# Highlands Fire Department
# Staffing and Deployment Analysis


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## EXECUTIVE SUMMARY

This analysis identifies the factors that need to be considered in planning the future needs of the HFD. Its focus is on the deployment of resources relative to structural fire protection. This analysis serves as the "core" around which other programs are planned for.

The document starts with an explanation of the considerations and assumptions that are utilized in analyzing and planning fire protection systems. It discusses and describes what fire companies do on the scene of an incident and how fire progresses through the structure. It also defines the response time model and how companies are strategically located. An explanation of NFPA 1710 is also given; this is an important section for the reader to understand.

The analysis then describes the current condition of staffing and deployment and contrasts it with *The Desired Future Condition*. This results in the following short and long term recommendations:

1. Build a Fire Station in Forest Highlands now (completed).

2. Acquire land at the intersection of Old Munds Highway and Mountainaire Road. Relocate Fire Station 23 to this location (currently under construction).

3. Relocate Bear Jaw Fire and Fuels Module to old Station 23..

4. Increase daily minimum staffing from five to eight when both new stations are completed and the budget allows for it.

5. Adopt an apparatus replacement cycle and purchasing plan that can be adapted to strategic planning process.

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## INTRODUCTION AND PURPOSE

Most people are not informed about the complexities associated with effective structural fire protection planning. The public usually views the system model as "simplistic" in nature and applies the following assumptions:

1. My "emergency" is the only one in progress.
2. The fire station is close by and will be on scene "quickly."
3. Only one fire "truck" will be required.
4. There will be adequate staffing on that truck to handle the emergency.

As most public fire protection professionals know, the above assumptions are often incorrect most of the time.

In reality, the planning model is much more complex. Complexity increases with the following:

1. Size of population served.
2. Size of service area.
3. Environmental factors (topography, street system, weather, etc.)
4. Diversity of potential risks.
5. Number of fire companies deployed.
6. Number of fire stations servicing the area.
7. Staffing model utilized (paid, volunteer, or combination).

The purpose of this analysis is to identify the factors that must be considered in planning for the future needs of the Highlands Fire District. The Fire District Board and the staff of the district must have a common "mental model" of the existing system before they can make effective decisions about its future. This analysis attempts to do the following:

1. Create a common understanding about basic structural fire protection planning issues affecting the district.
2. Presents recommendations to the Board to improve upon existing deficiencies.
3. Identifies options for the Board in considering the longer term planning issues that will affect the District.

**The focus of this analysis is on structural fire protection. There is relevance to planning for the Emergency Medical Services (EMS) system as noted in the document. This analysis should serve as the "core" around which other programs (e.g.; wildland fire, preventative services, fuel management, and public education) are planned for.**

## BACKGOUND ON STRUCTURAL FIRE PROTECTION PLANNING

### Tactical Responsibilities of Fire Companies

A fire company consists of two or more personnel assigned to an engine. Because the HFD does not have ladder truck companies, all fire ground operations utilize the *engine* as the basic platform for providing service. Engines carry a limited supply of water, various amounts and sizes of hose, and are designed with a large capacity fire pump on board. The basic tactical responsibilities of engine companies at structure fires are to:

- Lay a large diameter hose line from the closest hydrant to a position of greatest tactical advantage near the fire building.
- Extend a hose line from the engine to a position where exposed and endangered structures can be protected from advancing fire and flying brands.
- Advance a hose line from the engine into the fire building to prevent extension of fire into the uninvolved portions of the building (only after four personnel have arrived at the scene – OSHA and NFPA 1710 requirement **).
- Extinguish the fire with minimal structural and contents damage from fire, smoke and water.
- Search and remove fire victims from the areas of risk (**).
- Force entry into the structure and open up concealed spaces.
- Raise portable ground ladders to affect rescue of fire victims on upper floors and gain access to the roof for ventilation.
- Channel super-heated smoke from the interior of the structure to the outside by creating openings in the roof and utilizing existing openings.
- Shut-off utilities to the building.
- Perform salvage operations that minimizes smoke and water damage. Place the structure back into a usable condition if at all possible.

*Because of Occupational Health and Safety Administration (OSHA) Regulations and National Fire Protection Association (NFPA) Standards, we are required to assemble a minimum of four personnel on the scene before entering the interior of a burning structure. While two firefighters enter the structure for fire attack/rescue, two firefighters must remain outside the structure in position that will allow them to attempt "rescue" of the firefighters inside the structure if they become trapped or overcome.*

As can be imagined, it becomes extremely difficult to manage all of the associated tactics with a very limited number of personnel on the scene. For example, ventilation of the structure, even though it increases effectiveness as well as firefighter and civilian safety, often takes a backseat to other tactical operations.

## Fire Behavior in Structures

The services of the fire department are requested when conditions at the scene of an emergency are degrading very quickly. Whether the emergency is a fire, cardiac arrest, vehicle entrapment or similar “emergency in progress,” conditions at the scene are rapidly deteriorating. In the case of fire control efforts, it is important to develop an understanding of fire behavior within structures to gain an appreciation of the explosive growth of uncontrolled fire within a structure.

Through scientific testing conducted by the NFPA and the United States Fire Administration (USFA), as well as actual assessment of fire ground conditions, it has been determined that the first (5) five to (8) eight minute “window period” in the early phases of a structure fire correlates directly with factors that influence the chances of survival of building occupants and the extent of fire damage to the structure.

In a routine fire in a home where actual flame exists, the combustion process produces heated gases that, in turn, heat adjacent combustible surfaces. As a result of the rapidly developing fire, the temperature within the room rises very quickly from the fires incipiency, to a point when all the combustible contents within a confined area will ignite in a “flash-over” condition.

**Flash-over defined**: Ordinary combustibles in buildings have an ignition temperature of 400 to 1000 degrees Fahrenheit. As the room contents and wall/ceiling surfaces become heated, simultaneous ignition of all combustible material occurs resulting in a FLASH-OVER condition. In a matter of seconds, fire conditions produce a high level of super heated gases and fire spreads throughout the structure with dramatic speed.

Once flash-over has taken place, all materials in the original fire area become involved in the combustion process. The amount of heat energy increases, windows fail, thus enabling more oxygen to reach the fire and accelerate the combustion process. Anyone who has not escaped from the room at the point of flashover is unlikely to survive. Even the survival rate of firefighters, wearing full protective clothing and breathing apparatus, is very low due to the hostile environment of the atmosphere during flash-over.

## The Correlation to Emergency Medical Response

Medical emergencies have a similar time requirement. During heart attacks, respiratory distress, and cardiac arrests, it is imperative to intervene quickly. The heart, the brain, and other vital organs are oxygen dependent and quickly begin to deteriorate and fail without adequate perfusion.

Biological death and irreversible brain damage begins after four to six minutes. In addition, the success rate of defibrillation of the heart diminishes by 10 percent for each minute after the initiating event that caused the arrhythmia. If emergency medical personnel can be placed on the scene of a medical emergency prior to biological death, mortality rates decline and intervention effectiveness increases. The time period for effective EMS intervention closely correlates to the window we have to intervene before flash-over in a structure fire.

## Response Time Model

In an analysis of fire company deployment and staffing, the importance of time is related to the "exponential development" and propagation of fire within the structure. The tactical objective of the fire department is to provide sufficient firefighting resources on the scene to attack the fire prior to flash-over.

**Exponential Development of Fire Defined:** The fire growth rate relates to a fire doubling in size every 17 seconds. Radiated heat from the fire, in turn, heats adjacent combustible materials further intensifying the fire. The violent expansion of the atmosphere in the fire room then forces fire into other uninvolved rooms at a tremendous rate of speed**.**

**Attacking the fire prior to flashover significantly increases the chance of survivability of the occupants, increases the chance of saving the structure, and reduces the risk to firefighters.**

There are five critical time periods that must be considered in establishing the ability to attack structure fires in their incipiency prior to flash-over. The five time span periods are:

A. **DISCOVERY OF FIRE**: The time span that elapses between the inception of the fire, detection of the fire, and time to make initial contact with the Public Safety Answering Point (PSAP).

B. **ALARM HANDLING TIME**: The amount of time required to receive the call at the PSAP, determine the appropriate fire company assignments, and to initiate the dispatch of those companies to the scene of the emergency.

C. **TURNOUT TIME**: The amount of time required for the fire company to receive the dispatch from the PSAP, don the appropriate personal protective clothing, get on the engine, and start in the direction of the incident.

D. **COMPANY TRAVEL TIME**: The elapsed time span from the moment the company starts moving towards the incident and the arrival time of that company on the scene of the incident.

E. **SET-UP TIME**: The time span required to actually "set-up" operations where a full scale fire attack has been initiated.

At the present time, there are no national standards for "Discovery of Fire" time spans. Most public education programs address this issue as do code requirements for early detection and alerting (e.g.; smoke detectors, fire alarms, central station reporting etc.). There are no national standards for set-up time. Most fire departments continuously drill upon operations that place the first attack line on the fire in less than three minutes.

The remaining three time spans are usually referred to aggregately as "Response Time" (please note that this is different than Travel Time/Distance). There are national standards for the other time spans:

ALARM HANDLING: One (1) minute.
TURNOUT TIME: One (1) minute
COMPANY TRAVEL TIME: Three (3) minutes
(first due engine or four personnel on the scene)

These standards are based upon National Fire Protection Association (NFPA) standards as well as those set by the Insurance Services Office (ISO).

## Strategically Locating Fire Companies

When considering that fire companies spend two-thirds or more of their 24 hour shift operating in the fire station, it is evident that station location must become the point of focus in calculating the elapsed time between the company's receipt of alarm and their timely arrival at the fire.

To determine the most appropriate fire station location for companies, several factors must be considered in such an essential strategic planning effort. These factors are:

A. The level of demand for service. This is usually based upon population density. In some cases unusual hazards and risks will come into play.

B. The actual “travel time” required to reach various locations within the district from existing as well as potential fire station locations.
C. Consideration of future growth and development patterns.
D. Consideration of topographical as well as traffic features.
E. Acceptable elapsed time for the number of companies/personnel to arrive on the scene and begin fire attack.

## National Fire Protection Standard 1710

In 2001, the NFPA adopted a standard that has had far-reaching impact on this nation’s fire service. It is a planning and evaluation standard that specifies many of the concepts discussed so far. Here is a matrix that describes the nuts and bolts of 1710:

| | |
|---|---|
| First unit travel time: | 4 minutes/90% of the time* |
| Initial full assignment travel time: | 8 minutes/90% of the time* |
| First unit staffing: | 4 minimum |
| Full assignment staffing: | 14 (incl. IC) |
| First BLS unit travel time: | 4 minutes* |
| First ALS unit travel time: | 8 minutes* |

(*) includes turnout time of 1 minute

This standard is meant to apply to all fire departments that are “substantially all career.” To decide if a department is substantially all career, the following question is asked: Do volunteer firefighters supplement the career firefighters? If the answer is yes, then the department is “substantially all career.” If career firefighters are supplementing the volunteers, then it is a “substantially volunteer” department. There is no question that the HFD is a substantially all career fire department.

The next question of interest is one that deals with legal implications. We have not adopted 1710 as a standard of this department and there is not a legal requirement for us to do so. Non-compliance, however, does provide for some increased level of legal exposure. In a case of alleged negligence, the “reasonable person” theory will be utilized. Lawyers will ultimately look at the fire service at large to see if there is general agreement on relevant standards for what is reasonable. Undoubtedly, since NFPA is a consensus standard, it will be utilized as a benchmark in determining what is reasonable. For negligence to be established, however, a nexus must be associated between “damages” and non-compliance with the standard(s).

## THE CURRENT CONDITION OF DEPLOYMENT AND STAFFING

### Staffing and Apparatus Deployment

At the present time, the District staffs Station 25 (Forest Highlands) with three personnel and Station 23 (478 Kiowa St.) with a minimum of two (2) personnel. These stations are staffed 24 hours a day, 365 days a year. Minimum staffing is considered to be two (2) personnel at one station and three at the other, but every attempt is made to staff both stations with three (3) personnel on a daily basis.

Station 25 houses a Type I (structural) and Type III (structural/wildland-interface) engine. Station 23 houses a Type I engine, a Type III engine, a Type I tactical water tender (2000 gallon capacity) as well as a Type VI (wildland) engine. Station 25 will be the recipient of a Type I Tactical Water Tender in November of 2009.

Station 22 is located at 1068 Tolani Trail. It is staffed by the Fuels Crew on a Type VI engine. The Fuels crew staffs this station 10 hours a day, four days a week. There primary responsibility is fuels management. They are available as a primary response resource to wild land fires and also provide a support role for other types of incidents. During the normal work day and work week, staffing is augmented by administrative personnel.

Station 24 (Lake Mary Meadows Station) is strictly a volunteer station. A Type VI engine is located in a privately owned building that the District leases.

The Fire Chief, Deputy Chief, and Battalion Chief are available to perform all line and command functions.

Volunteers augment staffing in several different ways. Volunteers may provide the district with extra staffing during normal shifts. This arrangement brings staffing levels up to three or more on one or both engines during a portion of the shift. Volunteers also provide additional staffing during realized demand for service. They typically respond from home to the station. As would be expected, the availability of volunteers is higher in the evening and during the weekends due to the demands placed upon them by their employers.

All off-duty paid staff members are subject to recall if an incident occurs within the district.

## Travel Distance and Times

The average national travel time/distance model (based on actual models ran in five urban/suburban cities) indicates that an engine company normally travels at a speed of 30 miles an hour. This includes starting, slowing, stopping, reaccelerating, etc. throughout the distance traveled to the call. Communities who meet this standard typically assign a travel distance of 1.5 miles to the first due engines within their response area. The travel speed of 30 mph means and engine can travel 1.5 miles in the allocated travel time standard of three (3) minutes.

Staff suspected that travel speeds would be significantly less within the District when compared to the national average. This assumption was made due to topography, street width, and street construction. Several simulated responses were run throughout the District to determine an average response time speed. As suspected, the average response time speed within the district is significantly slower than the national average. The average range of speeds over a predetermined route varied from a low of 17 mph to a high of 24 mph. The average speed of the sample population (n=20) is 20 mph.

**The average response speed within the district is 20 mph. This is under the best of conditions (clear visibility, no ice, rain, or snow). This means that a fire company can travel a distance of one mile in three (3) minutes, two miles in six (6) minutes, etc.**

Another critical issue that has to be addressed are those relevant to NFPA 1710 and our own internal policies. That is, interior fire attack cannot begin until a minimum of four personnel are assembled at the incident. **This means, that in the majority of instances, the response time of the second due engine actually determines when fire attack can begin.** *The travel time and distance of the second due engine is the lowest common denominator for determining response distance and time, as well as optimal fire station locations.* **THIS WILL REMAIN THE CASE UNTIL WE STAFF ENGINES WITH A MINIMUM OF FOUR (4) PERSONNEL.**

**The existing condition, as depicted by the map for response Model #1, indicates response times in excess of 8 minutes for a large portion of the first due engine districts. Response times in excess of 8 minutes for the second due engine is the prevailing condition for the district; this means that the majority of the time we cannot assimilate four personnel on the scene within the standard.**

## THE DESIRED FUTURE CONDITION

### Fire Station Locations

It does not appear to be financially feasible to staff and deploy resources at the urban and suburban levels as recommended in NFPA 1710. This would require the district to staff fire stations at four personnel each throughout the District so that the entire map was "green" as depicted in Model #1. To do so, would require the district to raise its annual operating budget to a level that could not be supported by normal revenue gathering methods. . This does not take into account the need to raise additional capital for apparatus and fire stations.

**It would appear to be prudent to locate fire stations and provide adequate staffing so that the majority of the district would receive an adequate number of personnel to initiate structural fire attack in eight (8) minutes or less, 90 percent of the time.**

A number of Geographic Information Systems (GIS) models were ran to simulate placing fire stations in different locations throughout the District. Some of these models included the following combinations of station locations:

1. Existing Station 23 and the Forest Highlands Site.
2. **Forest Highlands site and the Mountainaire Rd. /Old Munds Highway site** (recommended sites by the model).
3. Existing Station 21 and 23 sites with the Central Station Site.
4. Station 22 site and Central Station Site
5. Forest Highlands Site and existing Sta. 21 and 23 sites
6. Forest Highlands Site, Existing Sta. 21 and 23 sites with Central Station Site

By far the most effective site from a geographical and financial perspective, as well as real/potential demand for service perspective is depicted by GIS Map 4. This model indicates the need for a station located on Forest Highlands Drive and a station at Mountainaire Road/Old Munds Highway. Both stations would be optimally staffed with a minimum of four personnel.

The advantages of this model include the following:

1. It provides the four person staffing required to initiate interior structural fire attack in an efficient and effective manner. The majority of the built out area of the district would receive a minimum of four people on the scene within the 8 minute standard. This is the area where most of the real demand for service is generated. Portions of rural Mountainaire and Forest Highlands would still lie slightly outside the standard.

2. Improved response to the Highland Meadows area as well as Old Munds Highway.
3. Easier, faster, and safer response to the I-17 corridor within the District.
4. Increase to the safety of the public and staff by reducing the exposure of Code 3 responses through neighborhoods and down steep slopes during winter.

Non-response time related advantages of the model include the following:

1. The ability to create a more customer service oriented environment for District residents. This includes a larger public meeting room of adequate size and with the required parking to meet the needs of the entire community (new Station 23 site).
2. The larger meeting room would also enable us to sponsor more training programs that typically require more physical space than we have now.
3. An adequate sized parking area would also provide staff with an area to conduct manipulative training sessions and exercises.
4. We already have a signed lease agreement with Forest Highlands for the land (This station is constructed and staffed).

Possible disadvantages to sitting stations in this location include the following:

1. Acquisition and cost of the land associated with the Mountainaire site (Site acquired through the Townsend Act and the station is under construction).
2. Increase in capital costs.
3. The entire political issue of moving/relocating stations within a jurisdiction. This can usually be mitigated through a public education program (little to no opposition was encountered).

In addition, Station 23 is functionally obsolete. It is inadequate in size, cannot staff four personnel and this makes it difficult to house any volunteers for shift work. There is lack of proper eating facilities, office area and general work area. In addition, many of the building's systems (septic, electrical, plumbing, etc.) are aged, not up to code and may be subject to catastrophic failure. Also, the type of apparatus that may be housed within the apparatus room is limited to smaller apparatus and not necessarily the size and type that are needed. The existing station could be sold to help finance the costs associated with its relocation.

**It is recommended that Station 23 be re-located in the approximate area of Mountainaire Road and Old Munds Highway within the next two to three years. (Under construction with a completion date of Spring 2010).**

## Staffing

The recommended model and relocation of stations assumes that our optimal staffing level is a minimum of four at each new station. This means that daily minimum paid staffing would increase from five to eight personnel over some period of time. The configuration of this staffing element would ultimately be one (1) captain, one (1) engineer and two (2) firefighters at each station. This staffing model allows the first due engine to initiate structural fire attack/primary search.

**It is recommended that daily minimum paid staffing be increased to eight per shift once both new stations are built and operating, and the budget allows for it.**

## Apparatus and Vehicles

The useful life span of fire apparatus is based upon type, topography, and usage. Based upon experience and best practices, this life span is a known factor that can be anticipated. Based on this knowledge the following recommendation is made:

**REPLACEMENT CYCLES**

**Type I Engine…….25 years**
**Type III Engine……..20 years**
**Type VI Engine……..15 years**
**Water Tenders……25 years**
**Staff and Command Vehicles……8 years and/or 125,000 miles.**

**Resource Types defined:**

| | |
|---|---|
| Type I Engine: | A structure firefighting engine of the heaviest type. |
| Type III Engine: | A lighter combination engine used in the interface to fight small structural fires as well as fire threatening structures from natural vegetation. |
| Type VI Engine: | A light, small capacity engine used in brush/forest firefighting. |
| Type I Tactical WT: | A commercial truck chassis with a pump and a tank capacity of 2000 gallons, pump and roll capability plus a foam system. |

Once this replacement cycle is identified, it can be utilized as planning tool for the budget and the strategic plan. In recent years, the District has successfully utilized short term financing (five years or less) to acquire/replace vehicles and apparatus. Although it is anticipated that this financing scheme would continue to be utilized in the future, it also gives the Board the opportunity to plan for the “cash” purchase of vehicles and apparatus.

## SUMMARY OF RECOMMENDATIONS

1 Build a Fire Station in Forest Highlands now (completed and staffed).

2 Acquire land at the intersection of Old Munds Highway and Mountainaire Road. Relocate Fire Station 23 to this location (land acquired and station under construction; completion in Spring of 2010).

3 Relocate the Bear Jaw Fire and Fuels Module to Old Station 23.

4 Increase daily minimum staffing from five to eight when both new stations are completed and the budget allows for it.

5 It is recommended that the District adopt the following replacement cycle and start an annual replacement fund to purchase new apparatus:

Type I Engines…….25 years
Type III Engines……..20 years
Type VI Engines……..15 years
Water Tenders……..25 years
Staff and Command Vehicles……...8 years and/or 125 K miles

**MAPS**

Map 1: Map 1 shows the existing condition with both stations depicted. The blue line (inclusive of green and red) shows those areas within the response time criteria set by the District. THIS MAP IS DECEPTIVE IN THAT IT DOES NOT INDICATE STAFFING LEVELS. MAPS 2 and 3 ACTUALLY DEPICT THE AREAS OUTSIDE THE STANDARD IF EACH ENGINE IS NOT STAFFED WITH FOUR (4) PERSONNEL.

Map 2: Travel time/distance analysis for existing Station 21.

Map 3: Travel time/distance analysis for existing Station 23.

Map 4: Map 4 shows the desired future condition for re-locating Stations 21 and 23. Once again, the standard is only met when both companies are staffed at four (4) personnel.

Map 5: Travel time/distance analysis for proposed Station 21.

Map 6: Travel time/distance analysis for proposed Station 23.