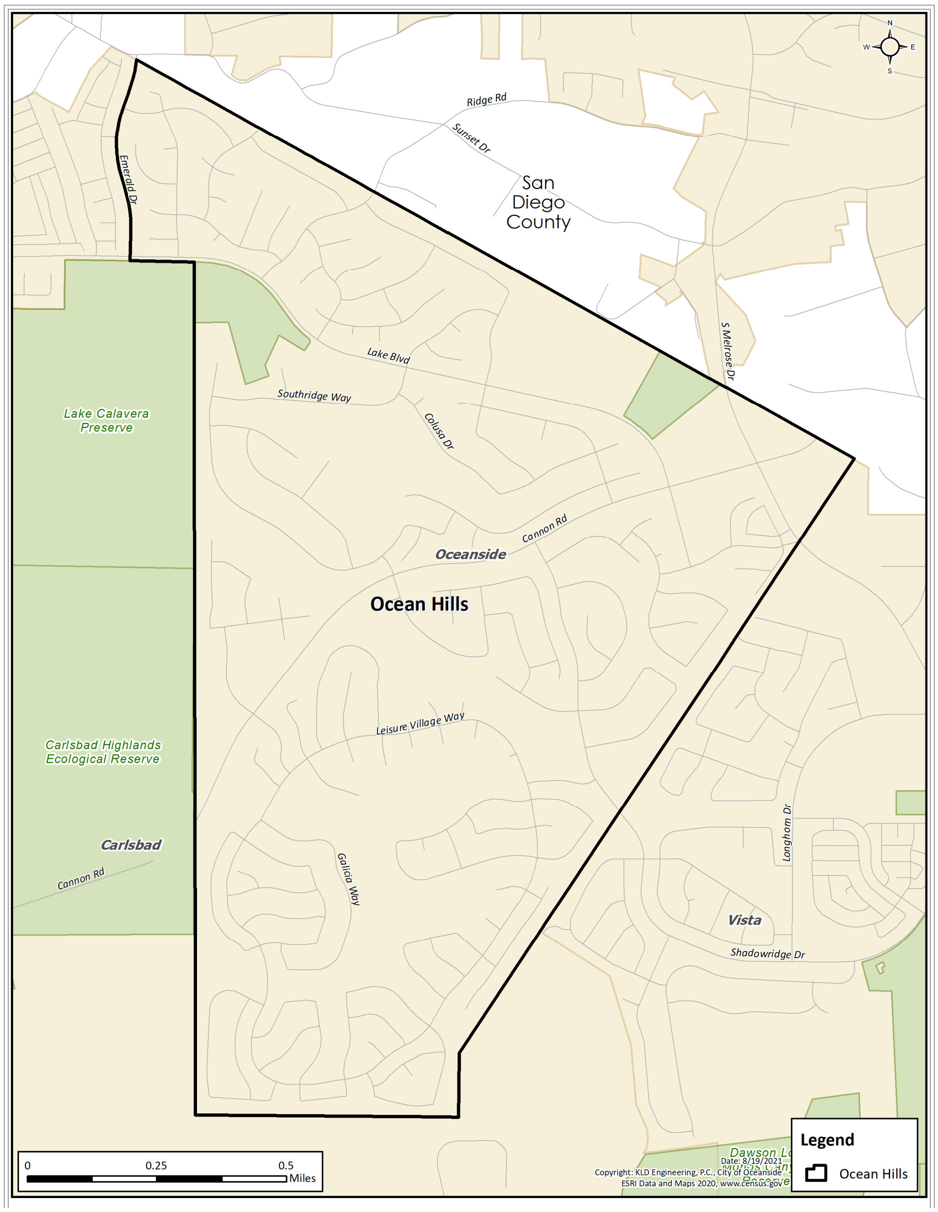
Neighborhood of Ocean Hills

Wildfire Evacuation Study



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EXECUTIVE SUMMARY

Wildfires, and the impacts thereof, are a critical issue facing the world. One of the most critical concerns during a wildfire is the availability of transportation services. Under normal circumstances, the transportation system provides capacity for evacuation 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 traffic congestion. Due to the proximity of Ocean Hills to natural and undeveloped lands and the recent occurrence of wildfires, Ocean Hills residents are concerned with the vulnerability of the neighbourhood. This study identifies congestion patterns, provides Evacuation Time Estimates (ETE) for three different combinations of circumstances, including time of day, day of week, season, and weather/roadway conditions and analyzes "what-if" scenarios for a potential evacuation of Ocean Hills. The objective of this study is to estimate evacuation times and test different tactics for reducing evacuation time so as to build a robust emergency plan to protect public health and safety in Ocean Hills in the event of a wildfire emergency.

The Neighborhood of Ocean Hills is one of the 16 neighborhoods that comprise the City of Oceanside which is located in northern San Diego County along the Pacific Ocean. There are approximately 7,700 permanent residents in Ocean Hills according to the 2020 Census. Ocean Hills is located in the south-eastern portion of the city near Calavera Park and natural lands. Ocean Hills is divided into 14 communities/homeowners' associations (HOAs) with distinct demographic characteristics. Figure 2-1 is a map of the various communities/HOAs that comprise Ocean Hills.

Ocean Hills has five primary ingress/egress routes. The key finding of this study is that the available roadway supply (evacuation routes and roadway network) is more than sufficient to service the evacuation demand (number of evacuating vehicles) within the neighborhood in a timely fashion. Traffic congestion within Ocean Hills clears prior to one hour and 30 minutes after the Advisory to Evacuate (ATE); see Section 5.2 for further discussion. Figure 5-5 also illustrates that traffic congestion within Ocean Hills is non-existent beyond one hour and 30 minutes after the ATE as the Trip Generation /Mobilization Time (time it takes evacuees to prepare for evacuation prior to getting in their vehicles and accessing evacuation route) and ETE curves are coincident beyond one hour and 30 minutes.

The roadway system surrounding Ocean Hills is robust. Cannon Rd is an excellent, high-capacity roadway with two outbound lanes. The roadways servicing Ocean Hills provide access to six different interchanges (Vista Way/Plaza Dr, S Emerald Dr, Vista Village Dr, Civic Center Dr, Mar Vista Dr, and Sycamore Ave) with CA-78, which is a high-capacity, high-speed, limited access freeway. The only prolonged traffic congestion within the area is at the Ocean Hills Country Club (OHCC), which is somewhat capacity constrained given the number of people living in the community and only two connections (Leisure Village Dr and Ocean Hills Dr) to the surrounding roadway system. Seagate Terrace, which only has one egress route (Mystra Dr) which is shared with Ocean Hills Senior Living and with New Venture Church, is congested for the first hour of the evacuation. Overall, there are few issues with evacuating Ocean Hills as the roadway system has ample capacity to service the vehicular demand. Evacuation times closely parallel mobilization times, and evacuation travel time is minimal.

Although evacuation of Ocean Hills alone is orderly given the roadway system and connections to CA-78, a larger scale evacuation for a rapidly spreading fire could increase evacuation time by up to 40 minutes as discussed in Appendix B, sub-section B.7.

Critical Findings

- An online demographic survey was conducted of the people living and working in Ocean Hills; 656 households responded to the survey. The survey gathered demographic information (average household size, vehicle ownership, etc.), behavioral responses (would evacuees listen to advisories issued by local officials, and time to complete mobilization activities. The responses to the survey indicated it would take at most 4 hours and 15 minutes to mobilize all the population in Ocean Hills. See Section 4 and Appendix A.
- The 100th percentile ETE are dictated by the time needed to mobilize rather than by traffic congestion, See Section 5 and Table 5-3.
- Reducing the mobilization time to one hour and 15 minutes creates congestion within the neighborhood such that ETE are dictated by traffic congestion rather than mobilization time. See Appendix B, sub-section B.1.
- "Shadow evacuation" is defined as people voluntarily evacuating from areas that are not at risk who have not been advised to evacuate. Shadow evacuees consume space on the same roadways used by people evacuating from the area at risk. This can cause delays and prolong evacuation times for the population at risk. This study considered a Shadow Evacuation Region extending form the boundaries of Ocean Hills to California State Highway 78 (CA-78). The demographic survey found shadow evacuation to be approximately 2% for the study area. A sensitivity study was conducted to test the impact on ETE of 25%, 50% and 100% shadow evacuation. The study found that the ETE for Ocean Hills were not impacted by shadow evacuation for the base mobilization time of 4 hours and 15 minutes. The traffic congestion in the Shadow Region is not significant enough that it propagates into Ocean Hills to delay evacuees and impact ETE. See Appendix B, sub-section B.2.
- Closure of one of the five egress routes out of the neighborhood does not have an impact on ETE as the additional congestion caused by roadway closures does not last longer than the mobilization time. See Appendix B, sub-section B.4.
- A sensitivity study was conducted to determine whether implementing a Traffic Management Plan (TMP) with police officers at critical intersections – Traffic Control Points (TCPs) – would impact ETE. The study found that the TMP would not significantly impact ETE; however, localized congestion within OHCC was reduced. Emergency planning officials could consider implementing such a TMP to help clear OHCC more expediently. See Appendix B, sub-section B.5.
- Rapid mobilization (one hour and 15 minutes) and full (100%) shadow evacuation could increase the 100th percentile ETE for Ocean Hills by up to 40 minutes. The results of this sensitivity study indicate it is imperative to educate the public to only evacuate if they are advised to do so. Significant shadow evacuation can delay the egress of those people who are most at risk. This

sensitivity study mimics a large-scale evacuation for a rapidly spreading fire. See Appendix B, sub-section B.7.

- An evacuation order during rush hour traffic (100% shadow evacuation and increased demand on CA-78) does not affect the 90th or 100th percentile ETE for Ocean Hills. The results of this sensitivity study indicate that traffic congestion along CA-78 and all major roadways that lead to CA-78 ramps is significantly worse than the base case scenario; however, the congestion does not propagate into Ocean Hills. See Appendix B, sub-section B.8.

Recommendations

- A steering committee comprised of the various stakeholders in the Neighborhood of Ocean Hills should be established to ensure that the critical findings and recommendations of this study are considered and implemented in emergency plans.
- Develop and distribute public information pamphlets to provide important information to the public to help them prepare for a wildfire emergency. Public information should include:
  - Prepare home in advance, have a bag ready to go
  - Know where to reunite with family
  - Know where to pick-up school children when schools are in session
  - Locations of reception centers
  - Evacuation routes
  - Having a vehicle available to evacuate and parking vehicles facing the nearest evacuation route
  - Know which emergency management area you live in.
  - Evacuate only when advised to do so.
  - Which emergency alert systems are available and how to register/opt-in to those systems
- Critical facilities (e.g., nursing homes and churches) in the neighborhood should have evacuation plans specific to the facility.
- Provide clear and concise messaging during a wildfire emergency to ensure that only those areas at risk will evacuate. Evacuation of Ocean Hills takes 40 minutes longer when the surrounding neighborhoods are also evacuating at the same time. If Ocean Hills is the only area at risk, messaging should be clear that only Ocean Hills should evacuate.
- Develop a registry for non-institutionalized mobility impaired and persons with access and functional needs, including those who do not own or have access to a private vehicle (the “transit dependent population”).
- Identify emergency management areas which can be clearly communicated to the public.
- Identify transit dependent pick-up points and routes to services these pick-up points. Communicate this information to the transit dependent population regularly. This study assumes

that transit dependent population will be picked up along Cannon Rd for the purpose of estimating evacuation time.

- Identify if there are dynamic message signs/variable message signs available to communicate important information to the public during an emergency, identify where these signs are, who controls the signs and how to mobilize the signs during an emergency.
- Identify transportation resources (buses, wheelchair transport vehicles, ambulances) to assist with the evacuation of the transit dependent population and access and functional needs population. These resources could be available locally or through mutual aid agreements or memorandums of understanding with neighboring communities, counties, or the state.
- Identify transit operators (bus drivers) to operate the transit vehicles evacuating the transit dependent population and population with access and functional needs. Periodically train these transit operators.
- Manual traffic control at critical intersections could reduce traffic congestion in some neighborhoods (i.e., the Ocean Hills Country Club). Identify who (law enforcement, CERT members, etc.) will perform manual traffic control, periodically train those who will perform manual traffic control, and identify resources (cones, barricades) that may be needed to assist with manual traffic control.

Table 5-3. Time to Clear Ocean Hills

	Summer		Summer
	Midweek	Weekend	Midweek Weekend
Scenario:	**(1)**	**(2)**	**(3)**
Percent of the Affected Population	**Midday**		**Evening**
	Good Weather	**Good Weather**	**Good Weather**
90%	1:55	1:50	1:50
100%	4:15	4:15	4:15

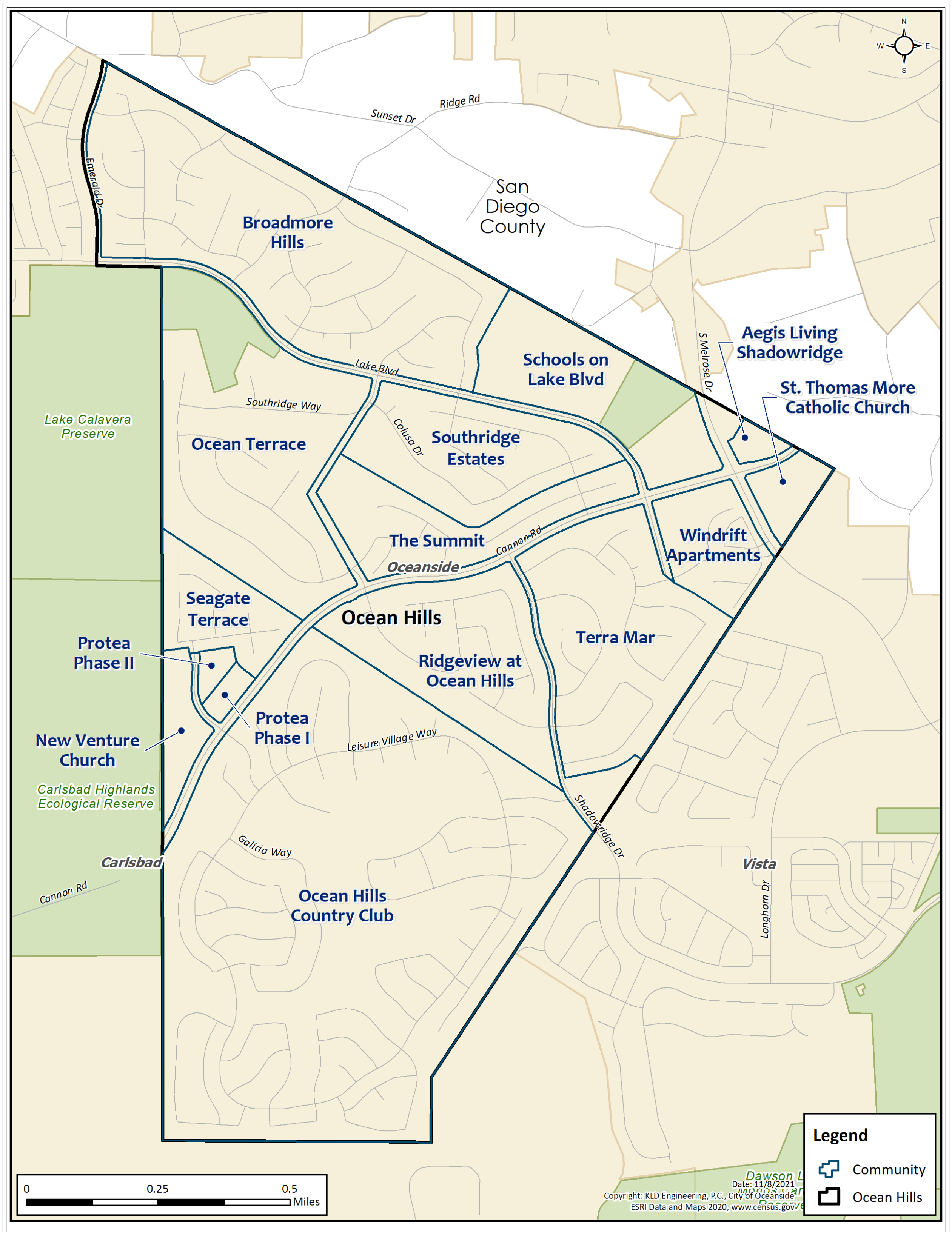


Figure 2-1. Community Boundaries

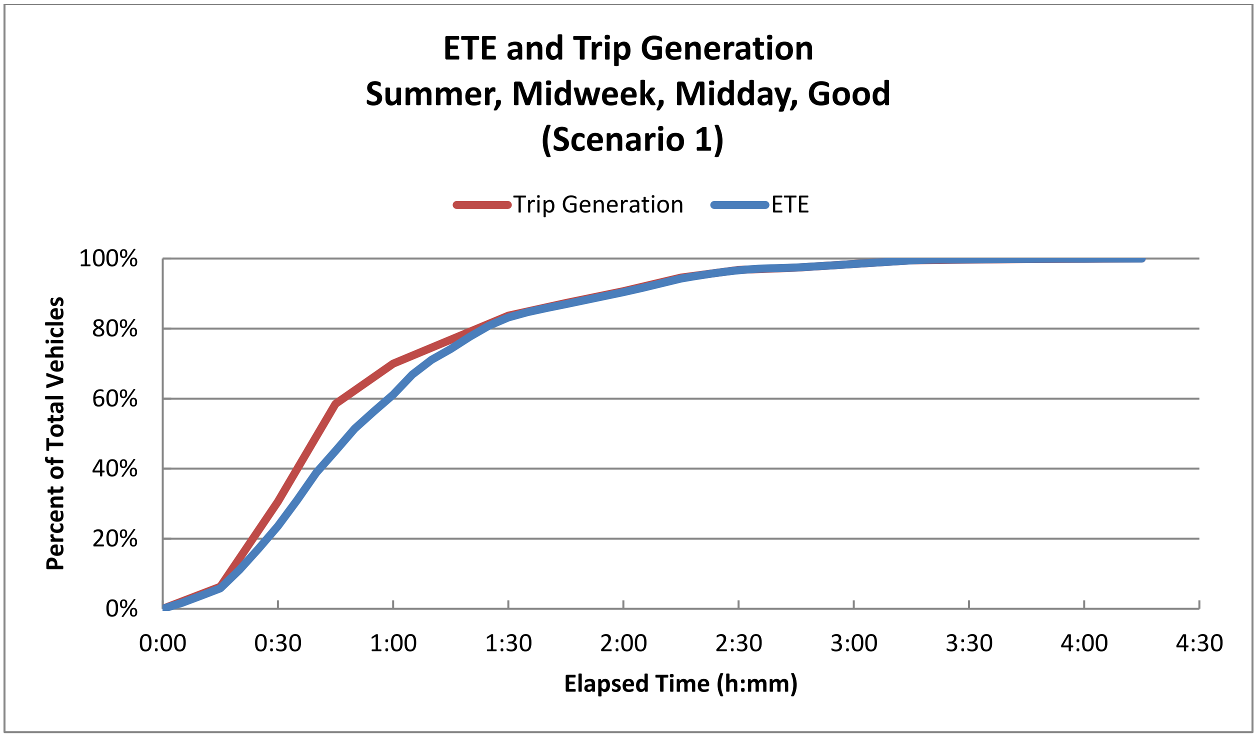


Figure 5-5. Evacuation Time Estimates - Scenario 1

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 Neighborhood of Ocean Hills, including preliminary activities of the project.

This report describes the analyses undertaken to examine anticipated traffic conditions and evacuation times associated with various rates of evacuation responses and alternative management strategies that could be used in response to them for the Neighborhood of Ocean Hills, California. This study, and the results contained within this report, will further inform, and enhance the Neighborhood of Ocean Hills emergency planning procedures.

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 Location of the Study Area

The Neighborhood of Ocean Hills is located in the City of Oceanside in San Diego County, California. The Neighborhood of Ocean Hills is located approximately 95 miles south of Los Angeles, CA and 45 miles north of San Diego, CA. Figure 1-1 displays the area surrounding the neighborhood. This map identifies the cities in the area and the major roadways.

1.2 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 Oceanside.
    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 Ocean Hills and the Shadow Region.
    d. Obtained demographic data from the 2020 Census (See Section 2.1).
    e. Conducted a random sample demographic survey of Ocean Hills residents via an online platform.
    f. Obtained data (to the extent available) for schools, medical facilities, visitors, service providers, and transportation resources available. The majority of this data was provided by the City of Oceanside and supplemented by phone calls to individual facilities and internet searches where no data was received.
2. Estimated distribution of trip generation times representing the time required by various population groups (permanent residents, employees, and tourists) to prepare

(mobilize) for the evacuation trip and updated where necessary. These estimates were based upon the demographic survey results and notification time calculation (see Section 4 and Appendix A).

3. Defined Evacuation Scenarios. These scenarios reflect the variation in demand, in trip generation distribution and in highway capacities, associated with different seasons, day of week, time of day and roadway conditions. The scenarios selected were bound by the normal wildfire season.

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

5. Prepared the input streams for the DYNEV II[1] system which computes ETE.

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

    b. Created the link-node representation of the evacuation network, which was 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 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.

6. Executed the DYNEV II model to determine optimal evacuation routing and compute ETE for all residents, visitors and employees ("general population") with access to private vehicles. Generated a complete set of ETE for all specified Scenarios.

7. Documented ETE results.

8. Tested what-if scenarios to evaluate alternative management strategies that could be used in response to wildfire situations.

[1] A traffic/evacuation simulation model (Dynamic Evacuation Simulation Model, or DYNEV-II) is used to compute ETE. The DYNEV II model incorporates the latest technology in traffic simulation and in dynamic traffic assignment. The DYNEV model was developed by KLD under contract with the Federal Emergency Management Agency (FEMA) and was independently validated by the U.S. Nuclear Regulatory Commission (NRC).

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

1.3 Data Estimates

1. The estimate of permanent resident population was based upon the 2020 U.S. Census population data from the Census Bureau website[3] (see Section 2.1).
2. Employees who commute into Ocean Hills were only assumed at the special facilities listed in Table 2-5.
3. Population estimates at special facilities were based on the data received from the City of Oceanside Fire Department, internet searches, and phone calls.
4. Evacuee mobilization times were based on a statistical analysis of data acquired from a random sample demographic survey of Ocean Hill residents conducted in 2021 (see Section 4 and Appendix A).
5. The relationship between permanent resident population and evacuating vehicles was extracted from the demographic survey. Average values of 1.89 persons per household (See Appendix A, sub-section A.3.1) and 1.35 evacuating vehicles per household (See Appendix A, sub-section A.3.2) were used for permanent resident population. The relationship between persons and vehicles for other population groups in the neighborhood is as follows:
    a. Employees: 1.09 employees per vehicle (demographic survey results) for all employers. See Section 2.4 and Appendix A, sub-section A.3.1.
    b. Visitors: assumed that visitors travel to Ocean Hills as a family in a single vehicle. Utilized the average household size of 1.89 persons as the family size. Thus, average vehicle occupancy is 1.89 visitors per vehicle. See Section 2.3
6. Roadway capacity estimates were based on the field survey performed in June 2021 and the application of the HCM 2016.

1.4 Study Methodological Assumptions

1. Three evacuation "Scenarios" representing different temporal variations (season, time of day, day of week) and conditions were considered. These Scenarios are outlined in Table 1-2.
2. Two roadway closure scenarios (wildfire events) were considered. The first wildfire event is assumed near Oak Riparian Park closing access to Lake Blvd from Ridge Rd to Normount Rd. The second event is assumed near Buena Vista Park closing access to Shadowridge Dr from Longhorn Dr to Antigua Dr. See Appendix B.
3. The notification time distribution (the time required for evacuees to receive notification of an evacuation) used in the study is based on the results of the demographic survey. Table 4-2 displays the notification distribution that was used in the study.
4. The Shadow Region is defined as the area beyond Ocean Hills south of California State Route 78 (CA-78) including parts of Carlsbad, Oceanside and Vista.
5. Approximately two percent (2%) of the population within the Shadow Region will voluntarily evacuate based on the results of the demographic survey.

[3] https://www.census.gov/programs-surveys/decennial-census/decade/2020/2020-census-results.html

6. The DYNEV II System was used to compute ETE in this study.
7. 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, except for those wildfire events wherein certain major evacuation routes are closed (see Item 2 above).

1.5 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, Alert San Diego County, 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 Neighborhood of Ocean Hills can be notified within 30 minutes of the advisory to evacuate.
3. One hundred percent (100%) of the people told to evacuate, will do so.
4. 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.
5. Buses will be used to transport those without access to private vehicles:
    a. Medical Facilities
        i. Buses, wheelchair transport vehicles and ambulances will be used to evacuate patients at medical facilities.
    b. Transit dependent general population are evacuated by bus.
    c. Access and functional needs population are included in the transit dependent population and will be evacuated by bus or trolley.
    d. Households with 3 or more vehicles were assumed to have no need for transit vehicles.
6. Transit vehicle capacities and maximum speed limits:
    a. Ambulatory transit-dependent persons and medical facility patients = 30 people per bus.
    b. Basic Life Support (BLS) ambulances = 2 persons.
    c. Wheelchair transport vehicles = 15 persons per wheelchair bus.
    d. The maximum bus speed assumed is 55 miles per hour, based on California Vehicle Code, Section 22406[4].
7. Transit vehicles mobilization times:
    a. Transit dependent buses are mobilized within 90 minutes of the advisory to evacuate.

[4] http://www.californiacarlaws.com/speed-limit/

   b. Vehicles will arrive at hospitals, medical facilities, and senior living facilities to be evacuated within 90 minutes of the advisory to evacuate.

8. Transit Vehicle loading times:
   a. Transit Dependent buses will require 1 minute of loading time per passenger.
   b. Buses for medical facilities will require 1 minute of loading time per ambulatory passenger.
   c. Wheelchair transport vehicles for medical facilities will require 5 minutes of loading time per passenger.
   d. Ambulances for medical facilities will require 15 minutes per bedridden passenger.
9. The percent breakdown of ambulatory (51%), wheelchair-bound (47%) and bedridden patients (2%) was provided by staff for Ocean Hills Senior Living. It is assumed the breakdown of patients is the same for Aegis Living Shadowridge as no data was provided by that facility.
10. It was assumed that drivers for all transit vehicles identified in Sections 2.5 and 2.6 are available.
11. Approximately seventy six percent (76%) of transit-dependent population will rideshare with a neighbor or friend, based on the demographic survey results.
12. 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 CA-78 to pass through the area. Dynamic and variable message signs (if available) may 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. See Section 2.7.
13. External Traffic was estimated to be reduced by 60% during evening scenarios (Scenario 3).
14. 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 being evacuated. See Section 2.8.
15. Trip generation time (also known as mobilization time, or the time to prepare for and begin the evacuation) are based upon the results of the demographic survey.
16. Based on the results of the demographic survey, 57 percent of the households in Ocean Hills excluding Ocean Hills Country Club (OHCC)[5] have at least 1 commuter; 36 percent of those households will await the return of household members before beginning their evacuation trip, based on the demographic survey results. Therefore, 21 percent (57% x 36% = 21%) of households will await the return of household members, prior to

[5] The commuter analysis was split between OHCC and the rest of Ocean Hills as most residents of the OHCC are retired.

beginning their evacuation trip. When OHCC commuters are included in this calculation, 14% of households will await the return of household members, prior to beginning their evacuation trip.

Table 1-1. Stakeholder Interaction

Stakeholder	Nature of Stakeholder Interaction
City of Oceanside Fire Department	Attended meetings to define methodology and data requirements. Assisted in data collection. Reviewed the demographic survey instrument.
Ocean Hills Country Club (OHCC)	Attended meetings to define methodology and data requirements. Provided information on guests and service providers that visit OHCC. Reviewed the demographic survey instrument.
Ocean Terrace Community	Attended meetings to define methodology and data requirements. Assisted in data collection. Reviewed the demographic survey instrument.
New Venture Grace Church	Attended meetings to define methodology and data requirements. Provided data for New Venture Grace Church and New Venture Christian School. Reviewed the demographic survey instrument.
Ocean Hills Senior Living	Attended meetings to define methodology and data requirements. Provided data for Ocean Hills Senior Living. Reviewed the demographic survey instrument.
Ocean Hills Assisted Living & Memory Care	Attended meetings to define methodology and data requirements. Reviewed the demographic survey instrument.
Seagate Terrace Community	Attended meetings to define methodology and data requirements. Reviewed the demographic survey instrument.

Table 1-2. Evacuation Scenario Definitions

Scenarios	Season	Day of Week	Time of Day	Conditions
1	Summer	Midweek	Midday	Normal
2	Summer	Weekend	Midday	Normal
3	Summer	Midweek, Weekend	Evening	Normal

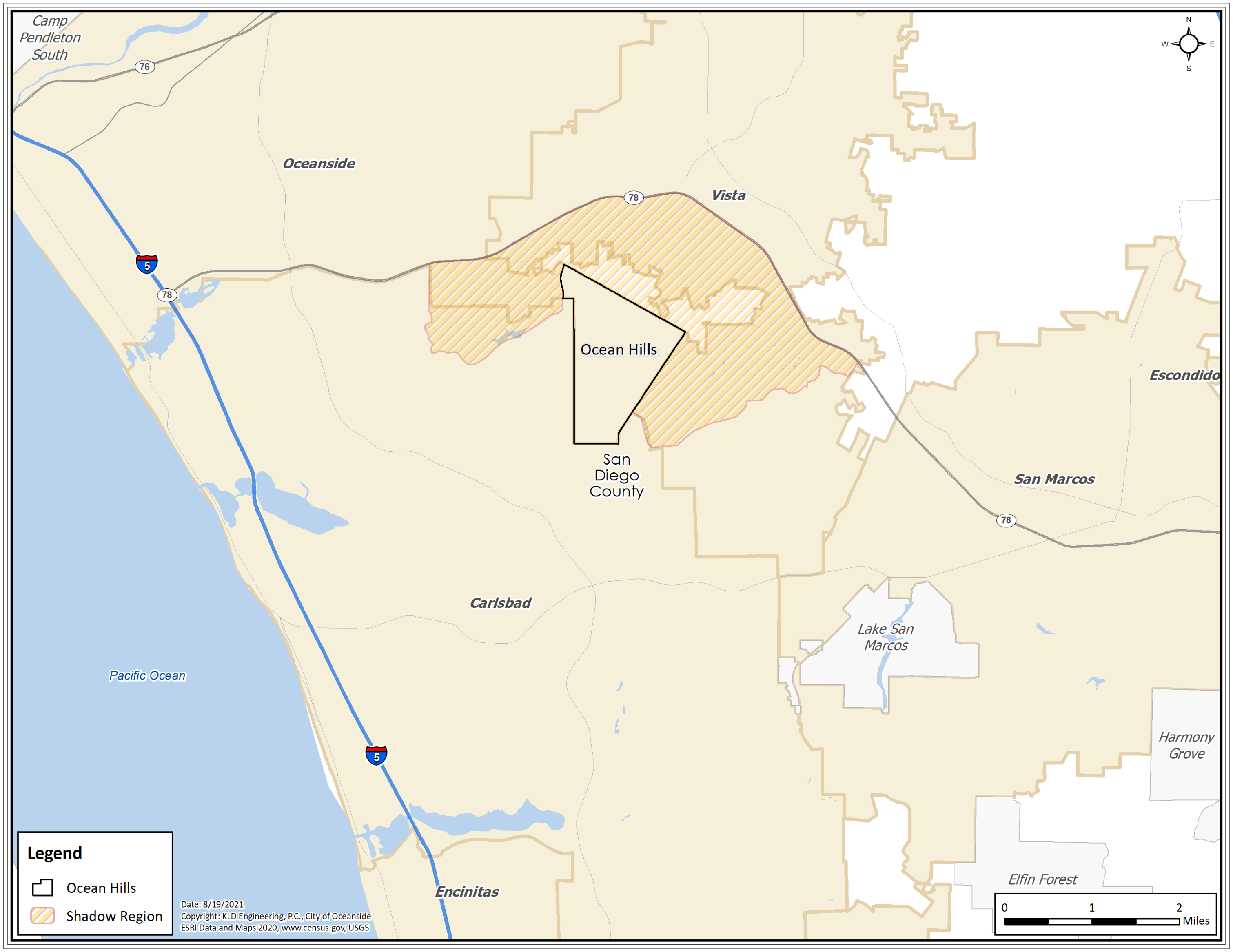


Figure 1-1. Study Area Location

2 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 the 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 Ocean Hills, stratified into groups (e.g., resident, visitor, employee, 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.

Our primary source of population data, the 2020 Census, however, is not adequate for directly estimating visitors who enter Ocean Hills throughout the year. These non-residents may dwell in Ocean Hills 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 Ocean Hills could be counted as a resident, again as an employee and once again as a visitor.
- A visitor who visits a church and spends time at a park, then goes shopping could be counted three times.

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 Ocean Hills.
- Visitors – people who reside outside of Ocean Hills but enter the area for a specific purpose (visiting family/friends, recreation) and then leave the area.
- Employees – people who reside outside of Ocean Hills and commute to work within Ocean Hills on a daily basis year-round.

Estimates of the population and number of evacuating vehicles for each of the population groups are presented for each community in Ocean Hills. The community boundaries are shown in Figure 2-1.

2.1 Permanent Residents

The permanent resident population estimates are based upon population and housing unit data extracted from the 2020 Census[1]. The population estimates are created by cutting the census block polygons by the community boundaries. Due to the similarities of the housing units in each census block, the ratio of housing units is used to estimate the population within the

[1] https://www.census.gov/programs-surveys/decennial-census/decade/2020/2020-census-results.html

updated census block polygons. The number of housing units of the updated census block polygons are identified by examining aerial imagery. A ratio of the total housing units of the original census block and the updated number of housing units (after cutting) is multiplied by the total block population to estimate what the population is within the community. Table 2-1 provides the permanent resident population within Ocean Hills for 2010 and for 2020. As indicated, the permanent resident population within Ocean Hills has increased by approximately 3.20% since the 2010 Census.

To estimate the number of evacuating vehicles, the 2020 permanent resident population is divided by the average household size and then multiplied by the average number of evacuating vehicles per household. The average household size (1.89 persons/household) was estimated using the demographic survey results (see Appendix A, sub-section A.3.1). The number of evacuating vehicles per household (1.35 vehicles/household – See Appendix A, sub-section A.3.2) was also adapted from the demographic survey results. Permanent resident population and vehicle estimates are presented in Table 2-2.

2.1.1 Schools, Preschools and Daycares

There are three schools and two preschools/daycares in Ocean Hills as shown in Figure 2-2. Information about these facilities is summarized in Table 2-3. If school is in session, parents will pick up their children prior to evacuating, according to the City of Oceanside. Thus, no school buses are needed to evacuate school children.

2.2 Shadow Population

A portion of the population living outside Ocean Hills may elect to evacuate without having been instructed to do so. This phenomenon is known as "shadow evacuation." Shadow evacuees consume space on the same roadways used by people evacuating from the area at risk. This can cause delays and prolong evacuation time for those leaving the area at risk. This study considered the Shadow Region shown in Figure 2-3, which includes portions of the cities of Carlsbad, Oceanside and Vista which surround Ocean Hills and are south of California State Route 78 (CA-78). Based on the demographic survey (see Appendix A, sub-section A.3.2), it is estimated that two 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 within Ocean Hills. There are 29,714 permanent residents and 21,217 vehicles in the Shadow Region.

2.3 Visitors

Visitors are defined as those people (who are not permanent residents, nor commuting employees) who enter Ocean Hills for a specific purpose (visiting, recreation). Visitors may spend less than one day or stay overnight in Ocean Hills. As displayed in Figure 2-2, there are three visitor attractions – Ocean Hills Country Club (OHCC), New Venture Church and St. Thomas More Catholic Church.

OHCC is a senior living community with a golf course. According to the OHCC staff, the golf course is only open to local residents, who have been included as permanent residents. Based on the data provided by OHCC, the community has an average of 120 daily visitors. It is assumed those visitors are family members or friends of the community residents and they commute to OHCC as a family. As such, the average household size of 1.89 persons per vehicle (see Appendix A, sub-section A.3.1) was used to estimate the evacuating vehicles. This results in 120 visitors evacuating in 63 vehicles.

According to New Venture Church, 400 people attend church on Sundays; 15% of attendees are local residents, the balance travel in from outside Ocean Hills. Thus, there are 340 (400 x (100% - 15%)) visitors to New Venture Church. It is assumed the visitors travel to the church as a family (1.89 persons per vehicle), resulting in 180 vehicles.

The data for St. Thomas More Catholic Church was not provided. The estimates of visitors and evacuating vehicles for this facility are based on an aerial imagery count of parking lot spaces and the average household size above. The aerial imagery shows the church has a capacity of 310 parking spaces and it is assumed that the parking lot is at capacity during peak times. As such, there are 586 (310 x 1.89) visitors and 310 vehicles evacuating from St. Thomas More Catholic Church.

In total, there are 1,046 visitors evacuating in 553 vehicles from Ocean Hills. Table 2-4 presents visitor population and vehicle estimates for Ocean Hills.

2.4 Year-round Employees

Employees who work year-round within Ocean Hills fall into two categories:

- Those who live and work in Ocean Hills
- Those who live outside of Ocean Hills and commute to jobs within Ocean Hills

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 Ocean Hills who will evacuate along with the permanent resident population.

KLD collected employment data for the major employers in Ocean Hills, which are summarized in Table 2-5. A vehicle occupancy of 1.09 employees per vehicle obtained from the demographic survey (See Appendix A, sub-section A.3.1, "Commuter Travel Modes") was used to determine the number of evacuating employee vehicles for each employer. There are also 180 service providers during weekdays at OHCC, evacuating in 165 vehicles. This is reduced by 83% during weekends, based on information provided by representatives from OHCC.

2.5 Nursing Homes

There are two nursing homes in Ocean Hills. A detailed breakdown of the current census including the percentage of ambulatory (51%), wheelchair bound (47%), and bedridden (2%)

was provided by staff from Ocean Hills Senior Living. Detailed data was not provided by Aegis Living Shadowridge. Since the average number of patients at medical facilities fluctuates daily, the percentage breakdown of the patients at Aegis Living Shadowridge was assumed to be the same as that of Ocean Hills Senior Living (see Section 1.5, Assumption 9). Table 2-6 summarizes the data and transportation requirements of nursing homes in Ocean Hills. As shown in these tables, 179 people have been identified as living in, or being treated in, these facilities at the time of this analysis. The number of ambulance runs is determined by assuming that 2 patients can be accommodated per ambulance trip; the number of wheelchair transport vehicles assumes 15 persons per wheelchair bus and the number of bus runs estimated assumes 30 ambulatory patients per trip (see Section 1.5, Assumption 6).

One of the nursing homes – Ocean Hills Senior Living – is a new facility and its residents are not included in the 2020 Census; the other nursing home – Aegis Living Shadowridge – has permanent residents that are included in the Census; however, these residents are transit dependent (will not evacuate in personal vehicles). As such, these residents are included in the permanent resident population, but no personal evacuating vehicles are considered. The vehicles in Table 2-2 have been adjusted accordingly.

2.6 Transit Dependent Population

The demographic survey (see Appendix A) 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 2-7 presents estimates of transit-dependent people. Note, it is reasonable and appropriate to consider that many transit-dependent persons will evacuate by ridesharing with neighbors, friends or family. For example, nearly 80 percent of those who evacuated from Mississauga, Ontario[2] 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 (see Appendix A, sub-section A.3.1, "Ridesharing") indicate approximately 76 percent ridesharing is appropriate for this area. As such, 76 percent ridesharing was utilized to estimate the transit dependent population within Ocean Hills.

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 for buses 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,

[2] 1979 Mississauga Train Derailment

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 2-7 by 50 percent, the demand for service can still be accommodated by the available bus seating capacity.

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

Table 2-7 indicates that transportation must be provided for 69 people. Therefore, a total of **3 bus runs** are required to transport this population outside of Ocean Hills.

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 all communities excluding OHCC[3]:

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

Where:

A = Percent of households with commuters

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

$$P = 2{,}580 \times [1.00\ \times 0.006 + 0.4880 \times (1.47 - 1) \times 0.5738 \times 0.6373 + 0.4320 \times (2.16 - 2) \times (0.5738 \times 0.6373)^2] = 256$$

$$B = ((1 - 0.7553) \times P) \div 30 = 3$$

These calculations are explained as follows:

- Number of households is computed by dividing the population (4,877) by the average household size (1.89) and equates to 2,580.
- All members (1.00 avg.) of households (HH) with no vehicles (0.6%) will evacuate by public transit or ride-share. The term 2,580 (number of households) x 0.006 x 1.00, accounts for these people.
- The members of HH with 1 vehicle (48.80%) away, who are at home, equal (1.47-1). The number of HH where the commuter will not return home is equal to (2,580 x 0.4880 x 0.47 x 0.5738 x 0.6373), as 57.38% of households outside of OHCC have a commuter, 63.73% 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

[3] The same calculation is done for OHCC where the Percent HH with commuters is 6.56%.

the product of these two terms.

- The members of HH with 2 vehicles (43.20%) that are away, who are at home, equal (2.16 – 2). The number of HH where neither commuter will return home is equal to 2,580 x 0.4320 x 0.16 x $(0.5738 \times 0.6373)^2$. 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 visitors 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 transit-dependent visitors or those with access and functional needs.

KLD designed a route to service the transit dependent population for Ocean Hills that starts from New Venture Grace Church and ends on Melrose Dr along Cannon Rd. It is assumed that all transit dependents would walk to and gather along Cannon Road for bus pick up.

2.7 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 CA-78 traversing the study area. 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. It is assumed that these signs, if available, will be activated within 30 minutes of the Advisory to Evacuate (ATE). Thus, traffic flows normally on CA-78 for the first 30 minutes of the evacuation; no vehicles are diverted. Once activated, it is assumed that external traffic will diminish over the next 90 minutes until all external traffic entering the study area has been stopped at 120 minutes following the ATE.

Average Annual Daily Traffic (AADT) data was obtained from Caltrans[4] 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 2-8. The DDHV is then multiplied by 30-minutes (time needed to activate dynamic and variable message signs) to estimate the total number of external vehicles loaded on the analysis network prior to diversion. As indicated in Table 2-8, there are 5,146 vehicles entering the study

[4] https://dot.ca.gov/programs/traffic-operations/census/

area as external-external trips prior to any diversion of traffic. Table 2-9 shows the assumed percentage of diverted vehicles throughout the evacuation.

As shown in Table 2-8, throughout the first two hours of the evacuation, the total external traffic that will enter the study area is 12,864 vehicles. This number is reduced by 60% for Scenario 3, which is an evening scenario.

CA-78 operates as a limited access freeway in the study area with three lanes in each direction. As per Section 3.3.3 of this report, freeways have a capacity of 2,250 passenger cars per hour per lane (pcphpl). Thus, the capacity of CA-78 is 6,750 passenger cars per hour (2,250 pcphpl x 3 lanes) in each direction. Table 2-8 indicates that 5,248 vehicles per hour and 5,043 vehicles per hour were considered for CA-78 eastbound and westbound, respectively, as external traffic for this study. These correspond to 78% and 75% of the roadway capacity for eastbound and westbound, respectively. Project stakeholders indicated that during rush hour traffic, CA-78 is highly congested which causes significant congestion along Melrose Dr and other roads in the study area. A sensitivity study was run wherein the external traffic considered on CA-78 was 90% of the roadway capacity for the first hour. After that first hour, it was assumed that traffic would be diverted via dynamic message signs/variable message signs along the highway. See Appendix B, sub-section B.8 for additional details.

2.8 Background Traffic

Section 4 discusses the time needed for the people in the study area to mobilize and begin their evacuation trips. As shown in Table 4-8, 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 routine traffic 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 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. There are 1,380 vehicles on the roadways in the study area at the end of fill time under Scenario 1 (summer, midweek, midday, normal) conditions.

2.9 Summary of Demand

A summary of population and vehicle demand is provided in Table 2-10 and Table 2-11, respectively. This summary includes all population groups described in this section. A total of 12,672 people and 19,729 vehicles (6,865 evacuating vehicles and 12,864 external vehicles) are considered in this study.

Table 2-1. Community Permanent Resident Population

Community	2010 Population	2020 Population
Aegis Living Shadowridge	80	84
Broadmore Hills	1,433	1,383
New Venture Church	0	0
Ocean Hills Country Club	2,224	2,754
Ocean Terrace	572	327
Protea Phase I	0	0
Protea Phase II	0	0
Ridgeview at Ocean Hills	394	301
Schools on Lake Blvd	0	0
Seagate Terrace	196	417
Southridge Estates	383	402
St. Thomas More Catholic Church	0	0
Terra Mar	1,160	934
The Summit	207	249
Windrift Apartments	827	864
TOTAL	**7,476**	**7,715**
Population Growth (2010 - 2020):		**3.20%**
Shadow Region	29,071	29,714
STUDY AREA TOTAL	**36,547**	**37,429**

Table 2-2. Permanent Resident Population and Vehicles by Community

Community	2020 Population	2020 Resident Vehicles
Aegis Living Shadowridge	84	0[5]
Broadmore Hills	1,383	988
New Venture Church	0	0
Ocean Hills Country Club	2,754	1,968
Ocean Terrace	327	233
Protea Phase I	0	0
Protea Phase II	0	0
Ridgeview at Ocean Hills	301	215
Schools on Lake Blvd	0	0
Seagate Terrace	417	298
Southridge Estates	402	287
St. Thomas More Catholic Church	0	0
Terra Mar	934	668
The Summit	249	178
Windrift Apartments	864	617
TOTAL	**7,715**	**5,452**
Shadow Region	29,714	21,217
STUDY AREA TOTAL	**37,429**	**26,669**

[5] Aegis Living Shadowridge has permanent residents that are included in the Census; however, these residents are transit dependent and will not evacuate in personal vehicles. Refer to Section 2.5 for further information.

Table 2-3. Schools and Preschools/Daycares in Ocean Hills

Community	Facility Name	Street Address	Municipality	Students
New Venture Church	New Venture Christian School	4000 Mystra Dr	Oceanside	500
Schools on Lake Blvd	Lake Elementary School	4950 Lake Blvd	Oceanside	800
Schools on Lake Blvd	Madison Middle School	4930 Lake Blvd	Oceanside	1,156
Schools on Lake Blvd	Montessori School of Oceanside	3525 Cannon Rd	Oceanside	157
Southridge Estates	Lucy's Family Childcare	4981 Marin Dr	Oceanside	12
			TOTAL	**2,625**

Table 2-4. Visitor Attractions in Ocean Hills

Community	Facility Name	Facility Type	Street Address	Municipality	Visitors	Vehicles
Ocean Hills Country Club	Ocean Hills Country Club	Golf Course	4600 Leisure Village Way	Oceanside	120	63
New Venture Church	New Venture Church	Church	4000 Mystra Dr	Oceanside	340	180
St. Thomas More Catholic Church	St. Thomas More Catholic Church	Church	1450 S Melrose Dr	Oceanside	586	310
				TOTAL	**1,046**	**553**

Table 2-5. Major Employers in Ocean Hills

Community	Facility Name	Street Address	Employees Commuting into Ocean Hills	Employee Vehicles Commuting into Ocean Hills
Aegis Living Shadowridge	Aegis Living Shadowridge	1440 S Melrose Dr	13[6]	12
New Venture Church	New Venture Christian School	4000 Mystra Dr	16	15
New Venture Church	New Venture Church	4000 Mystra Dr	6	6
Ocean Hills Country Club	Ocean Hills Country Club	4600 Leisure Village Way	214	196
Protea Phase I	Ocean Hills Senior Living	4500 Cannon Rd	51	47
Schools on Lake Blvd	Lake Elementary School	4950 Lake Blvd	33	30
Schools on Lake Blvd	Madison Middle School	4930 Lake Blvd	43	39
Schools on Lake Blvd	Montessori School of Oceanside	3525 Cannon Rd	50	46
Southridge Estates	Lucy's Family Childcare	4981 Marin Dr	2	2
St. Thomas More Catholic Church	St. Thomas More Catholic Church	1450 S Melrose Dr	16	15
		TOTAL	**444**	**408**

[6] Employment data for Aegis Living Shadowridge was not provided. The number of employees at this facility was estimated based on the staff-to-patient ratios for nursing homes. As per the regulations established by California Department of Public Health, the minimum number of direct care service hours per patient day required in a skilled nursing facility shall be 3.2 hours. The resident capacity at this nursing facility is 95, and assuming this facility provides 24-hour services, the minimum number of staff required is 13 (95 x 3.2 ÷ 24, rounded up). For detailed information, please refer to the following site: https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160AB2079

Table 2-6. Nursing Homes in Ocean Hills

Community	Facility Name	Capa-city	Current Census	Ambu-latory	Wheel-chair Bound	Bed-ridden	Buses	Wheel-chair Buses	Ambu-lances
Aegis Living Shadowridge	Aegis Living Shadowridge	95	84	42	40	2	2	3	1
Protea Phase I	Ocean Hills Senior Living	114	95	48	45	2	2	3	1
	TOTAL	**209**	**179**	**90**	**85**	**4**	**4**	**6**	**2**

Table 2-7. Transit-Dependent Population Estimates

Area	2020 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						
Excluding OHCC	4,877	1.00	1.47	2.16	2,580	0.60%	48.80%	43.20%	57.38%	63.73%	256	75.53%	63	1.29%
OHCC	2,754	1.00	1.47	2.16	1,457	0.60%	48.80%	43.20%	6.56%	63.73%	23	75.53%	6	0.22%
Total	7,631[7]				4,038						279		69	

[7] 84 people living at Aegis Living Shadow Ridge are counted as transit dependents but will evacuate in buses, wheelchair buses and ambulances. Hence, they are accounted for in Table 2-6.

Table 2-8. Study Area External Traffic

Road Name	Direction	Caltrans AADT[8]	K-Factor[9]	D-Factor[9]	Hourly Volume	External Traffic During the First 30 Minutes	External Traffic[10]
CA-78	EB	128,000	0.082	0.5	5,248	2,624	6,560
CA-78	WB	123,000	0.082	0.5	5,043	2,522	6,304
					TOTAL:	**5,146**	**12,864**

Table 2-9. External Traffic Diversion Percentages Over Time

Time Period	Percentage of External Traffic Diverted	External Traffic within the Study Area
0 - 30	0%	5,146
30 - 60	25%	3,859
60 - 90	50%	2,573
90 - 120	75%	1,286
120 - ∞	100%	0
	TOTAL:	**12,864**

[8] California Department of Transportation (Caltrans), https://dot.ca.gov/programs/traffic-operations/census/
[9] HCM 2016
[10] External Traffic displayed includes calculations as discussed in Section 2.7, which includes a diversion percentage (Table 2-9) after the first 30 minutes.

Table 2-10. Summary of Population Demand

Community	Residents	Transit-Dependent	Visitors	Employees	Medical Facilities	Schools	External Traffic	Total
Aegis Living Shadowridge	84	0	0	13	84	0	0	181
Broadmore Hills	1,383	0	0	0	0	0	0	1,383
New Venture Church	0	63[11]	340	22	0	500	0	925
Ocean Hills Country Club	2,754	6	120	214	0	0	0	3,094
Ocean Terrace	327	0	0	0	0	0	0	327
Protea Phase I	0	0	0	51	95	0	0	146
Protea Phase II	0	0	0	0	0	0	0	0
Ridgeview at Ocean Hills	301	0	0	0	0	0	0	301
Schools on Lake Blvd	0	0	0	126	0	2,113	0	2,239
Seagate Terrace	417	0	0	0	0	0	0	417
Southridge Estates	402	0	0	2	0	12	0	416
St. Thomas More Catholic Church	0	0	586	16	0	0	0	602
Terra Mar	934	0	0	0	0	0	0	934
The Summit	249	0	0	0	0	0	0	249
Windrift Apartments	864	0	0	0	0	0	0	864
Shadow Region	594[12]	0	0	0	0	0	0	594
Total	**8,309**	**69**	**1,046**	**444**	**179**	**2,625**	**0**	**12,672**

[11] The bus route starts along Cannon Rd near New Venture Church.

[12] There are 29,714 residents inside the Shadow Region. Only two percent of them would choose to evacuate during an emergency at Ocean Hills. (29,714 x 0.02 = 594).

Table 2-11. Summary of Vehicle Demand

Community	Residents	Transit-Dependent	Visitors	Employees	Medical Facilities[13]	School Buses	External Traffic	Total
Aegis Living Shadowridge	0	0	0	12	11	0	0	23
Broadmore Hills	988	0	0	0	0	0	0	988
New Venture Church	0	6[13]	180	21	0	0	0	207
Ocean Hills Country Club	1,968	0	63	196	0	0	0	2,227
Ocean Terrace	233	0	0	0	0	0	0	233
Protea Phase I	0	0	0	47	11	0	0	58
Protea Phase II	0	0	0	0	0	0	0	0
Ridgeview at Ocean Hills	215	0	0	0	0	0	0	215
Schools on Lake Blvd	0	0	0	115	0	0	0	115
Seagate Terrace	298	0	0	0	0	0	0	298
Southridge Estates	287	0	0	2	0	0	0	289
St. Thomas More Catholic Church	0	0	310	15	0	0	0	325
Terra Mar	668	0	0	0	0	0	0	668
The Summit	178	0	0	0	0	0	0	178
Windrift Apartments	617	0	0	0	0	0	0	617
Shadow Region	424[14]	0	0	0	0	0	12,864	13,288
Total	**5,876**	**6**	**553**	**408**	**22**	**0**	**12,864**	**19,729**

[13] One bus is equivalent to 2 passenger cars due to the longer vehicle type and more sluggish vehicle operating characteristics. As such, buses for transit dependent persons, ambulatory and wheelchair bound medical facility patients are doubled in the simulation.

[14] There are 21,217 resident vehicles inside the Shadow Region. Only two percent of them would be used during an evacuation (21,217 x 0.02 = 424).

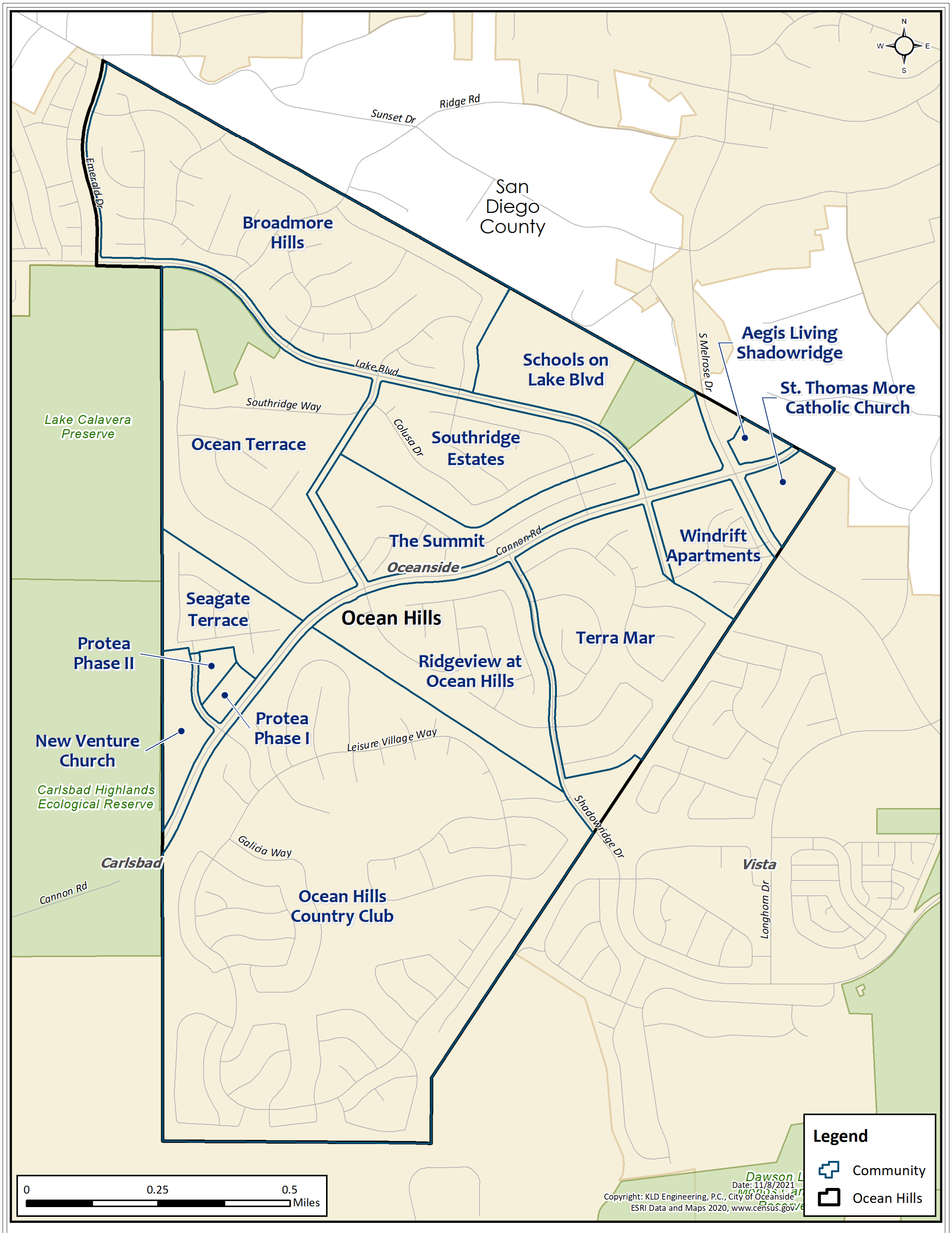


Figure 2-1. Community Boundaries

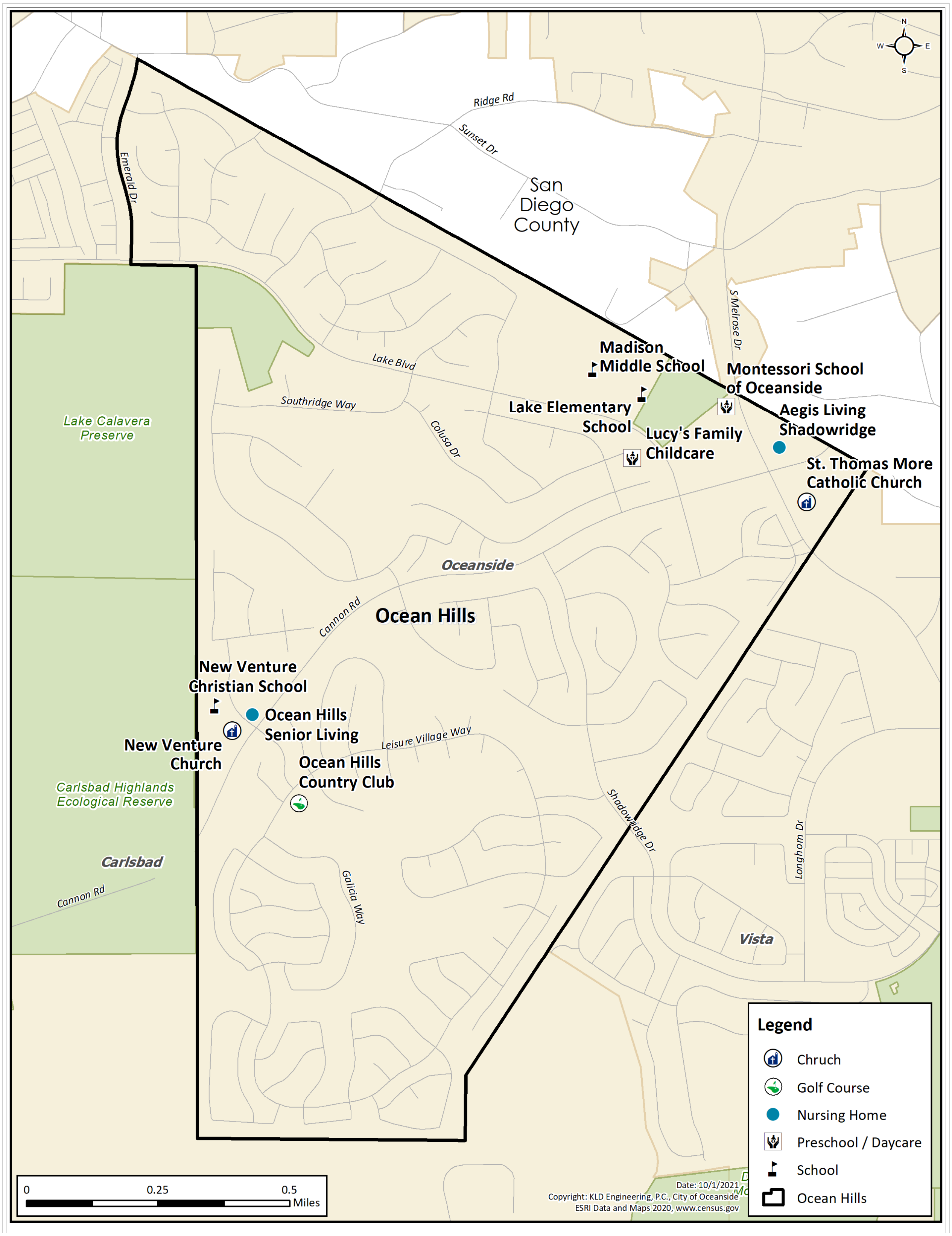


Figure 2-2. Special Facilities in Ocean Hills

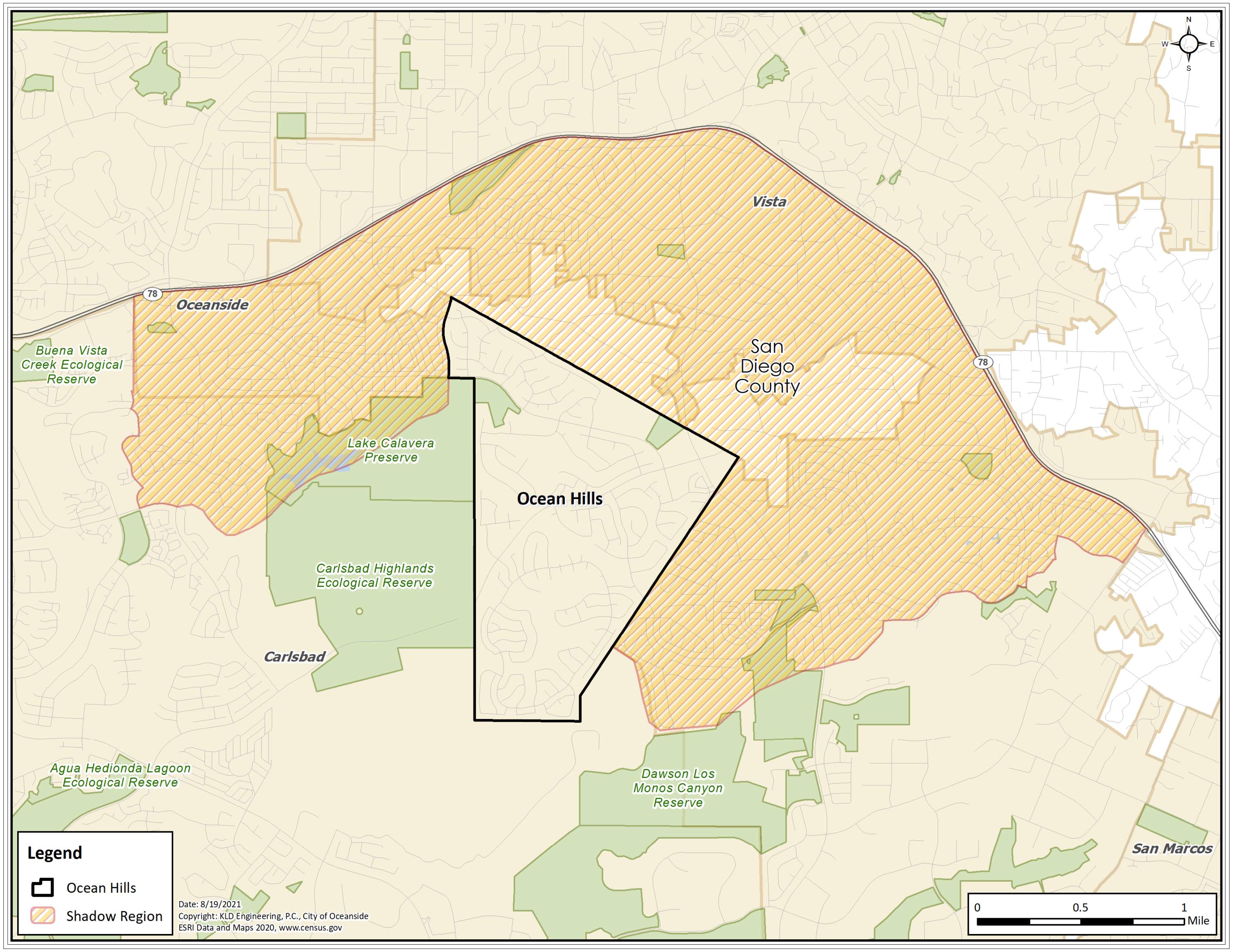


Figure 2-3. Shadow Region and Census Boundaries within the Study Area

3 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).

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.

3.1 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,

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

where:

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

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

$$h_m \geq h_{sat}$$

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

The above discussion is necessarily brief given the scope of this 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 Ocean Hills 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

[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.

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.

3.2 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 3-1 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. The ratio of these two numbers is 0.896 which translates into a capacity reduction factor of 0.90.

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

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.

3.3 Application to the Neighborhood of Ocean Hills 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 (CA-78 operates as a freeway in the study area)

Each of these classifications will be discussed.

3.3.1 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.

3.3.2 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.

3.3.3 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.

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).

3.3.4 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.

3.4 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. 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.

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.

3.5 Boundary Conditions

The link-node analysis network used for this study is finite. The analysis network extends well beyond Ocean Hills 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. 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 3.3.1 above) and multi-lane highways (Section 3.3.2 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.

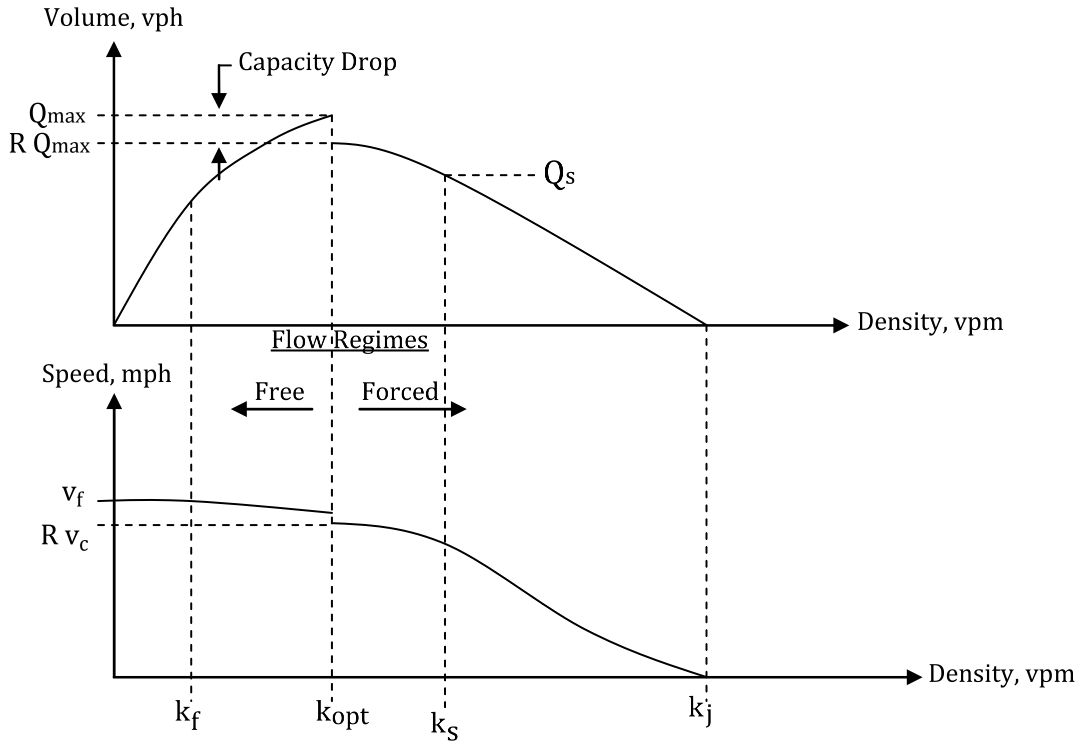


Figure 3-1. Fundamental Diagrams

4 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 sum of these distributions of elapsed times as the Trip Generation Time Distribution. This section documents how the trip generation time distributions were estimated.

4.1 Background

In general, during a wildfire emergency, priorities are given to protecting public health and safety, preservation of property and resource conservation. Depending on the severity, wind speed and direction of the wildfire, emergency officials may issue warnings that include evacuation to best protect public health and safety.

As a Planning Basis, this study adopts a conservative posture of a rapidly escalating wildfire, wherein evacuation is required, ordered promptly and no early protective actions are 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, social media, local news, door-to-door and other potential 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 not a representation that these events will occur within the indicated time frame. Rather, these assumptions are necessary in order to:

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

The notification process consists of two events:

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

The population within Ocean Hills is dispersed over an area of approximately 1.6 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 Ocean Hills at the time the emergency is declared. These people may be commuters, shoppers and other travelers who reside within Ocean Hills 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 Ocean Hills. 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 Ocean Hills might be notified by text message, television and/or radio (if available). Those well outside Ocean Hills might be notified by word-of-mouth, with potentially longer time lags. Furthermore, the spatial distribution of Ocean Hills 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 for an emergency evacuation is typically obtained from a demographic survey of residents. Such a survey was conducted for this study. Appendix A presents the survey results. The remaining discussion will focus on the application of the trip generation data obtained from the demographic survey to the development of the ETE documented in this report.

4.2 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 4-1.

These relationships are shown graphically in Figure 4-1.

- 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 Ocean Hills will follow sequence (c) of Figure 4-1. A household within Ocean Hills 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 4-1(a). A household within Ocean Hills that has no commuters at work, or that will not await the return of any commuters, will follow the second sequence of Figure 4-1(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 4-1(b). Visitors will always follow one of the sequences of Figure 4-1(b). Some visitors 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 4-1, 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.

4.3 Estimated Time Distributions of Activities Preceding Event 5

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

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

A demographic survey of Ocean Hills residents was conducted to study evacuation behavior of the population within the neighborhood. 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 such as phone calls, text messages, social media, and in person conversations. Since the survey was statistically significant at the 95% confidence level, it can be assumed that the population within the neighborhood will behave similarly to the survey respondents. The distribution of Activity 1 → 2 shown in Table 4-2 reflects data obtained by the demographic survey. This distribution is plotted in Figure 4-2.

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 B.

<u>Distribution No. 2, Prepare to Leave Work: Activity 2 → 3</u>

It is reasonable to expect that the vast majority of business enterprises within Ocean Hills will elect to shut down following notification and most employees would leave work quickly. Commuters, who work outside the neighborhood could, in all probability, also leave quickly since facilities outside the neighborhood would remain open and other personnel would remain. Essential workers (medical personnel, teachers) responsible for patients or students would require additional time to secure their facility. The distribution of Activity 2 → 3 shown in Table 4-3 reflects data obtained by the demographic survey. This distribution is plotted in Figure 4-2.

<u>Distribution No. 3, Travel Home: Activity 3 → 4</u>

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

<u>Distribution No. 4, Prepare to Leave Home: Activity 2, 4 → 5</u>

These data are provided directly by households that responded to the demographic survey. This distribution represents the time needed by residents to pack essential items. The distribution is plotted in Figure 4-2 and listed in Table 4-5.

4.4 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 4-6 presents the summing procedure to arrive at each designated distribution.

Table 4-7 presents a description of each of the final trip generation distributions achieved after the summing process is completed.

4.4.1 Statistical Outliers

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

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

In assessing outliers, there are three alternatives to consider:

1) Some responses with very long times may be valid, but reflect the reality that the respondent really needs to be classified in a different population subgroup, based upon 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 individually 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;
3) Outliers can be eliminated either because the response reflects a special population (e.g., special needs, transit dependent) <u>or</u> 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 4.09 standard deviations from the mean are allowed to be considered outliers, with gaps in the histogram expected.

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

5) As a practical matter, even with outliers eliminated by the above, the resultant histogram, viewed as a cumulative distribution, is not a normal distribution. A typical situation that results is shown below in Figure 4-3.
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, indicating that the network loads faster for the first 80-85% of the vehicles, potentially causing more (and earlier) congestion than otherwise modeled;
   - The last 10-15% of the real data “tails off” slower than the comparable “normal” curve, indicating that there is significant traffic still loading at later times.

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

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

This is done by using the data sets and distributions under different scenarios (e.g., commuter returning, no commuter returning in each). In general, these are additive, using weighting based upon the probability distributions of each element; Figure 4-4 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 <u>sequential</u> – preparation for departure follows the return of the 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 are used in their tabular/graphical form as direct inputs to later computations that lead to the ETE.

The DYNEV II simulation model is designed to accept varying rates of vehicle trip generation for each origin centroid, expressed in the form of histograms. These histograms, which represent Distributions A, C, and D, properly displaced with respect to one another, are tabulated in

Table 4-8 (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 4-1. 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 4-2. Time Distribution for Notifying the Public

Elapsed Time (Minutes)	Percent of Population Notified
0	0%
5	64%
10	85%
15	95%
20	97%
25	98%
30	100%

Table 4-3. Time Distribution for Employees to Prepare to Leave Work

Elapsed Time (Minutes)	Cumulative Percent Employees Leaving Work
0	0%
5	38%
10	61%
15	79%
20	89%
25	90%
30	93%
35	94%
40	95%
45	96%
50	96%
55	96%
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 4-4. Time Distribution for Commuters to Travel Home

Elapsed Time (Minutes)	Cumulative Percent Returning Home	Elapsed Time (Minutes)	Cumulative Percent Returning Home
0	0%	40	78%
5	5%	50	88%
10	11%	60	94%
15	24%	75	96%
20	44%	90	98%
25	54%	105	100%
30	63%		

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

Table 4-5. Time Distribution for Population to Prepare to Leave Home

Elapsed Time (Minutes)	Cumulative Percent Ready to Evacuate
0	0%
15	7%
30	54%
45	77%
60	77%
75	86%
90	88%
105	90%
120	93%
135	98%
150	98%
165	98%
180	99%
195	100%

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

Table 4-6. 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 4-7. Description of the Distributions

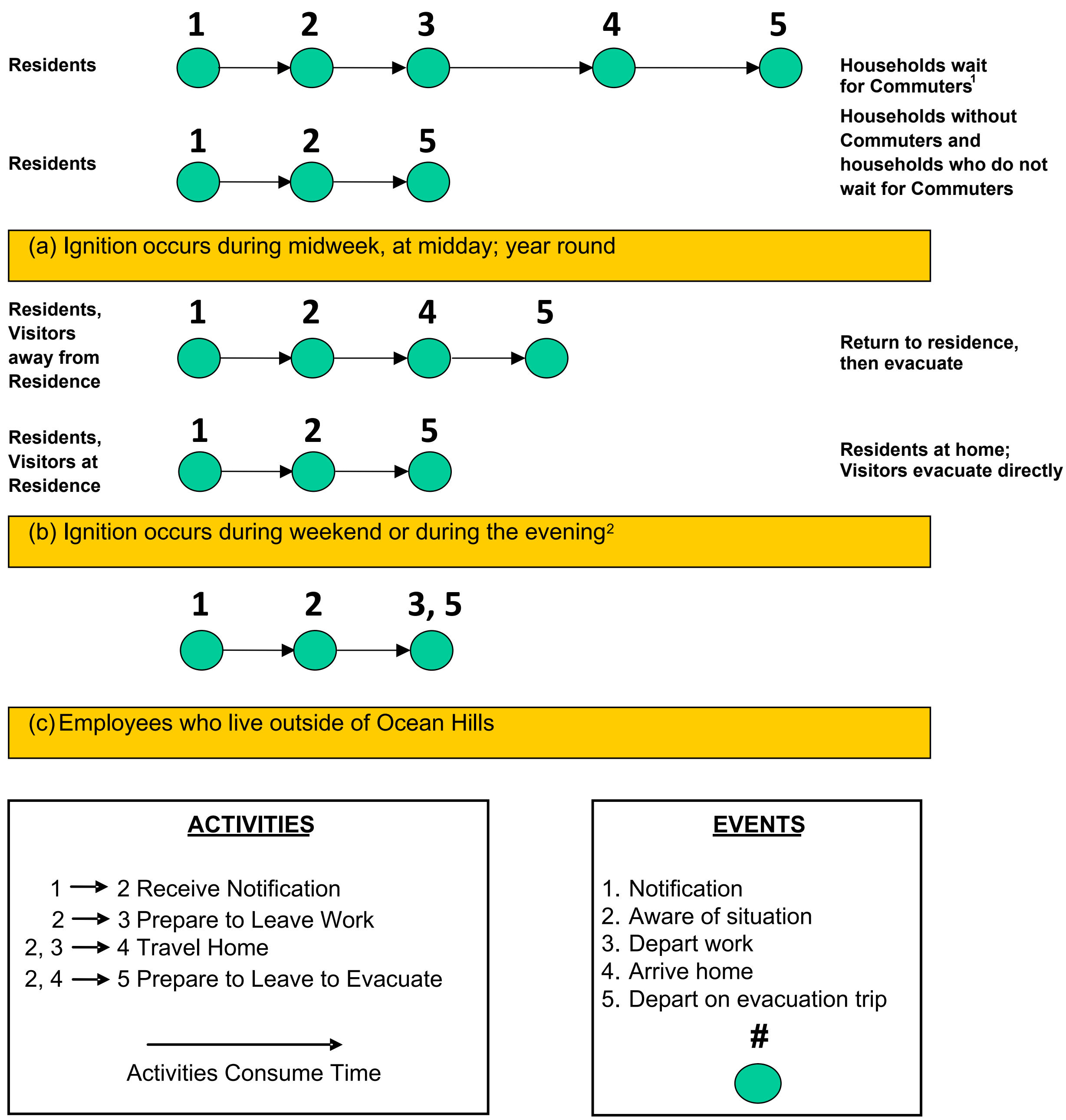
Distribution	Description
A	Time distribution of commuters departing place of work (Event 3). Also applies to employees (year-round and seasonal) who work within Ocean Hills who live outside, and to visitors within Ocean Hills.
B	Time distribution of commuters arriving home (Event 4).
C	Time distribution 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 4-8. Trip Generation Histograms for Ocean Hills Population

Time Period	Duration (Min)	Percent of Total Trips Generated Within Indicated Time Period			
		Employees (Year-round and Seasonal) (Distribution A)	Visitors (Distribution A)	Residents with Commuters (Distribution C)	Residents Without Commuters (Distribution D)
1	15	47%	47%	0%	3%
2	15	38%	38%	0%	27%
3	15	9%	9%	4%	34%
4	15	2%	2%	15%	12%
5	15	4%	4%	20%	5%
6	15	0%	0%	17%	6%
7	15	0%	0%	13%	2%
8	15	0%	0%	8%	3%
9	15	0%	0%	6%	4%
10	15	0%	0%	5%	2%
11	15	0%	0%	4%	0%
12	30	0%	0%	4%	2%
13	30	0%	0%	3%	0%
14	30	0%	0%	1%	0%
15	600	0%	0%	0%	0%

NOTE:

- Shadow vehicles are loaded onto the analysis network using Distribution C.



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

Figure 4-1. Events and Activities Preceding the Evacuation Trip

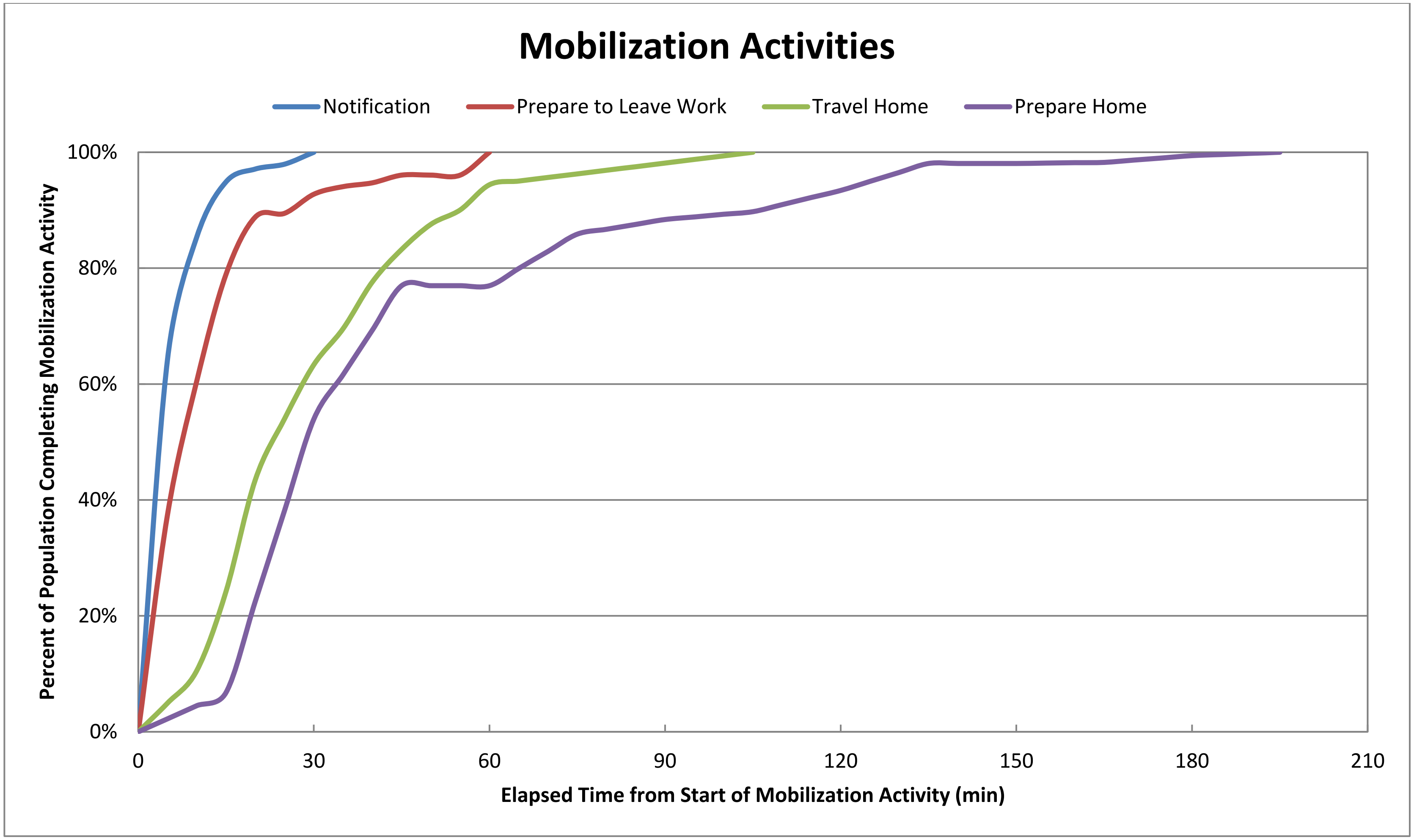


Figure 4-2. Evacuation Mobilization Activities

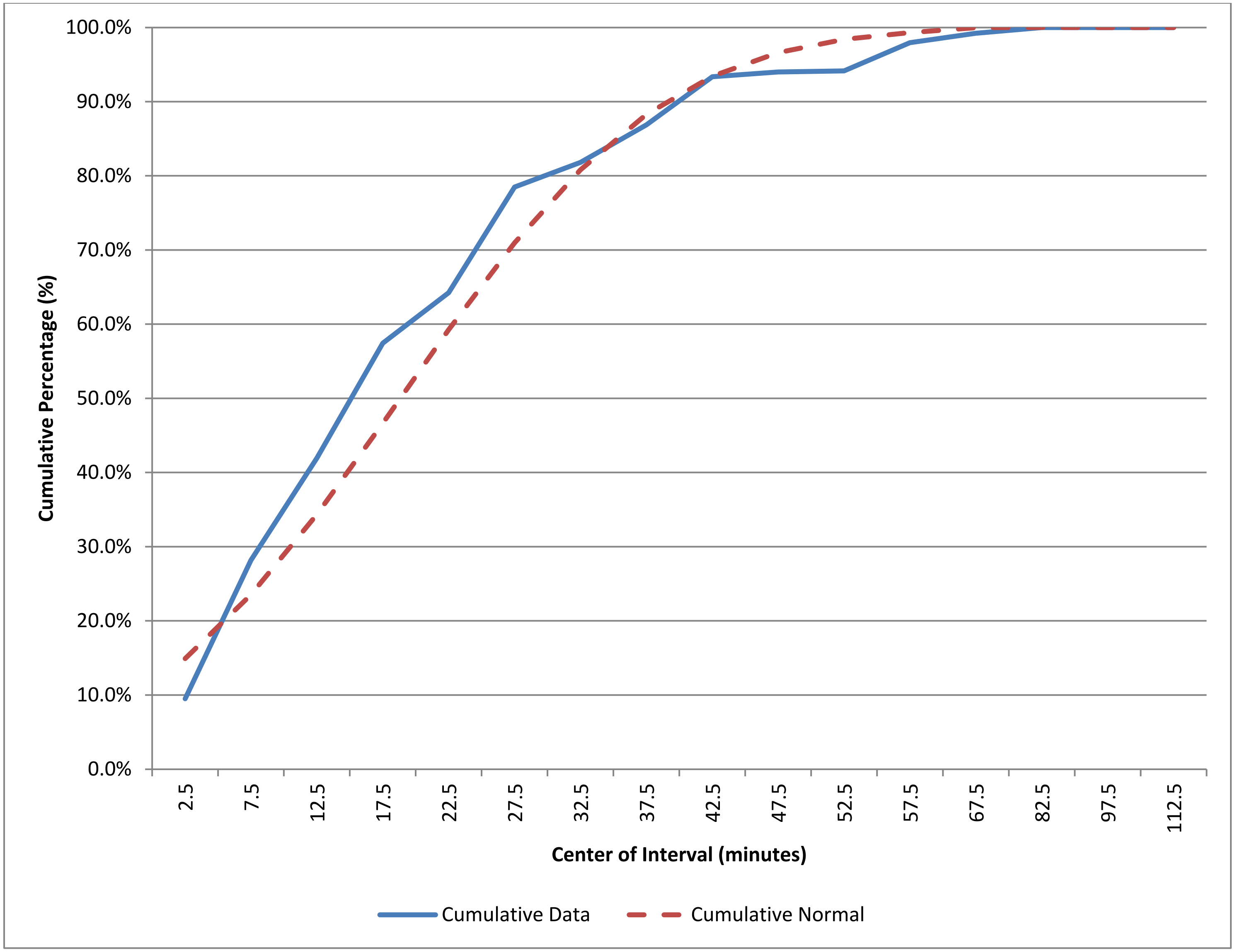


Figure 4-3. Comparison of Data Distribution and Normal Distribution

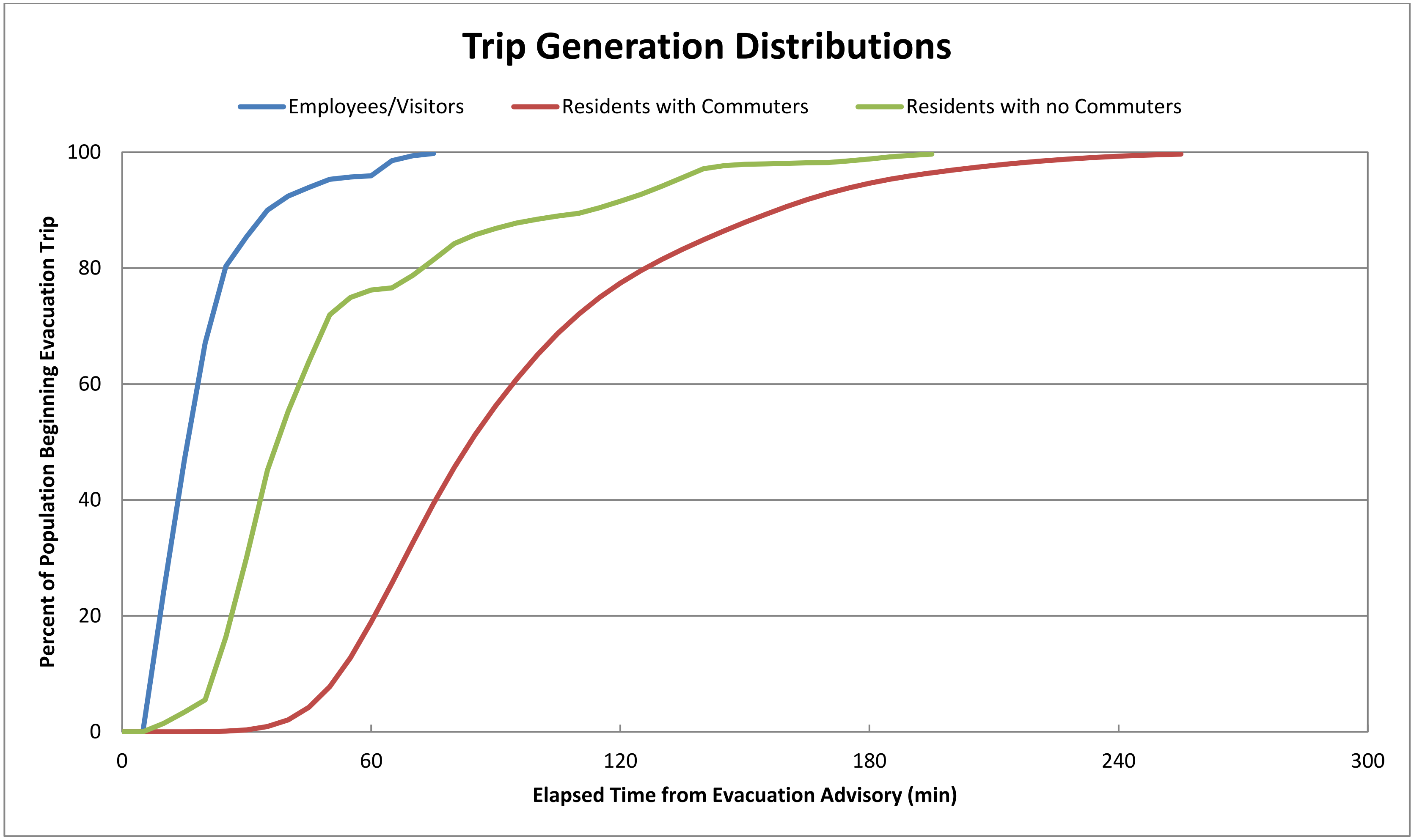


Figure 4-4. Comparison of Trip Generation Distributions

5 EVACUATION TIME ESTIMATES

5.1 Evacuation Scenarios

An evacuation scenario is a combination of circumstances, including time of day, day of week, season, and weather/roadway conditions. Scenarios define the number of people in each of the affected population groups and their respective mobilization time distributions. Three evacuation scenarios were evaluated. Table 1-2 is a description of all scenarios.

The percentage of each population group estimated to be in Ocean Hills during an emergency is summarized in Table 5-1. Table 5-2 presents the number of evacuating vehicles for each scenario based on the demand summarized in Section 2 and the scenario percentages in Table 5-1. The scenario percentages 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 57% (the number of households with at least one commuter) and 36% (the number of households with a commuter that would await the return of the commuter prior to evacuating) – 21%. When OHCC is included in this calculation, only 14% of households will await the return of household members, prior to beginning their evacuation trip. See assumption 16 in Section 1.5. It is estimated for weekend and evening scenarios that 10% of households with returning commuters (14%) will have a commuter at work during those times. Thus, scenarios 2 and 3 have 10% x 14% = 1.4%, rounded to 1% of households with returning commuters.
- Employment is estimated to be 100% during the week and 10% in the evenings and during the weekends.
- Service providers for OHCC are at maximum (100%) during midweek, midday and only 17% during the day on weekends, as per the data provided by OHCC. It is estimated that only 10% of service providers are present during evenings.
- Visitors for the church peak (100%) during the weekend, midday. Visitors are reduced to 25% for midweek, midday and reduced to 5% for evenings.
- Based on the data provided by OHCC, the rate of visitors at the club are the same (100%) during weekends and weekdays. It is assumed only 5% of visitors are present during evenings.
- Transit vehicles for the transit-dependent population and nursing home patients are 100% for all scenarios as it is assumed that the transit-dependent population and medical patients are present in Ocean Hills for all scenarios.
- External traffic is estimated to be reduced by 60% during evening scenarios and is 100% for all other scenarios.
- The shadow percentages are 2% (see assumption 5 in Section 1.4).

5.2 Patterns of Traffic Congestion during Evacuation

Figure 5-1 through Figure 5-4 illustrate the patterns of traffic congestion that arise during a summer, midweek, midday period under normal conditions (Scenario 1).

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

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

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

Figure 5-1 displays the congestion patterns in the study area 30 minutes after the advisory to evacuate (ATE). Pronounced congestion is already exhibited within OHCC. Moderate congestion (LOS D) is exhibited along CA-78 which services external-external trips through the study area. At this time, approximately 30% of vehicles have begun their evacuation trip and 25% of evacuating vehicles have successfully evacuated the area.

At 45 minutes after the ATE, Ocean Hills experiences peak congestion, as shown in Figure 5-2. South Melrose Drive exhibits LOS F conditions northbound from Cannon Road to Sunset Drive. The intersection of Leisure Village Drive (Mystra Drive) and Cannon Drive also experiences LOS F conditions. Portions of OHCC, New Venture Grace Church, Seagate Terrace, and Ocean Hills Senior living all meet at this intersection and compete for green time at the signalized intersection. Both roadways leaving OHCC are still operating at LOS F conditions. At this time, approximately 58% of vehicles have begun their evacuation trip and 47% of evacuating vehicles have successfully evacuated the area.

At one hour after the ATE, as shown in Figure 5-3, congestion has dissipated along South Melrose Drive, Shadowridge Drive and Mystra Drive; however, pronounced congestion remains within OHCC. Lake Boulevard is now operating at LOS C or better within Ocean Hills and is operating at

LOS F in the Shadow Region near Sky Haven Lane. CA-78 continues to operate at LOS C within the study area. At this time, approximately 70% of vehicles have begun their evacuation trip and 61% of evacuating vehicles have successfully evacuated the area.

All traffic congestion (LOS F) within Ocean Hills has dissipated at one hour and 30 minutes after the ATE, as shown in Figure 5-4. The last remnants of traffic volume within Ocean Hills are within OHCC, which is operating at LOS C or better. CA-78 is now operating at LOS B within the study area. All roadways within OHCC are operating at LOS A five minutes later at one hour and 35 minutes after the advisory, while CA-78 is operating at LOS A five minutes later at one hour and 40 minutes. At this time, approximately 83% of vehicles have begun their evacuation trip and 83% of evacuating vehicles have successfully evacuated the area.

After one hour and 30 minutes after the ATE, the rate at which vehicles mobilize and begin their evacuation trip equals the rate at which vehicles successfully evacuate the area, indicating no traffic congestion within Ocean Hills. Vehicles continue to mobilize and evacuate the area until four hours and 15 minutes after the ATE, which is the trip mobilization time.

5.3 Evacuation Rates

Evacuation is a continuous process, as implied by Figure 5-5 through Figure 5-7. These figures indicate the rate at which traffic flows out of Ocean Hills. 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 evacuating population mobilizes over four hours and 15 minutes, as discussed in Section 4. This disperses evacuees over a lengthy period of time; thus, as seen in Figure 5-5 through Figure 5-7, the maximum travel time experienced is approximately 15 minutes.

As indicated in these figures, there is typically a long "tail" to these distributions. The “tail” is the time needed to evacuate the last ten percent of population. As indicated in these figures, the tail starts around two hours after the ATE, and ends at four hours and 15 minutes after the ATE when mobilization time is complete. The tail can be caused by traffic congestion for densely populated areas as more than ten percent of the population is delayed at bottlenecks. The evacuation tail for Ocean Hills, however, is due to prolonged mobilization times for more than ten percent of the evacuating population.

Vehicles begin to evacuate an area slowly at first (moderate slope for the ETE curve), as people respond to the ATE at different rates. Then traffic demand builds rapidly (slope of ETE curve increases significantly). As more routes clear, the aggregate rate of egress slows (slope of ETE curve flattens) since many vehicles have already left Ocean Hills. 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.

5.4 General Population Evacuation Time Estimate Results

Table 5-3 presents the ETE values for all evacuation scenarios for both the 90th and 100th percentiles. The 100th percentile ETE equals 4:15 (Hours:Minutes) for all scenarios. Since the trip generation time is also 4 hours and 15 minutes, an ETE equal to the trip mobilization time implies that traffic congestion clears within Ocean Hills prior to the completion of mobilization time. This indicates that the quicker the evacuation population is mobilized (faster notification, less time to prepare home, leave work and drive home), the quicker the area will be evacuated (100th percentile ETE will be reduced). The 90th percentile ETE ranges between 1:50 (Hours:Minutes) and 1:55 (Hours:Minutes) for all scenarios.

Traffic congestion within Ocean Hills clears prior to one hour and 30 minutes after the ATE as indicated in Section 5.2 and in Figure 5-1 through Figure 5-4. Figure 5-5 through Figure 5-7 also illustrate that traffic congestion within Ocean Hills is non-existent beyond one hour and 30 minutes after the ATE as the Trip Generation (Mobilization Time) and ETE curves are coincident beyond one hour and 30 minutes. The roadway system surrounding Ocean Hills is robust. Cannon Road is an excellent, high-capacity roadway with two outbound lanes. The roadways servicing Ocean Hills provide access to six different interchanges (Vista Way/Plaza Dr, S Emerald Dr, Vista Village Dr, Civic Center Dr, Mar Vista Dr, and Sycamore Ave) with CA-78, which is a high-capacity, high-speed, limited access freeway. The only prolonged traffic congestion within the area is at OHCC, which is somewhat capacity constrained given the number of people living in the community and only two connections (Leisure Village Dr and Ocean Hills Dr) to the surrounding roadway system. Overall, there are few issues with evacuating Ocean Hills as the roadway system has ample capacity to service the vehicular demand. Evacuation times closely parallel mobilization times, and evacuation travel time is minimal.

5.5 Transit-Dependent Population Evacuation Time Estimate Results

This section details the computation 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 nursing homes.

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 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.

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.

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 when approximately 90% of their passengers have completed their mobilization. As shown in Figure 4-4 (Residents with no Commuters), approximately 90% of evacuees will complete their mobilization when the buses will begin their routes 90 minutes after the evacuation advisory.

Those buses servicing the transit-dependent evacuees will first travel through Ocean Hills, then proceed out of the area at risk. It is assumed that residents will walk to and congregate along Cannon Road and that they can arrive at the stops within 90 minutes after the evacuation advisory. A pickup time of 30 minutes is estimated for 3 individual stops to pick up passengers, with an average of 10 minutes of delay associated with each stop.

The travel distance along the respective pick-up routes within Ocean Hills was estimated using GIS mapping software. Transit vehicle travel times within Ocean Hills are computed using average speeds computed by DYNEV. Table 5-4 presents the transit-dependent population evacuation time estimates using the above procedures for normal conditions.

For example, the ETE for the transit vehicle is computed as 90 + 3 + 30 = 2:05 (rounded up to nearest 5 minutes). Here, 3 minutes is the time to travel 1.3 miles at 38.3 mph, the average speed output by the model for this route at 90 minutes.

Evacuation of Nursing Homes

The transit vehicle operations for this group are similar to those for transit-dependent 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 patients per ambulance.
- Wheelchair transport vehicles can accommodate 15 patients per wheelchair bus

Table 2-6 indicates that 4 bus runs, 6 wheelchair bus runs, and 2 ambulance runs are needed to service the two nursing homes within Ocean Hills.

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 5-5 summarizes the ETE for nursing homes within Ocean Hills. The distance from each nursing home to the boundary was measured using GIS software and is provided in Table 5-5 (“Dist. to Bdry”). Average speeds output by the DYNEV model for Scenario 1 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. All ETE are rounded up to the nearest 5 minutes.

As discussed in Section 1.5, Item 8, loading times for nursing homes are as follows:

- 1 minute per passenger for those who can walk from the nursing home to the bus
- 5 minutes per passenger for those in wheelchairs who will be assisted by medical staff onto wheelchair buses
- 15 minutes per passenger for those who are bedridden and will be loaded by medical staff into ambulances
- Concurrent loading on multiple buses, wheelchair buses, and ambulances at capacity is assumed, such that the maximum loading time is 30 minutes, 75 minutes and 30 minutes for buses, wheelchair buses, and ambulances, respectively.

For example, the calculation of ETE for Ocean Hills Senior Living's ambulatory patients is:

ETE: 90 + 30 (1-minute loading time per patient on multiple buses) + 2 = 122 min. or 2:05 rounded up to the nearest 5 minutes.

Table 5-1. Percent of Population Groups Evacuating for Various Scenarios

Scenario	Households With Returning Commuters	Households Without Returning Commuters	Employees	Church Visitors	Shadow	OHCC Visitors	OHCC Service Providers	Medical Vehicles	Transit Buses	External Through Traffic
1	14%	86%	100%	25%	2%	100%	100%	100%	100%	100%
2	1%	99%	10%	100%	2%	100%	17%	100%	100%	100%
3	1%	99%	10%	5%	2%	5%	10%	100%	100%	40%

Households with Returning Commuters ....Households of Ocean Hills residents who await the return of commuters prior to beginning the evacuation trip.
Households without Returning Commuters....Households of Ocean Hills residents who do not have commuters or will not await the return of commuters prior to beginning the evacuation trip.
Employees ....Year-round Ocean Hills employees who live outside Ocean Hills.
Church Visitors..People who are in Ocean Hills visiting New Venture Grace Church.
Shadow ....Residents in the shadow region who will spontaneously decide to relocate during the evacuation.
OHCC Visitors..Guests visiting residents of OHCC.
OHCC Service Providers.............................Service Providers present inside OHCC.
Medical and Transit Vehicles.....................Vehicle-equivalents present on the road during evacuation servicing nursing homes and transit-dependent people (1 bus is equivalent to 2 passenger vehicles).
External Through Traffic............................Traffic on CA-78 at the start of the evacuation. This traffic is stopped by access control 2 hours after the evacuation begins.

Table 5-2. Vehicle Estimates by Scenario

Scenario	Households With Returning Commuters	Households Without Returning Commuters	Employees	Church Visitors	Shadow	OHCC Visitors	OHCC Service Providers	Medical Vehicles	Transit Buses	External Through Traffic	Total Scenario Vehicles
1	769	4,683	243	123	424	63	165	22	6	12,864	19,362
2	77	5,375	24	490	424	63	28	22	6	12,864	19,373
3	77	5,375	24	25	424	3	17	22	6	5,146	11,119

Table 5-3. Time to Clear Ocean Hills

	Summer		Summer
	Midweek	Weekend	Midweek Weekend
Scenario:	**(1)**	**(2)**	**(3)**
Percent of the Affected Population	**Midday**		**Evening**
	Good Weather	**Good Weather**	**Good Weather**
90%	1:55	1:50	1:50
100%	4:15	4:15	4:15

Table 5-4. Transit-Dependent Evacuation Time Estimates

Bus Route	Mobilization (min)	Route Length (miles)	Speed (mph)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)
Ocean Hills Transit Dependent Population	90	1.3	38.3	3	30	**2:05**

Table 5-5. Nursing Home Evacuation Time Estimates

Medical Facility	Patient	Mobilization (min)	Loading Rate (min per person)	People	Total Loading Time (min)	Dist. To Bdry (mi)	Speed (mph)	Travel Time to Safety (min)	ETE (hr:min)
Ocean Hills Senior Living	Ambulatory	90	1	48	30	1.1	32.6	2	**2:05**
	Wheelchair Bound	90	5	45	75	1.1	33.2	2	**2:50**
	Bedridden	90	15	2	30	1.1	32.6	2	**2:05**
Aegis Living Shadowridge	Ambulatory	90	1	42	30	0.4	39.1	1	**2:05**
	Wheelchair Bound	90	5	40	75	0.4	39.3	1	**2:50**
	Bedridden	90	15	2	30	0.4	39.1	1	**2:05**
								Maximum ETE:	**2:50**
								Average ETE:	**2:20**

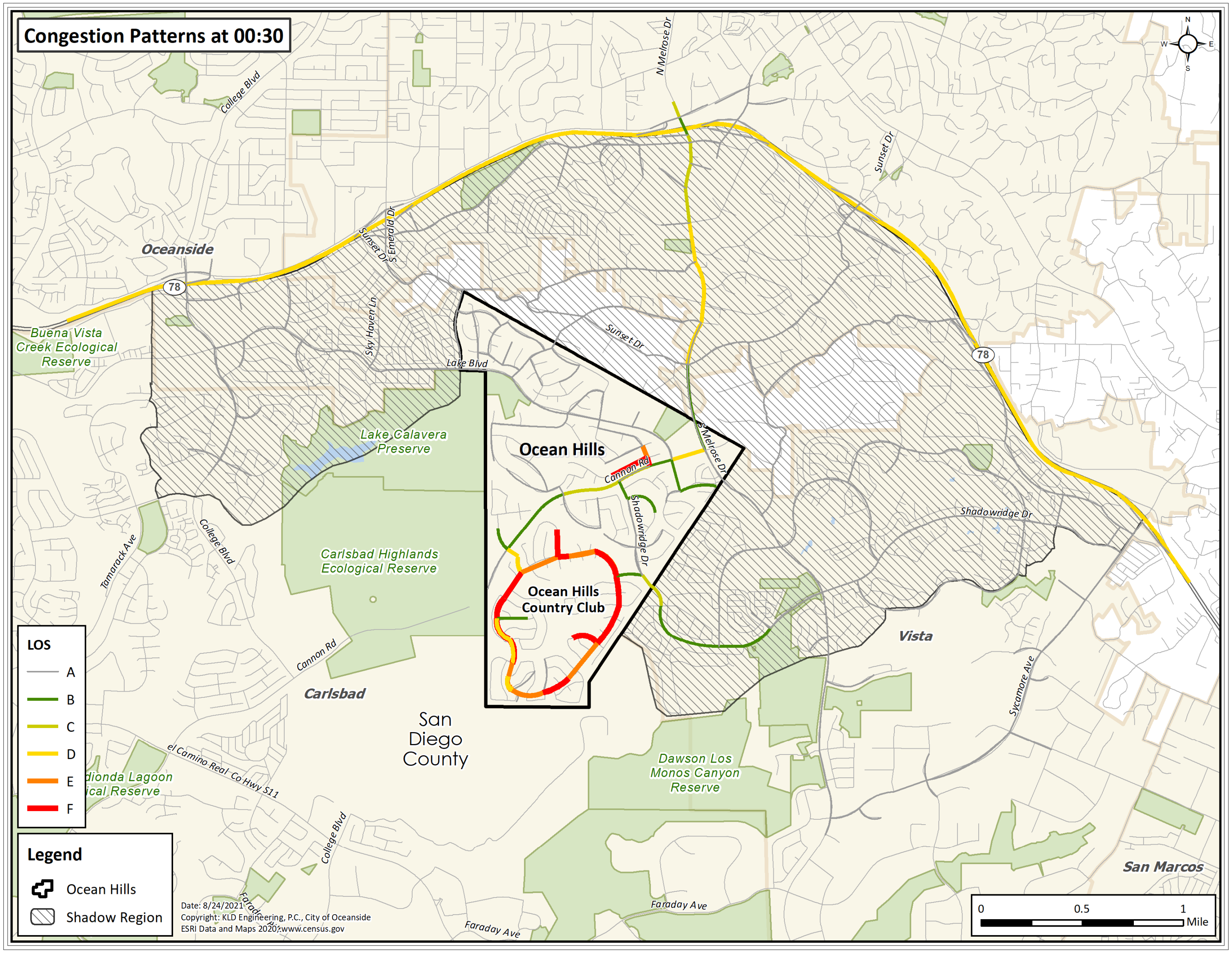


Figure 5-1. Congestion Patterns at 30 Minutes after the Advisory to Evacuate

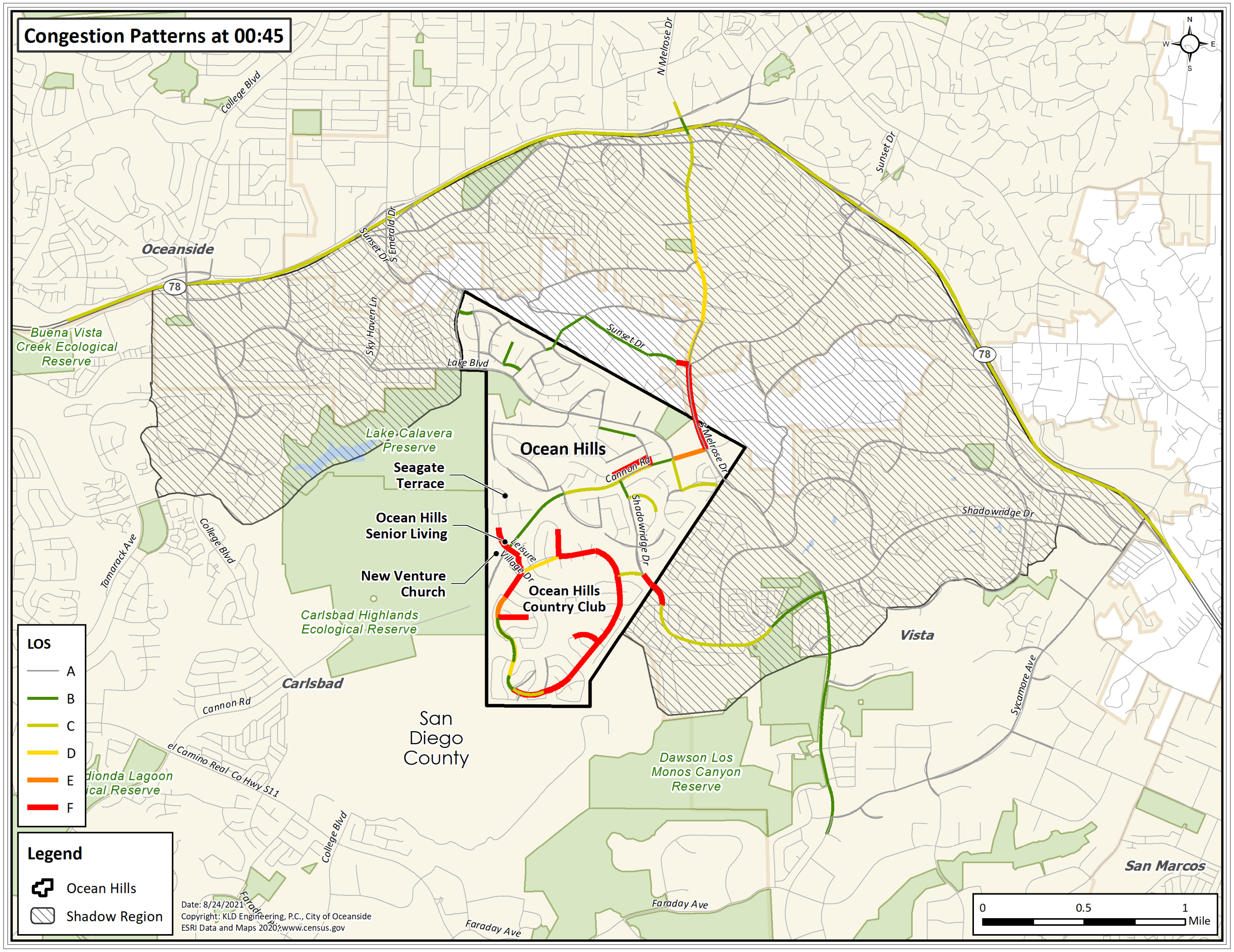


Figure 5-2. Congestion Patterns at 45 Minutes after the Advisory to Evacuate

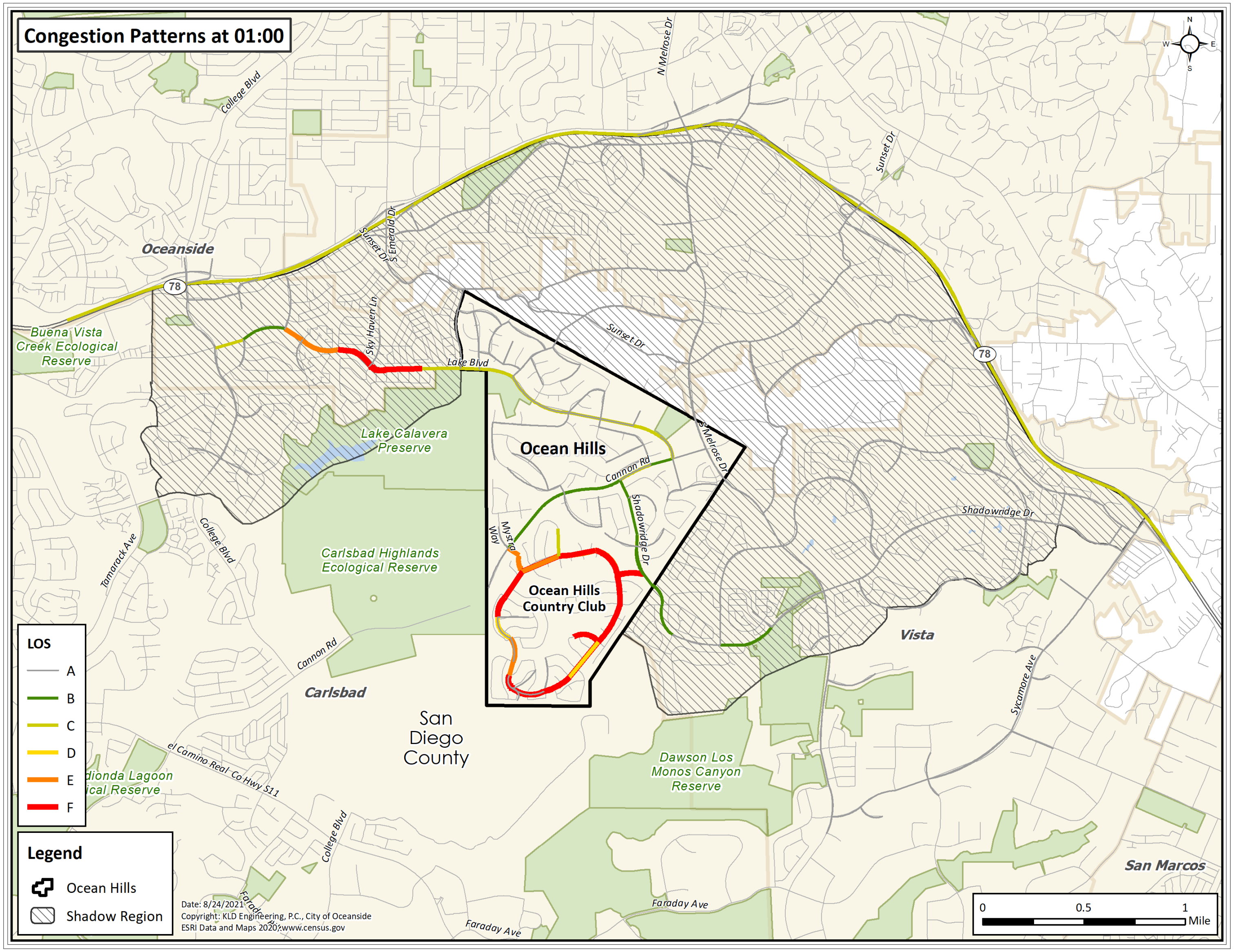


Figure 5-3. Congestion Patterns at 1 Hour after the Advisory to Evacuate

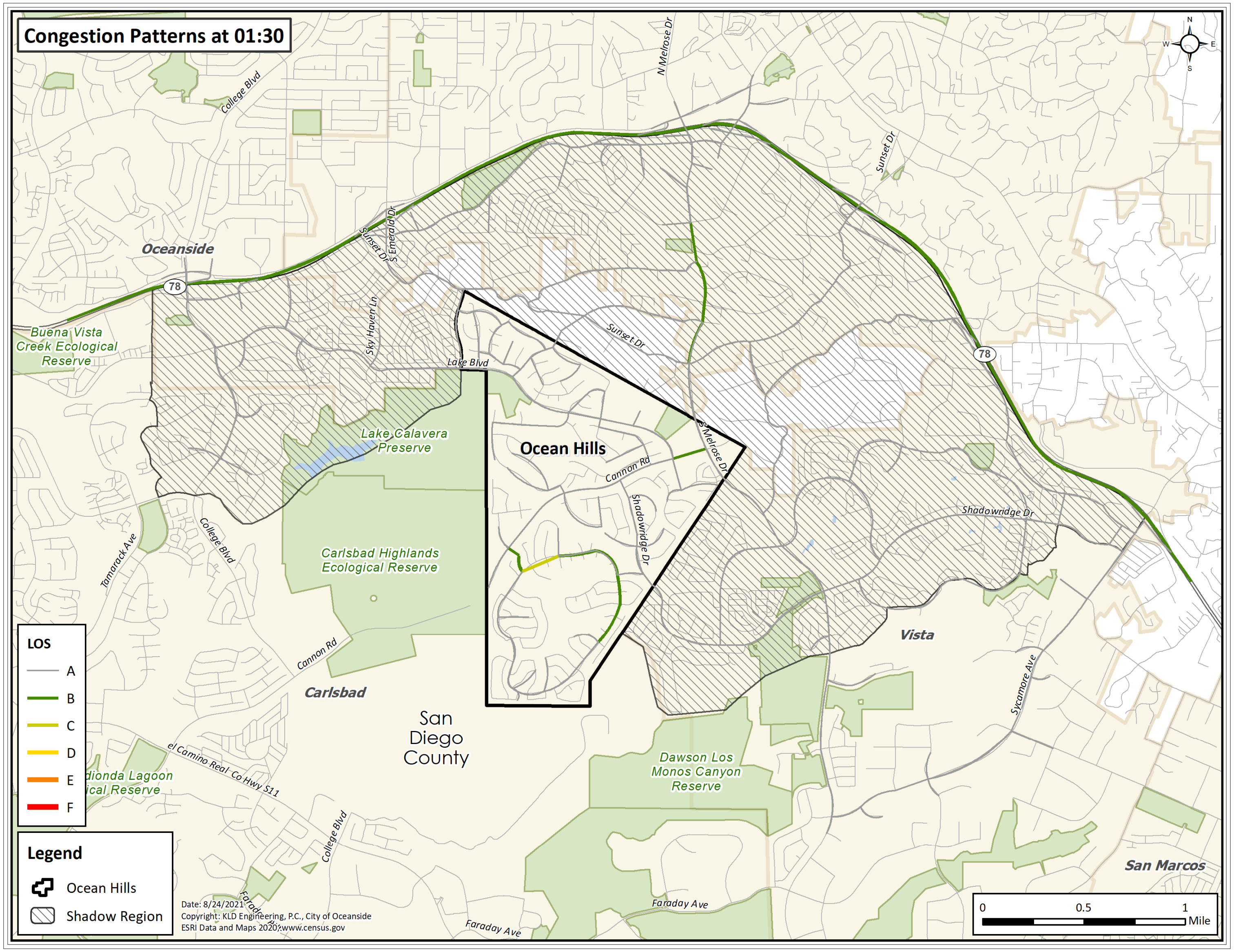


Figure 5-4. Congestion Patterns at 1 Hour and 30 Minutes after the Advisory to Evacuate

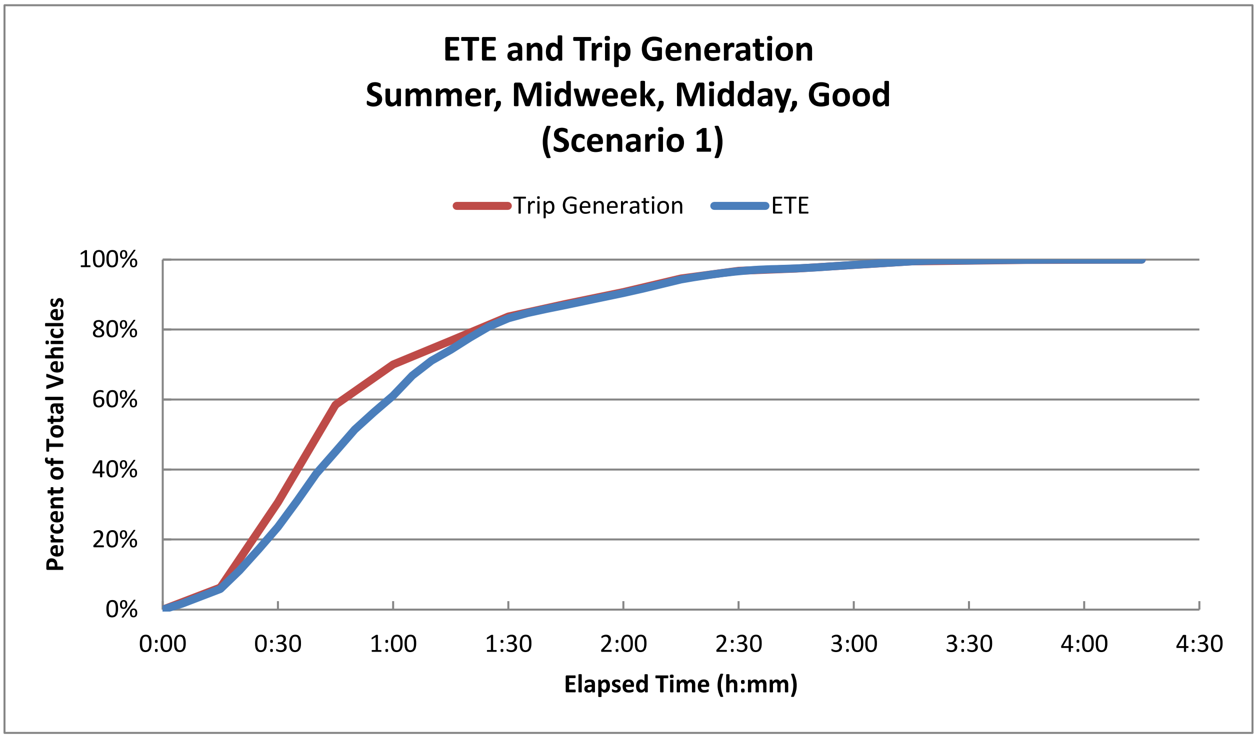


Figure 5-5. Evacuation Time Estimates - Scenario 1

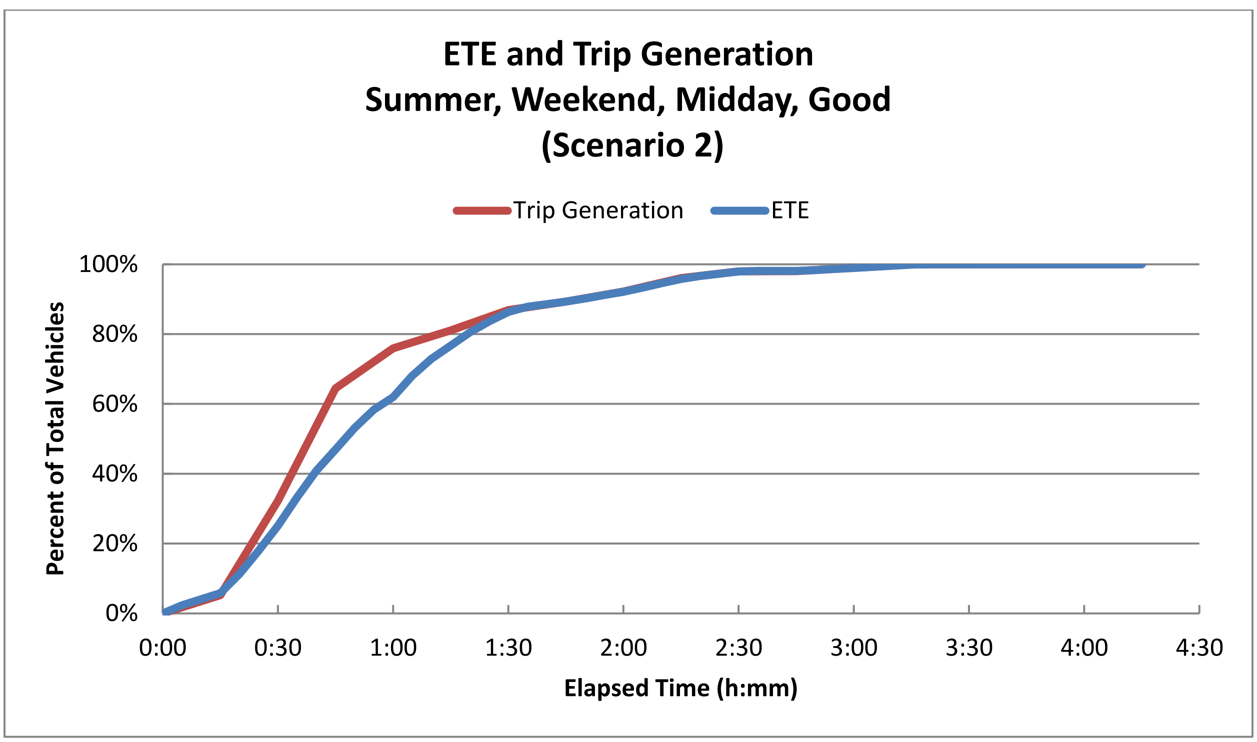


Figure 5-6. Evacuation Time Estimates - Scenario 2

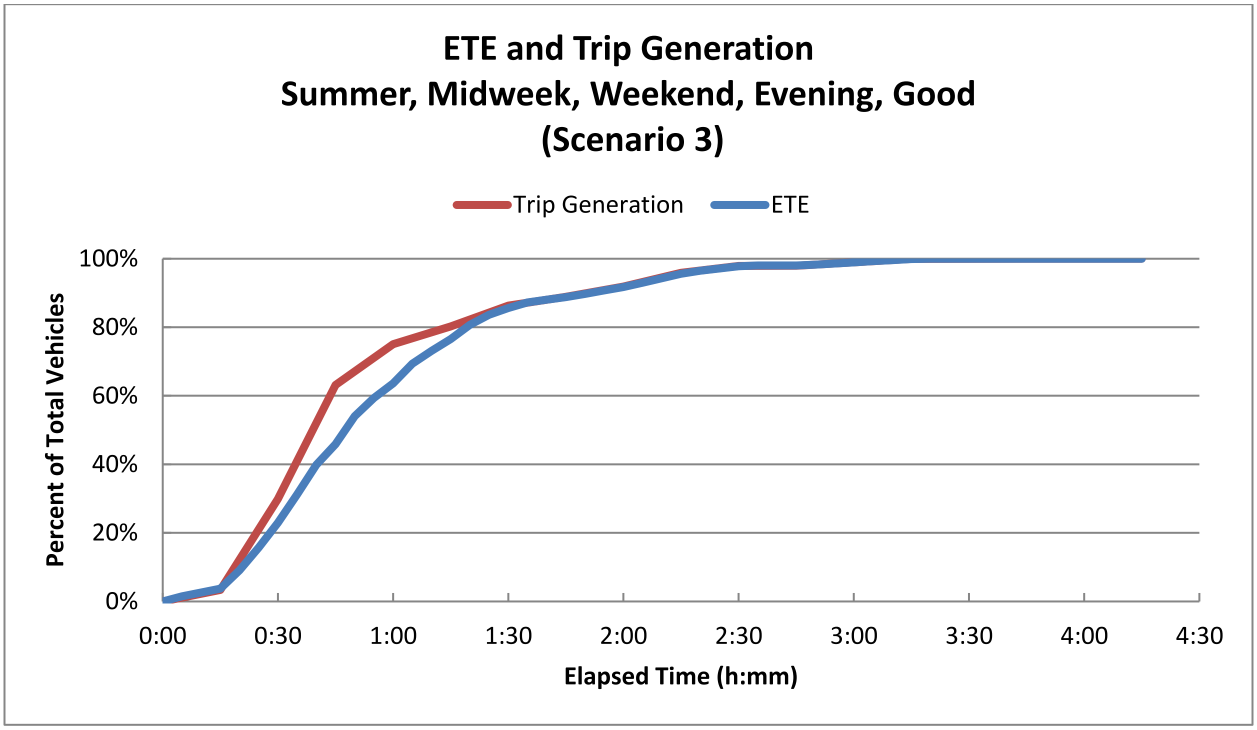


Figure 5-7. Evacuation Time Estimates - Scenario 3

APPENDIX A

Demographic Survey

A. DEMOGRAPHIC SURVEY

A.1 Introduction

The development of evacuation time estimates for the Neighborhood of Ocean Hills 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 Ocean Hills 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 …?”).

A.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.

The demographic survey was conducted through an online form. The website was advertised to the communities within the neighborhood from March 24, 2021, through June 8, 2021. During the survey period, 656 surveys were completed by residents of Ocean Hills, parents that have kids in schools within Ocean Hills, and employees working in Ocean Hills. Table A-1 shows the number of completed surveys by community/homeowner’s association (HOA) within Ocean Hills.

A.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, and certain technology uses in the household. 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. The time distribution data are processed to develop the trip generation distributions used in the evacuation modeling effort and are discussed in Section 4.

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.

A.3.1 Household Demographic Results

Household Size

Figure A-1 presents the distribution of household size within Ocean Hills based on the responses to the demographic survey. The average household contains 1.89 people.

Automobile Ownership

The average number of automobiles available per household in the study area is 1.65. The distribution of automobile ownership is presented in Figure A-2. It should be noted that less than 0.5% of households do not have access to a vehicle. Figure A-3 and Figure A-4 present the automobile availability by household size. As expected, all households of 2 or more people have access to at least one vehicle.

Ridesharing

An overwhelming proportion (76%) of the households surveyed responded that they could share a ride with a neighbor, relative, or friend if a car was not available to them when advised to evacuate.

Commuters

Figure A-5 and Figure A-6 present the distribution of the number of commuters in each household for the Ocean Hills Country Club (OHCC) and all other communities/HOAs in Ocean Hills besides OHCC, respectively. Commuters are defined as household members who travel to work or college on a daily basis. The data shows an average of 0.07 commuters per household inside Ocean Hills Country Club (OHCC), and an average of 1.00 commuter per household within the rest of Ocean Hills. The commuters within Ocean Hills will be handled separately in the study between OHCC and all other communities/HOAs as most OHCC residents are retired.

Commuter Travel Modes

Figure A-7 presents the mode of travel that commuters use on a daily basis. The vast majority of commuters use their private automobiles to travel to work. The data shows an average of 1.09 employees per vehicle, assuming 2 people per vehicle – on average – for carpools.

A.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 an evacuation?" The response is shown in Figure A-8. On average, evacuating households would use 1.35 vehicles.

"Would your family await the return of other family members prior to evacuating the area?" Of the survey participants who responded, approximately 36% said they would await the return of other family members before evacuating and 64% 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 43% of the households have pets and/or animals. Of the households that own pets and/or animals, 99% of them indicated that they own a domesticated animal (or household pet). This category includes dogs, cats, birds, reptiles, rabbits, chinchilla and fish. Approximately 1% of households own farm animals like chickens. Figure A-9 presents these percentages.

"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 99% of households that own pets and/or animals would take them during an evacuation. Of the households with pets and/or animals, 99% indicated that they have sufficient room in their vehicles to evacuate with them. Approximately 1% of respondents who have pets and/or animals would leave them at home during an evacuation. Of the respondents who would elect to take their animals with them during an evacuation, 18% would take them to a shelter, and 81% would take them somewhere else. These percentages are displayed in Figure A-10.

"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 98% of households who are advised to shelter-in-place would do so; the remaining 2% would choose to evacuate the area. Therefore, 2% of the population within the shadow region will voluntarily evacuate.

"Emergency officials advise you to evacuate due to an emergency. Where would you evacuate to?" Based on the responses, approximately 55% of evacuating households would evacuate to a friend/relative's home. Approximately 20% of households would evacuate to a hotel, motel, or campground. See Figure A-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. Based on the respondents who elected to answer, approximately 94% said they would notify a neighbor or a friend.

"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. From the respondents who elected to notify a neighbor or friend during an evacuation, 43% would choose to notify them in person. From the remaining respondents, 23% would notify neighbors or friends using a text message, 33% would notify them over the phone, and 1% would notify them using some form of social media. Figure A-12 displays these results.

"How would you rate the cell phone coverage in your area?" Figure A-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, 92% of respondents rated cell phone coverage as very reliable in their area. 8% of respondents rated their cell phone coverage as reliable for text only, unreliable or as no coverage.

"Would members of your household require Functional or Transportation needs during an evacuation?" Out of 656 survey respondents, 41 households stated they would need transportation assistance to evacuate. 7 households who require transportation assistance would require a bus, 9 households would require a medical bus/van, 2 households would require an ambulance and 22 households would require a wheelchair accessible vehicle. One household indicated that they would require some other form of transportation, as shown in Figure A-14.

"Have you opted into your local Emergency Alert and Warning systems?" Figure A-15 displays the percentages of respondents who have opted into their local emergency alert and warning systems by method. From the respondents, approximately 66% indicated that they have opted into their local emergency alert systems. Of the residents that have opted in, 29 percent indicated that they registered using their residential phone number, 86 percent using their cell phone number, 31 percent using their email address and/or 58 percent opted in by text message. It should be noted some people are opted into multiple methods of notification. The majority of the study area residents who are registered are opted into Alert San Diego (57 percent) while a few indicated they are opted into other emergency alert systems (three percent).

Table A-1. Completed Surveys by Community/HOA

Community/HOA	Number of Completed Surveys
Ocean Hills Country Club	518
Ocean Terrace	53
Seagate Terrace	38
The Summit	3
Ridgeview Estates	3
Southridge Estates	3
Terramar	1
Broadmore Hills	1
Windrift Apartments	24
Parents with School Children	5
Employees of Ocean Hills	1
Decline to State or Left Blank	6
TOTAL:	**656**

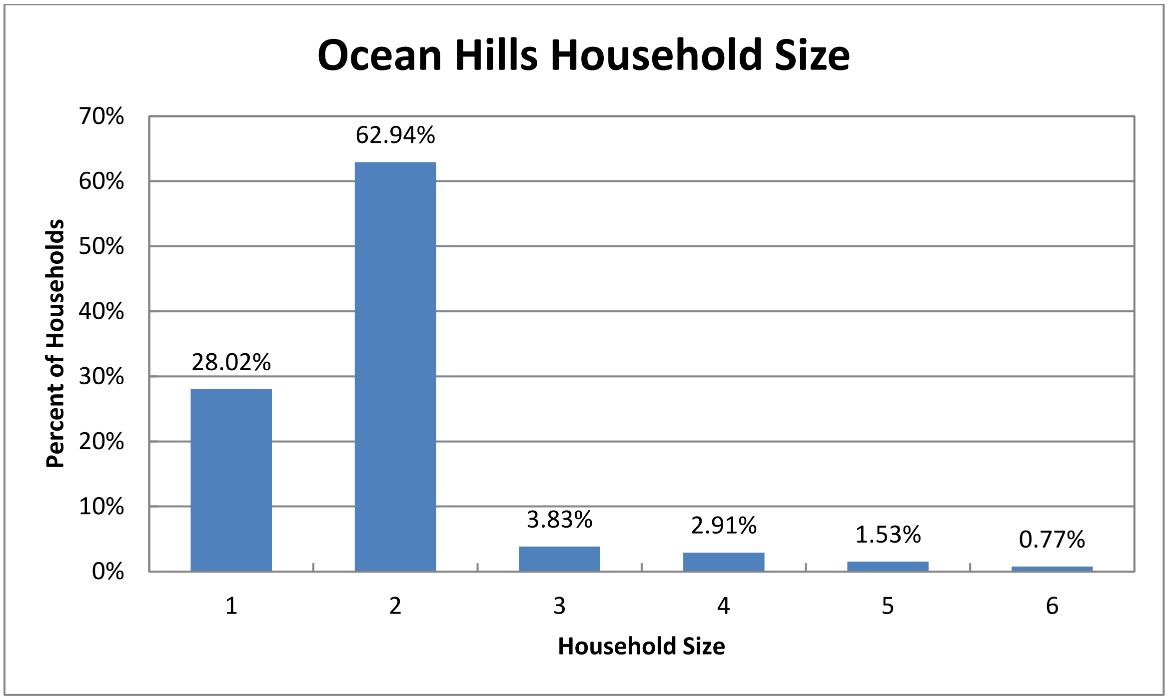


Figure A-1. Household Size in the Study Area

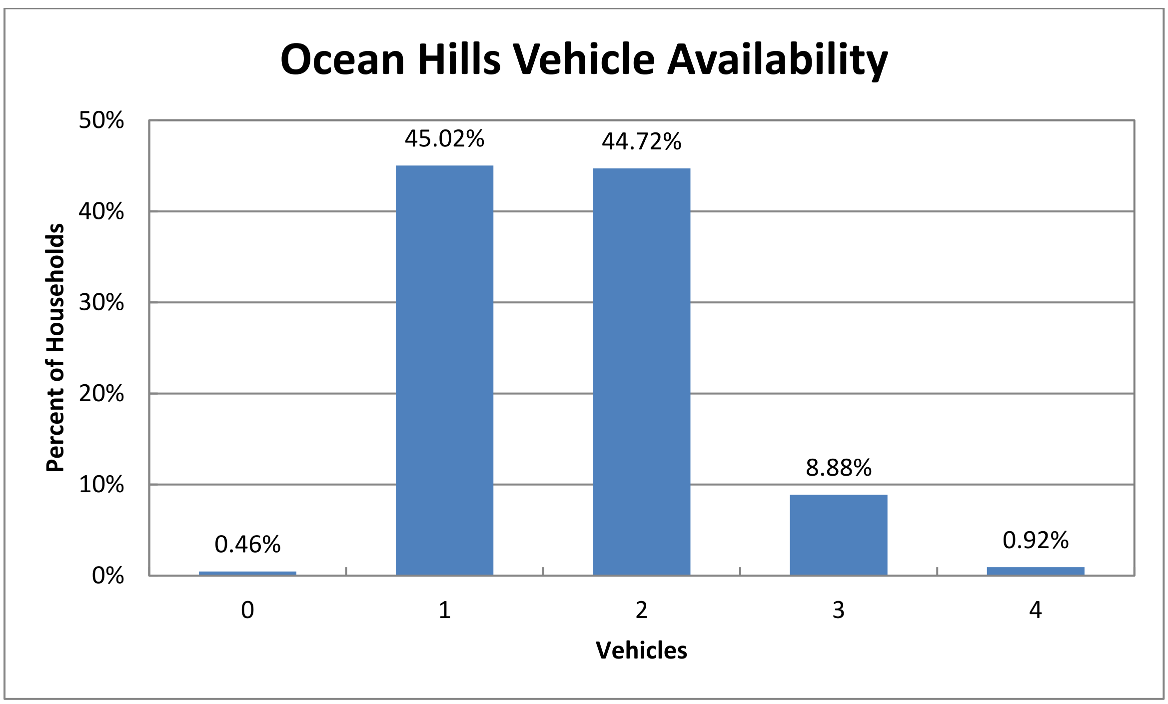


Figure A-2. Vehicle Availability

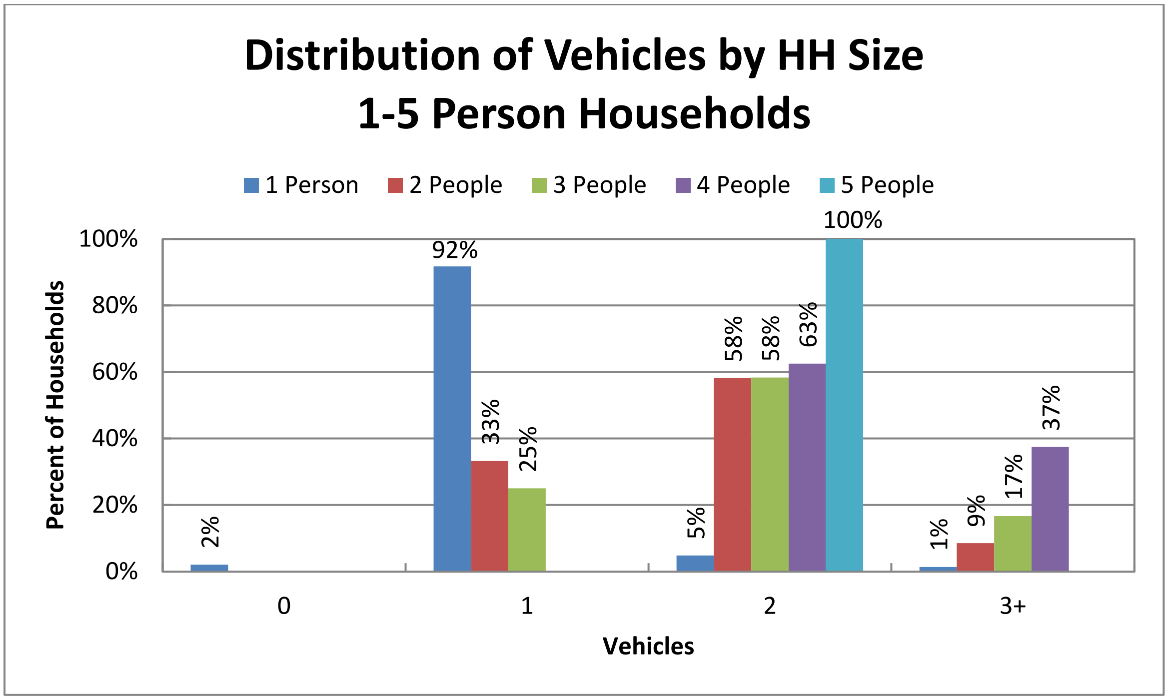


Figure A-3. Vehicle Availability – 1 to 5 Person Households

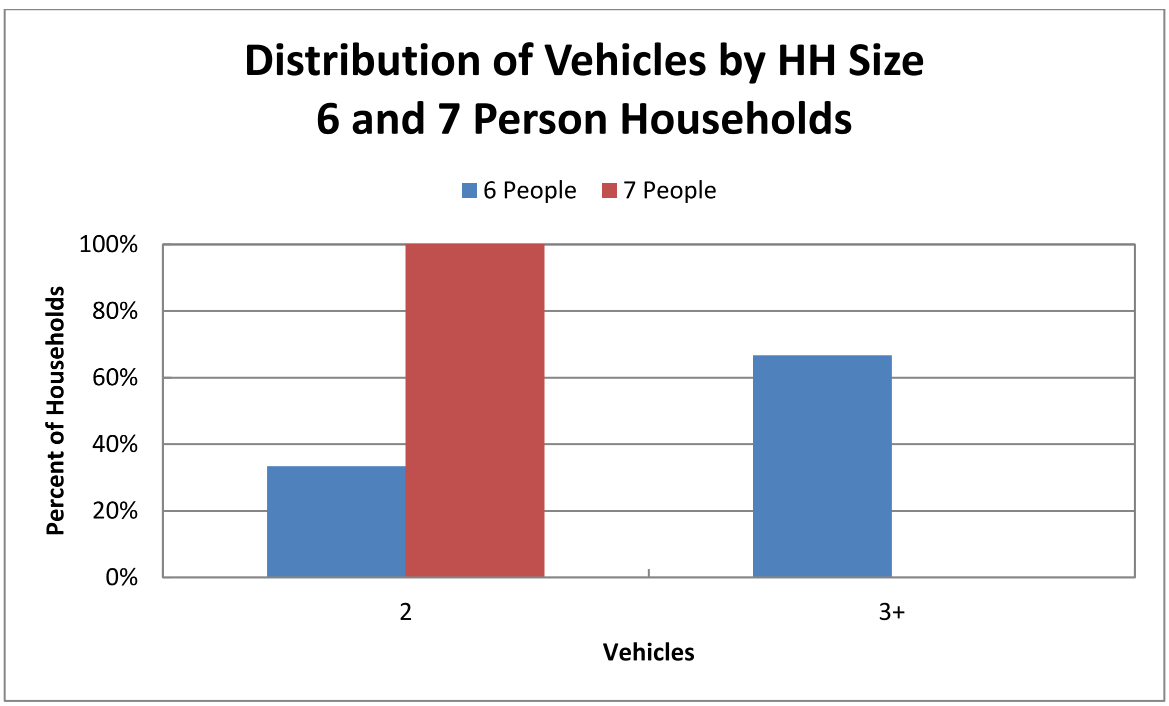


Figure A-4. Vehicle Availability – 6 to 7 Person Households

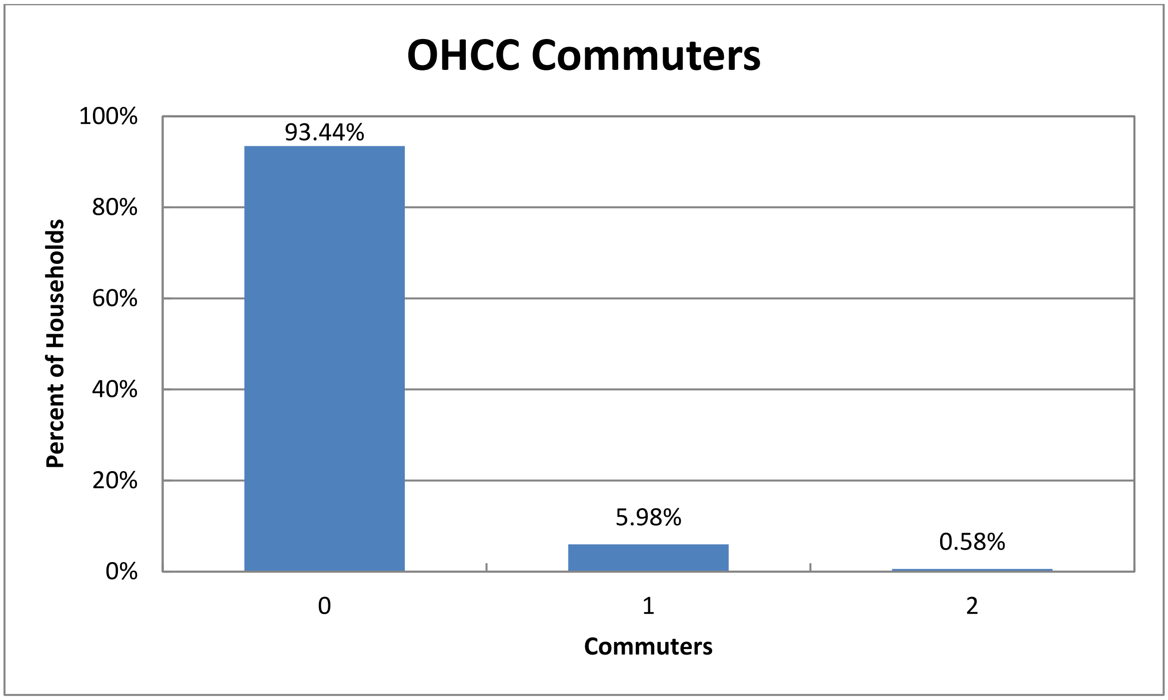


Figure A-5. Commuters in Households in OHCC

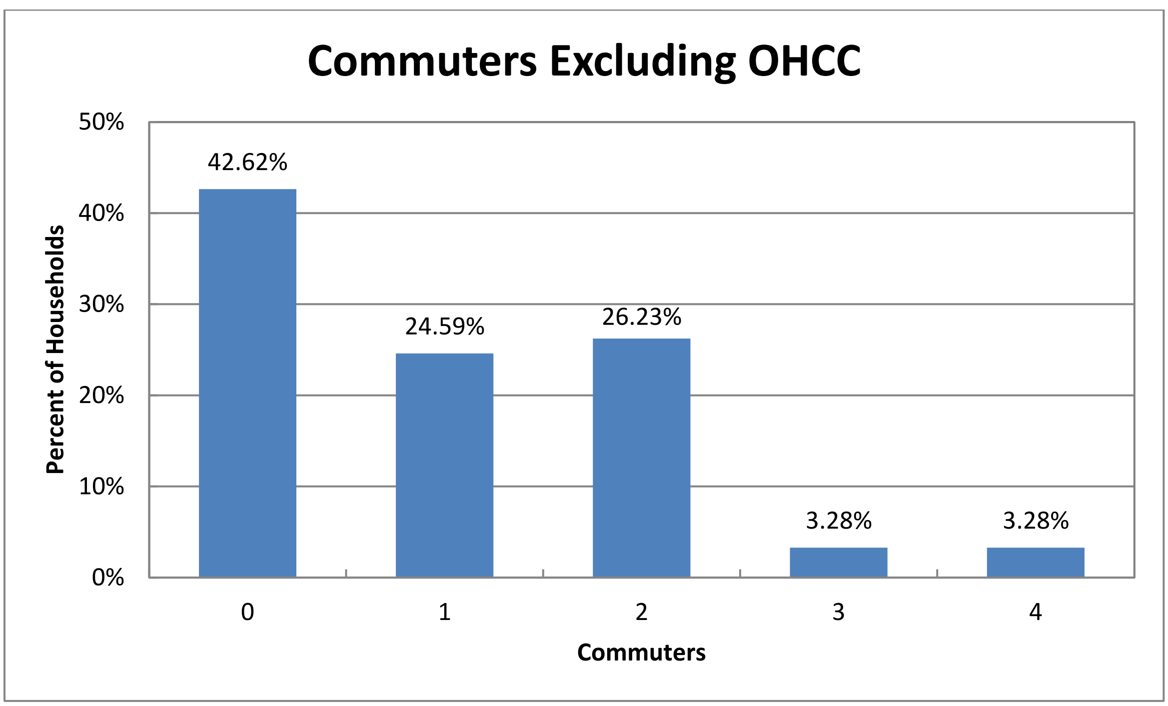


Figure A-6. Commuters in Households Excluding OHCC

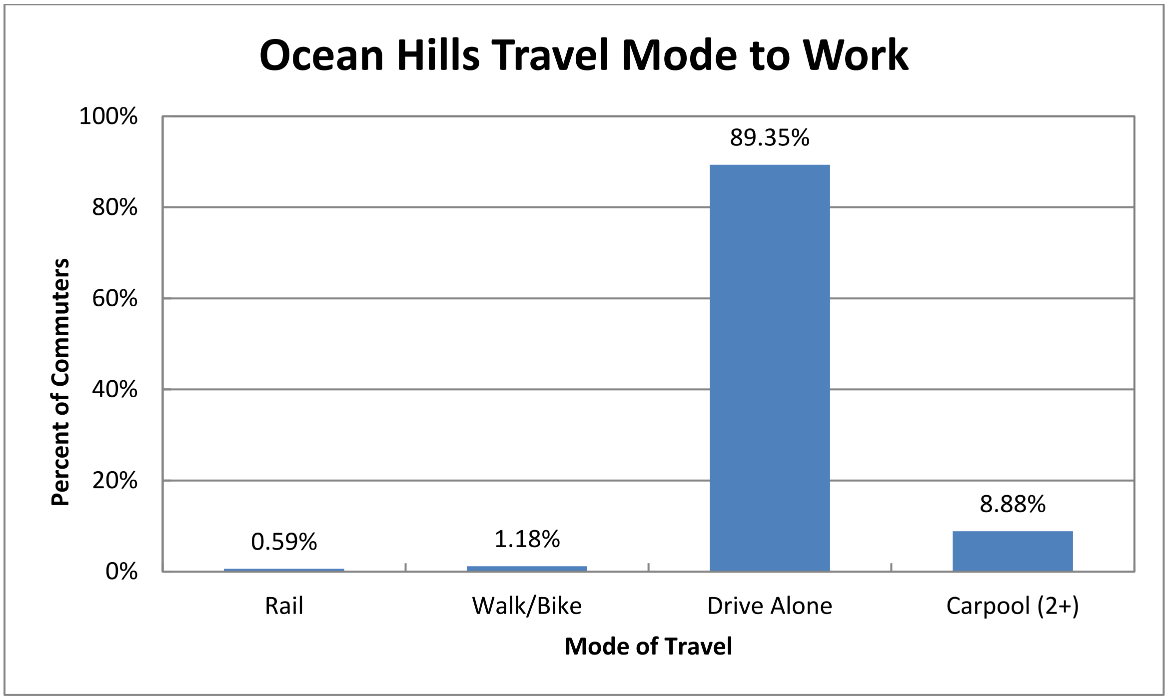


Figure A-7. Modes of Travel in the Study Area

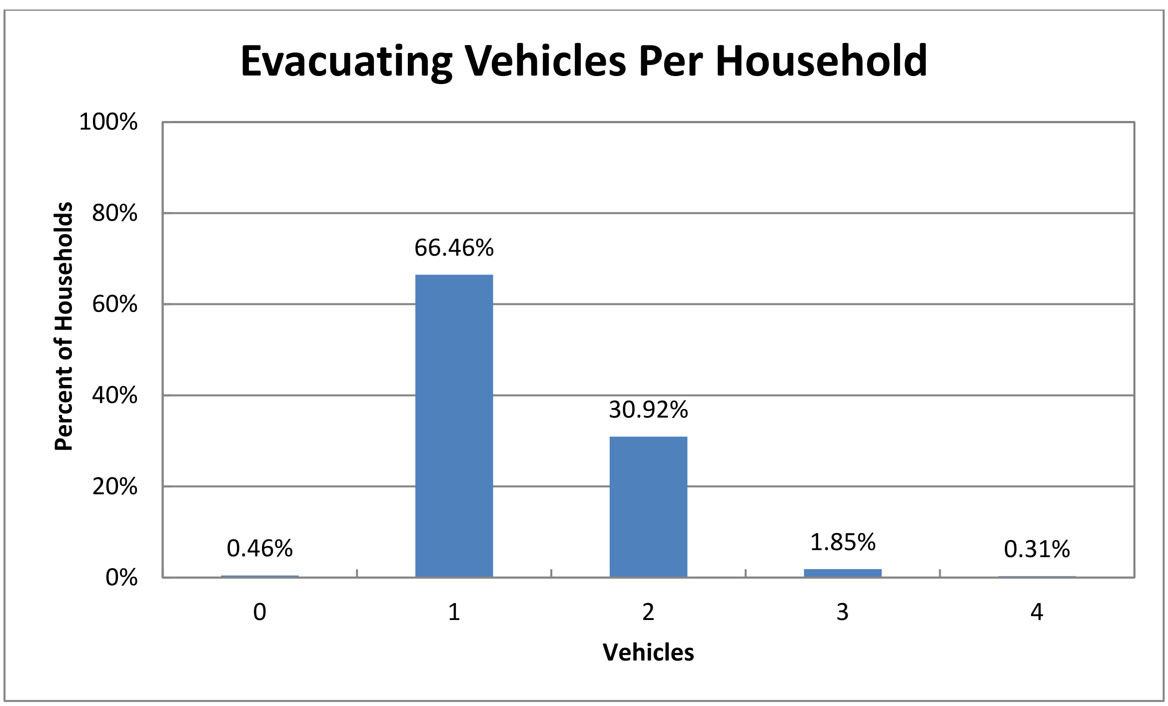


Figure A-8. Number of Vehicles Used for Evacuation

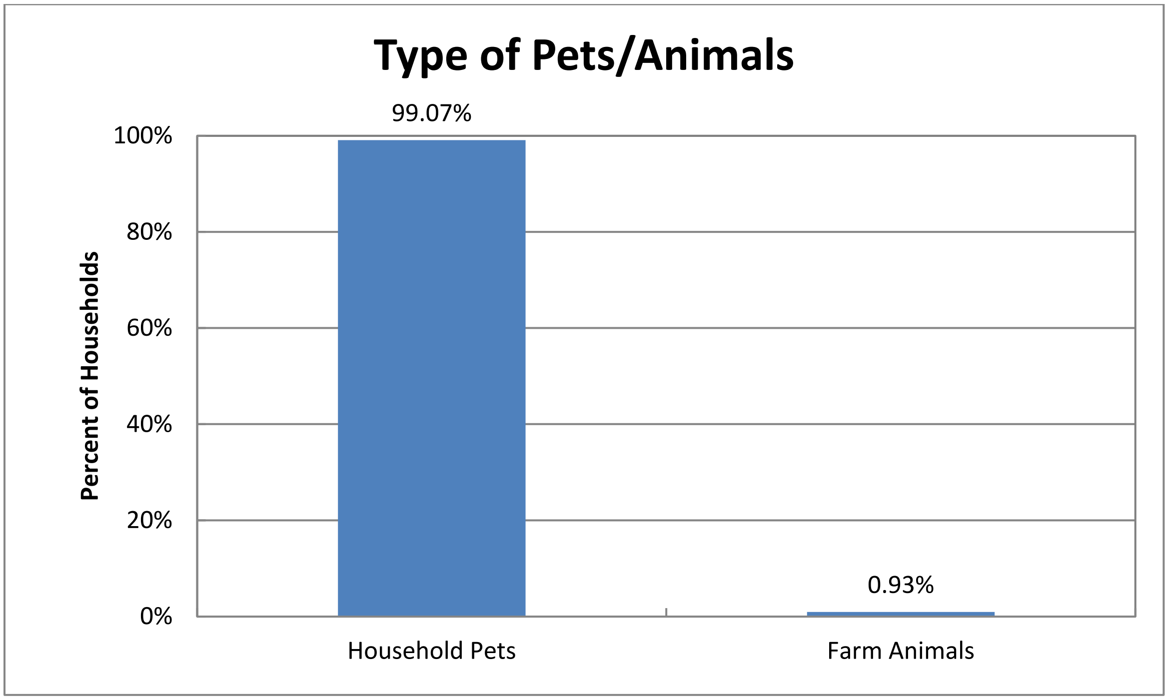


Figure A-9. Types of Pets/Animals

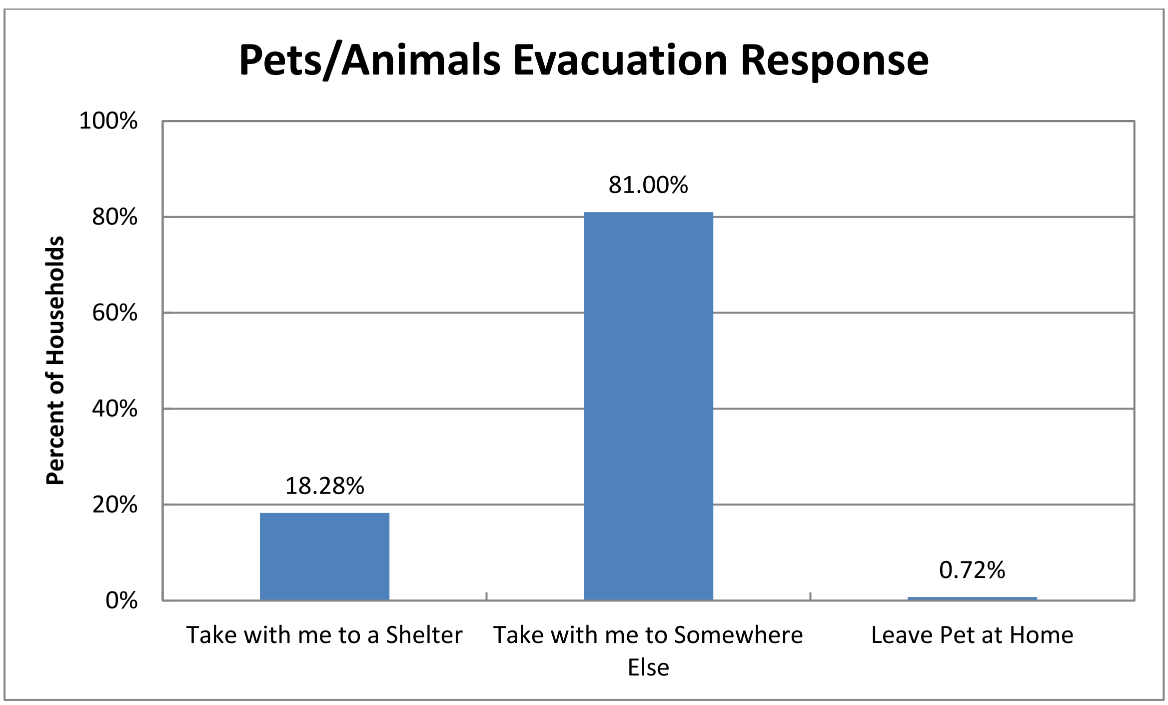


Figure A-10. Pets/Animals Evacuation Response

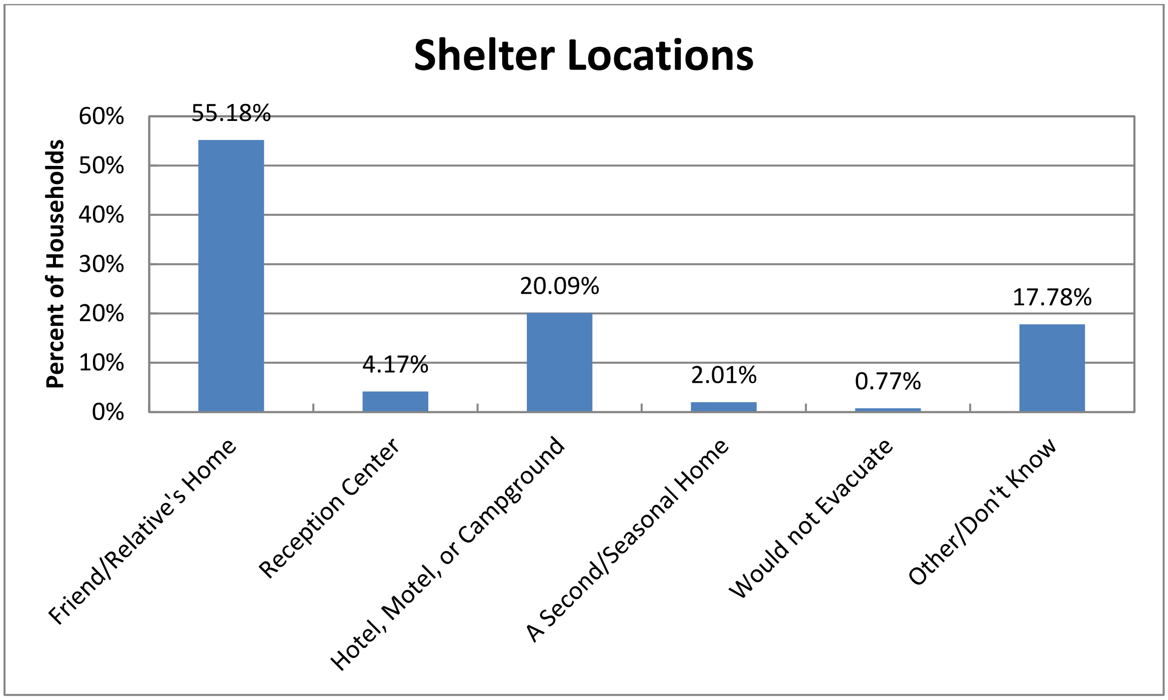


Figure A-11. Study Area Shelter Locations

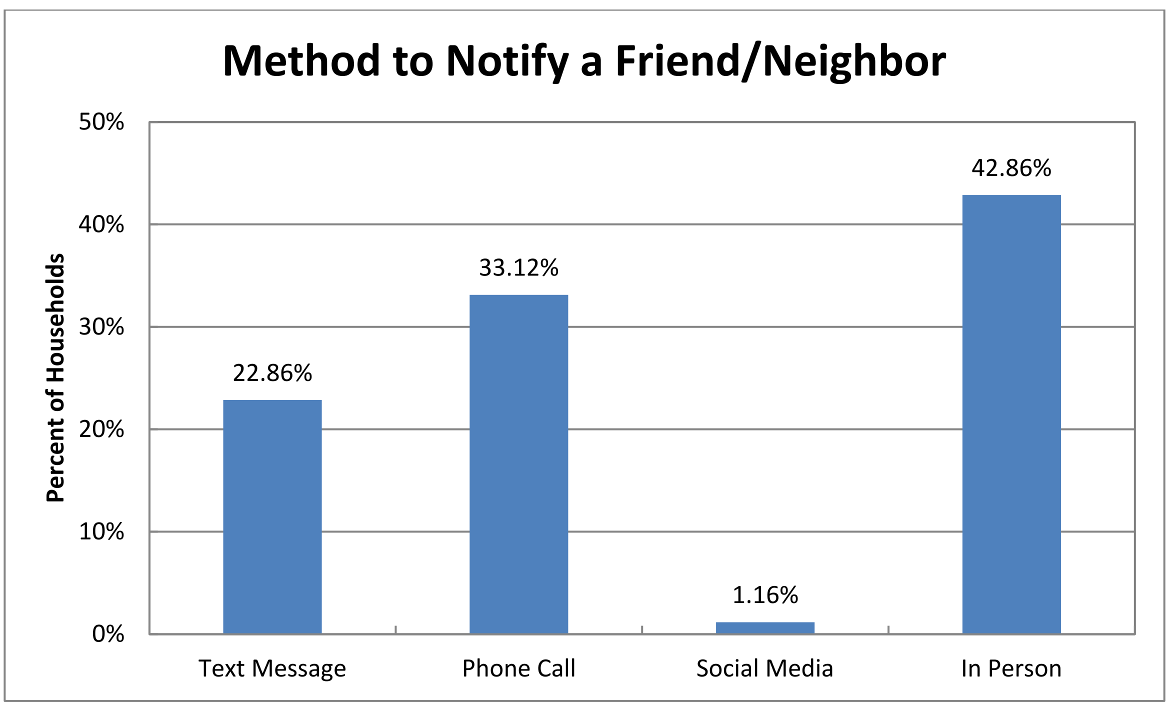


Figure A-12. Method to Notify a Friend/Neighbor

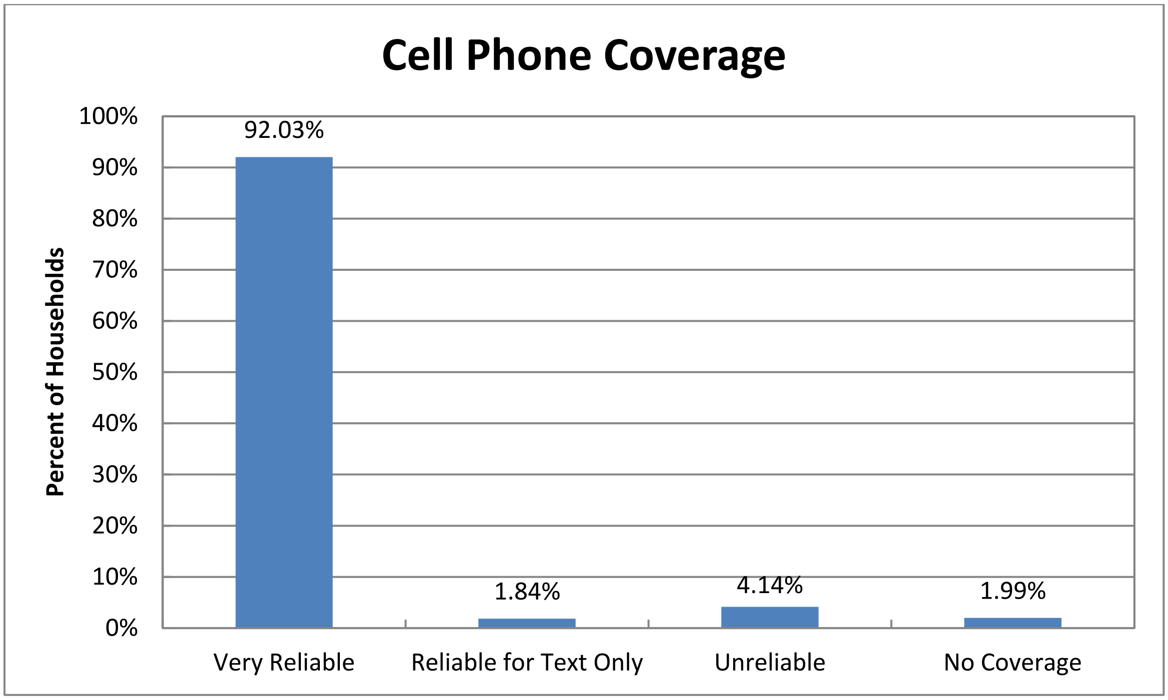


Figure A-13. Cell Phone Coverage

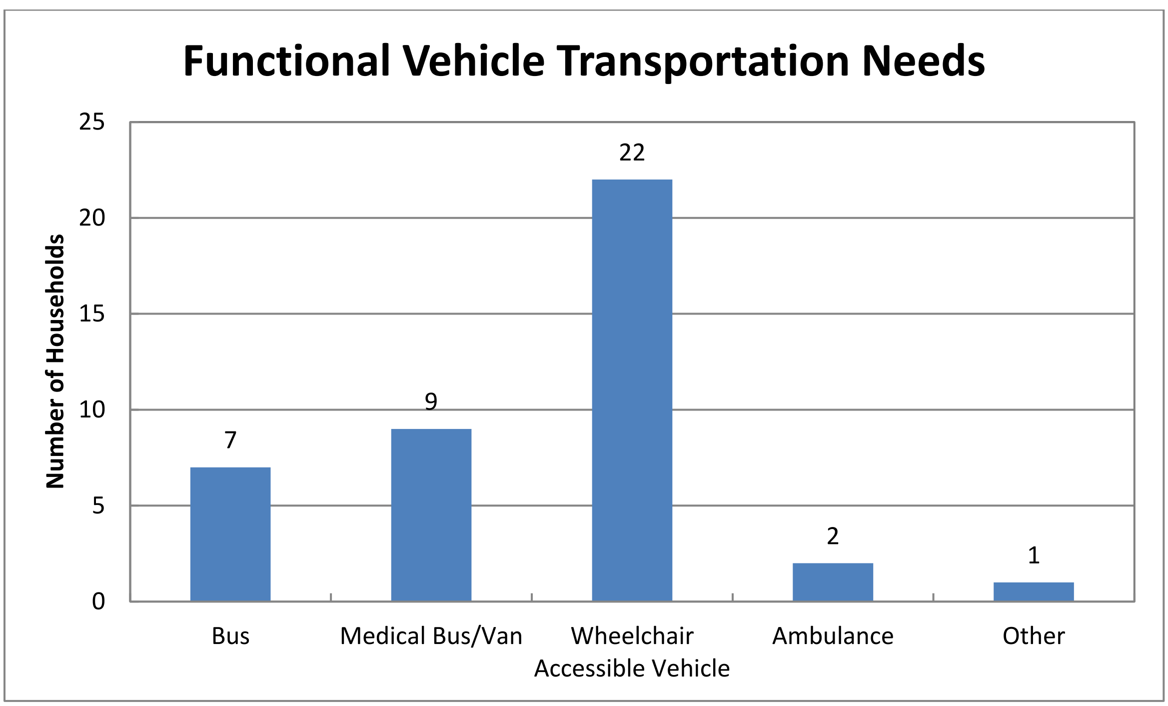


Figure A-14. Functional Vehicle Transportation Needs

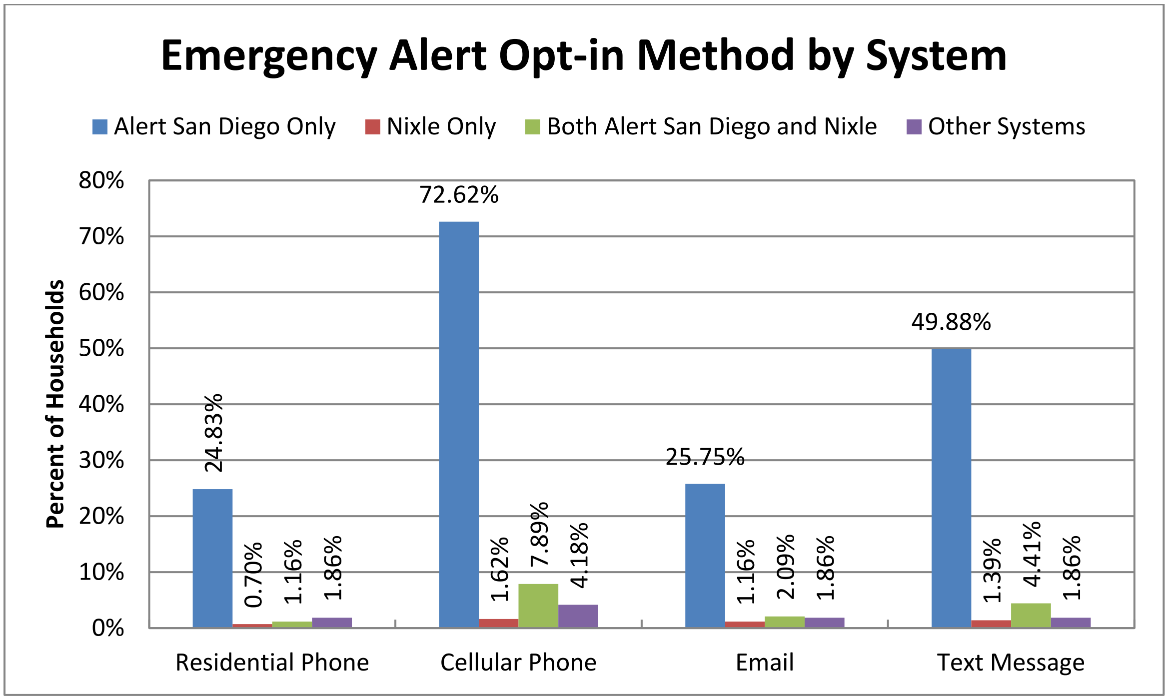


Figure A-15. Emergency Alert Opt-in Method by System

ATTACHMENT A

Demographic Survey Instrument

Ocean Hills Neighborhood Risk Assessment and Emergency Evacuation Preparedness Study

* Required

Purpose

The City of Oceanside Fire Department is currently undertaking an evacuation study to determine how long it would take to evacuate the Neighborhood of Ocean Hills under different circumstances (weekday versus weekend, midday versus evening, etc.). The results of this study will be used to enhance emergency response plans for Ocean Hills and help protect our residents and visitors. The survey below includes questions designed to estimate demographics for Ocean Hills that are not available from the U.S. Census Bureau. These demographics help determine the number of vehicles that will be evacuating Ocean Hills 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 only complete one survey per household. Please have the head of the household (18 years or older) complete the survey. Do not provide your name or any personal information, and the survey will take less than 15 minutes to complete. If you have questions or want additional information about the survey or the study, please feel free to email OHevacstudyinfo@kldcompanies.com.

1. What is your gender?

Mark only one oval.

- ◯ Male
- ◯ Female
- ◯ Decline to State
- ◯ Other: ____________________

2A. What is your home zip code? *

Mark only one oval.

- ◯ 92056
- ◯ 92057
- ◯ 92058
- ◯ 92010
- ◯ 92081
- ◯ 92083
- ◯ Decline to State
- ◯ Other: ____________________

2B. Do you have school children that attend Madison Middle School, Lake Elementary School, New Venture Christian School or The Classical Academy?

Mark only one oval.

- ◯ YES
- ◯ NO
- ◯ DECLINE TO STATE

2C. Which community do you live in?

Mark only one oval.

- ◯ Ocean Hills Country Club
- ◯ Ocean Terrace
- ◯ Seagate Terrace
- ◯ The Summit
- ◯ Ridgeview Estates
- ◯ Southridge Estates
- ◯ Terramar
- ◯ Broadmore Hills
- ◯ Windrift Apartments
- ◯ Other

3A. In total, how many running cars, or other vehicles are usually available to the household?

Mark only one oval.

- ◯ ONE
- ◯ TWO
- ◯ THREE
- ◯ FOUR
- ◯ FIVE
- ◯ SIX
- ◯ SEVEN
- ◯ EIGHT
- ◯ NINE OR MORE
- ◯ ZERO (NONE)
- ◯ DECLINE TO STATE

3B. In an emergency, could you get a ride out of the area with a neighbor or friend?
Mark only one oval.

- YES
- NO
- DECLINE TO STATE

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
- DECLINE TO STATE

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
- DECLINE TO STATE

6. How many people in your household have a work and/or school commute that has been temporarily impacted due to the COVID-19 pandemic?

Mark only one oval.

- ZERO
- ONE
- TWO
- THREE
- FOUR OR MORE
- DECLINE TO STATE

7. How many people in the household normally (during non-COVID conditions) commute to a job, or to college on a daily basis? *

Mark only one oval.

- ZERO
- ONE
- TWO
- THREE
- FOUR OR MORE
- DECLINE TO STATE

8A. Thinking about each commuter, how does each person usually travel to work or college?

THE NUMBER OF COMMUTERS MARKED MUST MATCH QUESTION 7 ABOVE. FILL IN THE APPROPRIATE ROW FOR EACH NUMBERED COMMUTER

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					

8B. What zip code does Commuter 1 work in?

____

8C. What zip code does Commuter 2 work in?

____

8D. What zip code does Commuter 3 work in?

____

8E. What zip code does Commuter 4 work in?

____

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 MNIUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 – 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

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 MNIUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 – 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

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 MNIUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 – 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

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 MNIUTES
- ⬭ 11-15 MINUTES
- ⬭ 16-20 MINUTES
- ⬭ 21-25 MINUTES
- ⬭ 26-30 MINUTES
- ⬭ 31-35 MINUTES
- ⬭ 36-40 MINUTES
- ⬭ 41-45 MINUTES
- ⬭ 46-50 MINUTES
- ⬭ 51-55 MINUTES
- ⬭ 56 – 1 HOUR
- ⬭ OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- ⬭ BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- ⬭ BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- ⬭ BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- ⬭ OVER 2 HOURS
- ⬭ DECLINE TO STATE

10-1. In a wildfire situation, 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 MNIUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 – 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

10-2. In a wildfire situation, 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 MNIUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 – 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

10-3. In a wildfire situation, 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 MNIUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 – 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

10-4. In a wildfire situation, 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 MNIUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 – 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

11. If 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 MIUNTES
- 2 HOURS 31 MINUTES TO 2 HOURS 45 MINUTES
- 2 HOURS 46 MINUTES TO 3 HOURS
- 3 HOURS TO 3 HOURS AND 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 AND 31 MINUTES TO 6 HOURS
- OVER 6 HOURS
- WILL NOT EVACUATE
- DECLINE TO STATE

12. Please specify the number of people in your household who require Functional or Transportation needs in an evacuation:
Mark only one oval per row.

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

13. Please choose one of the following:
If Don't Know, leave 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.

14A. Emergency officials advise you to shelter-in-place in a wildfire emergency because you are not in the area of risk. Would you:
If Don't Know, leave blank
Mark only one oval.

- ⬭ NOT EVACUATE
- ⬭ EVACUATE

14B. Emergency officials advise you to evacuate due to a wildfire. Where would you evacuate to?
Mark only one oval.

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

Fill in OTHER answer

____

15A. Do you have any pet(s) and/or animal(s)? *

Mark only one oval.

- YES
- NO
- DECLINE TO STATE

15B. What type of animals 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)
- [ ] DECLINE TO STATE
- [ ] OTHER: _______________________________

15C. What would you do with your animal(s) if you had to evacuate?
Mark only one oval.

- ⬭ TAKE PET WITH ME TO A SHELTER
- ⬭ TAKE PET WITH ME SOMEWHERE ELSE
- ⬭ LEAVE PET AT HOME
- ⬭ DECLINE TO STATE

15D. If you have animal(s) and would evacuate with them, do you have sufficient room in your vehicle(s) to evacuate with your animal(s)?
Mark only one oval.

- ⬭ YES
- ⬭ NO
- ⬭ WILL USE A TRAILER
- ⬭ DECLINE TO STATE
- ⬭ OTHER: ____________________

16. At your place of residence, how reliable is your cell phone signal?
Mark only one oval.

- ⬭ VERY RELIABLE TO RECEIVE TEXTS AND PHONE CALLS
- ⬭ RELIABLE FOR TEXT MESSAGES ONLY
- ⬭ I DO NOT ALWAYS RECEIVE CELL COMMUNICATIONS AT MY RESIDENCE
- ⬭ I DO NOT HAVE CELL SERVICE AT MY RESIDENCE
- ⬭ DECLINE TO STATE

17. Have you opted into your local Emergency Alert and Warning Systems?
Mark only one oval per row.

	OPTED IN ALERT SAN DIEGO	OPTED IN NIXLE	BOTH ALERT SAN DIEGO AND NIXLE	OTHER SYSTEMS
With Residential Phone	⬭	⬭	⬭	⬭
With Cellular Phone	⬭	⬭	⬭	⬭
With Email	⬭	⬭	⬭	⬭
With Text Message	⬭	⬭	⬭	⬭

18A. If Emergency officials notified you to evacuate, would you notify a neighbor or friend to evacuate as well?
If Don't Know, leave blank
Mark only one oval.

⬭ YES
⬭ NO
⬭ DECLINE TO STATE

18B. How would you notify your neighbor or friend to evacuate?
Check all that apply.

☐ TEXT MESSAGE
☐ PHONE CALL
☐ SOCIAL MEDIA
☐ IN PERSON
☐ DECLINE TO STATE
☐ OTHER: ____________________

18C. If you were to notify a neighbor or friend to evacuate, how long would it take you to notify them?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MNIUTES
- 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
- DECLINE TO STATE

APPENDIX B

Evacuation Sensitivity Studies

"What-if" Scenarios

B. 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.

B.1 Effect of Changes in Trip Generation Times

A sensitivity study was performed to determine whether changes in the estimated trip generation (mobilization) time impact the ETE. 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), how would the ETE be affected? These “what if” scenarios were considered for Scenario 1 – a summer, midweek, midday with normal conditions. Results are tabulated in Table B-1. Trip generation times of 1 hour and 15 minutes, 2 hours and 15 minutes and 3 hours and 15 minutes were tested.

As shown in Table B-1, if evacuees mobilize in one less hour, the 90th percentile ETE remains unchanged and the 100th percentile is equal to the new mobilization time. If evacuees mobilize in two hours less, the 90th percentile ETE is reduced by 15 minutes and the 100th percentile ETE is approximately the new mobilization time of 2 hours and 15 minutes. If evacuees mobilize in three hours less, the 90th percentile ETE is 35 minutes less compared to the base ETE; however, the 100th percentile ETE is no longer dictated by mobilization time. Rather, the 100th percentile ETE is dictated by traffic congestion as Ocean Hills clears 25 minutes after the completion of mobilization time.

As discussed in Section 5, there is traffic congestion within Ocean Hills for about one hour and 30 minutes. The 100th percentile ETE closely parallel the mobilization time for all mobilization times that exceed the traffic congestion period of one hour and 30 minutes, as clearly shown in Table B-1. The public should be educated of the importance of packing a bag ahead of time and mobilizing as quickly as possible during an emergency.

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

A sensitivity study was conducted to determine the effect on ETE of additional people who decide to relocate from the Shadow Region. The case considered was Scenario 1, a summer, midweek, midday, with normal conditions. The movement of people in the Shadow Region has the potential to impede vehicles evacuating from Ocean Hills. Refer to Section 2.2 for additional information on population within the Shadow Region. Shadow evacuation percentages of 25%, 50%, and 100% were tested.

Table B-2 presents the ETE for each of the cases considered. The results show that increasing the shadow population to 25%, 50% or 100% does not impact the 90th or the 100th percentile ETE. Both the 90th percentile ETE and the 100th percentile ETE are dictated by trip mobilization time. Increasing the shadow evacuation by more than 20,000 vehicles does not cause congestion within the shadow region that would propagate into Ocean Hills. As discussed in Section 5.5, the roadway system in the study area provides ample capacity to evacuate Ocean Hills and the Shadow Region.

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

The relationship between supply and demand is critical in estimating evacuation time. Evacuation travel supply is the ability of the roadway network to service 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 it is expensive and difficult to widen existing infrastructure or build additional roadways. Thus, it is good practice to attempt to reduce the evacuating traffic demand such that demand does not exceed capacity. The demographic survey of Ocean Hills indicated residents would use approximately 1.35 vehicles per household during an evacuation (see Appendix A). A sensitivity study was conducted to determine the effect on ETE when the evacuating vehicles per household was reduced to one.

As seen in Table B-3, during the base case scenario, residents evacuate in 5,452 vehicles (see Table 2-2). When the number of evacuation vehicles per household is reduced to one, the number of evacuating vehicles used by residents is reduced to 4,038 – an approximate 25% reduction in traffic demand. The case considered was Scenario 1 – a summer, midweek, midday, with normal conditions. When the evacuee traffic demand is reduced by approximately 25%, the 90^{th} percentile and the 100^{th} percentile ETE remain the same. Even though the demand is reduced by 25%, the trip mobilization time still dictates the ETE.

B.4 Effect of Direction of Wildfire Approach

Depending on the ignition point of the fire and winds during the emergency, a wildfire could block one or more egress routes leaving Ocean Hills. Two cases were considered to simulate potential roadway closures caused by flames or smoke from the wildfire:

1. Lake Boulevard closed from Ridge Rd to Normount Road
2. Shadowridge Drive closed from Longhorn Drive to Antigua Drive

These two cases were run for all scenarios; the results are presented in Table B-4.

B.4.1 Closure on Lake Boulevard

This case was run to represent a wildfire event that is near Oak Riparian Park wherein the flames and/or smoke are blocking Lake Boulevard from Ridge Road to Normount Road. The road closure is located such that all evacuees driving southbound on Ridge Road are forced northbound on Lake Boulevard and all evacuees driving southbound on Normount Road are forced southbound on Lake Boulevard. Northbound movement towards Lake Boulevard from Cannon Road is also blocked.

The 90^{th} percentile ETE range between 1:50 (Hours:Minutes) and 1:55 for all scenarios. The 100^{th} percentile ETE is equal to 4:15 (Hours:Minutes), which is the trip mobilization time. The available capacity along the remaining roads leaving the neighborhood is more than sufficient to service the evacuation demand of Ocean Hills. Hence, the ETE remains the same when compared to the base case.

B.4.2 Closure of Shadowridge Drive

This case was run to represent a wildfire event that is in Buena Vista Park and evacuation to the east of Longhorn Drive along Shadowridge Drive is not feasible. All evacuees traveling on Shadowridge are forced northbound on Longhorn Drive.

The 90th percentile ETE ranges between 1:50 (Hours:Minutes) and 1:55 for all scenarios. The 100th percentile ETE is equal to 4:15 (Hours:Minutes), which is the trip mobilization time. The available capacity along the remaining roads that leave the neighborhood is more than sufficient to service the evacuation demand of Ocean Hills. Hence, the ETE remains the same when compared to the base case.

B.5 Traffic Management Plan

A Traffic Management Plan (TMP) is typically designed for an area that is prone to wildfires to expedite the movement of evacuating traffic during an emergency. 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. TCPs are typically established within the area of risk to expedite the flow of traffic out of the area. ACPs are typically established on the boundary of the area of risk to stop the flow of traffic into the area.

The functions to be performed in the field are:

- Facilitate evacuating traffic movements that safely expedite travel out of the area at risk.
- 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.

This sensitivity study considered establishing TCPs at the following locations to facilitate the flow of evacuees from OHCC along Shadowridge Drive:

1. The intersection of Ocean Hills Drive and Shadowridge Drive
2. The intersection of Rosewood Street and Shadowridge Drive
3. The intersection of Longhorn Drive and Shadowridge Drive

Table B-5 represents the 90th and 100th percentile ETE results when these TCPs are implemented. Although the 90th and the 100th percentile ETE do not change compared to the base case scenario, it can be seen from Figure B-1 that the localized congestion within OHCC and along Shadowridge Drive is relieved by establishing these TCPs.

B.6 Event at New Venture Grace Church

New Venture Grace Church indicated they host concerts monthly that attract approximately 1,000 people. A sensitivity study was considered to quantify the effects of the additional traffic that the concert brings to the Neighborhood of Ocean Hills, in the event there is a wildfire emergency coincident with the concert.

Similar to the weekly visitors to the church (See Section 2.3), it is estimated that 15% of the 1,000 attendees are local residents; the balance of attendees travel in from outside Ocean Hills to the event as a family. Thus, the average household size of 1.89 people was used to estimate the evacuating vehicles for visitors attending the concert at the church.

Table B-6 represents the 90th and 100th percentile ETE results when the evacuation demand at the church is increased. The 90th percentile ETE ranges between 1:50 (Hours:Minutes) and 1:55 for all scenarios. The 100th percentile ETE is equal to 4:15 (Hours:Minutes), which is the trip mobilization time. The increased demand does not exceed the available roadway capacity and the ETE is still dictated by trip mobilization time.

B.7 Fast Mobilization & High Shadow Participation

As discussed in the sensitivity studies above, the available roadway capacity within Ocean Hills is ample such that ETE are dictated by mobilization time, not traffic congestion. As discussed in Section 5, congestion within Ocean Hills clears by one hour and 30 minutes after the ATE. In order to test the limits of the robust roadway system of Ocean Hills, a sensitivity study was run where the mobilization time was reduced to one hour and 15 minutes and the shadow participation rate was increased to 100% – a worst-case scenario.

Table B-7 represents the 90th and 100th percentile ETE results for this sensitivity study. The case considered was Scenario 1 – a summer, midweek, midday, with normal conditions. The 90th percentile ETE equals 1:35 (Hours:Minutes) and the 100th percentile ETE equals 2:20 (Hours:Minutes). As shown in Figure B-2, traffic congestion within Ocean Hills persists for 30 minutes after mobilization is complete for this case. Queuing in the shadow region is pronounced, such that queues spillback into Ocean Hills along Lake Blvd and Melrose Dr. Compared to Section B.1 above, the 90th percentile ETE increases by 15 minutes and the 100th percentile ETE increases by 40 minutes – a significant change. The results of this sensitivity study indicate it is imperative to educate the public to only evacuate if they are advised to do so. Significant shadow evacuation can delay the egress of those people who are most at risk.

Given the rapid mobilization and significant shadow evacuation, this sensitivity study mimics evacuation of a large-scale area for a rapidly spreading fire.

B.8 Congestion Patterns During Rush Hour Traffic

Rush hour or peak hour traffic is the part of the day during which traffic congestion on roadways is most severe, typically during the morning and afternoon commute. A sensitivity study was run to observe traffic patterns within Ocean Hills if an evacuation order was issued during rush hour. For this sensitivity study, the shadow participation rate was increased to 100% and external traffic along CA-78 was increased to near capacity (6,075 vehicles per hour in each direction, or 90% of the capacity of the roadway) for both directions. As discussed in Section 2.7, external traffic vehicles were diminished over two hours after the advisory to evacuate. For this sensitivity study, external traffic vehicles were diminished one hour after the advisory to evacuate.

Table B-8 presents the 90th and 100th percentile ETE results for this sensitivity study. The case considered was Scenario 1 – a summer, midweek, midday, with normal conditions. The 90th percentile ETE equals 1:55 (Hours:Minutes) and the 100th percentile ETE equals 4:15 (Hours:Minutes) – no change compared to the base case scenario. However, as shown in Figure B-3, CA-78 and all major roadways (Melrose Dr, Lake Blvd, Shadowridge Dr) that lead to CA-78 ramps are congested during rush hour at one hour and 15 minutes after the advisory to evacuate. Even though the congestion within Ocean Hills clears after one hour and 45 minutes, as shown in Figure B-4, major roadways that lead to CA-78 are still highly congested. The results of this sensitivity study indicate that if an evacuation order is given during rush hour traffic conditions, delays will occur outside of Ocean Hills, especially on roadways that lead to CA-78. However, the time to clear Ocean Hills is not impacted.

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

Trip Generation Time (Minutes)	Evacuation Time Estimates	
	90th Percentile	100th Percentile
1 Hour and 15 Minutes	1:20	1:40
2 Hours and 15 Minutes	1:40	2:20
3 Hours and 15 Minutes	1:55	3:15
4 Hours and 15 Minutes (Base)	1:55	4:15

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

Percent Shadow Evacuation	Evacuating Shadow Vehicles	Evacuation Time Estimate	
		90th Percentile	100th Percentile
2% (Base)	440	1:55	4:15
25%	5,506	1:55	4:15
50%	11,011	1:55	4:15
100%	22,023	1:55	4:15

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

Case	Evacuating Resident Vehicles	Evacuation Time Estimates	
		90th Percentile	100th Percentile
One Vehicle per HH	4,038	1:55	4:15
Base Case	5,452	1:55	4:15

Table B-4. 90th and 100th Percentile ETE – Road Closures

	Summer		Summer
	Midweek	Weekend	Midweek Weekend
Scenario:	**(1)**	**(2)**	**(3)**
	Midday		Evening
	Good Weather	Good Weather	Good Weather
90th Percentile ETE			
Base	1:55	1:50	1:50
Lake Boulevard Closure	1:55	1:50	1:50
Shadowridge Drive Closure	1:55	1:50	1:50
100th Percentile ETE			
Base	4:15	4:15	4:15
Lake Boulevard Closure	4:15	4:15	4:15
Shadowridge Drive Closure	4:15	4:15	4:15

Table B-5. Evacuation Time Estimates When Implementing a TMP

	Summer		Summer
	Midweek	Weekend	Midweek Weekend
Scenario:	(1)	(2)	(3)
	Midday		Evening
	Good Weather	Good Weather	Good Weather
90th Percentile ETE			
Base	1:55	1:50	1:50
TCP	1:55	1:50	1:50
100th Percentile ETE			
Base	4:15	4:15	4:15
TCP	4:15	4:15	4:15

Table B-6. Event at New Venture Grace Church

	Summer		Summer
	Midweek	Weekend	Midweek Weekend
Scenario:	(1)	(2)	(3)
	Midday		Evening
	Good Weather	Good Weather	Good Weather
90th Percentile ETE			
Base	1:55	1:50	1:50
Event at Church	1:55	1:50	1:50
100th Percentile ETE			
Base	4:15	4:15	4:15
Event at Church	4:15	4:15	4:15

Table B-7. Trip Generation & Shadow Evacuation Sensitivity

Trip Generation Time (Minutes)	Percent Shadow Evacuation	Evacuation Time Estimates	
		90th Percentile	100th Percentile
1 Hour and 15 Minutes	2% (Base)	1:20	1:40
1 Hour and 15 Minutes	100%	1:35	2:20

Table B-8. Rush Hour Traffic Sensitivity

Total External Traffic Vehicles	Percent Shadow Evacuation	Evacuation Time Estimates	
		90th Percentile	100th Percentile
12,864	2% (Base)	1:55	4:15
15,798	100%	1:55	4:15

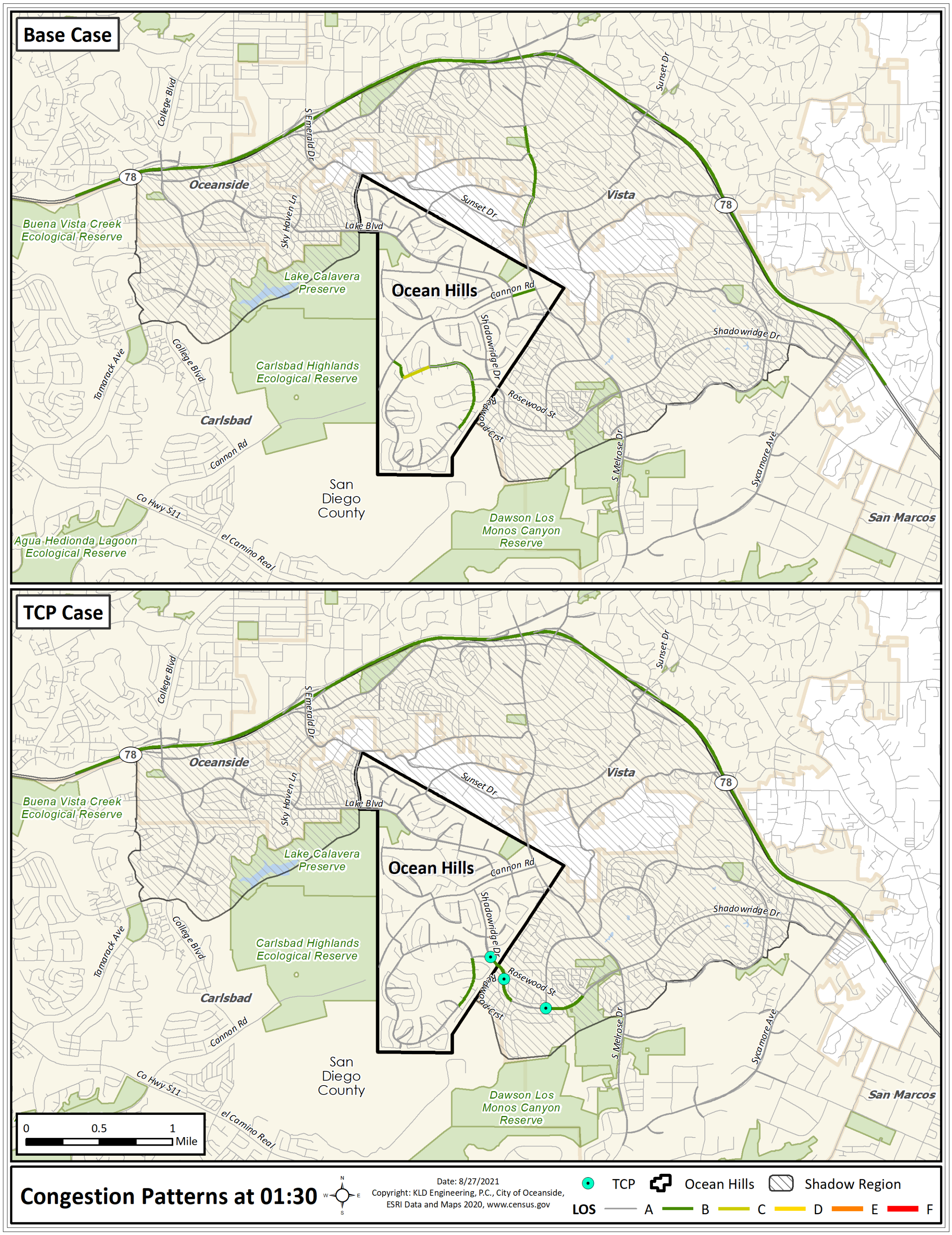


Figure B-1. Congestion Patterns at 1 Hour and 30 Minutes after the Advisory to Evacuate when Implementing TMP

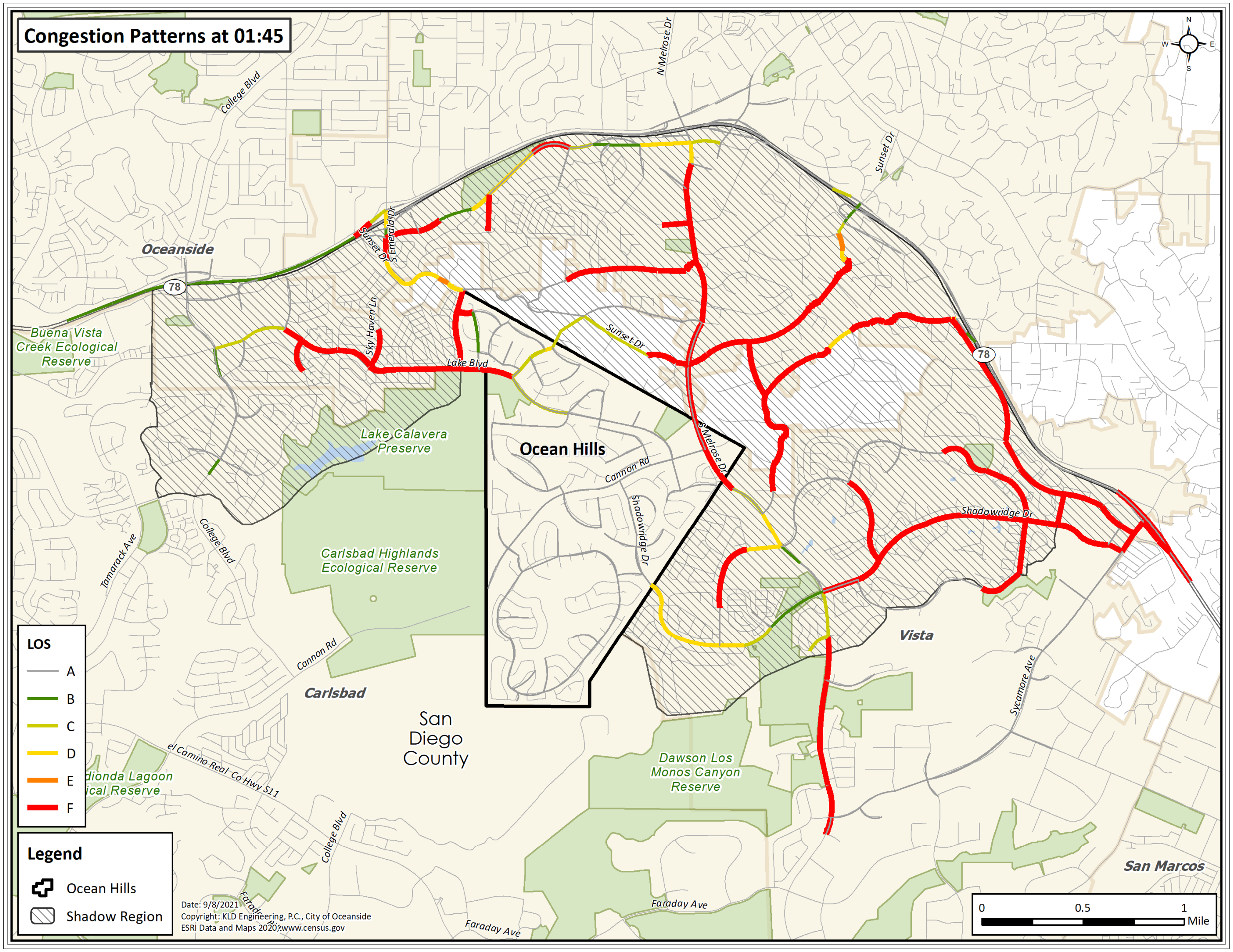


Figure B-2. Congestion Patterns at 1 Hour and 45 Minutes after the Advisory to Evacuate – Fast Mobilization Time and High Shadow Evacuation

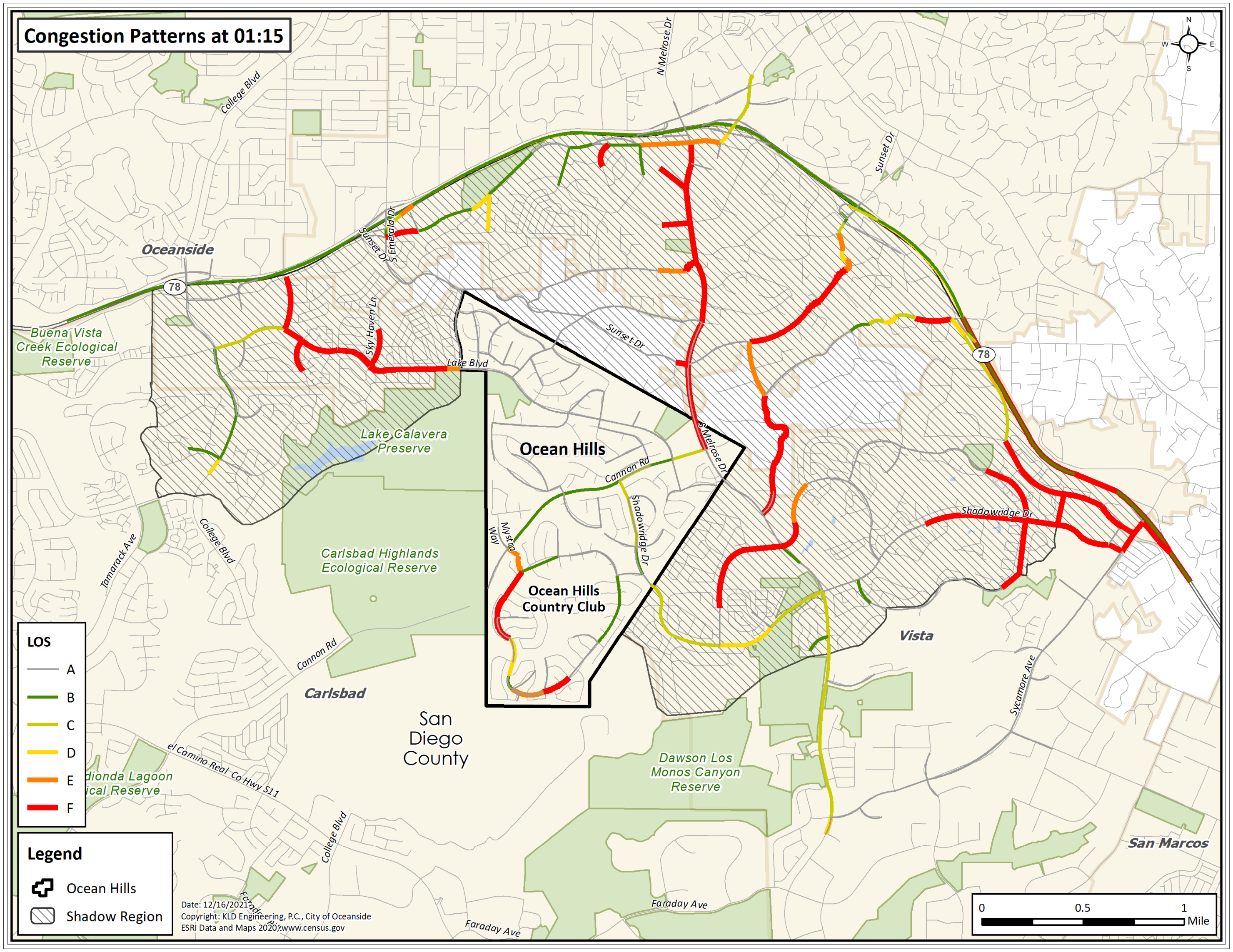


Figure B-3. Congestion Patterns at 1 Hour and 15 Minutes after the Advisory to Evacuate – Rush Hour Traffic

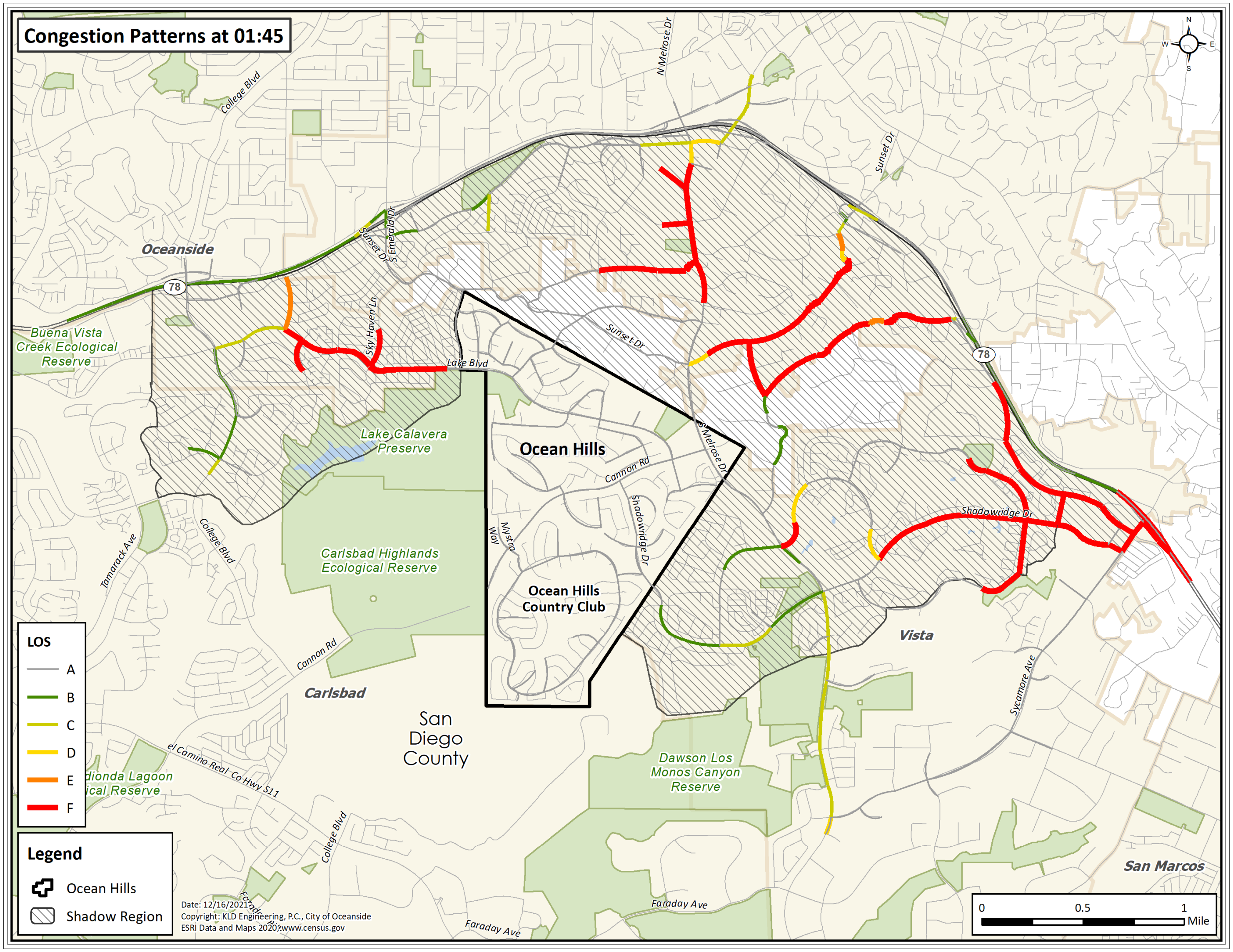


Figure B-4. Congestion Patterns at 1 Hour and 45 Minutes after the Advisory to Evacuate – Rush Hour Traffic