A number of major water supply programs have recently been undertaken to achieve water supply network resilience in the face of major earthquakes...This session includes a panel that integrates discussion of these issues across all the programs.
ASSURING SEISMIC RESILIENCE FOR THE LOS ANGELES WATER SYSTEM

C. Davis

1Water System Chief Resilience Officer and Resilience Program Manager, Los Angeles Department of Water and Power

Thursday, June 28
Water System Resilience Program

LADWP Summary Report (Sept. 2014)
  ◦ 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
  ◦ Seismic resistant pipes
  ◦ Protected fault crossings for the aqueducts
  ◦ Less dependence on imported water
  ◦ Water for fire fighters, protect against cascading fire hazards

Resilient Los Angeles (March 2018)
  ◦ Expanding program to include 53 actions in 15 goals

Focus on Extreme Events and Stressors
  ◦ Initial focus on earthquakes and fire
  ◦ Incorporating other events and stressors over time
Resilient Water System

A resilient water system is designed and constructed:
◦ to accommodate hazard-related damage with ability to continue providing services or;
◦ limit service outage times tolerable for community recovery efforts.

Resilience Management

Program Manager

Resilience Expert Panel
◦ Expert external advisors for Resilience Program
  ◦ Professor Thomas O’Rourke, Cornell University
  ◦ Dr. Kenneth Hudnut, USGS
  ◦ Professor Charles Scawthorn, U.C. Berkeley

Coordinate with LA City Chief Resilience Officer and other agencies
## 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>
<th>Description</th>
<th>Does water come out of tap?</th>
<th>Is it safe to Drink?</th>
<th>Can you get the amount you need?</th>
<th>Does Fire Dept. get what they need?</th>
<th>Is the water system in working order?</th>
</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), pre-disaster volumes (requires water rationing), fire flow requirements (impacting fire fighting capabilities), or pre-disaster functionality (inhibiting system operations).</td>
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<tr>
<td>Quality</td>
<td>Water to customers meets health standards (water purification notices removed). This includes minimum pressure requirements.</td>
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<tr>
<td>Quantity</td>
<td>Water flow to customers meets pre-event volumes (water rationing removed).</td>
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<tr>
<td>Fire Protection</td>
<td>Able to provide pressure and flow of suitable magnitude and duration to fight fires.</td>
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<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>
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</table>
1994 Northridge EQ Restorations
Resilient Water Supply

Seismic Resilience Water Supply Task Force

- Los Angeles Department of Water and Power
- Metropolitan Water District of Southern California
- California Department of Water Resources

5-year Action Plan

- Coordinate emergency response
- Seismic Assessments for all aqueducts
- Assess power/energy vulnerabilities for Aqueducts
  - Work with Power System, SCE, SCG
- Conduct joint emergency exercises
- Investigating aqueduct inter-ties for emergency use

Strengthen LAA

85% of LA water supply crosses San Andreas Fault
Proposed Seismic Enhancement Project

Potential Collapse Zones

Elizabeth Tunnel

Tunnel Supports Only

San Andreas Fault Zone

Tunnel Supports + Carrier Pipe

Tunnel Supports Only

Power Plant 1

Bouquet Reservoir
Future Water Supply Reliability
Less Dependence on Imported Water

FYE 2010 - 2014 Average
Total: 553,876 AFY

- LA Aqueduct 189,700
  34%
- MWD 293,010
  53%
- Local GW 64,809
  12%
- Recycled Water 7,803
  1%

Fiscal Year 2034 - 35
Total: 711,000 AFY

- LA Aqueduct 244,000
  33%
- MWD 168,227
  24%
- Local GW 110,405
  16%
- Recycled Water 59,000
  8%
- Water Transfers 40,000
  6%
- Stormwater Capture 25,000
  4%
- Conservation 64,368
  9%

1,000 AF = 1.233 MCM

*Per 2010 UWMP
Seismic Resilient Pipe Network

Transform the existing water pipe network into a SRPN using seismically robust pipes along strategic alignments in a manner allowing a post-earthquake damaged system to restore the water services meeting defined target performance criteria.

- made up of the entire set of pipes in the transmission and distribution subsystems.
- not defined as only seismically resistant or resilient pipes

Next-Generation (Resilient) Pipelines

**Ductile Iron Pipes**
- Kubota Earthquake Resistant Ductile Iron Pipe
- US Pipe TR-Extreme
- American Ductile Iron Pipe

**Steel Pipes**
- JFE Steel Pipe for Fault Crossings
- Butt Welded Joints

**Plastic Pipes**
- PVC
- HDPE

**In-Situ Linings**
- In-Situ Form

Seismic Resilient Pipe Network
Resilient Pipe Market – Encouraging Competition

Leading the way in developing and implementing new pipe products for resilient infrastructure systems

LADWP Pilot Projects
- Evaluate alternative pipe suppliers

Testing
- Manufacturers
- Universities

Guidelines and Standards
- LADWP
- Professional Societies (ASCE, AWWA)
- Water Agencies (MWD, EBMUD, SFPUC, PWB, SPU, etc.)

Large-scale split-box test basin at the Cornell University NEES Equipment Site
Seismic Resilient Pipe Network

Robust pipes placed at key locations and alignments

Transmission pipes provide Average Winter Day to pressure zones

Grid recommended to be defined by:
- LAFD capability to relay water through hoses (considering a maximum ~2-miles by 2-miles).
- High risk areas to meet emergency water distribution needs in residential areas requiring long restoration (considering ~0.5-miles by 0.5 miles)

Connect grid to important system links and critical customers using seismically robust pipes

In high seismic hazard areas, only use seismically robust pipes
- Liquefaction zones
- Fault rupture zones
- Landslide zones

Implementation:
- Pre-identify pipes needing to be seismically robust
- Install seismically robust pipes as part of on-going pipe replacement program
Seismic Resilient Pipe Network

Draft Seismic Resilient Distribution Network

Draft Seismic Resilient Transmission Network
Seismic Resilient Pipe Projects

Foothill Trunk Line Project

- LADWP’s Construction Forces – Open Trench
  Contractor – Jacking

- Approximately 2 miles of 54-inch diameter pipe and 2 miles 12” diameter pipe
- Construction started January 2018

Over 2 miles of distribution pipe is installed

Additional 10 miles of seismic resilient pipe purchased for installation with some under construction

Adding much more to develop the resilient network
Fire Fighting Water Supply

Work with Fire Department
- Fire hazard areas
- Alternate water sources
- Distances they can relay water with their equipment

Earthquake Resistant pipe grid, as part of seismic resilient pipe network

Use recycled water network to help fight fires
- Use earthquake resistant pipes

City-Wide Fire Following Earthquake Risk Assessment

San Francisco, 1906

Los Angeles, 1994
Thank you

QUESTIONS ?