Napa Water System Earthquake Response: like fine wine, the right blend of self-help and mutual aid

Joy Eldredge, Water General Manager

ABSTRACT

On August 24, 2014 at 3:20am the south Napa Earthquake struck 5 miles southwest of the City of Napa and 2 miles west of one of two major water treatment plants. The energy radiated north and affected the west side of the pressurized pipe network that makes up the transmission and distribution systems that carry potable water to over 84,000 residents throughout City of Napa and surrounding areas. The event, the largest earthquake in the San Francisco Bay Area since 1989, unveiled newly identified surface faults and wreaked havoc on water infrastructure.

The water system was impacted and the event instantly compromised a storage tank and caused the equivalent of more breaks than typically experienced over an entire year within the distribution system. It was apparent within hours, while the extent of damage was still being assessed, that mutual aid was required to protect public health, and effectively reinstate water service in a timely manner. CALWARN the established California Water and Wastewater Agency Response Network, offered to assist with the emergency response within one hour of the event.

The City of Napa coordinated with CALWARN, and water managers ordered 6 fully-functioning crews stocked with heavy equipment and materials. By the middle of day two, a production assembly line of pipe repair was established: digging, repairing, backfilling, trench plating, flushing, water quality analyzing, and paving each site. Local private contractors kept a steady supply of trucks for off-hauling spoils, delivering sand and aggregate bedding for backfill, setting up and closing down traffic control and barricades as needed. The operation quickly became an efficient operation of pipeline repair and site clean-up. Information and status of repairs was coordinated back to the Emergency Operations Center (EOC), status tracked and information pushed out to the public and media. Before the end of day two, an additional two crews were ordered and inserted into the leak repair assembly process. This paper is written to provide a brief description and background of the City of Napa's water system, describe the event and thought process during the uncertainty of the immediate aftermath, and share the successes of the response as well as the lessons learned to improve preparedness and execution for when the next one hits.

Joy Eldredge, Water General Manager, City of Napa, 1340 Clay Street, Napa, CA, USA 94559, phone: (707) 257-9319,fax: (707) 258-7831, JEldredge@cityofnapa.org

CITY OF NAPA WATER SYSTEM

The City of Napa's drinking water system is relatively small when compared to most water systems in the Bay Area, but is the largest potable water system in Napa Valley serving over 84,000 persons including 76,000 persons within the City of Napa, over 2,000 persons in unincorporated Napa County, retail service to over 6,150 persons in the City of St Helena. In addition, the Cities of Calistoga and American Canyon serve 5,300 and 20,450 persons respectively with water systems reliant on treat & wheel services provided by City of Napa (Napa.) In addition, 2,000 persons in the Town of Yountville are provided water from Napa's system on an emergency basis. Napa's water system stretches eight miles from the southern end of City limits, seventeen miles from the northern end of City limits, and is composed of 350 miles of pipe ranging in size from 4-inch to 42-inches diameter. The oldest portions of the system that remain today are mostly located in the heart of downtown. These pipes were constructed of cast iron in the 1880s. The transmission system includes twelve storage tanks totaling 30 million gallons located along the east and west hillsides of Napa and nine pump stations serving the higher elevations.

Napa water system consists of three water sources each with a corresponding treatment plant as follows:

Lake Hennessey is located 17 miles north of City limits and is the largest local reservoir with a storage capacity of 31,000 acre feet (AF) of water as established by construction of Conn Dam in 1948. The treatment plant is conventional treatment originally constructed in 1981. Maximum treatment capacity is 20 million gallons per day (MGD.) A double chamber 5 million buried gallon concrete storage tank serves as the clear well on site. Water is conveyed to the City via a 36-inch diameter steel transmission main.

Milliken Reservoir is located 3.5 miles northeast of City limits and stores 1390 AF of water stored behind a concrete radial arch dam that was established in 1923. The reservoir capacity was reduced by 16 feet in 2008 to address seismic concerns associated with the max probable earthquake occurring with the dam at full capacity. The project cored 5 holes in the dam to allow passive flow of water through the dam to reduce the water level. Raw water is released from the dam and flows via open channel flow to a point approximately two miles downstream. A 16-inch diameter above ground raw water steel pipe conveys water along a limited access trail to the water treatment plant. The plant, constructed in 1976 is direct filtration with a maximum capacity of 4 MGD. The clear well is a 2 MG steel tank and the transmission line is 14-inch welded steel.

State Water Project supplies are conveyed through the North Bay Aqueduct (NBA) originating in the Sacramento-San Joaquin Delta and diverted at the Barker Slough pumping plant east of Vacaville. The 21-mile NBA is shared with cities in Solano County and water is further pumped from the Cordelia Forebay to the two 5 MG steel terminal tanks adjacent to Napa's Barwick Jamieson Treatment Plant (BJTP.) BJTP is located eight miles south of City limits and in 2011 upgrades were completed to the original 1968 treatment plant since the roof of the operations building did not meet seismic standards. The BJTP has a capacity of 20 MGD and provides treat & wheel services of SWT supplies for Cities of Calistoga and American Canyon. The recently improved process includes pre- and intermediate ozone along with conventional treatment. The clear well is a 5 MG steel tank. The transmission line is 42-inch reinforced concrete cylinder pipe that transitions to 36-inch asbestos-cement pipe and 24-inch ductile iron pipe that conveys water north to the City where it meets the 36-inch steel Conn line.

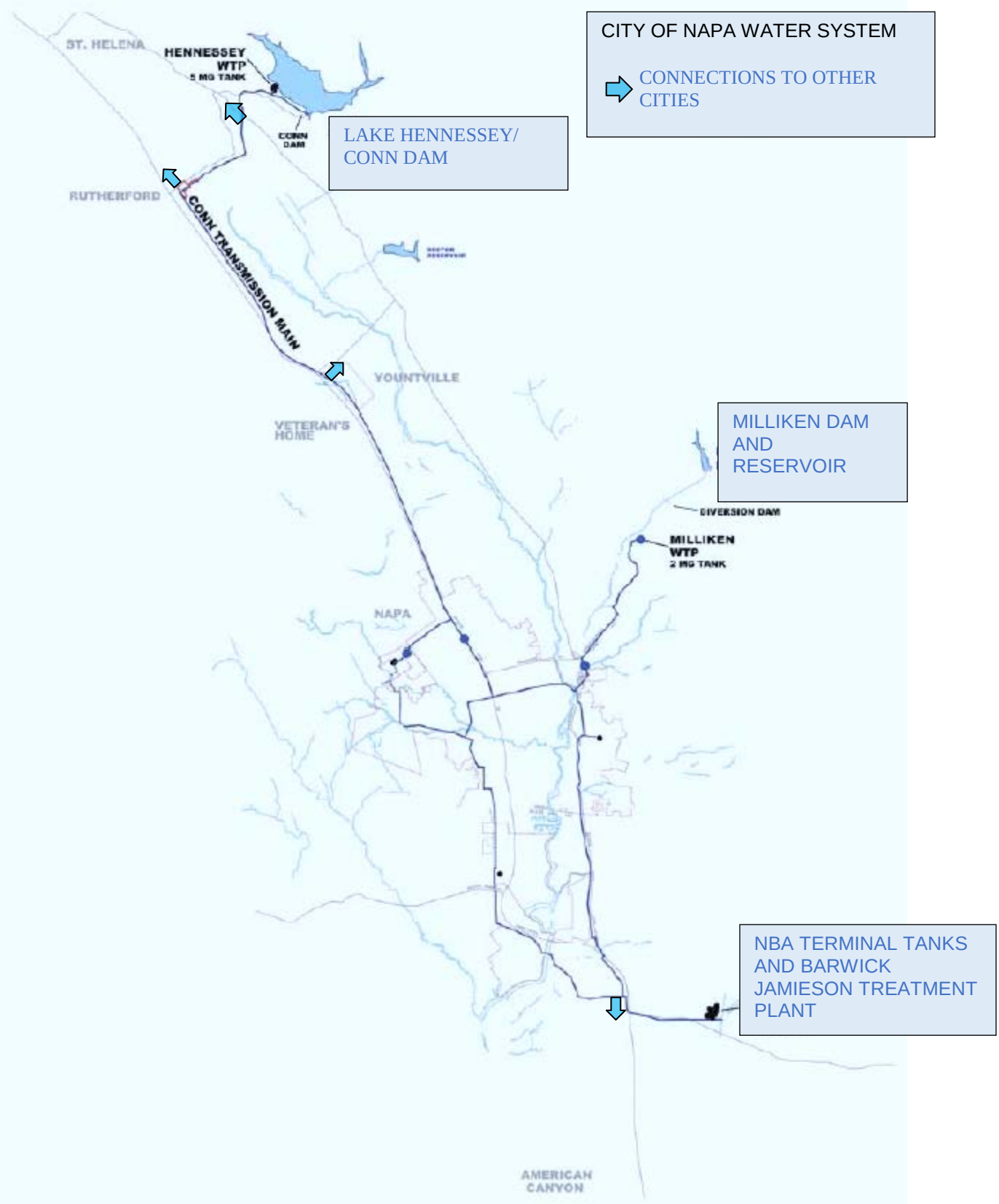

Figure 1. City of Napa Water Sources, Treatment Plants and Transmission Mains.

SEISMIC EVENT

At 0320, pacific time, on August 24, 2014, a 6.o magnitude earthquake occurred near the city Napa, California. The West Napa fault caused the earthquake and although the epicenter was 8 miles southwest of City of Napa, the shake maps indicate the energy radiated northwest along the fault and numerous surface faults were identified by staff and citizens alike to the west of downtown Napa as shown in Figure 2 [1]. As a result, the City of Napa's water system was most directly affected by the event when compared to utilities of neighboring systems.

SEISMIC EFFECTS ON CITY OF NAPA WATER SYSTEM

Water Treatment Operators on shift at the BJTP, located just 1 mile (1.6 km) from the reported epicenter felt the quake and made physical observations of the treatment plant. Typical demands in August range from 19 to 25 MGD depending on the temperature. Power was uninterrupted and the treatment plant showed no signs of damage. However, within the first three hours after the event system storage continued to decline as staff was deployed to physically inspect facilities to assess damage as best as possible with flashlights prior to daybreak. The treatment plant operator increased production from the BJTP. The two dams, Conn dam the earthen dam that retains Lake Hennessy and Milliken Dam, a concrete radial arch dam that holds back Milliken Reservoir both reported to show no impacts. All three treatment plants were reported to be in working order.

Water treatment staff were deployed to make physical inspections of water tanks that had no Supervisory Control and Data Acquisition (SCADA) communication with the treatment plant due to power outage or potential damage. Storage tanks levels were dropping rapidly and it was unknown whether the tank was leaking, the feed line was compromised, the outflow was compromised or the water level data was erroneous. Reports were received that all tanks, with the exception on one tank were in satisfactory condition. The 1 MG steel tank on the west side of town was empty and the field inspection reported that the corrugated metal roof was buckled, the roof framing was splintered and lay scattered on the ground around the tank and the valve to reduce flows from the tank was inoperable in automated and manual mode. The two pump stations that feed the tank continued to feed the tank while the level continued to drop as water flowed through the open valve to the system to feed the distribution leaks at lower elevations. Emergency generators were mobilized to these two pump stations to insure backup power in the event of an outage. The Hennessey Treatment Plant was started to increase higher pressure flows to the system in an effort to regain system storage.

Water management staff reported to the Water Administration office by 4:45 am to find the 1950's era former residential building chimney flue was shaken from the rooftop and lay in the front yard. The front door remained on its hinges but the door frame was cracked. There was no power at the facility. Inside the building shelves remained braced to the walls however binders and records were cleared from their places and were strewn across the floor as were whiteboards and wall mounted maps. All phones were off their hooks and computer monitors were on the floor.

City staff and emergency responders opened the Emergency Operations Center (EOC) and by 0500 the 911 dispatch call center was flooded with calls for assistance and reports of water outages and water line breaks in the streets. This report will focus on the response of the water system with reference to other services only as it related to water system operations and response.

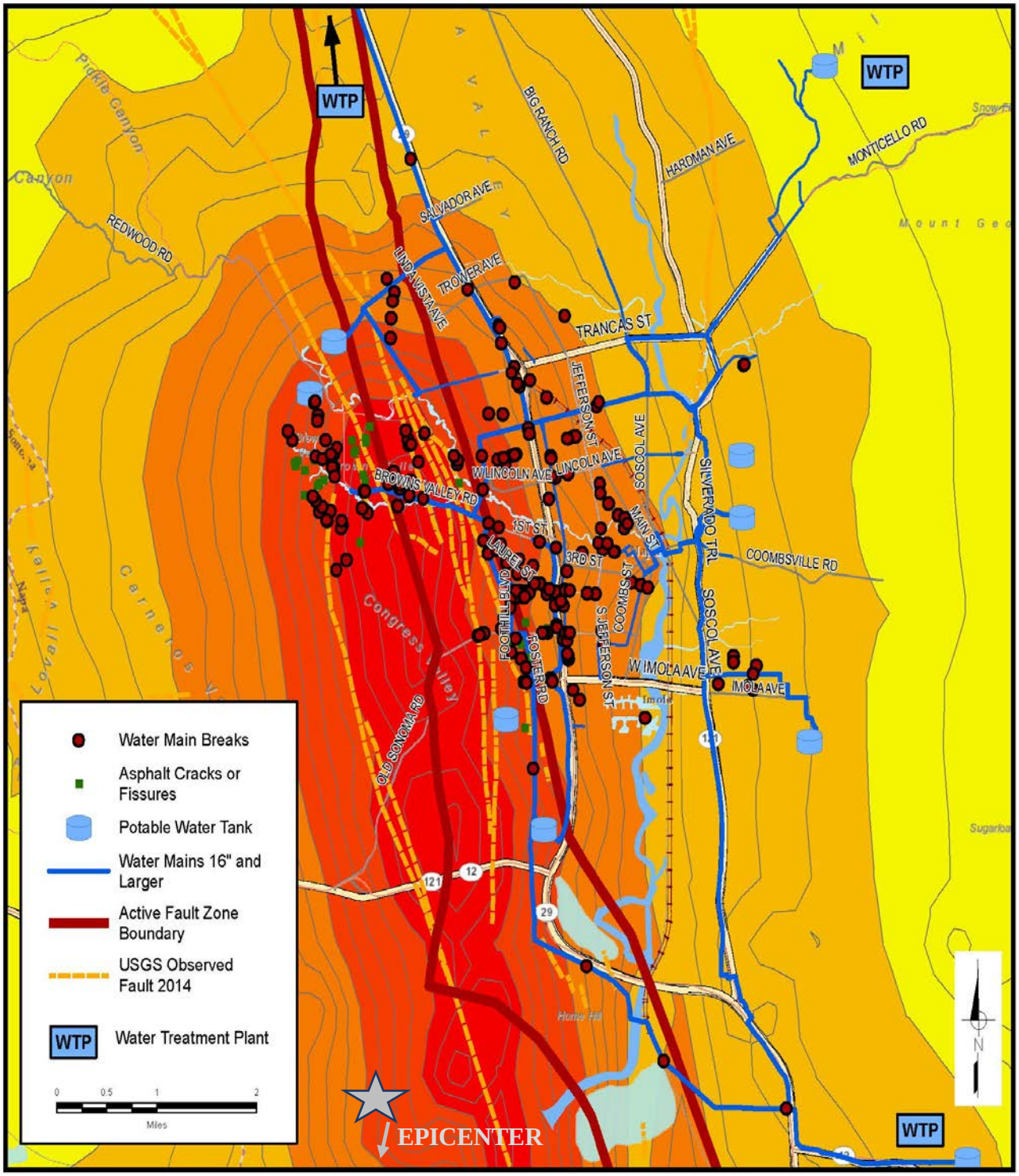

Figure 2. Epicenter of August 24, 2014 Event, Shake Intensity Map, West Napa Fault (Dashed) and Surface Faults (Green) and Water Storage Tanks (Blue)[1].

EMERGENCY RESPONSE

Day 1

Water management staff reported to the EOC and started a running list of water outages reported to the dispatch call center. Within hours, it was clear the water distribution system was experiencing many breaks. Water staff transferred to the corporation yard from where maintenance staff and heavy equipment are deployed. A Departmental Operations Center (DOC) was convened and a satellite dispatch center was created to receive calls for water system issues.

By 0900 there were over 60 water main leaks reported. Staff logged the locations, dispatched Napa water distribution crews and started to make repairs. The calls continued successively through the day. Field staff were divided into pre-determined emergency operation groupings of A and B shifts to prepare for 12-hour shifts and insure 24-hour operations. It should be noted that in a typical year Napa experiences between 70 and 110 leaks on its pipe network. For a system composed of 350 miles of pipe, 105 breaks are typical per annum of 3 breaks per 100 miles [2]. As the number of reported breaks topped 60 and the phone continued to ring indicating more reports of damage, local contractors were contacted to assist with the response. Four local contractors were contacted to assist with the response including three contractors under pre-existing contracts for assistance with emergency repairs. Leak repair crews were deployed and treatment plant flows were increased. Treated water production sustained 38 MGD or nearly twice the normal demands expected in the system. All efforts focused on maintaining system pressures and feeding the leaks to protect drinking water quality, avoid depressurization and potential backflow into the system.

Napa staff ordered fuel tanks for the Corporate Yard to avoid the need for refueling response vehicles at public gas stations. Other staff were assigned to build potable water stations and install them at hydrants in public parks for customers while repairs were made and service reinstated. Staff ordered hundreds of sets of repair kits including clamps, restraining joints, and pipe segments to increase inventory that would quickly be diminished.

CalWARN is the California Water/Wastewater Agency Response Network, a mutual aid and assistance agreement designed to help jurisdictions respond to incidents that require resources beyond the capability of the local utility [3]. The CalWARN Agreement identifies the administration of the program, describes how to request assistance, and describes response coordination and cost reimbursement. CalWARN members reached out to Napa water management staff within one hour of the event. Amongst prioritization of the initial response and upon receipt of damage assessment reports Napa requested five (5) Type III water distribution system repair teams that are fully equipped with heavy equipment, materials, and skilled labor to assist with the response. Napa prepared to receive and deploy the mutual aid teams including preparation of information packets including maps of staging and deployment locations, emergency incident (hospital) response centers, repair sites, as well as food, lodging, shuttles, fuel cards, and contact phone numbers. CalWARN crews were scheduled to arrive at 1100 on Day 2 after the incident, August 25, 2014. In addition to CalWARN, local municipalities within the County of Napa have pre-existing contracts to provide mutual aid services and after confirming their system status was normal, offered assistance.

Napa water management communicated with the State Division of Drinking Water (DDW) daily to discuss status. DDW was preparing to issue a systemwide boil water notice until staff

assured them this was not necessary. Many regions and pressure zones of the system were unaffected by the event and system pressures remained high due to efforts to increase treatment plant production, maintain outward pressure on leaks, and make sure water quality was not compromised. Napa and DDW agreed that communication of a precautionary boil water notice to customers who live within an area that was depressurized to facilitate a water main repair. Napa staff hung individual door tags to notify customers when the 48-hour bacteriological analyses confirmed the water is safe.

Day 2

At the start of Day 2 of the event, 10 leaks were repaired, and 90 leaks were confirmed in need of repair. Organization and deployment of mutual aid is critical to an effective operation. Napa water managers quickly established that Napa crews would be most effective as facilitators of system locations, system operations including closing valves and insuring leaks are properly isolated, keeping a steady supply of repair parts as appropriate according to the existing pipe material and size, advising as to local knowledge of pipe alignment and depth, and documenting the number of customer services that were within the shutdown area so they can be notified of the end of the precautionary boil water notice.

Contractors were organized by existing staff to assist with traffic control, haul materials to the site for backfill, haul spoils from the site or haul trench plates to the site as a temporary measure to secure the roadway. Napa staff and local mutual aid crews were directed to perform flushing operations, take water quality samples to the water treatment plant laboratory for bacteriological testing. By organizing the outside assistance in concert with the knowledge of Napa staff, CalWARN repair crews were able to stay focused on excavating and repairing leaks while the forward team prepared the site prior to arrival and the follow-up teams completed the site restoration and sample confirmation. Figure 3 shows the workflow and responsibilities of the teams.

As is commonplace for all emergency response actions where reimbursement funding is sought, documentation of work performed is vital. All crews logged their time, job locations, materials and vehicles used in their efforts. Timesheets were set up at the start of each work day and secured at the end of each work day with each individual signing in and out with a timed log.

Day 3

At the start of the third day there were a total of 120 leaks confirmed and two additional CalWARN Type III water distribution repair teams were ordered to join the effort. By the end of Day 3 the treatment plant production had reduced from 38 MGD to 29 MGD and it was apparent that the distribution was starting to return to normal even though 14 additional new leaks were reported that day. In many locations one leak would be repaired, and nearly backfilled, only to identify another leak just fifteen to fifty feet away within the same segment of pipe that was depressurized to facilitate repairs. In one western area of town there were 17 breaks within just a few city blocks. Nonetheless
the goal was set to release CalWARN and Mutual Aid crews by Day 6, Friday, and the start of the Labor Day holiday weekend.

Days 4-6

Production of leak repairs continued in a coordinated manner and CalWARN and mutual aid crews were sent home on Friday. By the end of day six over 120 leaks were repaired with just a few additional distribution leaks continuing to show through the weekend. The on-call customer service workers were busy for several additional weeks responding to customer calls for shut-offs and turn-ons so customers could repair private service lines. The system returned to normal customer demands

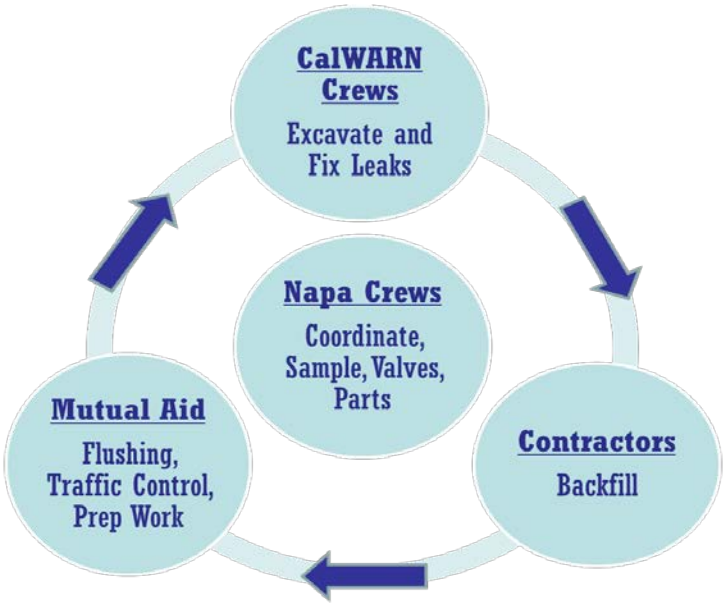

Figure 3. Sequence of Work and Responsibility of Napa Staff and Mutual Aid [1].

of 20 MGD. All samples proved safe and passed the bacteriological testing, proving the pre-cautionary notice was just that, pre-cautionary.

CONCLUSION

Throughout the response period several important lessons were learned. First and foremost, there is no substitute for preparedness. Each event will be unique in nature. Protocols in place for staff to report to work after securing their homes and families, and establishment of an Emergency Operations Center saves valuable time in the wake of uncertainty. Pre-existing contracts for mutual aid and the highly responsive network of CalWARN was very important to make the response as expedient as possible and reinstate water service to customers. Preparation to receive mutual assistance requires significant logistics to provide food, lodging and local transportation for the crews that have traveled to provide assistance. Administrative processes need to be in place to insure documentation of aid received including labor, materials, vehicles and all resources consumed, as well as photo documentation of the work performed.

Damage assessment in the initial hours after the event is critical to organizing the level of required response. Channeling customer calls to one appropriately sized call center, documenting the information in one central database, and gathering sufficient information from the customer is important to identify duplicate reports of leak locations. Documenting the address, logging the time

the call was received, time repair crews dispatched to make the repair, identification of property damage, and time repair completed is critical to prioritize response efforts. Napa staff worked 24-hour shifts to receive calls and to field verify the information reported from customers. Assigning field verification staff to geographic regions is key to efficient reporting and confirmation of status.

Logistics of the production process was greatly assisted by mapping repair sites in order to identify staging areas for backfill material and dump locations for asphalt and trench spoils to reduce travel time and prioritize system repairs. Communication protocols are critical to every emergency situation. A central clearing house for reports from the field populated in databases and maps insure continuity across shift changes and accessible, reliable data to decision makers. Communication of accurate information to regulators and other emergency responders allow the proper identification of need and allocation of resources for an organized and effective response. Control of information released to the media and the public insure confidence. Napa established press conferences twice daily to report on work completed and outstanding.

This report focused on the immediate response to the South Napa Earthquake and the initial impacts to the water system. Fortunately, the damage was limited to the pipe network, predominantly on the west side of the system as well as one storage tank while the supply sources (dams) and treatment plants were not compromised by the seismic event. However, during the six months following the event, the water system experienced an additional 120 breaks through the period. Repairs were performed by Napa staff with no outside assistance. Approximately ten weeks after the initial event, the 36-inch asbestos cement transmission main developed three simultaneous leaks at concrete collars joining pipe segments compromising the flow of water to isolated regions where only local distribution pipes were available to convey reduced volumes to customers. The repairs were made with the assistance of local contractors to restore normal service.

In the end, customers were understanding of the event, appreciative of the coordinated response, and patient while they recovered from the event. Napa staff learned a lot through the event and found that the professional water network and community really comes together in time of need.

ACKNOWLEDGEMENTS

The City of Napa Water Division is grateful for the immediate responsiveness, support and assistance from the following groups: contractors - Atlas Peak, GD Nielson, Hess, Northern Pacific, Commercial Power Sweep, the Barricade Company and V. Dolan Trucking; CalWARN - leaders Steve Dennis and Ray Riordan, leaders, managers and hard-working crews from Alameda County and Contra Costa Water Districts, East Bay Municipal Water District and City of Fairfield; neighboring Cities of American Canyon, Benicia, Calistoga and St Helena, Town of Yountville, Napa County, Napa Sanitation District and North Marin Water District. It was a team effort and the resources available allowed for swift action and minimal downtime for water customers.

REFERENCES

[1] Brun, P. 2014. "*Napa Rocks but... the Water is On*," presented at the 2014 ACWA Winter Conference.

[2] American Waterworks Association, "2016 Benchmarking survey: Leaks, efficiency, costs," February 2017.

[3] Articles of Agreement California Water/Wastewater Agency Response Network WARN 2007 Omnibus Mutual Assistance Agreement, September 2007.