

# Linking Lifeline Systems and Community Resilience

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**r**<sup>4</sup>

*The Four Fundamental  
Properties of Resilience*

*r*obustness

*r*edundancy

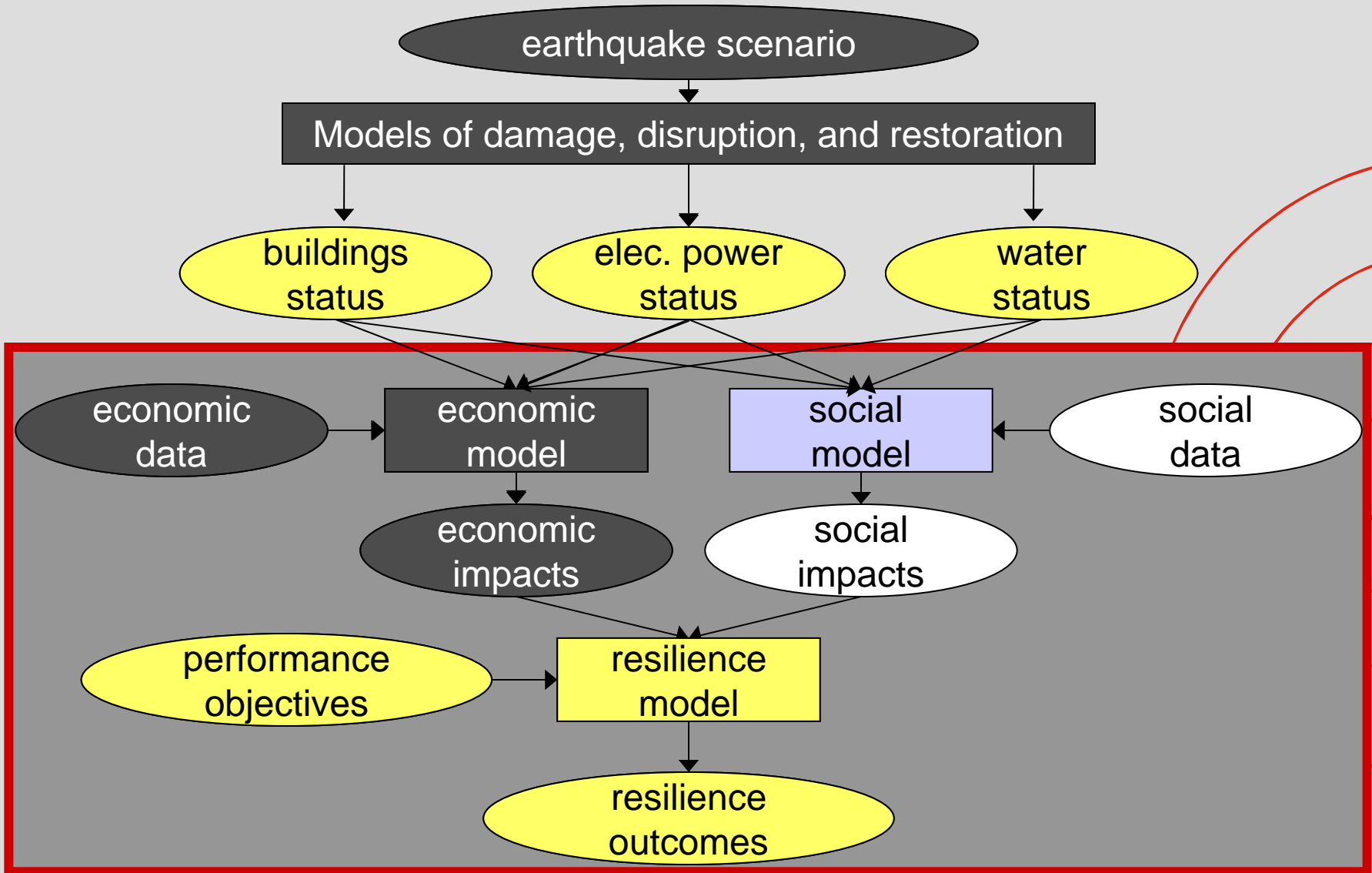
*r*esourcefulness

*r*apidity

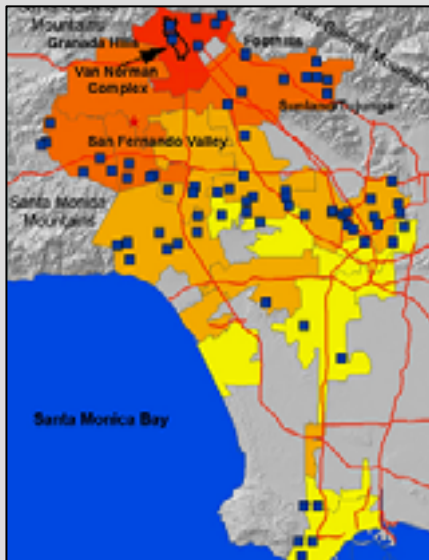
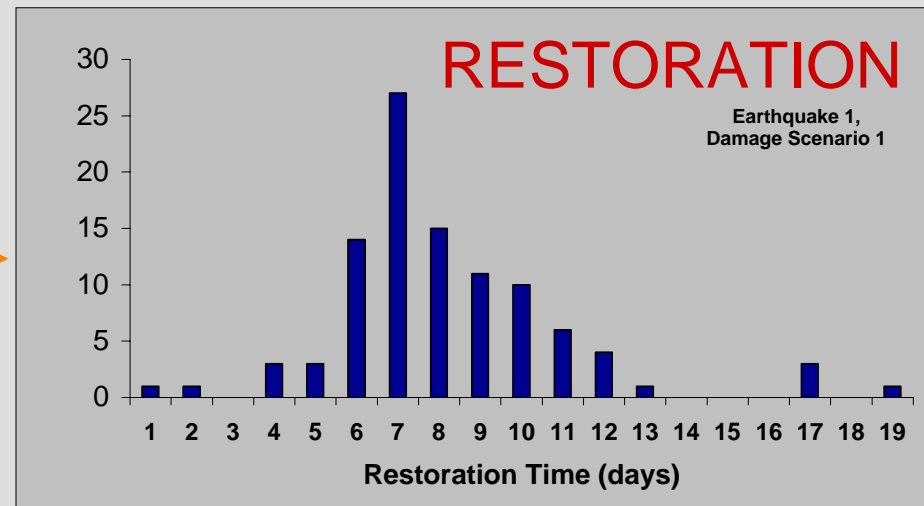
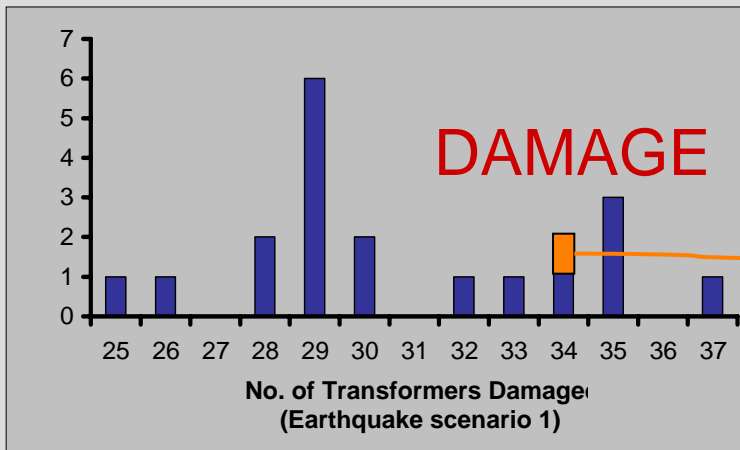
# **r**obustness

- Modeling community losses from lifeline disruption
- Multi-hazard loss modeling
- Measuring robustness

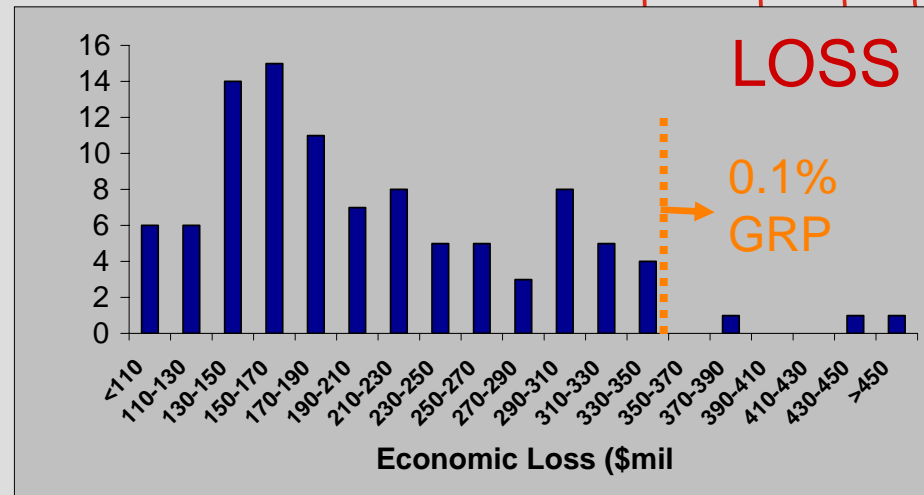
# Model of Community Resilience



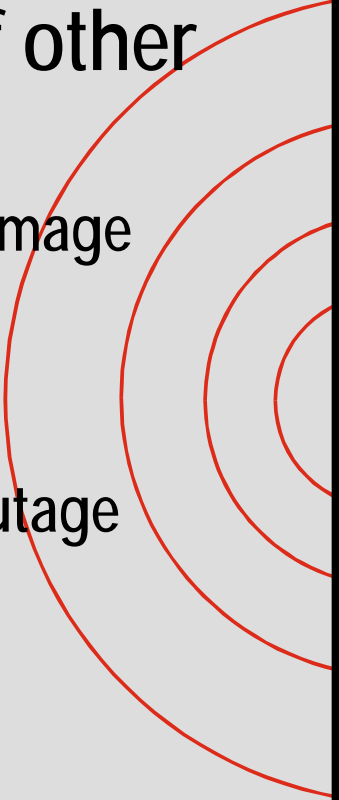
# Lifeline Loss Model



Courtesy of M. Shinozuka



# Multi-Source Loss Model

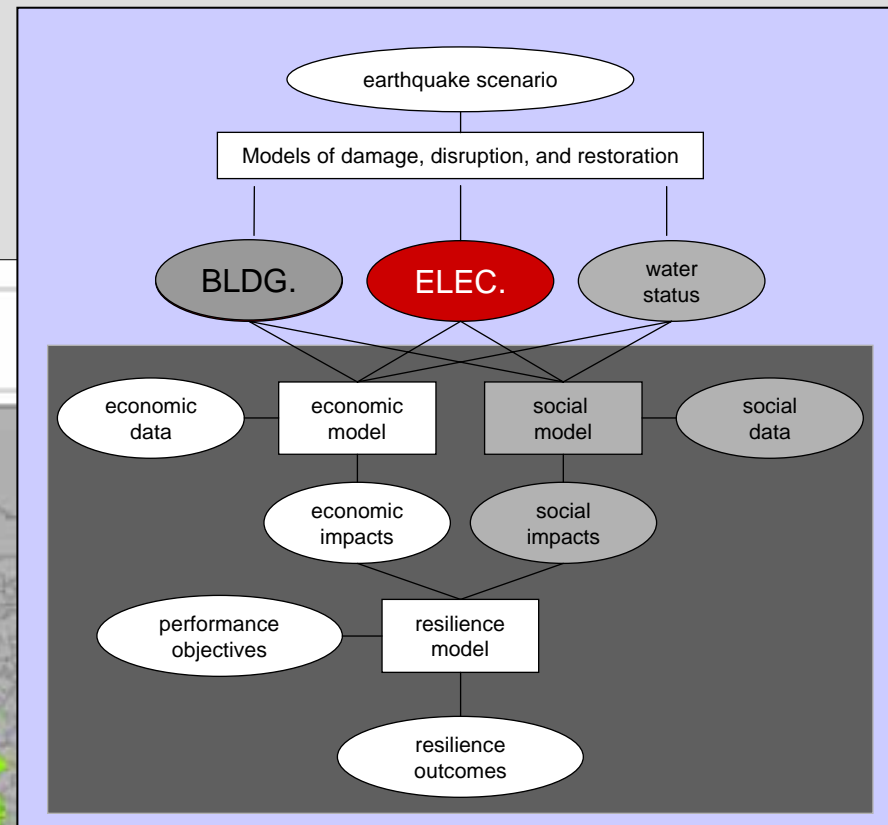
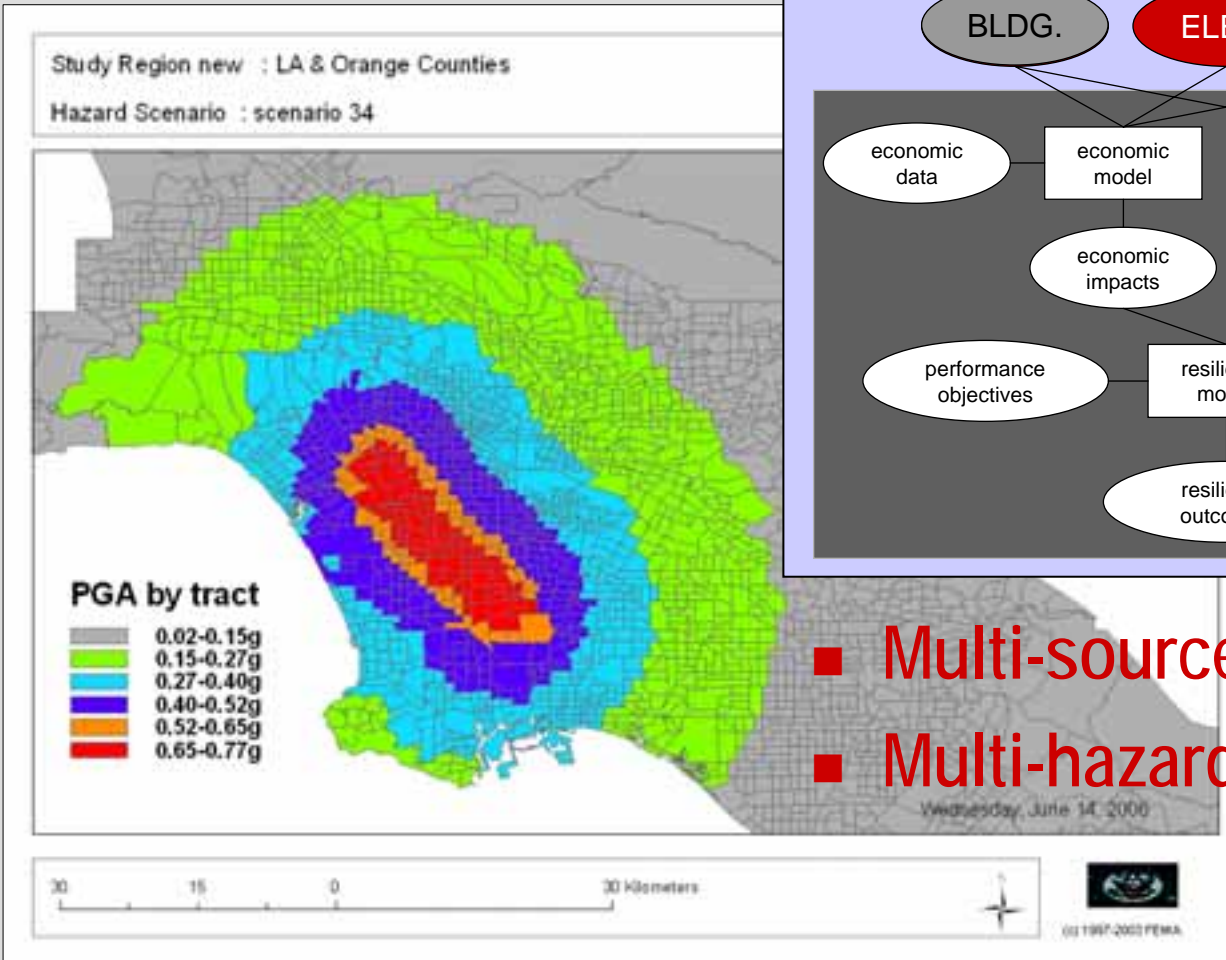
- Lifeline impacts modeled in context of other sources of disruption
    - ◆ MCEER lifeline outages; HAZUS building damage
    - ◆ Northridge data as basis
  - Significance:
    - ◆ Avoids double-counting loss from lifeline outage
    - ◆ Allows for interaction effects
    - ◆ More accurate and credible assessment of mitigation benefits
    - ◆ Flexibility for modeling different types of hazards
- 

# Multihazard Capability

- Hazards are represented as damage/outage events in this model
- Illustrative example:
  - Earthquake: lifeline outage + building damage
  - Terrorist event: lifeline outage only

# Example

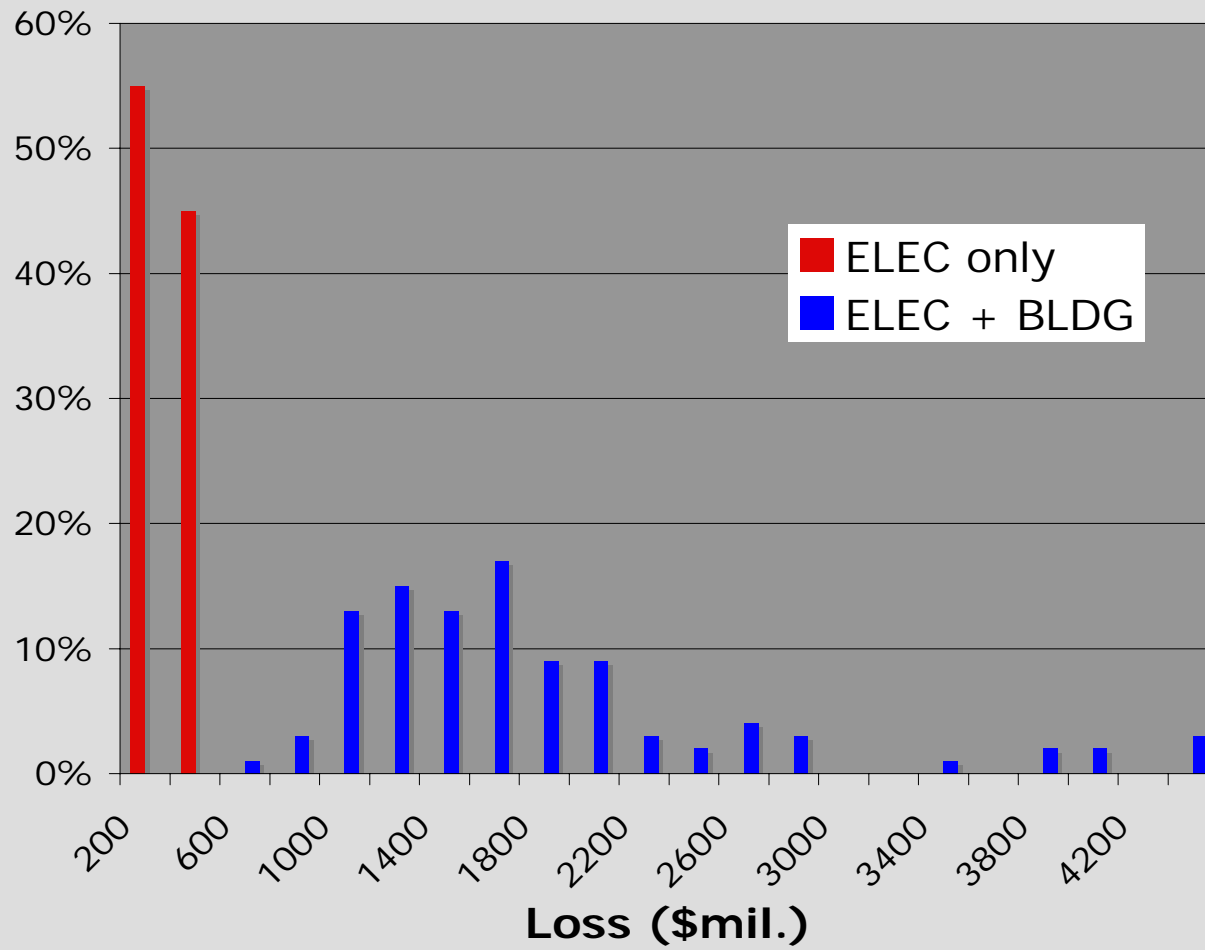
M 6.5 Newport-Inglewood



- Multi-source
- Multi-hazard potential

# Loss Results

(Earthquake #34, Electric damage #8,  
100 restoration/economic cases)

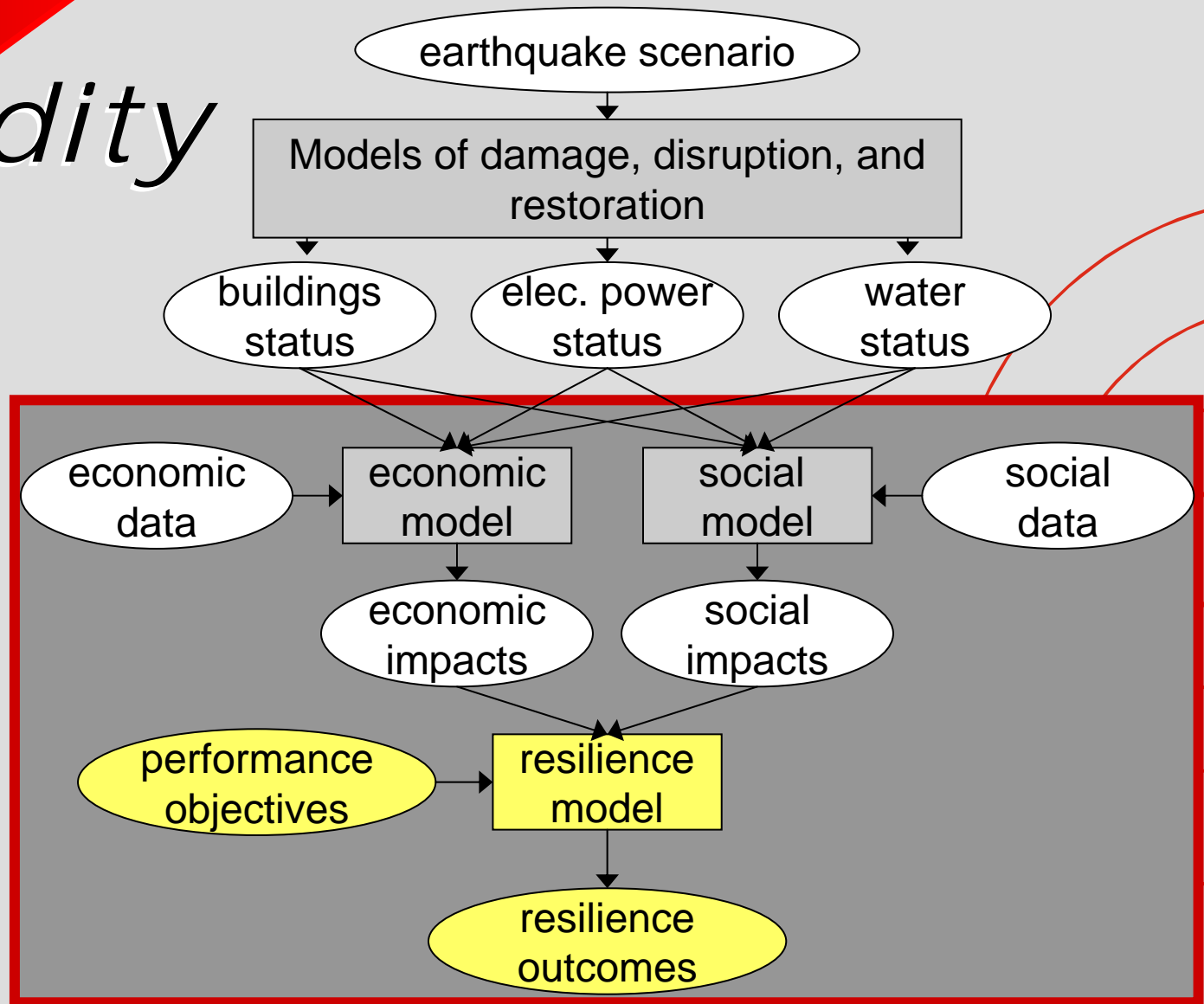


# Benefits of Hypothetical Mitigation

(EQ#34,dmg#8)

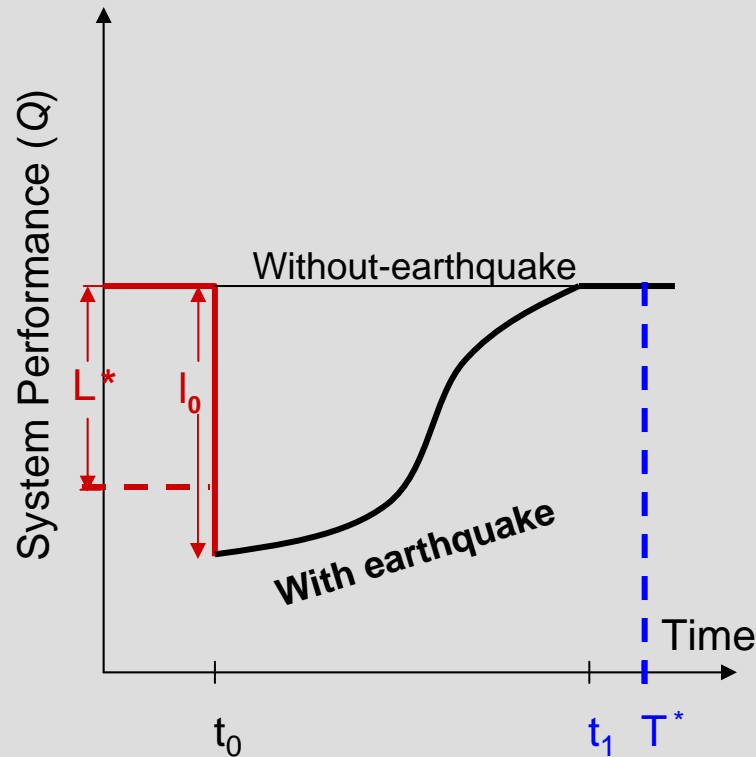
	ELEC only	ELEC + BLDG
<b>AVERAGE LOSS</b>		
Current state	\$191 m.	\$1,659 m.
Robustness +50%	\$97 m.	\$1,524 m.
Loss reduction benefit	\$94 m.	\$135 m.
<b>PROB. <math>L &gt; L^*</math></b>	<b><math>L^* = \\$100</math> m.</b>	<b><math>L^* = \\$1,000</math> m.</b>
Current state	99%	83%
Robustness +50%	50%	70%
Resilience benefit	49%	13%

# *R*apidity



# Performance Objectives

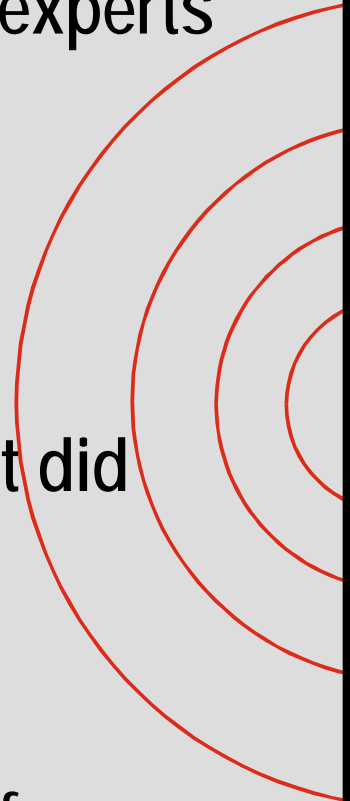
- What are appropriate performance objectives for mitigation planning?



	Robustness objective ( $L^*$ )	Rapidity objective ( $T^*$ )
Technical	<2 major pump stations lose function	<1 wk until all p.s. and 99% pipes intact
Organizational	<5% of pop. loses water service	<1 wk until 99% pop has water service
Economic	<5% GRP lost	<1 wk until return to 99% GRP

# Feedback from practitioners

- Interviews with 24 technical managers and experts (water, power, consultancies)
- Value of modeling community impacts and resilience recognized (esp. water industry)
- Some reservations expressed
- Responses insightful for framing issues but did not help quantify performance objectives
- Multi-stakeholder process and community involvement needed
  - utility take technical lead and synthesize input from other stakeholder groups

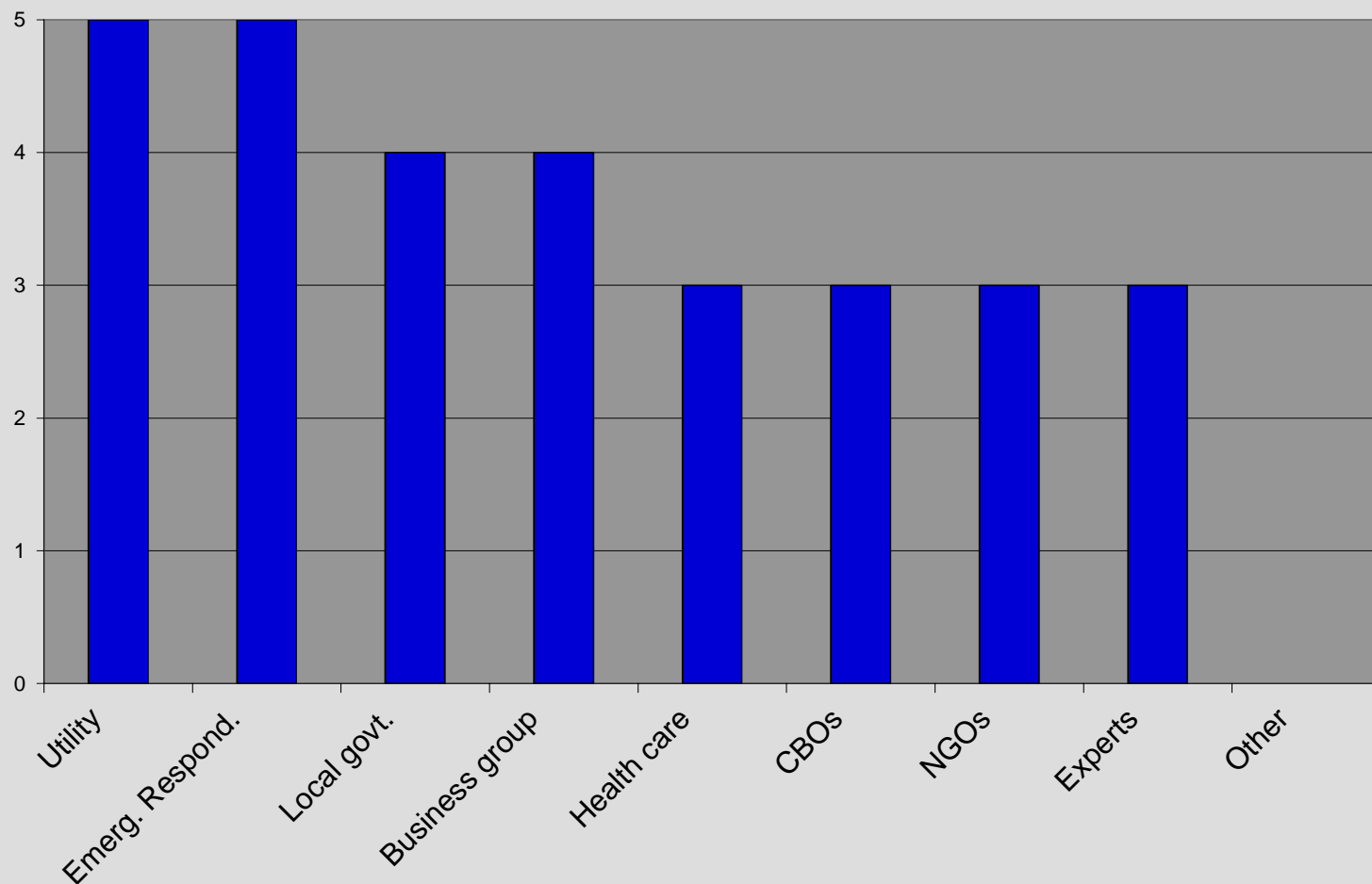


# Feedback from stakeholders

- Small, targeted L.A. survey under way
  - Representatives of stakeholder groups:
    - ◆ Utilities
    - ◆ Emergency response (EM, police, fire)
    - ◆ Health care
    - ◆ Local government (city council, neighborhood council)
    - ◆ CBOs and NGOs
    - ◆ Business groups
    - ◆ Technical experts
  - Goal: 15~30 responses (5 received to date)
  - Address gaps in bringing model into practical use

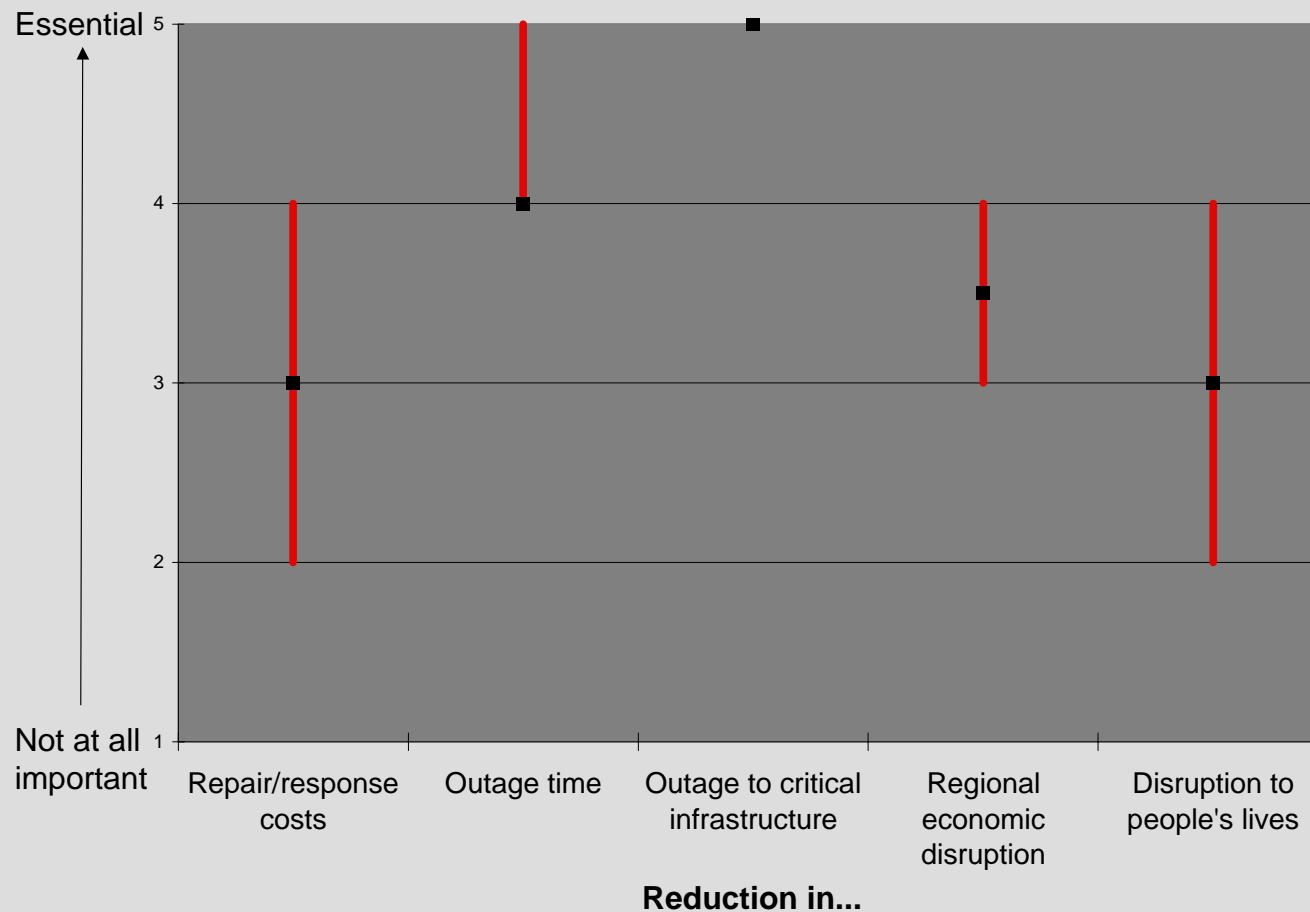
# Process Question

- What groups should participate in developing utility service goals for disasters?



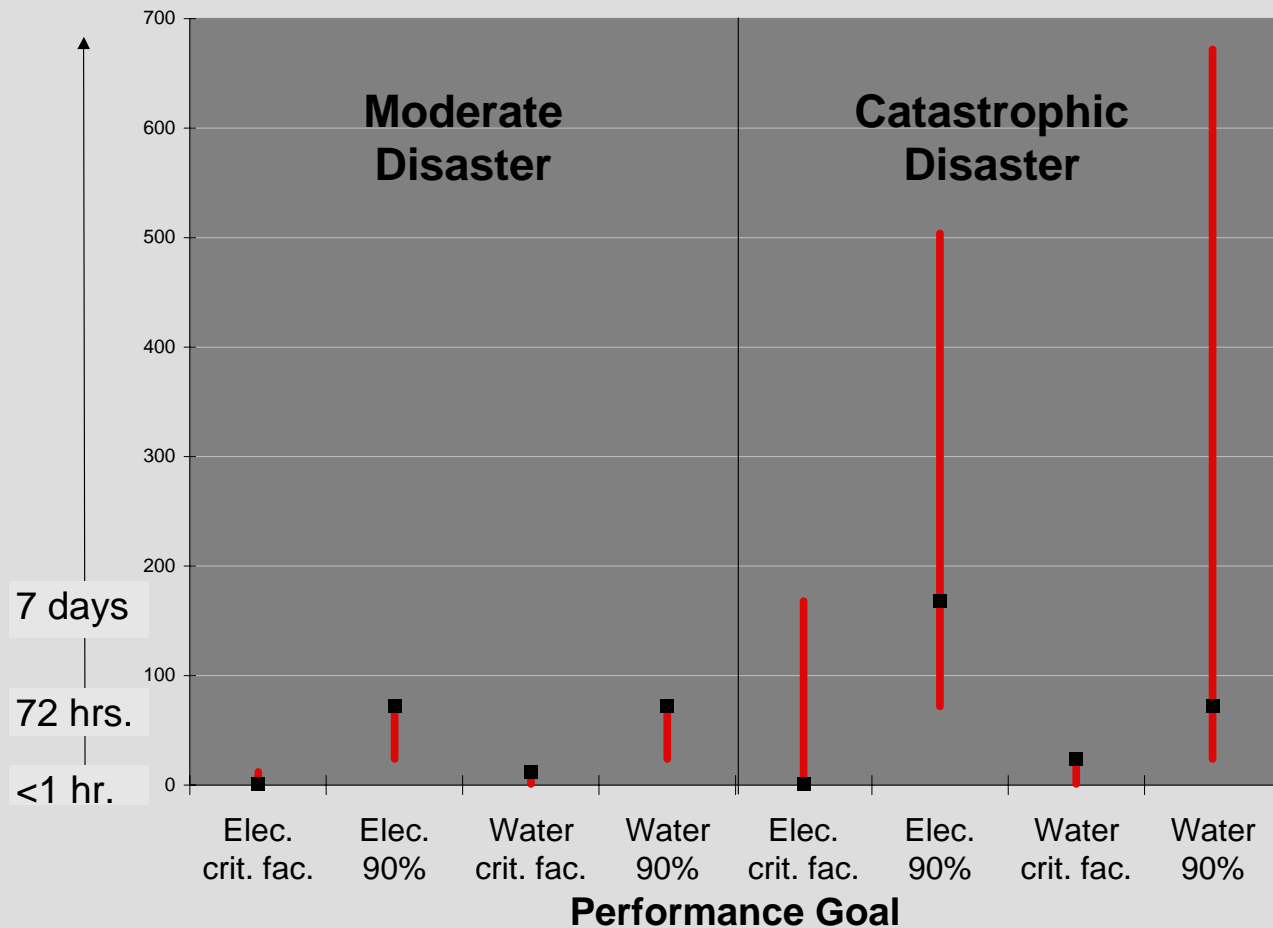
# Criteria Question

- How important is it to consider [various types of benefits] in mitigation decision-making?



# Performance Goals Question

- ◆ In a moderately damaging (catastrophic) disaster, electricity (potable water) should be available to critical facilities (90% of the population) within \_\_\_ hours/days

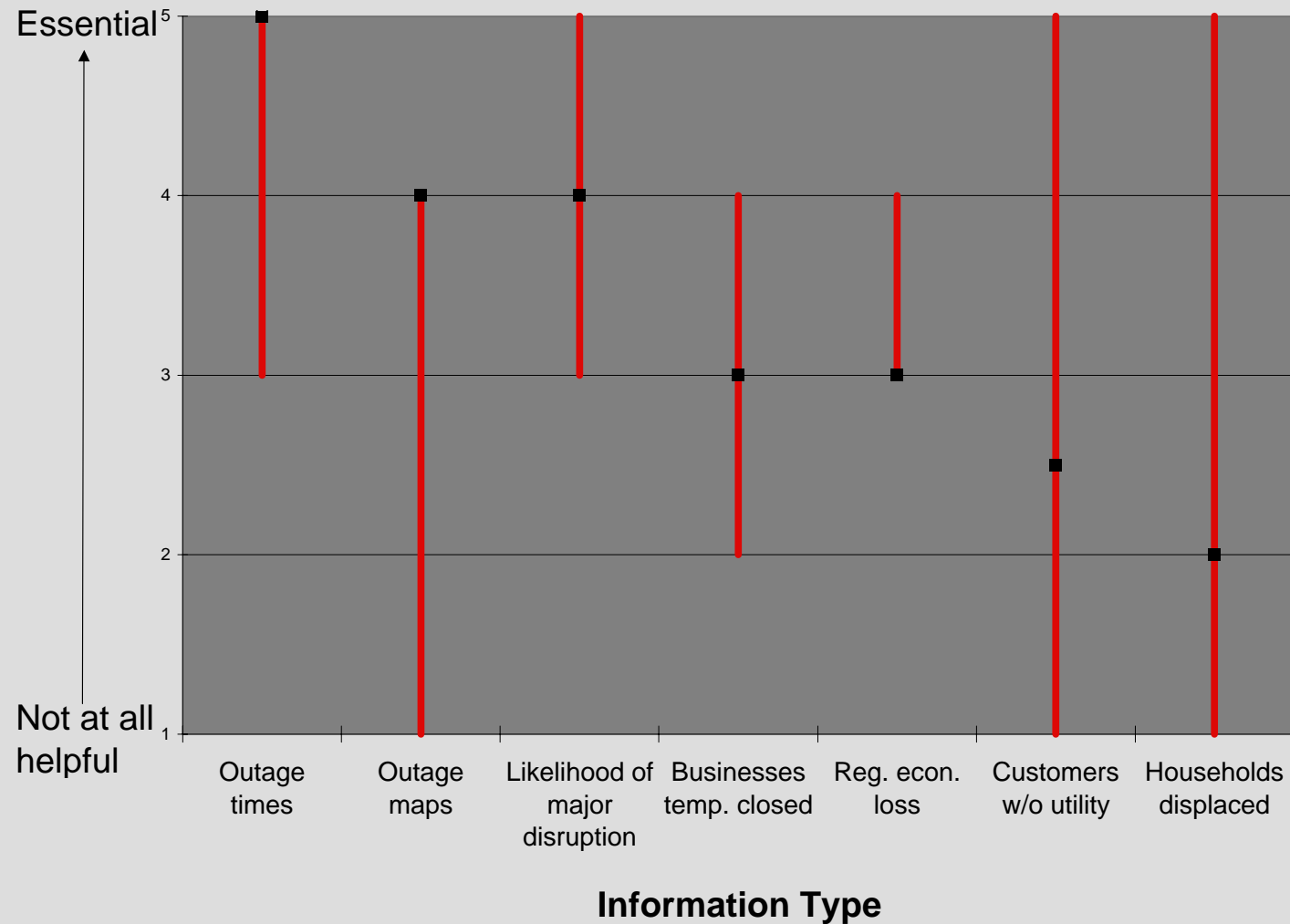


## Performance Goals (cont'd)

- Are these type of performance objectives appropriate? How can they be improved?
  - ◆ 4 of 5 indicated “appropriate”
  - ◆ 1 “not appropriate”
    - ◆ “Our experience as a wholesaler has frequently been that we can restore service delivery before the receiving retailer can recover the capacity to take the delivery and redistribute to the end user. The foregoing performance goals do not take such realities into account.”

# Information Sharing Question

- Helpfulness of [various] types of information?



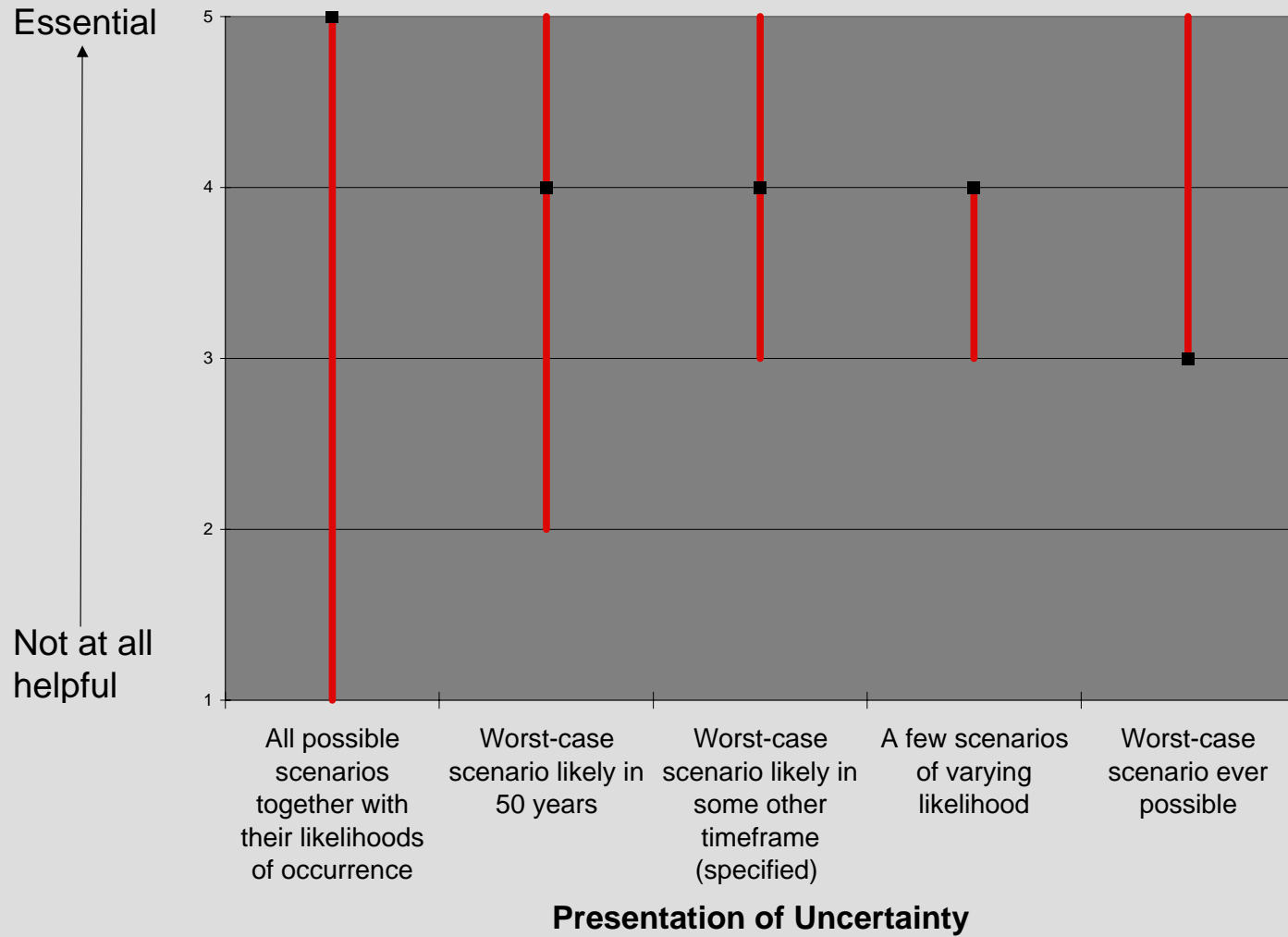
# Stakeholder Survey (cont'd)

- Comments:

- ◆ “Some of this information cannot be specified or predicted in advance. Most of the essential information is captured and disseminated in the course of the emergency response. Collecting some of this in advance would **potentially reveal vulnerabilities** to an audience that does not have a need to know and may also include adversaries interested in exploiting it.”

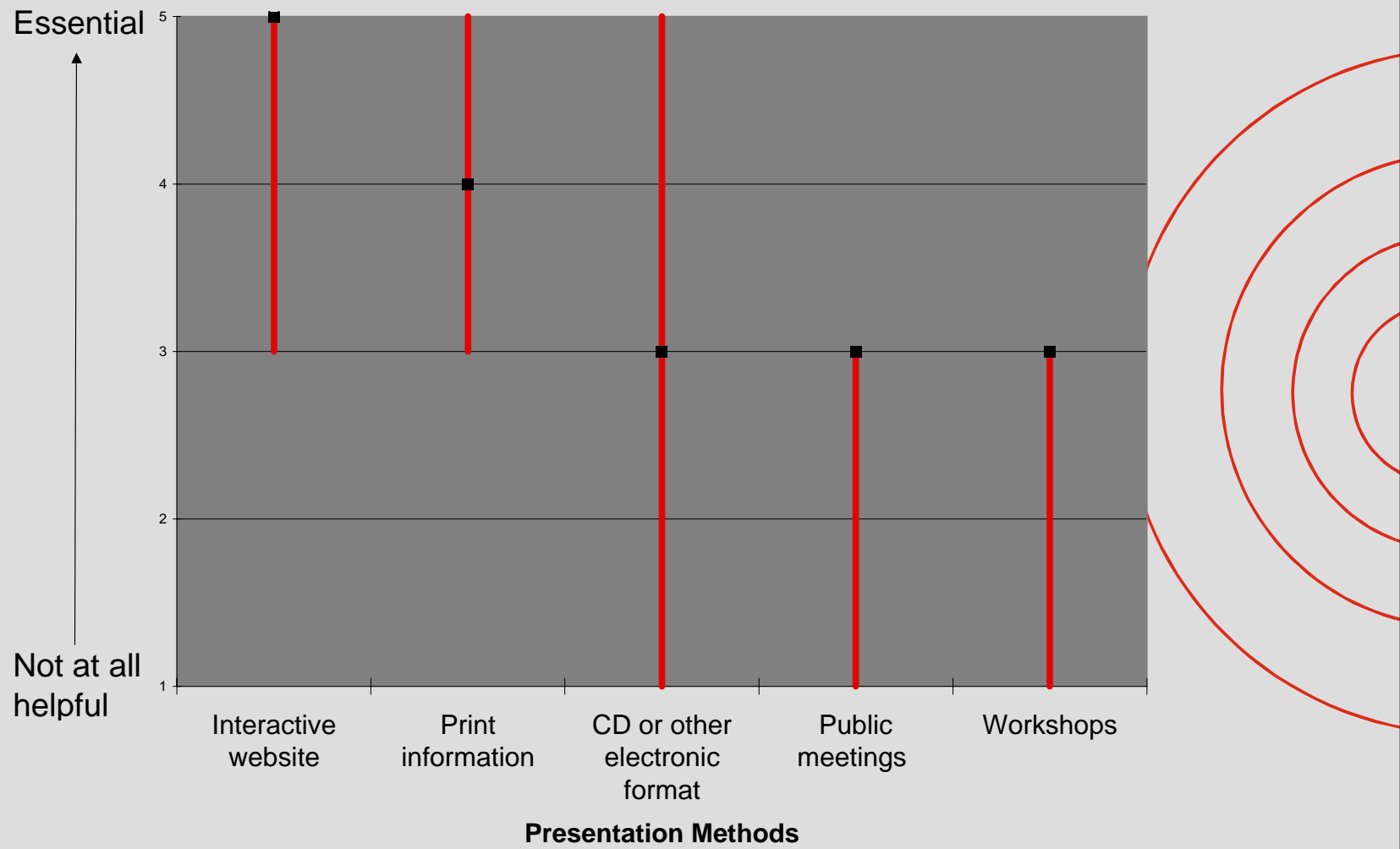
# Information Format Question

- Helpfulness of [various] presentations of uncertainty?



# Information Format (cont'd)

- Helpfulness of [various] presentation methods?



# Stakeholder Survey (cont'd)

- Comments:

- ◆ “A dark web site activated only when needed may be a particularly useful way of disseminating the information at the right time without fear of compromising data that may reveal exploitable vulnerabilities. Also, when really needed, all information sharing methods should be used in concert.”

# Summary

- Linking lifeline systems and community resilience through
    1. **Modeling community resilience** - robustness and rapidity
    2. **Seeking community involvement** - providing input to operationalize resilience measures, facilitate effective use of model
- 