CHAPTER 2

EARTHQUAKE PREPAREDNESS WITHIN THE EAST BAY MUNICIPAL UTILITY DISTRICT

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Introduction and Objective

After the initial shock of an earthquake, the threat of fire is all too prevalent. A water district must be prepared for such an event in order to minimize the dangers that threaten the public health and safety. My contribution within the Seminar is aimed at a detailed description and evaluation of the water system presently operated by the East Bay Municipal Utility District (EBMUD). My investigation is designed to describe the distribution system and the accompanying seismic hazards and ascertain what efforts EBMUD has made to identify and reduce those hazards that threaten life, property and rescue operations. In addition, construction costs, consumer rates and potential government assistance are discussed in relation to the earthquake issue. The City of Berkeley is wholly dependent on EBMUD for its regular water supply and services as well as continued operation and supply of water in the wake of a disaster.

Historical Perspective, San Fernando 1971

The San Fernando earthquake of 1971 (Richter magnitude 6.4) not only wreaked widespread havoc but also illustrated that fundamental changes were in order on the part of water district policy makers and engineers. What follows is a brief description of the earthquake as described in a U.S. Geologic Survey (USGS) report.[12]

The major impact of the earthquake on water systems was damage to hydraulic structures such as dams and distribution mainlines. Five major dams suffered damage, with Upper and Lower Van Norman dams coming near to failure. It was estimated that the replacement of the Lower Van Norman dam alone would cost thirty-four million dollars.[9] By comparison, the Pacoima dam experienced only one and a half million dollars worth of damage. At the time of the earthquake, Lower Van Norman dam was being filled and was fifty percent below maximum capacity. The shock destroyed much of the dam facing and caused a series of landslides into the reservoir. The dam was constructed by the hydraulic fill process common to dams built before established earthquake codes. As a result, the lack of stability to seismic waves inherent in the dam facing caused the subsequent near collapse. Fortunately, the dam held and proper action by dam operators lead to the safe release of water and quick evacuation of the eighty thousand people below the dam. The evacuation was in effect for four days and was a precautionary measure in the event that the dam ruptured from aftershocks.

Water service to San Fernando city residents and surrounding vicinity was drastically reduced or completely cut off. Some areas were without water for as long as fourteen days, due to the destruction of water mains, unsecured water tanks, aqueducts and canals.[8, 13] Damage to two main aqueducts cut off service to ten thousand homes in Los Angeles. Seventeen thousand San Fernando residents were without water and received their supply via portable tanker trucks that normally carried potable liquids such as beer and milk. Although damage to water equipment and systems was severe, other similar facilities suffered little or no damage. The nearly complete Castaic dam and powerplant, the California Aqueduct and tunnel through the Tehachapi Mountains are examples of facilities that sustained only light damage.[9]

The sole supply of water for San Fernando was from well fields just north of the city. The distribution conduits were so totally shattered from ground shaking, that only an almost completely new water system for the city proved cost effective.

However, like most earthquakes, San Fernando was highly instructive as engineers and designers of "modern" water and highway systems were forced to modify their design criteria and standards in response to a large earthquake. The information gathered later proved valuable to other vulnerable utility districts such as EBMUD.

EBMUD Distribution System

The main water source of the EBMUD system is Pardee Reservoir, located in the 575 square mile watershed of the Mokelumne River, thirty-eight miles northeast of Stockton. Water is transported from Pardee to East Bay terminal reservoirs via a 147 kilometer (92 mile) aqueduct system, which must cross two active earthquake fault zones (the Franklin-Calaveras and Concord faults) in the process of carrying water.[4]

The service area (FIGURE 1) spans 790 square kilometers (305 square miles) in both Alameda and Contra Costa counties. The elevations served range from sea level to 485 meters (1500 feet). The local system is comprised of 111 pressure zones, 5,310 kilometers (3300 miles) of pipe, 153 storage reservoirs and 112 pumping stations. This allows EBMUD to "move" treated water virtually anywhere in the operable system.[5]

In addition to the aqueducts, two of three main underground tunnels pass through the Oakland-Berkeley hills and consequently cross the Hayward fault enroute to filter plants west of the hills. The Claremont Tunnel carries filtered water from the Orinda filter plant to zones west of the hills, supplying nearly ninety percent of the City of Berkeley's water needs. The second tunnel connects the San Pablo reservoir and filter plant to the main Mokelumne aqueduct.

The local service area is comprised of the following five major reservoirs: San Pablo, Briones, Lafayette, Upper San Leandro and Chabot. The total capacity is 51.3 billion gallons

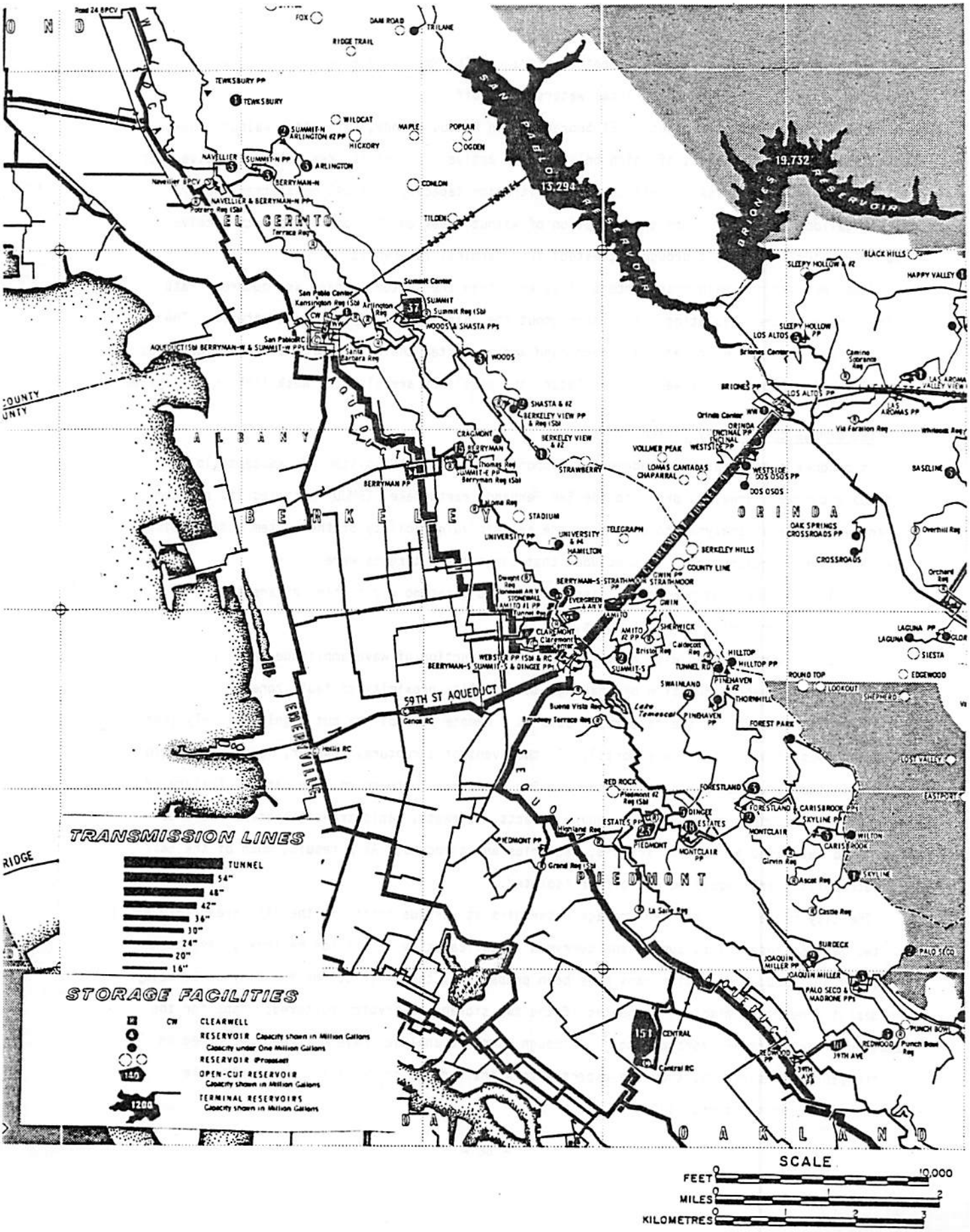

FIGURE 1. Berkeley-Oakland Service Area

SOURCE: East Bay Municipal Utility District, Map NRE-370

and is approximately 180 days of hot weather storage. The Mokelumne River water stored in these reservoirs is also supplemented by local watershed runoff.

There are seven filter plants: El Sobrante, San Pablo, Orinda, Lafayette, Walnut Creek, Upper San Leandro and Chabot, of which only six are active. Chabot is presently not active, but is available in emergencies. Their combined filtration capacity is 1,840 megalitres (487 million gallons per day). With the exception of Walnut Creek and Orinda, all plants receive local raw water (which is thoroughly treated) from terminal reservoirs.

Pipelines are the main transporters of water within the system. There are numerous rate control and pressure regulating valves throughout the thirty-three hundred mile network. The pipelines are both above ground and underground and are often the only source of water for areas east of the fault zones. As we will see later, the pipelines are also the weak link in the system.

Expected Damage to Berkeley System

It becomes clear that the fundamental components of the EBMUD system are susceptible to earthquake damage. However, prior to the San Fernando earthquake, EBMUD initiated its own comprehensive series of analyses to determine the seismic vulnerability of the system's dams, pipelines and storage reservoirs. It concluded that the primary threats were:

1. vertical and horizontal displacement and shearing and tilting of areas in proximity to fault zones, and
2. severe shaking with resulting damage a function of wave amplitude and frequency, duration of shaking, and facility proximity to fault zones.[1]

The rupture of any of the five major dams is a remote possibility but highly unlikely (see following section on mitigation efforts). In the event of a rupture, however, many lives would be lost in the populated areas of Oakland and San Leandro. Furthermore, the partial failure or leakage of a dam would cause many secondary effects. Streets, rapid transit systems and freeways would be closed as well as schools, factories and airports. As a result, much of the East Bay Metropolitan area would be cut off or isolated.[11]

The City of Berkeley has ten storage reservoirs at various points in the hill areas (FIGURE 1). The two largest reservoirs, Summit and Berryman (total capacity 52 million gallons), have been evaluated by EBMUD. Inundation maps have been prepared by the District for the City of Berkeley and depict zones that might be inundated if the two storage reservoirs ruptured. Maps for the remaining reservoirs are forthcoming.[3] Although complete analyses have not been performed on all the storage reservoirs, they are expected to withstand the shock of a major earthquake (Anton, oral communication, 1979).

Significant movement on the Hayward Fault will disrupt many or all aqueducts including the Claremont Tunnel, which delivers ninety percent of Berkeley's water needs. It is expected that all distribution lines, aqueducts and conduits will be impaired.[3] Hillside communities east of the fault zone would be placed in "double jeopardy" due to fire and landslide hazards while the city in general would suffer a reduction in service to only five percent of normal for twenty-four hours. Service would rise to twenty percent after twenty-four hours.[3]

The immediate shortage of water for fighting fires is an unsolved dilemma. The effectiveness of the fire departments in the Berkeley-Oakland areas will be ninety percent or more within fifteen minutes after the earthquake.[11] However, this estimate pertains to equipment and labor and does not imply ninety percent fire fighting effectiveness as fallen freeway structures, poor communications and broken water lines and other problems might significantly hinder recovery efforts. Furthermore, the threat of fire is compounded by the lack of automated sprinkler systems in many buildings of low fire resistance. This is especially true in the downtown sector of Berkeley (See Section II).

EBMUD Mitigation Efforts

Following the identification and evaluation of the potential hazards to the system, EBMUD has chosen to strengthen the two primary components, hydraulic fill dams and pipelines. The following discussion describes the efforts EBMUD has made to reduce these hazards as well as efforts in related areas such as repair equipment and labor allocations.

Hydraulic Fill Dams

Prior to San Fernando 1971, EBMUD, in cooperation with the State Division of Safety of Dams, had evaluated the seismic safety of all hydraulic fill dams. However, after the San Fernando earthquake, it became obvious that a reevaluation of the dams was required. It was discovered that two older dams, San Leandro and San Pablo, are relatively unsafe. An even older dam at Lake Chabot withstood the 1906 earthquake and will require only an increase of the dam free-board (portion of dam above water) to meet new safety standards. The total cost for renovations at Chabot is expected to be about one half million dollars.[2]

Modification at the Upper San Leandro dam involved construction of a entirely new dam while retaining the previous dam. The project required two years of work and was completed in August of 1977 at a total cost of eighteen million dollars. Renovations at San Pablo involve strengthening the dam and construction of a temporary aqueduct. Upon completion in 1980, total costs for San Pablo are expected to be nearly seventeen million dollars.[8]

In addition to the above modifications, EBMUD has also effected major improvements in the methods and timing involved in draining water from embankment and storage reservoirs. These

improvements have been made or are in progress at nine reservoirs at a total cost of five hundred thousand dollars.[2]

Pipelines

Pipelines underground and crossing the fault are most vulnerable to the effects of seismic activity. Ruptures in the pipes obviously limit the emergency distribution capabilities of the system. The probability of pipe rupture is increased due to many weak joints sealed with a sulfur compound common in World War II and post-war eras. According to Mr. Robert Sisco (Manager of Plant and Maintenance Division and Disaster Officer), a destructive bacterial process develops at the joint, thus weakening the seal. As a result, these joints are particularly susceptible to breakage during an earthquake. Replacement of this type of pipe formerly took place at a rate of ten to fifteen miles per year but has progressively been reduced to nearly two miles per year. Citing high costs as a significant factor, EBMUD has instead decided to concentrate on maximizing the distribution capability under adverse conditions.[10] Modifications to essential pipelines in fault zones include installation of flexible joints and above ground lines whenever possible as well as double welded joints, extra safety valves and conduits.

Overall Planning for an Earthquake

EBMUD's primary objectives after an earthquake are to repair distribution systems as rapidly as possible, thereby minimizing the potential of uncontrolled fires. In accomplishing these goals, the District has revised its Emergency Operations Plan and facilities and equipment management. Within budgetary and labor constraints, EBMUD has increased its repair and recovery capability by the following measures. Repair equipment and replacement parts are maintained at various strategic locations throughout the system. EBMUD has also made prior arrangements with private contractors and owners of commercial vehicles that normally carry potable liquids so that emergency repair and distribution efforts can be supplemented.[1, 2] It has always been and continues to be a major concern among EBMUD engineers that the distribution system retain the capability to move water to essential areas after a disaster. An effort towards this goal is evidenced throughout the Oakland-Berkeley hills in the form of fifty-eight special red hydrants. These hydrants are not only immediate sources of water but also are strategic points where water can be pumped to different pressure levels by portable diesel pumps or fire trucks. The manipulation of water pressures is the mechanism behind water distribution.[10] In addition, the District's decision to maintain reservoirs on both sides of the fault zone has strengthened the fire fighting water supply so that it now exceeds twice the maximum non-emergency daily demand.[2]

Whenever possible, EBMUD has installed short wave radios in repair vehicles and established accompanying emergency communication channels.[6] In this manner, contradictory or irrelevant data should be reduced, as theoretically only designated personnel will be allowed on the air waves.

Finally, EBMUD has installed three strong motion accelerographs at Briones Dam and inlet tower. The cost of the instruments was paid by the State of California. The instruments will allow for a swift and accurate determination of earthquake magnitude and thus are invaluable in aiding dam personnel to formulate the proper course of action after an earthquake.

Construction Costs vs. Consumer Rates

The projects undertaken to reduce risks related to earthquakes will cost thirty-six million dollars. The recent drought and subsequent reduced consumption, Proposition 13 and inflation have pushed EBMUD operating expenses higher at a comparatively rapid rate.[7] The District has stated that the construction costs for earthquake safety have contributed significantly to the overall costs. However, it is apparent that the potential earthquake hazard was great enough to warrant the necessary mitigation expenditures despite already rising operational costs. As a result, on April 27, 1979 the Board of Directors approved new higher rates for most of the District's residential customers.

With the exception of seismic instrumentation costs at Briones Dam noted earlier, EBMUD receives virtually no financial aid from any government agency.[10] I find this situation most disheartening as I would expect both the Federal and State governments to take a more positive approach to ensure the safety of the general public. It is my opinion that the State in particular, should allocate a portion of the well known state surplus (which consists of billions of dollars) to mitigation measures rather than allow the consumer to pay for the increased costs. Therefore, I would hope to see a more active effort on the part of EBMUD officials and consumer advocacy groups, to secure government (municipal, state or federal) funds for earthquake mitigation efforts that directly increase the safety of the public.

Discussion

In the aftermath of an earthquake, efficient mobilization of labor, the water supply and constant communication within the system are paramount. EBMUD has effectively attacked these issues among others already mentioned. It becomes apparent that EBMUD has not shirked its responsibility to the public in regards to earthquake safety. Indeed, its concern and active pursuit of earthquake preparedness began prior to the San Fernando earthquake. Clearly, EBMUD was not content to wait for an earthquake precedent to stimulate necessary changes and is to be commended for its foresight.

It was also interesting to note the fiscal conservatism exhibited by the District, especially after considering the significant effects that the recent drought and other phenomena have had on revenues. The latest approved rate increase designed to boost earnings by thirteen percent still just counterbalances the negative effects of the last five years. In comparison to other utility companies, EBMUD has acted responsibly in its encouragement of public participation during the rate increase hearings.

One aspect of preparedness perhaps requires more effort on the part of the District and the local fire departments. At present, EBMUD has no formal cooperative contingency plans with local fire departments.[10] I was somewhat surprised to learn that not even the basic logistics of a joint fire-fighting plan have been formulated by either parties. It seems logical to me that a plan that comprehensively explains the mechanics of the system would be of incalculable utilitarian benefit to the firefighters. Similarly, a semi-annual mock earthquake drill that requires the testing of emergency equipment, administrative procedures and active participation of all respective personnel would certainly improve basic readiness and ultimately serve the general public's best interest.

It is fair to conclude that the East Bay Municipal Utility District has accomplished many goals that will serve to reduce seismic hazards. Furthermore, it appears that the concern and direction exists within the higher echelon of the District to meet new challenges with progressive action as they arise in the future. EBMUD has prepared well in virtually all phases of administrative and technical operations for an earthquake that most experts consider inevitable. However, due to present geographical and geological conditions in the East Bay beyond human control, certain sectors of Berkeley will no doubt be without water for fighting fires.

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