

Running Head: GEOGRAPHIC INFORMATION SYSTEMS AS DATA NEXUS

Using Geographic Information Systems for Pre-Incident Planning

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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.

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Abstract

Emergency incident size-up is a critical function performed by all fire officers. Size-up begins the moment crews leave the station and the more information available the better the size-up will be. Unfortunately many firefighters still lose their lives due to inadequate size-ups. The problem is the fire service collects and stores volumes of data that would be useful to emergency responders for size-up: NFIRS data, NEMSIS data, inspection history, and special hazard information collected over years of experience, yet rarely is this data available during emergency response. The purpose of this Applied Research Project is to show that a Geographic Information System (GIS) acts as a nexus for all these data types and displays them graphically on digital maps familiar to firefighters. By using fire service GIS layers responders are able to create better incident action plans and share these plans more effectively amongst other responders. The descriptive method of research was used to determine what data was collected and stored by the Everett Fire Department, other city departments, and neighboring departments, and to determine if a GIS would easily display key pre-incident plan and special hazard information while responding. Procedures included an extensive literature review and compilation of NFPA 1620 pre-incident planning data points. Procedures also included interviews with subject matter experts and inventories of existing Everett Fire Department data sets compared against NFPA recommendations. Results determined GIS software is the ideal medium for displaying a summary of key NFPA 1620 information. This Applied Research Project recommends the creation of fire service GIS layers for display on mobile data computers for use during emergencies.

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Introduction

Effectively mitigating any emergency requires emergency responders to create a mental snapshot of a dynamic emergency event, known as a “size-up”, and then formulate and implement intervention plans that will bring the event to a safe conclusion. This technique is not always simple, evidenced by the eighty-two (National Fire Protection Association [NFPA], 2010) firefighters who gave their lives intervening in emergencies nationwide in 2009. Fire departments everywhere commit enormous resources collecting data of all kinds, much of which would be useful in pre-assembling these size-ups before they are needed, yet this rarely occurs. The purpose of this Applied Research Project (ARP) is to determine what data is available to the Everett Fire Department (EFD) which could be useful during emergency response and determine an effective way of utilizing it from the field.

The descriptive method of research was used to prepare this ARP. The research questions addressed were: What data is currently being collected and stored by the EFD? What data would be useful that is not being collected? What data is currently being collected by other city departments, utilities, or neighboring jurisdictions that may be of use to the EFD? What capability does Geographic Information Systems (GIS) software offer as a nexus for display of useful data? What functions does GIS software offer which would assist with emergency response? What hardware changes would be required to effectively utilize GIS software from the field? What barriers stand against effective GIS utilization?

Background and Significance

The City of Everett is populated by approximately 110,000 residents over forty-two square miles of land within Snohomish County, Washington. Everett is located approximately thirty miles north of Seattle on the Interstate 5 corridor and comprises the northern end of the

Puget Sound metropolitan region containing the cities of Seattle, Tacoma, Bellevue, and Everett among others. The region is home to 1.5 million residents. The City of Everett is old by west coast standards, incorporated in 1892 and is the seat of Snohomish County government. As an early western terminus of the Pacific Railroad, Everett exported lumber and lumber products to the United States and the world for the bulk of its first sixty years. Fantastic mill fires routinely occurred on Everett's waterfront and contributed to an early, rich firefighting tradition. Modern Everett is home to several multinational corporations including the Boeing Company's primary assembly factory for the 747, 767, 777, and 787 commercial aircraft. In addition to these and other private sector employers the City of Everett is also home to Naval Station Everett, homeport to the nuclear-powered aircraft carrier U.S.S. Abraham Lincoln and several other ships from her battle group.

The Everett Fire Department is a career fire department comprised of 177 uniformed personnel providing all-hazard emergency services including fire response, emergency medical services and transport including basic and advanced life support, technical rescue, hazardous materials technician-level response, fire code plan review, fire code inspection and enforcement, and a variety of supporting services. On a daily basis the Everett Fire Department staffs seven fire engines, one ladder company, three paramedic units, two basic-life support units and a battalion unit. Every apparatus in the fleet is equipped with a mobile data computer (MDC) and 900MHz modem for communication with CAD software. Each year the department answers an ever-increasing number of calls for service; in 2009 there were over 18,500 alarms. As is the case with most modern departments, over eighty percent of those requests were for medical assistance.

During medical alarms employees gather information on patient care reports (PCRs). The information gathered includes those data points recommended by the National EMS Information System (NEMIS) as well as local data including computer aided dispatching (CAD) incident identifiers and tracking times, and information pertinent for patient transport billing if necessary. PCRs are returned to the stations and the information gathered from the alarm is combined with the CAD data in a Fire Data Management (FDM) database and stored by the department. Stored EMS data is not accessible to responders during subsequent alarms.

For fire responses and other non-medical requests for service the Everett Fire Department collects fire incident information on paper and combines it with CAD data upon return to the fire station, where it is entered into FDM. The information collected during these non-medical responses is National Fire Incident Reporting System (NFIRS) data and stored in a database by the department. Stored NFIRS response data is not available to responders during alarms.

The Everett Fire Department performs annual code-compliance inspections of all commercial occupancies within its jurisdiction using the International Fire Code, 2006 edition. Four full-time inspectors handle the complex, high-hazard occupancies and fire suppression officers are assigned all routine commercial and multifamily occupancies within the city. During the course of those inspections the department records vast quantities of data about commercial occupancies including suppression systems data, detection systems data, alarm panel locations, and key box inventories. Beginning in 2010 data from inspections is being entered into a relational database via software called OneStep, which is not accessible from the field during emergency response.

During the course of plan review for new commercial structures the department is provided detailed architectural plans of all developments. These plans are often provided both

on paper and digitally, and fire department inspectors are on-site during most development to check on code compliance as construction progresses. The department does not store electronic plans provided by developers and makes no effort to store any plans once the construction final is approved. Responders have no access to plans data during emergency response.

The department is routinely provided with information from various city departments regarding the status of community resources: Street closures, road construction, water main closures, hydrants placed out-of-service, unstable driveways and addresses law enforcement has deemed unsafe, etc. Other public organizations often provide important data including public health notices or notices of reportable chemical quantities stored at the Port of Everett. All these pieces of data are evaluated by Chief Officers and disseminated to the employees via two paths: Information bulletins and safety bulletins. The path chosen is based on the potential impact to firefighter safety. Both information bulletins and safety bulletins are distributed to the fire stations on paper and posted with an expiration date, if applicable; employees are required by policy to visit these notices every morning at the start of shift. Neither information bulletins nor safety bulletins are available to responders during alarms and recalling the various notices and safety information while responding can be challenging at best.

In 2006 the department recognized the value of accurate site-plans for pre-incident planning. Two employees were assigned the herculean task of surveying commercial properties and creating simple site-plans that identify fire suppression features, utilities, key box locations, and in the case of multi-building complexes, the building numbers and private roadway characteristics. These site plans were completed for 175 addresses and are carried on apparatus both on paper and as electronic Portable Document Format (PDF) files hyperlinked in a sortable Excel worksheet. These site plans are routinely accessed by employees for incidents of all types

for site specific information. Unfortunately department priorities have not allowed the ongoing creation of new site plans or maintenance of the existing plans. There are still over 4,000 commercial and multifamily occupancies in the city which warrant site-plan information but have none available, and many of the existing plans now provide information that is out of date. None of the site-plans are linked in any way to OneStep inspection data so valuable current inspection history and owner/occupant information is not accessible via site-plans. Site plans for single family residences have not been attempted despite the occasional need for very serious safety notifications.

Finally, department members collect but do not record some of the most valuable data. Field experience during actual alarms exposes employees to small but critical pieces of information that can make the difference between successful emergency mitigation and catastrophe. So called “street smarts” said to come from experience and only passed down verbally is useful and recordable information: Knowledge of dogs that bite, hoarder homes found on aid calls, places the apparatus won’t fit, and the myriad of other details that are handed down from one crew to the next. Unfortunately Everett, like most departments facing the challenge of twenty-four hour staffing, often reassign personnel, and so in the dark of night employees regularly find themselves having to re-learn information other employees have already learned. It is shameful that in most cases the valuable information which could have saved time or made the difference between success and failure has already been learned by some members of the department but was not institutionalized. The difficulties with any pre-planning program is taking all these sources of raw data, compiling them, keeping them current, and then distilling the important information into an at-a-glance format useful to first responders.

When considering the enormity of the information available to the department and recognizing the time constraints placed on first responders during emergencies it becomes necessary to look for a way to sort and filter it in a meaningful way. The fire service's tool of the future can be found in its past: The map. Whether it is an address contaminated with active tuberculosis, an out-of-service hydrant, or a building with a basement, they all occupy a geographical location which can be tied to a map via geospatial coordinates and depicted with a symbol. The fire service has long experience reading maps and the transition to digital mapping is well underway. More important than the digitization of the map however, is the evolution of Geographic Information Systems (GIS) which allow information to be overlaid and viewed upon a map in layers and is updatable in real time.

Snohomish County has undertaken the process of upgrading its computer aided dispatching (CAD) software. The new version, supplied by a software vendor called New World Systems, will be active on all responder MDCs by June 2011 and includes a GIS viewer. The intent of New World Systems is to use the GIS viewer for the purpose of automated response route planning, (Wollenweber, 2010) but there are far more valuable purposes for GIS in the fire service. If the variety of useful data already mentioned can be related to a location on the map, it can be inputted into the GIS and displayed on the MDC while responders are en-route to an emergency.

Visualization of all these data types on GIS layers will allow the Everett Fire Department to better meet the United States Fire Administration's current goals. Objectives of all five goals would be addressed should the Everett Fire Department be able to access these various data sets during emergency responses. Prevention was the focus of Executive Analysis of Community Risk Reduction and the systematic institutionalization and utilization of all the information

collected by the Everett Fire Department is a potent risk reduction strategy. It would expand the use of modern data and information analysis in planning and preparedness. It would improve our decision making skills and improve our service delivery, improving our professional status. Finally it would improve our business systems and processes for the benefit of both the community at large and the employees serving them.

Literature Review

The National Fire Protection Association (NFPA) contributes a great deal to the standards set for fire department data collection. The vast majority of data points suggested for collection are intended for use in fire department post-performance analysis, rather than for recall during emergency response. The Fire Protection Handbook (NFPA, 1998) discusses and clearly recognizes the value of fire department information systems and lists useful managerial decisions which are made easier through data analysis: Positioning of capital resources, dispatching, human resources, budgeting, fleet maintenance, communications, permitting, and pre-fire planning. Other than the mention of “pre-fire planning” there is little discussion over several chapters for using information systems while mitigating emergencies. The NFPA does, however, recognize the information systems and stored data of a fire department as “crucial” to the success of the department. (NFPA, 1998, p. 10-45)

Further investigation of the NFPA’s intent on pre-incident planning reveals NFPA 1620: *Standard for Pre-incident Planning*. (NFPA, 2010) In 2010 the NFPA updated their stance on pre-incident planning and NFPA 1620 is now a standard, rather than simply a recommended practice. The NFPA makes it very clear that pre-incident planning should include a standard dataset, and offers a sample data collection form for that purpose. The scope and complexity of pre-incident plans are left for the local authority to determine. NFPA 1620 also states that pre-

incident plans shall be available to incident commanders both during and after emergency response. The recommended dataset for pre-incident planning is vast, and could be displayed in a variety of ways. For example, building construction type and features, or the facility management and utility systems could be described both graphically and textually.

Crucially relevant to this ARP is NFPA 1620, Chapter 9 where it is required that the pre-incident plan, or “*a summary of its key elements*” [italics added] be available to responders both while responding to, and operating upon an emergency incident. Unfortunately, the NFPA does not identify which data points among the volume of suggestions, are considered *key*. This critical decision is left to the local authority. Additionally, the NFPA does not identify a specific medium with which to deliver pre-incident plans to users; in fact methods of delivery are not discussed and thus left to the local jurisdiction as well.

The United States Fire Administration (USFA) manages the National Fire Incident Reporting System (NFIRS) and is responsible for determining the data points collected by NFIRS. In their 2009 report to Congress, the USFA admits the NFIRS dataset is out of date and “in need of modernization”. (United States Fire Administration [USFA], 2010) When discussing the useful purposes of NFIRS data the USFA lists its value for planning management but makes no mention of NFIRS data use during responses. The USFA advertises the NFIRS system as a national effort to assemble fire response data for use by local and national officials in understanding the national fire problem. (USFA, 2007)

In 2009 the USFA began a NFIRS enhancement project that includes four distinct phases with the intent of making NFIRS data both more relevant and more accessible by client departments. Part four of that project is the enhancement of a web-based user interface to the NFIRS data and includes a cryptic reference to the addition of GIS services and improved

administrative applications. This report to Congress briefly recognizes the value of GIS in fire department management planning but makes no mention of the possible use of GIS for tactical purposes. (USFA, 2010)

Initial fire scene size-up is widely discussed by fire service professionals as critical to the successful, safe mitigation of emergency incidents. Chief Michael Walker, (Oklahoma City, OK) asserts that the systematic size-up of emergency incidents begins while en-route to the alarm. “The decisions the first-arriving officer makes on a fire scene are critical to the success of that operation.” (Walker, 2009) This sentiment is repeated throughout trade journals and articles as well as nationalized incident management materials.

When firefighters fail to accurately share a size-up, lives may be lost. The 1994 Mary Pang Warehouse fire in Seattle, WA claimed the lives of four firefighters. During this event the incident commander and safety officer were operating on opposite sides of the structure and the IC was not aware there was a basement. The failure in this case was between the incident commander and his safety officer and divisions: None of them recognized that they were all seeing a different size-up image. Had a pre-incident plan been available which included structural features like the presence of a basement, or pictometry views of all four sides, the miscommunication may have been avoided and lives may have been saved. Critical issues identified in the USFA technical analysis of this tragedy (USFA, 1995) include the finding that command officers were faced with a very difficult size-up due to geography and multiple renovations. An additional finding that contributed to the loss was the lack of a pre-incident plan for the structure. Finally, Seattle Fire had warned their crews that the Pang warehouse was the target of arson threats but that special hazard information was not available to responders while responding.

Information management is cited by the USFA investigator as a contributing factor in the loss of life. The Mary Pang investigator recognized that:

The ability of an Incident Commander to make an appropriate risk assessment is necessarily based on the information that is available at any point in time and the Incident Commander's ability to process that information. The Incident Commander must use the available information in an expedient manner to direct the early stages of an operation and then continually update the information. (USFA, 1995, p. 21)

The lack of accurate, expedient information during emergency operations is a recurring theme in the study of fire incidents, and particularly those fire incidents resulting in firefighter fatalities. The volume of information available on the Pang warehouse prior to the arson fire would have been impossible to commit to memory. Only an accurate pre-incident plan could have contained it all.

The National Institute for Occupational Safety and Health (NIOSH) studies trends in firefighter deaths and investigates workplace factors which may have contributed to occupational injuries and fatalities. NIOSH investigated the Charleston, N.C. structure fire at the Super Sofa facility in which nine Charleston firefighters lost their lives as a part of the NIOSH *Fire Fighter Fatality Investigation and Prevention Program*. Among the preventative strategies for the future, NIOSH identifies the value of an initial size-up, as well as the need for ongoing pre-incident planning within fire jurisdictions. These factors are among those cited which contributed to the loss of life in Charleston and will prevent future firefighter fatalities. (National Institute for Occupational Safety and Health [NIOSH], 2009) With so many fire service leadership organizations recognizing the need for an accurate size-up and the value of pre-

incident planning the question becomes one of organizational willpower, as the sheer volume of work may appear overwhelming.

NFPA 1620 has identified the information needed for an accurate pre-incident plan and NFPA 170: *Standard on Fire Safety Symbols* (NFPA, 2009) provides the fire service with the legend necessary for drafting them uniformly. However, these two standards create a volume of textual and graphical information so vast it becomes cumbersome, at best, to manage and nearly impossible to utilize at-a-glance while responding to an emergency. Technology must be used to cull key information and make it readily accessible and comprehensible for responders.

The USFA defines a Geographic Information System as a “computer-based system used to capture, store, retrieve, manipulate, analyze and display spatial information”. (USFA, 2003) Virtually all data of interest to the fire service can be related to a specific place, and numerous sources are beginning to recognize the value of digitizing and displaying it graphically via GIS. In order for this to be possible, a GIS foundation must first be built. A comprehensive GIS will include base layers of information including land-use, transportation, zoning, vegetation, residential and commercial areas, standing water, flowing water, elevation and terrain to name a few. (ESRI) Additionally, satellite imagery and oblique-angle images can be linked to the base map allowing either a bird’s-eye view or a side view of all geographic features as offered by Pictometry International. (Pictometry International, 2010)

The National Alliance for Public Safety GIS (NAPSGIS) has identified multiple uses for GIS in the following fire department service areas: Planning, preparedness, response and recovery. Preplanning is a key component of providing preparedness and field intelligence gathering is a key component in providing emergency response, both of which are improved with GIS. The Alliance also identifies twenty other administrative and managerial uses for GIS in the

fire services that are of great benefit but outside the scope of this ARP. (National Alliance for Public Safety GIS) NAPSGIS advises that all aspects of emergency response can and should be addressed by GIS. In fact they recommend field personnel carry portable global positioning system (GPS) enabled computers with optical input for uploading of incident data directly from the scene for real-time large-scale event mitigation. (National Alliance for Public Safety GIS, 2007)

Mike Price, geologist and author for ArcUser magazine has written extensively on the creation of GIS for the fire service. Price asserts that an accurate and reliable street network model is the critical GIS base layer for the fire service. From the street map a variety of other data can be overlaid and then related to fire service resources. Everything from response times to graphical depictions of NFIRS and NEMSIS data can be overlaid to show chief officers, politicians, and community members areas which may be underserved or to demonstrate peak demand. For the responder en-route to an emergency incident, GIS offers the ability to find both the location of their apparatus and the location of the incident to plot a street route between those points. If street data is kept current with street closures or weight limitations the GIS can recommend a route that avoids those points. (Price, 2009)

Beyond an accurate street layer, Price identifies five other essential base layers for public safety GIS systems. (Price, 2010) He recommends a cadastral layer, which is a map layer delineating all property boundaries within a jurisdiction. When combined with assessor data it provides both a geometric element (property shape) and a text element (owner information, parcel identification numbers, etc.). Orthoimagery is the next recommended layer, which is aerial or satellite imagery of the jurisdiction. Orthoimagery ties the cadastral and transportation information together allowing users to recognize familiar terrain features. Administrative units,

including jurisdictional boundaries, urban growth areas, and public right-of-way are the next recommended layer with elevation and hydrography as the final two necessary layers.

With these essential six layers Price asserts public safety managers can begin to use GIS for all the potential purposes identified by the National Alliance for Public Safety GIS. Once the essential layers are fully developed, Price identifies numerous types of special data that would be useful to the fire service during emergency response: Fixed and portable fire protection facilities, water supply infrastructure, site specific hazards, industrial facility features, and hazardous materials storage. (Price, 2010)

For public safety to begin utilizing GIS, the NAPSGIS recommends the formation of a geospatial team made up of subject-matter experts from all contributing fields as well as technical expertise from the GIS field. (National Alliance for Public Safety GIS, 2007) The number of individuals required for a geospatial team will depend on the scope and volume of data involved and may include representatives from planning departments, utilities, police, and the fire service as well as a GIS technician. However, in the long run the success of a fire service GIS will depend on its comprehensibility and ease of navigation for the people who access it every day.

Users do not need to understand the technical workings of a GIS, but they must be able to use the interface and interpret the geospatial data. New users of GIS systems often struggle with the volume of data and are overwhelmed by the possible combinations of information offered by mature GIS. Managers who implement GIS incrementally have had greater success in slowly adapting a workforce culture to include this new technology. (Innes & Simpson, 1993)

Knowledge of a firefighter's service area used to be carried in the company officer's mind. Today the scope and complexity of any given service area is beyond the limit of a typical

fire officer's memory. A vast amount of data can be assimilated in a GIS and displayed graphically on a city base map similar to maps of the early 20th century. The difference is modern GIS maps are as fluid and reactive as the real world environment which they depict.

Real-time situational awareness and a size-up image that is shared via GIS among multiple responding fire officers allows firefighters to visualize the same images, make better decisions, and put a mitigation plan in action sooner and with greater effect. On the fire ground there is no substitute for good information; developing and effectively utilizing a GIS is the most effective way to store and quickly recall the information needed to make critical decisions and accurate risk assessments. (St. John, 2007)

Orange County, California has recognized the need for GIS and successfully created a "data warehouse" which includes information from old paper pre-incident plans, maps, and files and combined those with historical response information and dynamic data sources like weather service, traffic, and earthquake sensing stations. The combination of all these sources in a GIS has led to better decision making in the field and more efficient use of emergency resources in one of the largest fire service organizations in the nation. (Theodore, 2009)

Procedures

The descriptive method of research was used to prepare this ARP. An interview with Everett Fire Chief Murray Gordon on this topic occurred March 6, 2010, allowing the author to determine what, if any GIS capability the Everett Fire Department may already have. The Fire Chief also provided contact information for a City of Everett GIS technician in the utilities department and contact information for a New World Systems GIS specialist located in Troy, Michigan. (Gordon, 2010) Brent Linder is the City of Everett Utilities Department GIS specialist; an interview with Mr. Linder occurred on July 12, 2010 in his office at the utilities

department: 3200 Cedar Street, Everett, WA, 98201. A telephone interview was conducted with Britt Wollenweber, GIS Specialist for New World Systems, on July 22, 2010 connecting from his office in Michigan. An interview with Everett Fire Marshal Richard Robinson occurred on July 28, 2010 at Fire Station #1, 3619 Rucker Ave., Everett, WA 98201 to discuss the fire marshal's office electronic recordkeeping capability. A follow-up interview with the Fire Marshal was conducted to determine what political and financial barriers might stand in the way of effective utilization of GIS in Everett.

During the course of the interview with Linder he described the work done to date by the City of Everett in GIS base mapping and it is extensive. He referred to a City of Everett intranet location which could access the vast majority of City of Everett owned GIS data from any city-networked terminal. The internal web portal location is: <http://arcgisweb>. (Linder, 2010) This site is an Esri-powered web based GIS explorer and allows users to view the various layers of data maintained by the Everett Utilities Department in a read-only format. It also allows users with permission to access City of Everett owned Pictometry images. This tool was studied extensively as a means for determining the existing GIS data owned by the City of Everett.

A table of data recommended by NFPA 1620 was created. (Appendix A) The 1620 pre-incident plan data collected by the Everett Fire Department through NFIRS reporting, site plans, OneStep, or NEMESIS was inventoried and added to the table, with notation of where the data is stored. Finally, the EFD data that is stored was labeled as to whether or not it was accessible by responders during emergency incidents. (Appendix A) A list of NFPA 1620 recommended practices for pre-incident plans was created and compared to the existing site-plan program in use by the Everett Fire Department. (Appendix B)

An inventory of the GIS layer data that has been created by other City of Everett departments was created, and layers of use during emergency response were labeled. (Appendix C) To determine the capability of Everett Fire Department units to utilize and display GIS information in the field an inventory of MDC specifications was created and compared to the minimum hardware requirements for New World Systems GIS viewer. (Table 1)

Results

What data is currently being collected and stored by the Everett Fire Department, and what data would be useful that is not being collected? Study of the information being collected finds an accurate base of response data including NEMESIS and NFIRS data points as well as response time information being kept by CAD dispatching software. All three of these datasets are compiled by members as they return to the station after alarms and entered manually into an FDM database. All FDM data is stored and maintained on an enterprise server by the City of Everett Information Technology Department. Additionally, in 2010 the Everett Fire Department began electronic storage of code-compliance inspections in another unique database via software called OneStep marketed by One Step Information Systems, Parksville, British Columbia, Canada.

The department's existing site plans are stored on both paper and electronic media. The electronic site plans exist as artwork files (images) and are available as PDFs on the local hard drives of each MDC. The data points recommended for pre-incident planning in NFPA 1620 and currently collected by NEMESIS, NFIRS, CAD, OneStep, or proprietary site plans are listed in Appendix A. Appendix A also indicates whether each particular data point is accessible via MDC during responses. Assembling this information makes clear which NFPA 1620 data is already present in the EFD system and what data is needed but not currently being collected.

Of particular interest is NFPA 1620 8.1: *Special Hazards*. The department collects special hazard information from a wide range of sources and then stores it in a variety of locations. For example, the department may receive notice of a location with a patient suffering active tuberculosis and post a warning for such via information bulletin. Another example is a notification from the building department of “Do Not Enter” status, which might be caused by a variety of problems including structural integrity or legal dispute with the building owner. Members on alarms also collect special hazard information and pass it verbally to other crews but make no formal record of it, such as the known location of a hoarder home located during a medical incident. The lack of accessible special hazard information during emergency response places firefighter lives at greater danger.

What data is being collected by other city departments and neighboring jurisdictions that may be useful to responders during alarms? Other city departments are miles ahead of the fire department in the collection and display of data pertinent to their area of service. The Everett utilities department is the GIS coordinating department for the remainder of the city. GIS software is used by the utilities department to display data graphically, geo-located in its proper place in proper scale overlaid on map layers. Utilities have a wide range of data already on file in GIS format, hardware, and technical expertise which would be of great value to the fire department. (Linder, 2010) The scope of all GIS layers managed by the Utilities Department is listed in Appendix B.

The street department is currently using a handheld device called a Trimble Juno to geo-locate every street sign in the city, and they are noting its type, age, condition, and the direction it is facing. The device is a small GPS enabled handheld that will upload geo-coordinates as well

as pre-programmed items into the street department's database. Once entered, the street signs are displayed by GIS viewer in their location with their attributes. (Linder, 2010)

The two adjacent fire districts do not use GIS for response to alarms. Both Snohomish County Fire District 1, population 148,000, and the Marysville Fire District, population 60,000 use some GIS tools for planning purposes. Neither have any pre-incident planning layers available for the GIS viewer arriving with New World. Puget Sound Energy, the local natural gas utility, uses GIS software for mapping of their distribution lines in the City of Everett; an agreement to share that data would have to be struck.

What capability does GIS offer as a nexus for the various types of useful data, and what functions will GIS offer for use during emergency response? Price says GIS software will allow users to view institutional data that can be correlated to a specific location. (Price, 2010) GIS software may be terribly complex at its root level, but with the arrival of Arc/View GIS a GIS specialist is no longer required for most functions. (Bloom, 1998) The ability of GIS software to graphically display geo-located data makes it the obvious solution for quick and easy display of key NFPA 1620 information. It is particularly well suited to display special hazards, as they all have, by definition, a geographic location. GIS is the only plausible nexus for all the different data types collected by, or of interest to the Everett Fire Department. The imminent arrival of New World Systems software will provide the needed viewer for interpreting GIS data.

Linder explained the value of inserted hyperlinks within the GIS. Inserted hyperlinks allow information from other databases to open in new windows while the GIS map continues to run. Hyperlinks to images are also possible where up close imaging is needed of specific details, such as pipe valves or chemical storage facilities. Existing EFD site plans saved as PDF's or

architectural drawings submitted for plan review could also be inserted into a GIS as hyperlinks. (Linder, 2010)

What hardware changes are required to implement effective GIS? The minimum hardware requirements needed to run New World Systems software, including the GIS viewer are listed in Table 1. (Wollenweber, 2010) Existing MDCs are adequate for running New World software, with the notable exception of GPS enabled cellular broadband aircards. The cellular aircard is part of the county-wide agreement between New World and all participating jurisdictions and will be installed on all MDCs prior to the “go live” date of June 2011. There will be significant costs for the associated aircard data contracts with private cellular networks. The Everett Fire Department has already committed to the cost of this upgrade. (Gordon, 2010)

Table 1

MDC Hardware Requirements vs. Existing MDCs

New World Mobile Data Computer Requirements	EFD MDC Compliance
Intel Core 2 (Centrino) Processor	Yes
Windows Vista Business with XP Downgrade Option	Yes
2+ GB System Memory	Yes
80+ GB Hard Drive	Yes
13.3” LCD Display (Touch screen optional)	Yes
Backlit Keyboard	No
DVD-ROM	Yes
Integrated, GPS Enabled Cellular Modem/Aircard	No

What barriers stand against effective GIS utilization? A frank discussion with the Fire Marshal identified only a few barriers to using GIS to its full benefit. A GIS viewer is already

forthcoming with New World Systems, and the costs associated with hardware upgrades and software installations are already budgeted. The essential tools will all be in place. The costs of handheld GPS units, such as the Trimble Juno, present an obstacle with an approximate per unit price of \$500. Even though the cost of four units is barely a fraction of operating costs, with budgets being trimmed annually it is difficult to defend any new expenditures.

Another obstacle that will be encountered is employee resistance to new work and new technology. The fire service is not well known for embracing change and Everett is no exception. The final barrier identified by the Fire Marshal is potential political opposition. It is possible some in city government will oppose the collection of such sensitive private sector details or the easy availability of local emergency readiness information. (Robinson, 2010)

Discussion

Full adoption of NFPA 1620 is a worthy, but lofty goal for the Everett Fire Department. However, identifying key pre-incident planning information and displaying it via GIS is a very achievable ambition. Identifying key pre-incident planning information within the data already being collected by the Everett Fire Department and displaying it on several GIS map layers will allow responders to conduct better pre-arrival size-ups and improve the communication of strategy and tactics as units arrive at the scene. This is a mission-critical capability. (NFPA, 2010) (St. John, 2007) (Walker, 2009) The ability of GIS to change dynamically makes it a perfect tool for the fire service. The vast volume of information needed by fire officers for decision making is simply beyond their ability to remember, and should be supplemented with a database. (Bloom, 1998)

The availability of GIS base layers from the Utilities Department meets the minimum requirements of Price. (Price, 2009) The city has developed layers in such detail that many of

them will not be needed for emergency operations and should not be stored locally on MDCs. Some lesser details, like sewer mains or manhole covers, might be useful from time to time but should be set to default in the toggled off view. Essential layers should be defaulted on at startup and carefully evaluated for the scale at which details come into view. (Appendix C)

The fire service's long familiarity with and dependence on maps combined with the geographic nature of virtually all NFPA 1620 key pre-arrival information makes GIS the perfect tool for displaying this data in an at-a-glance format. The capabilities offered by GIS, including increasing and decreasing levels of detail with changes in map scale, as well as the ability to group like data into separate layers makes GIS the only solution for connecting all these different types of information. (Wollenweber, 2010)

NFPA 170, *Standard for Fire Safety Symbols*, Chapter 7, (NFPA, 2009) provides a comprehensive legend to be used by fire service professionals when creating pre-incident plans. There are many symbols available, not all of which are necessarily key pre-incident information. However, many of them are critical to fire officers and should be included in fire service GIS layers. NFPA does not determine which of the symbols contained in NFPA 170 are considered key symbols, (NFPA, 2010) so the Everett Fire Department will have to make its own determination about what information will be considered key.

This ARP identifies several life safety and basic suppression and detection features as key and divides them into logical layers. (Table 2) These details were chosen because water supply and suppression and detection systems are fundamental pre-arrival information. The presence of special hazards like flammable gasses or liquids is also essential pre-arrival information and is assigned a layer. The recommended items and layers can be expanded over

time, creating an incremental application of GIS technology as recommended. (Innes & Simpson, 1993)

The needed base layers for effective fire service GIS described by Price (Price, 2009) have been successfully created by other city departments: Transportation, cadastral, orthoimagery, administrative units, elevation and hydrography have already been created by the Utilities Department. The city has also purchased regularly updated pictometry database provided by Pictometry International, which allows any point on the GIS base maps owned by the city to be viewed at oblique angles from all four poles. The result is both high resolution satellite images and all four sides of every structure in the city, available at the click of a button for any city user.

Electronic hyperlinks can also be inserted into GIS layers. (Linder, 2010) Hyperlinks would open new windows on the MDC desktop and leave GIS running in the background. Hyperlinks to specific OneStep records would allow the user to first locate a specific structure within the map and then find the inserted hyperlink to open the inspection history for that facility. Existing site plans and stored architectural drawings can also be viewed via hyperlink. If full NFPA 1620 pre-incident plans are developed for high-risk occupancies they could be inserted into the GIS as hyperlinks as well.

Since it has never been recorded, it is impossible to determine how much special hazard information the department members have learned and forgotten over time. Special hazards may have been passed from one crew to the next and may be of significant life-safety value during future incidents but the entire department will not benefit without formally storing it and making it available during emergency response. GIS is the best tool for sharing special hazard information because it links the hazard to a location, and users will see the hazard notice as they

approach the location. Special hazard notices hung on the wall of a fire station are difficult to recall from the field.

It is true that employee resistance to change is an obstacle. (Robinson, 2010) However, the current workforce is increasingly computer savvy and has come to rely on the limited data already contained in the MDC. Once employees begin to utilize GIS data they will see its inherent benefits and begin to collect new data with more enthusiasm. Any political opposition encountered should be managed by showing the preventative value of pre-planning and the local, regional, and national emphasis on preventing loss before it occurs. The fire service is already at the heart of emergency preparedness planning and making better use of available data will only improve readiness at all levels. It would be a tenuous political position to be opposed to pre-incident planning.

Recommendations

The Everett Fire Department should expand the data it currently gathers. Appendix A clearly shows the department's collection of NFPA 1620 data is inadequate. Much of the 1620 information is being visualized by company officers during code compliance inspections, thus the department should work with the OneStep vendor to add some of those fields to OneStep software. Hoarding also presents a significant fire load problem for firefighters, who might change their tactics if approaching a known hoarder location. Hoarder homes are often identified on medical calls, thus the department should add a field to FDM to record hoarder home locations.

The Everett Fire Department should begin to develop fire service GIS layers for use with New World Systems GIS viewer to graphically display key and special hazard information to fire officers (Figures 2-6) while responding to alarms. The department should form an internal geo-

spatial team, which will serve a variety of GIS planning and implementation purposes. This team could represent the department during county-wide GIS planning meetings.

To that end, the department should lead an effort to create a county-wide fire service geospatial team so efforts are not duplicated and GIS symbology will flow seamlessly from one jurisdiction to another. This seamless flow of information will greatly enhance county-wide mutual aid performance. The county-wide geospatial team should determine which NFPA 1620 data is considered key for GIS layering and make that recommendation to the Snohomish County Fire Chiefs for countywide adoption.

The department should begin utilizing on-duty staff for collection of key information, and equip its fire inspectors with GPS enabled handhelds for instant marking of special hazards found during inspections. Company officers should utilize handheld GPS marking devices but if financial restraints do not allow this a paper collection system is also feasible. The geo-spatial team should serve as a funnel point for data submitted for placement on fire service GIS layers. The geospatial team would be responsible for proofing the quality of data submitted electronically and entering data provided by company officers on paper.

The department should change the default CAD map view planned for New World Systems. New World software should be preset to focus on the destination address, at a scale which will bring the fire service layers into view. (Figure 2, 3) Display of the response route is of little value for cities as small as Everett, where companies are very familiar with streets. Instead, fire officers would benefit from immediate submersion in key information and special hazards on file for the destination address.





The department should install the OneStep database in read-only format on all MDC's, allowing hyperlinks to be placed on a GIS layer which will recall site-specific inspection records.












The availability of OneStep records from the field will allow incident commanders to research recent inspection findings during alarms and to view up-to-date contact information.



The information considered key by the author for inclusion in fire service GIS layers and their corresponding symbology are listed in Table 2. These symbols should be contained in four layers: Control systems, water supply systems, building systems and special hazards. Due to the high contrasts found on base layer maps it is necessary for each symbol to also have high contrast. (see Figures 2, 3, 4) As a result of this, each class of item has been assigned separate but equally bright, high contrast identifying colors which are not described by NFPA. Text layers could also be created to provide supporting details for fire service features.

Table 2

Recommended Key Information, Mapping Symbology and Layer Placement

Item	Symbology	Layer
NFPA 170 6-2.1.2 Fire Department Key Box		White Outline Solid Red White Lettering
NFPA 170 6-2.1.3 Roof Access		White Outline Solid Red White Lettering
NFPA 170 6-2.2.1 Alarm Panel		White Outline Solid Red White Lettering
NFPA 170 6-2.4.1 Electric Shutoff		White Outline Solid Red White Lettering

NFPA 170 6-2.4.3.1.1 Liquefied Petroleum Gas Shutoff		White Outline Solid Red White Lettering	Control Systems
NFPA 170 6-2.4.3.1.2 Natural Gas Shutoff		White Outline Solid Red White Lettering	Control Systems
NFPA 170 6-4.2 Sprinkler Riser Valve		White Outline Solid Green White Lettering	Water Supply Systems
NFPA 170 6-4.3 Sprinkler Zone Valve		White Outline Solid Green White Lettering	Water Supply Systems
NFPA 170 6-4.4 Hose Connection		White Outline Solid Blue White Lettering	Water Supply Systems
NFPA 170 6-4.8 Fire Hydrant		White Outline Solid Blue White Lettering	Water Supply Systems
NFPA 170 6-4.9 Fire Department Connection		White Outline Solid Green White Lettering	Water Supply Systems
NFPA 170 6-5.4 Fire Pump Room		Black Outline Solid Yellow Black Lettering	Building Systems
NFPA 170 6-5.7 Electrical Transformer Room		Black Outline Solid Yellow Black Lettering	Building Systems
DOT Placard Flammable Gas Storage		White Outline Solid Red White Lettering	Special Hazards
DOT Placard Flammable Liquid Storage		White Outline Solid Red White Lettering	Special Hazards

NFPA 704 Hazardous Materials Storage		Black Outline Typical NFPA Blue/Red/Yellow	Special Hazards
Special/Unique Hazards Text to be determined by hazard		Black Outline Solid Orange Black Lettering	Special Hazards

There are a variety of other NFPA 170 symbols that could, and eventually should, be inserted into fire service GIS layers as key information. The timing of these additional symbols can be debated by the geospatial team with input from end users. Other possible symbols for consideration but not included in NFPA 170 are shown in Figure 1.

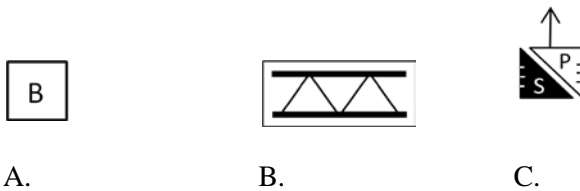


Figure 1. A: Basement below. B: Lightweight truss construction. C: Hyperlink to detailed site plans.

These symbols, when combined with GIS base layers allow the fire officer to begin his size-up while responding. The summary of key information and special hazards is demonstrated in figures 2-6.



Figure 2. Wide angle view of GIS base map showing a target building, exposures, and roadways. Fire service layers may be on, but viewing them requires zooming closer.

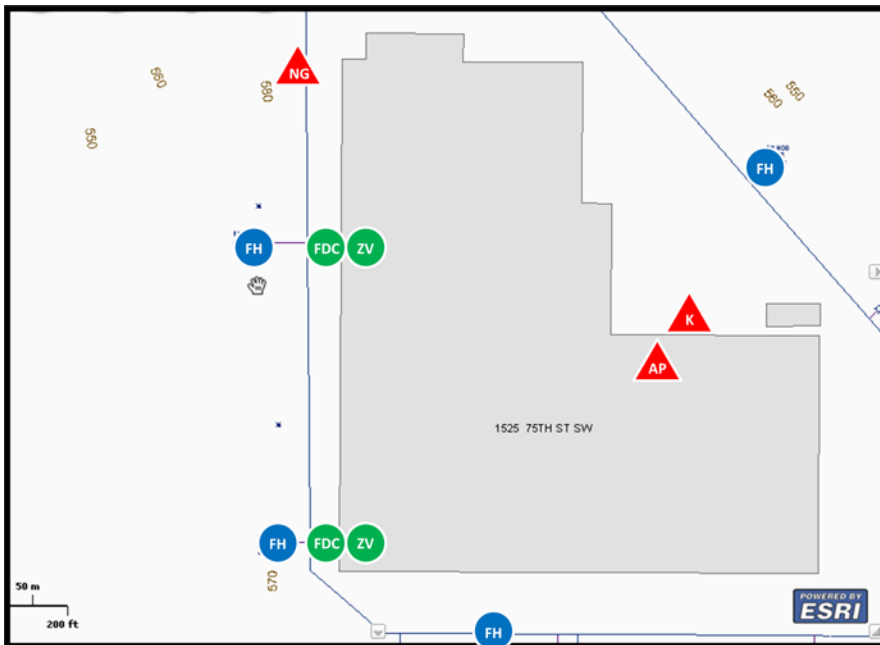


Figure 3. Close-up view of target building with control systems and water supply layers toggled on.

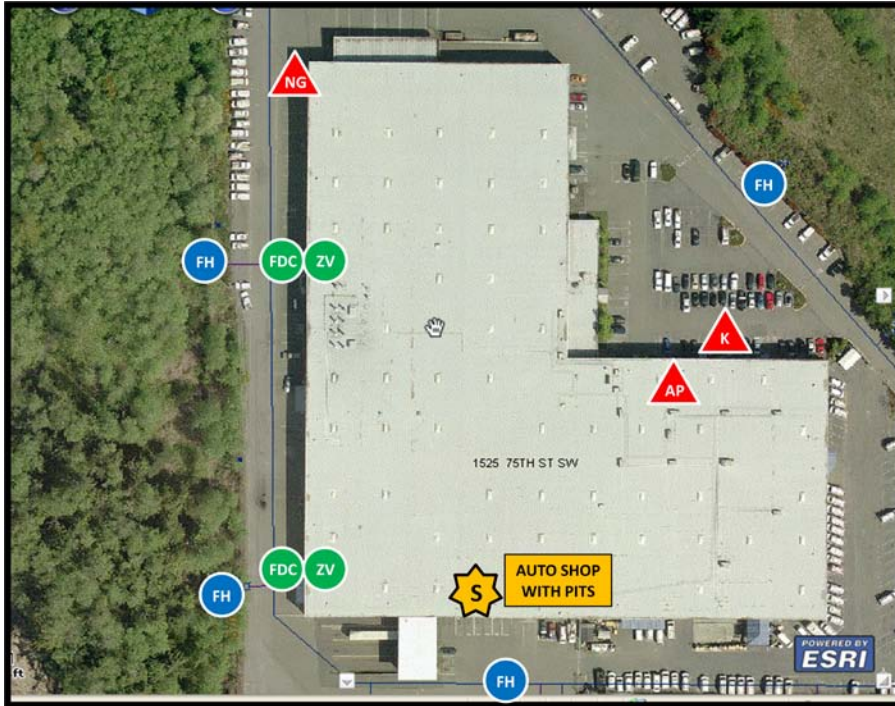


Figure 4. Target building with orthoimagery and special hazards layers added. The need for high contrast symbols is apparent.



Figure 5. GIS base map of residential neighborhood with special hazards and water supply layers.

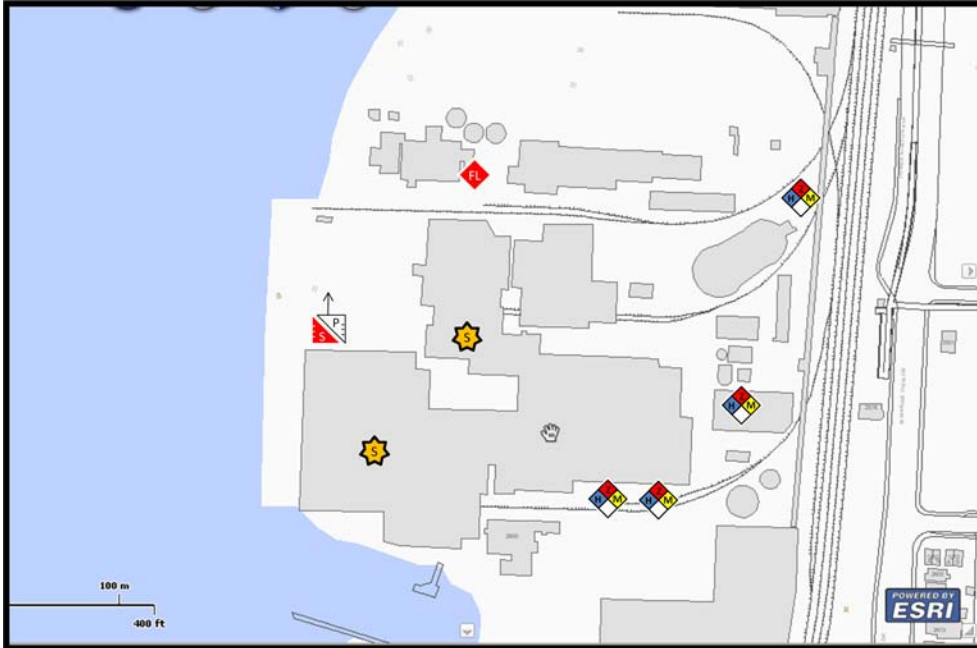


Figure 6. Overview of an Everett waterfront facility with special hazards layer and hyperlink to detailed site plans.

The fire service is currently collecting a wide range of data during its daily work activities. Unfortunately there is a disconnect between the collection and storage of that data and the ability to utilize it for improved performance in the field. GIS software is the nexus for all these pieces of information collected for different purposes by different members within an organization. GIS allows for effective use of key information by displaying it in a graphical format that is familiar to firefighters.

Full adoption of NFPA 1620 is a worthy goal for the Everett Fire Department, but would take years to accomplish. GIS allows an intermediate step, which would give company officers access to a summary of “key elements” (NFPA, 2010) while responding to alarms. This concept is recommended by the NFPA as an essential part of a pre-incident planning program, and will improve Everett’s firefighter safety and level of service to our community.

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Appendix A

NFPA 1620 Data, its EFD Collected Status, its Storage Location and Availability

Standard	Requirement	Collected	Location	Availability
5.2.1	Building Area	No		
5.2.1	Building Age	No		
5.2.1	Building Height	Partial	OneStep	In Station
5.2.2.1	Construction Type	Yes	OneStep	In Station
5.2.2.2	Wall construction and insulation details	No		
5.2.2.3	Roof construction details	Yes	OneStep	In Station
5.2.2.4	Floor construction details	No		
5.2.2.5	Other pertinent construction details	No		
5.2.2.6	Data regarding all structural access features	No		
5.2.2.7	Description of areas of potential fire spread	No		
5.2.2.8	Data regarding atriums	No		
5.2.2.9	Structural integrity of walls, roofs, and floors	No		
5.2.2.10	Site storage arrangements	No		
5.2.2.11	Fire command center location and fire rating of surrounding fire walls.	Partial	Site Plans	On Alarms
5.3.1	Emergency contact information	Yes	OneStep	In Station
5.3.2	Utility systems data	No		
5.3.2.1	Transformers with combustible liquids identified	No		
5.3.2.2	Electric utility rooms located	Yes	Site Plans	On Alarms
5.3.2.3	Emergency power capability recorded	No		
5.3.2.4	Manual activation method for emergency power described	No		
5.3.2.5	Domestic water shutoff identified	No		
5.3.2.6	Location of compressed and liquified gases	No		
5.3.2.7	Steam lines and boiler location and shutoff	No		
5.3.2.8.1	Systems with mutliple fuels supplies identified	No		
5.3.2.8.2	All gas shutoffs located	Partial	Site Plans	On Alarms
5.3.2.8.3	Location , size and shutoff for all LP tanks	Partial	Site Plans	On Alarms
5.3.2.8.4	Location of all fuel pumps, tanks, and shutoffs	No		
5.3.3.2	Note presence of fire/smoke resist elevator lobbies	No		
5.4.1	Access points for responding personnel	Partial	Site Plans	On Alarms
5.4.2.	Obstacles to access	Partial	Site Plans	On Alarms
5.5	Internal and external security features	No		
5.6	Fences and other barriers	Partial	Site Plans	On Alarms
5.7	Secutiry animals	No		
5.8.1	Security systems recorded	No		
5.8.2	Contact information for security system	No		
5.9.1	Exposures identified	No		
5.10.1	Site communications equipment identified	No		

Appendix A Cont'd

Standard	Requirement	Collected	Location	Availability
5.10.2	Fire communications equipment impacted	No		
6.2.1.1	Life-safety strategies for evacuation or defend in place identified	No		
6.2.1.2	Hours of operation	No		
6.2.1.2	Occupant Load	No		
6.2.1.2	Assistance for the disabled	No		
6.2.1.2	Strategies for protection of occupants other than evacuation	No		
6.2.2	All means of egress	Partial	Site Plan	On Alarms
6.3.1	Facility emergency action plan details	No		
6.3.2	Facility emergency response capability	No		
6.3.3	Special operations, processes, or hazards	No		
7.2	Firefighting water supply identified	Yes	Site Plan	On Alarms
7.2.1	Required fire flow predetermined	No		
7.2.2.1	Available water supply included	No		
7.2.2.2	Available water vs. fire flow required determined and addressed	No		
7.2.3	Public v. private water supplies identified	No		
7.2.4	Static water supplies identified	No		
7.2.5.1	Fixed tank systems identified and labeled	No		
7.3.1	Sprinkler systems locations, valves, areas served identified	Partial	Site Plan	On Alarms
7.3.2	Standpipe systems locations, valves, areas served identified	Partial	Site Plan	On Alarms
7.3.3	Fire pumps located and system identified	No		
7.3.4	FDC location and areas supplied identified	Partial	Site Plan	On Alarms
7.4	Non-water systems described and identified	Partial	Site Plan	On Alarms
7.5	Fire alarm systems, panels, annunciators described	Partial	Site Plan	On Alarms
7.6	Portable fire extinguishers located	No		
7.7.1	Smoke control systems identified	No		
7.7.2	Smoke and heat vents identified	No		
8.1	Any special hazards identified	Partial	Site Plan, NEMESIS, NFIRS	Partial
8.2	Transient conditions at discretion of AHJ	No		
8.3	Maximum inventory of hazmats included	No		
8.4.1	Large scale gatherings identified	No		
8.4.2.1	Use or storage of explosives identified	No		
8.4.2.1.1	Presense, volume, location and class of explosives identified	No		

Appendix A Cont'd

Standard	Requirement	Collected	Location	Availability
8.4.2.1.2	Other common materials that may explode identified	No		
8.4.2.1.3	Isolation and evacuation distances for explosives predetermined	No		
8.4.2.2	Features for storage and containment of flammable liquids identified	No		
8.4.2.3.1	Toxic or biologic agents located and identified	No		
8.4.2.3.2	Downrange effect of toxics or biologic agents predetermined	No		
8.4.2.4.1	Radioactive materials type and location	No		
8.4.2.4.2	Isolation and evacuation distances for radioactives predetermined	No		
8.4.3	Special hazardous atmospheres identified	No		

Appendix B

NFPA 1620: Pre-Incident Planning Recommended Practices vs.
Everett Fire Department Site-Plan Practices

Standard	Requirement	EFD Practice
4.1.5	NIMS Compliant IMS System in Use?	Yes
4.1.8	PIPs Begun during building design phase?	No
4.1.9	PIPs Evaluate Life Safety Hazard	No
4.1.9	PIPs Evaluate Structure Size	Partial
4.1.9	PIPs Evaluate Operations Complexity	No
4.1.9	PIPs Evaluate Economic Impact	No
4.1.9	PIPs Evaluate Location and Seasonal Change	No
4.1.9	PIPs Evaluate Presence of Hazardous Materials	No
4.1.9	PIPs Evaluate Susceptibility to natural disaster	No
4.3.1.3	PIPs Data evaluated for criticality	No
4.5	Standardized PIP Document?	Yes
4.6	NFPA 170 Symbols in use?	Partial
4.7	PIPs Distributed to essential users?	Yes
4.8	PIPs used for training in unique circumstances?	No
4.9	PIPs available to IC during incidents?	Yes
4.10.1	PIPs evaluated for accuracy post-incident?	No
4.10.2	PIPs revised as needed?	No
9.1	Summary of key PIP information available while responding	Partial
9.2	Critical PIP information available at time of dispatch	Partial
9.3.1	Initial response units described	No
9.3.3	Summary of initial actions based on life safety, scene stabilization and incident mitigation	No
9.3.4	IMS plan in place	Yes
10.1.1	Periodic testing of PIP and review of accuracy	No
10.2.1	Updates to PIP periodically	No

Appendix C

GIS Layers Owned by the City of Everett and their Usefulness during Emergency Response

Existing GIS Layer	Useful During Responses
Water Meters	Yes
Water Services	Yes
Water Hydrants	Yes
Water System Valves	Yes
Water Control Valves	Yes
Water Manholes	Yes
Water Network Structures	Yes
Water Fittings	
Water Cathodic Protection	
Water Mains	Yes
Water Casing	
Water Structures	Yes
Water Easements	
Sewer Service	Yes
Sewer System Valves	Yes
Sewer Manholes	Yes
Sewer Fittings	
Sewer network Structures	Yes
Sewer Mains	Yes
Sewer Casing	
Sewer Cathodic Protection	
Sewer Easement	
Storm Drainage Service	Yes
Storm Drainage Fittings	
Storm Drainage Manholes	Yes
Storm Drainage Catch Basins	Yes
Storm Drainage Equipment	Yes
Storm Drainage Mains	Yes
Natural Drainage	Yes
Drainage Casings	
Detention Facilities	Yes
Drainage Easements	
Street Signs	
Residential Parking Zones	
Preliminary Buildings	

Appendix C Cont'd

Existing GIS Layer	Useful During Responses
Preliminary Developments	
Buildings	Yes
Building Details Text	Yes
Quarter Sections	
Trees	
Landscaping	
Trails	Yes
Poles	
Contour	Yes
Street Centerline	Yes
Bridges	Yes
Streets and Paved Alleys	Yes
Dikes	Yes
City Property	
City Limits	Yes
Hydrography	Yes
Parcels	
Lots	Yes
Row	
Utility Easements	
Cadastral Easement	
Short Plat	
Subdivisions	
Urban Growth Area	
Central Business District	
Neighborhood Boundaries	
Annexations	
Zoning	
Landuse	
Zipcodes	
Index	
Pictometry Imagery	Yes
2009 Aerial Imagery	Yes
2007 Aerial Imagery	
2003 Aerial Imagery	