ALAMEDA COUNTY FIRE DEPARTMENT

VOLUME 2 OF 3 - TECHNICAL REPORT

STANDARDS OF COVERAGE REVIEW

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SECTION 1—INTRODUCTION AND BACKGROUND

Citygate Associates, LLC's (Citygate) Standards of Coverage technical review for the Alameda County Fire Department (ACFD or Department) field deployment functions is presented in this "Volume." Citygate's deployment scope of work and corresponding Work Plan was developed consistent with Citygate's Project Team members' experience in fire administration and deployment planning. Citygate utilizes various National Fire Protection Association (NFPA) publications as best practice guidelines, along with the self-assessment criteria of the Commission on Fire Accreditation International (CFAI).

1.1 DEPLOYMENT PART ORGANIZATION

This "Part" of **Volume 2** is structured into the following sections. *Part Two* of this volume contains an in-depth Community Risk Assessment. **Volumes 1** (Executive Summary) and **3** (Map Atlas) are separately bound.

Section 1 Introduction and Background: An introduction to the study and background facts about the Department.

Section 2 Standards of Coverage Introduction: An introduction to the Standards of Coverage (SOC) process and methodology used by Citygate in this review.

Section 3 Alameda County Fire Department Deployment Goals/Measures: An in-depth examination of the Department's ability to provide deployment coverage for each community's risks and meet the community's expectations and emergency needs.

Section 4 Staffing and Geo-Mapping Analysis: A review of: (1) the critical tasks that must be performed to achieve the Department's desired outcomes; and (2) the Department's existing fire station locations and possible future locations.

Section 5 Response Statistical Analysis: A statistical data analysis of the Department's incident responses.

Section 6 SOC Evaluation and Deployment Recommendation: A summary of deployment priorities and overall deployment recommendations.

Section 7 Next Steps: A summary of deployment short- and long-term next steps.

1.1.1 Goals of Deployment Analysis

This report will cite findings and make recommendations, if appropriate, that relate to each finding. Findings and recommendations are numbered sequentially throughout Sections 3 through 8 of this report. A complete list of all these same findings and recommendations, in order, is found in the Executive Summary. Sections 6 and 7 of this report bring attention to the highest priority needs and possible next steps.

This document provides technical information about the way fire services are deployed across the Department's service areas, the way they are legally regulated, and the way the Department currently operates. This information is presented in the form of recommendations and policy choices for the Department's leadership to discuss.

1.2 Standards of Coverage Scope of Work

The scope of the Standards of Coverage review included the following elements:

- Modeling the need and effects of the current fire station locations. Although this is not a study of fire agencies adjacent to the Department, the study considered the impacts of the Department's existing automatic aid agreements on the Department's needs.
- Establishing response time performance goals consistent with best practices and national guidelines from the NFPA and CFAI.
- Using an incident response time analysis program called StatsFD™ to review the statistics of prior historical performance.
- Using a geographic mapping response time measurement tool called FireView™ to measure fire unit driving time coverages.

1.2.1 SOC Study Questions

To prepare and develop this deployment study for the Department, Citygate reviewed computer data, response times, and past performance. As a result, this study addresses the following questions:

Is the type and quantity of apparatus and personnel adequate for the Department's deployment to emergencies?

What is the recommended deployment to deliver adequate emergency response times, both to the existing areas and new sections as growth continues to occur?

1.3 DEPARTMENT OVERVIEW[1]

The ACFD was formed on July 1, 1993 as a dependent special district with the Alameda County Board of Supervisors as its governing body. This consolidation brought together into a single jurisdiction the Castro Valley Fire Protection District, the Eden Consolidated Fire Protection District, and the County Fire Patrol.

Subsequently, the following communities have contracted with the ACFD:

- July 1, 1995 – City of San Leandro
- July 1, 1997 – City of Dublin
- August 1, 2002 – Lawrence Berkeley National Laboratory
- October 1, 2007 – Lawrence Livermore National Laboratory
- January 20, 2008 – Alameda County Regional Emergency Communications Center (ACRECC), transferred from Lawrence Livermore National Laboratory to the ACFD
- May 1, 2010 – City of Newark
- July 1, 2010 – City of Union City
- July 1, 2012 – City of Emeryville

At present, the ACFD provides all-risk emergency services to the unincorporated areas and its contract for service areas from 29 fire stations and 34 companies, serving a population of approximately 394,000. The diverse areas the ACFD serves range from densely populated urban areas, waterways, industrialized centers, and extensive urban interface wildfire hazards to

[1] https://www.acgov.org/fire/about/index.htm

agricultural and wildland regions. ACFD firefighters provide a wide variety of services to an ever-expanding, dynamic, and diverse area of roughly 508 square miles. These services include:

- Advanced Life Support (ALS)
- Fire Suppression
- Hazardous Materials Response
- Urban Search and Rescue
- Water Rescue
- Community Outreach and Education
- Disaster Preparedness
- Fire Prevention and Code Compliance.

The ACFD is also responsible for the administration and operation of the ACRECC. The dispatch center provides dispatch and regional communication center services for the ACFD, the Alameda County Emergency Medical Services Agency, the Camp Parks Combat Support Training Center, and the Cities of Alameda, Fremont, Livermore, and Pleasanton. The ACRECC is also the Dispatch/System Status Management Center for the County's ambulance service.

Department Facts

- 29 Fire Stations
- 4 Battalion Chiefs
- 27 Engine Companies
- 5 Ladder Truck Companies
- 2 Quint/Ladder Companies
- 1 Technical Rescue Company

Specialized Equipment

- Air/Light Support Unit
- Five Water Rescue Boats
- 2500 Gallon Water Tender
- Two Bulldozers
- Four Hazardous Material Response Vehicles

Specialized Response Teams

- Hazardous Materials
- Urban Search and Rescue
- Water Rescue

Fiscal Year 2016/2017 Budget

- $133,878,346

Authorized Positions

- 460

Reserve Firefighters

- 53 (as of 7/21/17)

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SECTION 2—STANDARDS OF COVERAGE INTRODUCTION

2.1 STANDARDS OF COVERAGE STUDY PROCESSES

The core methodology used by Citygate in the scope of its deployment analysis work is “Standards of Coverage,” which is a systems-based approach to fire department deployment as published by the CFAI. This approach uses local risk and demographics to determine the level of protection best fitting the Department’s needs.

The Standards of Coverage method evaluates deployment as part of a fire agency’s self-assessment process. This approach uses risk and community expectations regarding outcomes to help elected officials make informed decisions on fire and emergency medical services deployment levels. Citygate has adopted this methodology as a comprehensive tool to evaluate fire station locations. Depending on the needs of the study, the depth of the components may vary.

Such a systems approach to deployment, rather than a one-size-fits-all prescriptive formula, allows for local determination. In this comprehensive approach, each agency can match local needs (risks and expectations) with the costs of various levels of service. In an informed public policy debate, a governing board “purchases” the fire and emergency medical service levels the community needs and can afford.

While working with multiple components to conduct a deployment analysis is admittedly more work, it yields a much better result than using only a singular component. For instance, if only travel time is considered, and frequency of multiple calls is not considered, the analysis could miss over-worked companies. If a risk assessment for deployment is not considered, and deployment is based only on travel time, a community could under-deploy to incidents.

The Standards of Coverage process consists of the following eight elements:

Table 1—Standards of Coverage Process Elements

Element	Meaning
Existing Deployment Policies	Reviewing the deployment goals the agency has in place today.
Community Outcome Expectations	Reviewing the expectations of the community for response to emergencies.
Community Risk Assessment	Reviewing the assets at risk in the community. (In this Citygate study, see *Part Two—Community Risk Assessment*.)
Critical Task Study	Reviewing the tasks that must be performed and the personnel required to deliver the stated outcome expectation for the Effective Response Force.
Distribution Study	Reviewing the spacing of first-due resources (typically engines) to control routine emergencies.
Concentration Study	Reviewing the spacing of fire stations so that building fires can receive sufficient resources in a timely manner (First Alarm Assignment or the Effective Response Force).
Reliability and Historical Response Effectiveness Studies	Using prior response statistics to determine the percent of compliance the existing system delivers.
Overall Evaluation	Proposing Standard of Coverage statements by risk type as necessary.

Fire department deployment, simply stated, is about the speed and weight of the attack. Speed calls for first-due, all-risk intervention units (engines, trucks, and/or ambulances) strategically located across a community responding in an effective travel time. These units are tasked with controlling moderate emergencies, preventing the incident from escalating to second alarm or greater size, which unnecessarily depletes departmental resources as multiple requests for service occur. Weight is about multiple-unit response for serious emergencies, such as a room-and-contents structure fire, a multiple-patient incident, a vehicle accident with extrication required, or a heavy rescue incident. In these situations, enough firefighters must be assembled within a reasonable time frame to safely control the emergency, thereby keeping it from escalating to greater alarms.

This deployment design paradigm is reiterated in the following table:

Table 2—Fire Service Deployment Simplified

	Meaning	Purpose
***Speed* of Attack**	Travel time of first-due, all-risk intervention units strategically located across a department.	Controlling moderate emergencies without the incident escalating to second alarm or greater size.
***Weight* of Attack**	Number of firefighters in a multiple-unit response for serious emergencies.	Assembling enough firefighters within a reasonable time frame to safely control the emergency.

Thus, small fires and medical emergencies require a single- or two-unit response (engine and specialty unit) with a quick response time. Larger incidents require more crews. In either case, if the crews arrive too late or the total personnel sent to the emergency are too few for the emergency type, they are drawn into a losing and more dangerous battle. The science of fire crew deployment is to spread crews out across a community for quick response to keep emergencies small with positive outcomes, without spreading the crews so far apart that they cannot amass together quickly enough to be effective in major emergencies.

SECTION 3—ALAMEDA COUNTY FIRE DEPARTMENT DEPLOYMENT GOALS/MEASURES

3.1 WHY DOES THE ACFD EXIST AND HOW DOES IT DELIVER THE EXISTING FIRE CREW DEPLOYMENT SERVICES?

3.1.1 Existing Response Time Policies or Goals—Why Does the Agency Exist?

> **SOC ELEMENT 1 OF 8***
> **EXISTING DEPLOYMENT POLICIES**
>
> **Note: This is an overview of Element 1. The detail is provided on page 18.*

To date, the District's Board of Directors has not adopted fire and EMS outcome-based response time goals, by ordinance and/or in the County's General Plan Safety Element for the unincorporated area. Each contract city has its own unique performance measures in its contract with the ACFD. The ACFD did adopt response time measures and reports these to the County, its fire commission, and the contract cities. These are used by the ACFD in the annual budget and ongoing performance reports. The ACFD's performance goals are:

First unit on scene in 7:30 minutes from fire dispatch call pick up in urban areas, 90 percent of the time.

- **Dispatch** – 1:30 minutes
- **Turnout** – 2:00 minutes
- **First Travel** – 4:00 minutes

- **First Alarm Multiple Units in an Urban Area** – 8:00 minutes travel.

These response time goals were determined as good benchmark practices from NFPA standard 1710 for career fire departments.

Nationally recognized standards and best practices suggest using a time line with several important time measurements that include a definition of response time. Ideally, the clock start time is when the 9-1-1 police dispatcher receives the emergency call in the Sheriff's or local police department 9-1-1 center. The dispatcher transfers fire and EMS incident calls to the ACRECC to dispatch the needed resources. In this setting, the ACFD response clock starts when the fire dispatcher receives the 9-1-1 incident into the computerized fire dispatch system. The time segments for the ACFD's response include dispatch processing, crew alerting and leaving the station (commonly called turnout time), and actual travel time.

The ACFD's adopted response goals would partially meet the Standards of Coverage model for the CFAI.

3.1.2 Outcome Expectations and Best Practices Response Time Measures

SOC ELEMENT 2 OF 8
COMMUNITY OUTCOME EXPECTATIONS

The Standards of Coverage process begins with a review of existing emergency services outcome expectations. This can be restated as follows: for what purpose does the response system exist? Has the governing body adopted any response performance measures? If so, the time measures used must be understood and good data must be collected.

Current national best practice is to measure percent completion of a goal (e.g., 90 percent of responses) instead of an average measure. Mathematically this is called a "fractile" measure.[2] This is because the measure of average only identifies the central or middle point of response time performance for all calls for service in the data set. Using an average makes it impossible to know how many incidents had response times that were far beyond the average.

For example, Figure 1 shows response times for a fictitious city fire department in the United States. This jurisdiction is small and receives 20 legitimate calls for service each month. Each response time for the calls for service has been plotted on the graph. The call response times have been plotted in order from shortest response time to longest response time.

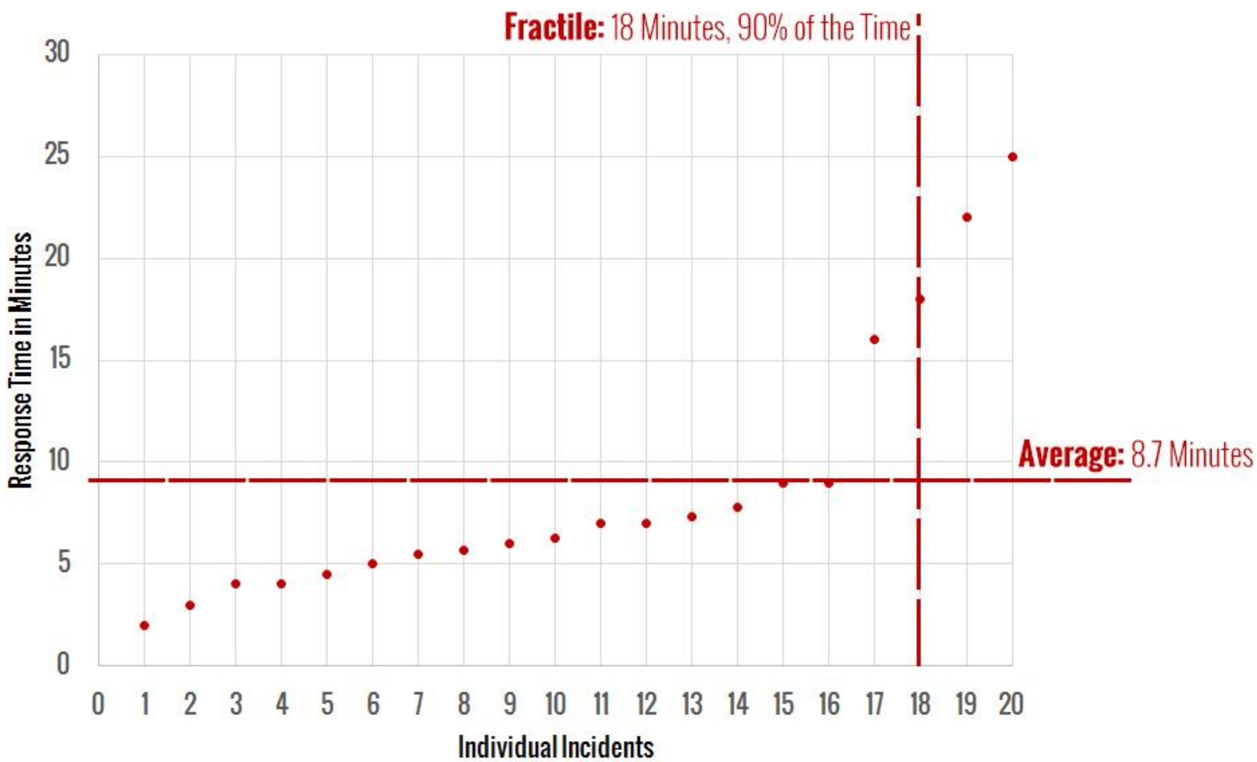
The figure shows that the average response time is 8.7 minutes. However, the average response time fails to properly account for four calls for service with response times far exceeding a threshold in which positive outcomes could be expected. In fact, it is evident in Figure 1 that, in

[2] A *fractile* is that point below which a stated fraction of the values lie. The fraction is often given in percent; the term percentile may then be used.

this fictitious community, 20 percent of responses are far too slow, and that this community has a potential life-threatening service delivery problem. Average response time as a measurement tool for fire departments is simply not sufficient. This is a significant issue in larger communities, if hundreds or thousands of calls are answered far beyond the average point.

By using the fractile measurement with 90 percent of responses in mind, this small community has a response time of 18:00 minutes, 90 percent of the time. This fractile measurement is far more accurate at reflecting the service delivery situation in this small jurisdiction.

<u>Figure 1—Fractile Versus Average Response Time Measurements</u>



More importantly, within the Standards of Coverage process, positive outcomes are the goal and, from that, crew size and response time can be calculated to allow efficient fire station spacing (distribution and concentrations). Emergency medical incidents have situations with the most severe time constraints. In a heart attack that stops the heart, a trauma that causes severe blood loss, or in a respiratory emergency, the brain can only survive 8:00 to 10:00 minutes without oxygen. Heart attacks make up a small percentage; drowning, choking, trauma constrictions, or other similar events have the same effect. In a building fire, a small incipient fire can grow to involve the entire room in 8:00 to 10:00 minutes. If fire service response is to achieve positive outcomes in severe emergency medical situations and incipient fire situations, ***all*** responding crews must arrive, assess the situation, and deploy effective measures before brain death occurs or the fire leaves the room of origin.

Thus, from the time the 9-1-1 call is received, an effective deployment system is ***beginning*** to manage the problem within a 7:00- to 8:00-minute total response time. This is right at the point that brain death is becoming irreversible or a fire has grown beyond the room of origin. Thus, the ACFD would need a first-due response goal within this time frame to provide hope for a positive outcome. It is important to note the fire or medical emergency continues to deteriorate from the time of inception, not the time the fire engine starts to drive the response route. Ideally, the emergency is noticed immediately and the 9-1-1 system is activated promptly. This step of awareness—calling 9-1-1and giving the dispatcher accurate information—takes, in the best of circumstances, one minute. Crew notification and travel time take additional minutes. Once arrived, the crew must walk to the patient or emergency, assess the situation, and deploy its skills and tools. Even in easy-to-access situations, this step can take two or more minutes. This time frame may be increased considerably due to long driveways, apartment buildings with limited access, multi-storied apartments or office complexes, high rise downtown buildings, or shopping center buildings, such as those found in parts of the County and contract city areas.

Unfortunately, there are times that the emergency has become too severe, even before the 9-1-1 notification and/or fire department response, for the emergency crew to reverse. However, when an appropriate response time policy is combined with a well-designed system, then only issues like bad weather, poor traffic conditions, or multiple emergencies will slow the response system down. Consequently, a properly designed system will provide citizens the hope of a positive outcome for their tax dollar expenditure.

For this report, "total" response time is the sum of the call processing / fire dispatch, crew turnout, and road travel time steps. This is consistent with the recommendations of the CFAI.

Finding #1:	The ACFD Board of Directors has not adopted a complete deployment measure based on best practices for fire and emergency medical services incidents in the unincorporated areas. Adopting a similar set of specialty response measures would meet the best-practice recommendations of the CFAI. Each contract agency has its own unique performance measures included in its contract with the ACFD.

3.2 Community Risk Assessment Introduction

SOC Element 3 of 8
Community Risk Assessment

Risk assessment is a major component of developing a Standards of Coverage (SOC) document. A risk assessment identifies the type of incidents a fire department will respond to and what resources and staffing it will need to mitigate the situation.

To better understand risk, it is necessary to define the types and levels of risk a community can encounter. For risk assessment in an SOC study, it is typical to consider low, moderate, high/special, and maximum risk occupancies. Risk also can be classified by probability and impact severity. Probability is defined as the likelihood of an incident occurring. Impact severity is defined as the effects of the incident on the community.

As part of this project, the ACFD requested an in-depth risk assessment. This comprehensive review is contained in *Part Two* of this study.

3.3 Community Expectations

Given the ACFD's agency response time goal and the historic funding level of fire services in both County and contract service areas, it is reasonable to assume that residents, employees, and visitors of the ACFD's service area can expect an effective level of fire service response. This response should keep time-sensitive events, such as serious medical emergencies, fires, and hazardous material releases, from becoming more serious or catastrophic.

3.4 Risk Assessment Result

Citygate's evaluation of the values at risk and hazards likely to impact the Department's service area yields the following key points:

- Just over 25 percent of the population are under 10 years or over 65 years of age and are considered to be particularly vulnerable to harm from a hazard occurrence.
- The population's ethnicity is predominantly Asian (31.75 percent), White (29.01 percent), and Hispanic/Latino (26.12 percent).
- More than three quarters of the population over 24 years of age has completed high school or the equivalent.
- Nearly 66 percent of the population 16 years of age or older are in the workforce; unemployment is approximately 5.5 percent.
- Over nine percent of the population is below the federal poverty level.

- Over 10 percent of the population has no health insurance coverage.
- There are 161 identified critical facilities / pieces of infrastructure within the Department's service area.
- Overall risk for five hazards related to emergency services provided by the Department range from MODERATE to HIGH, as shown in the following table.

Table 3—Overall Risk by Hazard

Risk		Planning Zone				
		Batt. 2	Batt. 3	Batt. 4	Batt. 7	Emeryville
1	Building Fire	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE
2	Wildland Fire	HIGH	HIGH	MODERATE	HIGH	MODERATE
3	Medical Emergency	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE
4	Hazardous Materials	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE
5	Technical Rescue	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE

Based on the aforementioned factors, the ACFD has staffed and designed its response system to field an "Effective Response Force" of multiple units to serious fires in buildings and wildland areas, and provides paramedic ambulances for emergency medical responses via contract.

The ACFD's multiple-unit force (First Alarm) is designed strong enough to stop the escalation of the emergency and keep it from spreading to greater alarms. These desired outcomes and adopted policy goals will be the foundation of updated deployment measures as part of this Standard of Response Cover process.

3.5 Existing ACFD Deployment

3.5.1 Existing Deployment Situation—What the ACFD Has in Place Currently

> ***SOC Element 1 of 8****
> **Existing Deployment Policies**
> **Note: Continued from page 13.*

For positive outcomes to building fires and serious medical emergencies which are consistent with the ACFD's fire/EMS response goals, this study will benchmark the Department's performance against the adopted goals, which are:

- Four (4:00) minutes travel time for the first-due unit to all types of emergencies in urban areas

- Eight (8:00) minutes travel time for multiple units needed at serious emergencies (First Alarm) in urban areas.

The ACFD's service capacity for building fire risk consists of a daily, on-duty response force of 112 personnel staffing 34 primary response units from 29 fire stations. These staffing and apparatus totals do not include the multitude of specialty apparatus, such as brush fire and hazardous material units.

Table 4—Daily Minimum Staffing per Unit for the ACFD – Fiscal Year 2016/17

Unit	Minimum	Staff	Extended Minimum
27 Engines	3/4	Firefighters per Day	83
5 Aerial Ladder Truck Companies	3	Firefighters per Day	15
2 Quints (Pumper/Ladder)	3	Firefighters per Day	6
1 Technical Rescue Unit	4	Firefighters per Day	4
Subtotal Firefighters	**-**	**-**	**108**
Battalion Chiefs/Command	4	Per Day for Command	4
Total			**112**

This daily staffing is adequate for the immediate response fire risk needs presented in most of the built-up urban areas of the County. On days when staffing levels allow, the threat of wildland fire is serious, or there are many specialty civic events, the ACFD can staff additional units with crews on focused overtime. However, for the daily staffing statement to be accurate as to adequacy for a building fire, the assumption is that the closest crews are available and all stations are staffed and not already operating on another emergency medical call or fire, which can and does happen. For example, if an engine and an ambulance unit are committed to an emergency medical services call, then an adjacent engine company or truck company must respond in its place to an additional incident. This situation will be evaluated separately in Section 5 of this volume.

The ACFD has solid automatic aid partnerships with the surrounding fire agencies for Battalions 2 and 3 that will send their closest units into the County if the County's units are committed or not as close to other emergencies.

Services Provided

The County funds an "all-risk" fire department providing the people and assets it protects with services that include structure fire, wildland fire, ambulance paramedics, technical rescue, and hazardous materials response, as well as other services.

Given these risks, the ACFD uses a tiered approach of dispatching different types of apparatus to each incident category. The ACRECC dispatchers and computer-aided-dispatch system selects the closest and most appropriate resource types. As an example, the following table shows the resources dispatched to common risk types:

Table 5—Resources Sent to Common Risk Types

Risk Type	Minimum Type of Resources Sent	Total Firefighters Sent
One-Patient EMS	1 Engine or Ladder Truck and Regional Ambulance	3 FF + 2 Amb.
Auto Fire	1 Engine or Quint	3 FF
Confirmed Residential Building Fire	3 Engines, 1 Rapid Intervention Company (Eng.), 1 Ladder Truck, 1 Rescue Unit, 2 Battalion Chiefs	21 FF
Commercial Building Fire	3 Engines, 1 Rapid Intervention Company (Eng.), 1 Ladder Truck, 1 Rescue Unit, 2 Battalion Chiefs	21 FF
Wildland Fire	3 Engines, 1 Dozer, 1 Water Tender, 1 Battalion Chief	12 FF
Hazardous Materials and Technical Rescue	1 Engine, 1 Ladder Truck, Specialty Unit(s) as needed, 1 Battalion Chief	10 FF
Technical Rescue	1 Engine, 1 Ladder Truck, 1 Tech Rescue Unit, 1 Battalion Chief	11 FF

Finding #2: The ACFD follows best practices by using a standard response dispatching plan that considers the risk of different types of emergencies and pre-plans the response. Each type of call for service receives the combination of engine companies, truck companies, ambulances, specialty units, and command officers customarily needed to handle each type of incident based on experience.

3.5.2 Emergency Unit Staffing

All engine and ladder companies are staffed daily with a minimum of three firefighters. The daily minimum shift staffing count is 108 firefighters *on firefighting units*, plus four supervisors. Per NFPA 1710, a minimum of 14 to 15 firefighters, plus a command chief, are required for a typical room and contents fire in a home in a suburban area. For a single-patient, acute emergency medical services event, one fire company plus an ambulance are needed.

The daily staffing depth of ACFD urban service areas is adequate to handle multiple medical emergencies and multiple serious building fires before overly relying on automatic aid. However, the ACFD does not need to use all its resources at once. In the automatic aid, closest-unit agreements, a mix of different agencies can be sent based on shortest response times. Doing so leaves other ACFD units available for simultaneous calls for service.

SECTION 4—STAFFING AND GEO-MAPPING ANALYSIS

4.1 CRITICAL TASK TIME MEASURES—WHAT MUST BE DONE OVER WHAT TIME FRAME TO ACHIEVE THE STATED OUTCOME EXPECTATION?

SOC ELEMENT 4 OF 8
CRITICAL TASK TIME STUDY

Standards of Coverage (SOC) studies use task time information to determine the number of firefighters needed within a time frame to accomplish the desired fire control objective on moderate residential fires and modest emergency medical rescues. The time it takes to complete one specific task is called an “evolution.” These task time evolutions are shown on Table 6 through Table 8 to demonstrate the amount of time the operations require. The following three tables start with the time of fire dispatch notification and finish with the outcome achieved. These tables are composite tables from Citygate clients in metropolitan fire agencies very similar to the ACFD, with minimum unit staffing at three personnel per engine or ladder truck. These tasks and times are also consistent with nationally published studies.[3]

[3] Report on Residential Fireground Field Experiments, National Institute of Standards and Technology Technical Note 1661, April 2010. NFPA 1710, Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments, 2016 Edition.

The evolution test results were obtained at training centers under best conditions; the day was sunny and moderate in temperature. The structure fire response times are from actual events, showing how units arrive at staggered intervals.

It takes a considerable amount of time after a task is ordered by command to accomplish the tasks and arrive at the desired outcome. This is because each task must be completed in order. The fewer the firefighters, the longer some task completion times will be. *Critical steps* are highlighted in ***gray*** in the table.

Task completion time is usually a function of the number of personnel ***simultaneously*** available. This is desirable so that firefighters can complete some tasks simultaneously.

Some tasks must be assigned to a minimum of two firefighters to comply with safety regulations. For example, two firefighters are required for searching a smoke-filled room for a victim.

Table 6 displays unit and individual duties that are required at a First Alarm fire scene for a typical single-family dwelling fire. This set of duties is taken from typical urban fire departments' operational procedures, which are entirely consistent with the customary findings of other agencies using the SOC process. No conditions existed to override the Occupational Safety and Health Administration (OSHA) 2-in/2-out safety policy which requires that firefighters enter serious building fires in teams of two, while two more firefighters are outside and immediately ready to rescue them should trouble arise.

The following table displays the critical tasks for the ACFD's response to a typical house fire in built-up suburban areas with three engines, one ladder truck, one Rapid Intervention Unit (engine), one technical rescue unit, and two Battalion Chiefs, for a minimum force total of **21** firefighters.

Scenario: *This is a simulated, two-story residential structure fire with an unknown rescue situation. Responding companies received dispatch information as typical for a witnessed fire. Upon arrival, they were told approximately 1,000 square feet of the home was involved in fire.*

Table 6—First Alarm Structure Fire – 21 Firefighters

Structure Fire Incident Tasks	Time from Arrival of First Engine	Total Response Time
Pre-arrival time of dispatch, turnout, and travel time at desired goal point		07:30
First engine on-scene	00:00	
Conditions report	02:37	
Supply line charged	03:00	
Charged line to second floor	03:48	
Rapid Intervention Team arrived and established	04:40	12:10
Forced entry	06:09	
First Battalion Chief and second engine arrival	03:38	
Third engine and Technical Rescue unit arrival	05:45	
Back-up attack line at door charged	06:15	
Water on fire	07:04	14:34
Ladder truck and second Battalion Chief arrival	07:56	
Primary search for victims	08:10	15:40
Ladders positioned	11:05	
Utilities secured	12:45	
Positive pressure ventilation	12:32	
Secondary search complete	15:53	23:23
Check for fire extension in hidden spaces	15:58	
Fire out / **incident under control**	**17:15**	**24:45**

The duties in Table 6, grouped together, form an *Effective Response Force* or *First Alarm Assignment*. The distinct tasks must be performed simultaneously and effectively to achieve the desired outcome; arriving on-scene does not stop the escalation of the emergency. While firefighters accomplish the tasks, the clock keeps running, which has been running since the emergency first started.

Fire spread in a structure can double in size during its free burn period. Many studies have shown that a small fire can spread to engulf the entire room in less than 4:00 to 5:00 minutes after free burning has started. Once the room is completely superheated and involved in fire (known as flashover), the fire will spread quickly throughout the structure and into the attic and walls. For this reason, it is imperative that fire attack and search commence before the flashover point occurs if the outcome goal is to keep the fire damage in or near the room of origin. In addition, flashover presents a serious danger to both firefighters and any occupants of the building.

For comparison purposes, Table 7 reviews the tasks needed on a typical auto accident rescue.

Scenario: *The situation modeled was a one-car collision with one patient. The driver required moderate extrication with power tools and the vehicle was upright with no fuel hazards. One engine, one ladder truck, one technical rescue unit, and one Battalion Chief responded with a total of 11 personnel.*

Table 7—Single-Patient Traffic Collision – 11 Firefighters

Vehicle Extrication Critical Tasks	Time from Arrival of First Engine	Total Reflex Time
Pre-arrival time of dispatch, turnout, and travel time at desired goal point		07:30
Engine on scene	00:00	
Assess and upgrade to rescue response	00:15	
Initial report	02:00	
Vehicle stabilization initiated	02:00	09:30
Protection firefighting line in place	02:25	
Technical Rescue Unit, Battalion Chief, and ladder truck arrival	02:00	
Patient assessed, vital signs obtained	03:48	11:18
Door forcibly opened and secured	04:48	
Patient on backboard and removed	05:40	13:10
Patient on gurney	06:00	
Patient under ambulance crew care and depart scene	**07:30**	**15:00**

As another comparison, Table 8 displays the critical tasks needed on a typical cardiac patient, full arrest.

Scenario: *This was a simulated one-patient full arrest indoors. A standard response of one engine and one ambulance responded with a total of six personnel.*

Table 8—Cardiac Arrest – Four Firefighters Plus an Ambulance with Two Personnel

Cardiac Arrest Critical Tasks	Time from Arrival of First Engine	Total Reflex Time
Pre-arrival time of dispatch, turnout, and travel time at desired goal point		7:30
First-due engine on scene	00:00	
Engine crew determine full arrest and start CPR	00:55	8:25
Ambulance on-scene	01:35	
Cardiac monitor attached to patient	02:10	
Auto pulse CPR unit attached	03:18	
Intravenous line placed	03:24	10:54
Bag valve mask ventilation started	03:42	
Epinephrine administered	05:32	13:02
Intubation completed	06:10	13:40
Defibrillate, positive change in patient rhythm	06:53	14:23
Patient on gurney	07:28	
Patient in ambulance	**10:45**	**18:15**

4.1.1 Critical Task Analysis and Effective Response Force Size

What does a deployment study derive from a response time and company task time analysis? The total task completion times (as displayed in the tables) to stop the escalation of the emergency must be compared to outcomes. Nationally published fire service “time vs. temperature” tables indicate that after about 4:00 to 5:00 minutes of free burning, a room fire will grow to the point of flashover. At this point, the entire room is engulfed, the structure becomes threatened, and human survival near or in the fire room becomes impossible. Additionally, brain death begins to occur within 4:00 to 6:00 minutes of the heart having stopped. Thus, the Effective Response Force must arrive in time to stop these catastrophic events from worsening.

The response and task completion times discussed previously show that the residents of ACFD service areas can expect positive outcomes and have a good chance of survival in a *serious* fire or medical emergency *if the assigned neighborhood unit is available to respond*.

Mitigating an emergency event is a team effort once the units have arrived. This refers to the “weight” of response analogy. If too few personnel arrive too slowly, then the emergency will worsen instead of improve. Control of the structure fire incident in the simulation still took 17:15 minutes after the time of the first unit’s arrival, or 24:45 minutes from fire dispatch notification.

The outcome times, of course, will be longer, with less desirable results, if the arriving force is later or smaller.

In the ACFD, the quantity of staffing and the arrival time frame can be critical in a serious fire. Fires in older and/or multi-story buildings could well require the initial firefighters needing to rescue trapped or immobile occupants. If a lightly-staffed force arrives, it cannot simultaneously conduct rescue and firefighting operations.

Fires and complex medical incidents require that the other needed units arrive in time to complete an effective intervention. Time is one factor that comes from ***proper station placement***. Good performance also comes from ***adequate staffing*** and training. However, major fires and medical emergencies in which the closest unit is not available to respond still challenge the ACFD's response system to deliver good outcomes. This factor **must** be considered when fire station locations are considered. If fire stations are spaced too far apart, then when one unit must cover another unit's area, or multiple units are needed, these units can be too far away and the emergency will worsen.

Previous critical task studies conducted by Citygate, the Standard of Response Cover documents reviewed from accredited fire agencies, and NFPA 1710 recommendations all arrive at the need for 15+ firefighters arriving within 8:00 minutes travel at a room and contents structure fire to be able to ***simultaneously and effectively*** perform the tasks of rescue, fire attack, and ventilation. Given that the ACFD sends *at least 21* of its own personnel (three engines, one ladder truck, one technical rescue, one Rapid Intervention Unit (engine), and two Battalion Chiefs) to an incident involving a working house fire, it is clear that the ACFD and its leaders understand that firefighting units arriving closely together, with adequate staffing, are needed to deliver a positive outcome that protects lives and property by stopping the escalation of the emergency.

A question one might ask is, "If fewer firefighters arrive, *what* from the list of tasks mentioned in Table 6 through Table 8 would not be done?" Most likely, the search team would be delayed, as would ventilation. The attack lines would only consist of two firefighters, which does not allow for rapid movement above the first-floor deployment. Rescue is conducted with only two-person teams; thus, when rescue is essential, other tasks are not completed in a simultaneous, timely manner. Performing only one of these may negatively impact a victim's outcome. It must always be remembered: effective deployment is about the **speed** *(travel time)* and the **weight** *(firefighters)* of the attack.

Twenty-one initial firefighters can handle a moderate-risk house fire; however, even an Effective Response Force of 21 firefighters will be seriously slowed if the fire is above the first floor, in a low-rise apartment building, or in a commercial/industrial building. This is where the capability to add personnel to the initial response or to add entire alarms of multiple units becomes important.

Delivering 21 personnel to a moderate risk residential building fire reflects the ACFD's goal to confine serious building fires to or near the room of origin and to prevent the spread of fire to adjoining buildings. This is a typical desired outcome in built-out areas and requires more firefighters more quickly than the typical rural outcome of keeping the fire contained to the building, not room, of origin.

4.2 Distribution and Concentration Studies—How the Location of First-Due and First Alarm Resources Affects the Outcome

SOC Element 5 of 8
Distribution Study

SOC Element 6 of 8
Concentration Study

The ACFD is served today by 29 active fire stations. Thus, the ACFD currently has 27 engines, two quints, and five trucks *in neighborhoods* for first response firefighting. It is appropriate to understand what the existing stations do and do not cover, if there are any coverage gaps needing one or more stations, and what, if anything, to do about them. Additionally, as the ACFD's service areas continue to develop, the number and location of additional fire stations that might be necessary must be considered.

In brief, there are two geographic perspectives to fire station deployment:

- **Distribution** – The spreading out or spacing of first-due fire units to stop routine emergencies.
- **Concentration** – The clustering of fire stations close enough together so that building fires can receive sufficient resources from multiple fire stations quickly. As indicated, this is known as the **Effective Response Force**, or, more commonly, the First Alarm Assignment—the collection of a sufficient number of firefighters on scene, delivered within the concentration time goal, to stop the escalation of the problem.

To analyze first-due fire unit travel time coverage for this study, Citygate used a geographic mapping tool called FireView™ that can measure theoretical travel time over the street network. For this time calculation, Citygate staff uses the base map and street travel speeds calibrated to actual fire company travel times from previous responses to simulate real-world coverage. Using these tools, Citygate ran several deployment tests and measured their impact on various parts of the County. The travel time measure used was 4:00 minutes for the first-due unit over the road network, which is consistent with the ACFD's adopted goal to deliver desirable outcomes in critical emergencies. For multiple unit incidents, 8:00 minutes travel was used per the ACFD's goal.

When 90 seconds is added for dispatch time, and 2:00 minutes for crew turnout times, then the maps effectively show the area covered within 7:30 minutes for the first-due response, and 11:30 minutes for a First Alarm assignment.

4.2.1 Traffic Congestion Impacts

Citygate's team members personally observed the current rush-hour traffic congestion in parts of the ACFD's service areas and have observed this in many other departments since the great recession ended. The legacy approach to predict fire apparatus travel times over a street network is insufficient. The approach does not accurately result in response times at peak commute hours because the traditional data set during commute hours is not sufficient.

Citygate thus obtained traffic throughput travel speed data from the company that provides real-time traffic data to internet-based traffic map applications. That company is a multi-national firm called HERE. This is the same data that drives internet-based map views of traffic congestion with red, yellow, and green segments to indicate flow impedance. HERE obtains traffic speed samples from a variety of public and private sources and measures traffic speeds in 15:00-minute time blocks, between intersections (segments), on a 24/7/365 basis for a rolling 36-month period.

To build the *traffic congestion* time-over-distance maps in this report, Citygate's model first uses actual fire apparatus travel times averaged over a 24-hour period for one year. Then traffic speed data is used to build a congested traffic model. Overall, the congestion impacts can be measured in the volume of road miles in the ACFD covered at peak and off-peak hours.

Table 9—Road Mile Coverage for First-Due and First Alarm Units (Active Stations)

Time Measure	Total Road Miles (Metro-Suburban within Battalions Only)	Non-Congested Miles Reached by Open Fire Stations	Congested Road Miles	Difference in Miles Covered
4:00-Minute First-Due Unit	1062.98	894.96 (***84%*** *of total public miles*)		**168.02**
		894.96	784.79 (***74%*** *of total public miles*)	**110.17**
8:00-Minute First Alarm	1062.98	*696.1* (***65%*** *of total public miles*)		**366.88**
		696.1	516.33 (***49%*** *of total public miles*)	**179.77**

As a starting point, **84 percent** of the Department's urbanized area public roads are within 4:00 minutes travel time of a fire station. This is *excellent first-due unit coverage;* a desirable goal is 90 percent, and many departments struggle to reach 75 percent coverage. Travel coverage fire stations at commute hours is negatively impacted down to **74 percent** of the road miles. The multiple-unit coverage at commute hours is more severely impacted from **65 percent** down to **49 percent** of the road miles as multiple units must travel across large sections of the Department's service communities. The following maps (see **Volume 3**) will show where this normal and reduced coverage occurs.

4.2.2 ACFD Deployment Baselines

Due to the size of the ACFD, each type of map to follow has a north, south, and east view.

Map #1 – General Geography, Station Locations, and Apparatus Types

These maps show the existing ACFD fire service areas, station locations and, using symbols, the primary, full-time staffed fire apparatus at each station. These are reference maps for the other map displays that follow.

Map #2a – Risk Assessment – Planning Zones

Risk assessment is an effort by a department to classify properties by potential impact on service demand levels. The risk assessment analysis in the ACFD categorized risks into four zones, shown on the risk maps as differently shaded areas.

Map #2b – Risk Assessment – Critical Facilities

These maps show the locations of the identified critical facilities to be protected from fire and other hazards. These facilities are essential to the quality of life and economic operation of a major urban area.

Map #2c – Risk Assessment – Needed Fire Flow (NFF) Large Fire Flow Buildings

Building fire risk, separate from the housing areas, was examined by understanding the locations of the higher fire flow buildings as calculated by the Insurance Service Office (ISO) as a measure of how zoning locates the educational, commercial, and industrial uses in ACFD service areas. These higher fire flow sites (shown in dark red) are the buildings that must receive a timely and effective First Alarm force to serious fires, thus requiring more firefighters in fewer minutes should a serious fire emerge. Most of these higher fire flow buildings are along the major road corridors.

While most prevalent in the various community core areas, zoning has placed commercial buildings in most all fire station districts and in all four of this study's risk assessment zones. Thus, an Effective Response Force (First Alarm) capability is needed in all the urbanized areas of the ACFD.

Map #3a/b – Fire Engine First-Due Unit Distribution at 4:00-Minute Travel

These two maps show, using light-green street segments for uncongested traffic (non-rush hour), the ACFD's response coverage for first-due units within a Departmental goal of 4:00 minutes *travel* time. Therefore, the limit of green color per station area is the distance an engine could reach within this time ***assuming*** it is in station and encounters no unusual traffic delays. The mapping software uses actual fire company speed limits per roadway type. Thus, the green projection is realistic for fire engines with normal traffic present.

As can be seen, in both unincorporated and contract city areas, there are very few streets not within reach of a fire station unit within 4:00 minutes travel time. Based on this perspective, the ACFD and the contract cites have effective first-due fire station coverage. There also should be some overlap between station areas so that a second-due unit can have a chance of an adequate response time when it covers a call in another fire company's first-due area.

Countywide, actual dispatch data *shows* travel times to be slightly slower in all but one station area, ranging from 4:30 to 5:30 minutes. This is due to the effects of the non-grid street design layout, open space areas, freeways that bisect parts of the ACFD, traffic congestion at times, and simultaneous incident demand at peak hours of the day.

Map series #3b, using data for peak-hour congested traffic, shows the congested 4:00-minute travel time coverage as smaller coverage areas in **dark** green. Citygate obtained traffic congestion data for each day's morning and evening rush hours. The mathematical variances are assessed and, if they are wide, maps are produced by day of the week, or just morning or evening. Where the variances are small, and thus the congestion patterns are very similar, Citygate uses one mid-point congestion period to illustrate the most common impact.

The reductions are modest and mostly limited to the edges of some services areas; northern Union City shows the largest loss (impact). This shows the coverage resilience of the well-located ACFD stations and that, while freeways and some interchanges can be very congested, many surface streets are not congested.

The purpose of computer response mapping is to determine and balance station locations. This geo-mapping design is then checked in the study against actual dispatch time data.

Map #4 – ISO Coverage Areas

These maps display the Insurance Service Office (ISO) preference that stations cover a 1.5-mile distance response area. Depending on the road network, the 1.5-mile measure usually equates to a 3:30- to 4:00-minute travel time. However, a 1.5-mile measure is a conservative indicator of station spacing and overlap. As can be seen, the ISO coverage is similar, but slightly less forgiving, than the 4:00-minute, *non-traffic-congested* travel time measure. This is because a "distance-based" measure cannot account for higher speeds on freeways and primary arterial streets that feed out into the neighborhoods.

These maps show that hardly any first-due fire company coverage gaps exist at the ISO 1.5-mile *distance measure* in the urban service areas of the ACFD.

Finding #3:	In the urban service areas, the ACFD has effective fire station placements, with only very small gaps at the edges of some communities or when there is significant traffic congestion. The gaps are too small to cost-effectively add stations.

Map #5a/b – Concentration (First Alarm Residential) at 8:00-Minute Travel; Normal and Traffic Congested

These maps show the Effective Response Force (ERF) *concentration* or massing of fire crews for serious fire or rescue calls. Building fires, in particular, require 15+ firefighters (per NFPA 1710) arriving within a reasonable time frame to work together and effectively to stop the escalation of the emergency. Otherwise, if too few firefighters arrive, or arrive too late in the fire's progress, the result is a greater alarm fire, which is more dangerous to the public and the firefighters.

The concentration map exhibits show the ACFD's ability to send a minimum of three engine companies, one truck company, and one Battalion Chief to residential building fires within 8:00 minutes travel time (11:30 minutes total response time). This measure ensures that a minimum of 21 firefighters and an ambulance can arrive on-scene to work ***simultaneously*** and effectively to stop the spread of a serious building fire.

These maps show in light green, *without traffic congestion,* where the ACFD's current fire station system should deliver the initial Effective Response Force during off-peak traffic hours.

As can be seen, given a longer travel time measure of 8:00 minutes, each of the three main service areas of the ACFD have multiple unit coverage challenges. However, each area's challenge is *different.*

East – The limiting unit is the Battalion Chief located too far east at Station 20. A later map in this study will look at the effect of moving the Battalion Chief to Dublin.

North – Emeryville is not close enough to San Leandro for First Alarm coverage, but the ACFD contracts with Oakland fire for the remaining engines, a ladder truck, and chief officer. This map does not show that complete coverage.

South – The western edges of both Newark and Union City are not within 8:00 minutes of all the units. This is particularly true for the last-due engine given that the quints run as ladders, three engines must all be moved west, and the Battalion Chief is too far in the northeast corner of Union City.

The next set of maps will "take apart" this composite force need and show the different coverages from engines, a quint/ladder truck, and a chief officer.

When traffic congestion is applied, only the small areas shown as dark green can receive this multiple-unit force within 8:00 minutes of travel. This reduction is appreciable in Dublin and Newark/Union City. The multiple units can reach the center of these areas, but not completely out to an edge.

Finding #4:	Only some of each urban core area is within 8:00 minutes travel time of an Effective Response Force assignment of three engines, one ladder truck, one rescue unit, and one Battalion Chief, with *no traffic congestion*. During traffic congestion, this coverage is further reduced in the east and south contract city areas.

Map #6a/b – Three Engines Only at 8:00-Minute Travel; Normal and Congested Traffic

This map series only shows the 8:00-minute coverage of three engine companies, or nine firefighters. Here, the green color shows the areas receiving three engines in 8:00 minutes travel time *given normal traffic*. The coverage for three engines is good everywhere under normal traffic. Also, in this map, the City of Oakland units are activated, showing the very good coverage into Emeryville. Under traffic congestion, only Union City is significantly impacted for three-engine coverage.

Map #7a/b – One Battalion Chief at 8:00-Minute Travel; Normal and Congested Traffic

These maps display the coverage for one Battalion Chief at 8:00 minutes travel time. Therefore, Maps #7a/b show the *minimum* ACFD-provided chief officer. As can be seen, even with four chief officers on duty, not all the edge areas can be covered *given normal traffic.* In the east zone, neither the ACFD nor the Livermore-Pleasanton Battalion Chief can reach the upper center of Dublin by the eighth minute. Newark is similarly affected as the Battalion Chief coming from northeast Union City cannot reach very far into Newark. In both these areas, traffic congestion further reduces the Battalion Chief travel time.

Map #8 – One Ladder Truck or Quint Coverage at 8:00-Minute Travel; Normal and Congested Traffic

Maps #8 displays the 8:00-minute travel time coverage for a minimum of one ladder truck, or a quint in the case of Newark and Union City. As can be seen, the ACFD's current ladder trucks can cover almost all the urban service areas and Emeryville from the Oakland contract units.

Finding #5:	The *single* ladder truck coverage is adequate for the current needs of the ACFD, but the coverage must be re-evaluated as new growth areas are added beyond the identified ladder truck and/or quint service areas.

Map #9 – All Incident Locations – Three Years

These maps show an overlay of the exact location for all incident types. It is apparent that there is a need for fire services on almost every street segment of the ACFD. The greatest concentration of calls is also where the greatest concentration of ACFD resources is available.

Map #10 – Emergency Medical Services and Rescue Incident Locations – Three Years

These maps further show only the emergency medical and rescue call locations. With the majority of the calls for service being emergency medical, virtually all areas of the ACFD need emergency medical services in any given year.

Map #11 – All Fire Type Locations – Three Years

These maps show the location of all fires in the ACFD for a three-year period. All fires include any type of fire call, from auto to dumpster to building. There are obviously fewer fires than medical or rescue calls. Even given this, it is evident that all first-due engine areas experience fires; the fires are more concentrated where the population is higher and the ACFD's resources are more concentrated. These also happen to be the areas where the building stock is older and not built to the latest building and fire codes.

Map #12 – Structure Fire Locations – Three Years

These maps show structure fire locations. While structure fires are a smaller subset of total fires, there are two meaningful findings from this map. First, there are still structure fires in every first-due fire company district. The location of many of the building fires parallels the older and higher risk building types in the ACFD where more significant risk and the ISO-evaluated buildings are more common. These areas and buildings are of significant fire and life loss risk to the ACFD's service communities. Second, fires in the more complicated building types must be controlled quickly or the losses can be very large.

Map #13 – EMS Incident Location Densities – Three Years

These maps examine, by mathematical density, where clusters of emergency medical services incident activity occurred. In this set, the darker density color plots the highest concentration of all incidents. This type of map makes the location of frequent workload more meaningful than simply mapping all incident locations, as done in map series #10.

This perspective is important because the deployment system needs an overlap of units to ensure the delivery of multiple units when needed for serious incidents or to handle simultaneous calls for service. When this type of map is compared with the concentration of engines in map series #6, the best concentration should be where the greatest density of calls for service occurs. This occurs in the core of the ACFD where the fire station spacing is the closest.

Map #14 – All Fire Types Incident Location Densities – Three Years

These maps are similar to map series #11, but display the densities of all types of fire incidents, again following a population and building density pattern.

Map #15 – Structure Fire Densities – Three Years

These maps show only the building fire workload by density. While there are small clusters of building fire occurrences, the greatest densities occur in the oldest and most densely developed sections of the ACFD.

4.2.3 Fire Station and Battalion Chief Alternative Coverage Analysis

Given the adequate fire station spacing identified in ACFD service areas, Citygate and ACFD staff reviewed their capital facilities needs report and discussed where it might be beneficial to look at a fire station relocation to improve coverage and/or parcel flexibility where a very old station needs a total rebuilding.

Additionally requested was a study of the effect of moving the eastern Battalion Chief from Station 20 at Lawrence Livermore National Laboratory to a more central-eastern area location in the City of Dublin.

The following mapping models look at these issues and offer insights to the staff as they make ongoing planning decisions.

Map #16 and #17 – Relocate the Eastern Battalion Chief

This map shows the effect of relocating Battalion 3 from Station 20 to Station 17 in central Dublin. As can be seen, the move increases chief coverage to all of Dublin, and south on I-680 to Sunol, but at the expense of the Laboratory and other incident coverage east and southeast to the County line. The moved coverage also overlaps the Livermore-Pleasanton Battalion Chief coverage from Fire Station 4 in south Pleasanton. The LPFD does not have a Battalion Chief based in the City of

Livermore. Map #17 shows the results of the move on the Effective Response Force (First Alarm) multiple-unit coverage (compare to Map #5a East) to essentially the western Tri-Valley area.

While this move to Dublin would cover a higher density of incidents, staff must consider that against the long, eastbound I-580 travel times during evening traffic congestion. Two chiefs cannot cover the entire urban, I-580 corridor, but the frequency of chief officer need incidents at the Laboratory or in the eastern hills is also a small quantity. In summary, the Dublin location works, but it would be a trade-off.

Map #18a/ b – Relocate Station 26

Station 26 is older and on a small parcel near a major curve in the road. ACFD staff asked to see what the coverage would look like if the station was moved to the north on Lake Chabot Road to the edge of the East Bay Regional Parks District (EBRPD) Lake Chabot Park property (Lake Chabot Road and Arcadian Drive). Given the zoning in the area, there are very few other available sites to test at this time.

Map #18a compares the multiple-unit coverage difference between the two sites at an 8:00-minute travel time. The effect is to shift the multiple unit coverage to the north away from the south the same amount that the station is moved north. These differences are not significant enough to be a primary factor in considering this move.

Map #18b shows the single-unit, typical emergency at 4:00 minutes travel time. The move does significantly move coverage to the north, but given the overlapping coverage of the current site by Stations 6, 24, and 25, the southern coverage reduction is not a serious factor. Normally, Citygate would not recommend a station be placed at the end of a coverage area or up against natural barriers, such as canyons or lakes. But in this case, given the stations to the south, the ACFD might prefer more northern coverage and to reduce its travel times to the lake and hillside recreation regions in that section of the County.

The ACFD can take these coverage changes into consideration along with, in this case, more significant issues such as parcel size, safe emergency unit egress into traffic, and acceptance by the neighborhood.

Map #19a–d – Relocate Station 22

This evaluation considers moving Station 22 either slightly to the west at Paseo Grande and Paseo Largavista (Site A) or more significantly west to Bockman and Channel Street (Site B). The Paseo Grande location (Site A) is only a block or two from the current location, so the differences are minimal for both single-unit travel coverage at 4:00 minutes and multiple-unit coverage at 8:00 minutes.

Site B relocates coverage significantly further west than Site A at 4:00 minutes, improving coverage to the western area streets but at the expense of overlap east of I-880.

The 8:00-minute multiple-unit coverage is significantly moved west. Both test sites remain almost entirely within the footprint of the existing 8:00-minute coverage for Station 22 (hence the absence of magenta in these maps). Either site could work, with the better single-unit coverage being from Site B. If the ACFD does not need the overlapping multiple-unit coverage east of I-880, then as with the Station 26 scenario, Citygate would suggest other factors, such as land cost, parcel size, and traffic egress safety, be larger factors in the siting decision.

SECTION 5—RESPONSE STATISTICAL ANALYSIS

5.1 HISTORICAL EFFECTIVENESS AND RELIABILITY OF RESPONSE—WHAT STATISTICS SAY ABOUT EXISTING SYSTEM PERFORMANCE

SOC ELEMENT 7 OF 8
RELIABILITY AND HISTORICAL RESPONSE EFFECTIVENESS STUDIES

The map sets described in Section 4 show the ideal situation for response times and the responses' effectiveness given perfect conditions with no competing calls, units all in place, and no simultaneous calls for service. Examination of the response time data provides a picture of responses in light of simultaneous calls, rush hour traffic conditions, units out of position for training, and delayed travel time for events such as periods of severe weather.

5.1.1 Data Set Identification

The Alameda County Fire Department provided National Fire Incident Report System (NFIRS 5) incident and computer-aided-dispatch (CAD) individual apparatus response data for the period 1/1/2014 through 12/31/2016. Apparatus response data was merged with NFIRS 5 data using a common incident number.

5.2 SERVICE DEMAND

In 2016, the ACFD responded to 42,680 incidents. During this time, the ACFD had a daily incident demand of 116.61 incidents, of which 2.55 percent were to fire incidents, 70.66 percent were to EMS incidents, and 26.79 percent were to "Other" incident types.

During this period, there were 58,090 individual apparatus responses. This means there was an average of 1.36 apparatus responses per incident. The ACFD has experienced a steady growth in the number of incidents from 2014 to 2016:

Figure 2—Number of Incidents by Year

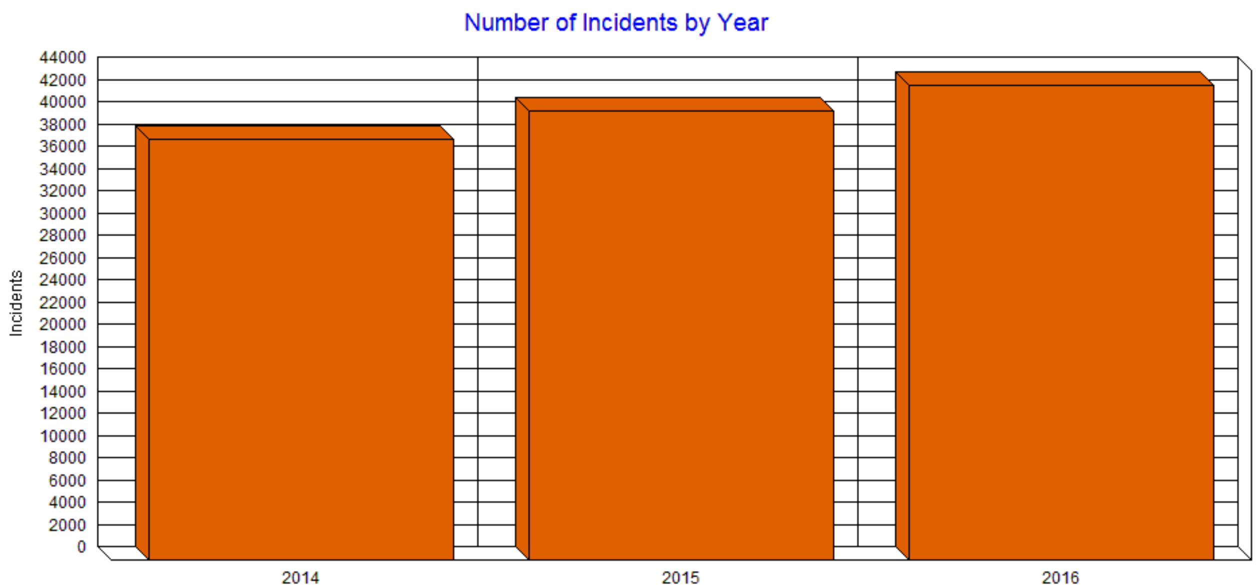
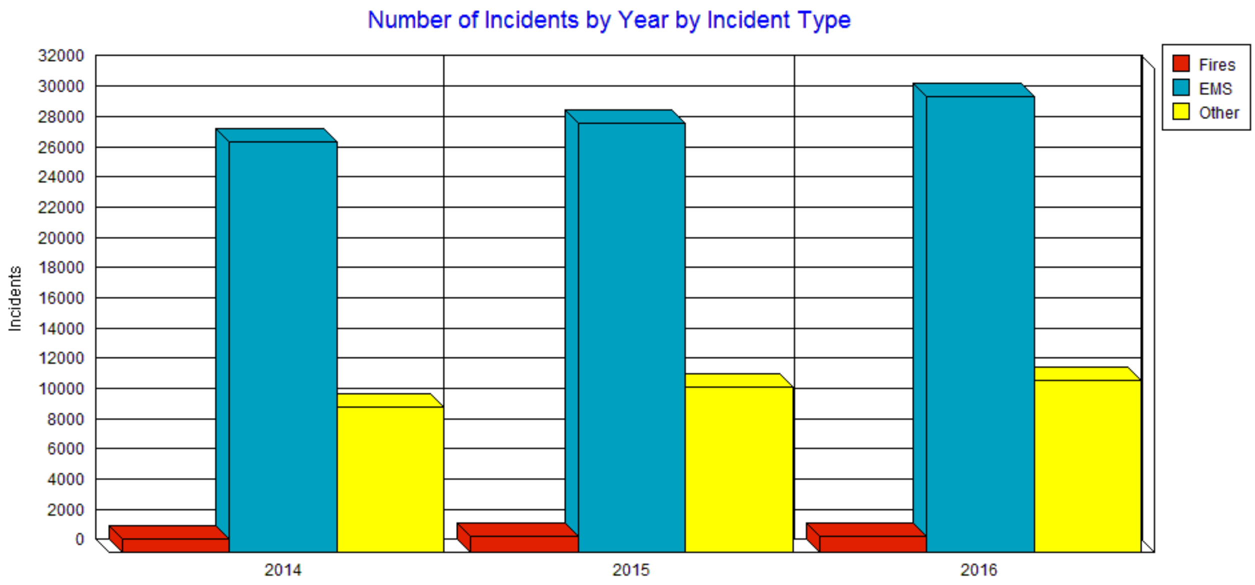


Figure 3 illustrates the number of incidents by incident type per year:

Figure 3—Number of Incidents by Year by Incident Type



As shown in Figure 4, when broken down by day of week, incident activity decreases slightly later in the weekend:

Figure 4—Number of Incidents by Day of Week by Year

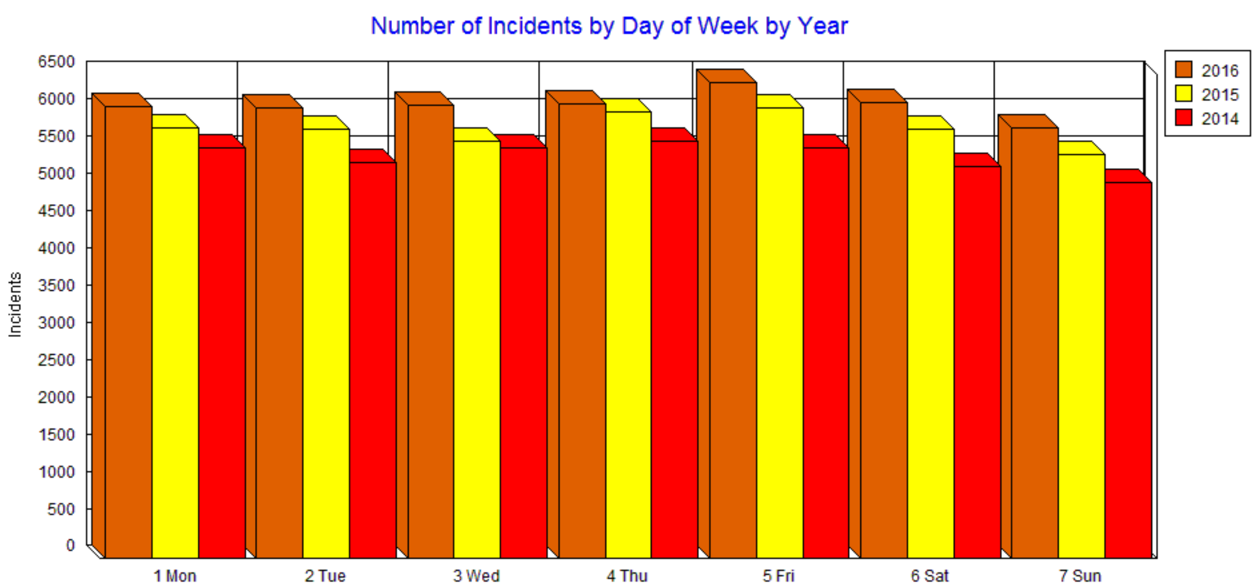


Figure 5 displays the breakdown of incidents by hour of the day by year. There is an increase in 2016 incidents during early afternoon and early evening hours:

Figure 5—Number of Incidents by Hour of Day by Year

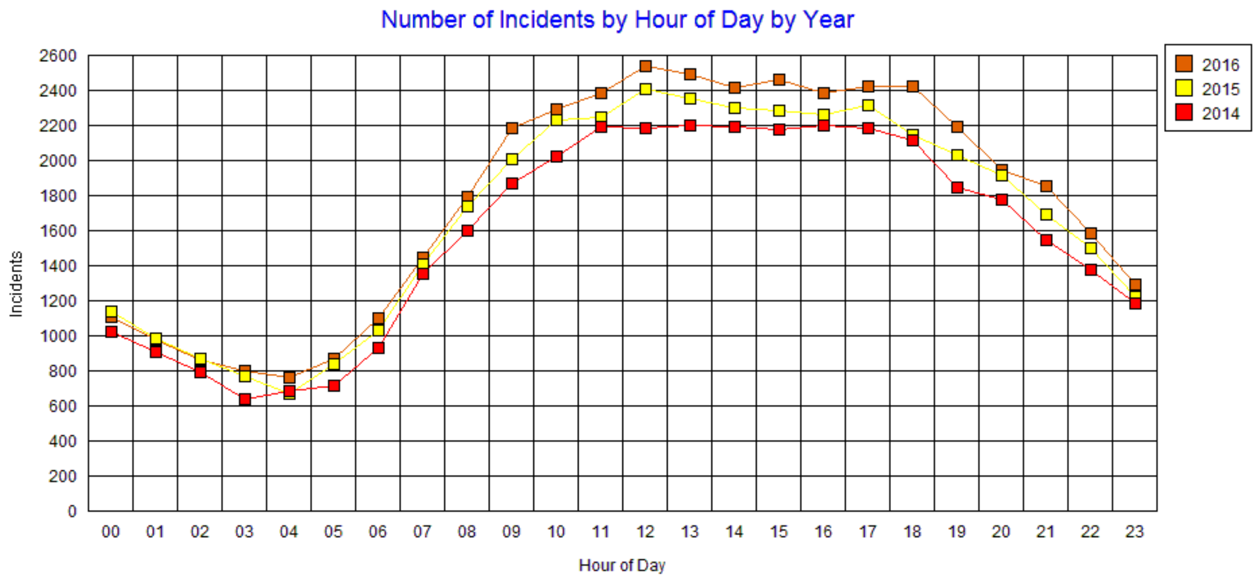


Table 10 shows hourly incident quantity by hour of day and day of week for 2016. Green areas have the least activity. Red areas have the heaviest activity. The greatest incident activity occurs in the late morning through early evening hours:

Table 10—Incidents: Quantity – Hour of Day and Day of Week – 2016

Hour	1 Mon	2 Tue	3 Wed	4 Thu	5 Fri	6 Sat	7 Sun	Total
00:00-00:59	129	155	161	118	157	176	217	1,113
01:00-01:59	134	115	134	120	134	166	176	979
02:00-02:59	116	123	112	116	118	143	136	864
03:00-03:59	109	105	108	101	108	130	140	801
04:00-04:59	96	105	102	111	115	113	120	762
05:00-05:59	136	121	137	104	134	118	123	873
06:00-06:59	169	172	166	152	172	126	143	1,100
07:00-07:59	197	208	265	254	206	160	162	1,452
08:00-08:59	274	299	246	265	293	213	208	1,798
09:00-09:59	335	323	323	332	332	268	276	2,189
10:00-10:59	308	331	361	384	335	306	274	2,299
11:00-11:59	357	349	340	344	376	311	312	2,389
12:00-12:59	374	405	353	364	379	378	286	2,539
13:00-13:59	353	331	365	356	393	381	315	2,494
14:00-14:59	380	335	351	340	351	339	325	2,421
15:00-15:59	335	348	365	350	391	345	330	2,464
16:00-16:59	347	325	352	352	361	351	303	2,391
17:00-17:59	372	338	326	358	375	352	306	2,427
18:00-18:59	362	361	347	311	356	370	322	2,429
19:00-19:59	310	323	283	313	288	345	333	2,195
20:00-20:59	264	260	263	295	284	279	308	1,953
21:00-21:59	243	260	260	263	286	295	253	1,860
22:00-22:59	212	201	214	229	242	252	242	1,592
23:00-23:59	169	165	171	180	215	220	176	1,296
Total	**6,081**	**6,058**	**6,105**	**6,112**	**6,401**	**6,137**	**5,786**	**42,680**

A detailed review of the types of properties to which the ACFD responds finds, in summary, that 47.3 percent of the serious fire and EMS incidents in 2016 occurred in residential dwelling and rental units (such as hotels) of all types. Another 17.5 percent occurred on roads, on highways, and in parking areas. Nursing and care facilities (not hospitals) accounted for another six percent. The remaining 29.2 percent occurred across a variety of commercial, industrial, and other properties. Given that the predominant land-use type is residential in most urban areas, the incident location types to which the ACFD responds are normal.

Finding #6:	The highest volume hours for incidents span from 9:00 a.m. through 8:00 p.m. Given this, if additional units are needed for high workload volumes or to cover for out-of-service training units, added units could be peak-hour units for 12 hours per day, six days per week.

5.2.1 Simultaneous Incident Demand

Simultaneous incidents occur when other incidents are underway at the time a new incident begins. In Alameda County, more than three-quarters of incidents occur when there is at least one other incident occurring in the jurisdiction. During 2016, 82.46 percent of incidents occurred while one or more other incidents were underway. Table 11 lists the proportion of simultaneous incident occurrence by the number of simultaneous incidents, where "1 or more" means that there are at least two incidents open, "2 or more" means there are at least three incidents open, etc.:

Table 11—Percentage of Simultaneous Incidents

Simultaneous Incidents	Proportion of Occurrence
1 or more	82.46%
2 or more	55.69%
3 or more	31.59%
4 or more	15.56%
5 or more	06.67%
6 or more	02.67%
7 or more	01.04%
8 or more	00.37%

In a large county system, simultaneous incidents in different station areas have very little operational consequence. However, when simultaneous incidents frequently occur within a single station area, there can be significant delays in response times.

Table 12 shows the quantities for simultaneous incidents within a single station area for the three years of data. The chart is organized to show the stations with the highest simultaneous incident activity first. Trends from year to year in each station area can be easily seen:

Table 12—Incidents: Quantity – Year by Station

Station	2014	2015	2016	Total
24	326	325	381	1,032
9	288	301	370	959
12	224	222	214	660
25	188	180	171	539
10	36	66	77	179
17	45	57	67	169
13	53	61	47	161
23	50	48	62	160
16	66	41	53	160
8	44	52	55	151
22	43	41	42	126
33	30	43	35	108
35	19	27	38	84
14	16	30	36	82
6	25	30	25	80
32	19	26	29	74
26	15	19	33	67
34	23	17	24	64
18	9	17	33	59
29	14	14	29	57
20	12	25	15	52
31	10	19	22	51
27	8	16	17	41
28	13	15	10	38
11	11	5	10	26
30	6	4	5	15
7	2	3	7	12
21	4	5	1	10
19	3	2	3	8
Total	**1,602**	**1,711**	**1,911**	**5,224**

5.3 Response Time Analysis

Once the types of incidents are quantified, incident analysis shifts to the time required to respond to those incidents. Fractile breakdowns track the percentage (and count the number) of incidents meeting defined criteria, such as the first apparatus to reach the scene within progressive time segments.

5.3.1 Response Time Performance

A person calling 9-1-1 measures the speed of fire department response from the time assistance is requested until the assistance arrives. This measurement is referred to as Call to First Apparatus Arrival (or Call to Arrival). Police departments, under state law, act as a Public Safety Answering Point (PSAP) for 9-1-1 calls. All 9-1-1 calls for fire or medical service in the ACFD service area are answered in the Sheriff's or local city police communications centers. Fire, EMS, and other rescue calls are routed to the ACRECC for processing and crew dispatching. This center handles all fire service dispatching in the ACFD and for additional contract cities, such as Alameda, Fremont, Livermore, and Pleasanton, and allows for a coordinated, closest-unit response regardless of jurisdiction of incident origin.

In an urban area, a total response time measure based on best practices is 7:30 minutes (or 450 seconds). This is formed from three component parts:

Table 13—Response Time Components

Time Component	Minutes	Description
Call Processing	1:30	Receive, determine need, alert crew
Turnout	2:00	Notify, don required protective gear, get moving
Travel	4:00	Drive to scene
Call to Arrival	**7:30 Minutes**	**Time from ACRECC receipt to first unit arrival**

There are three fundamental measurements of operational performance: call processing time, turnout time, and travel time.

Call processing begins when a request for assistance is first received and ends when the dispatch center communicates the location and nature of the emergency to responders.

Turnout begins with responder notification and ends when the fire apparatus begins traveling to the scene of the emergency.

Travel begins when the first response unit's wheels begin turning and ends when the apparatus arrives at the scene of the emergency.

Each of these basic measurements is calculated as the amount of time it takes to reach 90 percent compliance. Using call processing as an example, a set of incidents is selected and the amount of time it takes for 90 percent of requests for assistance to be dispatched to one or more apparatus can be calculated.

Also measured is the performance of a team of apparatus commonly called a "First Alarm," but more properly known in fire service deployment as an Effective Response Force (ERF). This team is dispatched to serious or high-risk incidents, such as building and wildland fires or technical rescues. It is a best practice to measure ERF travel from the first apparatus in the ERF to begin traveling to the emergency until the last apparatus necessary to establish the ERF team arrives on the scene. Thus, there are six types of response time performance outlined to meet best practices as recommended by the NFPA and the CFAI:

- Call Processing
- Turnout
- Travel
- Dispatch to Arrival
- Call to Arrival
- ERF Travel.

Information on each performance category is provided in the following sections. The following performance measurements are based on apparatus response data timestamps from 2016. Only in-jurisdiction fire and EMS incidents (where no mutual or auto aid was provided/given) were used for this analysis.

The times are shown in minutes and seconds and show the amount of time necessary for 90 percent of emergency incidents to be handled. Outlier specifications eliminate times that are unrealistically too low or too high.

5.3.2 Call Processing Performance

Table 14—Call Processing Analysis

Area	Time
Department-Wide	01:30

Finding #7:	National best practices as recommended by NFPA standard 1221 are for call processing to be 90 seconds 90 percent of the time and 120 seconds 99 percent of the time. The ACRECC is substantially meeting this goal.

5.3.3 Turnout Performance

Table 15—Turnout Time Analysis

Area	Time
Department-Wide	2:10

Station design can profoundly impact turnout time. However, other factors such as location confirmation, gearing-up, and other essential and non-essential response preparations can impact turnout time.

Finding #8:	A realistic goal for turnout time is 2:00 minutes to 90 percent of the emergency incidents. The ACFD is just over this goal and, with focus, can meet or beat this goal, especially during waking hours.

5.3.4 Travel Performance

The following travel times are reported by fire station areas and thus provide correlation to the geographic information systems mapping projections. Only one fire station area meets the 4:00-minute travel time goal, as shown in light gray:

Table 16—Travel Time Analysis

Station	2016
Department-wide	05:12
Battalion 2	05:01
Station 06	06:51
Station 07	07:11
Station 22	04:46
Station 23	04:34
Station 24	05:11
Station 25	04:39
Station 26	05:09
Battalion 3	04:58
Station 16	05:13
Station 17	04:45
Station 18	04:51
Station 20	03:26
Station 21	06:41
Battalion 4	05:00
Station 09	04:49
Station 10	05:37
Station 11	04:55
Station 12	04:44
Station 13	04:46
Station 19	06:03
Station 34	06:24
Station 35	04:42
Battalion 7	05:31
Station 27	04:31
Station 28	05:02
Station 29	04:54
Station 30	04:47
Station 31	06:13
Station 32	05:37
Station 33	05:49

Finding #9:	In the 2016 measurement period, the ACFD had a Department-wide 90 percent travel time of 5:12 minutes. This travel time is 1:00 minute longer than a best-practice-based goal of 4:00 minutes in urban areas. This travel time is fairly consistent across urbanized areas of the ACFD as only one station area was under a 4:00-minute travel time.

5.3.5 Call to Arrival Time Performance

This measure combines the steps of dispatch processing, crew notification with turnout, and travel time to 90 percent of fire and EMS incidents. Assuming the ACFD's ongoing use of a 7:30-minute goal for total response time, during 2016 the ACFD came within 23 seconds of reaching the call to arrival goal:

Table 17—Call to Arrival Time Analysis

Station	2016
Department-wide	07:53
Battalion 2	07:43
Station 06	09:14
Station 07	10:30
Station 22	07:34
Station 23	07:26
Station 24	07:47
Station 25	07:19
Station 26	07:57
Battalion 3	08:09
Station 16	08:10
Station 17	07:41
Station 18	07:58
Station 20	12:30
Station 21	12:53
Battalion 4	07:39
Station 09	07:19
Station 10	08:10
Station 11	07:38
Station 12	07:20
Station 13	07:19
Station 19	08:00
Station 34	09:09
Station 35	07:27
Battalion 7	08:00
Station 27	07:00
Station 28	07:49
Station 29	07:27
Station 30	07:20
Station 31	08:43
Station 32	08:03
Station 33	08:19

Finding #10:	Due to longer travel times, with the current quantity of fire stations, the ACFD comes within 23 seconds of a Department-wide call to arrival goal of 7:30 minutes. Given the varied topography in some of the suburban and rural areas in this measure, it would not be cost effective to add stations to gain the 23 seconds. Sixteen stations delivered service in less than 8:00 minutes in the most urbanized areas, which is commendable given the road network and topography.

5.3.6 First Alarm (Effective Response Force) Performance to Building Fires

The ACFD's response plan *for a single-family home fire* in the most urban western battalions is four engines, one ladder truck, one technical rescue unit, and two Battalion Chiefs for a minimum force total of **21** firefighting personnel. A best-practice-based travel time goal from NFPA 1710 for career fire departments in urban areas is that the *last* unit arrive within an 8:00-minute *travel time* to 90 percent of the First Alarm incidents.

Table 18 shows the 90 percent travel time for 46 incidents in 2016 where at least four engines and one ladder truck all arrived at the incident. Not all fires are serious enough for all the units to be needed, so the resultant ERF count is small and not as statistically significant. Thus, the following table only aggregates ERF measures by battalion areas:

Table 18—Travel Time for ERF Incidents

Area	2016
Department-wide	16:28 (46)
Battalion 2	11:04 (25)
Battalion 3	0
Battalion 4	11:35 (15)
Battalion 7	20:12 (6)

The travel times shown in Table 18 are reflective of the large size of some of the battalion areas and the way deploying the ladder truck to all urban areas within an 8:00-minute travel time is a limiting factor.

5.3.7 Engine and Truck Workload Capacity Analysis

Due to the simultaneous incident rates and the lengthy travel times (in many areas approaching 5:00 minutes), this section of incident measures presents demand on units by the hour of day it occurs and determines if the peak-hour demand is so high that response times suffer because units must cross the ACFD to cover for overly busy units.

The following tables depict a Unit-Hour Utilization (UHU) summary. The different colors illustrate the variation in demand: the lowest rates of activity are green, progressing up to yellow, and finally reach red, which indicates the greatest quantity of incidents or rate of activity. The percentage listed is the percentage likelihood a particular unit is assigned to a 9-1-1 incident at any given hour. This number considers not only the number of emergency incidents, but also the duration of the incidents. The busiest units are listed first.

It is important to consider the ideal maximum utilization percentage on a firefighting unit. During the nine-hour daytime work period, when crews on a 24-hour shift need to also pay attention to apparatus checkout, station duties, training, public education, and paperwork, plus the required physical training and meal breaks, Citygate recommends the maximum commitment UHU per hour *for a fire engine or ladder company* should not exceed 30 percent. Beyond that, the most important element to suffer will be training hours.

There is a need to gain maximum economic efficiency out of an ambulance unit that is expensive to staff. For an ambulance or low acuity squad working *less than* a 24-hour shift, such as an 8- to 12-hour shift, then the UHU can rise to 40–50 percent at a maximum. At that UHU level, peak-hour ambulance squad crews must then have additional duty days for training only, when they are not responding to incidents, to meet their annual continuing education and training hours requirements. Citygate recommends that a Fast Response Squad or ambulance crew on a 24- to 48-hour shift also should not be worked above 30 percent UHU or, if done for most of its core workday hours, its training and other duties will suffer.

Table 19 is a unit-hour utilization summary for the busiest 10 ACFD engine companies. The busiest engines are listed first.

Table 19—2016 Unit-Hour Utilization – Engine Companies

Hour	E24	E09	E13	E22	E33	E12	E23	E32	E25	E29
00:00	12.21%	8.38%	6.86%	6.66%	5.05%	5.68%	3.20%	5.38%	4.05%	4.60%
01:00	8.92%	7.15%	5.72%	5.21%	3.12%	4.46%	4.43%	3.72%	4.96%	3.78%
02:00	7.74%	7.93%	6.62%	12.07%	4.10%	4.02%	5.45%	3.92%	5.33%	2.74%
03:00	9.77%	8.34%	6.36%	3.64%	3.84%	6.02%	4.00%	1.98%	3.96%	4.48%
04:00	7.15%	6.40%	4.57%	5.19%	4.20%	2.10%	3.22%	2.54%	3.46%	3.06%
05:00	9.15%	7.27%	6.92%	4.73%	4.48%	4.34%	4.30%	4.17%	5.17%	3.59%
06:00	9.76%	8.65%	6.90%	6.66%	7.30%	3.42%	5.67%	5.89%	5.68%	5.28%
07:00	11.74%	10.92%	8.99%	7.65%	5.82%	6.33%	6.26%	4.84%	8.09%	5.71%
08:00	14.40%	9.61%	11.10%	10.97%	7.84%	6.48%	9.61%	7.87%	6.77%	5.49%
09:00	15.41%	12.49%	12.35%	11.42%	8.08%	9.21%	9.05%	7.98%	8.25%	7.63%
10:00	13.88%	11.00%	11.68%	11.42%	10.97%	10.98%	8.96%	10.25%	7.86%	7.63%
11:00	13.24%	12.00%	12.75%	12.14%	10.38%	10.32%	9.93%	10.46%	10.36%	6.15%
12:00	16.17%	14.53%	12.72%	15.05%	8.48%	13.67%	9.50%	10.25%	8.87%	9.00%
13:00	16.27%	12.76%	16.26%	12.50%	12.05%	9.68%	9.44%	7.53%	9.94%	8.82%
14:00	15.84%	12.18%	12.87%	11.17%	12.72%	10.03%	9.52%	11.86%	7.52%	11.23%
15:00	14.09%	12.92%	13.39%	10.55%	10.59%	12.14%	9.41%	13.93%	9.22%	11.36%
16:00	18.16%	14.14%	12.55%	12.31%	12.63%	9.33%	10.80%	9.14%	10.51%	8.64%
17:00	16.76%	16.21%	13.35%	12.05%	13.32%	12.72%	11.65%	12.61%	10.06%	10.63%
18:00	18.73%	15.67%	13.65%	12.72%	12.73%	10.02%	10.37%	8.91%	8.90%	9.00%
19:00	17.81%	12.91%	13.36%	9.83%	10.70%	10.10%	10.37%	9.70%	9.95%	6.67%
20:00	15.16%	12.46%	10.76%	13.57%	10.82%	8.45%	8.91%	8.60%	8.13%	8.31%
21:00	16.15%	14.38%	11.55%	10.63%	8.16%	8.85%	8.74%	6.84%	7.96%	8.75%
22:00	14.63%	11.52%	8.79%	9.12%	9.33%	6.87%	8.88%	7.47%	7.60%	6.53%
23:00	9.88%	9.71%	8.53%	6.21%	5.89%	5.70%	5.91%	6.77%	5.33%	6.50%

Table 20 displays a unit-hour utilization summary for the busiest 10 ladder companies:

Table 20—2016 Unit-Hour Utilization – Ladder Companies

Hour	T31	T28	T09	T12	T25	T17	T20
00:00	5.18%	4.95%	2.20%	1.80%	2.10%	1.24%	0.10%
01:00	4.03%	4.06%	3.04%	1.58%	1.82%	0.86%	0.15%
02:00	4.52%	2.55%	5.45%	3.12%	2.56%	1.19%	0.00%
03:00	2.63%	3.32%	1.77%	1.86%	0.73%	0.32%	0.94%
04:00	3.52%	2.13%	1.75%	1.10%	0.85%	0.47%	0.41%
05:00	4.39%	3.29%	1.51%	1.60%	2.11%	0.98%	3.71%
06:00	6.81%	4.80%	4.65%	1.99%	3.07%	1.08%	0.18%
07:00	9.91%	4.95%	4.13%	3.23%	2.57%	1.45%	0.28%
08:00	8.99%	6.25%	4.82%	2.15%	2.92%	2.07%	0.40%
09:00	9.91%	7.69%	9.59%	4.37%	4.93%	2.89%	0.51%
10:00	10.50%	9.00%	5.68%	5.96%	4.88%	3.39%	0.98%
11:00	10.44%	7.98%	7.36%	7.58%	7.10%	1.83%	0.64%
12:00	11.12%	7.52%	8.43%	8.76%	6.00%	2.69%	0.48%
13:00	12.32%	11.14%	8.41%	7.55%	5.85%	3.40%	0.84%
14:00	13.15%	9.61%	7.30%	6.28%	6.63%	3.71%	0.32%
15:00	11.92%	12.19%	7.26%	6.32%	6.48%	2.29%	0.65%
16:00	10.04%	8.00%	6.79%	7.24%	5.36%	2.20%	0.76%
17:00	13.44%	10.03%	7.40%	6.83%	4.10%	1.39%	0.74%
18:00	8.41%	8.66%	8.82%	5.20%	4.07%	2.66%	0.21%
19:00	10.14%	8.65%	4.29%	3.85%	5.18%	4.79%	0.34%
20:00	7.50%	7.24%	5.69%	3.96%	4.40%	2.67%	0.05%
21:00	9.94%	7.50%	6.26%	4.24%	4.28%	1.50%	0.15%
22:00	6.80%	4.90%	4.42%	4.36%	4.35%	4.90%	0.65%
23:00	4.78%	5.86%	2.71%	2.51%	1.51%	5.03%	0.21%

Finding #11: With only two engine companies approaching 20 percent unit-hour utilization workloads, no engines approach a Citygate-recommended threshold of 30 percent hour after hour. At this time, other than perhaps for covering units at training, adding units during the peak hours of the day is not yet essential to consider.

5.3.8 Training Unit Coverage Analysis

Almost every day, the Department must take a small number of units out of service for training at their training center or other regional classrooms. Given the data in this study, the ACFD asked for advice regarding which stations should be backfilled by units when one or two units are pulled out of each Battalion for training.

The process Citygate uses is multifaceted as no one measure tells the story. Table 21 shows the second-due unit travel times and the difference (delta) between the assigned unit (home) and the closest covering fire station (outside).

This table of covering units is used not only with the deltas but also the workload per station area. The workload analysis in Table 19 and Table 20 are used to show hourly demand. The final consideration is the station's placement on the maps, whether they are an "edge of area" station or more central to several other stations, and adjoining mutual aid.

These factors, in composite, generated the stations in red that Citygate recommends be backfilled when the home company is out of district for more than one hour. These recommendations are partially subjective and based on experience; the ACFD can add other factors and local knowledge into the decision. The important thing is that the ACFD learns to use a composite of several data tools to make these decisions.

Table 21—Fire and EMS Response Analysis – Primary Apparatus

Station Area	1st Arrivals	Home Resources	Outside Resources	Outside Percent	Overall Travel	Home Travel	Outside Travel	Delta Home/Out
Battalion 2								
6	3,127	2,590	537	17.17%	06:51 (3,045)	06:33 (2,550)	08:06 (495)	1:33
7	882	695	187	21.20%	08:11 (835)	07:32 (665)	08:48 (170)	1:16
22	5,501	4,401	1,100	20.00%	04:45 (5,404)	04:25 (4,323)	05:43 (1,081)	1:18
23	5,917	4,765	1,152	19.47%	04:30 (5,838)	03:56 (4,707)	05:38 (1,131)	1:42
24	9,473	8,506	967	10.21%	04:59 (9,284)	04:49 (8,350)	06:08 (934)	1:19
25	7,063	6,222	841	11.91%	04:41 (6,906)	04:32 (6,092)	05:48 (814)	1:16
26	2,597	2,249	348	13.40%	05:34 (2,497)	05:13 (2,167)	06:51 (330)	1:38
Battalion 3								
16	4,039	3,764	275	6.81%	05:42 (3,916)	05:22 (3,660)	08:45 (256)	3:23
17	2,678	2,482	196	7.32%	04:49 (2,543)	04:44 (2,361)	05:50 (182)	1:06
18	1,859	1,666	193	10.38%	04:49 (1,786)	04:28 (1,598)	06:06 (188)	1:38
20	851	750	101	11.87%	04:01 (699)	04:03 (617)	03:39 (82)	24 sec. less
21	129	82	47	36.43%	11:00 (98)	10:53 (67)	11:31 (31)	0:38
Battalion 4								
9	9,281	8,656	625	6.73%	04:56 (9,056)	04:44 (8,459)	06:36 (597)	1:52
10	4,500	3,180	1,320	29.33%	05:38 (4,400)	04:54 (3,131)	06:37 (1,269)	1:43
11	2,413	1,675	738	30.58%	04:59 (2,380)	04:44 (1,654)	05:21 (726)	0:37
12	7,628	5,922	1,706	22.36%	04:52 (7,475)	04:44 (5,801)	05:09 (1,674)	0:25
13	6,371	5,057	1,314	20.62%	04:48 (6,217)	04:21 (4,936)	05:59 (1,281)	1:38
19	379	368	11	2.90%	06:02 (338)	05:58 (330)	06:34 (8)	0:36
34	2,313	1,852	461	19.93%	06:06 (2,240)	05:31 (1,794)	07:09 (446)	1:38
35	3,589	3,126	463	12.90%	04:50 (3,524)	04:41 (3,077)	05:23 (447)	0:42
Battalion 7								
27	2,999	2,633	366	12.20%	04:53 (2,942)	04:19 (2,583)	06:57 (359)	2:38
28	3,186	2,530	656	20.59%	05:13 (3,127)	04:49 (2,482)	06:14 (645)	1:25
29	3,356	2,881	475	14.15%	05:02 (3,301)	04:32 (2,838)	06:28 (463)	1:56
30	1,521	1,206	315	20.71%	05:26 (1,508)	05:26 (1,194)	05:25 (314)	1 sec. less
31	3,774	3,221	553	14.65%	06:09 (3,722)	05:47 (3,183)	07:42 (539)	1:55
32	4,322	3,822	500	11.57%	05:29 (4,259)	04:47 (3,771)	07:55 (488)	3:08
33	5,505	4,719	786	14.28%	06:06 (5,430)	05:55 (4,668)	07:58 (762)	2:03

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SECTION 6—SOC EVALUATION AND RECOMMENDATIONS

6.1 OVERALL EVALUATION

SOC ELEMENT 8 OF 8
OVERALL EVALUATION

The ACFD serves a very diverse land-use pattern with a geographically challenging and limited road network in some areas. Population drives service demand and development brings population.

While the state-mandated fire code requires automatic fire sprinklers even in dwellings, it will be many more decades before enough buildings are replaced or remodeled using automatic fire sprinklers. For the foreseeable future, the ACFD's service areas will need both a first-due firefighting unit and Effective Response Force (First Alarm) coverage in all parts of the urbanized areas, consistent with current best practices, if the risk of a fire is to be limited to only part of the inside of an affected building.

While the volume of, and response times to, EMS incidents consume much of the District's attention, all communities need a "stand-by and readily available" firefighting force for when fires break out. The Fire Department provides advanced life support emergency care, but the threat of fire, even if low, still requires resources *in addition to EMS hourly demand* for an effective response to emerging fires.

A response time goal based on best practices and one consistent with the ACFD's current goal is to have a first responder arrive within 7:30 minutes from the receipt of the 9-1-1 call at the ACFD's regional fire dispatching center, ACRECC. To its credit, as reviewed in Table 22, the ACFD delivers Department-wide service to 90 percent of all incidents by 7:53 minutes.

Table 22—Call to Arrival Time

Area	2016
Department-wide	**07:53**
Battalion 2	07:43
Battalion 3	08:09
Battalion 4	07:39
Battalion 7	08:00

While some station areas that are more in the suburban edges or rural areas have times a little longer than this, the overall time of 7:53 minutes is very good compared to other Citygate clients serving large urban areas. While traffic congestion can be a factor at times, Citygate's mapping coverage study finds adequate fire station coverage from the existing number and placement of fire stations. Some stations will eventually need replacement due to age, and if the current parcel is deemed too small, they should be replaced at another site in the nearby area. In the future, if the workload increases to a level impossible to serve from a one-crew fire station, then the ACFD should consider peak-hour relief units primarily for the high volume of calls for emergency medical service.

6.1.1 The Path Ahead

If the ACFD wants to provide the following three outcomes, the ACFD must maintain the existing quantity of fire stations and monitor the ability of the busiest crews to deliver adequate response times. The three outcomes are:

- Provide equitable response times to all similar risk neighborhood
- Provide for depth of response when multiple incidents occur
- Provide for a concentration of response forces in the core for high-risk venues.

For its current risks and desired outcomes, the ACFD has the correct quantity of fire engines (pumpers) and quint/ladder trucks. If the ACFD and/or its contract city partners chooses not to continue these three policy goals for fire services delivery, then it should adopt a travel time goal that it can afford, understanding that longer response times will mean the most time-sensitive emergencies could experience worse-than-desired outcomes.

6.1.2 Complete List of Findings

Finding #1:	The ACFD Board of Directors has not adopted a complete deployment measure based on best practices for fire and emergency medical services incidents in the unincorporated areas. Adopting a similar set of specialty response measures would meet the best-practice recommendations of the CFAI. Each contract agency has its own unique performance measures included in its contract with the ACFD.
Finding #2:	The ACFD follows best practices by using a standard response dispatching plan that considers the risk of different types of emergencies and pre-plans the response. Each type of call for service receives the combination of engine companies, truck companies, ambulances, specialty units, and command officers customarily needed to handle each type of incident based on experience.
Finding #3:	In the urban service areas, the ACFD has effective fire station placements, with only very small gaps at the edges of some communities or when there is significant traffic congestion. The gaps are too small to cost-effectively add stations.
Finding #4:	Only some of each urban core area is within 8:00 minutes travel time of an Effective Response Force assignment of three engines, one ladder truck, one rescue unit, and one Battalion Chief, with *no traffic congestion*. During traffic congestion, this coverage is further reduced in the east and south contract city areas.
Finding #5:	The *single* ladder truck coverage is adequate for the current needs of the ACFD, but the coverage must be re-evaluated as new growth areas are added beyond the identified ladder truck and/or quint service areas.

Finding #6:	The highest volume hours for incidents span from 9:00 a.m. through 8:00 p.m. Given this, if additional units are needed for high workload volumes or to cover for out-of-service training units, added units could be peak-hour units for 12 hours per day, six days per week.
Finding #7:	National best practices as recommended by NFPA standard 1221 are for call processing to be 90 seconds 90 percent of the time and 120 seconds 99 percent of the time. The ACRECC is substantially meeting this goal.
Finding #8:	A realistic goal for turnout time is 2:00 minutes to 90 percent of the emergency incidents. The ACFD is just over this goal and, with focus, can meet or beat this goal, especially during waking hours.
Finding #9:	In the 2016 measurement period, the ACFD had a Department-wide 90 percent travel time of 5:12 minutes. This travel time is 1:00 minute longer than a best-practice-based goal of 4:00 minutes in urban areas. This travel time is fairly consistent across urbanized areas of the ACFD as only one station area was under a 4:00-minute travel time.
Finding #10:	Due to longer travel times, with the current quantity of fire stations, the ACFD comes within 23 seconds of a Department-wide call to arrival goal of 7:30 minutes. Given the varied topography in some of the suburban and rural areas in this measure, it would not be cost effective to add stations to gain the 23 seconds. Sixteen stations delivered service in less than 8:00 minutes in the most urbanized areas, which is commendable given the road network and topography.

Finding #11:	With only two engine companies approaching 20 percent unit-hour utilization workloads, no engines approach a Citygate-recommended threshold of 30 percent hour after hour. At this time, other than perhaps for covering units at training, adding units during the peak hours of the day is not yet essential to consider.
Finding #12:	Alameda County has established appropriate emergency evacuation protocols, procedures, and resources as an element of its Emergency Operations Plan.
Finding #13:	Alameda County has established an effective method to communicate emergency evacuation information to the public in a timely manner.
Finding #14:	Alameda County regularly utilizes, validates, and evaluates its emergency notification and evacuation protocols, procedures, and resources to ensure ongoing readiness and effectiveness.

6.1.3 Overall Deployment Recommendations

Based on the deployment analysis contained in this study, Citygate makes the following recommendations to slightly strengthen deployment performance and ensure quality paramedic coverage as incidents slowly increase year to year.

The first deployment step for the ACFD leadership in the near term is to adopt updated and complete performance measures from which to set forth service expectations and, on an annual budget basis, monitor and fund Fire Department performance. Currently, the ACFD reports performance metrics on a quarterly basis to each contract agency, the Fire Advisory Commission, and the Executive Management Oversight Committee.

Recommendation #1:	**<u>Adopt Elected Official Deployment Measures Policies</u>:** The ACFD elected officials should adopt updated, complete performance measures to direct fire crew planning and to monitor the operation of the Department. The measures of time should be designed to save patients where medically possible and to keep small but serious fires from becoming greater alarm fires. With this is mind, Citygate recommends the following measures:
1.1	<u>Distribution of Fire Stations – *Urban Areas*</u>: To treat medical patients and control small fires, the first-due unit should arrive within 7:30 minutes, 90 percent of the time, from the receipt of the 9-1-1 call in the regional fire communications center. This equates to a 1:30-minute dispatch time, a 2:00-minute company turnout time, and a 4:00-minute drive time in the most populated areas.
1.2	<u>Multiple-Unit Effective Response Force for Serious Emergencies – *Urban Areas*</u>: To confine fires near the room of origin and to treat up to five medical patients at once, a multiple-unit response of a minimum of four engines, one ladder truck, and one Battalion Chief, totaling 17 personnel, should arrive within 11:30 minutes from the time of 9-1-1 call receipt in fire dispatch 90 percent of the time. This equates to a 1:30-minute dispatch time, a 2:00-minute company turnout time, and an 8:00-minute drive time for multiple units in the most populated areas.

1.3	Hazardous Materials Response: Provide hazardous materials response designed to protect the community from the hazards associated with uncontrolled release of hazardous and toxic materials. The fundamental mission of the ACFD response is to minimize or halt the release of a hazardous substance so it has minimal impact on the community. It can achieve this with a total response time of 7:30 minutes or less, 90 percent of the time, for the first company capable of investigating a hazmat release at the operations level. After size-up and scene evaluation is completed, a determination will be made whether to request additional resources from the ACFD's hazardous materials response team.
1.4	Technical Rescue: Respond to technical rescue emergencies as efficiently and effectively as possible with enough trained personnel to facilitate a successful rescue. Achieve a total response time within 7:30 minutes, 90 percent of the time, for the first-due company for size-up of the rescue. Assemble additional resources for technical rescue capable of initiating a rescue within a total response time of 11:30 minutes 90 percent of the time. Safely complete rescue/extrication to ensure delivery of patient to a definitive care facility.
1.5	Emergency Medical Services: The ACFD should continue to provide first responder paramedic services to all neighborhoods within the response time goal of the County's Emergency Medical Services Agency. The existing First Responder Advanced Life Support agreements requires 8:30 minutes, 90 percent of the time, from crew notification for Medical Priority Dispatch System (MPDS) categories Echo, Delta, and Charlie and 12:45 minutes for MPDS categories Bravo and Alpha.

Recommendation #2:	The ACFD should monitor workload increases per company at peak hours of the day and, if they reach an hour-after-hour level that significantly lengthens response times, then the ACFD should consider peak-hour relief units primarily for the high volume of EMS calls for service.

7.1 NEXT STEPS

The purpose of a Standards of Coverage study is to compare the ACFD's current performance against the local risks to be protected and nationally recognized best practices. This analysis of performance forms the basis from which to make recommendations for changes, if any, in fire station locations, equipment types, and staffing.

The response time goals identified in Recommendation #1 will continue to support adequate service levels. Measurement and planning as the ACFD continues to evolve will be necessary for the ACFD to meet these goals. Citygate recommends that the ACFD's next steps be to work through the issues identified in this study over the following time lines:

7.1.1 Short-Term Steps

- Absorb the policy recommendations of this fire services study and ask the elected officials to formally adopt ACFD response time measures.
- Continue the facilities work to site, procure, and program funding for the needed aging fire station replacements.

7.1.2 Long-Term Steps

- Monitor the impact of incident growth and traffic congestion on individual fire companies at peak hours.

- If simultaneous incident demand and/or traffic congestion continues to decay response times, additional stations, or peak-hour engines, will become necessary to maintain response times to critical events.

PART TWO

Community Risk Assessment

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Section 8—Community Risk Assessment

8.1 Risk Assessment Overview

SOC Element 3 of 8
Community Risk Assessment

The third element of the SOC process is a community risk assessment. Within the context of an SOC study, the objectives of a community risk assessment are to:

1. Identify the values at risk to be protected within the community or service area
2. Identify the specific hazards with the potential to adversely impact the community or service area
3. Quantify the overall risk associated with each hazard
4. Establish a foundation for current/future deployment decisions and risk-reduction/hazard mitigation planning and evaluation.

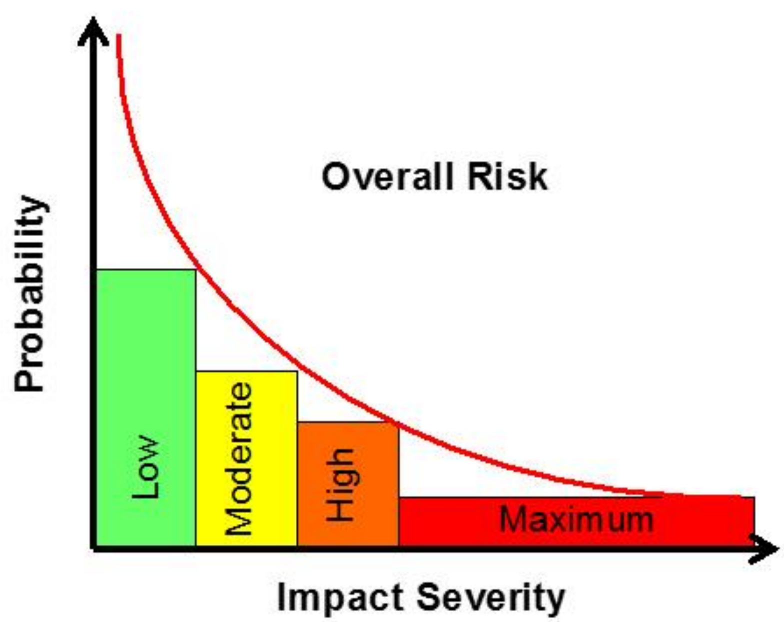
A hazard is broadly defined as a situation or condition that can cause or contribute to harm. Examples include fire, medical emergency, vehicle collision, earthquake, flood, etc. *Risk* is broadly defined as the *probability of hazard occurrence* in combination with the *likely severity of resultant impacts* to people, property, and the community as a whole.

8.2 RISK ASSESSMENT METHODOLOGY

The methodology employed by Citygate to assess community risk as an integral element of an SOC study incorporates the following elements:

1. Identification of geographic planning sub-zones (risk zones) appropriate to the community or jurisdiction
2. Identification and quantification (to the extent data is available) of the specific values to be protected from the various hazards within the community or service area
3. Identification of the fire and non-fire risks to be evaluated
4. Determination of the *probability of occurrence* for each risk
5. Identification and evaluation of multiple relevant *impact severity factors* for each risk by planning zone using agency/jurisdiction-specific data and information
6. Quantification of *overall risk* for each hazard based on probability of occurrence in combination with probable impact severity as shown in Figure 6.

Figure 6—Overall Risk Categories



Source: Commission on Fire Accreditation International (CFAI): *Community Risk Assessment: Standards of Coverage (6th Edition)*

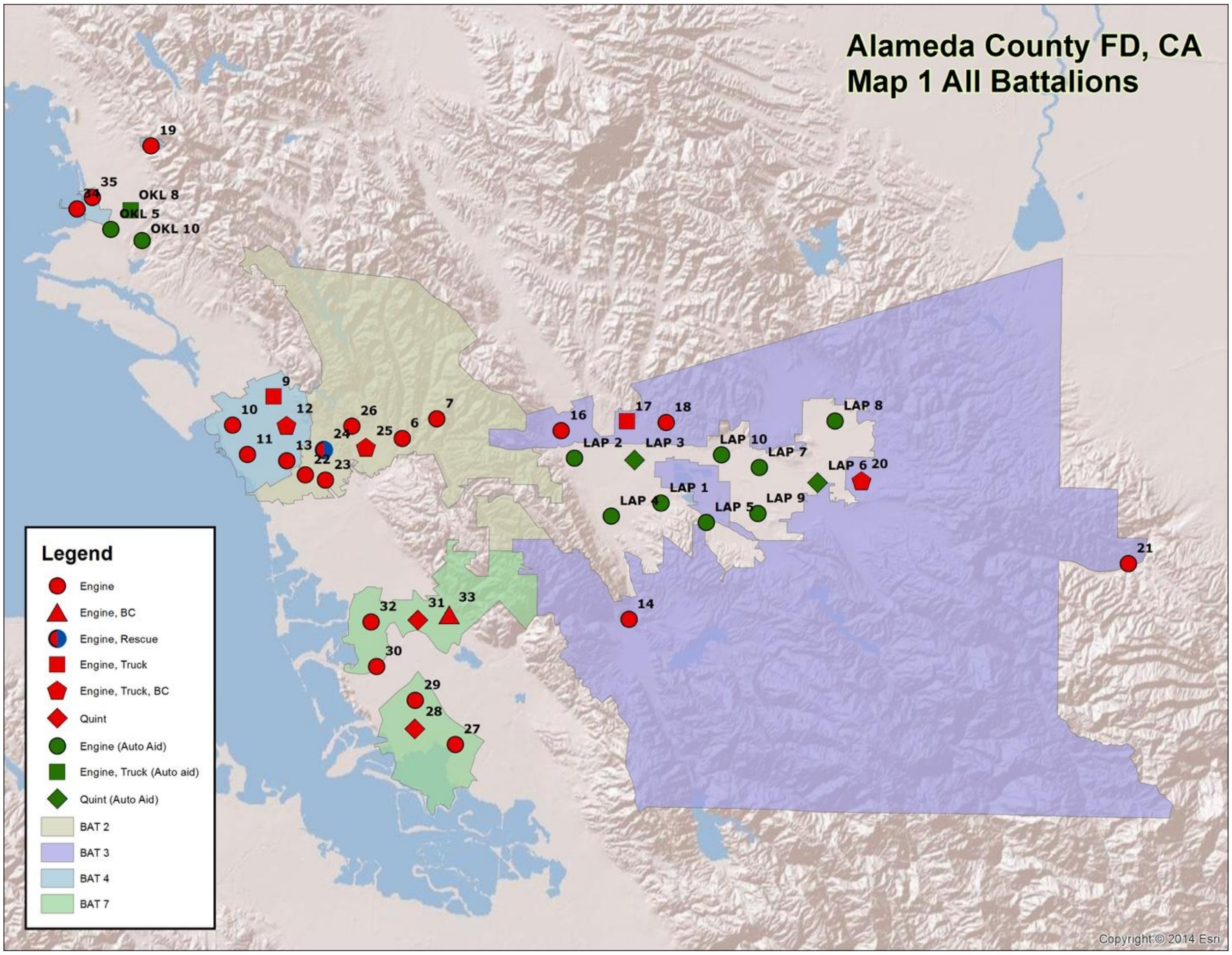
Citygate used multiple data sources for this study to understand the hazards and values to be protected in the Department as follows:

- U.S. Census Bureau population data and demographics
- Insurance Services Office (ISO) building fire flow and construction data
- Alameda County geographical information systems (GIS) data
- Alameda County General Plan and zoning information
- County and Local Hazard Mitigation Plans
- Department data and information.

8.3 PLANNING ZONES

The CFAI recommends that jurisdictions establish geographic planning zones to better understand risk at a sub-jurisdictional level. For example, portions of a jurisdiction may contain predominantly moderate risk building occupancies, such as detached single-family residences, while other areas contain high or maximum risk occupancies, such as commercial and industrial buildings with a high hazard fire load. If risk were to be evaluated on a jurisdiction-wide basis, the predominant moderate risk could outweigh the high or maximum risk and may not be a significant factor in an overall assessment of risk. If, however, those high or maximum risk occupancies are a larger percentage of the risk in a smaller planning zone, then it becomes a more significant risk factor. Another consideration in establishing planning zones is that the jurisdiction's record management system must also track the specific zone for each incident to be able to appropriately evaluate service demand and response performance relative to each specific zone. For this assessment, Citygate utilized five planning zones incorporating the Department's four operational battalions and the City of Emeryville, as shown in Figure 7.

Figure 7—Planning Zones



8.4 VALUES TO BE PROTECTED

This section identifies, describes, and quantifies (as data is available) the values at risk to be protected within the Department's service area. *Values at risk*, broadly defined, are people and physical objects of significant importance or value to the community or jurisdiction potentially at risk of harm or damage from a hazard occurrence. Values at risk typically include people, critical facilities/infrastructure, buildings, and key economic, cultural, historic, and/or natural resources.

8.4.1 People

Residents, employees, visitors, and travelers through a community or jurisdiction are vulnerable to harm from a hazard occurrence. Particularly vulnerable are specific at-risk populations, including those unable to care for themselves or self-evacuate in the event of an emergency. At-risk populations typically include children less than 10 years of age, the elderly, and people housed in institutional settings. Table 23 summarizes key demographic data for the Department's service area.

Table 23—Key Demographic Data

Demographic	2015	Percentage
Population	414,528	
Under 10 Years	52,624	12.70%
10–19 Years	48,036	11.59%
20–64 Years	261,919	63.19%
65 Years and Older	51,949	12.53%
Median Age	37.1	N/A
Housing Units	142,850	
Owner-Occupied	98,274	68.80%
Renter-Occupied	69,749	48.83%
Median Household Size	2.77	N/A
Education (Population over 24 Years of Age)	288,382	
High School Graduate	122,723	42.56%
Undergraduate Degree	66,438	23.04%
Graduate/Professional Degree	33,644	11.67%
Employment (population over 15 Years of Age)	332,500	
In Labor Force	219,333	65.96%
Employed	207,270	94.50%
Population Below Poverty Level	38,312	9.24%
Population with Health Insurance Coverage	370,432	89.37%

Source: U.S. Census Bureau (2015 data)

Of note from Table 23 is the following:

- Just over 25 percent of the population is under 10 or over 65 years of age
- 42.5 percent of the population over 24 years of age has completed high school or equivalency
- Nearly 35 percent of the population over 24 years of age has an undergraduate, graduate, or professional degree
- Nearly 66 percent of the population 16 years of age or older is in the workforce; of those, 5.5 percent are unemployed

- More than nine percent of the population is below the federal poverty level
- Nearly 90 percent of the population has health insurance coverage.

8.4.2 Critical Facilities/Infrastructure

There are 161 critical facilities / pieces of infrastructure within the Department's service area, as summarized in Table 24 and Figure 8 through Figure 10.[4] A hazard occurrence with significant impact severity affecting one or more of these facilities or pieces of infrastructure would likely adversely impact critical public or community services.

Table 24—Critical Facilities/Infrastructure

Area	Number
Alameda County Unincorporated	71
City of Dublin	25
City of Emeryville	13
City of Newark	4
City of San Leandro	43
Union City	5
Total	**161**

Source: Alameda County Fire Department

[4] Does not include Lawrence Berkeley or Lawrence Livermore National Laboratories. Each laboratory campus is considered a critical facility; however, critical facility data for each campus was not available for this assessment.

Figure 8—Critical Facilities (North)

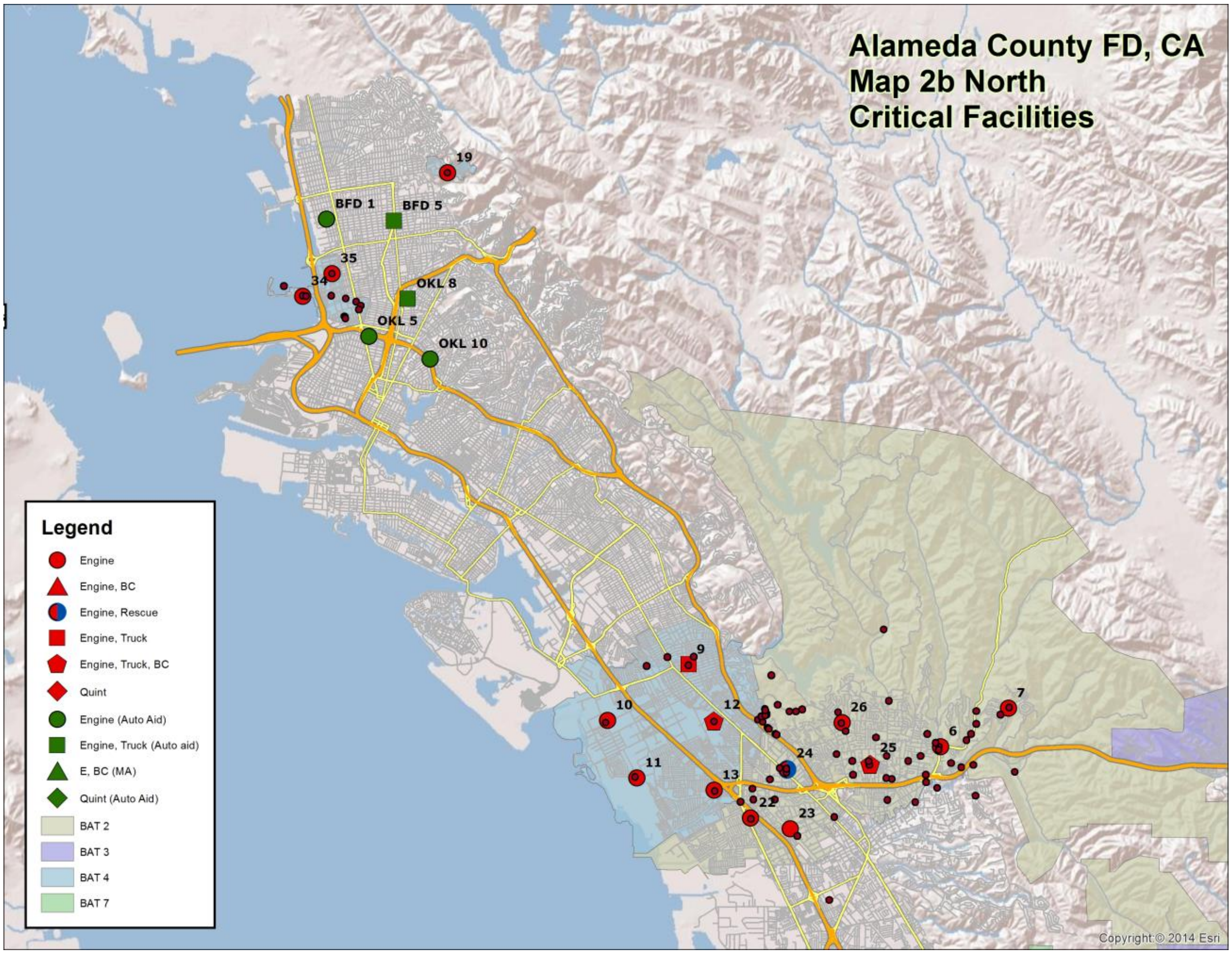


Figure 9—Critical Facilities (East)

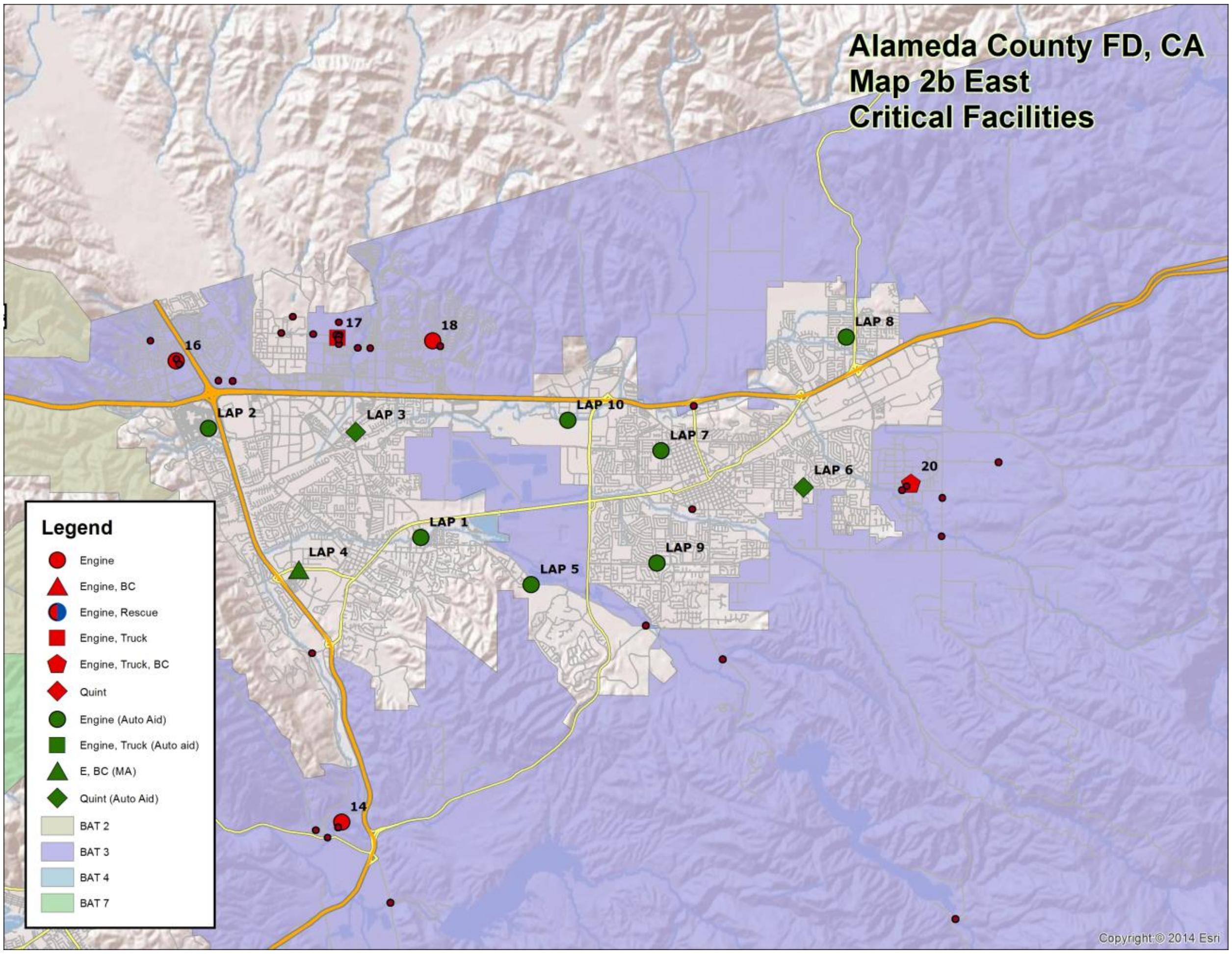
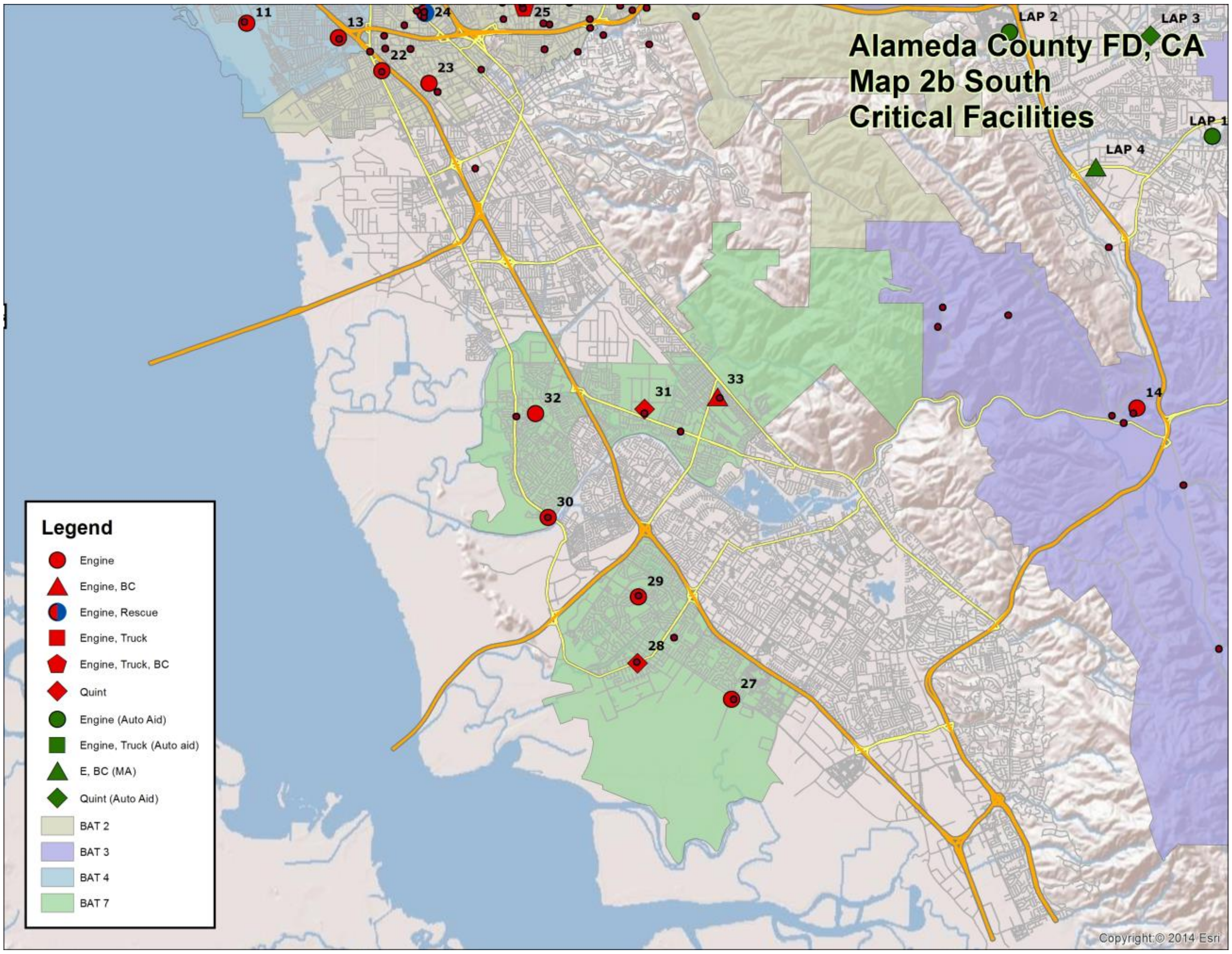


Figure 10—Critical Facilities (South)



8.4.3 Buildings

The CFAI identifies four risk categories relative to building occupancy as follows:

Low Risk – includes detached garages, storage sheds, outbuildings, and similar building occupancies that pose a relatively low risk of harm to humans or the community if damaged or destroyed by fire.

Moderate Risk – includes detached single-family or two-family dwellings; mobile homes; commercial and industrial buildings less than 10,000 square feet without a high hazard fire load; aircraft; railroad facilities; and similar building occupancies where loss of life or property damage is limited to the single building.

High Risk – includes apartment/condominium buildings; commercial and industrial buildings more than 10,000 square feet without a high hazard fire load; low-occupant load buildings with high fuel loading or hazardous materials; and similar occupancies with potential for substantial loss of life or unusual property damage or financial impact.

Maximum Risk – includes buildings or facilities with unusually high risk requiring an ERF involving a significant augmentation of resources and personnel, and where a fire would pose the potential for a catastrophic event involving large loss of life and/or significant economic impact to the community.

The Department's service area includes nearly 143,000 housing units, as well as a very large inventory of office, commercial, industrial, wholesale/retail, restaurant/bar, hotel/motel, church, school, government, healthcare, and other non-residential uses.

8.4.4 Economic Resources

Alameda County, California's seventh most populous county, has a strong, diverse economy that continues to expand post-recession. Key employment sectors include government, biomedical, retail distribution, manufacturing distribution, and energy.

8.4.5 Natural Resources

The Department's service area includes multiple parks and open space areas, including 58,596 acres owned or managed by the East Bay Regional Parks District.

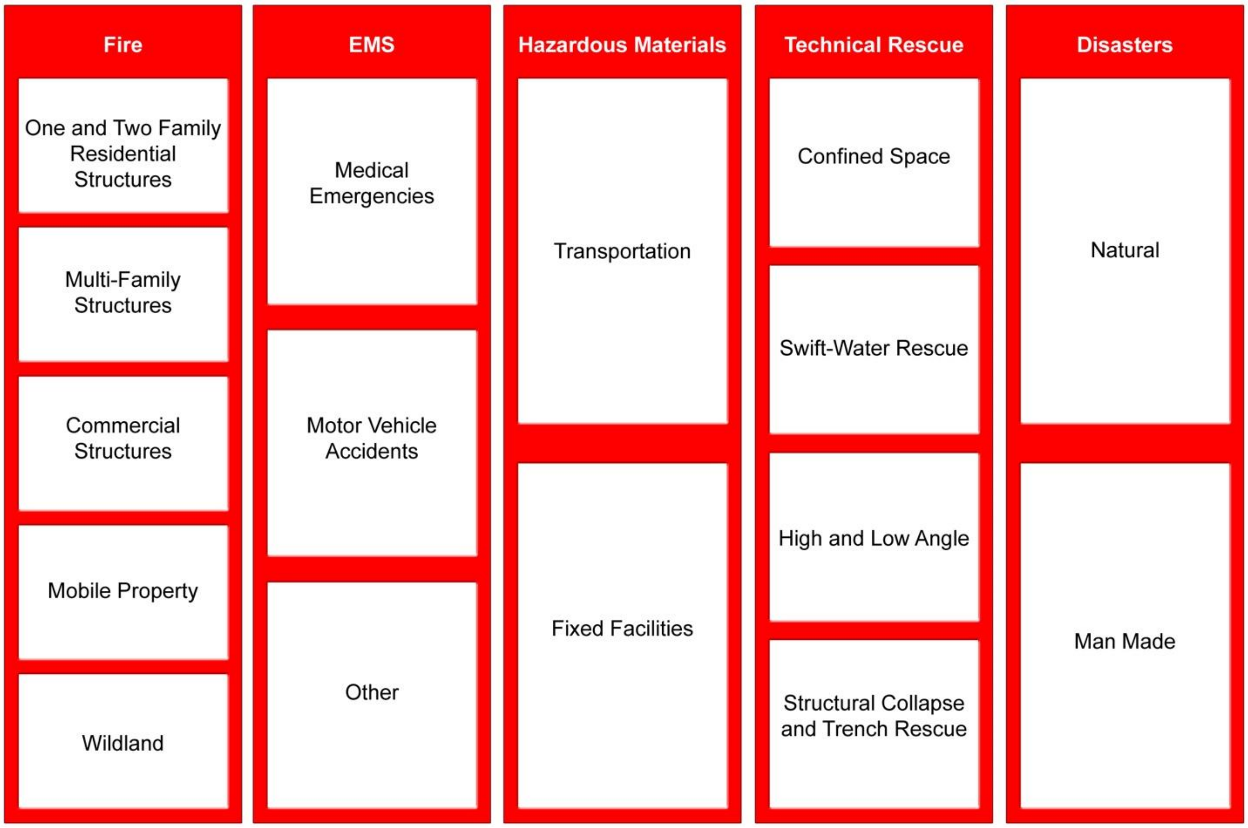
8.5 RISK IDENTIFICATION

Citygate utilizes prior risk studies where available, fire and non-fire hazards as identified by the CFAI, and agency/jurisdiction-specific data and information to identify the risks to be evaluated for this study.

The Alameda County 2016 Local Hazard Mitigation Plan (LHMP) identifies six natural hazards relating to services provided by the Department, including earthquake, flood, landslide, liquefaction, tsunami, and wildfire. Although the Department has no legal authority or responsibility to mitigate earthquake, liquefaction, flood, tsunami, or landslide risk other than for Department-owned facilities, it does provide services related to these hazards, including fire suppression, emergency medical services, technical rescue, and hazardous materials response.

The CFAI groups hazards into fire and non-fire categories, as shown in Figure 11. Identification, qualification, and quantification of the various fire and non-fire hazards are important factors in evaluating how resources are or can be deployed to mitigate those risks.

Figure 11—CFAI Hazard Categories



Source: CFAI *Standards of Coverage* (5th Edition)

Pursuant to review and evaluation of the hazards identified in the Alameda County LHMP, and the fire and non-fire hazards as identified by the CFAI as they relate to services provided by the Department, Citygate evaluated the following five hazards for this assessment:

1. Building Fire
2. Wildland Fire
3. Medical Emergency
4. Hazardous Materials Release/Spill
5. Technical Rescue.

8.6 SERVICE CAPACITY

Service capacity refers to the Department's available response force; the size, types, and condition of its response fleet and any specialized equipment; core and specialized performance capabilities and competencies; resource distribution and concentration; availability of automatic and/or mutual aid; and any other agency-specific factors influencing its ability to meet current and prospective future service demand relative to the risks to be protected.

The Department's service capacity for the various hazards includes a daily on-duty response force of 112 personnel staffing 27 engines, five trucks, two quints, one heavy rescue, one ambulance, and four Battalion Chiefs operating from 29 fire stations. The Department's Effective Response Force (ERF) for building fires consists of up to three engines, one ladder truck, one rescue, two Battalion Chiefs, and one Rapid Intervention Crew (Engine Company) for a total of 13–21 personnel. The Department also has specialized capability for hazardous materials, urban search and rescue, and water rescue incidents. In addition, the Department has mutual and automatic mutual aid agreements with the Livermore-Pleasanton Fire Department, the San Ramon Valley Fire Department, and the Camp Parks Fire Department. All of CAL FIRE's ground and air resources are also available for any wildland fire within the State Responsibility Areas of the County.

Medical emergency service capacity includes ground paramedic ambulance transportation services provided by Paramedics Plus under an exclusive operating area contract with Alameda County and 13 hospitals with emergency room services, including three accredited trauma centers.

8.7 PROBABILITY OF OCCURRENCE

Probability of occurrence refers to the probability of a future hazard occurrence over a specific period. Because the CFAI agency accreditation process requires annual review of an agency's risk assessment and baseline performance measures, Citygate recommends using the 12 months following completion of an SOC study as an appropriate period for the probability of occurrence evaluation.

Table 25 describes the five probability categories and related scoring used for this assessment.

Table 25—Probability of Occurrence

Score	Probability of Occurrence	Description	General Criteria
0	*Very Low*	Improbable	Hazard occurrence is *unlikely*
1	*Low*	Rare	Hazard *could occur*
2	*Moderate*	Infrequent	Hazard *should occur* infrequently
3	*High*	Likely	Hazard *likely to occur* regularly
4	*Very High*	Frequent	Hazard is *expected to occur* frequently

Citygate's SOC study uses recent multiple-year hazard response data to determine the probability of hazard occurrence during the ensuing 12 months.

8.8 IMPACT SEVERITY

Impact severity refers to the probable extent of hazard occurrence impacts on people, buildings, lifeline services, the environment, and the community as a whole, as described in Table 26.

Table 26—Impact Severity

Score	Impact Severity	General Criteria
1	Insignificant	No serious injuries or fatalities Few persons displaced for only a short duration No damage or inconsequential damage None or very minimal disruption to community No measurable environmental impacts Little or no financial loss
2	Minor	Few injuries; minor medical treatment only No fatalities Some persons displaced for less than 24 hours Some minor damage Minor community disruption; no loss of lifeline services Minimal environmental impacts with no lasting effects Minor financial loss
3	Moderate	Some hospitalizations Some fatalities Localized displacement of persons for up to 24 hours Localized damage Normal community functioning with some inconvenience; minor loss of lifeline services Some environmental impacts with no lasting effects, or small environmental impact with long-term effect Moderate financial loss
4	Major	Extensive injuries; significant number of persons hospitalized Many fatalities Significant displacement of many persons for more than 24 hours Significant damage requiring external resources Community services disrupted; some lifeline services potentially unavailable Some environmental impacts with long-term effects Major financial loss
5	Catastrophic	Large number of severe injuries and fatalities Local/regional hospitals impacted Large number of persons displaced for an extended duration Extensive damage Community unable to function without significant support; widespread loss of lifeline services Significant environmental impacts and/or permanent damage Catastrophic financial loss; inability to function without significant financial support

8.9 OVERALL RISK

Overall risk is determined by multiplying the *probability of occurrence score* by the *impact severity score*. The resultant total determines the overall *risk ranking* as described in Table 27.

Table 27—Overall Risk Ranking

Overall Risk Score	Overall Risk Ranking
0–5	LOW
6–12	MODERATE
13–16	HIGH
17–20	MAXIMUM

8.10 BUILDING FIRE RISK

One of the primary risks in any community is building fire risk. Factors influencing building fire risk include building density, building construction materials and methods, building occupancy, built-in fire protection systems, water supply, and building fire service capacity.

8.10.1 Building Fire Service Demand

There were 1,071 building fire incidents within the Department's service area over the most recent three-year period from January 1, 2014, through December 31, 2016, comprising 0.93 percent of total service demand over the same time period, as summarized in Table 28 and Figure 12 through Figure 14.

Table 28—Building Fire Service Demand

Risk	Year	Planning Zone					Total	Percent of Total Service Demand
		Batt. 2	Batt. 3	Batt. 4	Batt. 7	Emeryville		
Building Fire	2014	103	50	102	73	24	352	0.96%
	2015	116	39	105	72	16	348	0.91%
	2016	103	41	116	87	24	371	0.93%
Total		322	130	323	232	64	1,071	0.93%
Percent of Total Service Demand		0.88%	0.98%	0.99%	0.89%	0.97%	0.93%	

Source: Alameda County Fire Department Incident Records

Figure 12—Building Fires (North)

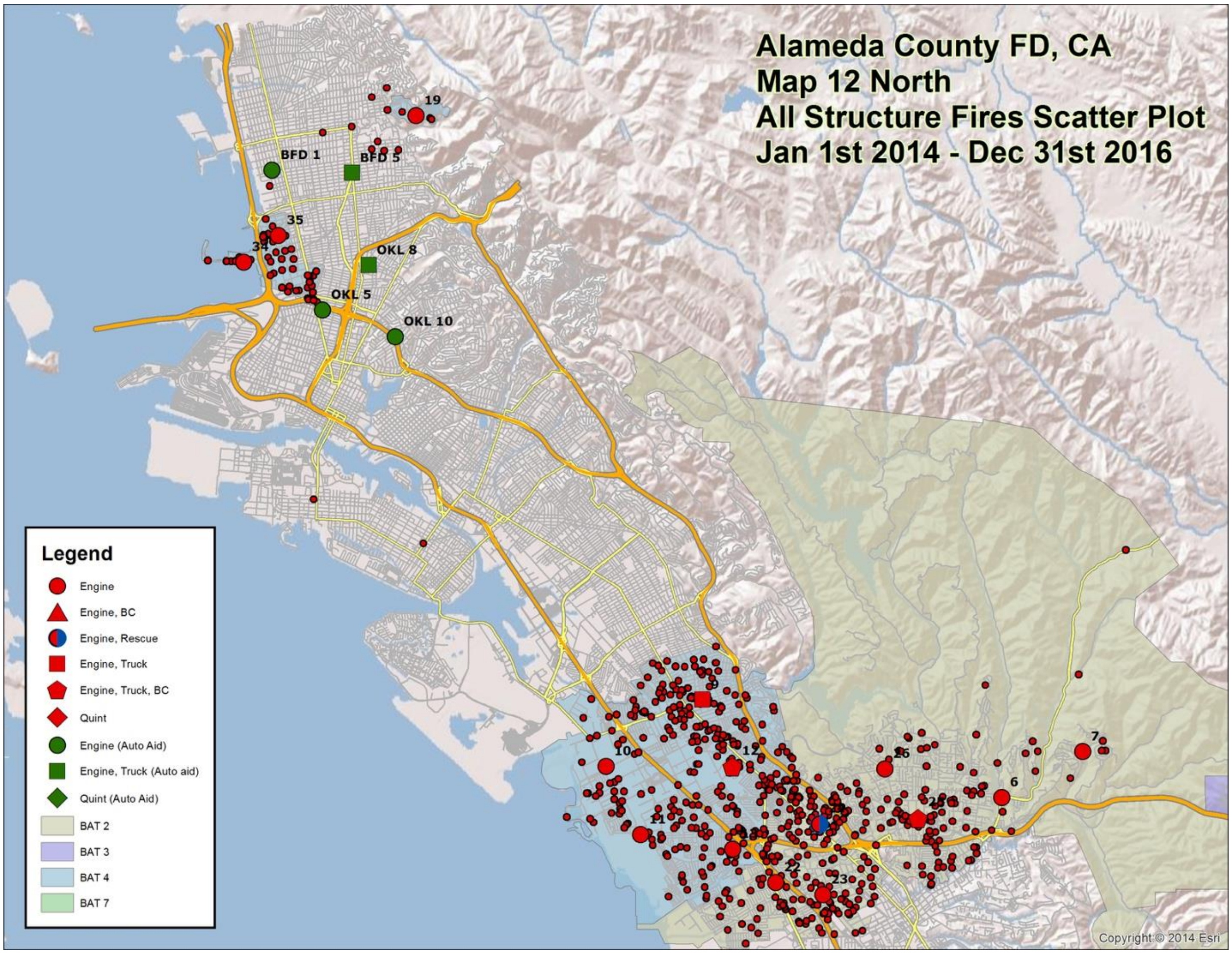


Figure 13—Building Fires (South)

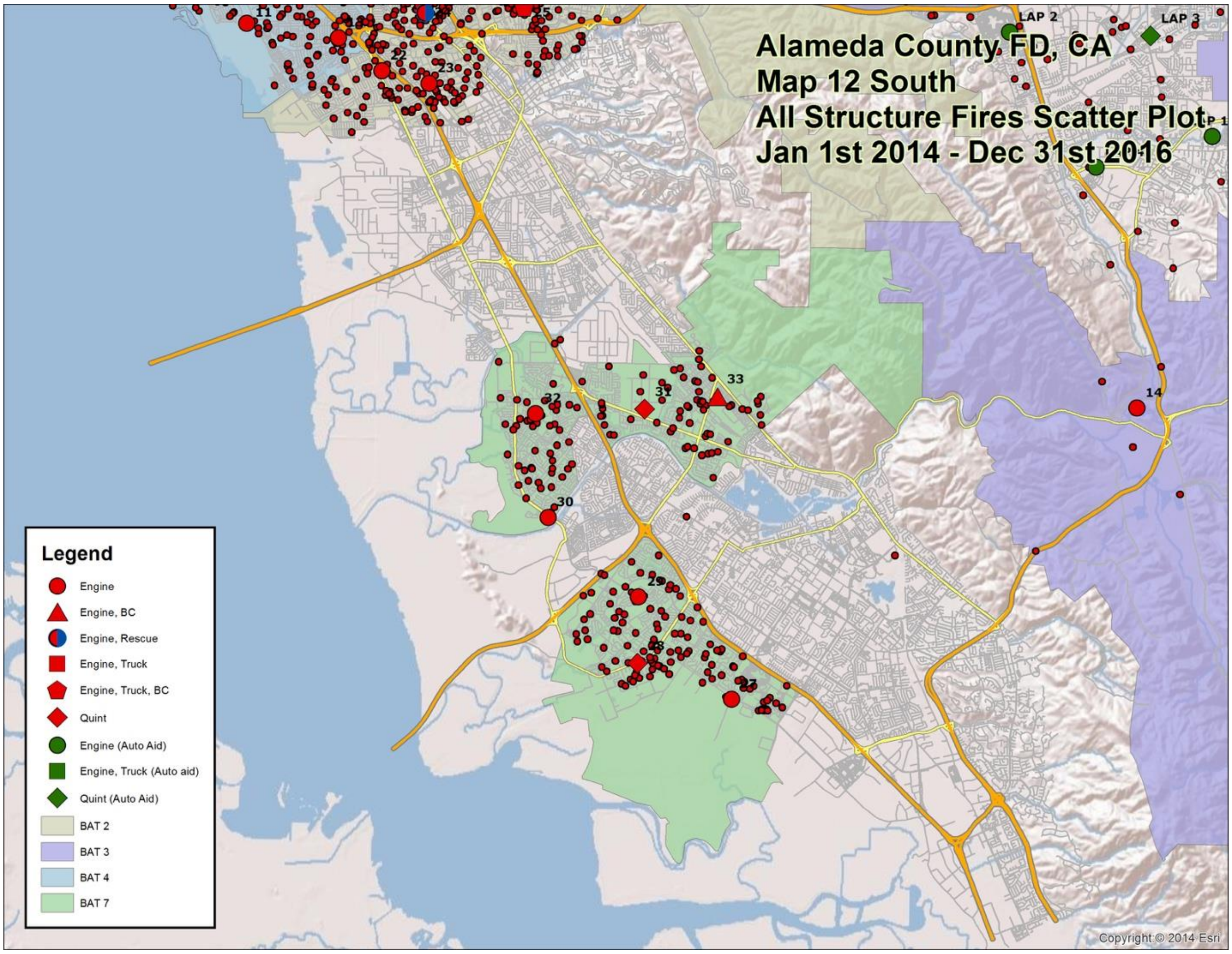
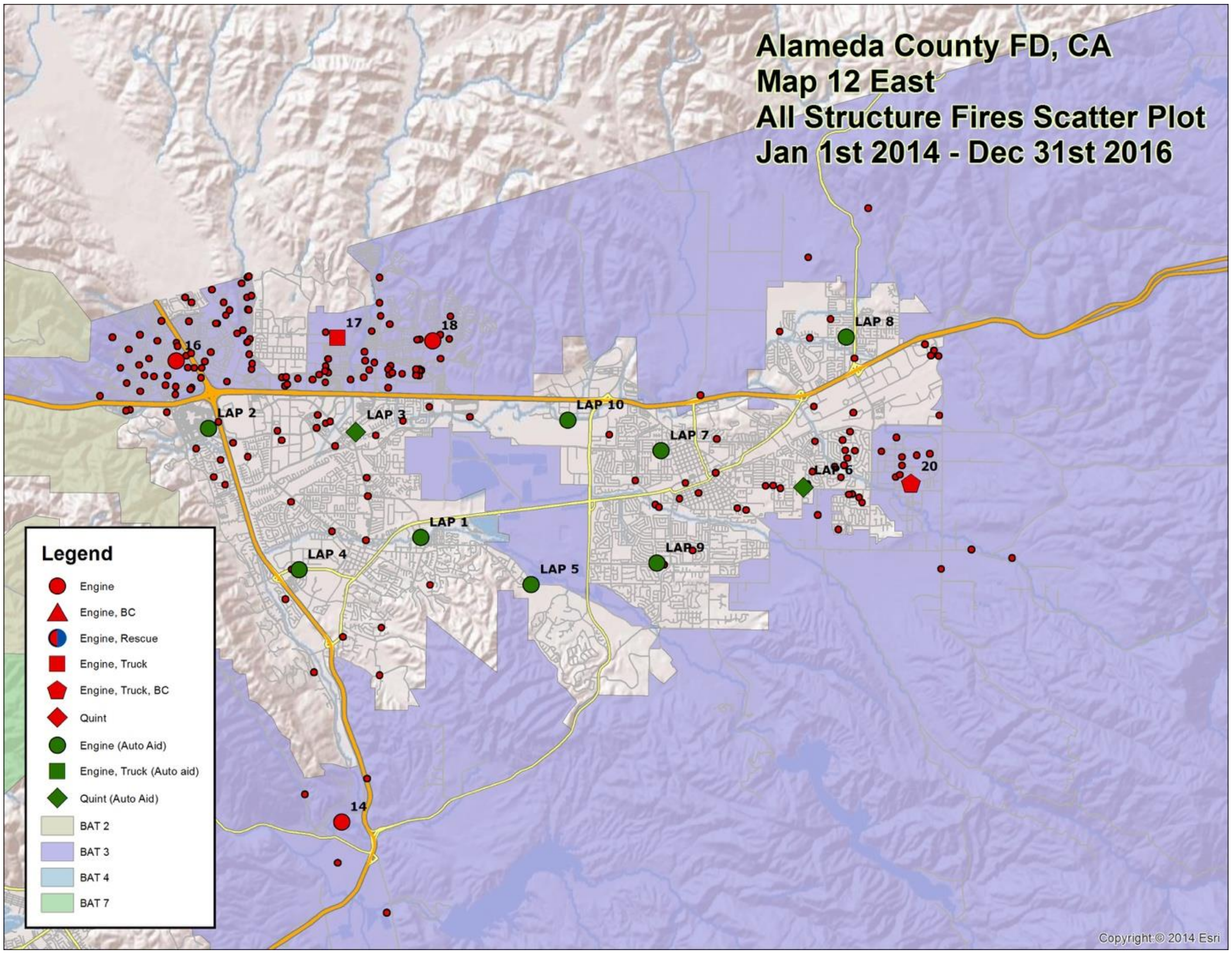


Figure 14—Building Fires (East)



As Table 28, Figure 12, Figure 13, and Figure 14 show, building fires accounted for less than one percent of total service demand over the previous three years, with the highest occurrence in Battalions 2 and 4. Also of note, the occurrence of building fires decreased slightly in 2015 from 2014 then increased nearly seven percent from 2015 to 2016. Although the occurrence of building fire is low compared to some other hazards, this data illustrates the need for an available effective building fire service capacity throughout the Department's service area.

8.10.2 Probability of Building Fire Occurrence

Table 29 summarizes Citygate's scoring for probability of future building fire occurrence by planning zone based on building fire service demand history from Table 28.

Table 29—Probability of Future Building Fire Occurrence Score

Risk	Planning Zone				
	Batt. 2	Batt. 3	Batt. 4	Batt. 7	Emeryville
Building Fire	4	4	4	4	4

8.10.3 Building Fire Impact Severity

Table 30 summarizes Citygate's scoring of probable building fire impact severity by planning zone. Factors influencing building fire impact severity include building density, building construction materials and methods, building occupancy, built-in fire protection systems, water supply, and building fire service capacity.

Table 30—Building Fire Impact Severity Score

Risk	Planning Zone				
	Batt. 2	Batt. 3	Batt. 4	Batt. 7	Emeryville
Building Fire	3	3	3	3	3

8.10.4 Overall Building Fire Risk Score and Rating

Table 31 summarizes the Department's overall building fire risk rating based on probability of occurrence from Table 29 and impact severity from Table 30.

Table 31—Overall Building Fire Risk Score

Building Fire Risk	Planning Zone				
	Batt. 2	Batt. 3	Batt. 4	Batt. 7	Emeryville
Total Risk Score	12	12	12	12	12
Risk Ranking	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE

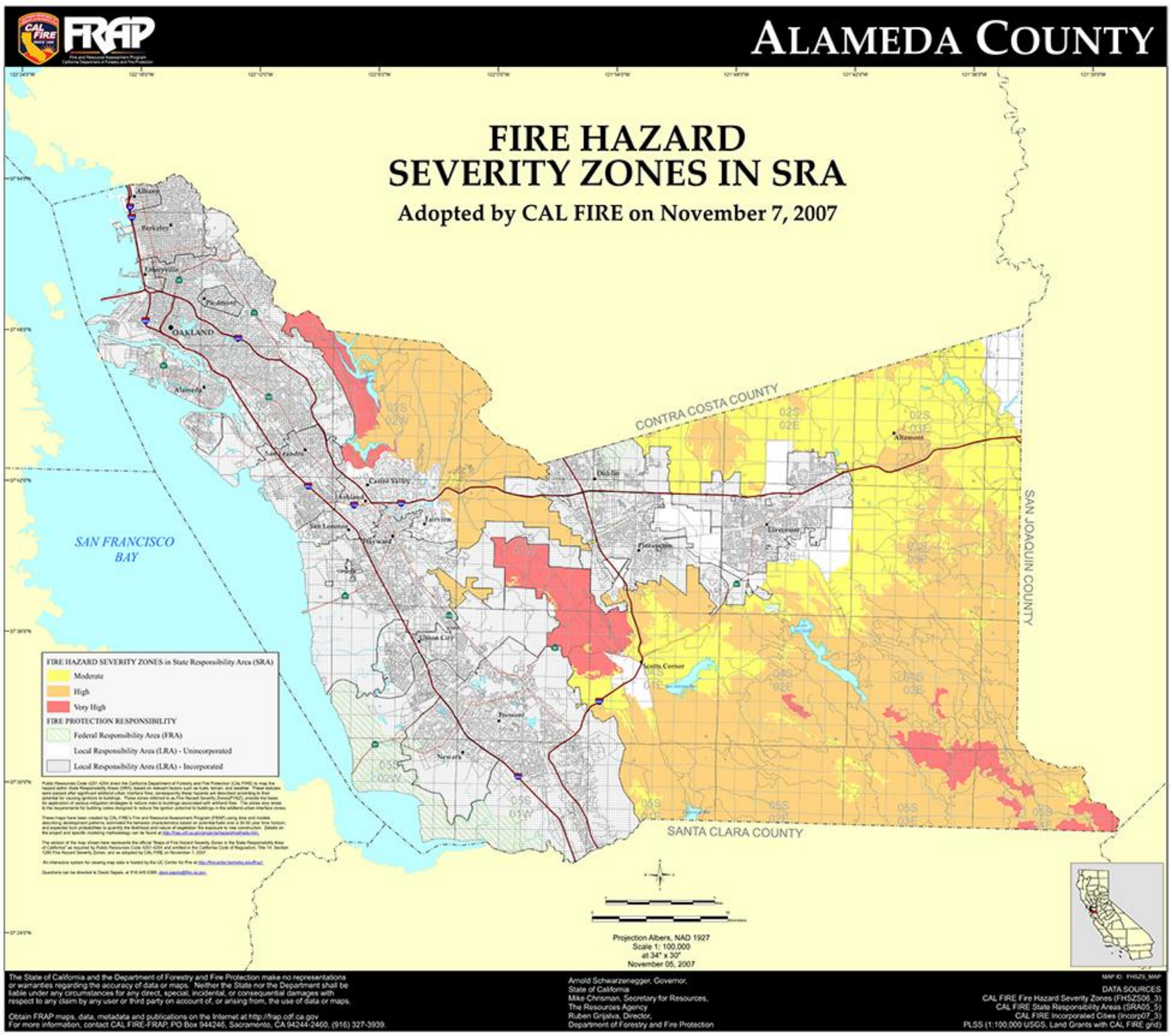
8.11 Wildland Fire Risk

Many areas of Alameda County are susceptible to a wildland fire; however, the highest risk is in the wildland-urban interface (WUI) areas where human population and related development exist within a predominantly wildland vegetation fuel environment.

8.11.1 Wildland Fire Hazard Severity Zones

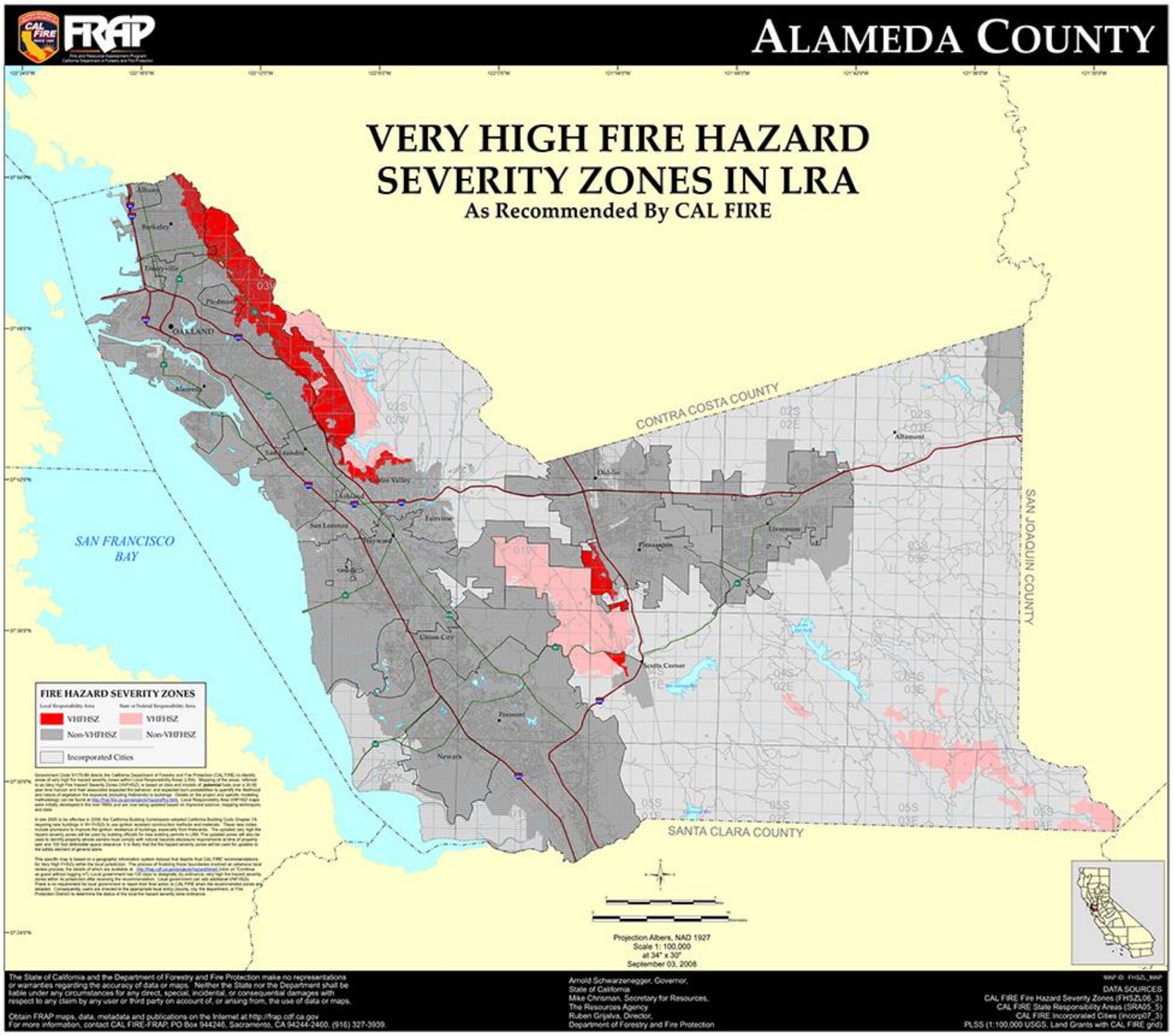
The California Department of Forestry and Fire Protection (CAL FIRE) designates wildland Fire Hazard Severity Zones (FHSZs) throughout the State based on analysis of multiple wildland fire hazard factors and modeling of potential wildland fire behavior. For State Responsibility Areas (SRAs) where CAL FIRE has legal and fiscal responsibility for wildland fire protection, CAL FIRE designates ***Moderate***, ***High***, and ***Very High*** FHSZs by county as shown in Figure 15.

Figure 15—SRA Fire Hazard Severity Zones



CAL FIRE also identifies ***Very High*** recommended FHSZs for Local Responsibility Areas (LRAs), where a local jurisdiction has legal and fiscal responsibility for wildland fire protection, including the Alameda County Fire Department, as shown in Figure 16.

Figure 16—LRA Fire Hazard Severity Zones



8.11.2 Wildland Fuels

Wildland fuel factors influencing fire intensity and spread include fuel type (vegetation species), height, arrangement, density, and fuel moisture. Wildland fuels within the Department's service area consist of a mix of annual grasses and weeds, manzanita/knob cone, chaparral, deciduous, eucalyptus, and mixed conifer trees. Once ignited, wildland fires can burn intensely and contribute to rapid fire spread under the right fuel, weather, and topographic conditions.

8.11.3 Weather

Weather elements such as temperature, relative humidity, wind, and lightning also affect wildland fire potential and behavior. High temperatures and low relative humidity dry out wildland fuels, creating a situation where fuels will more readily ignite and burn more intensely.

Wind is the most significant weather factor influencing wildland fire behavior; higher wind speeds increase fire spread and intensity. The annual wildland fire season in Alameda County, when wildland fires are most likely to occur due to fuel and weather conditions, is from early to mid-May through late September / early October. The County has a generally moderate climate with temperatures ranging from about 40° Fahrenheit to over 100° Fahrenheit, with an average of 260 sunny days per year and 21.5 inches of annual rainfall. Winds are generally from the west/northwest and are consistently strong enough to support the oldest wind-powered electrical generation facility in the country, located on the Altamont Pass is eastern Alameda County.

8.11.4 Topography

Alameda County's topography, ranging from sea level to over 3,800 feet at Discovery Peak, is predominantly flat west of Highway 580, transitioning to gentle to moderately steep slopes. This topography influences wildland fire behavior and spread as fires tend to burn more intensely and spread faster when burning uphill and up-canyon, except for a wind-driven downhill or down-canyon fire.

8.11.5 Wildland Fire History

Alameda County has a history of significant wildland fires as summarized in Table 32.

Table 32—Alameda County Wildland Fires

Fire Name	Date	Acres
Oakland Hills	October 19, 1991	1,520
Midway	July 11, 2006	6,400
Corral	August 13, 2009	12,500
Diablo	June 18, 2010	475
Grant	June 14, 2011	175
Flynn	July 14, 2011	917
Patterson	August 23, 2011	147
Welch	June 15, 2013	60
Vasco	June 8, 2013	240
Grant	July 4, 2013	50
Fallon	July 6, 2013	38
Highland	October 4, 2013	150
Christensen	May 28, 2015	242
Site	June 5, 2015	300
Tesla	June 25, 2015	53
Geary	July 2, 2015	45
Tesla	August 19, 2015	2,700

Source: Alameda County Local Hazard Mitigation Plan, Table 4-7

8.11.6 Wildland Fire Service Demand

Over the most recent three-year period, there were 363 wildland fire incidents within the Department's service area comprising 0.32 percent of total service demand over the same period, as summarized in Table 33.

Table 33—Wildland Fire Service Demand

Risk	Year	Planning Zone					Total	Percent of Total Service Demand
		Batt. 2	Batt. 3	Batt. 4	Batt. 7	Emeryville		
Wildland Fire	2014	14	33	8	27	4	86	0.23%
	2015	32	59	26	29	4	150	0.39%
	2016	17	62	17	31	0	127	0.32%
Total		63	154	51	87	8	363	0.32%
Percent of Total Service Demand		0.17%	1.16%	0.16%	0.33%	0.12%	0.32%	

Source: Alameda County Fire Department Incident Records

As Table 33 shows, wildland fires accounted for a very small percentage of total service demand, with the highest occurrence in Battalion 3, as would be expected due to the terrain and wildland fuels. Also of note, is the occurrence of wildland fires increased nearly 75 percent from 2014 to 2015, then decreased 15 percent in 2016. Table 33 also shows that wildland fires occur in every planning zone, illustrating the need for wildland fire service capacity throughout the entire service area.

8.11.7 Probability of Wildland Fire Occurrence

Table 34 summarizes Citygate's scoring for probability of future wildland fire occurrence based on historical wildland fire service demand from Table 33.

Table 34—Probability of Future Wildland Fire Occurrence Score

Risk	Planning Zone				
	Batt. 2	Batt. 3	Batt. 4	Batt. 7	Emeryville
Wildland Fire	4	4	4	4	3

8.11.8 Wildland Fire Impact Severity

Table 35 summarizes Citygate's scoring of probable wildland fire impact severity by planning zone. Factors influencing wildland fire impact severity include fire hazard severity zones, weather, wildland fuels, topography, wildland fire history, water supply, and wildland fire service capacity.

Table 35—Wildland Fire Impact Severity Score

Risk	Planning Zone				
	Batt. 2	Batt. 3	Batt. 4	Batt. 7	Emeryville
Wildland Fire	4	4	3	4	3

8.11.9 Overall Wildland Fire Risk Score and Rating

Table 36 summarizes the Department's overall wildland fire risk based on probability of occurrence from Table 34 and probable impact severity from Table 35.

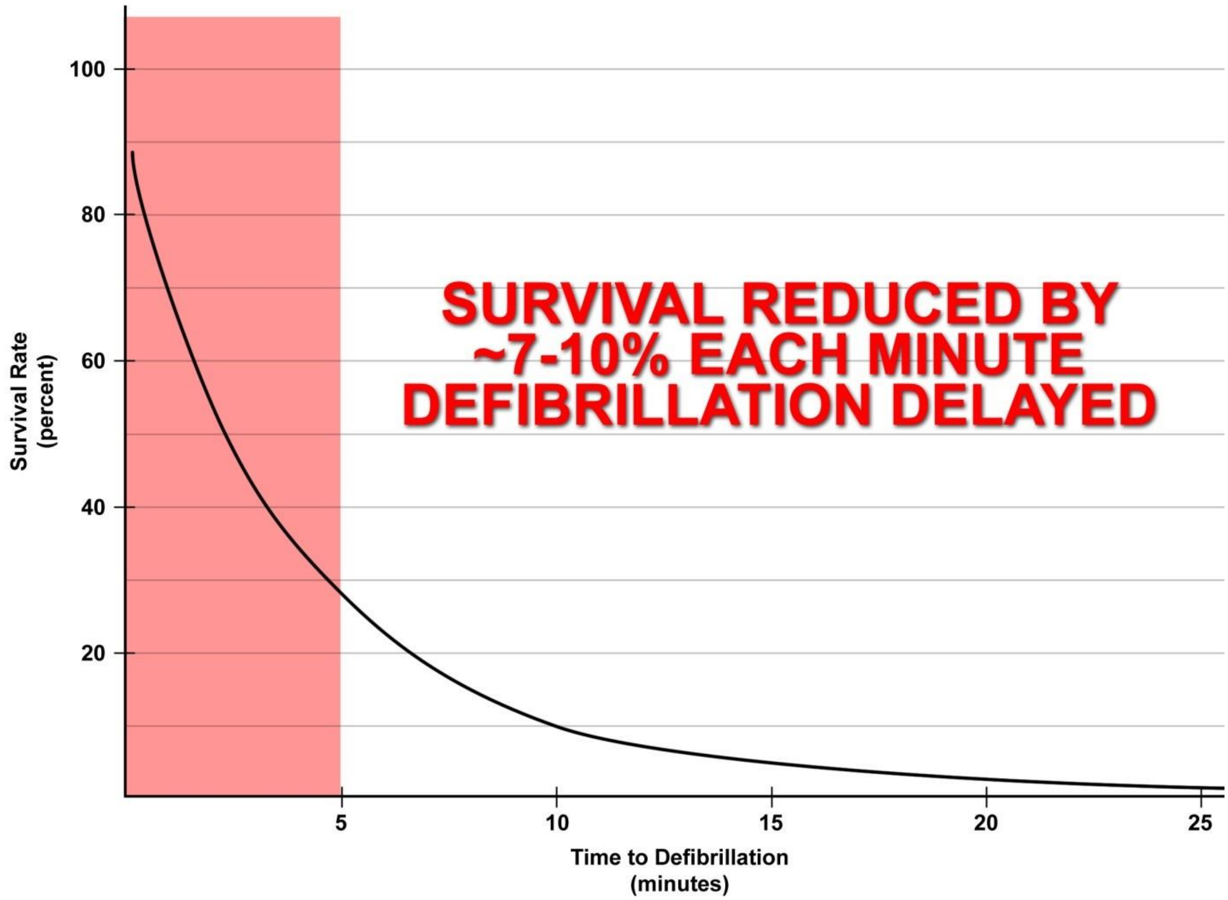
Table 36—Overall Wildland Fire Risk Score

Wildland Fire Risk	Planning Zone				
	Batt. 2	Batt. 3	Batt. 4	Batt. 7	Emeryville
Total Risk Score	16	16	12	16	12
Risk Ranking	**HIGH**	**HIGH**	**MODERATE**	**HIGH**	**MODERATE**

8.12 MEDICAL EMERGENCY RISK

Medical emergency risk in most communities is predominantly a function of population density, demographics, violence, health insurance coverage, and vehicle traffic. Medical emergency risk can be categorized as either a medical emergency resulting from a health-related condition or event, or a traumatic injury. One serious medical emergency is cardiac arrest or some other event where there is an interruption or blockage of oxygen to the brain. Figure 17 illustrates the reduced survivability of a cardiac arrest victim as time to defibrillation increases. While early defibrillation is one factor in cardiac arrest survivability, other factors can influence survivability as well, such as early CPR and pre-hospital advanced life support interventions.

Figure 17—Survival Rate Versus Time to Defibrillation



Source: www.suddencardiacarrest.com

8.12.1 Population Density

Because medical emergencies involve people, it seems logical that higher population densities generate higher medical emergency service demand than lower population densities. In Citygate's experience, this is particularly true for urban population densities. Population density across the Department's service area ranges from less than 1,000 to more than 15,000 per square mile.

8.12.2 Demography

Medical emergency risk tends to be higher among older, poorer, less-educated, and uninsured populations. According to the U.S. Census Bureau, 12.53 percent of the Department's service area population is 65 and older; 9.24 percent is at or below poverty level; more than 57 percent of the population over 24 years of age has less than a high school diploma or equivalent; and more than 10 percent of the population does not have health insurance coverage.[5]

8.12.3 Violence

As would be expected, medical emergency risk is also higher in communities or segments of communities with higher rates of violence. For 2014, the most recent year of available data, there were 588 violent crimes committed in unincorporated Alameda County.[6] Given the estimated population of 161,000, this represents a violent crime rate of 0.4 percent, suggesting that violent crime minimally influences the Department's unincorporated service area medical emergency risk.

8.12.4 Vehicle Traffic

Medical emergency risk tends to be higher in those areas of a community with high daily vehicle traffic volume, particularly those areas with high traffic volume travelling at high speeds. The Department's service area transportation network includes 11 highways that carry an annual average daily traffic volume of more than 1.33 million vehicles, with a peak-hour load of more than 114,000 vehicles.[7]

8.12.5 Medical Emergency Service Demand

Over the previous three years, there were 82,660 medical emergency incidents within the Department's service area comprising 71.78 percent of total service demand over the same period, as summarized in Table 37.

Table 37—Medical Emergency Service Demand

Risk	Year	Planning Zone					Total	Percent of Total Service Demand
		Batt. 2	Batt. 3	Batt. 4	Batt. 7	Emeryville		
Medical Emergency	2014	9,110	2,494	7,620	6,053	1,361	26,638	72.31%
	2015	9,080	2,464	7,870	6,310	1,469	27,193	71.12%
	2016	9,840	2,578	8,169	6,807	1,435	28,829	71.94%
Total		28,030	7,536	23,659	19,170	4,265	82,660	71.78%
Percent of Total Service Demand		77.01%	56.76%	72.16%	73.47%	64.67%	71.78%	

Source: Alameda County Fire Department Incident Records

[5] Source: U.S. Census Bureau (2015)

[6] Source: U.S. Department of Justice Uniform Crime Reporting Statistics

[7] Source: California Department of Transportation (2015)

As Table 37 shows, medical emergencies are the predominant component of the Department's total service demand, with the highest volume in Battalions 2, 4, and 7 where the population densities are highest. Also of note is that medical emergencies have increased approximately eight percent over the past three years. Table 37 also shows that medical emergencies occur throughout all five planning zones, illustrating the need for quick pre-hospital emergency medical service capacity throughout the entire service area.

8.12.6 Probability of Medical Emergency Occurrence

Table 38 summarizes Citygate's scoring for probability of future medical emergency occurrence based on historical medical emergency service demand from Table 37.

Table 38—Probability of Future Medical Emergency Occurrence Score

Risk	Planning Zone				
	Batt. 2	Batt. 3	Batt. 4	Batt. 7	Emeryville
Medical Emergency	4	4	4	4	4

8.12.7 Medical Emergency Impact Severity

Table 39 summarizes Citygate's scoring of probable medical emergency impact severity. Factors influencing medical emergency impact severity include population demographics, violence, vehicle traffic, and medical emergency service capacity.

Table 39—Medical Emergency Impact Severity Score

Risk	Planning Zone				
	Batt. 2	Batt. 3	Batt. 4	Batt. 7	Emeryville
Medical Emergency	3	3	3	3	3

8.12.8 Overall Medical Emergency Risk Score and Rating

Table 40 summarizes the Department's overall medical emergency risk based on probability of occurrence from Table 38 and impact severity from Table 39.

Table 40—Overall Medical Emergency Risk Score

Medical Emergency Risk	Planning Zone				
	Batt. 2	Batt. 3	Batt. 4	Batt. 7	Emeryville
Total Risk Score	12	12	12	12	12
Risk Ranking	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE

8.13 Hazardous Material Risk

Factors influencing hazardous material risk includes fixed facilities that store, use, or produce hazardous materials or waste; underground pipelines conveying hazardous materials; aviation, railroad, maritime, and vehicle transportation of hazardous materials into or through a jurisdiction; population density; vulnerable populations; emergency evacuation planning and related training; specialized hazardous material service capacity; and historic hazardous material service demand.

8.13.1 Hazardous Material Sites

Data provided by the Department identifies 21 buildings and facilities classified as hazardous occupancies by the State Building Code, or otherwise requiring a State or County hazardous material operating permit.

8.13.2 Hazardous Material Transportation

The Department's service area includes 11 highways that carry an annual average daily volume of more than 95,000 trucks, some of which transport hazardous materials, as summarized in Table 41.

Table 41—Average Annual Daily Truck Traffic

Highway	Crossing	AADT[1]	Truck AADT by Axles				% Truck AADT by Axles			
			2	3	4	5+	2	3	4	5+
13	Highway 24	185	153	26	4	2	82.52%	14.08%	2.43%	0.97%
24	Caldecott Lane	3,842	2,626	409	144	663	68.35%	10.64%	3.76%	17.25%
84	Highway 880	3,375	1,806	344	71	1,154	53.50%	10.20%	2.10%	34.20%
92	Highway 880	8,401	3,772	899	378	3,352	44.90%	10.70%	4.50%	39.90%
112	Highway 880	1,960	1,347	286	31	296	68.70%	14.60%	1.60%	15.10%
123	Highway 580	421	306	55	11	49	72.73%	13.07%	2.65%	11.55%
185	44th Avenue	610	484	62	6	58	79.35%	10.18%	0.99%	9.48%
238	Highway 580	19,551	4,262	1,564	567	13,158	21.80%	8.00%	2.90%	67.30%
580	First Street	21,960	4,019	681	461	16,799	18.30%	3.10%	2.10%	76.50%
680	Highway 84	10,579	3,047	1,026	899	5,607	28.80%	9.70%	8.50%	53.00%
880	Oak/Madison Street	24,610	7,826	3,199	886	12,699	31.80%	13.00%	3.60%	51.60%

[1] Average Annual Daily Trips

Source: California Department of Transportation

8.13.3 Population Density

Because hazardous material emergencies have the potential to adversely impact human health, it is logical that the higher the population density, the greater the potential population exposed to a hazardous material release or spill. As previously cited, the Department's service area population density ranges from less than 1,000 to more than 15,000 per square mile.

8.13.4 Vulnerable Populations

Populations particularly vulnerable to a hazardous material release/spill include those individuals or groups unable to self-evacuate, generally including children under the age of 10, the elderly, and persons confined to an institution or other setting where they are unable to leave voluntarily. Nearly 26 percent of the Department's service area population is under 10 or 65 and older.

8.13.5 Emergency Evacuation Planning, Training, Implementation, and Effectiveness[8]

Another significant factor influencing hazardous material risk is a jurisdiction's shelter-in-place/emergency evacuation planning and training. In the event of a hazardous material release or spill, time can be a critical factor in notifying potentially affected persons, particularly at-risk populations, to either shelter-in-place or to evacuate to a safe location. Essential to this process is an effective emergency plan that incorporates one or more mass emergency notification capabilities and pre-established evacuation procedures. It is also essential to conduct regular, periodic exercises involving these two emergency plan elements to evaluate readiness and to identify and remediate any planning and/or training gaps to ensure ongoing emergency incident readiness and effectiveness.

The Alameda County Sherriff's Office of Emergency Services administers AC Alert, the County-wide mass emergency telephone notification system. In addition to the Sherriff's Office being able to activate emergency notifications County-wide, the 14 cities and eight participating public safety agencies, including the Alameda County Fire Department, are also able to activate mass emergency notifications within their respective jurisdictions. In addition to being utilized for emergencies, AC Alert is regularly utilized in County/agency emergency management exercises to evaluate its ongoing effectiveness, and any deficiencies are included in respective exercise after action reports.

The Alameda County Sherriff's Office of Emergency Services also has a formal Emergency Evacuation Plan, currently under revision, that identifies specific emergency evacuation protocols and procedures, including evacuation routes and assembly points for each jurisdiction. This plan is also exercised/evaluated annually, at minimum.

Finding #12:	Alameda County has established appropriate emergency evacuation protocols, procedures, and resources as an element of its Emergency Operations Plan.
Finding #13:	Alameda County has established an effective method to communicate emergency evacuation information to the public in a timely manner.

[8] Reference: personal contact with Alameda County Senior Emergency Services Coordinator Theresa Langdon

Finding #14:	Alameda County regularly utilizes, validates, and evaluates its emergency notification and evacuation protocols, procedures, and resources to ensure ongoing readiness and effectiveness.

8.13.6 Hazardous Materials Service Demand

The Department responded to 803 hazardous materials incidents over the previous three years, constituting 0.70 percent of total service demand over the same period, as summarized in Table 42.

Table 42—Hazardous Materials Service Demand

Risk	Year	Planning Zone					Total	Percent of Total Service Demand
		Batt. 2	Batt. 3	Batt. 4	Batt. 7	Emeryville		
Hazardous Materials	2014	68	52	61	46	22	249	0.68%
	2015	77	44	82	63	18	284	0.74%
	2016	65	47	74	63	21	270	0.67%
Total		210	143	217	172	61	803	0.70%
Percent of Total Service Demand		0.58%	1.08%	0.66%	0.66%	0.92%	0.70%	

Source: Alameda County Fire Department Incident Records

As Table 42 indicates, hazardous material service demand constitutes a very small percentage of total service demand, with rather consistent occurrence across all five planning zones. Also of note is that hazardous materials responses have increased approximately eight percent over the past three years, with the highest occurrence in Battalions 2 and 4. While the Department's hazardous materials service demand is very low, the potential exists for very significant impact severity from a hazardous material spill/release due to population density and related vulnerable populations throughout most of the Department's service area.

8.13.7 Probability of Occurrence

Table 43 summarizes Citygate's scoring for probability of a future hazardous material occurrence based on recent hazardous material service demand history from Table 42.

Table 43—Probability of Future Hazardous Materials Occurrence Score

Risk	Planning Zone				
	Batt. 2	Batt. 3	Batt. 4	Batt. 7	Emeryville
Hazardous Materials	4	4	4	4	4

8.13.8 Hazardous Materials Impact Severity

Table 44 summarizes Citygate's scoring of probable hazardous material impact severity based on the impact factors previously discussed.

Table 44—Hazardous Materials Impact Severity Score

Risk	Planning Zone				
	Batt. 2	Batt. 3	Batt. 4	Batt. 7	Emeryville
Hazardous Materials	3	3	3	3	3

8.13.9 Overall Hazardous Materials Risk Score and Rating

Table 45 summarizes the Department's overall hazardous materials risk based on probability of occurrence from Table 43 and probable impact severity from Table 44.

Table 45—Overall Hazardous Materials Risk Score

Hazardous Materials Risk	Planning Zone				
	Batt. 2	Batt. 3	Batt. 4	Batt. 7	Emeryville
Total Risk Score	12	12	12	12	12
Risk Ranking	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE

8.14 Technical Rescue Risk

Technical rescue risk factors include active construction projects; structural collapse potential; confined spaces, such as tanks and underground vaults; bodies of water and rivers or streams; industrial machinery; transportation volume; and earthquake, liquefaction, flood, tsunami, and landslide potential.

8.14.1 Construction Activity

There is ongoing construction activity within the Department's service area, including residential, commercial, industrial, and infrastructure projects.

8.14.2 Confined Spaces

There are numerous permanent and temporary confined spaces within the Department's service area, including tanks, vaults, open trenches, etc.

8.14.3 Bodies of Water

There are numerous bodies of water within the Department's service area, including San Francisco Bay, San Leandro Reservoir, Lake Chabot, Cull Canyon Lake, Don Castro Reservoir, San Antonio Reservoir, Lake Del Valle, Calaveras Reservoir, Shadow Cliffs Lake, Lake Boris, and numerous streams and smaller bodies of water.

8.14.4 Transportation Volume

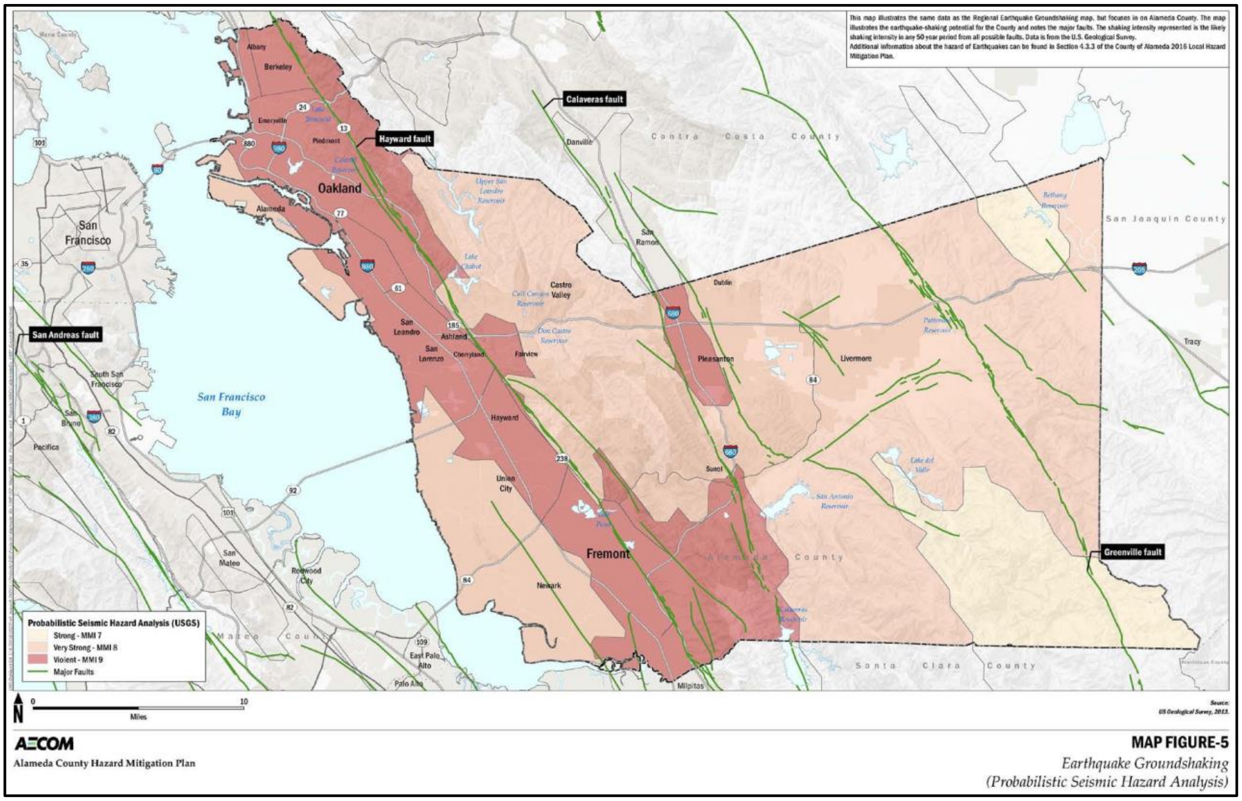
Another technical rescue factor is transportation-related incidents requiring technical rescue. This risk factor is primarily a function of vehicle, railway, maritime, and aviation passenger volume. Vehicle traffic volume is the greatest of these factors within the Department's service area, with 11 highways carrying nearly 1.34 million vehicles daily.

8.14.5 Earthquake Risk[9]

A significant earthquake has the greatest potential for resultant impact severity in Alameda County. The County has a number of known and potentially undiscovered faults, including the Hayward Fault with three fault segments, the San Andreas Fault with 10 fault segments, and the Northern Calaveras and Greenville Faults, as shown in Figure 18.

[9] Reference: County of Alameda 2016 Local Hazard Mitigation Plan, Section 4.3.3

Figure 18—Earthquake Fault Zones



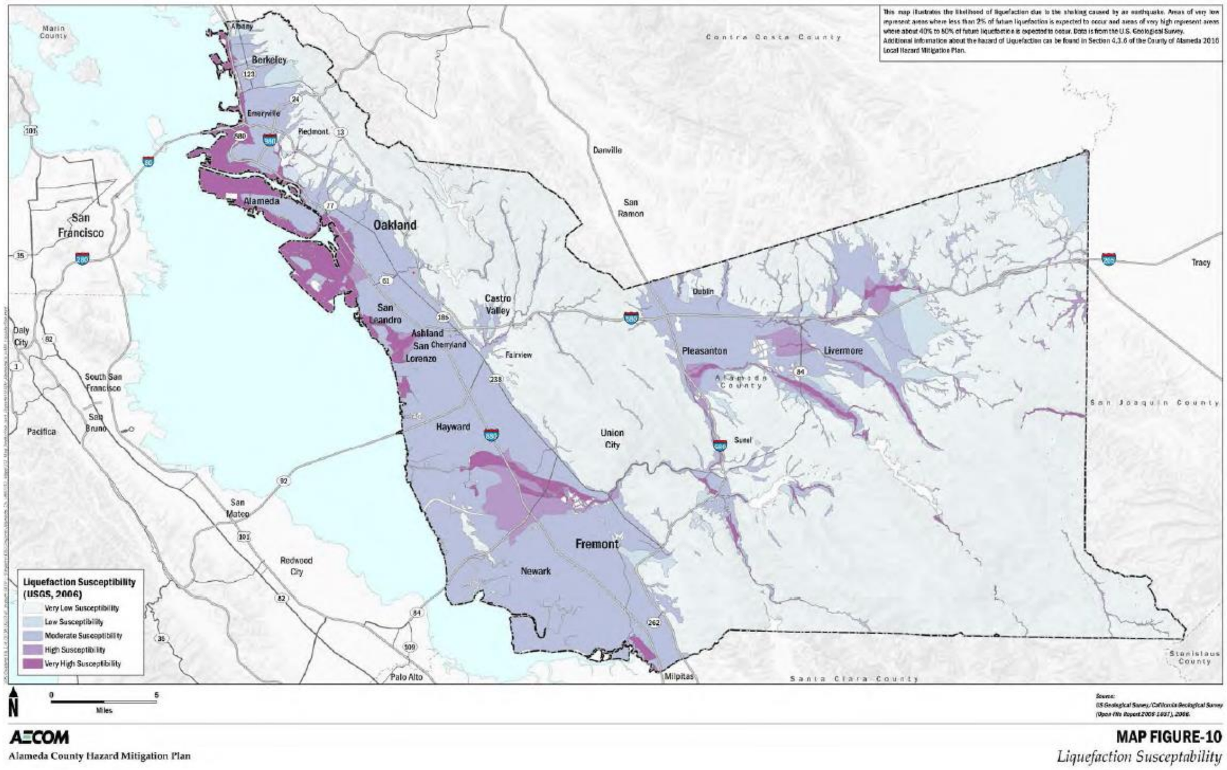
Source: County of Alameda 2016 Local Hazard Mitigation Plan, Appendix E

8.14.6 Liquefaction Risk[10]

Liquefaction is a secondary hazard from earthquakes, occurring when a seismic wave passes through saturated granular soil, distorting its structure, causing the soil to behave like a fluid resulting in lateral spread, loss of shear strength, and ground subsidence. Figure 19 shows the areas of Alameda County susceptible to liquefaction.

[10] Reference: County of Alameda 2016 Local Hazard Mitigation Plan, Section 4.3.6

Figure 19—Liquefaction Zones



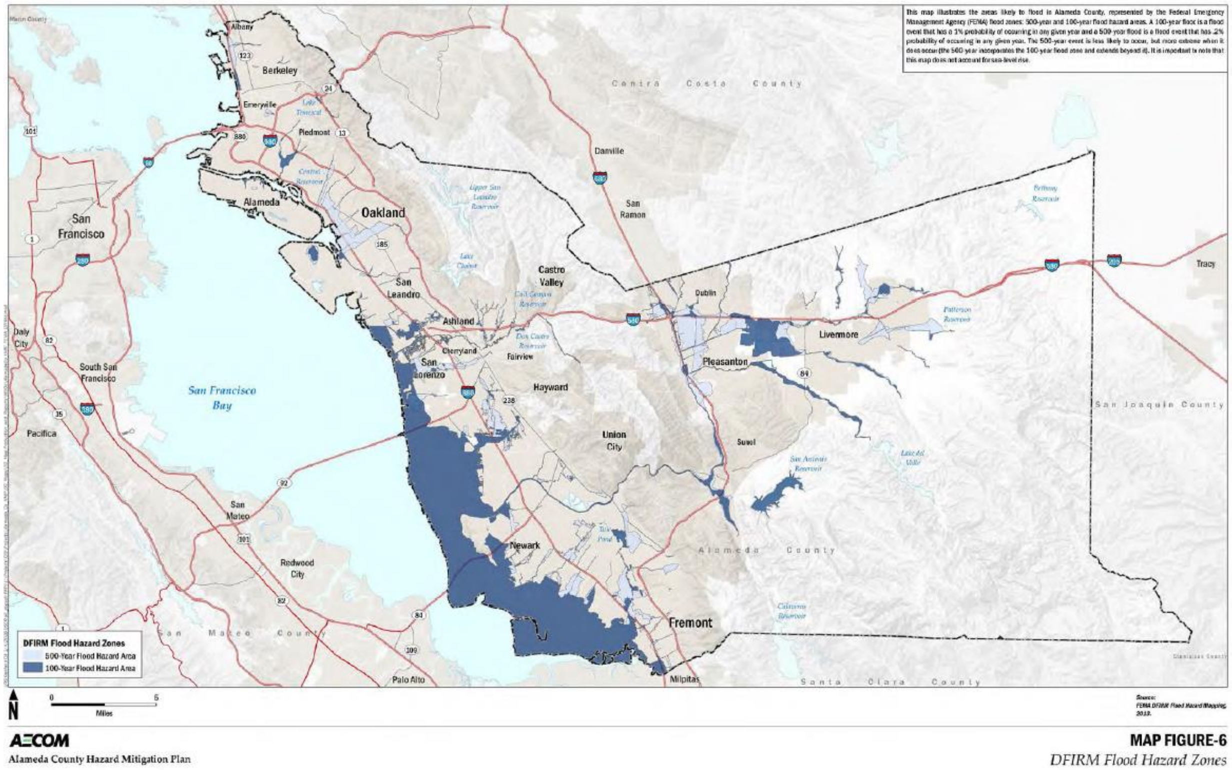
Source: County of Alameda 2016 Local Hazard Mitigation Plan, Appendix E

8.14.7 Flood Risk[11]

Alameda County has experienced 29 significant flood events since 1950. Numerous areas of Alameda County are susceptible to flooding, as shown in Figure 20. Areas along the southern coast of Alameda County are most susceptible to flooding, as well as areas in the Livermore and Pleasanton Valleys.

[11] Reference: County of Alameda 2016 Local Hazard Mitigation Plan, Section 4.3.4

Figure 20—Flood Hazard Areas



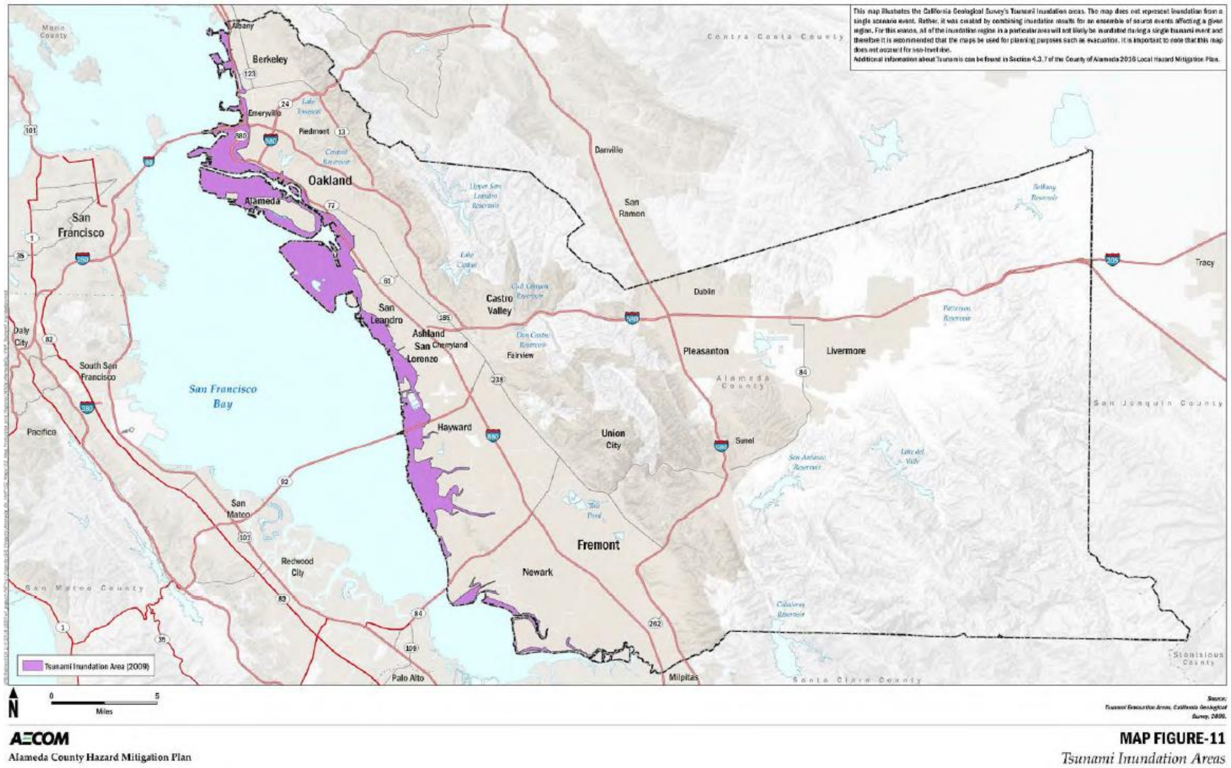
Source: County of Alameda 2016 Local Hazard Mitigation Plan, Appendix E

8.14.8 Tsunami Risk[12]

An earthquake anywhere in the Pacific Ocean can cause tsunamis around the entire Pacific basin, including Alameda County. Since the Pacific Rim is highly seismically active, tsunamis are not uncommon, but historically have been only a few meters in height. From 1812 to 2000, 22 tsunamis were recorded in the greater San Francisco Bay Area, none of which caused any significant damage in Alameda County. Figure 21 illustrates the potential tsunami inundation areas of the County where there is potential for significant damage and/or loss of life from a tsunami.

[12] Reference: County of Alameda 2016 Local Hazard Mitigation Plan, Section 4.3.7

Figure 21—Tsunami Inundation Areas



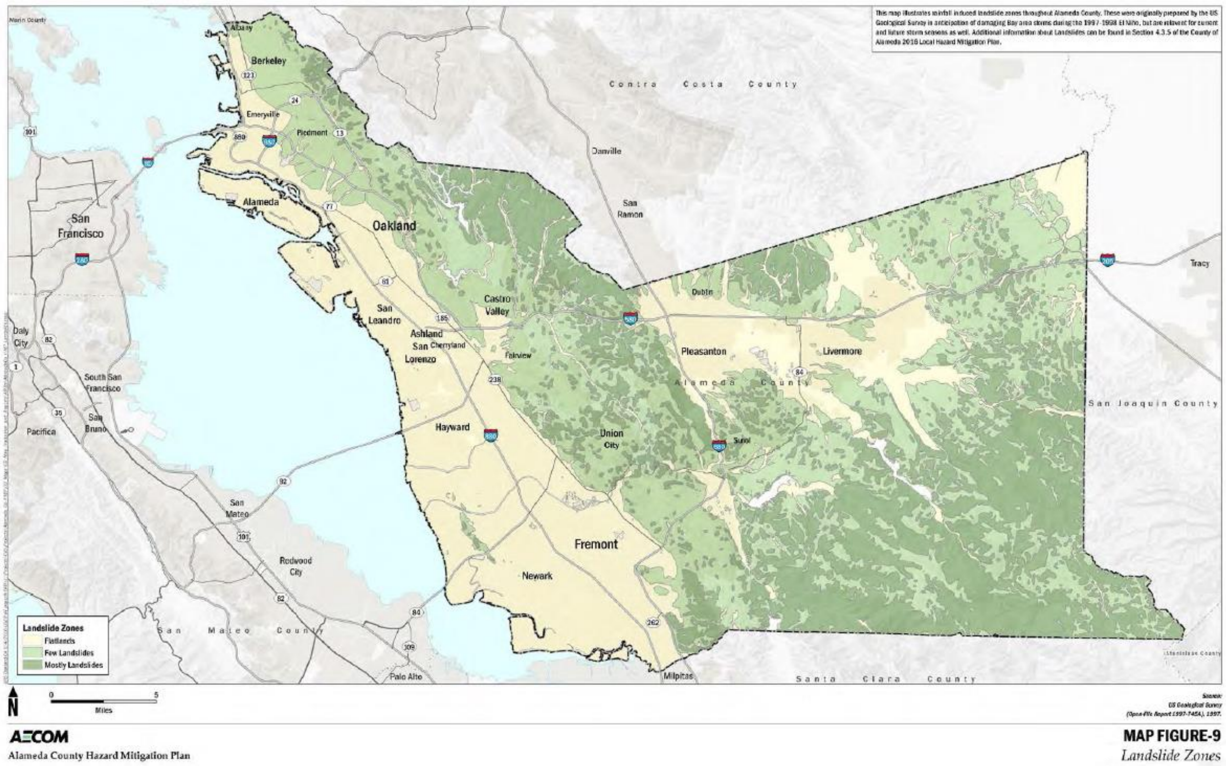
Source: County of Alameda 2016 Local Hazard Mitigation Plan, Appendix E

8.14.9 Landslide Risk[13]

Landslide refers to a dislodged mass of soil and/or rocks from a sloped surface. The susceptibility of a sloped surface to landslide depends on variations in geology, topography, vegetation, and weather. While landslides often occur with other natural hazards including earthquakes, heavy rain, waterway channel erosion, and wildland fires, they can also occur as a result of indiscriminate development of sloping ground or the creation of cut-and-fill slopes. Figure 22 shows the areas of Alameda County susceptible to landslide.

[13] Reference: County of Alameda 2016 Local Hazard Mitigation Plan, Section 4.3.5

Figure 22—Landslide Zones



Source: County of Alameda 2016 Local Hazard Mitigation Plan, Appendix E

8.14.10 Technical Rescue Service Demand

Over the most recent three-year period, the Department responded to 155 technical rescue incidents comprising 0.13 percent of total service demand for the same period, as summarized in Table 46.

Table 46—Technical Rescue Service Demand

Risk	Year	Planning Zone					Total	Percent of Total Service Demand
		Batt. 2	Batt. 3	Batt. 4	Batt. 7	Emeryville		
Technical Rescue	2014	2	7	11	8	11	39	0.11%
	2015	7	19	27	5	14	72	0.19%
	2016	6	7	17	1	13	44	0.11%
Total		15	33	55	14	38	155	0.13%
Percent of Total Service Demand		0.04%	0.25%	0.17%	0.05%	0.58%	0.13%	

Source: Alameda County Fire Department Incident Records

As Table 46 indicates, although technical rescue incidents occur annually in all five planning zones, technical rescue comprises a very small percentage of total service demand.

8.14.11 Probability of Occurrence

Table 47 summarizes Citygate's scoring of probability of a future technical rescue occurrence based on technical rescue service demand history from Table 46.

Table 47—Probability of Future Technical Rescue Occurrence Score

Risk	Planning Zone				
	Batt. 2	Batt. 3	Batt. 4	Batt. 7	Emeryville
Technical Rescue	3	3	4	3	4

8.14.12 Technical Rescue Impact Severity

Table 48 summarizes Citygate's scoring of probable technical rescue impact severity.

Table 48—Technical Rescue Impact Severity Score

Risk	Planning Zone				
	Batt. 2	Batt. 3	Batt. 4	Batt. 7	Emeryville
Technical Rescue	3	3	3	3	3

8.14.13 Overall Technical Rescue Risk Score and Rating

Table 49 summarizes the Department's overall technical rescue risk based on probability of occurrence scoring from Table 47 and impact severity scoring from Table 48.

Table 49—Overall Technical Rescue Risk Score

Technical Rescue Risk	Planning Zone				
	Batt. 2	Batt. 3	Batt. 4	Batt. 7	Emeryville
Total Risk Score	9	9	12	9	12
Risk Ranking	MODERATE	MODERATE	MODERATE	MODERATE	MODERATE