Metropolitan Water District’s Seismic Resilience Strategy

John E. Shamma

Facility Planning Unit Manager
Metropolitan Water District of Southern California
Metropolitan Water District of Southern California

Regional water wholesaler
26 Member Agencies
6 counties
Serving approximately 19 million residents
5,200 square mile service area
$1 trillion economy
Sources of Imported Water for Southern California
The Metropolitan Water District of Southern California

Owns and Operates

- 5 Regional Water Treatment Plants
- 16 Hydroelectric Plants
- 9 Water Reservoirs
- 7 Pumping Plants and 12 PCS

Conveyance and Distribution System

- Distributes untreated and treated water throughout Southern California
- Consists of approximately 1,100 miles of Aqueducts, Pipelines, and Tunnels
Susceptible to:
- Fault rupture
- Ground failure
- Shaking damage

Major Earthquake Faults and Metropolitan’s System

- California Aqueduct
  - West Branch
  - East Branch
- Los Angeles Aqueduct
- Colorado River Aqueduct
- Santa Monica Fault
- Whittier Fault
- Newport-Inglewood Fault
- Elsinore Fault
- San Andreas Fault
- San Jacinto Fault
Development of Seismic Resilience Strategy

Construction of Metropolitan’s system was completed in phases from the 1930’s through the 2000’s

Included few special provisions for seismic events

“It was desirable that faults be crossed at right angles, to minimize damage in the event of movement, and that some flexible type of conduit on or near the surface be used so that if repairs become necessary they will be as simple as may be...”

- Julian B. Hinds, Nov. 24, 1938
Development of Seismic Resilience Strategy

Since the system was completed, overall knowledge of the geology and seismicity within Southern California has greatly increased.

Significant advancements have also occurred in earthquake engineering and design.

- 1933 Long Beach Earthquake
- 1971 San Fernando Earthquake
- 1994 Northridge Earthquake
- 2011 Christchurch Earthquake
Metropolitan’s Multi-faceted Approach to Seismic Resilience

Over the last several decades, Metropolitan has proactively improved the seismic resilience of individual facilities and the entire conveyance system through a multi-faceted approach that consists of the following key components:

- Planning
- Engineering and Infrastructure Upgrades
- Operations and Emergency Response
- Partnerships
Metropolitan’s Multi-faceted Approach to Seismic Resilience

- Planning
  - Engineering and Infrastructure Upgrades
  - Operations and Emergency Response
  - Partnerships
Multi-faceted Approach
Planning

Increased emergency water storage in Southern California

- Constructed DVL
  - Nearly doubled the surface storage capacity in Southern California
  - Constructed on coastal side of major faults
  - Can directly supply 4 of 5 treatment plants
Multi-faceted Approach Planning

- Maintains enough emergency storage to withstand a six-month loss of imported supply to the region.
- DVL with local production, storage & conservation, can provide 6 months of emergency supply.
- Emergency storage requirements are reviewed periodically.
Multi-faceted Approach Planning

Support the California WaterFix which will reduce the seismic risk to SWP supplies from a major earthquake in the Delta region.
Metropolitan’s Multi-faceted Approach to Seismic Resilience

- Planning
- Engineering and Infrastructure Upgrades
  - Completed Projects
  - Future Projects
  - Innovation
- Operations and Emergency Response
- Partnerships
Multi-faceted Approach
Engineering & Infrastructure Upgrades

- Metropolitan established an ongoing seismic assessment and upgrade effort
  - Periodically reassess the seismic risk to infrastructure
  - Addresses key vulnerabilities

- Facility Assessments
  - Prioritized based on importance to water deliveries
  - Recurring basis
  - Goal is to have the ability to withstand a major earthquake

- Assessments are based on:
  - Most recent seismic codes
  - Site-specific geotechnical information
  - Most up-to-date earthquake magnitude projections

- In addition Metropolitan considers seismic risk in all refurbishment and replacement projects (R&R projects)
Metropolitan’s Multi-faceted Approach to Seismic Resilience

- Planning
- Engineering and Infrastructure Upgrades
  - Completed Projects
  - Future Projects
  - Innovation
- Operations and Emergency Response
- Partnerships
Multi-faceted Approach
Engineering & Infrastructure Upgrades

Metropolitan has invested over $250M over the past 20 years to upgrade facilities to withstand and continue operating after a major earthquake.
Multi-faceted Approach
Engineering & Infrastructure Upgrades

Most Notable Upgrades:
- CRA pumping plant buildings and penstocks
- Lake Mathews outlet tower
- Water treatment plant seismic upgrades
Metropolitan’s Multi-faceted Approach to Seismic Resilience

- Planning
- Engineering and Infrastructure Upgrades
  - Completed Projects
  - **Future Projects**
  - Innovation
- Operations and Emergency Response
- Partnerships
Multi-faceted Approach
Engineering & Infrastructure Upgrades

Over the next five years, Metropolitan plans to spend an additional $200M on seismic upgrades.
Sepulveda Feeder
Potential Liquefaction Zone

- Hydroelectric Plant & Pressure Control Structure
- Water Tanks
- San Diego Freeway I-405
- Sepulveda Feeder
- Potential Liquefaction Zone
Sepulveda Feeder
Background – PCCP Rehabilitation

- 12-year project to line 42 miles of 96 inch diameter PCCP with steel liner
  - Internal pressure is 360 psi
- At Sepulveda Canyon, 2 barrels of feeder, 2 tanks, & pressure control structure are vulnerable to slope movement & liquefaction at toe of slope
  - Potential shift of up to 1.7 ft downslope
- No bypass line or nearby isolation valves
- Santa Monica Fault & Newport-Inglewood Fault
  - Capable of producing M6.5 to M7.5 earthquake
**Sepulveda Feeder**

**Planned solution**
- Over-excavate & re-compact soil at toe of slope
- Relocate pressure control structure to toe of slope
- Install bypass line with E-R pipe
- Re-purpose or abandon tank closest to slope

**Design is underway** — Construction planned in stages from 2021 to 2023
Second Lower Feeder at the Newport-Inglewood Fault

- Newport-Inglewood Fault
- Limits of Fault Zone
- Second Lower Feeder
- Extent of Liquefiable Soil

Los Angeles River
10-year project to line 28 miles of 78 inch diameter PCCP with steel liner

- Internal pressure is 300 psi

Newport-Inglewood Fault

- Capable of producing M7.5 earthquake
- Potential horizontal rupture up to 16 ft at fault crossing, along with liquefaction

Planned solution

- Replace existing line with 78 inch E-R pipe
- Follow new alignment within fault zone
- Install new pipe in casing under river

Design is underway – Construction planned for 2020
**Casa Loma Siphon**

**Background – Permanent Repair of Leaks**

- CRA crosses Casa Loma Fault in 2 locations
  - Barrel No. 1 was originally concrete pipe, now 148 inch diameter steel pipe with sleeve-type couplings
    - Internal pressure is 21 psi
  - Regional subsidence has caused leaks for decades
  - External couplings are corroded – Internal seals installed as interim measure

- Casa Loma Fault (San Jacinto Fault System)
  - Capable of producing M6.7 earthquake
  - Potential rupture of 1 ft if fault ruptures on its own, or 10 feet if multiple reaches rupture
Planned solution

- Replace Barrel No. 1 with at least 300 ft of E-R pipe
- Two parallel 104 inch diameter lines

Prelim. design is underway – Const. planned for 2020
Diemer Filter Outlet Conduit
Background – Treatment Plant Reliability Project

- Over 12 structures & conduits at Diemer plant strengthened or relocated to meet seismic goals
- Conduit has 450 feet of 121 inch diameter steel pipe that is vulnerable to slope movement
  - Internal pressure is 10 psi
- Whittier Fault
  - Capable of producing M 6.8 earthquake
  - Potential shift of up to 4.5 ft downslope
- Planned Solution
  - Install deep caissons to protect pipe in place
  - Replace line with E-R pipe (future phase)
- Design completed – Construction in 2018
Diemer Filter Outlet Conduit

Deep Caissons to Stabilize Slope

Colluvium
The planned upgrades include voluntary seismic rehabilitation.

Estimated construction contract will range between $30 to $35M.

Estimated construction duration of 3 years.

- Reinforce 82 Beams
- Strengthen Panels
- Rebuild Slab
- Reinforce Columns
- Construct New Walls at Garage

11th National Conference on Earthquake Engineering
June 25 – 29, 2018
Metropolitan’s Multi-faceted Approach to Seismic Resilience

- Planning

Engineering and Infrastructure Upgrades

- Completed Projects
- Future Projects

Innovation

- Operations and Emergency Response
- Partnerships
Earthquake Resistant Ductile Iron Pipe (ERDIP)

- Proprietary technology developed by Kubota Corp.
- Absorbs large displacements & allows pipeline to remain intact, even as individual segments move.
Earthquake Resistant Steel Pipe Test Section (Courtesy of JFE Steel)
Multi-faceted Approach
Engineering & Infrastructure Upgrades

Examples where new innovative solutions are incorporated into planned projects include:

- The Second Lower Feeder PCCP Rehabilitation (at the Newport-Inglewood Fault Crossing)
- The repairs to Casa Loma Siphon No. 1 on the CRA (at the Casa Loma Fault Crossing)
Metropolitan’s Multi-faceted Approach to Seismic Resilience

- Planning
- Engineering and Infrastructure Upgrades
- Operations and Emergency Response
- Partnerships
Multi-faceted Approach
Operations & Emergency Response

- Metropolitan maintains its own manufacturing shop facilities to fabricate and repair equipment and roll steel pipe.
- The capability of these facilities has recently been upgraded substantially in order to expedite urgent repairs.
- Has the ability to repair at least two large diameter pipe breaks simultaneously.
Emergency Response

- Workshops and exercises are conducted regularly, including simulations of major seismic events

- Last year, Metropolitan conducted 75 emergency response exercises, many of them with member agencies and other critical utility partners including SCE, CalOES, DWR and other agencies throughout California
Infrastructure Upgrades & Emergency Response

Ready to go to designs:

- In addition to strengthening of the CRA’s Whitewater Tunnel portal near the San Andreas Fault
- Pre-event design of a bypass tunnel to expedite repairs
- Stockpiling key materials to expedite repairs at the fault crossing

Uplift results in less than 20% reduction in capacity

Damage at Fault Crossing from M7.8 event

- VERTICAL: 1 meter (3 feet)
- HORIZONTAL: 4 meters (12 ¾ feet)

Flow Direction
Metropolitan’s Multi-faceted Approach to Seismic Resilience

- Planning
- Engineering and Infrastructure Upgrades
- Operations and Emergency Response

Partnerships
Multi-faceted Approach
Partnerships

- Seismic Resilience Water Supply Task Force
  - Joint task force with LADWP and DWR
- Goal
  - Enhance the resilience of imported water supplies
Multi-faceted Approach Partnerships

- Enhance the resilience of CRA, SWP, and LA Aqueducts Facilities across the Southern San Andreas Fault

- This multi-agency collaboration seeks to
  - Develop a coordinated emergency response and recovery plan
    - Discuss and develop earthquake response strategies
    - Expedite repairs of imported water supply infrastructure
  - Investigate and develop mitigation options
Multi-faceted Approach Partnerships

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 interties for emergency use

Strengthen Aqueducts

85% of City of LA water supply crosses San Andreas Fault