Los Angeles Water System Seismic Resilience Program

Los Angeles Department of Water and Power
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Water System Resilience Program Manager

EERI 2016 Annual Meeting
April 7, 2016
Lifelines – Approaches to Mitigation
Resilience by Design

- Mayor Garcetti
- Dr. Lucy Jones, USGS
  - Mayor’s Science Advisor for Seismic Safety
- Address vulnerabilities in
  - Old buildings
  - **Water System**
  - Telecommunications
- Announced December 8, 2014
Water System Resilience Program

- LADWP Summary Report
  - Water System Seismic Resilience and Sustainability Program
  - Comprehensively integrates into all aspects of water system business
  - Continuous improvement, building upon 100 years of effort

- Resilience by Design - Fortify Our Water System
  - Water for fire fighters, protect against cascading fire hazards
  - Protected fault crossings for the aqueducts
  - Less dependence on imported water
  - Seismic resistant pipes
  - Resilience By Design Program

http://www.lamayor.org/earthquake
LADWP OVERVIEW

- Largest Municipal Utility in USA
- Founded 1902
- Serves 4-million people
  - 712,000 water service connections
- 1214-square kilometer (465 sq mile) service area
- 678 billion liter (179 billion gallon) annual water sales
- Receives water from:
  - 4 aqueducts
  - Local wells
- LADWP owns and operates the water and power systems
Water System Seismic Resilience

• A seismically resilient water system is designed and constructed to accommodate earthquake damage with ability to continue providing services or limit service outage times tolerable for community recovery efforts.

• We cannot prevent damage! This is too costly & takes too long
• We must modify the system to provide water to the community when they need it. Which requires knowledge of:
  • Water needs over the recovery time
  • Seismic hazards and potential impacts
• Resilience Management requires new tools to handle large and complicated geographically distributed systems exposed to many different seismic hazards posing different risks to the loss of services and ability to restore them following an earthquake
  • Working with engineers, researchers and scientists to develop the tools
WATER SUBSYSTEMS

Water System is made up of multiple subsystems having their own characteristics.

<table>
<thead>
<tr>
<th>Subsystems</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Water Supply Systems</td>
<td>Systems providing raw water for local storage or treatment including local catchment, groundwater, rivers, natural and manmade lakes and reservoirs, aqueducts.</td>
</tr>
<tr>
<td>Treatment Systems</td>
<td>Systems for treating and disinfecting water to make it potable for safe use by customers.</td>
</tr>
<tr>
<td>Transmission Systems</td>
<td>Systems for conveying raw or treated water. Raw water transmission systems convey water from a local supply or storage source to a treatment point. Treated water transmission systems, often referred to as trunk line systems, convey water from a treatment or potable storage point to a distribution area.</td>
</tr>
<tr>
<td>Distribution Systems</td>
<td>Networks for distributing water to domestic, commercial, business, industrial, and other customers.</td>
</tr>
</tbody>
</table>

Each subsystem is critical to providing services.
Los Angeles Department of Water and Power

Supply

Transmission

Distribution

Roscoe Blvd. Area

<table>
<thead>
<tr>
<th>Size</th>
<th>Length</th>
</tr>
</thead>
<tbody>
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<td>4</td>
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</tr>
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<td>20</td>
<td>3464</td>
</tr>
</tbody>
</table>
## WATER SYSTEM SERVICE CATEGORIES

Water System resilience is dependent upon the amount of service losses suffered and time to reestablish.

<table>
<thead>
<tr>
<th>Service Categories</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Water Delivery</td>
<td>Able to distribute water to customers, but the water delivered may not meet water quality standards (requires water purification notice), post-disaster volumes (requires water rationing), fire flow requirements (impacting fire fighting capabilities), or pre-disaster functionality (inhibiting system operations).</td>
</tr>
<tr>
<td>Quality</td>
<td>Water to customers meets health standards (water purification notices removed). This includes minimum pressure requirements.</td>
</tr>
<tr>
<td>Quantity</td>
<td>Water flow to customers meets pre-event volumes (water rationing removed).</td>
</tr>
<tr>
<td>Fire Protection</td>
<td>Able to provide pressure and flow of suitable magnitude and duration to fight fires.</td>
</tr>
<tr>
<td>Functionality</td>
<td>The system functions are performed at pre-event reliability, including pressure (operational constraints resulting from the disaster have been removed/resolved).</td>
</tr>
</tbody>
</table>

- Does water come out of tap?  
- Is it safe to Drink?  
- Can you get the amount you need?  
- Does Fire Dept. get what they need?  
- Is the water system in working order?
Water Accessibility Services

- **Accessibility Services**: the provision of water to customers through alternate sources or locations when the network is unable to provide normal services

- **Example A**: Providing prepackaged water while potable water cannot be provided through the network

- **Example B**: Aiding the Fire Department with alternate sources when water cannot be delivered through the network
LADWP
Resilience Program
Implementation
Aqueducts Importing Water

~88% of LA’s water crosses the San Andreas Fault

- All major aqueducts cross the San Andreas Fault
- Water Supply Task Force
  - Los Angeles Department of Water and Power
  - Metropolitan Water District of Southern California
  - California Department of Water Resources
- Post-event coordinated response and restoration
- Evaluate and mitigate aqueducts
  - Individually
  - As a regional system
Los Angeles Aqueduct SAF Crossing

- Risk Reduction solutions
  - Ductile pipe to allow water flow after fault rupture in event of low probability small rupture at this location

- Investigating Engineering Solutions for Maximum Expected Movements
  - Requires extensive investigations
  - Expensive solutions
  - May take a long-time to implement
  - Need to consider as part of larger system with California Aqueduct and CRA
Resilient Pipe Network

- The ultimate goal would be to replace all pipes in the City with seismic resistant pipes
- Begin with most strategic locations
- Develop funding/implementation plan

New Approach for distributing water to customers within a pressure zone

Kubota Corporation Earthquake Resistant Ductile Iron Pipe
Seismic Resilient Pipe Network

• Seismic Resilient Network
  • Designed and constructed to accommodate damage with ability to continue providing water or limit water outage times tolerable to community recovery efforts

• Identify Seismic Resistant Pipes

• Identify Seismic Hazard Areas

• Water System Resilient Strategies
  • Prevent damage
  • Post-event pipe repair, limit damage level
  • Redundancy
  • Isolation

• Responsibility to Community Resilience
  • Provide water to critical areas when needed by community for disaster recovery
  • Resilient arterial sub-network made of seismically robust pipes
  • Integrate with on-going asset management and pipe replacement programs
NEXT GENERATION HAZARD-RESILIENT PIPELINES

Wall Street Journal Photo
Pipe Materials - Future Opportunities

**Steel Pipes**

- JFE Steel Pipe for Fault Crossings

**In-Situ Linings**

- Collapsed Can Linings

- In-Situ Form

Specialized Design
- e.g. SFPUC
- Hayward Fault Crossing
NEXT GENERATION HAZARD-RESILIENT PIPELINES
LARGE-SCALE TESTING: NEXT GENERATION INFRASTRUCTURE
DEFORMABLE DUCTILE IRON JOINTS
ORIENTED POLYVINYL CHLORIDE (PVCO) JOINTS

Spigot Compressed into Bell
CONTROLLED BUCKLING
• Paradigm Shift in Pipeline Technology
• Market-Driven Research Funded by Industry
• Can’t Have Resilience Unless You Have a Market
• Next Generation Hazard-Resilient Pipeline Simulation Models
ERDIP Installation Sites

• Foothill Trunk Line (54” dia)
  • Crossing 1971 fault rupture
• 5 Pilot Project Sites [150mm (6”) to 300mm (12”) dia]
  • Contour Drive, East Valley District
  • Reseda Blvd., West Valley District
  • Temple Street, Central District
  • Western District
  • 94th Street, Harbor District
Fire Fighting Water Supply

- Work with Fire Department
  - Fire hazard areas
  - Alternate water sources
  - Distances they can relay water with their equipment
- Seismically robust pipe grid, as part of earthquake resilient pipe network
- Use reclaimed water network to help fight fires
  - Use earthquake resistant pipes
Plan to Improve the Water System for Managing the Fire Following Earthquake Risks

I. A long-term plan for developing a resilient water system for firefighting.

II. An emergency firefighting water supply plan.

(Water Accessibility Services)
Water Service Loss from ShakeOut Scenario

- Could have significant losses if ignitions lead to conflagrations in water outage areas
- ShakeOut Scenario predicts significant social impacts from FFE
- Goal: keep water loss from creating a catastrophe and economic recession/depression

Goal: provide greater fire fighting water supply reliability within existing network

Modeled performance of existing LADWP network
FFE Planning
FFE Risk Assessment

• Hazard Assessment
  • Building damage
  • Natural Gas System
  • Electric Power System
  • Flammable products, etc.
  • Urban-wildland interface
  • Wind

• Vulnerability Assessment
  • Earthquake effects on water system hydraulics and ability to meet fire protection services

• Consequence Assessment
  • Critical facilities and locations
  • Emergency refuge and operation centers
  • High potential for loss of life
  • Economic, financial, political centers
  • Dangerous chemicals and fuels
DON'T UNDERESTIMATE THE COMMUNITY INTEREST IN MOVING TOWARD MORE RESILIENT INFRASTRUCTURE NETWORKS

Los Angeles Tests Water Pipes That Stand Up to Quakes

By Hanshaw Kapp

Los Angeles has a come up with a strategy to prepare for the Big One—earthquake-proof water pipes made only in Japan. The Los Angeles Department of Water and Power recently finished installing a test batch of about 2,000 feet of a special kind of iron piping in the San Fernando Valley.

The piping, made by Japan's Kobetsu Co., was designed to withstand ground deformation, has endured 40 years of earthquakes in Japan—including the 8.0-magnitude Tohoku earthquake that struck in 2011, triggering a tsunami.

Unlike traditional water pipes, these so-called ductile iron pipes are able to withstand quakes because they can bend and flex instead of buckling under pressure. The system is engineered to work like a chain, meaning it doesn't break apart even if its various components are moving.

LADWP supervising engineer Craig Davis learned about the pipes in 2003 and negotiated to import some for the Los Angeles pilot project shortly after the 2011 quake. Mr. Davis, who was a water agency in San Francisco, Portland and Seattle have contacted him, expressing interest in similar projects. "We're just learning about it—and it's really only recently that you could identify this pipe system as earthquake-resistant," said Mr. Davis, who sent his chief work-cow trainer to Japan last year and has two Japanese reps on site supervising the Los Angeles installation.

Engineer Craig Davis is overseeing a test of Japanese-made earthquake-resistant water pipes in Los Angeles.

Los Angeles officials are trying to help Kobetsu find a manufacturing partner in the U.S. The Los Angeles Aqueduct, which channels water to Southern California residents from the Sierra Nevada more than 200 miles away, was built a century ago, and the city has worked to replace and retrofit the system's oldest cast-iron pipes in recent years. LADWP said it has installed 2,200 miles of new pipe since 1963 and replaced 105 miles of pipe since 2006.

But work crews have struggled to keep pace with worsening main bursts throughout the city. Engineers say bursts may have intensified since rules went into effect limiting outdoor water watering to certain times during the week, meaning more people are watering at the same time, causing increased pressure.

The Japanese quake-proof piping has endured forces like shaking, landslides and extreme temperature swings because it can expand, contract and bend without leaking or pulling apart, said Thomas O'Rourke, an engineering professor at Cornell University who studies such pipes. The flexible joints are still strong enough when they lock up to allow a heavy load of water to flow through the piping.

While some U.S. manufacturers also produce ductile iron pipe, those varieties haven't been designed with quakes in mind, nor have they been tested through nearly as many temblors as in Japan, Mr. O'Rourke said.

Meanwhile, the LADWP is adopting a different kind of plastic-piping technology used in New Zealand to protect Los Angeles's water supply as it crosses the San Andreas fault through a tunnel on its way to the city. Although continuous plastic pipes couldn't be easily integrated into most of the city's cast-iron distribution system, the agency plans to route water through one long tube just as it passes through the Elizabeth Tunnel, which could easily stay during a major quake. Construction is slated to begin in the fall on the $4 million project.