GEOGRAPHIC INFORMATION SYSTEM EMERGENCY SERVICES RESPONSE CAPABILITIES ANALYSIS

International Association of Fire Fighters
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BRANFORD FIRE DEPARTMENT

BRANFORD, CONNECTICUT

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Dedication

This Report is Dedicated to the Citizens of Branford, Connecticut, 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 Branford Professional Firefighters, Local 2533, to assess current Branford Fire Department response capabilities. This document will discuss the importance of maintaining adequate staffing in order to provide efficient and effective fire and emergency medical services to the Town of Branford, herein to be referred to as the Town.

The Branford Fire Department (BFD), herein to be referred to as the Department, is a municipal fire department located in the Town of Branford, in New Haven County, Connecticut. The Department provides fire suppression, technical rescue, and EMS first response and transport at the Advanced Life Support (ALS) level to a total area of 21.8 square miles within the Town.[1] In addition to all-hazard emergency responses, the Department performs other services for the Town such as fire prevention and safety programs, including fire-safety inspections. The Department also provides mutual aid response to the towns of East Haven, North Branford, and Guilford.

The Department maintains one fire station (Headquarters Station) staffed daily with a minimum of 8 career firefighters. Career personnel are trained to a minimum of firefighter/paramedic. There are also four stations that are staffed only by volunteers. The Town owns a sixth station, Station 6, which was closed in 1997. Current minimum career on-duty staffing levels at the Branford Fire Department allow for the deployment of two ALS transport units (Medics 1 and 2) both staffed with two firefighter/paramedics per unit, one engine company (Engine 1) staffed with three firefighter/paramedics, and one command vehicle (Car 6) staffed with a Deputy Chief. An ALS quick response unit (Rescue 2) is staffed Monday-Friday from 8:00 AM to 4:00 PM by one firefighter/paramedic working overtime.

In addition to the routinely staffed apparatus, the Department also maintains one truck company (Truck 1) for structure fire responses. However, this apparatus does not have a dedicated crew assigned to it as the Department utilizes the two firefighter/paramedics assigned to Medic 2 to cross-staff the unit for response. Cross-staffing is a practice where firefighters must select the apparatus to respond on based on the nature of the call. This type of staffing can create delays in response, especially when firefighters are out of the station on one apparatus and must respond back to the station to pick up the appropriate apparatus for the call. This practice can result in fire apparatus being taken out of service when an EMS incident occurs and can place ambulances out of service when a fire incident occurs. It can also have the effect of reducing the Department's overall ability to provide emergency services to the community. This situation is further

[1]U.S. Census Quick Facts for Branford, CT.

complicated by the requirement that if Medic 2 is needed to cross-staff Truck 1, Medic 2 must be in station and Medic 1, if not in station, must be available for response before Medic 2's crew can respond with Truck 1.

It should be noted that the Department staffs fire suppression apparatus below the effective and safe staffing levels required by industry standards. As a result of the insufficient staffing of fire suppression apparatus, the Department is unable to meet the requirements of the Occupational Safety and Health Administration's (OSHA) rules and regulations regarding safe operations in an Immediately Dangerous to Life or Health (IDLH) environment.

The provision of fire protection is an essential service that governments must provide. EMS, although not typically considered an essential service, is one that the citizens and government of Branford have come to expect and appreciate from the government. For the citizens, it provides a value-added service, improving on the public safety readiness and fire protection that they pay for through property taxes. For the government, it provides direct control over a service that impacts the lives and safety of the citizens, investments in property, and preparedness for emergencies, both small and large. However, in order for the fire department to be an effective and efficient service for both fire and EMS response, it must be staffed and deployed appropriately to address emergencies in an equitable manner, as they occur. The current staffing design of the Department relies on cross-staffing to deploy resources and is inconsistent with industry performance standards for response to fire and EMS incidents.

The Department has one suppression apparatus that is not cross-staffed. However, it is not staffed with the minimum personnel recommended by NFPA 1710. Improperly staffed apparatus reduces the capacity of the Department to respond to emergencies while increasing the likelihood of fatigue and injury for responders. Fatigue among responders could result in an increase in adverse events during suppression, rescue, and patient care events to victims, bystanders, and Department personnel. Additionally, insufficient staffing and the current practice of cross-staffing further reduces the Department's ability to address simultaneous requests for emergency service and could delay response to other requests for assistance when Department resources are unavailable.

As part of the assessment and analysis of the Department's response capabilities, the IAFF conducted a brief risk assessment of the Town. A review of the American Community Survey 2014 5-Year Estimates from the U.S. Census showed that 24.7% of the Town's population was in a vulnerable category based on age.[2] Vulnerable populations are those people that are at greater risk of impact from fire and other catastrophic incidents. This category consists of persons under the age of 5 (3.5%) and persons 65 years of age and older (21.2%), but does not include the special needs population.[3] Additionally, 7.7% of the population was living at or

[2] U.S. Census Bureau 2014 American Community Survey Demographic and Housing Estimates for Branford, CT
[3] Ibid.

below the poverty level.[4] There were 13,747 housing units within the Town, with the majority being single family residences (63.3%) and the remainder being multifamily structures (34.2%) and mobile homes (2.5%). Of all these structures, 50.4% were of pre-1970 construction, and 22.2% of all housing units were built in 1939 or earlier.[5] Typically, when there are high numbers of vulnerable residents and older buildings constructed before modern fire codes were developed, there is an increased demand on emergency services.

In addition to the risks identified through analysis of Census data, which are notable, the Town also has a number of high-hazard occupancies that increase the risk associated with fire and other industrial incidents. Among the high-hazard occupancies located in the Town and surrounding area are numerous multi-story buildings, chemical manufacturing facilities, hotels, light and heavy industrial facilities, and bioscience companies. These types of facilities increase the Town's risk for fire-related injuries and deaths, as well as increase demand on EMS resources. If the Department fails to appropriately staff companies and continues the practice of cross-staffing fire apparatus with personnel assigned to EMS units, it may be unable to respond to fires and other incidents in these high-risk environments in a timely manner and with enough personnel to mitigate the event.

The Department provided emergency incident data (incident type, date, and location) for over 23,000 emergency incidents that occurred from July 2011 through June 2015. As part of this analysis, each incident was plotted on a map using Geographic Information Systems (GIS) software and areas of incident concentration were identified and then compared to modeled response coverage. This showed several areas of increased incident concentration, including the area of greatest concentration, beyond a 4-minute travel time from the Headquarters Station.

The analysis and associated recommendations contained in this study are based on National Fire Protection Association standards and Occupational Safety and Health Administration regulations. NFPA 1710 is the consensus industry standard for career firefighter deployment and includes requirements for fire department arrival time, staffing levels, and fireground responsibilities.[6] NFPA 1500 *Standard on Fire Department Occupational Safety and Health Program* is the industry standard specifying the minimum requirements for a fire department's occupational safety and health program, as well as safety requirements for fire department members involved in rescue, fire suppression, emergency medical services, hazardous materials operations, special operations, and related fire department activities.[7] Paragraph (g)(4) of the United States Occupational Safety and Health Administration's revised respiratory protection standard, 29 CFR 1910.134 focuses on the safety of firefighters engaged in interior structural

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[4] U.S. Census 2014 American Community Survey Selected Economic Characteristic Estimates for Branford, CT
[5] U.S. Census 2014 American Community Survey Selected Housing Characteristic Estimates for Branford, CT
[6] NFPA 1710, 2016
[7] NFPA 1500, 2013

firefighting and requires a minimum of four firefighters on scene before beginning interior firefighting.

Key Findings

- Branford's fire suppression companies are inadequately staffed. Engine 1 has a minimum staff of 3 personnel and Truck 1 is cross-staffed with a minimum of two personnel. Fire suppression companies that are not staffed with a minimum of four firefighters are not in compliance with the company staffing objectives outlined in NFPA 1500 and NFPA 1710. When fire apparatus are understaffed, firefighters must wait until additional companies arrive with sufficient personnel prior to making entry into environments that are Immediately Dangerous to Life and Health (IDLH), such as structure fires. Current staffing levels only allow the Department to meet OSHA "2 In/2 Out" requirements on 32.3% of the roads within the total response area within 4 minutes.
- Cross-staffing can leave front-line suppression and EMS apparatus unstaffed as personnel must move between apparatus depending on the type of incident to which they are dispatched. When departments cross-staff apparatus instead of staffing them fulltime, personnel can be out of the station on the wrong type of apparatus when an incident occurs. When this happens they must respond to the station, switch apparatus, and then respond to the emergency or have another company respond from a greater distance with the appropriate equipment. Either scenario can lead to a delay in the arrival of the first company on scene, allowing a fire to continue to grow and delaying the initiation of medical care for someone who is sick or injured.
- Because of the current insufficient staffing levels, the Department is unable to assemble the minimum number of 15 firefighters on the scene of a low-hazard structure fire within 8 minutes as required by NFPA 1710.
- In addition to all-hazard emergency responses, the Department performs other services for the Town such as fire prevention and safety programs, including fire-safety inspections. For the purposes of this report, response coverage refers to the Department's coverage of the entire response area within the Town of Branford and does not address coverage of mutual aid responses. While the Department has volunteer members, volunteer membership and participation have been declining, making volunteer response inconsistent. This can delay response and places a greater demand on resources staffed by career personnel. Because of the many variables associated with volunteer response (such as personnel availability and the time taken to go to the station prior to responding), the volunteer component of the department cannot be included in the analysis.
- Currently, fire and EMS companies are only able to cover 32.3% of the roads in the response area within 4 minutes of travel if all units are available upon dispatch. The Fire Department is unable to provide coverage to large portions of the service area within 4

minutes. Response analysis also found that the Department is only able to cover 86.0% of roads within the response area within 8 minutes.

- Incident density analysis showed that the area of highest incident concentration is located in the southwestern corner of the Town, north of Station 4. This area appears to be beyond a 4-minute travel time from the Headquarters Station. High-risk occupancies located in this area include residential elderly care and rehabilitation facilities. The Department receives numerous requests for EMS resources from these locations.

Recommendations

It is recommended that the Branford Fire Department implement the following staffing and deployment changes. If implemented, the Department should see an increase in 4-minute first response and "2 In/2 Out" coverage. The Department would also be able to assemble a minimum of 15 firefighters within 8 minutes at the scene of a residential structure fire on 34.5% of roads within the Town, something it is currently unable to do.

- Increase staffing on Engine 1 to a minimum of four firefighters. Fire suppression companies that are not staffed with a minimum of four firefighters do not comply with the minimum company staffing requirements of industry standards and are not able to enter IDLH environments until other companies arrive on the scene. Increasing the minimum staffing on all fire suppression companies to four firefighters allows the first suppression company arriving on the scene of a structure fire to immediately begin interior fire suppression operations that comply with industry standards and OSHA regulations.
- Staff Truck 1 full-time with a minimum of four firefighters and end the practice of cross-staffing front-line suppression and EMS apparatus. Staffing Truck 1 full-time provides consistent ladder company and, because they are no longer cross-staffing Truck 1, Medic 2 availability. This improves overall resource availability and Department response capabilities.
- Staff Engine 4 full-time with a minimum of four firefighters. Station 4 is the closest station to the area of highest incident density within the Town. By staffing Engine 4 with a minimum of four personnel the Department's 4-minute "2 In/2 Out" coverage and 4-minute EMS first response coverage would be increased and include the area of highest incident density.
- Medic 1 & Medic 2 should be staffed, full-time, at a level that meets state and jurisdiction ALS transport unit staffing requirements. Consistent ALS transport availability, in conjunction with improved ALS first-response coverage provided by suppression companies, would improve overall EMS service delivery in much of the areas of increased incident density.

Conclusion

This analysis found that the Department's emergency operations capabilities suffer due to insufficient staffing levels and inadequate resource deployment. Current staffing practices require the Department to cross-staff Truck 1 with the crew from an EMS company, reducing overall emergency response capabilities. The lack of appropriate company staffing can lead to delays in the initiation of fire suppression activities and emergency medical treatment, increasing the likelihood of negative outcomes.

Density analysis of incidents from July 2011 through June 2015 found that there were large concentrations of reported incidents that are beyond a 4-minute response time from Headquarters, including the area of greatest incident density located in the south west area of the Town near Station 4. In order to comply with industry standards and regulations, the Department must change current staffing and deployment procedures and stop the practice of cross-staffing fire suppression and EMS apparatus. Additional firefighters should be hired and trained, and minimum on-duty staffing increased so that suppression companies and EMS units are appropriately staffed 24 hours per day, 365 days per year. The Town should establish minimum on-duty staffing on Engine 4 of no less than 4 firefighters per day to ensure adequate response coverage in the area of greatest call density. Once staffing has been increased, and as the Town continues to grow, additional gap analyses should be completed to identify those areas that have, or will have, significant demand for service and do not receive adequate 4- & 8-minute response coverage, such as the area of increased incident density north of Interstate 95. The results of those analyses can then be used by Town planners when making future staffing and deployment decisions.

Introduction

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The International Association of Fire Fighters (IAFF) Headquarters was contacted by the Branford Professional Firefighters, IAFF Local 2533, and asked to assess current Department operational capabilities. The information provided in this document is designed to help decision makers understand the depth of fire department operations and how staffing below levels called for in industry standards negatively impacts responders and the Town alike.

The Branford Fire Department has a total response area of 21.8 square miles. According to the 2014 U.S. Census American Community Survey Estimates the Town of Branford had an estimated population of 28,066 people. Of the Town's total population, 24.7% were categorized by the Census as being vulnerable, meaning they were either under the age of 5 or 65 years of age and older.[8] Emergency response coverage is provided from one station within the Town that has 24/7 career staffing, Headquarters Station on North Main Street, staffed with eight firefighters and four stations, Stations 2, 4, 5, & 9 that are staffed by volunteer firefighters. A sixth station, Station 6, was closed in 1997. The many variables associated with volunteer response (such as availability and the time required to go to the station prior to responding), make it difficult to accurately model the volunteer component of the department. Because of this, volunteer resources are not included in the analysis.

The career firefighters assigned to Headquarters respond with an understaffed engine company (Engine 1) staffed with three firefighter/paramedics, two ALS transport units (Medic 1 & Medic 2) that are each staffed by two firefighter/paramedics, and a command unit (Car 6) staffed by a Deputy Chief. The personnel assigned to Medic 2 also cross-staff Truck 1. In addition to the eight on-duty career personnel, there is one firefighter/paramedic on overtime that staffs an ALS quick response vehicle (Rescue 2) from 8:00 AM to 4:00 PM Monday through Friday.

Under the current staffing model, firefighters are required to cross-staff Truck 1 with personnel assigned to an ALS transport unit (Medic 2). Cross-staffing is a practice where firefighters are not assigned to a specific apparatus, but instead move between apparatus depending on the nature of the emergency to which they are responding. The risk of this practice is that firefighters may be out of the station on the wrong type of apparatus when dispatched to an incident. Cross-staffing can create a significant delay in the arrival of resources at the scene of an emergency, allowing fires to grow larger and delaying time critical treatment to those experiencing a medical emergency or injury. The cross-staffing of Truck 1 is further complicated by the requirement that both Medic 1 and Medic 2 be available for emergency response and that Medic 2 be in quarters. This practice makes the availability of Truck 1 inconsistent and can create additional delays in the arrival of a truck company and their unique capabilities at the scene of a structure fire.

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[8] U.S. Census Bureau 2014 American Community Survey Demographic and Housing Estimates for Branford, CT

The provision of fire protection is an essential service that governments must provide. In many states, EMS is not considered an essential service, but it has become an expectation that it be provided by the Town as well. The Department responds to an annual average of 5,792 calls for emergency service, approximately 70.0% of which are for EMS.[9] For this service to be effective and efficient, it must be staffed and managed appropriately to address emergencies in an equitable manner. By using personnel from EMS transport units to cross-staff suppression resources, the Department decreases the overall level of fire protection provided to the residents and negatively affects all citizens. It also reduces overall EMS response capabilities by reducing the first response resources provided by adequately staffed fire suppression companies equipped with EMS supplies and additional responders.

[9] Based on incident information from July 2011 through June 2015

Fire Suppression Operations

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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, as well as advances in modern prehospital 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.

In less than 30 seconds a small flame can burn out of control and become a major fire. During fire growth, the temperature of a fire rises to above 1,000° and Fahrenheit (F). It is generally accepted in the fire service that for a medium growth rate fire,[10] flashover - the very rapid spreading of the fire due to super heating of room contents and other combustibles - can occur. It is also worth noting that a flashover may occur more quickly depending on building construction materials and room contents that act as fuel.

As fires grow, the odds of survival for unprotected individuals inside the affected area decrease to a virtually non-existent level. The rapid response and arrival 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. Current minimum on-duty staffing does not allow for the assembly of 15 personnel within 8 minutes for a response to what is considered a low-hazard structure fire. A low-hazard structure fire is a fire in a typical, 2,000 square foot, single-family residential home with no basement or exposures.[11]

In Branford, the practice of cross-staffing fire apparatus and ambulances reduces the Department's ability to respond rapidly and efficiently to emergencies and increases the risk to the community. The current minimum on-duty staffing is below industry standards and can impede fireground tactics and increase property loss as result of fire and smoke damage. Additionally, reducing the number of on-duty personnel increases the likelihood of fire related injuries and deaths for responders and citizens alike while also delaying the initiation of emergency medical treatment at EMS incidents.

This section will explain fire growth and the importance of rapid fire department response with an appropriate number of resources.

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[10] 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.

[11] NFPA 1710, 2016 ed. Pg. 1710-19 §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 a chemical change to the material's surface which begins to convert from a solid and release combustible gases. If enough combustible gases are released the material will burn freely.

The 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 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 could 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 in 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.

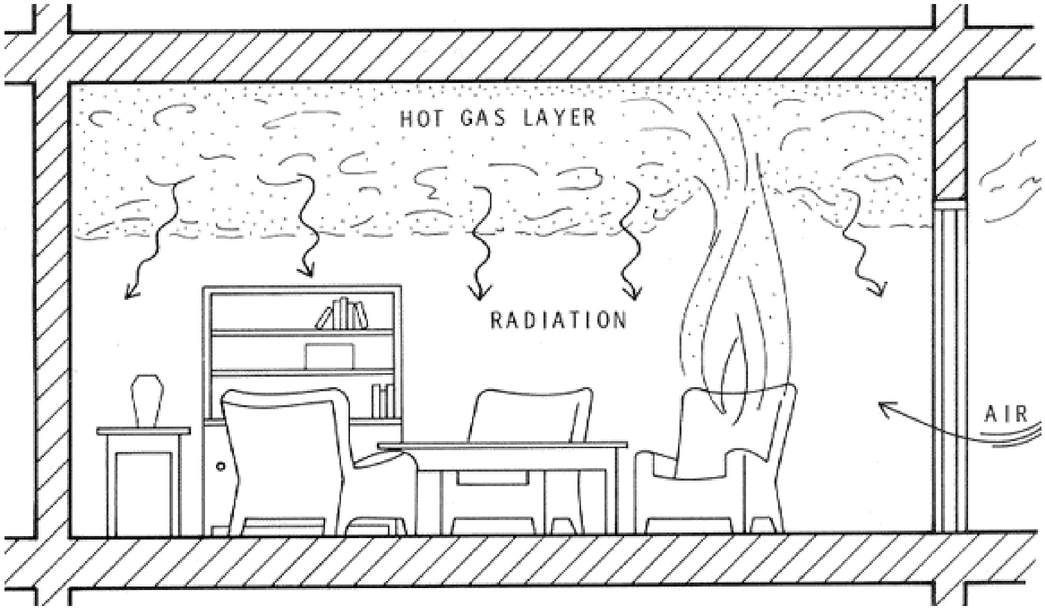

Figure 1: Fire Growth in a Compartment.[12] The above figure depicts the growth of fire in a compartment, which is an enclosed space or room in a building. In a compartment the walls, ceiling, floors, and objects absorb radiant heat produced by the fire. Unabsorbed heat is reflected back to the initial 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, 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 continues 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.”[13]

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 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 degrees F or greater. With enough existing oxygen at the floor level, flashover occurs, burning everything in the room at once.

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

The instantaneous eruption into flame generates a tremendous amount of heat, smoke, and pressure. The pressure has enough force to push beyond the room of origin and through doors and windows. Usually at the time of flashover, windows in the room will break, allowing for the entry of fresh air. The introduction of fresh air serves to further drive the growth of the fire by increasing the fire's temperature and spreading the fire beyond the room of origin.

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

Staffing deficiencies on primary fire suppression apparatus negatively affect the ability of the fire department to safely and effectively mitigate emergencies and therefore correlate directly with higher risks and increased losses. Continued fire growth beyond the time of firefighter arrival on scene is directly linked to the time it takes to initiate fire suppression operations. As indicated in Table 1, below, responding companies staffed with four firefighters are capable of initiating critical fireground operational tasks more efficiently than those with crew sizes below industry standards.

	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 1: Impact of Crew Size on a Low-Hazard Residential Fire.[14] 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. Because of insufficient suppression company staffing (the Department staffs as few as three firefighters on Engine 3 and two firefighters on the Ladder, assuming the Ladder can be staffed) first arriving companies must wait for additional companies before beginning interior operations.

First-arriving companies staffed with four firefighters are more efficient in all aspects of initial fire suppression and search and rescue operations when compared to two- or three-person

[14] 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.

companies. There is a significant increase in time to task completion for all the tasks if a company arrives on scene staffed with only three firefighters compared to four firefighters. According to the National Institute of Standards and Technology (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 as well as the increased risk of property damage and economic loss.

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 critical second-in company duties.

Insufficient numbers of emergency response units or inadequate staffing levels on those units expose citizens and firefighters to increased risk, further drain already limited fire department resources, and stress 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.

A prime objective of fire service agencies is to maintain enough strategically located personnel and equipment so that the minimum acceptable response force can reach a fire scene before flashover is likely.[15] Two of the most important elements in limiting fire spread are the quick arrival of sufficient numbers of personnel and equipment to attack and extinguish the fire as close to the point of origin as possible, as well as rescue any trapped occupants and care for the injured. Rapid and aggressive interior attack of structure fires, as close as possible to the point of origin, can reduce human and property losses. Sub-optimal staffing of arriving units may delay such an attack, thus allowing the fire to progress to more dangerous conditions for firefighters and citizens. "If the arriving units have adequate resources to handle the situation, then they will fight the fire aggressively and offensively. They will attack the problem head-on and, following department standards, will accomplish their objectives efficiently, effectively, and safely. If they do not have adequate resources to aggressively handle the situation, then they will have to fight

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

the fire in a defensive mode of attack. This mode will continue until enough resources can be massed to then change to an aggressive, offensive attack."[16]

NFPA 1500 and 1710 both recommend that a minimum acceptable fire company staffing level should be four members responding on, or arriving, with each engine and ladder company. Recall that at the scene of an emergency, the driver/operator of the engine must remain with the apparatus to operate the pump. Likewise, the driver/operator of the ladder truck must remain with the apparatus to safely operate the aerial device. Due to the demands of fireground activities, a fire attack initiated by three firefighters is not capable of affecting a safe and effective fire suppression and/or rescue operation until sufficient personnel arrive.

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 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 affecting a safe and effective fire suppression and/or rescue operation until additional personnel arrive. By that time, the fire may be beyond control and property and lives lost.

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 tasks associated with fire suppression and search and rescue. As units arriving with more firefighters increases, the overall time on the scene of the emergency decreases. In other words, the more firefighters available to respond and arrive early to a structure fire, the less time it takes to extinguish the fire and perform search and rescue activities, thus reducing the risk of injury and death to both firefighters and trapped occupants and reducing the economic loss.

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[16] National Institute for Occupational Safety and Health, High-Rise Apartment Fire Claims the Life of One Career Fire Fighter (Captain) and Injures Another Career Fire Fighter (Captain) – Texas, October 21, 2002.

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

Table 2: The Relationship between Crew Size and Scene Time.[17] The above table displays how companies staffed with larger sized crews 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. Stagger is the difference between the arrival of each responding company. In the above table, a "close" stagger was 1 minute apart and a "far" stagger was 2 minutes. In Branford, the practice of cross-staffing fire and EMS apparatus can leave apparatus unavailable to respond and result in longer stagger times between arriving fire apparatus.

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.[18] [19] 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.

Fire modeling was also used by researchers 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 provided 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.

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[17] 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

[18] Ibid.

[19] 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 Fire Fighters.

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.[20]

In 2014 alone, 57% of all firefighter fatalities were related to overexertion.[21] There is strong epidemiological evidence that heavy physical exertion can trigger sudden cardiac events.[22] Smaller crews are responsible for performing a number of task 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. 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.

In Branford, fire suppression apparatus are staffed with a minimum of three on the engine and two on the ladder if personnel are available. Because of this, firefighters operating on the scene of a fire or labor intensive rescue situation will be potentially overexerting for a prolonged period of time.

[20] 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.
[21] Fahy, R.F., LeBlanc, P.R., Molis, J.L. (June, 2015) Firefighter Fatalities in the United States-2014. NFPA.
[22] 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

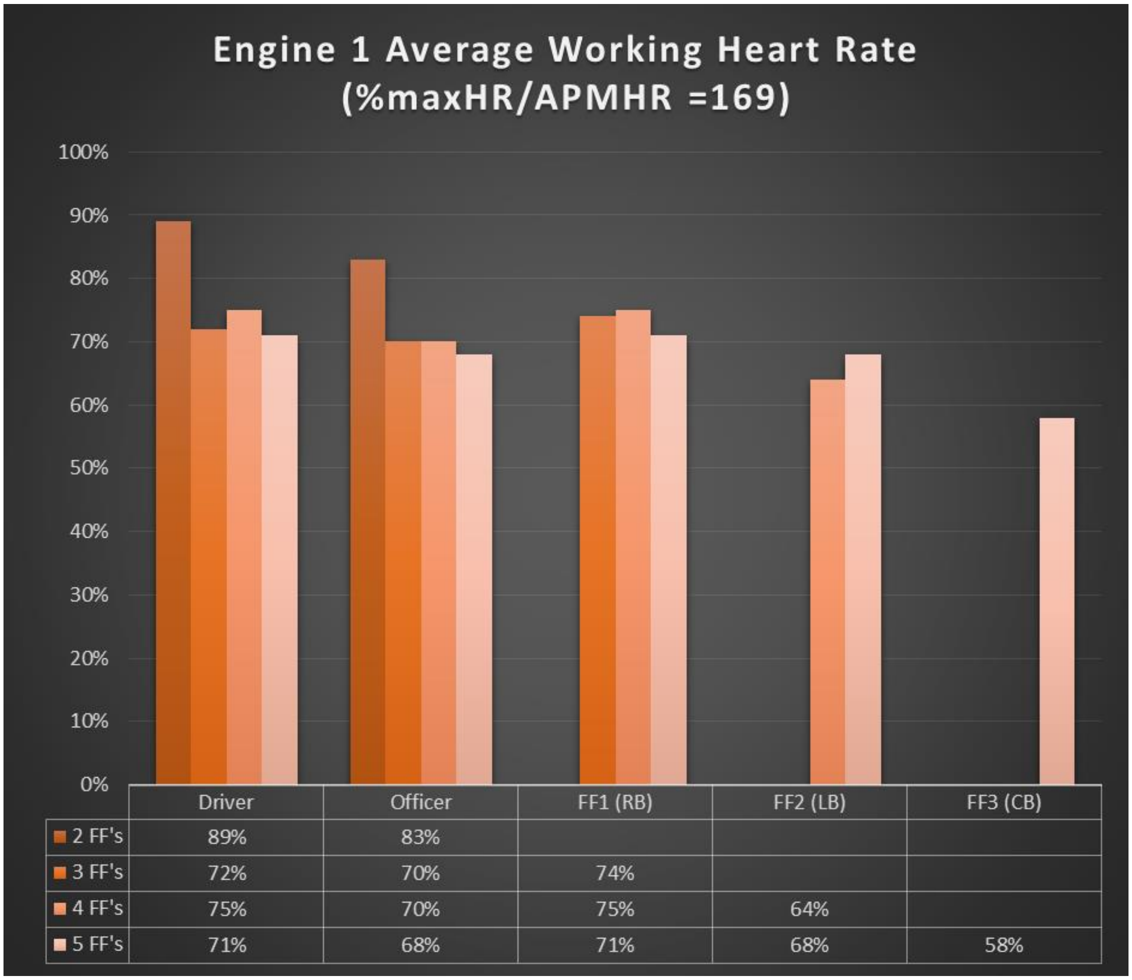

Chart 1: Average Peak Heart Rate of First Engine (E1) with Different Crew Sizes by Riding Position.[23] *In Chart 1, heart rates are expressed as a percent of maximal age-predicted maximal HR.* The average heart rates for firefighters on the first engine company were above 80% of age-predicted maximum 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.[24] 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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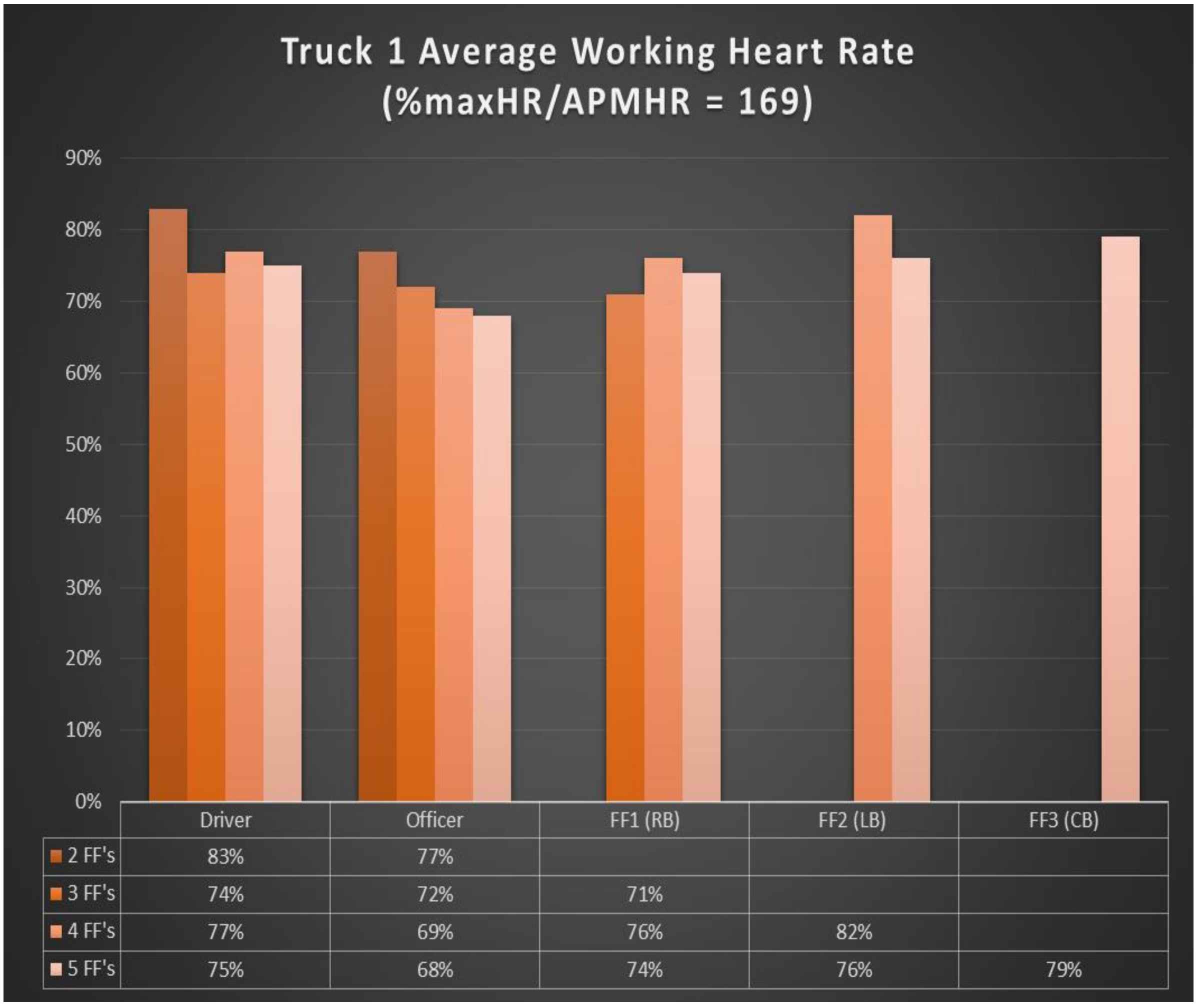
[23] Riding position for Chart 1 are as follows: Driver, Officer, Firefighter 1-Right Bucket (RB) seat, Firefighter 2-Left Bucket (LB) seat, Firefighter 3- Center Bucket (CB) seat. A fire company that is staffed with 2 will consist of a Driver and an "Officer."

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



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

Chart 2: Average Peak Heart Rate of First Truck (T1) with Different Crew Sizes by Riding Position.[25] *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.[26] 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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[25] 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."

[26] 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 3, below. 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.[27] As with inadequate staffing, this type of operation will continue until enough resources can be amassed to then change to an aggressive, offensive attack.

Fire modeling was also used by researchers 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 provided 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.

[27] 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	10.29	$212.00
Confined to object of origin	0.65	13.53	$1,565.00
Confined to room of origin, including confined fires by incident type[28]	1.91	25.32	$2,993.00
Beyond the room, but confined to floor of origin	22.73	64.13	$7,445.00
Beyond floor of origin	24.63	60.41	$58,431.00

Table 3: The Relationship between Fire Extension and Fire Loss.[29] 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.

[28] 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.

[29] National Fire Protection Association, NFPA 1710 (2016), Table A.5.2.2.2.1(b) Fire Extension Home Structure Fires, 2006-2010.

Initial Full Alarm Assignment

Initial Full Alarm Assignment Capability, as outlined in NFPA Standard 1710, states that the fire department shall, on incidents that are not in a high-rise structure, 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 assignment to a typical 2,000 ft^2 structure fire shall provide for the following:

Minimum Personnel for NFPA 1710 Full Alarm Assignment	
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 Firefighters
Initial Rapid Intervention Crew (IRIC)	2 Firefighters
Required Minimum Personnel for Full Alarm	**14 Firefighters & 1 Scene Commander**

Table 4: NFPA 1710 Full Alarm Assignment Personnel Requirements. The expected capabilities of a full alarm assignment that complies with NFPA 1710 requires a minimum contingent of 15 fire suppression personnel. NFPA 1710 also requires that supervisory chief officers be assisted by an aide[30] which will increase on-scene staffing to 16 personnel. If an engine company is used to support water supply operations and the Chief is provided with an aide, the minimum number increases to 17 personnel.

[30] NFPA 1710, § 5.2.2.2.5

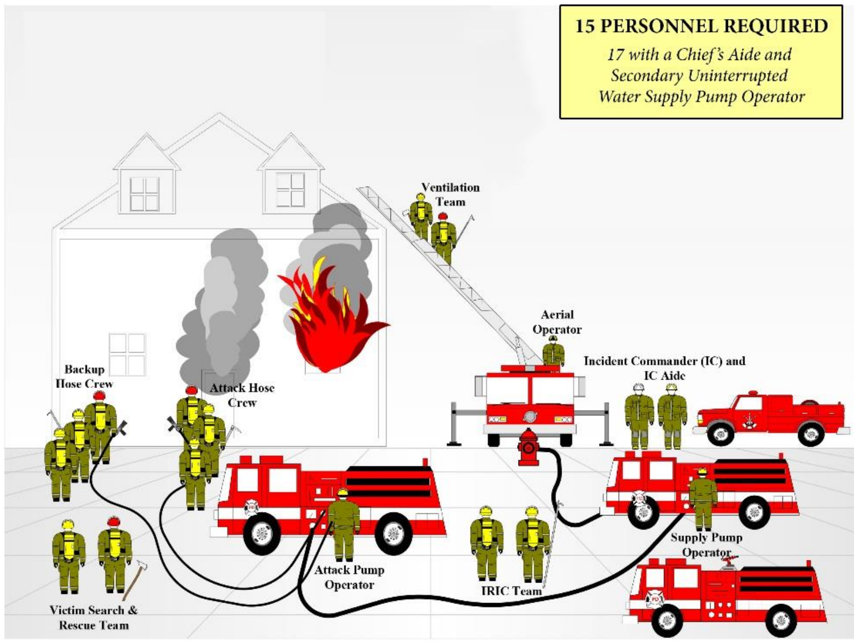

Figure 2: Initial Full Alarm Assignment Deployed Within 8 Minutes. The above figure depicts the full alarm assignment discussed in NFPA 1710, with an additional firefighter to act as an incident commander aide, and another additional firefighter to act as a pump operator for a supply apparatus. When personnel from fire apparatus must transition to ambulances to respond to EMS emergencies, available fire suppression resources are reduced.

In addition, NFPA 1710, §5.2.4.3.2 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. Data generated by the NFPA provides empirical proof that a rapid and aggressive interior attack can substantially reduce loss of life and the loss of property associated with structural fires. Each stage of fire extension beyond the room of origin directly increases the rate of civilian deaths, injuries, and property damage.

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.

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 revised respiratory protection standard, 29 CFR 1910.134. The focus of this section of the regulation 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 also covers the number of persons who must be on the scene before firefighting personnel may initiate an interior attack on a structural fire.[31] An interior structural fire (*an advanced fire that has spread inside of the building where high temperatures, heat and dense smoke are normally occurring*) would present an IDLH atmosphere and, therefore, require the use of respirators. In those cases, at least two standby firefighters outside the structure, in addition to the minimum of two inside needed to fight the fire, must be present before firefighters may enter the building.[32] 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."

One of the most important elements in limiting fire spread is the quick arrival of sufficient numbers of personnel and equipment to attack and extinguish the fire as close to the point of origin as possible, as well as rescue any trapped occupants and care for the injured. Several existing National Fire Protection Association standards address this time-critical issue. NFPA Standard 1710 recommends 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**,"[33] except when, "In jurisdictions with a high number of incidents or geographical restrictions, as identified by the AHJ, these companies shall be staffed with a minimum of five on-duty members," or "In jurisdictions 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."[34] Suppression 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 staffed with **a minimum of four on-duty members**."[35] NFPA 1710 further states that ladder or truck

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[31] Paula O. White, letter to Thomas N. Cooper, 1 November 1995 (OSHA)
[32] According to NFPA standards relating to firefighter safety and health, the incident commander may make exceptions to these rules if necessary to save lives. The Standard does not prohibit firefighters from entering a burning structure to perform rescue operations when there is a "reasonable" belief that victims may be inside.
[33] NFPA 1710, § 5.2.3.1 and § 5.2.3.1.1
[34] NFPA 1710, § 5.2.3.1.2 and § 5.2.3.2.1
[35] NFPA 1710, § 5.2.3.2 and § 5.2.3.2.1

companies “In jurisdictions with a high number of incidents or geographical restrictions, as identified by the AHJ, these fire companies shall be staffed with a minimum of five on-duty members,” and “In jurisdictions with tactical hazards, high-hazard occupancies, or dense urban areas, as identified by the AHJ, these companies shall be staffed with a minimum of six on-duty members.”[36]

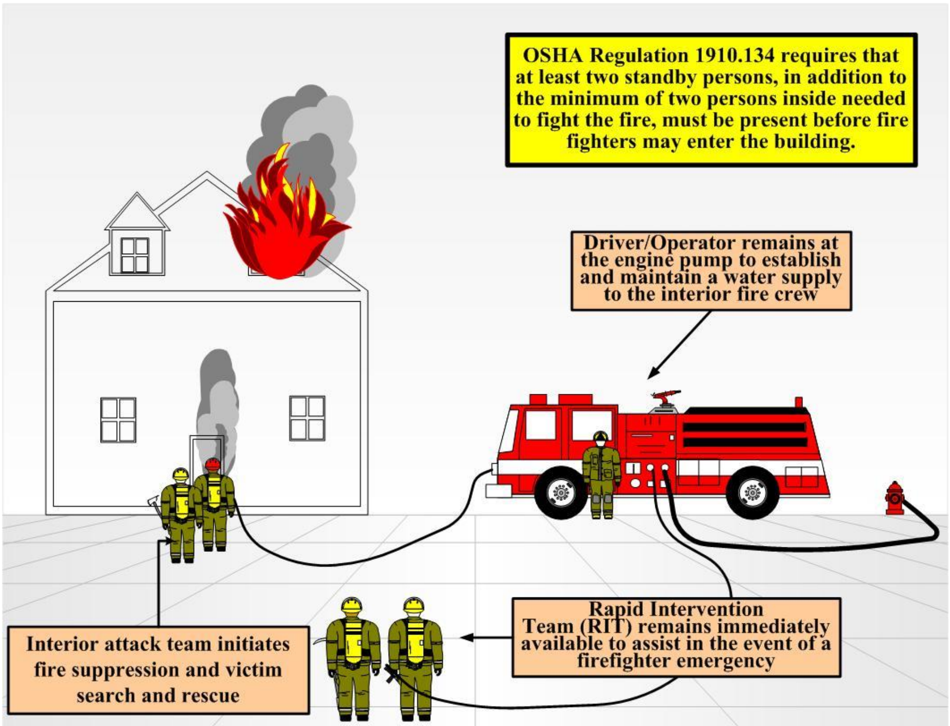

Figure 3: The OSHA “2 In/2 Out” Rule. The above figure depicts the number of firefighters required to meet OSHA regulation 1910.134, which demands one firefighter outside for every firefighter inside. In this sense the firefighters outside can support a secondary attack line and facilitate the rescue 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.

A number 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.

[36] NFPA 1710, § 5.2.3.2.2 and § 5.2.3.2.2.1

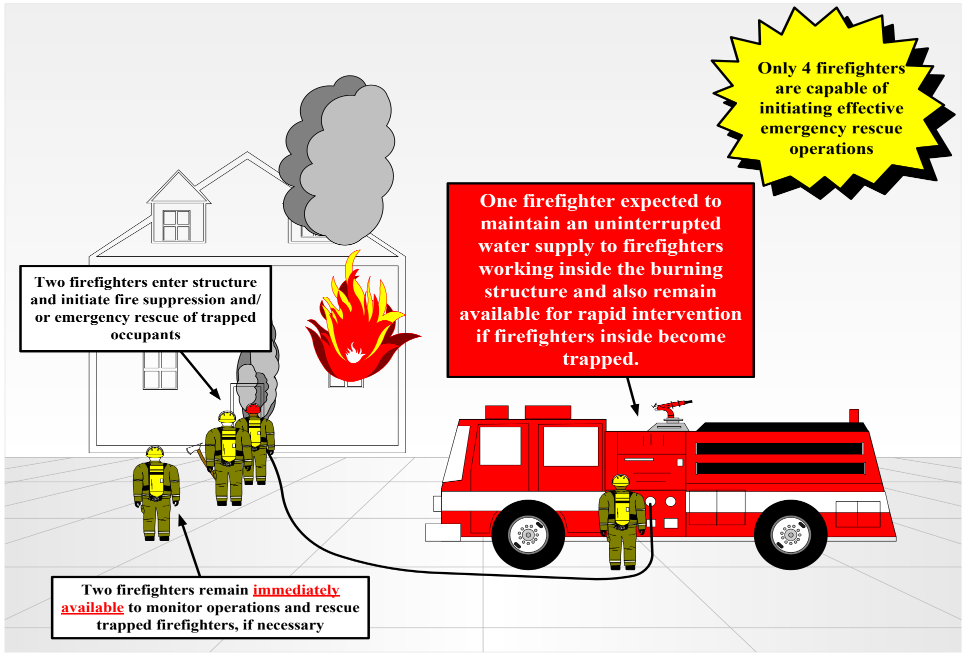

Figure 4: Emergency "2 In/2 Out" Operations. In the emergency model depicted above, the arriving fire apparatus is staffed with a crew of 4 personnel and operates under emergency conditions. In this case the driver/operator of the fire apparatus is also counted as a firefighter, which means he/she must be dressed in personal protective equipment (PPE) to be ready to participate in rescue if the need should arise. Analysis of BFD response capabilities found that Department resources (Engine 1 and at least one other company such as Medic 1) responding together from Headquarters could meet OSHA's "2 In/2 Out" requirements on 32.3%, assuming the Medic is available for response, of all roads in the total response area within 4 minutes travel. Because all career personnel respond from Headquarters this is the same as the total 4-minute response coverage time.

When confronted with occupants trapped in a burning structure and a single fire company is on scene, only a company staffed with four firefighters is able to 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 the "2 In/2 Out" regulation, and in a manner that minimizes the threat of personal injury. In crews with fewer than 4 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 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.

The Importance of Adequate Resources: Distribution

Distribution involves locating geographically distributed first-due resources for all-risk initial intervention. Stations should be located 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.[37] In this analysis, distribution is measured by the percentage of roads that are covered from each fire station within 4- and 8-minute travel times to adhere to NFPA 1710 standards.

A distribution study requires geographical analysis of first due resources. Distribution measures may include:[38]

- 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
- 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
    1. Population not served
    2. Area not served (square miles)
    3. Road miles not served (miles)
    4. 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 or not the fire department is achieving a reasonable response performance to handle emergencies.[39]

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[37] Commission on Fire Accreditation International, 5th Edition. 2008. Page 52.
[38] Ibid.
[39] Commission on Fire Accreditation International, 5th Edition. 2008. Page 53

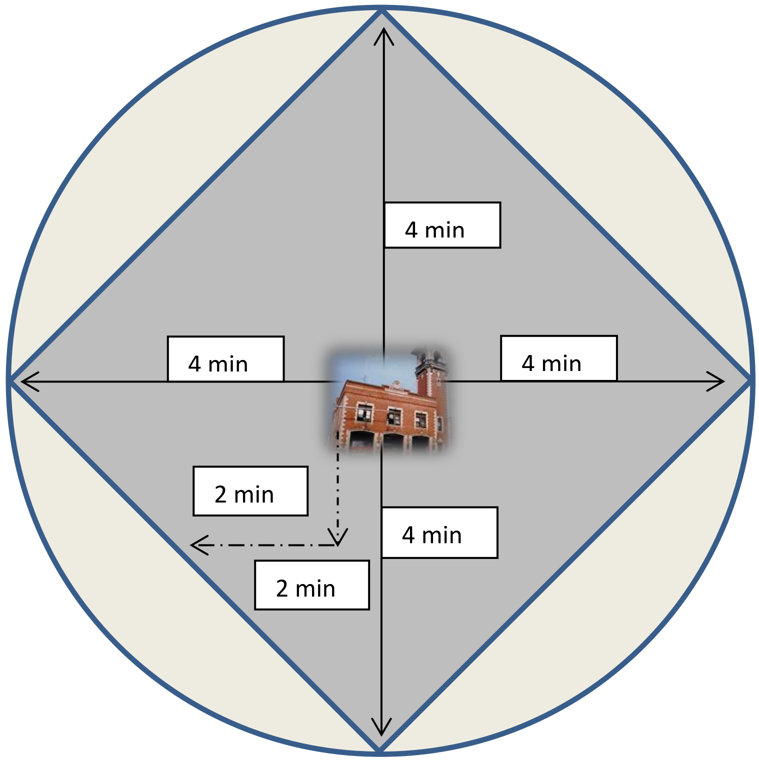

Figure 5: Normal distribution model for an initial 4-minute response area.[40] As depicted in the above figure, fire stations and emergency resources should be distributed throughout a community so that citizens receive equitable coverage and protection. However, there are additional points of concern when modeling a response district such as road network, traffic patterns, and building occupancies.

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 probabilities 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 the Town 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 with shorter travel times. But, would citizens in lower risk areas accept longer 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.

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.[41] Other issues occur such as reliability, call processing times and turnout times, and traffic which can affect the overall performance of response times.

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[40] Derived from Commission on Fire Accreditation International, 5th Edition. 2008. Page 54

[41] Commission on Fire Accreditation International, 5th Edition. 2008. Page 55

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.[42] Specialty units tend to be trucks, rescue units, hazmat, or command 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 department and a set goal of response time objectives for all-hazards emergencies within the Town.

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.[43]

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

Response to High-Hazard Fires

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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. In many cases 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, 2012 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.3.3.28 as high-hazard occupancies, represent an extraordinary challenge to fire departments and are some of the most challenging incidents a fire department encounters.

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 risk to firefighters and occupants increases in proportion to the height of the building and the height of the fire above grade level. 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 (Hall 2013), 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 million in direct property damage. Office buildings, hotels, apartment buildings, and health care facilities accounted for nearly half of these high-rise fires.

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 risk 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 on the buildings standpipe system more. 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[44] 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, 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 in regards to 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 the vast majority of 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. However, when responding to any high-hazard buildings or structures, which include high-rises, first responding fire apparatus should be staffed with five to six firefighters per NFPA 1710, upon the determination of the Authority Having Jurisdiction (AHJ).

Similar to residential structure fires, there are several critical tasks that must be accomplished in a high-rise fire. 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, since it takes longer to assemble an effective firefighting force and to access the fire floor, firefighters are likely to encounter a large volume of fire and will therefore have an extended fire attack. Because of this, it will be necessary to establish an equipment supply chain to transport equipment and resources up and down the building.

[44] Structural Firefighting Strategy and Tactics 2nd Edition. Klaene B., Sanders R. NFPA 2008

Search and Rescue

Search and rescue is a critical fireground task that is 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 complicated because conscious victims may retreat to areas in an attempt 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 team 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. Because of the larger search area, NFPA 1710 requires a minimum of four firefighters for searching and a minimum of four firefighters for evacuation management teams.

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 standpipes 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.

Because of the size of high-rise buildings and high-hazard structures in general, a larger number of firefighters is required for a ventilation team than would be for a residential structure. NFPA 1710 recommends a minimum of 4 firefighters to be assigned to ventilation.

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[45] 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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[45] 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 in four minutes of travel time for response to high-hazard structures:

- In jurisdictions with a high number of incidents or geographical restrictions, as identified by the AHJ, these companies shall be staffed by a minimum of five on-duty members.[46]
- In jurisdictions 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.[47]

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 a number of 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 7, on the next page, displays the minimum number of firefighters required to arrive in the first full alarm assignment to a high-rise fire.

[46] NFPA 1710. §5.2.3.1.2

[47] NFPA 1710. §5.2.3.1.2.1, §5.2.3.2.2, 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)
IRIC/RIC Two Floors Below the Involved Floor	6 Firefighters
Victim Search and Rescue Team	4 Firefighters
Point of Entry Accountability	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 5: 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.

As will be discussed later in the section regarding the Branford risk assessment, the Town has a number of high-hazard occupancies that range from wide-area manufacturing sites to high-rise structures. Of particular concern are several commercial buildings that include biotech, pharmaceutical, manufacturing, and numerous light and heavy industrial occupancies. Several of these buildings are within a 4-minute travel time of a fire station. However, many of these stations are staffed by volunteers. Because of the variability in volunteer response, the first arriving company may have to travel for longer times before reaching the scene. Delays in arrival because of increased travel times, combined with substandard company staffing and the need for multiple companies to be on the scene before beginning interior fire suppression operations, means that firefighters will likely be confronted with large volumes of fire once they are able to begin suppression operations.

The Department is not able to meet initial responding company staffing requirements for low-, medium-, and high-hazard occupancies due to low staffing levels. Even if the Department increased minimum suppression company staffing on Engine 1 and Truck 1 to meet NFPA 1710 requirements, there would not be enough personnel on-duty for a full alarm response to a low-hazard residential structure, let alone enough personnel to meet the staffing requirements for response to a high-hazard occupancy without the use of mutual aid resources. This is why the Department also needs to increase apparatus utilization.

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Fire Department EMS Operations

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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 the fire service the largest provider of prehospital EMS in North America. In many fire departments that deliver prehospital care, EMS calls can account for 75% or more of total call volume.

There are six main components of an EMS incident from start to finish.[48] 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.[49] 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 technicians and EMS supplies, are more centrally located and are able to affect 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 EMS response and transport provided by the fire department is that fire departments are already geared towards rapid response and 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 8 minutes.[50] 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, and survivable cardiac arrest. Many times, patients experiencing symptoms associated with these

[48] The Star of Life, designated by Leo R. Schwartz, Chief of EMS Branch, National Highway Traffic Safety Administration (NHTSA) in 1997.
[49] Moore-Merrell, L. et al. (2010) Report on EMS Field Experiments. Fire Fighter Safety and Deployment Study; Washington, DC, September 2010.); pp. 10.
[50] NFPA 1710: Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments

events may not recognize the seriousness of their symptoms, delaying a call for assistance.[51] [52] [53] [54] 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.[55]

Strokes, which are the third leading cause of death in the U.S., as well as a leading cause of disability, also benefit from expedient treatment in a facility providing definitive care. Ischemic stroke, a stroke caused by a blood clot, can be effectively treated if definitive care is received within 3 to 4.5 hours[56] of symptom onset. The sooner a patient receives definitive treatment, the less likely a patient is to suffer disability from this type of stroke. However, it is important to emphasize that before time critical treatment can be provided 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"[57] 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.[58]

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 for the previously mentioned conditions, are labor intensive. Patients suffering from ACS should not exert themselves in an effort to minimize any damage to cardiac muscle. Patients suffering from strokes are frequently unable to assist themselves because of physical effects of the event. An adequately sized crew is able to provide simultaneous interventions while assessment is being performed thereby reducing the on-scene

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

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

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

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

[55] 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.

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

[57] "Door to Needle" is an industry specific term that refers to the time the patient entered the emergency department to the time they 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.

[58] 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.[59]

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.[60] 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 focuses on a team-centric approach. Evidence-based research that suggests 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.[61] [62] This was linked to provider fatigue from administering chest compressions, indicating that providers should be rotated frequently to ensure effective depth and rhythm of chest compressions. Consensus documents from the AHA recommend that providers rotate with every two-minute cycle of CPR. It is also recommended that requests for EMS response for cardiac arrest 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 effective 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.[63] 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

[59] Moore-Merrell, L. et al. (2010) Report on EMS Field Experiments. Fire Fighter Safety and Deployment Study; Washington, DC, September 2010.
[60] Highlights of the 2010 American Heart Association Guidelines for CPR and ECC
[61] Determinants of Blood Flow during Cardiac Resuscitation in Dogs. Halperin, HR et al. *Circulation* 1986;73:539-550
[62] 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
[63] 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. Also, in addition to their medical needs, patients may require simultaneous physical rescue or extrication, protection from the elements, a safe physical environment, and management of surrounding non-medical sociologic concerns.[64] As firefighters provide an "all-hazards" level of response, they are trained in rescue, extrication, scene safety and security.

What occurs in the first few minutes after the onset of a medical emergency, particularly in cardiac emergencies, can impact patient outcomes. The rapid, efficient, and effective delivery of prehospital emergency medical care is dependent upon the rapid response of adequately trained personnel. Response time is a key component of an effective EMS system, and rapid response times are a fundamental advantage of fire-based EMS systems.[65]

A study conducted in coordination with the National Institutes of Standards and Technology (NIST), the International Association of Fire Chiefs (IAFC), the International Association of Fire Fighters (IAFF), Worcester Polytechnic Institute (WPI), and the Commission on Fire Accreditation International (CFAI) examined the effects of varying ALS personnel configurations on first responder companies and ambulances. The field experiments investigated the connection between appropriate staffing levels and the completion of typical EMS prehospital assignments for trauma and cardiac EMS scenarios.

[64] Pratt, E.D.; Katz, S.; Pepe, P.E>; Persse, D. (2007). Prehospital 9-1-1 Emergency Medical Response: The Role of the United States Fire Service in Delivery and Coordination. White paper.
[65] Ibid.

NIST EMS Study Results		
	Staffing	**Performance (minutes : seconds)**
Overall Trauma Scene Time	1 ALS on Engine +1 ALS on Ambulance	10:50
	Engine +2 ALS on Ambulance	13:06
Overall Cardiac Arrest Scene Time	1 ALS on Engine + 1 ALS on Ambulance	10:55
	Engine +2 ALS on Ambulance	11:39
All Tasks After Witnessed Cardiac Arrest*	1 ALS on Engine +1 ALS on Ambulance	6:35
	Engine +2 ALS on Ambulance	5:43

Table 6: Summary of NIST EMS Study Results. An ALS provider arriving on the engine can provide faster ALS care than a BLS engine having to wait for an ambulance to arrive with ALS providers. The difference in the results for "All Tasks After Witnessed Cardiac Arrest" may be attributable to the fact the arrest was scripted to take place immediately after the 12-lead ECG task end time in the experimental sequence. In experiments where the engine had no ALS providers and the ambulance arrived with two ALS providers, the ECG arrived with the ambulance so that there were instantly two ALS personnel on-scene rather than one as in the ALS engine/ALS ambulance scenarios.

Study results suggest that the early arrival of an ALS provider improves total on scene time starting from when EMS providers arrive at the patient's side to preparing the patient for transport, evidence that ALS placement can make a difference in response efficiency. Crews with one ALS provider on the engine and one ALS provider on the ambulance completed all required tasks faster than crews with a BLS engine and two ALS providers on the ambulance, demonstrating increased on-scene operational efficiency.

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Risk Assessment of Branford

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A risk assessment of the Town of Branford was completed to assess the likelihood of a harmful incident occurring that would require fire and/or emergency medical services. Part of this assessment included a review of 2014 U.S. Census American Community Survey Estimates data for the Town, which showed that 24.7% of the population were considered to be in a vulnerable category. A vulnerable population includes those people least able to react appropriately, or in a timely manner, to an incident such as a structure fire. This category consists of persons under the age of 5 (3.5%) and persons 65 years of age and older (21.2%), but does not include the special needs population.

According to the U.S. Fire Administration (USFA) - using data compiled from the US Census, the National Center for Health Statistics Mortality Data File, the 2013 NFPA Fire Experience Survey, and the National Fire Incident Reporting System (NFIRS) - in 2013 people ages 65 and up represented 14% of the total U.S. population, but accounted for 35% of all fire deaths. Additionally, the older the person, the more likely they are to be impacted by medical conditions and trauma, and also suffer fire-related injuries and death. The most common factor that explains why people over the age of 65 are impacted by these issues and place an increased demand on EMS and fire resources are the complications of aging.[66] As people age they develop visual and auditory impairments as well as mobility issues which slow reaction to falls, fires, and other situations that can result in harm. Coupled with multiple underlying health issues and multiple medications, elderly citizens can suffer from a variety of symptoms and side-effects that may include confusion.[67] For the individual, these factors increase the risk of a medical emergency, but for firefighter/EMS providers, they pose delays in the rescue and removal under any circumstance.

By contrast, children, although generally lacking the impairments brought on by advanced age, are unable to identify risk, determine the need for escape, or physically do so without the assistance of others.[68] Within the general category of birth to 14 years of age, the highest percentage of fatalities and injuries occur in the birth to 4 years of age category, accounting for 50.9% of deaths and 51% of injuries.[69] In addition to fire-related injuries and deaths, the general age group of birth to 14 years of age, although typically less likely to place a large demand on EMS services volume-wise, do test system preparedness and readiness because their immature anatomy and physiology make them less able to compensate in response to injury and illness than adults do. As a result, they are more likely to take dramatic downturns when sick or injured.

When assessing structural fire risk it is important to look at the number, type, and age of the housing stock in the area being assessed. In Branford, according to the US Census 2014 American Community Survey Estimated, there were 13,747 housing units, with the majority

[66] U.S. Fire Administration, Fire Risk in 2013, December 2015. Pgs. 2-3, 8-10
[67] Ibid.
[68] U.S. Fire Administration, Fire Risk in 2013, December 2015. Pgs. 2-3, 5-7
[69] Ibid.

being single family residences (63.3%) and the remainder being multifamily (34.2%), and mobile homes (2.5%). Of these structures, 50.4% were of pre-1970 construction, and 22.2% of all housing units were built in 1939 or earlier. Typically, when there are high numbers of vulnerable citizens and older buildings constructed before many current fire codes were developed, there is an increased demand on emergency services.

There is a relationship between fire, demand on EMS, and poverty that spans all age groups. To begin, it was estimated that in 2013, nationally, nearly 9.5% of adults 65 years of age and older and 19.9% of children under 18 years of age live at or below the poverty level in the United States.[70] In the Town of Branford, 7.7% of the total population lives at or below the poverty line. When broken down by age, 5.9% of adults 65 years of age and older and 11.5% of children 18 years of age and younger were living below the poverty level, based on the 2014 U.S. Census American Community Survey Estimates.[71] Of the latter category, 14.2% of related children were under 5 years of age.[72] People living at or below the poverty level are impacted more frequently by fires for a number of reasons. First, people living in poverty are likely to reside in substandard housing and have more occupants than the housing unit can comfortably and safely accommodate.[73] Because they have limited income, the impoverished are less likely or unable to maintain safe heating and electrical equipment and are more likely to use unsafe heating and light sources such as space heaters, open fires, and candles.[74] In addition to this, persons living in poverty are less likely to purchase and/or maintain early detection devices such as smoke alarms or other safety equipment, such as fire extinguishers. For children, many reside in not only substandard overcrowded housing, but single parent work schedules and an inability to afford child care result in unsupervised children, which may lead to accidental fires. In the United States the poverty level for a family of four in 2014 equated to an annual income of $23,850.00.[75]

Poverty not only increases the risk of fire, it also increases demand on EMS. This is due largely to the fact that persons living in poverty do not have access to primary care because they lack the ability to pay or because local health clinics may be poorly equipped and overcrowded. For example, in impoverished neighborhoods, children are slightly more likely to suffer from asthma, but are four times more likely to use the emergency department for treatment[76] and there

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[70] Income and Poverty in the United States: 2013, DeNavas-Walt, Carmen and Proctor, Bernadette D. U.S. Department of Commerce, Economics and Statistics Administration, U.S. Census Bureau, Issued September, 2014. Pg. 12

[71] U.S. Census Bureau 2014 American Community Survey Poverty Status In The Past 12 Months,

[72] U.S. Census Bureau 2014 American Community Survey Selected Economic Characteristic Estimates,

[73] U.S. Fire Administration, Fire Risk in 2013, December 2015. Pg. 6

[74] U.S. Fire Administration, Fire Risk in 2013, December 2015. Pages 8-9

[75] U.S. Health and Human Services: https://aspe.hhs.gov/2014-poverty-guidelines

[76] Childhood Asthma and Poverty: Differential Impacts and Utilization of Health Services. Halfon, Neal. Newacheck, Paul H. PEDIATRICS Vol. 91, No. 1 January 1, 1993. Pgs. 56-61

is also a higher population of people suffering from mental illness.[77] Because of their lack of, or diminished, funding and lack of access, as well as a number of other factors, people living at or below the poverty level have been shown to be three times more likely to use the emergency department as their primary means of care.[78] For many people below the poverty level the primary means of transport to the emergency department will be via ambulance.

In addition to the risks found in the demographic analysis, the Town also has a number of medium- and high-hazard occupancies that increase the Town's overall vulnerability. Among the high-hazard facilities within the Department's response area are long- and short-term residential facilities for convalescent, rehabilitative, and elderly care. These facilities pose unique obstacles for responders due to access and changing population volume. Additionally, the specific residents of these programs may have behavioral, emotional, and/or physical disabilities and dysfunctions that impact their ability to reason or follow directions in an emergency situation. For EMS responders, these populations place a high demand on providers and resources because of their specific needs in regards to transport and supportive medical care while in transit to the hospital. In some cases, certain residents may require additional personnel to respond and assist beyond the two providers that would arrive on an ambulance.

High-rise or multistory buildings with high occupancy counts and/or large vulnerable populations living or working within them pose significant risk for a variety of reasons. For high-rises, wide-area buildings, and buildings where manufacturing takes place, access into the building, search for victims, the isolation of fire, and arriving at the patient can be difficult due to security, obstacles associated with production, and extended travel distances on foot while burdened with equipment. Similarly, removing patients and fire casualties that are elderly, have special needs, and/or have disabilities and mobility issues present additional hardships for responders.

There are also a number of large area commercial manufacturing structures located within the response area that use hazardous materials in the production process. These types of facilities have an increased risk for fire-related injuries and deaths, as well as increased demand on EMS. Given these factors, the Department is likely to have a high and steady call volume.

As has been noted earlier, minimum staffing levels in the Department support one under-staffed engine company and one cross-staffed truck company, both responding out of the Headquarters station. Truck 1 is cross-staffed with two firefighters from Medic 2, if both Medic 1 AND Medic 2 are available and Medic 2 is in quarters. The NFPA 1710 standard requires that all fire suppression companies be minimally staffed with four firefighters,[79] and ambulances be staffed

[77] Racial/Ethical Disparities in the Use of Mental Health Services in Poverty Areas. Chow, et al. American Journal of Public Health, May 2003. Vol 93, No. 5
[78] Use of the ED as a Regular Source of Care: Associated Factors Beyond the Lack of Health Insurance. O'Brien et al. Annals of Emergency Medicine, Sept, 1997, Volume 30, Issue 3, Pgs. 286-291
[79] NFPA 1710, 5.2.3.1.1 & 5.2.3.2.1

with the number of trained personnel at the level prescribed by the state or provincial agency responsible for EMS licensing.[80] NFPA also requires that jurisdictions with target or high-hazard occupancies staff suppression companies with a minimum of five to six firefighters.[81]

If all suppression companies and ambulances were to be fully staffed, ambulances responding and arriving simultaneously with suppression companies could provide additional personnel on the scene of an incident, whether it is a response to a fire or EMS incident. For fire response, it means the first arriving fire apparatus would meet the industry staffing standard of a minimum of four members per suppression company and have sufficient personnel to meet OSHA mandates for initial interior operations. For EMS response, it means that an adequately-sized team can begin immediately providing care for sick and injured patients and safely remove the patient in a manner that reduces the risk of injury to providers and patients alike.

[80] NFPA 1710, 5.3.3.2.2.2 & 5.3.3.2.2.3
[81] NFPA 1710, 5.2.3.1.2.1 & 5.2.3.2.2.1

Staffing & Deployment Analyses

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Staffing and Deployment Analysis

In conducting this study it was important to ascertain where stations are located and if their distribution provides fair and equitable coverage to area citizens. In order to make this assessment, the IAFF created maps of the Town and the Department's response area, and then plotted the fire station locations. Computer modeling was then used to determine the distance apparatus could travel in 4 and 8 minutes and where effective firefighting forces could be assembled. The following table specifies the current minimum staffing and deployment of the Branford Fire Department and the addresses used in the computer generated maps.

BFD Station Locations, Deployment, and Staffing			
Station	**Address**	**Apparatus**	**Minimum Staffing**
Headquarters	45 North Main Street	Car 6 Engine 1 Medic 1 Medic 2 Truck 1 Rescue 2	(1) 1 Deputy Chief (3) 1 Capt./EMT-P, 2 FF/EMT-P (2) 2 FF/EMT-P (2) 2 FF/EMT-P Cross-staffed by Medic 2 1 FF/EMT-P on OT M-F 8am-4pm
Station 2	341 Main Street	Engine 2	Volunteer
Station 4	64 Shore Drive	Engine 4	Volunteer
Station 5	11 School Street	Engine 5 Rescue 5	Volunteer
Station 6	180 Pine Road	Closed	Closed
Station 9	6 Linden Avenue	Engine 9 TAC 9 (brush)	Volunteer

Table 7: Current Fire Station Locations, Staffing and Deployment. The above table provides the station addresses, apparatus housed at each station, and the minimum number of personnel assigned to each station on a daily basis. As can be seen in the table, and as will be discussed later, the current staffing of both Engine and Truck 1 is below industry standards and impacts operational safety and efficiency.

Travel times were modeled using ESRI ArcGIS version 10.3. Fire stations were identified on Geographic Information System (GIS) maps as starting points with vehicles traveling at posted road speeds. Travel was modeled using the average of traffic data for Wednesday afternoons at 5:00 PM EST. This specific day and time was selected as it typically corresponds to the heaviest travel time of the week.

When generating the maps a number of assumptions needed to be addressed prior to drawing conclusions from the analysis. These assumptions are as follows:

- Modeled travel speeds are based on reasonable and prudent road speeds. 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 increase 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.
    - Inadequate Road or Transit Capacity: The interaction of capacity problems with the aforementioned sources causes travel time to expand much faster than demand.[82]

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 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 also 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

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

- The computer model is unable to accurately portray the response of any recall personnel responding to assigned stations and then to the scene for a multiple alarm fire. As these firefighters are not available on a regular basis to respond immediately upon dispatch, their actual response times are not quantifiable. Therefore, responses by these individuals have been omitted from this analysis.

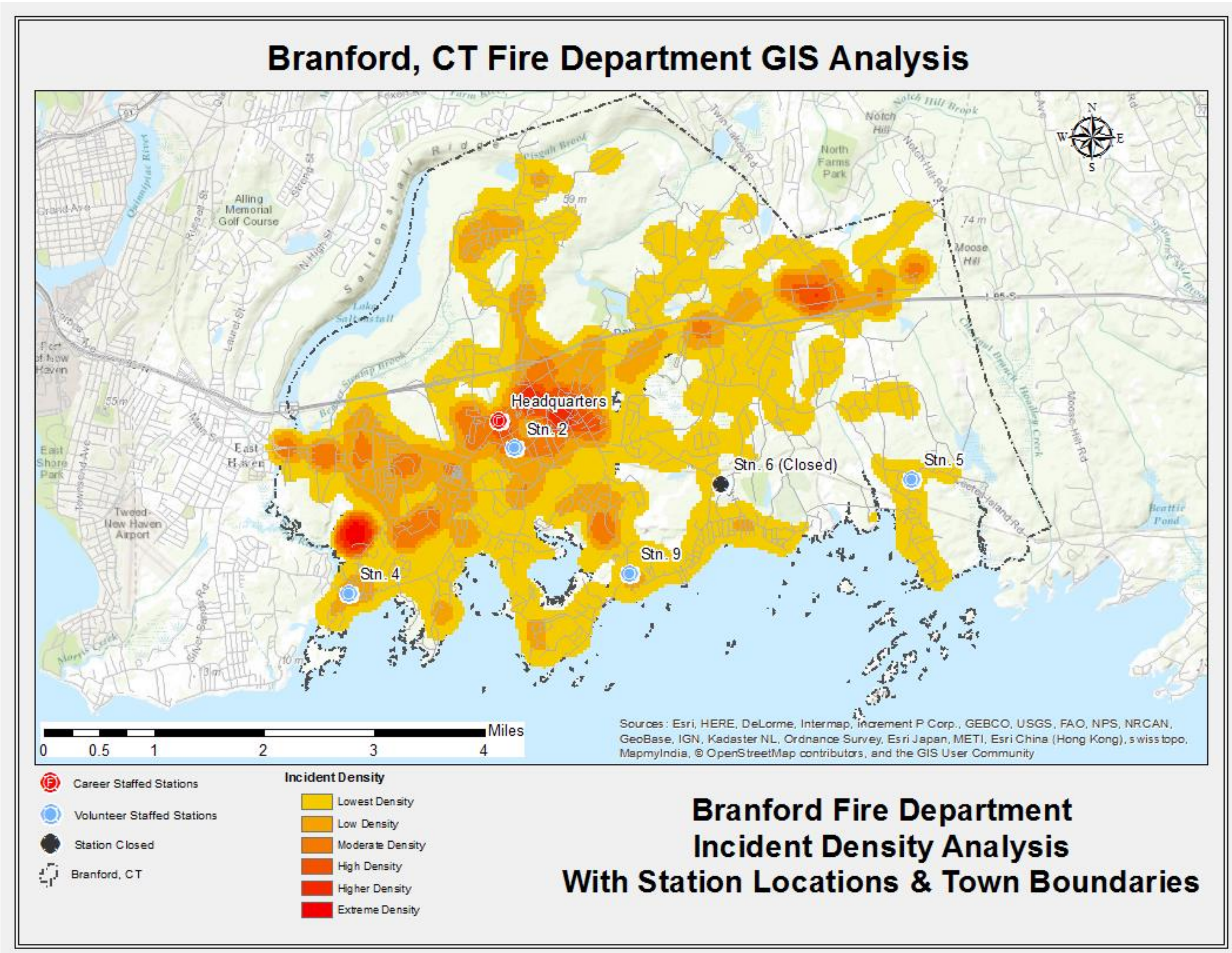
Incident Density

ArcView's GIS analytical toolsets can create density maps that represent point values for specific geographic features, such as the location of an emergency incident, and are helpful for showing where point features are concentrated.[83] To use individual points for each incident would quickly become confusing as they would begin to overlap and be stacked on top of each other. However, by transforming the point features into a density surface map, a clearer illustration of the concentrations of calls within the response area can be seen.

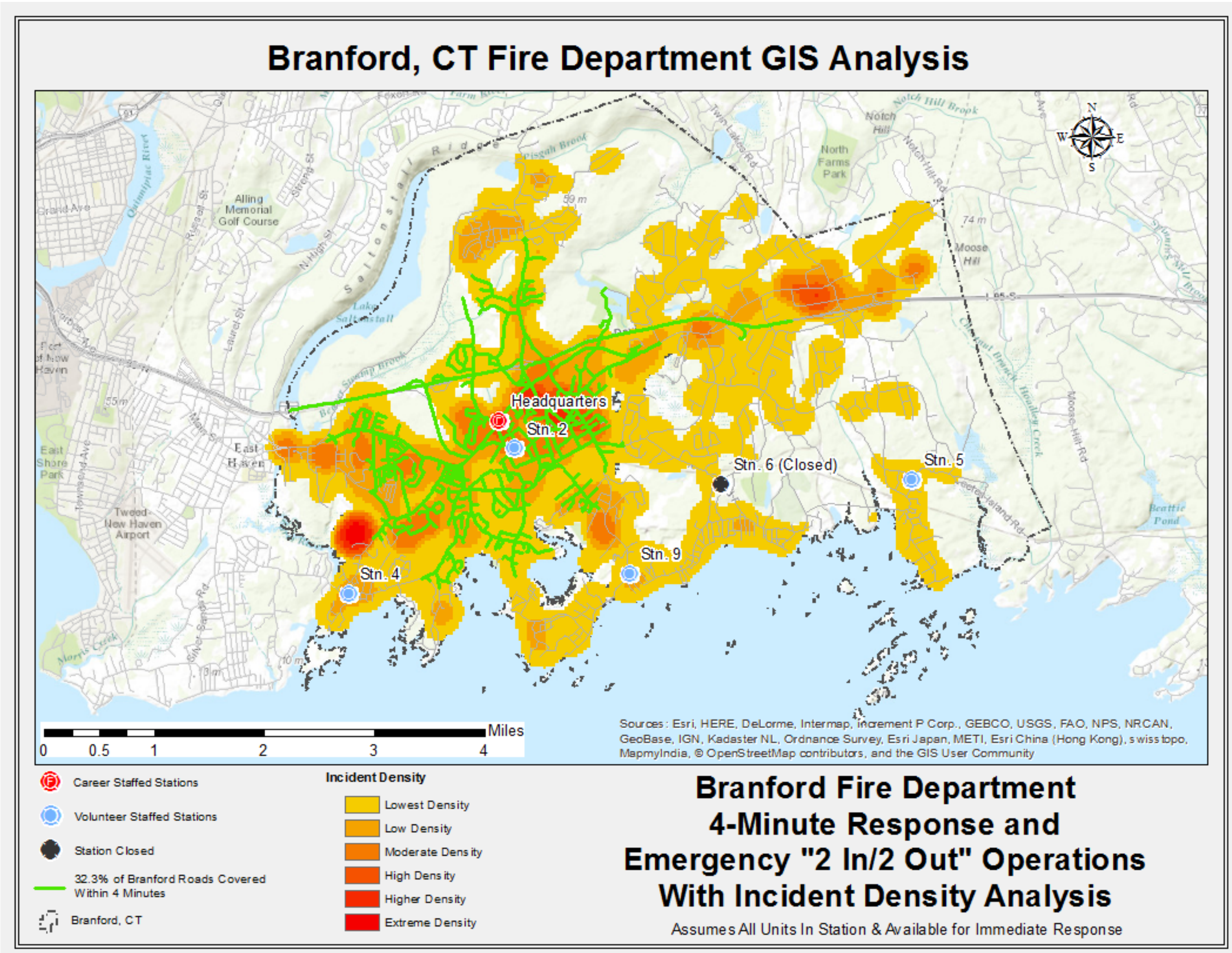
The Department provided emergency incident location data from July 2011 through June 2015 that was used to determine incident density. There were a total of 23,170 emergency incidents that were located on the map from the time period in question. Map 1, on page 62, shows the concentration of emergency incidents within the Department's response area along with station locations and Town boundaries.

The incident density analysis shows several areas of increased density that are currently served by volunteer stations. The area of highest density is located north of Station 4, beyond a 4-minute travel time from the Headquarters Station. Other areas of increased incident density are found near Headquarters Station, Station 9, Station 5, and in the north-east part of the Town, north of Interstate 95.

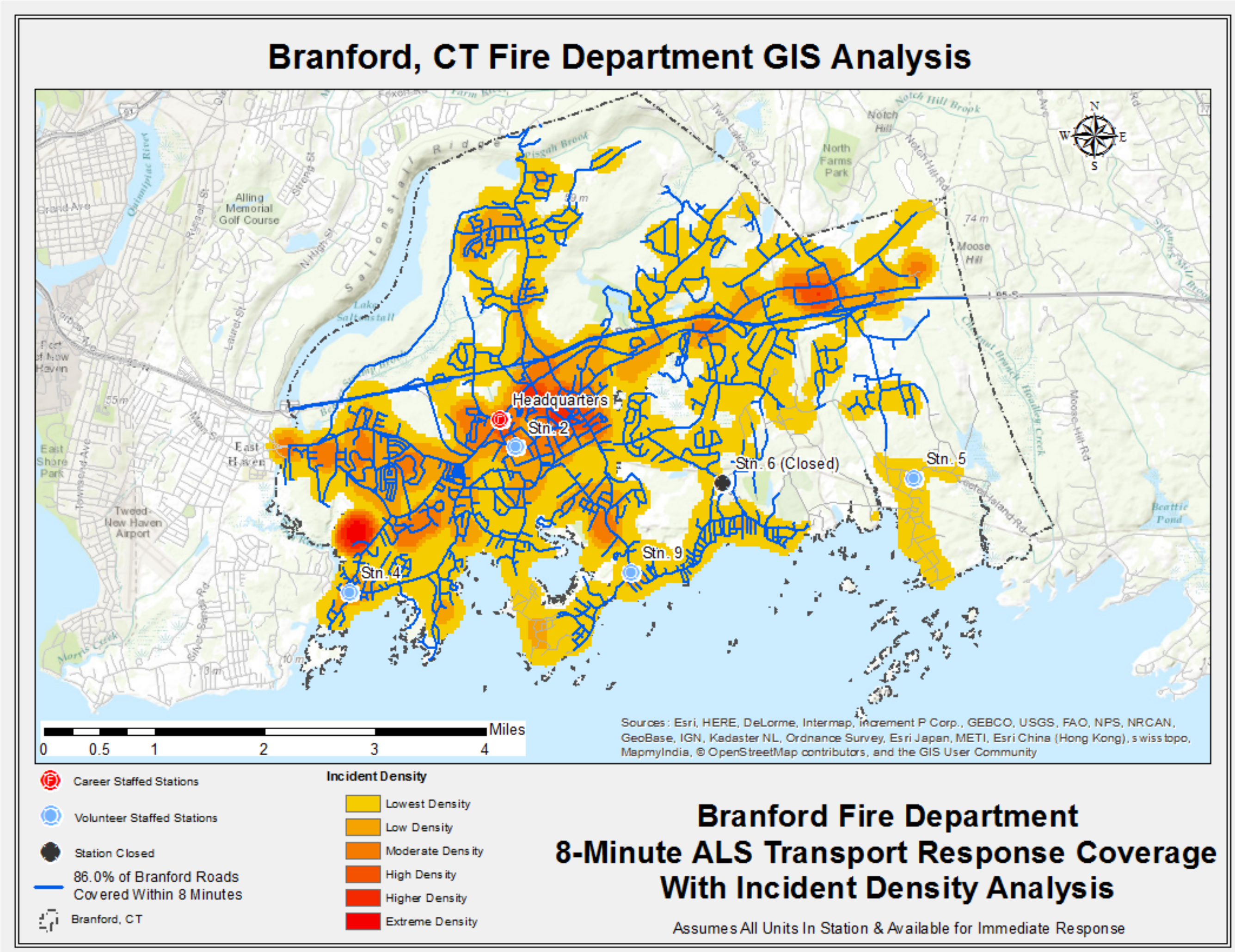
[83] Environmental Systems Research Institute. "An overview of the Density toolset" ArcView Software. 2005



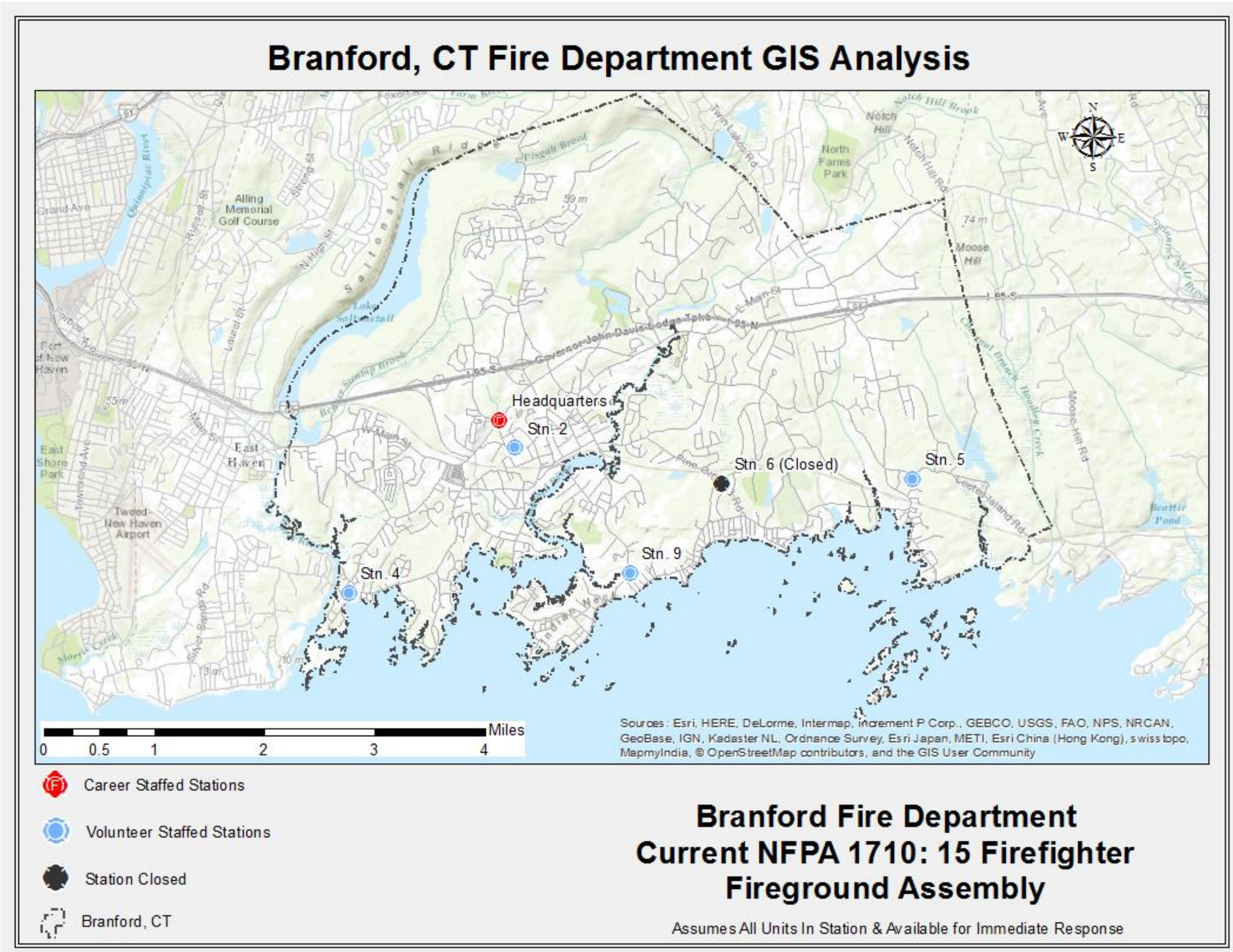
Map 1: Incident Density Analysis with Station Locations and Town Boundaries- The Department provided incident location data for over 23,000 emergency incidents that occurred within the response area between July 2011 and June 2015. To complete the density analysis, each incident was located on the map and areas of incident concentration were identified using ESRI density analysis tools. The areas with the greatest density are located north of Station 4, in the vicinity of Headquarters, and in the north-east part of the Town. Map 1 shows Town boundaries, incident densities, and the location of each BFD station, with the career station shown in red, volunteer stations in blue, and the closed station in black. Larger versions of all maps are included in Appendix B: Map Detail.



Map 2: Current 4-Minute Response and Emergency "2 In/2 Out" Operations With Incident Density. This map identifies the roads where the Department can assemble a minimum of 4 personnel on scene within 4 minutes of travel. Currently, apparatus and personnel that respond to a structure fire are capable of assembling 4 personnel on **32.3% of all roads located in the response area in 4 minutes or less,** *assuming units are in station and available to respond immediately upon dispatch*. The rapid arrival of sufficient numbers of personnel and equipment is crucial in limiting a fire's spread and stopping it as close to the point of origin as possible. Additionally, the OSHA respiratory protection standard (29 CFR 1910.134) requires a minimum of four firefighters be present before beginning an interior attack on a structure fire. There must be at least two personnel operating together on the interior, with a minimum of two more personnel outside the structure, ready to rescue the crew operating on the interior if needed. Current minimum staffing of the engine does not allow for that crew to meet these requirements without the arrival of additional resources at the scene of a structure fire. Both "2 In/2 Out" coverage and 4-minute response coverage are identical because all career resources currently deploy from the Headquarters Station. The incident density analysis showed that the area of greatest incident concentration was outside the Headquarters Station 4-minute coverage area, north of Station 4 (currently volunteer staffed).



Map 3: 8-Minute ALS Transport Response Coverage With Incident Density. This map identifies the roads where response can occur within 8 minutes of travel for both ALS transport units responding from BFD Headquarters. Currently, ALS transport units and personnel that deploy from this station are capable of responding to **86.0% of all roads located in the response area in 8 minutes or less**, *assuming units are in station and available to respond immediately upon dispatch*.

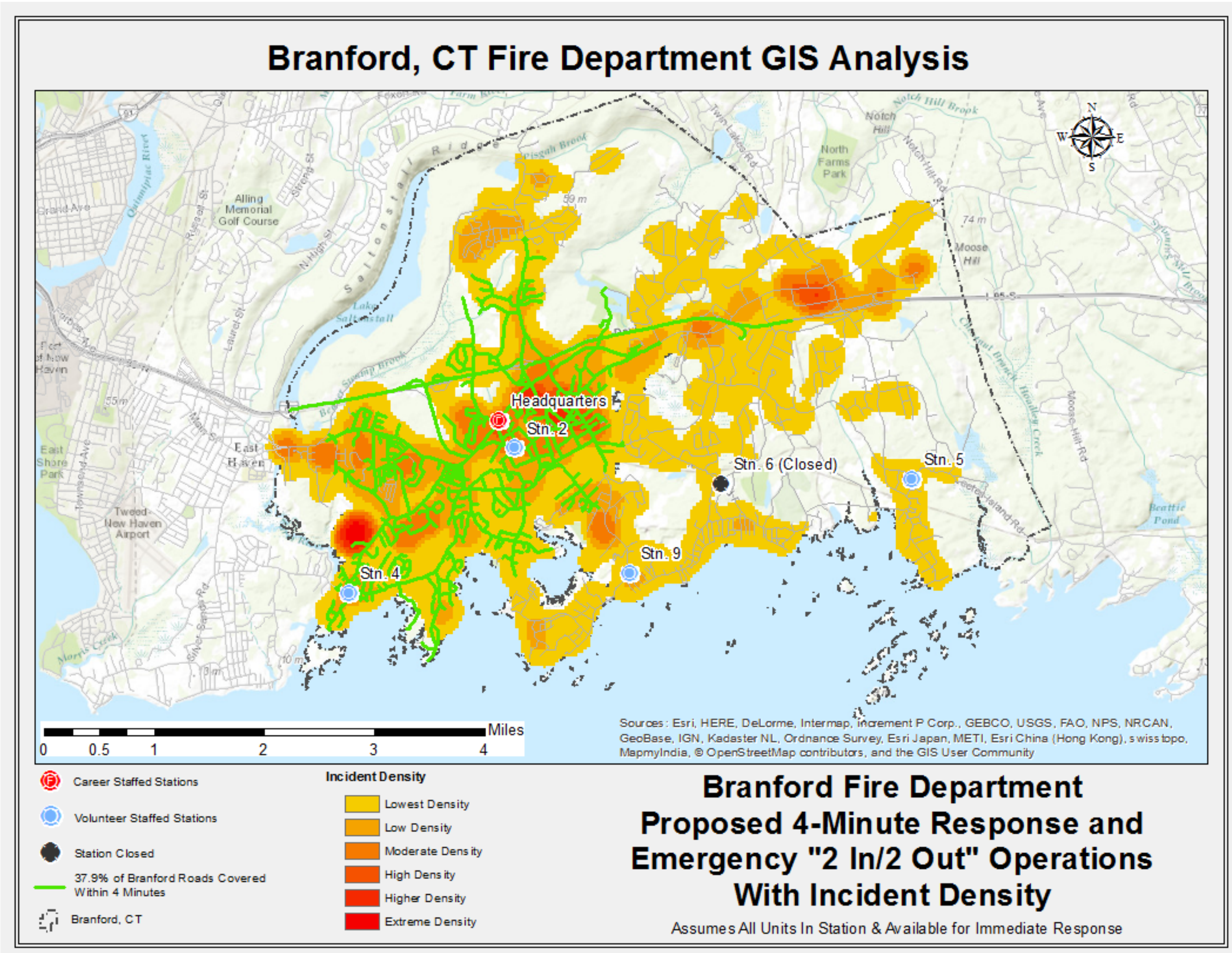


Map 4: Current 8-Minute NFPA 1710 Fireground Assembly. Current staffing levels prevent BFD from assembling a minimum of 15 firefighters on the scene of a residential structure fire within 8 minutes as called for in NFPA 1710. The rapid arrival of sufficient numbers of personnel and equipment is crucial in limiting a fire's spread and stopping it as close to its point of origin as possible. At current staffing levels, the Department cannot respond appropriately to a low-hazard residential structure fire, simultaneous requests for service when they are responding to a fire alarm, or to additional alarm assignments.

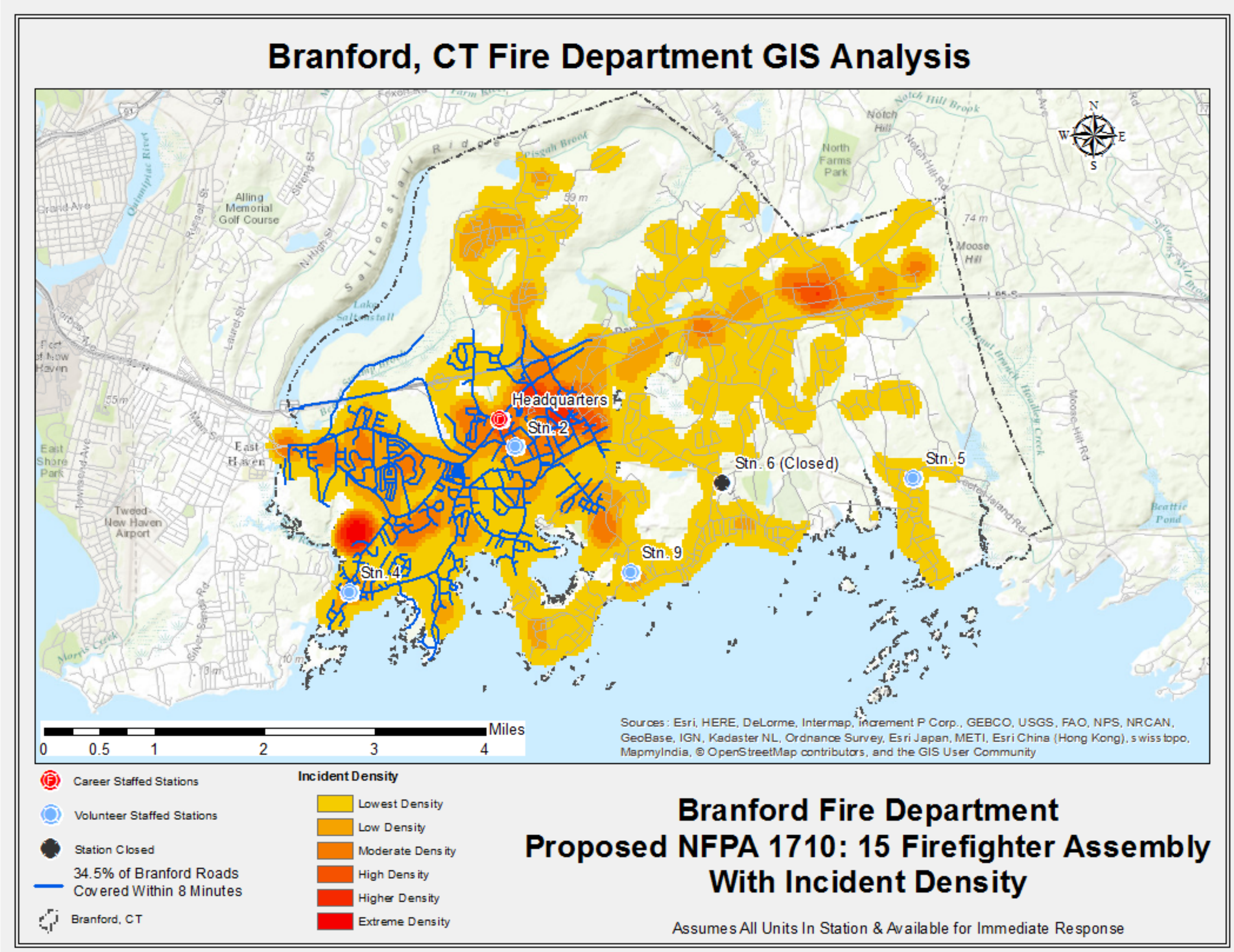
The response capabilities and incident density analyses identified several operational weaknesses within the Department. Recommended staffing and deployment changes are intended to address the most significant of these weaknesses: staff Engine 1, Truck 1, and Engine 4 (because of its proximity to an area of high incident density that does not receive adequate response coverage) with a minimum of 4 members 24 hours a day, 365 days a year, ending the practice of cross-staffing Truck 1 with personnel from Medic 2. The proposed staffing and deployment changes are listed in Table 8 below, and the modeled results of these changes are shown in maps 6 and 7 on pages 68 and 69 respectively. By implementing these changes, the Department should see an improvement in 4-minute response coverage in areas of the Town with greater incident density. The Department would also be capable of assembling a minimum of 15 firefighters on the scene of a low-hazard residential fire on 34.5% of roads within the Town. While this is a small geographic area, it is a significant improvement over the Department's current inability to assemble a sufficient firefighting force on the scene of a low-hazard residential fire within 8 minutes. The area of improved coverage also includes much of the area of increased incident density within the Town. Additionally, with personnel assigned to Medic 2 no longer required to take Medic 2 out of service to cross-staff Truck 1, overall availability of ALS transport units should improve, further increasing EMS response capabilities.

Proposed Branford Fire Department Staffing and Deployment			
Station	**Address**	**Apparatus**	**Minimum Staffing**
Headquarters	45 North Main Street	Car 6 Engine 1 Medic 1 Medic 2 Truck 1 Rescue 2	(1) 1 Deputy Chief (4) 1 Capt./EMT-P, 3 FF/EMT-P (2) 2 FF/EMT-P (2) 2 FF/EMT-P (4) 1 Officer/EMT-P, 3 FF/EMT-P 1 FF/EMT-P on OT M-F 8am-4pm
Station 2	341 Main Street	Engine 2	Volunteer
Station 4	64 Shore Drive	Engine 4	(4) 1 Officer/EMT-P, 3 FF/EMT-P
Station 5	11 School Street	Engine 5 Rescue 5	Volunteer
Station 6	180 Pine Road	Closed	Closed
Station 9	6 Linden Avenue	Engine 9 TAC 9 (brush)	Volunteer

Table 8: Proposed Branford Fire Department Staffing and Deployment. The above table provides the proposed minimum daily staffing for the Department. The recommended staffing changes are intended to improve the Department's operational efficiency and effectiveness. Industry staffing standards call for all suppression companies to be staffed with a minimum of 4 personnel. The recommended staffing changes would bring suppression company minimum staffing into compliance with these standards. OSHA respiratory protection requirements for operations in an IDLH environment require a minimum of four firefighters on scene. Pursuant to implementing the proposed changes, the Department would be able to meet that requirement with a single suppression company and not be required to wait for the arrival of a second company. Finally, by staffing Engine 4 on a full-time basis (24 hours per day, 365 days a year), 4-minute response coverage is improved in the area of Town with greatest incident density.



Map 5: Proposed 4-Minute Response and Emergency "2 In/2 Out" Coverage. If Engine 4 were placed in-service with a minimum staffing of four career personnel, "2 In/2 Out" coverage would increase to **37.9% of Branford roads**, *assuming all companies are in station and available for immediate response when dispatched*. The area of increased coverage would include the region of greatest incident density, north of Station 4. Because the Department deploys suppression companies as ALS first-response units, this also increases ALS first-response coverage in an area with a high concentration of EMS incidents and high-hazard occupancies.



Map 6: Proposed 8-Minute NFPA 1710 Fireground Assembly. Under current Department staffing levels, BFD is unable to assemble 15 personnel at the scene of a low-hazard residential structure within 8 minutes as called for in NFPA 1710. If Engine 1's minimum staffing is increased to four personnel, both Truck 1 and Engine 4 were permanently staffed with four personnel, and both Medic 1 and Medic 2 remain staffed with 2 personnel each, the Department could assemble a minimum of 15 firefighters within 8 minutes on **34.5% of Branford roads within 8 minutes**, *assuming all units are in station and available for immediate response when dispatched*. The area of improved coverage includes several areas of high incident density and high-hazard occupancies.

Conclusion

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This response capabilities analysis of the Branford Fire Department identified several operational weaknesses, one of which is daily minimum staffing that fails to meet industry standards. By failing to adequately staff each company, the Department is forced to rely on cross-staffing for emergency responses. As has been discussed in this report, cross-staffing comes with increased risk. If personnel are in-station when dispatched, they must get their personal protective equipment and move it to the appropriate unit prior to responding. This creates a delay in the response that can have a profound impact on both fire and medical emergencies. If personnel are out of the station and not on the appropriate apparatus type, they would have to respond to the station, move equipment, then respond to the incident, creating an even greater delay in the arrival of appropriate resources at the scene of the emergency.

When considering geographic response coverage, the Department fails to meet industry standards for both 4- and 8-minute coverage. NFPA 1710 requires the first arriving fire suppression apparatus, staffed with a minimum of four firefighters, to be on scene within 4 minutes of travel for 90% of all incidents. Computer models show that the Department can only respond to 32.3% of roads within the response area in 4 minutes. Branford Fire Department does not staff suppression apparatus with a minimum of four firefighters' Engine 1 is staffed with 3 personnel and Truck 1 is cross-staffed by the 2 personnel assigned to Medic 2 if they are available. Additionally, NFPA 1710 also calls for the assembly of a minimum of 15 firefighters on the scene of a low-hazard residential structure fire within 8 minutes. The Branford Fire Department does not have sufficient personnel on-duty to meet this requirement.

At the current minimum staffing level, the Department is only capable of complying with OSHA "2 In/2 Out" requirements when two apparatus have arrived at the scene of an incident. The Department can only meet this requirement on 32.3% of response area roads within 4 minutes. The OSHA regulation calls for a minimum of four firefighters to be on the scene before they can begin interior operations at a structure fire. If the first arriving company at a structure fire does not have sufficient personnel, they must wait for the arrival of another company, delaying the initiation of fire suppression operations and allowing the fire to continue to increase in size and intensity. This results in an increased likelihood of injury, loss of life, and economic loss.

The provision of emergency medical response by the Department to the residents of the Town is a value-added service that clearly meets the needs of the community at large. Analysis of response data from July 2011 through June 2015 found that the Department responded to an annual average of 5,792 emergency incidents. The majority of these incidents, 70.0%, were EMS incidents. However, current staffing levels reduce response capabilities and efficiency for both EMS and fire incidents. A tiered response system, where fully staffed suppression companies are capable of providing first-response EMS services with staffed ambulances providing transport increases overall coverage and EMS operational efficiency. If both fire and EMS units are properly staffed, the department can better meet industry standards and OSHA regulations for safe, efficient, and effective response to fires and rescue situations.

In conclusion, the Department should change operational procedures and stop the practice of cross-staffing first responding fire suppression and EMS apparatus. This will require that both Engine 1 and Truck 1 be staffed with a minimum of four firefighters each, and Medics 1 & 2 be minimally staffed in accordance with state regulations. To address gaps in response coverage, particularly in the area with the greatest incident concentration, the Department should staff Engine 4 with a minimum of four personnel on a permanent basis. Once these staffing inadequacies are addressed, the Department should evaluate response coverage gaps against trends in incident type, frequency, and location to determine future resource needs. As the Town continues to grow and change, the Department should be involved in future planning efforts to ensure that emergency service needs and concerns are addressed early in the development process. It is in this way that the Department can begin to improve its operational effectiveness and efficiency, providing those it serves with the quality of emergency services they have come to expect.

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.[84]

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

- 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.

- 5.2.3.1 & 5.2.3.1.1
    - 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 personnel.

- 5.2.3.2 & 5.2.3.2.1
    - 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 staffed with a minimum of four on-duty personnel.

- 5.2.3.1.2 & 5.2.3.2.2
    - In jurisdictions with tactical hazards, high hazard occupancies, high incident frequencies, geographical restrictions, or other factors as identified by the AHJ[85], these companies shall be staffed with a minimum of five or six on-duty personnel.

---

[84] NFPA 1710, 2010
[85] AHJ- Authority Having Jurisdiction

- 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.

- 5.2.4.1.1
    - The fire department's fire suppression resources shall be deployed to provide for the arrival of an engine company within a 240-second travel time to 90 percent of the incidents.

- 5.2.4.2.1
    - 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.

- 5.2.4.1.1
    - 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	***Minimum 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 Firefighters
Initial Rapid Intervention Crew (IRIC)	2 Firefighters
Required Minimum Personnel for Full Alarm	**14 Firefighters & 1 Scene Commander**

- 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

- 5.2.4.3.1
    - 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[86]	2 Firefighters
Required Minimum Personnel for Full Alarm	**27 Firefighters** **1 Incident Commander**

[86] 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."

- 5.2.4.4.1
    - 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)
IRIC/RIC Two Floors Below the Involved Floor	6 Firefighters
Victim Search and Rescue Team	4 Firefighters
Point of Entry Accountability	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**

- 5.3.3.2.2
  - EMS staffing requirements shall be based on the minimum levels needed to provide patient care and member safety.

- 5.3.3.2.2.2 & 5.3.3.2.2.3
  - Units that provide BLS (ALS re: 5.3.3.2.2.3) transport shall be staffed and trained at the level prescribed by the state or provincial agency responsible for providing EMS licensing.

- 5.3.3.3.3
  - When provided, the fire department's EMS for providing ALS shall be deployed to provide for the arrival of an ALS company within a 480-second travel time to 90 percent of the incidents, provided a first responder with AED or BLS unit arrived in 240 seconds or less travel time as established in Chapter 4.

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Appendix B: Map Detail

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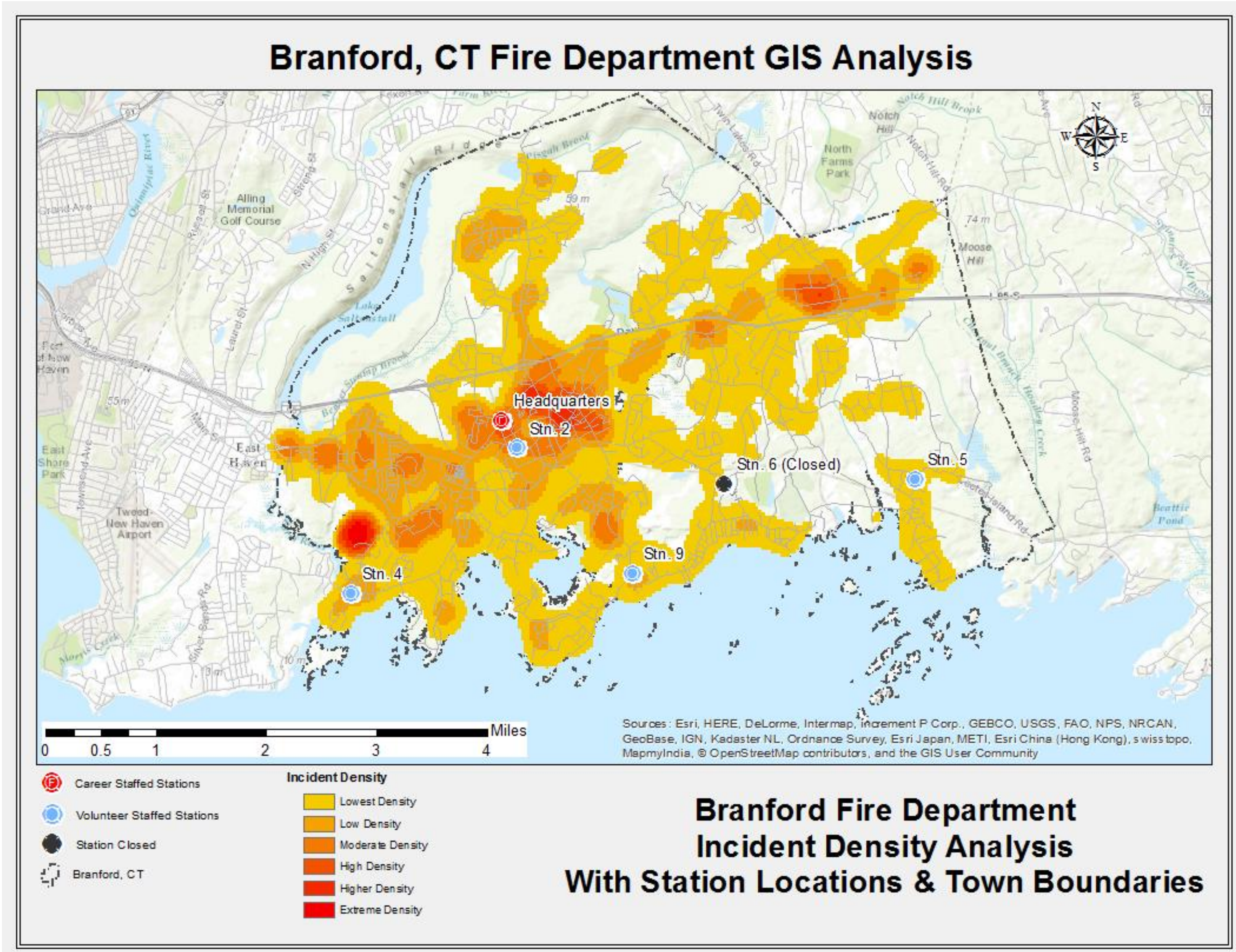
Branford, CT Fire Department GIS Analysis
Headquarters
Stn. 2
Stn. 4
Stn. 5
Stn. 6 (Closed)
Stn. 9
Alling Memorial Golf Course
North Farms Park
Notch Hill
Moose Hill
Lake Saltonstall
East Haven
East Shore Park
Tweed-New Haven Airport
Twin Lakes Rd
Notch Hill Rd
Moose Hill Rd
Townsend Ave
Silver Sands Rd
Laurel St
Russell St
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Strong St
Main St
Grand Ave
Beattie Pond
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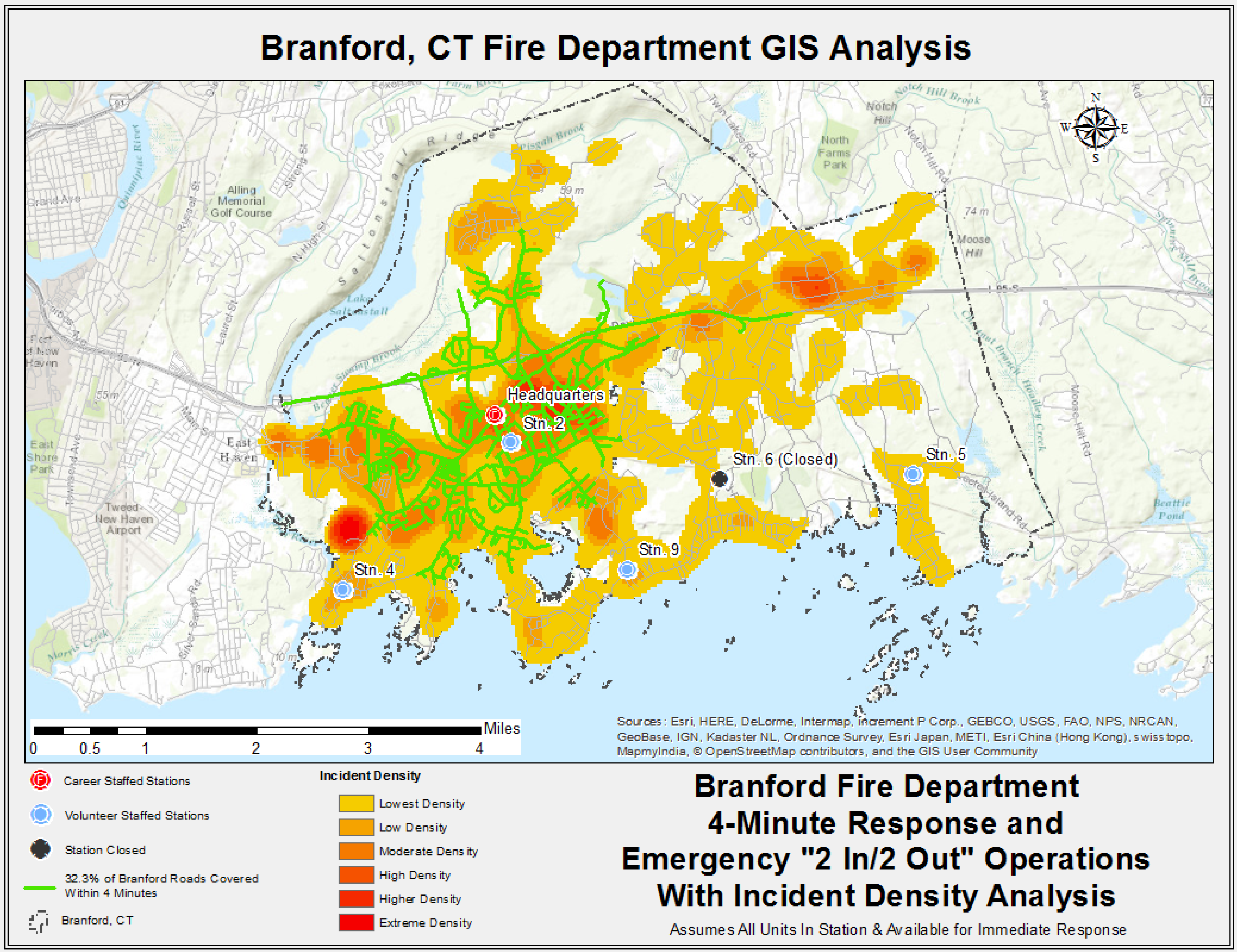
Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community
Career Staffed Stations
Volunteer Staffed Stations
Station Closed
Branford, CT
Incident Density
Lowest Density
Low Density
Moderate Density
High Density
Higher Density
Extreme Density
Branford Fire Department
Incident Density Analysis
With Station Locations & Town Boundaries


Branford, CT Fire Department GIS Analysis
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Stn. 2
Stn. 4
Stn. 5
Stn. 6 (Closed)
Stn. 9
Alling Memorial Golf Course
North Farms Park
Tweed-New Haven Airport
East Haven
East Shore Park
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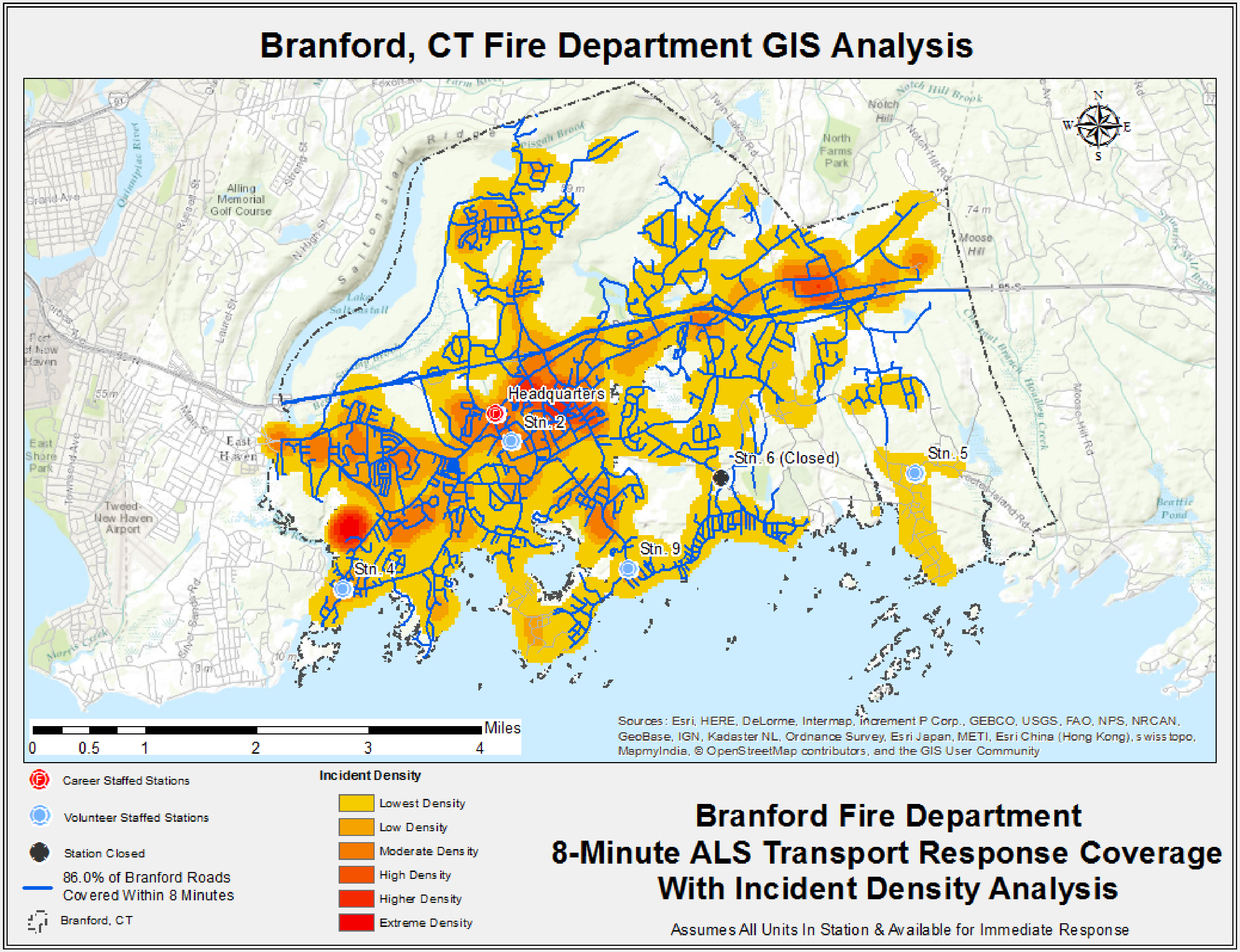
Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community
Career Staffed Stations
Volunteer Staffed Stations
Station Closed
32.3% of Branford Roads Covered Within 4 Minutes
Branford, CT
Incident Density
Lowest Density
Low Density
Moderate Density
High Density
Higher Density
Extreme Density
Branford Fire Department
4-Minute Response and
Emergency "2 In/2 Out" Operations
With Incident Density Analysis
Assumes All Units In Station & Available for Immediate Response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Stn. 6 (Closed)
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Alling Memorial Golf Course
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Career Staffed Stations
Volunteer Staffed Stations
Station Closed
86.0% of Branford Roads Covered Within 8 Minutes
Branford, CT
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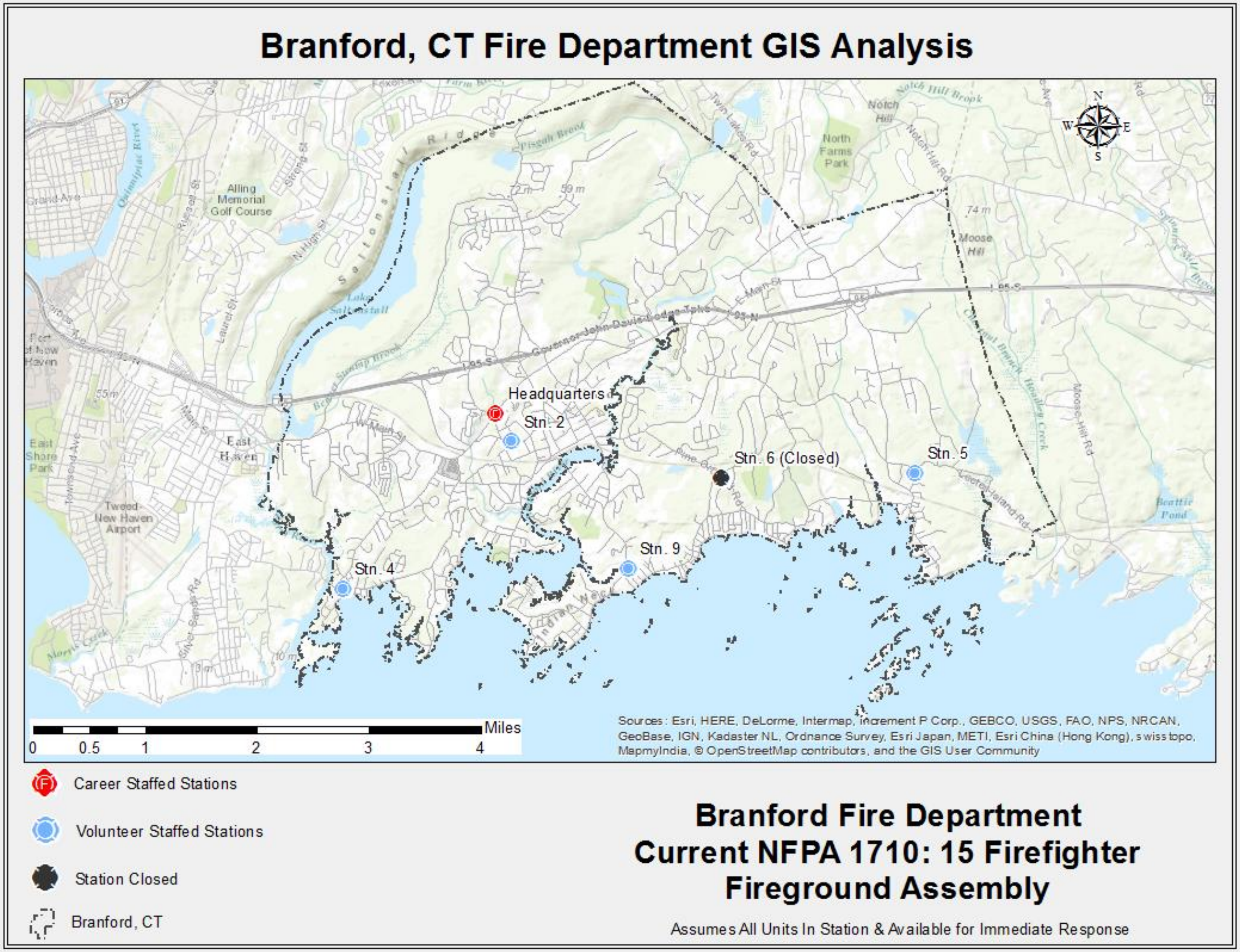
Lowest Density
Low Density
Moderate Density
High Density
Higher Density
Extreme Density
Branford Fire Department
8-Minute ALS Transport Response Coverage
With Incident Density Analysis
Assumes All Units In Station & Available for Immediate Response


Branford, CT Fire Department GIS Analysis
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Stn. 6 (Closed)
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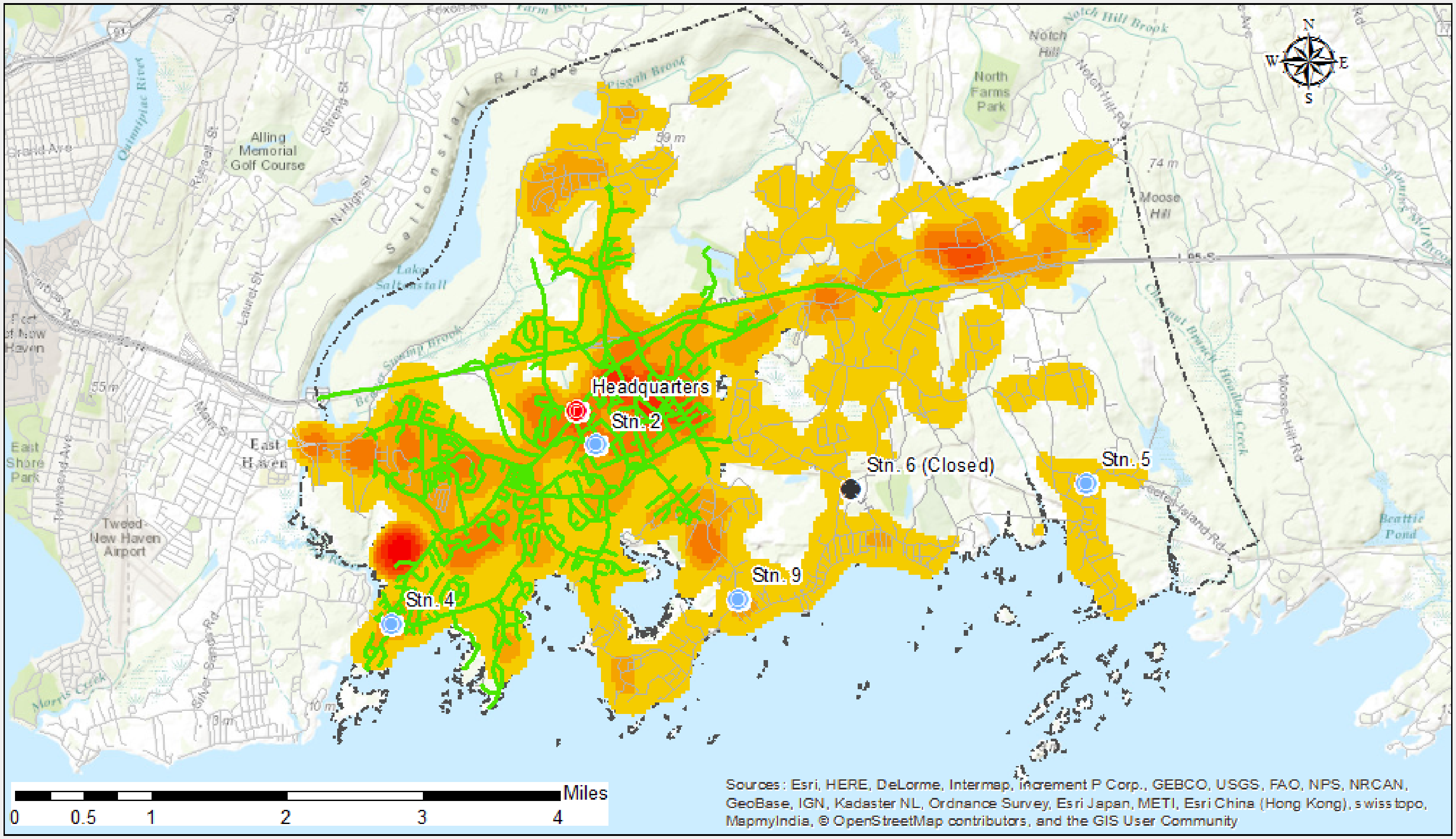
Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community
Career Staffed Stations
Volunteer Staffed Stations
Station Closed
Branford, CT
Branford Fire Department
Current NFPA 1710: 15 Firefighter
Fireground Assembly
Assumes All Units In Station & Available for Immediate Response

Branford, CT Fire Department GIS Analysis



Career Staffed Stations

Volunteer Staffed Stations

Station Closed

37.9% of Branford Roads Covered Within 4 Minutes

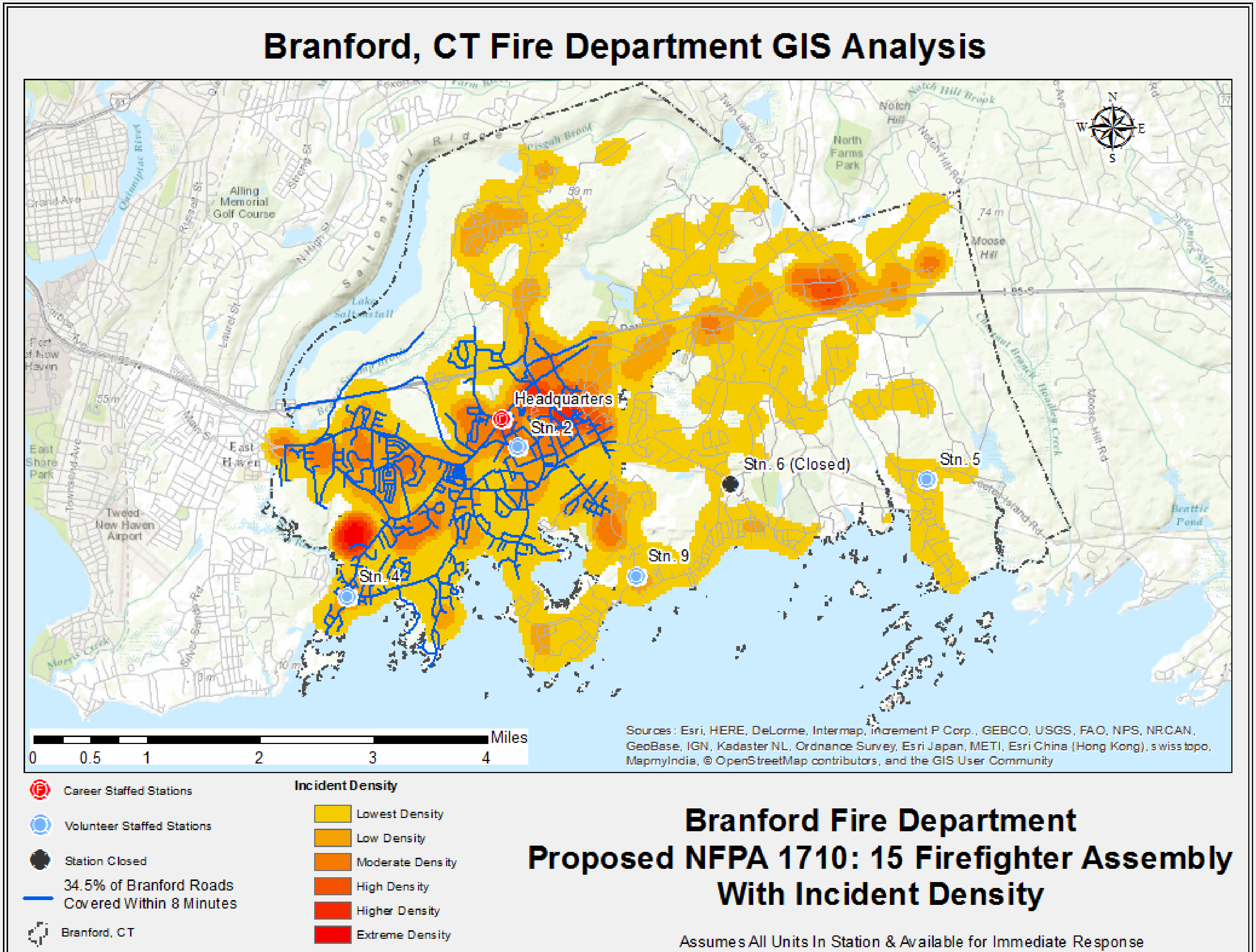
Branford, CT

Incident Density

- Lowest Density
- Low Density
- Moderate Density
- High Density
- Higher Density
- Extreme Density

Branford Fire Department Proposed 4-Minute Response and Emergency "2 In/2 Out" Operations With Incident Density

Assumes All Units In Station & Available for Immediate Response


Branford, CT Fire Department GIS Analysis
Headquarters
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Stn. 4
Stn. 5
Stn. 6 (Closed)
Stn. 9
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Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community
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Volunteer Staffed Stations
Station Closed
34.5% of Branford Roads Covered Within 8 Minutes
Branford, CT
Incident Density
Lowest Density
Low Density
Moderate Density
High Density
Higher Density
Extreme Density
Branford Fire Department
Proposed NFPA 1710: 15 Firefighter Assembly
With Incident Density
Assumes All Units In Station & Available for Immediate Response