The Loudoun County Combined Fire Rescue System

Loudoun County, VA

EMERGENCY OPERATIONS SERVICE PLAN

ESCI Emergency Services Consulting International

Providing Expertise and Guidance that Enhances Community Safety

October 2019

Emergency Services Consulting International
Providing Expertise and Guidance that Enhances Community Safety

October 15, 2019

Fire Chief Keith Johnson
Loudoun County Combined Fire-Rescue Headquarters
801 Sycolin Road, Suite 200
Leesburg, VA 20175

Re: Emergency Operations Comprehensive Service Plan

Dear Chief Johnson:

Emergency Services Consulting International, Inc. (ESCI) is pleased to provide this Report of the **Loudoun County Combined Fire-Rescue Emergency Operations Service Plan** for the Loudoun County Combined Fire-Rescue System (LC-CFRS). This document was prepared in accordance with the requirements of the terms of the initiating contract and subsequent discussions with system leadership and project team members.

The ESCI project team began collecting information concerning the LC-CFRS in early 2019. The team members recognize this report contains a large amount of information and ESCI would like to thank the LC-CFRS staff and many officials for their efforts in bringing this project to fruition. ESCI would also like to thank the various individuals and external organizations for their input, opinions, and candid conversations throughout this process. It is ESCI's sincere hope the information contained in this report is used to its fullest extent and the emergency services provided to the Citizens of Loudoun County and the surrounding area will be improved by its implementation.

Sincerely,

Sheldon Gilbert
Chief Executive Officer
Direct: 940.453.1366
Office: 1.800.757 3724
e-mail: Sheldon.Gilbert@esci.us

Table of Contents

Table of Figures

Acknowledgments

This project was possible only with the considerable support and leadership of the Loudoun County Combined Fire Rescue System. Emergency Services Consulting International wishes to thank and acknowledge the following representatives for their invaluable contributions to this project.

Loudoun County Board of Supervisors

Mr. Tim Hemstreet, County Administrator

Keith Johnson, System Chief

James Williams, Assistant Chief

John Caussin, Assistant Chief

Mark Schumacher, Captain/Project Manager

Mary Maguire, Administration / Finance Manager

Laura Rinehart, Public Information Officer

LC-CFRS Core Group Members

...and all the men and women of the Loudoun County Combined Fire Rescue System, who contributed to this report and who daily serve their community with honor and distinction.

Section I. Executive Summary

The Loudoun County Combined Fire Rescue System (LC-CFRS) contracted ESCI to develop a Comprehensive Service Plan for the emergency operations of the system and its member organizations. Fire prevention, training, administration, and other non-emergency support services are not included but may be scheduled for future study. Specifically, the project has three primary deliverables:

- **Evaluate current operational service delivery against NFPA 1710 and other recognized standards**. Using information provided by LC-CFRS, ESCI was tasked to establish an informational baseline, benchmark emergency operations performance, and provide a detailed analysis of existing conditions and emergency operations. As part of this review, ESCI was to evaluate current conditions in light of (1) service demand by incident type, location, and time of occurrence; and (2) response performance in terms of resource demand, distribution, deployment, unit workload, response time and reliability, and by system resilience.
- **Identify future service delivery needs**. ESCI was tasked to provide a basic community risk assessment to identify potential service gaps and redundancies, with consideration of community expectations, needs, and resources.
- **Provide recommendations for operational service delivery**. ESCI was tasked to identify system strengths, weaknesses, opportunities, and threats in order to conduct a SWOT analysis and to develop recommendations to improve and enhance the delivery of emergency services, for both the intermediate short-term and long-term. Where possible, recommendations were to include consideration of cost/benefit analysis, benchmarks, standards, and best practices.

Using organizational, operational, staffing, and geographic information system (GIS) models, this evaluation provides a comprehensive appraisal of the emergency operations of the Loudoun County Combined Fire Rescue System (referred to herein as "LC-CFRS" and "the County") as it was found upon ESCI's completion of fieldwork and data collection in October 2018.

ESCI based this evaluation on data provided by the County and collected during ESCI's fieldwork. The information is mirrored against a combination of Virginia State laws and regulations, National Fire Protection Association (NFPA) standards, Commission on Fire Accreditation International (CFAI) self-assessment criteria, health and safety requirements, federal and state mandates relative to emergency services and generally accepted best practices within the emergency services community, as well as the experience of ESCI's consultants.[1] [2]

Each section in the following report provides the reader with general information about that element, as well as observations and analyses of any significant issues or conditions. Supporting explanation is provided below each survey section, where needed. The evaluation begins with a baseline review of the County's organizational composition.

---

[1] *NFPA, National Fire Protection Association is a standard developing organization. Standards developed by NFPA are "voluntary consensus standards," created through procedures accredited for their consensus decision-making, openness, balance of interests represented, and fairness by the American National Standards Institute (ANSI).*

[2] *The CFAI organization is now a subsection of the Center for Public Safety Excellence (CPSE) but maintains its prime function of accrediting fire agencies.*

Critical Issues

Critical issues, as identified by Chief staff, were the need to:

- Maintain an adequate fire and EMS response to emergency and non-emergency incidents that is consistent with national standards such as NFPA 1710, 24 hours per day, 365 days per year.
- Ensure that all fire and rescue units are staffed with the required number of qualified fire and EMS personnel that operate in a safe manner.
- Ensure that LC-CFRS is supplied with the best resources (equipment, apparatus, and facilities) possible to allow its members to perform their job in the safest and most efficient manner.
- Ensure the successful recruitment and retention of a qualified Career and Volunteer workforce. LC-CFRS must look for ways to attract qualified people and keep them here. The volunteer companies are the foundation of the LC-CFRS. Each, organized and chartered under the Code of Virginia, provides community-based fire and rescue services throughout Loudoun County. For more than a century, out of an enduring desire to safeguard the public, hundreds of Loudoun County residents have volunteered in these companies and their history of service is woven into the fabric of the community.

Key Concepts and National Trends

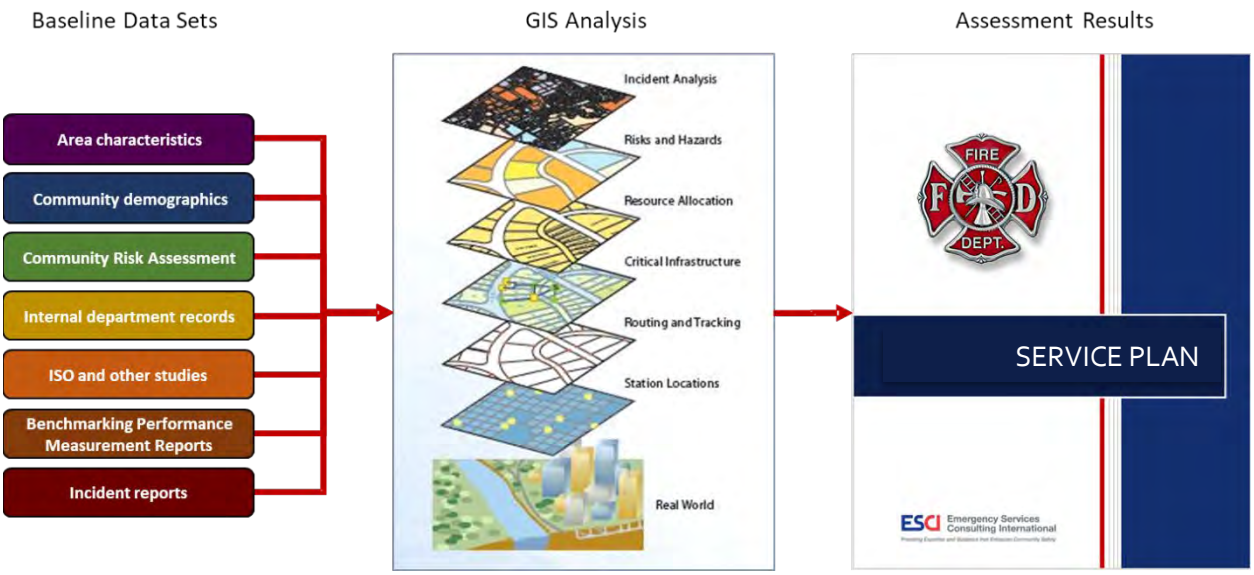
This report includes best practices based on nationally-recognized guidelines and criteria, including concepts from the National Fire Protection Association (NFPA), the Insurance Services Office (ISO), the Center for Public Safety Excellence (CPSE), laws and regulations of the Commonwealth of Virginia, and other generally-accepted practices for emergency services. Where applicable, the report is written and organized in a style that is consistent with:

Methodology

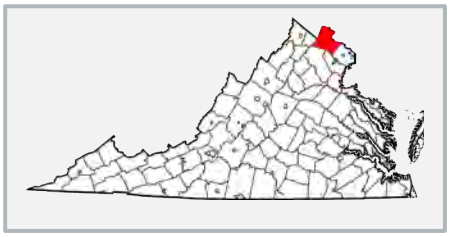
From the information provided by the LC-CFRS, ESCI was able to establish a baseline assessment of current conditions and service performance, centered around an organizational analysis of each specialized and technical service provided by LC-CFRS. The purpose of this evaluation was to assess LC-CFRS emergency operations in comparison to industry standards and best practices, as well as (1) create a benchmark against which options for future service delivery can be measured; and (2) understand how the department provides and coordinates system-wide service.

Where appropriate, ESCI used Geographic Information Systems (GIS) technology and historical reporting tools to visualize the data and provide additional information for strategic planning purposes. The following figure illustrates the conceptual GIS methodology as applied to this assessment.

GIS Methodology[3]



Community Risk Summary



Loudoun County is located in the far northern part of the Commonwealth of Virginia, bounded on the north by the Potomac River, on the east by Fairfax County, on the south by Prince William and Fauquier counties, and to the west by Clarke County and Jefferson County, West Virginia. The county seat of Leesburg is about 36 miles northwest of Washington, D.C. and 12 miles northwest of Washington Dulles International Airport (IAD). The 2018 estimated population is 402,561. This is a 28.9 percent increase since the 2010 Census (population 312,311) and represents an average 3.6 percent annual growth since that time. Loudoun County is the third-most populous county in the Commonwealth of Virginia and is ranked first in the U.S. in median household income for areas with a population of 65,000 or more. First settled in the 1720s, Loudoun County was officially established in 1757 and has held a significant place in American history.

Around the time of the American Revolution, it was Virginia's most populous county and well-established as an agricultural center. Important documents and archives were stored in the county seat, Leesburg, during the War of 1812. Several Civil War battles were fought in and around Loudoun County. The county has long been known for agriculture. Primary crops are grain, forage crops, fruits, and vegetables. Primary livestock are cattle and poultry; the county is ranked first in the Commonwealth for the production of horses and ponies. Although agriculture is still a strong driver of the county's economy, urbanization has caused the development of a robust and well-diversified service structure, home to airline, high tech, and internet-related companies.

[3] *Adapted from Datta, retrieved from geospatialworld.net, 2014.*

The tourism industry contributed more than $ 1.8 billion and the wedding industry is worth more than $118 million per year to the local economy in 2017. [4] "Agritourism" has become an important part of the county's economy, with over 150 of the county's 1,300 farms, plus 40 wineries and over 30 craft breweries participating in the program.[5] Many of the craft beverage makers have been recognized with regional, national and international awards. The craft beer boom has increased planting grapes, hops and honey of any jurisdiction in the Commonwealth.

Today, Loudoun County is a tale of two counties. To the east of Leesburg lies the densely-populated, urban area that has essentially become part of the greater-Washington suburban landscape that stretches across the entire eastern half of the county, across Fairfax County and into Washington D.C. and includes the majority of Washington Dulles International Airport. The airport serves over 21 million passengers each year and is also the home of the Udvar-Hazy Center of the Smithsonian Air & Space Museum. The Center welcomes more than 1.4 million visitors each year.

West of Leesburg and the Dulles Greenway, the county is rural in nature with small towns and unincorporated communities along the primary roadways. Historic sites, including roadhouses, schools, churches, bridges, and battlefields dot the county; there are more than 90 sites listed on the National Register of Historic Places, including six National Historic Landmarks.

Loudoun County is susceptible to a variety of hazards. A hazard is described as "a condition that presents the potential for harm or damage to people, property, or the environment." For convenience, hazards are often grouped into one of two categories by cause: natural and technological or human-caused.

Natural hazards are hazards which result from acts of nature and could include any of the following. Those identified as the most prominent physical or natural hazards faced by residents of Loudoun County are highlighted. [6, 7]

- Avalanche
- Animal disease outbreak
- Drought
- Extreme Cold
- Extreme Heat
- Flood
- Hurricane
- Landslide
- Lightning
- Snowstorm
- Severe Weather
- Thunderstorm
- Tornado
- Tsunami
- Volcanic Eruption
- Wildfire
- Winter Storm

[4] *"Top Ways Loudoun Count, Virginia, is No. 1." Retrieved from: https://biz.loudoun.gov/site-selection/loudoun-number-1.*

[5] *"Loudoun's Domestic Tourism Worth $1.8 Billion," Brian Tinsman, September 6, 2018. Retrieved from: https://biz.loudoun.gov/.*

[6] *CPG 201: Threat and Hazard Identification and Risk Assessment Guide—Second Edition, U.S. Office of Homeland Security, FEMA, August 2013.*

[7] *Northern Virginia Hazard Mitigation Plan Update, 2017. Retrieved from: http://arlington.granicus.com/MetaViewer.php?view_id=2&event_id=1101&meta_id=163110.*

Since 1972, the number of federally-declared disasters in Loudoun County (12) is lower than the county equivalent average for the rest of the Commonwealth (15), and about the same as the U.S. equivalent average (12.5).[8] The cause for each of these declarations is shown in the next figure. Although some of these declarations did not affect all areas of the county equally, they are an indication of the hazards present throughout the area.

Federally-Declared Disasters for Loudoun County, Jan 1977–Dec 2018

Type	Number	Percent
Flood	1	8.3 %
Tropical Storm/Hurricane [a]	5	41.7 %
Severe Storm	6	50.0 %
Total	**12**	**100.0 %**
Notes: [a] includes Hurricane Katrina evacuees		

Technological or human-caused hazards are hazards which result from accidents or failures of systems and structures; or from the actions of people, either accidental or intentional. Intentional actions are always deliberate; however, the intent may differ, i.e., a deliberate action may be planned, careless, reckless, or with the intent to cause harm. In careless or reckless acts, or those that are poorly planned and/or executed, the outcome may have unintended consequences. Regardless, the potential for harm or damages exists.

Typical types of technological/human-caused hazards are listed here. Any one of these could occur in Loudoun County as the result of an accident or equipment failure.

- Airplane Crash
- Workplace Violence
- Cyber Incident
- Dam/Levee Failure
- Fire or Explosion
- Hazmat/CBRNE Release
- Industrial/Mine Incident Medical Emergency
- Pandemic/Epidemic
- Pipeline Emergency
- Power Failure
- Structure Collapse
- Technical Rescue
- Terrorist Threat
- Train Derailment
- Urban Conflagration
- Dignitary Visits

Dignitary visits draw a large number of participants into places into soft target and crowded places locations. Soft targets and crowded places (ST-CPs), such as sports venues, schools, and transportation systems are easily accessible locations for large numbers of people with limited security or protective measures in place, making them vulnerable to attack. [9]

[8] *FEMA Disaster Declarations Summary—Open Government Dataset, U.S. Department of Homeland Security, last updated March 5, 2018. Retrieved from: https://www.fema.gov/media-library/assets/documents/28318.*

[9] *"Securing Soft Targets and Crowded Places Resources, U.S. Department of Homeland Security. Retrieved from: https://www.dhs.gov/publication/securing-soft-targets-and-crowded-places-resources.*

Intentional acts, like active shooter incidents or workplace violence, are likely to occur. Likewise, there are likely targets for deliberate acts such as critical facilities, communication systems, water and utilities, monuments, and areas where large groups congregate, *e.g.,* stadiums, conventions, and worship areas. Mitigation strategies include public awareness/education and continuous diligence by law enforcement and homeland security officials.

Geographical hazards are hazards associated with the natural and human-made characteristics of a community. These include:

- Climate and Weather
- Topography
- Wildland-urban Interface
- Land Use: Rural/Urban
- Transportation Networks
- Utilities
- Critical Infrastructure/Key Resources

The climate in Loudoun County is generally temperate, with a typical low temperature in winter of 20 degrees F and a high of 90 degrees F in the summer. Weather is moderate, but the area can experience severe storms, usually accompanied by high wind and the potential for flooding or snowstorm conditions.

Generally speaking, the highest occurrence of all fire emergencies corresponds to the areas of greatest population density. The average population density in the LC-CFRS service area is about 774 people per square mile. However, this figure does not accurately reflect the true nature of the community. Thus, it would be appropriate to consider LC-CFRS resource needs that correspond to the Policy Areas identified in the Loudoun County Comprehensive Plan: Urban, Suburban, Transition, and Rural.[10]

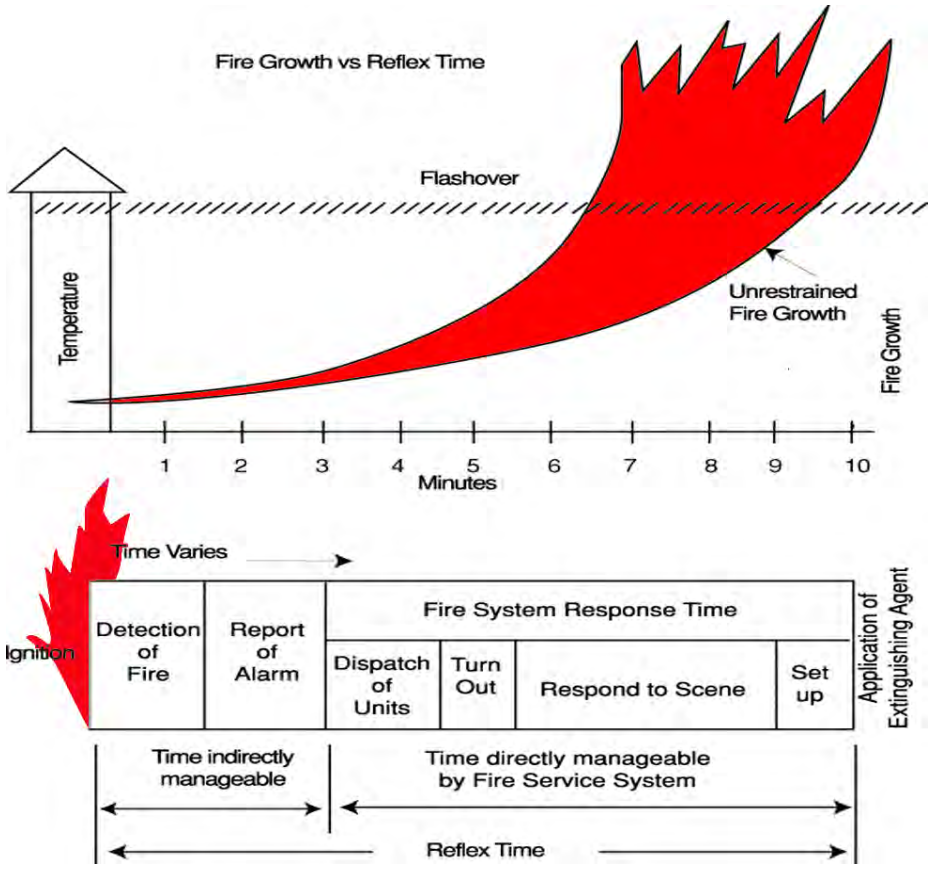
Dynamics of Fire in Buildings

Most fires within buildings develop in a predictable fashion unless influenced by highly flammable material. Ignition, or the beginning of a fire, starts the sequence of events. It may take several minutes or even hours from the time of ignition until a flame is visible. This smoldering stage is very dangerous, especially during times when people are sleeping, since large amounts of highly toxic smoke may be generated during this phase.

Once flames do appear, the sequence continues rapidly. Combustible materials adjacent to the flame heat and ignite, which in turn heats and ignites other adjacent material if sufficient oxygen is present. As the objects burn, heated gases accumulate at the ceiling of the room. Some of the gases are flammable and highly toxic.

The spread of the fire from this point continues quickly. Soon the flammable gases at the ceiling as well as other combustible material in the room of origin reach ignition temperature. At that point, an event termed "flashover" occurs; the gases and other material ignite, which in turn ignites everything in the room. Once flashover occurs, damage caused by the fire is significant and the environment within the room can no longer support human life. Flashover usually occurs about five to eight minutes from the appearance of flames in typically furnished and ventilated buildings. Since flashover has such a dramatic influence on the outcome of a fire event, the goal of any fire agency is to apply water to a fire before flashover occurs.

[10] *Envision Loudoun. DRAFT Loudoun 2040 Comprehensive Plan, version date: March 13, 2019. Retrieved from: https://www.loudoun.gov/DocumentCenter/View/149810/2019-03-13-Loudoun-2040-Comp-Plan?bidId=.*



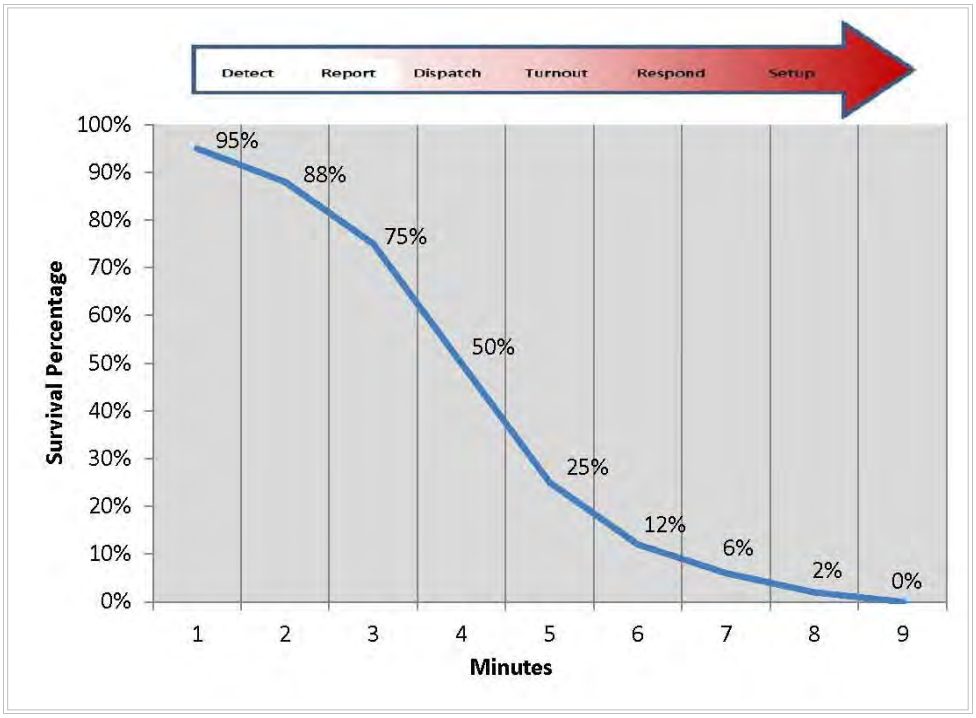
As is apparent by this description of the sequence of events, application of water in time to prevent flashover is a serious challenge for any fire department. It is critical, though, as studies of historical fire losses can demonstrate.

The National Fire Protection Association found that fires contained to the room of origin (typically extinguished prior to or immediately following flashover) had significantly lower rates of death, injury, and property loss when compared to fires that had an opportunity to spread beyond the room of origin (typically extinguished post-flashover).

Emergency Medical Event Sequence

Cardiac arrest is the most significant life-threatening medical event in emergency medicine today. A victim of cardiac arrest has mere minutes in which to receive lifesaving care if there is to be any hope for resuscitation. The American Heart Association (AHA) issued a set of cardiopulmonary resuscitation guidelines designed to streamline emergency procedures for heart attack victims and to increase the likelihood of survival. The AHA guidelines include goals for the application of cardiac defibrillation to cardiac arrest victims. Cardiac arrest survival chances fall by 7 to 10 percent for every minute between collapse and defibrillation. Consequently, the AHA recommends cardiac defibrillation within five minutes of cardiac arrest. As with fires, the sequence of events that lead to emergency cardiac care can be graphically illustrated, as in the following figure.

Cardiac Arrest Event Sequence



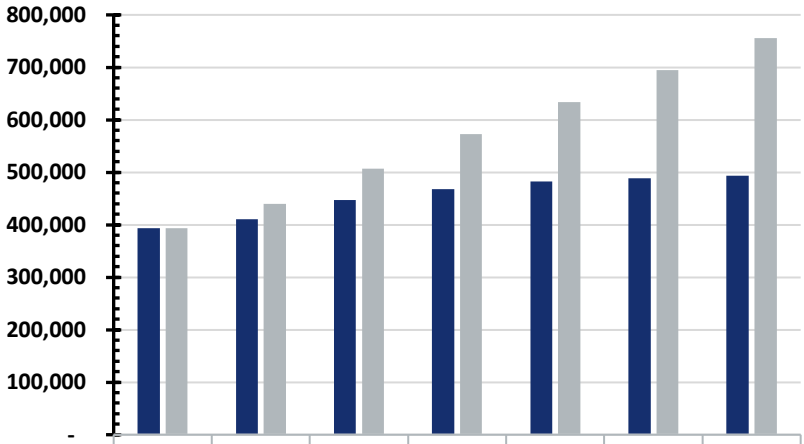
The percentage of opportunity for recovery from cardiac arrest drops quickly as time progresses. The stages of medical response are very similar to the components described for fire response. Recent research stresses the importance of rapid cardiac defibrillation and administration of certain medications as a means of improving the opportunity for successful resuscitation and survival.

Projecting Growth

All communities change over time. These changes to the population and composition can impact service demand. As populations increase or decrease, demand for services may increase or decrease accordingly, or may follow a different pattern based on the change to the demographic makeup. In this section, estimates on the future population of Loudoun County are discussed.

To provide estimations for future populations in Loudoun County, internal documents from Loudoun County were reviewed, as well as estimates created by the University of Virginia. In both cases, Loudoun County is expected to continue growing over time. While the Loudoun County estimates projected a decline in the rate of growth within the next 7 to 10 years, the University of Virginia estimates generally followed a linear path. As no prediction can guarantee 100 percent accuracy, both projections are presented with the expectation that the actual population total will fall somewhere within the range of the estimates.

Population Growth Estimates[11, 12]



	2018	2020	2025	2030	2035	2040	2045
Loudoun County	393,345	410,449	447,137	468,116	482,330	489,002	493,603
Univ. Virginia	393,345	440,445	506,719	572,994	633,952	694,911	755,869

As displayed in the figure, Loudoun County is projected to have a population between approximately 500,000 to 750,000 by the year 2045. LC-CFRS should anticipate a consistent annual increase in overall service demand, as well as a potential need for additional fire stations should urban sprawl continue out into once rural areas.

An important consideration to population is its relationship to service demand. Generally speaking, service demand will be greater in areas of higher population density than lower population density; however, the demographics of the area also play a large role in demand. For example, a newly constructed subdivision occupied by young professionals and families would likely be much less dependent upon emergency medical services than a neighborhood occupied primarily by retirees. Although the population densities may be equivalent, the dependence upon emergency responders would differ.

Service Demand

The demand for services is central to the existence of a fire department. Often as the population rises or falls, so too does the demand for services. As discussed in the previous section, the population of Loudoun County has grown rapidly since 1990. Because of this, it can be anticipated that the demand for service should increase year to year as well. An examination of LC-CFRS's call volume from 2013 through 2017 displayed an average annual growth of 4.3 percent with a Compound Annual Growth Rate (CAGR) of 3.8 percent. Annual service demand and its associated growth rates are illustrated in the following figure.

[11] *University of Virginia, Demographics Research Group of the Weldon Cooper Center for Public Service, March 2017, http://demographics.coopercenter.org.*

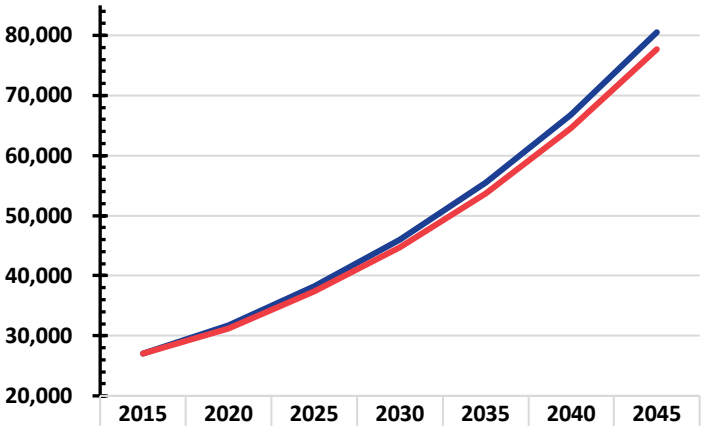
[12] *Loudoun County Demographic Forecast Series, December 2016.*

Change in Service Demand, 2013–2017

Year	Call Volume	Annual Growth Rate
2013	24,435	
2014	25,605	4.8%
2015	27,038	5.2%
2016	27,041	3.4%
2017	28,337	3.8%
Average Annual Growth		**4.3%**
Compound Annual Growth Rate		**3.8%**

Since service demand is often correlated to population, two estimates for service demand are provided in the following figure. The blue line represents growth as a function of the CAGR and 3.8 percent growth is applied annually through the year 2045. The second projection used Loudoun County's internally calculated annual growth year by year to calculate annual service demand growth as a function of the estimated annual population increase. The results are displayed in the following figure.

Service Demand Estimates



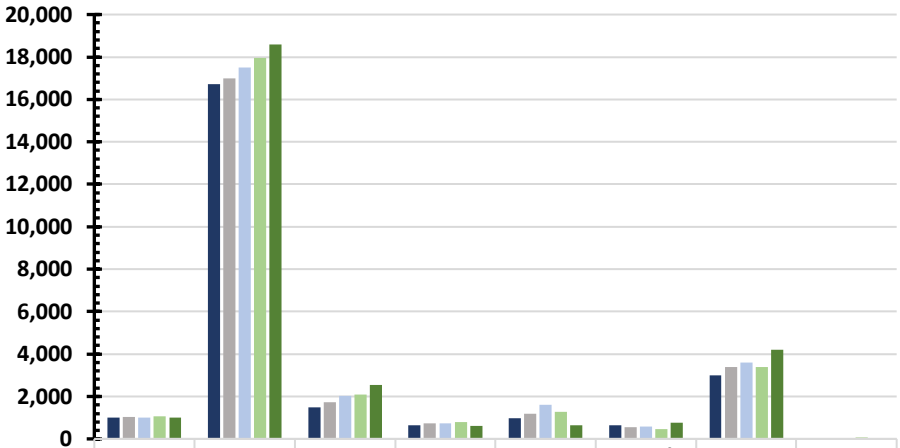
	2015	2020	2025	2030	2035	2040	2045
CAGR	27,038	31,692	38,189	46,017	55,451	66,818	80,516
LC Annual Population Growth Estimates	27,038	31,160	37,338	44,693	53,667	64,510	77,690

Beginning with the known demand for service in 2015, estimations were calculated moving forward through 2045 and displayed in 5-year intervals. As illustrated, both models follow similar paths with the final projection at the year 2045 separated by 2,826 incidents. At this rate of growth, LC-CFRS should anticipate doubling its current annual call volume by the year 2035 with an additional increase of approximately 25,000 calls annually 10 years later in 2045.

Service Demand Analysis

The following figure shows the numbers of incidents, by types of service demand, to which LC-CFRS responded from 2013 through 2017.

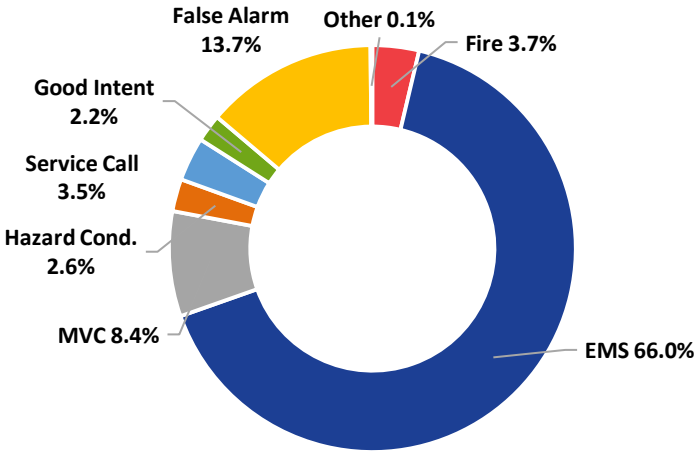
Annual Service Demand by Type, 2013–2017



	Fire	EMS	MVC	Hazard Cond.	Service Call	Good Intent/ Cancel	False Alarm	Other
2013	1,018	16,706	1,475	642	967	636	2,991	37
2014	1,026	17,005	1,721	738	1,180	562	3,373	26
2015	1,009	17,498	2,019	727	1,615	573	3,597	47
2016	1,058	17,961	2,098	799	1,284	454	3,387	81
2017	995	18,589	2,535	625	643	756	4,194	-

The percentages of total service demand are shown in the following figure. In this figure, MVC incidents were removed from EMS and displayed separately. If these are inserted into EMS, the total would be 74.4 percent.

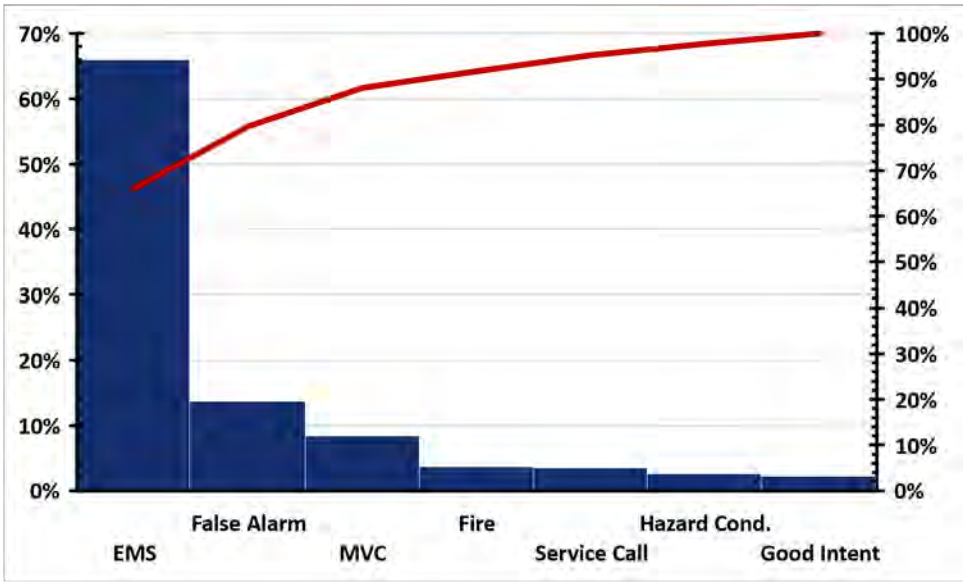
Percentage of Total Service Demand, 2016–2017



The next greatest category is false alarms at nearly 14 percent. MVCs responses make approximately 8 percent, and actual fire calls make up 3.7 percent of all calls. Finally, good intent, service calls, hazardous conditions, and all other calls result in 8.4 percent of the total calls from 2016 through 2017.

The following figure provides another description of call percentage. Each incident type is presented from the highest to lowest percentage of occurrence by call type, as well as how these totals contribute to the cumulative total. The scale on the left displays each incident type's relative percentage, and the line and scale on the right displays the cumulative percentage of calls and how each of these categories of calls contributes to the total number of calls, 2016 through 2017.

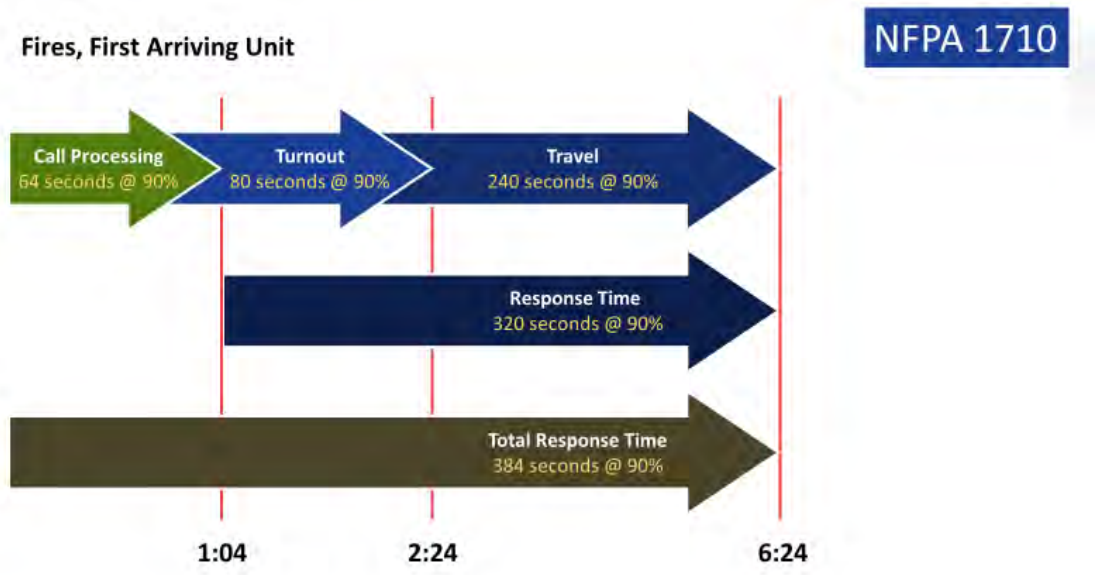
Incident Frequency by Percentage and Cumulative Total, 2016–2017



In addition to identifying the call or incident types and frequency of service demand, an understanding of when these events occur is critical to determining when system demand will most likely be at its greatest. Knowledge of high demand periods will assist administrators in determining whether staffing levels are sufficient for the demand and also in scheduling additional duties such as training, fire safety inspections, and vehicle maintenance.

NFPA 1710 Criteria

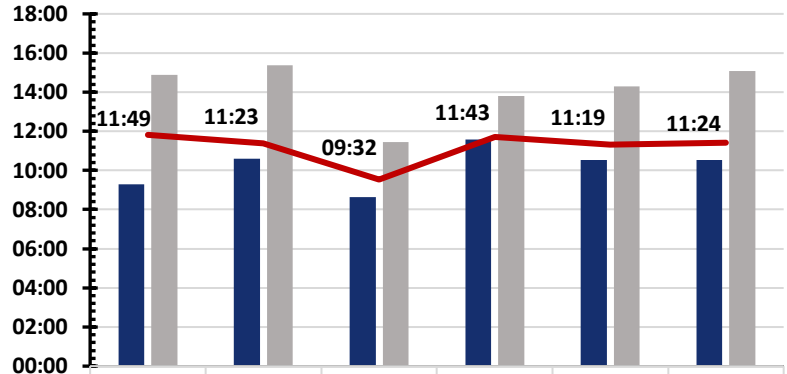
NFPA standards establish benchmarks for all areas of responsibility for a fire department. In this analysis, four- and eight-minute travel times are applied to each fire station. A four-minute standard, derived from NFPA 1710: *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*, for travel was selected as it is the consensus standard for career fire department travel times. The eight-minute travel time is the established period of travel time for an initial alarm assignment, meaning that all units needed to conduct fire suppression operations must arrive on the scene and commence operations within that period of travel time. NFPA 1710 allows for organizations to establish benchmarks based upon current performance and to establish benchmarks, or goals, for service delivery objectives. However, the travel time benchmark for career organizations is for the initial suppression unit to arrive on the scene in four minutes or less, 90 percent of the time and the arrival of the full initial alarm response within eight minutes, 90 percent of the time.



Total Response Time Performance

The next figure presents total response time (TRT) performance for the study period at the 90th percentile for various incident types, including the overall department performance. This represents the amount of time required for the first emergency unit to arrive on the scene from the time the initial emergency call was answered at the dispatch center.

Total Response Time Performance



	Fire	Rescue/ EMS	MVC	Hazard Condition	False Alarm	Total
Urban	09:18	10:36	08:38	11:34	10:31	10:32
Rural	14:53	15:23	11:27	13:49	14:18	15:04
Countywide	11:49	11:23	09:32	11:43	11:19	11:24

When the total response times are examined, LC-CFR can expect to provide the initial unit on the scene in 11 minutes, 24 seconds from the time the communications center received the emergency call, 90 percent of the time or better for all calls. MVCs once again displayed the best performance at 9 minutes, 32 seconds. Fires demonstrated the longest Total Response Time Performance at 11 minutes, 49 seconds. EMS calls for service can anticipate that a unit will arrive on scene within 11 minutes, 23 seconds or better from the time the emergency call is placed with the communications center 90 percent of the time.

Recommendations and Opportunities for Enhancement (OFE)

During this study, several issues, concerns, and opportunities were identified. The recommendations and sample best practices that follow are intended to accomplish the primary objectives which include:

1. Define and adopt expected service levels and performance standards for each of the Rural, Urban, and ultimately, Metro planning areas to be provided by the fire-rescue system should future growth dictate three response zones.
2. Adopt data collection elements and methods that will provide for the effective measurement and adjustment to operational system elements based on identified performance goals and triggers.
3. Identify service level improvement opportunities and additional resources to serve anticipated growth that can be implemented as funding becomes available. These enhancements should be implemented based on performance and outcome triggers impacted by growth, changes in the system risk profile, and increases in service delivery demands.
4. Identify opportunities and service delivery methods that will increase the coordination and consistency of resource assignments that align with defined system risk and service delivery needs, including coverage and capabilities of on-scene supervision and special operation resources. Implement increased cooperative effort strategies between LC-CFRS specialized service delivery elements as well as neighboring jurisdictions to assist with this goal.

The following recommendations are described as "Opportunity for Enhancement" (OFE) goals and should be considered as part of the LC-CFRS planning and implementation process. The recommendations and supporting information are intended to provide LC-CFRS administration and decision makers with data, samples, and best practices to assist with the growth and service enhancements that are necessary and desired to serve the growing and vibrant communities served by LC-CFRS. Each OFE can improve the department's ability to provide effective and efficient service.

OFE Goal A: Formally Adopt Rural, Urban, and future Metro Fire Planning Zones

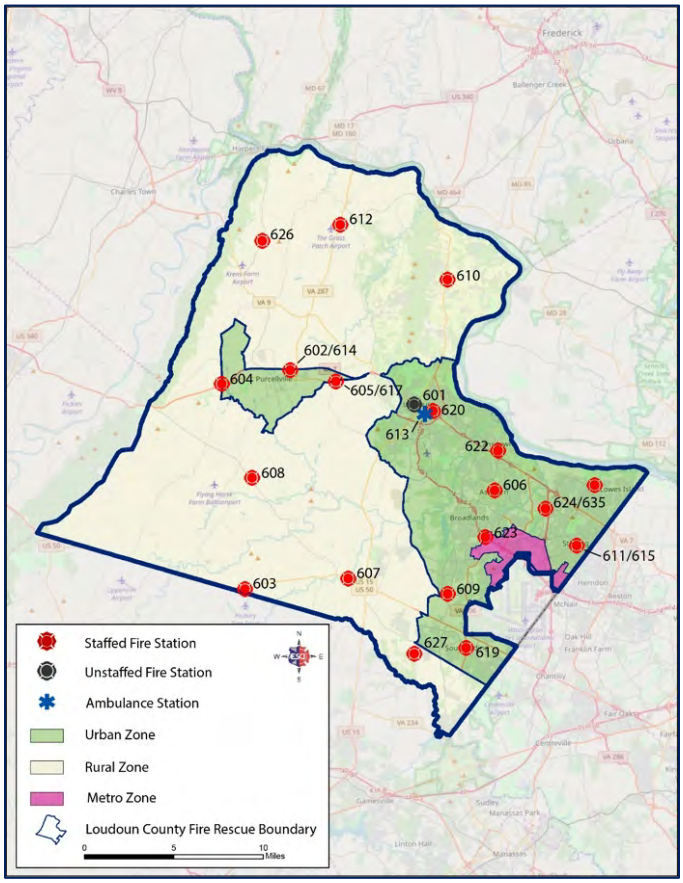
ESCI recommends the LC-CFRS identify and adopt fire planning zones, similar to the policy areas described in the County's 2040 Comprehensive Plans, as follows:

- **Metro**: This is the area immediately north and east of Washington Dulles International Airport. The new Metrorail Silver Line (August, 2020) will change the metro area. The metro area is on target to be the number one transit-oriented mixed-use location in Virginia, Specifically, the Gramercy District will become a 'smart city vision' premier, mixed-use, transit-oriented development which blends luxury residential, co-working, education, hotel, retail and high-rise office space into an integrated walkable lifestyle.[13] Other transit-oriented developments are expected to be developed all along the Metrorail Silver Line.[14] Corresponds to the plan's Urban Policy Area. Future growth and service demand for this zone will be elevated. It will include requirements for fire department high-rise response staffing and equipment.
- **Urban**: This area includes all populous areas of the county, generally east of Route 15, plus the Town and Joint Land Management Zones (JLMA) and the Transition Policy Area. This area is characterized by single- and multi-family neighborhoods, retail, employment, commercial—technology, data management, communications industries, industrial uses, airport-related businesses, and data center development. The area also provides a transition between the urban and rural areas of the county. It will also include some industrial spaces focused on quarry activity and energy infrastructure.
- **Rural**: This area includes all areas of the county west of the suburban area. It comprises about two-thirds of the county's land area and is characterized by traditional farming/agricultural land use with many winding, narrow, two-lane roadways and small communities, interspersed with multi-lane connector roads and large, estate-style homes on multi-acre properties in rural areas. Response challenges that differ from metro and suburban areas are limited access, long response travel times outside small communities, and wildland-urban interface protection.

[13] *"Gramercy District – An Innovation Campus." Retrieved from: https://www.citylink.ai/gramercydistrict.*

[14] *"Gramercy District Team Shares Smart City Vision with Loudoun Colleagues," John Banister, April 19, 2017. Retrieved from: https://www.bisnow.com/washington-dc/news/mixed-use/gramercy-district-loudoun-station-poised-to-transform-ashburn-when-silver-line-opens-73494.*

Fire Planning Zones



OFE Goal B: Formally Adopt Response Time Standards and Targets/Sample Goals

AND

OFE Goal C: Formally Adopt Effective Response Force Time Standards and Personnel Targets

Response standards and targets establish measurable goals for service delivery, which then form the baseline for the deployment of resources. Response performance goals must be tailored to match community expectations and conditions and be balanced against the financial challenges a community is able and willing to afford. Without defined goals and targets, an organization is unable to appropriately identify how effective it is providing services that meet community expectations.

Sample Response Goals

90TH PERCENTILE BENCHMARK GOALS (FIRST APPARATUS ON SCENE) – All Emergencies					
Performance Zone	**Call Processing Time**	**Turnout Time**	**Travel Time**	**Response Time (Dispatched To First Apparatus On Scene)**	**Total Response Time (Received At Dispatch To Arrived)**
Rural	01:30	01:00	11:00	12:00	13:30
Urban	01:30	01:00	6:00	07:00	8:30
Metro	01:30	01:00	5:00	6:00	7:30

90TH PERCENTILE PERFORMANCE BENCHMARKS (Effective Response Force) – Structure Fires						
Performance Zone	**Call Processing Time**	**Turnout Time**	**Travel Time**	**Response Time (Dispatched to First Apparatus On Scene)**	**Total Response Time (Received at Dispatch to Arrived)**	**Effective Response Force Personnel**
Rural	01:00	01:30	15:00	16:30	17:30	24
Urban	01:00	01:30	12:00	13:30	14:30	28
Metro	01:00	01:30	10:00	11:30	12:30	34

OFE GOAL D: INCREASE ENGINE COMPANY STAFFING LEVELS TO A FOUR PERSON MINIMUM TO MEET RECOMMENDED 1710 STAFFING STANDARDS.

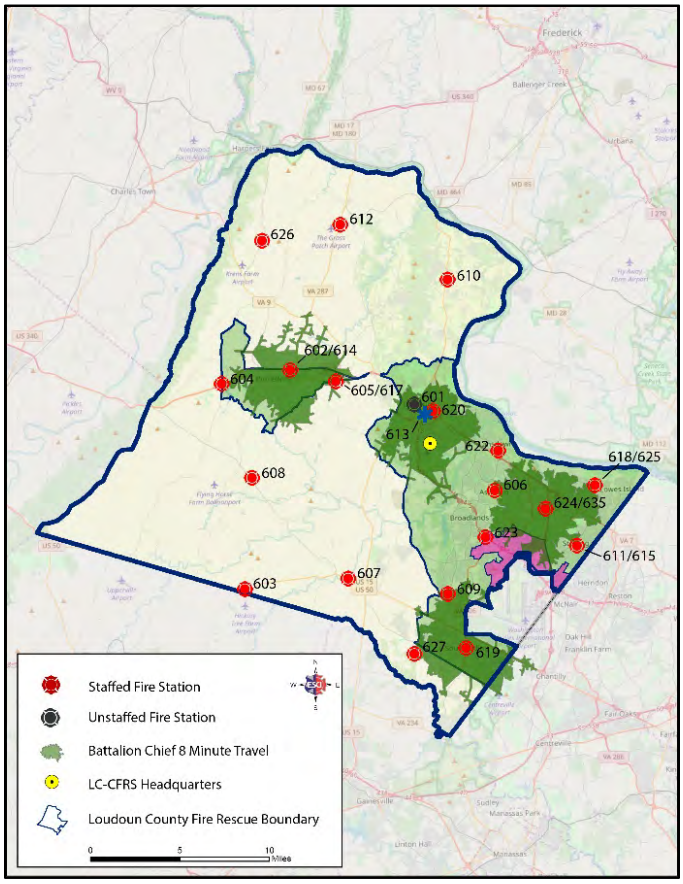
Currently, LC-CFRS is staffing engine companies with three personnel. Based on the current rural, urban, and metro planning areas risk profiles, ESCI has identified that LC-CFRS cannot assemble an effective response force in accordance with NFPA 1710 and NOVA adopted response standards. To match the ERF with the established risk profile and move forward toward meeting NFPA 1710 standards, ESCI recommends a phased implementation to four-person staffing on all staffed engines within the system.

	Staff (FTE) Added by Plan Year							
Notional Phasing	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**FY 2025**	**FY 2026**	**FY 2027**
Three-Year FTE	33	33	34					
Five-Year FTE	20	20	20	20	20			
Seven-Year FTE	15	15	15	15	15	15	10	

OFE Goal E: Add additional Battalion Chief to the Leesburg LC-CFRS Headquarters Area

Currently, each shift Battalion Chief is responsible for approximately 40 to 50 personnel. In addition, they are geographically **"not"** able to cover the system in the recommended NFPA 1710 response time to provide command and control as part of an ERF. This deficiency results in a very broad and less effective span of control over a very large geographic footprint. This configuration has resulted in significant limitations in general management, scene safety, officer development, succession planning, and other activities. In addition, during large incidents, LC-CFRS requests a second Battalion Chief resulting in large portions of the system left without incident commander coverage.

Additional BC at LC-CFRS Headquarters



OFE Goal F: Reduce Call Processing time and Implement Medical Priority Dispatch Tiered Response and consistent unit assignments that align with Risk and call type

Currently, the LC-CFRS dispatch call taking and dispatch times are in excess of NFPA standards. LC-CFRS dispatch has undertaken several initiatives and steps to enhance PSAP and dispatching services for the system. These efforts are to be commended and should be continued. ESCI has identified several best practices and recommendations for review and consideration by the LC-CFRS dispatch system to utilize as appropriate. LC-CFRS dispatch should continue monitoring both call answering and call processing performance on a monthly basis and strive to maintain or exceed adopted standards.

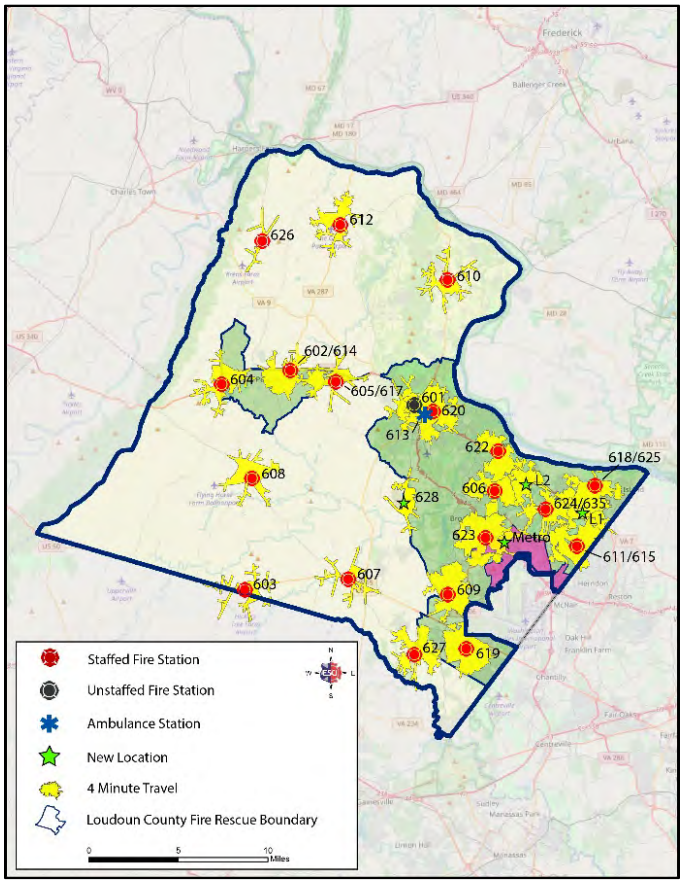
OFE Goal G: Improve Turnout Time Performance

Turnout time is the one component of total response time over which the fire department has the greatest control, and which is not affected by outside influences. Turnout time, or the time from when the call is received by the response units (dispatched) to when the unit is enroute to the scene (responding), affects overall response times. Reducing this response time component reduces total response time.

OFE Goal H: Evaluate Current and Future Station Locations to Improve First Response and ERF Capabilities

The analysis of long-range future resource deployment is an ongoing process, not one that is decided at one point in time and remains static. Circumstances change over time as the risk profile and population demographics within the LC-CFRS service area change. The deployment options presented here should be periodically reviewed and modified as needed. The options presented are intended to provide general guidelines for future station deployment based on existing conditions and future growth and development in the service area.

New Fire Station Locations



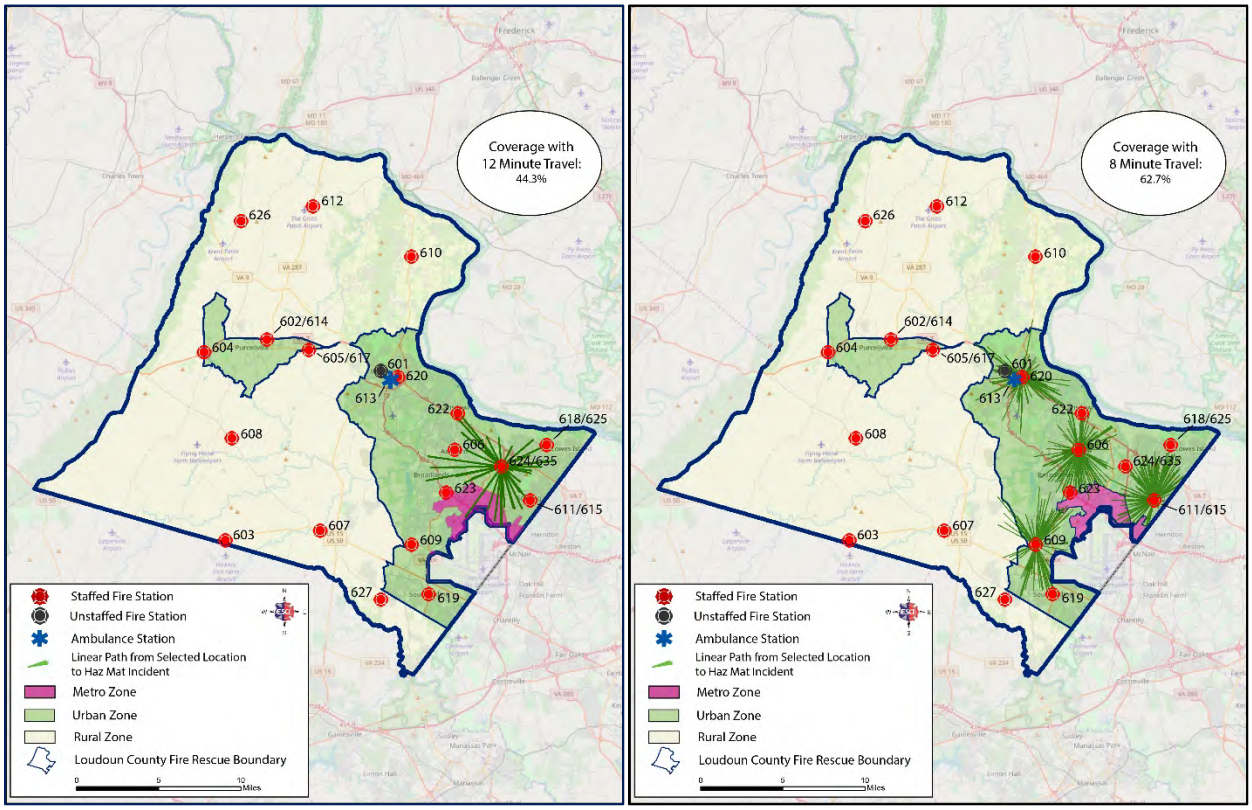
OFE GOAL I: Optimize the Location of LC-CFRS Hazardous Materials Unit and Staff Four Existing Heavy Rescue Response Units

In identifying the location of the hazardous materials response unit and support unit, LC-CFRS has considered staffing, response, utilization, and risk elements. Utilizing one dedicated hazmat response unit for the entire system creates geographical travel time and coverage challenges. Based on hazmat call response history, identified risks requiring a hazmat response, and optimized travel routes throughout the county, the analysis indicates that the optimal location of the hazardous materials response and support units is to Station 628 when it is built and operational. The new Station 628 facility appear more beneficial at this time and will centralize this resource within the county. This analysis was conducted with 8, 10, and 12-minute intervals with the same result. However, if travel time is increased to 15 minutes, Station 606 can respond to the greatest number of incidents and should be considered as an option as well.

LC-CFRS has staffed and located the Rescue Squads based on previous heavy rescue responses and associated risk. The heavy rescue units respond to technical rescue and fires throughout the entire system. Based on this core service and associated support by the additional cross-staffed rescue units, ESCI recommends staffing the rescue currently located at Station 624. By staffing this location, the percentage of incidents that the Rescue Squad can reach within 12 minutes increases in excess of 8 percent, and a staffed Rescue Squad resource is more centrally located to demand within Loudoun County. Additionally, the 12-minute travel time analysis showed that the difference between the currently staffed rescue's response times, and the increased staffing of the rescue at Station 624 resulted in significantly improved the response times and capabilities. Over 50 percent of the staffed rescue response calls saw a response within a 12-minute travel time.

In addition, ESCI recommends the remaining cross-staffed heavy rescues at Stations 606 and 620 be staffed with four personnel for response to fire and technical rescue incidents. This staffing level will significantly enhance the LC-CFRS ERF capabilities as well as provide rapid technical and heavy rescue capability throughout the entire system and all fire planning zones.

Optimized Haz Mat Location **Staffed Heavy Rescue Coverage**



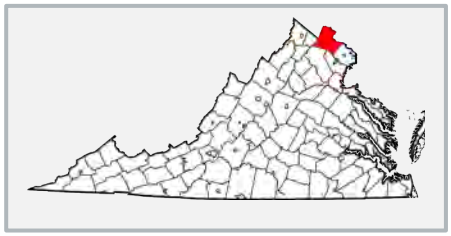
CONCLUSION

The ESCI project team began collecting information concerning the LC-CFRS in early 2019. The team members recognize this report contains a large amount of information and ESCI would like to thank the LC-CFRS staff and many officials for their efforts in bringing this project to fruition. ESCI would also like to thank the various individuals and external organizations for their input, opinions, and candid conversations throughout this process. It is ESCI's sincere hope the information contained in this report is used to its fullest extent and the emergency services provided to the Citizens of Loudoun County and the surrounding area will be improved by its implementation.

Section II. Introduction and Methodology

COMMUNITY CHARACTERISTICS[15]

Figure 1. Location of Loudoun County



Loudoun County is located in the far northern part of the Commonwealth of Virginia, bounded on the north by the Potomac River, on the east by Fairfax County, on the south by Prince William and Fauquier counties, and to the west by Clarke County and Jefferson County, West Virginia. The county seat of Leesburg is about 36 miles northwest of Washington, D.C. and 12 miles northwest of Washington Dulles International Airport (IAD). The 2018 estimated population is 402,561. This is a 28.9 percent increase since the 2010 Census (population 312,311) and represents an average 3.6 percent annual growth since that time. Loudoun County is the third-most populous county in the Commonwealth of Virginia and is ranked first in the U.S. in median household income for areas with a population of 65,000 or more.

First settled in the 1720s, Loudoun County was officially established in 1757 and has held a significant place in American history. Around the time of the American Revolution, it was Virginia's most populous county and well-established as an agricultural center. Important documents and archives were stored in the county seat, Leesburg, during the War of 1812. Several Civil War battles were fought in and around Loudoun County.

The county has long been known for agriculture. Primary crops are grain, forage crops, fruits, and vegetables. Primary livestock are cattle, alpacas, llamas, and poultry; the county is ranked first in the Commonwealth for the production of horses and ponies. Loudoun's equine industry provides a $180 million annual impact in the county.[16] A 2017 study conducted by Virginia Tech found that Loudon County accounts for more than fifty percent of Northern Virginia's agritourism dollars.[17]

Agritourism is defined as any activity carried out on a farm or ranch that lets members of the public view or enjoy rural activities. About 13 percent of Loudoun County farms participate in agritourism, which supports over 1.2 million attendees annually.[18] Fifty-five of the 195 agritourism sectors classified as farm-based wineries, vineyards, breweries, and distilleries, reported serving approximately 16,913 patrons each in 2018. [19]

---

[15] *"About Loudoun County," Loudoun County Government, Leesburg VA. Retrieved from: https://www.loudoun.gov.*

[16] *"Top Ways Loudoun Count, Virginia, is No. 1." Retrieved from https://biz.loudoun.gov/site-selection/loudoun-number-1.*

[17] *"Despite tech boom, Loudoun remains an Agricultural Leader," Jeff Clabaugh, April 12, 2019. Retrieved from:* https://wtop.com/business-finance/2019/04/despite-tech-boom-loudoun-remains-an-agricultural-leader/

[18] *"The Economic Impacts of Agritourism: Loudoun County, Virginia 2018," Vincent P. Magnini, Ph.D., April, 2019. Retrieved from: https://visitloudoun.org/tourism-industry/resources/research-important-documents/.*

[19] *"The Economic Impacts of Agritourism: Loudoun County, Virginia 2018," Vincent P. Magnini, Ph.D., April, 2019. Retrieved from: https://visitloudoun.org/tourism-industry/resources/research-important-documents/.*

Although agriculture is still a strong driver of the county's economy, urbanization has caused the development of a robust and well-diversified service structure, home to airline, high tech, and internet-related companies.

Loudoun County is one of the largest and fastest-growing data center hubs in the world. For every dollar the county invests into data centers, a $9.50 tax revenue is realized.[20]Today, Loudoun County is a tale of two counties. To the east of Leesburg lies the densely populated, urban area that has essentially become part of the greater-Washington suburban landscape that stretches across the entire eastern half of the county, across Fairfax County and into Washington D.C. and includes the majority of Washington Dulles International Airport. The airport serves over 21 million passengers each year and is also the home of the Udvar-Hazy Center of the Smithsonian Air & Space Museum. The Center welcomes more than 1.4 million visitors each year.

West of Leesburg and the Dulles Greenway, the county is rural in nature with small towns and unincorporated communities along the primary roadways. Historic sites, including roadhouses, schools, churches, bridges, and battlefields dot the county; there are more than 90 sites listed on the National Register of Historic Places, including six National Historic Landmarks.

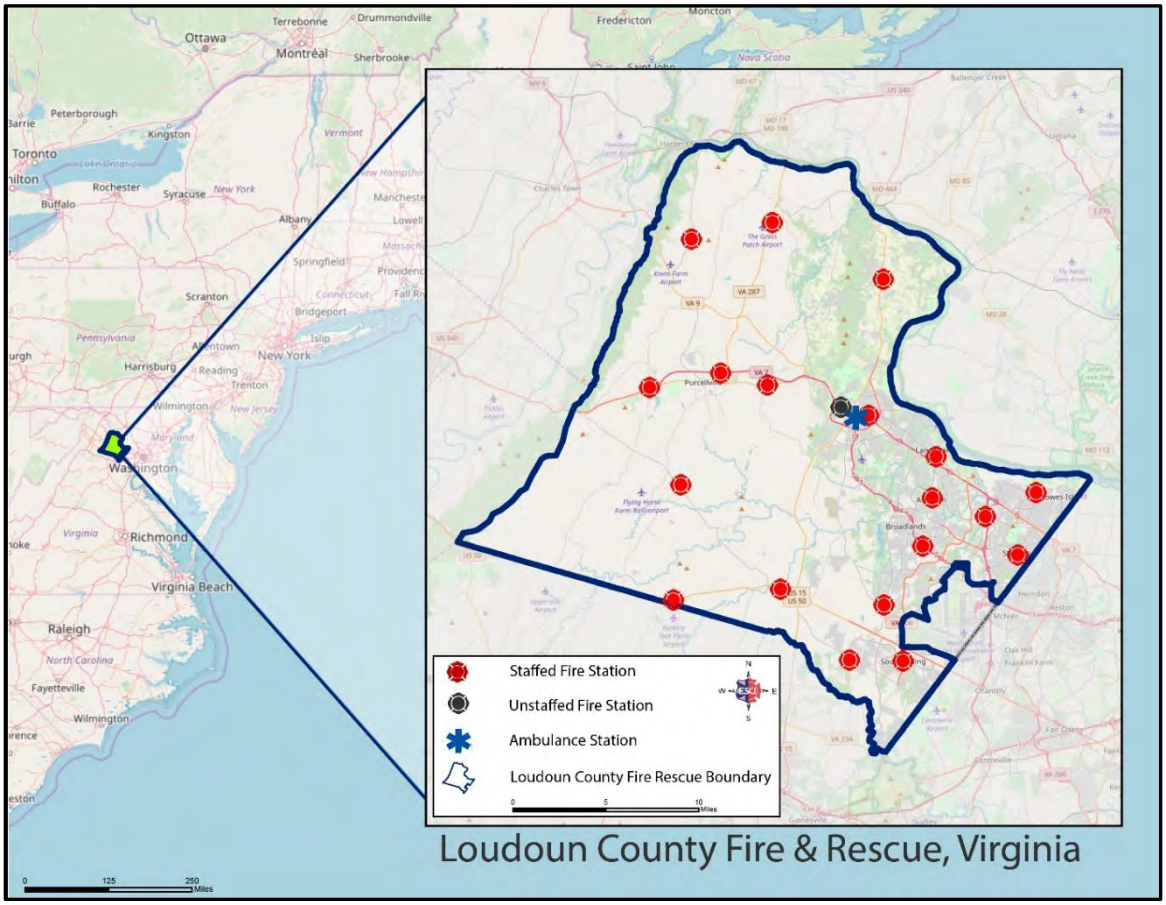
LC-CFRS Service Area

The service area jurisdiction of the Loudoun County Combined Fire Rescue System includes all areas of the county except for Washington Dulles International Airport. The jurisdiction includes 521 square miles, including 6 square miles of water and seven incorporated towns: Hamilton, Hillsboro, Leesburg, Lovettsville, Middleburg, Purcellville, and Round Hill. Loudoun County is a member of the Metropolitan Washington Council of Governments (MWCOG).

Loudoun County is surrounded by other entities that provide fire and other emergency response, all of which have interlocal agreements with the County. Many of the surrounding agencies share dispatch centers and resources through automatic and/or mutual aid agreements to respond resources to locations within the other's service area. For those areas with no formal agreement, Commonwealth Law, specifically the "Commonwealth of Virginia Emergency Services and Disaster Law of 2000," authorizes all agencies to assist one another upon request or by declaration of disaster. LC-CFRS coordinates its activities with the local Office of Emergency Management and with neighboring agencies, to include the timely annual renewal of all interlocal agreements. A report on agency responses, including participation in interlocal responses, is provided to the Fire Chief each year. The Loudoun County service area, along with surrounding response areas, is shown in the following figure.

[20] *"Top Ways Loudoun Count, Virginia, is No. 1." Retrieved from https://biz.loudoun.gov/site-selection/loudoun-number-1.*

Figure 2. Service Area and the Surrounding Area



System Overview

The Agency: Legal Basis and Governance

The LC-CFRS is a combination volunteer-career system, established by the Loudoun County Board of Supervisors in 2014, to establish a framework for governance of the independent fire and rescue companies in Loudoun County, as well as establish the position of system-wide chief and governance structure for the system including the creation of standardized operating policies and practices under the newly formed Executive Committee and respective subcommittees.

By County Ordinance, "combined system" or "LC-CFRS" means "every volunteer fire-fighting and EMS organization formed pursuant to Va. Code Title 27 and authorized by the Board of Supervisors to operate as a fire-fighting and/or EMS organization within the geographic boundaries of Loudoun County or any of its incorporated towns, as well as the Loudoun County Department of Fire, Rescue, and Emergency Management (DFREM)." [21] Currently, the recognized organizations of the LC-CFRS are:

[21] *Codified Ordinances of the County of Loudoun Virginia, Title Eight, Chapter 258, "Loudoun County Combined Fire Rescue System," current through Nov 18, 2018. Retrieved from: http://library.amlegal.com/nxt/gateway.dll/Virginia/loudounco_va/codifiedordinancesofthecountyofloudounvi?f=templates$fn=default.htm$3.0$vid=amlegal:loudounco_va.*

- Leesburg Volunteer Fire Company
- Purcellville Volunteer Fire Department, Inc.
- Round Hill Volunteer Fire Department, Inc.
- Hamilton Volunteer Fire Department
- Ashburn Volunteer Fire and Rescue Department
- Aldie Volunteer Fire Department, Inc.
- Philomont Volunteer Fire Department
- Arcola Volunteer Fire Department, Inc.
- Lucketts Volunteer Fire Company, Inc.
- Sterling Volunteer Fire Company, Inc.
- Lovettsville District Fire and Rescue Co., Inc.
- Loudoun County Volunteer Rescue Squad, Inc.
- Purcellville Volunteer Rescue Squad, Inc.
- Sterling Park Rescue Squad, Inc.
- Hamilton Volunteer Rescue Squad, Inc.
- Loudoun County Fire and Rescue

Combined, the LC-CFRS has over 1,500 volunteers and nearly 650 career staff. Many of these member departments have a long history of volunteer service; Leesburg Volunteer Fire Company dates back to 1803. Although volunteerism is becoming increasingly difficult, it is the desire of the LC-CFRS to continue to utilize both volunteers and paid personnel to provide residents and visitors with efficient and cost-effective fire protection, rescue, and emergency medical services, 24 hours per day.

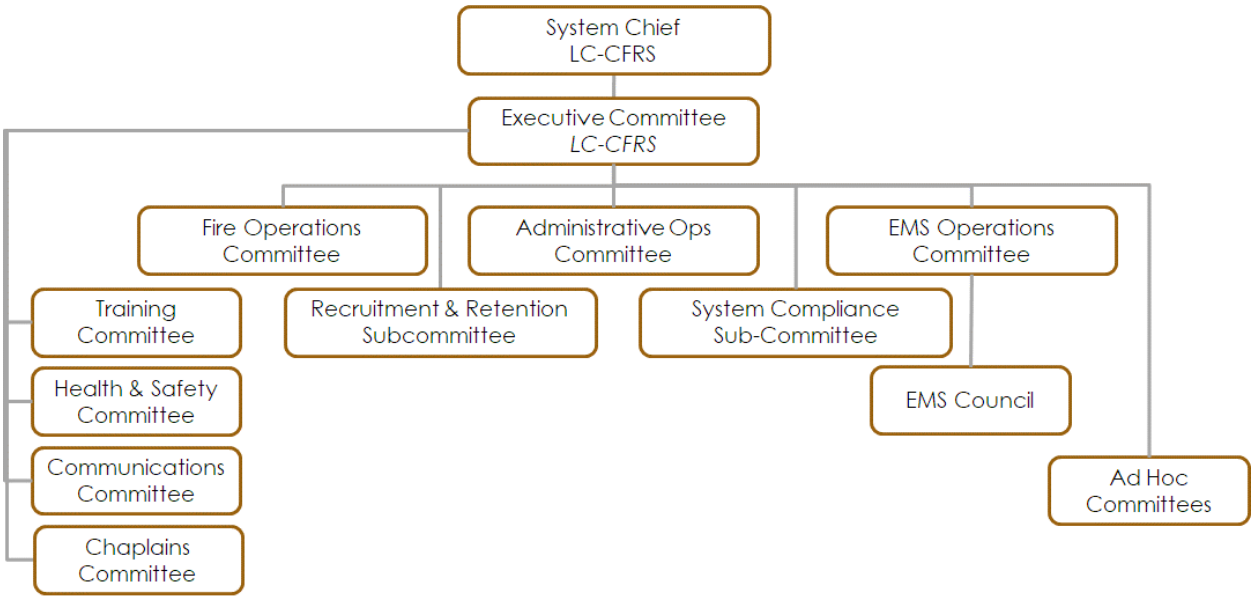
The LC-CFRS provides the following services:

- Administration and delivery of fire, EMS, and related training
- Coordination/mitigation of large-scale emergencies/disasters utilizing an all-hazards approach
- E-911 Emergency Communications Center
- Emergency response
- Fire prevention and investigation
- Hazardous materials response
- Logistics and maintenance
- Public Education and Community Outreach Programs
- Technical rescue: swiftwater and ice, confined space, trench, high angle, and extrication
- Training and continuing education
- Wildland firefighting

Organizational Structure

The fire and rescue service for Loudoun County consists of the 15 volunteer Fire and Rescue companies and the Department of Fire and Rescue (hereinafter referred to as "the Department"). A copy of the current organizational chart is shown here.

Figure 3. LC-CFRS Organizational Structure



Funding

As a county department, the LC-CFRS receives the bulk of its funding, about 93.7 percent ($83,526,406 of the $89,33,020 in FY 2019 adopted budget), through the collection of local taxes. The FY 2019 operating budget was $89,133,020—about 7.3 percent (or $6,070,293) higher than last years' budget—and 4.8 percent of the total Loudoun County Operating Appropriation of $1,843,241,150.

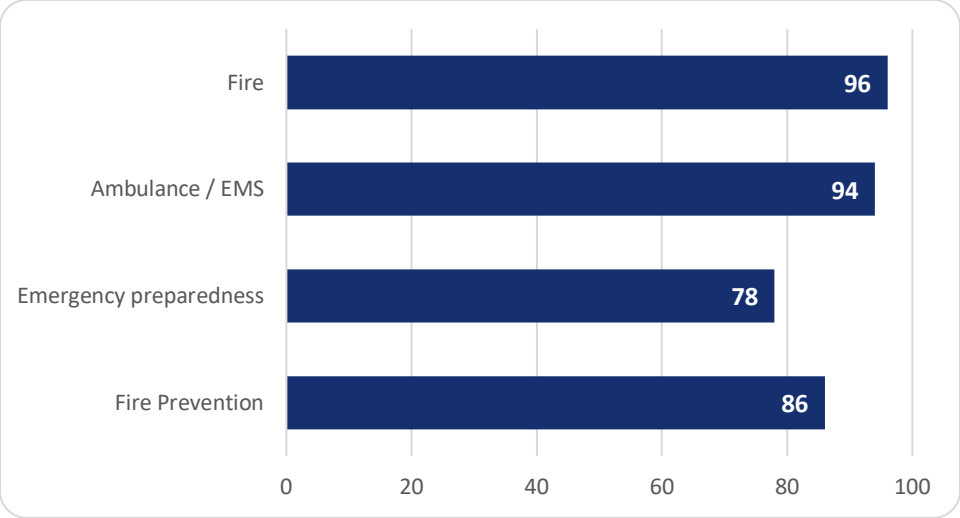
EMS transport revenues and distributions are not included in the FY 2019 operating budget. Actual revenues are contingent on transports completed, reimbursement rates, and payor mixes and are used for EMS system enhancements. Net revenues, after expenses for program administration, are distributed according to a formula adopted by the Loudoun County Board of Supervisors.

In future years, it is expected that the LC-CFRS will continue its transition from a mostly rural community response model to a suburban community response model while bolstering the administrative and technical support needs of the Department and its member organizations.

Community Expectations[22]

According to the latest survey of residents, the LC-CFRS is well-positioned to support safety, one of the three most important focus areas of the community—safety, mobility, and economy. Almost one in five (19 percent) of all survey respondents have used fire or rescue services in the past two years. Specific positive ratings, i.e., excellent or good, were among the highest of all governance sectors identified in the survey:

Figure 4. LC-CFRS Percent positive ratings, 2018 Survey of Residents



[22] *"Community Livability Report," Loudoun County, VA. 2018 Loudoun County Survey of Residents, conducted by the National Research Center, Inc. (NRC).*

Community Risk Summary

A detailed, all-risk, all-hazards Community Risk Assessment is beyond the scope of this project. However, a summary of the risks faced by LC-CFRS is necessary to understand and prioritize the specific capabilities and resources needed by the system to attain desired outcomes. This assessment relies on the use of both quantitative and qualitative data to describe community risk.

LC-CFRS acknowledges there are hazards in the community, that these hazards pose a risk to life and property, that these hazards vary in likelihood and impact, both on the community and the agency, and that these directly influence LC-CFRS planning and response activities.

It is impossible to include or predict all aspects and indicators of hazards and risk. There are simply too many variables of weather, human behavior, and systems malfunction. ESCI recommends that LC-CFRS conduct a formal Community Risk Assessment in order to ensure that plans contain the most accurate and up-to-date information available about community hazards, vulnerabilities, risks, and needs.

Risk

Simply stated, risk is the potential or likelihood of an emergency to occur. In its simplest form, risk may be quantified as the combination of the probability (or likelihood) of an event, and its consequence (or impact).

Likelihood is the "chance of something happening, whether defined, measured, or estimated objectively or subjectively, or in terms of general descriptors, frequencies, or probabilities."[23] The terms "impact" and "consequence" are often used interchangeably, with the subtle distinction that "impact" refers to effects or outcomes that are more immediate or acute, and "consequence" refers to effects or outcomes that are long-lasting or chronic. Most notably, consequences affect one or more of the following aspects of the community: ***human***—injury, illness, or loss of life; ***economic***—loss of income, cost to repair, rebuild, replace, and recover; ***social/cultural***—damage or loss to sites of historical, cultural, social, or religious significance; and ***environmental***—pollution, loss of habitat.

There are several ways to characterize risk. ESCI recommends that LC-CFRS identify and prioritize risks and target hazards using one or more of the ways listed here:

- By cause
- By geographical characteristics and land use
- By demographics
- By occupancy classification
- By planning zone

[23] *FEMA CPG-201.*

By Cause

Loudoun County is susceptible to a variety of hazards. A hazard is described as "a condition that presents the potential for harm or damage to people, property, or the environment." For convenience, hazards are often grouped into one of two categories by cause: natural and technological or human-caused.

Natural hazards are hazards which result from acts of nature and could include any of the following. Those identified as the most prominent physical or natural hazards faced by residents of Loudoun County are highlighted. [24, 25]

- Avalanche
- Animal disease outbreak
- Drought
- Extreme Cold
- Extreme Heat
- Flood
- Hurricane
- Landslide
- Lightning
- Snowstorm
- Severe Weather
- Thunderstorm
- Tornado
- Tsunami
- Volcanic Eruption
- Wildfire
- Winter Storm

Since 1972, the number of federally-declared disasters in Loudoun County (12) is lower than the county/county equivalent average for the rest of the Commonwealth (15), and about the same as the U.S. county/county equivalent average (12.5).[26] The cause for each of these declarations is shown in the next figure. Although some of these declarations did not affect all areas of the county equally, they are an indication of the hazards present throughout the area.

Figure 5. Federally-Declared Disasters for Loudoun County, Jan 1977–Dec 2018

Type	Number	Percent
Flood	1	8.3 %
Tropical Storm/Hurricane[a]	5	41.7 %
Severe Storm	6	50.0 %
Total	**12**	**100.0 %**

Notes: [a] includes Hurricane Katrina evacuees

Technological or human-caused hazards are hazards which result from accidents or failures of systems and structures; or from the actions of people, either accidental or intentional. Intentional actions are always deliberate; however, the intent may differ, i.e., a deliberate action may be planned, careless, reckless, or with the intent to cause harm. In careless or reckless acts, or those that are poorly planned and/or executed, the outcome may have unintended consequences. Regardless, the potential for harm or damages exists.

---

[24] *CPG 201: Threat and Hazard Identification and Risk Assessment Guide—Second Edition, U.S. Office of Homeland Security, FEMA, August 2013.*

[25] *Northern Virginia Hazard Mitigation Plan Update, 2017. Retrieved from: http://arlington.granicus.com/MetaViewer.php?view_id=2&event_id=1101&meta_id=163110.*

[26] *FEMA Disaster Declarations Summary—Open Government Dataset, U.S. Department of Homeland Security, last updated March 5, 2018. Retrieved from: https://www.fema.gov/media-library/assets/documents/28318.*

Typical types of technological/human-caused hazards are listed here. Any one of these could occur in Loudoun County as the result of an accident or equipment failure.

- Airplane Crash
- Workplace Violence
- Cyber Incident
- Dam/Levee Failure
- Fire or Explosion
- Hazmat/CBRNE Release
- Industrial/Mine Incident Medical Emergency
- Pandemic/Epidemic
- Pipeline Emergency
- Power Failure
- Structure Collapse
- Technical Rescue
- Terrorist Threat
- Train Derailment
- Urban Conflagration

Intentional acts, like active shooter incidents or workplace violence, are likely to occur. Likewise, there are likely targets for deliberate acts such as critical facilities, communication systems, water and utilities, monuments, and areas where large groups congregate, *e.g.,* stadiums, conventions, and worship areas. Mitigation strategies include public awareness/education and continuous diligence by law enforcement and homeland security officials.

By Geographical Characteristics and Land Use

Geographical hazards are hazards associated with the natural and human-made characteristics of a community. These include:

- Climate and Weather
- Topography
- Wildland-urban Interface
- Land Use: Rural/Urban
- Transportation Networks
- Utilities
- Critical Infrastructure/Key Resources

The climate in Loudoun County is generally temperate, with a typical low temperature in winter of 20 degrees F and a high of 90 degrees F in the summer. Weather is moderate, but the area can experience severe storms, usually accompanied by high wind and the potential for flooding or snowstorm conditions.

Loudoun County lies primarily within the Piedmont Region and is characterized by rolling hills, hard bedrock, and rich, well-draining top-soils. To the west, the foothills of the Blue Ridge Mountains are noted for thick forests and elevations as high as 4,000 feet. In areas of steep slopes and mountainsides, disturbance of surface soils and vegetation can lead to erosion, landslides, and adverse effects on watersheds. Along the Route 15 corridor is an area known as "Karst terrain." This region is characterized by the potential for underground cavities and sinkholes. Most of the town of Leesburg, plus the area north of town to the Potomac River, lies in this region.

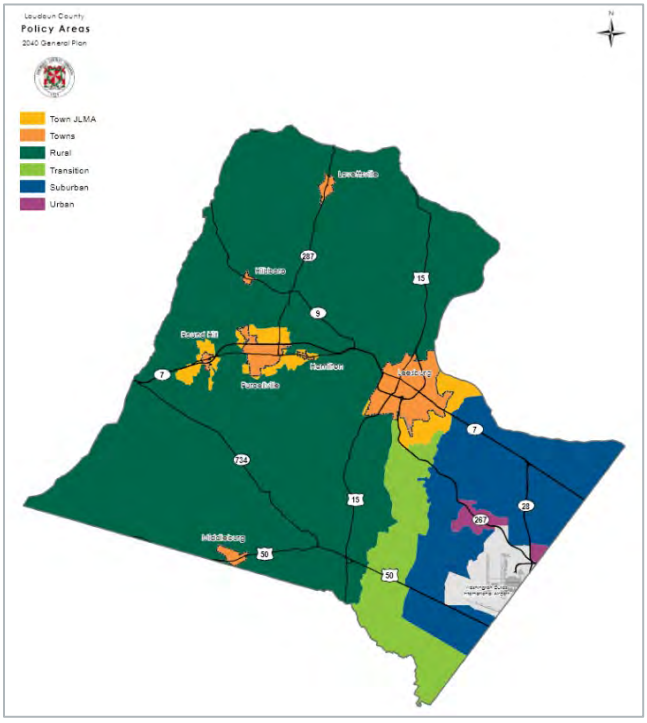
Generally speaking, the highest occurrence of all fire emergencies is highest in the areas of greatest population density. The average population density in the LC-CFRS service area is about 774 people per square mile. However, this figure does not accurately reflect the true nature of the community. Thus, it would be appropriate to consider LC-CFRS resource needs that correspond to the Policy Areas identified in the Loudoun County Comprehensive Plan: Urban, Suburban, Transition, and Rural.[27]

[27] *Envision Loudoun. DRAFT Loudoun 2040 Comprehensive Plan, version date: March 13, 2019. Retrieved from: https://www.loudoun.gov/DocumentCenter/View/149810/2019-03-13-Loudoun-2040-Comp-Plan?bidId=.*

The **Urban Policy Area**, shown in magenta, represents a new planning concept for Loudoun County just north and east of Washington Dulles International Airport. These areas, about 2,600 acres, are for multi-story, mixed-use, transit-oriented places that will provide housing, employment, entertainment, education, and retail, all in close proximity to the new Metrorail.

The **Suburban Policy Area**, shown in blue, has developed in a suburban pattern, predominated by single- and multi-family neighborhoods, retail, employment, commercial, technology, data management, and communications industries. The area around Washington Dulles International Airport is also expected to continue to be a major factor as a key location for industrial uses, airport-related businesses, and data center development as well as high-density residential.

Figure 6. Envision Loudoun 2040



The **Transition Policy Area**, shown in light green, is intended to serve as a "visual and spatial" transition between the urban and rural areas of the county. The area is planned for a diversity of clustered housing with limited commercial uses to support residents and some industrial spaces focused on quarry activity and energy infrastructure. The existing Transition Policy Area is under review and revision and will most likely include significant commercial, residential, and industrial components that will have significant impacts on LCCFR into the future.

The **Rural Policy Area**, shown in dark green, contains about two-thirds of the county's land area and twelve historic villages, and is characterized by the traditional farming/agricultural land use with many winding, narrow two-lane roadways and small communities, interspersed with multi-lane connector roads and large, estate-style homes on multi-acre properties in rural areas.

Town and Joint Land Management Zones (JLMA), shown in orange and gold, are home to the County's seven towns; each has the authority to exercise planning and zoning controls within their corporate limits. A JLMA is a planning area where Loudoun and each respective town set the limits for municipal water and sewer extension. These JLMA planning areas effectively serve as a growth boundary for each town and are intended to manage new growth and expansion outward from the towns.

Each Policy area will present varied and unique challenges to the LC-CFRS. Consider this:

- In the urban area, population density could be over 3,000 people per square mile, with significant transient traffic, congested mobility, and a large-number of mid-rise and high-rise buildings.
- In the suburban area, the greatest number of residential neighborhoods and the potential for a higher risk of residential fires and medical emergencies.

- In the transition area, the potential for quarry/industrial accidents and hazardous processes.
- In the rural area, limited access routes, long response travel times outside small communities, and potential for wildland-urban interface emergencies.

Any feature—natural or human-made—can create **barriers** that affect response travel time or access. There are two common types of response barriers found in the Loudoun County service area—permanent and temporary. Permanent barriers are primarily topological like the mountain ridges, creeks, and lakes. Many communities in the wildland-urban interface have restricted or limited access roads. Temporary barriers include construction zones and moveable barriers for traffic or crowd control. It is important for LC-CFRS responders to know where these barriers are, how they affect travel time and distance, and to map any changes to allow prompt response to emergencies.

Likewise, **transportation corridors and terminal sites** pose an increased risk due to the potential for a large loss of life, mobility disruptions, and social impact. The imminent expansion of the Metrorail system and associated residential, commercial, and technological development into Loudoun County will create a significant influx of population and complex development including high rise buildings in excess of 20 stories. This will enhance the risk profile and potential for transportation emergencies involving over-the-road, aircraft, rail, and pipeline emergencies. While the greatest risk is in the eastern part of the county, a transportation emergency could occur anywhere throughout the county.

A **target hazard** is any location at which there is a great likelihood of loss of life or property. Many buildings in the LC-CFRS service area are used for purposes that create more significant risk than others. High occupancy buildings, facilities providing care to vulnerable populations, and others may require greater numbers of emergency response resources during an emergency. Another target hazard is any site or structure defined as "critical infrastructure and key resources" (CIKR) essential for the functioning of a society and/or economy. Critical infrastructure is defined as a sector "whose assets, systems, and networks, whether physical or virtual, are considered so vital to the United States that their incapacitation or destruction would have a debilitating effect on security, national economic security, national public health or safety, or any combination thereof." There are sixteen defined Critical Infrastructure Sectors (CIS):[28]

- Chemical Sector
- Commercial Facilities Sector
- Communications Sector
- Critical Manufacturing Sector
- Dams Sector
- Defense Industrial Base Sector
- Emergency Services Sector
- Energy Sector
- Financial Services Sector
- Food and Agriculture Sector
- Government Facilities Sector
- Healthcare and Public Health Sector
- Information Technology Sector
- Nuclear Reactors, Materials, and Waste Sector
- Transportation Systems Sector
- Water and Wastewater Systems Sector

Examples of CIKR locations in Loudoun County include but are not limited to hospitals; airports; Metro Rail and associated development; government offices; pipelines; emergency operations and communications systems; cyber-centers; and utility providers.

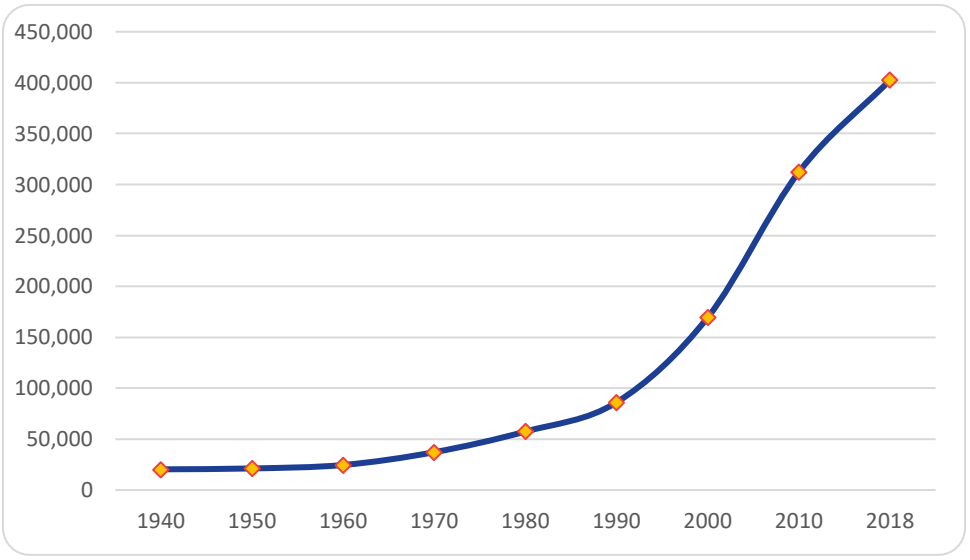
[28] *Ibid; https://www.dhs.gov/critical-infrastructure-sectors.*

By Demographics

Statistically speaking, 87 percent of all civilian fire fatalities in structure fires occur in the home (single- and multi-family dwellings, mobile homes, manufactured housing, and duplexes).[29] The U.S. Census estimates 136,506 housing units in Loudon County as of July 1, 2018, which, based on county building and development residential building permits for new construction, should increase to well over 137,500 by the end of 2019.[30] In addition, the Loudon County Foundations Report forecasts 2045 housing units will increase to 175,405.[31]

At the time of this study, the current service area population was estimated at 402,561. After decades of slow stagnation, the county population began to increase in the 1940s and has skyrocketed since the mid-sixties following completion of Washington Dulles International Airport. The fastest growth occurred from 1990 to 2010, with the county almost doubling in population every ten years. Growth has tapered somewhat since 2010, but still has maintained an estimated average annual growth rate of 3.6 percent between 2010 and 2018, as shown here.

Figure 7. Population History, 1940–2018



The area economy is driven by four major forces—white-collar service industries, agriculture, government service, and tourism. Thus, the area has an influx of people beyond the numbers calculated by the census. Often, these numbers exceed the actual resident population and greatly increase the population served by the LC-CFRS. As examples:

- An estimated 93,000 people commute into the area to work.
- An estimated 129,000 people commute out of the area to work.

---

[29] *Home Structure Fires, Ahrens, Marty. September 2017, National Fire Protection Association, Quincy, MA. Retrieved from https://www.nfpa.org/News-and-Research/Data-research-and-tools/Building-and-Life-Safety/Home-Structure-Fires.*

[30] *Number of housing units from U.S. Census Bureau. Retrieved from https://www.census.gov/quickfacts/fact/table/loudouncountyvirginia/RHI625218#RHI625218.*

[31] *Loudon County Foundations Report. March, 2017. Retrieved from https://www.loudoun.gov/DocumentCenter/View/126732/FINAL-FoundationsReport_3-16-2017sm?bidId=*

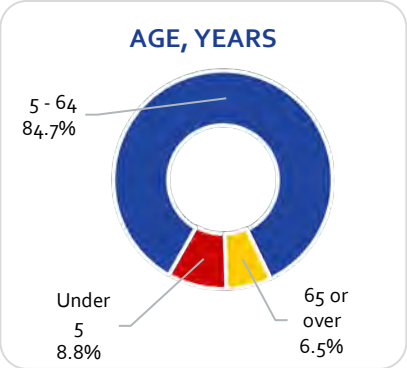
- An estimated 7.6 million vehicle road miles are traveled each day in the county.
- An estimated 57,500 people pass through the airport every day.
- An estimated 1.4 million people stay in area hotels and motels every year.

In addition to the number and distribution of the population, the demographics of the population can affect the amount of service demand and the nature of risk within a community. In urban cities, several factors have been identified that place groups of people at risk. An NFPA report has identified the groups that face a higher risk of being injured or killed in a fire as:[32]

- Children under 5 years of age;
- Older Adults over 65 years of age;
- People with disabilities;
- Language barrier; and
- People in low-income communities.

According to the latest information posted on the Loudoun County website, a considerable number of the residents of the LC-CFRS service area are in one or more at-risk population groups.[33] This segment of the population is more likely to use fire department services, especially EMS, than other population groups. As discussed in the Service Delivery analysis, EMS incidents represent a significant percentage of service demand. Older adults and individuals with lower income and no health insurance are more likely to use local EMS resources than individuals with health insurance and a personal physician.

Age: Senior citizens can have difficulty escaping from fire due to physical limitations. Quality of life issues and increased reliance on assisted living could affect service delivery and a number of resources required due to an increase in service demand for emergency medical services. The very young also represent a vulnerable population, both regarding their ability to escape a structure fire as well as their susceptibility to serious medical ailments such as asthma, traumatic events, choking, or injury from vehicular accidents.

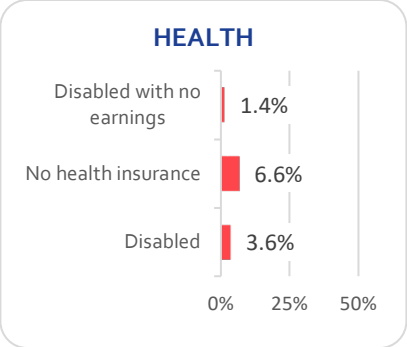


Almost 7 percent of the population is over 65 years of age. This is significantly lower than the same metric for Virginia (15 percent) and the national metric (15.6 percent).

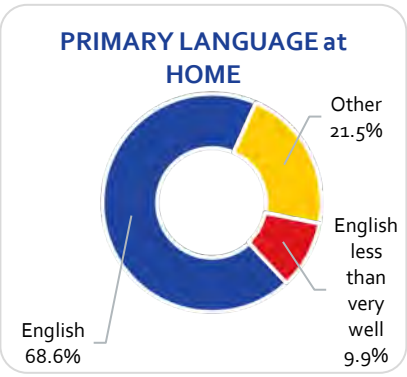
[32] *National Fire Protection Association, 2007; Urban Fire Safety Project, Emmitsburg, MD; retrieved from http://www.nfpa.org/public-education/by-topic/people-at-risk/urban-fire-safety/reports-and-presentations.*

[33] *For consistency with other Loudoun County reports, this report uses information published on the Loudoun County website. Retrieved from: https://www.loudoun.gov/1914/Demographic-Characteristics.*

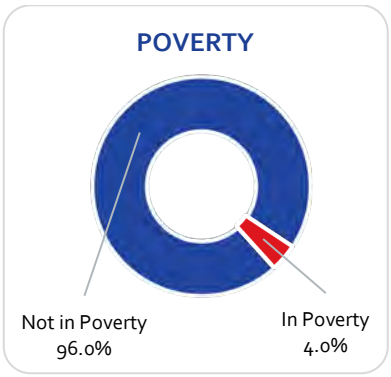
Disabilities: People with disabilities make up 3.6 percent of the population. These people may have difficulty or be incapable of self-preservation during an emergency. Likewise, people with no health insurance are more prone to chronic illness or exhibit poor physical condition simply because they do not seek treatment promptly. About 12.3 percent of the population has no health insurance; thus, they may require a higher level of fire-rescue response.

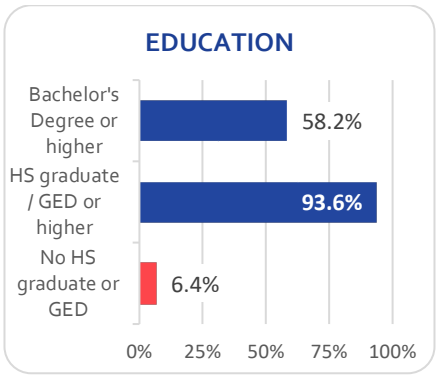


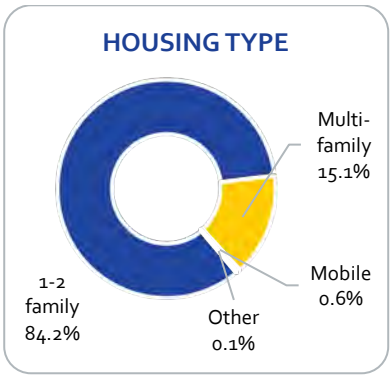
Language barrier: People may have cultural differences or language barriers that decrease the likelihood they would call for service or may affect their ability to communicate needs and concerns effectively. According to the NFPA, "Language barriers, cultural differences, and inexperience with unfamiliar home technologies are factors that mark the challenges of helping newcomers live safely from the threat of fire in the home."[34] About 24 percent of the population is foreign-born, and almost one-third of the population (31.4 percent) speak a language other than English at home. Of those that speak a language other than English at home, almost 10 percent speak English "less than very well."



Income: Likewise, low-income people are more at risk from fire or medical condition; about 4 percent of the resident population live below the poverty level.[35] Low income is often combined with other factors such as education or work status. Although not defined as an at-risk population, there is a higher life safety risk associated with housing type due to the number of people (multi-family dwellings) or other characteristics that may affect rescue efforts (mobile homes, R/Vs, and other).







[34] *Serving immigrant and refugee populations, National Fire Protection Association, 2017. Retrieved from: https://www.nfpa.org/Public-Education/Campaigns/Fire-Prevention-Week/Teaching-FPW/Serving-immigrant-and-refuge-populations.*

[35] *"The US. Census Bureau 2017 poverty threshold is defined as $12,488 for an individual, $25,094 for a family of four." Retrieved from https://www.census.gov/data/tables/time-series/demo/income-poverty/historical-poverty-thresholds.html.*

By Occupancy Classification

Another way to classify risk is by occupancy classification based on the intended use: certain occupancy types are inherently more prone to risk due to their use, size, height, hazardous operations or processes, or the number of occupants. For convenience, these may be grouped as described by NFPA 1730:[36]

- **High-Risk Occupancy**. An occupancy that has a history of high frequency of fires, high potential for loss of life or economic loss, or that has a low or moderate history of fires or loss of life but the occupants have a high dependency on the built-in fire protection features or staff to assist in evacuation during a fire or other emergency. Examples of high-risk occupancies are apartment buildings, hotels, dormitories, lodging and rooming, assembly, childcare, detention, educational, health care, and hazardous materials or processes.
- **Moderate-Risk Occupancy.** An occupancy that has a history of moderate frequency of fires or moderate potential for loss of life or economic loss. Examples of moderate risk occupancies are ambulatory health care, industrial, large mercantile and storage of combustibles.
- **Low-Risk Occupancy.** An occupancy that has a history of low frequency of fires and minimal potential for loss of life or economic loss. Examples of low-risk occupancies are storage, mercantile, and business.

Using the Loudoun County Fire Code as a classification tool, fire risk may be grouped as shown here.

Risk	*IBC Group*	*Examples*
High	A-1, A-2	Nightclub, restaurant, theater, airport/cruise ship terminal
	A-3, A-4, A-5	Arenas, museums, religious
	H-1, H-2, H-3, H-4, H-5	Hazardous materials sites (Tier II)
	B	All government & public buildings, other office buildings over 2 stories
	E	Schools, day care centers
	I-1, I-2, I-3, I-4	Hospitals, assisted living centers, correctional
	M	Strip centers, closed-air shopping malls, big box stores
	R-1, R-2, R-3, R-4	Hotels, motels, boarding houses (transient), congregate living facilities (transient), apartments, dormitories, fraternities/sororities, board & care facilities, vacation timeshares, live/work units, group homes
	Special Risk (Target hazard)	Railroads, Interstate highways, airports, any building with life safety risk beyond reach of preconnected hose lines > 200 feet
Moderate	F-1	Fabrication or manufacturing of combustible materials
	M	Mercantile, free-standing
	I-2, R-4	Foster group homes, assisted living homes
	S-1	Storage of combustible materials, car repair, hangars
Low	B	Outpatient clinics, general business, offices < 3 stories
	F-2	Fabrication or manufacturing of non-combustible materials
	R- 5	1- and 2-family dwellings, foster homes
	S-2	Storage of combustible materials
	U	Barns, silos, other unclassified

[36] *NFPA 1730: Standard on Organization and Deployment of Fire Prevention Inspection and Code Enforcement, Plan Review, Investigation, and Public Education Operations 2016 Edition, National Fire Protection association, Quincy, MA, 2015.*

By Planning Zone

For fire and EMS emergency response, the LC-CFRS has not adopted formal planning zones. ESCI recommends the LC-CFRS begin with the policy areas from the County's 2040 Comprehensive Plan. Each area can be further divided into response zones, such as battalions or districts that include one or more station locations. This recommendation has four key advantages:

- **It is consistent with and supports the comprehensive plan.** The plan describes the projected land use and occupancy mix, type, and size of buildings, and provides a foundation for long-range system and capital improvement planning;
- **It provides a logical way to define community risk and prioritize resource needs.** The plan provides information about hazards, risks, demographics, and regional mobility. This information provides the system with additional information that will assist with optimizing system resources to meet community needs, both now and in the future.
- **It is flexible.** The plan identifies projected and intended land use. LC-CFRS is a complex system with specialized risks and needs in different parts of the county. This recommendation will provide the system with a compelling reason to locate specific resources and personnel at specific locations, yet allow the system the flexibility to relocate or repurpose resources as needed to provide an emergency response that meets community needs and expectations 24/7/365, with a mix of volunteer and paid staff.
- **It simplifies system administration.** The use of policy area planning zones provides the LC-CFRS with the opportunity to create sub-zones to improve supervisor response time, provide administrative support of a workable number of stations and personnel, divide the supervisory workload, and provide additional opportunities for leadership development.

Section III. Analysis of Service Delivery

The most important—and usually the most visible—element of operations for an emergency services organization is the ability to deliver service in a timely fashion. Before leaders can set goals for the efficiency and effectiveness of the organization, it is imperative to first establish an understanding of how the service is currently organized, deployed, and managed.

The study of Service Delivery and Performance allows an organization to evaluate multiple facets of their system. Evaluation points include when and where incidents are most likely to occur, how often incidents occur in a given location, agency performance in the response to incidents and areas where resources are unable to reach that location within a given time period.

ESCI used data supplied by LC-CFRS to conduct an in-depth analysis of how multiple variables throughout the service delivery system affected LC-CFRS's ability to deploy emergency resources as well as to provide baseline performance metrics for service delivery.

The following figures provide an overview of NFPA 1710 requirements for first arriving units on structure fires, assembly of the alarm assignment, and effective response force for fires and EMS response requirements.

Figure 8. NFPA 1710 Requirements for First Responding Unit to Fires

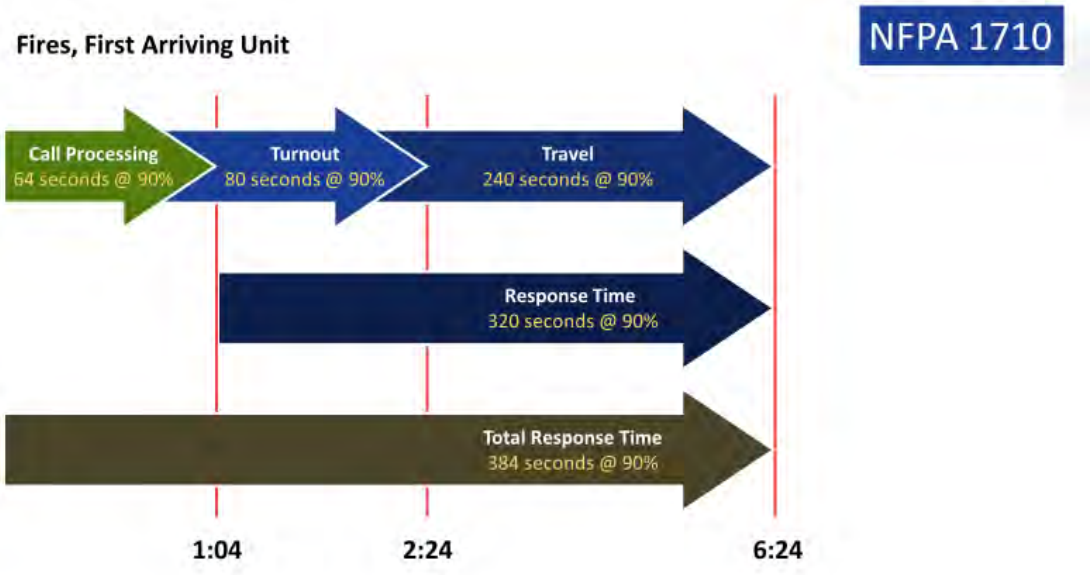


Figure 9. NFPA 1710 Requirements for Alarm Assignment to Fires

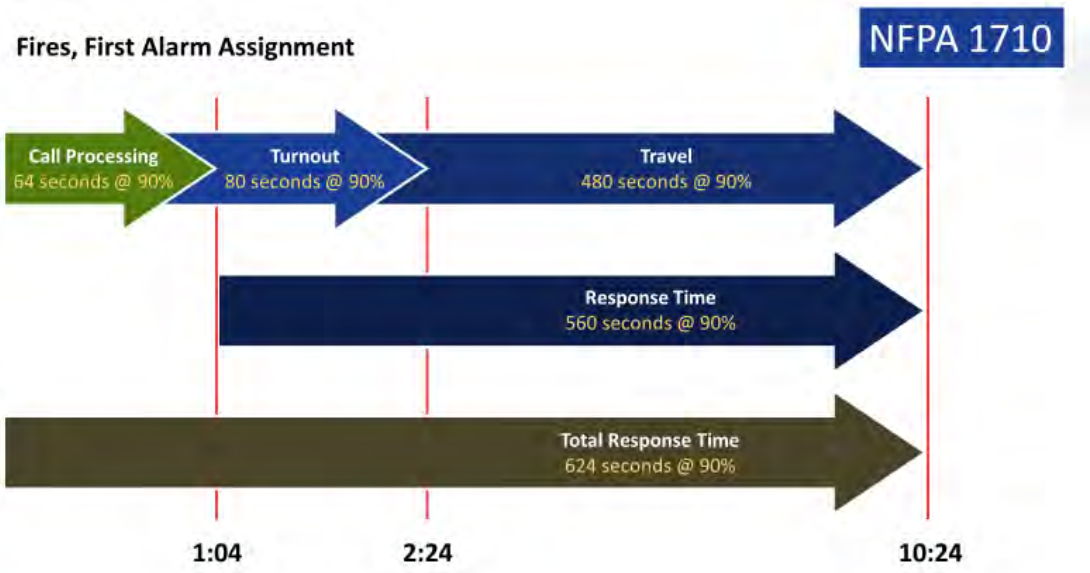
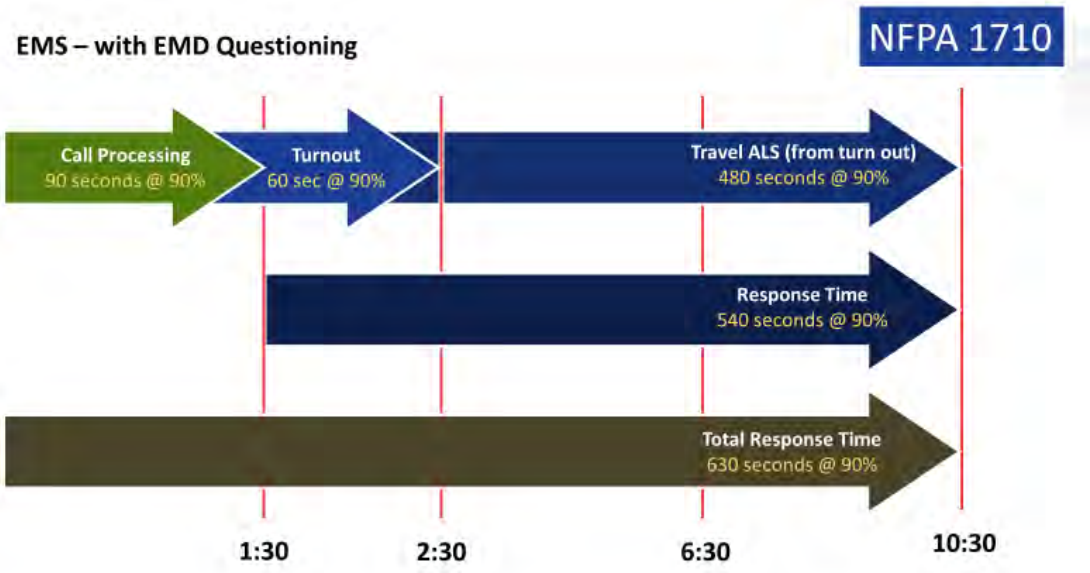


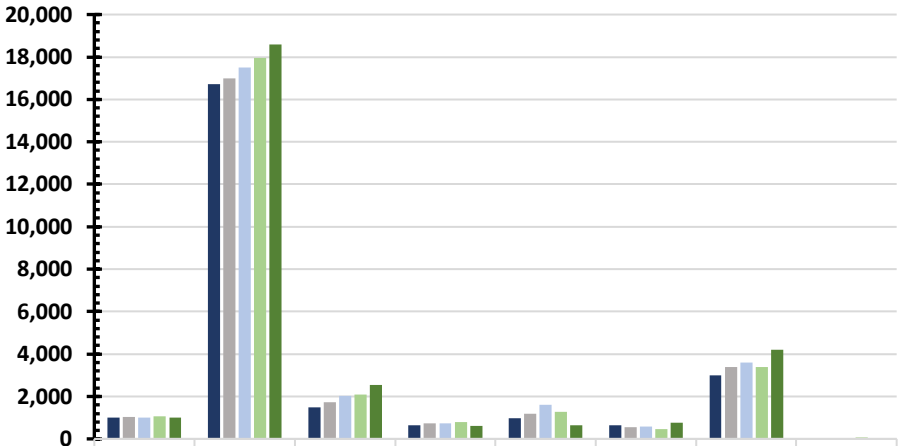
Figure 10. NFPA 1710 Response Requirements for Advanced Life Support (ALS) EMS Units



Service Demand Analysis

The following figure shows the numbers of incidents, by types of service demand, to which LC-CFRS responded to from 2013 through 2017.

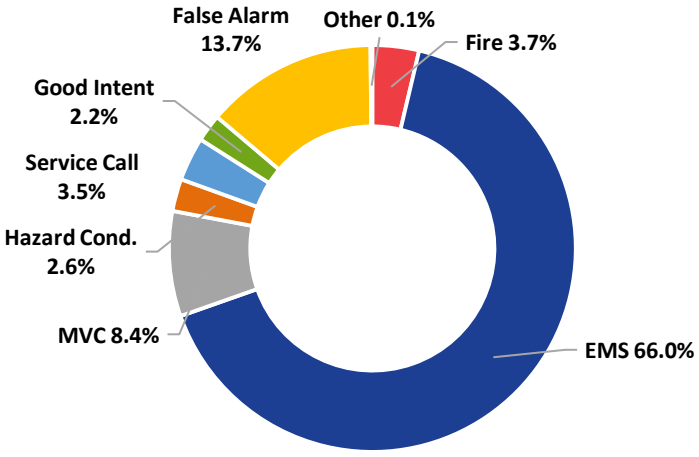
Figure 11. Annual Service Demand by Type, 2013–2017



	Fire	EMS	MVC	Hazard Cond.	Service Call	Good Intent/ Cancel	False Alarm	Other
2013	1,018	16,706	1,475	642	967	636	2,991	37
2014	1,026	17,005	1,721	738	1,180	562	3,373	26
2015	1,009	17,498	2,019	727	1,615	573	3,597	47
2016	1,058	17,961	2,098	799	1,284	454	3,387	81
2017	995	18,589	2,535	625	643	756	4,194	-

The percentages of total service demand are shown in the following figure. In this figure, MVC incidents were removed from EMS and displayed separately. If these are inserted into EMS, the total would be 74.4 percent. This was done intentionally to provide a comparison of performance to MVCs versus other medical calls.

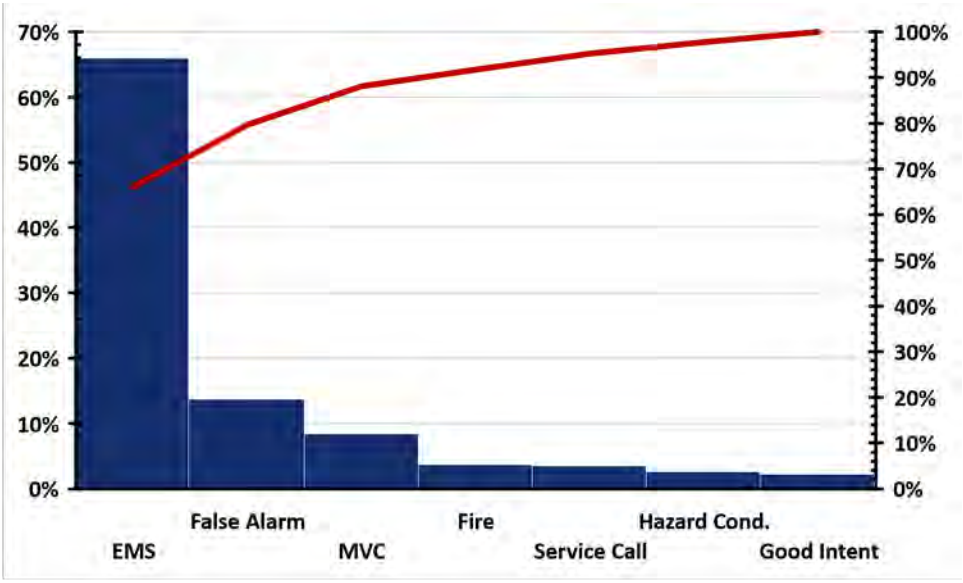
Figure 12. Percentage of Total Service Demand, 2016–2017



The next greatest category is false alarms at nearly 14 percent. MVCs responses make approximately 8 percent, and actual fire calls make up 3.7 percent of all calls. Finally, good intent, service calls, hazardous conditions, and all other calls result in 8.4 percent of the total calls from 2016 through 2017.

The following figure provides another description of call percentage. Each incident type is presented from the highest to lowest percentage of occurrence by call type, as well as how these totals contribute to the cumulative total. The scale on the left displays each incident type's relative percentage, and the line and scale on the right displays the cumulative percentage of calls and how each of these categories of calls contributes to the total number of calls, 2016 through 2017.

Figure 13. Incident Frequency by Percentage and Cumulative Total, 2016–2017



In addition to identifying the call or incident types and frequency of service demand, an understanding of when these events occur is critical to determining when system demand will most likely be at its greatest. Knowledge of high demand periods will assist administrators in determining whether staffing levels are sufficient for the demand and also in scheduling additional duties such as training, fire safety inspections, and vehicle maintenance.

In this section, service demand was analyzed three different ways to provide insight into when and where emergency incidents are most likely to occur within Loudoun County:

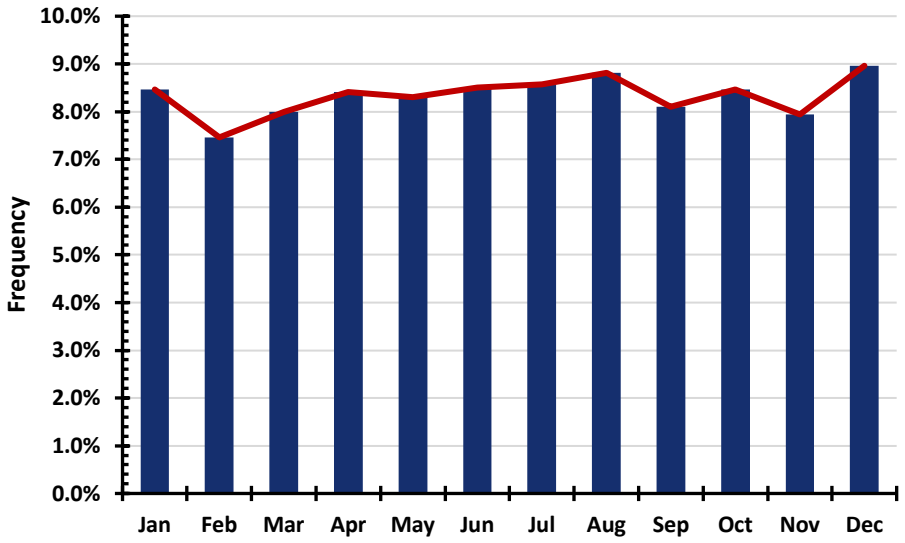
- **Temporal Variation**: This evaluation examines how incident patterns vary when analyzed over different periods of time. For the purpose of this study, ESCI looked at the LC-CFRS incident patterns by months, days, and hours.
- **Population Distribution**: ESCI established a basic understanding of where people live within Loudoun County and then correlated it with service demand to determine whether or not these populated areas affect service demand within LC-CFRS.
- **Incident Densities**: This evaluation illustrates where incidents are most likely to occur within the LC-CFRS response area. ESCI presents this information as geographic displays that indicate where LC-CFRS can anticipate the highest levels of service demand based upon incident spatial autocorrelation, or relationship to each based on their proximity to one another.

Temporal Variation

In this section, the patterns of activity based upon the time period observed—temporal variation—were examined. These patterns are illustrated by month, day, and hour to provide LC-CFRS with an insight as to when the organization can anticipate increases and decreases in service demand based on historical patterns.

The following figure shows the temporal variation of LC-CFRS's service demand by month. Each month is represented by the number of incidents occurring in that month compared to the total number of incidents that occurred from January 1, 2017, through December 31, 2017. These are presented as percentages relative to total service demand that occurred during the period of analysis.

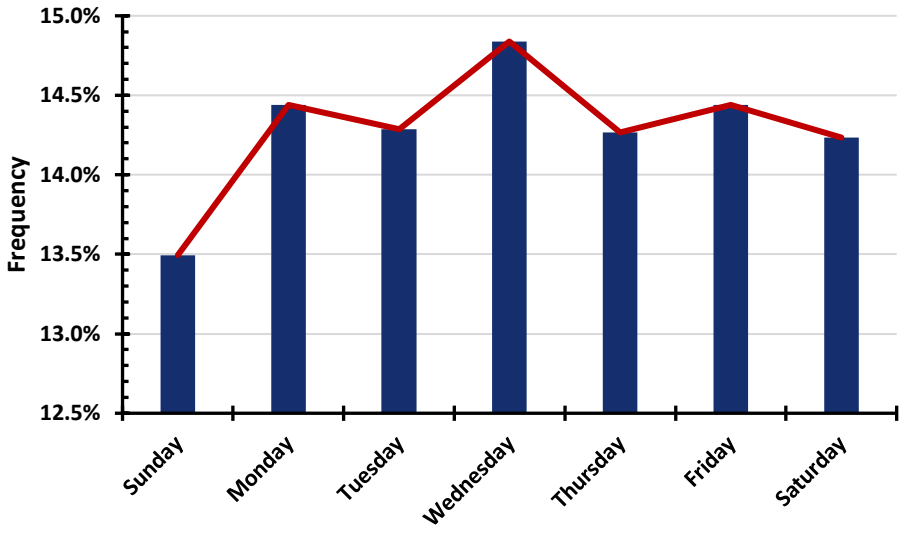
Figure 14. Service Demand by Month, 2017



Service demand across Loudoun County is consistent throughout the year. August and December represent the highest volume of demand throughout the year, with a decline in February and November. The number of incidents in the slowest month, February, is 2,049; and the highest month, December, had 2,461 incidents, a difference of 425 incidents or 1.5 percent. Overall, the variation in the number of incidents per month is small.

Next, the demand for service is examined by day of the week. In Figure 15, each day is presented with its relative frequency of occurrence as a percentage of total call volume.

Figure 15. Service Demand by Day, 2017

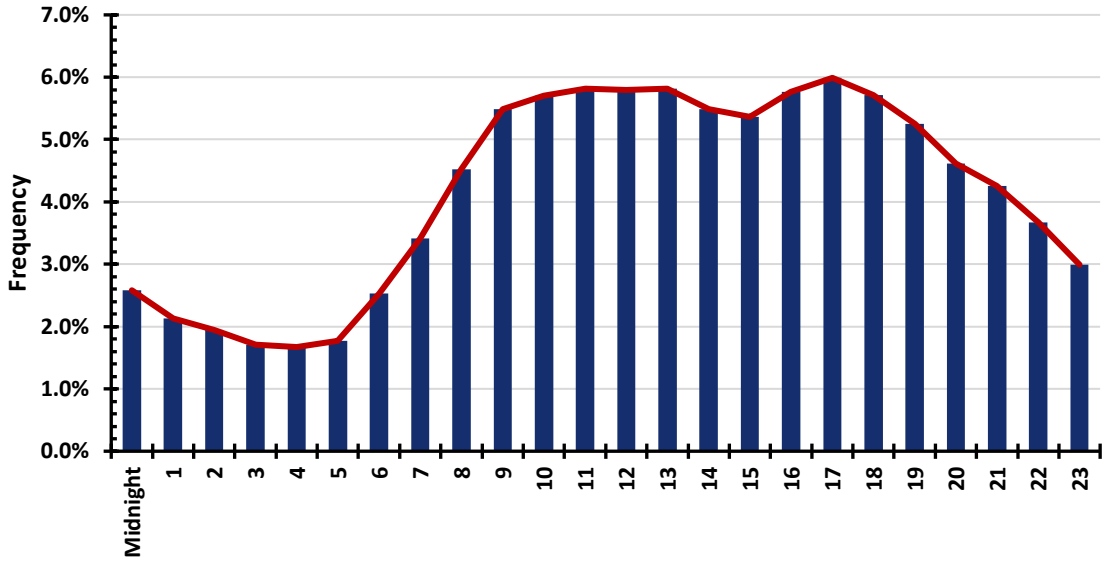


Service demand in Loudoun County is relatively consistent throughout the week. Peak demand is on Wednesdays with a high of 4,075, and the lowest demand is on Sundays at 3,706. There is a difference of 369 or 1.3 percent between the busiest and slowest days throughout the study period of 2017.

It is notable that Saturdays and Sundays were the two slowest days of the week, representing a combined total of 27.7 percent of the total service demand by day. This may suggest that commercial and business activities that occur Monday through Friday during the traditional work week are a key driver of service demand in Loudoun County. While the demand was relatively consistent at the time of this evaluation, LC-CFRS should monitor these patterns going forward to ensure that any changes in trends that could affect service delivery are recognized early.

The following figure presents temporal variations in service demand by hour.

Figure 16. Service Demand by Hour, 2017



When demand is analyzed for frequency by hour of the day, a pattern emerges. There is a spike in demand at five o'clock in the afternoon in Loudoun County, but it is followed by a drop off until four o'clock the next morning. Peaks are from eleven o'clock in the morning to one o'clock in the afternoon and at five o'clock in the evening. This pattern is consistent with the observation that people are more active during daylight hours leading to increased service demand. The LC-CFRS may want to examine further the spike in demand at five o'clock in the evening to assess if any risk reduction programs might be applicable or useful.

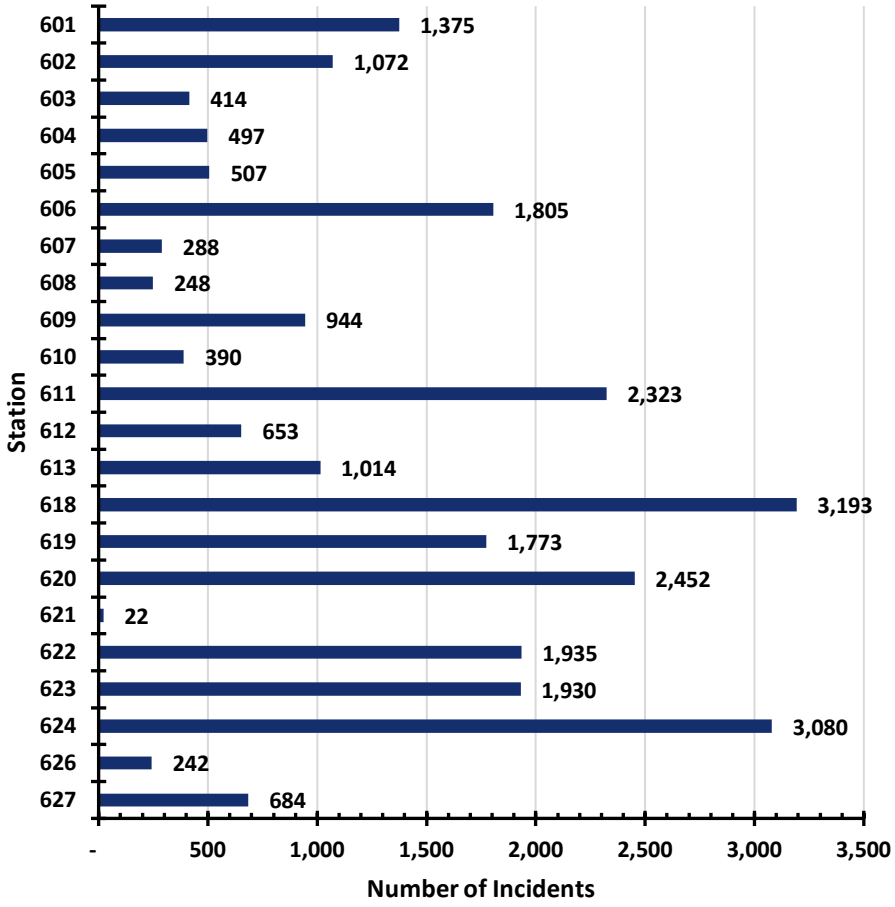
It is important to note is that while demand is lower in the early morning hours, fatal residential fires occur most frequently late at night or in the early morning. From 2009 to 2011, residential fire fatalities throughout the United States were highest between 0100 to 0200 and 0400 to 0500. The 8-hour peak period (11 pm to 7 am) accounted for 48 percent of residential fatal fires.[37]

[37] *Fatal Fires in Residential Buildings (2009–2011), Topical Fire report Series Volume 14, Issue 3/May 2013, U.S. Department of Homeland Security, U.S. Fire Administration, National Fire Data Center.*

Geographic Service Demand

In addition to the temporal analysis of workload, it is useful to examine the geographic distribution of service demand. The following figure shows the number of individual incidents by first due areas for the last year of data available at the time of the report, 2017.

Figure 17. Number of Incidents by First Due Area, 2017



Stations 618 and 624 are by far the busiest stations with the greatest number of incidents occurring within their zones. Other stations with relatively high call volumes are Stations 611 and 620 which have a call volume of approximately 2,400 calls per station on an annual basis. Call volume within these four stations combined represents 41.2 percent of the total call volume for the County. Service demand is allocated by geographical location relative to the station location, so it is difficult to closely balance all stations. A unit utilization and reliability analysis will determine if units are overloaded and if a strategy to rebalance the call load is necessary.

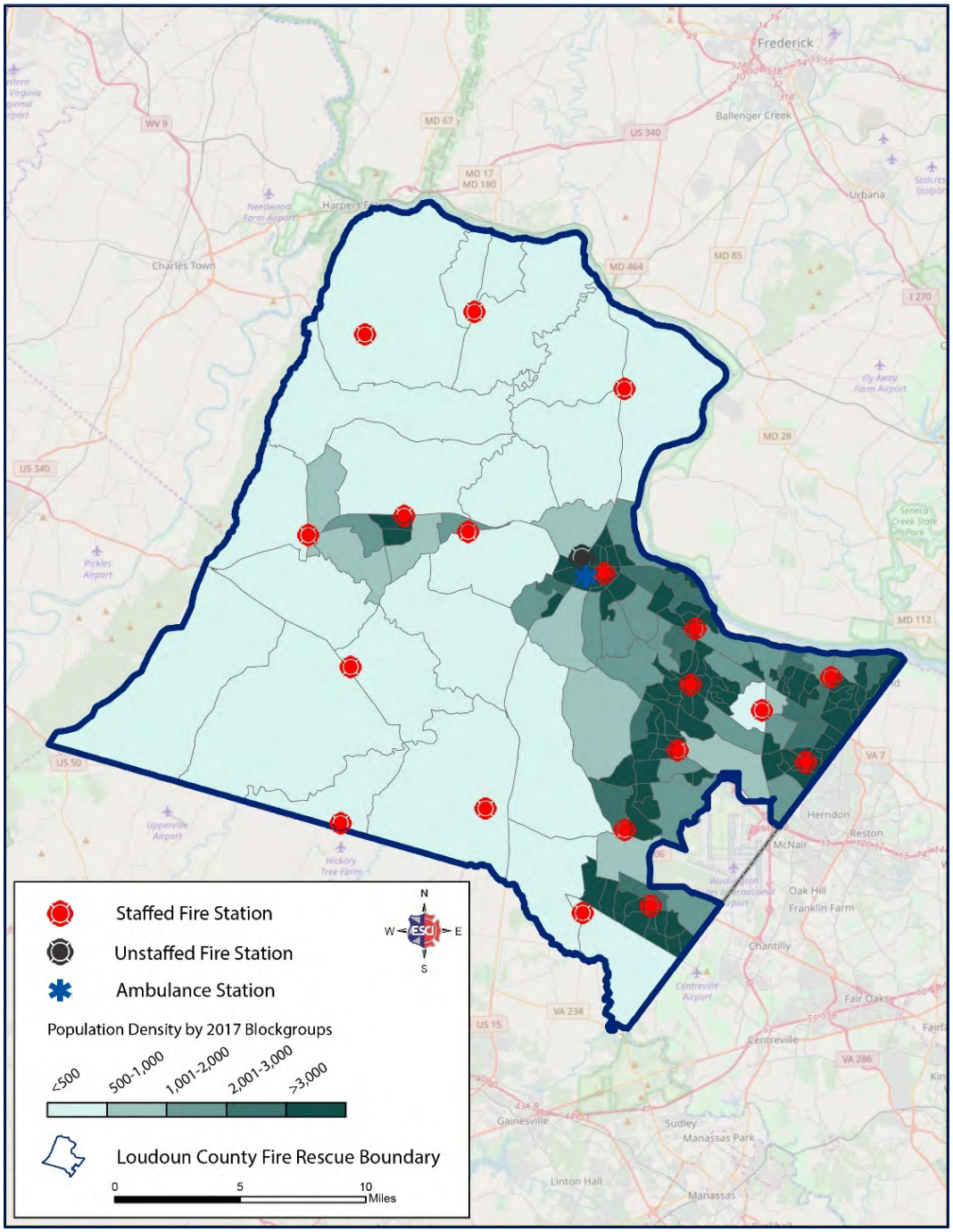
It is important for emergency service organizations to understand where people are located and how they are concentrated throughout the response area geographically. In this section, an overview of the current deployment strategy, which includes facility and apparatus locations, was analyzed using Geographical Information Systems (GIS) software to identify potential service gaps and redundancies of resources.

Increases and decreases in the activity of the population within Loudoun County appear to affect the levels of service demand experienced by the organization. To provide a foundation for this observation, the distribution of the population was examined and presented by U.S. Census Block Group Density. A block group is smaller than the Census Tract but larger than the Census Block. A block group consists of clusters of blocks within the same census tract. It is the smallest geographical unit for which the Bureau publishes sample data, i.e., data which is only collected from a fraction of all households.

The U.S. Census Bureau provides annual updates called "American Community Survey" (ACS) estimates. In the following figure, population density by block groups is illustrated based upon 2017 ACS population estimates and displayed as the number of people per square mile. Using the assertion that a direct relationship exists between the population of a given area and the service demand experienced, it is anticipated that greater levels of service demand should occur in the darker shaded areas of higher population densities than those of lower densities.

The darker colors in the following figure represent greater population densities and these areas can be refined to specific locations throughout the jurisdiction. In the Loudoun County study area, the highest population concentration is in the eastern section. Although there are several areas throughout the study area that have a density of 2,000 to 3,000 people per square mile, the majority of those areas are to the east.

Figure 18. Population Density by 2017 Block Groups

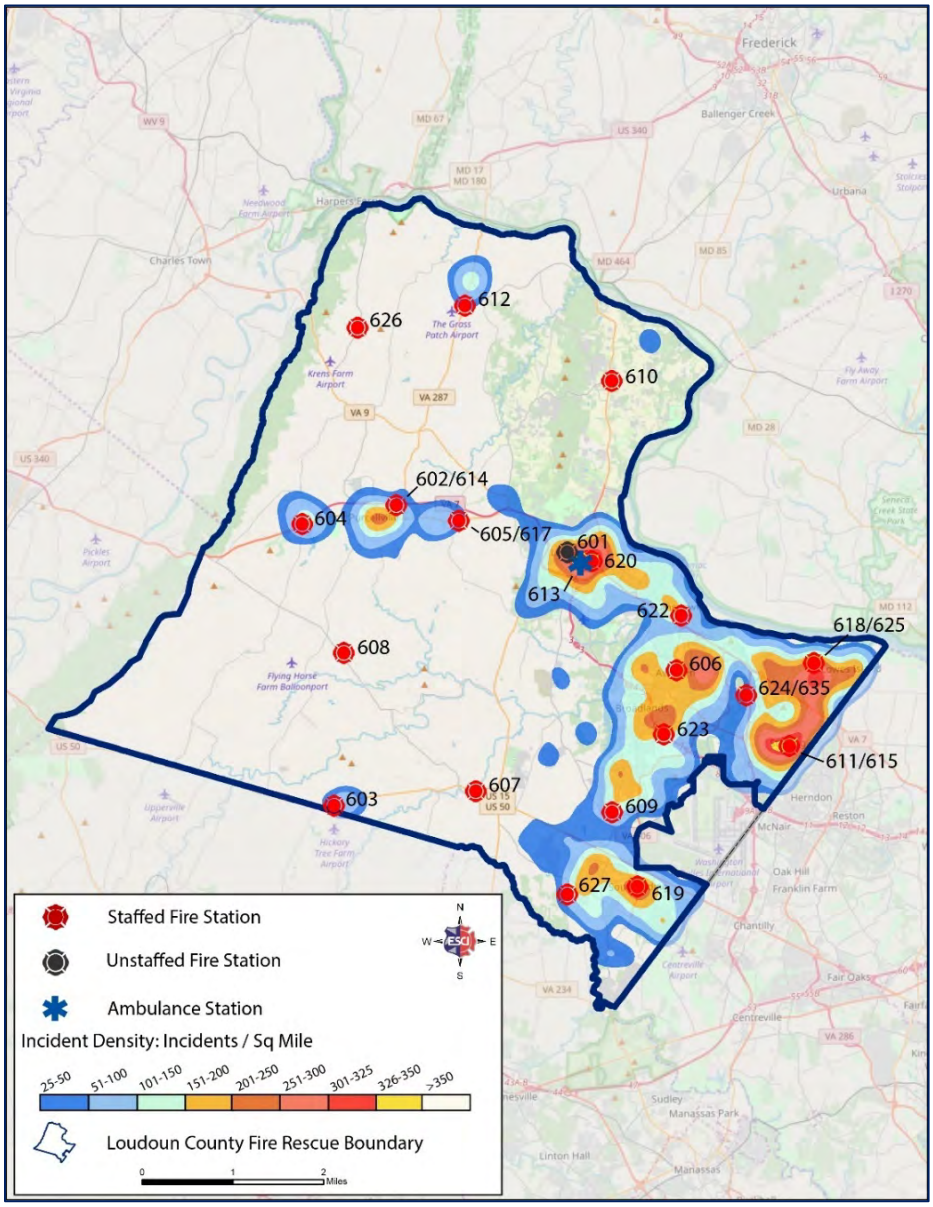


Based on the previously stated assertion that service demand is linked to human activity, the identification of areas with a higher population density should result in accurate predictions of where areas of increased service demand will occur. Next, the calculated incident densities based on the spatial autocorrelation of historic incident locations were examined to determine if areas of higher population densities, and presumably increased activity, resulted in corresponding areas of increased incident density.

The next figure provides the calculated incident densities occurring in the LC-CFRS service area based upon the actual locations of historical incidents. As expected, the areas of greatest density generally occurred in areas of higher population density. This relationship is important because as Loudoun County's population and the distribution of that population change, inferences about where service demand is likely to increase, or decrease, can also be made. This analysis provides LC-CFRS with a tool to demonstrate how and why service demand may change over time and lays the foundation for future service delivery methodologies in Loudoun County.

In this analysis, which is commonly referred to as Hot Spot Mapping, the relative proximity of incident locations is compared using GIS software and a relative scale of the incident rate per square mile is calculated. Hot Spot Mapping is commonly used in law enforcement to identify areas that stand out from the rest due to the frequency and proximity of occurrence relative to the rest of the service area.

Figure 19. Incident Density for all Incidents, 2016–2018

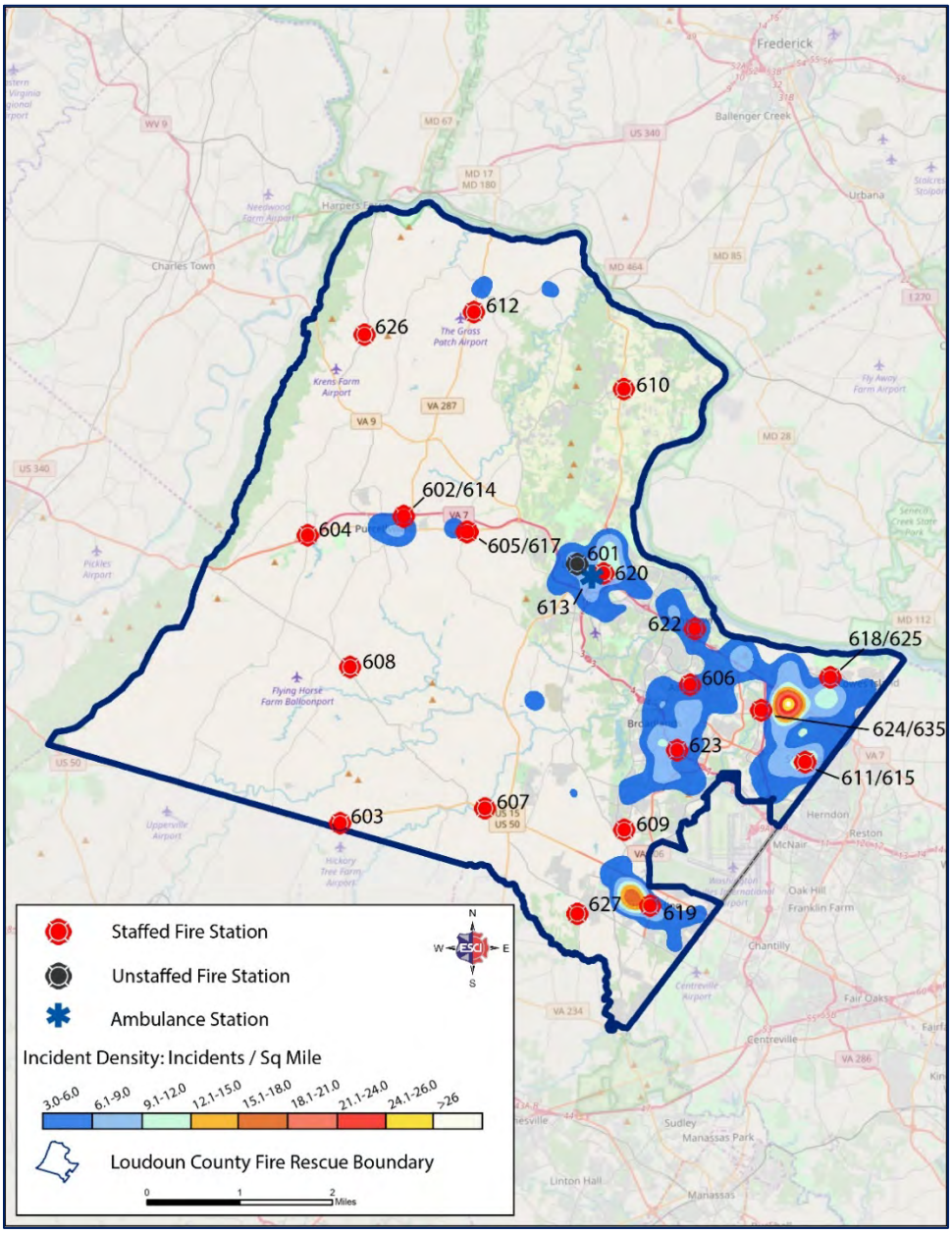


This figure shows the locations where incidents took place from 2016 through 2018. Due to the three-year analysis period, the accuracy of the highest density locations is statistically reliable.

Note that the locations of highest call density are located in close vicinity to stations clustered in the highest population and traffic centers. Assuming the units are in the station and available to respond to calls, this improves response times to the greatest number of service requests within those station response zones. Overall the highest incident density areas are within the response zones of Stations 618, 611, and 624 which are all located near one another in the same general area followed by Station 620, also located in a highly populated area. As important as it is to identify the high-density call areas, it is also important to note that there are *not* significantly moderate and high-density call clusters in areas without fire stations and available responders. This is indicative that at a high-level analysis, fire stations are consistently located where the call volume and risk are highest.

The following figure displays the incident density for only fire incidents.

Figure 20. Incident Density Map for Fire Related Calls, 2016–2018

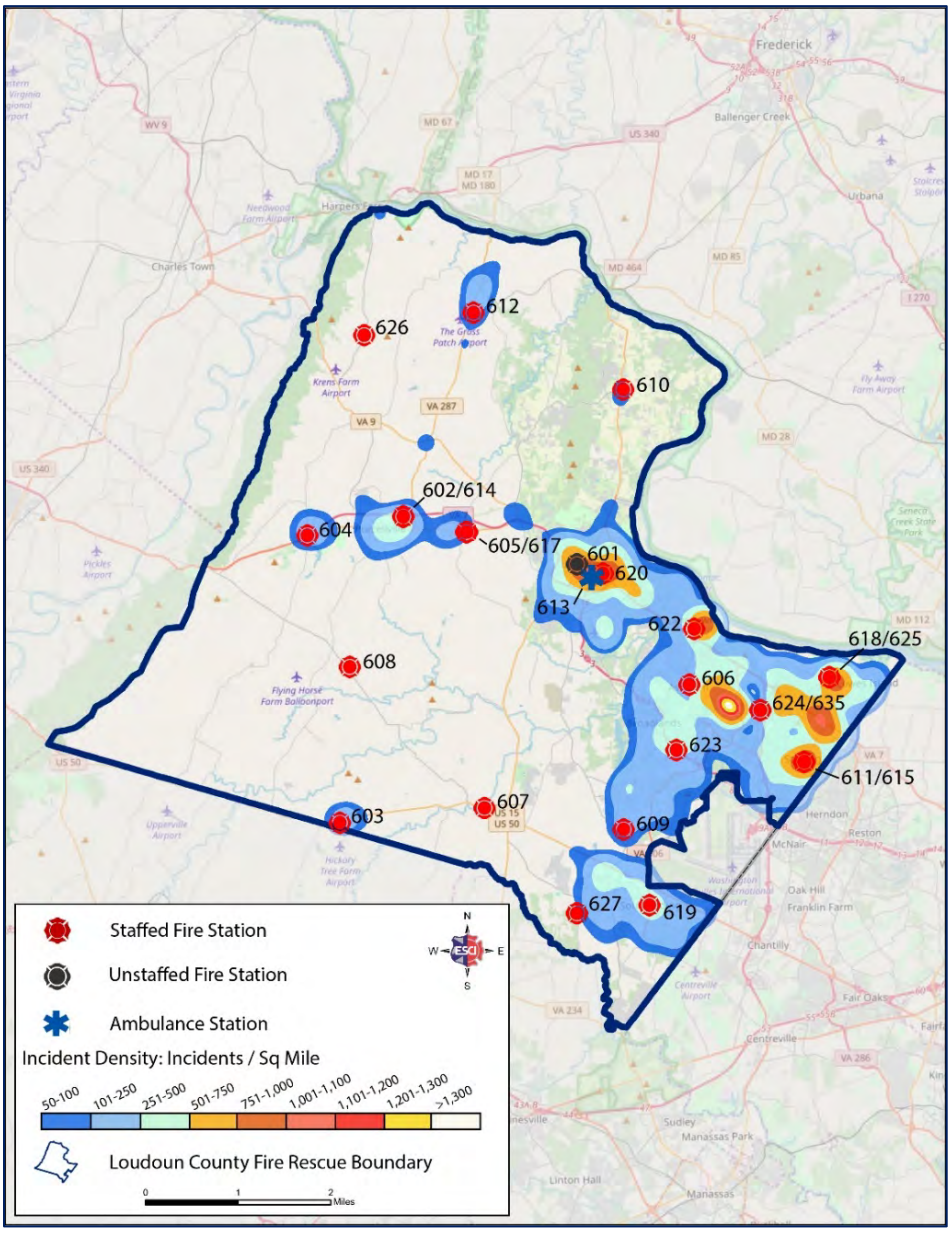


Note the locations of fire concentration shows a somewhat different pattern of incident density, however, these fires are generally located within the same station area with Stations 611, 618, and 624 showing a higher level of fire activity, as well as Station 619. This is also important to note that there are not clusters of fire calls in areas that do not have a significant number and depth of fire apparatus and stations; however, Station 619 does lie at the southern boundary of LC-CFRS's current deployment model. Additionally, although Station 627 is in the same general area, factors such as time of the day, day of the week, or current volunteer participation levels may influence the time it takes responders to arrive on the scene in sufficient number. This analysis will become crucial in the review of the LC-CFRS's ability to provide an effective response force (ERF) later in the report.

Without the necessary stations, apparatus, and an appropriate number of personnel, assembling an ERF can be difficult and empty out large portions of response areas. This level of resource utilization on a first alarm fire impacts the ability of LC-CFRS to meet concurrent and multiple fire incidents. This can have a direct result in the increased risk to the community, the inability of LC-CFRS to quickly manage incidents and reduce fire loss and negatively impact safety margins and staffing levels at fire and emergency incidents. The ability to provide an ERF in a timely manner and subsequent service delivery impacts are covered in depth later in this report.

In the next figure, EMS incident density is examined. Incident density mapping for all EMS incidents is displayed and compared with how these incidents align with the findings for fire-related incidents.

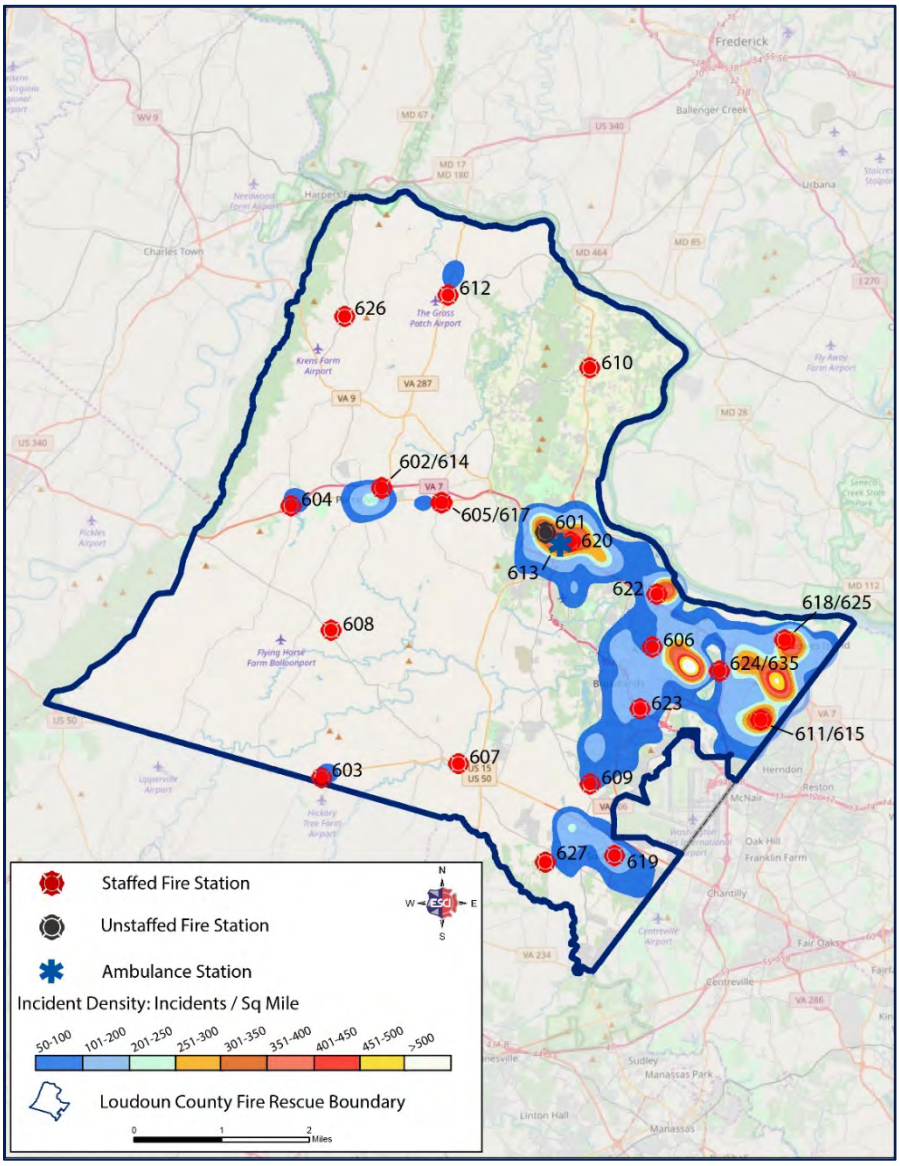
Figure 21. Incident Density Map for all EMS Calls, 2016–2018



Although the call type in this figure has changed, the population density driving service demand remains the same. Therefore, it is not surprising to see very similar patterns displayed when only EMS related incidents are analyzed for patterning. While the general patterns displayed are slightly different than the structure fire type incidents, it does display a similar pattern to the overall incident density map. This is most likely due to EMS incidents representing the predominant call type for LC-CFRS, resulting in hotspot patterns that are similar to one another.

Finally, in the last incident density analysis, only Priority 1 and 2 EMS call types are examined.

Figure 22. Incident Density Map for Priority 1 and 2 EMS Calls, 2016–2018



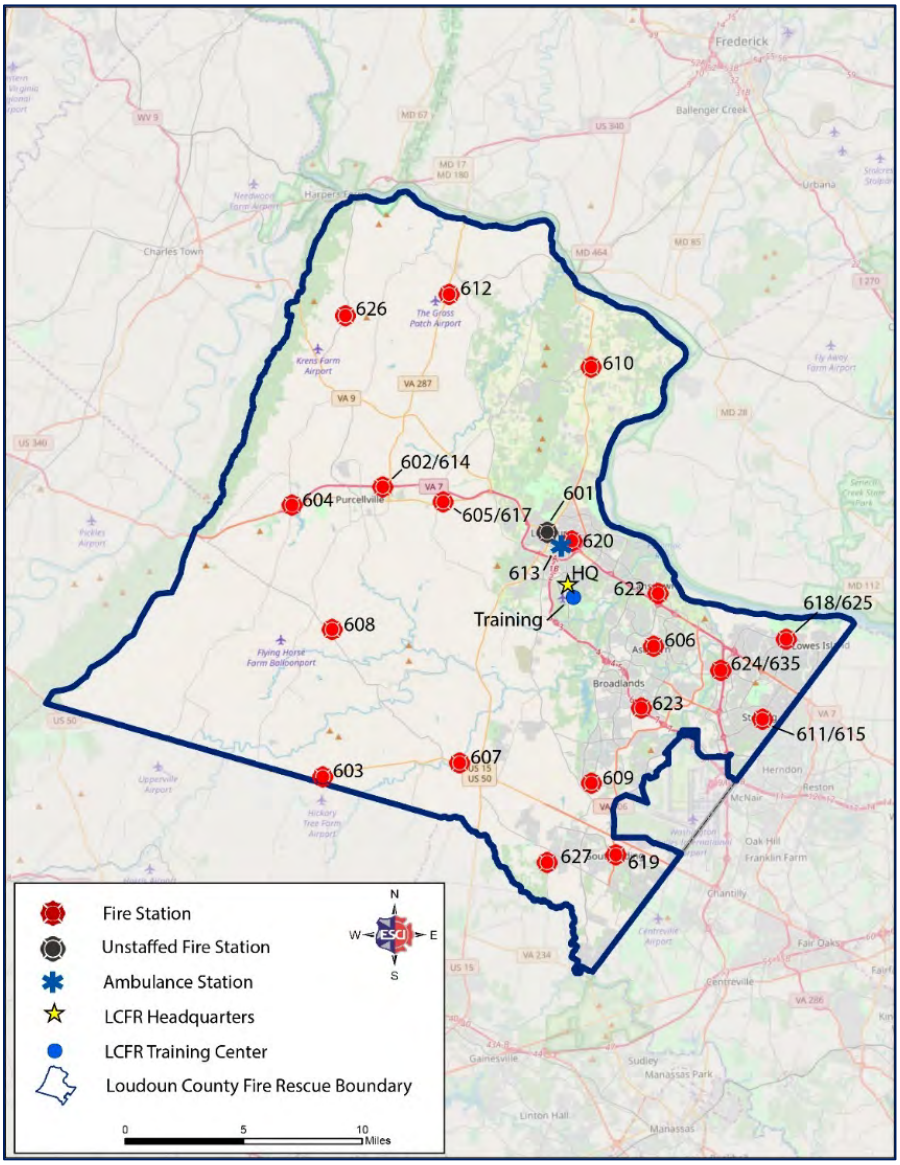
When only these serious medical calls are examined, the pattern remains very similar to that of all incidents and of all EMS incidents with most activity occurring in the densely populated areas near Stations 611, 618, 620, and 624. This is also illustrated by the higher service demand experienced by these stations relative to others. In the next section, a resource distribution analysis is provided to compare LC-CFRS with NFPA 1710.

Resource Distribution Analysis

In the *Resource Distribution Analysis* section, the distribution of LC-CFRS emergency resources is examined and compared to national standards. ESCI used Insurance Services Office (ISO) benchmarks and the National Fire Protection Association (NFPA) 1710 standard to assess the current performance capabilities and provide a baseline for future improvements. While these standards provide a benchmark with which to compare LC-CFRS performance based on national standards, it is ultimately the citizens of the LC-CFRS service area who must determine if service delivery performance meets their expectations or whether further improvements are required.

LC-CFRS operates twenty fire stations and protects a total service area of 507 square miles. LC-CFRS fire stations are located generally concentrated along the central and eastern areas of the response area.

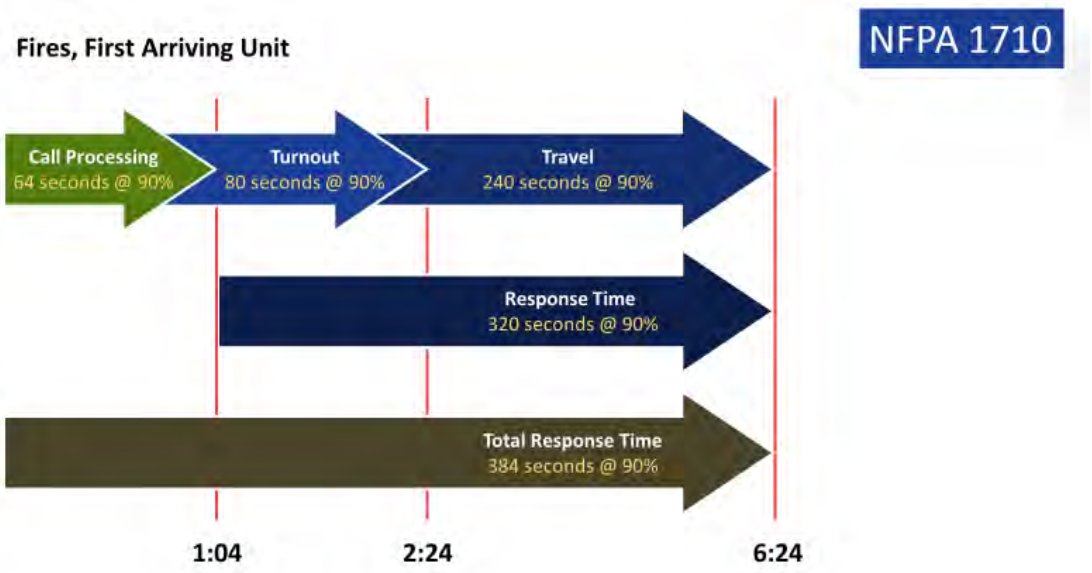
Figure 23. LC-CFRS Study Area



NFPA 1710 Criteria

NFPA standards establish benchmarks for all areas of responsibility for a fire department. In this analysis, four- and eight-minute travel times are applied to each fire station. A four-minute standard, derived from 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*, for travel was selected as it is the consensus standard for career fire department travel times. The eight-minute travel time is the established period of travel for an initial alarm assignment, meaning that all units needed to conduct fire suppression operations must arrive on the scene and commence operations within that time. NFPA 1710 allows for organizations to establish benchmarks based upon current performance and to establish benchmarks, or goals, for service delivery objectives. However, the travel time benchmark for career organizations is for the initial suppression unit to arrive on the scene in four minutes or less, 90 percent of the time and the arrival of the full initial alarm response within eight minutes, 90 percent of the time.

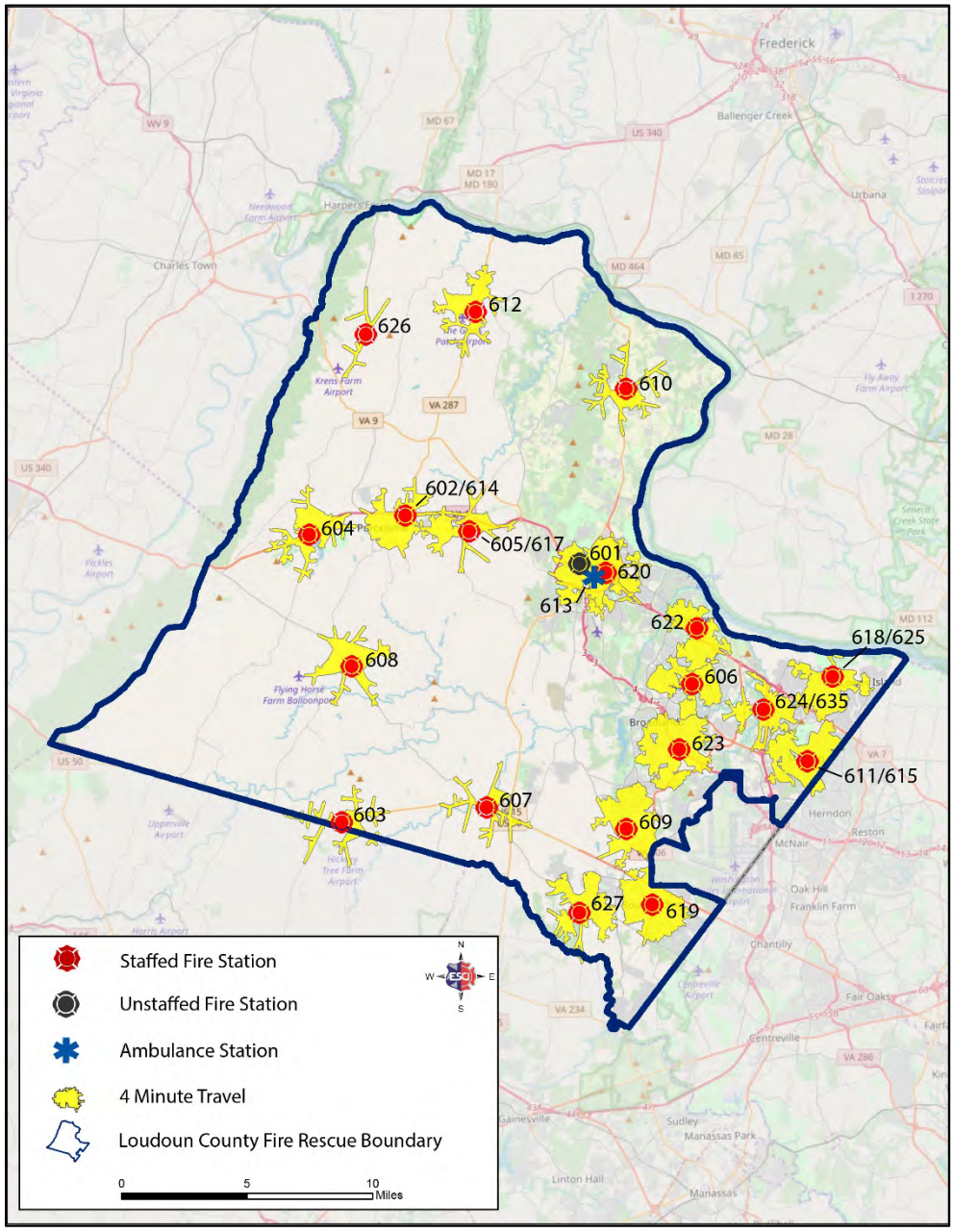
Figure 24. NFPA 1710 Requirements for First Responding Unit to Fires



Utilizing current GIS data, the figures on the following pages demonstrate potential travel times from the fire stations in the study area over the existing road network. Illustrated travel time is calculated using the posted speed limit and adjusted for negotiating one-way streets, turn delays, and intersection elevations.

The following figure demonstrates the predicted four-minute travel time as referenced in NFPA 1710.

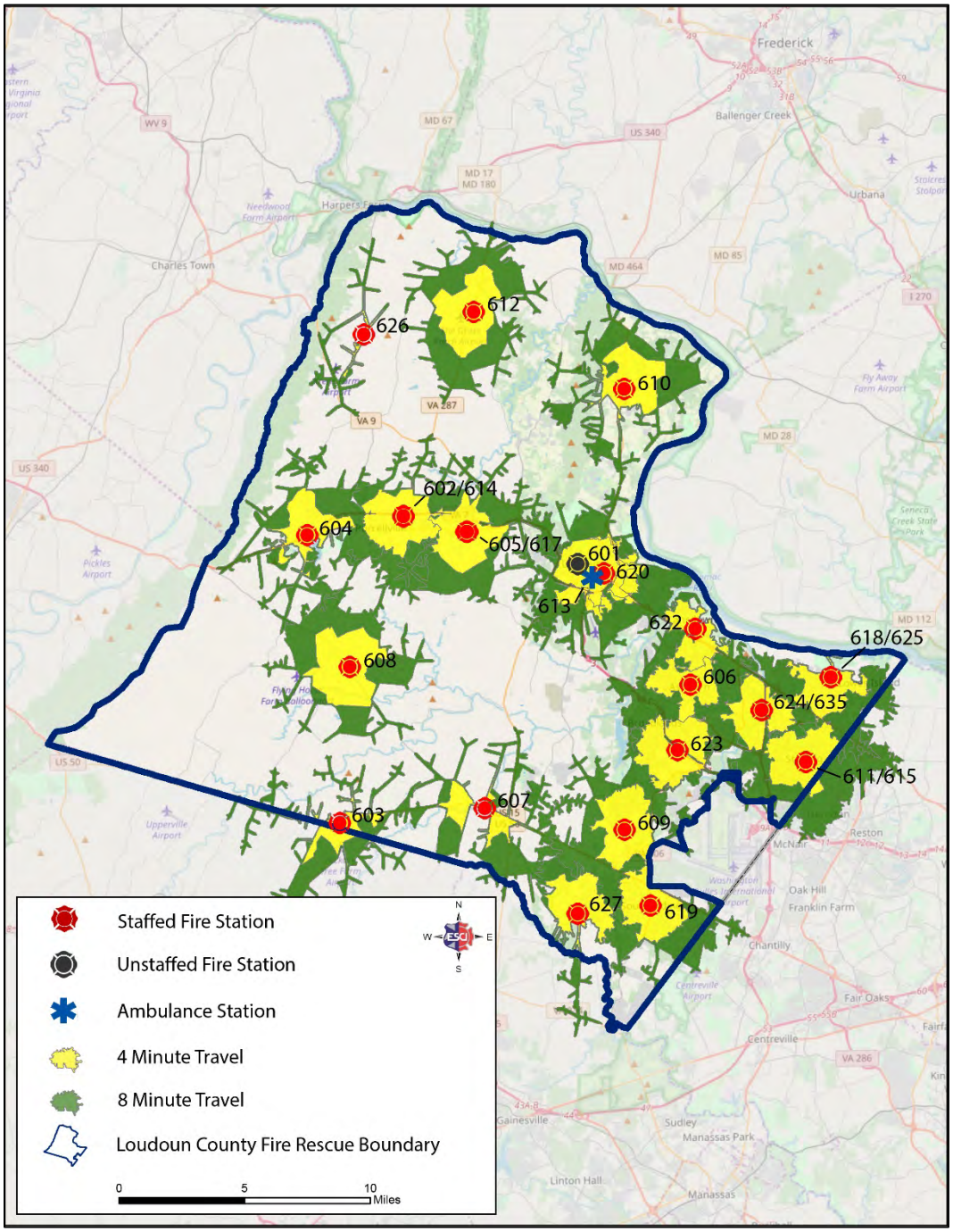
Figure 25. Four-Minute Travel from Staffed Stations



As seen in this figure, except for two stations, there is currently no overlap of four-minute travel times rom station to station. Some overlap does occur when eight-minute travel time is applied. This model is similar to that used by ISO in its overall coverage analysis. Due to the lack of overlap between station coverage areas in the four-minute model, if units in a particular station's service area are committed when an additional incident occurs within their area, LC-CFRS should anticipate extended response times due to longer travel times by responding units from other stations. The frequency at which multiple incidents occur, the impact to the overall system, and the ability for LC-CFRS to assemble an effective response force will be covered in greater detail in the following sections.

The next figure presents four- and eight-minute travel times for all staffed fire stations.

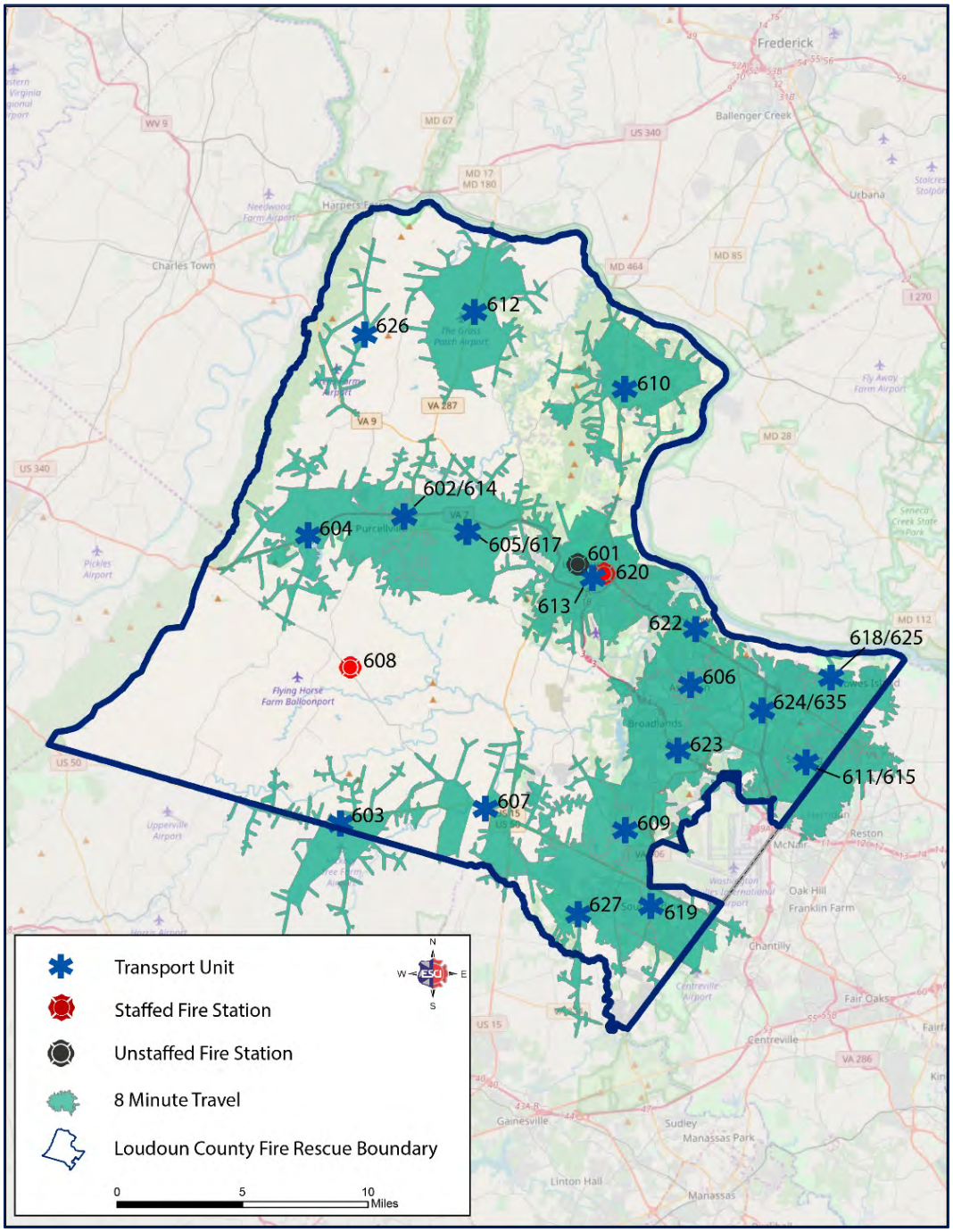
Figure 26. Four- and Eight-Minute Travel



It is apparent in this figure that most of the more densely populated sections of the study area are within eight minutes of a fire station, with predicted travel times over eight minutes occurring in areas of low population density.

Finally, EMS transport unit response is examined with an eight-minute travel time to reach the incident scene as indicated by NFPA 1710.

Figure 27. EMS Transport Unit Eight-Minute Travel

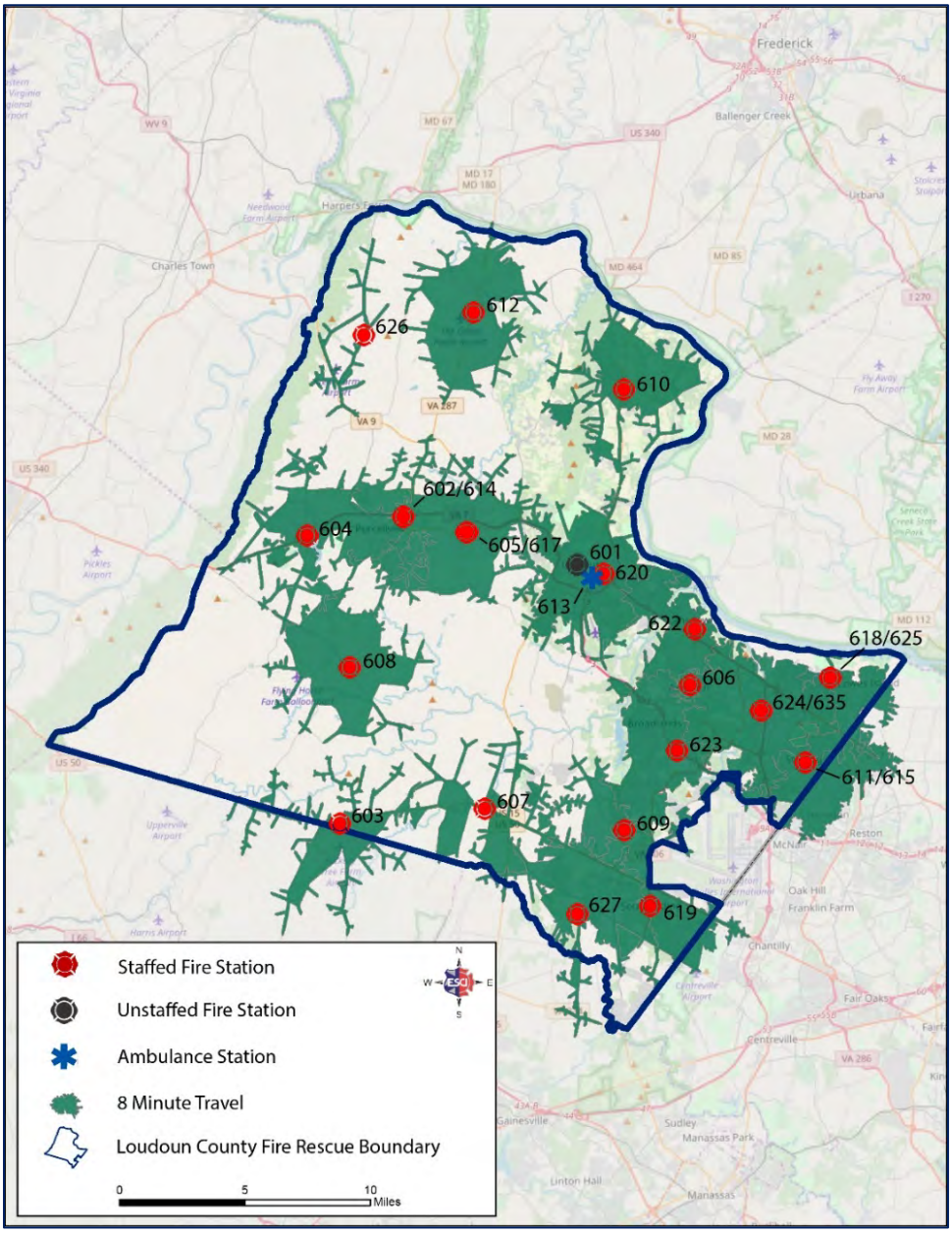


NFPA 1710 calls for the arrival of a fire department transport unit within a 480-second or eight-minute travel time, as long as the primary ALS first responder arrives on scene within a 240 second or less travel time. Although this figure illustrates large areas of the county that lack coverage, a review of the incident density maps reveals that the majority of service demand within the county is provided by one or more transport units within the required eight-minute travel.

Resource Concentration Analysis

The ability for fire departments to assemble resources from multiple areas to initiate safe and effective fire suppression and rescue operations is critical to the overall success of the department. Accepted firefighting procedures call for the arrival of the entire initial assignment—sufficient apparatus and personnel to effectively deal with an emergency based on its level of risk—within a reasonable amount of time. This is to ensure that enough people and equipment arrive soon enough to safely control a fire or mitigate an emergency before there is substantial damage or injury. LC-CFRS operates from 20 separate fire/EMS stations. The following figure provides LC-CFRS's ability to provide coverage within an eight-minute travel time from each staffed station within the county.

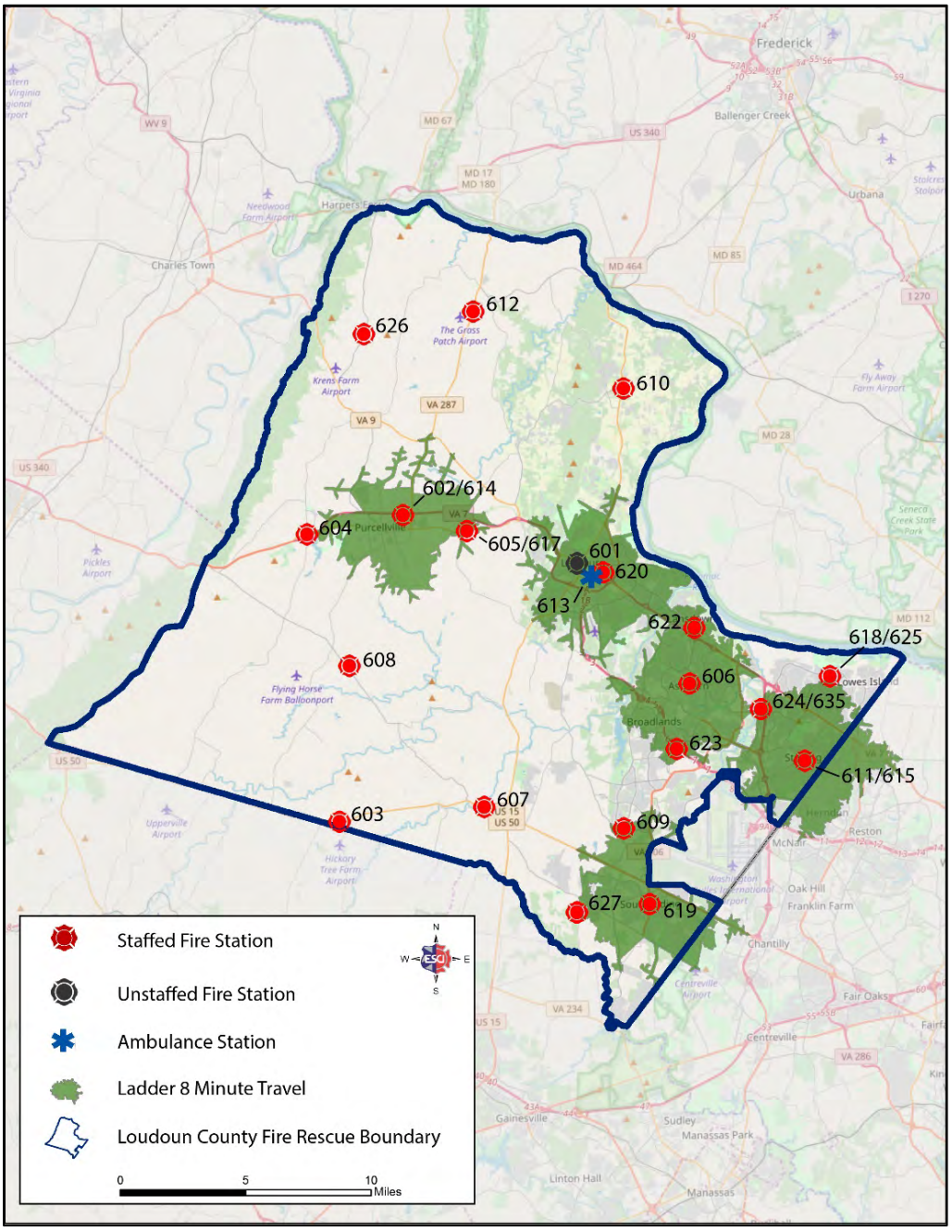
Figure 28. LC-CFRS Eight-Minute Travel



Eight minutes is the recommended objective for assembling an initial full alarm assignment (other than a high-rise) under NFPA 1710. This map shows the apparatus available within an eight-minute predicted travel time from each staffed fire station. Using this predictive travel assessment, the figure illustrates LC-CFRS's deployment capabilities, assuming that all units are in quarters and available.

Personnel responds with apparatus and it is important to know what number of personnel will be able to respond in this timeframe. The following figures predict the apparatus types and resources available within the eight-minute travel time.

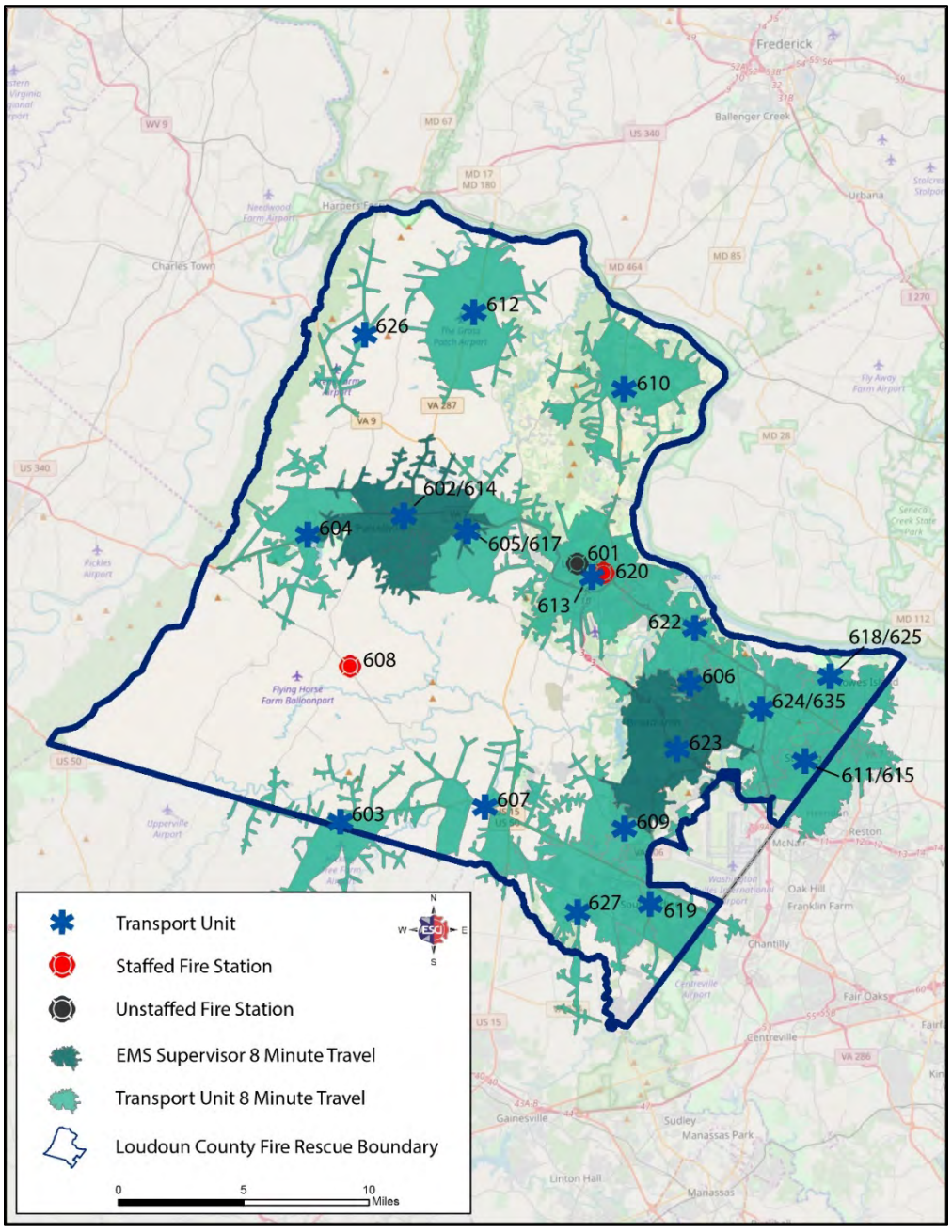
Figure 29. Resource Concentration for Ladder Company Response



In Figure 29, an eight-minute response area is depicted for truck companies to establish the area to which they can successfully contribute to an effective response force (ERF). This figure displays the maximum area that these resources can respond to and contribute to the assembly of an ERF in adequate time to promote a positive outcome for suppression. As seen in the figure, all Loudoun County truck company resources are located in the center and southeastern parts of the county in the areas of greatest population density. Coverage for other areas of the county including northern, southern, and western areas must anticipate prolonged travel times when awaiting ladder company resources.

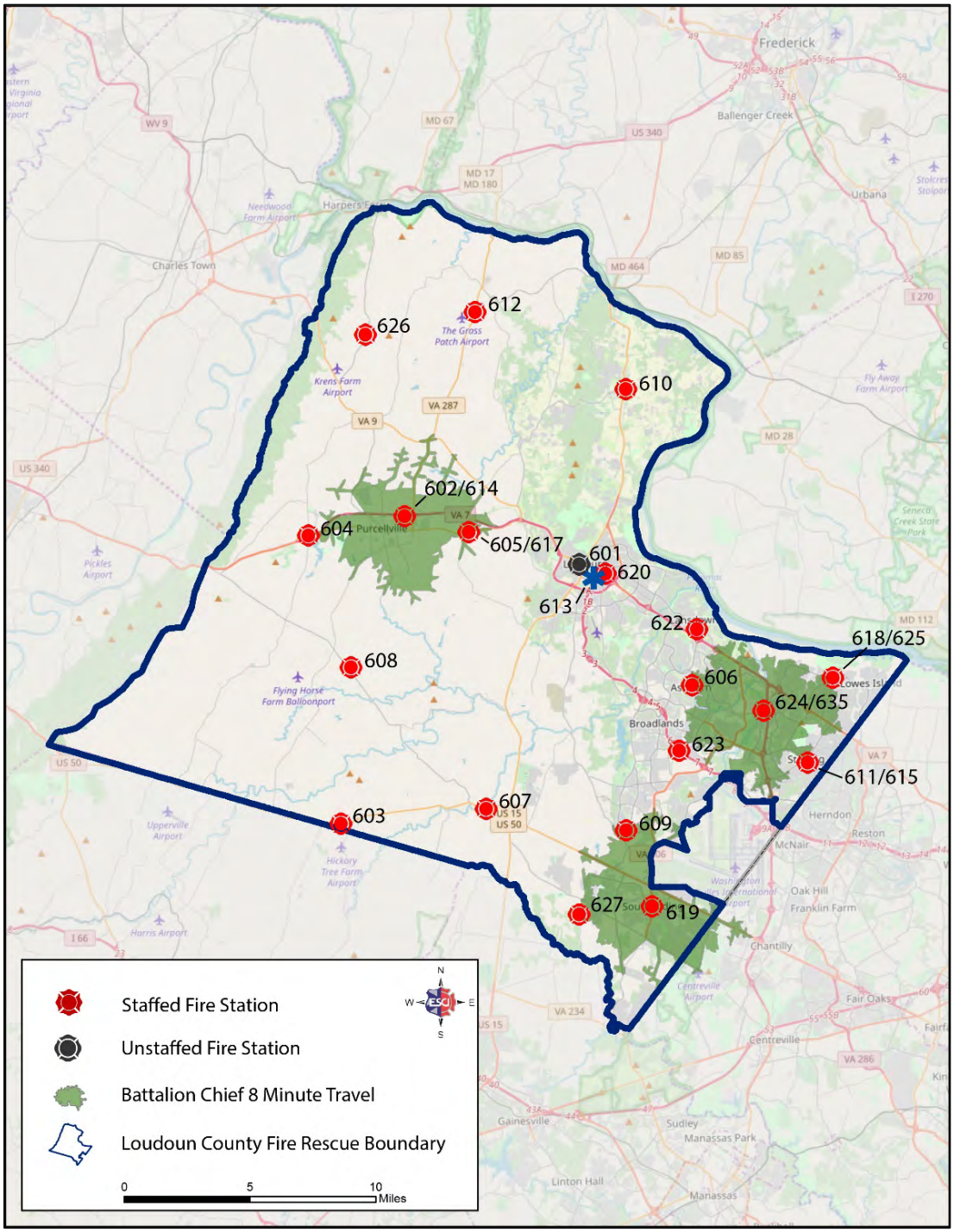
The next figure displays the EMS capabilities for LC-CFRS to respond both transport units and EMS Supervisors.

Figure 30. Resource Concentration for EMS Supervisors and Ambulance Response



LC-CFRS may consider adding additional EMS support resources, to include additional EMS supervisors and safety officers, at some point in the future. Currently, due to the size, traffic congestion, and distribution of calls, units requiring an EMS Supervisor may experience extended wait times for a resource to arrive on the scene. To provide an additional look at Supervisor distribution across the County, the next figure illustrates the location and distribution of LC-CFRS on-duty Battalion Chiefs.

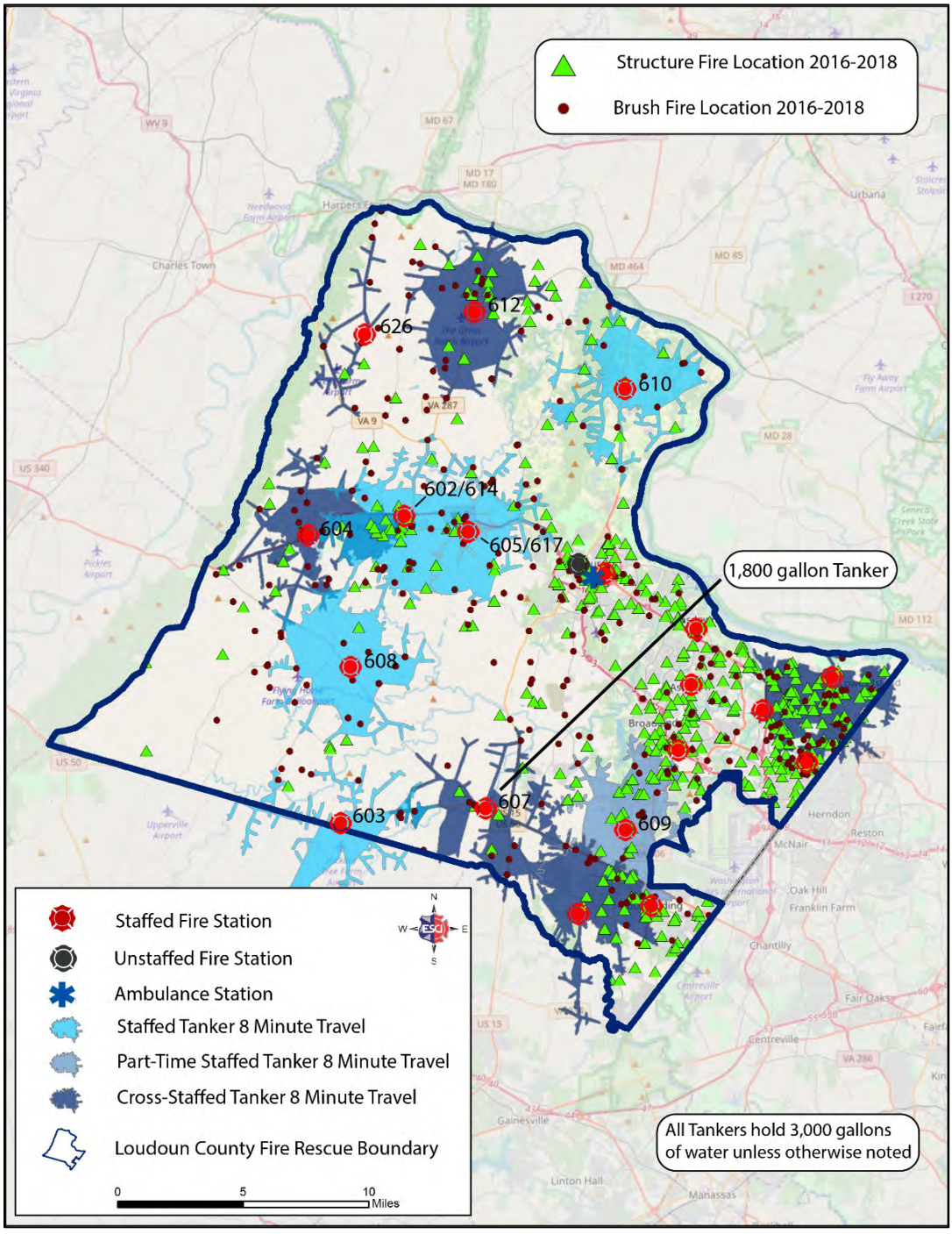
Figure 31. Resource Concentration of Battalion Chiefs



Currently, three battalion chiefs are distributed across areas of high population density. In the future, LC-CFRS may consider adding additional battalion chiefs to provide a more uniform countywide, as well as provide some degree of overlap in the areas of greatest risk.

Next, the distribution of tankers is examined and compared with the location of brush fires occurring between 2016 and 2018.

Figure 32. Resource Concentration of Tankers/Structure and Brush Fire Locations, 2016–2018



While the current distribution of tankers across the county provides adequate coverage for most of the rural area, fires occurring around Station 612 may have extended wait periods for tankers to deliver additional water for fires. LC-CFRS may consider adding an additional tanker to this area or redistributing resources to ensure adequate coverage.

Finally, the response capabilities for the heavy rescue and technical rescue team, followed by the hazardous materials response units, are reviewed and discussed.

Figure 33. Resource Concentration of Rescue Squads

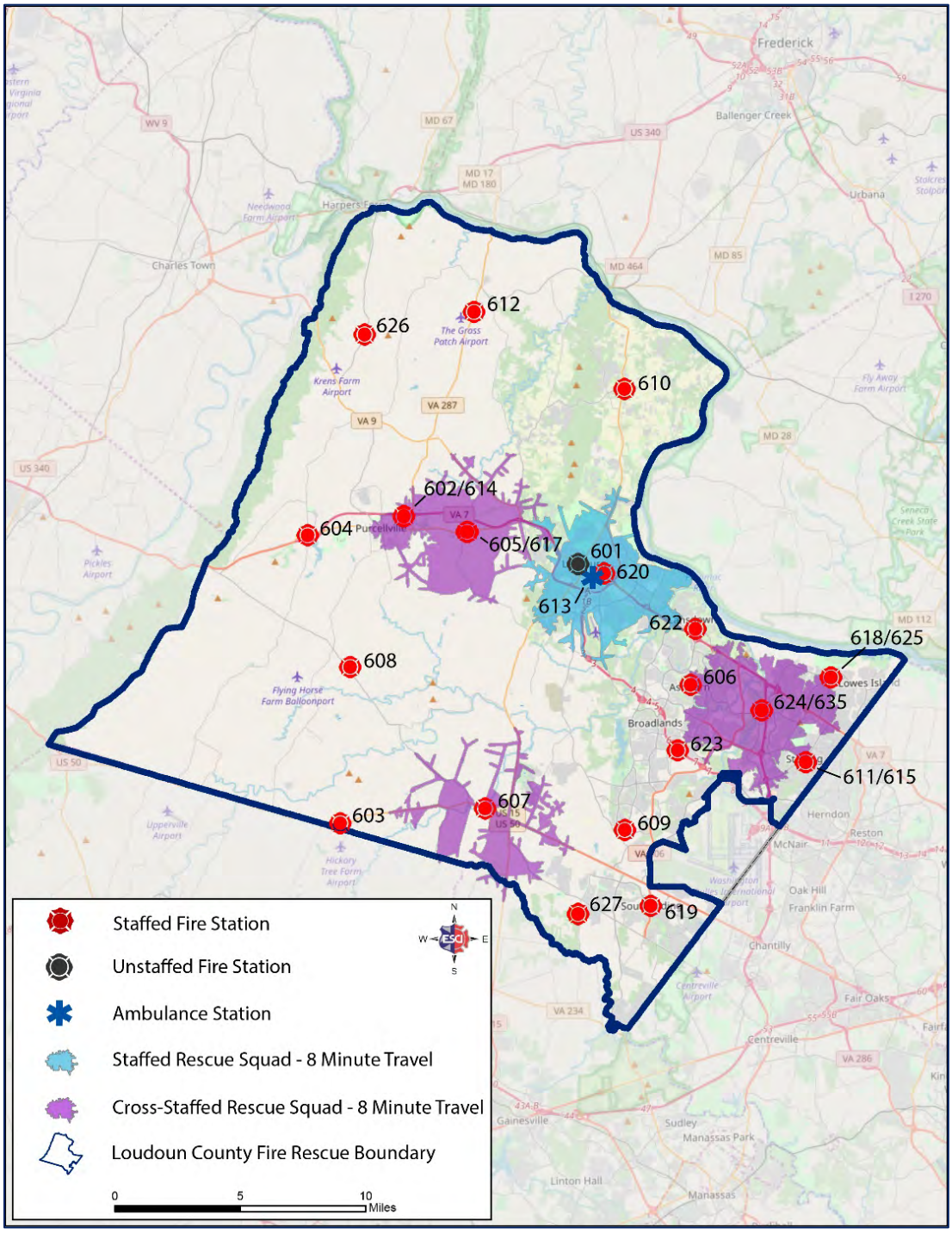
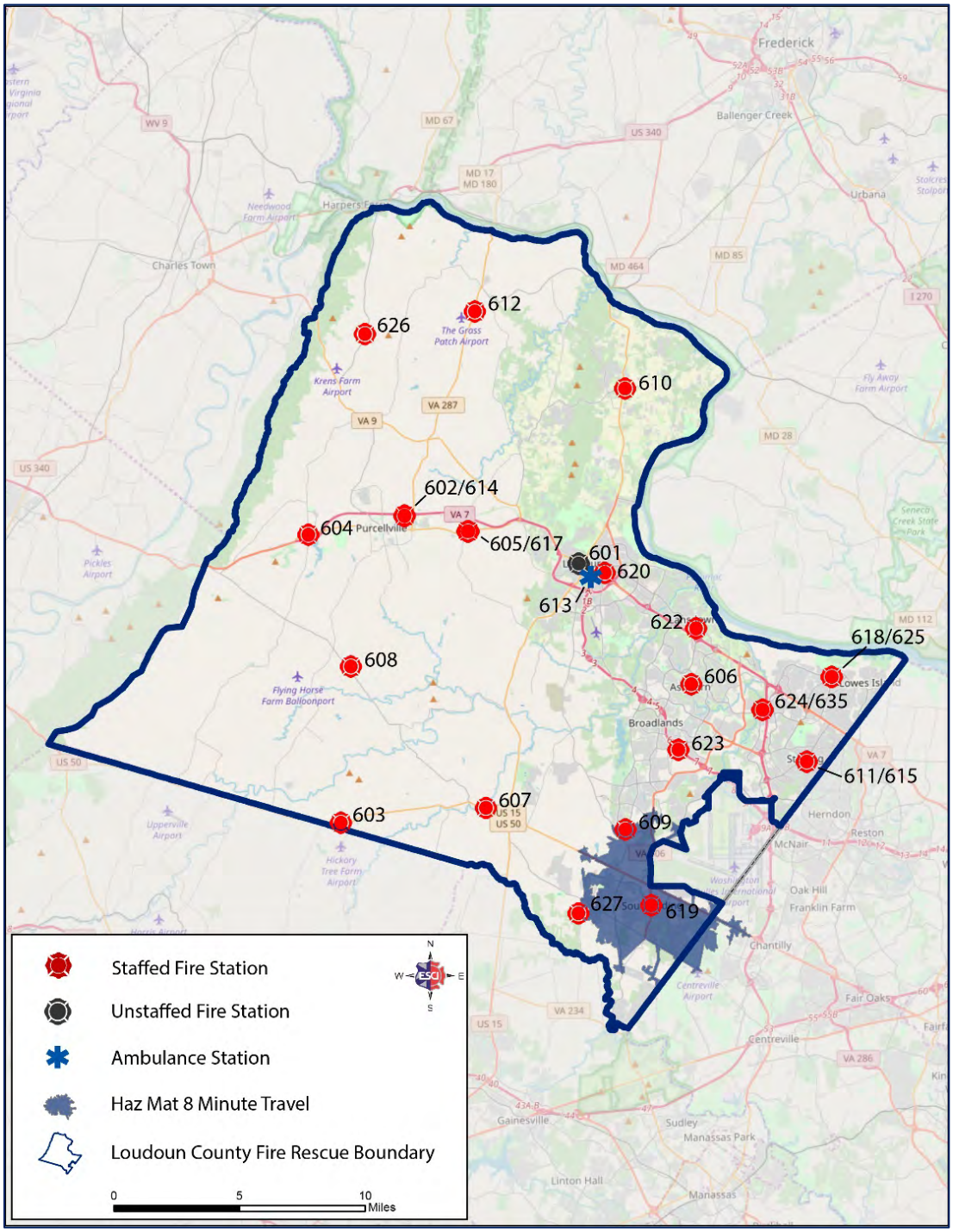


Figure 34. Resource Concentration of Hazardous Materials Resources



Technical rescue and hazardous materials rescue teams, apparatus, and equipment are specialized and resource-intensive programs to maintain. Although there are additional technical rescue and hazardous materials resources in the County, the resources at Station 619 represent the only resources of this kind in which LC-CFRS has allocated dedicated staffing. LC-CFRS plans to move Haz Mat 619 to Station 628 in "Leesburg South" in the future. ESCI agrees that this will provide an improved response footprint in accordance with identified Haz Mat risk factors.

Response Analysis

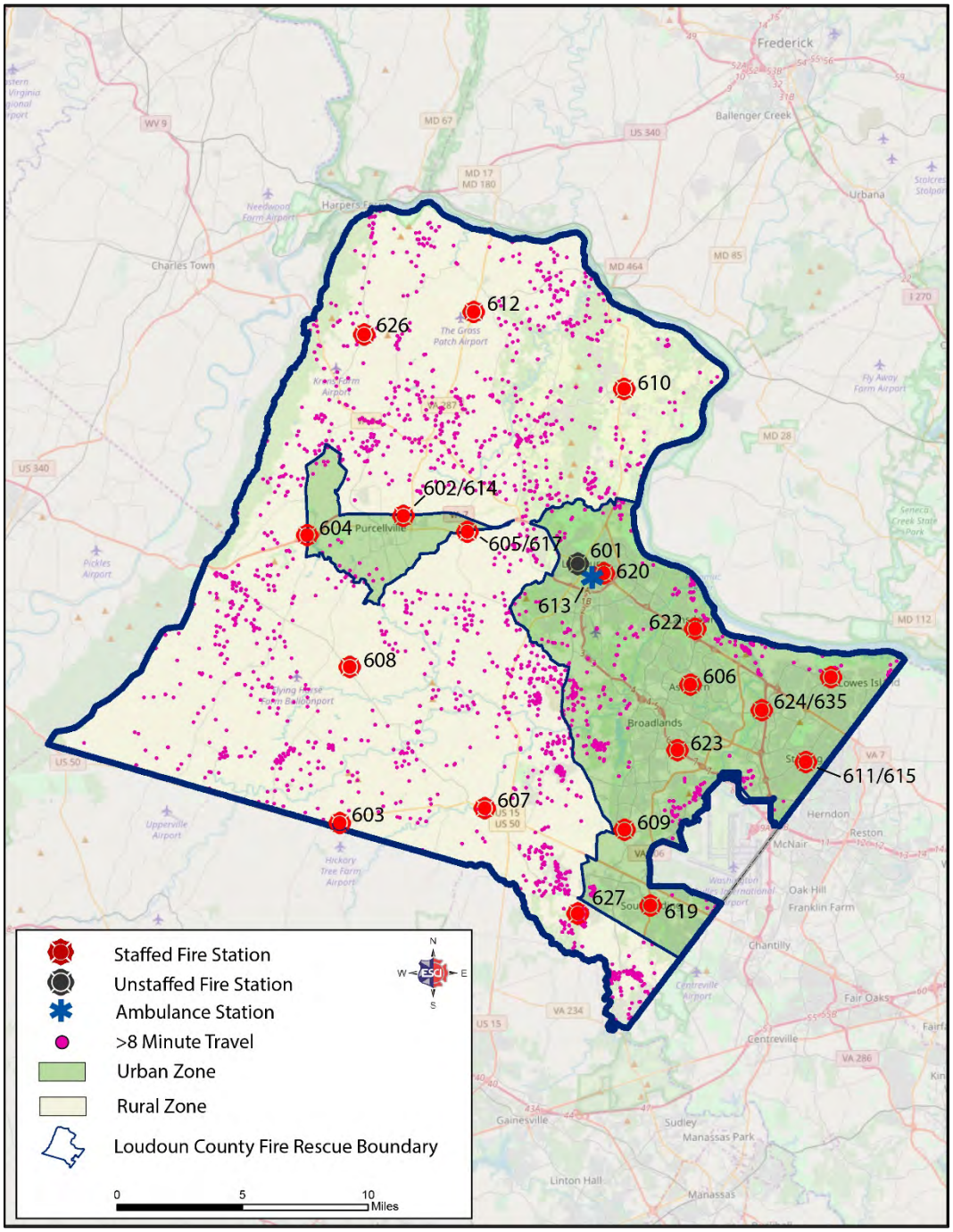
Response time performance is the single most publicly visible component of an emergency services delivery system. Policymakers and citizens want to know how quickly they can expect to receive emergency services. Due to the size, population distribution, and complexity of Loudoun County, ESCI conducted a series of analyses to provide LC-CFRS with baseline performance and response zones that accurately reflect the current NFPA 1710 capabilities within the county. The response zone analysis is presented first, followed by an analysis of fractile performance for each zone.

Response Zone Analysis

Loudoun County is comprised of areas with population densities ranging from high urban densities to rural, sparsely populated areas. Additionally, this change from urban to rural occurs relatively abruptly and in a sense, separates the county in two halves with an urbanized east and central corridor, and rural western half. Based on this difference, ESCI suggests that LC-CFRS consider two response standards within the County, an urban response standard and a rural response standard. Further, as heavier development continues around the Dulles Airport, the department might even consider a third, metro, response zone in the future.

The foundation for this recommendation was developed using GIS software to create a predictive analysis of travel times to incidents occurring from 2016 through 2018. Based on NFPA 1710, incident locations outside of a predicted eight-minute travel time are shown. The results revealed that LC-CFRS's deployment strategy closely aligns with population density and development and these predicted travel distances create a pattern that supports the suggestion that two response standards are appropriate at this time. The results of the analysis are shown in the following figure.

Figure 35. Predicted Travel Times Over Eight Minutes



In this figure, pink dots represent a predicted travel time greater than eight minutes (9.0 percent of total incidents). Additionally, an urbanized response zone overlay, shown in green, representing census block groups of population densities of greater than 500 people per square mile and a rural response zone, shown in tan, representing rural areas with population densities less than 500 people per square mile are displayed. The following figure provides a breakdown of predicted response performance by urban and rural response zones.

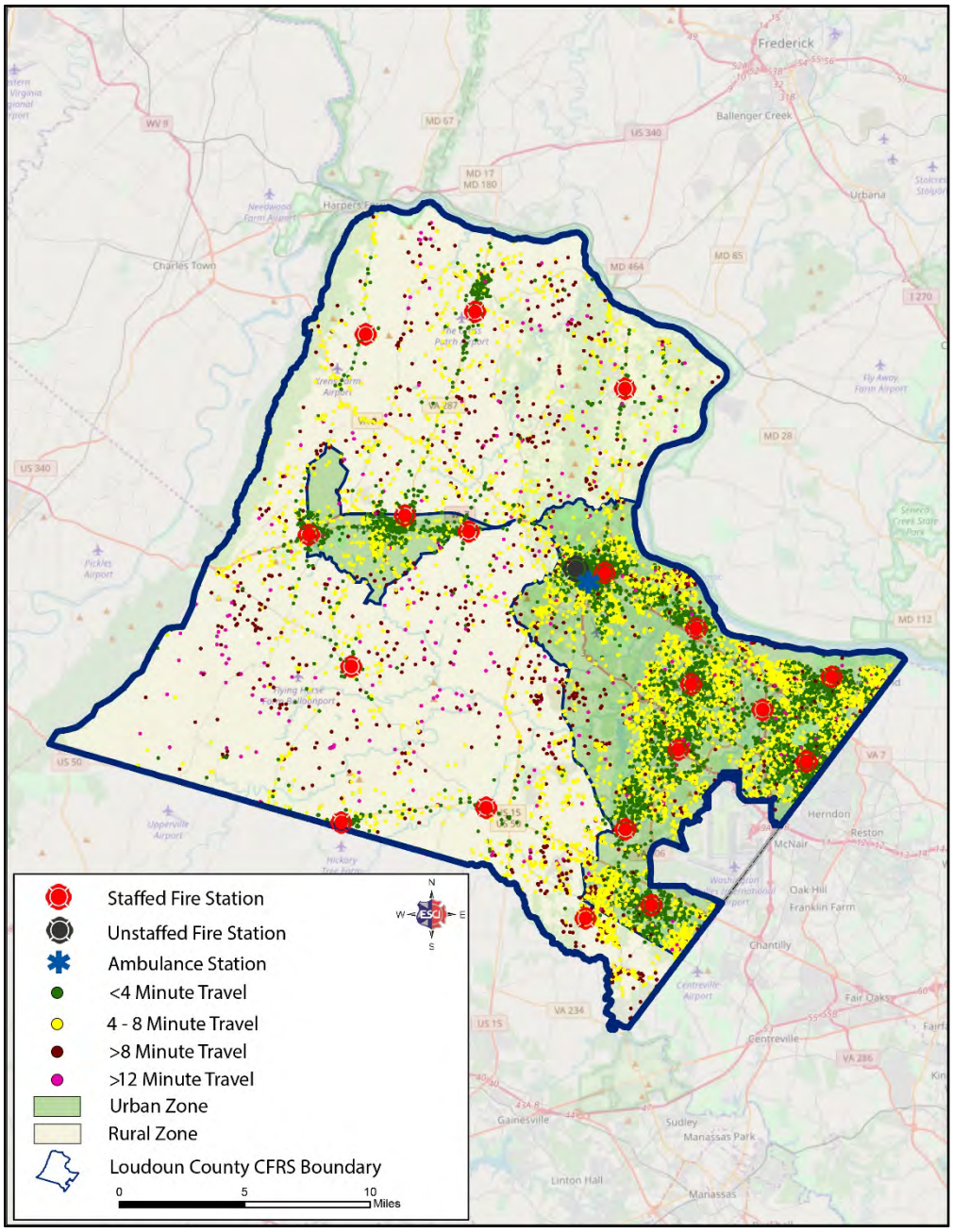
Figure 36. Urban and Rural Zone Call Distribution by Predicted Travel Time, 2016–2018

Predicted Travel Performance		
	Urban	**Rural**
< 4 Min	61.9%	23.3%
4–8 Min	34.7%	37.8%
> 8 Min	3.5%	38.9%
Total Number of Calls	41,694	7,782

When the predicted travel times and response zones based on population density are shown together, a pattern is evident in which fire stations within the urbanized zone tend to have high concentrations of service demand surrounding them with relatively few responses exceeding an eight-minute travel time, while the rural area displays a random "shotgun pattern" effect with much less call clustering and a higher rate of travel times over eight minutes.

To confirm the predicted findings, the following figure presents the same illustration using actual travel times to incident locations.

Figure 37. Actual Travel



As with the predicted performance, actual travel times show a similar pattern with four minutes or less (47.1 percent) shown in green, four to eight-minute travel (44.1 percent) shown in yellow, eight to 12-minute travel (6.3 percent) shown in maroon, and greater than 12-minute travel (2.5 percent) shown in pink. As with the previous figure, incidents within the urbanized area tend to cluster around fire stations and bullseye outward with relatively few responses greater than eight-minutes, while the rural area displays a more random distribution of incident locations.

The following figure provides the distribution of actual travel times within the urban and rural response zones with the total number of incidents measured for each. These figures represent incidents which occurred from 2016 through 2018 that contained travel times within the data.

Figure 38. Urban and Rural Zone Call Distribution by Actual Travel Time, 2016–2018

Actual Travel Performance		
	Urban	**Rural**
< 4 Min	50.8%	25.2%
4–8 Min	43.6%	47.1%
8–12 Min	3.9%	20.2%
> 12 Min	1.7%	7.5%
Total Number of Calls	35,489	5,937

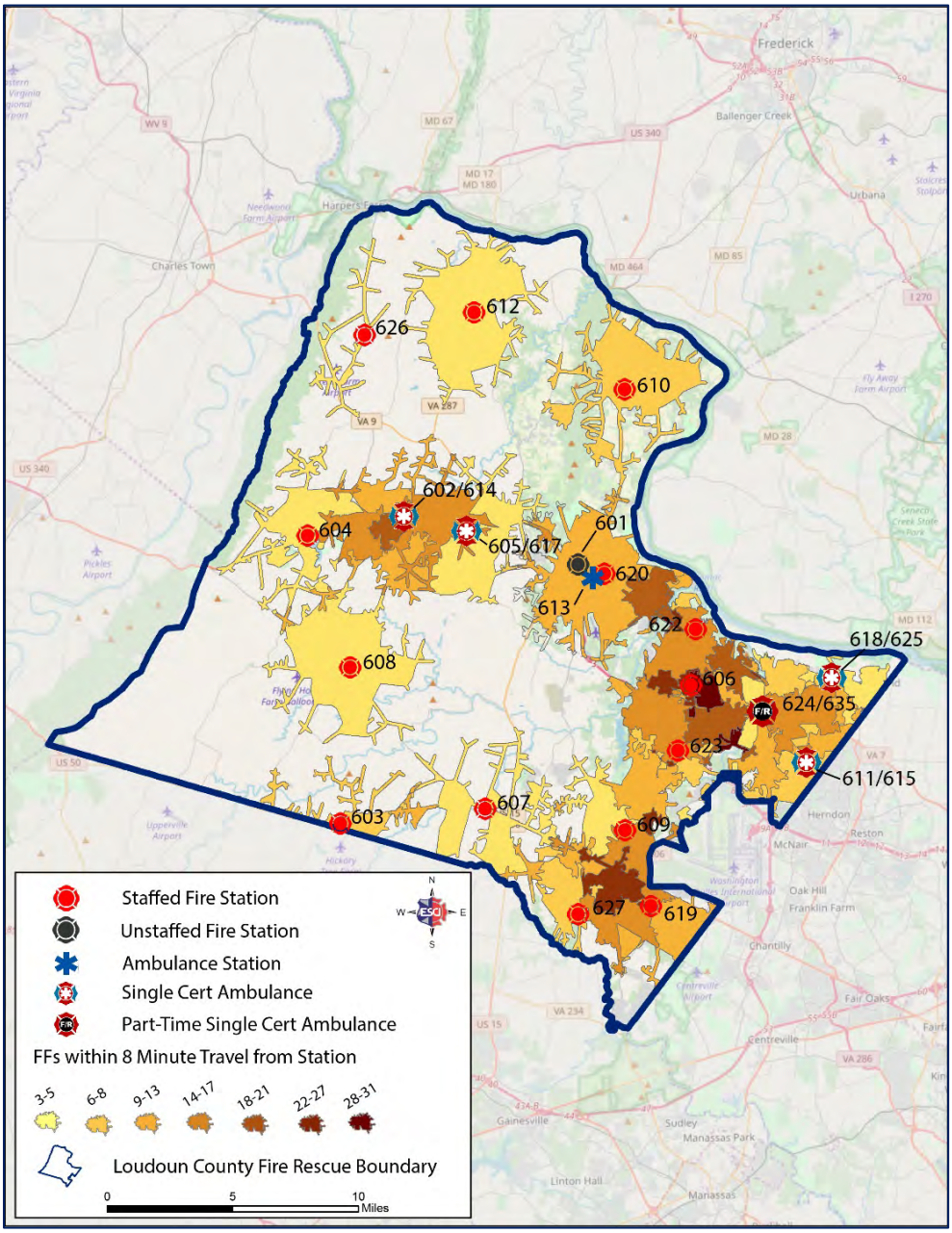
Within the urban zone, 94.4 percent of calls occurred within eight minutes; while in the rural zone, approximately three-quarters, or 72.3 percent, of calls occurred within an actual eight-minute travel time. Additionally, the majority of calls within the urban area had travel times of four minutes or less (50.8 percent) while in the rural zone, the four to eight-minute travel represents the largest classification of travel times.

Effective Response Force

The Resource Concentration Analysis examines LC-CFRS's ability to assemble an Effective Response Force (ERF) for moderate risk incidents, such as a single-story residential structure fire, within the time allowable by NFPA 1710. For this analysis, an eight-minute travel envelope is shown for each fire station and the minimum daily staffing at each was used to calculate total available resources that could be assembled within eight minutes at each station to depict LC-CFRS's capabilities. The results of this analysis are displayed with lighter colored areas representing low personnel response capabilities and darker colored areas representing denser resource capabilities.

The following figure presents a resource concentration analysis using the eight-minute NFPA 1710 standard for the assembly of an ERF using current LC-CFRS minimum staffing values. In the figure, fire resources within eight minutes of travel from their respective stations to the incident are displayed. As illustrated in the figure, there are districts in the study area, even with automatic aid, that cannot assemble an effective response force for even a moderate risk fire incident.

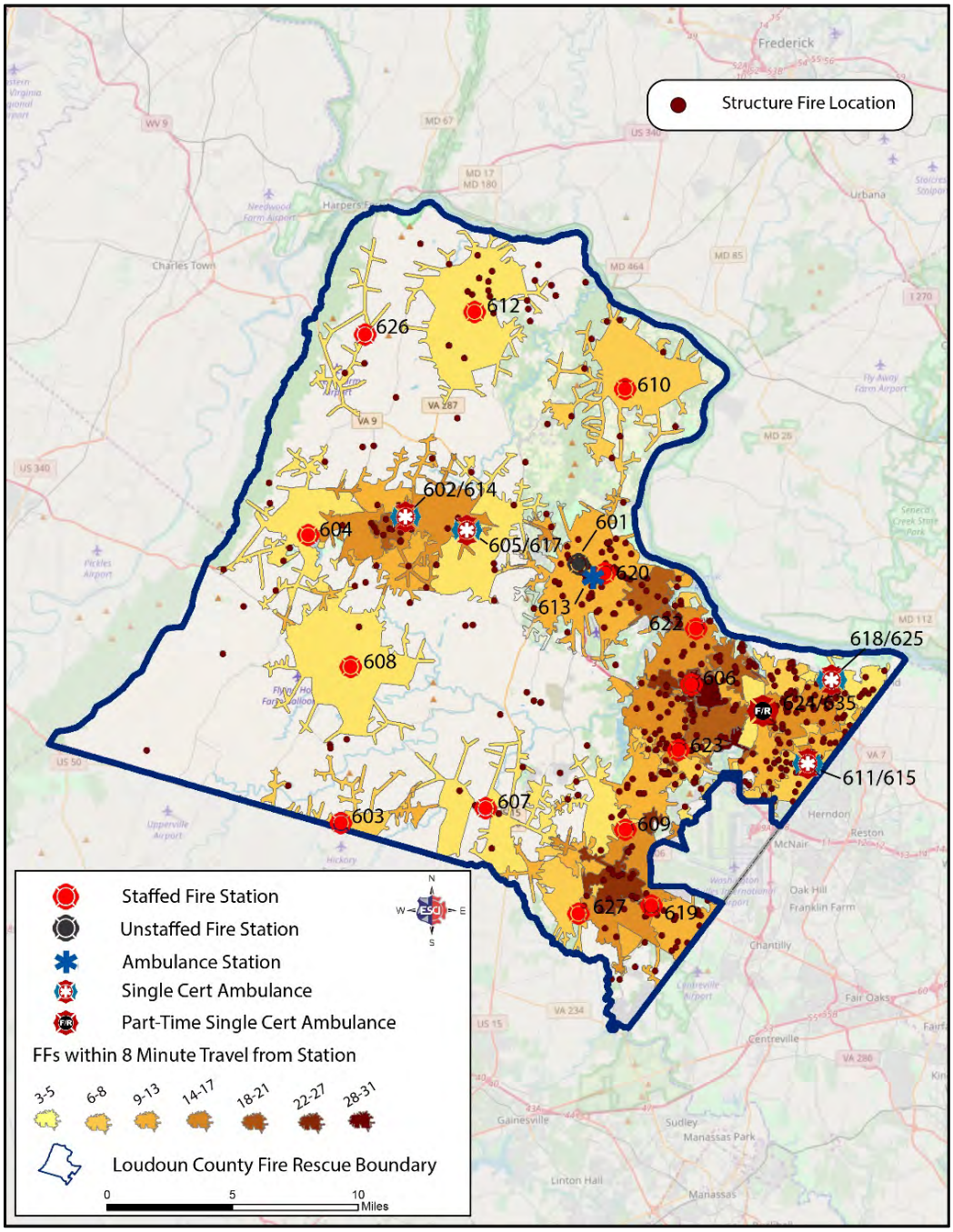
Figure 39. Effective Response Force



While there are several types of incidents that require large numbers of firefighters to effectively mitigate, working structure fires are one of the most common. Several critical tasks are required for such an event and, while these incidents can be mitigated with fewer firefighters, the opportunities for delays, injuries, and less than optimal suppression is likely. For example, a single story, 2,000 square foot residential structure fire will require 13 to 15 firefighters to complete all critical tasks and extinguish the fire while minimizing loss.

The following figure provides the same ERF map as shown previously, but with working structure fires overlaid to illustrate where the risks are occurring versus where fire department staff is located.

Figure 40. Effective Response Force with Working Structure Fires, 2016–2018



As seen in this display, although the majority of structure fires occurred in areas where firefighters could arrive on the scene in a timely manner and in sufficient number, northern areas of the county and remote locations could pose additional hazards to first arriving units who will be understaffed to appropriately suppress and extinguish the fire. It should also be noted that the utilization of Station 608 has an inherent delay in responses in and around the Jeb Stuart Road area which requires Station 608 units to travel around the road and take alternative routes. This obstacle can result in a three- to four-minute travel time delay.

Figure 41. Effective Response Force with Automatic Aid

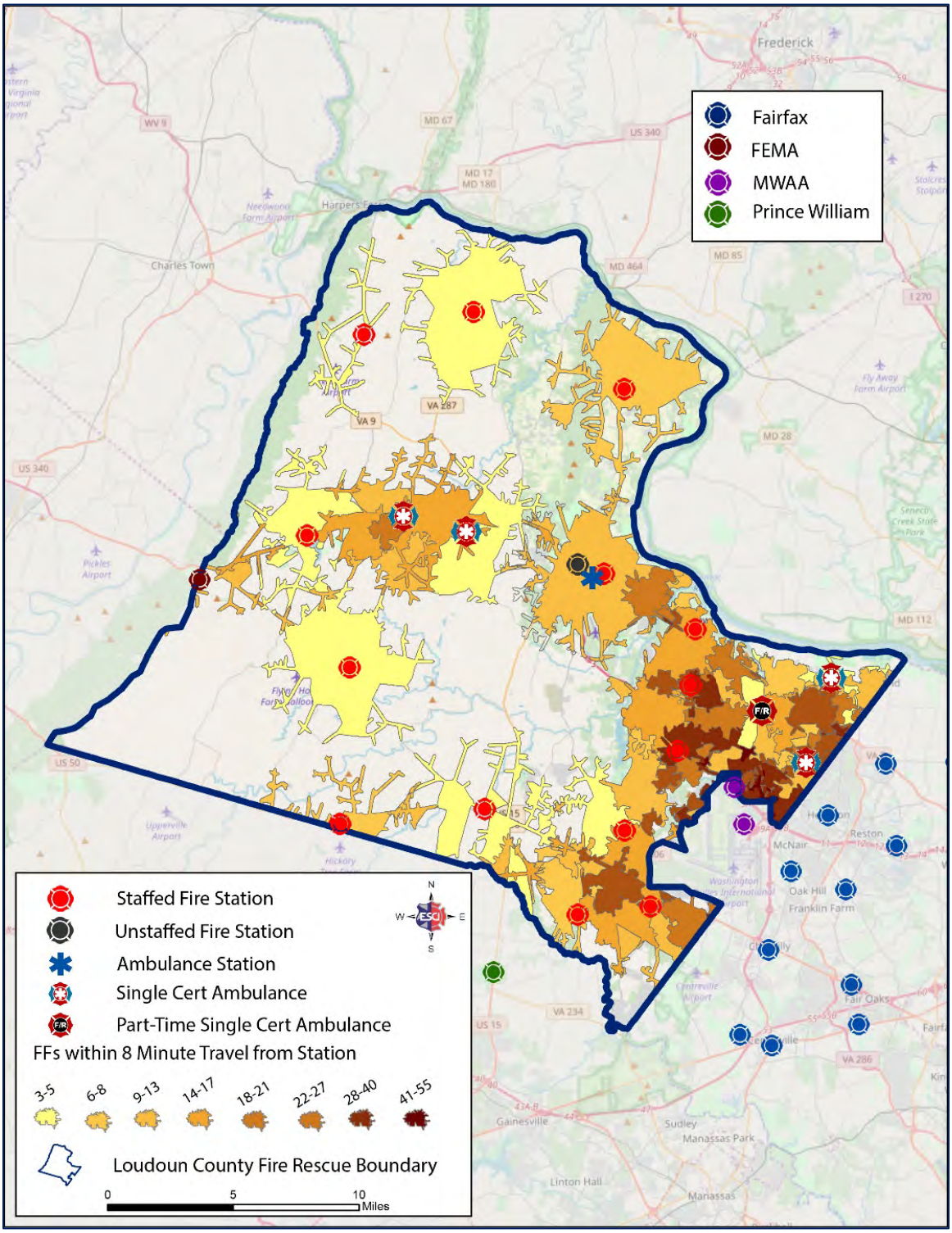


Figure 41 shows the impact on LC-CFRS's ability to assemble an ERF of a recent initiative in the NOVA region that provides for the automatic aid utilization of Fairfax County units based on a CAD-to-CAD interface without a delay in dispatching.

NFPA 1710 Fractile Analysis

Based on the findings from the previous section, fractile performance metrics will be presented in three classifications: Countywide, Urban and Rural performance. These response time performances are comprised of the following components:

- **Call Processing Time:** The time interval from when the call was initially received by the dispatch center until the first responding unit was notified.
- **Turnout Time:** The time interval between when units are notified of the incident and when the apparatus responds.
- **Travel Time:** The amount of time the responding unit actually spends on the road traveling to the incident until arrival at the scene. This is a function of speed and distance.
- **Response Time:** Calculated from the time the fire department is dispatched to the arrival of the first apparatus. Response Time equals the sum of "Turnout Time," and "Travel Time."
- **Total Response Time***:* Calculated from when a call is initially received by the dispatch center until the first responding unit arrives on the scene.

Tracking the individual components of response time enables organizations to identify deficiencies and areas for improvement. Once organizational leaders understand the current performance for Turnout Time, Travel Time, and Response Time, this information can be used to develop response goals and standards that are both relevant and achievable. Fire service best practice documents recommend that fire service organizations monitor and report the components of total response time.

The Time Continuum is the time between when a caller dials 911 and when assistance arrives. The Time Continuum is comprised of the three elements listed above—Turnout Time, Travel Time, and Response Time—and includes Call-Processing Time. The Call-Processing Time is the amount of time between when a call is answered by the 911 Primary Public Safety Answering Point (PSAP), and when resources are dispatched. Total Response Time is the sum of call-processing time, turnout time, and travel time.

The components of the LC-CFRS Time Continuum will each be evaluated in further detail in the next sections.

Call Processing Time Performance

The industry standard for call processing (or alarm handling) is NFPA 1221: *Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems*. This standard provides for communication centers to have processing times of not more than 64 seconds, 90 percent of the time. For special operations, calls requiring translation, or other factors described in the standard, times should not exceed 90 seconds at the 90th percentile.

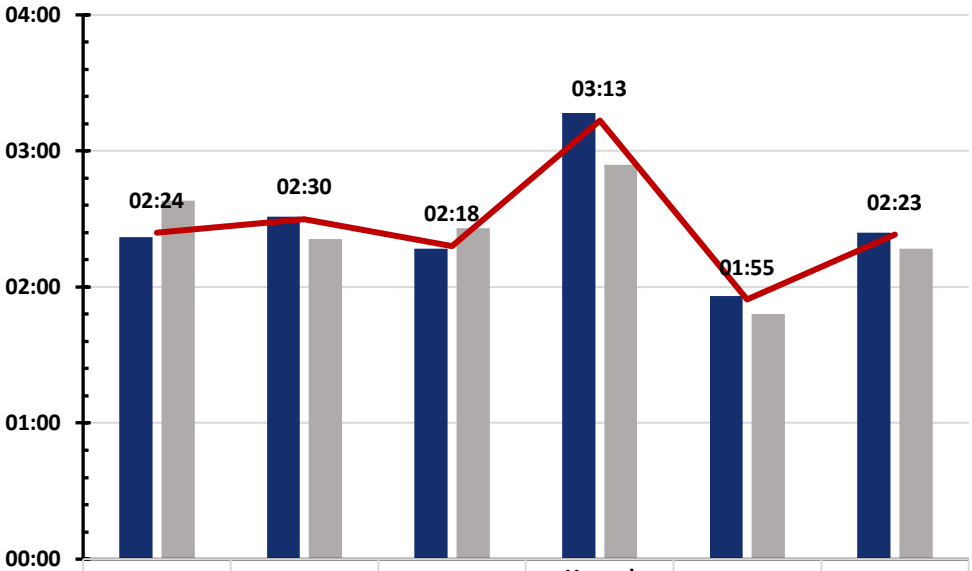
The next figure displays the call processing time results for CAD data provided by Loudoun County's communications center for 2017 and 2018. This information is presented to provide a comparison of the individual steps taken by the communications center when processing calls and their performance, provided in both average and 90th percentile categories for major call types and overall processing times. In 2017, LC-CFRS dispatch implemented Automated Secure Alarm Protocols (ASAP) for auto-generated calls for service from monitored alarm stations. This service and protocol have resulted in a significant reduction in call taking time for these types of monitored alarm sources.

Figure 42. Overall Call Processing Time Performance, 2017–2018

	Call Taking		Dispatch		Total Call Processing	
Call Type	90th Percentile	Average	90th Percentile	Average	90th Percentile	Average
Fire	01:47	01:14	00:43	00:24	02:15	01:32
EMS	02:06	01:18	00:30	00:24	02:26	01:41
MVC	02:03	01:14	00:37	00:20	02:21	01:25
False Alarms	01:53	01:10	00:39	00:21	02:12	01:18
Total	**02:02**	**01:15**	**00:34**	**00:23**	**02:21**	**01:31**

The next figure, and all preceding figures in this section, provide performance information based on the raw dataset provided by Loudoun County. These figures provide performance reporting based on incidents that occurred within the Urban Zone, census blocks with population densities greater than 500 people per square mile, the Rural Zone with densities less than 500 per square mile, and overall performance. The time frame of this data is from December 12, 2016, through August 14, 2018. Although the datasets differ in both source and timeframe, overall performance varied by only 2 seconds. The following figure illustrates the results.

Figure 43. Call Processing Times by Demand Zone



	Fire	Rescue/ EMS	MVC	Hazard Condition	False Alarm	Total
Urban	02:22	02:31	02:17	03:17	01:56	02:24
Rural	02:38	02:21	02:26	02:54	01:48	02:17
Countywide	02:24	02:30	02:18	03:13	01:55	02:23

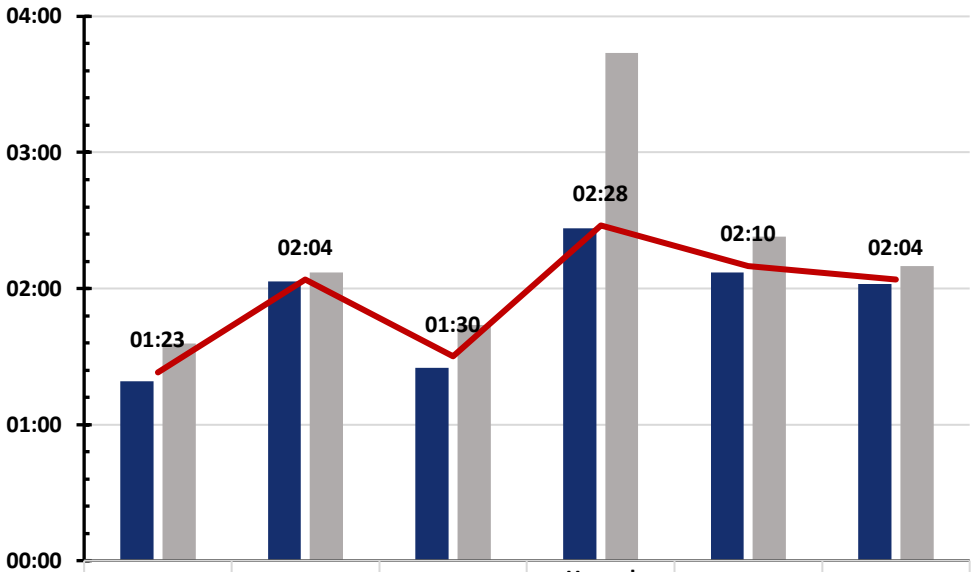
In Figure 43, calls were categorized using National Fire Incident Reporting System (NFIRS) classifications to the extent possible using LC-CFRS's Computer Aided Dispatch (CAD) descriptions. Currently, call processing time at the 90th percentile for fire responses is 2 minutes, 24 seconds, with EMS calls at 2 minutes, 30 seconds. This results in a total call-processing time of 2 minutes, 23 seconds—nearly double the recommended benchmark.

Turnout Time Performance

Turnout time is the second component of the response continuum. This is one element that is directly affected by response personnel. Turnout is the time it takes personnel to receive the dispatch information, move to the appropriate apparatus, and begin responding to the incident. NFPA 1710 recommends turnout time of 60 seconds or less for EMS incidents, and 80 seconds for fire incidents and special operations. It has been ESCI's experience that these performance goals are difficult to achieve, and that a standard of 90 to 120 (1 minute, 30 seconds, to 2 minutes) for career-staffed fire departments are more reasonable and achievable. This is affirmed in a study published in 2010 by the NFPA.

Currently, turnout time at the 90th percentile for LC-CFRS fire responses is 1 minute, 23 seconds, with EMS calls at 2 minutes, 4 seconds. This results in a total turnout time of 2 minutes, 4 seconds which is nearly double the recommended benchmark of 60 seconds or less.

Figure 44. Turnout Time Performance



	Fire	Rescue/ EMS	MVC	Hazard Condition	False Alarm	Total
Urban	01:19	02:03	01:25	02:27	02:07	02:02
Rural	01:36	02:07	01:44	03:44	02:23	02:10
Countywide	01:23	02:04	01:30	02:28	02:10	02:04

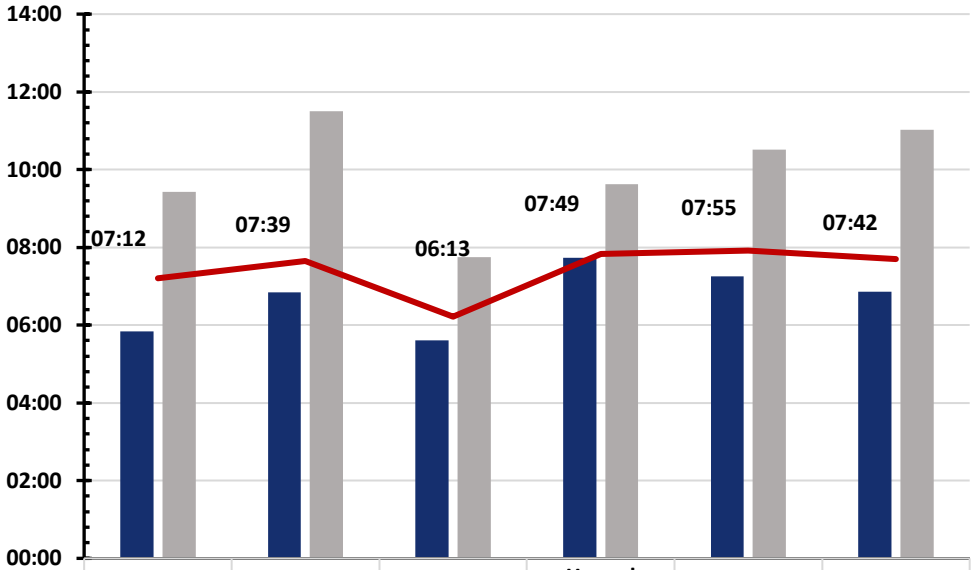
Travel Time Performance

Travel time is potentially the longest component of total response time. The locations of fire stations and the distance apparatus must travel have the most significant influence on response time. The quality and connectivity of streets, traffic, and geography are also factors.

NFPA 1710 suggests a travel time of four minutes for the arrival of the first-due unit to an emergency incident (measured at the 90th percentile). The Center for Public Safety Excellence/Commission on Fire Accreditation International's Standards of Cover offers guidelines for performance objectives based on population density, service demand, community risk, and current baseline response performance. NFPA 1710 also recommends annual evaluations of service-delivery performance for each of the geographic areas (as defined by the organization) within the jurisdiction of the fire department. In this report, ESCI has presented LC-CFRS's travel time and response performance by multiple incident types to provide an understanding of how performance varies based upon the incident.

The overall travel time for LC-CFRS countywide was 7 minutes, 42 seconds at the 90th percentile. The shortest travel times were related to MVC calls at 6 minutes, 13 seconds, with the longest times responding to false alarms at 7 minutes, 55 seconds.

Figure 45. Travel Time Performance



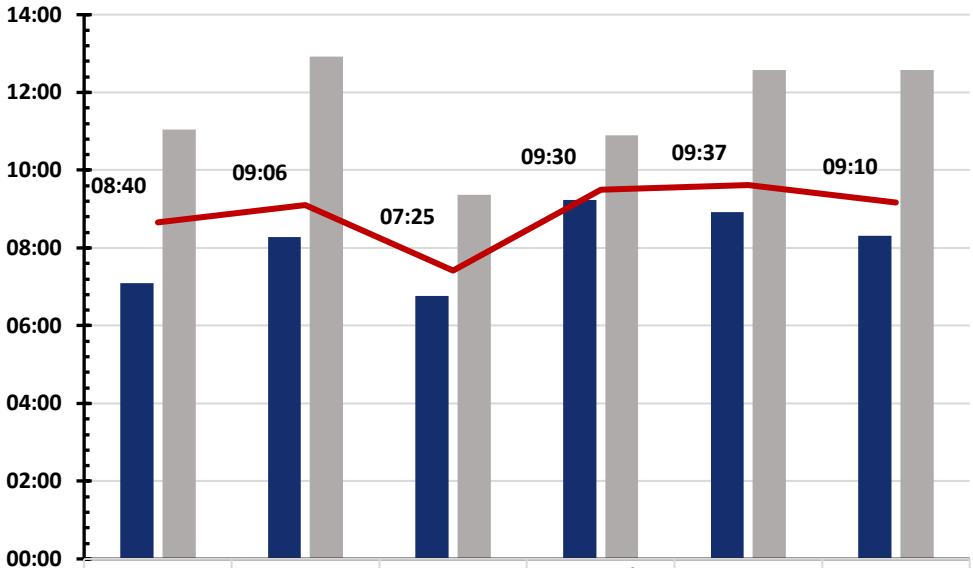
	Fire	Rescue/ EMS	MVC	Hazard Condition	False Alarm	Total
Urban	05:51	06:51	05:36	07:44	07:15	06:52
Rural	09:25	11:30	07:45	09:37	10:31	11:01
Countywide	07:12	07:39	06:13	07:49	07:55	07:42

Response Time Performance

Response Time Performance measures the time from initial notification until the first unit arrives on the scene, at the 90th percentile. The information is presented by multiple incident types, as well as a total for all incidents.

The response time for all call types combined countywide is 9 minutes, 10 seconds. False alarms represented the longest response time at 9 minutes, 37 seconds, and MVCs the fastest response time at 7 minutes, 25 seconds. EMS response times at the 90th percentile were 9 minutes, 6 seconds.

Figure 46. Response Time Performance

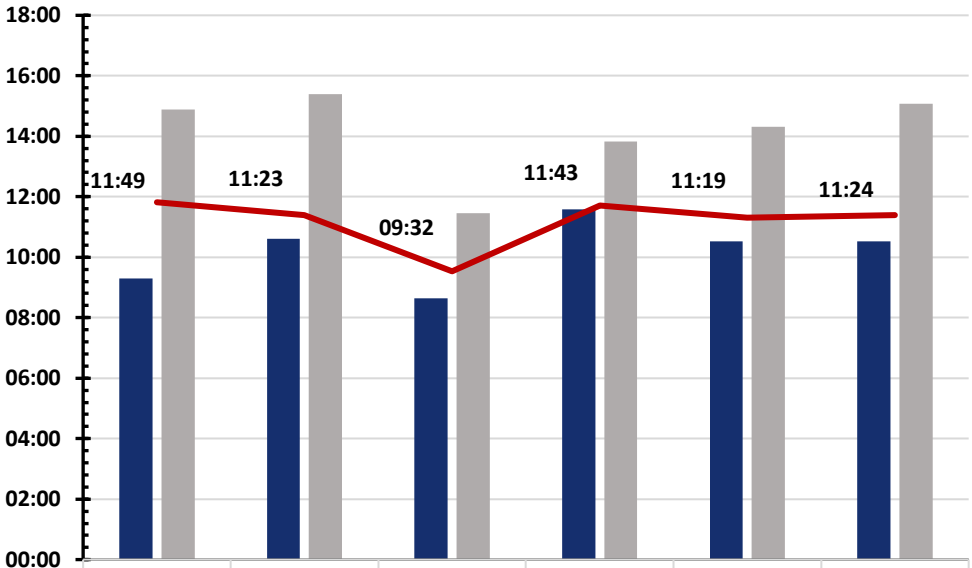


	Fire	Rescue/ EMS	MVC	Hazard Condition	False Alarm	Total
Urban	07:06	08:17	06:46	09:14	08:55	08:19
Rural	11:03	12:55	09:22	10:53	12:35	12:35
Countywide	08:40	09:06	07:25	09:30	09:37	09:10

Total Response Time Performance

The next figure presents total response time (TRT) performance for the study period at the 90th percentile for various incident types, including the overall department performance. This represents the amount of time required for the first emergency unit to arrive on the scene from the time the initial emergency call was answered at the dispatch center.

Figure 47. Total Response Time Performance



	Fire	Rescue/ EMS	MVC	Hazard Condition	False Alarm	Total
Urban	09:18	10:36	08:38	11:34	10:31	10:32
Rural	14:53	15:23	11:27	13:49	14:18	15:04
Countywide	11:49	11:23	09:32	11:43	11:19	11:24

When the total response times are examined, LC-CFR can expect to provide the initial unit on the scene in 11 minutes, 24 seconds from the time the communications center received the emergency call, 90 percent of the time or better for all calls. MVCs once again displayed the best performance at 9 minutes, 32 seconds. Fires demonstrated the longest Total Response Time Performance at 11 minutes, 49 seconds. EMS calls for service can anticipate that a unit will arrive on scene within 11 minutes, 23 seconds or better from the time the emergency call is placed with the communications center 90 percent of the time.

Response Reliability

Due to the nature of deployment methodology used by LC-CFRS, the measurement of unit hour utilization and system reliability based upon first due assignments is not possible at this time. ESCI suggests that should LC-CFRS wish to monitor and report this data in the future, first due response zones should be based upon staffed facilities and primary first due units assigned to allow for accurate tracking and reporting performance.

Mutual and Automatic Aid Systems

It is virtually impossible for an organization to possess absolutely all of the personnel and equipment resources that it could ever need to mitigate every incident within its jurisdiction. It is for this reason that fire departments often enter into agreements to work together and share resources.

There are two main types of agreements: mutual aid and automatic aid. In mutual aid agreements, two or more organizations agree that, when requested, they will supply the other agency with the requested resources, if available. For emergency services, this typically occurs through the request of the responding apparatus or on-scene personnel. The difference between mutual aid and automatic aid is that automatic aid is deployed just as the name implies—automatically. When an emergency call is received by the dispatch center, all available resources are examined based on the appropriate unit-type and their proximity to the call. Typically, the closest unit is dispatched, regardless of the jurisdiction in which the incident occurred.

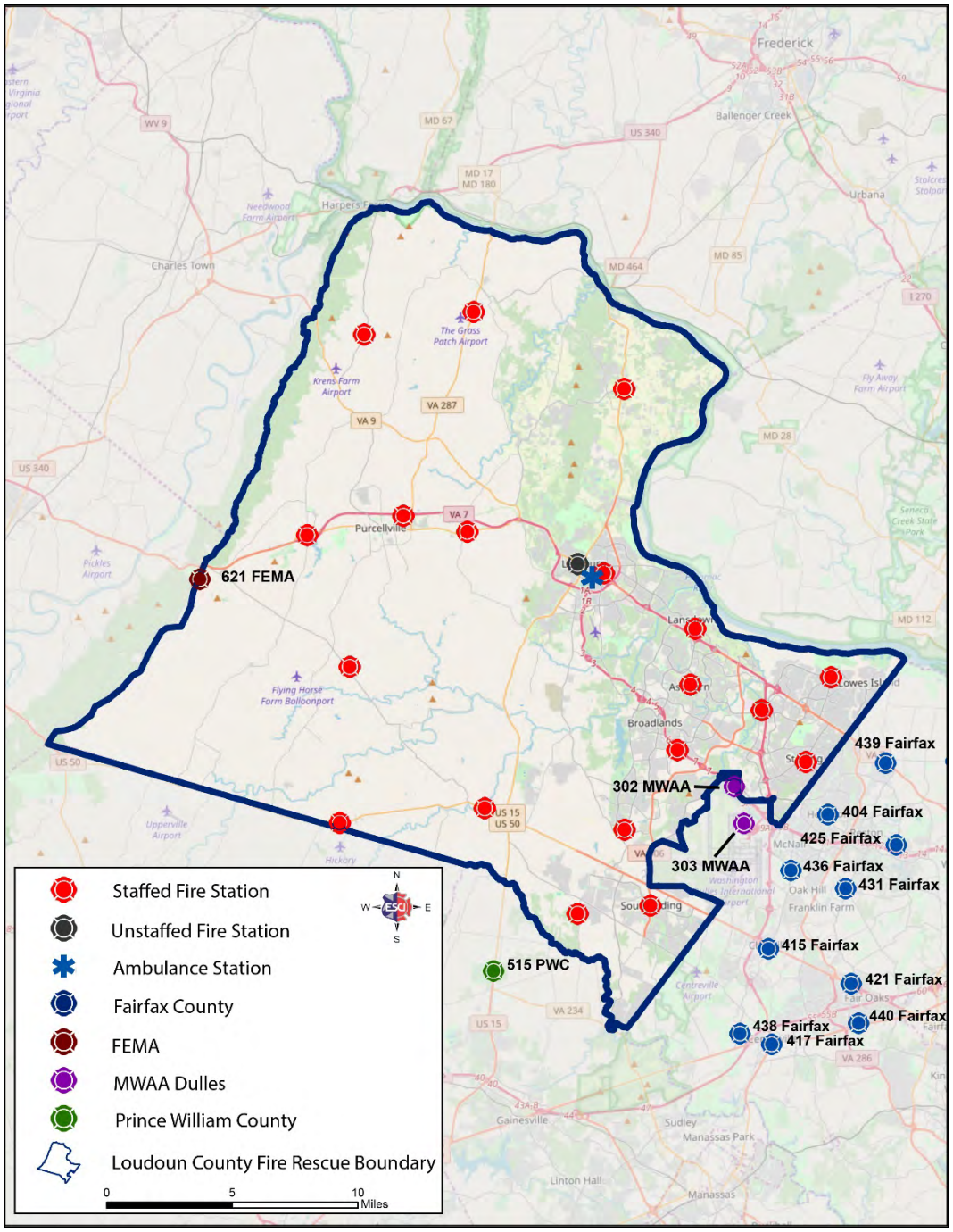
LC-CFRS utilizes both automatic aid and mutual aid responses. Loudoun County has recently joined the Northern Virginia *CAD2CAD* Exchange which links departments in Loudoun County, Fairfax County, Fairfax, Alexandria, and Arlington County together through their computer-aided dispatch (CAD) systems. In addition, Prince Williams County will have a CAD-to-CAD interface with LC-CFRS in July 2019. This will result in additional responses to and from both jurisdictions. These CAD-to-CAD interfaces eliminate the need for separate phone calls to determine the closest appropriate unit. The result is automatic closest unit dispatch and lower response time for the initial arrival unit.[38]

Currently, LC-CFRS utilizes automatic aid from several stations in Fairfax County and MWAA. The ones listed here are the most actively used automatic aid stations:

- Station 404
- Station 412
- Station 415
- Station 436
- Station 438
- Station 439
- MWAA Station 302
- MWAA Station 303

[38] *Northern Virginia CAD2CAD Exchange, CAD2CAD Success Story, National Information Exchange Model (NIEM).*

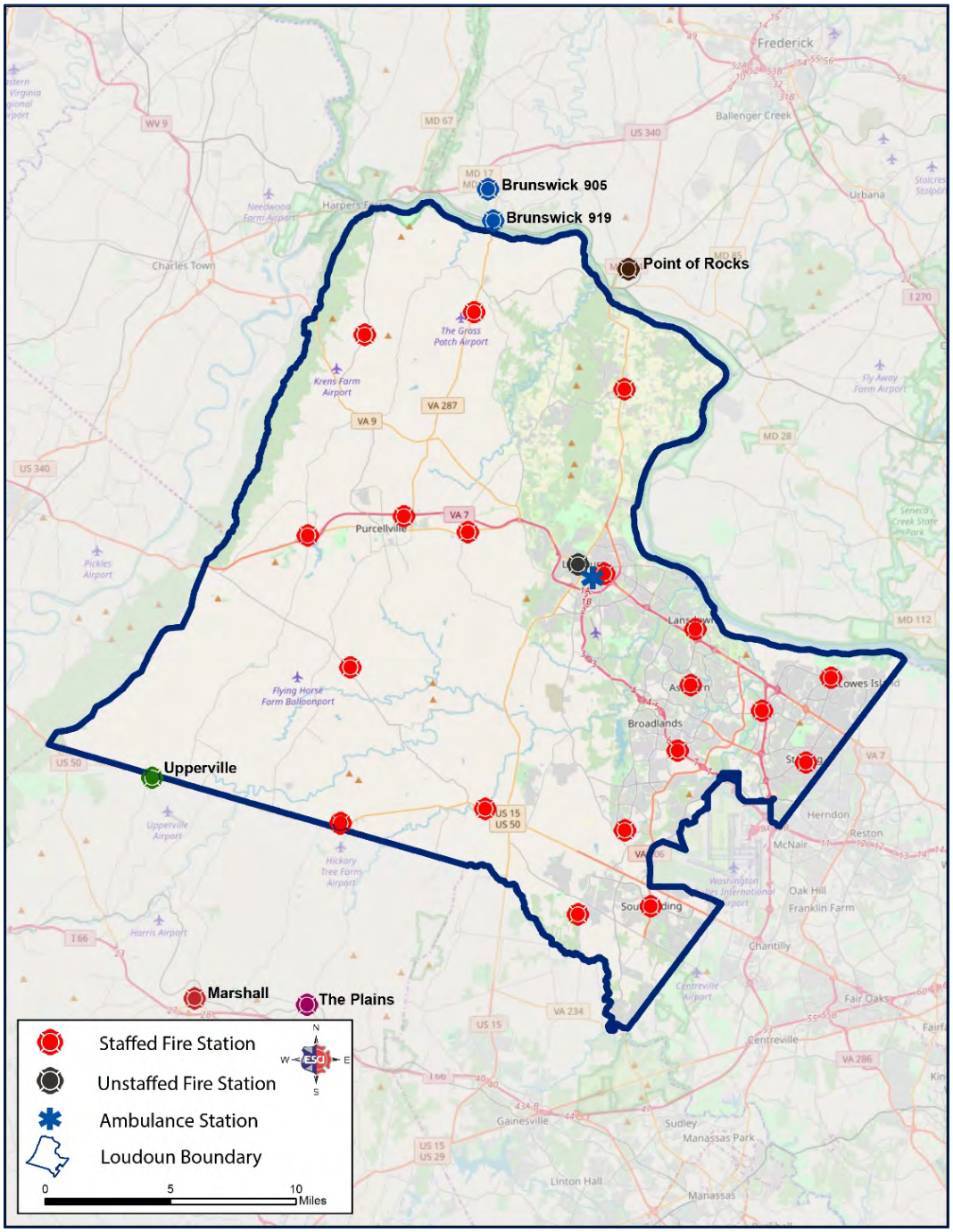
Figure 48. Automatic Aid Partners



The LC-CFRS also requests mutual aid from the following stations from time-to-time:

- In Fauquier County, VA: Stations 1103, 1104, and 1105
- In Frederick County, MD: Stations 905, 919, and 928

Figure 49. Mutual Aid Partners



Other stations in Clarke County (VA), Jefferson County (WV), Frederick, Montgomery, and Washington counties (MD) are available for mutual aid response; however, it has been reported to ESCI that the reliability of these units, in terms of availability, response time, and number of personnel arriving on a unit, has been inconsistent. As a result, they are not routinely called by LC-CFRS to respond to an incident in Loudoun County.

Section IV. Conclusions and Opportunities for Enhancements

Overall Evaluation

This LC-CFRS Emergency Operations Comprehensive Service Plan required the completion of an intensive analysis of all aspects of the agencies' deployment policies. The analysis used various tools to review historical performance, evaluate risk, validate response coverage, and define critical tasking and alarm assignments. The analysis relied on the experience of staff officers and their historical perspective, combined with historical incident data captured by both the Loudoun County Dispatch and Communication Center and the LC-CFRS records management system.

An overview of community risk identifies the risks and challenges faced by the fire department. Geospatial characteristics, topographic and weather risks, transportation network risks, physical assets, and critical infrastructure were reviewed. Medical incidents, motor vehicle accidents requiring scene stabilization or extrication, and structure fires are identified as the primary risks requiring fire department intervention. As a factor of risk, community populations and demographics were evaluated using a hazard vulnerability assessment that scores against historical and projected service demand. Population and service demand have increased over the past decade and will continue to increase in the future.

Evaluating risk using advanced geographic information systems (GIS) tools provided an increased understanding of community risk factors and led to an improved deployment policy.

During the analysis of service level objectives, critical tasking assignments have been discussed for incident types ranging from a basic medical emergency to a high-rise structure fire. Critical tasking requires a review of on-scene staffing requirements to mitigate the effects of an emergency. These tasks ultimately determine the resource allocation necessary to achieve successful operations.

The review of historical system performance evaluates each component of the emergency incident sequence. These included call processing, turnout time, and travel time. Beyond the response time of the initial arriving units, the additional components of concentration and effective response force, reliability, and call concurrency were evaluated.

Based on the analysis and considering community expectations, recommendations or enhancements are offered to improve the delivery of fire and emergency services to the community by the LC-CFRS. It is not expected that all will be implemented in the short-term. Some may need to wait until economic conditions or service demand allow for their implementation. However, all the recommendations offered chart a course to improved capability and service.

RECOMMENDATIONS

During this study, several issues, concerns, and opportunities were identified. The recommendations and sample best practices that follow are intended to accomplish the primary objectives listed which include:

1. Define and adopt expected service levels and performance standards for each of the Rural, Urban and, ultimately, Metro planning areas to be provided by the fire rescue system should future growth dictate three response zones.
2. Adopt data collection elements and methods that will provide for the effective measurement and adjustment to operational system elements based on identified performance goals and triggers.
3. Identify service level improvement opportunities and additional resources to serve anticipated growth, that can be implemented as funding becomes available. These enhancements should be implemented based on performance and outcome triggers impacted by growth, changes in the system risk profile, and increases in service delivery demands.
4. Identify opportunities and service delivery methods that will increase the coordination and consistency of resource assignments that align with defined system risk and service delivery needs, including coverage and capabilities of on-scene supervision and special operation resources. Implement increased cooperative effort strategies between LC-CFRS specialized service delivery elements as well as neighboring jurisdictions to assist with this goal.

The following recommendations are described as "Opportunity for Enhancement" (OFE) goals and should be considered as part of the LC-CFRS planning and implementation process. The recommendations and supporting information are intended to provide LC-CFRS administration and decision makers with data, samples and best practices to assist with the growth and service enhancements that are necessary and desired to serve the growing and vibrant communities served by LC-CFRS. Each OFE can improve the department's ability to provide effective and efficient service to the community.

OFE Goal A: Formally Adopt Rural, Urban, and future Metro Fire Planning Zones

ESCI recommends the LC-CFRS identify and adopt fire planning zones, similar to the policy areas described in the County's 2040 Comprehensive Plans, as follows:

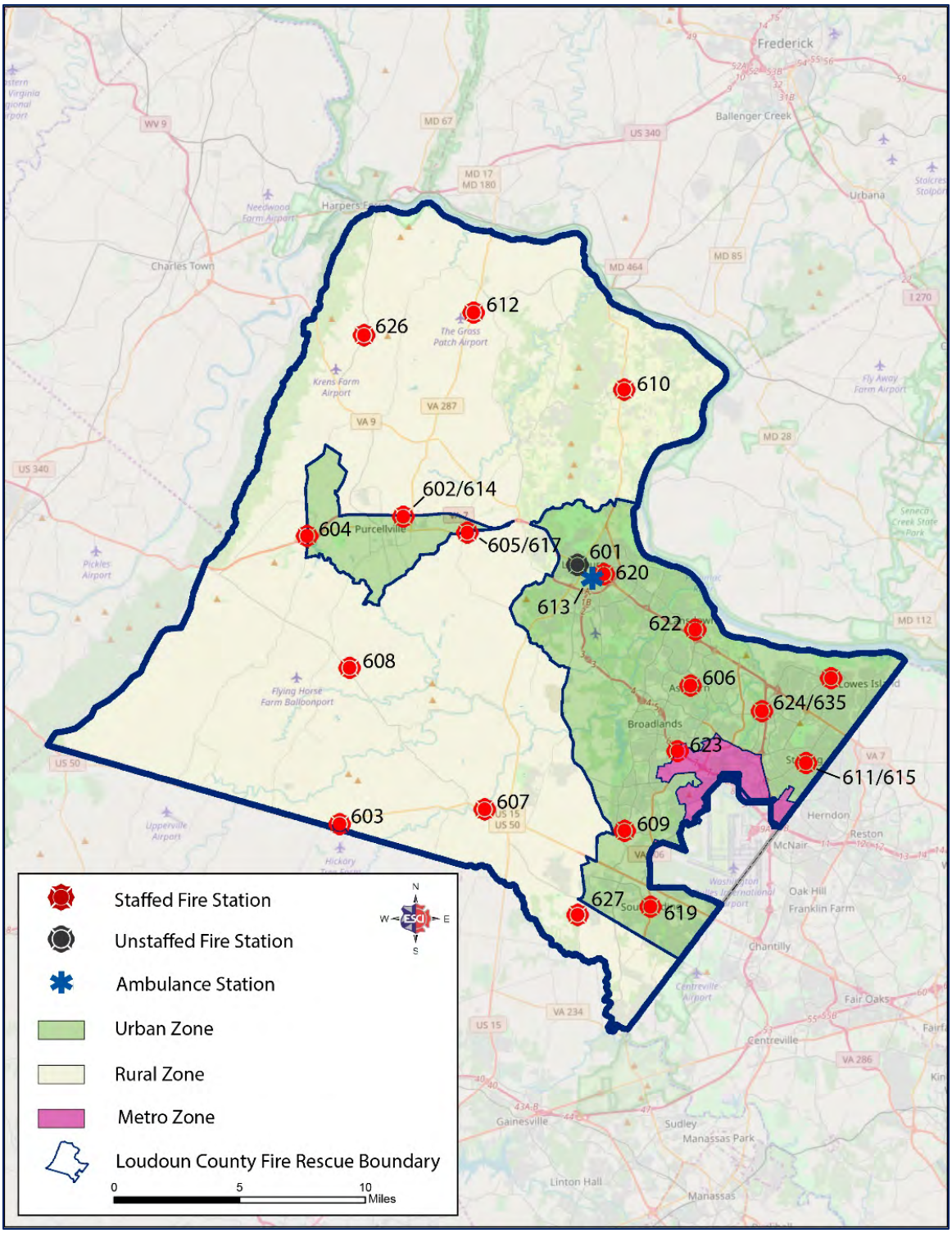
- **Metro**: This is the area immediately north and east of Washington Dulles International Airport. This area will be characterized by densely populated, multi-story, mixed-use, transit-oriented places for housing, employment, entertainment, education, and retail, all in close proximity to the new Metrorail Silver Line. This zone corresponds to the plan's Urban Policy Area and should be considered at a future date as growth and service demand dictate.
- **Urban**: This area includes all populous areas of the county, generally east of route 15, plus the Town and Joint Land Management Zones (JLMA) and the Transition Policy Area. This area is characterized by single- and multi-family neighborhoods, retail, employment, commercial—technology, data management, communications industries, industrial uses, airport-related businesses, and data center development. The area also provides a transition between the urban and rural areas of the county. It will also include some industrial spaces focused on quarry activity and energy infrastructure.
- **Rural**: This area includes all areas of the county west of the suburban area. It comprises about two-thirds of the county's land area and is characterized by traditional farming/agricultural land use with many winding, narrow, two-lane roadways and small communities, interspersed with multi-lane connector roads and large, estate-style homes on multi-acre properties in rural areas. Response challenges that differ from metro and suburban areas are limited access, long response travel times outside small communities, and wildland-urban interface protection.

If desired, each area can be further divided into response zones, such as battalions or districts that include one or more station locations. This recommendation has five key advantages:

- **It is consistent with and supports the comprehensive plan.** The plan describes the projected land use and occupancy mix, type, and size of buildings, and provides a foundation for long-range system and capital improvement planning;
- **It provides a logical way to define community risk and prioritize resource needs.** The plan provides information about hazards, risks, demographics, and regional mobility. This information provides the system with additional information that will assist with optimizing system resources to meet community needs, both now and in the future.
- **It provides a natural delineation aligned with community risk and service demand to measure performance goals and outcomes.** ESCI has provided sample performance measures that most closely align with the risk and service delivery for each of the corresponding fire planning zones. LC-CFRS needs to establish data collection methods and metrics that accurately measure performance and outcomes relating to adopted fire planning zone standards (OFE Goal B)
- **It is flexible.** The plan identifies projected and intended land use. LC-CFRS is a complex system with specialized risks and needs in different parts of the county. This recommendation will provide the system with a compelling reason to locate specific resources and personnel at specific locations, yet allow the system the flexibility to relocate or repurpose resources as needed to provide an emergency response that meets community needs and expectations 24/7/365, with a mix of volunteer and paid staff.

- **It simplifies system administration.** The use of policy area planning zones provides the LC-CFRS with the opportunity to create sub-zones to improve supervisor response time, provide administrative support of a workable number of stations and personnel, divide the supervisory workload, and provide additional opportunities for leadership development.

Figure 50. Urban, Rural, and Metro Planning Zones



OFE Goal B: Formally Adopt First Unit Response Time Standards and Targets/Sample Goals

Response standards and targets establish measurable goals for service delivery, which then form the baseline for the deployment of resources. Response performance goals must be tailored to match community expectations and conditions and be balanced against the financial challenges a community is able and willing to afford. Without defined goals and targets, an organization is unable to appropriately identify how effective it is providing services that meet community expectations.

The LC-CFRS has done a commendable job establishing department recognized response measurement standards measured against NFPA 1710. Those standards, which were detailed earlier in this report, address call processing times, turnout times, and response times for the first unit on the scene. In addition, standards are in place for emergency medical responses.

To review, the following figure demonstrates the NFPA 1710 emergency response performance goals for the first apparatus on the scene at an emergency incident. In addition, current LC-CFRS baseline performance from July 2014 to July 2016 is displayed.

Figure 51. LC-CFRS Current Emergency Response Time Performance Standards

90TH PERCENTILE BASELINE PERFORMANCE AND BENCHMARK GOALS (FIRST APPARATUS ON SCENE)				
	Call Processing	Turnout	Travel	Response Time (Dispatched to First Apparatus On-Scene for all Emergencies)
LC-CFRS 90% Baseline	02:23	02:04	7:42	9:46
NFPA 1710 Goal	01:04	01:00	4:00	06:04

In reviewing LC-CFRS system performance, ESCI found that, in general, baseline response and performance do not meet NFPA 1710 recommended best practices. ESCI recommends that the LC-CFRS develop and formally adopt a single set of emergency response performance goals that incrementally work toward compliance with NFPA 1710 standards as warranted by the system risk profile and available resources. These incremental response performance goals should address each fire planning zone and include the components of response performance (call processing time, turnout time, and travel time) as well as overall response performance goals for predominant risks present in the community.

A well-defined, formally adopted set of response goals that move the LC-CFRS toward NFPA 1710 compliance will accommodate more effective planning. Further, when considering future deployment of resources, potentially as a collaborative effort and combining the use of personnel and equipment from other agencies, it is important that decisions be made using the same goals. In other words, it is much easier to strike a single target, rather than having different performance standards.

The following figure displays combined 90th percentile sample performance goals, by response time component as well as total response time, for the first arriving unit on emergency calls in the three recommended response performance zones.

Figure 52. Sample Emergency Response Goals – Components of Response Time for First Responding Unit

90TH PERCENTILE BENCHMARK GOALS (FIRST APPARATUS ON SCENE), ALL EMERGENCIES					
Performance Zone	Call Processing Time	Turnout Time	Travel Time	Response Time (Dispatched To First Apparatus On Scene)	Total Response Time (Received At Dispatch To Arrived)
Rural	01:04	01:00	11:00	12:00	13:04
Urban	01:04	01:00	6:00	07:00	8:04
Metro	01:04	01:00	5:00	6:00	7:04

These suggested response baselines are based upon actual findings as discussed in the service delivery section of the report. The following two figures provide both current NFPA 1710 compliance and predicted performance by planning zone based upon incident locations. Although some emergency call activity occurred in the Metro planning zone during the timeframe of the data provided, due to the lack of roadways, infrastructure, and future development, the performance within that area cannot be currently projected with any degree of accuracy. The next figure provides actual performance based on NFPA 1710 standards followed by suggested standards based on actual benchmarked performance and planning zones.

Figure 53. Current Travel Performance Compared to NFPA 1710 Benchmark by Planning Zone

	Travel Time	Metro	Urban	Rural
Current	4 Minutes	46.9%	64.0%	26.9%
	8 Minutes	43.5%	32.9%	61.4%
New Stations	4 Minutes	52.1%	74.9%	26.9%
	8 Minutes	45.9%	22.3%	61.4%

Based on the performance in the previous figure, predicted performance baselines were calculated to provide realistic performance measurements for LC-CFRS and are illustrated in the next figure.

Figure 54. Predicted Performance by Travel Time and Planning Zone

	Old	New
Metro 5 Minute Travel	N/A	N/A
Urban 6 Minute Travel	91.9%	93.5%
Rural 14 Minute Travel 1710	90.9%	90.9%
Rural 10.5 Minute Travel 1720	80.6%	80.6%

The NFPA 1710 response performance benchmarks vary significantly from the current 90th percentile performance of LC-CFRS. The previous figure shows some sample response time goals for various parts of the response time continuum in the various recommended LC-CFRS response zones. The total response time goal (call processing to the arrival of the first apparatus) provides opportunities to decrease call processing and turnout time which can significantly improve overall response times of the first due unit. The combination of the recommended dispatch, turnout time and travel time combined with the addition of new staffed stations will allow the overall 90th percentile response time of the first responding unit to approach the recommended 7 minutes 4 seconds , Metro Zone; 8 minutes 4 seconds Urban Zone; and the 13 minutes, 4 seconds Rural Zone total response time targets countywide.

ESCI believes that adopting the sample, recommended emergency response time goals for the first arriving unit allows LC-CFRS an opportunity to develop a compliance methodology to monitor actual response performance. This will provide LC-CFRS leaders with the necessary data to monitor compliance of the adopted standards and adjust the adopted response performance goals as needed.

All Emergency Incidents – First Unit Response Performance Standard

For 90 percent of all emergency incidents, the first apparatus shall arrive within 13 minutes, 20 seconds in the rural fire planning area, 8 minutes 20 seconds in the urban fire planning zone, and 7 minutes, 20 seconds response in the metro fire planning zone (911 call pick up to the first unit on scene). The first apparatus on the scene shall be capable of establishing command, providing for scene safety, or initiating Basic Life Support (BLS) or Advanced Life Support (ALS) patient care.

Fire Suppression Incident – Firs Unit Response Performance Standard

For 90 percent of all emergency fire suppression incidents, the first fire apparatus staffed with a minimum of three personnel shall arrive within 13 minutes, 20 seconds in the rural fire planning area, 8 minutes, 20 seconds in the urban fire planning zone, and 7 minutes, 20 seconds response in the metro fire planning zone (911 call pick up to the first unit on scene). The first fire apparatus on the scene shall be capable of establishing command, initiating scene size-up, and initiating a defensive fire attack operation.

All EMS Incidents – First Unit Response Performance Goal

For 90 percent of all emergency EMS incidents, the first on scene apparatus shall arrive within 13 minutes, 04 seconds in the rural fire planning area, 8 minutes, 04 seconds in the urban fire planning zone, and 7 minutes, 04 seconds response in the metro fire planning zone (911 call pick up to the first unit on scene). The first on scene unit shall be staffed with a minimum of two personnel, who are capable of performing patient assessment, determining life-threatening conditions, and initiating patient care.

Advanced Life Support EMS Incidents – First Unit Response Performance Goal

For 90 percent of all emergency Advanced Life Support (ALS) EMS incidents, the first on scene apparatus shall arrive within a 10-minute, 30-second response time for the rural, urban, and metro fire planning zones (911 call pick up to the first unit on scene). The first on scene ALS equipped unit shall be staffed with a minimum of two personnel, at least one of which must be certified to provide an ALS level of patient care.

OFE Goal C: Formally Adopt Effective Response Force Time Standards and Personnel Targets

Figure 55. Sample NFPA 1710 ERF Response Goals – Components of Response Time

90TH PERCENTILE PERFORMANCE BENCHMARKS (EFFECTIVE RESPONSE FORCE), STRUCTURE FIRES						
Performance Zone	Call Processing Time	Turnout Time	Travel Time	Response Time (Dispatched to Full ERF On Scene)	Total Response Time (Received at Dispatch to Arrived)	Effective Response Force
Rural	01:04	01:20	15:00	16:20	17:24	24
Urban	01:04	01:20	12:00	13:20	14:24	28
Metro	01:04	01:20	10:00	11:20	12:24	34

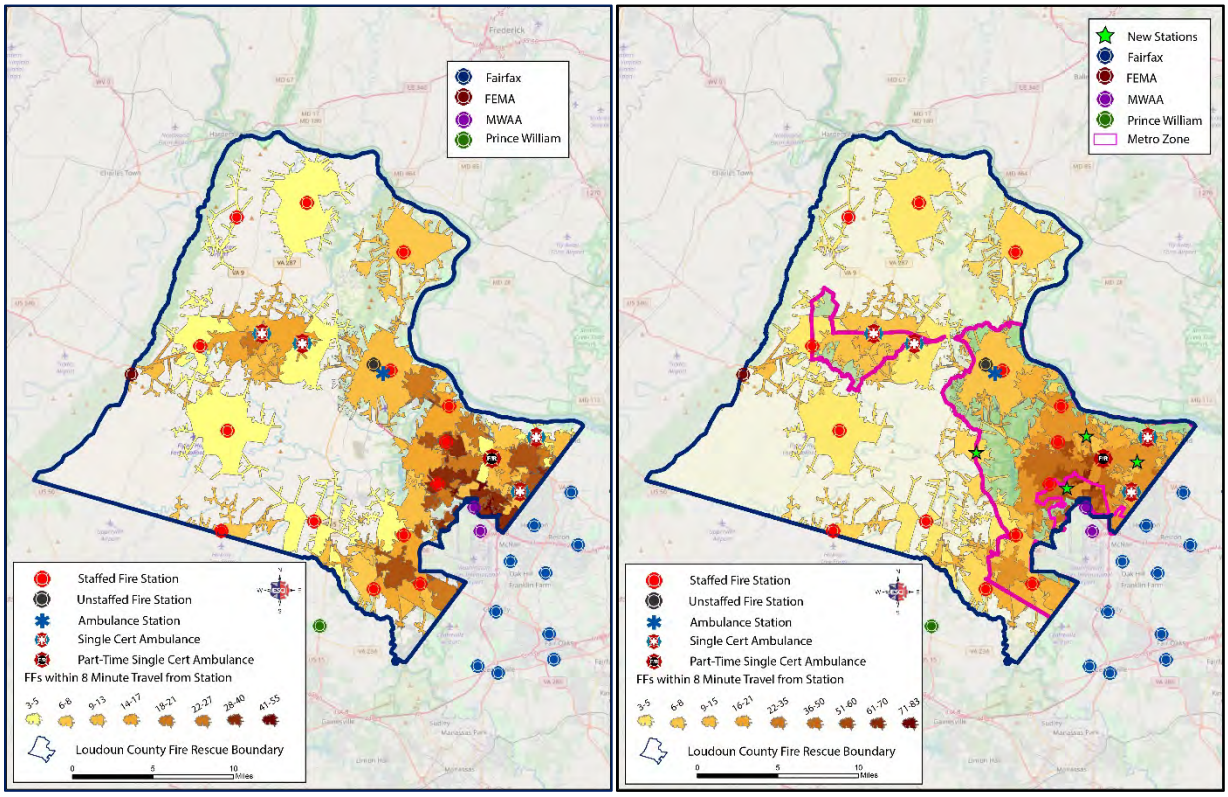
The response time benchmarks recommended in the previous figure for structure fires exceed the response times found in NFPA 1710 for a moderate structure fire response in the urban, rural, and metro areas. These sample goals reflect the LC-CFRS risk profile of each fire planning zone, incident history, and proposed response capacities with the addition of three proposed stations in the Urban and Metro planning zones and assume incremental four-person staffing levels as proposed in OFE Goal D. These response goals also assume the utilization of automatic aid resources from Fairfax County Fire in the Metro and Urban fire planning zone as part of an integrated response system.

Moderate Risk Structure Fire – Effective Response Force (ERF) Response Performance Goal

For 90 percent of all emergency structure fire incidents, the ERF with a minimum of 24 in the rural fire planning zone and 28 personnel in the urban fire planning zones shall be deployed with a minimum of three engines, one aerial, one ambulance, and one command vehicle and shall arrive in 13 minutes, 20 seconds in the urban planning area, and 16 minutes, 20 seconds in the rural planning area, respectively, 90 percent of the time (from dispatch to arrival of the established ERF on scene). A minimum of a ERF with 34 personnel in the Metro Planning Zone on a minimum of three engines, two trucks, one ambulance, and one command vehicle shall arrive in 11 minutes, 20 seconds 90 percent of the time. The ERF shall be capable of establishing incident command, maintaining a sustained fire flow and water supply, advancing fire attack lines and back-up lines, initiating victim search and rescue, ventilation, and controlling utilities.

Note that the effective response force may include mutual or automatic aid resources. If aid from adjacent agencies is required to achieve the ERF, it is essential that these resources be included in the initial dispatch. This reduces the response time necessary to assemble adequate resources to mitigate the emergency. This initial ERF does not necessarily represent the entire alarm assignment, as additional units may be assigned based on long-term incident needs and risks. Additional engines, ladders, or other specialty companies are assigned to higher risk responses to accomplish additional critical tasks that are necessary beyond the initial attack and containment.

Figure 56. Effective Response Force: LC-CFRS vs LC-CFRS with Automatic Aid and Additional Stations



OFE Goal D: Increase engine company staffing levels to a four-person minimum to meet recommended NFPA 1710 staffing standards

Currently, LC-CFRS is staffing engine companies with three personnel. Based on the current rural, urban, and metro planning area risk profiles, ESCI has identified that LC-CFRS cannot assemble an effective response force in accordance with NFPA 1710 and NOVA adopted response standards as displayed in Figure 57. To match the ERF with the established risk profile and move toward meeting NFPA 1710 standards, ESCI recommends a phased implementation to maintain four-person staffing on all staffed engine and rescue companies within the system.

LC-CFRS has a definable need for additional ERF personnel of at least 24 in the rural fire planning zone to deal with a limited rural water supply, old Victorian balloon type construction without fire breaks, and a lack of fire extinguishment systems in the large complex housing stock. In addition, significant density, risk, and growth in the urban planning area, as well as complex transportation centers, additional high-rise buildings, and increasing risks in the metropolitan planning area warrant a phased transition to minimum four-person staffing on all fire response apparatus. The following NFPA 1710 and NOVA staffing guidelines consistently establish the LC-CFRS ERF number of personnel.

Figure 57. LC-CFRS Initial 1st Alarm; 2,000 SF Residential Structure Fire

NFPA 1710		NOVA COG	
Apparatus	**Personnel**	**Apparatus**	**Personnel**
2 Battalion Chiefs	2	2 Battalion Chiefs	2
3 Engine Companies	12	4 Engine Companies	12
2 Aerial Companies	8	2 Aerial Companies	8
Total	**22**	**Total**	**22**
Rural Water Supply Tanker	**2**		**2**

The Importance of Crew Size to Overall Scene Time

Studies have shown that the more personnel that arrive on engine and ladder truck companies to the scene of a fire, the less time it takes to complete all aspects of fire suppression and search and rescue. As units arriving with more firefighters increases, the overall time on the scene of the emergency decreases. In other words, the more firefighters available to respond and arrive early to a structure fire, the less time it takes to extinguish the fire and perform search and rescue activities, thus reducing the risk of injury and death to both firefighters and trapped occupants and reducing the economic loss to the property.

Figure 58. The Relationship between Crew Size and Scene Time[39]

Overall Scene Time Breakdown by Crew Size		
Scenario	**Total Time**	**Efficiency**
4-Person Close Stagger	0:15:14	
3-Person Close Stagger	0:20:30	25% Less Efficient
2-Person Close Stagger	0:22:16	29% Less Efficient
4-Person Far Stagger	0:15:48	
3-Person Far Stagger	0:21:17	26% Less Efficient
2-Person Far Stagger	0:22:52	31% Less Efficient

This figure displays how companies staffed with larger crew sizes will be on the scene of an emergency for a shorter time than smaller sized companies. Extended scene time due to smaller crew size could be translated to mean that emergency resources will be unavailable longer to address other emergencies that may arise.

As Figure 58 shows, units that arrive with only two firefighters on an engine or ladder truck are on the scene of a fire almost 7 minutes longer than units that arrive with four firefighters on each crew. Responding units arriving with only three firefighters on an apparatus are on the scene of a fire 5 to 6 minutes longer than units that arrive with four firefighters on each apparatus. In addition to crew size, the time between the arriving crews matters to overall effectiveness and total on scene time.

In the NIST study on the low hazard residential fires, close stagger was defined as a 1-minute time difference in the arrival of each responding company. Far stagger was defined as a 2-minute time difference in the arrival of each responding company.[40, 41] The results show a consistent pattern of units arriving with four firefighters in a close stagger or far stagger will decrease the overall time at the scene of the emergency compared to units that arrive with two or three firefighters and are more efficient in fire suppression tasks as well.

---

[39] *Averill, J.D., et al. Report on Residential Fireground Field Experiments. NIST Technical Note 1661. National Institute of Standards and Technology; Gaithersburg, MD, April 2010.*

[40] *Ibid.*

[41] *One minute and two-minute arrival stagger times were determined from analysis of deployment data from more than 300 U.S. fire departments responding to a survey on fire department operations conducted by the International Association of Fire Chiefs and the International Association of Firefighters.*

Physiological Strain on Smaller Crew Sizes

The same NIST study also examined the relationship between crew size and physiological strain. Two important conclusions were drawn from this part of the experiments:

- Average heart rates were higher for members of small crews.
- These higher heart rates were maintained for longer durations.[42]

In 2014 alone, 57 percent of all firefighter fatalities were related to overexertion.[43] There is strong epidemiological evidence that heavy physical exertion can trigger sudden cardiac events.[44] Smaller crews are responsible for performing a number of tasks that are designed to be performed by multiple people and frequently in teams of two. This means that firefighters on smaller crews are required to work harder than larger crews to accomplish multiple tasks. Additionally, as discussed previously, firefighters on smaller crews will also be working longer than larger sized crews. Working harder and longer in high heat and dangerous, stressful environments increases the likelihood of firefighters suffering an injury, or worse dying, as a result of overexertion.

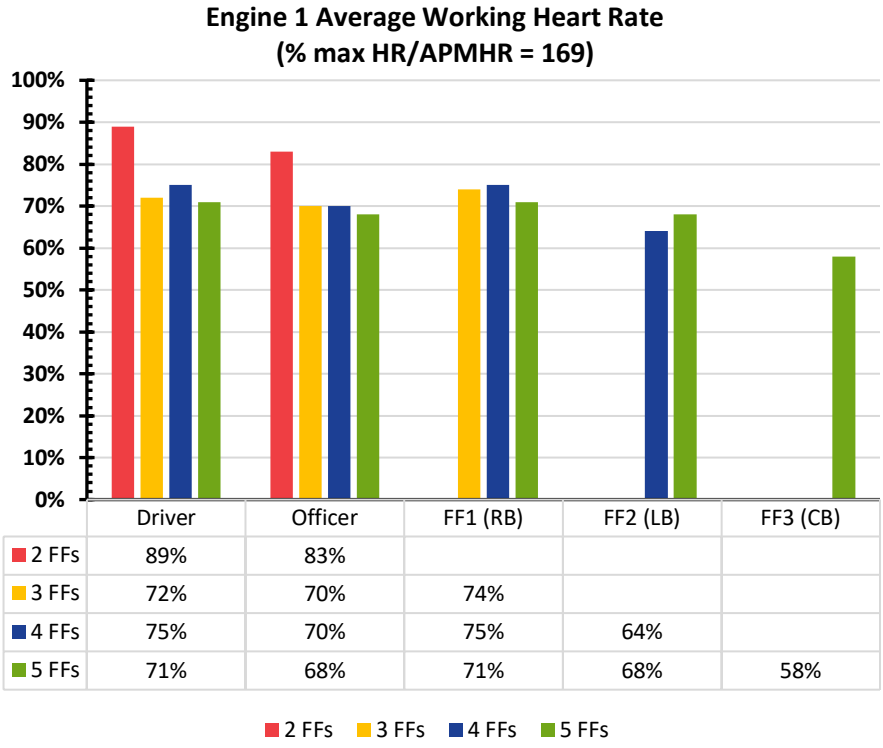
Figure 59 and Figure 60, on the following pages, highlight the cardiovascular impact on firefighters based on crew size for the first arriving engine and truck company. The heart rates of firefighters of crew sizes ranging from two to five firefighters were measured as they participated in the NIST study. The study was able to conclude that not only do smaller crews work harder and longer than larger crews, their heart rates are also more elevated for longer periods of time as well. This increases the risk of firefighters suffering an injury or death from overexertion. A firefighter suffering a medical emergency on the scene of a working fire, EMS, or rescue incident negatively impacts outcomes and increases the risk to the community, the citizen requiring assistance, and the firefighter.

[42] *Averill, J.D. et al. (2010). Report on Residential Fireground Field Experiments. NIST Technical Note 1661. National Institute of Standards and Technology; Gaithersburg, MD, April 2010.*

[43] *Fahy, R.F., LeBlanc, P.R., Molis, J.L. (June 2015) Firefighter Fatalities in the United States, 2014. NFPA.*

[44] *Albert, C.A., Mittleman, M.A., Chae C.U., Lee, I.M., Hennekens, C.H., Manson, J.E. (2000) Triggering Sudden Death from Cardiac Causes by Vigorous Exertion. N Engl J Med 343(19): 1355–1361.*

Figure 59. Average Peak Heart Rate of First Engine (E1) with Different Crew Sizes by Riding Position[45]



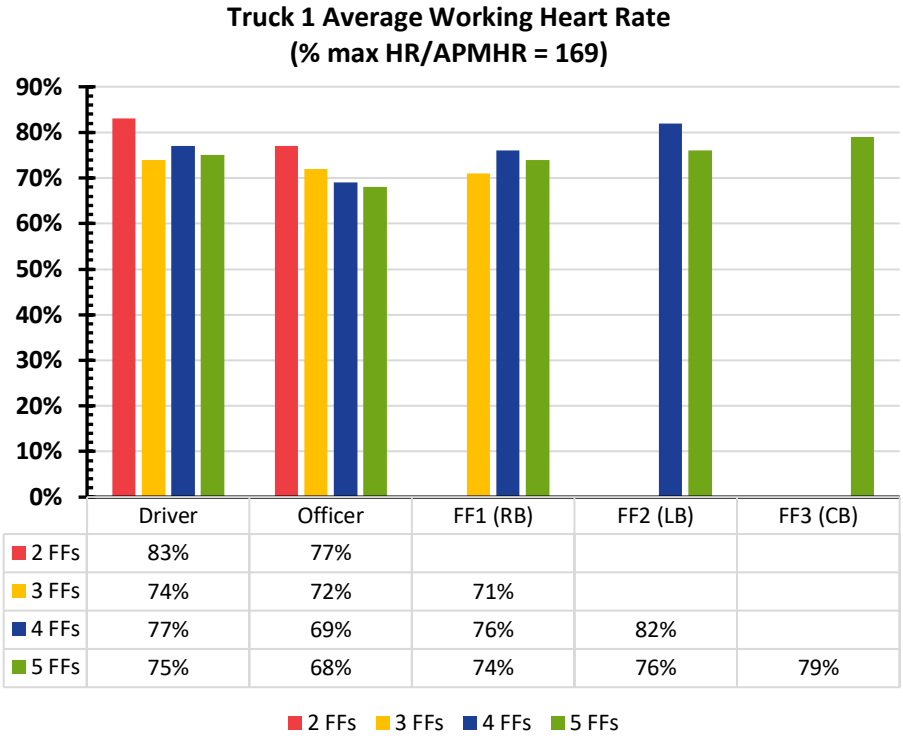
	Driver	Officer	FF1 (RB)	FF2 (LB)	FF3 (CB)
2 FFs	89%	83%			
3 FFs	72%	70%	74%		
4 FFs	75%	70%	75%	64%	
5 FFs	71%	68%	71%	68%	58%

In Figure 59, heart rates are expressed as a percent of age-predicted maximal heart rate (APMHR). The average heart rates for firefighters on the first engine company were above 80 percent of age-predicted maximum values when only two firefighters were working. When staffing was at two firefighters, the driver of the apparatus had an average peak heart rate of nearly 90 percent of the age-predicted maximum. This is largely due to the number of additional tasks the driver must perform to prepare the engine to pump water to the fire and then join the officer to stretch hose to the fire. As can be seen, the larger the crew size, the lower the heart rate.[46] Decision makers could potentially reduce their liability for firefighter injury and death by ensuring staffing is compliant with the minimum recommended industry standards of four firefighters per apparatus.

[45] *Riding positions for the figure are as follows: Driver, Officer, Firefighter 1 – Right Bucket (RB) seat, Firefighter 2 – Left Bucket (LB) seat, Firefighter 3 – Center Bucket (CB) seat. A fire company that is staffed with two will consist of a Driver and an "Officer."*

[46] *Smith, D.L., Benedict, R. Effect of Deployment of Resources on Cardiovascular Strain of Firefighters. April 2010. Pp 5–7.*

Figure 60. Average Peak Heart Rate of First Truck (T1) with Different Crew Sizes by Riding Position[47]



	Driver	Officer	FF1 (RB)	FF2 (LB)	FF3 (CB)
2 FFs	83%	77%			
3 FFs	74%	72%	71%		
4 FFs	77%	69%	76%	82%	
5 FFs	75%	68%	74%	76%	79%

In Figure 60, heart rates are expressed as a percent of age-predicted maximal heart rate. The average heart rates for firefighters on the first truck company were above 80 percent of age-predicted maximum values when only two firefighters were working.[48] Decision makers could potentially reduce their liability for firefighter injury and death by ensuring staffing is compliant with the minimum recommended industry standards of four firefighters per apparatus.

The Importance of a Rapid Response

Uncontained fire in a structure grows with every passing minute. Any delay in the initiation of fire suppression and rescue operations, such as the 5- to 7-minute delay that results from smaller sized crews of firefighters, translates directly into a proportional increase in expected property, life, and economic losses as is shown in Figure 61. It warrants emphasizing that if a structure has no automatic suppression or detection system, a more advanced fire may exist by the time the fire department is notified of the emergency and is able to respond. Fires of an extended duration weaken structural support members, compromising the structural integrity of a building and forcing operations to shift from an offensive to defensive mode.[49] As with inadequate staffing, this type of operation will continue until enough resources can be amassed to then change to an aggressive, offensive attack.

---

[47] *Riding positions for the figure are as follows: Driver, Officer, Firefighter 1 – Right Bucket (RB) seat, Firefighter 2 – Left Bucket (LB) seat, Firefighter 3 – Center Bucket (CB) seat. A fire company that is staffed with two will consist of a Driver and an "Officer."*

[48] *Smith, D.L., Benedict, R. Effect of Deployment of Resources on Cardiovascular Strain of Firefighters. April 2010. Pp 5–7.*

[49] *According to the NFPA, "it's important to realize that every 250 GPM stream applied to the building can add up to one ton per minute to the load the weakened structure is carrying."*

In the NIST study on the low-hazard residential fire, researchers also used fire modeling to mark the degree of the toxicity of the environment for a range of growth fires (slow, medium, and fast). Occupant exposures were calculated both when firefighters arrive earlier to the scene, and when arriving later. The modeling proved that the longer it takes for firefighters to rescue trapped occupants, the greater the risk posed to both the firefighters and occupants by increasing atmospheric toxicity in the structure.

Figure 61. The Relationship between Fire Extension and Fire Loss[50]

Rate Per 1,000 Fires			
Fire Extension in Residential Structures:	**Civilian Deaths**	**Civilian Injuries**	**Average Property Damage**
Confined fires (identified by incident type)	0.00	10.29	$212
Confined to object of origin	0.65	13.53	$1,565
Confined to the room of origin, including confined fires by incident type[51]	1.91	23.32	$2,993
Beyond the room, but confined to floor of origin	22.73	64.13	$7,445
Beyond floor of origin	24.63	60.41	$58,431

This figure displays the rates of civilian injuries and deaths per 1,000 fires, as well as property damage. Following the far-left column from top to bottom, each row represents a more advanced level of fire involvement in a residence. Typically, the more advanced the fire, the larger the delay in suppression. Assuming an early discovery of a fire, companies staffed with larger crew sizes help to minimize deaths, injuries, and property loss. This highlights why a 5- to 7-minute delay in suppression activities by smaller sized crews results in higher economic losses to a residence.

OSHA's "2 In/2 Out" Regulation

The "2 In/2 Out" Regulation is part of paragraph (g)(4) of the United States Occupational Safety and Health Administration's (OSHA) revised respiratory protection standard, 29 CFR 1910.134. The focus of this important section is the safety of firefighters engaged in interior structural firefighting. OSHA's requirements for the number of firefighters required to be present when conducting operations in atmospheres that are immediately dangerous to life and health (IDLH) also covers the number of persons who must be on the scene before firefighting personnel may initiate an interior attack on a structural fire.

[50] *National Fire Protection Association, NFPA 1710 (2016), Table A.5.2.2.2.1(b) Fire Extension in Home Structure Fires, 2006–2010.*

[51] *NFIRS 5.0 has six categories of confined structure fires including cooking fires confined to the cooking vessel, confined chimney or flue fires, confined incinerator fires, confined fuel burner or boiler fires or delayed ignition, confined commercial compactor fires, and trash or rubbish fire in a structure with no flame damage to the structure or its contents. Homes include one- and two-family homes (including manufactured housing) and apartments or other multifamily housing. These statistics are national estimates based on fires reported to U.S. municipal fire departments and so exclude fires reported only to federal or state agencies. National estimates are projections. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire. Property damage has not been adjusted for inflation.*

An interior structural fire (*an advanced fire that has spread inside of the building where high temperatures, heat, and dense smoke are normally occurring*) would present an IDLH atmosphere and, therefore, require the use of respirators. In those cases, at least two standby persons, in addition to the minimum of two persons inside needed to fight the fire, must be present before firefighters may enter the building.[52, 53] This requirement is mirrored in NFPA 1500, which states that "a rapid intervention team shall consist of at least two members and shall be available for rescue of a member or a team if the need arises. Once a second team is assigned or operating in the hazardous area, the incident shall no longer be considered in the 'initial stage,' and at least one rapid intervention crew shall be required."

NFPA Standard 1710 also supports the OSHA regulation by requiring a minimum of four personnel on all suppression apparatus. Portions of the 1710 Standard recommend that "fire companies whose primary functions are to pump and deliver water and perform basic firefighting at fires, including search and rescue… shall be staffed with **a minimum of four on-duty members**" while "fire companies whose primary functions are to perform the variety of services associated with truck work, such as forcible entry, ventilation, search and rescue, aerial operations for water delivery and rescue, utility control, illumination, overhaul and salvage work… shall [also] be staffed with **a minimum of four on-duty members**."[54, 55]

For either fire suppression company, NFPA 1710 states that "In jurisdictions with a high number of incidents or geographical restrictions, as identified by the AHJ, these companies shall be staffed with a minimum of five on-duty members" and "In jurisdictions with tactical hazards, high-hazard occupancies, or dense urban areas, as identified by the AHJ, these companies shall be staffed with a minimum of six on-duty members."[56, 57]

ESCI recommends achieving this four-person staffing level incrementally over a time frame, such as five years, to ensure that qualified firefighting personnel can be hired, trained, and funded in a realistic manner. As discussed under the financial section of Appendix A, LC-CFRS operates a four shift or platoon schedule which requires five FTE to fill each 24-hour riding position on a staffed LC-CFRS apparatus. This staffing factor of 1.25 provides for relief staffing (sick/vacation and other overtime coverage). For 20 engine companies, LC-CFRS will need to add 25 personnel per shift for a total of 100 personnel.

---

[52] *According to NFPA standards relating to firefighter safety and health, the incident commander may make exceptions to these rules if necessary to save lives. The Standard does not prohibit firefighters from entering a burning structure to perform rescue operations when there is a "reasonable" belief that victims may be inside.*

[53] *Paula O. White, letter to Thomas N. Cooper, 1 November 1995 (OSHA).*

[54] *NFPA 1710, § 5.2.3.1 and § 5.2.3.1.1.*

[55] *NFPA 1710, § 5.2.3.2 and § 5.2.3.2.1.*

[56] *AHJ, Authority Having Jurisdiction.*

[57] *NFPA 1710, §5.2.3.1.2, § 5.2.3.1.2.1, § 5.2.3.2.2, and § 5.2.3.2.2.1. 25.*

The following two figures give notional phasing options of three, five, or seven years as examples so that LC-CFRS can evaluate and implement staffing impacts as growth and risk profiles change, and financial resources become available. The cost projections which follow use the average FY 2019 salary and benefits for a Pay Grade 1 Firefighter (see Appendix A for a detailed description of pay/benefits and how they are used for future modeling of staff additions). The first figure shows FTEs added each year of the notional plan to achieve four-person staffing while the second figure shows the annual cost including the onboarding cost for the incrementally added FTE and the recurring cost of the previously added FTE for a total annual cumulative cost per plan year.

Figure 62. Notional Phasing Plan for Four-Person Staffing – Incremental FTE

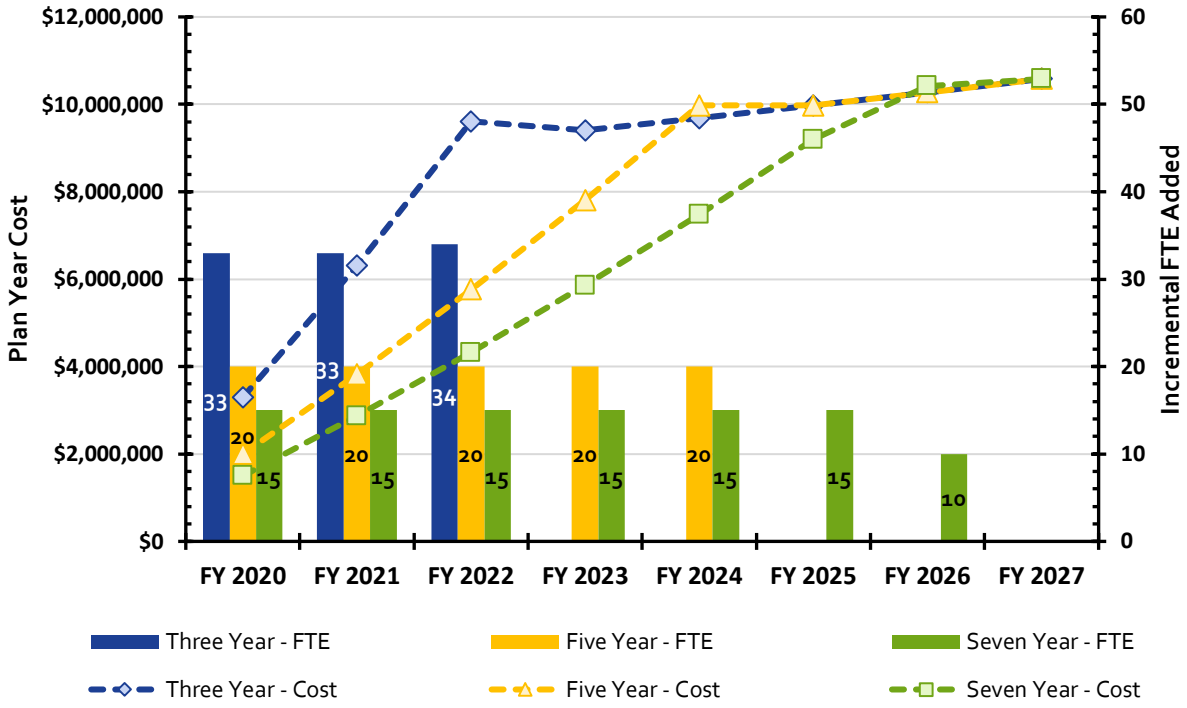
	Staff (FTE) Added by Plan Year							
Notional Phasing	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027
Three-Year FTE	33	33	34					
Five-Year FTE	20	20	20	20	20			
Seven-Year FTE	15	15	15	15	15	15	10	

Figure 63. Notional Phasing Plan for Four-Person Staffing – Cumulative Annual Costs

	Initial & Recurring Costs by Plan Year							
Notional Phasing	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027
Three-Year Cost	$3,297,669	$6,311,436	$9,608,693	$9,400,261	$9,682,268	$9,972,737	$10,271,919	$10,580,076
Five-Year Cost	$1,998,587	$3,825,113	$5,759,542	$7,806,708	$9,971,633	$9,972,737	$10,271,919	$10,580,076
Seven-Year Cost	$1,498,940	$2,868,835	$4,319,657	$5,855,031	$7,478,724	$9,194,656	$10,419,509	$10,580,076

The following figure provides a comparison of the annual costs and incremental staff additions needed to achieve four-person staffing on 20 engine companies. Each notional plan contemplates adding staff in FY 2020, the initial plan year, at different rates over three, five, and seven years. Clearly, annual costs rise much faster under a three-year phasing approach than under a seven-year phasing plan. By FY 2027, the annual cost of the additional 100 FTE is approximately $10.6 million.

Figure 64. Comparison of Cumulative Annual Cost and Incremental FTE Addition to Achieve Four-Person Staffing over Various Time Frames

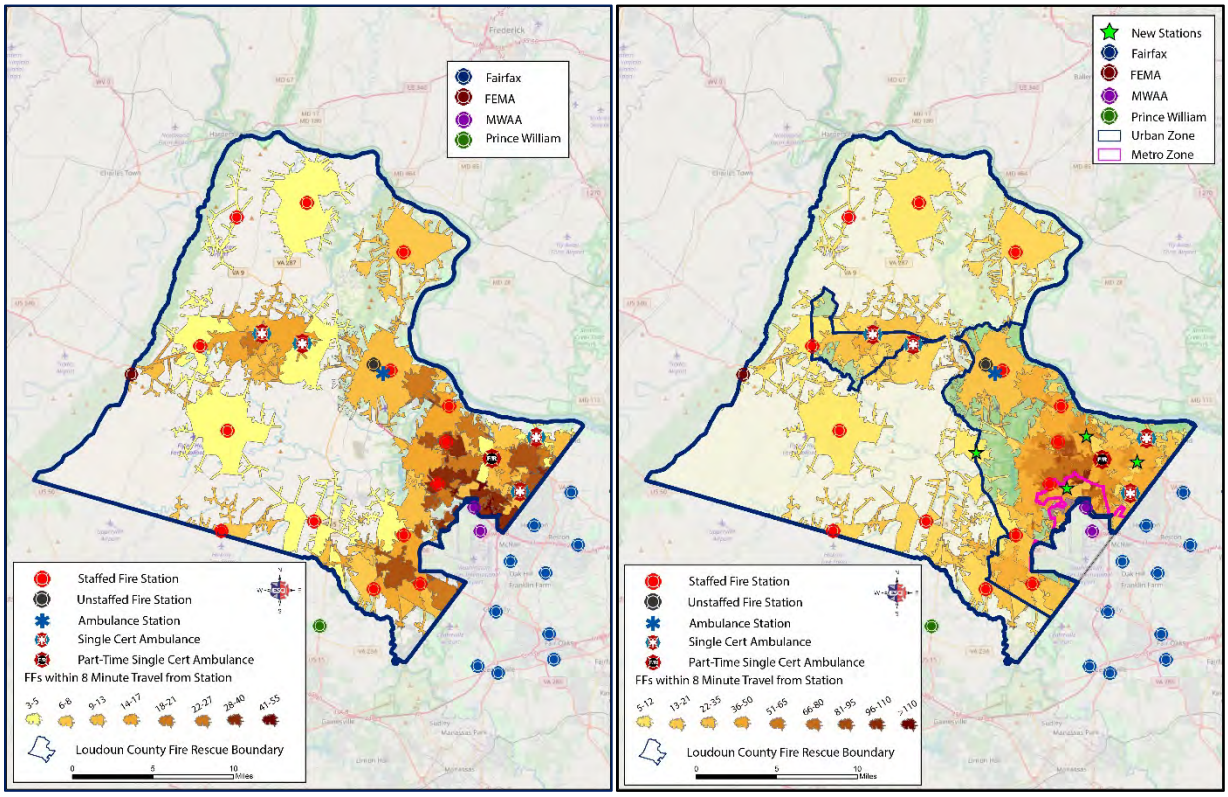


ESCI recommends that LC-CFRS add four-person staffing to all new fire stations as they are put online. It is recommended that staffing up to four-person staffing on all remaining engine companies be prioritized in the following Phases:

- Phase I: Provide four-person staffing to the rural planning zone engine companies based on unit hour utilization, fire history, and evolving risk profile within the planning zone. This will address difficult ERF assembly and rural water supply issues in the timeliest manner.
- Phase II: Increase to four-person staffing on existing urban zone planning area engine companies based on changing risk profile, fire history, and unit hour utilization.
- Phase III: Increase the existing metro planning zone engine companies to four-person staffing based on call volume, fire history, and changing risk profiles with consideration to the availability of surrounding planning zone and automatic aid resources that can be assembled in the established response time standards.

This phased staffing approach will best address rural fire and water supply issue where it is difficult to assemble an ERF in a timely manner. Urban and metro zones will benefit from four-person staffing from the new fire stations and available automatic aid and surrounding LC-CFRS fire planning zone companies, resulting in better capabilities to assemble an ERF within a shorter time frame then the rural fire planning zone.

Figure 65. Effective Response Force with Automatic Aid and Additional Stations



OFE Goal E: Add additional Battalion Chief to the Leesburg LC-CFRS Headquarters Area

Currently, each shift Battalion Chief is responsible for approximately 40 to 50 personnel. In addition, they are geographically **"not"** able to cover the system in the recommended NFPA 1710 response time to provide command and control as part of an ERF. This deficiency results in a very broad and less effective span of control over a very large geographic footprint. This configuration has resulted in significant limitations in general management, scene safety, officer development, succession planning, and other activities. In addition, during large incidents, LC-CFRS requests a second Battalion Chief resulting in large portions of the system left without incident commander coverage.

Span of Control

LC-CFRS's BCs currently maintain a span-of-control ratio of one Battalion Chief to 8 to 10 Captains (1:10), as well as command and control responsibilities for additional responding volunteer officers and personnel. According to the *National Incident Management System* (NIMS), the optimal span of control for incident management is one supervisor to five subordinates (1:5).[58] The *Incident Command System* (ICS) 200 training course states, "Management studies have shown that the span of control for a supervisor falls within a range of three to seven…" The lesson plan also states that the general rule for a span of control in ICS is one supervisor to five subordinates.[59] The generally accepted industry standard is a ratio of one supervisor to 3 to 7 subordinates. These recommendations on the span of control are applicable to both the management of emergency incidents as well as the day-to-day administrative and supervisory activities of the Battalion Chiefs.

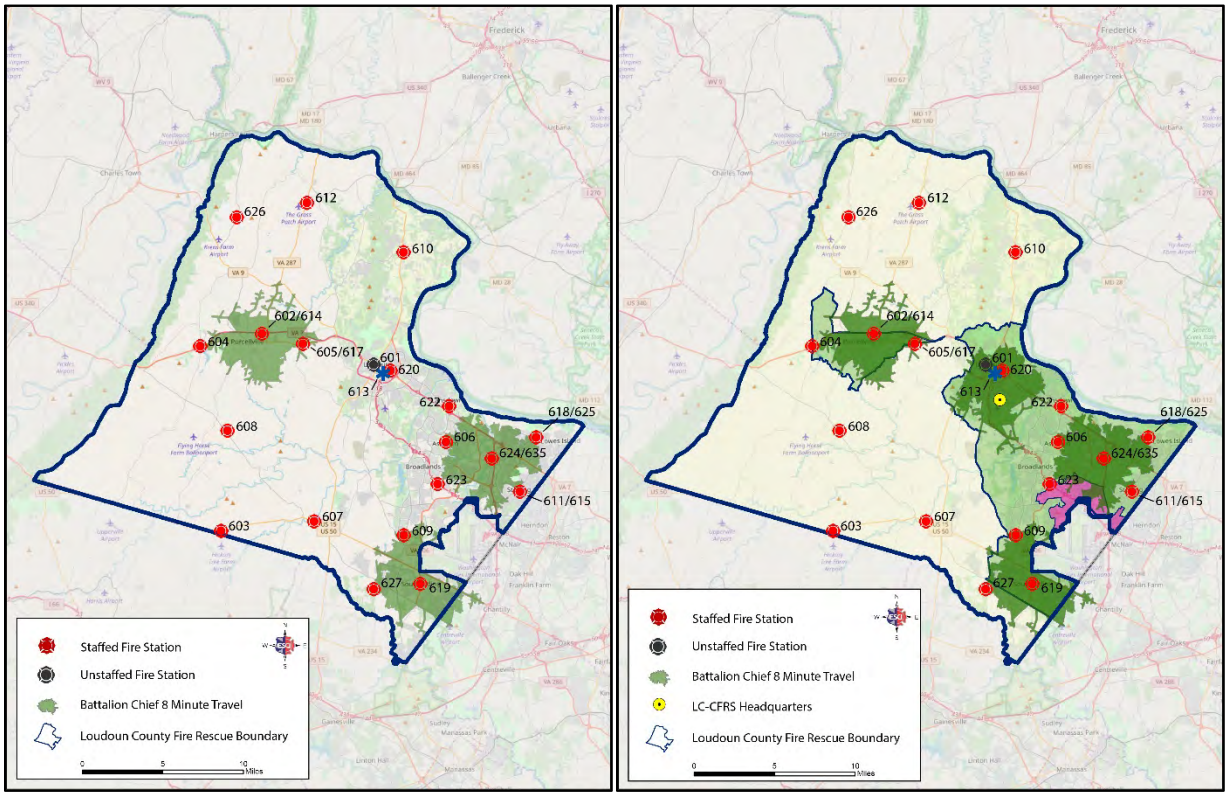
ESCI recommends an additional BC be assigned to the Leesburg headquarters area. This initial coverage should be during peak demand hours from around 0700 to 2100 hours. This position should transition to 24/7 coverage as soon as possible to increase command, control, and supervisory capabilities for line personnel during low-frequency high-risk hours.

The FY 2019 average annual salary and benefits package of the Battalion Chief position (Pay Grade F6) is $167,934 which is anticipated to increase at approximately $5,000 per year for the next several years. In order to add one 24/7 Battalion Chief, given the current four platoon system and relief factor of 1.25, LC-CFRS would need to add five FTE at an initial cost of approximately $935,000 in FY 2020. This includes one-time on-boarding costs of approximately $70,000 for the five FTE. The recurring cost of the five positions would rise from approximately $865,000 in FY 2020, to $1.06 million by FY 2027. One option for consideration would be to phase in the 24/7 Battalion Chief position over a period of years by initially hiring a smaller number of FTE to staff a 40-hour, or some similarly scheduled, position.

[58] *National Incident Management System, Third Edition. U.S. Department of Homeland Security, Federal Emergency Management Agency (FEMA); October 2017.*

[59] *IS-200.B: ICS for Single Resources and Initial Action Incidents. U.S. Department of Homeland Security, Federal Emergency Management Agency (FEMA); 2013.*

Figure 66. Current vs. Future Battalion Chief Coverage



OFE Goal F: Reduce Call Processing time and Implement Medical Priority Dispatch Tiered Response and consistent unit assignments that align with Risk and call type

Currently, the LC-CFRS dispatch call taking and dispatch times are in excess of NFPA standards. LC-CFRS dispatch has undertaken several initiatives and steps to enhance PSAP and dispatching services for the system. These efforts are to be commended and should be continued. ESCI has identified several best practices and recommendations for review and consideration by the LC-CFRS dispatch system to utilize as appropriate. LC-CFRS dispatch should continue monitoring both call answering and call processing performance on a monthly basis and strive to maintain or exceed adopted standards.

The NFPA 1221 standard recommends answering all emergency lines within 15 seconds, 95 percent of the time.[60] NFPA 1221 further recommends that call processing takes 64 seconds or less from call pick up to notification of first responding units, 90 percent of the time.[61] There are exceptions to this standard based on the type of event that is reported. The following are some call/event handling techniques that LC-CFRS can consider that will assist with compliance of NFPA standards:

Call Answering:

- Historical call records should be reviewed to determine call volume by hour and day to determine days and times where maximum staffing should be on hand. Shift schedules should then be adjusted to ensure staffing availability at peak times.
- Install an Automated Call Distribution (ACD) system. ACDs can be used in medium to large dispatch centers to automatically route the next incoming emergency phone call to the next available telecommunicator. The telecommunicator receives a "zip" tone to indicate an incoming call, eliminating the need for the telecommunicator to initiate the call. This is an efficient method to distribute workload and ensures the call is answered as quickly as possible. ACD systems are configured to handle emergency lines before non-emergency lines.
- If an ACD system is not practical/feasible, it is critical to have defined roles for telecommunicators that dictate the need for the immediate answering of emergency lines. Policies should be in place defining the primary, secondary, and tertiary responsibilities of each position on the dispatch floor.
- Agency policy should state that telecommunicators should put non-emergency calls on hold immediately and answer new emergency calls coming in.

[60] *Section 7.4.1 National Fire Protection Association Technical Standard 1221, Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems, 2019 Edition.*

[61] *Section 7.4.3 National Fire Protection Association Technical Standard 1221, Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems, 2019 Edition.*

Call Processing:

- Time savings can be had in the initial three components of call interrogation:
  - *Location Verification*—LC-CFRS should continue to train their telecommunicators on effective call interrogation techniques with the goal of getting the location as quickly as possible. Additional technology can help with location verification as well. While current wireless 911 technology can get you close to where the caller is, it is still several years away from pinpointing exactly where a wireless caller is. LC-CFRS uses third-party software that uses the GPS coordinates from the phone to give the telecommunicator a more accurate location.
  - *Callback Number*—this information needs to be verified by the telecommunicator on wireline and wireless calls.
  - *What's going on?*—Quickly determining what the request for help is will depend on the telecommunicator's call interrogation training. They need to ask questions of the caller in the order that the telecommunicator needs it, and not let the caller give information as they think the telecommunicator wants it.
- Event Routing
  - The radio dispatcher will retrieve the call from a pending queue in CAD, determine the correct emergency unit response, and commit the event. Delays can occur here if the radio dispatcher does not see the new pending event or did not hear an audible tone announcing a new event. The most common cause of delay here is a distraction—the radio dispatcher is doing some other task, is on a phone call, or simply is not facing their pending screen to see the new event. It is imperative to ensure that the radio dispatchers are not responsible for tasks that take their attention away from radios and pending calls to reduce call pending times.
  - Determining the correct ERFs/ERUs for response will depend on how much automation is available from a CAD system. Having dependable unit status/availability in the system allows the radio dispatcher to merely verify the recommendation in CAD and send the alerts out. If the dispatcher has to verify the availability of units, or if the CAD system is not configured to recommend the appropriate resources, it will take additional time.
- ERF/ERU Notification
  - LC-CFRS uses an automated fire station alerting system. Once the radio dispatcher assigns the ERFs/ERUs, the system automatically sends the event data to the ERFs/ERUs. This is usually counted in milliseconds and is not a factor in call processing.

Medical Priority Dispatch System Tiered Response

Appropriate triage and dispatching of emergency medical calls is a component of maintaining the viability and integrity of an EMS service delivery system. The use of a Medical Priority Dispatch System (MPDS) allows for more efficient utilization of emergency and non-emergency resources. Instead of sending a full complement of EMS responders, traveling with lights and sirens to every medical incident, including minor ones, calls are triaged at the dispatch center. Using a nationally accepted system of screening and prioritizing information for a caller, the appropriate level of response is then determined to assure an effective level of resource allocation to a serious emergency, while also limiting the volume and speed of response to minor incidents. Once the EMS system is appropriately triaging and dispatching medical emergency calls, the LC-CFRS will be able to better utilize resources, allowing them to adapt to future increased call volume and expanded service delivery. This type of non-emergent dispatch and response system will necessitate additional non-emergency or mobile integrated health care response goals that accommodate most appropriate resource response from a greater distance.

While current medical priority dispatch protocols are utilized by LC-CFRS with a BLS or ALS tiered response, improvements can be made to the system. While this is a locally determined approach, and utilized in other jurisdictions, it does not fully leverage the proven and realized benefit of a fully implemented and managed MPDS system. An MPDS system that is meeting national standards can dispatch the right resource in a timely manner that connects the patient to the most appropriate medical resource in a manner that avoids bad outcomes and increased risk and liability.

In order to manage an MPDS system in a manner that ensures timely and accurate dispatch and pre-arrival instructions, it is recommended that LC-CFRS dispatch become an Accredited Center of Excellence (ACE) through the International Academies of Emergency Dispatch.

Financial Impact: Primary elements of an ACE accredited dispatch center are in place. The incremental cost of implementing an accredited system of MPDS will need further study and be provided by LC-CFRS.

Implementation/Review of Tiered Response to EMS Incidents

When a request for emergency medical service is received at LC-CFRS dispatch, call takers ask a series of questions to determine the nature and severity of the medical emergency. These questions are designed to quickly determine if the incident is potentially life-threatening or not. The primary purpose of this questioning process is to identify the most appropriate response. Life-threatening incidents require more resources (personnel and equipment) than non-life-threatening incidents.

Implementation of tiered EMS response can also be used to determine if ambulance resources are dispatched to an incident. Some EMS incidents may only require a single first responder advanced life support (FRALS) response to provide patient evaluation. Use of tiered EMS response can reduce the number of units sent to EMS incidents.

A conservative approach to a tiered response can be implemented. This approach would pre-alert and dispatch the closest FRALS and ambulance with lights and siren. Once MPDS protocols are completed, and the call is classified as an Alpha or Omega non-emergent call, the response can be downgraded to non-lights and sirens or cancellation of the ambulance pending an evaluation of the patient by the FRALS unit.

Financial Impact: By prioritizing calls and sending only the appropriate apparatus, the department would save on fuel and maintenance costs (fewer responses to low priority medical calls), and would possibly defer future costs of hiring additional staff by adding response capacity (more available unit hours) into the system.

Implementation of Consistent Unit and Personnel Assignment to Incidents that Align with Identified Risk and Call Type

Currently, primary units are dispatched to emergencies within the LC-CFRS service area. Based on the primary company or fire station providing service to the identified service area, any number of units and personnel configurations are utilized to respond to the same types of calls. This frequently results in inconsistency and the inability to measure Unit Hour Utilization (UHU), unit effectiveness, and the consistent use of resources by call type and determinant.

ESCI recommends that consistent unit and personnel dispatch and deployment standards be developed and implemented by fire planning zones. This will ensure a consistent response throughout the system and allow for the measurement of utilization by individual units, stations, service areas, and planning zones.

In addition, ESCI recommends that LC-CFRS consider consistent volunteer shift schedules at stations not having career personnel assigned. This will greatly enhance the predictability and measurement of response performance and outcomes in stations not staffed by paid personnel. These schedules should take into account the impact on scheduled volunteer staffing by surge capacity as reported in the service delivery section of the report. These staffing models will need to be supported with additional volunteer and paid staff to address regularly occurring and predictable surges and call capacity.

LC-CFRS is to be commended for their efforts in bringing the number of companies and staff together to form an integrated system of response and planning. ESCI encourages this continued system-wide approach to operations, policies, and processes to include the enhanced integration of volunteer and paid staff.

OFE Goal G: Improve Turnout Time Performance

Turnout time is the one component of total response time over which the fire department has the greatest control, and which is not affected by outside influences. Turnout time, or the time from when the call is received by the response units (dispatched) to when the unit is enroute to the scene (responding), affects overall response times. Reducing this response time component reduces total response time.

The NFPA 1710 Standard for Career Fire Departments calls for turnout times of 60 seconds for EMS incidents and 80 seconds for fire incidents. It is ESCI's experience that the NFPA turnout time goals are difficult to achieve. This is affirmed in a study published in 2010 by the NFPA.[62] As previously discussed, the LC-CFRS overall turnout time performance is approximately 2 minutes, 4 seconds, 90 percent of the time. In the combined response performance goal recommendations, ESCI recommends that LC-CFRS adopt a turnout time goal of 90 seconds (1:30) for 90 percent of emergency incidents.

ESCI recommends that the department monitor unit turnout time performance and provide the information to emergency response personnel for self-correction. With good information, training, and properly designed facilities that allow for the rapid and efficient movement, responders can improve turnout time and hence total response time performance.

OFE Goal H: Evaluate Current and Future Station Locations to Improve First Response and ERF Capabilities

The analysis of long-range future resource deployment is an ongoing process, not one that is decided at one point in time and remains static. Circumstances change over time as the risk profile and population demographics within the LC-CFRS service area change. The deployment options presented here should be periodically reviewed and modified as needed. The options presented are intended to provide general guidelines for future station deployment based on existing conditions and future growth and development in the service area.

ESCI recommends that LC-CFRS consider a response time goal for the first apparatus to arrive within 13 minutes, 04 seconds in the rural fire planning area, 8 minutes, 04 seconds in the urban fire planning zone, and 7 minutes, 04 seconds in the metro fire planning zone (911 call pick up to the first unit on scene).

To meet this proposed response standard, ESCI recommends that LC-CFRS consider the addition of three new fire stations within the urban and metro fire planning area. This will result in an enhanced response to the urban and metro response planning zone area where the department is not currently meeting the sample 90th percentile response time. These station locations will provide for a 7-minute, 30-second to 8-minute, 30-second response time for first due units within the identified response gaps, as well as enhancing systemwide ERF capabilities.

[62] *Quantitative Evaluation of Fire and EMS Mobilization Times, May 2010, available www.nfpa.org/foundation.*

The following approximate new station locations are recommended and in the following order based on the recommended triggers:

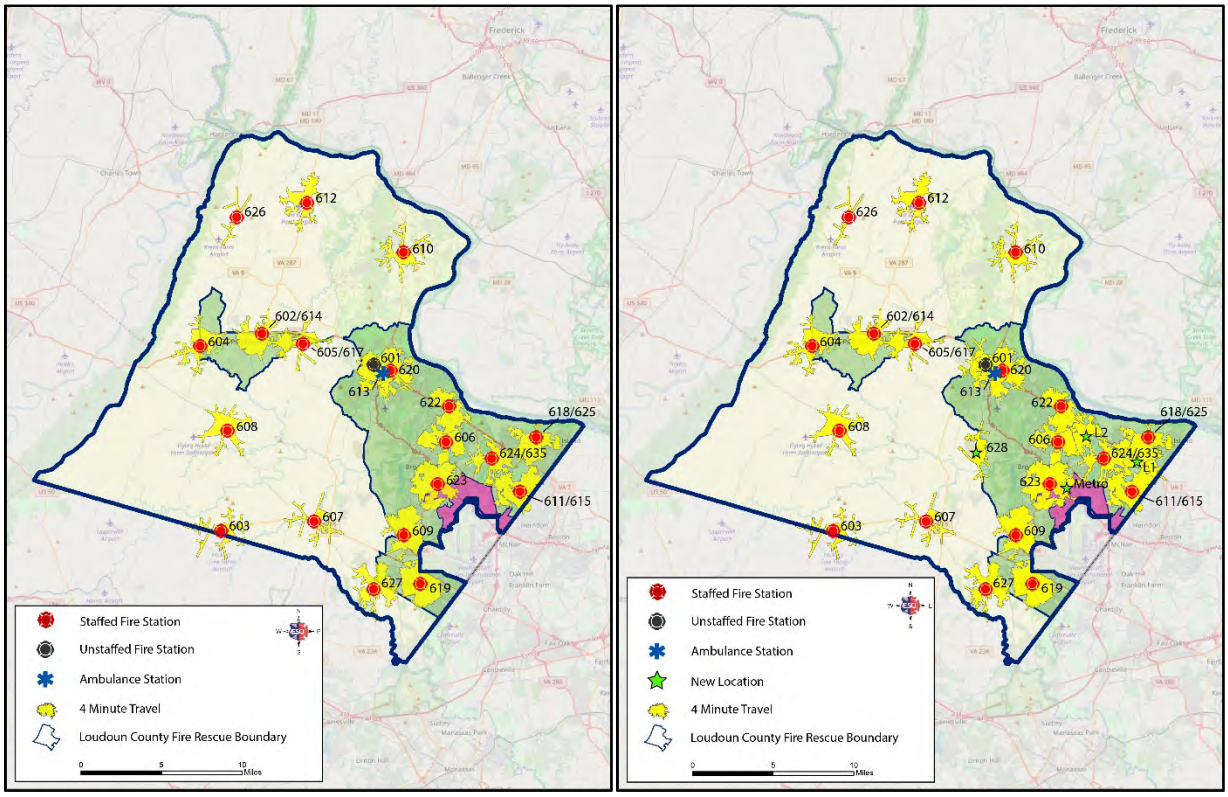
Figure 67. Approximate Locations of New Stations

Station	Approximate Location
Metro	Shellhorn Rd/Loudoun County Pkwy
First Location	Bartholomew Fair Dr/Harry Byrd Hwy
Second Location	Exchange St/Russell Branch Pkwy
Third Location	Evergreen Mills Road

This operational and staffing model will best meet the response needs and risk profile of the proposed station response areas. Based on the population and risk profile, ESCI recommends that an engine and ambulance be located in the three stations outside of the Metro area and two engine companies, a truck company, a rescue company, a battalion chief, and an ambulance in the Metro planning zone station located in the vicinity of Shellhorn Road and Loudoun County Parkway (this location is based on the current road network and will need to be optimized once the metro road network is completed). Given the lack of current transportation and other infrastructure in the metro areas near Dulles Airport, the location analyzed is approximate and it is understood that modeled times based upon this station will change as the proposed location changes.

The following figure displays the portions of the LC-CFRS service area within four minutes travel of the proposed *additional* stations in the urban and metro fire planning zones. These new stations and locations will optimize the LC-CFRS first unit and ERF response to meet the recommended performance goals.

Figure 68. Four-Minute Travel with New Stations



As discussed in the Community Risk and Service Delivery analysis, the underserved urban and metro fire planning zones are immediately north and east of Washington Dulles International Airport. These areas have service gaps that impact first due and ERF capabilities within these zones. These zones are characterized by densely populated, multi-story, mixed-use, transit-oriented places for housing, employment, entertainment, education, and retail, all in close proximity to the new Metrorail Silver Line. In addition, there are multi-family neighborhoods, retail, employment, commercial—technology, data management, communications industries, industrial uses, airport-related businesses, and data center development. The identified response gaps are in large part due to the inability to get to high call volume areas due to limited road networks, traffic and congestion, and a lack of geographic station and unit presence in these dense and growing areas.

The following discussion presents options for the future deployment of stations and resources within the LC-CFRS service area. GIS software is used to model travel time over the existing street network. Travel time is calculated using the current speed limit and adjusted to account for negotiating intersections and turns. In some cases, the speed limit has been adjusted to account for recent street network improvements. Multiple different locations were evaluated to arrive at the station locations modeled in this portion of the recommendations. The locations displayed are meant to illustrate the approximate location of proposed stations.

In most cases, ESCI does not recommend placing fire stations on or near jurisdictional borders. This is primarily because doing so will effectively cut that station's service area in half. Whether measuring performance using ISO or NFPA standards, fire stations located on borders will typically have approximately half of the service area footprint as other stations located at least 1.5 miles away from a border. In some cases, such as joint fire stations with other agencies, locations with high target hazards or some other justifiable reason, the suggestion to place a fire station on a boundary line may be acceptable.

ESCI also recommends that LC-CFRS look at alternative fire station location options. Given the level and cost of complex development in the urban and metro fire planning zones, LC-CFRS may consider utilization of nontraditional fire station locations, such as an available warehouse or commercial structure that has significant square footage available at a reduced cost. The ability to find and fund a two- to three-acre parcel for a dedicated fire station may be impractical or not possible.

Future development and population growth will significantly drive and determine service delivery needs and service demand. In the absence of approved development plans, and verifiable population and risk profile changes, ESCI recommends the following triggers for new fire station and resource deployment. ESCI recommends that LC-CFRS utilize these criteria to determine the timing of new fire station locations and increased resources as development and population levels increase.

CRITERION GRID TO DETERMINE WHEN A NEW STATION IS NEEDED				
Action Choices	Travel Distance	Criterion		
		Response Time Parameter	Out of Area Calls	Building/Risk Inventory
Maintain status quo	All risks within 1.5 miles	1st due company is within 5 minutes total response time, 90 percent of the time	100% in first due area	Existing inventory and infill
Temporary facilities and minimal staffing	Risks 1.5 to 3.0 miles from existing station	1st due company Exceeds 4-minutes travel time 10% of the time, but never exceeds 8 minutes	More than 10% of calls are in adjacent area	New area has 25% of same risk distribution as in initial area
Permanent station needed	Risk locations exceeding 4.0 miles from the station	1st due company Exceeds 4-minutes travel time 20–25% of the time. Some calls < 8 minutes	More than 20–25% of calls are in outlying area	New area has 35% of same risk distribution as in initial area of coverage
Permanent station essential	Outlying risk locations exceeding 5.0 miles from the 1st station	1st due company Exceeds 4-minutes travel time 30% of the time. Some calls < 10 minutes	More than 30% of calls are in outlying area	New area has 50% of same risk distribution as in initial area

The financial impact can be calculated for the addition of fire stations and/or single or multiple response units (engine company, ladder company, ambulance, or rescue company and/or fire station) at any time between FY 2019 and FY 2024 using the data provided in Appendix A under the section Financial Basis for Cost Projections.

Using FY 2019 as the basis for cost projections, a BLS engine company would cost $2,672,808 in staff and capital costs if added in FY 2019 with a recurring staff cost of $1,561,808 in FY 2020 which would escalate annually to $1,757,828 by FY 2024. Further, there would be operating costs for the apparatus as well as annual capital apparatus and equipment replacement costs to consider.

Addition of a ladder company in FY 2019 would cost $3,659,239 in staff and capital costs with a recurring staff cost of $1,991,936 in FY 2020 which would escalate to $2,241,942 by FY 2024. Addition of an ALS ambulance in FY 2019 would cost LC-CFRS $1,482,360 if added in FY 2019 with a recurring cost of $952,441 in FY 2020 escalating to $1,071,981 by FY 2024. Again, there would be operating costs for both unit types as well as annual capital apparatus and equipment replacement costs to consider in fully evaluating the cost of adding these units.

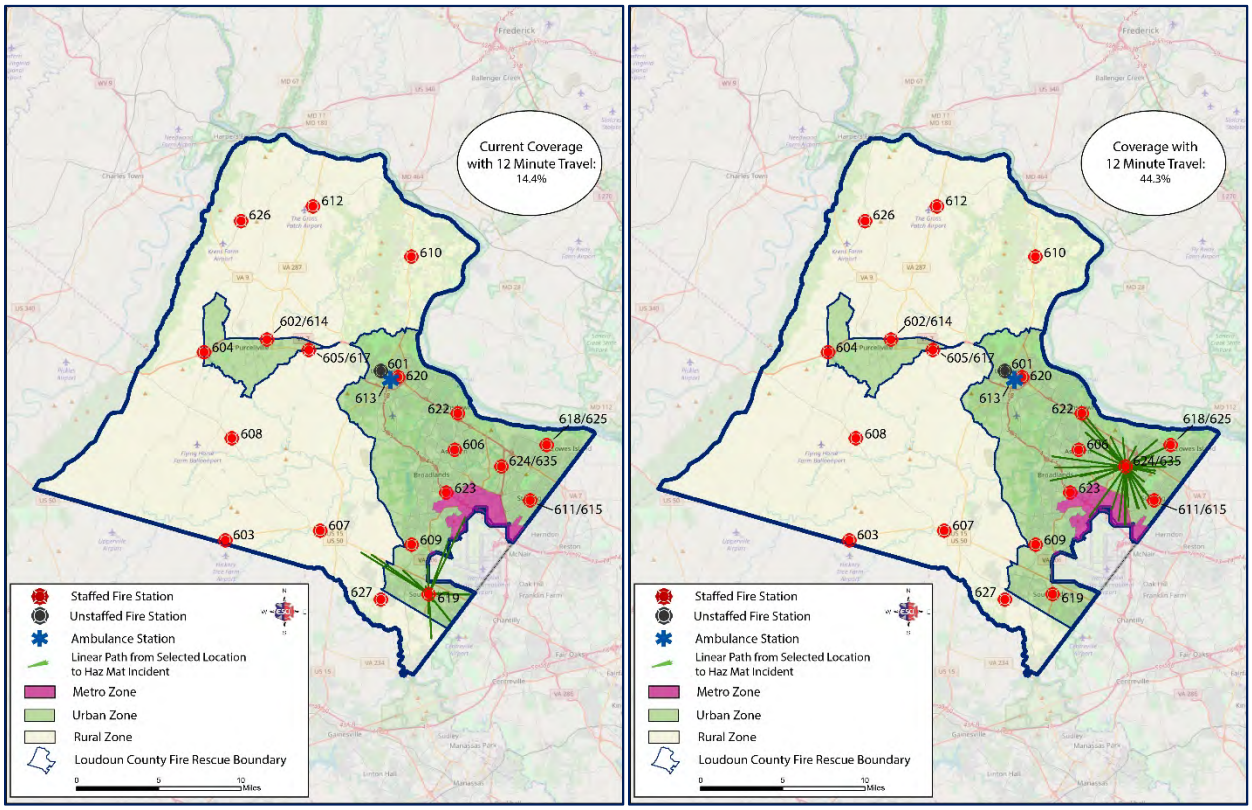
Adding a new fire station using a standardized 18,500 square foot station floor plan similar to the Lucketts station in FY 2019 would cost approximately $9.8 million and add $123,150 in annual operating costs. With inflation of building and operating costs, the same station, if added in FY 2024, would cost approximately $12.2 million to construct and furnish and almost $130,000 in annual operating costs. As discussed in Appendix A, land costs have not been included in the estimate because they are highly variable and often are received through developer proffers.

OFE GOAL I: Optimize the Location of LC-CFRS Hazardous Materials Unit and Staff four Existing Heavy Rescue Response Units

LC-CFRS operates a hazardous materials (hazmat) response Heavy Rescue body type vehicle out of Station 619 as well as a hazardous materials support unit. This is a "level A" resource, the highest level of hazmat response capability. To achieve level A capability, a combination of highly technical equipment is necessary, along with appropriately trained, technician-certified personnel. The department staffs a minimum total number of 6 hazardous materials technicians for response each day from Station 619. The Battalion Chief assigned to Battalion 3 is also normally a Hazardous Materials Technician.

In identifying the location of the hazardous materials response unit and support unit, LC-CFRS has considered staffing, response, utilization, and risk elements. Utilizing one dedicated hazmat response unit for the entire system creates geographical travel time and coverage challenges. Based on hazmat call response history, identified risks requiring a hazmat response, and optimized travel routes throughout the county, the analysis indicates that the optimal location of the hazardous materials response and support units is to Station 628 when it is built and operational. The new Station 628 facility appear more beneficial at this time and will centralize this resource within the county. This analysis was conducted with 8, 10, and 12-minute intervals with the same result. However, if travel time is increased to 15 minutes, Station 606 can respond to the greatest number of incidents and should be considered as an option as well.

Figure 69. Hazmat Current and Optimized Locations



LC-CFRS staffs a Rescue Squad at Station 620, however daily staffing does not require that all members assigned to the unit be trained in technical rescue incidents. Four other units are cross-staffed with members who have various levels of technical rescue training, but it is not always required on those apparatus.

LC-CFRS has staffed and located the Rescue Squads based on previous heavy rescue responses and associated risk. The heavy rescue units respond to technical rescue and fires throughout the entire system. Based on this core service and associated support by the additional cross-staffed rescue units, ESCI recommends staffing the rescue currently located at Station 624. By staffing this location, the percentage of incidents that the Rescue Squad can reach within 12 minutes increases in excess of 8 percent, and a staffed Rescue Squad resource is more centrally located to demand within Loudoun County. Additionally, the 12-minute travel time analysis showed that the difference between the currently staffed rescue's response times, and the increased staffing of the rescue at Station 624 resulted in significantly improved the response times and capabilities. Over 50 percent of the staffed rescue response calls saw a response within a 12-minute travel time.

In addition, ESCI recommends the remaining cross-staffed heavy rescues at Stations 607 and 617 be staffed with four personnel for response to fire and technical rescue incidents. This staffing level will significantly enhance the LC-CFRS ERF capabilities as well as provide rapid technical and heavy rescue capability throughout the entire system and all fire planning zones.

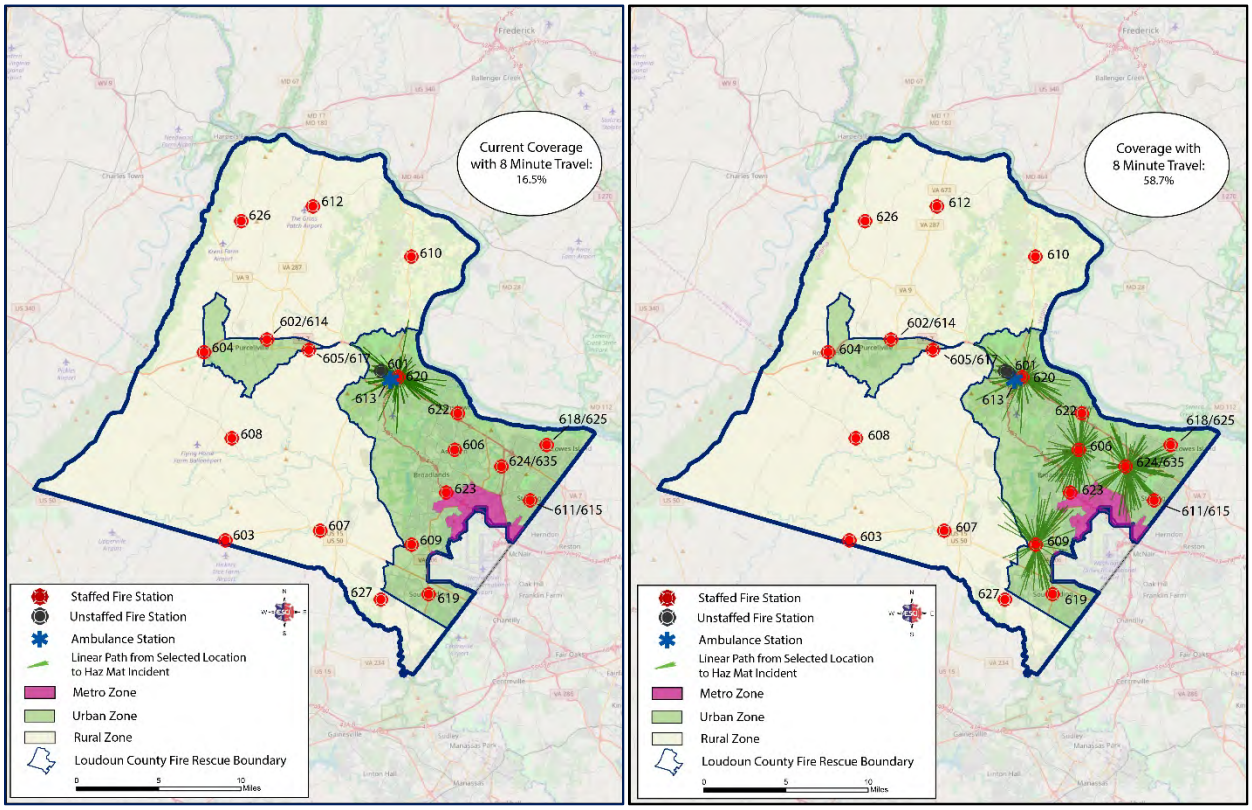
The cost to fully staff the three, existing cross-staffed heavy rescue units with four personnel per shift or platoon is based on the full cost for staffing one rescue unit as shown in the following figure. The model assumes that the units will be staffed with higher trained firefighters (Technical Rescue Technician or F2 level) and will have an officer on each of the four platoons, one of whom will be a Captain. The FY 2019 average annual total compensation (unit cost) for the positions is shown below along with the number of those FTEs required to staff all four platoons and accommodate a 1.25 relief factor (a total of 20 FTE per rescue unit).

Figure 70. FY 2019 Personnel Cost to Staff Heavy Rescue Unit

BLS Heavy Rescue Company			
Position	**Number**	**Unit Cost**	**Total Cost**
Technician	15	$99,688	$1,495,319
Lieutenant	4	$114,069	$456,275
Captain	1	$144,003	$144,003
Crew Total	**20**		**$2,095,597**

In FY 2019, it would cost approximately $2.1 million in recurring personnel costs to fully staff a four-person heavy rescue unit with the requirement for a total of 20 additional FTE. This cost would escalate at approximately 3 percent annually such that by FY 2027 the recurring cost to staff one heavy rescue unit would be approximately $2.65 million. Onboarding costs for one fully staffed unit in FY 2019 would be $275,000. Fully staffing three heavy rescue units with four-person staffing would require an additional 60 FTE and, as indicated above, in FY 2020 it would cost LC-CFRS approximately $6.5 million in personnel costs and $835,000 in one-time on-boarding costs.

Figure 71. Rescue Squad Current and Optimized Locations



CONCLUSION

The ESCI project team began collecting information concerning the LC-CFRS in early 2019. The team members recognize this report contains a large amount of information and ESCI would like to thank the LC-CFRS staff and many officials for their efforts in bringing this project to fruition. ESCI would also like to thank the various individuals and external organizations for their input, opinions, and candid conversations throughout this process. It is ESCI's sincere hope the information contained in this report is used to its fullest extent and the emergency services provided to the Citizens of Loudoun County and the surrounding area will be improved by its implementation.

Appendix A: Current Conditions—Review of Additional Organizational Elements

Staffing and Personnel Management

Staffing

An organization's greatest asset is its people. It is important that special attention is paid to managing human resources in a manner that achieves maximum productivity while ensuring a high level of job satisfaction for the individual. Consistent management practices combined with a safe working environment, equitable treatment, the opportunity for input, and recognition of the workforce's commitment and sacrifice are key components impacting job satisfaction.

The size and structure of an organization's staffing are dependent upon the specific needs of the organization. These needs must directly correlate to the needs of the community and a structure that works for one entity may not necessarily work for another agency. This section provides an overview of the Loudoun County Combined Fire Rescue System's staffing configuration and management practices.

Fire department staffing can be divided into two distinctly different groups. The first group is what the citizens typically recognize and is commonly known as the operations unit, which can be generally classified as the emergency response personnel. The second group typically works behind the scenes to provide the support needed by the operation's personnel to deliver an effective emergency response and is commonly known as the administrative section.

Administrative and Support Staffing

One of the primary responsibilities of the response team's administration is to ensure that the operations segment of the organization has the ability and means to respond to and mitigate emergencies in a safe and efficient manner. An effective administration and support services system is critical to the success of a response agency.

Like any other part of a municipal fire department or rural agency, administration and support need appropriate resources to function properly. By analyzing the administrative and support positions within an organization we can create a common understanding of the relative resources committed to this function compared to industry best practices and similar organizations. The appropriate balance of administration and support compared to operational resources and service levels is critical to the success of the department in accomplishing its mission and responsibilities.

Typical responsibilities of the administration and support staff include planning, organizing, directing, coordinating, and evaluating the various programs within the department. This list of functions is not exhaustive and other functions may be added. It is also important to understand these functions do not occur in a linear fashion and can more often occur concurrently. This requires the Fire Chief and administrative support staff to focus on many different areas at the same time.

The following figure reviews the organizational administration and support structure of the Loudoun County Combined Fire Rescue System.

Figure 72. LC-CFRS Administrative and Support Staffing

Position Title	Number of Positions	Hours Worked per Week	Work Schedule
Paid, Full-time Administrative or Support	Individuals considered as full-time employees and who provide services mainly intended to manage, plan, or support the activities the agency and its programs.		
Fire Chief	1	40	8am–5pm
Assistant Chief	2	40	8am–5pm
Operations Chiefs	4	42	24/7
Deputy Chief of EMS	1	40	Varies
Deputy Chief of Training	1	40	Varies
BC of EMS	1	42	Varies
BC of Training	1	42	Varies
Admin. Assistant	3	40	Varies
Admin./Finance	1	40	Varies
Executive Liaison	1	40	Varies
Buyer	1	40	Varies
PIO	1	40	Varies
Admin. Manager	1	40	Varies
Budget	1	40	Varies
Internal Affairs	1	40	Varies
EMS Billing Manager	1	40	Varies
Cost Recovery	1	40	Varies
Cost Recovery Coding	1	40	Varies
Volunteer Coordinator	1	40	Varies
Volunteer Services	1	40	Varies
Planner	1	40	Varies
OMD	1	40	Varies
QA/QI	2	40	Varies
Captain HR	1	42	Varies
Lieutenant HR	2	42	Varies
HR Manager	1	40	Varies
Admin. Assistant HR	1	40	Varies
Captain Research/Data	1	42	Varies
Captain Fleet	1	42	Varies
Technician Fleet	1	42	Varies
Logistics Manager	1	40	Varies

Position Title	Number of Positions	Hours Worked per Week	Work Schedule
Firefighter Logistics	1	42	Varies
EMS Admin. Assistant	1	40	Varies
BC of Facilities	1	40	Varies
Technician Facilities	2	42	Varies
Facilities Manager	1	40	Varies
ECC Manager	1	40	Varies
Cad Analyst	1	42	Varies
Records Admin.	1	40	Varies
Technician of RSSA	1	42	Varies
BC of Communications	1	40	Varies
CAD Specialist	1	42	Varies
GIS Specialist	1	40	Varies
GIS assistant	1	40	Varies
BC of Occupational Health & Safety	1	42	Varies
Captain of OHS	1	42	Varies
BC Special Operations	1	42	Varies

ESCI notes that currently the level of administrative and support staffing represents roughly 9.8 percent of the department's total staffing. It is our experience that typically effective administrative staffing totals for a fire department operation range from 12 percent to 15 percent of agency totals. After reviewing the functions and responsibilities assigned to the work group, ESCI concludes that the number of FTEs (full-time equivalents) assigned is below what is normally needed to appropriately accomplish the responsibilities of the County. Furthermore, several of these administrative positions are also tasked with operational duties in some situations. The incorrect staffing of the administrative and support functions creates a situation in which important organizational activities, at best, are delayed; but in worst case scenarios, get completely missed. When administrative members are engaged in operational duties, their administrative duties are placed on hold during the emergency.

Administration

The administrative function oversight within the department is currently established with the position of Fire Chief and two Assistant Chiefs during the week working an administrative 40-hour week schedule. Some of the typical responsibilities of the Fire Chief include planning, organizing, directing, and budgeting for all aspects of the department's operations. The current number of positions assigned to this activity is below the needs to meet these expectations as the daily operational needs can detract from the ability to focus only on administrative needs.

Administrative Support

LC-CFRS currently operates with a healthy administrative support system yet is still short of what is normally required. Each of the positions assigned to administration harness some level of a support function for the department, as well as some transition to operational roles when duties arise, and the system is strained. Furthermore, several operational positions are assigned administrative roles to assist with support functions.

Emergency Response Staffing

It takes an adequate and properly trained staff of emergency responders to put the appropriate emergency apparatus and equipment to best use in mitigating incidents. Insufficient staffing at an operational scene decreases the effectiveness of the response and increases the risk of injury to all individuals involved.

Tasks that must be performed at a fire can be broken down into two key components—life safety and fire flow. Life safety tasks are based on the number of building occupants, and their location, status, and ability to take self-preservation action. Life safety-related tasks involve search, rescue, and evacuation of victims. The fire flow component involves delivering sufficient water to extinguish the fire and create an environment within the building that allows entry by firefighters.

The number and types of tasks needing simultaneous action will dictate the minimum number of firefighters required to combat different types of fires. In the absence of adequate personnel to perform concurrent action, the commanding officer must prioritize the tasks and complete some in chronological order, rather than concurrently. These tasks include:

- Command
- Scene safety
- Search and rescue
- Fire attack
- Water supply
- Pump operation
- Ventilation
- Back-up/rapid intervention

The first 15 minutes is the most crucial period in the suppression of a fire. The timing of this 15-minute period does not start when the firefighters arrive at the scene but begins when the fire initially starts. How effectively and efficiently firefighters perform during this period has a significant impact on the overall outcome of the event. This general concept is applicable to fire, rescue, and medical situations. Critical tasks must be conducted in a timely manner in order to control a fire or to treat a patient. LC-CFRS is responsible for assuring that responding companies can perform all described tasks in a prompt, efficient, and safe manner.

Considerable ongoing local, regional, and national discussion and debate draws a strong focus and attention to the matter of firefighter staffing. Frequently, this discussion is set in the context of firefighter safety. NFPA 1710: *Standard for Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments* specifies the number of firefighters assigned to a particular response apparatus, often characterized as a "minimum of four personnel per engine company." ESCI notes that the more critical issue is the number of firefighters that are assembled at the scene of an incident in conjunction with the scope and magnitude of the job tasks expected of them, regardless of the type or number of vehicles upon which they arrive.

Setting the staffing levels is a determination that is made at the community level based on risk, capability, and citizen expectations. There are not mandated requirements that fit all situations, although NFPA 1710 has objectives to meet regarding the number required for some typical scenarios. Additionally, there is a process for LC-CFRS to conduct its own critical staffing analysis later in this report.

Some terms are used nearly interchangeably, such as the assembly of firefighters on an incident, may be called the "Initial Full Alarm Assignment," or called an "Effective Firefighting Force" (EFF), or "Effective Response Force" (ERF). ESCI will attempt to describe the NFPA 1710 levels for this effective response force for three different scenarios.[63]

The following initial full alarm assignment is for a single-family, 2,000-square foot, residential two-story structure without a basement and no exposures.

Figure 73. Initial Full Alarm Assignment for Residential Structure Fire

Initial Full Alarm Assignment 2,000 SF Residential Structure Fire	
Incident Commander	1
Water Supply Operator	1
2 Application Hose Lines	4
1 Support Member per line	2
Victim Search and Rescue Team	2
Ground Ladder Deployment	2
Aerial Device Operator	1
Incident Rapid Intervention Crew (2FF)	2
Total	**15**

The following figure describes an initial full alarm assignment for an open-air strip-type shopping center.

Figure 74. Initial Full Alarm Assignment for Strip Shopping Center

Initial Full Alarm Assignment Open Air Strip Shopping Center (13,000 SF to 196,000 SF)	
Incident Commander	1
Water Supply Operators	2
3 Application Hose Lines	6
1 Support Member per line	3
Victim Search and Rescue team	4
Ground Ladder Deployment	4
Aerial Device Operator	1

[63] *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 (National Fire Protection Association 2016 ed.) Article 5.2.4 Deployment.*

Rapid Intervention Crew (4FF)	4
EMS Care	2
Total	**27**

The following is an initial full alarm assignment for a three-story apartment building with a single 1,200-square foot apartment fire.

Figure 75. Initial Full Alarm Assignment in a Three-Story Apartment Building

Initial Full Alarm Assignment 1,200 SF Apartment (3-story garden apartment)	
Incident Commander	2
Water Supply Operators	2
3 Application Hose Lines	6
1 Support Member per line	3
Victim Search and Rescue Team	4
Ground Ladder Deployment	4
Aerial Device Operator	1
Rapid Intervention Crew (4FF)	4
EMS Care (1 crew)	2
Total	**28**

These are generalizations that are representative of different types of structures and risks. Each department may handle these types of fires with fewer or more personnel, however, this describes the work functions that must take place for the handling of a fire.

In addition, LC-CFRS should consider a safety officer in operation staffing for monitoring and assessing safety hazards or unsafe situations while developing measures for ensuring personnel safety.

When a fire escalates beyond what can be handled by the initial assignment, or the fire has unusual characteristics such as a wind-driven fire, or has been accelerated with a highly flammable compound, additional personnel will be needed. There are also types of scenarios that may not be fires, but mass casualty incidents, explosions, tornadoes, etc., that may need additional staffing. It is difficult or impossible to staff for these worse case incidents. These require a strong mutual aid or automatic aid plan for assistance.

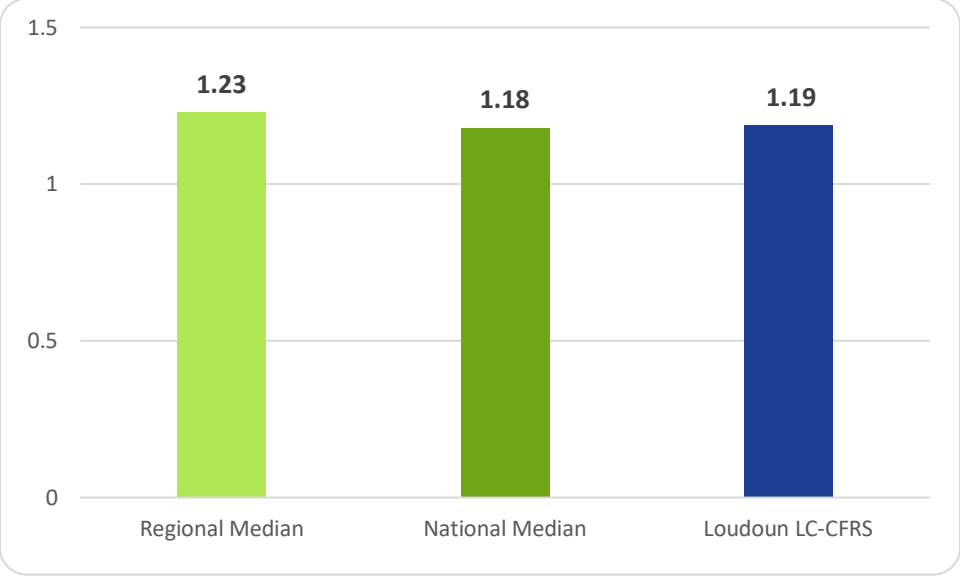
The following figure depicts the emergency staffing employed by Loudoun County Combined Fire Rescue System.

Figure 76. LC-CFRS Emergency Response Staffing

Position Title	Number of Positions	Hours Worked per Week	Work Schedule
Paid Full-time Operational			
Fire Chief	1	40	8am–5pm
Assistant Chief	2	40	8am–5pm
Deputy Chief	9	42	24/72
Battalion Chief	17	42	24/72 or 6am–6pm or 7/12
Captain	40	42	24/72 or 6am–6pm on a 5/12 or 7/12
Lieutenant	89	42	24/72 or 6am–6pm on a 5/12 or 7/12
Technician	99	42	24/72 or 6am–6pm on a 5/12 or 7/12
Firefighter	275	42	24/72 or 6am–6pm on a 5/12 or 7/12
Firefighter/Paramedic	77	42	24/72 or 6am–6pm on a 5/12 or 7/12

A means of comparison, also used on a national basis, is that of measuring the number of firefighters on staff per 1,000 population of the service area. The following figure illustrates the current comparison of LC-CFRS staffing with both national and regional norms.

Figure 77.Firefighters per 1,000 Population[64]



[64] *U.S. Fire Department Profile, 2016, National Fire Protection Association, Fire Analysis and Research, Quincy, MA.*

The 2016 National Fire Experience Survey indicates the national median rate of career firefighters for the area per 1,000 population is 1.18 and the regional rates of career firefighters per 1,000 population is 1.23. Within Loudoun County Combined Fire Rescue System, the department rate of career firefighters per 1,000 population is 1.19. These comparisons do not consider the area covered and are general comparisons by populations served. This comparison in and of itself does not indicate a necessary change in staffing, but it does serve as a point of reference for analysis of current operational endeavors.

LC-CFRS shift operations are accomplished using a four-platoon system, working 24-hour shift rotations that yield a 42-hour work week. Each shift is led by one Deputy Chief (4 total) that serves as the senior officer on the shift. These Deputy Chiefs answer directly to the Assistant Chief who is on a weekly 40-hour schedule. These individuals are responsible for all aspects of the shift operations and serve as the Fire Chief's representative at significant incidents.

LC-CFRS operates with a single company officer assigned to each engine, aerial, and heavy rescue daily with one station commander assigned to each station. The department has promoted apparatus operators who serve as the individual responsible for all aspects of maintaining and operating fire engines and aerial units. Each station is staffed daily with career firefighters. When fully staffed, each fire engine has one Company Officer, one Driver Engineer, and one Firefighter. An aerial apparatus has one Company Officer, one Driver Engineer, and two Firefighters. The heavy rescue assigned to Station 620 has one Company Officer, one Driver Engineer, and two Firefighters. Each medic/ambulance has two Firefighters. This represents a total minimum shift operation staffing of 126 including the Deputy Chief, Battalion Chief Officers, EMS Captains, and Safety Officer with a total staffing of 443 budgeted FTE persons across all shifts.

The current officer (89 FTEs) to firefighter (349 FTEs) ratio for full-time positions within LC-CFRS operations is at 25.5 percent. ESCI sees this ratio in the range of 25 to 33 percent. Currently, Loudoun County Fire and Rescue System is operating at the lower end of the normal ratio ESCI experiences for officer to firefighter ratio. LC-CFRS also employs volunteers who are managed by these same operational officers. This can exacerbate the ability for officers to effectively manage their subordinates as the span of control is increased. As the department increases, staffing the need for more company officers will become necessary to maintain the current span of control.

LC-CFRS directs the following first alarm assignment for structure fires.

Figure 78. LC-CFRS Initial 1st Alarm; 2,000 SF Residential Structure Fire

NFPA 1710		NOVA COG	
Apparatus	**Personnel**	**Apparatus**	**Personnel**
2 Battalion Chiefs	2	2 Battalion Chiefs	2
3 Engine Companies	12	4 Engine Companies	12
2 Aerial Companies	8	2 Aerial Companies	8
Total	**22**	**Total**	**22**

The on-duty staffing meets the need for a routine house fire, however, will not be sufficient for a strip shopping mall or an apartment building unless there is fire protection built-in to these structures. These types of fires will require additional alarm activations.

The current shift staffing for the department if all personnel assigned to the shift are on-duty at one time is approximately 126 budgeted positions. On a typical day, as in most jurisdictions, the full authorized staffing referenced is not available due to vacations, sick leave, universal leave, or other types of leave.

Staff Allocation to Various Functions

LC-CFRS allocates its staff similarly across each of its 20 stations based on the specific geographic requirements and service level needs of the area. The staff for each station is responsible for receiving the call for service and then responding the appropriate apparatus. For example, a fire call for service would require the fire engine, whereas the emergency medical call for service would require the ambulance. Some stations are equipped with a tanker and brush truck apparatus. If required to respond these apparatuses, staff are required to move from their current apparatus assignment and relocate to the required or requested apparatus. The Deputy Chief and Battalion Chiefs provide necessary command and control coverage during incidents and manage the administrative duties for the shift. This allocation of staff across the stations and units is a typical staffing model across the United States for career organizations. The allocated staffing available in the County is 126 when all units are filled.

Staff Scheduling Methodology

LC-CFRS utilizes a traditional four platoon system operating on a 24-hour shift rotation per position to achieve this minimum staffing of 126. The total number of positions required per jurisdiction becomes a policy decision established based on the needs of the jurisdiction. The jurisdiction also then establishes the number of employees needed above the minimum to allow for vacancies due to vacation, sick, and other types of leave yielding an overall number of full-time employees required to ensure necessary staffing according to policy is available daily. This staffing methodology is very common across the United States for firefighters to work a 24-hour period and is proven to be effective for agencies with moderate workloads. Large agencies with heavy workloads have implemented different staffing models to avoid employee fatigue. Staffing for a 24-hour period reduces the number of crew changes that occur in a given time period.

All personnel are trained as firefighters with most trained at a minimum of Emergency Medical Technician level. Many firefighters have been trained to the paramedic levels. The department provides Advanced Life Support (ALS) services.

Deployment Methods and Staffing Performance for Incidents

The current staffing of the emergency response division is established at 126 individuals per shift from 0600 hours. It is important to note that this staffing level is only realized when all personnel are on duty. On duty numbers are regularly impacted by traditional vacation and sick leave. This number includes the Deputy Chief, Battalion Chiefs, safety, and EMS Captains and allows for 126 persons to staff the department's 20 fire stations daily. Fully staffed, this equates to a force capable of meeting the response needs of the community. Fire departments across the United States typically establish a "minimum staffing" level. This number reflects the minimum number of personnel a department will have on duty before beginning to hire overtime. LC-CFRS has established a minimum number of 125 personnel as its minimum staffing level. This is due to the heavy rescue's ability to operate with a minimum of three on occasion when needed.

Responsibilities and Activity Levels of Personnel

In every fire department, there exist a number of activities that must be accomplished that are outside of the "regular" duties of responding to emergency incidents. These typically involve general maintenance of self-contained breathing apparatus (SCBA), hose testing, air monitor calibration, EMS quality assurance, and various committees. LC-CFRS relies upon contracted services to handle hose testing, ladder testing, and SCBA certification. LC-CFRS uses individuals who have a particular interest in these additional areas to accomplish other department programs and tasks. In addition to the benefit of completing these tasks, the additional responsibilities serve to further develop the knowledge, skills, and abilities of participating individuals. These individuals learn project management, time management, and budgeting skills that prepare them for future promotional opportunities.

PERSONNEL MANAGEMENT

Although the delivery of emergency services to the citizens and visitors of a community is critical, effective management and organization of an emergency services agency are just as critical to its success. The personnel that delivers those services are the backbone of the system. However, without proper administrative and support personnel to handle supervision, command, and control, operational personnel may not be able to perform satisfactorily.

It is commonly understood that an organization's greatest asset is its people. While the purchase of capital equipment can appear to be expensive when viewed as a one-time expense, the reality is personnel expenses typically account for more than 70 percent of an organization's expenses. It is important that special attention is given to managing human resources in a manner that achieves maximum productivity while ensuring a high level of job satisfaction for the individual. Consistent management practices combined with a safe working environment, equitable treatment, the opportunity for input, and recognition of the workforce's commitment and sacrifice are key components impacting job satisfaction.

In this section, ESCI will review and analyze the policies, procedures, job descriptions, and other personnel management related activities of Loudoun County Combined Fire Rescue System.

Policies, Rules & Regulations, and Guidelines

LC-CFRS has an established process of reviewing its Policy Manual which includes System Wide Procedures (SWPs). The LC-CFRS organizes and delivers its policy and procedures to their employees during new hire orientation and also directs them to the website where it can be found. Human resources review the administrative portion every two years. A good way to assure this review is to have a committee of LC-CFRS members review one-third of the guidelines each year recommending changes. There should also be a process to trigger changes in a guideline that has been modified due to a new method or a technology change. Those documents are appropriate and necessary for the effective operation of the department. Because they lay the foundation upon which the fire department operates, it is essential that those fundamental documents be current. ESCI recommends a committee be established for policy review and recommendations.

Job Descriptions

LC-CFRS employs several different job descriptions that are not unlike other agencies of similar size and organization. The department currently employs the positions of Firefighter/EMT, Firefighter/ Paramedic, Lieutenant, Captain, Battalion Chief, Deputy Fire Chief, Assistant Fire Chief, and Fire Chief. A review of current job descriptions reveals that some of the descriptions are dated and in need of review and possible revision if the duties described are different from actual practices. Job descriptions should receive periodic review and revision.

Compensation

An agency's ability to attract, hire, and retain employees has a direct impact on its ability to provide the desired services effectively and efficiently. LC-CFRS is no different. Agencies should provide periodic reviews of current compensation structures, market competitiveness, and County compensation philosophies. These internal and external comparisons of equitable positions and workloads ensure the agency can attract and maintain an effective workforce. Turnover of employees involves increased costs for equipment, training, and onboarding procedures.

Disciplinary Process

Under the existing organizational configuration, personnel-related decisions are made at different levels. The Fire Chief has the ability to hire, discharge, and promote. Discipline can be issued at several levels of the organization based on the severity of the infraction. The policy is outlined in the LC-CFRS Policy Manual. Personnel-related decisions can, and often do, subject an organization to potentially extensive liability exposure. Risk is presented that can result from a hiring mistake, improperly processed disciplinary process, wrongful termination claims, and more. Access to legal counsel can reduce this liability. The LC-CFRS employees are afforded an appeal process.

Counseling Services

Our nation's firefighters are faced with emotional needs that are very different and unique to the occupation. The percentage of firefighters struggling with career-related stress is very high with suicide rates climbing each year. These issues manifest themselves through higher divorce rates and addictions such as alcohol, drugs, or gambling. Frequently seen in recent studies and another major concern is Post Traumatic Stress Disorder (PTSD). As these symptoms occur, employees need a support system in place that is readily accessible from someone who is qualified and truly understands his/her circumstances.

Several programs can provide assistance. Critical Incident Stress Management, Employee Assistance Programs, and Intervention Programs to name a few. LC-CFRS should strive to develop a structured Critical Incident Stress Debriefing program for its members. This program should be communicated to make each member aware of the availability of resources. A Behavioral Health Coordinator is to be hired during the first part of the upcoming budget year. This position will be charged with the creation of a career support team.

Application, Recruitment, and Retention Process

LC-CFRS periodically advertises on their website and sends notifications to localities and affiliations to advertise openings within the department. The Human Resources Lieutenant also goes to specific events to recruit new employees. The application process requires the normal background, reference, and qualifications checks. There is a physical standard established for new recruits and an interview is conducted after successful knowledge testing is completed. A medical evaluation is required, however, psychological testing is not. A polygraph is administered to all candidates for hire.

Performance Reviews, Testing, Measurement, and Promotion Process

LC-CFRS provides annual performance testing. Probationary employees receive an end of probation review to ensure the probationary employee has met the job satisfaction requirements to maintain employment. The department uses periodic physical competence testing. The department provides periodic performance reviews of knowledge, skills, and abilities. Promotional testing is done every two years or as soon as a list is exhausted on an as needed basis to fill open positions.

Health and Safety

NFPA 1500: *Standard on Fire Department Occupational Safety and Health Program* is the industry standard for development and administration of a fire department safety program. At the time of this report, LC-CFRS has a safety committee in place as well as cancer, hearing, and exposure sub-committees. The establishment and empowerment of a safety committee can be one of the best tools to increase the safety of firefighters. ESCI strongly encourages the department to ensure all activities of the safety committee are in alignment with Chapter 4 of NFPA 1500. To be effective, safety committees must be diverse in their representation from across the department, ensuring representation by shift, rank, function, and interest, and including representation from non-uniformed and staff members as well. LC-CFRS should establish and evaluate the diversity of representation within the safety committee.

The safety committee should meet monthly and include in its mission raising awareness and modifying member behaviors that will result in a safe work environment. Additionally, the committee should review all accidents, injuries, near-miss incidents, and workplace safety suggestions. The committee should analyze the information before them and report their findings to the Fire Chief. As opposed to being reactionary through the development of additional rules, it is recommended that the committee should work to implement member safety education programs and encourage members' safety self-awareness. The committee should maintain regular and open meeting times and locations; minutes of the meetings should be recorded and posted for all members of the department to review. A diverse representation of command staff and employees should constitute the committee, as is appropriate, and minutes are taken at the meetings. ESCI underscores the importance of maintaining a functioning safety committee.

Fire Prevention

Due to the scope and purpose of this study, Fire Prevention was not evaluated. However, some general information about the LC-CFRS Fire Marshal's Office is contained below. Should Loudoun County wish to pursue a master plan in the future, specific information regarding the Fire Marshal' s Office would be included.

Investigations

As fire and life safety code enforcement, the fire marshal's office provides investigations such as:

- Fires
- Explosions
- Hazardous material releases
- Environmental crimes.

In addition, the Fire Marshal is responsible for the Bomb Squad/Explosive Ordinance Disposal (EOD) Team.

Community Outreach and Education

The LC-CFRS has an ongoing program for community outreach and education. A detailed discussion is outside the scope of this report; however, examples of programs include:

- School prevention programs and fire drills, K-12.
- The Fire Marshal's Office along with operations personnel assistance provides a school prevention program for first grade education program for all students in Loudon County.
- At-risk populations over 65 years of age, about 1,575 programs a year to 32,162 participants, plus operations-based programs.
- Quarterly newsletter that highlights fire safety tips; e.g., chimney, electrical, cooking, CO, and seasonal fire safety.
- Smoke alarm awareness and installation. In 2018, 822 alarms were installed, with an average of 520 smoke alarms installed annually over the last 5 years.
- Juvenile Fire Setter Program with an average of 20 children per year.

Community Risk Reduction

An emerging trend in the fire service nationally is a concept called Integrated Community Risk Reduction (CRR). CRR is an integrated approach to risk management that marries emergency operations and prevention strategies into a more cohesive approach to reducing risks in any community. It includes the fire department partnering with the community, non-profit organizations, and any private sector agencies with a nexus to an identified community risk.

The concept starts with the fire department mining data to quantify community risk. Once the community risks have been identified, they are prioritized based on the frequency of emergency service demand or consequence (to the victim, to the community, to the local economy). Upon prioritizing the risks, strategies are developed to mitigate the risks. These strategies are incorporated into a CRR plan, which integrates resources across the fire department, partner agencies, and the community to implement the various strategies in a cohesive manner. After plan implementation, the results are reviewed to determine the impact on the risks. Adjustments are made, as necessary, based on the results and the process is refined and continuously re-implemented.

> *If the community is better prepared, they will need to rely less on local government.*

The risks are not limited to structure fires. They can include falls, drowning, interface exposure, disasters, or any risk requiring fire department response. Risk can also be localized by station area. Station Captains, in collaboration with fire prevention staff and community groups, can develop and manage a station area-specific CRR plan as a subset of the fire department's plan. CRR lends itself well to a volunteer supported effort, led by competent professional leadership. CRR also includes public education for risk reduction. A prepared and informed community is a safer community.

Emergency Medical Services Support and System Oversight

As with most fire departments, medical emergencies account for most calls to which the County responds. One of the goals of a fire department is to provide the best possible care to its citizens in a timely and effective manner. One element that makes up an effective and efficient EMS program is to have the EMS system integrated with the community's overall health care system. One way to ensure this element is met is to assign an internal person to manage the fire department's emergency medical system. Another element involves ensuring personnel are properly trained and equipped to handle emergency medical situations they respond to. Here again, dedicating a person to ensure these aspects are addressed will help personnel and the department better serve the community. NFPA 450: *Guide for Emergency Medical Services & Systems*, provides a technical reference to addressing the multiple elements of emergency medical systems and will be used where applicable in this section of the report.

Emergency Medical Services in Virginia operate under the State Board of Health. The State Board of Health has the responsibility to promulgate, amend, and repeal, as appropriate, regulations for the provision of emergency medical services per Article 2.1 (§ 32.1-111.1. et seq.) of Chapter 4 of Title 32.1 Code of Virginia. The State Board of Health has established the authority of Chapter 31 Title 12, Virginia Emergency Medical Services Regulations. The State of Virginia regulations requires licensure of all EMS systems in the state. LC-CFRS is a recognized and licensed EMS agency by the State of Virginia and therefore governed by the rules described. Requirements of the Statute and Rule also require the system to have one Operational Medical Director (OMD) who is a licensed physician holding an endorsement as an EMS physician from the Office of EMS. All units shall have approved radio communication system.

Staffing of BLS and ALS units are also defined. Specifically listed:

- Pursuant to Chapter 31 Title 12- 12VAC5-31-1210, Virginia BLS transport vehicles are required to have, at a minimum, an Emergency Medical Technician (EMT) and a driver meeting the requirements in section 12VAC5-31-1210.
- Pursuant to Chapter 31 Title 12, 12VAC5-31-1250, ALS transport vehicles are required to have, at a minimum, an ALS attendant-in-charge, and an EMT.

Emergency medical calls account for approximately 66 percent of the calls for service to which LC-CFRS responds. This figure is consistent with the rates realized by most agencies across the United States. LC-CFRS functions as a fire-based advanced life support (ALS) emergency medical services (EMS) response system. As a fire-based system, the advanced life support functions and transport functions are provided by LC-CFRS. The fire-based system is a common system utilized across the United States and is growing in usage. The advantage of the fire-based system is LC-CFRS does not have to rely on other agencies for initial first response and/or subsequent transport. All career LC-CFRS firefighters are certified as at least basic emergency medical technicians (EMTs) at a minimum with 77 paramedics. All volunteers are certified at the Emergency Medical Responder level as a minimum with some certified at higher levels. The system operates 14 advanced life support (ALS) ambulances and four basic life support (BLS) ambulances. Most of the other units are BLS.

Figure 79. Minimum Staffing by Unit Type

Unit Type	Staffing	Certification Level
Ambulance	2	1 EMT/ 1 Driver
Medic Unit	2	1 Intermediate or Paramedic/ 1 EMT
Heavy Rescue	4	BLS
Ladder	4	BLS
Engine	3	Mostly BLS, only 1 Engine ALS

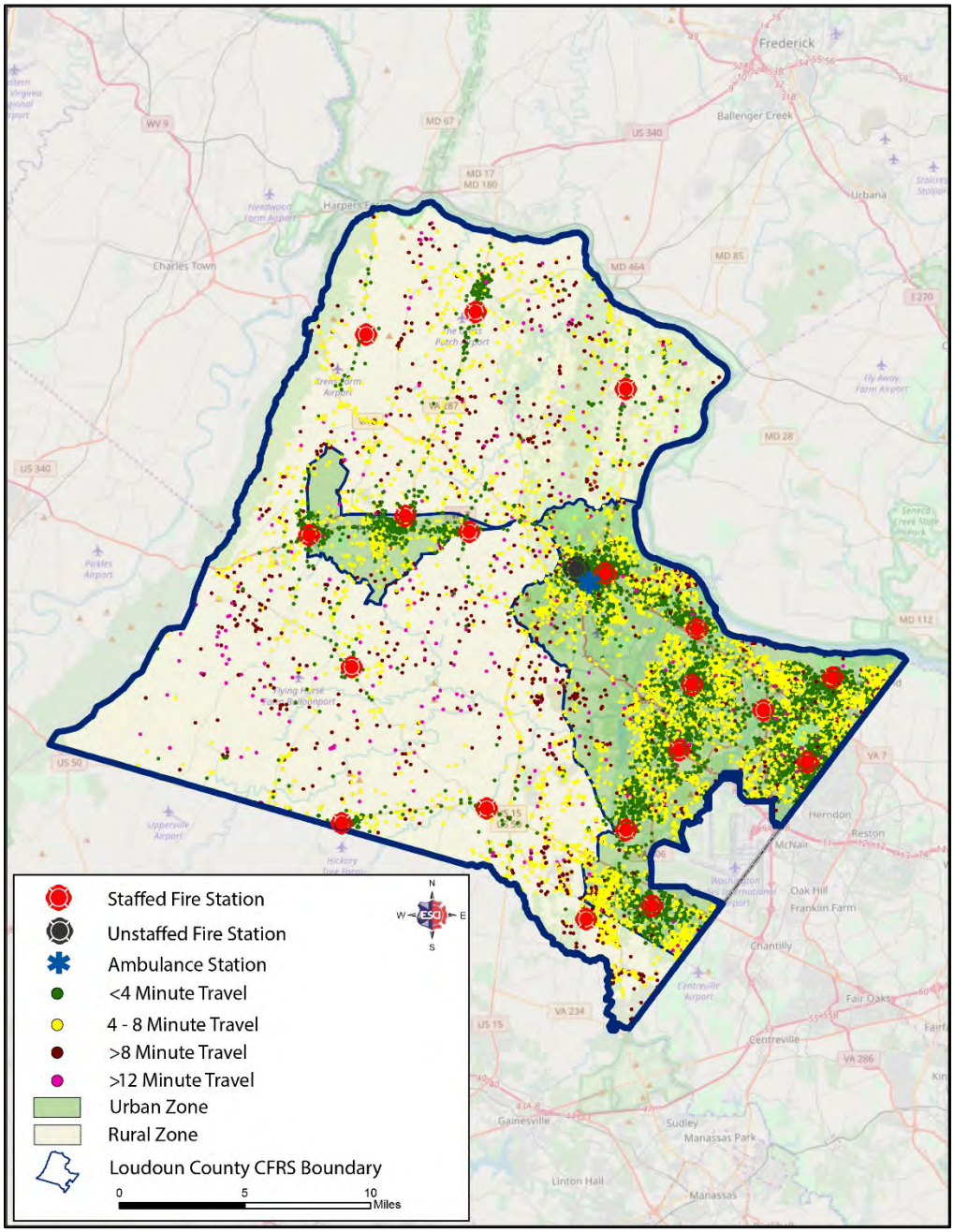
NFPA 1710: *Standard for Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments* recommends basic life support (BLS) units arrive in four minutes or less travel time and advanced life support (ALS) within eight minutes as long as the BLS unit is equipped with an automatic external defibrillator. Furthermore, personnel deployed to ALS emergency responses shall include a minimum of two members trained at the emergency medical technician-paramedic level and two members trained at the emergency medical technician level arriving on scene within the established travel time discussed.[65]

[65] *NFPA 1710, Standard for Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments, Chapter 5.3.3.3.2*

Chapter 31 Title 12, 12VAC5-31-630 states a designated emergency response agency shall conform to the local responding interval, or in the absence of a local standard the EMS agency shall develop a standard in conjunction with OMD and local government in the best interests of the patient and the community. The EMS agency shall use the response time standard to establish a time frame the EMS agency complies with on a 90 percent basis within its primary service area (i.e., a time frame in which the EMS agency can arrive at the scene of a medical emergency in 90 percent or greater of all calls). It is recommended that LC-CFRS establish a response standard in conjunction with the stated requirements of Chapter 31 Title 12 of the Virginia Department of Health Regulations for emergency medical service response and NFPA 1710: *Standard for Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*. This may require additional resources or conversion of existing resources to advance life support capabilities to meet these standards.

The following figure on the next page depicts a pictorial representation of actual travel times experienced by LC-CFRS.

Figure 80. Historical Calls for EMS Calls of Service, Actual Travel Times at 90th percentile



The ability to meet established response time benchmarks are detailed in the *Service Delivery and Performance* section of the report. That analysis details the ability for LC-CFRS to meet established 90 percent response goals.

Medical Control and Oversight

The EMS Division is headed by the Deputy Chief of Emergency Medical Services (EMS) Operations. This is a full-time administrative position. The Deputy Chief of EMS Operations also oversees the Battalion Chief of EMS, Quality Assurance Officer, eight EMS Captains, one administrative staff assistant, and works in conjunction with the Medical Director. As growth continues, future consideration should be given to an additional EMS Supervisor.

LC-CFRS utilizes a licensed physician to serve as the Medical Director for the agency. The Emergency Department physicians at four receiving facilities function as the online medical control. The presence of a physician to serve as medical oversight is required by NFPA 1710: *Standard for Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments Chapter 5.3.4.3* and Virginia law. The Medical Director serves as the authority for LC-CFRS to provide emergency medical response. The Medical Director for LC-CFRS is a board-certified physician in Emergency Medicine. Patient Care protocols have been approved by the Medical Director. The Medical Director for LC-CFRS participates in quality assurance reviews.

Quality Assurance/Quality Improvement

Like all fire and EMS agencies, LC-CFRS has a commitment to providing quality patient care to patients who are injured or ill. As described, the process of patient care is guided by protocols and policies, and sometimes direct consultations with physicians. Patient care protocols and agency policies have changed over time for a variety of reasons. The reason can include inputs, sometimes including research in the medical profession, anecdotal evidence from neighboring agencies, and even legal advice from governing bodies.

Quality Assurance means all planned or systemic actions necessary to provide adequate confidence that a service or product will satisfy, given requirements for quality. The purpose is to assess the medical performance of paramedics and EMTs. LC-CFRS does not have a defined EMS system quality management program in place. NFPA 1710: *Standard for Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments Chapter 5.3.4* requires the fire department to institute a quality management program to ensure that the service has met the time objectives for all medical responses. Chapter 31, Title 12 also requires a quality management program (QM) to be in place. However, areas for improvement have been identified by LC-CFRS but system performance criteria and objectives have not been identified. System performance is not evaluated.

LC-CFRS has a defined clinical quality management (QM) program in place that is staffed with one Captain and one Paramedic. Given the size, volume, and complexity of the LC-CFRS EMS services, the existing program has limitations on the amount of call review—retrospective, concurrent, and future—analysis that can be conducted. Clinical key performance indicators (KPI) have not been established. The department does not hold internal quality management and improvement committee meetings. The Medical Director participates in the system and provides feedback to individual field providers. Patient refusals are reviewed, and patient care reports are spot checked for accuracy. The results of the current quality management efforts are reported in annual reports. When available select incidents are tracked for patient outcomes. The agency participates in patient care protocol development and there is a system in place to address patient complaints. ESCI recommends that LC-CFRS enhance the existing QA/QI program to include, but not be limited to, a prompt review of patient care records, direct observation, and comparison of performance standards for drugs, equipment, system protocols, and procedures.

Quality Improvement is the process of working toward higher levels of performance or quality associated with changes in system or process design, rather than improving process compliance quality assurance.

Areas for quality improvement should be identified and prioritized. System performance should have criteria and objectives established. Specifically, objectives should be been defined for rescue unit hour utilization and response times. System performance should be evaluated daily, monthly, quarterly, and annually.

Logistical Support

LC-CFRS uses a minimum level of equipment on each unit to ensure stock is available for use. The brand of cardiac monitor and defibrillator is Physio Control Life Pack 15 and LC-CFRS has 58 units on hand. The department also has 102 automatic external defibrillators Life Pack 1000 (AED). The ambulances for LC-CFRS use Stryker Power Cots, a significant capital expenditure.

LC-CFRS has inventory control measures in place and uses the CompX brand controlled medication security program. All units receive daily equipment checks. Staff spend time researching new medical equipment for use by LC-CFRS units and there is a durable EMS equipment maintenance program in place.

EMS Training and Skills Evaluation

LC-CFRS utilizes an EMS Chief, EMS Battalion Chief, and EMS Captains as well as various Field Training Officers (FTO) to deliver and conduct in-service training. The department documents clinical skills for each member as well as maintains documentation of advanced clinical skill success rates. Continuing medical education (CME) is provided by the EMS division in an effort to meet state and local CME requirements. These requirements are monitored for compliance. There is a Field Training and Evaluation Program in place that uses FTOs to ensure provider proficiency.

EMS Call Prioritization

Ensuring emergency service arrives in a timely manner is only one component of an emergency services delivery system. Additional consideration must be given to ensuring the right resources arrive to assist. The LC-CFRS dispatch center currently utilizes the Emergency Medical Dispatch (EMD) protocol when dispatching LC-CFRS units. As part of its ongoing quality assurance/quality improvement, LC-CFRS should continually review methods to ensure the appropriate types of units are responding to emergency medical calls. Many agencies have implemented programs to reduce the number of times larger apparatus are sent to medical calls, and other communities have established criteria under which fire department apparatus will be dispatched. This is a determination that LC-CFRS must make in light of its community's needs and expectations. However, the issue needs to be part of the formal planning processes for LC-CFRS and County leadership.

Hazardous Materials Support and Response Capabilities

Hazardous material incidents are a part of most every fire department's call volume. While this type of emergency response does not occur as often as some other emergency incidents, they can pose a very high risk due to the challenges and dangers of this type of incident. LC-CFRS has the capability to respond to hazardous material incidents.

LC-CFRS responds and mitigates hazardous material incidents throughout their region. Department training and training with other in-and-out of county fire departments happen periodically during the year. All of the team members utilize the NFPA 472: *Standard for Competence of Hazardous Materials/ Weapons of Mass Destruction Incidents* Job Performance Requirements (JPRs) that relate to hazardous materials in order to meet the continuing education requirements for certification purposes.

When a hazardous materials incident occurs one of the two hazardous materials units is requested, LC-CFRS is responsible for staffing the unit so it can respond to the scene. LC-CFRS cross-staffs their hazardous materials response units between other in-service units. This affects the department's internal staffing capabilities to respond to other incidents that occur within the fire jurisdiction.

Given the significant risk hazardous materials incidents pose to LC-CFRS and their personnel, LC-CFRS has highly prioritized its response readiness to manage an incident of this nature. The amount of hazardous materials transiting the County via aircraft, marine, rail, and highway is substantial. However, the transportation routes are not the only risk the community faces. Industrial warehousing activities increase risk due to the handling of these raw materials. LC-CFRS operates a hazardous materials response Heavy Rescue out of Station 19 as well as a hazardous materials support unit. This is a "level A" resource, the highest level of hazmat response capability. To achieve level A capability, a combination of highly technical equipment is necessary, along with appropriately trained, technician-certified personnel. The department staffs a minimum total number of six Hazardous Materials Technicians for response each day from Station 19. The Battalion Chief assigned to Battalion 3 is also normally a Hazardous Materials Technician.

Hazmat certification levels are defined by NFPA 472: *Standard for Competence of Hazardous Materials/ Weapons of Mass Destruction Incidents* and the Occupational Safety and Health Administration (OSHA) in CFR 1920.120. The highest level of certification for responders is the "Technician" level. Of the personnel in LC-CFRS 70 are certified at the Technician level, and all other responders are certified to the operations level resulting in a considerable response capability. In addition, there are 5 to 10 personnel certified as Hazardous Materials Incident Commanders.

The National Fire Protection Association (NFPA) defines a Hazardous Materials Safety Officer certification level in their standard NFPA 472: *Standard for Competence of Hazardous Materials/Weapons of Mass Destruction Incidents*. LC-CFRS has 5 to 10 Hazardous Materials Technicians trained to this certification level, which is an industry best practice.

ESCI staff performed a comprehensive assessment based on industry standard practice and consistent with the Occupational Safety and Health Administration (OSHA), NFPA 472: *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, NFPA 473: *Standard for Competencies for EMS Personnel Responding to Hazardous Materials/Weapons of Mass Destruction Incidents*, NFPA 1710: *Standard for Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*, and the International Fire Service Training Association. The assessment was not a hazard-based risk analysis of the community, but instead, is based on a minimum level of capability regardless of hazardous materials incident type. It measured four major areas. These four areas were:

- Standard Operating Procedures, Policies, and Guidelines
- Human Resources
- Training
- Equipment

Standard Operating Procedures, Policies, and Guidelines

The first area of evaluation involves the established standard operating procedures, policies, and guidelines used to manage the team. LC-CFRS does not have a designated Emergency Response Plan per se for hazardous materials incidents. However, they do refer to the Northern Virginia Manual for Firefighting and Emergency Operations which has a section for hazardous material operations. They have the components of an ERP also located in several different documents. The existence of Loudoun County Combined Fire Rescue System's Emergency Response Plan (ERP) is related to the mandate from the Occupational Safety and Health Administration (OSHA) 29 CFR 1910.120 (q)(1), which requires that employers establish emergency procedures to be followed when responding to emergencies involving hazardous materials. ESCI recommends that the existing documents be combined into one document to satisfy the ERP requirements. This plan should also be available online to all employees and reflect pre-planning and coordination with outside shareholders.

The Incident Command System is a standard on-site command and control system used to manage emergency incidents and planned events. LC-CFRS has adopted and uses the NIMS system to manage its incidents. This system defines the lines of authority, roles, and responsibilities for managing large scale incidents. Furthermore, it designates a single incident commander as well as recognizes the Unified Command concept. Passing of command to senior officials is recognized and the Safety Officer is identified.

During hazardous materials responses, LC-CFRS maintains available advanced life supports services on the scene for responders during actual and potential immediately dangerous to life and health (IDLH) atmospheres. These advanced life support personnel are specifically trained in the medical aspects of hazardous materials. However, team leaders believe they need more personnel trained to perform these functions. The roles of the emergency medical support personnel are clearly defined. Medical treatment protocols for handling medical emergencies involving hazardous materials have been approved by the organization's Medical Director.

The standard operating procedures used by LC-CFRS addresses safe distances and areas of refuge for responders who may require it. It further identifies the required personal protective equipment to be employed along with emergency equipment. The procedures identify site security and control as well as establishes the usage of a personal accountability system. The procedures are thorough and detail the use of emergency evacuation procedures, decontamination procedures to include collection and disposal of runoff. Finally, the procedures for after-action reports and critiques are specified for the department but do not specifically require them of hazardous materials response as called for in the OSHA required ERP. LC-CFRS does provide for deployment of resources outside of the jurisdiction for both local, regional, and state assistance.

The LC-CFRS hazardous materials team has a personal protective equipment plan. This plan is very detailed and outlines the policies describing a method to address the hazard-based selection of protective ensembles, their use and limitations, work mission duration, maintenance and storage, decontamination and disposal, training and fitting, donning and doffing, and inspection procedures. Occupational Safety and Health Administration (OSHA) in CFR 1910.120 requires the employer to implement safe work procedures for the use of personal protective equipment in the workplace as well as train workers in its use. The regulation continues to require the employer to ensure that employees are complying with the regulations. LC-CFRS has policies in place to ensure this happens. All personnel are required to use a minimum of positive pressure, self-contained breathing apparatus until the atmosphere has been quantified. This is often referred to as a "no drop" policy.

LC-CFRS has policies and procedures that reference the usage of air monitors during the emergency response. These policies include documented maintenance procedures and calibration of their air monitors. Loudoun County Combined Fire Rescue System's procedures require the establishment of a site-specific safety plan and has policies that reference a standardized methodology for assigning incident levels to hazardous materials emergencies. The policies and procedures outline the specific procedures for various tasks that team members may be required to perform, such as spill or leak control.

Team leaders discussed the dispatch matrix or algorithm for deploying hazardous materials resources was not appropriate at times. Ensuring the department's dispatch protocols and or algorithms are comprehensive and thorough when providing hazardous materials resources is important because it ensures the resources are dispatched and available when needed. LC-CFRS should ensure the dispatch algorithms are updated and reflect the current need and requests for services experienced by the community regarding hazardous materials response.

Human Resources

Occupational Safety and Health Administration (OSHA) in CFR 1910.120 requires that employers ensure that firefighters establish teams of two or more when working and that a rescue team suitably equipped is readily available. Listed specifically in the regulations are incidents involving hazardous materials. The accepted industry standard practice requires seven Hazardous Materials Technicians to facilitate minimal entry during a hazardous materials response based on commonly required scene functions. These seven people must be dispatched on the initial hazardous materials emergency response once it is determined that an emergency does exist.

Of these seven, one should be the designated Hazardous Materials Safety Officer trained in accordance with NFPA 472: *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, and another the Incident Commander. LC-CFRS has a minimum staffing requirement of six hazardous materials personnel assigned for the day. There is a provision to activate call backs to ensure the needed requirements to respond with personnel and equipment to fully meet the needs of the incident. Ensuring that the initial alarm assignment contains the industry best practice should continue to be a goal for the organization.

The biggest critical need identified by team leaders is the need for dedicated Hazardous Materials Technician staffing of hazardous materials units. The current cross-staffing of units creates a situation in which hazardous materials members are committed to other types of calls and not available for hazardous materials responses. While these hazardous materials service calls are less frequent than other types of calls for service, they can have significant impacts on the community if responders are unavailable when they do arise. Furthermore, only one response apparatus for hazardous materials exists making the chance of unavailable resources more likely.

LC-CFRS has a written medical surveillance plan for personnel assigned to the hazardous materials response team. This policy requires an opinion from a physician and provides for periodic examinations as determined by the physician. The medical surveillance plan does provide for a medical assessment after exposures above the permissible exposure limit (PEL). All employees receive proper fitting for respiratory protective equipment.

Training

The LC-CFRS hazardous materials team certifies that its members have achieved technician level training in accordance with NFPA 472: *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incident*. The department keeps records for documenting initial and refresher training and requires the completion of a task book for all members and certifies all members who are required to use respiratory protection. All members have been trained to a minimum level of medical first responder. The LC-CFRS hazardous materials team has a plan for annual refresher training and measurement of continued competency of all team members. Team leaders have expressed that the ability to train more during the shift on these practices should be increased to enhance efficiency and proficiency for rescuers. Dedicated staffing to the hazardous materials unit would allow for this to happen.

Equipment

An objective review of equipment available for hazardous materials response was conducted. LC-CFRS has an adequate supply of decontamination equipment. This equipment consists of the required containment and collection items as well as the necessary solutions for decontamination operations. Gross decontamination, as well as technical decontamination operations, were evaluated and found to be adequate for the type of operations the department may encounter.

The inherent ability of hazardous materials emergencies to progress into longer-term operations dictates the need for effective rehabilitative efforts. LC-CFRS has arrangements in place for the sheltering of personnel during the rehabilitation process in an area out of the heat, cold, and elements. The means by which this is accomplished can be varied. Ambulances, buses, ventilated tents, and shelter are all possible means to achieve the desired outcome. LC-CFRS has policies in place to obtain meals for responders during extended operations.

LC-CFRS has various methods for analysis and detection of hazardous materials. This includes PH paper, multi-gas monitoring equipment, radiological monitors, and colorimetric chemical detection and analysis. There are also sufficient supplies for gathering and collecting samples. LC-CFRS uses the True Defender, MX908, Smiths Detection products, and First Defender to increase ability from simple detection to actual identification of specific compounds.

At a minimum, one portable radio must be available for every entry team member who is at any level of dress, (multiple entry teams and back up teams) as well as any team member who is coordinating a function (decontamination, science, safety, group leader, etc.). LC-CFRS has the communication capability to do this and has made it part of their standard operating procedures.

LC-CFRS has an assortment of equipment to handle LPG leaks. Further spill and leak capabilities are available for various other types of hazardous materials releases. LC-CFRS has a full array of chlorine leak kits at their disposal including rail car chlorine kits. Moving equipment for handling drums is also available. LC-CFRS stocks more than the appropriate amount of overpack drum capabilities.

LC-CFRS provides adequate fire protection capabilities with foam application if required. There is an adequate amount of foam on hand as well as in reserve should the need materialize as well as the equipment to operate at 250 gallons per minute during application. LC-CFRS has the capability for Class D metal fire extinguisher usage.

LC-CFRS stocks the necessary medical equipment to monitor and provide treatment for team members during entry. As discussed previously in the report there are medical treatment providers available with hazardous materials toxicology training, however, additional training is required to increase the number of personnel who can serve in this role.

LC-CFRS maintains an adequate number of reference materials and has the ability to provide internet capabilities for research. LC-CFRS does employ a weather station for immediate on-site analysis.

LC-CFRS carries a standard complement of protective ensembles for rescuers. These include both 60 and 30-minute SCBA bottles with sufficient reserve bottles and a cascade system to support long term operations. LC-CFRS also requires responders to bring their issued turnout gear to ensure each rescuer has adequate NFPA compliant protective equipment that has been sized appropriately. This reduces the amount of equipment required to be stored for deployment. Industry best practices require each person operating as part of the team to be assigned NFPA compliant firefighting protective equipment.

Team leaders also expressed concern for the ability to effectively provide service when their primary response unit is out of service. Consideration should be given to an appropriate reserve unit for hazardous materials responses.

Technical Rescue Services Support and Response Capabilities

Much like hazardous materials incidents, LC-CFRS includes a special operations component that is in place to respond to technical rescue incidents. The disciplines for which the agency is partially prepared includes structural collapse rescue, confined space rescue, rope (high angle) rescue, vehicle/machinery rescue, trench, surface water rescue, swift water rescue, and ice rescue. The technical rescue operations are well structured and appropriate training is in place, however, there is a need for continued and additional training to ensure all rescuers are prepared. Members assigned to technical rescue duties are assigned to the Heavy Rescue at Station 620, however, daily staffing does not require that all members assigned to the unit be trained in technical rescue incidents. Four other units are cross-staffed with members who have various levels of technical rescue training, but it is not always required on those apparatus. One of the major concerns expressed was the inability to train enough people to the required standard for technical rescue and ensure the units are staffed with those people.

ESCI staff performed a comprehensive assessment based on the current standard practices consistent with the Occupational Safety and Health Administration (OSHA) 29 CFR 1910.146, NFPA 1006: *Standard for Technical Rescuer Professional Qualifications*, NFPA 1670: *Standard on Operations and Training for Technical Search and Rescue Incidents*, NFPA 1710: *Standard for Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*, and the International Fire Service Training Association. The assessment was not a hazard-based risk analysis of the community, but instead, is based on a minimum level of capability. This assessment covered the same format as the hazardous materials assessment described earlier in this report. These four areas were:

- Standard Operating Procedures, Policies, and Guidelines
- Human Resources
- Training
- Equipment

Standard Operating Procedures, Policies, and Guidelines

The first area of evaluation involves the established standard operating procedures, policies, and guidelines used to manage the team. LC-CFRS does not have an established plan for Technical Rescue incidents. ESCI recommends the development of an emergency response plan (ERP) with associated Standard Operating Procedures (SOPs) for such incidents. The plan should be available online to all employees and reflect pre-planning and coordination with outside stakeholders. All other department members should also be governed by specific SOPs and Standard Operating Procedures (SOPs) regarding technical rescue incidents.

The Incident Command System is a standard on-site command and control system used to manage emergency incidents and planned events. LC-CFRS has adopted and uses the NIMS system to manage its incidents. This system defines the lines of authority, roles, and responsibilities. Furthermore, it designates a single Incident Commander as well as recognizes the "Unified Command" concept. Passing of command to senior officials is recognized and the Safety Officer is identified.

During technical rescue responses, LC-CFRS maintains available advanced life support services on the scene for responders during actual and potential immediately dangerous to life and health (IDLH) atmospheres. These advanced life support personnel are specifically trained in the medical aspects of technical rescue incidents or hazardous materials. The roles of the emergency medical support personnel are clearly defined. Medical treatment protocols for handling medical emergencies involving technical rescue incidents have been approved by the organization's Medical Director. Medical Treatment Protocols are a definite benefit to advanced life support personnel.

The normal department SOPs used by LC-CFRS addresses the required personal protective equipment to be employed along with emergency equipment. The procedures identify site security and control as well as establishes the usage of a personal accountability system. The department SOPs are thorough and detail the use of emergency evacuation procedures. Finally, they also detail the procedures for after-action reports and critiques.

Another current operational shortfall is the commitment of a technical rescue unit to routine medical calls. The current deployment algorithm does not reserve technical rescue units for true emergency and technical rescue calls. Since the County only has one dedicated Heavy Rescue, it should be considered that this unit remains available for specialized rescue calls when at all possible and not be assigned to routine or urgent medical calls unless other units are unavailable.

Human Resources

The Florida Association of Search and Rescue Resource Typing for Heavy and Light Technical Rescue Resources recommends for light technical rescue teams, six Technical Rescue Technicians should be present for light technical rescue operations as an industry standard. Furthermore, the Department of Homeland Security resource typing documents requires a minimum of six rescuers for a collapse rescue team. NFPA 1710: *Standard for Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*, requires that employers ensure that firefighters establish teams when working and that a suitably equipped rescue team is readily available, when firefighters are required to engage in emergency responses that require specific and advanced training and specialized equipment. LC-CFRS does not have a dedicated technical rescue team, but rather members with training assigned to specific apparatus to perform technical rescue duties. ESCI recommends the actual formation of a dedicated team to provide structure to the department's efforts.

LC-CFRS does not have a written medical surveillance plan for personnel assigned to technical rescue duties. Each employee receives the NFPA 1582 annual physical but there are no other provisions made for technical rescue members. This policy requires an opinion from a physician, and it provides for periodic examinations as determined by the physician. Because the Loudoun County Combined Fire Rescue System's technical rescue members are expected to perform rescues in confined spaces, all employees receive proper fitting for respiratory protective equipment for use during confined space entry.

Training

The Loudoun County Combined Fire Rescue System's technical rescue members receive their certification through the Virginia Department of Fire Programs to ensure that its members have achieved technician level training in accordance with NFPA 1006: *Standard for Technical Rescuer Professional Qualifications*. LC-CFRS keeps records for documenting initial and refresher training. The organization does not require the completion of a task book for all members. Each member is certified to use respiratory protection. All members have been trained to a minimum level of medical first responder. The Loudoun County Combined Fire Rescue System's technical rescue members assigned to R620 are supported in additional training throughout the year for annual refresher training or measurement of continued competency. Annual skill assessment sheets are completed for all team members and annual requirements for confined space entries are maintained.

It is noted that the technical rescue members have identified difficulty in obtaining initial and continued training for members. New members must attend a long and extensive training regimen that requires a significant commitment from the department to cover. As with many TRTs, the amount and variety of skills required to be maintained amongst the various disciplines often make it difficult to cover all of them frequently enough. Monthly training sessions are not currently conducted; however, full team training would be beneficial and ensure greater proficiency and team cohesion once established. The department should strive to secure train-the-trainer level courses for each discipline and provide the necessary training for other members of the department.

Equipment

The disciplines involved with technical rescue require an extensive amount of necessary equipment to meet the demands of the incident. LC-CFRS uses a well-structured mix of deployment methods to deliver the necessary resources to the scene. The ability to assemble the equipment and resources is further complicated by the expensive nature of this equipment. LC-CFRS has some equipment, however, does not have all of the necessary equipment to safely and effectively mitigate these types of calls.

LC-CFRS has a strong complement of technical rescue equipment including four boats and the needed equipment for water and ice rescue. Current shortfalls include the ability to perform confined space entries and trench rescue. The department currently lacks all the necessary equipment to mitigate these types of incidents. Current capabilities can be augmented with some increased training and a dedicated capital expenditure planning for replacement items. Team leaders have identified several of these shortfalls and have already begun the process of addressing them.

EMERGENCY DISPATCH COMMUNICATIONS

According to Section 6.4 of NFPA 1710, the "fire department shall have a reliable communications system to facilitate prompt delivery of public fire suppression, EMS, and special operations."[66] In particular, "all communications facilities, equipment, staffing, operating procedures, performance objectives, and reporting shall comply with NFPA 1221." While NFPA 1710 is fairly general in terms of communications capabilities, NFPA 1221 sets the standards for communications centers.[67] The following analysis is based on the standards set in NFPA 1221.

Facilities

LC-CFRS has its communications center co-located with the Loudoun County Sheriff's Office (LCSO) Communications in Leesburg, Virginia. The Fire Dispatch operation is organizationally separate from the Sheriff's Dispatch but they share facilities and some dispatch systems. The communications center is in a three-story Loudoun County-owned building located next to the Leesburg Executive Airport. The building is ordinary construction with the Technology Room utilizing both water sprinkler and FM200 fire suppression systems. The building was remodeled in 2015, and NFPA 1221 standards were referenced in completing the remodel, but a detailed 1221 review has not been conducted. The building is located within the FEMA 500-year flood plain.

The communications center is located on the second floor of the building. The LC-CFRS and LCSO have administrative facilities on the third floor. The first floor contains a delicatessen and a bank. An independent heating, ventilation, and air conditioning (HVAC) system was installed solely for the dispatch center and separate from the rest of the building. The communications center cannot independently isolate the HVAC system from outside air. The HVAC system is located on the ground level with barriers in front of the equipment to prevent damage from vehicles. As-built drawings of the dispatch center and its associated wiring configurations are on file in the communications center.

Power for the building comes from Virginia Power in a single point of entry in underground lines. The building has a Single-Point Facility Grounding System for lightning/surge protection. The building has a diesel-powered engine-driven generator, using an automatic transfer switch to go from commercial power to generator power when commercial power is lost. There is a back-up generator on-site, as well as connections to allow for a portable generator to be brought in. There is a 200-gallon fuel tank which is shared between the primary and backup generators.

The engine-driven generator feeds an Uninterruptable Power Supply (UPS) (batteries), which can supply conditioned power to critical systems for up to 13 hours in the event of a generator failure. The engine-driven generator is tested weekly, and the system is placed under an electrical load test once per quarter. The automatic transfer switch is tested at the same time the load test is completed. All engine-driven generator testing is conducted by Loudoun County, which keeps records of testing.

---

[66] *National Fire Protection Association, Technical Standard 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.*

[67] *National Fire Protection Association, Technical Standard 1221, Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems, 2019 Edition.*

One side of the dispatch center has windows the length of the room. All windows are reported to be rated for bullet resistance to Level 4 as defined in ANSI/UL 752: *Standard for Bullet-Resistant Equipment*, and reported to be rated against hurricane damage. The closest access to public roadways is 200 feet. Bollards are positioned in front of building walls to prevent intentional damage by vehicles. After normal business hours, parking lots are closed to public access. The area surrounding the building is in FEMA Flood Zone X, Area of Minimal Flood Hazard. While the building is next to an airport, it is not in the runway flight path. There are no fall hazards in the vicinity of the building (taller buildings or trees). The building is located next to a municipal airport. The building has a fire alarm and fire suppression system in compliance with NFPA 72.[68] There are two locked doors between public areas and the communications center. Access through these doors is via key card.

An Alternate Site is located approximately 2.93 miles away (approximately 6 minutes' travel time). It is a fully functional set up and can be brought up in minutes. It is the alternate answer point for 911. The equipment is exercised and tested once a quarter.

Technology

Since LC-CFRS is co-located with LCSO, they share technology. CAD, 911 CPE, and radio are all shared. CAD has login restrictions to keep LCSO separate from LC-CFRS. While LC-CFRS's communication center operation is heavily dependent on current technology, they still maintain a wired public fire alarm system (fire alarm boxes) that is connected in the communications center via an electronic receiver with an audible alarm. LC-CFRS has determined that the system still functions well enough to support the system.

The communications center CAD system is called Premier One, provided by Motorola. The hardware for the system was upgraded 2 ½–3 years ago, and they installed a software upgrade a couple of months ago. The CAD system is on the UPS system to ensure continuing operations in case of a power failure. The CAD system runs on redundant servers, ensuring minimal downtime. In case of a complete failure of the CAD system, the telecommunicators will revert to runcard printouts and hand-written dispatch tickets.

In addition to basic call entry functions, there are several interfaces to the system to enhance functionality:

- Mobile Data Computers (MDCs)
- 911 Automatic Location Information Download
- Radio Push to Talk Identifications
- Records Management Systems – Motorola, Orion, Alpine
- Fire Station Alerting – Westnet
- CAD to CAD – North Virginia Operational Area, primarily with Fairfax County
- Automated Secure Alarm Protocol (ASAP) in joint operation with LCSO

[68] *National Fire Protection Association, Technical Standard 72, National Fire Alarm and Signaling Code, 2019 Edition.*

Access to the Internet is through a stand-alone computer at each dispatch workstation and not connected to any critical systems. Appropriate firewalls are in place to prevent denial of service or ransomware attacks.

The primary dispatch circuit is a connection from CAD to the Westnet fire station alerting system. In case of loss of connectivity or station hardware issues, a message is sent to the communications center notifying them of the outage. The secondary circuit is a radio broadcast of the event information.

Telephone service is provided by Verizon. Power 911 telephone consoles are supplied by West. The system is scheduled for an upgrade at the end of February. There are 62 911 trunks, and four 10-digit emergency lines, which is more than adequate for the 97,283 911 calls received in 2018. TDD/TTY communications with the deaf and hard of hearing community are facilitated through the Power 911 software which is tested daily. Text to 911 is also accomplished by software built into the Power 911 system. The communications center is also working with RapidSOS, a third-party application that allows the communications center to get more accurate wireless locations and citizens with the option to add pertinent information that is then available to the communications center personnel.

Next Generation 911 is a nation-wide project to move 911 from old analog equipment to new IP-based technology. The communications center is working with the Commonwealth of Virginia on regional solutions for Next Generation 911.

The 911 alternate answer center is the back-up dispatch center—10 miles away. The interim solution in case of immediate evacuation of the communications center is five cell phones dedicated to an emergency evacuation. Communications center personnel notify West to reroute 911 calls to the cell phones until the back-up center is operational, then reroute the 911 calls to the back-up center.

The radio system is supplied by Motorola and is an 11-frequency trunked system. Loudoun County upgraded to the trunked radio system in 2002, with an upgrade to a P25 digital system in 2012. Consoles in the communications center are Motorola MCC 7500s. Loudoun County has paid staffing (IT department) that maintains the system but Hankey's Radio (Contractor) completes repairs. Coverage is reported to be good, with multiple towers located in the county. There are no issues with busy notifications, so the system appears to be sized appropriately.

The logging recorder is provided by Media Works (Eventide) and was installed four years ago, with frequent upgrades from Media Works. The logging system records all radio traffic, taking audio from headset input, position audio, and talk group. The system also records all telephone consoles, both by position and by individual phone line. There are instant recall recorders at each dispatch positions. Recordings from the system are retained for one year unless they are pulled for legal reasons.

Budget

Budget for the Communications Division is $5,421,569.

Staffing

There are 42 personnel assigned to the Communications Center. The job descriptions are:

- Emergency Communications Center Manager (1)
- Assistant Emergency Communications Center Manager (1)
- Line Supervisor (4)
- Communications Training Officer (CTO) (4)
- Dispatcher (21)
- Call Taker (4)
- CAD Specialist (1)
- CAD Analyst (1)
- GIS Technician (1)
- GIS Analyst (1)
- Radio Technician (1)
- MDC Technician (1)
- Support Person (Radio and MDC) (1)

Currently, the Communications Center is fully staffed with six personnel per shift. Minimum staffing currently is three Dispatchers/Call Takers and one Supervisor per shift. They are moving towards a minimum of four Dispatchers/Call Takers per shift. The Dispatchers/Call-Takers and Line Supervisors work a 12-hour shift schedule. They work two-day shifts, then two-night shifts, then four days off. This averages out to 48 hours per week. That means that the personnel receive 8 hours of overtime built into their pay, but there is minimal overtime over and above that amount. With the 8-day rotation, their days off move, giving all personnel the opportunity for some, or all, of a weekend off. Dispatch personnel do not have any other ancillary duties to perform over and above dispatch responsibilities.

The Call-Taker is the entry-level position. They spend 8 weeks in the classroom, where they complete the Association of Public Safety Communications Officials, International (APCO) Fire Dispatcher course and Emergency Medical Dispatcher (EMD) certification from Priority Dispatch. They are then assigned to a CTO for the remainder of their training on the job. The last week of their training, personnel are assigned to three ride-alongs with an ambulance crew, an engine company, and a Battalion Chief to get first-hand knowledge of what happens in the field. Depending on their individual progress they have up to one year to complete their training, which is also their probationary period.

In addition to Continuing Education training for their EMD certification, call takers and dispatchers have opportunities to apply for in-service dispatcher training from various training organizations. There are no certifications available for fire dispatching. Training records are kept in an employee's personnel file, which is kept indefinitely.

The support staff for the communications center consists of technicians and analysts for CAD, mapping (GIS) and radio/mobile data. There are also three personnel assigned to the information technology (IT) issues. While they are Loudoun County employees, they are dedicated to working on technology at the communications center.

Operating Procedures

Steps of an event, from call answer to station/unit notification:

- Call-Taker answers 911 or 10-digit emergency line.
- Call-Taker inputs pertinent information into CAD.
- Once sufficient information has been entered, the event is placed into a pending queue.
- Radio Dispatcher pulls the event from the pending queue and based on the event type and available resources, commits units to the event.
- The WestNet Fire Station Alerting system is activated in the station.
- Simultaneously, CAD sends a text message to Everbridge, a software application that will notify the appropriate phones/pagers.
- Dispatcher then broadcasts the event information on the primary dispatch talk group.
- Responding units verify response on a command talk group.
- Working incidents are assigned to a tactical talk group for fireground operations. A Dispatcher is also dedicated to that talk group.

The communications center performs Emergency Medical Dispatching (EMD) through software from Priority Dispatch. Quality assurance is performed by Priority Dispatch under contract.

Loudoun County uses a public emergency notification system from Everbridge to provide not only LC-CFRS personnel notification, but broad-based emergency notification messages to the general public.

Performance Objectives

The National Emergency Number Association (NENA) and the National Fire Protection Association (NFPA) have set performance standards for answering and processing of emergency events. NENA has established a standard of "ninety percent (90 percent) of all 911 calls arriving at the Public Safety Answering Point (PSAP) shall be answered within ten (10) seconds during the busy hour (the hour each day with the greatest call volume, as defined in the NENA Master Glossary). Ninety-five percent (95 percent) of all 911 calls should be answered within twenty (20) seconds."[69] NFPA 1221 calls for "Ninety-percent of events received on emergency lines shall be answered within 15 seconds, and 95 percent of alarms shall be answered within 20 seconds." This criteria is also used for performance standards in NFPA 1710.

[69] *NENA Call Answering Standard/Model Recommendation NENA 56-005.1, June 10, 2006, Revised 8/31/2017.*

NFPA 1221 also has a standard for call processing that NENA does not. The standard is "Emergency alarm processing for the highest prioritization level emergency events list in 7.4.3.1 through 7.4.3.2 shall be completed within 60 seconds, 90 percent of the time." Alarm processing is defined as from the time a phone call starts ringing until emergency response units are notified. The LC-CFRS Communications Center does not currently monitor or measure these performance standards.

Financial Basis for Cost Projections

Revenues and expenditures comprising total funding and the cost of operating the fire department are found in several discrete operating budgets; the Loudoun County General Fund (GF), which is funded primarily through ad valorem tax revenues and the Restricted Grant Fund, which is funded primarily through federal and Virginia State funds with minor private and GF matching funds. Additionally, in FY 2016, the County instituted the EMS Transport Reimbursement Fund to enhance EMS services.

Major capital expenditures including fire station and other capital facility costs, as well as apparatus and major equipment purchases, are primarily accounted for in the County Capital Improvement Program (CIP) budget; separately from the fire department operating budget. The County operates on a July 1 to June 30 fiscal year and uses a full accrual basis for fund accounting. A detailed review of historical revenue, expenditure, fund balance, and cash flow in the separate funds was not undertaken in this study.

In order to estimate the future costs of any recommended improvements, it is first necessary to understand current year (Fiscal Year 2019) estimated costs for various decision unit components such as firefighter salary/benefits, onboarding costs, apparatus and equipment costs, and fire station construction and operating costs. Depending upon when these components may be added to the system, the FY 2019 costs can be escalated based upon known or anticipated increases due to such influences as projected inflation for each component, Board authorized pay increases, rising benefit costs, or some combination of factors.

Policy decisions regarding the adoption of any enhancements designed to improve service level are generally evaluated based upon projected initial and recurring cost versus the benefit provided. In order to understand the future costs of any enhancement, it is important to evaluate improvements in terms of decision units. A decision unit in the case of this LC-CFRS study can be considered a career-staffed ambulance, engine or ladder company, or an operating fire station with various staffed units. These decision units are comprised of components such as personnel with various associated initial and recurring costs, capital apparatus and facility acquisition, and recurring capital operating costs.

The following discussion uses actual LC-CFRS FY 2019 costs, to the extent they are available, as a basis for costing of various decision unit components whose costs can then be escalated to that point in time when they may be added to the system. In other words, if LC-CFRS determines that it needs to add an engine company to its operation in three years, the following FY 2019 personnel, capital, and operating costs will serve as a basis for the addition of that unit were it to be added in FY 2019. The escalation factors for the various components of that decision unit, as provided by the department, will then be applied to show the future cost at the point in time the department wishes to add that unit.

Fiscal Year 2019 Personnel Recurring / On-Boarding Costs

The next figure provides average annual base salary, benefit, and total compensation costs for firefighter positions for Grade F1 (Firefighter/EMT and/or Firefighter/Paramedic), F2, F4, and F5. It is anticipated that additional, career-staffed apparatus would require some combination of these five positions. While it might be more appropriate to utilize starting salary and benefit costs for firefighter positions on various units, using an average of existing positions will give a better "worst case" cost scenario so that recommended improvements do not end up costing more than originally projected.

Figure 81. Average Annual Base Salary/Benefits Various LC-CFRS Uniformed Positions, FY 2019

Rank	Grade	Average Base Salary	Average Benefits	Total Compensation
Firefighter/EMT	F1	51,542	31,978	**$83,520**
Firefighter/Paramedic	F1	65,542	35,878	**$101,420**
Technician	F2	64,188	35,500	**$99,688**
Lieutenant	F4	75,435	38,633	**$114,069**
Captain	F5	98,848	45,155	**$144,003**

The following figure provides current average benefit costs for uniformed positions within LC-CFRS. When adding positions, it is also important to include first year on-boarding costs along with the recurring cost of each new position. The figure following the benefit summary identifies those on-boarding costs as determined by the department for FY 2019 ($13,766). After the initial year, these costs would not continue, and the only recurring costs associated with the new position would be the total annual compensation. However, it is also understood that the department's annual operating costs over time would increase due to added PPE replacement, training, and other associated employee costs.

Figure 82. Average Annual Firefighter Benefit Costs, FY 2019

Employer-Paid Benefits Summary	
Holiday Pay (average)	$5,156.87
FICA Employer Contributions (average)	$5,005.60
Health Insurance	$15,000.00
VRS Employer Contribution (average)	$6,700.30
Retirement Health Savings Plan	$2,100.00
Deferred Comp. Match	$520.00
Group Life Insurance (average)	$857.17
Disability Insurance	$112.54
Average Employer-Paid Benefits	**$35,452.48**

Figure 83. New Hire Firefighter On-Boarding Costs, FY 2019

Firefighter On-Boarding Cost	
Item	**Cost**
Background Check/Polygraph	$830
NFPA Physical	$1,000
Recruit School, Books and Supplies	$1,045
Uniforms	$2,560
SCBA Facepiece	$325
Turnout Gear	$5,000
Health and Wellness Workshop	$1,500
Technology Package (Office)[1,2]	$1,506
Total per Position	**$13,766**

[1] Reflects only office technology for station use; public safety radios, etc. typically budgeted with apparatus purchases.
[2] Allows for one County technology package per 3 FTEs.

Fiscal Year 2019 Capital Apparatus/Equipment Costs

The next figure identifies FY 2019 apparatus costs based upon the current LC-CFRS specifications for each apparatus class. Also included is the estimated cost to equip each type of vehicle. This table illustrates first year capital cost only and does not consider annual or recurring operating costs such as fuel, oil and routine maintenance costs (parts and labor). In order to build an accurate cost of adding each type of apparatus, these recurring costs would need to be considered for future years. Further, the department should consider an annual apparatus replacement cost as part of its annual apparatus replacement program based upon life expectancy and usage for each vehicle class.

Figure 84. Apparatus and Equipment Costs, FY 2019

FY 2019 Apparatus Cost			
Vehicle Class	**Apparatus**	**Equipment**	**Total**
Pumper	$775,000	$175,000	**$950,000**
Ladder	$1,300,000	$150,000	**$1,450,000**
Tanker	$510,000	$95,000	**$605,000**
Brush/Grass Truck	$190,000	$20,000	**$210,000**
Ambulance	$315,000	$105,000	**$420,000**

Fiscal Year 2019 Facility Capital/Operating Costs

The last category of costs considered as part of any potential future service level upgrade to consider are fire station costs; both initial construction and annual operating costs. Land costs will vary considerably depending upon many factors, such as market condition, developer proffers, environmental, and other factors, therefore, are not included in the estimated cost of a new fire station. The LC-CFRS's most recently programmed fire station is the Lucketts facility whose estimated costs are provided in the following figure, although they are not included in the FY 2019 CIP.[70]

Figure 85. Station Construction Costs, FY 2019

Lucketts Fire Station Costs	
A/E	$958,060
Building Construction	$8,140,286
FF&E	$240,000
Other Costs	$442,000
Total (excluding land)	**$9,780,346**

After construction costs are considered, there is an annual operating cost for a new facility that will be comprised of multiple components. The Loudoun County Department of General Services (DGS) provides facilities maintenance, utilities, and related operating costs for various fire department and other County facilities on a square footage basis. LC-CFRS also budgets for some routine station operating costs such as various O&M needs as outlined in the following figure. These costs are estimated at approximately $34,000 per station and would be in addition to the DGS costs.

Figure 86. Station Operating Costs Paid Directly by LC-CFRS, FY 2019

Category/Item	Amount
Internal Services	
Printing/Copying	$2,500.00
Telephone	$13,500.00
Materials and Supplies	
Laundry and Janitorial	$7,500.00
Office Supplies	$4,000.00
Minor Equipment	$5,000.00
Books and Subscriptions	$500.00
Other Operating Supplies	$1,000.00
Total	**$34,000.00**

[70] *Personal Communication, email from Alan Druga, February 13, 2019, providing information about Lucketts fire station from Planner Maria Taylor.*

Costs paid indirectly to DGS by LC-CFRS for other station operating costs are based upon the charge rates shown in the following figure.

Figure 87. Station Operating Costs Paid Indirectly by LC-CFRS to DGS for Services, FY 2019

Item	Cost per sq. ft.	Cost per Month	Cost per Year
Utilities	$2.27		
Maintenance	$2.16		
Snow Removal	$0.33		
Building Alarms		$60.00	
Pest Control			$270.00
Recycling			$100.00

An average of all current volunteer and career fire stations and/or other facilities gives an approximate square footage value for a typical LC-CFRS building of 11,500-square feet. However, new stations are programmed for a larger, standardized footprint of approximately 18,500-square feet.[71] Based upon this new, standardized floor plan square footage and the next figure, the annual indirect DGS charges would be $89,150, and the direct LC-CFRS O&M charges would be $34,000, for an annual fire station operating cost of approximately $123,150.

[71] *Personal Communication, email from Alan Druga, April 5, 2019, stating that Planner Maria Taylor confirms new standard fire station floor plan comprises 18,500 square feet.*

Figure 88. Estimated Direct/Indirect Average Annual LC-CFRS Fire Station Operating Costs, FY 2019

Item	Cost per sq ft	Cost per Month	Cost per Year
Indirect Costs (DGS Charges)			
Utilities	$2.27		$41,995
Maintenance	$2.16		$39,960
Snow Removal	$0.33		$6,105
Building Alarms		$60.00	$720
Pest Control			$270
Recycling			$100
Direct Costs (LC-CFRS O&M)			
Internal Services			
Printing/Copying			$2,500
Telephone			$13,500
Materials and Supplies			
Laundry and Janitorial			$7,500
Office Supplies			$4,000
Minor Equipment			$5,000
Books and Subscriptions			$500
Other Operating Supplies			$1,000
Total			**$123,150**

Fiscal Year 2019 Decision Unit Staffing Costs

In order to provide for relief staffing (sick/vacation and other overtime coverage), LC-CFRS budgets for five personnel to cover each required seat on an apparatus that is staffed 24/7 using four shifts or platoons. In other words, the department uses a relief factor of 1.25. The following figure shows total number of personnel needed by rank and pay grade for a BLS and ALS engine company (all but one engine company is currently staffed as a BLS unit) and a BLS and ALS ambulance company (some are staffed with two paramedics and some are staffed with one EMT and one paramedic).

An engine is staffed with three firefighters on each of four shifts; a firefighter, a technician (equipment operator), and an officer. A ladder or aerial truck would be staffed with four firefighters per shift so total staffing would include five additional personnel versus an engine. Each 24-hour seat or position requires five budgeted personnel to ensure minimum daily staffing (one FTE for each of four platoons plus an additional FTE as relief factor). The officer position is filled with four Lieutenants and one Captain. The FY 2019 cost per rank needed for one FTE is shown along with the total cost for all personnel required in each rank for all four shifts and relief coverage to maintain the minimum staffing.

Figure 89. Estimated Decision Unit Staffing Costs, FY 2019

BLS Engine Company			
Position	Number	Unit Cost	Total Cost
Firefighter/EMT	5	$83,520	$417,600
Technician	5	$99,688	$498,440
Lieutenant	4	$114,069	$456,275
Captain	1	$144,003	$144,003
Crew Total	15		$1,516,318

ALS Engine Company			
Position	Number	Unit Cost	Total Cost
Firefighter/Paramedic	5	$101,420	$507,100
Technician	5	$99,688	$498,440
Lieutenant	4	$114,069	$456,275
Captain	1	$144,003	$144,003
Crew Total	15		$1,605,817

BLS Ambulance Company			
Position	Number	Unit Cost	Total Cost
Firefighter/EMT	5	$83,520	$417,600
Firefighter/EMT	5	$83,520	$417,600
Crew Total	10		$835,201

ALS Ambulance Company			
Position	Number	Unit Cost	Total Cost
Firefighter/EMT	5	$83,520	$417,600
Firefighter/Paramedic	5	$101,420	$507,100
Crew Total	10		$924,700

Decision Unit Cost Projection

Using the estimated decision unit staffing costs provided as a starting point, and various assumptions about cost increases over time, decision unit costs are projected through FY 2024 in the following figure. Personnel salary and benefit costs have been projected to increase by County staff at 3 percent annually while operating costs have been projected to increase by 1 percent annually.[72] Historical apparatus and equipment costs have been observed by ESCI to increase at approximately 4 percent annually. According to Zarenski (2019), non-residential construction costs are estimated to have increased at 4–5 percent over the past four years and are expected to continue increasing at that rate.[73]

Figure 90. Projected Decision Unit Costs, FY 2019 through FY 2024

Decision Unit	Personnel Recurring Costs[1]					
	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Engine (BLS)	$1,516,318	$1,561,808	$1,608,662	$1,656,922	$1,706,629	$1,757,828
Engine (ALS)	$1,605,817	$1,653,992	$1,703,612	$1,754,720	$1,807,362	$1,861,582
Ladder (BLS)	$1,933,919	$1,991,936	$2,051,694	$2,113,245	$2,176,642	$2,241,942
Amb (BLS)	$835,201	$860,257	$886,065	$912,647	$940,026	$968,227
Amb (ALS)	$924,700	$952,441	$981,014	$1,010,445	$1,040,758	$1,071,981
Decision Unit	**Personnel On-Boarding Costs[2]**					
	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Engine	$206,490	$208,555	$210,640	$212,747	$214,874	$217,023
Ladder	$275,320	$278,073	$280,854	$283,662	$286,499	$289,364
Ambulance	$137,660	$139,037	$140,427	$141,831	$143,250	$144,682
Decision Unit	**Capital Apparatus (Equipped) Cost[3]**					
	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Engine	$950,000	$988,000	$1,027,520	$1,068,621	$1,111,366	$1,155,820
Ambulance	$420,000	$436,800	$454,272	$472,443	$491,341	$510,994
Ladder	$1,450,000	$1,508,000	$1,568,320	$1,631,053	$1,696,295	$1,764,147
Decision Unit	**Capital Facility (Initial and Recurring) Cost[2, 4]**					
	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Construction	$9,780,346	$10,220,462	$10,680,382	$11,161,000	$11,663,245	$12,188,091
Operating	$123,150	$124,382	$125,625	$126,882	$128,150	$129,432

[1]Cost increase based upon department projected annual salary and benefit increase of 3%

[2]Cost increase based upon department projected annual operating increase of 1%

[3]Cost increase based upon industry average annual increase of 4%

[4]Cost increase based upon historical non-residential construction cost increase over the last four years of 4–5%

[72] *Personal Communication, email from Alan Druga, April 5, 2019, referencing Loudoun County budget office assumptions.*

[73] *Zarenski, Ed (2019); Construction Cost Inflation-Commentary 2019, in Construction Analytics Economics Behind the Headlines; see https://edzarenski.com/2016/09/12/construction-cost-inflation-commentary/.*

The first table in the figure shows total annual staff costs for a BLS and ALS engine company as well as a BLS and ALS ambulance as projected from FY 2019 through FY 2024. The second table shows what the one-time on-boarding costs would be to hire the number of firefighters needed to fully staff each unit. For example, if 15 FTE were added in FY 2019 to staff a BLS engine, it would cost $1,516,318 in personnel costs plus $206,490 in on-boarding costs for a total of $1,722,808 the first year. Personnel costs would then increase at 3 percent annually so that the personnel costs for the same 15 firefighters on that engine company would be $1,757,828 by FY 2024. If a ladder company were to be added, the personnel costs would need to be escalated by 5 additional FTEs whenever it was planned.

The following two tables in the figure show the capital costs; the first table shows the equipped apparatus cost throughout the projection period while the second table shows the facility construction and operating costs through FY 2024. Using the Lucketts projected costs, a standardized station of 18,500 square feet would cost approximately $9.8 million to construct in 2019 with an annual operating cost of $123,150. That same station, if constructed in FY 2024 would cost approximately $12.2 million and have an operating cost of $129,432. Purchasing an equipped engine in FY 2019 would cost $950,000 while that same engine in FY 2024 would cost $1,155,820.

The projected figures for various decision unit components can be used as an approximate guide to determine the cost of implementing various potential enhancements as recommended in the study at whatever point over the next five years the County finds appropriate and is able to fund them.

CAPITAL ASSETS & CAPITAL IMPROVEMENT PROGRAMS

Capital assets include all facilities, all rolling stock (apparatus), and the key equipment used on the apparatus dedicated to achieving the mission of the LC-CFRS. The single most expensive infrastructure elements in a fire department are the facilities and apparatus. Because of this expense, planning must be developed to address replacement, refurbishment, and maintenance. The funding of these elements is difficult to absorb for most agencies in a single year; thus, a multi-year funding strategy or funding source must be identified. The replacement or refurbishment must be planned far enough ahead of actual expense to allow the agency time to acquire the funds necessary to implement the plan.

Facilities

Appropriately designed and maintained facilities are critical to a fire department's ability to provide services in a timely manner and with the appropriate deployment of assets. ESCI observed and reviewed the fire stations operated by LC-CFRS. The findings are summarized in the following pages and any areas of observed concern are identified.

Common Facility Issues

The dates of construction for the LC-CFRS stations range from early 1950 to 2016, and most stations are considered to be well-maintained and will serve the department for some time into the future. However, the condition of at least three fire stations originally constructed in the 1950s and 1960s have been identified as ranging from poor to fair. These stations have been remodeled several times and need additional attention. Items needing attention include sleeping facilities, showers and decontamination areas.

Not all of the LC-CFRS facilities are equipped with washer extractors to allow firefighters to effectively decontaminate their gear following exposure to carcinogens. The rates of cancer among firefighters is significantly higher than the standard population. Firefighters must have the ability to protect themselves from carcinogenic particulates they are exposed to during firefighting activities. This includes the installation washer "extractors" at all LC-CFRS facilities. Additionally, personal protective equipment must also be stored in an environment protecting the gear from exposure to vehicle exhaust fumes and ultraviolet (UV) lighting.

Of specific concern, relative to the exposure of firefighters, is employee exposure to diesel exhaust in the apparatus bays of the fire and rescue stations. Several of the LC-CFRS facilities do not have proper exhaust capture equipment installed on emergency response apparatus or in the stations to reduce firefighter exposure to carcinogenic particulates when vehicles are started in the apparatus bay when departing or returning to the station.

Many of the LC-CFRS facilities have sprinkler systems installed and all have smoke detectors. The presence of fire sprinkler systems in both residential and non-residential properties is of significant concern for today's fire service. These systems have proven to be highly effective in the protection of human lives and the suppression of fire prior to them becoming large and catastrophic. Fire stations are not immune from exposure to fire and many fire stations across the United States have experienced devastating fires. The installation of sprinkler systems with these remaining facilities should be of utmost concern to the leadership of LC-CFRS and a plan should be established to install the systems as quickly as possible.

A significant number of LC-CFRS were identified as not being compliant with the American Disabilities Act (ADA). These non-compliance issues range from stations not being entirely accessible or areas only being partially accessible. The inability, or limited ability, of a segment of LC-CFRS not having direct and unfettered access to these facilities is a significant issue leadership must address as quickly as possible.

A significant number of LC-CFRS facilities have apparatus bays in which emergency response vehicles must back into when returning to the station. Most of these bays are at older facilities, which were constructed during a time period when this was considered to be an acceptable practice. A significant number of accidents involve emergency response vehicles when backing. It is considered to be an "industry best practice" to construct fire stations with drive-through bays to avoid the opportunities for firefighters to back into a station and reduce the opportunities for backing accidents to occur.

New Stations

As LC-CFRS begins to address the replacement of fire stations, it is advisable to adopt a "standardized" design wherever possible. It appears that the department is well on its way towards doing so with the Lucketts and other proposed stations. Newly constructed stations should take into consideration NFPA 1500, 1710, 1720, and 1851. These standards address specific design considerations to improve firefighter health and safety. NFPA 1500: *Standard on Fire Department Occupational Safety, Health, and Wellness Programs* addresses the separation of crew quarters from apparatus bays to protect firefighters from carcinogens, as well as workout and exercise facilities to improve cardiac health. NFPA 1851: *Standard on Selection, Care, and Maintenance of Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting* addresses laundry facilities for personal protective equipment, uniforms, and bedding. While 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* pertains to response times, the proper design of a fire station can have a positive impact on turnout times. Collectively, these NFPA standards can have a positive impact on the effectiveness of the department and the safety of its most valuable resource.

Apparatus

The size, age, and deployment of a fire department's fleet of vehicles (emergency response and support) have a significant impact upon the service capabilities of an organization. It is critical than a fire department establish an appropriate inventory level of its emergency and non-emergency vehicles that allows it to effectively serve its community and constituents well. Fire departments that maintain larger fleets tend to experience excessive capital expenditures when replacing vehicles and excessive expenses mainlining vehicles. Additionally, older vehicles tend to increase maintenance costs and can potentially have a negative impact on response reliability as units experience increased breakdowns and longer out-of-service times.

NFPA 1901: *Standard for Automotive Fire Apparatus*, NFPA 1911: *Standard for the Inspection, Maintenance, Testing, and Retirement of In-Service Emergency Vehicles*, and NFPA 1912: *Standard for Fire Apparatus Refurbishing* are three specific standards that are used to inform and guide fire department leadership in the management and oversight of emergency services fleets through effective specification, purchase, refurbishment, maintenance, and retirement of fire apparatus.

Annex D of NFPA 1901 provides guidelines for fleet replacement and future apparatus procurement. Specific to fire trucks, Annex D recommends a 15-year maximum frontline operation with a subsequent ten-year maximum reserve operation. Upon completing the frontline and reserve cycles, the guidelines recommend units should be removed from inventory.

Various factors can have either a positive or negative impact on the life expectancy of an emergency response apparatus. Fire trucks and aerial devices located in "busy" portions of a jurisdiction can realize an even shorter life-cycle as the units are exposed to harsher operations. These units often experience increased breakdowns due to wear and tear, which reduces apparatus availability and increased maintenance costs. The following figure provides an alternative evaluation process that can be used as a guide to assist with fleet replacement decisions.

Figure 91. Evaluation Components and Points for Apparatus Replacement

Evaluation Components	Points Assignment Criteria	
Age	One point for every year of chronological age, based on in-service date	
Miles/Hours	One point for every 10,000 miles or 1,000 hours	
Service	1 point for Light Duty use 3 points for Normal Duty use 5 points for Severe Duty use Example: Fire Pumpers are classified as severe duty service.	
Condition	1 point: Excellent 2 points: Good 3 points: Fair 4 points: Poor 5 points: Severe accident or major component replacement This category takes into consideration body condition, interior condition, accident history, anticipated repairs, etc. The better the condition the lower the points assignment.	
Reliability	1 point: In repair shop once every three months or less 3 points: In repair shop once every month 5 points: In repair shop two or more times per month	
Point Ranges	**Condition Rating**	**Condition Description**
Under 18 points	Condition I	Excellent
18 to 22 points	Condition II	Good
23–27 points	Condition III	Consider Replacement
28 points or higher	Condition IV	Immediate Replacement

With 163 pieces of apparatus, LC-CFRS maintains a very large fleet of emergency and non-emergency vehicles. This number is reflective only of the pieces of equipment owned by LC-CFRS and does not include units owned by other entities. Overall, the fleet is considered to be well maintained.

Capital Replacement Planning

Fire apparatus are typically unique pieces of equipment, often very customized to operate efficiently in a narrowly defined mission. A pumper may be engineered such that the compartments fit specific equipment and tools, with virtually every space on the truck designated in advance for functionality. This same vehicle, with its specialized design, cannot be expected to function in a completely different capacity, such as a hazardous materials unit or a rescue squad. For this reason, fire apparatuses are very expensive and offer little flexibility in use and reassignment. As a result, communities across the country have sought to achieve the longest life span possible for these vehicles.

Unfortunately, no mechanical piece of equipment can be expected to last forever. As vehicles age, repairs tend to become more frequent, parts more difficult to obtain, and downtime for repair increases. Given the emergency mission that is so critical to the community, this factor of downtime is one of the most frequently identified reasons for apparatus replacement.

Due to the large expense of fire apparatus, most communities find the need to plan for the cost of replacement. To properly do so, agencies often turn to the long-accepted practice of establishing a life cycle for the apparatus that results in a replacement date anticipated well in advance. Forward-thinking organizations then set aside incremental funds during the life of the vehicle so replacement dollars are ready when needed.

The same holds true for fire stations, training grounds, and other fixed facilities. And as support equipment becomes costlier, particularly EMS equipment, planning for the replacement of these items is of equal importance.

As part of the site visit, ESCI surveyed capital replacement planning efforts for LC-CFRS and the findings are listed below.

Facility Replacement

The department has a capital replacement schedule in place for fixed facilities. The program uses a six-year "rolling" window that is updated annually. Funding for the program is accomplished through the County's debt obligation bonds.

Apparatus Replacement

The department has also established a capital improvement plan to address the replacement of fire engines, aerials, and other emergency response vehicles. The plan extends to 2037 and is funded through the County's obligation bonds.

Support Equipment Replacement

LC-CFRS also maintains a Support Equipment Fund to address the need to replace major capital equipment. This type of equipment includes self-contained breathing apparatus and cardiac monitors. The funding for this comes through the Major Equipment Replacement fund and is established through 2037. As part of the plan, LC-CFRS has an establish purchase interval for capital equipment.

Appendix B: Development of Response Standards and Targets

There are three main factors the lead to successful mitigation of emergencies; sufficient numbers of well-trained *personnel*, arriving on reliable and well-equipped *apparatus* appropriate to the task at hand, *quickly enough* to make a positive difference in property preserved or lives saved. The previous sections of this report have laid out the current staffing levels, facilities and equipment, and response performance for LC-CFRS. The following describes the consequences of failing to deliver sufficient personnel and equipment early enough to mitigate the emergency addressed.

Dynamics of Fire in Buildings

Most fires within buildings develop in a predictable fashion unless influenced by highly flammable material. Ignition, or the beginning of a fire, starts the sequence of events. It may take several minutes or even hours from the time of ignition until a flame is visible. This smoldering stage is very dangerous, especially during times when people are sleeping, since large amounts of highly toxic smoke may be generated during this phase.

Once flames do appear, the sequence continues rapidly. Combustible material adjacent to the flame heat and ignite, which in turn heats and ignites other adjacent materials if sufficient oxygen is present. As the objects burn, heated gases accumulate at the ceiling of the room. Some of the gases are flammable and highly toxic.

The spread of the fire from this point continues quickly. Soon the flammable gases at the ceiling as well as other combustible material in the room of origin reach ignition temperature. At that point, an event termed "flashover" occurs; the gases and other material ignite, which in turn ignites everything in the room. Once flashover occurs, damage caused by the fire is significant and the environment within the room can no longer support human life. Flashover usually occurs about five to eight minutes from the appearance of flames in typically furnished and ventilated buildings. Since flashover has such a dramatic influence on the outcome of a fire event, the goal of any fire agency is to apply water to a fire before flashover occurs.

Although modern codes tend to make fires in newer structures more infrequent, today's energy-efficient construction (designed to hold heat during the winter) also tends to confine the heat of a hostile fire. In addition, research has shown that modern furnishings generally ignite more quickly and burn hotter (due to synthetics). In the 1970s, scientists at the National Institute of Standards and Technology found that after a fire broke out, building occupants had about 17 minutes to escape before being overcome by heat and smoke. Today, that estimate is as short as three minutes.[74] The necessity of effective early warning (smoke alarms), early suppression (fire sprinklers), and firefighters arriving on the scene of a fire in the shortest span of time is more critical now than ever.

[74] *National Institute of Standards and Technology, Performance of Home Smoke Alarms, Analysis of the Response of Several Available Technologies in Residential Fire Settings, Bukowski, Richard, et al.*

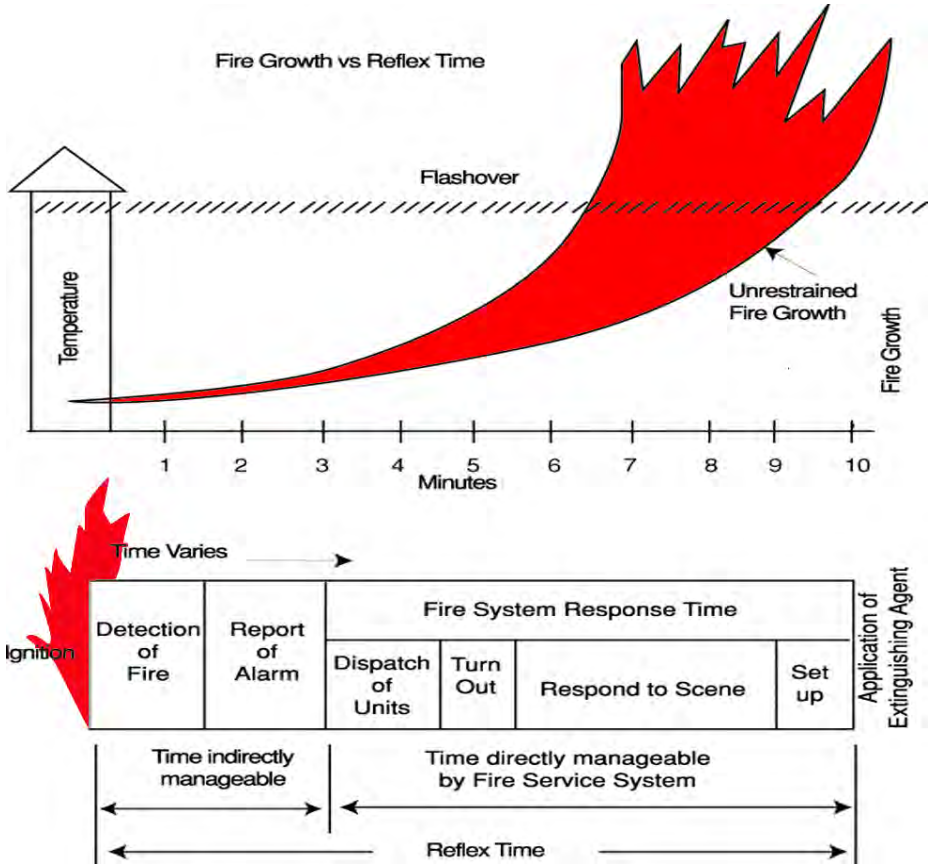
The prompt arrival of at least four personnel is critical for structure fires. Federal regulations (CFR 1910.120) require that personnel entering a building involved in fire must be in groups of two. Further, before personnel can enter a building to extinguish a fire, at least two personnel must be on scene and assigned to conduct search and rescue in case the fire attack crew becomes trapped. This is referred to as the two-in, two-out rule. However, if it is *known* that victims are trapped inside the building, a rescue attempt can be performed without additional personnel ready to intervene outside the structure. Further, there is no requirement that all four arrive on the same response vehicle. Many fire departments rely on more than one unit arriving to initiate an interior fire attack.

Perhaps as important as preventing flashover is the need to control a fire before it does damage to the structural framing of a building. Materials used to construct buildings today are often less fire resistive than the heavy structural skeletons of older frame buildings. Roof trusses and floor joists are commonly made with lighter materials that are more easily weakened by the effects of fire. "Lightweight" roof trusses fail after five to seven minutes of direct flame impingement. Plywood I-beam joists can fail after as little as three minutes of flame contact. This creates a dangerous environment for firefighters.

In addition, the contents of buildings today have a much greater potential for heat production than in the past. The widespread use of plastics in furnishings and other building contents rapidly accelerate fire spread and increase the amount of water needed to effectively control a fire. All of these factors make the need for early application of water essential to a successful fire outcome.

The next figure illustrates the sequence of events during the growth of a structure fire over time.

Figure 92. Fire Growth vs. Reflex Time



As is apparent by this description of the sequence of events, application of water in time to prevent flashover is a serious challenge for any fire department. It is critical, though, as studies of historical fire losses can demonstrate.

The National Fire Protection Association found that fires contained to the room of origin (typically extinguished prior to or immediately following flashover) had significantly lower rates of death, injury, and property loss when compared to fires that had an opportunity to spread beyond the room of origin (typically extinguished post-flashover). As evidenced in the following figure, fire losses, casualties, and deaths rise significantly as the extent of fire damage increases.

Figure 93. Fire Extension in Residential Structures—United States

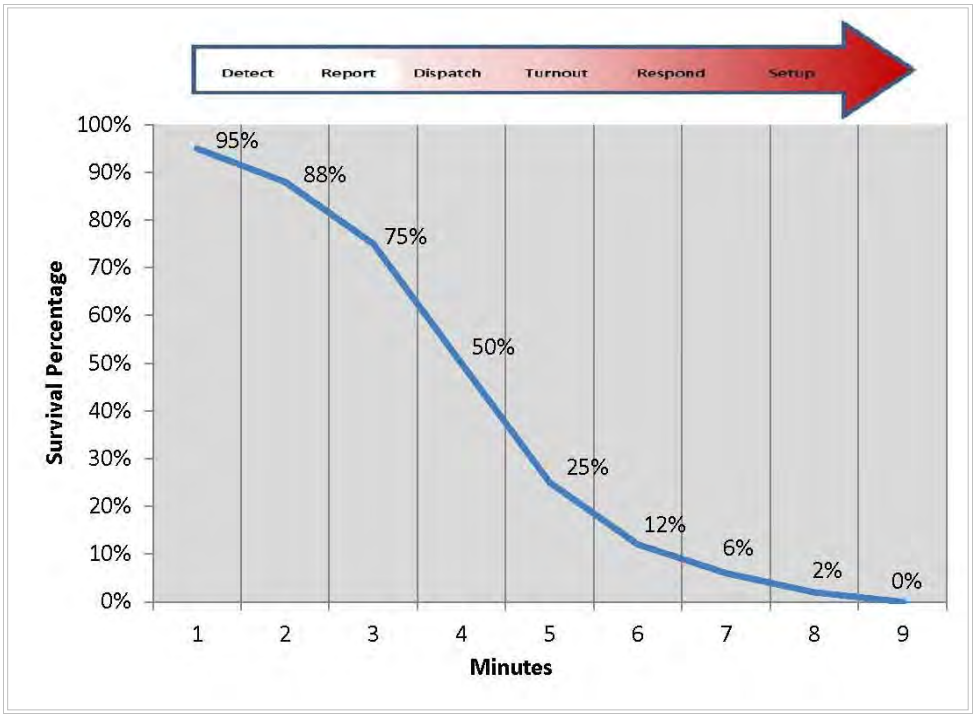
Consequence of Fire Extension in Residential Structures 2011–2015			
Fire Extension	Rates per 1,000 Fires		
	Civilian Deaths	Civilian Injuries	Average Dollar Loss Per Fire
Confined to room of origin or smaller	1.8	24.8	$4,200
Confined to floor of origin	15.8	81.4	$36,300
Confined to building of origin or larger	24.0	57.6	$67,600

Source: National Fire Protection Association

Emergency Medical Event Sequence

Cardiac arrest is the most significant life-threatening medical event in emergency medicine today. A victim of cardiac arrest has mere minutes in which to receive lifesaving care if there is to be any hope for resuscitation. The American Heart Association (AHA) issued a set of cardiopulmonary resuscitation guidelines designed to streamline emergency procedures for heart attack victims and to increase the likelihood of survival. The AHA guidelines include goals for the application of cardiac defibrillation to cardiac arrest victims. Cardiac arrest survival chances fall by 7 to 10 percent for every minute between collapse and defibrillation. Consequently, the AHA recommends cardiac defibrillation within five minutes of cardiac arrest. As with fires, the sequence of events that lead to emergency cardiac care can be graphically illustrated, as in the following figure.

Figure 94. Cardiac Arrest Event Sequence



The percentage of opportunity for recovery from cardiac arrest drops quickly as time progresses. The stages of medical response are very similar to the components described for fire response. Recent research stresses the importance of rapid cardiac defibrillation and administration of certain medications as a means of improving the opportunity for successful resuscitation and survival.

People, Tools, and Time

Time matters a great deal in the achievement of an effective outcome to an emergency event. Time, however, is not the only factor. Delivering sufficient numbers of properly trained, appropriately equipped personnel within the critical time period completes the equation.

For medical emergencies, this can vary based on the nature of the emergency. Many medical emergencies are not time critical. However, for serious trauma, cardiac arrest, or conditions that may lead to cardiac arrest, a rapid response is essential. Equally critical is delivering enough personnel to the scene to perform all of the concurrent tasks required to deliver quality emergency care. For a cardiac arrest, this can be up to six personnel; two to perform CPR, two to set up and operate advanced medical equipment, one to record the actions taken by emergency care workers, and one to direct patient care. Thus, for a medical emergency, the real test of performance is the time it takes to provide the personnel and equipment needed to deal effectively with the patient's condition, not necessarily the time it takes for the first person to arrive.

Critical Tasks, Risk, and Staffing Performance

The goal of any fire service organization is to provide adequate resources within a period of time to reasonably mitigate an emergency event. However, all emergency events inherently carry their own set of special circumstances and will require varying levels of staffing based upon factors surrounding the incident. Properties with high fire risk often require greater numbers of personnel and apparatus to effectively mitigate the fire emergency. Staffing and deployment decisions should be made with consideration of the level of risk involved. Common risk categories used in the fire service are:

- **Low risk**—Areas and properties used for agricultural purposes, open space, low-density residential, and other low intensity uses.
- **Moderate risk**—Areas and properties used for medium density single family residences, small commercial and offices uses, low-intensity retail sales, and equivalently sized business activities.
- **High risk**—Higher density businesses and structures, mixed-use areas, high-density residential, industrial, warehousing, and large mercantile structures.

Fire emergencies are even more resource critical. Again, the true test of performance is the time it takes to deliver sufficient personnel to initiate the application of water to a fire. This is the only practical method to reverse the continuing internal temperature increases and ultimately prevent flashover. The arrival of one person with a portable radio does not provide fire intervention capability and should not be counted as "arrival" by the fire department. The following figure displays the NFPA 1710: *Standard for Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments* critical tasks expected to be performed by firefighters concurrently, referred to as the "effective response force" (ERF).

Figure 95. NFPA 1710 Effective Response Force by Task & Building Type

Task	Single-Family Dwelling[1]	Open-Air Strip Mall[2]	Apartments[3]	High-Rise[4]
Command	1	2	2	2
Apparatus Operator	1	2	2	1
Handlines (2 members on each)	4	6	6	4
Support Members	2	3	3	
Victim Search & Rescue Team	2	4	4	4
Ground Ladders/Ventilation	2	4	4	
Aerial Operator (if ladder used)	1	1	1	
Initial Rapid Intervention Team	2	4	4	
Initial Medical Care Component		2	2	
Building Fire Pump Monitor				1
Hoseline–Floor Above Fire				2
Rapid Intervention Team				4
Accountability Officers (fire floor & floor above)				4
Evacuation management teams				4
Elevator Operations Manager				1
Incident Safety Officer				1
Interior Staging Manager				1
Member Rehabilitation				2
Vertical Ventilation Crew				4
Lobby				1
Transport Equipment				2
External Base Operations				1
EMS Crews with Transport				4
Total Required:	**15**	**28**	**28**	**43**

[1] Typical 2,000 ft., two-story single-family dwelling without basement and no exposures

[2] Typical open-air strip mall/shopping center ranging from 13,000–196,000 feet

[3] Typical 1,200-foot apartment within a three-story, garden-style apartment building

[4] Building with the highest floor greater than 75 feet above the lowest level of fire department vehicle access

Again, critical tasks are those activities that must be conducted in a timely manner by firefighters at emergency incidents in order to control the situation, stop loss, and to perform necessary tasks required for a medical emergency. LC-CFRS is responsible for assuring that responding companies are capable of performing all of the described tasks in a prompt, efficient, and safe manner.

All Risk Critical Resource Tasking

Fire departments respond to many incidents other than structure fires, including hazardous materials (dangerous goods) releases, motor vehicle collisions, basic and advanced life support medical emergencies, and non-structural fires. Personnel responding to these types of incidents should be assigned tasks similar to structure fires.

The following figures are provided as an example for these types of incidents, although ESCI recommends that LC-CFRS conduct its own field validation exercises with its crews, including mutual aid resources, to verify the critical tasking analysis provided. After field validation is complete, LC-CFRS may find that the critical tasking can be adjusted appropriately upward or downward for each incident type.

Figure 96. Sample Non-Structure Fire Critical Tasking

Task	Personnel
Command	1
Pump Operator	1
Primary Attack Line	2
Total	**4**

Figure 97. Sample Hazardous Materials Incident Critical Tasking

Task	Personnel
Command	1
Pump Operator	1
Primary Attack Line	2
Back-Up Line	2
Support Personnel	7
Total	**13**

Figure 98. Sample Motor Vehicle Collision with Entrapment Critical Tasking

Task	Personnel
Command	1
Pump Operator	1
Primary Attack Line	2
Extrication	3
Patient Care	2
Total	**9**

Response Time Performance Objectives

To initiate the process of developing performance objectives, several items must be considered. Although the specific information needed to complete this process will vary with each organization, the following items will generally need to be addressed during this process. Historical call data must be collected and analyzed to determine current performance baselines and identify any gaps in data required; response zones must be established based on an agreed upon criteria (i.e., population zones, geographic boundaries, etc.); and benchmarks established as goals for these demand zones.

Current Response Goals

ESCI emphasizes the importance of establishing and regularly monitoring performance metrics for the deployment of resources. These metrics serve as the foundation for determining whether or not the organization is meeting the expectations of the community that it serves. Without regular and consistent performance evaluation, it is impossible to set and achieve goals established to meet community expectations.

Response standards established by the department must originate from the community served to create a balance between what is desired and what can be afforded. Because of this, ESCI cannot establish baseline and benchmark performance metrics for a given organization. However, recommendations based upon the analysis conducted throughout this report may be helpful in serving as a starting point for these discussions with the community served or may serve as a reevaluation tool for the organization's current standards.

Response standards are individual to each organization. Multiple factors such as staffing, financial constraints, size of the service area, and political will influence each department's ability to set achievable goals and objectives for response.

Additionally, LC-CFRS may consider establishing separate standards for fire/special operations response and EMS responses. This will allow for greater discernment between these types of calls and create a body of data for richer analysis. Another consideration related to performance metrics is the additional response standard for ALS calls at the 90th percentile. Currently, no field exists within the data to differentiate between ALS and BLS calls which makes the reporting of performance against this standard problematic. LC-CFRS may find it helpful to develop a mechanism to capture the final determinant and nature of the call within the call center database for future analysis.

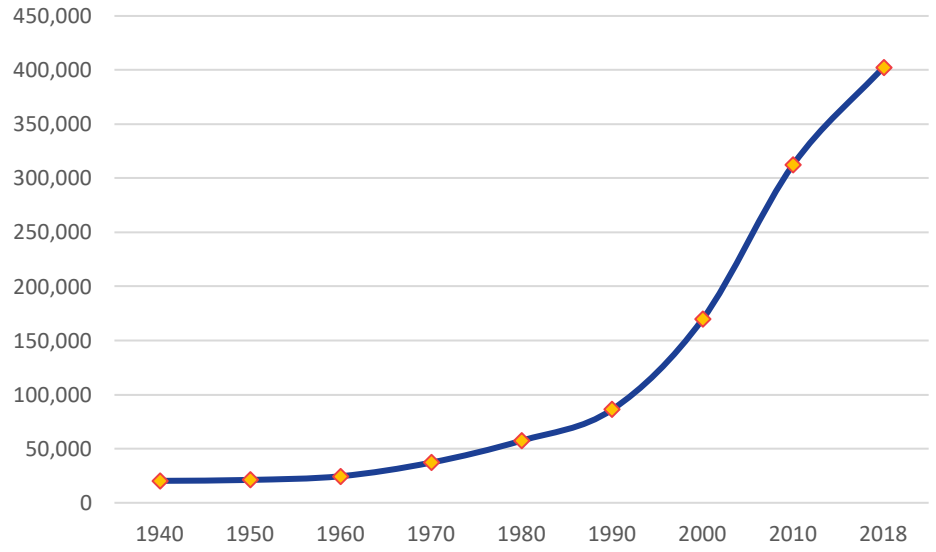
Appendix C: Projections—Population and Service Demand

Population Growth

Historical Growth

At the time of this study, the current service area population was estimated at 402,561. After decades of slow stagnation, the county population began to increase in the 1940s and has skyrocketed since the mid-sixties following completion of Washington Dulles International Airport. The fastest growth occurred from 1990 to 2010, with the county almost doubling in population every ten years. Since 2010, growth has slowed slightly, with an average annual growth rate of 2.9 percent between 2010 and 2018. The following figure illustrates resident population growth since 1940.

Figure 99. Population History, 1940–2018



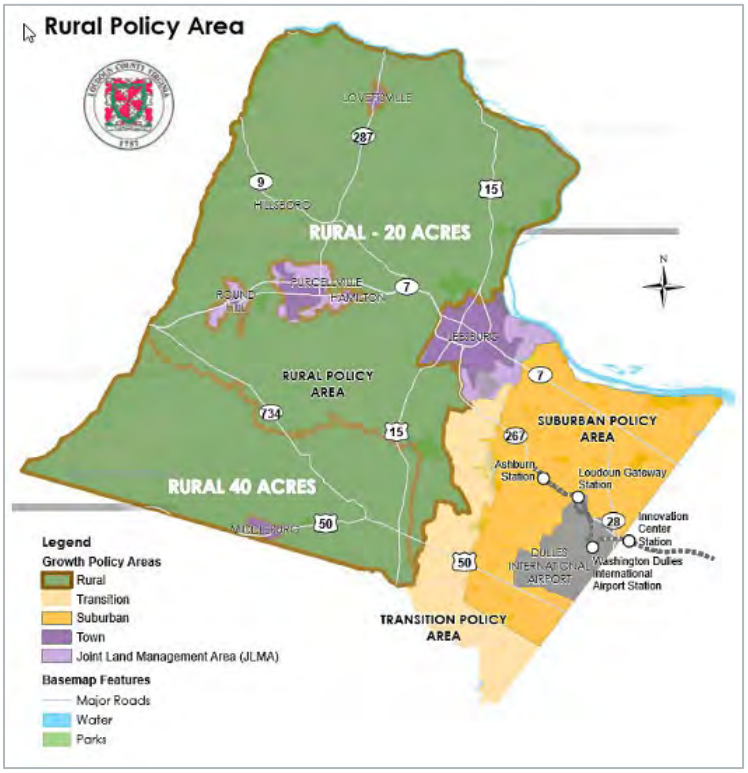
Transient Population and Demographic Information

The area economy is driven by four major forces—white-collar service industries, agriculture, government service, and tourism. Thus, the area has an influx of people beyond the numbers calculated by the census. Often, these numbers exceed the actual resident population. As examples:

- An estimated 93,000 people commute into the area to work.
- An estimated 129,000 people commute out of the area to work.
- An estimated 7.6 million vehicle road miles are traveled each day in the County.
- An estimated 57,500 people pass through the airport every day.
- An estimated 1.4 million people stay in area hotels and motels every year.

The eastern part of the county is urban in nature, with a population density over 1,000 people to well over 3,000 people per square mile. This part of the county is by a large number of single-family neighborhoods, dense neighborhoods including multi-family housing significant commercial and light industrial development, many multi-lane roads, large "big box" stores, and a large number of mid-rise buildings, plus a few high-rise buildings.

Figure 100. Rural Policy Area



The western and northern parts of the county are rural in nature, characterized by the traditional farming/agricultural land use with many winding, narrow two-lane roadways and small communities, interspersed with multi-lane connector roads and large, estate-style homes on multi-acre properties in rural areas. Some of these individual properties have the potential for a larger loss of life and property than traditional rural structures and lie within the wildland-urban interface (WUI).

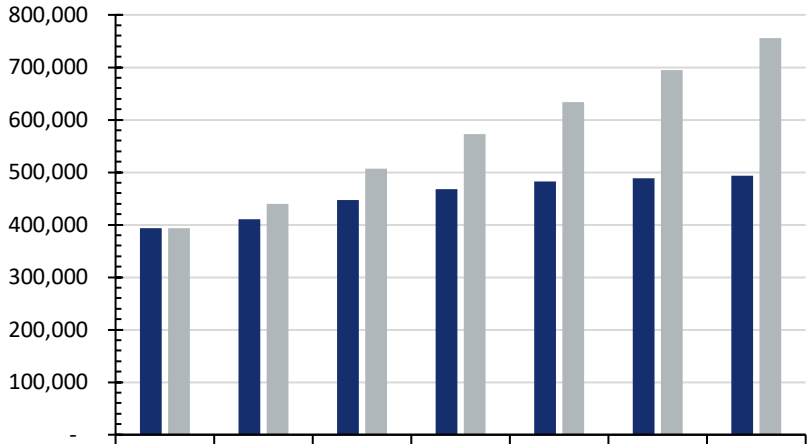
Separating these two areas is the Transition Policy Area, an area that lies below Route 7 and is intended to serve as a "visual and spatial" transition between the urban and rural areas of the county. This area is characterized by higher population densities than allowed in rural areas, along with specific and unique development opportunities that incorporate both suburban and rural features.

Projecting Growth

All communities change over time. These changes to their populations and compositions can impact service demand. As populations increase or decrease, demand for services may increase or decrease accordingly, or may follow a different pattern based on the change to the demographic makeup. In this section, estimates on the future population of Loudoun County are discussed.

To provide estimations for future populations in Loudoun County, internal documents from Loudoun County were reviewed, as well as estimations created by the University of Virginia. In both cases, Loudoun County is expected to continue growing over time. While the Loudoun County estimates projected a decline in the rate of growth within the next 7–10 years, the University of Virginia estimates generally followed a linear path. As no prediction can guarantee 100 percent accuracy, both projections are presented with the expectation that the actual population total will fall somewhere within the range of the estimates.

Figure 101. Population Growth Estimates[75, 76]



	2018	2020	2025	2030	2035	2040	2045
Loudoun County	393,345	410,449	447,137	468,116	482,330	489,002	493,603
Univ. Virginia	393,345	440,445	506,719	572,994	633,952	694,911	755,869

As displayed in the figure, Loudoun County is projected to have a population between approximately 500,000 to 750,000 by the year 2045. LC-CFRS should anticipate a consistent annual increase in overall service demand, as well as a potential need for additional fire stations should urban sprawl continue out into once rural areas.

An important consideration to population is its relationship to service demand. Generally speaking, service demand will be greater in areas of high population density than lower population density; however, the demographics of the area also play a large role in demand. For example, a newly constructed subdivision occupied by young professionals and families would likely be much less dependent upon emergency medical services than a neighborhood occupied primarily by retirees. Although the population densities may be equivalent, the dependence upon emergency responders would differ.

Service Demand

The demand for services is central to the existence of a fire department. Often as the population rises or falls, so too does the demand for services. As discussed in the previous section, the population of Loudoun County has grown rapidly since 1990. Because of this, it can be anticipated that the demand for service should increase year to year as well. An examination of LC-CFRS's call volume from 2013 through 2017 displayed an average annual growth of 4.3 percent with a Compound Annual Growth Rate (CAGR) of 3.8 percent. Annual service demand and their associated growth rates are illustrated in the following figure.

[75] *University of Virginia, Demographics Research Group of the Weldon Cooper Center for Public Service, March 2017, http://demographics.coopercenter.org.*

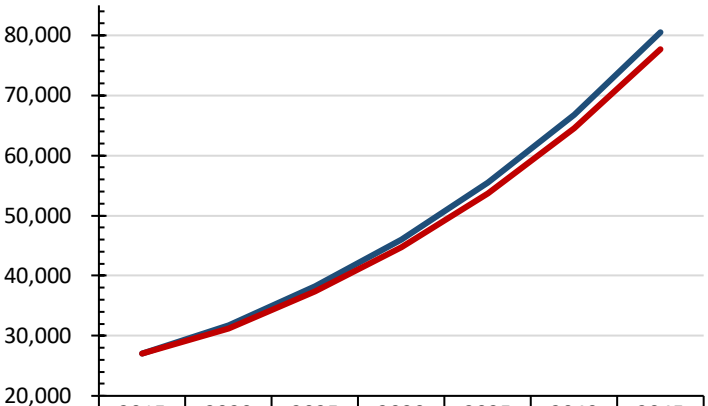
[76] *Loudoun County Demographic Forecast Series, December 2016.*

Figure 102. Change in Service Demand, 2013–2017

Year	Call Volume	Annual Growth Rate
2013	24,435	
2014	25,605	4.8%
2015	27,038	5.2%
2016	27,041	3.4%
2017	28,337	3.8%
Average Annual Growth		**4.3%**
Compound Annual Growth Rate		**3.8%**

Since service demand is often correlated to population, two estimations for service demand are provided in the following figure. The blue line represents growth as a function of the CAGR and 3.8 percent growth is applied annually through the year 2045. The second estimation used Loudoun County's internally calculated annual growth year by year to calculate annual service demand growth as a function of the estimated annual population increase. The results are displayed in the following figure.

Figure 103. Service Demand Estimates



	2015	2020	2025	2030	2035	2040	2045
CAGR	27,038	31,692	38,189	46,017	55,451	66,818	80,516
LC Annual Population Growth Estimates	27,038	31,160	37,338	44,693	53,667	64,510	77,690

Beginning with the known demand for service in 2015, estimations were calculated moving forward through 2045 and displayed in 5-year intervals. As illustrated, both models follow similar paths with the final projection at year 2045 separated by 2,826 incidents. At this rate of growth, LC-CFRS should anticipate doubling their current annual call volume by year 2035 with an additional increase of approximately 25,000 calls annually 10 years later in 2045.

Appendix D: Projections—Response Time Thresholds and Triggers, When is a New Station Needed?

When a community creates a fire department and builds its first fire station, a response time criterion is usually established. This response time anticipates that it applies to 100 percent of the area covered by the boundaries of that fire station. This is especially true when there is only one fire station and a small area to cover. Simply speaking, a central fire station is among the first public buildings created in most communities, no matter how small. As the community grows away from that station in incremental steps, the expectation is that the original fire station will still provide adequate coverage.

However, that expectation is fraught with many problems. In the simplest of terms, the total area covered by a fire department may or may not be highly developed initially; and even if a crew responds, it may not do so in a timely manner. When population and service area increase, there is often pressure to add full-time staff and to consider adding additional stations.

In fact, there are many variations on this theme. Older, established cities tended to be denser and smaller in dimension, but they often annex new areas. Newer communities may be created from a much larger area than the first fire station can cover. Urban sprawl, which is currently an active discussion in other areas of public policy, has resulted in the timing of additional fire station construction and staffing being a topic of concern.

Station Siting

Usually, when a fire department constructs its first fire station in the area, the values at risk and hazards to be protected are within a close driving distance. In effect, the first fire station in a community is a *centroid*. That is, the local fire station is the center of the response capacity of the jurisdiction. Earlier in the 20th century, fire stations were often characterized on maps by having a circle drawn around the station with a 1.5-mile radius. This was sometimes used to describe the area of coverage. However, fire apparatus respond using the roadbed that consists of angles and distances that did not result in the circle being the true description of the coverage. Not only that, but one cannot place fire stations exactly three miles apart and have the two circles overlap. When they are placed closer together than the 1.5-mile radius, there is not only overlap but also gaps where there does not appear to be coverage.

Later, the circle was replaced by diamond-shaped templates that could be overlaid over the station and rotated to estimate the relative advantage of road distances. The contemporary method used to evaluate fire stations is based upon using the actual road-network in a computer model. This system uses time and distance to create a network that more closely represents how far the company can respond from its fire station, using the adopted time standard. A few years ago, the method that was in vogue was called FLAME. This is an acronym for Fire Station Location and Mapping Environment. From the time the first station is built, it creates an expectation that the facility can and will provide a timely response to calls for service in an area surrounding that facility.

When the original criterion was set for response time from that facility, there was an immediate *location allocation* created by that station. The station provides a response to a given area within a reasonable time in a pattern that essentially is an overlay on the streets and highways that radiate outward from that location. Even before any incidents occur in a community, the road-network geography and the topographical attributes of a community create a *dynamic segmentation* that results in the ability of fire professionals to reasonably predict what areas can be, and those that will not be, covered. Today, the preferred tool for conducting this type of analysis is through Geographical Information Systems (GIS).

There are many infrastructure components that have an effect on the *location-allocation* concept. Among these are road and highway networks; impedance factors, such as traffic patterns and processes (stoplights and signs); and turn impedance, i.e., roadbed configuration and elevation impedance (slope). It is axiomatic that there is an inverse distance-weighting factor that results in longer response times to areas further away from the centroid of the station. This is called distance *decay*. The manner and means of response involve the use of the roadbed, but also involve dealing with differences in elevation and competing vehicles on the roadbed. In short, the further away from the location of an incident and the higher the impedance for response, the less effective any specific resource is in dealing with the initial stages of an emergency event as you move away from the station's location.

The use of the concept of using *travel time* itself is not exactly new. However, for many years the basic criterion was road mileage only. The standard that was normally applied was that a fire station was expected to be able to reach any incident within 1.5 miles of the station within five minutes of driving time. Time was a secondary consideration. That standard was based upon data from the 1940s with respect to road conditions and traffic patterns. A lot has changed since then. For decades, the Insurance Services Office (ISO) has based fire station locations on a 1.5-mile separation. In general, this has served as a *rule of thumb*, but it does not deal with the vagaries of physical response (such as geography, transportation, and weather). Secondarily, it does not place any emphasis on response needed for Emergency Medical Service (EMS) incidents, such as basic life support (BLS) or advanced life support (ALS).

The concept of using actual travel time today is based upon a more accurate representation of the level of service for an all-risk approach. It is more performance-based. Today, most fire agencies set a time standard that includes three elements, two of which were missing from the strict use of mileage for station location—specifically, alarm processing time and turnout time. The actual time of road travel has often been used to set the community's expectation of performance.

Using this approach, stations are seldom located in a linear fashion. This concept is based on the time intervals identified in the Standards of Response Coverage section of the *Self-Assessment Manual* published by the Commission on Fire Accreditation International. This process leads to the development of a standard of response cover, or a time and level of staffing designed to control an emergency at a minimum level of loss. The process is, however, a policy choice based on risk and local conditions.

The basic performance standards for time goals are based on the rapid speed of fire growth and consequences of emergency medical situations over a short time frame. It has been determined that both fires and medical emergencies can gain a foothold that results in unnecessary losses when the times are excessive. An example of common benchmark time standards used is:

- Alarm processing time—60 seconds
- Turnout time—90 seconds
- Travel time
  - Fire response—four minutes, 90 percent of the time
  - BLS response—four minutes, 90 percent of the time
  - ALS response—eight minutes, 90 percent of the time

The contemporary method of measuring performance looks at response time on incidents as an indicator of levels of service. The way this is done is two-fold. The first is to measure the actual performance during emergencies; the second is to monitor the system to determine when the system fails to achieve the performance goals.

One point of caution—response time criterion should only be applied to calls that are emergency calls. When incidents are analyzed, the data should be reviewed to assure that non-emergency calls are not used when calculating performance. There are many calls for service that fire departments log as incidents that are non-threatening scenarios, and the responding companies will handle them on an as-needed basis. To include these times in the analysis of emergency services tends to skew the outcome, leading to a false service indicator.

Response Failure

To understand when response failure occurs, we must define first what is being measured and how we measure the performance goal. For example, a basic question to be answered is whether a department is protecting the dirt or the incidents. Are we going to measure the percentage of performance by first-due district or department-wide? Generally, fire protection practitioners try to position stations to cover 90 percent of the ground in each first-due district, to provide overlap for concentration, redundancy for multiple calls, and for equity of access for customer service. It is economically impossible to cover 100 percent of the ground. Based on actual call loading, agencies could strive for 80 to 90 percent of the calls within first-due and concentration total reflex measures.

If the measure for either area or incidents is set at 80 to 90 percent effectiveness, how much *slop* over the performance measure is acceptable? For example, if an historical incident measure is at the 85th percentile, but the other five percent is covered in the next 60 seconds, is that acceptable?

Maybe yes, maybe no. It is important to understand that the values at risk, the type of unmet calls, and the total number of calls can combine to create a need. If the deficiency is only five percent (say 25 calls out of 500), the significance of the gap depends largely on the size of the data sample and on the amount of geographic area represented.

For example, if the performance requirement was to arrive at the scene of an emergency within five minutes of travel time, 90 percent of the time, this criterion could be applied to one year of response data to see if the goal was achieved. It should be noted that this criterion allows for ten percent of the calls to be beyond the five minutes of traveling time over a given reporting period. This provides flexibility in the assessment of coverage to cope with anomalies, such as extra-ordinary response conditions, responding from out of the district, or for delays caused by simultaneous alarms.

This raises an additional question: Of the ten percent overage, how many of the incidents are covered within the next 30 to 60 seconds?

The first indication of a problem of providing service is when a number of alarms that exceed the performance standard are documented. This may or may not be a function of new growth. It could be the result of in-fill that causes a higher number of alarms for the company than it can service. This is especially true when alarms come in simultaneously.

Moreover, when areas are being developed that begin to extend travel times, they do not automatically become the source of new alarms. In fact, new construction often has a period of several years before adding to fire service demand. The same is not necessarily true from the perspective of emergency medical service.

When a New Station or Response Resource is Needed

The question that many communities have to address is when is a fire station, additional response resource, or alternative response program required to meet time goals? Obviously, this has been answered in any community that has more than one fire station or response unit. The problem comes in finding a quantifiable threshold to determine that point for each specific situation because it varies from community to community and even within a specific jurisdiction. The overall answer is part financial and part professional judgment. In fact, in the literature of the fire service today, there is very little definitive guidance on how this should be accomplished.

There are several steps that can be identified. They consist of:

- Identifying areas with minimum coverage
- Identifying feasible locations for a new facility or response resource
- Evaluating those locations using specific criterion

The description in this document is based upon a growing body of knowledge acquired by ESCI and aimed at quantifying this process. What is unfortunate is that there is no universally acceptable algorithm. The fire protection planning process allows for an evaluation of potential loss as a result of deteriorating response times. One form of measurement is to assess the road and transportation network to ascertain the percentage of road mileage that theoretically is covered by the time criterion. This is done using computer-based modeling that will create a polygon that describes the areas of coverage. In fact, this process will also identify gaps and deficiencies where response time is not adequate.

As growth and development extend beyond the range of travel time of one station, the percentage of calls that exceed the performance requirement should begin to increase. It should be noted that growth, in and of itself, does not create an instantaneous demand. New construction has the advantage of better codes, a higher level of ownership interest, and limited deterioration of fire-breeding conditions.

A more subtle difference in today's fire service is the fact that community demand for medical services is almost from day one of occupancy. In short, this means that new construction may place more values and lives at risk, but the demand for service will be incremental. When demand for service does begin, it will be based upon two factors—nature of the occupancy and hazards that are present.

Incident increase may first appear as a change in the performance of an existing company in the annual analysis of emergency calls. For example, if a station has 1,000 alarms and a 90 percent compliance rate with the response standard, there would be about 100 alarms per year that were beyond the goal. This would be the baseline for existing response performance. If the following year, the number of alarms was 1,200 and percentage dropped to 85 percent, this would indicate that the department is losing ground on response performance. If the change in the number of alarms had merely increased because of more calls in the same area, the response time percentage should have remained similar. One exception to this rule is when a single company has such a high call volume that it cannot handle all calls without call queuing.

However, since the alarm rate went up and the performance went down, the failure threshold may be approaching. The change in alarms that were not met may now go to 180 (15 percent of the overall). As stated earlier, analysis needs to be performed on the deficiency to determine how many of those incidents were handled in the increment of 60 seconds beyond the performance time.

Based upon actual response time analysis, one threshold that needs to be considered is the increase in alarms and the percent of calls handled under the criterion adopted. Anything more than a ten percent increase in calls and a ten percent reduction in performance is a signal to evaluate the level of service provided.

In larger departments, most practitioners are factoring out non-emergency calls and for actual incident performance, only looking at *core emergencies*. The definition of core can be made locally based on risk and importance to the community, but they are usually structure fires and moderate to severe status EMS calls.

In general, if more than one measure must be slipping, an evaluation of all Standards of Coverage factors, along with the reason why the data is slipping, is required. A one-year snap-shot may not be valid if the agency had a big storm event, a catastrophic weather event, major wildland fire, and stacked a bunch of calls for just a month of the year.

Incident analysis approach depends upon having emergencies, which does not address what is at risk. That is where the mapping technology applies. As structures and different types of fire problems are constructed on the ground, they may represent additional lives and property that are at risk that deserve equity in protection. One of the elements for creating a governmental entity is to control land use and to create mechanisms for collecting taxes and determining ownership. Furthermore, these same individuals and properties are paying the taxes, fees, and permits for the level of service provided. In one sense, when growth occurs, the new properties are usually safer than the older part of the community because they are constructed to a higher standard.

What is clear to almost any community is that being slightly out of the response standard range does not trigger a new facility or additional response unit from an existing facility.

Assessed valuation or increased revenues in the form of benefit assessment or mitigation fees provide an incentive for new fire stations to be constructed and/or additional units staffed when the fire agency can afford them. One threshold that needs to be carefully monitored is the revenue stream that accrues from development. That revenue stream should provide a threshold when different elements of future fire stations or additional response units can be determined. For example, it takes several years to evolve a location into a fire station site. As the revenue stream proceeds, funds could be available for site acquisition, initial plans and specifications, site treatment, and construction. This may be a multi-year process.

One industry threshold for additional response capabilities should be to provide a new fire station or additional response unit into the appropriate zone in the county or jurisdiction that has more than 35 to 50 percent of its parcels developed. Some of the secondary measures currently being used are 300 to 500 calls for service for any individual fire company or a service population of 10,000 to justify a full-time paid company or response unit. The following criterion grid illustrates a series of measures that may be useful in deciding when a new fire station or additional response unit should be deployed within a county. Similar grids should be developed to help establish triggers for the deployment of additional emergency equipment and personnel in the LC-CFRS response areas that are difficult to currently serve and areas experiencing significant development.

CRITERION GRID TO DETERMINE WHEN A NEW STATION IS NEEDED				
Action Choices	Travel Distance	Criterion		
		Response Time Parameter	Out of Area Calls	Building/Risk Inventory
Maintain status quo	All risks within 1.5 miles	1st due company is within 5 minutes total response time, 90 percent of the time	100% in first due area	Existing inventory and infill
Temporary facilities and minimal staffing	Risks 1.5 to 3.0 miles from existing station	1st due company Exceeds 4-minutes travel time 10% of the time, but never exceeds 8 minutes	More than 10% of calls are in adjacent area	New area has 25% of same risk distribution as in initial area
Permanent station needed	Risk locations exceeding 4.0 miles from the station	1st due company Exceeds 4-minutes travel time 20–25% of the time. Some calls < 8 minutes	More than 20–25% of calls are in outlying area	New area has 35% of same risk distribution as in initial area of coverage
Permanent station essential	Outlying risk locations exceeding 5.0 miles from the 1st station	1st due company Exceeds 4-minutes travel time 30% of the time. Some calls < 10 minutes	More than 30% of calls are in outlying area	New area has 50% of same risk distribution as in initial area

The decision process has to be placed in the context of staffing pattern decisions. It is not uncommon to have a station constructed and have the staffing patterns utilizing alternative response options evolve over the years from one system to another. In the case of a station or alternative response resource under consideration, it should be anticipated that a policy decision needs to be made with respect to the staffing system to be used as soon as possible. Conversely, a fully staffed paid company has a significant price tag to it.

ESCI's experience has been that it takes multiple elements of the standards of coverage to be out-of-balance along with having additional economic resources to justify an additional paid company or staffing increase on one or more companies.

Appendix E: Loudoun County All Hazard Risk Assessment

This section provides information about fire/EMS-related risks that exist in the service area. It is intended to assist fire department official to (1) identify fire/EMS-related hazards and risks within the community; (2) prioritize risks in order to develop effective risk reduction strategies; and (3) determine the appropriate resources necessary to reduce fire-related risks and attain the desired outcomes. This assessment relies on the use of both quantitative and qualitative data to describe the fire/EMS protection needs of the community.

This section is intended to provide insight into *what* needs exist, *where* those needs exist, and *how* those needs are expected to change in the future. Physical, economic, and demographic data were utilized to assess the fire/EMS-related hazards and risks that threaten the community, to include:

- Current hazard classification, planning, and mitigation measures from various sources;
- Specific information provided by LC-CFRS about target hazards and land use; and
- Planning zones established by LC-CFRS.

Methodology

Simply stated, community risk assessment (CRA) is "the identification of potential and likely risks within a particular community, and the process of prioritizing those risks." This concept is consistent with the FEMA concept of "whole community" and a shared responsibility for emergency preparedness.[77] Thus, CRA is a critical component of the core capabilities, or phases, of emergency management—prevent, prepare, respond, and recover, as shown here.

Figure 104. CRA and the Core Capabilities of Emergency Management

LC-CFRS acknowledges there are hazards in the community, that these hazards pose a risk to life and property, that these hazards vary in likelihood and impact, both on the community and the agency, and that these directly influence LC-CFRS planning and response activities.

LC-CFRS has expanded the basic risk analysis process to match the "all hazards—all risk" methodologies common to emergency management. In addition to the traditional characteristics of likelihood and community impact, this approach provides qualitative data about the probability and consequences of an incident, plus additional information about warning time, duration, and agency impact.

[77] *National Planning Frameworks, U.S. Department of Homeland Security, FEMA, 2018. Retrieved from: https://www.fema.gov/whole-community#.*

Defining Risk

It is important to understand and agree upon the methodology of defining risk before a risk assessment may be conducted. For consistency, the following words have specific meaning in this context:[78]

- Risk
- Likelihood
- Consequence
- Hazard
- Threat
- Vulnerability

Risk

Simply stated, risk is the potential or likelihood of an emergency to occur. In its simplest form, risk may be quantified as the combination of the probability (or likelihood) of an event, and its consequence (or impact). For the purpose of this assessment, the agency has used a Priority Risk Index (PRI) similar to the one used by emergency management organizations but adapted to account for day-to-day emergency responses.

Likelihood or Probability

Likelihood is the "chance of something happening, whether defined, measured, or estimated objectively or subjectively, or in terms of general descriptors, frequencies, or probabilities."[79]

Consequence or Impact

In this context, the terms "impact" and "consequence" are often used interchangeably. In fact, the CPSE definition of consequence is the "effect, impact, or outcome" of some significance; yet goes on to define impact in terms of "the drain effect on the community standards of deployment and coverage capacity when an emergency event occurs." ESCI uses the terms interchangeably, with the subtle distinction that "impact" refers to effects or outcomes that are more immediate or acute, and "consequence" refers to effects or outcomes that are long-lasting or chronic. Most notably, consequences affect one or more of the following aspects of the community: ***human***—injury, illness, or loss of life; ***economic***—loss of income, cost to repair, rebuild, replace, and recover; ***social/cultural***—damage or loss to sites of historical, cultural, social, or religious significance; and ***environmental***—pollution, loss of habitat.

Hazard

A hazard is described as "a condition that presents the potential for harm or damage to people, property, or the environment." Often, hazards are interrelated—hurricanes can cause flooding and tornadoes, fires can cause injuries that require medical intervention, and so forth. Others contain elements that create a chain of events that may lead to "incidents within an incident"—severe storms may cause flooding that causes electrical outages that lead to unplanned release of reactive materials that requires a fire/hazmat response; while at the same time the flooding has stranded motorists that require water rescues and sheltering. Also, some hazards, such as wildfire in a remote region, may impact a large area yet cause little damage. On the other hand, other hazards like a tornado or structure fire may impact a relatively small area, yet cause extensive property damage.

---

[78] *Except as noted, definitions are from the Community Risk Assessment: Standards of Cover, 6th Edition, CPSE, 2016.*

[79] *FEMA CPG-201.*

Threat

A threat is simply an event that involves a hazard and is now in position to cause harm or damage to people, property, or the environment. *A threat is what we are trying to protect against.*

Vulnerability

Vulnerability is "an assessment of how well or how poorly protected you are against an event."[80] Vulnerability can be influenced by several factors as listed here. Thus, vulnerability may be reduced by planning, preparation, and mitigation activities. Alternatives could include adoption and enforcement of codes, maintenance and control measures, by public awareness and notification, and by planning.

- Predictability
- Temporal distribution
- Spatial distribution and extent
- Physical characteristics
- Shielding or hardening
- Magnitude
- Speed of onset
- Duration
- Resilience

A Cautionary Note

It is impossible to include or predict all aspects and indicators of hazards and risk. There are simply too many variables of weather, human behavior, and systems malfunction. ESCI recommends that LC-CFRS routinely and consistently review and update their Community Risk Assessment and Hazard Mitigation Plan. In this way, the LC-CFRS can ensure that plans contain the most accurate and up-to-date information available about community hazards, vulnerabilities, risks, and needs.

Unique Risk Factors Associated with the Community

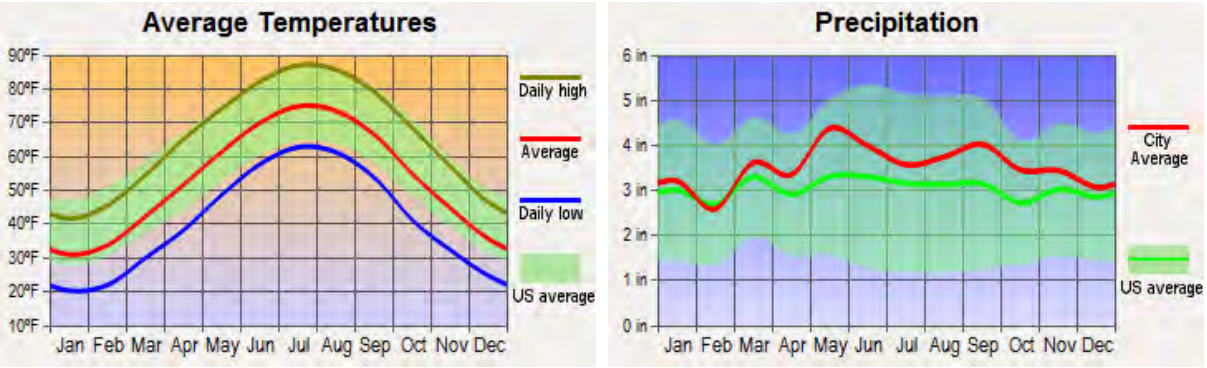
Every community has risks that are unique to that community. These include natural hazards associated with climate and topography; population and demographics; technological and human-caused hazards; types of structures and their intended use, and the type of service and transportation infrastructure.

Climate

The area around Loudoun County is generally temperate and is classified as humid subtropical. As shown here, the region experiences four distinct seasons, with a typical low temperature in winter of 20 degrees F and a high of 90 degrees F in the summer. July is the hottest month; January is the coldest. The relative humidity is about the same as the U.S. average, about 70 percent year-round, and reaches 50 to 90 percent in late summer. The County receives about 42 inches of rainfall annually, with May being the wettest month. The average monthly rainfall is about 3.5 inches per month; however, this number can be somewhat higher in summer months; snowfall can begin as early as October, reaches its peak of 8 inches in January, and can persist as late as April.

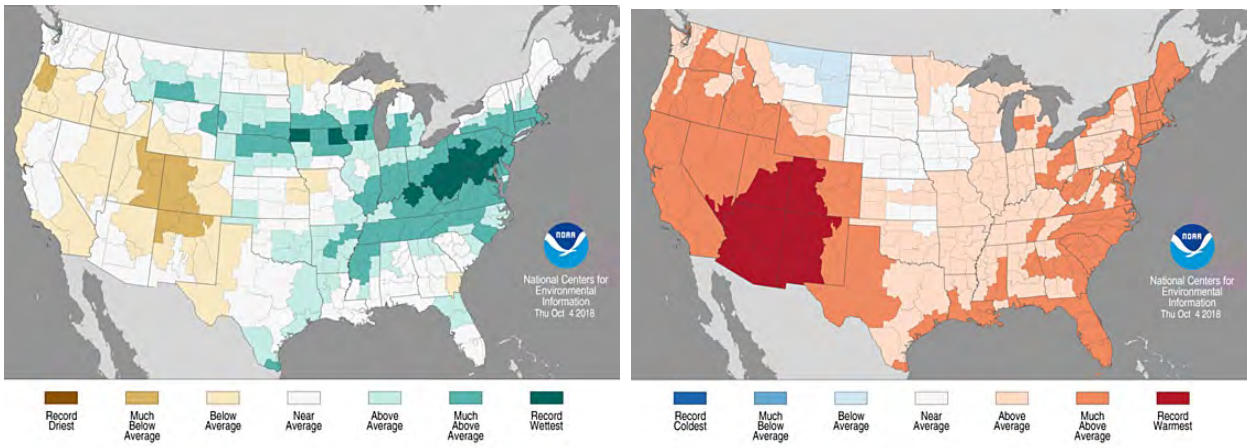
[80] *Disaster Theory, Walter G. Green III, PhD, CEM, University of Richmond, 2008.*

Figure 105. Temperature and Rainfall Totals for Leesburg, VA[81]



Across the Loudoun County region, recent trends have been higher temperatures and more rainfall. As shown here, the year-to-date temperature for the region is much above average than the historic average from 1895–2018. Precipitation for the same period is much above average.

Figure 106. Temperature and Rainfall Trends[82]



Topography and Ecosystem Characteristics

There are five basic physiographic provinces in the Commonwealth of Virginia. Loudoun County lies primarily within the Piedmont Region. Located between I-95 to the east and the foothills of the Blue Ridge Mountains to the west, the Piedmont geology is characterized by rolling hills, hard bedrock, and rich, well-draining topsoils. The Blue Ridge region to the west is noted for thick forests and elevations as high as 4,000 feet. In areas of steep slopes and mountainsides, disturbance of surface soils and vegetation can lead to erosion, landslides, and adverse effects on watersheds. Along the Route 15 corridor is an area known as "Karst" terrain. This region is characterized by the potential for underground cavities and sinkholes; most of the town of Leesburg, plus the area north of town to the Potomac River, lies in this region.

[81] *Source: City-Data.com. Retrieved from: http://www.city-data.com.*

[82] *Source: National Oceanic and Atmospheric Administration. Retrieved from: https://www.ncdc.noaa.gov/temp-and-precip/.*

Native plants include a wide variety of grasses, vines, shrubs, and trees—most notably pine, oak, and hickory—due to the temperate climate and soil conditions. Toward the west and the Blue Mountains, grasslands give way to dense forests of maple, cherry, birch, ash, hickory, oak, and pine. Loudoun County is home to many species of birds, waterfowl, and wildlife—most notably songbirds, turkeys, eagles, ducks and geese, deer, fox, bear, and butterflies.

In the wildland-urban interface and more remote areas of the region, there are several plant species, all of which readily support combustion to varying degrees and can burn with great intensity, especially in the southeast portions of the county. The overall area can be characterized as having vegetation of low to moderate combustibility arranged in a relatively continuous fashion, both horizontally and vertically. The topology of the region is another contributing factor: the steeper the slope, the higher the relative combustibility. Persistent drought is not currently a combustibility factor in Loudoun County.

Response Barriers

There are two common types of response barriers found in the service area—permanent and temporary. Permanent barriers are primarily topological like the mountain ridges, creeks, and lakes. Many communities in the wildland-urban interface have restricted or limited access roads. Temporary barriers include construction zones and moveable barriers for traffic or crowd control. It is important for LC-CFRS responders to know where these barriers are, how they affect travel time and distance, and to map any changes to allow prompt response to emergencies.

Service Infrastructure[83]

Electricity/Solar

Loudoun has a dependable, abundant, and affordable power supply to meet the needs of residents, visitors, businesses, and farms. The Panda Stonewall Energy Center is a 778-MW, gas-fired, combined cycle power plant located south of Leesburg. Multiple substations located around business and transportation corridors provide the option for dual, redundant feeds from primary suppliers Dominion Virginia Power and/or NOVEC. A number of companies provide solar energy.

Natural Gas

Washington Gas is the primary supplier for the area. Customers have the option of buying natural gas from independent natural gas suppliers, which could result in lower gas prices. Alternative fuel sources such as oil are also available.

[83] *Utilities, Loudoun County Department of Economic Development. Retrieved from: https://biz.loudoun.gov/business-services/utilities/.*

Public Water and Sewer Systems[84]

Each incorporated town in Loudoun County is responsible for providing water and sewer service to residents of that town. Within their designated service areas, Loudoun Water, formerly the Loudoun County Sanitation Authority, provides public water and sewer service for Loudoun County residents who live outside incorporated towns. Residents, businesses, and farms outside a service area must rely on private well and septic. Loudoun Water makes reclaimed water available to commercial and industrial customers located in a designated service area. Use of reclaimed water helps conserve drinking water while preventing additional nitrogen and phosphorous from entering local rivers and streams.

Fiber/Internet Service

Loudoun maintains major presences from virtually every major telecommunications provider in the country, both from the perspective of fiber/backbone build-out, and business/support presence. The county hosts several world-class network operators. Internet service is provided by a large number of internet and broadband service providers—up to 70 percent of the world's internet traffic flows through Loudoun's "Data Center Alley" every day.[85]

Transportation Network

Loudoun County has a robust transportation network with several multi-options available for resident, visitors, and network for transportation in the county. The Northern Virginia Transportation Authority (NVTA) is the authority responsible for developing and implementing regional transportation plans.[86]

Over-the-Road

Loudoun County has several arterial, or primary, roadways as shown in the following figure.

- Route 7 runs east-west in the central and northern part of the county and extends through Tysons Corner (outside the county to the east), Sterling, Ashburn, Leesburg, Hamilton, Purcellville, Round Hill, and Winchester (outside the county to the west).
- Route 9 runs east-west in the central part of the county and joins Highway 7 just east of Paconian Springs and extends through Hillsboro, and Charles Town (outside the county to the west).
- U.S. Highway 50 runs east-west in the southern part of the county and extends through Fairfax and Chantilly (outside the county to the east), then passes south of Washington Dulles International Airport to Arcola, Aldie, Middelburg, and Winchester (outside the county to the west).
- U.S. Highway 15 runs north-south in the central part of the county and extends through Frederick, MD (outside the county to the north), Lucketts, Leesburg, and extends through Warrenton (outside the county to the south).
- Route 28 runs north-south in the eastern part of the county and begins at the intersection with U.S. Highway 7 between Sterling and Ashburn, then extends past Washington Dulles International Airport and through Chantilly and Manassas (outside the county to the south).

---

[84] *Loudon Water. Retrieved from: https://www.loudounwater.org/.*

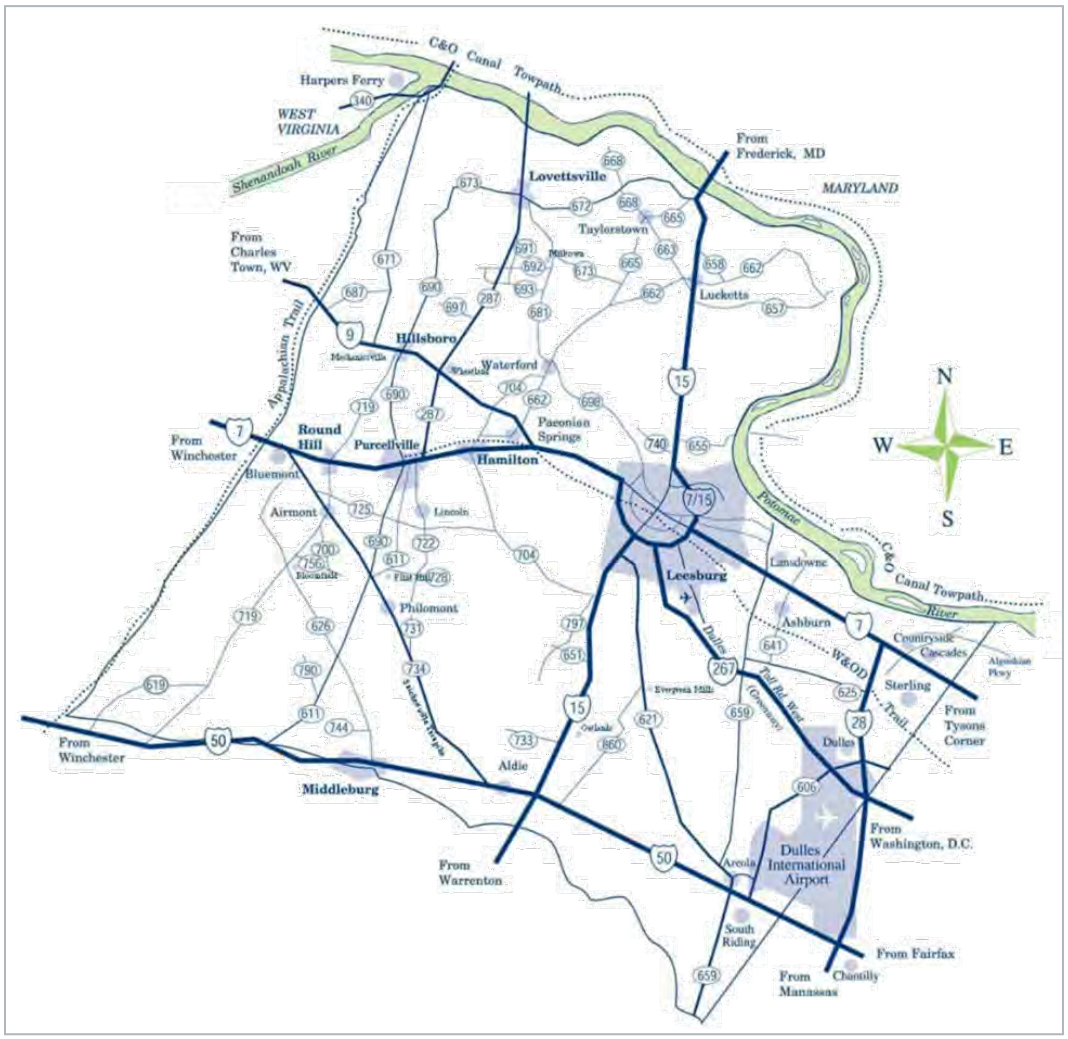
[85] *Loudoun County department of Economic Development. Retrieved from: https://biz.loudoun.gov/key-business-sectors/data-centers/.*

[86] *Source: Transaction Technical Report. 2018. Retrieved from: https://nvtatransaction.org/resources/.*

- Loop 7/15 extends around the town of Leesburg from Hwy 7 to the west, then southward and around until it joins Hwy 15 on the north side of Leesburg.
- Tollway 267 Dulles Greenway runs southeast-northwest in the central part of the county and extends from Washington, D.C. (outside the county to the east), and north of Washington Dulles International Airport to Leesburg.

Several county roads connect these arterial roadways and communities throughout the county. Most are two-lane, paved roads designated as scenic byways with limited shoulders and passing areas.

Figure 107. Major Roadways[87]

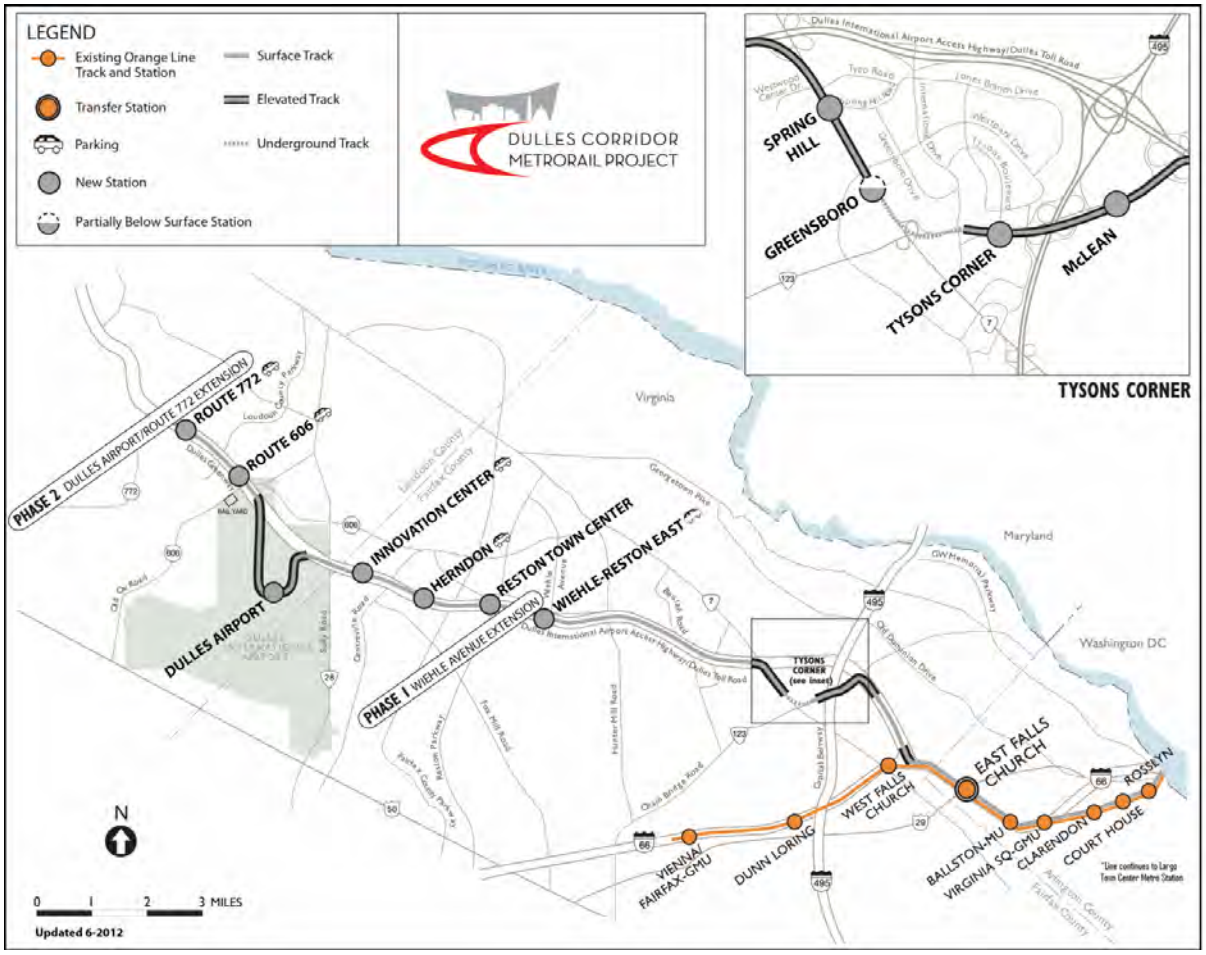


[87] *Loudon County Roadways. Retrieved from: https://www.loudounhistory.org/map-loudoun-with-roads/.*

Rail

There are no rail lines in Loudoun County. A branch line of CSX from Martinsburg, WV, to the coal-fired Dickerson Generating Station west of Dickerson, MD, is north of and follows the Potomac River between Harper's Ferry, WV, and Dickerson, MD. In 2020, the Metro Silver Line extension from Washington, D.C. will add three new commuter train stations—Washington Dulles International Airport, Loudoun Gateway (near the Dulles North Transit Center park-and-ride lot), and Ashburn, and provide one-seat, no-transfer rides from Loudoun County to the nation's capital. The 23-mile route will generally follow the Tollway 267 right-of-way with a deviation to the passenger terminals at Dulles. The stations are being built by the Metropolitan Washington Airports Authority (MWAA) and will be operated by the Metropolitan Washington Area Transit Authority (MWATA).

Figure 108. Silver Line Extension



Marine

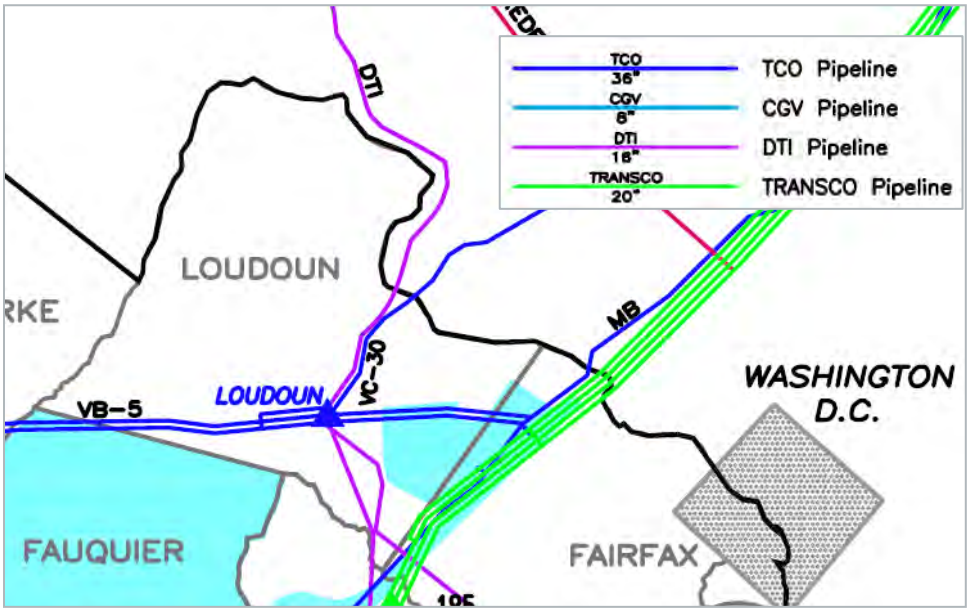
There are no marine transportation routes or ports in Loudoun County.

Pipeline

There are five main gas transmission lines and two compressor stations in Loudon County as shown in the following figure. There are also numerous smaller gas distribution lines that feed residential and commercial customers.

- **DTI PL-1 pipeline.** Large diameter gas pipeline in central Loudoun County running south-north, owned by Dominion Energy Transmission, Inc.
- **DTI Cove Point pipeline.** Large diameter gas pipeline in south Loudoun County, running southeast-northwest, owned by Dominion Energy Transmission, Inc.
- **TCO VB-5 pipeline.** Large diameter gas pipeline in central Loudoun County, running west-east, owned by TransCanada Corp (Columbia Gas Transmission).
- **TCO MB pipeline.** Large diameter gas pipeline along the Loudoun/Fairfax County line, running southwest-northeast, owned by TransCanada Corp (Columbia Gas Transmission).
- **TCO MC pipeline.** Large diameter gas pipeline in central Loudoun County, running southwest-northeast, owned by TransCanada Corp (Columbia Gas Transmission).
- **Transco pipelines.** 30-, 36-, and 42-inch gas pipelines along the Loudoun/Fairfax County line, running southwest-northeast, owned by Transco, Inc.
- **DTI Compressor Stations.** Loudoun Compressor Station and Leesburg Compressor Station, south of Leesburg on Cove Point Lane (coordinates Lat 38.997684; Long -77.592739).

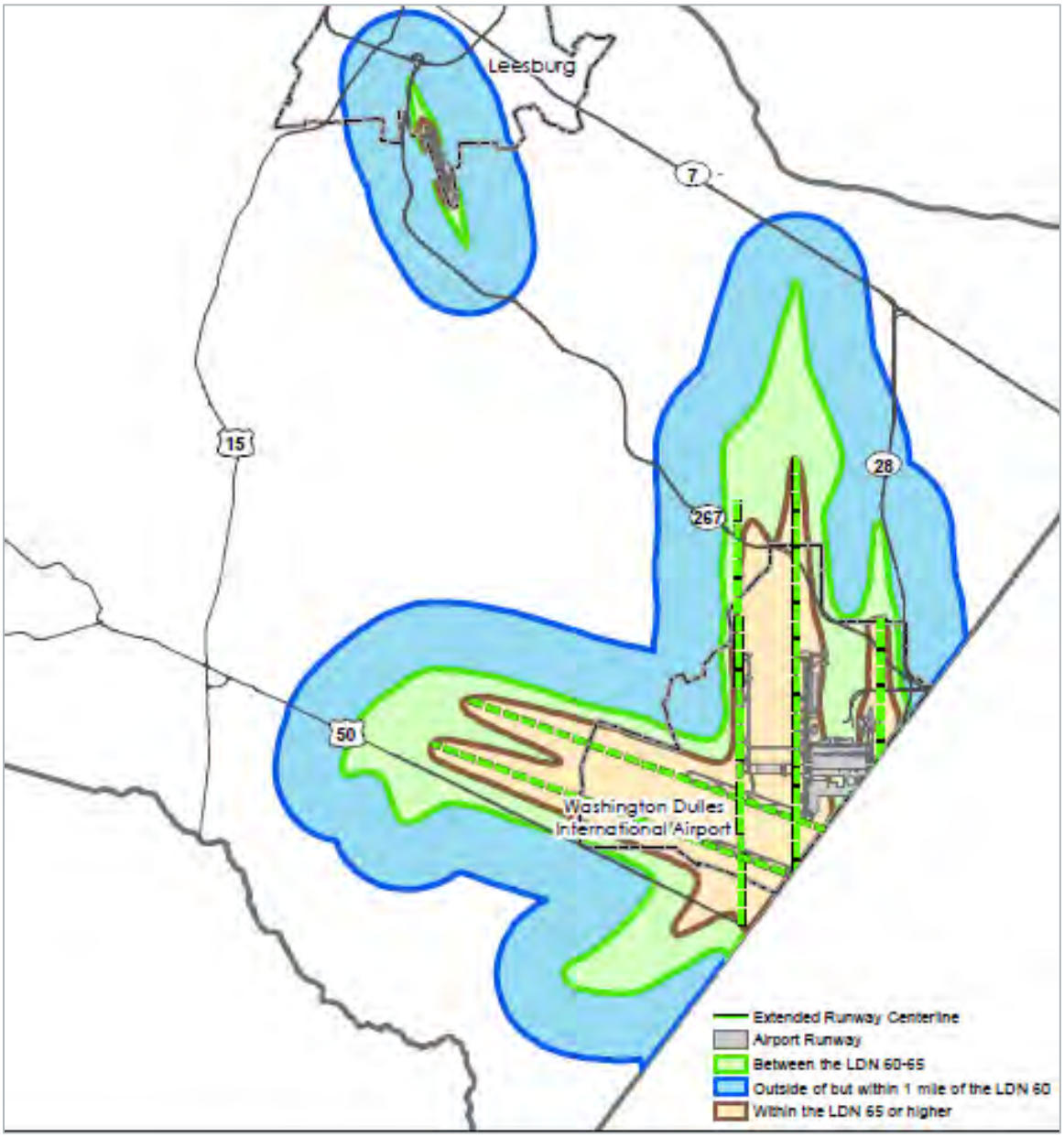
Figure 109. Gas Transmission Pipeline Routes[88]



Air

Washington Dulles International Airport (IAD) is officially located in Chantilly, VA, just outside Loudoun County; however, most of the airport's territory lies within Loudoun County. The airport covers approximately 12,000 acres, has four main runways, and 135 airline gates. Opened in 1962, the airport is a major hub for domestic and international air travel, serving over 21 million passengers each year. With all facilities in the master plan complete, the airport could accommodate 70 million annual passengers from 250 gates. The airport is also home to the Udvar-Hazy Center of the Smithsonian Air & Space Museum. The Center welcomes more than 1.4 million visitors each year. There is also a small executive airport near Leesburg. This proximity of both airports to developed areas and the resultant noise impact is shown in the following figure.

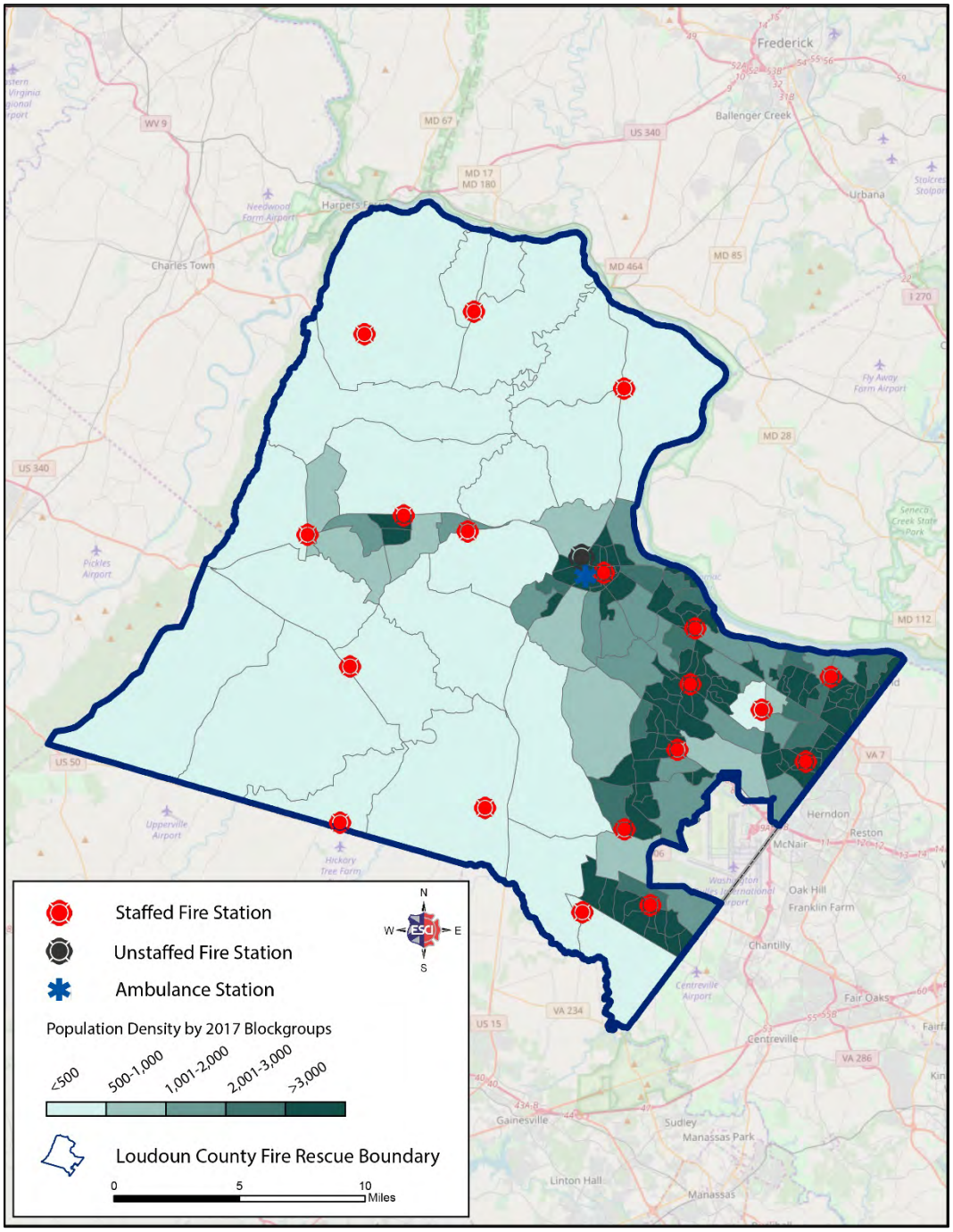
Figure 110. Aircraft Corridors



Population Density

The average population density in the LC-CFRS service area is about 773 people per square mile. However, this figure does not accurately reflect the true nature of the community; it is inappropriate for planning purposes to characterize the entire area as either rural or urban. As shown in the following figure, the population density is highest in the east and decreases farther to the west. As expected, the areas of highest population density correspond to the locations of multi-unit housing, dense urbanization, and older, close-in neighborhoods.

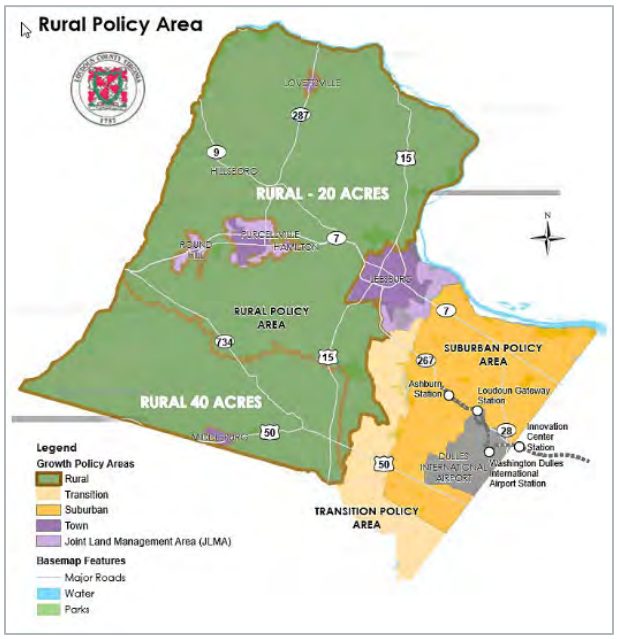
Figure 111. Population Density



Rather, as shown in the preceding figure, it would be more appropriate to use two classifications within the county, based on population density, as follows.[89]

The eastern part of the county is **urban** in nature, with a population density over 1,000 people to well over 3,000 people per square mile. This part of the county is comprised of many single-family neighborhoods, dense neighborhoods including multi-family housing significant commercial and light industrial development, many multi-lane roads, large "big box" stores, and many mid-rise buildings, plus a few high-rise buildings.

Figure 112. Rural Policy Area



The western and northern parts of the county are **rural in nature,** characterized by the traditional farming/ agricultural land use with many winding, narrow two-lane roadways and small communities, interspersed with multi-lane connector roads and large, estate-style homes on multi-acre properties in rural areas. Some of these individual properties have the potential for larger loss of life and property than traditional rural structures, and many lie within the wildland-urban interface (WUI).

Separating these two areas is the **Transition Policy Area**, an area that lies below Route 7 and is intended to serve as a "visual and spatial" transition between the urban and rural areas of the county. This area is characterized by higher population densities than allowed in rural areas, along with specific and unique development opportunities that incorporate both suburban and rural features.

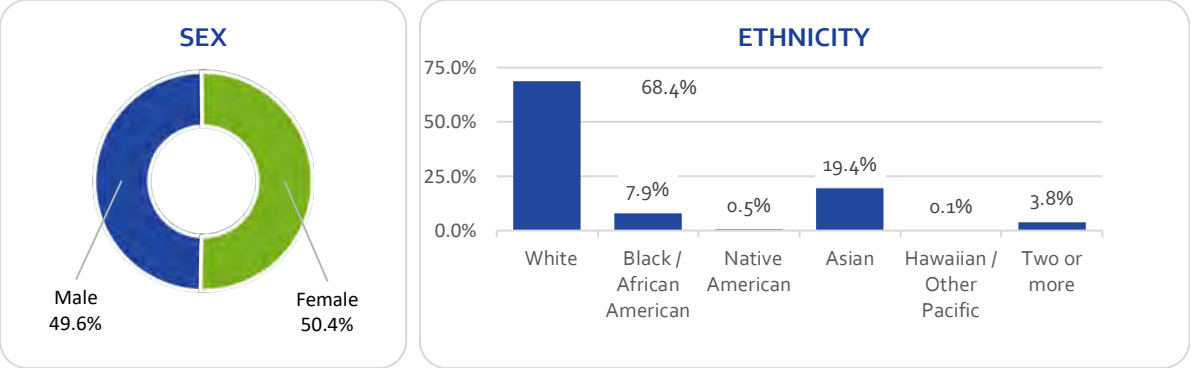
[89] *To maintain consistency with well-established fire service classifications, LC-CFRS has chosen to use the population density classifications shown here.*

Metropolitan	• Population over 200,000 people • Population density over 3,000 people per square mile • Inner city neighborhoods with numerous mid-rise and high-rise buildings
Urban	• Population over 30,000 people; and/or • Population density over 2,500 people per square mile • Significant commercial/industrial development, dense neighborhoods, and some mid-rise or high-rise buildings
Suburban	• Population of 10,000 to 29,999; and/or • Population density between 1,000 and 2,500 people per square mile • Single/multi-family neighborhoods, smaller commercial developments
Rural	• Population of less than 10,000 people • Population density less than 1,000 people per square mile • Low density residential, little commercial development, and significant farm or open space uses
Wilderness Frontier Undeveloped	• Rural • Not readily accessible by a publicly or privately maintained road

Demographics

Selected demographics—age, sex, ethnicity, housing type, income level, primary language, education, health, and assessed property values—are shown in the following figures.

Figure 113. Selected Demographics[90]



At-Risk Populations

In addition to the distribution of the population, the demographics of the population can affect the amount of service demand and the nature of risk within a community. In urban cities, several factors have been identified that place groups of people at risk. An NFPA report has identified the groups that face a higher risk of being injured or killed in a fire as:[91]

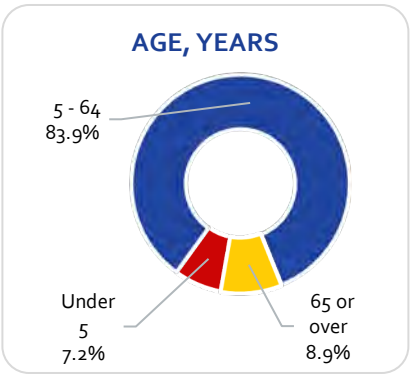
- Children under 5 years of age;
- Older Adults over 65 years of age;
- People with disabilities;
- Language barrier; and
- People in low-income communities.

According to the latest Census Bureau estimate, a considerable number of the residents of the LC-CFRS service area are in one or more at-risk population groups. This segment of the population is more likely to use fire department services, especially EMS, than other population groups. As discussed in the Service Delivery analysis, EMS incidents represent a significant percentage of service demand—over 66.0 percent of all responses. Older adults and individuals with lower income and no health insurance are more likely to use local EMS resources than individuals with health insurance and a personal physician.

[90] *U.S. Census Bureau, Quick Facts. Retrieved from: https://www.census.gov/quickfacts/fact/table/.*

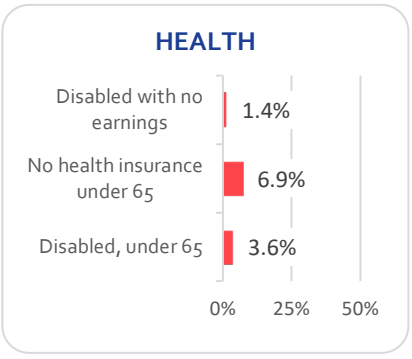
[91] *National Fire Protection Association, 2007; Urban Fire Safety Project, Emmitsburg, MD; retrieved from http://www.nfpa.org/public-education/by-topic/people-at-risk/urban-fire-safety/reports-and-presentations.*

Age: Senior citizens can have difficulty escaping from fire due to physical limitations. Quality of life issues and increased reliance on assisted living could affect service delivery and the number of resources required due to an increase in service demand for emergency medical services. The very young also represent a vulnerable population, both regarding their ability to escape a structure fire as well as their susceptibility to serious medical ailments such as asthma, traumatic events, choking, or injury from vehicular accidents.

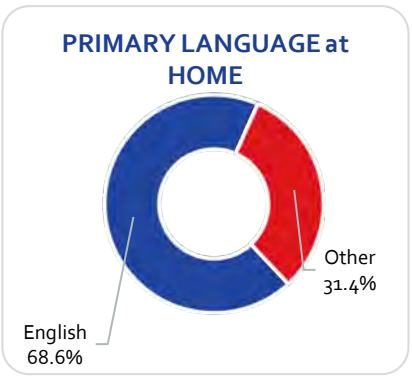


Almost 9 percent of the population is over 65 years of age. This is significantly lower than the same metric for Virginia (15 percent) and the national metric (15.6 percent).

Disabilities: People under 65 years of age with disabilities make up 3.6 percent of the population. These people may have difficulty or be incapable of self-preservation during an emergency. Likewise, people under 65 years of age with no health insurance are more prone to chronic illness or exhibit poor physical condition simply because they do not seek treatment promptly. About 12.3 percent of the population are under 65 and have no health insurance; thus, they may require a higher level of fire-rescue response.

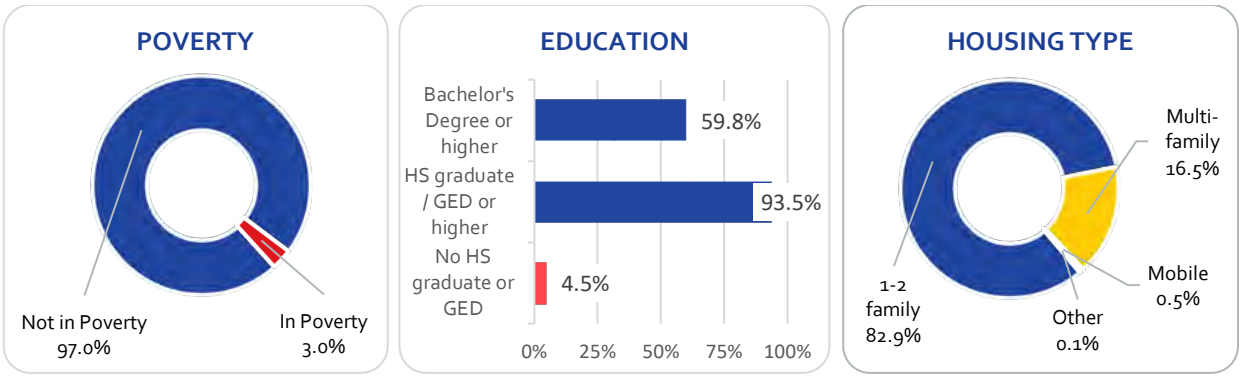


Language barrier: People may have cultural differences or language barriers that decrease the likelihood they would call for service or may affect their ability to communicate needs and concerns effectively. According to the NFPA, "Language barriers, cultural differences, and inexperience with unfamiliar home technologies are factors that mark the challenges of helping newcomers live safely from the threat of fire in the home."[92] About 24 percent of the population is foreign-born, and almost one-third of the population speak a language other than English at home.



[92] *Serving immigrant and refugee populations, National Fire Protection Association, 2017. Retrieved from: https://www.nfpa.org/Public-Education/Campaigns/Fire-Prevention-Week/Teaching-FPW/Serving-immigrant-and-refuge-populations.*

Income: Likewise, low-income people are more at risk from fire or medical condition; about 3 percent of the resident population live below the poverty level.[93] Low income is often combined with other factors such as education or work status. Although not defined as an at-risk population, there is a higher life safety risk associated with housing type due to the number of people (multi-family dwellings) or other characteristics that may affect rescue efforts (mobile homes, R/Vs, and other).



[93] *"The US. Census Bureau 2017 poverty threshold is defined as $12,488 for an individual, $25,094 for a family of four." Retrieved from https://www.census.gov/data/tables/time-series/demo/income-poverty/historical-poverty-thresholds.html.*

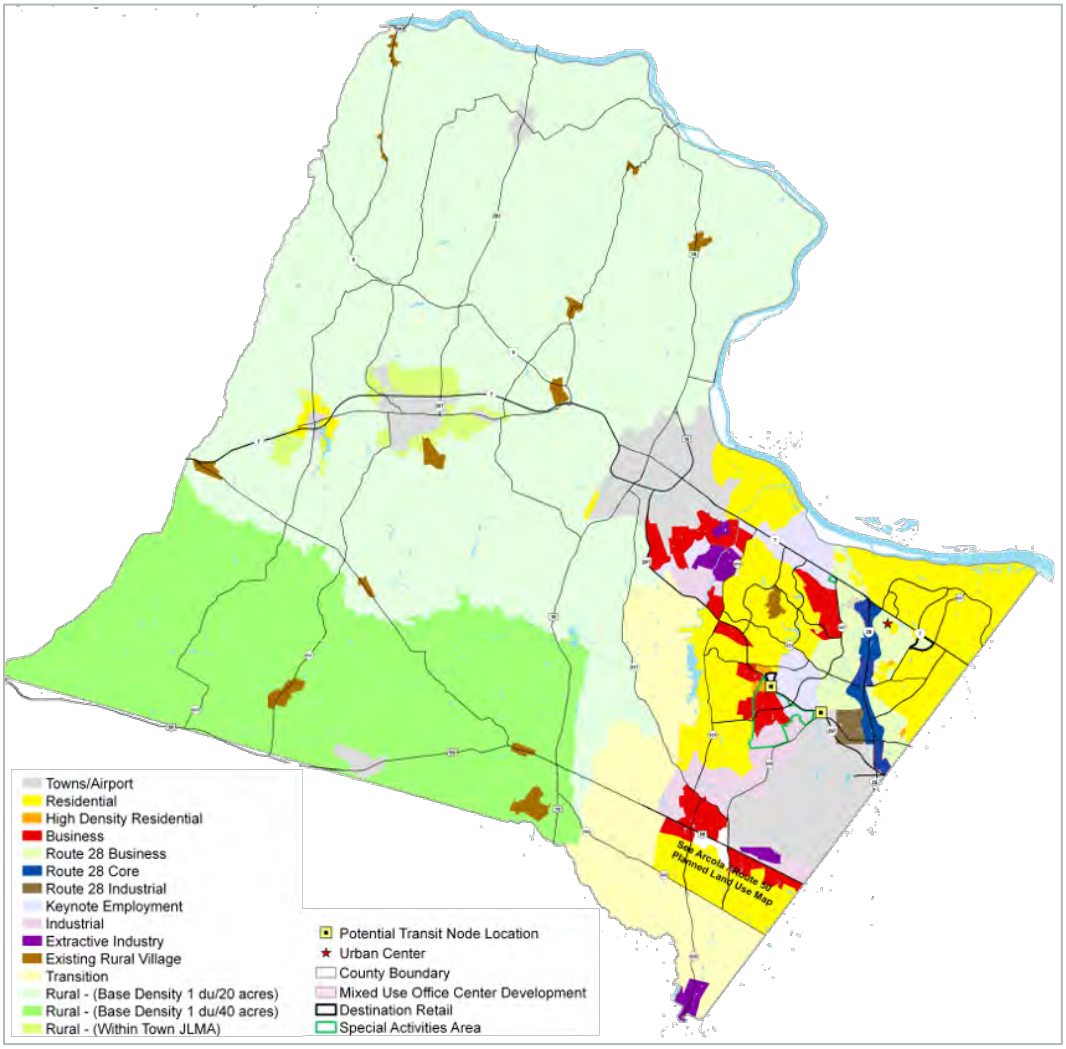
Physical Assets Protected

A physical asset is a tangible asset (one that can be seen or touched) that has value. A physical asset can be a parcel of land, a building or structure, personal property or inventory, and vehicles or machines. The LC-CFRS provides protection for a variety of physical assets. For the purpose of this report, physical assets are real property, buildings, and structures.

Land Use

Current land use in the urban area is predominantly residential, followed by business "cores" along arterial roadways and in selected areas that are zoned for commercial use. The western part of the county is zoned for rural use with a limit of 1 dwelling unit for every 40 acres in the southern part of the county and one dwelling unit for every 20 acres elsewhere. Additional requirements that result in mixed-use exist in various parts of the transition zone.

Figure 114. Land Use/Zoning[94]

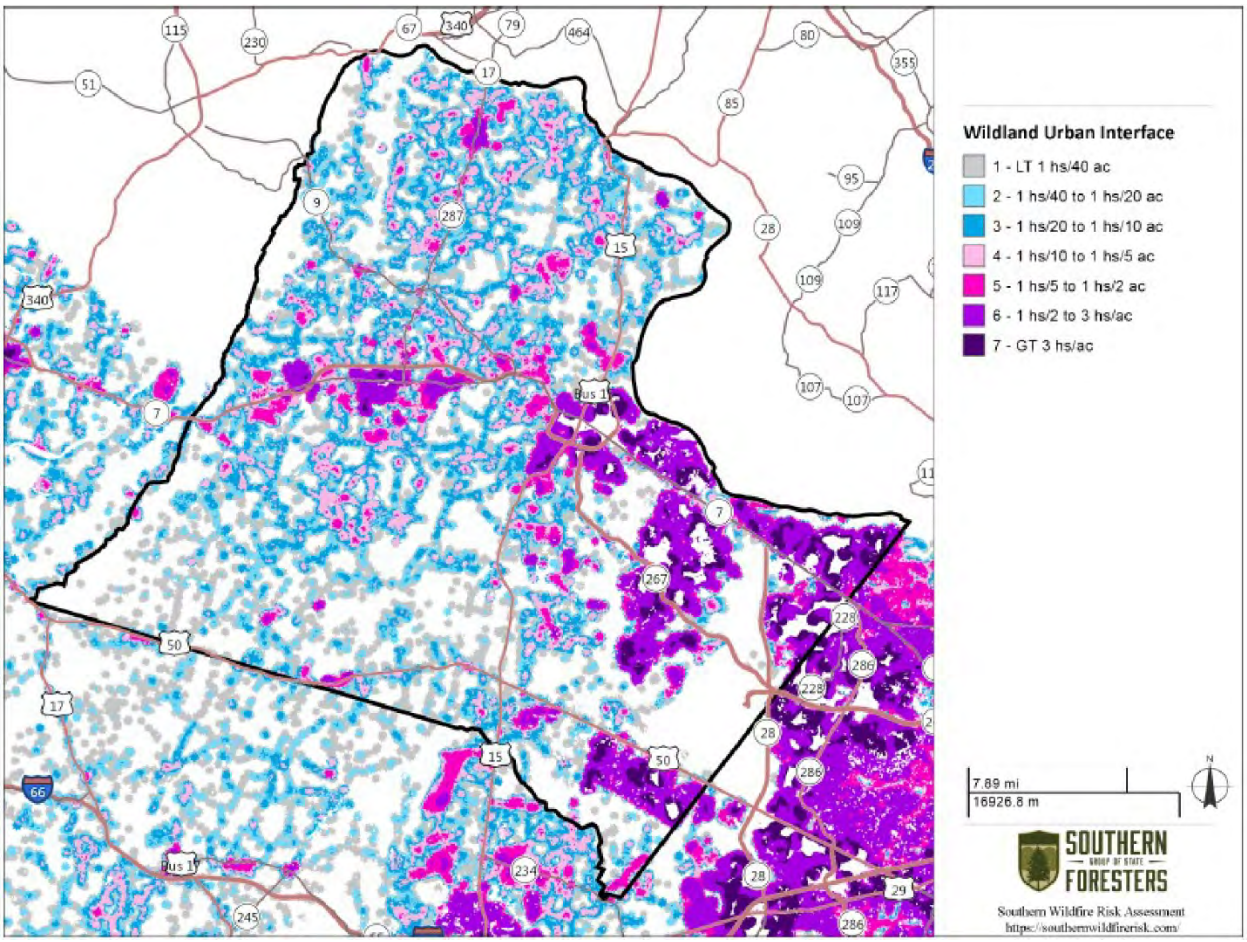


[94] *Virginia Places.org. Retrieved from: http://www.virginiaplaces.org/population/popdensity.html.*

Wildland-Urban Interface Areas

An urban interface is an area where urban development meets other land uses. Usually, the term refers to the wildland-urban interface where urban development meets nature. The entire area surrounding the central, developed County core is in the wildland-urban interface (WUI). Generally, vulnerability—the potential impact—is greatest in the areas with the highest number of structures (primarily single-family residences) per acre. In Loudoun County, it is estimated that about 81 percent of the population resides within the WUI. The primary WUI area is in the urban areas to the east and along the Route 7 corridor as shown here.

Figure 115. Wildland-Urban Interface Areas[95]

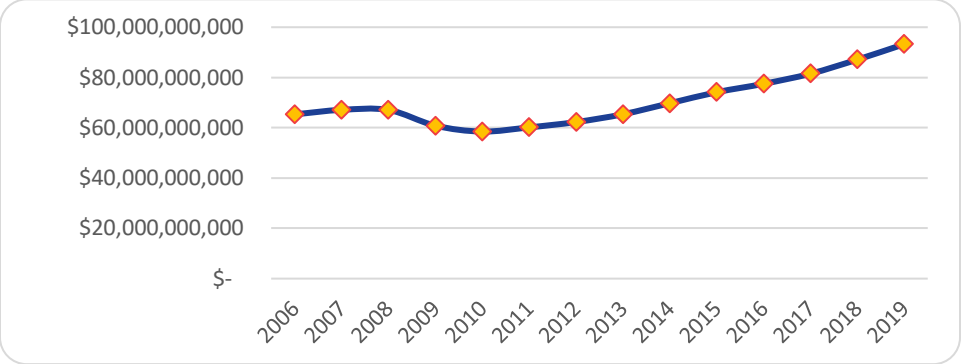


[95] *Southern Wildfire Risk Assessment. Southern Group of State Foresters. Retrieved from: https://www.southernwildfirerisk.com/.*

Assessed Value

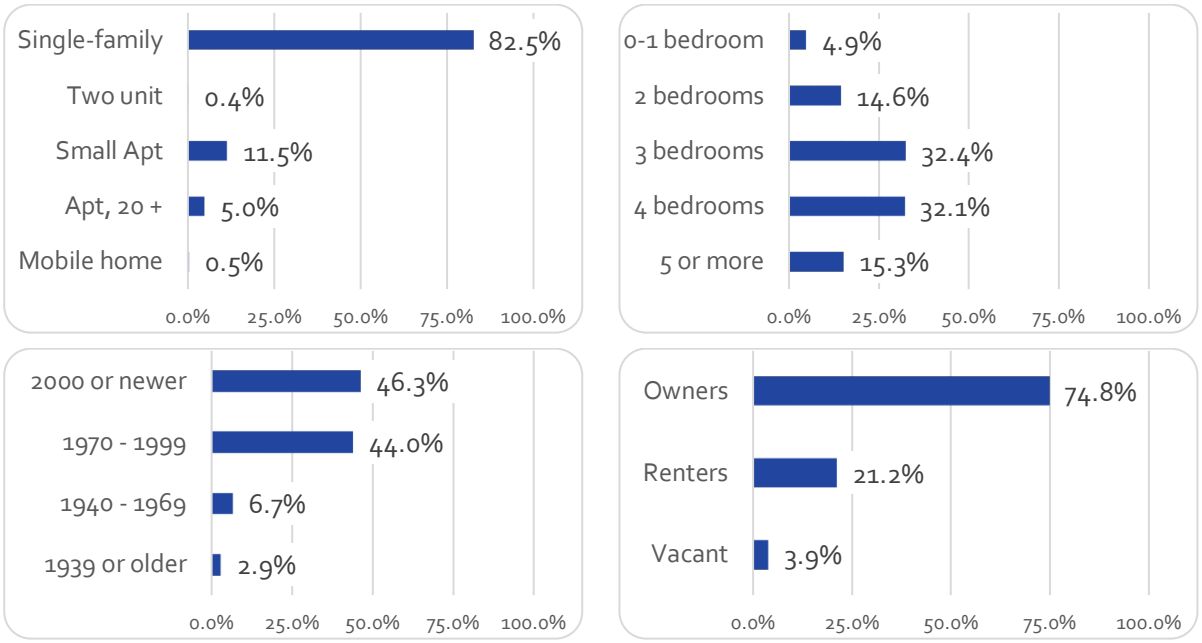
The size, value, age, and condition of buildings and other structures create potential risk factors. Generally, larger, older, and less-maintained buildings have lower relative value and may be at higher risk. Assessed values are an indicator of economic health and development. As shown in the next figure, the assessed values of the area have grown steadily since the effects of the Great Recession of 2007–2009. The average annual growth rate in assessed value has been about 6.6 percent over that period.

Figure 116. History of Assessed Value



The LC-CFRS service area contains a significant number and dollar value of buildings. As in most communities, the predominant occupancy type in the LC-CFRS service area is residential. Details of residential structures are shown in the following figure. As shown, most homes are recently-built, owner-occupied, single-family residences.

Figure 117. Residential Structures[96]



[96] *U.S. Census Bureau, American Fact Finder.*

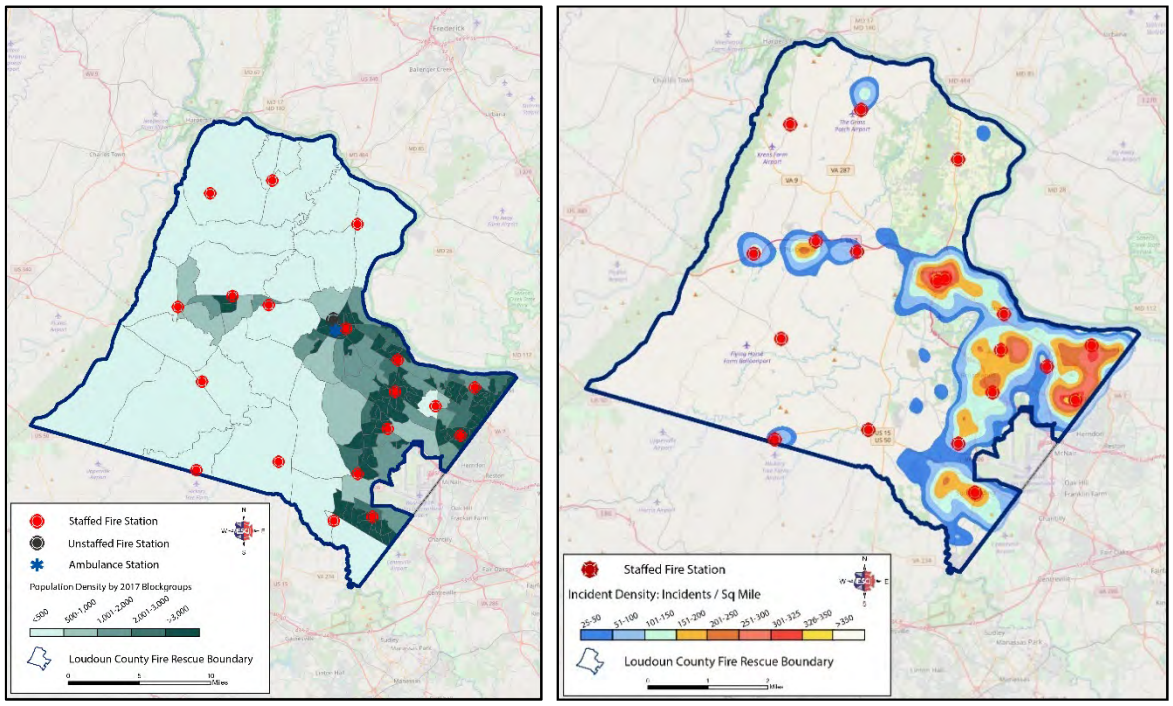
CLASSIFYING RISK

RISK BY GEOGRAPHICAL PLANNING ZONE

For fire and EMS emergency response, the LC-CFRS has not adopted formal planning zones. For the purposes of this study, ESCI used the urban and rural areas of the county as planning zones, as shown in the following figure, to describe the system and unit performance utilizing historical response information provided by the LC-CFRS.

As shown below, it appears that the areas displaying the highest population density correspond to the areas with the highest service demand. Additional research is needed to determine whether or not incident density is similar for all incident types, or if it differs by incident type, *e.g.* fire, EMS, motor vehicle collisions, and so forth. To assist with this research and the need for additional resources, it is important for LC-CFRS to consider additional planning zones, such as battalions or districts that include one or more station locations, based on call type (fire or EMS), number of stations, response workload, travel time, geographic size, population, or combination of factors.

Figure 118. Population Density and Service Demand



RISK BY LAND USE DESIGNATION

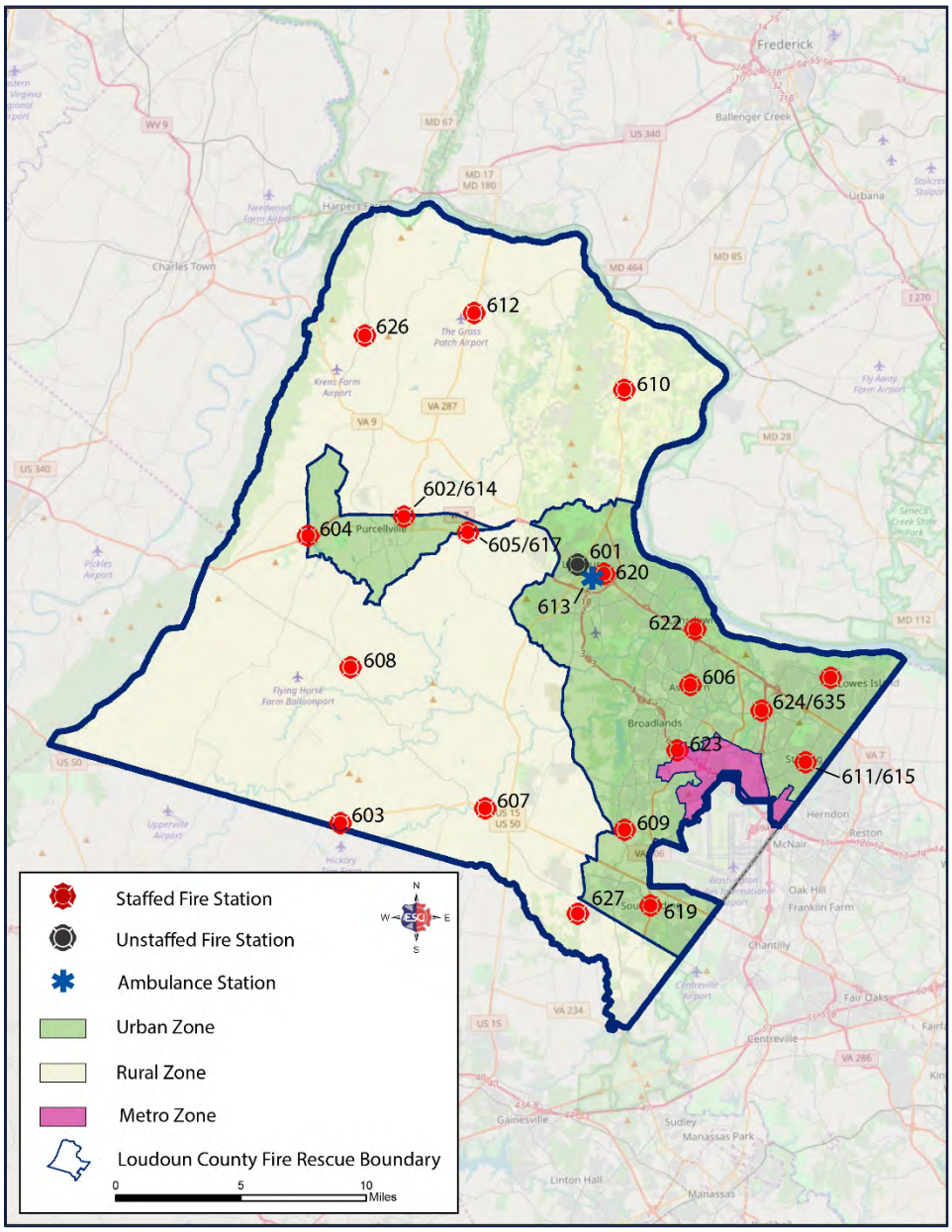
Generally, the main occurrence of all fire emergencies is highest in the areas of greatest population density. Thus, it would be appropriate to consider fire planning zones that correspond to those identified in the Loudoun County comprehensive plan: Urban, Suburban, Transition, and Rural.[97]

[97] *Envision Loudoun. Loudoun 2040 Comprehensive Plan.*

ESCI used GIS software and other sources to examine current land use within the service area. Risk is assigned based on the intended use as follows:

- **Rural area (Low risk).** Areas zoned for agricultural purposes, open space, low-density residential and other low intensity uses.
- **Transition area (Moderate Risk).** Areas zoned for medium-density single-family properties, small commercial and office uses, low-intensity retail sales, and equivalently sized business activities.
- **Suburban/Urban Area (High Risk).** Higher-intensity business districts, mixed-use areas, high-density residential, industrial, warehousing, and large mercantile centers.

Figure 119. Fire Planning Zones



Risk by IBC Occupancy Group (Risk-Based occupancy model)

Virginia uses the International Building Code (IBC) as the basis for the Virginia Uniform Statewide Building Code (USBC). The Virginia Uniform Statewide Building Code is a state regulation promulgated by the Virginia Board of Housing and Community Development. The Board's purpose is to establish minimum regulations to govern the construction and maintenance of buildings and structures. Individual buildings or building complexes are categorized by the risk associated with the intended use of the building(s).

The USBC is divided in three stand-alone parts. Part I, known as the Virginia Construction Code, contains regulations in relation to construction of new buildings and structures. Part II, known as the Virginia Existing Building Code, regulates rehabilitation of existing buildings and occupancy changes or additions in existing buildings and structures. Part II, known as the Virginia Maintenance Code, regulates the maintenance of existing structures and is enforced at the option of local governments. [98]

PRI Risk	*IBC and USBC Groups*	*Examples*
High	A-1, A-2	Nightclub, restaurant, theater, airport/cruise ship terminal
	A-3, A-4, A-5	Arenas, museums, religious
	H-1, H-2, H-3, H-4, H-5	Hazardous materials sites (Tier II)
	B	All government & public buildings, other office buildings over 2 stories
	E	Schools, day care centers
	I-1, I-2, I-3, I-4	Hospitals, assisted living centers, correctional
	M	Strip centers, closed-air shopping malls, big box stores
	R-1, R-2, R-3, R-4	Hotels, motels, boarding houses (transient), congregate living facilities (transient), apartments, dormitories, fraternities/sororities, board & care facilities, vacation timeshares, live/work units, group homes
	Special Risk (Target hazard)	Railroads, Interstate highways, airports, any building with life safety risk beyond reach of preconnected hose lines > 200 feet
Moderate	B	Outpatient clinics, general business, offices < 3 stories
	F-1	Fabrication or manufacturing of combustible materials
	M	Mercantile, free-standing
	I-2, R-4	Foster group homes, assisted living homes
	S-1	Storage of combustible materials, car repair, hangars
Low	F-2	Fabrication or manufacturing of non-combustible materials
	R-5	1- and 2-family dwellings, foster homes
	S-2	Storage of combustible materials
	U	Barns, silos, other unclassified

[98] *2015 Virginia Construction Code – Part I of the Virginia Uniform Statewide Building Code, Effective September 4, 2018. Retrieved from: https://www.dhcd.virginia.gov/sites/default/files/Docx/building-codes-regulations/archive-codes/2015/2015-virginia-construction-part-1-code.pdf.*

Natural Hazards and Vulnerabilities

Since 1972, the number of federally-declared disasters in Loudoun County (12) is lower than the county/county equivalent average (15) and about the same as the U.S. county/county equivalent average (12.5).[99] The cause for each of these declarations is shown in the next figure. Although some of these declarations did not affect all areas of the county equally, they are an indication of the hazards present throughout the area.

Figure 120. Federally-Declared Disasters, Jan 1977–Dec 2018

Type	Number	Percent
Flood	1	8.3 %
Tropical Storm/Hurricane[a]	5	41.7 %
Severe Storm	6	50.0 %
Total	**12**	**100.0 %**
Notes: [a] includes Hurricane Katrina evacuees		

According to the Northern Virginia Hazard Mitigation Plan (HMP), the most prominent physical or natural hazards faced by residents of Loudoun County are shown below:[100]

- Drought
- Flood
- Earthquake
- Landslide
- Karst
- Tornado
- Wildfire
- Wind
- Winter Weather

[99] *FEMA Disaster Declarations Summary, Open Government Dataset, U.S. Department of Homeland Security, last updated March 5, 2018. Retrieved from: https://www.fema.gov/media-library/assets/documents/28318.*

[100] *Northern Virginia Hazard Mitigation Plan Update, 2017. Retrieved from: http://arlington.granicus.com/MetaViewer.php?view_id=2&event_id=1101&meta_id=163110.*

Appendix F: Correlation of This Report to the CFAI Accreditation Model

This Community Risk Assessment and Standards of Cover document in Appendix D contain specific elements correlating to the Center for Public Safety Excellence 9th edition accreditation model found in the Fire and Emergency Services Self-Assessment (CFAI FESSAM) 9th Edition.

Item	Performance Indicator	Yes/No
Red text denotes a **Core Competency**		
2A.1	Service area boundaries for the agency are identified, documented, and legally adopted by the authority having jurisdiction.	
2A.2	Boundaries for other service responsibility areas, such as automatic aid, mutual aid, and contract areas, are identified, documented, and appropriately approved by the authority having jurisdiction.	
2A.3	The agency has a documented and adopted methodology for organizing the response area(s) into geographical planning zones.	
2A.4	The agency assesses the community by planning zone and considers the population density within planning zones and population areas, as applicable, for the purpose of developing total response time standards.	
2A.5	Data that includes property, life, injury, environmental, and other associated losses, as well as the human and physical assets preserved and or saved, are recorded for a minimum of three (initial accreditation agencies) to five (currently accredited agencies) immediately previous years.	
2A.6	The agency utilizes its adopted planning zone methodology to identify response area characteristics such as population, transportation systems, area land use, topography, geography, geology, physiography, climate, hazards and risks, and service provision capability demands.	
2A.7	Significant socio-economic and demographic characteristics for the response area are identified, such as key employment types and centers, assessed values, blighted areas, and population earning characteristics.	
2A.8	The agency identifies and documents all safety and remediation programs, such as fire prevention, public education, injury prevention, public health, and other similar programs, currently active within the response area.	
2A.9	The agency identifies critical infrastructure within the planning zones.	
2B.1	The agency has a documented and adopted methodology for identifying, assessing, categorizing, and classifying risks throughout the community or area of responsibility.	

Item	Performance Indicator	Yes/No
Red text denotes a **Core Competency**		
2B.2	The historical emergency and non-emergency service demand frequency for a minimum of three immediately previous years and the future probability of emergency and non-emergency service demands, by service type, have been identified and documented by planning zone.	
2B.3	Event consequence loss and save data that includes property, life, injury, environmental, and other losses and saves are assessed for three (initial accreditation agencies) to five (currently accredited agencies) immediately previous years.	
2B.4	The agency's risk identification, analysis, categorization, and classification methodology has been utilized to determine and document the different categories and classes of risks within each planning zone	
2B.5	Fire protection and detection systems are incorporated into the risk analysis.	
2B.6	The agency assesses critical infrastructure within the planning zones for capabilities and capacities to meet the demands posed by the risks.	
2C.1	Given the levels of risks, area of responsibility, demographics, and socio-economic factors, the agency has determined, documented, and adopted a methodology for the consistent provision of service levels in all service program areas through response coverage strategies.	
2C.2	The agency has a documented and adopted methodology for monitoring its quality of emergency response performance for each service type within each planning zone and total response area.	
2C.3	Fire protection systems and detection systems are identified and considered in the development of appropriate response strategies.	
2C.4	A critical task analysis of each risk category and risk class has been conducted to determine the first-due and effective response force capabilities, and a process is in place to validate and document the results.	
2C.5	The agency has identified the total response time components for delivery of services in each service program area and found those services consistent and reliable within the entire response area.	
2C.6	The agency has identified the total response time components for delivery of services in each service program area and assessed those services in each planning zone	
2C.7	The agency has identified efforts to maintain and improve its performance in the delivery of its emergency services for the past three (initial accreditation agencies) to five (currently accredited agencies) immediately previous years.	
2C.8	The agency's resiliency has been assessed through its deployment policies, procedures, and practices.	

Item	Performance Indicator	Yes/No
Red text denotes a **Core Competency**		
2D.1	The agency has documented and adopted methodology for assessing performance adequacies, consistencies, reliabilities, resiliencies, and opportunities for improvement for the total response area.	
2D.2	The agency continuously monitors, assesses, and internally reports, at least quarterly, on the ability of the existing delivery system to meet expected outcomes and identifies the remedial actions most in need of attention.	
2D.3	The performance monitoring methodology identifies, at least annually, future external influences, altering conditions, growth and development trends, and new or changing risks, for purposes of analyzing the balance of service capabilities with new conditions or demands.	
2D.4	The performance monitoring methodology supports the annual assessment of the efficiency and effectiveness of each service program at least annually in relation to industry research.	
2D.5	Impacts of incident mitigation program efforts, (such as community risk reduction, public education, and community service programs), are considered and assessed in the monitoring process.	
2D.6	Performance gaps for the total response area, such as inadequacies, inconsistencies, and negative trends, are determined at least annually.	
2D.7	The agency has systematically developed a continuous improvement plan that details actions to be taken within an identified timeframe to address existing gaps and variations.	
2D.8	On at least an annual basis, the agency formally notifies the authority having jurisdiction (AHJ) of any gaps in the operational capabilities and capacity of its current delivery system to mitigate the identified risks within its service area, as identified in its standards of cover.	
2D.9	On at least an annual basis, the agency formally notifies the AHJ of any gaps between current capabilities, capacity, and the level of service approved by the AHJ.	
2D.10	The agency interacts with external stakeholders and the AHJ at least once every three years, to determine the stakeholders' and AHJ's expectations for types and levels of services provided by the agency.	