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Leading Community Risk Reduction

An evaluation of earthquake preparedness and response capabilities in the communities of Moraga and Orinda California

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Certification Statement

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

Signed: Bryan Collins

Abstract

The problem was the communities of Moraga and Orinda did not have a functioning earthquake response plan. The purpose of this research was to evaluate existing plans, identify missing components, and outline steps for an improved emergency preparedness and response plan. Through descriptive research, the probable effects of an earthquake on the communities, preparedness and response measures already taken by the communities and their public safety agencies, what other “at risk” cities are doing, and alternatives for improvements were answered. The research was carried out through literature review, and surveys. Results showed the importance of a comprehensive approach to preparedness and response, and the need for such in these communities. Recommendations included additional policy development, training, and public outreach.

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Introduction

In the San Francisco bay area of Northern California earthquakes have become a way of life. This region of California is often referred to as “earthquake country” as there are a number of significant faults that traverse the region. The San Andreas, Hayward, Calaveres, and San Gregorio are just a few examples of major faults in the area.

Earthquakes occur in California when there is a sudden slip on a fault. Stresses in the earth’s outer layer push the sides of the fault together. This stress builds up, and the rocks slip or break suddenly releasing energy in waves that travel through the earths crust and cause the shaking that we feel during an earthquake. When these breaks extend to the surface, we see movement on the faults or surface ruptures. Because faults are weak areas in the earth’s surface, earthquakes tend to occur repeatedly in these weakened areas. This is the case in the San Francisco Bay Area (USGS, 2005).

When earthquakes occur the violent ground shaking can cause significant damage to roads, bridges, buildings and utilities. This has been evidenced many times by significant quakes such as the major earthquake and fire that destroyed a large part of San Francisco in 1906, and in recent history the devastating earthquakes that have occurred in Iran, and Pakistan.

In 1989 the Loma Prieta earthquake struck the greater bay area with significant force. The earthquake occurred on October 17, 1989 at approximately 5:04 pm. The earthquake was centered on the San Andreas Fault, which lies approximately 55 miles southeast of San Francisco in the Santa Cruz mountains. The quakes effects were felt throughout the state of California, from San Diego in the south, to the Oregon border in the north, to the state of Nevada to the east. When the 20 second long, magnitude 6.9 earthquake had ended it left a tremendous amount of devastation. Direct damage was estimated at 6.8 billion, with the costs of business interruption factored in, the estimates reached as high as 10 billion dollars. Over 62 people died, a remarkably low number given the time and size of the quake. At least 3,700 people were injured and over 12,000 were displaced. In excess of 18,000 homes were damaged, with 963 being totally destroyed. Over 2,500 other buildings were damaged with 147 of those

being destroyed. In addition, a section of roadway on the San Francisco Oakland bay bridge had collapsed, as well as the upper deck section of Interstate 880 near Cypress Street in the city of Oakland (EQE Engineering, 1989).

The communities of Moraga and Orinda, California lie in center of the San Francisco bay area and in close proximity to both the San Andreas, and Hayward fault lines. The threat of earthquakes is a reality and poses a significant risk to the citizens and property of these two communities.

Experts in the prediction of earthquakes indicate that the probability of a 7.0 major earthquake on a known or unknown fault in the San Francisco Bay Area is greater than 62 percent probability before the year 2032.

The problem is that the communities of Moraga and Orinda do not have functioning earthquake preparedness and emergency response plan for an earthquake related incident. This leaves these communities, their residents, and emergency personnel vulnerable should a large geological event occur.

The purpose of this research project is to evaluate any existing plans, identify the missing components, and outline the steps necessary for the design and implementation of an improved emergency preparedness and response plan.

Descriptive research methodology was used to answer the following three questions:

1. What are the probable effects on the communities of Moraga and Orinda in the event of a major earthquake occurring in the San Francisco bay area?
2. What earthquake preparedness and response measures have been taken by the two communities thus far, and what have the primary emergency response agencies of fire and police done to prepare?
3. What have other “at risk” cities and communities done in preparation for the next earthquake and what additions would improve the plan for these two communities?

Background and Significance

The Town of Moraga and the City of Orinda lie approximately 20 miles east of San Francisco, California in the suburbs of Contra Costa County.

These neighboring communities are similar, in that they are reasonably small well-educated bedroom communities, where a large number of professionals live and commute into the cities of Oakland, San Francisco, and the Silicon Valley area of San Jose.

Both of the communities governmental structures are modestly small with a city manager / town manager reporting to an elected city/town counsel. Both have public works departments, which are staffed with a handful of personnel who are generally available during normal business hours (8-5 pm), with some personnel available via pager after hours, weekends or for emergencies. The town of Moraga police department is a city department with approximately 13 sworn police officers including the chief of police. Typical patrol strength is 3 officers per shift. The city of Orinda contracts with the Contra Costa County Sheriffs department to provide its police services. The city of Orinda police department has 15 sworn officers, with a typical shift staffing level of 3or 4 officers.

The Moraga-Orinda Fire District (MOFD) was formed in 1997, when an affirmative vote of over 83 percent of the residents approved a plan to consolidate two former independent Fire Districts into one. The MOFD provides services to the town of Moraga, city of Orinda, and the community of Canyon, along with some other unincorporated areas of Contra Costa County.

The MOFD provides protection to an area of approximately 63 square miles with a population of approximately 50,000 people, along with a private university. The District provides a high level of service including fire suppression and prevention, code enforcement, advanced life support transport, technical rescue, hazardous material response capabilities, and an aggressive all risk community education program. These services are provided out of five fire stations staffed with four engine companies, one truck company, two advanced life support transport ambulances, and a shift battalion chief. Staffing levels consist of three personnel on the engines and truck companies, of which at least one is licensed paramedic, and a minimum of

two paramedics on each of the transport ambulances. The MOFD is a fully paid professional department, which operates a three-shift schedule and employs approximately 70 personnel including support staff.

The MOFD's organizational structure is relatively flat. The District Fire Chief reports directly to a five member elected Board of Directors. Five battalion level chief officers manage the various major divisions of the department, which include operations/IT Services, fire prevention/code enforcement, personnel, training and education, and support services. The three battalion chief's assigned to the various shifts also manage the day-to-day operations of those shifts including emergency responses. All five of these chief officers report directly to the fire chief.

California's susceptibility to earthquakes is well established. In Northern California the San Francisco bay area straddles the boundary where two of the earth's largest tectonic plates meet and slowly move past one another. When boundary faults break and the North American and Pacific plates lurch past each other, earthquakes occur.

The Loma Prieta earthquake measuring 6.9 magnitude on the Richter scale was the largest earthquake to strike the contiguous United States in 37 years, (Bernknopf & Soller, 1994) and the largest quake to strike the San Francisco bay area since the great San Francisco earthquake of 1906. Despite the widespread, regional damage across the bay area, the communities of Moraga and Orinda sustained relatively light damage. There were no major structure fires or collapses reported in either of the cities. This can be at least partially attributed to the fact that the trembler occurred on the San Andreas Fault with the epicenter of the quake approximately 50 miles to the southwest.

History and science indicate that in the future more large earthquakes will occur along the major faults in the San Francisco bay area, just as they have in the past. Of the faults that traverse this region the Hayward and San Andreas appear to pose the highest risk. Two sections of the Hayward fault the northern and southern segments, have the potential to produce a magnitude 7.0 or greater earthquake causing widespread devastation. In fact the probability of a

major earthquake of magnitude 6.7 or greater striking in the San Francisco bay area before the year 2032 has been estimated at 62 percent (USGS, 2003). The northern section of the Hayward fault passes directly through the Oakland – Berkeley hills which lies within the Moraga-Orinda Fire District and within two miles of the city of Orinda. With these facts in mind, the communities of Moraga and Orinda have sufficient cause to be concerned, and based on the above probabilities should be preparing for the eventuality of the next large quake.

Surprisingly, these communities to date have not done much preparedness work for this eventuality, perhaps resting on their good fortune of the past. Both communities have acknowledged the risks, and have some minimal preparedness information available, but to date serious policy development and interagency training has yet to take place.

The Moraga-Orinda Fire district has adopted an "all risk" disaster plan, which addresses general disaster guidelines, but has done little planning or training specifically for an earthquake scenario. Without a comprehensive plan and policies in place, the communities and responders would be at significant risk during a devastating earthquake.

In order to adequately respond to and effectively mitigate a disaster of this potential, a concerted effort involving both communities, its public safety members, and county government needs to be embarked upon.

The objective of this research is to analyze what currently exists, what others have done, and to outline improvements to be considered or implemented.

This applied research project is being conducted as part of the Leading Community Risk Reduction course through the National Fire Academy. Specifically, this research relates to the objectives in course unit two, "Assessing Community Risk". This research paper is intended to support the United States Fire Administration (USFA) 5 year operational objective of "To promote within communities a comprehensive, multi-hazard risk reduction plan led by or including the local fire service organization" (United States Fire Administration, 2004)

Descriptive research will examine the probable effects of a major quake on these communities, and what measures have been taken to prepare thus far by these communities and

their public safety agencies. In addition this research will examine what other "at risk" communities have done to prepare, and finally, will recommend what additional measures would improve the current plans for these two communities.

Literature Review

The review of literature for this Applied Research Paper (ARP) began at the National Fire Academy's (NFA) Learning Resource Center (LRC) located in Emmitsburg, Maryland, the fall of 2005. The very helpful staff of the LRC assisted this researcher in the collection of journals, books and articles relating to the subject of earthquake preparedness and response in the public sector. Utilizing the LRC card catalogue, this researcher also examined current information on geological event probabilities, specifically in the San Francisco bay area, along with current practices of municipalities in and around the bay area. Upon this authors return home, research was continued at the Contra Costa County public library, in Walnut Creek, California. In addition, various sources with the MOFD library along with numerous internet sites and searches were utilized, which availed a significant amount of information on this subject.

What are the probable effects on the communities of Moraga and Orinda in the event of a major earthquake occurring in the San Francisco bay area?

The Hayward fault traverses south through the east bay from San Pablo bay through Berkeley, Oakland, Fremont, into the city of San Jose. The fault line runs through the Oakland-Berkley hills, which lie within the Moraga-Orinda Fire District and just a few miles from the communities of Orinda and Moraga. The last known major quake on the Hayward fault occurred in 1868, thus the Hayward fault is considered a prime candidate in Northern California for a magnitude 7 earthquake within the next 30 years.

Seismologists who attempt to predict earthquakes suggest that fault areas that have been quiet for a century or longer like the northern section of the Hayward fault are ripe for a significant trembler. An earthquake of this magnitude would constitute a significant seismic hazard for the six to seven million people at risk in the area (Berkeley Seismological Laboratory, 2003). In one scenario a 6.9 magnitude earthquake strikes on the Hayward fault and

over 155,000 housing units are made uninhabitable. 360,000 people are forced from their homes. Over 110,000 people require publicly provided shelter. At the same time the phone systems are overloaded and rendered virtually useless. Power outages are significant and widespread. Water and sewer services are out of service due to numerous pipe breaks. The transportation system is crippled by over 1,600 road closures. (Association of Bay Area Governments, 2003).

Ground shaking during the Loma Prieta earthquake lasted just over 15 seconds. The damage from this short but violent period of shaking was enormous. Communities from the Monterey bay area north to the San Francisco bay area suffered severe damage. Damage estimates to private property were estimated to be in excess of 3.5 billion dollars, with an additional 3 billion dollars damage to public property.

The Loma Prieta earthquake reinforced the scientific theory that the intensity of the earths shaking is affected by local soils conditions. Amplified ground motion can affect structures on unconsolidated deposits at great distances from the earthquake source, and is thought to be a significant factor in the damage to structures such as the San Francisco Bay Bridge, the collapsed Cypress section of Interstate 880 in Oakland, and the Interstate 280 and Embarcadero viaducts (BAREPP, 1990).

Locally, the effects of a similar quake could have devastating effects on the communities of Orinda and Moraga. Both communities have areas that are considered to be at high risk for liquefaction (ABAG, 2005). Liquefaction, the transformation of loose, saturated sandy material into a fluid like condition, causes substantial damage to structures over wide areas. In fact, liquefaction was considered to be a significant factor in the damage that was sustained in the Marina District of San Francisco, the area south of Market Street in San Francisco, the Oakland International Airport and port facility, Treasure Island, and the approaches to the San Francisco bay bridge during the Loma Prieta earthquake. This liquefaction of the soils under buildings causes collapse, and results in significant structural damage, ruptures of gas and electric services, and contributes to the start and spread of fires in these collapsed areas.

Structural seismic safety plays a large part in a buildings ability to withstand shaking from an earthquake. As a result of increasingly stringent earthquake seismic requirements, new construction in the area is considered to be fairly well protected from extensive damages. However, older construction built when building codes were not nearly as stringent in terms of seismic capabilities, does not fare well at all.

The city of Orinda has a significant amount of housing and a commercial business area that is of this older construction era. Orinda's central business district was mostly built in the 1970's and earlier, before good seismic design provisions were available. Approximately three quarters of Orinda's housing is over 30 years old, and as such, has the same earthquake vulnerability. In addition, there are many unreinforced masonry and adobe homes in the City of Orinda. Historically these unreinforced type buildings tend to suffer severe structural damage, and are considered at significant risk.

The Town of Moraga could expect a similar damage scenario with a quake occurring along the Hayward fault line. Much of the commercial area within the town was built along the same time line as in the city of Orinda. This researcher would expect that those buildings that have not undergone a seismic retrofit project would be subject to significant damages that would be similar to that in the city of Orinda.

The housing stock in Moraga is generally considered to be newer than that located in Orinda and does not have the number of unreinforced masonry and adobe building that can be found in the neighboring city of Orinda.

The fact that Moraga's residential housing stock is considered to be newer generally speaking, does not exonerate it in terms of potential damage. The town does have a fair number of residences that date back prior to the adoption and enforcement of stricter seismic building codes.

Two water reservoirs owned by the East Bay Municipal Utilities District (EBMUD) lie within the city of Orinda, San Pablo dam, and Briones reservoir. Together the two reservoirs hold approximately 106,000 acre-feet of drinking water. Modeling shows that in the event of a

large earthquake with a dam failure that the majority of flooding would occur north of the city of Orinda in the neighboring communities of San Pablo, and El Sobrante. The flooding that would occur within the community of Orinda is projected to be mainly watershed property, and would not be a significant amount. However, the impact of this massive amount of water on the nearby communities could be devastating. In addition, this large volume of water could potentially cut off routes for disaster response mutual and automatic aid, from the communities of San Pablo, and El Sobrante into the Moraga-Orinda Fire District.

Damage and disruption to infrastructure most certainly will occur. If the Loma Prieta quake is used to compare transportation damage and disruption, the bay area will again suffer significant problems. In the Loma Prieta quake the bay area transportation system suffered a significant blow. The collapse of the cypress structure accounted for the deaths of at least 40 of the people killed in the quake, with the falling section of the Bay bridge causing one fatality and prolonged traffic disruption to millions (BAREPP, 1990).

Locally, Highway 24, a ten lane heavily traveled roadway, which connects the East bay with Oakland-Berkeley and passes directly over the top of the Hayward fault line, is sure to sustain significant damage. Portions of Highway 24 are elevated, and these elevated sections lie in close proximity to the fault line. One such elevated section cuts through the center of the city of Orinda, and damage to this elevated section would likely impact a major arterial roadway underneath it, which runs north and south between Orinda and the town of Moraga. This arterial also is one of only two major roadways to get into and out of portions of south Orinda and the town of Moraga. Damage to this arterial could render it impassable for a period of time, thus virtually cutting the Fire District in half. Units from the north portion of the district would be cut off from access to the southern portion of the district and vice a versa. If this were to occur response personnel numbers would be cut in half and resources would be somewhat isolated for a period of time.

Highway 24 also serves as a major transportation corridor through the Oakland-Berkeley hills from Contra Costa County into Alameda County. This is accomplished via three

underground bores known as the Caldecott tunnel. Each hour approximately 4,300 vehicles pass through these bores (Metropolitan Transportation Commission, 2003). Disruption of traffic through these bores would limit automatic and mutual aid responses from the Oakland/Berkeley area. In addition, it would force commuters to take alternate routes into the Oakland – San Francisco area. These alternate routes, several of which are limited in their capacity, would be overtaxed, creating significant delays and increased commute times for tens of thousands of commuters.

Bay Area Rapid Transit (BART) which carries thousands of passengers daily through the Oakland-Berkeley hills has two underground bores that run parallel to those of the Caldecott tunnel. Damage to either or both of these transit bores would only amplify traffic, and congestion issues. In BART's own assessment of earthquake vulnerability they estimate the traffic impact resulting from a service disruption in one of their underground bores to be a net increase of 60 to 80 minutes for commuters along the Highway 24 corridor, this is assuming that the Caldecott tunnel is still functioning (Bay Area Rapid Transit, 2004).

Damage to utilities is likely to be severe. A major earthquake on the Hayward fault would likely cause significant damage to the East Bay Municipal Utilities District (EBMUD) water system. ABAG (1998) in its report entitled "On Shaky Ground" predicts the potential of 5,500 pipe breaks, the isolation of service areas due to major water tunnel failures, up to 65 water distribution reservoirs damaged and rendered unusable, 87 pumping plants out of service resulting in up to two thirds of the population served by the district losing service for up to six months. The financial impacts in the EBMUD service areas could be as much as $2 billion in repair costs and business related losses.

Pacific Gas and Electric's (PG&E) power system would certainly suffer damage. Its ability to deliver power would be lost in some areas for up to several days. Depending on the time of the year, this power disruption could hinder citizen's ability to heat or cool their homes. Because of the mild yearly climates in the bay area this might not be a significant risk to the healthy population, but for the elderly or those with chronic illness there could be increased risk

for hypo and hyperthermia. In addition those that depend on electric powered medical devices could potentially lose that capability placing them at great risk. Downed live electrical lines would also present a hazard to the citizens and emergency responders.

Disruption to communications is expected to occur and could be severe. Telephone communications may be impacted by extreme congestion on the public network. After events like this it is not uncommon to see call volumes increase up to three hundred percent of normal. Typically as these call volumes increase the network automatically engages a process called line load control, which restricts a percentage of incoming calls into the impacted area. Emergency response circuits will receive priority restoration (ABAG, 1998).

Cellular telephones may not be a reliable alternative communications system, as these wireless services have at least one connection through the local network and are subject to the same congestion. In many cases the phone system relies on commercial power, which may be disrupted for several days. Emergency backup power generators could be functional at telephone facilities, but are subject to the sustained availability of fuel.

The two communities also face the risk of numerous structural fires after a major earthquake. During the Northridge earthquake of 1994, in excess of 600 natural gas pipeline ruptures occurred beneath the streets. A number of these leaks then led to explosions, sending plumes of smoke and flames into the air. Broken gas lines within or connected to structures also resulted in fires. With the disruption to the water supply system, fighting these fires was very difficult. At least 600 buildings burned, including over 170 mobile homes. Firefighters resorted to using water from helicopter drops and water tankers to extinguish the fires after approximately 6 hours (Vogel, 1996).

The potential for hazardous materials events also exists. Because the two communities are comprised of mainly residential and light commercial uses, the use and storage of hazardous materials is minimal. However, a number of large swimming pools reside in the District's response areas, and most utilize chlorine gas to treat the water. Some of these swim facilities are located in neighborhoods, potentially exposing large numbers of citizens to the toxic gas, should

a rupture or release occur. An incident secondary to a large earthquake is a real possibility at one of these facilities, and needs to be adequately addressed in a preparedness plan and training.

The research indicates that although the two communities are suburban and less densely built and occupied than many metropolitan areas, significant potential exists for damage, business disruption, and loss of life in and around the communities in the event of a major earthquake on the Hayward fault line, or elsewhere on a fault within the greater bay area. The amount and extent of these damages would be determined by a number of variables such as which fault line, time of day, size and depth of the earthquake etc. and can only be measured in terms of probabilities at this time.

What earthquake preparedness and response measures have been taken by the two communities thus far, and what have the primary emergency response agencies of police and fire done to prepare?

After the Loma Prieta earthquake awareness was keen throughout the bay area and indeed the State of California, in terms of earthquake potential, vulnerability, and preparedness steps that needed to be taken. The massive amount of damage and destruction was fresh in the minds of citizens and public policy makers alike. Momentum was building in communities around the damage stricken bay area to institute changes that would help the area cope in the wake of the next devastating earthquake. More stringent building codes were being drafted and phased into practice, and many residents were taking the recommended steps of securing high storage items, and checking the foundations of their homes to assure that the structure itself was bolted to the foundation. At the same time the area was coping with the devastation to its infrastructure and the significant loss of life that had occurred.

As is the case with disasters, public awareness is at its highest shortly after the event, and maintains this heightened level for a period of time, before falling off and slowly fading away, at which time the public views the potential for a recurrence much as they did prior to the catastrophic event taking place (ABAG, 2005).

The communities of Moraga and Orinda were reacting much in the same way as many cities within the bay area. A collective sigh of relief was being felt, along with the reality that the region was spared potential catastrophic damage and loss of life in this earthquake, mainly because the epicenter was located some 50 plus miles south of the densely populated San Francisco bay area. The USGS (2003) in its report on "Understanding earthquake hazards in the San Francisco Bay Region" points out the fact that in 1995 when a earthquake of the same magnitude of the Loma Prieta struck Kobe, Japan, another bayside urban area thought to be well prepared for earthquakes, more than 6,000 people died and the damage amounted in excess of $100 billion dollars. Had the Loma Prieta quake been centered in San Jose, San Francisco, or Oakland, similar losses could have occurred.

In Moraga and Orinda some local efforts were being undertaken to raise public awareness about earthquake preparedness, and some information was becoming available through both cities building and planning departments regarding seismic strengthening and retrofitting. However, before much momentum and effort could be capitalized upon, yet another disaster hit the Oakland, east bay area.

In October of 1991, a wildfire that started in the Oakland/Berkeley hills near the Alameda and Contra Costa County line erupted into a conflagration that consumed in excess of 3,000 homes and structures, and cost loss of life to both civilians and public safety personnel. Again the region suffered a major negative economic impact. The majority of attention to follow throughout the early and mid 90's was geared around this latest disaster. Legislation was passed requiring defendable space around structures, fuel mitigation plans were introduced and fire resistive building materials were being required in the hills areas. Because a portion of the Moraga-Orinda Fire District is in the Oakland / Berkeley hills, the district and both communities were heavily involved and committed to supporting this effort.

In the meantime much of the momentum centered around earthquake preparedness seemed to fade away. Both communities had in place plans that addressed disaster preparedness in general, but very little specifically information dealing with earthquakes. These plans

discussed disaster potential in general terms, and had a framework established for the activation of local Emergency Operation Centers (EOC's). However, neither of the two communities had an EOC that could sustain or support a long duration event. Both sites for the EOC's were within existing city buildings that had other primary uses. Annual funding to support and upgrade the two EOC's was minimal, and currently amounts to just a couple of hundred dollars per year combined.

In the event of a disaster, the plan was to convert the use of these rooms into an EOC to function and support operations during the disaster. In the city of Orinda, somewhat regular exercises were run during the early 1990's. Annually, the city leaders, and staff, in conjunction with the police and fire departments would run a mock tabletop disaster designed to exercise response training, communications, the incident management system, and the EOC itself. However, these annual exercises stopped in the mid 1990's and since have not resumed on a regular basis as of today. In the Town of Moraga, it appears that similar types of tabletop exercises were conducted within the town also in the early 1990's. As with the city of Orinda, these drills have not been done since sometime in the mid 1990's on an interagency basis. In addition, as of this date, this author cannot find any evidence of any joint disaster drills or preparedness projects between the two communities of any type. The two communities have communications capabilities within their own jurisdictions, primarily utilizing the Nextel cellular phone system, and some staff members have capabilities to contact other agency representatives. However, for the majority of field personnel that work within the two cities that would be expected to respond to perform certain functions in the event of a disaster, their ability to communicate appears to be quite limited.

The two police agencies have copies of these disaster plans and appear to have roles in the formulation of any updates or changes that might occur to the disaster plans. Both police agencies indicate that all officers have been trained in the use of California's Standard Emergency Management System (SEMS). However, neither of the departments indicate that any ongoing or refresher training has taken place.

The city of Orinda police officers carry first aid equipment and portable Automatic External Defibrillators (AED's) in each of their patrol cars. Certification and ongoing training is provided to the police personnel through the Moraga-Orinda Fire Dept's Emergency Medical Services (EMS) division on an annual basis. Each patrol and staff officer has the ability to communicate with fire and some city personnel via the Nextel phone system, or directly with the MOFD via a common portable radio channel. The police department is involved in a neighborhood watch program along with a Community Emergency Response Team (CERT) program within the city of Orinda (Orinda Public Safety Advisory Committee, 2005). The CERT program is still in the formative stages and new members are being trained on a regular basis, with the hope that community volunteers will be able to offer assistance to others within the community and to public safety personnel in the event of a large disaster. Additionally, the Orinda PD is able to draw upon the considerable law enforcement resources of the Contra Costa County Sheriff's Office via request for automatic aid. Based on the information that this author was able to gather the police department does not have any specific policies or procedures in place, in the event of a large earthquake, beyond sending a staff member to the city of Orinda EOC as a departmental representative.

The town of Moraga police department likewise lacks any specific policies or procedures to deal with a large earthquake. Like the city of Orinda, the Moraga police department is involved in the formation and training of citizens to be part of the CERT program within the community. These citizens are then relied upon to render assistance to others in the community in the event of a large disaster. Patrol officers are also trained in first aid, carry miscellaneous first aid equipment, and carry AED's in their vehicles. Like in Orinda, the ongoing training and maintenance of this equipment is coordinated and provided by the MOFD's EMS Division. Communications capabilities mirror those of the Orinda PD, in that Nextel cellular coverage, and a common portable radio frequency is available for interoperability with other local emergency resources. Likewise, the Town of Moraga police have access to a large pool of law

enforcement resources from surrounding jurisdictions, primarily the Contra County Sheriff's department.

Both Moraga and Orinda are now operating under new leadership. The city manager of Orinda and the town manager of Moraga are new to their positions and have been in the respective communities less than one year. Interestingly, both new leaders have significant experience and background in emergency planning, having performed that function as part of their responsibilities in the cities that they worked in prior.

In the city of Orinda, a subcommittee was recently appointed by the city counsel to review, evaluate, and recommend changes to the city's emergency operations plan. This subcommittee is conducting meetings with various stakeholders within the city, and when complete will have recommendations to the city counsel in terms of additional preparedness and response capabilities, in addition to whether any local, state, or federal assistance is available to help with these concerns. Also, construction is now underway to include new city and police offices. Within this new complex, a new and dedicated EOC will be housed. Although this author has not viewed the plans personally, reports from counsel meetings and correspondence indicates that it will be a hardened, state of the art facility, with backup power capabilities, and a dedicated EOC. This new facility will bring the city staff, along with the police department staff, into the same building allowing for greater interaction and coordination should a disaster occur. The fire department administrative offices however will not be included in the new city offices and will remain located approximately a block away. This being the case, the city has taken a significant first step in its capability to manage a disaster that affects the local area.

In Moraga, the police department in currently in the process of relocating to a new building which by all accounts should serve their needs much better. This new building is existing, but built in the recent past under recent building codes, which assure it is considerably more seismically sound than the former police department facility. Within this new facility the police department is organizing an EOC. At this date it is unclear whether this new EOC will be dedicated only for EOC use, or if it will also be utilized for other functions on a daily basis, and

converted to an EOC in the event of a disaster. The town manager is working with police department staff to equip and supply the new EOC. In addition, he has instructed the police chief to plan and organize some disaster training, with the possibility of drills to be conducted in the 2006 calendar year.

The Moraga-Orinda Fire District has in place, an internal emergency disaster plan that was created several years ago. Within this plan, earthquake procedures are outlined in general terms, in that overall responsibilities are designated, along with the use of the California standardized incident management system. However, the document does not contain any specifics in terms of policies or procedures for use by the line firefighters or battalion commanders in the event of an earthquake. As of this date no policies, procedures, or training information sheets exist within the Moraga-Orinda Fire District to guide its response personnel during a seismic emergency. The regional fire communications center, which does virtually all emergency dispatching and communications for fire agencies with Contra Costa County, has in place some standard operational procedures that it utilizes when it is notified that an earthquake has occurred. These procedures deal mainly with assuring that communication links, computer systems, and mobile data terminals are functioning and operational.

In terms of critical infrastructure, the fire district has done a considerable amount of work over the last 10 years to assure that its facilities are secure should a large earthquake occur. Approximately 10 years ago all fire department facilities were surveyed by an engineering firm to assess their seismic safety. It was determined that none of the districts 5 fire stations, nor its administrative building met current seismic requirements for public safety facilities and were susceptible to significant damage in the event of a large earthquake on the Hayward fault. All buildings needed to be either retrofitted, or replaced in order to sustain a strong earthquake and remain functional for the emergency responders. The fire district board of directors moved quickly to approve the immediate retrofit of 2 stations and embarked on an aggressive replacement schedule for the remaining facilities. To date, all but one of the fire department

facilities has been either retrofitted, or replaced, and meets current seismic safety standards for public safety buildings and critical infrastructure.

All fire department facilities are equipped with backup generation capabilities, to keep them functional should a loss of power occur. These generators have the capability for long duration use and the capacity to power all the essential computer, alarm, communication systems, along with the living quarters for each facility. Each station has its own independent above ground fuel storage and pumping capability to allow for fueling of fire department apparatus. Communications systems are redundant and are built to withstand earthquakes, and regionally two communication support vehicles are available, each able to function as a standalone dispatch center in the event that the central dispatch center is rendered inoperable.

Every fire station has bottled water and food supplies to last in excess of 72 hours should the need occur. In addition, several of the stations have multi causality caches that include backboards, medical supplies, meals ready to eat (MRE) and portable communication radios. The fire district has a functioning multi casualty plan, but no other specific information or procedures for personnel to follow in the event that this equipment is needed. As noted earlier, no other policies or procedures currently exist to guide personnel in this type of an emergency.

What have other "at risk" cities and communities done in preparation for the next earthquake, and what additions would improve the plan for these two communities?

In California because of the inherent risk of earthquakes many municipalities and public agencies have earthquake policies, information and preparedness measures in place. The city of Los Angeles for instance, both through the city website and the fire department has an extensive amount of information available. The city website has information available for use by the public in the form of preparedness information for residences, small businesses and others. The Los Angeles Fire Department has an extensive amount of information available both for the layperson and more technical response and policy information. Known as its Emergency earthquake operational plan (EEOP) the fire department has spelled out extensive and specific response policies for all levels within their organization. This document covers areas such as

command and control, communications, reconnaissance, action plans, fire fighting, water supply, search and rescue, multi causality, helicopters, hazardous materials, documentation, recall of off duty personnel, and bureau responsibilities. In addition, at the conclusion of this 80 plus page document are attachments addressing non-structural hazard mitigation measures, and the section of the government code that covers legal authority and responsibility (City of Los Angeles Fire Department, 2006).

The City of Seattle recognizes that it lies in an area that is considered at high risk for seismic activity, and in fact has had a number of significant earthquake events in the past. Therefore, the city has posted a great deal of information geared toward the public which is available through the city website. Information on preparedness, recovery, first aid, emergency lighting and heating, and shutting off utilities is available from this site (City of Seattle, 2006).

A preparedness handbook is available through the Salt Lake City Fire Departments website. This detailed handbook cover many items including earthquake tips, family and home planning, first aid, useful supplies and equipment, earthquake plan, safe drinking water, auto survival kit, emergency lighting, shutting off utilities, securing your home furnishings, and helping children and adults cope with disaster. The Salt Lake area is prone to earthquakes and the city emphasizes earthquake preparedness as a way of life for its residents. One particularly useful section of the handbook outlines suggestions to take during an earthquake. This section recommends actions for citizens at home, work, in a vehicle, crowed stores or other public areas, theaters, stadiums and more.

Palo Alto California lies just below San Francisco in the south bay. It's location lies in very close proximity to the San Andreas Fault, which runs down the south bay area. This is the same fault that produced the Loma Prieta Earthquake of 1989. Available from the city of Palo Alto is an emergency plan that outlines disaster preparedness measures in place for the city and community. As an addendum, there is information available on earthquakes for use during an after an event. The city has provided a comprehensive plan and made it available via a website

download, which provides a valuable service and information to the citizens of Palo Alto (City of Palo Alto Fire Department, 2006)

The Moraga-Orinda Fire District borders the city of Berkeley CA. Berkeley is well known in the region for having taken great measures to assure that the city is prepared and ready to respond to an earthquake. The City of Berkeley (2006) has a great deal of information is available via the website, and through pamphlets and brochures. The city has produced a comprehensive guide entitled “The Earthquake Home Safety Guide” which details some excellent information to be used by the average homeowner or citizen to prepare for an earthquake. It’s in a checklist format, and also allows spaces for homeowners to write in important information such as the locations of utility shutoffs, family contact information, out of state relatives or friends, school phone numbers, address, and more. The city of Berkeley has also designated an individual within the fire department who has the specific responsibility when it comes to earthquake mitigation measures. The position was apparently funded as a result of a Federal Emergency Management Association (FEMA) initiative called Project Impact. Included in Berkeley’s program is a fee waiver for all building permits for seismic retrofit work to single and multiple family dwellings. In addition, the city gives back up to one third of its 1.5% property transfer tax if the homeowners or building owners use the funds for earthquake structural mitigation measures. The result has been that approximately 62% of their single and multi family dwellings have been retrofitted since the inception of the program, which was shortly after the Loma Prieta earthquake in 1989.

The city of Carlsbad, California has created a home inspection checklist that is downloadable directly from its website. This easy to use tool is reported to take approximately 30 minutes to complete as you walk through your home. The goal of the checklist is to identify potential hazards by utilizing the worksheet, and make simple corrections prior to an earthquake event. In addition the website offers the public tips on how to prepare before an earthquake, in terms of logistical needs and supplies, offers advice on what to do during an earthquake, and finally what steps to take after the quake has subsided (City of Carlsbad, 2006). This easy to use

information is designed to be very user friendly and provides a great deal of preparedness and response information to the public.

In San Francisco the city's fire department in conjunction with a local news agency has a tremendous wealth of information that is available via the World Wide Web. Topics ranging from, the do's and don'ts during earthquakes, to preparedness measures, retrofitting tips, lessons learned from prior quakes, live maps from the USGS that estimate the shaking potential based on location within the bay area, and much more. In addition there are numerous links that take the reader to specific sites for further information and technical advice (SF Gate.Com, 2006). One can find out just about anything to do with earthquakes when visiting this site, if not at the site then through one of its extensive links.

Much like the City of Los Angeles fire department has done, the Fremont CA. fire department has created a very detailed policy for use within its agency in the event of an earthquake. This information spells out responsibilities for every level within the fire department and is very user friendly as it goes into detailed explanation of each position within the response framework and addresses their function, who they interact with and report to, the location that they are to report and more. The Fremont fire department makes this information available to other emergency response agencies through request, and should be viewed as an excellent template for those agencies that are looking to further define responsibilities, or create policy for use during an earthquake.

The San Jose fire department through its division of training has earthquake response policies available for other fire departments use. These policies outline lines of authority, response actions, mitigation steps and other pertinent response information for use by fire personnel during an earthquake event. Again, these are made available for agencies looking to improve, or create policy for emergency responders. The review of information such as this could prove to be beneficial in terms of reducing the amount of work necessary to create policy within one's agency. Modifications to these types of policies can usually allow just about any

jurisdiction to create and tailor a policy that works for it, taking into account any special circumstances that may exist within ones own agency.

The information and texts that were utilized during this literature review, yield a great deal of information on earthquake preparedness and response. Outlined, were a number of different approaches, with some being quite detailed, and others providing basic information. A great deal of information exists to indicate that the potential for a devastating earthquake in the bay area, and specifically on the Hayward fault is more likely than not, sometime in the next 25 years. Research also indicates the potential for damage, destruction, and loss of life is considerably high for most communities in the bay area, especially during certain hours of the day.

With the construction types and age of the housing stock within the Moraga-Orinda Fire District the potential for devastation is great, given a significant size earthquake along the northern Hayward Fault line. One could reasonably expect based on literature available that significant damage would likely occur to the infrastructure in the area, resulting in severe economic loss, and disruption.

Many communities have begun to make information available to both the public and their emergency responders to help guide them in the event of a disaster such as this. Much of this information is available through the agencies website, or direct contact with a department in that agency.

While most if not all of this literature review focused on public agencies, there is a wealth of information discovered by this author during the literature review, dealing specifically with corporate readiness and preparation. Although corporate preparation is not the intended focus of this research paper, in many cases corporate America is a step ahead of public agencies when addressing catastrophes that could impact their economic security. Review of this research might yield interesting information also.

Procedures

The research procedures utilized this his report started in the fall of 2005, with the collection and analysis of literature contained in the LRC at the National Fire Academy in Emmitsburg, Maryland. Included in this analysis were applied research projects completed by other Executive Fire Officer candidates, the review of periodicals, journals, and published books dealing with the subject of earthquake preparedness, response and mitigation that were available in the LRC. Upon this author's return home the literature review continued and included the resources available at the Ygnacio Valley branch of the Contra Costa County Library, as well as extensive online searches for information. While utilizing the library, books and journals on the subject matter of earthquake preparedness and response were sought out and analyzed for relevance.

Search criteria used on the World Wide Web included earthquakes, preparedness, mitigation, response, city web sites, public agency resources, along with scientific journals on earthquake potential in the bay area. These web searches revealed numerous links to online resources, which had a great deal of information on the subjects.

Descriptive research was utilized to answer the following questions:

1. What are the probable effects on the communities of Moraga and Orinda in the event of a major earthquake occurring in the San Francisco bay area?
2. What earthquake preparedness and response measures have been taken by the two communities thus far, and what have the primary emergency response agencies of fire and police done to prepare?
3. What have other "at risk" cities and communities done in preparation for the next earthquake and what additions would improve the plan for these two communities?

Information obtained from the literature review was analyzed to help produce a list of questions that was included in a survey instrument. The survey was developed, and three survey groups were solicited for their participation. One survey was distributed to 15 fire agencies in and around the area considered to be "at risk" in the San Francisco bay area (Appendix C), with the

second survey being sent to 15 police agencies, again, in and around the bay area (Appendix D). The third survey was sent to 15 "at risk" cities within the bay area, and this information can be reviewed at the end of this report in (Appendix E). The fire department survey was sent to both city departments and fire protection districts. Fire departments were utilized because this research directly applies to the fire department for which this author is employed. It was also utilized because of the fact that fire agencies are usually included as a primary emergency responders to events such as earthquakes. Likewise, police agencies are viewed in the same way, so the information provided could give insight into their response capabilities considering they are a primary responder.

Finally, the survey was sent to cities to solicit input as to what steps if any they had taken in light of the potential risk in the bay area. The survey instrument for police and fire along with the cover letter (Appendix A) was sent via electronic mail to the training division, and in some cases directly to the agency chief when a training contact was not available. Surveys were sent out on January 8th, 2006. Respondents were asked to return the surveys to this author via email, U.S. Mail, or facsimile, by January 23rd, 2006. Twelve (80%) of the fire departments responded to the survey. Eleven (73%) of the police agencies surveyed responded with information.

City governments were surveyed because of the vital role they play in local emergency preparedness and response. Many in the community rely on the information that is provided by their city leaders when it comes to preparedness measures, and response questions. The internet-based web pages for the cities typically provided the electronic mail addressees of the city or town managers, or in some cases directly to someone assigned emergency planning. These local government officials were asked to provide information regarding their preparedness measures taken, information available to the public, method of disseminating the information to the public, along with any special programs they might have in place. The survey along with the cover letter (Appendix B) was also sent out on January 8th, 2006. Again the respondents were

asked to return the survey information via electronic mail, U.S. Mail, or facsimile to this author by January 23rd, 2006. Ten (66%) of the cities responded with information to the survey.

These surveys gathered information to help answer several of the research questions. The result of these survey's and the literature review were then utilized in the results section of this research paper. Overall the response percentages were slightly higher than this researcher had expected based on past experience with surveys, and are considered to be an adequate sampling for the intended data tabulations.

The information gathered was also used to help this author in the formulation of his recommendations that are contained in this research paper. The survey results are included as Appendices F, G, and H in this research report.

Limitations and Assumptions

This researcher assumes that the various authors' of materials utilized within this research report are knowledgeable in the subject matter, and provided valid information in their written documents. It is also assumed that the various respondents to the three survey instruments were knowledgeable, and truthful in their answers, and presented accurate data pertaining to the questions that they were being asked. The questions contained within the survey instrument were developed by this author, and were not validated through any other means, and therefore could be viewed as a limitation to the information contained in this research report. The survey size is also a limiting factor and should be considered when analyzing the results. The results represent a relatively small grouping of fire and police agencies, along with local governments, and thus could be easily skewed. These results should therefore be looked at within their limiting context.

The literature review should also be considered a limiting factor. While an extensive effort was made to gather and analyze literature, the search was not all-inclusive and should be viewed as such. It should be noted that this author attempted to conduct unbiased research for this report, however all the above limitations should be taken into consideration when evaluating this research report.

Definition of terms

Epicenter: The point on the earth's surface located vertically above the point of origin of an earthquake.

Fault: A fracture in the continuity of a rock formation caused by shifting or dislodging of the earth's crust.

Liquefaction: The transformation of loose, saturated, sandy material into a fluid like condition.

Magnitude: A measure of the amount of energy released by an earthquake as indicated on the Richter scale.

Redundancy: Repetition or duplication of elements in electronic or communication equipment to provide functional alternatives in the event of a failure.

Seismic: Pertaining to an earthquake, or caused by an earthquake.

Results

What are the probable effects on the communities of Moraga and Orinda in the event of a major earthquake occurring in the San Francisco bay area?

Results obtained from the research clearly show that in the wake of a large earthquake the communities of both Moraga and Orinda could face significant damage and a broad range of emergencies. Historical accounts of prior earthquakes along with current scientific opinions point to the potential for massive damage, loss of live, and serious economic disruption in the aftermath of a large earthquake centered on the Hayward fault (ABAG, 2005).

The literature review findings indicate that some or all of the following could be expected locally in the Moraga and Orinda areas:

1. Property damage ranging from moderate to severe, with the potential for structural collapse and fire.
2. Potential for large loss of life
3. Significant disruption and damage to transportation infrastructure
4. Disruption of lifelines – that is; utilities such as water, natural gas, electricity
5. Liquefaction in areas with sand fill

6. Potential for communication failures in telephone, cable, and radio
7. Numerous medical emergency incidents with the potential for multiple casualties
8. Hazardous material releases
9. Potential for damage to the tunnel passageways that connect the east bay to Oakland/ San Francisco
10. Potential for minor flooding in Orinda should damage occur to either of the dams. Downstream flooding to neighboring communities could be severe however.

Emergencies on the magnitude of those listed above would most certainly overwhelm the response capabilities of police and fire agencies for up to 72 hours after the incident (ABAG, 1998). The Berkeley Seismological Laboratory (2003) estimates that the probability of a catastrophic earthquake event occurring sometime before 2035 on the Hayward fault line is in excess of 60%. Similar and sometimes slightly differing estimates were obtained during the literature review from other sources including the Association of Bay Area Governments, and the USGS. Given the number of sources cited in the literature review it is apparent that science is in general agreement as to the probability of a large seismic event in this area.

What earthquake preparedness and response measures have been taken by the two communities thus far, and what have the primary emergency response agencies of fire and police done to prepare?

In research conducted by this author it appears that shortly after the Loma Prieta quake struck the San Francisco bay area, both of the communities were engaged in an attempt to develop information and procedures that would help them during future earthquake events. City building officials were drafting more stringent building standards to help mitigate some of the types of damage that was seen with the Loma Prieta quake. Many single and multi family residences slipped off their foundations because the building code at the time did not require the structure be secured to its foundation. However, it is also evident the focus and priority shifted from earthquake preparedness and response, to wildland urban interface fire mitigation and

prevention as a result of one of America's costliest conflagrations that occurred in the Oakland/Berkeley hills the fall of 1991.

The communities of Moraga and Orinda continued to occasionally exercise emergency preparedness drills that involved multiple agencies in mock response scenarios. However, in the mid 1990's these drills subsided and have not been resumed to this day. Research would indicate that little in way of earthquake preparedness or response policy development or training has taken place with the exception of the adoption of more stringent seismic safety codes, until just recently. With the recent hiring of the new city manager in Orinda, and a new town manager in Moraga, preparedness activity appears to be on the upswing. With the construction of the new city office complex in Orinda, the city is taking a significant step by creating a dedicated EOC within the facility. All indications suggest that it will be well equipped, and hardened to withstand the effects of a large earthquake, while providing city and emergency staff with excellent operating conditions.

In Moraga, it appears that the EOC will be rebuilt in an existing structure that will be occupied by the Moraga police department. However, this author was able to find little in the form of written plans or documentation that would give any great detail as to what the facility will actually end up having in it, or whether it will be a dedicated room or shared and used for other purposes. It is also unclear at this time whether or not this facility in Moraga will have the ability to be self-sustainable in the event of a prolonged power and utility outage.

What is clear in the research is that the new town manager has placed a priority emphasis on preparedness training, and the updating of the towns emergency response plan. This appears promising.

Little, if any, has been done in the way of preparedness information that would be made available to the public. Unlike many cities cited in this research paper, the two communities have very little information available on their websites for the public to access. Some written materials are available if citizens physically stop in at the planning or building departments of the two communities.

In terms of training and education for the city employees, it appears that while some training took place during the 90's, many of those that were employed by the cities either no longer work there, or have forgotten the bulk of the material that they were trained in. City staff has limited communication capabilities, and this researcher found many of the phone numbers listed in the city staff phone directories, were incorrect or outdated. This will be a limiting factor should it continue uncorrected, and the area suffers a large disaster.

The two police agencies have undergone incident management training and are certified in the use of SEMS. However, this researcher was unable to ascertain when the last training or refresher class had been given to these employees. With retirements and rotation of personnel it remains unclear as to how many officers in the respective forces are confident and comfortable in the use of an incident management system.

Both agencies have made progress in the recent years in terms of equipment carried by the patrol officers as is evidenced by the addition of first aid bags and automatic heart defibrillators to their vehicles. This researcher was able to substantiate ongoing training in the use of this emergency medical equipment via a search of general training documentation from the Moraga-Orinda fire district. The two police agencies are involved in the CERT program, which once functional is intended to provide basic level trained volunteers within the community. These volunteers are then relied on for basic first aid, and some other simple tasks, along with neighborhood coordination in the event of a large disaster. Research indicates that this is a growing trend in the bay area, and many agencies are implementing these programs. Learning from past disasters, it is clear that a certain segment of the population wants to help, and if provided with a basic level of training can be an effective way to augment emergency response personnel. That is the intent of the CERT program.

Both police chiefs have been charged by their respective cities to participate in larger multi-jurisdictional exercises, but it is unclear how often this is occurring if at all. Communications capabilities of the agencies appear to be solid, and both forces have redundant

capabilities in this area. It also is apparent that the capability for interagency communication operability exists within both police departments.

The Moraga-Orinda fire department has taken significant steps in hardening and rebuilding of its facilities to withstand the damaging effects of a large earthquake. Likewise, the facilities appear to be able to remain self sufficient for a period of days with adequate fuel, water and supplies.

Operationally, the department is well equipped and trained to respond to emergencies of all types. However, lacking specific policy and guidance, response personnel will likely be unsure of how to handle emergencies on the magnitude of those that are predicted. The literature review reveals the existence of a district emergency disaster plan, however this plan lacks specific information on earthquake mitigation and response measures.

Communications systems are advanced and redundant and appear to be strong point in this assessment. There is no indication that personnel at the level of chief officer have been afforded an opportunity to practice or train for a large scale disaster, other than the recent weapons of mass destruction exercises that have taken place both locally and on a regional basis.

In the event of a large earthquake, the city and department disaster plans call for the fire department chief officers to report to either the EOC at the city, or to staff the district operations center (DOC) which is located at fire administration. These plans do not specify which chief officers are tasked to respond to where. It appears that at the very least some confusion might exist in the early stages of a large disaster incident.

This researcher has not found any evidence of a plan to utilize off duty personnel in the event of an earthquake disaster. Based on past experience, a number of off duty personnel, both law enforcement and fire department, have responded back to work to assist with earthquake response. Many bay area departments have identified policies and processes, to help assure that coverage is adequately maintained, and that personnel are utilized where they are most needed. Without these policies which specify when to respond back, where to report, and what the

expectations are for responding personnel, the fire and police agencies are running the risk of "freelancing" which is a serious safety and accountability issue.

What have other "at risk" cities and communities done in preparation for the next earthquake and what additions would improve the plan for these two communities?

Research would indicate that the public sector agencies understand the risk associated with earthquakes, and the importance of educating the public and planning for these events. According to research by this author various methods are being utilized to accomplish this.

Of the fire departments that were surveyed, eight of them (66%) responded that they currently have a functioning disaster plan in place. Response notes indicated that some of the departments have in fact a quite detailed and exercised plan, while others utilize a more generic or general disaster planning approach. Four of the respondents (33%) indicated that they were not aware of any disaster plan within their department. Based on the survey question it is not necessarily clear in those cases whether a plan just does not exist or whether a plan exists but the respondents were unaware of it. Further questioning would be required to get this level of detail.

Of those that responded their department had a plan in place, when asked if the plan specifically addressed earthquakes five of the eight (62%) indicated that it did. When posed with the question as to whether the agency had any specific policies or procedures for response personnel to follow five of the eight (62%) indicated that they did.

In terms of exercising the plan or training with the plan, seven of the eight fire departments (87%) indicated that they regularly conduct or participate in interagency training.

Fire departments were asked if their agency provided any preparedness information aside from that which may be provided by the city or municipality, and ten of the twelve surveyed (83%) indicated that they did. Eight of the ten indicated that the information was available via the department website, while two responded that the information was available in printed form for distribution.

When asked to give an overall assessment of their department's preparedness and response capabilities to a major earthquake, two of the respondents rated their capabilities as "excellent", two "fair", and one "poor". The majority of the respondents seven (58%) of twelve rated their capabilities as "good".

Police agencies were sent the same survey instrument as was sent to the fire agencies. Results from the survey then allow for an assessment and comparison of emergency response and preparedness capabilities by this first responder agency.

Of the police departments that responded six (54%) indicated that they had a functional disaster response plan in place. When asked if those plans included any specific information in regards to earthquakes, two indicated that it did. When responding to the question as to whether the agency has any specific policies or procedures for emergency responders to utilize in the event of an earthquake, two departments indicated that they did.

When asked the question as to whether the department regularly participates in interagency training or exercises, two respondents (18%) indicated that their agency regularly participated interagency training exercises. Based on notations included with the responses these training exercises ranged from live field exercises, to EOC or tabletop exercises conducted with multiple affected agencies. In terms of emergency preparedness information and its availability, five respondents (45%) indicated that information was available aside from the information that may be made available through some other city department or the municipality itself. Of those five, four of the respondents indicated that the information was made available through the department website, while one department makes information available through handouts or brochures. When asked to give an overall rating as to their department's response and mitigation abilities in the event of a major earthquake, three of the eleven respondents (27%) rated their department's capabilities as "excellent". The majority of respondents (54%) rated their abilities as "good", while two responded "fair" and one responded as "poor".

A similar survey was sent to various cities in the bay area, however the questions were changed to help assess their response and preparedness levels, but their facilities, training, and

public outreach efforts. When asked if their municipality had a functioning disaster plan nine out of ten (90%) responded yes. Of those nine, three (33%) indicated that their plan specifically addresses the threat of earthquakes. Regarding the outreach efforts, when asked if the municipality provided any preparedness information or mitigation information to the public, again nine out of ten (90%) indicated that they did. Interestingly, all nine responses indicate that the information is made available via the city website or a direct link from there. This research indicates and it is clear to this researcher, that the trend of disseminating information, and communicating with the public via electronic means in no longer the exception, but rather the rule in today's society. When asked if their municipality had a functioning EOC seven of the respondents answered yes. Of those seven, three of those EOC's are dedicated for the sole use of supporting and coordinating operations in the event of a large-scale emergency. On the question of training, seven of the respondents (70%) say their municipality regularly participates in ongoing training exercises for disasters, with all seven indicating that other agencies such as public works, fire, police, and local utilities were also involved in this training. When asked to rate overall their ability to respond to a large scale earthquake, six (60%) rated their capabilities as "excellent", two "good", one "fair" and one responded that their municipality would have a "poor" response.

Responses to the survey instrument indicates that generally speaking the cities or municipalities within the survey area feel like their ability to respond to an earthquake or large scale disaster is at least adequate. In fact, the majority of the municipality's indicate that they believe their response capabilities are excellent. Of the two first responder agencies that were surveyed, a lesser level of overall capabilities was expressed. While the majority of both police and fire agencies felt that there response and or preparedness for response was "good" only five responses from both agencies would rate their abilities as excellent. The research may indicate a disconnect of sorts between those first responder agencies and the municipalities that they serve. The municipalities clearly think that they have better preparedness and/or response capability

than those who would be on the front lines of the response. This would be an area requiring further in-depth analysis into perceptions, and communications between various agencies.

The survey responses indicate the level of detail that some agencies have available for both preparedness and response to large earthquakes. The communities of Moraga and Orinda would benefit from some of the information and tactics that are being used elsewhere in the bay area. For instance, some of the responding agencies have a great deal of information available on preparedness measures, and make this information available via their website. Both the city of Orinda, the town of Moraga, the police agencies and fire department have websites available. Posting of this information would seem beneficial in terms of public outreach, and would allow residents the opportunity to educate themselves on preparedness and mitigation measures. It would also allow the agencies of fire and police to communicate any special needs or instructions to the residents, describe response capabilities, evacuation or shelter in place instructions, self-sufficiency measures and more. For those with no Internet access, printed forms, information, and brochures should continue to be made available.

A number of agencies that were surveyed also have specific policies and procedures for emergency response personnel to follow in the event of a large-scale disaster. Both police agencies, and the MOFD would benefit from developing and implementing similar policies and procedures. First responders need to know what the expectations are and what specific procedures need to be followed in emergency situations. Earthquakes should not be an exception to this premise. Many of these policies and procedures are available from the various agencies in the survey, and would be easily attainable and could readily be adjusted to fit into the local agencies operational plan.

While the improvements to the EOC in Orinda, and the potential for improvements in Moraga, these communities would benefit from additional training, both intra and interagency. Exercises could be conducted on a regular basis and would strengthen the two communities' response capabilities and lines of communication. While it is evident that they are not alone among bay area communities, they would benefit from more specific information on the types

of disasters that could strike them specifically. Again, examples of this are readily available from other agencies within the bay area, and the city of Berkeley, which shares a border with Orinda, has an excellent example of a disaster plan. Both communities would benefit from the ongoing review and adjustment to their building codes. While both have made significant strides in improving and strengthening their seismic standards since the Loma Prieta, continued advances in engineering and building materials make this an important area to monitor and adjust.

Based on the assessment by this author of the survey materials the above-mentioned items would be significant first steps in improving the capabilities for disaster response and preparedness, especially in the event of an earthquake. These suggested items are being done in other municipalities within the bay area, and most of the template information is readily available.

Discussion

This section will discuss the relationship between specific findings of others obtained during the literature review, and the feedback collected by the survey instrument. This author's interpretation and analysis of these findings will also be discussed. In addition, this author will discuss the organizational implications of his findings.

The prediction of earthquakes while a much-improved science is anything but exact. Over the years improvements in technologies, coupled with lessons learned from prior seismic events has allowed scientists to predict with more certainty when and where earthquakes will occur in the future (Berkeley Seismological Laboratory, 2003). The San Francisco bay area lies in an earthquake prone region where two of the earth's largest tectonic plates meet and slowly move past each other (USGS, 2003). A great deal of research and analysis has been conducted in this area, and as a result scientists have predicted with reasonable certainty that a large earthquake is inevitable in this region. In fact, the chances of a 7.0 or greater earthquake occurring in this region are in excess of 60 percent in the next 27 years (Association of Bay Area Governments, 2003). With these facts in mind, it would seem logical to assume that the communities and

municipalities that lie in this region would be among the best prepared to handle this type of occurrence.

The survey instrument results obtained by this author would substantiate that assumption in several cases, however it also shows an apparent lack of preparedness and ability to respond by some agencies.

USGS (2003) talks about the inevitability of large earthquakes in the bay area region and advises that taking actions based on the likelihood of future quakes will help save lives and protect property. The city of Berkeley, California has heeded this advice and based on the information obtained through the survey instrument and literature review is considered on the forefront of preparedness and mitigation efforts in the region.

In the communities of Moraga and Orinda, efforts are underway to improve training, facilities, interagency cooperation and communications. In light of this, the research would indicate that a great deal of work still needs to be done in these two communities.

In a review of the city of Orinda's emergency operations plan conducted by the Orinda public safety advisory committee, recommendations were made to seek grant funds, rewriting the emergency operations plan, development of a recovery plan, improvements of communications capabilities, and more frequent and expanded training exercises (Orinda Public Safety Advisory Committee Sept.2005). These are needed improvements in order to be able to effectively prepare for and respond to the anticipated earthquakes that are predicted for this region.

According to ABAG (2005) in order to adequately address the after-effects of a large magnitude earthquake, communities must prepare using a multifaceted approach. Hazard recognition, preparation, response and mitigation, along with recovery planning needs to be in place and trained upon. Many communities surveyed have begun this process as is evidenced by the results of the survey instrument, and in fact most agencies either the city government itself, or the local police or fire department has made some materials available to help the communities in the areas of hazard recognition and preparation. This material and approach

appears to be a solid one, and is supported by the literature review information compiled by this author.

It is also clear from survey results that many municipalities fall short in the area of specific response policies, recovery guidelines, dedicated EOC facilities, and perhaps most importantly training for their first responders. Many respondents reported that they were not aware of a specific plan that addressed response expectations, which could lead to confusion and fragmented responses when a large quake occurs. If in fact these agencies have plans in place, then it appears that they have not been effectively communicated to the response personnel in the field.

ABAG (1998) reports that municipalities can expect pipeline ruptures, electrical and natural gas disruption, communication failures, structural collapses, structural fires, potential flooding due to dam leakage or breakage, and multiple causalities in the event of a large earthquake on the Hayward fault line. For first responders to be able to effectively assess, prioritize, and respond to these types of emergencies they need to have sound policy and procedural information in place which has been exercised and trained upon (EQE Engineering, 1989).

The literature review finds a number of agencies in the bay area, and others located elsewhere in the state of California that have developed and implemented policy and procedures for their first responders to follow. Some such as those from the Los Angeles fire department are quite detailed and extensive (City of Los Angeles Fire Department, 2006), while others address baseline information. These documents are readily available from these agencies, and those without such documents in place would be well served in the review and consideration of these documents for use as templates in their own organizations.

The Moraga-Orinda fire district would benefit from this type of process, as it currently lacks any specific response policies or procedures for its response personnel to utilize.

With its infrastructure at risk, the communities of Moraga and Orinda would benefit from further outreach efforts to its communities, and the continued review and adjustment of its

building guidelines and codes. Literature review suggests that this information is also readily available either online or from different municipalities in the area via direct contact.

In an overall assessment of the capabilities of the two communities, weighed against the risks, and what some other communities in the area have in place, the communities and their public safety first responder agencies could make many more improvements. Many of these improvements such as policy development, training, and community outreach can be done without incurring a significant financial impact upon the agencies (SF Gate.Com, 2006). Models are in place and assessable for comparative use, and while would require some staff time in research and development; come at a fairly low cost considering the potential risks faced.

The implications of inaction to the two communities and their emergency response agencies should not be understated. Literature review evidence strongly supports the probabilities of large seismic events on or near the Hayward fault line in the future, and suggests that damage and destruction could cause not only significant loss of life, but enormous negative financial impact to the area and its citizens in a range that could exceed the 10 billion dollar loss as a result of the Loma Prieta earthquake (Association of Bay Area Governments, 2003).

Without a solid plan in place, one can reasonably expect chaos in the early stages of a catastrophic event, followed by unnecessary risk taking, confusion, communication breakdowns, and an overall ineffectiveness and frustration of first responders tasked with responding to the event (Bernknopf & Soller, 1994). This failure to adequately respond to the emergency, will likely slowdown and hamper recovery efforts after the event (Vogel, 1996).

The citizens of these communities should be able to reasonably expect that the emergency response agencies task with their safety, have proper planning, established guidelines, policy, and procedures to deal with these types of expected events. Without such materials in place, and personnel trained in utilizing them, the communities and their public safety agencies are open for severe criticism at the least, in the aftermath of such an event. This was the case after the

Oakland Hills fire of 1991. The Oakland fire department and its communications center faced intense scrutiny surrounding its abilities and handling of the event. (EQE Engineering, 1989) This pubic scrutiny and criticism would be difficult to rebut, given the information concerning risk and probability that is available through sources such as those contained in this literature review and survey instruments.

Given a proactive approach, one could reasonably expect that a great deal of preparedness and response planning could take place in a fairly compressed time frame. Considering the current environment the two communities appear to be very receptive to improvements, and the timing with the two new city managers seems to be excellent. A coordinated and cooperative effort by the communities and their respective police agencies, with the Moraga-Orinda Fire Department playing a key role, could be undertaken with the expectation that the end results would lead to a much improved level of planning and response capabilities within the communities. Not knowing when the next quake will hit, it would be prudent to move expeditiously in this author's opinion. With good fortune and some luck, a solid plan could be in place in the event of the next catastrophic earthquake.

It is evident that some bay area communities have taken necessary steps to increase their citizen's awareness of the inherent risks associated with this area. In addition, a number have implemented policies and procedures for their first responders to follow. Building codes are being strengthened, and retrofit work is happening in the private as well as the public sector. Recovery plans are being put in place that include damage assessment tools, and help from both state and federal government agencies. This proactive approach to readiness is clearly worth the cost and efforts that municipalities incur to enact it and the benefits are supported by the literature review materials studied by this author.

Recommendations

Based on the analysis of the literature review, and survey instruments, it is recommended that the MOFD along with the city of Orinda, town of Moraga, and their respective police agencies, aggressively research and develop a comprehensive strategy for dealing with a local earthquake emergency. This effort should include at a minimum the following components:

Outreach to the communities by the development of a public information tool that is easily accessible by the citizens. Preferably this would be web based but also available in hardcopy for those without Internet access.

A commitment by the two municipalities to commit resources in the form of time, money, and personnel to research and develop an updated disaster plan that includes specific information for the types of disasters that the bay area, and local jurisdictions are likely to face. This plan should also incorporate a mechanism for periodic review and revision to allow for changes based on new information, technologies, or lessons learned from other disasters.

The continued development and improvement of a hardened EOC that would allow emergency managers and city staff to adequately function in command and operational roles for an extended period of time during a disaster. These EOC's should also support the necessary personnel for damage assessment, and initial recovery efforts.

Reoccurring training and exercises that allow various levels and agencies within the two communities to practice and refine their skills, respective to their responsibilities as outlined in the updated disaster plan. It is recommended that these training exercises occur on a frequent basis, and test all facets of the emergency response system capabilities including communications.

Continued efforts by the planning and building departments to improve and enforce seismic safety standards within the communities. Focused attention should be paid to identifying those structures within the two communities, which are at the greatest risk due to structural collapse. Incentive programs for retrofit applications and work has been successful in

neighboring jurisdictions and would be an area in which further research and possible implementation would be beneficial.

Development of policies and procedures that clearly define the expectations of those that work for city government. All new employees should be oriented and trained as to their respective responsibilities in the event of a large-scale disaster such as an earthquake.

Both communities would be well served to continue the development and training of citizens that are capable and willing to assist in the event of an emergency. The CERT programs underway in both the communities are an excellent example of this.

This author recommends that the emergency response agencies such as police and fire develop policies and procedures to guide their personnel for both on and off duty in the event of a local disaster such as an earthquake. Incident management positions should be clearly identified with the corresponding responsibilities and expectations clearly spelled out. Both agencies should be intricately involved in on going training both within their respective agencies and in conjunction with training exercises with city personnel. This is particularly important for those that may function in the command and general staff positions during a disaster.

Continued hardening of facilities would be prudent, with the goal of self-sufficiency for up to 72 hours being strived for. This hardening of facilities should include extended supplies of fuel for diesel generators, backup radio communications capabilities, food and water to feed personnel, and medical equipment and supplies to provide medical care for potentially large numbers of people.

The public safety agencies should also consider procuring any specialized equipment that may be needed by the police and fire personnel to assist with search and rescue in collapsed structures.

The public safety agencies in conjunction with the two cities should consider as part of a comprehensive approach, how damage assessment is going to be carried out, particularly in the time before state or federal assistance is available. The Federal Emergency Management

Agency's (FEMA) HAZUS program would be an excellent place to begin, as it provides for hazard scenario damage estimation and recovery planning. This tool is available to public entities for no cost.

These above recommendations if implemented would provide for a coordinated disaster response and preparedness approach, that would significantly benefit the two communities, their citizens, and provide for emergency responder safety and effectiveness.

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APPENDIX A
Fire/Police Department Survey
Electronic Mail

As part of the Leading Community Risk Reduction course at the National Fire Academy students are required to complete an applied research project as part of the requirements for the Executive Fire Officer program. I am conducting research on earthquake preparedness and response. Preparedness planning could be described as measures taken to inform or assist community members and or emergency response personnel in the event that a large earthquake were to strike in your area.

The survey attached will take only a few minutes to complete. When complete, please return the survey to bc6@mofd.org

or mail to:

Bryan Collins, Moraga-Orinda Fire District,
33 Orinda Way, Orinda CA 94563

or fax to:

Fax: Bryan Collins
925-253-0419

Please feel free to contact me using any of the above, if you have any questions.

Thank you for your assistance with this important research project. Your information is of key importance in the completion of this applied research project.

Person completing survey:	
Fire/PD Dept. name:	
Address:	
Telephone/Email:	

APPENDIX B

Local Government Survey
Electronic mail

To: [Name]
[title]
[agency]
[address]

Fr: Bryan Collins
Battalion Chief, Moraga-Orinda Fire District

Re: Earthquake Preparedness

As part of the Leading Community Risk Reduction course at the National Fire Academy students are required to complete an applied research project as part of the requirements for the Executive Fire Officer program. I am conducting research on earthquake preparedness measures taken by city governments.

Preparedness planning could be described as measures taken to inform or assist community members and or emergency response personnel in the event that a large earthquake were to strike in your area.

The survey attached will take only a few minutes to complete. When complete, please return the survey to bc6@mofd.org

or mail to:

Bryan Collins, Moraga-Orinda Fire District,

33 Orinda Way, Orinda CA 94563

or fax to:

Fax: Bryan Collins

925-253-0419

Please feel free to contact me using any of the above, if you have any questions.

Thank you for your assistance with this important research project. Your information is of key importance in the completion of this applied research project.

Person completing survey:	
Agency name:	
Address:	
Telephone/Email:	

APPENDIX C

Fire Agency survey

Earthquake preparedness

1. Does your agency have a functional disaster response plan in place?

2. If yes, does it specifically address earthquakes?

3. Does the department have a specific policy and/or procedures for response personnel to follow in the event of an earthquake?

4. Does your fire department supply any preparedness information aside from what may be provided by your city or county government?

5. If yes, how is it provided?

6. Does your department regularly conduct or participate in interagency disaster training?

7. Overall how would you rate your department's preparedness for response/mitigation of a major earthquake?

APPENDIX D

Police Agency survey
Earthquake preparedness

1. Does your agency have a functional disaster response plan in place?

2. If yes, does it specifically address earthquakes?

3. Does the department have a specific policy and/or procedures for response personnel to follow in the event of an earthquake?

6. Does your Police department supply any preparedness information aside from what may be provided by your city or county government?

7. If yes, how is it provided?

6. Does your department regularly conduct or participate in interagency disaster training?

7. Overall how would you rate your department's preparedness for response/mitigation of a major earthquake?

APPENDIX E

Survey of Local Governments
Earthquake Preparedness

1. Does your municipality have a functioning disaster plan?

2. If yes, does it specifically address earthquakes?

3. Does the municipality provide any preparedness information or mitigation information to the public?

4. If yes, how is this provided?

5. Does your municipality have a function Emergency Operations Center (EOC)?

6. If yes, is it dedicated for use only as an EOC?

7. Does the municipality regularly participante in disaster training exercises?

8. If yes, are other city departments involved?

9. How would you rate your municipality's ability to respond to a large-scale earthquake?

APPENDIX F

Fire Survey Results

	Disaster Plan		Earthquake specific		Specific Policy		Provide Info		How provided	Disaster training		Overall rating
Fire Department	Yes	No	Yes	No	Yes	No	Yes	No		Yes	No	
Fremont FD	X		X		X		X		website			excellent
South County FD	X		X		X		X		website	X		good
Contra Costa County FD		X		X		X		X				good
Oakland FD	X			X		X	X		handouts		X	good
Richmond FD		X		X		X		X				good
San Francisco FD	X		X		X		X		website	X		good
San Jose FD	X			X		X	X		website	X		good
Marin County FD	no reply		no reply		no reply		no reply		no reply	no reply		no reply
Alameda County FD	X		X		X		X		website	X		excellent
Santa Rosa FD	X			X		X	X		handouts	X		fair
Monterey FD	no reply		no reply		no reply		no reply		no reply	no reply		no reply
Salinas FD		X		X		X	X		website			fair
Alameda City FD	no reply		no reply		no reply		no reply		no reply	no reply		no reply
Santa Clara County FD	X		X		X		X		website	X		good
Vallejo FD		X		X		X	X		website	X		poor

APPENDIX G

Police Survey Results

	Disaster Plan		Earthquake specific		Specific Policy		Provide Info		How provided	Disaster training		Overall rating
Police Department	Yes	No	Yes	No	Yes	No	Yes	No		Yes	No	
Fremont PD	X		X		X		X		website	X		excellent
Newark PD	no reply		no reply		no reply		no reply		no reply	no reply		no reply
Contra Costa County SO		X		X		X		X			X	fair
Oakland PD		X		X		X	X		handout		X	good
Richmond PD	no reply		no reply		no reply		no reply		no reply	no reply		no reply
San Francisco PD		X		X		X	X		website		X	excellent
San Jose PD	X			X		X	X		website		X	good
Marin County SO		X		X		X		X			X	good
Alameda County SO	X			X		X		X			X	good
Santa Rosa PD	X			X		X		X			X	poor
Monterey PD	no reply		no reply		no reply		no reply		no reply	no reply		no reply
Salinas PD		X		X		X		X			X	fair
Alameda City PD	X		X		X		X		website	X		excellent
Santa Clara County SO	X			X		X		X			X	good
Vallejo PD	no reply		no reply		no reply		no reply		no reply	no reply		no reply

APPENDIX H

Local Government Survey Results

	Disaster Plan		Earthquake specific		Have EOC		Dedicated EOC		Provide Info		How provided	Disaster training		Other Depts		Overall rating
City	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No		Yes	No	Yes	No	
Fremont	X		X		X		X		X		website	X		X		excellent
Newark	no reply		no reply		no reply		no reply		no reply		no reply	no reply		no reply		no reply
Concord	X			X	X			X	X		website	X		X		excellent
Oakland	X		X		X			X	X		website	X		X		excellent
San Rafael		X		X		X		X		X			X		X	fair
San Francisco	X		X		X		X		X		website	X		X		excellent
San Jose	X			X	X			X	X		website	X		X		excellent
Marin	no reply		no reply		no reply		no reply		no reply		no reply	no reply		no reply		no reply
Sunnyvalle	X			X	X			X	X		website	X		X		good
Santa Rosa	X			X		X		X	X		website		X		X	poor
Monterey	no reply		no reply		no reply		no reply		no reply		no reply	no reply		no reply		no reply
Salinas	no reply		no reply		no reply		no reply		no reply		no reply	no reply		no reply		no reply
Alameda	X			X	X		X		X		website	X		X		excellent
Santa Clara	X			X		X		X	X		website		X		X	good
Vallejo	no reply		no reply		no reply		no reply		no reply		no reply	no reply		no reply		no reply