Simulation of Los Angeles Water Supply and Distribution in Response to M7.8 San Andreas Earthquake

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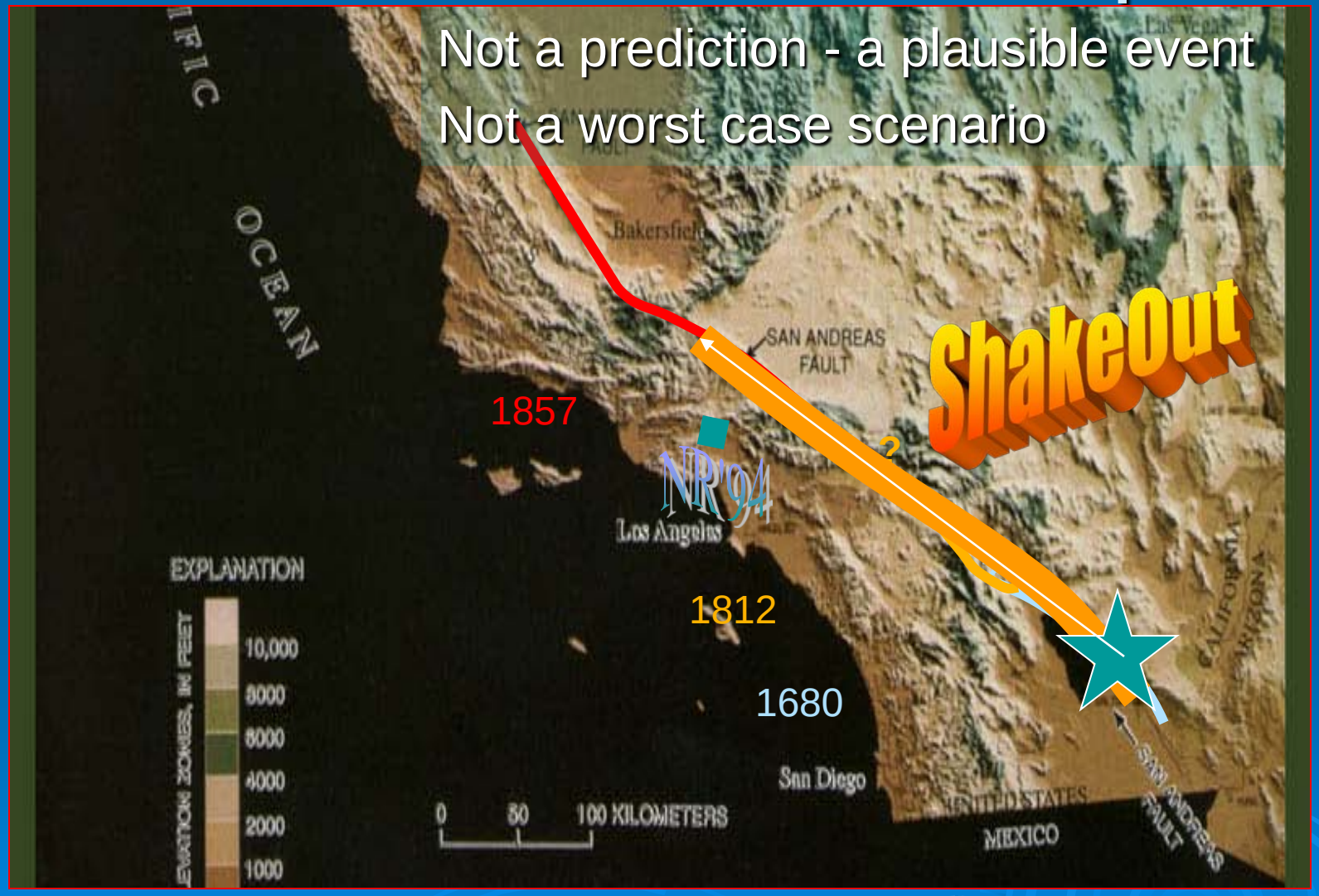
Presentation Outline

- Earthquake Scenario Description
- Regional Water Supply Impacts
- LADWP Water System Impacts

ShakeOut Scenario Earthquake



- Recurrence Interval ~150 years without latest 'open' interval
- Currently, elapsed time of ~ 300 years appears longer than any previous recurrence interval

Supply Transmission

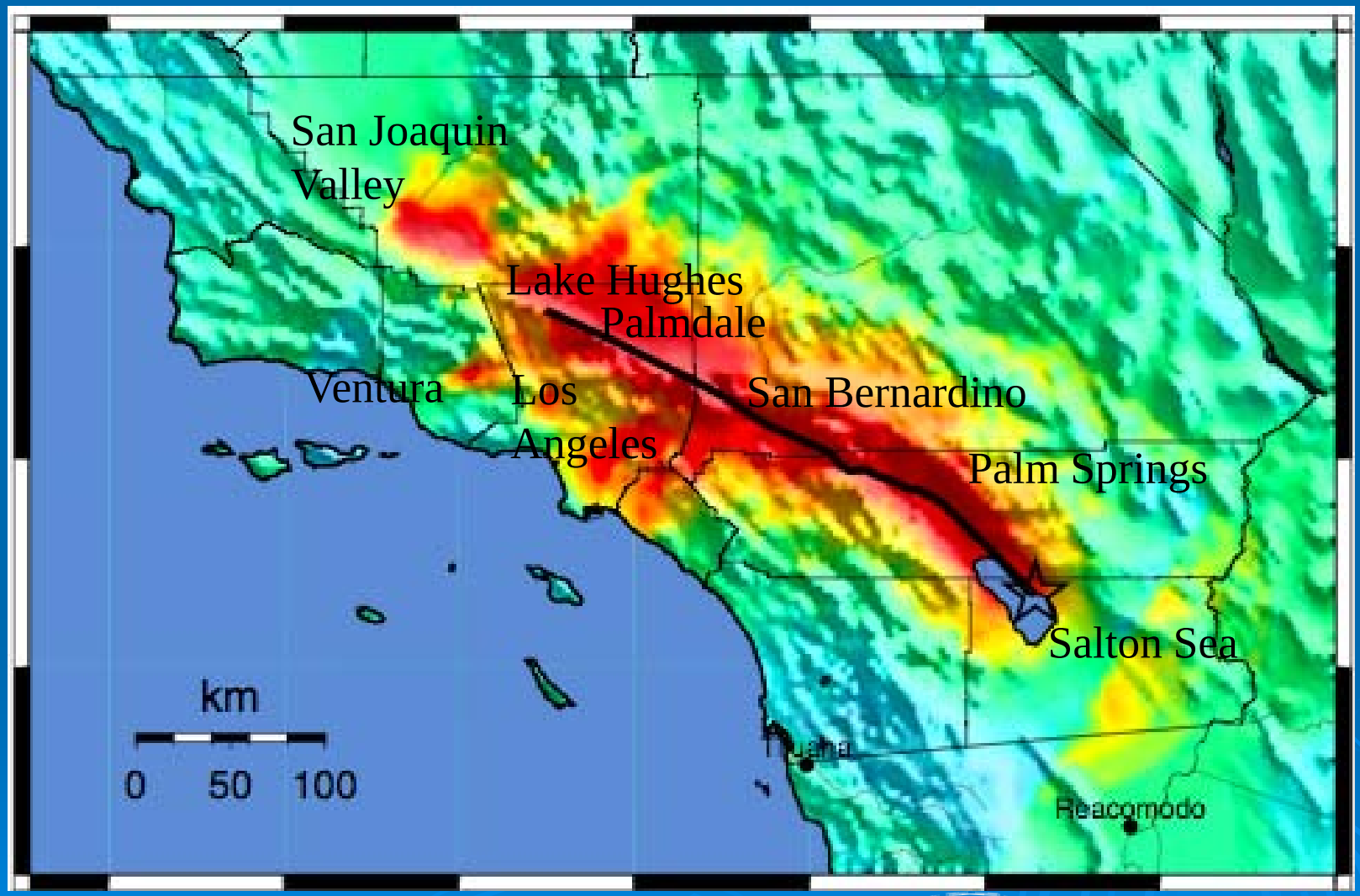
- Aqueducts
- Southern California highly dependant on imported water
  - Population
  - Economy
- 70% domestic supply
- San Andreas Fault Impact

Colorado River Aqueduct

Coachella Canal

All American Canal

Shaking Intensity



Fault Rupture

Los Angeles Aqueducts
3.3 m movement
Elizabeth tunnel (2.9 m dia.)

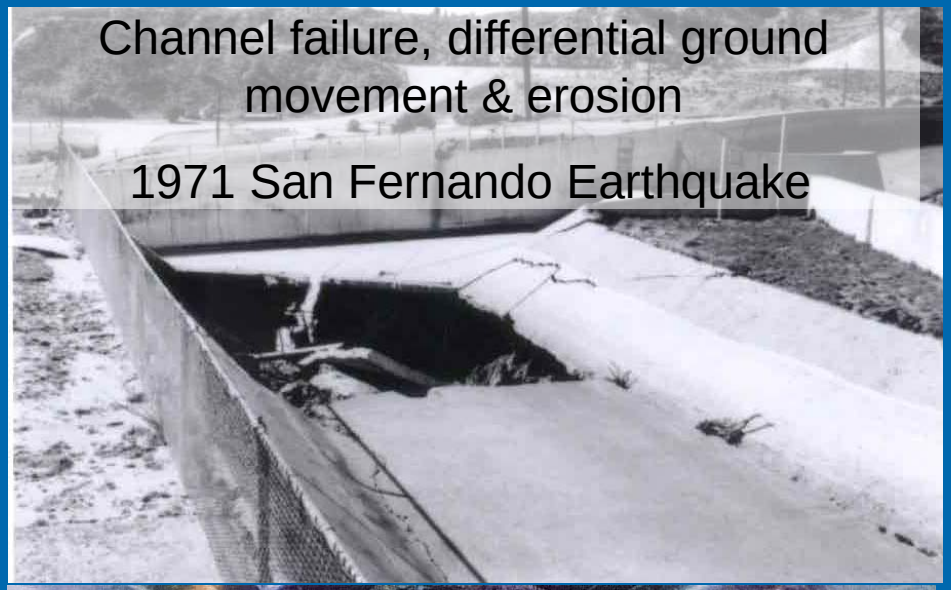
California Aqueduct
East Branch
3 to 5 m movement
Embankment levees,
pipes, tunnels
3+ locations

Colorado River Aqueduct
0.5 to 1.3 m fault slip
4 locations, close proximity
4m+ total uplift
Pipes, Tunnels

Coachella Canal
7 to 9 m movement
3 locations
Levees ruptured

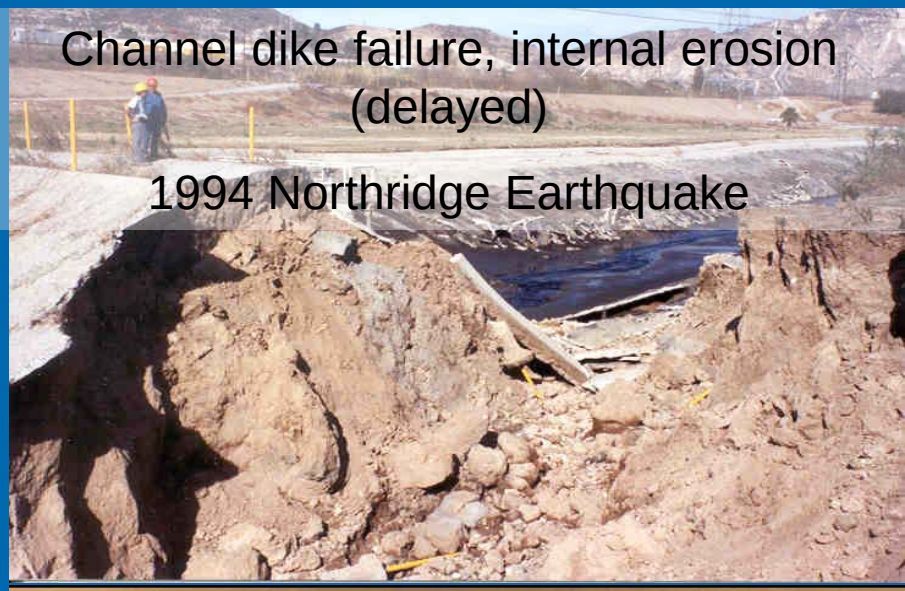
Complete Disruption of Import Water!

Aqueduct Historical Earthquake Damage



Channel failure, differential ground movement & erosion

1971 San Fernando Earthquake



Channel dike failure, internal erosion (delayed)

1994 Northridge Earthquake

Tunnel lining failure

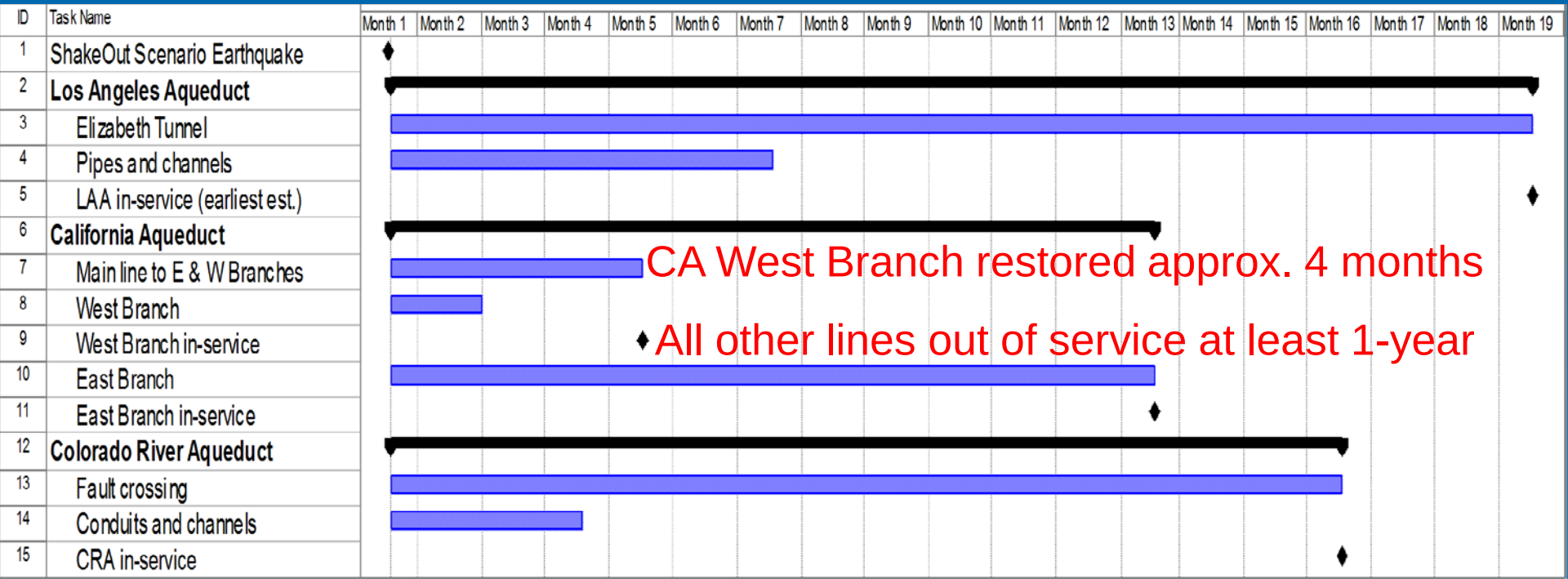
1995 Kobe Japan Earthquake

3 m right-lateral fault movement, 2.2 m diameter pipe

1999 Izmit Turkey Earthquake

Local Storage and Aqueduct Restoration Estimates

- 6 months local storage (MWD, 2005 estimate)
  - Not available to all
  - Severe rationing, 25% minimum
  - Ground water over draft
    - Environmental concerns
- Aqueducts restored 4 to 18 months (minimum)
- Inadequate Supplies!!

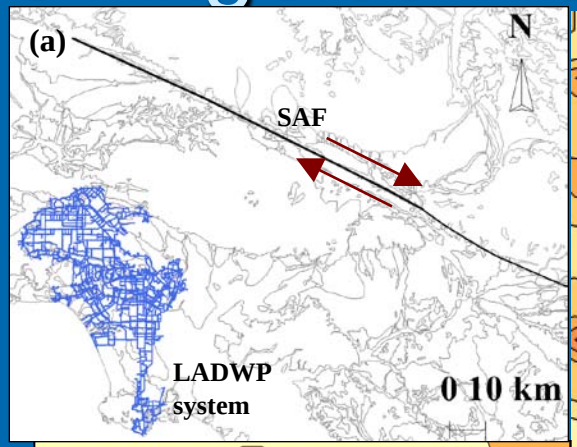


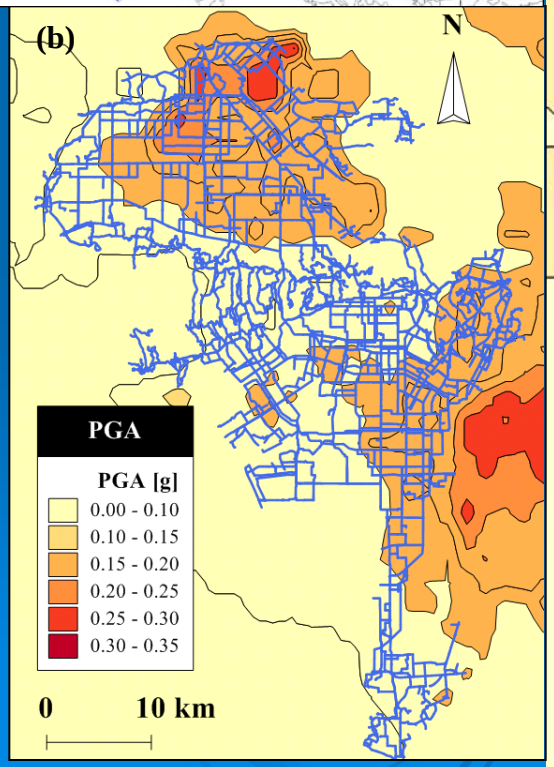
Scenario Response
Los Angeles Water System

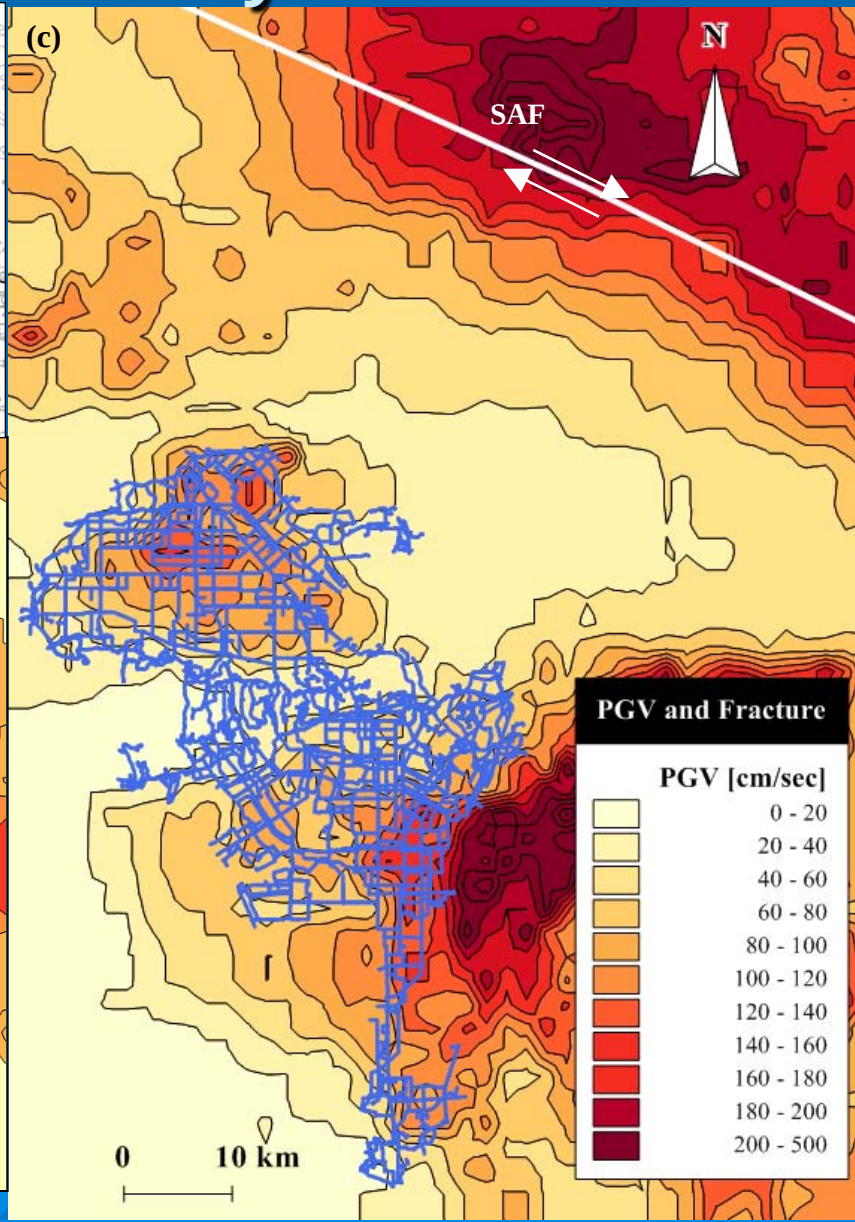
- 50 miles from San Andreas Fault

LA Scenario impacts:

- Large PGV
  - 200 cm/s
- Small PGA
  - 0.3g
- Long shaking duration
  - 1 minute
- Significant pipe damage
  - Large ground strain
- Limited damage to other components





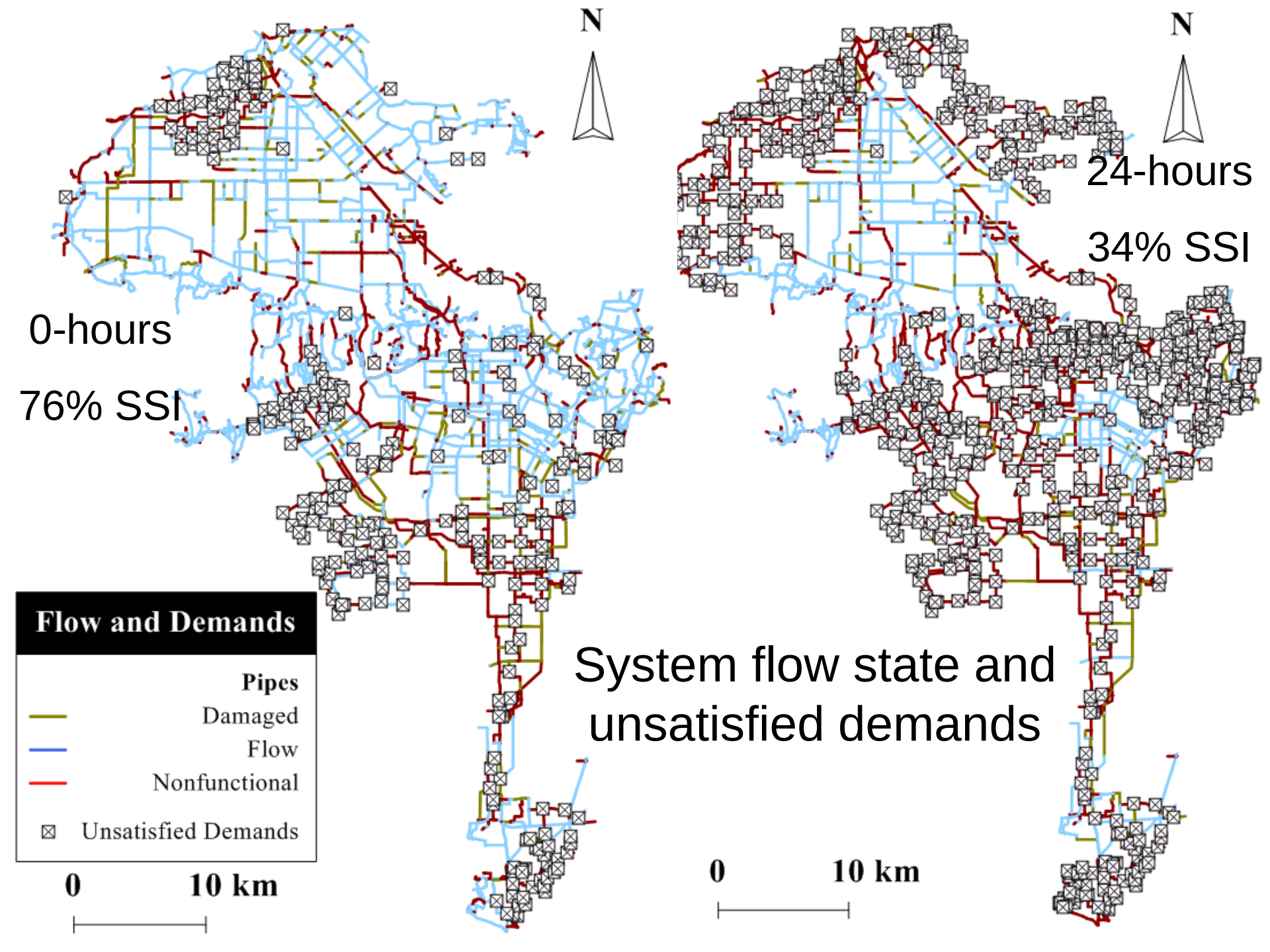


LADWP Water System

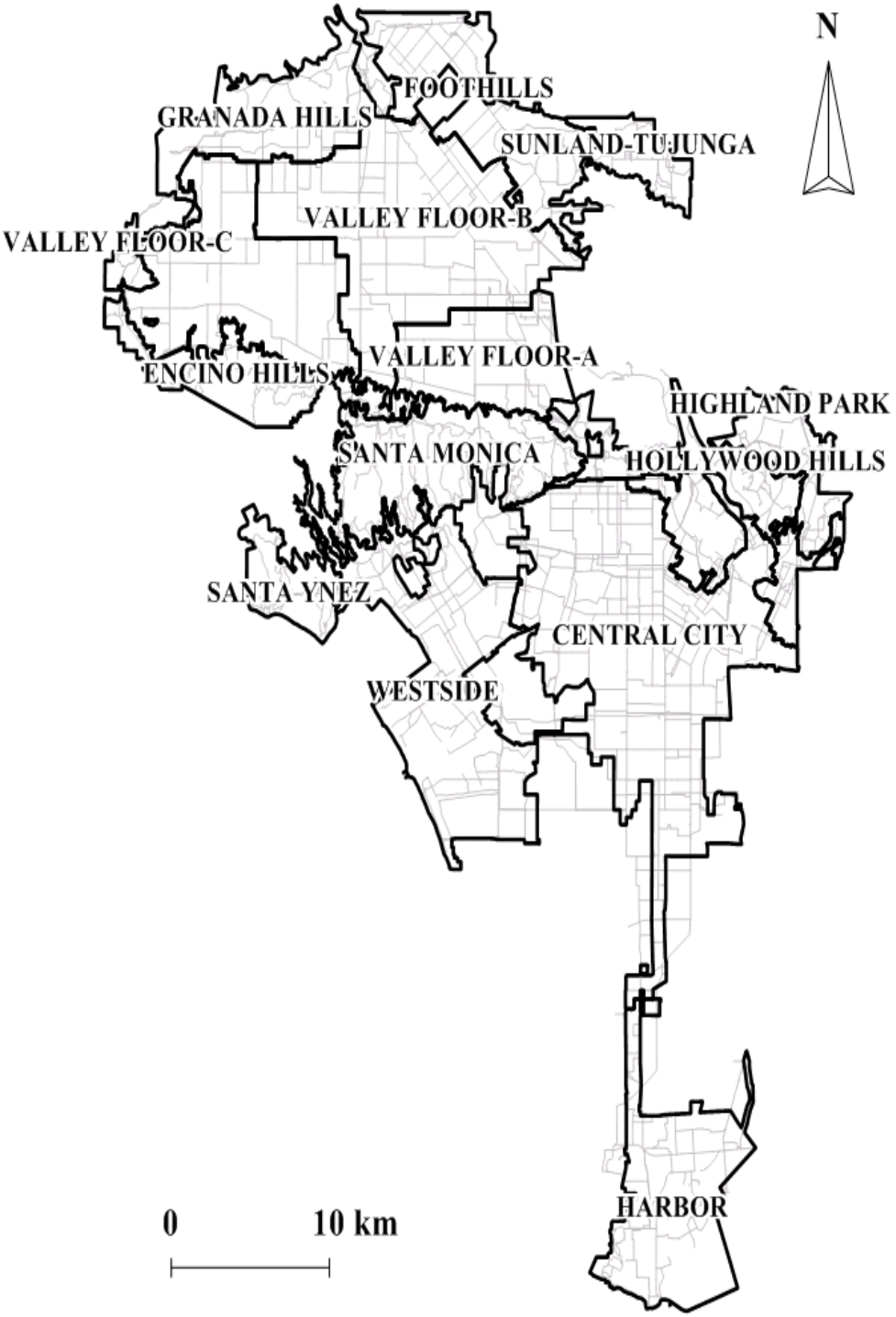
- 85% supply from aqueducts: LAA, CRA, CA-A
  - 35 MWDSC connections
- 15% supply from local ground water
- 7,230 miles (11,640 km) distribution and trunk pipes
- 108 tanks and reservoirs
  - Largest in-system storage in world
- Serves 4.1 million people + business and industry
  - Approximately 20% of affected population in Shakeout Scenario

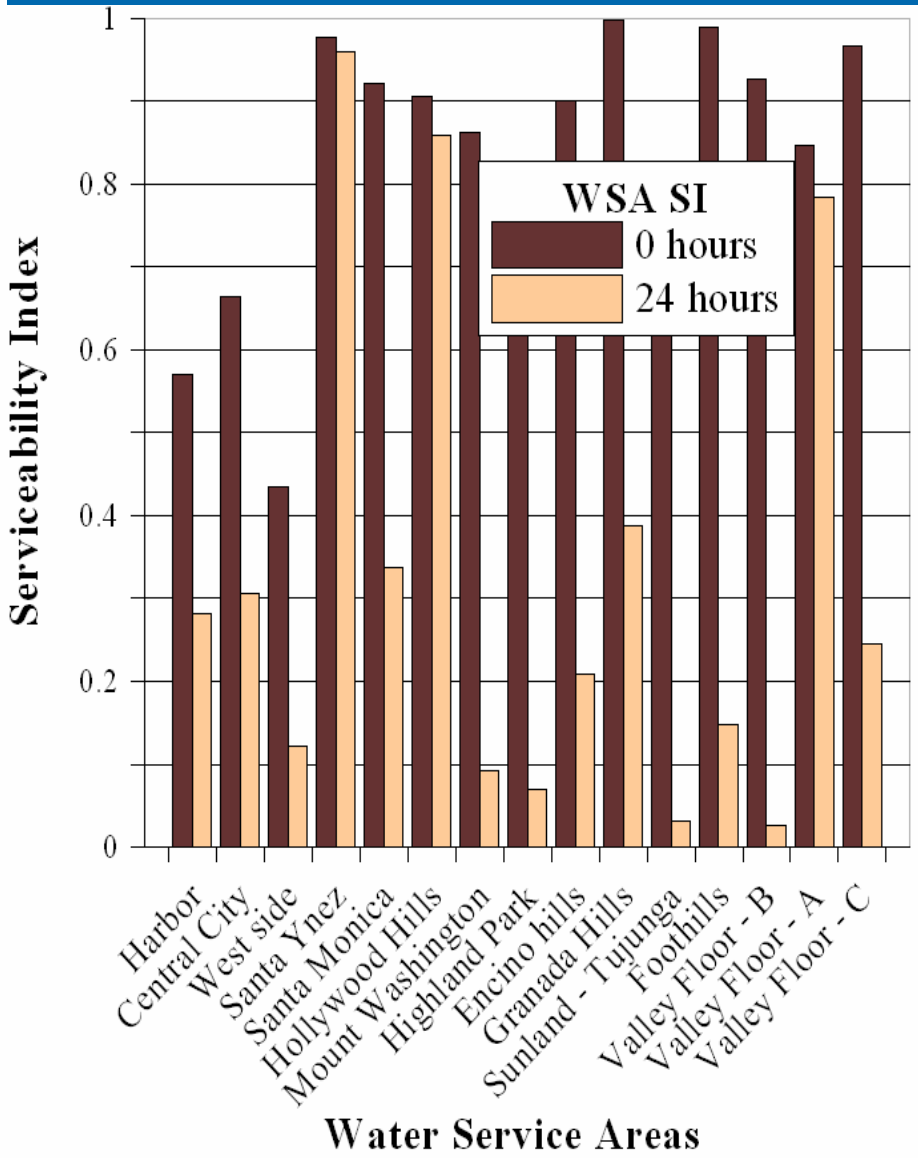
ShakeOut Scenario Impacts

- Graphical Iterative Response Analysis for Flow Following Earthquakes (GIRAFFE)
  - System simulation, statistical (Monte Carlo)
  - Cornell University-LADWP Collaboration
- 2,700 pipe repairs
  - 193 breaks
  - 2471 leaks
  - For comparison: 1,100 repairs in 1994
- System Serviceability Index (SSI)
  - ratio of water available at all system nodes after the earthquake to water available before the earthquake
  - SSI = 76% at 0-hours
  - SSI = 34% in 24-hours
    - 66% of normal water demand not met
    - Severe deterioration in the ability to deliver water results from damaged and leaking pipelines
    - Does not account for fire demand


N
0-hours
76% SSI
N
24-hours
34% SSI
Flow and Demands
Pipes
Damaged
Flow
Nonfunctional
Unsatisfied Demands
0
10 km
System flow state and unsatisfied demands
0
10 km

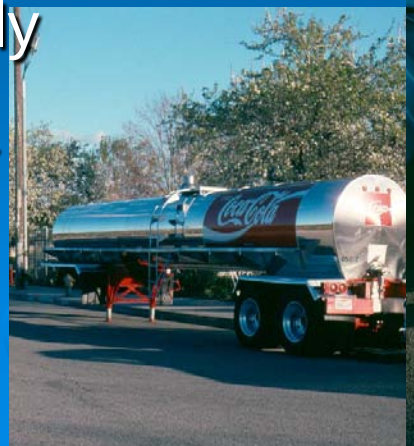
SI by Service Area





Restoration

- Lengthy process (months)
- Local storage loss
  - leaky pipes drain tanks and reservoirs in days
- SSI continues to decline until local emergency supplies instated and regional supplies restored
- Water purification notices
- Complete restoration cannot be achieved until aqueducts restored (15+ months)
  - DWR & MWD disperse supplies to many agencies
  - Agencies dependent upon others abilities
- Restoration time exceeds local supply capabilities
  - Up to 30% can be met with groundwater
- Severe water rationing mandates
  - (25% to 70%)



Recovery
Kobe Japan Example

	Week 1	Week 2	Weeks 3 & 4	Week 5
Key word	Want to know	Irritation	Anxiety, impatience	Anger
Contents	Situation? Tank truck? Recovery date?	Want to take a bath	Water supply is insufficient	Very tired and exhausted

- In Japan tolerance < 5 weeks
- Not sure Southern California society is as tolerable!

Regional Economics

- $213.3 Billion total losses estimated
- $87 Billion loss from fire
  - 40% of total
- $53 Billion business interruption loss from water
  - 25% of total
  - 55% of all business interruption
  - Assumes all aqueducts restored in 6 months
- Business interruption losses may be greatly underestimated
  - Assumed 6 month aqueduct restoration
- Water + fire account for great majority of losses

Summary

- Earthquake effects to water supply & distribution systems has greatest impact of all aspects considered in ShakeOut
- Economy cannot fully recover without water
  - Ports cannot operate without potable water
  - Food services, grocery stores, etc.
  - Some Industry dependent on water
  - People just can't live without water
- Regional interdependency
  - All agencies must prepare and work together to protect our health, safety, and welfare from this and other scenario disasters

Proposed Policies from Scenario Evaluation

- Policies can be made to improve earthquake resilience
  - Boil Water Notice → Tap Water Safety Notice
  - Develop Supply Agency Coordination Team
    - e.g. DWR, LADWP, MWDSC
    - Coordinate repairs to priority aqueducts, depending on actual damage
    - Can also work together to prioritize & implement pre-earthquake mitigations
    - Set up mutual assistance agreements

Questions?