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Local Fire Department Emergency Management Planning Solutions

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A Major Individual Project submitted in partial satisfaction of the requirements
for the degree of Master of Science in Geographic Information Systems

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The report of Christopher Brown is approved.

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I would also like to thank the mysterious creator of the quote page. If it weren't for that document I may have lost it in the second term. I would like to formally invite anyone in Lewis Hall to check the S: drive and write down anything you hear around you, however, per the rules of the page, without quoting yourself!

Good luck to all future students and cohorts. I hope you all get as lucky as I did with your group.

ABSTRACT

Local Fire Department Emergency Management Planning Solutions

by
Christopher T. Brown

Geographic information systems (GIS) technology is a valuable tool when it comes to asset and emergency management response planning. This paper outlines the procedures involved in using GIS to effectively support the City of Montclair, California's incident response procedures by organizing their map resources into formats that are easy to use and easily accessible. GIS tools were be used to create a map book as well as a custom search tool that are user friendly, readily updated, more data rich, and more accurate than the City's existing system. This tool gives emergency managers a greater understanding of their surroundings and infrastructure with which to plan their responses.

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List of Acronyms

ESRI – Environmental Systems Research Institute
FEMA – Federal Emergency Management Agency
GIS – Geographic Information Systems
MBDS – Map Book Developer’s Sample
MFD – Montclair Fire Department

1. Introduction

Local fire departments in the United States rely on plans and managers to lay out a tactical response to an incident in their jurisdiction. An incident can occur quickly making easily accessible data critical to the response effort. Due to an ever-evolving urban environment, this data constantly needs to be updated to reflect current and ongoing changes. The efficient and effective response of local fire departments not only saves lives and protects property, but it affects the mental, physical, and economical status of a society in general.

Services offered by local fire departments vary from place to place, based on community needs, department funding sources, population, and existing resources. For example, a densely populated, industrialized city in southern California may have more need for special hazardous material clean up than a county in Maine that may have special weather monitoring concerns based on winter snows.

To meet the need for access to spatial information during an incident response, departments have implemented different techniques to get information to emergency managers. Typically, map sheets are developed that detail each part of a department's response area. The amount of detailed information needed by an emergency manager showing critical infrastructure and area information, is too great to be shown effectively on a small map because of clutter and subsequent confusion with map symbols (Monmonier, 1996). Maps created to aid in emergency response need to be viewed inside departmental fire trucks en route to an incident and therefore need to be small enough yet still detailed enough to be of benefit.

Each aspect of local infrastructure can potentially affect a fire department's response to an incident. Buildings and parking lots have many entrances and exits, intersections can force drivers of emergency vehicles to deal with heavy traffic congestion, street networks can be complicated, and addresses can be counter-intuitive.

Fire department response planners also need to consider industrial, commercial, and residential areas, which all have different characteristics. To deal with these considerations pre-planned site maps, referred to as pre-plans, are used to show very detailed site information. For instance, information such as fire alarm shut offs, hazardous materials, unit numbers, and detailed building layouts for apartment complexes, commercial buildings, industrial plants, and other areas, are common on typical pre-plans. The pre-plans are stored in binders with separate plans, on multiple sheets of paper, that need to be updated. These pre-plans need to be organized in an intuitive and efficient manner in order to be easily accessible should the need arise.

1.1. Statement of Problem

Fire departments need to plan for their response to incidents within their response area. In modern times, hazardous materials, complex fire-fighting utility networks, multi-story buildings, commercial complexes, and other factors have made detailed on-site information necessary to give decision makers the ability to respond effectively. The information also needs to be disseminated efficiently to give managers engaged in deploying rapid response personnel and equipment the details of an area in as little time as possible.

Responders need:

- Accurate and precise data
- Maps that are up-to-date
- Spatial data specifically created for the fire department
- Access to city GIS resources

This information is needed to help citizens who depend on the efficient, timely, and informed response of any local fire department.

1.2. Client

The client for this project was the Montclair Fire Department (MFD), which provides fire protection services for the city of Montclair, California. Mr. Steven Dague, the city's GIS Specialist, served as the point of contact and facilitated further contact with officials at the MFD. Mr. Robert Crouch, a cartographer for the Fire Department, was the main contact in the MFD. Mr. Crouch assisted in tailoring the project to the needs of the Fire Department.

Montclair is in southern California, in the southwest corner of San Bernardino County. To the west it borders Los Angeles County (Figure 1.1 - Location of Montclair, CA).

Figure 1.1 - Location of Montclair, CA

1.3. Project Scope

The primary goal of this project was to organize the planning resources used by the MFD in such a way that the emergency management system could deal with the issues discussed in the project problem statement. As a result the project only included considerations for data within the jurisdiction of the MFD. In addition, the application will only be deployed on MFD response vehicles.

This project was also developed as a prototype system and it is expected that future revisions and updates will be continuously implemented by the GIS staff of Montclair to keep the system up to date. These updates will include ongoing data collection, data creation, application improvements, and current cartographic representations of the data.

1.4. Overview of the Project Solution

Many data layers were created for incorporation into the final emergency response data dissemination system. All of the information that was depicted on the original MFD original map book pages was represented with other city and county data specified in the requirements. The fire hydrants data layer was created by digitizing data from digital scans of the map book pages, in combination with surveyed data using GPS equipment. Street name annotation was created to match the existing map book, and to make sure that each street was accurately named on each page. The pre-plans were scanned and hyper-linked to the parcels with which they are associated. Helicopter landing zones and points of interest were created as data layers and identified with annotation. All of this generated data was then imported into a personal geodatabase. Static maps were generated from the project data using the Map Book Developer Sample from ESRI's ArcScripts website (http://arcscripts.esri.com). 28 map pages in Portable Document Format (PDF) format were created with the same organization as the existing map book. The map book sample required that a grid layer be create to be used as was the reference grid.

The second part of the solution for this project was the development of an application to facilitate the digital display of map pages and pre-plans. Although many options were considered for this stage of the project, two factors were instrumental the decision making process: connection speeds, and the monitors used for data display. Due to slow connection speeds within the city limits, a web-based application incorporating Google Earth or Microsoft Virtual Earth was eliminated as an option The requirement that the application had to run on small, slow, touch-screen operated computers in the responding vehicles also aided in finalizing the development of the application so that it could be as efficient as possible given these limitations. The final design incorporated the generation of a digital map grid composed of 28 sections covering the entire study area, where each section was hyper-linked to the detailed static maps pertaining to that section.

1.5. System Diagram

The technical system diagram is shown in Figure 1.2, and shows the general flow of data used for the project from hardcopy format to the touch-screen computer viewing environment. The general system diagram is shown in Figure 1.3, and shows the components that make up the final emergency response data retrieval application.

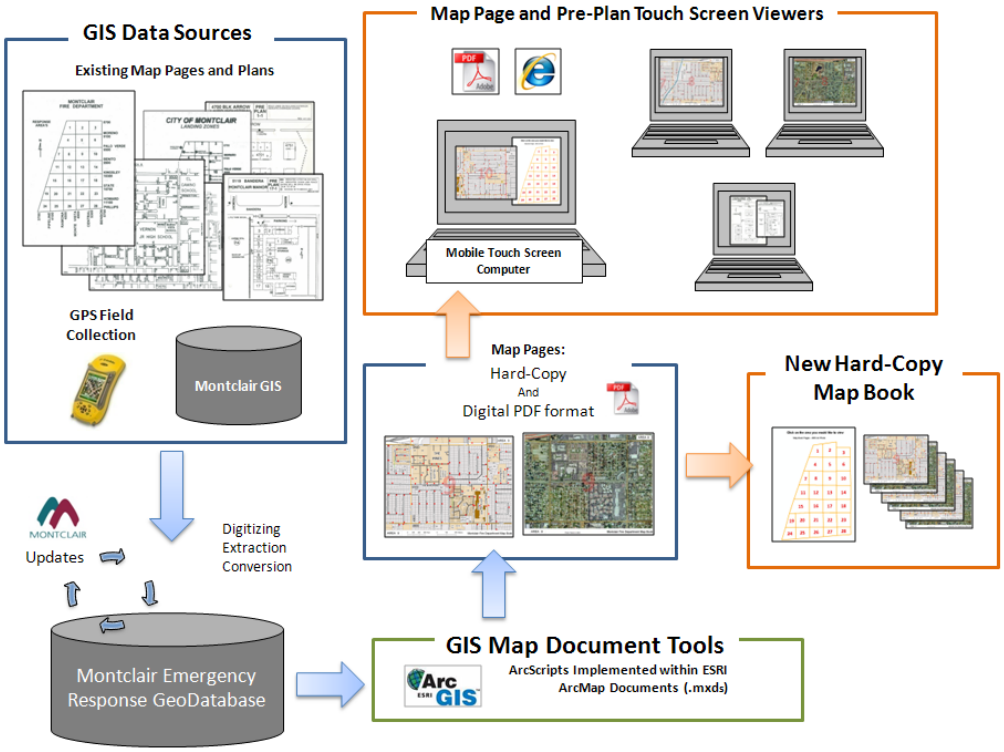


Figure 1.2 - Technical System Diagram

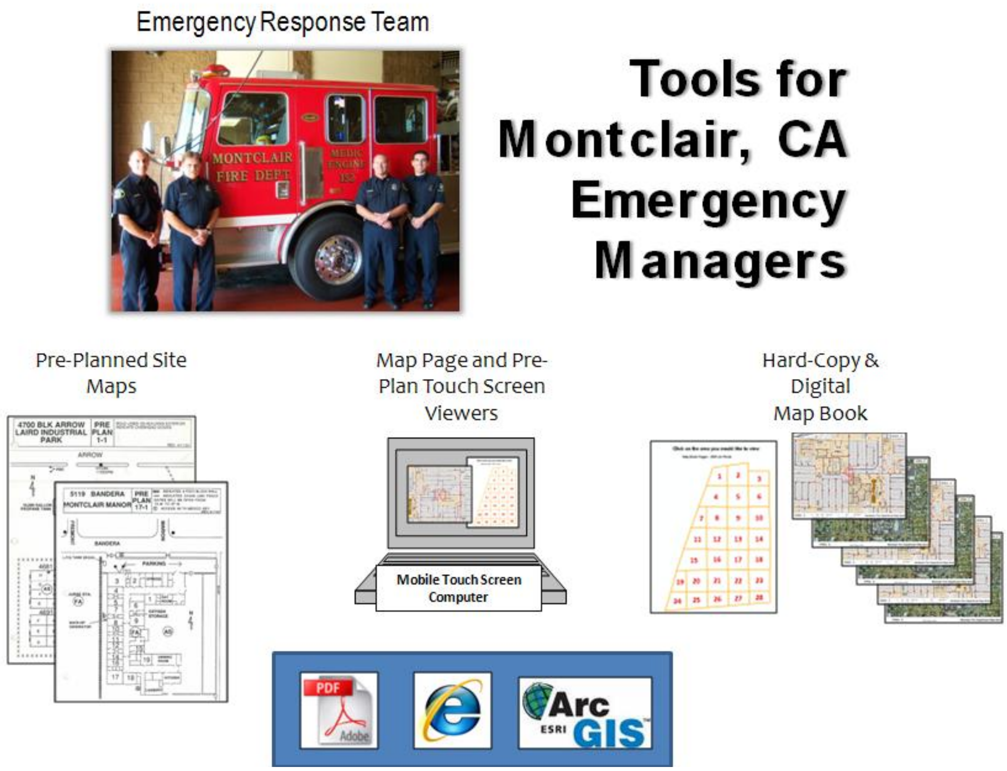


Figure 1.3 - General System Diagram

1.6. Audience

This project outline has been written for GIS professionals intending to implement emergency management solutions in local government. Further insight into the deployment of a low cost alternative solution will be interesting to people or organizations working with limited financial resources. The outline of this project may also be useful as an informative resource for GIS professionals looking to implement strategies similar to those employed for this project. Fire department personnel that are directly involved in the creation, management, or use of geographic information in Montclair will also find the information presented useful.

1.7. Paper Outline

This paper is organized into six chapters. Chapter Two outlines the existing system in Montclair, while Chapter Three discusses the background of the project by looking at a literature review and relevant case studies. Chapter Four introduces the project's requirements, design, and a proposed solution incorporating these requirements. Chapter Five discusses the project's database design considerations. Chapter Six describes the steps taken to complete the project with a discussion of mistakes made, lessons learned, and suggestions for improvements to the project. Chapter Seven outlines general conclusions and suggestions for future work.

2. Project Background

Every day around the world citizens face dangerous situations that can pose risks to their safety. Government agencies are tasked with mitigating or responding to such emergency situations. These public safety organizations are funded by tax dollars and are in place to help keep the public safe.

One aspect that differentiates one organization from another is the area of coverage. Federal agencies like the Federal Emergency Management Agency (FEMA) are in place to respond to major events around the country, whereas local government agencies focus on local areas. Intermediate agencies such as county and state fire departments also exist to oversee responses within their respective jurisdictions.

2.1. Literature Review

2.1.1. Emergency Management

Emergency management has been studied in depth in the context of large-scale disaster response and planning. The literature pertaining to this aspect of emergency response routinely mentions Hurricane Katrina, the attacks on the World Trade Center in 2001, and other large disasters. According to the National Research Council's report *Successful Response Starts With a Map,* "Disasters [like these] suddenly result in extensive negative economic and social consequences for the populaces they affect, typically including physical injury, loss of life, property damage, physical and emotional hardship, destruction on physical infrastructure, and failure of administrative and operational systems. All disasters threaten the general welfare of some populace; thus, government intervention is warranted to minimize the negative consequences of disaster, and, ultimately, to restore order" (NRC, 2007).

In disasters, emergency managers have many responsibilities. To enable them to make the best possible decisions, the first thing they need to know is where the disaster has occurred, where the disaster victims are located geographically, where any hazards that might impede response progress are located, and where the available local resources situated. Many studies have been done on the "golden hour", or the optimum time within which the response to a disaster should occur in order to minimize damage to property and danger to the public. To respond quickly and effectively, the information a manager needs can be summarized on a map, or a series of maps (NRC, 2007).

Maps are a key element to any emergency management effort. Data standards, data sharing, and data dissemination methods are common themes in past research (NRC, 2007; Greene, 2002). Data standards need to be in place in order for many datasets to be easily combined after a disaster that covers many jurisdictions. It is necessary for agreements to be in place that facilitate the free flow of information between different agencies with business privacy and security issues taken into consideration (NRC, 2007; Greene, 2002; Kataoka, 2007). Past research has effectively argued that spatial data is paramount for effective emergency response in the wake of a disaster. The emergency response cycle shown in Figure 2.1 depicts the stages in the emergency management cycle. Preparedness before the disaster, response after the disaster, and finally, recovery and mitigation are all necessary stages within the cycle. The main focus for this project was the preparedness stage of the cycle, and the decision-making process during this stage. The preparedness phase typically includes identifying data requirements, developing data sets, and sharing data across agencies. Locating asset and risk infrastructure and developing applications for the use of the data are also considerations defined in this phase (NRC, 2007).

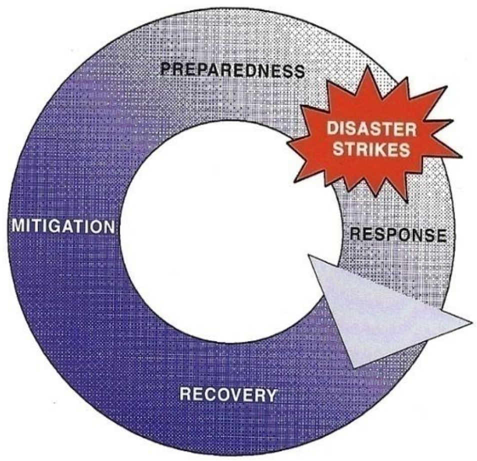


Figure 2.1 Emergency Response Cycle (NRC, 2007)

The local government emergency response solution outlined in this paper is similar in some ways to work that has been previously done in this field, but also contains distinct differences. Figure 2.2 illustrates the relationship on an administrative scale between the large organizations discussed in the emergency management literature and local governments, showing how different agencies all the way up to the President's office get involved with disaster relief.

Local government response, shown in the red "local first responders" area of Figure 2.2, takes place at a smaller map scale, within a smaller time frame, and usually includes a smaller number of affected people. These factors that are typical of local disaster response create different needs that must be addressed when developing solutions for a local government client as opposed to a state or county client.

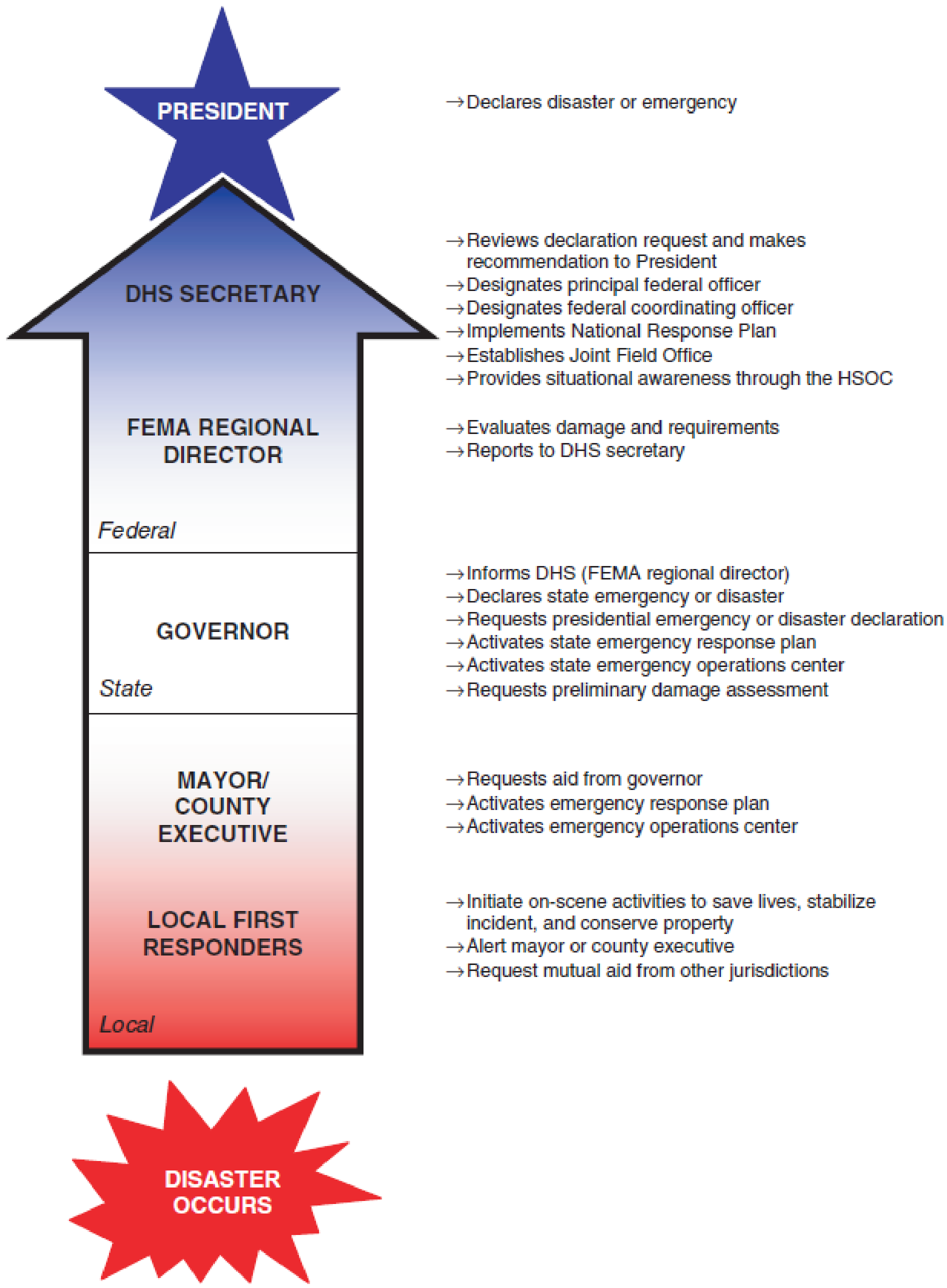


Figure 2.2 - Emergency Response Hierarchy (NRC, 2007)

Fire departments have limited budgets. Often the "boots and suits" approach is taken in a fire department's funding decisions. This approach usually sees fire departments around the country using funding to buy more hardware to do their job, rather than focusing the funding on data sharing, collection, and standards initiatives. In this situation, a fire department's mapping needs can be overlooked (Creating a Safer Nation, 2006).

Local government emergency response utilizes planning tools where a certain level of information is provided for every location within an agency's response zone. This means that all maps or applications created for use within the emergency management framework need to be simple and easy to use, quickly getting the information into the hands of people who need it. In addition, in local government, "tax-reduction initiatives, burgeoning needs for new kinds of local government services, and demands that whatever is being done be done better and faster" (Amdahl, 2001), are things that effect the budget allocated to a fire department. These factors lead to other considerations for any emergency response tools developed at a local small scale as opposed to a larger state or national scale.

2.2. GIS in Local Government Emergency Management

Firefighters have to quickly conceive and implement plans and strategies to put out fires and minimize the damage that they can inflict. "Finding out where the fire is and getting there has never been easy, and quick response times have always been critical to success." (Amdahl, 2001) The increased pressure to respond quickly and efficiently, coupled with ever-evolving urban infrastructure and the continued increase in population sizes makes it easy to see how emergency response has become increasingly difficult to implement. The underlying causes of fires are also changing as more hazardous materials are manufactured and transported resulting in the need for a wider variety of fire-fighting strategies. This creates a clear need for detailed maps and site plans with which to respond (Amdahl, 2001).

The system in place today for firefighters to plan a response is a simple one. As a fire-truck driver navigates traffic and approaches the incident, a second firefighter in the truck consults large binders full of information in hard copy form to plan the incident response (Amdahl, 2001). These binders contain maps of the town at a large scale showing relevant points of interest such as fire hydrants, schools, hazardous material information, and pre-fire surveys (Amdahl, 2001).

As communities grow, fire hazard data must be maintained to provide emergency managers the information needed to make decisions and consider factors as they currently are, not as they were in the past (Greene, 2002). This creates a need for fast, comprehensive update techniques. Finally, an emergency response manager in local government needs details about a responding area that include water sources, fire hydrants, schools, pre-plans, and, depending on the region, other spatial data (Amdahl, 2001).

Pre-plans are needed in areas with detailed infrastructure information that might be useful to fire response teams. In commercial complexes, industrial areas, and multi-family complexes, more detail is needed because there are many assets within a small area. A map with many elements in a small area can be misleading if the elements are not shown on a large scale map (Monmonier, 1996). This creates the need for effective symbolization of different infrastructure components for site specific maps that fire departments use in order to make the maps readable and easy to understand.. Typical symbols on such maps include sprinkler systems, multiple floors of a building, electrical boxes, and hazardous materials.

Fire departments are also using GIS techniques to make a case for the increased need of a larger budget to develop and implement the tools needed to respond effectively to any incident. Lower response times and lower costs, resulting from the effective compilation of more relevant spatial information within a GIS present "vivid, compelling, and persuasive" arguments to town organizations that control the budget (Greene, 2002). Fire departments are also using GIS to lower insurance costs by showing that critical response infrastructure is within the insurance company's "safe" distance to areas, like high rise buildings, that have special response considerations (Greene, 2002).

The solution used by many fire departments to visualize and disseminate spatial information is the generation and maintenance of a map book. This is usually created by tessellating a fire department's service area into grid rectangles. These grid squares can fit detailed information onto the common 8.5x11 inch or 11.5x17 inch paper sizes. These standard paper sizes are useful because a fireman needs to flip through map book pages in tight quarters. The grid also makes it possible to give each map a grid number, making it easier to reference different parts of the city to each grid. Common systems include numeric progressive numbering or a combination of letters and numbers e.g., 1A or A1. With this grid system in place, each address in the city can be indexed as being on a certain grid number. Emergency responders can therefore use an incident address to quickly find the relevant map page and, subsequently, all the relevant area information.

There have been many projects implemented in the pursuit of useful geographical tools for response organizations, most notably Missouri City, TX, Glendale, CA, Gallatin County, MO, and the East Bay Municipal Utility District serving the San Francisco Bay area. A wealth of information was presented by these organizations and their consultants at the annual ESRI User Conferences from 1997 to 2005. A number of authors (Somarriba 1997; Tepera 1999; Hochstein 2000; Oevermann 2004; Skahill 2004; Bowman 2005) highlight the challenges and best practices for effective geographic tool creation. For example:

- Towns should be divided into areas of equal or specified unequal areas based on either uniform scale or administrative boundaries.
- A reference index based on spatial divisions should be created.
- Map books should be created, and they should be mobile, with a maximum page size of 11"x17" for use in a responding vehicle.

The examination of all of this relevant emergency response literature contributed to the final solution developed as part of this project in order to take advantage of the suggested and researched best practices.

2.3. Cartography and GIS

There has been a great deal of research in cartography on the subject of feature label placement. The purpose of labels on a map is to convey the names of features to a reader of that map. The goal is to make it as clear as possible which feature each label is referring to (Imhof, 1975). Traditional mapping deals with the arrangement of hand drawn text labels on a map. In GIS a computer must use algorithms to place labels, give different labels different weights to determine overlaps, and apply many universal traits to the text placed (Christensen, 1995; Imhof, 1975). Traits include all font modifications available on a computer.

Considerations for cartographic representations through a GIS range widely from issues of scale to issues of projections and coordinate systems. Careful planning and execution of mapping projects must take place to make sure the representations on a map are accurate and represent true conditions on the ground (Monmonier, 1996).

2.4. Study Area

Montclair, California is home to about 60,000 people and covers an area of about 5 square miles. The city is also densely populated with almost 7300 people per square mile, and is steadily growing with the addition of at least 5000 new residents between 2000 and 2007 as shown in Figure 2.3.

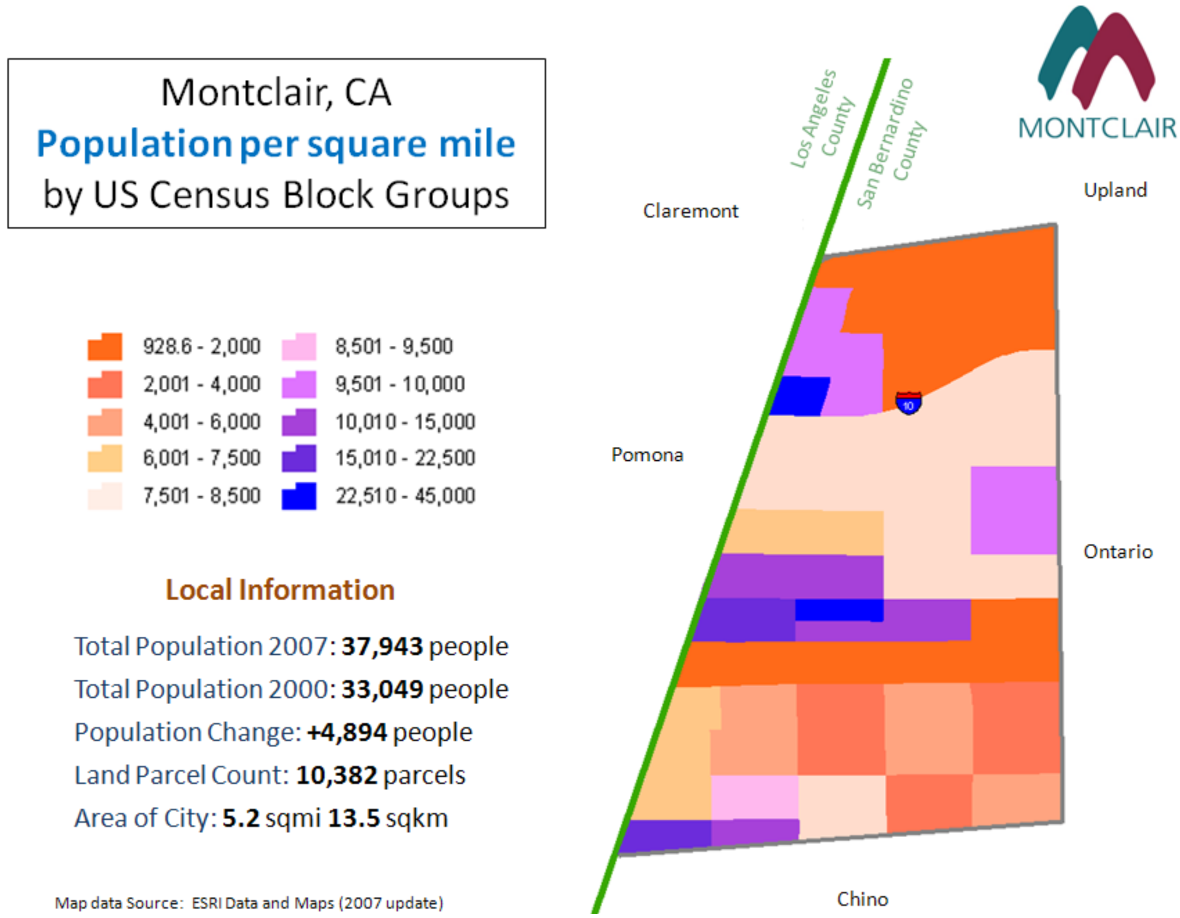


Figure 2.3 - Montclair Population Statistics Map

Montclair is almost completely urbanized, with many commercial complexes, industrial plants, and multi-family housing units. Through interviews with MFD personnel and research into the department's history, many types of incidents were identified that the local fire department typically responds to. Figure 2.4 shows a graph obtained from the fire department depicting calls for service in 2007. The figure shows that 4% of calls were for fire response, 1% for hazardous conditions, and 68% were for emergency medical services (EMS) or rescues. Other calls were extraneous and did not require intensive fire department resources, and therefore are not discussed in this report.

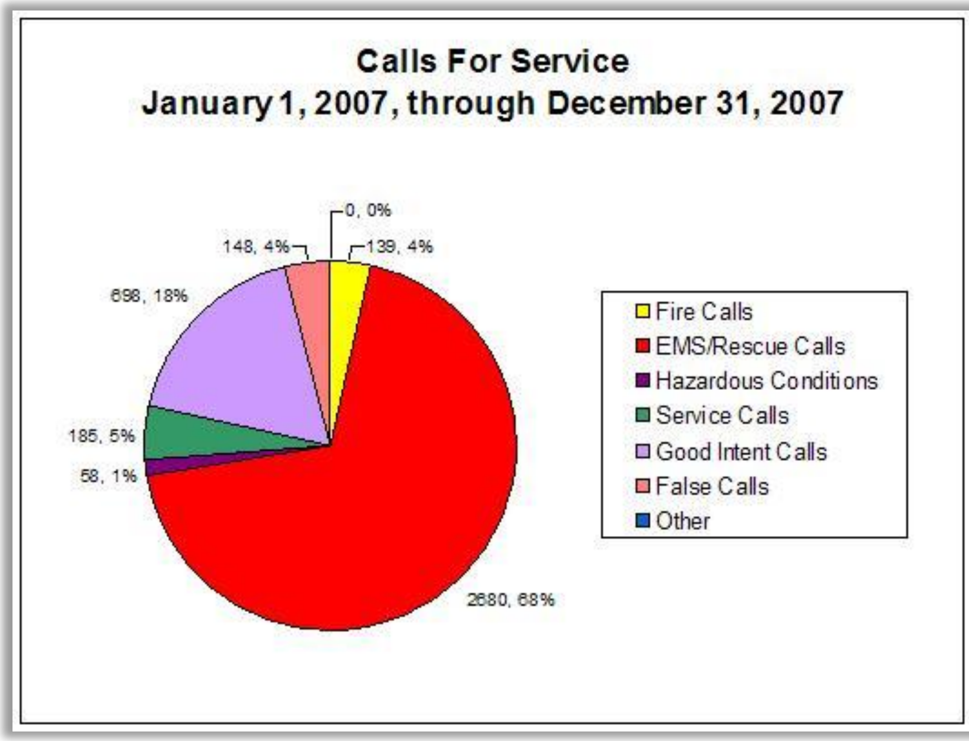


Figure 2.4 - MFD Call Statistics (Montclair, 2008)

A working knowledge of the local area is critical to incident response. In the 1960's, the system in place for fire department response in Montclair was as follows:

"When an alarm was received, the man on duty would write the address on a blackboard and sound the recall siren. He would then respond by himself in the 1948 Ford high-pressure unit. The call-men would respond to the station, read the address on the blackboard, and respond with the 1943 pumper." (Montclair, 2008)

There was no information on exactly how the responders found the incident site and planned a response. There was also no indication whether there was a need for maps. No maps may have been needed in the past when cities were smaller and less complex (Amdahl, 2006). Alternatively, firemen, especially in small communities, may have found geospatial information to be superfluous because of vast personal knowledge of the area (NRC, 2007). In 2004, the MFD had mobile data computers installed in the responding vehicles (Montclair, 2008). Emergency management and local government issues, including the need for quick area analysis in the response to an incident, cartographic considerations for labels on map, and Montclair's expanding population and infrastructure base, are important considerations when developing applications to assist fire departments in incident response.

3. Existing System Analysis

First and foremost, the new system created for this project had to function at least as well as the existing system. All of the same information needed to be displayed on the new maps while each layer in the existing map book needed to be re-created in a digital format. Annotation, point, line, and polygon layers needed to be created, updated, or modified to meet the specific needs of the Montclair Fire Department (MFD). In order to maintain all relevant data on the existing map books, the generated digital layers were stored in a geodatabase. To better understand the existing system, and subsequently the requirements for the new system, a detailed analysis of the MFD system was conducted.

3.1. Existing System Description

In a response situation, an emergency manager uses maps to locate an incident and gain a better understanding of surrounding infrastructure and points of interest. In the current incident response system, a manager views the relevant map pages in the map book while a colleague drives to an incident in the response vehicle. This creates a need for a compact, easy to use resource to access and read map sheets. These maps could be in hard copy books similar to the current system, or, as the MFD prefers, they could be displayed on the mobile data computer (MDC) in the vehicles.

Montclair uses a map book, street index, large wall map, and pre-plans to retrieve relevant information on areas within the city. Captain Robert Crouch manages the maps that were created in 1970, as well as the fire department personnel responsible for revisions to the maps. These revisions are made by hand, and a record of each revision is typically noted on the corner of the map (Figure 3.1). Updates are done by different people at different times, making consistency and completeness difficult to maintain.

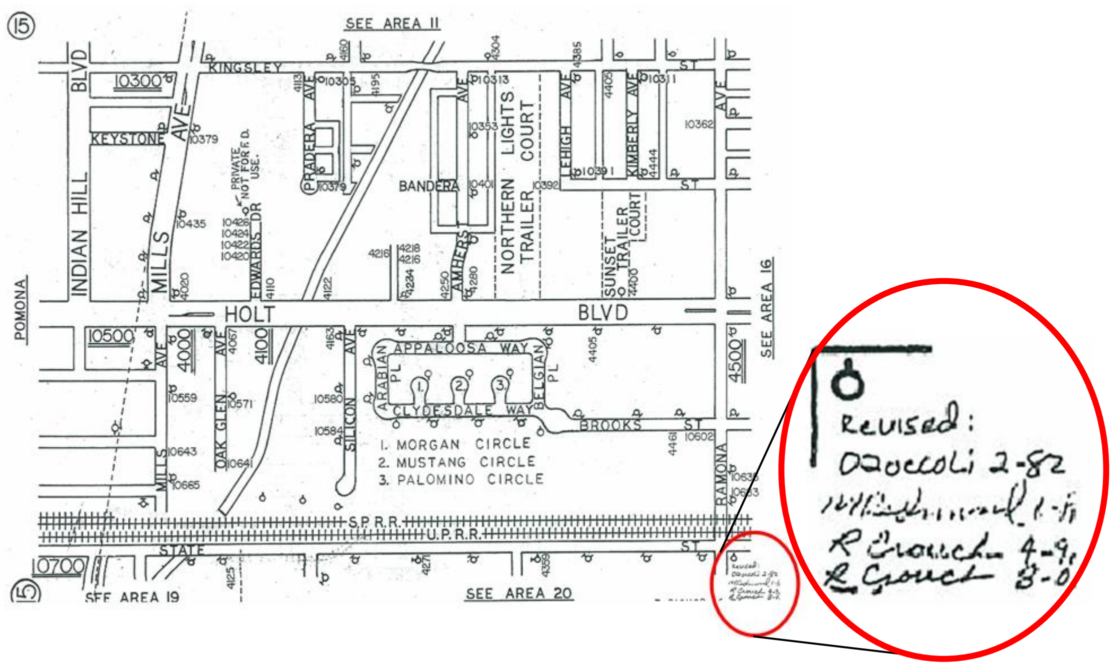


Figure 3.1 - Existing Update Scheme

In each station there is a large wall map of the entire city at a small scale of about 1:45000. A small section is reproduced in Figure 3.2.

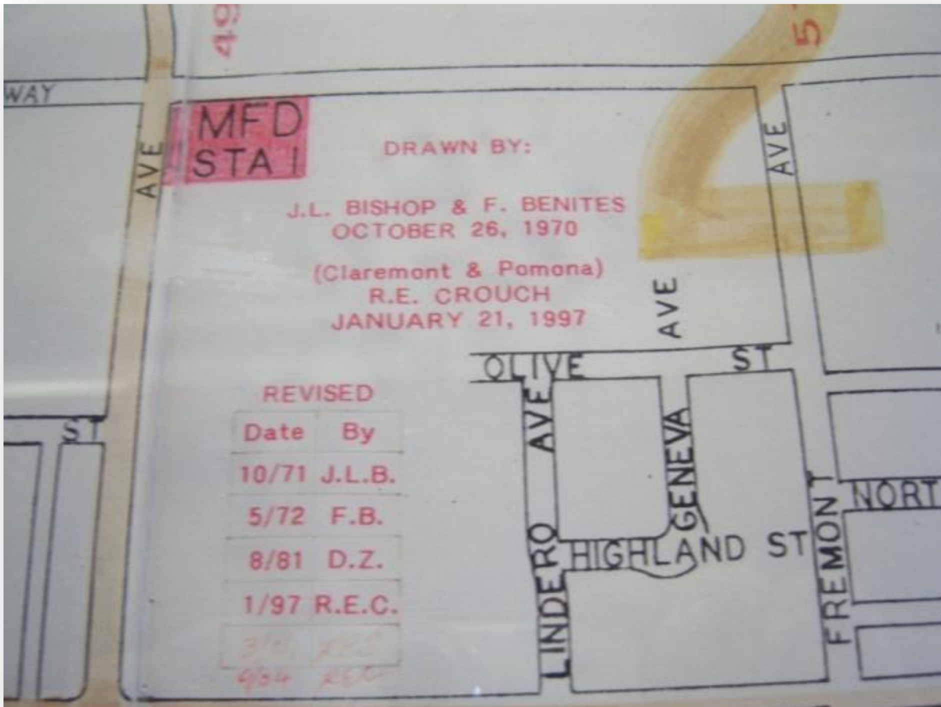


Figure 3.2 - Section of large wall map currently used by Fire Department

The text on the map in the figure again shows the manual update method used by the fire department. The revision dates also show that Montclair has been steadily growing and changing, making timely and consistent map updates necessary.

3.1.1. Pre-plan Description

Certain properties in the MFDs response area have detailed response plans and maps to use in a response (Figure 3.3). These maps are referred to as pre-plans and contain local maps and other information useful to a response effort. They are coded by the grid number they are found on for easy reference, and ordered based on date of creation. These identifiers can be used to look up a pre-plan in a binder that contains the plans in numerical order and based on the date of creation. This is discussed in further detail in section 6.1.6.

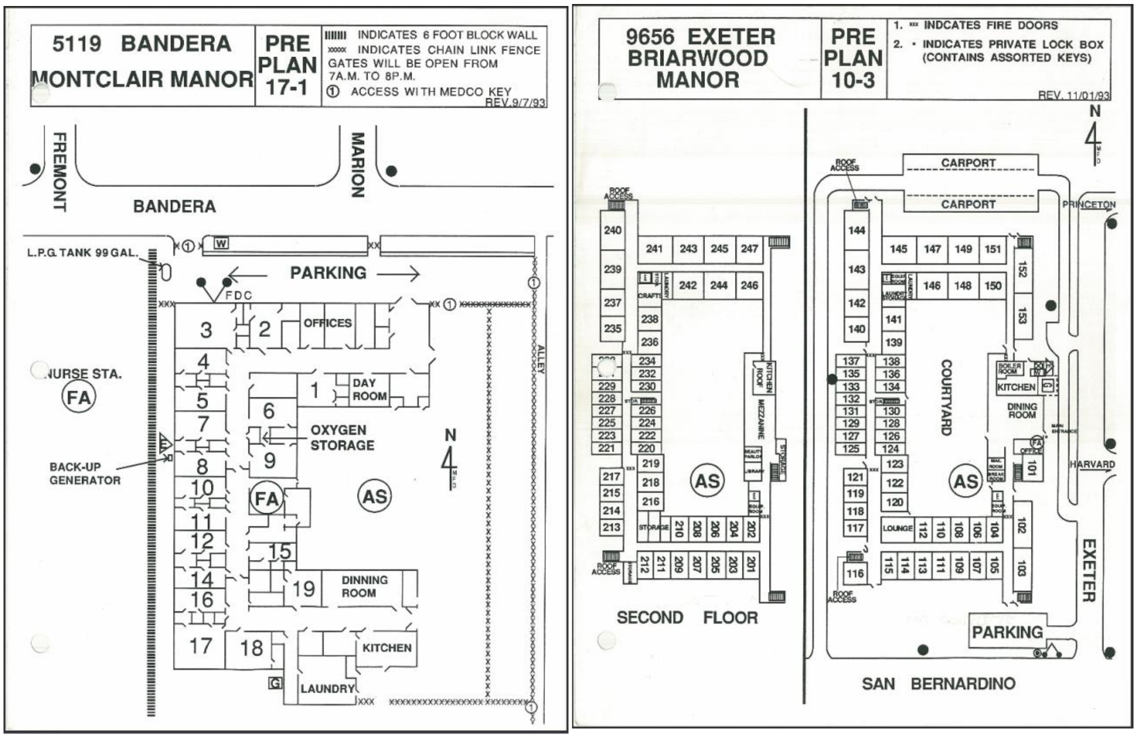


Figure 3.3 - Sample Pre-Plans

3.1.2. Existing System Workflow Description

The system currently used by emergency responders to get spatial tactical response information, described below, is a set of tools that enables responders to get information relevant to a specific location in as little time as possible. The workflow, as it stands in Montclair today, is as follows:

1. A call comes in from an emergency 911 dispatching system. In this case, the neighboring city of Ontario's response agency takes all calls from residents within its jurisdiction, then relays a message to the MFD, which initiates a response. The information about the call is limited to a location in the form of a street address and a brief description of the nature of the problem. This information is relayed to fire fighters through a public announcement system, often waking them up in the middle of the night.
2. At this point, the MFD personnel start to use the geographic information distribution system that is in place.
   a) First, the firemen will look up the address on a printed word document updated by a secretary at the MFD to find out which grid/area number contains the address or intersection they are responding to. The first page of this document is depicted in Figure 3.4.

MONTCLAIR FIRE DEPARTMENT

STREET/AREA INDEX

Grid / Area Number

STREET	AREA
Ada Avenue	
10700-10800	23
11100-11200	27
Adobe Court	
10400	16
Alamitos Street	
4300	7
4500-4600	8
5300-5600	10
Allesandro Street	
4500-4600	4
Alto Street	
9000	3
Amherst Avenue	
9700-9800	7
9900-10200	11
10300-10400	15
11100	25
Appaloosa Way	
4100-4300	15
Applegate Street	
5400	23
Arabian Place	
10500	15
Armsley Street	
5500-5600	6
Arrow Highway	
4500-4800	1
4900-5200	2
5300-5600	3

STREET	AREA
Aspen Drive	
5100	9
Autoplex Drive	
9400	5
Bandera Street	
4400	15
4500-4800	16
4900-5200	17
5500-5600	18
Barrington Way	
5200	22
Bel Air Avenue	
9200	6
9500-9800	10
9900-10200	14
11000	23
Belgian Place	
10500	15
Belvedere Way	
5200	22
Benito Street	
4200-4600	7
4700-4800	8
4900-5200	9
5300-5600	10
Benson Avenue	
8700-9000	3
9100-9400	6
9500-9800	10
9900-10200	14
10300-10600	18
10700-11000	23
11100-11200	28

Figure 3.4 - Street/Area Index

b) The driver of the responding vehicle will look at the large map on the wall of the vehicle garage (Figure 3.5) to find out where the grid section is and plan a preliminary route to the incident location.

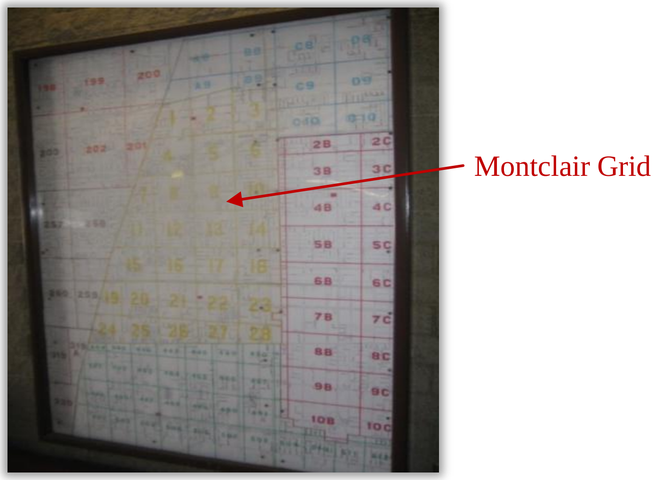


Figure 3.5 - Wall Map

c) The firemen responding then head to the location. While in the truck, a response manager finds the relevant map page in the map book based on the street index shown above and the graphical index shown below (Figure 3.6).

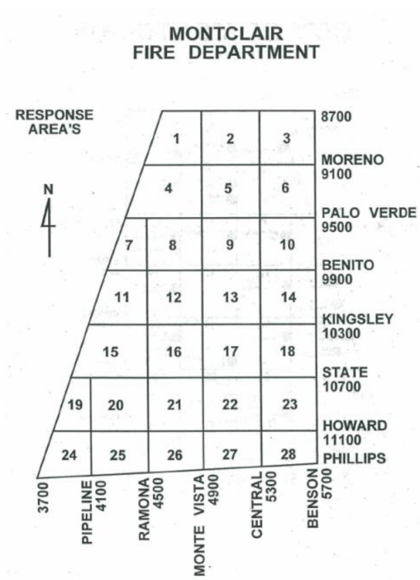
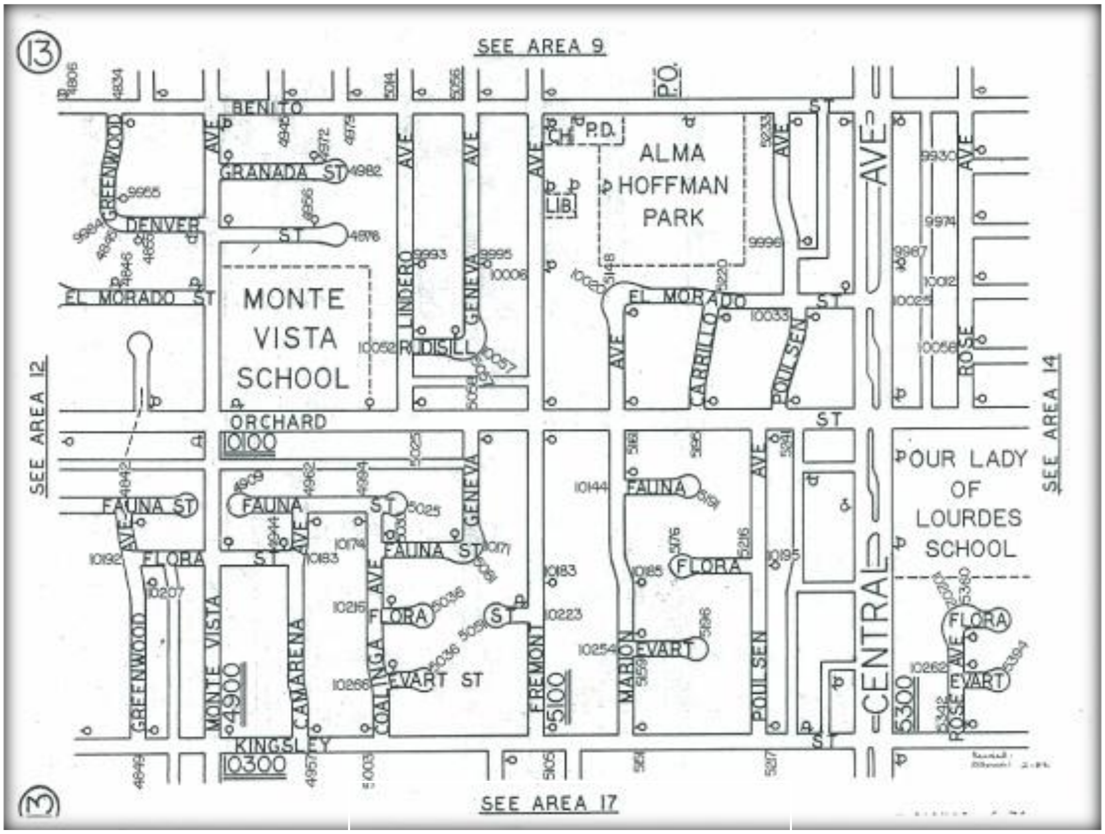


Figure 3.6 - Map Book Street Index

d) While in the truck, a response manager plans out the tactical effort of the fire department's response using the map page (Figure 3.7). The manager also looks to see if the target response address is depicted on a pre-plan, contained in a binder kept in the responding vehicles (Figure 3.8).



- Street names
- Addresses
- Fire Hydrants
- Points of interest

Figure 3.7 - Sample Map Page

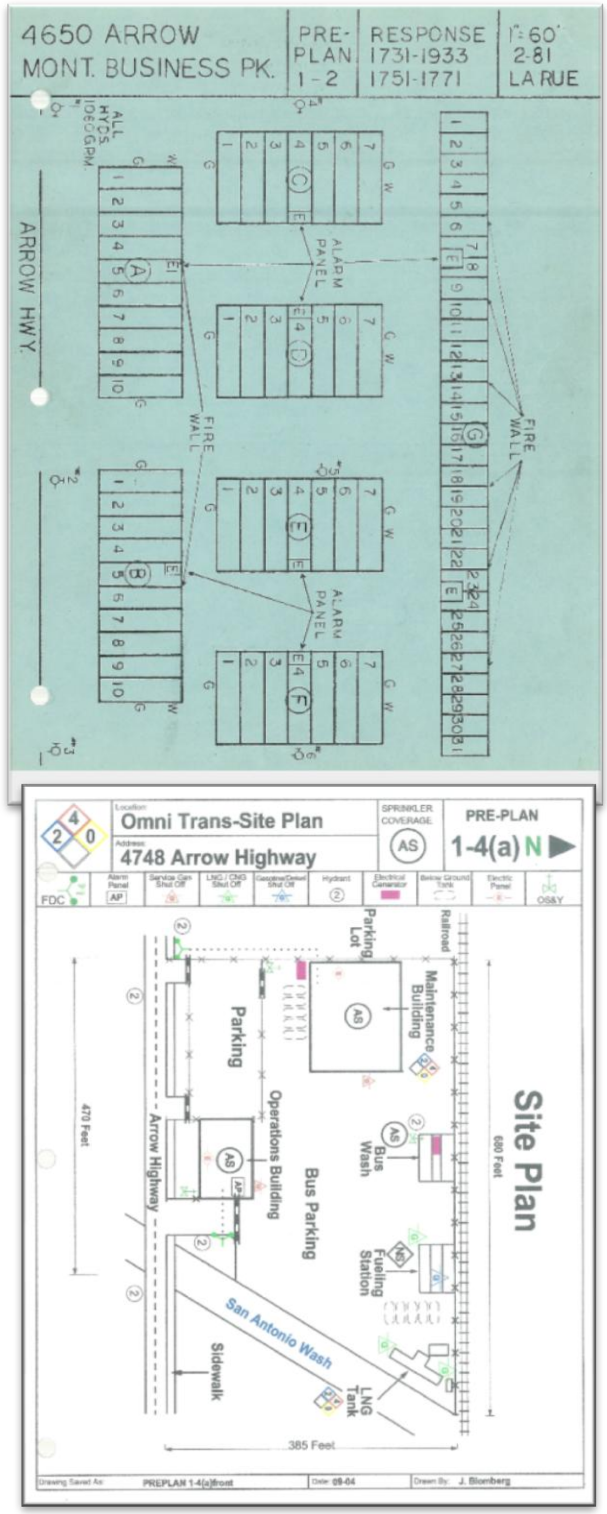


Figure 3.8 - Sample Pre-Plans

The progression of map and indexing tools used in the existing system workflow is shown in Figure 3.9.

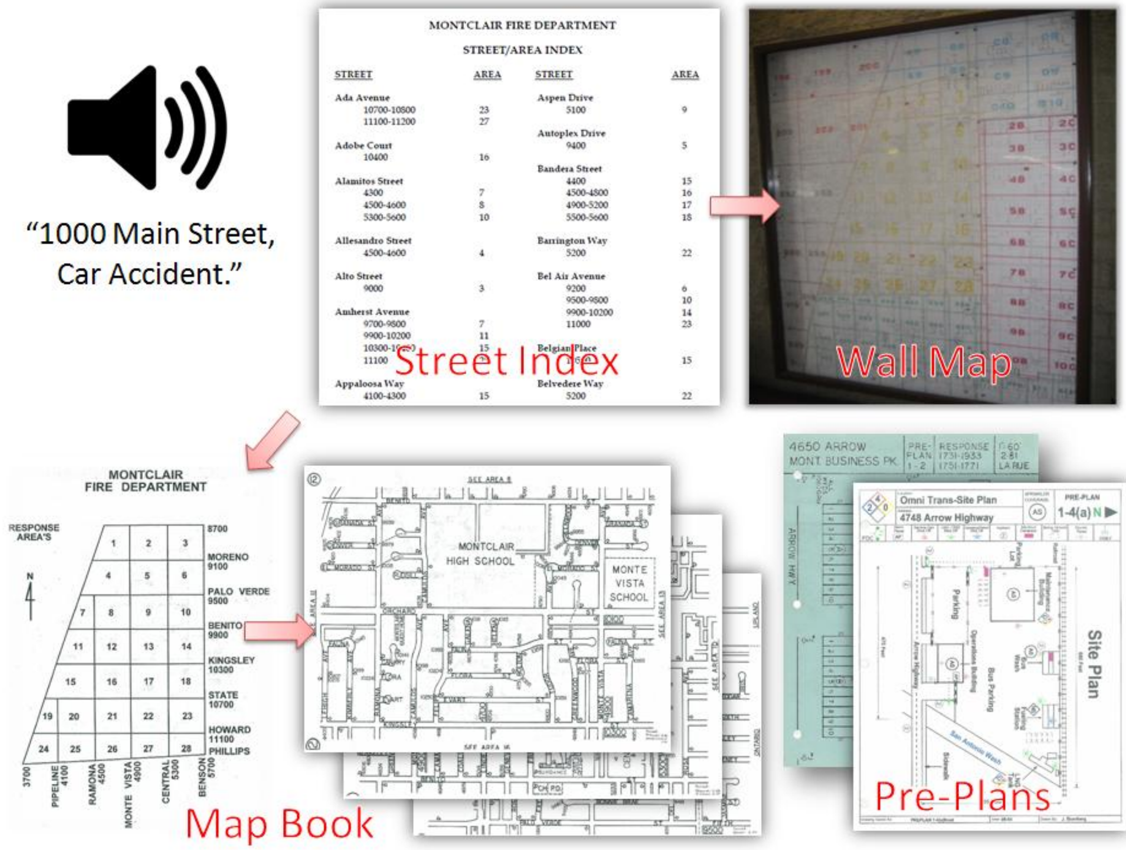


Figure 3.9 - Existing System Workflow

3.2. The Map Book and Emergency Management

The maps used currently are specifically used for incident response planning. An example of one of the 28 maps currently used is shown in Figure 3.10.

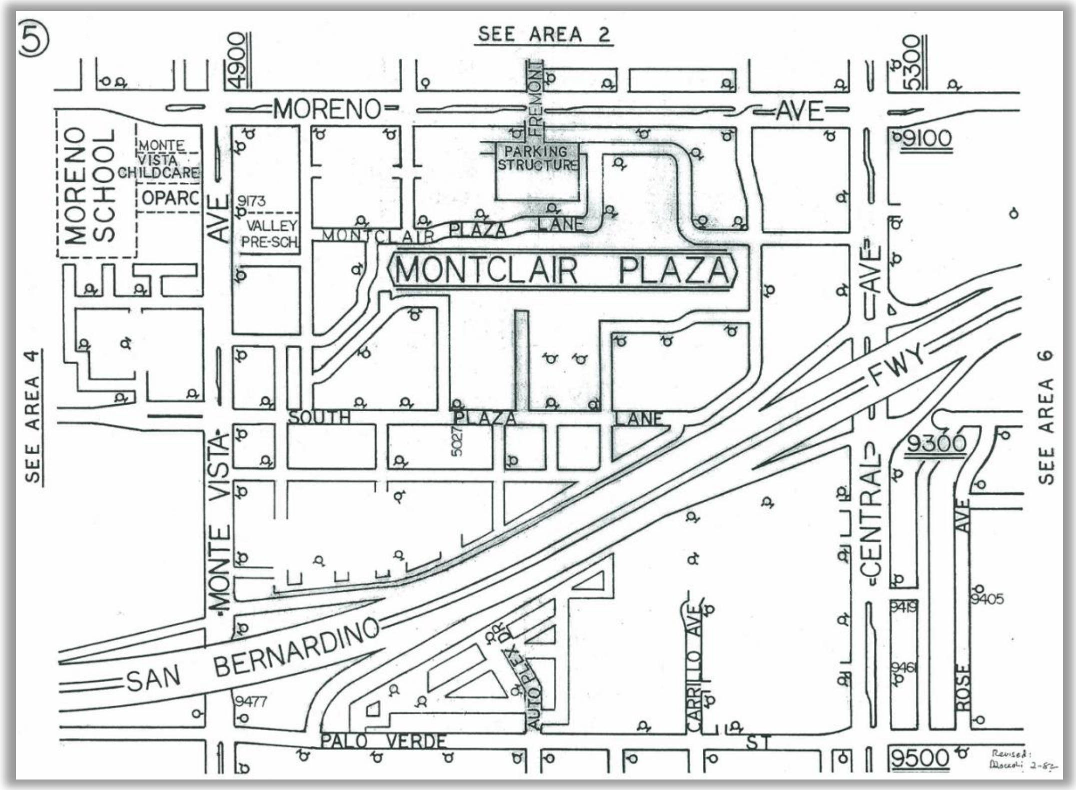


Figure 3.10 - Existing Map Page

On the way to a structure fire or medical emergency, many things need to be considered that can simply and easily be answered by a well laid out map. Firemen typically refer to this process as "fact finding before the response." Decisions based on fact finding include:

- How should we approach the incident?
- How should we enter a building?
- How many units are required for an effective response?
- What type of fire attack should be used?
- What resources will we need to respond? Police or Ambulance?
- Will people be there?
- Is it densely populated?
- Will we need crowd control?
- Will we need traffic control?
- What streets are in the area?

These types of questions are typical spatial questions that a map can be efficient at answering. The map book gives responders information about street names, addresses, landmarks, helicopter landing zones, adjacent map grids, surrounding cities, fire hydrant locations, street medians, railroads, and fire stations. The relationship between the decisions and questions, showing what map features affect which decisions, is outlined in Figure 3.11. The questions, down the left side of the figure, can be directly or indirectly answered by elements of the maps, across the top of the figure. For example, street names directly help a responder find out what streets are in the area, alternatively the aerial photograph can only indirectly tell a responder whether the area is densely populated with an overhead depiction of the area.

	Points of Interest	Vehicle Travel Lanes	Fire Hydrants	Helicopter Landing	Addresses	Buildings	Street Names	Railroad Tracks	Parcels	Aerial Photograph
How should we approach the incident?		●	○		●	○	●	○	●	●
How should we enter a building?	●					●		○	○	●
What number of units are required?	○	○	○	○		○			○	○
What resources do we need?	●	●	●	●		●			●	●
What type of fire attack should be used?	○	●	●	○		●		○	●	●
Will we need Police? Ambulance?	○	○				○			○	○
Where is the address on the street?		○	○	●	●	●	●		●	○
Will people be there?	○	○				○			○	○
Is it densely populated?		○				○			○	○
Will we need crowd control?	○	○				○			○	○
Will we need traffic control?	●	●				○			●	●
What streets are in the area?		●				●	●		●	●

○ Indirectly Relevant ● Directly Relevant

Figure 3.11 – Data requirements vs. emergency management tactical information

The city is tessellated into 28 grid rectangles, and the map book consists of these individual rectangles as 28 separate map sheets. Through interviews, requirements were determined for a new system that improves the current update procedures, the accuracy of data shown on the maps, and the continuity in the planning tools, specifically pre-plans and map pages.

4. Requirements and Design

4.1. System Requirements

System requirements to fulfill the goals of the project were determined through the background investigation discussed in the chapters Two and Three as well as through interviews conducted with the MFD. Data relevant to the creation of a new and efficient emergency response system were identified. Functional and non-functional requirements were developed to assist in refining the project scope, and to guide the implementation of the project to ensure that all necessary capabilities were included in the final application.

4.2. Functional Requirements

Functional requirements were determined after the analysis of the existing system. It was decided that the system shall be able to do the following:

- Allow updates to be made to data
- Output map pages
- Retrieve and display map pages
- Have the following options for all addresses:
    - Link to old map book pages from a map
    - Link to new map book pages from a map
    - Link to scanned pre-plans from a map

4.2.1. Data Requirements

The first specific functional requirement was that the system would need to display as much information as the existing system, including:

- Location of fire hydrants
- Location of points of interest/landmarks
- Street names with each street labeled on each map
- General address ranges
- Surrounding grid areas and surrounding city information
- Current grid number designation

Other crucial data were identified by the MFD through interviews. These data included data that needed to be created, converted, or collected as layers inside a database including:

- GPS-located fire hydrants
- Parcel line boundaries
- Specific parcel address number designations
- Helicopter landing locations

- Large building footprints
- Parcels with a pre-plan associated with them
- Aerial photograph

These data layers each contain information relevant to different aspects of emergency response planning. For example, parcel lines can inform a manager about population density and zoning type based on the parcel sizes, layouts, and other patterns recognizable on a map, for example, if there is a high concentration of small parcels within an area, that area is most likely residential.

The following non-functional requirements were developed at the beginning of the project:

- The system should store data in a geodatabase
- A digital map book should be created based on the existing layout of response grids
- The system should run on response vehicle computers
- The system should be able to create map sheets automatically
- The system should be accurate as of May 2008
- The data should be updateable
- The map book should be created using Montclair's existing emergency response grid
- The map pages, pre-plans, and other documents should be organized according to the type of map or document they were
- The file name of each map or document should be unique for identification purposes
- All documents and maps should be stored digitally on each MDC
- The system should not rely on ESRI software in the responding vehicles to accommodate the slow processing speed of the response computers

4.3. System Architecture

The data update and storage system relies on ESRI's ArcGIS software, unlike the application in the response vehicles that had to be custom created to be used with a touch screen. A personal geodatabase was utilized because it supports a variety of spatial information formats, can keep strict projection and coordinate system guidelines for all data in the database, allows for the storage of metadata describing project data, and allows for rules like topology and domains to be created for editing tasks. Additional components of the system include static digital maps, static hard copy maps, an application for retrieving digital maps, as well as an update routine to keep information current.

The hard copy and digital maps are created using ArcMap. A script from ESRI's ArcScripts website is used to generate the static maps. The maps are created from this script, and each time they are generated they include the latest information from the geodatabase. Montclair's GIS specialist can perform updates to the data through the map documents also.

The system has four major outputs including a central database for data updates, a map creation engine for the map documents, map dissemination tools in the form of a spatial indexing application for the vehicles, and hard copy map books to be used during emergency response. Figure 4.1 shows the inputs and outputs of the system as well as a brief look at the intermediate steps used to get through the process.

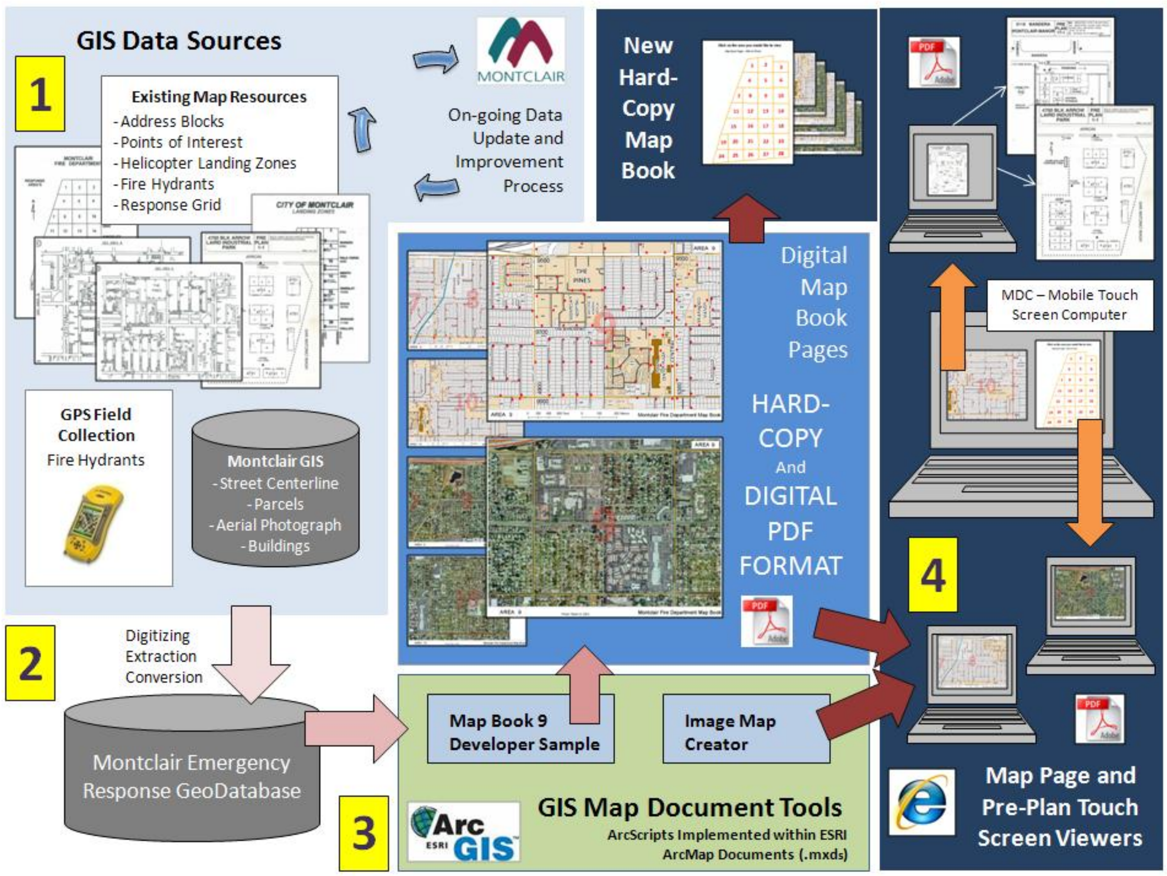


Figure 4.1 - System Architecture

The plan used to manage the project tasks is discussed in the next section.

4.4. Project Plan

The practical considerations for the completion of the project, including the project work plan, workflow, schedule, and risks, are outlined and discussed in this section. The solution to the problem of emergency management faced by the MFD was solved by designing and implementing the system architecture laid out in the previous section.

There were seven major tasks associated with this project: requirements analysis, data collection and data creation, database design, graphic design, application development, system implementation and system training.

The requirements analysis was accomplished with Fire Department staff as well as GIS personnel in Montclair to come up with a list of data needed to complete the project. In this critical exercise decisions were made on data collection strategies and data formats and types.

Data creation and collection were completed based on the findings of the needs assessment. Initially there were about 20 individual data layers that were identified for collection or creation. This data creation was completed using a variety of methods such as digitizing from scans, digitizing from the aerial photograph, GPS field collection, and finally, obtaining existing data from different organizations. Data sets were reviewed by the client and accepted for use in the system.

The data import stage was where data were created and then organized by location and spatial reference, while the metadata was completed after the data had been collected. All layers were initially created as shapefiles for greater flexibility, and subsequently imported into a geodatabase.

The graphic design phase included the creation of all map layouts and design elements for the map products used as output of the system. All marginalia, colors, font, symbology, covers, and graphics for the map book pages, map book cover pages, indices, and application elements were created during this phase of the project. These elements included locator indices, titles, north arrows, scale bars, and fonts applied to elements displayed on the maps. At each step of this process samples were provided to the MFD staff for review and comment. When the designs met with approval, hard copies were made and submitted for further evaluation by MFD employees. This process continued internally between the GIS staff and the fire department after project was completed.

Application development included the creation of a program to be used in the responding vehicles for the retrieval of static map documents. Networking, internet, and local storage issues were dealt with. The update process was also defined. This update process consists of a workflow that was explained and demonstrated to the City's GIS staff. The application has been deployed to the City for testing.

The implementation phase included the steps of installing the application on response vehicle computers as well as testing each computer on which the system was installed. ArcGIS workflows for map updates were also introduced to the Montclair GIS office staff with ArcMap documents and data transfer to Montclair computers for future updates.

Training on the system functionality was conducted to teach end users how to use the products as the final step.

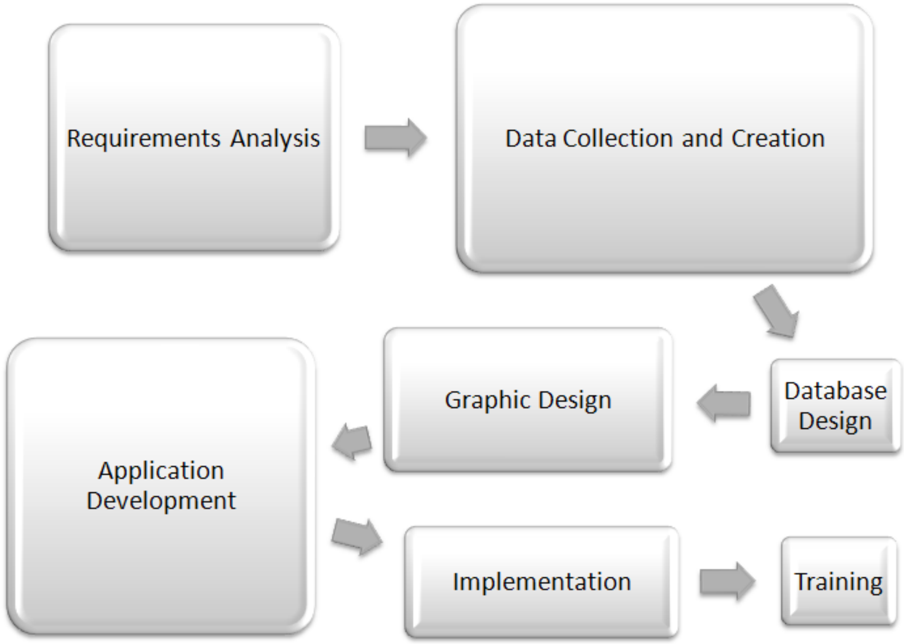


Figure 4.2 depicts the project's workflow graphically. Major steps are defined with decision making processes deemed necessary for successful project completion. The size of each box symbolizes the approximate amount of time spent on each phase of the project.

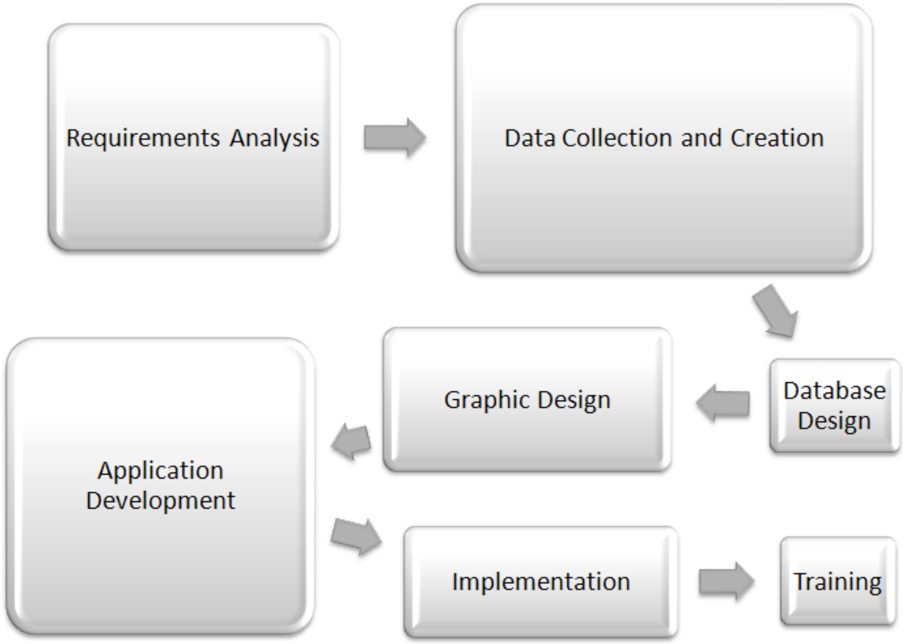


Figure 4.2 - Workflow Diagram

4.5. Schedule

The timeline for the project was January through December of 2008. There were a number of high level tasks as well as low level tasks that needed to be tackled in order to complete the project. A documentation process was included in the schedule to record the methods implemented to complete each phase of the project. These steps are outlined in the Gantt chart in Figure 3.9

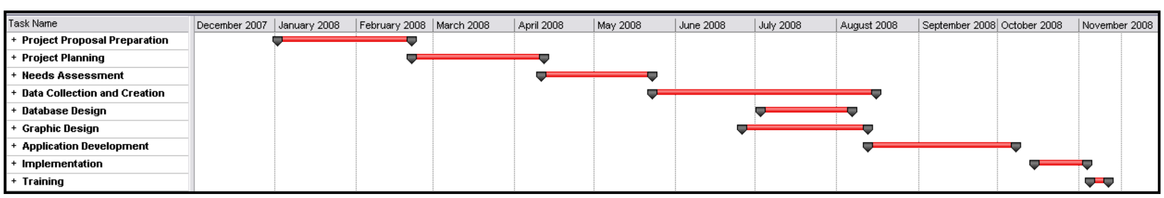


Figure 4.3 – Gantt Chart of the project plan

4.6. Risk Analysis

This project involved many risks. Table 3.1 is a risk analysis table with sections for risks, measurements of risk, ways to mitigate the risks, and an overall number to show relative exposure associated with each risk. The two scales of measurement are probability and severity. Each of these scales range from 1 to 5, with 5 being the most severe risk, and 1 being the least severe risk. Risks included scope creep, software updates, and client management.

Table 3.1 – Risk Table

Risk	Severity	Prabability	Mitigation	Exposure
Scope Creep	4	3	Communicate with client Set clear objectives	12
Software Update	3	5	Learn about the update Attempt to rely less on ESRI software Plan alternatives for completing the project	18
Client Management	5	1	Keep client motivated Beta testing as pieces become available	5

4.7. Assessment of Project Plan

The project was completed successfully and did not stray significantly from the initial project plan. Data collection and creation took more time than initially thought, mainly due to the time spent training additional staff who had no former experience with ArcGIS software. Once this phase was completed, a significant amount of management time was needed to check all data created for completeness and accuracy. Topology rules, domains, ranges, and other editing controls would have helped to maintain the integrity of the data and reduce the management time needed.

Scope creep was managed by ensuring that a clear outline of the steps necessary to complete the project was developed even before the project was initiated. The application created was tested as early as possible to make sure that the software update of ArcGIS 9.2 to 9.3 was not going to affect the project. These steps were taken to mitigate the risks identified at the outset of the project and they were successful.

5. Database Design

5.1. Conceptual Design

The conceptual design for this project depicts the classes and attributes that go into creating a plan for an emergency manager to use in emergency response. A responder looks for information that affects the tactical aspects of an incident response. Figure 5.1 - UML shows this design presented in the Unified Modeling Language (UML).

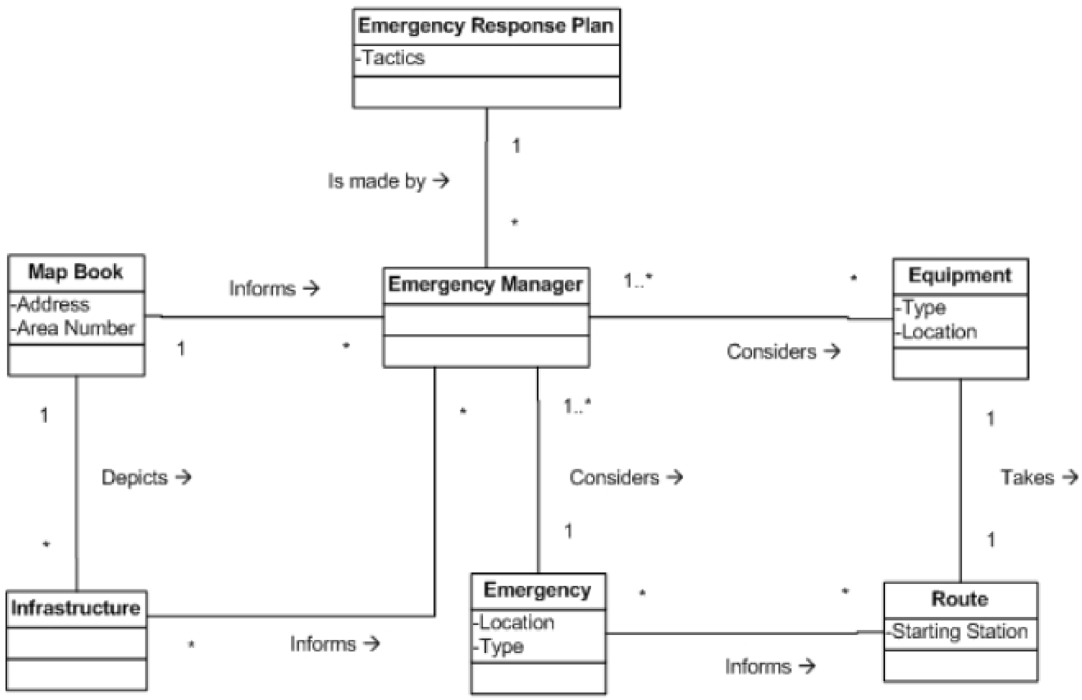


Figure 5.1 - UML Class Diagram

The design shows that a tactical response is dependent on details about an emergency, the location of an emergency, type of equipment available, the location of that equipment, and a detailed understanding of the surrounding infrastructure.

Infrastructure consists of a number of components as shown in Figure 5.2. An emergency manager is informed of equipment location and availability through communication with personnel tasked with assigning resources to different tasks. The manager is informed about the nature and location of an emergency by a dispatcher reporting on details obtained from a 911 phone call or another agency's on-site description and request for assistance. The maps are typically used to display all critical response infrastructure. The database storing the data used to generate the infrastructure maps used by a manager needs to store spatial infrastructure data with specific attributes that can be used to symbolize different infrastructure components cartographically.

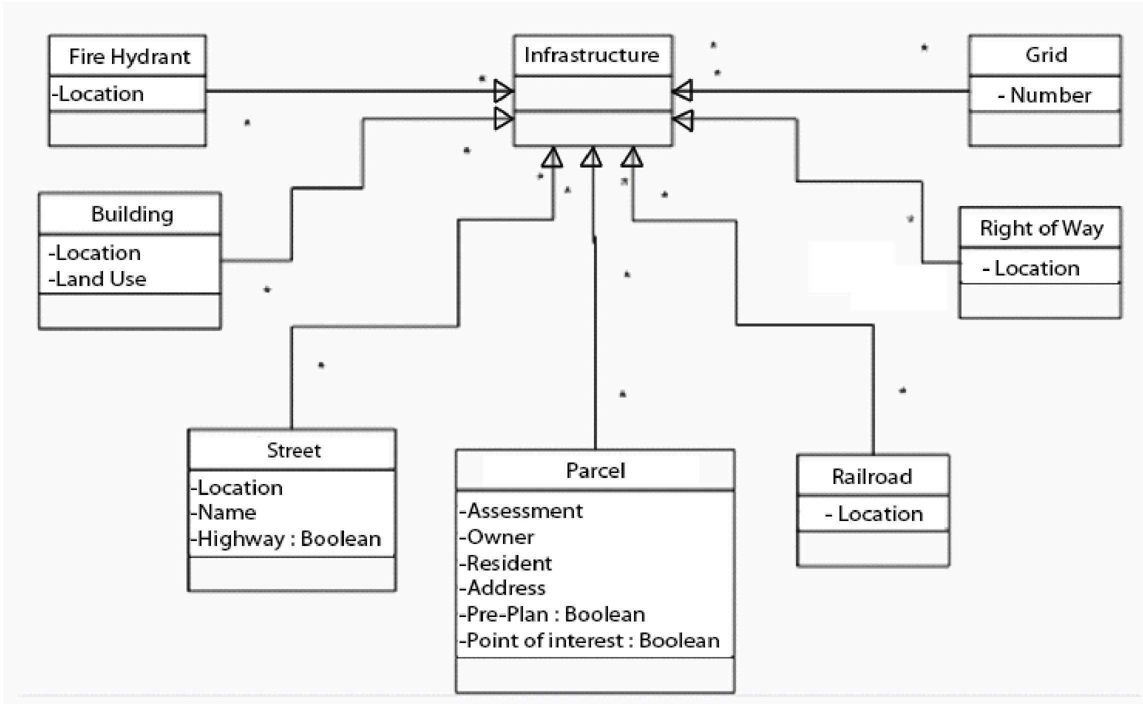


Figure 5.2 - Infrastructure Diagram

The conceptual design shows that map pages are central to any response plan. Local infrastructure is depicted on the corresponding map page within the map book. The infrastructure is made up of the sub classes shown in Figure 5.1. The presence and location of different infrastructure components directly affects a manager's plan for a response. For example, parcel owners need to be contacted if the MFD needs to get into a secure area. Managers therefore need to have access to parcel information and street names surrounding an incident in order to position response forces. Fire hydrant locations also help managers decide how to allocate resources, and buildings surrounding a fire need to be identified in order to initiate property protection strategies. These facts were used to come up with the logical database design discussed in the next section. The logical design was the backbone of the database created for the project.

5.2. Logical Database Design

A review of the conceptual design led to insights about data to be collected as well as annotation that would need to be created to represent data attribute information on the map for features like streets and parcels. Defining the logical design assisted in the design of the final project database. During this phase of the project, data layer specifications were defined. Some of the considerations specific to spatial database design include whether features are created as points, lines, polygons, or annotation. Annotation is typically derived from attributes of the different infrastructure features.

Street names, addresses, the names of points of interest, bordering town names, and grid numbers were generated as annotation in order to make the final maps more readable and easier to understand. Streets and railroads were depicted as lines. Grid squares, parcels, and large buildings were created as polygons. Fire hydrants and helicopter landing zones were created as point features.

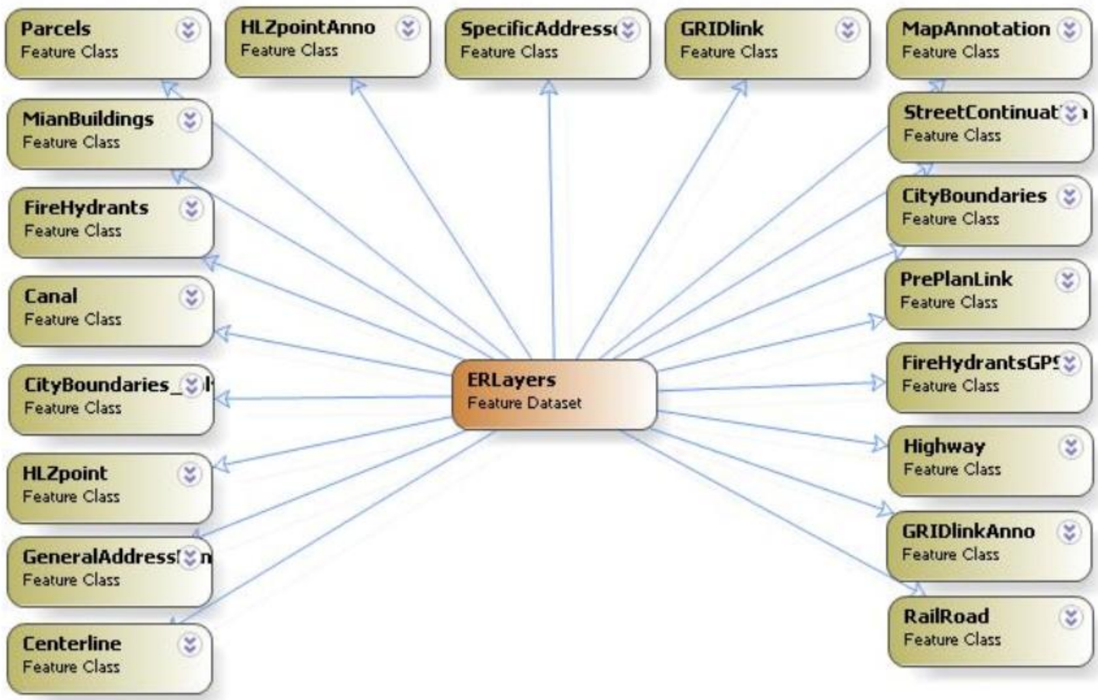


Figure 5.3 - Logical Database Design

The database was created with one feature dataset containing all data depicted on the maps, and keeps all important spatial information, such as projection and coordinate information, consistent. For this data generated for this project the California State Plane Zone 5 projection and coordinate system were used. The aerial photograph stored in MrSID file format was not included within the geodatabase but stored in a separate folder. The photograph is discussed in more detail in section 6.1.3. The logical design displays the information used to derive the layers that were created in the implementation phase of the project. The purpose of each layer on the final maps led to how each layer was named. For example, the "GRIDlink" layer is a polygon layer depicting the grid that Montclair is tessellated into for indexing. The "link" in the name means that the layer contains the path name to the documents it will link to in the final application.

6. Implementation

To meet the functional requirements of the project, a database and application were created. Based on the requirements, it was clear that many data layers would be needed to complete the map books. An application that works within the ArcMap environment was implemented to streamline map book page production, drawing data directly from the database. A light-weight application was created using a script that runs inside ArcMap that can be deployed on any computer running a web browser such as Microsoft's Internet Explorer.

6.1. Data Creation

The data creation process involved the use of many data sources including:

- Existing maps from the MFD
- Existing pre-plans
- Existing GIS data maintained by Montclair GIS staff
- GPS field collection of data points

These sources, as well as the data derived from them, are depicted in Figure 6.1. All red text shows a layer that is shown on the final map books. Each time a step was completed and colored red in the diagram, it was also listed in the far right final layer column, which shows a list of layers used in the project. The green color for a step signified that the resulting layers were good to use in the maps directly from the Montclair GIS office. The gray colors in the GPS field collection row signify that the field verification step that will lead to a final fire hydrant layer is ongoing.

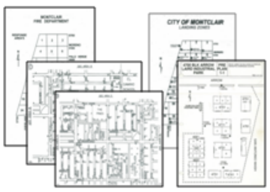
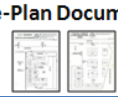
GIS Data Resources	Initial Steps	Resulting Layer	Further Steps	Resulting Layer	Final Layer
Existing Map Resources 	Heads-Up Digitizing	Points of Interest (Point) Helicopter Landing Locations (Point) Fire Hydrants (Point)	Label, Export & Match	Points of Interest (Annotation) Helicopter Landing Locations (Annotation)	**Original Fire Hydrant Locations** **Points of Interest - Labels** **Helicopter Landing Zones - Labels**
	Annotation creation	St. Name Cont. Lines (Line) Border Town Names (Annotation) General Address numbers (Annotation)			**Street Name Continuation Lines** **Bordering Town Labels** **General Address Numbers**
Montclair GIS	Editing- To match FD Maps	Street Centerline (line)	Extract Features	Canal (line) Rail Roads (line)	**Street Centerline** **Canal Line** **Rail Road Tracks**
	Topology Validation	FD Response Grid (Polygon)	Input Path Names Label, Export & Match	Grid Link (Hyperlink - Polygon) Grid Numbers (Annotation)	**Response Grid** **Response Grid Labels**
	Add border cities & merge	Parcels (Polygon)	Label, Export & Move to fit	Addresses (Annotation)	**Specific Address Labels** **Parcel Boundaries**
	Good as-is	Main Buildings (Polygon) Aerial Photo (MrSID Raster)			**Main Buildings** **Aerial Photograph**
GPS Field Collection	Field Collection	Fire Hydrants GPS	MFD Field Verification	Final Fire Hydrant Layer (Point)	**Fire Hydrant Locations**
Pre-Plan Documents 	Parcel Coverage Identification	Parcels Covered by a Pre-Plan	Attribute update: Plan information & Path Names	Pre-Plan Link (hyperlink - polygon)	**Parcels depicted by a Pre-Plan**

Figure 6.1 - Data Creation Workflow (colors explained in text)

There were some repeated processes in the data creation methods for each data source including heads-up digitizing and annotation creation, in addition to some data conversion, extraction, and storage techniques. Each data source will be discussed in depth in sections 6.1.1, 6.1.2, and 6.1.3.

6.1.1. Data Creation Considerations

The first steps to any data creation effort in the development of a GIS are to specify the scale at which the final maps will be made, and to define the spatial reference and projection for the data. All data created for this project were collected at a scale of 1 to 5000, or finer, and the spatial reference and projection was California State Plane Zone 5. This projection is based on a Lambert Conformal Conic projection specifically suited to the area defined as "Zone 5" in Southern California.

The scale for this project was determined through a few simple steps. The final size of the maps, based on the requirements, was 8.5 by 11 inches. This is the most common paper size used in the United States, and it is the size of the existing map book. To get scale information, the response grid was loaded into ArcMap. In the layout view, the page and print settings were set to represent an 8.5 by 11 inch print size. The largest grid, grid 4, was put into the layout and zoom-adjusted to have its borders near, but not exceeding, the edge of the page. The scale 1 to 5000 on the map fit this configuration the best once the scale had been reduced to the nearest thousand for ease of use. This scale also creates enough overlap along the edges of each map page.

6.1.2. Existing Plans and Maps from the MFD

This section will discuss the techniques used to create digital spatial data from the existing map book and the existing pre-planned site maps. These techniques were used to generate the following data layers:

- Points of interest
- Helicopter landing zones
- Fire hydrant locations
- Street name continuation lines
- Border town names
- General address numbers
- Street names
-

Initially, each layer was created using heads-up digitizing. The process utilized ESRI's ArcMap software to edit each line, point, and annotation feature listed above. To digitize new data, a copy of the map book was scanned into digital format and used to create features with the editor toolbar in ArcMap, shown in Figure 6.2.

Figure 6.2 - ArcMap Editor Toolbar

Using the toolbar's "Create New Feature" option, editors can create points, lines, polygons, and annotation. Defining a layer type in ArcCatalog when a layer is initially created ensures that all features generated once this layer has been selected in edit mode will match this initial definition. Figure 6.3 shows the options available to define layer types so an editor can be sure that the feature will be of the type selected.

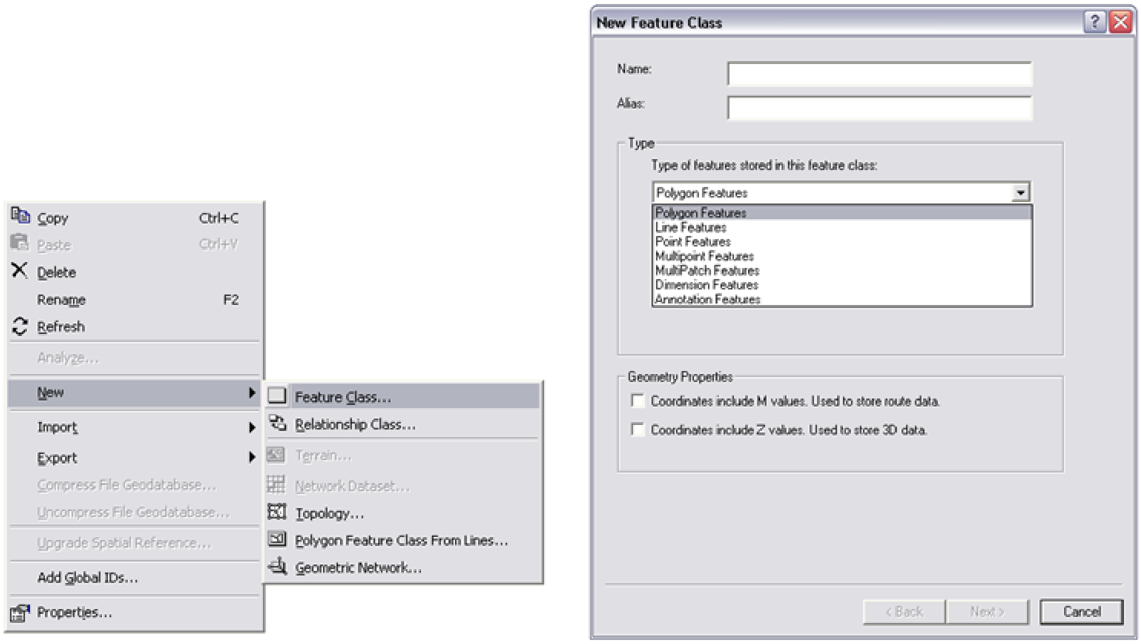


Figure 6.3 - ArcCatalog Layer Creation

In ArcCatalog, a user must right click inside the workspace of a geodatabase to get the drop down shown in the left image of the Figure 6.3. Once the layers had been created, new features were digitized and stored within these layers. The fire hydrant layer, street name continuation lines, bordering town names, and general address numbers were created in this step. Figure 6.4 shows subsets of the different layers from the existing map book.

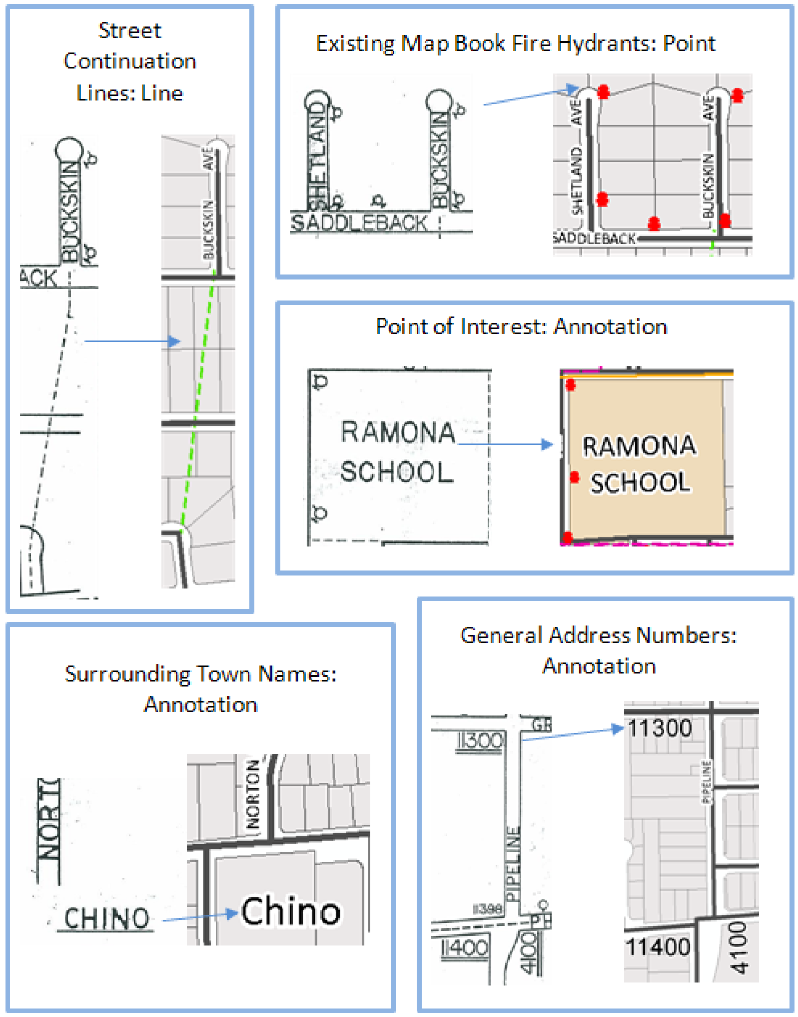


Figure 6.4 - Existing Map Book Data

Helicopter landing zones were created in a similar fashion from the general landing zone map, depicted on the second page of the existing map (Figure 6.5). The close up section on the figure shows that each landing zone, represented by a large circular symbol on the map, has a unique name.

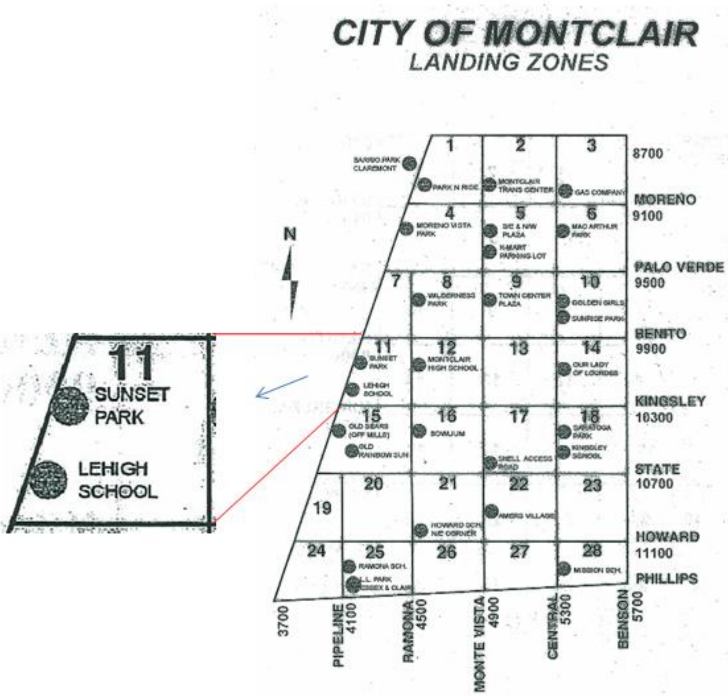


Figure 6.5 - Helicopter Landing Zone Map

Keeping the dot symbol and annotation in mind, a new point layer was created with a field in the attribute table used to store the name of the landing site. A portion of this table is shown in Figure 6.6. This field made it possible to label the landing zones. This process is outlined in Figure 6.7.

Attributes of HLZpoint

OBJECTID *	SHAPE *	name
1	Point	BARRIO PARK, CLAREMONT
2	Point	PARK N RIDE
3	Point	MONTCLAIR TRANS CENTER
4	Point	GAS COMPANY
5	Point	MORENO VISTA PARK
6	Point	S\E & NW PLAZA
7	Point	S\E & NW PLAZA
8	Point	K- MART PARKING LOT
9	Point	MC ARTHUR PARK
10	Point	WILDERNESS PARK
11	Point	TOWN CENTER PLAZA
12	Point	SUNRISE PARK
13	Point	GOLDEN GIRLS
14	Point	SUNSET PARK
15	Point	LEHIGH SCHOOL

Figure 6.6 - Helicopter Landing Zone Attribute Table

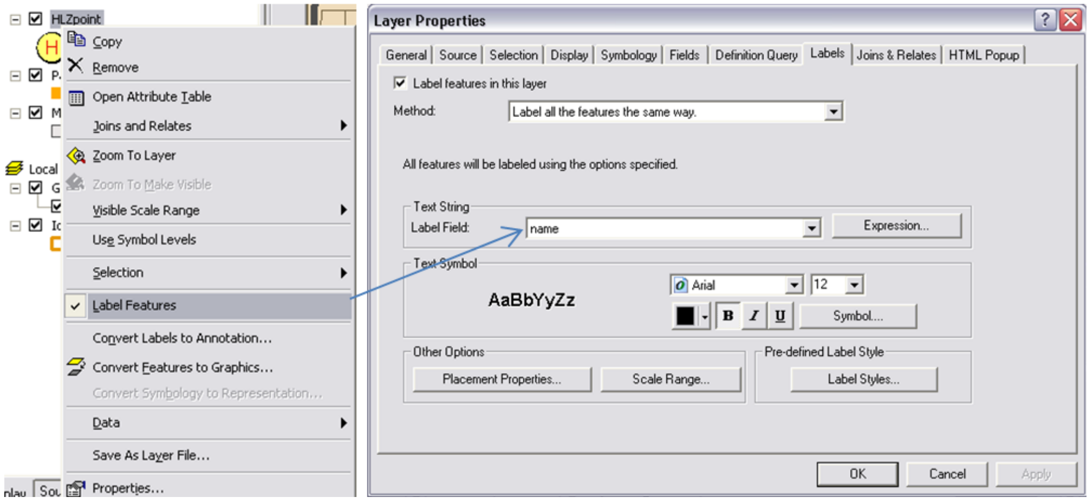


Figure 6.7 - Auto-Labeling Steps

Right clicking on a layer in the table of contents in ArcMap will bring up the window on the left of Figure 6.7. Clicking on ‘Label Features’ will turn labels on, but it is also necessary to go to the properties window of the layer to set the field being labeled and the symbology of the labels. The symbol for the helicopter landing zones (HLZs), a capital “H” inside a circle, was custom designed to signify what a helicopter landing pad would look like on the Earth’s surface if a structure was made to specifically accommodate a helicopter. Montclair indicated that there are detailed plans for each landing zone, but these were not available for the project. If these plans become available, other information could be displayed on the maps, like the actual boundary of the landing zone. The labels and symbol are shown in Figure 6.8.

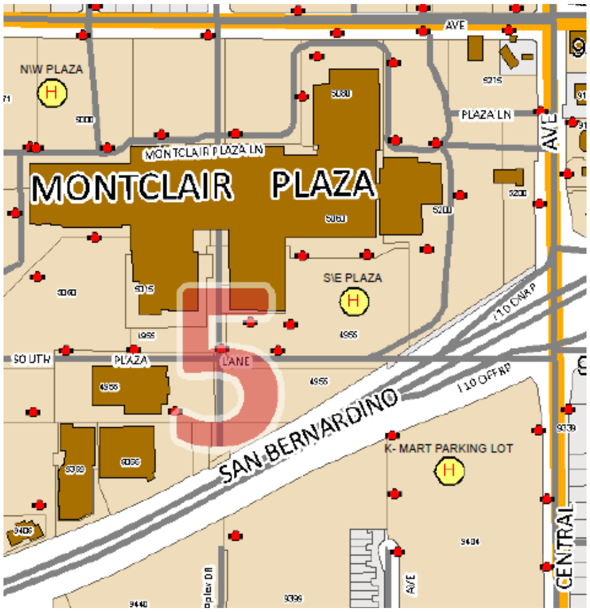


Figure 6.8 - HLZ Labels and Symbol

In the case of some landing zones, the label was unnecessary because the zone was inside a point of interest with the same name as shown below in Figure 6.9.

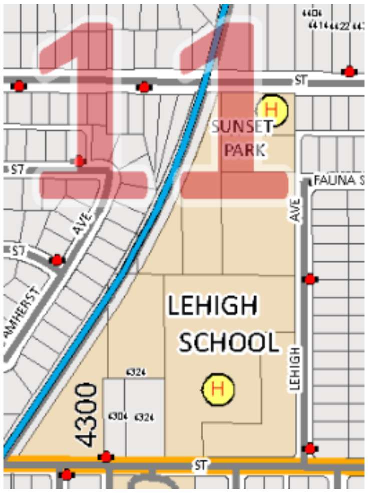


Figure 6.9 - HLZ with Point of Interest Annotation

Initially, the project focused on creating an auto-labeling scheme, as used for HLZs, through the ArcGIS extension Maplex. This extension is a labeling engine that comes with an ArcInfo license, and is available as an additional extension at other license levels. There are many options for labeling streets included in Maplex. The default name placement for the centerlines obtained from Montclair is shown in Figure 6.10. Using

Maplex, many different settings for labels can be set. These settings are depicted in Figure 6.11.

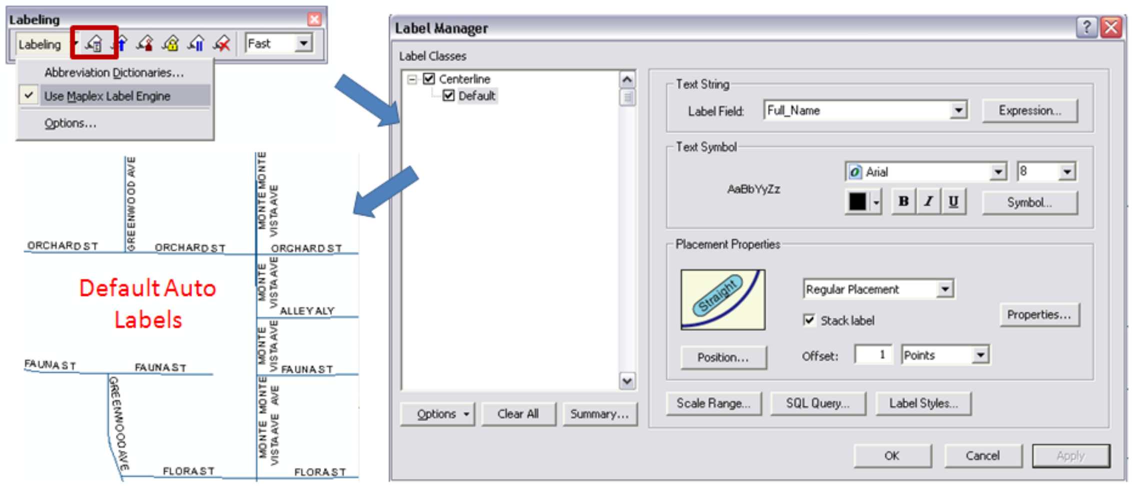


Figure 6.10 - Default Auto Labeling

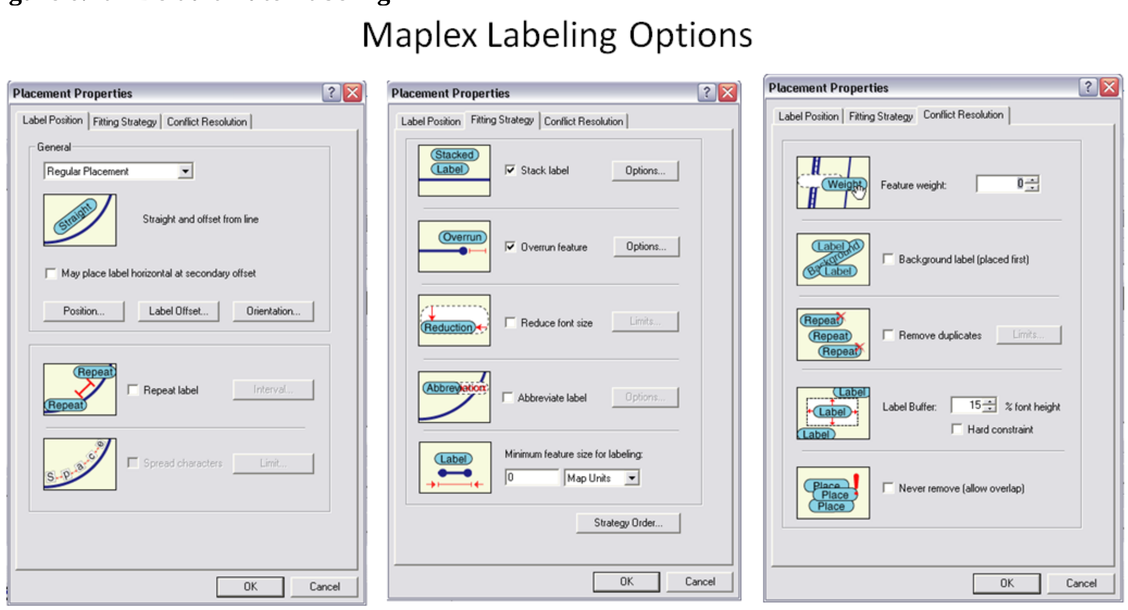


Figure 6.11 - Maplex Labeling Options

After an in-depth study of auto-labeling parameters and the Maplex options, it was determined that neither ArcMap’s auto-labeling nor the Maplex extension would produce labels as good as the existing maps.

There were many subsequent considerations and ramifications based on this decision. First, auto-labeling would have allowed street name placement to be updated on-the-fly.

This would mean that as features were added to the centerline layer, which maintains each street in the city, they would be automatically labeled upon the creation of the map pages for updates. These advantages of auto-labeling, however, were not enough to outweigh the poor cartographic results, so manually placed ArcMap layer of annotation was used for the project.

This layer was created using the existing map book as a guide. It was decided to create annotations by matching the existing map books with cartographic representations. This was done to make sure every street had a label on each map sheet and to keep continuity between the existing map book and the new book created in this project. Each street name being labeled on each map sheet was an important consideration since a responder ideally does not need to consult adjacent map sheets to determine the names of any features. A sample of the final street name annotation compared to the existing map page is shown in Figure 6.12

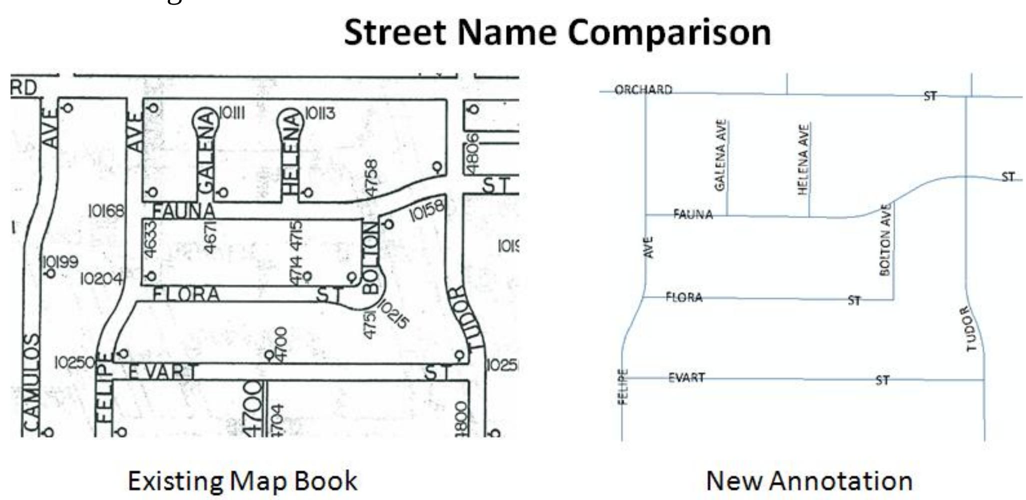


Figure 6.12 - Street Name Comparison

An important part of any annotation layer is the scale at which the layer is created. Annotation and scale are linked meaning that settings for the annotation's font size are directly tied to the scale of the final map sheets. The scale for this project, discussed in section 6.1.1, was 1:5000. Through testing and comparison, the final font size for the layer was chosen to be nine point. All street names were hand placed in this fashion. Later, the street names, point of interest annotations, and surrounding town names were combined into one layer called "MapAnnotation." This kept editing simple and made management of the database easier.

6.1.3. Existing Montclair GIS Data

The second source of data for the project was the existing data maintained by the GIS staff of Montclair. Montclair maintains over 300 data layers, all of which were obtained at the onset of the project. These layers vary in their completeness, accuracy, and purpose, but after an extensive investigation, only a few data layers were used for this project. Very few of the existing layers were intended for the fire department, which made integration of the layers difficult, necessitating customization on most layers.

To meet the project requirements, six data layers provided by Montclair were used. These layers are listed below.

- Aerial Photograph
- Main Building Footprints
- City Borders
- Street Centerline
- Parcel Boundaries
- MFD Response Grid

Four of these layers, the centerline, response grid, city border, and parcels, needed to be updated and customized to meet project needs and the others, the air photo and building footprints, were ready to use.

The aerial photograph and main building footprint layers were ready to use in the map book as they were. The photograph was taken in 2002 by Stuart Technologies and has a three inch resolution. It is stored as a MrSID raster file outside the database for the project. This format is more stable and keeps the file storage size down considerably. The photograph was initially imported into the project geodatabase, but proved to degrade performance and created larger file sizes. Figure 6.13 shows the fine resolution offered to emergency managers by the aerial photograph.

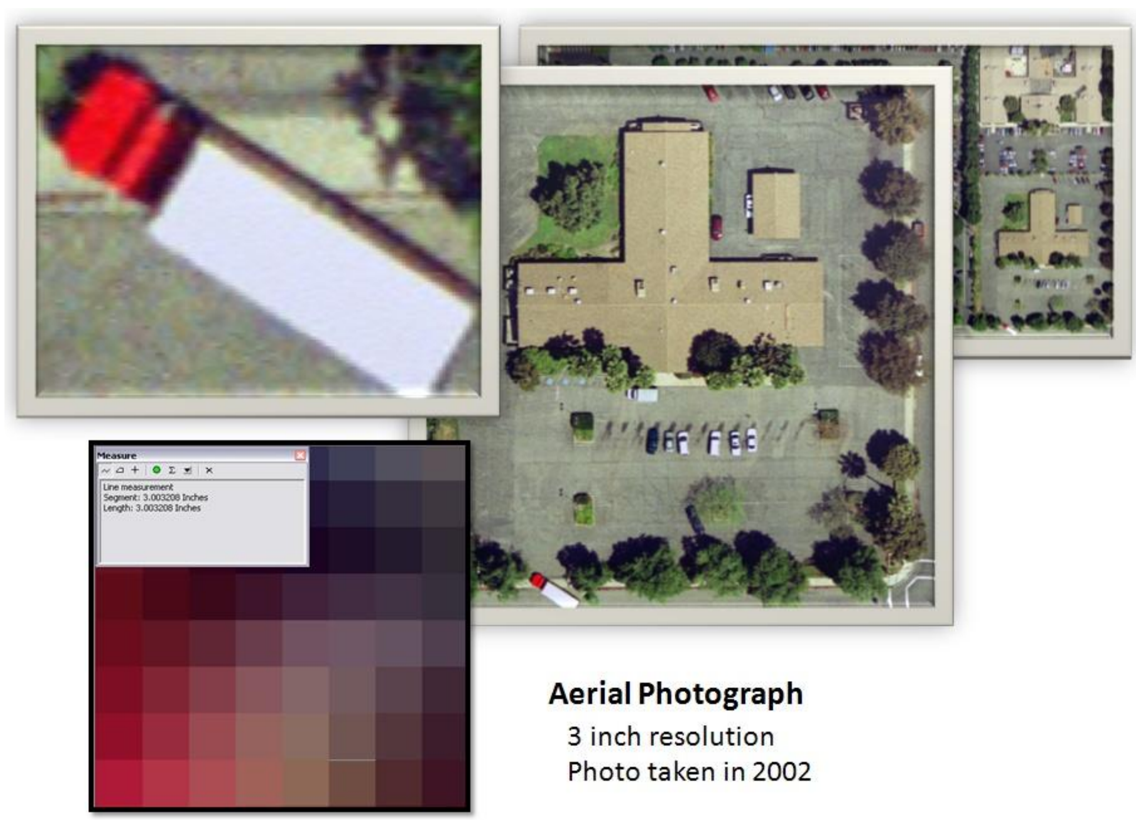


Figure 6.13 - Aerial Photograph Perspective

The “MainBuilding” layer in Montclair’s database portrayed the building footprints of all significant buildings in Montclair. A building’s significance was determined by Montclair GIS staff, who digitized the buildings from the aerial photograph. The main building layer and aerial photograph are displayed in the final map book design.
The town border polygon that depicted Montclair’s municipal boundaries was also used. To match the existing map book, the boundary layer needed to be merged to the surrounding city boundaries. The resulting use of the layer on the map pages is shown in Figure 6.14. The surrounding city borders used were obtained from ESRI’s data and maps collection from 2007.

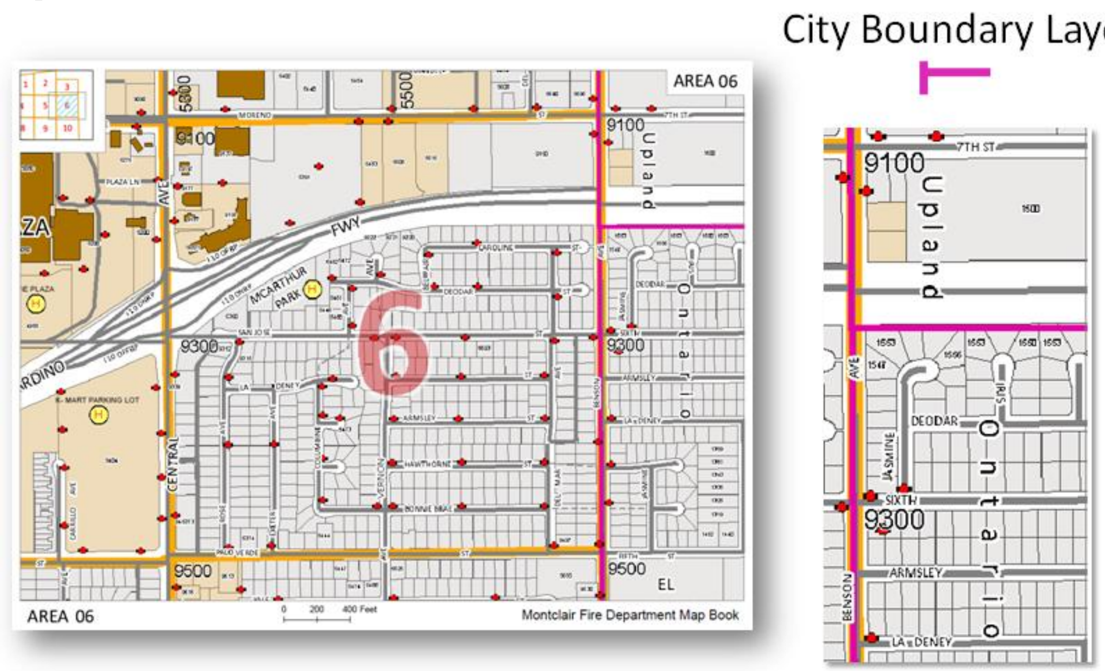


Figure 6.14 - City Boundary Layer

The existing map books show representations of the surfaces used by responding vehicles, including private streets, alleys, and private multi-family development roads. This depiction of paved surfaces and other rights-of-way is a prominent feature of the books. To represent these features in the new map books, custom editing was needed. The discrepancy between existing layers and the existing map books is show in Figure 6.15. This discrepancy is mainly due to the different look and feel of the response lanes. On the old maps there is a hand drawn depiction of the lane in which a vehicle can travel, and on the new map parcels in light gray, depicting rights-of-way, with the centerline in dark gray, depicting pavement, indirectly display response lanes.

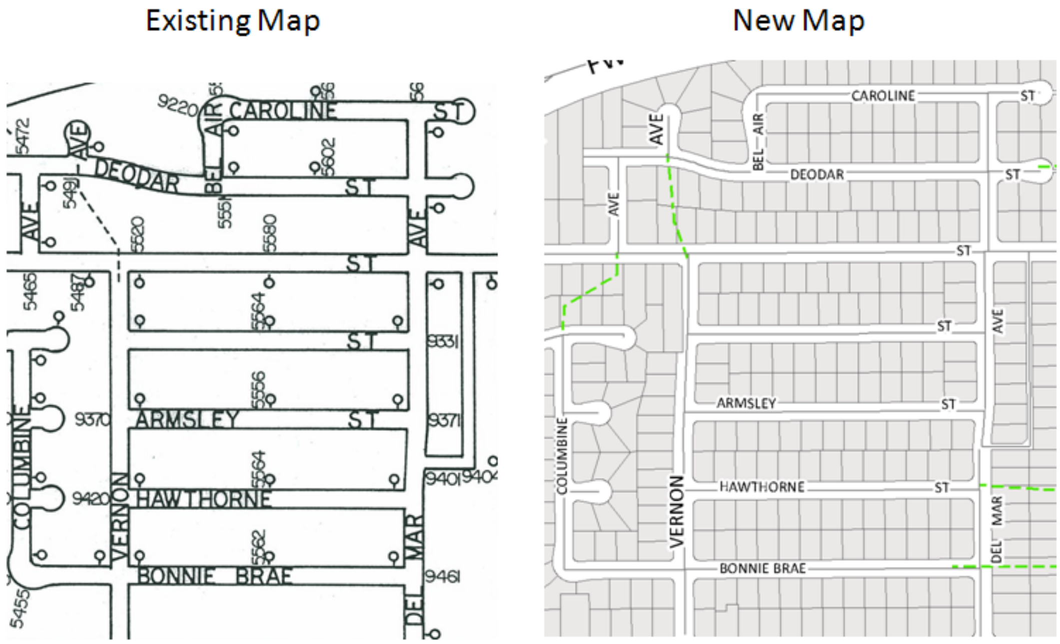


Figure 6.15 - Comparison of Response Lane Depiction

The two layers that show the responding vehicle lanes in the new digital maps are the city parcel layer and the street centerline layer, obtained from Montclair and customized to reflect information from the existing map book.

The centerlines had to be modified to represent the pathways responding vehicles could use, as depicted in the existing map book. To do this, the aerial photograph was used to find accurate representations of surfaces represented in the map book. First, discrepancies between the map book and the centerline layer were noted, and a new line was digitized to represent the travel pathways inside complexes and along alleys.

The parcel lines were also used to create specific address annotation. The annotation numbers were created to help give responders the detailed address information shown on the existing maps. To create the annotation, the parcels were labeled by their house numbers, stored in the layer's attribute table, and maintained by the county. On inspection, this auto-labeling was too confusing because the labels became cluttered. Subsequently, only parcels over 5000 square feet in area were labeled, improving readability. These labels were then converted to annotation and symbolized at six point font size at a 1:5000 scale (Figure 6.16 - New Specific Address Numbers).

Figure 6.16 - New Specific Address Numbers

The parcel data was also modified by merging it with surrounding municipality parcel layers, obtained from San Bernardino County and Los Angeles County GIS offices. These layers offer data on surrounding city layouts, shown in Figure 6.17.

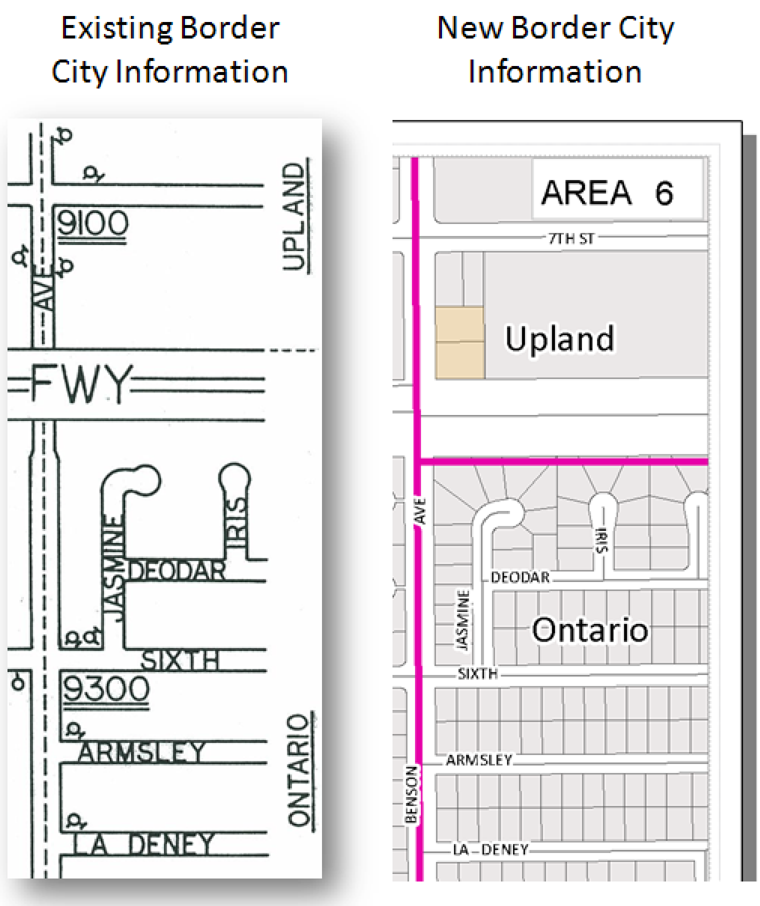


Figure 6.17 - Border City Information Comparison

The response grid was the final layer obtained from the Montclair GIS office. The grid was originally created for a small scale map, and topology had to be checked and fixed to get rid of gaps and overlaps between polygons.

The grid was used to create map page grid number annotation. It was labeled and the labels were then converted to annotation from a field in the grid polygon attribute table called "fire_num." The grid and the annotation were used in the final map pages and other places to lay out the town and show how the grids are organized to facilitate map page searching. The application created with the map books was made utilizing the grid and annotation.

6.1.4. GPS Field Collection

A Global Positioning System (GPS) receiver was utilized in this project to create the layer showing fire hydrant locations. This process was undertaken to verify and collect all fire hydrant locations. Fire hydrants were originally digitized off the existing map book, making a point for each location. It was determined through interviews with the MFD that this layer was not sufficient for the project because it was out-of-date and inaccurate. Once the data collection was completed, the GPS fire hydrants and digitized hydrants were compared and displayed a large discrepancy (Figure 6.18 - Fire Hydrant Discrepancy).

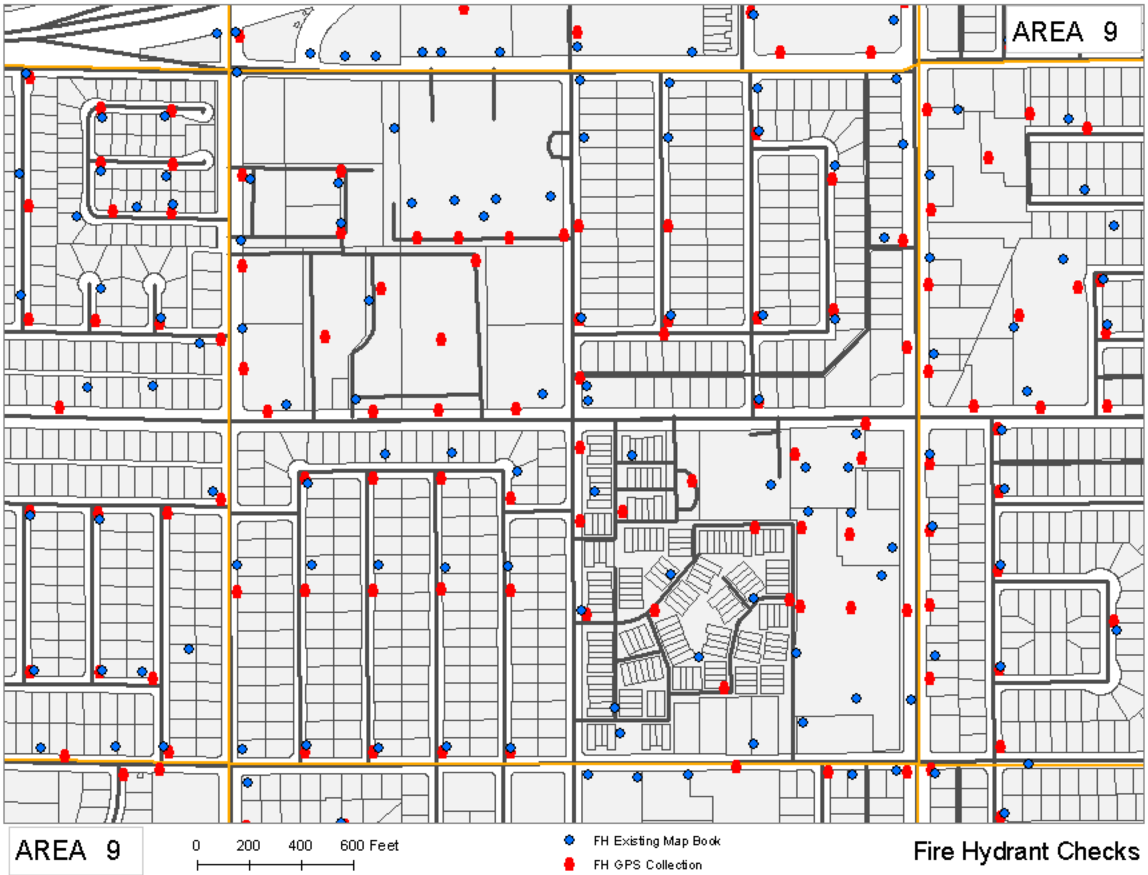


Figure 6.18 - Fire Hydrant Discrepancy

The GPS project started with a pilot GPS collection effort. The effort collected fire hydrant locations for one grid in the city. To complete this effort a team, consisting of Montclair GIS staff, two interns, and project management, was sent into the field with survey grade GPS units. Once the project was proven to be feasible a full scale collection was implemented.

The GPS units used for collection, shown in Figure 6.19, were Trimble Geo XH hand held units. One was borrowed from the University of Redlands MS GIS program and the other was owned by the Montclair GIS office.

Figure 6.19 - GPS Trimble Geo XH

The existing map book was used in the field by project staff to find the depicted fire hydrant locations and to keep track of progress. Many new hydrants were found that were not shown in the map books and many hydrants shown in the map books were not found in the field. The final maps show the GPS collected hydrants layer. A set of maps was created for the MFD (Figure 6.18) to check places where hydrants were depicted and not found, or found and not depicted on the maps. The MFD will report to Montclair GIS staff with updates on the fire hydrant layer after checking these inconsistencies. The GPS collection effort utilized Trimble's TerraSync software.

There were also considerations for the accuracy of collection. GPS point collection accuracy can be increased with a higher number of test points collected for each survey. The Montclair GIS staff previously determined that ten test points collected with a carrier signal would collect a point that was no more than a meter away from the actual location of the fire hydrant. This measurement was considered to be as accurate as the existing map book, meeting the requirements of the project. Upon execution of the collection, it was found that this measure of accuracy was appropriate.

6.1.5. Data Creation Discussion

During the data creation process, a few things were identified that might be done differently if a project like this is conducted again. The editing would have been more precise and accurate if sub-classes, domains, and ranges for data values and data types, as well as topology rules had been set up using the ArcGIS environment.

Cleaning data took up a large amount of project management time. For example, if a domain was set up for the different types of annotation being created for a street name, i.e. main road, subdivision, or alley, then the values in the feature attribute table would have been uniform for symbolization. This means that there would have been no case errors, like Main Street vs. main street, and there would have been no spelling errors, like Maine Stret. These errors were common in the editing process. Layers that would have benefited from this include the parcels, centerline, and fire hydrants.

Also, topology would have helped with the street centerline editing. As it was, many of the multi-family development centerline segments, as well as alleys, were digitized but not connected to the existing network of streets. Simply setting up a topology rule that mandated that all street end nodes must be covered by another part of the centerline, a segment or node, would have fixed the problem.

The specific address labeling and annotation could have also improved. The manually placed labels on the existing map are specific to each fire hydrant and show addresses more precisely than the parcel labeling. Parcel labeling lacks readily identifiable street association because the parcel's frontage is not shown on the map. Either hand placing all address labels or showing the frontage of each parcel, with an arrow or driveway digitization, would have been better options, but both would have required a much longer data creation process.

6.1.6. Pre-Plan Links

Pre-plans were identified as an important source of information MFD in the needs assessment phase of the project. These documents had been used as a static resource and it was determined to be a requirement that the new system incorporate the plans. The plans were added to the system using techniques that required editing, research, and PDF manipulation.

Initially, the plans were scanned into a PDF file format. Plans with two pages simply had the extra pages appended to the first in one PDF document with two pages. As part of the scanning process, each plan was given a unique name. The names were printed on 144 out of 148 documents. The plans without names were given names based on the convention used by the MFD; each plan was identified with two numbers. The first is the grid number the property being depicted is found on, followed by a hyphen and a number representing the order in which it was added to the collection of plans. For example, plan 2-5, shown in Figure 6.20, was the fifth plan added to a property on grid number two.

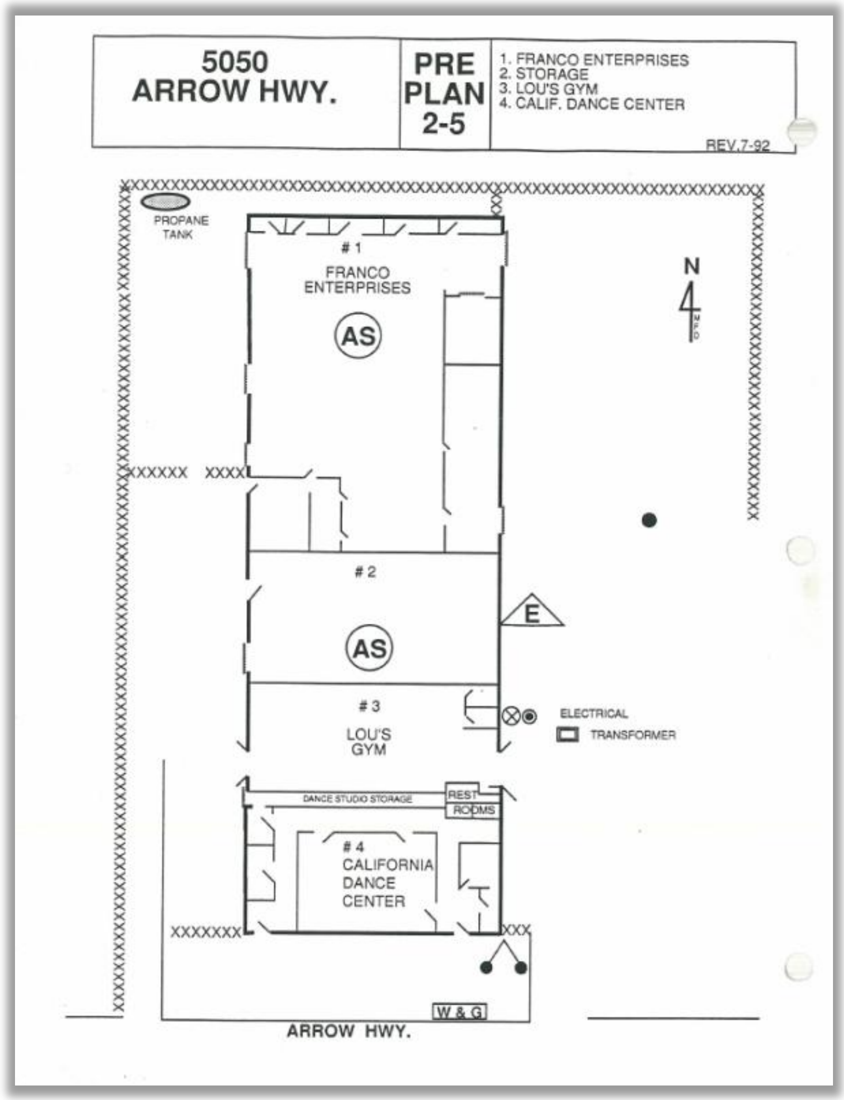


Figure 6.20 - Sample Pre-Plan 2-5

As seen on the plan, the address of the property is shown, in this case, 5050 Arrow Highway. Although this address seemed at first to be the more logical name for the document, it proved that the grid-dash-order was better suited to the project. This will be discussed further in section 6.3 below.

To show the plans on the map pages, it was determined that each property depicted on a plan should be linked to that plan. The link was determined through visual inspection. A new layer was created to facilitate this association called PrePlanLink. The layer created was a polygon that would facilitate the copy and pasting of shapes from the parcels layer into the new layer. This new layer also had attributes about each plan, including the plan's name, address, location, description, date updated, and scale. APN number and owner name were copied over from the parcels layer with the shape. A sample of the attribute table is shown in Figure 6.21.

Attributes of PrePlanLink

Pre_Plan_A	APN	OWNER_NAME	Pre_Plan_N	Revised_Da	Scale	Comments
10200 Lehigh, Hehigh School	100939119	CITY OF MONTCLAIR	11-1	5/21/92		school is entirely fenced, S=storage room, all stora
10300 Poulsen, Kingsley Patio Homes	101062282	HOUSING AUTHORITY/CNTY OF SB	17-8	8/1/92		xxx indicates gates, north and south gates are aut
10342-10398 Ramona, Pinebrook	100949231	WATTERWORTH, HENRY G TR	15-7	9/3/96		can use MEDCO Key at all gates, MEDCO Key or ca
10611-10653 Ramona, Block Plan	101207204	CITY OF MONTCLAIR REDEVELOPMENT AGEN	16-5	8/12/95		Aluminum and magesium alloy scrap storage at Tri-
10685 Central, Shell Bulk Plant	101105227	AYRES SELF-STORAGE OF MONTCLAIR LTD	18-3	1/1/79		MEK, acetone, & kerosene pumped and stored near
10735 Kadota, U. S. Lubricants	101219117	KERBER, JEFFREY	19-2	5/8/95		Knox box on south wall of office, keys to building a
10816 Fremont, Wave rebels	101131101	SMITH, CLAY R	22-1	1/31/96		
10838 Vernon, Golden Arrow Trailer Park	101126131	NAMIMATSU, HIROSHI TR	23-2	2/14/1973		20' width, driveways 400' lay from hydrant #1
11250 Ramona, Monterey Manor Mobilehome p[ark	101236101	AUGUSTA HOMES VILLA MONTCLAIR	25-2	8/4/93		
11255 Central Ave., Echos of Faith Church	101161101	ECHOS OF FAITH REVIVALS INC	28-2	6/27/96		SO. gate usually locked, NO. gate unlocked during
3912 Mission	101220112	NIJJAR, SWARANJIT S TR	19-4			there is a hydrant on the corner of Kadota and Mis
3954 Hampton Drive, Hollywood Homes	101301120	RUIZ, MIGUEL	24-1			
3964 Mission Pomona Skateland	101220110	YANIK, ROBERT J TRUST 4-4-03	19-1	4/14/1983	1"=40'	high voltage wires on west side of building, restrict
4138 Mission Blvd. Shady Lane Trailer Park	101218105	STRAWN, L B TR	20-1	3/01/96		manager is in # 61
4161 Mission Blvd. Montclair Mobile Park	101224128	WUO, STEVE T	20-2	11/1978	1"=30'	cars parked in roadway, private prtection includes

Figure 6.21 - PrePlanLink Table

Each property associated with a plan was imported into this new layer and symbolized on the new maps as a tan color. With this symbolized, emergency managers were given access to a spatial delineation of parcels based on existing plans. Previously, a manager might not have known a plan existed for a property involved in a response event. This is shown in Figure 6.22.

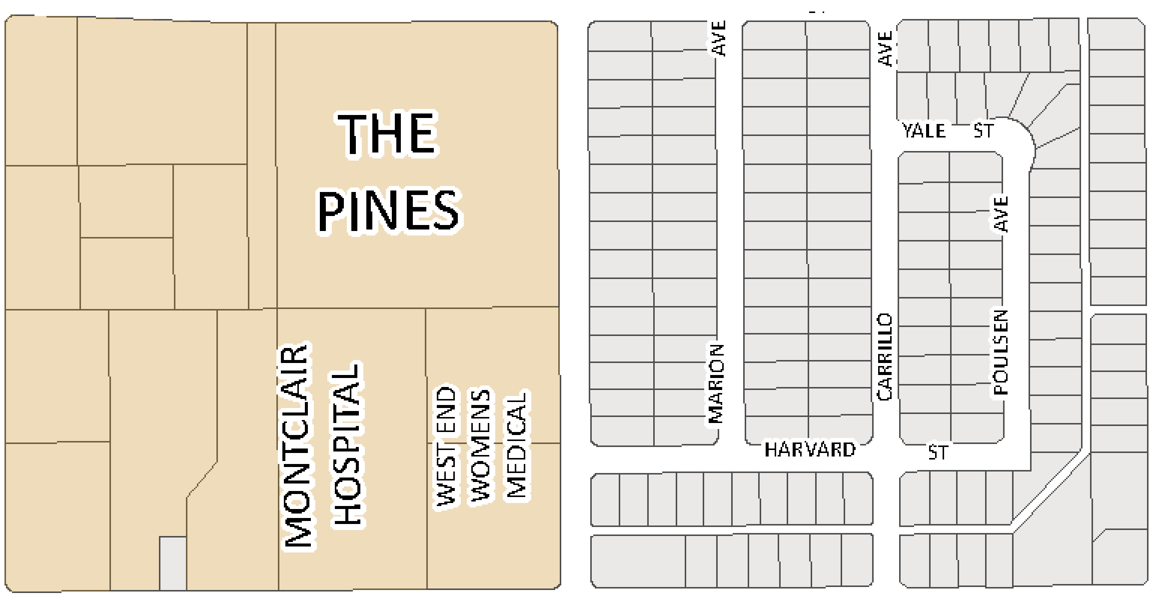


Figure 6.22 - Pre-Plan Delineation

Clearly The Pines, Montclair Hospital, and the West End Women's Medical Center have a plan in the binder, but the area to the east does not.

6.2. Map Book Creation

Requirements for this project specified a light weight solution to the problem. To effectively disseminate the information stored in a proprietary ESRI geodatabase, it was first converted into a different format. A solution involving free, light weight software already installed on the MDCs, with static documents stored in a standard format directly on each MDC was implemented. Specifically, a developer sample that comes with the ArcGIS suite developer tool kit was used.

The sample has some features that were very useful for this project. It can output a set of maps in Adobe's portable document files (PDFs) automatically with some set up. The exported pages go to a user specified location and are named according to a field in the attribute table of the layer input as the index layer. The sample can also change layout features based on fields in the index layer's table. Finally, the maps can be set to be output with the same scale making uniform map measurement possible. Figure 6.23 shows the process which involves clicking on a custom button, set up with the MBDS install, and going through a set of dialogue boxes to set specifications such as output scale, index layer, and data frame source.

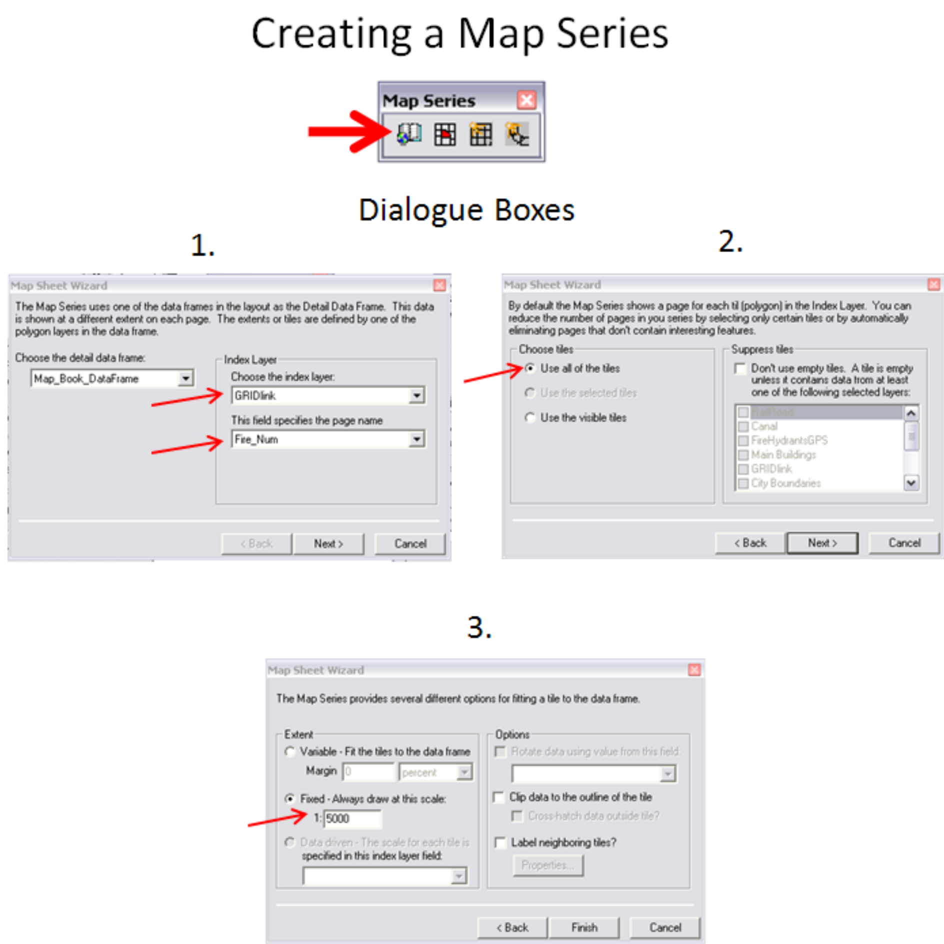


Figure 6.23 - Creating a Map Series

The Map Series toolbar appears after installation of the MBDS. Clicking on the far left icon on the toolbar brings up the wizard outlined in the diagram. Settings specific to this project are denoted by the red arrows. The GRIDlink layer was used as the index layer, and the fire_num attribute was used as the page number. All of the tiles were used, shown in box 2, and the scale was fixed at 1:5000 ft, shown in box 3. Once this is complete the new map series tab in the table of contents in ArcMap will look like Figure 6.24.

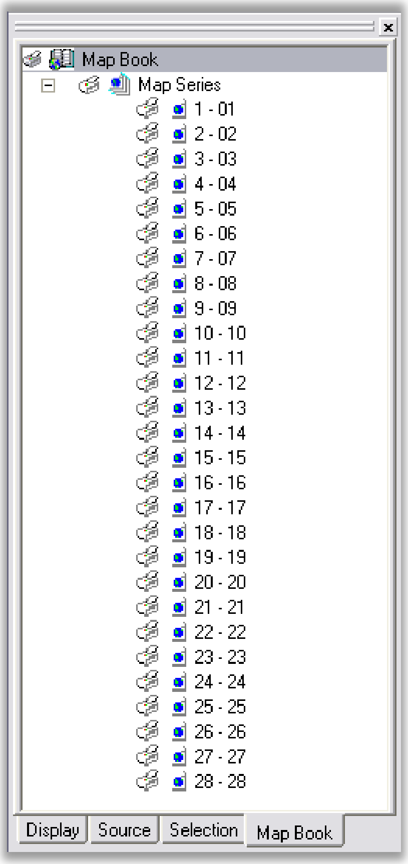


Figure 6.24 - Map Book tab in TOC

After this step, some things needed to be set up. For the MBDS to output pages with the correct page number on the layout, the layout item needs to be tagged as a dynamically updating element (Figure 6.25). This process includes selecting layout elements and tying them with a field of attributes in the index layer for the map book, making the layout elements update when a map is selected to be printed, exported, or viewed.

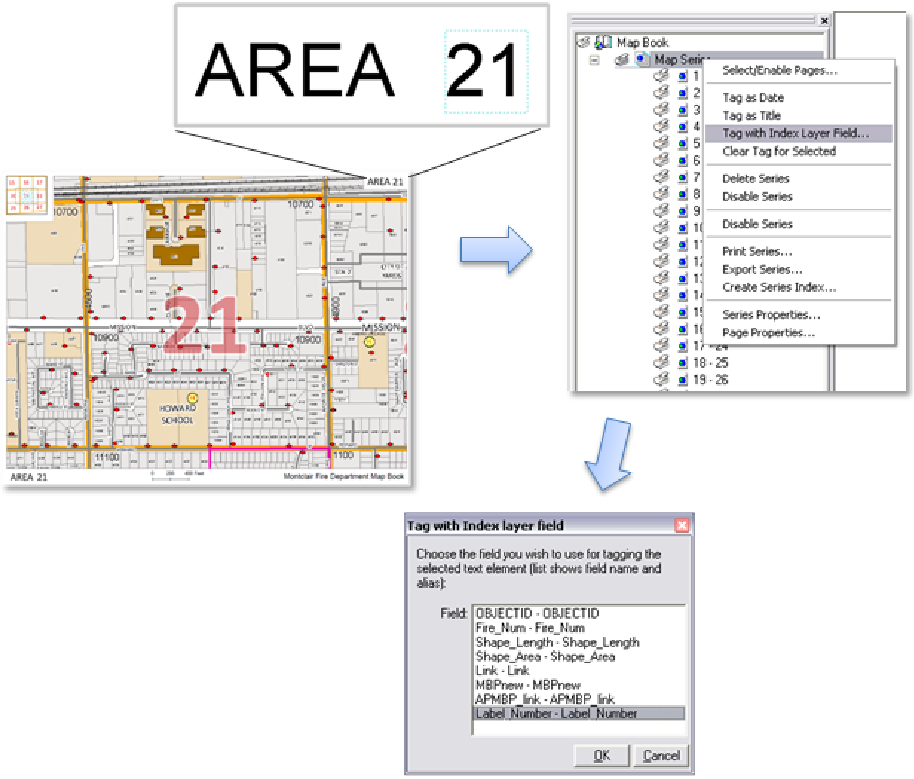


Figure 6.25 - Creating Dynamic Layout Elements

To create auto-updating elements, select the text to be updated (the 21 outlined in the blue selection box in the top right of Figure 6.25), right click on “Map Series” in the map book tab of the table of contents (TOC), and select the correct field, in this case the “Label Number,” to be the value added to replace the text.

The map pages also have a locator index. This was specified by the requirement that managers need to know what grids surround the one they are looking at. To do this, a small map with a small scale is in the top left corner of the map, showing the grid outlines, grid numbers, a designation indicating which grid is being viewed, and a display of the whole area being covered by the map. (Figure 6.26)

Figure 6.26 - Locator Index

There are three steps to creating a custom locator index like the one used in this project (Figure 6.26). The steps involved in making a custom locator index are data frame modifications including showing the current extent of an associated data frame with a box, custom symbology for the selected layer, and index layer symbolization.

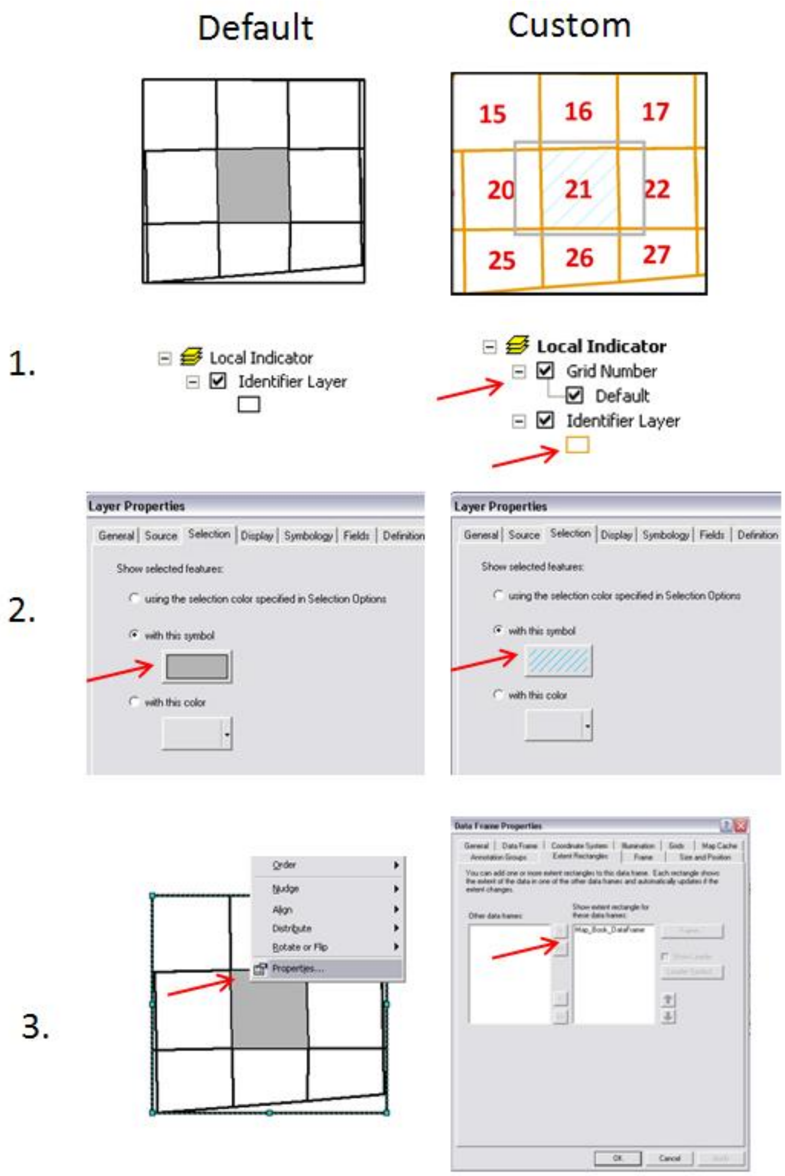


Figure 6.27 - Steps to Create a Custom Locator Index

Firstly, add in the grid annotation and re-symbolize the identifier layer, which will be the layer used to create the map series. For step two, switch the selection details in the selection tab of the properties of the identifier layer to be a light blue cross hatch. Finally, right click on the data frame in the layout view, go to its properties, and add the data frame to the extent rectangles box and symbolize it to be hollow with a light gray outline. This index is dynamic and updates itself for each map exported by the command to create a full set of PDFs, outlined in the next paragraph.

The following diagram outlines the steps to output the map pages into a folder, name them correctly, and set the correct dots per inch (DPI) value. To export a full set of maps, a user right clicks on the “map series” title in the table of contents map book tab and selects export series. Settings for the exported maps, such as file type, resolution, file name, and page output selection, are set with the window that pops up.

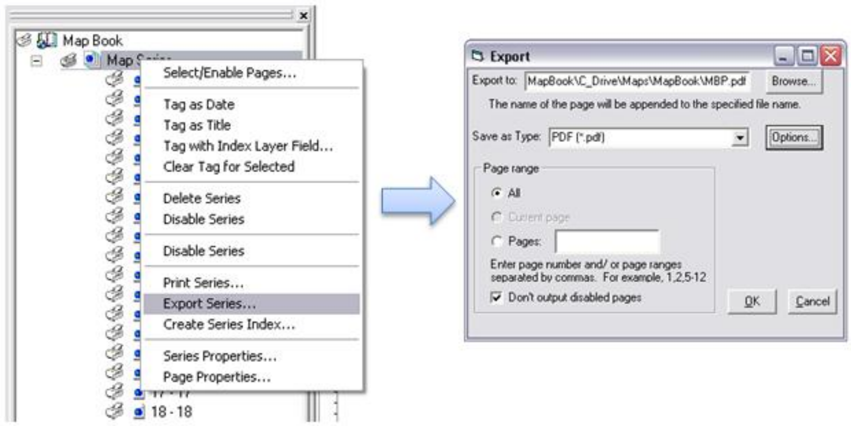


Figure 6.28 - Map Book Export Settings

Uniform naming conventions are important for the created static documents accessible by the application discussed in section 6.3. In this case, map book pages are called “MBP_#” and map pages with the aerial photo are called “MBP_AP_#”. In this case, “#” refers to the grid number of the map. The storage of the documents is also important. For this project, a single repository was created on the main local drive of the work computer. This folder contains all data created for the project and is discussed in the next section.

6.3. Map Page Application

The application for the project had specific requirements: it had to be light weight in processing time; it had to be run outside an ArcGIS license; all information used needed to be stored locally on the responding vehicle MDCs; and it had to be optimized for a touch screen interface.

A light weight application refers to its size and functional speed. The MDCs have 512 MB of RAM, meaning that they cannot run very complex programs. The MDCs run on Windows XP which has been optimized for ease of use in a touch screen environment in the responding vehicles. The computers have been customized to run a program which aides in emergency management. A picture of the program running on the touch screen is shown in Figure 6.29.

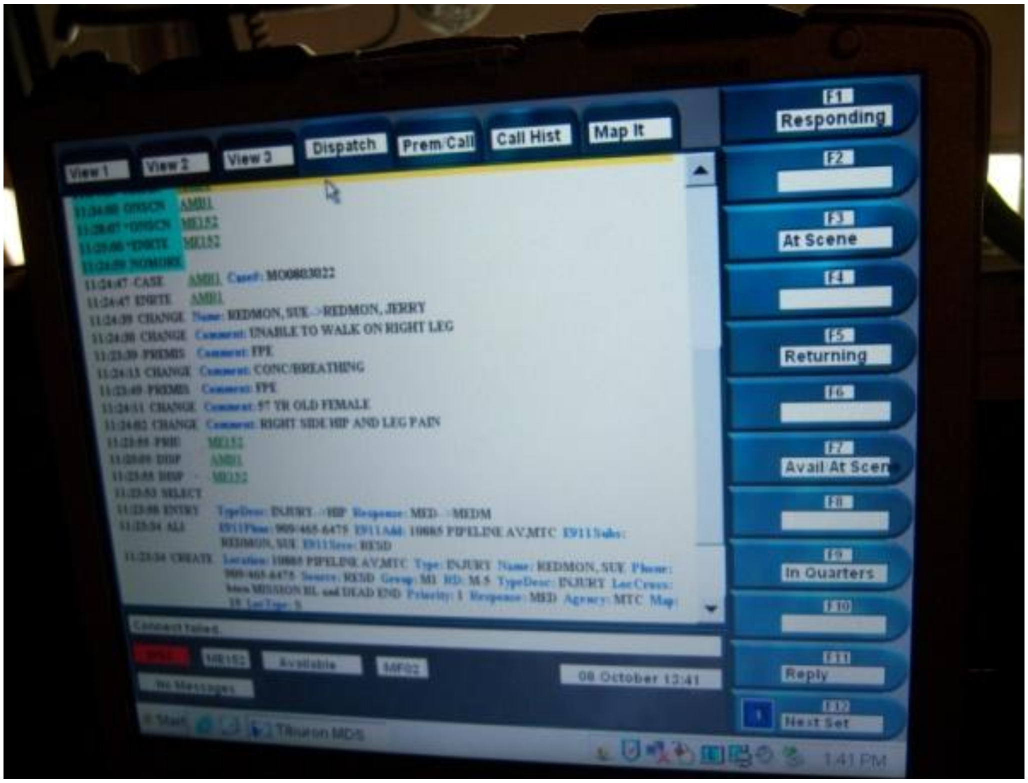


Figure 6.29 - Response Application on MDC

The program is set up on each mobile computer to display the current status of all incidents currently requiring response by the MFD. Caller name, victim name, situation, status of Montclair resources, call history, and other information are obtained through this program. To display this image in the passenger seat of the vehicle, depicted in Figure 6.30, a monitor cable is run from a tough-book laptop computer, shown in Figure 6.31, in the back section of the vehicle.

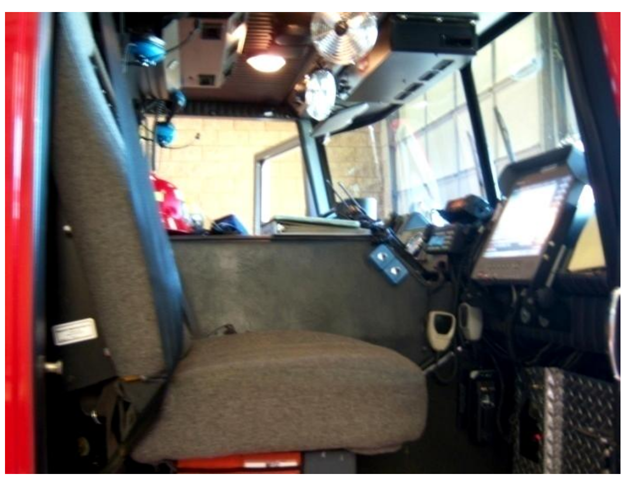


Figure 6.30 - Passenger Seat Set-up

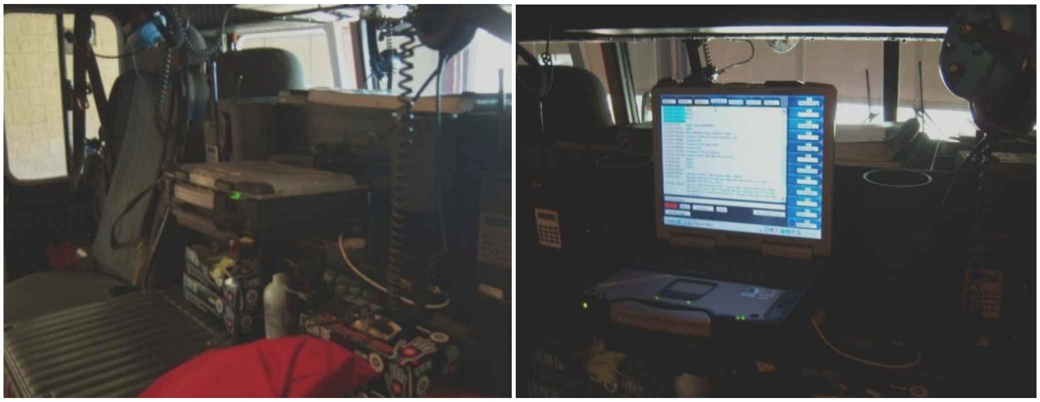


Figure 6.31 – MDC/Tough Book: closed (left), open (right)

Because there is no keyboard in the front seat of the vehicle, a touch screen application was needed.

This project took advantage of the fact that Internet Explorer version 6 is installed and running on the MDC. Image maps were created using a script obtained from ESRI's ArcScripts website. An image map is an HTML page that displays a 'clickable' image. The "map" refers to the fact that each pixel on the image is assigned to a document. When clicked on, or in this case touched, the document associated with that area of the image will open. The initial page of the application is displayed in Figure 6.32, and the retrieval process is shown in Figure 6.33. To find an air photo map, new map, or old map, a user first touches the picture of that map on the first page, then touches the grid number of the map he or she is looking for.

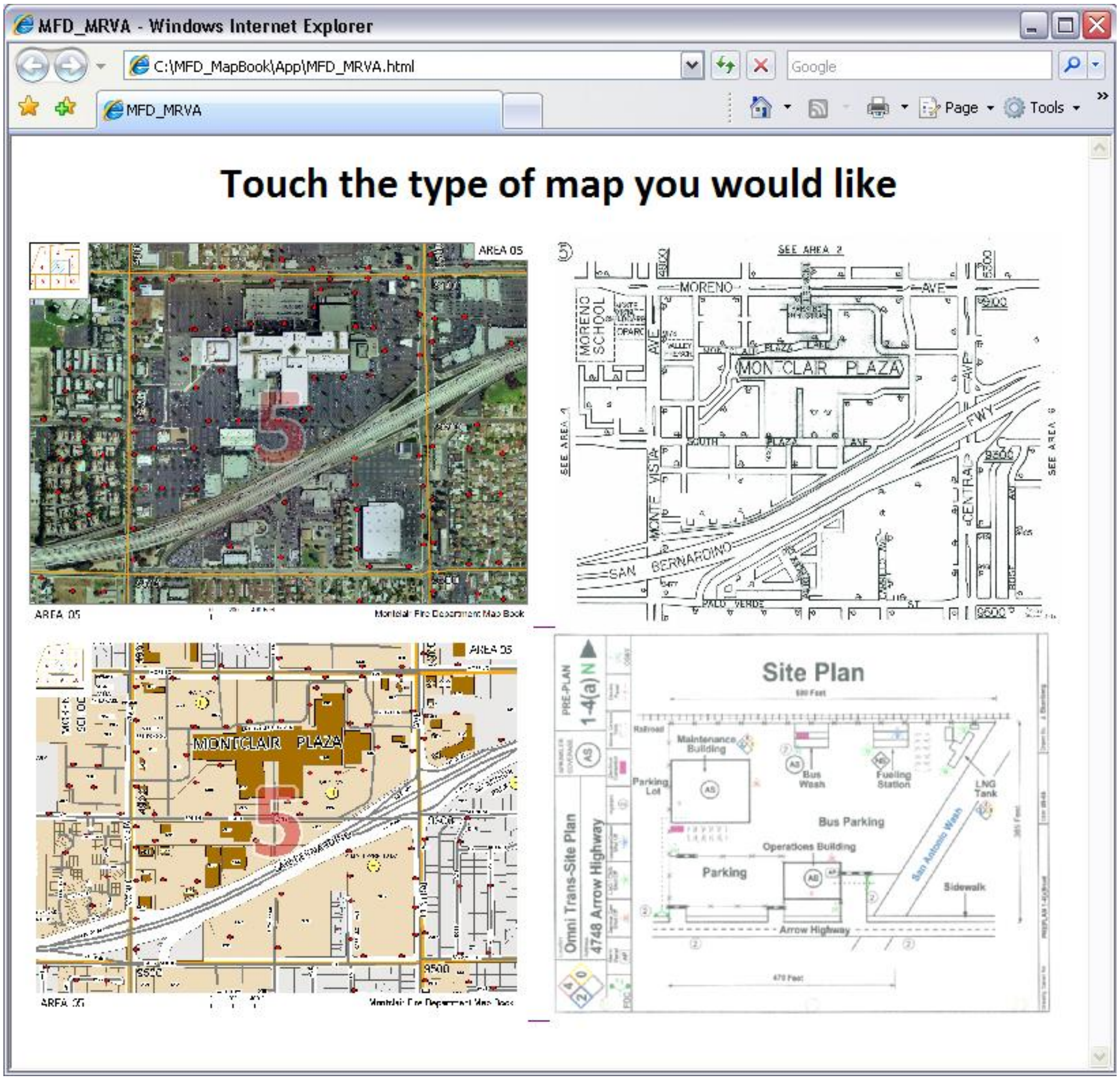


Figure 6.32 - Application View

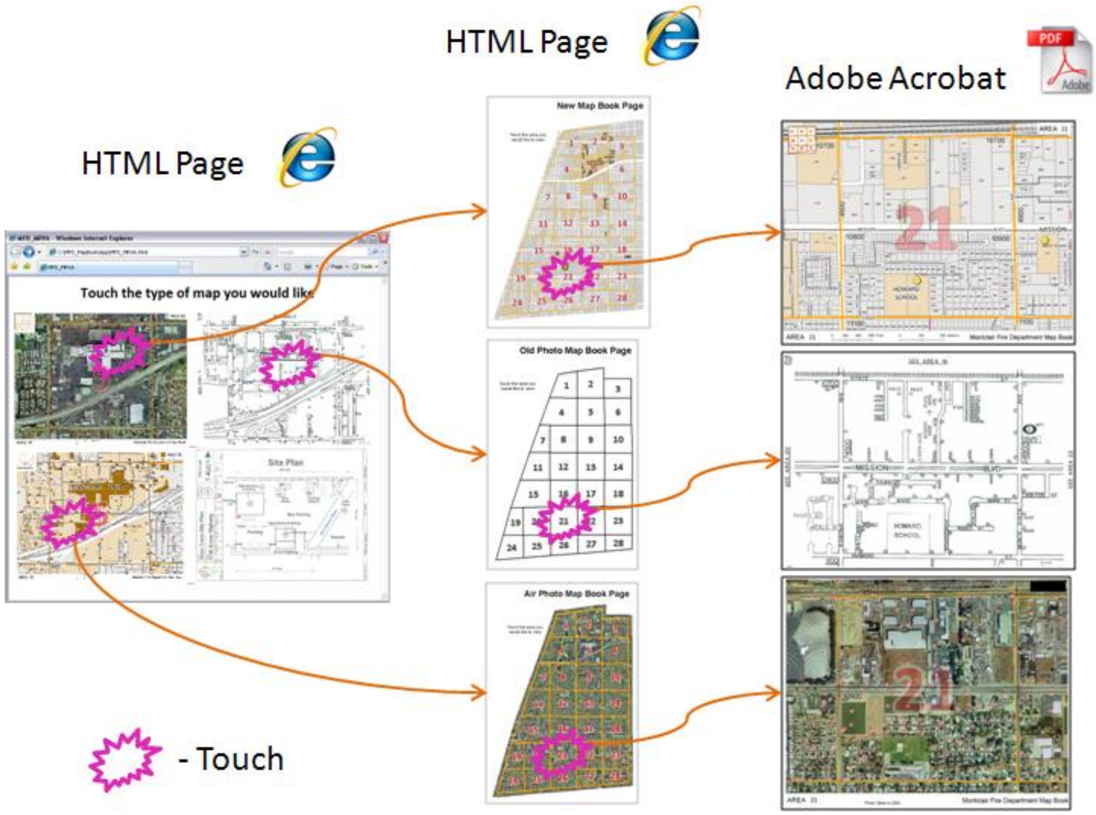


Figure 6.33 - Map Page Retrieval Process

Three image maps were created for the project to retrieve the three digital representations of each map page created, as depicted in Figure 6.33. The aerial photograph map view, the new map page, and the scanned existing map page are linked to individual image maps. These secondary pages were made to represent the page that they link to. The aerial photograph is displayed behind the maps showing the aerial photograph, the new map book page style, with colors similar to the map pages, is applied to the new map book retrieval page, and the old map retrieval page is in black and white to mimic the style of the old maps. Each document was created and stored as a PDF file which allows them to be displayed while users can interact with the files using pan and zoom tools. The PDF documents can also be printed through Adobe Acrobat's free viewer, also installed on the MDCs. A map page is shown in Acrobat in Figure 6.34.

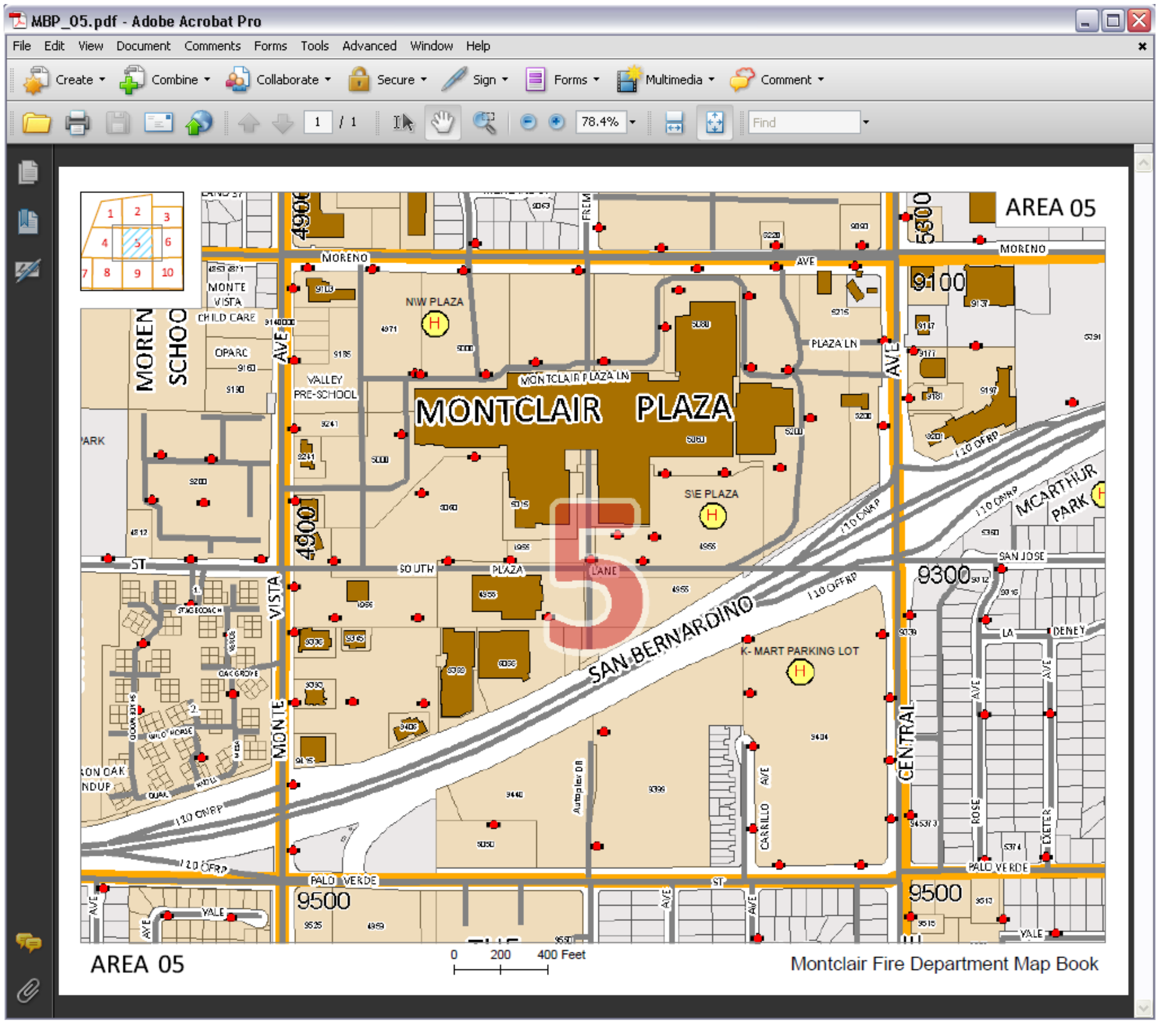


Figure 6.34 - Adobe Acrobat View

To create the image maps, the script adds a button to a toolbar. The button is shown in Figure 6.35

Figure 6.35 - Image Map Button

To set up the response grid layer for the map, a path has to be set for the link to the document. Paths go directly to the C: drive of a computer so maps can be replaced and loaded quickly. The path name for each document in this case was "C:\maps\mapbook\-name-". These paths, showing which document they refer to in the field name, are shown in fields of the GRIDLink layer in Figure 6.36.

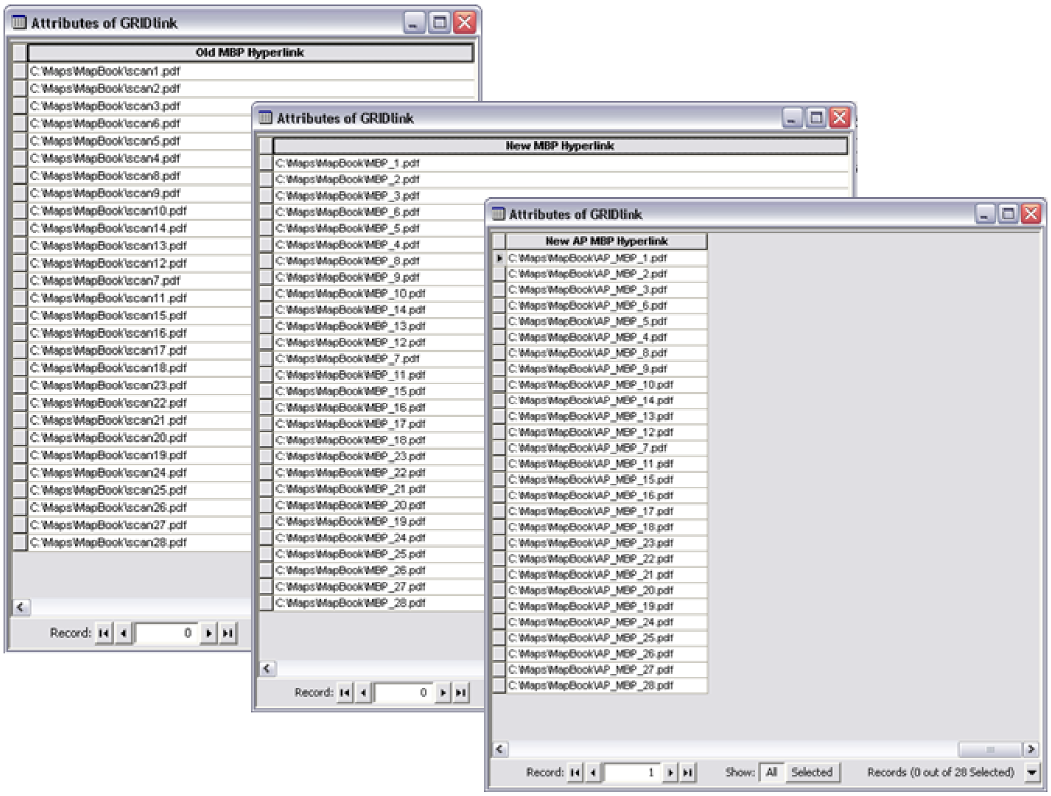


Figure 6.36 - Attribute Links

To create the image map, the user highlights the GRIDLink layer in the TOC, zooms to a layout that will be the final image (whatever is in the data frame will be counted as part of the image), making sure to be in the data view, and clicks on the button. Once clicked, a user follows these steps: identify the field with the link you would like to reference as the "Name Attribute" and "HREF Attribute." Users should also make sure that the image map name is recognizable to make it easy for a responder to recognize which document is retrieved by which image map. The graphic interface for these steps is quickly outlined in steps 1, 2, and 3 in Figure 6.37.

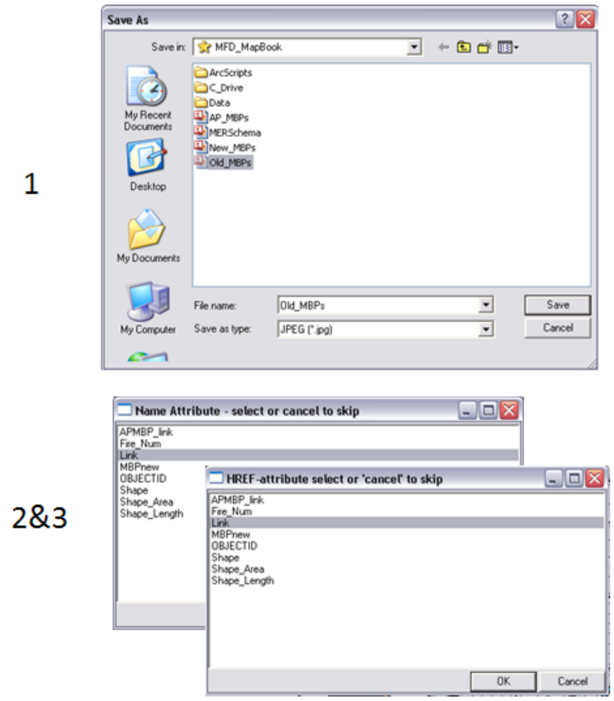


Figure 6.37 - Image Map Creation Steps

Once an image map is created for each document, they are stored on the desktop of the MDCs. The image maps have a static path name to the PDF documents, so as long as the documents are in the correct place, on the C: drive under maps\mapbook\ in this case, and they are named correctly, the documents will open when a grid is touched.

A further use of the image maps was another application that links the pre-plans to the response grid. This map shows the PrePlanLink properties symbolized in the tan color and makes the plans accessible through the map, the same way that map pages are accessible through the initial image map. Figure 6.38 shows the process to retrieve a plan from the touch screen interface in the vehicle.

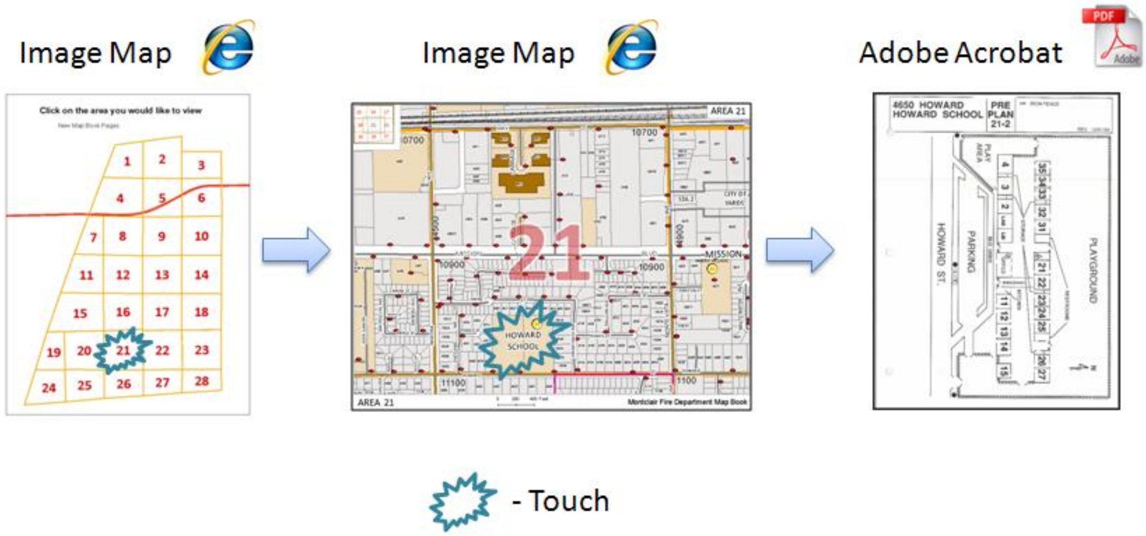


Figure 6.38 - Pre-Plan Image Map Access

The paths to each pre-plan were created in the PrePlanLink layer. Each property indicated in the PrePlanLink layer was given a path created using the plan number field. The SQL code to create the path name is ‘"C:\maps\preplan\"+ [Pre_Plan_N]+".pdf"’, shown in Figure 6.39. With the application deployed, emergency managers have the option to view three versions of each map page. This can be done on the touch screen or in the map book. The pre-plan can also be viewed in digital format on the touch screen.

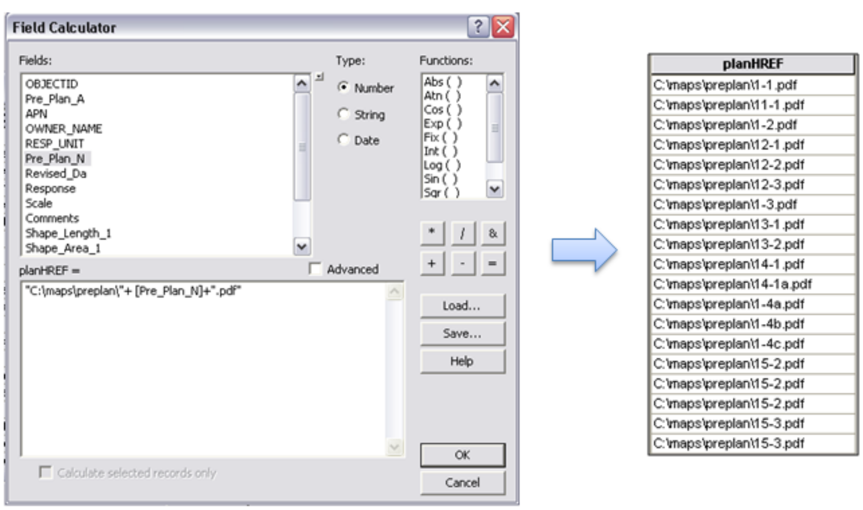


Figure 6.39 - Path Name Creation

6.3.1. Update Process

The map book pages have to be updated as infrastructure conditions change in Montclair. In interviews with emergency mangers, it was made clear that this update process would not be a large consideration for the maps because Montclair is “99% built-out,” as quoted from MFD and GIS staff in Montclair, but inevitably, there will be some changes in the layers included on the maps.

A page was inserted into the map book with details on the update process. That page’s contents are show in Appendix A.

There are many considerations for updates of the map pages. Mainly, the updates will come from MFD personnel who notice changes on the map pages for fire hydrant locations or pre-plan links. The parcel lines and centerline will be maintained by the Montclair GIS office and imported into the MFD response database as necessary.

All documents are created from one central database, so any updates made digitally will be reflected in map pages each time the MBDS is run. To get the application up-to-date, the digital map pages need to be replaced in the map book folder. In this case, the C:\maps\mapbook folder needs to be updated on each vehicle. The Montclair GIS office will take control of all operation after delivery of the system.

6.3.2. Training

Through the course of two visits to the MFD in August and October, 2007, fire department personnel were trained to use the application on the MDCs. The map book did not need explanation because it is a replica of the system currently in place. The image maps proved to be easy to explain and were well received by MFD personnel.

The Montclair GIS staff was also shown in detail how each part of the system worked. Update procedures were described in terms of the map book recreation, application updates, and digital data updates.

7. Discussion

7.1. Results

The goal of the project was getting responding agencies more information about the areas in which they work each day. Considerations for map books used in emergency management were researched along with GIS data collection strategies and best practices. The application created for this project effectively retrieves static documents through a spatial selection user interface accessed through the response vehicle computer.

The information on the maps is utilized by emergency managers for incident response planning involving events such as medical emergencies, fires, or hazardous material spills. Because of this, maps need to be up-to-date to give managers the most accurate information to use in tactical planning. To meet this need, a new ArcGIS data storage and update routine was created to facilitate data and map updates based on the data created and collected. Pre-plan documents and maps were also linked to the map pages and map pages to the town response grid in a touch screen application that resides on Montclair's emergency response vehicle mobile data computers. Data including GPS collected points, air photos, parcels, street names, and helicopter landing zones among others, was collected or created, imported, and exported to meet the needs of managers controlling the tactical response of Montclair's fire department.

This project resulted in many things to be used by MFD emergency management personnel.

- A digital geodatabase was created to facilitate the display and updating of critical emergency response spatial data
- A new hard copy map book was created with enhanced, updated information
- Pre-Plans were digitally linked to the emergency response management system
- Montclair's aerial photograph was incorporated into the emergency response workflow
- Scale was added to each map page, facilitating accurate measurement on the maps
- Building footprints were incorporated into the map books
- Applications were created to view all map documents digitally on the MDC in each response vehicle
- Applications were created utilizing free software and ArcGIS customizations coordinating with only one ArcInfo level license

Each map also has a locator index that shows which grids are surrounding the area and street name annotation was created and placed so that every street depicted on every map is named.

Unlike Google Earth™, Map Quest™, Yahoo Maps™, or any other online mapping application, the information displayed for the client includes specific feature information for the City of Montclair and the application does not require an internet connection. The project improves the decision making process involved in an incident response by giving responders access to important information that would not be readily available or understood in a non-spatial format. The results of the project for the client include a faster information gathering process, data-rich map book, and a greater overall spatial understanding for fire department emergency managers to plan a response to an incident inside the Montclair. These improvements to Montclair's emergency response mapping systems will continue to grow as the MFD begins to review the data and each layer becomes finely tuned with updates from firemen in the field and from Montclair GIS data creation initiatives.

7.2. Legal Issues

It is recommended that Montclair officials fully check each data layer for quality assurance and control before deploying the final products. Also, the City Attorney's office should be informed of the preliminary status of the new fire department map book data to avoid any negative legal issues potentially brought against the town by citizens affected by incomplete data. It is recognized by project staff that all data will need to be checked by the fire department before use, including but not limited to, fire hydrants, street names, and helicopter landing zones. A disclaimer page in the map books describes the state of the data (Appendix C).

7.3. Future Work

An emergency management tool was created in this project. There are, however, ways to improve the system in the future. First, more layers could be added to the response database to be shown on the maps. Digitizing all building footprints, driveways, and multi-story buildings into new layers to be displayed on the maps would be just a few layers of information that could improve the management decision making process. This was not done for this project because the time needed to digitize these features was outside the project's scope.

Each helicopter landing location has had a survey done to outline its physical characteristics. This project application would benefit from an option to view these plans. This could be done by creating a polygon covering the area depicted to be the landing zone by each plan, and linking that to another image map.

Updating the pre-plans would also improve the system in many ways. The plans are a mix of old and new plans with vastly different degrees of information. Creation of standards for the plans and digitization of all features would be a good next step to make sure information on each plan is not out-of-date. A preliminary project to facilitate some information transfer from pre-plans to map pages would be to digitize all fire alarm shutoff panels, sprinkler shutoffs, fences, walls, and hazardous materials that are only shown on pre-plans. These are common things found on pre-plans, and simple lines and points on the final maps would easily show these layers.

The aerial photograph has three inch resolution that goes to about three feet when the image is converted to a PDF format. If this resolution could be preserved, responders could use the information, down to the location of a single tree, to make decisions. The image cannot be viewed in the responding vehicles because of the limited capabilities of their computers. If the computers are upgraded in the future, an ArcReader application, or other image viewing application, could be put in the trucks to enable the viewing of the full resolution photograph.

A further area of future work would be an interface to access property information contained in the parcel layer obtained from the county. The MFD has made it known that building materials for houses, types of roofs, and assessment values would be useful to emergency planning initiatives. This information access would be suited to an ArcServer application, or an online service. In the future, the MDCs could potentially have adequate wireless connection speeds to make an online solution viable.

The application run on the MDC for emergency management would be greatly enhanced if the map pages were available from an interface inside that application. In that case, the manager would not have to minimize that application to access the image maps, as is currently necessary. If there was a way to have the map page up on the screen showing the incident response area when responders get into a response vehicle, the system would be improved.

Automated, streamlined updates for the map pages and application would be another improvement. If the application was a web service running off a central server, updates could be made each night, or each minute, to the maps if the data could be dynamically served to the application on the MDCs. A local network that updated the map pages automatically each time a truck returned to an MFD station was a strategy considered at the onset of this project, but not implemented due to time restrictions. In terms of updates, another improvement would be to create an application that could track updates of data and export map pages that had changes automatically, or to report to GIS staff which pages had updates so the books could be updated.

Currently, the MFD is waiting for data from the water district that Montclair is a part of, which is responsible for all fire hydrants within the Montclair borders. It would be interesting to get this data and check for inconsistencies, look at flow rates and fire suppression coverage, check pressure zone considerations, and propose new fire hydrant sites based on proximity to existing hydrants.

Finally, it would be useful to symbolize pre-plans on the map book pages so a reader could tell where each pre-plan's boundary is, how many pre-plans are associated with each area, and how pre-plans overlap. Currently, parcel lines are used to designate pre-plan coverage, but there is no boundary for areas that contain pre-plans that are adjacent to one another. A new layer of pre-plan footprints would be useful in conjunction with some annotation with pre-plan numbers on the maps corresponding to pre-plan coverage.

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Appendix A

Update Page

Montclair Fire Department Map Book – Update Procedures

Data Updates

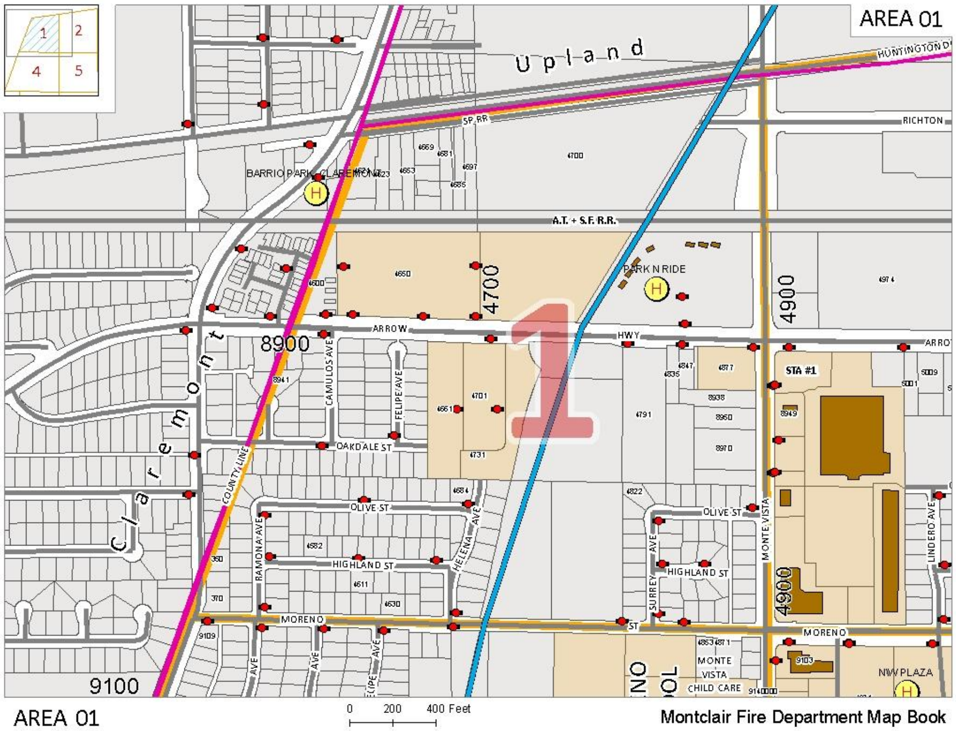
1. Obtain and replace parcel boundaries from Montclair GIS staff
2. Add new subdivision or construction centerlines
3. Add new centerline segment street names
4. Add new main building names to map annotation
5. Update any building footprints added
6. Update fire hydrants installed or removed
7. Add new pre-plan parcels – be sure to fill out attribute information

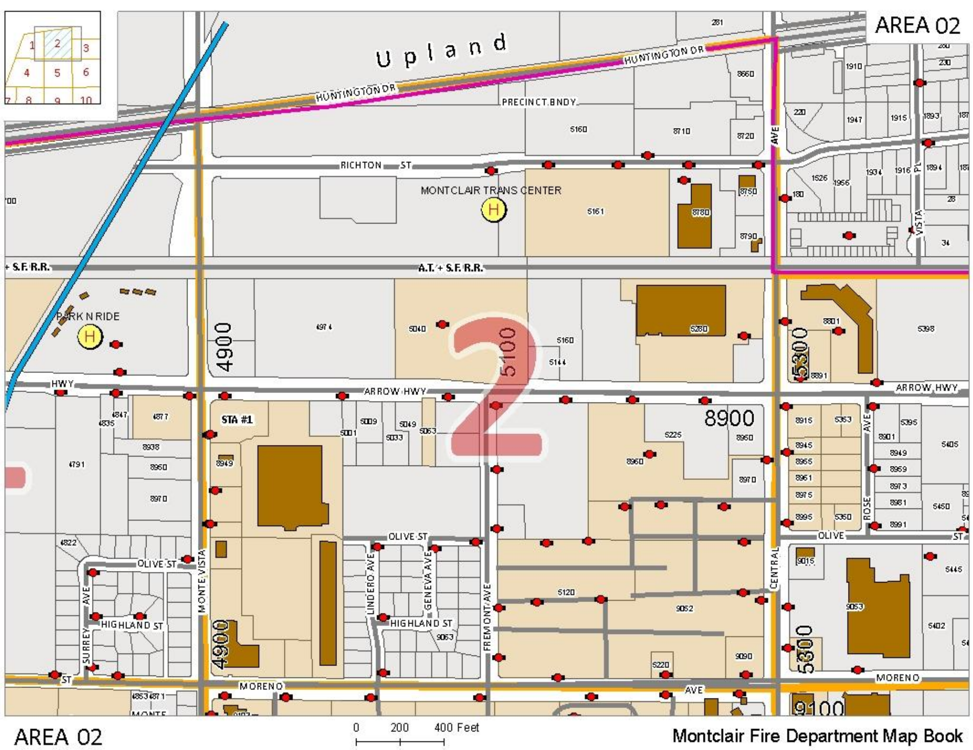
Application and Map Book updates

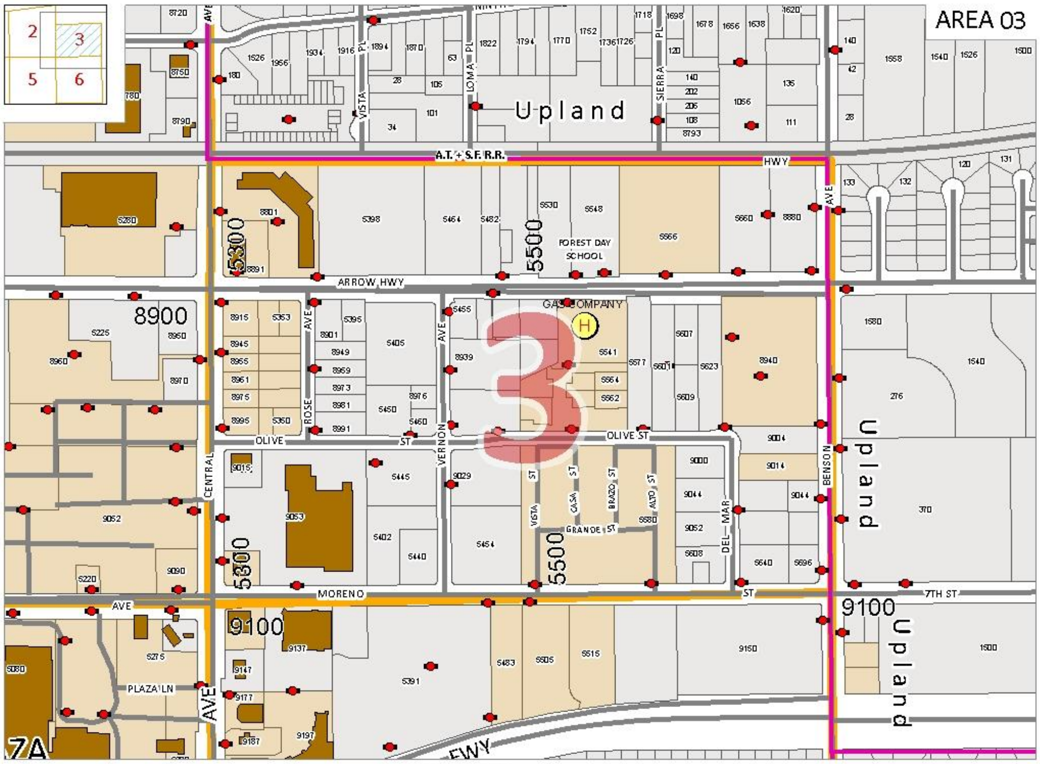
1. Re-print any pages with changes
2. Replace the pages in the map books
3. Link new aerial photographs to air photo map page and recreate the set
4. Create new PDF files for each map book page created (keep naming standard – "MBP_#" AND "AP_MBP_#")
5. Replace PDF files in responding vehicles MDCs
6. IF PRE-PLAN UPDATES – re-create image map map pages and replace on responding vehicles

Appendix B

Map Book Pages







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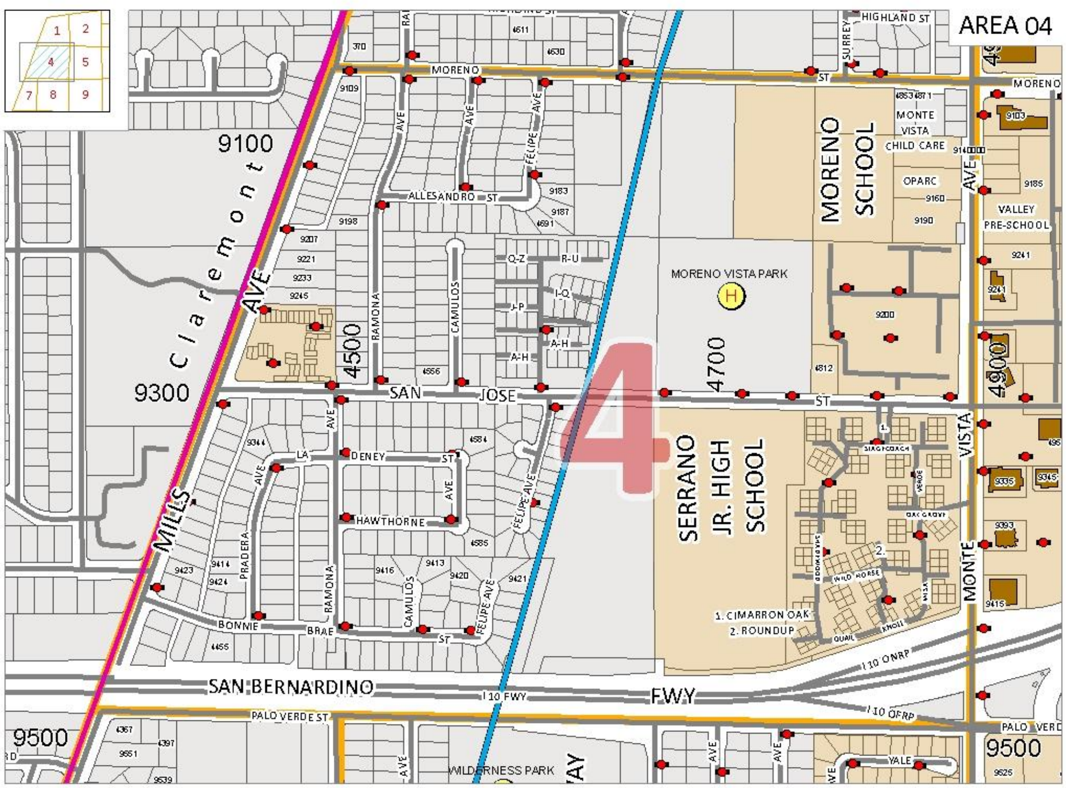
Montclair Fire Department Map Book



AREA 04

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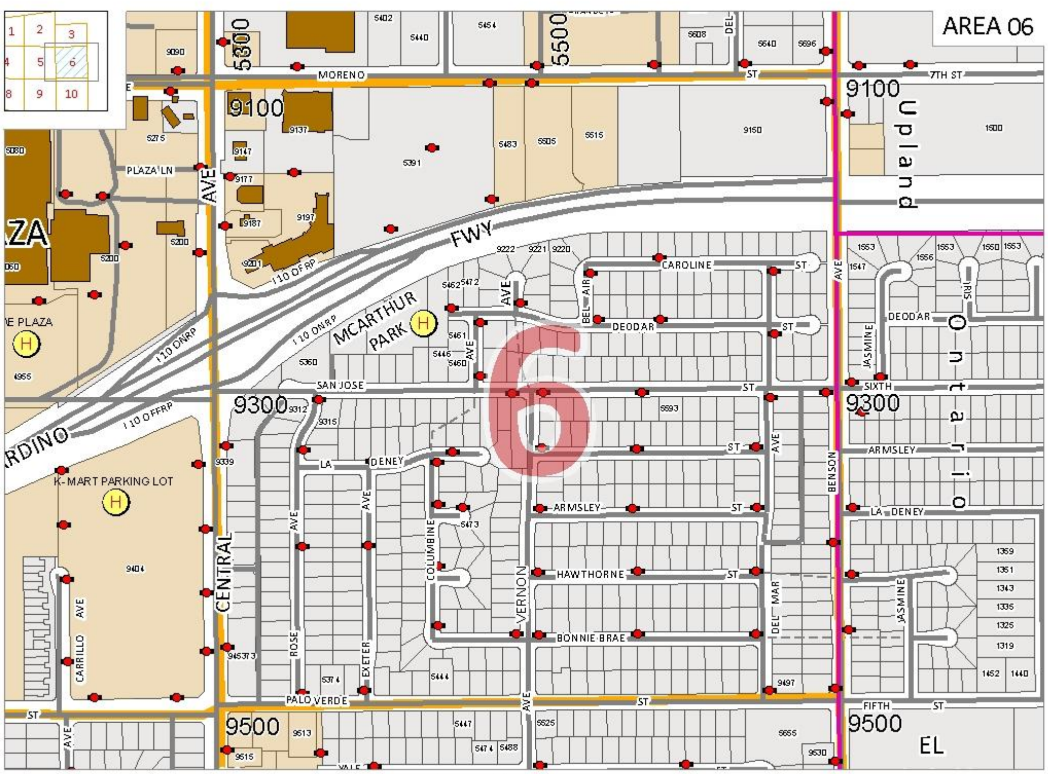
Montclair Fire Department Map Book

AREA 05 | 0 200 400 Feet | Montclair Fire Department Map Book



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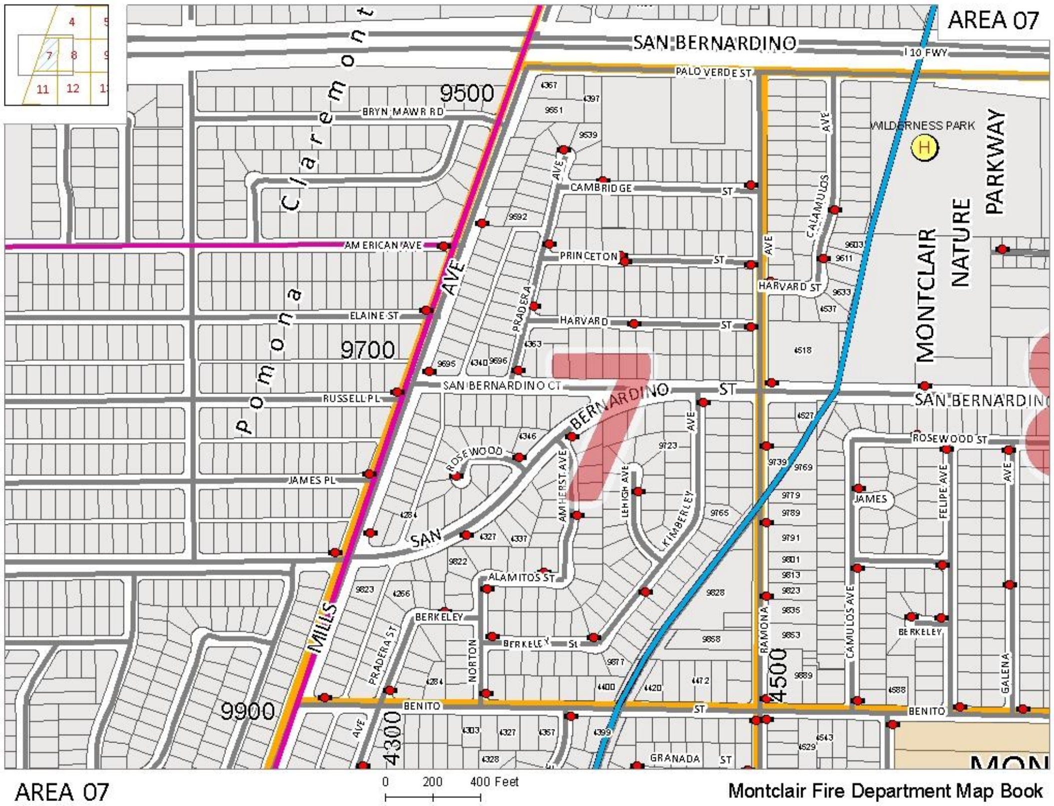
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PRINCETON ST
HARVARD ST
ELAINE ST
9700
RUSSELL PL
SAN BERNARDINO CT
SAN BERNARDINO ST
ROSEWOOD
JAMES PL
ALAMITOS ST
BERKELEY
BERKELEY St
BENITO ST
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4300
4500
GRANADA ST
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MONTCLAIR NATURE PARKWAY
CALAMULOS
RAMONA
CAMULOS AVE
FELIPE AVE
GALENA
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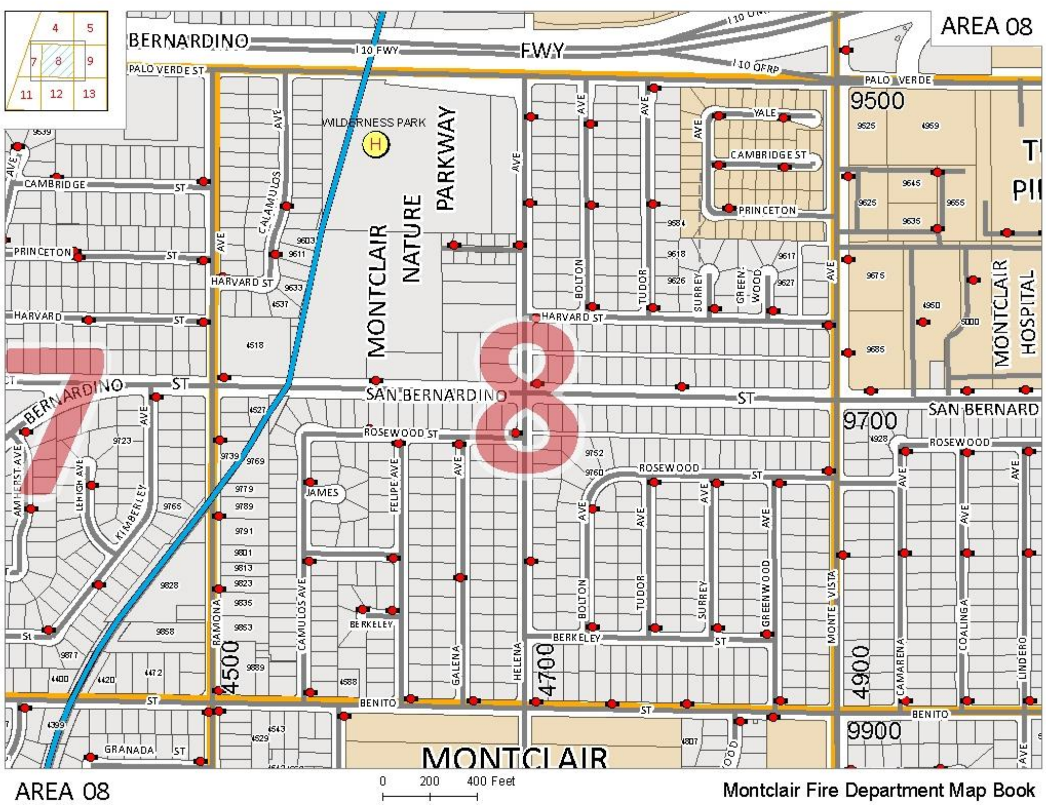
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SURREY
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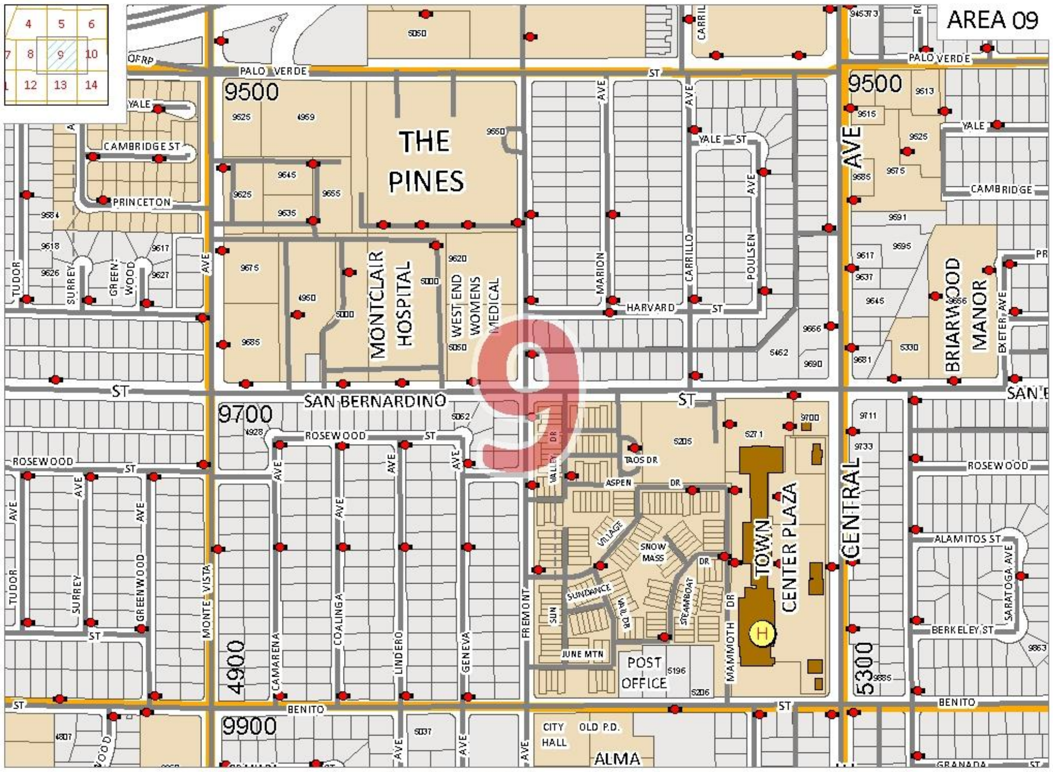

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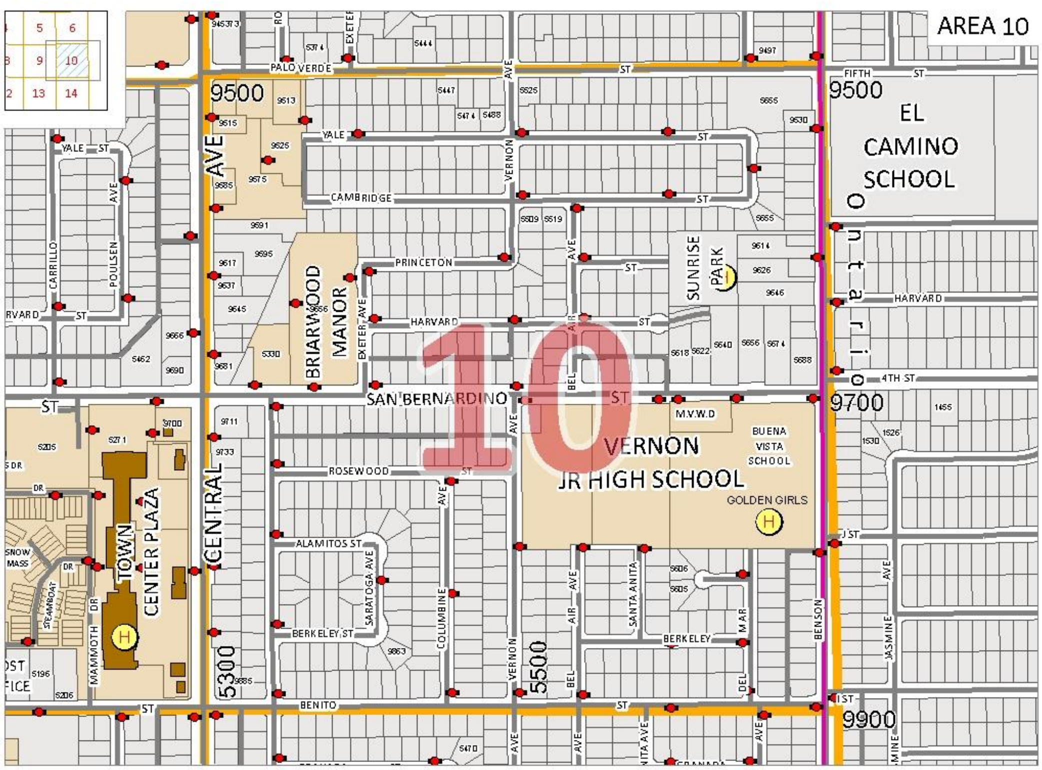

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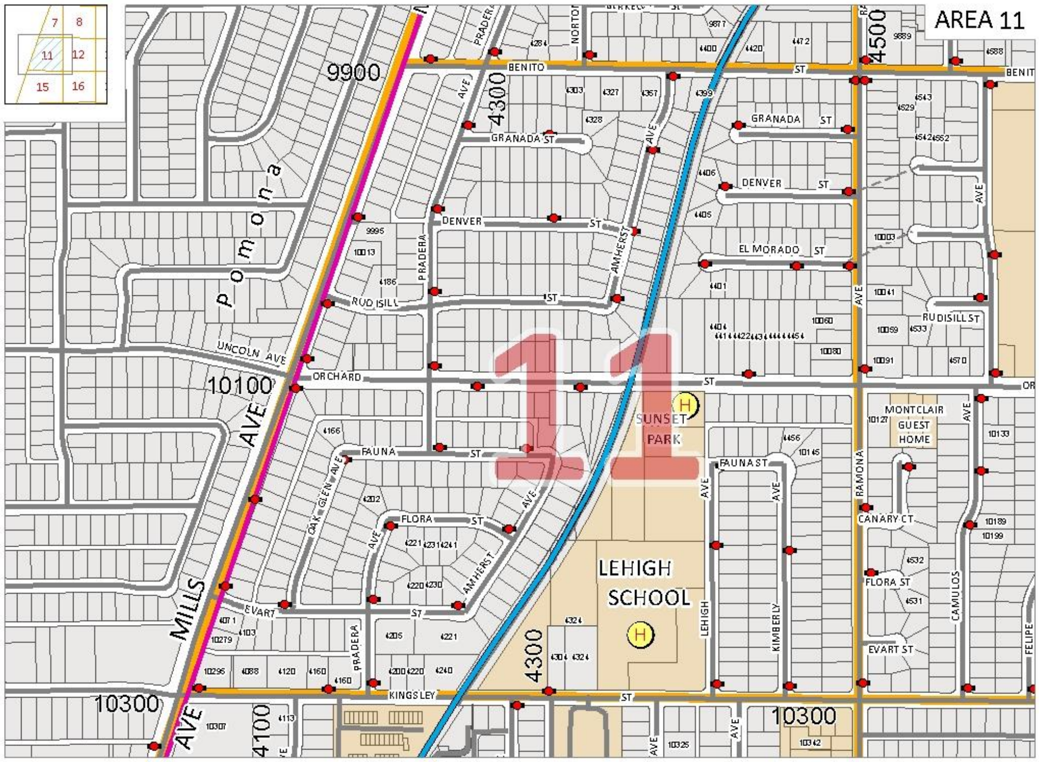

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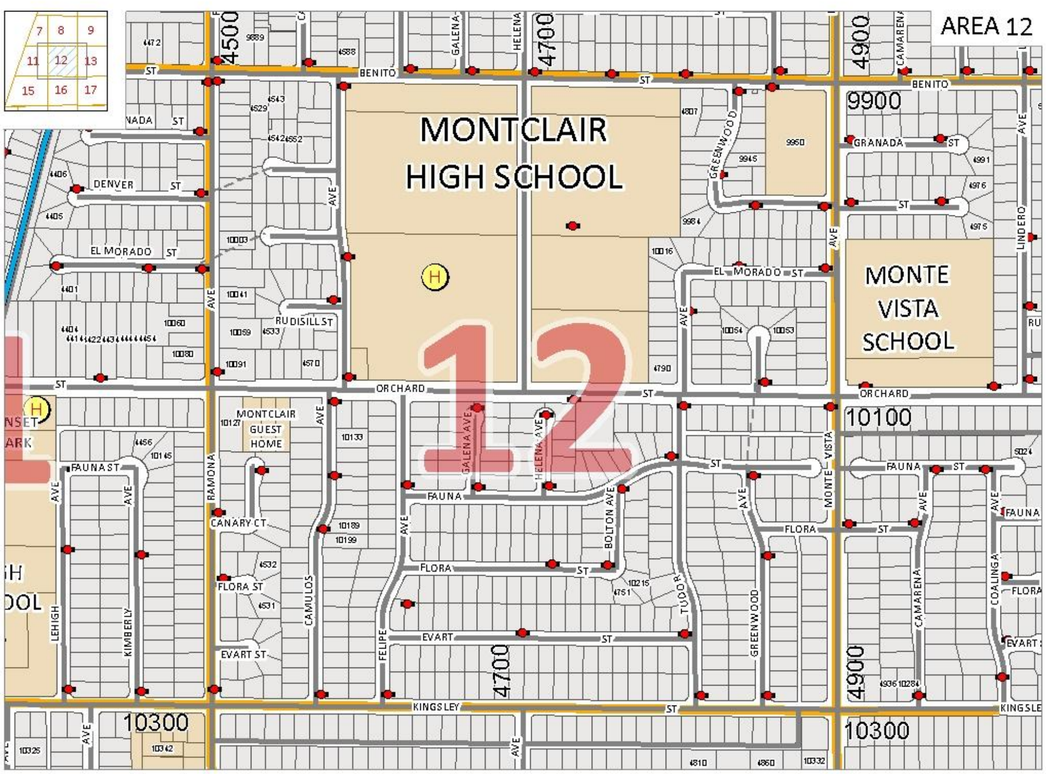

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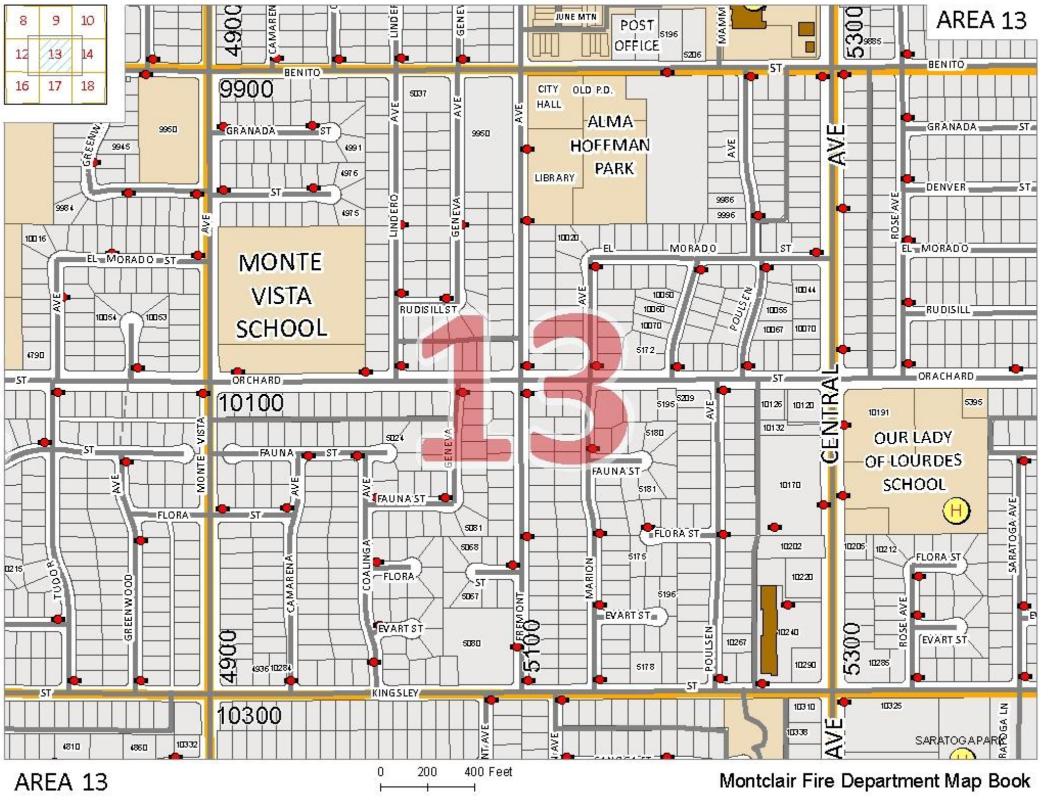

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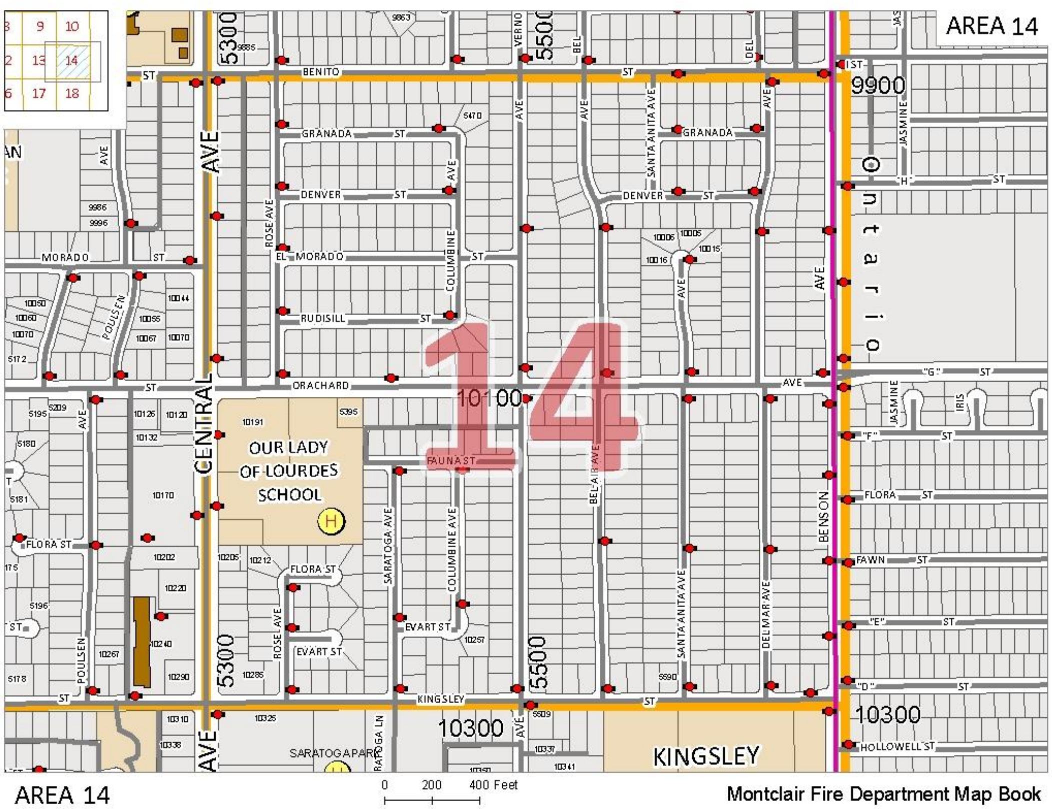

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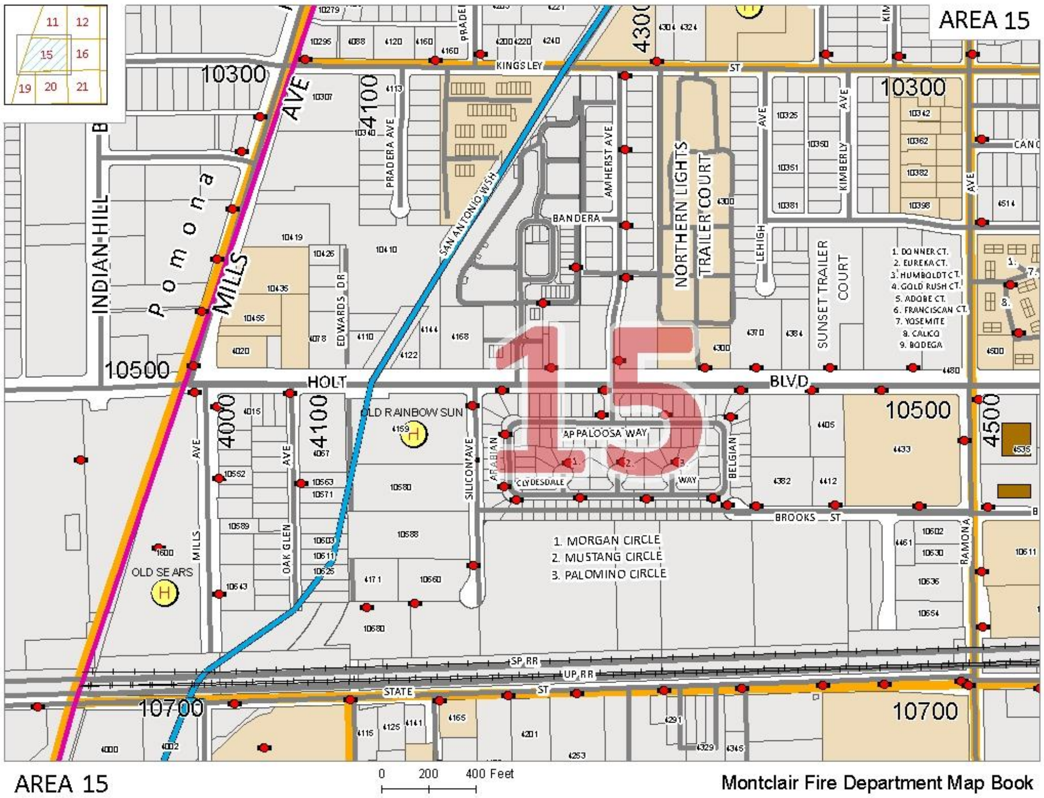
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CLYDESDALE WAY
OLD RAINBOW SUN
OLD SEARS
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2. MUSTANG CIRCLE
3. PALOMINO CIRCLE
1. DONNER CT.
2. EUREKA CT.
3. HUMBOLDT CT.
4. GOLD RUSH CT.
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8. CALICO
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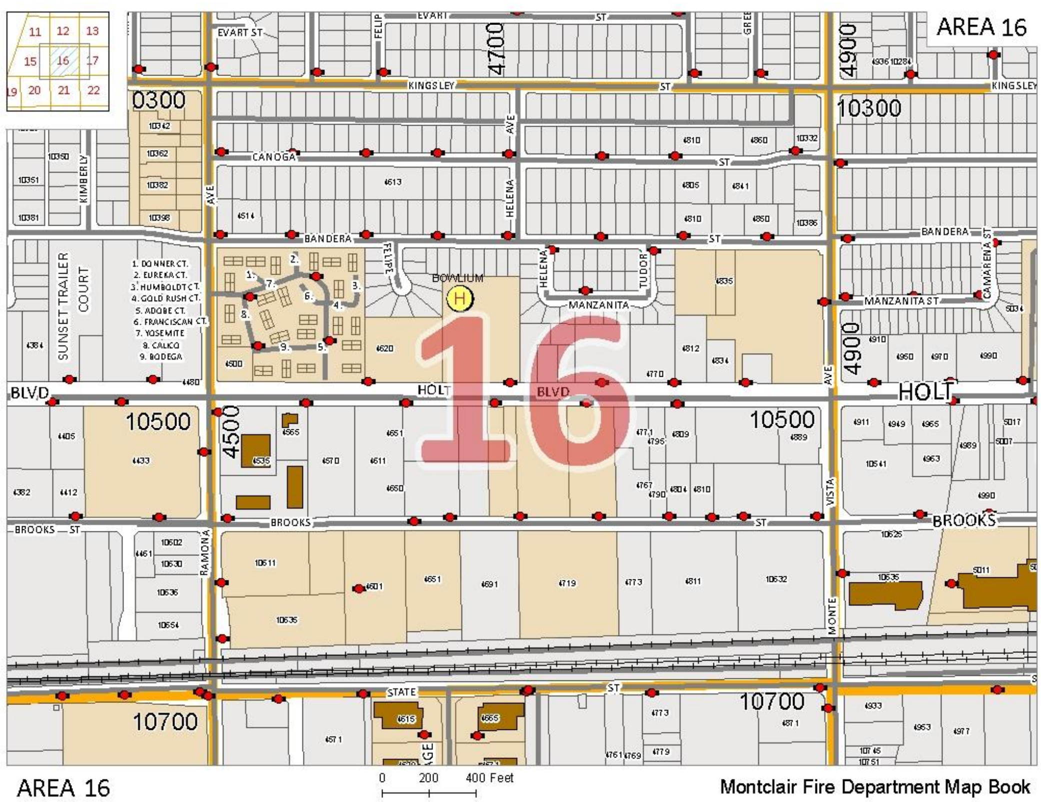
Montclair Fire Department Map Book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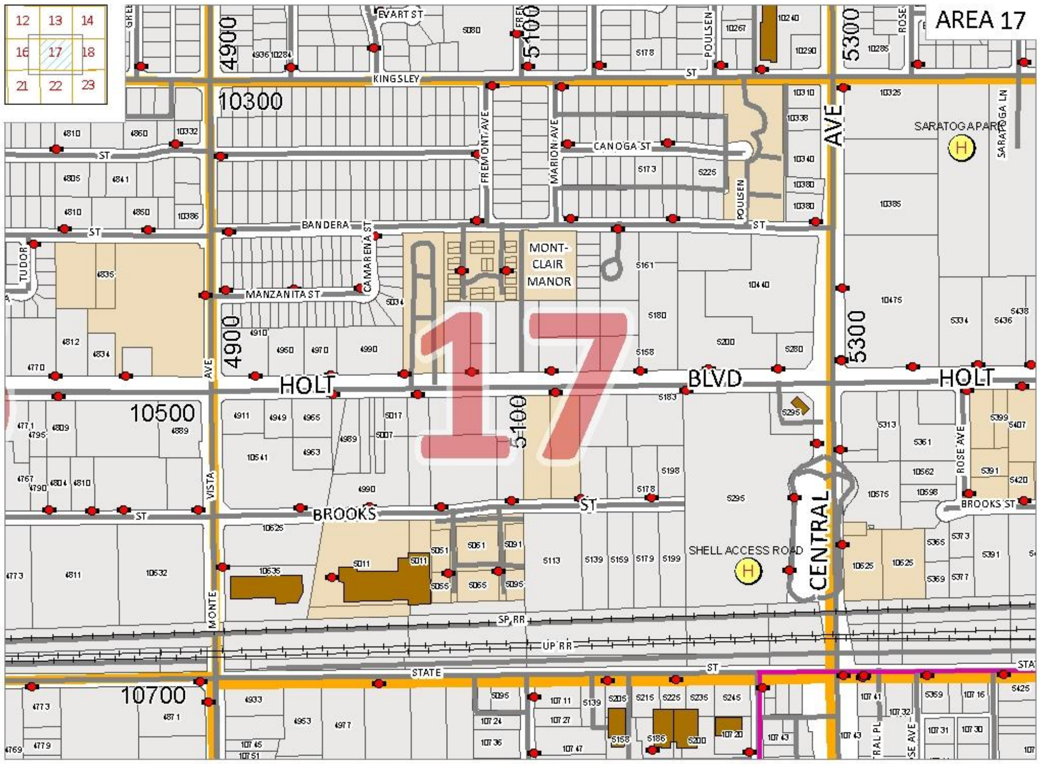
Montclair Fire Department Map Book



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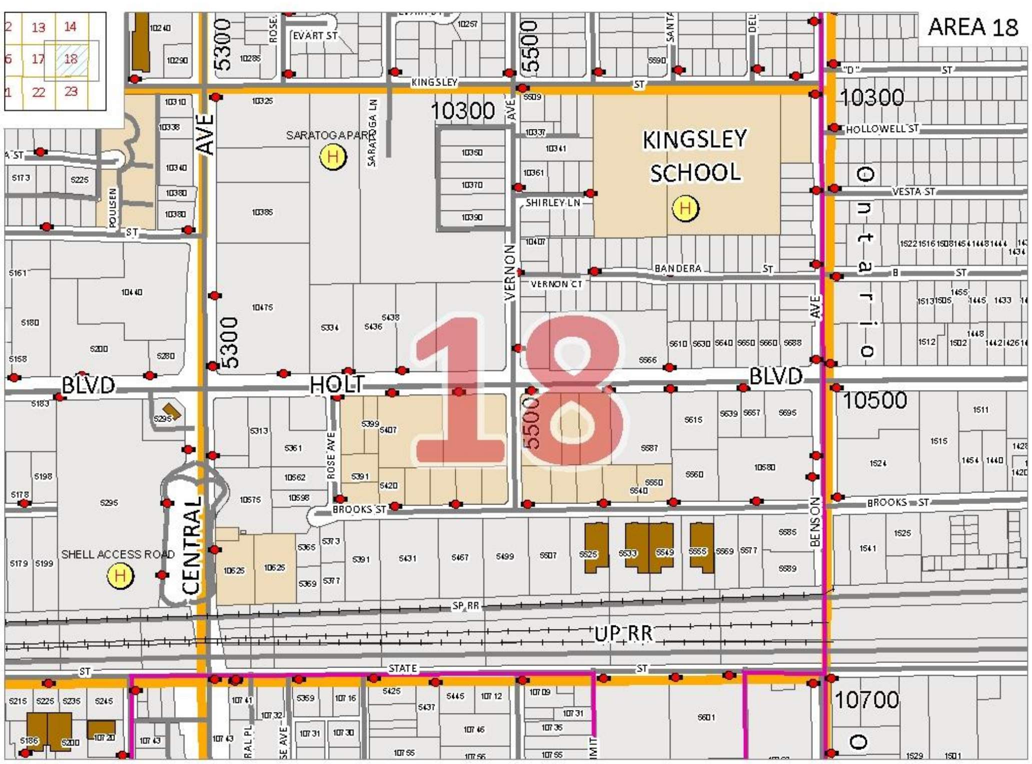

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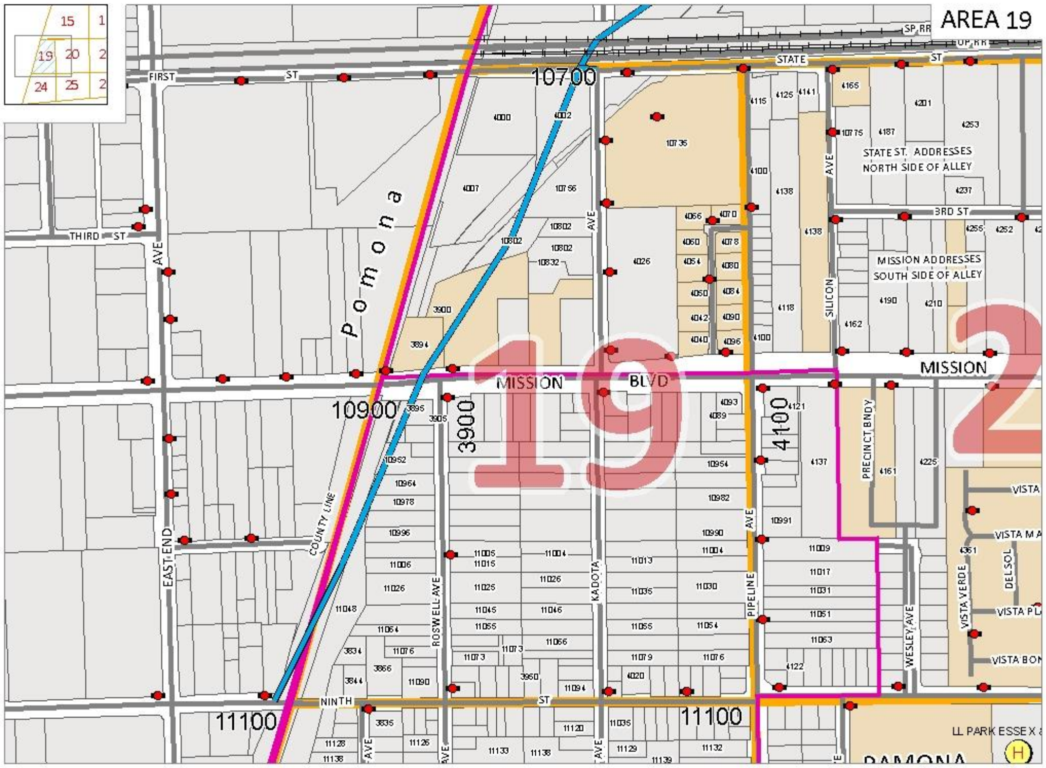

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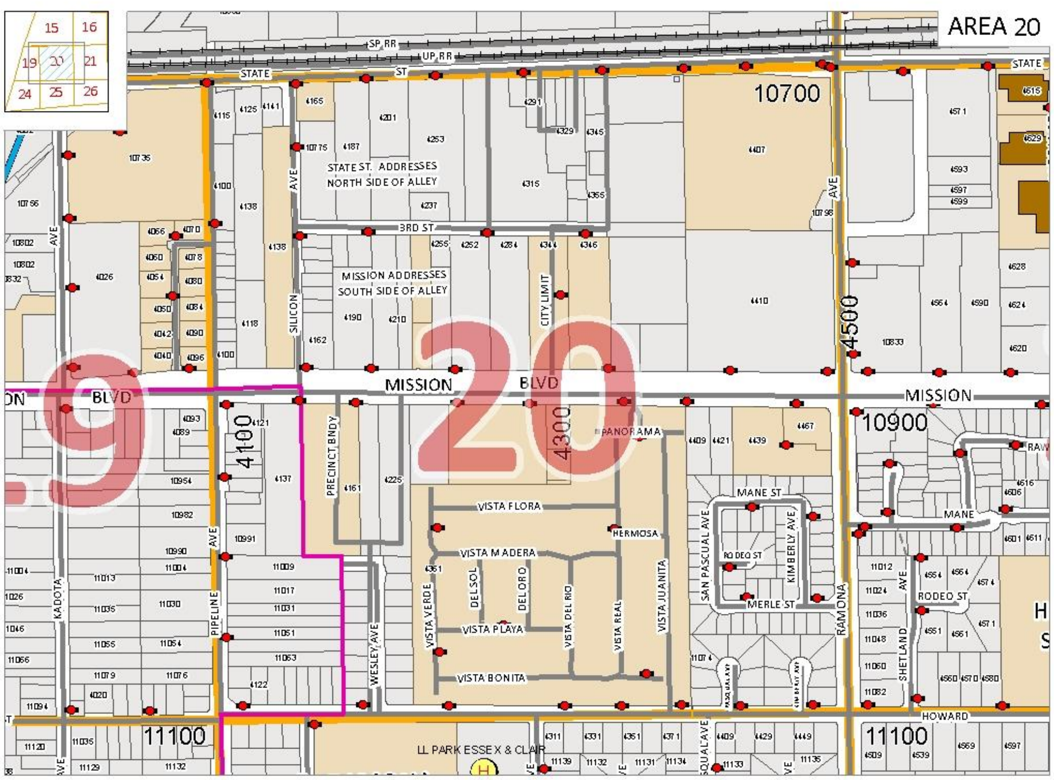

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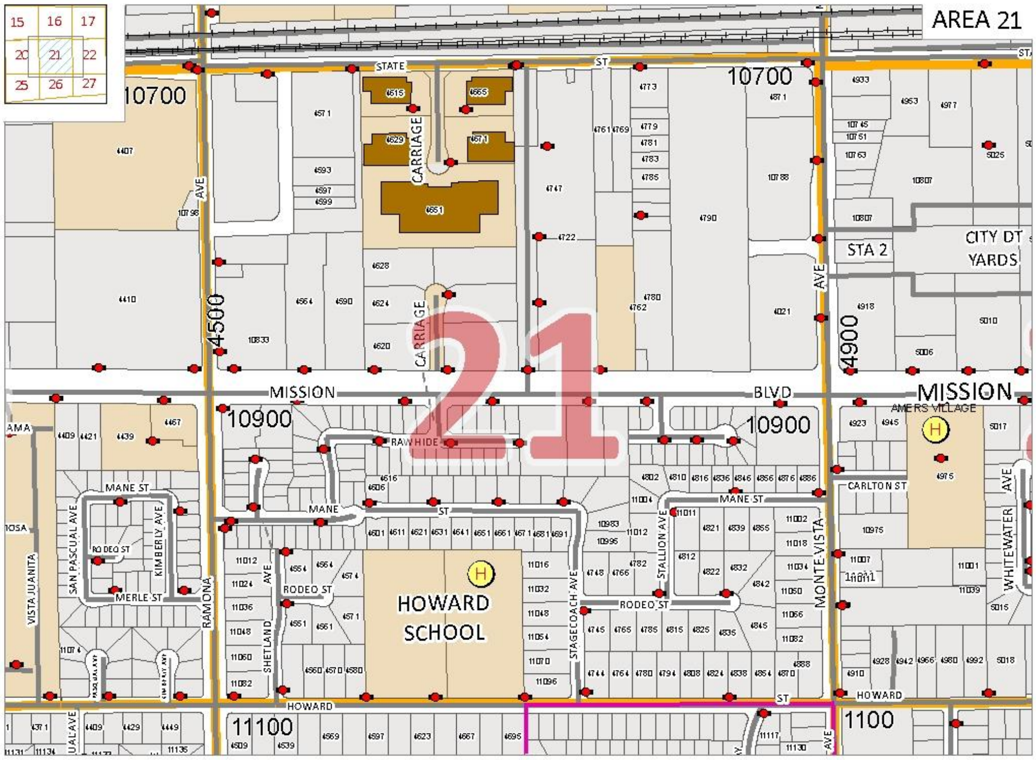

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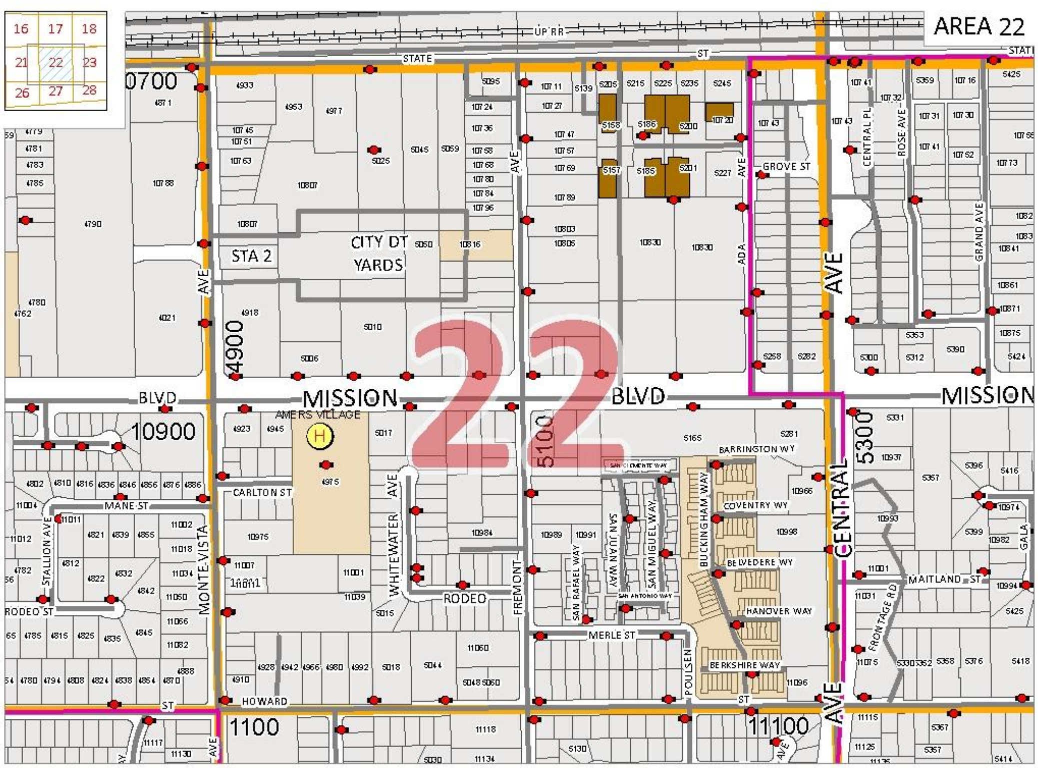

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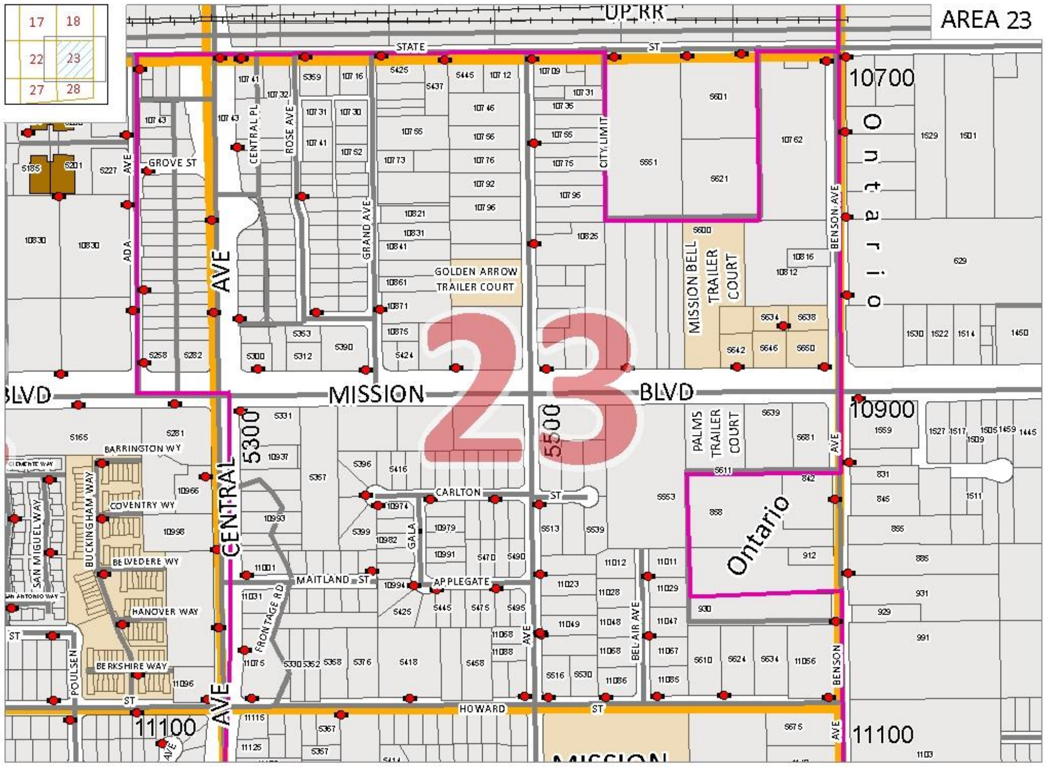

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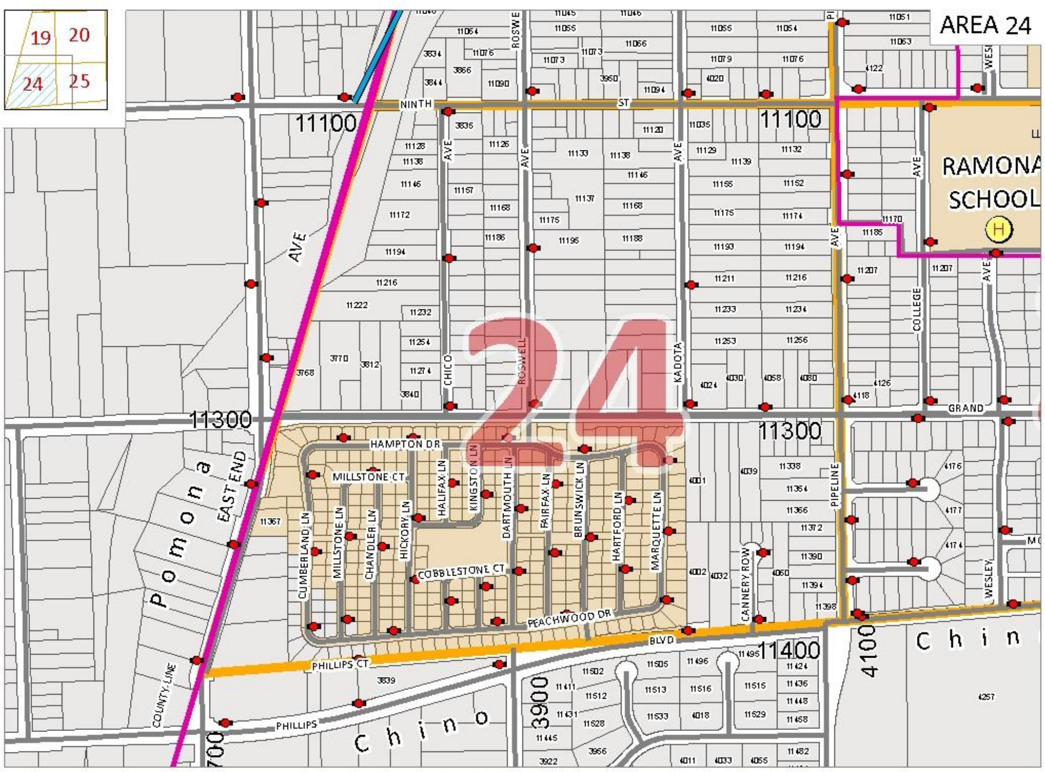

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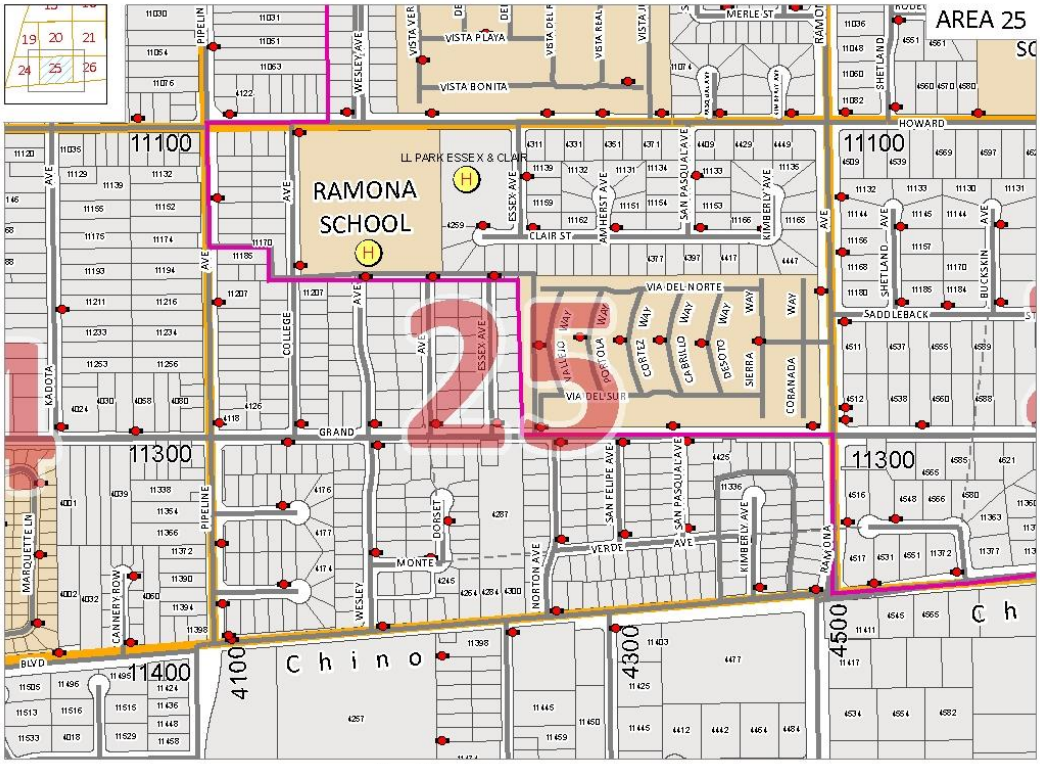

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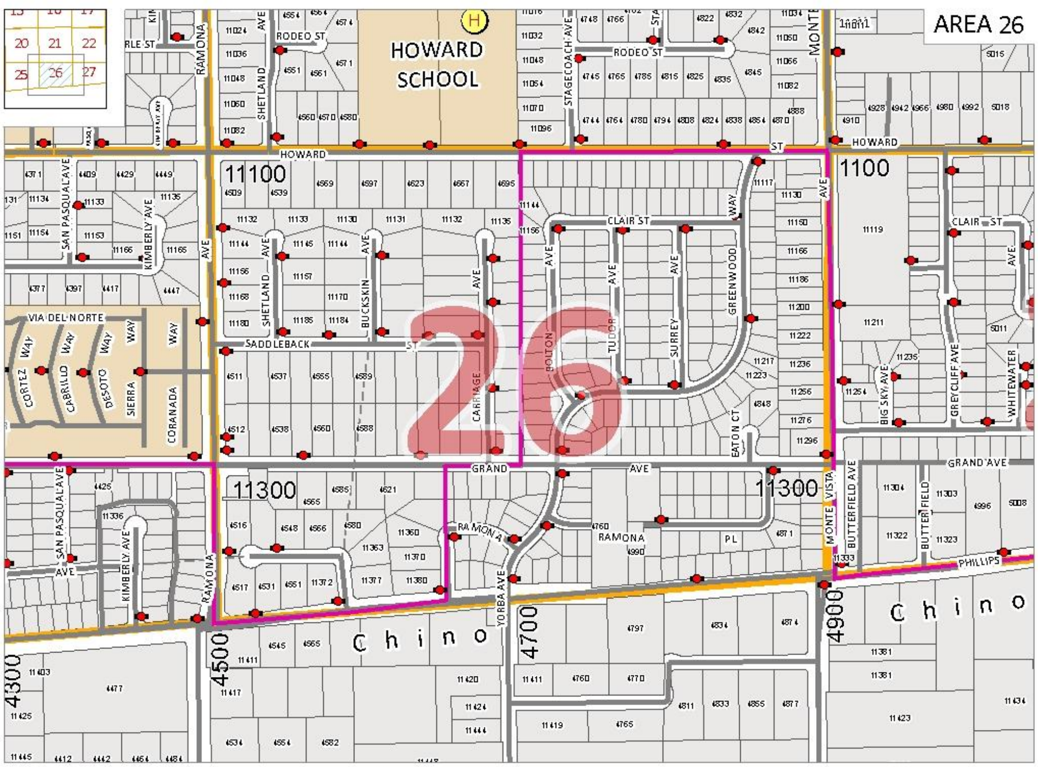

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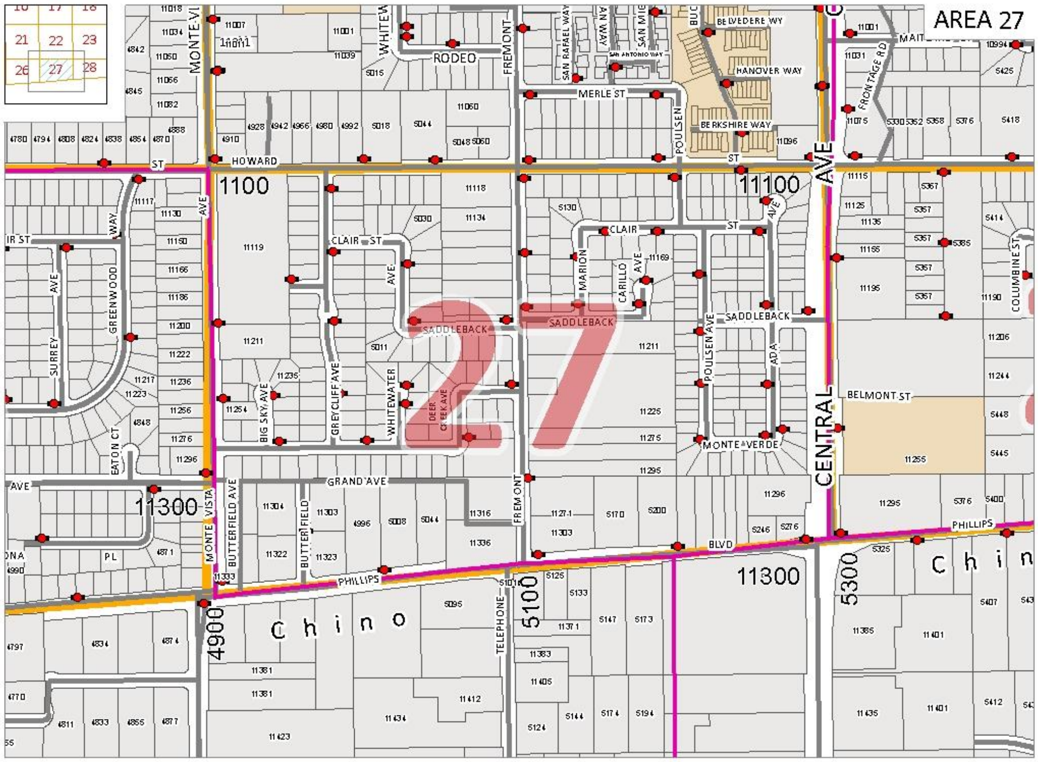

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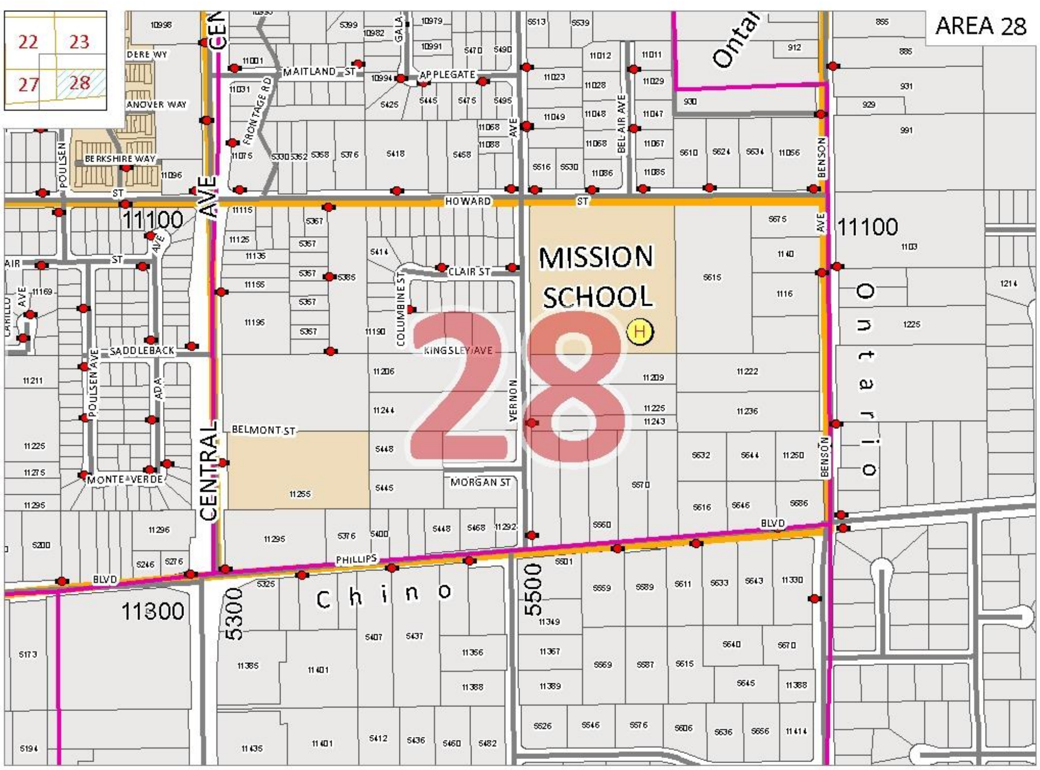

AREA 28 Montclair Fire Department Map Book

Appendix C

Disclaimer Page

This map book is currently under review. Data layers are not guaranteed to be accurate. Each feature on these maps should be vetted by Montclair officials to verify features depicted**.**