Geographic Information System Emergency Services Response Capabilities Analysis

FINAL REPORT

International Association of Fire Fighters
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Washington, DC 20006

Central Metro Fire and Rescue

St. Louis County, Missouri

December 2020

Dedication

This Report is Dedicated to the Citizens of St. Louis County, Missouri who Deserve the Most Efficient and Effective Fire, Rescue, and Emergency Medical Services Available.

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Executive Summary

The International Association of Fire Fighters (IAFF) Headquarters was engaged by the Professional Fire Fighters of Eastern Missouri, IAFF Local 2665, to provide information and resources to decision makers in the cities and towns of central St. Louis County. Local 2665 requested an assessment of 15 municipal fire departments'[1] response capabilities if they were consolidated into one fire protection district.[2] The consolidated fire department would be referred to as Central Metro Fire and Rescue (CMFR).[3] Using geographic information systems (GIS) mapping software, response capabilities were assessed based on industry standards contained in the National Fire Protection Association (NFPA®) 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*.

This report will discuss the importance of maintaining adequate resources consisting of fire stations, apparatus, and personnel needed to provide effective and efficient fire and EMS response. Inadequate staffing levels on apparatus expose civilians and firefighters to increased risk. It also further drains fire department resources and stresses the emergency response system by requiring additional apparatus to respond to incidents from farther distances. The smaller the crew size, the more tasks an individual must complete, which contributes to delays in initiating fire attack and containing fire, which leads to diminished efficiency in stopping fire loss.

This report will also discuss the benefits a fire protection district may have on administrated alignment, communications, data collection, education and training, resource maintenance, and standards and operational procedures. This report will provide decision makers with the necessary information to understand the negative impact current deployment practices have on daily operations and identify areas where additional resources may be needed to ensure effective and efficient fire and EMS response.

[1] Missouri Revised Statute 320.200.3. An agency or organization that provides fire suppression and related activities, including but not limited to fire prevention, rescue, emergency medical services, hazardous material response, or special operation to a population within a fixed and legally recorded geographical area.
[2] Missouri Revised Statute 321.010.1 Is a political subdivision which is organized and empowered to supply protection by any available means to persons and property against injuries and damage from fire and from hazards which do or may cause fire, and which is also empowered to render first aid for the purpose of saving lives, and to give assistance in the event of an accident or emergency of any kind.
[3] Brentwood, Clayton, Crestwood, Des Peres, Frontenac, Glendale, Kirkwood, Ladue, Maplewood, Olivette, Richmond Heights, Rock Hill, Shrewsbury, University City, and Webster Groves Fire Departments

Key Findings

- CMFR's engine companies are typically staffed with three firefighters. Apparatus not staffed with a minimum of four firefighters do not meet the company staffing objectives outlined in NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program* and NFPA 1710. Because units are not staffed with four, firefighters must rely on supplemental personnel arriving later before making entry into environments that are immediately dangerous to life and health (IDLH), such as structure fires, in order to meet objectives outlined in industry standards and Occupational Safety and Health Administration (OSHA) rules and regulations.

- Industry-wide safety and performance standards requires that the first-arriving apparatus be on scene within four minutes or less of travel to 90% of incidents.[4] Currently, the department is capable of responding on 65.0% of roads within CMFD's response boundary in four minutes or less of travel. Pursuant to implementing the staffing and deployment recommendations made herein, the department would likely be able to respond on 68.3% of roads within CMFR's response boundary within four minutes or less of travel, which is a 5.2% **increase** in coverage compared to CMFR's current staffing and deployment.

- The OSHA "2 In/2 Out" Regulation[5] requires two firefighters committed to interior suppression be supported by two firefighters on the exterior of the structure for safety. Currently, the department is capable of assembling a minimum of four firefighters on 33.3% of roads within CMFR's response boundary in four minutes or less of travel. Pursuant to implementing the staffing and deployment recommendations made herein, the department would likely be able to assemble a minimum of four firefighters in four minutes or less of travel on 68.3% of roads within CMFR's response boundary, which is a 105.1% **increase** in coverage compared to CMFR's current staffing and deployment.

- Industry-wide safety and performance standards requires that the second-arriving apparatus be on scene within six minutes or less of travel to 90% of fire incidents. IAFF recommends that the second apparatus to a fire incident should be a ladder company. Currently, the department can respond with a minimum of one ladder company on 38.2% of roads within CMFR's response boundary in six minutes or less. Pursuant to implementing the staffing and deployment recommendations made herein, the department

[4] Percentages (response capabilities for both current and recommended configurations) given in this document are based on a desire to cover one hundred percent of all road segments within a fire department's response area. These percentages are used as a proxy for the percentage of incidents covered, as it is impossible to predict where all of a jurisdiction's future emergencies will occur. Therefore, the emergency response capabilities presented herein are represented by the percentage of all road segments the department can reach within the specified time parameters.
[5] 29 CFR 1910.134.

would likely be able to respond with a minimum of one ladder company in six minutes or less of travel on 50.1% of roads within CMFR's response boundary, which is a 31.1% **increase** in coverage compared to CMFR's current staffing deployment.

- Industry-wide safety and performance standards states that an ALS unit must be on scene within eight minutes or less provided a BLS-equipped unit is on scene within four minutes or less of travel to 90% of medical incidents. Currently, the department is capable of providing an ALS transport unit on 91.3% of roads within CMFR's response boundary in eight minutes or less of travel. Pursuant to implementing the staffing and deployment recommendations made herein, the department would likely be able to respond with a minimum of ALS transport unit in eight minutes or less of travel on 94.8% of roads within CMFR's response boundary, which is a 3.9% **increase** in coverage compared to CMFR's current staffing deployment.

- Industry-wide safety and performance standards requires a minimum of 16 firefighters and one command officer to arrive on the scene of a low-hazard structure[6] fire within eight minutes or less of travel to 90% of incidents. Currently, the department is capable of assembling a minimum of 17 firefighters on 25.5% of roads within CMFR's response boundary in eight minutes or less of travel. Pursuant to implementing the staffing and deployment recommendations made herein, the department would likely be able to assemble a minimum of 17 firefighters within eight minutes or less of travel on 59.9% of roads within CMFR's response boundary, which is a 134.9% **increase** in coverage compared to CMFR's current staffing and deployment.

- Industry-wide safety and performance standards requires a minimum of 26 firefighters and one incident commander and one aide to arrive on the scene of a medium-hazard structure[7] fire within eight minutes or less of travel to 90% of incidents. Currently, the department is capable of assembling a minimum of 28 firefighters on 2.0% of roads within CMFR's response boundary in eight minutes or less of travel. Pursuant to implementing staffing and deployment recommendations made herein, the department would likely be able to assemble a minimum of 28 firefighters within eight minutes or less of travel on 34.1% of city roads, which is a 1,584.1% **increase** in coverage compared to the department's current response capabilities.

- Industry-wide safety and performance standards requires a minimum of 36 firefighters, six officers, and one incident commander to arrive on the scene of a high-hazard

[6] Low-hazard structures are typically two-story single-family dwellings without a basement and with no exposures. NFPA 1710 §5.2.4.1.
[7]. Medium-hazard structures consist of open-air strip shopping centers and three-story, garden-style apartment buildings. NFPA 1710 §5.2.4.2 and NFPA 1710 §5.2.4.3

structure[8] fire within 10 minutes and 10 seconds of travel to 90% of incidents. Currently, the department is capable of assembling a minimum of 43 firefighters on 0.7% of roads within CMFR's response boundary in 10 minutes and 10 seconds or less of travel. Pursuant to implementing the staffing and deployment recommendations made herein, the department would likely be able to assemble a minimum of 43 responders within 10 minutes and 10 seconds or less of travel on 42.0% of roads within CMFR's response boundary, which is a 5,839.5% **increase** in coverage compared to the department's current response capabilities.

- Structures that are greater than 75 feet tall, square footage greater than 196,000 ft^2, schools, and hospitals were identified as high-hazard structures. Currently, the department can assemble a minimum of 43 firefighters within 10 minutes and 10 seconds on 7.2% of high-hazard structures within CMFR's response boundary. Pursuant to implementing the staffing and deployment recommendations made herein, the department would be able to assemble a minimum of 43 firefighters within 10 minutes and 10 seconds on 66.7% of high-hazard structures within CMFR's response boundary, which is a 827.3% **increase** in response coverage compared to CMFR's current high-hazard response capabilities.

Recommendations

- The 15 municipal fire departments should consolidate into the Central Metro Fire and Rescue (CMFR). If consolidated into CMFR, CMFR should:
    - Operate under one unified dispatch system for fire and EMS communications. Implementation of a unified dispatch system should include updating the CAD system, adding GIS capabilities, and improving data collection.
    - Create department-wide performance objectives based on industry standards.
    - Standardize equipment, develop standard operating procedures (SOP), and develop standard operating guidelines (SOG) throughout the department.
    - Establish region-wide fire codes for all municipalities within CMFR's response boundary to assist in better fire prevention efforts.

[8] High-hazard structures are buildings with the highest floor greater than 75 ft. above the lowest level of fire department vehicle access. High-hazard occupancies are those structures that present a high-life hazard or large fire potential due to construction, configuration, or the presence of specific materials, processes, or contents.
NFPA 1710 §5.2.4.4.

    - Set department-wide training standards and operate a centralized and unified training academy.

    - Establish and operate its own maintenance facility.

- CMFR should staff all engine, ladder, and heavy rescue companies with a minimum of four multi-role firefighters at all times to meet the minimum staffing objectives stated in NFPA 1500 and NFPA 1710.

- CMFR should staff battalion chief cars with a battalion chief and a chief's aide[9] to meet the staffing objectives stated in NFPA 1710.[10]

- CMFR should place an additional ladder company into service and position it at Maplewood Fire Station. This will increase the department's six-minute ladder response and its low-, medium-, and high-hazard response capabilities.

- CMFR should place a heavy rescue company into service and position it at Richmond Heights Fire Station. This will limit the number of times CMFR has to request regional heavy rescue resources to respond to incidents within CMFR's response boundary.

- CMFR should stop the practice of contracting out EMS transport to private ambulance companies in the municipalities of Crestwood, Maplewood, and Rockhill, and instead it should provide EMS transport at the ALS level to these municipalities.

- CMFR should routinely perform risk and hazard assessments, along with a review of system demand, to identify the potential threats to the community so that stakeholders and decision makers can make informed decisions on how to best mitigate, or at least minimize, these threats.

[9] A firefighter or fire officer assigned to a supervisory chief officer to assist with the logistical, tactical, and accountability functions of incidents, division, or sector command.
[10] NFPA 1710 §5.2.2.2.5

Executive Summary Conclusion

The provision of fire protection and EMS response are essential services that governments must provide. However, in order for these services to be effective and efficient, they must be staffed and positioned appropriately to address emergencies in an equitable manner, as they occur. A fire department should be designed to adequately respond to a number of emergencies occurring simultaneously in a manner that aims to minimize the loss of life and the loss of property that the fire department is charged to protect. Staffing and deployment decisions should be made taking into account the historical location of calls, response times to specific target hazards, compliance with departmental Standard Operating Procedures (SOPs), existing industry standards and the citizens' expectations of receiving an adequate number of qualified personnel on appropriate apparatus within acceptable time frames to make a difference in their emergency.

Currently, fire suppression resources are not deployed adequately for the arrival of the first-arriving apparatus within four minutes or less of travel to 90% of incidents. CMFR's response capabilities do not meet objectives in the industry standard NFPA 1710, which require the first-arriving apparatus staffed with a minimum of four firefighters on scene within four minutes or less of travel, the assembly of 17 firefighters to a low-hazard structure fire within eight minutes or less of travel, the assembly of 28 firefighters to a medium-hazard structure fire within eight minutes or less of travel, and the assembly of 43 firefighters to a high-hazard structure fire within ten minutes and ten seconds or less of travel to 90% of incidents.

CMFR's engine companies are typically staffed with less than four firefighters. Staffing below the minimum staffing levels significantly limits the department's emergency response capabilities. Staffing all suppression apparatus (engines, ladders, and heavy rescues) with a minimum of four multi-role firefighters, staffing battalion chief cars with a battalion chief and chief aid, and adding a ladder and heavy rescue company will increase the department's ability to meet OSHA's 2 In/2 Out regulation. It will also increase six-minute ladder and eight-minute heavy rescue response coverage, and the improve CMFR's ability to assemble the required effective response forces at low-, medium-, and high-hazard structure fires.

Operating under one unified dispatch system will improve response capabilities by eliminating the delay in notifying mutual aid units. It will improve call processing and dispatch times, resulting in personnel and resources arriving on scene of an incident sooner. It will also enhance CMFR's ability to collect and analyze data.

The findings in this report will provide decision makers with information on how the department's current response capabilities compare to industry standards and how the lack of resources negatively affects CMFR's ability to appropriately respond to incidents within their response boundary. This report will also discuss other improvements in operations that will occur by consolidating into one fire protection district.

Background

The International Association of Fire Fighters (IAFF) Headquarters was engaged by the Professional Fire Fighters of Eastern Missouri, IAFF Local 2665, to create a data-driven document for St. Louis County cities, towns, and fire department administrators to assist with informed decisions regarding emergency response.

The 15 fire departments that would be consolidated into Central Metro Fire and Rescue (CMFR) are: Brentwood, Clayton, Crestwood, Des Peres, Frontenac, Glendale, Kirkwood, Ladue, Maplewood, Olivette, Richmond Heights, Rock Hill, Shrewsbury, University City, and Webster Groves. Currently, these departments provide fire suppression, technical rescue, HAZMAT, and emergency medical services (EMS) first response at the advanced life support (ALS) level to 19 municipalities[11] and medical transport at the ALS level to 15 municipalities[12] in St. Louis County. Due to a lack of resources, technical rescue and HAZMAT incidents may require resources sent from regional teams (primarily from St. Louis Fire Department). Four of the 15 departments do not provide medical transport (Crestwood, Glendale, Maplewood, and Rockhill) and one of the 15 departments does not provide ALS first response (Rockhill). Crestwood, Maplewood, and Rockhill have contracts with private ambulance companies to perform medical transport in their municipalities and Glendale receives medical transport from Kirkwood Fire Department. In addition to emergency responses, all of these departments perform other services for these municipalities such as fire prevention and safety programs, which include fire-safety inspections.

Combined, the 15 fire departments operate 20 fire stations consisting of 16 engines, 14 ALS medic transport units, five ladder companies,[13] four battalion cars, and two rescue companies. Typically, engine companies are staffed with three firefighter paramedics,[14] ladder companies with four firefighter paramedics, medic units with two firefighter paramedics, and rescue units[15] with two firefighter paramedics. These departments typically do not staff engine companies to provide for effective, efficient, and safe emergency operations required by industry standards and

[11] Brentwood, Clayton, Crestwood, Crystal Lake Park, Des Peres, Frontenac, Glendale, Huntleigh, Kirkwood, Ladue, Maplewood, Oakland, Olivette, Richmond Heights, Rock Hill, Shrewsbury, University City, Warson Woods, and Webster Groves.

[12] Brentwood, Clayton, Crystal Lake Park, Des Peres, Frontenac, Huntleigh, Kirkwood, Ladue, Oakland, Olivette, Richmond Heights, Shrewsbury, University City, Warson Woods, and Webster Groves.

[13] The ladder apparatus are quints. Quint apparatus have a permanently mounted fire pump, a water tank, a hose storage area, an aerial device with a permanently mounted water-way and a complement of ground ladders. Quints are designed to operate as both an engine and ladder company, but if to be used as such simultaneously, staffing above the minimum of four is required

[14] Engines 1414, 2514, and 3114 are staffed with two firefighter paramedics and one EMT and Engine 3414 is staffed with three EMTs.

[15] Has limited storage space for technical rescue equipment and will respond to incidents that may need technical rescue operations but are not staffed with the necessary personnel to safely perform technical rescue duties.

the Occupational Safety and Health Administration's (OSHA) rules and regulations. Staffing apparatus below the minimums set by industry standards has been shown to result in crews being less efficient in completing critical fireground tasks.

Currently, each of these municipal fire departments has their own response boundary (typically the municipality boundary) within which they are responsible for providing emergency response. While each department has their own primary response boundary, the departments have automatic and mutual aid agreements with each other. Automatic aid agreements allow for resources to be immediately dispatched, while mutual aid allows for dispatch centers to communicate with each other to request nearby resources be dispatched to the incident. Both of these methods of deploying resources are designed to lift political geographic barriers between fire departments. They do not, however, in the current model due to outdated computer-aided dispatch (CAD) systems.

The fire departments proposed in this consolidation operate using four separate dispatch systems.[16] Fire departments that use the same dispatch system operate using automatic aid and departments that use different dispatch systems operate using mutual aid. Using different dispatch systems results in delays in dispatching mutual aid units, which increase the time it takes for the appropriate number of firefighters and equipment to arrive on scene. Operating under one dispatch system will eliminating the time delay of having to contact another dispatch center to request additional units to respond. Using multiple dispatch system also limits the department's ability to accurately collect data because response data is collected in different formats. It will also assist in data collection that will help the department evaluate its response coverage, examine its demand and workload, and perform community risk assessments.

Table 1 outlines the dispatch system used by each fire department.

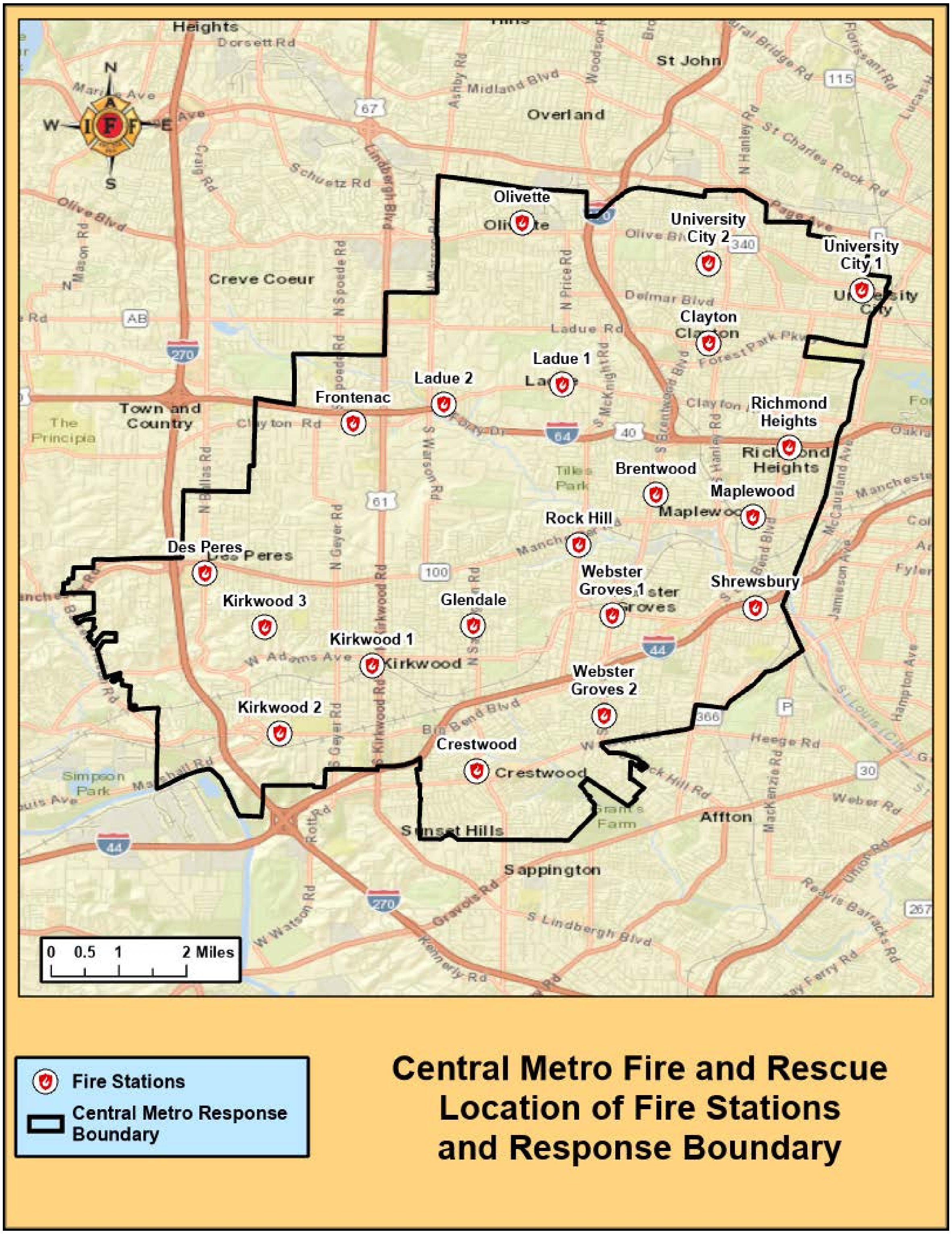
[16] Central County 911 (CCE911), East Central Dispatch Center (ECDC), Kirkwood, and University City.

Dispatch System	CCE911	ECDC	Kirkwood	University City
Fire Departments	Crestwood	Brentwood	Des Peres	University City
	Frontenac	Clayton	Glendale	
	Ladue	Maplewood	Kirkwood	
	Non-CMFR Automatic and Mutual Aid	Olivette		
		Richmond Heights		
		Rock Hill		
		Shrewsbury		
		Webster Groves		

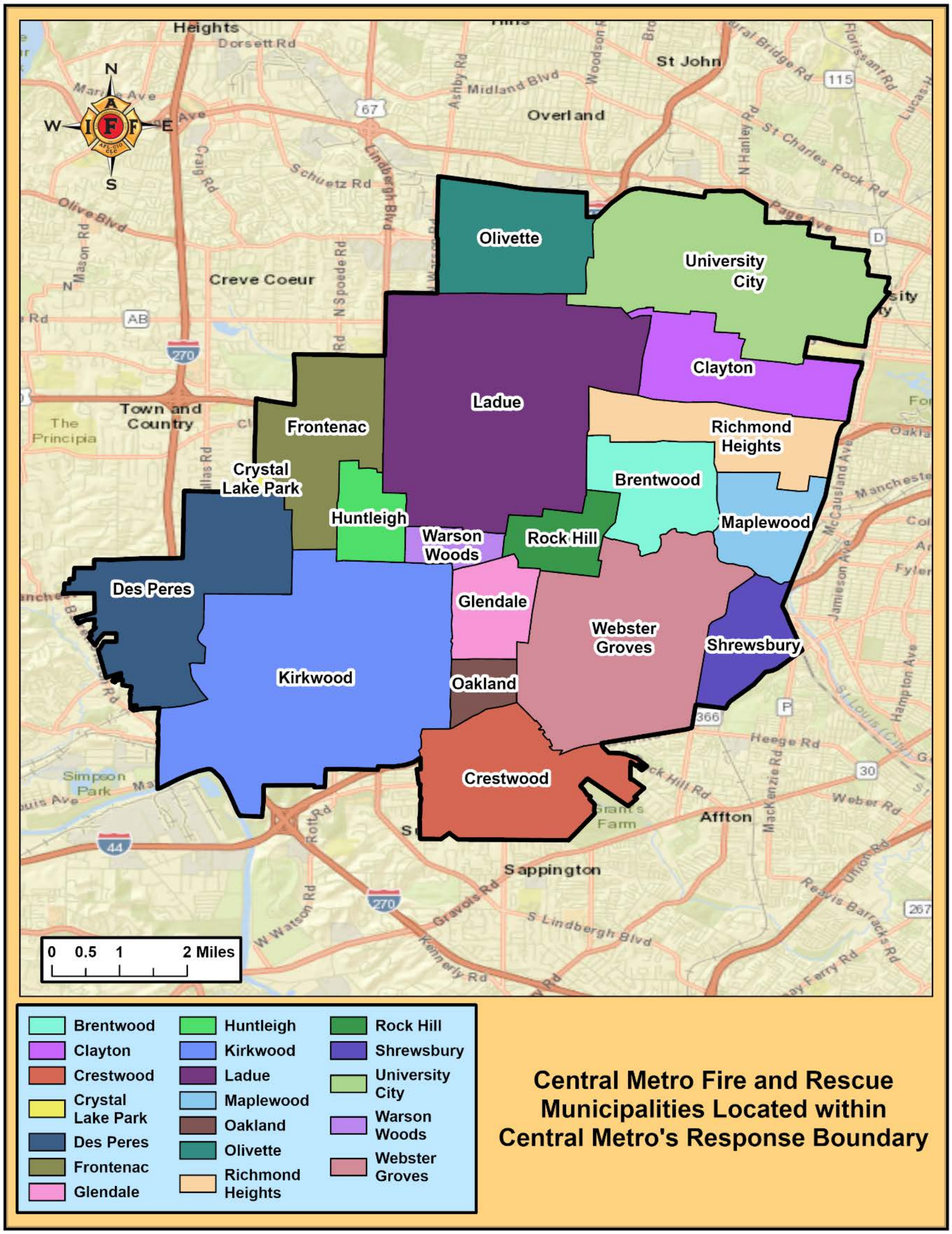
Table 1: Dispatch System by Fire Department. Table 1 depicts the dispatch system used by each fire department. Fire departments that use the same dispatch system operate using automatic aid and departments that use different dispatch systems operate using mutual aid. Automatic aid agreements allow for resources to be immediately dispatched, while mutual aid allows for dispatch centers to communicate with each other to request nearby resources be dispatched to the incident.

Fire protection and EMS response are essential services that governments must provide. The information provided in this document is designed to help decision makers understand the depth of fire department operations and how current staffing and deployment negatively impact responders and citizens in the municipalities within CMFR's response boundary.

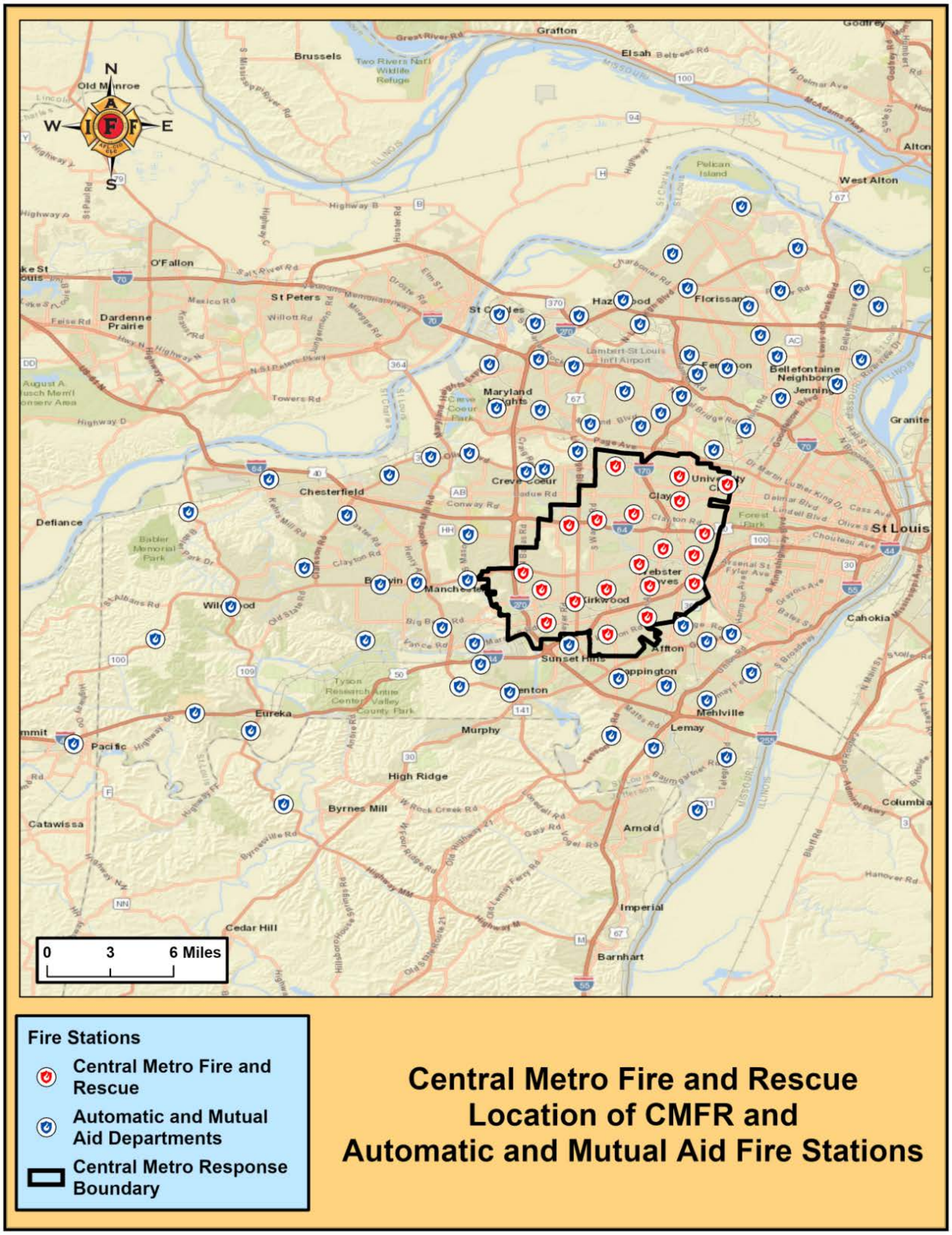
The following maps show CMFR's response area, the municipalities in its response area, CMFR and mutual aid fire stations, and dispatch systems used for each municipality.



Map 1: Location of Fire Stations and Response Boundary. Map 1 depicts the locations of CMFR's fire stations and response boundary. CMFR's response boundary covers 19 municipalities in St. Louis County.

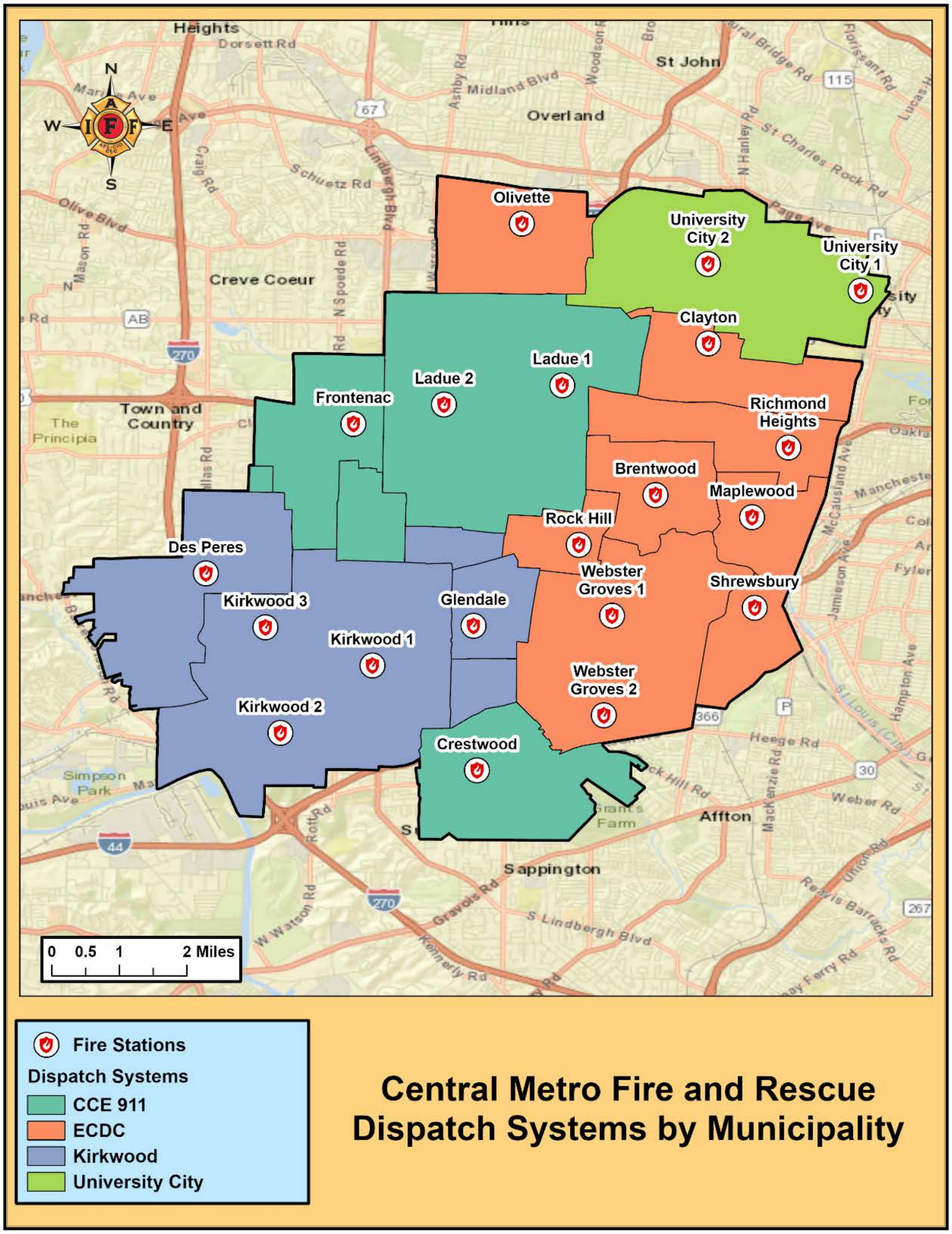


Map 2: Municipalities Located within Central Metro's Response Boundary. Map 2 depicts the municipalities located within CMFR's response boundary. Currently, the cities of Crystal Lake Park, Huntleigh, Oakland, and Warson Woods do not have their own fire departments and contract fire and EMS response from CMFR fire departments.



Map 3: Location of CMFR and Automatic and Mutual Aid Fire Stations. Map 3 depicts the locations of CMFR and Automatic and Mutual Aid fire stations.[17] Automatic and mutual aid fire stations include fire departments that use one of the four dispatch systems used by CMFR but are not one of the 15 fire departments included in the proposed CMFR merger.

[17] List of automatic/mutual aid fire stations located in Appendix B: Automatic/Mutual Aid Fire Stations



Map 4: Dispatch Systems by Municipality. Map 4 depicts the dispatch system used by each municipality within CMFR's response boundary. The fire departments that use the same dispatch system operate using automatic aid and departments that use different dispatch systems operate using mutual aid. Departments operating using mutual aid will experience delays in requesting resources increasing the time it takes for the appropriate number of firefighters and equipment to arrive on scene. Operating under one dispatch system will improve response times by eliminating the time delay of having to contact another dispatch center to request additional units to respond to an incident.

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Risk Assessment

A significant part of planning for future fire department strategies is knowing the risks in the community. As such, risk characteristics within the nineteen municipalities that CMFR would be responsible for providing fire and EMS response were examined for this report. CMFR would be responsible for responding to nineteen municipalities,[18] which account for approximately 55 square miles. In 2017, the nineteen municipalities had a total population of approximately 188,000 residents.[19]

In addition to the general population, it is important to identify subgroups that can drive emergency services demand. A vulnerable population is defined as a group of people who are unable to, or have a reduced ability to, anticipate, cope with, resist, and recover from the impacts of a disaster. According to the U.S. Census Bureau 2013 - 2017 American Community Survey 5-Year Estimates, 23.5% of population was in a vulnerable category based on age. This category consists of persons under the age of five (5.9%) and persons 65 years of age and older (17.6%). In addition, 3.2% of the population have a disability. These groups may be unable to care for themselves or have multiple health issues. Furthermore, 7.1% of the population was living at or below the poverty line.[20] Those living in poverty generally cannot afford those things that are needed for good health, such as quality food, regularly health care visits, and the out-of-pocket cost of seeking health care. Those living in poverty have an increase likelihood of having a fire in their residence due to overcrowding, unsafe heating source, and/or the lack of fire alarms resulting in fire-related injury or death. Typically, people in these groups are at an increased risk for medical complications and fire-related injury or death.

The risk assessment also examined housing characteristics. Based on 2013 - 2017 American Community Survey 5-Year Estimates, there were 84,894 housing units. The majority were single-family residences (71.3%), followed by two to 19-unit multi-family structures (20.3%), more than 20-unit multi-family structures (8.2%), and the remainder were mobile homes (0.1%). Of these structures, 73.8% were constructed before 1970 and 25.7% were built in 1939 or earlier.[21] Typically, older buildings constructed before current fire codes were developed place an increased demand on emergency services.

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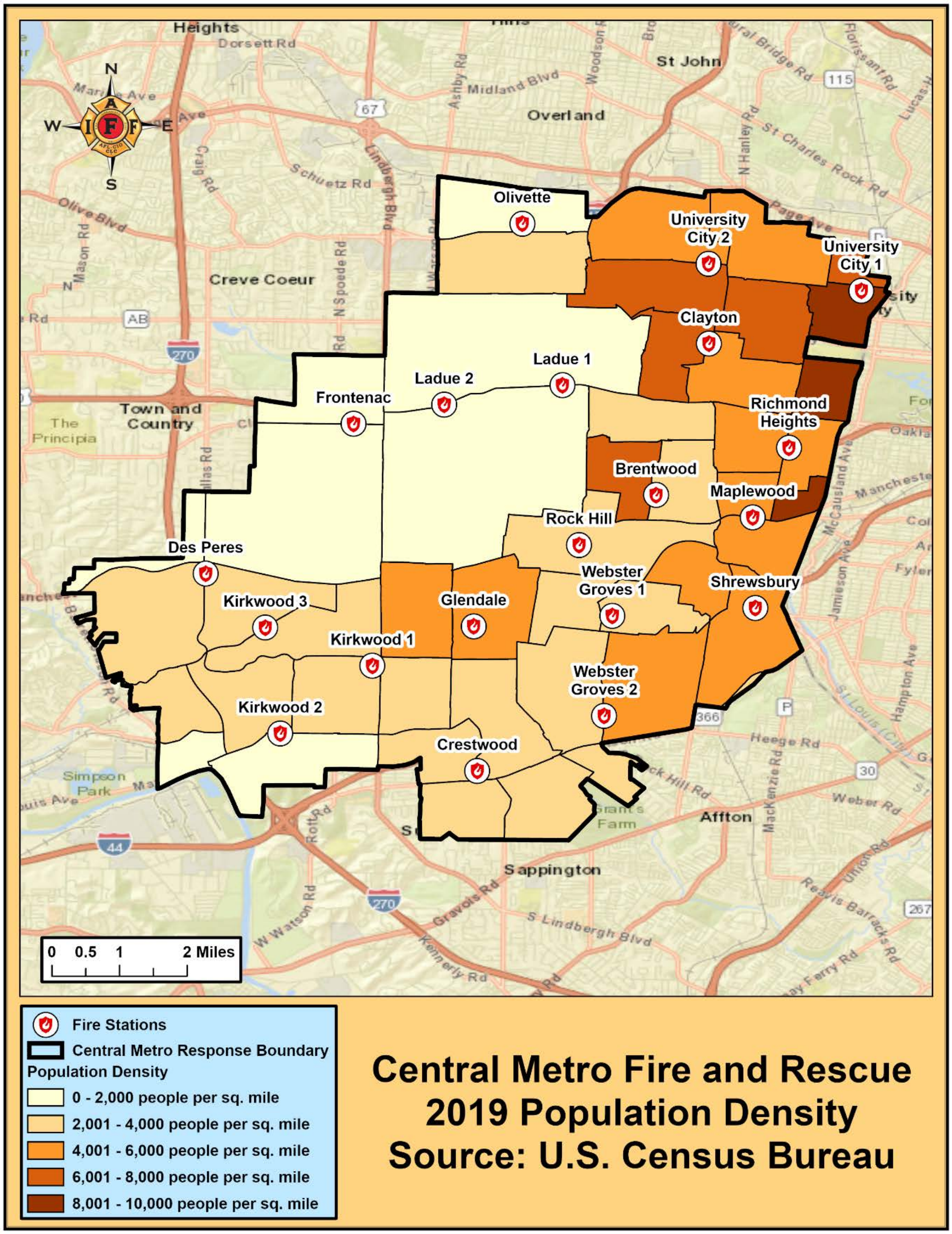
[18] Brentwood, Clayton, Crestwood, Crystal Lake Park, Des Peres, Frontenac, Glendale, Huntleigh, Kirkwood, Ladue, Maplewood, Oakland, Olivette, Richmond Heights, Rock Hill, Shrewsbury, University City, Warson Woods, and Webster Groves.
[19] https://data.census.gov/cedsci/table?q=St%20Louis%20County&tid=ACSDP5Y2017.DP05&hidePreview=false
[20] Ibid.
[21] Ibid

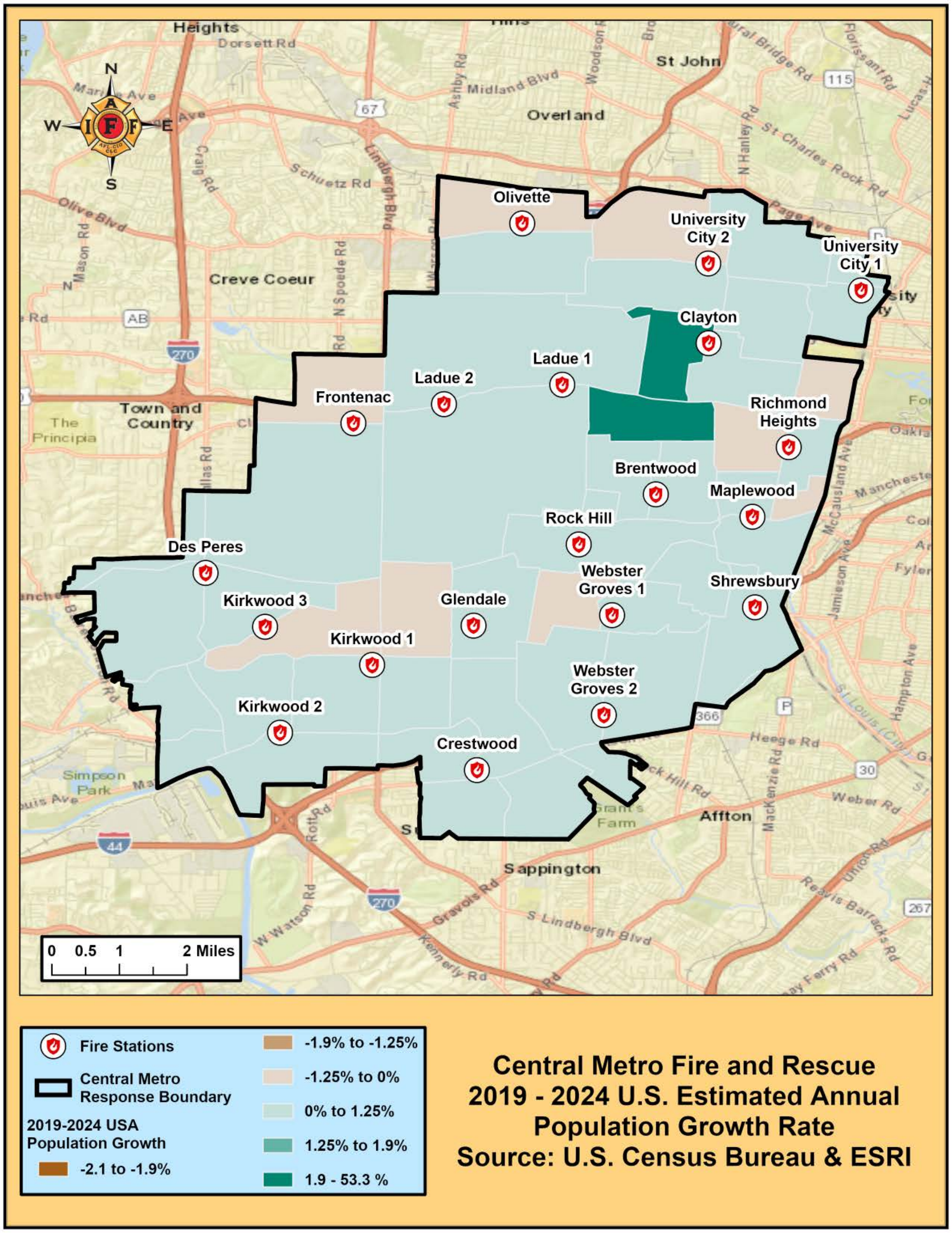
In addition, the municipalities are also at risk for natural disasters. According to the St. Louis Regional Hazard Mitigation Plan 2015 - 2020[22], the municipalities are subject to severe weather (high winds, tornadoes, thunderstorms, and hail), flooding, winter weather (heavy snow, ice storms, extreme cold and wind chills), and earthquakes. Due to the treacherous and threatening conditions to which these potential hazards expose the public, CMFR must be equipped with the necessary resources to respond to all types of disasters.

The following maps show where the risks discussed above occurs within CMFR's response area.

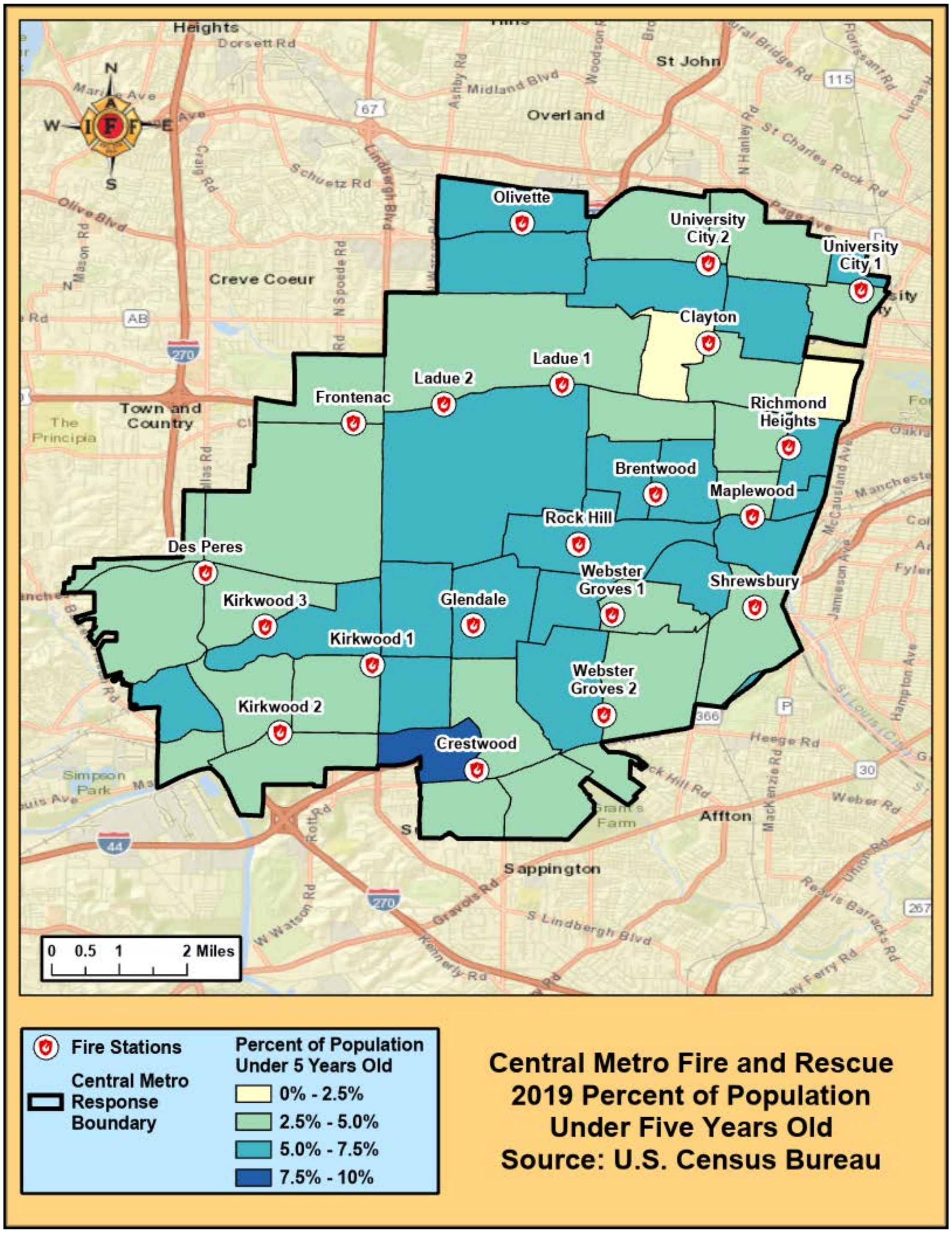
[22] https://www.ewgateway.org/wp-content/uploads/2017/07/AllHazMitPlanUpdate-Approved.pdf



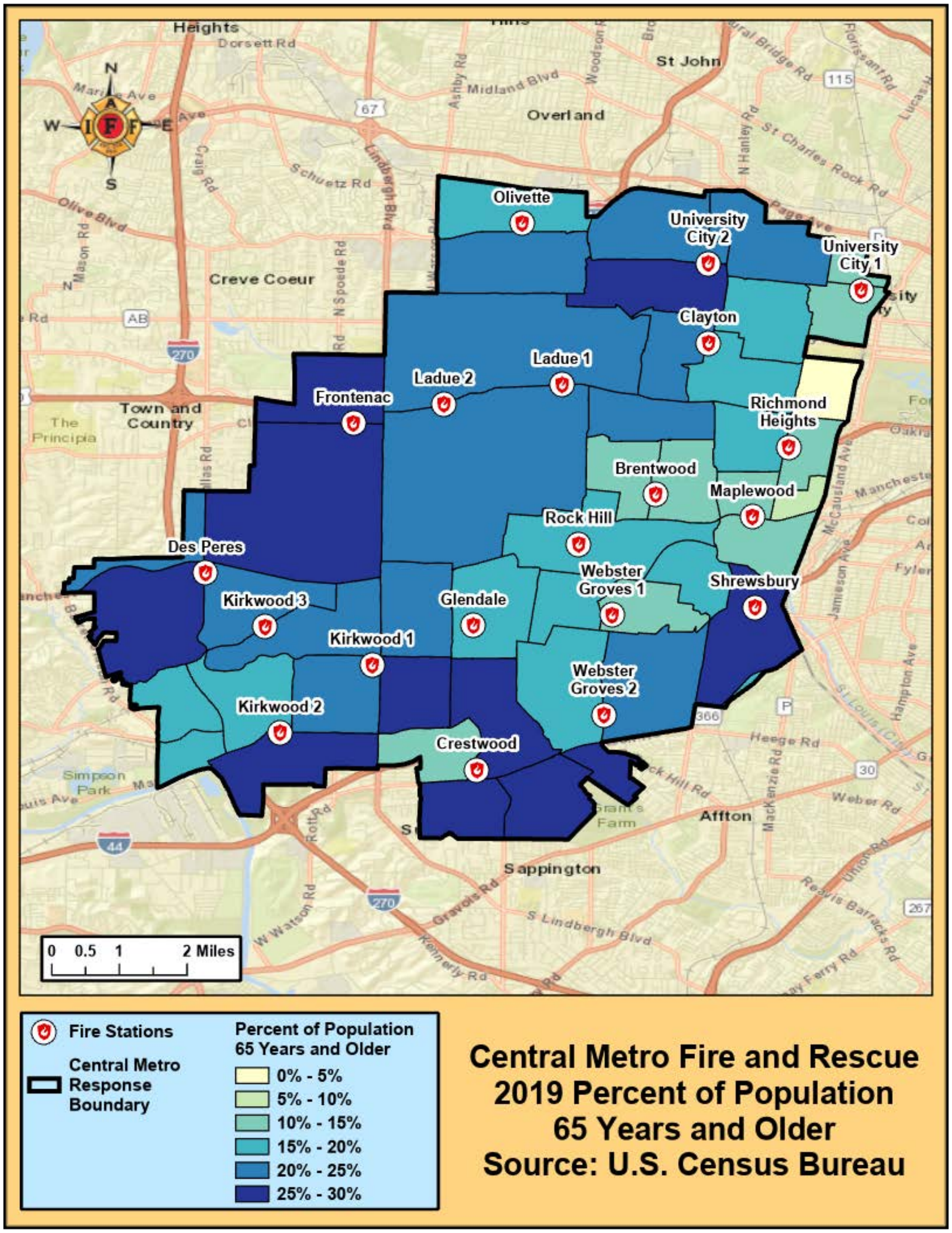
Map 5: 2019 Population Density. Map 5 depicts the cities and towns of central St. Louis County's population density in 2019. Areas with a high population density are likely to have a high volume of emergency incidents, resulting in a larger demand placed on the department in these areas.



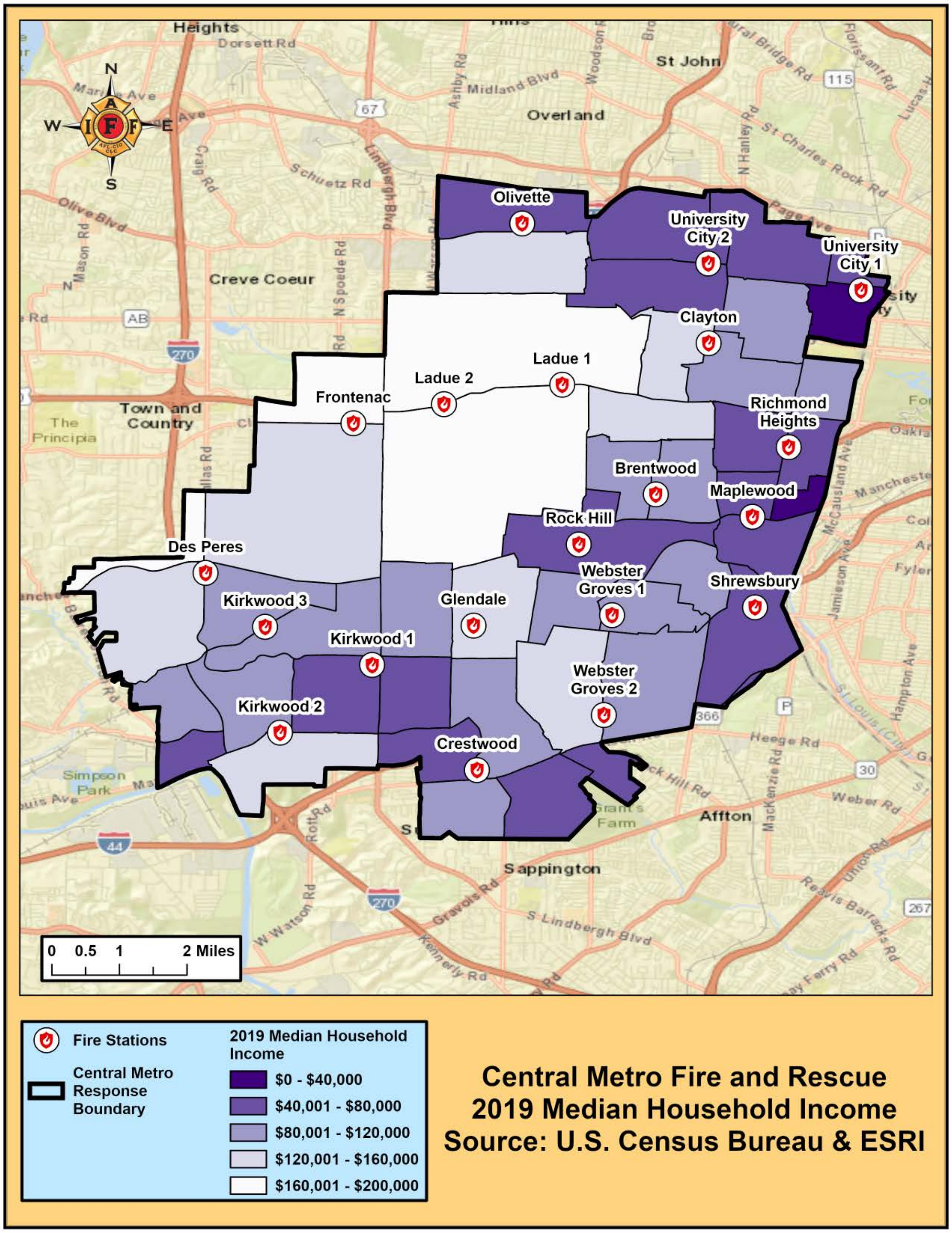
Map 6: 2019 - 2024 U.S. Estimated Annual Population Growth Rate. Map 6 depicts the estimated annual population growth rate from 2019 – 2024. Based on these estimates, most of the municipalities in the CMFR response area should experience an increase in population of the next five years. Areas that have a positive estimated population growth rate will likely experience an increase in emergency services requests. Typically, as population increases, so does demand.



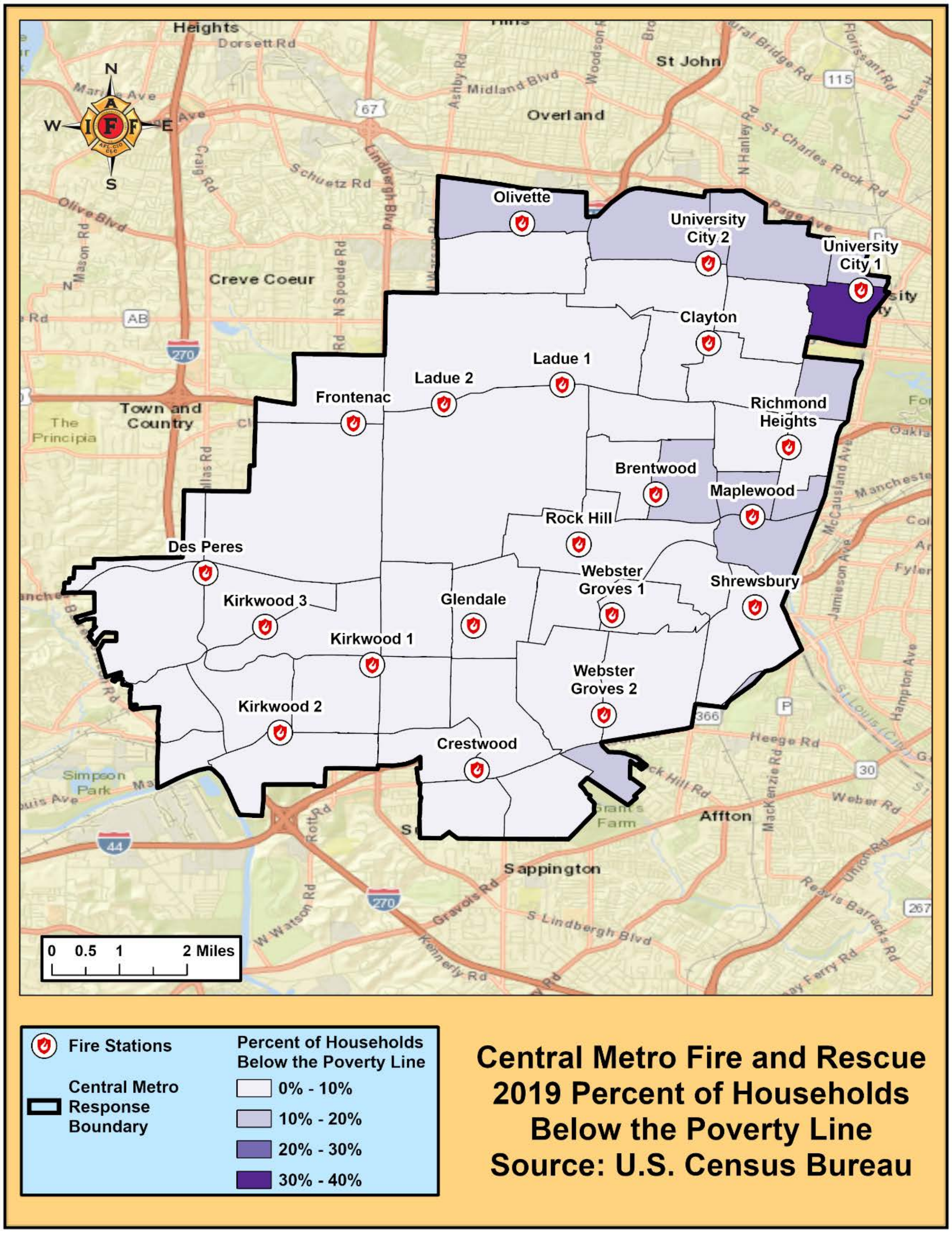
Map 7: 2019 Percent of Population Under Five Years Old. Map 7 reflects the percentage of the total population under five years old. This map assists in identifying areas of vulnerability in the community that will most likely need assistance before, during, and after a hazardous event. Dark blue areas have a high percentage of younger populations compared to other areas. According to a NFPA 2010 study "Demographic and Other Characteristics Related to Fire Deaths or Injuries," 10% of home fire fatalities from 2003 to 2007 were people under five years old. This age group also tends to place an increased demand on emergency medical resources.



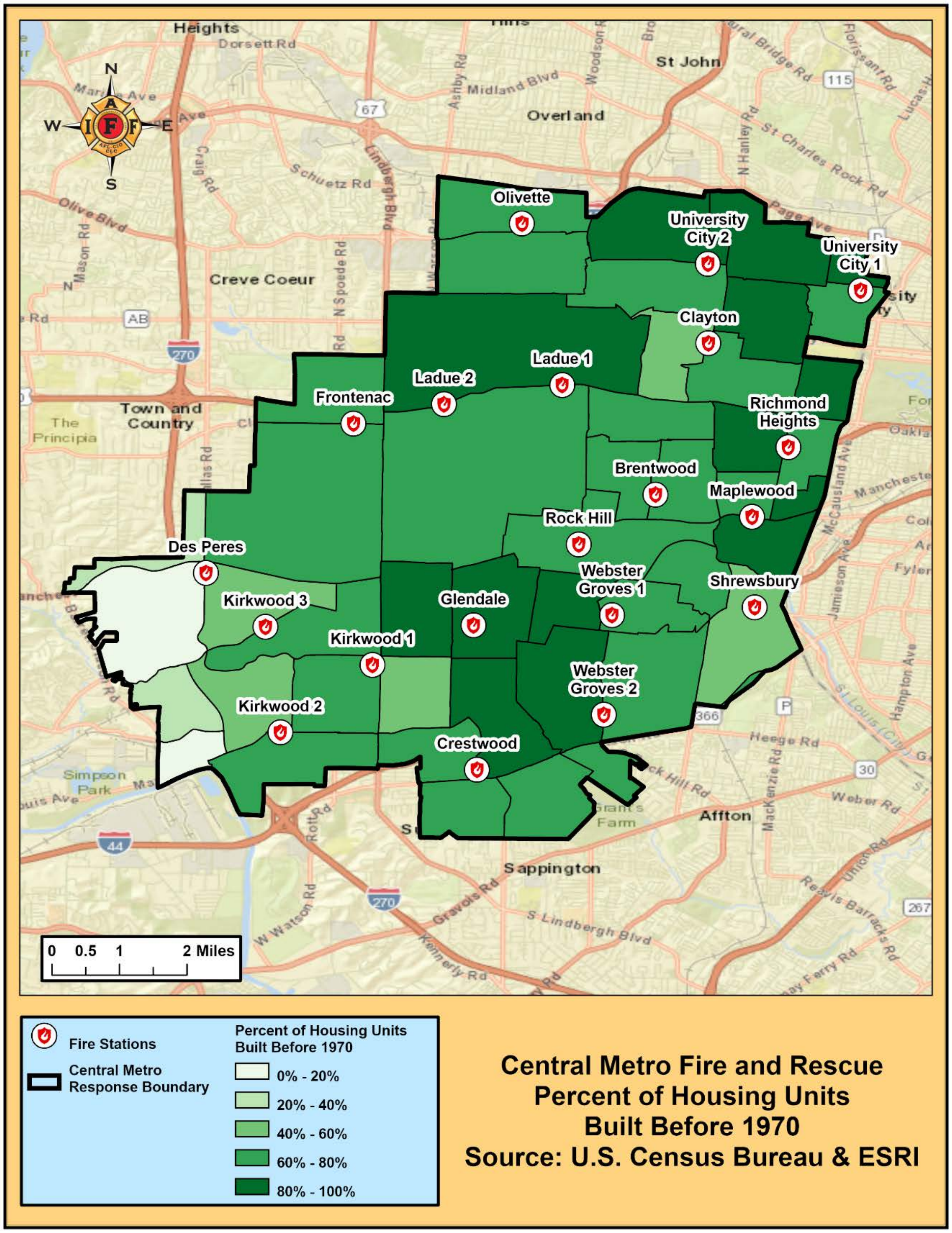
Map 8: 2019 Percent of Population 65 Years and Older. Map 8 reflects the percentage of the total population aged 65 years and older. This map assists in identifying areas of vulnerability in the community that will most likely need assistance before, during, and after a hazardous event. Typically, people aged 65 and older are at a higher risk for injury or death because of their inability or reduced ability to evacuate in an emergency. According to a NFPA 2010 study "Demographic and Other Characteristics Related to Fire Deaths or Injuries," 28% of home fire fatalities from 2003 to 2007 were people 65 years of age or older. This age group also tends to place an increased demand on emergency medical resources.



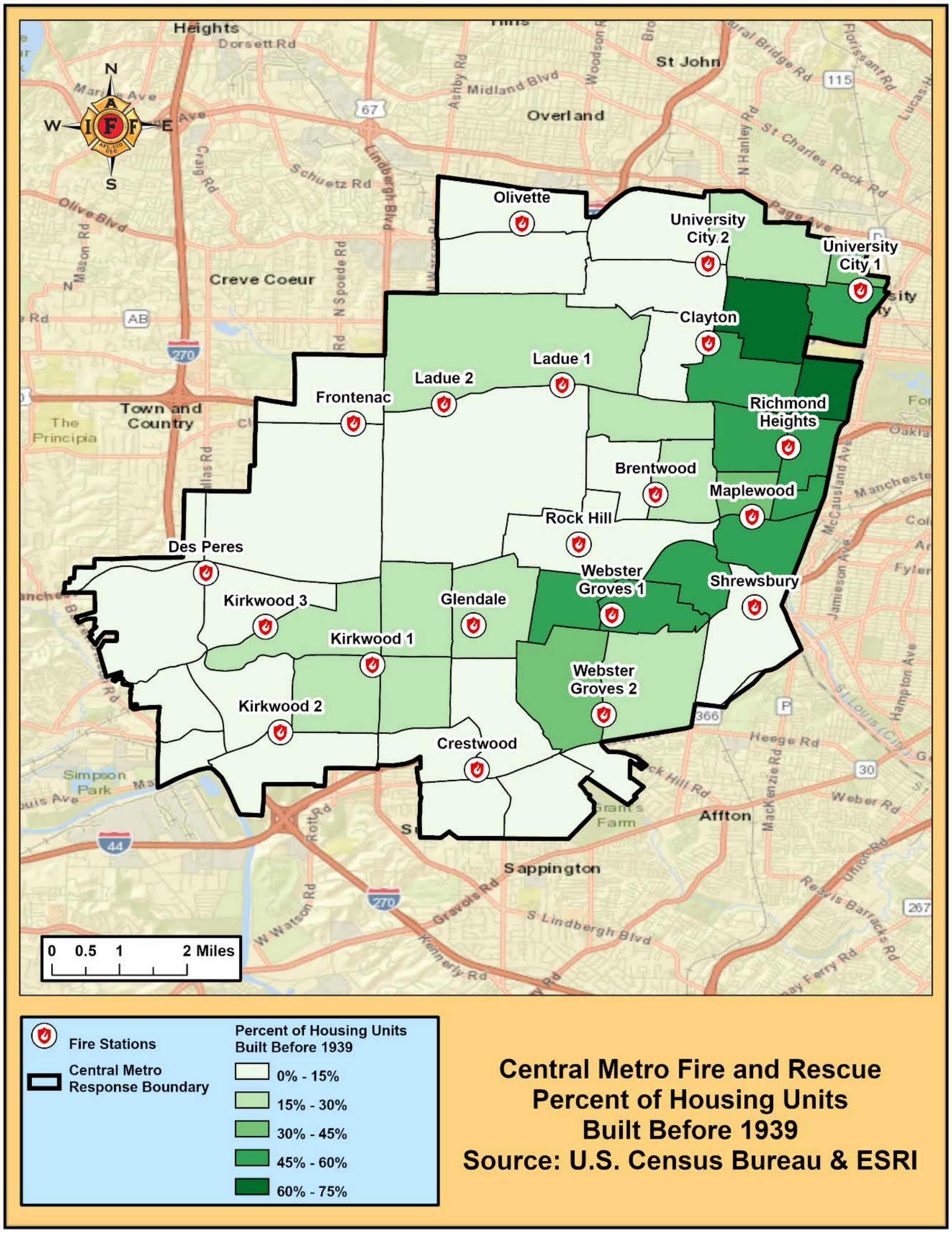
Map 9: 2019 Median Household Income. Map 9 depicts the median household income in 2019. The median household income for the United States is $57,652. Typically, areas with a lower median household income are more likely to have a lack of fire alarms, issues maintaining the property, unsafe sources of heating (space heaters), and/or overcrowding resulting in a higher risk for fire related injury or death.



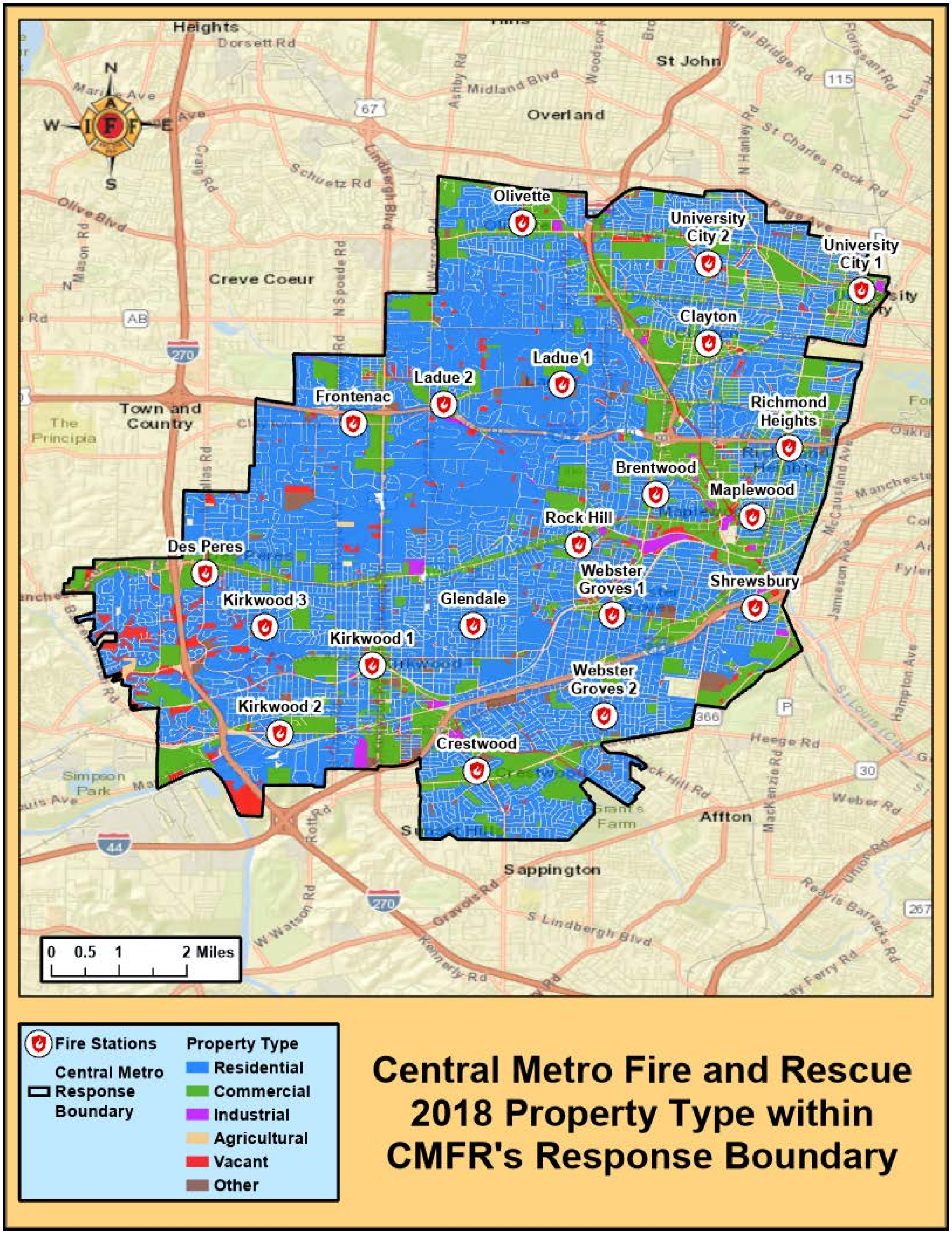
Map 10: 2019 Percent of Households Below the Poverty Line. Map 10 depicts the percent of households that lives below the poverty line. In the U.S. overall, 14.5% of the population lives below the poverty line. Typically, people that live at or below the poverty line are at a higher risk for medical complications due to the lack of a primary care physician and or having a fire in their residence due to overcrowding, unsafe heating source, and/or the lack of fire alarms resulting in fire-related injury or death.



Map 11: Percent of Housing Units Built Before 1970. Map 11 depicts the percentage of housing units built before 1970. Typically, when there are high numbers of older buildings constructed before many current fire codes were developed and poorly maintained properties there is an increased demand on emergency services.

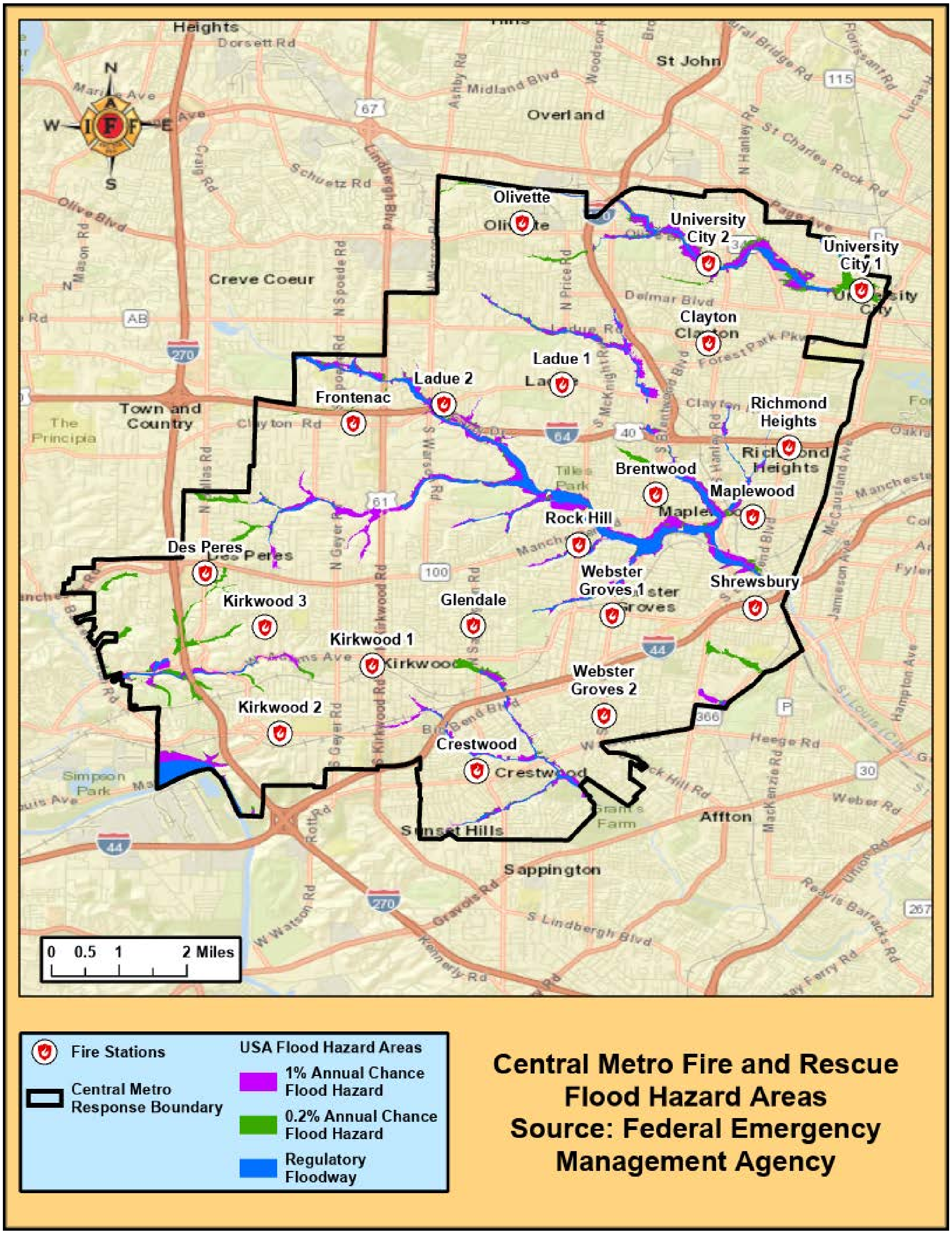


Map 12: Percent of Housing Units Built Before 1939. Map 12 depicts the percentage of housing units built before 1939. Typically, when there are high numbers of older buildings constructed before many current fire codes were developed and poorly maintained properties, there is an increased demand on emergency services.



Map 13: 2018 Property Type within CMFR's Response Boundary. Map 13 defines the property type of areas located within CMFR's response boundary. Based on square mileage, the area is 82.8% residential, 11.6% commercial, 2.0% vacant, 2.0% other[23], 1.5% industrial, and 0.1% agriculture.

[23] Other property type includes public land, place of religious assembly, and open green space.



Map 14: Flood Hazard Areas. Map 14 depicts the locations of potential flood hazards areas in portions of St. Louis County. High-risk areas defined by FEMA are areas that have a 1.0% or greater chance of experiencing flooding in a given year and/or having a 26% chance of experiencing flooding during a 30-year period. The "0.2% annual chance flood hazard" are areas that have 0.2% chance of annual flooding and are typically areas with minimal flooding hazard.

Fire Suppression Operations

The business of providing emergency services has always been labor intensive and remains so today. Although new technology has improved firefighting equipment and protective gear and has led to advances in modern medicine, it is the firefighters who still perform the time-critical tasks necessary to contain and extinguish fires, rescue trapped occupants from a burning structure, and provide emergency medical and rescue services.

A small flame can quickly burn out of control and become a major fire in a short period of time. This is because fire grows and expands exponentially as time passes. In the time frame of fire growth, the temperature of a fire rises to above 1,000° Fahrenheit (F). It is generally accepted in the fire service that for a medium growth rate fire,[24] flashover--the very rapid spreading of the fire due to super heating of room contents and other combustibles—can occur. Assuming an immediate discovery of a fire, followed by an un-delayed call to 9-1-1, and dispatch of emergency responders, flashover is likely to occur within 8 minutes of fire ignition. However, studies conducted by the Underwriters Laboratory (UL) and the National Institute of Standards and Technology (NIST) have proved that, due to new building construction materials and room contents that act as fuel, flashover may occur much sooner.

At the point of flashover, the odds of survival for unprotected individuals inside the affected area are virtually non-existent. The rapid response of an appropriate number of firefighters is therefore essential to initiating effective fire suppression and rescue operations that seek to minimize fire spread and maximize the odds of preserving both life and property.

This section will explain fire growth and the importance of fire department response to a low-hazard structure fire. A low-hazard structure fire is defined as a fire that occurs in a typical, 2,000 square foot, single-family residential home with no basement or exposures.[25]

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[24] As defined in the *Handbook of the Society of Fire Protection Engineers*, a fast fire grows exponentially to 1.0 MW in 150 seconds. A medium fire grows exponentially to 1 MW in 300 seconds. A slow fire grows exponentially to 1 MW in 600 seconds. A 1 MW fire can be thought-of as a typical upholstered chair burning at its peak. A large sofa might be 2 to 3 MWs.

[25] NFPA 1710, 2020 ed. Pg. 1710-20 A.4.1.2.5.1

Fire Growth

The Incipient Phase

The first stage of any fire is the incipient stage. In this stage a high heat source is applied to a combustible material. The heat source causes chemical changes to the material's surface which converts from a solid and begins to release combustible gases. If enough combustible gases are released the material will begin to burn freely.

This process is exothermic, which means that it produces heat. The heat being generated raises the temperature of surrounding materials, which in turn begin to release more combustible gases into the environment and begins a chemical chain reaction of heat release and burning. At this point the fire may go out if the first object completely burns before another begins or the fire can progress to the next stage, which is called the Free Burning Phase.

The Free Burning Phase

The second stage of fire growth is the "free" or "open burning" stage. When an object in a room starts to burn, (such as the armchair in Figure 1, following page), it burns in much the same way as it would in an open area. In this phase of the fire, oxygen in the air is drawn into the flame and combustible gases rise to the ceiling and spread out laterally. Simultaneously, the materials that are burning continue to release more heat, which heats nearby objects and materials to their ignition temperature, and they begin burning as well. Inside a room, unlike in an open area, after a short period of time confinement begins to influence fire development. The combustible gases that have collected on the ceiling will eventually begin to support fire and will begin to burn. Thermal radiation from this hot layer begins to heat the ceiling, the upper walls, and all the objects in the lower part of the room which will augment both the rate of burning of the original object and the rate of flame spread over its surface.

When this occurs, the structure fire reaches a critical point: either it has sufficient oxygen available to move on to the next stage or the fire has insufficient oxygen available to burn and it progresses back to the incipient stage. However, since structures are not airtight, there is a low likelihood of the fire depleting the available oxygen. During this stage of fire growth, toxic chemicals released by the fire and high heat are enough to burn people in the immediate area and disorient and/or incapacitate people in the structure. Without rapid response and aggressive intervention by an adequately staffed fire department, the fire will likely spread to the rest of the structure.

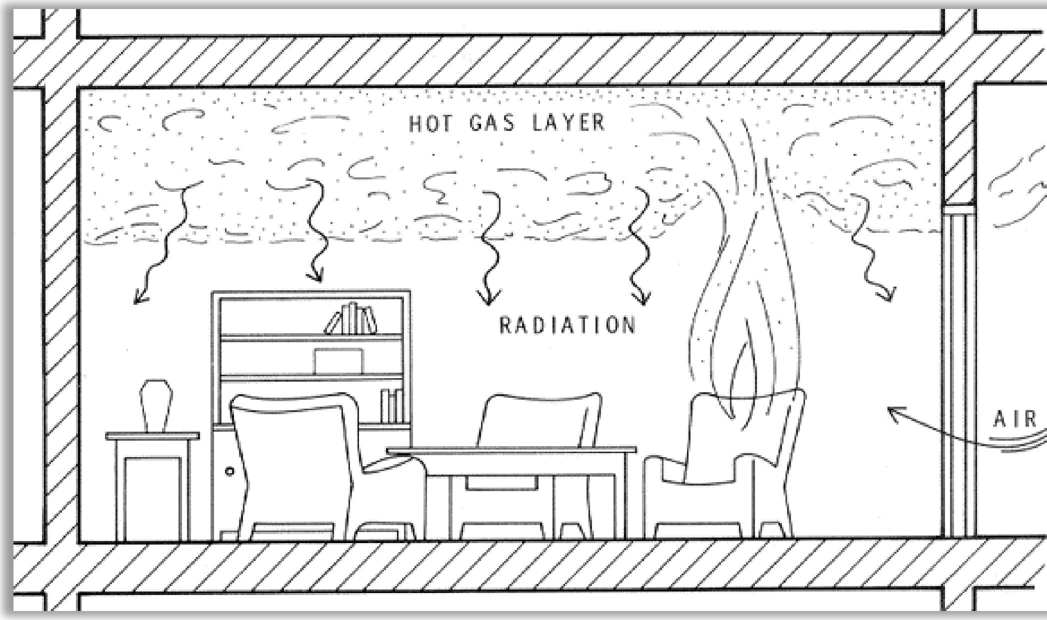

Figure 1: Fire Growth in a Compartment.[26] The above figure depicts the growth of fire in a compartment, which is an enclosed space or room in a building. In a compartment the walls, ceiling, floors, and objects absorb radiant heat produced by the fire. Unabsorbed heat is reflected back to the initial fuel source, which is depicted by the armchair above. This reflected heat continues to increase the temperature of the fuel source and therefore the rate of combustion. Hot smoke, combustible gases, and super-heated air will then rise to the ceiling and spread at first laterally across the ceiling, but later downward towards other fuel sources and the floor of the compartment. As this toxic, super-heated cloud touches cooler materials, the heat is conducted to them, thus increasing their temperature and eventually leading to pyrolysis, which is the process where a fuel source begins to release flammable vapor. This release of flammable vapor leads to further fire growth and eventually flashover. Flashover is the point at which all exposed fuel sources in a compartment ignite.

If there is sufficient oxygen, then the fire will continue to grow and the heating of the other combustibles in the room will continue to the point where they reach their ignition temperatures more or less simultaneously. If this occurs, all combustible materials in the room will spontaneously ignite. This transition from the burning of one or two objects to full room involvement is referred to as flashover. [27]

Flashover

Flashover, when it occurs, is the most significant event during a structure fire. As combustible gases are produced by the two previous stages, they are not entirely consumed and are therefore available fuels. These "available fuels" rise and form a superheated gas layer at the ceiling that

[26] Image courtesy of University of California at Davis Fire Department
[27] J.R. Mehaffey, Ph.D., Flammability of Building Materials and Fire Growth, Institute for Research in Construction (1987)

continues to increase, until it begins to bank down to the floor, heating all combustible objects regardless of their proximity to the burning object. In a typical structure fire, the gas layer at the ceiling can quickly reach temperatures of 1,200˚ F and higher. With enough existing oxygen at the floor level, flashover occurs, which is when everything in the room ignites at once. The instantaneous eruption of flames generates a tremendous amount of heat, smoke, and pressure. The pressure generated from this explosion has enough force to push fire beyond the room of origin and into the rest of the structure, as well as through doors and windows.

As has been noted, at the time of flashover, windows in the room will break. When these windows break, as a result of the increased pressure in the room, a fresh supply of air from the outside of the building is available to help the fire grow and spread. Based on the dynamics of fire behavior in an unprotected structure fire, any decrease in emergency unit response capabilities will correlate directly with an increase in expected life, property, and economic loss.

The Importance of Adequate Staffing: Concentration

Industry-wide safety and staffing standards recommend that a minimum acceptable fire company staffing level should be four members responding on, or arriving with, each engine and ladder company responding to any type of fire.

A prime objective of fire service agencies is to maintain enough strategically located personnel and equipment so that the minimum effective firefighting force can reach a reasonable number of fire scenes before flashover occurs.[28] Of utmost importance in limiting fire spread is the quick arrival of sufficient numbers of personnel and equipment to attack and extinguish the fire, as well as rescue any trapped occupants and care for the injured. Sub-optimal staffing of arriving units may delay such an attack, thus allowing the fire to progress to more dangerous conditions for firefighters and civilians.

Staffing deficiencies on primary fire suppression apparatus negatively affects the ability of the fire department to safely and effectively mitigate emergencies and therefore correlates directly with higher risks and increased losses, both physically and economically. Continued fire growth beyond the time of firefighter on scene arrival is directly linked to the time it takes to initiate fire suppression operations. As indicated in Table 2, responding companies staffed with four firefighters are capable of initiating critical fire ground operational tasks more efficiently than those with crew sizes below industry standards.

[28] University of California at Davis Fire Department website; site visited June 7, 2004.
< http://fire.ucdavis.edu/ucdfire/UCDFDoperations.htm >

	Engine Company Duties				Ladder Company Duties			
Fireground Tasks	**Advance Attack Line**	**% Change**	**Water on Fire**	**% Change**	**Primary Search**	**% Change**	**Venting Time**	**% Change**
4 Firefighters	0:03:27		0:08:41		0:08:47		0:04:42	
3 Firefighters	0:03:56	12% Less Efficient	0:09:15	6% Less Efficient	0:09:10	4% Less Efficient	0:07:01	32% Less Efficient
2 Firefighters	0:04:53	29% Less Efficient	0:10:16	15% Less Efficient	0:12:16	28% Less Efficient	0:07:36	38% Less Efficient

Table 2: Impact of Crew Size on a Low-Hazard Residential Fire.[29] The above table compares and contrasts the efficiencies of suppression companies in the completion of critical tasks for fire control and extinguishment. The smaller the crew size, the more tasks an individual must complete as a team member, which contributes to the delay in initiating fire attack and contributes to diminished efficiency in stopping fire loss. Currently, CMFR typically staffs engine companies with three firefighters and ladder companies with four firefighters.

First-arriving companies staffed with four firefighters are more efficient in all aspects of initial fire suppression and search and rescue operations compared to two- or three-person companies. There is a significant increase in time for all the tasks if a company arrives on scene staffed with only three firefighters compared to four firefighters. According to the NIST Report on Residential Fireground Field Experiments, four-person crews are able to complete time critical fireground tasks 5.1 minutes (nearly 25%) faster than three-person crews. The increase in time to task completion corresponds with an increase in risk to both firefighters and trapped occupants.

With four-person crews, the effectiveness of first-arriving engine company interior attack operations *increases* by 12% to 29% efficiency compared to three- and two-person crews respectively. The efficacy of search and rescue operations also *increases* by 4% to 28% with four-person crews compared to three- and two-person crews. Moreover, with a four-person company, because the first-in unit is staffed with a sufficient number of personnel to accomplish its assigned duties, the second-in company does not need to support first-in company operations and is therefore capable of performing other critical fireground tasks that are likely to improve safety and outcomes.

At the scene of a structure fire, the driver/operator of the first engine company on the scene must remain with the apparatus to operate the pump. This leaves one firefighter to assist the operator in securing a water source from a hydrant and two firefighters to deploy a hoseline and stretch it to the fire. After assisting the operator, the third firefighter should begin to assist the other two

[29] 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.

firefighters with advancing the hoseline into the building and to the location of the fire. Before initiating fire suppression, the supervising officer of the first arriving engine company is also responsible for walking around the building to assess the situation, determine the extent of the emergency, and request any additional resources necessary to mitigate the fire.

Similarly, the driver/operator of the first arriving ladder company must remain with the apparatus to safely position and operate the aerial device while the other three firefighters also perform critical fireground tasks such as ventilation and search and rescue. Due to the demands of fireground activities, a fire attack initiated by companies with only three or fewer firefighters is not capable of effecting a safe and effective fire suppression and/or rescue operation until additional personnel arrive.

Insufficient numbers of emergency response units, or inadequate staffing levels on those units, exposes civilians and firefighters to increased risk. It also further drains already limited fire department resources and stresses the emergency response system by requiring additional apparatus to respond from further distances. Failing to assemble sufficient resources on the scene of a fire in time to stop the spread and extinguish the fire, conduct a search, and rescue any trapped occupants puts responding firefighters and occupants in a dangerous environment with exponential risk escalation such that it is difficult to catch up and mitigate the event to a positive outcome.

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 tasks associated with fire suppression, search and rescue, and other critical fireground activities. As dispatched units arrive with sufficient numbers of firefighters, the overall time on the scene of the emergency decreases since critical fireground tasks can be completed simultaneously rather than in sequence. This also results in the decrease of on-scene risk levels. 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.

Overall Scene Time Breakdown by Crew Size		
Scenario	**Total Time**	**Efficiency**
4-Person Close Stagger	0:15:44	
3-Person Close Stagger	0:20:30	23% 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

Table 3: The Relationship between Crew Size and Scene Time.[30] The above table displays how companies staffed with larger crew sizes will be on the scene of an emergency for a shorter time than smaller sized companies. This lag on scene could be translated to mean that emergency resources will be unavailable longer to address other emergencies that may arise.

As Table 2 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 fire, 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.[31] [32] 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.

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[30] Ibid.
[31] Ibid.
[32] 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.[33]

In 2018 alone, 44% of all firefighter fatalities were related to overexertion.[34] There is strong epidemiological evidence that heavy physical exertion can trigger sudden cardiac events.[35] 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 earlier, 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.

Charts 1 and 2, 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 2 to 5 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.

[33] 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.
[34] Fahy, R.F., Molis, J.L. (June, 2019) Firefighter Fatalities in the United States-2018. NFPA.
[35] 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

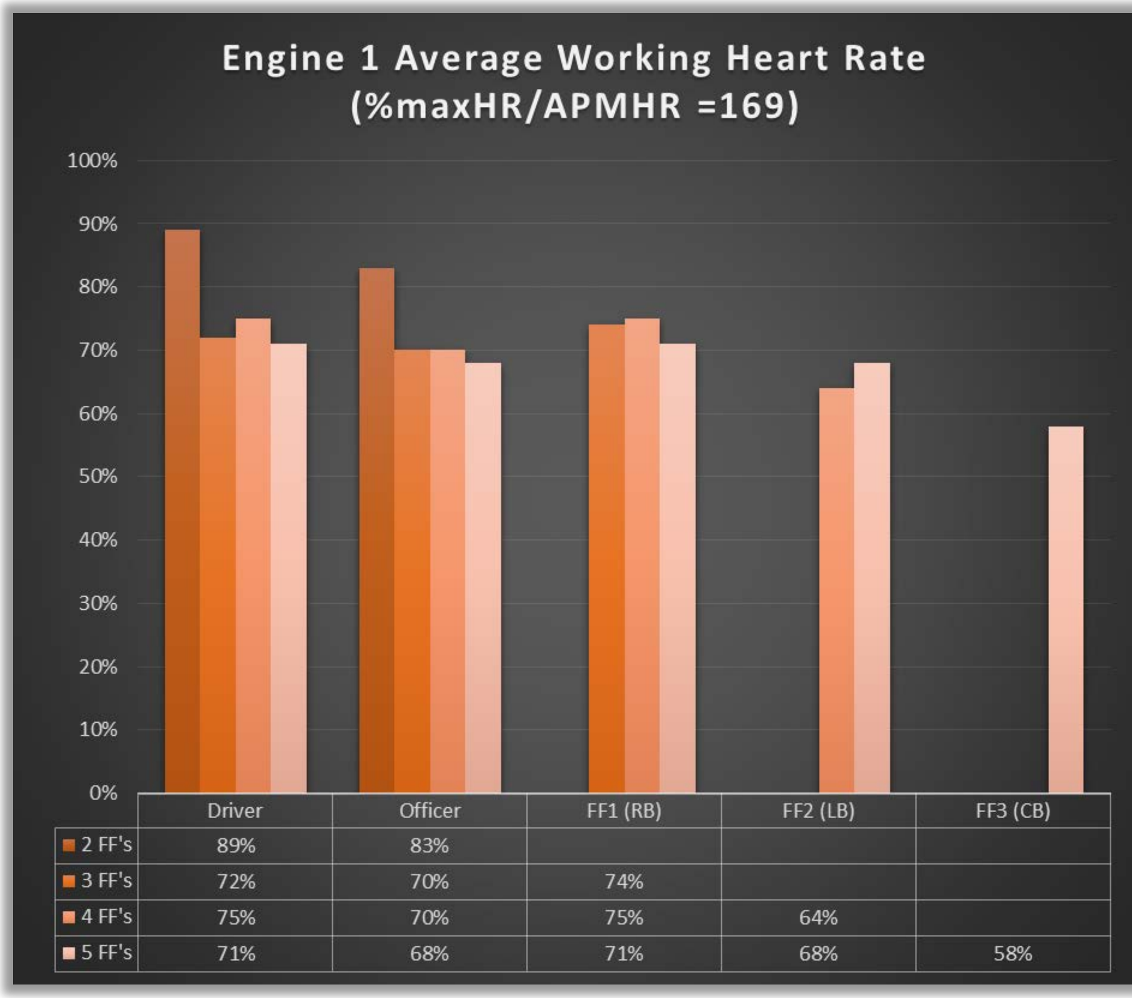

Chart 1: Average Peak Heart Rate of First Engine (E1) with Different Crew Sizes by Riding Position.[36] *In Chart 1, heart rates are expressed as a percent of maximal age-predicted maximal HR.* The average heart rates for firefighters on the first engine company were above 80% of age-predicted maximum values when only 2 firefighters were working. When staffing was at 2 firefighters, the driver of the apparatus had an average peak heart rate of nearly 90% 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.[37] 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.

[36] Riding position for Chart 1 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 2 will consist of a Driver and an "Officer."

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

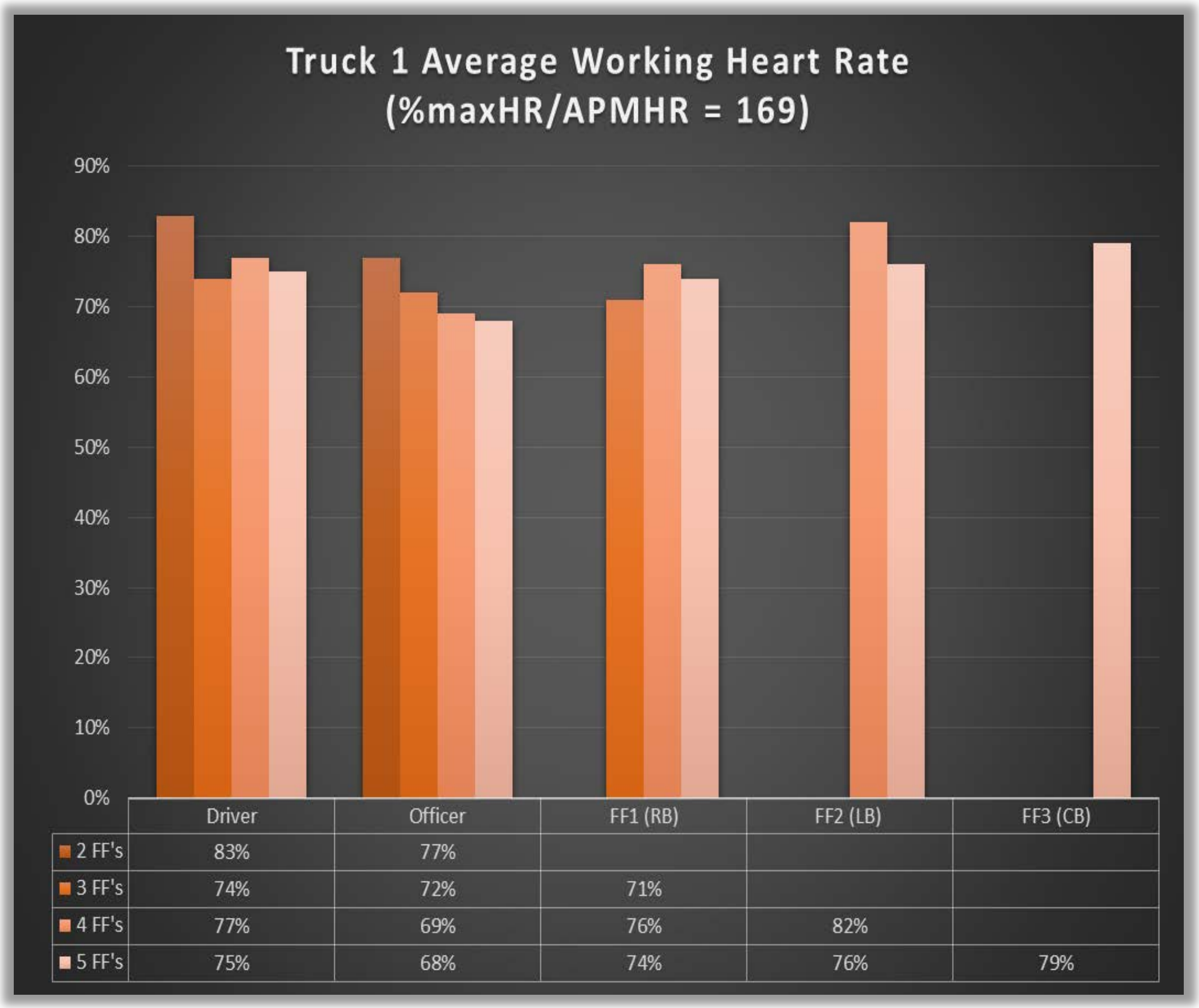

Chart 2: Average Peak Heart Rate of First Truck (T1) with Different Crew Sizes by Riding Position.[38] *In Chart 2, heart rates are expressed as a percent of maximal age-predicted maximal HR.* The average heart rates for firefighters on the first truck company were above 80% of age-predicted maximum values when only 2 firefighters were working.[39] 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.

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[38] Riding position for Chart 2 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 2 will consist of a Driver and an "Officer."

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

The Importance of a Rapid Response

Uncontained fire in a structure grows exponentially 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 Table 4, following page. 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.[40] As with inadequate staffing, this type of operation will continue until enough resources can be amassed to mitigate the event.

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 showed 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.

[40] 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.”

Rate Per 1,000 Fires			
Flame Spread:	**Civilian Deaths**	**Civilian Injuries**	**Average Dollar Loss per Fire**
Confined fires (identified by incident type)	0.00	8.7	$200
Confined to object of origin	0.4	11.1	$1,200
Confined to room of origin, including confined fires by incident type[41]	1.8	23.8	$4,000
Beyond the room, but confined to floor of origin	16.2	76.3	$35,000
Beyond floor of origin	24.6	55.0	$65,900

Table 4: The Relationship between Fire Extension and Fire Loss.[42] The above table displays the rates of civilian injuries and deaths per 1,000 fires, as well as the average 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. 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 environment and, therefore, require the use of respirators. In those cases, at least two standby persons, in addition to the minimum of two persons inside

[41] NFIRS 5.0 has six categories of confined structure fires, including cooking fires confined to the cooking vessel, confined chimney or flue fire, confined incinerator fire, confined fuel burner or boiler fire or delayed ignition, confined commercial compactor fire, 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.

[42] National Fire Protection Association, NFPA 1710 (2020), Table A.5.2.2.2.1 Fire Extension in Residential Structures, 2012-2016.

needed to fight the fire, must be present before firefighters may enter the building.[43] [44] 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**,"[45] 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**."[46]

However, the number of personnel required per fire suppression apparatus increases with risk and demand. NFPA 1710, 2020 edition states that engine and ladder companies that are assigned to first-due districts that have a high number of incidents, geographic restrictions[47], geographic isolation[48], or areas considered to be urban[49] with regards to population density, all as identified by the AHJ, should be staffed with a minimum of five firefighters. First-due districts that have tactical hazards, high hazard occupancies, or densely populated urban areas[50], as identified by the AHJ, shall have companies that are staffed with six firefighters.[51]

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

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

[45] NFPA 1710, § 5.2.3.1 and §5.2.3.1.1.

[46] NFPA 1710, § 5.2.3.2 and §5.2.3.2.1.

[47] Geographic Restriction is a defined condition, measure, or infrastructure design that limits response and/or results in predictable response delays to certain portions of the jurisdiction.

[48] Geographic Isolation is a first-due response zone or jurisdiction with staffed resources where over 80% of the response area is outside of 10-minute travel time from the next closest staffed suppression apparatus.

[49] An urban area is an incorporated or unincorporated area with a population over 30,000 people and /or a population density over 1,000 people per square mile but less than 2,999 people per square mile.

[50] A dense urban area is an incorporated or unincorporated area with a population density of over 200,000 people and/or a population density of over 3,000 people per square mile.

[51] 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.

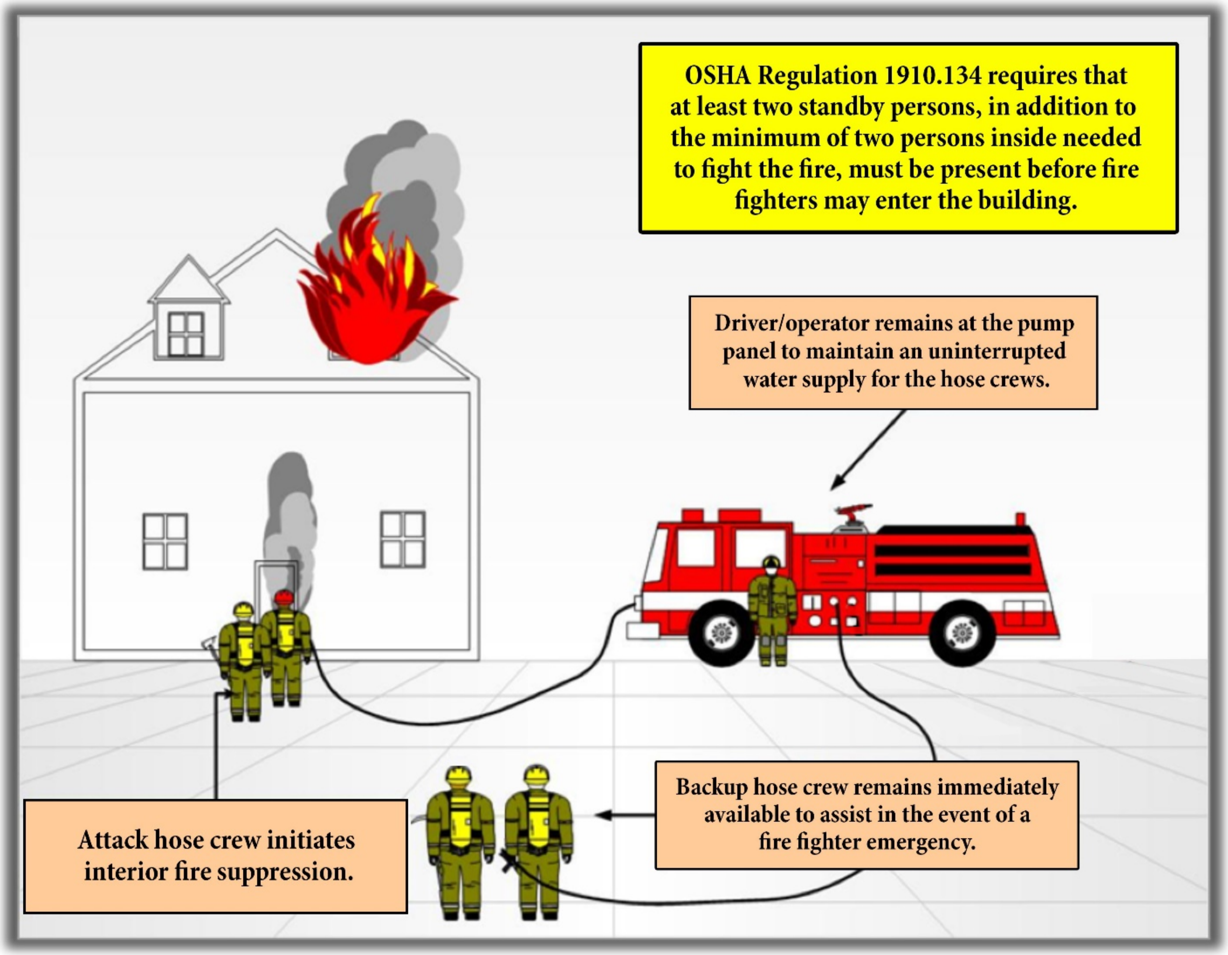

Figure 2: The OSHA "2 IN/2 Out" Regulation. The above figure depicts the number of firefighters required to meet OSHA regulation 1910.134, which demands one firefighter outside for every firefighter inside. The firefighters outside can support a secondary attack line and facilitate the rescue of trapped or disabled firefighters should the need arise. In this scenario the driver/operator of the apparatus is not counted towards the total number of firefighters.

Several examples of incidents exist in which the failure to follow the "2 In/2 Out" regulation have contributed to firefighter casualties. For example, in Bridgeport, Connecticut in July 2010, two firefighters died following a fire where NIOSH later found that although a "Mayday" was called by the firefighters, it wasn't responded to promptly as there was no Incident Safety Officer or Rapid Intervention Team (RIT) readily available on scene. In a second case, two firefighters were killed in a fire in San Francisco, California in June 2011. The initial RIT was re-assigned to firefighting duties, and the back-up RIT did not arrive on scene until after the victims were removed.

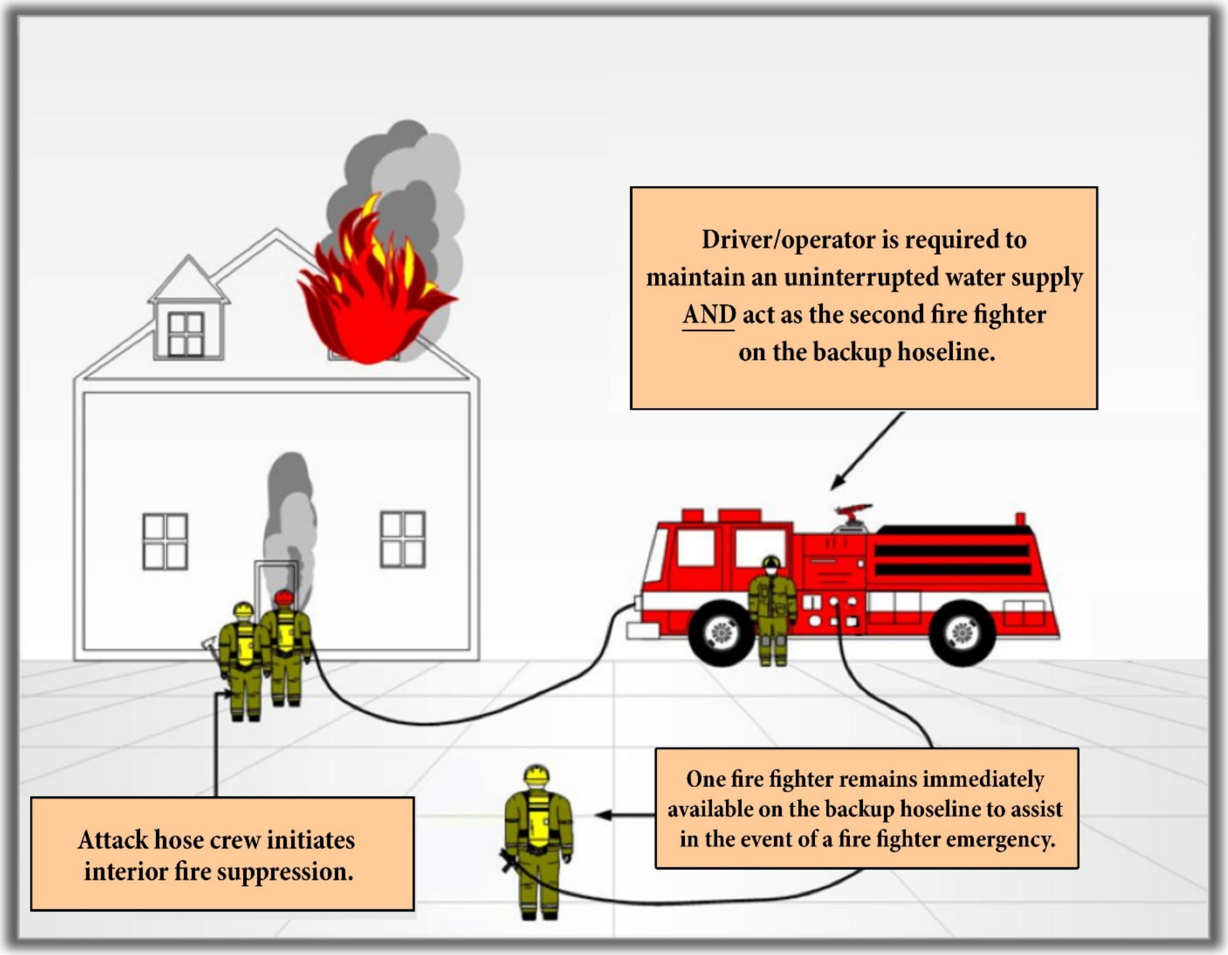

Figure 3: Emergency "2 In/2 Out" Operations. In the emergency model depicted above, the arriving fire apparatus is staffed with a crew of 4 personnel and operates under emergency conditions. In this case the driver/operator of the fire apparatus is also counted as a firefighter, which means that firefighter must be dressed in personal protective equipment (PPE) and be ready to participate in rescue if the need should arise.

When confronted with occupants trapped in a burning structure and a single fire company is on scene, only a company staffed with four firefighters can initiate emergency search and rescue operations in compliance with the "2 In/2 Out" Regulation. As indicated in the previous graphic, this requires the complete engagement of every firefighter from the first-in fire company, staffed with four, to participate in the effort, and means that the driver-operator of the apparatus must tend to the pump to ensure the delivery of water to the firefighters performing the initial attack and search and rescue operations and be prepared to make entry with the remaining firefighter should the crew operating inside become trapped.

Regardless, when there exists an immediate threat to life, only a company of four firefighters can initiate fire suppression and rescue operations in compliance with "2 In/2 Out" Regulation, and in a manner that minimizes the threat of personal injury. In crews with fewer than four firefighters, the first-in company must wait until the arrival of the second-in unit to initiate safe and effective fire suppression and rescue operations. This condition underlines the importance and desirability of fire companies to be staffed with a minimum of four firefighters and stresses the benefit of four-person companies and their ability to save lives without having to wait for the second-in company to arrive.

Initial Full Alarm Assignment

Initial Full Alarm Assignment Capability, as outlined in NFPA Standard 1710, recommends that the "fire department shall have the capability to deploy an initial full alarm assignment within a 480-second travel time to 90 percent of the incidents… [and that the] initial full alarm shall provide for the following:

Assignment	Required Personnel
Incident Command	1 Officer
Uninterrupted Water Supply	1 Pump Operator
Water Flow from Two Handlines	4 Firefighters (2 for each line)
Support for Handlines	2 Firefighters (1 for each line)
Victim Search and Rescue Team	2 Firefighters
Ventilation Team	2 Firefighters
Aerial Operator	1 Firefighter
Initial Rapid Intervention Crew (IRIC)	4 Firefighters
Required Minimum Personnel for Full Alarm	**16 Firefighters & 1 Incident Commander**

Table 5: NFPA 1710, §5.2.4.1.1. This breakdown of the expected capabilities of a full alarm assignment, in compliance with NFPA 1710, requires a minimum contingent of 17 fire suppression personnel

In addition, NFPA 1710, §5.2.4.6.2 states, "The Fire Department shall have the capability for additional alarm assignments that can provide for additional command staff, members, and additional services, including the application of water to the fire; engagement in search and rescue, forcible entry, ventilation, and preservation of property; safety and accountability for personnel; and provision of support activities…"

The ability of adequate fire suppression forces to greatly influence the outcome of a structural fire is undeniable and predictable. Each stage of fire extension beyond the room of origin directly increases the rate of civilian deaths, injuries, and property damage.

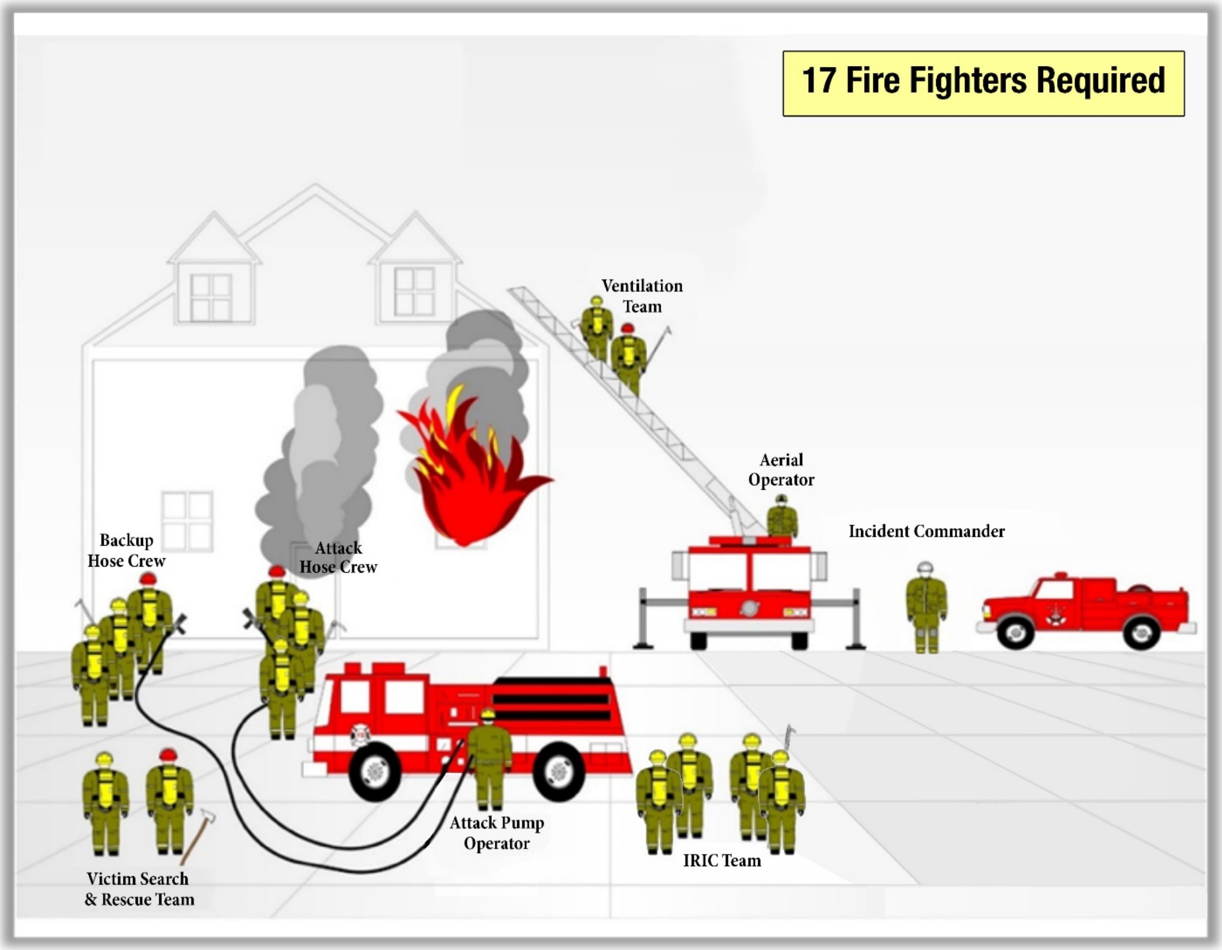

Figure 4: Initial Full Alarm Assignment Deployed Within 8 Minutes, 17 Firefighters Required. The above figure depicts the full alarm assignment required by NFPA 1710 as discussed in Table 4.

Fire growth is exponential, growing in a non-linear manner over time. Extending the time for crew assembly by waiting for additional crews to arrive causes on-scene risk to escalate. The higher the risks at the time firefighters engage in fire suppression, the greater the chance of poor outcomes including civilian injury or death, firefighter injury or death, and increased property loss.

High-Rise Operations

Although this section specifically addresses fire response to high-rise buildings, it is important to note that the discussion can be extrapolated to large area buildings such as manufacturing centers, warehouses, grocery stores, schools, and other structures with a high fire load and populations.

Overview of High-Rises

High-rise buildings were once found exclusively in urban cities. However, today they are commonly found in small and mid-sized suburban communities as well. Many high-rise buildings in suburban areas are newer, shorter, and protected by automatic sprinkler systems, although this is not always a guarantee. NFPA 101, Life Safety Code, 2015 Edition and the International Code Council's International Building Code both define a high-rise structure as a building more than 75 ft. (23 m) in height, measured from the lowest level of fire department vehicle access to the bottom of the highest occupied floor. High-rises, which are described in NFPA 1710 §A.3.3.36 as high-hazard occupancies, represent an extraordinary challenge to fire departments and are some of the most challenging incidents firefighters encounter.

High-rise buildings may hold thousands of people above the reach of fire department aerial devices and the chance of rescuing victims from the exterior is greatly reduced once a fire has reached flashover. The risks to firefighters and occupants increase in proportion to the height of the building and the height of the fire above grade level.[52] This is especially true once firefighters are operating above the reach of aerial ladders on truck companies. In these situations, the only viable means of ingress or egress is the interior stairs. Therefore, a sound fire department deployment strategy, effective operational tactics, and engineered fire protection systems cannot be separated from firefighter safety. As in any structure fire, engine company and truck company operations must be coordinated.

High-rise buildings present a unique threat to the fire service. Multi-floor fires such as the Interstate Building Fire, One Meridian Plaza Fire, World Trade Center collapse, Cook County Administration Building Fire, and Deutsche Bank Building Fire each represented serious challenges to the operational capabilities of a modern fire department. According to the NFPA, between 2007 and 2011, there were an estimated 15,400 reported high-rise structure fires per year that resulted in associated losses of 46 civilian deaths, 520 civilian injuries, and $219

[52] Klaene, B. and Sanders, R. (2007). Structural Firefighting: Strategies and Tactics- High-Rise. Jones and Bartlett 2007.

million in direct property damage. Office buildings, hotels, apartment buildings, and health care facilities accounted for nearly half of these high-rise fires.[53]

Although the frequency of fires in high-rise structures is low, they pose a high consequence of loss with regards to injury, loss of life, and property damage. Even if a department does not respond to high-rise buildings at present, it may in the future as urban sprawl continues and/or jurisdictional border restrictions and population growth require taller buildings to meet residential needs.

High-Rise Firefighting Tactics

As has been stated, in a high-rise fire the risks to firefighters and occupants increases in proportion to the height of the building and the height of the fire above ground level. As the level of the fire floor gets higher, firefighters are required to carry more equipment further and must rely more on the building's standpipe system. A standpipe system is a piping system with discharge outlets at various locations usually located in stairwells on each floor in high-rise buildings that is connected to a water source with pressure supplemented by a fire pump[54] located in the building and/or a fire apparatus with pumping capabilities.

A fire in a high-rise building can threaten occupants and responding firefighters. Because of the amount of time it takes firefighters encumbered with equipment to access the involved floors, the fire may have expanded well past the area of origin. This means that firefighters can encounter a large volume of fire and darkened conditions when they arrive on the involved floors. This can be further complicated if the building is not equipped with a sprinkler system. Additionally, open-layout floor plans such as office buildings with cubicle farms can challenge both the standpipe's flow capacity and fire department resources regarding search, rescue, and hoseline deployment. The most effective way to extinguish a high-rise fire is by mounting an offensive attack as early as possible, because in most historic high-rise fires, the best life safety tactic is extinguishing the fire. Good high-rise firefighting tactics and firefighter/occupant safety cannot be separated. As with a residential structure fire, the first arriving suppression apparatus should be on the scene within four minutes of travel time.

Like residential structure fires, there are several critical tasks that must be accomplished. However, unlike residential firefighting in a 2,000 square foot residence, firefighters working at a high-rise fire must travel upwards of more than three stories and carry additional equipment beyond the normal requirements. Additionally, as it takes longer to assemble an effective firefighting force and to access the fire floor, firefighters are likely to encounter a large volume

[53] Hall, J.R. (2013), High-Rise Building Fires. NFPA.
[54] Structural Firefighting Strategy and Tactics 2nd Edition. Klaene B., Sanders R. NFPA 2008

of fire and will therefore have an extended fire attack. Because of this, it is necessary to establish an equipment supply chain to transport equipment and resources up and down the building.

Search and Rescue

Search and rescue are critical fireground tasks that comprise a systematic approach to locating possible victims and removing those victims from known danger to a safe area. In a residential structure fire, searches are normally conducted by a crew of two firefighters, supplemented by an attack or ventilation crew. However, high-rise structures pose challenges regarding search and rescue that are not typically encountered in residential housing. For commercial high-rises and wide-area structures, large open areas and cubicle farms require additional search and rescue teams so that thorough searches can occur over a larger area than found in most residences. In addition to these larger areas, search and rescue can be further complicated because conscious victims may retreat to areas to find shelter from heat and smoke. These areas may differ from places where they are typically seen by coworkers, making locating them difficult if they are unaccounted for.

In residential high-rises, apartments typically lack two exits and usually share a common hallway for egress. Doors left open by victims fleeing fire can allow fire and smoke to spread into the hallway and impact escape attempts. Firefighters will be slowed in their search since they will be required to force their way into numerous apartments to search for victims. For this reason, regardless of commercial or residential, it is essential for there to be multiple search and rescue teams operating per involved floor to quickly locate victims in large surface areas. It is also necessary for additional search and rescue teams to search the floors above the fire and the highest floor of the building, due to how fire and smoke spread to the rest of the building. Search and rescue teams should also be supplemented with evacuation management teams to assist injured or disabled victims down the stairwells so searching can continue. It should be noted that in regard to high-rise fire suppression, crews larger than four performed searches faster than crews of four, thus minimizing a person who is trapped exposure to fire and toxic gases.

Fire Extinguishment

Fire extinguishment is a critical factor, since the intensity and size of the fire will determine the extent to which combustion gases are heated and how high they will rise inside the building. Building suppression systems, both active and passive, can impact fire growth, occupant safety, and firefighter safety and effectiveness. Such features include active fire detection and automatic sprinkler systems that are designed to either extinguish the fire or contain it until firefighters arrive.

Once firefighters are on scene, they will complete a series of fire confinement and extinguishment tasks. Firefighters access the structure, locate the fire, locate any avenues of spread, place hoselines, and establish a water supply. Once a water supply is established, water should be placed at the seat of the fire or in the compartment containing the fire to extinguish it. Unlike residential structure fires where hoselines can be stretched from the fire apparatus into the structure, high-rise structures require the use of standpipe systems to combat fire. This requires firefighters to carry multiple sections of hose to the affected floors and connect into the system to fight fire. Minimally, firefighters must deploy two hoselines to the involved floor and one hoseline to the floor above the fire. The third hoseline supports a number of critical tasks in the suppression effort. Principally, it is used to protect search and rescue teams, but also to stop the spread of fire as a result of conduction and convection through exposed pipes, metal framing, and ventilation systems.

Ventilation

Ventilation affects both search and rescue and fire extinguishment. Coordinated ventilation may be implemented at any time during the operation, but it should be coordinated with suppression and interior rescue activities. Ventilation is used to channel and remove heated air, smoke, fire gases, and other airborne contaminants. Applying proper ventilation at the right time and place is key to firefighter and occupant safety. Venting at the wrong time or place can draw active fire toward fresh air, which will injure or kill anyone in its path. In instances of high-rise fire suppression, adequate and appropriate ventilation is important to keep stairways free of smoke and noxious gases for victims who are evacuating.

Support

As has been discussed, fire suppression in a high-rise or high-hazard structure requires the establishment of a supply chain to shuttle equipment to different locations. Additionally, with increased resources and personnel, there is an increased need for additional supervision and accountability.

One critical support variable in high-rise fire operations is the availability of reliable elevators. If firefighters can safely use the elevators to move people and equipment, fire-ground logistics may be significantly improved. When the fire is located several floors above ground level, there is a strong inclination to use the elevators. However, fire service access elevators[55] may not be available in all buildings. Therefore, adequate stairways are necessary for firefighters to transport equipment and reach the fire floor for suppression.

Moving supplies and staff up 10, 20, 30, or more stories is an arduous task. If it is not properly managed, firefighters may be exhausted and unable to fight the fire or rescue trapped occupants.

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[55] A fire service elevator is engineered to operate in a building during a fire emergency and complying with prescriptive building code requirements and the American Society of Mechanical Engineers (ASME) A 17.1 safety standard for elevators.

Additionally, joint use of stairways by firefighters moving upward and occupants attempting to evacuate may increase the overall evacuation time of the occupants, as well as delay the firefighters' efforts to begin critical tasks such as fire suppression or search and rescue operations. As such, it is important to have multiple firefighters to help carry equipment upstairs and manage resource distribution.

To accomplish the critical fireground tasks associated with high-rise firefighting and meet the minimum staffing objectives for task completion, NFPA 1710 recommends the following company sizes for the first arriving unit(s) on the scene within four minutes of travel time for response to high-hazard structure:

- In first-due response areas with a high number of incidents, geographical restrictions, geographical isolation, or urban areas, as identified by the AHJ, these companies shall be staffed by a minimum of five on-duty members.[56]

- In first-due response areas with tactical hazards, high-hazard occupancies, or dense urban areas, as identified by the AHJ, these fire companies shall be staffed with a minimum of six on-duty members.[57]

As indicated by the tasks that must be accomplished on a high-rise fireground, understanding the required resources is critical. The number of firefighters needed to safely and effectively combat a high-rise fire may be large. Although an offensive fire attack is the preferred strategy whenever conditions and resources permit, a defensive attack that limits operations to the outside of a building and generally results in more property damage must be considered when risks to firefighter safety are too great and benefits to building occupants are negligible. The offensive vs. defensive decision is based on several factors: fireground staffing available to conduct an interior attack, a sustained water supply, the ability to conduct ventilation, and risk vs. benefit analysis regarding firefighter and occupant safety. Table 6, on the next page, displays the minimum number of firefighters required to arrive in the first full alarm assignment to a high-rise fire.

[56] NFPA 1710. §5.2.3.1.2 and §5.2.3.2.2
[57] NFPA 1710. §5.2.3.1.2.1 and §5.2.3.2.2.1.

Assignment	***Required Personnel***
Incident Command	1 Incident Commander 1 Incident Command Aide
Uninterrupted Water Supply	1 Building Fire Pump Observer 1 Fire Engine Operator
Water Flow from Two Handlines on the Involved Floor	4 Firefighters (2 for each line)
Water Flow from One Handline One Floor Above the Involved Floor	2 Firefighters (1 for each line)
Rapid Intervention Crew (RIC) Two Floors Below the Involved Floor	4 Firefighters
Victim Search and Rescue Team	4 Firefighters (2 per team)
Point of Entry/Oversight Fire Floor	1 Officer 1 Officer's Aide
Point of Entry/Oversight Floor Above	1 Officer 1 Officer's Aide
Evacuation Management Teams	4 Firefighters (2 per team)
Elevator Management	1 Firefighter
Lobby Operations Officer	1 Officer
Trained Incident Safety Officer	1 Officer
Staging Officer Two Floors Below Involved Floor	1 Officer
Equipment Transport to Floor Below Involved Floor	2 Firefighters
Firefighter Rehabilitation	2 Firefighters (1 must be ALS)
Vertical Ventilation Crew	1 Officer 3 Firefighters
External Base Operations	1 Officer
2 EMS ALS Transport Units	4 Firefighters
Required Minimum Personnel for Full Alarm	**36 Firefighters** **1 Incident Commander** **6 Officers**

Table 6: Number of Firefighters for an Initial Full Alarm to a High-Rise Fire. Fighting fire in high-rise structures poses many unique obstacles and challenges other than are found in a residential structure fire. Hose cannot be deployed directly from fire apparatus and needs to be carried, with other equipment, to the location of the fire. Search and rescue is impacted by large areas and accessibility concerns. Additionally, because of delays in access, firefighters are likely to encounter a high volume of fire which will necessitate a supply chain to equip ongoing suppression efforts. A single alarm response to a high-rise building minimally requires 43 responders, consisting of 36 firefighters, 1 incident commander, and 6 officers.

Fire Department EMS Operations

In recent years, the provision of emergency medical services has progressed from an amenity to a citizen-required service. More than 90% of career and combination fire departments provide some form of emergency medical care, making fire departments the largest group of prehospital EMS providers in North America. In many fire departments that deliver prehospital care, EMS calls can equate to over 75% of total call volume.

There are six main components of an EMS incident from start to finish.[58] These are (1) detection of the incident, (2) reporting of the incident to a 9-1-1 center, (3) response to the incident by the appropriate emergency resources, (4) on scene care by emergency response personnel, (5) care by emergency personnel while in transit to a medical care facility, and (6) transfer of the patient from emergency response personnel to the medical care facility. Not all EMS events will necessitate all six components, as when a patient refuses treatment, or is treated at the scene and not transported.

In an analysis of data from over 300 fire departments in the United States, first responder units, which are typically fire engines, arrived prior to ambulances approximately 80% of the time.[59] This is likely due to the fact that fire stations housing first responder units, which are equipped and staffed with dual-role firefighter/emergency medical service technicians and supplies, are more centrally located and are able to effect a quicker response and provide life-saving procedures in advance of an ambulance. This reinforces why it is in the best interest of the public good for the fire department to provide EMS transport as well as first response.

The benefit of supporting EMS transport within fire department operations is that fire departments are already geared towards rapid response and rapid intervention. Strategically located stations and personnel are positioned to deliver time critical response and effective fire suppression and are therefore equally situated to provide effective response to time critical requests for EMS service. Both fire suppression and EMS response are required by industry standards to have adequate personnel and resources operating on scene within 4 minutes. In both fire suppression and EMS incidents, time is directly related to the amount of damage, either to the structure or the patient.

When ambulance response is prolonged, a patient will be further delayed in reaching a medical facility to receive definitive care. This is especially dangerous for incidents of chest pain, stroke,

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[58] The Star of Life, designated by Leo R. Schwartz, Chief of EMS Branch, National Highway Traffic Safety Administration (NHTSA) in 1997.
[59] Moore-Merrell, L. et al. (2010) Report on Residential EMS Field Experiments, Fire Fighter Safety and Deployment Study; Washington, DC, September 2010.

and survivable cardiac arrest. Many times, patients experiencing symptoms associated with these events may not recognize the onset indicators and immediately call for assistance.[60] [61] [62] [63] Acute Coronary Syndrome (ACS), or heart attack, is the number one leading cause of death in the United States. Experts agree that an ACS event should receive definitive care from a hospital within one hour of onset of symptoms. One study found that definitive care for ACS within one hour of onset improves survivability by 50% and 23% if definitive care was given within 3 hours.[64]

Strokes, which are the number three cause of death in the U.S., as well as a leading cause of disability, also benefit from expedient treatment in definitive care. Ischemic stroke, which is a stroke caused from a blood clot, can be effectively treated if definitive care is received within 3 to 4.5 hours[65] of onset of symptoms. The sooner a patient receives definitive treatment from onset of symptoms, the less likely a patient is to suffer disability from this type of stroke. However, it is important to emphasize that before the time critical treatment can be administered to the patient in the hospital, there is a time intensive assessment that must be performed to ensure the patient is qualified to receive the treatment. The current benchmark for an ischemic stroke patient "door to needle"[66] is less than or equal to 60 minutes. However, Steps Against Recurrent Stroke (STARS) registry shows that the median door to needle time is 96 minutes or 1 hour and 36 minutes.[67]

In two-tiered EMS systems that deploy with sufficient resources, there is an increased likelihood that a patient will receive an ambulance and a first responding fire apparatus in not only a timely manner, but also frequently at the same, or close to the same time. This is extremely beneficial to the patient as most EMS responses, particularly the previously mentioned conditions, are labor intensive. Patients suffering from ACS should not perform any form of exertion as to minimize any damage that is occurring. Patients suffering from strokes are frequently unable to exert due to physical disabilities caused by the incident. An adequately sized crew is able to provide simultaneous interventions while assessment is being performed, thereby reducing the on-scene

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[60]American Heart Association, *Heart Disease and Stroke Statistics-2005 update,* Dallas, TX: AHA 2005

[61] Time from Symptom Onset to treatment and outcomes after thrombolytic therapy. Newby LK, et al. *J Am Coll Cardiol.* 1996:27:1646-1655

[62] An International Perspective on the Time to Treatment of Acute Myocardial Infarction. Dracup, K. et al. *J Nurs Scholarsh* 2003;35:317-323

[63] Prehospital and In-hospital Delays in Acute Stroke Care. Evanson, KR, et al. *Neuroepidemiology* 2001;20:65-76

[64] Association of patient delays with symptoms, cardiac enzymes, and outcomes in acute myocardial infarction. Rawles, JM. Et al. *Eur Heart J.* 1990; 11:643-648.

[65] Thrombolysis with Alteplase 3 to 4.5 Hours after Acute Ischemic Stroke. Hacke, W. et al. *N Engl J Med*. 2008;359:1317-1329

[66] "Door to Needle" is an industry specific term that refers to the time the patient entered the emergency department to the time the received the treatment. A drug named recombinant tissue plasminogen activator (rt-PA) is utilized to dissolve the thrombosis causing the stroke. Current FDA approvals limit this drug's use to 3-4.5 hours from initial symptoms and require a CT scan and labs before administration.

[67] Improving Door-to-Needle Times in Acute Ischemic Stroke: The Design and Rational for the American Heart Association/American Stroke Association's Target: Stroke Initiative. Fonarow, Gregg, et al. *Stroke* 2011;42:00-00

time. Following completion of critical tasks, the crew can then facilitate a safe removal of the patient to the ambulance and minimize the risk of injury to patient and provider.[68]

One of the most labor intensive and time critical requests for EMS response is cardiac arrest, which globally affects 20-140 out of every 100,000 people. Traditionally, the American Heart Association (AHA) taught a method of cardiac resuscitation that involved single rescuer performance of prioritized action.[69] However, there was a gap between instruction and practice which led to confusion and may have potentially reduced survival. In reality, providers respond and function in teams larger than two.

The AHA's guidelines for cardiac resuscitation focus on a team-centric approach. Evidence-based research suggested that the manner in which CPR was being performed was inherently inefficient and only provided 10-30% of the normal blood flow to the heart and 30-40% to the brain.[70] [71] This was linked to provider fatigue from administering chest compressions, and as such, these studies indicate that providers should be rotated to ensure effective depth and rhythm of chest compressions. Consensus documents from the AHA recommend that providers should rotate with every two-minute cycle of CPR. It is also recommended that requests for EMS service for cardiac arrest also have a team leader to organize priorities and direct resources as they arrive or are needed. The team leader would also be responsible for identifying symptoms of fatigue and making appropriate assignment adjustments to ensure maximally efficient CPR.

Although the AHA and other researchers have not identified what an optimally sized crew for effective team-centric CPR should be, some consensus literature from AHA has mentioned that five providers were best suited to perform resuscitation. However, providers may be required to perform multiple tasks. Industry best practices, through the guidance of Medical Directors, have suggested six providers would be most successful in minimizing confusion and redundancy.

An EMS crew consisting of six personnel would require four personnel arriving with the first responding fire apparatus and two with the ambulance.[72] For an all-ALS system, two of the six should be Paramedics, with a minimum of one assigned to each of the responding apparatus. Some ALS systems require two Paramedics on the ambulance and a minimum of one on the first responding fire apparatus. However, these deployment options are determined by State directive

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[68] Moore-Merrell, L. et al. (2010) Report on Residential EMS Field Experiments, Fire Fighter Safety and Deployment Study; Washington, DC, September 2010.
[69] Highlights of the 2010 American Heart Association Guidelines for CPR and ECC
[70] Determinants of Blood Flow during Cardiac Resuscitation in Dogs. Halperin, HR et al. *Circulation* 1986;73:539-550
[71] Increased Cortical Cerebral Blood Flow with LUCAS, a New Device for Mechanical Chest Compressions Compared to Standard External Compressions during Experimental Cardiopulmonary Resuscitation. Rubertson S, et al. *Resuscitation*. 2005;65:357-363
[72] NFPA 1917: Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments

or Medical Director's discretion. Regardless of the make-up of the EMS certification level of the providers on scene, an ALS integrated cardiac arrest response should provide for the following: a lead provider, an airway manager, two providers to interchangeably deliver chest compressions, a provider to establish an intravenous medication line and administer medications, and a provider to operate the monitor.

Fire Department Deployment

Before discussing the staffing and deployment analysis of Central Metro Fire and Rescue resources, it is imperative to understand the intricacies of distribution and concentration.

The Importance of Adequate Resources: Distribution

Distribution involves locating geographically distributed, ideal first-due resources for all-risk initial intervention. Distribution describes first due arrival. Station locations are needed to assure rapid deployment for optimal response to routine emergencies within the response jurisdiction. Distribution can be evaluated by the percentage of the jurisdiction covered by the first-due units within adopted public policy service level objectives.[73] In this case, distribution is measured by the percentage of roads that are covered from each fire station within four-[74], six-[75], eight-minute[76] and 10-minutes and 10-seconds[77] travel times to adhere to NFPA 1710, 2020 edition. Four minutes of travel time is the allowable maximum travel time for the first arriving apparatus at the scene of a fire, first responding unit to an EMS incident, and BLS ambulance if there is not a first responding unit already on the scene.

Distribution study requires geographical analysis of first due resources. Distribution measures may include:[78]

- Population per first-due company
- Area served per first-due company (square miles)
- Number of total road miles per first-due company (miles)
- Dwelling unit square footage per first-due company

[73] Commission on Fire Accreditation International, 5th Edition. 2008. Page 52.
[74] Four minutes of travel time is the allowable maximum travel time for the first arriving apparatus at the scene of a fire, first responding unit to an EMS incident, and BLS ambulance if there is not a first responding unit already on the scene.
[75] Six minutes of travel time is the maximum amount of travel time permitted for the second arriving apparatus. Although not explicitly stated, it is recommended that this apparatus be the ladder truck or a company that will be assigned to ladder duties.
[76] Eight minutes of travel time is the maximum amount of travel time permitted for a low- and medium-hazard alarm assignment and the arrival of an ALS resource, assuming a BLS unit is already on the scene within 4 minutes of travel time.
[77] Ten minutes and ten seconds of travel time is the maximum amount of travel time permitted for a high-hazard alarm assignment.
[78] Commission on Fire Accreditation International, 5th Edition. 2008. Page 52.

- Maximum travel time in each first-due company's protection area

- Catchment areas (4-minute road response from all fire stations) to determine gap areas and overlaps of first-due resources

- Areas outside of actual performance
    - Population not served
    - Area not served (square miles)
    - Road miles not served (miles)
    - Dwelling unit square footage not served

- First-due unit arrival times (Engine, Truck, ALS unit, etc.)

A major item to be considered in the distribution of resources is travel time. It should be a matter of public policy that the distribution of fire stations in the community is based on the element of travel time and the response goal. Travel time should be periodically sampled and analyzed to determine whether the fire department is achieving a reasonable response performance to handle emergencies.[79]

Evaluating a small number of incidents for response time performance also does not reflect the true performance of the department. Analyzing tens of thousands of incidents measured over 3-5 years will provide a more accurate assessment of the delivery system performance. Completing the same analysis over a period will allow for trend analysis as well.[80]

Distribution strives for an equitable level of outcome: everyone in the community is within the same distance from a fire station. Distribution is based on the probability that all areas experience equal service demands, but not necessarily the same risk or consequences as those demands for service in other areas. For example, suburban communities in a jurisdiction may have the same service demand as an industrial factory area, but the level of risk is very different. This can have an impact on fire station locations as placement would probably put the stations near high risk areas to provide shorter travel times. Additionally, EMS response times based on medical emergencies will drive equal distribution in the community and negate distribution based on risk, as the risk is equal.

[79] Commission on Fire Accreditation International, 5th Edition. 2008. Page 53.
[80] Ibid.

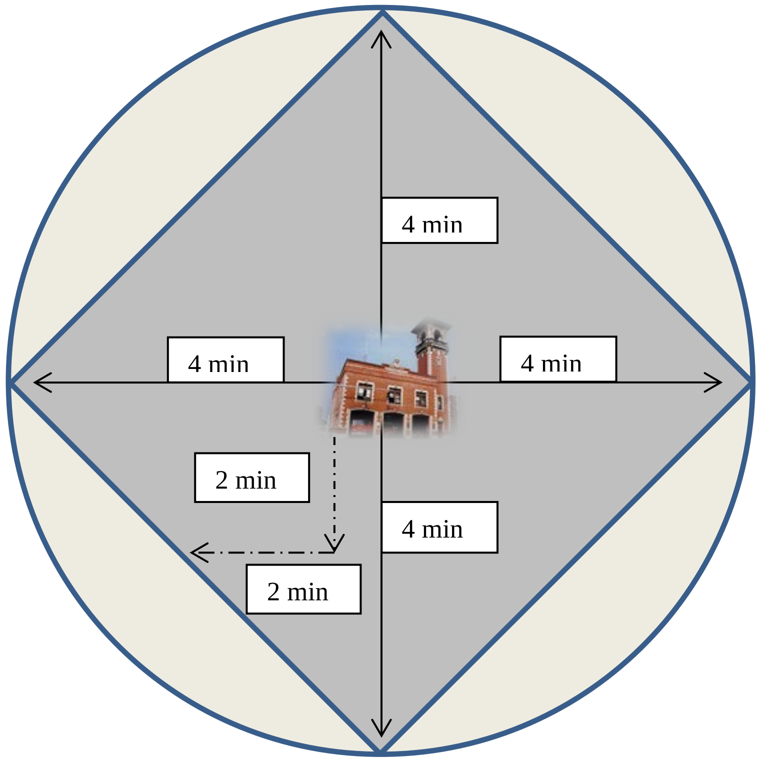


Figure 5: Normal Distribution Model for an Initial 4-Minute Response Area.[81] As depicted in the above figure, fire stations and emergency resources should be distributed throughout a community so that citizens receive equitable coverage and protection. However, there are additional points of concern when modeling a response district such as road network, traffic patterns, and building occupancies.

First unit arrival times are the best measure of distribution. It should be noted that if an area experiences fire unit arrival times outside the adopted performance measure, in this case 4-minute travel time per NFPA 1710, it does not necessarily mean it has a distribution issue.[82] Other issues occur such as reliability, call processing times and turnout times, and traffic which can affect the overall performance of response times.

An effective response force for a fire department is impacted not only by the spacing of fire stations but also by the type and amount of apparatus and personnel staffing the stations. To assemble the necessary apparatus, personnel, and equipment within the prescribed timeframe, all must be close enough to travel to the incident, if available upon dispatch. The placement and spacing of specialty equipment is always challenging.[83] Specialty units tend to be trucks, rescue units, hazmat, or battalion personnel. Most often there are less of these types of equipment and personnel compared to the first-line response of engines and medic units. Selecting where to put specialty units requires extensive examination of current and future operations within the fire

[81] Derived from Commission on Fire Accreditation International, 5th Edition. 2008. Page 53
[82] Commission on Fire Accreditation International, 5th Edition. 2008. Page 55
[83] Commission on Fire Accreditation International, 5th Edition. 2008. Page 62

department and a set goal of response time objectives for all-hazards emergencies within a jurisdiction.

Distribution vs. Concentration

Major fires have a significant impact on the resource allocation of any fire department. The dilemma for any fire department is staffing for routine emergencies and also being prepared for the fire or emergency of maximum effort. This balancing of distribution and concentration staffing needs is one that almost all fire agencies face on an ongoing basis.

The art in concentration spacing is to strike a balance with respect as to how much overlap there should be between station areas. Some overlap is necessary to maintain good response times and to provide back-up for distribution when the first-due unit is unavailable for service or deployed on a prior emergency.

Concentration pushes and pulls distribution. Each agency, *after risk assessment and critical task analysis,* must be able to quantify and articulate why its resource allocation methodology meets the governing body's adopted policies for initial effective intervention on both a first-due and multiple-unit basis.[84]

[84] Commission on Fire Accreditation International, 5th Edition. 2008. Pages 62-63

Mapping Analysis of Central Metro Fire and Rescue

In creating this document, it was important to ascertain where stations are located and if they are located to provide fair and equitable coverage to the citizens. In order to make this assessment, the IAFF created maps of the department's response area and plotted the fire stations. Computer modeling was then used to determine the distance apparatus could travel in four-, six-, eight-, and 10-minutes and 10-seconds.

Travel times were modeled using ESRI ArcGIS Pro version 2.6. Fire stations were identified on Geographic Information System (GIS) maps as starting points with vehicles traveling at road speeds based on historic traffic conditions.

Prior to drawing conclusions from the mapping analysis, the following assumptions should be considered:

- Modeled travel speeds are based on reasonable and prudent historical traffic speeds occurring on Wednesday at 5:00 pm.[85] Actual response speeds may be slower, and the associated travel times greater, with any unpredictable impedances including, but not limited to:
    - Traffic Incidents: Collisions and vehicle breakdowns causing lane blockages and driver distractions.
    - Work Zones: Construction and maintenance activity that can cause added travel time in locations and times where congestion is not normally present.
    - Weather: Reduced visibility--road surface problems and uncertain waiting conditions result in extra travel time and altered trip patterns.
    - Special Events: Demand may change due to identifiable and predictable causes.
    - Traffic Control Devices: Poorly timed or inoperable traffic signals, railroad grade crossings, speed control systems, and traveler information signs contribute to irregularities in travel time.

[85] Historical traffic data contained in ESRI's StreetMap Premium, Version 19.3.

- Inadequate Road or Transit Capacity: The interaction of capacity problems with the aforementioned sources causes travel time to expand much faster than demand.[86]

In addition, it is reasonable to suggest that because larger emergency vehicles are generally more cumbersome and require greater skill to maneuver, their response may be more negatively affected by their weight, size, and in some cases, inability to travel narrow surface streets.

As discussed, computer modeling only considers travel time of apparatus. Decision makers should understand that once apparatus and personnel arrive on the incident scene there are other essential tasks that must be completed which require additional time before access, rescue, and suppression can take place. Tasks such as establishing a water supply, forcible entry (access), and deployment of an attack line are not considered in the computer modeling. Other additional factors include:

- The time from arrival of the apparatus to the onset of interior fire operations (access interval) must be considered when analyzing response system capabilities.

    - The access interval is dependent upon factors such as distance from the apparatus to the task location and the elevation of the incident and locked doors or security bars which must be breached.

    - Impediments like these may add to the delay between discovery of a fire and the initiation of an actual fire attack.

- The reliability of a community's hydrant system to supply water to fire apparatus.

- Weather conditions

[86] David Shrank and Tim Lomax, The 2003 Urban Mobility Report, (Illinois Transportation Institute, Illinois A&M University: September 2003).

Current Staffing and Deployment

For this portion of the study, response capabilities were examined based on CMFR current staffing and deployment. Because CMFR deploy units using four different dispatch systems, CMFR experiences delays in notifying those units operating with a different dispatch system. To account for this, a two-minute response delay was applied to those units responding using a different dispatch system than the dispatch system used in the municipality where the incident occurred.[87]

The following table specifies the current locations of the 20 stations and the apparatus and staff deploying from those stations.

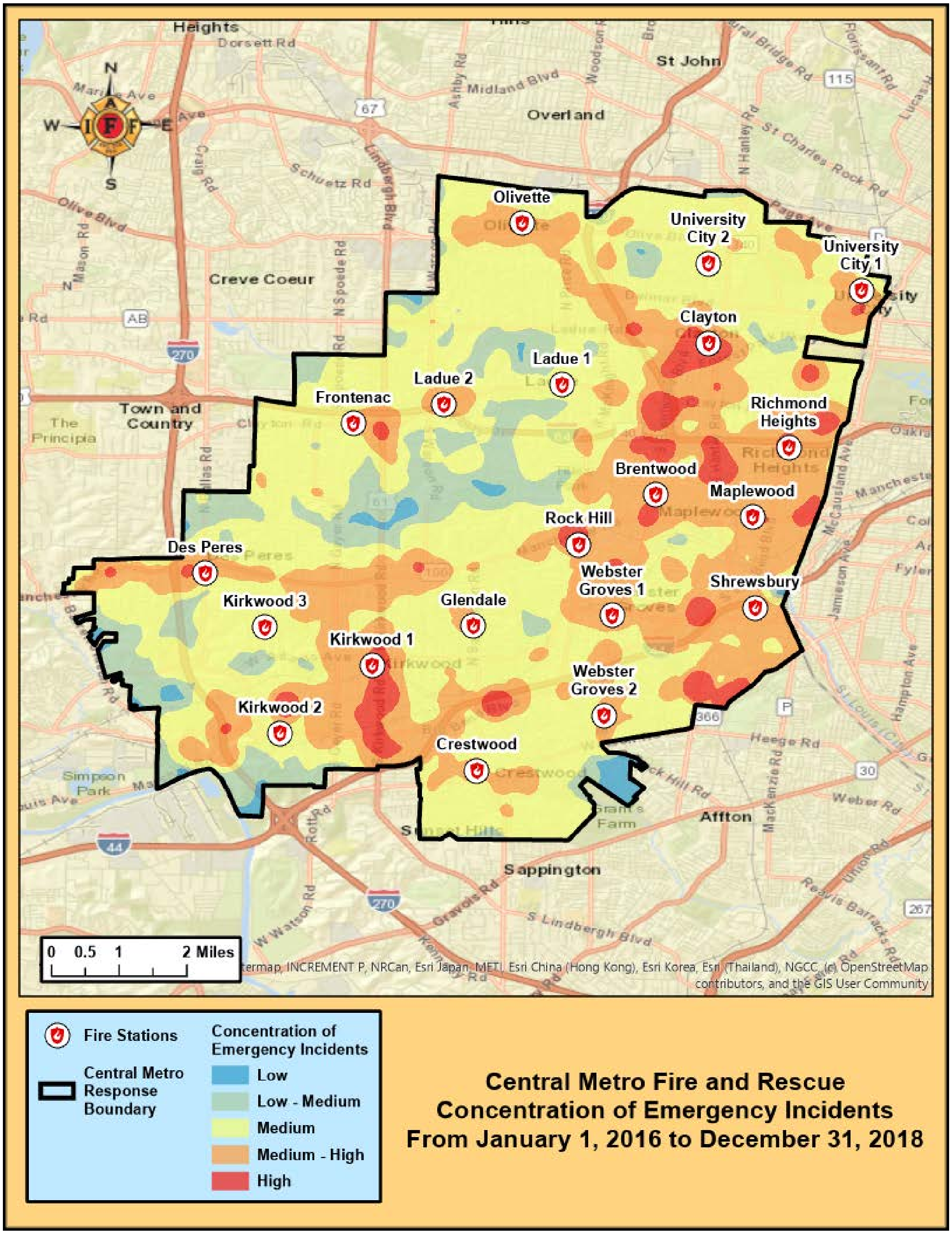
Station Name	Address	City	Apparatus	Staffing
Brentwood	8756 Eulalie Ave.	Brentwood	Engine 2514 Medic 2517	5
Clayton	10 N. Bemiston Ave.	Clayton	Engine 3214 Ladder 3212 Medic 3217 Battalion Car 3203	11
Crestwood	1 Detjen Dr.	Crestwood	Engine 1214 Rescue 1219	6
Des Peres	1000 N. Ballas Rd.	Des Peres	Engine 2814 Medic 2817	5
Frontenac	10555 Clayton Rd.	Frontenac	Engine 2914 Medic 2917	5
Glendale	424 Sappington Rd.	Glendale	Engine 1414	3
Kirkwood House 1	137 W. Argonne Dr.	Kirkwood	Engine 1514 Medic 1517	5
Kirkwood House 2	11804 Big Bend Rd.	Kirkwood	Engine 1524 Medic 1527	5
Kirkwood House 3	1321 W. Essex Ave.	Kirkwood	Ladder 1535 Medic 1537	5
Ladue House 1	9213 Clayton Rd.	Ladue	Engine 3914 Medic 3917	5
Ladue House 2	9911 Clayton Rd.	Ladue	Engine 3924	3
Maplewood	7601 Manchester Rd.	Maplewood	Engine 3114 Rescue 3116	5
Olivette	1140 Dielman Rd.	Olivette	Engine 2714 Medic 2717	5

Table 7: Current Fire Station Locations and Staffing. Table 7 displays where apparatus are housed and the current staffing levels.

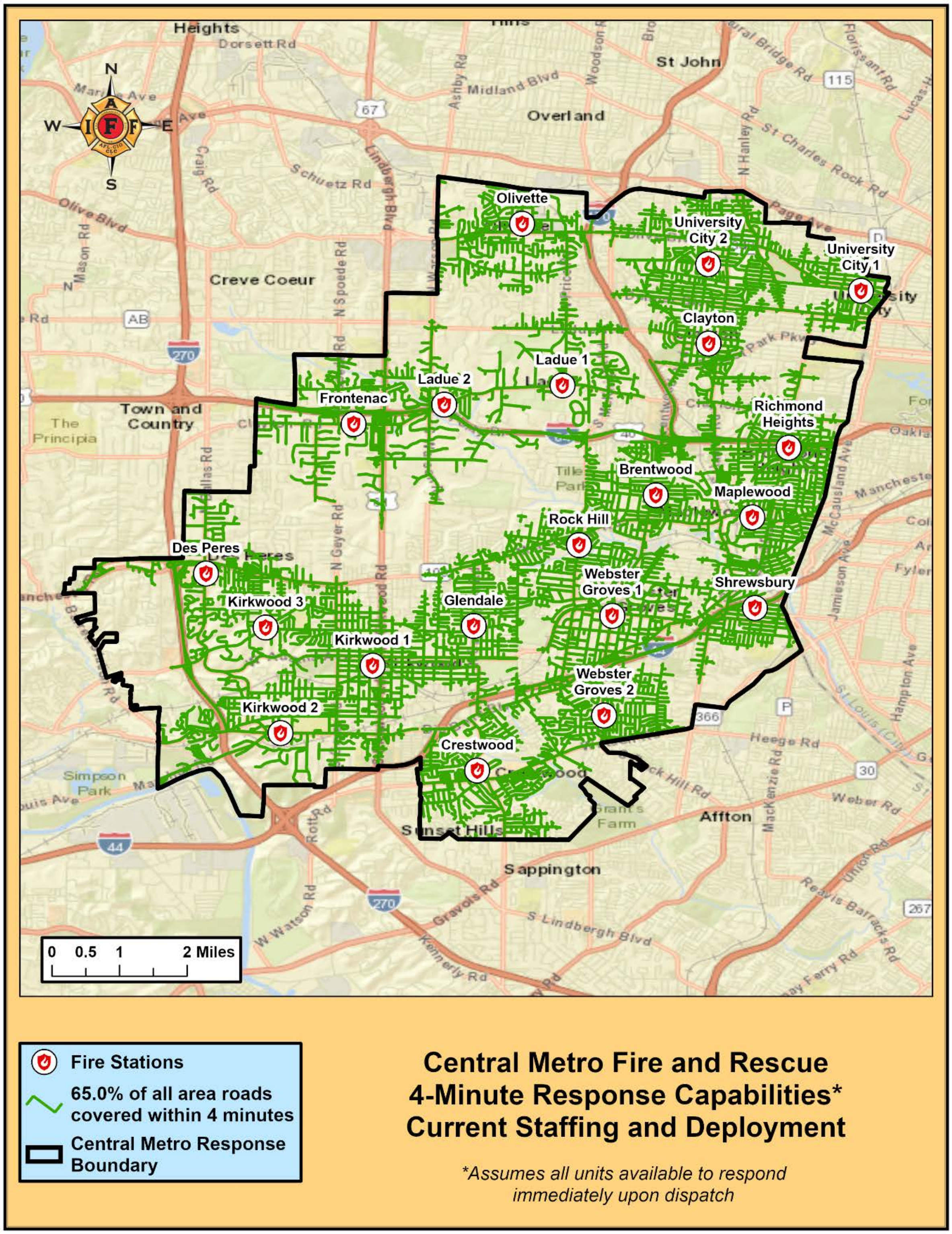
[87] Local 2665 estimates the average delay in notifying departments using a different dispatch system is two minutes.

Station Name (Continued)	Address (Continued)	City (Continued)	Apparatus (Continued)	Staffing (Continued)
Richmond Heights	7447 Dale Ave.	Richmond Heights	Engine 2114 Medic 2117 Battalion Car 2102	6
Rock Hill	827 N. Rock Hill Rd.	Rock Hill	Engine 3414	3
Shrewsbury	4400 Shrewsbury Ave.	Shrewsbury	Engine 1814 Medic 1817	5
University City House 1	863 Westgate Ave.	University City	Ladder 2615 Medic 2617 Battalion Car 2603	7
University City House 2	1043 North and South Rd.	University City	Ladder 2625 Medic 2627	6
Webster Groves House 1	6 S. Elm Ave.	Webster Groves	Ladder 2015 Medic 2017 Battalion Car 2005	7
Webster Groves House 2	1302 S. Elm Ave.	Webster Groves	Engine 2024	4

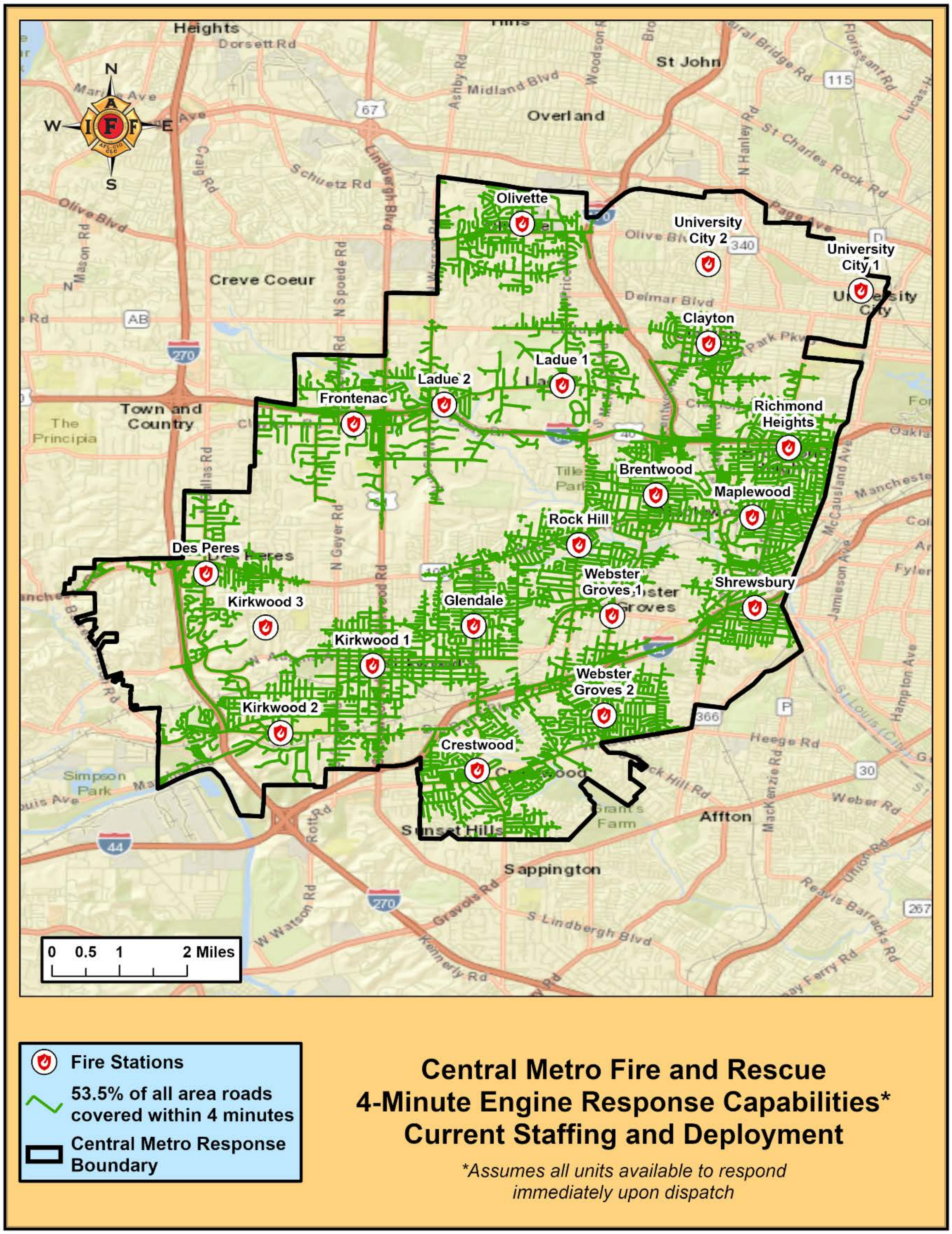
Table 7 (Continued): Current Fire Station Locations and Staffing. Table 7 displays where apparatus are housed and the current staffing levels.



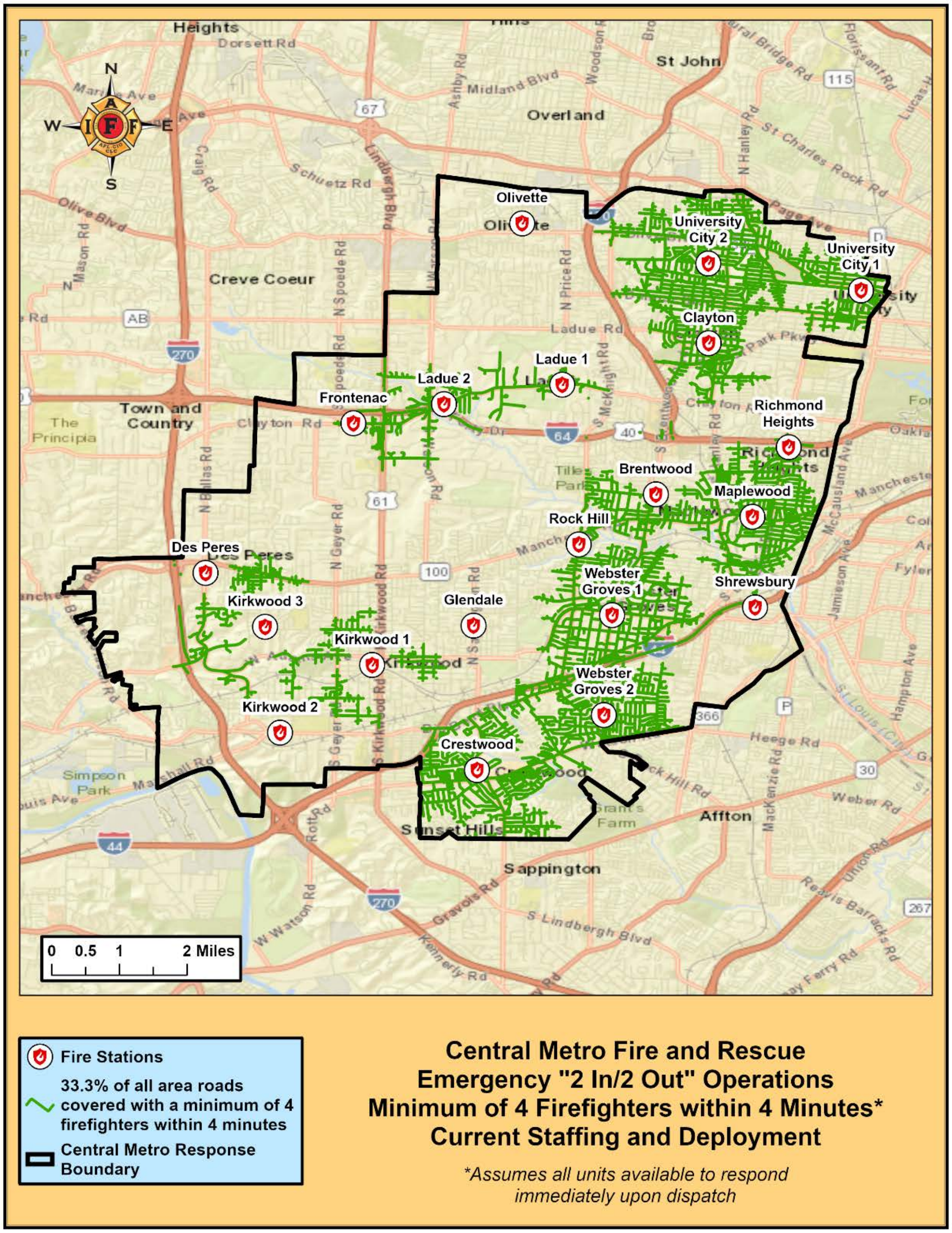
Map 15: Concentration of Emergency Incidents from January 1, 2016 to December 31, 2018. Map 15 depicts the concentration of incidents from January 1, 2016 to December 31, 2018. The highest concentration of incidents was south of Kirkwood 1, north of Brentwood and Maplewood, and near Clayton. Additional resources should be positioned at fire stations that experience a high concentration of emergency responses to ensure timely, safe, and effective response.



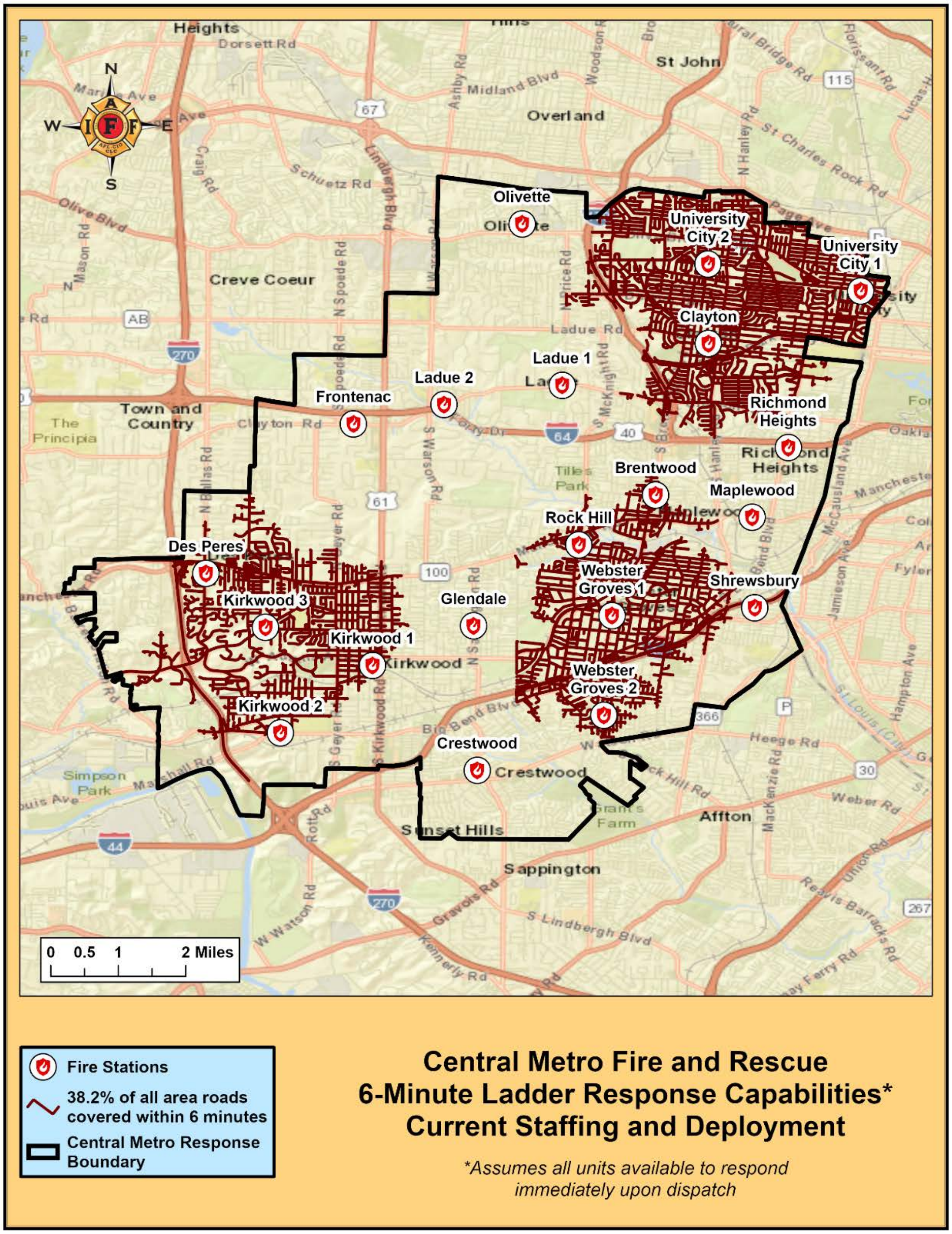
Map 16: 4-Minute Response Capabilities, Current Staffing and Deployment. Map 16 identifies the roads CMFR's companies can reach within four minutes or less of travel. Currently, the department is capable of responding on 65.0% of roads within CMFR's response boundary in four minutes or less of travel.



Map 17: 4-Minute Engine Response Capabilities, Current Staffing and Deployment. Map 17 identifies the roads CMFR's engine companies can reach within four minutes or less of travel. Currently, a minimum of one engine company can respond on 53.5% of roads within CMFR's response boundary in four minutes or less of travel.

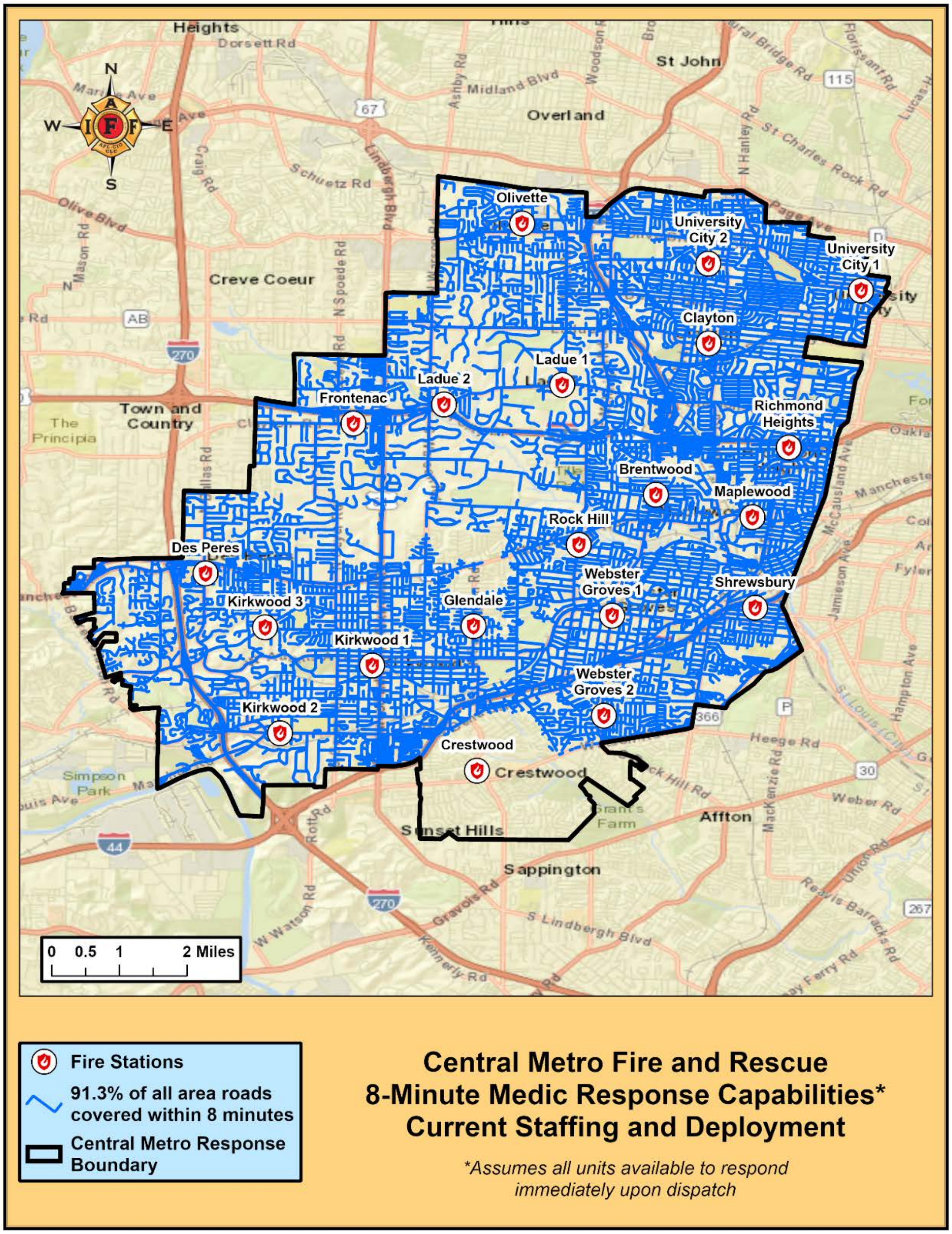


Map 18: Emergency "2 In/2 Out" Operations, Minimum of 4 Firefighters within 4 Minutes, Current Staffing and Deployment. Map 18 identifies the roads where a minimum of four firefighters can assemble on scene within four minutes or less of travel. Currently, the department is able to assemble a minimum of four firefighters on 33.3% of roads within CMFR's response boundary in four minutes or less. Because all units are not all staffed with a minimum of four, firefighters must rely on supplemental personnel arriving later before making entry into environments that are immediately dangerous to life and health, such as structure fires, in order to meet objectives outlined in industry standards and OSHA rules and regulations.



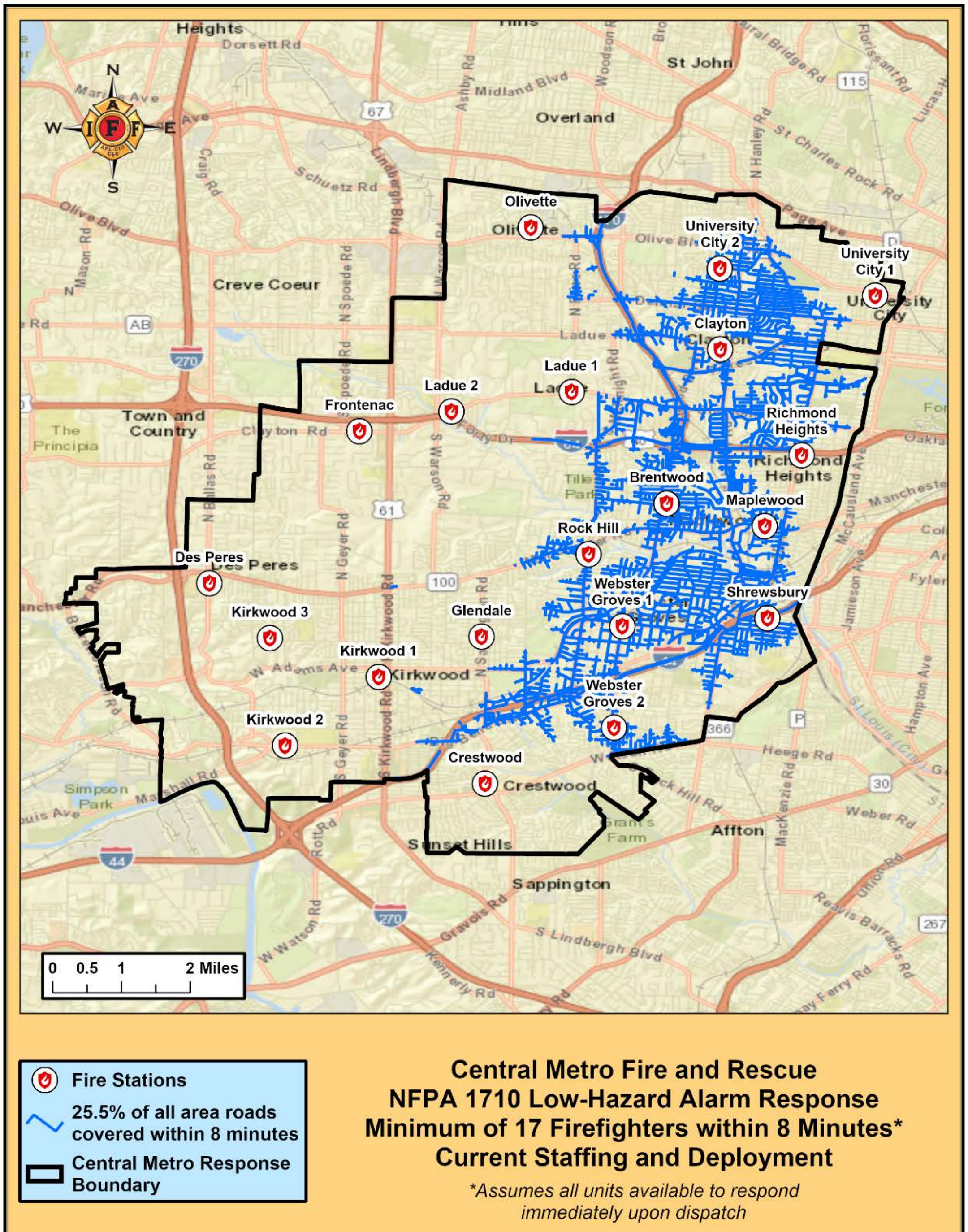
Map 19: 6-Minute Ladder Response Capabilities, Current Staffing and Deployment. Map 19 identifies the roads CMFD's ladder companies can reach within six minutes or less of travel. NFPA 1710 requires that the second-arriving apparatus be on scene within six minutes or less of travel to 90% of fire incidents.[88] IAFF recommends that the second apparatus be a ladder company. Currently, a minimum of one ladder company can respond on 38.2% of roads of within CMFR's response boundary in six minutes or less of travel.

[88] NFPA 1710 §4.1.2.1.4



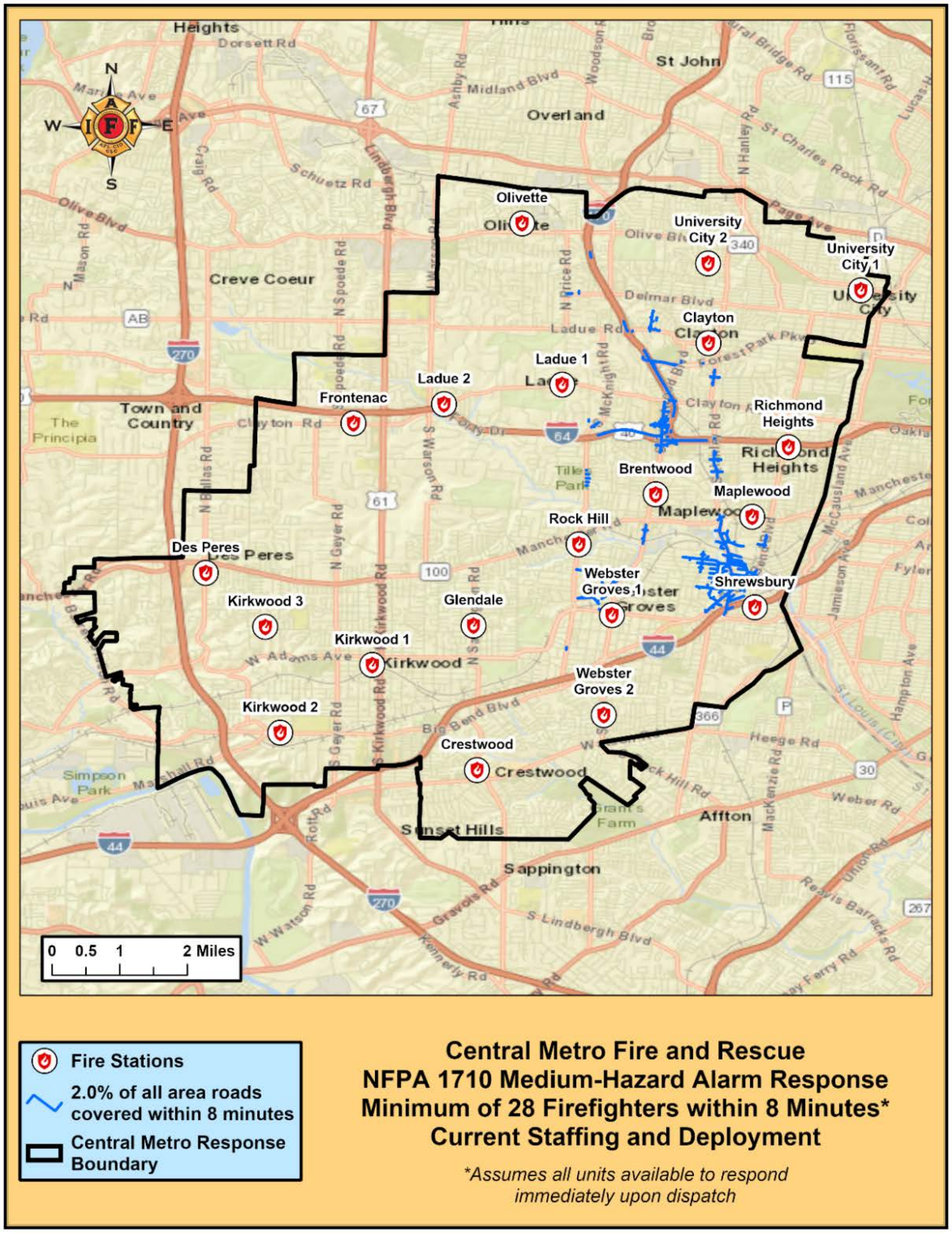
Map 20: 8-Minute Medic Response Capabilities, Current Staffing and Deployment. Map 20 identifies the roads CMFR's medic units, which are staffed and equipped to provide ALS procedures, can reach within eight minutes or less of travel. NFPA 1710 requires the arrival of an ALS equipped company within eight minutes or less of travel to 90% of incidents, provided a first responder with an AED or a BLS unit arrived in four minutes or less of travel.[89] Currently, the department is capable of providing an ALS transport unit on 91.3% of roads within CMFR's response boundary in eight minutes or less of travel.

[89] NFPA 1710 §4.1.2.1.8



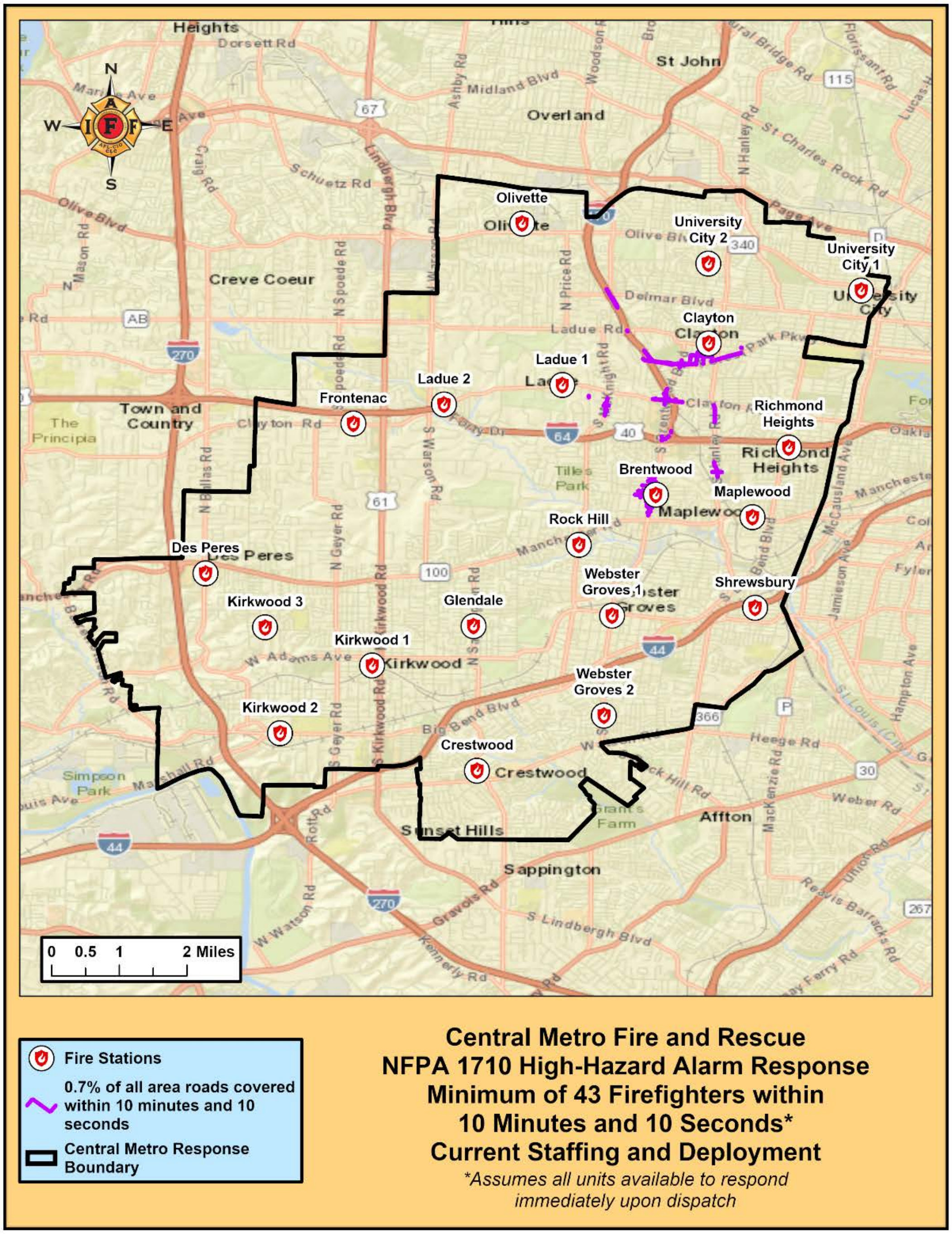
Map 21: NFPA 1710 Low-Hazard Alarm Response, Minimum of 17 Firefighters within 8 Minutes, Current Staffing and Deployment. Map 21 identifies the roads where a minimum of 17 firefighters can assemble within eight minutes or less of travel. A typical low-hazard structure is defined as a 2,000 square foot, two-story single-family dwelling without a basement and with no exposures.[90] Currently, the department can assemble a minimum of 17 firefighters within eight minutes or less of travel on 25.5% of roads within CMFR's response boundary.

[90] NFPA 1710 §5.2.4.1.1



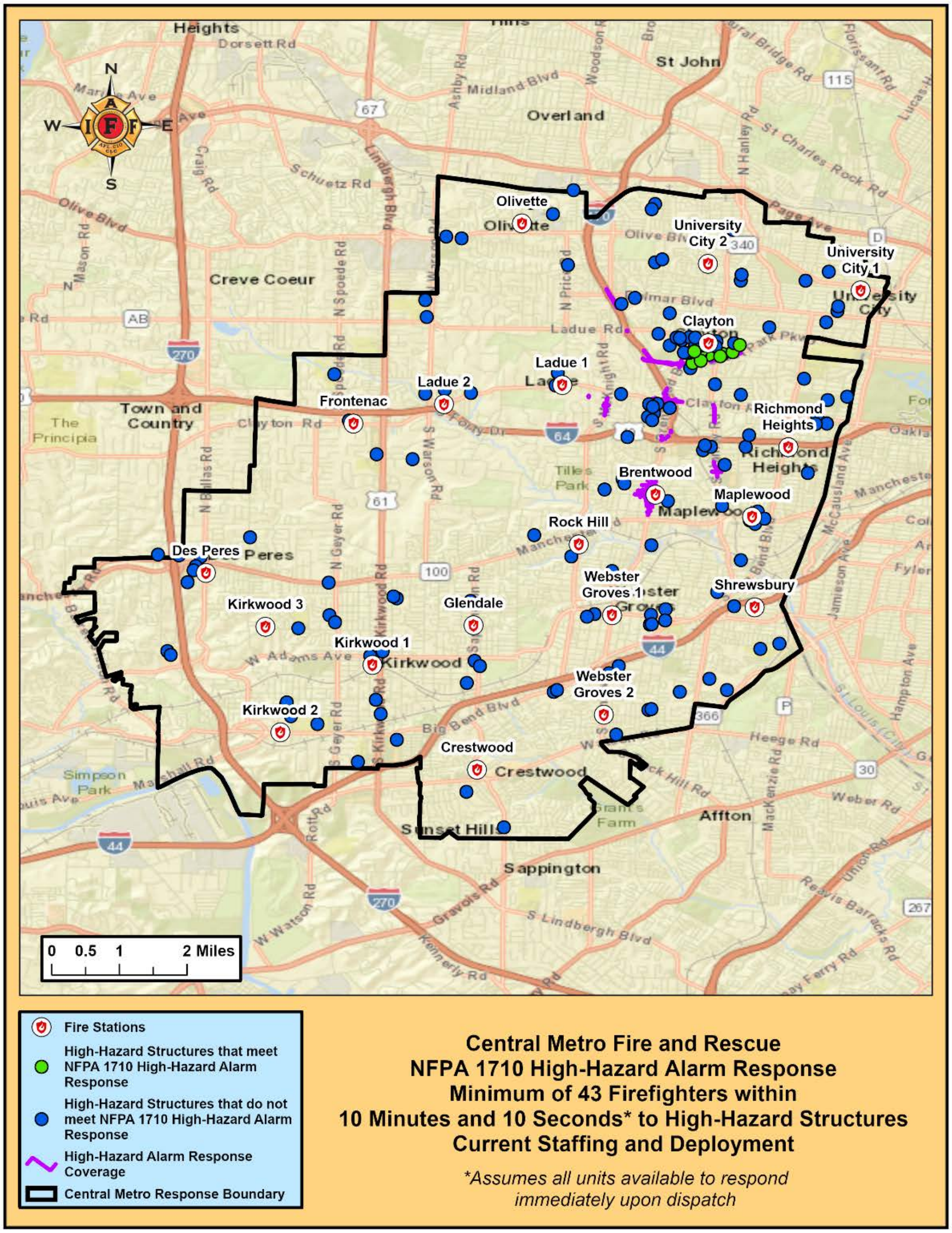
Map 22: NFPA 1710 Medium-Hazard Alarm Response, Minimum of 28 Firefighters within 8 Minutes, Current Staffing and Deployment. Map 22 identifies the roads where a minimum of 28 firefighters can assemble within eight minutes or less of travel. A typical medium-hazard structure is defined as an open-air shopping center or three-story garden-style apartment building.[91] Currently, the department can assemble a minimum of 28 firefighters within eight minutes or less of travel on 2.0% of roads within CMFR's response boundary.

[91] NFPA 1710 §5.2.4.2.1 and §5.2.4.3.1.



Map 23: NFPA 1710 High-Hazard Alarm Response, Minimum of 43 Firefighters within 10 Minutes and 10 Seconds, Current Staffing and Deployment. Map 23 identifies the roads where a minimum of 43 firefighters can assemble within 10 minutes and 10 seconds or less of travel. A typical high-hazard structure is a structure where the highest floor is greater than 75 feet above fire department vehicle access and large-area buildings such as manufacturing centers, warehouses, grocery stores, schools, and other structures with a high fire load and populations.[92] Currently, the department can assemble a minimum of 43 firefighters within 10 minutes and 10 seconds on 0.7% of roads within CMFR's response boundary.

[92] NFPA 1710 §5.2.4.4.1 and A.5.2.4.6.1



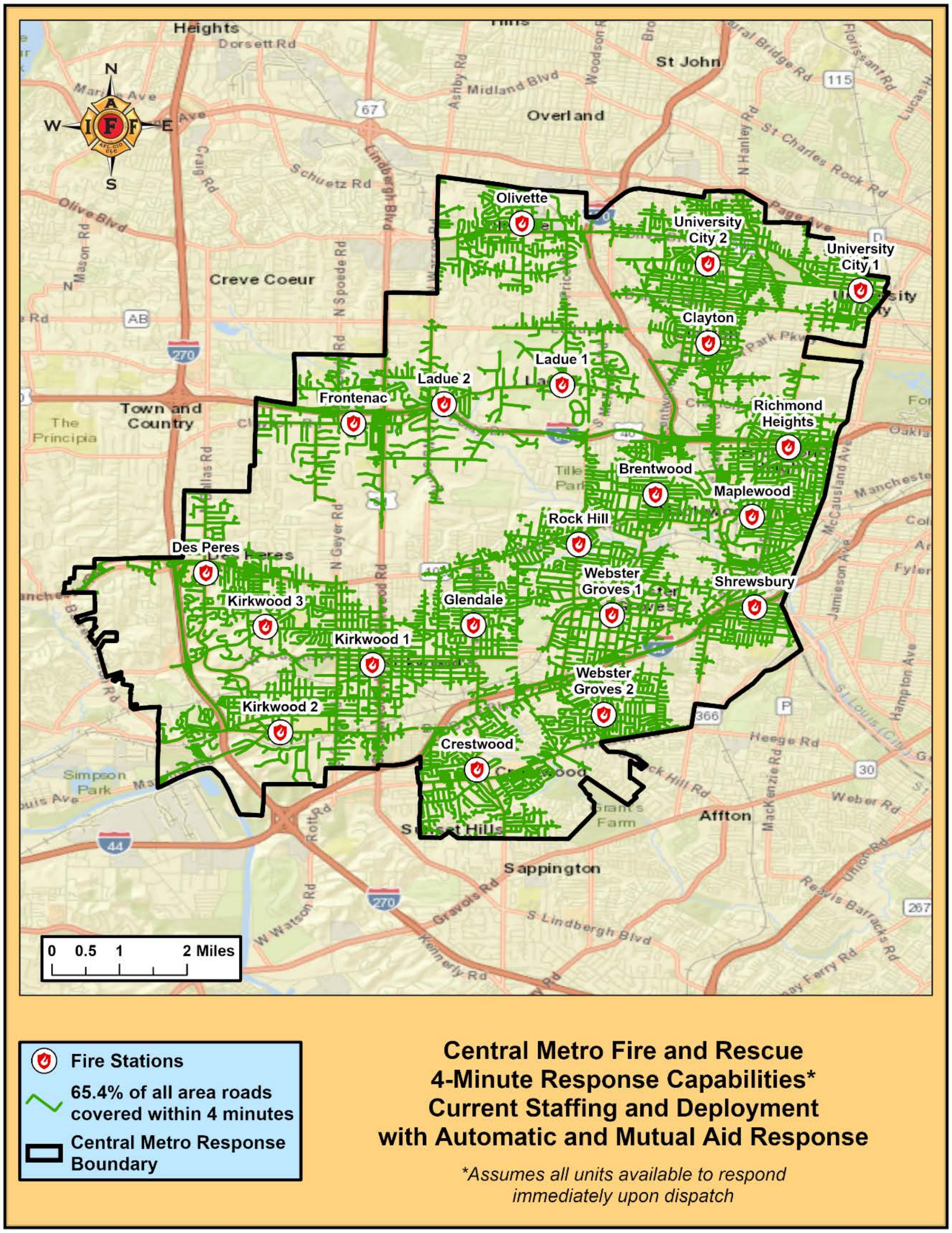
Map 24: NFPA 1710 High-Hazard Alarm Response, Minimum of 43 Firefighters within 10 Minutes and 10 Seconds to High-Hazard Structures, Current Staffing and Deployment. Map 24 identifies the high-hazard structures where a minimum of 43 firefighters can assemble within 10 minutes and 10 seconds or less of travel. Structures that are greater than 75 feet tall, square footage greater than 196,000 ft^2, schools, and hospitals were identified as high-hazard structures. Currently, the department can assemble a minimum of 43 firefighters within 10 minutes and 10 seconds on 7.2% of high-hazard structures within CMFR's response boundary.

Current Staffing and Deployment with Automatic and Mutual Aid Response

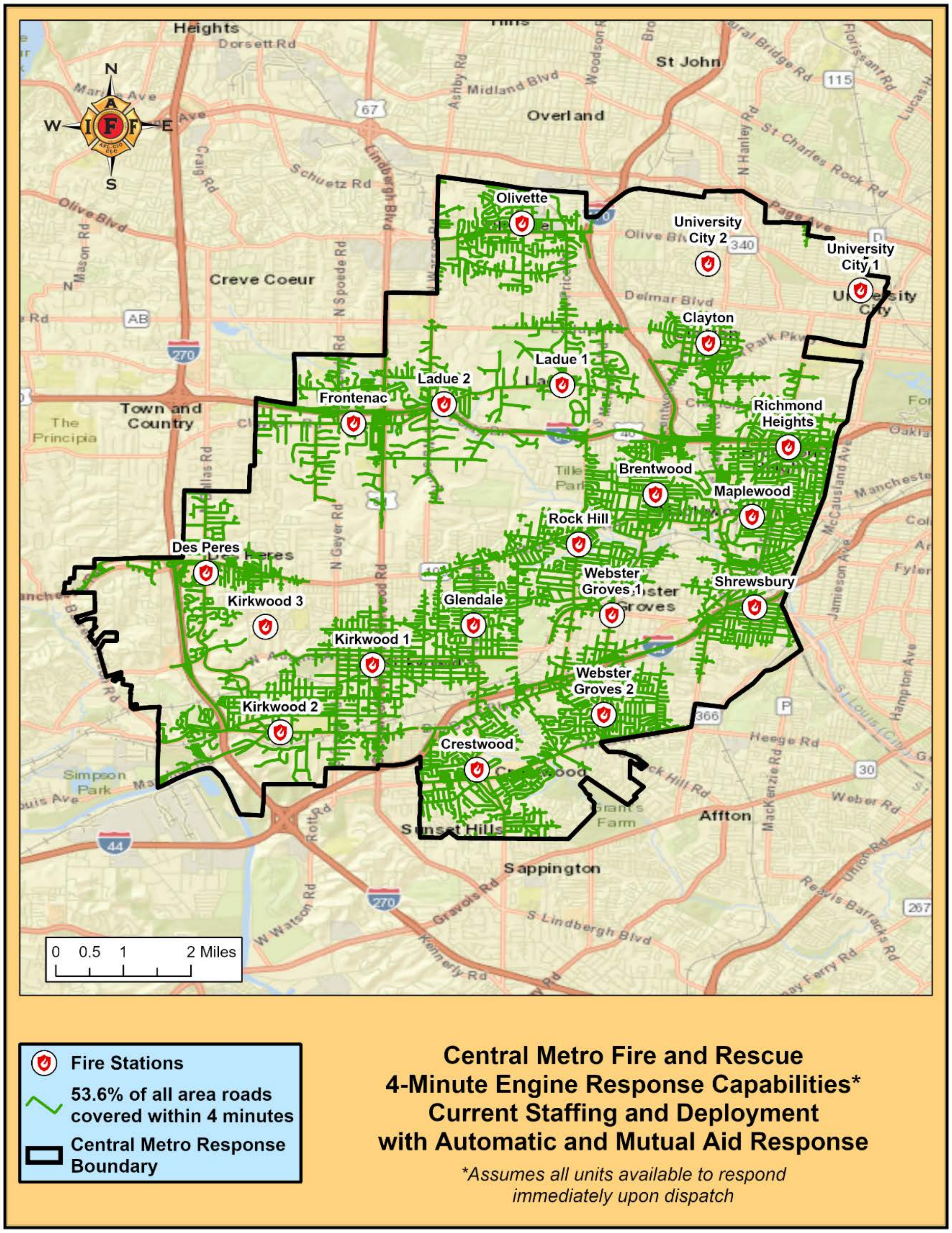
For this portion of the study, response capabilities were examined based on CMFR's current staffing and deployment with assistance from automatic and mutual aid fires departments outside of CMFR. Because CMFR and automatic and mutual aid fire departments deploy units using four different dispatch systems, CMFR experiences delays in notifying those units using a different dispatch system. To account for this, a two-minute response delay was applied to those units responding using a different dispatch system than the dispatch system used in the municipality where the incident occurred.[93]

Table 7 (p.61 – 62) list the current locations of the CMFR's stations and the apparatus and staff deploying from those stations and Appendix B: Automatic and Mutual Aid Fire Stations (p.119 - 122) list the location of the automatic and mutual aid fire stations and the apparatus and staff deploying from those stations.

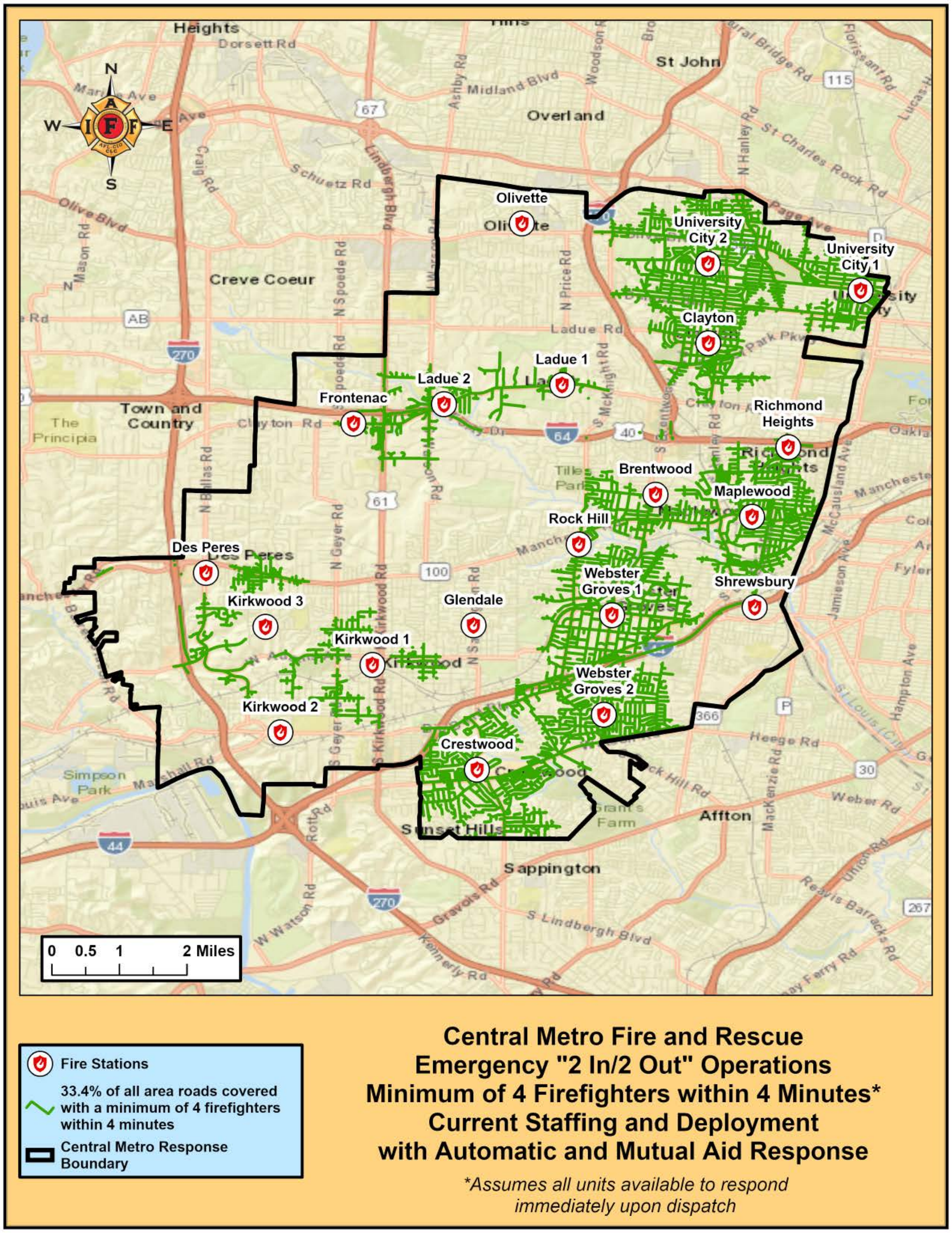
[93] Local 2665 estimates the average delay in notifying departments using a different dispatch system is two minutes.



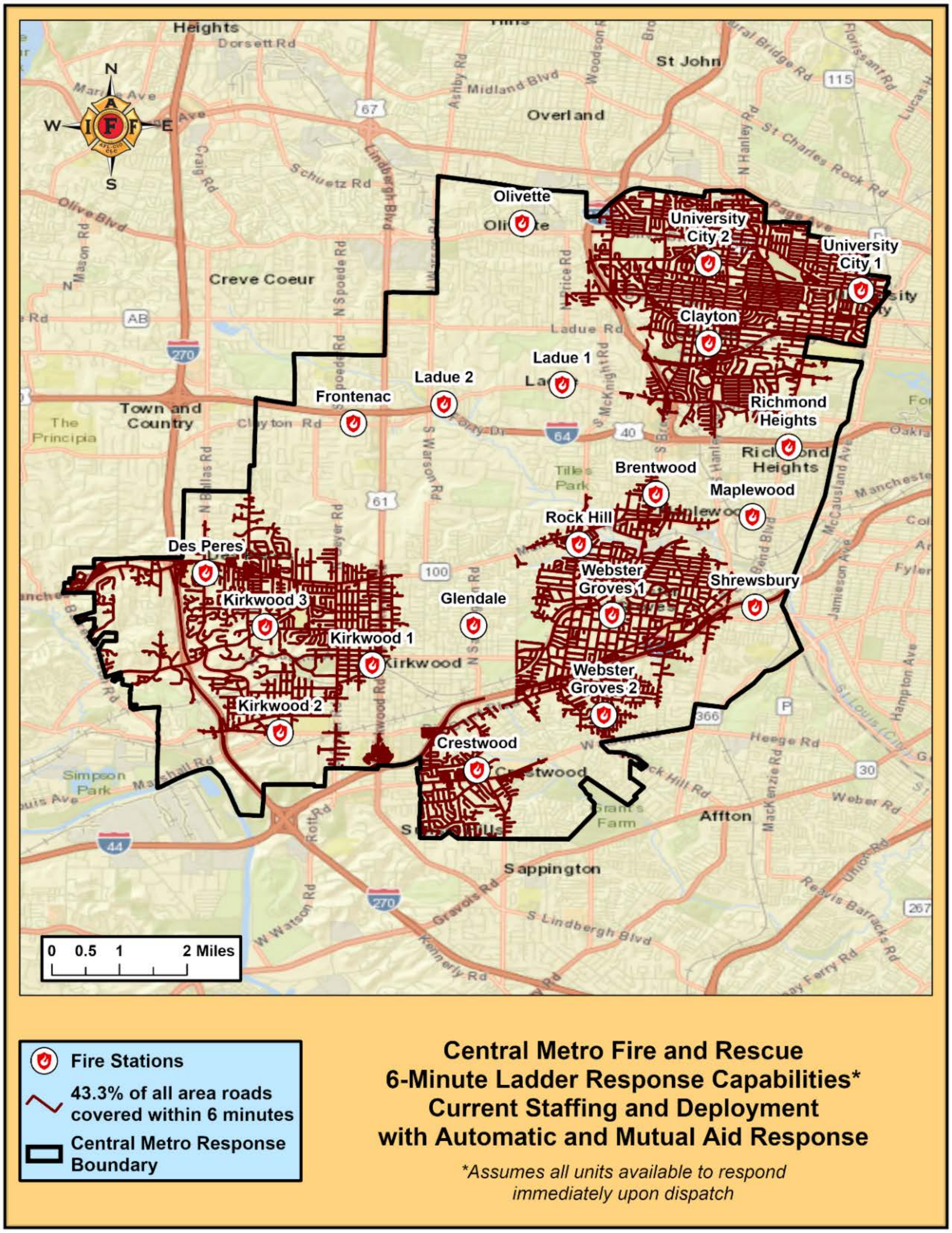
Map 25: 4-Minute Response Capabilities, Current Staffing and Deployment with Automatic/Mutual Aid Response. Map 25 identifies the roads CMFR and automatic and mutual aid fire departments can reach within four minutes or less of travel. Currently, the departments are capable of responding on 65.4% of roads within CMFR's response boundary in four minutes or less of travel.



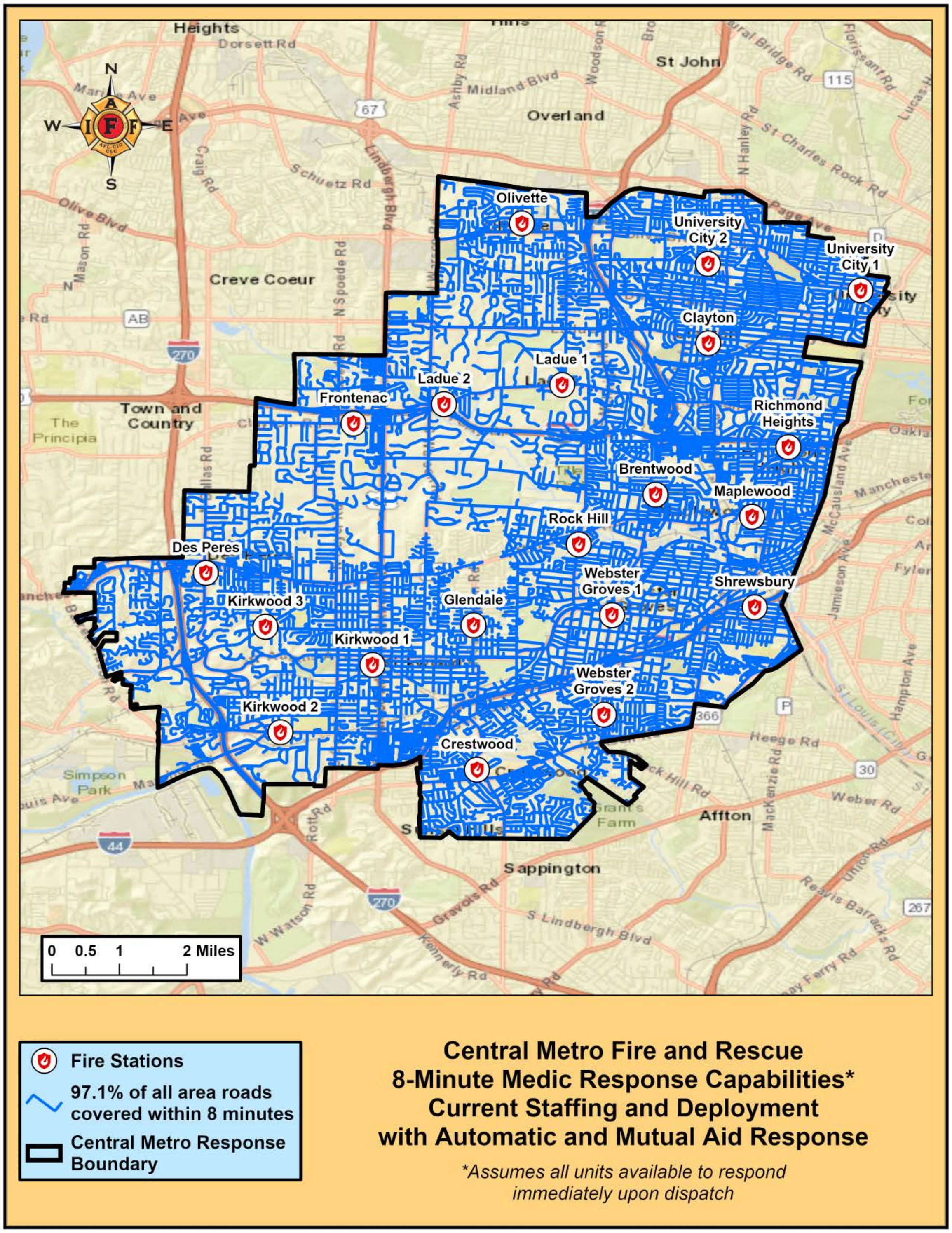
Map 26: 4-Minute Engine Response Capabilities, Current Staffing and Deployment with Automatic and Mutual Aid Response. Map 26 identifies the roads CMFR and automatic and mutual aid fire departments' engine companies can reach within four minutes or less of travel. Currently, the departments are able to respond with a minimum of one engine company on 53.6% of roads within CMFR's response boundary in four minutes or less of travel.



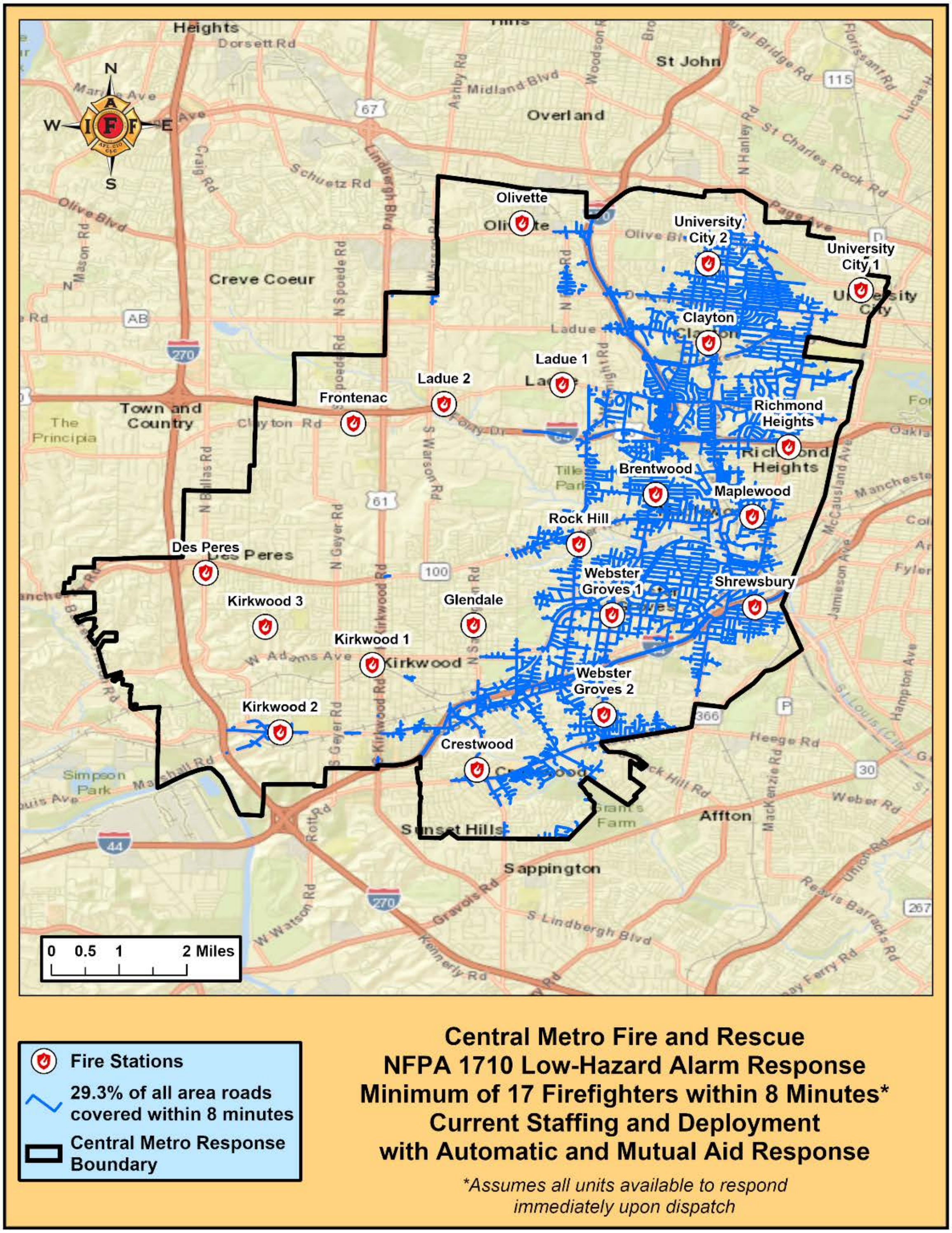
Map 27: Emergency "2 In/2 Out" Operations, Minimum of 4 Firefighters within 4 Minutes, Current Staffing and Deployment with Outside Automatic and Mutual Aid Response. Map 27 identifies the roads where CMFR and automatic and mutual aid fire departments can assemble a minimum of four firefighters on scene within four minutes or less of travel. Currently, the departments are able to assemble a minimum of four firefighters on 33.4% of roads within CMFR's response boundary in four minutes or less.



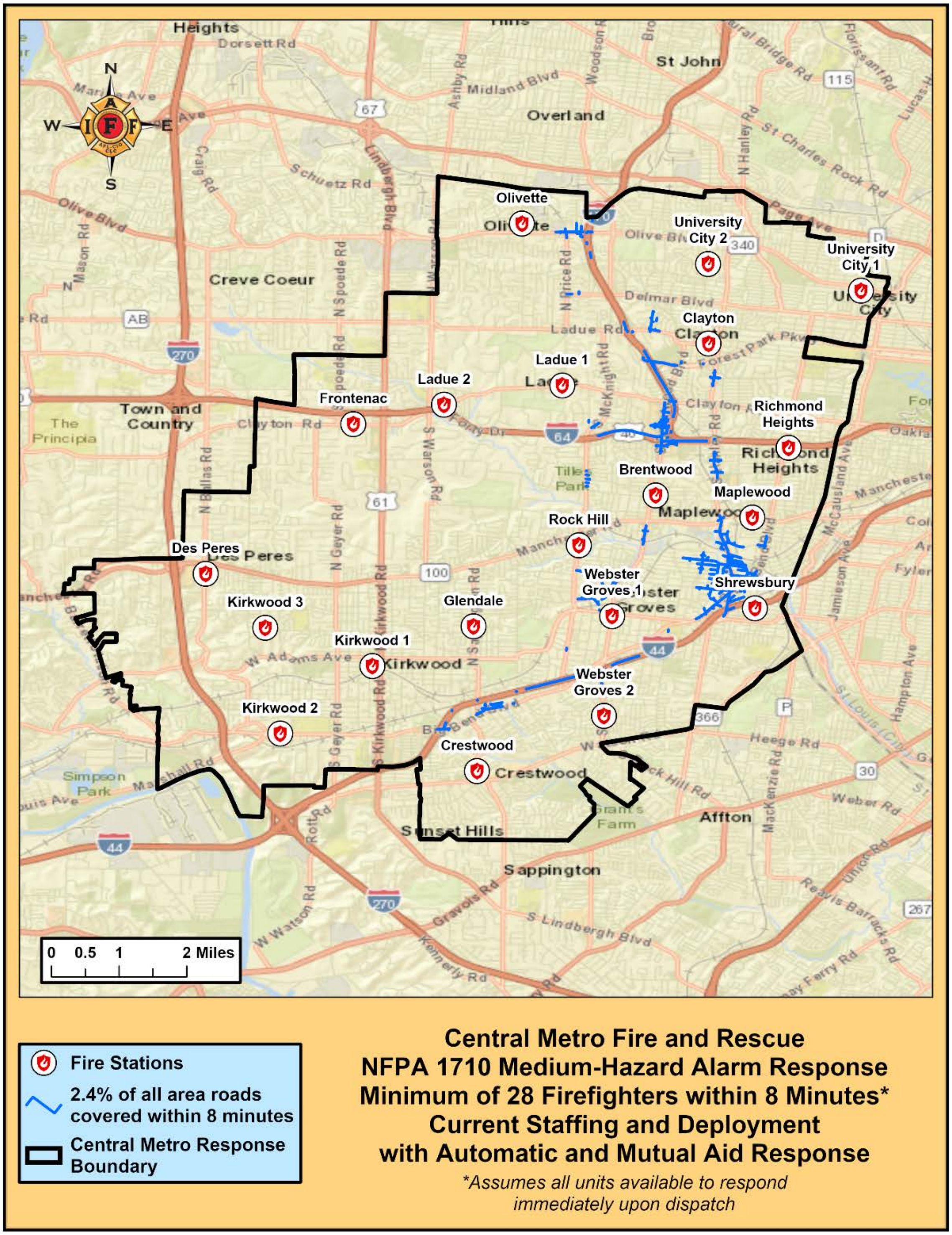
Map 28: 6-Minute Ladder Response Capabilities, Current Staffing and Deployment with Automatic and Mutual Aid Response. Map 28 identifies the roads CMFR and automatic and mutual aid fire departments' ladder companies can reach within six minutes or less of travel. Currently, the departments are able to respond with a minimum of one ladder company on 43.3% of roads of within CMFR's response boundary in six minutes or less of travel.



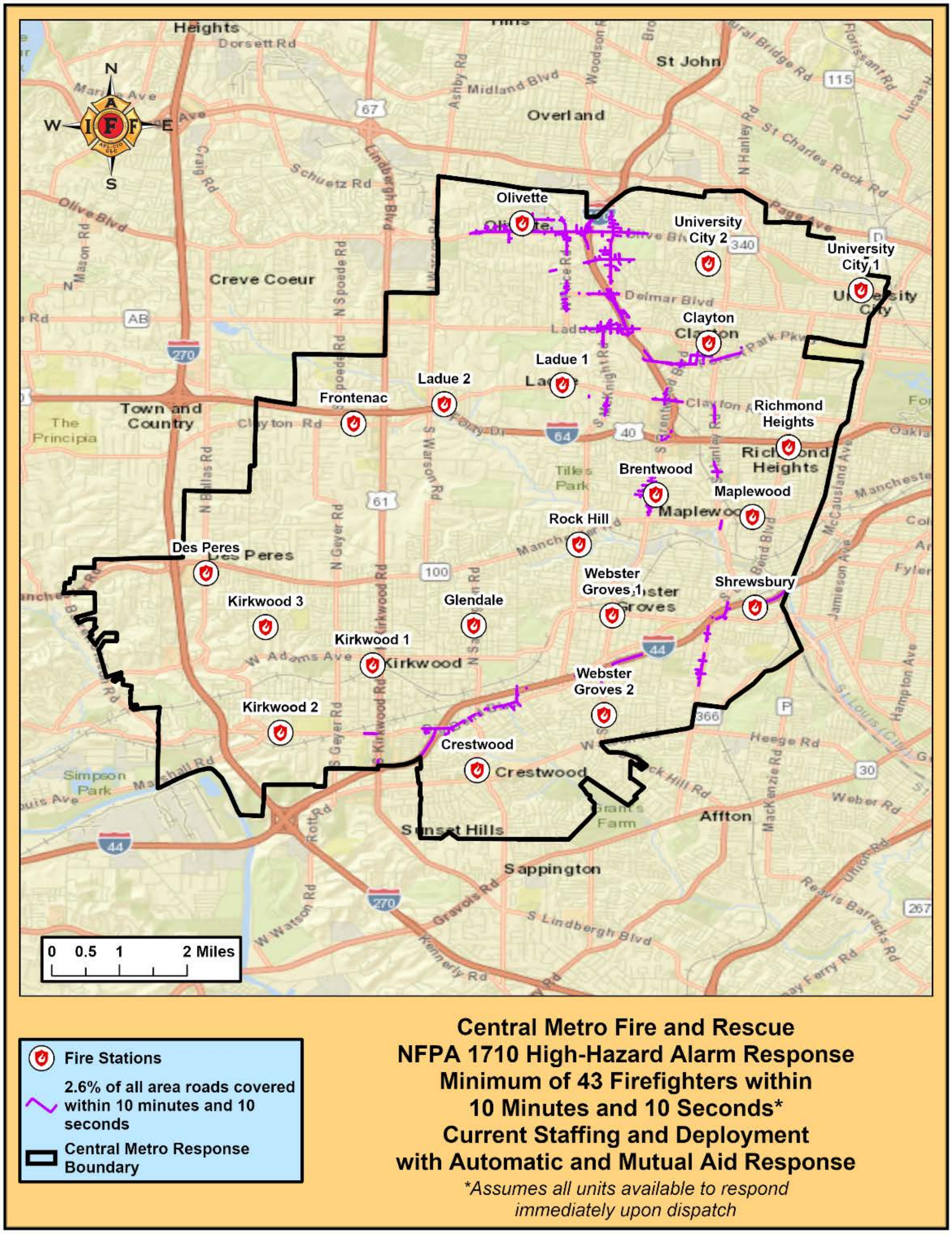
Map 29: 8-Minute Medic Response Capabilities, Current Staffing and Deployment Automatic and Mutual Aid Response. Map 29 identifies the roads CMFR and automatic and mutual aid fire departments' medic units, which are staffed and equipped to provide ALS procedures, can reach within eight minutes or less of travel. Currently, the departments are capable of providing an ALS transport unit on 97.1% of roads within CMFR's response boundary in eight minutes or less of travel.



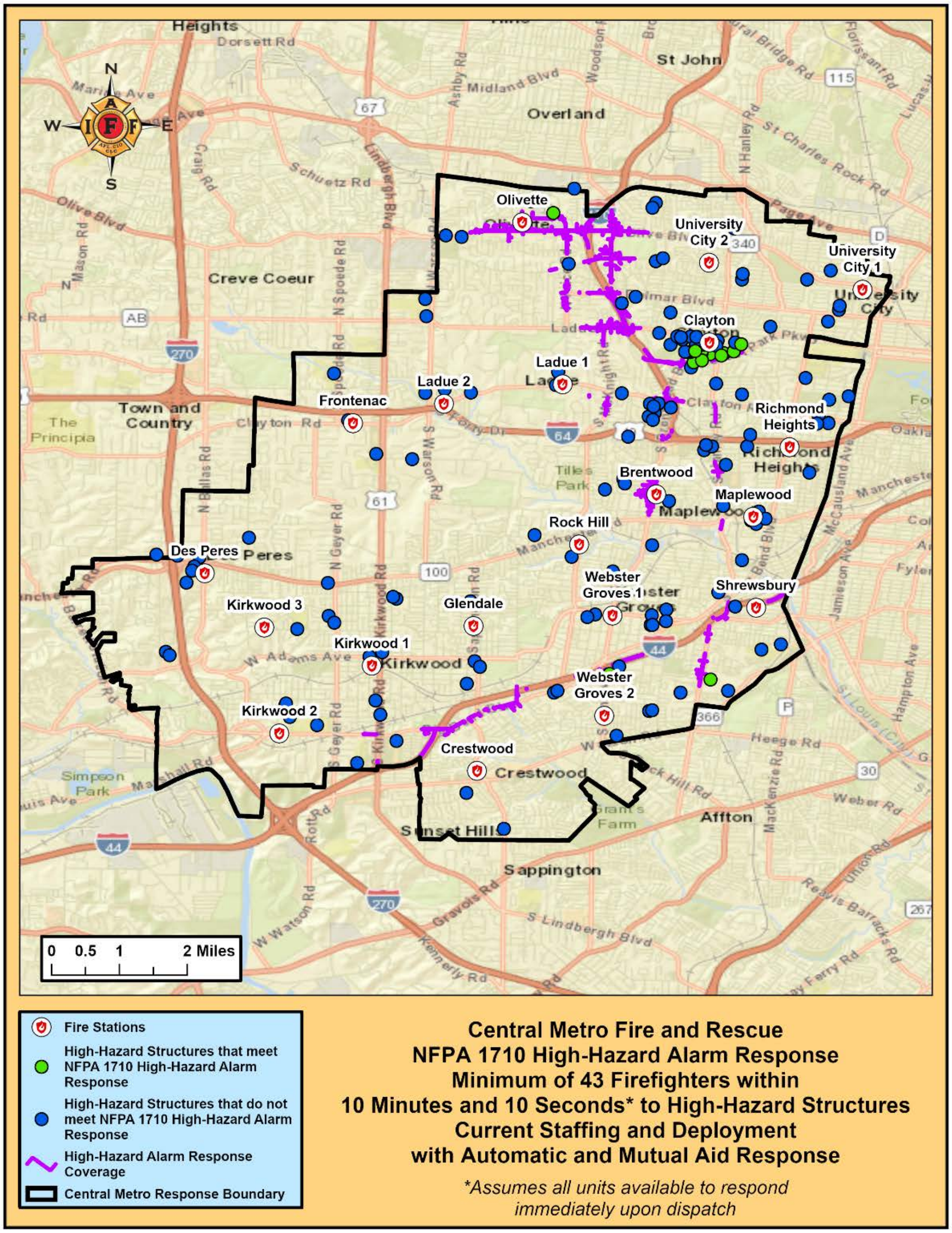
Map 30: NFPA 1710 Low-Hazard Alarm Response, Minimum of 17 Firefighters within 8 Minutes, Current Staffing and Deployment with Automatic and Mutual Aid Response. Map 30 identifies the roads where CMFR and automatic and mutual aid fire departments can assemble a minimum of 17 firefighters within eight minutes or less of travel. Currently, the departments can assemble a minimum of 17 firefighters within eight minutes or less of travel on 29.3% of roads within CMFR's response boundary.



Map 31: NFPA 1710 Medium-Hazard Alarm Response, Minimum of 28 Firefighters within 8 Minutes, Current Staffing and Deployment with Automatic and Mutual Aid Response. Map 31 identifies the roads where CMFR and automatic and mutual aid fire departments can assemble a minimum of 28 firefighters within eight minutes or less of travel. Currently, the departments can assemble a minimum of 28 firefighters within eight minutes or less of travel on 2.4% of roads within CMFR's response boundary.



Map 32: NFPA 1710 High-Hazard Alarm Response, Minimum of 43 Firefighters within 10 Minutes and 10 Seconds, Current Staffing and Deployment with Automatic and Mutual Aid Response. Map 32 identifies the roads where CMFR and automatic and mutual aid fire departments can assemble a minimum of 43 firefighters within 10 minutes and 10 seconds or less of travel. Currently, the departments can assemble a minimum of 43 firefighters within 10 minutes and 10 seconds on 2.6% of roads within CMFR's response boundary.



Map 33: NFPA 1710 High-Hazard Alarm Response, Minimum of 43 Firefighters within 10 Minutes and 10 Seconds, Current Staffing and Deployment with Automatic and Mutual Aid Response. Map 33 identifies the high-hazard structures where CMFR and automatic and mutual aid fire departments can assemble a minimum of 43 firefighters within 10 minutes and 10 seconds or less of travel. Structures that are greater than 75 feet tall, square footage greater than 196,000 ft^2, schools, and hospitals were identified as high-hazard structures. Currently, the departments can assemble a minimum of 43 firefighters within 10 minutes and 10 seconds on 9.2% of high-hazard structures within CMFR's response boundary.

ArcGIS Location-Allocation

At the request of Local 2665, analysis was performed to assess department resources and identify optimal locations for additional apparatus. The analysis concluded that the department should add a ladder and a heavy rescue company. Currently the department can respond with a ladder company on only 38.2% of roads of roads within CMFR's response boundary in six minutes or less. In addition, CMFR does not operate a heavy rescue company with its own dedicated crew. Due to the extensive road network and risk in the community, CMFR should place a heavy rescue company in service full-time with its own dedicated crew. By adding a heavy rescue company, CMFR will be able to provide the necessary resources and trained personnel to perform technical rescue and HAZMAT without having to wait for regional teams to respond. Relying on regional teams to respond to these types of incidents will result in longer wait times for these resources to arrive on scene. Additional apparatus must be considered in order to improve response capabilities and to allow for safer and more effective firefighting operations.

ArcGIS's Location-Allocation tool within the Network Analyst toolset generates optimal sites to locate a resource. The Location-Allocation tool can present multiple resource scenarios in an objective manner, thus providing decision makers with the flexibility to choose the best deployment options for their municipality. Depending on the factors input into the Location-Allocation tool, different optimal locations for resources will be output. For example, entering travel times of six or eight minutes may result in different apparatus locations. Location-allocation is a process that helps decision makers answer questions; however, it is not a process that *completely* answers the question. The software outputs a recommendation of a location or locations based on time requirements and demand points. Other factors may play a role in final apparatus locations that go beyond GIS analysis such as anticipated community risk, frequency of simultaneous calls for service, and available space for apparatus in fire stations. It is also important to note that as population increases, it is likely that demand for emergency services will also increase. Decision makers should consider adding apparatus and resources now as a means of increasing public safety resources in line with the accelerated growth of the community.

Location-Allocation Methodology

The Location-Allocation tool uses demand points as features that are allocated to each individual fire station. The tool utilizes the existing locations of stations and the desired number and type of additional apparatus to determine the optimal locations that enable the department to cover the most demand points within a defined time parameter. The demand points used for the location-allocation analysis were incident location data from January 1, 2016 to December 31, 2018, and road network data (street points) within the CMFR's response boundary.

Location-allocation[94] was used to determine fire stations that are optimal locations to deploy a ladder and a heavy rescue company to increase the department's response capabilities. Two variables representing demand were used in the location-allocation analysis.

1) CAD data from January 1, 2016 through December 31, 2018: This variable accounts for the coverage of actual incidents. The locations of historical incidents were used to determine where to place a ladder and a heavy rescue to maximize their ability to respond to those incidents within a travel time of six or eight minutes, respectively. Only incident types where a heavy rescue unit would respond were used when examining where to add a heavy rescue unit.

2) Road network data (street points): This variable accounts for the coverage of roads. Road network points consider recently developed areas when identifying the optimal location of additional apparatus. Recently developed areas most likely have not experienced a high volume of incidents in the past. By using street points, these areas will be considered as areas that may need a fire station.

Using these two variables, the Location-Allocation tool calculated where additional apparatus should be located to ensure the department can arrive on scene to the greatest amount of demand points (incidents and street points), assuming all units are available to respond immediately upon dispatch.

Maximize Coverage[95]

Maximize coverage, a method within the Location-Allocation tool, is frequently used to locate apparatus because emergency services are required to arrive at all demand points (incidents) within a specified response time. Maximize coverage identifies the best location for a resource based on its ability to arrive at the most demand points. Note that it is important for all organizations, and critical for emergency services, to have accurate and precise data so that analysis results correctly model real-world results.

The following list describes how the Maximize Coverage tool handles demand:

- Any demand point outside all facilities' impedance cutoffs (travel time) is not allocated to any facility.

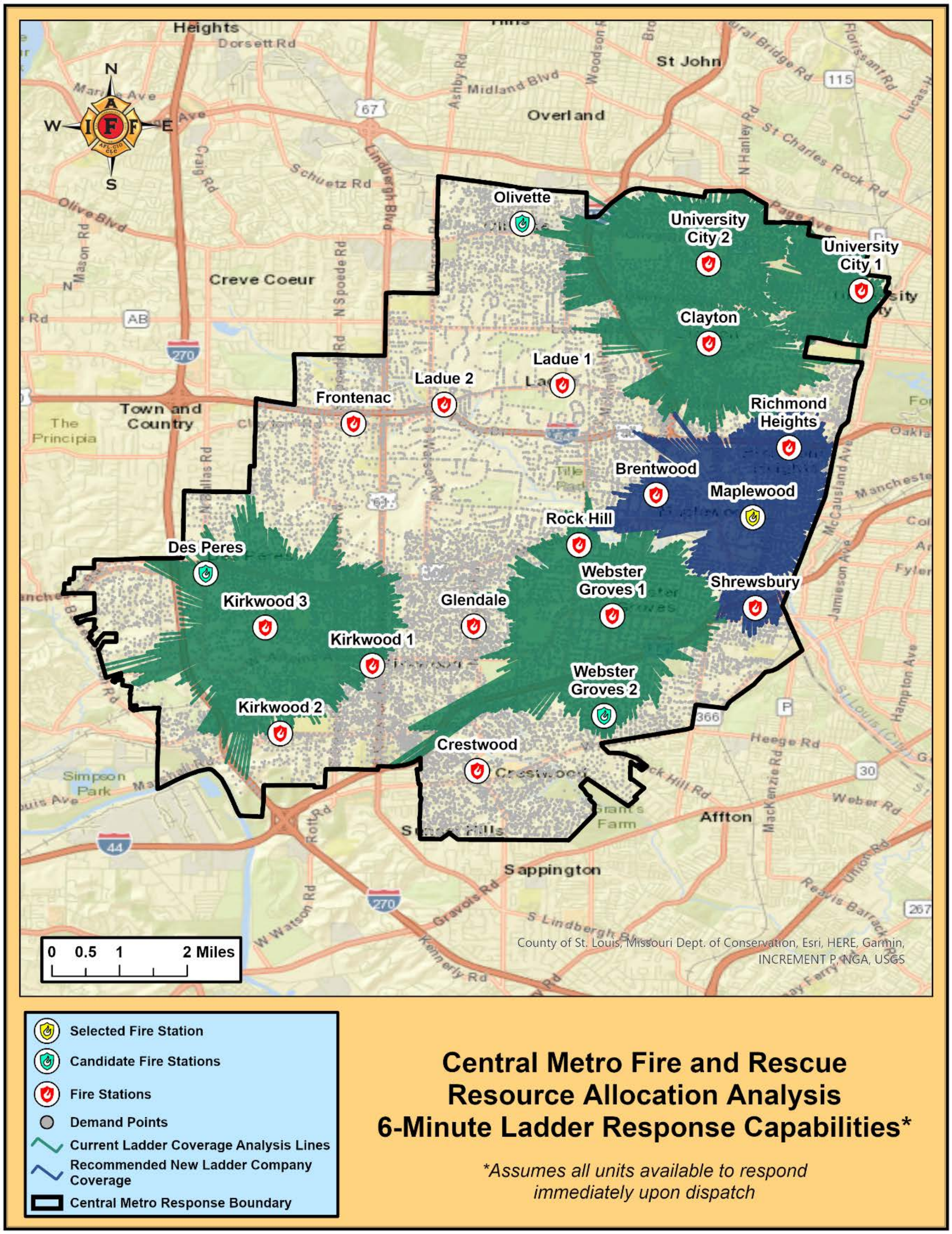
[94] Refers to algorithms used primarily in a geographic information system to determine an optimal location for one or more facilities that will service demand from a given set of points.
[95] ESRI Help Topic on Location-Allocation. ArcGIS version 10.1. 2011.

- A demand point inside the impedance cutoff (travel time) of one facility has all its demand weight allocated to that facility.

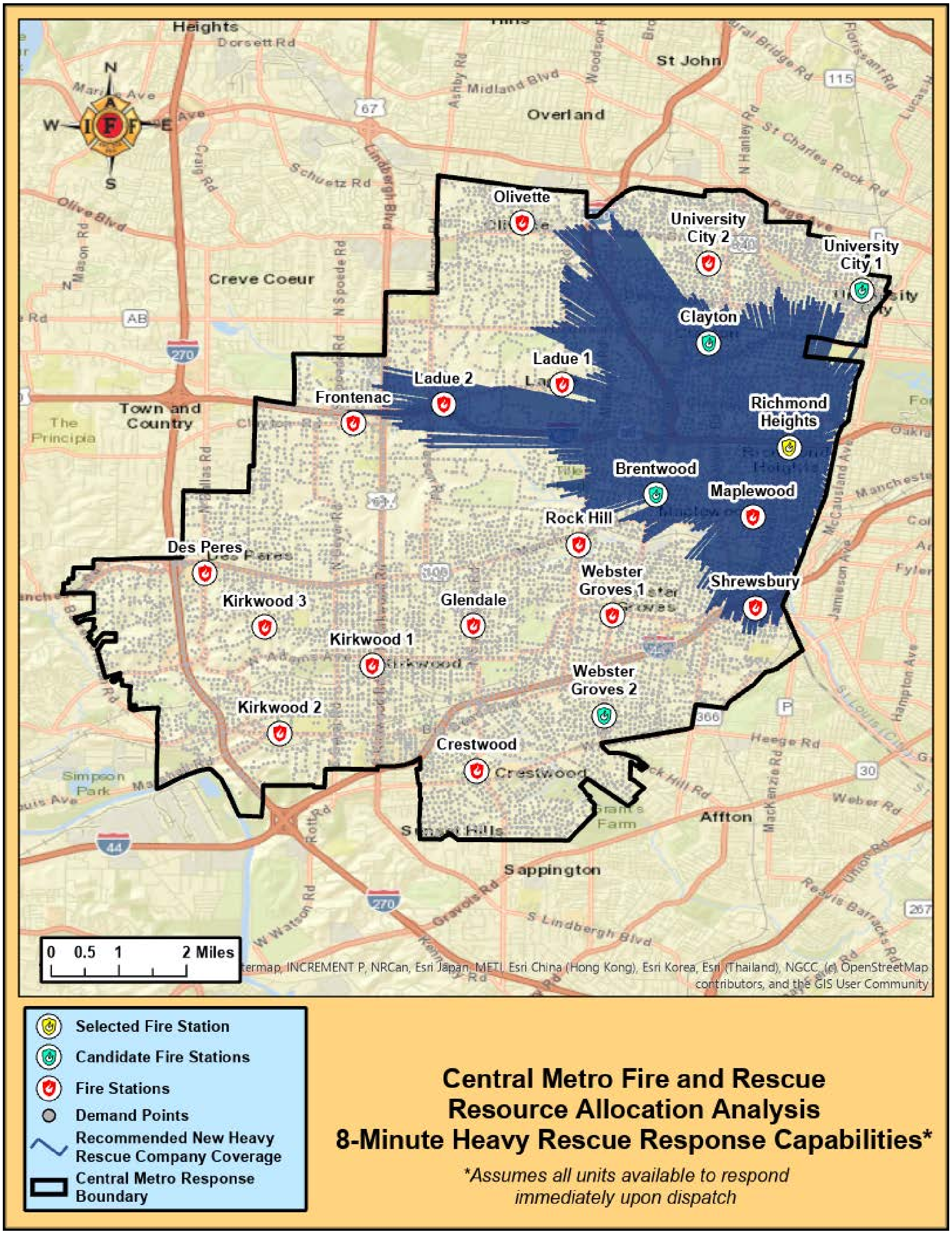
- A demand point inside the impedance cutoff (travel time) of two or more facilities has all its demand weight allocated to the nearest facility only.

Apparatus Placement Results

Local 2665 provided a list of fire stations that could fit additional apparatus. The following fire stations were candidates for a ladder company: Des Peres, Maplewood, Olivette, and Webster Groves House 2. The following fire stations were candidates for a heavy rescue company: Brentwood, Clayton, Richmond Heights, University City House 1, and Webster Groves House 2. The output of the location-allocation analysis recommended the optimal location for an additional ladder company was at Maplewood Fire Station and a heavy rescue company at Richmond Heights Fire Station.



Map 34: Resource Allocation Analysis 6-Minute Ladder Response Capabilities. Map 34 identifies the optimal location for CMFR to house an additional ladder company. Adding a ladder company to Maplewood Fire Station increases CMFR's response capabilities the most compared to the other candidate fire stations that could fit a ladder company.



Map 35: Resource Allocation Analysis 8-Minute Heavy Rescue Response Capabilities. Map 35 identifies the optimal location for CMFR to house a heavy rescue company. Adding a heavy rescue company to Richmond Heights Fire Station increase CMFR's response capabilities the most compared to the other candidate fire stations that could fit a heavy rescue ladder company.

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Recommended Staffing and Deployment

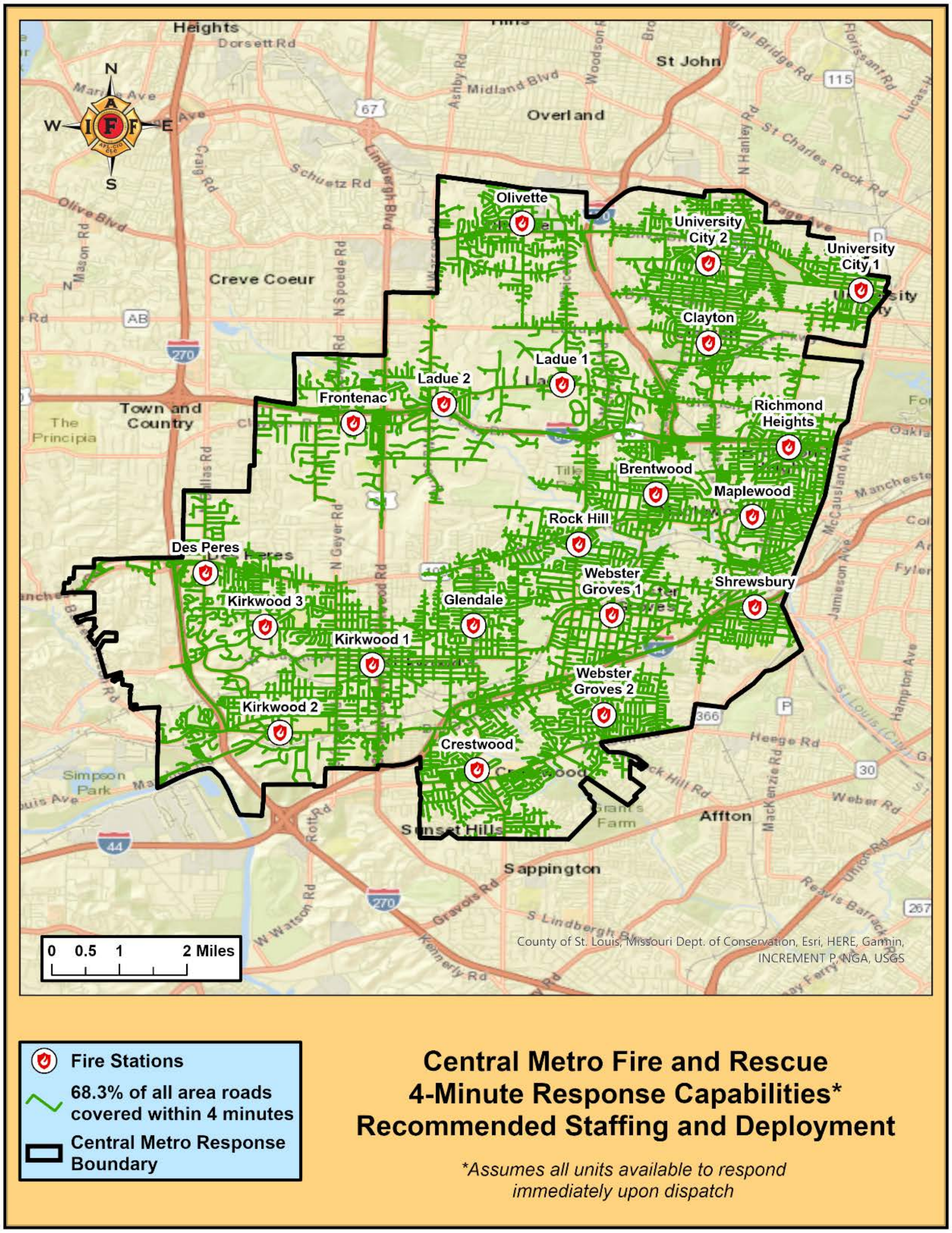
For this portion of the study, a staffing and deployment scenario was examined where all suppression apparatus would be staffed in accordance with industry standards minimum staffing level of four firefighters, and the battalion chief cars would be staffed with a battalion chief and a chief aide. CMFR would also add a heavy rescue and a ladder company. The heavy rescue would be housed at Richmond Heights Fire Station and the ladder would be housed at Maplewood Fire Station. Under this scenario, CMFR would operate under one unified dispatch system eliminating the notification delays CMFR currently experiences.

Station Name	Station Address	City	Apparatus	Staffing
Brentwood FD	8756 Eulalie Ave.	Brentwood	Engine 2514 Medic 2517	**6**
Clayton FD	10 N. Bemiston	Clayton	Engine 3214 Ladder 3212 Medic 3217 Battalion Car 3203	**12**
Crestwood FD	1 Detjen Dr.	Crestwood	Engine 1214 Rescue 1219	6
Des Peres FD	1000 N. Ballas Rd.	Des Peres	Engine 2814 Medic 2817	**6**
Frontenac FD	10555 Clayton Road	Frontenac	Engine 2914 Medic 2917	**6**
Glendale FD	424 Sappington Road	Glendale	Engine 1414	**4**
Kirkwood House 1	137 W. Argonne	Kirkwood	Engine 1514 Medic 1517	**6**
Kirkwood House 2	11804 Big Bend	Kirkwood	Engine 1524 Medic 1527	**6**
Kirkwood House 3	1321 W. Essex Ave.	Kirkwood	Ladder 1535 Medic 1537	**6**
Ladue House 1	9213 Clayton Road	Ladue	Engine 3914 Medic 3917	**6**
Ladue House 2	9911 Clayton Road	Ladue	Engine 3924	**4**
Maplewood FD	7601 Manchester Road	Maplewood	Engine 3114 **Ladder 3115** Rescue 3116	**10**
Olivette FD	1140 Dielman Rd.	Olivette	Engine 2714 Medic 2717	**6**

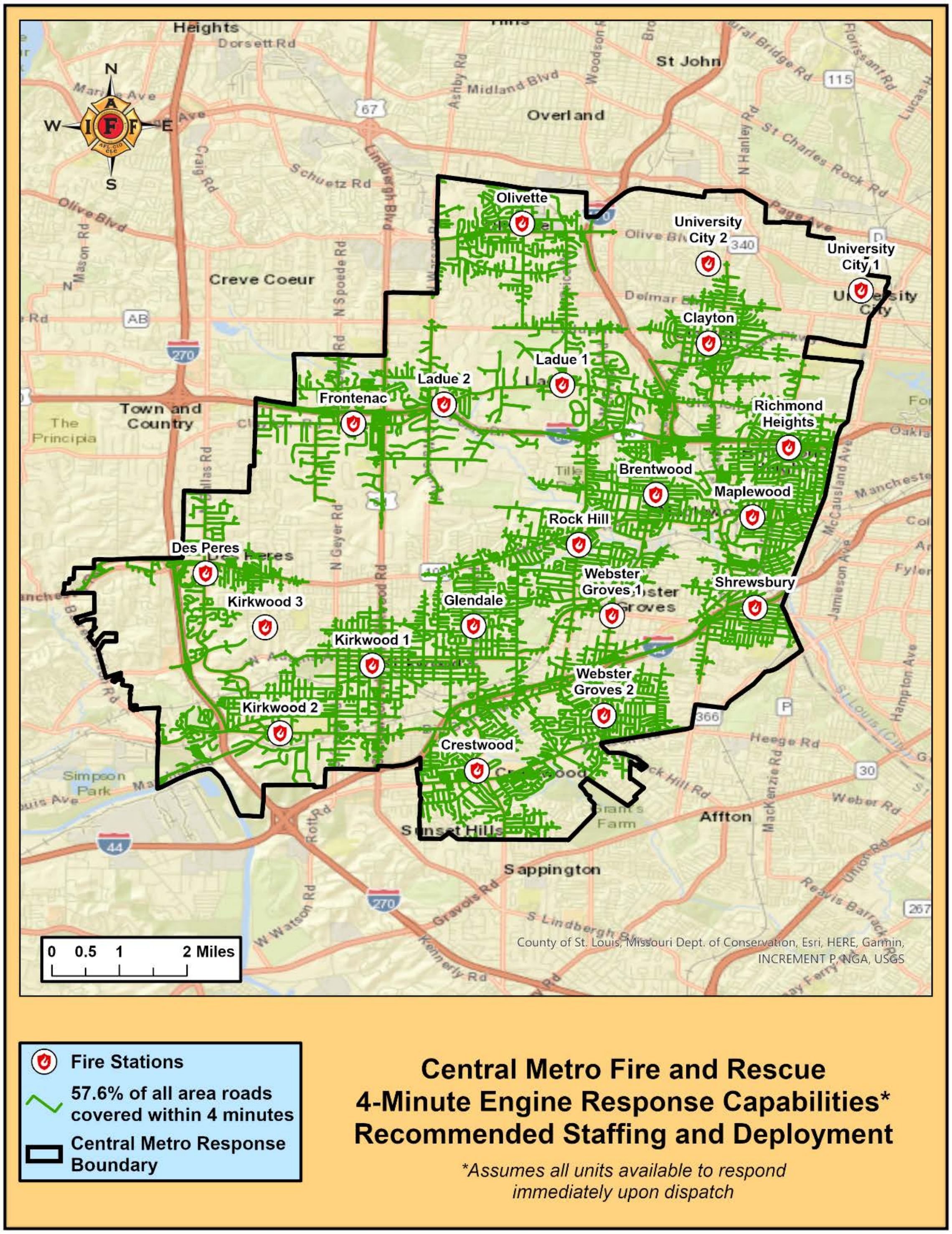
Table 8: Fire Station Locations and Recommended Staffing and Deployment. Table 8 displays where apparatus are housed and the recommended staffing levels. Staffing modification are highlighted in yellow.

Station Name (Continued)	Station Address (Continued)	City (Continued)	Apparatus (Continued)	Staffing (Continued)
Richmond Heights FD	7447 Dale Avenue	Richmond Heights	Engine 2114 **Heavy Rescue 2116** Medic 2117 Battalion Car 2102	**12**
Rock Hill FD	827 N. Rock Hill Road	Rock Hill	Engine 3414	**4**
Shrewsbury FD	4400 Shrewsbury Ave.	Shrewsbury	Engine 1814 Medic 1817	**6**
University City House 1	863 Westgate	University City	Ladder 2615 Medic 2617 Battalion Car 2603	**8**
University City House 2	1043 North and South	University City	Ladder 2625 Medic 2627	6
Webster Groves House 1	6 S. Elm Ave	Webster Groves	Ladder 2015 Medic 2017 Battalion Car 2005	**8**
Webster Groves House 2	1302 S. Elm Ave	Webster Groves	Engine 2024	4

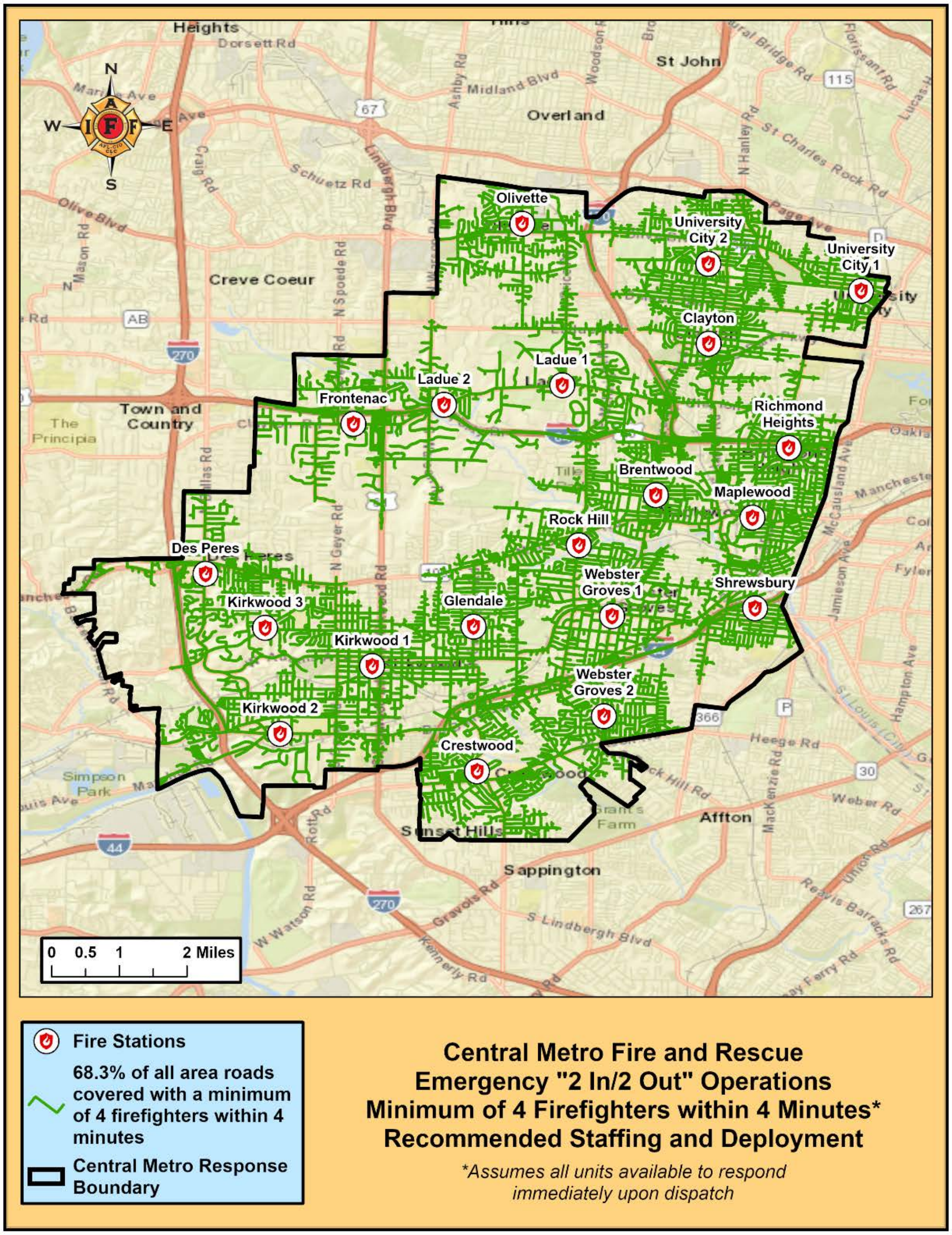
Table 8 (Continued): Fire Station Locations and Recommended Staffing and Deployment. Table 8 displays where apparatus are housed and the recommended staffing levels. Staffing modification are highlighted in yellow.



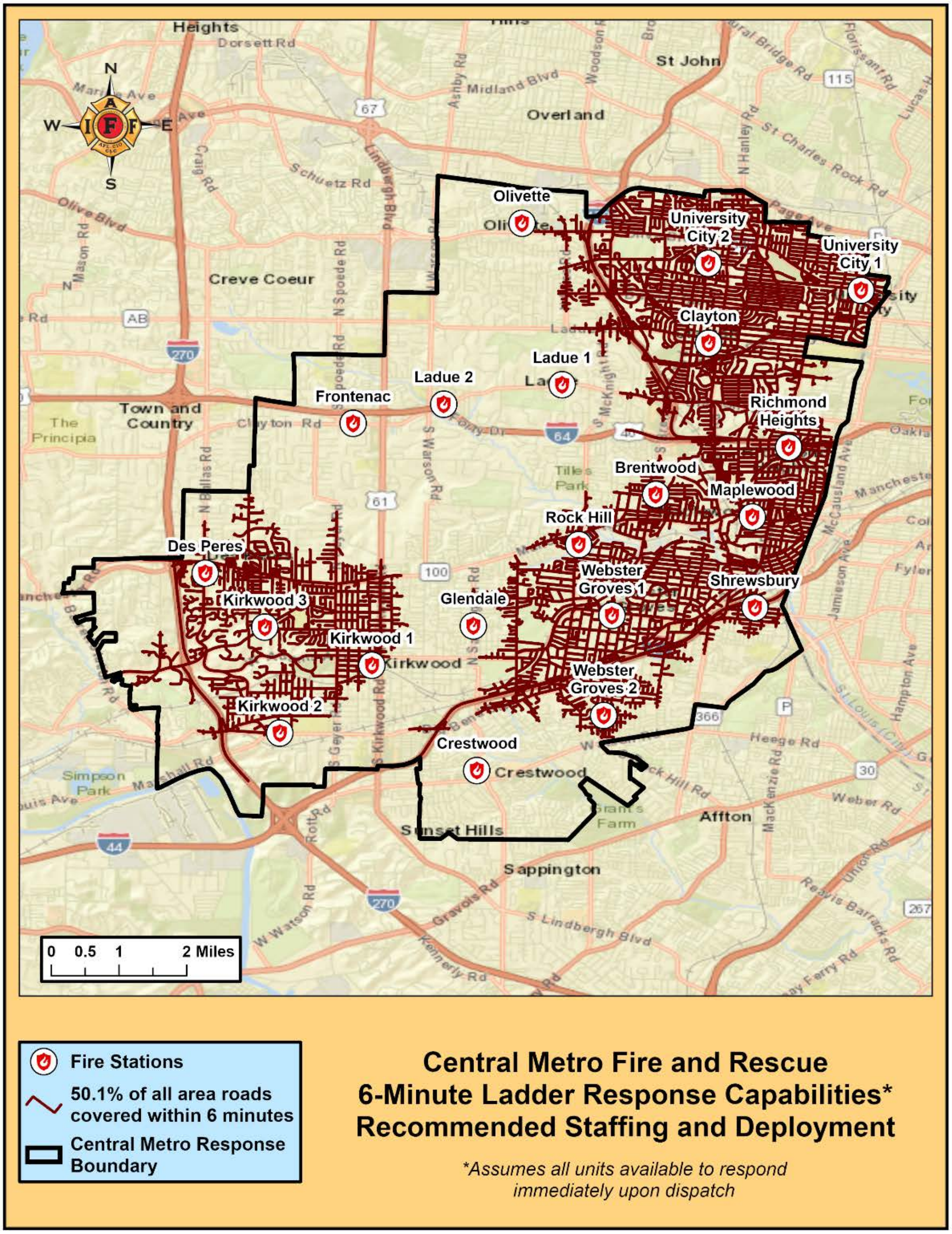
Map 36: 4-Minute Response Capabilities, Recommended Staffing and Deployment. Map 36 identifies the roads where CMFR's companies can reach within four minutes or less of travel. Based on this recommended staffing and deployment configuration, the department would be capable of responding on 68.3% of roads within CMFR's response boundary in four minutes or less of travel, which is a 5.2% **increase** in response coverage compared to CMFR's current response capabilities.



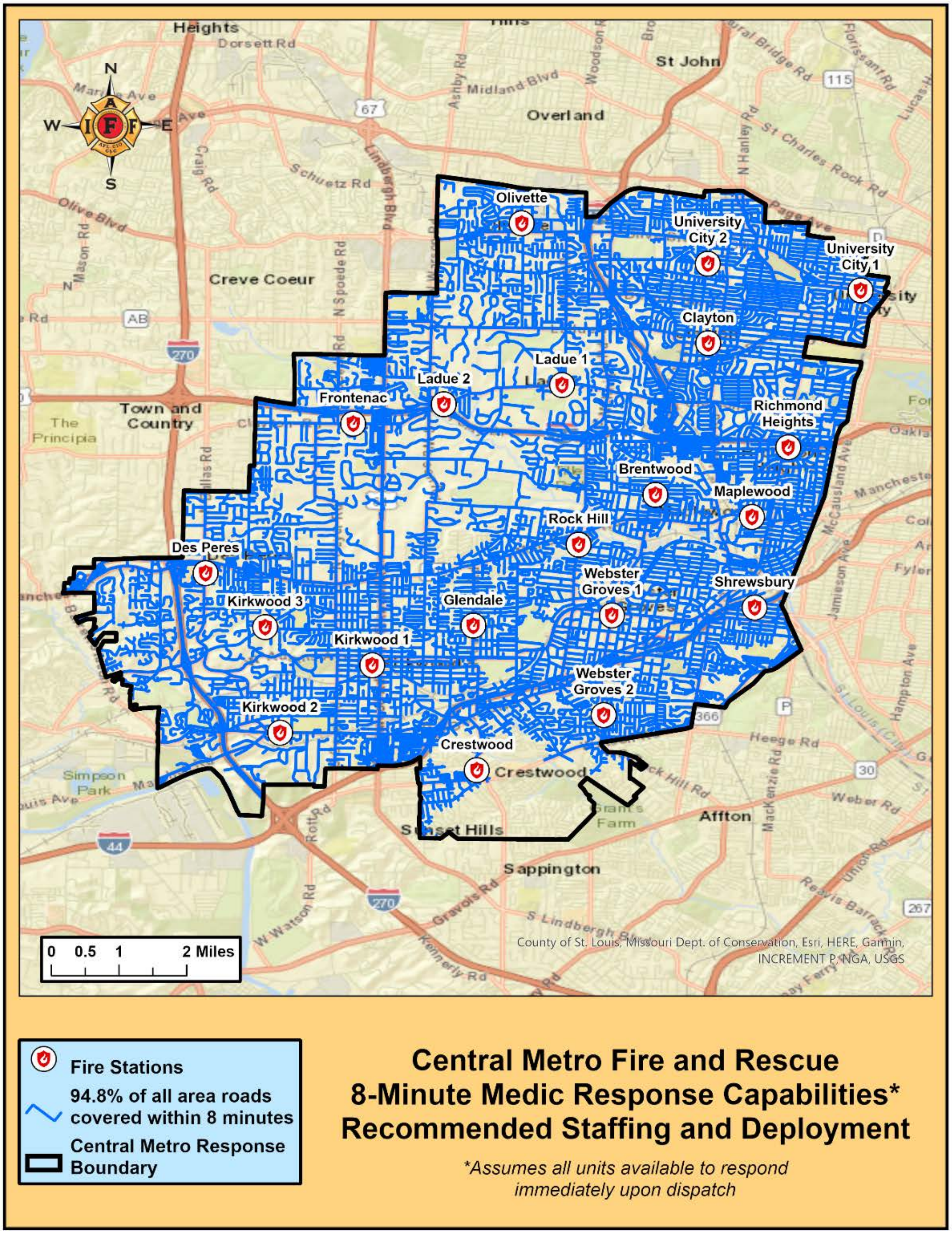
Map 37: 4-Minute Engine Response Capabilities, Recommended Staffing and Deployment. Map 37 identifies the roads where CMFR's engine companies can reach within four minutes or less of travel. Based on this recommended staffing and deployment configuration, the department would be capable of responding with one engine company on 57.6% of roads within CMFR's response boundary in four minutes or less of travel, which is a 7.8% **increase** in response coverage compared to CMFR's current engine response capabilities.



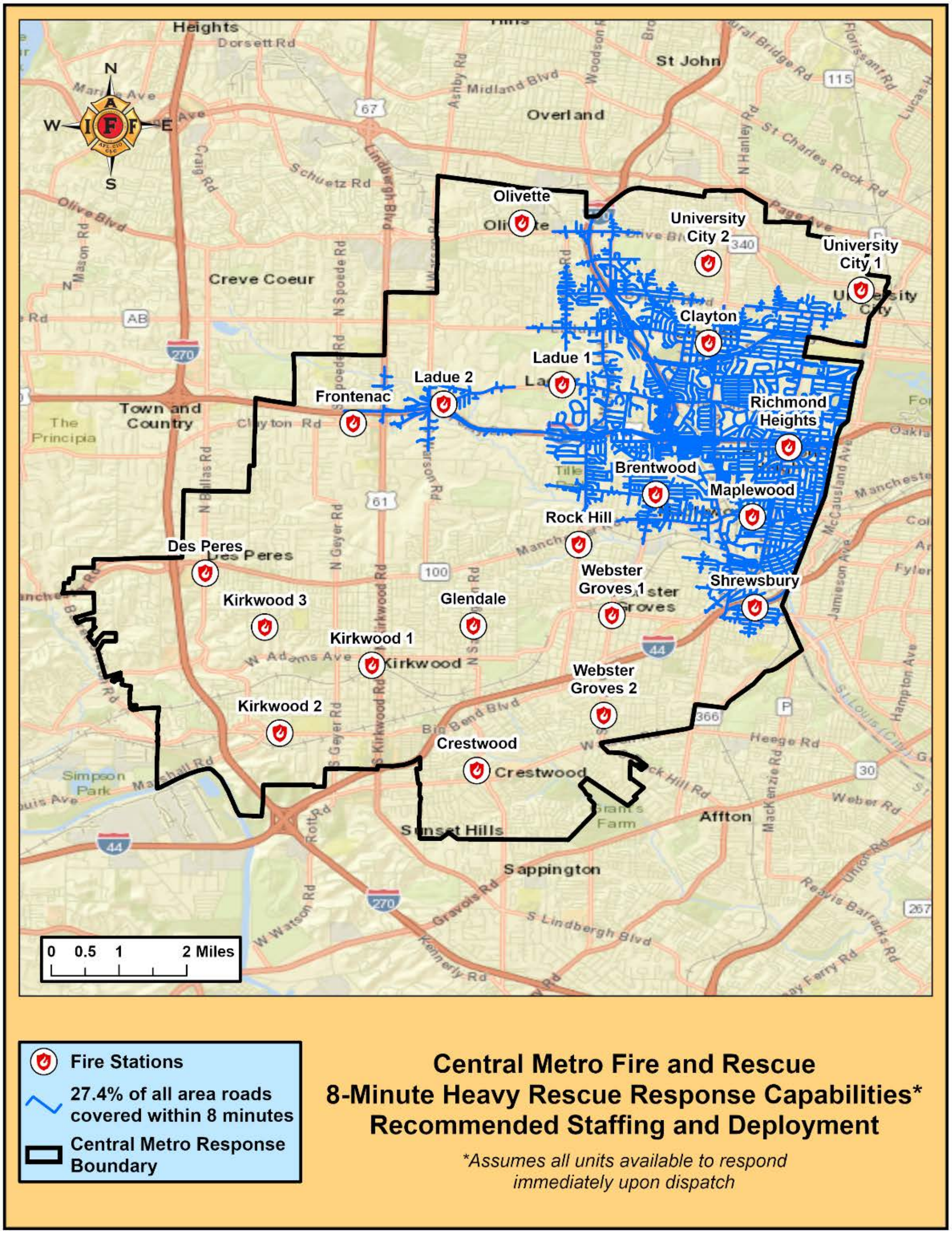
Map 38: Emergency “2 In/2 Out” Operations, Minimum of 4 Firefighters within 4 Minutes, Recommended Staffing and Deployment. Map 38 identifies the roads where a minimum of four firefighters can assemble on scene within four minutes or less of travel. Based on this recommended staffing and deployment configuration, the department would be able to assemble a minimum of four firefighters on scene within four minutes or less of travel on 68.3% of roads within CMFR’s response boundary, which is a 105.1% **increase** in response coverage compared to CMFR’s current emergency “2 In/2 Out” response capabilities.



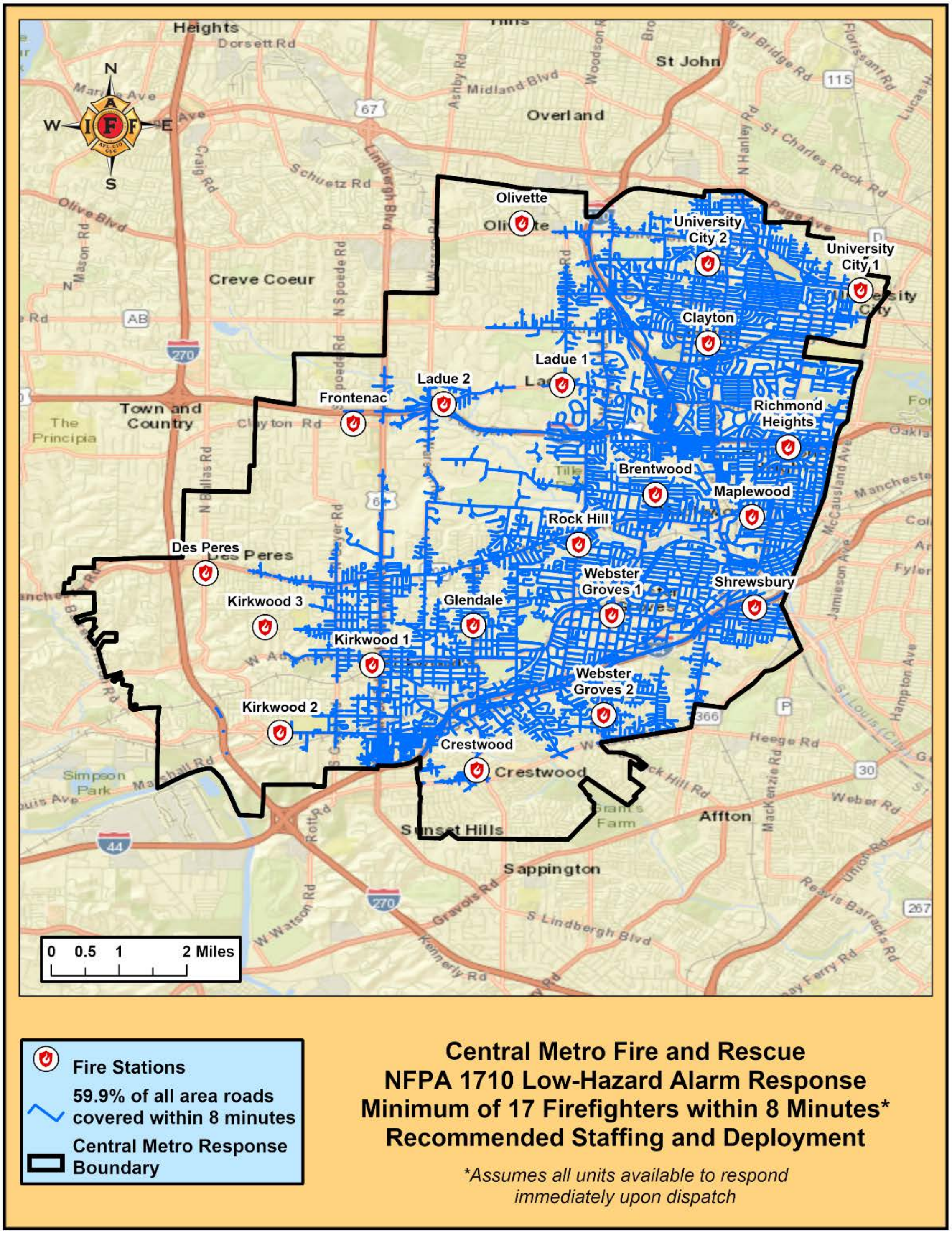
Map 39: 6-Minute Ladder Response Capabilities, Recommended Staffing and Deployment. Map 39 identifies the roads where CMFD's ladder companies can reach within six minutes or less of travel. Based on this recommended staffing and deployment configuration, the department would be capable of providing a minimum of one ladder company on scene within six minutes or less of travel on 50.1% of roads within CMFR's response boundary, which is a 31.1% **increase** in response coverage compared to CMFR's current ladder response capabilities.



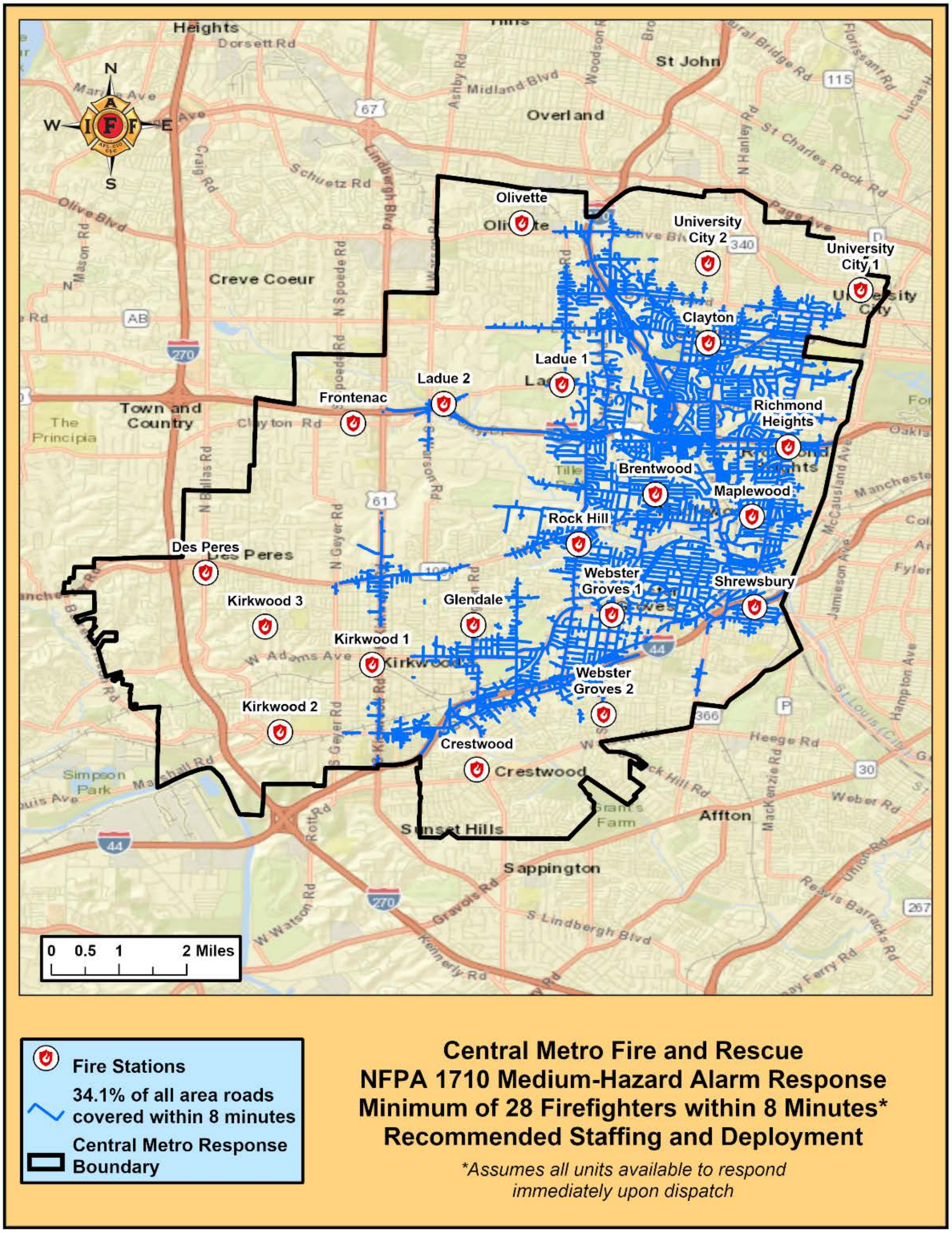
Map 40: 8-Minute Medic Response Capabilities, Recommended Staffing and Deployment. Map 40 identifies the roads where CMFR's medic units, which are staffed and equipped to provide ALS procedures, can reach within eight minutes or less of travel. Based on this recommended staffing and deployment configuration, the department would be capable of providing a minimum of one medic unit on scene within eight minutes or less of travel on 94.8% of roads within CMFR's response boundary, which is a 3.9% **increase** in response coverage compared to CMFR's current medic response capabilities.



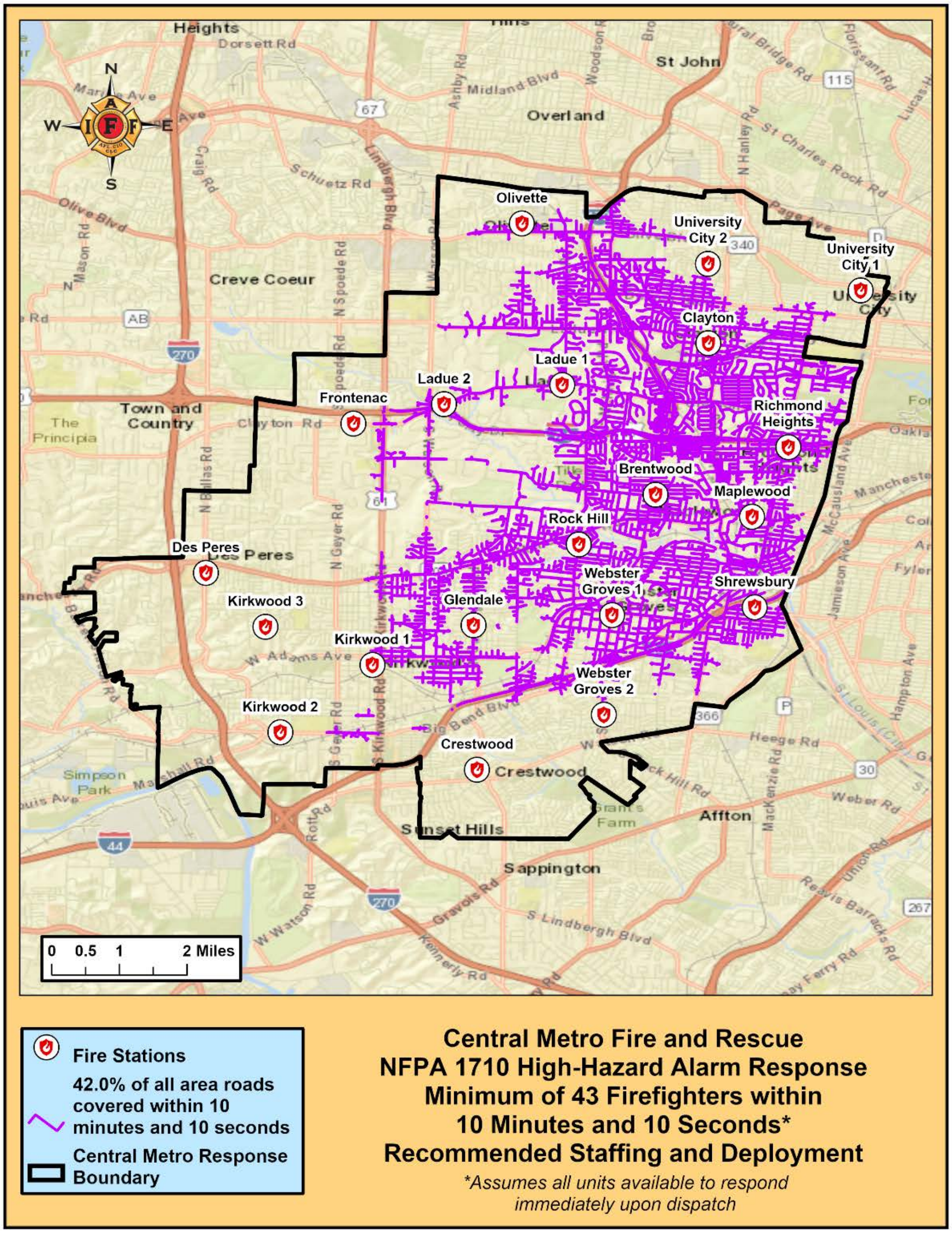
Map 41: 8-Minute Heavy Rescue Response Capabilities, Recommended Staffing and Deployment. Map 41 identifies the roads where CMFD's heavy rescue company could reach within eight minutes or less of travel. Based on this recommended staffing and deployment configuration, the department would be capable of providing a heavy rescue company on scene within eight minutes or less of travel on 27.4% of roads within CMFR's response boundary. The department currently cannot provide this service anywhere in the response area.



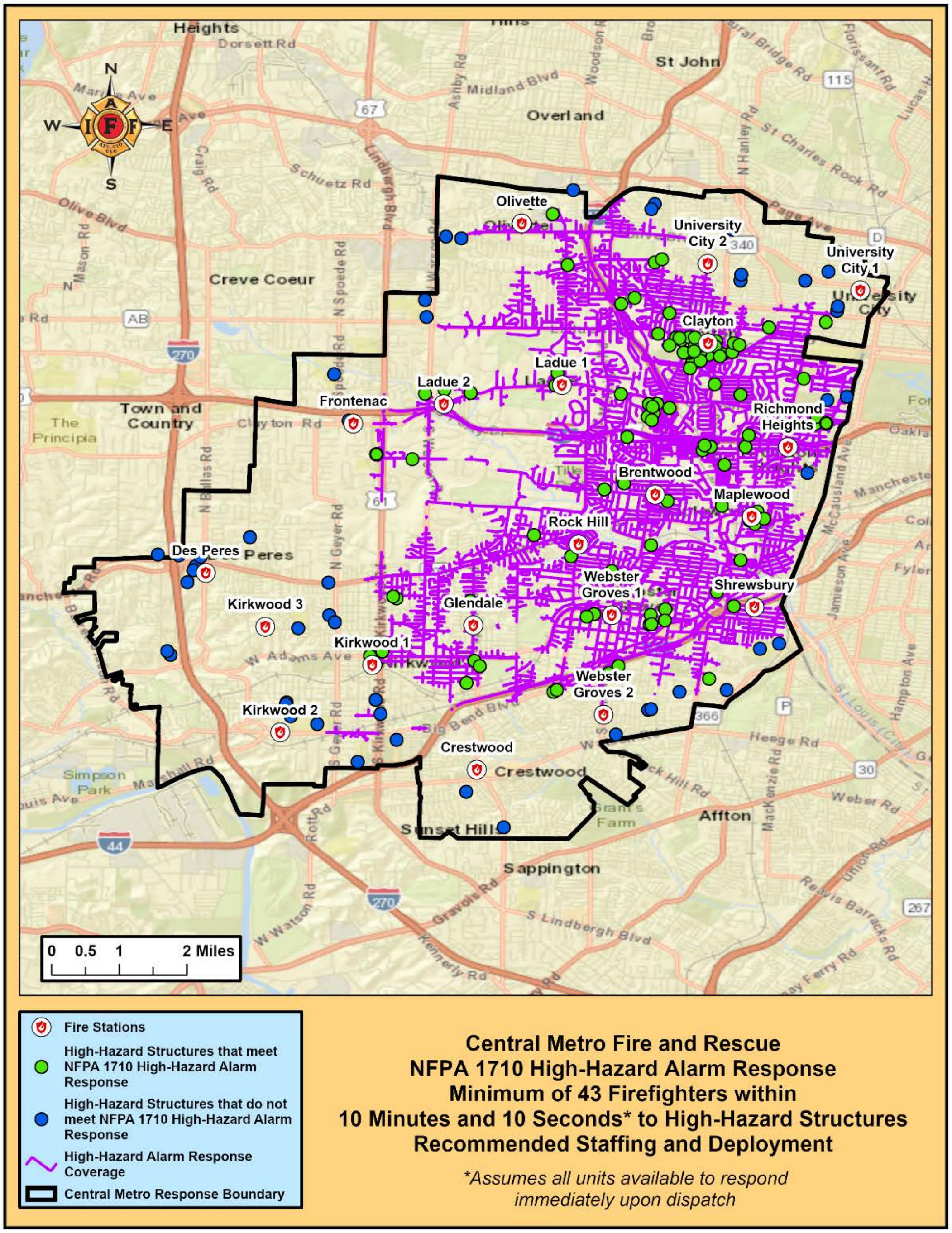
Map 42: NFPA 1710 Low-Hazard Alarm Response, Minimum of 17 Firefighters within 8 Minutes, Recommended Staffing and Deployment. Map 42 identifies the roads where a minimum of 17 firefighters can assemble within eight minutes or less of travel. Based on this recommended staffing and deployment configuration, the department would be able to assemble a minimum of 17 firefighters within eight minutes or less of travel on 59.9% of roads within CMFR's response boundary, which is a 134.9% **increase** in response coverage compared to CMFR's current low-hazard response capabilities.



Map 43: NFPA 1710 Medium-Hazard Alarm Response, Minimum of 28 Firefighters within 8 Minutes, Recommended Staffing and Deployment. Map 43 identifies thee roads where a minimum of 28 firefighters can assemble within eight minutes or less of travel. Based on this recommended staffing and deployment configuration, the department would be able to assemble a minimum of 28 firefighters within eight minutes or less of travel on 34.1% of roads within CMFR's response boundary, which is a 1,584.1% **increase** in response coverage compared to CMFR's current medium-hazard response capabilities.



Map 44: NFPA 1710 High-Hazard Alarm Response, Minimum of 43 Firefighters within 10 Minutes and 10 Seconds, Recommended Staffing and Deployment. Map 44 identifies the roads where a minimum of 43 firefighters can assemble within 10 minutes and 10 second or less of travel. Based on this recommended staffing and deployment configuration, the department would be able to assemble a minimum of 43 firefighters within 10 minutes and 10 seconds or less of travel on 42.0% of roads within CMFR's response boundary, which is a 5,839.5% **increase** in response coverage compared to CMFR's current high-hazard response capabilities.



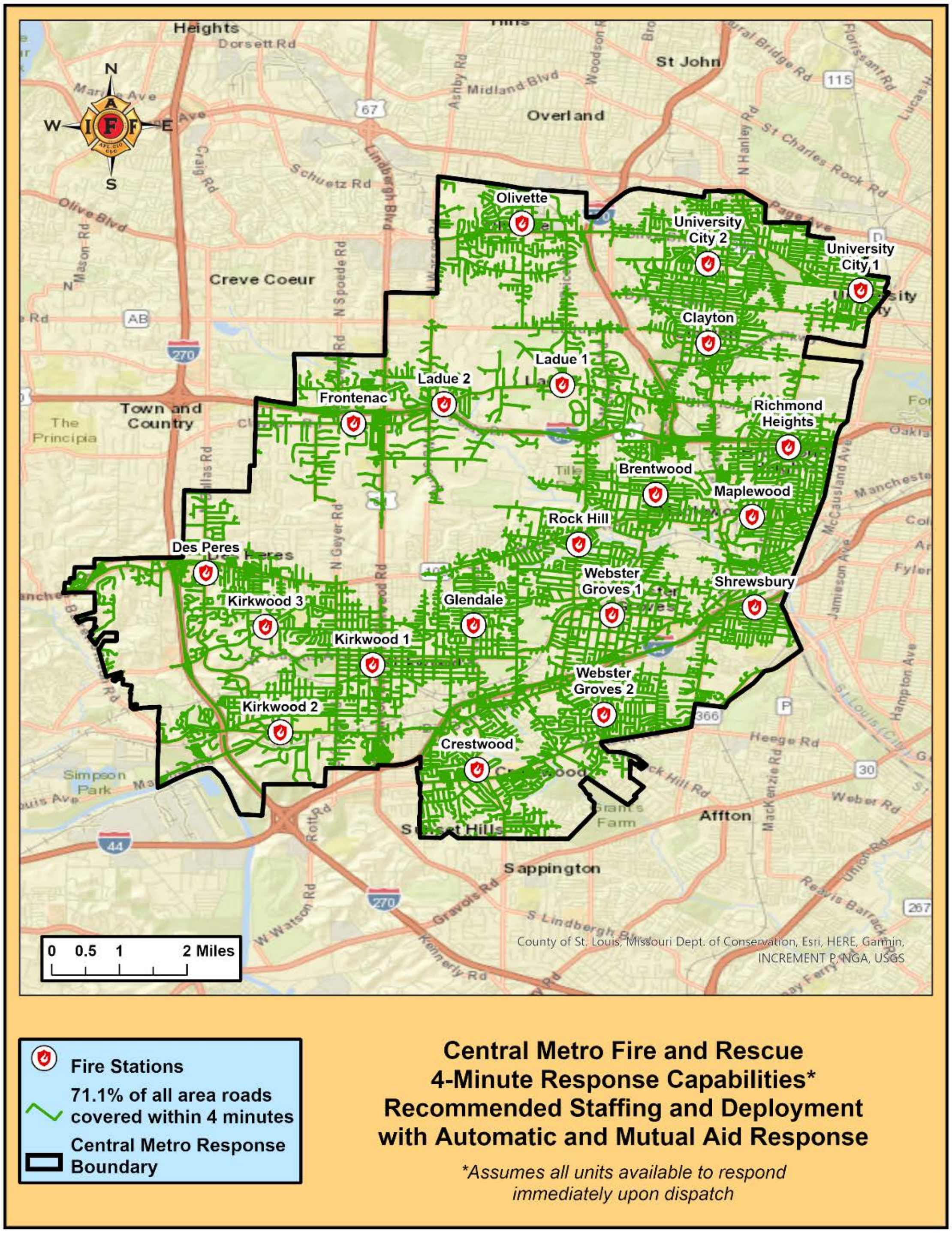
Map 45: NFPA 1710 High-Hazard Alarm Response, Minimum of 43 Firefighters within 10 Minutes and 10 Seconds to High-Hazard Structures, Recommended Staffing and Deployment. Map 45 identifies the high-hazard structures where a minimum of 43 firefighters can assemble within 10 minutes and 10 second or less of travel. Structures that are greater than 75 feet tall, square footage is greater than 196,000 ft^2, schools, and hospitals were all categories as high-hazard structures. Based on this recommended staffing and deployment configuration, the department would be able to assemble a minimum of 43 firefighters within 10 minutes and 10 seconds on 66.7% of high-hazard structures within CMFR's response boundary, which is a 827.3% **increase** in response coverage compared to CMFR's current high-hazard response capabilities.

Recommended Staffing and Deployment with Automatic and Mutual Aid Response.[96]

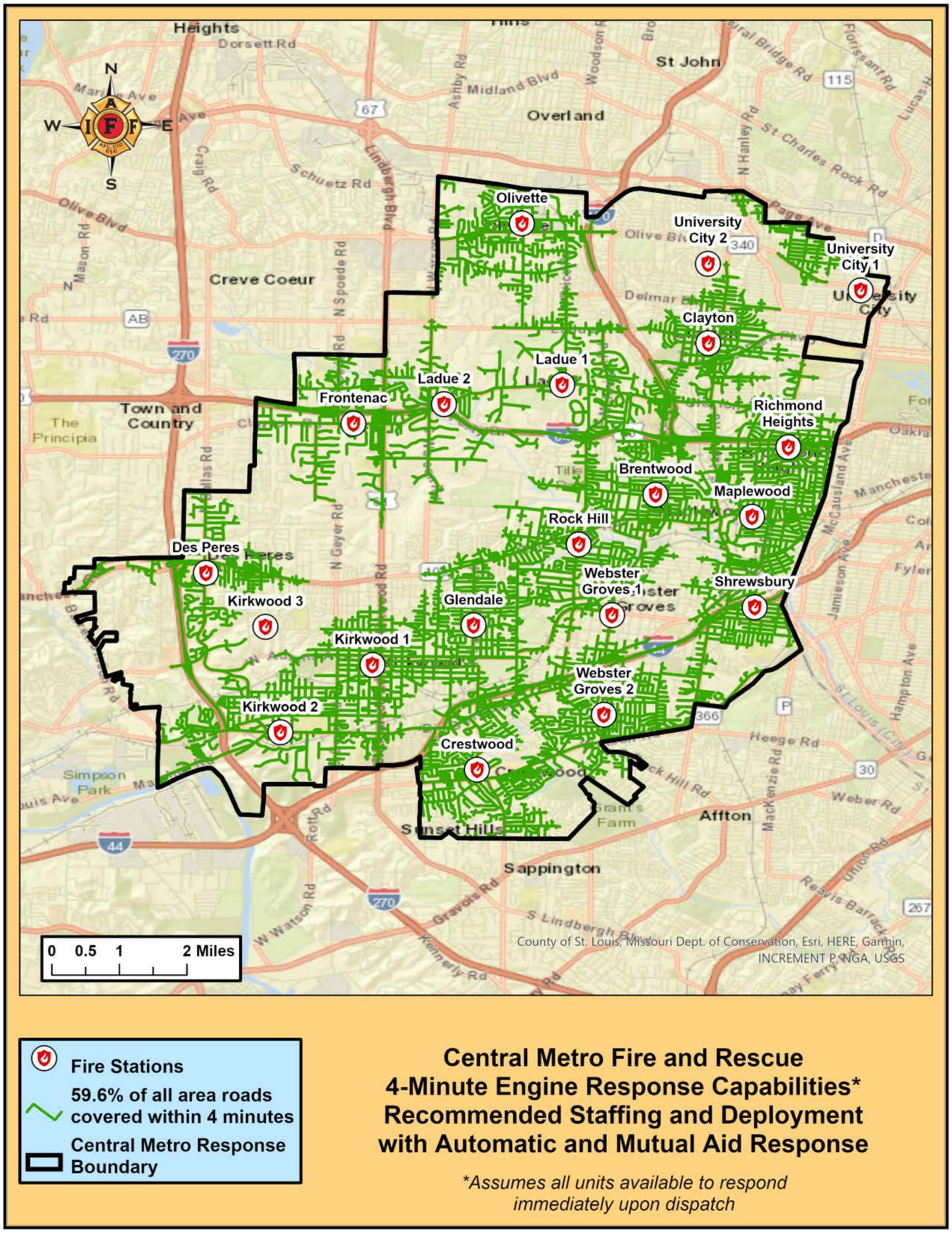
For this portion of the study, a staffing and deployment scenario was examined where all suppression apparatus would be staffed in accordance with industry standards minimum staffing level of four firefighters, and the battalion chief cars would be staffed with a battalion chief and a chief aide. CMFR would also add a heavy rescue and a ladder company. The heavy rescue would be housed at Richmond Heights Fire Station and the ladder would be housed at Maplewood Fire Station. Under this scenario, CMFR would operate under one unified dispatch system. Deploying units using the same dispatch system would terminate the notification delay CMFR currently experiences.

Table 8 (p.88 – 89) list the current locations of the CMFR's stations and the recommended apparatus and staff deploying from those stations and Appendix B: Automatic and Mutual Aid Fire Stations (p.119 – 122) list the location of the automatic and mutual aid fire stations and the apparatus and staff deploying from those stations.

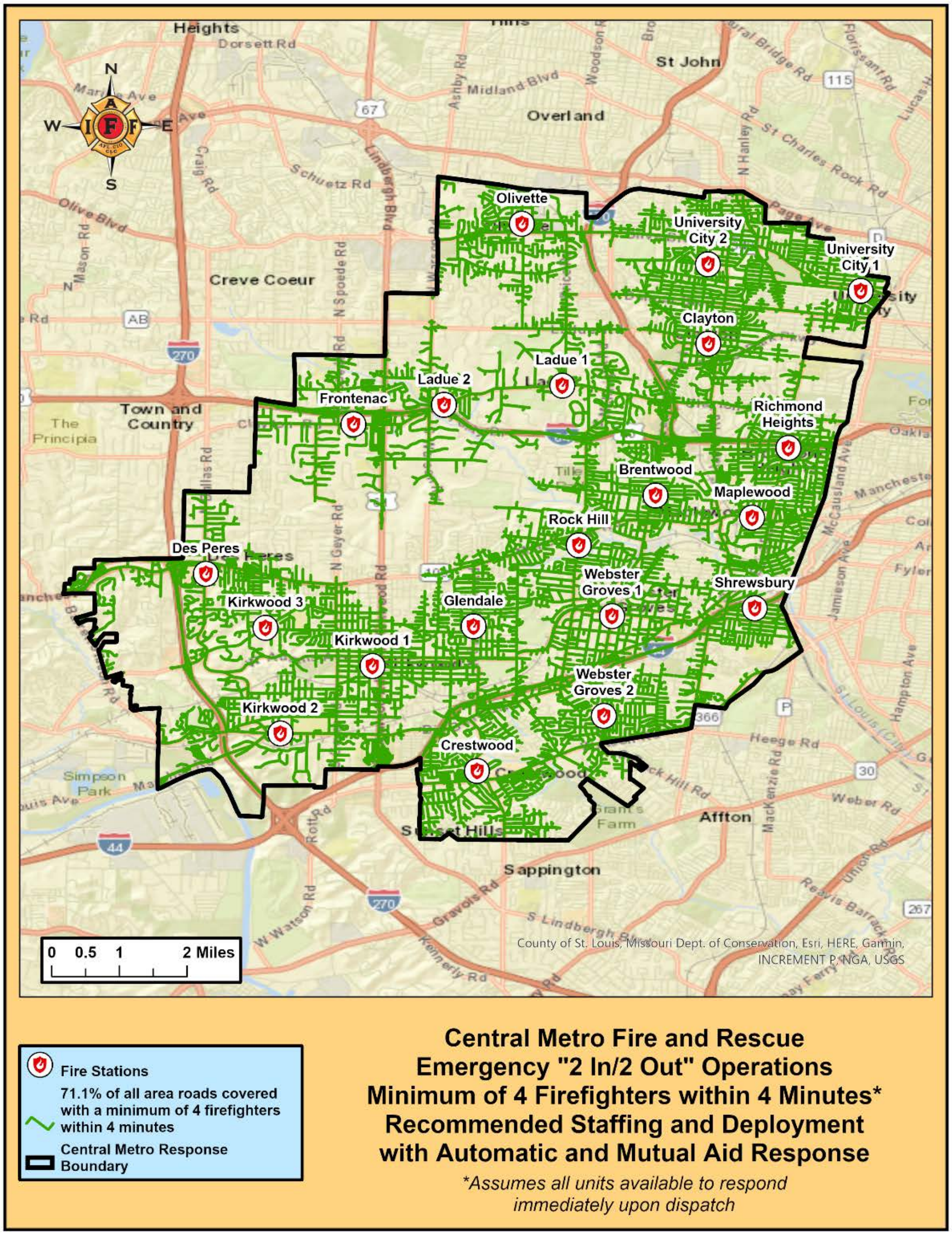
[96] Based on recommended staffing and deployment configuration with automatic and mutual aid response, CMFR's 8-minute heavy rescue response capability is not altered compared to the recommended staffing and deployment configuration. Therefore, this map was not included.



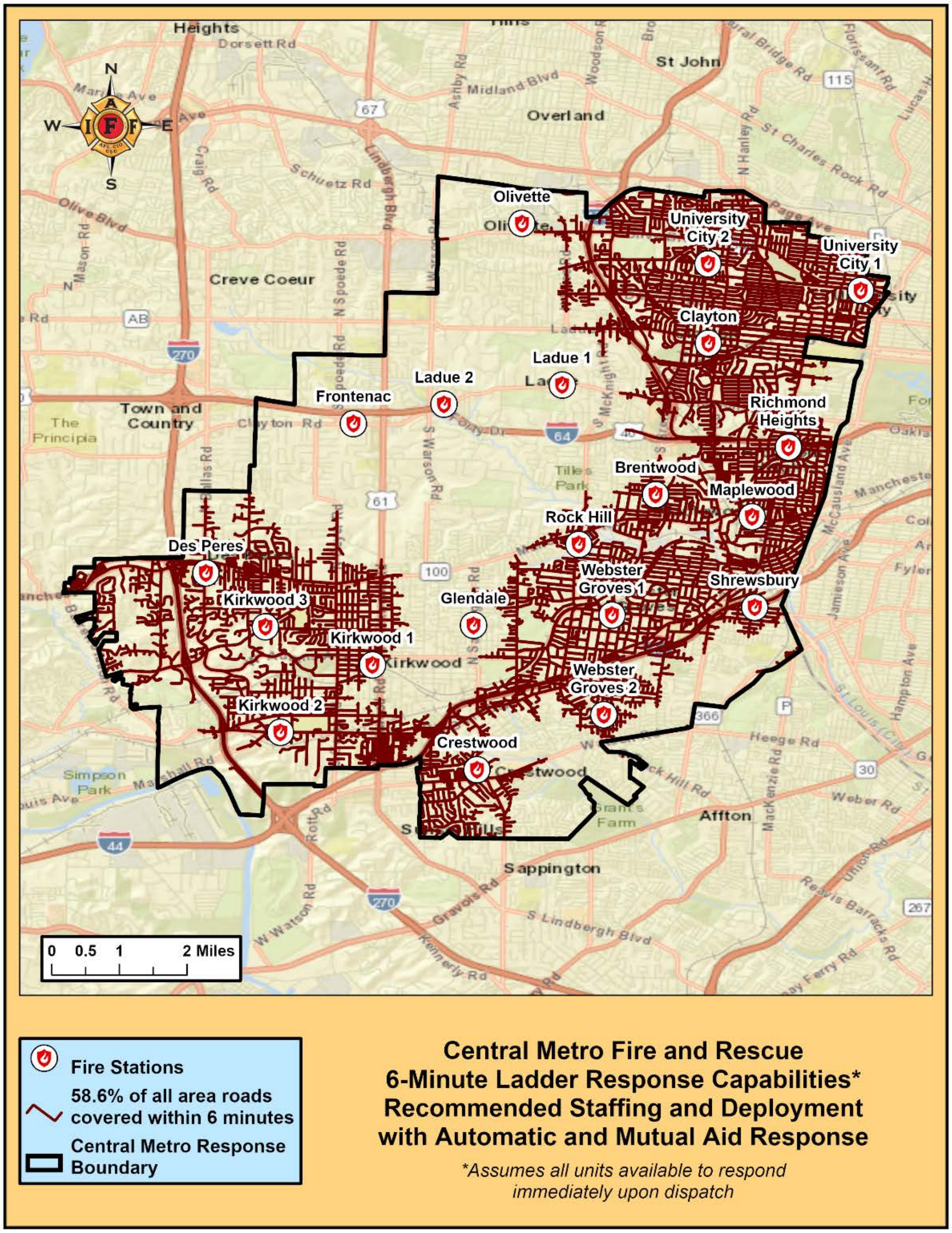
Map 46: 4-Minute Response Capabilities, Recommended Staffing and Deployment with Automatic and Mutual Aid Response. Map 46 identifies the roads where CMFR and automatic and mutual aid departments can reach within four minutes or less of travel. Based on this recommended staffing and deployment configuration, the departments would be capable of responding on 71.1% of roads within CMFR's response boundary in four minutes or less of travel, which is an 8.8% **increase** in response coverage compared to CMFR current response capabilities with automatic and mutual aid response.



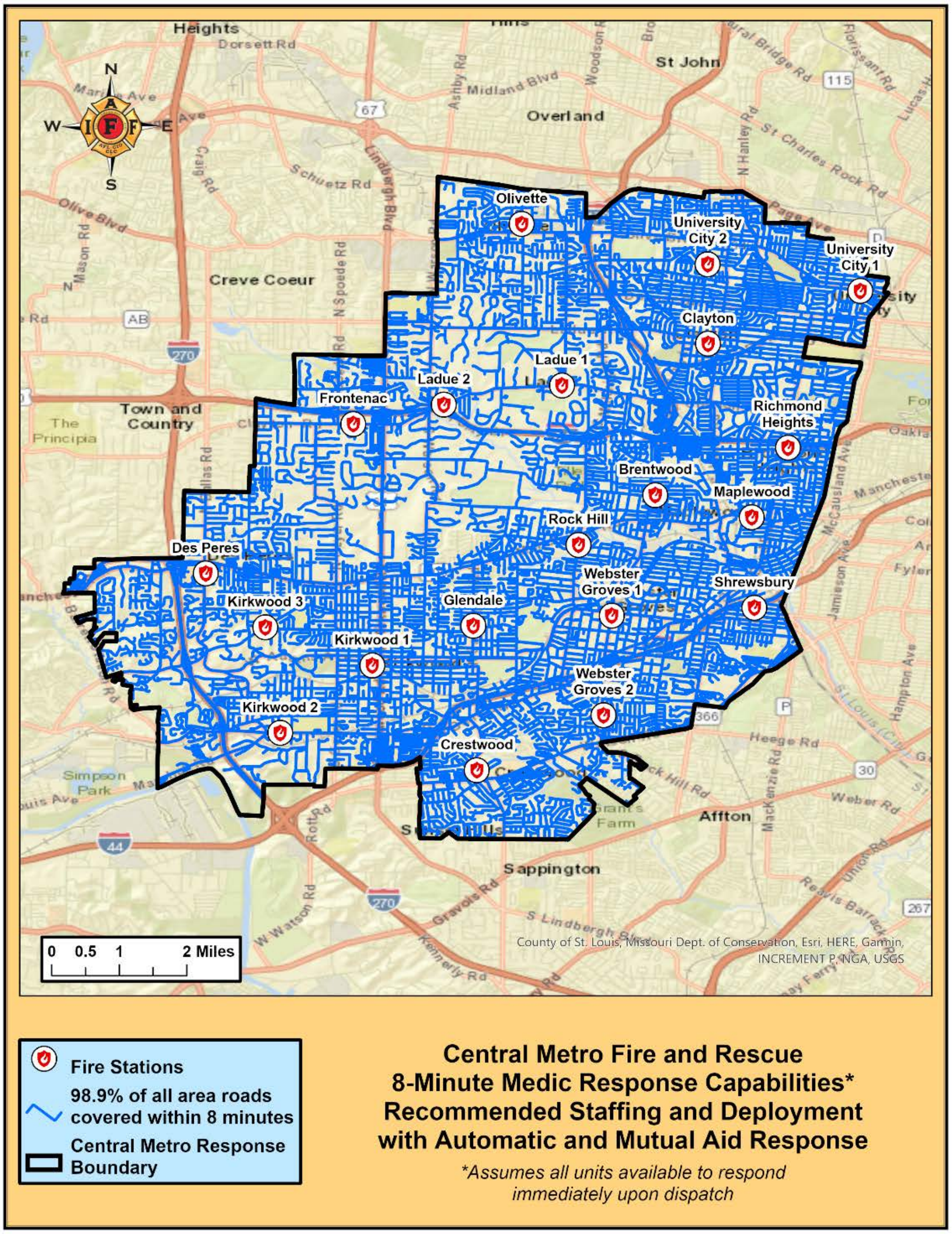
Map 47: 4-Minute Engine Response Capabilities, Recommended Staffing and Deployment with Automatic and Mutual Aid Response. Map 47 identifies the roads where CMFR and automatic and mutual aid departments' engine companies can reach within four minutes or less of travel. Based on this recommended staffing and deployment configuration, the departments would be capable of responding with a minimum of one engine company on 59.6% of roads within CMFR's response boundary in four minutes or less of travel, which is an 11.1% **increase** in response coverage compared to CMFR's current response capabilities with automatic and mutual aid response.



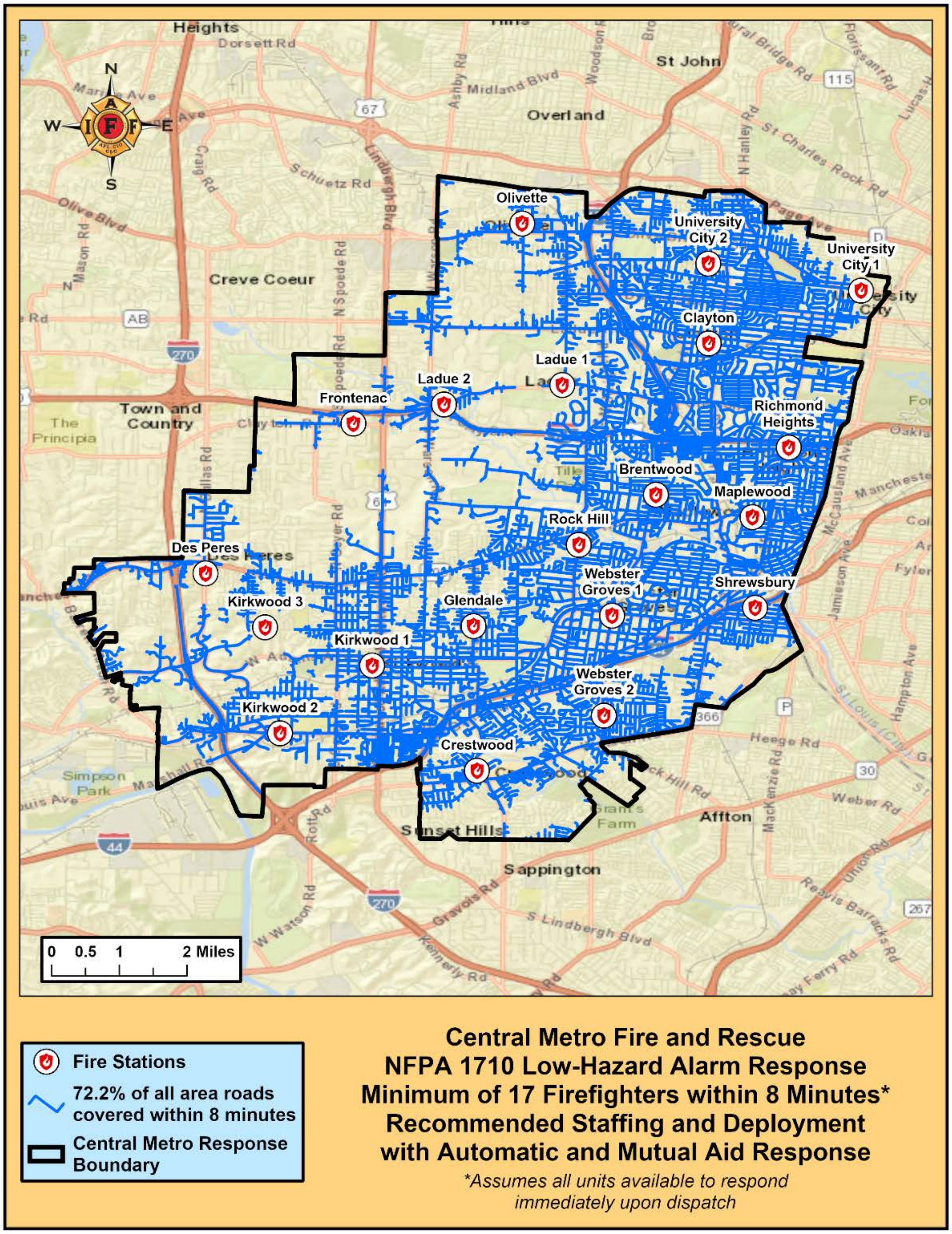
Map 48: Emergency "2 In/2 Out" Operations, Minimum of 4 Firefighters within 4 Minutes, Recommended Staffing and Deployment with Automatic and Mutual Aid Response. Map 48 identifies the roads where a minimum of four firefighters can assemble on scene within four minutes or less of travel. Based on this recommended staffing and deployment configuration, the departments would be able to assemble a minimum of four firefighters on scene within four minutes or less of travel on 71.1% of roads within CMFR's response boundary, which is a 112.6% **increase** in response coverage compared to CMFR's current response capabilities with automatic and mutual aid response.



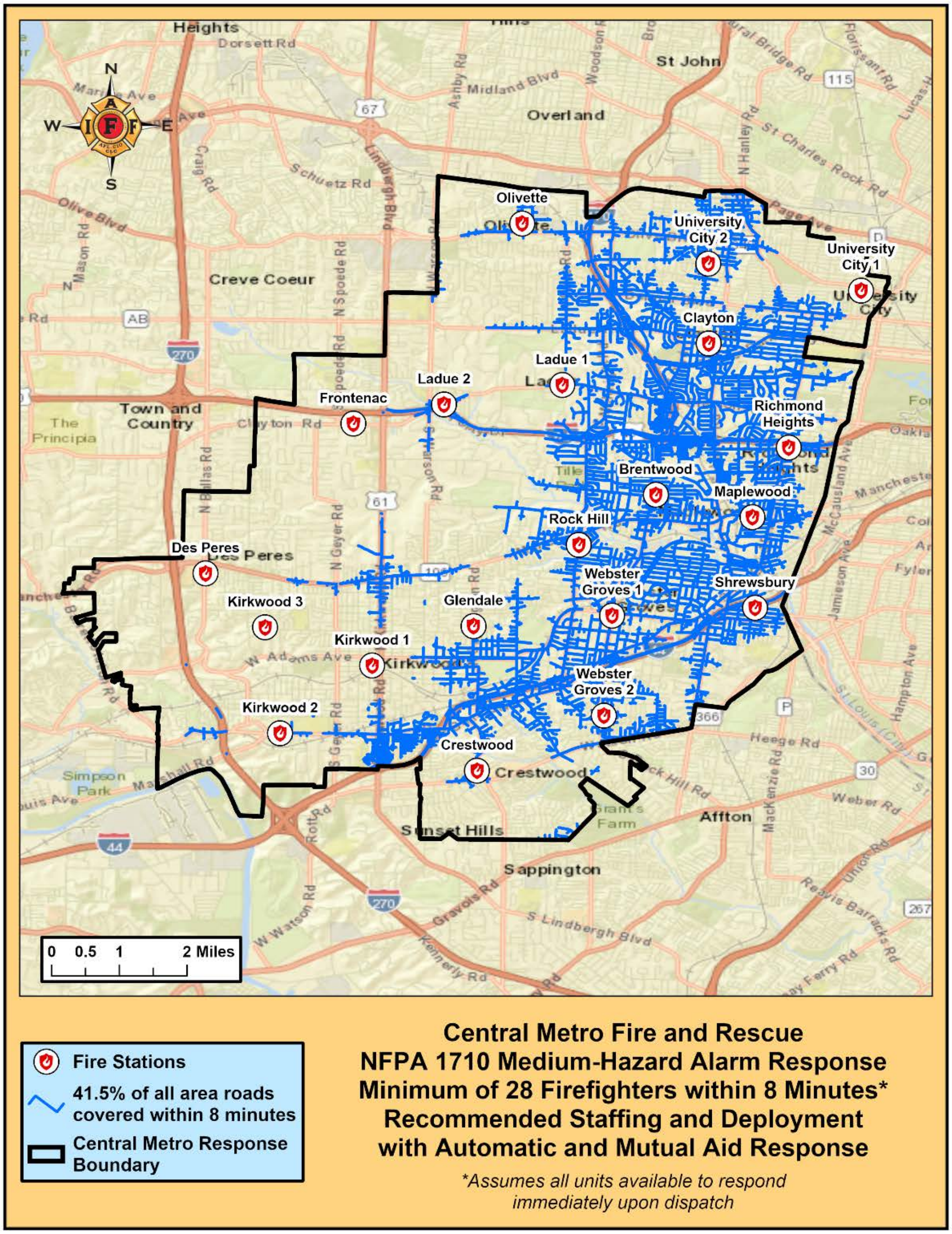
Map 49: 6-Minute Ladder Response Capabilities, Recommended Staffing and Deployment with Automatic and Mutual Aid Response. Map 49 identifies the roads where CMFR and automatic and mutual aid departments' ladder companies can reach within six minutes or less of travel. Based on this recommended staffing and deployment configuration, the departments would be capable of providing a minimum of one ladder company on scene within six minutes or less of travel on 58.6% of roads within CMFR's response boundary, which is a 35.3% **increase** in response coverage compared to CMFR's current response capabilities with automatic and mutual aid response.



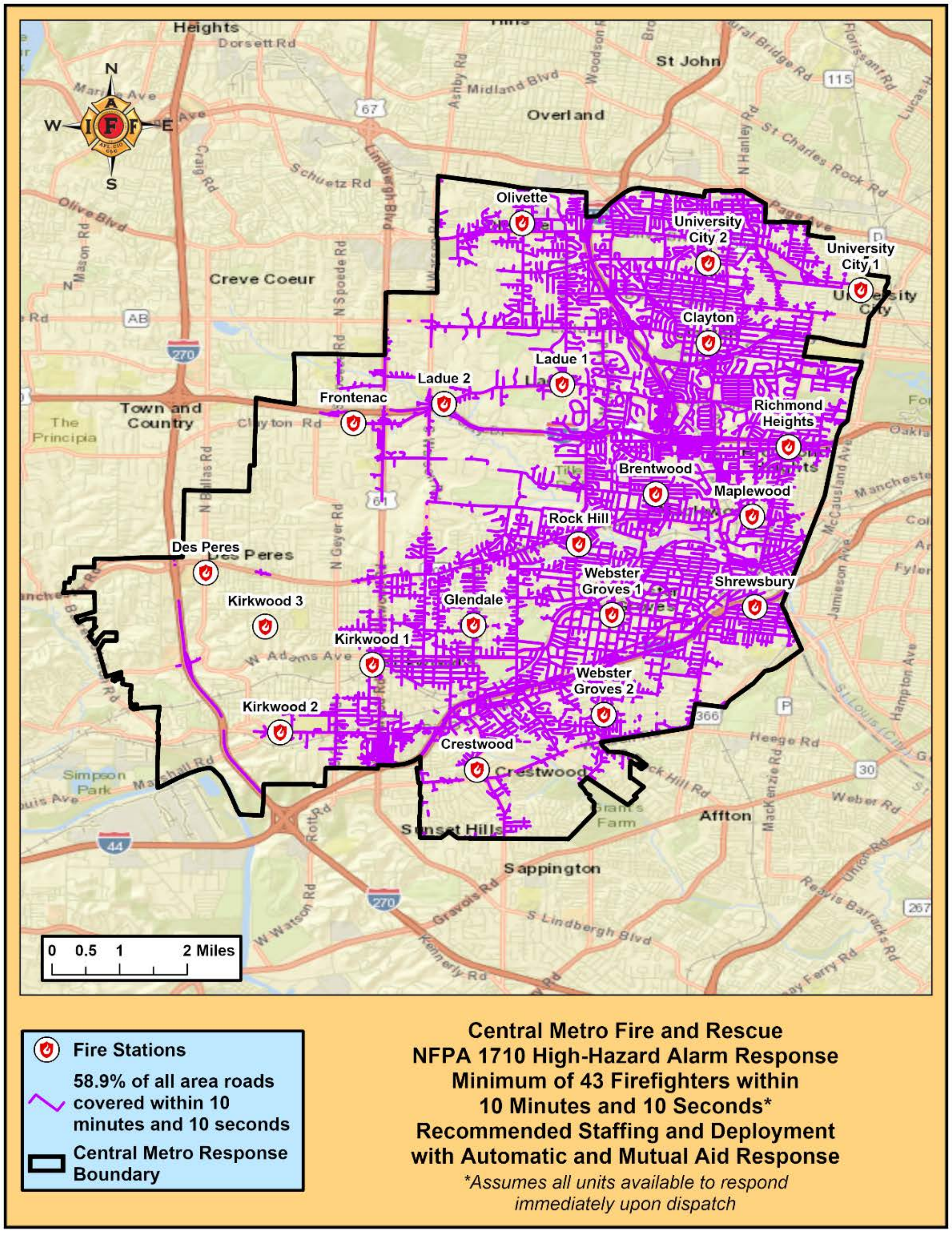
Map 50: 8-Minute Medic Response Capabilities, Recommended Staffing and Deployment with Automatic and Mutual Aid Response. Map 50 identifies the roads where CMFR and automatic and mutual aid departments' medic units, which are staffed and equipped to provide ALS procedures, can reach within eight minutes or less of travel. Based on this recommended staffing and deployment configuration, the departments would be capable of providing a minimum of one medic unit on scene within eight minutes or less of travel on 98.9% of roads within CMFR's response boundary, which is a 1.8% **increase** in response coverage compared to CMFR's current response capabilities with automatic and mutual aid response.



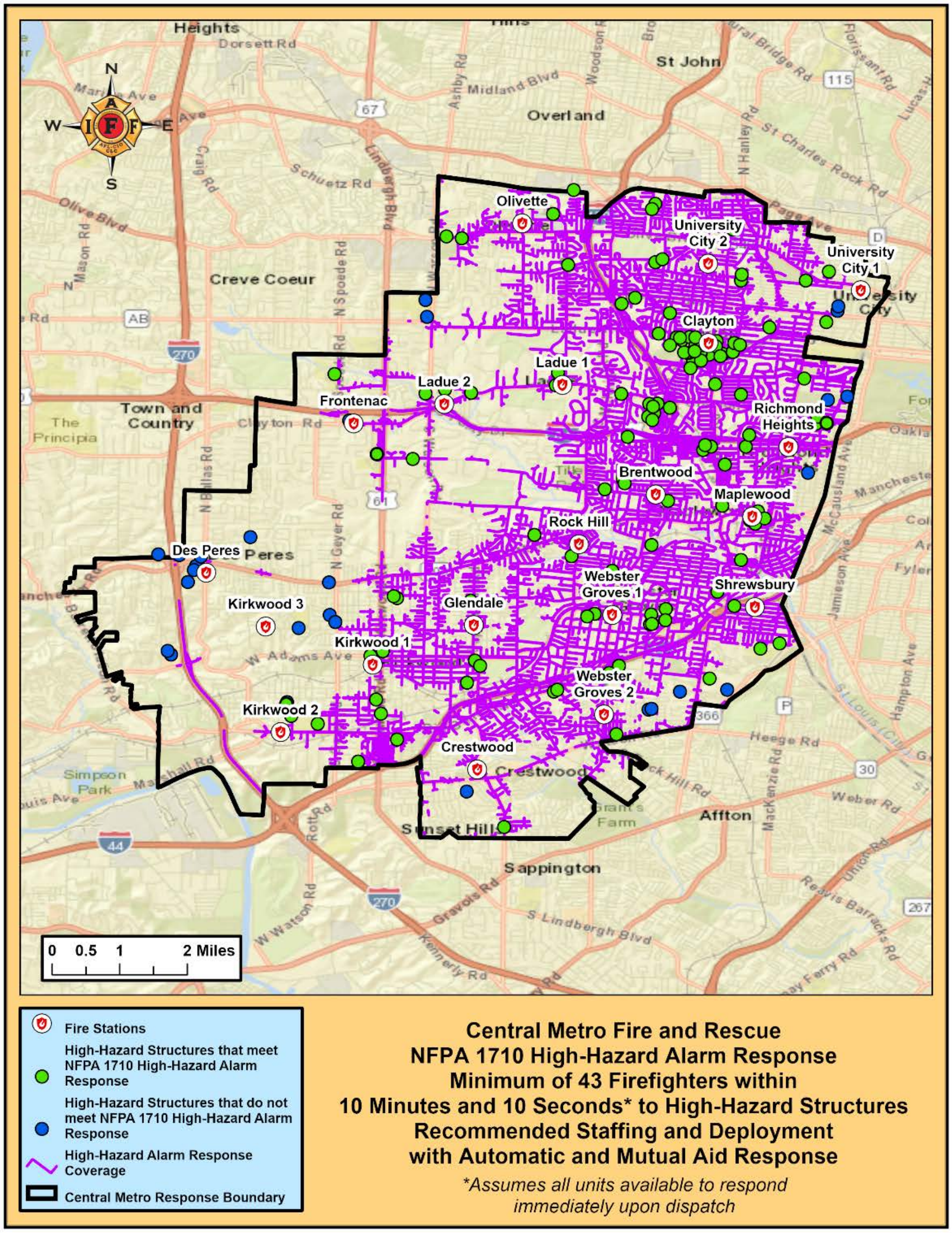
Map 51: NFPA 1710 Low-Hazard Alarm Response, Minimum of 17 Firefighters within 8 Minutes, Recommended Staffing and Deployment with Automatic and Mutual Aid Response. Map 51 identifies the roads where CMFR and automatic and mutual aid departments can assemble a minimum of 17 firefighters within eight minutes or less of travel. Based on this recommended staffing and deployment configuration, the departments would be able to assemble a minimum of 17 firefighters within eight minutes or less of travel on 72.2% of roads within CMFR's response boundary, which is a 146.0% **increase** in response coverage compared to CMFR's current response capabilities with automatic and mutual aid response.



Map 52: NFPA 1710 Medium-Hazard Alarm Response, Minimum of 28 Firefighters within 8 Minutes, Recommended Staffing and Deployment with Automatic and Mutual Aid Response. Map 52 identifies the roads where CMFR and automatic and mutual aid departments can assemble a minimum of 28 firefighters within eight minutes or less of travel. Based on this recommended staffing and deployment configuration, the departments would be able to assemble a minimum of 28 firefighters within eight minutes or less of travel on 41.5% of roads within CMFR's response boundary, which is a 1,621.0% **increase** in response coverage compared to CMFR's current response capabilities with automatic and mutual aid response.



Map 53: NFPA 1710 High-Hazard Alarm Response, Minimum of 43 Firefighters within 10 Minutes and 10 Seconds, Recommended Staffing and Deployment with Automatic and Mutual Aid Response. Map 53 identifies the roads where CMFR and automatic and mutual aid departments can assemble a minimum of 43 firefighters can assemble within 10 minutes and 10 second or less of travel. Based on this recommended staffing and deployment configuration, the departments would be able to assemble a minimum of 43 firefighters within 10 minutes and 10 seconds or less of travel on 58.9% of roads within CMFR's response boundary, which is a 2,201.4% **increase** in response coverage compared to CMFR's current response capabilities with automatic and mutual aid response.



Map 54: NFPA 1710 High-Hazard Alarm Response, Minimum of 43 Firefighters within 10 Minutes and 10 Seconds to High-Hazard Structures, Recommended Staffing and Deployment with Automatic and Mutual Aid Response. Map 54 identifies the high-hazard structures where CMFR and automatic and mutual aid departments can assemble a minimum of 43 firefighters can assemble within 10 minutes and 10 second or less of travel. Structures that are greater than 75 feet tall, square footage is greater than 196,000 ft^2, schools, and hospitals were all categories as high-hazard structures. Based on this recommended staffing and deployment configuration, the departments would be able to assemble a minimum of 43 firefighters within 10 minutes and 10 seconds on 81.7% of high-hazard structures within CMFR's response boundary, which is a 792.9% **increase** in response coverage compared to CMFR's current response capabilities with automatic and mutual aid response.

Summary of Response Capabilities based on Current and Recommended Staffing

Staffing Scenario	4-Minute Coverage (%)	4-Minute Engine Coverage (%)	Emergency "2 In/2 Out" Operations (%)	6-Minute Ladder Coverage (%)	8-Minute Heavy Rescue Coverage (%)	8-Minute ALS Medic Coverage (%)	NFPA 1710 Low-Hazard Alarm Response (%)	NFPA 1710 Medium-Hazard Alarm Response (%)	NFPA 1710 High-Hazard Alarm Response (%)
Current	65.0%	53.5%	33.3%	38.2%	0.0%	91.3%	25.5%	2.0%	0.7%
Current with Automatic and Mutual Aid Response	65.40%	53.6%	33.4%	43.3%	0.0%	97.1%	29.3%	2.4%	2.6%
Recommended	68.3%	57.6%	68.3%	50.1%	27.4%	94.8%	59.9%	34.1%	42.0%
Recommended with Automatic and Mutual Aid Response	71.1%	59.6%	71.1%	58.6%	27.4%	98.9%	72.2%	41.5%	58.9%

Table 9: Response Capabilities based on Current and Recommended Staffing and Deployment Scenarios. Table 9 displays the percentages of roads covered within CMFR's response boundary under four different deployment scenarios.

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Conclusion

In conclusion, regardless of the type of response, fire suppression companies are not staffed in compliance with industry standards for safe, efficient, and effective response to fires or rescue situations. CMFR's engine companies are typically staffed with three firefighters. Apparatus not staffed with a minimum of four firefighters do not meet the minimum industry staffing standards objectives outlined in NFPA 1500 and NFPA 1710. Additionally, CMFR's current response capabilities do not meet travel time objectives in the industry standard NFPA 1710, which requires the first-arriving apparatus to be on scene within four minutes or less of travel and a ladder company to be on scene within six minutes or less of travel. It also requires the assembly of 17 firefighters at a low-hazard structure fire within eight minutes or less, 28 firefighters at a medium-hazard structure fire within eight minutes or less, and 43 firefighters at a high-hazard structure fire within 10 minutes and 10 seconds or less for 90% of incidents.

By consolidating the 15 municipal fire departments into CMFR there will be improvements in fire and EMS response. Improvements include enhanced communication and deployment by operating under one dispatch center, standardized equipment, procedures, operational guidelines, and training, and centralized apparatus repair at one maintenance. These consolidation improvements will not only enhance department response capabilities but should also save the department money by operating under one administration.

While it is impossible to predict where most of a jurisdiction's fire and medical emergencies will occur, the Central Metro Fire and Rescue should examine where emergencies have typically occurred in the past and make efforts to ensure these areas continue to enjoy the same level of coverage, while adjusting resources and deployment as needed in an effort to achieve complete compliance with industry standards. Areas with accelerated development and population growth will require additional coverage in the future. Any projected increase in emergency response demands should also be considered before changes are implemented, focusing on associated hazard types and planned response assignments.

As explained by the Commission on Fire Accreditation International, Inc. in its Creating and Evaluating Standards of Response Coverage for Fire Departments manual, "If resources arrive too late or are understaffed, the emergency will continue to escalate…What fire companies must do, if they are to save lives and limit property damage, is arrive within a short period of time with adequate resources to do the job. To control the fire before it reaches its maximum intensity requires geographic dispersion (distribution) of technical expertise and cost-effective clustering (concentration) of apparatus for maximum effectiveness against the greatest number and types of risks." Optimally, there needs to be a balance between both elements.

The ramifications of low staffing levels, as they pertain to the loss of life and property within a community, are essential when considering a fire department's deployment configuration. A fire department should be designed to adequately respond to several emergencies occurring simultaneously in a manner that aims to minimize the loss of life and the loss of property that the fire department is charged to protect. Any proposed changes in staffing, deployment and station location should be made only after considering the historical location of calls, response times to specific target hazards, compliance with departmental Standard Operating Procedures, existing industry standards, including NFPA 1500 and NFPA Standard 1710, and the citizens' expectation of receiving an adequate number of qualified personnel on appropriate apparatus within acceptable time frames to make a difference in their emergency.

Appendix A: Performance Standards

The National Fire Protection Association (NFPA) produced NFPA 1710 *Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*. NFPA 1710 is the consensus standard for career firefighter deployment, including requirements for fire department arrival time, staffing levels, and fireground responsibilities.[97]

Key Sections included in the 1710 Standard that are applicable to this assessment are:

- **4.1.2.1** The fire department shall establish the following performance objectives for the first-due response zones that are identified by the AHJ:
  - (3) 240 seconds or less travel time for the arrival of the first engine company at a fire suppression incident[98]
  - (4) 360 seconds or less travel time for the arrival of the second company with a minimum staffing of 4 personnel at a fire suppression incident
  - (5) For other than high-rise, 480 seconds or less travel time for the deployment of an initial full alarm assignment at a fire suppression incident
  - (6) For high-rise, 610 seconds or less travel time for the deployment of an initial full alarm assignment at a fire suppression incident
  - (7) 240 seconds or less travel time for the arrival of a unit with first responder with automatic external defibrillator (AED) or higher-level capability at an emergency medical incident
  - (8) 480 second or less travel time for the arrival of an advanced life support (ALS) unit at an emergency incident, where this service is provided by the fire department provided a first responder with an AED or basic life support (BLS) unite arrived in 240 seconds or less travel time.

- **4.3.2** The fire department organizational statement shall ensure that the fire department's emergency medical response capability includes personnel, equipment, and resources to deploy at the first responder level with AED or higher treatment level.

- **5.2.3 Operating Units**. Fire company staffing requirements shall be based on minimum levels necessary for safe, effective, and efficient emergency operations.

[97] NFPA 1710, 2020
[98] All travel time objectives are to be achieved 90% of the time

- **5.2. 3.1 Engine Companies.** Fire companies, whose primary functions are to pump and deliver water and perform basic firefighting at fires, including search and rescue, shall be known as engine companies shall be staffed with a minimum of four on-duty personnel.

    - 5.2.3.1.1 These companies shall be staffed with a minimum of four on-duty personnel.
    - 5.2.3.1.2 In first-due response zones with a high number of incidents, geographical restrictions, geographic isolation, or urban areas, as identified by the AHJ, these companies shall be staffed with a minimum of five on-duty members.
    - 5.2.3.1.2.1 In first-due response zones with tactical hazards, high-hazard occupancies, or dense urban areas, as identified by the AHJ, these fire companies shall be staffed with a minimum of six on-duty members.

- **5.2.3.2 Ladder/Truck Companies.** 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 be known as ladder or truck companies… shall be staffed with a minimum of four on-duty personnel.

    - 5.2.3.2.1 These companies shall be staffed with a minimum of four on-duty personnel.
    - 5.2.3.2.2 In first-due response zones with a high number of incidents, geographical restrictions, geographic isolation, or urban areas, as identified by the AHJ, these companies shall be staffed with a minimum of five on-duty members.
    - 5.2.3.2.2.1 In first-due response zones with tactical hazards, high-hazard occupancies, or dense urban areas, as identified by the AHJ, these fire companies shall be staffed with a minimum of six on-duty members.

- **5.2.3.4 Fire Companies with Quint Apparatus**

    - 5.2.3.4.1 A fire company that deploys with quint apparatus designed to operate as either an engine company or a ladder company, shall be staffed as specified in 5.2.3.
    - 5.2.3.4.2 If the company is expected to perform multiple roles simultaneously, additional staffing, above the levels specified in 5.2.3, shall be provided to ensure that those operations can be performed as required.

- **5.2.4.1** The initial full alarm assignment to a structure fire in a typical 2000 ft^2 … two-story single-family dwelling without basement and with no exposures shall provide for the following

Assignment	***Required Personnel***
Incident Command	1 Officer
Uninterrupted Water Supply	1 Pump Operator
Water Flow from Two Handlines	4 Firefighters (2 for each line)
Support for Handlines	2 Firefighters (1 for each line)
Victim Search and Rescue Team	2 Firefighters
Ventilation Team	2 Firefighters
Aerial Operator	1 Firefighter
Initial Rapid Intervention Crew (IRIC)	4 Firefighters
Required Minimum Personnel for Full Alarm	**16 Firefighters & 1 Incident Commander**

- **5.2.4.2 Open-Air Strip Shopping Center Initial Full Alarm Assignment Capability**

  - 5.2.4.2.1 The initial full alarm assignment to a structure fire in a typical open-air strip shopping center ranging from 13,000 ft^2 to 196,000 ft^2 (1203 m^2 to 18,209 m^2) in size

And

- **5.2.4.3 Apartment Initial Full Alarm Assignment Capability**

  - 5.2.4.3.1 The initial full alarm assignment to a structure fire in a typical 1200 ft^2 (111 m^2) apartment within a three-story, garden-style apartment building shall provide for the following:

Assignment	***Minimum Required Personnel***
Incident Command	1 Incident Commander 1 Incident Command Aide
Uninterrupted Water Supply (2)	2 Firefighters
Water Flow from Three Handlines	6 Firefighters (2 for each line)
Support for Handlines	3 Firefighters (1 for each line)
Victim Search and Rescue Teams	4 Firefighters (2 per team)
Ladder/Ventilation Teams	4 Firefighters (2 per team
Aerial Operator	1 Firefighter
Rapid Intervention Crew (RIC)	4 Firefighters
EMS Transport Unit[99]	2 Firefighters
Required Minimum Personnel for Full Alarm	**27 Firefighters** **1 Incident Commander**

[99] The Standard further states, “Where this level of emergency care is provided by outside agencies or organizations, these agencies and organizations shall be included in the department plan and meet these requirements.”

- **5.2.4.4 High-Rise Initial Full Alarm Assignment Capability.**
    - 5.2.4.4.1 Initial full alarm assignment to a fire in a building with the highest floor 75 ft. (23 m) above the lowest level of fire department vehicle access shall provide for the following:

Assignment	***Required Personnel***
Incident Command	1 Incident Commander 1 Incident Command Aide
Uninterrupted Water Supply	1 Building Fire Pump Observer 1 Fire Engine Operator
Water Flow from Two Handlines on the Involved Floor	4 Firefighters (2 for each line)
Water Flow from One Handline One Floor Above the Involved Floor	2 Firefighters (1 for each line)
Rapid Intervention Crew (RIC) Two Floors Below the Involved Floor	4 Firefighters
Victim Search and Rescue Team	4 Firefighters
Point of Entry/Oversight Fire Floor	1 Officer 1 Officer's Aide
Point of Entry/Oversight Floor Above	1 Officer 1 Officer's Aide
Evacuation Management Teams	4 Firefighters (2 per team)
Elevator Management	1 Firefighter
Lobby Operations Officer	1 Officer
Trained Incident Safety Officer	1 Officer
Staging Officer Two Floors Below Involved Floor	1 Officer
Equipment Transport to Floor Below Involved Floor	2 Firefighters
Firefighter Rehabilitation	2 Firefighters (1 must be ALS)
Vertical Ventilation Crew	1 Officer 3 Firefighters
External Base Operations	1 Officer
2 EMS ALS Transport Units	4 Firefighters
Required Minimum Personnel for Full Alarm	**36 Firefighters 1 Incident Commander 6 Officers**

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Appendix B: Automatic and Mutual Aid Fire Stations

Station	Address	City	Apparatus	Staffing
Affton House 1	9282 Gravois Rd	St Louis	Ladder 1115 Medic 1117	5
Affton House 2	8110 Valcour Ave	St Louis	Engine 1124	3
Affton House 3	4990 Seibert Ave	St Louis	Medic 1137	2
Berkeley House 1	8401 Airport Rd	Berkeley	Engine 3611 Ladder 3612 Medic 3617	8
Berkeley House 2	9363 Natural Bridge Rd	Berkeley	Engine 3620 BC 3602	5
Black Jack House 1	12490 Old Halls Ferry Rd	Black Jack	Engine 3710	3
Black Jack House 2	18955 Old Jamestown Rd	St Louis	Engine 3720 Medic 3727	5
Black Jack House 3	5675 N US Highway 67 St	Florissant	Ladder 3735 Medic 3737 BC 3702	6
Community House 1	8847 St Charles Rock Rd	St Louis	Engine 3810 Medic 3817	5
Community House 2	9411 Marlowe Ave	Overland	Ladder 3822 Medic 3827 BC 3802	6
Community House 3	3736 Geraldine Ave	St Ann	Engine 3830	3
Creve Coeur House 1	11720 Olive Blvd	Creve Coeur	Ladder 2315 Medic 2317 BC 2302	7
Creve Coeur House 2	10940 Schuetz Rd	Creve Coeur	Engine 2324 Medic 2327	5
Eureka House 1	4849 Highway 109 St	Eureka	Engine 2414 Ladder 2412 Medic 2417	8
Eureka House 2	1815 West 5th St	Eureka	Engine 2424 Medic 2427	5
Eureka House 3	3570 White Oak School Road	Eureka	Engine 2434 Medic 2437	4
Fenton House 1	845 Gregory Ln	Fenton	Engine 1314 Ladder 1312 Medic 1317	8
Fenton House 2	1385 Horan Dr	Fenton	Ladder 1325 Medic 1327	5
Fenton House 3	1620 Smizer Mill Rd	Fenton	Engine 1334 Medic 1337	6

Station (Continue)	Address (Continue)	City (Continue)	Apparatus (Continue)	Staffing (Continue)
Fenton House 4	12500 Rott Rd	Sunset Hills	Ladder 1345 Medic 1347	5
Ferguson House 1	200 S Florissant Rd	Ferguson	Engine 3014 Medic 3017 BC 3002	7
Ferguson House 2	10701 West Florissant Ave	Ferguson	Engine 3024 Medic 3027	6
Florissant Valley House 1	661 St Ferdinand St	Florissant	Ladder 4015 Medic 4017 BC 4002	6
Florissant Valley House 2	1925 Pohlman Rd	Florissant	Engine 4024 Medic 4027	5
Florissant Valley House 3	1910 Shackelford Rd	Florissant	Engine 4034 Medic 4037	5
Hazlewood House 1	6100 North Lindbergh Blvd	Hazelwood	Engine 4114 Medic 4117	6
Hazlewood House 2	6800 Howdershell Rd	Hazelwood	Ladder 4125 BC 4102	4
Kinloch House 1	5684 Martin Luther King Blvd	Kinloch	Engine 4310	3
Lemay House 1	1201 Telegraph Rd	St Louis	Engine 1614 Medic 1617	5
Maryland Heights House 1	2600 Schuetz Rd	Maryland Heights	Engine 4414 Medic 4417	6
Maryland Heights House 2	12828 Dorsett Road	Maryland Heights	Ladder 4425 Medic 4427	6
Mehlville House 1	3241 Lemay Ferry Rd	St Louis	Engine 1710 Medic 1717	5
Mehlville House 2	5434 Telegraph Rd	St Louis	Engine 1720 Medic 1727	5
Mehlville House 3	4811 S Lindbergh Blvd	Sunset Hills	Engine 1730 Medic 1737	5
Mehlville House 4	13117 Tesson Ferry Rd	St Louis	Engine 1740 Medic 1747	5
Mehlville House 5	11020 Mueller Rd	St Louis	Engine 1750 Ladder 1752 Medic 1757	8
Mehlville House 6	6870 Telegraph Rd	St Louis	Ladder 1765	4
Mehlville House 7	5501 Old Lemay Ferry Rd	St Louis	Ladder 1775 Medic 1777	5
Metro North House 1	1815 Chambers Rd	St Louis	Engine 4610 Medic 4618 BC 4502	6
Metro West House 1	14835 Manchester Rd	Ballwin	Ladder 3312 Medic 3317	5
Metro West House 2	1000 New Ballwin Rd	Ballwin	Engine 3324 Medic 3327	5

Station (Continue)	Address (Continue)	City (Continue)	Apparatus (Continue)	Staffing (Continue)
Metro West House 3	17065 Manchester Rd	Wildwood	Ladder 3332 Medic 3337	5
Metro West House 4	16060 Clayton Rd	Ellisville	Engine 3344 Medic 3347 BC 3302	6
Metro West House 5	18601 Starck Ln	Wildwood	Engine 3354 Medic 3357	5
Mid County House 1	1875 Pennsylvania Ave	St Louis	Engine 4511 Medic 4517	6
Monarch House 1	15700 Baxter Rd	Chesterfield	Ladder 2212 Medic 2217	5
Monarch House 2	18424 Wild Horse Creek Rd	Wildwood	Engine 2224	4
Monarch House 3	1201 Fernview Dr	Chesterfield	Engine 2234 Medic 2237	5
Monarch House 4	14898 Olive Blvd	Chesterfield	Ladder 2242 Medic 2247	5
Monarch House 5	155 Long Rd	Chesterfield	Engine 2254 Medic 2257	5
Northeast House 1	7100 Natural Bridge Rd	Beverley Hills	Engine 4714 Medic 4717 Medic 4727 BC 4002	8
Pattonville House 0	13900 St Charles Rock Rd	Bridgeton	BC 4802	1
Pattonville House 1	11555 St Charles Rock Rd	Bridgeton	Ladder 4815 Medic 4817	6
Pattonville House 2	3365 Mckelvey Rd	Bridgeton	Engine 4824	4
Pattonville House 3	2222 Maryland Heights Expy	Maryland Heights	Ladder 4835 Medic 4837	6
Riverview House 1	9933 Diamond Dr	St Louis	Medic 4917	2
Riverview House 2	9207 Bellefontaine Rd	St Louis	Engine 4924 BC 4902	5
Riverview House 3	7215 West Florissant	Jennings	Engine 4930 Medic 4937	6
Robertson House 1	12641 Missouri Bottom Rd	Hazelwood	Engine 5014 Medic 5017	5
Robertson House 2	3820 Taussig Ave	Hazelwood	Engine 5024 Ladder 5025 Medic 5027 BC 5002	9
Spanish Lake House 1	12220 Bellefontaine Rd	Spanish Lake	Engine 5110 Medic 5117 BC 5102	7
Valley Park House 1	840 St Louis Ave	Valley Park	Engine 1914 Medic 1917	5
Valley Park House 2	55 Crescent Ave	Valley Park	Engine 1924 Medic 1927	5
West County EMS House 1	223 Henry Ave	Manchester	Engine 3514 Medic 3517	5

Station (Continue)	Address (Continue)	City (Continue)	Apparatus (Continue)	Staffing (Continue)
West County EMS House 2	13790 Manchester Rd	St Louis	Ladder 3525 Medic 3527	5
West County EMS House 3	13443 Clayton Rd	Town and Country	Engine 3534 Medic 3537	5
West Overland House 1	10789 Midland Blvd	West Overland	Engine 5214 Medic 5217	5

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