DISASCAPE TO PREEMPTIVE LANDSCAPE:

RESILIENT PARKS FOR EARTHQUAKE DISASTER MANAGEMENT

by

NOBUKO OGAWA

(Under the Direction of SUNGKYUNG LEE)

ABSTRACT

This thesis casts a new light on traditional use of parks by discussing whether existing parks in the U.S. can be used for disaster management and what features should be improved for unqualified parks, especially for earthquakes. First, this thesis analyzes Japanese disaster prevention parks in respect to their types and functions, focusing on disaster prevention, disaster relief, and post-disaster recovery. Next, overlay analysis is conducted to identify a project site in the United States. The Hazus program in conjunction with GIS is used to conduct this analysis. Based on the analysis, three districts in the city of Oakland California are chosen for a case study. Forty-one parks in the region are surveyed to evaluate the feasibility of implementing Japanese strategies. The result of this research suggests that parks in Oakland can improve their capability to prepare for future earthquakes by modifying signs, restrooms, and water features and creating firebreak features if necessary. This paper intends to open a dialog to discuss parks as essential tools for disaster management that landscape architects take charge of.

INDEX WORDS: Earthquake, Disaster Management, Urban Parks, Hazus, Japanese Disaster Prevention Parks, Oakland (California)

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DEDICATION

To my father, who taught me love for books

To my mother, who taught me love for people

To my professors, who taught me love for work

To my country, who taught me love for nature

To my friends, who taught me love for life

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CHAPTER 1: DISASCAPE AS A NEW NORM

Introduction

In 1995, I experienced the Great Hanshin-Awaji Earthquake, also called the Kobe Earthquake, which killed more than 6,000 people and left 300,000 homeless. Although my family members and home were safe, two of my classmates were missing for weeks and the images of broken highways and stricken buildings left me with a vivid impression of the fragility of human-created structures and the sheer strength of nature. Since natural hazards are unavoidable in Japan, we had regular earthquake drills and learned what to do when one happens.

Growing up in Japan, located in the Ring of Fire volcanic zone encircling the Pacific Ocean, natural hazards were part of my life, but these extremes of nature are becoming increasingly universal. According to the Office of U.S. Foreign Disaster Assistance (cited in Sudmerier-Rieux et al. 2006), the number of annual worldwide disasters increased about thirty times between 1930 and 2006. The United Nations Development Programme (UNDP) (2004) reported that the losses from those disasters skyrocketed from 40 billion dollars during the period of 1950-90 to 660 billion dollars between 1990 and 1999. Specifically in urban areas, economic losses and human death tolls have been greatly increasing due to the concentration of development associated with population growth. On the global scale, urban population has quadrupled in the past fifty years, with more than half of the world population now living in cities (Calthorpe 2012). Both increased frequency of natural disasters and this densification have increased the risk of living in an urban area.

To respond to those issues, various organizations have advocated disaster prevention on the grounds that it is cost-effective and ethical (Sudmerier-Rieux et al. 2006), emphasizing investments in ecosystems and natural barriers. World Bank reported that every dollar invested in disaster reduction can actually result in seven dollars of saving (cited in Sudmerier-Rieux et al. 2006). In this respect, some researchers have addressed the importance of urban parks and other open space to mitigate disaster impacts as it has been observed that parks function as crucial locations for the disaster recovery process (Saito 2006 and Sudmerier-Rieux et al. 2006).

However, in the United States where the risk of natural disasters has been very prominent, there have been few regulations established for parks in respect to disaster management. In order to improve the disaster-management functions of urban parks in the United States, this thesis examines disaster prevention parks in Japan, where urban park regulations have been developed to mitigate natural disasters, especially after the Hanshin-Awaji Earthquake. After analyzing their measures for those parks, I focus on the three aspects of disaster prevention parks: disaster preparedness, disaster relief, and post-disaster recovery and conduct a case study in Oakland, the San Francisco East Bay, California. Then, this thesis aims at inquiring into the possibilities and limitations of applying Japanese disaster management for parks in Oakland and suggests what can be modified for them to be qualified as disaster prevention parks.

Definitions of Disaster and Disascape

The Oxford English Dictionary defines a disaster as “an unexpected event such as a bad accident, a flood or a fire that kills a lot of people or causes a lot of damage.” From this definition, it can be inferred that two components constitute a disaster: an agent which impacts a society and the society which receives negative effects from the agent. The agent alone does not necessarily qualify as a disaster. Bowden (2011) articulated this point by comparing a 7.0 magnitude earthquake in the Mojave Desert region of California in October 1999 and the earthquake of the same magnitude in Haiti in January 2010. The former was not considered to be a disaster by the public due to its slight impact on human society; meanwhile, the latter was a catastrophic disaster because of its location and the negative influences incurred on the core of Haitian society. As Bowden pointed out, when a disaster is discussed, it is usually measured through human components, including death toll and economic loss. To understand a disaster, therefore, it is important to consider not only its physical impacts, but also its influence on and multi-dimensional meanings for a society.

Aware of the importance of a disaster's social dimension, Miller and Rivera (2008) defined a disaster as

> A naturally occurring or human-induced event that causes severe damage to the surrounding environment in which agents of society incur physical, social, economic and/or psychological damages, resulting in a disruption of the routine interactions, ultimately leading to a failure in the existing social network. The failure in the existing or 'normal' social order is soon replaced during the initial traumatization of the disaster by a new set of norms that govern daily existence (4).

The United Nations Office for Disaster Risk (UNISDR) (2004) furthered this point by discussing the difference between hazards and disasters.

> Strictly speaking, there is no such thing as a 'natural' disaster, but there are natural hazards, such as cyclones and earthquakes. The difference between a hazard and a disaster is an important one. A disaster takes place when a community is affected by a hazard (usually defined as an event that overwhelms that community's capacity to cope). In other words, the impact of the disaster is determined by the extent of a community's vulnerability to the hazard. This vulnerability is not natural. It is the human dimension of disasters, the result of the whole range of economic, social, cultural, institutional, political and even psychological factors that shape people's lives and create the environment that they live in.

These definitions imply two important points. One is that the level of a disaster depends on social factors rather than natural factors. The other is that controlling an ability of society to cope with hazards can change the society's vulnerability to the hazards.

In this thesis, a disaster is defined as "an unpredictable natural event that changes the human-built environments and the lives of residents to the extent that their physical, social, and ecological needs are unsatisfied and the residents are required to take adaptive actions to the changed environment". I have coined the term "disascape" to describe a landscape highly exposed to and vulnerable to a natural hazard, which fails to cope with the hazard so that its "normal" condition can be greatly altered. This term signifies physical, social, and ecological changes of the landscape and its incapability to function as a system.

Parks for Resiliency

To approach the issues of disascape and inquire into solutions on assisting a disascape to become a preemptive landscape, this thesis will focus on the use of parks. Why are parks important for disaster management? It is mainly because of their flexibility to respond to different conditions. The goal of a pre-emptive landscape is not a static state. A pre-emptive landscape should be functional both in regular conditions and emergency conditions, such as a disaster. This idea resonates with Hester's idea of resilient urbanity (2006). He stated that resilient cities have "internal ability to persist—to recover from easily without significant loss from illness, misfortune, attack, natural or social disaster, or other dramatic disturbance. And it can readily absorb change" (139). Likewise, pre-emptive landscape should have a capability to flexibly respond to expected disasters without breaking the essence of a society. Hester compared this flexible function to a defensive team in football, which bends but does not collapse. Parks can function as such a defensive team for a city. As the Great Hanshin-Awaji Earthquake (GHAE) proved, even after such a devastating earthquake, many parks received less damage compared to other infrastructure and became centers for residents to rebuild their lives. Therefore, parks have a potential to become the media to preserve the essence of inherent local culture, ecosystem, and social order while functioning as a catalyst for a city to achieve a new norm in the post-disaster state.

In addition, parks are almost universal components of cities and open to a wide range of populations in cities. Other urban open spaces, such as temples and schools, may not exist in certain societies and their uses can be limited to certain populations. In this sense, using parks for disaster management has a higher potential to be applied for a variety of cultures.

Interestingly enough, Hester (2006) cited the GHAE as an example to illustrate his idea of a resilient city. He stated that resiliency of a city can be measured from three aspects: “the inherent form of the landscape itself, the way that people relate to the landscape in which they dwell, and the actions of people themselves” (142). He argued that places with less damage after the GHAE had some advantageous traits regarding the three points he listed. Those places included development built on stable geologic land, communities with more consideration to natural forces in terms of building codes or practices of retrofitting old facilities, and neighborhoods which had stronger social networks due to historic events and strife against the government. Disaster prevention parks can possibly contribute to his three points at the same time. By strategically placing parks, they can not only become firebreaks but also prevent precarious development on unstable geological formations, averting potential liquefaction at the time of an earthquake. Furthermore, parks can stage an opportunity for residents to become familiar with natural ecosystems by harvesting rainwater, creating community gardens and camping. Those activities can help residents deepen their interaction with each other. The last two factors may not seem to be directly related to pre-emptive landscape. However, familiarity with local ecosystems and residential communities can help a neighborhood to work together over time and rebuild after a disaster. Taken as a whole, parks are worthwhile analyzing and modifying for disaster management because they can preserve ecosystems, which can mitigate disasters, and they are often open to visitors from diverse neighborhoods, unlike schools or temples, which can contribute to resilient urbanity.

The Structure of This Thesis

The structure of this thesis is as follows: The second chapter conducts a literature review of Japanese disaster prevention parks to examine how vulnerability to hazards can be reduced through the use of parks. By inquiring into how the experience of the 1995 Great Hanshin-Awaji Earthquake impacted the county's regulation of parks, this thesis then establishes criteria of what functions of parks should be considered for application to parks in the United States. Specifically, their types, functions, planning, and designs will be examined.

Chapter three aims to identify appropriate sites for implementing disaster prevention parks in the United States. This process is two-fold. First, based on features of Japanese prevention parks, locations in the U.S. which show similar qualities are identified. For example, Japanese disaster prevention parks are often designed to prepare for an earthquake. Thus, locations in the U.S. with high vulnerability to earthquakes will be analyzed. This thesis specifically reviews the Bay Area in California as the general region for the study because of its high probability for earthquakes in the near future and the great risk of economic and social damages.

In the second stage of the process, this thesis will further narrow down specific regions for disaster prevention park application. This stage utilizes McHargian overlay analysis (McHarg 1969), using the Hazus program in conjunction with Geographic Information System (GIS). This overlay analysis weighs different factors of a possible major earthquake, including subsequent fires, expected debris, and possible short term evacuees. Population density is also added to the overlay analysis in order to evaluate which district of the Bay Area is most in need of disaster prevention parks. From this process, three districts in the city of Oakland, California are chosen as a case study.

Chapter four evaluates forty-one parks in three districts of the city of Oakland, surveying whether they can function as disaster prevention parks. Chapter five discusses the implications of this case study based on parks' usefulness in disaster preparedness, disaster relief, and post-disaster recovery process. It also draws a cross section of the entire process, analyzes the limitations of this thesis and suggests further studies. Chapter six then speculates on the possible benefits of applying disaster prevention parks in the global context and concludes the thesis.

CHAPTER 2: LESSONS FROM JAPAN

The 1995 Great Hanshin-Awaji Earthquake

In order to examine how parks can be used after a disaster and retrofitted to mitigate the next disaster, one of the best examples would be the development of Japanese disaster prevention parks after the 1995 Great Hanshin-Awaji Earthquake (GHAE). This thesis attempts to distill the principles of the post-quake development of Japanese parks and establish a model of evaluating parks for mitigating disasters.

The GHAE became a milestone for disaster management planning in Japan. The 20-second tremor with 6.8 moment magnitude scale completely destroyed the city of Kobe, located 20 km (12.4 miles) away from its epicenter, immediately affecting 1.5 million citizens. This earthquake revealed the fragility of modern infrastructure and impacted building codes of transportation facilities, leading to a review of emergency response policies for disasters. The earthquake also drew people's attention to the importance of open space, including parks and school yards, because of their usefulness as evacuation areas. Saito (2006) listed the following points as the reasons why evacuees chose to stay in parks. Parks and school grounds with large open spaces received relatively small damage from fires or building collapse, providing space for refugee camping and storing goods necessary for disaster relief. Open space also made it easy for rescuers to approach those parks. In this earthquake, specifically, evacuees exceeded the expected number, and schools designated as evacuation areas were not large enough to accommodate all the evacuees. Those who could not get into schools chose to stay in nearby parks. In addition, it is reported that trees in parks gave a sense of safety against aftershocks. In the long term, citizens found that open space presented opportunities for affected citizens to congregate and interact, especially when parks were originally managed by community members and neighbors were familiar with the local park. This function was important for them when rebuilding their communities.

Types + Functions of Parks in Japan

According to Saito (2006), among all the parks affected by the GHAE, only 0.8 percent of them became completely unusable. Compared to buildings and hard infrastructure, parks received less damage, allowing them to more readily become evacuation destinations, especially those most often used by residents prior to the disaster. Survey of affected areas showed that approximately 341 out of 1165 parks (30 percent) were used after the earthquake (Japanese Garden Institute 1995, in Saito 2006). Specifically in the city of Kobe, 176 out of 367 parks (48 percent) were used for some manner of recovery process. Saito’s study illustrated the use of parks based on their sizes. Five main kinds of parks used after the GHAE were: block park (Gaiku Kouen), community park (Kinrin Kouen), neighborhood park (Chiku Kouen), multi-use park (Sougou Kouen), and regional park (Koueki Kouen). The size of each park is listed in Table 1.

Block Park (Gaiku Kouen)	Serving residents living within 250 m (about 820 ft) from the park. Size is about 0.25 ha (about 0.62 acres)
Community Park (Kinrin Kouen)	Serving residents living within 500 m (about 1640 ft) from the park. Size is about 2 ha (about 4.94 acres)
Neighborhood Park (Chiku Kouen)	Serving residents living within 1 km (about 3280 ft) from the park. Size is about 4 ha (about 9.88 acres)
Multi-use Park (Sougou Kouen)	Designed for multi-uses, including walking, performance, recreation, and sports. Size is about 10-50 ha (about 24.71-123.55 acres)
Regional Park (Koueki Kouen)	Serving residents in the entire prefecture. Size is about 50 ha (about 123.55 acres)

Table 1: Park Types in Japan (Ministry of Land. Infrastructure and Transport 2014a)

The Disaster Reduction and Human Renovation Institution (1997) stated that middle-size parks (including community parks and neighborhood parks) near residential districts were more heavily used than other parks. The Japanese Institute of Landscape Architecture (1995, in Saito 2006) shared the same conclusion and reported that, in the city of Kobe, neighborhood parks and community parks that were larger than 2500 m^2 (0.75 acres) were the most heavily used, while the use of parks smaller than 1000 m^2 (0.25 acres) was extremely low. Saito (2006) referred to their proximity to residential areas and relatively large open space as reasons for the use by affected citizens. Those study results raised the question of how parks smaller than 0.25 acres can be integrated into disaster prevention strategies. This is crucial in urban parks since available open space is often limited in cities. If a community only possesses a small park and there is no open space which can be developed into a larger-size disaster prevention park, the small park should be retrofitted to function as at least a safe enough temporary evacuation area. Deciding which parks should be retrofitted, thus, requires a comprehensive approach to examine an entire vulnerable area and analyze where disaster prevention parks are insufficient.

Legal Framework of Disaster Prevention Parks

How parks were used after the GHAE even significantly altered the legal framework of disaster prevention parks in Japan. The parks used after the earthquake included parks which were not specified as legal disaster prevention parks at that time. Before the GHAE, only multi-use parks (about 25 acres) and greenways were legally considered to be disaster prevention measures. After the earthquake however, in 1996, middle-size parks, including community parks and neighborhood parks, were added to this list. This movement signified the importance of strengthening community-based approaches to disaster management, which was revealed in the GHAE. Shaw (2014) reported that 98 percent of evacuees were rescued by local neighborhoods while only 2 percent were helped by the formal rescue efforts. He also pointed out that this recognition of the valuable role of local communities for disaster management is not limited to Japan. In fact, the United Nations Office for Disaster Risk (UNISDR) also emphasized such community involvement as a tool to increase resilience against disasters (2004). While the Japanese government stressed the importance of middle-size parks, it also recognized the importance of a prefecture-level park which can support and manage smaller parks. In 1998, regional parks (larger than 123 acres) got listed as disaster prevention parks to function as headquarters to deliver emergency necessities to smaller parks, both in urban and rural areas.

Table 2 summarizes the types of Japanese disaster prevention parks and their sizes as well as the population densities they target.

Name	Park Type	Size	Targeted Population Density	Year Implemented
Disaster Management Headquarters	Regional Park	More than 50 ha (123.55 acres)		1998
Main Refugee Base	Regional Park/ Multi-use Park	More than 10 ha (24.71 acres)	More than 40 ppl/ ha (16 ppl/ acre)	1978
Temporary Refugee Base	Community Park/ Block Park/ Neighborhood Parks	More than 1 ha (2.47 acres)	DID area (more than 500 ppl with 16 ppl/ acre density)	1996
Evacuation Route	Greenway	10 m wide (32.8 ft)	More than 40 ppl/ ha (16ppl/ acre)	1978

Table 2: Disaster Prevention Parks (In Saito 2006)

Use of Disaster Prevention Parks

The Japanese Institute of Landscape Architecture categorized six uses for the parks: (1) Short-term shelter, (2) Distribution of medical and other supplies, (3) Combination of (1) and (2), (4) Temporary housing, (5) Storage of wrecks, garbage, and cars, (6) Less intense use, including temporary evacuation. Within a week after the GHAE, 67.4 percent of the parks used for the recovery process in the city of Kobe were used for less intense use and temporary evacuation. Following this use, 19.0 percent were used for short-term shelter, and 13.1 percent for storage. In the second and third week, less intense use decreased to 48.7 percent. Meanwhile, the combination of (1) and (2) increased to 16.8 percent. Although types of use may change over time after a disaster, the GHAE underscored that urban parks have a crucial role in disaster recovery processes. Specifically their open spaces gained attention because of its protected large open space which can accommodate evacuees and wreckage of destroyed structures. In addition to those functions, trees to buffer the open space and surrounding buildings, water features to counteract potential fires, and offices to contact other facilities should be considered (Ministry of Land Infrastructure, Transport and Tourism 2013).

Three Pillars of Disaster Prevention Parks

Ikeda (2014) stated that there are three pillars for disaster risk management: disaster preparedness, disaster relief, and post-disaster recovery. There are other ways to categorize the main factors for disaster management. For example, the National Governor's Association (1978 cited in Phillips 2009) suggested those three pillars plus mitigation as components of comprehensive disaster management. According to him, the difference between mitigation and preparedness is that former addresses structural aspects, such as building of levees to prevent flooding, and the latter is more related to non-structural aspect, such as planning and educational efforts. In this thesis, I regard efforts and activities conducted prior to a disaster as one category and call it preparedness.

Mileti (1999) extensively explained disaster preparedness, disaster relief, and post-disaster recovery in his book. The following definitions describe each aspect: preparedness activities include anticipating "problems in disasters so that ways can be devised to address the problems effectively and so that resources needed for an effective response are in place beforehand" (215); Response efforts are emergency measures, such as providing emergency shelter, searching for and rescuing victims, and caring for the injured; and Recovery is designed to "restore community functions through replacement of capital stocks to pre-disaster levels and returning the appearance of the community to normal to the final phase, which involved promoting future economic growth and development" (229). Ikeda pointed out that, while disaster relief is often emphasized and receives a lot of assistance from other countries, the other two aspects tend not to gain enough attention and resources. Although those three pillars are interrelated, balanced considerations should be paid to each pillar when designing disaster prevention parks. This thesis discusses the roles and designs of disaster prevention parks based on those definitions of the three pillars in disaster management.

Disaster Preparedness for Parks

For disaster preparedness, it is important to consider the systematic placement of parks to examine if there are sufficient open spaces, especially for the purpose of firebreak and evacuation. To mitigate possible fires from an earthquake and ensure that residents can reach assigned evacuation areas, planners must pay attention to transportation infrastructure, water facilities, and fire stations. In addition, other public facilities may function similarly to parks. For example, schools and temples with large open spaces and green areas can be considered as alternatives to parks. The following diagram shows a basic planning concept for disaster prevention parks and associated facilities.

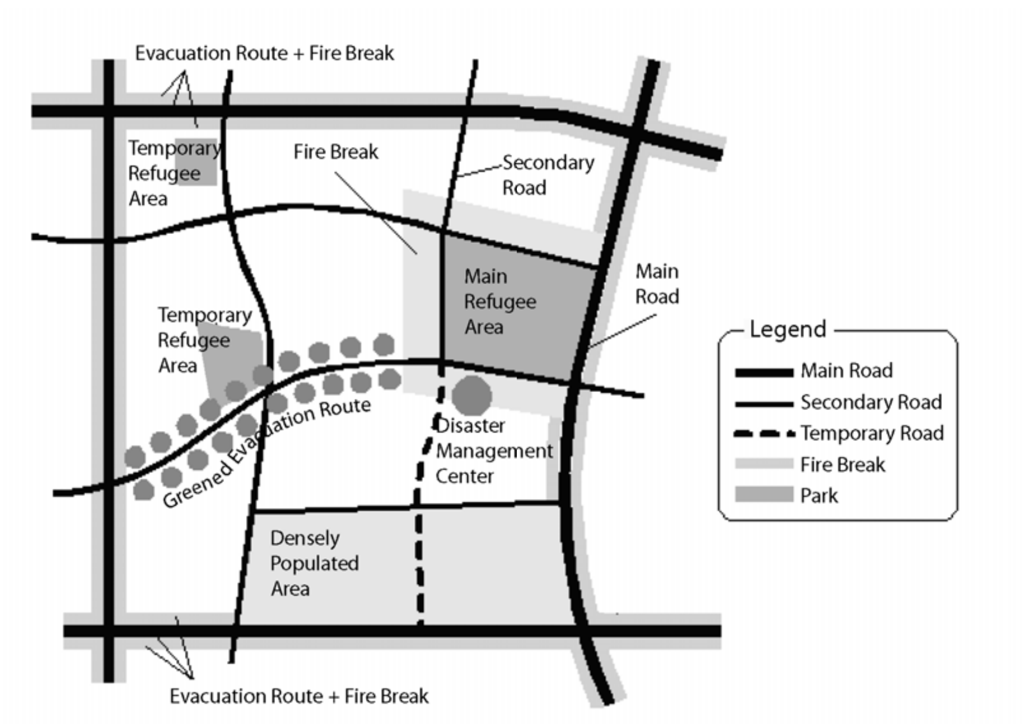


Figure 1: Planning for Disaster prevention parks (Ministry of Land, Infrastructure, Transport, and Tourism 2014b)

As the diagram above shows, a densely populated area should have access to an evacuation route with a firebreak, which is connected to both temporary refugee areas and main refugee areas. According to Japanese Institute of Landscape Architecture (1995 in Landscape and Urban Green Infrastructure in Japan (LUGIJ) 2005), 66 percent of fires which followed the GHAE stopped along the main roads. The other 22 percent was prevented from spreading thanks to buildings. The remaining 12 percent of firebreak was open space.

When the 1923 Kanto Earthquake struck a very dense area of Sumida-ku, Tokyo, it killed 38,000 people. Meanwhile, in Fukagawa-Ishizaku-tei which was about as large as Sumida-ku, there were 20,000 people whose lives were saved because they evacuated to greenspace (Japan Academic Council 1997). Compared to the Kanto Earthquake where about 30 percent of firebreaks were open space, including parks, the contribution of such function by open space (12 percent) in the GHAE was relatively small. This might have reflected the lack of open space in the affected area of the earthquake. Still, the importance of open space was well-pronounced after the GHAE and encouraged study of parks as firebreak tools. Some studies concluded that as long as it is wider than 30 m (about 100 ft) on each side, open space in a park can satisfy a firebreak purpose. To mitigate fires, the presence of water is also important. Open water, like ponds, wells, and tanks are encouraged in disaster prevention parks.

Along with open space and water, trees are helpful in mitigating fire. When a tree encounters fire, it condenses its moisture to create a protective filter outside of its bark. A sufficient number of trees can protect buildings from fire. Therefore, trees can be placed to surround open space and protect it. To select trees for this purpose, LUGIJ (2005) created a list of trees based on appropriate places for planting, which were categorized into three zones (F, P, S). F zone is areas most vulnerable to fire, such as dense residential areas. In this zone, trees should be highly ignition resistant. P zone is around open space. Trees in this zone should be not only ignition-resistant, but also shielding the inside space. However, it is important that those trees do not completely blind the view to the inside open space for security reasons. The third zone, S zone, is open space. Trees in this zone should be selected mainly based on the relationship to possible helicopter landing in the case of evacuation. They also suggested some planting design patterns. All the possible designs included combinations of low and high trees. This conclusion coincides with the study of the Japan Academic Council (1997). As examples, LUGIJ introduced *Machilus thunbergii* and *Castanopsis sieboldii* as tall trees and *Osmanthus fragrans* and *Viburnum awabuki* as low trees.

Together with fire, falling of buildings can intensify the damage of an earthquake. Trees actually play a further role in preventing this secondary hazard. Their roots can support land and prevent corruption of buildings. Those trees can support not only their own weights but also that of falling buildings. The Disaster Reduction and Human Renovation Institution (1997) stated that trees prevented buildings from falling in 57 places during the GHAE. Even when the first floor was broken, some trees supported the second floor. Trees can also protect people by improving the microclimate. They can alleviate rain, wind, sunlight, and even air pollution.

Disaster Relief for Parks

Parks' functions for disaster relief are mainly related to accommodating emergency evacuees. To safely direct them to safe places in parks, lights and signs are crucial. The GHAE happened at 5:57 am. It was close to the sunrise and during the time of a full moon. Therefore, darkness did not prevent evacuees from accessing parks. However, if the earthquake had happened at night during a new moon, it would have been necessary for signs to direct evacuees to their destinations. To ensure those signs and lights are available, even if a disaster destroys a city’s utilities, parks should have lights powered by solar panels and other back-up systems. Those lights should be placed to direct evacuees to the entrances of parks and to the final destination of open space in those parks.

It is also important to consider how people, cars, and even helicopters can access parks. To ensure access to a park and protect it, the Disaster Reduction and Human Renovation Institution (1997) stipulated that there should be a 6 m (about 20 ft) wide street facing a park with a space of at least 100 ft x 100 ft for helicopter landings. LUGIJ (2005) further speculated details of entrance and helicopter landing space. Required entrance space depends on the expected number of evacuees. However, in an emergency situation, it is difficult to estimate how many people can be present in an unexpected time near a specific park. Therefore, it is important that an entrance is flexible to accept populations with different needs. To enable this, entrances should have fences or shrubs which can be removed in an emergency situation, so that it can accommodate a large population, if necessary. Along with the entrance, the pressure resistance of the ground should receive attention. To support heavy vehicles such as fire trucks and ambulance, helicopter landings, and a large number of people, some turf may not be appropriate. LUGIJ suggested improved Bermuda Grass and Kentucky Bluegrass to be the most appropriate for this purpose. They also introduced a new technology to integrate plastic or concrete frameworks to further strengthen the ground.

Disaster Recovery Process

Lastly, for parks to contribute to disaster recovery processes, it is important to consider what features are necessary to sustain a regular life. One of the toughest parts of evacuation experiences may be lack of restrooms. It was reported that, after GHAE, public restrooms in parks were overused and filled with waste (Disaster Reduction and Human Renovation

Institution (DRHRI) 1997). Although the affected area of the earthquake had advanced infrastructure at that time, most water pipes were broken and toilets were not usable. Therefore, a massive number of temporary lavatories were requested. At one point, as many as 9,200 temporary toilets were provided. However, most of the cities were not accustomed to such preparations and it took them a long time to provide enough toilets. According to DRHRI (1997), toilets were one of the issues evacuees kept complaining about. To prevent such a situation after the GHAE, manhole toilets have been implemented in a number of parks. A manhole toilet is directly connected to a sewer line and can be used as a toilet during post-disaster recovery. In this way, a number of toilets can be prepared and waste treatment is relatively easy.

Figure 2: Manhole Toilet Figure 3: Well + Pump
(Tokyo Metropolitan Park Association 2014)

Another crucial necessity is water. When the GHAE happened, more than a million households experienced water outages. Ten days later, about 50 percent of the water system had recovered. Even a month later, 20 percent of the affected households still did not have water service (LUGIJ 2005). To ensure the provision of water, parks should have water storage systems which can be used even when their water lines do not function (Disaster Reduction and Human Renovation Institution 1997). Examples include water tanks, wells, rainwater harvesting barrels, and ponds. Open water sources, like ponds, can be also used for multiple purposes ranging from washing dishes to extinguishing fires. If evacuees need to depend on those sources for drinking water, there should be filtration facilities as well. For those people, parks can also accommodate benches that can convert to grills which allow evacuees to cook.

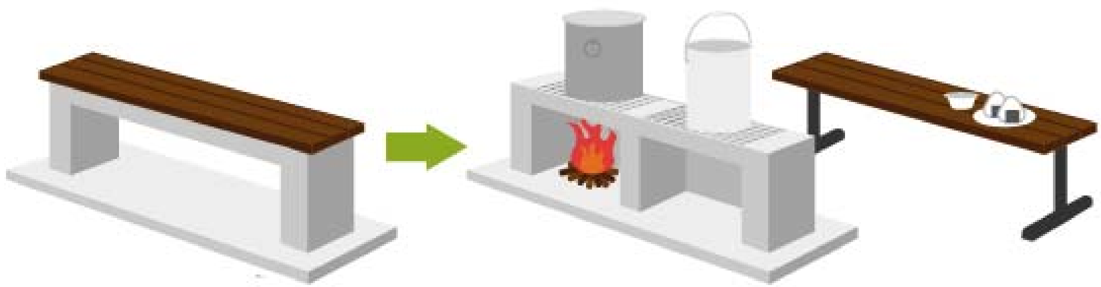


Figure 4: Bench to Grill (Tokyo Metropolitan Park Association 2014)

It is also noteworthy that vegetation played an important role for the post-disaster recovery process. Following the GHAE, various individuals and groups engaged in activities to promote greening the city of Kobe (Saito 2006). Those groups included Rubble to Flowers (Garekini Hana Wo), Tachigi Volunteer Foundation, Acorn Shell Net Kobe (Donguri Net Kobe), Hanshin Green Net, and Hyogo Green Network (Disaster Reduction and Human Renovation Institution 1997). All the organizations mainly recognized the therapeutic effect of vegetation on evacuees. In addition, Sudmeier-Rieux, Masundire, and Rietbergan (2006) pointed out that edible plants can become important assets that can alleviate lack of food in the recovery process.

Programming is essential to connect community members to disaster prevention parks so that they are familiar with the parks when a disaster happens. Since the GHAE, some Japanese cities have developed programming and features which can be helpful both before and after a disaster. The programming includes barbeque parties, survival camping, community gardening, and town tours through parks (Japan Academic Council 1997). Barbeque parties can train residents to use fire outside. Survival camp can let them have evacuation experiences using benches, wells, and trees. Community gardening can allow residents to grow local food without depending on supplies from outside. Town tours can ensure that residents memorize evacuation routes and deepen their understanding of the city. Those experiences can be useful when a disaster really happens, and they can enhance community interaction.

For the programming of a larger scale park, the Miki Disaster Management Park (MDMP) is a useful example. It provides sports facilities in a regular base and functions as a disaster management headquarters when a disaster occurs. 200 ha (about 500 acres) of land accommodates track fields, ball fields, a gymnasium, and camping sites. Specifically, the park's disaster management strategy focuses on storage for emergency food and management for use as the headquarters to support satellite parks in the prefecture. MDMP is the first park of this kind in this scale.

	Regular Use	**After a Disaster**
Track Field	400 m track (9 lanes) Lawn for soccer and other sports	Storage Truck Yard Redistribution of rescue supplies and relief materials
Second Track Field	400 m track (8 lanes) Lawn for soccer and other sports	Temporary heliport
Baseball Field	Baseball (13000 m^2)	Temporary Heliport
Ball Field	3 lawn fields for soccer and rugby	Temporary camping site for a relief crew and volunteers
Parking Lot	2100 lots space for regular cars and 26 lots space for buses	Accommodation of volunteers Temporary storage Redistribution of rescue supplies and relief materials
Gymnasium	Basketball, Volleyball, Tatami mat for martial arts	Temporary storage Redistribution of rescue supplies and relief materials
Tennis Court	9 inside tennis courts	Accommodation of volunteers Temporary storage Redistribution of rescue supplies and relief materials
Camping Area	Camping	Temporary camping site for a relief crew and volunteers
Natural Area	Environmental Education	Temporary camping site for a relief crew and volunteers

Table 3: Miki Disaster Management Park Functions (in Saito 2006)

Figure 5: Miki Disaster Management Park Plan View (Miki Disaster Management Park 2014)

Application for the United States

The parks discussed in this chapter were specifically designed for the Japanese context. Although disasters are prevalent worldwide, there are contextual differences between Japan and other parts of the world. Therefore, it is important to consider the applicability of Japanese disaster management measures to other countries.

In the case of the United States, the idea of creating parks which can accommodate different concerns both in social and ecological needs, including disaster management, coincides with the idea of Sustainable Parks, a main emerging park type in the United States according to Cranz and Bolland (2004). They argued that changes in park typology had reflected changes in social concerns in the United States. They characterized the Sustainable Park as self-sufficient, integrating larger urban systems outside the park, and creating new standards for aesthetics and landscape management. This type of park especially stresses concerns on both ecological and human health. Also, it addresses aesthetics of temporality, process, and complementarity. Their claim that parks should be solutions for the overall health of nature and humans and need to respond to changes reinforces the raison d'etre of disaster prevention parks in the United States.

Since the United States is a much larger country, there should be regional frameworks rather than national ones to respond to local needs. Also, Japanese disaster prevention parks often focus on earthquakes and fires. Therefore, the applicability of their measures should focus on the places which are exposed to and vulnerable to those hazards.

As for key organizations, the American Red Cross and the Federal Emergency Management Agency (FEMA) seem to cooperate with local Park and Recreational divisions in order to determine the use of parks for disaster management. For example, they operate recreational centers attached parks as shelters and or volunteer reception centers when a disaster happens (City of Oakland 2013). However, their focuses are buildings in parks not open space or vegetation. Although FEMA uses parks for temporary shelters and creates FEMA camps, their quality doesn't seem to be sufficient to facilitate the community's recovery process. For example, the FEMA camp is often located far from the center of their home city and evacuees lack access to social services (Levitan 2009) As a result, residents would have difficulty finding new jobs and permanent housing. Another issue is that the community is decentralized and citizens feel insecure and isolated in temporary housing (Spiegel 2007). Thus, there are good chances that Japanese disaster management measures for parks can contribute to the improvement of urban parks in the United States in respect to disaster management.

Features necessary for designing parks for disaster management in this chapter will be used in Chapter 4 in discussion of the possible application of Japanese disaster prevention parks in the context of the United States. But before that, the next chapter will analyze how to identify appropriate sites for disaster management parks in the U.S.

CHAPTER 3: KOBE TO THE SAN FRANCISCO BAY AREA

Ten years after the GHAE, the 2005 World Conference on Disaster Reduction was held in Kobe. In the conference, the Hyogo Framework for Action (HFA) was adopted as a framework to tackle the task of disaster mitigation worldwide.

In the United States, almost 75 million people in 39 states can be possibly exposed to earthquake hazards. Because of its concentration of faults, the west coast states provide good candidates to apply Japanese disaster prevention parks. Among them, California is the most vulnerable state in terms of possible damage because of its increasing population and heavily concentrated infrastructure, which can be observed from the estimated economic damage due to an earthquake (Figure 9). Together with Japan, the west coast of the United States is located on the Ring of Fire, which means that a number of earthquake faults lie under the ground (Figure 6). In California, the San Andreas Fault divides two tectonic plates which are moving in the opposite directions of north and south. Most of the land is on the eastern North American Plate. Meanwhile, some major cities, including San Francisco, are on the western Pacific plate. Those plates move at the speed of 1.6 inches a year (Eadie 2005).

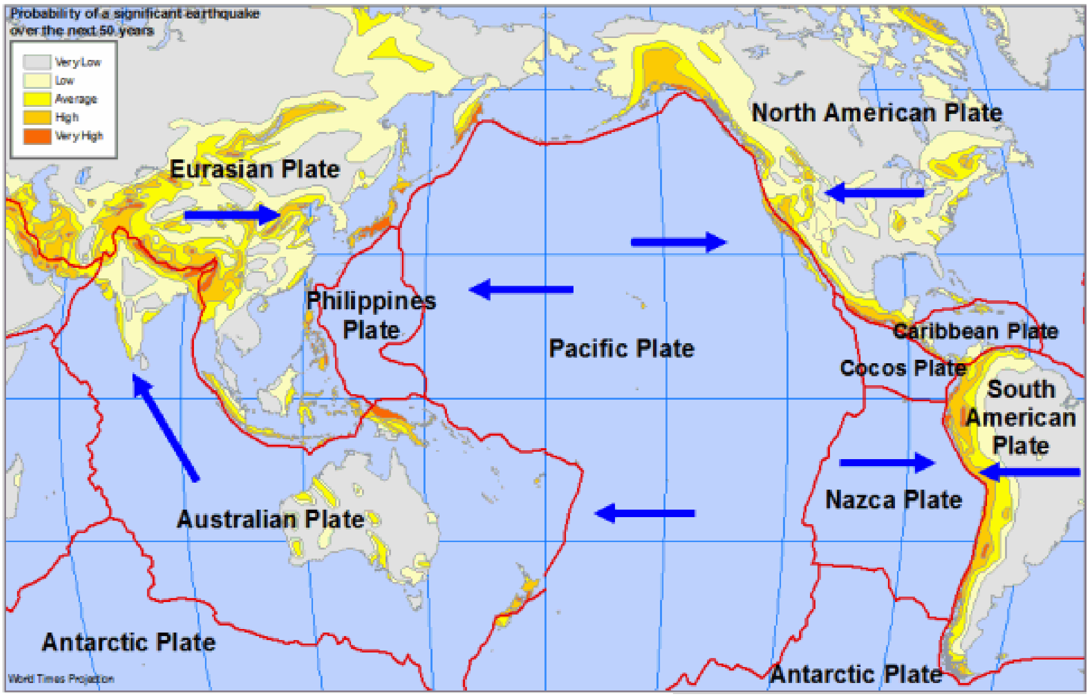


Figure 6: The Ring of Fire (cited in Rodrigue 2004)

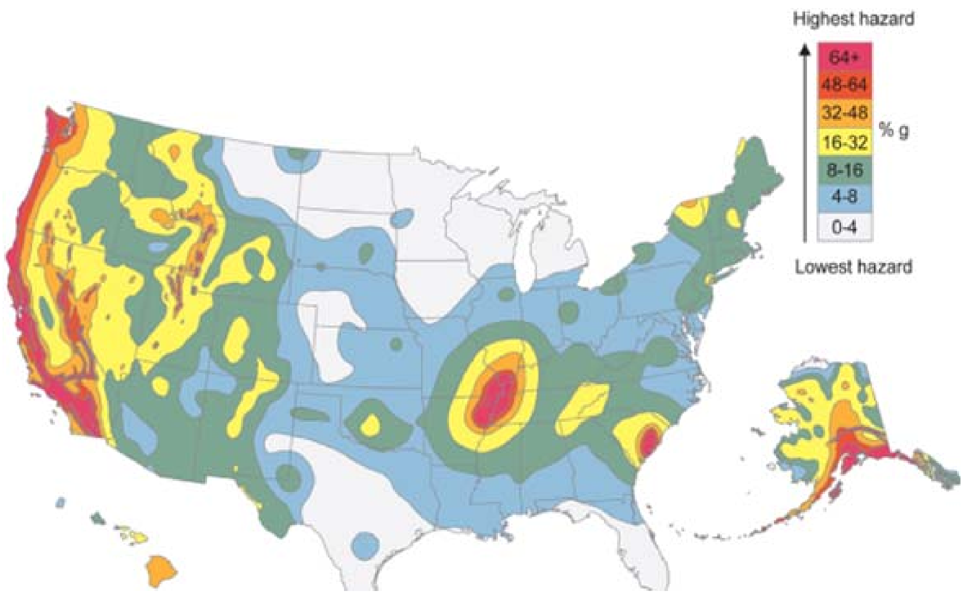


Figure 7: The Potential Shaking Hazard from Future Earthquakes Indicated by the Potential Ground Motion (a percentage of the acceleration due to gravity (g)) (U.S. Geological Survey, Dept. of the Interior, Earthquake Hazards)
(cited in The Encyclopedia of Earth 2011)

It is a convoluted task to predict when an earthquake will happen. However, from historical data displayed in Figure 8, it seems that the San Andreas Fault seems to cause a devastating major earthquake once every 150 to 200 years (USGS 2012b). The most recent one was the 1906 San Francisco Earthquake. Its 7.9 moment magnitude tremor and subsequent fire destroyed almost eighty percent of the city. It is inevitable that the next “Big One” will hit California within the next hundred years. To prepare for that hazard, the state has strengthened its hard infrastructures, including buildings, developed mitigation policies, and implemented emergency response training (Eadie 2005).

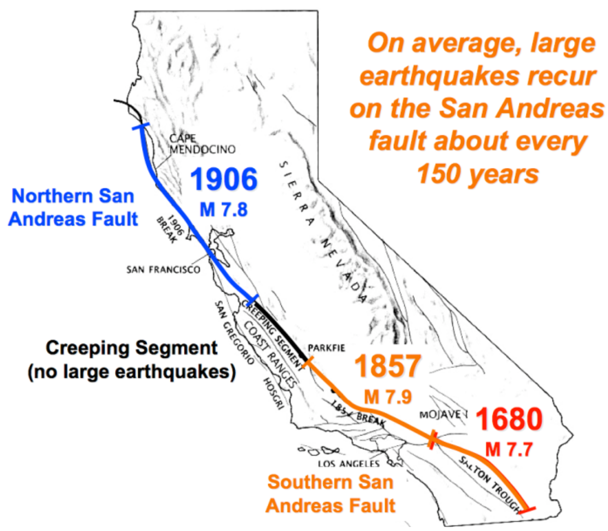


Figure 8: Faults in California (Johnson 2007)

In addition to the great probability of earthquake occurrence, high concentration of population and infrastructure make California very vulnerable to a disaster. According to the Federal Emergency Management Agency, twelve out of the top twenty areas which would receive the greatest economic losses are in California. Figure 9 shows the vulnerable areas with their potential economic loss. The areas in California are shown with red bars. The region that ranks as number 1 is the Los Angeles-Long Beach-Santa Ana area with $1.312 billion of economic loss under the estimated annualized earthquake. The second is San Francisco-Oakland-Fremont area with $781 million loss.

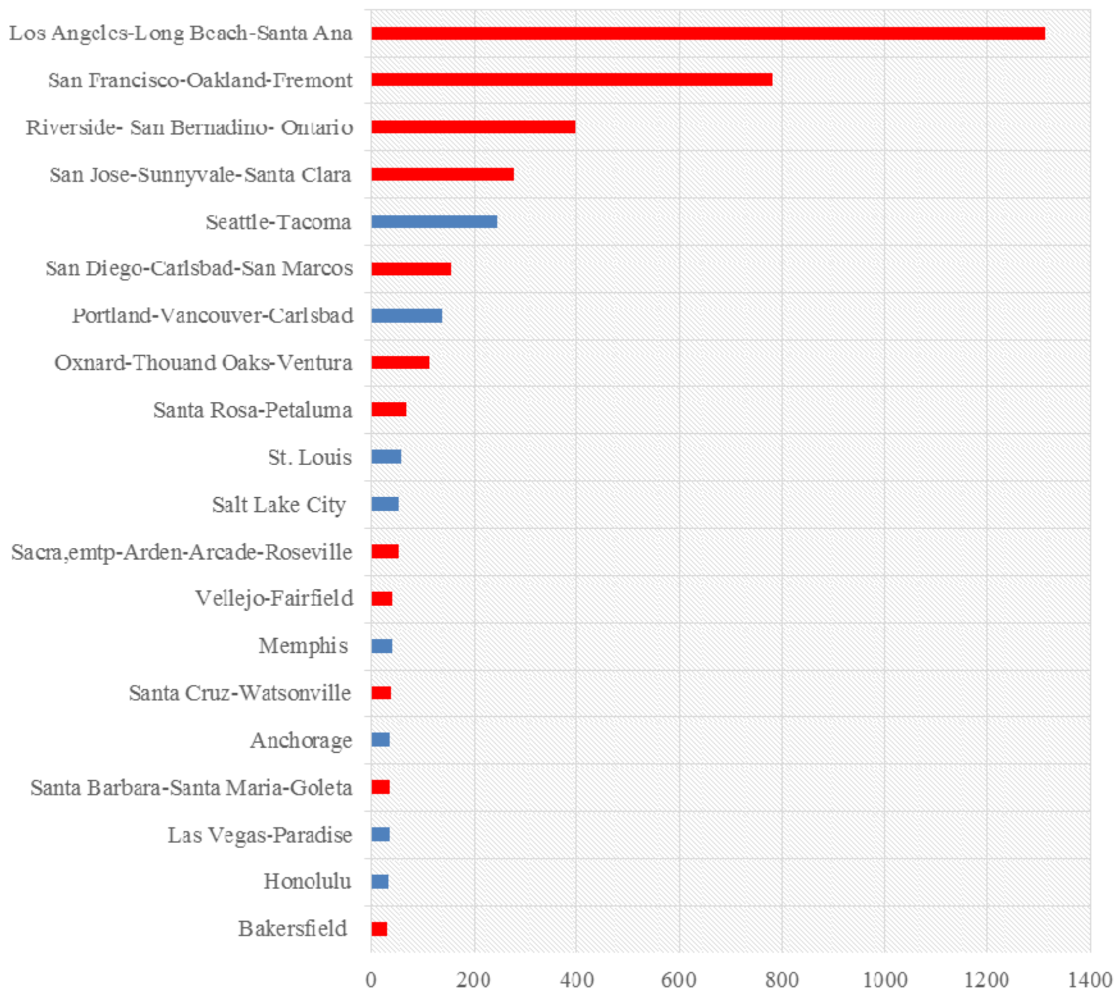


Figure 9: U.S. Metropolitan Areas with Estimated Annualized Earthquake Losses of More Than Million (in millions) Source FEMA Publication 366, HAZUS MH Estimated Annualized Earthquake Losses for the United States (April 2008). Annualized earthquake losses (AEL) calculated in 2005 dollars.(FEMA)
(cited in Johnson 2007)

The United States, especially California, have been increasing their attention to earthquake management. Influential earthquakes include the 1989 Loma Prieta Earthquake (M6.9, 63 killed, $5.9B losses) (Pacific Earthquake Engineering Research Center 2005) and the 1994 Northridge Earthquake (M6.7, 20 killed, $20B in direct losses). Along with the GHAE, those earthquakes made Californians realize that an earthquake can create profound damage in densely populated urban areas (USGS 2012a).

Nevertheless, there is very little study on disaster preparation in the field of landscape architecture even in California. Yumeji (1983) listed some reasons why it is hard to plan for earthquakes in the U.S.: (1) The frequency of large earthquakes is not enough to motivate Americans to integrate earthquake mitigation into planning measures; (2) Americans are often unwilling to invest in long term planning; (3) The high fiscal cost of disaster mitigation. Not to mention, not much attention has been paid to open space for its value as an earthquake mitigation tool. Therefore, this thesis will try to apply principles of Japanese disaster prevention parks to parks in California so that the knowledge can contribute to disaster risk mitigation for the next "Big One".

Case Study

In this thesis, the San Francisco Bay Area (San Francisco-Oakland-Fremont) was chosen to evaluate whether existing parks can function like disaster prevention parks in Japan and what improvement can be suggested. The Bay Area consists of nine counties and 100 cities, which are home to approximately seven million residents and the source of a $400 billion economy. The population is concentrated in the city of San Francisco and the coastal area of southern counties. Evacuation centers are located in those densely populated areas. There are three major reasons why the site was selected:

1) Geography, Population Density, and Infrastructure

The Bay Area, especially the East Bay, shares a lot of similarities in its geography with Kobe. First of all, they lie along major faults. Also, they are both sandwiched by a bay and hills. Finally, they are both port cities with the concentration of population and infrastructure. Those similarities would make application of disaster prevention parks appropriate. In fact, the GHAE became a catalyst to invest in the retrofit of the San Francisco City Hall, the Golden Gate Bay bridges, medical facilities, BART subway system, and the University of Berkeley campus for seismic upgrade (Eadie 2005).

2) High Chance of Next Earthquake

An earthquake in North California would be caused not only by the San Andreas Fault but also by the Hayward Fault, which runs through the East Bay. U.S. Geological Survey seismologists concluded that this fault will cause a major earthquake (magnitude 6.7 or greater) by 2032 with 62 percent probability. This earthquake will possibly displace 360,000 residents and leave 110,000 people homeless. As one of the functions of disaster prevention parks is to accommodate evacuees, they can play an important role for such a large number of displaced residents.

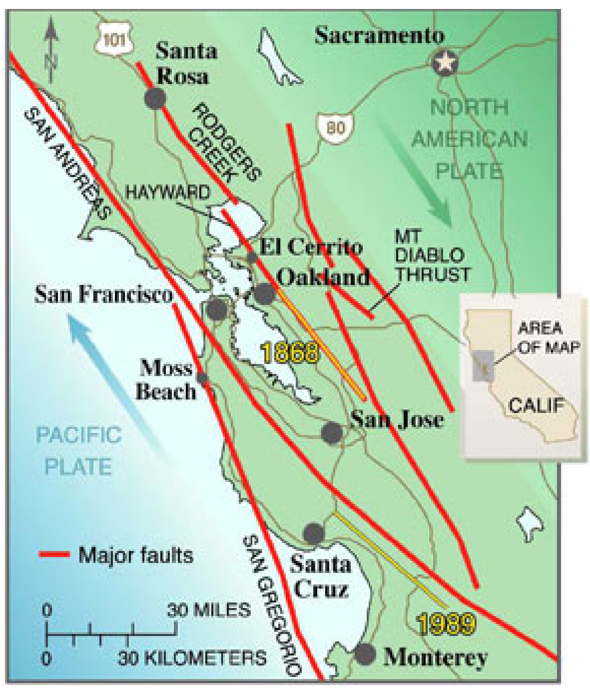


Figure 10: Faults and Plate Motions in the San Francisco Bay Region (USGS 2012a)

3) The Legacy of the Great 1906 San Francisco Earthquake

Like Kobe, San Francisco has experienced a devastating earthquake. On April 8, 1906, the San Francisco Earthquake shocked a large part of the west coast. With the epicenter near the city of San Francisco, the rupture killed more than 3,000 citizens (Greely 1906), left 225,000 people homeless and caused $400 million in losses (NOAA 1972). Because of this tragedy, however, the scientific study of earthquakes in the U.S. advanced faster than ever. Also, to commemorate the earthquake, there is an annual ceremony at Lotta's Fountain on Market Street. Those legacies of the earthquake would provide reasons for the governors, researchers, and citizens to easily accept mitigation measures for earthquakes through disaster prevention parks.

Because of those reasons, the Bay Area is an ideal place to test if principles of Japanese disaster prevention parks can work outside the context of Japan. In the next section, I will describe how this thesis will investigate the possible use of parks for disaster management.

Inventory and Analysis

Method

In this thesis, this preliminary stage of analysis relied on spatial data on population density and estimated damage from disasters, including subsequent fires, estimated debris, and potential population who need short-term shelters. The research was conducted using Geographic Information System (GIS) 10.0 with the plug-in of Hazus-MH 2.1. Hazus is the software designed by the Federal Emergency Management Agency (FEMA) to support communities for disaster management. Specific hazards programmed include hurricanes, flooding, and earthquakes. It was initiated in 1992. The purpose of the program is to identify vulnerabilities of specific areas, evaluate preparedness for a specific disaster, calculate the potential economic and social losses when a disaster occurs, and assess priorities for disaster mitigation. The program integrates inventory (exposure) data of general building types and their occupancies, lifelines, demographics, and hazard specific information, including elevation and building configurations. For an earthquake analysis, the data is based on census tract. It is important to note that provided results from Hazus are only estimates.

USGS (2014) stated that Hazus is a reliable program for disaster management. Also, a number of studies have used Hazus for estimating the effects of earthquakes in the United States (Moffatt and Cova 2010). The Hazus-MH Technical Manual (FEMA 2003) provides the details of approaches and data collection methods. The data sources can depend on geographic variables. For example, ground-shaking outcomes can come from either computations of the Hazus program itself or seismology specialists (Moffatt and Cova 2010). Although there is always uncertainty with estimating the damage from an earthquake, Hazus is currently the most accepted tool to calculate earthquake damage in the nation.

Hazus was used to examine statistical information of earthquakes in the San Francisco Bay Area with nine counties. The analyses are based on the scenario of moment magnitude 6.7, which is considered to be the minimum tremor for a major earthquake, and 100 year probability. The potential damages from the scenario were analyzed in three categories: subsequent fires, debris, and population in need of short-term shelter. The complete list of the Hazus data in this scenario is attached at the end of this thesis (Appendix A).

Subsequent Fires

The subsequent fires were investigated based on the water needed to put them out, or fire demand, with the unit of gallons per minute (gpm) in census tract level. In the Hazus model, the dependent variables to estimate the fire include the number of ignitions, an estimate of the size of the potential burned area and estimated exposed population as well as buildings in terms of monetary values (FEMA 2003). Ignition refers to each fire that occurs and persists after an earthquake which requires a response from fire departments. Ignitions counted in Hazus include both fires immediately after an earthquake as well as fires which start after a while, usually within a day. Hazus particularly processed ignition data of seven American historic earthquakes after 1970 to create a regression model (FEMA 2003).

$$\text{Ignition/Building Total Floor Area} = 0.581895\,(PGA)^2 - 0.029444\,(PGA)$$

Where PGA= Peak Ground Acceleration

This formula proved to be very accurate by the USGS which tested correlation between ignition data and ground motions for seven earthquakes in the past, including the 1971 San Fernando, 1989 Loma Prieta, and 1994 Northridge earthquakes (FEMA 2003). Based on this ignition data, Hazus further calculates the possible spread of fire using the formula developed by Hamada (1975 cited in FEMA 2003), which incorporates wind velocity, building dimensions, and space between buildings. The calculated data is used to estimate required water flow (gpm).

In the overlay analysis for this thesis, output of fire demand was reclassified as the following: the least suitable is smaller than 2,500 gpm not needed, between 2,500 and 7,500 gpm is moderately suitable, and more than 7,500 gpm is most suitable. This classification is grounded on the fact that dense areas of San Francisco require fire demand of 2500 gpm. Therefore, a fire which needs more than 2,500 gpm will require extra measures to put out. However, some studies argue that post-earthquake conflagration may vary from 7500 to 12000 gpm (Scawthorn 2011).

Debris

Removing debris is a crucial part of disaster relief. It can block roads, preventing ambulances from reaching the injured and utility companies from fixing power and water lines. Therefore, parks' function to store debris is very useful. Debris identified in Hazus is of two types. One is that which usually stays in large pieces, such as reinforced concrete and steel, which requires special treatment to break before being transported, and the other is smaller types, such as brick, wood, and glass, that can be more easily carried with bulldozers and other tools. Both kinds are measured by their weight (thousands of tons) and in census tract level. Hazus estimates possible debris by calculating building damage during an earthquake. It is important to note that debris from other structures, such as bridges, is not calculated in this module. In the scenario, 4,026,000 tons of wood/ brick and 7,119,000 tons reinforced concrete/steel are expected to be left as debris (11,146,000 tons total). In the overlay analysis, the total weights of both kinds of debris per acre were used. The least suitable value is less than 50 tons per acre, medium suitable is between 51 and 200 tons per acre, and most suitable is more than 201 tons per acre.

Short-term Shelter

Earthquakes can significantly damage habitability of buildings and cause some residents to seek either short- or long-term public shelters. Parks can play primary roles by providing open space for tents or mobile homes. Hazus computes the number of people who need public shelter in the short term. It does not calculate the long-term shelter demands because there is a wide variation in the possible estimates. In the East Bay, it is expected that 25,139 people will need short-term shelter. It first calculates displaced households through the loss of residential buildings or major utilities, including water and power. The module does not deal with failure of other facilities, such as dam and waste release, which may result in household displacement. Then, this result is combined with other factors, including income breakdown, percentage of homeowners and renters, and age breakdown of households. This is because not every displaced household seeks public shelters. Some of them may find shelter in their family members' homes or hotels. At the same time, past studies have shown that the number of people who seek public shelter may exceed the population who lost their homes. One of the studies says that 80 percent of the homeless population in the pre-disaster state usually seeks public shelter after a disaster. Also, some people may evacuate to public shelter without any severe damage to their residence. As a result, those who seek public shelters may exceed the population which needs evacuation by 50 percent (FEMA 2003). Therefore, Hazus incorporates those social factors into the calculation. For example, 62 percent of the households with less than $10,000 income are expected to seek public shelter, while only 13 percent of those who have more than $35,000 are expected to evacuate to public facilities. Table 4 shows the list of default fractions in the Hazus model. This can be manually altered as needed. In the overlay analysis, the expected number of people per acre (ppa) was used to determine the values for suitability. Least suitable is less than 0.2 ppa, medium suitability is between 0.3 and 0.8 ppa, most suitable are more than 0.9 ppa.

Household Description	Default
Income	
Household Income < $10,000	0.62
$10,000 < Household Income < $15,000	0.42
$15,000 < Household Income < $25,000	0.29
$25,000 < Household Income < $35,000	0.22
$35,000 < Household Income	0.13
Ethnicity	
White	0.24
Black	0.48
Hispanic	0.47
Asian	0.26
Native American	0.26
Ownership	
Own Dwelling Unit	0.40
Rent Dwelling Unit	0.40
Age	
Population Under 16 Years Old	0.40
Population Between 16 and 65 Years Old	0.40
Population Over 65 Years Old	0.40

Table 4: Fraction of Households Likely to Seek Public Shelter (FEMA 2003)

In addition to the data computed in Hazus, the population density was added to the overlay analysis. Density of population and associated buildings can often multiply the damage of disasters. Fire can be easily spread if wooden buildings concentrate, and more buildings can cause more debris. Also, dense areas can produce more evacuees than sparsely populated areas. Japanese disaster prevention parks' target population density is almost equivalent to 40 people per acre (ppa). Therefore, in the overlay analysis, least suitable is less than 40 ppa, moderately suitable is between 40 and 80 ppa, and most suitable is more than 80 ppa.

Overlay Analysis Process (Figure 11)

In order to compare different areas and display the suitability of disaster prevention parks, weighed overlay analysis was conducted in GIS, using the data derived from Hazus and population density. Cell size for each value was set to be 100 feet by 100 feet. As discussed above, each data's value was reclassified into least suitable, moderately suitable, and most. After the reclassification, this analysis overlaid the sets of the data with the assumption that each one is equally important. Figure 12 illustrates the result of the overlay. The darker area highlights the intersection of locations with high population density and heavy expected damage from future earthquakes, thus representing higher suitability for disaster prevention parks. Along the major roads, the suitability is relatively high. The concentrations of dark areas can be found in the northeastern part of San Francisco and north tip of Alameda. This may be due to both the existence of major roads and proximity to the bay. Referring back to Figure 11, it can be confirmed that those two areas would receive severe damage in all the three categories of subsequent fires, debris, and short-term shelter. This thesis will focus on the north tip of Alameda, districts 1, 2, 3 of Oakland city, for further study (Figure 12).

Figure 11: Overlay Analysis Process

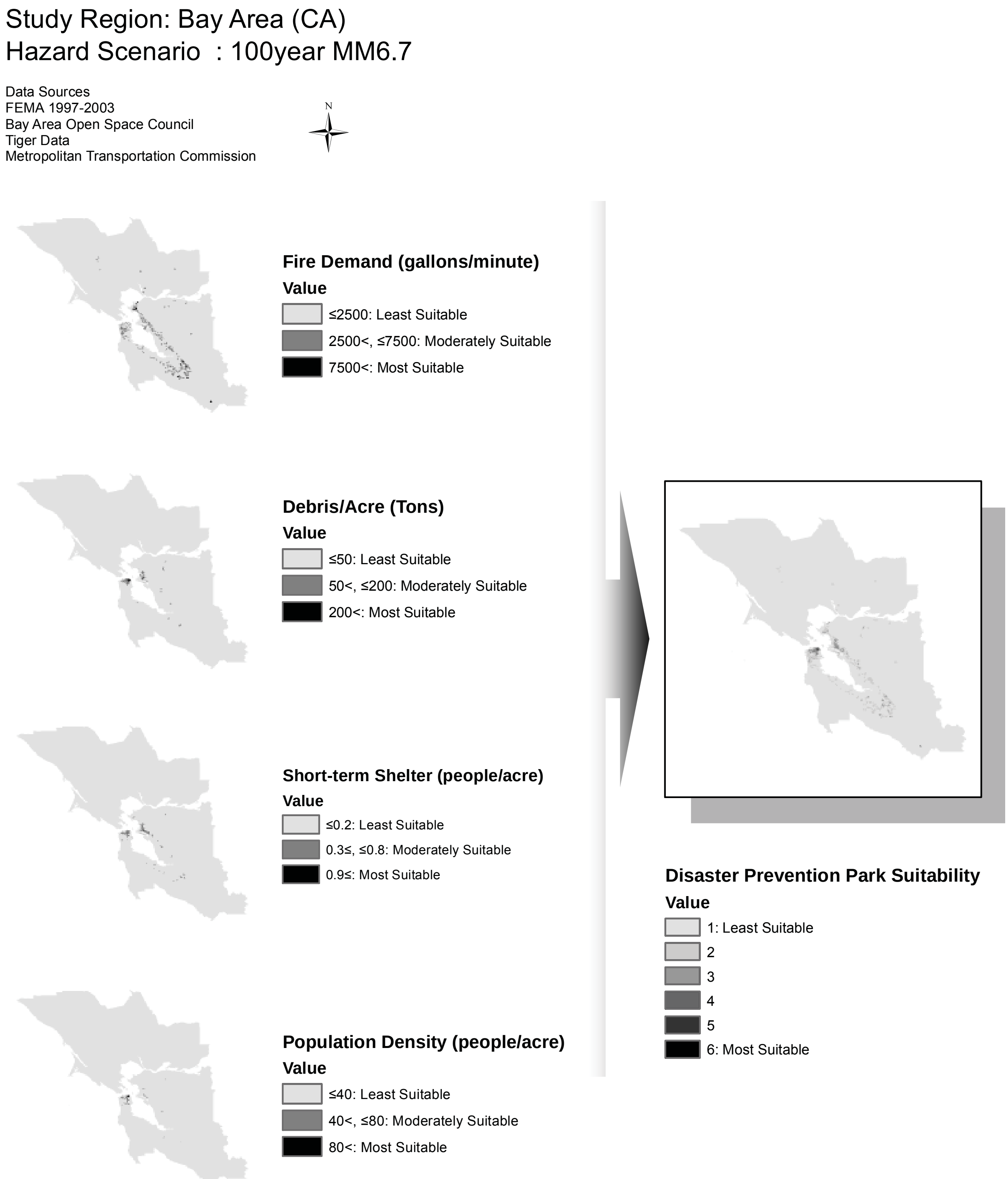
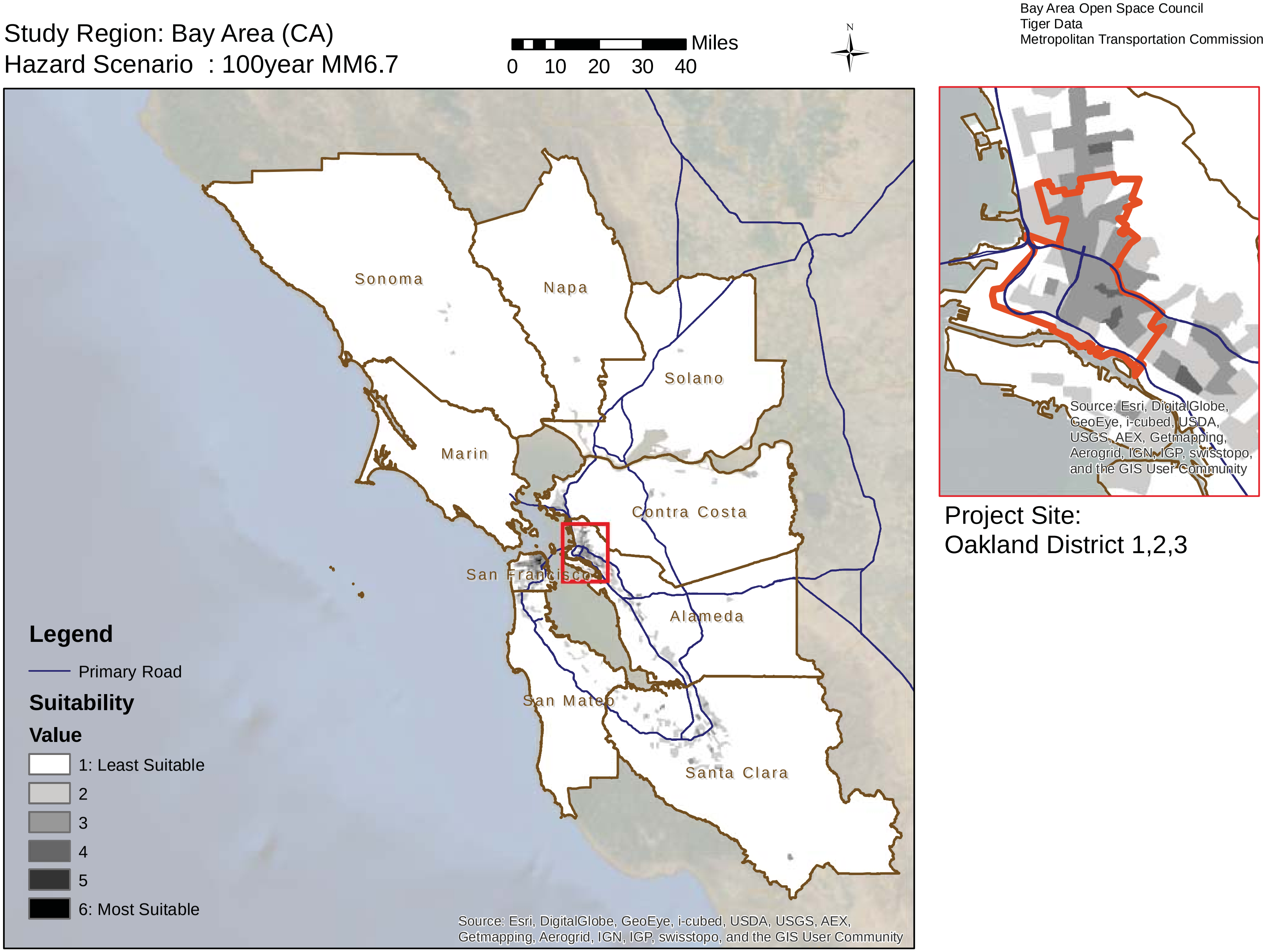


Figure 12: Overlay Analysis in Bay Area



CHAPTER 4: EVALUATION OF OAKLAND

From the analysis of the previous chapter, there were two regions identified as vulnerable urban areas. One is the northeastern part of San Francisco (supervisorial district 5, 6), and the other is the northwestern part of Alameda, which belongs to the city of Oakland (district 1, 2, 3). Since the overlay analysis illustrates that Oakland has larger regions vulnerable to damage from earthquakes, this thesis inquires into the possibility of using existing parks as disaster prevention parks in Oakland district 1, 2, 3 (Figure 12).

Among forty-one parks in the study area, there are two small size block parks (smaller than 0.25 acres), two medium size block parks (between 0.26 and 0.50 acres), sixteen large size block parks (between 0.51 and 2.50 acres), fifteen community parks (between 2.51 and 10.0 acres), four neighborhood parks (between 10.1 and 24.0 acres), and two multi-use parks (between 24.1 and 123.0 acres). There is no regional park (larger than 123.1 acres). The locations of each park are shown in Figure 13. Figure 14 shows major characteristics of parks in each category. The characteristics were grouped into four. One is plaza type, the second type is playground combined with other uses, except for sports fields, and the third type is sports fields combined with other uses, the last one is lawn, greenway, or either of them. Small block parks are either plaza or playground. They are accessible to the public. For medium-size block parks, playground was a major type. It also provides free access to the public, but playground facilities may occupy those parks, leaving little open space. Open space here means space without any vertical objects, which can be used for evacuation or helicopter landing. When the size of a park becomes large enough to become a large block park, sports fields appear. Sometimes, those parks are not open to the public and fenced to block non-paying visitors. Some of them are attached to nearby schools and their opening hours to the public are limited. Those large parks often combine different functions, such as playground and sports fields or lawn, playground, and plaza. Likewise, community parks are often multi-functional. However, it can be also huge lawn space or greenway, providing expansive open space to the public. The neighborhood parks and multi-use parks are both multi-functional, as well. Mosswood Park is a combination of sports field, lawn, and playground, while San Antonio Park is lawn, sports field, playground, and a building. Two of the largest parks in the project site, which fall in the category of multi-use park, are located on the waterfront, which accommodates both local residents and tourists. Interestingly, both of them do not possess either a playground or sports field.

Figure 13: Parks in Oakland

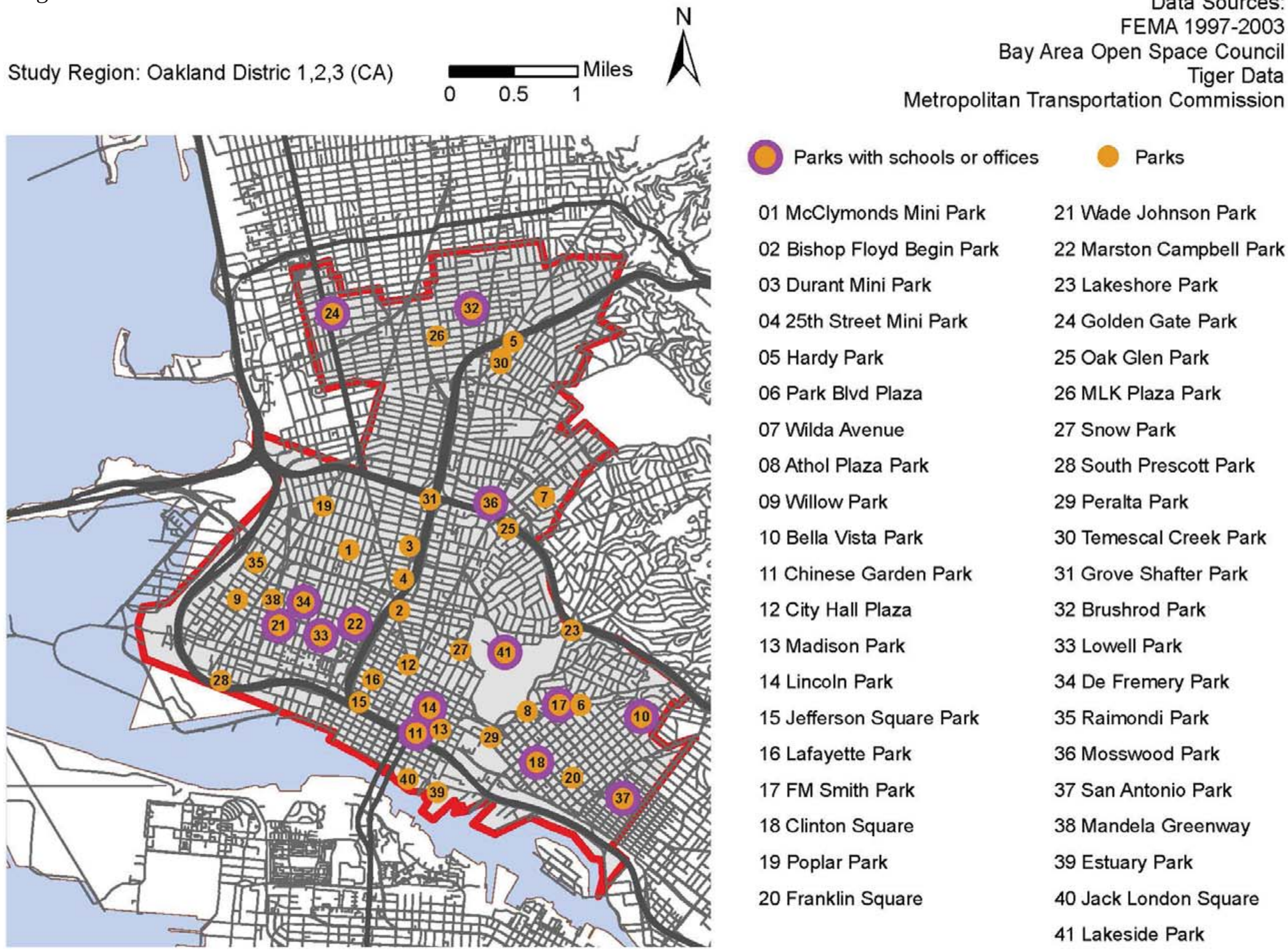
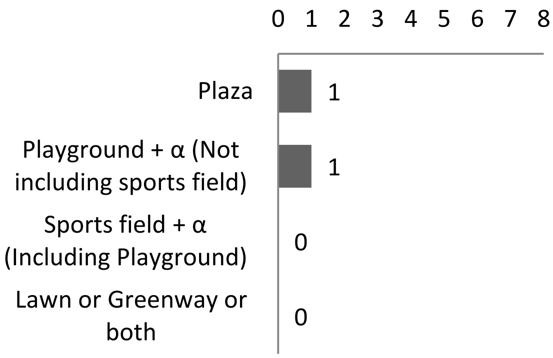


Figure 14: Characteristics of Parks in Oakland

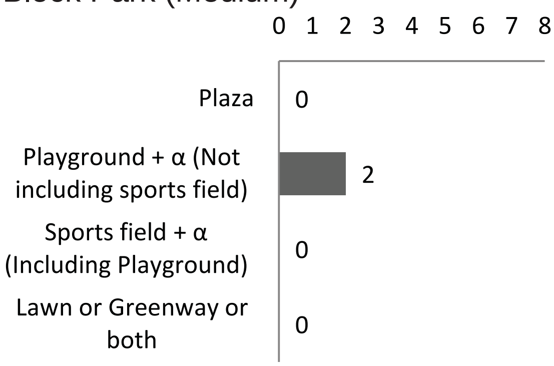
Block Park (Small)



McCrymonds Park (Playground)

Bishop Floyd Begin Park (Plaza)

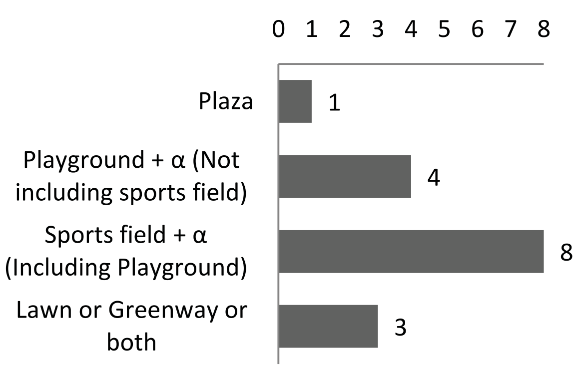
Block Park (Medium)



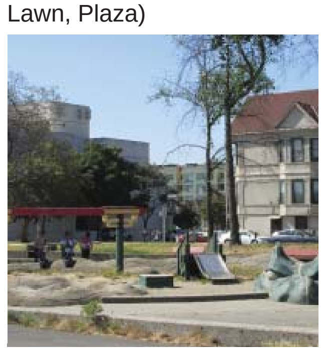
Durant Mini Park (Playground + Community Garden)

25th Street Mini Park (Playground)

Block Park (Large)

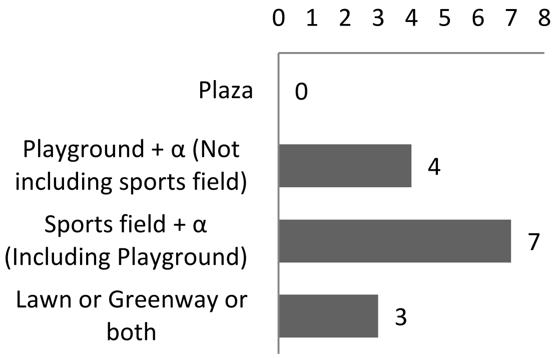


Madison Park (Playground, Lawn, Plaza)



Lincoln Park (Sports field, Playground, Lawn, Building)

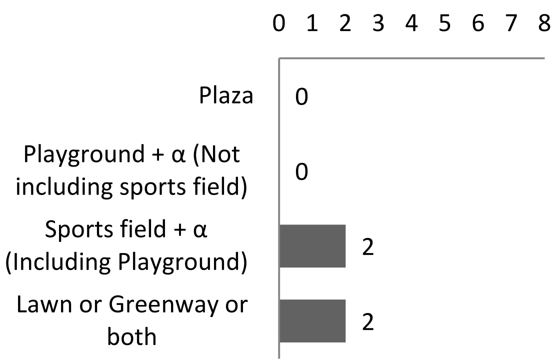
Community Park



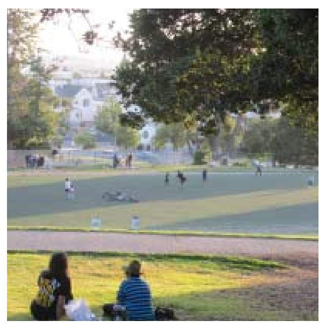
De Fremery Park (Sports fields, Playground, Lawn, Pool, Building)

Temescal Creek Park (Greenway)

Neighborhood Park

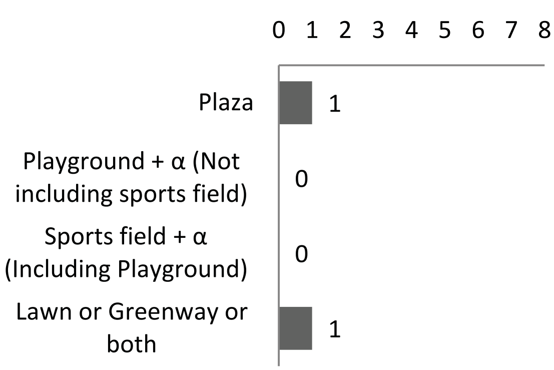


San Antonio Park (Sports fields, Playground, Lawn, Building)



Estuary Park (Lawn, Greenway, Waterfront)

Multi-use Park



Jack London Square (Plaza, Waterfront)

Lakeside Park (Lawn, Greenway, Garden, Waterfront)

Evaluation Purpose and Method

The purpose of this analysis is to identify which parks can be used as disaster prevention parks and what features should be improved for unqualified parks to become disaster prevention parks. Forty-one parks in districts 1, 2, and 3 of Oakland city were assessed for appropriateness to become disaster prevention parks, using GIS data, Google Earth, and the city website. The assessment was reevaluated through the site visit which occurred between June 4 and 10, 2014.

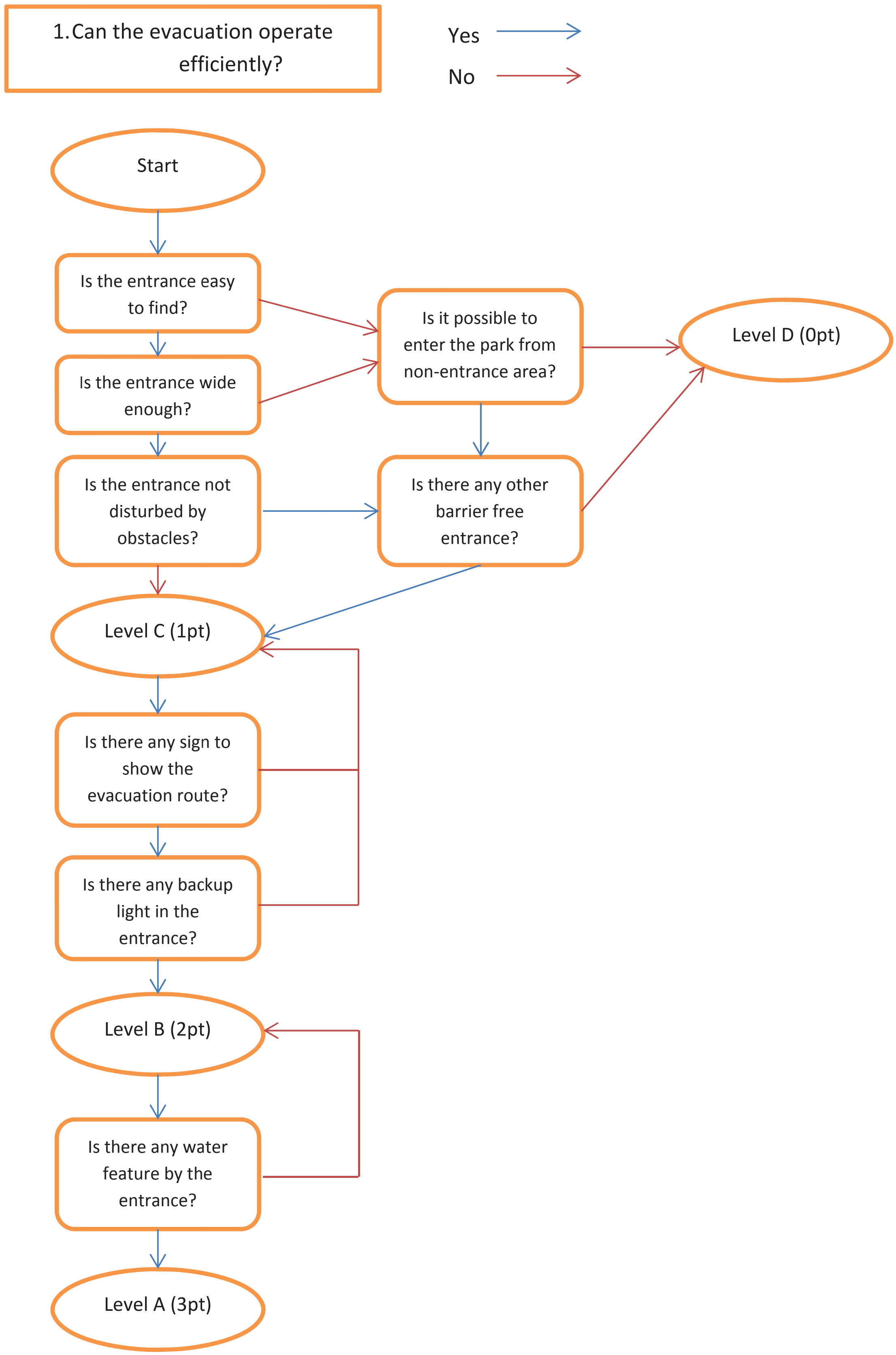
To evaluate each park, the evaluation method developed by the Organization for Landscape and Urban Green Infrastructure in Japan (LUGIJ 2005) was used. LUGIJ categorized criteria into four groups: temporary evacuation, disaster relief, recovery process, and daily preparedness for a disaster. To evaluate those functions, they set up eight sequences of questions to determine whether a park is appropriate to function for disaster management. The first two are for emergency evacuation, questions three through five regard firebreaks and temporary stays in a park, the sixth question asks about the recovery process, and the last two evaluate the park's daily management for a disaster. The first three categories coincide with the previously discussed three functions of disaster management. Disaster preparedness concerns firebreaks, which are asked about in the second and the third LUGIJ sequences of questions. Disaster relief focuses on evacuation, which are the main focuses of the first and forth sequences of questions. The fifth and sixth sequences of questions emphasize what are needed for the disaster recovery process.

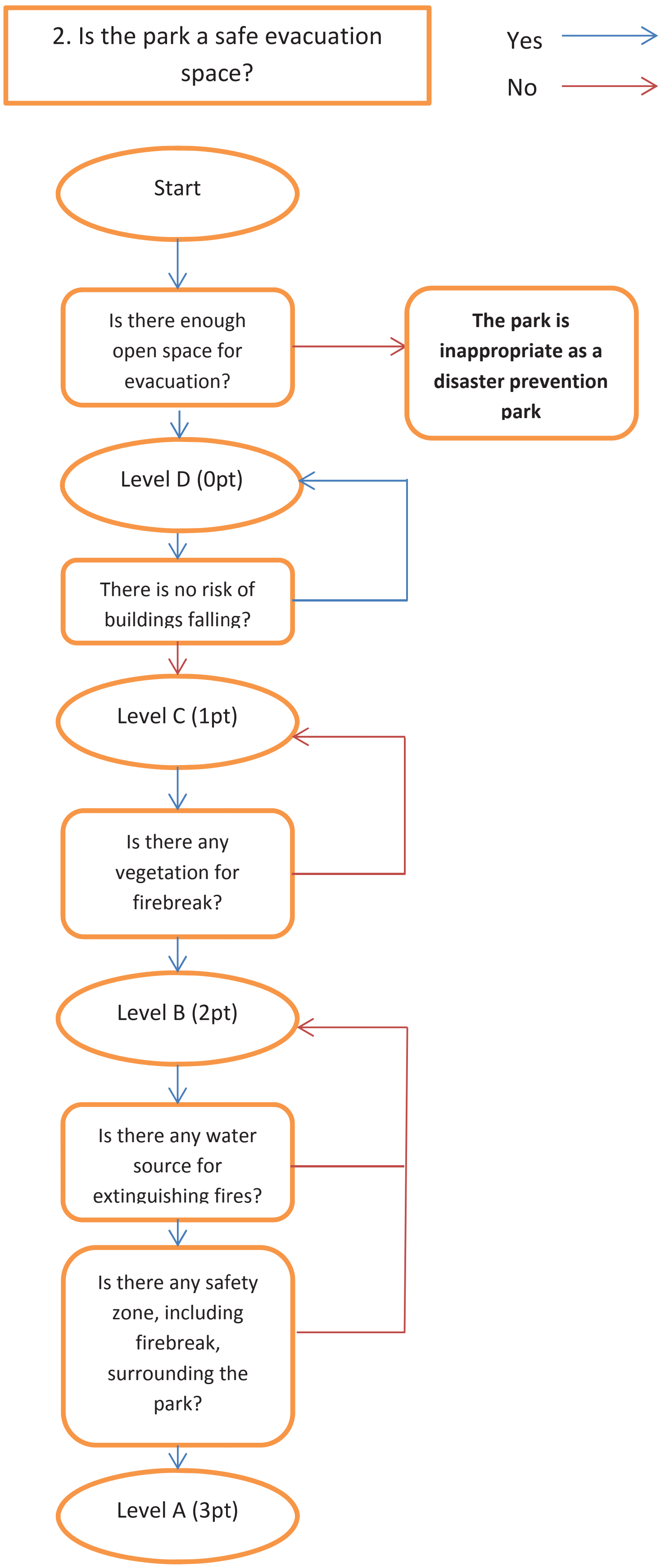
Although daily management is vital for disaster prevention parks, the evaluation of this thesis focuses on the hardscape design aspect, thus omitting the last two sequences of questions about daily management. The daily management questions include whether there is an annual investigation for disaster management and if there is an earthquake drill in the neighborhood.

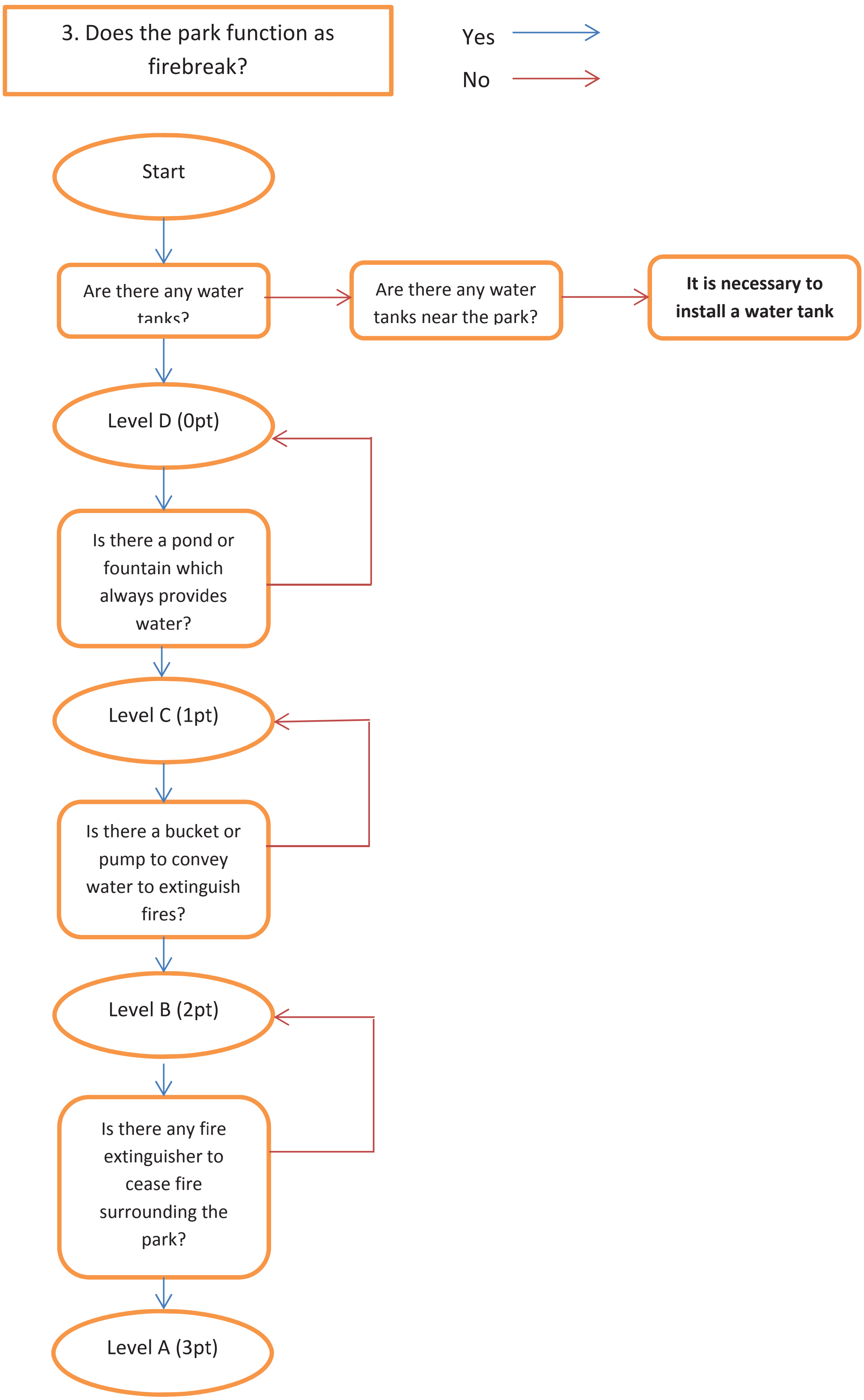
They are hard to relate to park designs; therefore, it is recommended they be investigated in future studies.

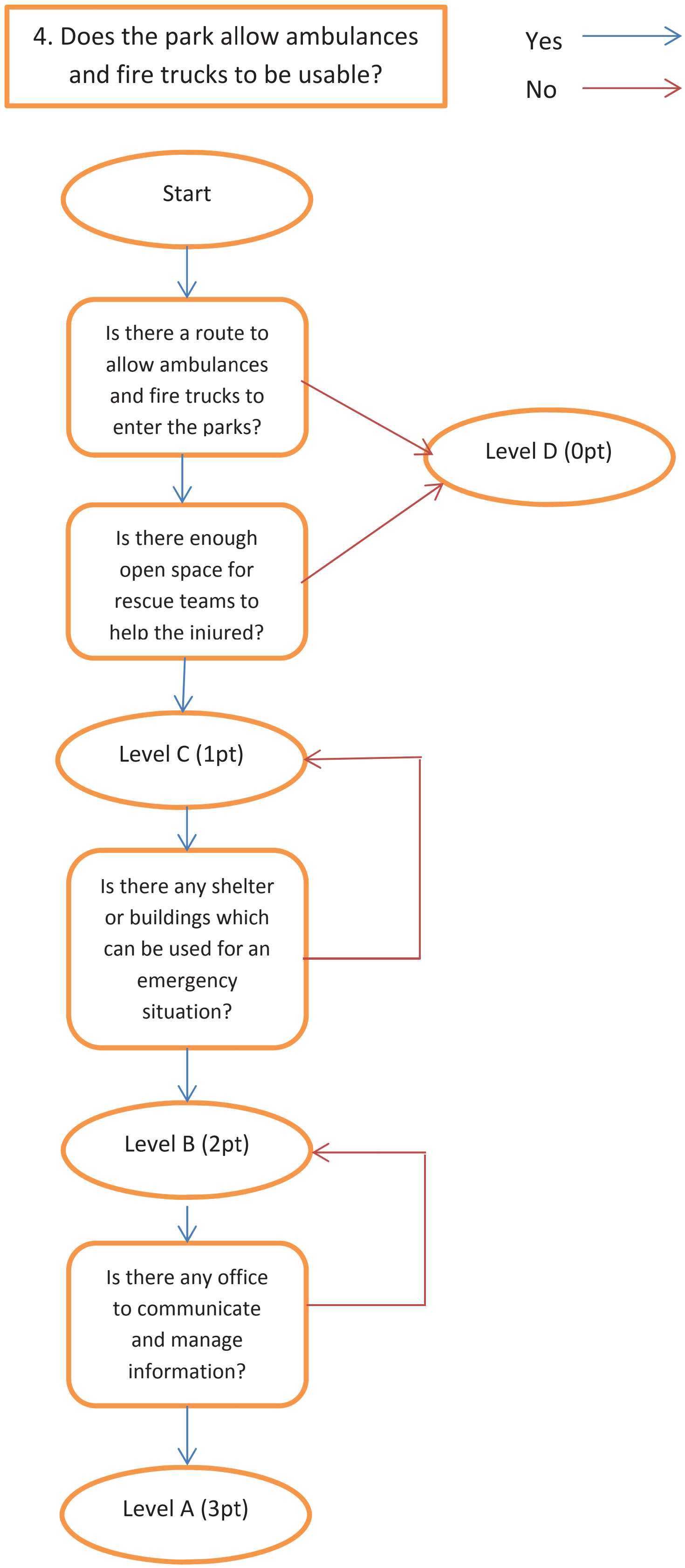
For the LUGIJ metrics, depending on the answers to each question, the park gains points which range from 0 to 3 for each category. The score of each category should be added and divided by 6 to calculate the LUGIJ evaluation. 0 to 0.9 means that a park is not appropriate as a disaster prevention park. 1 is the lowest level (= d) to be a disaster prevention park. 1.1 to 1.5 means “c”, 1.5 to 2.5 means “b” levels as a disaster prevention park. If the score marks more than 2.6, the park is very suitable for disaster management, for accommodating evacuees and contributing to the disaster recovery process. For example, Lake Shore Park scored 1, 1, 2, 2, 2, 3 for each sequence of questions, which gives a total score of 11. This number is divided by 6 and becomes 1.8. This means that the park is the level b disaster prevention park. The six categories of questions are shown below in Figure 15.

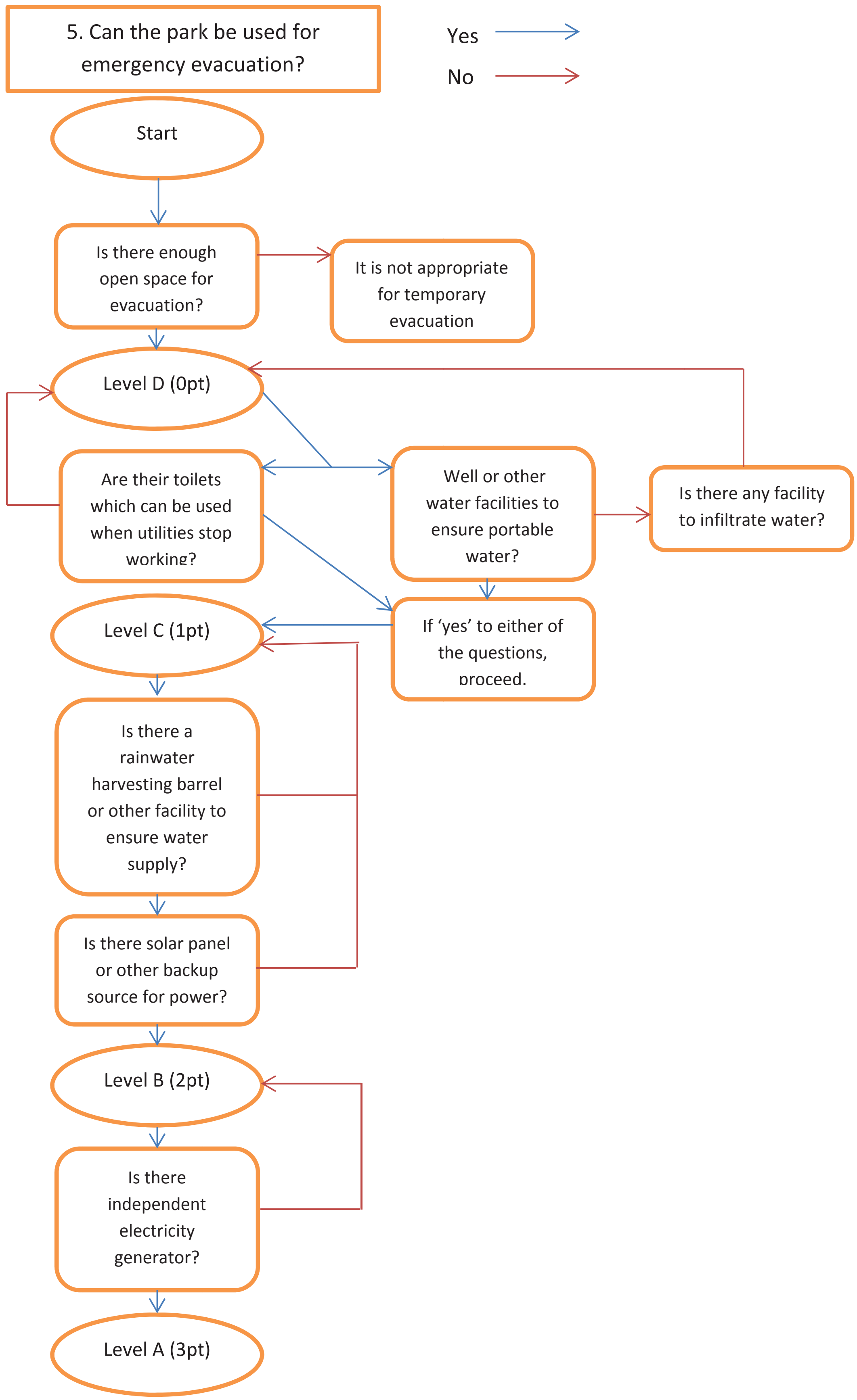
Figure 15: LUGIJ Metrics

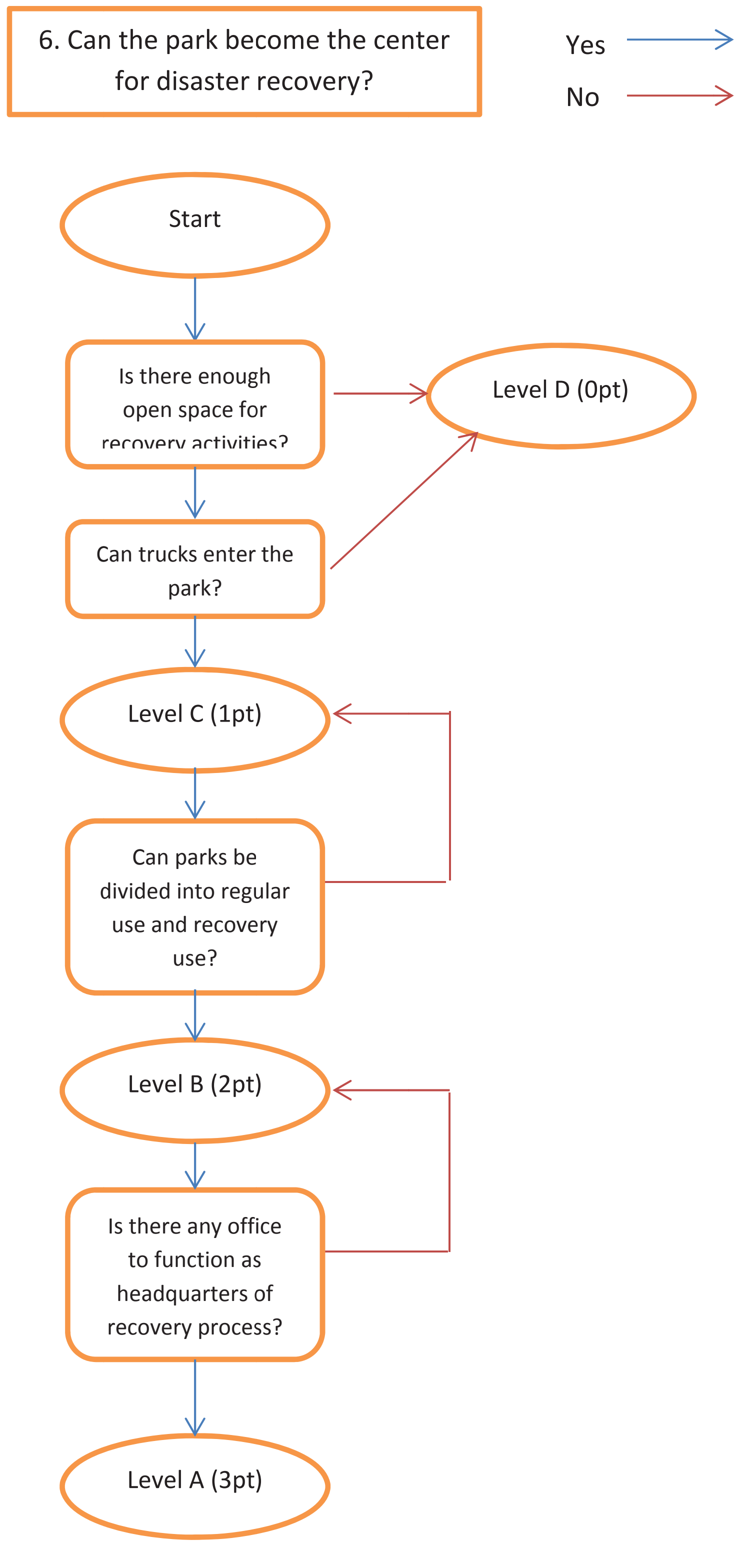



2. Is the park a safe evacuation space?
Yes
No
Start
Is there enough open space for evacuation?
The park is inappropriate as a disaster prevention park
Level D (0pt)
There is no risk of buildings falling?
Level C (1pt)
Is there any vegetation for firebreak?
Level B (2pt)
Is there any water source for extinguishing fires?
Is there any safety zone, including firebreak, surrounding the park?
Level A (3pt)


3. Does the park function as firebreak?
Yes
No
Start
Are there any water tanks?
Are there any water tanks near the park?
It is necessary to install a water tank
Level D (0pt)
Is there a pond or fountain which always provides water?
Level C (1pt)
Is there a bucket or pump to convey water to extinguish fires?
Level B (2pt)
Is there any fire extinguisher to cease fire surrounding the park?
Level A (3pt)


4. Does the park allow ambulances and fire trucks to be usable?
Yes
No
Start
Is there a route to allow ambulances and fire trucks to enter the parks?
Level D (0pt)
Is there enough open space for rescue teams to help the injured?
Level C (1pt)
Is there any shelter or buildings which can be used for an emergency situation?
Level B (2pt)
Is there any office to communicate and manage information?
Level A (3pt)


5. Can the park be used for emergency evacuation?
Yes
No
Start
Is there enough open space for evacuation?
It is not appropriate for temporary evacuation
Level D (0pt)
Are their toilets which can be used when utilities stop working?
Well or other water facilities to ensure portable water?
Is there any facility to infiltrate water?
Level C (1pt)
If 'yes' to either of the questions, proceed.
Is there a rainwater harvesting barrel or other facility to ensure water supply?
Is there solar panel or other backup source for power?
Level B (2pt)
Is there independent electricity generator?
Level A (3pt)


6. Can the park become the center for disaster recovery?
Yes
No
Start
Is there enough open space for recovery activities?
Level D (0pt)
Can trucks enter the park?
Level C (1pt)
Can parks be divided into regular use and recovery use?
Level B (2pt)
Is there any office to function as headquarters of recovery process?
Level A (3pt)

To elaborate and modify the LUGIJ evaluation, the following points of each park were recorded.

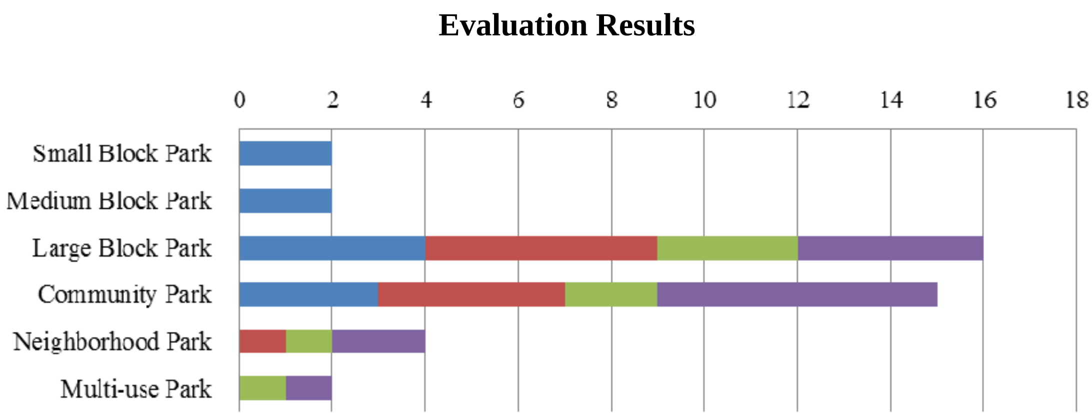
1. Disaster Preparedness and Fire Break
    a. Open space (100 ft x 100 ft)
    b. Trees to buffer between the open space and the surrounding area
    c. Water features to stop fires
2. Disaster Relief
    a. 20 ft wide street in front of entrance
    b. Barrier-free entrance
    c. Open space to become a heliport (100'x 100' for block, community neighborhood parks: 330' x 330' for multi-use park) (Osaka Prefecture 2014)
    d. Trees to prevent structures from falling
    e. Signs to guide evacuees to protected area
    f. Light
3. Post-Disaster Recovery
    a. Shelter or Office
    b. Division between possible temporary housing space and regular use
    c. Restroom
    d. Access for large vehicles
    e. Community amenities, such as gardens, to relieve evacuee's stress

The reason why these criteria were used in addition to the LUGIJ evaluation method is because the latter was especially designed for parks in Japan and may not be applicable to the US context. The limitations of the LUGIJ metrics will be discussed later.

The final evaluation results are recorded as the following.

Not Appropriate: The park is not appropriate as a disaster prevention park
Temporary: The park can be used for firebreak and initial evacuation
Recovery: The park can be used for post-disaster recovery process
Temporary/Recovery: The park can be used for both temporary evacuation and recove*ry process*

Please refer to Appendix B for the full report of the evaluation.



	Multi-use Park	Neighborhood Park	Community Park	Large Block Park	Medium Block Park	Small Block Park
Not appropriate	0	0	3	4	2	2
Temporary Evacuation	0	1	4	5	0	0
Post-Disaster Recovery	1	1	2	3	0	0
Temprary/ Recovery	1	2	6	4	0	0

Table 5: Evaluation Results

Eleven parks were evaluated as "not appropriate" as disaster prevention parks. The main reason for this evaluation is limited open space in those parks. Four of them were small and medium block parks, each of which does not have large space as a whole. Three large block parks were also regarded as unsuitable for disaster prevention parks for the same reason. Although the area of a park is large, open space for Glen Park and Peralta Park was very limited because those parks were mostly occupied with trees. City Plaza Park would not function as a disaster prevention park since it is surrounded by large buildings, which may fall into the open space. Similarly, Grove Shafter Park would not be functional because it is too close to a highway, which even runs above the park.

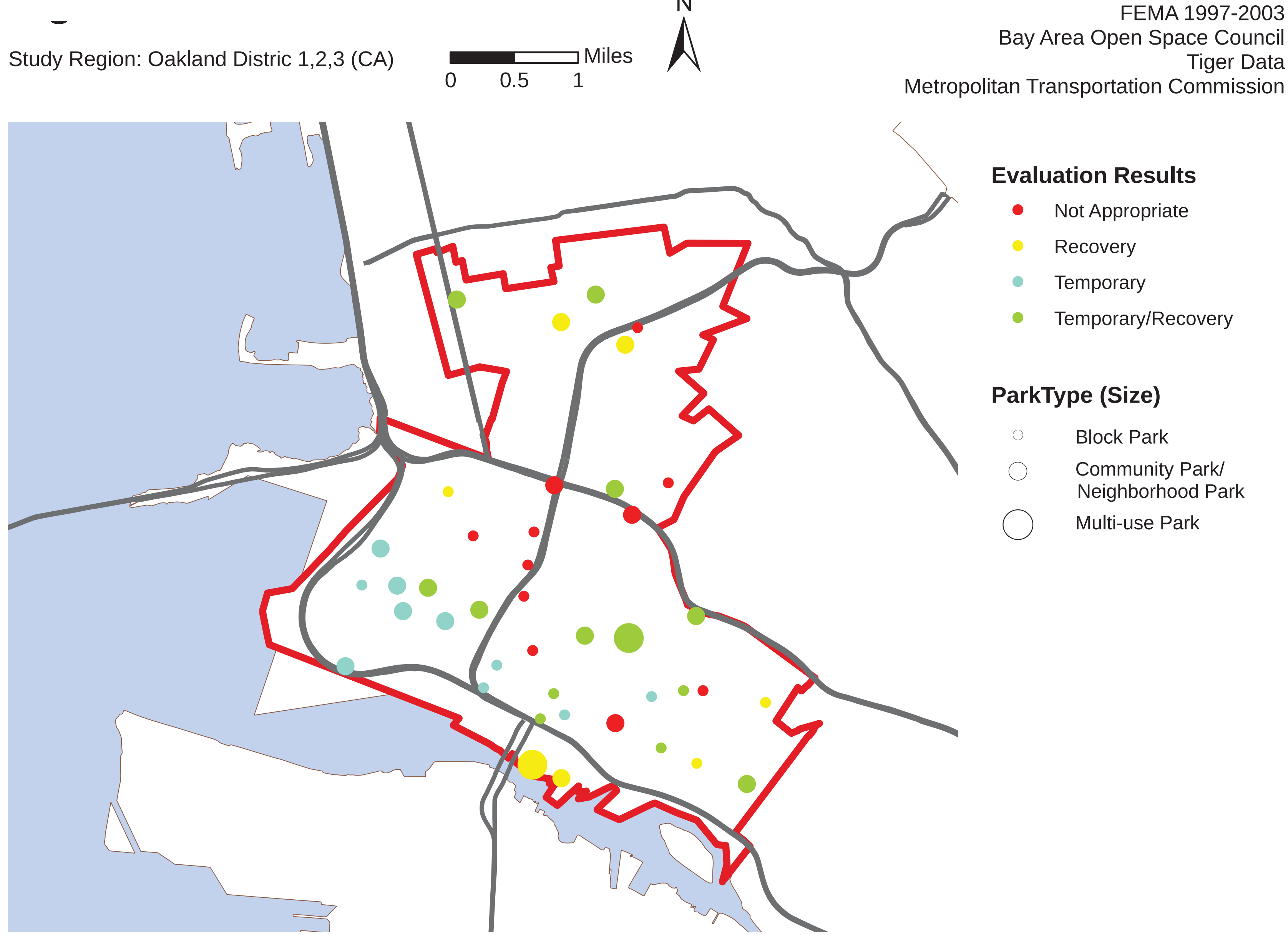
Ten parks were regarded as disaster prevention parks for "temporary" evacuation. Two of the large block parks, Athol Plaza Park and Willow Park, do not have enough open space. However they may be functional as temporary shelters because there are wide enough roads outside of the parks, which would protect open space from falling buildings or fire. Unlike in

Japan, road width in Oakland is usually wider than 20 feet. In some places, roads may be wide enough to work as buffers for firebreak purposes, even if the park itself is not large enough. Those roads should be investigated together with parks for disaster management. Also, the surrounding buildings are not always high, except for the City Hall Plaza area. Therefore, buffering trees may not be always necessary to prevent buildings from falling. For the same reason, Mandela Greenway can function as a temporary evacuation place. The park is elongated and does not have wide enough open space. However, it does have two wide car travel lanes plus one parking lane for each side. Since it is located in an industrial area and residential area, the building heights are relatively low. Therefore, the park is well protected from fire and falling buildings. The other six parks have enough open space, but would not be appropriate for the recovery process because they do not have offices or buildings which can exchange information with outside of parks and manage a long stay of evacuees in those parks.

Seven parks were considered to function only for post-disaster recovery. Poplar Park, Franklin Square, Bella Vista Park and MLK Plaza Park are large enough. The first two even have facilities to function as offices for disaster recovery bases. They would not work for temporary evacuation in the time of an earthquake because they have fences all the way around and can be locked for certain hours. Bella Vista Park does not have an office, but is connected to Bella Vista Elementary School. Therefore, it can be an appropriate location to lead the recovery process. MLK Plaza Park may need to be a recovery place despite a lack of an office because there are not many parks around the area and it is a dense residential area which may require a lot of evacuation places. Temescal Creek Park is located in a similarly dense residential area. It is a greenway, which is mostly occupied with trees and a creek. However, it is facing a large DMV parking lot and hosts a weekly farmer’s market, which is the largest in the city. Therefore, in combination with this parking lot, the park can accommodate a large number of evacuees and contribute to the recovery process. Estuary Park and Jack London Square also possess large open spaces. However, they face the bay and can be hit by flooding during an earthquake. Therefore, they are not appropriate for temporary evacuation sites.

The remaining thirteen parks were considered to be appropriate as disaster prevention parks for both temporary evacuation and recovery process. FM Smith Park, Chinese Garden Park, Clinton Square, Lincoln Park, Bushrod Park, DeFreamery Park, Mosswood Park, San Antonio Park, and Lakeside Park all have building facilities which can exchange information with outside parks and manage the long term evacuees. In addition, with the exception of Chinese Garden Park and Lincoln Park, those parks have partially fenced sports fields or playgrounds which can separate regular uses and uses for recovery process. Lakeshore Park and Snow Park do not have possible office space. However, the first two are flanked by Lakeside Park which is the largest park and have a few office buildings. Therefore, they can function together. Among those parks, Lincoln Park, Bushrod Park, and DeFreamy Park are specifically identified as parks for casualty collection/ debris storage as well as sheltering. Therefore, their building facilities are occasionally checked for resistance to seismic damage.

Figure 16: Evaluation Results

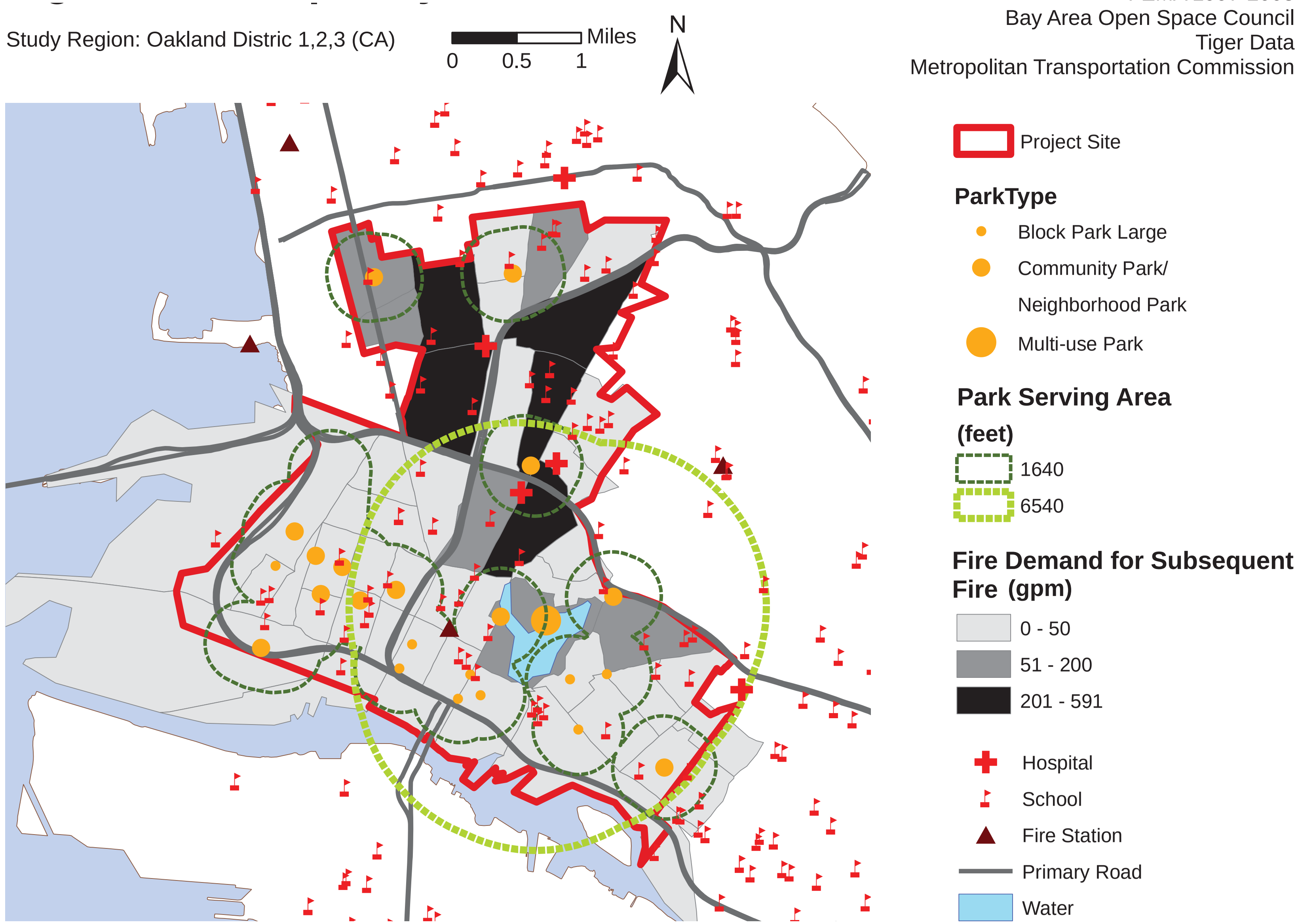


Temporary Evacuation (figure 17)

Figure 17 shows parks usable for temporary evacuation based on the types of parks. They are represented by yellow dots in different sizes. The smallest dots represent block parks, medium ones are either community parks or neighborhood parks, and the largest ones are multi-use parks. The reasons why community parks and neighborhood parks are combined are their similarity in characteristics and that there were only three neighborhood parks for temporary evacuation. This map also illustrates the serving area of those parks. The serving area of block parks, community parks, and neighborhood parks is a 1640 feet radius. That of multi-use park is 6540 feet. The serving area was determined based on the study of the Guidebook of Disaster Prevention Park Techniques (2005). It says that temporary evacuation areas (block parks and community parks) should be located within 500 m (1640 ft) from residence and main refugee areas (Neighborhood Parks and Multi-use Parks) should be located within 2 km (6540 ft) from residences. This is because the first three parks are expected to function as temporary evacuation places, and evacuees may eventually move to multi-use parks.

Fire Demand, or water needed to extinguish expected fires (gallons per minute or gpm), is also illustrated on the map. This shows the extent of vulnerability to fire after an earthquake. The darker the color is, the more possibility of fire to occur and thus increasing necessity for more water. Fire stations are mapped to show the distance between their locations and areas which are more vulnerable to fires. As observed on the map, the northern part of the project site is more vulnerable to fires, but they do not have fire stations. This is dense residential area, so it is preferable to have more disaster prevention parks which can prevent fire and collect evacuees. Schools are also mapped to examine if their grounds can possibly become alternatives to parks. However, those are also scattered in the northern region. It is noteworthy that estimated fire demand is relatively low compared to fire expected after an earthquake, considering that some earthquakes can cause fires as high as 12,000 gpm (Scawthorn 2011). The size of fires is subject to change, depending on the wind speed, moisture of the air, and availability of fire trucks at that specific time. Furthermore, it goes without saying that disaster prevention parks' function is not limited to preventing fires. Therefore, implementing disaster prevention parks in the northern part of the project site is still recommended.

Figure 17: Temporary Evacuation



Post-disaster Recovery (Figure 18)

Figure 18 shows parks appropriate for post-disaster recovery function. As in figure 17, parks and their serving areas are shown based on their types and serving sizes. Hospitals and schools are also displayed to show if those parks have access to further aid assistance, such as for the injured

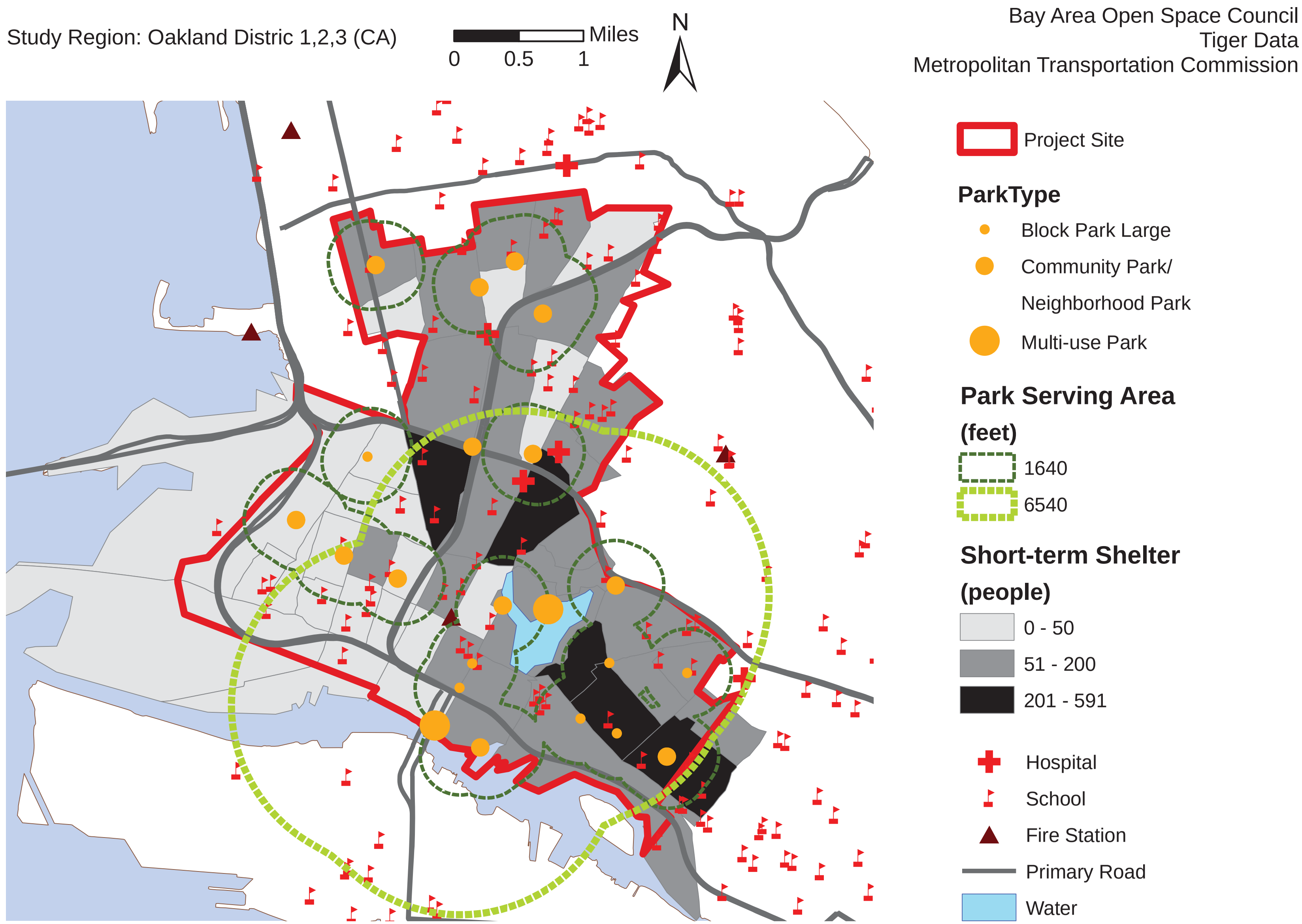
Instead of fire demand, the map illustrates the expected population for short-term shelter. The darker the color, the more people are expected to need short-term shelters. Multi-use parks are located near those areas which are expected to create more population in need of short term shelters; they are appropriate candidates to host shelters.

44.63 acres of open space exist in those parks. Again, open space here is space without vertical objects and is protected from falling buildings or threat of fire. The guidebook states that each temporary refugee requires about 2 m^2 of space. This means that open space in parks would provide space for 90,293 evacuees. Based on the Hazus model, there will be about 39,217 displaced people under the moment magnitude of 6.7 earthquakes. Therefore, it seems that existing parks provide enough space for those potential evacuees. However, parks that are large enough to be evacuation areas are concentrated in the southern part of the study region. Thus, there should be more block parks and community parks in the northern part to become temporary evacuation sites.

Although it is not shown on the map, it is important to consider evacuees who may need to stay in parks for the long-term. According to the Hazus model, 25,139 people are expected to seek short-term public shelters after a 6.7 magnitude earthquake. With the given open space, if temporary housing is a FEMA trailer (32’ x 8’), there will be about 2086 trailers that can be located in the open space. However, there should be space for regular use as well as storage for debris, which is expected to be about 454 tons in total. It is important to plan how open space in parks can be divided for those different uses. Having divisions of parks also needs to be translated to regular uses of parks.

Also, it is worthwhile to note again that many evacuees usually prefer to stay with family members or friends. Also they may go to hotels if they can afford it. Some statistics state that only 20 percent of evacuees usually chose such temporary shelters (Phillips 2009). Phillips also recommended that existing apartments and homes should be first considered to be temporary shelters. Therefore, the actual number of long-term evacuees in parks is expected to be fewer than 7,843 households.

Figure 18: Post-Disaster Recovery



CHAPTER 5: IMPLICATIONS OF THE STUDY

Disaster Preparedness and Firebreak

Disaster preparedness functions, especially for firebreaks, seem to be the weakest aspect of parks in the United States among all the other functions. Twenty-six parks have enough open space. However, only seven parks have some sort of tree buffer between open space and the surroundings. However, the rows of trees are not always continuous or thick enough. Since trees are often present in parks, by carefully designing placement of those trees, they have more potential to strengthen parks' functions to decrease threat of fire. Only nine parks possess water features. Those water features include natural water, such as a lake or river, and recreational pools in sports fields. Water features are not only useful to extinguish fire, but also they can attract people. Lack of water features and vegetation buffers make it hard for parks in Oakland to work as disaster prevention parks based on the LUGIJ metrics.

However, some may question if parks in Oakland really need firebreak features. The highest fire demand calculated in Hazus was 591 gpm in the project site. This value is relatively low, considering that some subsequent fire reaches fire demand of 12,000 gpm (Scawthorn 2011). Of course there is always possibility that fire can be larger than the estimated size. However, it is necessary to evaluate how many firebreak features parks in Oakland should have based on the need of the city.

Disaster Relief and Emergency Evacuation

Access

Unlike firebreaks, many parks in Oakland are functional for disaster relief. As aforementioned, access in terms of width of roads in front of parks is usually ensured for parks in Oakland. In fact, thirty-eight parks have enough road width in front of the park. Thirty-seven parks also have barrier-free entrances with ramps, while others, especially sports fields, have limited access because of fences. Although sports fields often have large areas, it is sometimes hard to even find entrances because they are fenced. Those parks are Bella Vista Park, Franklin Square, Popular Park, MLK Plaza Park, Raimondi Park and 25th Street Mini Park. They are mostly fenced all the way around. Although they have restrictions in access, they are cleaner and looked safer. Depending on how safe the community is, a fence may be needed. Also, baseball fields and other ball sports require some fences to capture balls which otherwise may fly outside the park. Therefore, fencing may not be necessarily removed for disaster prevention purposes.

If a park is large enough, partial fences seem to work well. In San Antonio Park, only sports fields were fenced and the lawn was open to sidewalks. It welcomes visitors while providing protection for those inside and outside of sports fields. However, this partial fence may not be always a solution. Wade Johnson Park was partially fenced. But inside the fenced basketball court, there was a lot of trash and people who seemed to be homeless. The park was underutilized and seemed to be very unsafe.

Signs and Lighting

Among all the features for disaster relief, signs and lighting need to be modified most. No parks have signs to direct evacuees to safer open space when they come to the entrance. Sign implementation should be planned with consideration of lighting. All the site visits were made during day time. Therefore, it is difficult to determine whether lighting works well to guide evacuees to protected space. Eleven parks seem to have substantial lighting.

Post-Disaster Recovery

Restrooms and Water

There are main two features which require modifications for Oakland parks to be functional in the post-disaster recovery process. One is the lack of restrooms. Twenty-one parks had restrooms. However, there are only usually two or three in each park, and they may not be enough when a large number of people need to stay in parks for a long time. Also, they may not be functional if water lines stop. Therefore, manhole toilets which can be used only after a disaster would be good to be implemented.

The other is portable water. Twenty-two parks provide drinking fountains. Among them, seventeen were useful. However, there is no back-up system to prepare portable water when the water line gets damaged. Thus, it will be useful to consider installing water tanks or wells which can provide portable water in a case of disaster. They can also consider rainwater harvesting or other methods to ensure that evacuees would have access to water. Those water features can be used for community gardens or some amenities in regular use.

Office Facilities

Buildings which can work as office space are found in seventeen parks. They are mainly located in parks larger than Large Block Parks. To complement the lack of offices in smaller parks, it will be useful to place overhead structures, such as pergolas, in smaller parks to function as emergency office space.

Some parks are attached to recreational centers and they seem to be livelier than parks of the same size. Examples include Golden Gate Park, Brushrod Park, De Fremery Park, and Lincoln Park. They are used not only for public events, but also for personal events, such as baby showers. Those events attract local residents and increase the use of parks, which seems to increase cleanness and safety.

Long-term Use

For the longer use of parks, such as for temporary housing, the division of areas for evacuees and regular users of parks is crucial. Currently, twenty-four parks already have such division of spaces. They can be divided by trees or fences. If the open space is large enough, however, temporal dividers may be placed to create subdivisions.

Nine parks are accessible for large vehicles, such as ambulances and fire trucks. The number seems to be sufficient as not every park is expected to have temporary shelters. Lastly, if evacuees live in parks, there should be some amenities for them to release stress and bond with other community members. Since they are parks, they are often equipped with amenities, including recreational facilities and plants. Although the social aspect or psychological aspects of disaster prevention parks are not strongly pronounced in this thesis, it is important to consider those factors when one designs disaster prevention parks.

Homeless People

Among the forty-one parks, seemingly homeless people were observed in eighteen of them. Many of them stayed in either Lakeside Park and its nearby parks or parks in west Oakland, which include Bishop Floyd Begin Park, Lafayette Park, and Wade Johnson Park. A large homeless population in parks may pose two challenges when a park is used for temporary shelter or the center for recovery process. One is that public shelter may be occupied by those homeless people instead of those who lost their houses because of an earthquake. The other is that Oakland residents may be reluctant to live in a park because of their daily experience of seeing homeless people living there. As a result, providing public shelter in a park may not contribute to the recovery process from an earthquake.

Lakeside Park

Located in the center of the city, Lakeside Park by the Lake Merritt is an iconic symbol of Oakland. Possessing large open space and water bodies, this park would play an important role as a disaster prevention park once a disaster happens. However, there are some issues which are worth considering. As aforementioned, this park accommodates a large number of homeless people. If this park accommodates disaster evacuees, one needs to consider how to approach existing people who are already living there. Some of them occupy shelters, such as a pergola, in the park. Other residents who may need to gain attention are birds. There are more birds than people in the park and they are legally protected. This enormous number of birds also leaves large amounts of droppings. If people would live in the park, the cleanliness of this park and its water should be examined. While it seems to be challenging to accommodate evacuees in this park, there are also opportunities for this park to become a successful disaster prevention park. First of all, this park is well-used by local residents for jogging, community gardens, and water sports. Also, the center of the park is a Bonsai Garden with Torii gates which was dedicated to Frank Ogawa and commemorates the 40th anniversary of Oakland and Fukuoka's sister city relationship. This connection to Japan may be used to promote Japanese disaster prevention park measures in Oakland.

Limitations of This Thesis and Suggested Further Study

Overlay Analysis

In this thesis, spatial overlay analysis was conducted. Although it is widely used in various research projects, there are some noteworthy limitations. One is the subjectivity of overlay analysis. While McHarg who propagated the overlay method emphasized the objectivity of the method, it cannot be denied that compilation of data to create the overlay analysis is inevitably prone to the subjectivity of designers. Being aware of the danger of creating bias through mapping, Dunstan (1983) questioned "Are we really designing with nature, or are we simply addicted to our maps and the technology behind them?" (61). Given that mapping is subjective, Herrington (2010) called for the importance of scrutinizing what information should be included and what should be omitted from a map.

Therefore, it is valuable to review what possible bias can exist in the overlay analysis conducted in this thesis. Perhaps, the biggest assumption or bias might be that disaster management should be prioritized in dense areas. Surely, dense areas will most likely receive heavier damage than sparsely populated areas if an earthquake hits the region. However, large parts of the U.S., even California, are much less dense than at least Japan. For example, the Mw 6.9 Great Hanshin-Awaji Earthquake destroyed thousands of buildings and killed more than 6,000 individuals, while the Mw 6.7 Northridge earthquake in southern California resulted in the deaths of 3 people with relatively small damage to buildings. At the same time, the former affected 1.5 million people, while the latter affected 3 million people (FEMA 2003).

Additionally, the US has more diverse populations ethnically and economically. Those factors may play important roles to determine which area is more vulnerable to a disaster. An example to illustrate this point is the Hurricane Katrina in New Orleans. Smith (2006) pointed out that the rich had cars and financial foundations to move out of the city immediately after the disaster. Meanwhile, the poor were evacuated to the Superdome where not enough facilities were present to sustain their lives, and they were even prevented from moving to the West Bank neighborhood by suburban sheriffs. Thus, this case implies that disaster prevention parks are more demanded in economically poor neighborhoods rather than just dense areas. These examples suggest that simply copying disaster management measures in Japan will not solve issues in the United States. Thus, great research efforts are needed to examine how to adapt Japanese disaster prevention park principles and what should be modified to fit the US context.

Additionally, reclassifications of values to conduct suitability analysis also depend on the subjectivity of a researcher. In this thesis, the reclassifications of fire demand and population density are based on the previous studies. Meanwhile, because of the absence of previous studies, expected debris and possible populations for short-term shelters were based on the natural breaks in GIS. Further studies should suggest what divisions will be appropriate to reclassify those values.

Another limitation imposed by the spatial overlay analysis is its stationary condition. Although the map is static, cities change every day and every second. Overlay analysis precludes accounting for the actual variation in the situation at which vulnerabilities change every moment. For example, for the subsequent fire, wind speed, wind direction, and speed for the fire engine truck can strongly influence the damage of fire and necessary water to extinguish it. Those can depend on the weather or the day the earthquake happens and the traffic situation at that specific time. Therefore, it is important for planners to understand such variability in cities.

Nevertheless, to identify parks which can be used for disaster management, overlay analysis with Hazus data seems to be a very powerful tool. It integrates different possible damages in an earthquake and allows users to compare different regions based on their vulnerability to expected risks. To maximize the use of the program, there should be a professional to update basic data for each region and cross check if the data is consistent with local data. Also, Hazus has an ability to integrate other hazards, including flood and hurricane. Flooding can inundate parks, which make disaster prevention parks unusable when an earthquake and flooding happen at the same time. So, Hazus' function to create models which combine different hazards is useful to specify possible locations for disaster management parks.

LUGIJ Metrics

LUGIJ Metrics can be a starting point to assess the usefulness of an urban park for disaster management. However, in the United States, signs to guide evacuees and vegetation to prevent fires are not common. Unless they are provided, no park can gain more than one point for the first two sequences of questions. This may skew the potential for a park to function as a disaster prevention park. Without a water tank, a park cannot gain any points for the third sequence of questions. Implementing signs may not be very expensive, but installing vegetation to prevent fires and water tanks can be costly projects. Therefore, it is important to evaluate whether a park really needs to implement those features. One method is using Imagawa's Fire Assessment System (IFAS). It conducts detailed analysis of trees and nearby buildings to estimate possible fires. This can be substituted with the Hazus for calculating rough fire demand in the United States. As aforementioned, fire demand in the project site was not really high. Therefore, features for firebreak should not be overly emphasized when a disaster prevention park is considered.

Long-term Management Issues

As this thesis focused on design aspects of disaster prevention parks, it did not greatly examine their management aspect. For example, if the entrances of parks have enough space, but people usually park bikes there and it blocks the entrance, this would hinder evacuees from moving into parks when an earthquake happens. Those aspects related to human behavior and local customs needed to be analyzed to plan disaster prevention parks in Oakland. Another management aspect which was not discussed in this thesis was whether community members are routinely engaged in activities to be prepared for a disaster. Those activities include annual investigation of facilities which can be used post-disaster, such as water tanks and manhole toilets, and earthquake drills to practice evacuation. Also, programming suggested in Japan, such as barbeque parties to practice making fires outside and town tours through parks to follow their evacuation routes. This kind of effort will further strengthen the disaster preparedness of the community.

Since a disaster is not a one-time event, it is crucial to consider how to sustain efforts to prepare for a disaster. While discussing the importance of community-based approaches to disaster management, Shaw (2014) pointed out that it is local governments and policies that play crucial roles to sustain commitments to disaster risk reduction efforts. In the context of the United States, one of the most important public agencies would be the Federal Emergency Management Agency (FEMA). The organization not only provides disaster-related information, such as the Hazus, to local communities, but also offers funding, like the federal Natural Hazard Mitigation Program. Other public agencies which deal with natural hazards are the U.S. Geological Survey (USGS), the National Oceanic and Atmospheric Administration (NOAA), the U.S. Army Corps of Engineers, the Centers for Disease Control, the U.S. Forest Service, and the

Environmental Protection Agency (Randolph 2004). Further study to examine how to link community efforts, park-design professionals such as landscape architects, local governments, and the federal agencies listed above is a key to successfully implementing disaster prevention park principles in the U.S. in the long term.

This kind of long-term perspective is especially important in the context of the United States. Randolph criticized the pitfall that American disaster management agencies often encounter: namely, “a disaster-relief-rebuild-disaster” syndrome. Disaster relief efforts in the U.S. often lack attention to the long-term vulnerability and create monetary and humanitarian investment in the places which might be hit by a subsequent disaster, resulting in more relief and continuing the cycle of disaster-relief-rebuild-disaster. Nelson and French (2002) also articulated this point by conducting research on the 1994 Northridge earthquake in southern California. They concluded local governments were often ineffective in enforcing restrictions on the development in the areas vulnerable to hazards because they were afraid of limiting profits. Therefore, to implement disaster prevention parks in Oakland also requires support from larger agencies, including the California state government and the FEMA, in order to avoid compromise through focusing on short-term profits.

This tendency of overweighing immediate fiscal profits over the long-term benefits, such as disaster risk reduction, however, can be approached from a different angle with disaster prevention parks. Urban parks, especially in dense area, usually raise property values around the community. One study (Crompton 2001) showed that properties facing parks usually have 20 percent higher property values compared to the land without the park. Even two or three blocks away from the park, property values are usually 10 percent higher. Therefore, successful disaster prevention parks can allow communities to pursue both immediate profits and the long-run disaster risk reduction.

Moreover, disaster prevention parks can address other social issues in the United States. To make parks accessible to people with different needs in the case of emergency evacuation, it can strengthen the barrier-free aspects. Also, by providing opportunities for community gardens, parks can contribute to food security. Furthermore, probably most important for California, disaster prevention parks can alleviate the issue of water shortage by installing rain harvesting tanks or other water recycling facilities. It is reported that California is suffering from three major water-related issues: lack of water for increasing number of population, drought from climate change and groundwater pollution (Thor 2013). Although harvesting and storing water in parks may not be a complete solution to this enormous challenge, it can contribute to mitigating the issue.

As such, features of disaster prevention parks can benefit both the disaster risk reduction aspect and other social issues. This is important because the parks' main purpose is not disaster management. Therefore, it is crucial to consider how disaster management functions can be integrated into other uses. This four-dimensional practice will be more and more important where urbanization is intensified and limited resources are available for increasing numbers of people. As discussed earlier, programming barbeque parties, survival camping, and community gardening would be an effective method to design features of parks across time before and after a disaster. Without considering how people can use those parks on a daily basis, they may not be functional when a disaster happens. As aforementioned, parks which were often used by residents before a disaster functioned more effectively as an evacuation destination when the

GHAE happened. This management aspect of disaster prevention parks need further study for successful implementation of disaster prevention parks in Oakland.

CHAPTER 6: TOWARDS PREEMPTIVE LANDSCAPE

Disascape: Across Time, Across Scale

Discussing resilience and sustainability, Holling, Gunderson, and Peterson (2002) emphasized the importance of looking at systems from different scales and times. They also argued that systems in different scales and times can impact each other. For example, the GHAE physically affected only the Kansai Region of Japan. But its impact went beyond the region. It hit the economy of the entire country and also influenced perspectives towards earthquakes worldwide. Meanwhile, a global scale movement, such as the Hyogo Framework for Action in the 2005 World Conference, provided a direction for how local communities can prepare for the next disaster. The focuses of this thesis were local and regional scales. While designing specific features of parks for disaster management purposes, it is important to consider the placement of those parks and their special relationship to roads with firebreaks and other public facilities. Those two considerations are crucial when designing disaster prevention parks. Beyond those concerns, however, it is also worthwhile to discuss disaster prevention parks from a global scale. Obviously, vulnerabilities to earthquakes are not limited to either Japan or the United States. The challenge is prominent, especially countries around the Ring of Fire. Because it is a shared struggle for different counties, it can offer a chance for them to work together to respond to the issue. Clements (cited in Ikeda 2014) from New Zealand, the country which also suffered from a catastrophic earthquake in 2011, stated his impression after he witnessed the international cooperation for the disaster relief:

> It underlines the ways in which we all know in our heart of hearts that there is a common humanity that unites all of us irrespective of our cultural, linguistic, or

> national differences. It’s a pity that this common humanity is often only realized in times of crisis. It is important, therefore, that we maintain this “disaster spirit” in normal times as well (14)

Studying the use of parks for disaster management, thus, can be a catalyst for such international cooperation under the banner of “knowledge as a global public good” (cited in Stiglitz 1977, 308) and benefit humanity across nations and generations.

Conclusion

This thesis inquired into possible application of Japanese disaster prevention parks in the context of the United States. This study is significant on the grounds that it looked at parks from a new perspective of disaster management. In the current condition, although natural hazards and their damages are more and more prominent in the United States, there is little consideration for parks to be designed for disaster management.

This thesis indicated that many parks in the city of Oakland can function as disaster prevention parks with some modifications. Specifically, signs, restrooms, and water features should be improved. Features for firebreak should be implemented after observing that Oakland is susceptible to possible fire damage after an earthquake.

As a major earthquake is expected to happen in the near future, it is valuable to consider retrofitting existing parks to prepare for an earthquake and minimize its potential damage. In addition, modifications of parks should be part of a holistic approach to tackle earthquake disasters, which requires collaborations of different organizations, such as City of Oakland Parks and Recreation, the Federal Emergency Management Agency, the Red Cross, Oakland School Districts, and others. This study has not focused on political or economic aspect of the implementation of disaster prevention parks. Thus, further research can look into the implications for those fields.

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Region Name SF-Bay_Earthquake

Earthquake Scenario: SF-Bay_100p_MM6.7

Print Date: February 12, 2014

Totals only reflect data for those census tracts/blocks included in the user's study region.

Disclaimer:
The estimates of social and economic impacts contained in this report were produced using Hazus loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, geotechnical, and observed ground motion data.

Table of Contents

Section

General Description of the Region

Hazus is a regional earthquake loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of Hazus is to provide a methodology and software application to develop earthquake losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from earthquakes and to prepare for emergency response and recovery.

The earthquake loss estimates provided in this report was based on a region that includes 9 county(ies) from the following state(s):

California

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 7,022.18 square miles and contains 1,405 census tracts. There are over 2,466 thousand households in the region which has a total population of 6,783,760 people (2002 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 2,086 thousand buildings in the region with a total building replacement value (excluding contents) of 679,481 (millions of dollars). Approximately 92.00 % of the buildings (and 0.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 47,984 and 11,415 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

Hazus estimates that there are 2,086 thousand buildings in the region which have an aggregate total replacement value of 679,481 (millions of dollars) . Appendix B provides a general distribution of the building value by State and County.

In terms of building construction types found in the region, wood frame construction makes up 87% of the building inventory. The remaining percentage is distributed between the other general building types.

Critical Facility Inventory

Hazus breaks critical facilities into two (2) groups: essential facilities and high potential loss facilities (HPL). Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants and hazardous material sites.

For essential facilities, there are 79 hospitals in the region with a total bed capacity of 19,905 beds. There are 2,581 schools, 166 fire stations, 194 police stations and 6 emergency operation facilities. With respect to high potential loss facilities (HPL), there are 255 dams identified within the region. Of these, 118 of the dams are classified as 'high hazard'. The inventory also includes 878 hazardous material sites, 0 military installations and 1 nuclear power plants.

Transportation and Utility Lifeline Inventory

Within Hazus, the lifeline inventory is divided between transportation and utility lifeline systems. There are seven (7) transportation systems that include highways, railways, light rail, bus, ports, ferry and airports. There are six (6) utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power and communications. The lifeline inventory data are provided in Tables 1 and 2.

The total value of the lifeline inventory is over 59,399.00 (millions of dollars). This inventory includes over 4,607 kilometers of highways, 3,575 bridges, 93,617 kilometers of pipes.

Table 1: Transportation System Lifeline Inventory

System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	3,575	11,964.10
	Segments	3,179	30,999.20
	Tunnels	7	66.30
		Subtotal	**43,029.60**
Railways	Bridges	109	16.30
	Facilities	34	90.50
	Segments	845	1,441.90
	Tunnels	3	1.80
		Subtotal	**1,550.50**
Light Rail	Bridges	112	15.40
	Facilities	286	761.60
	Segments	323	457.90
	Tunnels	0	0.00
		Subtotal	**1,234.90**
Bus	Facilities	32	41.20
		Subtotal	**41.20**
Ferry	Facilities	20	26.60
		Subtotal	**26.60**
Port	Facilities	142	283.60
		Subtotal	**283.60**
Airport	Facilities	21	223.70
	Runways	42	1,594.50
		Subtotal	**1,818.20**
		Total	**47,984.40**

Table 2: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	936.20
	Facilities	12	471.50
	Pipelines	0	0.00
		Subtotal	**1,407.70**
Waste Water	Distribution Lines	NA	561.70
	Facilities	68	5,344.00
	Pipelines	0	0.00
		Subtotal	**5,905.70**
Natural Gas	Distribution Lines	NA	374.50
	Facilities	1	1.30
	Pipelines	0	0.00
		Subtotal	**375.80**
Oil Systems	Facilities	14	1.70
	Pipelines	0	0.00
		Subtotal	**1.70**
Electrical Power	Facilities	43	5,581.40
		Subtotal	**5,581.40**
Communication	Facilities	129	15.20
		Subtotal	**15.20**
		Total	**13,287.40**

Earthquake Scenario

Hazus uses the following set of information to define the earthquake parameters used for the earthquake loss estimate provided in this report.

Scenario Name	SF-Bay_100p_MM6.7
Type of Earthquake	Probabilistic
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	100.00
Longitude of Epicenter	NA
Latitude of Epicenter	NA
Earthquake Magnitude	6.70
Depth (Km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Building Damage

Building Damage

Hazus estimates that about 357,277 buildings will be at least moderately damaged. This is over 17.00 % of the buildings in the region. There are an estimated 13,963 buildings that will be damaged beyond repair. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the Hazus technical manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 below summarizes the expected damage by general building type.

Table 3: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	2,587	0.26	1,700	0.23	1,188	0.41	409	0.74	125	0.90
Commercial	50,310	5.01	31,661	4.37	26,068	9.06	9,376	16.90	2,852	20.42
Education	2,000	0.20	1,181	0.16	866	0.30	303	0.55	81	0.58
Government	966	0.10	594	0.08	478	0.17	183	0.33	51	0.37
Industrial	12,015	1.20	8,112	1.12	7,564	2.63	2,898	5.22	877	6.28
Other Residential	126,999	12.63	95,764	13.22	57,688	20.04	23,274	41.95	5,958	42.67
Religion	3,761	0.37	2,366	0.33	1,701	0.59	631	1.14	190	1.36
Single Family	806,504	80.24	582,984	80.48	192,285	66.80	18,401	33.17	3,830	27.43
Total	1,005,143		724,362		287,839		55,475		13,963	

Table 4: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	914,493	90.98	664012	91.67	218,613	75.95	20,302	36.60	4,209	30.15
Steel	15,899	1.58	10677	1.47	12,256	4.26	5,094	9.18	1,522	10.90
Concrete	19,131	1.90	12750	1.76	9,094	3.16	3,930	7.08	1,101	7.88
Precast	11,968	1.19	8131	1.12	8,735	3.03	3,263	5.88	1,059	7.58
RM	35,141	3.50	14397	1.99	12,680	4.41	4,962	8.94	1,126	8.07
URM	2,898	0.29	3320	0.46	4,555	1.58	2,747	4.95	1,363	9.76
MH	5,612	0.56	11075	1.53	21,905	7.61	15,177	27.36	3,584	25.66
Total	1,005,143		724,362		287,839		55,475		13,963	

*Note:
RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 19,905 hospital beds available for use. On the day of the earthquake, the model estimates that only 13,943 hospital beds (70.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 96.00% of the beds will be back in service. By 30 days, 100.00% will be operational.

Table 5: Expected Damage to Essential Facilities

		# Facilities		
Classification	**Total**	**At Least Moderate Damage > 50%**	**Complete Damage > 50%**	**With Functionality > 50% on day 1**
Hospitals	79	0	0	79
Schools	2,581	0	0	1,563
EOCs	6	0	0	4
PoliceStations	194	0	0	133
FireStations	166	0	0	138

Transportation and Utility Lifeline Damage

Table 6 provides damage estimates for the transportation system.

Table 6: Expected Damage to the Transportation Systems

System	Component	Number of Locations				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50 %	
					After Day 1	After Day 7
Highway	Segments	3,179	0	0	3,179	3,179
	Bridges	3,575	7	1	3,564	3,573
	Tunnels	7	0	0	7	7
Railways	Segments	845	0	0	845	845
	Bridges	109	0	0	109	109
	Tunnels	3	0	0	3	3
	Facilities	34	0	0	34	34
Light Rail	Segments	323	0	0	323	323
	Bridges	112	0	0	112	112
	Tunnels	0	0	0	0	0
	Facilities	286	1	0	286	286
Bus	Facilities	32	1	0	32	32
Ferry	Facilities	20	0	0	20	20
Port	Facilities	142	0	0	142	142
Airport	Facilities	21	0	0	21	21
	Runways	42	0	0	42	42

Note: Roadway segments, railroad tracks and light rail tracks are assumed to be damaged by ground failure only. If ground failure maps are not provided, damage estimates to these components will not be computed.

Tables 7-9 provide information on the damage to the utility lifeline systems. Table 7 provides damage to the utility system facilities. Table 8 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, Hazus performs a simplified system performance analysis. Table 9 provides a summary of the system performance information.

Table 7 : Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	12	12	0	0	12
Waste Water	68	36	0	0	68
Natural Gas	1	0	0	1	1
Oil Systems	14	13	0	0	14
Electrical Power	43	19	0	0	43
Communication	129	82	0	129	129

Table 8 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	46,809	8401	2100
Waste Water	28,085	4220	1055
Natural Gas	18,724	1446	361
Oil	0	0	0

Table 9: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without Service				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	2,466,019	382,453	258,840	127,521	0	0
Electric Power		23,991	13,063	4,432	714	38

Induced Earthquake Damage

Fire Following Earthquake

Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. Hazus uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 90 ignitions that will burn about 1.00 sq. mi 0.01 % of the region's total area.) The model also estimates that the fires will displace about 12,965 people and burn about 969 (millions of dollars) of building value.

Debris Generation

Hazus estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 11.15 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 36.00% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 445,840 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Social Impact

Shelter Requirement

Hazus estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 39,217 households to be displaced due to the earthquake. Of these, 25,139 people (out of a total population of 6,783,760) will seek temporary shelter in public shelters.

Casualties

Hazus estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows;

- Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
- Severity Level 2: Injuries will require hospitalization but are not considered life-threatening
- Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum and 5:00 PM represents peak commute time.

Table 10 provides a summary of the casualties estimated for this earthquake

Table 10: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	173	43	6	13
	Commuting	1	1	1	0
	Educational	0	0	0	0
	Hotels	89	20	3	5
	Industrial	196	49	7	14
	Other-Residential	3,857	800	92	177
	Single Family	3,620	429	17	28
	Total	**7,937**	**1,342**	**126**	**238**
2 PM	Commercial	9,886	2,457	371	729
	Commuting	6	7	13	2
	Educational	1,850	445	67	130
	Hotels	17	4	1	1
	Industrial	1,446	358	53	103
	Other-Residential	700	147	17	32
	Single Family	635	77	4	5
	Total	**14,540**	**3,495**	**524**	**1,003**
5 PM	Commercial	7,348	1,826	278	533
	Commuting	253	324	563	108
	Educational	331	80	12	24
	Hotels	27	6	1	2
	Industrial	904	224	33	64
	Other-Residential	1,465	308	37	68
	Single Family	1,386	167	8	11
	Total	**11,713**	**2,934**	**931**	**810**

Economic Loss

The total economic loss estimated for the earthquake is 55,152.54 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

The total building-related losses were 52,552.71 (millions of dollars); 15 % of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 61 % of the total loss. Table 11 below provides a summary of the losses associated with the building damage.

Table 11: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Losses							
	Wage	0.00	97.43	1,346.75	57.80	68.73	1,570.70
	Capital-Related	0.00	41.51	1,249.51	34.81	16.92	1,342.76
	Rental	322.07	549.42	768.62	30.59	33.31	1,704.01
	Relocation	1,206.96	436.44	1,150.59	131.56	253.90	3,179.46
	Subtotal	**1,529.03**	**1,124.80**	**4,515.46**	**254.76**	**372.87**	**7,796.93**
Capital Stock Losses							
	Structural	2,722.71	962.50	1,708.98	407.07	285.69	6,086.95
	Non_Structural	13,834.39	5,865.91	5,756.59	1,515.94	956.31	27,929.14
	Content	4,567.14	1,487.85	2,915.00	1,045.40	493.92	10,509.31
	Inventory	0.00	0.00	63.02	161.25	6.11	230.38
	Subtotal	**21,124.24**	**8,316.25**	**10,443.58**	**3,129.67**	**1,742.03**	**44,755.78**
	Total	**22,653.28**	**9,441.06**	**14,959.04**	**3,384.43**	**2,114.90**	**52,552.71**

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, Hazus computes the direct repair cost for each component only. There are no losses computed by Hazus for business interruption due to lifeline outages. Tables 12 & 13 provide a detailed breakdown in the expected lifeline losses.

Hazus estimates the long-term economic impacts to the region for 15 years after the earthquake. The model quantifies this information in terms of income and employment changes within the region. Table 14 presents the results of the region for the given earthquake.

Table 12: Transportation System Economic Losses
(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	30,999.20	$0.00	0.00
	Bridges	11,964.08	$416.09	3.48
	Tunnels	66.28	$2.81	4.24
	Subtotal	**43029.60**	**418.90**	
Railways	Segments	1,441.85	$0.00	0.00
	Bridges	16.26	$0.28	1.73
	Tunnels	1.85	$0.07	3.54
	Facilities	90.54	$25.12	27.75
	Subtotal	**1550.50**	**25.50**	
Light Rail	Segments	457.90	$0.00	0.00
	Bridges	15.35	$0.39	2.52
	Tunnels	0.00	$0.00	0.00
	Facilities	761.62	$198.92	26.12
	Subtotal	**1234.90**	**199.30**	
Bus	Facilities	41.16	$10.95	26.59
	Subtotal	**41.20**	**10.90**	
Ferry	Facilities	26.62	$0.00	0.00
	Subtotal	**26.60**	**0.00**	
Port	Facilities	283.57	$74.52	26.28
	Subtotal	**283.60**	**74.50**	
Airport	Facilities	223.67	$54.29	24.27
	Runways	1,594.49	$0.00	0.00
	Subtotal	**1818.20**	**54.30**	
	Total	**47984.40**	**783.40**	

Table 13: Utility System Economic Losses
(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.00	$0.00	0.00
	Facilities	471.50	$89.36	18.95
	Distribution Line	936.20	$37.80	4.04
	Subtotal	**1,407.71**	**$127.17**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	5,344.00	$831.13	15.55
	Distribution Line	561.70	$18.99	3.38
	Subtotal	**5,905.69**	**$850.12**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	1.30	$0.14	11.00
	Distribution Line	374.50	$6.51	1.74
	Subtotal	**375.76**	**$6.65**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	1.70	$0.28	17.03
	Subtotal	**1.65**	**$0.28**	
Electrical Power	Facilities	5,581.40	$829.64	14.86
	Subtotal	**5,581.40**	**$829.64**	
Communication	Facilities	15.20	$2.55	16.75
	Subtotal	**15.22**	**$2.55**	
	Total	**13,287.43**	**$1,816.40**	

Table 14. Indirect Economic Impact with outside aid
(Employment as # of people and Income in millions of $)

LOSS		Total	%

Country Listing for Region

Alameda,CA

Contra Costa,CA

Marin,CA

Napa,CA

San Francisco,CA

San Mateo,CA

Santa Clara,CA

Solano,CA

Sonoma,CA

Regional Population and Bulding Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
California					
	Alameda	1,443,741	107,963	30,009	137,972
	Contra Costa	948,816	79,686	14,655	94,341
	Marin	247,289	25,870	5,734	31,604
	Napa	124,279	9,774	3,151	12,925
	San Francisco	776,733	61,019	23,081	84,101
	San Mateo	707,161	61,610	14,552	76,163
	Santa Clara	1,682,585	130,233	33,078	163,312
	Solano	394,542	27,133	5,503	32,636
	Sonoma	458,614	37,600	8,823	46,424
Total State		**6,783,760**	**540,888**	**138,586**	**679,478**
Total Region		**6,783,760**	**540,888**	**138,586**	**679,478**

Appendix B: Oakland Park Evaluation

Key	Name	Type	Size	LUGIJ		Fire Break			Emergency Evacuation							Recovery Process					
			Acres	Score	Level	Open space (100 ft x 100 ft)	Tree buffer	Water feature	20ft wide street in front of the entrance	Barrier-free entrance	Entry besides the main entrance	Open Space for heliport	Trees to protect open space	Sign to lead evacuees	Lighting	Shelter/Office	Division between possible temporary housing + regular use	Restrooms	Access for large vehicles	Community amenities	Final Evaluation
Small Block Parks																					
1	McCrymonds Park	Playground	0.17	0.7	x				✓	✓	✓		✓		✓						Not appropriate
2	Bishop Floyd Begin Park	Plaza	0.25	0.5	x				✓	✓	✓		✓								Not appropriate
Medium Block Parks																					
3	Durant Mini Park	Playground, Community garden	0.32	0.8	x				✓	✓			✓							✓	Not appropriate
4	25th Street Mini Park	Playground	0.38	0.3	x		✓		✓	✓			✓		✓					✓	Not appropriate
Large Block Parks																					
5	Hardy Park	Playground, Dog park	0.78	1.1	c			✓	✓	✓	✓							✓			Not appropriate
6	Park Blvd Plaza	Lawn	0.79	0.8	x				✓	✓	✓										Not appropriate
7	Wilda Avenue	Greenway	0.90	0.5	x			✓	✓	✓	✓										Not appropriate
8	Athol Plaza Park	Lawn, Sportsfield	1.01	0.9	x				✓	✓	✓						✓				Temporary
9	Willow Park	Playground, Sportsfield	1.13	1	d				✓	✓	✓						✓	✓		✓	Temporary
10	Bella Vista Park	Lawn, Playground, Sportsfield	1.28	1.7	b	✓			✓	✓		✓				✓	✓	✓			Recovery
11	Chinese Garden Park	Lawn, Building	1.33	1.3	c	✓			✓	✓	✓	✓				✓		✓	✓	✓	Temporary/ Recovery
12	City Hall Plaza	Plaza	1.33	0.8	x		✓		✓	✓	✓										Not appropriate
13	Madison Park	Lawn, Plaza, Playground	1.38	1	d	✓			✓		✓	✓	✓		✓	✓	✓				Temporary
14	Lincoln Park	Lawn, Sports field, Playground, Building	1.38	1.7	b	✓			✓	✓	✓				✓	✓	✓	✓		✓	Temporary/ Recovery
15	Jefferson Square Park	Playground, Sports field, Dog Park	1.38	0.6	x	✓			✓	✓		✓					✓			✓	Temporary
16	Lafayette Park	Lawn, Playground, Plaza	1.39	1.2	c	✓			✓	✓	✓	✓	✓				✓	✓		✓	Temporary
17	FM Smith Park	Lawn, Sports field, Playground, Building	1.69	1.7	b	✓			✓	✓	✓	✓	✓			✓	✓	✓		✓	Tempory/ Recovery
18	Clinton Square	Lawn, Playground, Building	2.00	1.7	b				✓	✓	✓					✓	✓	✓			Tempory/ Recovery
19	Poplar Park	Sports fields, Playground, Building	2.03	1	d	✓	✓		✓			✓	✓								Recovery
20	Franklin Square	Lawn, Sportsfield	2.25	1.7	b	✓			✓			✓				✓	✓	✓			Recovery
Community Parks																					
21	Wade Johnson Park	Lawn, Playground, Sports field	2.54	1.5	c	✓	✓		✓	✓		✓				✓	✓				Temporary
22	Marston Campbell Park	Lawn, Playground, Connected to school	2.77	1.7	b	✓			✓	✓	✓	✓				✓	✓	✓	✓	✓	Temporary/ Recovery
23	Lakeshore Park	Lawn, Playground	3.39	1.5	c	✓			✓	✓	✓	✓				✓	✓	✓			Temporary/ Recovery
24	Golden Gate Park	Sports field, Playground, Building	3.49	1.7	b	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓		✓	Temporary/ Recovery
25	Glen Park	Greenway	3.64	0.8	x			✓	✓	✓	✓										Not appropriate

Key	Name	Type	Size	LUGIJ		Fire Break			Emergency Evacuation							Recovery Process					
			Acres	Score	Level	Open space (100 ft x 100 ft)	Tree buffer	Water feature	20ft wide street in front of the entrance	Barrier-free entrance	Entry besides the main entrance	Open Space for heliport	Trees to protect open space	Sign to lead evacuees	Lighting	Shelter/Office	Division between possible temporary housing + regular use	Restrooms	Access for large vehicles	Community amenities	Final Evaluation
26	MLK Plaza Park	Lawn, Playground, Community garden	3.85	0.8	x	✓				✓		✓								✓	Recovery
27	Snow Park	Lawn	3.99	0.8	x	✓			✓	✓	✓	✓									Temporary/ Recovery
28	South Prescott Park	Lawn, Playground	4.27	0.8	x	✓			✓	✓		✓					✓		✓		Temporary
29	Peralta Park	Greenway	4.69	1	d			✓		✓											Not appropriate
30	Temescal Creek Park	Greenway	5.01	1.3	b			✓		✓	✓						✓	✓			Recovery
31	Grove Shafter Park	Lawn, Sports field	5.61	0.7	x	✓			✓	✓	✓	✓								✓	Not appropriate
32	Brushrod Park	Lawn, Sports field, Building	7.74	1.7	b	✓			✓	✓	✓	✓				✓	✓	✓	✓	✓	Temporary/ Recovery
33	Lowell Park	Lawn, Playground, Community garden, Sports field	8.71	1.3	c	✓	✓		✓	✓	✓	✓	✓				✓	✓	✓		Temporary
34	De Fremery Park	Lawn, Playground, Sports fields, Pool, Building	9.43	1.7	b	✓		✓	✓	✓	✓	✓				✓	✓	✓	✓	✓	Temporary/ Recovery
35	Raimondi Park	Sports fields, Playground	9.67	1.3	c	✓			✓			✓			✓		✓	✓			Temporary/Temporary
Neighborhood Parks																					
36	Mosswood Park	Lawn, Playgroud, Sports field	10.33	1.7	b	✓	✓		✓	✓	✓	✓				✓	✓	✓	✓	✓	Temporary/ Recovery
37	San Antonio Park	Sports fields, Lawn, Playground, Building	10.62	1.8	b	✓	✓		✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	Temporary/ Recovery
38	Mandela Greenway	Lawn, Greemway	12.49	0.8	x				✓	✓	✓										Temporary
39	Estuary Park	Lawn, Greenway, Waterfront	18.70	0.8	x	✓		✓	✓	✓	✓										Recovery
Multi-use Parks																					
40	Jack London Square	Waterfront, Plaza	41.91	1.8	b	✓		✓	✓	✓	✓	✓				✓	✓	✓			Recovery
41	Lakeside Park	Lawn, Waterfront, Greenway, Garden	78.68	2	b	✓		✓	✓	✓	✓	✓				✓	✓	✓			Temporary/ Recovery