

Determining the need for automatic aid agreements for the City of Greer Fire Department

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Greer, SC

Appendices Not Included. Please visit the Learning Resource Center on the Web at <http://www.lrc.dhs.gov/> to learn how to obtain this report in its entirety through Interlibrary Loan.

Certification Statement

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

Signed: *Dorian K. Flowers*
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Abstract

The problem was that the City of Greer did not utilize automatic aid. The purpose of this applied research project was to determine if automatic aid agreements would benefit the City of Greer Fire Department. Evaluative research was utilized to answer the following research questions: (a) Based on the current geographic layout of the City, does every address in the City fall within the ISO/PPC five mile response of a City of Greer Fire Station? (b) How many addresses fall outside of an initial engine company travel time of four minutes? (c) How many addresses fall outside of an initial full alarm assignment travel time of eight minutes? (d) Would automatic aid agreements improve ISO/PPC five mile response coverage? (e) Would automatic aid agreements improve initial engine company response based on the four minute travel time included in NFPA 1710? (f) Would automatic aid agreements improve initial full alarm response based the eight minute travel time included in NFPA 1710?

The procedures in this applied research project included a literature review, data analysis of available Geographic Information System (GIS) data and quantitative analysis of the data created during the GIS data evaluation processes.

Based on the results of this study, it was determined that automatic aid agreements with surrounding agencies would benefit the City of Greer Fire Department and the community by reducing response times associated with travel from the nearest fire station to the location of the incident and increasing the level of coverage while providing additional resources on the scene of working structure fires and other critical incidents.

It was recommended that the City of Greer Fire Department enter into automatic aid agreements with surrounding departments based on the study.

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Introduction

The City of Greer Fire Department (Department) does not utilize automatic aid. Previously, the Department has relied solely on its off duty personnel and mutual aid requests for additional personnel on large or involved incidents. While this method of operation may be effective in getting enough personnel to a specific location eventually, it does not address the time required to assemble the necessary personnel. Time is a critical factor in producing a favorable outcome. Because of this, the purpose of this research project is to determine if automatic aid agreements benefit the City of Greer Fire Department.

The primary research methodology used in this applied research project was evaluative research. The research questions for this project are: Based on the current layout of the City, does every address in the City fall within the ISO/PPC five mile response of a City of Greer Fire Station? How many addresses fall outside of an initial engine company travel time of four minutes? How many addresses fall outside of an initial full alarm assignment travel time of eight minutes? Would automatic aid agreements improve ISO/PPC five mile response coverage? Would automatic aid agreements improve initial engine company response based on the four minute travel time included in NFPA 1710? Would automatic aid agreements improve initial full alarm response based on the eight minute travel time included in NFPA 1710?

Background and Significance

The City of Greer (City) is located in upstate South Carolina, northeast of Greenville, SC and west of Spartanburg, SC. The City is split west and east by the county lines of Greenville and Spartanburg Counties. Based on the 2013 Census estimate, the population is approximately 27,167. The City is 21.76 square miles in size. This works out to an approximate population density of 1,248 people per square mile. Since 1990, the population has grown by 126%. The

projected growth within the Greer area is projected to be significant over the next 15 years. According to the Greer Community Master Plan, “our community should be prepared to accommodate a population that exceeds 100,000!” (Greer Partnership for Tomorrow, 2015, p. 3). The population is made up of a primarily younger population. Based on the 2010 Census, those aged 18 and younger account for 26.6% of the total population of the City (“USA QuickFacts,” 2015).

Over the past several years, the City has seen tremendous growth in both population and geographic size. The Greer Fire Department (Department) currently responds from three fire stations. Two of these fire stations are owned by the City, while the third is owned by the Pelham-Batesville Fire Department. This third location includes a co-staffed engine company consisting of both City personnel and Pelham-Batesville personnel. The Department does not currently utilize automatic aid from neighboring fire departments. Many of these neighboring fire departments are staffed full-time with personnel available to respond immediately. Instead of automatic aid, the Department has relied on call back personnel and mutual aid requests. This method of operation leads to significant delays in assimilation of adequate personnel to effectively mitigate significant incidents.

This applied research project will determine if automatic aid agreements will benefit the Department based on time and distance from current City fire station locations. The research conducted in this applied research project are directly related to the third year Executive Fire Officer Course titled, Executive Analysis of Fire Service Operations in Emergency Management (EAFSOEM) because it evaluates and analyzes the current method of operation within the Department in regards to use of automatic aid agreements to provide the best possible service to its citizens (Federal Emergency Management Agency, 2014).

The United States Fire Administration publishes its goals every four years. This applied research project directly relates to Goal 3: Enhance the Fire and Emergency Services' Capability for Response to and Recovery from All Hazards. Within this goal, three of the five key initiatives are addressed by this project. Those key initiatives are: (a) Enhance fire and emergency services capabilities to respond to and recover from all hazards incidents through training, education, exercise and evaluation. (b) Enhance data-driven decision-making through information sharing among federal, state, local, tribal and territorial partners. (c) Encourage the adoption of technological tools to enhance fire and emergency services' capability of, preparation for, response to, and recovery from all hazards. This project will be used to educate the public, elected officials, and the Department on automatic aid agreements and how they can enhance the capabilities to respond faster and more effectively to incidents within the City of Greer. It will use data to drive the decision making process, and will encourage the adoption of technological tools to enhance the Department's ability to prepare, respond, and recover from all hazards (United States Fire Administration [USFA], n.d.).

Literature Review

The highly technical nature of this applied research project required that the author search for relevant resources. As a matter of full disclosure, the author had previously attended several hands on courses specific to the ESRI ArcGIS® software platform. This training also included specific training using the ArcGIS® Network Analyst extension. The basis of this applied research project heavily involves this extension.

Several resources were reviewed for or in support of conducting this applied research project. As the fire service becomes more and more advanced, the dependency on technology also increases. In the past several years, the fire service has begun using information and facts to

make better decisions and to ensure that it is providing the best and most efficient service to its customers. Information systems have become a critical tool in the decision making process for fire service leaders. Gone are the days when using scare tactics work to drive elected officials to make multi-million dollar decisions. “New tools like geographic information systems (GIS) and improved communications technology is improving the ability of fire officers to accomplish their goals and objectives” (Barr & Eversole, 2003, p. 3).

GIS allows the fire officer to visually reference geographic data in a way like has never been possible in the past. GIS is used today in many ways. For example, multiple incident records can be geocoded and shown visually on a map in a way that helps to identify areas of high call volume also known as hotspots. Many departments are using GIS to create traditional map books and electronic pre-fire plans showing critical geo located points, such as utility shutoffs. Using GIS for these planning tools can provide the additional benefit of allowing the user to provide data in layers. Doing so creates a dynamic map of sorts where the fire officer can turn spatial layers on and off at will to create a custom view on the fly that only shows the relevant data. Additionally GIS allows the creation and study of network data sets. It is this ability that allows the fire officer to determine distances from fire stations to incidents, create fire response zones, identify the quickest routes, and to determine how far a fire apparatus can travel from a fire station in a given amount of time. Using this information, the fire department can model its current deployment as well as the effects of adding or deleting fire stations (Carter & Rausch, 2008), (Buckman III, 2006).

Network analyst is an extension for the ESRI ArcGIS® platform. It allows the user to analyze transportation networks. It includes five tools for solving six different transportation network problems. The six tools are route, closest facility, service area, origin-destination cost

matrix, vehicle routing, and location allocation. Transportation network datasets are constructed from points, lines, and turns. While there are two types of network systems, the one that we focus on in the transportation network for the purposes of this applied research project are known as undirected flow systems, meaning the flow is not controlled by the system and resources make their own decisions about how to traverse the network (roadways). In this example, a resource might be a fire apparatus traveling from a fire station to an incident location. The driver of the apparatus will make decisions on how best to navigate the roadways to travel from point A to point B. A transportation network can allow the user to model various components of the system based on the resources. For example, turns within the network can be modeled to be a restriction (no left turns) or to incur a time penalty (left hand turns take longer than right hand turns). The primary tool utilized in this applied research project was the service area tool (ESRI Educational Services, 2008).

As a management tool, GIS is becoming more important every day. Many fire departments today employ their own GIS analyst. These specialists understand not only the geographic information systems they work with, but also understand how those systems interact with service delivery from a fire department perspective. “These individuals are vital partners in development of modern planning and standards of response coverage and providing actual onsite incident management tools” (Graner, 2006, p. 166). Designing and maintaining emergency response geographic information systems is a highly technical process and is becoming more important every day. One trend in the fire service is accreditation. The Center for Public Safety Excellence (CPSE) requires a department to create a standards of cover document as part of the accreditation process. Without GIS, this would be close to impossible (Graner, 2006).

The Insurance Services Office, Inc. (ISO) has created the Fire Suppression Rating Schedule (FSRS) to determine a Public Protection Class (PPC) rating for fire departments it rates. The PPC ratings range from 1 – 10 with a rating of 1 being the best. ISO require for maximum credit, one fire engine within 1.5 miles and a ladder/service company within 2.5 miles. Additionally, all addresses protected by a fire department must be within 5 road miles of a fire station with limited exceptions. Under the latest version of the FSRS, automatic aid may be utilized to help meet the required distances. These automatic aid companies must respond automatically on all structure fires within a given response area at first dispatch. The FSRS does allow as an alternative to the 1.5 mile engine company and 2.5 ladder/service company a deployment analysis in accordance with the NFPA 1710, the Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments. NFPA 1710 requires a travel time of four minutes for the arrival of the initial engine company and eight minutes for the full initial alarm assignment of apparatus 90% of the time. In contrast, ISO is a little more lenient when it comes to the deployment analysis and only requires a travel time of five minutes and thirty-three seconds for the arrival of the initial engine company and nine minutes and thirty-three seconds for the full initial alarm assignment of apparatus 90% of the time. For the purposes of this applied research project five miles, four minute travel, and eight minute travel was utilized (Insurance Services Office, Inc. [ISO], 2012), (National Fire Protection Association [NFPA], 2010).

When using time-based transportation networks, the user must take variables into account. For example, in the real world, there are slopes, turns, and speeds that must be taken into account. Large fire apparatus will not be able to traverse a street network as quickly as a

small passenger vehicle. Some slopes may be too steep and therefore are unacceptable for the angle of departure or arrival of most large fire apparatus. Additionally, turns take longer in large heavy fire apparatus because of the additional time required to slow down and then accelerate after exiting a turn. All of these variables must be considered when creating a model using a network dataset. All network datasets must be tuned to the local jurisdiction and then tested and validated (Price, 2009), (Price, 2012).

As the fire service evolves, the decisions made by fire department leadership will continue to be scrutinized more than ever before. One such example is the International City/County Management Association (ICMA). In a publication titled, "Managing Fire and Emergency Services" the use of GIS is discussed in depth. Additionally, the use of multijurisdictional data is included when analyzing deployment strategies for fire departments. The ICMA encourages the use of GIS for fire and emergency services and specifically speaks about off-the-shelf software and open-source software. Currently, off-the-shelf software is much more robust in the area of network analysis. As time goes on, this may change. The cost of off-the-shelf software can be a major road block for smaller departments, while open-source may be more cost effective. In many cases, open-source software can have a steeper learning curve than its off-the-shelf counterpart (Thiel & Jennings, 2012).

The chosen literature helped shape this applied research project in many ways. Some literature, such as the fire service references helped support the need for such research and demonstrated the importance to the fire service as a whole. Others, such as the more technical references assisted the author in designing the network dataset that was used to run the analysis and in answering the selected research questions. And finally, references such as the FSRs and the NFPA 1710 standard helped the author design the research questions. All of these references

combined helped to create the final applied research project and determine the benefit of automatic aid within the City of Greer Fire Department.

Procedure

This applied research project was conducted to determine if the Department would benefit from automatic aid agreements with surrounding agencies. The evaluative research method was the primary method used to answer the research questions and to determine a recommendation for automatic aid agreements. In order to develop a final recommendation, local GIS data was reviewed and analyzed to determine if automatic aid agreements would benefit the Department and community. A comprehensive review of available literature was conducted to determine a methodology that would allow the Department to answer the associated research questions. During the review of available literature, an emphasis was placed on identifying methodologies that would allow a quantitative look at travel times and the number of addresses that would be positively affected by the use of automatic aid agreements. The final procedure proved to be highly technical and the step by step process is described in order to allow this applied research project to be recreated.

The first step was to determine the GIS software that would be utilized to answer the research questions. For this research project, ESRI ArcGIS was selected based on the familiarity of this product to the author. The second step was to obtain a clean and well-structured street data set. The City purchased a base street data set from HERE NAVSTREETS™ (previously NAVTEQ) for a cost of \$5,400.00 and signed a contract that included annual updates for a period of three years. Due to the fact that the City is spread into two counties, it was necessary to purchase GIS data for both counties at a base price of \$3,000.00 per county. By signing a three agreement with annual updates, the City received a \$600.00 discount. The decision to purchase

commercial data was due to the lack of confidence and consistency in GIS data supplied and maintained by two separate county GIS departments.

Once the data was received, additional calculations had to be made within the attribute tables to create miles (distance) and minute (time) fields. The attribute tables for the data received only included meters and speed categories. These updates were critical to the creation of a viable routable network dataset that would allow for analysis of distance and time in terms of engine response and the inherent differences between heavy vehicles and standard driving patterns as used in the base data. Once the necessary updates were made to the base data, the ESRI Network Analyst extension could be used to develop a navigable network data set. This network data set became the basis to answer each of the research questions. ESRI Network analyst allows the user to graphically display time and distance studies.

In order to most accurately predict response times and distances for the department, it was necessary to include the use of a network dataset, the collection of data and algorithms required to conduct network analysis against the acquired HERE streets. At its most basic level, the network dataset requires a street feature class with excellent end-to-end connectivity and speed/distance calculations that echo the capabilities of the responding apparatus.

There are two factors to consider when building a network dataset. The Spatial Aspect includes the physical features themselves, as represented by either points, lines, or polygons, and occupying physical space (that is, they can be referenced by coordinates on a spatial plane and displayed on a map). The Attribution aspect refers to tabular data that enhances the spatial aspect and provides in-depth qualitative and quantitative features like time, distance, names, or other information that gives a sense of meaning to the points, lines, and polygons that make up a geographic feature dataset.

The backbone of ESRI's Network Analyst Dataset is a full functioning street line feature network where every segment of the feature class is connected to every other part of the network by having the endpoints of each segment occupying the exact spatial location of the endpoint of the segments to either side of it (see *Figure 1*). Any part of the network that is not connected, both through overshoots or dangles, will not be accessible by Network Analyst and will result in abnormalities in the results. It is important to validate the geometry of the network and identify and correct these errors before beginning network analysis.



Figure 1. Example of line segments that do not connect

Keep in mind that not every line segment should be connected end to end, as in the case of bridges. Allowing one line to overshoot another without a break will model a situation where there is no intersection and prevent the network dataset routing off the side of an overpass (see *Figure 2*).

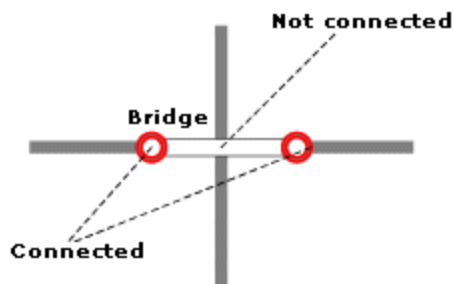


Figure 2. Example of overpass in network data set

The following street feature attributes are required to run network analysis utilized in this applied research project:

1. Street Name – In order to enhance directionality and give meaning to the spatial representations of lines on the map, the [StreetName] attribute allow decision makers to identify the network in a way that feels familiar. In a network dataset, this text attribute is called when generating turn-by-turn directions, or when allocating an incident address as a network location for analysis.
2. Address Range – Knowing where an address falls along a street segment enhances the quality of the network dataset by allowing for identification of given landmarks, and for increasing spatial awareness for emergency responders. The format for address ranges can be [FromAddressR], [ToAddressR] & [FromAddressL], [ToAddressL] using text as a field type.
3. Speed/MPH – Knowing how quickly an apparatus can traverse any given line segment is critical in being able to accurately predict their response time to a given address. Each segment should be assigned an [MPH] attribute using the double precision floating point number type, which allows for fractional speeds if required for more detailed analysis.
4. Distance – By combining the speed and length of each road segment in miles or feet, network analysis can begin to predict the amount of time needed in order to traverse a given route. Ultimately, this combination of attributes gives rise to the response times yielded by the network dataset. The attribute field for [Length_Miles] should be a double precision floating point number type, and be populated by calculating the length from the native [shape.length] attribute included in all ESRI line feature classes.

5. Minutes – This attribute stores the time taken to traverse each line segment based on the relationship between the [MPH] and [Length_miles] attributes previously discussed. The formula for calculating this field is $[\text{Length_miles}]/([\text{MPH}]/60)$. For example, using a street with a length of five miles and a speed of 25 MPH, the equation would be:
 $[5.000]/([25]/60) = [5.000]/0.41666667 = 12$. This means it will take 12 minutes to travel five miles at 25 MPH.
6. One-way – The one-way attribute will restrict portions of the network by disallowing travel in one direction. The format for this attribute field is usually a text or string set to a single character Boolean. Typical attributes will be “b” for allowing travel in both directions, “F” for allowing travel only from the geometric start point of the line to the end point, or “T” for allowing travel only from the geometric end point of the line to the start point.

Once the required street feature attributes were created in the base data, the following steps were taken to create the network data set:

1. Open ArcCatalog and navigate to the geodatabase intended to house the network model.
2. Create a new Feature Dataset in the geodatabase the network model will reside in. For this project, we named the database container “Routing” (see *Figure 3*)

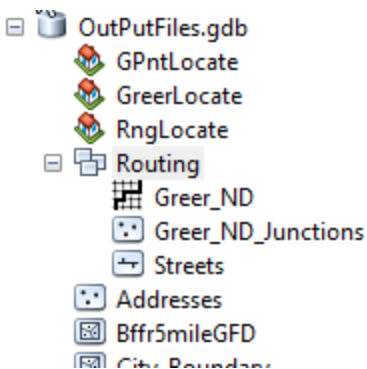


Figure 3. Naming the database container

3. Import the street feature class into this new feature dataset. Remember that all features participating in the Network Dataset must reside in the same container.
4. The Network Analyst Extension in ArcCatalog must be activated in order to achieve this step. Select Customize on the navigation menu, then click extensions to access the Network Analyst Extension (see *Figure 4*).

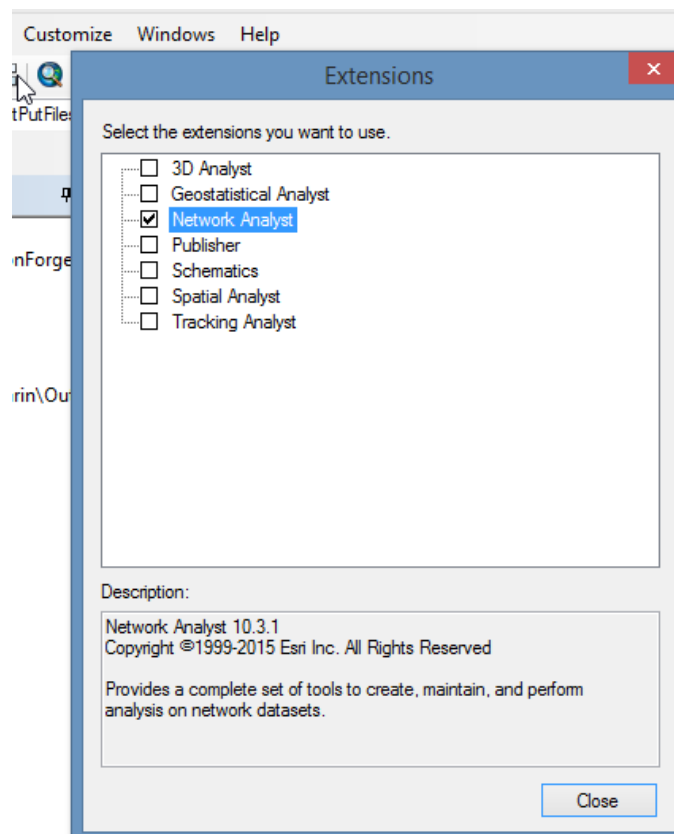


Figure 4. Activate the Network Analyst Extension within ArcCatalog

5. Once the streets have been loaded, right-click the feature dataset and point to New, then choose Network Dataset from the list of available options (see *Figure 5*).

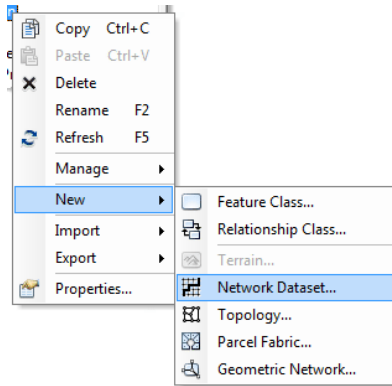


Figure 5. Create new Network Dataset

6. Name the new network dataset, then select a version for it depending on the need for backward compatibility with other users. Check the streets feature class to assign it as a source for the network dataset. Click yes to model turns for the network, and then set the connectivity for the network to End Point. For this research project, we did not need to utilize elevations and selected “No” at the elevations dialog screen.
7. The network attributes pane controls how the network will handle navigation. Adding the minutes attribute as a default, along with the distance in miles attribute allows the network to access these numbers directly from the streets feature class for use during the service area creation (see *Figure 6*).



Figure 6. Network attributes pane

8. The final step in the creation of the network dataset includes the creation of directions based on the street feature class. Allocating the StreetName field as the primary table in this dialog window results in the creation of on-demand directions while using the routing functionality of Network Analyst (see *Figure 7*).

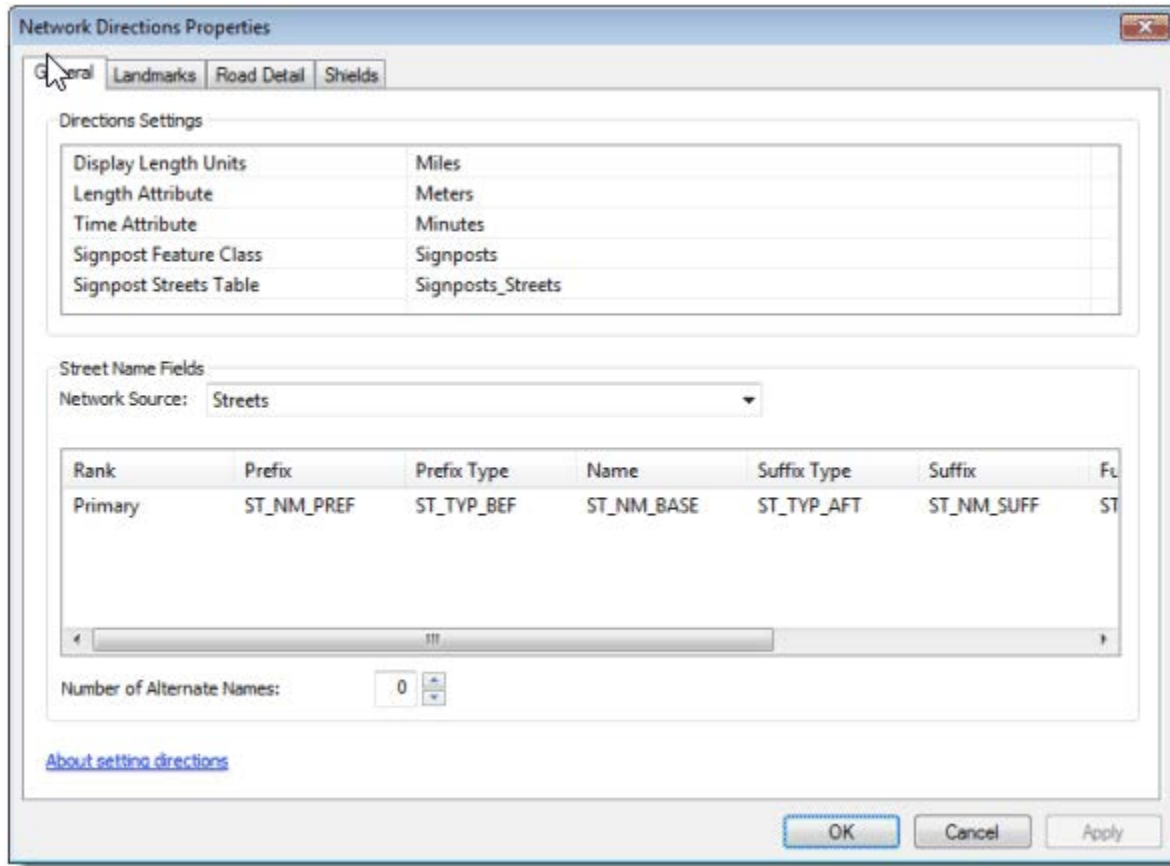


Figure 7. Directions dialog window

A summary of the created network is displayed at the end of this sequence of adjustments, which is useful for replicating the settings of the network dataset at a later date. The network dataset will need to be built in order to allow for the creation of additional feature classes, namely nodes and edges. Once this process has completed successfully, the network dataset is ready for use.

Open ArcMap and add the Network dataset to the “Table of Contents” by dragging and dropping the files into place. A dialog opens asking if all features associated with the network dataset should be added. It is useful to accept this step and group all the participating features into a named “Network” group. They can be symbolized and assigned scale dependencies based

on the required look and feel of the map. Locate and activate the Network Analyst Toolbar and window, which will display the facilities, incidents, and routes for the analysis (see *Figure 8*).

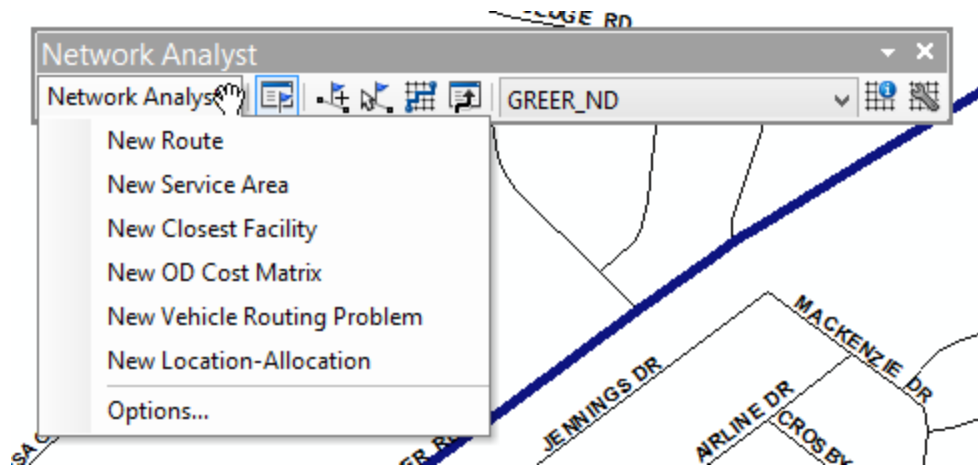


Figure 8. Toolbar dialog box

For the purposes of this research topic, the Service Area analysis tool was used. The Greer City Fire Stations were added as Facilities, and the analysis settings for the new service area were adjusted to five miles, four minutes, and eight minutes as required by the research (see *Figures 9 and 10*).

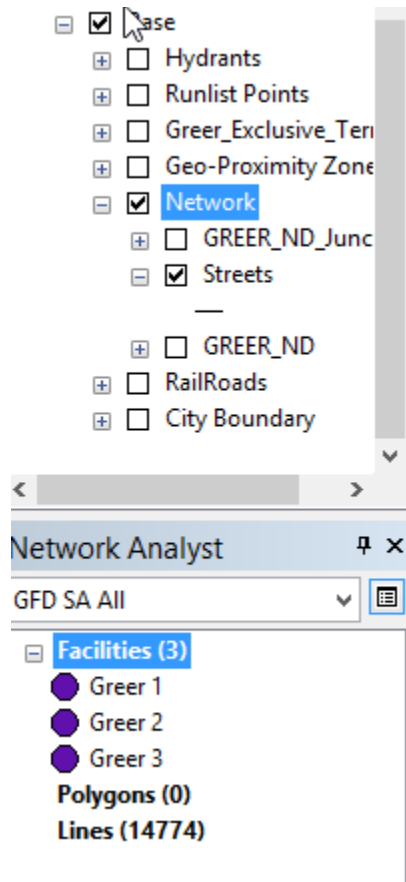


Figure 9. Adding facilities

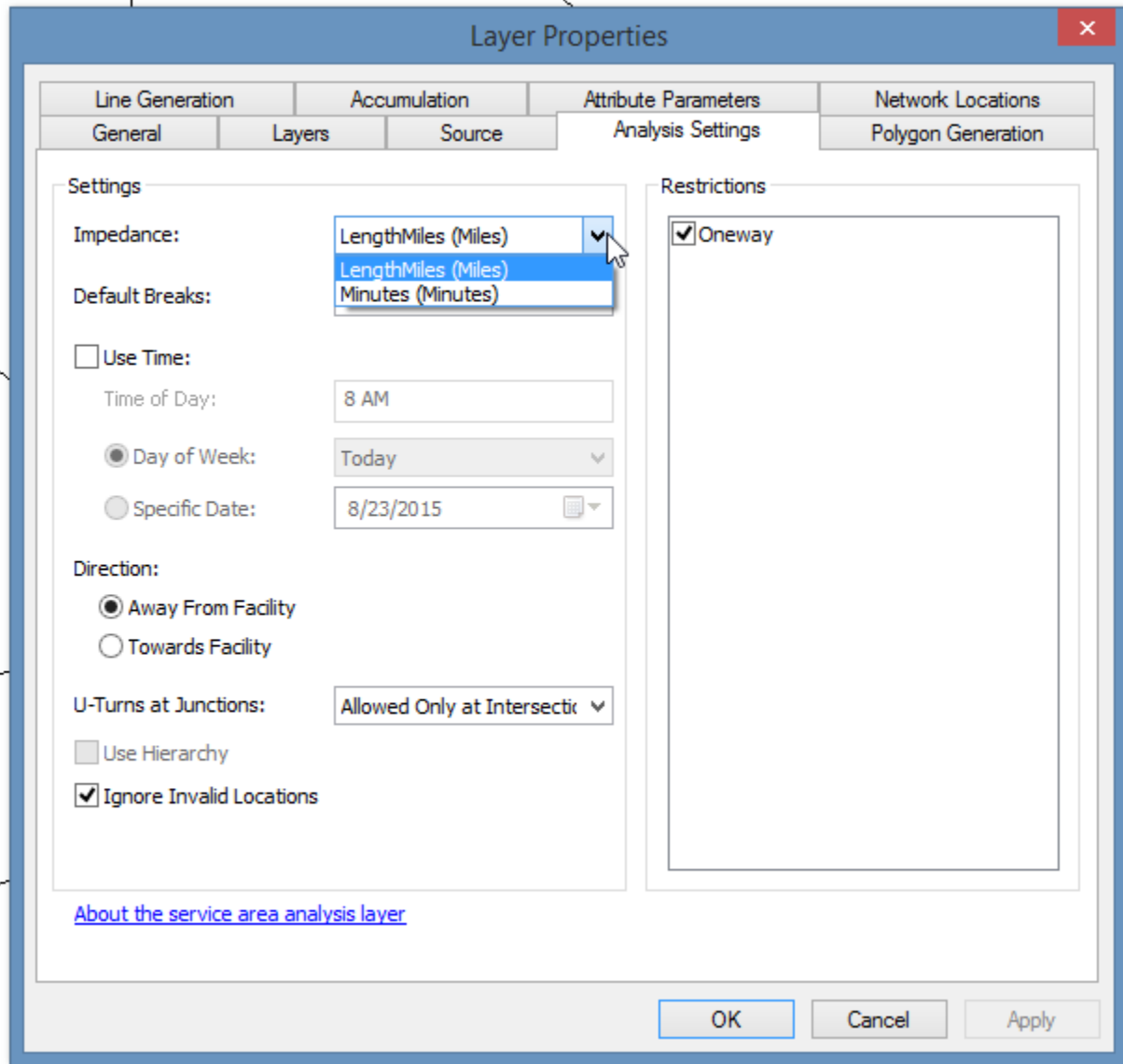


Figure 10. Adjusting settings

Based on the current geographic layout of the City, does every address in the City fall within the ISO/PPC five mile response of a City of Greer Fire Station?

In order to answer this question, a new ESRI ArcGIS map (.mxd) file was created. Once created, the network data set as previously described was added to the map. In addition, the locations for each of the three City of Greer fire stations were added to the map. A new service

area layer was created using Network Analyst. Each City fire station was loaded as a facility and the proper settings were set to create generalized polygons trimmed to 300 feet and allocated to the closest of each station. The distance was set to five miles and the time attribute was not utilized for this study. Once the new service area was created, the City boundary was overlaid and both address points and parcels were added to the map. Finally, any areas that were determined to be more than the ISO/PPC five miles from one of the three City fire stations were identified, each were further examined to identify the number of addresses that each area included by using spatial analytics designed to count the number of georeferenced points falling outside of the defined service area.

How many addresses fall outside of an initial engine company travel time of four minutes?

In order to answer this question, a new ESRI ArcGIS map (.mxd) file was created. Once created, the network data set was added to the map. In addition, the locations for each of the three City of Greer fire stations were added to the map. A new service area layer was created using Network Analyst. Each City fire station was loaded as a facility and the proper settings were set to create generalized polygons trimmed to 300 feet and allocated to the closest of each station. The time attribute was set to four minutes and the distance attribute was not utilized for this study. The travel times used for this stage of the analysis were based upon the capabilities of a 32,000lb fire engine, assuming an emergency response under normal weather conditions. Once the new service area was created, the City boundary was overlaid and both address points and parcels were added to the map. Finally, any areas that were determined to be more than a four minute travel time from one of the three City fire stations were identified. The attribute table was opened and those address points that did not fall within a four minute response from one of the three City fire stations were summed.

How many addresses fall outside of an initial fill alarm assignment travel time of eight minutes?

In order to answer this question, a new ESRI ArcGIS map (.mxd) file was created. Once created, the network data set was added to the map. In addition, the locations for each of the three City of Greer fire stations were added to the map. A new service area layer was created using Network Analyst. Each City fire station was loaded as a facility and the proper settings were set to create generalized polygons trimmed to 300 feet and allocated to the closest of each station. The time attribute was set to eight minutes and the distance attribute was not utilized for this study. The travel times used for this stage of the analysis were based upon the capabilities of a 32,000lb fire engine, assuming an emergency response under normal weather conditions. Once the new service area was created, the City boundary was overlaid and both address points and parcels were added to the map. Finally, any areas that were determined to be more than an eight minute travel time from one of the three City fire stations were identified. The attribute table was opened and those address points that did not fall within a four minute response from one of the three City fire stations were summed.

Would automatic aid agreements improve ISO/PPC five mile response coverage?

In order to answer this question, a new ESRI ArcGIS map (.mxd) file was created. Once created, the network data set as previously described was added to the map. In addition, the locations for each of the three City of Greer fire stations were added to the map. A new service area layer was created using Network Analyst. In addition to Each City fire station, all of the surrounding outside agency fire stations that include full-time personnel were loaded as facilities and the proper settings were set to create generalized polygons trimmed to 300 feet and allocated to the closest of each station. The distance was set to five miles and the time attribute was not utilized for this study. Once the new service area was created, the City boundary was overlaid

and both address points and parcels were added to the map. The results were reviewed and compared to the results from research question 1.

Would automatic aid agreements improve initial engine company response based on the four minute travel time included in NFPA 1710?

In order to answer this question, a new ESRI ArcGIS map (.mxd) file was created. Once created, the network data set was added to the map. In addition, the locations for each of the three City of Greer fire stations were added to the map. A new service area layer was created using Network Analyst. Each City fire station and the surrounding outside agency fire stations which include full-time staffing were loaded as facilities and the proper settings were set to create generalized polygons trimmed to 300 feet and allocated to the closest of each station. The time attribute was set to four minutes and the distance attribute was not utilized for this study. The travel times used for this stage of the analysis were based upon the capabilities of a 32,000lb fire engine, assuming an emergency response under normal weather conditions. Once the new service area was created, the City boundary was overlaid and both address points and parcels were added to the map. Finally, any areas that were determined to be more than a four minute travel time from any of the included fire stations were identified. The attribute table was opened and those address points that did not fall within a four minute response from any of the included fire stations were summed.

Would automatic aid agreements improve initial full alarm response based on the eight minute travel time included in NFPA 1710?

In order to answer this question, a new ESRI ArcGIS map (.mxd) file was created. Once created, the network data set was added to the map. In addition, the locations for each of the three City of Greer fire stations were added to the map. A new service area layer was created

using Network Analyst. Each City fire station and the surrounding outside agency fire stations which include full-time staffing were loaded as facilities and the proper settings were set to create generalized polygons trimmed to 300 feet and allocated to the closest of each station. The time attribute was set to eight minutes and the distance attribute was not utilized for this study. The travel times used for this stage of the analysis were based upon the capabilities of a 32,000lb fire engine, assuming an emergency response under normal weather conditions. Once the new service area was created, the City boundary was overlaid and both address points and parcels were added to the map. Finally, any areas that were determined to be more than an eight minute travel time from any of the included fire stations were identified. The attribute table was opened and those address points that did not fall within an eight minute response from any of the included fire stations were summed.

The limitations of these procedures include data quality, knowledge of the technology used in the study, availability of the tools such as ESRI ArcGIS® and the Network Analyst Extension, the willingness to accept the results. Data quality is critical. In order for a network dataset to be created, there must be a vertex at every connection point. Additionally, the basic fields required for time and distance based analysis must exist or must be created and they must be of the correct data type. Without the proper tools and the knowledge to utilize those tools, the user will not experience a successful outcome. Finally, all of the data in the world will not be useful if the user and decision makers are not willing to accept the results. In many cases, emotion and a sense of ownership can result in a reluctance to accept data results that do not correspond with the user's desired outcome (ESRI Educational Services, 2008).

Results

The results of this applied research project demonstrated many areas for improvement. The data supports the need for the Department to enter into automatic aid agreements with outside agencies. Each research question is described below and includes detailed results for each.

Based on the current geographic layout of the City, does every address in the City fall within the ISO/PPC five mile response of a City of Greer Fire Station?

The network model was used to determine if every address within the City falls within the ISO/PPC five mile response of a City of Greer Fire Station. In *Figure 11* the results of the five mile analysis shows three areas of the City that include parcels and addresses that fall outside of five miles from one to the City fire stations. In order to further detail these three areas, each were zoomed in on to get better clarification of the possible impacts.

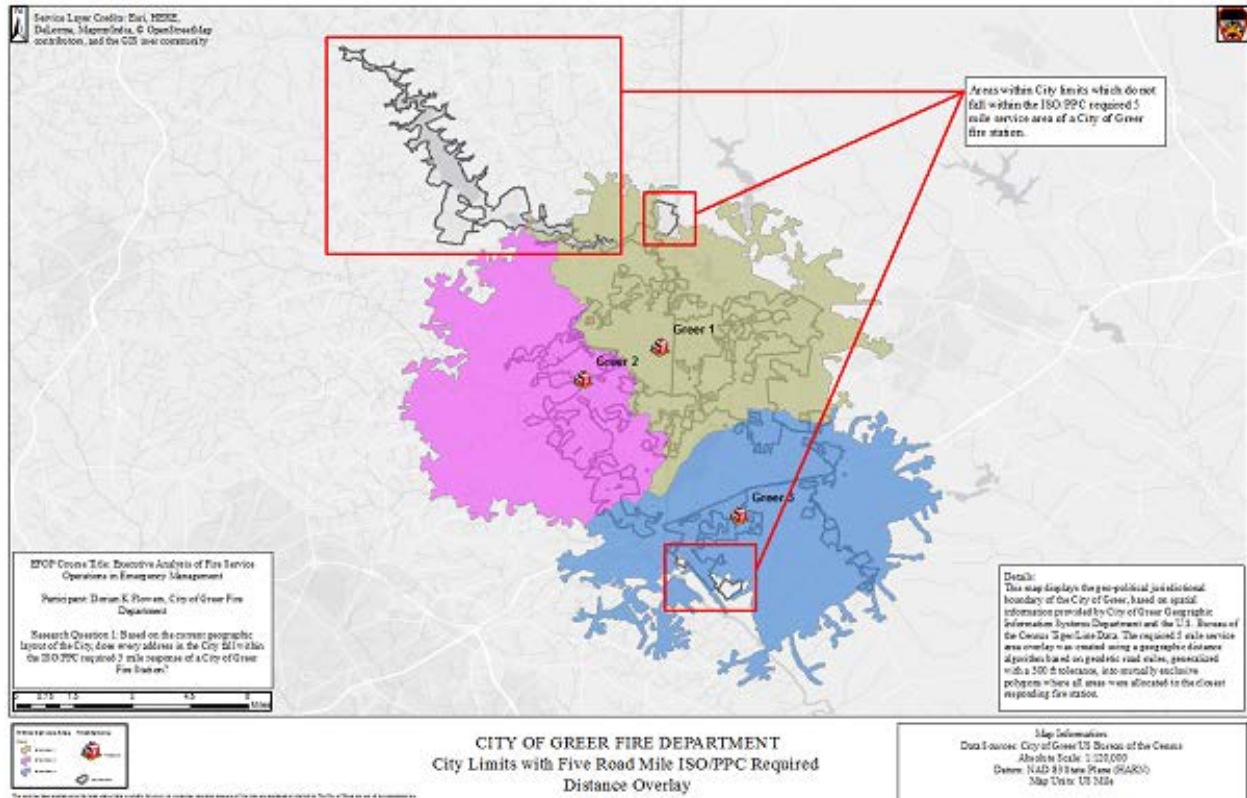


Figure 11. Current five mile coverage area

The three areas that were identified as being outside of the five mile response are identified by the three red boxes. The largest is the box to the northwest of the City. There is a very small pocket directly north of the center of the City, and finally the third location in south-southeast of the City.

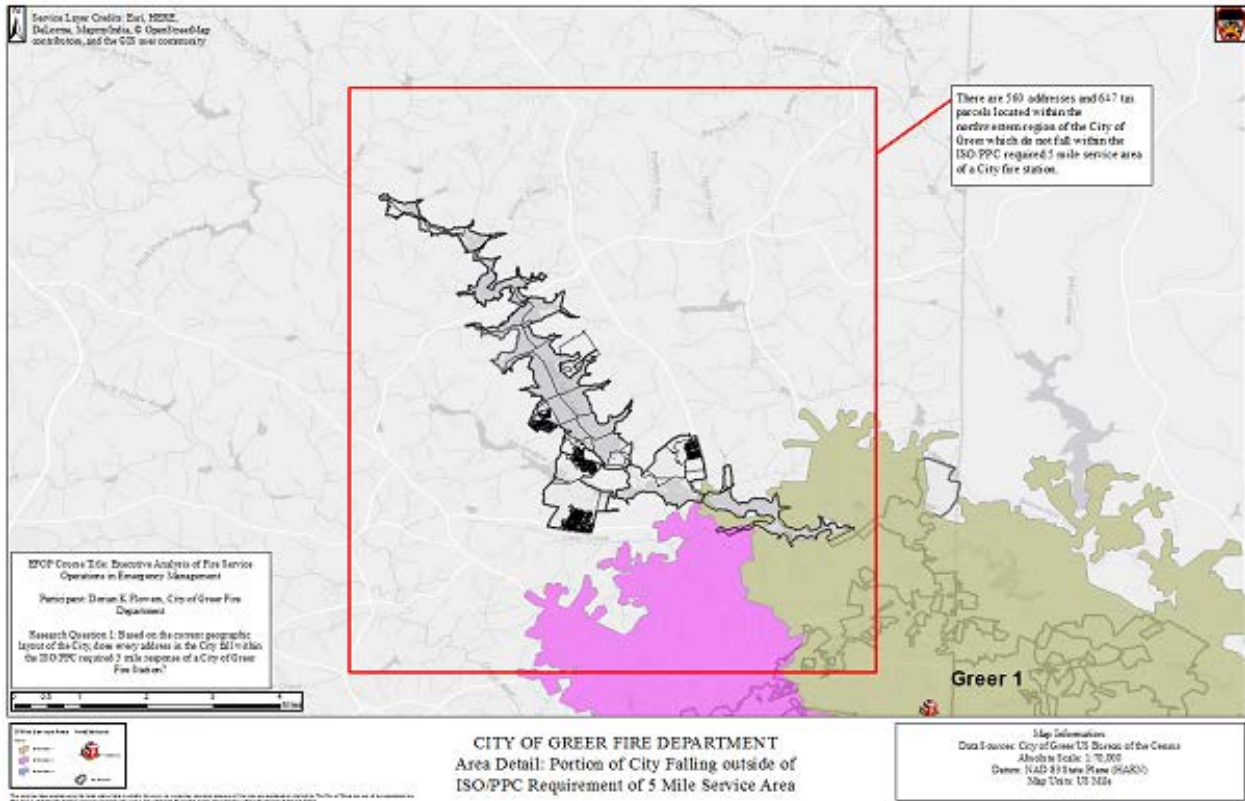


Figure 12. Five mile coverage study area 1

When zooming in with greater detail and turning on the address point layer, the author identified several address points in the larger of the three study areas that represent actual structures that fall outside of the five mile response from one of the City fire stations. This area does cause concern due to lack of coverage within five miles of a City fire station. This area can be seen in detail above in (see Figure 12).

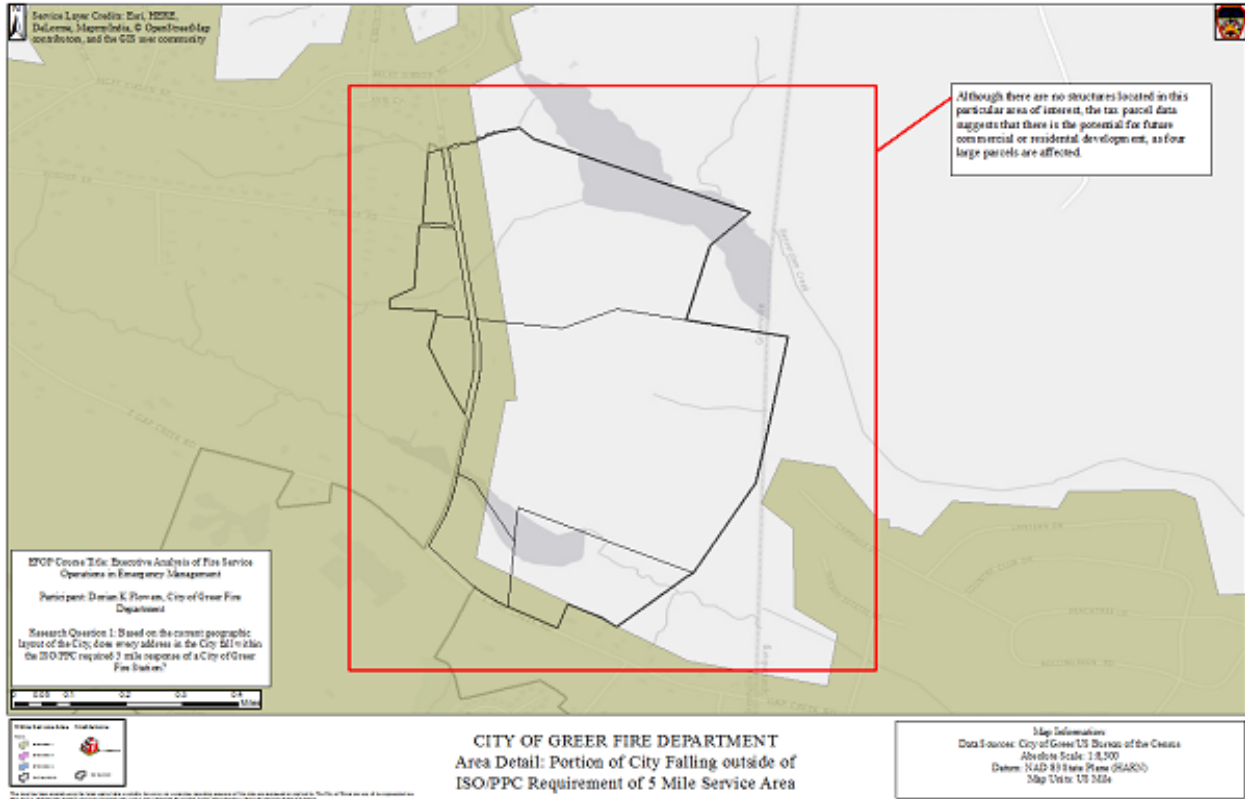


Figure 13. Five mile coverage study area 2

In the second area located north of the City, it was determined that only parcels were located outside of the five mile response area. No address points were located in this study area. Upon further investigation, these parcels did not include structures and were owned by the local utility authority. Based on this information, this area did not cause a great deal of concern. For additional detail (see Figure 13).

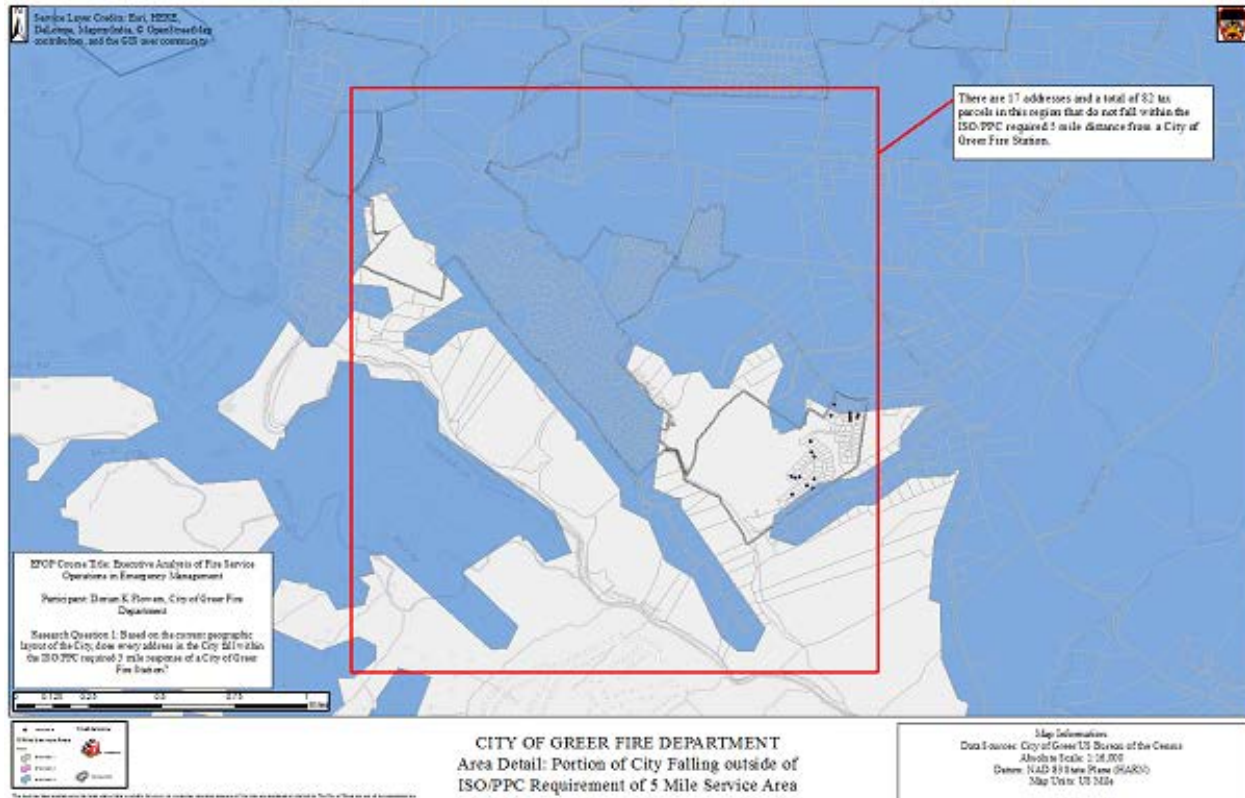


Figure 14. Five mile coverage study area 3

In the third and final study area for research question one, several address points were identified to be outside of the five mile response of a City fire station. These address points represent actual structures, all of which are residential (see Figure 14). This area does warrant concern for five mile coverage.

How many addresses fall outside an initial engine company travel time of four minutes?

After creating a four minute response area for each of the three City fire stations, all address points not falling inside of the resulting polygons were selected. It was determined that 4,396 addresses (32.88% of all city addresses) fall outside of a 4 minute initial alarm response area from the City of Greer Fire Stations (see Figure 15). All of the addresses that were determined to be outside of the initial engine company travel time of four minutes were exported and are included in Appendix A.

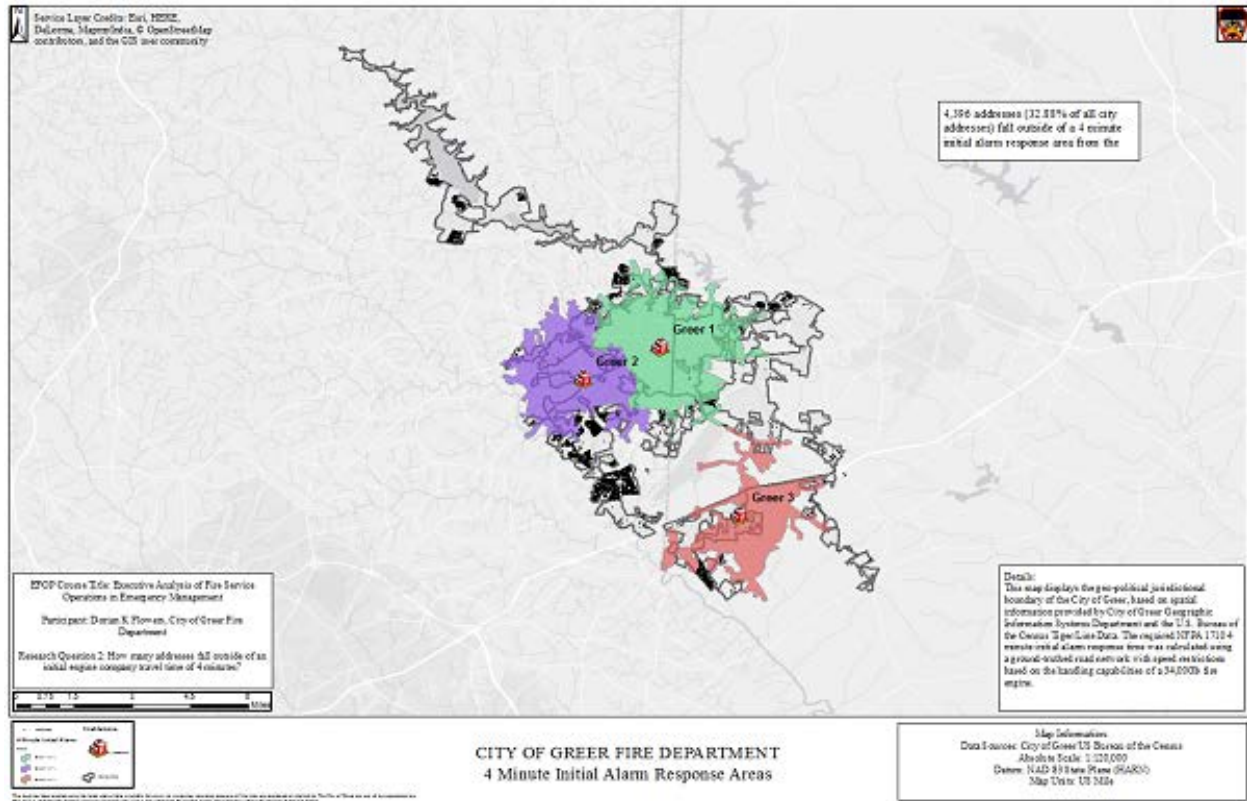


Figure 15. Four minute response coverage without automatic aid

How many address fall outside of an initial full alarm assignment travel time of eight minutes?

The same procedure completed to answer research question 2 was repeated with the time parameter set to eight minutes travel time. In this case, there are 619 addresses (4.63% of all city addresses) that fall outside of an 8 minute initial full assignment response area from the City of Greer Fire Stations. This result was to be expected but still falls short of meeting the requirements of providing an initial full alarm assignment within eight minutes (see *Figure 16*). All of the addresses that were determined to be outside of the initial engine company travel time of four minutes were exported and are included in *Appendix B*.

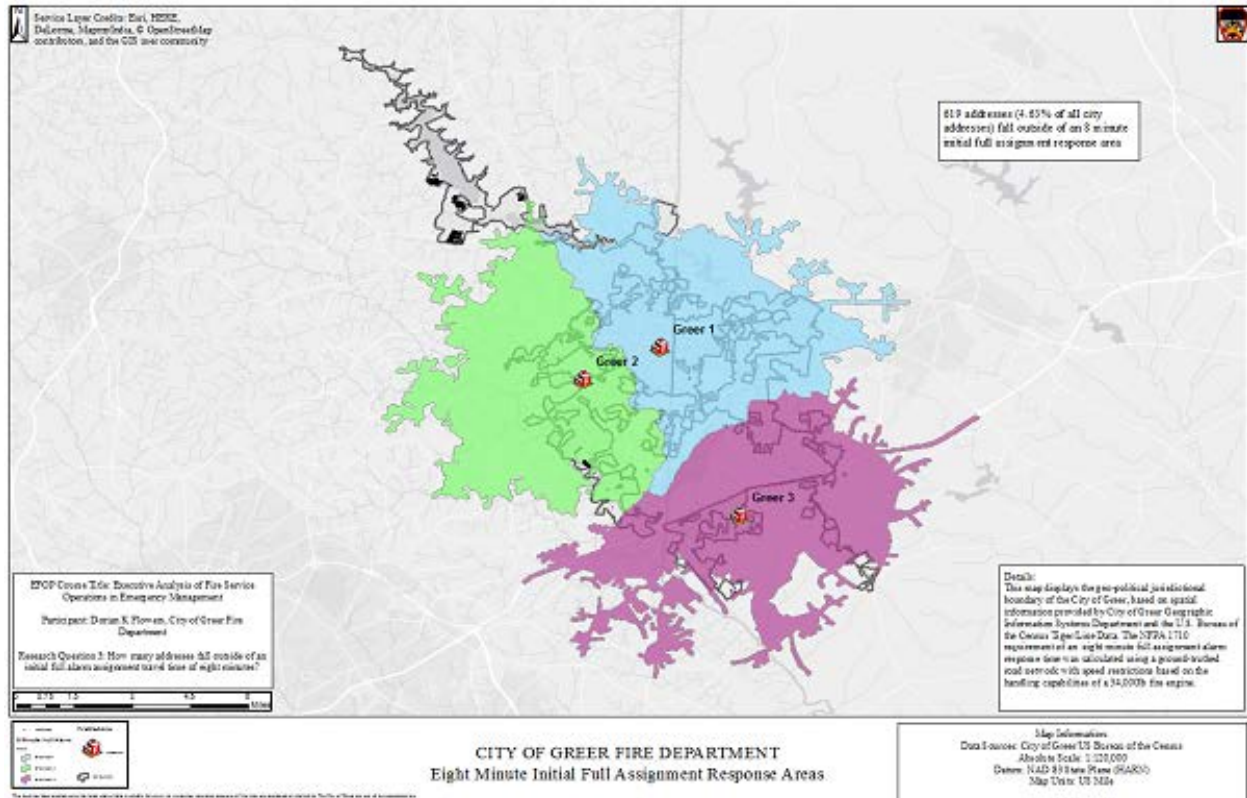


Figure 16. Eight minute coverage without automatic aid

Would automatic aid agreements improve ISO/PPC five mile response coverage?

After identifying areas of the City that fell outside of the five mile response areas of the City fire stations, all surrounding fire departments and their respective stations if staffed 24 hours per day were added to the analysis. By adding these additional fire stations, it is immediately apparent that all of the City can be covered within five miles of a rated fire station (see *Figure 17*) with automatic aid agreements.

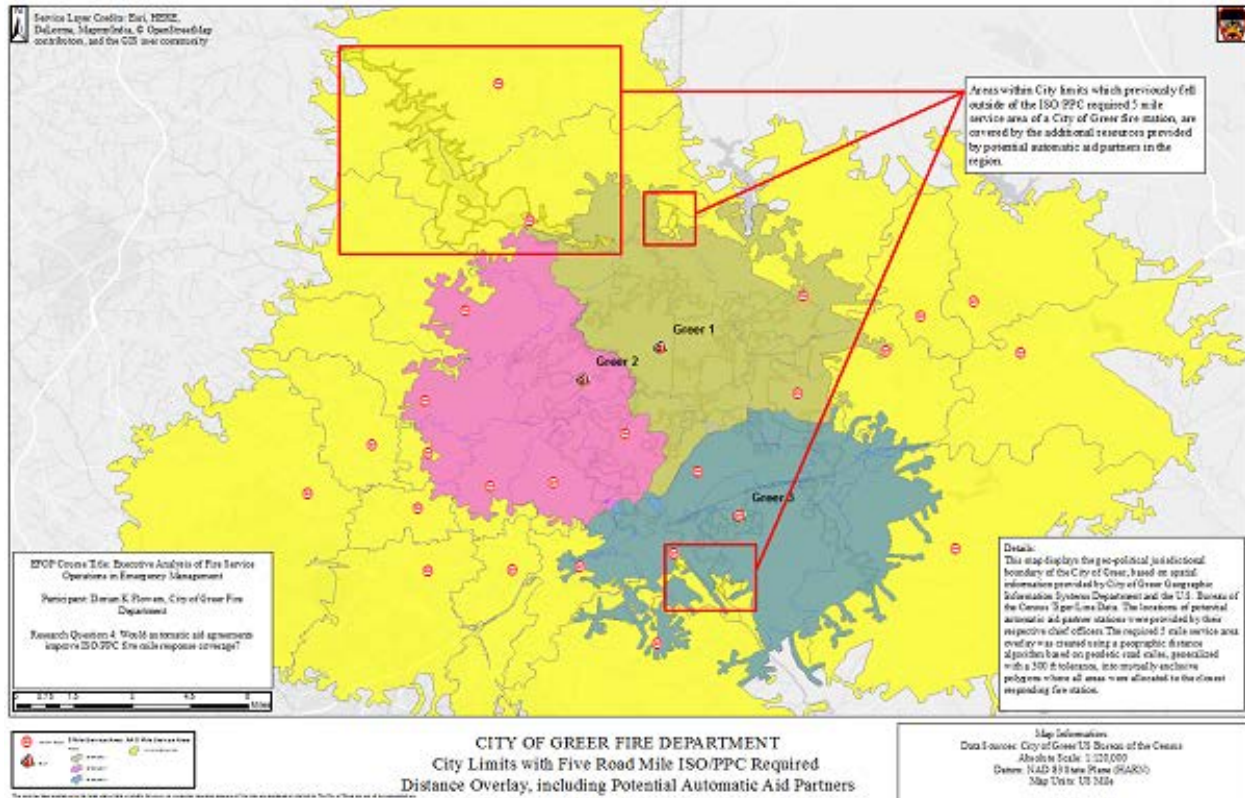


Figure 17. Five mile coverage with automatic aid

Would automatic aid agreements improve initial engine company response based on the four minute travel time included in NFPA 1710?

In answering research question 2, it was determined that 4,396 addresses (32.88% of all City addresses) initially fell outside of a 4 minute initial alarm response area from one of the City of Greer Fire Stations. The addition of automatic aid partners reduces that number to 1,108 addresses, which is an improvement of 74.79% over the initial analysis, and an overall coverage of 91.71% of all the 13,369 city addresses. This is an obvious improvement of response to the City addresses that previously fell outside of a four minute initial response time (see Figure 18). Again, this result supports the use of automatic aid to improve the overall response provided the citizens of the City of Greer. All of the addresses that were determined to be outside of the initial

engine company travel time of four minutes were exported and are included in *Appendix C*.

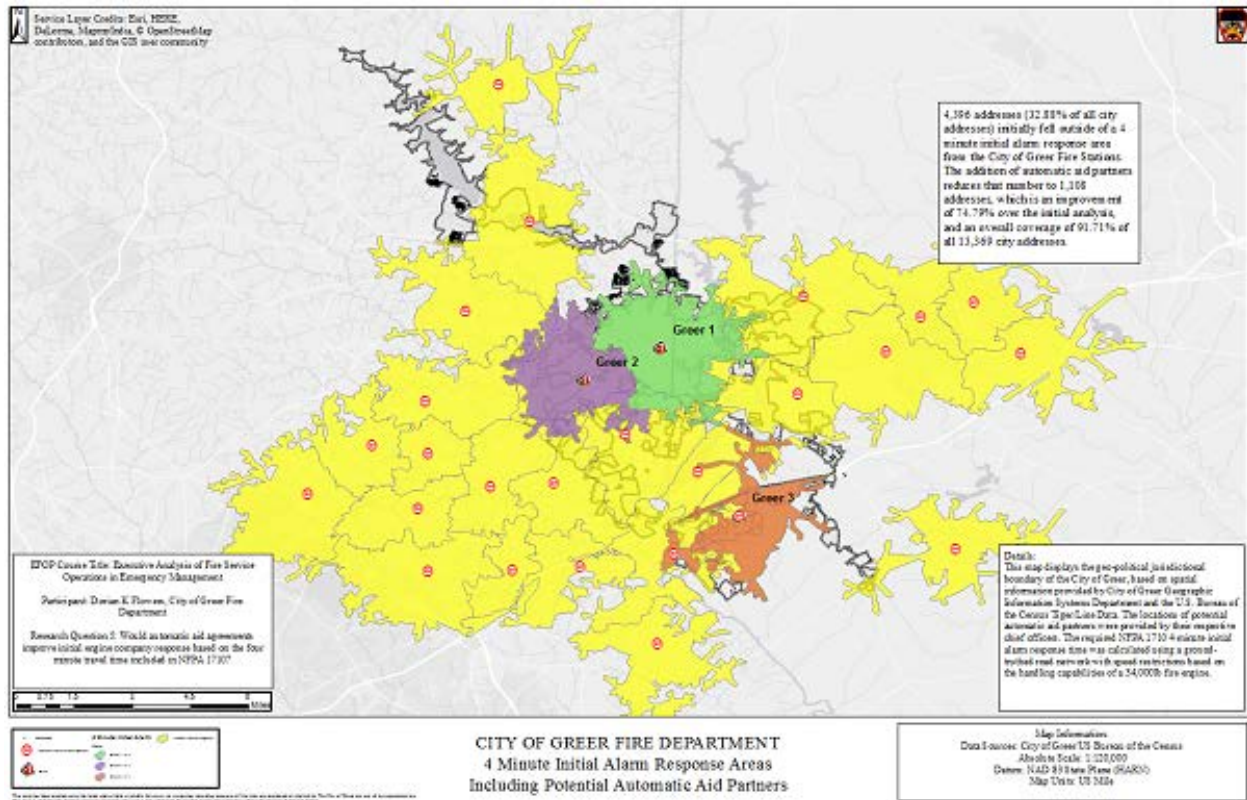


Figure 18. Four minute coverage with automatic aid

Would automatic aid agreements improve initial full alarm response based on the eight minute travel time included in NFPA 1710?

All 619 addresses falling outside of the eight minute initial full assignment response time from the City of Greer fire stations identified in research question 3 would be covered by an eight minute initial full assignment response area by utilizing automatic aid from surrounding jurisdictions (see *Figure 19*). This result also support the use of automatic aid agreements to improve the overall response to City of Greer addresses.

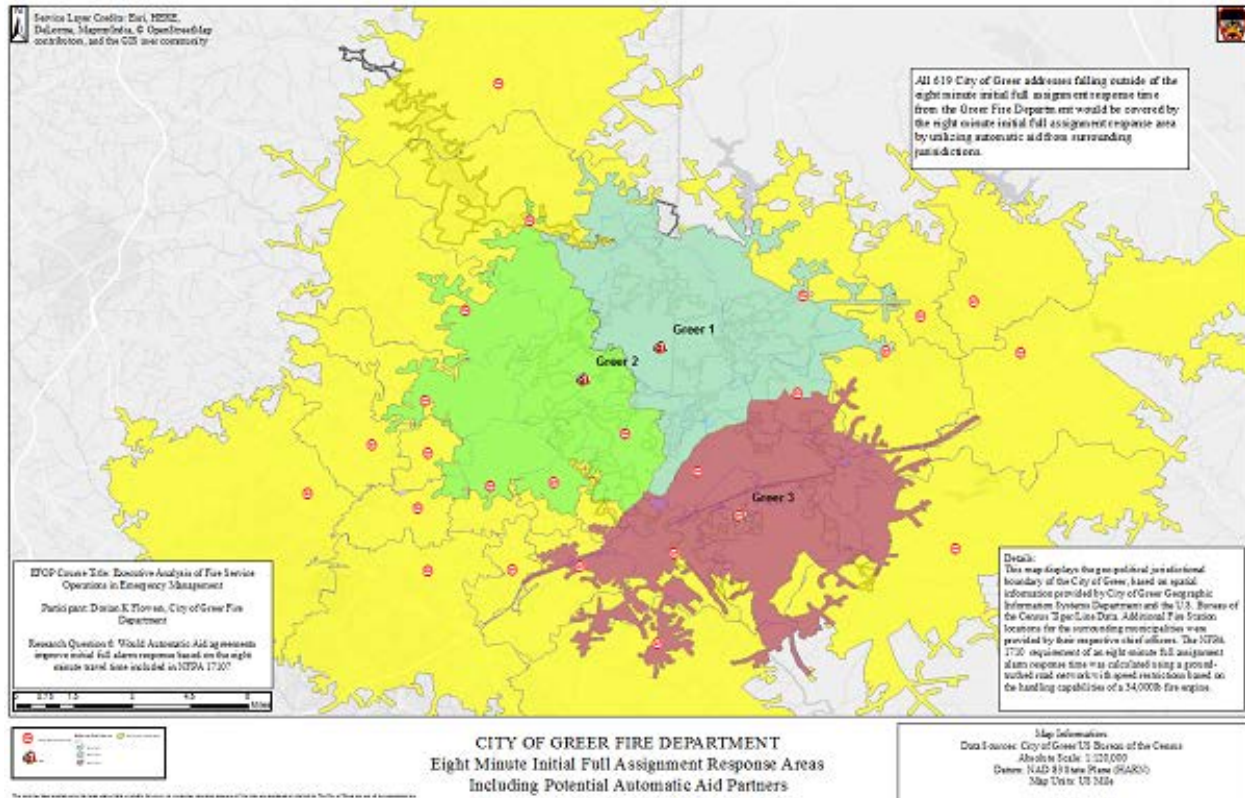


Figure 19. Eight minute coverage with automatic aid

Discussion

The results of this study demonstrates the need to utilize automatic aid agreements. The City of Greer currently cannot meet even the most basic requirement of maintaining a five mile response as required by ISO (ISO, 2012). Furthermore, there is a large number of City addresses (4,396) that are greater than four minutes travel time from one of the City fire stations and a smaller number of City addresses (619) that are greater than eight minutes travel time from one of the City fire stations. NFPA 1710 requires a four minute initial company response and an eight minute initial full alarm response time (NFPA, 2010). By utilizing automatic aid, both of these response criteria improve significantly.

Without the use of GIS software such as ArcGIS® and the Network Analyst Extension, answering these study questions would be much more difficult or nearly impossible. Having a good base network dataset is critical in performing the required analysis (Price, 2012). Such data is useful in convincing stakeholders of the need to make improvements to the response system. With the proper tools and providing the correct information, leaders can make informed decisions on how to make large capital investments (Price, 2009).

Technology is changing the future of the fire service. The days of providing only basic data and using scare tactics have long since passed. City and County management associations such as the ICMA and peer based accreditation programs such as those driven by CPSE will mandate the extensive use of factual data and sound methodologies for answering tough questions (Thiel & Jennings, 2012). Many fire service references and handbooks mention the use of technology and specifically GIS to answer time based response questions. Such data driven decisions are already engrained in the culture of many fire departments across the Nation and will only see an increase in acceptance and use as we move further into the technology age (Buckman III, 2006).

With the current size of the City and considering the expected level of growth in the future, now is the time to be making decisions that will allow the City to prepare for the future. The City has already experienced significant growth and based on the Community Master Plan completed in 2015, the City population is expected to grow by almost 75,000 residents in the next 15 years. With this growth, additional demands will be placed on all City services, especially public safety (Greer Partnership for Tomorrow, 2015).

The author believes that this study supports the use of automatic aid agreements within the City of Greer. After demonstrating visually that there are major gaps in coverage that could

be significantly improved by simply developing automatic aid agreements, it is evident that this is a tool that will likely help the City better meet the needs today and plan for the future. The organizational implications are significant. First, the residents that currently fall outside of the various standards of response as defined by ISO and NFPA would quickly experience better service. The staff of the Greer Fire Department would quickly experience the benefit of additional personnel on the scene of working fires, resulting in improved safety for all personnel. The faster response with more personnel will likely improve the outcomes for our citizens.

Recommendations

Based on the results of this study and the literature review the fire department should immediately begin developing automatic aid agreements with surrounding agencies. The data clearly supports the need for automatic aid agreements and demonstrates areas that are in critical need for additional resources. The fire department should begin training with the surrounding departments and developing policies and procedures that allow all responding agencies to work together at the scene of fires and other significant events. The next steps should include an additional GIS study to determine a run order based on response sub-zones and travel times from automatic aid fire stations. These run orders should be programmed into the computer aided dispatch (CAD) system to ensure the appropriate units are dispatched based on call type, resource allocation, and travel times. The fire department and future readers should continue to embrace changes in technology and make use of GIS with network datasets to create transportation networks that allow informed, data driven decisions.

References

- Barr, R. C., & Eversole, J. M. (Eds.). (2003). *The fire chief's handbook* (6th ed.). Tulsa, OK: PennWell Corporation.
- Buckman III, J. M. (Ed.). (2006). *Chief officer's desk reference*. Sudbury, MA: Jones and Bartlett Publishers.
- Carter, PhD, H. R., & Rausch, E. (2008). *Management in the fire service* (4th ed.). Sudbury, MA: Jones and Bartlett Publishers.
- ESRI Educational Services. (2008). *Working with ArcGIS network analyst*. United States of America: ESRI.
- Federal Emergency Management Agency. (2014). *Executive analysis of fire service operations in emergency management - EAFSOEM student manual*. Emmitsburg, MD: FEMA.
- Graner, R. (2006). *The fire chief's toolbox*. Tulsa, OK: PennWell Corporation.
- Greer Partnership for Tomorrow. (2015). *Greer Community master plan*. Retrieved from <http://plangreer.com/Brochure/>
- Insurance Services Office, Inc. (2012). *Fire suppression rating schedule*. Jersey City, NJ: Insurance Services Office, Inc.
- National Fire Protection Association. (2010). *NFPA 1710: Standard for the organization and deployment of fire suppression operations, emergency medical operations, and special operations to the public by career fire departments*. Quincy, MA: NFPA.
- Price, M. (2009). Convincing the chief: Proving time-based networks really work. *ArcUser*, 50-54. Retrieved from <http://www.esri.com/news/arcuser/0309/files/chief.pdf>
- Price, M. (2012). *Fire mapping: Building and maintaining street networks in ArcGIS*. Retrieved from ESRI: <http://www.esri.com/library/ebooks/fire-mapping-street-networks.pdf>

Thiel, A. K., & Jennings, C. R. (Eds.). (2012). *Managing fire and emergency services*. Washington, D.C.: ICMA Press.

USA QuickFacts: Greer, SC. (2015). Retrieved from

<http://www.census.gov/quickfacts/table/PST045214/4530985,00>

United States Fire Administration. (n.d.). *U.S. Fire Administration America's fire and emergency services leader strategic plan fiscal years 2014–2018*. Retrieved from

https://www.usfa.fema.gov/downloads/pdf/publications/strategic_plan_2014-2018.pdf