Lifelines and Utilities

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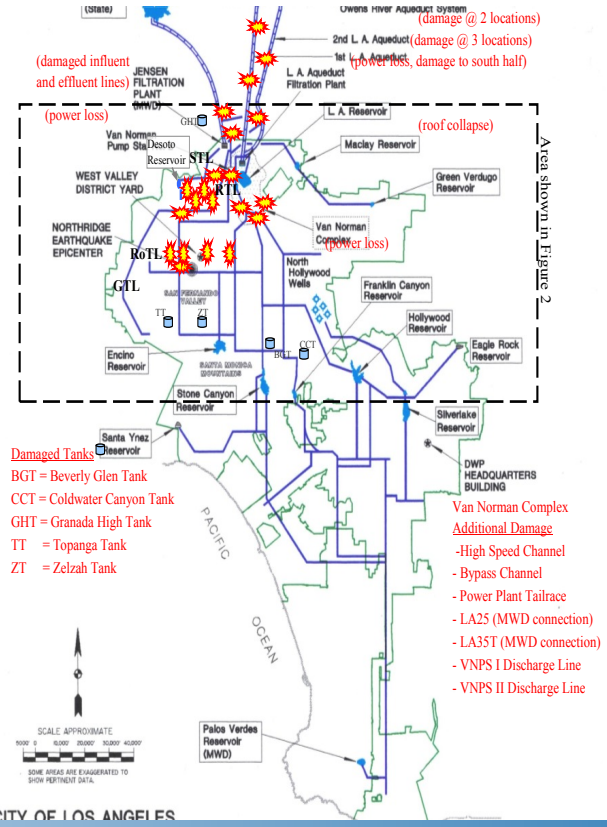
Impacts – Lifelines and Utilities

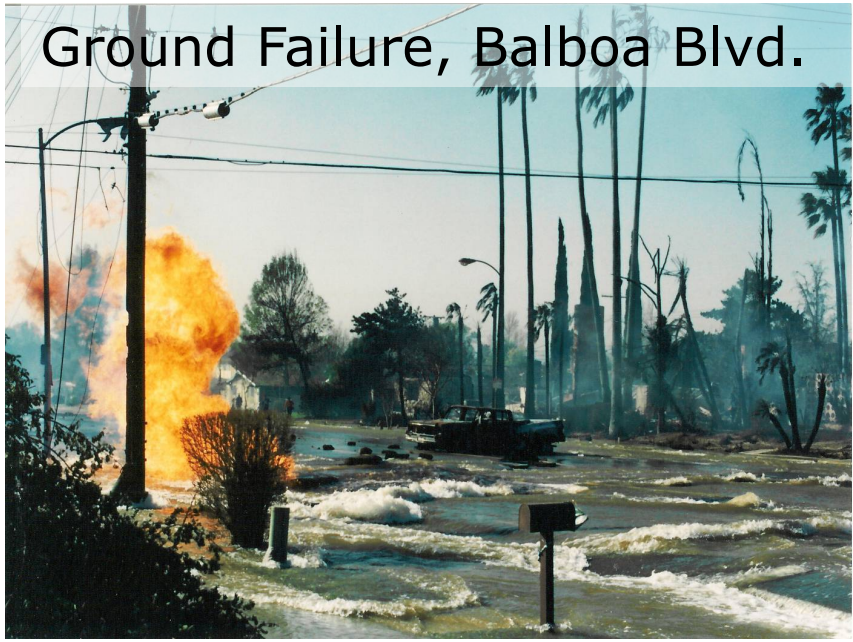
- Overview of:
  - Water
  - Wastewater
  - Gas
  - Electric Power
  - Liquid Fuels
  - Telecommunications
  - Fire Following Earthquake
  - Water Retaining Dams
  - Lifeline Interdependencies and interactions
- Lifeline Damages in the San Fernando, Santa Clarita and Simi Valleys + LA/SM basins

Impacts

- Water Systems
  - Thousands of pipe repairs
  - Damage to Aqueduct and transmission lines
  - Service impacts to ~1Mil people
  - Boil Water notices issued
  - Loss of water to fight fires
  - Services restored within weeks
  - System repair completed in years
- Sewer System
  - Pipe damages
  - Service outages not substantial



Impacts


Ground Failure, Balboa Blvd.

- Natural Gas
  - So. California Gas Company
  - Pipe damages
    - 35 transmission (old lines)
      - 3 fires
    - 154 distribution (steel)
  - All newer pipes performed well
  - 151,000 customers out of service (88% shut off own service)
  - 51 natural gas related fires (private property)
  - 172 mobile homes destroyed by fire (lack of seismic bracing)
  - 82% of customers restored in 2-3 weeks

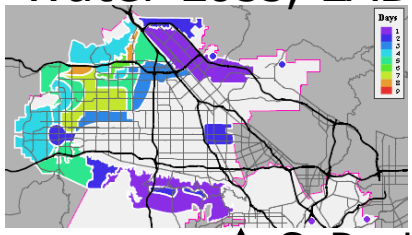
Impacts

- Electric Power
  - LADWP and SCE most impacted
  - Damages to Transmission Towers, Converter & Receiving Stations.
  - Power lost to entire City of LA for 1st time ever
  - LA restored 93% customers in 1.5 days, completed within 2 days
  - SCE had 825,000 customer outages, restored in 20 hours
  - Power Grid impacts resulted in outages across Western USA and Canada

Impacts

- Liquid Fuels
  - 1 older 1925 transmission line damaged
  - New pipelines were undamaged
  - Several oil spills
    - 1 caught fire, damaging cars & homes
- Fire Following Earthquake
  - 110 documented ignitions
  - 80% structure fires
  - Some gas ignition - power resumed
  - Water loss in ignition areas
  - Alt. water needed
    - Swimming pools

Water Loss, LADWP



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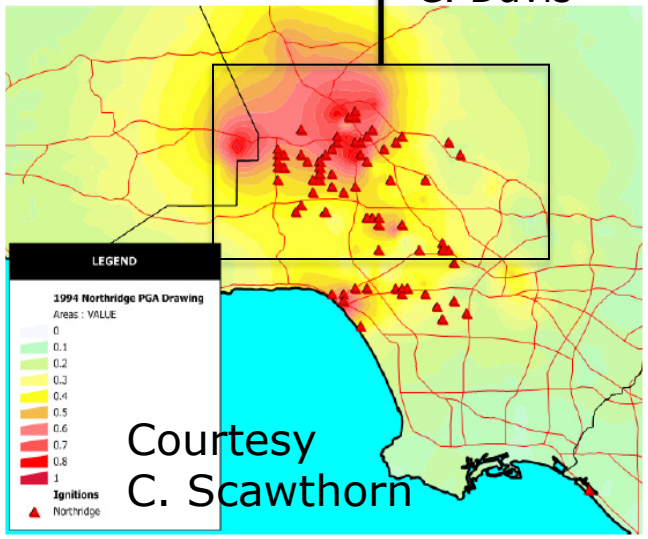
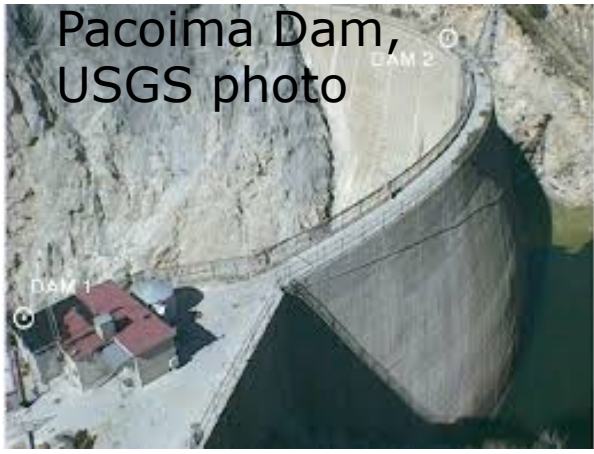


Figure 2.7 1994 Northridge earthquake ignitions overlaid on peak ground accelerations.

Impacts

- Telecommunications (Pac Bell, GTE, AT&T)
  - Performed reasonably well
  - 5 switch failures (3-13.5 hrs outage)
  - 911 worked well
  - Call volume increase 4x, caused delays
  - 35 cell sites down, all restored within 72 hrs.
- Water Retaining Dam Performance
  - Dams performed well
  - No safety related incidents
  - Some required damage repairs

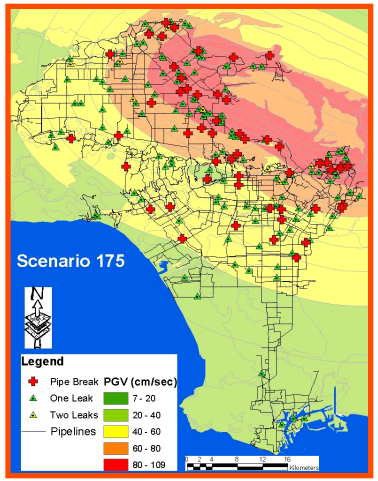
Pacoima Dam



Pacoima Dam, USGS photo

Outcomes 1

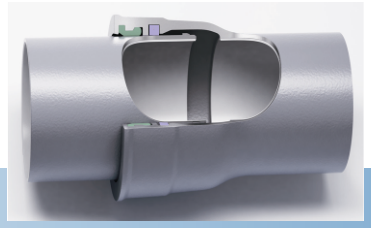
- In 1994 large improvement programs were ongoing/ completed following 1971 San Fernando Earthquake
  - All improvements implemented post-1971 worked
- Billions of $'s spent to improve systems since 1994
  - Hardening, redundancy, dispersion
- Improvements in system modeling and performance prediction (e.g., SERA, GIRAFFE)
- Improved Emergency Response Capabilities
  - NIMS, SIMS
  - Temporary Services
  - Emergency Water
  - Mobile EOC's and Laboratories



- Many organizations implementing ShakeCast and ShakeMap

Outcomes 2

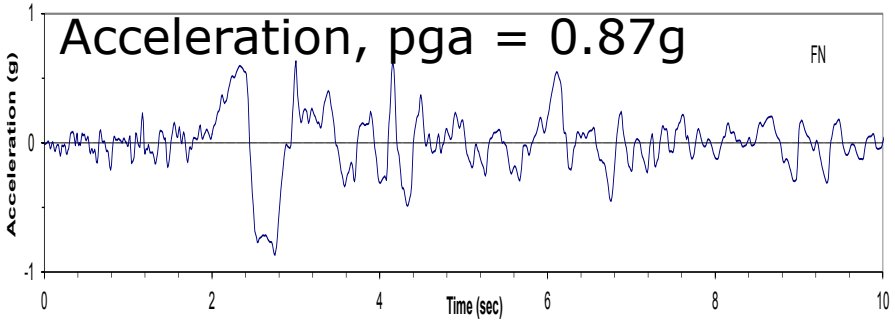
- Increased equipment seismic qualification criteria (IEEE 693), design criteria, inspections
- Maintain spare equipment & material inventory
- ASCE TCLEE – Lifeline Interdependency Committee
- American Lifelines Alliance (1998-2006)
  - Identifies need for lifelines guidance (Guidelines Matrix)
- Water pipe seismic design guidelines
- Improved existing standards incorporating lessons learned
- Installation of Earthquake Resistant Ductile Iron Pipes (ERDIP) for Water

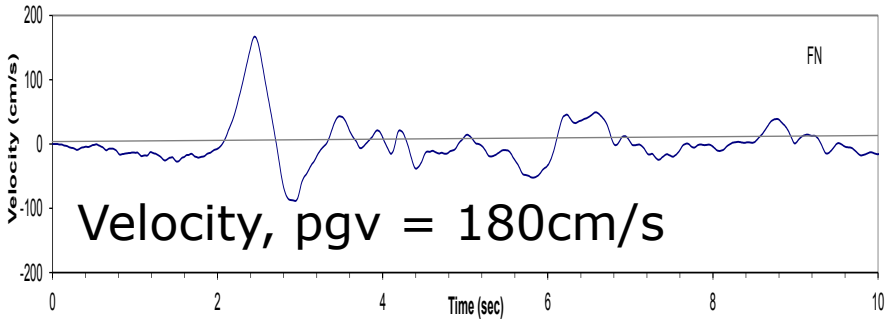


Japanese ERDIP

Outcomes 3

- Equipment and facilities were designed to meet or exceed most standards and codes prior to 1994
- In 1994, LADWP recorded largest ground motions (velocity/ground strain) at the time
- We now know that large directivity pulses can be devastating to lifeline systems and account for this in design criteria



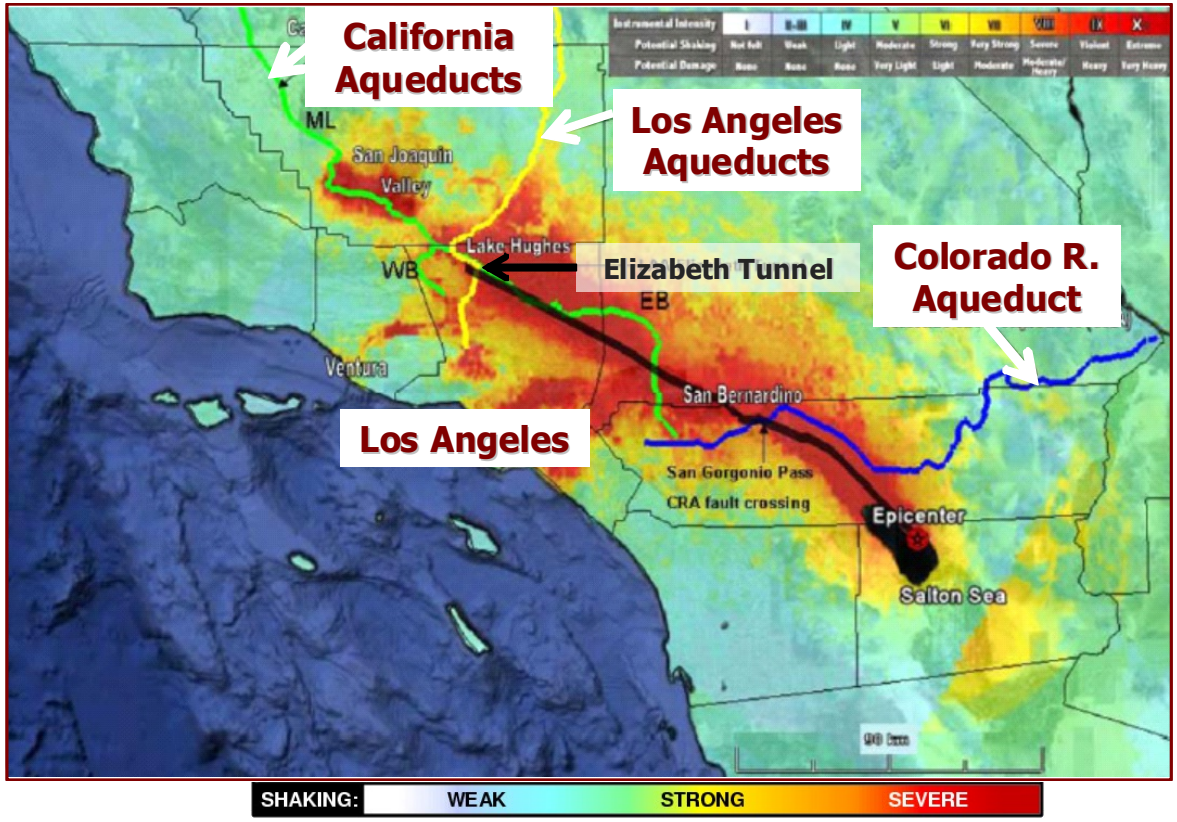


Outcomes 4

- Improved pipeline design across ground failures
- Mobile Homes – gas meter assembly changed to prevent damage when mobile home moves
- City of LA mandates for gas earthquake valves (applies to new or sold homes)
- State requirement to strap water heaters
- Automatic shut-off valves for high pressure gas lines (in place for reasons other than the 1994 Earthquake)

ShakeOut Scenario

Regional M7.8 Earthquake Scenario on San Andreas Fault



Davis & O'Rourke, 2011, "ShakeOut Scenario: Water System Impacts from a Mw7.8 San Andreas Earthquake," *EQS*, 27:2, pp 459-476

Water Supply Results

- Aqueduct flow restoration > 18 mo.
- Insufficient supply
- Severe rationing
- Firefighting impacts
- Some w/o water for 6 months or more
- Greatest economic impact of all
  - >50% total BI
  - >25% total losses
  - >2/3 fire + water

Next Steps and Recommendations for Water Supply Systems

- Southern California Water Supply is too critical to fail, aqueduct water losses for minimum 12 to 18 months is too long!
  - A Water Supply Task Committee (WSTC) needs to be formed by the supply agencies (LADWP, MWD, DWR)
  - The WSTC should coordinate their efforts for
    - identifying water supply vulnerabilities,
    - how to mitigate, and
    - planning for emergency response and recovery

Next Steps and Recommendations for Lifelines and Utilities

- Greater integration of system modeling with participation of critical infrastructure operators is needed.
  - Visualization of results is critical for communicating to decision makers, city councils, and local governments
- Improved assessment of regional economic impacts from lifeline system disruption is needed, especially for interdependencies
  - Initiate research and implementation on utility sector level.
- Consistent lifeline system performance and restoration goals need to be created

Next Steps and Recommendations for Lifelines and Utilities

- An interdisciplinary "council" for addressing potential for post-earthquake ignitions, firefighting capabilities, and firefighting water supply is needed
  - Include all lifeline utility, firefighting, and seismic safety stakeholders
  - Lifelines (gas, liquid fuels, electric power) interact to potentially ignite fires
  - The critical need for post-earthquake firefighting water supply is not being addressed
- Lifeline specific guidelines and standards for community resilience need to be developed
  - Especially for water and wastewater systems

Next Steps and Recommendations for Lifelines and Utilities

- Telecommunication systems need to standardize methods to ensure post-earthquake cell site power
- Maps identifying potential ground displacements need to be prepared and available for all to use
  - Ground Failure causes the greatest lifeline disruption – to all lifeline pipes and cables
- Emergency Action Plans need to be prepared by Dam owners
- Research is needed in the area of dam safety and how utilities interact to make resilient communities
- All Lifelines and utilities need to collaborate in Earthquake Early Warning development and implementation

Next Steps and Recommendations for Lifelines and Utilities

- Southern California has not experienced a regional disaster (e.g., ShakeOut Scenario)
- We all need to learn from recent international earthquake disasters and implement new lessons learned to get better prepared
  - M9.0 Great East Japan Earthquake, 2011
  - M6.2 Christchurch NZ Earthquake, 2011
  - M8.2 Maule Chile Earthquake, 2010
- Earthquakes present continuous learning opportunities and lessons to implement