Station Optimization Study

Lincoln Fire & Rescue

September 2014

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Executive Summary

In an effort to maximize the use of existing personnel, a comprehensive study using state of the art geographical information system (GIS) technology was undertaken beginning in April 2011. Several concepts for consideration by the city elected officials were developed.

In the past, Lincoln fire stations were built on sites that were located in the general area where changes in service were indicated by city growth, response times to actual incidents, increased or anticipated calls for service or increased risk in the area. This method of locating fire stations on parcels of land designated for public use, or land that was available at little or no cost to the city has yielded an array of station locations that may not be the ideal location for rapid uniform response across the city.

The guiding principles of this effort are:

- follow fire and emergency medical services industry response standards
- Maintain accredited status through the achievement of established baselines and benchmarks as they pertain to travel time.
- develop a uniform service level for all street addresses within the city
- increase staffing on all engine and truck units to 4 person crews
- provide services with existing personnel resources
- consider future annexation areas
- focus primarily on travel distance and time
- consider community demographics if possible

This redeployment could provide for a reduction in response times utilizing fewer apparatus. In addition, through the reduction of apparatus the department could increase the staffing level on each apparatus from the current three or four personnel to a consistent level of four personnel. These changes in the LF&R response profile would be achieved through a more efficient geographical location of fire stations.

If a reduction in the number of apparatus and associated physical resources could be experienced through this concept, it would provide for increased efficiency an organizational goal of the department. Increasing the staffing levels on apparatus would bring LF&R into compliance with fire service industry national standards. A recent study completed by the National Institute of Standards and Technology (NIST) demonstrated increased efficiency and a decreased time frame for the completion of critical fire ground tasks when comparing four person versus three person staffing on engine and truck companies. In addition, the increase in staffing could correlate to an increase in safety as well for citizens and LF&R personnel alike.

An analysis of a four minute travel time to existing address points showed that LF&R could effectively respond to 87,306 of 87,853 address points within a four minute or less travel time if all fire stations were optimally located. This meant that per this study 99.38% of the current addresses within the City of Lincoln could be responded to by LF&R with a 4 minute or less travel time if all 14 stations were optimally located, compared to the coverage of 90.36% from the existing fire station locations. ***This would be an improvement of 9% in service by the department without increased staffing.***

LF&R

Optimum Station Project

Options Pros & Cons

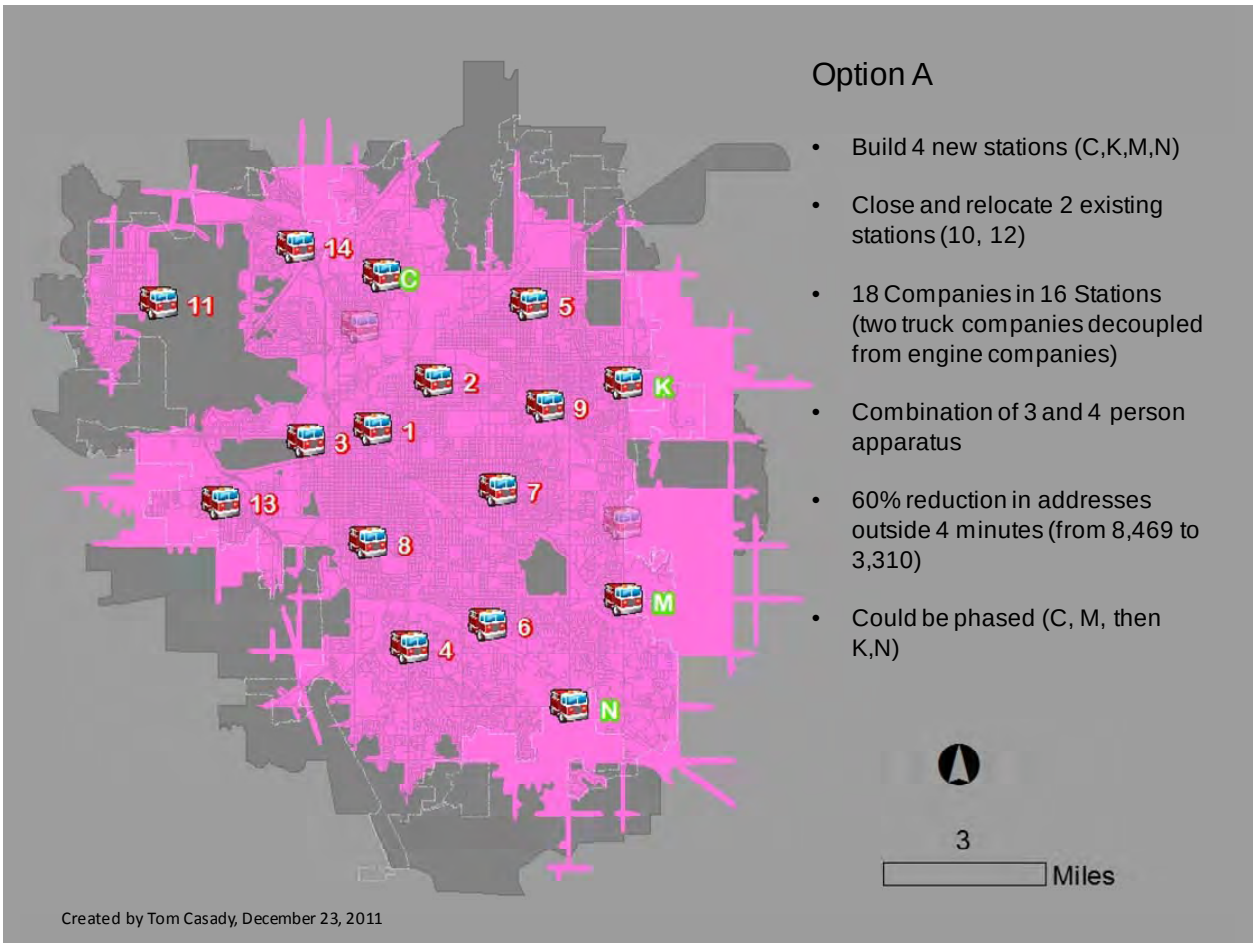
Option "A"

Pros

- Utilizes 2 ladder apparatus for first responder to EMS incidents
- Utilizes existing staffing from station 10 1440 Adams to staff a relocated station 10
- Utilizes existing staffing from station 12 2100 South 84th to staff a relocated station 12
- Utilizes existing truck company staffing from station 5 3640 Touzalin to staff new station 15
- Utilizes existing truck company staffing from station 7 1345 South Cotner to staff new station 16
- Relieves overcrowding of apparatus at station 7
- Greatest of the three options in terms of opportunity to meet existing and future service demand
- Greatest potential for enhancing first due coverage ability
- Increases the number of addresses to which LF&R can establish an effective response force per our established response time goal by 29.89%
- Increases the number of addresses to which LF&R can respond to within 4 minutes or less from 90.36% currently to 96.23%

Cons

- Construction of four new fire stations *(one more than current CIP*)
- Does not provide four personnel on all engine & ladder apparatus (8 -18 or 44% of Apparatus)


Option A
• Build 4 new stations (C,K,M,N)
• Close and relocate 2 existing stations (10, 12)
• 18 Companies in 16 Stations (two truck companies decoupled from engine companies)
• Combination of 3 and 4 person apparatus
• 60% reduction in addresses outside 4 minutes (from 8,469 to 3,310)
• Could be phased (C, M, then K,N)
14
C
11
5
2
K
9
3
1
7
13
8
M
6
4
N
3
Miles
Created by Tom Casady, December 23, 2011

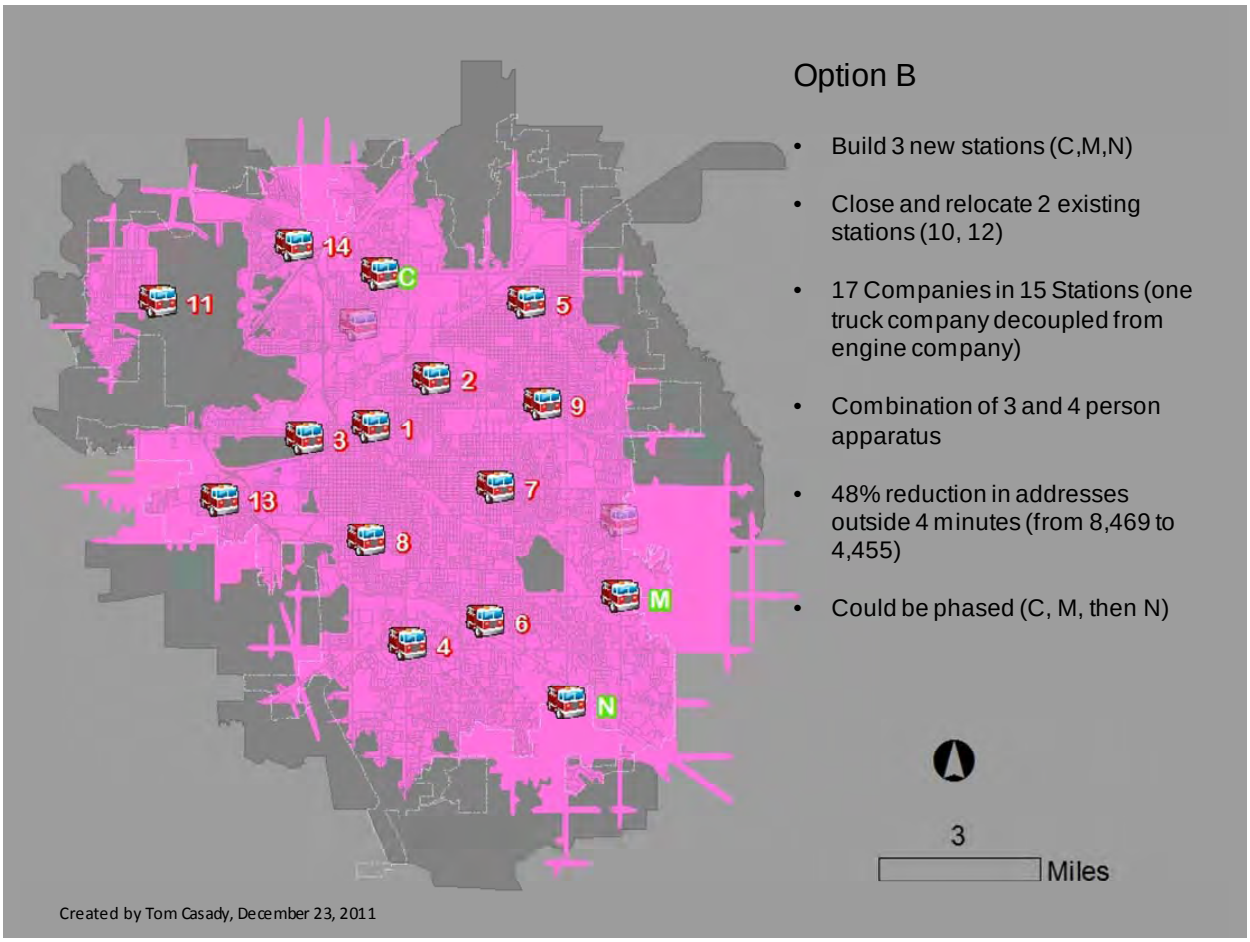
Option "B"

Pros

- Utilizes 1 ladder apparatus for first responder to EMS incidents
- Utilizes existing staffing from station 10 1440 Adams to staff a relocated station 10
- Utilizes existing staffing from station 12 2201 South 84th to staff a relocated station 12
- Utilizes existing truck company staffing from station 7 1345 South Cotner to staff new station 15
- Relieves overcrowding of apparatus at station 7
- Enhances first due response to the South East portion of the city
- Increases the number of addresses to which LF&R can establish an effective response force per our established response time goals by 18.27%
- Increases the number of addresses to which LF&R can respond to within 4 minutes or less from 90.36% currently to 94.92%

Cons

- Construction of three new fire stations *(same as current CIP)*
- Does not provide four personnel on all engine & ladder apparatus (11 of 17 or 64% of Apparatus)


Option B
• Build 3 new stations (C,M,N)
• Close and relocate 2 existing stations (10, 12)
• 17 Companies in 15 Stations (one truck company decoupled from engine company)
• Combination of 3 and 4 person apparatus
• 48% reduction in addresses outside 4 minutes (from 8,469 to 4,455)
• Could be phased (C, M, then N)
14
C
11
5
2
9
3
1
7
13
8
M
6
4
N
3
Miles
Created by Tom Casady, December 23, 2011

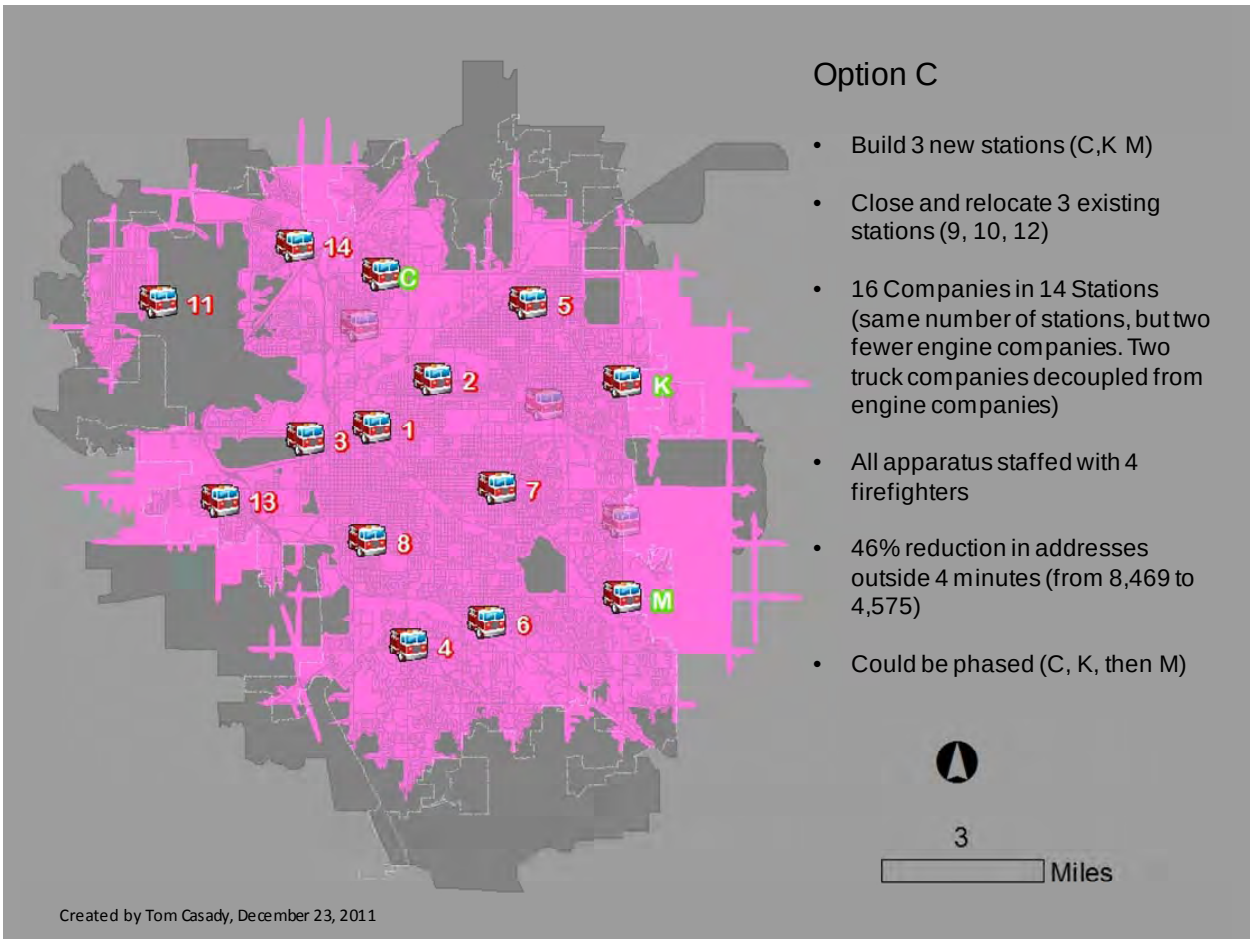
Option "C"

Pros

- Utilizes 2 ladder apparatus for first responder to EMS incidents
- Maximizes the efficiency of existing personnel
- Allows for 4 person staffing on all engine & ladder apparatus without increased personnel
- Fewer units responding for fire incidents to achieve effective fire force staffing level
- Reduced (improved) time of completion of critical fire ground tasks
- Utilizes existing staffing from station 10 1440 Adams to staff a relocated station 10
- Utilizes existing staffing from station 9 901 North Cotner to increase staffing city wide
- Utilizes existing staffing from station 12 2201 South 84th to increase staffing city wide
- Utilizes existing truck company staffing from Station 5 3640 Touzalin to staff a new station for EMS & fire response
- Utilizes existing truck company staffing from station 7 1345 South Cotner to staff a new station for EMS & fire response
- Relieves overcrowding of apparatus at station 7
- Enhances first due response to the East portion of the city and into the proposed growth area's
- Increases the number of addresses to which LF&R can establish an effective response force per our established response time goals by 26.99%
- Increases the number of addresses to which LF&R can respond to within 4 minutes or less from 90.36% currently to 94.78%

Cons

- Construction of three new fire stations *(same as current CIP)*
- Elimination of Station 9 901 North Cotner
- Elimination of Station 12 2201 South 84th
- Reduction in response area overlaps with an increased level of risk in not meeting response time goals


Option C
• Build 3 new stations (C,K M)
• Close and relocate 3 existing stations (9, 10, 12)
• 16 Companies in 14 Stations (same number of stations, but two fewer engine companies. Two truck companies decoupled from engine companies)
• All apparatus staffed with 4 firefighters
• 46% reduction in addresses outside 4 minutes (from 8,469 to 4,575)
• Could be phased (C, K, then M)
14
C
11
5
2
K
3
1
13
7
8
M
6
4
3
Miles
Created by Tom Casady, December 23, 2011

Introduction & Background

Lincoln Fire & Rescue provides an array of services, which include both non-emergency & emergency response to citizens' needs, and ambulance services as required by Chapter 2.20 (Fire Department), and Title 7.0 Ambulance Transportation Code of the Lincoln Municipal Code.

The department currently staffs 14 fire stations located across the city. During the history of our community, as the city has grown both by population and geography new stations have been proposed by the department in an effort to continue to meet the increased service demands of residents. The department monitors its fire suppression performance utilizing citizen feedback, unit response times, fire fatalities and fire damage costs in an ongoing effort to assure that loss is minimized. In addition to response times as required by municipal code, the department monitors its Emergency Medical Service (EMS) performance through methodology such as cardiac arrest saves, STEMI (ST segment elevation myocardial infarction) to treatment times, as well as stroke alert program performance.

Fire personnel are assigned to a 24-hour tour of duty (56 hours average workweek) at each fire station. This duty shift has proven to be highly cost effective in the fire service nationwide. Because each station is occupied continuously day in and day out, each station must be able to withstand this never-ending use. In addition, due to the 24-hour shift it is critical that employees have adequate facilities while on duty to assure that they are fit, trained and properly able to maintain their vehicles and equipment in a *constant state of readiness* to respond within seconds of dispatch from the 911 communications center. Adequate fire station facilities play a vital role in assuring that personnel, apparatus and equipment are ready to respond when needed for an emergency.

In the past, fire stations were built on sites that were located in the general area where changes in service were indicated by city growth, response times to actual incidents, increased or anticipated calls for service or increased risk in the area. This method of locating fire stations on parcels of land designated for public use, or land that was available at little or no cost to the city has yielded an array of station locations that may not be the ideal location.

In an effort to maximize the use of existing personnel, a comprehensive study using state of the art geographical information system (GIS) technology was undertaken beginning in April 2011.

Lincoln Fire & Rescue Chief John Huff directed Captain Julie Talero (GIS analyst) to develop a series of maps of the city of Lincoln with possible recommended locations for fire stations. The guiding principles of this effort:

- follow fire and emergency medical services industry response standards
- develop a uniform service level for all street addresses within the city
- increase staffing on all engine and truck units to 4 person crews
- provide services with existing personnel resources
- consider future annexation areas
- focus primarily on travel distance and time

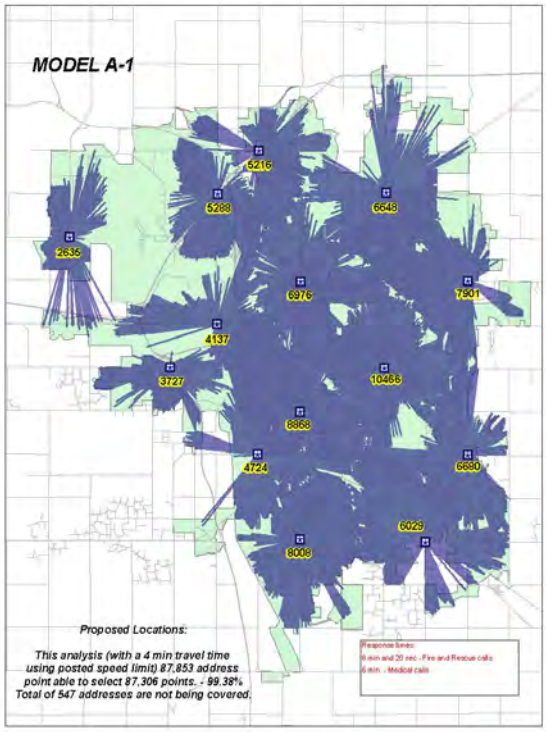
- consider community demographics if possible

In consultation with Dr. Juan Paul Ramirez (UNL), Jeff McReynolds (City of Lincoln GIS Manager) and others, Captain Julio Talero created GIS map points for 87,853 street addresses within the city of Lincoln incorporated city limits. The team was directed to identify 12-16 optimum fire station locations to provide a 4-minute or less response travel time to as many of the city addresses as possible utilizing a combination of current and new locations as identified by the data points.

In September of 2011, Captain Eric Jones LF&R Accreditation Manager and Captain Scott Wiebe EMS Supervisor were added to the effort to develop the supporting documentation. Both were instrumental in the development of the LF&R Standard of Coverage document developed for LF&R Commission on Fire Accreditation International (CFAI) accreditation and were very familiar with current fire service industry response standards. The first meeting of this expanded team was held in September of 2011. In attendance were Fire Chief John Huff, Battalion Chief Leo Benes, Battalion Chief Dean Staberg, LF&R GIS Analyst Captain Julio Talero, Captain Scott Wiebe, and Captain Eric Jones. Chief Huff described in detail a concept regarding the redeployment of physical and personnel resources. This redeployment could provide for a reduction in response times utilizing fewer apparatus. In addition, through the reduction of apparatus the department could increase the staffing level on each apparatus from the current 3/4 personnel to a consistent level of four personnel. These changes in the LF&R response profile would be achieved through a more efficient geographical location of fire stations. Chief Huff requested that the team develop several concepts for consideration by the city elected officials.

If a reduction in the number of apparatus and associated physical resources could be experienced through this concept, it would provide for increased efficiency, an organizational goal of the department. Operating cost savings and a budget reduction might be possible by eliminating the annual operating expenses for older less energy efficient stations being replaced by new facilities. Increasing the staffing levels on apparatus would bring LF&R into compliance with fire service industry national standards. A recent study completed by the National Institute of Standards and Technology (NIST) demonstrated increased efficiency and decreased time to critical tasks completion when four personnel versus three personnel are staffed on engine and truck companies. In addition, the increase in staffing could correlate to an increase in safety as well for citizens and LF&R personnel alike.

It was expressed in this meeting that the efforts to date in the optimal locating of fire stations was done through an analysis of a four minute travel time to existing address points. This data showed that LF&R could effectively respond to 87,306 of 87,853 existing address points within a four minute or less travel time if all stations were optimally located as geographically indicated on the following map. This meant that per this study 99.38% of the current addresses within the City of Lincoln could be responded to by LF&R with a 4 minute or less travel time, compared to the coverage of 90.36% from the existing locations. This would be an improvement of 9% in service by the department without increased staffing. The following map shows 14 fire station locations and the preliminary study.



The concept of increasing the staffing on apparatus would be accomplished through the elimination of two existing apparatus, with the personnel being reallocated to increase the number of personnel on all other apparatus, without adding new employees to the department's budget. For example, LF&R would remove from service two fire apparatus (engine or truck company) however; LF&R would maintain 14 (some relocated) fire stations.

Discussion at this initial meeting developed a unanimous conclusion; that determining optimal station location included much more research than the identification of address points within a four-minute travel time. Through research methods historically utilized through accreditation documents such as the LF&R Standard of Response Coverage document, it was conveyed that several additional factors would need to be included in the research to establish an effective and accurate station optimization study.

Chief Huff directed the group to cohesively continue the research and develop and create an optimal station relocation plan for review by the city elected officials In addition, Chief Huff stated that the organization was moving towards the two-year budget cycle and needed the study completed in a timely manner.

This document and its research is a combined effort of LF&R Accreditation and GIS personnel. Our approach was absolutely and strictly objective as we worked proactively to develop a plan based upon the information discovered. The optional plans and their respective conclusions were developed by this team. Great effort has been invested to ensure that an objective and unbiased assessment was completed for each station deployment option.

GIS Methodology

The purpose of this research project was to determine optimal fire station locations based on service demands within a reasonable response time. Our goal was to develop a methodology that would support the identification of ideal geographical areas for the relocation of fire stations. One of the key objectives of this analysis was to compare demand distribution between the existing fire station locations to the multiple optimal sites. The project includes the use of Geographical Information System (GIS) Location-allocation analysis tool, maps and spatial information technologies. Location-allocation models enable our team to determine the optimal locations of fire stations to provide services in the most efficient way. In addition, existing data relating to geographical street network, travel time benchmarks, existing address points and cross street intersections were used.

The methodology consists of several distinct steps;

1. Identification of street intersections within the city limits using a one-square-mile grid system.
2. Distribution/service demand primarily was based on address points and 5 years of (2005-2010) historical incident data. We were able to use this attribute to evaluate present and future service demand.
3. Various Location-allocation models were studied to determine which model was the most efficient in covering more demands than others. We ran four different analyses based on the varying number of fire stations, from 13 up to 16 locations with a target travel time of 4 minutes or less from these locations.
4. Additional analysis was performed to identify how this model would be with multiple variables such as Population Density, Effective firefighting Response Force and Incident Hot Spots relating to 5 yrs. worth of data to Fire and EMS types of calls.
5. This study also assessed the impact of 4 minute travel time overlapping that occurs between the existing versus the optimal location. The study provided information pertaining to overlapping distance in square miles, number of calls and address points within these areas.
6. The final step was to develop a generic algorithm integrating the above data. Utilizing Arc GIS Network Analyst we were able to determine optimal locations by performing a location-allocation analysis. Each model was constructed based on real road network information. With the use of this infrastructure we were able to demonstrate performance levels from each of the models against the road network as well as achieve a reasonable overlapping distance between fire stations (redundancies of services). These models were ranked and grouped to identify ideal station locations.

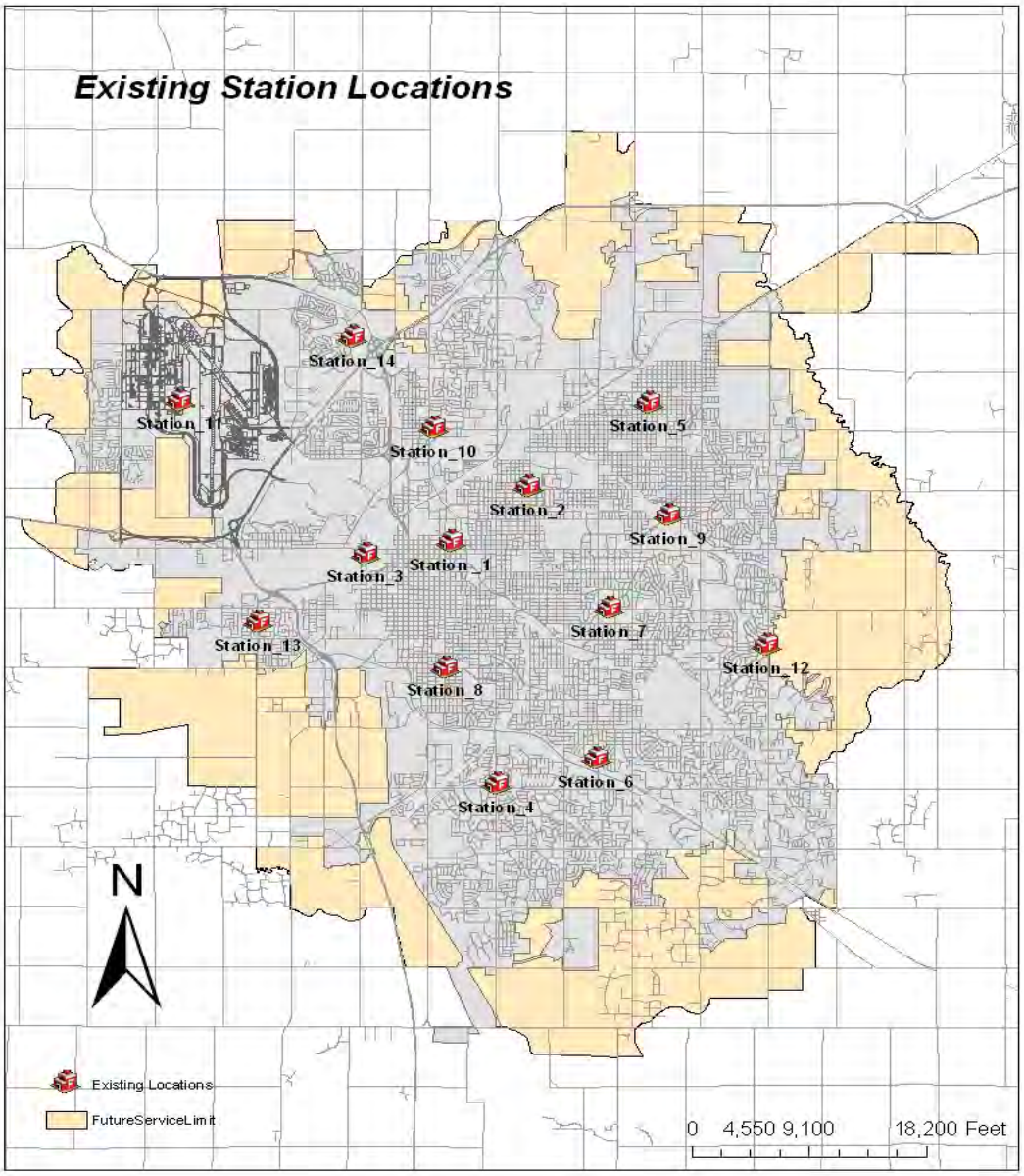
The optimal location of fire stations has been extensively studied and a range of models have been developed. This study narrows the search for potential site locations. The methodology provides decision makers with relevant information to select the best location for fire stations and to ensure that the relocation will meet industry response time benchmarks. Each of these models provides different

spatial patterns based on the number of stations. However, it provides a sound basis for which site selections and acquisition can be based on.

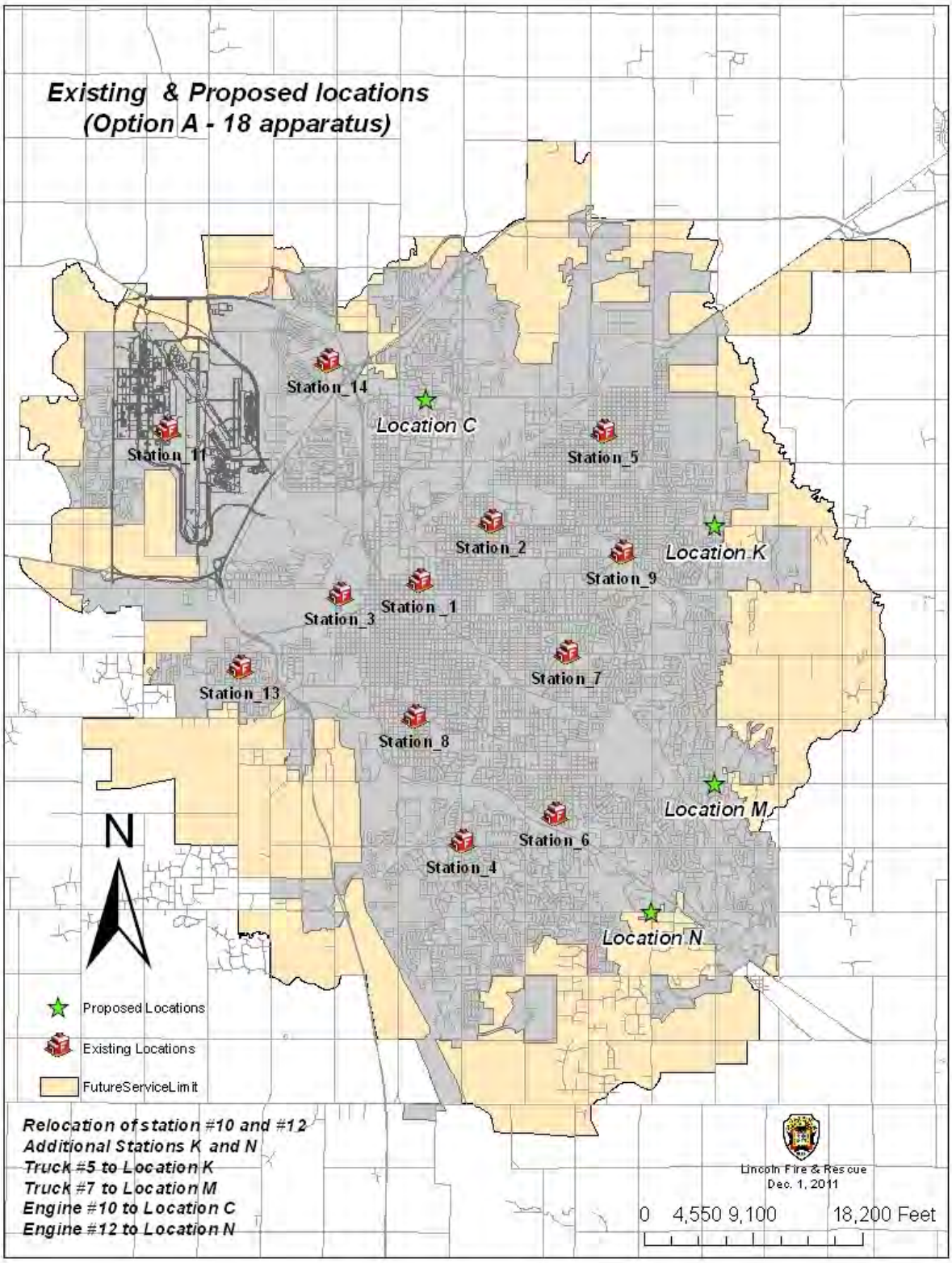
Station Optimization Options

The research team has evaluated numerous options for the optimal deployment of stations within the incorporated city limits, the department's primary jurisdiction. The following maps represent the three best options studied.

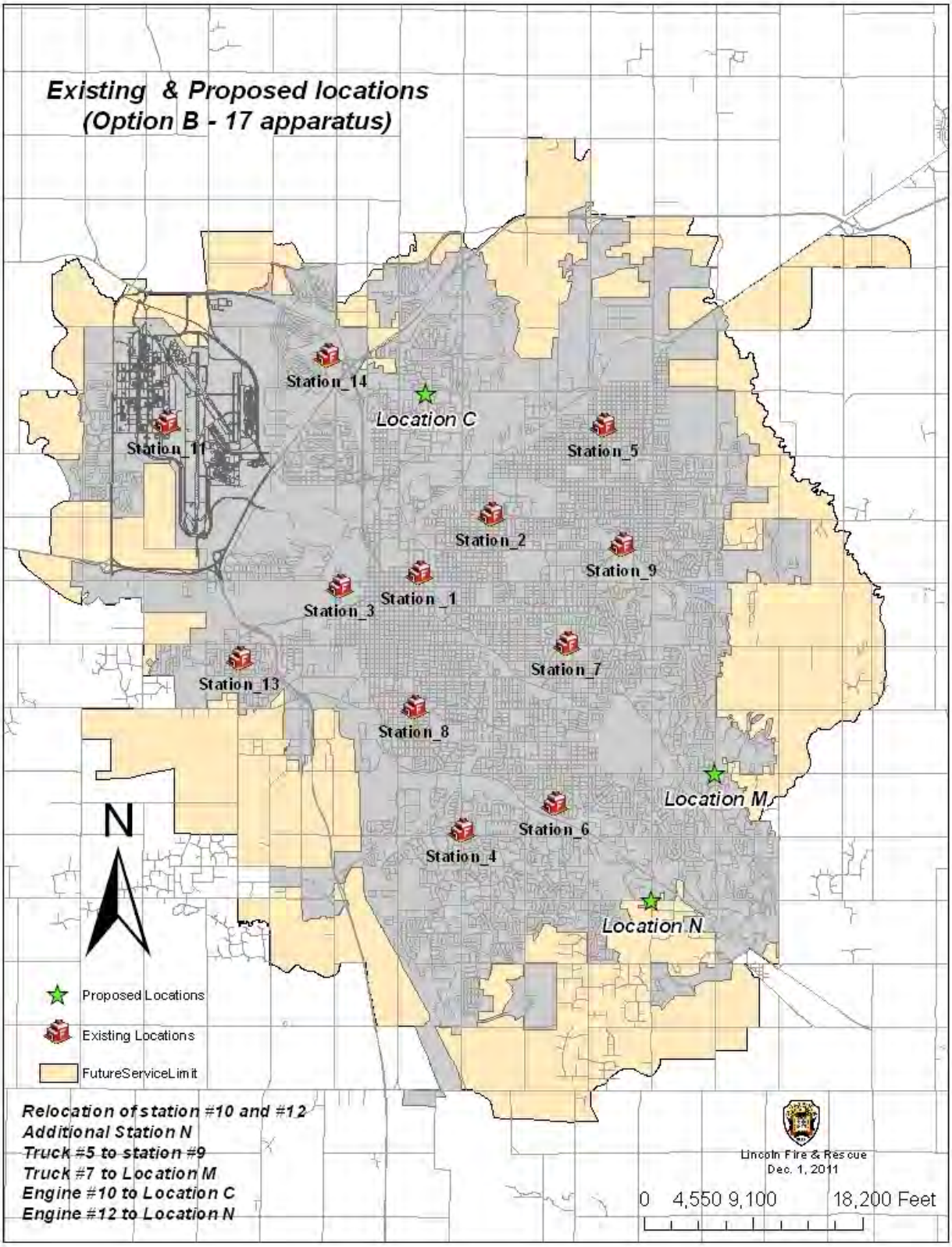
Existing Locations



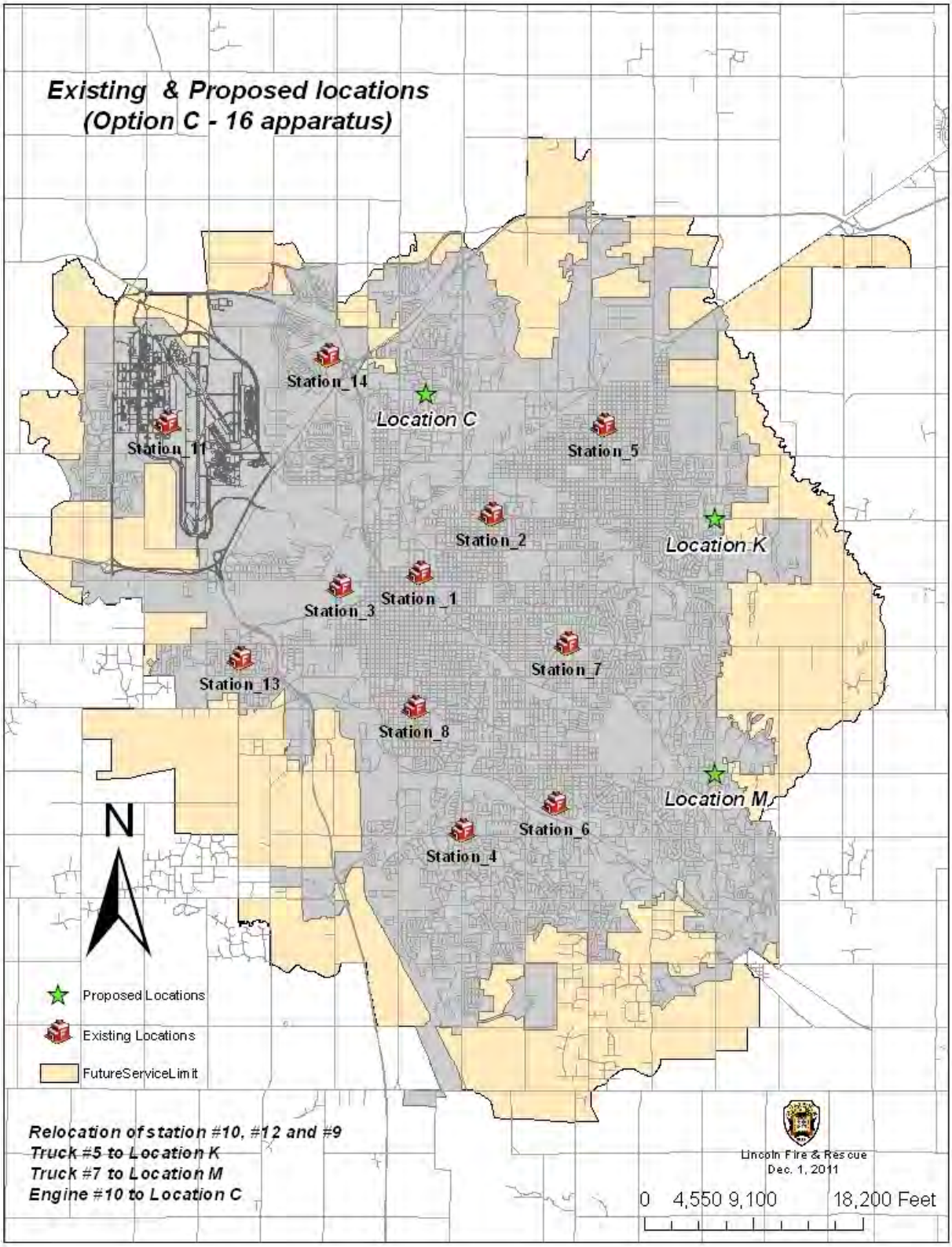
Option A


Existing & Proposed locations
(Option A - 18 apparatus)
Station_14
Location C
Station_11
Station_5
Station_2
Location K
Station_9
Station_1
Station_3
Station_7
Station_13
Station_8
Location M
Station_6
Station_4
Location N
N
Proposed Locations
Existing Locations
FutureServiceLimit
Relocation of station #10 and #12
Additional Stations K and N
Truck #5 to Location K
Truck #7 to Location M
Engine #10 to Location C
Engine #12 to Location N
Lincoln Fire & Rescue
Dec. 1, 2011
0 4,550 9,100 18,200 Feet

Option B


Existing & Proposed locations
(Option B - 17 apparatus)
Station_14
Location C
Station_11
Station_5
Station_2
Station_9
Station_1
Station_3
Station_7
Station_13
Station_8
Location M
Station_6
Station_4
Location N
N
Proposed Locations
Existing Locations
FutureServiceLimit
Relocation of station #10 and #12
Additional Station N
Truck #5 to station #9
Truck #7 to Location M
Engine #10 to Location C
Engine #12 to Location N
Lincoln Fire & Rescue
Dec. 1, 2011
0 4,550 9,100 18,200 Feet

Option C


Existing & Proposed locations
(Option C - 16 apparatus)
Station_14
Location C
Station_11
Station_5
Station_2
Location K
Station_1
Station_3
Station_7
Station_13
Station_8
Location M
Station_6
Station_4
N
Proposed Locations
Existing Locations
FutureServiceLimit
Relocation of station #10, #12 and #9
Truck #5 to Location K
Truck #7 to Location M
Engine #10 to Location C
Lincoln Fire & Rescue
Dec. 1, 2011
0 4,550 9,100 18,200 Feet

Research Methodology

As the team began to approach this research, it quickly became apparent that there were inconsistencies as to how this has been approached on a fire service industry wide level. Numerous National Fire Academy Executive Fire Officer (EFO) papers have been written by fire service leadership on the methodology of optimal station location, however, it was noted that many of these research papers were tailored specifically to each individual organization. In addition, many of the studies performed on a municipal level reflected the individual and dynamic methodologies of the EFO papers. It became apparent that there was little existing data on a standardized algorithm for station location studies.

Through researching this topic, the team discovered a study, which was contracted through a private and reputable consulting firm. The study was provided by Tri Data (a division of System Planning Corporation of Virginia) for the Oklahoma City Fire Department. This study immediately grabbed our attention as the methodology included concepts used to study and measure department performance that we currently use in the accreditation process. These concepts include not just distribution, but reliability and concentration as well.

In addition to the Tri Data study, we cross-referenced the methodology with the ESRI white paper," GIS for Fire Station Locations and Response Protocol." While one methodology fell short in a particular area, the other made up for the shortfalls. Combining the methodology of these processes ensured a comprehensive research method was established by the LF&R team.

A long-standing goal of LF&R is to align with national standards and practices. When this can be achieved, the organization has the capability of objectively measuring its performance and programs. We wanted to ensure that this study would mirror the organizational goals it has established through the accreditation program. We also wanted the study to mirror the same type of data analysis such as fractile vs. average representation of data.

An important aspect that we acknowledged early in this study was how little room for error the organization has in regard to compliance with nationally established response time standards as well as locally adopted travel time baselines and benchmarks. If the department were to pursue any change to its current response profile, the organization may experience a decrease in travel time performance. Currently, LF&R is not in compliance with established travel time <u>benchmarks</u> (with the exception of Municipal Ordinance governing medic unit response times). LF&R is marginally compliant with established travel time <u>baselines</u>. However, even a slight decrease in travel time performance could render the organization non-compliant with minimally acceptable baseline travel time standards. Although, if LF&R were to just maintain the <u>current</u> station and apparatus configuration travel time performance may continue to decline approaching non-compliance with adopted travel time baselines.

It should also be noted that it was recognized by the team that it would be fiscally impossible to relocate every fire station in the City of Lincoln to its most optimal location. Therefore, we attempted to

approach this from the perspective that we would attempt to provide a number of different yet realistic deployment "options."

Through the research of the team, several different studies would be completed and then compared to determine optimal number of stations and locations. As the final step of the study, we would utilize historical call data in each of the options utilizing our current deployment strategy as the baseline performance for comparisons.

The research group decided that the following studies would be completed to effectively gather the needed data to determine an optimal station plan:

Distribution

Distribution involves locating geographically distributed, first due resources for all-risk initial intervention. This would include medical fire rescue and hazmat response. Distribution is simply describing first due arrival. Distribution can be evaluated by the percentage of the jurisdiction covered by the first-due units within the adopted public policy service level objectives.

Distribution strives for an equitable level of outcome - everyone in the community is within a comparable distance from a fire station. Distribution is primarily based upon the probability that all areas within the jurisdiction experience equal service demands, not totally of the same risk or consequence as those of the demands for service in other areas.

LF&R's most stringent service level objective would be a response measurement of a four minute or less "first due" travel time for medical, fire and technical rescue emergency response. The research group felt that the initial study performed prior to the expansion of this research team adequately addressed an analysis of distribution from the perspective of that given deployment strategy. However, further distribution analysis would be necessary to determine the optimal station plan based upon distribution. To draw a conclusion of how many and where to locate fire stations in the most efficient manner based upon only this study would have been inadequate.

Lincoln Fire & Rescue has adopted the nationally recognized time performance standards as outlined in National Fire Protection Agency Standard (NFPA) 1710. LF&R measures and analyzes the organizations performance exhaustively at minimum annually per this performance standard.

Utilization of a standard time performance is beneficial in this study as it is an objective and quantifiable measure of system performance. Mapping this data utilizing GIS along with the locations of incidents where the desired performance level is not being achieved will assist in a 360-degree evaluation of appropriate distribution.

As stated, first unit arrival times are the best measure of distribution. It should be noted that if an area experiences fire unit travel times outside of the adopted performance measure, it does not necessarily mean it has a distribution issue. Other factors such as concentration and reliability must be considered.

Concentration

A concentration study required an analysis of the arrangement of multiple resource spacing (close enough together so that the Effective Response Force (ERF) can be assembled at the scene within the adopted timeframes.

While distribution is about first unit arrival, concentration is about having enough of the right equipment and staff arriving in a timeframe that allows them to be effective servicing the demand/situation. Distribution is about time and distance while concentration is about calls for service and the risk level being protected. Concentration places an emphasis on call volume. It is important to view the density of calls within a geographic area.

Distribution vs. Concentration

In essence, small fires do not make much of a difference in the resource allocation of any fire department. Major fires have a significant impact. The dilemma any fire agency has is staffing for routine emergencies and being prepared for the fire of maximum effort. This balancing act of distribution and concentration staffing needs is one that almost all fire agencies face on an ongoing basis.

The art in concentration is to strike a balance with respect to how much overlap there should be between station areas. Some overlap is necessary to maintain good response times and to provide make-up for distribution when the first-due unit is busy at a prior incident.

Reliability

In general, reliability is the ability of a person or system to perform and maintain its functions in routine circumstances as well as in hostile or unexpected circumstances. In the case of emergency services, reliability looks at actual incident history data to measure historical performance in accordance with adopted performance measures.

A unit unavailable for response provides no service to the community. The unit may be out of service for a multitude of reasons including; another emergency response, training, maintenance, etc. If a unit is not available 80% of the time, it is not reasonable to expect the unit to perform at the 80th percentile.

One way to look at reliability is through the concept of unit hour utilization. The concept originated in the private EMS service through the development of a standard to maximize the efficiency of ambulance units. Unit hour utilization (UHU) is a calculation that estimates the amount of time a unit is occupied on emergency calls as a percentage of the total amount of hours a unit is staffed and available for response (here at LF&R all front line units are staffed 24/7). In other words, UHU measures the percentage of on-duty time consumed by emergency service field activities. A higher UHU means a lower availability for calls. Poor availability negatively influences response times.

Tri Data states:

"Most believe that a UHU between 35-46% for EMS is economically efficient. (Private industry standard)If a UHU is greater than 45%, units are often not available and response times suffer. If a UHU is below 35%, units may not be utilized efficiently. Many communities (public ambulance providers) choose to aim for a UHU in the 12-25% range to improve or maintain response times."

"There are no guidelines for UHU levels for fire units; however, many larger departments recently evaluated by Tri Data experience truck or engine UHUs between 5 and 15%. If a unit is out of its station on a call more than 10% of the time, then it is unlikely to meet response time goals of 90% of calls in 4 minute or less travel times, since a second further away station would have to respond. Thus, a UHU of 5.15% is consistent with a goal of being at an incident location about 90% of the time."

Service Demand

Observing historical service demand can be done several different ways utilizing historical data driven analysis. There are three primary methods:

Call Type – Normally summarized by overall, first due, station, and unit.

Location of Calls – Normally depicted via map and described in chart form. It is imperative that we study where our service demands are located so we place our resources in the most appropriate location.

Frequency of Calls – These considerations deal with the time of day and the number of calls that are concurrent within a given area.

While this research will focus primarily upon the location or even more specifically the concentration of call types within the jurisdiction, it will not focus on the frequency of those call types. The reason why is that frequency has been studied exhaustively in the LF&R Standard of Response Coverage document and it is felt that frequency is not a vital aspect to this study.

Workload

Determining how busy units are is important for establishing their availability for the next call and provides some insight on how much capacity various units have to handle more work, or whether additional units are needed.

An analysis of workload also can indicate whether a new station should be built or an additional apparatus placed into service. It can also show whether current stations should be close or units moved.

An emergency response system must incorporate the necessary redundancies based on whether adjacent stations or units are likely to be available for emergency response. Below or the guidelines as published by Tri Data that outline the redundancy levels needed to meet response time goals according to response levels and are based upon their experience with workloads and how they affect availability;

1. **Very Low (<500 responses/yr.)** – Simultaneous calls are infrequent and unit availability usually is assured. Stations can be spaced a maximum distance possible to achieve stated travel time objectives.

2. **Low (500-999 responses/yr.)** – Few calls will overlap and unit availability usually is assured. Stations/units can be spaced at the maximum distance possible to achieve stated travel time objectives.

3. **Moderate (1,000 – 1,999 responses/yr.)** – Some overlap of calls will occur, usually at peak demand periods; however, stations/units are usually available. Stations/units must be located with marginal overlap to achieve stated travel time objectives.

4. **High (2,000 – 2,999 responses/yr.)** – Additional overlap of calls will likely occur; however, stations/units will probably be available for emergency response. Stations/units must be located with significant overlap to achieve stated travel time objectives.

5. **Very High (3,000 – 3,999 responses/yr.)** – Overlapping calls occur daily, usually during peak demand periods, and working incidents occur frequently. The closest station/unit may not be available, thus requiring the response of adjacent stations/units. Stations/units must be located with significant overlap to achieve stated service level objectives. This may be accomplished through the co-location of additional units in existing stations.

6. **Extremely High (>4,000 responses/yr.)** – Overlapping calls may occur hourly, regardless of the time of day. The closest station/unit is likely to be unavailable thus requiring the response of adjacent stations/units. Frequent transfers or move-ups are required for the delivery system to meet demand. Stations/units must be located with redundancy (back-up units) to achieve stated travel time objectives established by the community. This footprint is usually found in very densely populated urban areas and is especially evident in EMS services located in urban areas with very high demand for service.

The 3,000 – 3,999 response level (very high category above) is the point at which units are often considered “busy” and availability needs to be evaluated.

Cardiac Arrest Survivors and Distance from Existing Stations

LF&R has noted a correlation between cardiac arrest survival and their respective distance from existing fire stations. This should be a consideration when determining the number and placement of fire stations.

Critical Task Analysis

To effectively respond to a given incident, it is necessary to understand what types of equipment and the number of properly trained personnel that are needed to mitigate each given incident. The identification of this is accomplished through a process called critical task analysis.

The number of personnel and resources is important to the location and number of fire stations. The number of apparatus, type of apparatus, and their respective staffing affect the optimal locating of these resources. Not only do we need to study the amount of time a given apparatus with a set number of personnel on it arrive at an incident, but the subsequent units and their staffing as well.

LF&R has completed critical task analysis for a multitude of incident types, however, as our response profile changes we must study how this effects the number of personnel and equipment on incident locations to complete these critical tasks. For example, if LF&R were to *increase the minimum staffing level to four personnel per apparatus this would decrease the number of apparatus necessary to respond to a structure fire.* This decrease in service demand may reveal a decrease in the number of total apparatus necessary to meet our prescribed service level objectives.

Fractile vs. Average Data Analysis

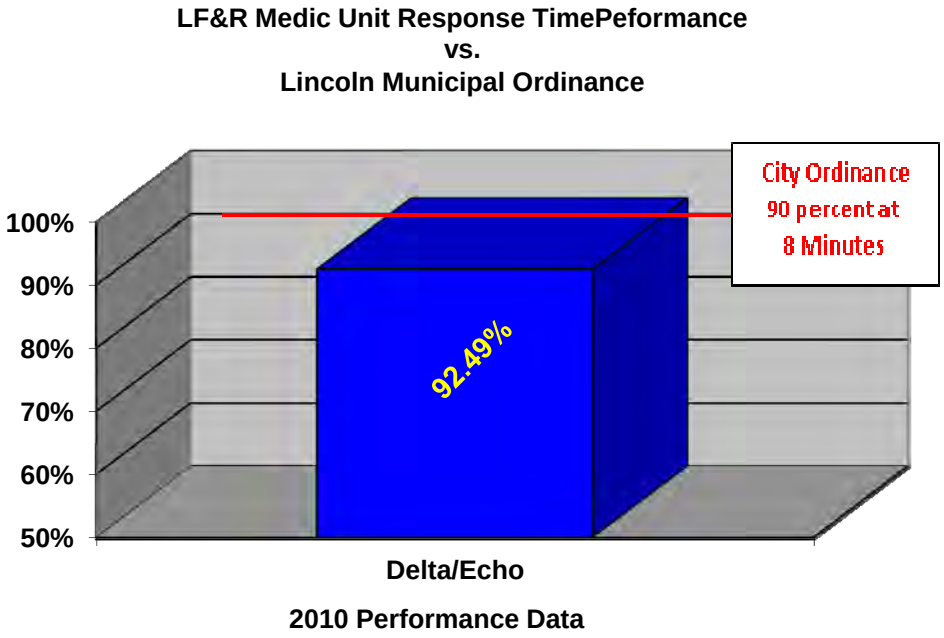
All research conducted in this project were consistent with the current guidelines as set forth by the Commission on Fire Accreditation International. This included the parameter of data analysis and how it relates to fractile vs. average analysis.

For example, evaluating "average" response times is an inadequate analytical method. Evaluating a small number of incidents and arriving at a five-minute response time will only show one level of performance. Analyzing tens of thousands of incidents and evaluating response time provided a more reliable and accurate assessment of the delivery of system performance. Completing the same analysis over a period allows for trend analysis as well.

Exclusion of Medic Unit Apparatus

In December of 2009, LF&R performed an extensive study on the optimal deployment of medic unit (ambulance) apparatus. This study was titled, "*Medic Units Relocation Addition Study."* The study utilized Geographic Information Systems (GIS) as well as established response time benchmarks developed through the accreditation process to deploy medic unit apparatus in the most effective and efficient manner possible. Following the study recommendation, LF&R redeployed existing units to different fire station locations and ultimately achieved a more equitable distribution of workload while improving response time performance.

As LF&R is experiencing the highest performance ever achieved as of yet in terms of response time performance, the study group feels that the current placement of these apparatus is optimum. None of the options described in this study necessitate the need to relocate medic unit apparatus.


LF&R Medic Unit Response TimePeformance
vs.
Lincoln Municipal Ordinance
City Ordinance
90 percent at
8 Minutes
100%
90%
80%
70%
60%
50%
92.49%
Delta/Echo
2010 Performance Data

Limitations

While time was a limiting factor in this study, technical capability was not. The technical and GIS capability of LF&R is far above most other municipal fire organizations and is considered a best practice among other departments.

To perform the level of research per the stated methodology requires time. The amount of unit responses the City of Lincoln experiences generates a tremendous amount of data. This data is analyzed not just geospatially, but also broken down into many different components. Each of these components is compared both to national standards and to locally prescribed ordinance. This level of research and analysis can take many months to produce.

One factor removed from the study was community demographics. This study was removed from this project primarily due to time; however, it was also removed because we felt we could represent the most efficient deployment of apparatus and stations based upon current and historical data. By maintaining existing stations in addition to future stations alternative deployment options can be enjoyed. As future service demand changes, infrastructure could be added, relocated, or subtracted as deemed necessary at that point in time to continue to deploy resources in the most efficient manner possible. LF&R has studied demographic factors as they relate to risk in the Standards of Response Coverage Document.

Traditionally the fire service through the United States Fire Administration (USFA) has analyzed data regarding trends in emergency response. Through the compilation of data, high-risk socio-economic groups have been identified. When analysis of these socio-economic groups can be achieved within a jurisdiction prediction can be made as to the future service demand in these areas. An example of this would be predictable trends in geographic locations within the city where aging demographics will exist. This aging demographic generates a greater service demand using Emergency Medical Services (EMS). The City of Lincoln currently is rated as a class 3 city (on a scale of 1 to 10 with 1 being the best) by the Insurance Services Office (ISO) Public Protection Classification (PPC). As ISO continues to be less used as a definitive basis for insurance costs, there may be little fiscal impact either positive or negative to property owners by being in a certain PPC. Regardless, any redeployment or change in our current response profile may have an impact to our PPC and should be considered prior to an organizational change.

Truck apparatus are a limited resource within LF&R as we currently have four front line truck companies. The number of trucks in the department's fleet has not increased since 1954. The truck companies are a critical asset at structure fires as they are equipment to provide victim search/rescue, ventilation salvage and overhaul and aerial ladder water application as part of firefighting suppression operations. As this is a limited resource that does affect the assembly of the effective response force at fire incidents additional research is required to determine where they should be placed to provide the greatest benefit.

One of these studies includes analysis of building heights and street setbacks, which affect the truck company's aerial capability.

Current Performance and Option Analysis

An important consideration during the study of fire station relocation is the impact to existing and future response time performance. As an Internationally Accredited Agency, Lincoln Fire & Rescue (LF&R) utilizes the response time performance standards and methodology established by the Commission on Fire Accreditation (CFAI) and the National Fire Protection Association (NFPA).

CFAI and the NFPA have established a standard approach to developing, assessing and monitoring response time performance. There are several key components of a typical response to an emergency event. The end user i.e. the citizen of fire and EMS services is primarily concerned about the length of time required from when they call 911 until a fire engine or medic unit arrives at the scene of their emergency. This is an example of the "Total Response Time". The three time elements that comprise the total response time are call-processing, turn out time and travel time.

Call Processing Time- "Call Processing" time starts when a 911 call is answered and ends when the apparatus is dispatched to the incident.

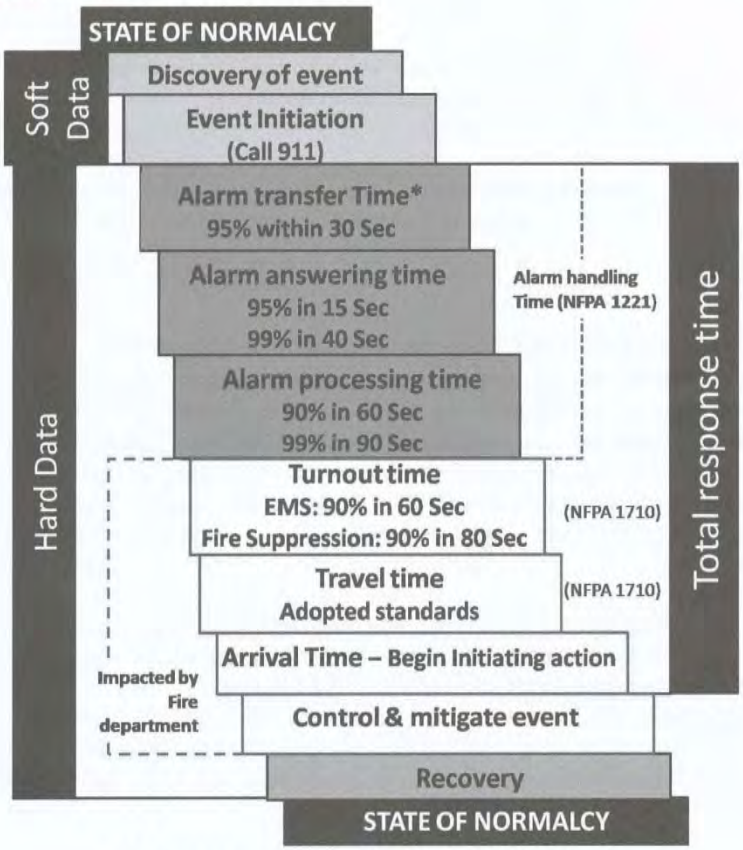
Turnout Time- "Turnout Time" starts when firefighters are alerted in the stations and ends when the firefighters board the apparatus and are enroute to the incident.

Travel Time- "Travel Time" starts when the apparatus or medic unit is en route to the incident and ends when the apparatus arrives at the scene**.**

Call Processing Time + Turnout Time+ Travel Time = Total Response Time

For example, a four-minute or less Travel Time roughly equates to a six minute or less Total Response Time. The historic LF&R Travel Time performance highlighted below would be equal to the percentage of time in which a first response vehicle arrives at an emergency in six minutes or less.

Figure 3-14 Cascade of Events



For the purposes of station optimization, the primary focus on the response time impact focused on travel time i.e. the amount of time it takes an emergency vehicle to drive to the incident. Call processing and turnout time were not considered in the study as they have no bearing on the geographic positioning of fire stations or apparatus.

LF&R has established baseline and benchmark standards for travel time performance.

Benchmark- a standard from which something can be judged. Response time benchmarks are industry "best practices" that an agency can strive to meet. The benchmark response time goals for LFR apparatus are compliant with National Fire Protection Association 1710 standards.

Baseline- a database from which something can be judged. According to CFAI, apparatus response time baselines should be no less than 70% of the associated benchmark. A response time baseline is viewed as the minimally acceptable response time for LF&R apparatus that is consistent with accreditation standards. Medic Unit response time standards are based on Lincoln Municipal Code 7.08.050.

LF&R completed three levels of analysis regarding travel time performance. The first analysis involved the study of resource distribution. The study of distribution involves locating geographically distributed resources for all-risk intervention. Distribution is simply describing "first due" arrival. The study of apparatus distribution focused on being able to reach the maximum number of addresses in the prescribed four-minute travel time from current and proposed fire station locations. The current deployment of fourteen fire stations allows first due apparatus to reach 79,389 of the 87,853 addresses in the City of Lincoln resulting in the coverage of 90.36% of addresses in a benchmark standard of a four minute or less travel time. The proposed fire station optimization plan "A" allows first due apparatus to reach 96.23% of addresses in a four minute or less travel time. Option "B" allows first due apparatus to reach 94.92% of addresses in a four minute or less travel time and Option "C" allows first due apparatus to reach 94.78% of addresses in a four minute travel or less time.

Currently, LF&R utilizes a fire engine or fire truck as the designated first response vehicle. Station locations must allow rapid deployment to minimize and terminate average or routine emergencies. The goal of resource distribution is to provide an equitable level of outcome across the entire city

First Due Engine/Truck Company Travel Time Standards

NFPA 1710 4.1.2.1 *240 seconds or less travel time for the arrival of the first arriving engine company at a fire suppression incident.*

NFPA 1710 - 4.1.2.4 *The fire department shall establish a performance objective of not less than 90 percent for the achievement of each response time objective specified in 4.1.2.1.*

LFR Management Policy 101.03**

Benchmark

Four minutes (240 seconds) or less travel time for the first due apparatus to the scene of emergent fire suppression, medical, hazardous materials or technical rescue incident 90 percent of the time.

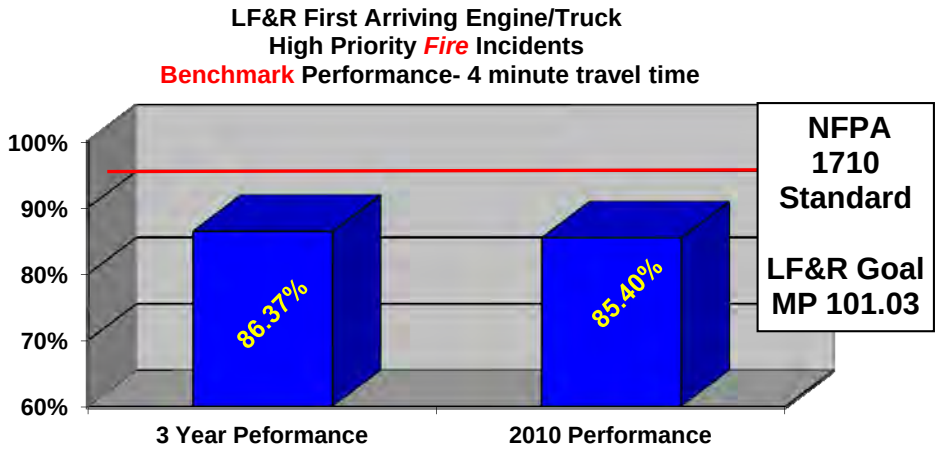
Baseline

Five minutes (300 seconds) or less travel time for the first due apparatus to the scene of emergent fire suppression, medical, hazardous material or technical rescues incident 90 percent of the time.

The following graphs highlight LF&R's "first due" travel time performance for structure fires, high priority medical emergencies and technical rescue incidents. As illustrated in the tables, LF&R is not compliant with NFPA travel time standards benchmarks but is compliant with established travel time baselines. As a point of clarification, the adopted travel time *"baseline"* is the minimally acceptable travel time according to LF&R and CFAI principles.

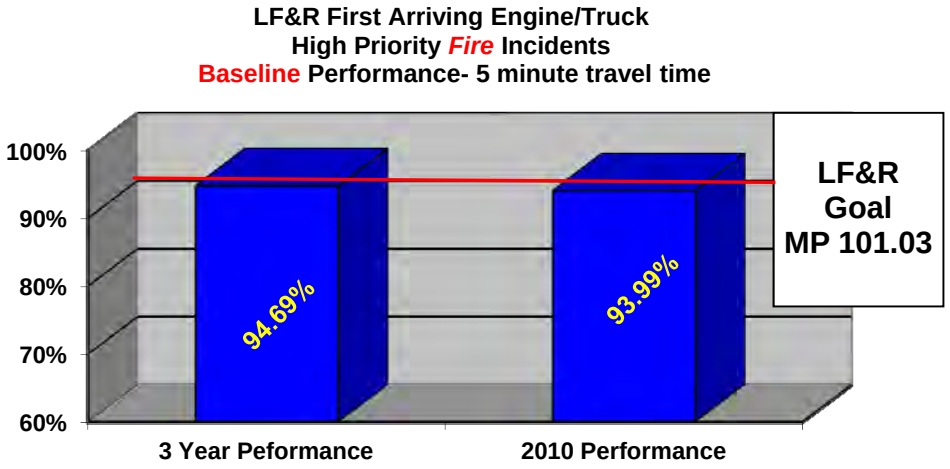
LF&R Historic Travel Time Performance for first arriving Engine/Truck Company

First Engine/Truck Four Minute Travel Time 1 Year *Benchmark* Performance-Structure Fire



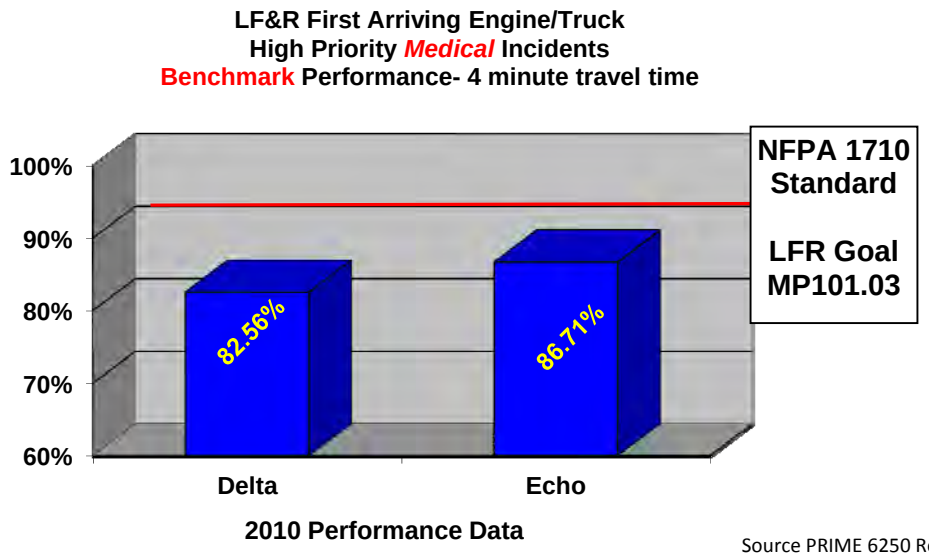
Source PRIME 6250 Report

First Engine/Truck Four Minute Travel Time 3 Year *Baseline* Performance-Structure Fire



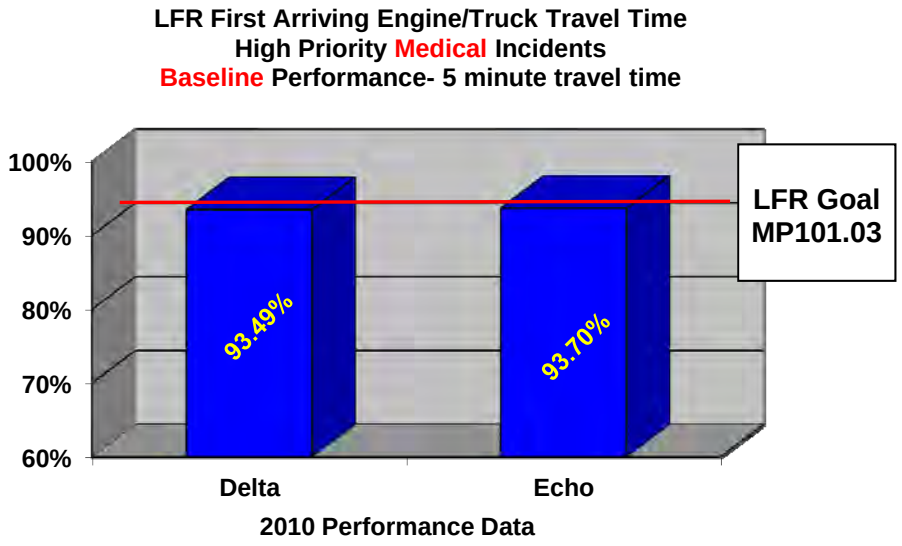
Source PRIME 6250 Report

First Engine/Truck Four Minute Travel Time 1 Year *Benchmark* Performance-Critical Medical



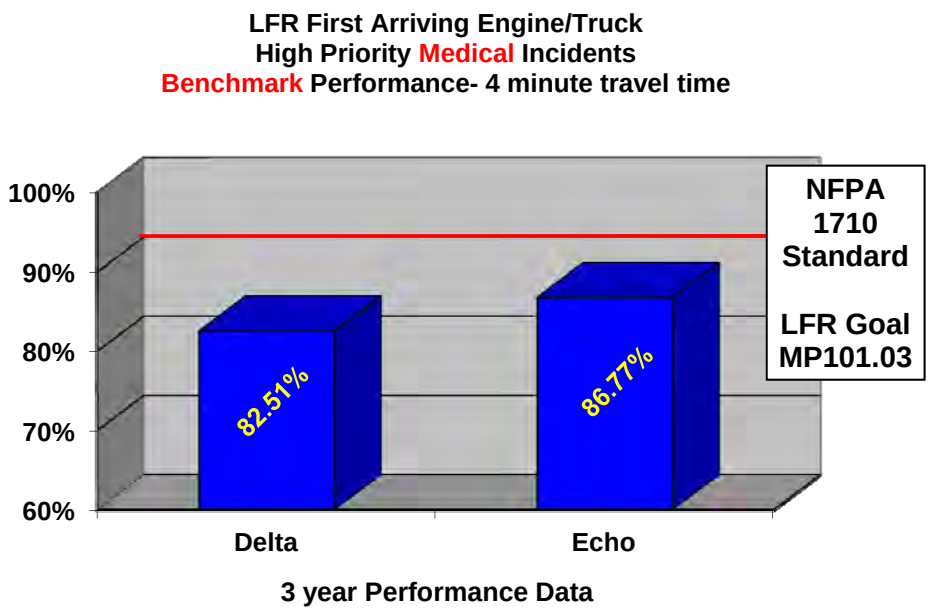
Source PRIME 6250 Report

First Engine/Truck Four Minute Travel Time 1 Year *Baseline* Performance-Critical Medical



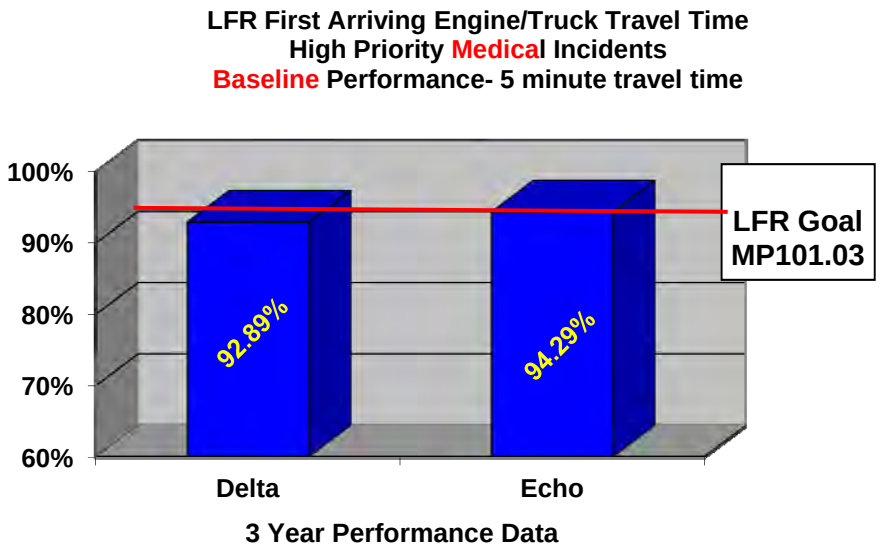
Source PRIME 6250 Report

First Engine/Truck Four Minute Travel Time 3 Year *Benchmark* Performance-Critical Medical



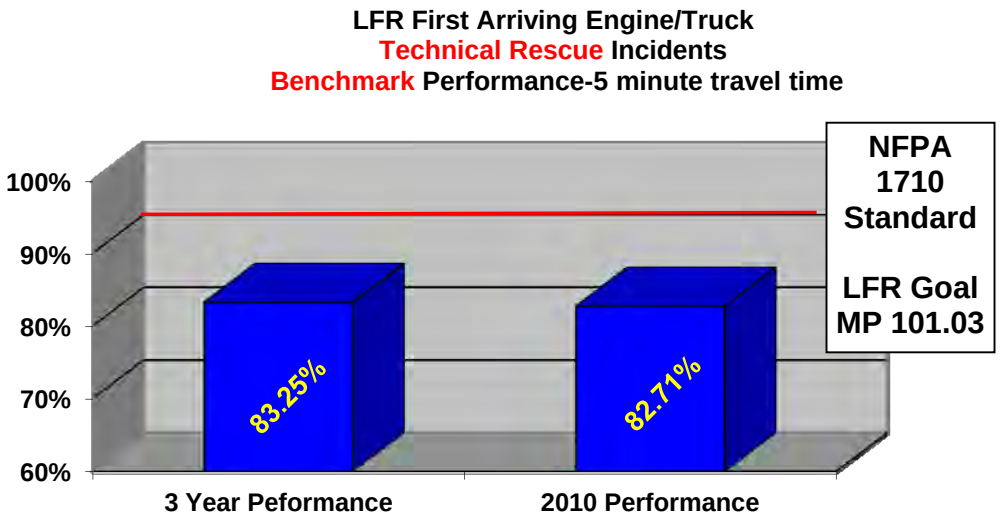
Source PRIME 6250 Report

First Engine/Truck Four Minute Travel Time 3 Year *Baseline* Performance-Critical Medical



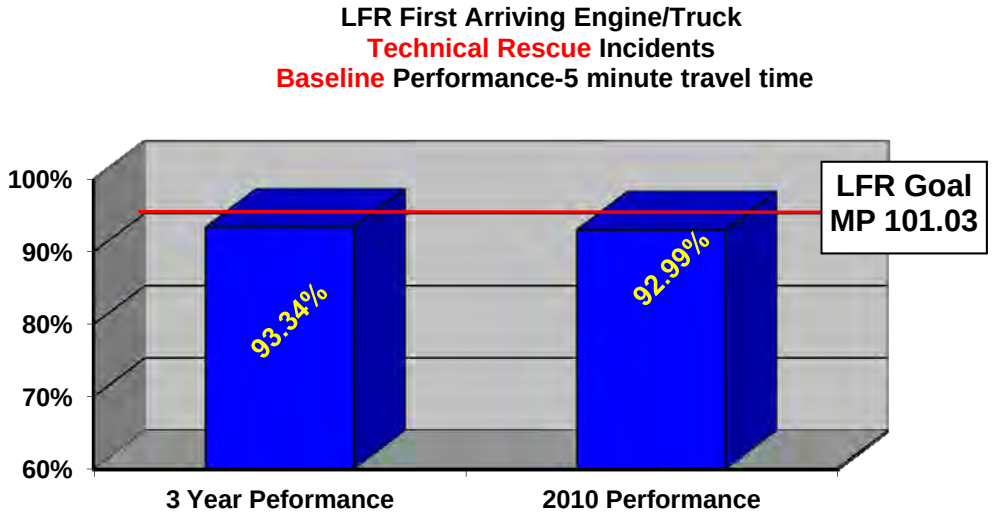
Source PRIME 6250 Report

First Engine/Truck Four Minute Travel Time 1 Year *Benchmark* Performance-Technical Rescue



Source PRIME 6250 Report

First Engine/Truck Four Minute Travel Time 1 Year *Baseline* Performance-Technical Rescue



Source PRIME 6250 Report

The "first due" historic travel time performance highlights the fact that LF&R is currently not compliant with travel time benchmarks which are based on NFPA 1710 Standards. LF&R is compliant with travel time baselines that are calculated at 70% of the associated benchmark. A ninety percent compliance with the established baseline is the minimum acceptable standard according to LF&R and CFAI principles. The following table highlights individual engine companies travel time performance to "high priority" incidents for 2010.

Engine Company	Highest Priority Incident Count	(4) Minute Benchmark Travel Compliance	(5) Minute Baseline Travel Compliance
1	645	95.35%	99.07%
2	321	88.47%	96.88%
3	278	86.69%	93.88%
4	274	76.64%	92.70%
5	312	82.05%	93.91%
6	322	76.71%	93.91%
7	298	87.92%	96.31%
8	354	93.22%	97.46%
9	323	92.26%	98.76%
10	342	67.84%	84.80%
11	26	34.62%	73.08%
12	201	77.61%	93.03%
13	135	71.85%	85.19%
14	177	48.59%	76.27%

Source PRIME 6250 Report

*Highest Priority Calls= (Confirmed Structure Fire, Medical-Delta & Echo, Rescue Alarm)

As illustrated, LF&R is currently experiencing resource distribution problems as evidence by failure to meet "first due" travel time benchmark goal. Currently, LF&R is in the low to mid 80th percentile "first due" travel time compliance when responding to high priority emergencies.

Two potential factors can cause "first due" travel time performance problems. The first is a lack of adequately distributed fire stations to cover the city i.e. not enough stations for the geographical area covered.

The second possible cause of "first due" travel time performance problems is apparatus reliability and availability. The study of reliability and availability focuses on the amount of time an apparatus is in service and available to respond to calls. For instance, if an apparatus is committed to emergency

response, required training, public education or events for six hours out of a twenty four period the apparatus is only available seventy five percent of the time. Obviously, as the unit reliability and availability decreases, travel time will increase as adjoining apparatus will have to respond into the area of apparatus that is already committed. In an effort to assess the availability of LF&R engine and truck companies we evaluated Unit Hour Utilization: UHU is the amount of time an engine or truck spends on an emergency as a percentage of the total amount of hours the unit in service. For example, a staffed "first due" engine or truck that is staffed twenty-four hours a day 365 days a year that does not respond to a call would be available 8,760 hours or a UHU of 0.00%.

UHU Formula= $\frac{\text{(Number of calls)} \times \text{(time spent on calls)}}{\text{8,760hrs}}$

Tri Data, a System Planning Corporation completed a comprehensive fire station relocation study for the City of Oklahoma City Fire Department. According to Tri Data "If a unit is out of its station on a call more than 10 percent of the time, then it is unlikely to meet response time goals of 90 percent of calls in 4-minute travel time, since a second further away station will have to respond. Thus a UHU of **5.15** percent is consistent with a goal of being there about 90 percent of the time."

The following table highlights LF&R Unit Hour Utilization for "first due companies. This is the time actually spent on calls and does not include time spent training, preforming vehicle maintenance or public education.

Apparatus	2010 Calls For Service	UHU
Engine 1	3,103	10.19%
Engine 2	1,476	5.84%
Engine 3	1,483	5.66%
Engine 4	1,236	5.19%
Engine 5	1,474	5.37%
Engine 6	1,560	6.46%
Engine 7	1,584	6.81%
Engine 8	1,695	5.99%
Engine 9	1,592	6.54%
Engine 10	1,546	6.84%
Engine 11	250	1.17%
Engine 12	1,047	4.51%
Engine 13	685	3.00%
Engine 14	855	4.15%
Truck 1	1,518	5.71%
Truck 5	883	3.35%
Truck 7	1,069	3.76%
Truck 8	963	3.22%

Source: 2010 LF&R Annual Report

As illustrated, ten of fourteen engine companies as well as one truck company have a UHU above 5.15% as recommended in the Tri Data Study.

Apparatus reliability and availability can be addressed two ways. The first is by locating stations with adequate overlap. Adequate overlap allows a reasonable response to an adjoining fire stations response area if the abutting station is committed on another call for service, required training, apparatus maintenance or a public education event.

A second approach to addressing apparatus reliability and availability is to co-locate apparatus in response areas with significant call volume. A high call volume equals a high UHU and a decrease in reliability. A second co-located apparatus can share workloads and respond to call in the primary response area in the event the co-located apparatus is already committed. A limitation of only addressing reliability and availability by co-locating apparatus without adequate response area overlap is the inability of an apparatus to respond into an abutting stations response area within established response time standards.

An example of the importance of fire station overlap can be expressed by the geographical relationship that currently exists in the area served by Fire station 9 (Engine 9) located at 901 North Cotner Blvd. and Fire Station 7 (Engine 7) located at 1345 South Cotner Blvd. Currently, Engine 9 and Engine 7 have a 4 minute or less travel overlap of 3.802 miles. This equates to 4,836 addresses that can be covered by both Engine 7 and Engine 9 within a 4 minute or less travel time. Theoretically, this illustrates that if Engine 9 was committed on a call or out of service for some other reason and subsequent call for service occurred in the overlap area, Engine 7 would be able to respond to the call within the 4 minute or less travel time *benchmark.*

Upon analyzing five years' worth of incident data there were 1,571 calls, which occurred in the overlap area. If Station 9 were closed and relocated to Location "K", the overlap area would be significantly less. In fact, only 385 of the 1,571 calls occurring in the overlap area would now be covered in a 4 minute or less travel time benchmark. In addition, only 993 of the 4,836 addresses, which previously fell in the overlap area, would now be covered by relocating Fire station 9 to location K.

It is a recommendation of the research group that LF&R utilize a combination of apparatus co-location and station overlap to best serve the needs of the community. In areas of high call volume (high UHU) an additional apparatus (engine or truck company) should be co-located to share the workload and provide the area with adequate reliability to the primary response area. Adding additional fire stations staffed by splitting existing co-located companies housed in an area with a low UHU will provide the adequate coverage and overlap for areas of growth within the city. In other words, relocation of existing crews without adding FTE's.

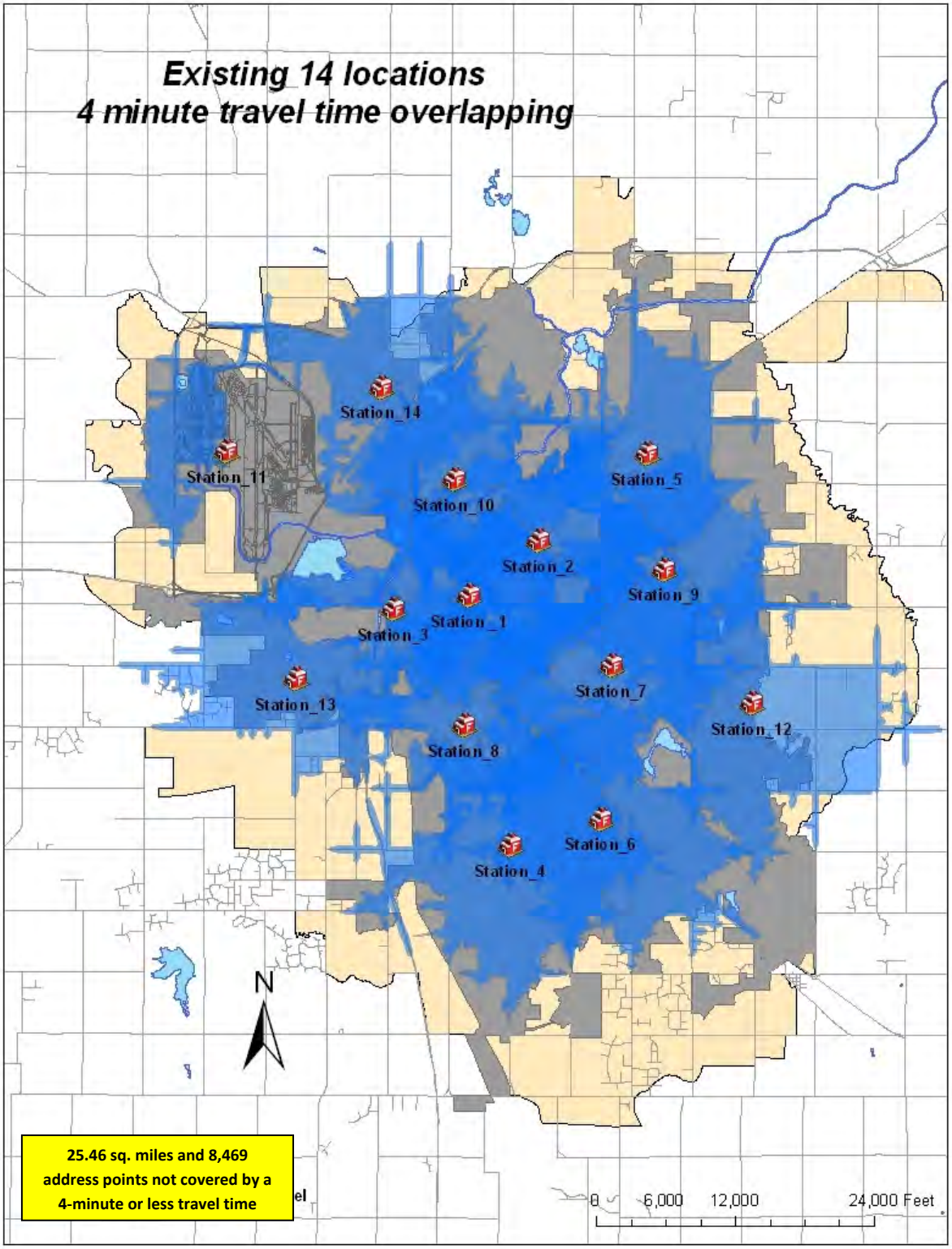
Option "A" provides for the greatest station/response area overlap. By maintaining existing fire station locations and apparatus, adding two additional fire stations and relocating fire stations 10, 11 and 12 there would be excellent response area overlap. It should be noted that additional fire station locations

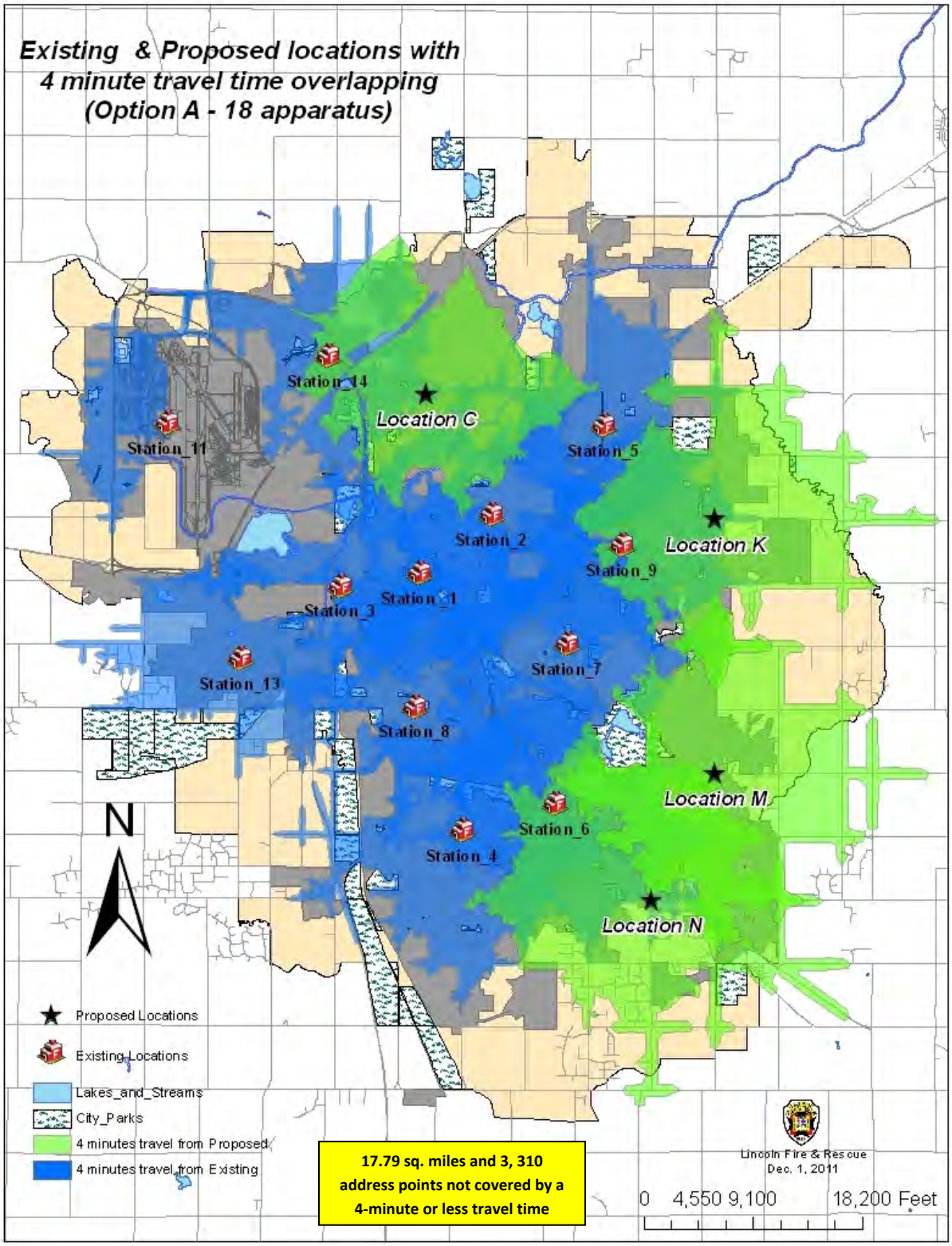
would be staffed by splitting up two of the lower call volume stations with co-located engine and truck companies.

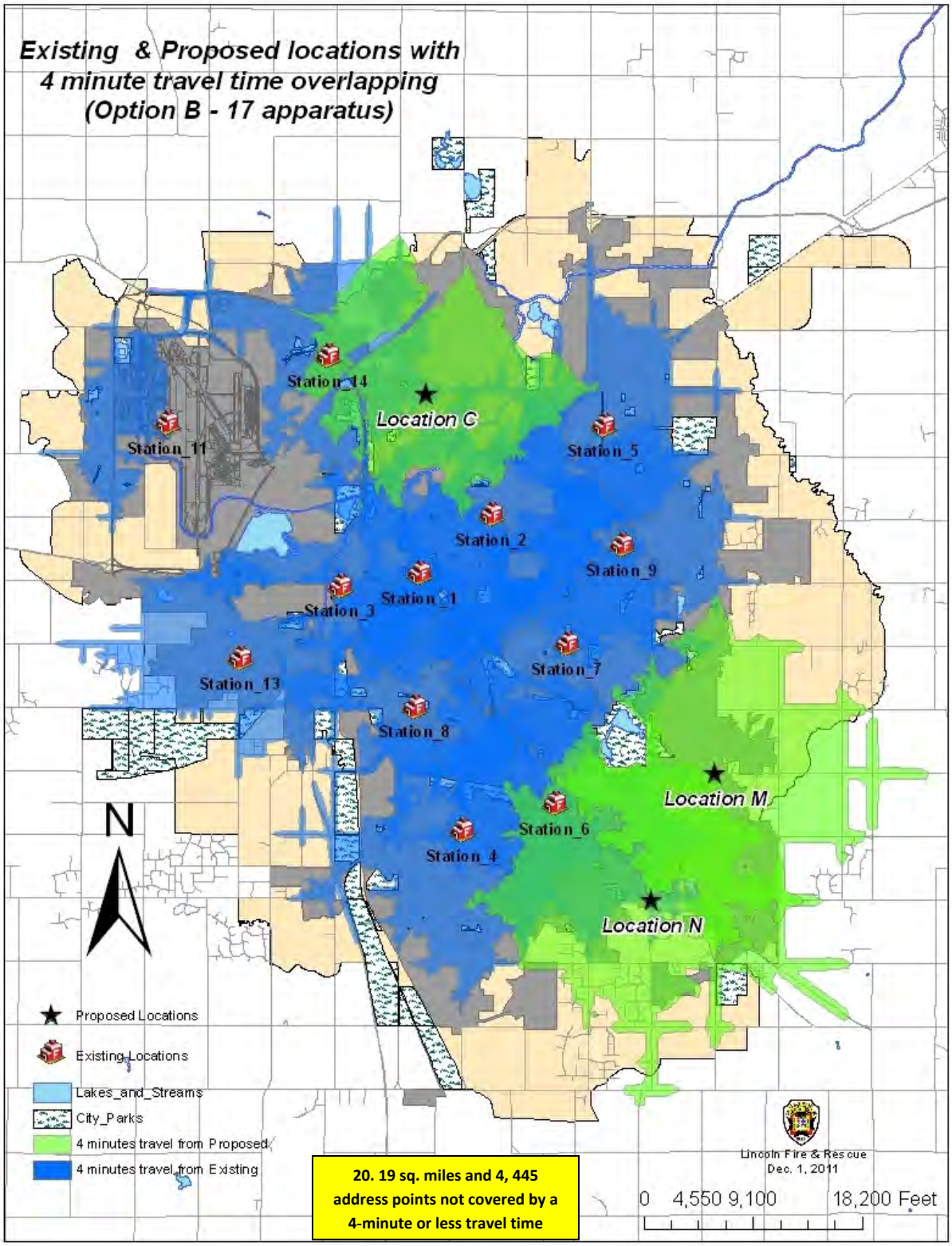
Option “B” increases the number of fire stations by one to 15 total stations but reduces the number of fire apparatus’ from 14 to 13. The additional station would be staffed by splitting up a station with a co-located company. Under the provisions of this plan there is enhanced response coverage in the Southeast part town secondary to an additional fire station while maintaining current response area overlap.

Option “C” maintains the current number of fire stations at 14 but reduces the number of fire apparatus’ by two. This plan calls for the relocation to two fire stations currently located in areas which significant call volume thus decreasing the amount of response area overlap. As a result, this could increase response time performance when concurrent calls for service occur and the primary engine or truck company is already committed.

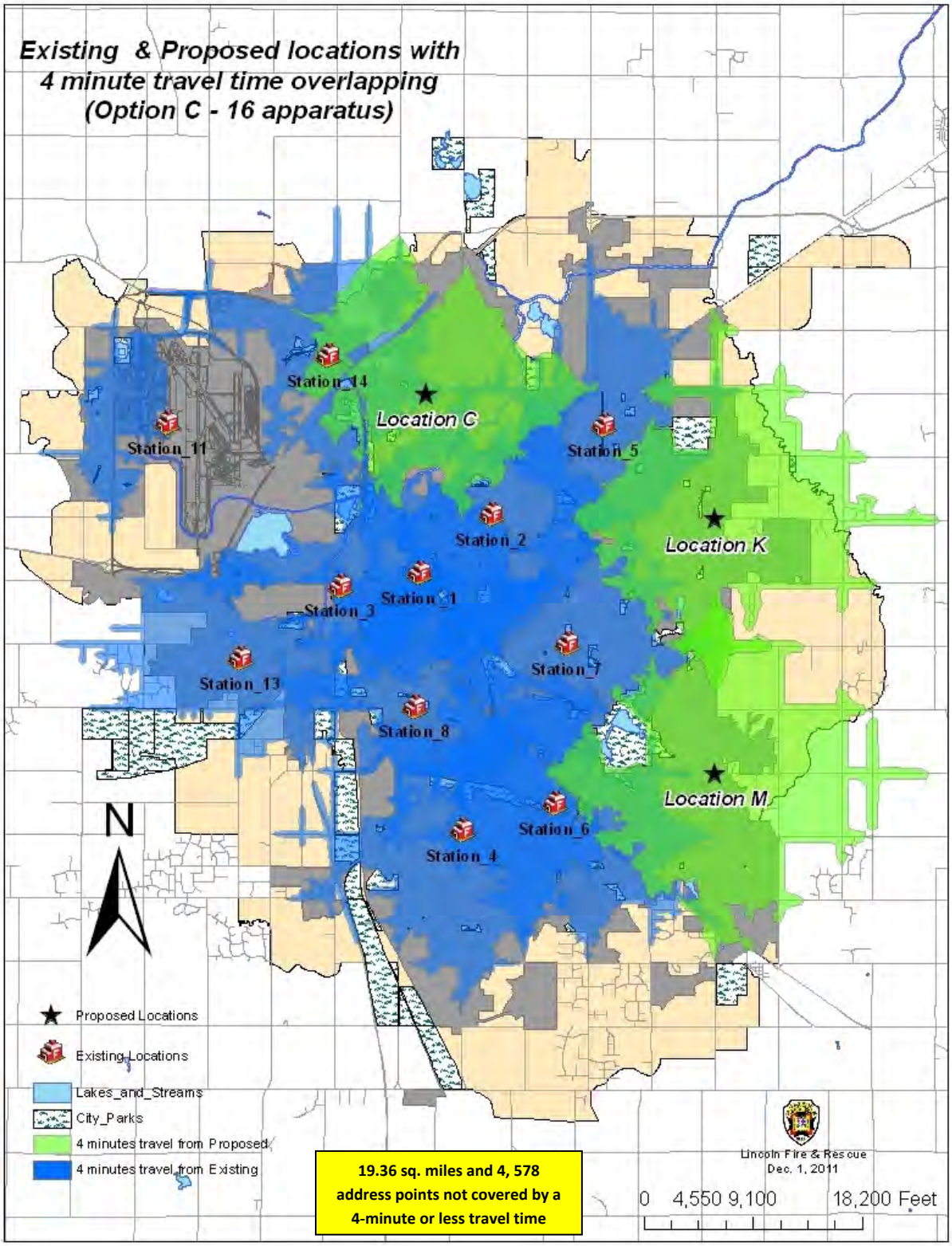
The following maps illustrate current and future response area overlap for options “A”, “B” and “C”.


Existing 14 locations
4 minute travel time overlapping
Station_14
Station_11
Station_10
Station_5
Station_2
Station_9
Station_1
Station_3
Station_7
Station_13
Station_12
Station_8
Station_6
Station_4
N
25.46 sq. miles and 8,469 address points not covered by a 4-minute or less travel time
0 6,000 12,000 24,000 Feet


Existing & Proposed locations with
4 minute travel time overlapping
(Option A - 18 apparatus)
Station_14
Location C
Station_11
Station_5
Station_2
Location K
Station_9
Station_1
Station_3
Station_7
Station_13
Station_8
Location M
Station_6
Station_4
Location N
N
Proposed Locations
Existing Locations
Lakes_and_Streams
City_Parks
4 minutes travel from Proposed
4 minutes travel from Existing
17.79 sq. miles and 3, 310 address points not covered by a 4-minute or less travel time
Lincoln Fire & Rescue
Dec. 1, 2011
0 4,550 9,100 18,200 Feet



20. 19 sq. miles and 4, 445 address points not covered by a 4-minute or less travel time


Existing & Proposed locations with
4 minute travel time overlapping
(Option C - 16 apparatus)
Station_14
Location C
Station_11
Station_5
Station_2
Location K
Station_1
Station_3
Station_7
Station_13
Station_8
Location M
Station_6
Station_4
N
Proposed Locations
Existing Locations
Lakes_and_Streams
City_Parks
4 minutes travel from Proposed
4 minutes travel from Existing
19.36 sq. miles and 4, 578 address points not covered by a 4-minute or less travel time
Lincoln Fire & Rescue
Dec. 1, 2011
0 4,550 9,100 18,200 Feet

First Due Engine/Truck Company (4) Minute Travel Time Comparison Table

Relocation Option	Sq. Miles Covered	Addresses Covered
Existing Stations	66.21	79,384
Option "A"	72.88	84,543
Option "B"	70.48	83,398
Option "C"	71.31	83,275
City of Lincoln	Sq. Miles Total 90.67	Addresses Total 87,853

Call Density and Population Hot Spots

In an effort to determine existing and future workloads the research group analyzed current areas of high call volume as well as current population density.

The following statements draw a link between population density and the demand for services.

According to Tri Data "Demand will grow at the same rate as population"

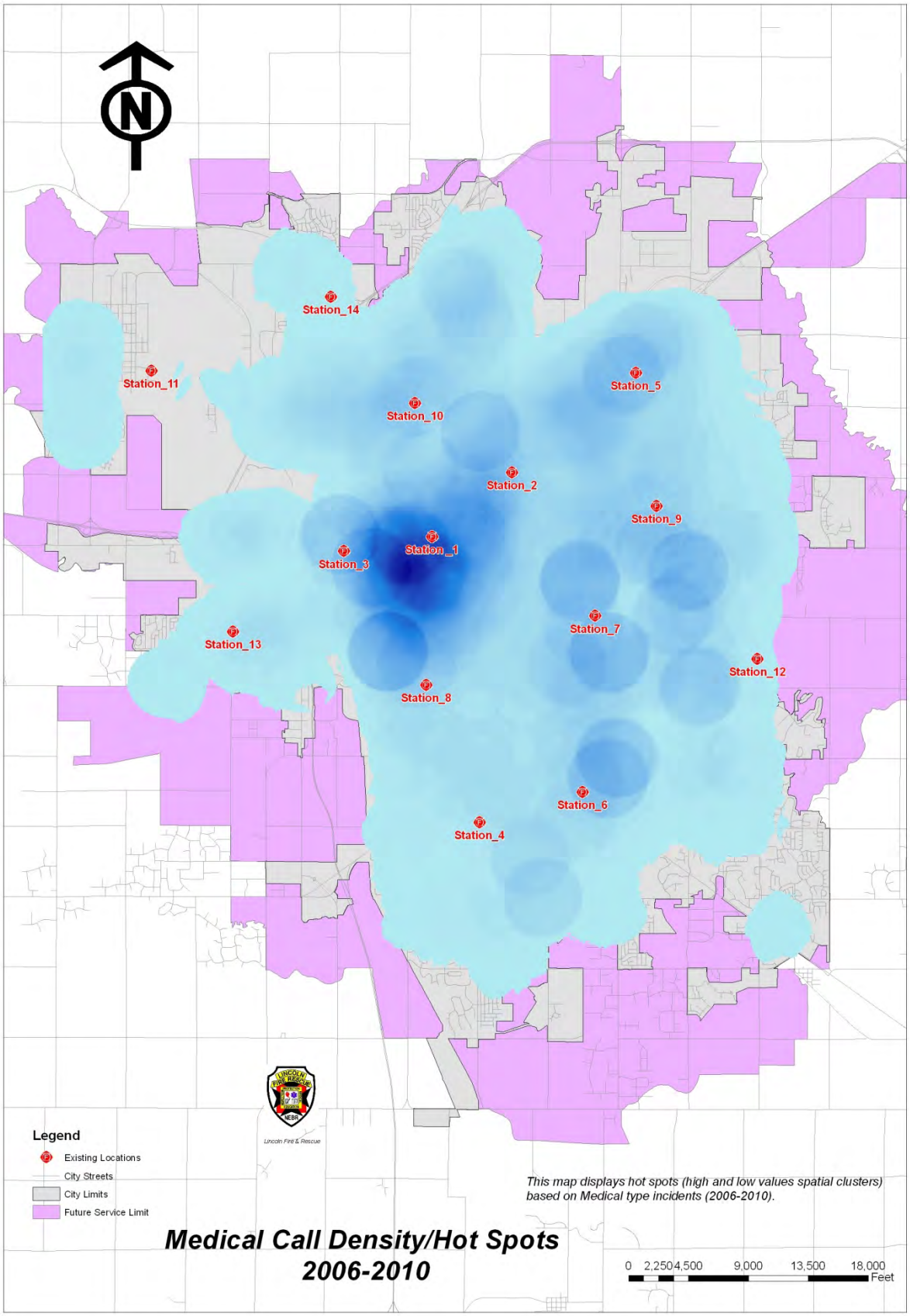
According to the Center for Public Safety Excellence (CPSE) "Generally speaking the lower the density the lower every other factor tends to be….. Ex. calls, values at risk and even financial resources to support the departments financial needs.

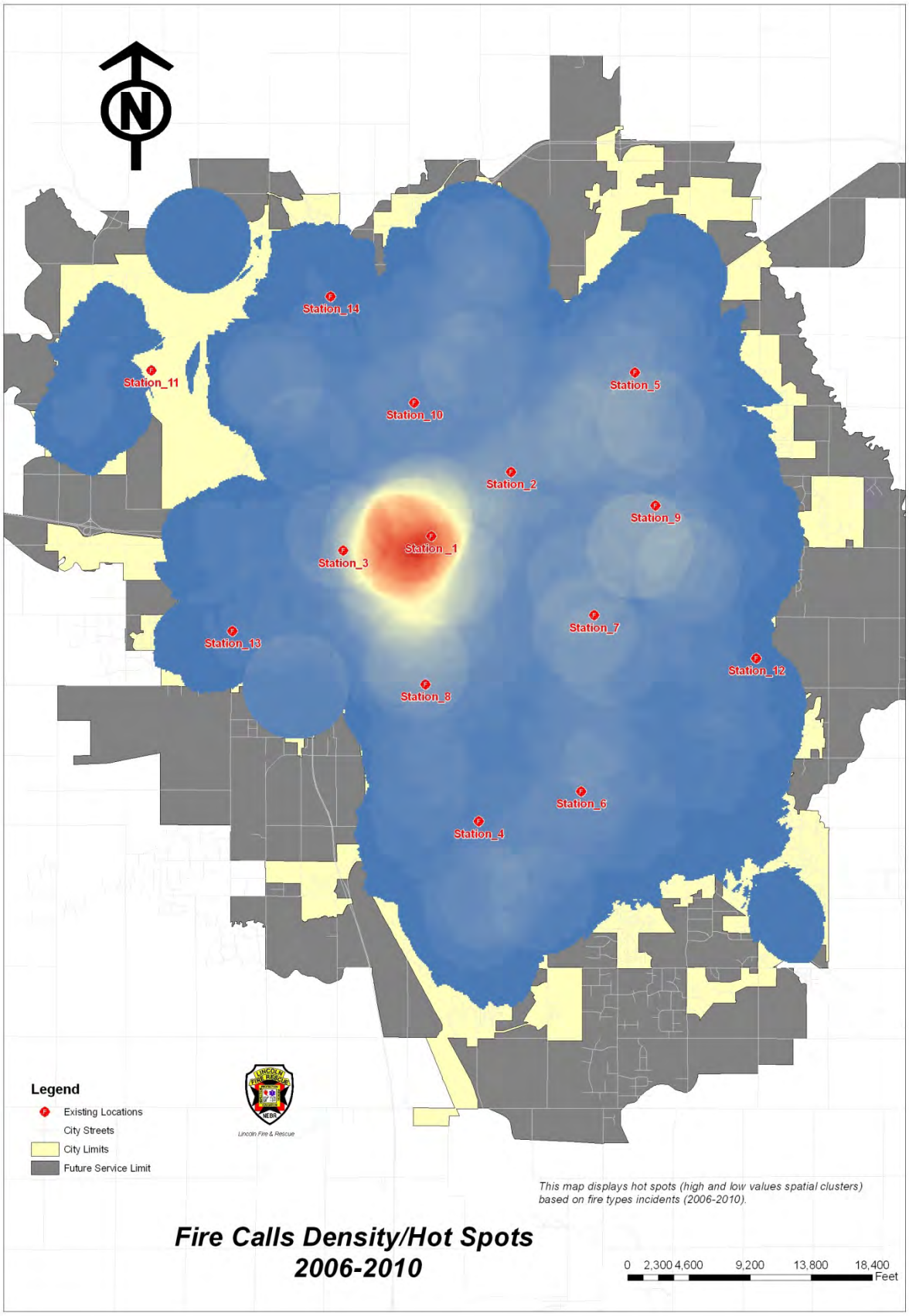
Based on population density and existing incidents "hot spots" the research group has significant concerns about relocating stations away from existing call volume and population centers.

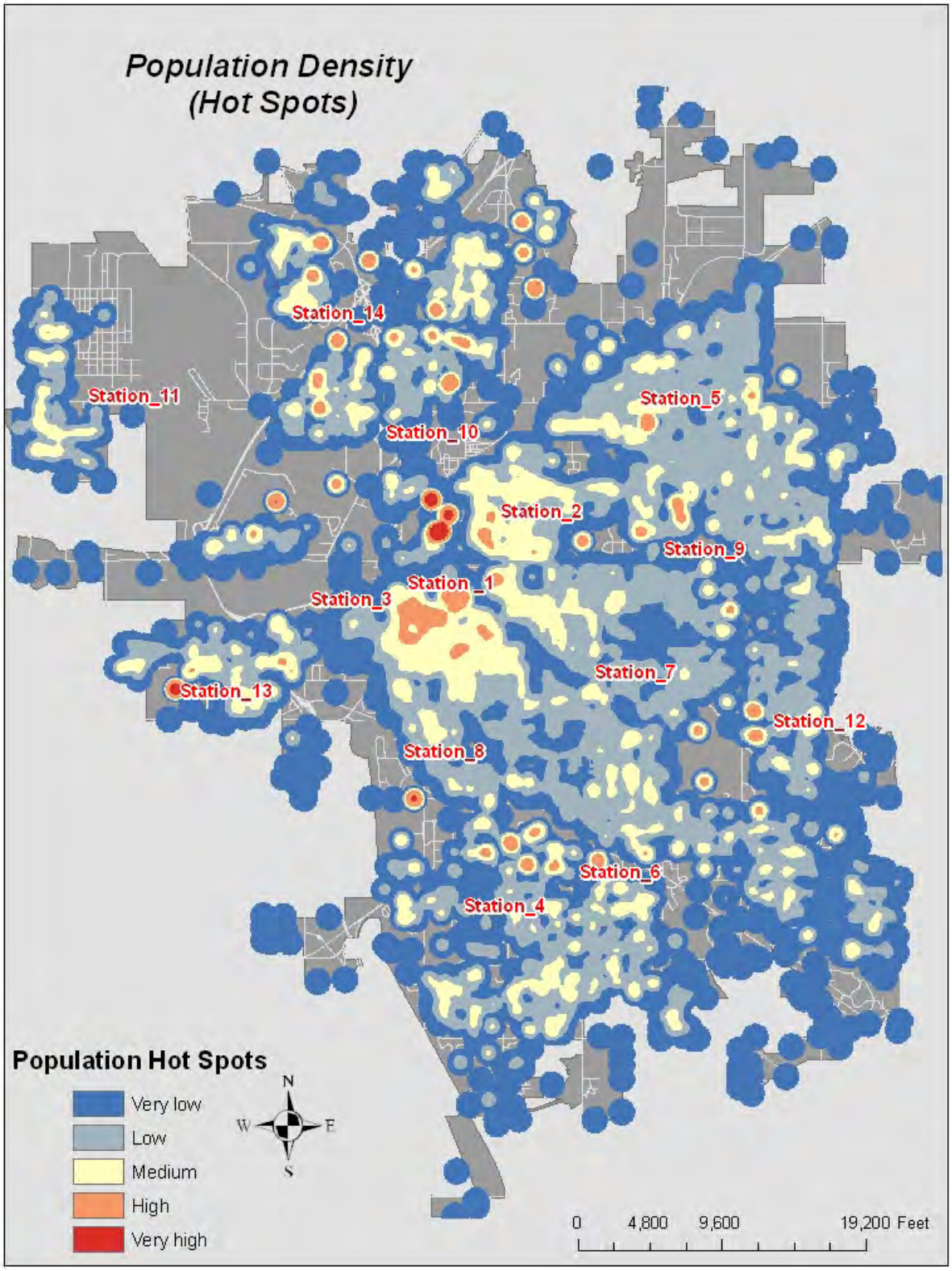
An area of particular concern that would be impacted by Option "C" would be the core of the city in an area encompassing the existing response area of Fire stations 5, 7, and 9. This area in particular continues to have moderate demand for service and it is reasonable to state that demand as it relates to increasing population density will continue to grow in this area. Currently, this area enjoys reliability through existing station locations; however, implementation of Option "C" while potentially beneficial to other areas of the jurisdiction may have a negative impact in areas such as this. As stated earlier, reliability in this area as well redistributed workload continues to be a concern.

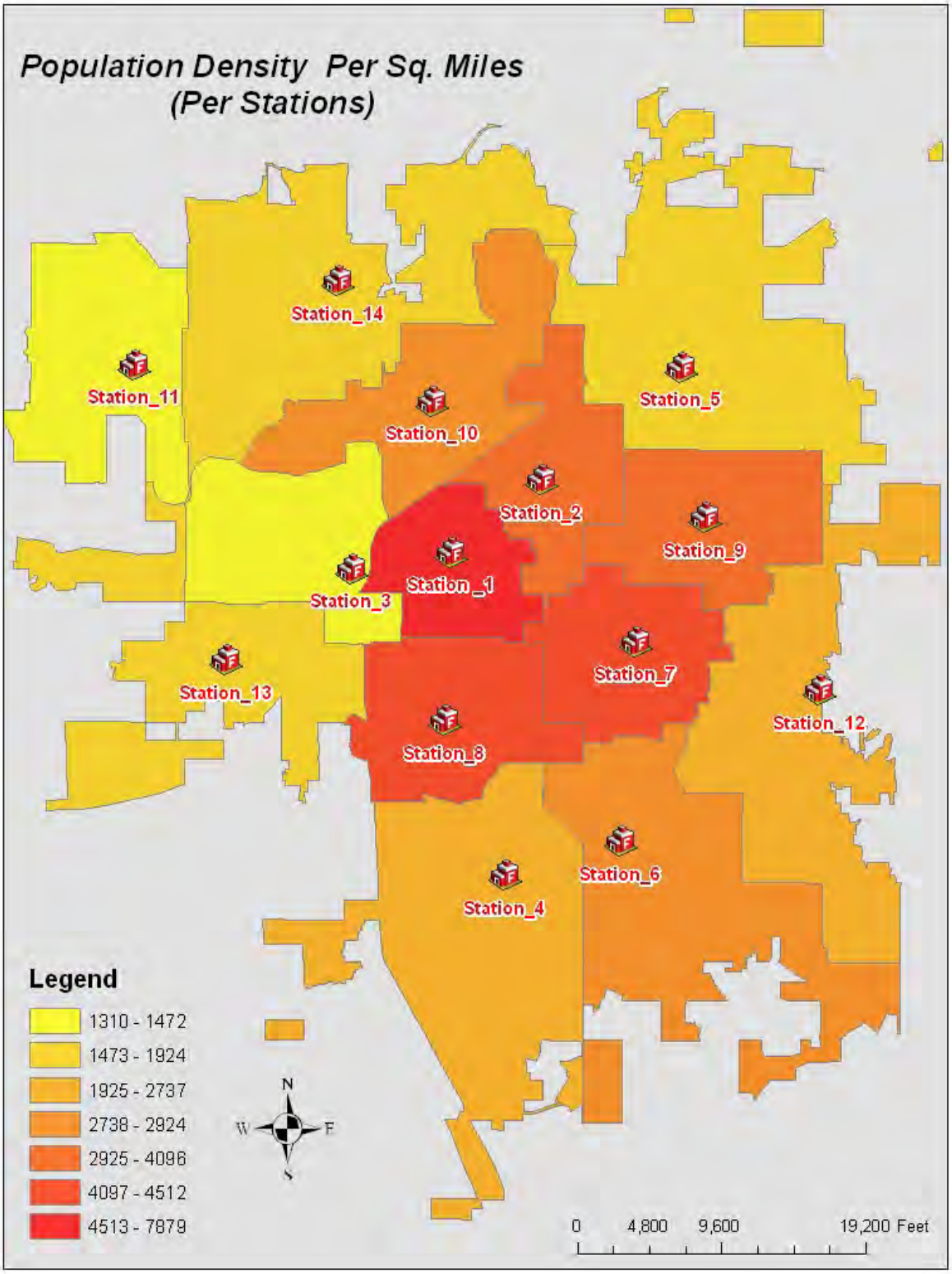
The following maps depict call density for both fire and EMS incidents as well as population density as it relates to fire station location, 4 minute or less travel time and fire-planning zone.

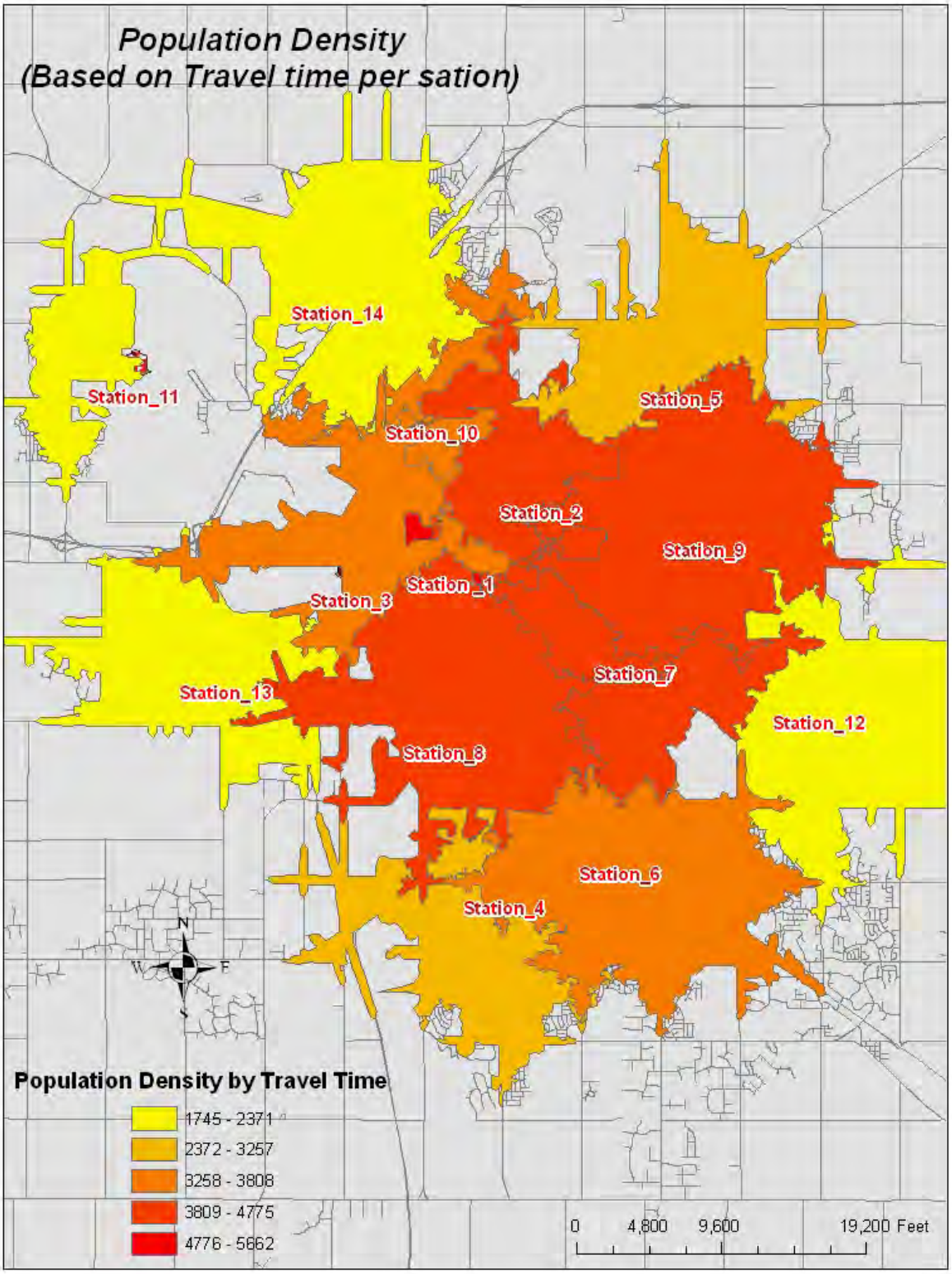
In depth study of call density and population hot spots impacts was limited by the period available to complete the study that may require continued analysis


N
Station_14
Station_11
Station_5
Station_10
Station_2
Station_9
Station_1
Station_3
Station_7
Station_13
Station_12
Station_8
Station_6
Station_4
Lincoln Fire & Rescue
Legend
Existing Locations
City Streets
City Limits
Future Service Limit
This map displays hot spots (high and low values spatial clusters) based on Medical type incidents (2006-2010).
Medical Call Density/Hot Spots
2006-2010
0 2,250 4,500 9,000 13,500 18,000
Feet


N
Station_14
Station_11
Station_5
Station_10
Station_2
Station_9
Station_1
Station_3
Station_7
Station_13
Station_12
Station_8
Station_6
Station_4
Legend
Existing Locations
City Streets
City Limits
Future Service Limit
Lincoln Fire & Rescue
This map displays hot spots (high and low values spatial clusters) based on fire types incidents (2006-2010).
Fire Calls Density/Hot Spots
2006-2010
0 2,300 4,600 9,200 13,800 18,400
Feet


Population Density
(Hot Spots)
Station_14
Station_11
Station_5
Station_10
Station_2
Station_9
Station_1
Station_3
Station_7
Station_13
Station_12
Station_8
Station_6
Station_4
Population Hot Spots
Very low
Low
Medium
High
Very high
N
W
E
S
0
4,800
9,600
19,200 Feet


Population Density Per Sq. Miles
(Per Stations)
Station_14
Station_11
Station_10
Station_5
Station_2
Station_9
Station_1
Station_3
Station_7
Station_13
Station_12
Station_8
Station_6
Station_4
Legend
1310 - 1472
1473 - 1924
1925 - 2737
2738 - 2924
2925 - 4096
4097 - 4512
4513 - 7879
N
W
E
S
0
4,800
9,600
19,200 Feet


Population Density
(Based on Travel time per sation)
Station_14
Station_11
Station_5
Station_10
Station_2
Station_9
Station_1
Station_3
Station_7
Station_13
Station_12
Station_8
Station_6
Station_4
N
W
E
S
Population Density by Travel Time
1745 - 2371
2372 - 3257
3258 - 3808
3809 - 4775
4776 - 5662
0
4,800
9,600
19,200 Feet

Resource Concentration

The study of resource concentration focused on the analysis of resource grouping so the initial attack force and effective response force can be supported. The goal of the initial attack force is to initiate mitigation efforts. The goal of the effective response force is to stop further escalation of an incident. The potential risk of an event occuring increases with frequency of incidents as well as not having the available resources to respond to and manage the incident. The majority of incidents which require an effective response force (ERF) include structure fires and technical rescue incidents. Current LF&R standards direct that an ERF for a structure fire includes 3 engine companies and 2 truck companies which at minimum staffing levels would provide the assembly of 15 firefighters. The development of the number of fire fighters which comprise an ERF is based on critical task analysis and NFPA 1710 Standards.

The current *benchmark* and *baseline* travel time standards for the effective response force are as follows:

Effective Response Force Travel Time Standards

NFPA 1710 – ***4.1.2.1*** *480 seconds or less travel time for the deployment of an initial full alarm assignment at a fire suppression incident.*

NFPA 1710 - 4.1.2. 4 *The fire department shall establish a performance objective of not less than 90 percent for the achievement of each response time objective specified in 4.1.2.1.*

LFR Management Policy 101.03*

Benchmark

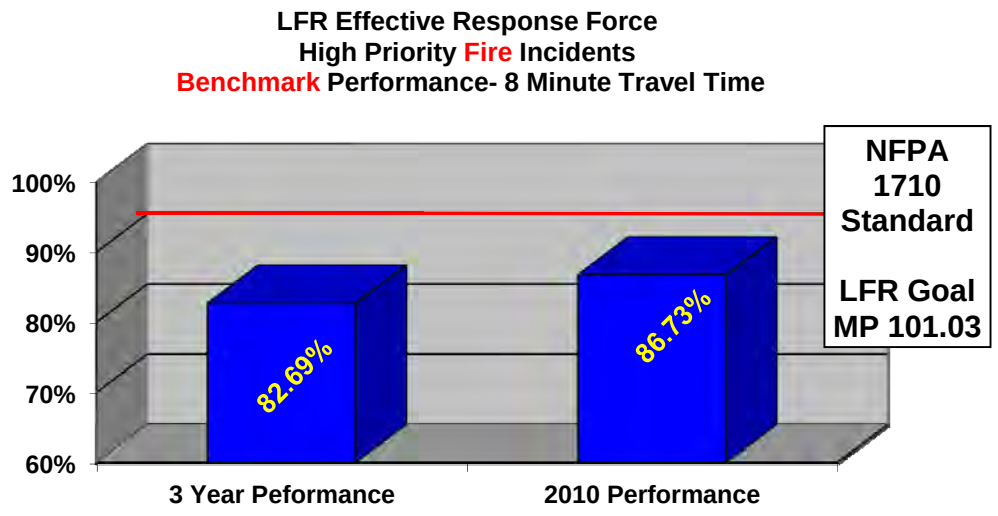
Eight minutes (480 seconds) or less travel time for the effective response force to the scene of emergency fire suppression, technical rescue or hazardous materials incident 90 percent of the time.

Baseline

Ten minutes (600 seconds) or less travel time for the effective response force to the scene of emergency fire suppression, hazardous materials or technical rescue incident 90 percent of the time.

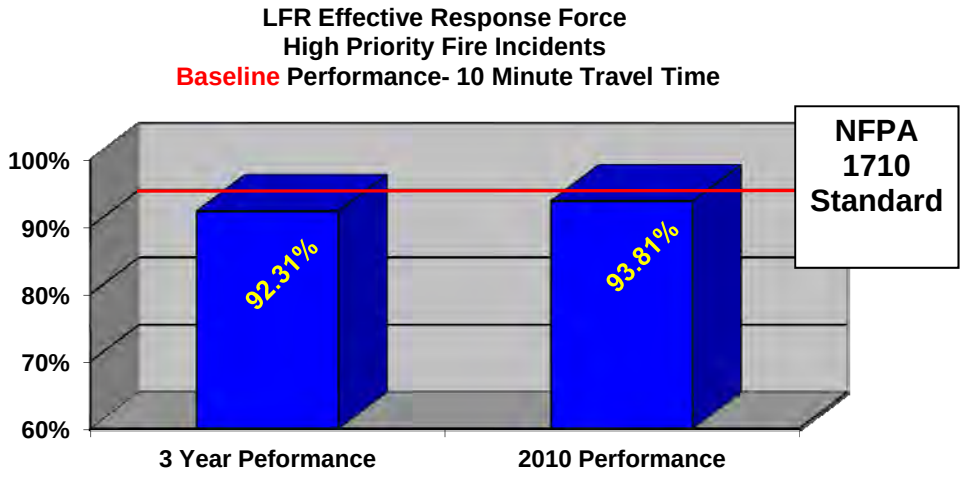
LF&R Historic Effective Response Force Travel Time to Structure Fires

Effective Response Force Travel Time 1 & 3 Year *Benchmark* Performance-Structure Fires



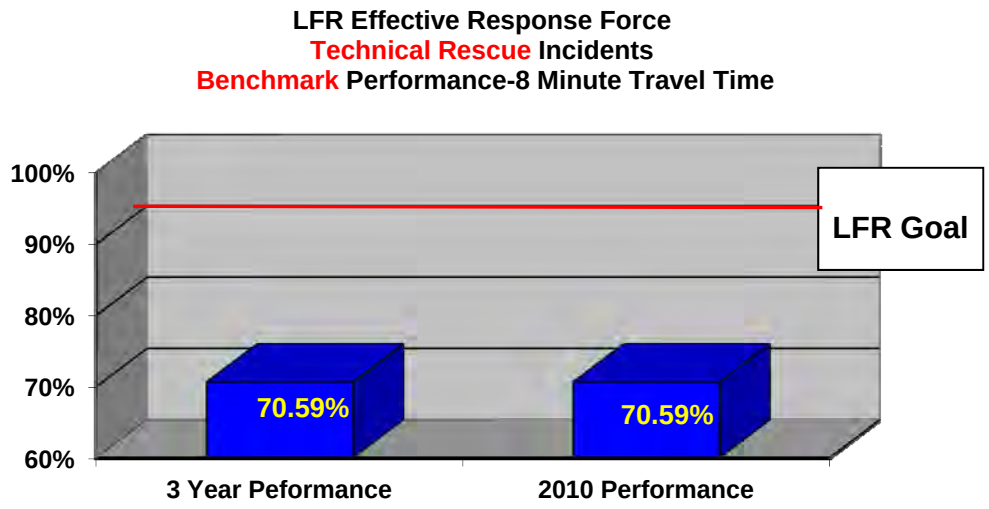
Source PRIME 6290 Report

Effective Response Force Travel Time 1 & 3 Year *Benchmark* Performance-Structure Fires



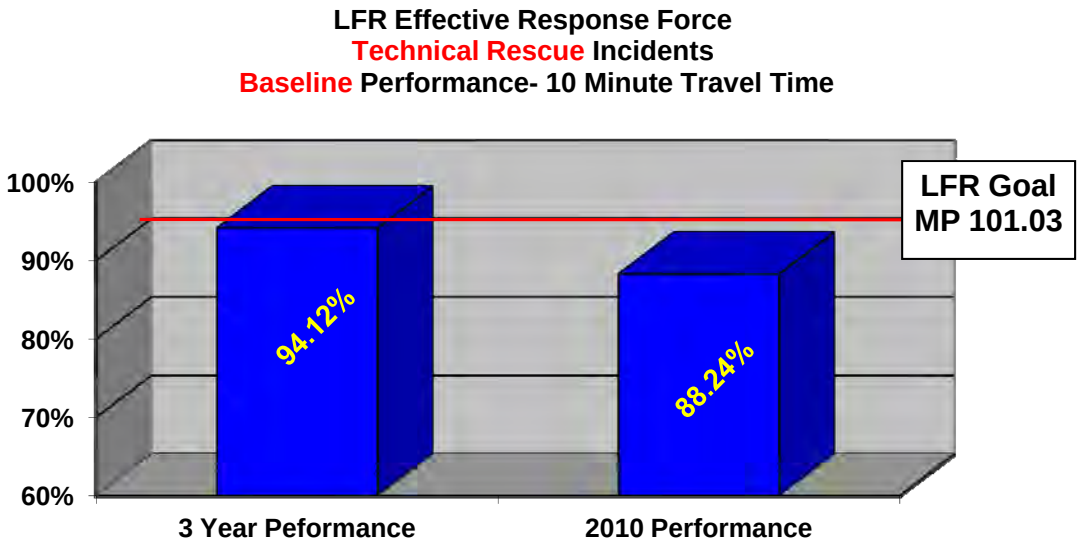
Source PRIME 6290 Report

Effective Response Force Travel Time 1 & 3 Year *Benchmark* Performance-Technical Rescue



Source PRIME 6290 Report

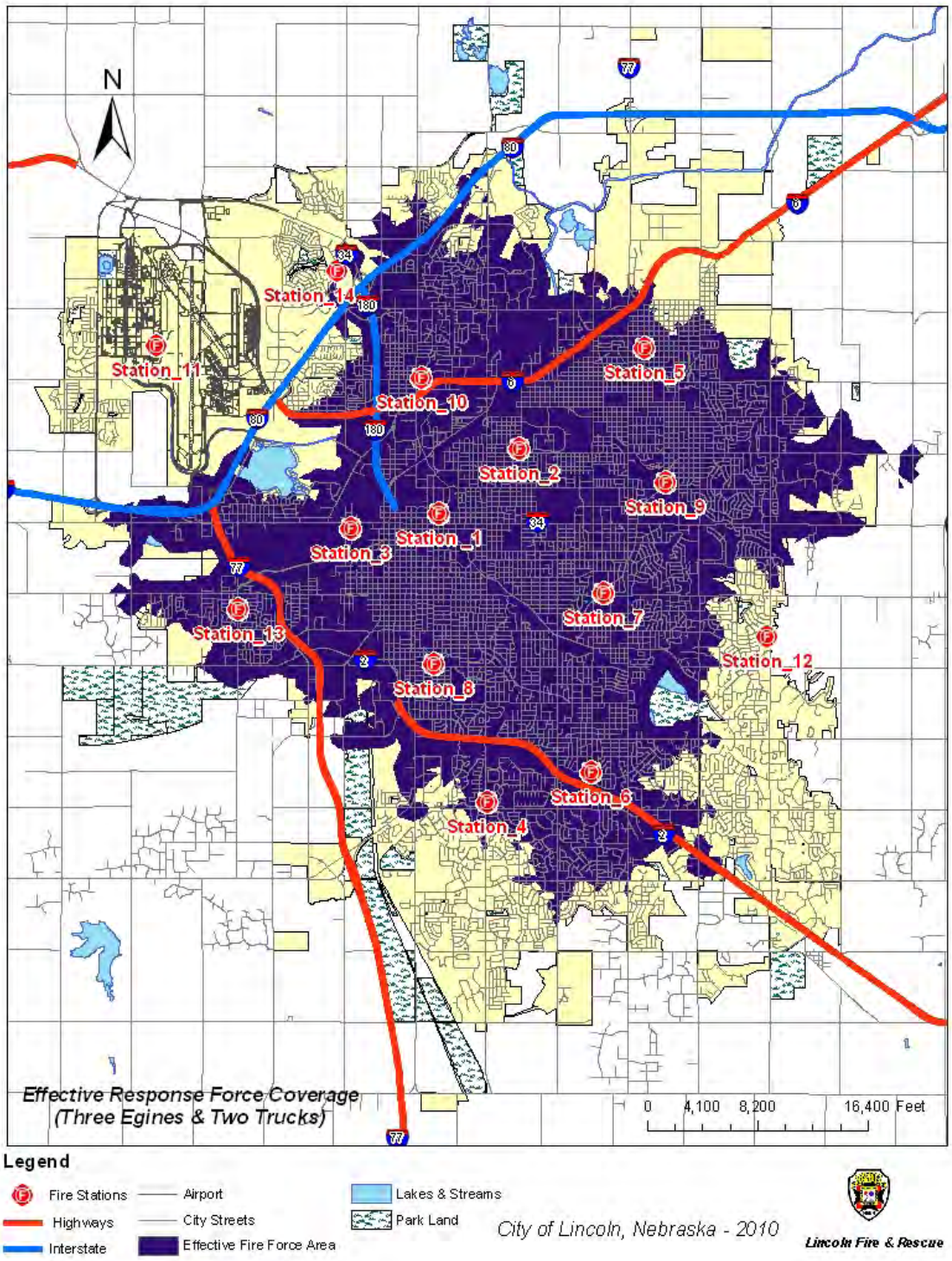
Effective Response Force Travel Time 1 & 3 Year *Baseline* Performance-Technical Rescue



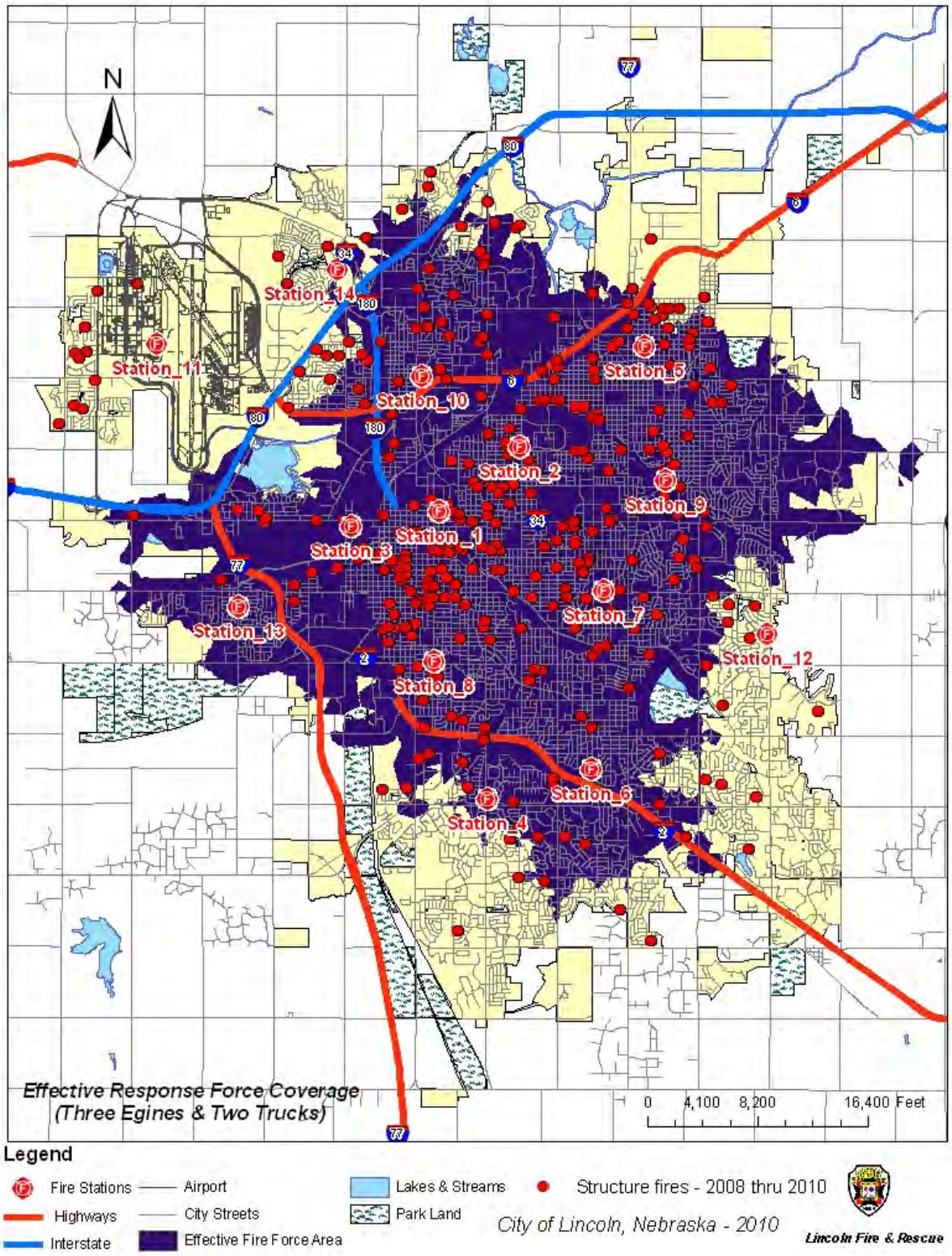
Source PRIME 6290 Report

The following maps depict the ERF coverage for current station deployment and future deployment for options A, B and C.

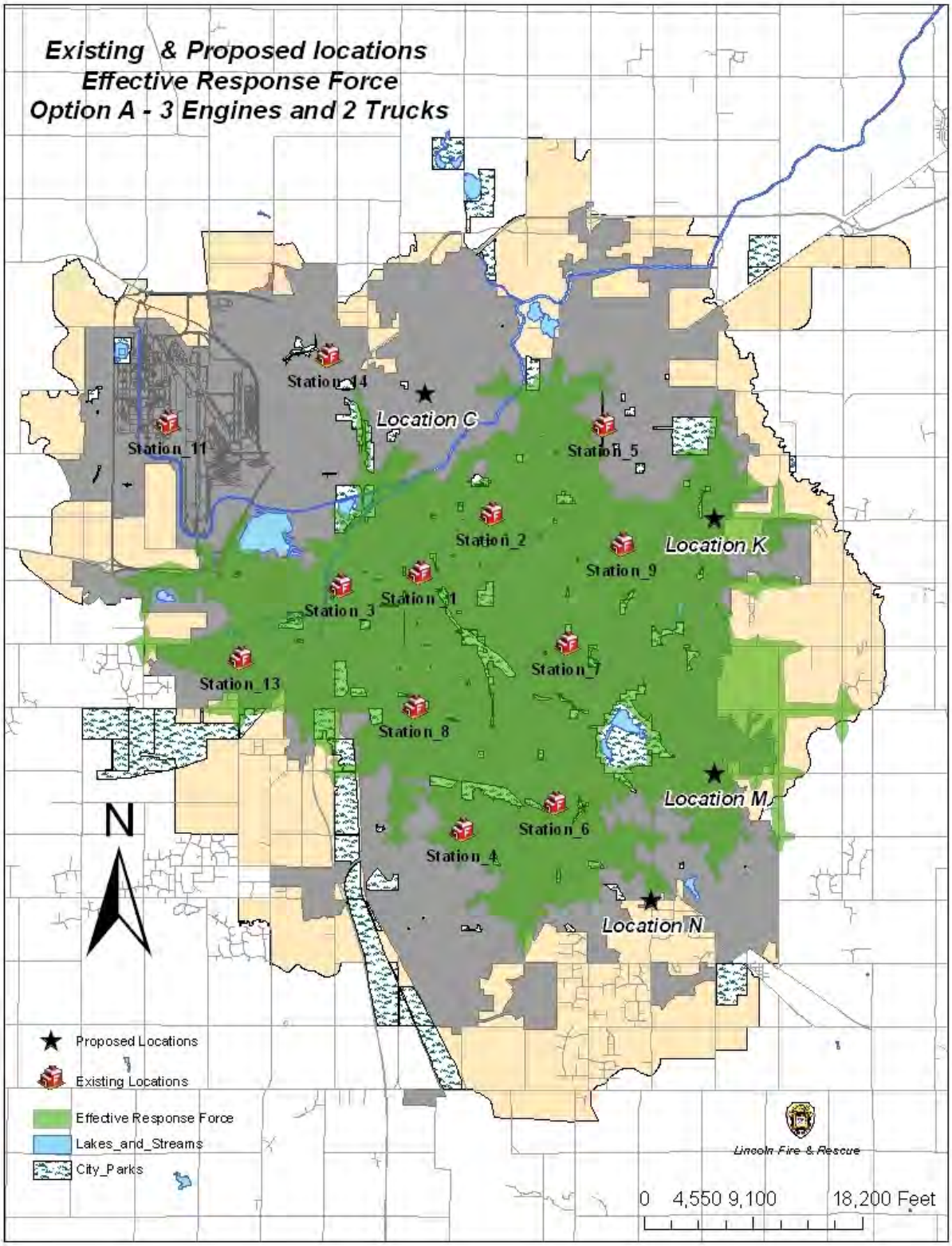
Effective Response Force Coverage from existing station locations



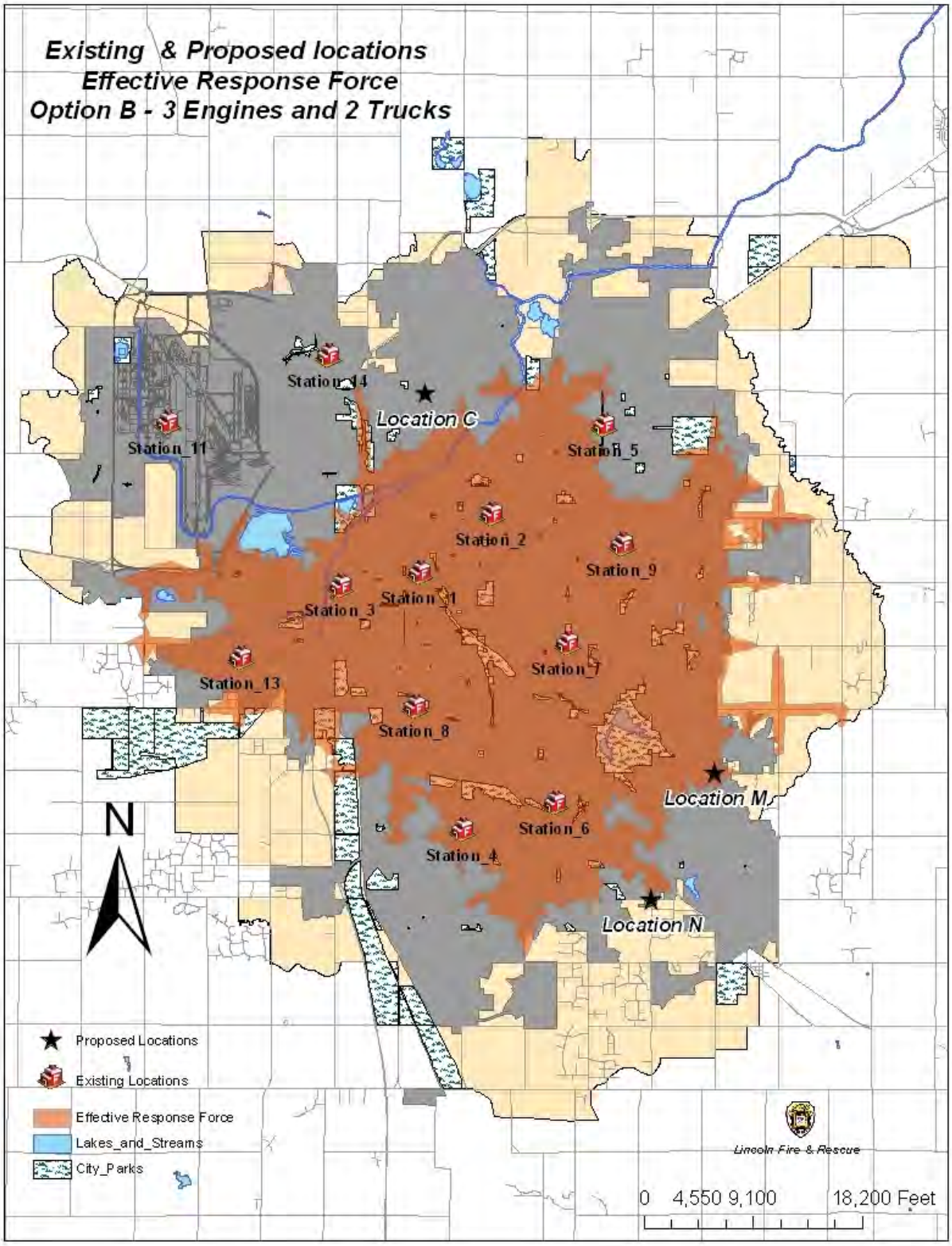
Effective Response Force Coverage from existing stations including structure fires 2008-10



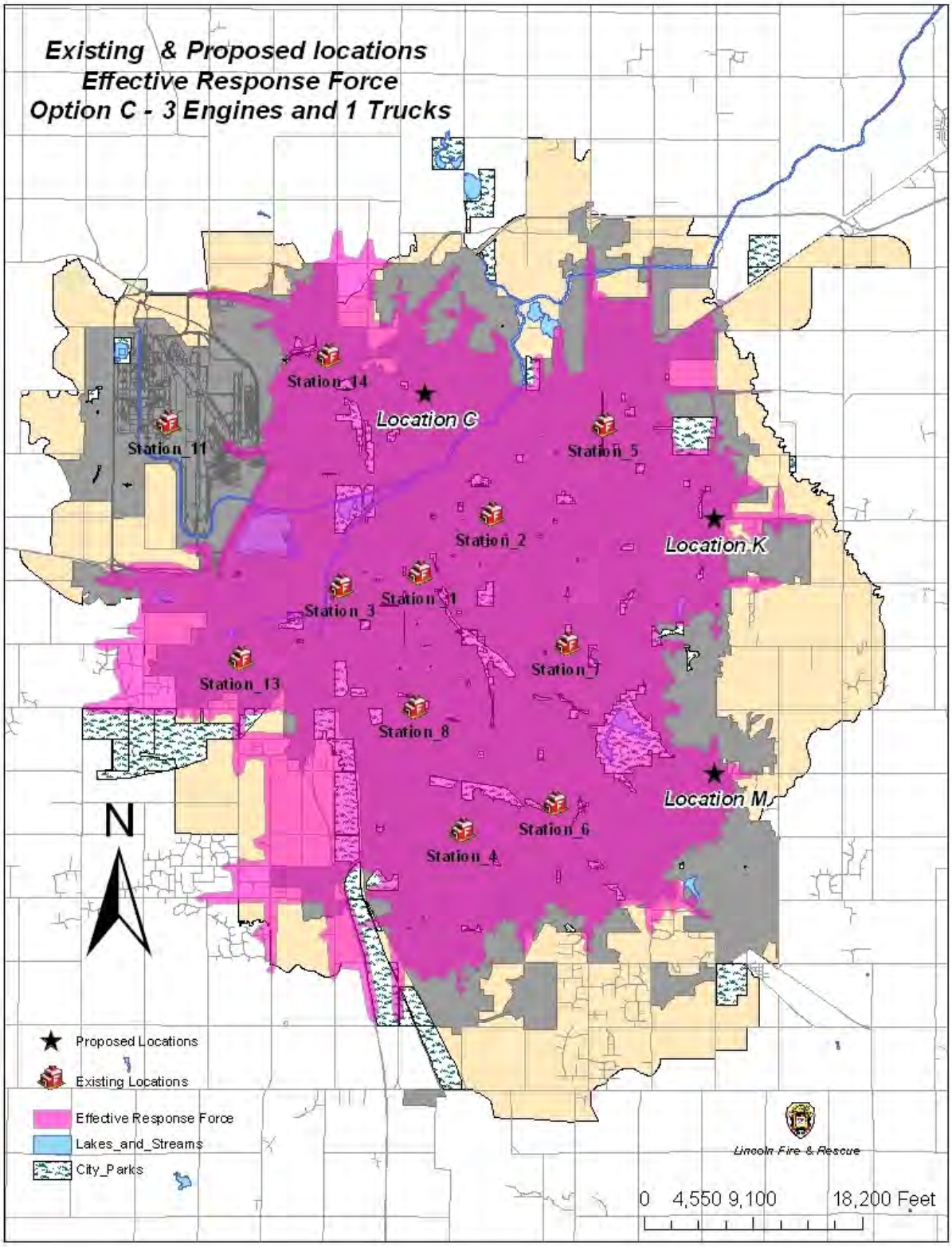
Effective Response Force Coverage from Option "A"



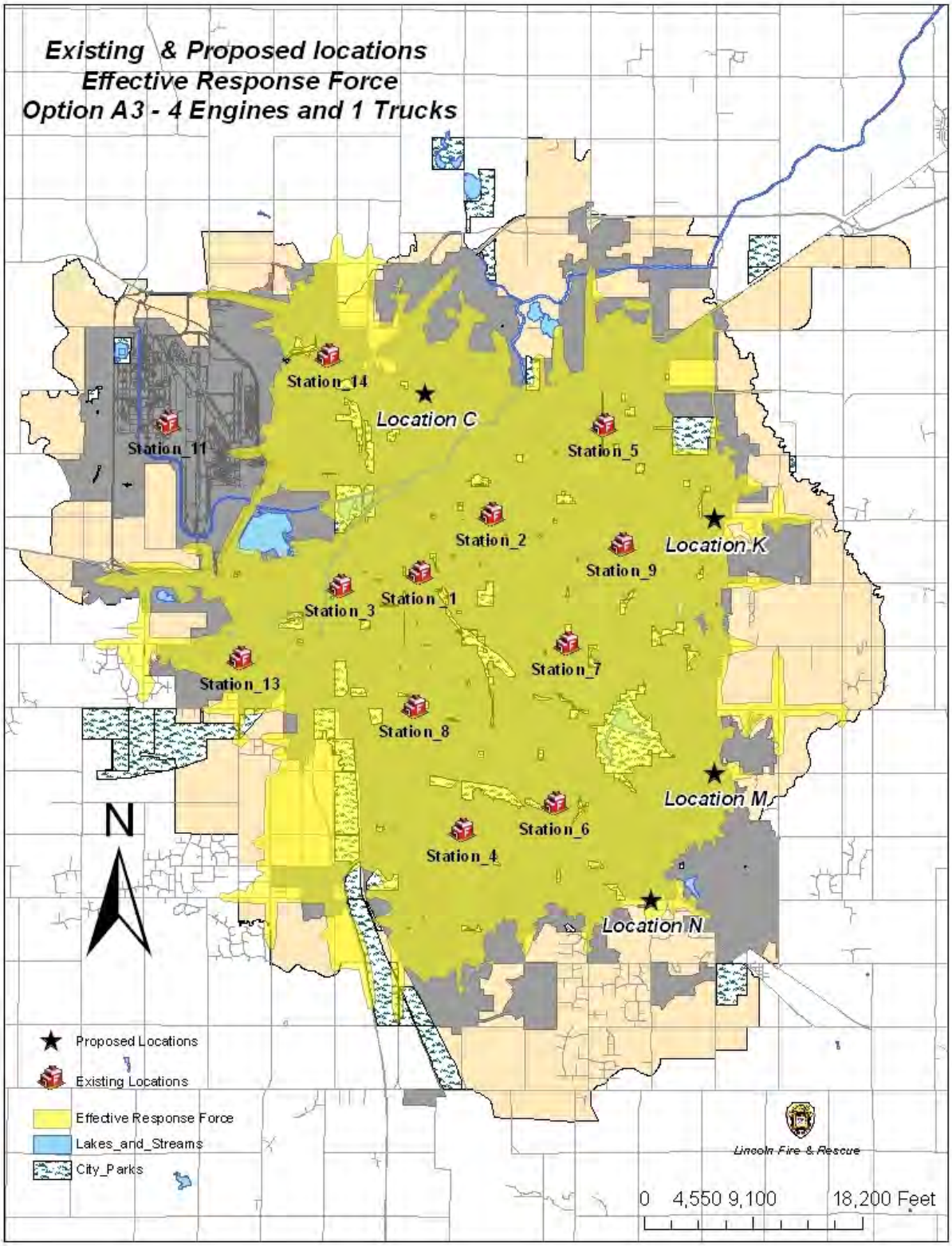
Effective Response Force Coverage from Option "B"



Effective Response Force Coverage from Option "C"



Effective Response Force Coverage from Option "A-3"



LF&R is not currently meeting established *benchmark* travel time standards for response to structure fires. However, LF&R is meeting the minimally acceptable *baseline* standard.

In an effort to further explore options to enhance the Effective Response Force (ERF) coverage the research group considered several different models of response based on both the number of square miles and addresses than can be covered in an 8-minute travel time *benchmar*k. As stated earlier, the assembly of the ERF for a structure fire is complete when 15 firefighters have arrived on the scene. Currently, the ERF is comprised of 3-engine companies and 2-truck companies, which provides 15 fire fighters even at minimum staffing levels.

Upon analyzing the data it is clearly apparent that the response of multiple truck companies has the largest impact on the ERF coverage area. This is because LF&R deploys so few truck company apparatus. Limited truck company resources cause an increased travel time for "second truck" arrival at incidents. As a result of this finding we considered alternate response profiles and truck locations for the *optimal* assembly of the ERF.

3-Engine Companies and 1-Truck Company

Due the fact that Option "C" provides four personnel on each company an ERF could be assembled with 3-engines and 1-truck providing 16 firefighters with four companies

4-Engine Companies and 1-Truck Company

If Option "A" or "B" is selected the research group believes in may be prudent to further explore a response profile which includes 4-engine companies and 1-truck company for the assembly of an ERF. Currently, engine companies outnumber truck companies at a greater than 3:1 ratio. A response reconfiguration of 4-engines and 1-truck for an ERF would still provide a minimum of 15 firefighters while allowing the ability to reallocate workload from a primarily fire to EMS workload for relocated truck companies. By reallocating workloads LF&R could realize significant increases in "first due" engine or truck company coverage ability. In addition, 4 engines and 1 truck for option "A" provides the opportunity to cover the largest percentage of address points as highlighted in the table below

Effective Response Force (8) Minute Travel Time Comparison Table

Relocation Option	Effective Response Force	Sq. Miles Covered	Addresses Covered
Existing Stations	3-Engines 2-Trucks	47.66	59,978
Option "A"	3-Engines 2-Trucks	49.68	56,760
Option "B"	3-Engines 2-Trucks	47.74	56,744
Option "C"	3-Engines 1-Truck	76.52	76,170
Option "A-2"	3-Engines 2 Trucks: T5@ Station 9	49.16	56,967
Option "B-2"	3-Engines 2 Trucks: T5@ Station 9	47.74	56,744
Option "A-3"	4-Engines 1-Truck	74.72	77,909
Option "B-3'	4-Engines 1-Truck	66.82	70,938
City of Lincoln	Current Demographics	Sq. Miles 90.67	Addresses 87,853

National Institute of Standards Technology & Underwriters Laboratory

NIST Report on Residential Fire Ground Field Experiments

In April of 2010 the National Standards of Technology (NIST) released a landmark study titled "**Report on Residential Fire ground Field Experiments."** The NIST Study evaluated the impact of crew size on the completion of critical fire ground tasks. According the Commission on Fire Accreditation International critical tasks are those specific tasks required, within an appropriate period, to successfully mitigate an incident. The NIST Study measured twenty-two fire ground tasks and the time to complete each task with varying levels of apparatus staffing to include two, three, four and five person staffing for each apparatus.

Results:

Overall Scene Time: The four-person crews operating on a low-hazard structure fire completed all the tasks on the fire ground (on average) seven minutes faster—nearly 30%—than the two-person crews. **The four-person crews completed the same number of fire ground tasks (on average) 5.1 minutes faster—nearly 25 %—than the three-person crews.**

Time to Water on Fire: There was a 10% difference in the "water on fire" time between the two- and three-person crews. **There was an additional 6% difference in the "water on fire" time between the three- and four-person crews.** (i.e., four-person crews put water on the fire 16% faster than two person crews did)

Ground Ladders and Ventilation: The **four-person crews operating on a low-hazard structure fire completed laddering and ventilation (for life safety and rescue) 30 % faster than the two-person crews and 25 % faster than the three-person crews**.

Primary Search: The three-person crews started and completed a primary search and rescue 25 % faster than the two-person crews complete. **The four- and five-person crews started and completed a primary search 6 % faster than the three-person crews** and 30 % faster than the two-person crew. A 10 % difference was equivalent to just over one minute.

Hose Stretch Time: In comparing four-and five-person crews to two-and three-person crews collectively, the time difference to stretch a line was 76 seconds. In conducting more specific analysis comparing all crew sizes to the two-person crews the differences are more distinct. Two-person crews took 57 seconds longer than three-person crews to stretch a line. Two-person crews took 87 seconds longer than four-person crews to complete the same tasks. Finally, the most notable comparison was between two-person crews and five-person crews—more than 2 minutes (122 seconds) difference in task completion time.

Apparatus Stagger: In addition to crew sizes, the experiments assessed the effects of stagger between the arriving companies. **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**. **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 of fire department operations conducted by the International Association of Fire Chiefs (IAFC) and the International Association of Fire Fighters (IAFF).

Conclusions

As a result to the NIST fire ground study it is reasonable to conclude that the timing of critical task completion is directly related to the number of firefighters staffed on each apparatus as well as the total number of firefighters on scene. Apparatus' with staffed with more firefighters complete critical tasks in less time. Option "B" and "C" of the Station Optimization plan allow for enhanced staffing on engine and truck companies.

The portion of the NIST Study that warrants further consideration concerning station optimization is the "apparatus stagger" utilized in the experiments. Based on information obtained from 300 U.S. fire departments, the study directed that apparatus' in the close stagger group arrive in 1-minute intervals. The apparatus' in the far stagger group arrived in 2-minute intervals.

Station optimization option "B" and "C" both include a reduction in the number of fire apparatus. Option "B" and "C" both provide for enhanced staffing on fire apparatus. In fact option "C" would provide for 4 personnel staffing on all engine and truck companies. However, by reducing the number of apparatus from 18 to 16 it is likely that the next arriving company at an incident would be delayed. Whereas, Option A maintains the number of fire apparatus 18 and adds two more stations, which would, likely decrease amount of time before a second and subsequent apparatus arrive.

In essence, the question that must be answered: Is it better to staff fire engines and trucks with four personnel and experience a delay of the 1st arriving company and subsequent companies? (OR) Is it better to separate stations with a co-located engine and truck company and add fire station locations and staff with 3 personnel resulting in a reduced response time?

As a result to the NIST fire ground study it is reasonable to conclude that the timing of critical task completion is directly related to the number of firefighters staffed on each apparatus as well as the total number of firefighters on scene. Apparatus with staffed with more firefighters get critical task done in less time. Option "B" and "C" of the Station Optimization plan allow for enhanced staffing on fire apparatus.

The portion of the NIST Study that warrants further consideration concerning station optimization is the "apparatus stagger" utilized in the experiments. Based on information obtained from 300 U.S. fire

departments, the study directed that apparatus' in the close stagger group arrive in 1-minute intervals. The apparatus' in the far stagger group arrived in 2-minute intervals.

Station optimization option "B" and "C" both include a reduction in the number of fire apparatus. However, Option "B" and "C" both provide for enhanced staffing on remaining fire apparatus. In fact option "C" would provide for 4 personnel staffing on all engine and truck companies. However, by reducing the number of apparatus from 18 to 16 it is likely that the next arriving company at an incident would be delayed. Whereas, Option A maintains the number of fire apparatus 18 and adds two more stations, which would, likely decrease amount of time before second and subsequent apparatus arrive.

In essence, the question that must be answered: Is it better to staff fire engines and trucks with four personnel and experience a delay of the 1st arriving company and subsequent companies? (OR) Is it better to separate stations with a co-located engine and truck company and add fire station locations and staff with 3 or 4 personnel depending on the daily staffing count?

UL Impact of Ventilation on Fire Behavior in Legacy and Contemporary Residential Construction

On December 14, 2010 Underwriters Laboratories (UL) released study findings on the Impact of Ventilation on Fire Behavior in Legacy and Contemporary Residential Construction. UL "There is a continued tragic loss of firefighters' and civilian lives, as shown by fire statistics. It is believed that one significant contributing factor is the lack of understanding of fire behavior in residential structures resulting from natural ventilation and use of ventilation as a firefighter practice on the fire ground. **The changing dynamics of residential fires as a result of the changes in construction materials, building contents and building size and geometry over the past 50 years add complexity to the influence of ventilation on fire behavior**.

UL conducted a series of 15 full-scale residential structure fires to examine this change in fire behavior and the impact of firefighter ventilation tactics."[1]

Two of the experiments conducted by UL which examined how modern day furnishings in comparison to legacy furnishings impact fire growth. The following excerpts from the study highlights the importance of rapid response as conditions in today's fires rapidly become untenable for both victims and firefighters.

"The times to flashover show that the a flaming fire in a room with modern furnishings leaves significantly less time for occupants to escape the fire. It also demonstrates to the fire service that in

[1]http://www.ul.com/global/documents/offerings/industries/buildingmaterials/fireservice/ventilation/DHS%202008%20Grant%20Report%20Final.pdf

most cases the fire has either transitioned to flashover prior to their arrival or became ventilation limited and is waiting for a ventilation opening to increase in burning rate."

"The modern room transitioned to flashover in 3 minutes and 30 seconds"
"The legacy transitioned to flashover 29 minutes and 30 seconds after ignition"

Table 12 Comparison flashover times

Experiment	Modern	Legacy
1	3:20	29:30
2	3:30	Not Achieved

This study is important when considering fire station location in that today's structure fires have a much narrower time frame before the conditions inside the structure become untenable for trapped occupants.

NIST Report on EMS Field Experiments

In September of 2010 the National Standards of Technology (NIST) released a study similar to the fire ground experiments, which analyzed the impact of staffing on Emergency Medical Services (EMS) Incidents. The Report on EMS Field Experiments was to determine how first responder crew size, where ALS providers are placed and how the number of ALS providers influences the effectiveness of EMS. As in the fire ground study, the EMS study measured crew effectiveness by the amount of time required to complete tasks on patient scenarios. A sample of the patient care tasks that were measured include

Specifically

Part 1- Time-to-task experiments related to gaining access to a patient and removing the patient from the incident scene.

Part 2- Time-to-task experiments related to the care of a victim with multi-system trauma.

Part 3- Time-to-task experiments related to the care of a victim with chest pain and witnessed cardiac arrest.

Results

Patient Access and Removal: With regard to accessing the patient, crews with three or four first responders reached the patient around half a minute faster than smaller crews with two first responders. The patient removal results show substantial differences associated with crew size. Crews with three- or four-person first responders complete removal between 1.2 – 1.5 minutes

faster than smaller crews with two first responders. **All crews with first responders complete removal substantially faster (by 2.6 - 4.1 minutes) than the ambulance-only crew.**

Trauma: Overall, field experiments reveal that four-person first responder crews completed a trauma response faster than smaller crews. Towards the latter part of the task response sequence, four-person crews start tasks significantly sooner than smaller crews of two or three persons. Additionally, crews with one ALS provider on the engine and one on the ambulance completed all tasks faster and started later tasks sooner than crews with two ALS providers on the ambulance. **This suggests that getting ALS personnel to the site sooner matters.** Crews with an **ALS provider on the engine and one ALS provider on the ambulance completed all required tasks 2.3 minutes (2 minutes 15 seconds) faster than crews with a BLS engine and two ALS providers on the ambulance.** Additionally, first responders with **four-person first responder crews completed all required tasks 1.7 minutes (1 minute 45 seconds) faster than three-person crews** and 3.4 minutes (3 minutes and 25 seconds) faster than two-person crews.

Cardiac: Regardless of ALS configuration, crews responding with four first responders completed all cardiac tasks (from at-patient to packaging) more quickly than smaller first responder crew sizes **As noted in the trauma scenario, crew size matters in the cardiac response**. **Crews with an ALS provider on the engine and one ALS provider on the ambulance completed all required tasks 45 seconds faster than crews with a BLS engine and two ALS providers on the ambulance**. Regardless of ALS configuration, **crews responding with four first responders completed all cardiac tasks from the 'at patient time' to completion of packaging 70 seconds faster than first responder crews with three persons,** and 2 minutes and 40 seconds faster than first responder crews with two persons. Additionally, ***after the patient arrested***, an assessment of time to complete remaining tasks revealed that first responders with **four-person crews completed all required tasks 50 seconds faster than three-person crews** and 1.4 minutes (1 minute 25seconds) faster than two-person crews.

EMS Response to Time Critical Events: In an analysis of data from more than 300 U.S. Fire Departments, first responder units arrived prior to ambulances in approximately 80 % of responses (IAFC/IAFF 2005). This response capability is likely attributed to the **strategic locations of fire stations housing the engines and the fact that engines are often more densely located than ambulance transport units**.

The Relation of Time-to-Task Completion and Risk: **Delayed response, combined with inadequate personnel resources exacerbates the likelihood of negative patient outcomes**. While rapid response is critical to patient survival, the personnel who respond must also be highly competent in patient assessment and stabilizing treatment delivery.

Conclusions

As in the NIST fire ground study, the NIST report on **EMS Field Experiments** proved that time to critical task completion is directly impacted by the number and the qualifications of the providers on scene of an emergency medical services incident. The most efficient deployment of staffing is to have a paramedic with a complement of EMT's on the first responding vehicle (engine or truck company), followed by a medic unit with an additional paramedic and EMT. Current LF&R staffing patterns align with recommendations in the NIST medical study by having a goal of staffing each first response vehicle with a paramedic and a complement of EMT's followed by a medic unit with one paramedic and one EMT. As highlighted in the NIST fire ground study one has to ask themselves: in a critical medical emergency i.e. cardiac arrest is it better to arrive later with more personnel or sooner with fewer personnel?

NFPA 1710- Medical response time standards

NFPA Standard 1710 also recommends that personnel deployed to ALS emergency responses include a minimum of two members trained at the emergency medical technician-basic level and two members trained at the emergency medical technician-paramedic level, arriving at the scene within the established time frame of two hundred and forty seconds (four minutes) or less for BLS units and four hundred and eighty seconds (eight minutes) or less for ALS units provided that a first-responder with Automated External Defibrillator (AED) or BLS unit arrived in two hundred forty seconds (four minutes) or less travel time, or at the minimum levels established by the authority having jurisdiction.[2]

A 1998 position paper published by the Emergency Medical Directors' Association of California highlighted the relationship between the timing of key resuscitative efforts and the probability of survival.

Collapse to CPR	Collapse to Defibrillation	Probability of Survival
≤ 5 Minutes	**≤ 10 Minutes**	**37%**
≤ 5 Minutes	**>10 Minutes**	**7%**
> 5 Minutes	**≤ 10 Minutes**	**20%**
> 5 Minutes	**> 10 Minutes**	**0%**

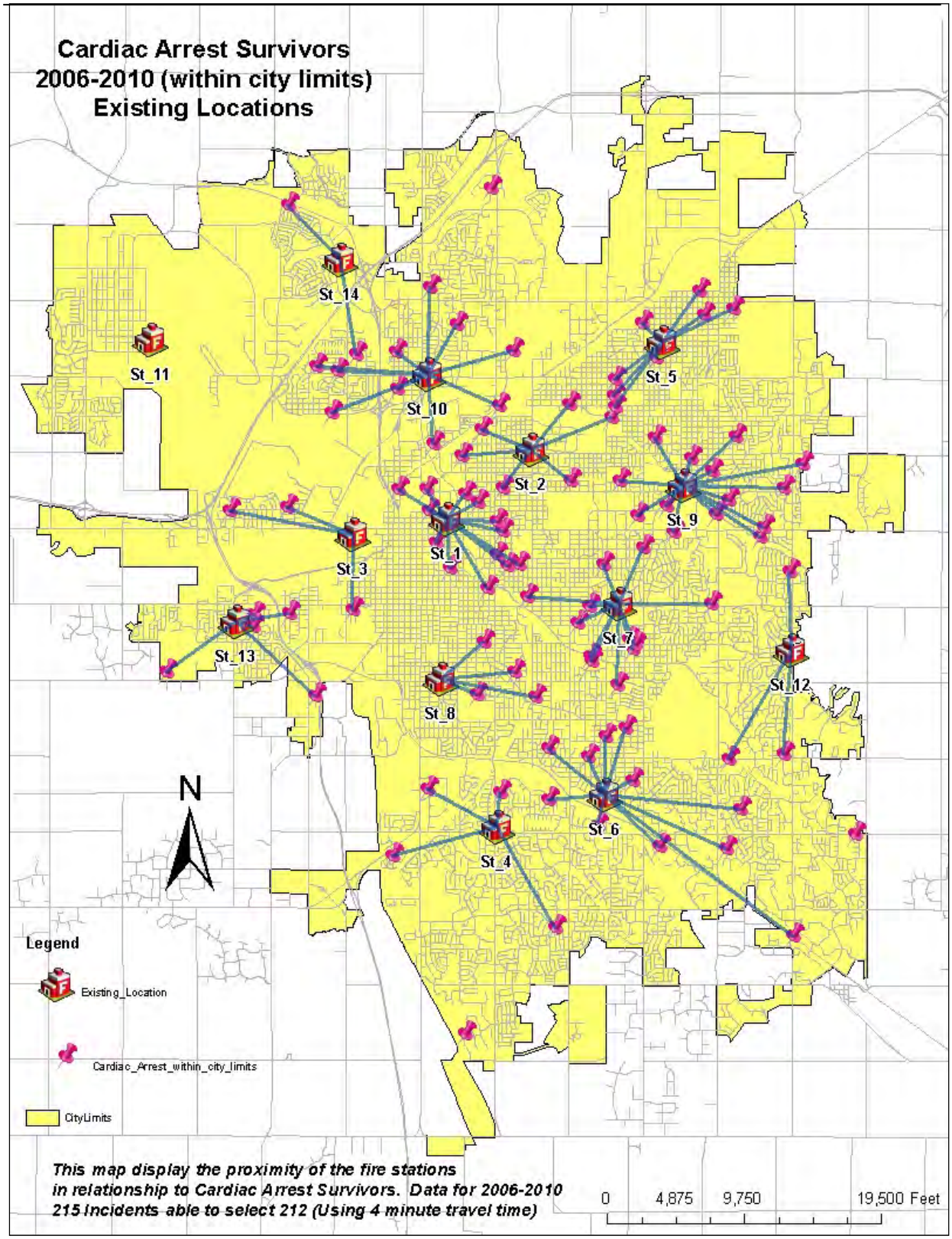
Annually, LF&R provides care for approximately 158 victims suffering cardiac arrest. The number of cardiac arrest treated by LF&R is on an upward trend from 134 arrests in 2006 to 175 arrest in 2010.

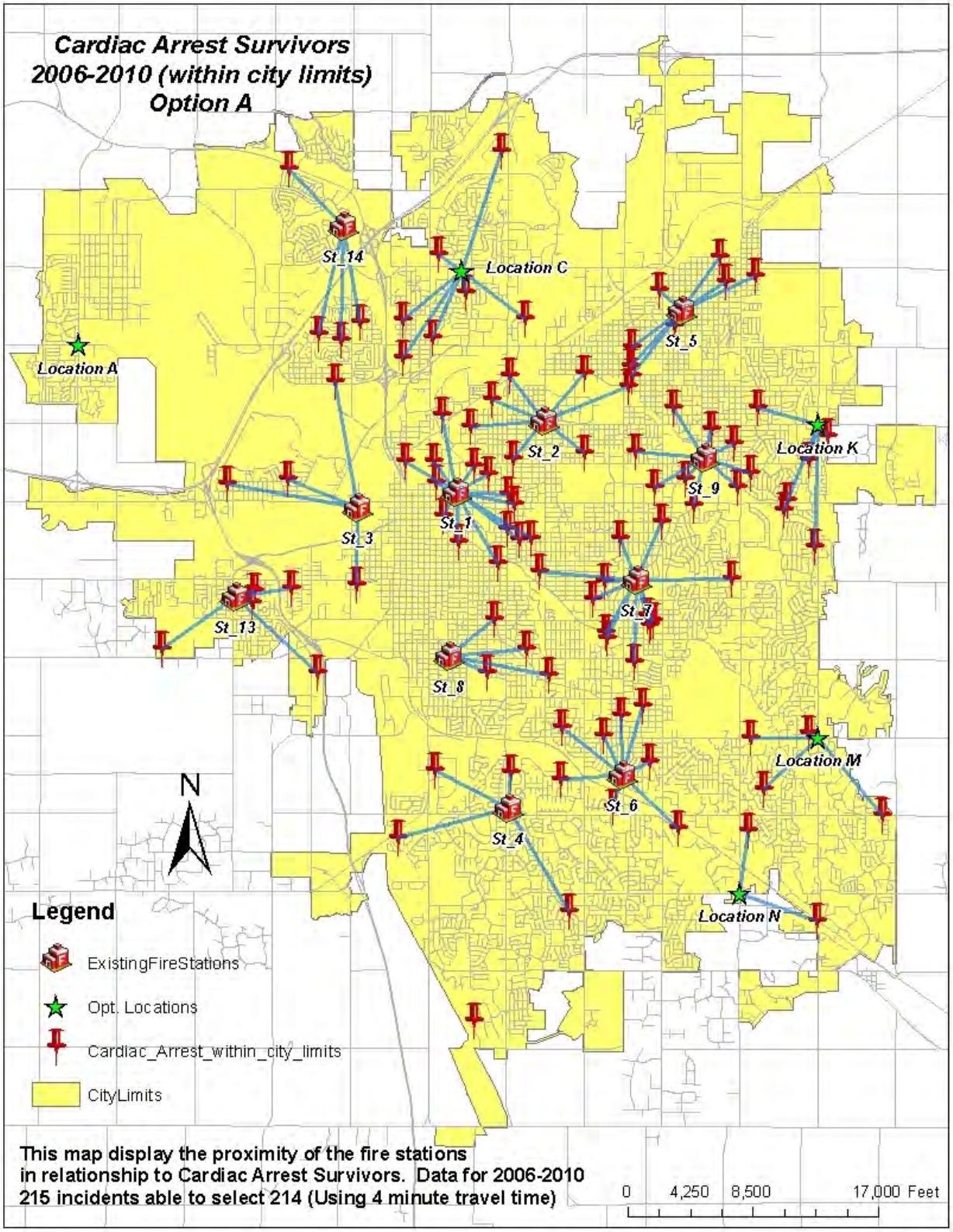
[2] NFPA 1710, Section 5.3.3.3.4: Personnel deployed to ALS emergency responses shall include a minimum of two members trained at the emergency medical technician-paramedic level and two members trained at the emergency medical technician-basic level arriving on scene within the established travel time.

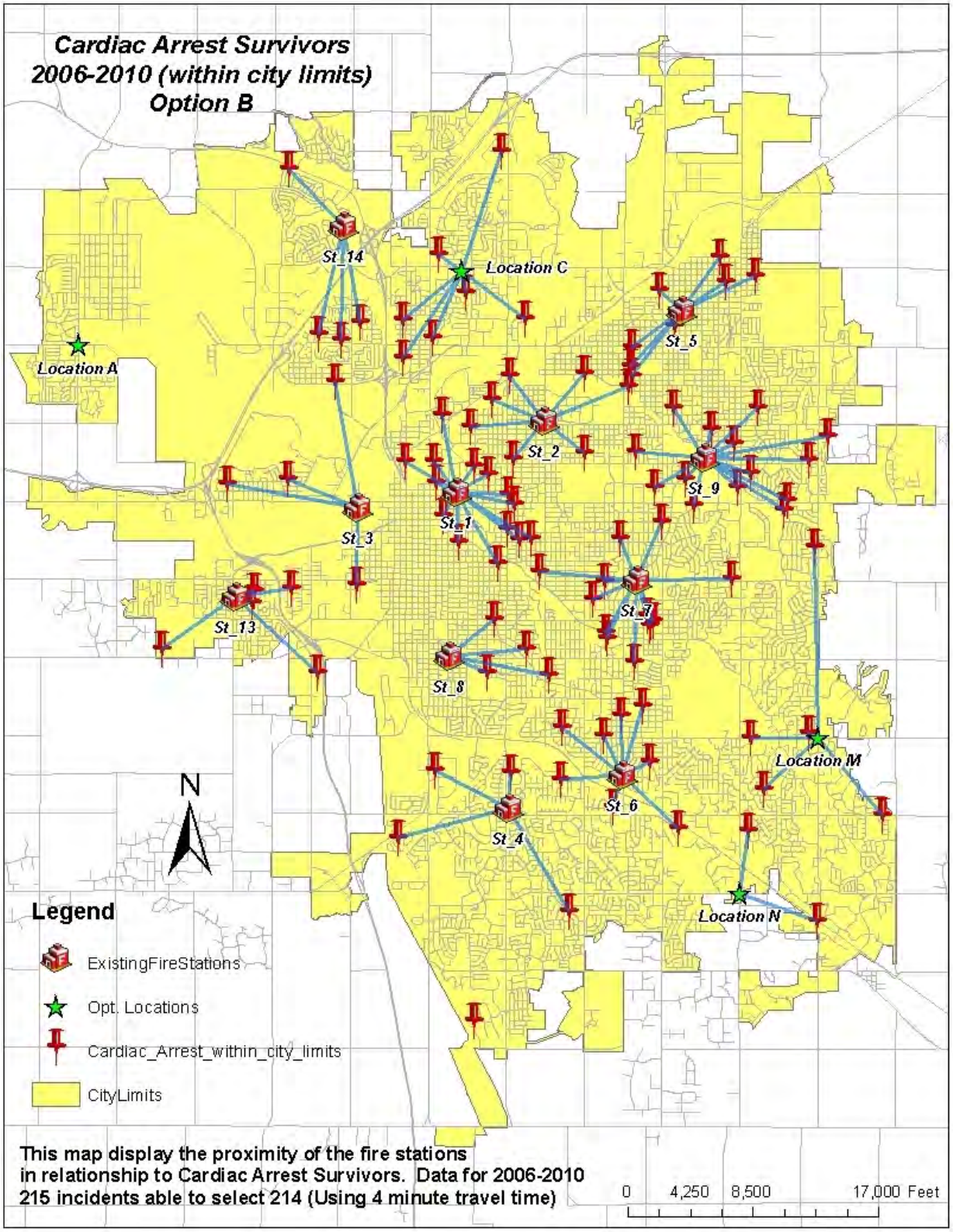
Option “A” of the optimization plan would provide the greatest opportunity for a rapid response of the first response vehicle i.e. engine or truck company with a paramedic on board. However, Option “A” would only routinely provide for three personnel staffed on a first due engine or truck company. In contrast, Option “B” and Option “C” would provide more staffing on first due companies by having a reduced number first “due” companies in service.

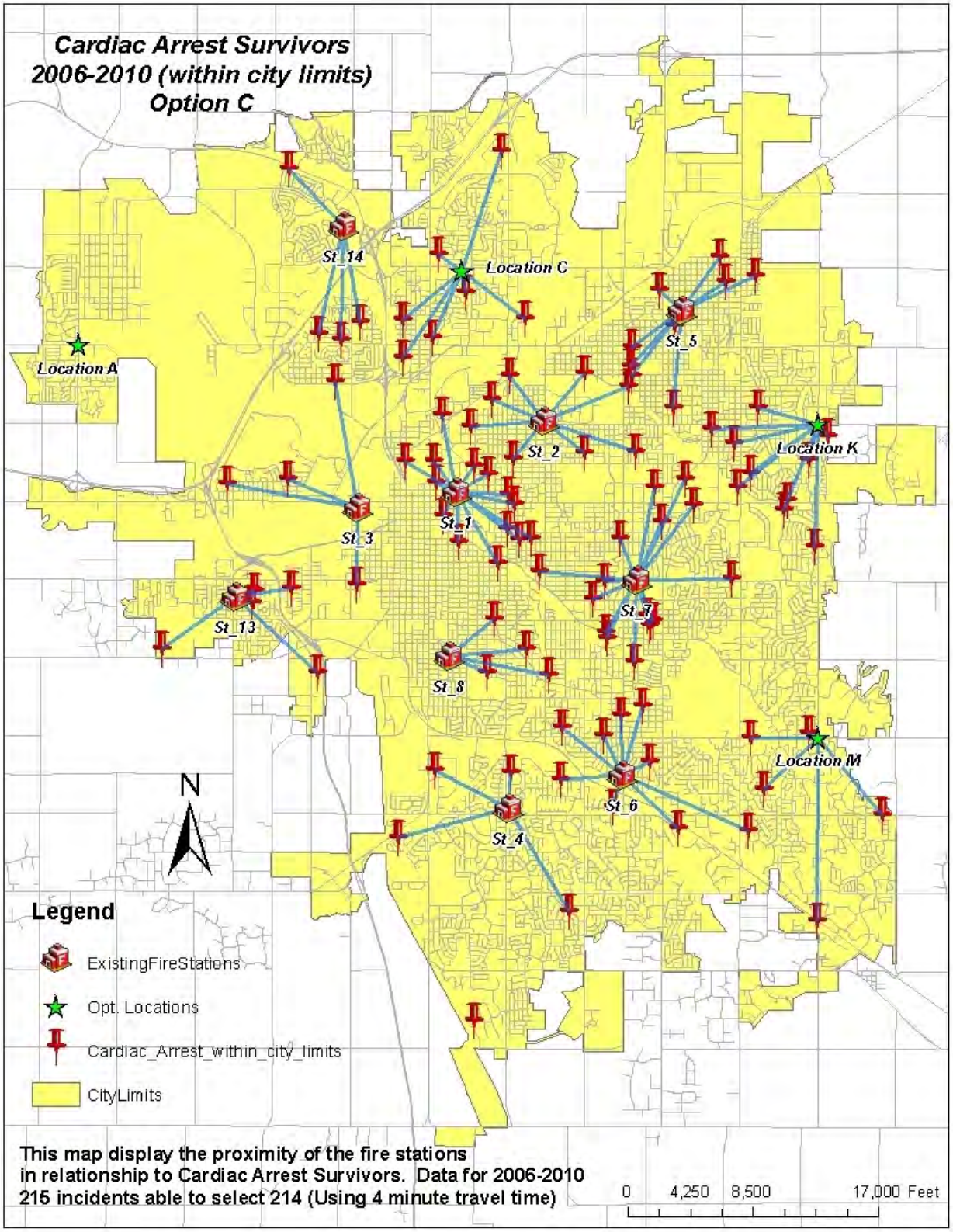
Each of the proposed options locations for station location would have provided a “first due” engine or truck company to arrival in 4 minute or less travel time in 214 of the 215 cases in which a patient suffered a cardiac arrest. However, as illustrated earlier there does appear to be a correlation between the geographical proximity of a fire station to the location of a patient who survived a cardiac arrest.

The following maps depict geographic location of cardiac arrest **survivors** over the last 5 years in comparison to current and proposed fire station locations included in Option A, B & C.


Cardiac Arrest Survivors
2006-2010 (within city limits)
Existing Locations
St_14
St_11
St_10
St_5
St_2
St_9
St_1
St_3
St_7
St_13
St_12
St_8
St_6
St_4
N
Legend
Existing_Location
Cardiac_Arrest_within_city_limits
CityLimits
This map display the proximity of the fire stations
in relationship to Cardiac Arrest Survivors. Data for 2006-2010
215 Incidents able to select 212 (Using 4 minute travel time)
0
4,875
9,750
19,500 Feet


Cardiac Arrest Survivors
2006-2010 (within city limits)
Option A
St_14
Location C
St_5
Location A
St_2
Location K
St_9
St_1
St_3
St_7
St_13
St_8
Location M
St_6
St_4
Location N
N
Legend
ExistingFireStations
Opt. Locations
Cardiac_Arrest_within_city_limits
CityLimits
This map display the proximity of the fire stations
in relationship to Cardiac Arrest Survivors. Data for 2006-2010
215 incidents able to select 214 (Using 4 minute travel time)
0 4,250 8,500 17,000 Feet


Cardiac Arrest Survivors
2006-2010 (within city limits)
Option B
St_14
Location C
St_5
Location A
St_2
St_9
St_1
St_3
St_7
St_13
St_8
Location M
St_6
St_4
Location N
N
Legend
ExistingFireStations
Opt. Locations
Cardiac_Arrest_within_city_limits
CityLimits
This map display the proximity of the fire stations
in relationship to Cardiac Arrest Survivors. Data for 2006-2010
215 incidents able to select 214 (Using 4 minute travel time)
0 4,250 8,500 17,000 Feet


Cardiac Arrest Survivors
2006-2010 (within city limits)
Option C
St_14
Location C
St_5
Location A
St_2
Location K
St_1
St_3
St_7
St_13
St_8
Location M
St_6
St_4
N
Legend
ExistingFireStations
Opt. Locations
Cardiac_Arrest_within_city_limits
CityLimits
This map display the proximity of the fire stations
in relationship to Cardiac Arrest Survivors. Data for 2006-2010
215 incidents able to select 214 (Using 4 minute travel time)
0
4,250
8,500
17,000 Feet

Considerations

If Lincoln Fire & Rescue were to implement any change in its respective response profile there would be a myriad of logistical and organizational considerations that would need to be explored. To maximize the efficiency of the system the City of Lincoln would likely incur some fiscal impact through the relocation of infrastructure and changing the response duties of other existing units.

In addition, other pieces of infrastructure could be added to the system to increase its efficiency. Increasing the use of traffic preemption devices allow units to get to calls faster and automatic vehicle location systems increase efficiency of the system by always sending the closest units.

The research group identified the following items that we felt needed consideration as LF&R moves forward in developing a redeployment strategy.

Automatic Vehicle Location Systems (AVL)

Implementation of an AVL system allows the closest available unit to be dispatched to an incident potentially decreasing the response time to an emergent call for service. Currently, LF&R operates utilizing “individual response zones” where the jurisdiction is broken down into geographic areas of responsibility. While a unit may be assigned that area of responsibility, it may not truly be the closest apparatus.

As the traditional role of the fire service transitions to an all hazards response, the fire service has experienced a decrease in individual unit reliability due to out-of-service times caused by; an increase in the number of responses, an increase in the different types of responses, an increase in the number of personnel and apparatus required at traditional responses such as fires and medicals, and increased out of service training times as training for the multitude of responses has increased.

As these demands have increased, the amount of time a unit is not in the fire station has significantly decreased as compared to the past. An AVL system would send the closest unit available as opposed to the unit from the closest fixed station.

An AVL system can be integrated into the Computer Aided Dispatch System (CAD) and the Mobile Data Terminals (MDT) currently in place to provide improved routes of travel thus further reducing response times.

Currently, LF&R has much of the infrastructure in place to implement an AVL system. Investment in the current CAD system needs to take place before the AVL system can be implemented. It is the recommendation of this research group that AVL continue to be researched and considered as a potential option to increase the efficiency of LF&R.

Traffic Signal Preemption

Lincoln Fire & Rescue has proactively supported a strong traffic signal preemption network within the City of Lincoln. The implementation and continued support of the program has had a positive impact on response times as well as civilian and firefighter safety since its implementation.

This research group applauds the implementation and support of this program and supports the continued integration of traffic preemptive technology as the service demand, population density, and geographical boundaries expand.

Changing the Roles of Truck Company Response

As we explored in the study the potential in changing the traditional truck company response to include front line medical response several topics came up and should be noted in this study for more discussion.

The study group realized that an increase in efficiency could be found within LF&R through the utilization of truck companies in medical response. Historically, these units have been co-located with engine companies whose responsibility was to handle front line medical response. In theory, by separating these units we are able to add front line medical response resources without having to add personnel.

Additional fiscal savings could be experienced through the use of what the fire service refers to as a ladder tender. A ladder tender could be a suburban or like vehicle, which is equipped as a first response unit for medical calls. In essence, the truck company could utilize the ladder tender to respond to medical calls thus reducing wear and maintenance and fuel costs for the truck apparatus. The cost of replacement for truck apparatus has risen significantly in the last 20 years and is approaching $750,000.

Further consideration will have to be given in terms of equipping these ladder tender units. To equip these units to mirror that of engine companies, the purchase of additional equipment will be needed. The most significant cost will be that of the LifePak 15 defibrillator at roughly $30,000 each.

Through this study it has become apparent that our truck companies are a limited resource and utilizing the truck companies to maximize efficiency must be carefully considered.

Rescue Engine Companies

As the truck companies continue to be a limited asset within LF&R, further decrease in truck reliability will be experienced through utilization of the truck apparatus as front line medical response units.

A method utilized in many municipalities to offset this problem is through the designation of rescue engine companies. A rescue engine company is essentially an engine company that carries some of the rescue equipment found on traditional truck companies. In many cases this is a basic set of hydraulic rescue equipment.

Through utilization of rescue engine companies a decrease in truck company demand can be experienced. The truck company that is an expensive resource is utilized less saving money and the life cycle of the unit is increased.

The implementation of this concept could be implemented at little to no cost. All personnel receive rescue training as recruits thus no additional training would be needed to implement this concept. As LF&R replaces existing equipment such as hydraulic tools on the truck companies the older equipment can be distributed to these rescue engine companies.

Risk Based Response

A growing trend in the fire service is the concept of a risk-based response. Essentially, the response profile sent to a given incident is based off the predetermined risk level for that structure.

A great example of this is the response to structure fires. Currently, the response to a typical residential structure fire in the City of Lincoln is comprised of 3 engine companies, 2 truck companies, 1 medic unit, 1 air unit, 1 battalion chief, and a fire inspector. This response profile is based on critical task analysis for a residential structure fire and is what we feel is adequate. However, this is the exact same response profile that we would initially deploy to a fire at the Embassy Suites in the downtown area. This would likely be inadequate to effectively mitigate a high-rise incident.

With risk-based response, an organization may enjoy increased efficiency through the deployment of an appropriate response to each individual structure. This is accomplished through an effective pre-plan program and the establishment of a risk rating system. This potential increase in efficiency needs to be further evaluated.

Future Fire Station Design

LF&R needs to acknowledge fire station design as an impact to the future efficient deployment of resources in the future. As service demands within the jurisdiction are dynamic, what is viewed as a low demand area today may present as significant in the future.

Currently many of LF&R stations are limited in terms of on-site expansion and can only accommodate a certain number of personnel and size of apparatus. This limits deployment options as collocation of apparatus and size limitations of certain stations negate optimal deployment.

As the City of Lincoln grows and new fire service infrastructure is acquired, consideration for future service demand needs to be considered in terms of housing additional personnel, number of units, and apparatus of increasing size.

Training and Reliability

As service demand continues to increase with an organizational workforce that has remained relatively static, apparatus reliability is going to continue to decrease. As the fire service continues to increase its

responsibility as an all hazard response service, training requirements and time spent meeting those requirements will also increase.

LF&R needs to consider alternative training plans that limit the out of service time of front line response units. This out of service time directly influences organizational response times negatively. This is occurring with the existing response profile and will increase if the current profile is reduced through the elimination of apparatus. The decrease in the number of responding apparatus will decrease adjacent coverage of response areas (reliability). LF&R should revisit its policy regarding numbers of apparatus out of service at any given time.

Fire Station 11

The research group believes that a fundamental part of station optimization should be the relocation of Fire station 11, which is currently located on the west apron of the Lincoln Municipal Airport.

The Airpark Fire Station has recently come under scrutiny due to low call volume. However, the Airpark area creates unique response challenges for LF&R as the airport itself creates a geographical barrier for service from stations located east of the airport. The current location on the west apron of the airport is located at a significant travel distance from the area where the majority of incidents occur. In fact, the 4-minute *benchmark* "first due" travel time compliance for Engine 11 in 2010 when responding to high priority incidents was a dismal 34.62% while the 5 minute travel time *baseline* for the same time period was 73.08%. As noted earlier, a 4-minute or less travel time equals a six minute total response time and a 5 minute travel time equals a seven minute total response time.

The airpark area has experienced significant residential and commercial growth over the last several years. The population density per square mile based on the 2000 census was 893 residents per square mile. The population density per square mile based 2010 census increased to 1,310 residents per square mile that nearly matches the density per square mile of Fire Station 3 in the downtown area at 1,473 residents per square mile.

The research group believes that moving Fire Station 11 in the area of NW 48th and West Adams will enhance services to the airpark area, the interstate corridor as well as the new jail located on West "O" Street. There is a correlation between fire service marketing and use of service. It does seem reasonable to assume that increased visibility as well as continued population growth will increase the utilization of LF&R services in the area served by Fire station 11.

Critical Task Analysis of Medic Unit Use at Working Incidents

LF&R needs to study the use of the medic unit as a component of the Effective Response Force at working fire incidents. The medic unit personnel need to be integrated into the critical tasks identified to be completed and the footprint of the typical structure fire response analyzed.

Statement of Findings

General

Each of the Options considered within this research project create both opportunities and limitations for LF&R. The following points highlight some of the major discussion points to be considered as this project moves forward.

- The research group strongly supports a movement to ensure 4 personnel are staffed on each engine and truck company. It has been scientifically proven that critical tasks can be completed sooner on both fire and EMS incidents if apparatus (engine/truck companies) are staffed with four personnel rather than three. However, the fundamental question that must be answered is "Arrive sooner with three personnel or later with four personnel?" Currently, seventy-six percent of LF&R responses are to EMS incidents. We believe that decreasing the footprint of apparatus could adversely influence the "first due" travel time performance. We believe that the most prudent way to maintain response to existing service demands as well as future demands is to add two stations staffed be splitting co-located engine/truck companies.
- The research group believes that current incident workload could be more evenly distributed by expanding the current scope of truck company responsibilities to include primary response to medical incidents. As a result of expanding truck company responses to medical incidents LF&R should realize an improvement in the "first due" *benchmark* travel time compliance while maintaining response area overlap thus improving reliability.
- The current LF&R deployment model of truck companies creates response challenges as the geographic spread of 90.67 sq. miles is covered by four truck company apparatus. The research group believes that the effective response force coverage for the city could be enhanced by considering an alternate response profile for structure fires. A response of either 3 engines and 1 truck for Option "C" or 4 engines and 1 truck for Option "A" creates a 30% increase in the ERF coverage area thus increasing existing truck company reliability while maintaining or enhancing the "fist due" response coverage.

Option "A"

The research group believes that option "A" provides the greatest opportunity to meet existing and future demands for fire & rescue services. As the City of Lincoln continues to grow we believe that it will be exceptionally difficult to maintain, let alone enhance "first due" and "ERF" travel time performance without adding fire stations. Currently, LF&R is in the low to mid 80th percentile compliance with a "first due" 4 minute or less benchmark travel time compliance. LF&R is also in the low to mid 80th percentile *benchmark* compliance for an 8-minute travel time for the effective response force for structure fires.

We recommend that LF&R build two additional stations and relocate Stations 10, and 12. Adding fire stations to the east Hwy 2 corridor and the North 84th Street area will significantly enhance *"first due"* response times to growing areas within the city. Coupled with an adjusted ERF response profile of four

engines and one truck, LF&R will realize a significant enhancement to ERF coverage ability under Option "A".

The staffing and apparatus for Stations 15 and Station 16 could be provided by moving Truck 5 out of Station 5 and Truck 7 out of Station 7 as they are currently co-located with an engine company.

Relocation of Truck 7 also relieves an apparatus-overcrowding problem at Station 7. Currently, Medic 7 parks in front of Engine 7 and must be moved each time Engine 7 responds independently because Station 7 only has two apparatus bays.

The major drawback of Option "A" is the fact that is does not provide four personnel on every apparatus. However, the current labor agreement defines a minimum daily staffing level of 76 fire fighters on duty every day. A minimum level of 76 firefighters includes staffing for six front line medic units, an EMS Supervisor a Hazmat/ Air 14 Fire Apparatus Operator and a minimum staffing level of four fire fighters on 8 of 18 (44%) percent of engine/ truck companies. The total daily staffing requirement when management positions are added results in 78 fire fighters on duty each day.

8 Engine or Truck Companies x 4 firefighters	**32 fire fighters**
10 Engine or Truck Companies x 3 firefighters	**30 fire fighters**
6 Medic Units x 2 firefighters	**12 fire fighters**
1 EMS Supervisor	**01 fire fighter**
1 Hazmat/Air 14 FAO	**01 fire fighter**
1 OIC (Officer in Charge)	**01 battalion chief**
1 ICT (Incident Command Technician)	**01 fire fighter**
Total	**78 fire fighters**

As highlighted earlier, critical tasks for both Fire and EMS incidents are completed earlier with more personnel. However, we project that if more personnel arrive later into the incident the benefits realized by additional four person staffing on each engine and truck may be lost by a delayed response.

Based on research, we believe that in light of current expanding service area within the city, an enhanced response time of a "first due" and "ERF" with engines and truck staffed with three personnel provides certain and distinct advantages over an extended response time with four personnel on each engine/truck company. This is especially evident in terms of a rapid response to a medical incident as in 2010 seventy six percent of LF&R incident responses were for medical emergencies.

The research group strongly encourages the exploration of a funding mechanism that would provide four personnel on every engine and truck company. We believe that four person staffing coupled with the fire station locations highlighted in Option "A" would provide an exceptional level of fire and rescue services for the City of Lincoln.

Option "B"

The research group views Option "B" as an exploratory venture that maintains existing station locations while enhancing service levels by splitting a co-located engine and truck company. In addition, Option "B" would provide a window into the efficacy of the ladder tender arrangement while allowing a means to retreat to traditional engine and truck responsibilities without incurring a devastating financial impact in the event the ladder tender arrangement proves to be a detriment to fire & rescue services.

Option "B" significantly enhances *"first due"* engine /truck company coverage to the Southeast part of Lincoln as well as the City as a whole evidenced by the (4) minute travel time polygon displayed on pg. 33 of this document. Option "B" provides an increase in first due coverage ability of 4.27 sq. miles and 4,014 addresses over existing fire station locations and apparatus deployment. However, as Option "B" provides an increase in "first due" engine/truck company coverage there is a corresponding decrease in the ERF coverage ability. Under Option "B" when 3-engine companies and 2-truck companies comprise the ERF, Option "B" provides coverage to .08 sq. miles and 3,234 less addresses than current station locations and apparatus deployment.

It should be noted that Option "B" will enhance the number of engine/ truck companies that could be staffed with four fire fighters. The reduction in the number of apparatus from fourteen to thirteen would provide twelve additional firefighters to be reassigned to existing companies. The reassignment of these personnel would provide for eleven engine/truck companies to be staffed with four personnel, six engine/ truck companies to be staffed with three personnel while maintaining staffing for six medic units, one EMS Supervisor and an FAO for Hazmat/Air 14.

In light of a significant decrease in the ERF coverage ability and more enhanced opportunities via Option "A" and "C" the research group views option "B" as the least favorable of the three available options being considered.

Option "C"

The conclusions reached by the research group regarding Option "C" are as follows: The distinct advantage of Option "C" is a progression to a staffing level of four fire fighters on all engine and truck companies. The provision of four personnel staffed on each engine /truck company is realized through the reduction in the number of front line apparatus from eighteen to sixteen. Based on recent published studies it is clearly evident that time to critical tasks completion is directly related to the number of personnel on each apparatus operating at a fire or EMS incident i.e. the more personnel on each apparatus the faster critical tasks are completed.

However, the last time a fire station was added in the City of Lincoln was in 1997. Since that time, the City of Lincoln has grown by 20.64 square miles or 13,230.70 acres. We strongly support the staffing of four fire fighters on engine/truck companies. Option "C" does enhance EFF coverage to a point equal with Option "A" and Option "C" certainly enhances both first due and EFF coverage over existing station and apparatus deployment. However, the corresponding reduction in response area overlap in Option "C" continues to be of paramount concern.

As stated earlier, LF&R has a very narrow window for error when considering current travel time *benchmarks* and *baselines* as it relates to the current number of fire stations and a possible reduction in the number of fire apparatus

According to the Commission of Fire Accreditation International if an agency experiences less than 90% compliance with established response *baselines* the agency is outside of "industry best practices" and a plan must be in place to address response time shortfalls.

Conclusion

The desire of the management team of Lincoln Fire & Rescue is to assure that fire stations are located strategically across the city to allow for a rapid response when needed by any member of the community. This study provides elected officials with several options to consider assisting the LF&R management team to assure emergency services are uniformly available to residents of our community, while meeting local and fire and EMS industry standards.

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UPDATE TO STATIONOPTIMIZATION STUDY

LINCOLN FIRE & RESCUE

August, 2014

This document supplements the 2012 Lincoln Fire & Rescue Station Optimization Study with updated data, information, and analysis.

Continued Population Growth

The optimization study was released in January, 2012, but data for the study was collected in 2011. Since that time, three new population estimates for Lincoln have been released by the United States Census Bureau. The Bureau issues estimates annually, but these are estimates as of July 1 or the preceding year. In 2011, when the optimization study was prepared, Lincoln's most recent population estimate was 259,096 as of July 1, 2010. Today, Lincoln's most recent population estimate is 268,738 as of July 1, 2013. The increase is 9,642 or 3.7%. Lincoln is growing by about 3,300 people every year.

Annexations

Since 2011, Lincoln land area was 90.8 square miles. Annexations in 2012, 2013, and 2014 have occurred, raising the area by over two square miles, to 98.82 square miles. Most of these annexations have occurred in the areas that would be served by the four stations identified in the optimization study.

New Development

Accompanying growth has been new development. In 2012, 2013, and the first seven months of 2014, 8,359 building permits were issued for new construction. Of these, 3,416 were for residential dwellings. Much of this new development continues to occur at the fringe in three of the four areas identified as optimal sites for the location of fire stations: near 84th and Holdrege, near 84th and Pioneers, and near 70th and Pine Lake Road. The optimization study considered the future service area of Lincoln, as identified in the comprehensive plan. Since new development has occurred within areas already anticipated, it does not materially impact the validity of the study. No major new roadway projects have taken place that would significantly alter response time projections. The primary impact of new development is that the supply of land available around the optimal fire station locations is dwindling. It will be important to analyze the coverage areas as specific parcels for stations are identified, to assess the impact of deviations from the optimal locations on the increment of improvement in coverage.

Response Activity

LF&R incident response activity continues to rise in relative proportion to the growth in population. In 2010, the year prior to the completion of the optimization study, total incident response was 19,602 76.52 % of which were for emergency medical service (EMS) incidents. In 2013 the total was 21, 357 with 78.29% being EMS. From January 1, to August 31, 2014 there have been 15,260 incidents of which 79.51% were EMS. At this pace the department will respond to an estimated 22, 890 total incidents in 2014, an increase of 1,533 over 2013.

St. Michael's Parish and School

The Catholic Diocese of Lincoln opened St. Michael's School just as the station optimization study was being prepared in the fall of 2011. Since that time, the school and church have been fully occupied. Considerable residential building has occurred in the immediate area. While this area was already within the future service limits identified in the comprehensive plan and considered in the optimization study, the rapidity of the building boom has been impressive. Simply put, the rooftops have sprung up more quickly than most citizens would realize.

Lincoln Public Schools Bond Issue

In the spring of 2014, citizens approved a bond issue for the Lincoln Public Schools. This bond issue includes the construction of two new schools: an elementary school northwest of 70th and Yankee Hill Road, and a middle school on land located in Jensen Park, near 84th and Yankee Hill Road. These areas are already slated for future development in the comprehensive plan, but based on past experience; the siting of these two schools may be expected to speed up nearby residential development.

Lincoln Police and Lincoln Fire & Rescue Colocation

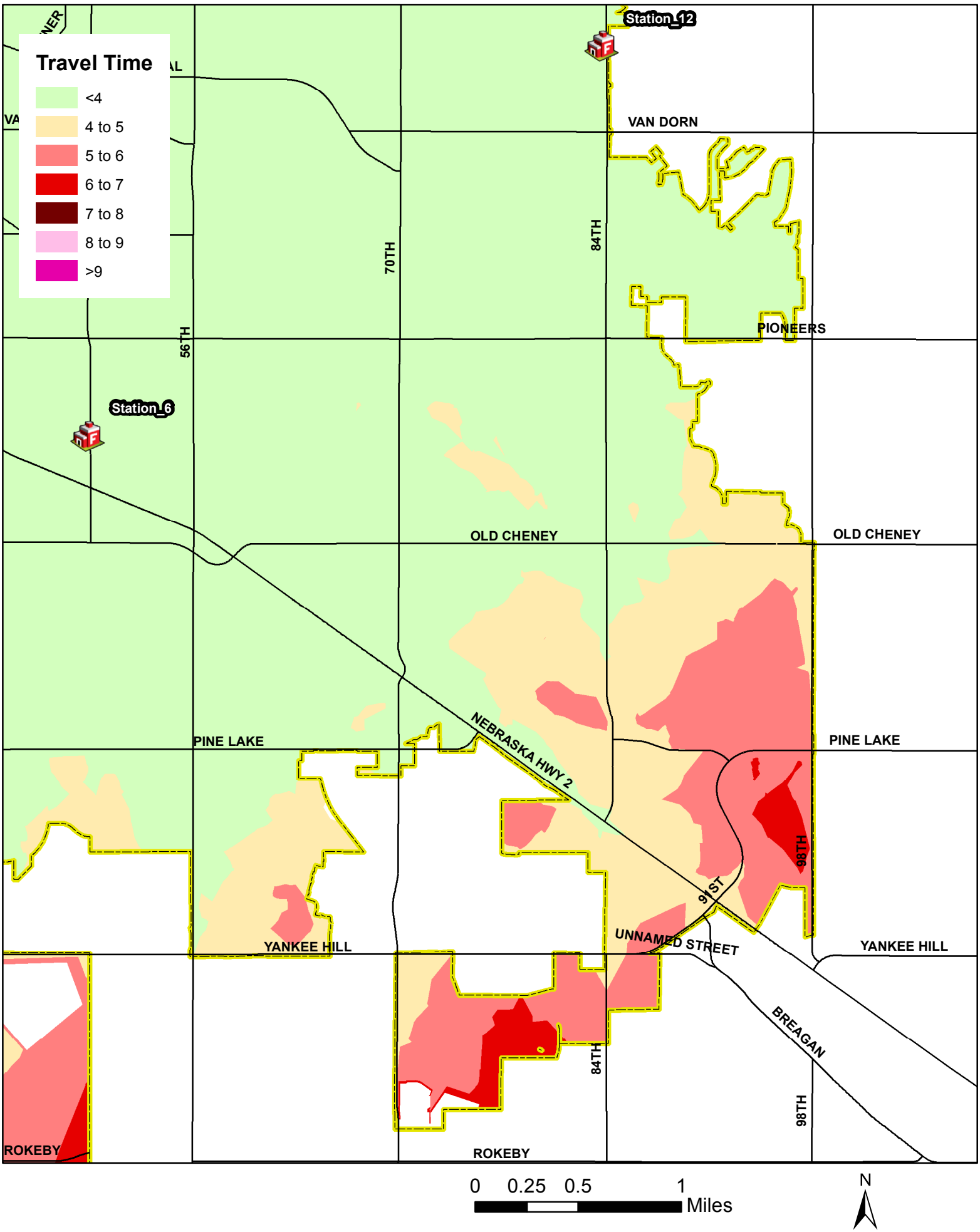
Since the study was originally published, much more work has been done to combine pre-existing capital improvement projects from police and fire into a joint facility in southeast Lincoln. Preliminary site plans and take-off estimates have been produced, and LPD has calculated the likely savings in time, mileage, and fuel that would result from deployment from a southeast station, rather than downtown. It appears that either one of the southeast fire station locations, M or N, would be suitable as the joint facility. Land availability will be a major determinant, since the police/fire facility has a considerably larger footprint than a standalone fire station.

Summary

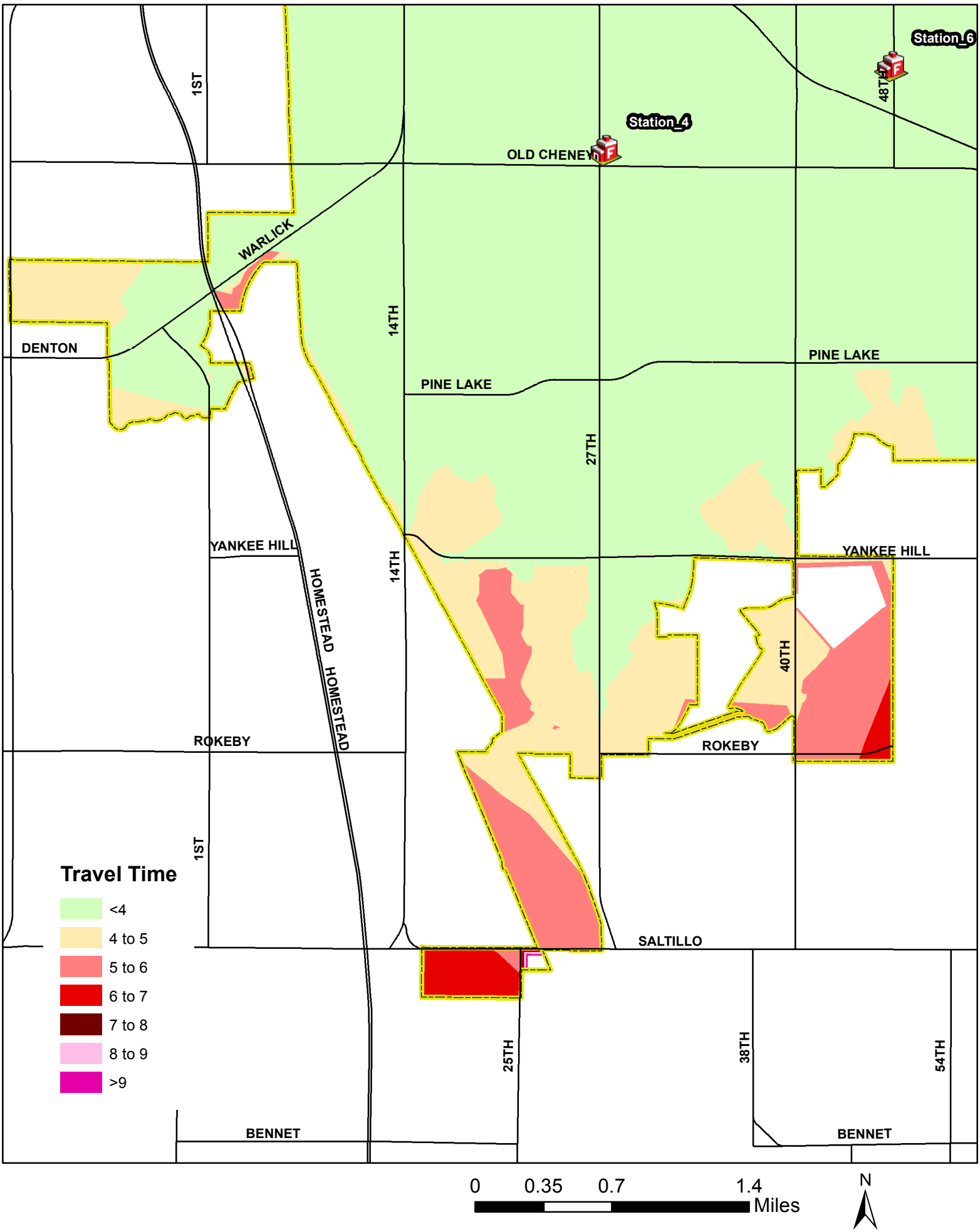
The 2012 optimization plan identified 8,469 addresses inside the city limits of Lincoln, but beyond four minutes travel time from a fire station. Since that data was originally collected, the number of addresses has grown to 9,783 as of August 25, 2014. This number will continue to grow, as land is annexed and as new development occurs. The optimization plan, however, remains valid since this growth has been

within the projected areas for Lincoln's future service limit. In fact, the increment of improvement offered by the fire station optimization is now even better. Whereas in 2012 the plan would have reduced the number of addresses beyond four minutes by 60%, the reduction would now be approximately 66%. Rapid development in the far southeast corner of the City suggests that station M, optimally near 70th and Pine Lake Road, is a greater priority than it was in 2012.

South East Lincoln



South Lincoln



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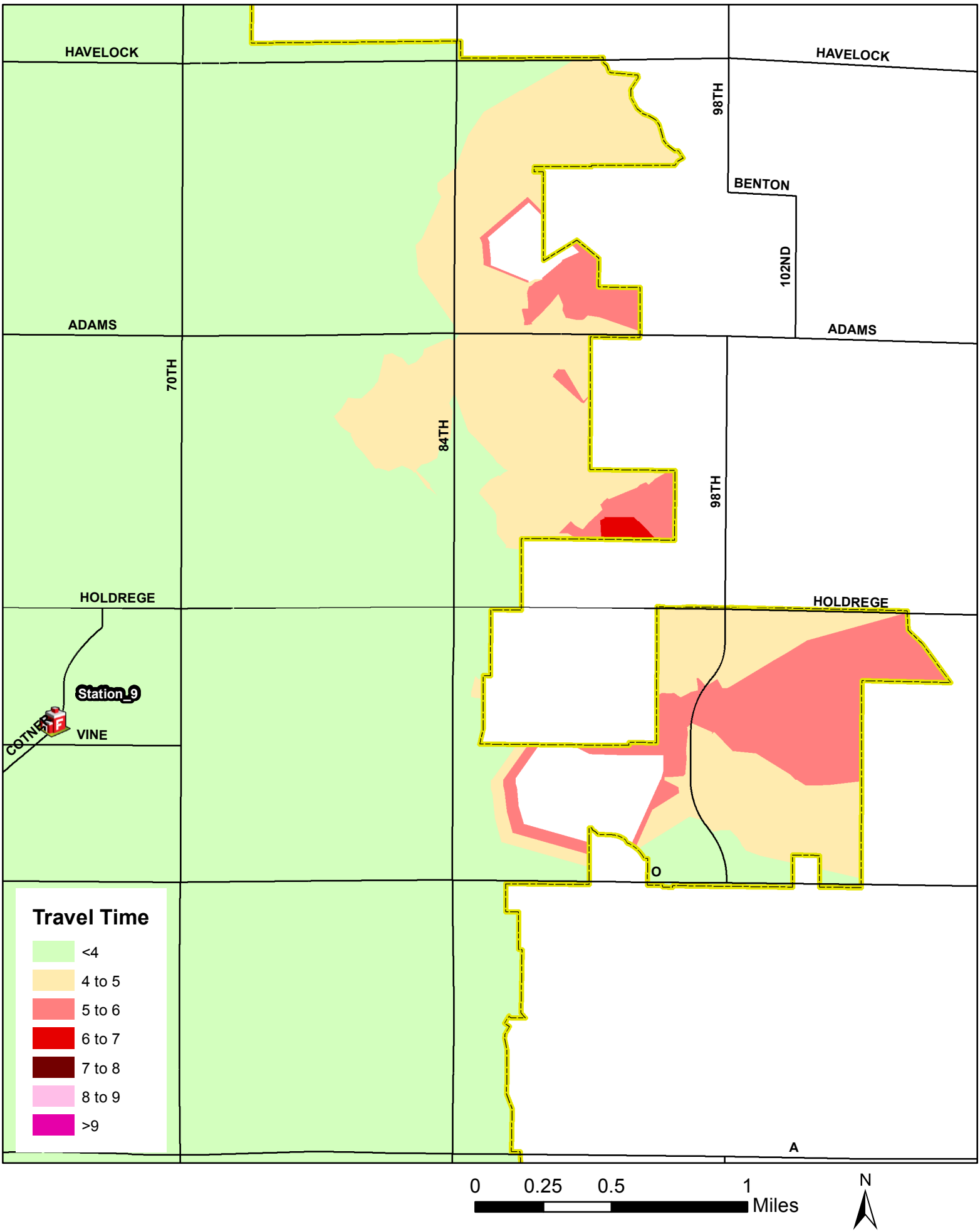
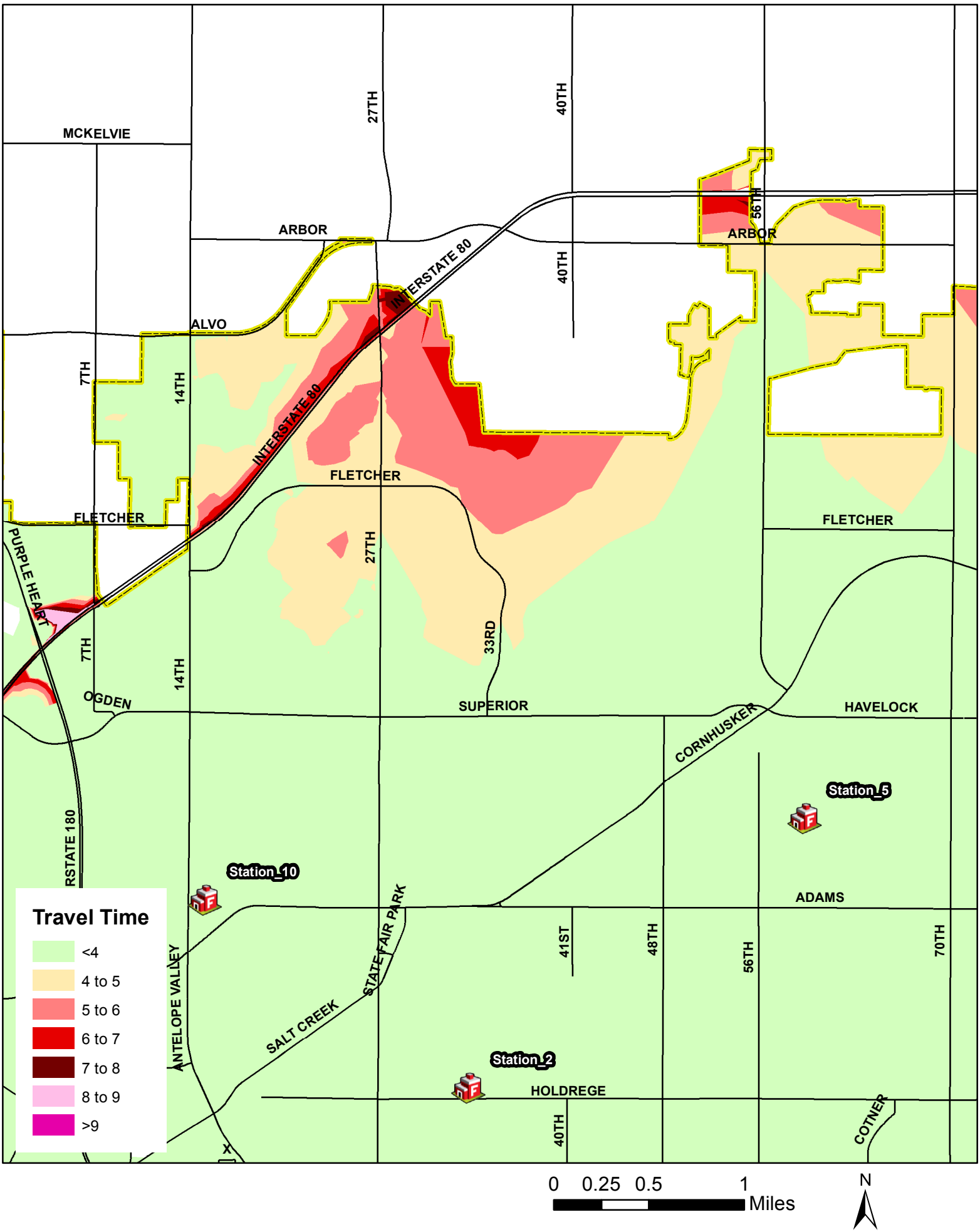
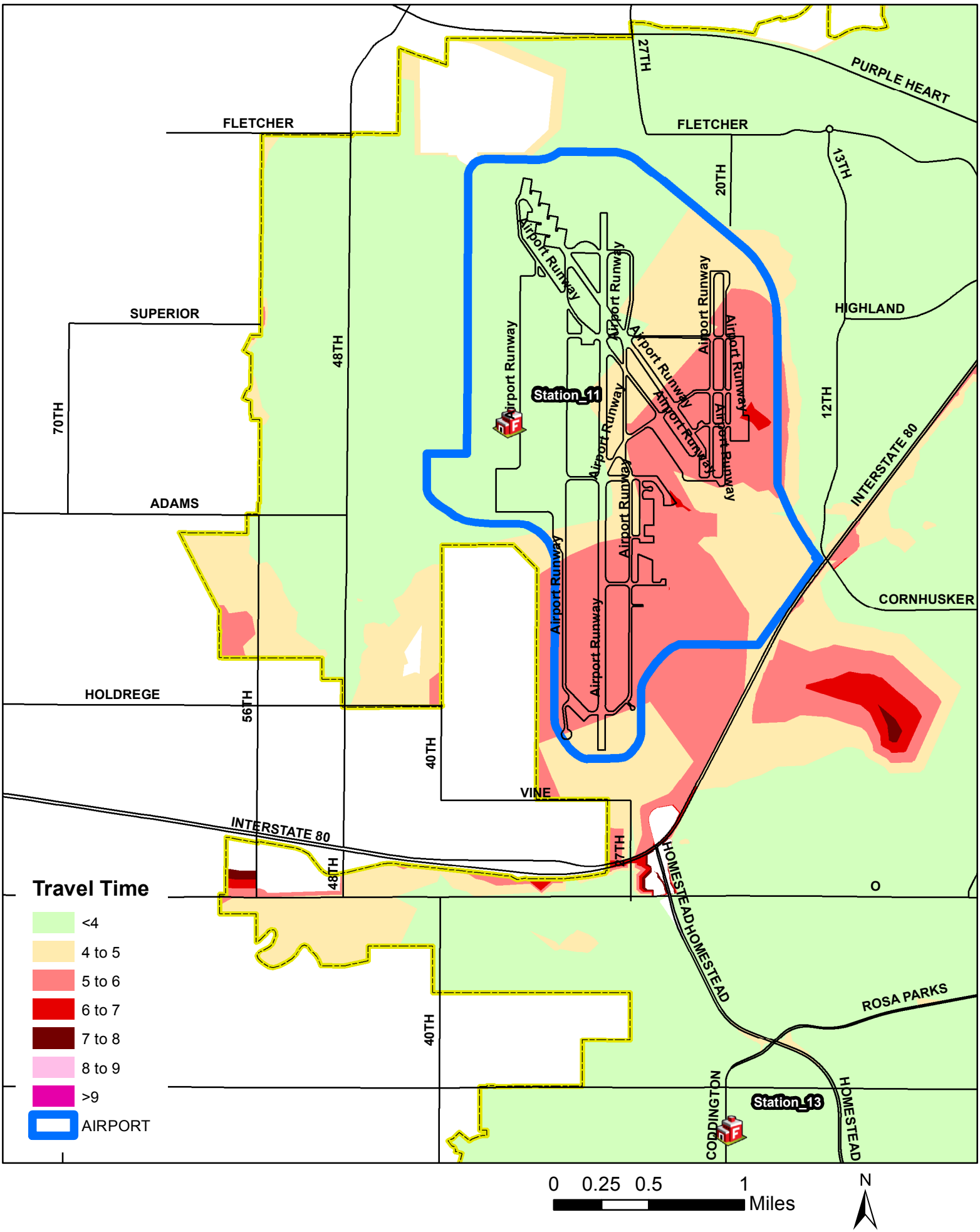


Station 10 Area



Station 11 Area