GEOGRAPHIC INFORMATION SYSTEM EMERGENCY SERVICES RESPONSE CAPABILITIES ANALYSIS

FINAL REPORT

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OSHAWA FIRE SERVICES

Oshawa, ON

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Dedication

This Report is Dedicated to the Citizens of Oshawa and Surrounding Areas who Deserve the Most Efficient and Effective Fire, Rescue, and Emergency Medical Services Available.

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Table of Contents

Executive Summary

This report summarizes the results of a station location, staffing, workload, and emergency vehicle travel time analysis for Oshawa Fire Services (OFS) at the request of the Oshawa Professional Firefighters Association, International Association of Fire Fighters (IAFF) Local 465. This study assessed OFS' current response against the industry standard and assessed OFS' workload to make data driven recommendations. OFS currently operates six fire stations and provides emergency response services to the City of Oshawa including fire prevention and suppression, contractual emergency medical services (EMS) first response, technical rescue including high angle, confined space, trench and water, and hazardous materials response. Additionally, OFS provides specialty services response outside of the city of Oshawa.

OFS staffs frontline fire suppression apparatus with four firefighters, which is the minimum staffing level outlined in industry standards. The National Fire Protection Association (NFPA®) Standard 1710, *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments, 2020 Edition*, requires that fire suppression apparatus be staffed with a minimum crew size of four firefighters. However, the number of firefighters per shift, and the number of available staffed suppression apparatus are not adequate to meet industry standards for safe, efficient, and effective response to fires occurring within medium-, or high-hazard occupancies throughout Oshawa.

Response Analysis and Methodology

OFS provided computer-aided dispatch (CAD) data for the time period spanning January 1, 2016 through December 31, 2018. The CAD data contains information about the address and geographic coordinates of the incident, type of apparatus responding from each station, the time the call was received, the dispatch time, en route time, time of arrival on scene, the incident close time, and the time when a unit becomes available for service after responding to an incident. The CAD data also contained a brief description of each incident that was used to identify incident types of calls. The workload analysis examined the CAD data to assess the workload of the service, the efficiency of OFS' resources, and the need for additional resources.

The OFS' workload was evaluated using several parameters, including: total number of incidents and apparatus responses per year, the ratio of responding units per incident, time on task, the volume of incidents and responses per first-due district, station of origin of an apparatus, the number of times a station's apparatus responded within another station's first-due district, average travel times of responding apparatus, and the 90th percentile and average travel times of the first arriving OFS apparatus. These factors were examined to determine how changes in deployment and apparatus placement, which increased response capacity in some areas of Oshawa and reduced response capacity in other areas, have affected OFS' response capabilities and how performance may be improved through the implementation of staffing and deployment enhancements.

Using Geographic Information Systems (GIS), analysis was performed to evaluate response capabilities under OFS' current staffing and deployment configuration and how OFS' response capabilities may improve if deploying an additional fire suppression apparatus at Station 1, staffed to meet NFPA 1710 minimum staffing objectives. Using historical traffic patterns,[1] analysis was performed to examine OFS' ability to meet industry standard response requirements such as 4-minute initial unit arrival, 6-minute second company arrival, the assembly of a minimum of four personnel at an incident scene within 4 minutes, and the assembly of the minimum numbers of personnel required for low-, medium-, and high-hazard structure fires. [2] [3] [4]

Key Definitions

As stated above, an examination of the OFS' historical call volume data (January 1, 2016 to December 31, 2018) was completed to evaluate OFS' response capabilities and performance. The following definitions were created to identify terminology used in the OFS' CAD reporting system and specific characteristics used to evaluate the service's performance.

Incident: refers to an emergency to which fire service mobile and personnel resources are dispatched to intervene and mitigate. An incident may require a single or multiple apparatus to respond.

Call: synonymous with "incident" above. These terms are used interchangeably in this report.

Response: refers to an individual unit being dispatched and traveling to the scene of an incident.

First-Due District: refers to a fixed geographic area established by the service's administration that contains a fire station and that is typically served by the personnel and apparatus assigned to that station.

First-due Area: synonymous with first-due district and first-due response zone.

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[1] Historical traffic data contained in ESRI's StreetMap Premium, version 19.3.

[2] A "typical, residential structure fire" is one occurring in 186 sq. m (2000 sq. ft.) single-family dwelling without basement and with no exposures.

[3] NFPA 1710 defines medium-hazard structures as open-air strip shopping centers and three-storey, garden style apartment buildings.

[4] A "high-hazard occupancy" is one that "presents a high life hazard or large fire potential due to its construction, configuration, or the presence of specific materials, processes, or contents." NFPA 1710, §3.2.28

First-due Response Zone: synonymous with first-due district and first-due area.

Call Time: refers to the time when the alarm (request for emergency) is answered by the dispatch center.

Dispatch Time: refers to the time when units and personnel are assigned to an incident.

En Route Time: refers to the time when units and personnel are beginning their travel to the emergency.

On Location Time: refers to the time when the assigned units and personnel arrive at the incident location.

Travel Time: refers to the time interval that begins when a unit is en route to the emergency scene and ends when the unit arrives at the scene.[5]

Response Time: refers to the time interval that begins with call time and ends with on-scene arrival time.

Available Time: refers to the time after an emergency response when a unit is available again to respond. With OFS, a unit does not necessarily need to return to the station before being designated as available.

Time on Task: refers to the measure of time that a unit spends on location at an incident. Time on task is calculated by subtracting available time from on location time.

90th Percentile: refers to the value below which 90% of observations fall.

The following definitions were created to identify fire service-related terminology used in some of the literature cited in this document that may differ from terminology typically used in Oshawa.

Company: as defined in NFPA 1710, refers to "A group of members…usually organized and identified as engine companies, ladder companies, rescue companies, squad companies, or multi-functional companies…arriving at the incident scene on fire apparatus."[6] In Oshawa the term "crew" is used for company.

Multi-Hazard Response Capable Vehicle: a pumper or aerial apparatus. Apparatus equipped to respond to fires, medical emergencies, or rescue situations.

[5] NFPA 1710 §3.3.64.7 (2020)
[6] NFPA 1710 §3.3.15 (2020)

Engine Company: as defined in NFPA 1710, refers to "fire companies whose primary functions are to pump and deliver water and perform basic firefighting at fires, including search and rescue."[7] In Oshawa the term "pumper" is used for engine.

Ladder or Truck Company: as defined in NFPA 1710, refers to "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." [8] In Oshawa the term "aerial" is used for ladder or truck.

Key Findings

Community Risk

- All census tracts within Oshawa experienced estimated population growth between 2016 and 2019 and Oshawa grew overall by an estimated 8.6%. The estimated population growth rate for that time period varied among census tracts from about 3% for the lowest to about 18% for the highest.

- Census Tract 532 0010.00 is located in Oshawa's downtown and completely contained within Station 1's first-due district. Based on census data, this part of Oshawa has a higher concentration of risk factors for both fire and medical emergencies, when compared to Oshawa overall, including:

    - Greater population density – Oshawa's population density is 1,094 residents/ km^2 compared to Census Tract 532 0010.00's population density of 2,391 residents/ km^2.

    - Greater proportion of residents vulnerable based on age (+5.5%).

    - Greater median age (+5.8 years).

    - Greater proportion of households classified as low income (+23%).

    - Lower proportion of dwellings that are single-detached houses (-43.3%).

[7] NFPA 1710 §5.2.3.1 (2020)
[8] NFPA 1710 §5.2.3.2 (2020)

- Greater proportion of dwellings that are apartment buildings 5 or more storeys (+36%).

- Greater proportion of dwellings that are "other attached" dwellings (+7.64%).

- Greater proportion of dwellings that were built in or before 1960 (+12.0%).

Workload

- OFS responded to 5,550 incidents in 2018, an increase of 10.6% from 2016.

- Number of incidents do not equal the number of required responding units. An accurate calculation of demand needs to examine the number of required responding units.

- From 2016 to 2018 OFS required the response of a total of 29,879 units to a total of 15,855 incidents. Any non-medical incident typically requires the response of more than one OFS unit. Alarms, accidents and fires required the most responding OFS units. During the three years, on average:

    - Each incident required the response of 1.9 OFS units.

    - Each alarm required the response of 3.8 OFS units.

    - Each accident required the response of 2.1 OFS units.

    - Each fire required the response of 2.7 OFS units.

    - Each structure fire required the response of 4.8 OFS units.

    - Each public hazard incident required the response of 1.4 OFS units.

    - Each medical incident required the response of 1 OFS unit.

- OFS units spent the highest percentage of time on task (35.3% of the total time) in Station 1's first-due district.

- From 2016 to 2018 the greatest volume of total incidents occurred within Station 1's first-due district. Station 1's first-due district experienced nearly double the volume of the second busiest first-due district, Station 2's. During the three years:
    - 36.2% of all incidents of any type occurred within Station 1's first-due district, which was the highest focus of demand when compared to the rest of the city.
    - 43.2% of all alarm incidents occurred within Station 1's first-due district, which was the highest focus of demand when compared to the rest of the city.
    - 32.5% of all accident incidents occurred within Station 1's first-due district, which was the highest focus of demand when compared to the rest of the city.
    - 32% of all fire suppression incidents[9] occurred within Station 1's first-due district, which was the highest focus of demand when compared to the rest of the city.
    - 33.9% of all structure fire incidents occurred within Station 1's first-due district, which was the highest focus of demand when compared to the rest of the city.
    - 41.3% of all medical incidents occurred within Station 1's first-due district, which was the highest focus of demand when compared to the rest of the city.
    - 28.1% of all public hazard incidents occurred within Station 1's first-due district, which was the highest focus of demand when compared to the rest of the city.
- After a frontline suppression apparatus was removed from Station 1 in April of 2017, all stations increased the number of unit responses into Station 1's first-due district, with most responding from Stations 2, 3 and 4. Unit responses into First-Due District 1:
    - Increased by 64% in 2017, and 15% more in 2018 from Station 2.
    - Increased by 100% in 2017, and 22% more in 2018 from Station 3.
    - Increased by 83% in 2017, and 19% more in 2018 from Station 4.
- From 2016 to 2018 incidents increased by 12.3% for Station 1's first-due district, compared to 10.6% for OFS overall.

[9] Fire suppression incidents include structure fires.

- When a frontline suppression apparatus was removed from Station 1 in April of 2017, Station 1 needed to service increasing demand with reduced response capacity. This corresponded to the following findings relevant to response to incident types that must meet NFPA 1710 travel time objectives, fire suppression and emergency medical incidents:
    - From 2016 to 2018 there was an increase in the frequency of responses from non-first-due units into Station 1's first-due district.
    - Non-Station 1 units responding into First-Due District 1 to fire or emergency medical incidents had, on average, 1 minute 28 seconds longer travel times than Station 1 units.
    - As the frequency of fires and emergency medical incidents increased within Station 1's first-due district, the frequency of responses from other units into Station 1's first-due district also increased.
    - From 2016 to 2018 the percentage of responses by non-Station 1 units into Station 1's first-due district that were the *first arriving unit* on scene of a fire or emergency medical incident increased. In 2016 it was 16% and increased to 30% in 2017 and 33% in 2018.
    - Non-Station 1 *first arriving units* responding into District 1 to fire or emergency medical incidents had an average travel time 42 seconds longer and a 90th percentile travel time one minute longer than Station 1 units.
    - District 1 experienced a spike in the number of fires where *the first arriving unit* had a travel time of greater than four minutes in 2018. Station 1's first-due district experienced 47, 46, and 60 such fires in 2016, 2017 and 2018, respectively.
    - In Oshawa in 2016, 20% of all medical emergencies where the travel time of the *first arriving unit* exceeded four minutes occurred within Station 1's first-due district. By 2018 that percentage rose to 40%.
- From 2016 to 2018 for fire suppression incidents and medical emergencies throughout Oshawa, non-first-due units tend to have longer travel times. The average travel time was one minute and 51 seconds longer than for first-due units.

- From 2016 to 2018 for *first arriving units* to fire suppression incidents and medical emergencies throughout Oshawa, non-first-due units tend to have longer travel times. The average travel time was one minute longer than for first-due units, and the 90th percentile was one minute longer.

- From 2016 to 2018, for fire suppression incidents, the 90th percentile travel time was consistently six minutes for the *first arriving suppression apparatus*, which exceeds the NFPA 1710 travel time objectives by two minutes.

- From 2016 to 2018, for fire suppression incidents, the 90th percentile travel time for the second arriving suppression apparatus met NFPA 1710 travel time objectives. The 90th percentile travel time was six minutes each year.

- From 2016 to 2018, the *first arriving suppression apparatus* had a travel time of greater than four minutes for 23.1% of fire suppression incidents. Station 1's first-due district accounted for the highest percentage of these fires where the *first arriving suppression apparatus* did not meet NFPA 1710 travel time objectives, with 36.6% of them occurring within its boundary.

- From 2016 to 2018, for emergency medical incidents, the 90th percentile travel time for the *first arriving unit* met NFPA 1710 travel time objectives in 2017, but not in 2016 or 2018. The 90th percentile travel time was four minutes in 2017, and five minutes in 2016 and 2018.

- From 2016 to 2018, the *first arriving unit* had a travel time of greater than four minutes for 10.9% of emergency medical incidents. Station 1's first-due district accounted for the highest percentage of these medical emergencies where the *first arriving unit* did not meet NFPA 1710 travel time objectives, with 36.3% of them occurring within its boundary.

Mapping Analysis

- Based on this geographic information system (GIS) assessment of the areas within Oshawa, OFS is able to respond with four firefighters on 64.3% of roads[10] within four minutes when at typical staffing levels, assuming all units are available immediately upon dispatch.

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

- Based on this GIS assessment of the areas within Oshawa, OFS is able to provide for the arrival of 17 firefighters on 34.2% of roads within eight minutes at typical staffing levels, assuming all units are available immediately upon dispatch. The arrival of 17 firefighters within eight minutes is the standard for safe, effective, and efficient operations at a typical, residential structure fire.[11] [12] Pursuant to implementing staffing and deployment recommendations, OFS would likely be able to assemble a minimum of 17 fire fighters within eight minutes of travel on 44.2% of roads, which equates to a 29.2% **increase** in response coverage.

- Based on this GIS assessment of the areas within Oshawa, OFS is only able to provide for the arrival of 26 firefighters on 0.2% of roads within eight minutes at typical staffing levels, assuming all units are available immediately upon dispatch. The arrival of 26 firefighters within eight minutes is the standard for safe, effective, and efficient operations at a typical garden-style apartment building or open-air strip shopping center structure fire.[13] [14] Pursuant to implementing staffing and deployment recommendations, OFS would likely be able to assemble a minimum of 26 fire fighters within eight minutes of travel on 8.1% of roads, which equates to a 3,662% **increase** in response coverage.

- Based on this GIS assessment of the areas within Oshawa, OFS is not able to provide for the arrival of 39 firefighters on any roads within Oshawa within ten minutes, ten seconds at typical staffing levels. The arrival of 39 firefighters within ten minutes, ten seconds is

[11] A "typical, residential structure fire" is one occurring in 186 m^2 (2000 ft^2), two-storey single-family dwelling without basement and with no exposures. NFPA 1710, §5.2.4.1.1

[12] A 17th firefighter is needed to operate an aerial device. Even if an aerial device is not in use, a ground ladder will likely be in use at a typical residential structure fire and a 17th firefighter will be needed to maintain the ground ladder while firefighters traverse the ladder and crews operate on the roof.

[13] A "typical, open-air strip shopping center fire" is one occurring in a 1,203 m^2 to 18,209 m^2 (13,000 ft^2 to 196,000 ft^2) open-air strip shopping center. A "typical apartment" is one occurring in a 111 m^2 (1,200 ft^2) apartment within a three-storey, garden style apartment building. NFPA 1710, §5.2.4.2.1 and NFPA 1710, §5.2.4.3.1

[14] OFS does not provide medical transport. Therefore, OFS would be required to arrive with a total of 26 personnel (24 firefighters, one incident commander, and one chief's aide), rather than 28, to a medium-hazard structure fire. NFPA 1710, §5.2.4.2.1(9) requires, "The establishment of an initial medical care component consisting of at least two members capable of providing immediate on-scene emergency medical support and transportation that provides rapid access to civilians or members potentially needing medical treatment." Agencies outside of OFS that possess emergency medical transport capabilities should be included in the deployment plan to meet NFPA 1710 Open-Air Strip Shopping Center and Apartment Initial Full Alarm Assignment requirements.

considered to be the standard for safe, effective, and efficient operations at a fire occurring at a high-rise [15] [16] or other high-hazard occupancy.[17]

- Based on this GIS assessment of the areas within Oshawa, OFS is able to respond with a second suppression company that is an aerial apparatus to a structure fire occurring on 40.4% of roads within six minutes at typical staffing levels, assuming all units are available immediately upon dispatch. [18]

- Based on this GIS assessment of the areas within Oshawa, OFS is able to respond with basic life support (BLS) first response capabilities on 64.3% of roads within four minutes, assuming all units are available immediately upon dispatch.[19]

Recommendations

The recommendations listed below are based on the performance objectives in NFPA 1710, the findings of the GIS evaluation of the current staffing and deployment practices of OFS, and the findings of the evaluation OFS workload based on CAD data. It is recommended that:

- OFS should deploy an additional suppression company, a multi-hazard response capable vehicle, staffed with a minimum of four firefighters at all times, from Station 1.

- OFS should add additional fire suppression resources to areas that are experiencing high volumes of incidents where the first arriving units exceed NFPA 1710 travel time objectives. When first-due units are unavailable to respond, units from other first-due districts, on average, have to travel farther distances to arrive on scene compared to first-due units, resulting in longer travel times.

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[15] A "high-rise" is an occupancy "with the highest floor greater than 23 m (75 ft) above the lowest level of fire department vehicle access." NFPA 1710, §5.2.4.4.1

[16] In addition to 39 firefighters, "The establishment of an initial medical care component consisting of a minimum of two crews with a minimum of two members each with one member trained to the ALS level capable of providing immediate on-scene emergency medical support, and transport that provides rapid access to civilians or members potentially needing medical treatment." NFPA 1710, §5.2.4.4.1(18). Due to emergency medical transport capabilities within Oshawa being provided by an entity other than OFS, the calculation of OFS' response capabilities counted only 39 personnel rather than 43. Agencies outside of OFS that possess emergency medical transport capabilities should be included in the deployment plan to meet NFPA 1710 High-Rise Initial Full Alarm Assignment requirements.

[17] A "high-hazard occupancy" is one that "presents a high life hazard or large fire potential due to its construction, configuration, or the presence of specific materials, processes, or contents." NFPA 1710, §3.3.36

[18] "The fire department shall establish the following objectives…360 seconds (6 minutes) or less time for the arrival of the second company with a minimum staffing of 4 personnel at a fire suppression incident." NFPA 1710, §4.1.2.1(4). Although not explicitly stated, it is recommended that at a structure fire this apparatus be the ladder truck or a company that will be assigned to ladder duties.

[19] "The fire department shall establish the following objectives…240 seconds (4 minutes) or less travel time for the arrival of a unit with first responder with automatic AED or higher level of capacity at an emergency medical incident." NFPA 1710, §4.1.2.1(7)

Executive Summary Conclusion

This analysis assessed the capabilities of OFS and determined that suppression apparatus are staffed to meet industry standard minimum staffing objectives, with four firefighters each. However, geographic assessment of the OFS' staffing and deployment model and analysis of OFS' workload demonstrated that additional staffed suppression apparatus are needed to increase the coverage areas within OFS' response jurisdiction, so OFS can respond in a more effective and timely manner.

Call volume is increasing in Oshawa each year and areas of the city that are experiencing the highest call volumes and increases have had emergency response capabilities reduced. Although adding a new fire station improved OFS' geographic coverage, not increasing the number of staffed suppression apparatus has reduced OFS' capacity to meet demand. For example, the volume of incidents where the first arriving units exceed NFPA 1710 travel time objectives is increasing as is the frequency that non-first-due units must respond into high demand areas. The increasing frequency of such incidents in areas that are experiencing increasing demand is an indication that additional resources may be needed. Adding additional staffed suppression apparatus will increase the ability to respond in a manner prescribed by the objectives of NFPA 1710 to fires occurring in low- and medium-hazard occupancies.

In order to provide efficient and effective service, OFS resources must be positioned appropriately. Industry standards aim for the first unit to arrive at the scene of fire and medical emergencies rapidly because delays of even seconds may result in death or injury and may make controlling a fire more difficult. In Oshawa's case, resources were removed from its downtown, the area with the most residents living in poverty and the most concentrated elderly population, and an area that is currently being developed and revitalized. As investment is made in this part of Oshawa, public safety should not be neglected. This report is intended to serve as a tool to help city decision makers ensure that OFS is properly equipped and staffed to serve the needs of all citizens and visitors to Oshawa, safely and effectively.

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Background

The International Association of Fire Fighters (IAFF) Headquarters was engaged by the Oshawa Professional Firefighters Association, IAFF Local 465, to create a data-driven document for city and fire service administrators to assist with informed decisions regarding emergency response.

In July of 2016 Oshawa Fire Services (OFS) opened and began providing emergency response from a sixth fire station, Fire Station 6. Fire Station 6 is located at 2339 Simcoe Street North, in the northern part of Oshawa as an attempt to meet increasing demand in the area. With its strategy for adding emergency response capacity to Station 6, OFS increased the overall distribution of personnel and apparatus, while decreasing the overall density of personnel and apparatus. Essentially, capacity was increased in some areas of Oshawa and decreased in others, as demand grew throughout Oshawa. Furthermore, this response capacity was removed from the most impoverished part of Oshawa.

Prior to the opening of Station 6, response to this area was provided by units responding from Stations 3 and 5. However, rather than increasing on-duty staffing and adding a new frontline apparatus when Station 6 was opened, staffing and apparatus were displaced from other stations and eventually the second pumper from Station 1 was permanently relocated to Station 6 on April 10, 2017.[20]

Station 1's first-due district experiences the greatest volume of overall incidents, fire suppression incidents and emergency medical incidents in Oshawa. After Station 1's response capabilities were reduced, instances of units from other stations responding into Station 1's first-due district have increased as has the frequency where these units arrived before Pumper 21. On average, units from outside of Station 1's first-due district have to travel farther distances to arrive on scene resulting in longer travel times. Such results are predictable when resources are removed from the area of Oshawa with the highest demand for emergency services.

Oshawa is currently experiencing growth, and city initiatives are currently targeting development in areas throughout the city, but particularly in downtown, currently the area with the highest demand for emergency services.[21] Additionally, Ontario Tech University is developing its downtown campus location and is expecting an increased student population at the downtown campus in coming years. OFS does not currently have an adequate number of firefighters per

[20] OFS began responding from Station 6 in July 2016 and Pumper 211 ceased daily responses in July of 2016. Also, on July 19, 2016 continuing until April 9, 2017 Aerial 23 was moved from Station 3 to Station 1. Prior to July 19, 2016, Pumper 21 and Pumper 211 responded from Station 1 and were each staffed with 4 firefighters at all times. Pumper 23 and Aerial 23 responded from Station 3 and were also each staffed with 4 firefighters at all times. On April 10, 2017 continuing to the present, Aerial 23 was moved back to Station 3, leaving only Pumper 21 at Station 1.

[21] Oshawa city government website; site visited April 20, 2020. < https://www.oshawa.ca/city-hall/development.asp>

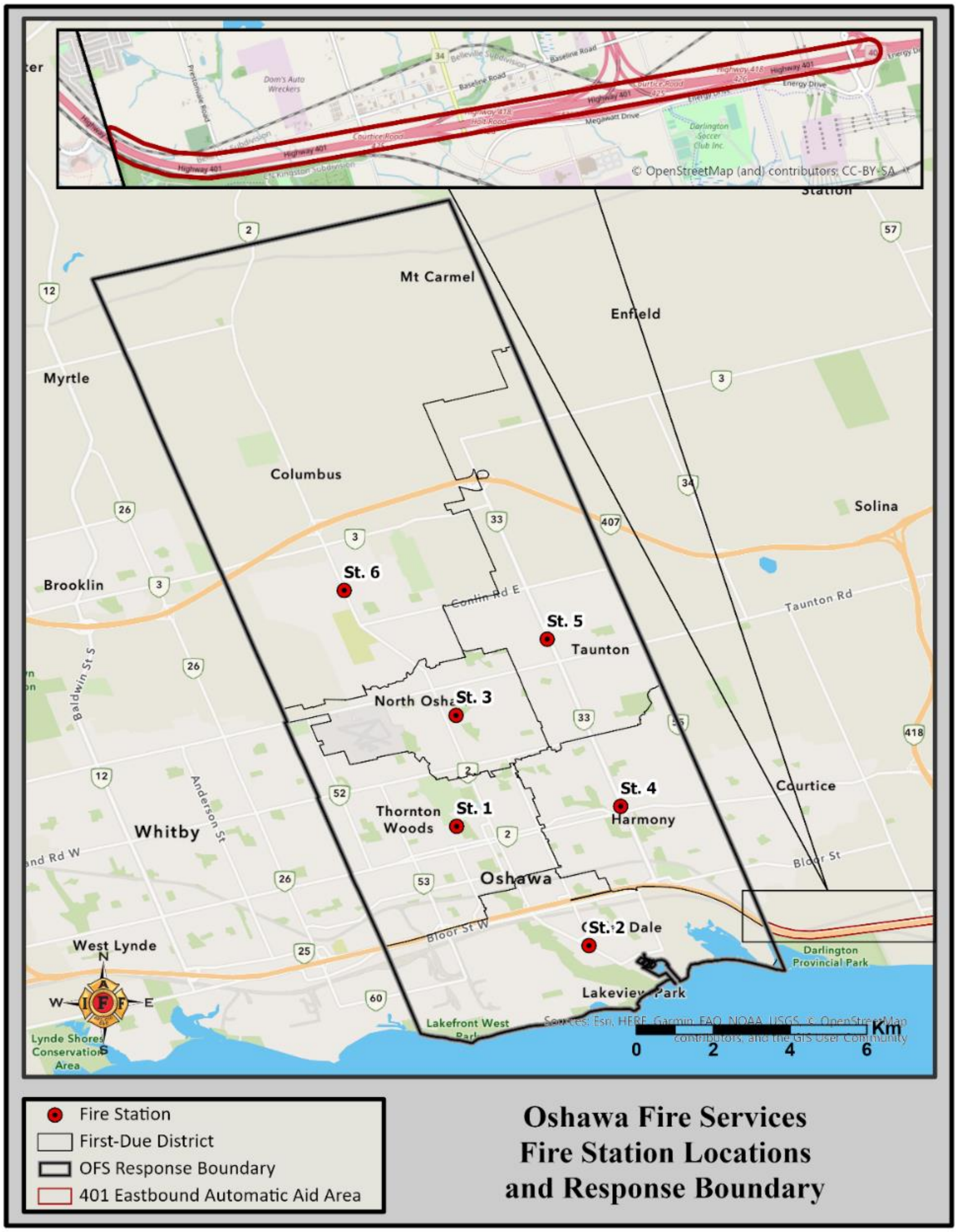
shift or an adequate number of frontline apparatus to provide emergency response that meets the objectives of industry standards for safe, efficient, and effective response to fires or rescue situations, and with expected future growth, these inadequacies will worsen.

Already, after resources were removed from Station 1 in 2017, negative effects on the ability of OFS to respond have been realized. Travel times for units responding to incidents within Station 1’s first-due district have been lengthening as Station 1 increasingly relies on outside units to respond within its first-due district, and outside units are increasingly the first arriving at fires and emergency medical incidents. Responses by non-Station 1 units to fires and emergency medical incidents occurring in Station 1’s first-due district increased from 2016 to 2018, with 199, 250 and 369 such responses, in 2016, 2017 and 2018 respectively. Delays of even seconds can increase the risk of injury and death in medical emergencies and fires. Non-Station 1 units had, on average, one minute, 28 second longer travel times than Station 1 units. Additionally, any delays in response to fires can increase the chances of a fire spreading throughout a structure or flashing over and increase the difficulty of finding and rescuing trapped victims.

The information provided in this document is designed to help decision makers understand the depth of fire service operations and how low staffing levels and inadequate resources negatively impact responders and citizens in Oshawa.

Risk Characteristics

Oshawa, in the province of Ontario, is located on the shores of Lake Ontario, approximately 61 kilometers east of Toronto. The city encompasses an area of 145.6 square kilometers. OFS is responsible for responding to all emergencies that occur in Oshawa.



Map 1: OFS Station Locations and Response Boundary. Map 1 depicts OFS fire station locations, response boundary and first-due districts for fire stations. Also depicted in the inset is an area of 401 eastbound, outside of Oshawa, where OFS provides automatic aid with two pumper units.[22] Due to the locations of 401 entry points, Clarington Emergency Fire Services is unable to respond in this area in a timely manner. This area reaches east from the Oshawa boundary along 401, and in July of 2017 was extended from Courtice Road east to Holt Road.

[22] OFS units that typically respond in this area are Pumper 22 and Pumper 24. Due to the distance of travel required, these units typically spend more time travelling to and from incidents that occur here than within Oshawa.

Oshawa's census metropolitan area (CMA) had a population of 379,848 in 2016 and was the fourteenth largest CMA in Canada, according to Statistics Canada.[23] The city itself had a population of 159,458 residents in 2016, and an overall population density of 1,094.9 residents per square kilometer.[24] Between the 2011 census and 2016 census, the population of Oshawa grew by 6.6%.[25]

Further assessment of the 2016 census revealed that 22.0% of the population was in a vulnerable category based on age. This category consists of persons under the age of 5 (5.5%) and persons who are 65 years of age and older (16.5%).[26] These populations typically place an increased demand on public safety resources because these groups are at a higher risk of fire-related injury and death because of their inability, or reduced ability, to evacuate in an emergency situation. Citizens in the older demographic group may also be unable to care for themselves, have disorders or take medication that slow their ability to respond quickly, or have multiple health issues. Additionally, for the 2015 calendar year, 14.5% of the population was considered low-income based on the low-income measure, after tax (LIM-AT).[27] [28] These are residents who generally lack the means to properly maintain residences which can lead to an increased risk for fire.

The city had a total of 62,595 occupied private dwellings of which 55.6% were single-detached houses, 11.5% were apartment buildings with 5 or more storeys, and 32.9% were other attached dwellings.[29] Of these 62,595 structures, 26.1% were built in 1960 or earlier.[30] Typically, vacant housing and older buildings constructed before fire codes were developed can lead to an increased demand on emergency services.

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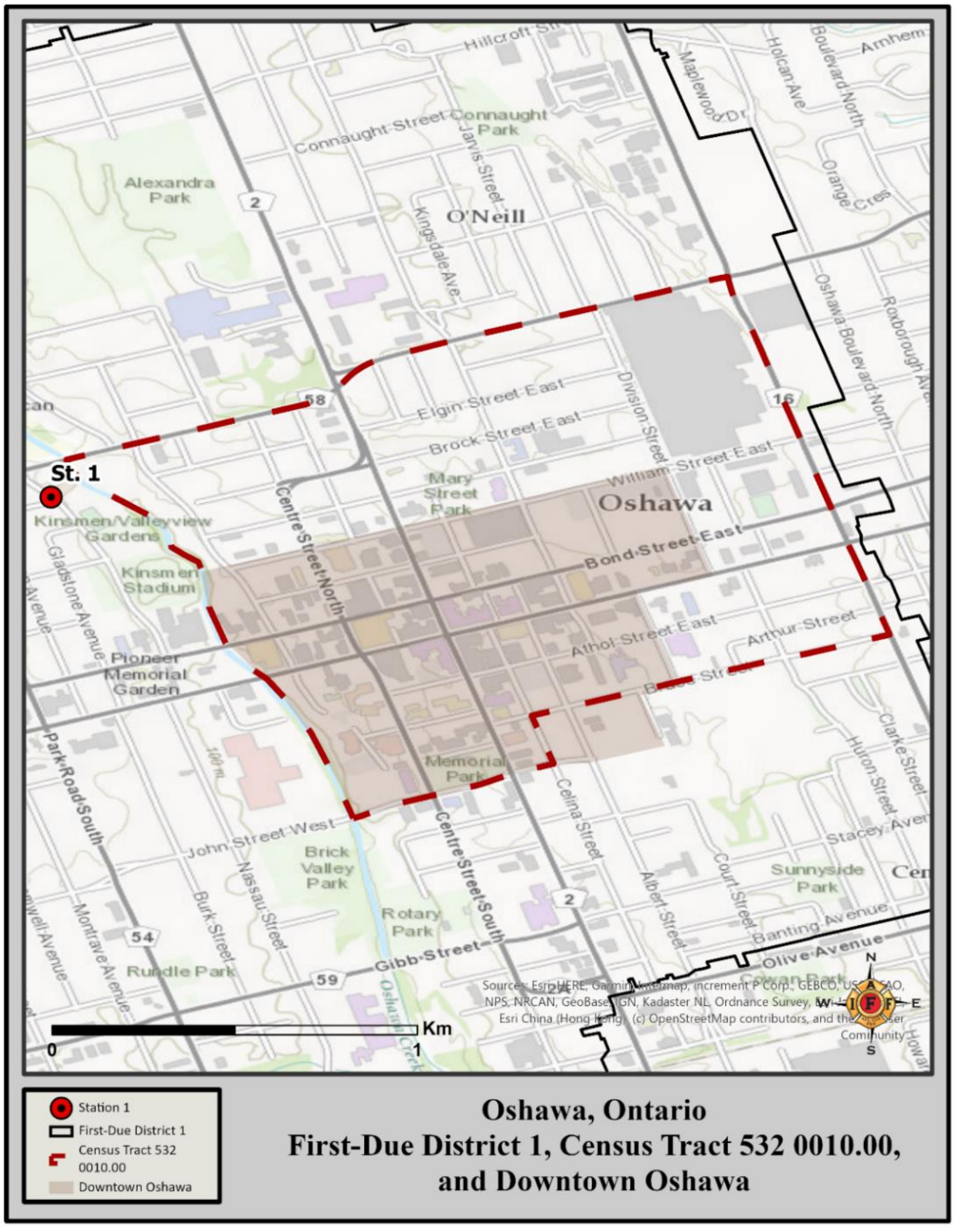
[23] Statistics Canada. 2017. *Oshawa [Census metropolitan area], Ontario and Ontario [Province]* (table). *Census Profile*. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017. http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E (accessed January 31, 2018).
[24] Statistics Canada. 2017. *Oshawa, CY [Census subdivision], Ontario and Durham, RM [Census division], Ontario* (table). *Census Profile*. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017.
http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E (accessed January 31, 2018).
[25] Ibid.
[26] Ibid.
[27] Statistics Canada. 2017. *Oshawa, CY [Census subdivision], Ontario and Durham, RM [Census division], Ontario* (table). *Census Profile*. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017.
http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E (accessed January 31, 2018).
[28] Low-income status for the 2016 Census was based on the 2015 calendar year.
[29] Statistics Canada. 2017. *Oshawa, CY [Census subdivision], Ontario and Durham, RM [Census division], Ontario* (table). *Census Profile*. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017.
http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E (accessed January 31, 2018).
[30] Ibid.

Before presenting a series of maps highlighting the overall demographic and physical characteristics related to Oshawa, a census tract in Station 1's first-due district is worth highlighting due to its risk relative to other parts of Oshawa, as OFS emergency response capacity has been reduced in this area.



Map 2: First-Due District 1, Census Tract 532 0010.00, and Downtown Oshawa. Map 2 depicts a portion of Station 1's first-due district which completely encompasses Census Tract 532 0010.00 and Oshawa's downtown, also known as the Business Improvement Area (BIA), as defined by the Downtown Oshawa Board of Management in 1974. [31]

[31] The Downtown Oshawa BIA website; site visited April 16, 2020. < https://downtownoshawa.ca/explore-downtown-oshawa-bia.php >

Statistics Canada records tract-level data for the same statistical measures that were discussed previously for the city of Oshawa. Census Tract 532 0010.00, located in Station 1's first-due district had a population of 4,524 residents in 2016 and a population density of 3,486 residents per square kilometer.[32] Since the 2011 census, the population of Tract 532 0010.00 has grown by 1.2%.[33] Between 2016 and 2019 Oshawa grew by an additional 8.6%, and Tract 532 0010.00 grew by an additional 9.5%.

Further assessment of the 2016 census revealed that 27.5% of the population was in a vulnerable category based on age. This category consists of persons under the age of 5 (3.8%) and persons who are 65 years of age and older (23.7%).[34] Additionally, for the 2015 calendar year, 37.5% of the population was low-income based on the Low-income measure, after tax (LIM-AT).[35] [36] As discussed previously, typically, populations within these categories have an increased likelihood of being injured or killed in fires and place a high demand on emergency medical services.

This tract had a total of 2,570 occupied private dwellings of which 12.3% were single-detached houses, 47.5% were apartment buildings with 5 or more storeys, and 40.5% were other attached dwellings.[37] Of these 2,570 structures, 38.1% were built in 1960 or earlier.[38] Typically, when there are high numbers of vulnerable citizens and older buildings constructed before current fire codes were developed, there is an increased demand on emergency services. Given these factors for housing and population, it is likely OFS has a steady call volume originating from the area within this tract.

Table 1, on the next page, summarizes the differences between the city of Oshawa and Census Tract 532 0010.00 in terms the various Statistics Canada measures that have been discussed.

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[32] Statistics Canada. 2017. *Oshawa, CY [Census subdivision], Ontario and Durham, RM [Census division], Ontario* (table). *Census Profile*. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017.
http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E (accessed January 31, 2018).
[33] Ibid.
[34] Ibid.
[35] Ibid.
[36] Low-income status for the 2016 Census was based on the 2015 calendar year.
[37] Statistics Canada. 2017. *Oshawa, CY [Census subdivision], Ontario and Durham, RM [Census division], Ontario* (table). *Census Profile*. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017.
http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E (accessed January 31, 2018).
[38] Ibid.

Category	Oshawa	532 0010.00	Difference
Population Density	1,094.9/km^2	3,486/km^2	**+ 2,391.1/km^2**
Growth Rate 2016 - 2019	8.6%	9.5%	**+ 0.9%**
Median Age	41.2 years	47 years	**+ 5.8 years**
Vulnerable Based on Age	22.0%	27.5%	**+ 5.5%**
Vulnerable Based on Age - Under 5	5.5%	3.8%	**- 1.7%**
Vulnerable Based on Age - 65+	16.5%	23.7%	**+ 7.2%**
Low Income	14.5%	37.5%	**+ 23.0%**
Low Income – Under 5	22.5%	58.8%	**+ 36.3%**
Low Income – 65+	9.6%	29.4%	**+ 19.8%**
Single-detached House	55.6%	12.3%	**- 43.3%**
Apartment Building 5+ Storeys	11.5%	47.5%	**+ 36.0%**
Other Attached Dwelling	32.9%	40.54%	**+ 7.64%**
Built in 1960 or earlier	26.1%	38.1%	**+ 12.0%**

Table 1: Comparison of Census Statistics Between Oshawa and Census Tract 532 0010.00. The above table displays the various measures from Statistics Canada for the city of Oshawa overall and Census tract 532 0010.00. All data are from Statistics Canada and references the 2016 census, except 2019 population. 2019 population is based on 2019 population estimates by Environics Analytics.

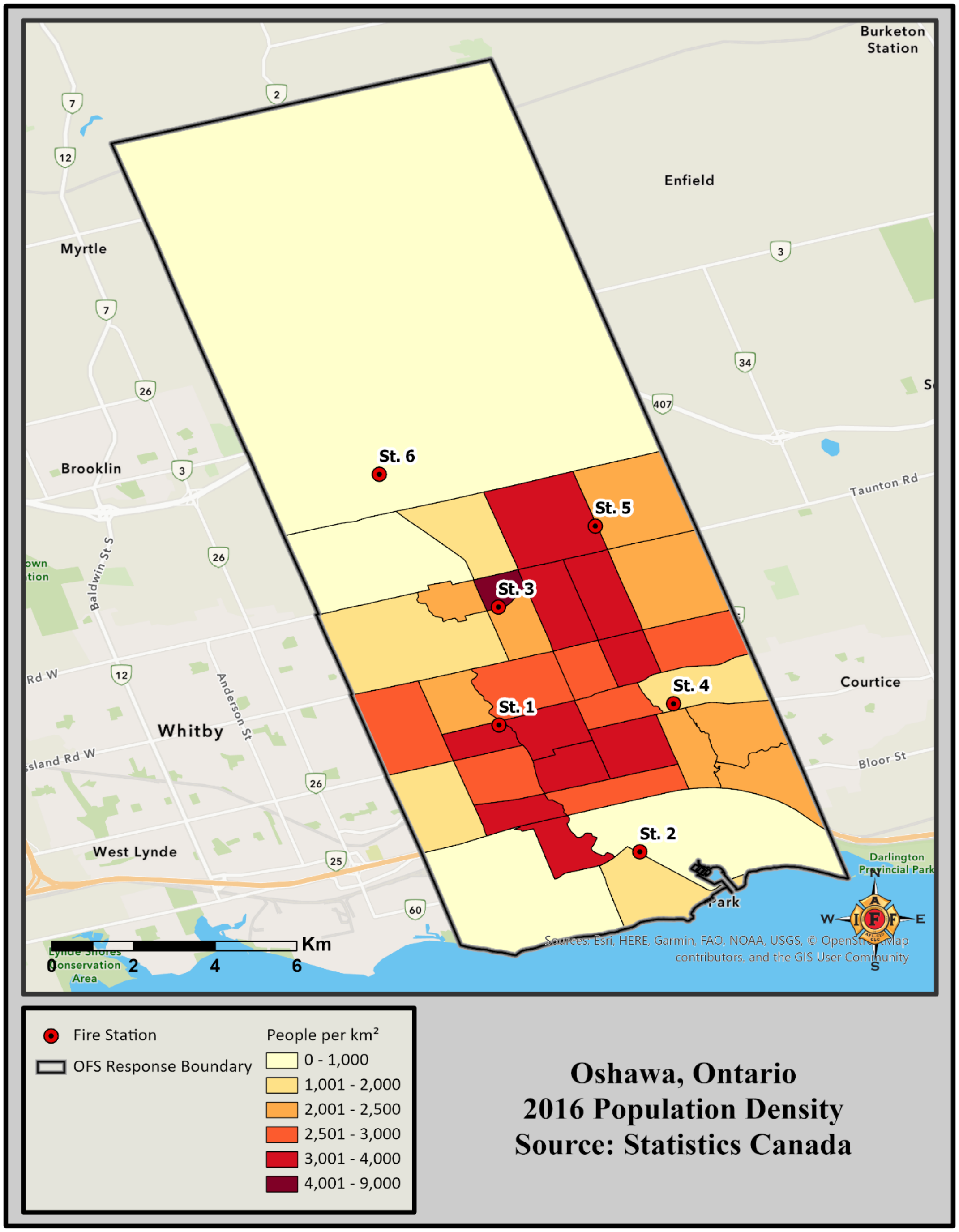
When considering OFS' capacity to respond from Station 1, that most of downtown Oshawa (as seen in Map 2, page 18) is contained within Tract 532 0010.00 [39], and that both are entirely within Station 1's first-due district. According to the Downtown Oshawa Business Improvement Area (BIA), recently Oshawa's downtown has been the focus of extensive development and is the prime spot in Canada to find employment. As the Downtown Oshawa BIA states on its website:

> The changes to downtown Oshawa over the past two years have spurred a new focus on Oshawa and the downtown. Recently voted the top place in Canada to find employment, there is a renewed interest in investing in our downtown. Oshawa has over $120 million being invested in the downtown. Our downtown core boasts two new fully accessible hotels, a future convention centre, the historic Genosha Hotel is currently being converted to residential units while maintaining its original glory. [40]

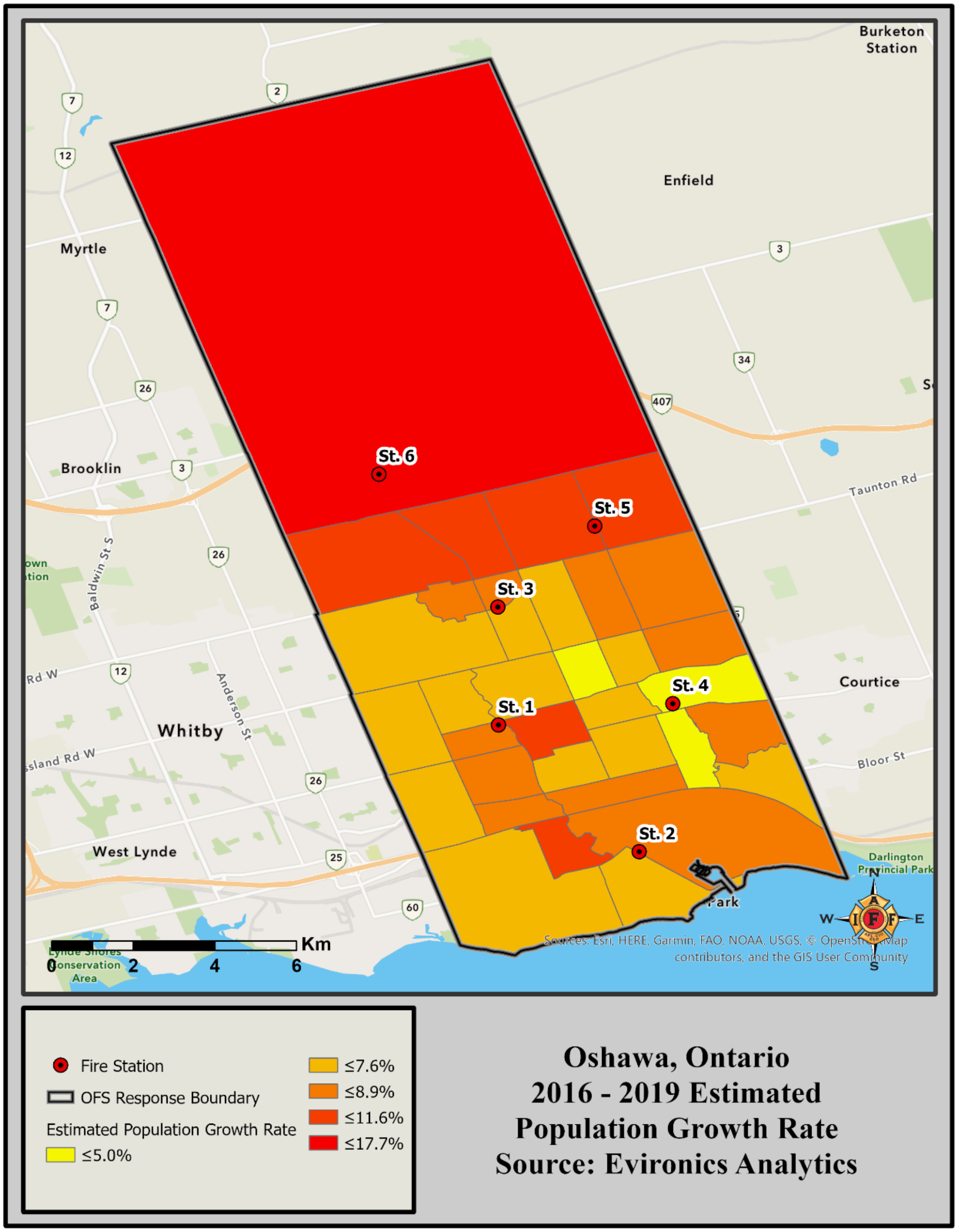
An important factor in assessing risk in a community is assessing daily population fluctuations beyond the permanent resident population in the community. According to 2019 population estimates, the population of Tract 532 0010.00 more than doubles in daytime hours, increasing by 147%. Tract 532 0010.00 has the second highest daytime growth rate of all Oshawa census tracts, and the second highest total daytime population of all Oshawa census tracts.

[39] The Downtown Oshawa BIA website; site visited January 31, 2018. <https://downtownoshawa.ca/about-the-bia>
[40] Ibid.

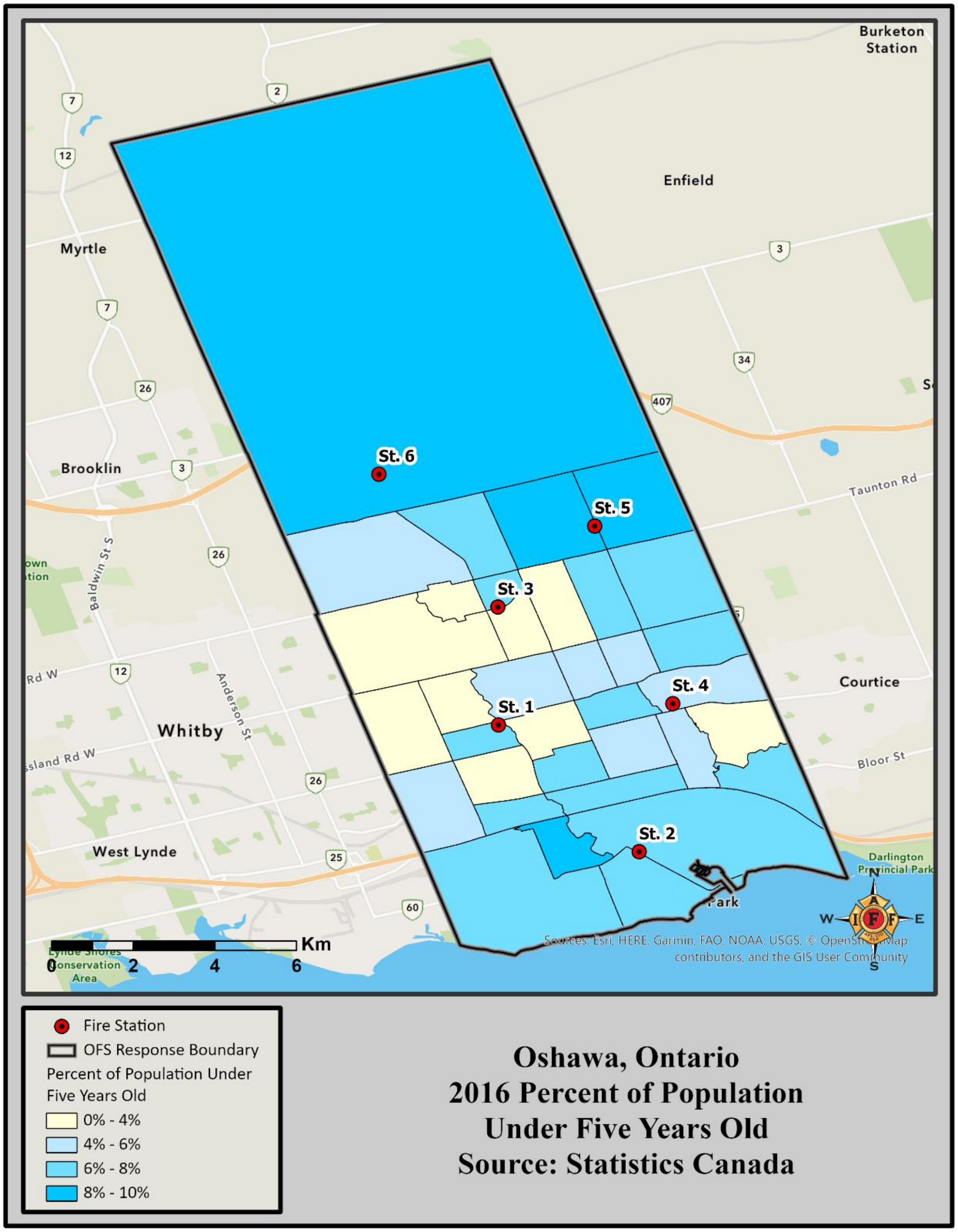
The following maps depict various demographic and physical characteristics of Oshawa overall.



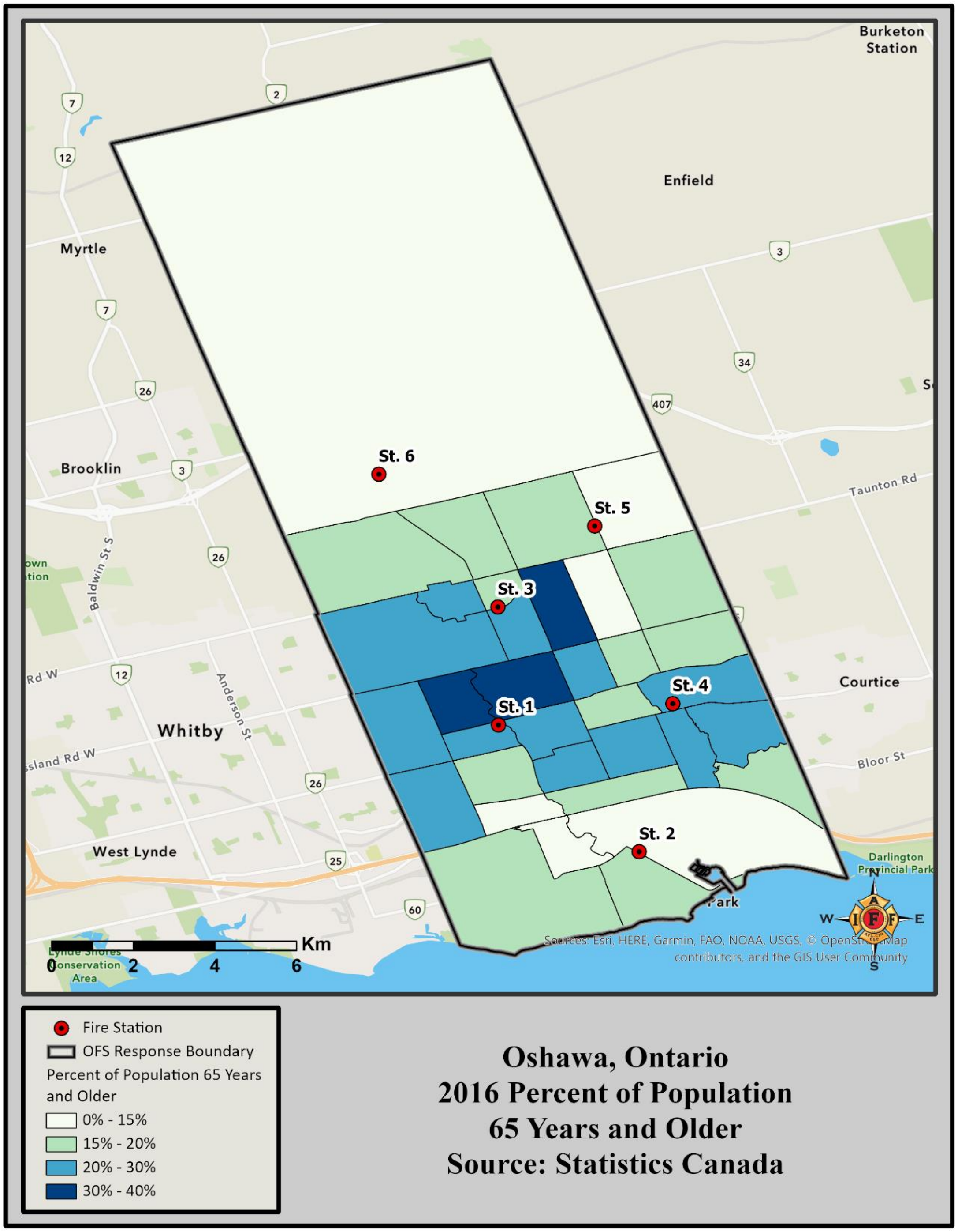
Map 3: 2016 Population Density. Map 3 shows the 2016 population density in people per square kilometer, by census tract and based on the 2016 Canadian Census, of OFS' response jurisdiction. Demand on emergency units is typically expected to be greater in areas with greater population density.



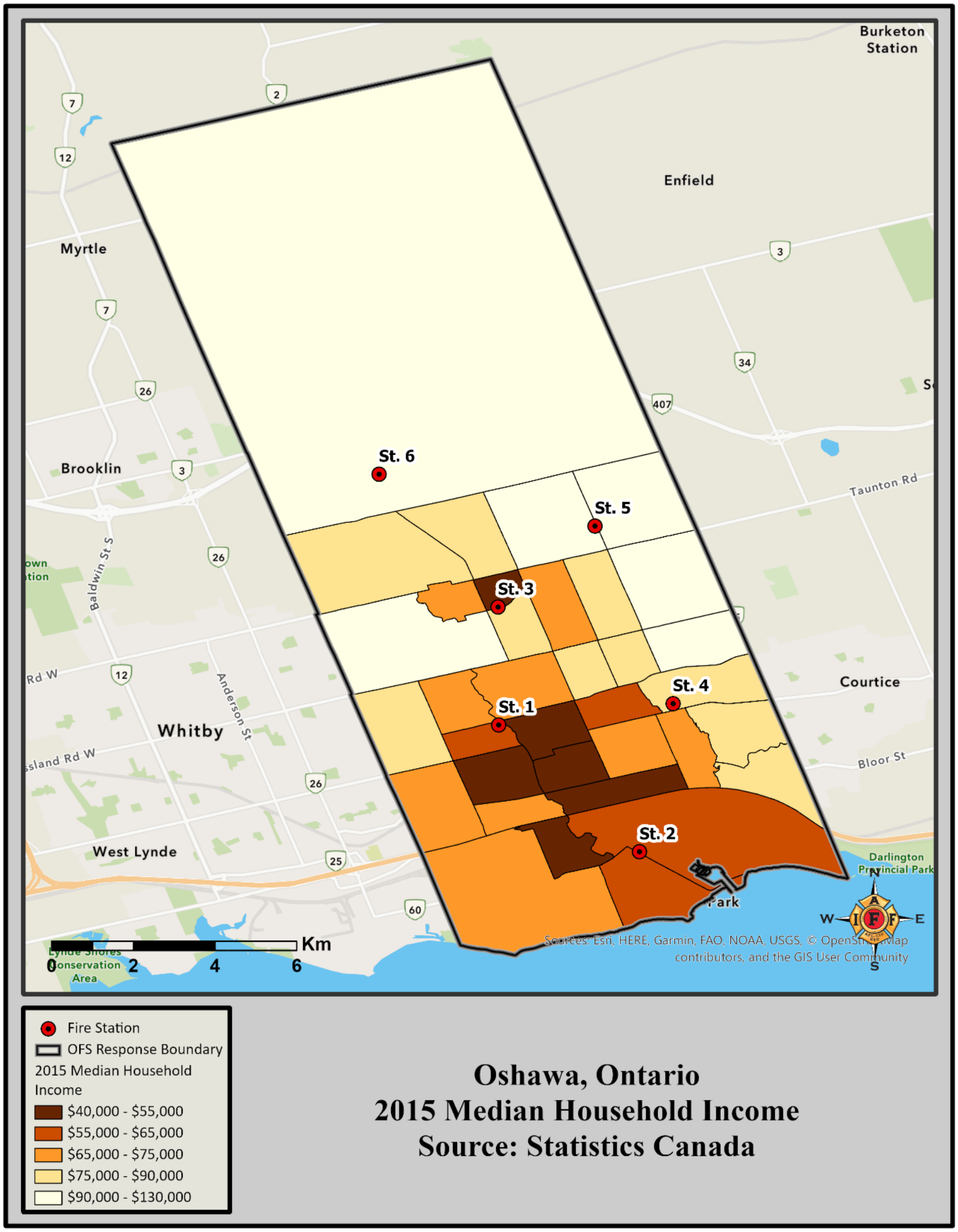
Map 4: 2016 – 2019 Estimated Population Growth Rate. Map 4 depicts the estimated population growth rate from 2016 to 2019 by census tract and based on the 2016 Canadian Census and Environics Analytics' 2019 population estimates, of OFS' response jurisdiction. Overall, the population of Oshawa grew by an estimated 8.6% between 2016 and 2019. Areas that have an estimated population growth rate will likely experience an increase in emergency services requests. Typically, as population increases, so does demand.



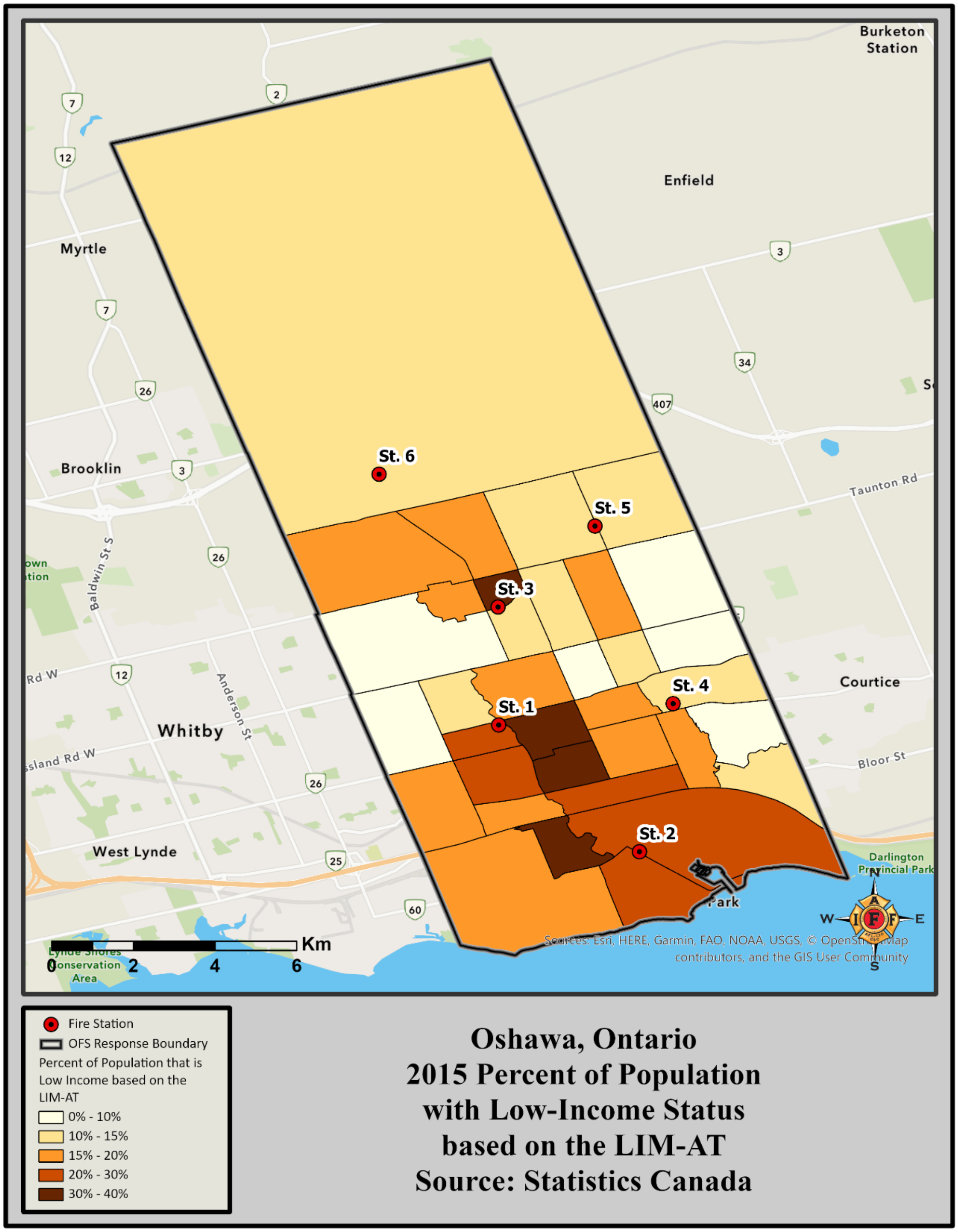
Map 5: 2016 Percent of Population Under Five Years Old. Map 5 depicts the percentage of the total population under five years old per census tract. This map assists in identifying areas of vulnerability in the community that will most likely need assistance before, during and after a hazardous event. Typically, people under five years old are at a higher risk for injury or death because of their inability or reduced ability to evacuate in an emergency. This age group also tends to place an increased demand on emergency medical services.



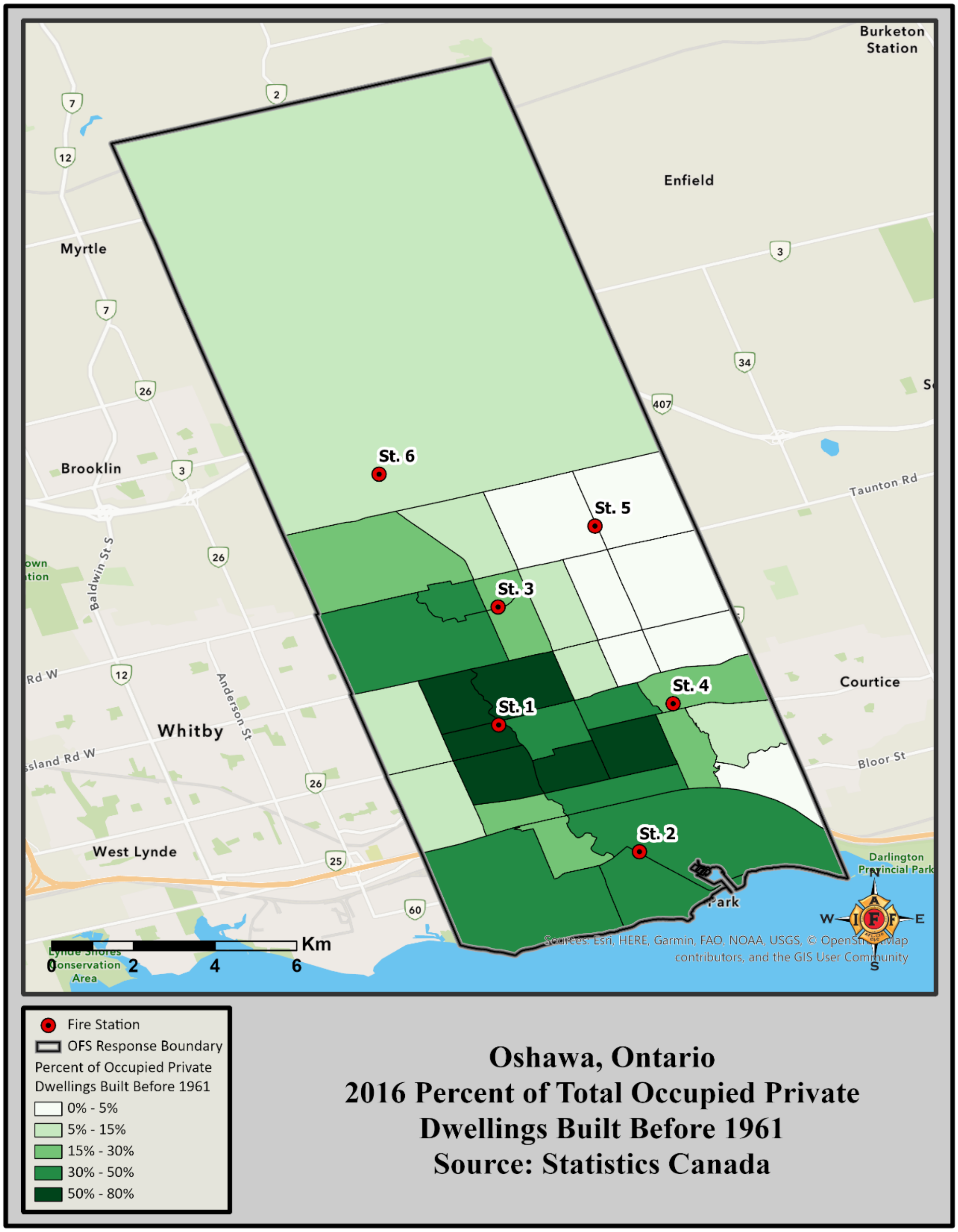
Map 6: 2016 Percent of Population 65 Years and Older. Map 6 depicts the percentage of the total population aged 65 years and older per census tract. This map assists in identifying areas of vulnerability in the community that will most likely need assistance before, during and after a hazardous event. Typically, people aged 65 and older are at a higher risk for injury or death because of their inability or reduced ability to evacuate in an emergency.



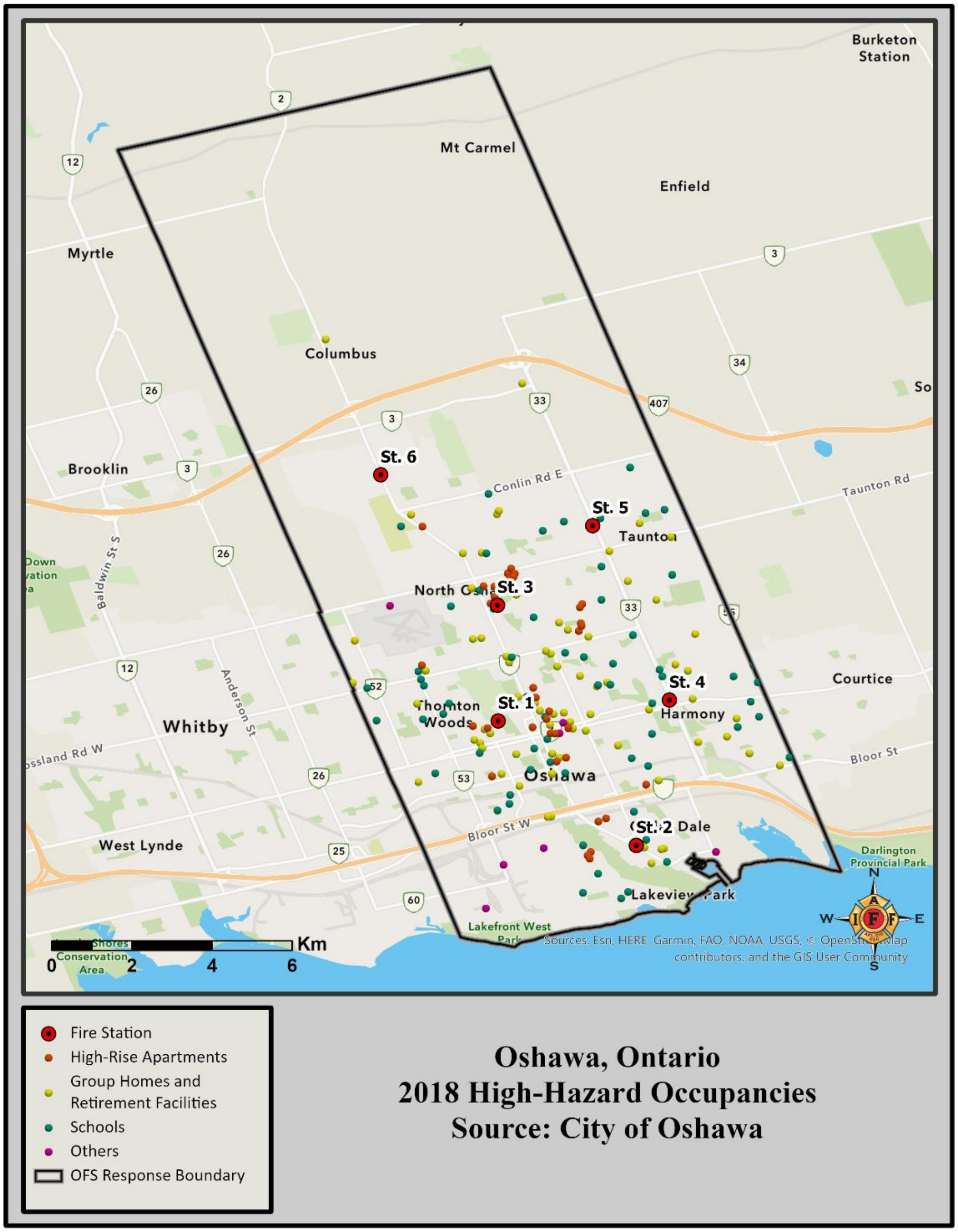
Map 7: 2015 Median Household Income. Map 7 depicts the median household income per census tract in 2015. The overall median household income for the city of Oshawa was $70,211. In 2015 the median household income for Ontario was $74,287, and for Canada overall was $70,336. Typically, areas with a lower median household income experience higher call volume as people with lower income are at a higher risk for medical complications and/or having a fire in their residence resulting in fire-related injury or death.



Map 8: 2015 Percent of Population with Low-Income Status based on the LIM-AT. Map 8 depicts the percentage of the population with Low-Income Status based on the LIM-AT. Like Map 7 on the previous page, this map indicates areas of Oshawa with a greater density of low-income residents. Typically, areas with a lower median household income experience higher call volume as people with lower income are at a higher risk for medical complications and/or having a fire in their residence resulting in fire-related injury or death.



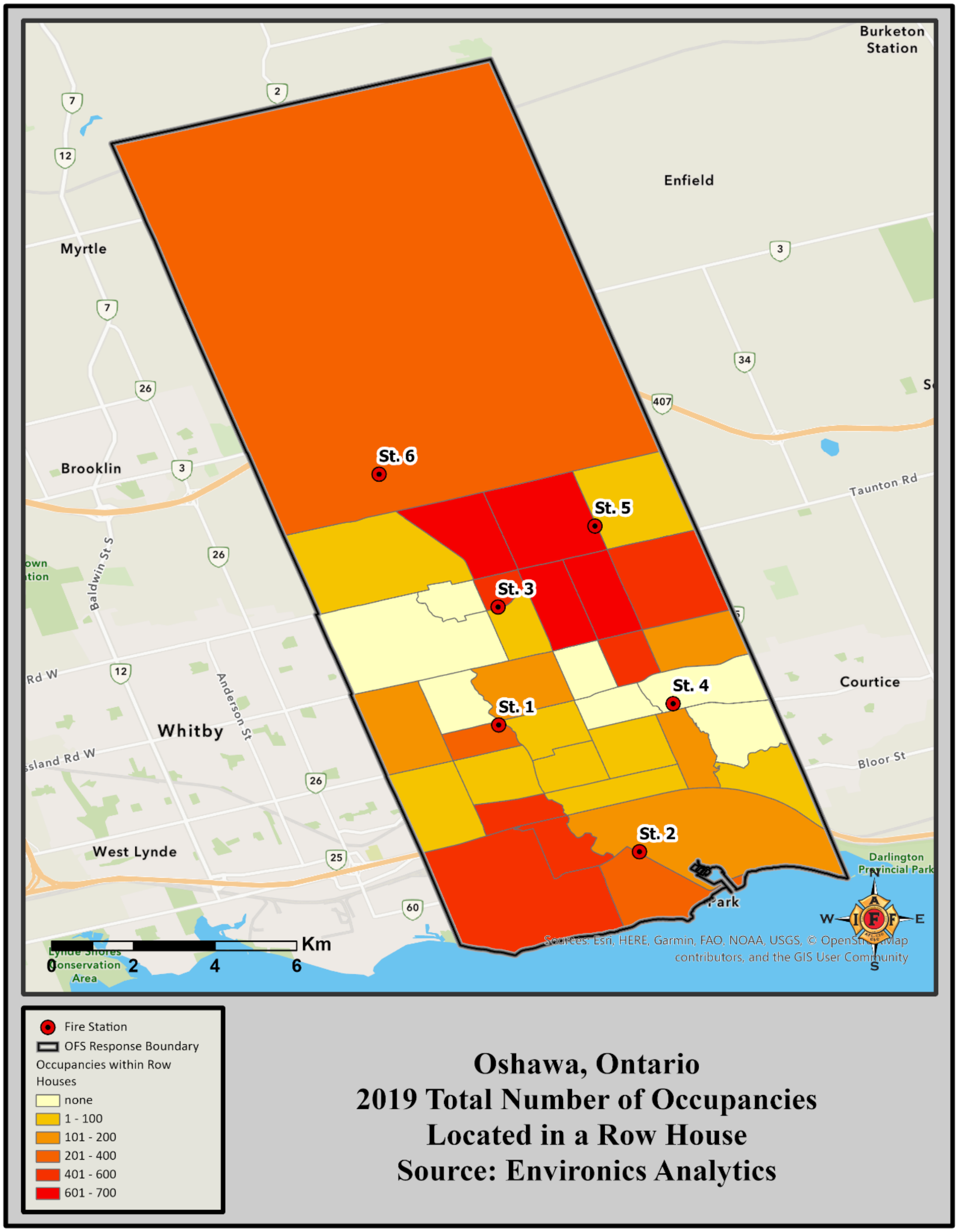
Map 9: 2016 Percent of Total Occupied Private Dwellings Built Before 1961. Map 9 depicts the number of occupied private dwellings built before 1961. Typically, when there are high numbers of older buildings constructed before many current fire codes were developed, there is an increased demand on emergency services.



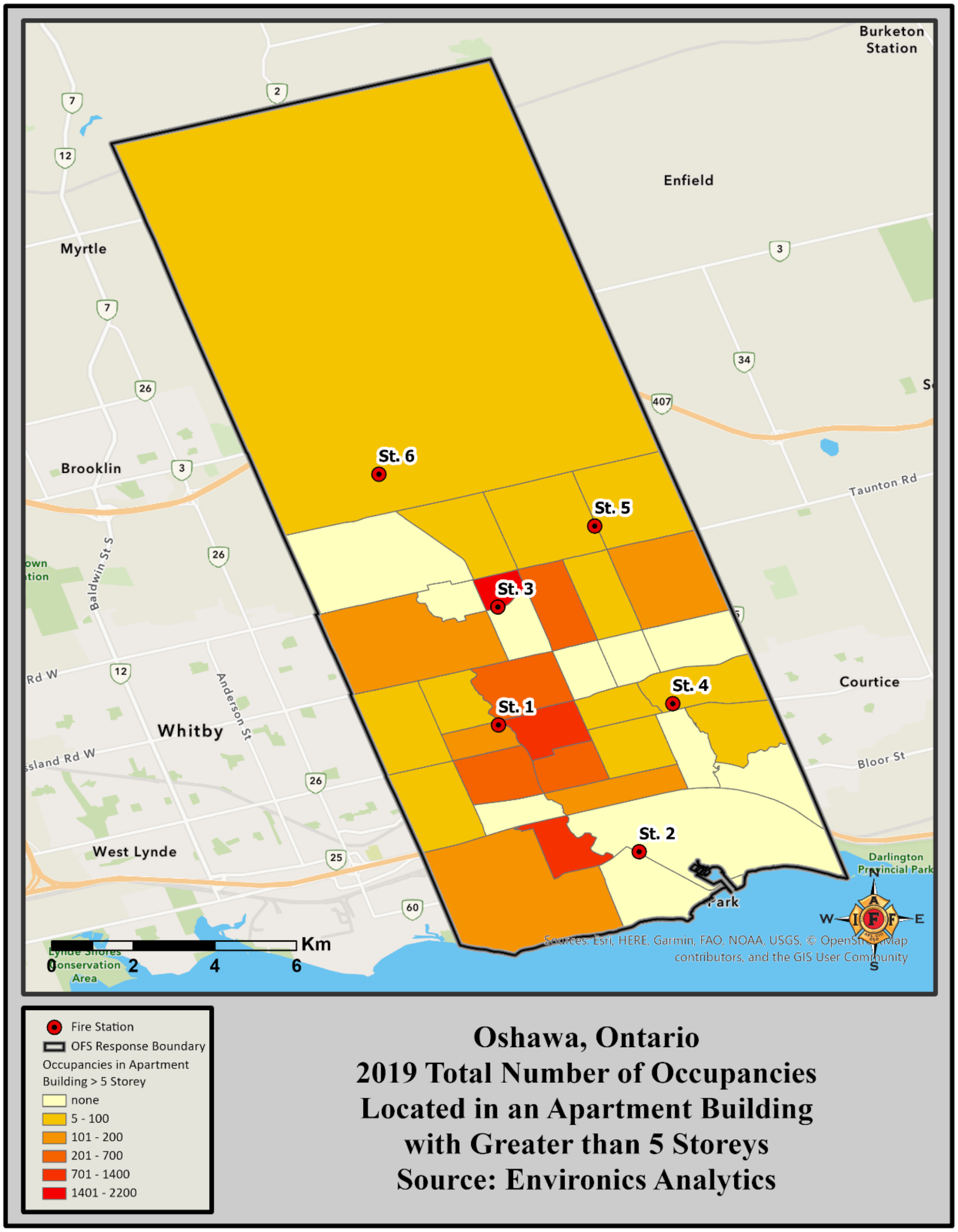
Map 10: 2018 High-Hazard Occupancies. Map 10 depicts the locations of various types of high-hazard occupancies in Oshawa such as apartments seven stories and above, schools, group homes and retirement facilities. Other includes high-hazard occupancies such as the hospital, the Tribute Communities Centre, and large industrial facilities. NFPA 1710 defines a high-hazard occupancy as one that "presents a high life hazard or large fire potential due to its construction, configuration, or the presence of specific materials, processes, or contents." [41] [42]

[41] NFPA 1710, § 3.3.36.

[42] "These occupancies include schools, hospitals, and other special medical facilities, nursing homes, high-risk residential occupancies, neighborhoods with structures in close proximity to one another, high-rise buildings, explosive plants, refineries, and hazardous materials occupancies." NFPA 1710, §A.3.3.36.



Map 11: 2019 Total Number of Occupancies Located in a Row House. Map 11 depicts the number of occupancies within row houses per census tract. Row houses present a greater level of risk than a detached single-family dwelling unit with no exposures and therefore require a larger effective response force for a one alarm assignment.



Map 12: 2019 Total Number of Occupancies Located in an Apartment Building with Greater than 5 Storeys. Map 12 depicts the number of occupancies within apartment buildings greater than five storeys per census tract. Fires occurring in five storey apartment require an initial full alarm assignment consisting of at least 26 firefighters, assembled within eight minutes travel to meet the objectives of NFPA 1710. Fires occurring in a building more than 23 m in height, measured from the lowest level of fire service vehicle access to the bottom of the highest occupied floor, require an initial full alarm assignment consisting of at least 39 firefighters, assembled within ten minutes, ten seconds travel to meet the objectives of NFPA 1710.

Fire Suppression Operations

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

A small flame can quickly burn out of control and become a major fire in a short period of time. This is because fire grows and expands exponentially as time passes. In the time frame of fire growth, the temperature of a fire rises to above 538° Celsius (C). It is generally accepted in the fire service that for a medium growth rate fire,[43] flashover--the very rapid spreading of the fire due to super heating of room contents and other combustibles—can occur. Assuming an immediate discovery of a fire, followed by an un-delayed call to 9-1-1, and dispatch of emergency responders, flashover is likely to occur within 8 minutes of fire ignition. However, studies conducted by the Underwriters Laboratory (UL) and the National Institute of Standards and Technology (NIST) have proved that, due to new building construction materials and room contents that act as fuel, flashover may occur much sooner.

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

This section will explain fire growth and the importance of fire service response to a low-hazard structure fire. A low-hazard structure fire is defined as a fire that occurs in a typical, 186 square meter, single-family residential home with no basement or exposures.[44]

Fire Growth

The Incipient Phase

The first stage of any fire is the incipient stage. In this stage a high heat source is applied to a combustible material. The heat source causes chemical changes to the material's surface which

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[43] 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.

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

converts from a solid and begins to release combustible gases. If enough combustible gases are released the material will begin to burn freely.

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

The Free Burning Phase

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

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

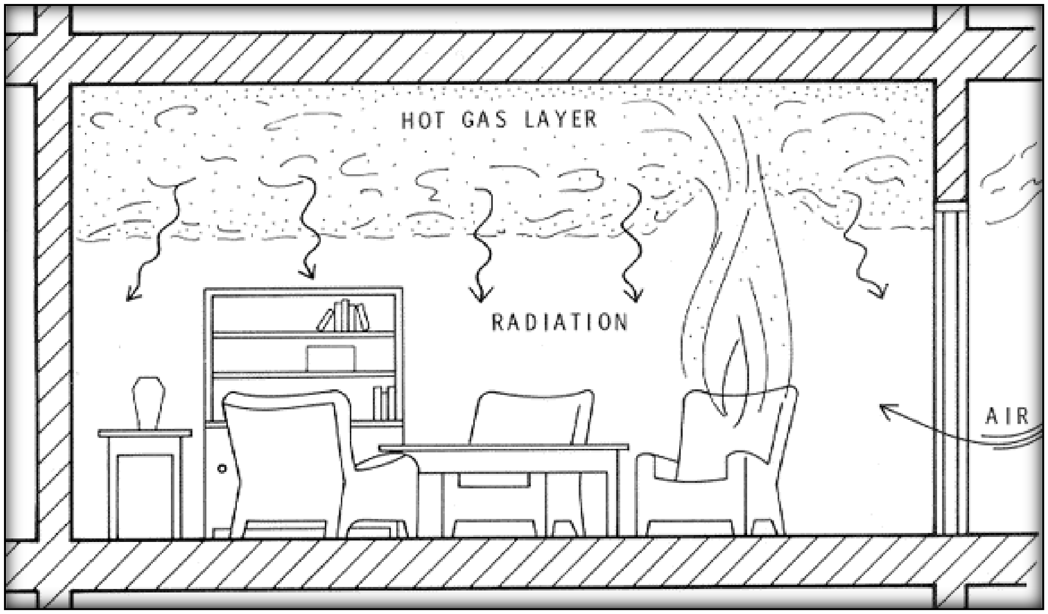

Figure 1: Fire Growth in a Compartment.[45] The above figure depicts the growth of fire in a compartment, which is an enclosed space or room in a building. In a compartment the walls, ceiling, floors, and objects absorb radiant heat produced by the fire. Unabsorbed heat is reflected back to the initial fuel source, which is depicted by the armchair above. This reflected heat continues to increase the temperature of the fuel source and therefore the rate of combustion. Hot smoke, combustible gases, and super-heated air will then rise to the ceiling and spread at first laterally across the ceiling, but later downward towards other fuel sources and the floor of the compartment. As this toxic, super-heated cloud touches cooler materials, the heat is conducted to them, thus increasing their temperature and eventually leading to pyrolysis, which is the process where a fuel source begins to release flammable vapor. This release of flammable vapor leads to further fire growth and eventually flashover. Flashover is the point at which all exposed fuel sources in a compartment ignite.

If there is sufficient oxygen, then the fire will continue to grow and the heating of the other combustibles in the room will continue to the point where they reach their ignition temperatures more or less simultaneously. If this occurs, all combustible materials in the room will spontaneously ignite. This transition from the burning of one or two objects to full room involvement is referred to as flashover. [46]

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

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

regardless of their proximity to the burning object. In a typical structure fire, the gas layer at the ceiling can quickly reach temperatures of 648.9˚ C and higher. With enough existing oxygen at the floor level, flashover occurs, which is when everything in the room ignites at once. The instantaneous eruption of flames generates a tremendous amount of heat, smoke, and pressure. The pressure generated from this explosion has enough force to push fire beyond the room of origin and into the rest of the structure, as well as through doors and windows.

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

The Importance of Adequate Staffing: Concentration

NFPA 1500 and 1710 both recommend that a minimum acceptable fire company staffing level should be four members responding on, or arriving with, each pumper and aerial company responding to any type of fire.

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

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

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

Table 2: Impact of Crew Size on a Low-Hazard Residential Fire.[47] 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. OFS typically staffs fire suppression apparatus with four firefighters.

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

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

At the scene of a structure fire, the driver/operator of the first pumper 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 pumper company is

[47] 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.

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

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

The Importance of Crew Size to Overall Scene Time

Studies have shown that the more personnel that arrive on pumper and aerial truck companies to the scene of a fire, the less time it takes to complete all tasks associated with fire suppression, search and rescue, and other critical fireground activities. As dispatched units arrive with sufficient numbers of firefighters, the overall time on the scene of the emergency decreases since critical fireground tasks can be completed simultaneously rather than in sequence. This also results in the decrease of on-scene risk levels. In other words, the more firefighters available to respond and arrive early to a structure fire, the less time it takes to extinguish the fire and perform search and rescue activities, thus reducing the risk of injury and death to both firefighters and trapped occupants and reducing the economic loss to the property.

Overall Scene Time Breakdown by Crew Size		
Scenario	**Total Time**	**Efficiency**
4-Person Close Stagger	0:15:44	
3-Person Close Stagger	0:20:30	23% Less Efficient
2-Person Close Stagger	0:22:16	29% Less Efficient
4-Person Far Stagger	0:15:48	
3-Person Far Stagger	0:21:17	26% Less Efficient
2-Person Far Stagger	0:22:52	31% Less Efficient

Table 3: The Relationship between Crew Size and Scene Time.[48] The above table displays how companies staffed with larger crew sizes will be on the scene of an emergency for a shorter time than smaller sized companies. This lag on scene could be translated to mean that emergency resources will be unavailable longer to address other emergencies that may arise.

As Table 3 shows, units that arrive with only two firefighters on a pumper or aerial 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.[49] [50] 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.

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.[51]

[48] 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.
[49] Ibid.
[50] One-minute and two-minute arrival stagger times were determined from analysis of deployment data from more than 300 U.S. fire departments responding to a survey on fire department operations conducted by the International Association of Fire Chiefs and the International Association of Firefighters.
[51] 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.

In 2018 alone, 44% of all firefighter fatalities were related to overexertion.[52] There is strong epidemiological evidence that heavy physical exertion can trigger sudden cardiac events.[53] Smaller crews are responsible for performing a number of tasks that are designed to be performed by multiple people and frequently in teams of two. This means that firefighters on smaller crews are required to work harder than larger crews to accomplish multiple tasks. Additionally, as discussed earlier, firefighters on smaller crews will also be working longer than larger sized crews. Working harder and longer in high heat and dangerous, stressful environments increases the likelihood of firefighters suffering an injury, or worse dying, as a result of overexertion.

Charts 1 and 2, on the following pages, highlight the cardiovascular impact on firefighters based on crew size for the first arriving pumper and aerial company. The heart rates of firefighters of crew sizes ranging from 2 to 5 firefighters were measured as they participated in the NIST study. The study was able to conclude that not only do smaller crews work harder and longer than larger crews, their heart rates are also more elevated for longer periods of time as well. This increases the risk of firefighters suffering an injury or death from overexertion. A firefighter suffering a medical emergency on the scene of a working fire, EMS, or rescue incident negatively impacts outcomes and increases the risk to the community, the citizen requiring assistance, and the firefighter.

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[52] Fahy, R.F., Molis, J.L. (June, 2019) Firefighter Fatalities in the United States-2018. NFPA.
[53] 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

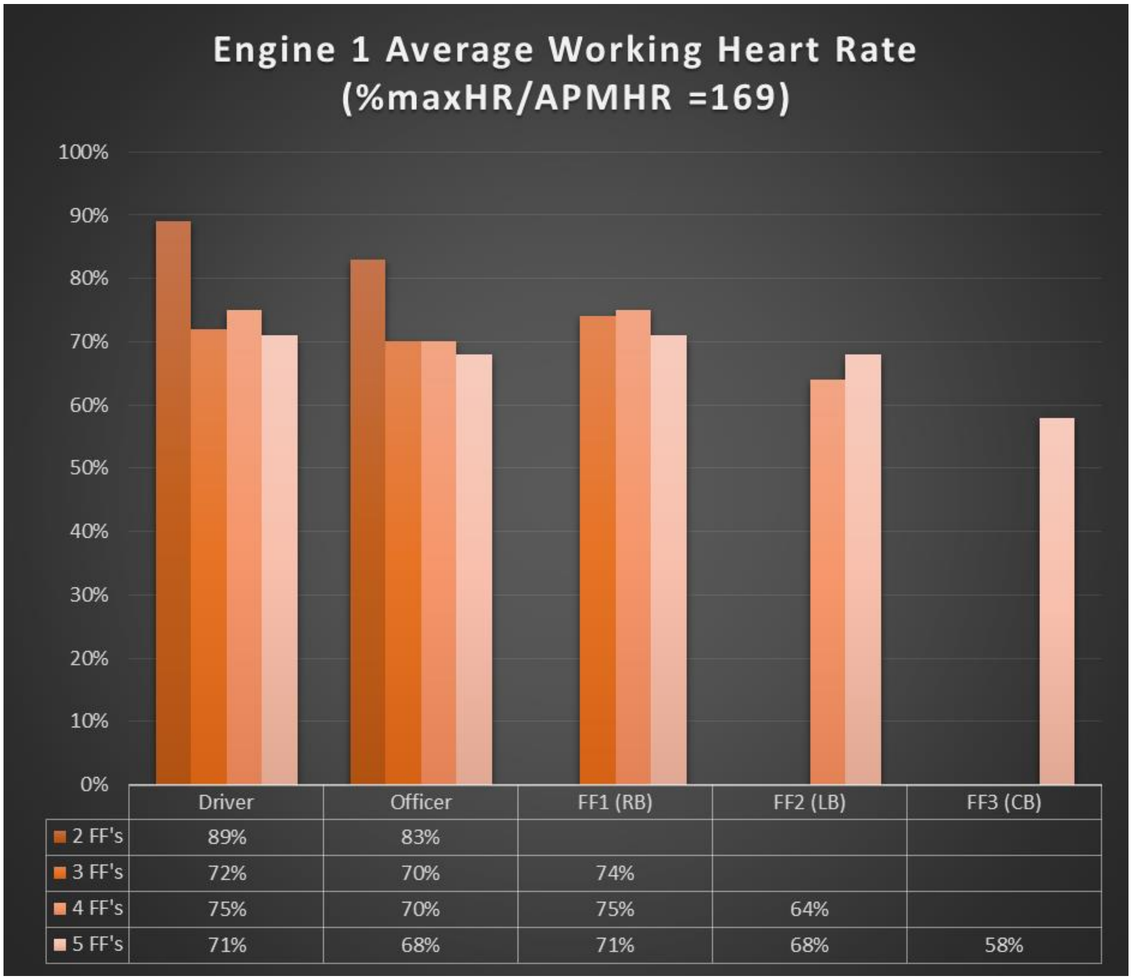

Chart 1: Average Peak Heart Rate of First Engine (E1) with Different Crew Sizes by Riding Position.[54] *In Chart 1, heart rates are expressed as a percent of maximal age-predicted maximal HR.* The average heart rates for firefighters on the first engine company were above 80% of age-predicted maximum 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.[55] 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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[54] 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."

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

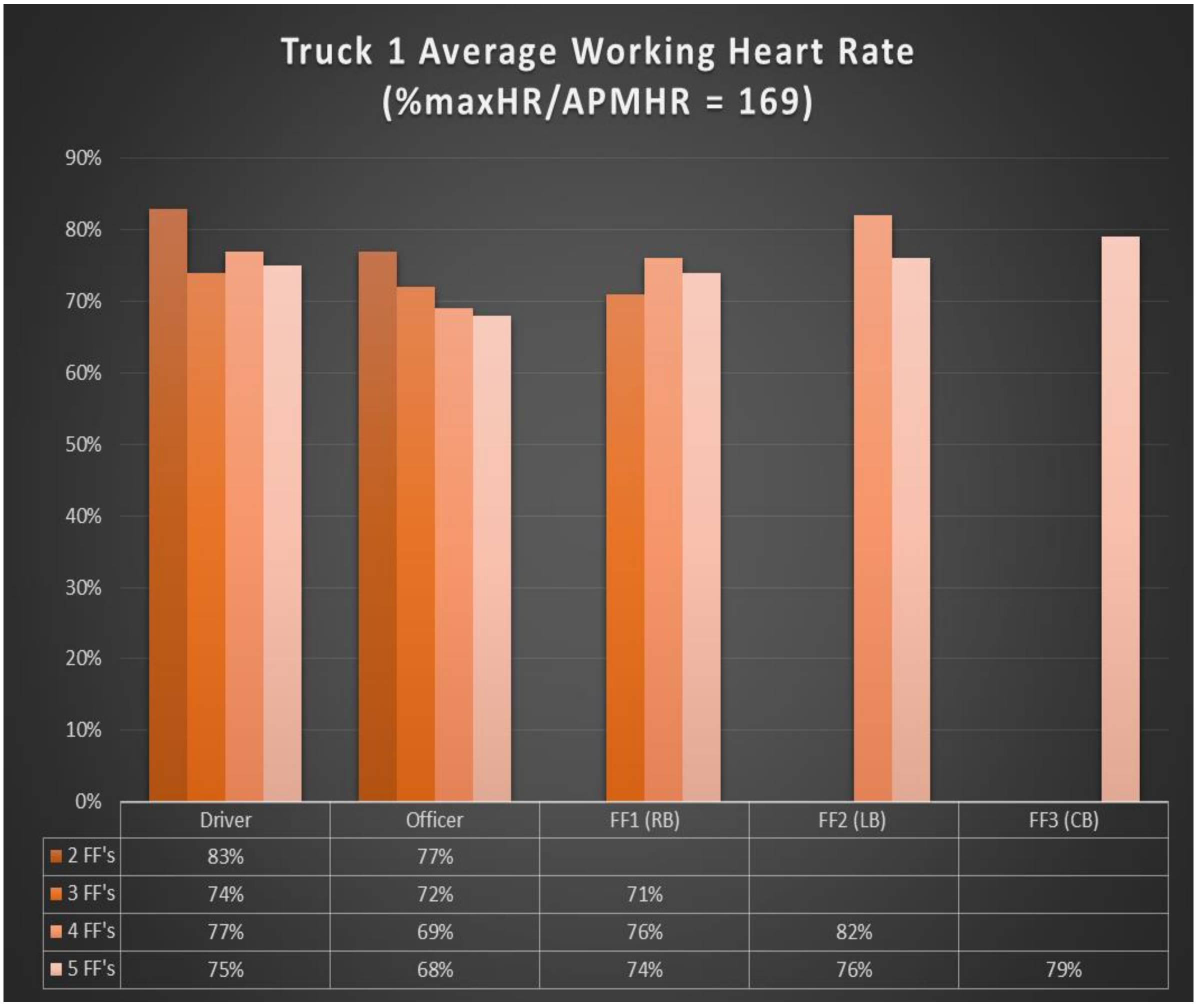

Chart 2: Average Peak Heart Rate of First Truck (T1) with Different Crew Sizes by Riding Position.[56] *In Chart 2, heart rates are expressed as a percent of maximal age-predicted maximal HR.* The average heart rates for firefighters on the first truck company were above 80% of age-predicted maximum values when only 2 firefighters were working.[57] 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.

[56] 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."

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

The Importance of a Rapid Response

Uncontained fire in a structure grows exponentially with every passing minute. Any delay in the initiation of fire suppression and rescue operations, such as the 5- to 7-minute delay that results from smaller sized crews of firefighters, translates directly into a proportional *increase* in expected property, life, and economic losses as is shown in Table 4, following page. It warrants emphasizing that if a structure has no automatic suppression or detection system, a more advanced fire may exist by the time the fire service 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.[58] As with inadequate staffing, this type of operation will continue until enough resources can be amassed to mitigate the event.

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

[58] 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** [59]
Confined fires (identified by incident type)	0.00	8.7	$264
Confined to object of origin	0.4	11.1	$1,584
Confined to room of origin, including confined fires by incident type [60]	1.8	23.8	$5,280
Beyond the room, but confined to floor of origin	16.2	76.3	$46,200
Beyond floor of origin	24.6	55.0	$86,988

Table 4: The Relationship between Fire Extension and Fire Loss.[61] 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.

Ontario's Fire Ground Effectiveness Sub-Model

The OFM established the Fire Ground Effectiveness Sub-Model as part of its Comprehensive Fire Safety Effectiveness Model. The Fire Ground Effectiveness Sub-Model defines the necessary components of the delivery of fire ground suppression activities.

[59] The monetary values in this table are given in Canadian Dollars. A conversion of US$1 = CA$1.32 was used on December 5, 2019.

[60] 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.

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

Within the Sub-Model, the following eleven factors have been identified as having an impact on fire suppression activities:[62]

1. Fire Risk/Fire Demand
2. Response Time
3. Fire Ground Staffing
4. Fire Fighter Performance
5. Fire Ground Command and Control
6. Operational Guidelines
7. Firefighter Safety
8. Apparatus and Equipment
9. Water Supply
10. Availability of Fire Suppression Staffing
11. Fire Prevention and Public Fire Safety

The Fire Ground Staffing element determines activities which may be performed depending on crew size. These activities are "…functions that can be carried out by the crew which is first to arrive and assemble at the scene." [63] According to the OFM, the number of members of the first arriving crew dictate which activities may be initiated.

For a crew of three firefighters, the OFM states, "Interior rescue and suppression operations should not be attempted except in limited circumstances." [64] According to the OFM, a first arriving crew of three firefighters would be capable of performing the following tasks (as dictated by the situation):

- establishment of a water supply from a hydrant (if available)
- establishment of pumper operations
- laying of one hose line to the point of entry into the involved structure
- limited exterior fire fighting including the raising of a ladder beyond the first floor of the structure
- limited exposure protection of surrounding structures
- setting up of a ground monitor

[62] "Fire Ground Effectiveness Sub-Model." Fire Ground Effectiveness Sub-Model | Ministry of Community Safety and Correctional Services, Office of the Fire Marshal, www.mcscs.jus.gov.on.ca/english/FireMarshal/FireServiceResources/ComprehensiveFireSafetyEffectivenessModel/FireGroundEffectivenessSub-Model/fireground_submodel.html.
[63] "Fire Attack Teams." Fire Ground Effectiveness Sub-Model | Ministry of Community Safety and Correctional Services, Office of the Fire Marshal, www.mcscs.jus.gov.on.ca/english/FireMarshal/FireServiceResources/ComprehensiveFireSafetyEffectivenessModel/FireGroundEffectivenessSub-Model/fireground_submodel.html.
[64] Ibid.

- external rescue using a ladder extended to the point of exit for those persons in the building capable of self-help
- rendering first aid to persons who have exited the involved structure
- forcible entry operations
- shutting off utilities to the structure
- limited ventilation functions
- very limited salvage capability [65]

Additionally, OFM points out that, "some of the foregoing operations, particularly those involving ground ladders, will likely compromise fire ground command and/or pumper operations."[66] The OFM also outlines "**operations which <u>cannot</u> be accomplished safely until such time as additional assistance has arrived on-site.**" [67] These operations include:

- deployment of back-up protection lines
- *conducting interior suppression or rescue operations (except in very limited circumstances)*
- ventilation operations requiring access to the roof of the involved structure
- the use of large (65 mm) hand-held hose lines
- establishment of a water supply from a static source within reasonable time limits [68]

Four-person first arriving crews are also limited in the tasks capable of being accomplished until an external water supply is established. Only *after* an external water supply is established, the following tasks may be accomplished with a four-person crew:

- two-person interior search and rescue with no hand-held back-up line
- two-person interior structure fire fighting with no rescue component and no hand-held back-up line
- limited roof level ventilation operations
- laddering operations
- salvage operations [69]

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[65] "Fire Attack Teams." Fire Ground Effectiveness Sub-Model | Ministry of Community Safety and Correctional Services, Office of the Fire Marshal, www.mcscs.jus.gov.on.ca/english/FireMarshal/FireServiceResources/ComprehensiveFireSafetyEffectivenessModel/FireGroundEffectivenessSub-Model/fireground_submodel.html.
[66] Ibid.
[67] Ibid. Emphasis added
[68] Ibid.
[69] Ibid.

Some additional tasks are also possible with a four-person first arriving crew, but only to a limited extent. These include:

- use of large (65 mm) diameter hand lines
- establishment of a water supply from a static source
- establishment of a second point of entry and approach to the fire location in the structure
- preparing for a second area of search and rescue for person(s) in need of rescue [70]

The size of all suppression crews participating in fireground operations throughout the duration of firefighting operations at the scene of a structure fire is also significant as it relates to fireground efficiency and effectiveness and firefighter health and safety. The fewer members on all crews will require other personnel to work harder and longer, and/or require more resources be dispatched to the scene from farther away. The importance of crew size when conducting firefighting operations in a high-rise structure is discussed later in this document in the "High-Rise Operations" section.

OSHA's "2 In/2 Out" Regulation

The "2 In/2 Out" Regulation is part of paragraph (g)(4) of the United States Occupational Safety and Health Administration's (OSHA) revised respiratory protection standard, 29 CFR 1910.134. The focus of this important section is the safety of firefighters engaged in interior structural firefighting. OSHA's requirements for the number of firefighters required to be present when conducting operations in atmospheres that are immediately dangerous to life and health (IDLH) also covers the number of persons who must be on the scene before firefighting personnel may initiate an interior attack on a structural fire. An interior structural fire (*an advanced fire that has spread inside of the building where high temperatures, heat and dense smoke are normally occurring*) would present an IDLH environment and, therefore, require the use of respirators. In those cases, at least two standby persons, in addition to the minimum of two persons inside needed to fight the fire, must be present before firefighters may enter the building.[71] [72] 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."

[70] "Fire Attack Teams." Fire Ground Effectiveness Sub-Model | Ministry of Community Safety and Correctional Services, Office of the Fire Marshal, www.mcscs.jus.gov.on.ca/english/FireMarshal/FireServiceResources/ComprehensiveFireSafetyEffectivenessModel/FireGroundEffectivenessSub-Model/fireground_submodel.html.

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

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

NFPA Standard 1710 also supports the OSHA regulation by requiring a minimum of four personnel on all suppression apparatus. Portions of the 1710 Standard recommend that "fire companies whose primary functions are to pump and deliver water and perform basic firefighting at fires, including search and rescue… shall be staffed with **a minimum of four on-duty members**,"[73] while "fire companies whose primary functions are to perform the variety of services associated with truck work, such as forcible entry, ventilation, search and rescue, aerial operations for water delivery and rescue, utility control, illumination, overhaul and salvage work… shall [also] be staffed with **a minimum of four on-duty members**."[74]

However, the number of personnel required per fire suppression apparatus increases with risk and demand. NFPA 1710, 2020 edition states that engine and ladder companies that are assigned to first-due districts that have a high number of incidents, geographic restrictions[75], geographic isolation[76], or areas considered to be urban[77] with regards to population density, all as identified by the AHJ, should be staffed with a minimum of five firefighters. First-due districts that have tactical hazards, high hazard occupancies, or densely populated urban areas[78], as identified by the AHJ, shall have companies that are staffed with six firefighters.[79]

[73] NFPA 1710, § 5.2.3.1 and §5.2.3.1.1.
[74] NFPA 1710, § 5.2.3.2 and §5.2.3.2.1.
[75] Geographic Restriction is a defined condition, measure, or infrastructure design that limits response and/or results in predictable response delays to certain portions of the jurisdiction.
[76] Geographic Isolation is a first-due response zone or jurisdiction with staffed resources where over 80% of the response area is outside of 10-minute travel time from the next closest staffed suppression apparatus.
[77] An urban area is an incorporated or unincorporated area with a population over 30,000 people and /or a population density over 1,000 people per square mile but less than 2,999 people per square mile. This approximates to a density of over 622 people per square kilometer but less than 1,864 people per square kilometer.
[78] A dense urban area is an incorporated or unincorporated area with a population density of over 200,000 people and/or a population density of over 3,000 people per square mile. This approximates to a density of over 1,865 people per square kilometer.
[79] NFPA 1710, § 5.2.3.1.2, §5.2.3.1.2.1, §5.2.3.2.2, and §5.2.3.2.2.1.

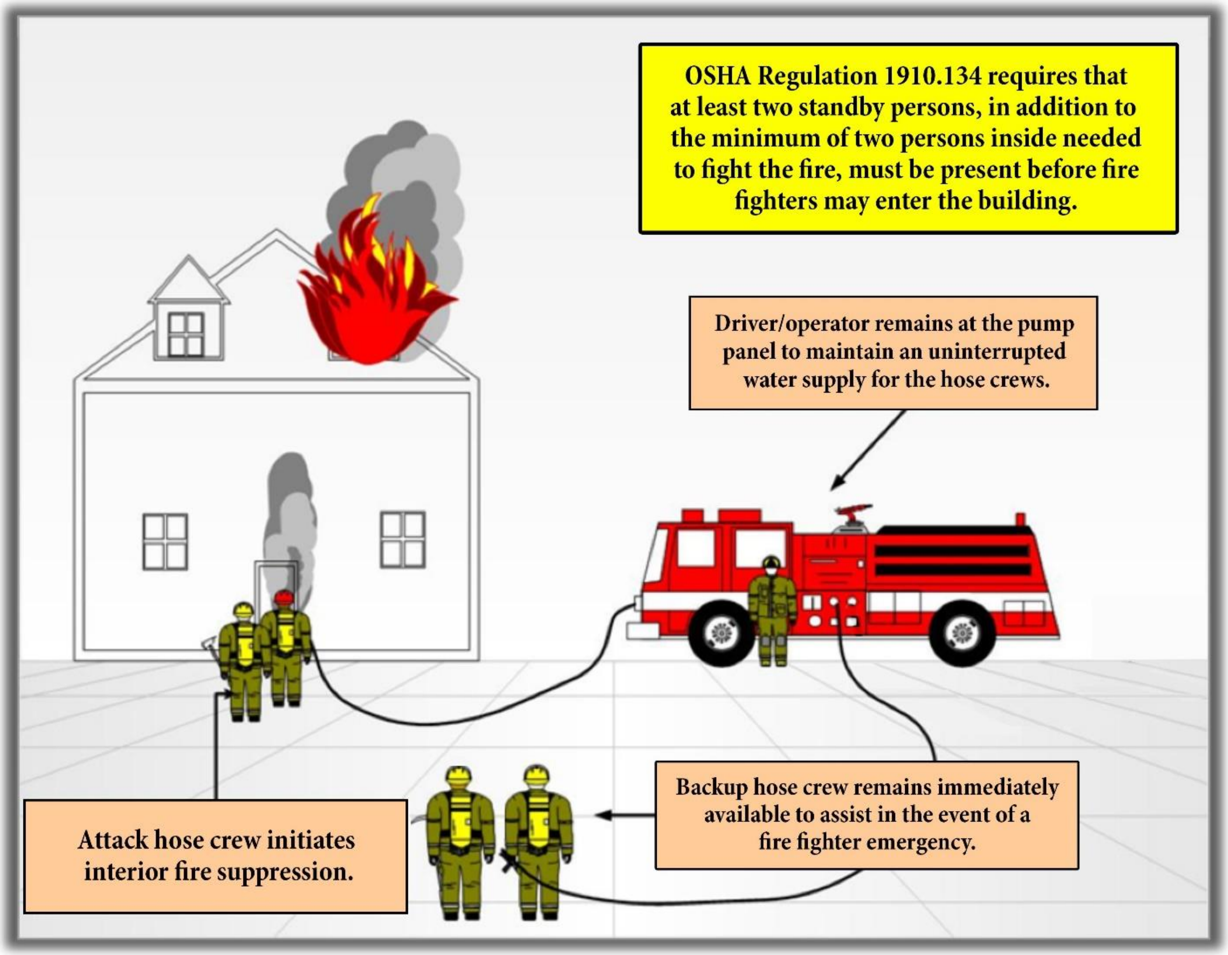

Figure 2: The OSHA "2 IN/2 Out" Regulation. The above figure depicts the number of firefighters required to meet OSHA regulation 1910.134, which demands one firefighter outside for every firefighter inside. The firefighters outside can support a secondary attack line and facilitate the rescue of trapped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

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

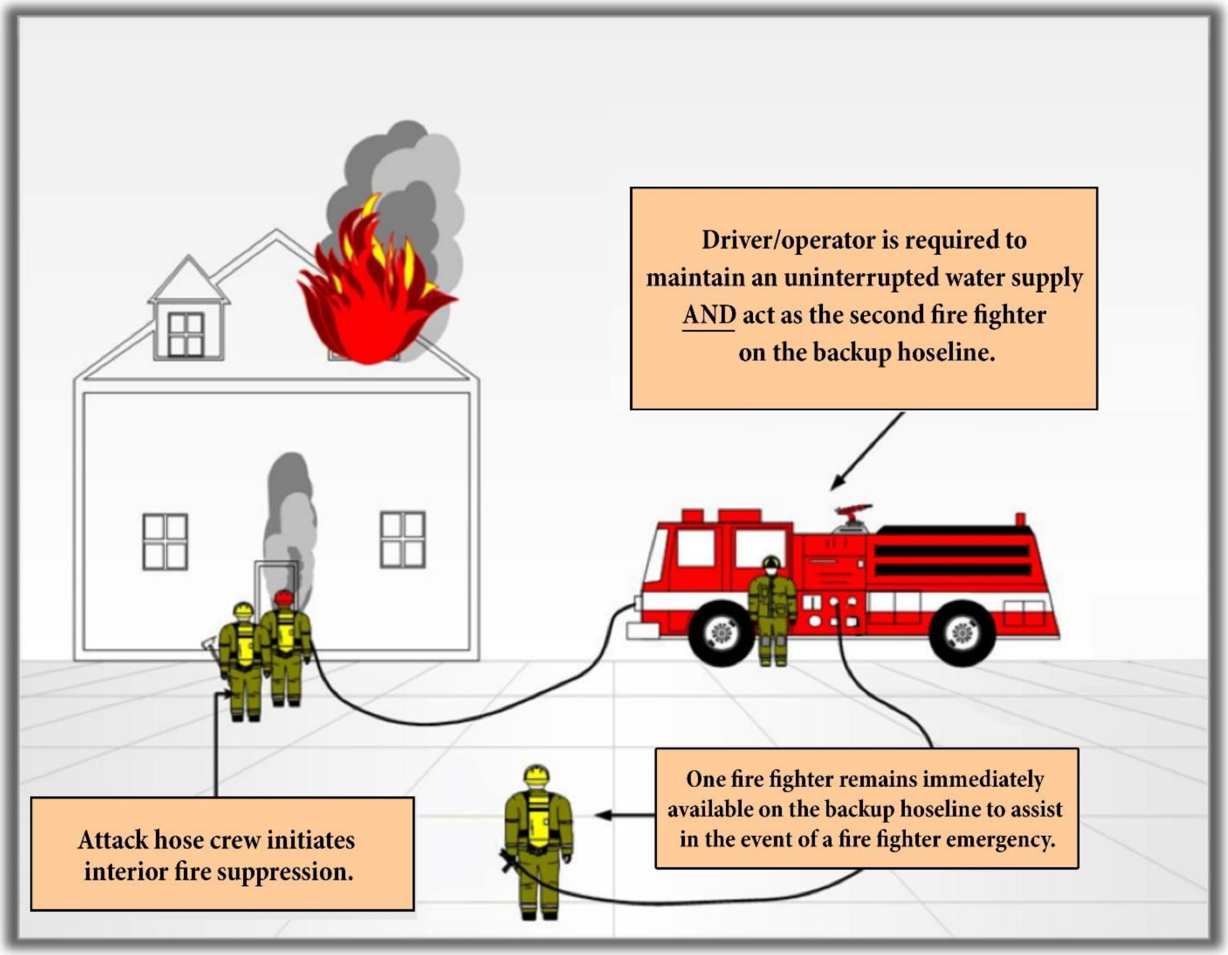

Figure 3: Emergency "2 In/2 Out" Operations. In the emergency model depicted above, the arriving fire apparatus is staffed with a crew of 4 personnel and operates under emergency conditions. In this case the driver/operator of the fire apparatus is also counted as a firefighter, which means that firefighter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

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

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

Initial Full Alarm Assignment

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

Assignment	*Required Personnel*
Incident Command	1 Officer
Uninterrupted Water Supply	1 Pump Operator
Water Flow from Two Handlines	4 Firefighters (2 for each line)
Support for Handlines	2 Firefighters (1 for each line)
Victim Search and Rescue Team	2 Firefighters
Ventilation Team	2 Firefighters
Aerial Operator [80]	1 Firefighter
Initial Rapid Intervention Crew (IRIC)	4 Firefighters
Required Minimum Personnel for Full Alarm	**16 Firefighters & 1 Scene Commander**

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

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

[80] Even if an aerial device is not used, the use of a ground ladder requires one firefighter to maintain the ladder while personnel traverse the ladder and while crews operate on the roof.

In the Initial Full Alarm Assignment, one firefighter is designated to operate an aerial device if one is in use at the incident. However, even if an aerial device is not used, in order to maintain safe operations, the use of a ground ladder requires one firefighter to maintain (heel) the ladder while firefighters traverse the ladder and while crews operate on the ladder or roof. Also, depending on the length of the ground ladder, three or more firefighters may be required to raise and properly position the ladder.[81] Furthermore, according to the Canadian Center for Occupational Health and Safety (CCOHS) regarding ladder use in any workplace, when utilizing a "long" ladder, "have a second person hold the bottom of a long ladder, especially when tying or untying an extension ladder."[82] One such example of the failure to follow this practice occurred in Saint-Sulpice, Quebec in December 2012.[83] Two firefighters were injured when operating off an unheeled ladder, using a chainsaw to ventilate a roof. The ladder butt was unsecured and the ladder slipped, causing both firefighters to fall.

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

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[81] IAFC, NFPA, Firefighting Skills and Hazardous Materials Response, Canadian Fourth Edition. April 2019. P 401.
[82] Canadian Center for Occupational Health and Safety, "OHS Answer Fact Sheets", <https://www.ccohs.ca/oshanswers/safety_haz/ladders/climbing_safely.html>, site visited June 12, 2020.
[83] Structure fire in Saint-Sulpice, Quebec. December 2012. Incident footage: <https://www.youtube.com/watch?v=2nt0DT0nXq8>.

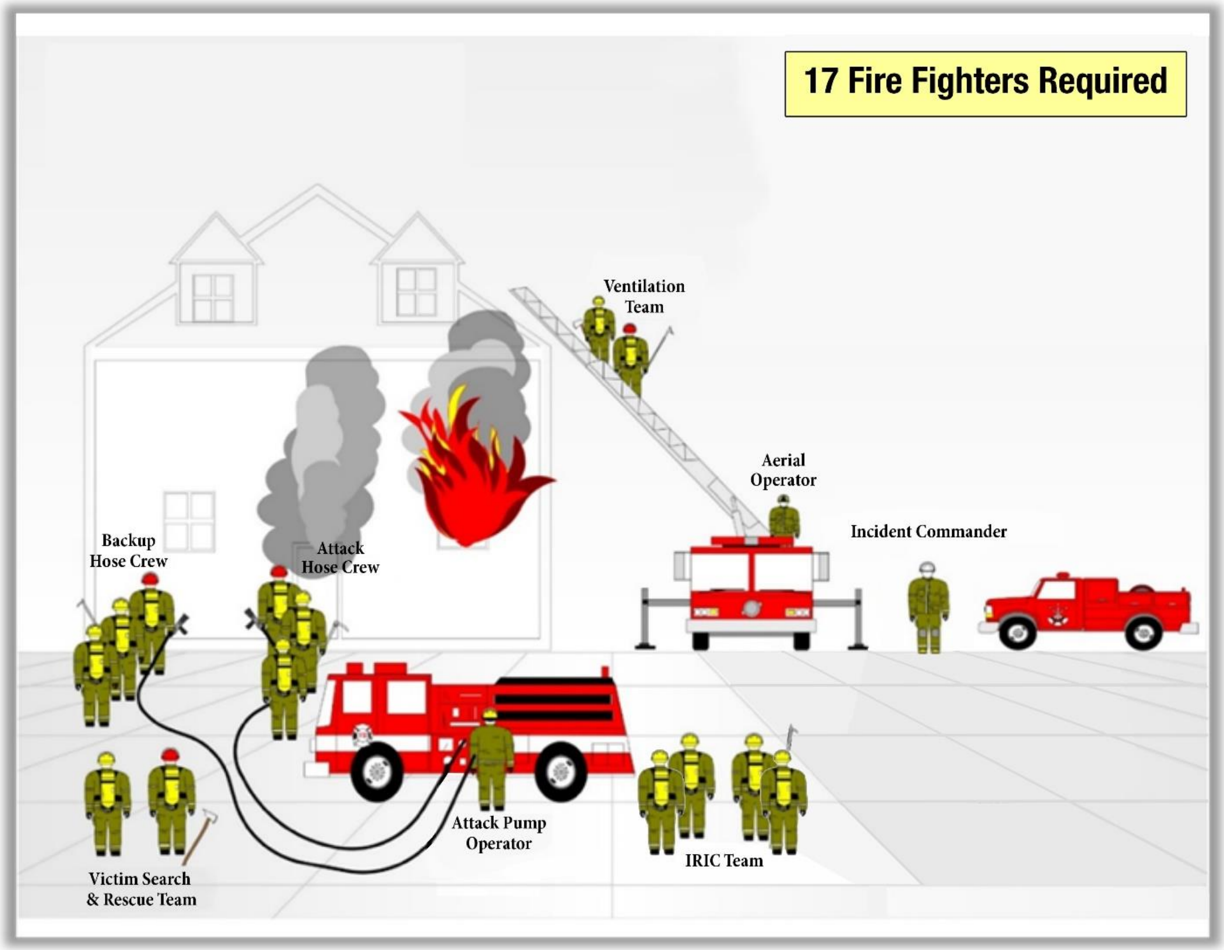

Figure 4: Initial Full Alarm Assignment Deployed Within 8 Minutes, 17 Firefighters Required. The above figure depicts the full alarm assignment required by NFPA 1710 as discussed in Table 5. In the absence of an aerial or use of an aerial device, if a ground ladder is in use a firefighter is required to maintain the ladder while personnel traverse the ladder and while crews operate on the roof.

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.

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High-Rise Operations

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

Overview of High-Rises

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

High-rise buildings may hold thousands of people above the reach of fire service aerial devices and the chance of rescuing victims from the exterior is greatly reduced once a fire has reached flashover. The risks to firefighters and occupants increase in proportion to the height of the building and the height of the fire above grade level.[84] This is especially true once firefighters are operating above the reach of aerial ladders on aerial companies. In these situations, the only viable means of ingress or egress is the interior stairs. Therefore, a sound fire service deployment strategy, effective operational tactics, and engineered fire protection systems cannot be separated from firefighter safety. As in any structure fire, pumper company and aerial company operations must be coordinated.

High-rise buildings present a unique threat to the fire service. Multi-floor fires such as the Alexis Nihon Plaza Fire, Jackson Street Apartments Fire, Wellesley St. E Fire, 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 service. According to the NFPA, in the United States, 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

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

property damage. Office buildings, hotels, apartment buildings, and health care facilities accounted for nearly half of these high-rise fires.[85]

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.

Currently, OFS is not capable of responding with 39 firefighters as required to assemble an Initial Full Alarm Assignment to a high-rise fire. In the event of a fire occurring in a high-rise anywhere in Oshawa, OFS must rely on firefighters and apparatus from neighboring cities to provide sufficient response. It is not likely that these additional resources would arrive on scene within ten minutes, ten seconds.

High-Rise Firefighting Tactics

As has been stated, in a high-rise fire the risks to firefighters and occupants increases in proportion to the height of the building and the height of the fire above ground level. As the level of the fire floor gets higher, firefighters are required to carry more equipment further and must rely more on the building's standpipe system. A standpipe system is a piping system with discharge outlets at various locations usually located in stairwells on each floor in high-rise buildings that is connected to a water source with pressure supplemented by a fire pump[86] located in the building and/or a fire apparatus with pumping capabilities.

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

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

Like residential structure fires, there are several critical tasks that must be accomplished. However, unlike residential firefighting in a 186 square meter residence, firefighters working at a high-rise fire must travel upwards of more than three storeys and carry additional equipment beyond the normal requirements. Additionally, as it takes longer to assemble an effective firefighting force and to access the fire floor, firefighters are likely to encounter a large volume of fire and will therefore have an extended fire attack. Because of this, it is necessary to establish an equipment supply chain to transport equipment and resources up and down the building.

Search and Rescue

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

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

Fire Extinguishment

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

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

Ventilation

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

Support

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

One critical support variable in high-rise fire operations is the availability of reliable elevators. If firefighters can safely use the elevators to move people and equipment, fire-ground logistics may be significantly improved. When the fire is located several floors above ground level, there is a strong inclination to use the elevators. However, fire service access elevators[87] may not be

[87] 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.

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 storeys is an arduous task. If it is not properly managed, firefighters may be exhausted and unable to fight the fire or rescue trapped occupants. Additionally, joint use of stairways by firefighters moving upward and occupants attempting to evacuate may increase the overall evacuation time of the occupants, as well as delay the firefighters' efforts to begin critical tasks such as fire suppression or search and rescue operations. As such, it is important to have multiple firefighters to help carry equipment upstairs and manage resource distribution.

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

- In first-due response areas with a high number of incidents, geographical restrictions, geographical isolation, or urban areas, as identified by the AHJ, these companies shall be staffed by a minimum of five on-duty members.[88]
- In first-due response areas with tactical hazards, high-hazard occupancies, or dense urban areas, as identified by the AHJ, these fire companies shall be staffed with a minimum of six on-duty members.[89]

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

[88] NFPA 1710. §5.2.3.1.2 and §5.2.3.2.2
[89] NFPA 1710. §5.2.3.1.2.1 and §5.2.3.2.2.1.

Assignment	Required Personnel
Incident Command	1 Incident Commander 1 Incident Command Aide
Uninterrupted Water Supply	1 Building Fire Pump Observer 1 Fire Engine Operator
Water Flow from Two Handlines on the Involved Floor	4 Firefighters (2 for each line)
Water Flow from One Handline One Floor Above the Involved Floor	2 Firefighters (1 for each line)
Rapid Intervention Crew (RIC) Two Floors Below the Involved Floor	4 Firefighters
Victim Search and Rescue Team	4 Firefighters (2 per team)
Point of Entry/Oversight Fire Floor	1 Officer 1 Officer's Aide
Point of Entry/Oversight Floor Above	1 Officer 1 Officer's Aide
Evacuation Management Teams	4 Firefighters (2 per team)
Elevator Management	1 Firefighter
Lobby Operations Officer	1 Officer
Trained Incident Safety Officer	1 Officer
Staging Officer Two Floors Below Involved Floor	1 Officer
Equipment Transport to Floor Below Involved Floor	2 Firefighters
Firefighter Rehabilitation	2 Firefighters (1 must be ALS)
Vertical Ventilation Crew	1 Officer 3 Firefighters
External Base Operations	1 Officer
2 EMS ALS Transport Units[90]	4 Firefighters
Required Minimum Personnel for Full Alarm	**36 Firefighters** **1 Incident Commander** **6 Officers** **Total Personnel: 43**

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

[90] NFPA 1710. §5.2.4.4.1 Provision of a minimum of two members to manage member rehabilitation. At least one of the members shall be trained to the ALS level. Provision of a minimum of two crews trained in emergency medical services with on-scene transport capability, each crew with a minimum of two members. At least one of the members shall be trained to the ALS level. Where this level of emergency medical care is provided by outside agencies or organizations, these agencies and organizations shall be included in the deployment plan and meet these requirements

It should be noted that although the OFS does not provide ALS response or transport, the intent of this section of the NFPA 1710 high-rise standard is to provide a means of rehabilitation for firefighters to minimize the risk of injury and death. OFS should require the provincial EMS agency to provide two ALS ambulances staged outside of the structure. Two firefighters should be stationed inside the building in the staging area to monitor firefighters for signs of exhaustion, dehydration, and other signs and symptoms of a medical emergency. As the rehab area is on the interior of the building, it is advisable that firefighters perform this critical task, as provincial EMS workers lack the training or personal protective equipment to operate in or near an IDLH environment. As such, allowing provincial EMS workers to operate in the building and mere floors below the floor or floors that are on fire creates an unnecessary risk to everyone operating at the scene of a high-rise fire.

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Fire Service Deployment

Before discussing the staffing and deployment analysis of OFS resources, it is imperative to understand the intricacies of distribution and concentration.

The Importance of Adequate Resources: Distribution

Distribution involves locating geographically distributed, ideal first-due resources for all-risk initial intervention. Distribution describes first due arrival. Station locations are needed to assure rapid deployment for optimal response to routine emergencies within the response jurisdiction. Distribution can be evaluated by the percentage of the jurisdiction covered by the first-due units within adopted public policy service level objectives.[91] In this case, distribution is measured by the percentage of roads that are covered from each fire station within 4-[92], 6-[93], 8-minute[94], 10-minute and 10 second[95] travel times, and to adhere to NFPA 1710, 2020 edition. Six minutes of travel time is the allowable maximum travel time for the second arriving apparatus at a fire suppression incident. While not specified in NFPA 1710, industry best practices, as modeled in the NIST fireground studies, dictate that the second arriving be an aerial company or a company that will be assigned ladder work. [96] Four minutes of travel time is the allowable maximum travel time for the first arriving apparatus at the scene of a fire and a first responding unit to an emergency medical incident.

Distribution study requires geographical analysis of first due resources. Distribution measures may include:[97]

- Population per first-due company
- Area served per first-due company (square kilometers)
- Number of total road kilometers per first-due company (kilometers)

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[91] Commission on Fire Accreditation International, 5th Edition. 2008. Page 52.
[92] Four minutes of travel time is the allowable maximum travel time for the first arriving apparatus at the scene of a fire or first responding unit to an emergency medical incident.
[93] Six minutes of travel time is the maximum amount of travel time permitted for the second arriving apparatus..
[94] Eight minutes of travel time is the maximum amount of travel time permitted for a low- or medium-hazard alarm assignment.
[95] Ten minutes and ten seconds of travel time is the maximum amount of travel time permitted for a high-hazard alarm assignment.
[96] Although not explicitly stated, it is recommended that for structure fires this apparatus be the aerial apparatus or a company that will be assigned to ladder duties based on industry best practices for structural firefighting. The NIST fireground studies for response to residential and high-rise fires modeled response with the second arriving apparatus being an aerial apparatus.
[97] Commission on Fire Accreditation International, 5th Edition. 2008. Page 52.

- Dwelling unit square meterage 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 kilometers)
    3. Road kilometers not served (kilometers)
    4. Dwelling unit square meterage not served

- First-due unit arrival times (Pumper, Aerial, BLS 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 OFS is achieving a reasonable response performance to handle emergencies.[98]

Evaluating a small number of incidents for response time performance also does not reflect the true performance of the service. Analyzing tens of thousands of incidents measured over 3-5 years will provide a more accurate assessment of the delivery system performance. Completing the same analysis over a period will allow for trend analysis as well.[99]

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

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

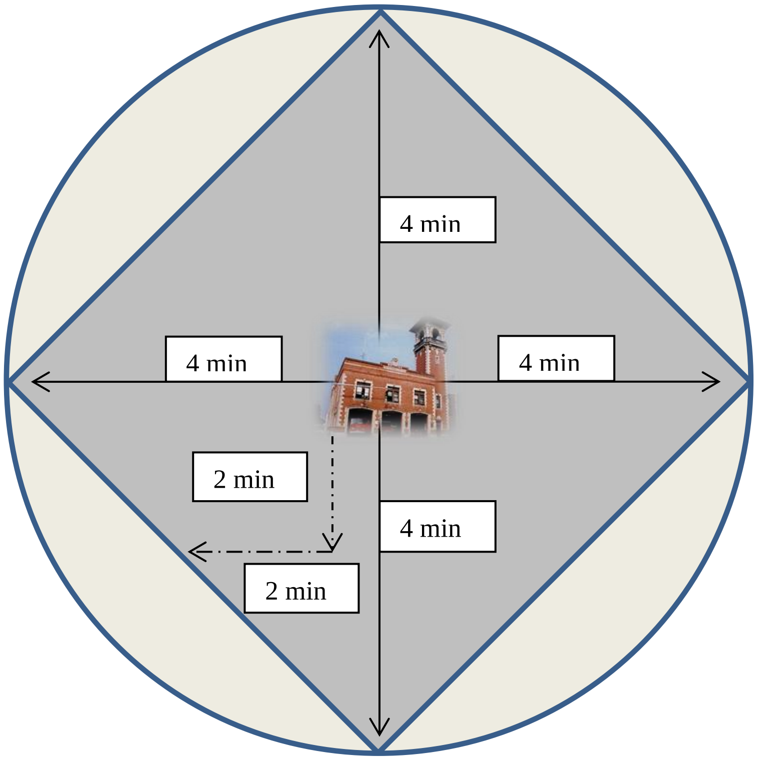

Figure 5: Normal Distribution Model for an Initial 4-Minute Response Area.[100] As depicted in the above figure, fire stations and emergency resources should be distributed throughout a community so that citizens receive equitable coverage and protection. However, there are additional points of concern when modeling a response district such as road network, traffic patterns, and building occupancies.

First unit arrival times are the best measure of distribution. It should be noted that if an area experiences fire unit arrival times outside the adopted performance measure, in this case 4-minute travel time per NFPA 1710, it does not necessarily mean it has a distribution issue.[101] Other issues occur such as reliability, call processing times and turnout times, and traffic which can affect the overall performance of response times.

An effective response force for a fire service 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.[102] Specialty units tend to be aerials, rescue units, hazmat, or Battalion personnel. Most often there are less of these types of equipment and personnel compared to the first-line response of pumper units. Selecting where to put specialty

[100] Derived from Commission on Fire Accreditation International, 5th Edition. 2008. Page 53
[101] Commission on Fire Accreditation International, 5th Edition. 2008. Page 55
[102] Commission on Fire Accreditation International, 5th Edition. 2008. Page 62

units requires extensive examination of current and future operations within OFS and a set goal of response time objectives for all-hazards emergencies within Oshawa.

Distribution vs. Concentration

Fires have a significant impact on the resource allocation of any fire service. The dilemma for any fire service is staffing for routine emergencies and 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.[103]

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

Mapping Analysis of Oshawa Fire Services

In creating this document, it was important to ascertain where stations were located and if they were located to provide fair and equitable coverage to the citizens. In order to make this assessment, the IAFF created maps of OFS' response area and plotted the fire stations.

Computer modeling was then used to determine the distance apparatus could travel in four, six, and eight minutes. The following table specifies the current locations of the 6 fire stations.

Station	Address	Apparatus	Typical Staffing
1	199 Adelaide Avenue West	Pumper 21 Car 25	**3 Firefighters (FF), 1 Captain** **1 Platoon Chief**
2	1111 Simcoe Street South	Pumper 22 Aerial 22	**3 FF, 1 Captain** **3 FF, 1 Captain**
3	50 Beatrice Street East	Pumper 23 Aerial 23	**3 FF, 1 Captain** **3 FF, 1 Captain**
4	50 Harmony Road North	Pumper 24	**3 FF, 1 Captain**
5	1550 Harmony Road North	Pumper 25 Rescue 25	**3 FF, 1 Captain** **Cross-staffed**
6	2339 Simcoe Street North	Pumper 26 Tanker 26	**3 FF, 1 Captain** **Cross-staffed**

Table 7: Current Fire Station Locations and Staffing. The above table displays where apparatus are housed and how they are typically staffed.

Travel times were modeled using ESRI ArcGIS Pro, version 2.3.0. Fire stations were identified on Geographic Information System (GIS) maps as starting points with vehicles traveling at speeds based on historical traffic.

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

- Modeled travel speeds are based on historical traffic speeds occurring on Wednesdays at 5 pm.[104] Actual response speeds may be slower, and the associated travel times greater, with any unpredictable impedances including, but not limited to:
    - Traffic Incidents: Collisions and vehicle breakdowns causing lane blockages and driver distractions.
    - Work Zones: Construction and maintenance activity that can cause added travel time in locations and times where congestion is not normally present.
    - Weather: Reduced visibility--road surface problems and uncertain waiting conditions result in extra travel time and altered trip patterns.
    - Special Events: Demand may change due to identifiable and predictable causes.
    - Traffic Control Devices: Poorly timed or inoperable traffic signals, railroad grade crossings, speed control systems, and traveler information signs contribute to irregularities in travel time.
    - Inadequate Road or Transit Capacity: The interaction of capacity problems with the aforementioned sources causes travel time to expand much faster than demand.[105]

Note that the historical traffic data incorporates historical instances of impedances from above list that have occurred within Oshawa in the past. The relevance of the list above relates to the consideration of travel times in the *future* and unpredictable impedances that may occur in the *future*.

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

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

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[104] Historical traffic data as contained in ESRI's StreetMap Premium, Version 19.3.
[105] David Shrank and Tim Lomax, The 2003 Urban Mobility Report, (Illinois Transportation Institute, Illinois A&M University: September 2003).

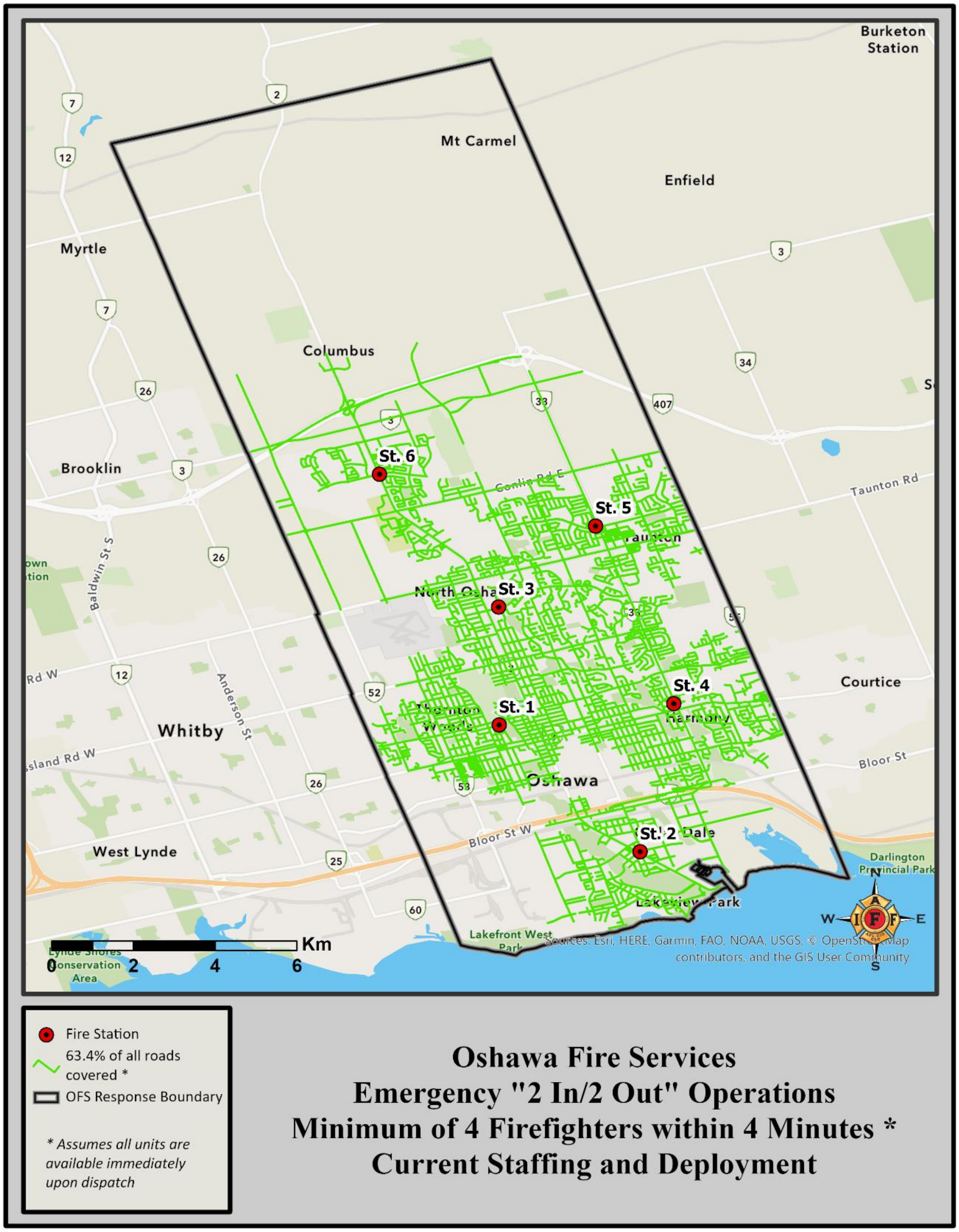
- The time from arrival of the apparatus to the onset of interior fire operations (access interval) must be considered when analyzing response system capabilities.
    - The access interval is dependent upon factors such as distance from the apparatus to the task location and the elevation of the incident 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.

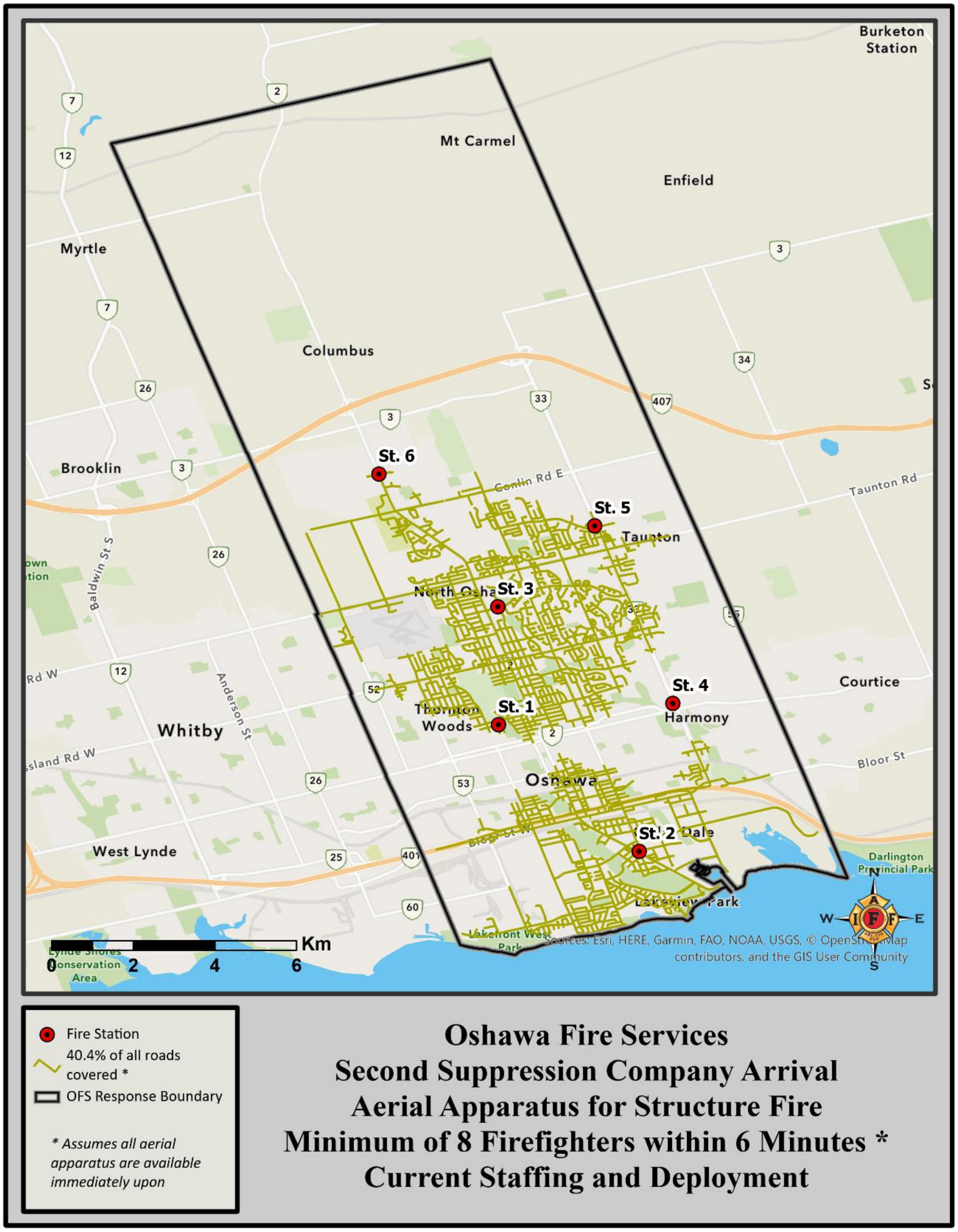
- Weather conditions

Emergency Response Capabilities: Current Staffing Levels

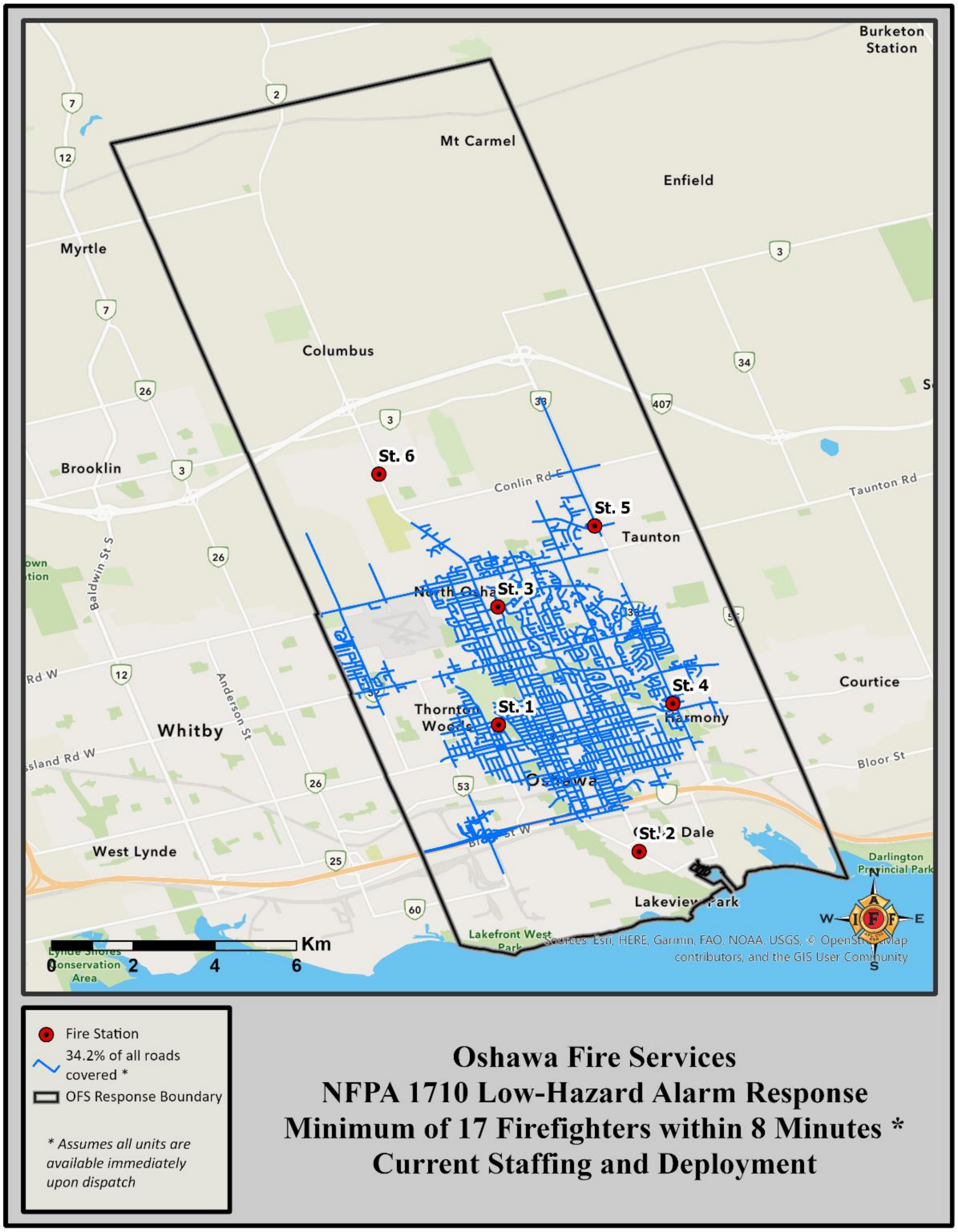
The following Geographic Information System (GIS) maps present the results of a response capabilities analysis of OFS. The staffing and deployment configuration examined in this section includes typical daily staffing levels as described in Table 7.



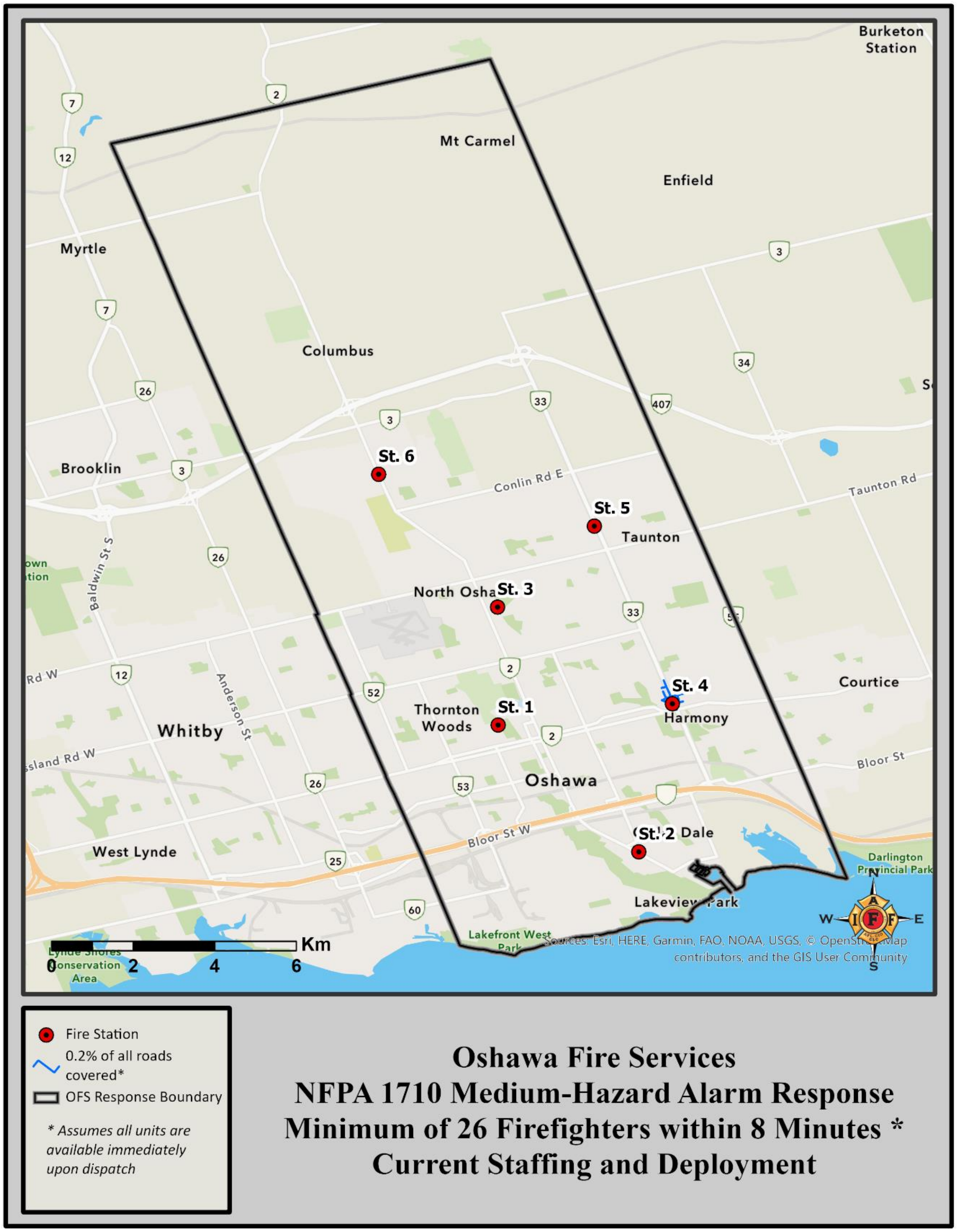
Map 13: Emergency "2 In/2 Out" Operations, Minimum of 4 Firefighters within 4 Minutes, Current Staffing and Deployment. Map 13 identifies those roads where a minimum of four firefighters can assemble on scene within four minutes of travel when at typical staffing levels at each station. Assuming all units are in service and available to respond at the time of dispatch, OFS is capable of responding with four firefighters on 64.3% of roads within Oshawa within four minutes.



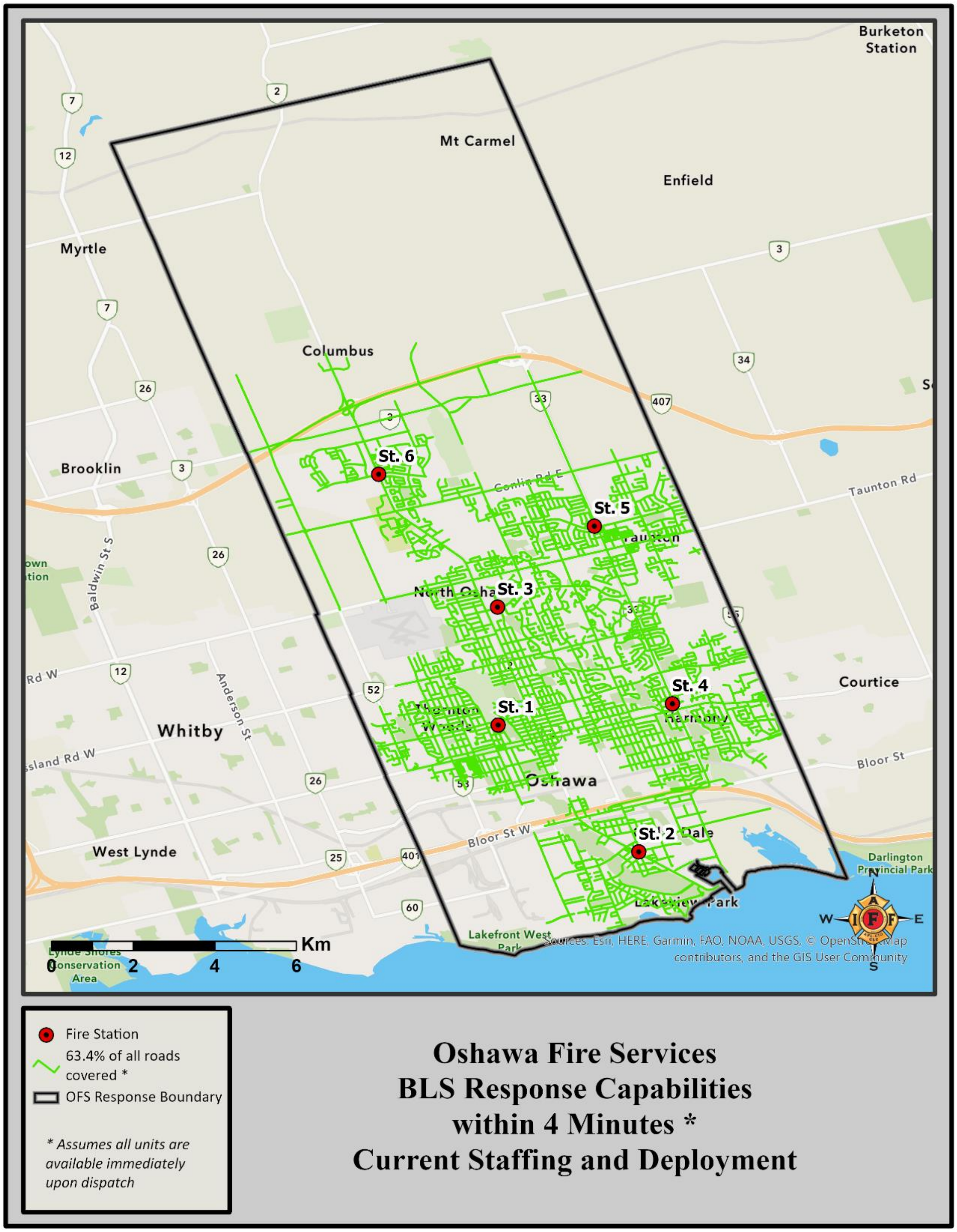
Map 14: Second Suppression Company Arrival, Aerial Apparatus for Structure Fire, Minimum of 8 Firefighters within 6 Minutes, Current Staffing and Deployment. Map 14 identifies those roads where OFS can respond to a structure fire with a second company that is an aerial apparatus within six minutes of travel when at typical staffing levels at each station. NFPA 1710 does not specify that the second suppression apparatus must be an aerial apparatus, but industry best practices dictate that it should be an aerial apparatus. Currently Stations 2 and 3 deploy an aerial apparatus. Assuming all aerial apparatus are in service and available to respond at the time of dispatch, OFS is capable of responding with a second suppression company that is an aerial apparatus on 40.4% of roads within Oshawa within six minutes.



Map 15: NFPA 1710 Low-Hazard Alarm Response, Minimum of 17 Firefighters within 8 Minutes, Current Staffing and Deployment. Map 15 identifies those roads where 17 firefighters are able to assemble on scene within eight minutes of travel when at typical staffing levels. Assuming all units are in service and available to respond at the time of dispatch, OFS is capable of assembling a minimum of 17 firefighters on 34.2% of roads within Oshawa within eight minutes.



Map 16: NFPA 1710 Medium-Hazard Alarm Response, Minimum of 26 Firefighters within 8 Minutes, Current Staffing and Deployment. Map 16 identifies those roads where 26 firefighters are able to assemble on scene within eight minutes of travel when at typical staffing levels. Assuming all units are in service and available to respond at the time of dispatch, OFS is capable of assembling a minimum of 26 firefighters on 0.2% of roads within Oshawa within eight minutes. OFS is essentially unable to assemble an effective response force to a medium-hazard occupancy anywhere in Oshawa.



Map 17: BLS within 4 Minutes, Current Staffing and Deployment. Map 17 identifies those roads where OFS is capable of responding with basic life support (BLS) capabilities within four minutes of travel. Assuming all units are available immediately upon dispatch, OFS is capable of responding with BLS capabilities on 64.3% of roads within Oshawa within four minutes.

Oshawa Fire Services Workload Analysis

The workload analysis presented in this section is based on the computer aided dispatch (CAD) data provided by OFS from January 1st, 2016 through December 31st, 2018. The CAD data include an incident identifier number, responding apparatus, location of incident, call time, dispatch time, en route time, on location time, the times corresponding to when apparatus and personnel have cleared the incident, the times when a unit is available for dispatch, and an incident type designation.

Several factors should be contemplated when evaluating the workload of OFS. As discussed previously, the population of Oshawa is growing, and all first-due districts are experiencing population growth. All are experiencing growing demand for emergency services. The area of Oshawa with the greatest historical demand had a frontline fire suppression apparatus removed and the effects of this are evident in the CAD data.

This workload analysis found that Station 1's first-due district had the highest demand from 2016 to 2018 and that after the removal of a frontline fire suppression apparatus from Station 1 in April of 2017, Station 1 increasingly relied on units from other stations to respond within its first-due district. Those units also increasingly became the first unit to arrive on scene at emergencies. As non-first-due units typically have to travel farther distances to reach the scene of an incident, they also typically have longer travel times. After OFS removed the frontline suppression apparatus from Station 1, the number of fires and emergency medical incidents where the first arriving apparatus failed to meet the travel time objectives of NFPA 1710 increased. These delays of response increase risk to citizens and firefighters.

Two aspects of particular note in OFS' historical call data should be understood when examining the workload analysis.

First, due to the shifting of apparatus locations during the three-year study period, viewing individual station workloads based on apparatus response volumes does not result in an accurate picture of individual station demand, and is not helpful for determining where resources are needed. A more accurate analysis is based on incident location. Station demand is assessed based on the volume of incidents occurring within a station's first-due district. It is necessary to assess demand in this way in order to identify the problems that resulted from the removal of Station 1 resources.

The second, relates to how particular incident types contribute to the OFS workload. At first glance, the highest percentage of incident type is medical incidents. However, when analyzing the workload of a fire service, one should consider the number of responding units required and the time required to operate on scene of various incident types. Incident types that have less volume than medical incidents, but greater volume of responding units required are fire suppression, accidents, and alarms. Fire suppression incidents, for example, required, by far, the most OFS time operating on scene than any other incident type, 34% of all OFS time operating at the scene of incidents. By contrast, time spent operating on scene at medical incidents accounted for only 14% of total OFS time operating at the scene of incidents. Based on the OFS response data, it is not accurate to say OFS' ability to respond to non-medical incidents is hindered by medical incident volume. The CAD shows that while medical incidents are more frequent, the balance of incident types place the bulk of demand on OFS resources in terms of responding units required and time on task required. OFS should be adequately resourced to respond in a safe and effective manner to all types of hazards that occur within Oshawa.

To evaluate the OFS workload, several parameters were measured, including: total number of incidents and apparatus responses per year, the ratio of responding units per incident, time on task, the volume of incidents and responses per first-due district, station of origin of an apparatus, the number of times a station's apparatus responded within another station's first-due district, average travel times of responding apparatus, and the 90th percentile and average travel times of the first arriving OFS apparatus. The statistics used in this analysis are based on responses by OFS units.

<u>Data Parameters</u>

CAD data provided by OFS list all incidents responded to by OFS personnel and resources from January 1, 2016 to December 31, 2018. Parameters were created to evaluate the suitability of individual records to allow accurate examination of the OFS' workload and past performance. Below are the parameters used when evaluating usability of the data:

- Records with missing data in reporting of en route time, arrival time, and/or incidents that were cancelled before the first apparatus arrived on scene were excluded from the time on task and travel time analysis.[106]

- Incidents that were not located within OFS' response boundary or could not be geographically located due to inaccurately entered latitude/longitude and/or address information were excluded from the travel time analysis.[107]

[106] 24.2% of responses were excluded due errors in reporting en route time, arrival time, or were cancelled before arriving on scene.
[107] 0.9% of incidents were excluded from the travel time analysis portions of the report due to being located outside of OFS' response boundary or couldn't be geographically located due to errors in reporting the latitude/longitude or address in the CAD.

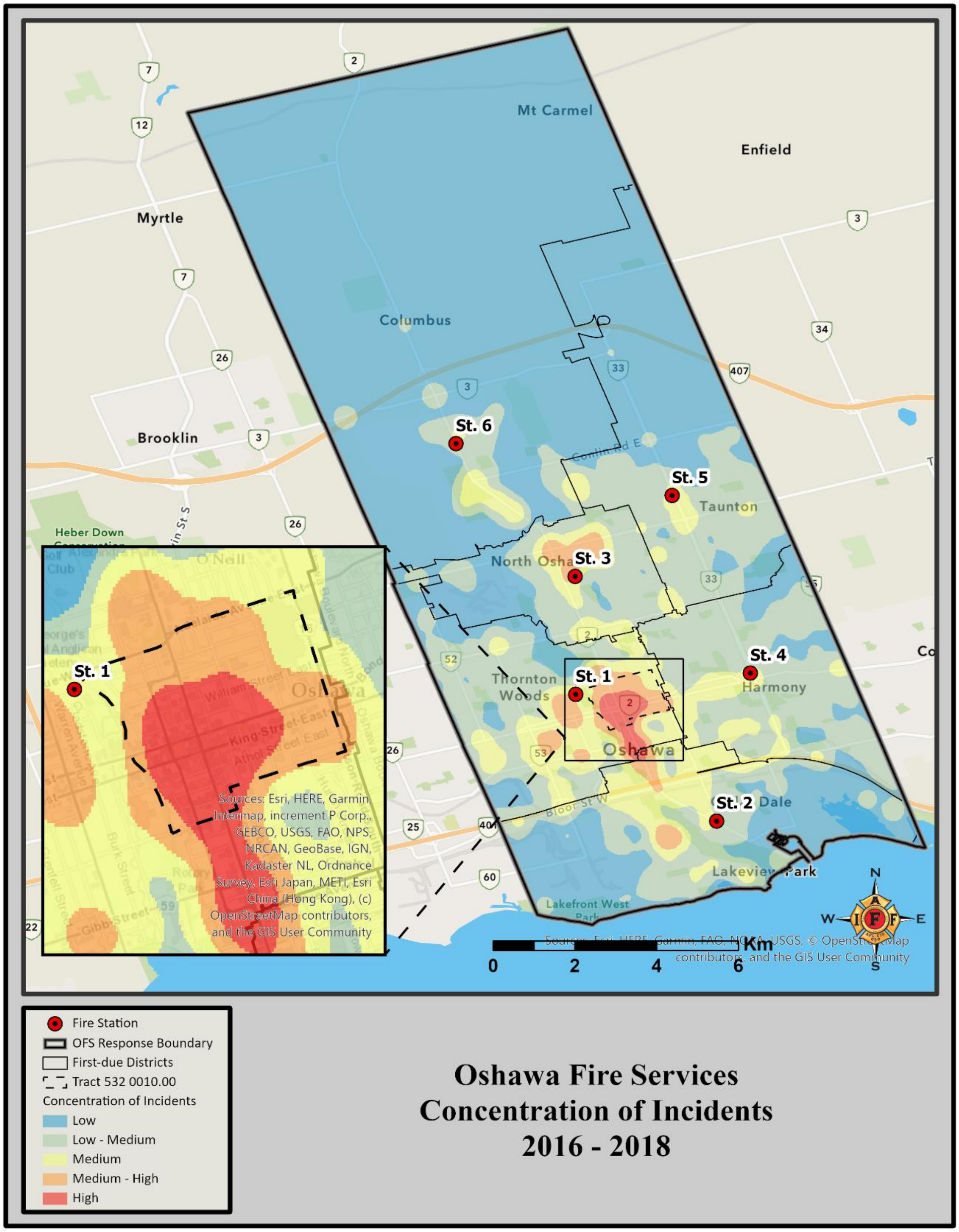
- Duplicate records were excluded from the dataset. [108]

Call Volume Analysis

In the three-year time period evaluated in this analysis, OFS responded to 5,017 incidents in 2016, 5,291 incidents in 2017, and 5,550 in 2018. The unit responses required to address these incidents were 9,537, 9,823, and 10,554 for each reported year, respectively. Overall incidents increased by 5.5% from 2016 to 2017 and by 4.9% from 2017 to 2018. Each year during this time period the greatest volume of incidents were located within Station 1's first-due district.

Map 18 shows the overall concentration of incidents throughout Oshawa during the three-year period and includes an inset of the portion of First-Due District 1 that includes Census Tract 532 0010.00.

[108] 0.6% of records were excluded from the dataset as they were duplicate entries.



Map 18: Concentration of Incidents, 2016 – 2018. Map 18 depicts OFS fire station locations, response boundary, and first-due district boundaries, and the concentration levels of incidents of all types from January 1, 2016 to December 31, 2018. The highest concentration of incidents was located in the downtown area of Oshawa including the census tract discussed earlier, Census Tract 532 0010.00, within Station 1's first-due district. Additional resources should be positioned at fire stations that experience a high concentration of incidents to ensure timely, safe, and effective response.

Service demand must assess the number of responses as well as the number of incidents. When assessing OFS' workload it is important for decision makers to note that, typically, one incident does not equate to one response. Simply counting incidents does not give an accurate picture of demand and does not allow proper allocation of resources and personnel. Medical incidents, for example, account for the highest percentage of incident types that occur within Oshawa when simply counting incidents, but on average require only 1 responding unit, and therefore do not place as much stress on OFS resources as other incident types such as alarms, accidents, and fires.

On average, for the three years, an incident of any type required 1.9 responding units. The purpose of a workload analysis is to ensure that resources and personnel are available and properly located to meet demand, and detail is revealed when responding units are counted. Chart 3 shows the overall incident and response volume for OFS for 2016, 2017, and 2018.

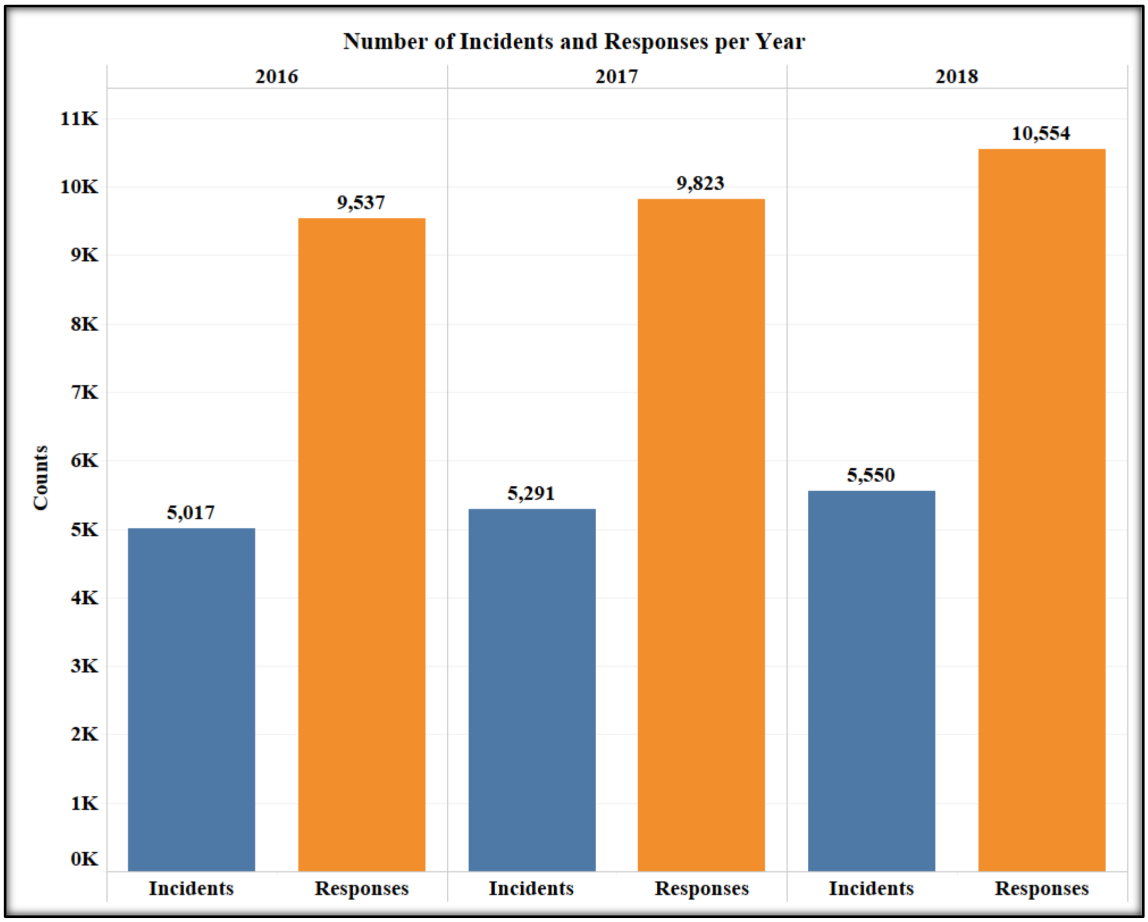


Chart 3: Number of Incidents and Responses per Year. This chart shows the number of incidents to which OFS responded and the number of total responses from OFS apparatus for each of 2016, 2017, and 2018. OFS responded to 5,017 incidents in 2016, 5,291 incidents in 2017, and 5,550 incidents in 2018. The responses required to address these incidents were 9,537, 9,823 and 10,554 for those respective years. On average, for the three years, one incident required about 1.9 responses.

Incident Types

Chart 4 shows each category of incident type as a percentage of the total incidents for the year, for each of the three years.[109] For each year the greatest percentage of incidents were within the medical category followed by the accident category. As discussed above, this is simply a count of the various incident types, not accounting for number of unit responses.

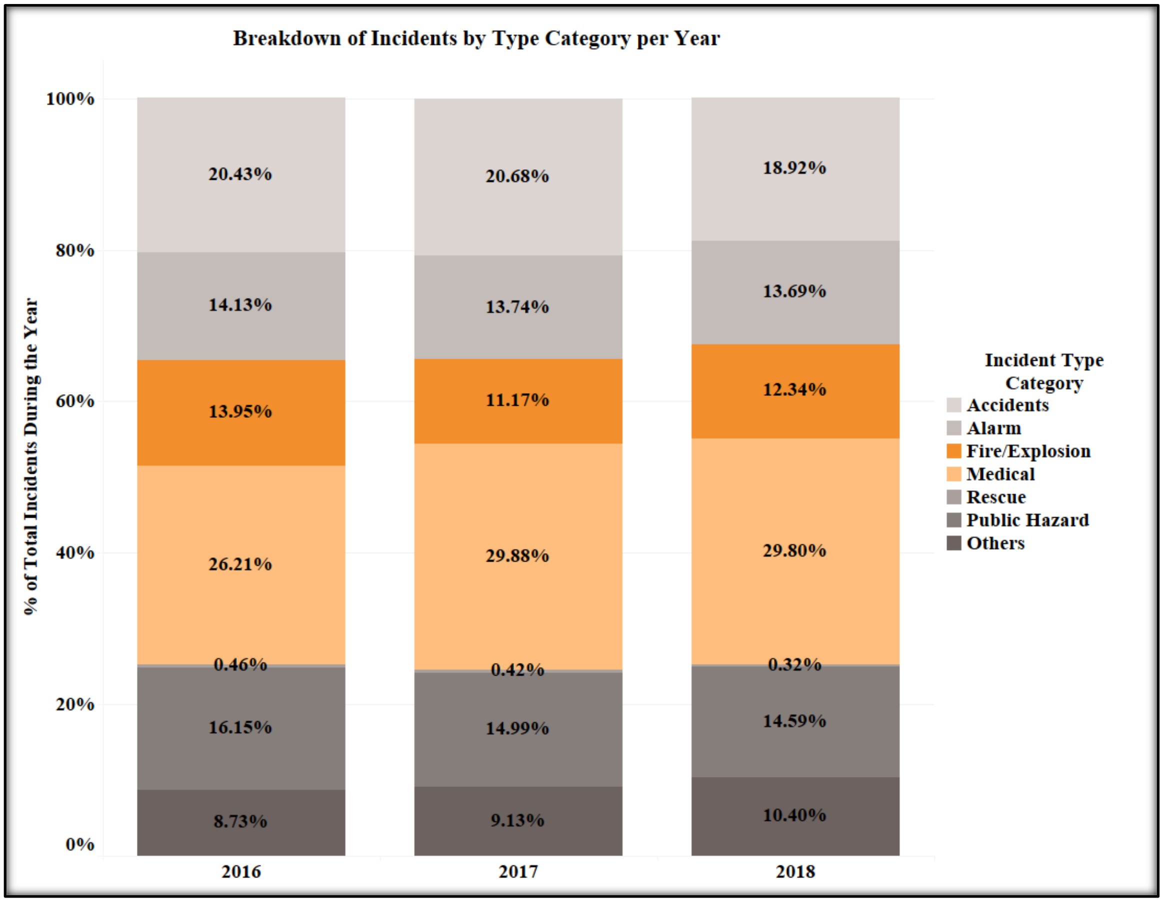


Chart 4: Breakdown of Incidents by Type Category per Year. [110] [111] [112] This chart shows the percentage of each of seven incident type categories of the incident total for each year. Each year the greatest percentage of incidents were medical incidents. As discussed earlier, incident counts do not equal counts of responding units or time spent operating on location at the incident. Incident type categories that required more responding units than medical include alarms, accidents and fires. Incident type categories such as fires, alarms, accidents, and public hazards all required more time on task than medical.

[109] Incident type categories were taken exactly as they appear in the CAD data as received from OFS. Incident type categories used in the CAD data include: Accident, Alarms, Fire/Explosion, Medical, Other Response, Public Hazard, and Rescue.
[110] The Rescue type category involves incidents requiring various types of specialized rescue such as rope rescue, elevator rescue, trench rescue, water rescue, etc. 49% of incidents in this category were elevator rescue.
[111] The Public Hazard type category involves incidents such as CO detector checks, bomb threats, down wires, down trees, natural gas, etc. Most were check calls (38%), CO detector with no symptoms (37%),and natural gas (13%).
[112] Other included incidents such as 911 unknown, automobile lockout, and assistance to other agencies/public service. Most (85%) were 911 unknown.

Moving beyond the simple incident count represented in Chart 4, Chart 5 on the next page shows the responses to each category of incident types as a percentage of the total responses for the year, for each of the three years.[113] Identification of historical rates of responding units required for various incident types is essential for identifying the quantity and type of staffed apparatus needed for OFS to meet demand. As noted earlier, for OFS from 2016 to 2018, on average each incident required 1.9 responding units. Chart 5 illustrates the demand each year from each incident type category on actual individual unit responses. Note, for example, that the medical category was greatest in terms of percentage of incidents but that several types of incidents required more unit responses, including alarms, accidents, and fires. Each of these incident types, on average, required at least two responding units while medical incidents typically required only one unit to respond. During the three years, alarms required an average of 3.8 responding units, fires required an average of 2.7 responding units, and accidents required an average of 2.1 responding units. Additionally, the subset of fires that are structure fires, required an average of 4.8 responding units per incident.

[113] Incident type categories were taken exactly as they appear in the CAD data as received from OFS. Incident type categories used in the CAD data include: Accident, Alarms, Fire/Explosion, Medical, Other Response, Public Hazard, and Rescue.

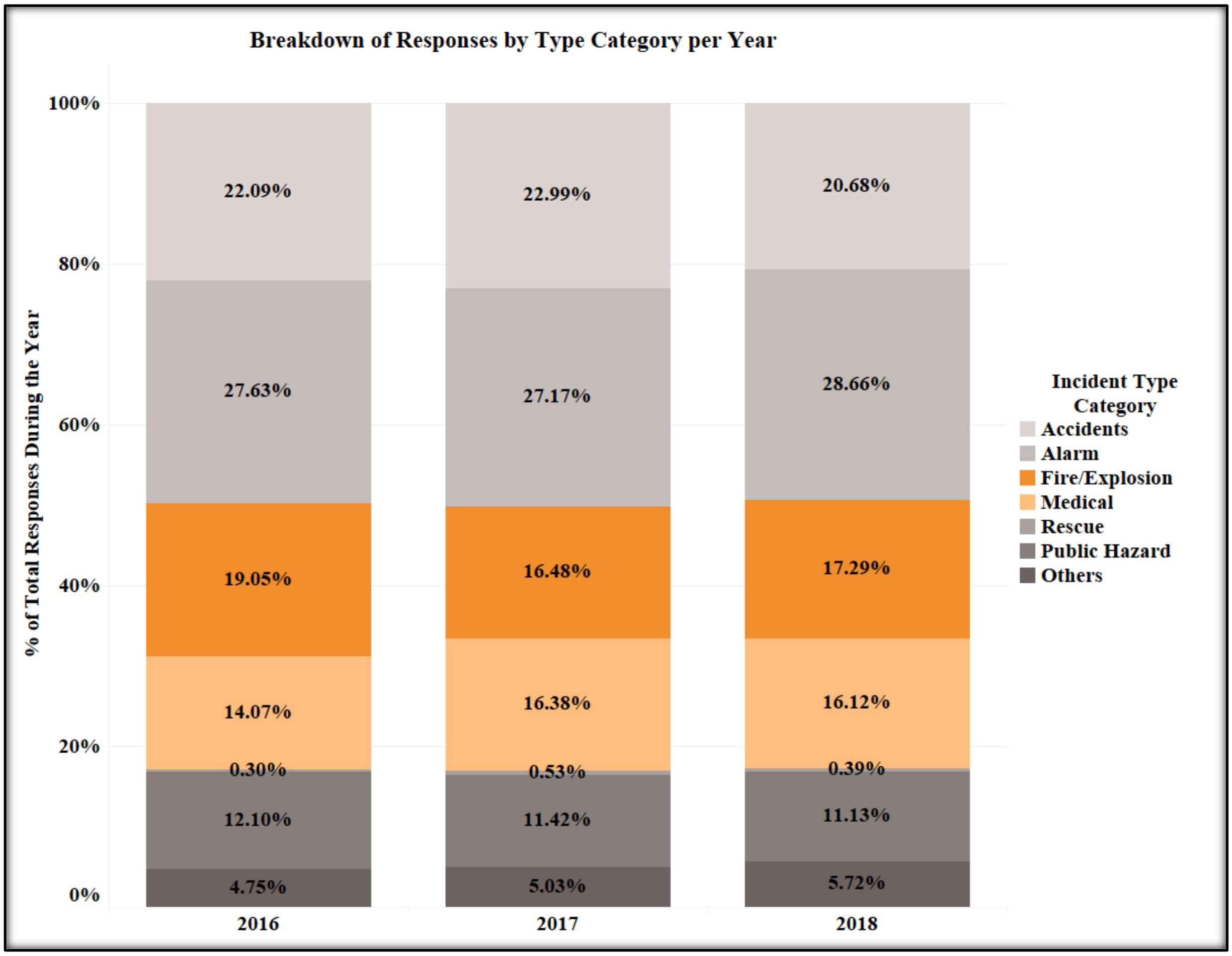


Chart 5: Breakdown of Responses by Type Category per Year. This chart shows the percentage of unit responses to each of seven incident type categories of the unit response total for each year. Each year the greatest percentage of responses were to alarms. Note again that, number of incidents do not equal number of required unit responses. The medical category was highest in terms of incident count, but alarms, accidents, and fires required more responding units. Count of responding units relates to time on task depending on the category. Alarm incidents typically do not have long time on task values despite requiring many responding units. Fires, on the other hand, require many responding units that each typically spend more time on scene than units responding to any other incident type.

Two categories, alarm and fire[114], that require the most number of units to respond to a single incident, had the most notable discrepancies between Charts 4 and 5. Both of these incident types require that multiple fire suppression apparatus respond each time an incident occurs. The information in these two charts is particularly helpful for decision makers to ensure that the necessary resources are allocated to respond to the volume of calls expected for various incident types. The terms *incident* and *response* are sometimes conflated in information provided to

[114] In this document the term "fire" or "fire suppression" incident is sometimes used to describe any incident identified within the OFS CAD data as "Fire/Explosion". Also, in some cases the term "structure fire" is used to describe incidents identified within the OFS CAD data as the "Fire/Explosion" sub-category of "Fire/Explosion:Structural".

decision makers. In Oshawa from 2016 to 2018, the volume of medical *incidents* was higher than the volume of fire *incidents* each year, but the volume of *responses* required for fire incidents was greater than the volume of *responses* required for medical incidents each year. Table 8 lists the total number of unit responses required for each incident type during the three-year period.

Incident Type	Total Unit Responses
Alarm	8,325
Accident	6,351
Fire/Explosion	5,217
Medical	4,642
Public Hazard[115]	3,446
Other[116]	1,537
Rescue[117]	122

Table 8: Total Unit Responses, 2016 - 2018. [118] This table shows the total number of unit responses per incident type category for each of the seven incident type categories as classified in the CAD data, from 2016 to 2018. Note that the medical category was first in terms of total incidents but fourth in terms of responding units required.

These findings, based on historical call data, underscore the need for OFS to have the capacity to respond to multiple hazard types that may occur in Oshawa at any given time. Alarm, accidents, fire, medical, and public hazard all required at least 3,000 responding units. Analysis of response capacity must account for responding unit volumes.

Building on this examination of incidents and responses is a metric, time on task[119], that further illustrates how OFS emergency response resources are deployed. Time on task is the measure of time that a unit spends on location at an incident. The time on task of all responding units to an incident can be summed to calculate the total time spent by OFS units at an incident and is an indication of the varying amount of work that must be performed by firefighters when responding to different types of incidents. This creates a more vivid picture of demand. Chart 6 shows the percentage of total time on task by OFS units for each of the incident type categories for the three years.

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[115] The Public Hazard type category involves incidents such as CO detector checks, bomb threats, down wires, down trees, natural gas, etc. Most were check calls (38%), CO detector with no symptoms (37%), and natural gas (13%).
[116] Other included incidents such as 911 unknown, automobile lockout, and assistance to other agencies/public service. Most (85%) were 911 unknown.
[117] The Rescue type category involves incidents requiring various types of specialized rescue such as rope rescue, elevator rescue, trench rescue, water rescue, etc. 49% of incidents in this category were elevator rescue.
[118] Incident type categories were taken exactly as they appear in the CAD data as received from OFS. Incident type categories used in the CAD data include: Accident, Alarm, Fire/Explosion, Medical, Other, Public Hazard, and Rescue.
[119] The time on task for a given incident is defined as the time interval between the arrival time on the scene of the incident and the time when the unit is cleared from the incident.

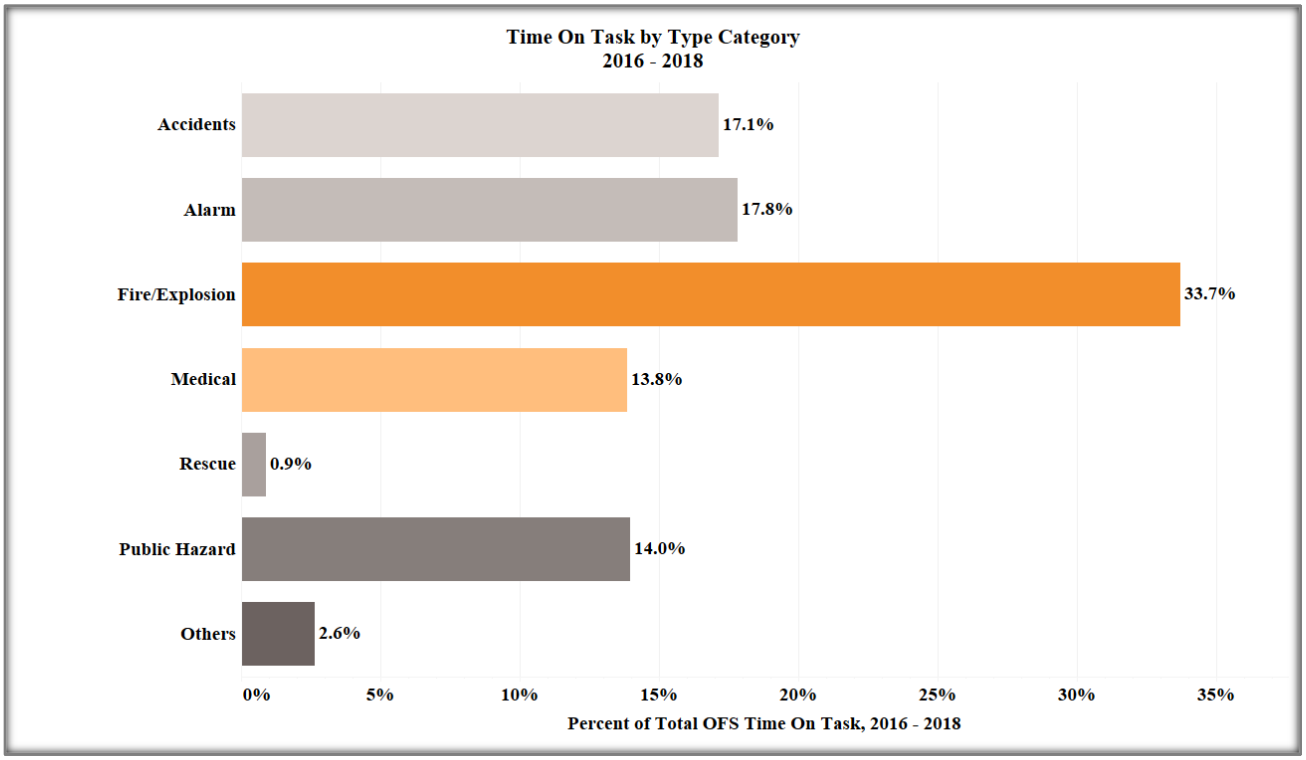


Chart 6: Time on Task by Type Category, 2016 – 2018. This chart shows the percentage of time on task for each incident type category out of the sum of all time on task for OFS units during the three-year period. During the three years, time on task of OFS units at fire suppression incidents occupied 33.7% of all on-scene time for all OFS units. 33.7% represents 102,110 total minutes of time on task at fire suppression incidents. Units responding to medical incidents occupied 13.8% of total OFS time on-scene, or 41,941 total minutes.

Time on task is a useful gauge for decision makers to determine how existing resources are utilized, and the time on task total for fire suppression incidents relative to other types of incidents indicates that, as it pertains to deployment, more OFS time is allocated to fire suppression incidents than any other category. As demand for emergency services continues to increase year by year in Oshawa, OFS will need to add additional personnel and resources to meet the increasing demand. Therefore, assuming no radical departures from the ratios illustrated in Chart 6, OFS and decision makers should expect to add additional fire suppression resources in the future.

The following series of charts further detail the breakdown of incidents and unit responses for alarm, accident, fire, and medical incidents for each of the three years.

Chart 7 shows the subset of overall incidents per year that were alarm incidents, and the number of responses by OFS units to those incidents each year. Alarms require the deployment of multiple suppression apparatus and place the highest demand on OFS resources in regard to unit responses, but typically require lower amounts of on-scene time than other types of incidents. As reported in Table 8, from 2016 to 2018, alarm incidents required the response of 8,325 units, an average of 3.8 responding units per incident. Chart 7 is helpful for visualizing this relationship between incidents and unit responses required per incident.

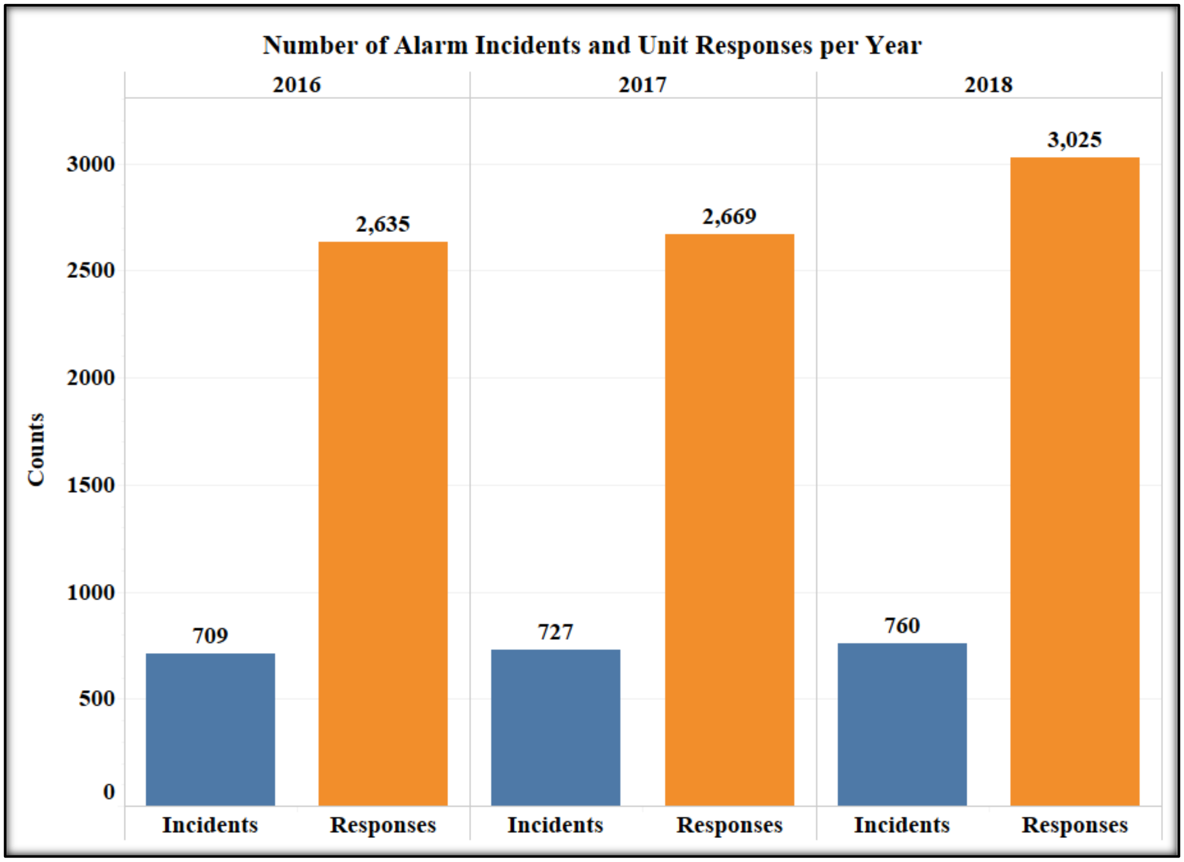


Chart 7: Number of Alarm Incidents and Unit Responses per Year.[120] This chart shows the number of alarm incidents to which OFS responded and the number of responses to these incidents by OFS apparatus for each of 2016, 2017, and 2018. OFS responded to 709 alarms in 2016, 727 alarms in 2017, and 760 alarms in 2018. The number of unit responses required to address these incidents were 2,635, 2,669, and 3,025 for those respective years. Alarm incidents required more responding OFS units than any other type of incident during the three years.

Chart 8 shows the subset of overall incidents per year that were accident incidents, and the number of responses by OFS units to those incidents each year. 99% of accident incidents in the CAD data are classified as vehicle accidents.[121] Vehicle accidents may require labor intensive tasks such as vehicle extrication and may involve hazardous conditions for firefighters. As reported in Table 8, from 2016 to 2018, accident incidents required the response of 6,351 units,

[120] Fire suppression incidents include incidents that were classified in the CAD as "Fire/Explosion".
[121] Incidents classified as Vehicle accidents may or may not include extrication as such detail was not provided in the CAD data. The remaining approximately 1% of accidents were classified in the CAD data as "Accident:Aircraft" or "Accident:Rail:Pedestrian/Motor Vehicle".

an average of 2.1 responding units per incident. Chart 8 is helpful for visualizing this relationship between incidents and unit responses required per incident.

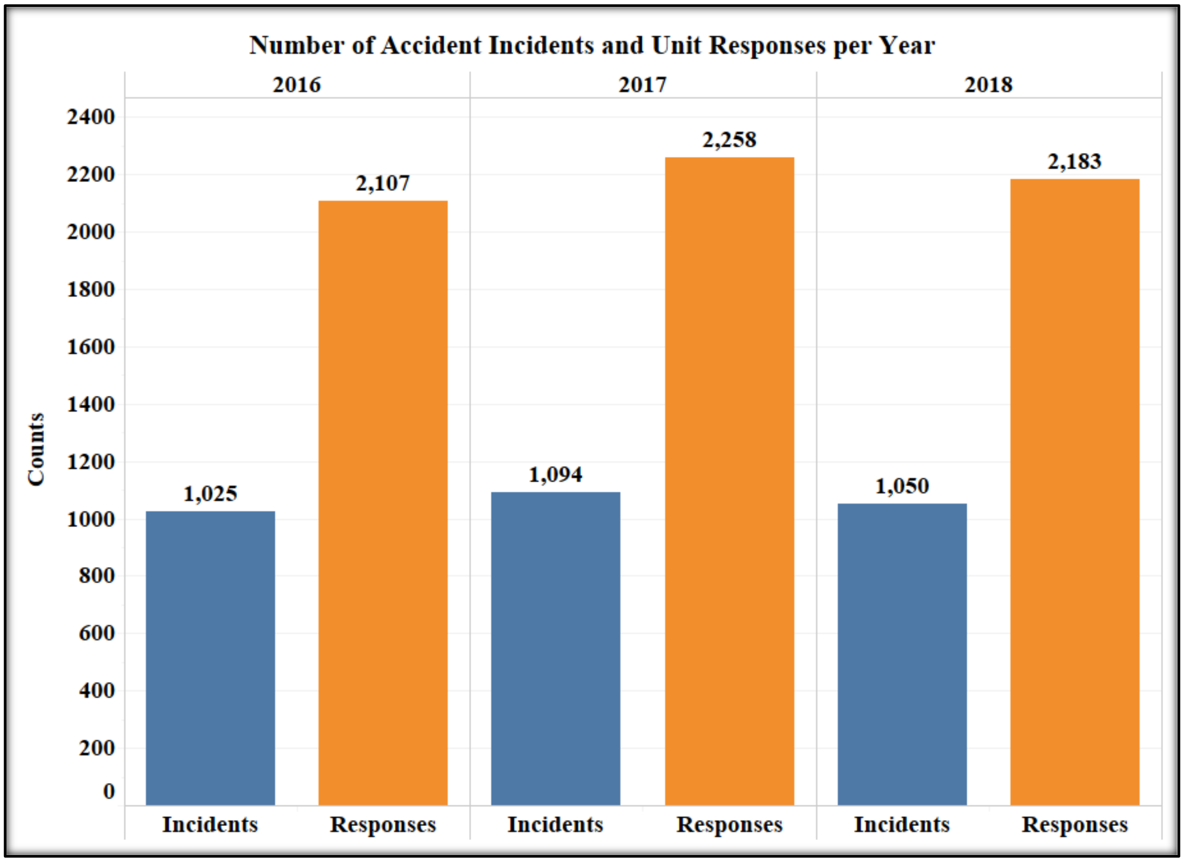


Chart 8: Number of Accident Incidents and Unit Responses per Year.[122] This chart shows the number of accident incidents to which OFS responded and the number of responses to these incidents by OFS apparatus for each of 2016, 2017, and 2018. OFS responded to 709 accidents in 2016, 727 accidents in 2017, and 760 accidents in 2018. The number of unit responses required to address these incidents were 2,635, 2,669, and 3,025 for those respective years. Accident incidents required the second highest number of responding OFS units during the three years.

Chart 9 shows the subset of overall incidents per year that were fire incidents, and the number of responses by OFS units to those incidents each year. Fires require the deployment of multiple suppression apparatus and place the third highest demand on OFS resources in regard to unit responses. 43% of fires in Oshawa were structure fires, and 76% of the units responding to fires responded to structure fires. Later in this analysis, the fact that OFS spent more time on-scene responding to fires from 2016 to 2018 than any other type of incident, will be discussed. As reported in Table 8, from 2016 to 2018, fire incidents required the response of 5,217 units, an average of 2.7 responding units per incident. Out of those responses, 3,983 were to structure

[122] Fire suppression incidents include incidents that were classified in the CAD as "Fire/Explosion".

fires and each structure fire required an average of 4.8 responding units. Chart 9 is helpful for visualizing this relationship between incidents and unit responses required per incident.

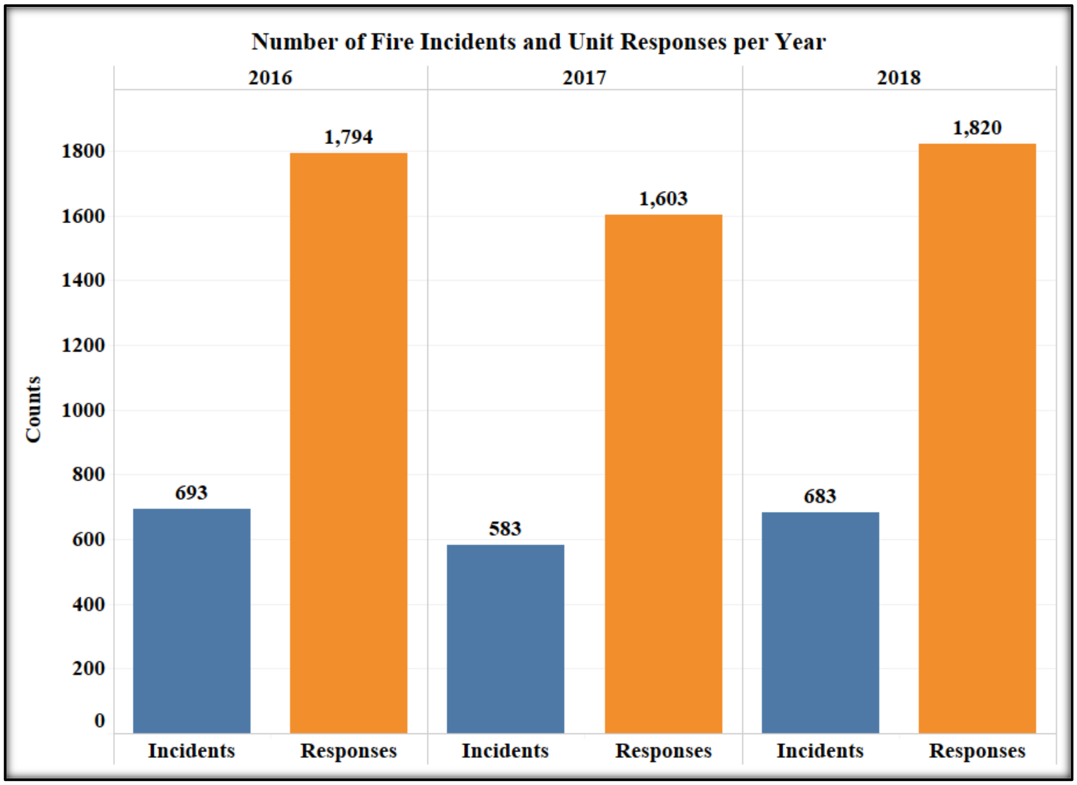


Chart 9: Number of Fire Incidents and Unit Responses per Year.[123] This chart shows the number of fire incidents to which OFS responded and the number of responses to these incidents by OFS apparatus for each of 2016, 2017, and 2018. OFS responded to 693 fires in 2016, 583 fires in 2017, and 683 fires in 2018. The number of unit responses required to address these incidents were 1,794, 1,603, and 1,820 for those respective years. Fire incidents required the third highest number of responding OFS units during the three years. Responding to fires also required more total on-scene time than any other type of incident and is discussed in the time on task portion of this workload analysis.

Chart 10 shows the subset of overall incidents per year that were medical incidents, and the number of responses by OFS units to those incidents each year. Medical incidents rarely required the response of more than one OFS unit, as is evident in the chart. Medical incidents represented the highest percentage of any incident type, but required fewer unit responses than alarms, accidents, or fires. As reported in Table 8, from 2016 to 2018, medical incidents required the response of 4,642 units, an average of 1.02 responding units per incident. The relationship of number of incidents to unit responses is clear in Chart 10.

[123] Fire suppression incidents include incidents that were classified in the CAD as "Fire/Explosion".

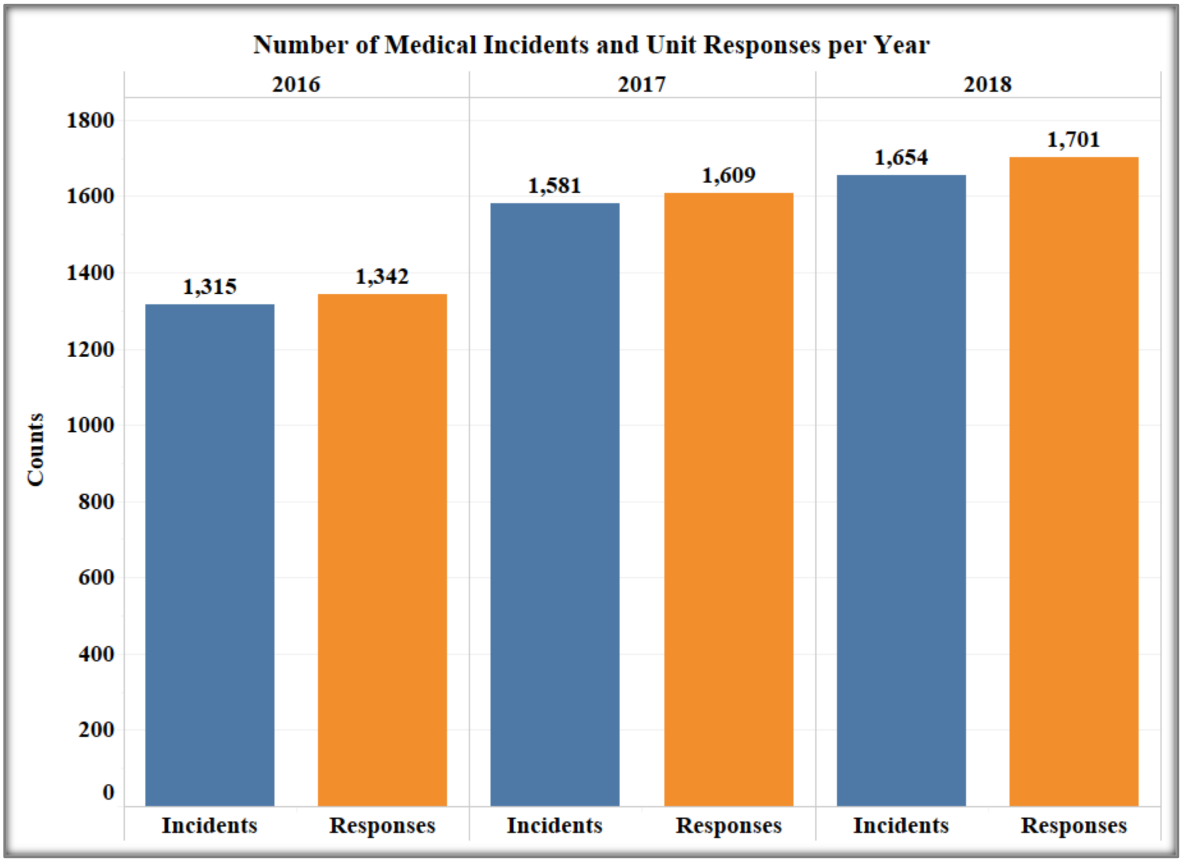


Chart 10: Number of Medical Incidents and Unit Responses per Year. This chart shows the number of medical incidents to which OFS responded and the number of unit responses to these incidents from OFS apparatus for each of 2016, 2017, and 2018. OFS responded to 1,315 medical incidents in 2016, 1,581 medical incidents in 2017, and 1,654 medical incidents in 2018. The responses required to address these incidents were 1,342, 1,609, and 1,1701 for those respective years. Despite being the incident type with the greatest volume of incidents, medical incidents required fewer responding units and less time on-scene than alarms, accidents, or fires during the three years

The findings in this analysis regarding historical call volumes show that, when evaluating workload, a count of incident volumes of various types alone is not an accurate indicator of personnel and apparatus needs. A more detailed picture is created when unit response volumes and time on task are examined. OFS must be capable of responding to all hazards that occur in Oshawa, and the findings presented here show that historically, volume of personnel and apparatus utilization is not equal to incident volume.

While call volume and time on task indicate what types of emergency resources will likely be needed, historical location of incidents indicates where emergency resources will likely be needed.

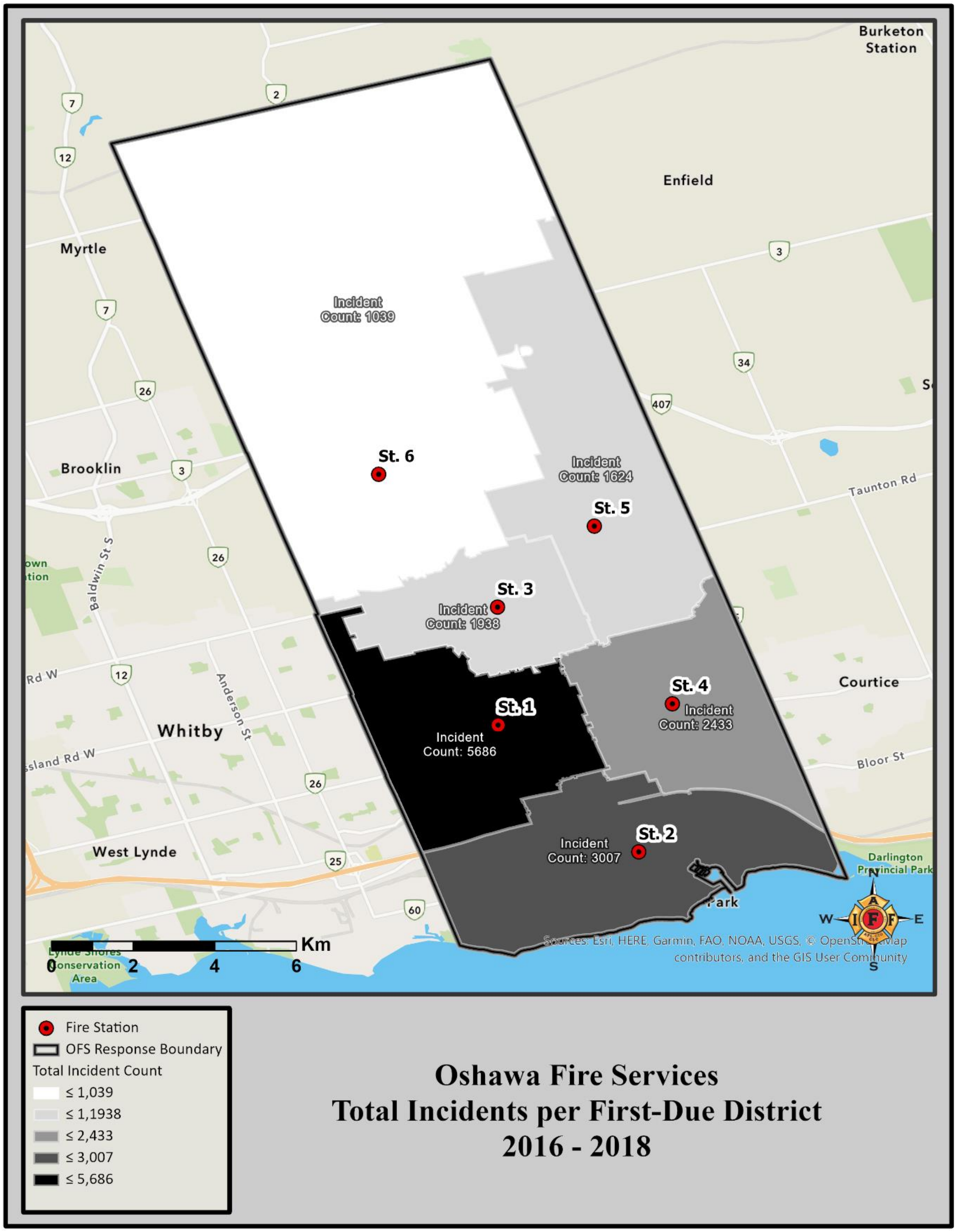
Incidents per First-Due District

Examining the historical locations of OFS call volume helps to inform decision makers about where current OFS resources are utilized in Oshawa, and how the OFS workload is distributed amongst OFS fire stations. A first-due district refers to a fixed geographical area established by a services' administration that contains a fire station and that is typically served by the personnel and apparatus assigned to that station.[124] Typically, in Oshawa, the closest unit to an incident location is the first unit dispatched to an incident and is a unit originating from the fire station located in the first-due district where that incident occurs. First-due districts that experience growth in the volume of incidents and apparatus responses may require additional resources to ensure that demand can be met in these areas in a timely, efficient and effective manner. If resources are removed from a first-due district with high and growing demand, as is the case in First-Due District 1 in Oshawa, a negative impact on the ability to address demand in a timely and effective manner is anticipated.

Segmenting call volume geographically rather than by station call volume is helpful with Oshawa, as Station 6 was opened 2016 and the number of staffed suppression apparatus per shift was not increased. Instead, staffed suppression apparatus was moved from other stations including Stations 1 and 3 to cover the new station. It is misleading in Oshawa's situation to present call volumes by station apparatus as an indication that demand is decreasing for a fire station. This is because opening Station 6 and shifting multiple suppression companies from other OFS stations has resulted in a decrease of the station response volumes, which, however, is not due to a decrease in the incident volume within those first-due districts. For city decision makers, one of the more helpful details of OFS historical response that is revealed through analysis is that, after the removal of a frontline suppression apparatus from Station 1, non-Station 1 units have had to increase responses into First-Due District 1. Decisions about the placement of resources should be informed by the historical locations of incidents.

Map 19 classifies each first-due district based on the volume of incidents of all types that occurred within each first-due district boundary, from January 1, 2016 to December 31, 2018. The greatest volume of incidents occurred within First-Due District 1, which was 36.2% of all incidents in Oshawa.

[124] OFS opened and began responding from Station 6 in July of 2016, in this section incidents that occurred within the geographic area that is currently First-Due District 6 are assigned accordingly even if they occurred in the first six months of 2016. In order to keep statistically consistent, consistent geographic areas should be used.



Map 19: Total Incidents per First-Due District, 2016 - 2018. Map 19 shows the total incidents of all types per first-due district for the three-year study period. The most incidents occurred within First-Due District 1. Total incident counts for each first-due district are indicated on the map. A frontline suppression apparatus was removed from Station 1 in 2017, and units from other stations have had to increase responses into First-Due District 1 to compensate.

Chart 11 shows total count of incidents of all types, for each year in each first-due district. This chart illustrates the incident volumes and the year-to-year fluctuations in incident volume within each first-due district. In five of the six first-due districts the volume of incidents increased from year to year. The exception is First-Due District 4, where there was a slight decrease after 2016. First-Due District 4 still had a volume consistently above 700 incidents each year and this area was always the third busiest first-due district in Oshawa. Note that the volume of incidents that occurred within First-Due District 1 was nearly double that of the next busiest first-due district.

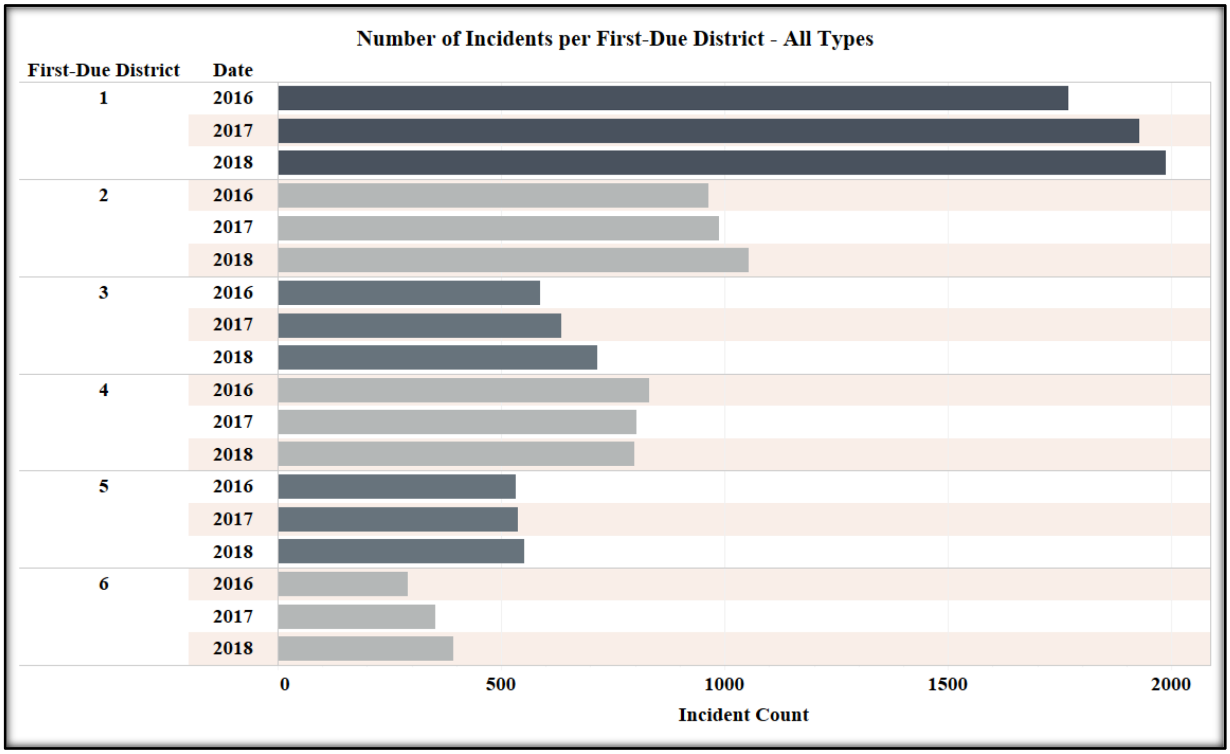


Chart 11: Number of Incidents per first-Due District – All Types. This chart shows the number of incidents that occurred in each first-due district during 2016, 2017 and 2018. This chart reflects the fact that demand was increasing in most of Oshawa during the three-year period. The volume of incidents occurring in First-Due District 1 was nearly double that of the second busiest, First-Due District 2.

Chart 12 shows the total time on task in each first-due district, for OFS units responding to all incidents from 2016 to 2018. Greater value of time on task for a first-due district indicates greater demand for the response of units from outside of the first-due district. Demand for outside units to respond can be mitigated by adding additional resources to a fire station in an area with high time on task values. Incidents in First-Due District 1 required the more time on task than any other area, and adding resources to Station 1 will reduce the amount of time that units from other stations will have to spend responding within Station 1's first-due area.

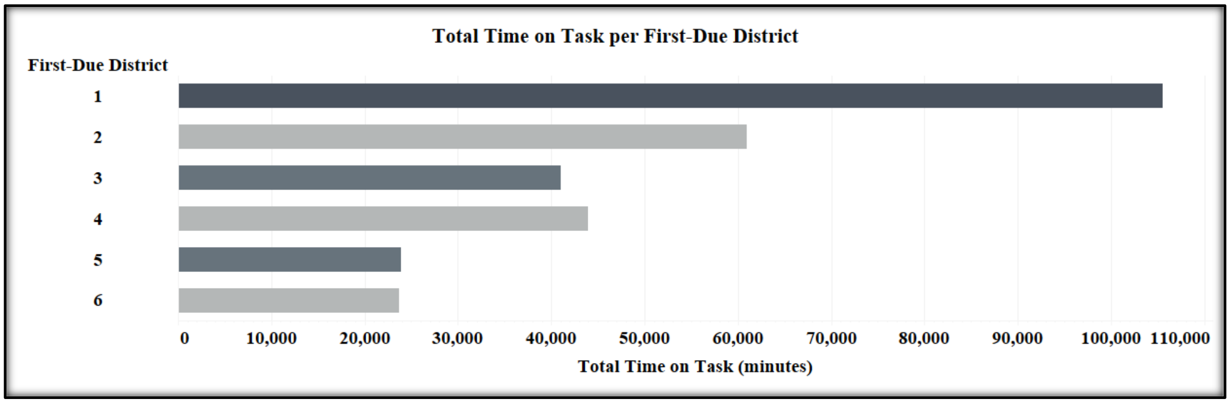


Chart 12: Total Time on Task per First-Due District. This chart shows the total time on task for OFS units in each first-due district during the three-year period. During the three years, time on task of OFS units responding to incidents occurring within First-Due District 1 accounted for 35.3% of all on-scene time for all OFS units. 35.3% represents 105,589 minutes of time on task. After a frontline suppression apparatus was removed from Station 1 more of this on-scene response time was contributed by non-Station 1 units.

As discussed earlier in this report, in 2017 OFS removed a frontline fire suppression apparatus from Station 1. Station 1's first-due district continues to experience the highest volume of incidents and experiences increasing demand each year. Analysis of the CAD data shows that since April of 2017, all other stations have had to increase the number of responses into Station 1's first-due district. This increases the average distance that responding units have to travel to reach incidents that occur in First-Due District 1, increases response times, and increases the likelihood that if an incident occurs within one of the other first-due areas, a first-due unit will not be available. Delays of even seconds can increase the chances of injury to firefighters and citizens. These findings suggest that additional fire suppression resources should be deployed from Station 1 and that the removal of frontline suppression apparatus from Station 1 reduced OFS' ability to provide timely response in First-due District 1.

Chart 13 shows this increase of unit responses into First-Due District 1 from other stations over the years. Most of the responding units came from Stations 2, 3 and 4, with a sharp increase in these responses starting in 2017. Unit responses from Station 2 increased by 64% in 2017 and a further 15% in 2018. Unit responses from Station 3 increased by 100% in 2017 and a further 22% in 2018. Unit responses from Station 4 increased by 83% in 2017 and a further 19% in 2018. This is significant as non-Station 1 units responding into Station 1's first-due district had average travel times one minute, seven seconds longer than Station 1 units.

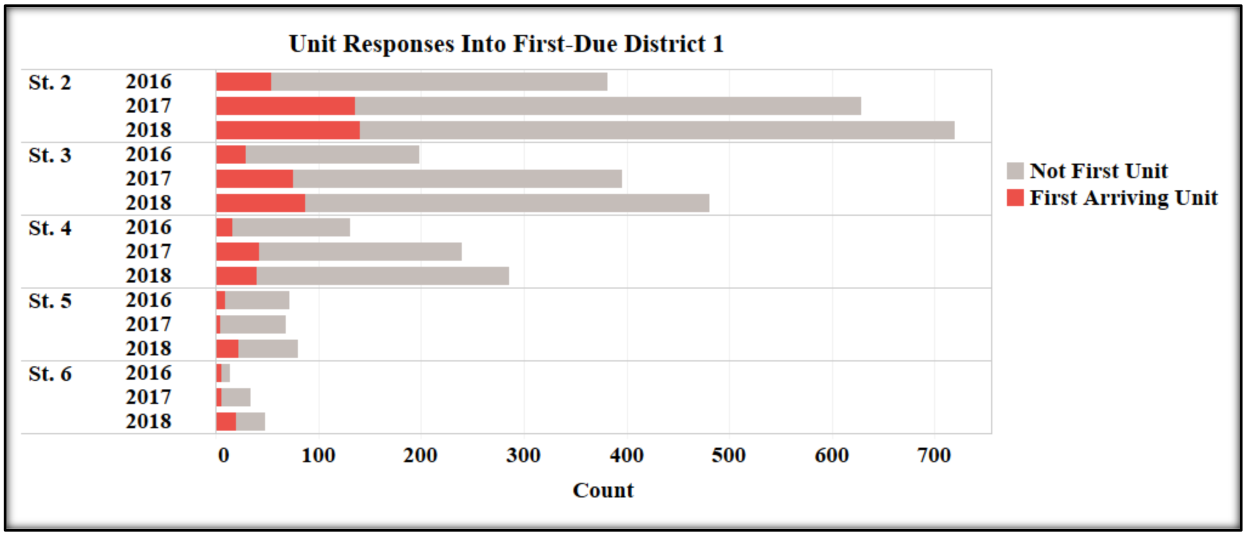


Chart 13: Unit Responses Into First-Due District 1. This chart shows the number of responses by non-Station 1 units into Station 1's first-due district each year. Also indicated in red on the chart are the number of those responses that were the first arriving unit. This chart quantifies the amount other stations needed to increase responses to address demand in First-Due District 1 after a frontline suppression apparatus was removed from Station 1. Sharp increases in both overall responses and first arriving units are seen in 2017 from the closest three stations, 2, 3 and 4. Average travel times of non-Station 1 units were one minute, seven seconds longer than Station 1 units.

The following series of charts show the total incident count for each of the alarm, accident, fire and medical type categories, for each year in each first-due district. They underscore the fact that First-Due District 1 is the highest focus of concentration of demand in Oshawa. As shown in Chart 13 above, when Station 1 response capacity was reduced other stations had to compensate for lack of Station 1 resources. Additional apparatus in Station 1 will allow a greater number of incidents occurring in First-Due District 1 to be serviced by first-due units, and reduce the likelihood that non-Station 1 units will be unavailable to service demand in their own first-due areas.

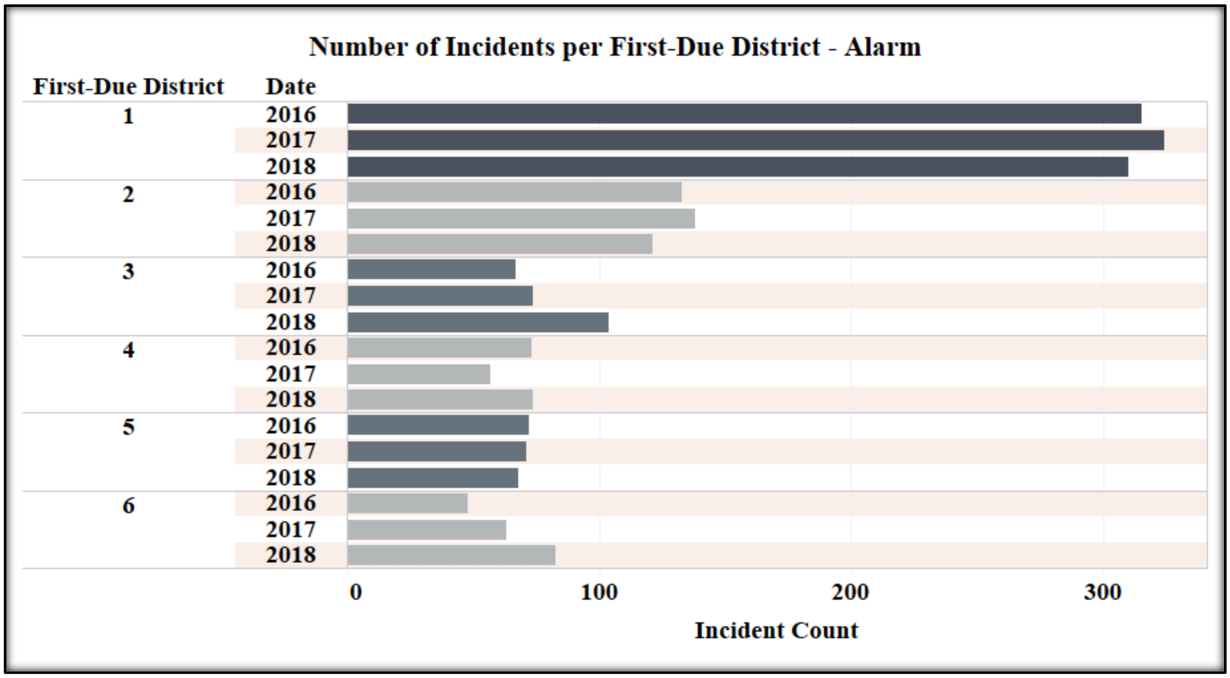


Chart 14: Number of Incidents per First-Due District – Alarm. This chart shows the number of alarm incidents that occurred in each first-due district during 2016, 2017 and 2018. Each alarm requires multiple responding suppression apparatus, so the removal of a frontline suppression apparatus from Station 1 means that at least one additional unit will be required to respond from another station when an alarm incident occurs within First-Due District 1. As can be seen, the majority (43.2%) of alarm incidents occurred within First-Due District 1.

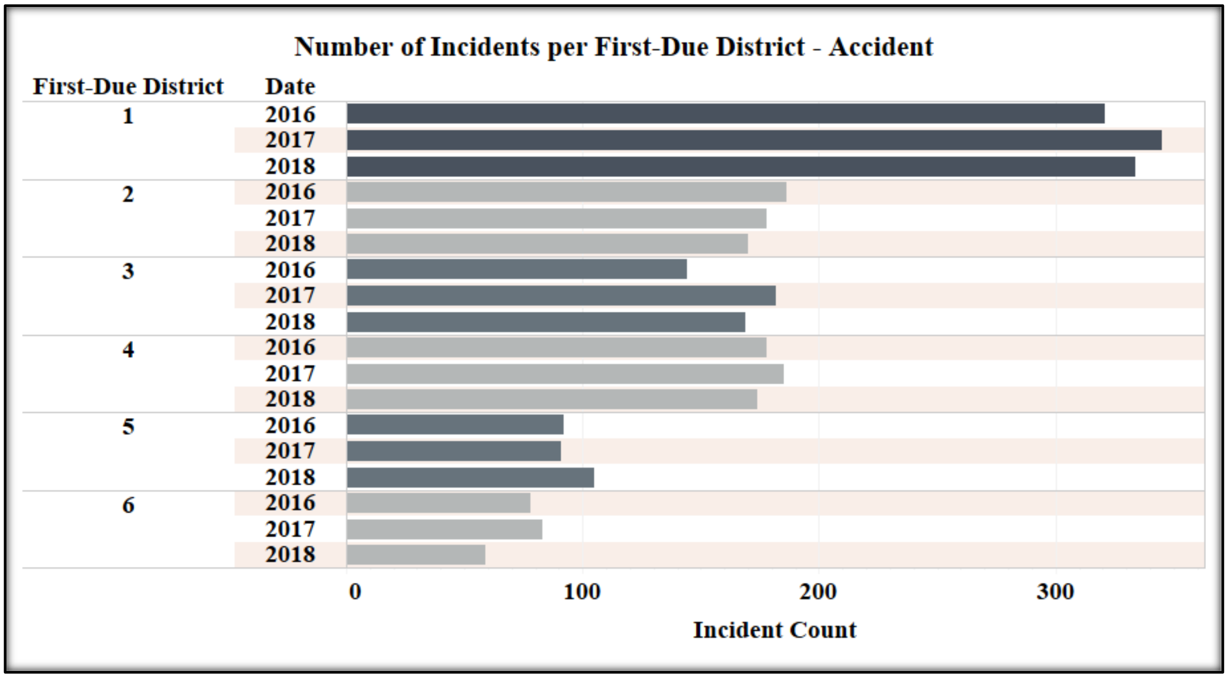


Chart 15: Number of Incidents per first-Due District – Accident. This chart shows the number of accidents that occurred in each first-due district during 2016, 2017 and 2018. Each accident typically requires multiple responding suppression apparatus, so the removal of a frontline suppression apparatus from Station 1 means that at least one additional unit will be required to respond from another station when an accident incident occurs within First-Due District 1. As can be seen, the majority (35.2%) of accidents occurred within First-Due District 1.

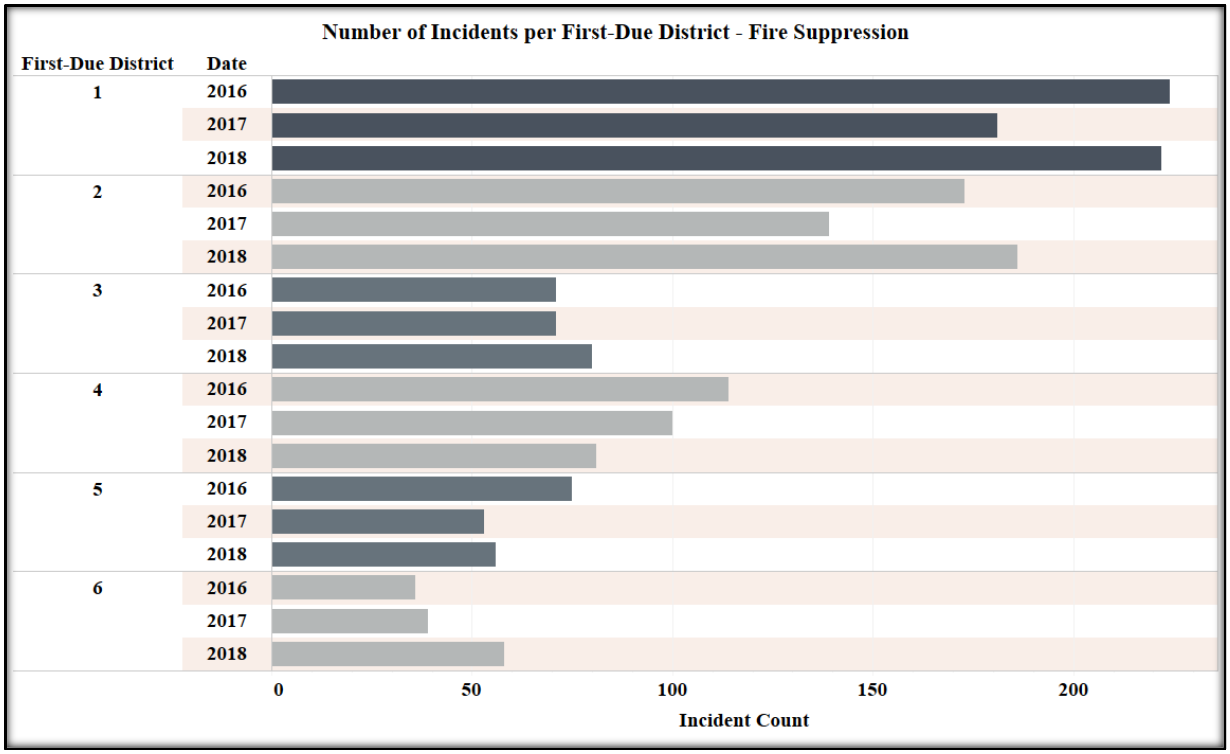


Chart 16: Number of Incidents per First-Due District – Fire Suppression. This chart shows the number of fire suppression incidents that occurred in each first-due district during 2016, 2017 and 2018. For fire suppression incidents that occurred in First-Due District 1, an average of 2.8 units were required to respond. For those that were structure fires, an average of 4.8 units were required to respond. Because of the removal of a frontline suppression apparatus from Station 1, fires that occur within First-Due District 1 require at least one additional unit to respond from another station. More often than any other station, additional units come from Station 2, which is the second busiest first-due district for fires. As can be seen, the majority (32%) of fires occurred within First-Due District 1.

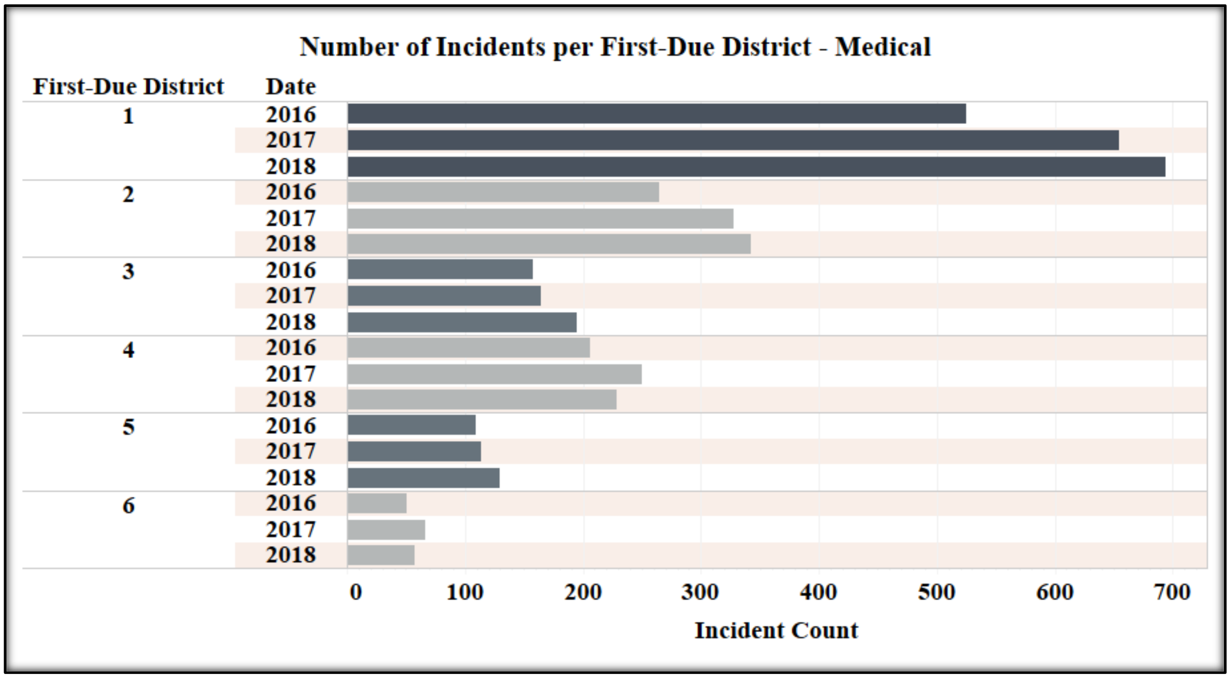
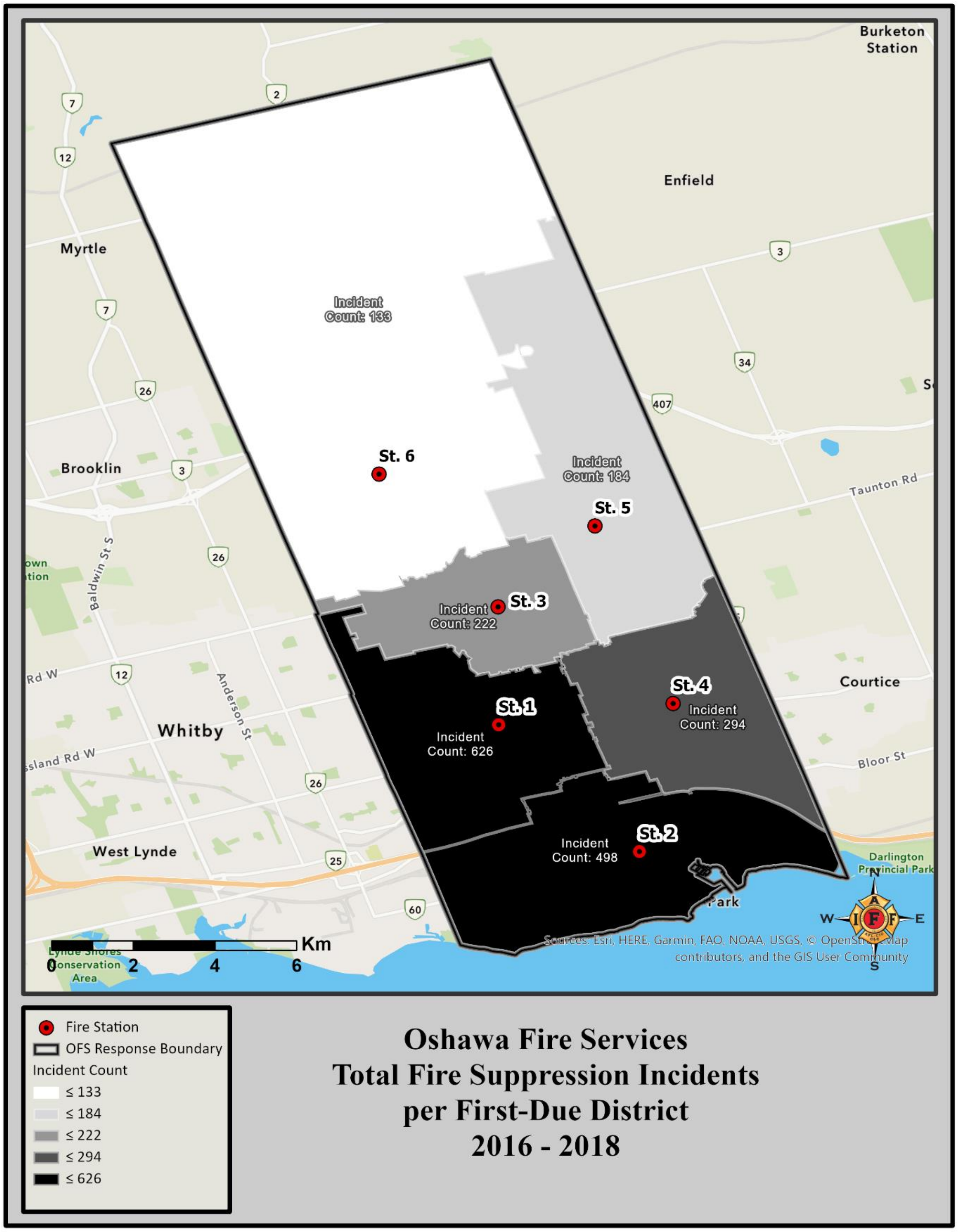


Chart 17: Number of Incidents per First-Due District – Medical. This chart shows the number of medical incidents that occurred in each first-due district during 2016, 2017 and 2018. During the three years, Station 1's first-due district had more than twice as many medical incidents as the second busiest. Similar to the last several charts, the majority (41.3%) of medical incidents occurred within First-Due District 1.

Two incident types, fire suppression and emergency medical[125], require response that adheres to travel time objectives enumerated in NFPA 1710. The Travel Time Analysis section later in this workload analysis will show that OFS' ability to meet NFPA 1710 travel time objectives has been reduced in First-Due District 1 between 2016 and 2018. The following maps indicate the volume of fire suppression and emergency medical incidents per first-due district in Oshawa during the three-year period.

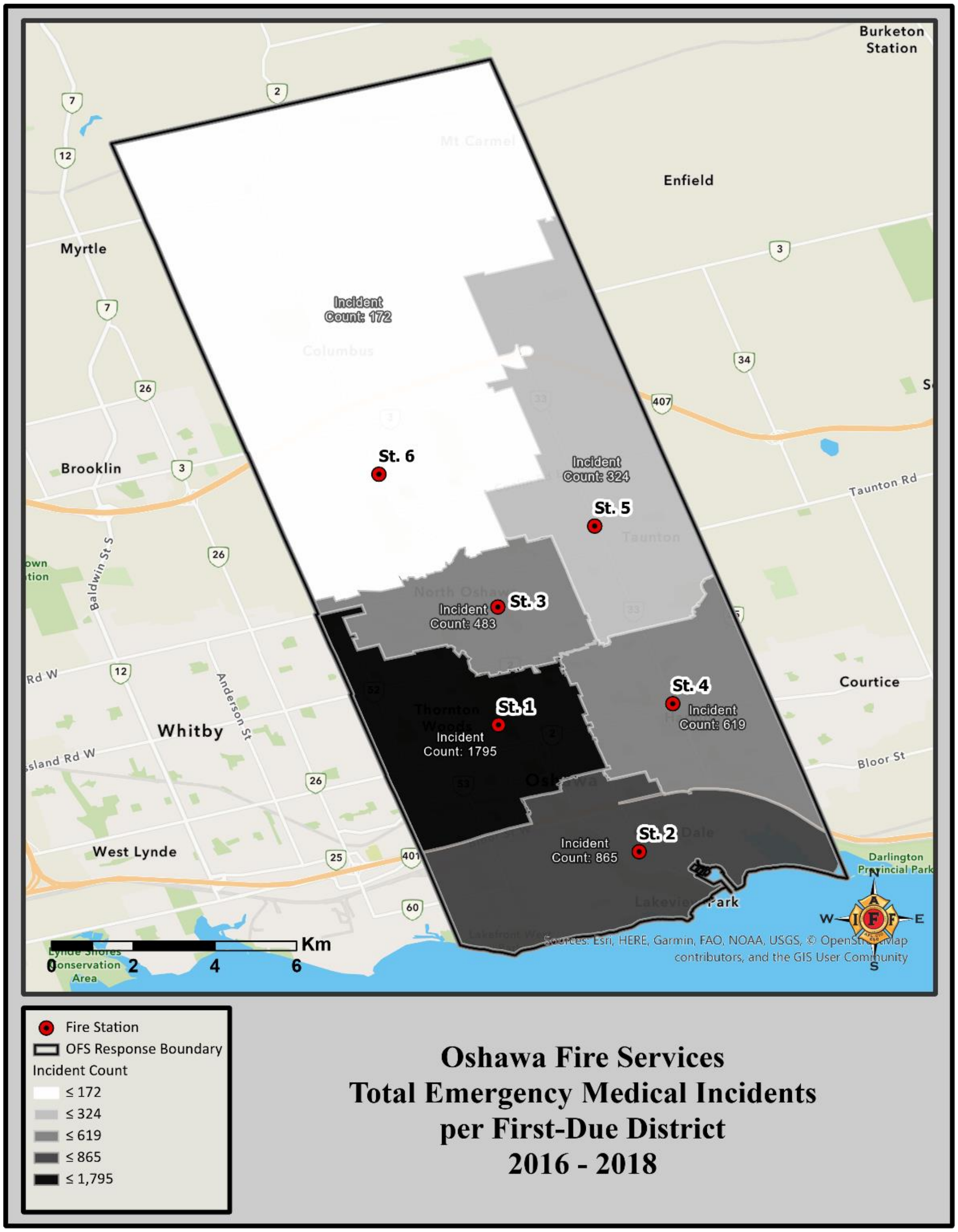
[125] Only medical incidents classified as emergency are subject to NFPA 1710 travel time objectives. Medical emergencies constitute 94% of all medical incidents in the CAD data. The remaining 6% of medical incidents are "Medical:Assist" and "Medical:PAD Alarm", which are not subject to NFPA 1710 travel time objectives.



Map 20: Total Fire Suppression Incidents per First-Due District, 2016 - 2018. Map 20 shows the total fire suppression incidents per first-due district for the three-year period. The most fire suppression incidents occurred within First-Due District 1 followed by First-Due District 2. After a frontline suppression apparatus was removed from Station 1, all other OFS stations have increased their frequency of response to fires occurring within Station 1's first-due district. Station 2 sends more responding units to fires occurring in First-Due District 1 than any other station. Total fire suppression incident counts for each first-due district are indicated on the map.

From 2016 to 2018 a single fire suppression incident within Oshawa required the response of an average of 2.7 OFS units. First-Due District 1 was consistent with that average (only slightly higher 2.8 responses per fire suppression incident), however, as shown in Map 20, the occurrence of fire suppression incidents was more frequent than in other first-due districts. Consequently, Station 1's first-due district has a higher frequency of incidents that require more suppression units than are available at Station 1, resulting in a greater reliance upon outside units to respond within First-Due District 1. Inevitably, removal of a frontline suppression apparatus from Station 1 in April of 2017, coupled with increasing demand, increased reliance on outside units. The CAD data shows that all other OFS stations have had to increase the frequency of sending units to respond to fires in First-Due District 1 and that Station 2 sends the most units. This is likely to increase the number of incidents where the first arriving unit on scene is dispatched from outside of First-Due District 1, therefore causing longer response times.

Map 21 shows the volume of emergency medical incidents that occurred in each first-due district. As with fire suppression incidents, the most emergency medical incidents occurred within First-Due District 1.



Map 21: Total Emergency Medical Incidents, per First-Due District, 2016 – 2018. Map 21 shows the total emergency medical incidents per first-due district for the three-year study period. Total emergency medical incident counts for each first-due district are indicated on the map. The most emergency medical incidents, 1,795, occurred within First-Due District 1, more than double the volume of the next busiest first-due district, First-Due District 2. After a frontline suppression apparatus was removed from Station 1, units from other stations had to increase responses into Station 1's first-due area. Non-first-due units typically have to travel farther distances and have greater response times than first-due units. Seconds of delay may be critical to the survival of a citizen experiencing a medical emergency.

During the three-year study period, 42.2% of all emergency medical incidents in Oshawa occurred within First-Due District 1. Emergency medical incidents occurring in Oshawa rarely require the response of multiple OFS units. Considering this fact, looking at the number of responses from non-Station 1 units into First-Due District 1 is particularly helpful. When examining responses to emergency medical incidents occurring within First-Due District 1 it is evident that demand has increased as available resources at Station 1 have been reduced. Consequently, reliance on units from other stations to respond in to First-Due District 1 has increased. As with fires, it is critical that the first unit arrive on scene rapidly, with a travel time of four minutes or less. On average, units traveling greater distances have longer travel times.

Chart 18 examines responses to fire suppression or emergency medical incidents into First-Due District 1. Chart 18 shows that, from 2016 to 2018, as emergency incident volume has increased, responses by Station 1 units have not increased, while responses from other stations have increased. From 2016 to 2018 responses by non-Station 1 units to these types of incidents in First-Due District 1 have increased by 85.4%. Non-first-due units typically have to travel farther distances than first-due units. Additionally, when units frequently respond outside of their own first-due districts, delays to response to incidents occurring within their own first-due districts are more likely.

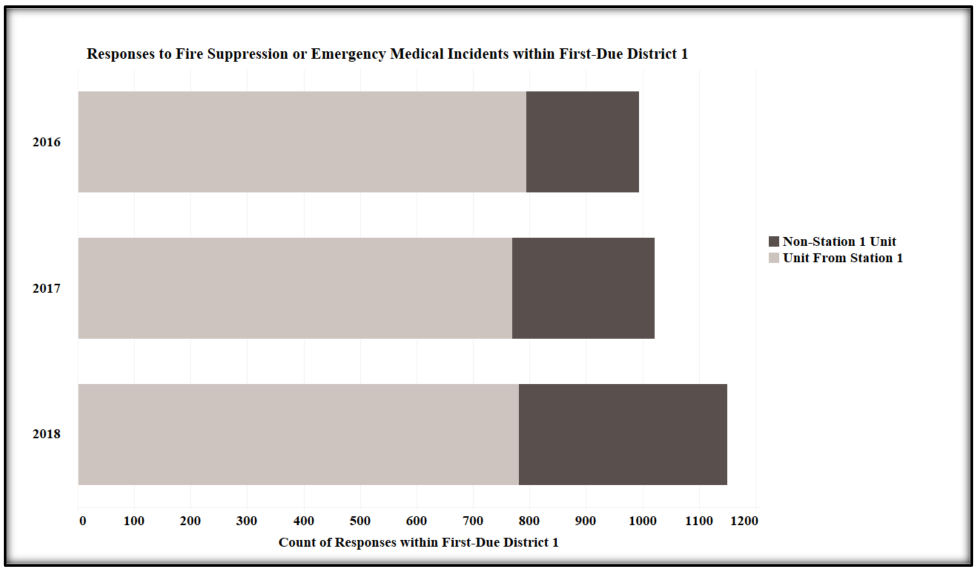


Chart 18: Responses to Fire Suppression or Emergency Medical Incidents within First-Due District 1.[126] This chart shows the number of responses to fire suppression or emergency medical incidents that occurred within First-Due District 1 during 2016, 2017 and 2018. The shading indicates if the response came from a Station 1 unit (light grey), or an outside unit (dark grey). Note that the volume of total responses to incidents of these types into First-Due District 1 from outside units increased after the frontline suppression apparatus was removed from Station 1. The increased reliance on outside units resulted in higher travel times. Outside units had, on average, one minute, 28 second longer travel times.

[126] Individual breakdown of Station 1 unit responses (light grey) shows that Pumper 21 accounted for 53.3% of responses in 2016, 93.8% of responses in 2017, and 99.9% of responses in 2018.

In order to reduce the number of incidents requiring a unit from a different first-due district and, as a result, reduce response times, OFS should staff an additional all-hazards response capable apparatus in Station 1, which is in the area of the city with the highest concentration of incidents.

Chart 19 illustrates the percentage of those responses by outside units (the dark grey shading in Chart 18) that were the first arriving unit on scene at a fire suppression or emergency medical incident. Chart 19 indicates that the percentage of responses by outside units into First-Due District 1 that were the first arriving unit on scene (blue shading) increased each year. By 2018 one third of all non-Station 1 responding units to fires or medical emergencies were the first to arrive on scene.

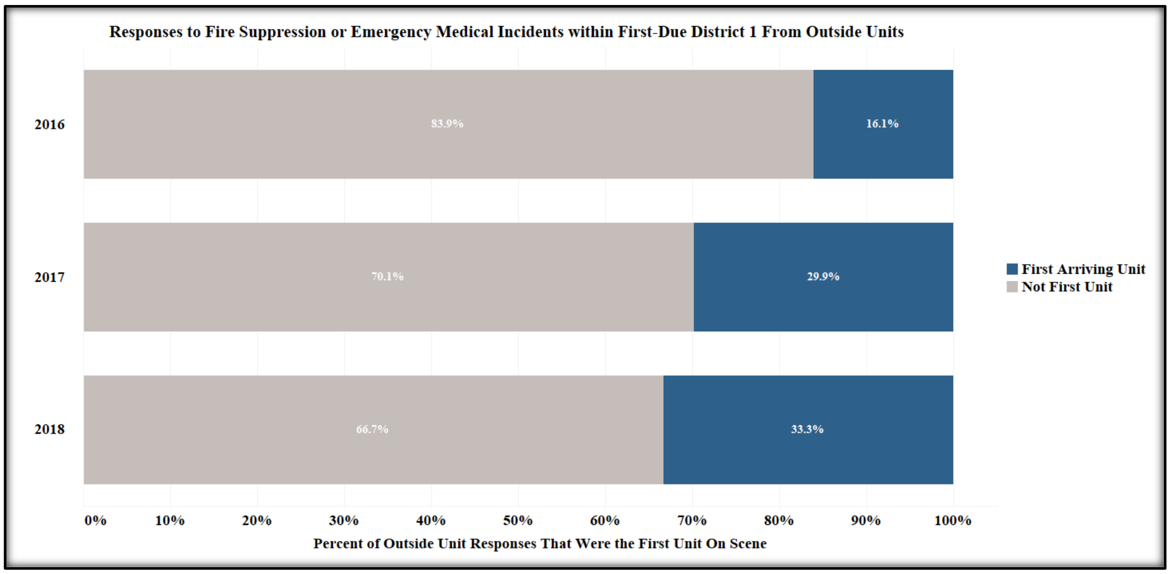


Chart 19: Responses to Fire Suppression or Emergency Medical Incidents within First-Due District 1 From Outside Units. This chart considers only the responses made by non-Station 1 units into First-Due District 1, for 2016, 2017 and 2018. The percentage of such responses where the non-Station 1 unit was the first unit to arrive on scene is indicated in blue shading. These results show that after a frontline suppression apparatus was removed from Station 1 the percentage of these responses increased. In 2018, one third of all outside unit responses were the first arriving unit. Outside units responding to these types of incidents inside of First-Due District 1 had, on average, one minute, 28 seconds longer travel times.

In Oshawa, Station 1's first-due district each year has the highest volume of overall incidents, fire suppression incidents, and emergency medical incidents, and this volume continues to grow each year. The reduction to Station 1's emergency response capabilities in 2017 occurred within this context. The CAD data from 2016 to 2018 shows an increase of the volume of responses from non-Station 1 units into Station 1's first-due district, and also shows that an increasing percentage of units that are the first to arrive on scene are from other stations. Non-first-due units, on average, have to travel greater distances and have longer response times. This negatively affected OFS performance. After the frontline suppression apparatus was removed from Station 1, First-Due District 1 experienced a greater number of incidents where the first arriving apparatus did not meet NFPA 1710 travel time objectives.

The Travel Time Analysis section will show that Station 1's first-due district had the highest number of incidents where the first arriving apparatus did not meet NFPA 1710 travel time objectives. All such cases are failures of OFS to meet demand in a manner prescribed in industry standards. In order to meet demand and reduce response times to all types of emergencies, and increase the safety of the community, OFS needs to staff an additional all-hazards response capable apparatus in Station 1.

Travel Time Analysis [127] [128] [129]

The travel time analysis examined the en route and arrival on scene times included in the CAD data to calculate the travel times for apparatus responding to fire suppression and emergency medical incidents.[130] NFPA 1710 requires a travel time of four minutes (240 seconds) or less to 90% of fire suppression incidents for the first arriving engine company, and a travel time of six minutes (360 seconds) or less to 90% of fire suppression incidents for the second arriving suppression company. BLS capable units are also required to achieve a four-minute or less travel time to 90% of emergency medical incidents.

As stated above, NFPA 1710 requires a travel time of 240 seconds or less for the arrival of the first arriving suppression company at a fire suppression incident, identified in the CAD data by the Fire/Explosion designation. OFS did not meet this travel time objective during the three-year study period. From 2016 to 2018, for fire suppression incidents, the 90th percentile travel time of first arriving suppression company was six minutes each year. Also, as stated above, NFPA 1710 requires a travel time of 360 seconds or less for the arrival of the second arriving suppression company at a fire suppression incident. OFS did meet this travel time objective

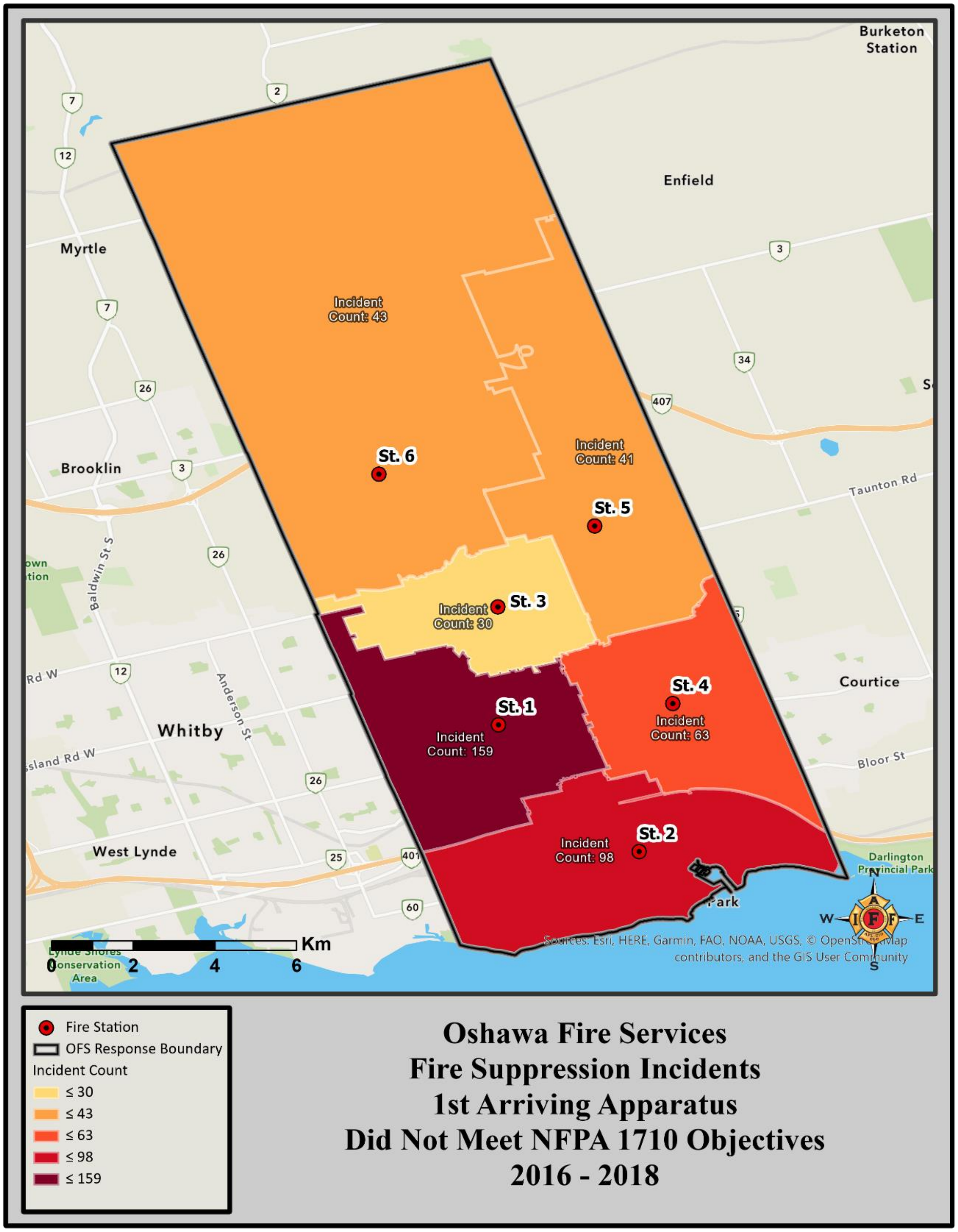
[127] This analysis excluded CAD entries where the en route and/or arrival on scene times are missing or inaccurately reported (24.2% of entries), as well as incidents that where the location was outside of Oshawa city limits or inaccurately reported (0.9%).
[128] Travel time analysis for fire suppression incidents only considers incidents classified in the CAD data as "Fire/Explosion:Structural" and "Fire/Explosion:Non-Structural".
[129] Travel time analysis for emergency medical incidents only considers incidents classified in the CAD data as "Medical:Emergency". Medical incidents that are classified as "Medical:Assist" and "Medical:PAD Alarm" are excluded from this analysis.
[130] The timestamps reported in the CAD data for 2016, 2017 and 2018 reported only month, day, year, hour of the day, and minute corresponding to each event. Seconds were not reported. The travel time analysis performed by the IAFF is limited by the fact that the time stamps provided in the CAD files made available to the IAFF specify only hour of the day and minutes, but not seconds (for example: 12:30:00). The IAFF is not aware if these times are rounded to the nearest whole minute or if the seconds are just dropped. For example, if a unit arrives on scene at 12:30:50 the time stamp could be reported as 12:30:00 or rounded to 12:31:00. In the absence of this information, there is a 60 seconds uncertainty on the time stamps. This caveat should be kept in mind, as it may affect interpretation of analysis results.

during the three-year study period. From 2016 to 2018, for fire suppression incidents, the 90th percentile of the second arriving suppression company was six minutes each year.

Additionally, as stated above, NFPA 1710 requires a travel time of 240 seconds or less for the arrival of a BLS capable unit at an emergency medical incident, identified in the CAD data by the Medical:Emergency designation. OFS did meet this travel time objective in 2017 when the 90th percentile was four minutes. However, OFS did not meet this travel time objective in 2016 and 2018 when the 90th percentile was five minutes.

The increasing volume of calls will decrease the likelihood of meeting the NFPA 1710 travel time objectives unless the proper resources are added to meet the increasing demand.

Map 22 depicts, by volume per first-due district, fire suppression incidents where the travel time of the first arriving unit exceeded four minutes for 2016, 2017, 2018. During this time period, for fire suppression incidents throughout Oshawa, the first arriving unit had a travel time of greater than four minutes 22.5% of the time. First-Due District 1 accounted for the highest percentage of these fires with 37% of them occurring within its boundary. First-Due Districts 1 and 2 together accounted for 59% of all cases. Reliance on non-first due units contributes to these failures as in Oshawa, first arriving units to fires that were non-first due units had an average travel time that was one minute, five seconds greater than first-due units.



Map 22: Fire Suppression Incidents, 1st Arriving Apparatus Did Not Meet NFPA 1710 Objectives, 2016 – 2018. Map 22 classifies first-due districts according to the number of fire suppression incidents where the first arriving suppression apparatus had a travel time of greater than four minutes during the 3-year period. Each first-due district is labeled with the total number of such incidents that occurred in that first-due district. First-Due District 1 had the greatest number of these incidents, and the frequency increased when a frontline suppression apparatus was removed from Station 1. Delays to response increase the likelihood of injury or death of firefighters and citizens.

Map 22, however, does not tell the full story. Chart 20 below shows the year-to-year progression, per first-due district, of fire suppression incidents where the travel time of the first arriving suppression apparatus exceeded four minutes. An increase of such instances occurred in First-Due District 1 in 2018. This increase reinforces findings from this workload analysis that after the removal of a frontline apparatus from Station 1, other stations had to increase responses into Station 1's first-due district, that these non-first due units were increasingly the first to arrive on scene, and that typically non-first-due units had greater response times than first-due units. OFS should add additional fire suppression resources to areas that are experiencing high volumes of fires where the first arriving units exceed NFPA 1710 travel time objectives. First-Due District 1 has the highest frequency of such fires.

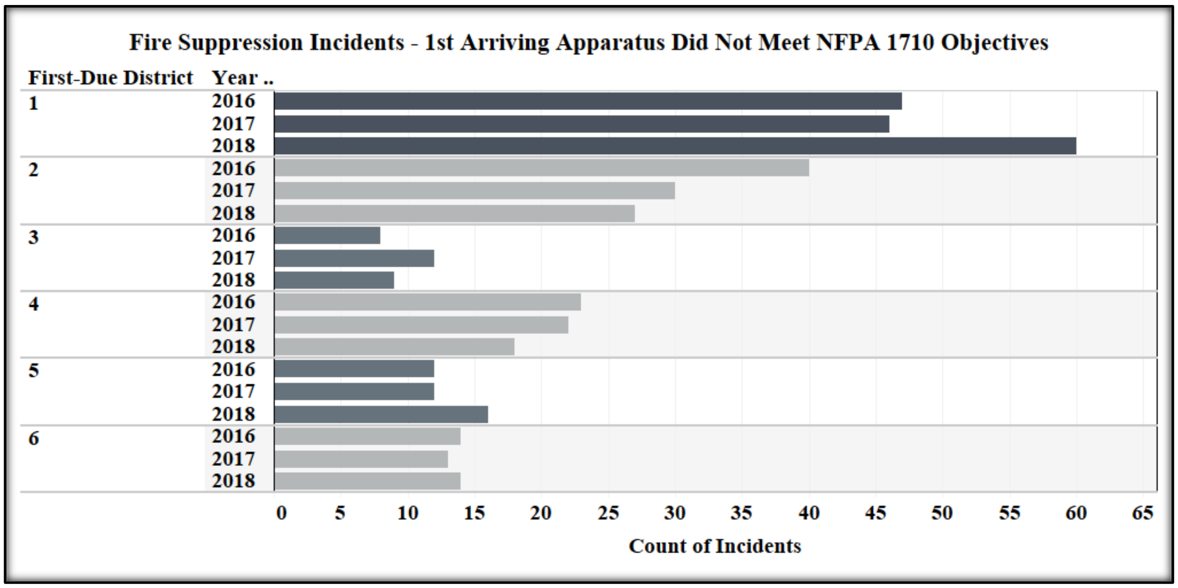
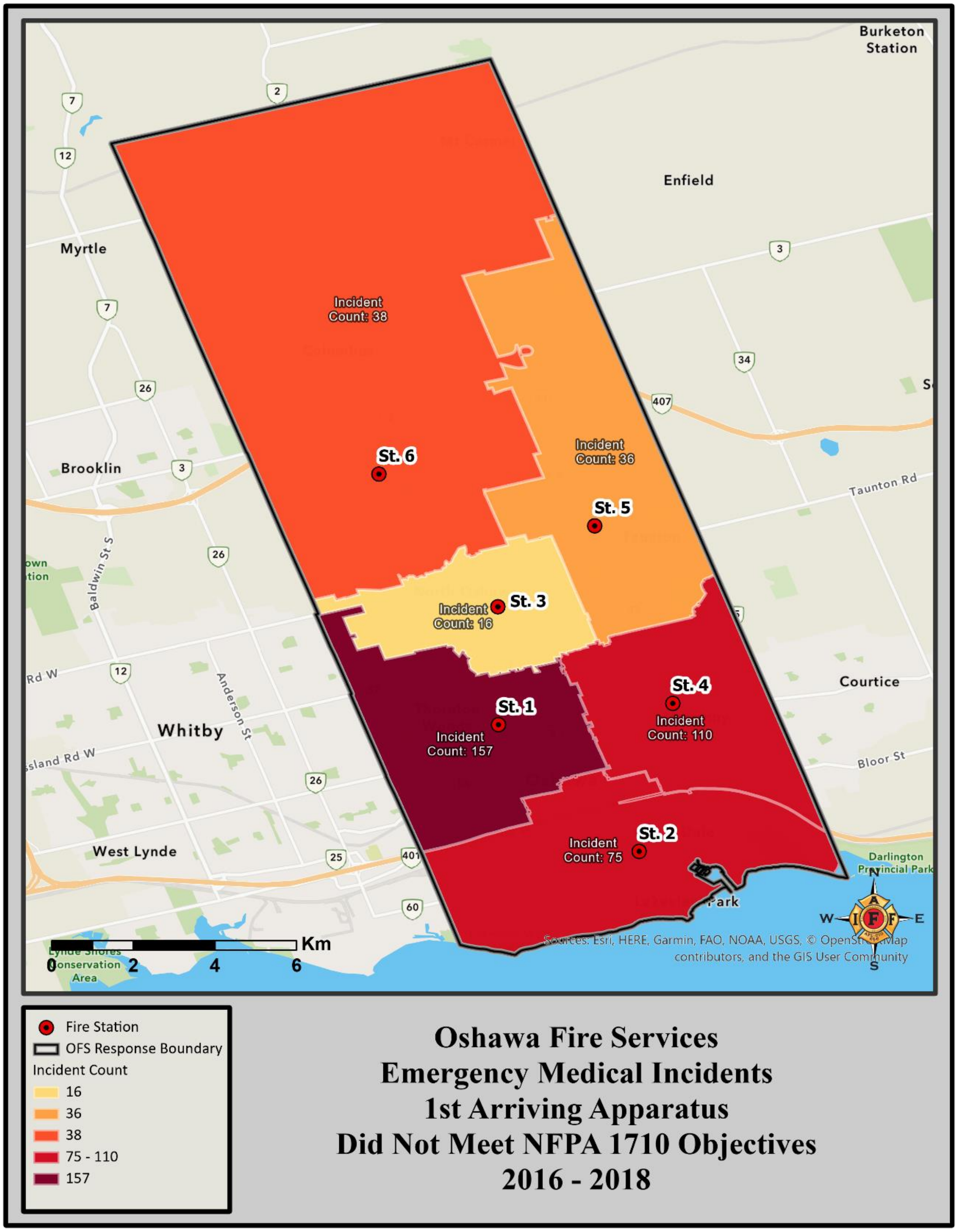


Chart 20: Fire Suppression Incidents – 1st Arriving Apparatus Did Not Meet NFPA 1710 Objectives. This chart shows the volume of fire suppression incidents where the first arriving suppression apparatus had a travel time of greater than four minutes, per first-due district, per year. These incidents increased in First-Due District 1 after a frontline suppression apparatus was removed from Station 1. Station 1 had to rely on more units responding from other stations into its first-due district. Non-first-due units typically have to travel farther distances to arrive on scene and have longer response times.

Map 23 depicts, by volume per first-due district, emergency medical incidents where the travel time of the first arriving unit exceeded four minutes for 2016, 2017, 2018. During this time period, for emergency medical incidents, the first arriving unit had a travel time of greater than four minutes 10.9% of the time. First-Due District 1 accounted for the highest percentage of these medical emergencies with 36.3% of them occurring within its boundary. First-Due Districts 1 and 4 together accounted for 61.8% of all cases.



Map 23: Emergency Medical Incidents, 1st Arriving Apparatus Did Not Meet NFPA 1710 Objectives, 2016 – 2018. Map 23 classifies first-due districts according to the number of emergency medical incidents where the first arriving apparatus had a travel time of greater than four minutes during the 3-year period. First-Due District 1 had the greatest number of these incidents, more than double that of the second highest, and frequency increased when a frontline suppression apparatus was removed from Station 1. After April of 2017 Station 1 had to rely on an increasing number of responding units from other stations into its first-due district. Each first-due district is labeled with the total number of such incidents that occurred in that first-due district.

As with the previous discussion of fire suppression incidents, the data displayed in Map 23 can be dissected to reveal year-to-year changes, per first-due district, of the volume of emergency medical incidents where the travel time of the first arriving apparatus exceeded four minutes. An increase in the volume of such medical emergencies occuring within Station 1's first-due district is evident in Chart 21. A fact of particular note is that in 2016 20% of all medical emergencies in Oshawa where the travel time of the first arriving apparatus exceeded four minutes were located in First-Due District 1. In 2017 when Station 1 response capacity was reduced, this proportion rose to 42% and was 40% in 2018. Again, as with fire suppression incidents, it is not unexpected that an increase of medical emergencies where the travel time of initial arriving units exceeded NFPA 1710 travel time objectives ooccurred within Station 1's first-due district.

When Station 1 response capabilities were reduced, instances of first arriving apparatus being non-Station 1 apparatus have increased. At the same time, this situation has been worsened by the overall call volume increase observed in Oshawa: resources were reduced where the demand was increasing, decreasing the efficiency of the OFS and the safety of the citizens of Oshawa. Between 2016 and 2018 total call volume for Station 1's first-due district increased by 12.3%, and for OFS overall increased by 10.6%. When first-due units are unavailable to respond, units from other first-due districts typically have to travel farther distances to arrive on scene, resulting in longer travel times. OFS should add additional multi-hazard response capable apparatus to areas that are experiencing high volumes of incidents where the first arriving units exceed NFPA 1710 travel time objectives. This is particularly urgent in Station 1's first-due district.

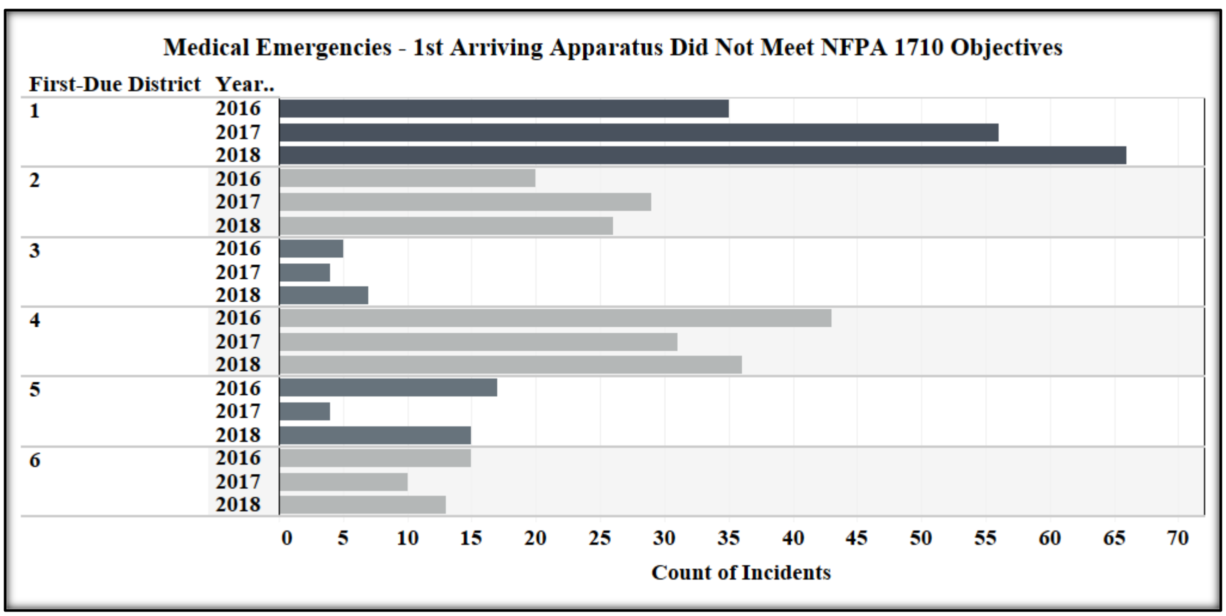


Chart 21: Medical Emergencies - 1st Arriving Apparatus Did Not Meet NFPA 1710 Objectives. This chart shows the volume of emergency medical incidents where the first arriving apparatus had a travel time of greater than four minutes, per first-due district, per year. Station 1's first-due district had more such medical emergencies than any other.

The following chart considers the travel time of the first arriving unit at the scene of fire and emergency medical incidents, for cases where the first-arriving unit was the first-due unit and for cases where a non-first-due unit was the first on scene. It is evident in the chart that outside units tend to have longer travel times: the average travel time was 60 seconds longer than the average travel time for first-due units, and the 90th percentile travel time was 60 longer. As discussed in this report, delays of even a few seconds can have a negative impact on the outcome of medical and fire emergencies, creating a significant risk for the community.

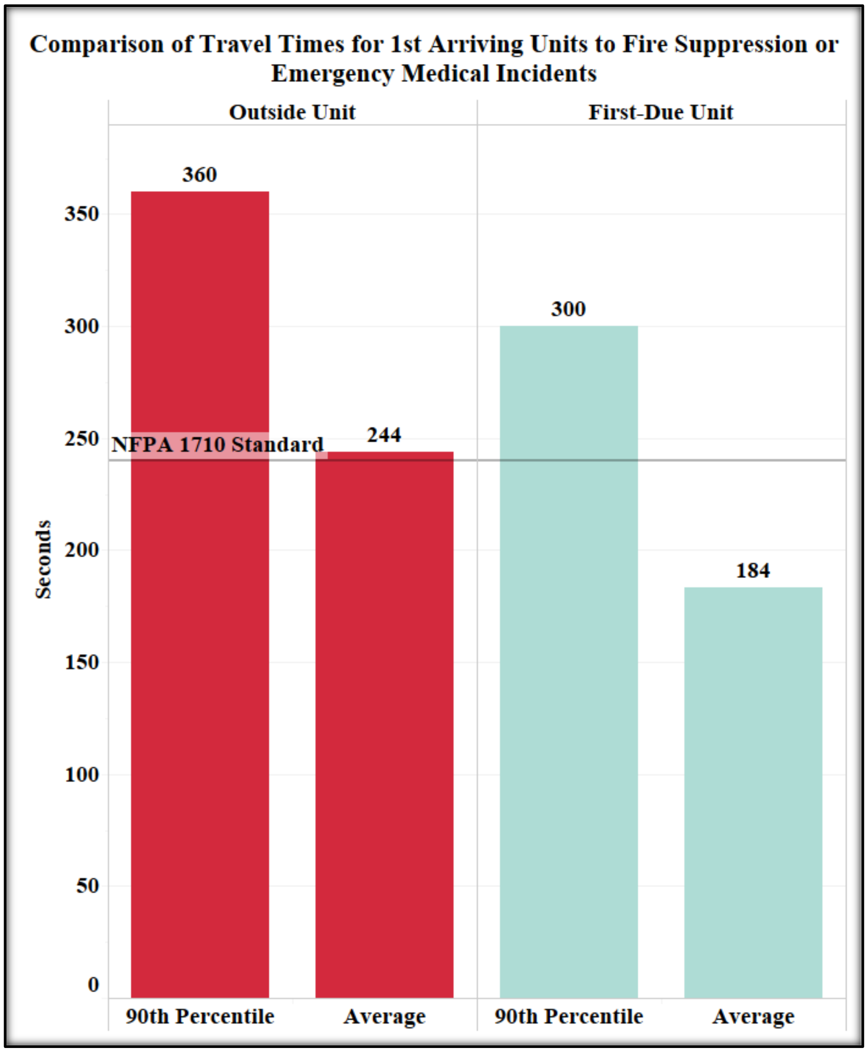


Chart 22: Comparison of Travel Times for 1st Arriving Units to Fire Suppression or Emergency Medical Incidents. This chart compares the 90th percentile and average travel times of the first arriving apparatus to fire suppression or emergency medical incidents, between outside units and first-due units throughout Oshawa, from 2016 to 2018. The average travel times of non-first-due units were 60 seconds longer than for first-due units, and the 90th percentile travel time was 60 seconds longer. After removal of a frontline suppression apparatus from Station 1, Station 1 had to increasingly rely on units from other stations to respond in its first-due district, and these outside units were increasingly the first to arrive at a fire or medical emergency.

The findings in this travel time discussion show that OFS is not able to meet NFPA 1710 travel time objectives for a safe and timely response. The observed increasing demand throughout Oshawa is likely to cause even longer response times, as the same number of units will have to address an increasing number of calls. Especially in Station 1's first-due district, the number of incidents where the travel time of the first arriving unit exceeded 4 minutes has been increasing. Station 1 has had to rely more on units responding from other stations. With the increase in demand for all types of incidents, especially in the area of Station 1, it will be crucial for OFS to staff at least one additional multi-hazard response capable apparatus in Station 1. Incident volume in Oshawa is increasing as the population grows, and, the additional staffed apparatus is necessary in order to reduce response times and improve the safety of the citizens of Oshawa, and increase the likelihood that, when needed, the victims of emergencies will receive a response from an OFS unit within a safe time.

Recommended Minimum Staffing Levels

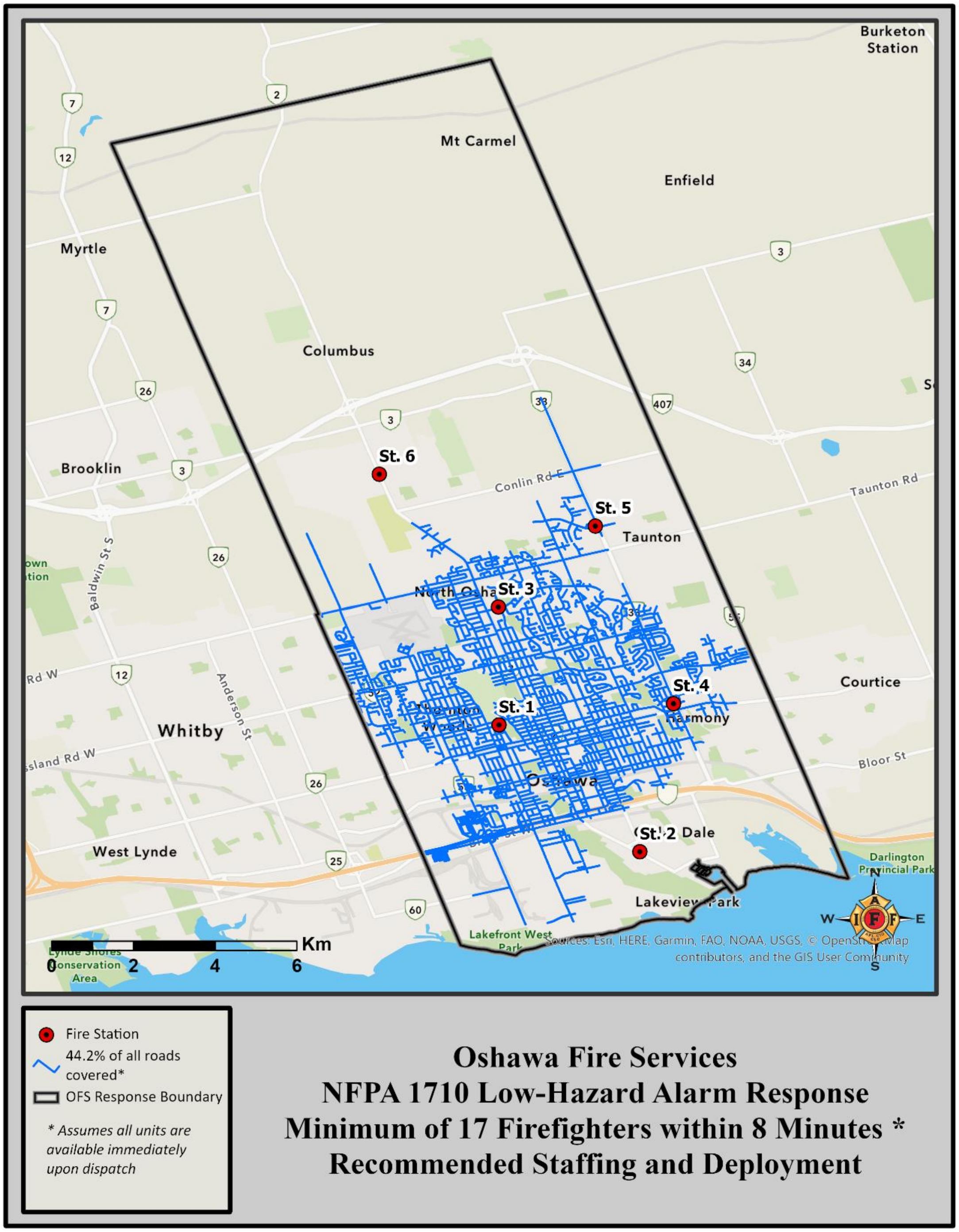
Additional staffing is required in order to bring OFS closer to meeting industry staffing and performance objectives and to allow for safer and more effective firefighting operations. An additional multi-hazard response capable vehicle, specifically a fire suppression apparatus, staffed with a minimum of four firefighters at all times, is recommended at Station 1. This recommendation is based on the findings of the OFS Workload Analysis and the OFS Mapping Analysis. As reported in the OFS Workload Analysis, from 2016 to 2018, OFS units spent more time operating on scene at fire suppression incidents than any other type of incident, by a wide margin. Additionally, OFS units spent the more time on-scene at incidents occurring within Station 1's first-due district than any other first-due district. After a frontline fire suppression apparatus was removed from Station 1 in April of 2017, other stations had to increase responses into Station 1's first-due area, and response times increased.

The level of demand present in Station 1's first-due can be serviced in a more timely, efficient and effective manner if additional fire suppression capabilities are added to Station 1.

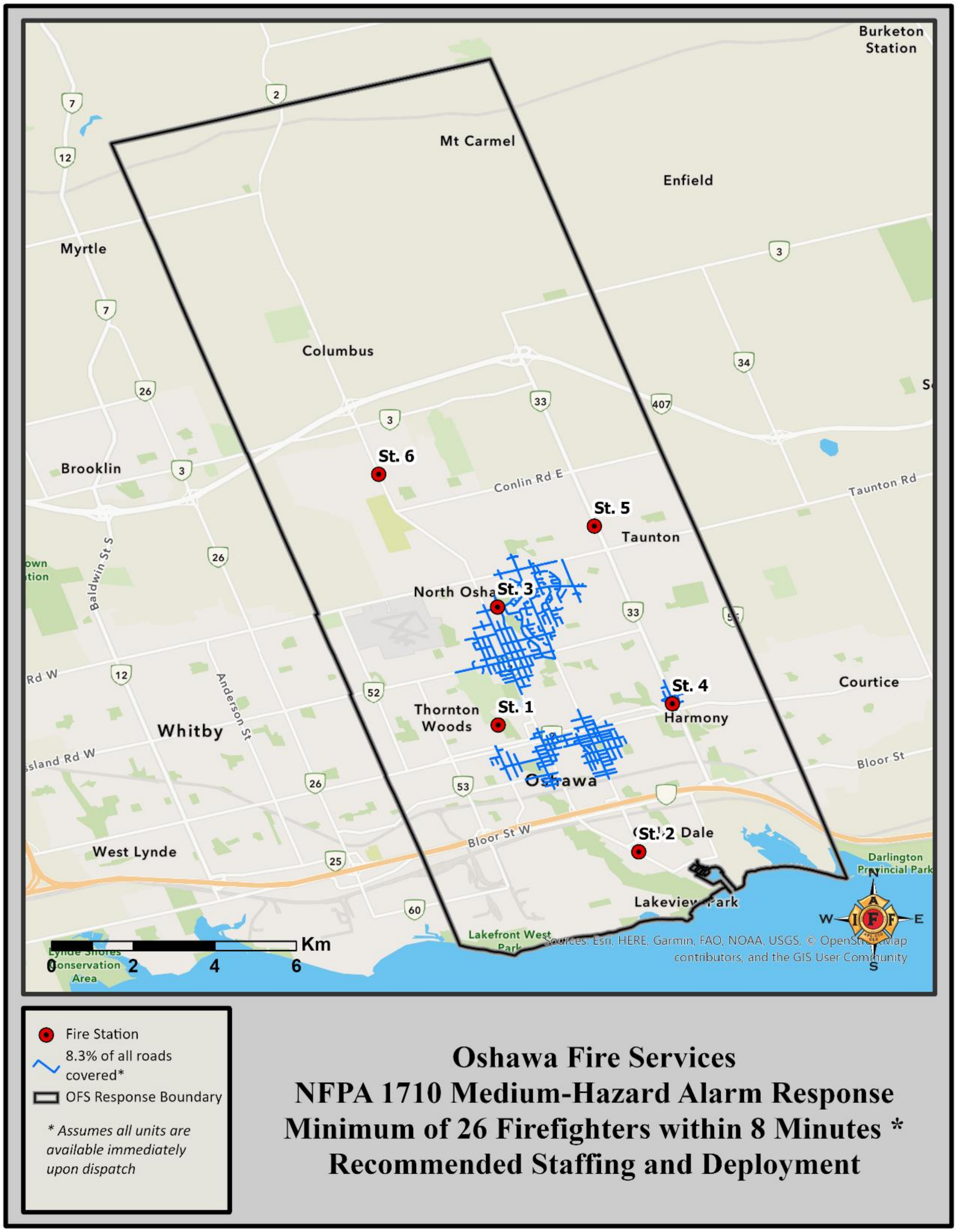
Station	Address	Apparatus	Typical Staffing
1	199 Adelaide Avenue West	Pumper 21 *Pumper* Car 25	**3 Firefighters (FF), 1 Captain** ***4 FF*** **1 Platoon Chief**
2	1111 Simcoe Street South	Pumper 22 Aerial 22	**3 FF, 1 Captain** **3 FF, 1 Captain**
3	50 Beatrice Street East	Pumper 23 Aerial 23	**3 FF, 1 Captain** **3 FF, 1 Captain**
4	50 Harmony Road North	Pumper 24	**3 FF, 1 Captain**
5	1550 Harmony Road North	Pumper 25 Rescue 25	**3 FF, 1 Captain** **Cross-staffed**
6	2339 Simcoe Street North	Pumper 26 Tanker 26	**3 FF, 1 Captain** **Cross-staffed**

Table 9: Recommended Minimum Staffing and Deployment Levels. The above table displays where apparatus would be housed and the recommended minimum staffing for each apparatus.

The following GIS maps present the anticipated response capabilities analysis of OFS pursuant to implementation of the staffing and deployment configuration described in Table 9 above.



Map 24: NFPA 1710 Low-Hazard Alarm Response, Minimum of 17 Firefighters within 8 Minutes, Recommended Staffing and Deployment. Map 24 identifies those roads where a minimum of 17 firefighters will likely be able assemble on scene within eight minutes if additional suppression apparatus and personnel are deployed as recommended in Station 1. Pursuant to this scenario, OFS will likely be capable of assembling at least 17 firefighters on 44.2% of roads within the Oshawa within eight minutes. This translates to a 29.2% ***increase*** in response capabilities above existing conditions. This would increase the area where OFS would be capable of assembling an initial full alarm assignment to a 186 m^2 single-family dwelling within eight minutes.



Map 25: NFPA 1710 Medium-Hazard Alarm Response, Minimum of 26 Firefighters within 8 Minutes, Recommended Staffing and Deployment. Map 25 identifies those roads where a minimum of 26 firefighters will likely be able assemble on scene within eight minutes if additional suppression apparatus and personnel are deployed as recommended in Station 1. Pursuant to this scenario, OFS will likely be capable of assembling at least 26 firefighters on 8.3% of roads within Oshawa within eight minutes. This translates to a 3,662% ***increase*** in response capabilities above existing conditions.

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Conclusion

In conclusion, regardless of the type of response, despite staffing suppression apparatus with four firefighters each, which is the minimum number required for efficient and effective fireground operations, Oshawa Fire Services does not have an adequate number of firefighters per shift or an adequate number of staffed apparatus to provide emergency response that meets the objectives of industry standards for safe, efficient, and effective response to fires, medical emergencies, or rescue situations.

Station 1 response capacity was reduced, and Station 1 was faced with the task of responding to the area with the highest focus of demand in Oshawa, and an area whose demand is growing at a faster rate than the rest of the city, with less resources. That demand had to be serviced by other stations. Unfortunately, units from other stations had longer travel times – one minute, seven seconds longer than Station 1 units. Delays of even seconds can change the outcome of an emergency.

Under current staffing conditions, only 61.2% of roads are served by four firefighters assembling on the scene of a fire within four minutes. Dispatch data indicate that from 2016 to 2018, 23.1% of fire suppression incidents had a first arriving suppression company that had a travel time of greater than four minutes. Out of those fires, more than one third were located within Station 1's first-due district, Oshawa's busiest, indicating that additional staffed suppression apparatus are needed. Furthermore, when first arriving units at fires or emergency medical incidents are responding outside of their own first-due districts, average travel times are 60 seconds longer and 90th percentile travel times are 60 seconds longer. After a frontline suppression apparatus was removed from Station 1, instances of fires and emergency medical incidents where the first arriving apparatus had a travel time greater than four minutes increased. These findings underscore the need for additional staffed suppression equipped to respond to multiple hazards.

Increasing the amount of staffed suppression apparatus will also likely increase the ability of OFS to assemble an effective response force to fires occurring in low-, or medium -hazard occupancies as directed by NFPA 1710. Under current staffing conditions, OFS can only respond with 17 firefighters to a low-hazard structure fire within eight minutes travel on 34.2% of roads, and with 26 firefighters to a medium-hazard structure fire within eight minutes travel on 0.2% of roads. OFS does not have a sufficient number of firefighters to respond with 39 firefighters to any high-hazard structure in Oshawa.

Deficiencies in staffing and apparatus utilization contribute to delays in response to emergencies in Oshawa. Response delays are likely to increase as resources have been decreased in Oshawa's downtown, the area with the highest demand, while the city continues to grow. Oddly, while growth is promoted in Oshawa's downtown, emergency resources available to respond downtown have been reduced. The historical data suggest that additional suppression apparatus are needed at Station 1, rather than additional stations, due to the high demand, and increasing response times in Station 1's first-due area. It is essential that service resources are able to meet demand. OFS' current insufficiencies indicate the need for additional resources. As resources become scarce as demand increases, performance will worsen. When units are forced to respond outside of their own first-due districts, lack of resources in the most problematic areas is transferred to areas thought to have adequate resources. This increases the risk of death or injury due to fire for both citizens and firefighters of Oshawa. It also increases the risk of considerable property loss for housing units and businesses in many areas of the city, even outside of the areas with the highest demand.

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

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

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

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Appendix

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 service arrival time, staffing levels, and fireground responsibilities.[131]

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

- **4.1.2.1** The fire department shall establish the following performance objectives for the first-due response zones that are identified by the AHJ:
  - (3) 240 seconds or less travel time for the arrival of the first engine company at a fire suppression incident[132]
  - (4) 360 seconds or less travel time for the arrival of the second company with a minimum staffing of 4 personnel at a fire suppression incident
  - (5) For other than high-rise, 480 seconds or less travel time for the deployment of an initial full alarm assignment at a fire suppression incident
  - (6) For high-rise, 610 seconds or less travel time for the deployment of an initial full alarm assignment at a fire suppression incident
  - (7) 240 seconds or less travel time for the arrival of a unit with first responder with automatic external defibrillator (AED) or higher-level capability at an emergency medical incident
  - (8) 480 second or less travel time for the arrival of an advanced life support (ALS) unit at an emergency incident, where this service is provided by the fire department provided a first responder with an AED or basic life support (BLS) unite arrived in 240 seconds or less travel time.
- **4.3.2** The fire department organizational statement shall ensure that the fire department's emergency medical response capability includes personnel, equipment, and resources to deploy at the first responder level with AED or higher treatment level.

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

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

- **5.2. 3.1 Engine Companies.** Fire companies, whose primary functions are to pump and deliver water and perform basic firefighting at fires, including search and rescue, shall be known as engine companies shall be staffed with a minimum of four on-duty personnel.
    - 5.2.3.1.1 These companies shall be staffed with a minimum of four on-duty personnel.
    - 5.2.3.1.2 In first-due response zones with a high number of incidents, geographical restrictions, geographic isolation, or urban areas, as identified by the AHJ, these companies shall be staffed with a minimum of five on-duty members.
    - 5.2.3.1.2.1 In first-due response zones with tactical hazards, high-hazard occupancies, or dense urban areas, as identified by the AHJ, these fire companies shall be staffed with a minimum of six on-duty members.

- **5.2.3.2 Ladder/Truck Companies.** Fire companies whose primary functions are to perform the variety of services associated with truck work, such as forcible entry, ventilation, search and rescue, aerial operations for water delivery and rescue, utility control, illumination, overhaul and salvage work, shall be known as ladder or truck companies… shall be staffed with a minimum of four on-duty personnel.
    - 5.2.3.2.1 These companies shall be staffed with a minimum of four on-duty personnel.
    - 5.2.3.2.2 In first-due response zones with a high number of incidents, geographical restrictions, geographic isolation, or urban areas, as identified by the AHJ, these companies shall be staffed with a minimum of five on-duty members.
    - 5.2.3.2.2.1 In first-due response zones with tactical hazards, high-hazard occupancies, or dense urban areas, as identified by the AHJ, these fire companies shall be staffed with a minimum of six on-duty members.

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

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

Assignment	***Required Personnel***
Incident Command	1 Officer
Uninterrupted Water Supply	1 Pump Operator
Water Flow from Two Handlines	4 Firefighters (2 for each line)
Support for Handlines	2 Firefighters (1 for each line)
Victim Search and Rescue Team	2 Firefighters
Ventilation Team	2 Firefighters
Aerial Operator [133]	1 Firefighter
Initial Rapid Intervention Crew (IRIC)	4 Firefighters
Required Minimum Personnel for Full Alarm	**16 Firefighters & 1 Scene Commander**

[133] Even if an aerial device is not used, the use of a ground ladder requires one firefighter to maintain the ladder while personnel traverse the ladder and while crews operate on the roof.

- **5.2.4.2 Open-Air Strip Shopping Center Initial Full Alarm Assignment Capability**
    - 5.2.4.2.1 The initial full alarm assignment to a structure fire in a typical open-air strip shopping center ranging from 13,000 ft^2 to 196,000 ft^2 (1203 m^2 to 18,209 m^2) in size

And

- **5.2.4.3 Apartment Initial Full Alarm Assignment Capability**
    - 5.2.4.3.1 The initial full alarm assignment to a structure fire in a typical 1200 ft^2 (111 m^2) apartment within a three-storey, 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[134]	2 Firefighters
Required Minimum Personnel for Full Alarm	**27 Firefighters** **1 Incident Commander**

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

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

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

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