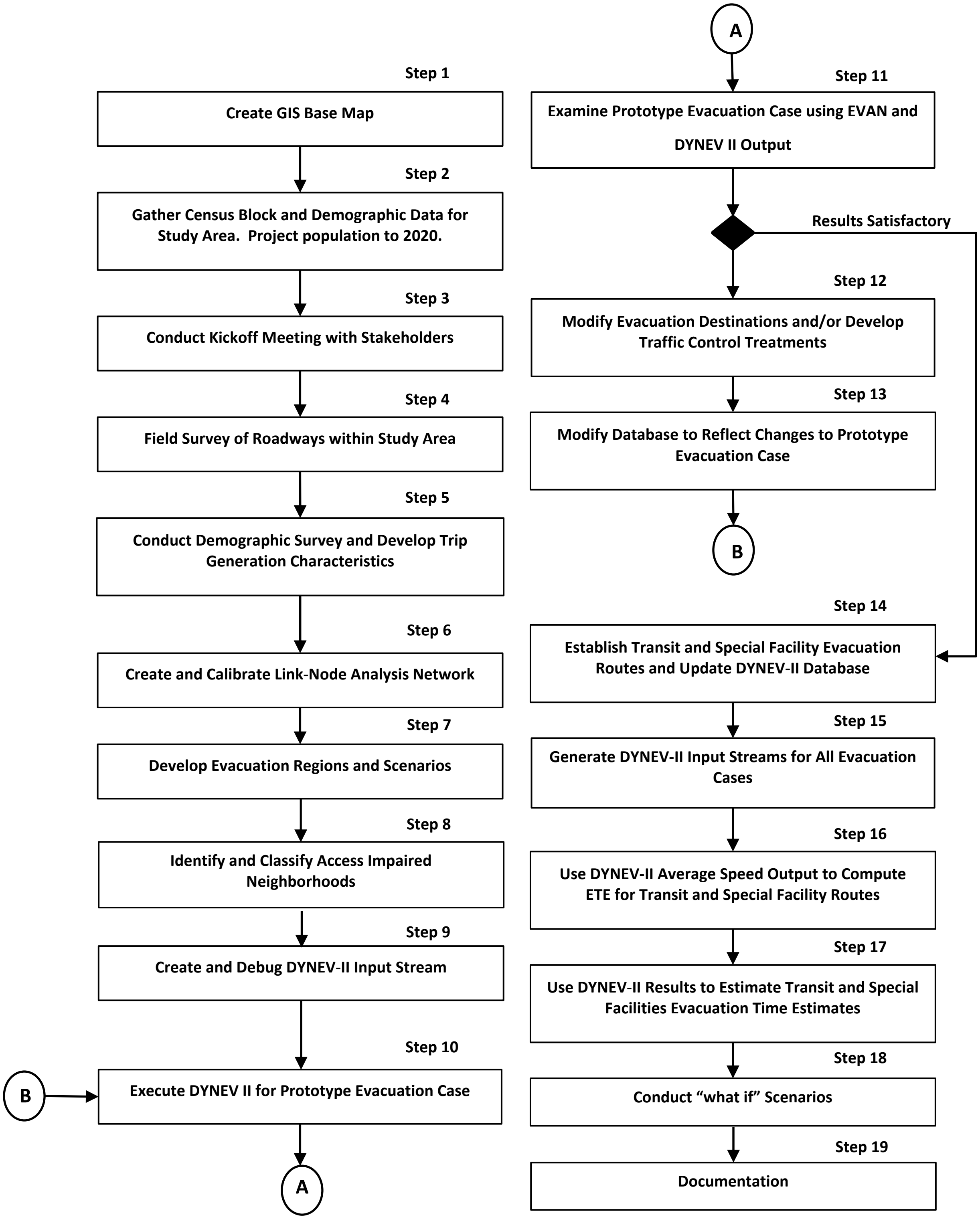


Figure D-1. Flow Diagram of Activities

APPENDIX E

Facility Data

E. FACILITY DATA

This appendix lists population information, as of January 2021, for special facilities that are located within the EMZ that were used in this study. Special facilities are defined as schools, preschools/daycares, and medical facilities. Tourist population is included in the tables for golf courses, hiking trails, theatres, and lodging facilities. OnTheMap employment data (see Section 3, sub-section 3.4) is summarized in the table for major employers. Maps of each school, preschool/daycare, medical facility, major employer, golf course, hiking trail, theatre, and lodging facility are also provided.

Table E-1. Schools and Preschools/Daycares within the EMZ

EMZ	Facility Name	Facility Type	Street Address	Municipality	Enrollment
2	Children's World	Preschool/Daycare	175 N Main St	Ashland	10
2	Oregon Child Development	Preschool/Daycare	265 N Main St	Ashland	213
3	Pea Pod Village	Preschool/Daycare	518 Auburn St	Ashland	10
3	Reflective Hearts Childcare	Preschool/Daycare	414 Courtney St	Ashland	10
3	Southern Oregon University	School	1250 Siskiyou Blvd	Ashland	5,000
4	Memory Lane Preschool	Preschool/Daycare	1615 Clark Ave	Ashland	20
4	Rain and Shine Preschool	Preschool/Daycare	Harmony Ln	Ashland	20
6	Ashland Middle School	School	100 Walker Ave	Ashland	900
6	Bellview Elementary School	School	1070 Tolman Creek Rd	Ashland	460
6	John Muir Elementary School	School	100 Walker Ave	Ashland	270
6	Stone Soup Playschool	Preschool/Daycare	782 Park St	Ashland	10
6	Walker Elementary School	School	364 Walker Ave	Ashland	340
7	Ashland High School	School	201 S Mountain Ave	Ashland	1,000
7	Head Start	Preschool/Daycare	421 Walker Ave	Ashland	20
10	Helman Elementary School	School	705 Helman St	Ashland	360
				EMZ TOTAL:	**8,643**

Table E-2. Medical Facilities within the EMZ

EMZ	Facility Name	Street Address	Municipality	Cap-acity	Current Census	Ambul-atory Patients	Wheel-chair Patients	Bed-ridden Patients
2	Asante Ashland Community Hospital	280 Maple St	Ashland	125	125	63	31	31
2	Linda Vista Nursing & Rehab Center	135 Maple St	Ashland	100	100	50	25	25
10	Ashland Surgery Center	658 N Main St	Ashland	25	25	13	6	6
			EMZ TOTAL:	**250**	**250**	**126**	**62**	**62**

Table E-3. Major Employers within the EMZ

EMZ	Facility Name	Street Address	Municipality	Employees (Max Shift)	Employees Commuting into the EMZ	Employee Vehicles Commuting into the EMZ
1	Various locations throughout the EMZ[1]			111	74	70
2				151	100	94
3				938	627	593
4				0	0	0
5				271	181	171
6				711	475	448
7				129	86	81
8				898	599	565
9				81	54	51
10				159	106	100
			EMZ TOTAL:	**3,449**	**2,302**	**2,173**

---

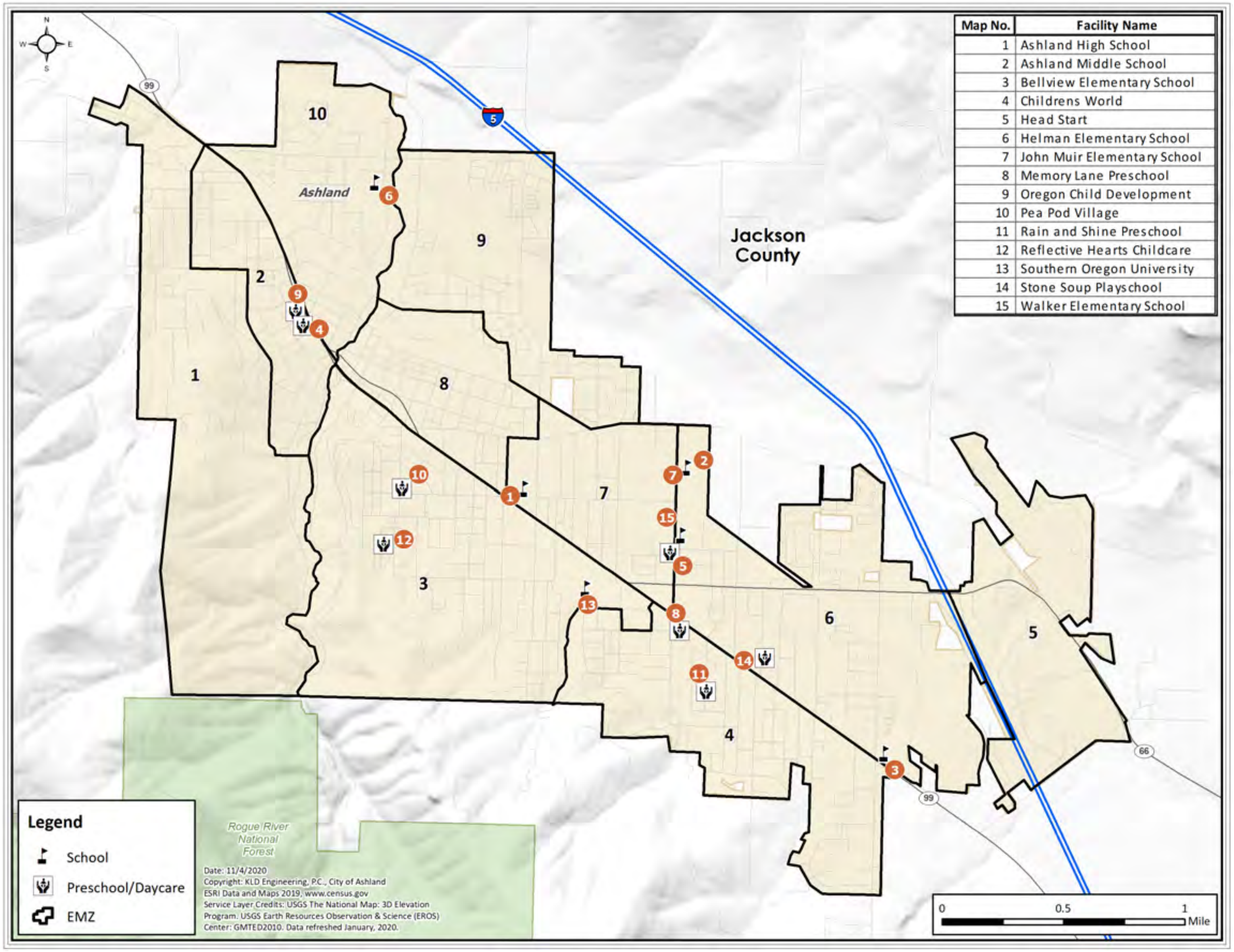
[1] The major employer locations identified by the Census Bureau are shown in Figure E-3. The locations are represented by circles which increase in size proportional to the number of non-EMZ employees present in each Census Block.

Table E-4. Recreational Facilities and Lodging Facilities within the EMZ

EMZ	Facility Name	Facility Type	Street Address	Municipality	Tourists	Vehicles
1	Lithia Park	Hiking Trail	Winburn Way	Ashland	1,000	280
2	Acid Castle Boulders Access Point	Hiking Trail	183 Hitt Rd	Ashland	75	38
3	Ashland Springs Hotel	Lodging	212 E Main St	Ashland	140	63
3	Columbia Hotel	Lodging	262 E Main St	Ashland	48	22
3	Oregon Shakespeare Festival	Theatre	15 S Pioneer St	Ashland	1,975	886[2]
3	Winchester Inn	Lodging	35 S 2nd St	Ashland	42	19
4	Oredson Todd Woods	Hiking Trail	Lupine Dr	Ashland	180	90
5	Ashland Hills Hotel & Suites and Convention Center	Lodging	2525 Ashland St	Ashland	366	164
5	Best Western Windsor Inn	Lodging	2520 Ashland St	Ashland	186	83
5	Holiday Inn Express & Suites Ashland	Lodging	565 Clover Ln	Ashland	130	58
5	Oak Knoll Golf Course	Golf Course	3070 OR-66	Ashland	50	50
6	Cedarwood Inn Hotel	Lodging	1801 Siskiyou Blvd	Ashland	100	45
6	Rodeway Inn	Lodging	2359 Ashland St	Ashland	96	43
6	Super 8 by Wyndham Ashland	Lodging	2350 Ashland St	Ashland	132	59
7	Ashland Motel - University	Lodging	1145 Siskiyou Blvd	Ashland	52	23
7	Flagship Inn-Ashland	Lodging	1193 Siskiyou Blvd	Ashland	122	55
7	Palm Hotel	Lodging	1065 Siskiyou Blvd	Ashland	32	14
7	Timbers Motel	Lodging	1450 Ashland St	Ashland	60	27
9	North Mountain Park	Hiking Trail	620 N Mountain Ave	Ashland	180	150
10	Plaza Inn & Suites	Lodging	98 Central Ave	Ashland	184	83
				EMZ TOTAL:	**5,150**	**2,252**

---

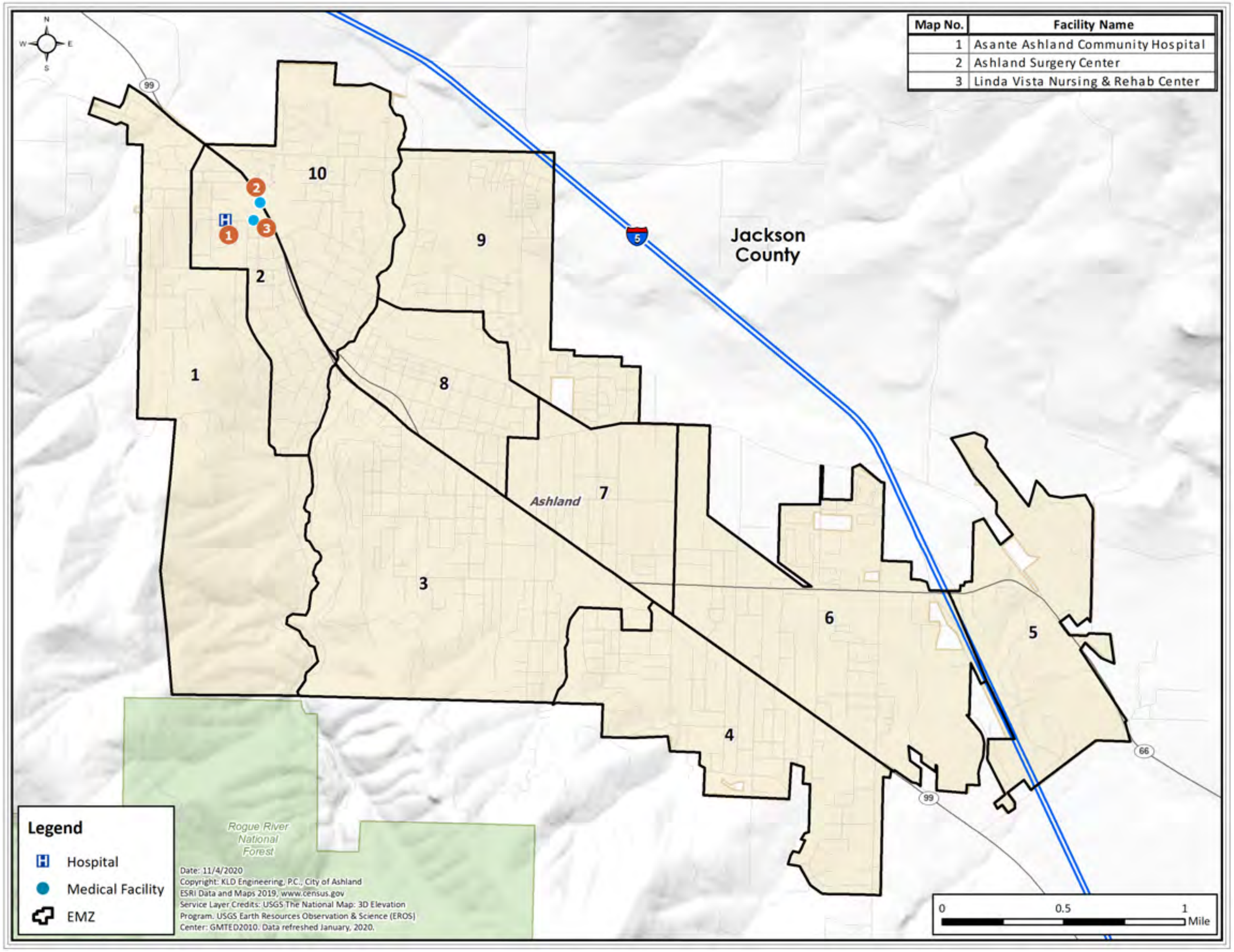
[2] There is limited parking capacity at Oregon Shakespeare Festival in EMZ 3. According to the city, the vehicles for the festival park at multiple places near the theatre in EMZs 2, 3 and 8. For detailed information, please refer to Section 3.



Map No.	Facility Name
1	Ashland High School
2	Ashland Middle School
3	Bellview Elementary School
4	Childrens World
5	Head Start
6	Helman Elementary School
7	John Muir Elementary School
8	Memory Lane Preschool
9	Oregon Child Development
10	Pea Pod Village
11	Rain and Shine Preschool
12	Reflective Hearts Childcare
13	Southern Oregon University
14	Stone Soup Playschool
15	Walker Elementary School

Date: 11/4/2020
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation Program. USGS Earth Resources Observation & Science (EROS) Center: GMTED2010. Data refreshed January, 2020.

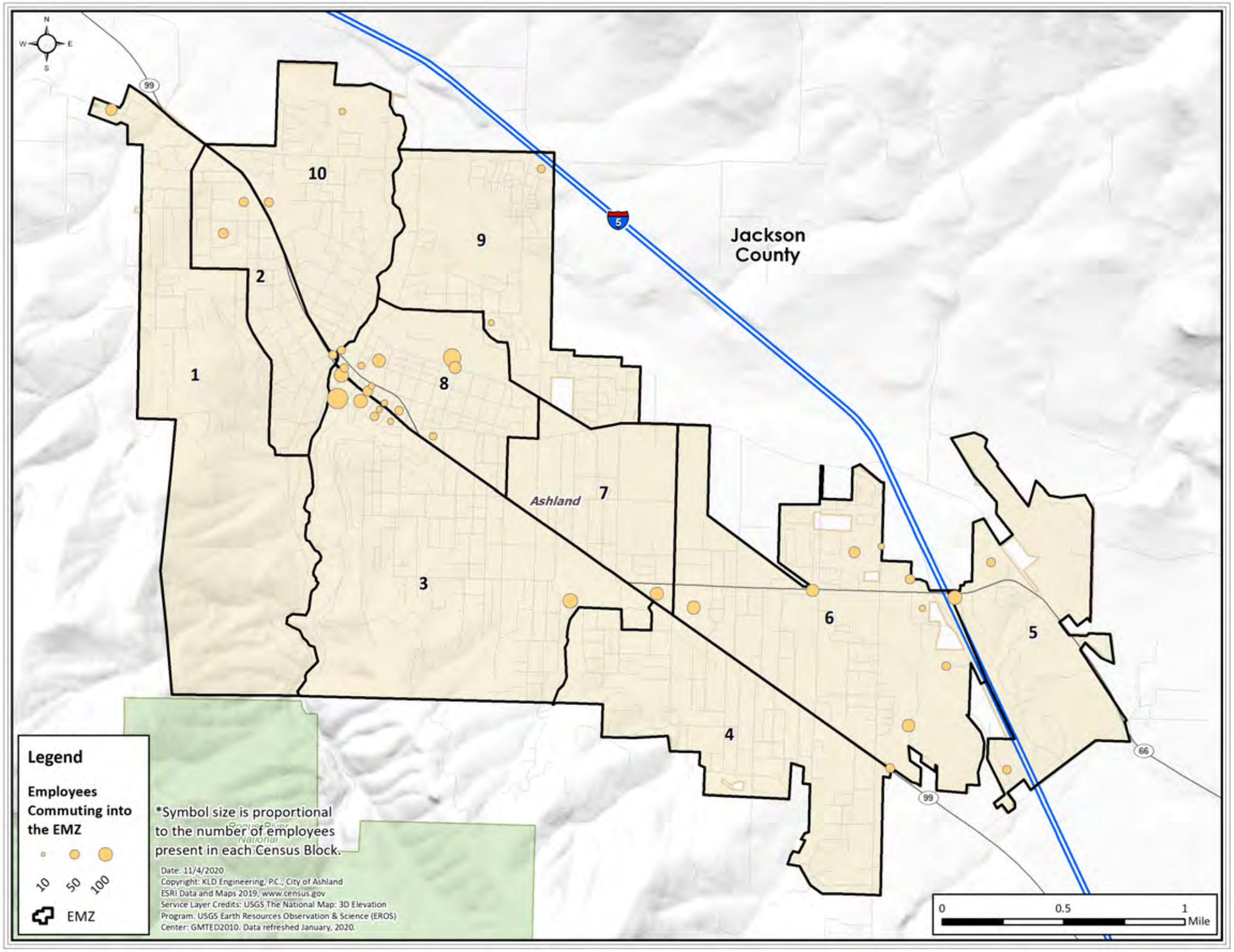
Figure E-1. Schools and Preschools/Daycares within the EMZ



Map No.	Facility Name
1	Asante Ashland Community Hospital
2	Ashland Surgery Center
3	Linda Vista Nursing & Rehab Center

Date: 11/4/2020
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation Program. USGS Earth Resources Observation & Science (EROS) Center: GMTED2010. Data refreshed January, 2020.

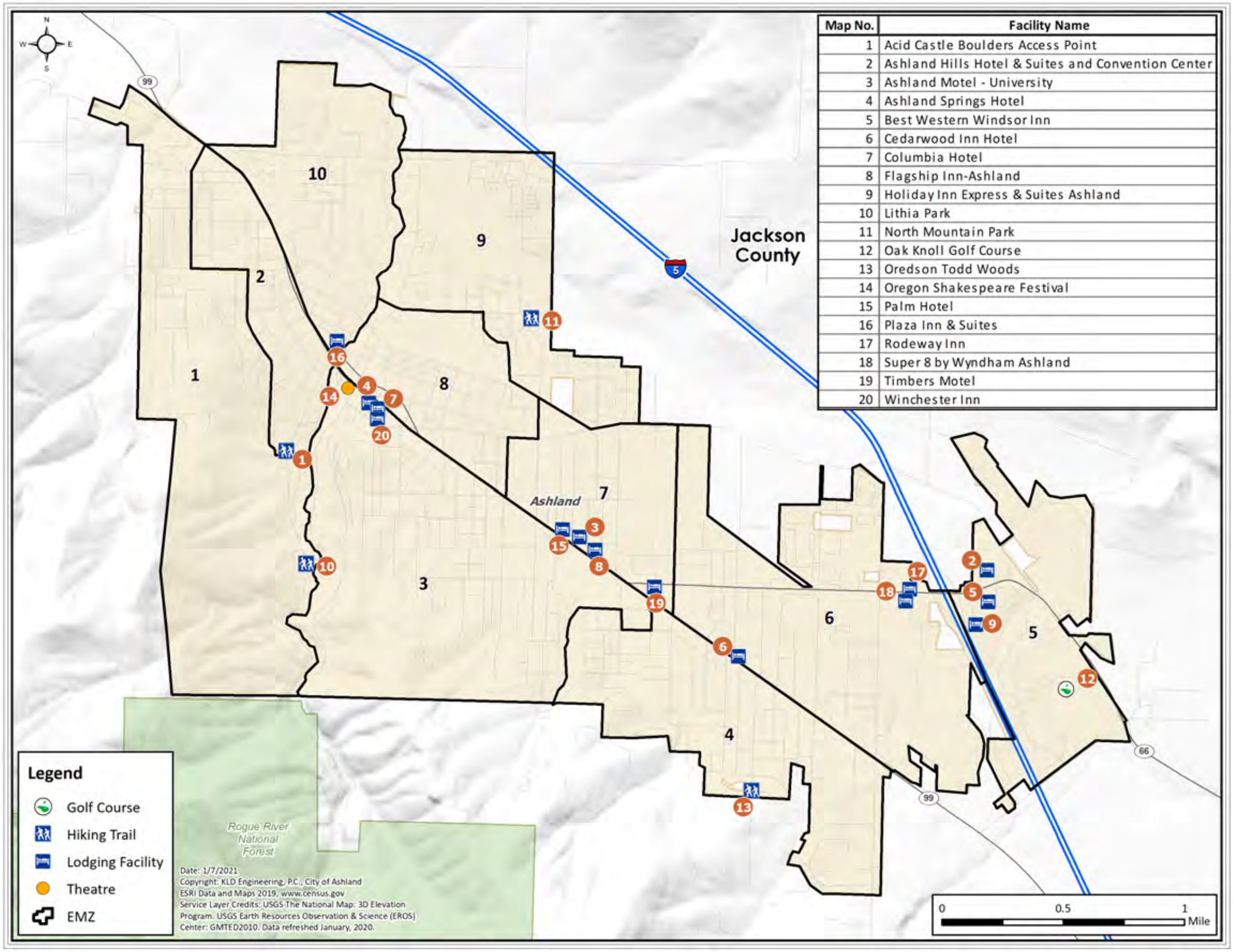
Figure E-2. Medical Facilities within the EMZ



*Symbol size is proportional to the number of employees present in each Census Block.

Date: 11/4/2020
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation Program. USGS Earth Resources Observation & Science (EROS) Center: GMTED2010. Data refreshed January, 2020.

Figure E-3. Major Employers within the EMZ



Map No.	Facility Name
1	Acid Castle Boulders Access Point
2	Ashland Hills Hotel & Suites and Convention Center
3	Ashland Motel - University
4	Ashland Springs Hotel
5	Best Western Windsor Inn
6	Cedarwood Inn Hotel
7	Columbia Hotel
8	Flagship Inn-Ashland
9	Holiday Inn Express & Suites Ashland
10	Lithia Park
11	North Mountain Park
12	Oak Knoll Golf Course
13	Oredson Todd Woods
14	Oregon Shakespeare Festival
15	Palm Hotel
16	Plaza Inn & Suites
17	Rodeway Inn
18	Super 8 by Wyndham Ashland
19	Timbers Motel
20	Winchester Inn

Date: 1/7/2021
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation
Program. USGS Earth Resources Observation & Science (EROS)
Center: GMTED2010. Data refreshed January, 2020.

Figure E-4. Recreational Facilities and Lodging Facilities within the EMZ

APPENDIX F

Demographic Survey

F. DEMOGRAPHIC SURVEY

This appendix presents the results obtained from a Demographic Survey that was conducted in support of this study. Outlined below is the survey sampling plan, results obtained, and survey instrument (See Attachment A).

F.1 Introduction

The development of evacuation time estimates for the City of Ashland Emergency Management Zones (EMZs) requires the identification of travel patterns, car ownership and household size of the population. Demographic information can be obtained from Census data, however, 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 EMZs and consequently may not accurately represent the anticipated behavioral characteristics of the evacuating populace.

These concerns are addressed by conducting a demographic survey of a representative sample of the study area population. The survey is designed to elicit information from the public concerning family demographics and estimates of response times to well defined events. The design of the survey includes a limited number of questions of the form "What would you do if …?" and other questions regarding activities with which the respondent is familiar ("How long does it take you to …?").

F.2 Survey Instrument and Sampling Plan

Attachment A presents the final survey instrument used for the demographic survey. A draft of the instrument was submitted to stakeholders for comment. Comments were received and the survey instrument was modified accordingly, prior to conducting the survey.

Following the completion of the instrument, a sampling plan was developed. A sample size of 2,471 **completed** survey forms yields results with a sampling error of approximately ±2.30 at the 99% confidence level. The sample must be drawn from the study population (see Section 3.1) converted to households using the average household size of 2.06 people per household based upon 2014-2018 Census data since the goal is to survey individual households rather than individual people. A list of zip codes in the study area was developed using geographic information system (GIS) software.

The demographic survey was conducted through an online form. The demographic survey primarily advertised utilizing a mass notification system, Nixle. Additionally, the survey was posted electronically on the city's websites and Facebook pages.

F.3 Survey Results

The results of the survey fall into three categories. The first category is household demographic results. Household demographic information includes such factors as household size, automobile ownership, automobile availability, commuters, cellphone coverage, and emergency alert and warning system subscription. The second category of survey results is about evacuation responses. This section contains results regarding how residents in the study area would respond to an evacuation. The third category of results contains time distributions for performing certain pre-evacuation activities. 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 "Decline to State" option for a response. It is accepted practice in conducting surveys of this type to accept the answers of a respondent who offers a DK or "Decline to State" response for a few questions. To address the issue of occasional DK/declined 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/declined responses are ignored, and the distributions are based upon the positive data that is acquired.

F.3.1 Household Demographic Results

Household Size

Figure F-1 presents the distribution of household size within the EMZs based on the responses to the demographic survey. The average household contains 2.23 people. The estimated household size (2.06 persons) used to determine the survey sample 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.

Automobile Ownership

The average number of automobiles available per household in the study area is 1.88. The distribution of automobile ownership is presented in Figure F-2. It should be noted that only 1.14% of people do not have access to a vehicle. Figure F-3 and Figure F-4 present the automobile availability by household size. As expected, nearly all households of 2 or more people have access to at least one vehicle. Figure F-5 shows the percent of households that own an electric vehicle. Approximately 13 percent of households own at least one electric vehicle.

Ridesharing

An overwhelming proportion (88%) of the households surveyed responded that they could share a ride with a neighbor, relative, or friend if a car is not available to them when advised to evacuate.

Functional or Transportation Needs

Approximately 7% of households have a person with functional or transportation needs. Figure F-6 shows the breakdown of the percentage of households with each type of need. The majority of these people would need a bus to evacuate. It should be noted that about 8.7% of these people have their own transportation but have a walking or mobility issue/disability.

Commuters

Figure F-7 presents the distribution of the number of commuters in each household. Commuters are defined as household members who travel to work or college on a daily basis. The data shows an average of 0.52 commuters per household in the study area, and approximately 36% of households have at least one commuter.

Commuter Travel Modes

Figure F-8 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 1.06 employees per vehicle, assuming 2 people per vehicle – on average – for carpools.

Commuter Travel Patterns

Figure F-9 presents the destination area code that commuters travel to on a daily basis. Of the respondents who commute on a daily basis, approximately 62% work within Ashland (97520 area code). Of the remaining 38%--12% commute to 97504, 9% commute to 97501 and the remaining commute to other locations.

F.3.2 Evacuation Response

Several questions were asked to gauge the population's response to an emergency. These are now discussed:

"How many vehicles would your household use during a wildfire evacuation?" The response is shown in Figure F-10. On average, evacuating households would use 1.43 vehicles.

"Would your family await the return of other family members prior to evacuating the area?" Of the survey participants who responded, approximately 39% said they would await the return of other family members before evacuating and 61% indicated they would not await the return of other family members.

"What type of pet(s) and/or animal(s) do you have?" Based on the responses, approximately 62% of the households have pets and/or animals. Of the households that own pets and/or animals, 90.5% of them indicated that they own a domesticated animal (or household pet). This category includes dogs, cats, birds, reptiles, and fish. Approximately 6.5% of households own farm animals like horses, chickens, goats, and pigs. Approximately 3% of households indicated that they own other pets/animals but did not specify.

"If you have a household pet and/or an animal, would you take your pet with you if you were asked to evacuate the area?" Based on the responses to the survey 98% of households that own pets and/or animals would take them during an evacuation; the remaining 2% would leave them at home. Of the respondents who would elect to take their animals with them during an evacuation, 18% would take them to a shelter, and 80% would take them somewhere else. Of the households with pets and/or animals, 96% indicated that they have sufficient room in their vehicles to evacuate with them. Approximately 2% would use a trailer to evacuate their pet/animal.

"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 94% of households who are advised to shelter-in-place would do so; the remaining 6% would choose to evacuate the area. Therefore, 6% of the population within the shadow region and within the EMZs not advised to evacuate will voluntarily evacuate.

"Emergency officials advise you to evacuate due to a wildfire. Where would you evacuate to?" Based on the responses, approximately 39% would evacuate to a friend/relative's home. Approximately 29% answered "Don't Know/Other". Approximately 24% would evacuate to a hotel, motel, or campground. Less than one percent would choose not to evacuate. See Figure F-11 for complete results.

"Emergency officials advise you to evacuate. Would you notify a neighbor or friend to evacuate as well?" This question is designed to elicit information regarding notification between residents in the study area. Approximately 94% of respondents said they would notify a neighbor or a friend. The remaining 6% said they would not.

"How would you notify a neighbor or friend to evacuate during an emergency?" This question is designed to see how respondents in the study area would notify neighbors or friends during an evacuation, if they chose to do so. From the respondents who elected to notify a neighbor or friend during an evacuation, the majority (39%) would notify in person. From the remaining respondents, there was a near equal split between using text messages and phone calls at about 29% for each, and 3% of respondents would use some form of social media. Figure F-12 displays these results.

"How would you rate the cell phone coverage in your area?" Figure F-13 presents how the respondents rated cell phone coverage in their area. The purpose of this question was to gain insight into how well a cell phone based alert and/or notification would be received. This question was added for informational purposes only and was not used in this study. As shown in the figure, the data is more heavily weighted towards good or better with 85% of respondents rating their cell phone reception in their area as good, very good, or excellent. The remaining approximately 15% rated cell phone coverage as fair, poor or very poor in their area. (Less than one percent indicated that they do not have a cell phone available.)

"Have you opted into your local Emergency Alert and Warning systems?" Figure F-14 displays the percentages of respondents who have opted into their local emergency alert and warning systems and by method. The majority of the study area residents who are registered are opted into either NIXLE or Citizen Alert (99 percent) while a few indicated they are opted into other emergency alert systems (less than one percent). Of the respondents, 17 percent indicated that they registered using their residential phone number, 79 percent using their cell phone number, 38 percent using their email address and/or 75 percent opted in by text message. It should be noted some people are opted into multiple methods of notification.

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 would it take you to notify a neighbor or friend to evacuate?" This question is designed to see how long it would take respondents to notify a neighbor or friend should they choose to do so. From the respondents who elected to notify a neighbor or friend during an evacuation, approximately 63% responded they would notify them in 5 minutes or less, 22% said it would take them between 6 and 10 minutes to notify a neighbor or friend, and 10% said it would take them between 11 and 15 minutes. The remaining approximately 5% aid it would take them 20 minutes or more to notify a neighbor or friend during an evacuation. This distribution is displayed in Figure F-15.

"How long does it take the commuter to complete preparation for leaving work/college?" Figure F-16 presents the cumulative distribution; in all cases, the activity is completed by 60 minutes. Approximately, 90% can leave in less than 30 minutes.

"How long would it take the commuter to travel home?" Figure F-17 presents the work to home travel time for the EMZ. Approximately 92% of commuters can arrive home within 30 minutes of leaving work; all within 60 minutes.

"How long would it take the family to pack clothing, secure the house, and load the car?" Figure F-18 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-18 has a long "tail." Approximately 90% of households can be ready to leave home within 105 minutes; the remaining 10% of households require up to an additional 90 minutes.

F.4 Conclusions

The demographic survey provides valuable, relevant data associated with the study area population. This data is used to quantify demographics specific to the study area and "mobilization time", which can influence evacuation time estimates.

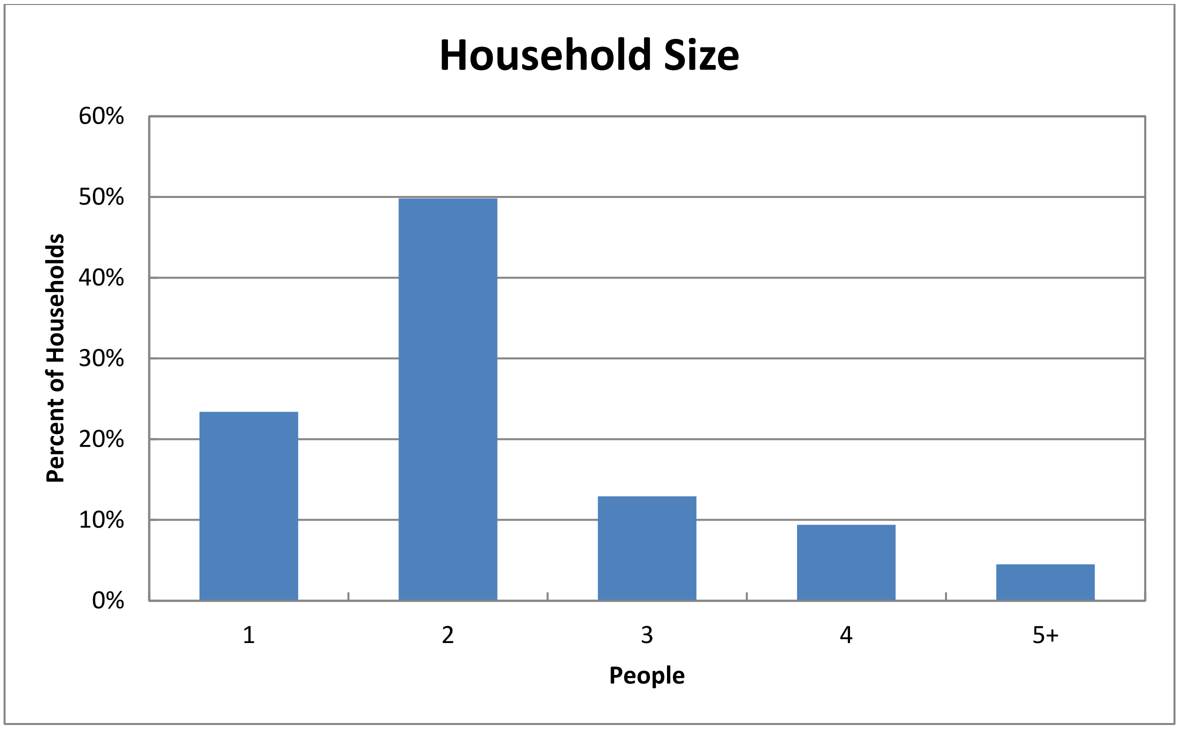


Figure F-1. Household Size in the Study Area

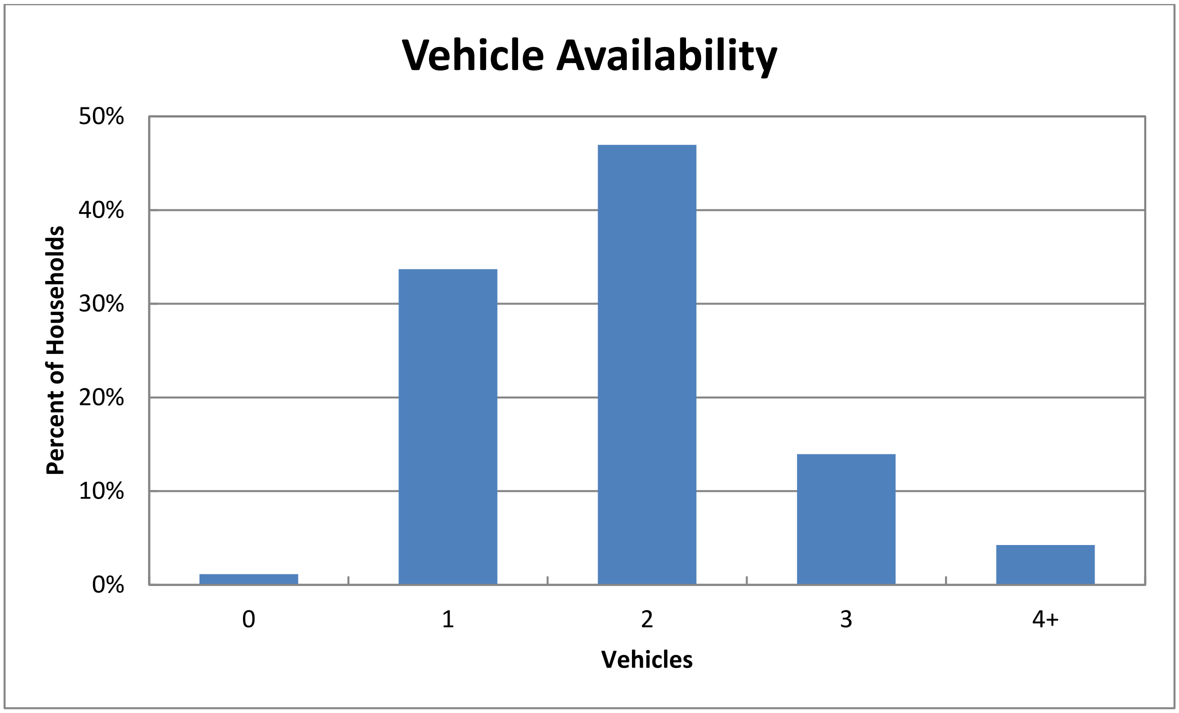


Figure F-2. Vehicle Availability

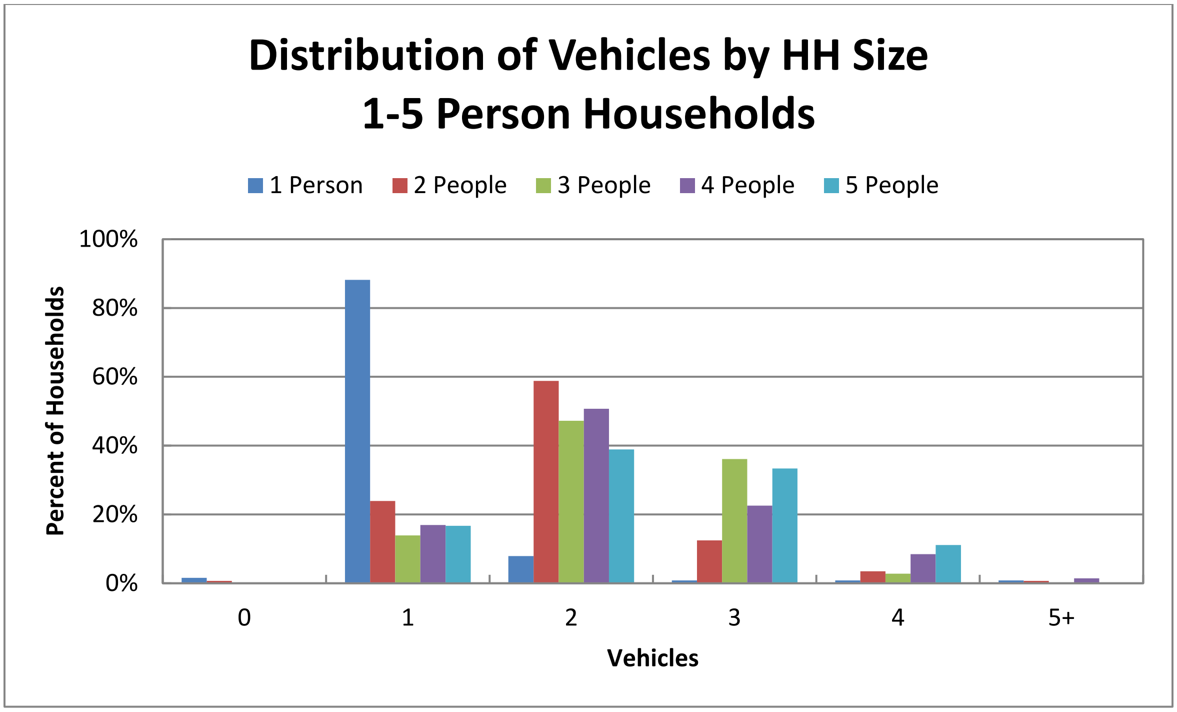


Figure F-3. Vehicle Availability - 1 to 4 Person Households

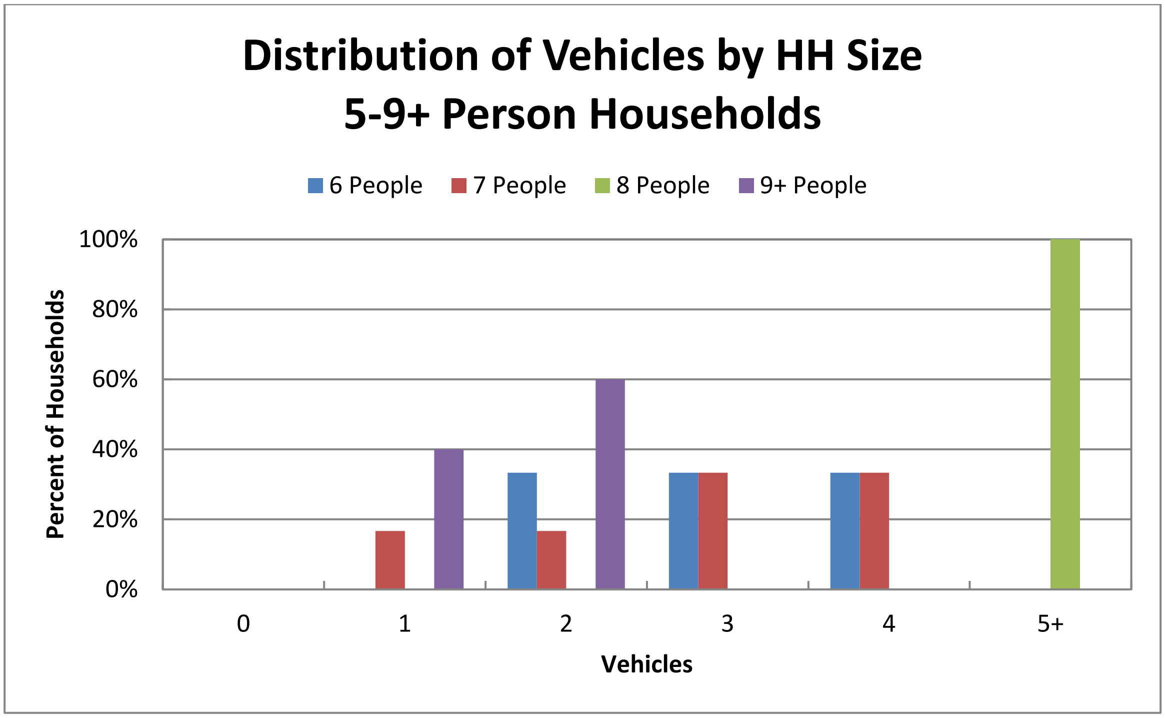


Figure F-4. Vehicle Availability – 5 to 7+ Person Households

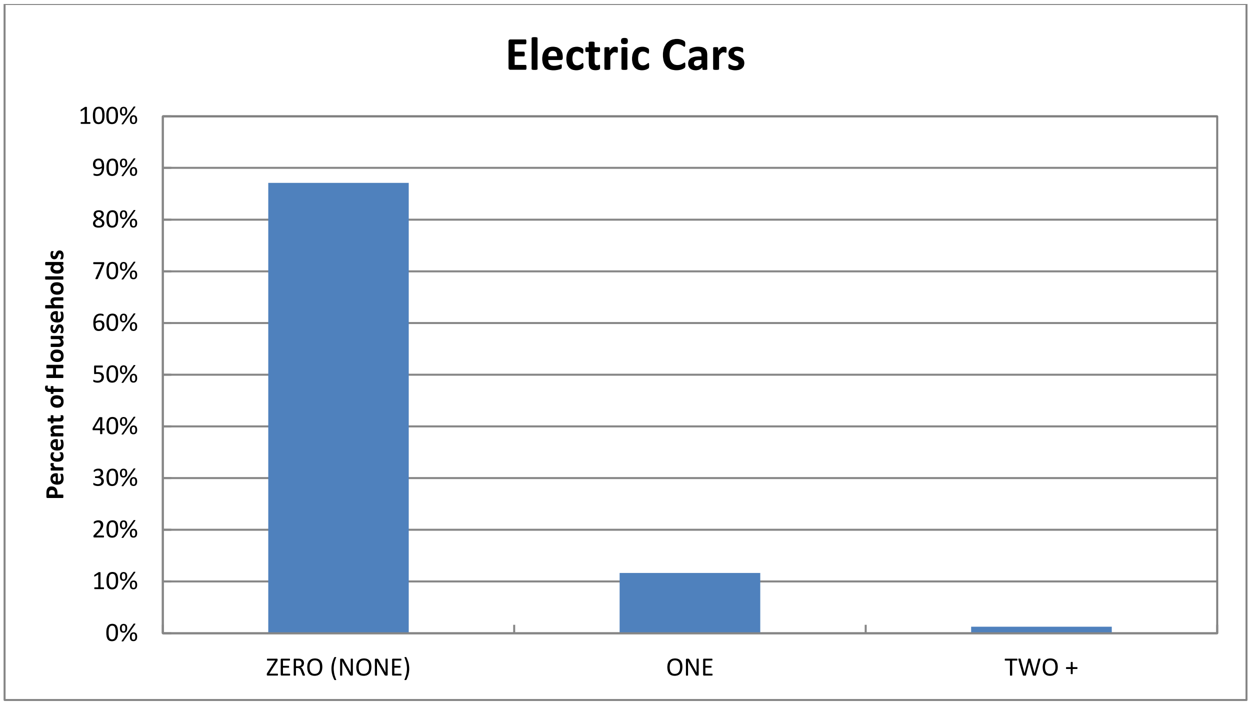


Figure F-5. Electric Vehicle Ownership

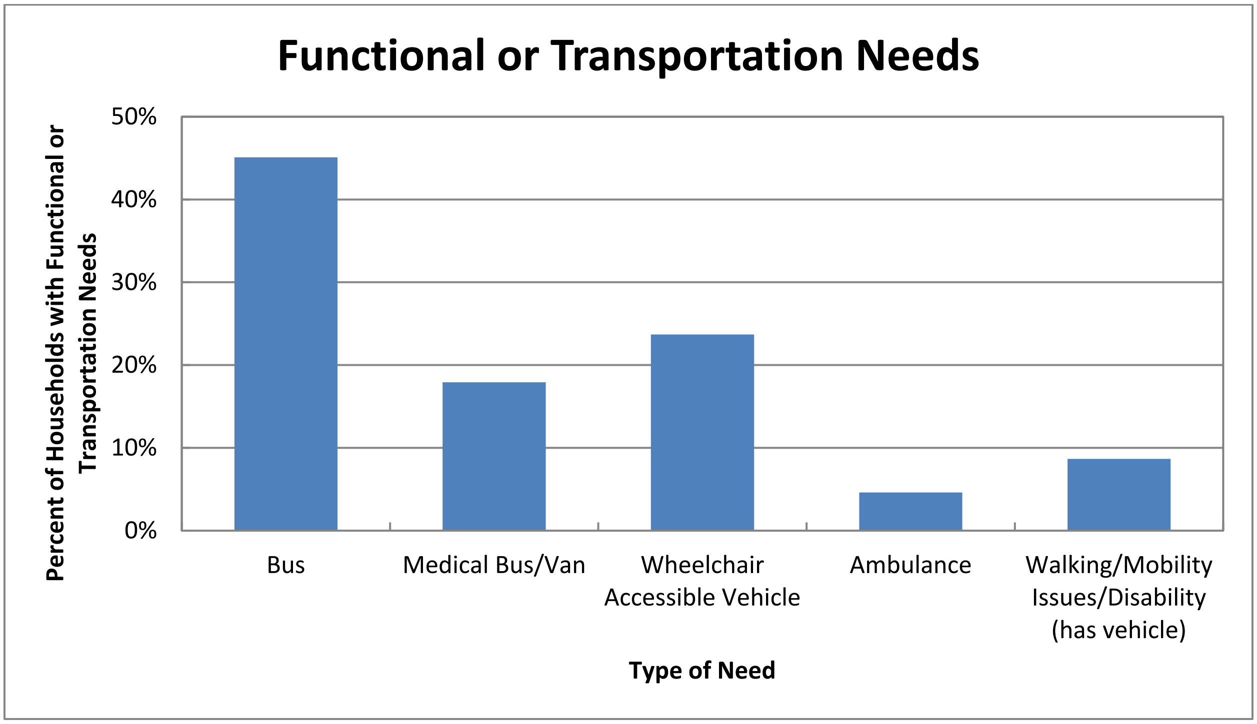


Figure F-6. Functional or Transportation Needs

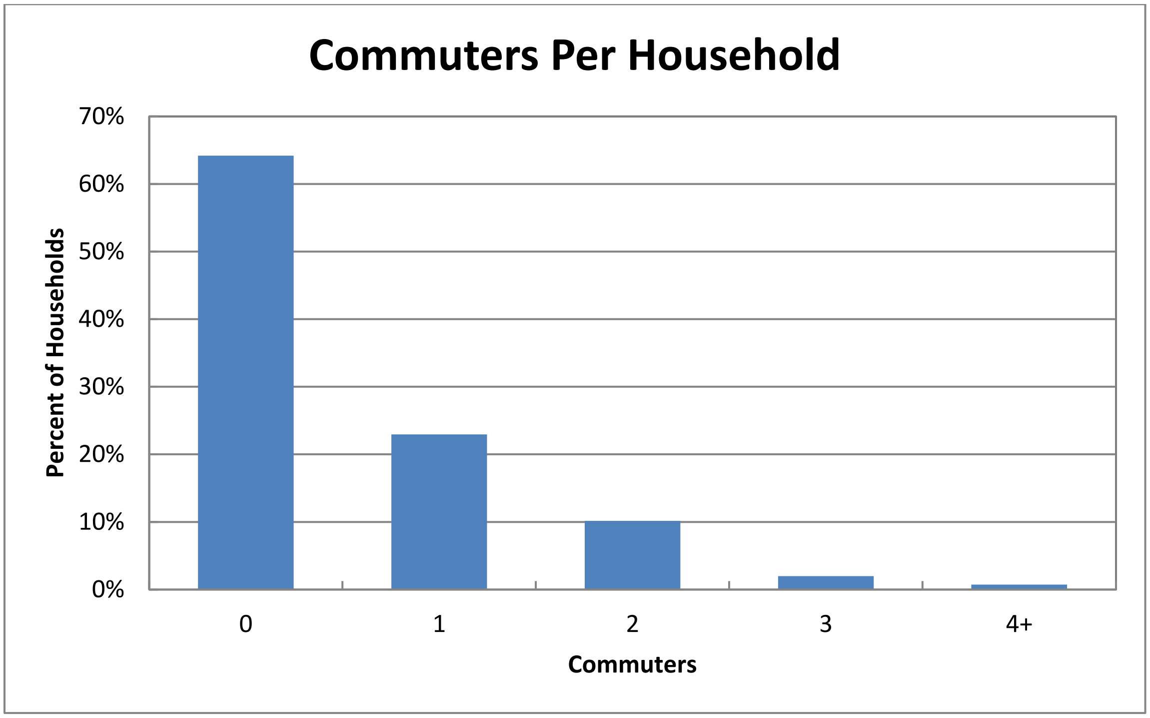


Figure F-7. Commuters in Households in the Study Area

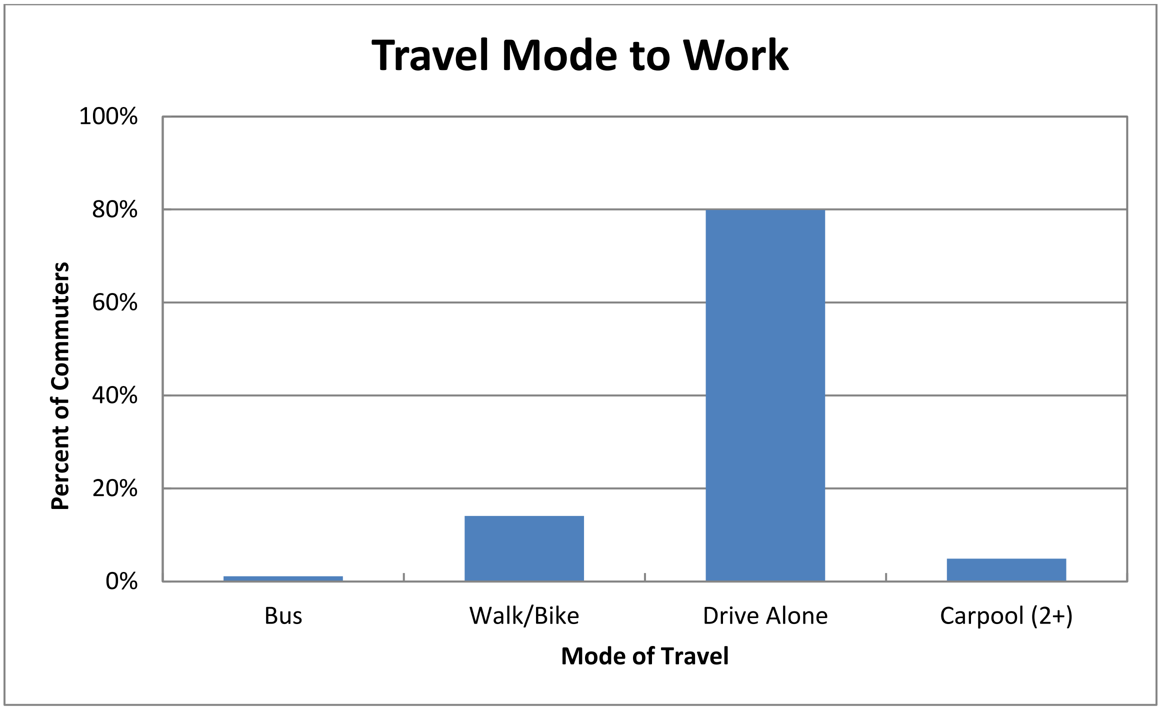


Figure F-8. Modes of Travel in the Study Area

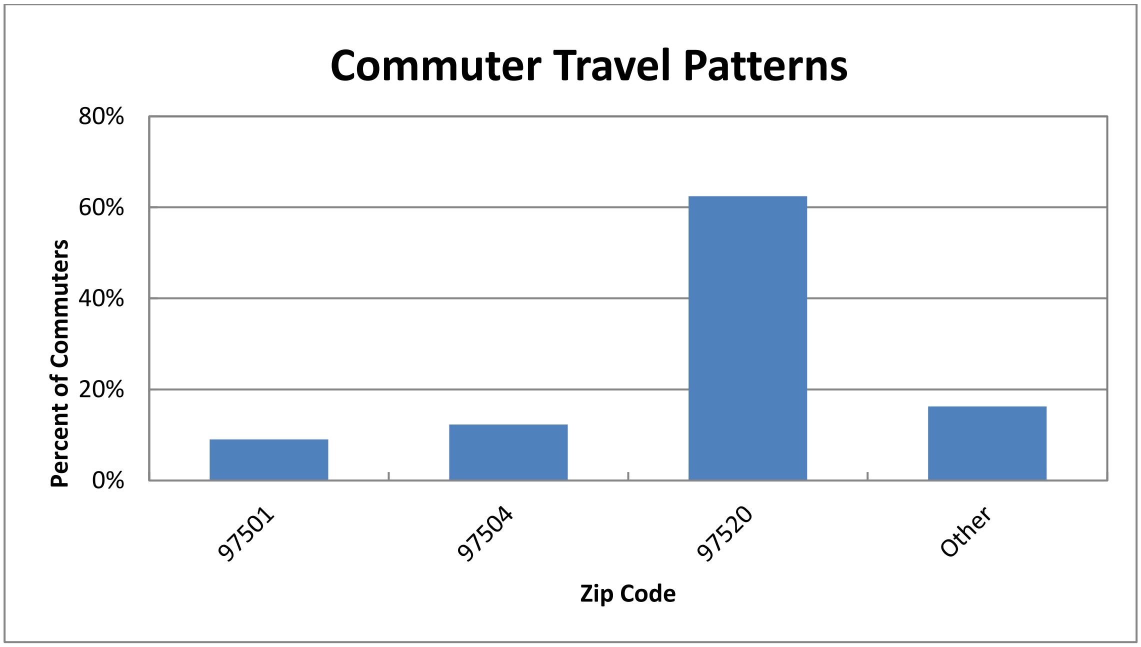


Figure F-9. Commuter Travel Patterns

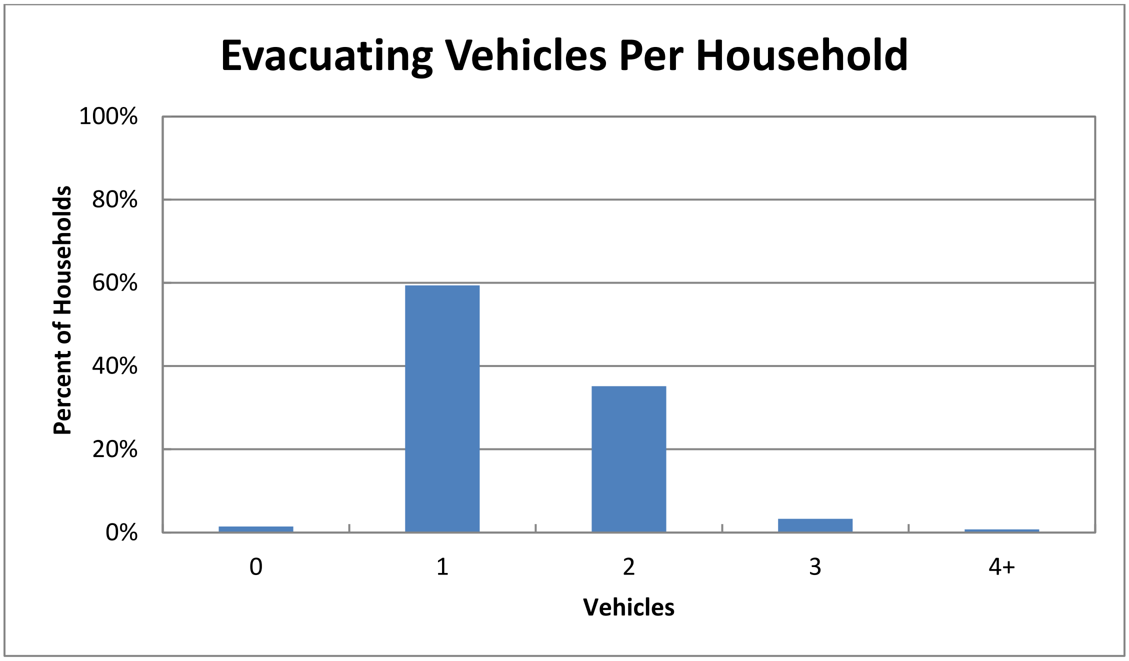


Figure F-10. Number of Vehicles Used for Evacuation

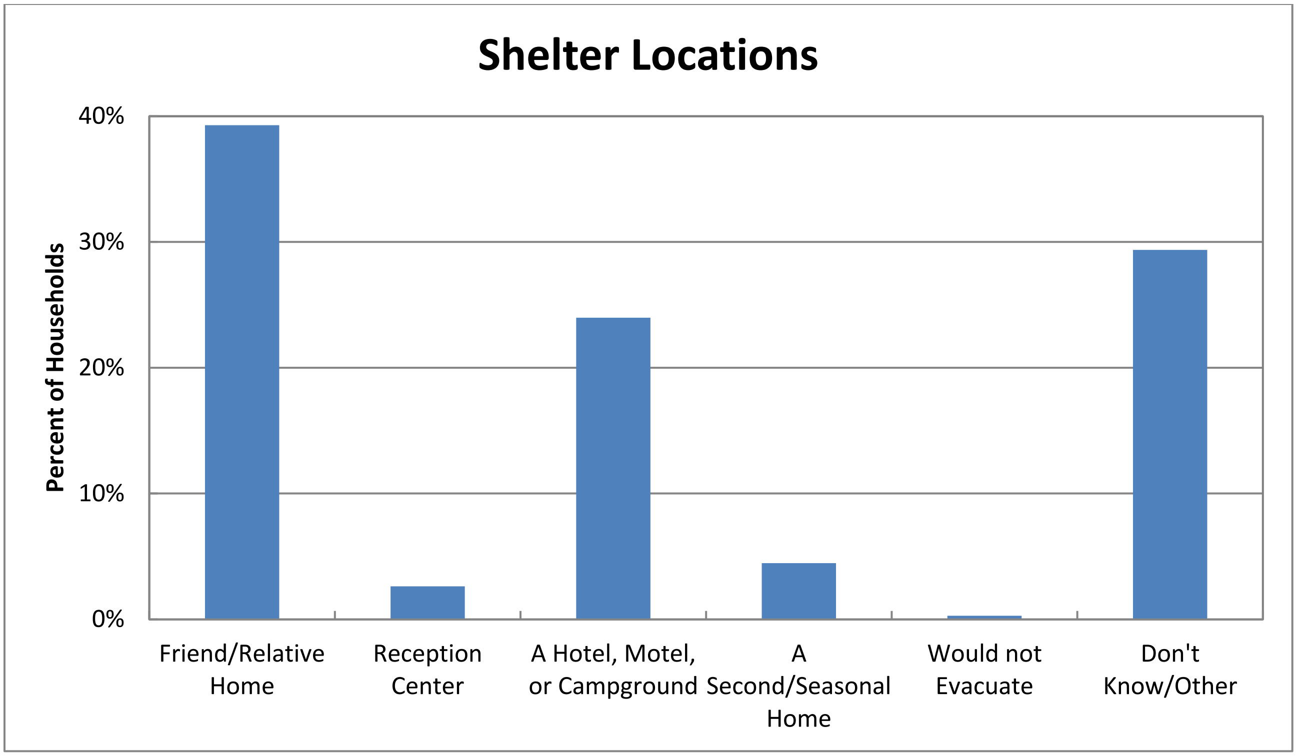


Figure F-11. Study Area Shelter Locations

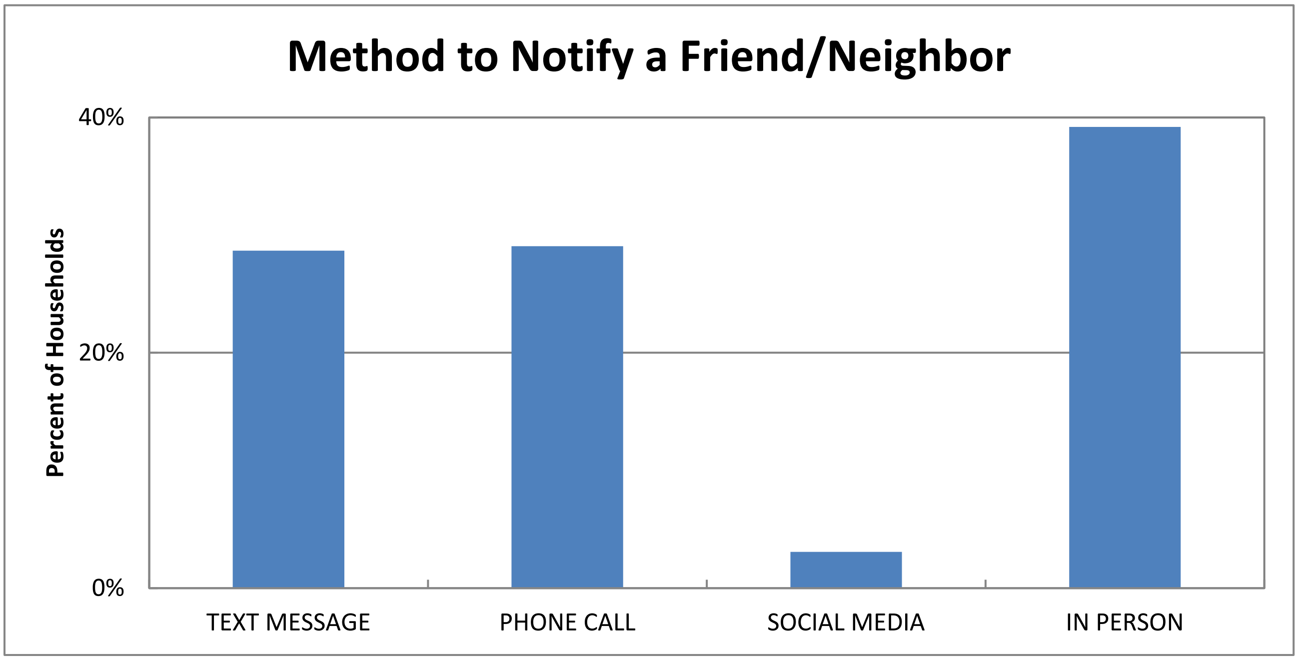


Figure F-12. Method to Notify a Friend/Neighbor

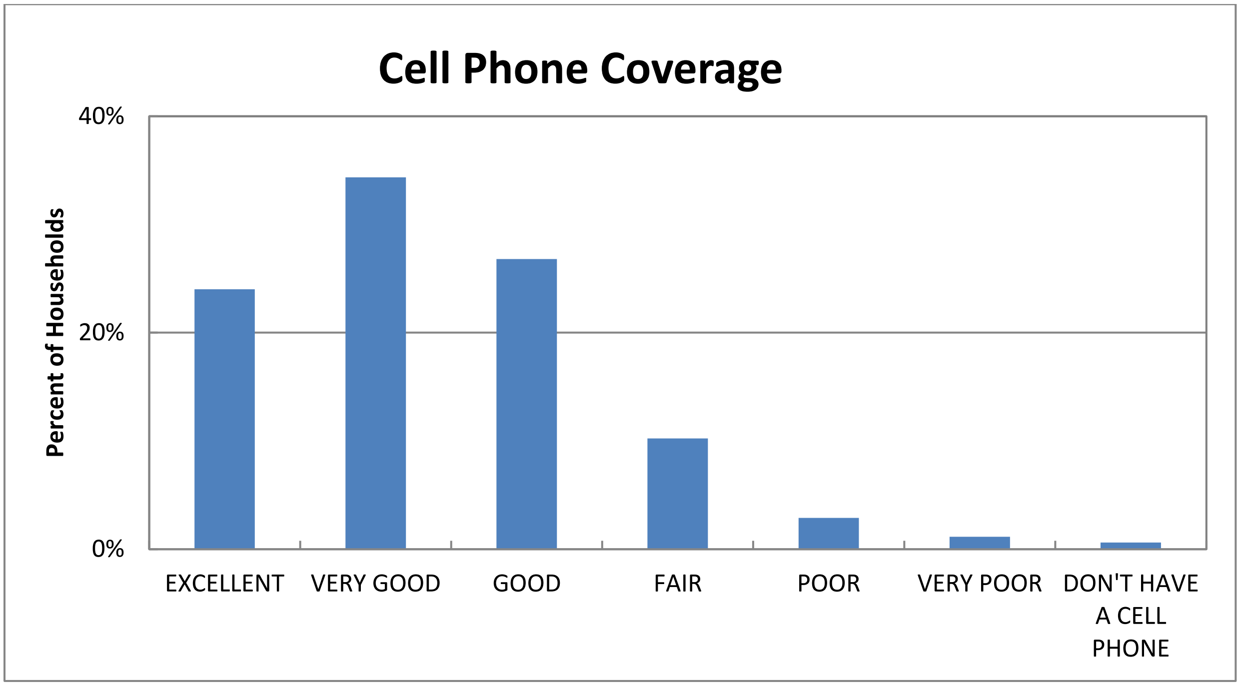


Figure F-13. Cell Phone Coverage

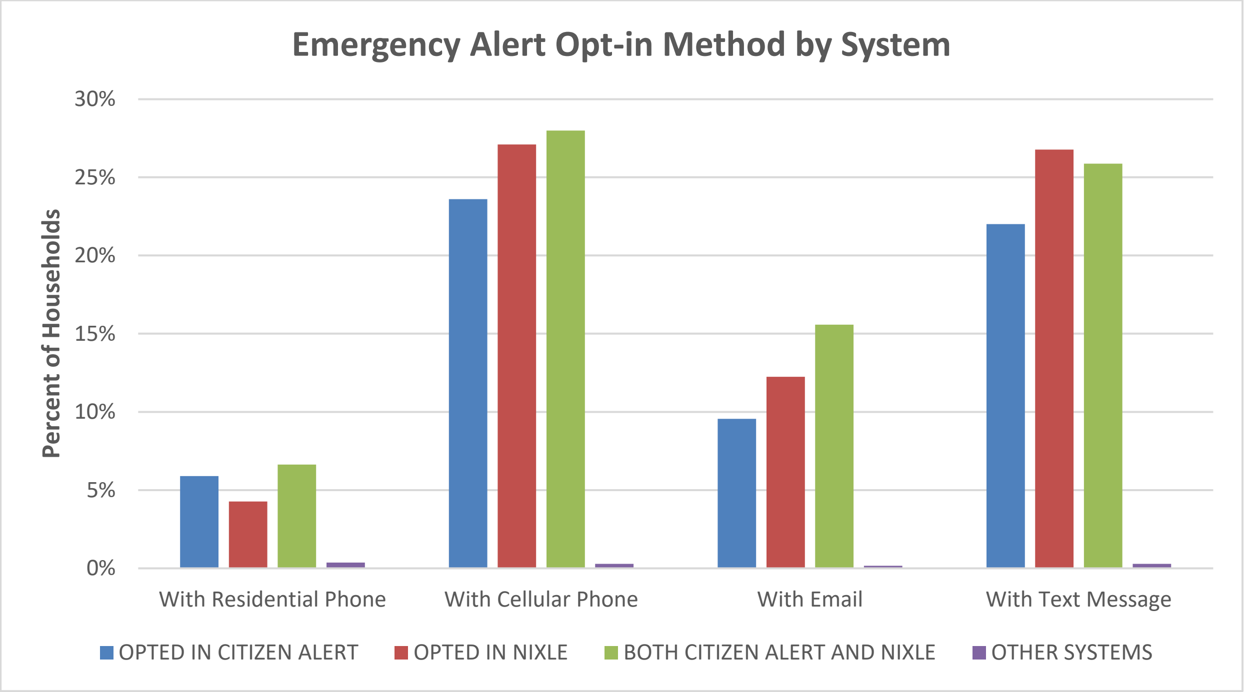


Figure F-14. Emergency Alert Opt-in Method by System

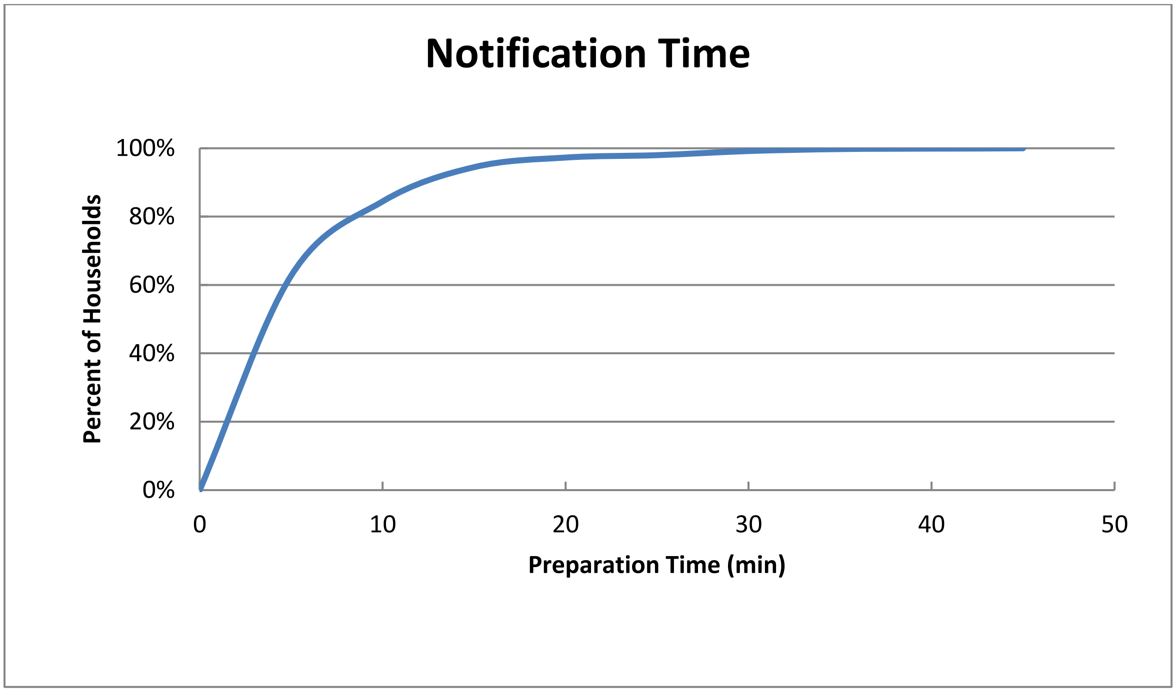


Figure F-15. Notification Time

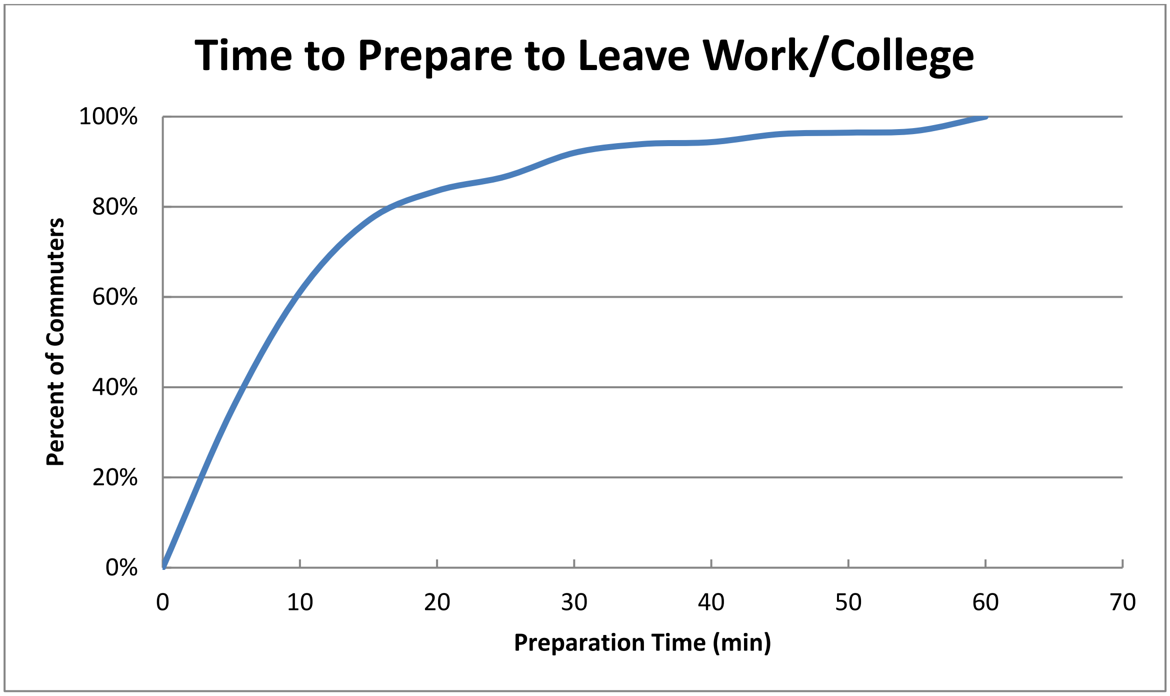


Figure F-16. Time Required to Prepare to Leave Work/College

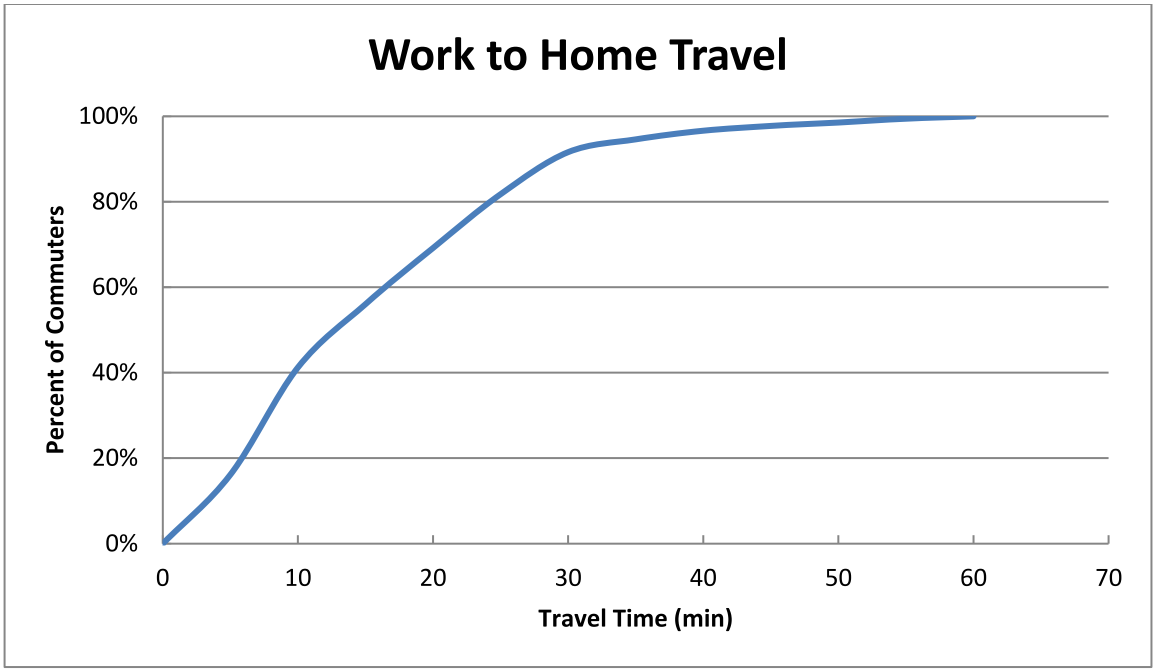


Figure F-17. Time to Travel Home from Work/College

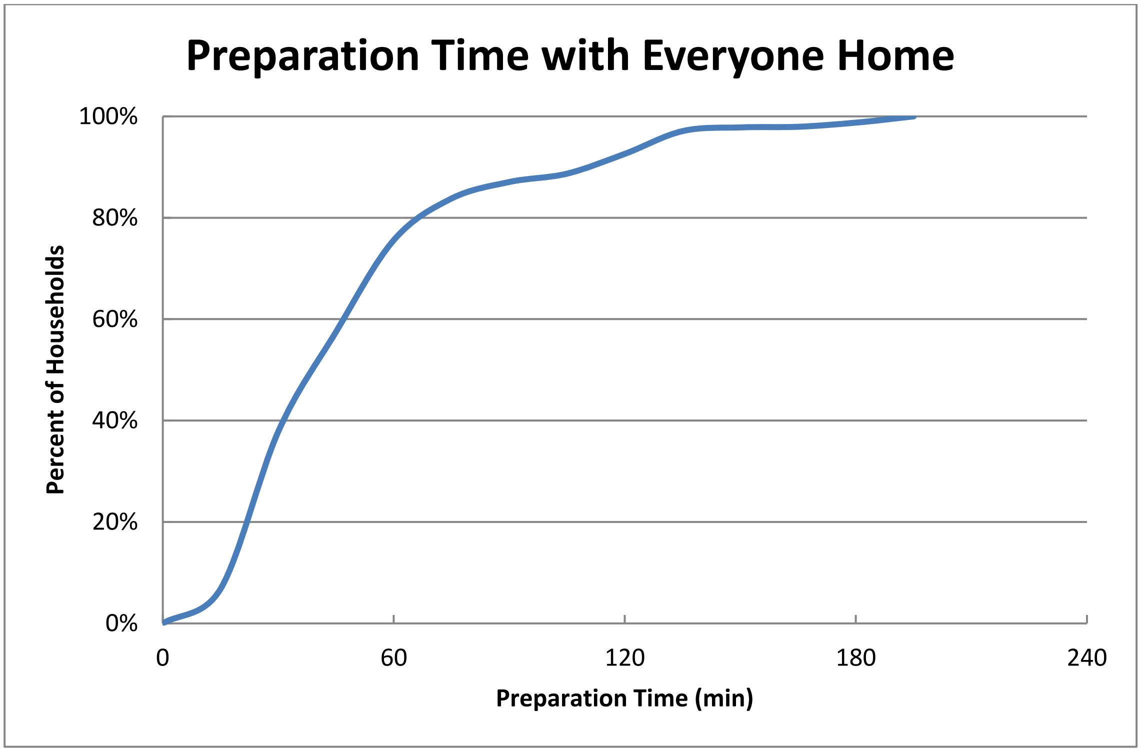


Figure F-18. Time to Prepare Home for Evacuation

ATTACHMENT A

Demographic Survey Instrument

City of Ashland Wildfire Egress Study

* Required

Purpose

The City of Ashland is currently undertaking an evacuation study to determine how long it would take to evacuate the City under different circumstances (weekday versus weekend, midday versus evening, etc.). The results of this study will be used to enhance emergency response plans for the City and help protect our residents and visitors. The survey below includes questions designed to estimate demographics for the City that are not available from the U.S. Census Bureau. These demographics help determine the number of vehicles that will be evacuating the City in the event of an emergency. The survey also includes questions designed to estimate the time needed by residents and visitors to prepare to evacuate.

Please do not provide your name or any personal information, and the survey should take less than 5 minutes to complete.

1. What is your home zip code? *

Mark only one oval.

○ 97520
○ 97530
○ 97535
○ 97501
○ 97502
○ 97503
○ 97504
○ Prefer not to say
○ Other: ______________________

2A. In total, how many running cars, or other vehicles are usually available to the household?

Mark only one oval.

- ○ ONE
- ○ TWO
- ○ THREE
- ○ FOUR
- ○ FIVE
- ○ SIX
- ○ SEVEN
- ○ EIGHT
- ○ NINE OR MORE
- ○ ZERO (NONE)
- ○ PREFER NOT TO SAY

2B. Of these running cars, or other vehicles, how many of them are powered by electric?

Mark only one oval.

- ○ ONE
- ○ TWO
- ○ THREE
- ○ FOUR
- ○ FIVE
- ○ SIX
- ○ SEVEN
- ○ EIGHT
- ○ NINE OR MORE
- ○ ZERO (NONE)
- ○ PREFER NOT TO SAY

2C. If you didn't have a car, would you be able to get a ride out of the area with a neighbor or friend?

Mark only one oval.

- ○ YES
- ○ NO
- ○ YES, IF THEY WERE HOME
- ○ UNSURE
- ○ PREFER NOT TO SAY

3. Please specify the number of people in your household who require Functional or Transportation needs (public/private transportation assistance - bus - or specialized vehicle due to a medical condition - wheelchair transport or ambulance) in an evacuation:

Mark only one oval per row.

	0	1	2	3	4	More than 4
Bus	○	○	○	○	○	○
Medical Bus/Van	○	○	○	○	○	○
Wheelchair Accessible Vehicle	○	○	○	○	○	○
Ambulance	○	○	○	○	○	○
Other	○	○	○	○	○	○

If Other for Question 3, Please Specify:

____

4. How many vehicles would your household use during a wildfire evacuation?

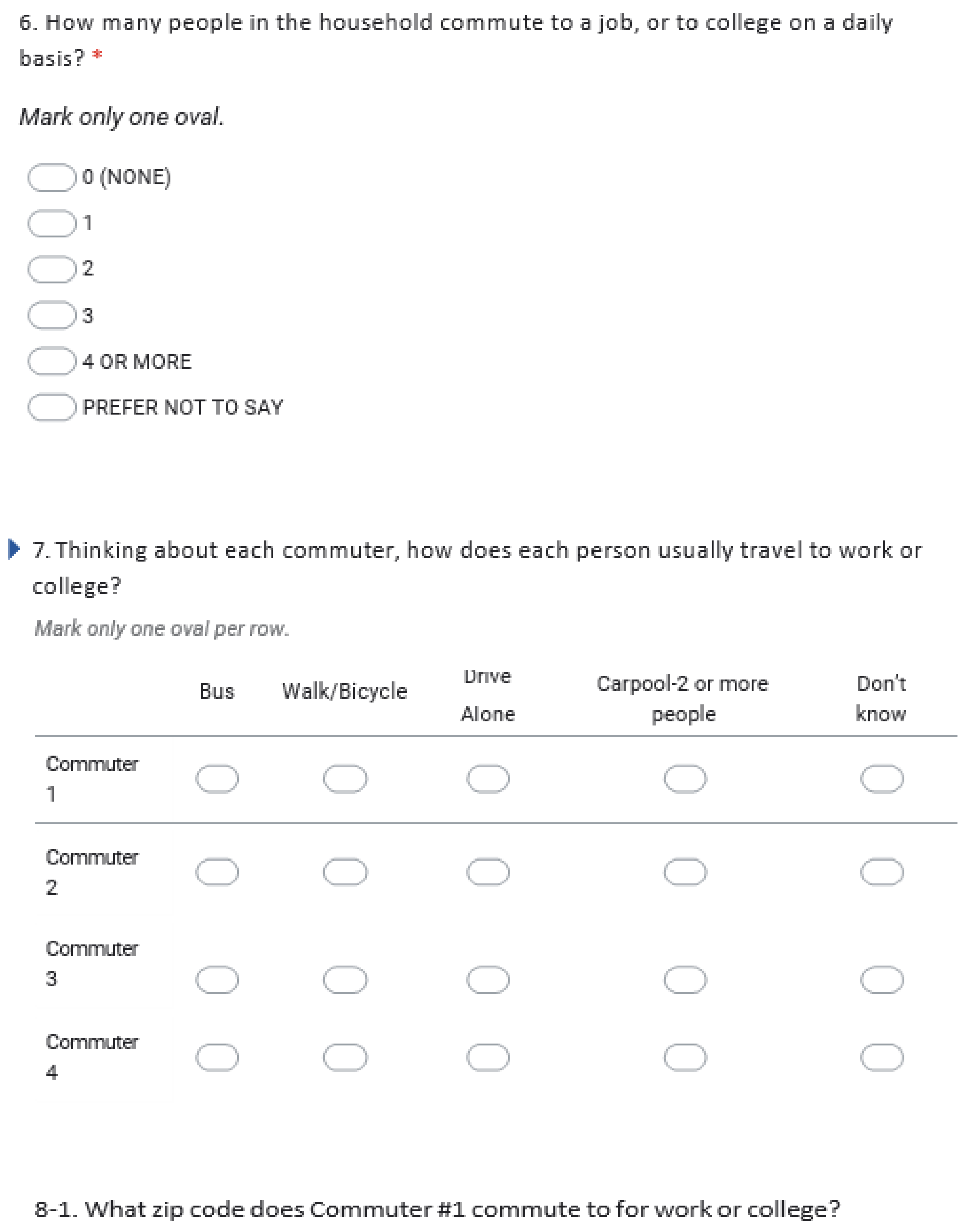
Mark only one oval.

○ 0 (NONE)
○ 1
○ 2
○ 3
○ 4
○ 5
○ 6
○ 7
○ 8
○ 9 OR MORE
○ I WOULD EVACUATE BY BICYCLE
○ I WOULD EVACUATE BY BUS
○ PREFER NOT TO SAY

5. How many people usually live in this household?

Mark only one oval.

- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ 6
- ○ 7
- ○ 8
- ○ 9
- ○ 10
- ○ 11
- ○ 12
- ○ 13
- ○ 14
- ○ 15
- ○ 16
- ○ 17
- ○ 18
- ○ 19 OR MORE
- ○ PREFER NOT TO SAY



6. How many people in the household commute to a job, or to college on a daily basis? *

Mark only one oval.

- ○ 0 (NONE)
- ○ 1
- ○ 2
- ○ 3
- ○ 4 OR MORE
- ○ PREFER NOT TO SAY

7. Thinking about each commuter, how does each person usually travel to work or college?

Mark only one oval per row.

	Bus	Walk/Bicycle	Drive Alone	Carpool-2 or more people	Don't know
Commuter 1	○	○	○	○	○
Commuter 2	○	○	○	○	○
Commuter 3	○	○	○	○	○
Commuter 4	○	○	○	○	○

8-1. What zip code does Commuter #1 commute to for work or college?

8-2. What zip code does Commuter #2 commute to for work or college?

8-3. What zip code does Commuter #3 commute to for work or college?

8-4. What zip code does Commuter #4 commute to for work or college?

9-1. How much time on average, would it take Commuter #1 to travel home from work or college?

Mark only one oval.

- ○ 5 MINUTES OR LESS
- ○ 6-10 MINUTES
- ○ 11-15 MINUTES
- ○ 16-20 MINUTES
- ○ 21-25 MINUTES
- ○ 26-30 MINUTES
- ○ 31-35 MINUTES
- ○ 36-40 MINUTES
- ○ 41-45 MINUTES
- ○ 46-50 MINUTES
- ○ 51-55 MINUTES
- ○ 56 - 1 HOUR
- ○ OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- ○ BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- ○ BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- ○ BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- ○ OVER 2 HOURS
- ○ PREFER NOT TO SAY
- ○ Other: ____________________

If Over 2 Hours for Question 9-1, Please Specify:

____

9-2. How much time on average, would it take Commuter #2 to travel home from work or college?

Mark only one oval.

- ○ 5 MINUTES OR LESS
- ○ 6-10 MINUTES
- ○ 11-15 MINUTES
- ○ 16-20 MINUTES
- ○ 21-25 MINUTES
- ○ 26-30 MINUTES
- ○ 31-35 MINUTES
- ○ 36-40 MINUTES
- ○ 41-45 MINUTES
- ○ 46-50 MINUTES
- ○ 51-55 MINUTES
- ○ 56 - 1 HOUR
- ○ OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- ○ BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- ○ BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- ○ BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- ○ OVER 2 HOURS
- ○ PREFER NOT TO SAY
- ○ Other: ____________________

If Over 2 Hours for Question 9-2, Please Specify:

____

9-3. How much time on average, would it take Commuter #3 to travel home from work or college?

Mark only one oval.

- ○ 5 MINUTES OR LESS
- ○ 6-10 MINUTES
- ○ 11-15 MINUTES
- ○ 16-20 MINUTES
- ○ 21-25 MINUTES
- ○ 26-30 MINUTES
- ○ 31-35 MINUTES
- ○ 36-40 MINUTES
- ○ 41-45 MINUTES
- ○ 46-50 MINUTES
- ○ 51-55 MINUTES
- ○ 56 - 1 HOUR
- ○ OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- ○ BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- ○ BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- ○ BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- ○ OVER 2 HOURS
- ○ PREFER NOT TO SAY
- ○ Other: ____________________

If Over 2 Hours for Question 9-3, Please Specify:

____

9-4. How much time on average, would it take Commuter #4 to travel home from work or college?

Mark only one oval.

○ 5 MINUTES OR LESS
○ 6-10 MINUTES
○ 11-15 MINUTES
○ 16-20 MINUTES
○ 21-25 MINUTES
○ 26-30 MINUTES
○ 31-35 MINUTES
○ 36-40 MINUTES
○ 41-45 MINUTES
○ 46-50 MINUTES
○ 51-55 MINUTES
○ 56 - 1 HOUR
○ OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
○ BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
○ BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
○ BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
○ OVER 2 HOURS
○ PREFER NOT TO SAY
○ Other: ____________________

If Over 2 Hours for Question 9-4, Please Specify:

____

10-1. A wildfire is impacting the area where you live, work or go to college, approximately how much time would it take Commuter #1 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

○ 5 MINUTES OR LESS
○ 6-10 MINUTES
○ 11-15 MINUTES
○ 16-20 MINUTES
○ 21-25 MINUTES
○ 26-30 MINUTES
○ 31-35 MINUTES
○ 36-40 MINUTES
○ 41-45 MINUTES
○ 46-50 MINUTES
○ 51-55 MINUTES
○ 56 - 1 HOUR
○ OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
○ BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
○ BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
○ BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
○ OVER 2 HOURS
○ PREFER NOT TO SAY
○ Other: ______________________________

If Over 2 Hours for Question 10-1, Please Specify:

____

10-2. A wildfire is impacting the area where you live, work or go to college, approximately how much time would it take Commuter #2 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

○ 5 MINUTES OR LESS
○ 6-10 MINUTES
○ 11-15 MINUTES
○ 16-20 MINUTES
○ 21-25 MINUTES
○ 26-30 MINUTES
○ 31-35 MINUTES
○ 36-40 MINUTES
○ 41-45 MINUTES
○ 46-50 MINUTES
○ 51-55 MINUTES
○ 56 - 1 HOUR
○ OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
○ BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
○ BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
○ BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
○ OVER 2 HOURS
○ PREFER NOT TO SAY
○ Other: ____________________

If Over 2 Hours for Question 10-2, Please Specify:

____

10-3. A wildfire is impacting the area where you live, work or go to college, approximately how much time would it take Commuter #3 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

- ○ 5 MINUTES OR LESS
- ○ 6-10 MINUTES
- ○ 11-15 MINUTES
- ○ 16-20 MINUTES
- ○ 21-25 MINUTES
- ○ 26-30 MINUTES
- ○ 31-35 MINUTES
- ○ 36-40 MINUTES
- ○ 41-45 MINUTES
- ○ 46-50 MINUTES
- ○ 51-55 MINUTES
- ○ 56 - 1 HOUR
- ○ OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- ○ BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- ○ BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- ○ BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- ○ OVER 2 HOURS
- ○ PREFER NOT TO SAY
- ○ Other: ____________________

If Over 2 Hours for Question 10-3, Please Specify:

____

10-4. A wildfire is impacting the area where you live, work or go to college, approximately how much time would it take Commuter #4 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

- ○ 5 MINUTES OR LESS
- ○ 6-10 MINUTES
- ○ 11-15 MINUTES
- ○ 16-20 MINUTES
- ○ 21-25 MINUTES
- ○ 26-30 MINUTES
- ○ 31-35 MINUTES
- ○ 36-40 MINUTES
- ○ 41-45 MINUTES
- ○ 46-50 MINUTES
- ○ 51-55 MINUTES
- ○ 56 - 1 HOUR
- ○ OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- ○ BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- ○ BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- ○ BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- ○ OVER 2 HOURS
- ○ PREFER NOT TO SAY
- ○ Other: ______________________

30. If Over 2 Hours for Question 10-4, Please Specify:

____

11. If you were advised by local authorities to evacuate due to a wildfire, how much time would it take the household to pack clothing, medications, secure the house, load the car, and complete preparations prior to evacuating the area?

Mark only one oval.

- ○ LESS THAN 15 MINUTES
- ○ 15-30 MINUTES
- ○ 31-45 MINUTES
- ○ 46 MINUTES - 1 HOUR
- ○ 1 HOUR TO 1 HOUR 15 MINUTES
- ○ 1 HOUR 16 MINUTES TO 1 HOUR 30 MINUTES
- ○ 1 HOUR 31 MINUTES TO 1 HOUR 45 MINUTES
- ○ 1 HOUR 46 MINUTES TO 2 HOURS
- ○ 2 HOURS TO 2 HOURS 15 MINUTES
- ○ 2 HOURS 16 MINUTES TO 2 HOURS 30 MINUTES
- ○ 2 HOURS 31 MINUTES TO 2 HOURS 45 MINUTES
- ○ 2 HOURS 46 MINUTES TO 3 HOURS
- ○ 3 HOURS TO 3 HOURS 15 MINUTES
- ○ 3 HOURS 16 MINUTES TO 3 HOURS 30 MINUTES
- ○ 3 HOURS 31 MINUTES TO 3 HOURS 45 MINUTES
- ○ 3 HOURS 46 MINUTES TO 4 HOURS
- ○ 4 HOURS TO 4 HOURS 15 MINUTES
- ○ 4 HOURS 16 MINUTES TO 4 HOURS 30 MINUTES
- ○ 4 HOURS 31 MINUTES TO 4 HOURS 45 MINUTES
- ○ 4 HOURS 46 MINUTES TO 5 HOURS
- ○ 5 HOURS TO 5 HOURS 30 MINUTES
- ○ 5 HOURS 31 MINUTES TO 6 HOURS
- ○ OVER 6 HOURS
- ○ WILL NOT EVACUATE
- ○ PREFER NOT TO SAY
- ○ Other: ______________________________

If Over 6 Hours for Question 11, Please Specify:

____

12. Please choose one of the following:

If you do not know what you would do, or you prefer not to answer, please leave this question blank.

Mark only one oval.

○ During a wildfire situation, I would await the return of household members to evacuate together.

○ During a wildfire situation, I would evacuate independently and meet other household members later.

13A. Emergency officials advise you to not evacuate in a wildfire emergency because you are not in the area of risk. Would you:

Mark only one oval.

○ NOT EVACUATE

○ EVACUATE

○ DON'T KNOW/PREFER NOT TO SAY

evacuate to?

Mark only one oval.

- ○ A RELATIVE’S OR FRIEND’S HOME
- ○ A RECEPTION CENTER
- ○ A HOTEL, MOTEL OR CAMPGROUND
- ○ A SECOND/SEASONAL HOME
- ○ WOULD NOT EVACUATE
- ○ DON'T KNOW
- ○ OTHER (Specify Below)
- ○ PREFER NOT TO SAY

Fill in OTHER answers for 13B

____

14A. Do you have any pet(s) and/or animal(s)? *

Mark only one oval.

- ○ YES
- ○ NO
- ○ PREFER NOT TO SAY

14B. What type of pet(s) and/or animal(s) do you have?

Check all that apply.

☐ DOG
☐ CAT
☐ BIRD
☐ REPTILE
☐ HORSE
☐ FISH
☐ CHICKEN
☐ GOAT
☐ PIG
☐ OTHER SMALL PETS/ANIMALS (Specify Below)
☐ OTHER LARGE PETS/ANIMALS (Specify Below)
Other: ☐ ______________________________

Mark only one oval.

○ PREFER NOT TO SAY

14C. What would you do with your pet(s) and/or animal(s) if you had to evacuate?

Mark only one oval.

○ TAKE PET WITH ME TO A SHELTER
○ TAKE PET WITH ME SOMEWHERE ELSE
○ LEAVE PET AT HOME
○ PREFER NOT TO SAY

14D. Do you have sufficient room in your vehicle(s) to evacuate with your pet(s) and/or animal(s)?

Mark only one oval.

○ YES
○ NO
○ WILL USE A TRAILER
○ PREFER NOT TO SAY
○ Other: ______________________________

15. How would you rate the cell phone coverage in your area?

Mark only one oval.

○ EXCELLENT
○ VERY GOOD
○ GOOD
○ FAIR
○ POOR
○ VERY POOR
○ DON'T HAVE A CELL PHONE
○ PREFER NOT TO SAY

16. Have you opted into your local Emergency Alert and Warning Systems?

Mark only one oval per row.

	OPTED IN CITIZEN ALERT	OPTED IN NIXLE	BOTH CITIZEN ALERT AND NIXLE	OTHER SYSTEMS
With Residential Phone	○	○	○	○
With Cellular Phone	○	○	○	○
With Email	○	○	○	○
With Text Message	○	○	○	○

Mark only one oval.

○ I DID NOT OPT IN
○ PREFER NOT TO SAY

17A. If emergency officials notified you to evacuate, would you notify a neighbor or friend to evacuate as well?

Mark only one oval.

○ YES
○ NO
○ PREFER NOT TO SAY

17B. How would you notify your neighbor or friend to evacuate?

Check all that apply.

☐ TEXT MESSAGE
☐ PHONE CALL
☐ SOCIAL MEDIA
☐ IN PERSON
☐ PREFER NOT TO SAY
Other: ☐ ____________________

17C. How long would it take you to notify your neighbor or friend to evacuate?

Mark only one oval.

○ 5 MINUTES OR LESS
○ 6-10 MINUTES
○ 11-15 MINUTES
○ 16-20 MINUTES
○ 21-25 MINUTES
○ 26-30 MINUTES
○ 31-35 MINUTES
○ 36-40 MINUTES
○ 41-45 MINUTES
○ 46-50 MINUTES
○ 51-55 MINUTES
○ 56 - 1 HOUR
○ OVER 1 HOUR
○ PREFER NOT TO SAY

APPENDIX G

Evacuation Regions

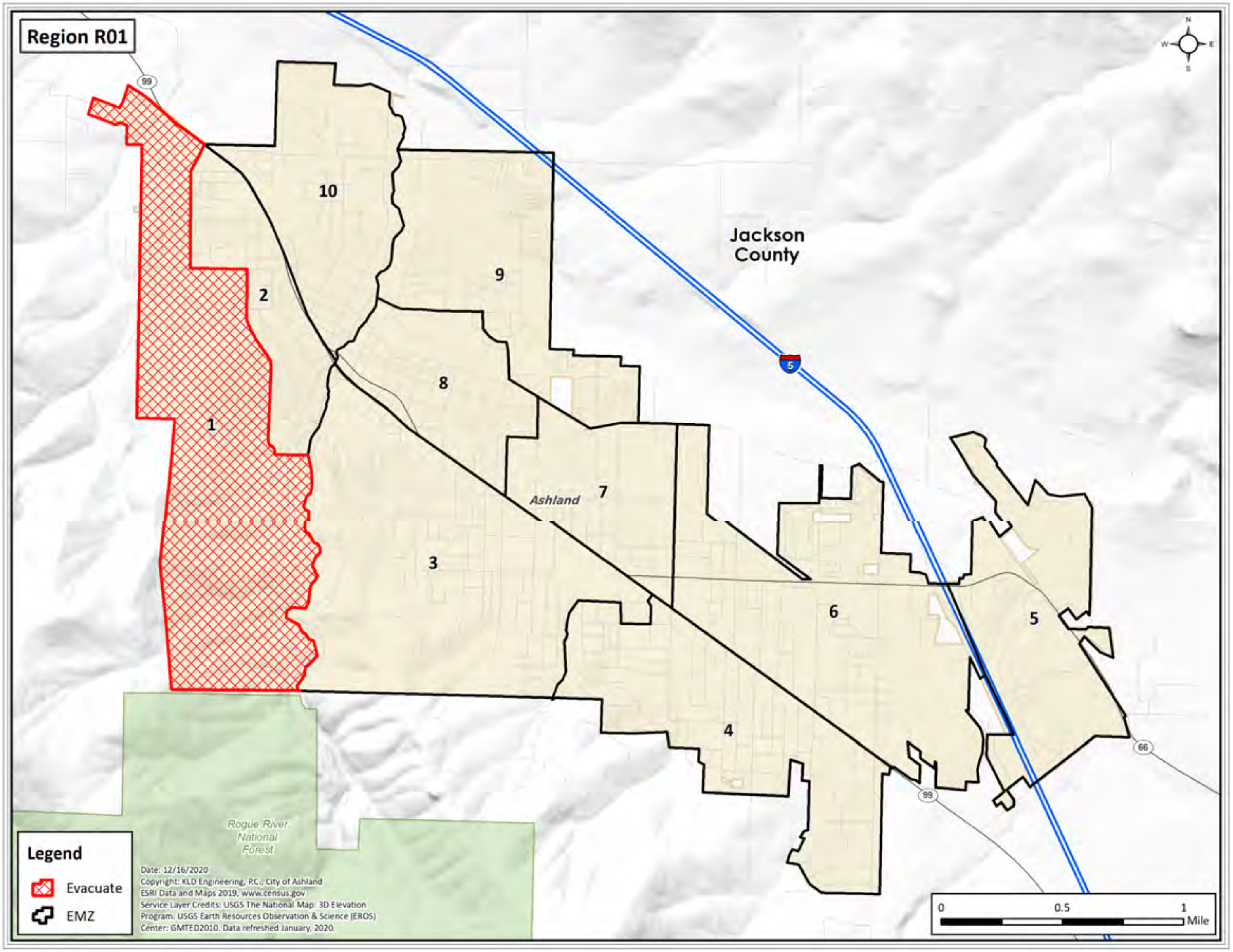
G EVACUATION REGIONS

This appendix presents the evacuation percentages for each Evacuation Region (Table G-1) and maps of all Evacuation Regions. The shelter-in-place percentages presented in Table G-1 are based on the methodology discussed in assumption 3 of Section 2.3 and the results of the demographic survey.

The evacuation regions were created based on the City of Ashland Evacuation Management Zones (EMZs). Regions R01 through R10 represent evacuations of each individual EMZ by itself. Regions R11 through R17 are evacuations of combinations of EMZ based on the origin of a potential wildfire and prevailing winds. Lastly, Region R18 is the evacuation of all EMZs at once.

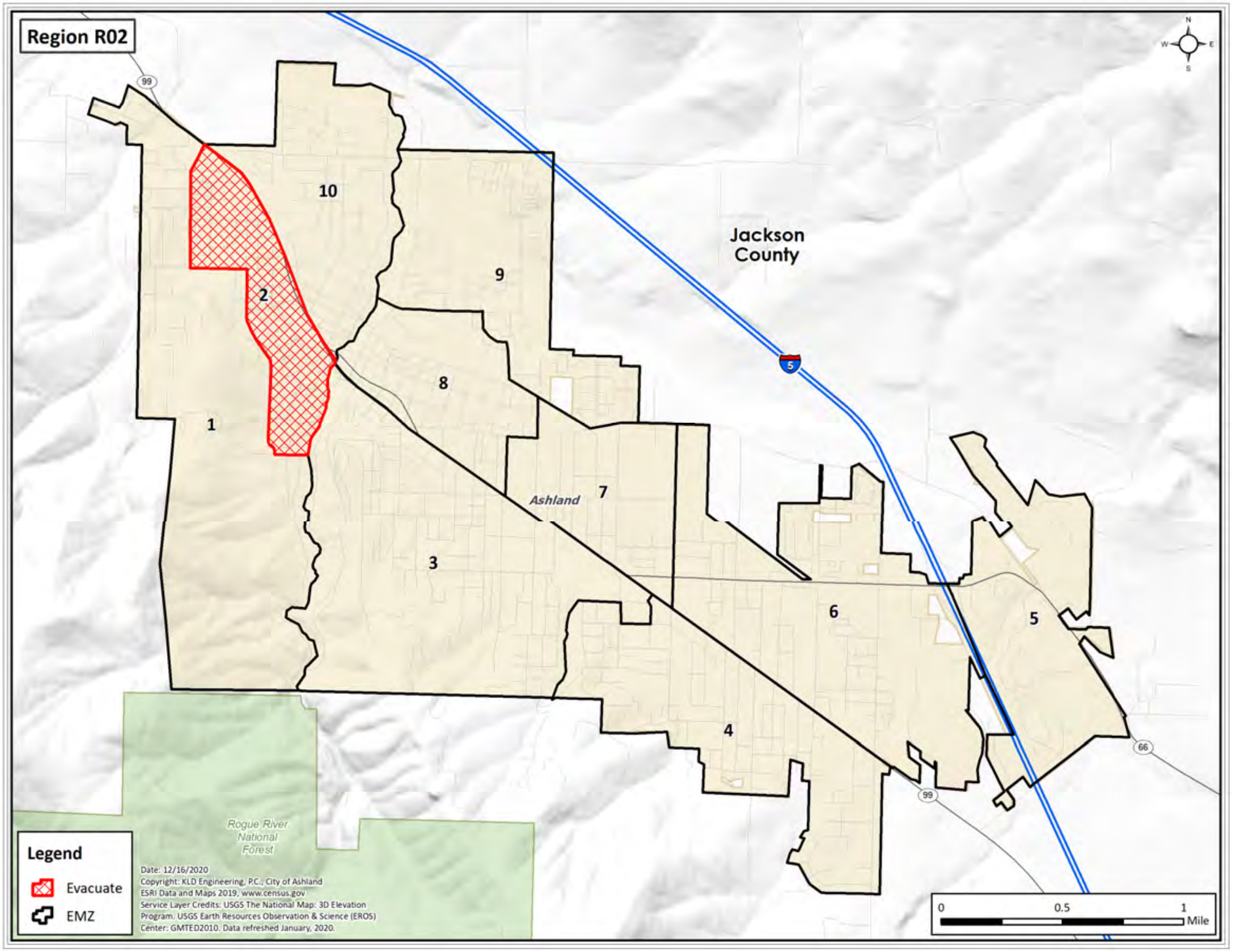
Table G-1. Percent of EMZ Population Evacuating for Each Region

Region		Emergency Management Zone (EMZ)									
	Description	1	2	3	4	5	6	7	8	9	10
R01	EMZ 1	100%	6%	6%	6%	6%	6%	6%	6%	6%	6%
R02	EMZ 2	6%	100%	6%	6%	6%	6%	6%	6%	6%	6%
R03	EMZ 3	6%	6%	100%	6%	6%	6%	6%	6%	6%	6%
R04	EMZ 4	6%	6%	6%	100%	6%	6%	6%	6%	6%	6%
R05	EMZ 5	6%	6%	6%	6%	100%	6%	6%	6%	6%	6%
R06	EMZ 6	6%	6%	6%	6%	6%	100%	6%	6%	6%	6%
R07	EMZ 7	6%	6%	6%	6%	6%	6%	100%	6%	6%	6%
R08	EMZ 8	6%	6%	6%	6%	6%	6%	6%	100%	6%	6%
R09	EMZ 9	6%	6%	6%	6%	6%	6%	6%	6%	100%	6%
R10	EMZ 10	6%	6%	6%	6%	6%	6%	6%	6%	6%	100%
R11	Western Ashland - EMZ1, EMZ2, EMZ3, EMZ4	100%	100%	100%	100%	6%	6%	6%	6%	6%	6%
R12	Eastern Ashland - EMZ5, EMZ6, EMZ7, EMZ8, EMZ9, EMZ10	6%	6%	6%	6%	100%	100%	100%	100%	100%	100%
R13	Northern Ashland - EMZ1, EMZ2, EMZ10	100%	100%	6%	6%	6%	6%	6%	6%	6%	100%
R14	Central Ashland - EMZ3, EMZ7, EMZ8, EMZ9	6%	6%	100%	6%	6%	6%	100%	100%	100%	6%
R15	Southern Ashland - EMZ4, EMZ5, EMZ6	6%	6%	6%	100%	100%	100%	6%	6%	6%	6%
R16	Northern and Central Ashland - EMZ1, EMZ2, EMZ3, EMZ7, EMZ8, EMZ9, EMZ10	100%	100%	100%	6%	6%	6%	100%	100%	100%	100%
R17	Southern and Central Ashland - EMZ3, EMZ4, EMZ5, EMZ6, EMZ7, EMZ8, EMZ9	6%	6%	100%	100%	100%	100%	100%	100%	100%	6%
R18	All EMZs	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
EMZ(s) Shelter-in-Place						EMZ(s) Evacuate					



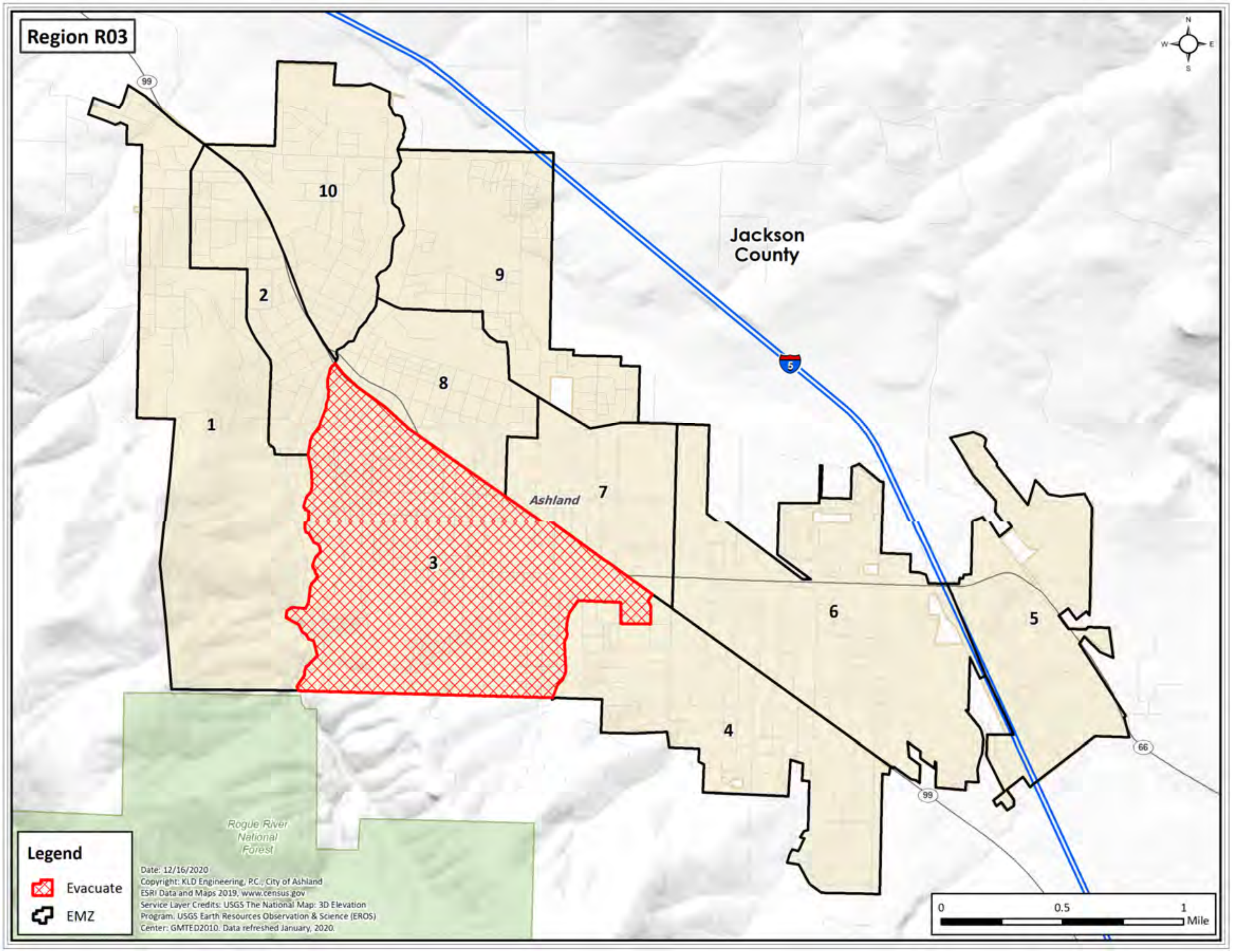
Date: 12/16/2020
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation Program. USGS Earth Resources Observation & Science (EROS) Center: GMTED2010. Data refreshed January, 2020.

Figure G-1. Region R01



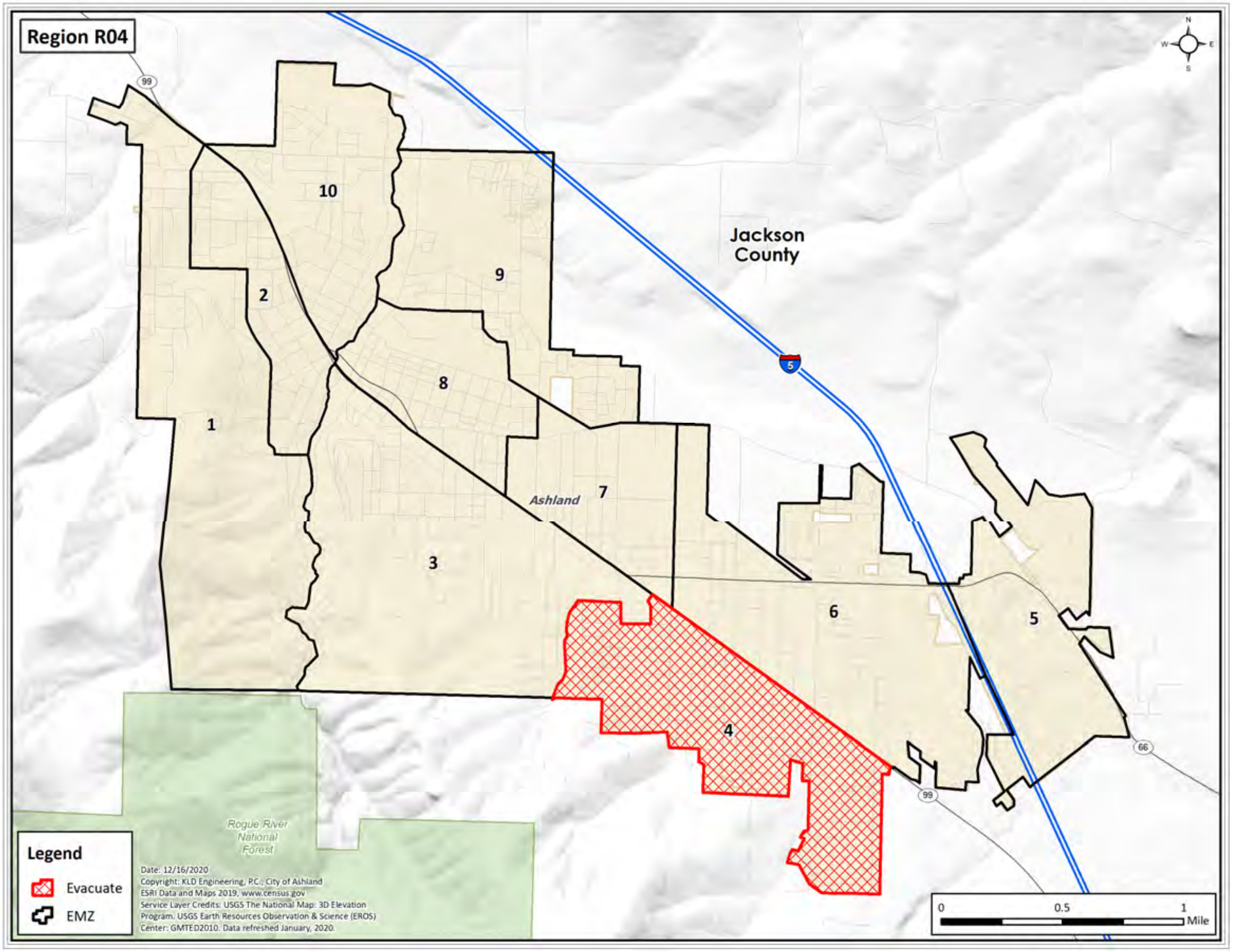
Date: 12/16/2020
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation Program. USGS Earth Resources Observation & Science (EROS) Center: GMTED2010. Data refreshed January, 2020.

Figure G-2. Region R02



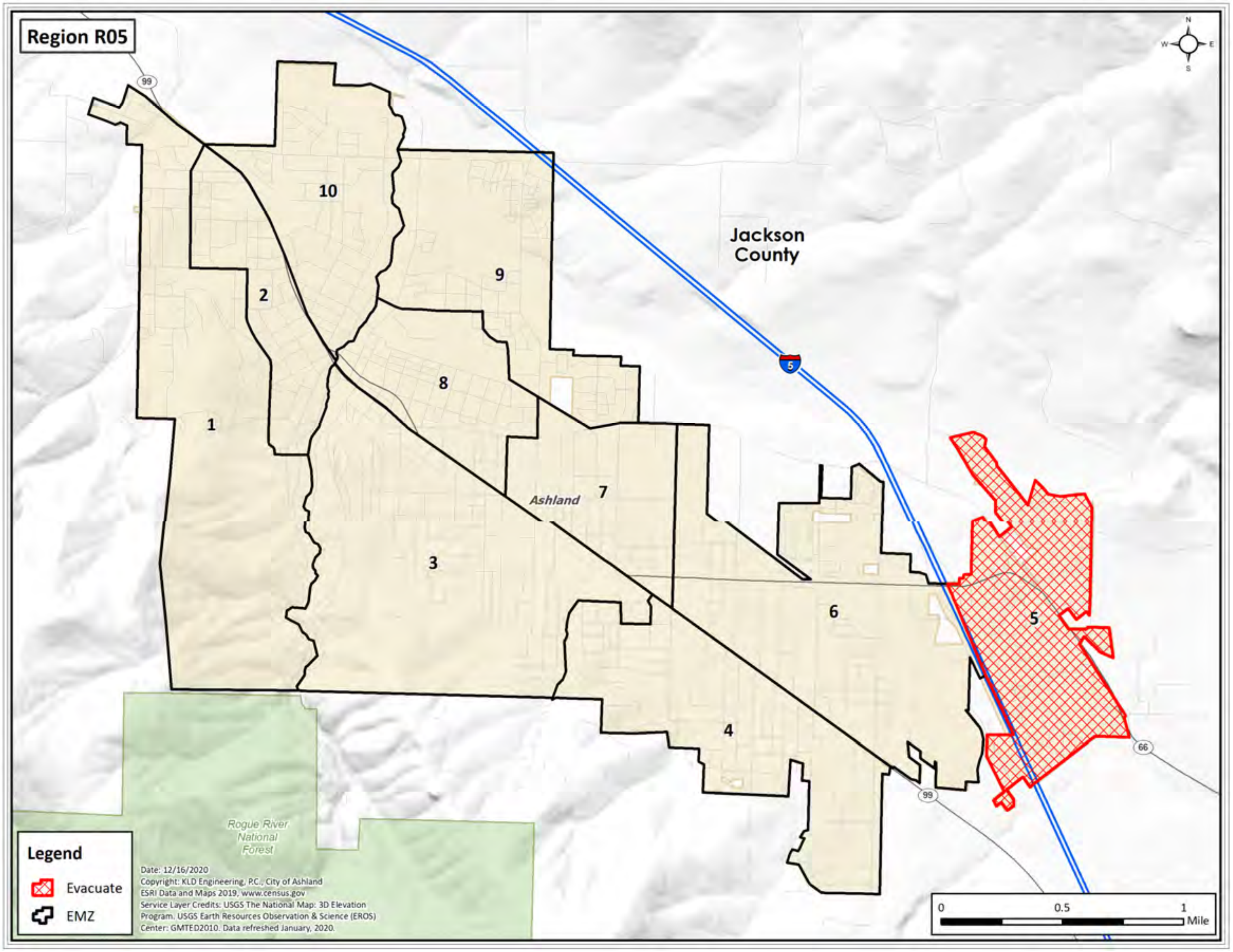
Date: 12/16/2020
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation Program. USGS Earth Resources Observation & Science (EROS) Center: GMTED2010. Data refreshed January, 2020.

Figure G-3. Region R03



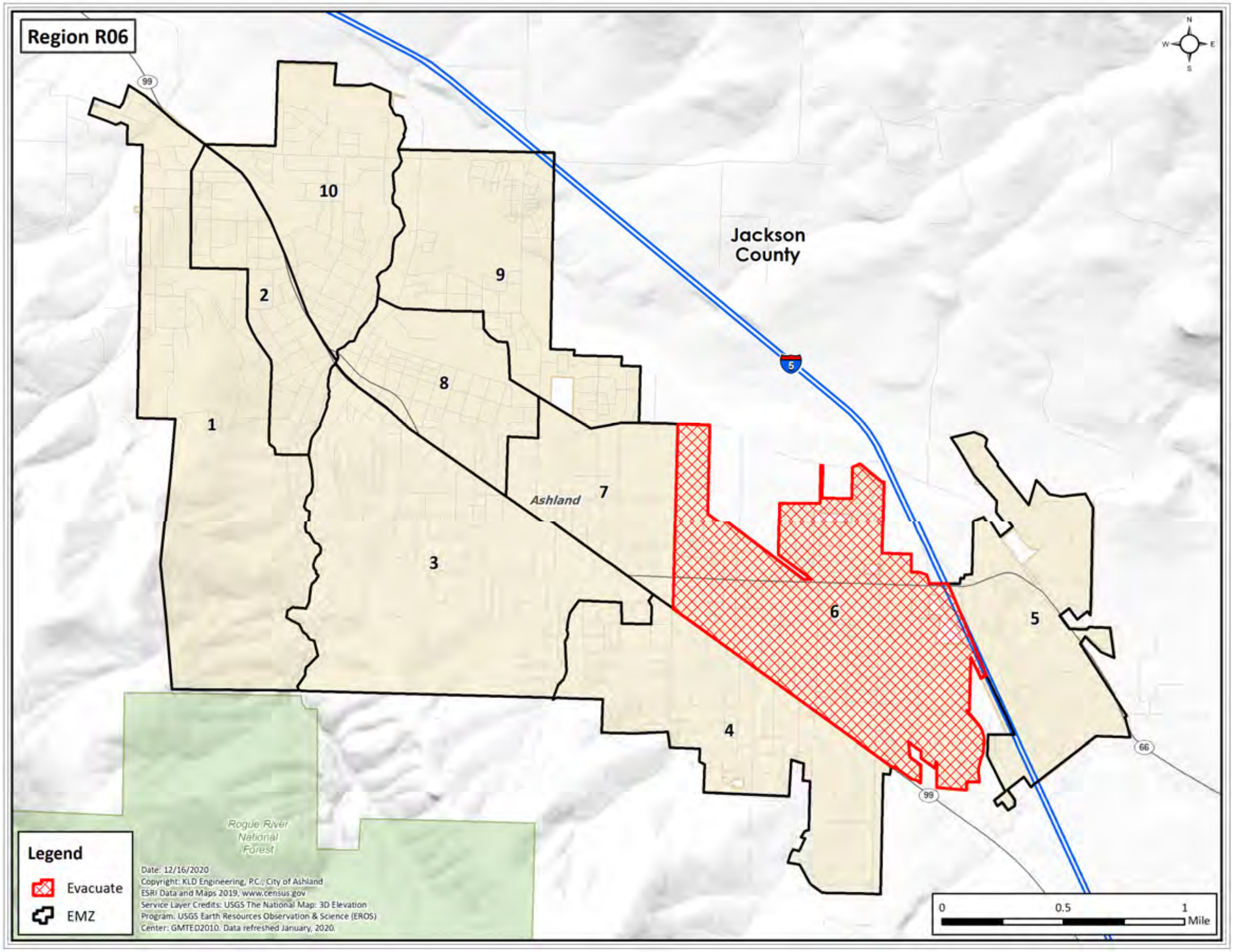
Date: 12/16/2020
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation
Program. USGS Earth Resources Observation & Science (EROS)
Center: GMTED2010. Data refreshed January, 2020.

Figure G-4. Region R04



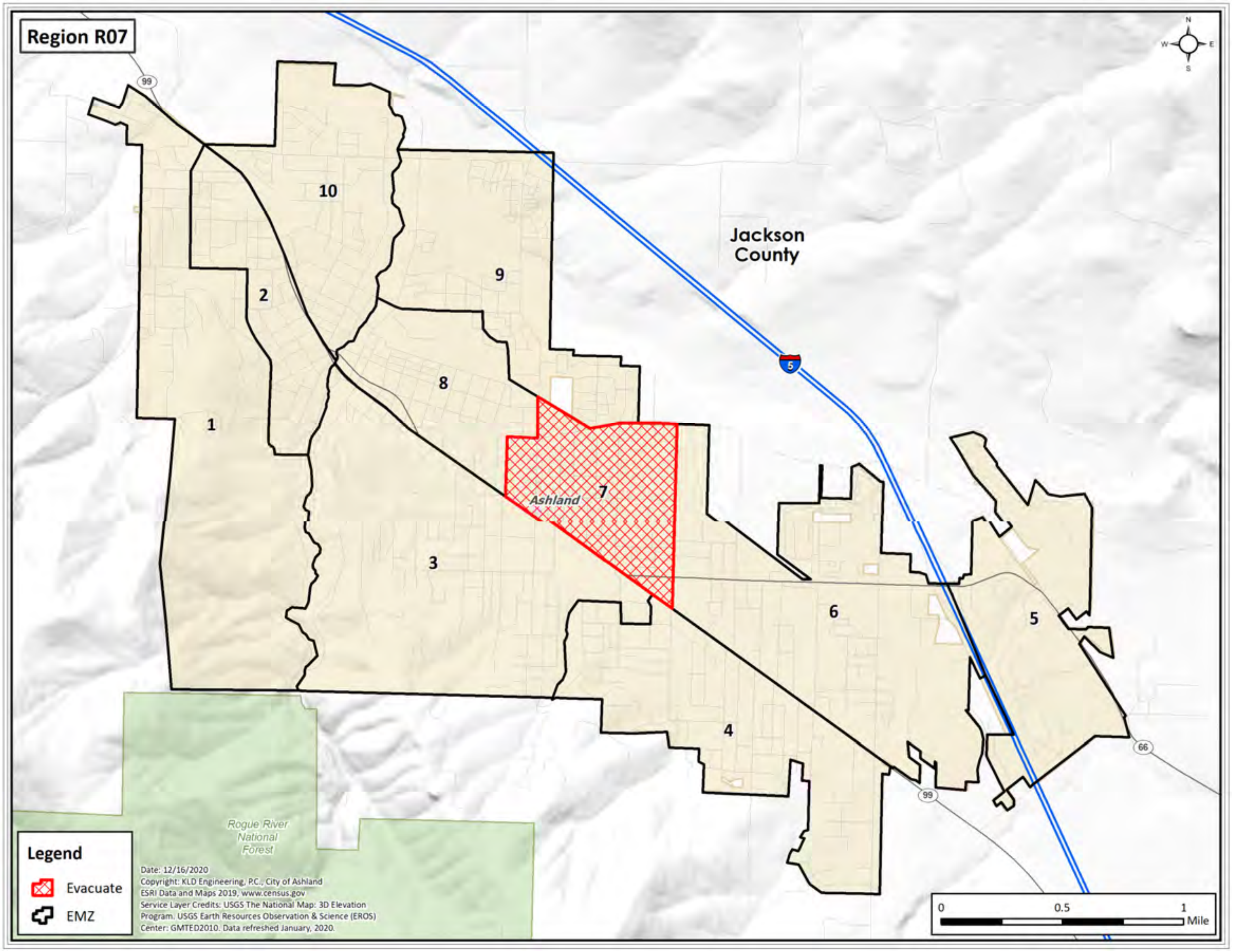
Date: 12/16/2020
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation
Program. USGS Earth Resources Observation & Science (EROS)
Center: GMTED2010. Data refreshed January, 2020.

Figure G-5. Region R05



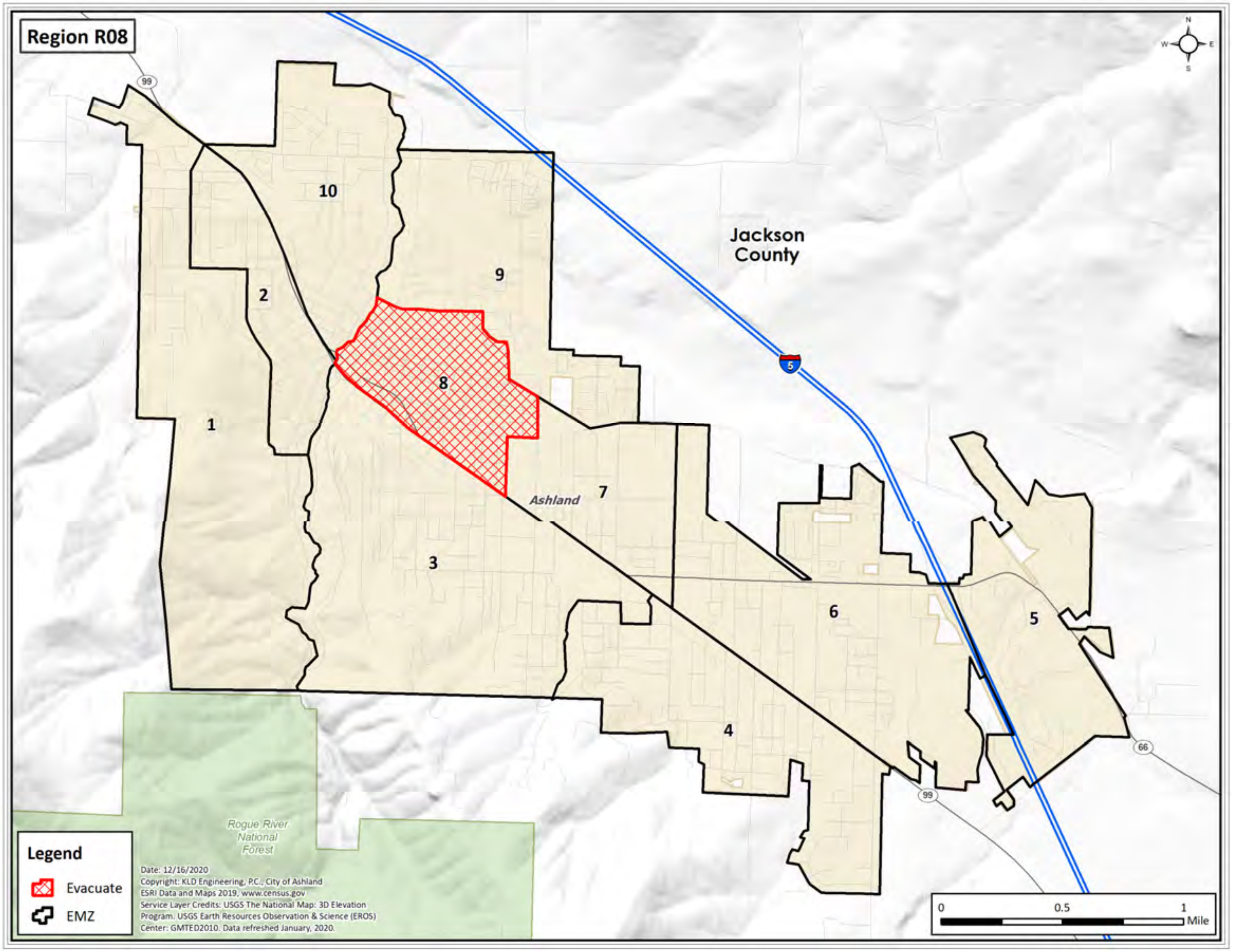
Date: 12/16/2020
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation Program. USGS Earth Resources Observation & Science (EROS) Center: GMTED2010. Data refreshed January, 2020.

Figure G-6. Region R06



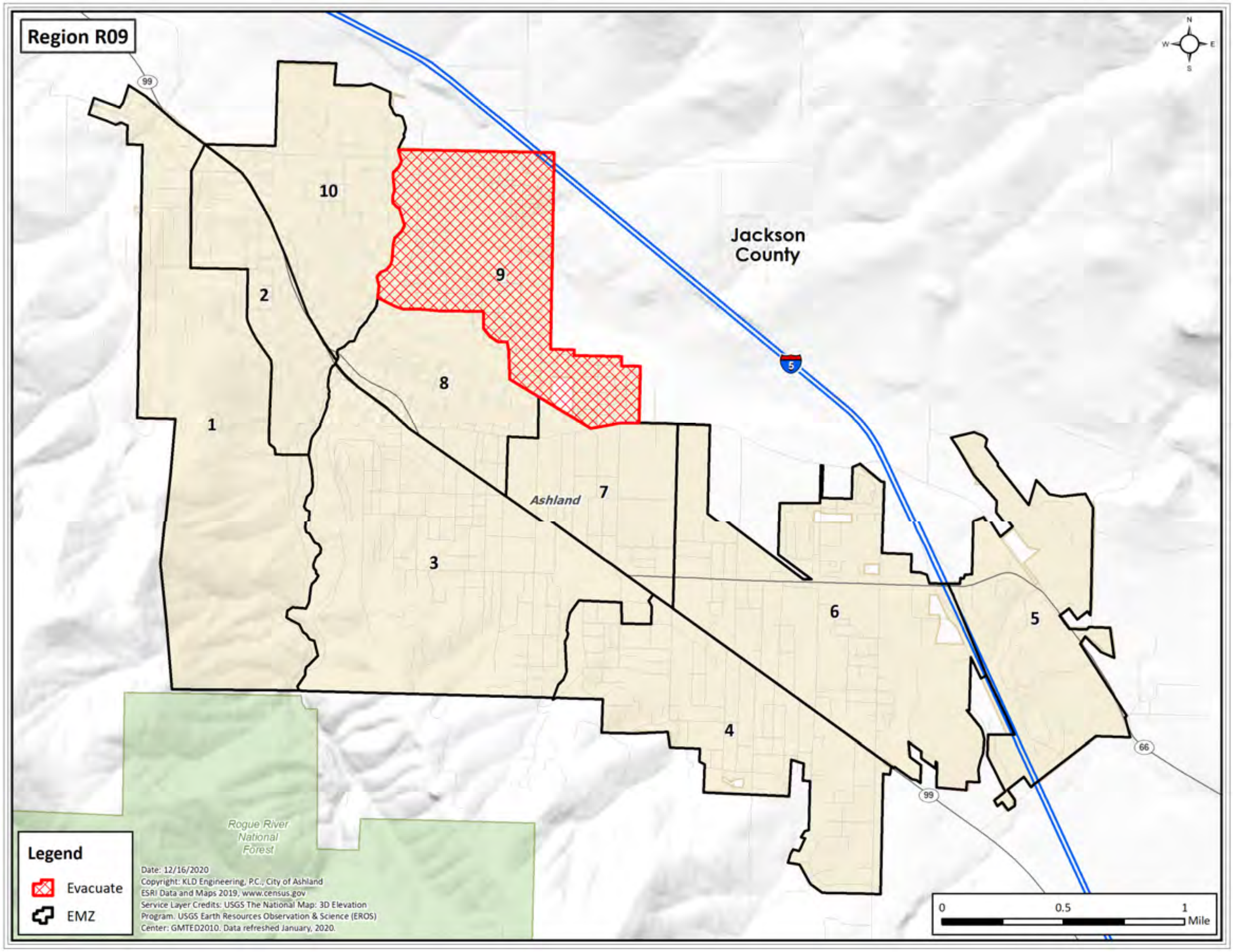
Date: 12/16/2020
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation
Program. USGS Earth Resources Observation & Science (EROS)
Center: GMTED2010. Data refreshed January, 2020.

Figure G-7. Region R07



Date: 12/16/2020
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation
Program. USGS Earth Resources Observation & Science (EROS)
Center: GMTED2010. Data refreshed January, 2020.

Figure G-8. Region R08



Date: 12/16/2020
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation Program. USGS Earth Resources Observation & Science (EROS) Center: GMTED2010. Data refreshed January, 2020.

Figure G-9. Region R09

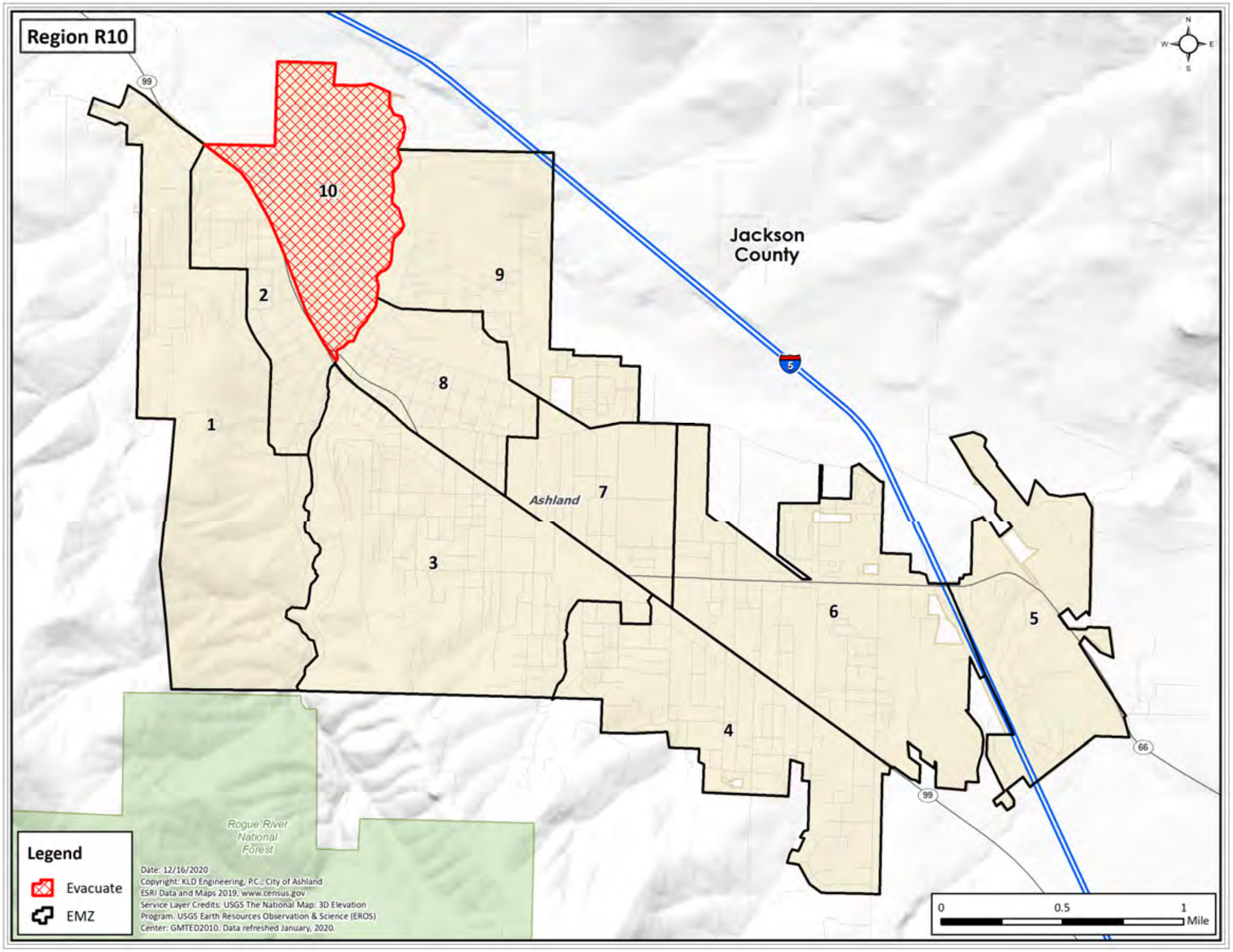
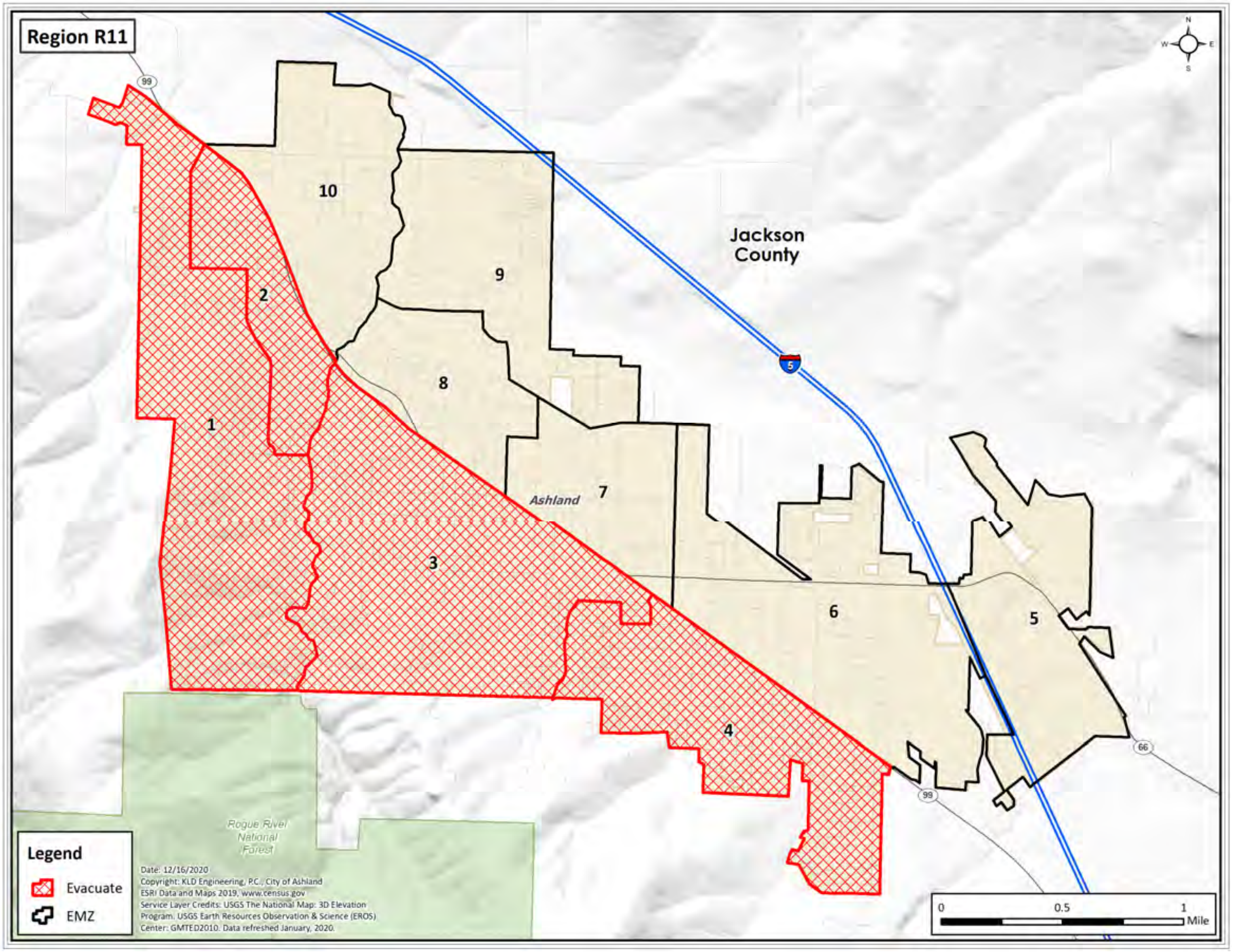
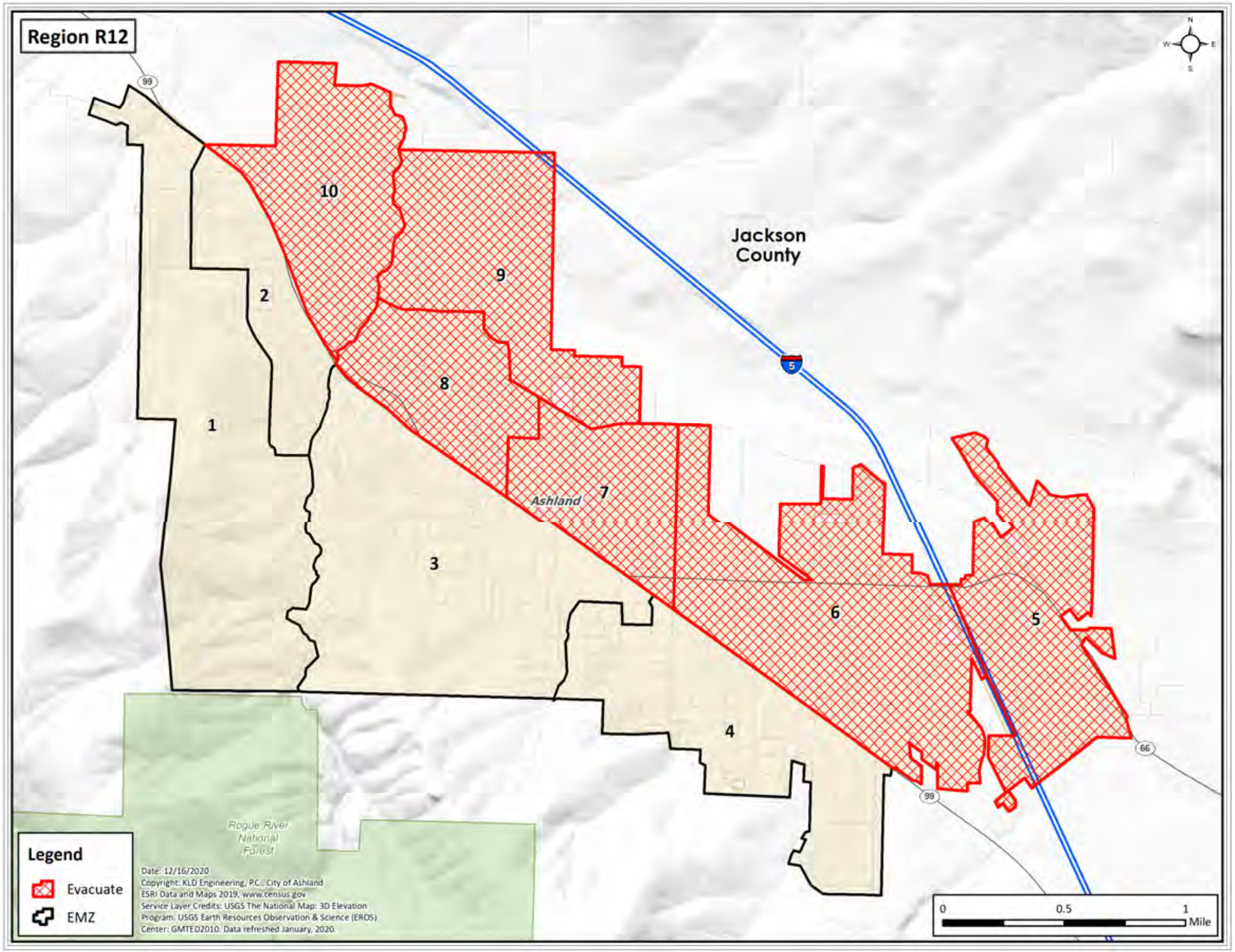


Figure G-10. Region R10



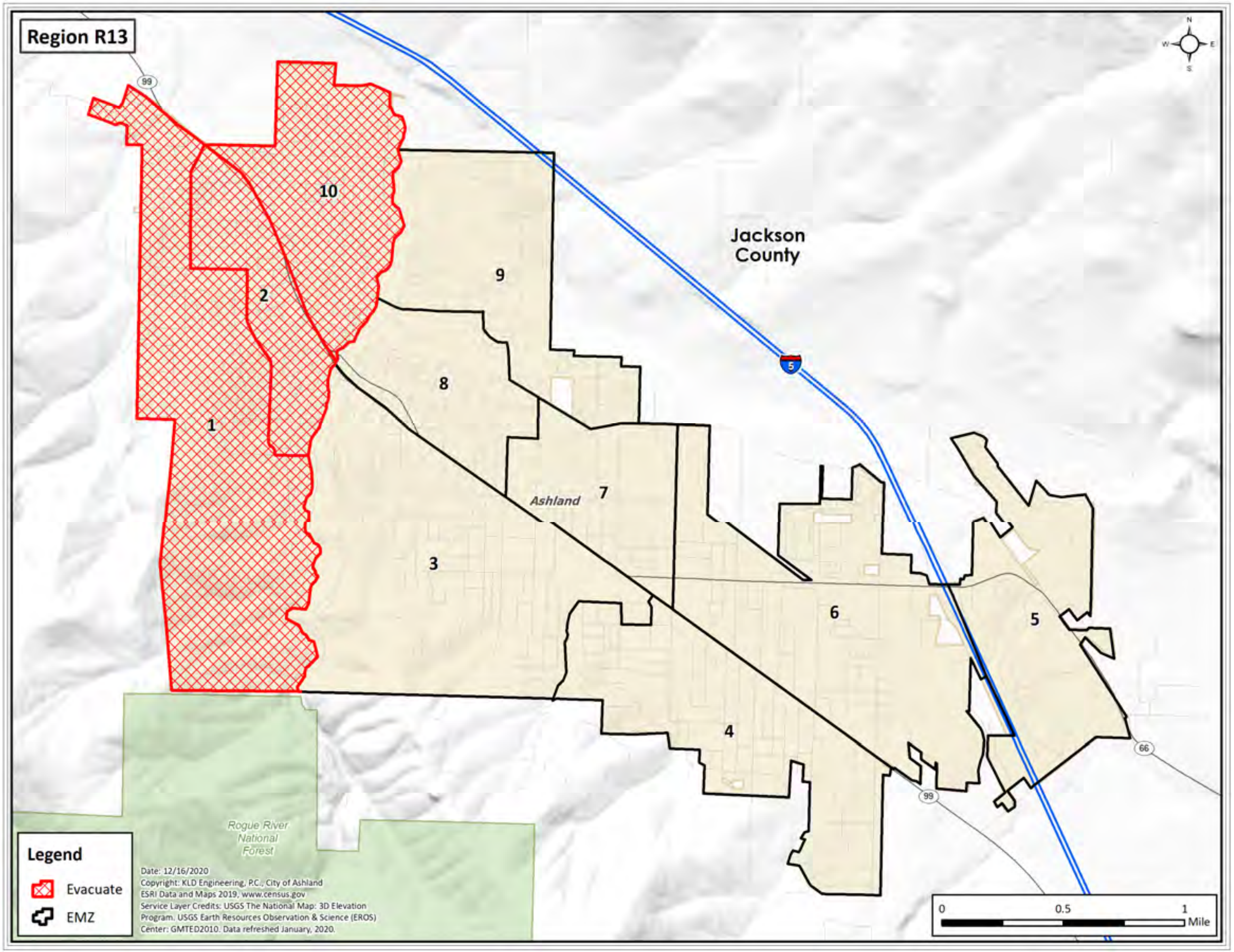
Date: 12/16/2020
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation Program. USGS Earth Resources Observation & Science (EROS) Center: GMTED2010. Data refreshed January, 2020.

Figure G-11. Region R11



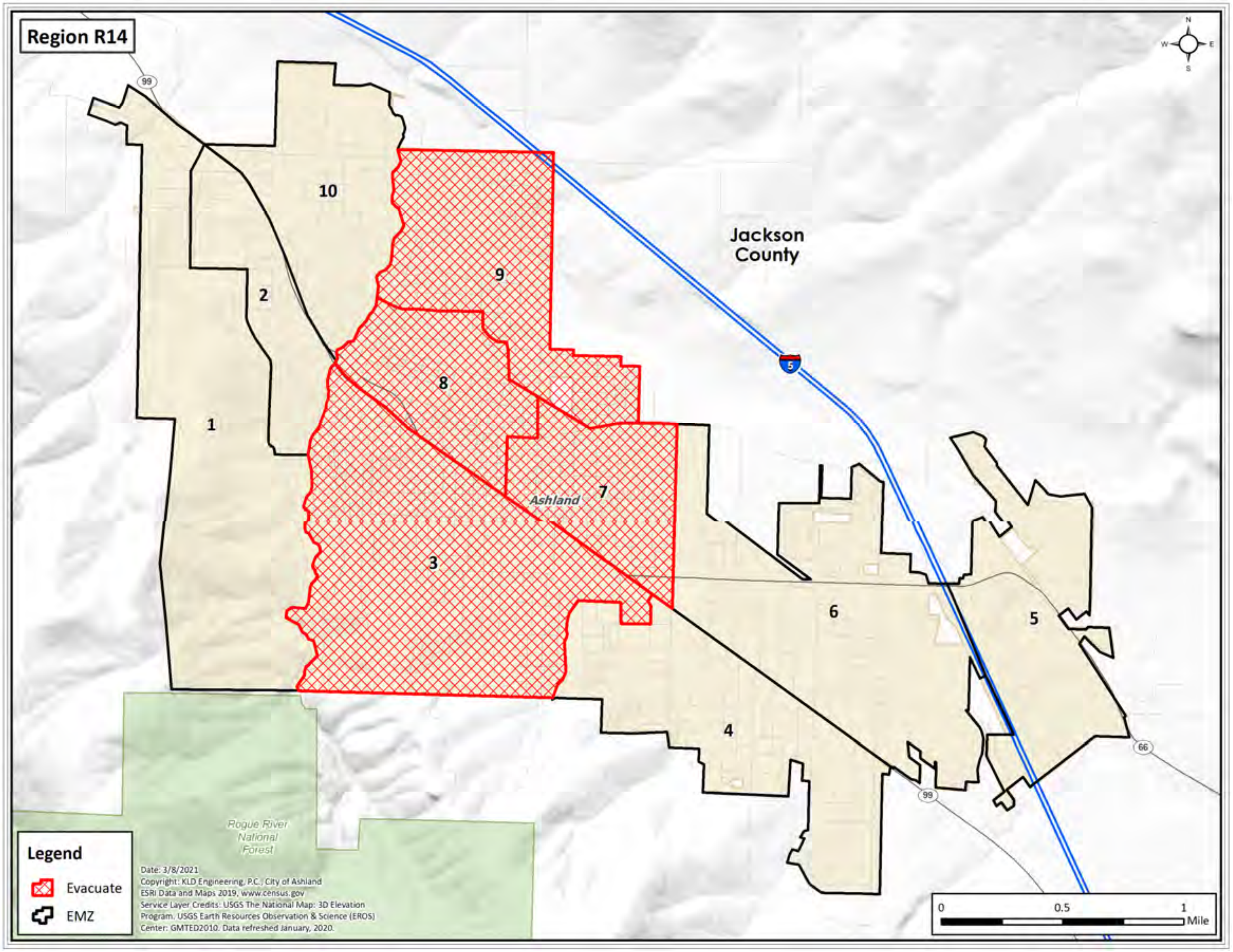
Date: 12/16/2020
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation Program. USGS Earth Resources Observation & Science (EROS) Center: GMTED2010. Data refreshed January, 2020.

Figure G-12. Region R12



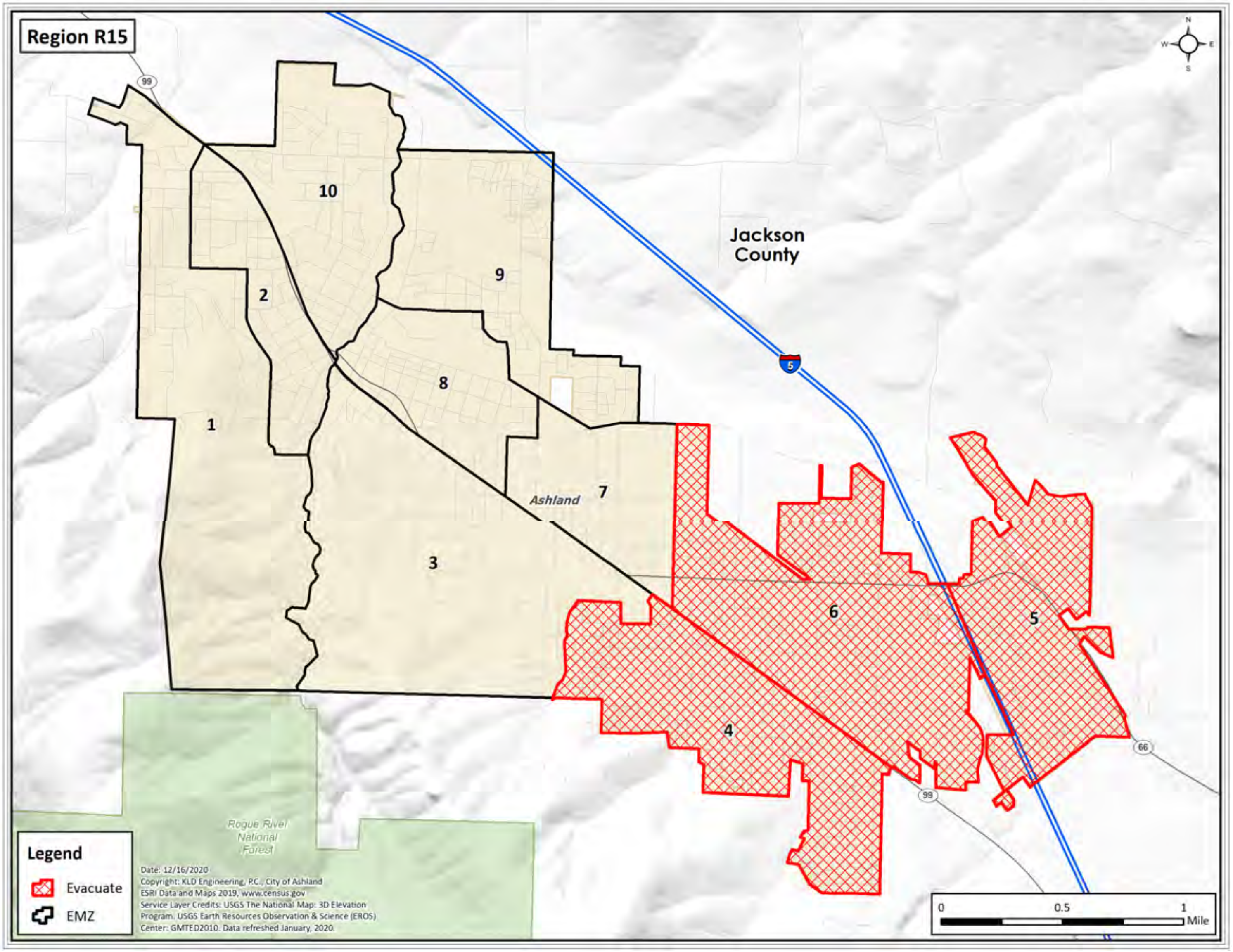
Date: 12/16/2020
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation Program. USGS Earth Resources Observation & Science (EROS) Center: GMTED2010. Data refreshed January, 2020.

Figure G-13. Region R13



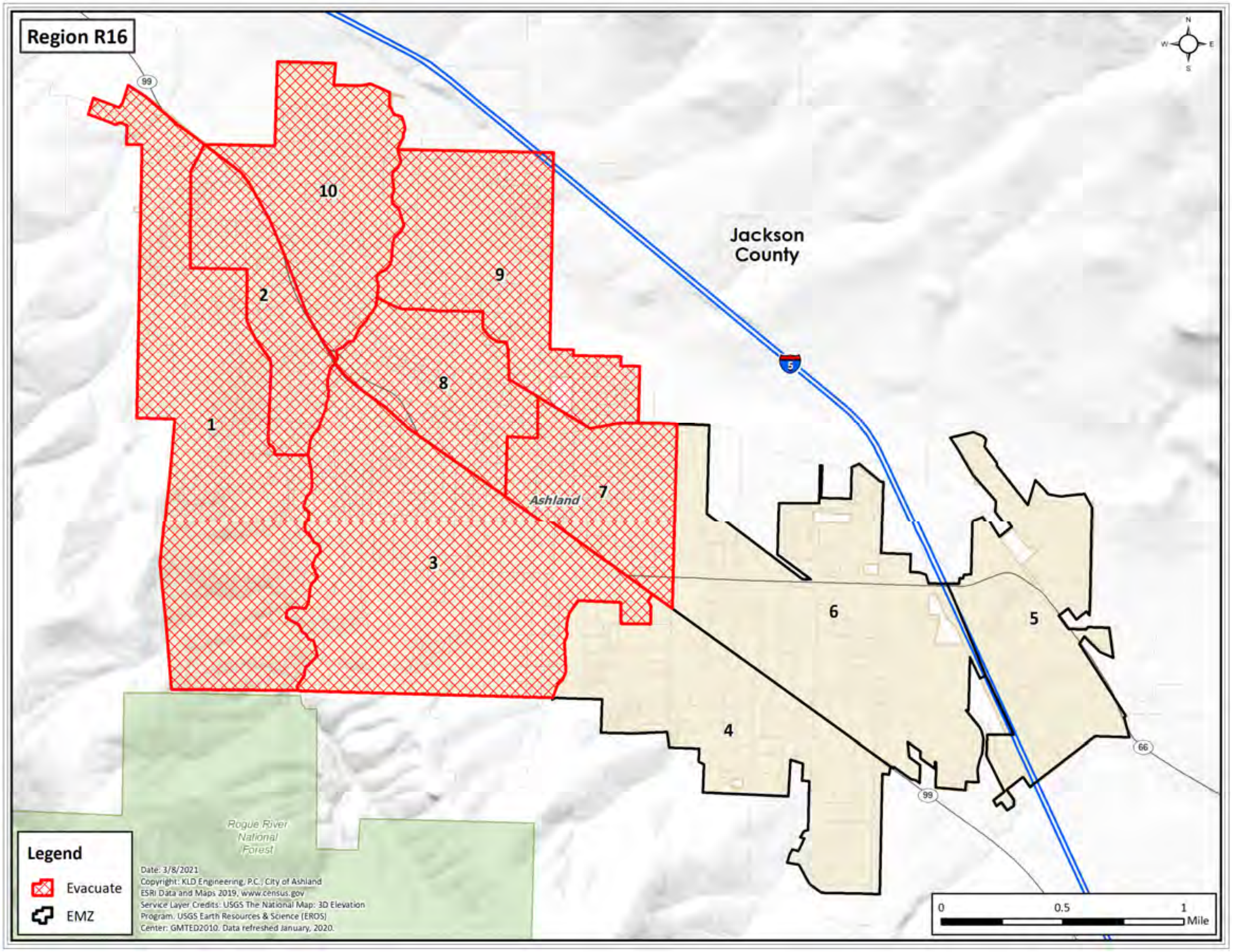
Date: 3/8/2021
Copyright: KLD Engineering, P.C.; City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation Program. USGS Earth Resources Observation & Science (EROS) Center: GMTED2010. Data refreshed January, 2020.

Figure G-14. Region R14



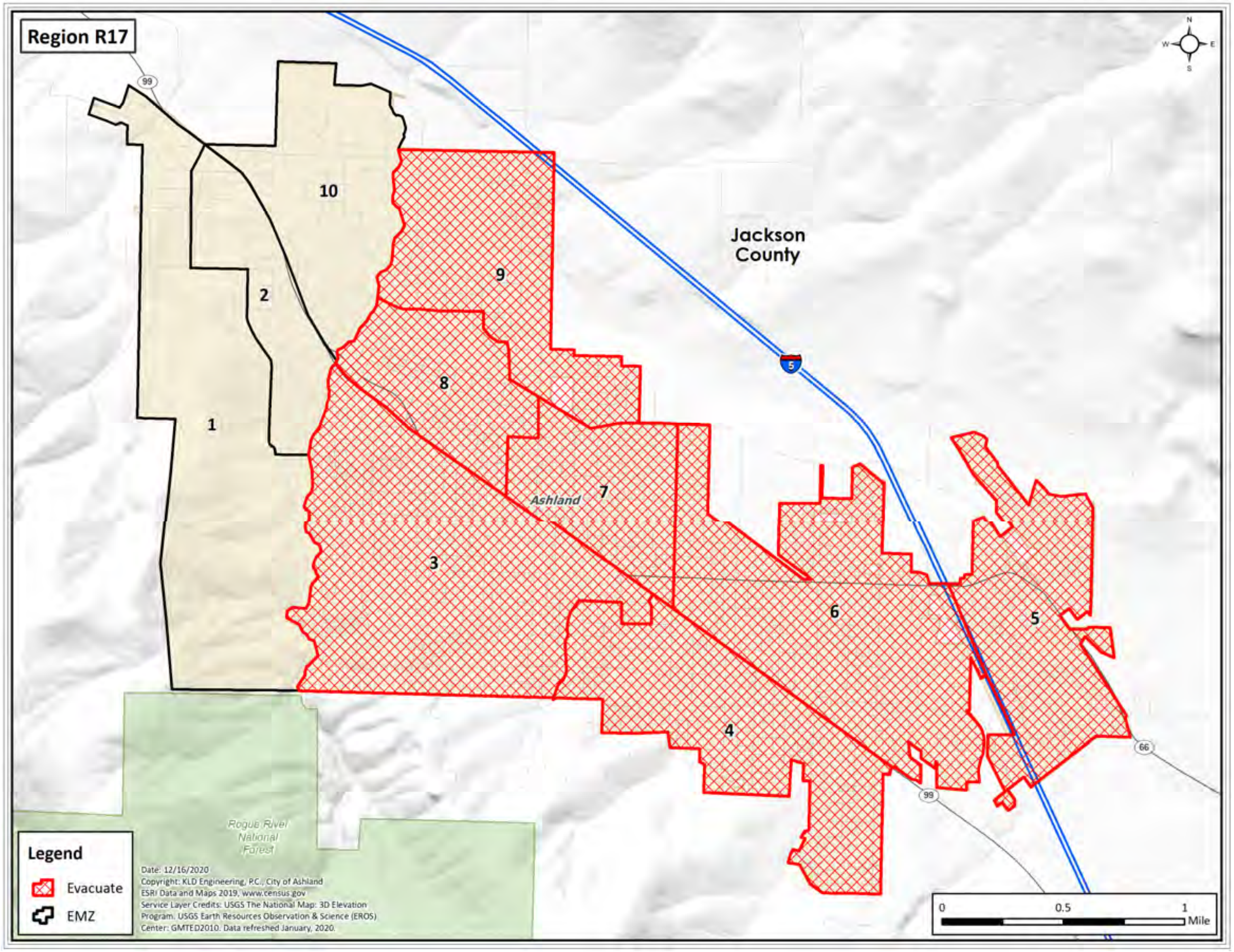
Date: 12/16/2020
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation Program. USGS Earth Resources Observation & Science (EROS) Center: GMTED2010. Data refreshed January, 2020.

Figure G-15. Region R15



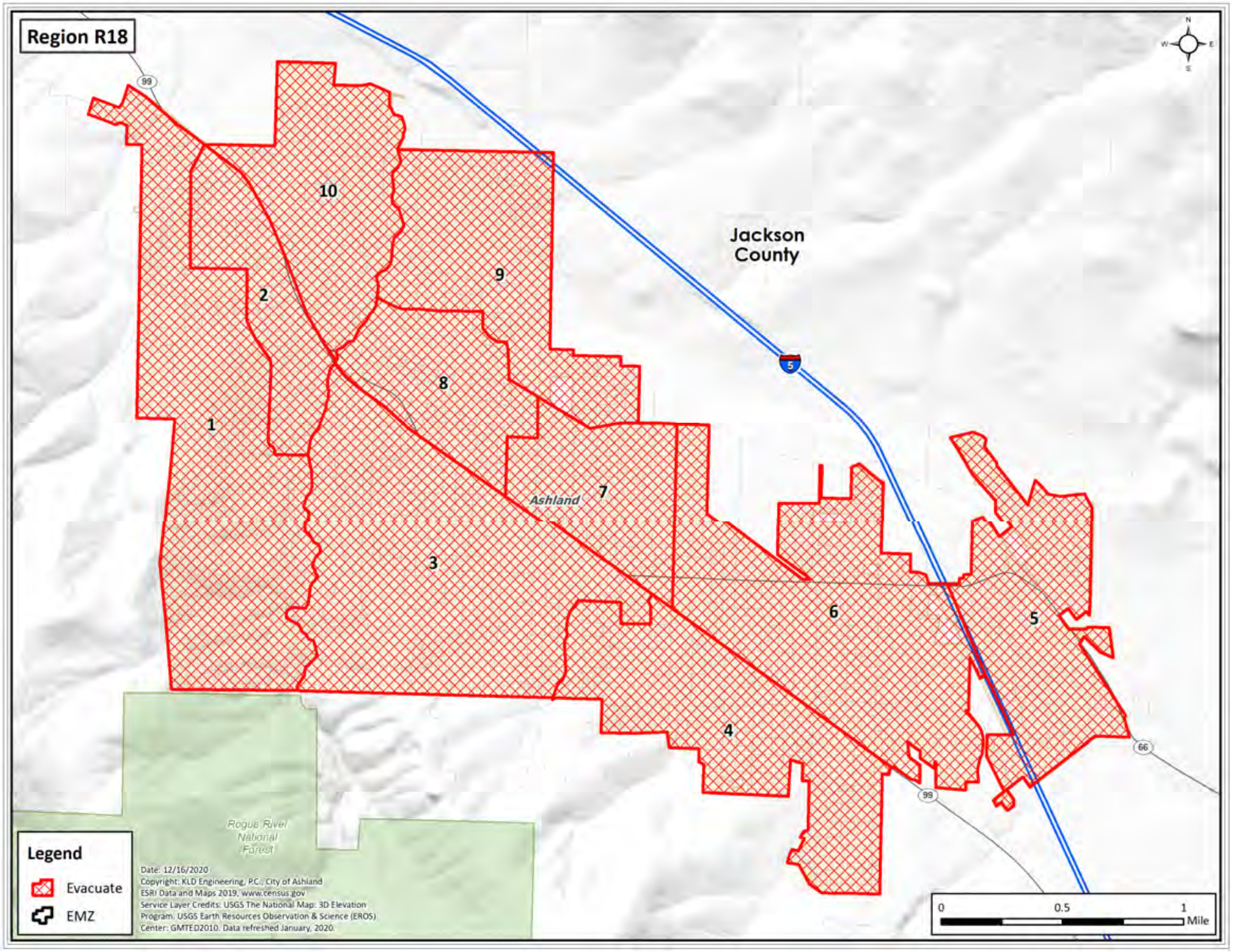
Date: 3/8/2021
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation Program. USGS Earth Resources & Science (EROS) Center: GMTED2010. Data refreshed January, 2020.

Figure G-16. Region R16



Date: 12/16/2020
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation Program. USGS Earth Resources Observation & Science (EROS) Center: GMTED2010. Data refreshed January, 2020.

Figure G-17. Region R17



Date: 12/16/2020
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: USGS The National Map: 3D Elevation Program. USGS Earth Resources Observation & Science (EROS) Center: GMTED2010. Data refreshed January, 2020.

Figure G-18. Region R18

APPENDIX H

Evacuation Roadway Network

H. EVACUATION ROADWAY NETWORK

This appendix presents the evacuation roadway network used in the study. As discussed in Section 1.3, a link-node analysis network was constructed to model the roadway network within the study area. Figure H-1 provides an overview of the link-node analysis network. The figure has been divided up into 14 more detailed figures (Figure H-2 through Figure H-15) which show each of the links and nodes in the network.

The analysis network was calibrated using the observations made during the field survey conducted in July 2020. Table H-1 lists the characteristics of each roadway section modeled in the study area. Each link is identified by its road name and the upstream and downstream node numbers. The geographic location of each link can be observed by referencing the grid map number provided in Table H-1. The roadway type identified in Table H-1 is generally based on the following criteria:

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

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

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

Table H-2 identifies each node in the network that is controlled and the type of control (stop sign, yield sign, pre-timed signal, actuated signal, traffic control point) at that node. Uncontrolled nodes are not included in Table H-2. The location of each node can be observed by referencing the grid map number provided.

Table H-1. Evacuation Roadway Network Characteristics

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
1	1	67	OR-99	MINOR ARTERIAL	1,080	2	12	4	1,900	45	1
2	1	190	COLVER RD	LOCAL ROADWAY	196	1	12	4	1,700	40	1
3	1	222	SUNCREST RD	COLLECTOR	489	1	12	4	900	20	1
4	2	38	OR-99	COLLECTOR	2,116	1	12	4	1,700	45	13
5	2	336	CROWSON RD	LOCAL ROADWAY	2,355	1	12	4	1,700	40	14
6	3	4	I-5	FREEWAY	2,440	2	12	8	2,250	70	13
7	3	10	I-5	FREEWAY	2,689	2	12	8	2,250	70	14
8	4	3	I-5	FREEWAY	2,440	2	12	8	2,250	70	13
9	4	5	I-5	FREEWAY	1,833	2	12	8	2,250	70	11
10	4	8	I-5 FREEWAY RAMP	FREEWAY RAMP	747	2	12	4	1,750	45	11
11	5	4	I-5	FREEWAY	1,833	2	12	8	2,250	70	11
12	5	6	I-5	FREEWAY	2,471	2	12	8	2,250	70	11
13	5	7	I-5 FREEWAY RAMP	FREEWAY RAMP	933	1	12	4	1,750	45	11
14	6	5	I-5	FREEWAY	2,471	2	12	8	2,250	70	11
15	6	14	I-5	FREEWAY	1,206	2	12	8	2,250	70	11
16	7	4	I-5 FREEWAY RAMP	FREEWAY RAMP	986	1	12	4	1,700	45	11
17	7	8	OR-66	COLLECTOR	575	1	12	4	1,750	30	11
18	8	5	I-5 FREEWAY RAMP	FREEWAY RAMP	1,151	1	12	4	1,700	45	11
19	8	7	OR-66	COLLECTOR	575	1	12	4	1,750	30	11
20	8	74	ASHLAND ST	COLLECTOR	844	1	12	4	1,575	35	11
21	9	7	OR-66	LOCAL ROADWAY	1,131	2	12	4	1,750	30	11
22	9	306	TOLMAN CREEK ROAD	COLLECTOR	653	1	12	4	1,350	30	11
23	9	307	TOLMAN CREEK ROAD	COLLECTOR	1,160	1	12	4	1,350	30	11
24	10	3	I-5	FREEWAY	2,689	2	12	8	2,250	70	14
25	10	11	I-5	FREEWAY	2,764	2	12	8	2,250	70	14
26	11	10	I-5	FREEWAY	2,764	2	12	8	2,250	70	14
27	11	12	I-5	FREEWAY	2,608	2	12	8	2,250	70	14
28	12	11	I-5	FREEWAY	2,608	2	12	8	2,250	70	14
29	12	13	I-5	FREEWAY	2,196	2	12	8	2,250	70	14
30	13	12	I-5	FREEWAY	2,196	2	12	8	2,250	70	14

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
32	14	6	I-5	FREEWAY	1,206	2	12	8	2,250	70	11
33	14	15	I-5	FREEWAY	2,680	2	12	8	2,250	70	11
34	15	14	I-5	FREEWAY	2,680	2	12	8	2,250	70	11
35	15	16	I-5	FREEWAY	2,027	2	12	8	2,250	70	8
36	16	15	I-5	FREEWAY	2,027	2	12	8	2,250	70	8
37	16	17	I-5	FREEWAY	3,454	2	12	8	2,250	70	8
38	17	16	I-5	FREEWAY	3,454	2	12	8	2,250	70	8
39	17	18	I-5	FREEWAY	507	2	12	8	2,250	70	8
40	18	17	I-5	FREEWAY	507	2	12	8	2,250	70	8
41	18	19	I-5	FREEWAY	2,260	2	12	8	2,250	70	7
42	19	18	I-5	FREEWAY	2,260	2	12	8	2,250	70	7
43	19	20	I-5	FREEWAY	984	2	12	8	2,250	70	5
44	20	19	I-5	FREEWAY	982	2	12	8	2,250	70	5
45	20	21	I-5	FREEWAY	2,397	2	12	8	2,250	70	5
46	21	20	I-5	FREEWAY	2,397	2	12	8	2,250	70	5
47	21	22	I-5	FREEWAY	2,120	2	12	8	2,250	70	5
48	22	21	I-5	FREEWAY	2,120	2	12	8	2,250	70	5
49	22	23	I-5	FREEWAY	2,850	2	12	8	2,250	70	5
50	23	22	I-5	FREEWAY	2,850	2	12	8	2,250	70	5
51	23	24	I-5	FREEWAY	1,270	2	12	8	2,250	70	5
52	24	23	I-5	FREEWAY	1,270	2	12	8	2,250	70	5
53	24	25	I-5	FREEWAY	1,855	2	12	8	2,250	70	4
54	24	73	I-5 FREEWAY RAMP	FREEWAY RAMP	1,159	1	12	4	1,750	45	5
55	25	24	I-5	FREEWAY	1,854	2	12	8	2,250	70	4
56	25	26	I-5	FREEWAY	2,912	2	12	8	2,250	70	4
57	25	72	I-5 FREEWAY RAMP	FREEWAY RAMP	1,351	1	12	4	1,700	30	4
58	26	25	I-5	FREEWAY	2,912	2	12	8	2,250	70	4
59	26	27	I-5	FREEWAY	3,029	2	12	8	2,250	70	4
60	27	26	I-5	FREEWAY	3,029	2	12	8	2,250	70	4
61	27	28	I-5	FREEWAY	2,724	2	12	8	2,250	70	4
62	28	27	I-5	FREEWAY	2,724	2	12	8	2,250	70	4
63	28	29	I-5	FREEWAY	1,599	2	12	8	2,250	70	4

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
64	28	91	I-5 FREEWAY RAMP	FREEWAY RAMP	580	1	12	4	1,700	45	4
65	29	28	I-5	FREEWAY	1,598	2	12	8	2,250	70	4
66	29	30	I-5	FREEWAY	2,020	2	12	8	2,250	70	2
67	29	90	I-5 FREEWAY RAMP	FREEWAY RAMP	290	1	12	4	1,700	45	4
68	30	29	I-5	FREEWAY	2,020	2	12	8	2,250	70	2
69	30	31	I-5	FREEWAY	2,656	2	12	8	2,250	70	1
70	31	30	I-5	FREEWAY	2,656	2	12	8	2,250	70	1
71	32	13	OR-99	FREEWAY RAMP	1,964	1	12	4	1,700	45	14
72	34	32	OR-99	COLLECTOR	899	1	12	4	1,700	45	14
73	35	34	OR-99	COLLECTOR	983	1	12	4	1,700	45	14
74	38	35	OR-99	COLLECTOR	2,708	1	12	4	1,700	45	14
75	40	2	OR-99	COLLECTOR	2,806	1	12	4	1,750	25	13
76	40	308	TOLMAN CREEK ROAD	COLLECTOR	1,357	1	12	4	1,350	30	13
77	41	127	S MOUNTAIN AVE	COLLECTOR	451	1	12	4	1,125	25	10
78	41	233	OR-99	COLLECTOR	812	2	12	4	1,750	30	9
79	41	339	OR-99	COLLECTOR	541	2	12	4	1,900	30	10
80	42	233	OR-99	COLLECTOR	480	2	12	4	1,750	30	9
81	42	237	OR-99	COLLECTOR	680	2	12	4	1,900	30	9
82	43	44	OR-99	COLLECTOR	205	2	12	4	1,750	30	9
83	43	240	OR-99	COLLECTOR	676	2	12	4	1,750	30	9
84	44	96	E MAIN ST	COLLECTOR	1,675	1	12	4	1,350	30	9
85	44	148	LITHIA WAY	MINOR ARTERIAL	338	2	12	4	1,750	20	9
86	45	227	LITHIA WAY	MINOR ARTERIAL	477	2	12	4	1,750	20	9
87	46	254	LITHIA WAY	MINOR ARTERIAL	304	2	12	4	1,900	20	9
88	46	256	OAK ST	LOCAL ROADWAY	343	1	12	4	1,125	25	9
89	47	241	OR-99	COLLECTOR	501	2	12	4	1,900	30	7
90	48	49	OR-99	COLLECTOR	1,114	1	12	4	1,350	30	7
91	49	50	OR-99	COLLECTOR	643	1	12	4	1,350	30	6
92	50	51	OR-99	COLLECTOR	488	1	12	8	1,350	30	6
93	51	52	OR-99	COLLECTOR	942	1	12	8	1,575	35	6
94	52	159	OR-99	COLLECTOR	311	1	12	4	1,700	40	6
95	53	54	OR-99	COLLECTOR	986	1	12	4	1,700	40	6

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
96	54	55	OR-99	COLLECTOR	319	1	12	4	1,700	40	6
97	55	56	OR-99	COLLECTOR	1,007	1	12	8	1,700	50	6
98	56	57	OR-99	COLLECTOR	906	1	12	4	1,700	50	5
99	57	58	OR-99	COLLECTOR	804	1	12	4	1,700	50	5
100	58	242	OR-99	COLLECTOR	687	2	12	4	1,750	50	5
101	59	179	S VALLEY VIEW RD	COLLECTOR	737	1	12	4	1,575	35	4
102	59	244	OR-99	COLLECTOR	2,298	2	12	8	1,900	50	4
103	60	61	OR-99	COLLECTOR	3,013	1	12	8	1,700	55	4
104	60	180	TALENT AVE	LOCAL ROADWAY	790	1	12	4	1,125	25	4
105	61	62	OR-99	COLLECTOR	1,892	1	12	8	1,700	55	4
106	62	63	OR-99	COLLECTOR	2,316	1	12	4	1,700	45	4
107	62	185	CREEL RD	LOCAL ROADWAY	1,270	1	12	4	1,125	25	4
108	63	186	ARNOS	LOCAL ROADWAY	954	1	12	4	1,125	25	4
109	63	245	OR-99	COLLECTOR	1,065	1	12	4	1,700	45	4
110	64	65	OR-99	MINOR ARTERIAL	2,114	2	12	4	1,750	45	3
111	65	193	W VALLEY VIEW RD	LOCAL ROADWAY	1,152	2	12	4	1,900	40	3
112	65	294	OR-99	MINOR ARTERIAL	727	2	12	4	1,900	45	3
113	66	1	OR-99	MINOR ARTERIAL	584	2	12	4	1,750	45	1
114	67	68	OR-99	MINOR ARTERIAL	1,318	2	12	4	1,900	45	1
115	68	69	OR-99	MINOR ARTERIAL	2,396	1	12	4	1,275	45	1
116	70	108	OR-66	MINOR ARTERIAL	974	2	12	4	1,750	30	10
117	70	109	OR-99	COLLECTOR	1,176	2	12	4	1,750	45	10
118	70	123	OR-99	COLLECTOR	273	2	12	4	1,750	30	10
119	72	24	I-5 FREEWAY RAMP	FREEWAY RAMP	627	1	12	4	1,700	45	5
120	72	73	S VALLEY VIEW RD	COLLECTOR	851	1	12	4	1,575	35	4
121	73	25	I-5 FREEWAY RAMP	FREEWAY RAMP	792	1	12	4	1,700	30	4
122	74	8	ASHLAND ST	COLLECTOR	841	1	12	4	1,750	35	11
123	74	75	ASHLAND ST	COLLECTOR	567	1	12	4	1,575	35	11
124	75	74	ASHLAND ST	COLLECTOR	572	1	12	4	1,575	35	11
125	75	332	ASHLAND ST	COLLECTOR	431	1	12	4	1,575	35	12
126	77	78	GREEN SPRINGS HWY	COLLECTOR	496	1	12	4	1,575	35	12
127	77	332	ASHLAND ST	COLLECTOR	164	1	12	4	1,575	35	12

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
128	78	79	GREEN SPRINGS HWY	COLLECTOR	739	1	12	4	1,575	35	14
129	79	80	GREEN SPRINGS HWY	COLLECTOR	732	1	12	4	1,575	35	14
130	80	81	GREEN SPRINGS HWY	COLLECTOR	1,218	1	12	4	1,575	35	14
131	81	82	GREEN SPRINGS HWY	COLLECTOR	491	1	12	4	1,700	35	14
132	82	83	GREEN SPRINGS HWY	COLLECTOR	2,563	1	12	4	1,575	35	14
133	82	115	CROWSON RD	LOCAL ROADWAY	758	1	12	4	1,700	40	14
134	83	84	GREEN SPRINGS HWY	COLLECTOR	1,163	1	12	4	1,575	35	14
135	84	85	GREEN SPRINGS HWY	COLLECTOR	1,832	1	12	4	1,575	35	14
136	85	86	GREEN SPRINGS HWY	COLLECTOR	939	1	12	4	1,575	35	14
137	86	87	GREEN SPRINGS HWY	COLLECTOR	2,326	1	12	4	1,575	35	14
138	87	88	GREEN SPRINGS HWY	COLLECTOR	1,861	1	12	4	1,575	35	14
140	90	28	I-5 FREEWAY RAMP	FREEWAY RAMP	1,652	1	12	4	1,700	45	4
141	90	91	W VALLEY VIEW RD	LOCAL ROADWAY	1,337	1	12	4	1,350	30	4
142	91	29	I-5 FREEWAY RAMP	FREEWAY RAMP	1,125	1	12	4	1,700	45	4
143	91	90	W VALLEY VIEW RD	LOCAL ROADWAY	1,334	1	12	4	1,350	30	4
144	91	205	W VALLEY VIEW RD	LOCAL ROADWAY	480	1	12	4	1,350	30	4
145	92	93	COLVER RD	LOCAL ROADWAY	738	1	12	4	1,700	45	1
146	93	94	COLVER RD	LOCAL ROADWAY	1,603	1	12	4	1,700	50	1
147	94	95	COLVER RD	LOCAL ROADWAY	444	1	12	4	900	50	1
148	96	44	E MAIN ST	COLLECTOR	1,676	1	12	4	1,750	30	9
149	96	97	E MAIN ST	COLLECTOR	1,034	1	12	4	1,750	30	9
150	97	96	E MAIN ST	COLLECTOR	1,034	1	12	4	1,350	30	9
151	97	98	E MAIN ST	COLLECTOR	1,770	1	12	4	1,350	30	10
152	97	127	S MOUNTAIN AVE	COLLECTOR	1,298	1	12	4	1,125	25	10
153	98	97	E MAIN ST	COLLECTOR	1,769	1	12	4	1,750	30	10
154	98	112	E MAIN ST	COLLECTOR	1,230	1	12	4	1,350	30	10
155	98	249	WIGHTMAN ST	COLLECTOR	528	1	12	0	1,125	25	10
156	99	100	E MAIN ST	COLLECTOR	584	1	12	4	1,350	30	10
157	100	101	E MAIN ST	COLLECTOR	1,477	1	12	4	1,350	30	10
158	101	322	E MAIN ST	COLLECTOR	388	1	12	4	1,350	30	11
159	102	103	E MAIN ST	COLLECTOR	258	1	12	4	1,350	30	11
160	103	104	TOLMAN CREEK ROAD	COLLECTOR	564	1	12	4	1,350	30	11

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
161	103	105	E MAIN ST	COLLECTOR	834	1	12	4	1,350	30	11
162	104	103	TOLMAN CREEK ROAD	COLLECTOR	564	1	12	4	1,350	30	11
163	104	320	TOLMAN CREEK ROAD	COLLECTOR	627	1	12	4	1,350	30	11
164	105	103	E MAIN ST	COLLECTOR	829	1	12	4	1,350	30	11
165	105	106	E MAIN ST	COLLECTOR	1,621	1	12	4	1,350	30	11
166	106	107	E MAIN ST	COLLECTOR	596	1	12	4	1,125	25	11
167	107	302	E MAIN ST	COLLECTOR	2,061	1	12	4	1,125	25	11
168	108	70	OR-66	MINOR ARTERIAL	974	2	12	4	1,750	30	10
169	108	109	WALKER AVE	LOCAL ROADWAY	646	1	12	4	1,750	25	10
170	108	110	OR-66	MINOR ARTERIAL	1,378	2	12	4	1,900	30	10
171	108	124	WALKER AVE	COLLECTOR	1,842	1	12	2	900	20	10
172	109	108	WALKER AVE	LOCAL ROADWAY	646	1	12	4	1,750	25	10
173	109	111	OR-99	COLLECTOR	1,431	1	12	4	1,700	45	13
174	110	113	OR-66	MINOR ARTERIAL	1,026	2	12	4	1,750	30	10
175	110	315	NORMAL AVE	LOCAL ROADWAY	640	1	12	4	1,125	25	10
176	111	275	OR-99	COLLECTOR	253	1	12	4	1,700	40	13
177	112	99	E MAIN ST	COLLECTOR	903	1	12	4	1,350	30	10
178	112	124	WALKER AVE	COLLECTOR	1,592	1	12	2	900	20	10
179	113	312	FAITH AVE	LOCAL ROADWAY	941	1	12	4	1,125	25	11
180	113	323	OR-66	MINOR ARTERIAL	797	2	12	4	1,900	35	11
181	114	311	FAITH AVE	LOCAL ROADWAY	676	1	12	4	1,125	25	13
182	114	317	OR-99	COLLECTOR	1,012	1	12	4	1,700	40	13
183	115	82	CROWSON RD	LOCAL ROADWAY	758	1	12	4	1,700	40	14
184	115	336	CROWSON RD	LOCAL ROADWAY	890	1	12	4	1,700	40	14
185	116	65	E MAIN ST	COLLECTOR	276	2	12	4	1,750	30	3
186	117	64	E RAPP RD	LOCAL ROADWAY	876	1	12	4	1,125	25	4
187	117	187	TALENT AVE	LOCAL ROADWAY	1,915	1	12	4	1,575	35	3
188	118	59	W JACKSON RD	LOCAL ROADWAY	191	1	12	4	1,750	25	4
189	119	51	MAPLE ST	LOCAL ROADWAY	478	1	12	4	1,125	25	6
190	120	215	S LAUREL ST	LOCAL ROADWAY	421	1	12	4	1,125	25	6
191	121	48	N LAUREL ST	LOCAL ROADWAY	1,055	1	12	4	1,125	25	7
192	121	146	W HERSEY ST	LOCAL ROADWAY	596	1	12	4	1,125	25	7

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
193	121	161	N LAUREL ST	LOCAL ROADWAY	681	1	12	4	1,125	25	7
194	122	47	HELMAN ST	LOCAL ROADWAY	1,495	1	12	4	1,750	25	7
195	122	121	W HERSEY ST	LOCAL ROADWAY	630	1	12	4	1,125	25	7
196	122	160	HELMAN ST	LOCAL ROADWAY	708	1	12	4	1,125	25	7
197	123	70	OR-99	COLLECTOR	273	2	12	4	1,750	45	10
198	123	125	WIGHTMAN ST	COLLECTOR	1,693	1	12	0	1,125	25	10
199	123	339	OR-99	COLLECTOR	1,612	2	12	4	1,900	30	10
200	124	108	WALKER AVE	COLLECTOR	1,841	1	12	2	1,750	20	10
201	124	112	WALKER AVE	COLLECTOR	1,591	1	12	2	900	20	10
202	125	123	WIGHTMAN ST	COLLECTOR	1,693	1	12	0	1,750	25	10
203	125	124	IOWA ST	COLLECTOR	1,262	1	12	4	1,125	25	10
204	125	249	WIGHTMAN ST	COLLECTOR	1,090	1	12	0	1,125	25	10
205	127	41	S MOUNTAIN AVE	COLLECTOR	451	1	12	4	1,750	25	10
206	127	97	S MOUNTAIN AVE	COLLECTOR	1,298	1	12	4	1,750	25	10
207	127	125	IOWA ST	COLLECTOR	1,723	1	12	4	1,125	25	10
208	129	215	HIGH ST	LOCAL ROADWAY	1,256	1	12	4	1,125	25	9
209	129	251	GRANITE ST	LOCAL ROADWAY	408	1	12	4	1,125	25	9
210	130	250	GRANITE ST	LOCAL ROADWAY	616	1	12	4	1,125	25	9
211	131	130	GRANITE ST	LOCAL ROADWAY	1,496	1	12	4	1,125	25	9
212	132	131	GRANITE ST	LOCAL ROADWAY	1,084	1	12	4	1,125	25	9
213	133	137	HOLLY ST	LOCAL ROADWAY	1,220	1	12	4	1,125	25	9
214	133	143	GERSHAM ST	LOCAL ROADWAY	493	1	12	4	1,125	25	9
215	134	43	OR-99	COLLECTOR	429	2	12	4	1,900	30	9
216	134	44	E MAIN ST	LOCAL ROADWAY	263	1	12	4	1,750	30	9
217	134	148	N 3RD ST	LOCAL ROADWAY	252	1	12	4	1,125	25	9
218	135	142	LIBERTY ST	LOCAL ROADWAY	1,344	1	12	4	1,125	25	9
219	135	235	ASHLAND ST	LOCAL ROADWAY	357	1	12	4	1,125	25	9
220	136	137	HARRISON ST	LOCAL ROADWAY	654	1	12	4	1,125	25	9
221	137	138	HARRISON ST	LOCAL ROADWAY	514	1	12	4	1,125	25	9
222	137	142	HOLLY ST	LOCAL ROADWAY	671	1	12	4	1,125	25	9
223	138	139	HARRISON ST	LOCAL ROADWAY	440	1	12	4	1,125	25	9
224	138	141	IOWA ST	LOCAL ROADWAY	652	1	12	4	1,125	25	9

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
225	139	237	HARRISON ST	LOCAL ROADWAY	190	1	12	4	1,125	25	9
226	141	42	LIBERTY ST	LOCAL ROADWAY	252	1	12	4	1,750	25	9
227	142	141	LIBERTY ST	LOCAL ROADWAY	491	1	12	4	1,125	25	9
228	143	134	GERSHAM ST	LOCAL ROADWAY	1,494	1	12	4	1,125	25	9
229	143	217	IOWA ST	LOCAL ROADWAY	968	1	12	4	1,125	25	9
230	144	147	E HERSEY ST	LOCAL ROADWAY	2,465	1	12	4	1,125	25	7
231	144	3114	N MOUNTAIN AVE	COLLECTOR	803	1	12	4	1,125	25	8
232	145	122	W HERSEY ST	LOCAL ROADWAY	982	1	12	4	1,125	25	7
233	145	163	OAK ST	COLLECTOR	1,730	1	12	4	1,125	25	7
234	146	49	W HERSEY ST	LOCAL ROADWAY	457	1	12	4	1,125	25	7
235	147	145	E HERSEY ST	LOCAL ROADWAY	227	1	12	4	1,125	25	7
236	148	238	LITHIA WAY	MINOR ARTERIAL	462	2	12	4	1,750	20	9
237	149	150	WILMER ST	LOCAL ROADWAY	629	1	12	4	1,125	25	6
238	150	49	WILMER ST	LOCAL ROADWAY	869	1	12	4	1,125	25	6
239	150	119	SCENIC DR	LOCAL ROADWAY	1,088	1	12	4	1,125	25	6
240	151	159	SHERIDAN ST	LOCAL ROADWAY	1,062	1	12	4	1,125	25	6
241	151	286	SHERIDAN ST	LOCAL ROADWAY	92	1	11	0	1,125	25	6
242	152	153	MONTE VISTA DR	LOCAL ROADWAY	212	1	11	0	1,125	25	6
243	153	154	MONTE VISTA DR	LOCAL ROADWAY	349	1	11	0	1,125	25	6
244	154	155	SCHOFIELD ST	LOCAL ROADWAY	307	1	12	4	1,125	25	6
245	155	54	SCHOFIELD ST	LOCAL ROADWAY	275	1	12	4	1,125	25	6
246	159	53	OR-99	COLLECTOR	392	1	12	4	1,700	40	6
247	160	161	ORANGE ST	LOCAL ROADWAY	687	1	12	4	1,125	25	7
248	161	121	N LAUREL ST	LOCAL ROADWAY	681	1	12	4	1,125	25	7
249	161	162	ORANGE ST	LOCAL ROADWAY	891	1	12	4	1,125	25	7
250	162	261	GLENN ST	LOCAL ROADWAY	124	1	12	4	900	20	7
251	163	145	OAK ST	COLLECTOR	1,730	1	12	4	1,125	25	7
252	163	164	OAK ST	COLLECTOR	1,561	1	12	4	1,125	25	7
253	164	163	OAK ST	COLLECTOR	1,561	1	12	4	1,125	25	7
254	164	168	OAK ST	COLLECTOR	763	1	12	4	1,700	40	7
255	165	160	HELMAN ST	LOCAL ROADWAY	741	1	12	4	1,125	25	7
256	166	165	HELMAN ST	LOCAL ROADWAY	653	1	12	4	1,125	25	7

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
257	167	164	E NEVADA ST	LOCAL ROADWAY	804	1	12	4	1,125	25	7
258	167	166	HELMAN ST	LOCAL ROADWAY	922	1	12	4	1,125	25	7
259	168	169	OAK ST	COLLECTOR	663	1	12	4	1,700	40	7
260	169	170	OAK ST	COLLECTOR	493	1	12	4	1,700	40	7
261	170	171	EAGLE MILL RD	COLLECTOR	710	1	12	4	1,700	45	5
262	171	172	EAGLE MILL RD	COLLECTOR	478	1	12	4	1,700	45	5
263	172	173	EAGLE MILL RD	COLLECTOR	552	1	12	4	1,700	45	5
264	173	174	EAGLE MILL RD	COLLECTOR	423	1	12	4	1,700	45	5
265	174	175	EAGLE MILL RD	COLLECTOR	3,587	1	12	4	1,700	45	5
266	175	176	EAGLE MILL RD	COLLECTOR	564	1	12	4	1,700	45	5
267	176	177	EAGLE MILL RD	COLLECTOR	855	1	12	4	1,700	45	5
268	177	178	EAGLE MILL RD	COLLECTOR	313	1	12	4	1,700	45	5
269	178	179	EAGLE MILL RD	COLLECTOR	1,648	1	12	4	1,700	45	5
270	179	59	S VALLEY VIEW RD	COLLECTOR	736	1	12	4	1,750	35	4
271	179	72	S VALLEY VIEW RD	COLLECTOR	1,486	1	12	4	1,575	35	4
272	180	181	TALENT AVE	LOCAL ROADWAY	547	1	12	4	1,125	25	4
273	181	182	TALENT AVE	LOCAL ROADWAY	1,633	1	12	4	1,125	25	4
274	182	183	TALENT AVE	LOCAL ROADWAY	500	1	12	4	1,125	25	4
275	183	184	TALENT AVE	LOCAL ROADWAY	1,509	1	12	4	1,125	25	4
276	184	185	TALENT AVE	LOCAL ROADWAY	366	1	12	4	1,125	25	4
277	185	62	CREEL RD	LOCAL ROADWAY	1,270	1	12	4	1,125	25	4
278	185	186	TALENT AVE	LOCAL ROADWAY	2,439	1	12	4	1,125	25	4
279	186	63	ARNOS	LOCAL ROADWAY	954	1	12	4	1,125	25	4
280	186	117	TALENT AVE	LOCAL ROADWAY	1,669	1	12	4	1,125	25	4
281	187	188	TALENT AVE	LOCAL ROADWAY	515	1	12	4	1,575	35	3
282	188	206	TALENT AVE	LOCAL ROADWAY	193	1	12	4	1,125	25	3
283	189	190	TALENT AVE	LOCAL ROADWAY	351	1	12	4	1,350	30	1
284	190	1	COLVER RD	LOCAL ROADWAY	196	1	12	4	1,750	40	1
285	190	191	COLVER RD	LOCAL ROADWAY	1,077	1	12	4	1,700	40	1
286	191	192	COLVER RD	LOCAL ROADWAY	375	1	12	4	1,700	40	1
287	192	92	COLVER RD	LOCAL ROADWAY	4,566	1	12	4	1,700	50	1
288	193	248	W VALLEY VIEW RD	LOCAL ROADWAY	521	2	12	4	1,750	40	4

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
289	194	195	MOUNTAIN VIEW DR	LOCAL ROADWAY	443	1	12	4	1,125	25	4
290	195	193	MOUNTAIN VIEW DR	LOCAL ROADWAY	493	1	12	4	1,125	25	4
291	196	197	SUNCREST RD	LOCAL ROADWAY	1,565	1	12	2	1,350	30	4
292	197	198	SUNCREST RD	LOCAL ROADWAY	1,147	1	12	2	1,350	30	2
293	198	199	SUNCREST RD	LOCAL ROADWAY	493	1	12	2	1,350	30	2
294	199	200	SUNCREST RD	LOCAL ROADWAY	908	1	12	2	1,350	30	2
295	200	201	SUNCREST RD	LOCAL ROADWAY	480	1	12	2	1,350	30	2
296	201	202	SUNCREST RD	LOCAL ROADWAY	1,239	1	12	4	1,350	30	2
297	202	203	SUNCREST RD	LOCAL ROADWAY	1,942	1	12	4	1,350	30	2
298	203	204	PAYNE RD	COLLECTOR	1,294	1	12	2	675	45	2
299	205	196	W VALLEY VIEW RD	LOCAL ROADWAY	829	1	12	4	1,350	30	4
300	206	231	E MAIN ST	COLLECTOR	334	1	12	4	1,350	30	3
301	206	300	TALENT AVE	LOCAL ROADWAY	503	1	12	4	1,350	30	3
302	207	206	MAIN ST	LOCAL ROADWAY	1,951	1	12	4	1,125	25	3
303	208	207	WAGNER CREEK RD	LOCAL ROADWAY	227	1	12	4	1,125	25	3
304	208	246	FOSS RD	LOCAL ROADWAY	662	1	12	4	1,350	30	3
305	209	92	WALDEN RD	LOCAL ROADWAY	2,505	1	12	4	1,700	45	3
306	210	208	WAGNER CREEK RD	LOCAL ROADWAY	1,445	1	12	4	1,350	30	3
307	210	211	W RAPP RD	COLLECTOR	2,601	1	12	4	1,350	30	3
308	211	212	E RAPP RD	LOCAL ROADWAY	196	1	12	4	900	20	3
309	212	213	E RAPP RD	LOCAL ROADWAY	631	1	12	4	1,125	25	3
310	213	117	E RAPP RD	LOCAL ROADWAY	665	1	12	4	1,125	25	3
311	214	267	PEACHY RD	LOCAL ROADWAY	1,226	1	12	4	1,125	25	13
312	214	3109	WALKER AVE	LOCAL ROADWAY	2,024	1	12	4	1,125	25	13
313	215	48	S LAUREL ST	LOCAL ROADWAY	457	1	12	4	1,125	25	7
314	217	138	IOWA ST	LOCAL ROADWAY	277	1	12	4	1,125	25	9
315	217	240	SHERMAN ST	LOCAL ROADWAY	884	1	12	4	1,750	25	9
316	218	228	OR-99	MINOR ARTERIAL	370	2	12	4	1,750	25	9
317	219	203	SUNCREST RD	COLLECTOR	551	1	12	4	1,700	45	2
318	220	219	SUNCREST RD	COLLECTOR	434	1	12	4	1,700	45	1
319	221	247	SUNCREST RD	COLLECTOR	1,127	1	12	4	1,350	30	1
320	221	292	CLEARVIEW DR	COLLECTOR	235	1	12	4	1,125	25	1

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
321	222	221	SUNCREST RD	COLLECTOR	791	1	12	4	1,125	25	1
322	223	226	N MOUNTAIN AVE	COLLECTOR	926	1	12	4	1,125	25	8
323	223	260	N MOUNTAIN AVE	COLLECTOR	556	1	12	4	1,700	40	8
324	224	225	N MOUNTAIN AVE	COLLECTOR	757	1	12	4	1,125	25	7
325	225	144	N MOUNTAIN AVE	COLLECTOR	900	1	12	4	1,125	25	7
326	226	223	N MOUNTAIN AVE	COLLECTOR	926	1	12	4	1,125	25	8
327	226	224	N MOUNTAIN AVE	COLLECTOR	1,179	1	12	4	1,125	25	7
328	227	46	LITHIA WAY	MINOR ARTERIAL	232	2	12	4	1,900	20	9
329	227	229	PIONEER ST	COLLECTOR	260	1	12	4	1,750	20	9
330	228	134	OR-99	COLLECTOR	433	3	12	4	1,750	30	9
331	229	218	OR-99	MINOR ARTERIAL	486	2	12	4	1,750	25	9
332	229	227	PIONEER ST	COLLECTOR	260	1	12	4	1,750	20	9
333	230	73	N VALLEY VIEW RD	COLLECTOR	1,138	1	12	4	1,575	35	4
334	231	232	E MAIN ST	COLLECTOR	237	1	12	4	1,350	30	3
335	232	116	E MAIN ST	COLLECTOR	247	1	12	4	675	15	3
336	233	41	OR-99	COLLECTOR	812	2	12	4	1,750	30	9
337	233	42	OR-99	COLLECTOR	480	2	12	4	1,750	30	9
338	234	41	S MOUNTAIN AVE	LOCAL ROADWAY	1,338	1	12	4	1,750	25	10
339	235	233	BEACH ST	LOCAL ROADWAY	1,795	1	12	4	1,750	25	9
340	235	234	ASHLAND ST	LOCAL ROADWAY	727	1	12	4	1,125	25	9
341	236	79	DEAD INDIAN MEMORIAL RD	LOCAL ROADWAY	344	1	12	4	900	20	14
342	237	42	OR-99	COLLECTOR	681	2	12	4	1,900	30	9
343	237	240	OR-99	COLLECTOR	462	2	12	4	1,750	30	9
344	238	45	LITHIA WAY	MINOR ARTERIAL	360	2	12	4	1,900	20	9
345	238	228	2ND ST	COLLECTOR	373	1	12	0	1,750	30	9
346	239	238	N 2ND AVE	LOCAL ROADWAY	509	1	12	4	1,750	25	9
347	239	256	B ST	LOCAL ROADWAY	1,023	1	12	2	1,125	25	9
348	240	43	OR-99	COLLECTOR	677	2	12	4	1,900	30	9
349	240	237	OR-99	COLLECTOR	462	2	12	4	1,900	30	9
350	241	48	OR-99	COLLECTOR	355	1	12	4	1,125	25	7
351	242	59	OR-99	COLLECTOR	1,134	2	12	4	1,750	50	5

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
352	243	242	JACKSON RD	LOCAL ROADWAY	192	1	12	4	900	20	5
353	244	60	OR-99	COLLECTOR	1,680	1	12	8	1,700	55	4
354	245	64	OR-99	MINOR ARTERIAL	447	2	12	4	1,750	45	4
355	246	209	FOSS RD	LOCAL ROADWAY	4,780	1	12	4	1,700	40	3
356	247	220	SUNCREST RD	COLLECTOR	1,348	1	12	4	1,700	45	1
357	248	90	W VALLEY VIEW RD	LOCAL ROADWAY	738	1	12	4	1,350	30	4
358	249	98	WIGHTMAN ST	COLLECTOR	528	1	12	0	1,125	25	10
359	249	125	WIGHTMAN ST	COLLECTOR	1,090	1	12	0	1,125	25	10
360	250	129	GRANITE ST	LOCAL ROADWAY	1,160	1	12	4	1,125	25	9
361	251	253	OR-99	MINOR ARTERIAL	137	2	12	4	1,900	25	9
362	252	255	WATER ST	LOCAL ROADWAY	313	1	10	2	900	20	9
363	252	256	B ST	LOCAL ROADWAY	351	1	12	2	1,125	25	9
364	253	229	OR-99	MINOR ARTERIAL	654	2	12	4	1,750	25	9
365	254	47	LITHIA WAY	LOCAL ROADWAY	486	2	12	4	1,900	20	9
366	254	255	LITHIA WAY	LOCAL ROADWAY	139	1	12	2	900	15	9
367	255	253	WATER ST	LOCAL ROADWAY	129	1	10	2	900	20	9
368	256	46	OAK ST	LOCAL ROADWAY	344	1	12	4	1,125	25	9
369	256	252	B ST	LOCAL ROADWAY	352	1	12	2	1,125	25	9
370	256	305	OAK ST	LOCAL ROADWAY	628	1	12	4	1,125	25	7
371	257	260	N MOUNTAIN AVE	COLLECTOR	1,136	1	12	4	1,700	40	7
372	257	3112	EAGLE MILL RD	COLLECTOR	335	1	12	4	1,350	30	5
373	258	259	E NEVADA ST	COLLECTOR	3,363	1	12	4	1,700	40	8
374	259	223	E NEVADA ST	COLLECTOR	618	1	12	4	1,700	40	8
375	260	223	N MOUNTAIN AVE	COLLECTOR	556	1	12	4	1,700	40	8
376	260	257	N MOUNTAIN AVE	COLLECTOR	1,136	1	12	4	1,700	40	7
377	261	50	GLENN ST	LOCAL ROADWAY	575	1	12	4	900	20	7
378	262	236	DEAD INDIAN MEMORIAL RD	LOCAL ROADWAY	2,402	1	12	4	1,700	50	12
379	263	303	TOLMAN CREEK ROAD	COLLECTOR	1,830	1	12	4	1,750	30	13
380	264	114	OR-99	COLLECTOR	551	1	12	4	1,700	40	13
381	265	264	PARK ST	LOCAL ROADWAY	2,181	1	12	4	1,125	25	13
382	266	265	CRESTVIEW DR	LOCAL ROADWAY	643	1	12	4	1,125	25	13

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
383	266	267	HILLVIEW DR	LOCAL ROADWAY	1,009	1	12	4	1,125	25	13
384	267	111	HILLVIEW DR	LOCAL ROADWAY	1,613	1	12	4	1,125	25	13
385	268	133	GUTHRIE ST	LOCAL ROADWAY	1,316	1	12	4	1,125	25	9
386	268	135	ASHLAND ST	LOCAL ROADWAY	2,007	1	12	4	1,125	25	9
387	269	234	ASHLAND ST	LOCAL ROADWAY	271	1	12	4	1,125	25	10
388	270	269	ELKADER ST	LOCAL ROADWAY	1,314	1	12	4	1,125	25	10
389	271	270	ELKADER ST	LOCAL ROADWAY	1,412	1	12	4	1,125	25	13
390	274	214	PINECREST	LOCAL ROADWAY	926	1	12	4	900	20	13
391	275	264	OR-99	COLLECTOR	600	1	12	4	1,700	40	13
392	275	315	NORMAL AVE	LOCAL ROADWAY	952	1	12	4	1,125	25	13
393	276	96	8TH ST	LOCAL ROADWAY	655	1	12	4	1,125	25	9
394	277	239	B ST	LOCAL ROADWAY	352	1	12	4	1,125	25	9
395	277	298	B ST	LOCAL ROADWAY	732	1	12	4	1,125	25	9
396	278	279	E NEVADA ST	LOCAL ROADWAY	723	1	12	4	1,125	25	6
397	279	280	E NEVADA ST	LOCAL ROADWAY	228	1	12	4	1,125	25	6
398	280	281	E NEVADA ST	LOCAL ROADWAY	603	1	12	4	1,125	25	7
399	281	282	E NEVADA ST	LOCAL ROADWAY	744	1	12	4	1,125	25	7
400	282	161	N LAUREL ST	LOCAL ROADWAY	1,946	1	12	4	1,125	25	7
401	282	167	E NEVADA ST	LOCAL ROADWAY	849	1	12	4	1,125	25	7
402	283	149	WILMER ST	LOCAL ROADWAY	617	1	12	4	1,125	25	6
403	283	288	WALNUT ST	LOCAL ROADWAY	1,324	1	12	4	1,125	25	6
404	284	283	WILMER ST	LOCAL ROADWAY	737	1	12	4	1,125	25	6
405	285	284	WILMER ST	LOCAL ROADWAY	629	1	12	4	1,125	25	6
406	286	151	SHERIDAN ST	LOCAL ROADWAY	92	1	11	0	1,125	25	6
407	286	152	MONTE VISTA DR	LOCAL ROADWAY	98	1	11	0	1,125	25	6
408	287	288	WILEY ST	LOCAL ROADWAY	387	1	12	4	1,125	25	6
409	288	151	WALNUT ST	LOCAL ROADWAY	797	1	12	4	1,125	25	6
410	289	150	SCENIC DR	LOCAL ROADWAY	657	1	12	4	1,125	25	6
411	290	284	WRIGHTS CREEK DR	LOCAL ROADWAY	638	1	12	4	1,125	25	6
413	292	221	CLEARVIEW DR	COLLECTOR	235	1	12	4	1,125	25	1
414	292	293	CLEARVIEW DR	COLLECTOR	231	1	12	4	1,125	25	1
415	293	292	CLEARVIEW DR	COLLECTOR	231	1	12	4	1,125	25	1

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
416	293	294	CLEARVIEW DR	COLLECTOR	406	1	12	4	1,125	25	1
417	294	66	OR-99	MINOR ARTERIAL	729	2	12	4	1,900	45	1
418	294	293	CLEARVIEW DR	COLLECTOR	406	1	12	4	1,125	25	1
419	295	229	PIONEER RD	LOCAL ROADWAY	346	1	12	0	1,750	30	9
420	296	228	2ND ST	COLLECTOR	372	1	12	0	1,750	30	9
421	297	248	DRIVEWAY	LOCAL ROADWAY	225	1	12	4	1,750	25	4
422	298	276	B ST	LOCAL ROADWAY	1,123	1	12	4	1,125	25	9
423	298	277	B ST	LOCAL ROADWAY	732	1	12	4	1,125	25	9
424	299	298	5TH ST	LOCAL ROADWAY	467	1	12	4	1,125	25	9
425	300	189	TALENT AVE	LOCAL ROADWAY	730	1	12	4	1,350	30	1
426	300	206	TALENT AVE	LOCAL ROADWAY	503	1	12	4	1,350	30	3
427	300	294	NEW ST	LOCAL ROADWAY	483	1	12	4	1,125	25	1
428	301	300	SUNNY ST	LOCAL ROADWAY	441	1	12	4	1,125	25	1
429	302	77	E MAIN ST	COLLECTOR	83	1	12	4	1,125	25	12
430	303	40	TOLMAN CREEK ROAD	COLLECTOR	2,918	1	12	4	1,750	30	13
431	304	298	5TH ST	LOCAL ROADWAY	455	1	12	4	1,125	25	9
432	305	145	OAK ST	LOCAL ROADWAY	733	1	12	4	1,125	25	7
433	306	9	TOLMAN CREEK ROAD	COLLECTOR	653	1	12	4	1,750	30	11
434	306	320	TOLMAN CREEK ROAD	COLLECTOR	1,098	1	12	4	1,350	30	11
435	307	9	TOLMAN CREEK ROAD	COLLECTOR	1,160	1	12	4	1,750	30	11
436	307	308	TOLMAN CREEK ROAD	COLLECTOR	1,137	1	12	4	1,350	30	13
437	308	40	TOLMAN CREEK ROAD	COLLECTOR	1,357	1	12	4	1,750	30	13
438	308	307	TOLMAN CREEK ROAD	COLLECTOR	1,137	1	12	4	1,350	30	13
439	309	308	DIANNE ST	LOCAL ROADWAY	656	1	12	0	1,125	25	13
440	310	307	TAKELMA WAY	LOCAL ROADWAY	643	1	12	0	1,125	25	13
441	311	114	FAITH AVE	LOCAL ROADWAY	676	1	12	4	1,125	25	13
442	311	312	FAITH AVE	LOCAL ROADWAY	605	1	12	4	1,125	25	13
443	312	113	FAITH AVE	LOCAL ROADWAY	941	1	12	4	1,750	25	11
444	312	311	FAITH AVE	LOCAL ROADWAY	605	1	12	4	1,125	25	13
445	313	312	MAE ST	LOCAL ROADWAY	311	1	12	1	1,125	25	13
446	314	311	WINE ST	LOCAL ROADWAY	337	1	12	1	1,125	25	13
447	315	110	NORMAL AVE	LOCAL ROADWAY	640	1	12	4	1,125	25	10

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
448	315	275	NORMAL AVE	LOCAL ROADWAY	952	1	12	4	1,125	25	13
449	316	315	FREMONT ST	LOCAL ROADWAY	598	1	12	0	1,125	25	10
450	317	40	OR-99	COLLECTOR	1,577	1	12	4	1,700	40	13
451	318	317	CLAY ST	COLLECTOR	2,200	1	12	1	1,125	25	13
452	319	317	CLAY ST	COLLECTOR	1,871	1	12	1	1,125	25	13
453	320	104	TOLMAN CREEK ROAD	COLLECTOR	628	1	12	4	1,350	30	11
454	320	306	TOLMAN CREEK ROAD	COLLECTOR	1,098	1	12	4	1,350	30	11
455	321	320	ABBOTT AVE	LOCAL ROADWAY	654	1	12	0	1,125	25	11
456	322	102	E MAIN ST	COLLECTOR	645	1	12	4	1,350	30	11
457	322	325	CLAY ST	COLLECTOR	853	1	12	1	1,125	25	11
458	323	9	OR-66	MINOR ARTERIAL	1,299	2	12	4	1,750	35	11
459	323	324	CLAY ST	COLLECTOR	755	1	12	1	1,125	25	11
460	324	323	CLAY ST	COLLECTOR	755	1	12	1	1,125	25	11
461	324	325	CLAY ST	COLLECTOR	1,077	1	12	1	1,125	25	11
462	325	322	CLAY ST	COLLECTOR	853	1	12	1	1,125	25	11
463	325	324	CLAY ST	COLLECTOR	1,077	1	12	1	1,125	25	11
464	326	324	VILLARD ST	LOCAL ROADWAY	423	1	12	1	1,125	25	11
465	327	325	CREEK DR	LOCAL ROADWAY	849	1	12	1	1,125	25	11
466	328	123	INDIANA ST	COLLECTOR	311	2	12	0	1,750	30	10
467	329	328	INDIANA ST	COLLECTOR	927	1	12	0	1,350	30	10
468	329	3109	OREGON ST	LOCAL ROADWAY	1,126	1	12	0	1,350	30	13
469	330	329	INDIANA ST	COLLECTOR	947	1	12	0	1,350	30	13
470	331	74	SUTTON PL	LOCAL ROADWAY	506	1	12	1	1,350	30	11
471	332	75	ASHLAND ST	COLLECTOR	431	1	12	4	1,575	35	12
472	332	77	ASHLAND ST	COLLECTOR	163	1	12	4	1,575	35	12
473	333	332	OAK KNOLL DR	COLLECTOR	222	1	12	1	1,350	30	12
474	334	333	OAK KNOLL DR	COLLECTOR	414	1	12	1	1,350	30	12
475	335	334	OAK KNOLL DR	COLLECTOR	447	1	12	1	1,350	30	14
476	336	2	CROWSON RD	LOCAL ROADWAY	2,355	1	12	4	1,750	40	14
477	336	115	CROWSON RD	LOCAL ROADWAY	890	1	12	4	1,700	40	14
478	337	336	OAK KNOLL DR	COLLECTOR	335	1	12	1	1,350	30	14
479	338	337	OAK KNOLL DR	COLLECTOR	598	1	12	1	1,350	30	14

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
480	339	41	OR-99	COLLECTOR	540	2	12	4	1,750	30	10
481	339	123	OR-99	COLLECTOR	1,611	2	12	4	1,750	30	10
482	340	269	ASHLAND ST	LOCAL ROADWAY	173	1	12	4	1,125	25	10
483	340	339	UNIVERSITY WAY	LOCAL ROADWAY	1,011	1	12	8	1,350	30	10
484	350	340	ASHLAND ST	LOCAL ROADWAY	504	1	12	4	1,125	25	10
627	3109	109	WALKER AVE	LOCAL ROADWAY	386	1	12	4	1,750	25	13
628	3110	226	FAIR OAKS AVE	LOCAL ROADWAY	990	1	12	4	1,125	25	7
629	3111	170	EAGLE MILL RD	COLLECTOR	952	1	12	4	1,700	40	5
630	3112	3111	EAGLE MILL RD	COLLECTOR	1,507	1	12	4	1,700	40	5
631	3113	163	SLEEPY HOLLOW	COLLECTOR	746	1	12	4	1,350	30	7
632	3114	144	N MOUNTAIN AVE	COLLECTOR	803	1	12	4	1,125	25	8
633	3114	3115	N MOUNTAIN AVE	COLLECTOR	416	1	12	4	1,125	25	10
634	3115	97	N MOUNTAIN AVE	COLLECTOR	1,635	1	12	4	1,750	25	10
635	3115	3114	N MOUNTAIN AVE	COLLECTOR	416	1	12	4	1,125	25	10
636	3116	3115	VILLAGE GREEN DR	LOCAL ROADWAY	345	1	12	0	1,125	25	10
637	3117	98	WRIGHTMAN ST	LOCAL ROADWAY	880	1	12	0	1,125	25	10
639	8002	31	I-5	FREEWAY	2,852	2	12	8	2,250	70	1
(exit link)	31	8002	I-5	FREEWAY	2,852	2	12	8	2,250	70	1
(exit link)	69	8003	OR-99	MINOR ARTERIAL	757	1	12	4	1,275	45	1
(exit link)	95	8005	COLVER RD	LOCAL ROADWAY	2,638	1	12	4	900	50	1
(exit link)	204	8006	PAYNE RD	COLLECTOR	957	1	12	2	675	45	2
(exit link)	13	8001	I-5	FREEWAY	1446	2	12	4	2250	70	14
(exit link)	88	8004	GREEN SPRINGS HWY	COLLECTOR	1755	1	12	4	1575	35	14

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

Node	X Coordinate[1] (ft)	Y Coordinate[1] (ft)	Control Type	Grid Map Number
1	4301313	220754	Actuated	1
2	4334929	191395	TCP - Actuated	13
7	4333870	196621	Actuated	11
8	4334445	196630	Actuated	11
9	4332741	196678	Actuated	11
40	4332645	193025	Actuated	13
41	4325289	198249	Actuated	10
42	4324223	198980	Stop	9
44	4322650	200221	Actuated	9
46	4321324	201453	Stop	9
47	4320711	201931	Actuated	9
48	4320275	202668	Actuated	7
49	4319856	203690	Stop	7
50	4319685	204310	Stop	6
51	4319451	204738	Actuated	6
54	4317710	206641	Stop	6
59	4314371	210093	Actuated	4
62	4307467	215682	Stop	4
63	4305647	217114	Stop	4
64	4304473	218065	Actuated	4
70	4327269	196853	Actuated	10
72	4314474	212309	Stop	4
73	4314326	213147	Stop	4
74	4335247	196844	Stop	11
77	4336285	196511	Stop	12
82	4338254	193425	Stop	14
90	4305235	219402	Stop	4
91	4306405	218950	Stop	4
92	4295153	220541	Stop	1
96	4324317	200079	Stop	9
97	4325348	199997	Actuated	10
98	4327091	200301	Stop	10
103	4332375	199426	Stop	11
108	4328242	196819	Actuated	10
109	4328228	196173	Actuated	10
110	4329620	196777	Stop	10
111	4329385	195330	Stop	13
112	4328320	200251	Stop	10
113	4330646	196733	TCP - Actuated	11
114	4330526	194514	Stop	13
117	4303793	217512	Stop	3

Node	X Coordinate[1] (ft)	Y Coordinate[1] (ft)	Control Type	Grid Map Number
121	4320822	203570	Stop	7
122	4321376	203270	Stop	7
123	4327034	196991	Actuated	10
124	4328292	198660	Stop	10
125	4327030	198684	Stop	10
127	4325307	198700	Stop	10
134	4322397	200292	Actuated	9
135	4324166	196894	Stop	9
137	4323514	198258	Stop	9
138	4323551	198771	Stop	9
141	4324202	198729	Stop	9
142	4324185	198238	Stop	9
143	4322308	198801	Stop	9
144	4324941	202706	Stop	7
145	4322258	202839	Stop	7
148	4322498	200523	Stop	9
150	4318988	203662	Stop	6
151	4317750	205815	Stop	6
154	4317409	206362	Stop	6
159	4318812	205813	Stop	6
161	4321105	204189	Stop	7
163	4322693	204513	Stop	7
164	4322781	206072	Stop	7
170	4322507	207881	Stop	5
179	4314468	210823	Stop	4
185	4306733	214646	Stop	4
186	4305027	216389	Stop	4
190	4301153	220641	Stop	1
193	4303977	219436	Stop	4
203	4304283	223182	Stop	2
206	4302002	219362	Stop	3
214	4328167	193764	Stop	13
215	4319896	202412	Stop	7
221	4302431	220629	Stop	1
223	4325433	206361	Stop	8
226	4325010	205537	Stop	7
227	4321511	201317	Actuated	9
228	4322062	200567	Actuated	9
229	4321384	201090	Actuated	9
233	4324616	198704	Actuated	9
234	4325249	196912	Stop	10
235	4324522	196912	Stop	9
237	4323664	199368	Stop	9

Node	X Coordinate[1] (ft)	Y Coordinate[1] (ft)	Control Type	Grid Map Number
238	4322233	200898	Actuated	9
239	4322383	201385	Stop	9
240	4323291	199640	Actuated	9
242	4315261	209390	Actuated	5
248	4304498	219429	Actuated	4
249	4327086	199773	Stop	10
250	4320146	200298	Stop	9
252	4321133	201952	Stop	7
253	4320931	201558	Stop	9
255	4320995	201671	Yield	9
256	4321438	201777	Stop	9
261	4320194	204576	Stop	7
264	4330067	194818	Stop	13
267	4329392	193717	Stop	13
275	4329592	195185	Stop	13
284	4317006	203715	Stop	6
288	4317739	205018	Stop	6
294	4302273	219862	Stop	1
298	4323410	201040	Stop	9
300	4301792	219819	Stop	1
307	4332710	195518	Stop	13
308	4332696	194381	Stop	13
311	4330566	195189	Stop	13
312	4330585	195794	Stop	13
315	4329601	196137	Stop	10
317	4331347	193922	Stop	13
320	4332790	198429	Stop	11
322	4331493	199401	Stop	11
323	4331443	196716	Stop	11
324	4331448	197471	Stop	11
325	4331480	198548	Stop	11
332	4336150	196604	Stop	12
336	4336786	192844	Stop	14
339	4325709	197909	Stop	10
3109	4328229	195787	Stop	13
3115	4325406	201631	Stop	10

[1] Coordinates are in the North American Datum of 1983 Oregon South State Plane

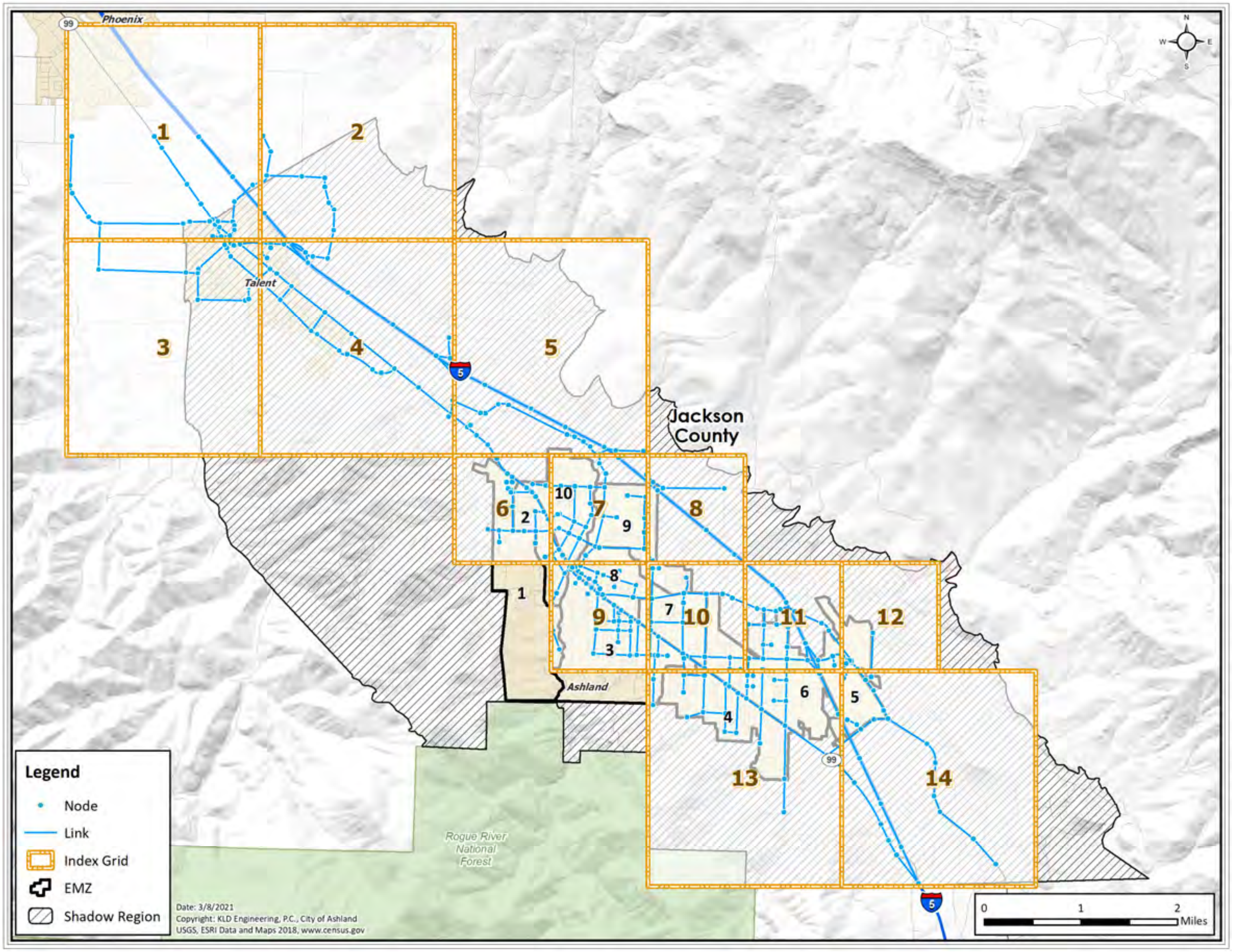


Figure H-1. Evacuation Time Estimate Study Link-Node Analysis Network

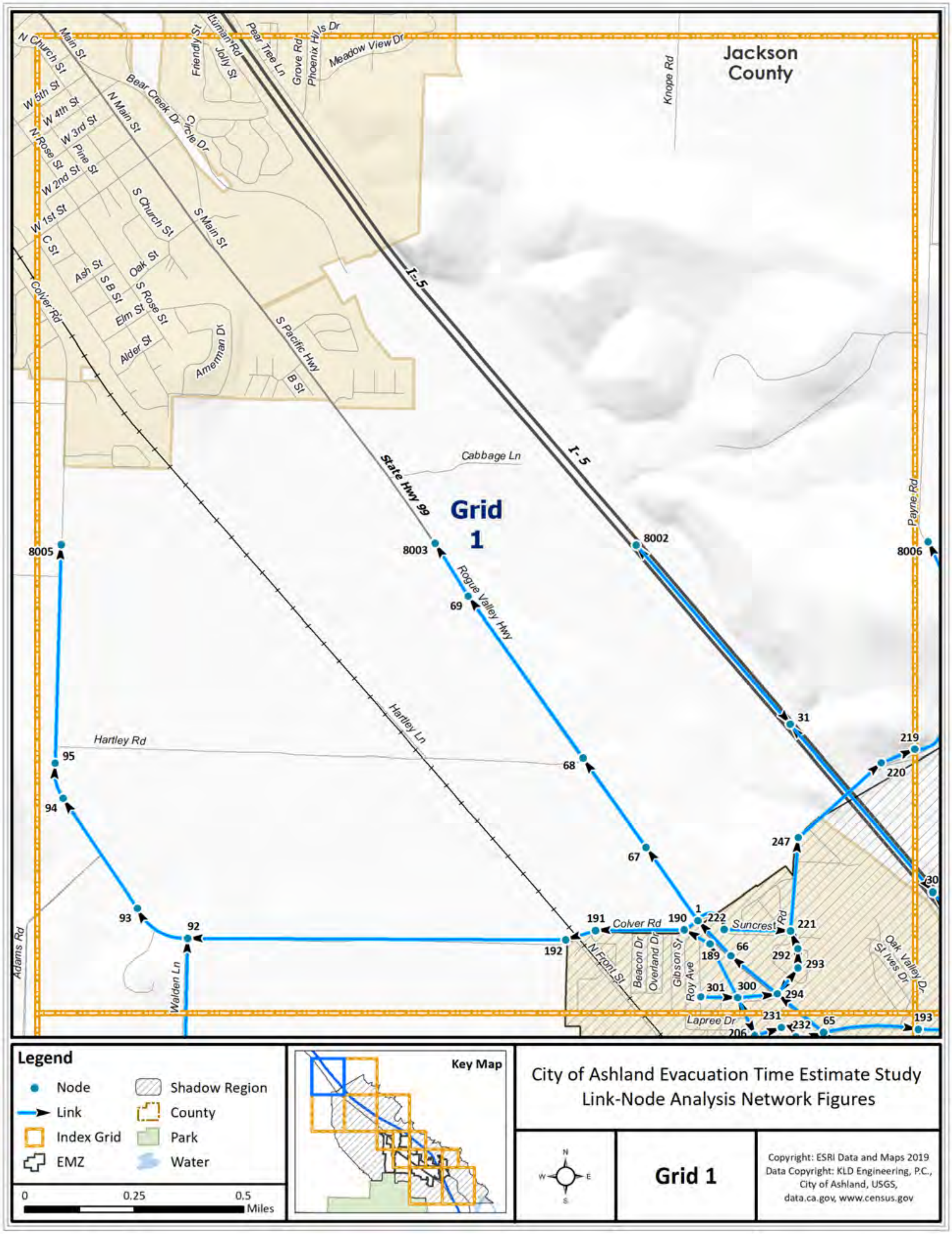


Figure H-2. Link-Node Analysis Network – Grid 1

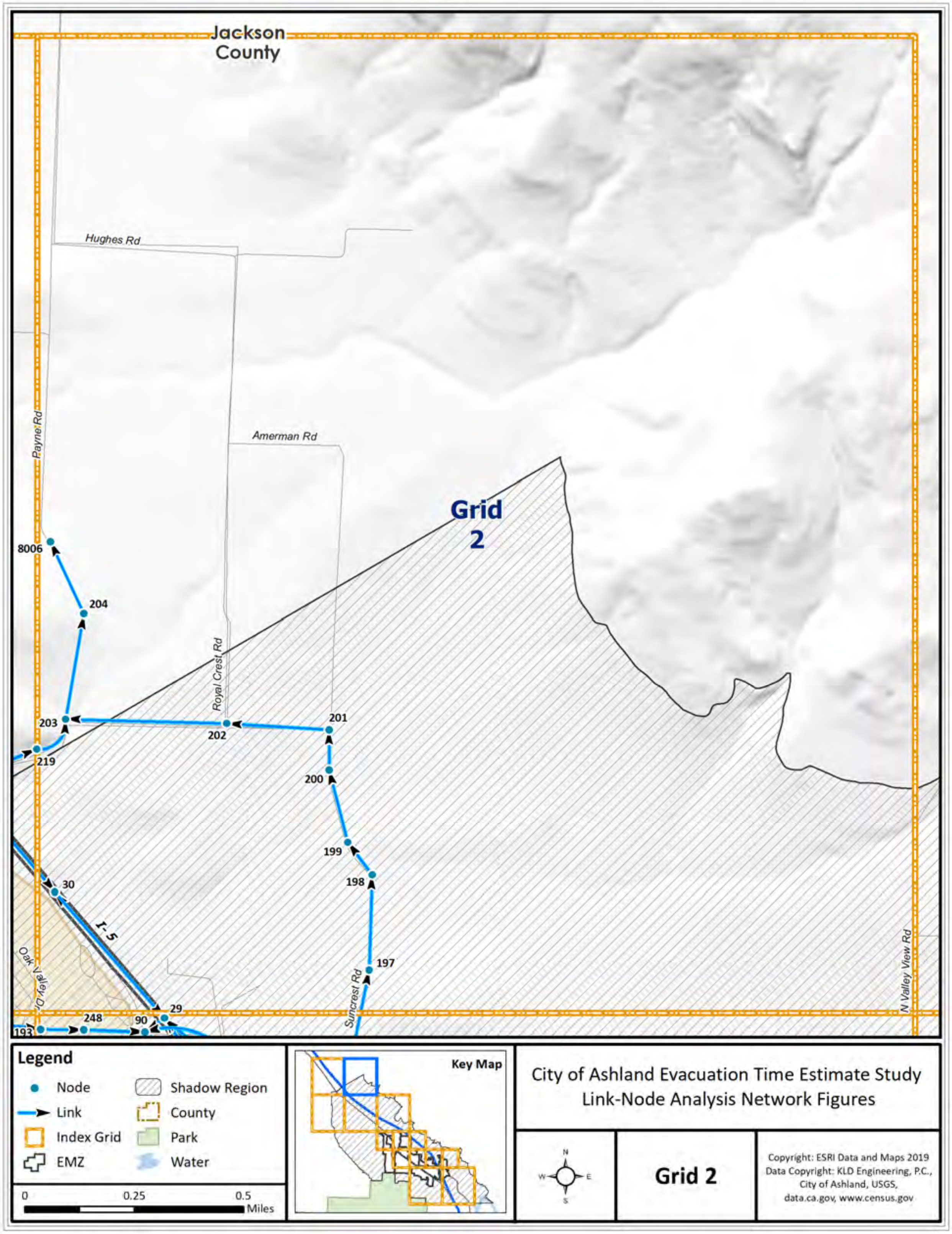


Figure H-3. Link-Node Analysis Network – Grid 2

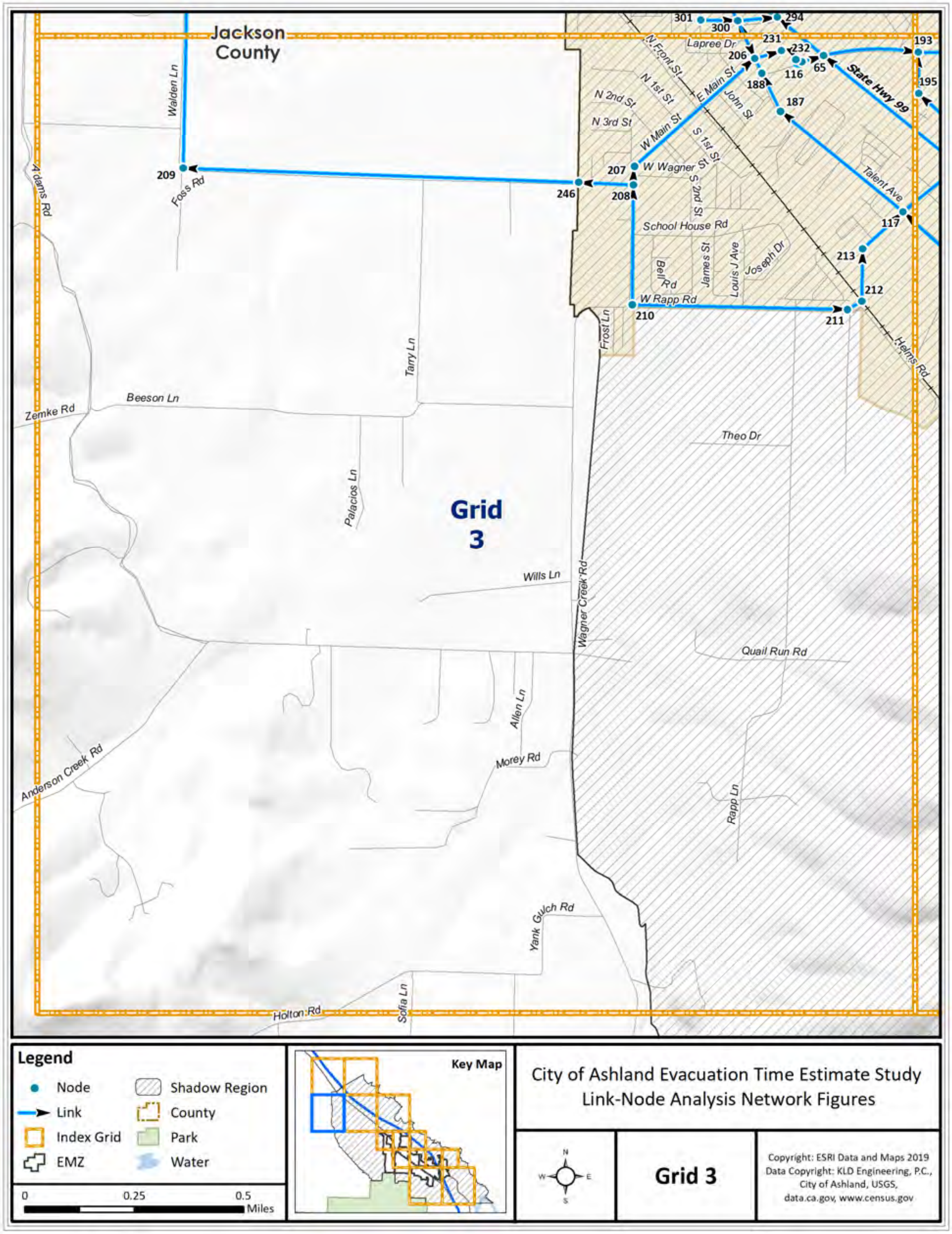


Figure H-4. Link-Node Analysis Network – Grid 3

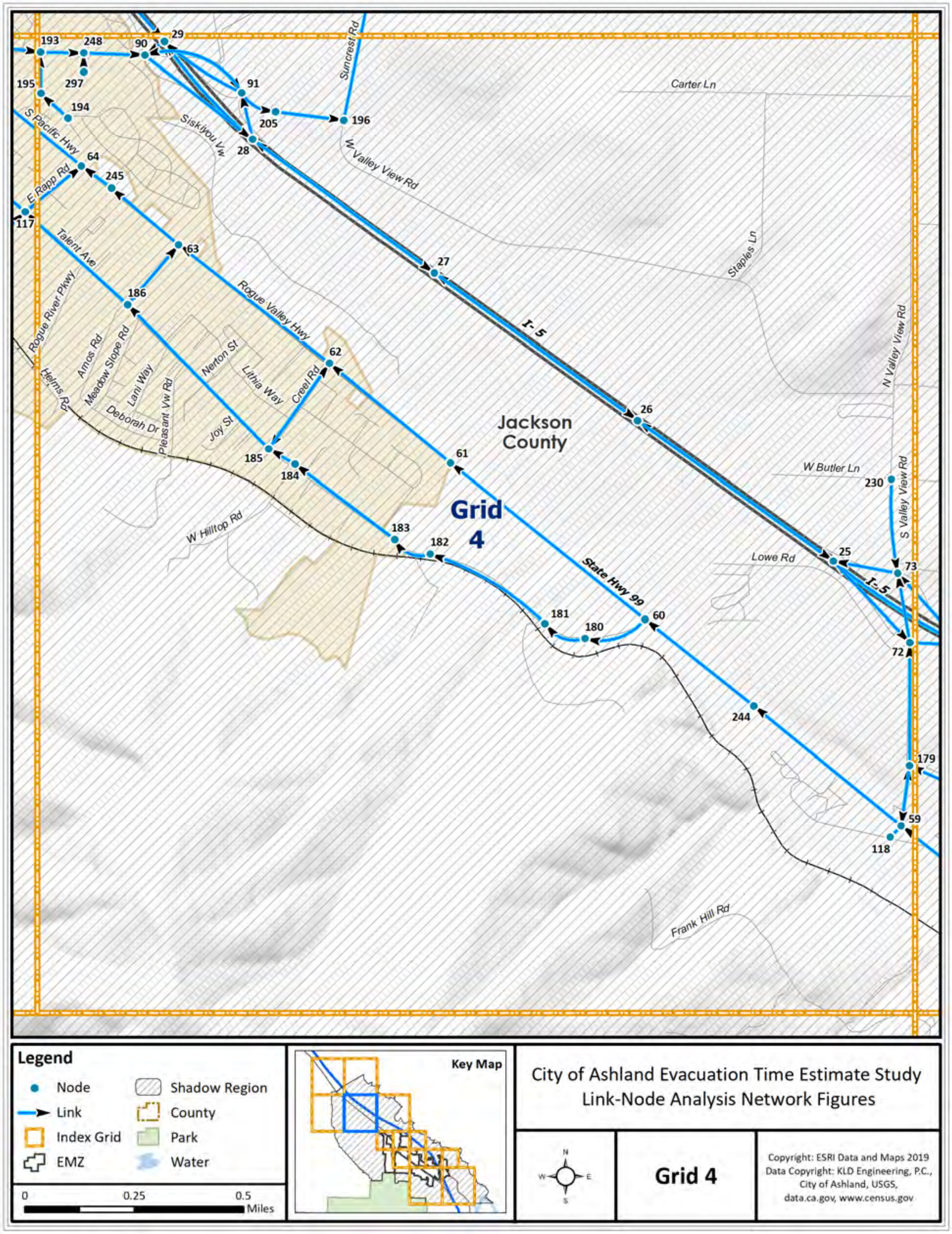


Figure H-5. Link-Node Analysis Network – Grid 4

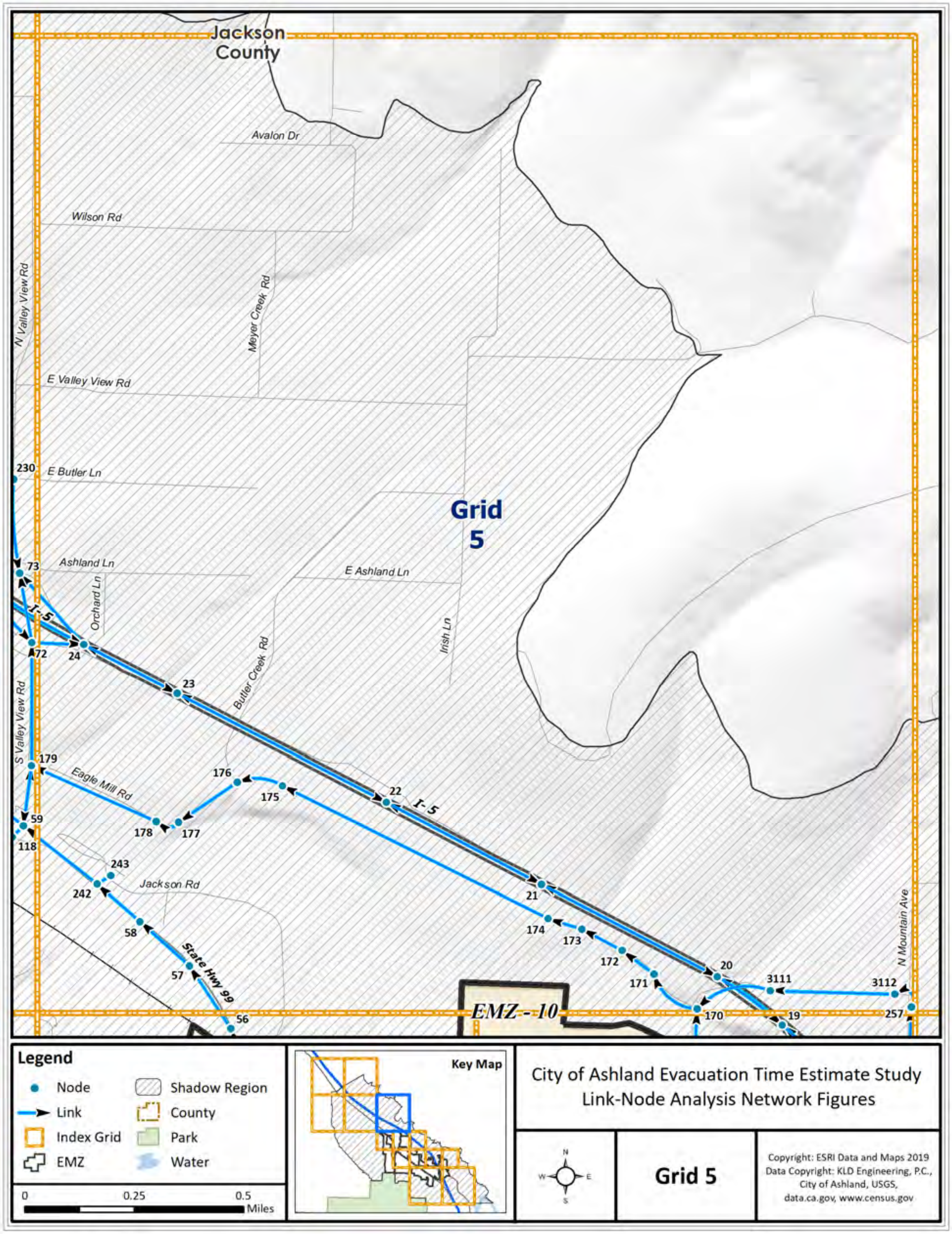


Figure H-6. Link-Node Analysis Network – Grid 5

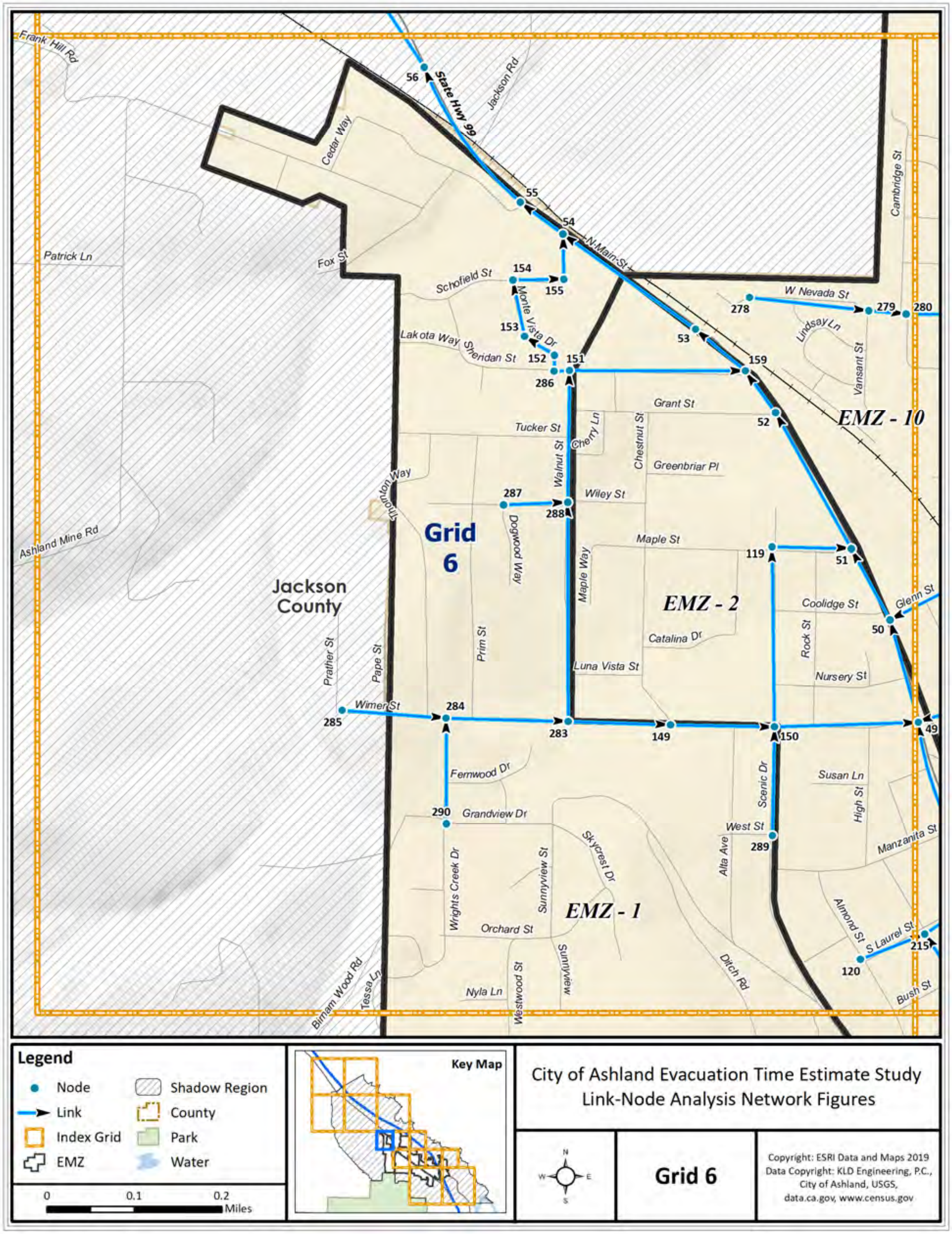


Figure H-7. Link-Node Analysis Network – Grid 6

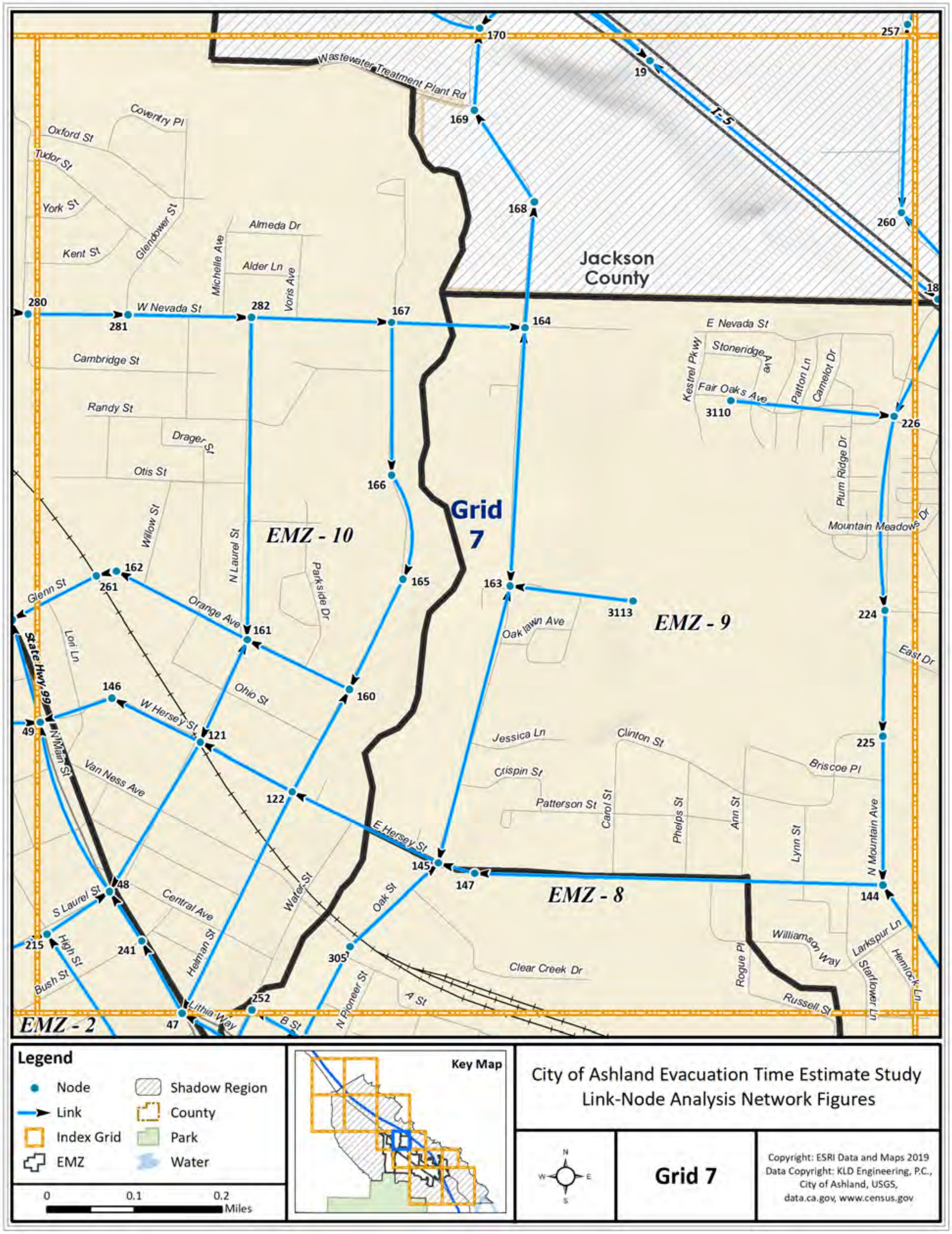


Figure H-8. Link-Node Analysis Network – Grid 7

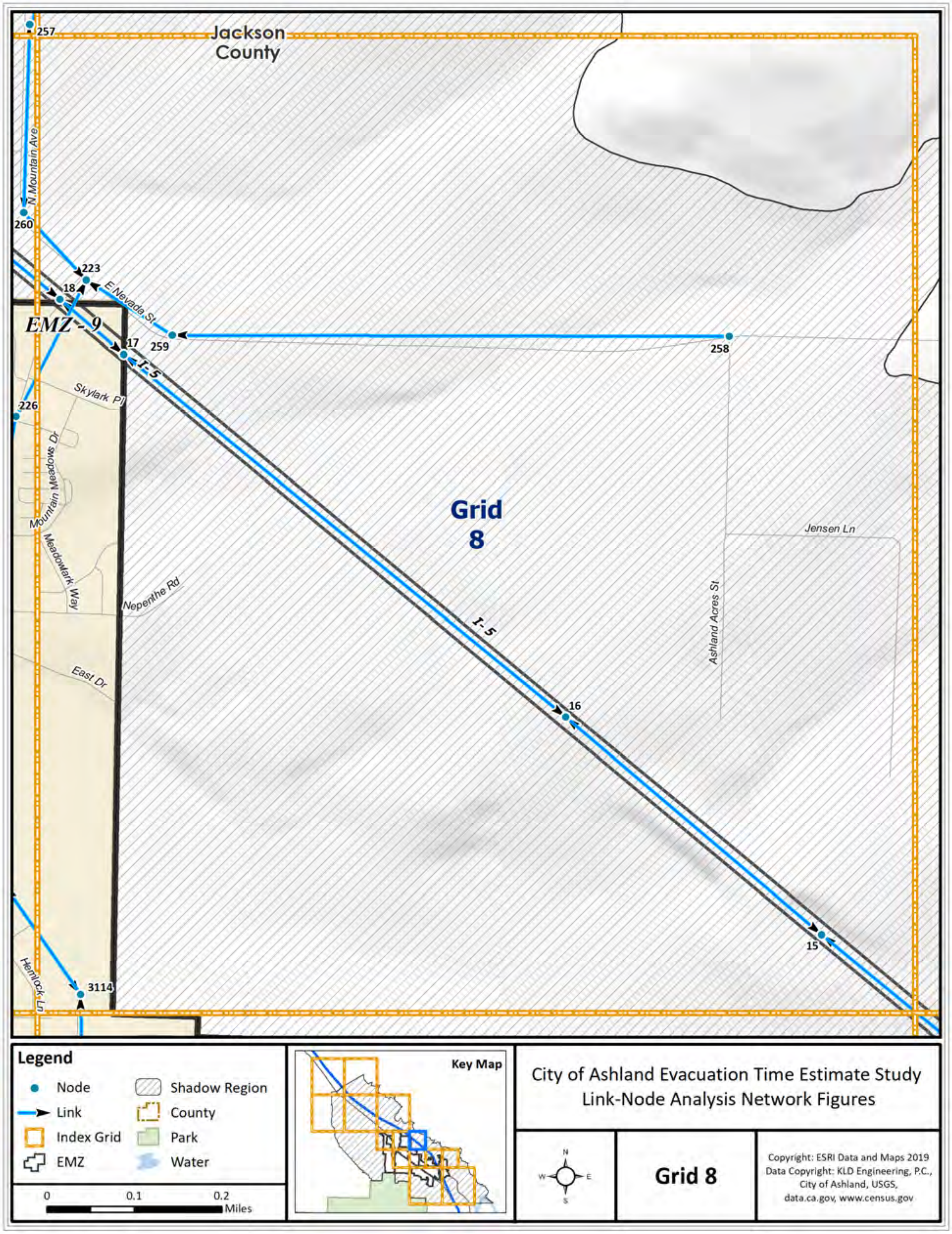


Figure H-9. Link-Node Analysis Network – Grid 8

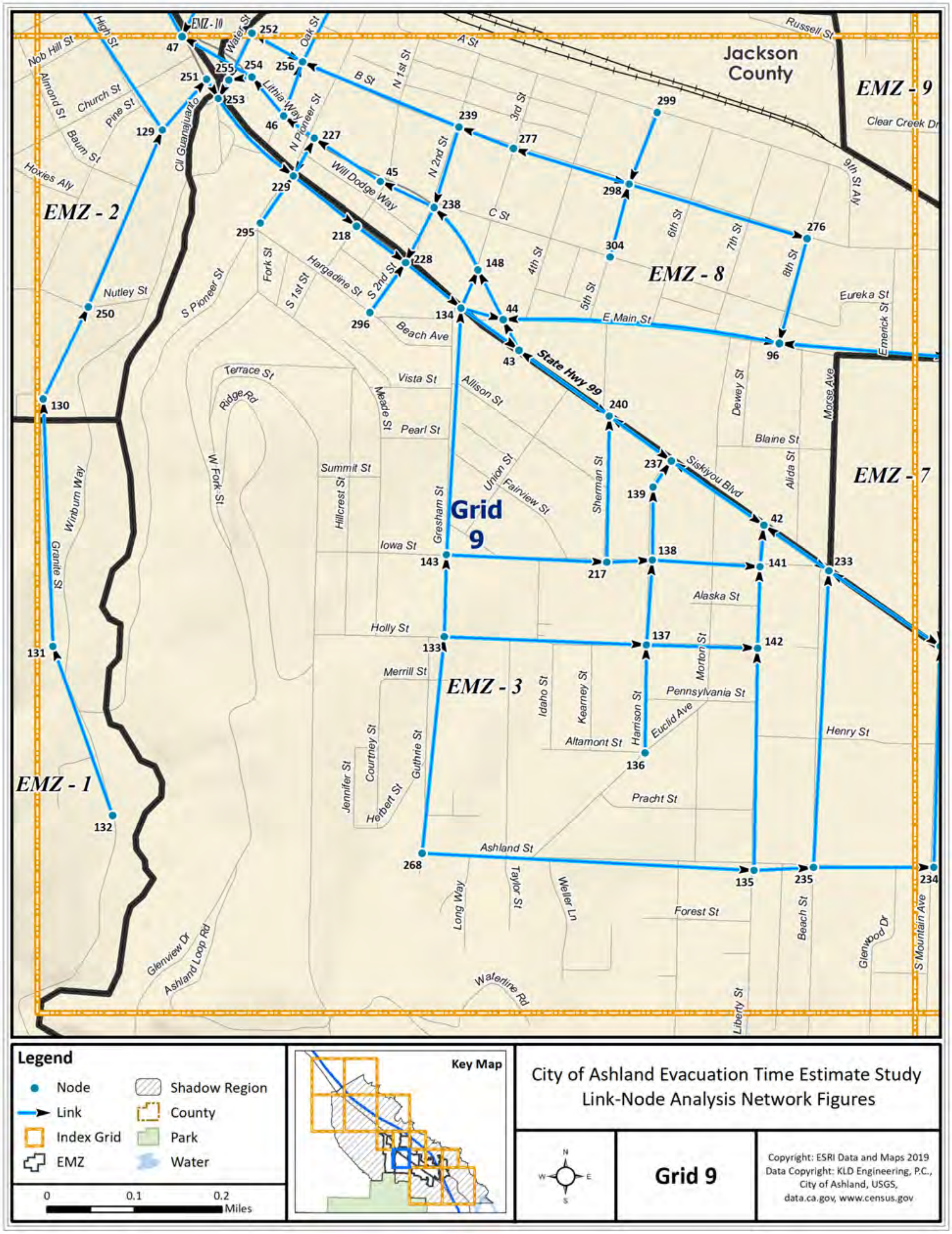


Figure H-10. Link-Node Analysis Network – Grid 9

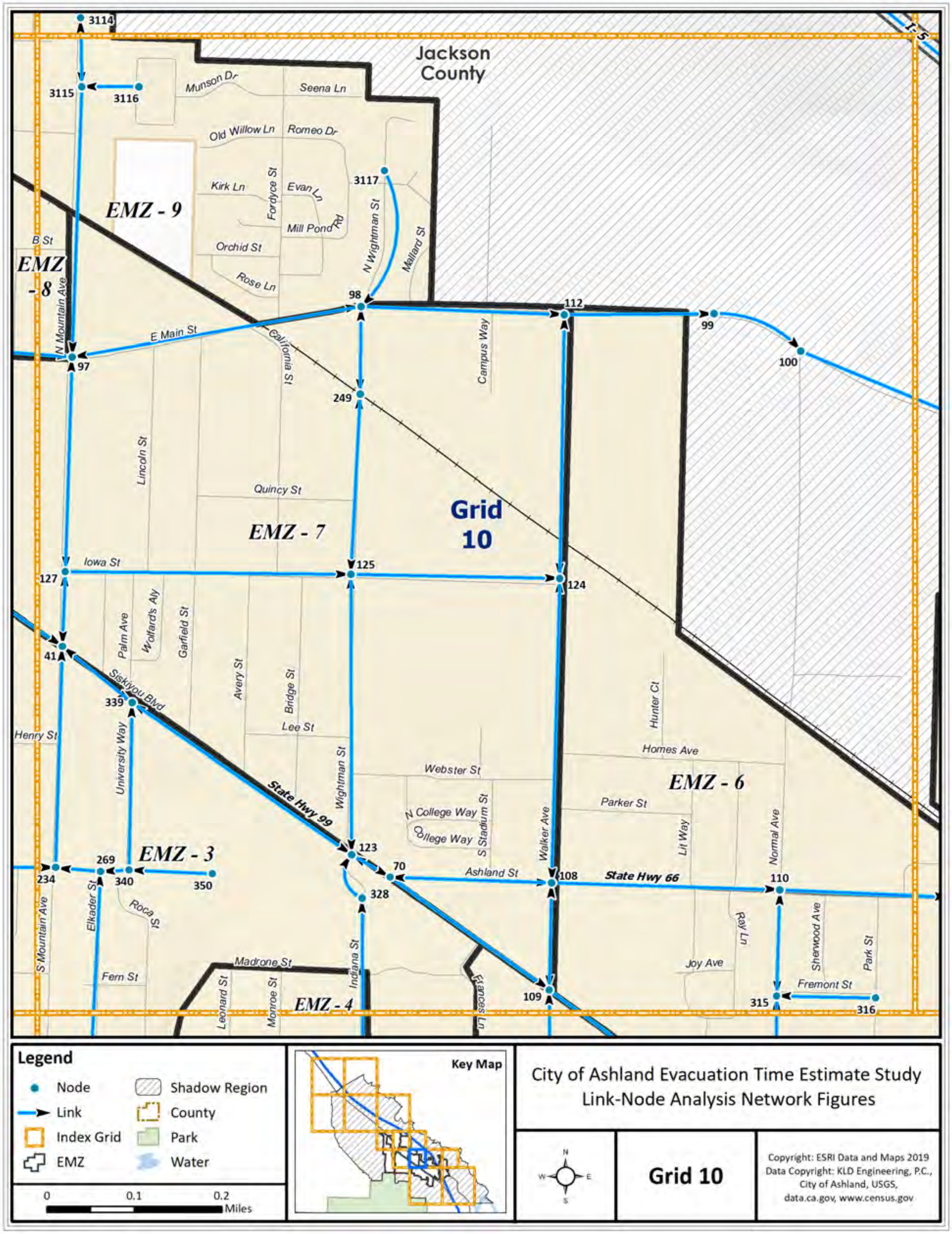


Figure H-11. Link-Node Analysis Network – Grid 10

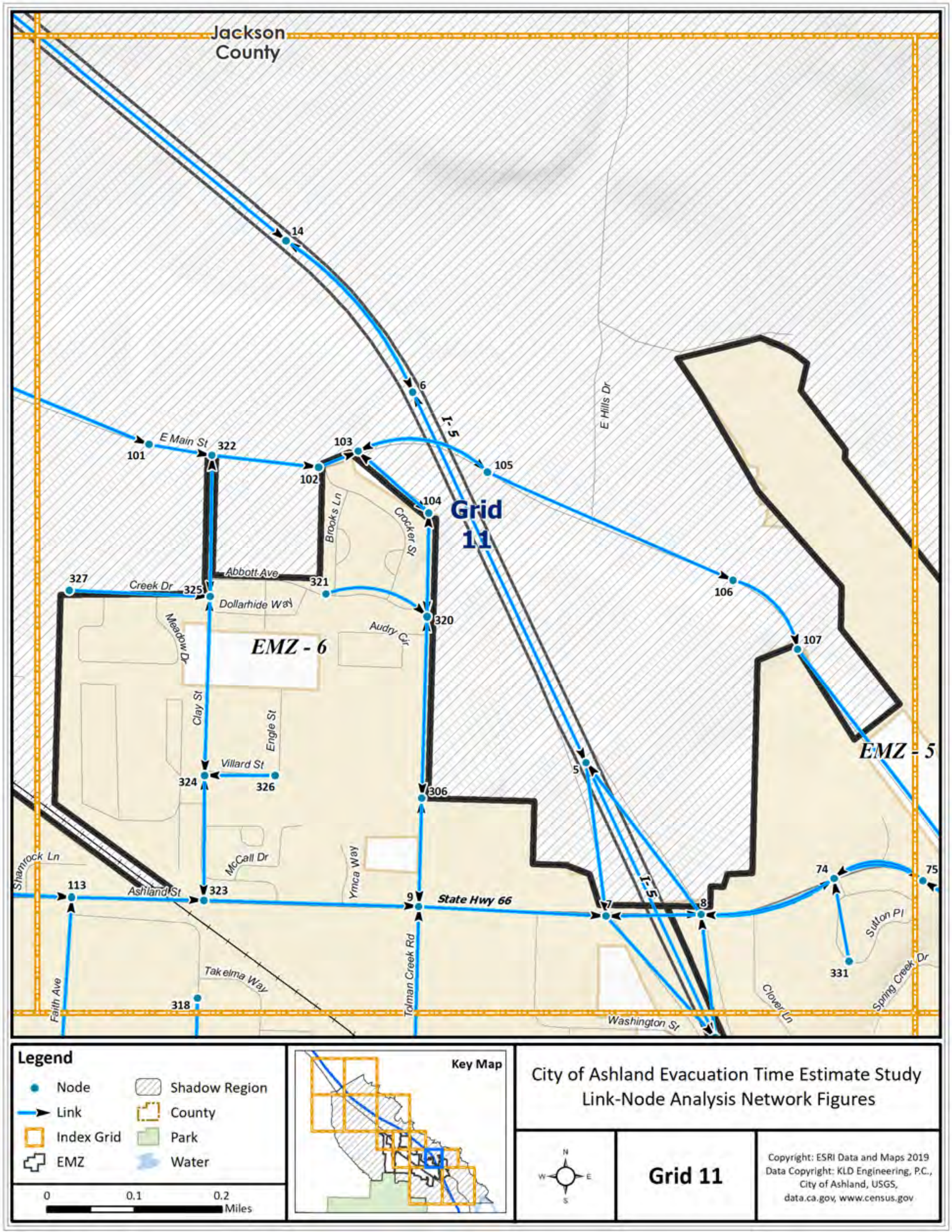


Figure H-12. Link-Node Analysis Network – Grid 11

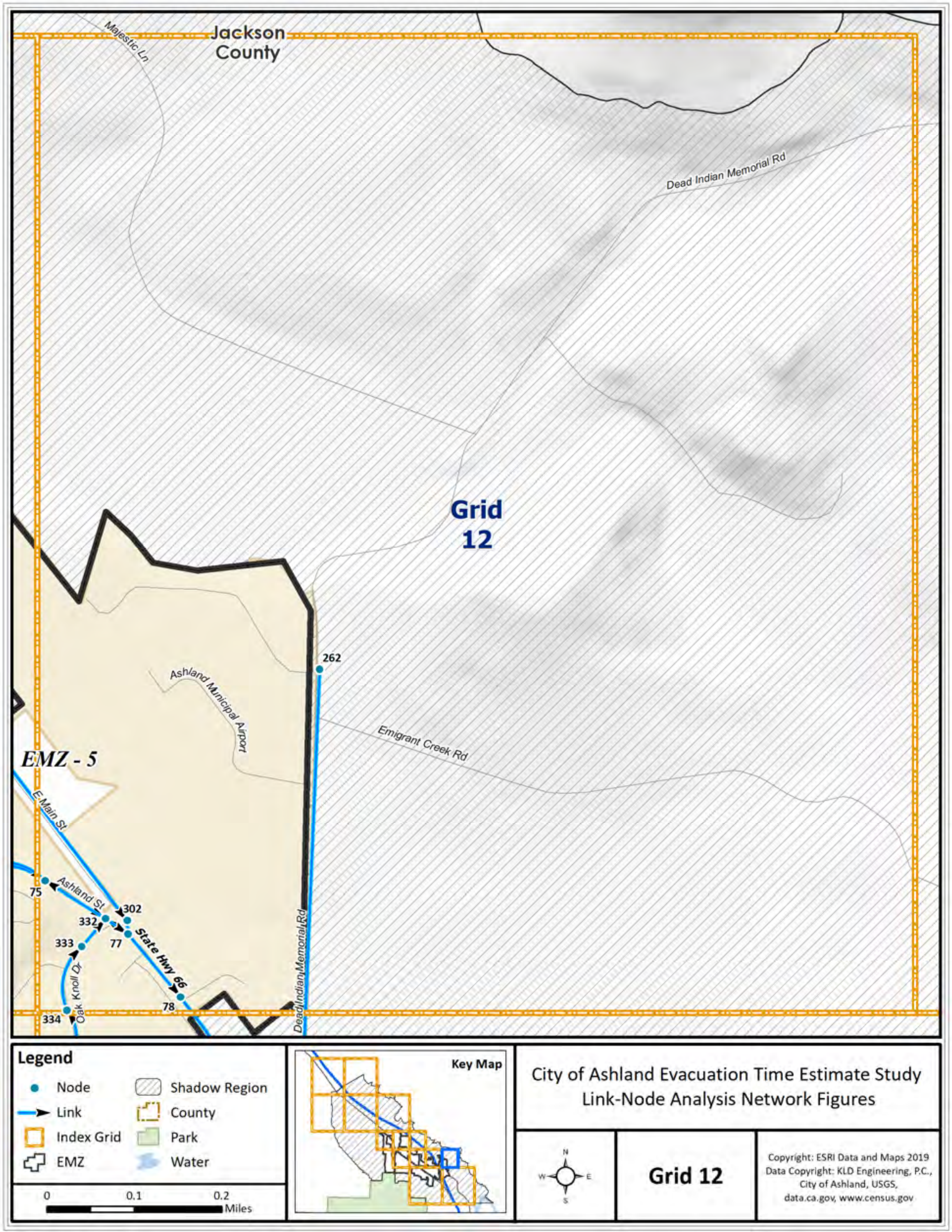


Figure H-13. Link-Node Analysis Network – Grid 12

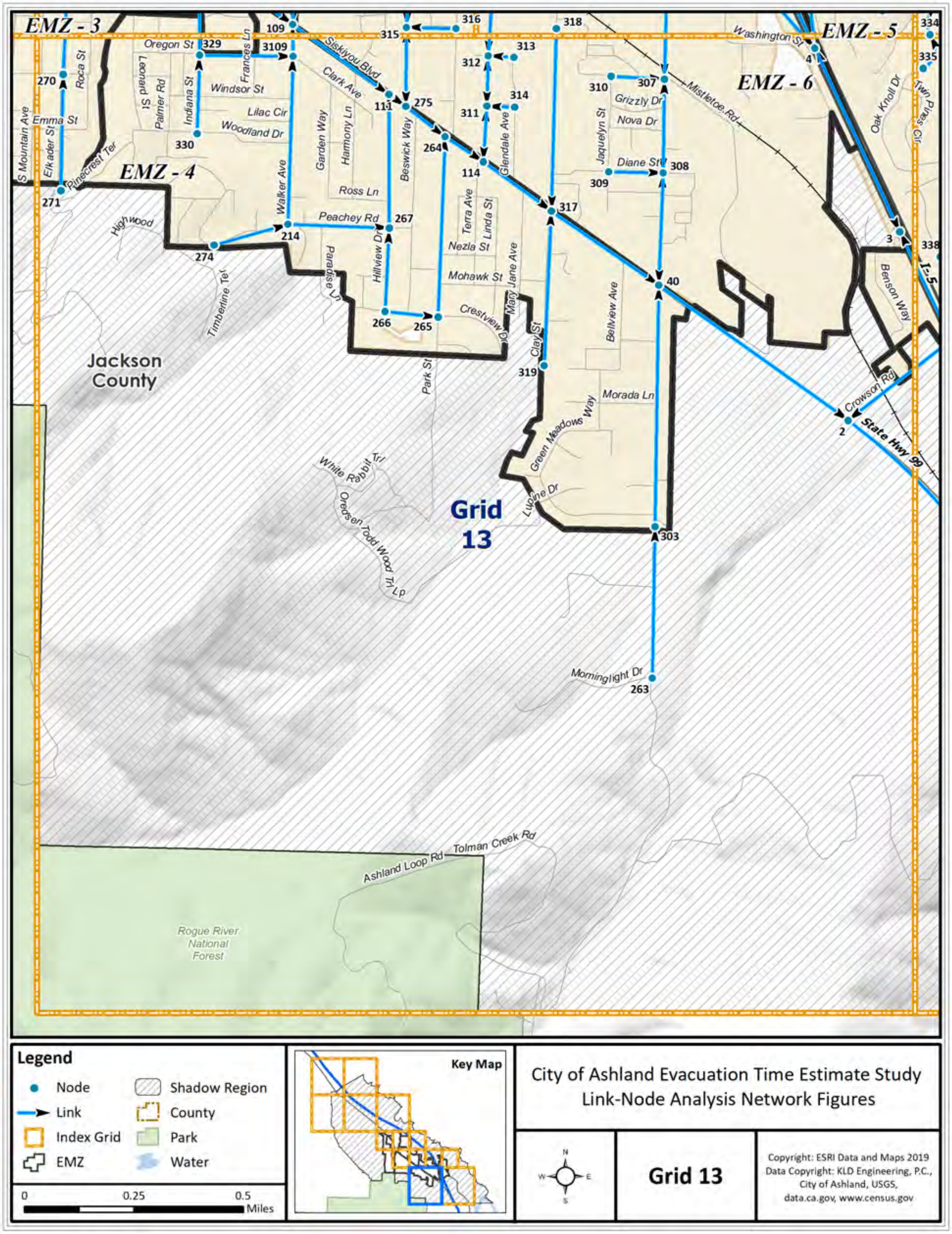


Figure H-14. Link-Node Analysis Network – Grid 13

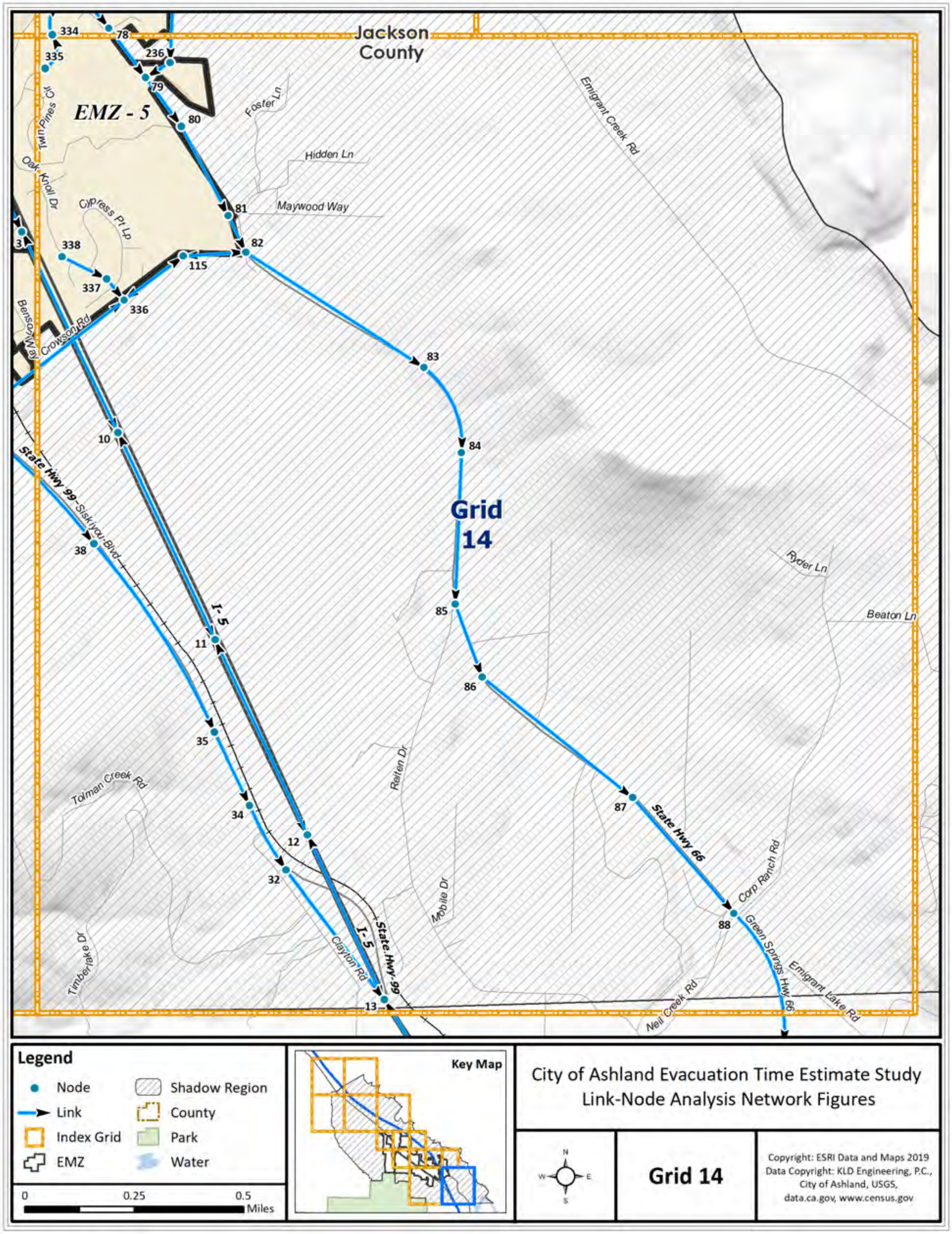


Figure H-15. Link-Node Analysis Network – Grid 14

APPENDIX J

Evacuation Sensitivity Studies

“What-if” Scenarios

J. EVACUATION SENSITIVITY STUDIES

This appendix presents the results of a series of sensitivity analyses, or "what-if" analyses. These analyses are designed to identify the sensitivity of the Evacuation Time Estimate (ETE) to changes in some base evacuation conditions.

J.1 Effect of Changes in Trip Generation Times

A sensitivity study was performed to determine whether changes in the estimated trip generation (mobilization) time influence the ETE for an evacuation of all EMZs (Region R18). Specifically, if the tail of the mobilization distribution were truncated (i.e., if those who responded most slowly to the evacuation order, could be persuaded to respond much more rapidly) or if the tail were elongated (i.e., spreading out the departure of evacuees to limit the demand during peak times), how would the ETE be affected? These "what if" scenarios were considered for a fall, midweek, midday scenario (Scenario 4). Results are tabulated in Table J-1. Trip Generation times of 3 hours, 4 hours (Base) and 5 hours were tested.

As seen shown in Table J-1, if evacuees mobilize in one less hour the 90th and 100th percentile ETEs is reduced by 5 minutes and 20 minutes, respectively. If evacuees were to mobilize in one hour more, the 90th percentile ETE remains the same while the 100th percentile ETE increases by one hour. As discussed in Section 7, congestion within the ETE exists within the EMZs for just over 3 hours and 30 minutes. As such, if the time to mobilize is less than 3 hours and 40 minutes, congestion dictates the 100th percentile ETE. If the time to mobilize is longer than 3 hours and 40 minutes, the 100th percentile is dictated by the trip generation time.

J.2 Effect of Changes in the Number of People in the Shadow Region Who Relocate

A sensitivity study was conducted to determine the effect on ETE due to changes in the percentage of people who decide to relocate from the Shadow, see Figure 7-1. The case considered was Scenario 4, Region R18; a fall, midweek, midday evacuation of the entire EMZ. The movement of people in the Shadow Region has the potential to impede vehicles evacuating from an Evacuation Region. Refer to Sections 3.2 and 7.1 for additional information on population within the Shadow Region. Shadow evacuation percentages of 0 and 100 were tested to bound the analysis.

Table J-2 presents the ETE for each of the cases considered. The results show that decreasing the shadow population to 0 percent reduces the 90th percentile ETE by 5 minutes while the 100th percentile ETE remains the same. A full evacuation (100%) of the Shadow Region increases the ETE by 10 minutes for the 90th percentile and 5 minutes for the 100th percentile – not a significant change.

The Shadow Region was defined as the area beyond the EMZ including the City of Talent to the north, Emigrant Lake to the south and the surrounding ridgelines. All of these areas are sparsely populated areas. Therefore, changes in the percentage of people that decide to voluntarily evacuate beyond the city limits will have little to no impact on an evacuation of the City of Ashland.

J.3 Effect of Reducing the Evacuation Demand – One Vehicle per Household

The relationship between supply and demand is very important in computing evacuation time. Evacuation travel supply is the ability of the roadway network to serve the traffic demand (number of evacuating vehicles) during an emergency. In this context, when the demand exceeds the supply (available capacity), congestion occurs causing delay and prolonging the evacuation. The roadway capacity is often difficult to increase as its expensive and difficult to widen existing infrastructure or build additional roadways. Thus, it is good practice to attempt reduce the evacuating traffic demand such that demand does not exceed capacity. The demographic survey of the EMZs indicated residents would use approximately 1.43 vehicles per household (HH) during an evacuation (see Appendix F). A sensitivity study was conducted to determine the effect on ETE when the evacuating vehicles per household was reduced to one (a 43% reduction in evacuating vehicles).

As seen in Table J-3, during the base case scenario, there are 13,666 residential vehicles evacuating from the EMZ (see Table 3-4). When the number of evacuation vehicles per household is reduced to one, the number of evacuating residential vehicles is reduced to 9,560. The case considered was Scenario 3, Region R18; a fall, midweek, midday scenario and an evacuation of all EMZs. When the evacuating traffic demand is reduced by approximately 40%, the 90th percentile ETE is reduced by 30 minutes – a significant change – and the 100th percentile ETE is not affected. The 100th percentile ETE is still dictated by congestion. Efforts should be made to inform the general population that reducing the number of vehicles each household uses during an evacuation can greatly reduce the amount of time needed to evacuate the area.

J.4 Effect of Direction of Wildfire Approach

Depending on the origin and prevailing winds, a wildfire can block one or more egress routes out of the EMZ. Alternatively, emergency officials could decide to reserve egress routes for first responders and emergency vehicles and only use I-5 northbound or southbound for evacuees. Two cases were run to simulate various roadway cases:

1. A scenario wherein a wildfire is to the south of the city and all traffic is forced northbound, and
2. A scenario wherein a wildfire is to the north of the city and all traffic is forced southbound.

These two cases were run for Scenario 4, Region R18; a fall, midweek, midday scenario for an evacuation of all EMZs. The results are shown in Table J-4.

J.4.1 A Wildfire to the North wherein Traffic is Forced Southbound

This case was run to represent a wildfire event that originates to the north-west of the Ashland City limits and evacuation to the north along I-5 and OR-99 are not feasible. As shown in Table J-4, when EMZ evacuees are unable to evacuate northbound due to the proximity of the approaching wildfire, the 90th percentile ETE and 100th percentile ETE increase by 3 hours and 10 minutes and 3 hours and 25 minutes, respectively.

Under these circumstances, vehicles are forced to reroute to I-5 southbound, OR-99 southbound (which eventually merges with I-5), and OR-66 southbound. These roadways, or ramps giving access to these roadways, are oversaturated. As a result, congestion within the EMZ worsens, delays increase, and ETE increases when compared to the base case.

J.4.2 A Wildfire to the South wherein Traffic is Forced Northbound

This case was run to represent a wildfire event that originates south of the City limits and evacuation to the south along I-5, OR-99 and OR-66 are not feasible. Table J-4 shows the 90th and 100th percentile ETE results when EMZ evacuees are unable to evacuate southbound due to the proximity of the approaching wildfire. The 90th percentile ETE increases by 2 hours and 25 minutes and the 100th percentile ETE increases by 2 hours and 35 minutes for this scenario.

Under these circumstances, vehicles are forced to reroute to OR-99 northbound and I-5 northbound. OR-99 is oversaturated and the ramps that give access to I-5 are oversaturated. As a result, congestion within the EMZ worsens, delays increase, and ETE increases when compared to the base case.

J.4.3 Patterns of Traffic Congestion due to Wildfire Approach

Figure J-1 through Figure J-8 show the patterns of congestion for the wildfire cases discussed above and the base case at each hour into the evacuation up to 7 hours and 25 minutes after the advisory to evacuate. Case 1 is the case wherein there is a wildfire to the north and traffic is forced to the south. Case 2 is the case wherein there is a wildfire to the south and traffic is forced to the north. Case 3 is the base case wherein traffic can choose to go north or south.

At 1 hour into the evacuation, as shown in Figure J-1, all cases show peak congestion in the EMZs. Congestion along OR-99, OR-66, and E Main St is severe in all cases. When compared to Case 3, Downtown Ashland (EMZs 2, 8, and 10) are less congested because those vehicles are now forced south and cause the south of the EMZ (EMZs 3, 7, 4, and 6) to be more congested for Case 1.

When comparing the Case 3 to Case 2, congestion patterns within the EMZ are similar, except for worse congestion in EMZ 8 and 9 as vehicles reroute along N Mountain Rd to gain access to Oak St to evacuate the area northbound. Congestion along Crowson Rd and OR-99 southbound and OR-66 southbound is less in the southern wildfire case as vehicles are not permitted to evacuate in that direction.

Figure J-2 compares the patterns of congestion at 2 hours into the evacuation for all wildfire cases. When comparing Case 1 to Case 2, congestion in EMZs 2, 8, 9, and 10 is less, but congestion in EMZs 3, 4, 5, 6, and 7 is worse. The vehicles from the northern EMZs are getting stuck in the central and southern EMZs as OR-99, OR-66, and the I-5 on ramps process all of the vehicles that are attempting to use them to evacuate.

Alternatively, comparing Case 2 to Case 3, congestion patterns are similar, but congestion in EMZs 8 and 9 are worse due to traffic along N Mountain Rd, and congestion in EMZ 5 is better since vehicles cannot evacuate in that direction.

Figure J-3 compares congestion patterns at 3 hours after the advisory to evacuate. In this figure, the impacts of the loss of the northbound evacuation routes in Case 1 and the southbound evacuation routes in Case 2 become obvious. In Cases 1 and 2, OR-99 remains more congested - the direction of congestion is dependent on the wildfire case – than in Case 3. EMZ 3 is more congested in Cases 1 and 2 than Case 3. When comparing Case 1 to Case 3, EMZs 1, 2, 9, and 10 are mostly clear of congestion. All other EMZs, however are more congested in Case 1 than Case 3. Looking at Case 2, congestion within the EMZ is mostly equally dispersed as vehicles attempt to access the only I-5 ramp within the EMZ (along Ashland St/OR-66) and OR-99 northbound.

Figure J-4 shows the pattens of congestion at 4 hours after the advisory to evacuate for all wildfire cases. At this time, Case 3 is completely clear of congestion. Cases 1 and 2 continue to show severe congestion within the EMZ. OR-99 and OR-66/Ashland St to access the I-5 on ramp remain at LOS F. Congestion for Case 1 is consolidated to central and southern Ashland, while congestion for Case 2 is dispersed across nearly all EMZs.

When comparing the patterns of congestion at 5 hours into the evacuation for all closure cases, shown in Figure J-5, congestion only occurs on OR-99 and local roadways that intersect OR-99 for Case 1. For Case 2, severe congestion remains on the majority of OR-99 northbound and OR-66 east and westbound. Oak St continues to exhibit congested conditions as well, as vehicles attempt to find alternative routes to evacuate the area.

At 6 hours into the evacuation, as shown in Figure J-6, congestion has dissipated in both Case 1 and Case 2, but still remains along OR-99 in Case 1 and in EMZ 6 in Case 2.

Figure J-7 shows the patterns of congestion at 7 hours after the advisory to evacuate. All congestion in Case 2 has cleared at this time as all evacuees cleared the area at 6 hours and 35 minutes after the advisory to evacuate (see Table J-4). Congestion remains along OR-99 southbound in Case 1.

Figure J-8 shows the last remnants of congestion in Case 1 along OR-99 southbound and Crowson Rd at 7 hours and 20 minutes after the advisory to evacuate. All congestion clears (and all vehicles successfully evacuate the area) 5 minutes later for this case.

J.5 Additional "What-if" Scenarios

Local officials from the City of Ashland requested additional "what-if" scenarios looking into the potential impacts to evacuation of the addition of the bridge over Bear Creek connecting E Nevada St, additional access to I-5 via Freeway ramps on N Mountain Ave and if a combination of both roadway improvements. Figure J-9 shows the location of the bridge and on ramps.

Table J-5 represents the 90th and 100th percentile ETEs for all three aforementioned cases. The addition of the E Nevada St bridge over Bear Creek decreases the 90th percentile ETE by 10 minutes. Adding on ramps to I-5 near N Mountain Ave also decreases the 90th percentile ETE by 10 minutes. Adding both the bridge and the I-5 on ramps reduced the 90th percentile ETE by 15 minutes. The 100th percentile ETE remained unchanged for all cases since it is dictated by the time needed to mobilize, and in all cases, the trip generation time is 4 hours.

Local officials from the City of Ashland requested also requested an analysis on the impact on the evacuation with an expansion of OR-99 northbound and S Valley View Rd. An additional lane was added on OR-99 from the intersection of Helman St to the intersection of Jackson Rd (where the roadway widens to two lanes in each direction). An additional lane was added on S Valley View Rd between OR-99 and the I-5 ramps. An additional sensitivity study where in both roadways were expanded was also conducted.

Table J-5 represents the 90th and 100th percentile ETEs for these cases as well. The addition of a travel lane on OR-99 northbound decreases the 90th percentile ETE by 20 minutes. The addition of a travel lane on S Valley View Rd has no impact on ETE. The addition of a travel lane on both roadways decreases the 90th percentile by 25 minutes. The 100th percentile ETE remained unchanged for all cases since it is dictated by the time needed to mobilize, and in all cases, the trip generation time is 4 hours.

Lastly, a case was considered wherein all of the above (bridge on E Nevada St, additional ramps at N Mountain Rd, and additional lanes on OR-99 and S Valley View Rd) was implemented. The 90th percentile ETE decreased by 25 minutes. The 100th percentile ETE remains unchanged (since it is dictated by trip generation time).

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

Trip Generation Time	Evacuation Time Estimates for All EMZs	
	90th Percentile	100th Percentile
3 Hours	3:05	3:40
4 Hours (Base)	3:10	4:00
5 Hours	3:10	5:00

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

Percent Shadow Evacuation	Evacuating Shadow[1]	Evacuation Time Estimate for All EMZs	
		90th Percentile	100th Percentile
0	0	3:05	4:00
6 (Base)	451	3:10	4:00
100	6,490	3:20	4:10

---

[1] The Evacuating Shadow Vehicles, in Table J-2, represent the residents who will spontaneously decide to relocate during the evacuation. The basis, for the base values shown, is a 6% relocation of shadow residents. See Section 6 for further discussion.

Table J-3. Evacuation Time Estimates for Reduction in Demand

Case	Evacuating Resident Vehicles	Evacuation Time Estimates for All EMZs	
		90th Percentile	100th Percentile
One Vehicle per HH	9,560	2:40	4:00
Base Case (1.43 Evacuating Vehicles per HH)	13,666	3:10	4:00

Table J-4. Evacuation Time Estimates for Direction of Wildfire Approach

Case	Evacuation Time Estimates for All EMZs	
	90th Percentile ETE	100th Percentile
Base Case	3:10	4:00
Wildfire to the North (Northbound Roadways Closed – Traffic forced Southbound)	6:20	7:25
Wildfire to the South (Southbound Roadways Closed – Traffic forced Northbound)	5:35	6:35

Table J-5. Evacuation Time Estimates for Additional "What-if" Scenarios

Case	Evacuation Time Estimates for All EMZs	
	90th Percentile ETE	100th Percentile
Base Case	3:10	4:00
E Nevada St over Bear Creek	3:00	4:00
I-5 Ramps near Nevada St	3:00	4:00
E Nevada St over Bear Creek and I-5 Ramps	2:55	4:00
Additional Lane on OR-99 Northbound	2:50	4:00
Additional Lane on S Valley View Rd	3:10	4:00
Additional Lanes on OR-99 NB and S Valley View Rd	2:45	4:00
All of the above	2:45	4:00

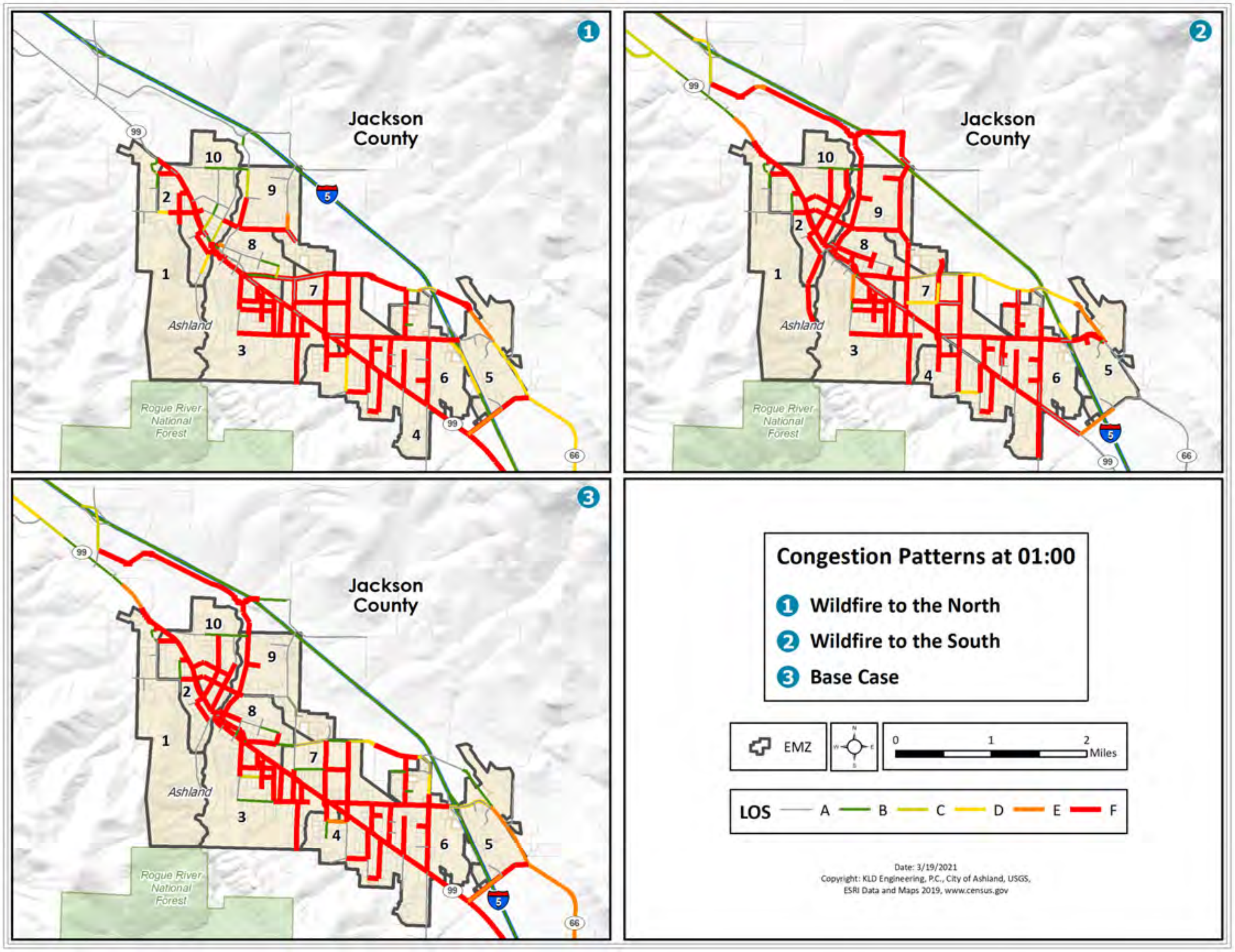
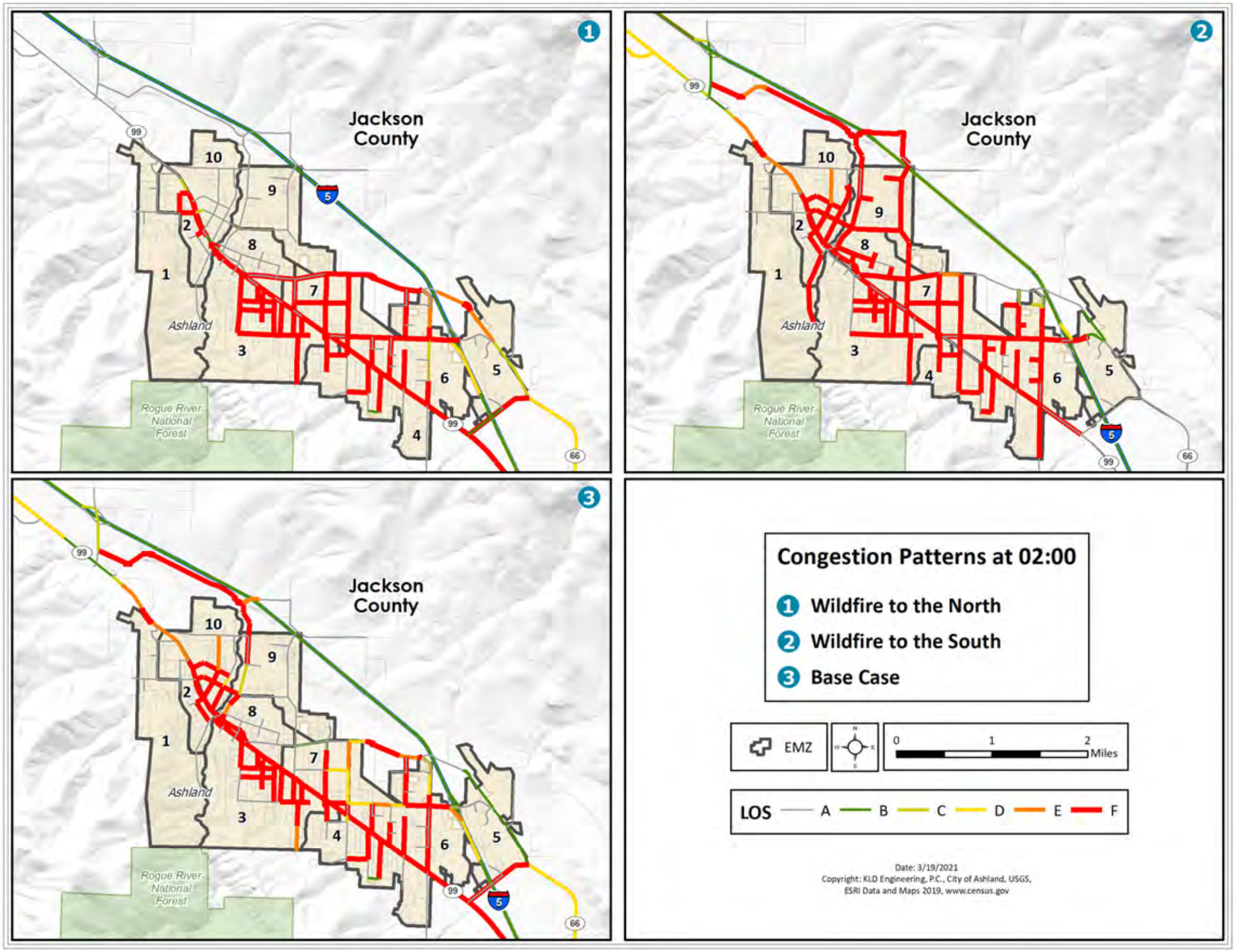
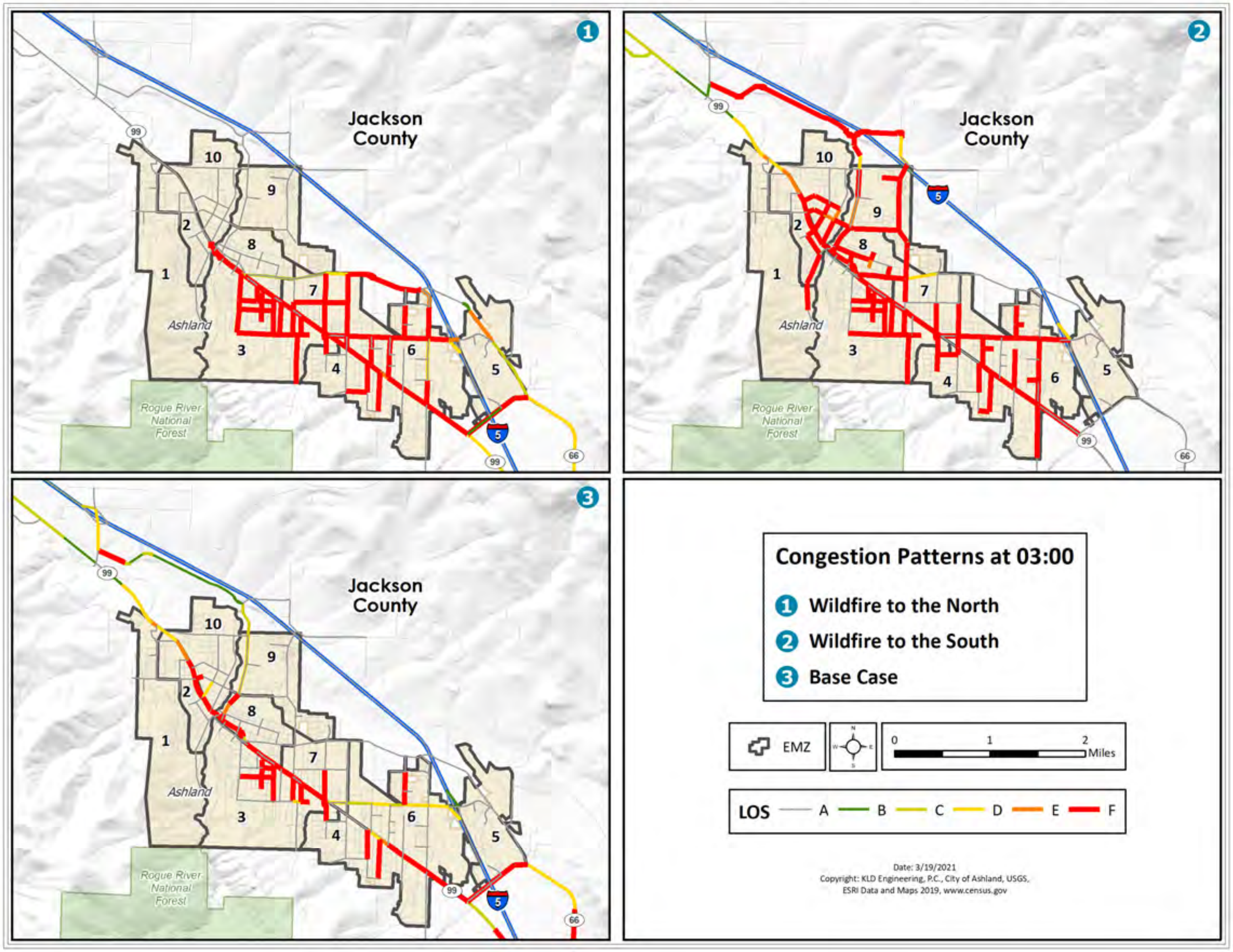


Figure J-1. Wildfire Approach Congestion Pattern Comparison at 1 Hour after the Advisory to Evacuate



Date: 3/19/2021
Copyright: KLD Engineering, P.C., City of Ashland, USGS, ESRI Data and Maps 2019, www.census.gov

Figure J-2. Wildfire Approach Congestion Pattern Comparison at 2 Hours after the Advisory to Evacuate



Date: 3/19/2021
Copyright: KLD Engineering, P.C., City of Ashland, USGS, ESRI Data and Maps 2019, www.census.gov

Figure J-3. Wildfire Approach Congestion Pattern Comparison at 3 Hours after the Advisory to Evacuate

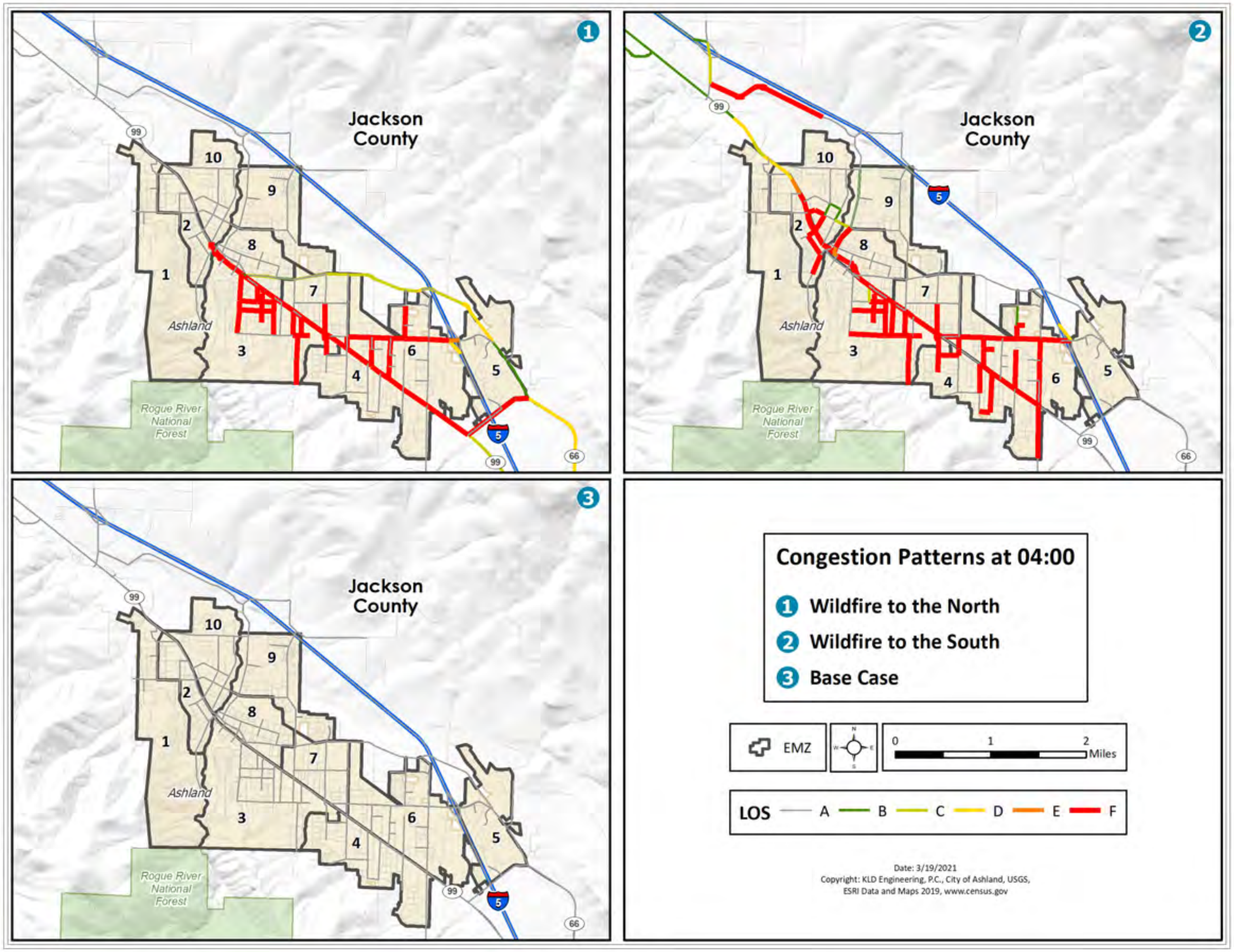
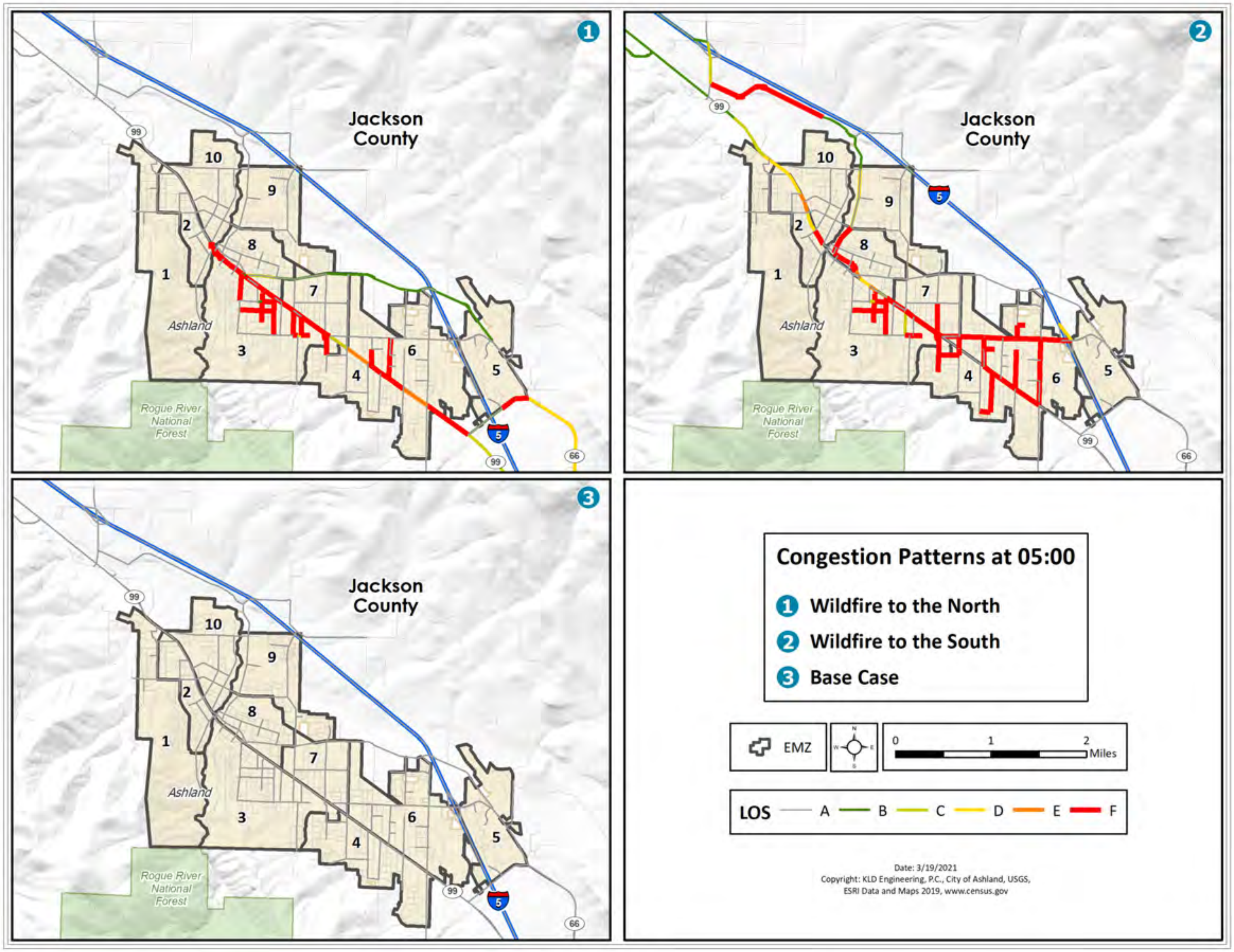


Figure J-4. Wildfire Approach Congestion Pattern Comparison at 4 Hours after the Advisory to Evacuate



Date: 3/19/2021
Copyright: KLD Engineering, P.C., City of Ashland, USGS, ESRI Data and Maps 2019, www.census.gov

Figure J-5. Wildfire Approach Congestion Pattern Comparison at 5 Hours after the Advisory to Evacuate

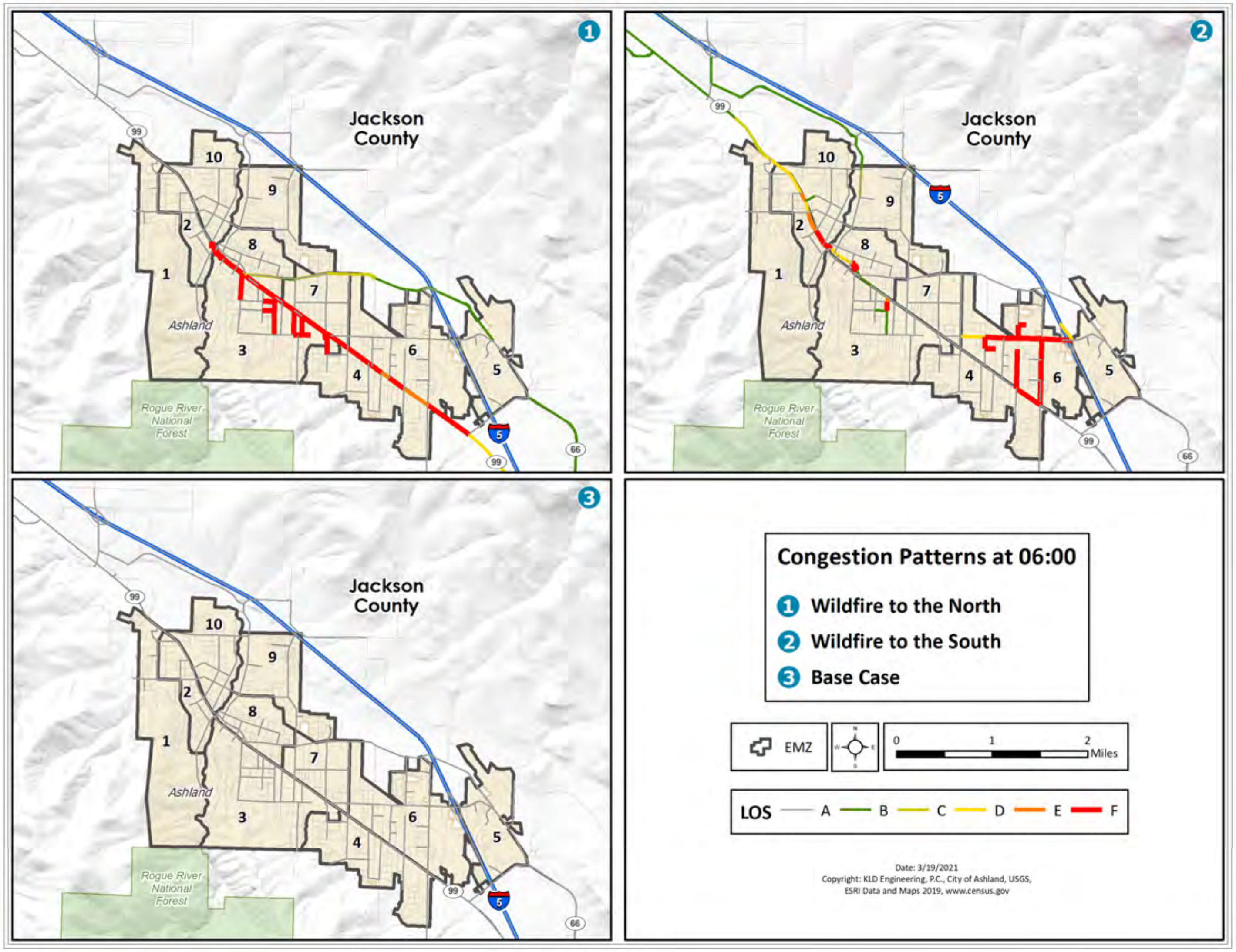
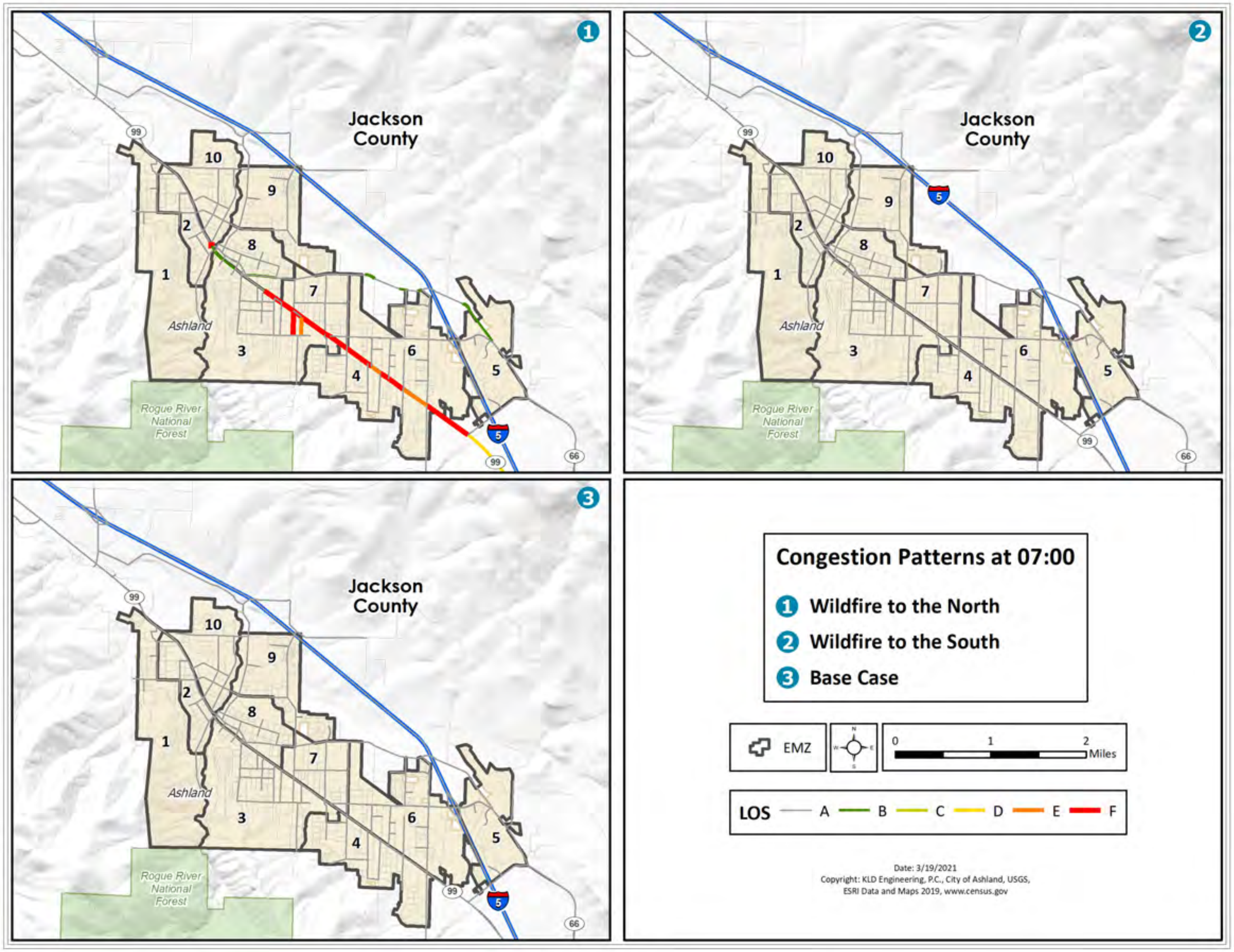
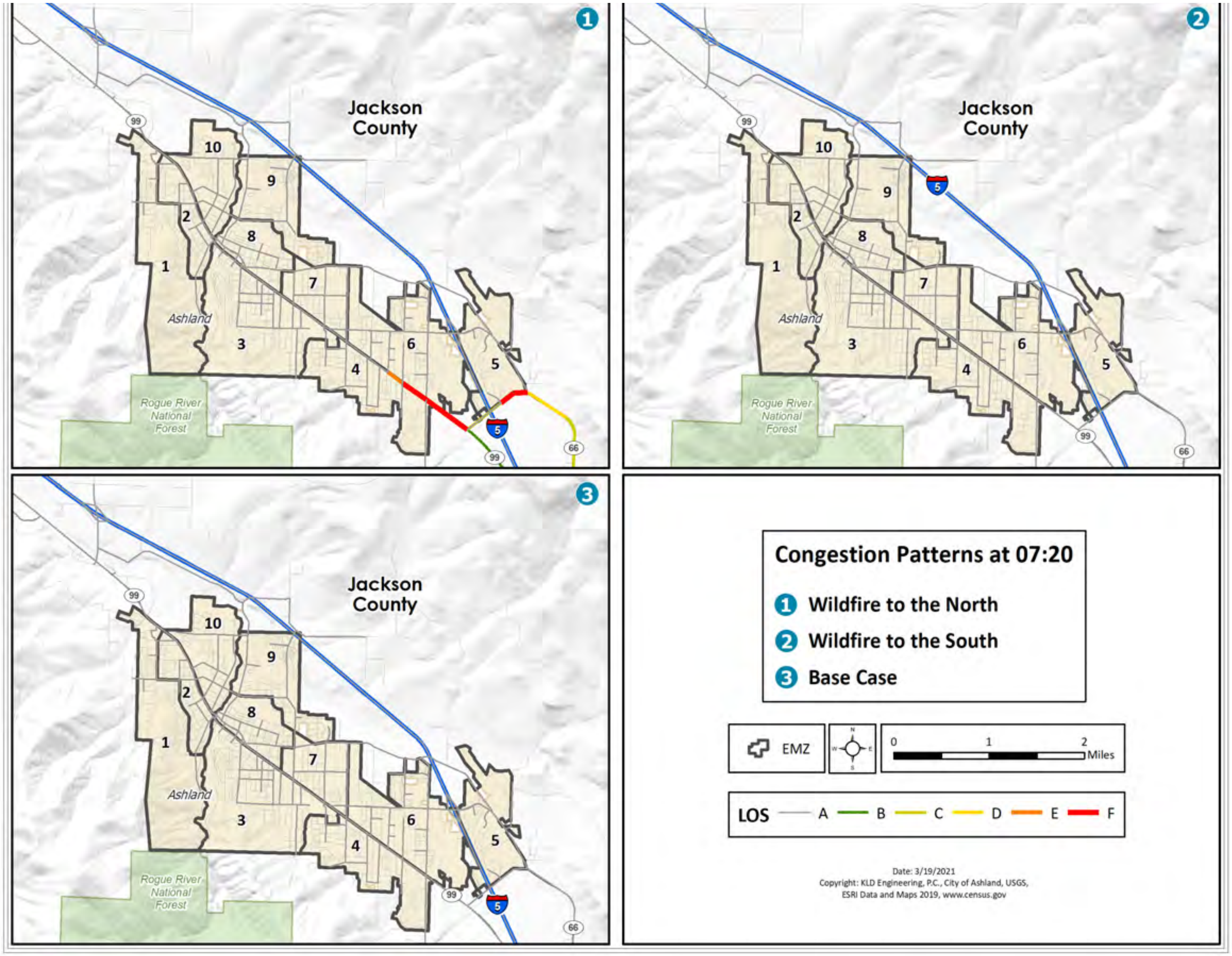


Figure J-6. Wildfire Approach Congestion Pattern Comparison at 6 Hours after the Advisory to Evacuate



Date: 3/19/2021
Copyright: KLD Engineering, P.C., City of Ashland, USGS, ESRI Data and Maps 2019, www.census.gov

Figure J-7. Wildfire Approach Congestion Pattern Comparison at 7 Hours after the Advisory to Evacuate



Date: 3/19/2021
Copyright: KLD Engineering, P.C., City of Ashland, USGS, ESRI Data and Maps 2019, www.census.gov

Figure J-8. Wildfire Approach Congestion Pattern Comparison at 7 Hours and 20 Minutes after the Advisory to Evacuate

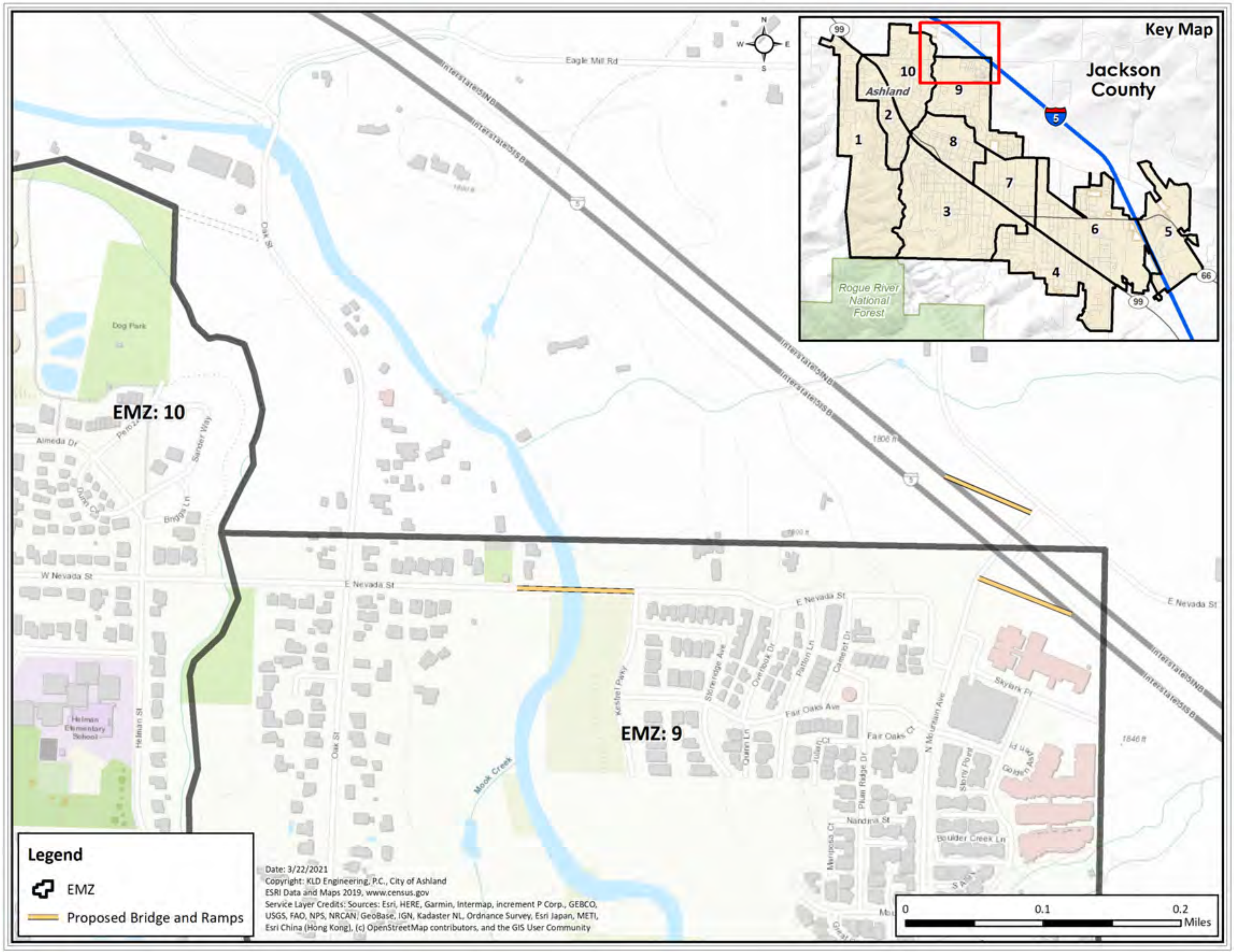

Date: 3/22/2021
Copyright: KLD Engineering, P.C., City of Ashland
ESRI Data and Maps 2019, www.census.gov
Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Figure J-9. E Nevada St Bridge and I-5 On Ramps