UTAH EARTHQUAKE RESILIENCY WORKSHOP

April 27, 2016

Utah Seismic Safety Commission

EERI UTAH CHAPTER

REAVELEY ENGINEERS + ASSOCIATES
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STRUCTURAL ENGINEERS ASSOCIATION OF UTAH

AGEC Applied GeoTech

Partial funding for this educational opportunity is generously provided by the **Division of Occupational and Professional Licensing and the Education and Enforcement Fund.**

SCHEDULE

7:30 - 8:00 am	Registration & Check-in	
8:00 - 8:15	Introductions	
8:15 - 9:00	Keynote Speaker: Chris Poland, SE, NAE	Tab 1
9:00 - 9:45	Earthquakes: Public Perception vs Reality	Tab 2
9:45 - 10:00	Break	
10:00 - 10:50	The Critical Three: Schools, Housing & Jobs	Tab 3
10:55 - 11:45	Utah's Economic Resilience: Getting the Wheels Rolling Again	Tab 4
11:45 - 12:30	Lunch	
12:30 - 1:15	State Healthcare Resiliency Efforts: What Can We Learn?	Tab 5
1:20 - 2:05	Public Works and Lifelines: Understanding the Interdependencies	Tab 6
2:10 - 3:00	Role of Government: Mitigation Efforts & Recovery Expectations	Tab 7
3:00 – 3:15	Break	
3:15 - 4:00	Closing Keynote: Kent Yu, SE Learning from the Oregon Resiliency Plan	Tab 8
4:00 - 5:00	Discussion & Planning	Tab 9

Welcome

On behalf of the Organizing Committee of the Utah Earthquake Resiliency Workshop, I would like to welcome you, and thank you for your attendance. Please feel that you are a participant, rather than just an attendee. Your comments, questions, and recommendations during the day will be beneficial, not only to the Workshop, but could help to drive policy and change.

We recently learned that there is a "High likelihood of damaging earthquakes during the lifetime of many Utah resident." (Utah Geological Survey/USGS press release, April 18, 2016). This workshop will focus on the issues addressing the, "when it happens event." Utah and its counties, cities, neighborhoods, families, individuals, businesses, service providers, and everyone else, will be greatly impacted when it happens. As you will see in this workshop, there are things that must be done soon, and things that must be worked on over the next series of year, but the message of the day is to begin now to make these changes. As we begin to make these changes, we change the direction of the ship. Our ultimate goal is to improve the time and effort that it takes to recover from the event that eventually will occur. We need your help to make this happen.

This event is being organized by the Earthquake Engineering Research Institute (EER) Utah Chapter in conjunction with the Utah Safety Commission (Leon Berrett – Chair). Please refer to the back cover of your program to learn more about the EERI Utah Chapter. We are a multi-discipline organization comprised of engineers, scientists, architects, planners, public officials, and social scientists. Your attendance today indicates your interests in understanding the effects of earthquakes in Utah. Please consider joining the Utah Chapter to show your commitment to help us reduce the harmful effects of earthquakes in Utah.

This workshop would not possible without the generous support of our sponsors. Please extend your thanks to them for helping to make this event possible.

Best regards,

Brent Maxfield
2016 Past President
EERI Utah Chapter
Organizing Committee Chair

Organizing Committee

Brent Maxfield – Chair

Members of the Committee

Brad Bartholomew
Leon Berrett
Bob Carey
Jessica Chappell
Mathew Francis
Kevin Franke
Jerod Johnson
Barry Welliver

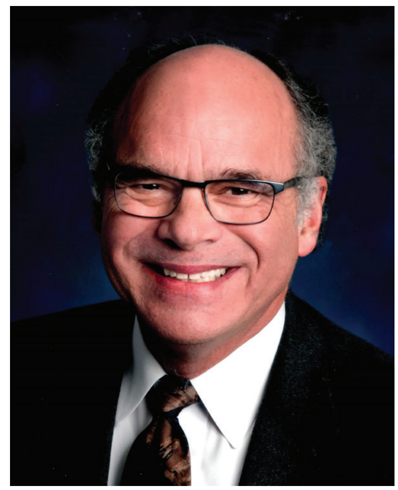
TAB 1

Chris Poland

TAB #1

Keynote Speaker

CHRIS POLAND, SE, NAE



A world renowned authority on earthquake engineering and champion of disaster resilience, Chris Poland's passion for vibrant, sustainable and healthy communities drives his current consulting practice. He focuses on community resilience and the buildings and systems that contribute to it.

Chris served on the Board of Directors for SPUR, co-chaired their Resilient City Initiative and led the publication of "The Disaster Resilient City". He was the founding co-chair of the San Francisco Lifelines Council with Mayor Edwin Lee and served from 2009 through 2014. Chris was recently appointed to the Executive Committee of the new ASCE Infrastructure Resilience Division. He is a Disaster Resilience Fellow in the National Institute of Standards and Technology and member of the team of authors that developed their Community Resilience Planning Guide and is currently involved in numerous follow-on projects. Chris was inducted into the National Academy of Engineering in 2009.

His structural and earthquake engineering career spans over 42 years and includes hundreds of projects related to the design of new buildings, seismic analysis and strengthening of existing buildings, as well as the development of guidelines and standards that are used worldwide. He was a Senior Principal, Chairman and CEO of Degenkolb Engineers during his 40 years with the firm from 1974 through 2014.

Disaster Resilience Planning

Chris D. Poland

Consulting Engineer

NIST Community Resilience Fellow

Chairman and CEO Degenkolb Engineers (retired)

April 27, 2016

Chris D. Poland
CONSULTING ENGINEER

What has Disaster Resilience Become?

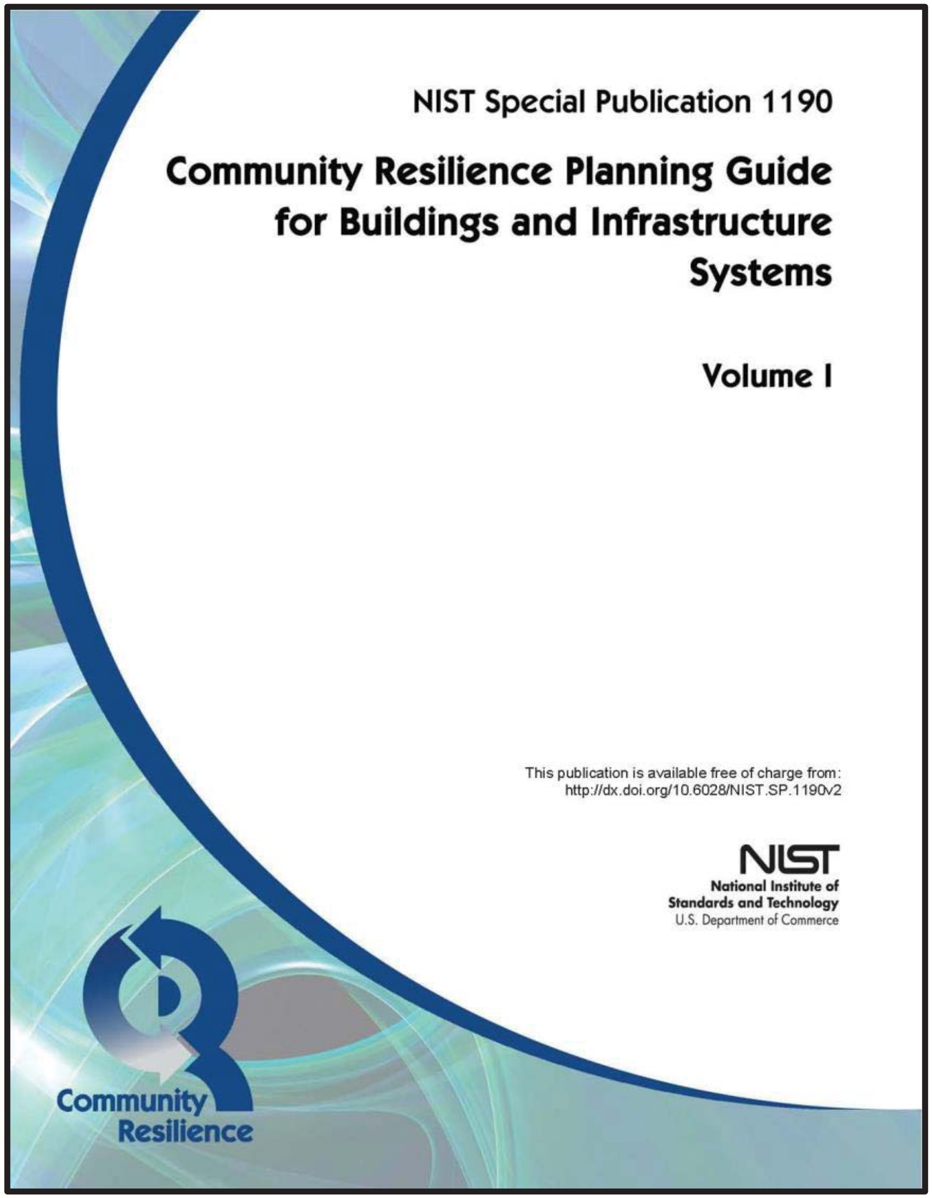
The term "resilience" means the ability to *prepare for* and *adapt to* changing conditions and *withstand* and *recover rapidly* from disruptions

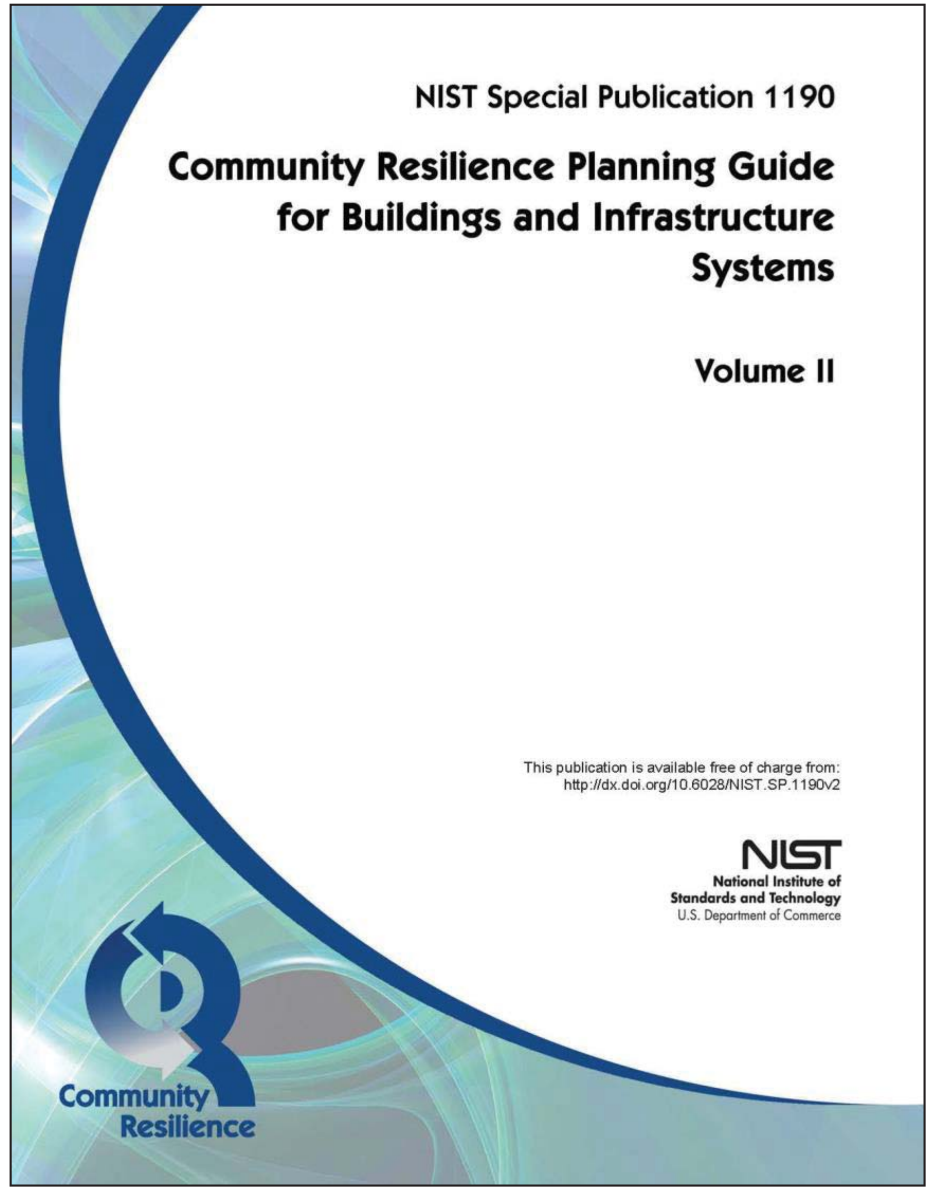
As defined in Presidential Policy Directive 21.

The emphasis is not solely on mitigating risk, but implementing measures to ensure the ability to live better today and have the Social, Economic, Natural and Built Environments recover to normal, or near normal function, in a reasonable timeframe.

Resilience Plans

2005 UNISDR Hyogo Framework for Action
Building the Resilience of Nations and Communities
2009 SPUR – The Resilient City
2011 Oregon Resilience Plan
2011 CARRI Community Resilience System
2011 National Disaster Recovery Framework (Series)
2012 Resilient Washington State
2012 CART Communities Advancing Resilience Toolkit
2014 Hurricane Sandy Rebuilding Strategy
2014 Rockefeller City Resilience Framework
2014 Resilience by Design, City of Los Angeles
2015 NIST Community Resilience Planning Guide
2015 Sendai Framework for Disaster Risk Reduction





Google *NIST Resilience Planning Guide* for a free down load

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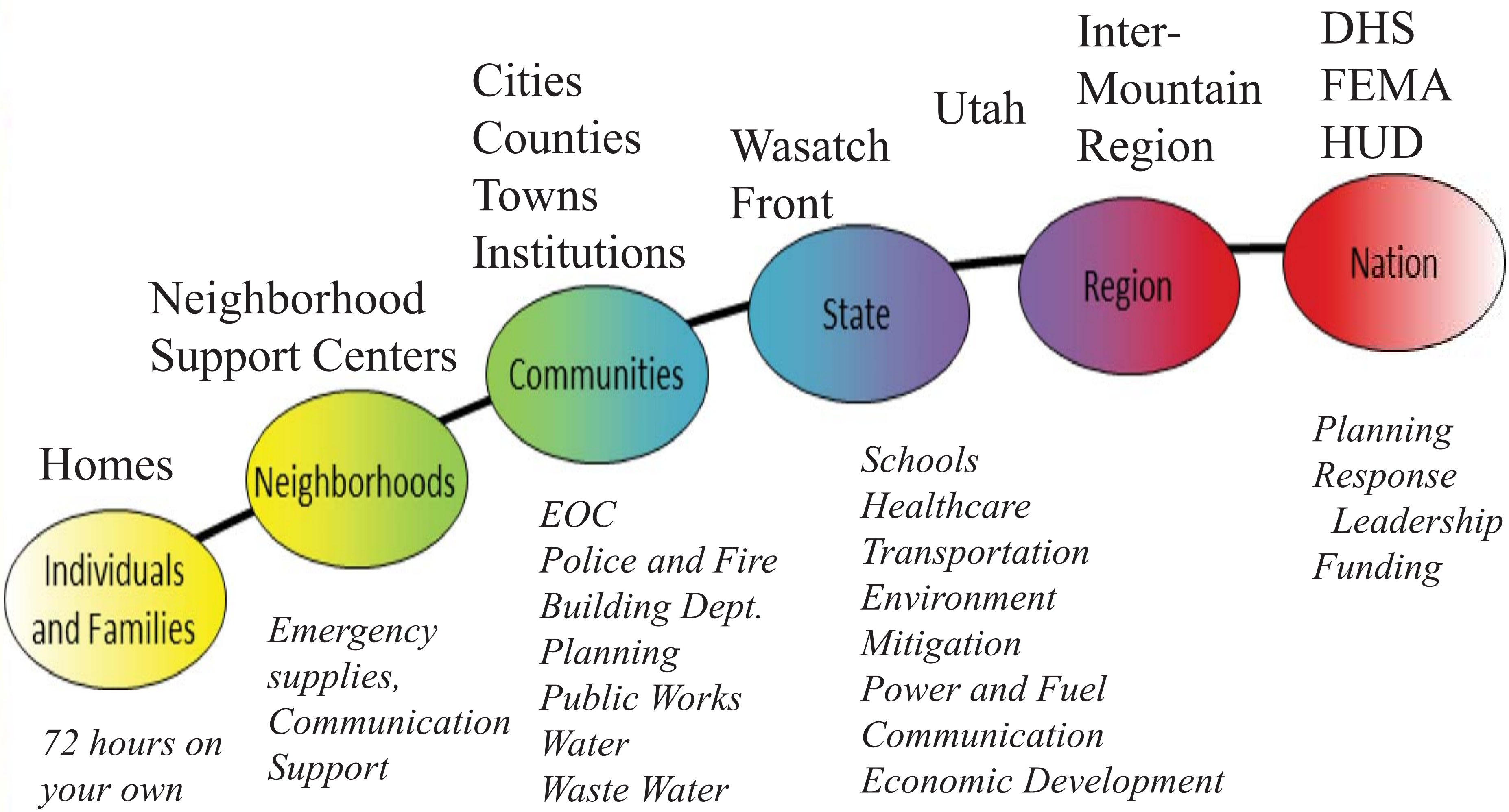
Utah Communities

… a place designated by geographic boundaries that functions under the jurisdiction of a governance structure…



Adapted and redrawn from Plodinec 2013

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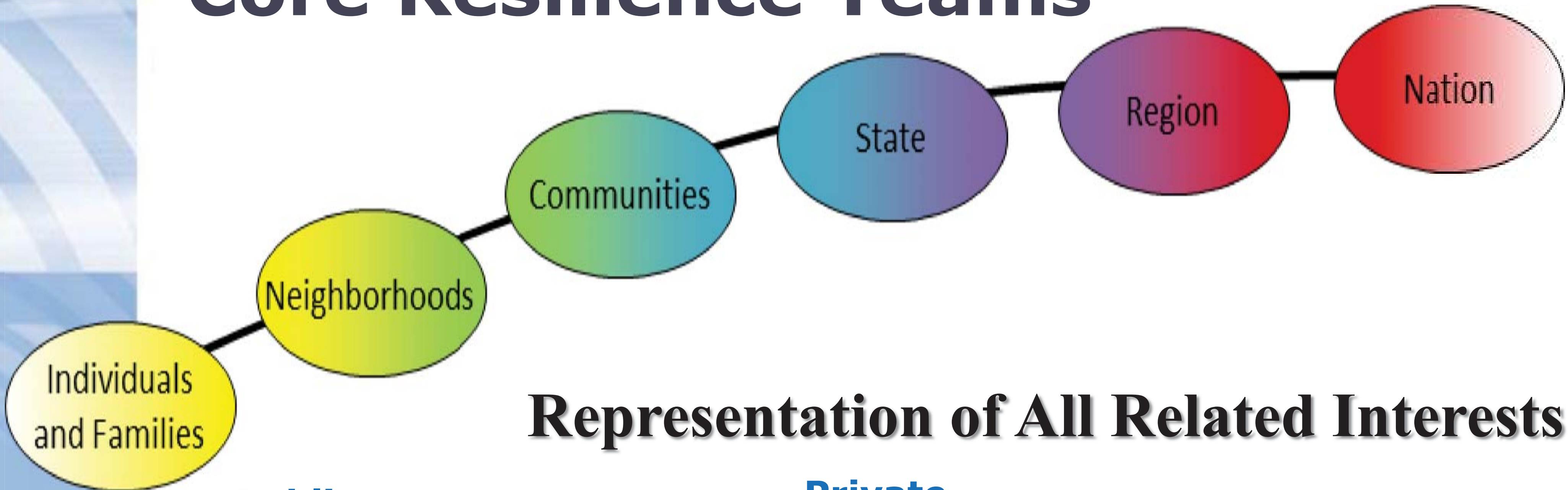
Developing a "Community" Resilience Plan

1. Form a planning team
2. Understand the situation
3. Determine goals and objectives
4. Plan development
5. Plan preparation, review, and approval
6. Plan implementation and maintenance

Figure 1-1: Six-step planning process for community resilience

Core Resilience Teams



Representation of All Related Interests

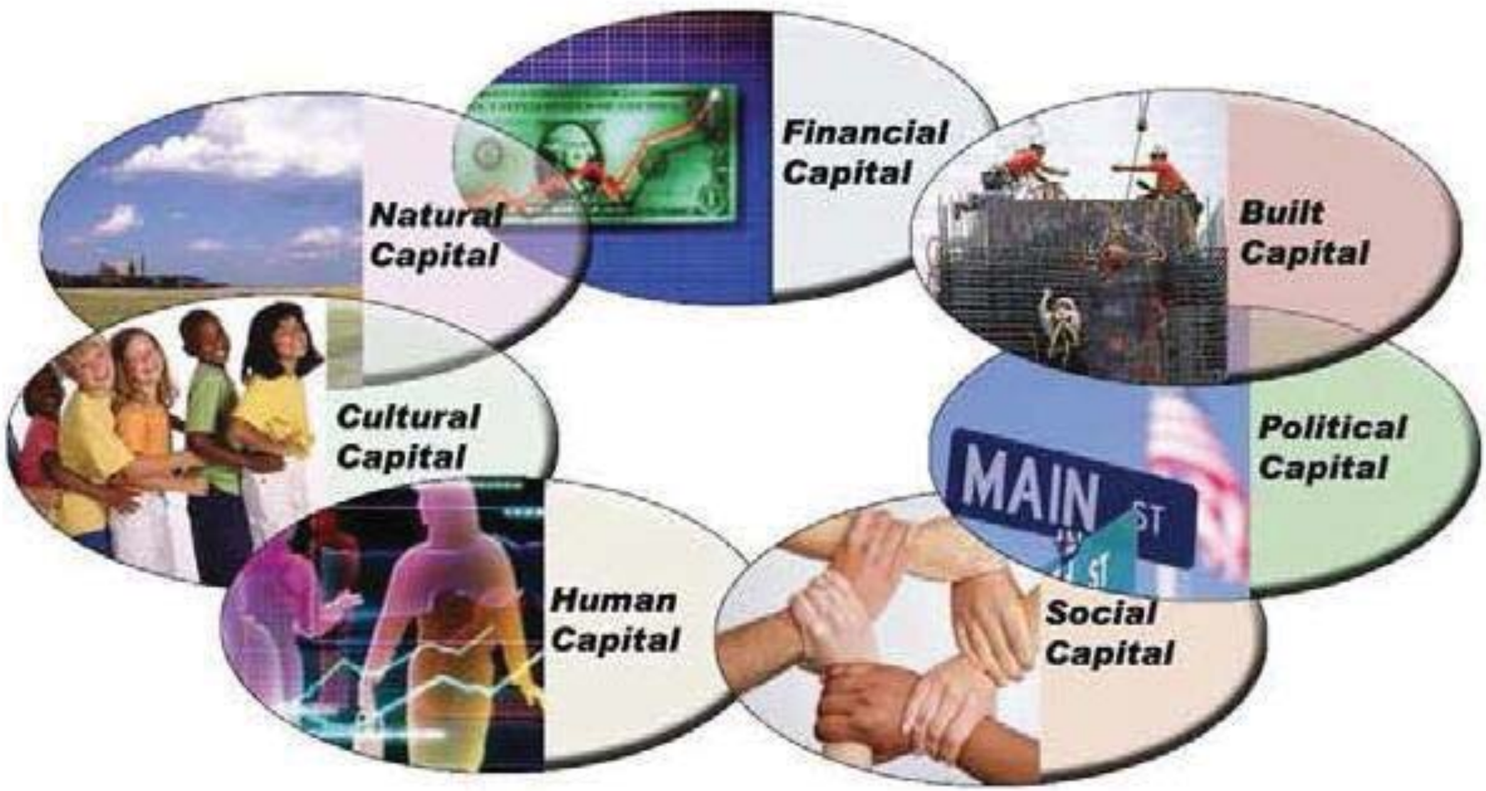
Public

- Elected Officials
  - Mayor, City Council
- Local Government
  - Planning & Building Dept, Public Works, Education, Human Services

Private

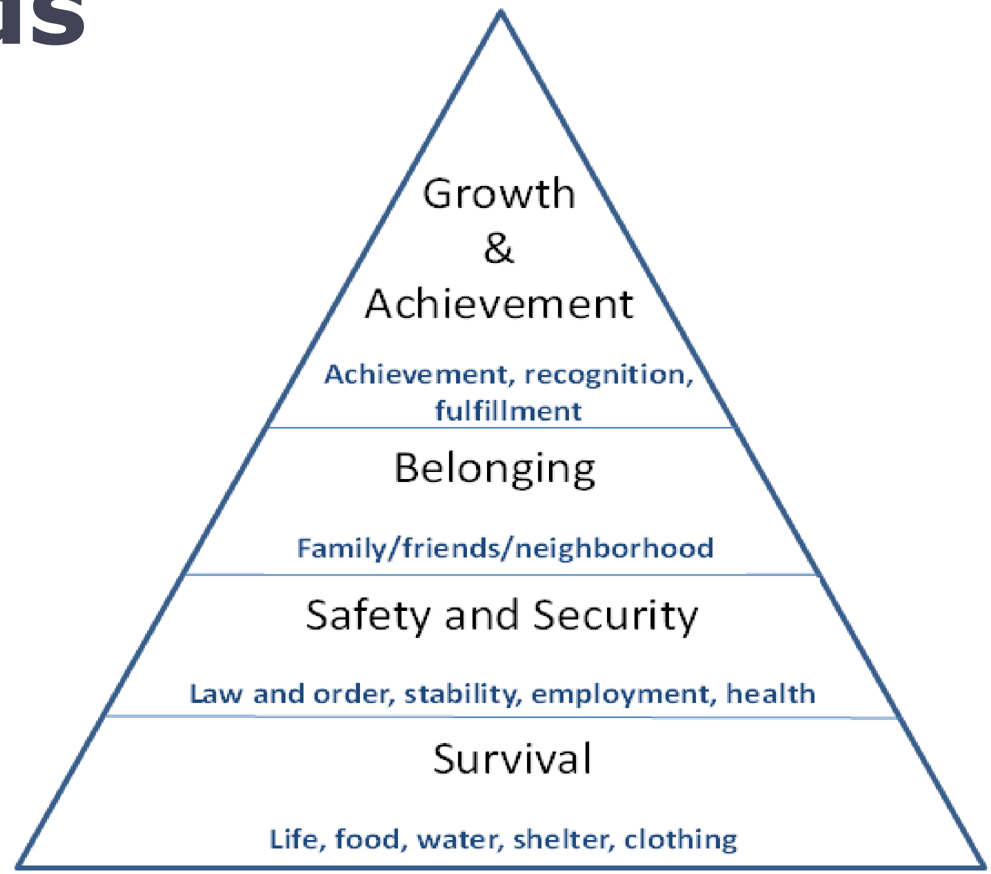
- Business and Services
  - Banking, Utility providers, Health care, Media
- Organizations
  - Non-Governmental, Voluntary Org. Active in Disasters, Community Service
- Community Members

Understanding Community Assets



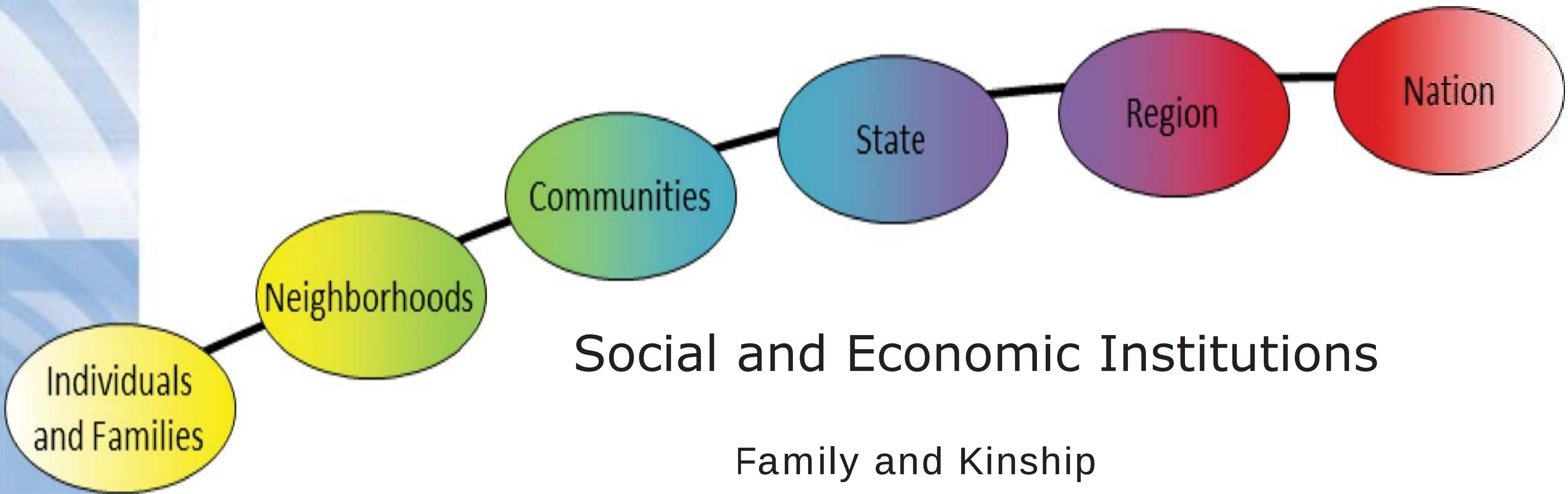
Source: NIST CRPG 2015/ from Flora et al, 2008

Understanding Community Member Needs



Source: Erica Kuligowski 2015

Understand Social Institutions

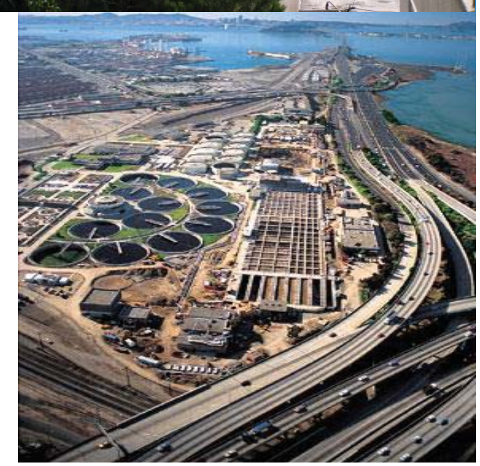


Social and Economic Institutions

Family and Kinship
Economic
Government
Health Care
Education
Community Service Organizations
Religious/Other Belief Systems
Media

- Source: Erica Kuligowski 2015

Understand the Built Environment



Buildings

Individual structures including the equipment and contents that house people and support social institutions

Building Clusters

A set of Buildings that serve a common function such as housing, healthcare, retail, etc.

Infrastructure

Physical networks, systems, and structures that support community social institutions including transportation, energy, communications, water and waste water.

Building Clusters

Critical Facilities

Cluster	Occupancy

Emergency Housing

Cluster	Occupancy
Skilled Nursing Facilit	
Emergency Medical	
Public Information	
Emergency Shelters	

Community Recovery

Cluster	
Commercial	
Industrial	
Manufacturing	
Colleges and Univ	

Housing and Neighborhoods

Cluster	Occupancy
Essential City services	Community Centers
	Social Services
	Courts
	Waste management
Essential retail	Grocery stores
	Day Care Centers
Essential Medical	Poison Centers
	Dialysis centers
	Medical Offices
	Mental Health Agencies
	Pharmacies
	Rehabilitation Centers
Essential NGO	Religious facilities and Culteral Centers
	Social Service facilities
Residential Housing	Multi-family housing
	Single family housing
Schools	K-12 Schools
Essential retail	Neighborhood Retail
	Fitness Centers
Essential City Services	Libraries

Link Social Institutions and the Built Environment

Define the Recovery of the Built Environment

Organize around recovering functionality over time

Source: National Disaster Recovery Framework

Survival

Safety and Security

Belonging

Growth and Achievement

When is each cluster and system needed for recovery?

Set Just in Time Functionality Goals

- **Short-Term**: Secure, Rescue, Stabilize, Clear Routes
  - Clusters: Critical Facilities, Emergency Housing
    Related Infrastructure Systems
- **Mid-Term:** Restore Neighborhoods, meet social needs
  - Clusters: Housing, healthcare, main street businesses, schools, churches
    Related Infrastructure Systems
- **Long-Term**: Community Social and Economic Recovery
  - Clusters: Commercial and Industrial Businesses
    Related Infrastructure Systems

Characterize Hazards

- **Prevalent Hazards**
  - Wind, Earthquake, Inundation,
  - Fire, Snow, Rain,
  - Human caused

- **Hazard Level:**
  - **Routine** level that is expected to occur frequently
  - **Expected** level equal to the design level used for buildings
  - **Extreme** level that is the maximum considered possible

- **Hazard Intensity**:
  - **Area affected** defined as "local, community, or regional"
  - **Disruption Level** defined as "minor, moderate, or severe"

Determine Anticipated Performance

- Estimate anticipated performance during recovery which depends on
  - Damage level - Condition and capacity of structural and nonstructural systems
  - Recovery time - Materials, equipment, and labor needed for restoration
  - Dependencies on other systems that may be damaged

Performance Metric for Buildings

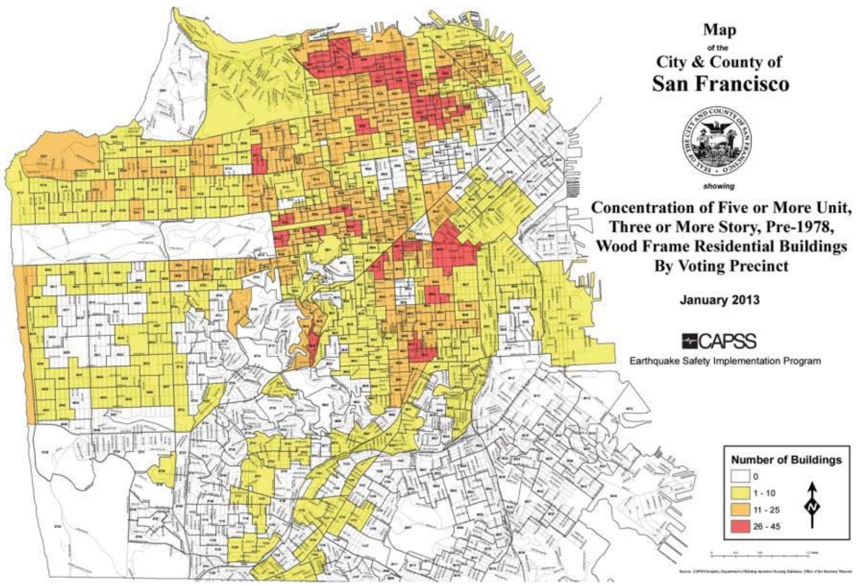
- **Level of Functionality** after the event
  - Operational,
  - Useable during Repair,
  - Not Usable,
  - Collapse
- **Recovery time available**
  - Days,
  - Weeks,
  - Months




Set Recovery time frames for Building Clusters

Percentage of functional building's in a cluster available

30%: Able to initiate Assigned Activities
60%: Able to initiate usual operations
90%: Operating at normal capacity



Example Building Resilience Matrix

Functional Category: Cluster	(4) Support Needed	(5) Target Goal	Expected Hazard Level								
			Phase 1 – Short-Term			Phase 2 – Intermediate			Phase 3 – Long-Term		
			Days			Wks			Mos		
			0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Critical Facilities	....	A									
Emergency Operation Centers			90%							X	
First Responder Facilities			90%							X	
Acute Care Hospitals			90%							X	
Non-ambulatory Occupants (prisons, nursing homes, etc.)			90%							X	
Emergency Housing		B									
Temporary Emergency Shelters			30%	90%							X
Single and Multi-family Housing (Shelter in place)			60%			90%					X
Housing/Neighborhoods		B									
Critical Retail				30%	60%	90%					X
Religious and Spiritual Centers					30%	60%	90%				X
Single and Multi-family Housing (Full Function)					30%		60%		90%		X
Schools					30%	60%	90%				X
Hotels & Motels					30%		60%	90%			X
Community Recovery		C									
Businesses - Manufacturing						30%	60%	90%			X
Businesses - Commodity Services						30%	60%		90%		X
Businesses - Service Professions						30%		60%		90%	X
Conference & Event Venues						30%		60%		90%	X

Clusters Phases Performance Levels

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Transportation Infrastructure	Support Needed[4]	Design Hazard Performance								
		Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
		Days			Weeks			Months		
		0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Ingress (goods, services, disaster relief)										
Local Roads, Bridges and Tunnels										
State Highways, Bridges and Tunnels										
National Highways, Bridges and Tunnels										
Regional Airport										
National/International Airport										
Military Airports										
Marine Port										
Ferry Terminal										
Subway Station										
Rail Stations										
Egress (emergency egress, evacuation, etc)										
Local Roads, Bridges and Tunnels										
State Highways, Bridges and Tunnels										
National Highways, Bridges and Tunnels										
Regional Airport										
National/Int'l Airport										
Military Airports										
Subway Station										
Ferry Terminal										
Rail Stations										
Community Recovery										
Critical Facilities										
Hospitals										
Police and Fire Stations										
Emergency Operational Centers										
Emergency Housing										
Residences										
Emergency Responder Housing										
Public Shelters										
Housing/Neighborhoods										
Essential City Service Facilities										
Schools										
Medical Provider Offices										
Retail										
Community Recovery										
Residences										
Neighborhood retail										
Offices and work places										
Non-emergency City Services										
All businesses										

Transportation

Communications Infrastructure	Support Needed[4]	Design Hazard Performance								
		Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
		Days			Weeks			Months		
		0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Power - Electric Utilities										
Community Owned or Operated Bulk Generation										
Generation Requiring Fuel Transport (Coal, Gas, Oil fired)										
In Place Fueled Generation (Hydro, solar, wind, wave, compressed air)										
Storage (Thermal, Chemical, Mechanical)										
Community Owned or Operated Distributed Generation										
Generation Requiring Fuel Transport (Coal, Gas, Oil fired)										
In Place Fueled Generation (Hydro, solar, wind, wave, compressed air)										
Storage (Thermal, Chemical, Mechanical)										
Transmission and Distribution (including Substations)										
Critical Facilities										
Hospitals, Police and Fire Stations / Emergency Operations Centers										
Debris / recycling centers/ Related lifeline systems										
Emergency Housing										
Public Shelters / Nursing Homes / Food Distribution Centers										
Emergency shelter for response / recovery workforce/ Key Commercial and Finance										
Housing/Neighborhood										
Essential city services facilities / schools / Medical offices										
Houses of worship/meditation/ exercise										
Buildings/space for social services (e.g., child services) and prosecution activities										
Community Recovery										
Commercial and industrial businesses / Non-emergency city services										
Residential housing restoration										

Electrical Energy

Communications Infrastructure	Support Needed[4]	Design Hazard Performance								
		Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
		Days			Weeks			Months		
		0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Core and Communications Buildings										
Communications Hub (e.g., Central Office, IXP, Data Centers, etc.)										
First/Last Mile										
Critical Facilities										
Hospitals										
Police and fire stations										
Emergency Operation Center										
Emergency Housing										
Residences										
Emergency responder housing										
Public Shelters										
Housing/Neighborhoods										
Essential city service facilities										
Schools										
Medical provider offices										
Retail										
Community Recovery Infrastructure										
Residences										
Neighborhood retail										
Offices and work places										
Non-emergency city services										
Businesses										

Communication

Functional Category: Cluster	Support Needed[4]	Overall Recovery Time for Hazard – Routine, Expected or Extreme								
		Phase 1 – Short-Term			Phase 2 -- Intermediate			Phase 3 – Long-Term		
		Days			Wks			Mos		
		0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Source										
Raw or source water and terminal reservoirs										
Raw water conveyance (pump stations and piping to WTP)										
Water Production										
Well and/or Treatment operations functional										
Transmission (including Booster Stations)										
Backbone transmission facilities (pipelines, pump stations, and tanks)										
Water for fire suppression at key supply points (to promote redundancy)										
Control Systems										
SCADA or other control systems										
Distribution										
Critical Facilities										
Wholesale Users (other communities, rural water districts)										
Hospitals, EOC, Police Station, Fire Stations										
Emergency Housing										
Emergency Shelters										
Housing/Neighborhoods										
Potable water available at community distribution centers										
Water for fire suppression at fire hydrants										
Community Recovery Infrastructure										
All other clusters										

Water

Functional Category: Cluster	Support Needed[4]	Design Hazard Performance								
		Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
		Days			Weeks			Months		
		0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Treatment Plants										
Treatment plants operating with primary treatment and disinfection										
Treatment plants operating to meet regulatory requirements										
Trunk Lines										
Backbone collection facilities (major trunk line, pump stations, siphons, relief mains, aerial crossings)										
Flow equalization basins										
Control Systems										
SCADA and other control systems										
Collection Lines										
Critical Facilities										
Hospitals, EOC, Police Station, Fire Stations										
Emergency Housing										
Emergency Shelters										
Housing/Neighborhoods										
Threats to public health and safety controlled by containing & routing raw sewage away from public										
Community Recovery Infrastructure										
All other clusters										

Wastewater

Example Summary Resilience Matrix

Summary Resilience Table	Design Hazard Performance								
	Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
	Days			Weeks			Months		
	0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Critical Facilities									
Buildings	90%							X	
Transportation		90%	X						
Energy		90%	X						
Water			90%		X				
Wastewater				90%				X	
Communication	90%			X					
Emergency Housing									
Buildings				90%					X
Transportation			90%	X					
Energy			90%	X					
Water			90%		X				
Wastewater				90%				X	
Communication				90%	X				
Housing/Neighborhoods									
Buildings						90%			X
Transportation			90%	X					
Energy			90%	X					
Water				90%				X	
Wastewater					90%			X	
Communication				90%			X		
Community Recovery									
Buildings								90%	X
Transportation				90%	X				
Energy			90%	X					
Water				90%				X	
Wastewater							90%	X	
Communication				90%			X		

Example Gap Analysis

Summary Resilience Table	Design Hazard Performance								
	Phase 1 Short-Term			Phase 2 Intermediate			Phase 3 Long-Term		
	Days			Weeks			Months		
	0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Critical Facilities									
Buildings	90%							X	
Transportation		90%	X						
Energy		90%	X						
Water			90%		X				
Wastewater				90%				X	
Communication	90%			X					
Emergency Housing									
Buildings				90%					X
Transportation			90%	X					
Energy			90%	X					
Water			90%		X				
Wastewater				90%				X	
Communication				90%	X				
Housing/Neighborhoods									
Buildings						90%			X
Transportation			90%	X					
Energy			90%	X					
Water				90%				X	
Wastewater					90%			X	
Communication				90%			X		
Community Recovery									
Buildings								90%	X
Transportation				90%	X				
Energy			90%	X					
Water				90%				X	
Wastewater							90%	X	
Communication				90%			X		

Gaps

Develop Implementation Strategy

- Select solutions to address priority performance gaps
  - Determine how alternative solutions can be combined to meet community goals
  - Consider collaborative projects
- Develop implementation strategies
  - Quantify benefits through impact on public safety and social needs
  - Evaluate economic impacts on the community - costs and savings
  - Consider short and long term benefits versus costs.
  - Set consistent design standards for new projects.

Implementation

Administrative Strategies

- Organize and maintain a Resilience Office within the Executive Branch
- Develop a Community Resilience Plan and incorporate into the General Plan
- Adopt the latest National Building Code and maintain an effective building department
- Adopt appropriate land use planning regulations
- Set special design standards for high hazard zones such as flood plains, coastal area, areas susceptible to liquefaction and land sliding, etc.
- Assure effectiveness of the building department
- Adopt guidelines and standards to evaluate and retrofit buildings and lifelines that include a transparent rating system

Implementation

Administrative Strategies, continued

- Develop processes and standards for post event assessments and repairs
- Elevate the level of inter-system communication between life line providers through a life-lines council
- Collaborate with adjacent communities
- Develop and implement education programs for all stakeholders to enhance understanding, preparedness, and opportunities for mitigation.
- Insist on the development of consistent codes and standards that are compatible with resilience planning and set transparent performance goals for all buildings and lifeline systems.

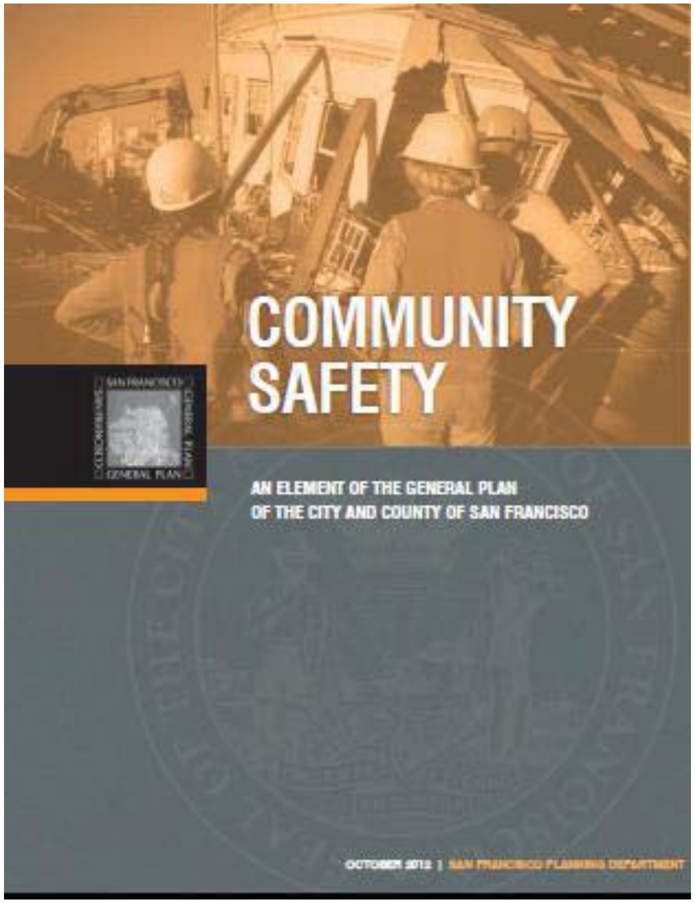
Implementation

Construction Strategies

- Prioritize gaps between desired performance and existing conditions as shown in the Resilience Matrix and mitigate when possible.
- Identify and implement opportunities for natural system protection such as sediment and erosion control, stream restoration, forest management, etc.
- Evaluate and retrofit public buildings
- Develop incentives to encourage resilience based new construction and voluntary mitigation.
- Enact mandatory retrofit programs as needed for community resilience

Resilient San Francisco

- Defined in the Community Safety Element of the General Plan and is non binding
- Includes 4 Objectives and 83 Policies
  - Mitigation
  - Emergency Preparedness
  - Response
  - Recovery and Reconstruction
- One of the Rockefeller 100 Resilient Cities
- Soon to publish their 100 RC Resilient Action Plan



110 Years in the Making

- Initiated by the 1906 Earthquake and Fire
- Stimulated by the 1989 Loma Prieta Earthquake
- Triggered by the 100th Anniversary of 1906
- Defined by the 2009 SPUR Resilient City Initiative and the 2011 Community Action plan for Seismic Safety (CAPSS) for expected and extreme earthquakes
  - City's 10 Year Capital Plan
  - Earthquake Safety Improvement Program (ESIP) for privately owned buildings
  - San Francisco Lifelines Council
- Moving forward as a 100 Resilient City

Driven forward by an interested Mayor

SPUR
SAN FRANCISCO
PLANNING + URBAN RESEARCH
ASSOCIATION

The Resilient City:

Defining what San Francisco needs from its seismic mitigation policies for three phases

Before the Disaster, Response, Recovery

www.spur.org

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San Francisco's 10 year Capital Plan

- Initiated in 2006
- A sustainable plan. focused on long term safety, accessibility, and modernization of publically owned buildings and systems
- Includes sustainability and resilience goals
- Addressing sea level rise
- Prioritization based on maximizing multiple benefits

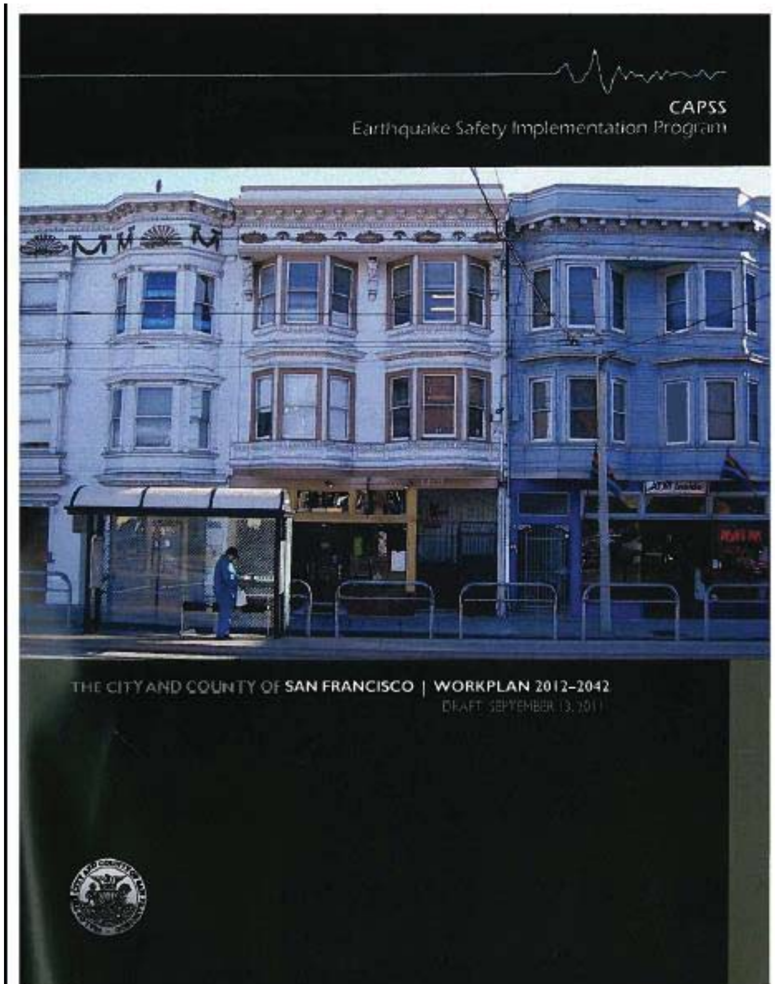
Earthquake Safety Improvement Program

30 year program to mitigate privately owned buildings and prepare for recovery.

Community developed and supported through CAPSS

A formal program with staff within the City Administrators Office

Provides a three step approach.



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ESIP

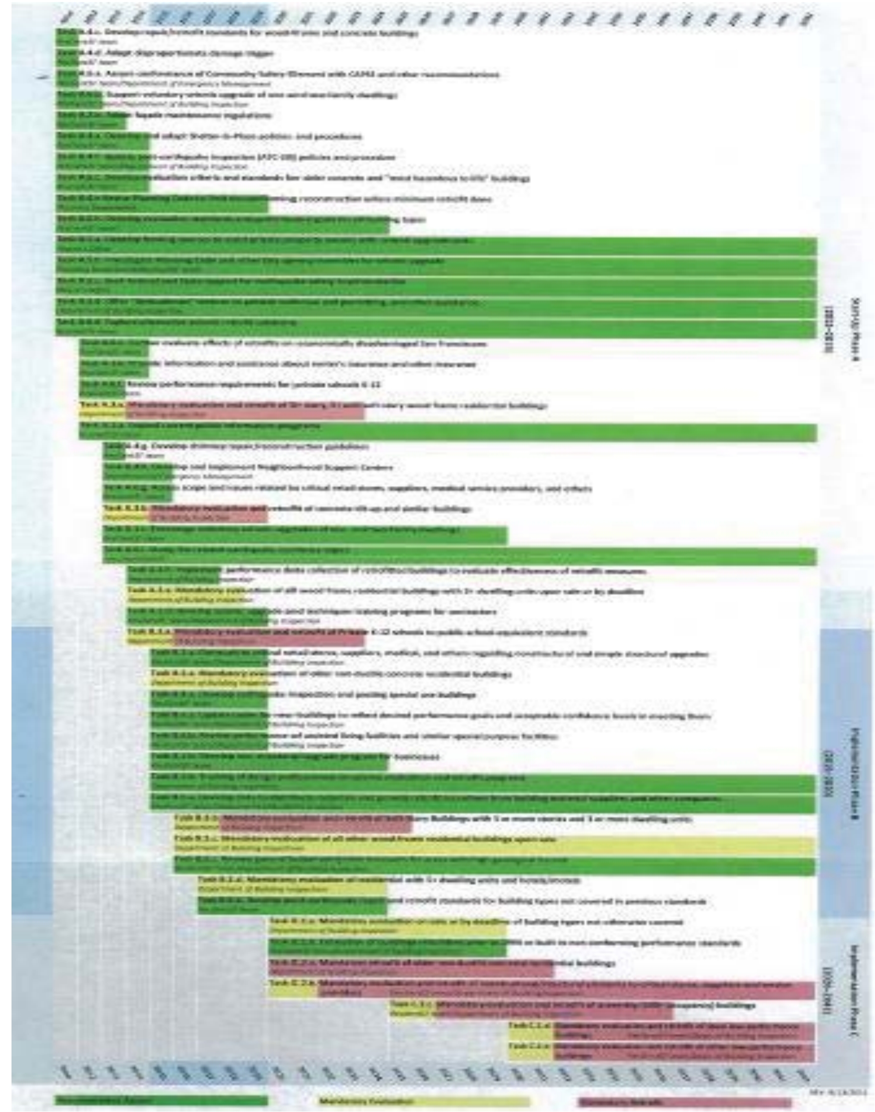
- Includes 50 tasks and three phases of effort
  - Start Up – High Risk Safety Issues
  - Implementation Critical
  - Followed by all other gaps.

- Three step approach to resilience.
  - Facilitate the market
  - Nudge the market
  - Retrofit with a deadline

Recommended Action

Mandatory Evaluation

Mandatory Retrofit



Soft Story Legislation

Mandatory retrofit ordinance with a 2020 completion date

5000+ Pre '78, Wood Frame, 3+ stories, 5+ units

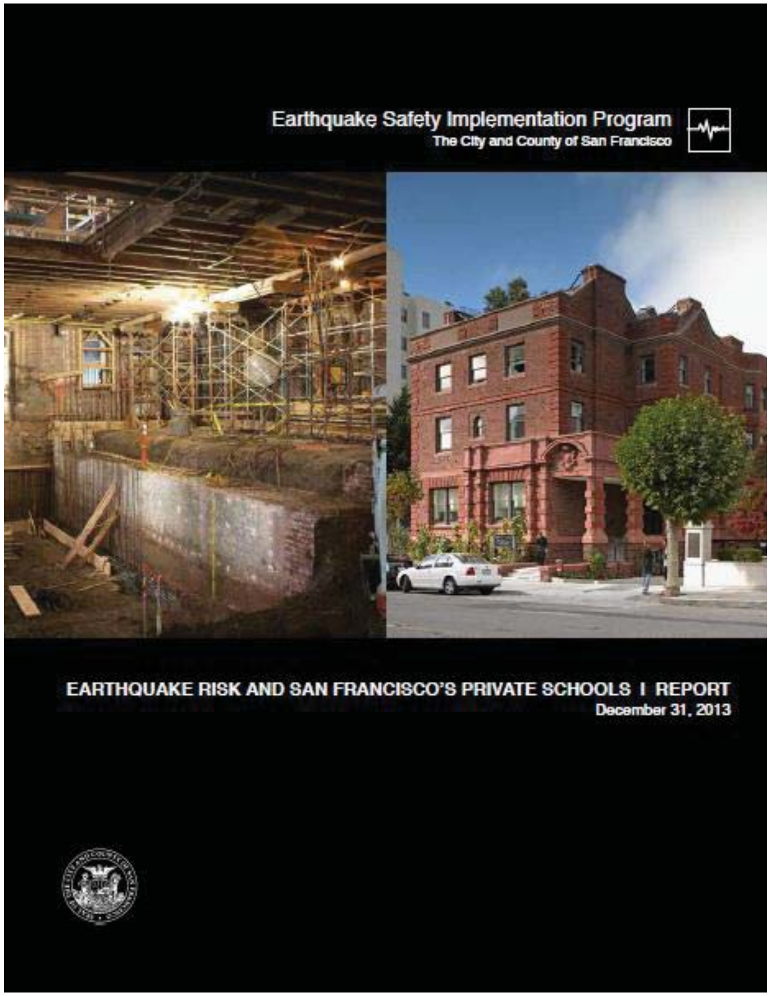
Mitigates one of the most significant potential impacts to San Francisco

Retrofit goal is shelter-in-place

500+ completed to date

Private Schools

- California Public Schools are safe
- Private Schools are not regulated
- 105 (57%) of the Schools in SF housed in potentially dangerous buildings
- 2014 Ordinance required evaluation and reporting
- Expect that understanding the vulnerability will resolve the risk.
- 99.9% compliance, some schools are retrofitting



San Francisco Lifelines Council

- 11 Primary and 19 Secondary Providers
- Meet quarterly, share openly, review lessons learned worldwide
- Began with current vulnerabilities and plans
- Includes regular review of lessons learned
- Special Studies in completed or process
  - Routes and access
  - Cell sites
  - Table top exercises
  - Interdependencies
  - Sea Wall Study

Los Angeles Times

BREAKING NEWS

It could cost $3 billion to prevent an earthquake from wreaking havoc along San Francisco's famous Embarcadero

Los Angeles Times | April 18, 2016 | 6:01 AM

Companion Programs

- Neighborhood Empowerment Network
- Neighborhood Emergency Response Teams
- Building Occupancy Resumption Program
- Community Engagement
- Give2SF
- SF Community Agencies Responding to Disasters
- SF Ready
- Vial of Life
- 72 hours.org
- 100 RC

CITY & COUNTY OF SAN FRANCISCO
100 RESILIENT CITIES

PIONEERED BY THE ROCKEFELLER FOUNDATION 100 RESILIENT CITIES

2014 | 2015 | 2016 | 2017

Jan Apr Jul Oct Jan Apr Jul Oct Jan Apr Jul Oct Jan

- San Francisco appoints the world's first Chief Resilience Officer
- Phase 1: Launch
- Stakeholder Engagement Workshop
- Phase 2: Focus Area Workshops
- Draft Scope of Work Resilient Action Plan Development
- Regional Design Competition Stakeholder Meeting
- Sea Level Rise Vulnerability Assessment of all City Assets
- City Hall Post Earthquake Inspection Exercise
- **Resilient San Francisco Strategy Release**
- Implementation / Neighborhood Charrettes

186 **Individuals Representing,**

31 **City Departments, and**

56 **Organizations**

86 **Diagnostic Tasks Completed in Phase 2**

ESIP

Suggested Next Steps

- Understand and coordinate with other resilience planning activities
  - DHS Critical Infrastructure Planning
  - State of Utah
  - Wasatch Front
  - Existing City and County Plans
- Develop a conceptual resilience plan for the Wasatch Front *(who can do this?)*
  - Develop suite of scenarios
  - Set performance levels,
  - Estimate (guess) anticipated performance
  - Summarize into generalize performance matrices
  - Identify temporary solutions including mutual aid

Suggested Next Steps

- Incorporate resilience plan concepts into existing General and Special plans
  - Department of Homeland Security
    - Utah Critical Infrastructure Resilience Symposium
  - UDOT
    - Unified Transportation Plan 2011-2040
    - Long Range Transportation Plan 2015-2040
  - Utilities
    - Utah Sustainable Transportation and Energy Plan
  - City and County
    - General and Land Use Plans
    - Economic Development Plans
  - Business Continuity
  - NGO Service Provider
  - Civil Society Service Providers

Questions
and
Comments

Utah Earthquake Resiliency Workshop
April 27, 2016

TAB 2

Earthquakes

TAB #2

Earthquakes: Public Perception vs. Reality

PANELISTS
Dr. James C. Pechmann
Dr. Steven F. Bartlett, PE
Brent Maxfield, SE

MODERATOR
Dr. Jerod Johnson, SE

The panel of engineers and seismologists will share perceptions the public has in regard to how engineers use the building code to design buildings and the performance expectations of code-designed buildings following an earthquake.

They will also cover the ground motions the code requires to be used for building design and how these ground motions relate to what could happen in a magnitude 7 earthquake.

DR. JAMES C. PECHMAN
Seismologist, Department of Geology & Geophysics
University of Utah

Dr. Pechmann is a seismologist in the Department of Geology and Geophysics at the University of Utah, where he is currently a Research Associate Professor. He earned a B.A. degree in Geology in 1976 from Hamilton College and a Ph.D. in Geophysics in 1983 from the California Institute of Technology.

In his 33 years at the University of Utah he has done research on earthquake hazards, seismotectonics, earthquake source properties and ground motions and crustal structure in the eastern Basin and Range Province.

Dr. Pechmann has also provided technical and scientific support for the University of Utah seismic network's ongoing operation, development, and data analyses, supervised graduate student research, and done some teaching and consulting work. He has served on many committees and working groups related to earthquake hazards, including the Working Group on Utah Earthquake Probabilities which recently released the results of its six-year-long project.

DR. STEVEN F. BARTLETT, PE
Department of Civil & Environmental Engineering
University of Utah

Dr. Bartlett has a bachelor of science in geology (1983) and a doctorate in civil engineering (1992) with an emphasis in geotechnical engineering from Brigham Young University.

He is a licensed professional engineer in the State of Utah and has 25 years of design and construction experience working with Westinghouse, Woodward-Clyde Consultants, Utah Department of Transportation Research Division and the University of Utah. Currently, he is an associate professor of Civil and Environmental Engineering at the University of Utah.

His research interests are in the development, design and long-term performance monitoring of construction technologies for transportation systems and infrastructure with an emphasis on rapid construction techniques, improving seismic resiliency and risk and vulnerability assessments.

EARTHQUAKES: PUBLIC PERCEPTION VS. REALITY

BRENT MAXFIELD, SE
Civil/Structural Engineer,
Special Projects Department
The Church of Jesus Christ
of Latter-day Saints

Brent is a Professional Structural Engineer with over 30 year experience working on structural and seismic projects. He is currently employed by The Church of Jesus Christ of Latter-day Saints.

Brent is an active member of local professional societies. He has served two terms on the Board of the Structural Engineers Association of Utah (SEAU) and is currently the Past President of the Earthquake Engineering Research Institute (EERI) Utah Chapter. He is the author of three books on the use of the software program Mathcad.

Brent has been instrumental in getting the Building Occupancy Resumption Program (BORP) adopted in Salt Lake City, Murray City and Farmington.

In 2012, he was named the Utah Engineer of the Year by the Utah Engineers Council.

DR. JEROD JOHNSON, SE
Principal Structural Engineer
Reaveley Engineers +
Associates

Jerod is a principal with Reaveley Engineers + Associates and has over 22 years of design and construction experience. He received his degrees at the University of Utah and is currently an adjunct professor teaching courses in concrete, masonry and timber design and also serves as a guest lecturer and member of multiple graduate student committees.

Dr. Johnson's continuing research is focused toward structural dynamics and earthquake engineering where he has been principal investigator for analytical studies of the effectiveness of nonlinear tuned mass dampers for improving building resilience. He has also undertaken major research projects investigating the effect of aging and stability on base isolation system performance.

He has played a key role in some of the most significant projects of the region including the Salt Palace Expansion, South Towne Exposition Center and the Utah State Capitol Renovation and Base Isolation. He is a regularly featured author for SEAU monthly newsletter and Structure magazine, the official monthly publication of the National Council of Structural Engineers Associations.

He currently serves on the board of directors as past president of SEAU and has served as a member of the board for the Utah Chapter of the Earthquake Engineering Research Institute.

Utah Earthquake Resiliency Workshop, April 27, 2016
Panel Discussion on "Earthquakes: Public Perception vs. Reality"

Figures from panel member
James C. Pechmann
University of Utah Seismograph Stations

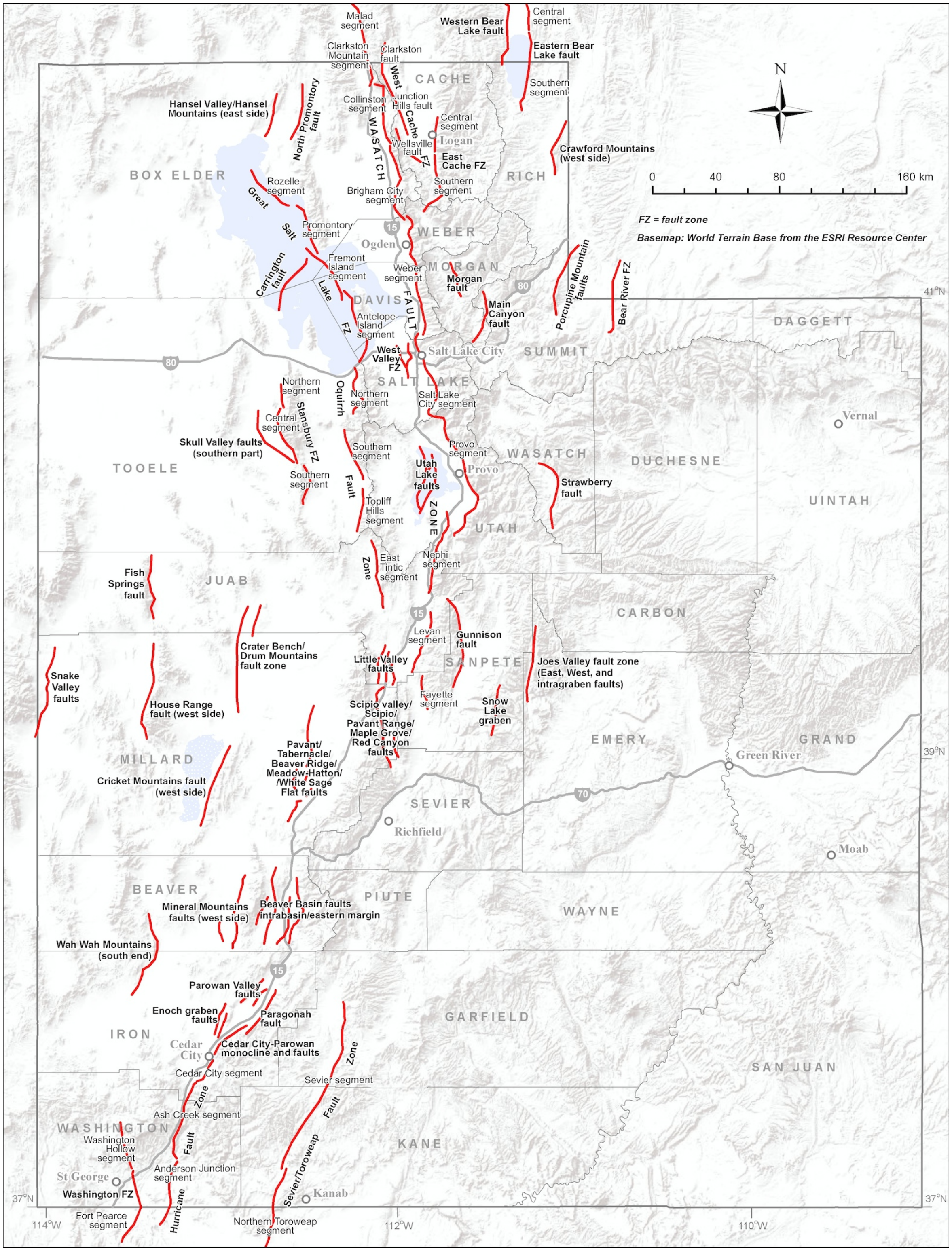


Figure 1. Generalized fault map of Utah showing all known late Quaternary faults (most recent movement < 130,000 yrs) considered capable of generating an M ≥ 6.75 earthquake (Lund, 2014). For a more complete and detailed fault map, see the following Utah Geological Survey web page: http://geology.utah.gov/resources/data-databases/qfaults/ .

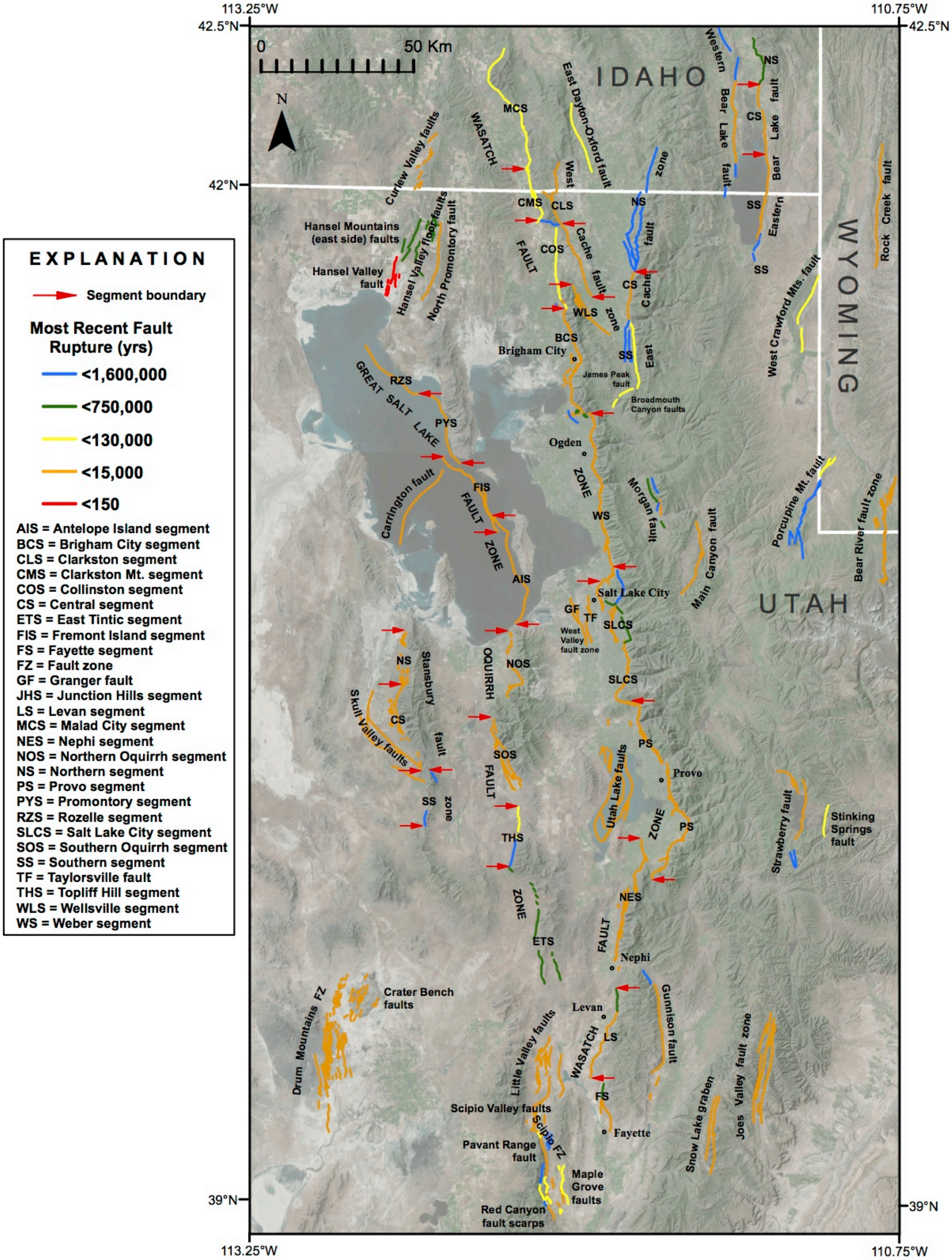


Figure 2. Faults and fault segments in the Wasatch Front region that were considered in the Working Group on Utah Earthquake Probabilities probabilistic earthquake forecast (Wong et al., 2016). Base imagery from the USGS and National Aeronautics and Space Administration (http://imagery.arcgisonline.com).

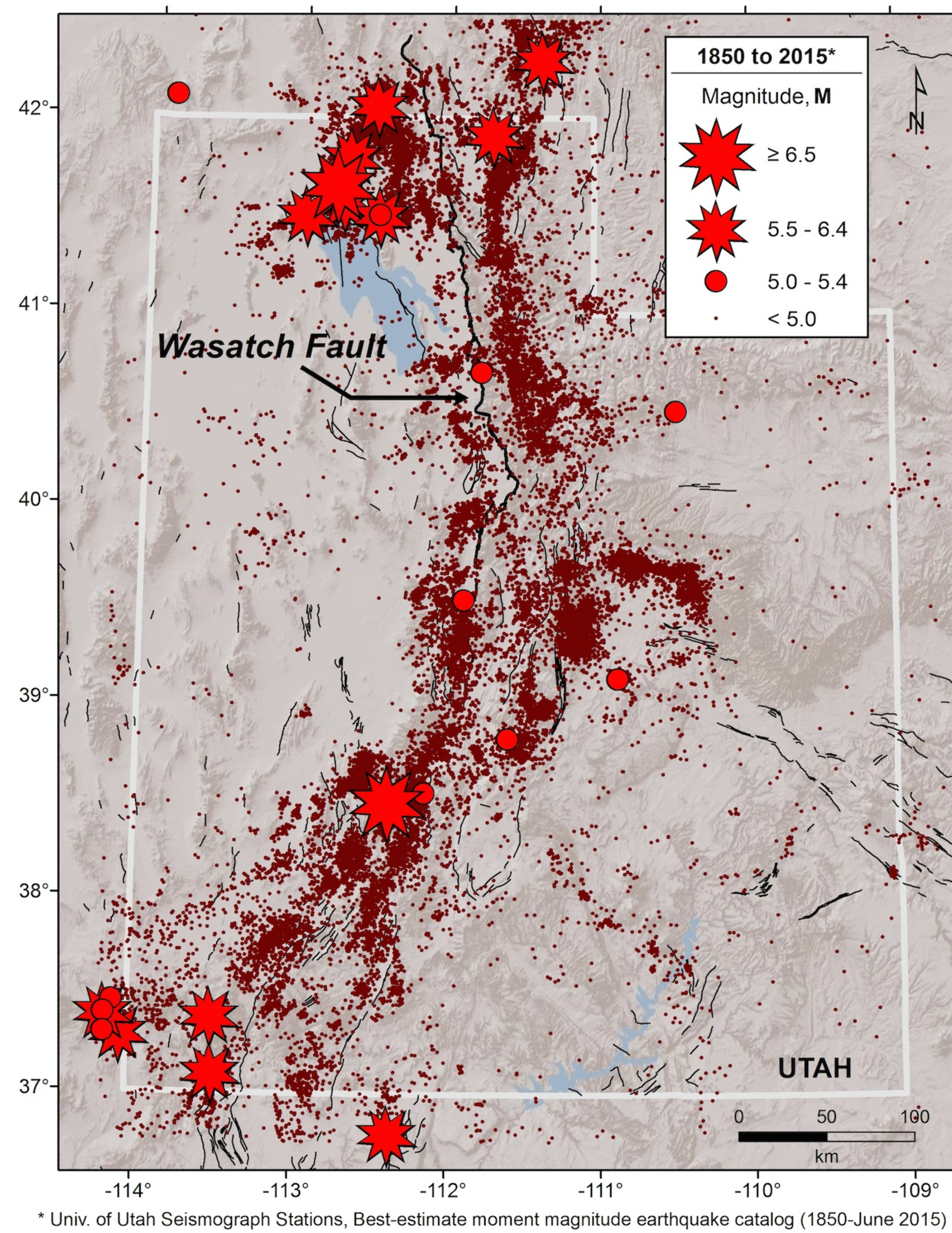


Figure 3. Epicenter map of earthquakes in the Utah region from 1850 through 2015 (from Walter Arabasz, University of Utah Seismograph Stations). Epicenters are scaled by best estimate moment magnitudes (see Arabasz et al., 2016). Magnitude completeness thresholds vary with location and time. The black lines are Quaternary faults from Black et al. (2003).

Table 1. *Largest mainshocks in the Utah Region, **M** ≥ 4.85, 1850–September 2012 (Arabasz et al., 2016).*

ID	Year	MoDay	**Hr:Min** (UTC/GMT)	Region[1]	M[2]	σ	Long W	Lat N	Depth[3] (km)	BEM Type[4]
1	1884	1110	08:50	*Paris, Idaho*	5.58	0.50	111.400	42.300	-----	Mpred|Io
2	1901	1114	04:39	Tushar Mountains	6.63	0.29	112.400	38.500	-----	Mpred|Xnon
3	1902	1117	19:50	Pine Valley	6.34	0.50	113.520	37.393	-----	Mpred|Io
4	1909	1006	02:41	*Hansel Valley*	5.58	0.50	112.700	41.800	-----	Mpred|Io
5	1910	0522	14:28	*Salt Lake City*	5.28	0.29	111.800	40.700	-----	Mpred|Xnon
6	1921	0929	14:12	Elsinore	5.45	0.29	112.150	38.683	-----	Mpred|Xnon
7	1934	0312	15:05	*Hansel Valley*	**6.59**	0.30	112.795	41.658	9	Mobs
8	1937	1119	00:50	*Idaho-Nevada-Utah tri-state area*	5.40	0.37	113.900	42.100	-----	M~|MxSJG
9	1950	0118	01:55	NW Uinta Basin	5.30	0.20	110.500	40.500	-----	M~|UknPAS
10	1959	0721	17:39	Arizona-Utah border	5.55	0.14	112.370	36.800	-----	Mpred|Xmix
11	1962	0830	13:35	*Cache Valley*	**5.75**	0.15	111.733	41.917	10	Mobs
12	1962	0905	16:04	*Magna*	4.87	0.12	112.089	40.715	7*	Mpred|Xmix
13	1963	0707	19:20	*Juab Valley*	**5.06**	0.15	111.909	39.533	4	Mobs
14	1966	0816	18:02	Nevada-Utah border	5.22	0.20	114.151	37.464	7*	Mpred|Xvar
15	1967	1004	10:20	Marysvale	**5.08**	0.15	112.157	38.543	14	Mobs
16	1975	0328	02:31	*Pocatello Valley, Idaho*	**6.02**	0.06	112.525	42.063	5	Mobs
17	1988	0814	20:03	*San Rafael Swell*	5.02	0.13	110.890	39.133	17	Mpred|Xvar
18	1989	0130	04:06	So. Wasatch Plateau	**5.20**	0.10	111.614	38.823	25	Mobs
19	1992	0902	10:26	St. George	**5.50**	0.10	113.506	37.105	15	Mobs

[1] Unless indicated otherwise, all epicenters are within Utah; italics indicate epicenters within the WGUEP Region.
[2] Bold values are observed moment magnitude, $\mathbf{M}_{obs}$; other values, best-estimate moment magnitudes.
[3] Listed only where there is instrumental focal-depth control; asterisk indicates restricted focal-depth.
[4] Best-estimate moment magnitudes, based either on $\mathbf{M}_{obs}$, $\mathbf{M}^{\sim}$ (a magnitude type assumed to be equivalent to **M**), or $\mathbf{M}_{pred}$ from magnitude conversion relationships. Xnon indicates best estimate from inverse-variance weighting of non-instrumental size measures; Xmix, from non-instrumental and instrumental size measures; Xvar, from instrumental size measures. See Arabasz et al. (2016) for explanation of other details.

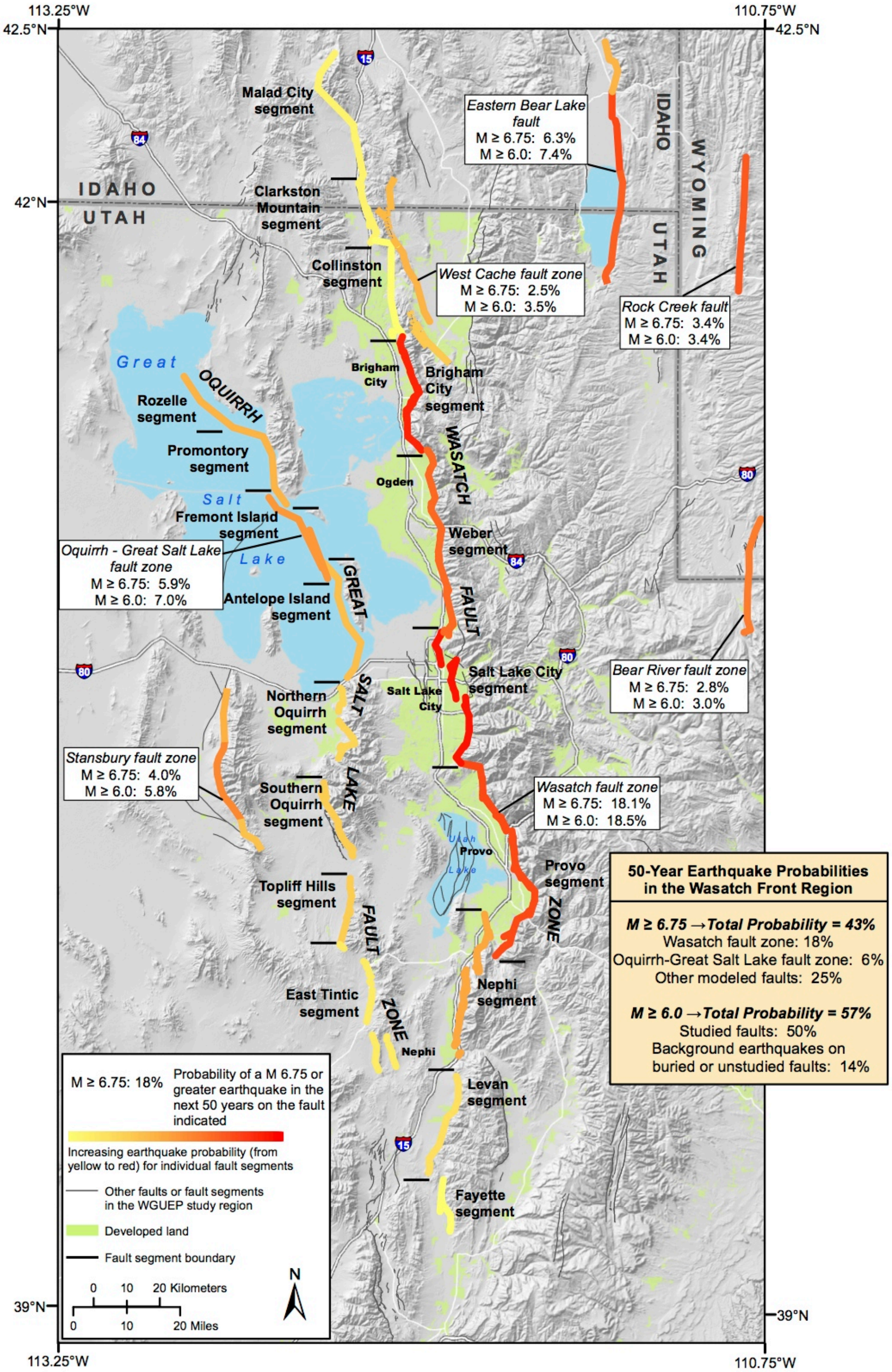


Figure 4. Probabilities of one or more earthquakes of **M** 6.0 and M 6.75 or greater in the next 50 years (2014-2063) in the Wasatch Front region estimated by the Working Group on Utah Earthquake Probabilities (Wong et al., 2016). "Other modeled faults" are those faults other than the Wasatch and Oquirrh-Great Salt Lake fault zones.

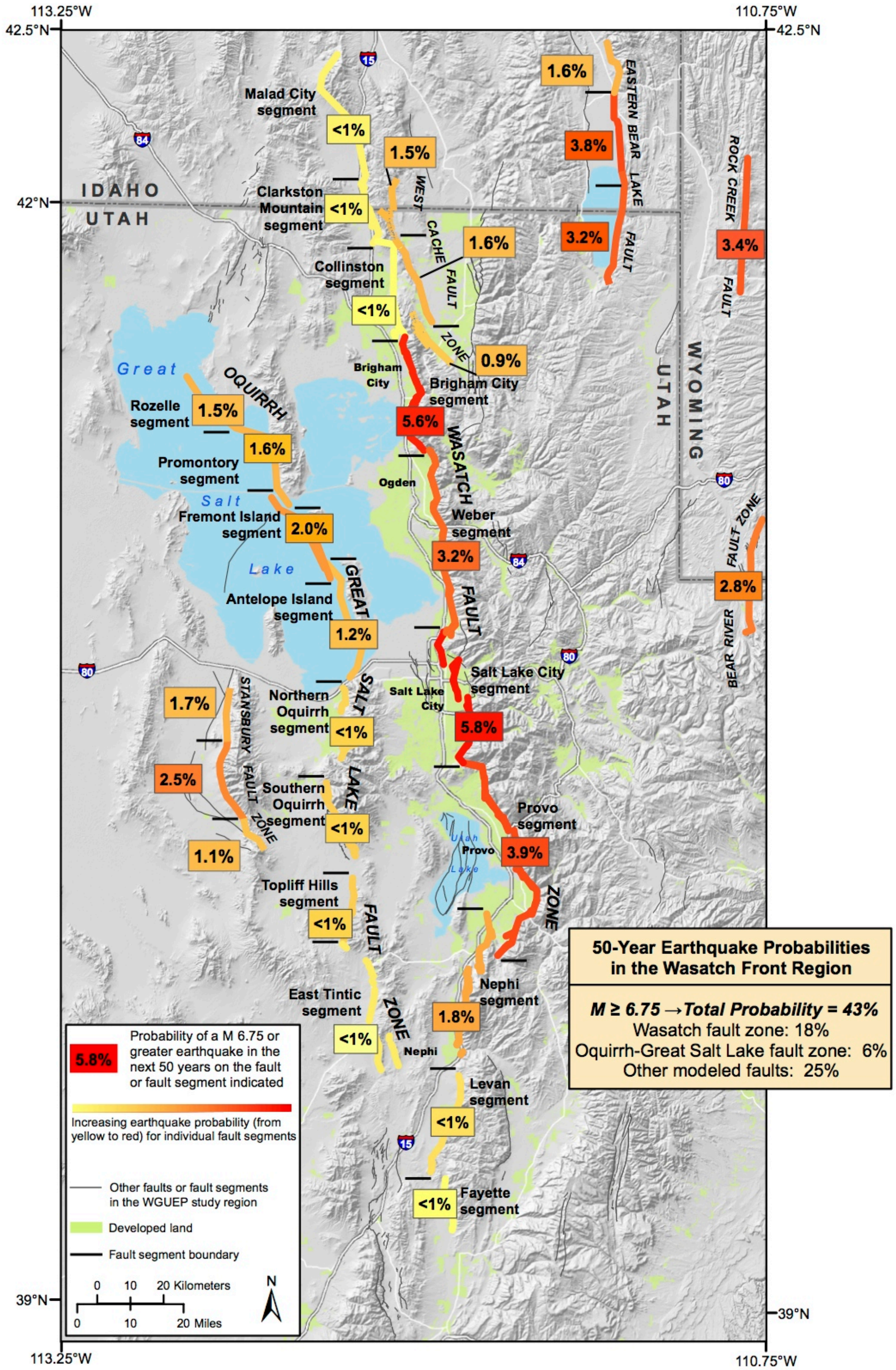


Figure 5. Probabilities of one or more earthquakes of **M** 6.75 and greater in the next 50 years on selected fault segments in the Wasatch Front region, as estimated by the Working Group on Utah Earthquake Probabilities (Wong et al., 2016).

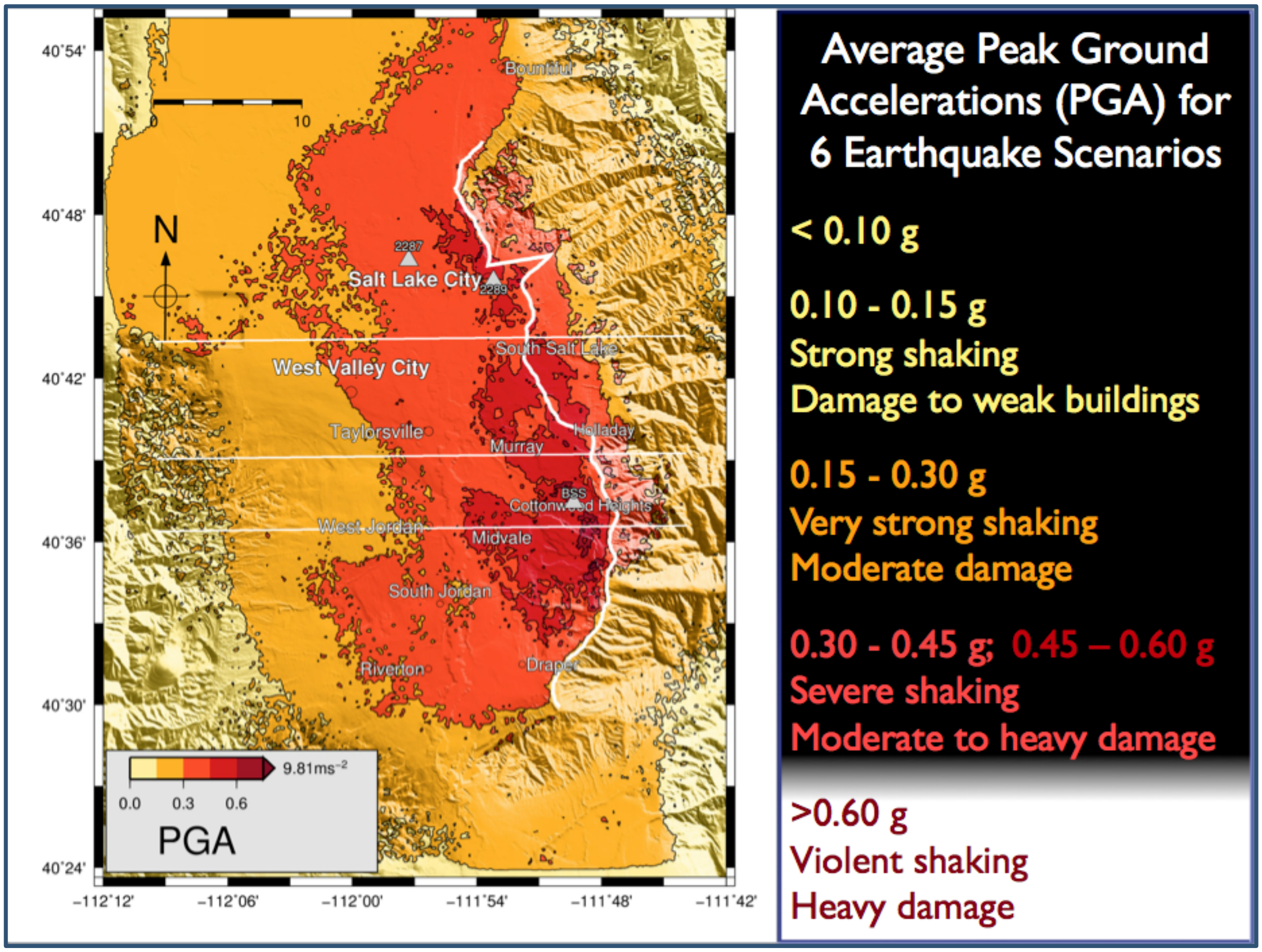


Figure 6. Map of predicted peak horizontal ground accelerations (PGA) from an M 7.0 earthquake on the Salt Lake City segment of the Wasatch fault (Roten et al., 2012). The PGAs are geometric means from numerical simulations of six scenario earthquakes with different starting points and fault rupture details. The PGAs from each scenario were corrected for soil nonlinearity. The white line shows the surface trace of the fault break.

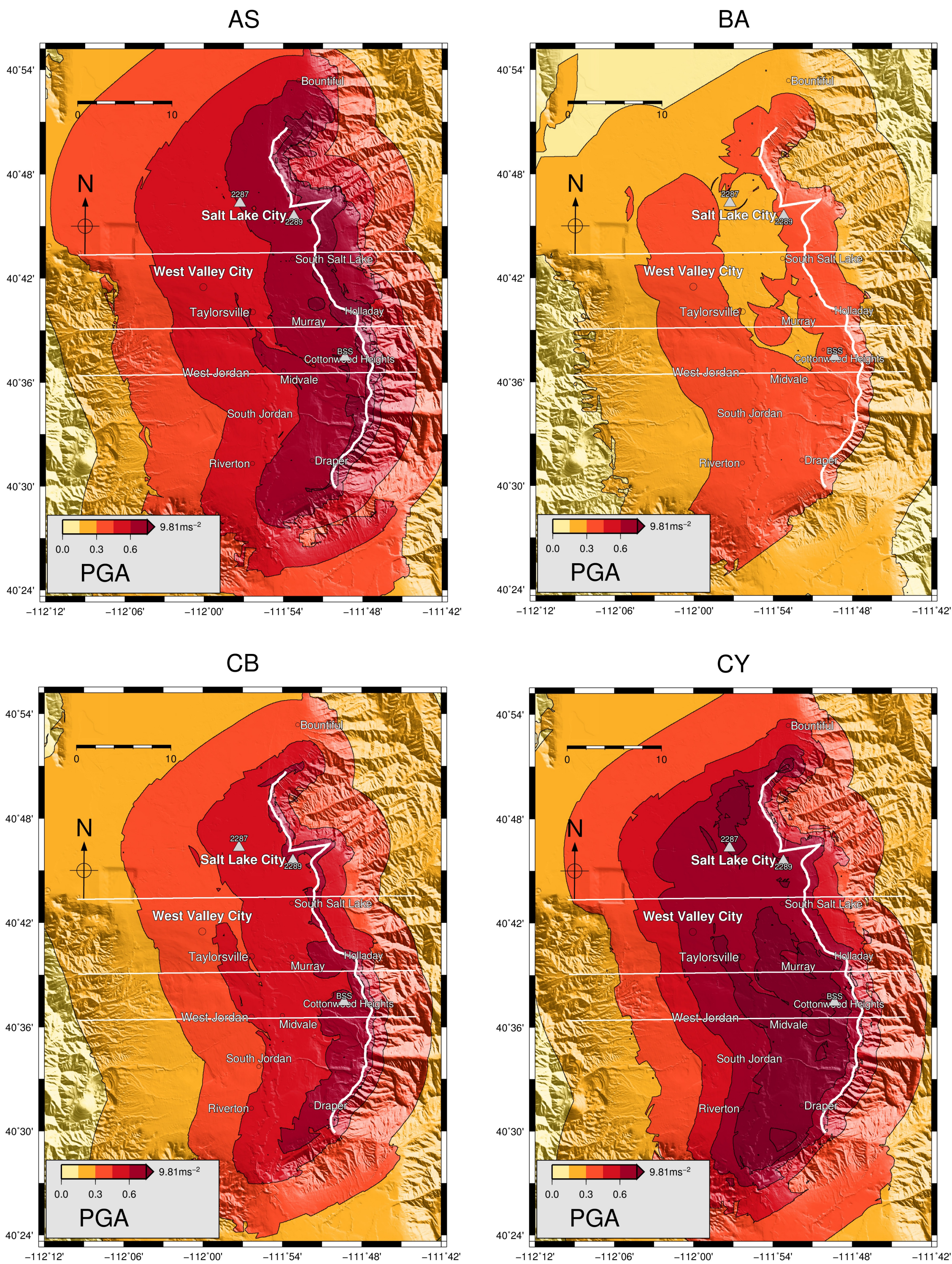


Figure 7. Map of predicted peak horizontal ground accelerations from an M 7.0 earthquake on the Salt Lake City segment of the Wasatch fault (Roten et al., 2012, electronic supplement). The predictions are from four different ground motion prediction equations, as indicated by the labels at the top of each panel: AS (Abrahamson and Silva, 2008), BA (Boore and Atkinson, 2008), CB (Campbell and Bozorgnia, 2008), and CY (Chiou and Youngs, 2008).

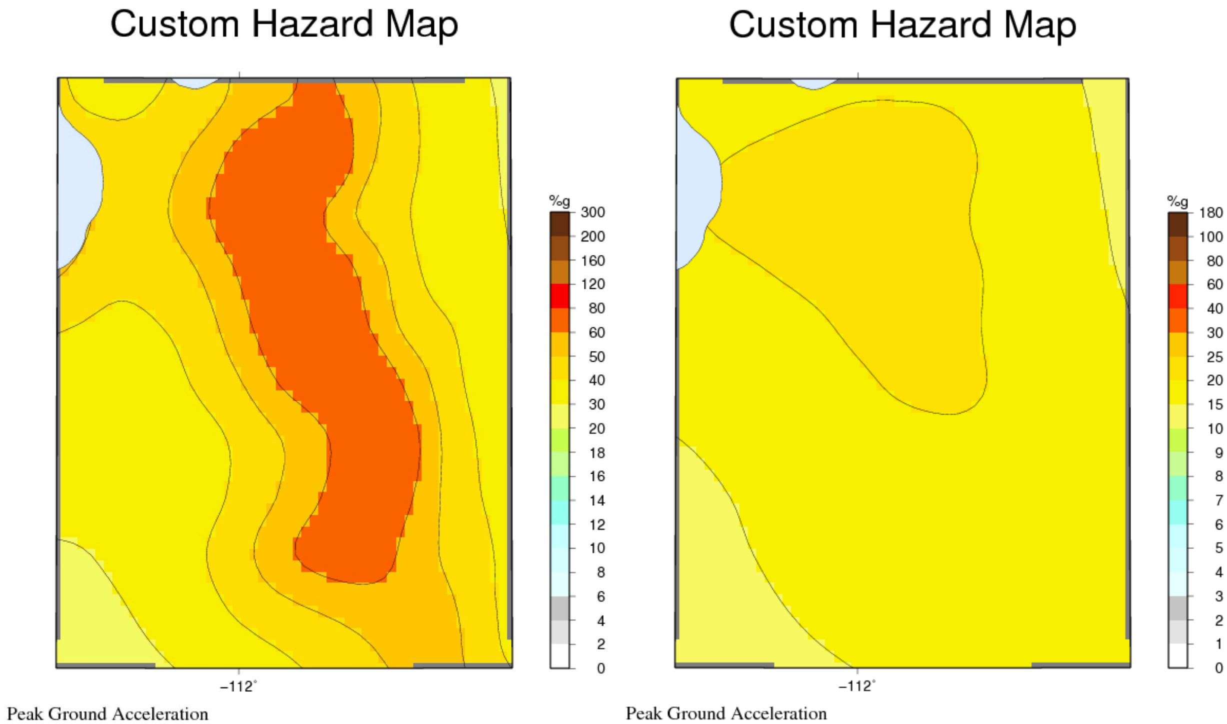


Figure 8. Probabilistic seismic hazard maps of the Salt Lake Valley region showing peak horizontal ground accelerations with a 2% (left) and 10% (right) probability of exceedance in 50 years. The area shown is approximately the same as in Figures 7 and 8. These maps were extracted from the 2008 United States National Seismic Hazard Maps (Petersen et al., 2008) using the custom hazard mapping tool at http://geohazards.usgs.gov/hazards/apps/cmaps/ . These maps are for uniform firm-rock site conditions, defined by an average shear wave velocity in the uppermost 30 m (V_s30) of 760 m/s. The probabilistic ground motion maps in this figure are not directly comparable to the deterministic ground motion maps in Figures 6, 7, and 9, which are for the more realistic, spatially variable V_s30 values in Version 3c of the Wasatch Front Community Velocity Model (Magistrale et al., 2008, 2009).

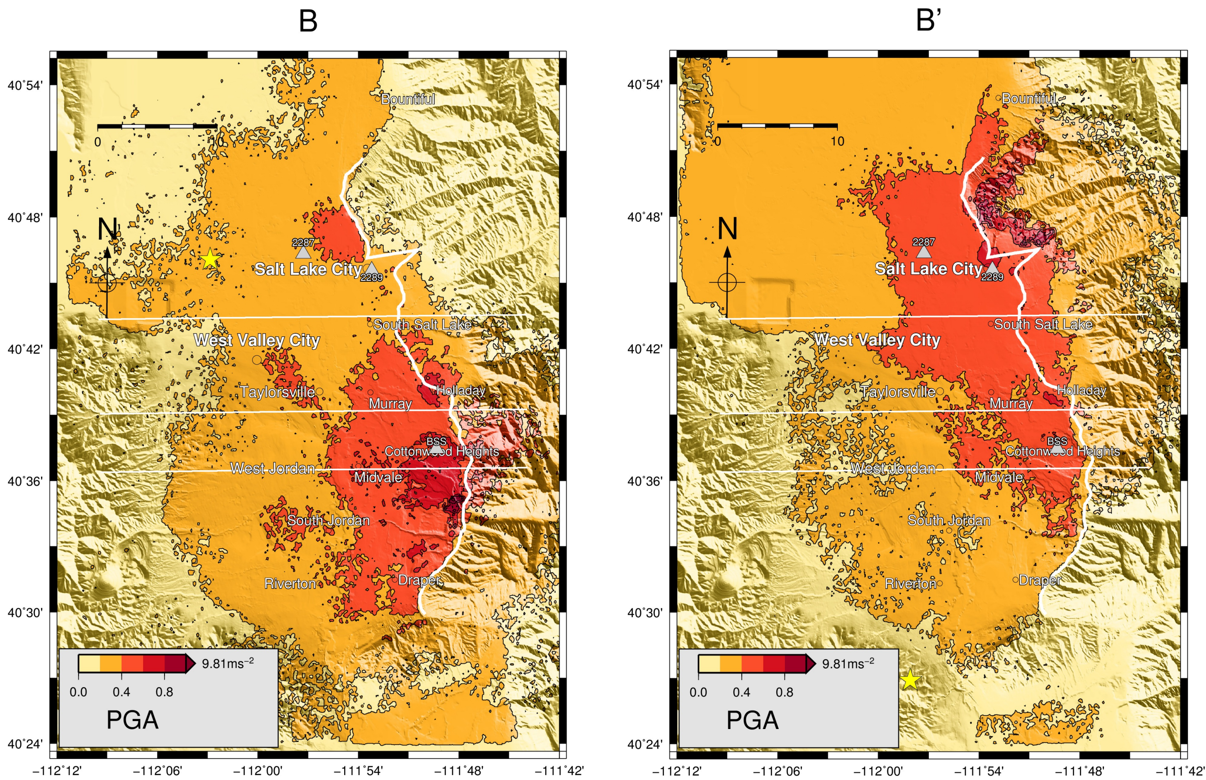


Figure 9. Maps of predicted peak horizontal ground accelerations from numerical simulations of two different scenarios for an M 7.0 earthquake on the Salt Lake City segment of the Wasatch fault (Roten et al., 2012, electronic supplement). In scenario B on the left, the fault break starts at the yellow star in the northwestern part of the Salt Lake Valley and propagates southward. In scenario B´ on the right, the fault break starts at the yellow star on the southwestern edge of the valley and propagates northward. Note the large differences in the ground shaking patterns for the two scenarios. The PGAs from each scenario were corrected for soil nonlinearity. The white line shows the surface trace of the fault break.

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Scenario for a Magnitude 7.0 Earthquake on the Wasatch Fault–Salt Lake City Segment

Hazards and Loss Estimates

**Developed by the
Earthquake Engineering Research Institute,
Utah Chapter**

**Prepared for the
Utah Seismic Safety Commission**

June 4, 2015

Executive Summary

Earthquakes pose the greatest natural threat to Utah's people, built environment, and economy. For planning purposes, a scenario is presented that describes the massive physical, economic, and social impacts that will result from a future large magnitude 7.0 earthquake on the Salt Lake City segment of the Wasatch fault. The concentration of population, infrastructure, and economic activity in the Wasatch Front urban corridor, literally astride the Wasatch fault, aggravates Utah's earthquake vulnerability.

Earthquakes pose the greatest natural threat to Utah's people, built environment, and economy

A key aim of this report is to present a realistic picture of the effects of the Wasatch fault scenario earthquake—in particular, how long it may take the state of Utah and its residents to fully recover and the potential long-term impacts on Utah's economy. This report was developed by the Utah Chapter of the Earthquake Engineering Research Institute with assistance from earthquake professionals in the Utah community. Funding was provided by the Federal Emergency Management Agency (FEMA). Our primary audience is the Utah Seismic Safety Commission, whose mission is to identify earthquake-related hazards and risks to the state of Utah and its inhabitants and to promote actions that will mitigate these hazards and risks to reduce earthquake losses. More broadly, this report is intended to inform policy makers, emergency managers, and the general public.

The ultimate goal of this report is to catalyze public and private actions that will increase pre-disaster resiliency through earthquake preparedness—being prepared to WITHSTAND, to RESPOND, and to RECOVER. Prepared to WITHSTAND requires: the strengthening of weak buildings to reduce loss of life and injury; addressing the seismic vulnerability of schools and government-owned buildings; encouraging more robust building design; and reducing potential interruptions to business operations and essential services. Prepared to RESPOND requires: understanding the scope of disaster-response needs; anticipating loss of utilities; exercising response plans; anticipating the need to inspect, in a timely way, hundreds of thousands of buildings for safe occupancy; and adopting policies that will facilitate fast and thorough post-earthquake inspections of buildings that house vital businesses and essential services. Prepared to RECOVER requires: establishing beforehand laws, rules, and ordinances that address issues foreseeable in circumstances of disaster recovery; planning for resiliency to recover at individual, family, and community levels; developing continuity plans for businesses and schools; planning to provide essential utilities on a temporary basis; and planning for restoring essential utilities on a permanent basis.

The scenario earthquake is a real verifiable threat. At least 22 large surface-faulting earthquakes ("Big Ones") of about magnitude 7 have occurred during the past ~6,000 years, about once every 300 years on average, along one of the five central segments of the Wasatch fault between Brigham City and Nephi. The average repeat time of Big Ones on the Salt Lake City segment is about 1,300–1,500 years. The last one occurred around 1,400 years ago—enough time for strain energy to build up to unleash another.

The estimated short-term economic loss is over $33 billion

The expected severity and distribution of strong ground shaking during the scenario earthquake is modeled using the U.S. Geological Survey's ShakeMap computer program. As a result of rupture of the entire Salt Lake City segment of the Wasatch fault, most of the Salt Lake Valley will experience severe ground shaking; strong potentially damaging ground shaking will extend along the Wasatch Front urban corridor from southern Utah Valley to north of Ogden. Besides ground shaking, other physical effects associated with the scenario earthquake will include: rupture of the ground surface (up to 8 feet vertically) along the trace of the Wasatch fault from Draper to North Salt Lake; widespread liquefaction of sediments in lowland areas of the Salt Lake Valley, potentially damaging structures and facilities; perhaps hundreds of landslides and rockfalls, especially under wet conditions, in areas of steep rock slopes and river embankments that experience strong to severe ground shaking; and extensive ground subsidence, possibly resulting in flooding by the Great Salt Lake, depending on lake level.

More than 84,000 households are expected to be displaced with nearly 53,000 individuals seeking shelters

Hazus is a standardized, nationally applicable software package developed by FEMA for loss and risk assessment associated with earthquakes, hurricanes, and floods. A pivotal part of this report addresses the economic and social impacts of the scenario earthquake, using Hazus and Geographic Information Systems (GIS) technology. Aggregate loss estimates are for a region that encompasses Utah's 12 most northern counties: Box Elder, Cache, Davis, Juab, Morgan, Rich, Salt Lake, Summit, Tooele, Utah, Wasatch, and Weber.

There will be a need to evaluate for safe occupancy more than 300,000 structures in 30 days, which will require about 2,400 building inspectors

Loss estimates for the scenario earthquake indicate disastrous impact. The estimated short-term economic loss is over $33 billion. This includes (1) direct building-related capital losses (including structural, non-structural, content, and inventory) of $24.9 billion, (2) income losses of $6.9 billion, and (3) lifeline-related losses of $1.4 billion. More than 84,000 households are expected to be displaced with nearly 53,000 individuals seeking shelters. Depending on the time of day, there will be an estimated 2,000 to 2,500 deaths, and the estimated number of people injured and needing hospital care ranges from 7,400 to 9,300. Essential lifelines such as water, electricity, gas, and sewer will be disrupted for days to months, and in some locations in the Salt Lake Valley, perhaps longer. An example challenge will be the need to evaluate for safe occupancy more than 300,000 structures in 30 days, which will require about 2,400 building inspectors. Another challenge will be the removal of debris generated by the earthquake—requiring over 820,000 truckloads at 25 tons per truck.

Essential lifelines such as water, electricity, gas, and sewer will be disrupted for days to months, and in some locations in the Salt Lake Valley, perhaps longer

For response planning, an operational picture of the scenario earthquake disaster is provided by Hazus maps variously showing the expected distribution of damaged buildings, displaced households, highway infrastructure impacts, impaired hospitals and hospital bed availability, potential search and rescue needs, and the location of care facilities for the elderly. Similarly, for recovery planning, Hazus maps are presented that show the distribution of direct building economic losses; likely damaged electrical, natural gas, and oil facilities; concrete and steel debris and associated haulage implications for highways; and the distribution of non-English speaking populations (for communicating disaster-related information).

Nine recommendations to improve seismic safety and resiliency conclude the report

The conclusion of the report is a call to action—to make Utah and its communities more resilient to earthquake disaster. Utah is NOT prepared for a major Wasatch fault earthquake. We end with nine recommendations to the Utah Seismic Safety Commission that are intended to stimulate and guide discussion with public officials and all stakeholders for effective action and change.

Recommendations to the Utah Seismic Safety Commission

1

INFORM THE GOVERNOR'S OFFICE AND THE UTAH STATE LEGISLATURE

Inform the Governor's Office and the Utah State Legislature of the expected physical, economic, and social impacts of a major Wasatch fault earthquake in the Salt Lake Valley. Emphasize what will cripple the state's recovery and what will prevent a catastrophe. State leaders should be encouraged to form a high-level public/private task force to address, as a priority, the resiliency and post-earthquake recovery of critical infrastructure and vital elements of Utah's economy.

2

INFORM STAKEHOLDERS

Inform public and private stakeholders in local jurisdictions, businesses, school districts, higher education, and neighborhoods of the grim reality following an earthquake. This could occur through press releases, public outreach, and town hall meetings. Provide these stakeholders with short-term and long-term actions they can take to make their response and recovery more efficient. We advise a proactive approach with the news media, helping them write compelling stories about this potential post-earthquake scenario along the Wasatch Front. The after-effects of this scenario earthquake must not be a surprise to anyone.

3

ASSESS THE OPERABILITY OF CRITICAL FACILITIES

Identify critical facilities including schools, police stations, fire stations, and acute care hospital buildings that have risk of inoperability after an earthquake. Establish a long-range plan to improve their post-earthquake operability.

4

PROMOTE POST-EARTHQUAKE RECOVERY PLANNING BY UTILITY PROVIDERS

Encourage every utility (public, private, and municipal) to create action plans that address the issues raised in this scenario report so that they can maintain services or restore them as soon as possible following an earthquake.

5

ADVOCATE SEISMIC RETROFITTING OF VULNERABLE BUILDINGS

Advocate the development of local and state legislation, as well as the necessary funding, requiring mandatory seismic retrofits of buildings that pose a life-safety risk, such as unreinforced masonry and non-ductile concrete structures that are for public use. Encourage local jurisdictions to create incentives for private building owners to increase resilience of their communities through seismic improvements to vulnerable structures.

6

ENCOURAGE ADOPTION OF POLICIES FOR BUILDING OCCUPANCY RESUMPTION

Encourage the adoption of the Building Occupancy Resumption Program (BORP) in all jurisdictions along the Wasatch Front and by the Utah Division of Facilities and Construction Management for state-owned buildings. This program (already adopted by Salt Lake City and Murray City) allows businesses and other building owners to pre-certify inspectors for emergency, post-earthquake evaluation of their facilities—which will enable them to quickly assess their buildings, begin recovery, and resume operations significantly faster.

7

PROMOTE IMPROVEMENT AND APPLICATION OF GEOLOGIC HAZARDS INFORMATION

Advocate continued state and federal support to improve information and maps on earthquakes and related geologic hazards. Promote these tools to the state, counties, and cities for land-use planning, development decisions, scenario planning, emergency response, and recovery planning.

8

ADVOCATE CONTINUED SUPPORT FOR CRITICAL SEISMIC MONITORING IN UTAH

Advocate continued state and federal support for operating and enhancing Utah's regional/urban seismograph network to ensure the availability of critical information for emergency management, emergency response, and future earthquake engineering. In the event of a large earthquake as outlined in this scenario, near-real-time information on the extent and severity of ground shaking will be vital for situational awareness. The ensuing earthquake information products from the network will be needed to guide short-term and long-term recovery efforts.

9

ADVOCATE DISASTER RESILIENCY PLANNING

Use the work done for this scenario to more fully engage stakeholders in developing disaster resiliency plans. This report is a first step that outlines the enormity of what will likely happen in this scenario earthquake, which can serve as a lesson for the rest of the state. What is needed next are plans that will expedite recovery and prevent catastrophe—whether after a large earthquake or any other large-scale disaster.

Key Seismic Concepts for the Workshop

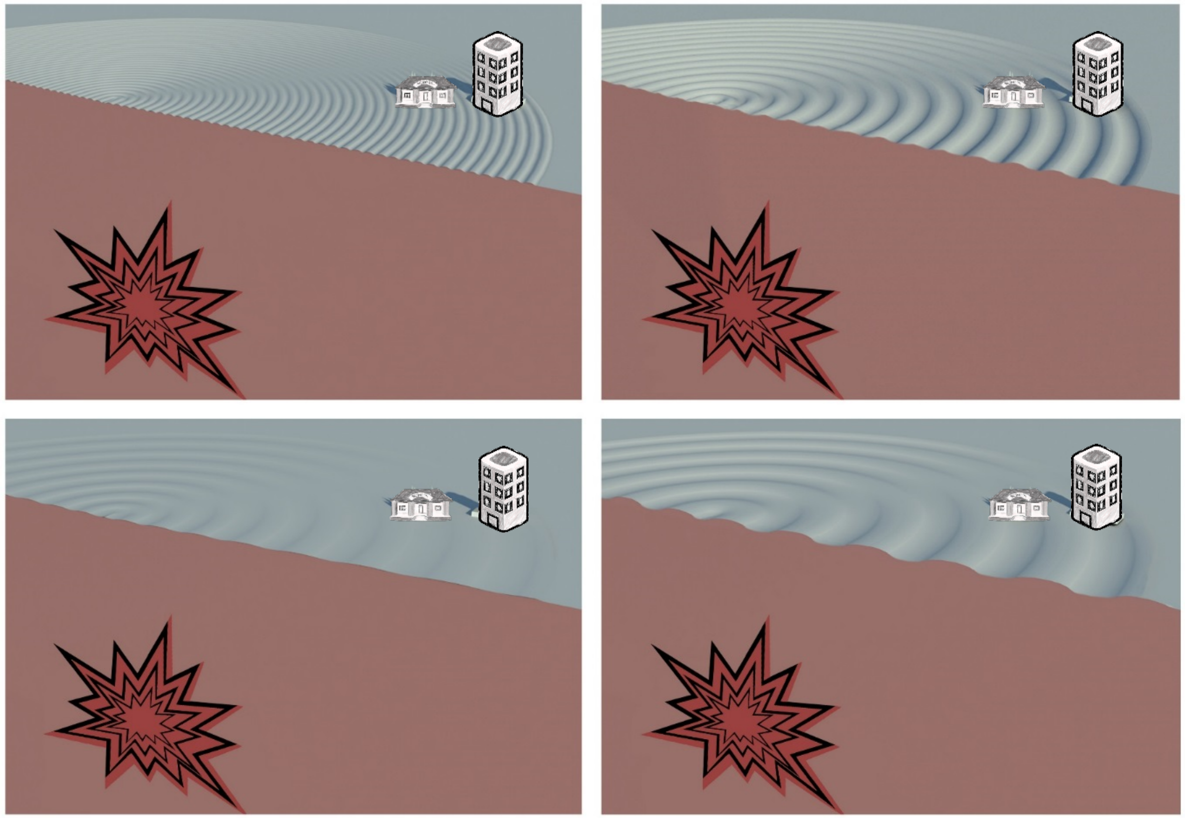
- Understand the difference between Seismic Waves (Shaking Intensity) vs Earthquake Magnitude.
- The code allows building damage, resulting in costly repairs and building downtime.
- The code sets a minimum building performance that is not adequate for a resilient Wasatch Front community.
- The code does not require buildings to be designed for the higher shaking intensity that a Wasatch fault earthquake could generate.
- Owners and communities who care about resiliency must determine the performance they want their buildings to have from possible Wasatch Front earthquakes and design accordingly. If they do not do this, the code sets the default performance.

Key Takeaways

- A code designed building does not equal a no-damage building.
- The code design shaking intensity does not adequately protect buildings from a Wasatch fault earthquake.
- For a resilient Wasatch Front, we must design for more than the minimum code requirements.

Shaking Intensity

Not Magnitude



Earthquake releases energy.
Energy creates variable surface waves.
Wave intensity can only be predicted within a range.
Building performance depends on which waves impact building.

Modified Mercalli Index (MMI) (Measure of Intensity)

To understand the impact of an earthquake,

MMI is More Critical than Magnitude

- Because shaking intensity is what determines damage, look at MMI not magnitude
- Scale of I to X+

Location	Date	Magnitude	MMI
Japan	2016-04	7.0	IX
Christchurch	2011-06	6.1	IX
Haiti	2010-01	7.0	IX
Ecuador	2016-04	7.8	VIII
Japan	2016-04	6.0	VIII
Japan	2011-03	9.0	VIII
Chilie	2010-02	8.8	VIII

Intensity Scale

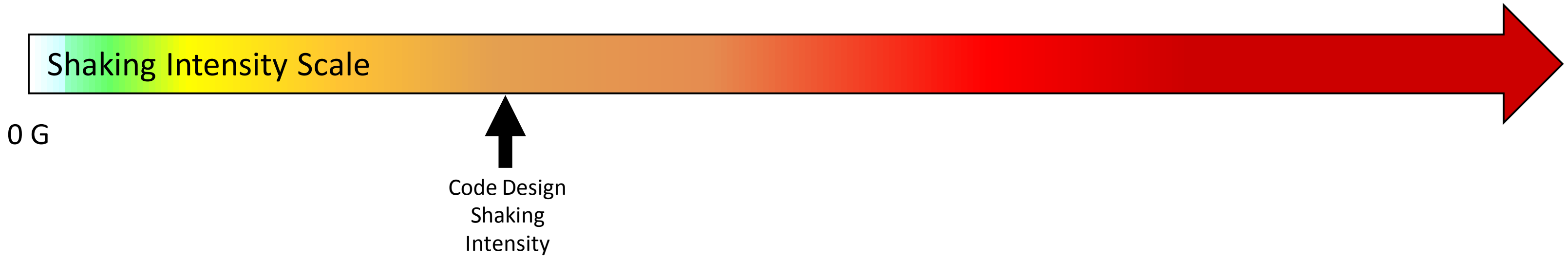
Intensity	Shaking
I	Not felt
II	Weak
III	Weak
IV	Light
V	Moderate
VI	Strong
VII	Very strong
VIII	Severe
IX	Violent
X	Extreme

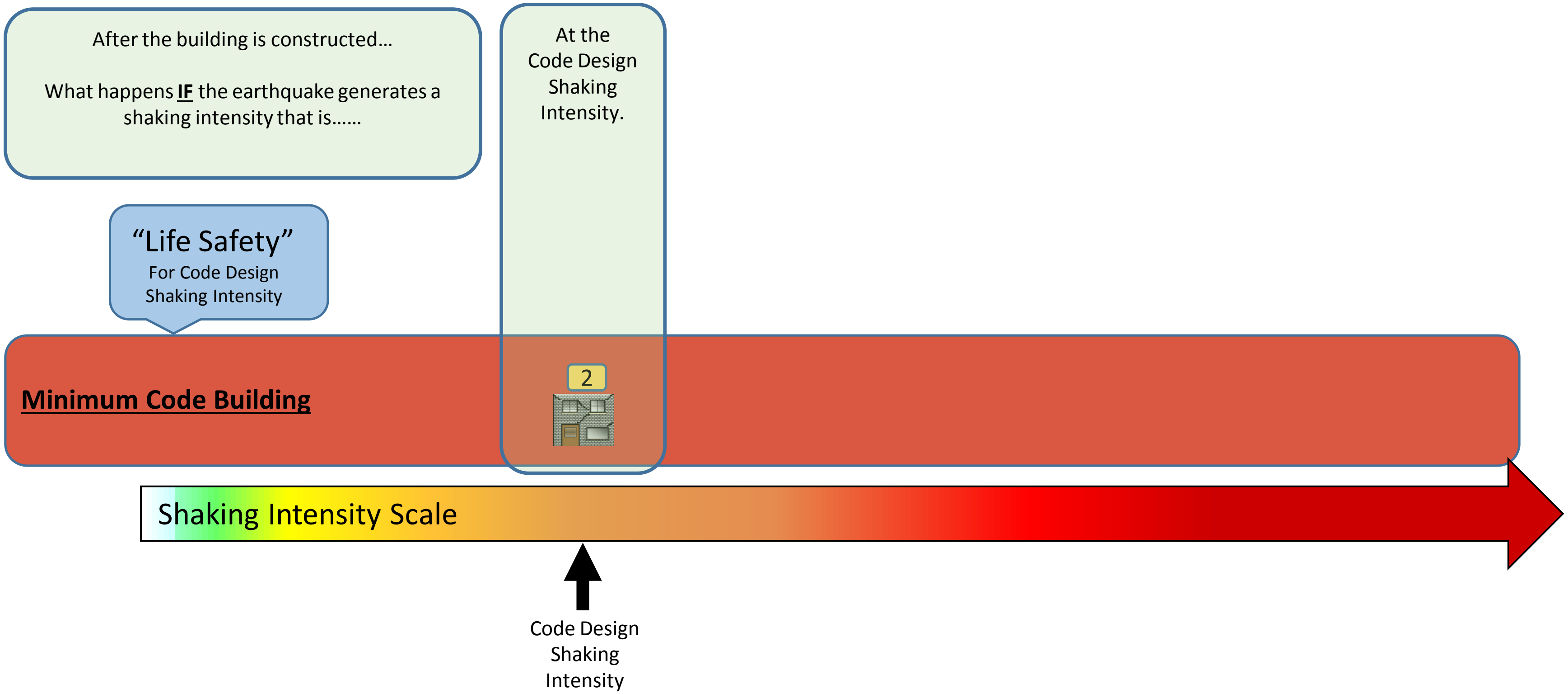
Building Code Damage Expectations

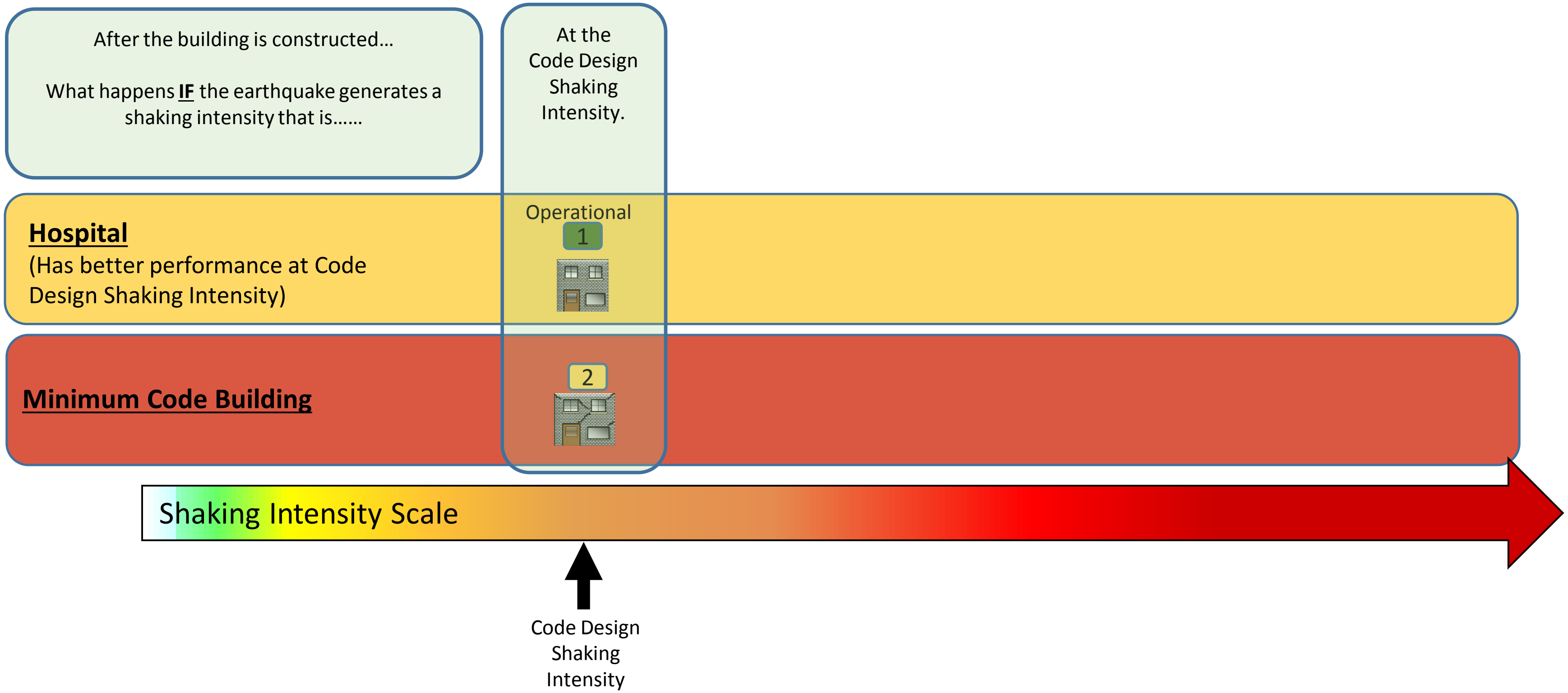
Damage State	Structural Damage	Nonstructural Components Damage	Building Systems	Deaths	Dollars	Downtime
1 	Minimal	Some	Functioning	None	$	Repair while occupied
2 	Minor to Major	Major, but minimal falling hazards	Loss of functionality, except life safety systems are functional	Low probability	$$	Building closed for repairs. Weeks to years
3 	Significant – Could be on verge of collapse. Code allows for 10% of buildings to collapse.	Some failure with falling hazards	No systems may be operational	Low from building Collapse. Possible from falling debris.	$$$ Could be total loss	Months to years
4 	Building Collapse	The collapse point is not defined by the code and is a function of many variables such as type of seismic system used, quality of construction, ductile detailing, etc. Advanced structural analysis is required to estimate point of collapse.				

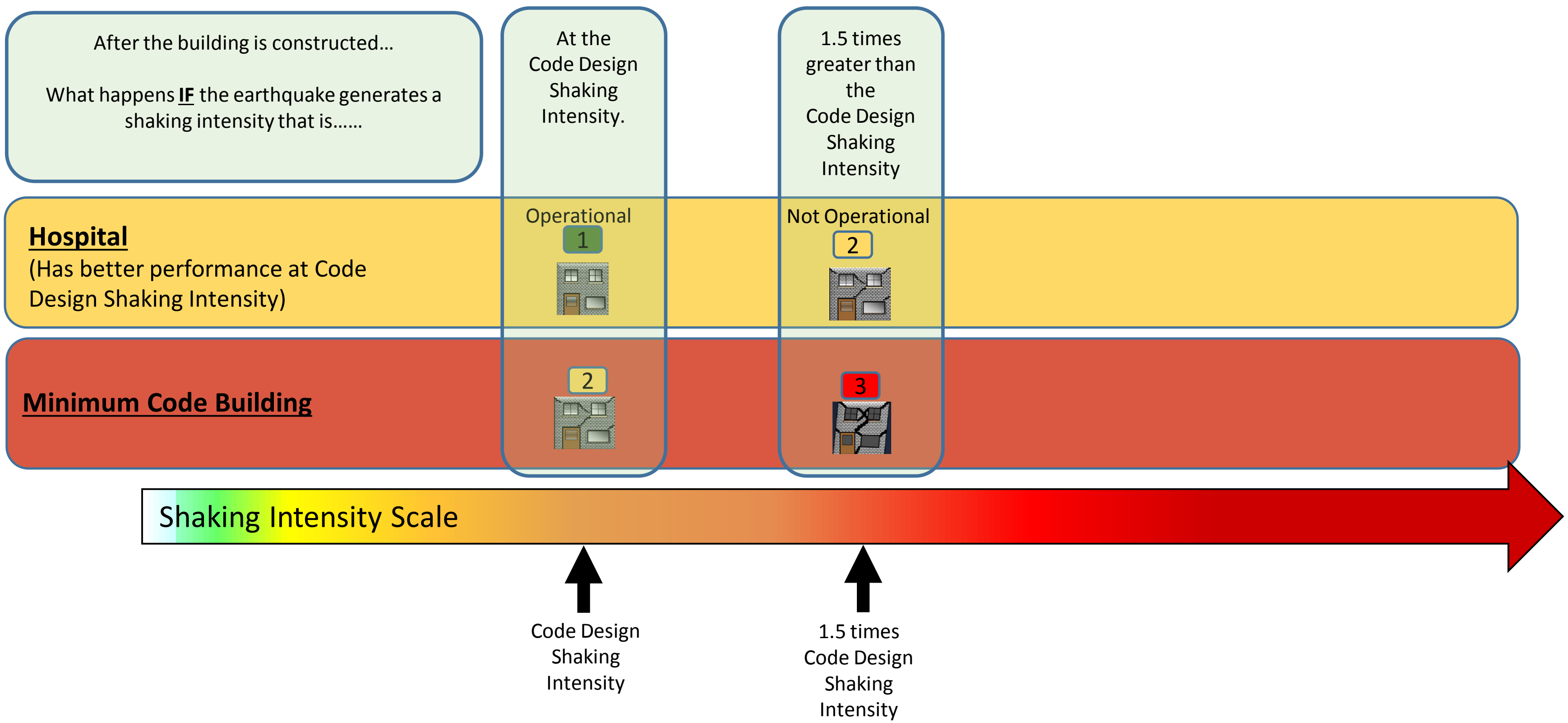
Code Design Shaking Intensity is set by the building code. It is the minimum Design Shaking Intensity allowed to be used. It **<u>CAN</u>** be exceeded.

(Influenced greatly by frequency of large earthquakes,
Fewer large earthquakes = lower
More large earthquakes = higher)

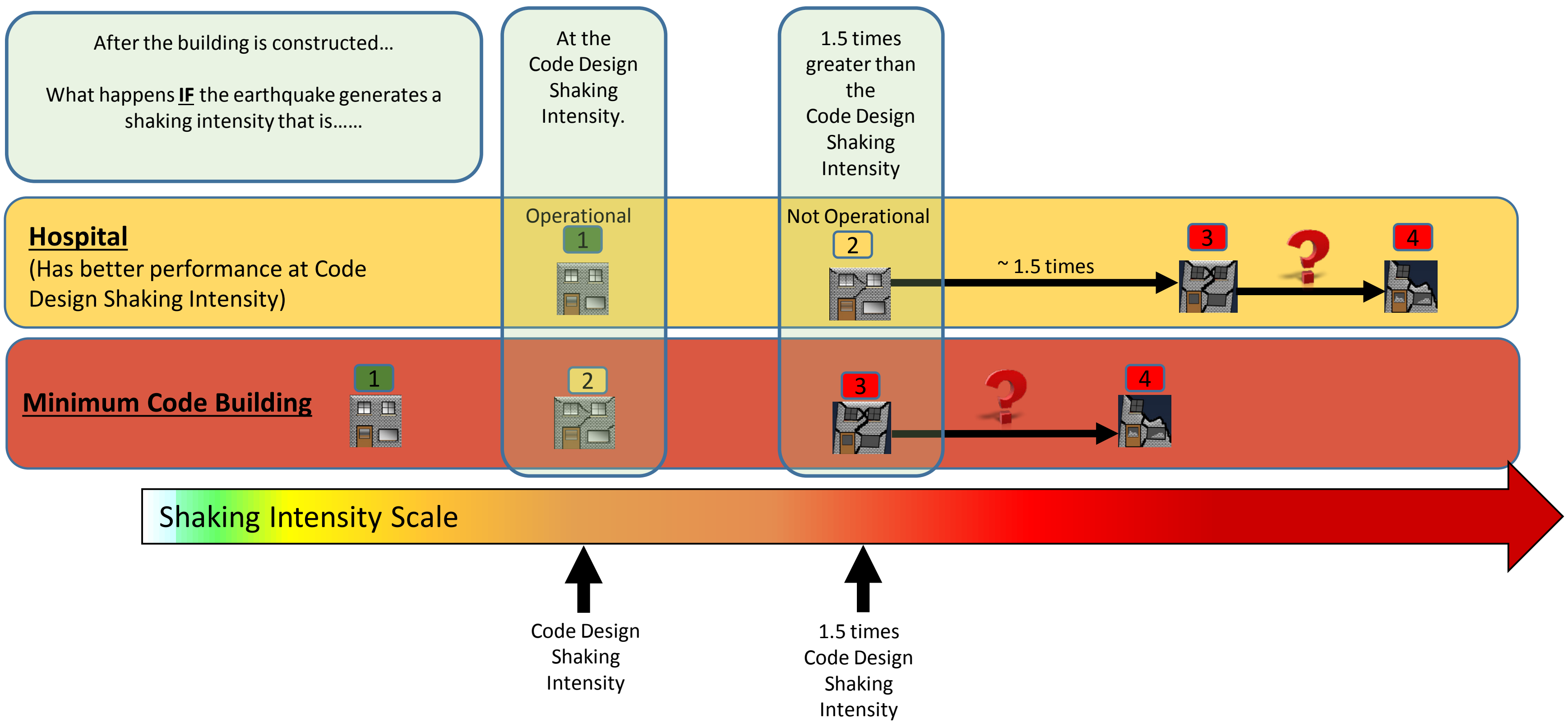


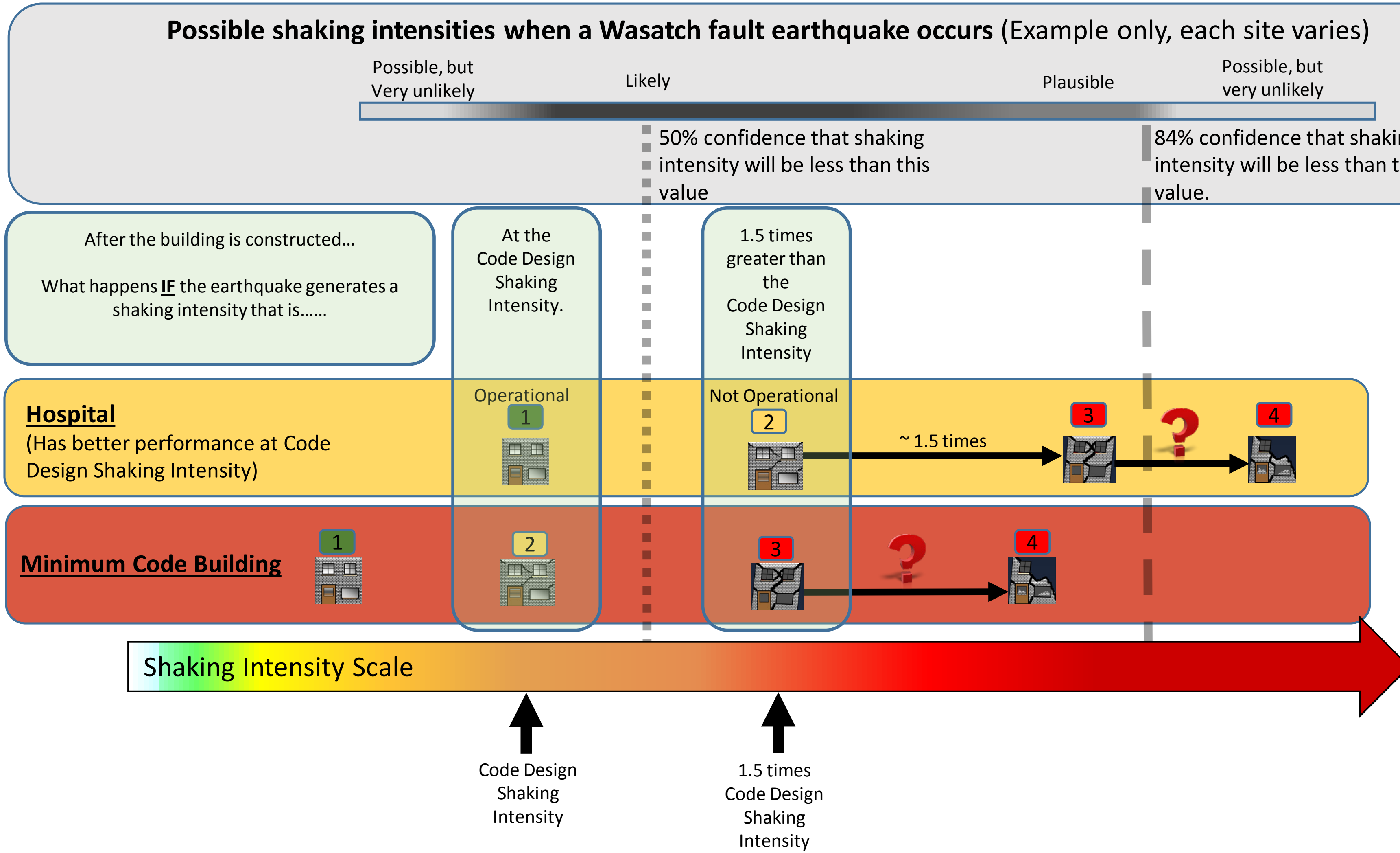

After the building is constructed…
What happens IF the earthquake generates a shaking intensity that is……
At the Code Design Shaking Intensity.
"Life Safety"
For Code Design Shaking Intensity
Minimum Code Building
2
Shaking Intensity Scale
Code Design Shaking Intensity


After the building is constructed…
What happens IF the earthquake generates a shaking intensity that is……
At the Code Design Shaking Intensity.
Hospital
(Has better performance at Code Design Shaking Intensity)
Operational
1
Minimum Code Building
2
Shaking Intensity Scale
Code Design Shaking Intensity


After the building is constructed…
What happens IF the earthquake generates a shaking intensity that is……
At the Code Design Shaking Intensity.
1.5 times greater than the Code Design Shaking Intensity
Hospital
(Has better performance at Code Design Shaking Intensity)
Operational
1
Not Operational
2
Minimum Code Building
2
3
Shaking Intensity Scale
Code Design Shaking Intensity
1.5 times Code Design Shaking Intensity

The collapse point is not defined by the code and is a function of many variables such as type of seismic system used, quality of construction, ductile detailing, etc. Advanced structural analysis is required to estimate point of collapse. It could happen prior to Damage State 3 (not likely), immediately after, or considerably further




Possible shaking intensities when a Wasatch fault earthquake occurs (Example only, each site varies)
Possible, but Very unlikely
Likely
Plausible
Possible, but very unlikely
50% confidence that shaking intensity will be less than this value
84% confidence that shaking intensity will be less than this value.
After the building is constructed…
What happens IF the earthquake generates a shaking intensity that is……
At the Code Design Shaking Intensity.
1.5 times greater than the Code Design Shaking Intensity
Hospital
(Has better performance at Code Design Shaking Intensity)
Operational
1
Not Operational
2
~ 1.5 times
3
?
4
Minimum Code Building
1
2
3
?
4
Shaking Intensity Scale
Code Design Shaking Intensity
1.5 times Code Design Shaking Intensity

Examples

Location	Building Height	Code Design Shaking Intensity	1.5 times Design intensity	Wasatch Fault Earthquake		
				50% Confidence intensity will be less than this	84% Confidence intensity will be less than this	Ratio 84%/Design
Ogden	Mid	0.48 G	0.72 G	0.60 G	1.19 G	2.5
Salt Lake	Short	0.97 G	1.46 G	1.23 G	2.34 G	2.4
Provo	Mid	0.70 G	1.05 G	0.96 G	1.76 G	2.3
Draper	Short	0.96 G	1.44 G	1.03 G	1.85 G	1.9
Oquirrh	Short	0.78 G	1.17 G	0.73 G	1.19 G	1.5

Data courtesy of Bret Lingwall

TAB 3

The Critical 3

TAB #3

The Critical 3: Schools, Housing & Jobs

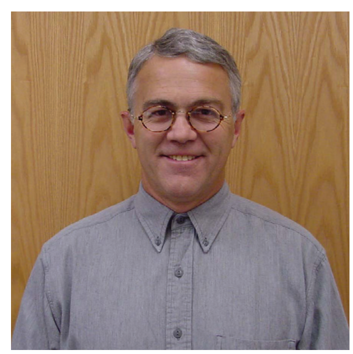
PANELISTS
Sheila Curtis
Jenefer Youngfield
Ralph Ley
Dr. Jerod Johnson, SE

MODERATOR
Barry Welliver, SE

How will buildings perform following earthquakes? The intent of building codes is to protect lives, but does it adequately address the building damage that could occur to a code-designed building?

These questions lead to a discussion of whether specific buildings should be designed to a higher standard than required by building code to help better protect schools, housing and businesses. Damaged, unoccupied buildings could adversely affect recovery efforts.



THE CRITICAL 3: SCHOOLS, HOUSING & JOBS

SHEILA CURTIS
DEM Operations Planner
Dept. of Public Safety,
Division of Emergency Mgmt.

Sheila is the Operations Officer for the Utah Division of Emergency Management and has been there for over five years. She has been in Emergency Management for over 20 years starting at the city level of emergency management.

She is also over the Utah Housing Task Force. Sheila has been deployed through EMAC twice to the state of New York.

She has been very active in various communities with neighborhood watch, Youth City Council and the Lions Club. She also helped start the first Millard County CERT Program.

Sheila served as a council member for the Town of Hinckley for over six years. She was the Eagle Mountain City Emergency Manager for six years at which time she started the CERT program, helped start the Youth City Council and helped with the Neighborhood Watch program.

She loves to go rock hunting in the deserts of our lovely Utah and enjoys camping with her family of four girls and seven grandkids.

JENEFER YOUNGFIELD
Construction & Facility
Specialist, Utah State Office
of Higher Education

Jenefer has 32 years of experience in the K-12 public school construction and facility safety and security. She is responsible for the oversight, support, training and assurance of compliance of LEAs (Local Education Agencies – school districts and charter schools) and those involved in K-12 public school construction, facility safety and security procedures, including: federal, state and local codes, rules, laws, and guidelines; the School Construction Resource Manual; the USOE Emergency Preparedness Planning Guide for Public Schools; ADA (Americans with Disability Act) accessibility; Office of Civil Rights (OCR) facility related reviews, seismic; fire; energy; FEMA (Federal Emergency Management Act).

She is a Certified Public Manager and a member of the Utah State Parent Teacher Association Safety Committee. Jenefer is also a member of the State Emergency Response Team (SERT) including the following annexes:

- ESF 3: Public Works & Engineering
- ESF 6: Mass Care
- ESF 7: Logistics
- ESF 11: Agriculture & Natural Resources

A graduate of Weber State University in Science, Jenefer is chair of the Utah State Building Licensing Board is International Code Council certified and DOPL licensed. She is also certified by the Utah Seismic Safety Commission as a building safety assessment disaster service worker.

RALPH LEY
Protective Security Advisor - Utah District, U.S. Department of Homeland Security

Ralph has served as the Protective Security Advisor (PSA) for the Utah District since November 2006. He serves in an advising and reach-back capacity for the Commissioner, Utah Office of Public Safety. As a PSA, he facilitates and coordinates resilience and vulnerability assessments for public and private sector entities; acts as a physical and technical security advisor to Federal, State, and local law enforcement agencies; and facilitates federal training, tools and other resources.

Joining the Department of Homeland Security (DHS) in February 2004, Ralph worked as the Plans and Policies Branch Chief, held oversight of the Dams and Commercial Facilities Critical Infrastructure Sectors and oversight of the Office of Infrastructure Protection's overseas risk program initiatives with Canada and Great Britain. Ralph has also served as the Chief of the High Value Targets (HVT) Assessment Unit with seven teams conducting security assessments at U.S. critical infrastructure sites.

Prior to joining DHS, Ralph worked in the private sector as a Program Manager at a defense-based manufacturing company in Florida. He previously served 22 years in the U.S. Air Force Special Operations Command working with foreign and joint counter-terrorist teams, and with joint service teams performing security assessments.

BARRY H. WELLIVER, SE
Principal Structural Engineer
BHW Engineers

Barry has been involved in structural engineering since 1973. Moving from Connecticut to pursue an interest in earthquake engineering, he chose California as his classroom. There he worked for several prominent firms before establishing his own private practice in 1979. After 22 years in California, he moved with his family to Utah where he currently practices.

He has been actively involved in the Structural Engineers Associations of California and Utah serving on and chairing several committees. His interests in seismic engineering lead to involvement with the Utah Seismic Safety Commission (USSC) beginning in 1996 as an observer and later as delegate commissioner for the Structural Engineers Association of Utah (SEAU).

Barry has been an advocate for seismic improvements in older existing hazardous buildings and served as the chair of USSC from 2002-2006.

For five years he advocated for state-wide school hazard inventory at the Utah Legislature and his efforts resulted in legislation and funding to complete rapid visual screening of Utah schools.

He has co-authored numerous publications related to seismic advocacy including Putting Down Roots in Earthquake Country: Handbook for Earthquake Safety in Utah.

Improving Seismic Safety of Schools

School Earthquake Safety Initiative • Earthquake Engineering Research Institute

Barry H. Welliver

Background

- Graduated University of Connecticut 1973 BS Civil Engineering immediately moved to the SF Bay area to study earthquakes
- Active in SEAONC 1973-1995 then moved to Utah
- Active in SEAUtah as president and helping found existing buildings, website, and emergency response committees
- Chair of Utah Seismic Safety Commission 2002-2006
- Advocated for state-wide school hazard inventory at Utah legislature 2008 – 2013 resulting in legislation and funding to complete RVS of Utah schools
- EERI School Earthquake Safety Initiative (SESI), chair (2014-present)
- FEMA ATC 122 *Reducing the Risk to Our Schools from Natural Hazards and Improving the Safety of Our Children*, project technical director (2015 – present)

Barry H. Welliver

Schools Related Presentations & Activities:

- Utah Facilities Operations & Maintenance Assoc.:
  - 2004 Fall Conference: Seismic Safety of Utah's Public Schools
  - 2005 Fall Conference: Incremental Seismic Rehabilitation of School Buildings (K-12)
  - Utah Schools RVS program – compile ROVER database of Utah schools (April 2013 – present) legislation + funding
- NETAP training slide development and presentation for FEMA 395 *Incremental Seismic Rehabilitation of Schools*
- United Nations Office for Disaster Risk Reduction – *Second Safe School Leaders meeting – Tehran, I.R. Iran (October 2015)*

Barry H. Welliver

Schools Related Publications:

- Co-author of seismic advocacy documents:
  - Putting Down Roots in Earthquake Country: Handbook for Earthquake Safety in Utah (Dec. 2008)
  - FEMA 420 Engineering Guidelines for Incremental Seismic Rehabilitation (December 2008)
  - Utah Schools Pilot Rapid Visual Screening using ROVER (2009) – final report *Utah Students at Risk – The Earthquake Hazards of School Buildings*

Currently the Utah Division of Emergency Management (DEM) facilitates two distinct mechanisms that businesses can employ to build resilience to possible disruptions such as an earthquake, a cyber-related threat, or other natural and man-made hazards.

The Utah Public-Private Partnership (UP3) is a section within DEM with a sole mission to connect the private sector with the emergency management community at the local, county, and state, levels.

Be Ready Business

The first UP3 program for assisting businesses is the *Be Ready Business* program that facilitates bi-monthly forums throughout Utah, focusing on business continuity and disaster recovery objectives. These Private Sector Preparedness Councils (PSPCs) are held in St. George, Provo, Salt Lake City, Tooele, and Ogden.

These meetings feature subject matter experts from private and public sectors providing helpful information and real-world examples in building resilience into critical operations that will shorten disruption and get a business back to normal operations as quickly as possible.

The PSPC meetings are free, and open to all businesses of any size. For information on a PSPC near you contact Logan Sisam at Lsisam@utah.gov

Infrastructure Resilience Program

Additionally, UP3 manages the Infrastructure Resilience Program. This program works closely with the Department of Homeland Security (DHS) and the Utah Statewide Information and Analysis Center (SIAC) to promote and assist with missions to prevent, protect, and mitigate, all hazards that can disrupt Utah businesses.

UP3 can connect businesses with a strong catalog of free resources to assist with cyber security and physical site security resilience activities. Connecting private and public sectors provides opportunities to partner in building whole community resilience. A large-scale disaster such as an earthquake will require capabilities from both sectors to respond, restore, and recover as quickly as possible.

For more information on these resources contact Matt Beaudry, mbeaudry@utah.gov.
Section Manager
UP3 - Utah Public-Private Partnership
Connecting Utah's private sector with emergency management to build whole community resilience
Cell: 801-834-8942
Fax: 801-538-3770
Utah Division of Emergency Management

What is BORP?

Concepts:

- Building codes are driven to safeguard against major structural failures and loss of life, **not to limit damage or maintain function.**
- The building code does not address the potential downtime or loss of function or financial loss attributable to these issues.
- Even well designed buildings are susceptible to significant downtime and financial loss.

Tools:

- ATC 20 –1: *Post-earthquake Safety Evaluation of Existing Buildings*. Enables placarding of existing buildings. Green placards reflect structures safe to occupy.
- Armies of qualified volunteers become deputized by local authorities and perform placarding.

At Issue:

- Volunteers will be spread too thin to perform placarding in a timely manner.
- Businesses will suffer due to mandatory down-time associated with a declared state of emergency. Many may not recover.

A Solution:

BORP—Building Occupancy Resumption Program

What is it? A pre-emptive strategy wherein owners or stakeholders pre-emptively hire qualified inspectors to perform the ATC-20 investigation. Designated inspectors are pre-authorized to perform the evaluation and are pre-deputized by the jurisdiction having authority to perform the evaluation. Upon a declaration of a state of emergency, inspectors are contractually bound to perform ATC-20 building inspections (usually within 72 hours).

The Aim:

- Enable immediate re-occupancy where possible.
- Enable business to enter the queue early for repairs and restoration.

Jurisdictions who have adopted BORP:

- Salt Lake City, Murray City, others?

TAB 4

Economic Resilience

TAB #4

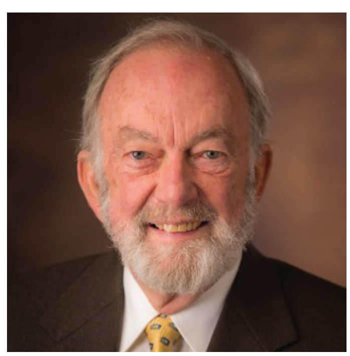
Utah's Economic Resilience: Getting the Wheels Rolling Again

PANELISTS
Lance Davenport
Matthew Lund
James A. Wood

MODERATOR
Bob Carey

Panelists will share ways to prevent an economic catastrophe following a magnitude 7 earthquake along the Wasatch fault.

In addition to discussing contemporary building codes -- including their strengths and weaknesses with respect to resilience and economic loss -- they will share their perspectives regarding the economics of recovery following a large earthquake.



UTAH'S ECONOMIC RESILIENCE: GETTING THE WHEELS ROLLING AGAIN

LANCE DAVENPORT
Public Safety & Security
Larry H. Miller Sports and Entertainment

Lance joined the Larry H. Miller Group of Companies in 2013 as the director of safety and risk management where he had oversight for safety and risk management of each of the group's businesses and properties and assisted with emergency planning, preparedness and response. In August 2015, Lance moved to Larry H. Miller Sports and Entertainment where he now oversees public safety and security for LHMSE enterprises. He serves as the team security director for the Utah Jazz, and assists with the implementation, coordination and oversight of NBA security standards for the Vivint Smart Home Arena.

Prior to joining the group, Lance served as commissioner of the Utah Department of Public Safety, an appointment made by Utah Governor Jon Huntsman in January 2009. Previous to his appointment, he served as the superintendent of the Utah Highway Patrol. He began his law enforcement career as a UHP trooper in 1984 and held every rank in the department before being appointed the superintendent/colonel in 2006. He retired from public safety service in July 2013.

He earned an Associate of Science degree in law enforcement from Weber State University and graduated cum laude with a bachelor's degree in criminal justice. Lance is also a 2003 graduate of the FBI National Academy and a 2010 graduate of the FBI National Executive Institute. He completed the Leadership Certificate Program at the University of Utah in 1998.

MATTHEW LUND
Budget & Policy Economist
Utah Governor's Office of Management & Budget

Matthew is a budget and policy economist with the Utah Governor's Office of Management and Budget.

His professional responsibilities include analyzing policy priorities related to transportation projects and physical infrastructure investments, reviewing and recommending budgetary changes for state agencies, forecasting economic indicator data and serving as a proxy voting member on the State Building Board and Internal Service Fund Rate Committees, among other duties.

Prior to serving in the Governor's office, Matt worked as a tax economist at the Utah State Tax Commission specializing in income taxes. He holds a PhD in Economics from the University of Utah.

UTAH'S ECONOMIC RESILIENCE: GETTING THE WHEELS ROLLING AGAIN

JAMES A. WOOD
Ivory-Boyer Senior Fellow
Kem C. Gardner Policy Institute
University of Utah

James is the Ivory-Boyer Senior Fellow at the Policy Institute. He specializes in several research areas including housing, construction, real estate, and economic development.

He has published over 100 articles and studies related to the Utah economy. This includes housing markets, community development, regional economics and economic development. Hehas conducted numerous studies on local housing market conditions, and was the principal investigator on a sustainable communities grant through the U.S. Department of Housing and Urban Development. He was also the principal investigator on a two-year cost-benefit study of homeless participants in Utah's Housing First Program.

A member of the Governor's Council of Economic Advisors, he also serves on the board of the Salt Lake Home Builders Association, the Salt Lake County Housing Trust Fund, NeighborWorks Salt Lake and is a member of the State of Utah Revenue Assumptions Working Group.

A graduate of the University of Utah with a B.S. in finance and four years of graduate study in economics, Mr. Wood joined the business school in 1975 and spent over 25 years as a researcher and senior research analyst. He served as director of the Bureau of Economic and Business Research from 2002 to 2015.

BOB CAREY
Operations Section Manager & Operations Chief Earthquake Program Manager, Division of Emergency Management, State of Utah

A graduate of Westminster College with Bachelor of Science degrees in both environmental studies and geology, Bob is the Operations Section Manager and Operations Chief, Utah Division of Emergency Management.

He has served for 22 years as the Earthquake Program Manager, Utah Division for Emergency Management, and in state service for over 25 years. He also serves as staff to the Utah Seismic Safety Commission.

Bob serves on the following committees/councils:

- Committee Member on the URM Ad-hoc Committee
- Committee Member on the Utah Committee for Urban Strong Motion Monitoring
- State Delegate to the Western States Seismic Council
- Committee Member on the Basin and Range Subcommittee

He served as a team member of the Multi-Agency Damage Evaluation Team for the 2009 Wells Earthquake and Utah Division of Comprehensive Emergency Management Response Team for the 1992 St. George Earthquake. He was team leader of Multi-Agency Evaluation Task Force for the 1994 Northridge Earthquake.

Bob is a member of the Structural Engineers Association of Utah's Existing Buildings Committee, Utah State Hazard Mitigation Team and board member of the Utah Chapter of the Earthquake Engineering Research Institute.

Larry H. Miller Group of Companies

Lance Davenport

Vice President, Public Safety

LHM Sports and Entertainment

Background

- 2013 - LHM Management Corporation, Safety and Risk Management
- 2015 - LHM Sports and Entertainment, Public Safety

LHM Group of Companies Includes:

- Larry H. Miller Dealerships - 50+ located in 7 Western States
- Utah Jazz – NBA Basketball Team
- Salt Lake Bees - Minor League Baseball Team
- Megaplex Theatres – 17 Movie Theaters located in Utah and Nevada
- Tour of Utah – Bicycle Race

LHM Group of Companies

- Vivint Smart Home Arena – Home of the Jazz
- Fanzz – 100+ Sports Apparel Stores in 22 States
- KJZZ 14 Television Station
- The Zone Sports Network – 1280 AM and 97.5 FM
- Saxton Horne – Communication/Marketing

LHM Group of Companies

- Total Care Auto – Extended Auto Warranties
- Prestige Financial – Auto Financing
- All Star Catering – Food Services
- Jordan Commons – Office Tower
- Miller Family Real Estate – Property Development and Management

LHM Group of Companies

- Miller Inspiration –
- Salt Lake City Stars – NBA Development League Team

LHM Role in Helping Economy Recover Quickly?

- Continue fulfilling the LHM mission and vision - to enrich lives, and to be the best place to work and do business
- Being relevant to our customer base
- Remaining economically viable
- Maintaining profitability

Resources To Assist Recovery?

- Businesses located across large geographical area footprint
- 10,000 Employees
- Facilities
- Philanthropy

Steps Taken to Ensure LHM Resiliency

- Emergency Response Plans
- Employee Preparedness
- Insurance Coverage – property, business interruption.
- Communication Plan
- Recovery Strategy

Economic Recovery Following a Earthquake or other Disaster

Matt Lund

Governors Office of Management and Budget

Is the State of Utah prepared financially for an earthquake or other disaster?

- Significant amount of reserves
  - Disaster Recovery Fund: $20.5 million
  - General Rainy Day Fund: $141.2 million
  - Nonlapsing Balances: $259.5 million
  - Cash Funded Buildings: $313.8 million
  - Cash Funded Roads: $163 million
  - Bonding Capacity: $1.8 billion
  - Unemployment Insurance: $16 million

What industries would be impacted?

NONAGRICULTURAL EMPLOYMENT BY INDUSTRY
SALT LAKE CITY MSA
(thousands)

	March		Percent	February	January
	2016(p)	2015	Change	2016(r)	2016(r)
Total Nonagricultural Employment	**685.8**	**668.3**	**2.6**	**682.7**	**677.4**
Natural Resources, Mining, Construction	35.7	35.4	0.8	35.3	35.5
Manufacturing	55.5	54.5	1.8	55.2	54.9
Durable Goods	37.4	36.5	2.5	37.1	37.0
Non-durable Goods	18.1	18.0	0.6	18.1	17.9
Wholesale Trade	31.5	31.3	0.6	31.5	31.0
Retail Trade	71.8	69.5	3.3	71.8	71.6
Transportation, Warehousing, Utilities	33.6	32.8	2.4	33.8	33.8
Information	18.0	17.8	1.1	18.1	17.9
Financial Activities	56.1	52.4	7.1	55.4	55.1
Professional and Business Services	116.9	115.1	1.6	116.2	115.8
Educational and Health Services	80.6	76.5	5.4	80.6	79.1
Leisure and Hospitality	58.8	57.0	3.2	58.2	57.2
Other Services	20.4	21.4	-4.7	20.6	20.3
Government	106.9	104.6	2.2	106.0	105.2
Federal Government	12.7	12.1	5.0	12.7	12.6
State Government	47.0	45.5	3.3	46.5	46.1
Local Government	47.2	47.0	0.4	46.8	46.5
Private Sector	578.9	563.7	2.7	576.7	572.2

Note: The Salt Lake City Metropolitan Statistical Area (MSA) is comprised of Salt Lake, Tooele, and Summit counties.
Source: U.S. Bureau of Labor Statistics, Current Employment Statistics 4/15/16 p = preliminary r = revised

- Downtown Salt Lake is predominately service/finance/retail based.
- Construction industry would actually get a boost following disaster.
- Will natural resources be impacted?
- Impact to tourism?
- Diverse economy in Utah should lessen impact and help recovery.

Mitigation Strategies

- Tax incentives
  - Income and corporate taxation
  - Accelerated depreciation
- Temporary housing support
  - Need to retain workforce
- Business loans
  - Small businesses will have most difficulty
- Speed up permitting process
  - Rebuild as fast as possible
- Tourism marketing
  - Need individuals to keep traveling to Utah

What are steps following a disaster?

1. Post disaster economic impact study
2. Post disaster economic recovery process
3. Establish workgroups to gather data and information
4. Comprehensive economic analysis
5. Create plan with action strategy

Economic Impact of Magnitude 7.0 Earthquake on Salt Lake Segment of Wasatch Fault

James Wood
Ivory-Boyer Senior Fellow
jim.wood@utah.edu

Kem C. Gardner
POLICY INSTITUTE
THE UNIVERSITY OF UTAH

INFORMED DECISIONS™

Kem C. Gardner Policy Institute • David Eccles School of Business • 1655 E. Campus Center Dr. • Salt Lake City, UT 84112-8939
801-587-3860 • fax 801-587-3380 • gardner.utah.edu

Increasing Likelihood of "Big One"

- In past 6,000 years at least 22 magnitude 7 have occurred on the Wasatch Fault.
- Once every 300 years on average, one of five central segments of Wasatch Fault has "Big One".
- For the Salt Lake Segment average repeat time is about 1,300 to 1,500 years. Last one occurred 1,400 years ago.
- Scenario earthquake, strong shaking from Payson to Ogden and rupture of ground (up to 8 feet vertically) along fault from Draper to North Salt Lake.

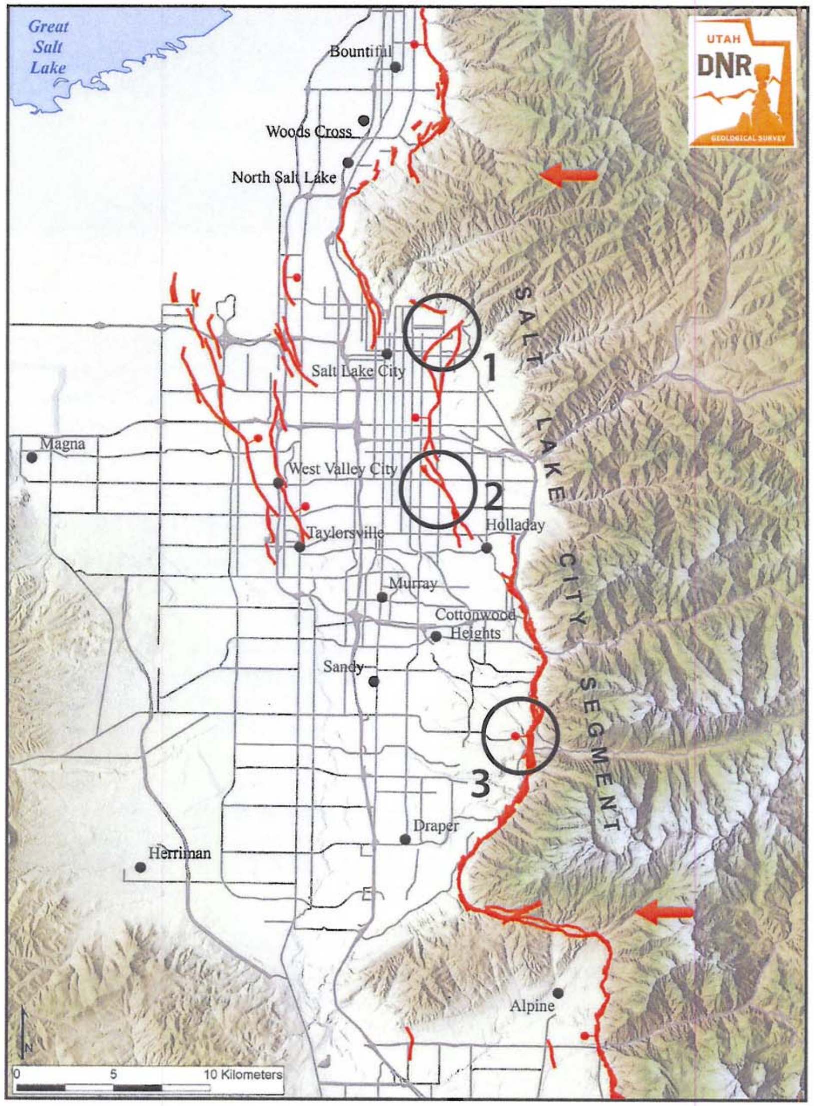


Figure 5(a) Map of the Salt Lake City segment of the Wasatch fault and the West

Economic Impact Depends Preparedness

- Withstand – building designs, strengthening weak buildings, vulnerability of public buildings.

- Respond – understanding scope, inspection requirements post quake, prioritize inspection.

- Recover – rules, ordinances that address foreseeable circumstances, development of contingency plans for businesses, schools, hospitals, etc.

Economic Impact of 7 M Scenario
Loss of $33.2 Billion

- Building-Related $24.9 billion, Income Related $6.9 billion, Lifeline-Related $1.4 billion.
- Complete destruction of 55,400 buildings.
- Households without potable water 483,600; after 90 days 332,800.
- Households without electricity 444,600; after 90 days 800.
- Fatalities – 2,000 to 2,500; life threatening injuries 7,400 to 9,300.

Costliest U.S. Natural Disasters

- Hurricanes – Miami 1926 ($164.8B), Katrina 2005 ($113. 5B), Galveston 1900 ($104.3B), Galveston 1915 ($71B), Andrew 1992 ($58.5B).

- Earthquakes – Northridge, CA 1994, 6.7 ($44B), San Francisco Bay 1989, 6.9 ($10B), Seattle area 2001, 6.8 ($2B), Alaska 1964, 9.2 ($570M), San Fernando 1971, 6.6 ($553M). **Scenario Ranks 2nd.**

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Greatest Fatalities from U.S. Natural Disasters – **Scenario ranks 4th**

- Galveston 12,000 (1900), San Francisco Earthquake 6,000 (1906), Florida Cyclone 3,000 (1928), Johnstown Flood 2,200 (1889), Louisiana Cyclone 2,000 (1893), Katrina 1,836 (2005).

TAB 5

Healthcare

TAB #5

State Healthcare Resiliency Efforts: What Can We Learn?

PANELISTS
Dr. Judith Mitrani-Reiser
Michael W. Stever

MODERATOR
Bob Carey

Hospitals are designed to the IBC using a Seismic Importance Factor of 1.5, but what does this mean in terms of a hospital's ability to operate following a magnitude 7 earthquake?

Designing only to the code may not provide the operational elements necessary to service the public. Even with relatively robust code requirements, many seismic requirements beyond structural systems are often overlooked, which can lead to major adverse effects in an earthquake.

The Utah Department of Health has studied this issue and will present their findings and relate these to other government and nongovernment organizations.

STATE HEALTHCARE RESILIENCY EFFORTS: WHAT CAN WE LEARN?

DR. JUDITH MITRANI-REISER
Assistant Professor of Civil Engineering and Emergency Medicine
Johns Hopkins University

Dr. Mitrani-Reiser is an Assistant Professor of Civil Engineering and Emergency Medicine, and the Director of the Sensor Technology and Infrastructure Risk Mitigation (STIRM) Laboratory at Johns Hopkins University. Her research is focused on the performance assessment of critical infrastructure, the safety and economic impact of hazards on the built environment, the effective communication of these risks to the public, informed decision making for use in emergency management and policy making, and the interaction of humans with the built environment.

She also collaborates internationally with the Pontificia Universidad Católica de Chile, and the University of Canterbury in New Zealand.

Dr. Mitrani-Reiser is a member of the American Society of Civil Engineers (ASCE), the Earthquake Engineering Research Institute (EERI), the Seismological Society of America (SSA), and the World Association for Disaster and Emergency Medicine (WADEM).

She is the Secretary for ASCE's Subcommittee on Multi-Hazard Mitigation, and is a member of ASCE's Committee on Disaster Resilience of Structures and of the Committee of Critical Facilities in ASCE's Infrastructure Resilience Division, and a member of EERI's Learning From Earthquakes Committee.

She is currently the faculty advisor for the Society of Professional Hispanic Engineers and is the founder of the Postdoctoral Association at Johns Hopkins University.

MICHAEL W. STEVER
Emergency Manager
Utah Department of Health,
EMS & Health Preparedness

Mr. Stever is the Emergency Manager for Utah Department of Health, EMS/Preparedness Bureau. He oversees and assists in coordination of all aspects of Emergency Management in planning, preparedness, response and recovery.

Mr. Stever also serves as occasional adjunct instructor/facilitator for the Emergency Management Institute at the National Emergency Training Center in Emmitsburg, Maryland. He has served in leadership positions on the National Board of the Association of Contingency Planners, the Utah Chapter of the Association of Contingency Planners and the Utah Emergency Manager's Association.

Prior to working for the Utah Department of Health, Mr. Stever served as the Emergency Program Manager for Salt Lake City. Previously he served the State of Utah as State Training Officer, Exercise Training Officer, and most recently, Training Program Manager.

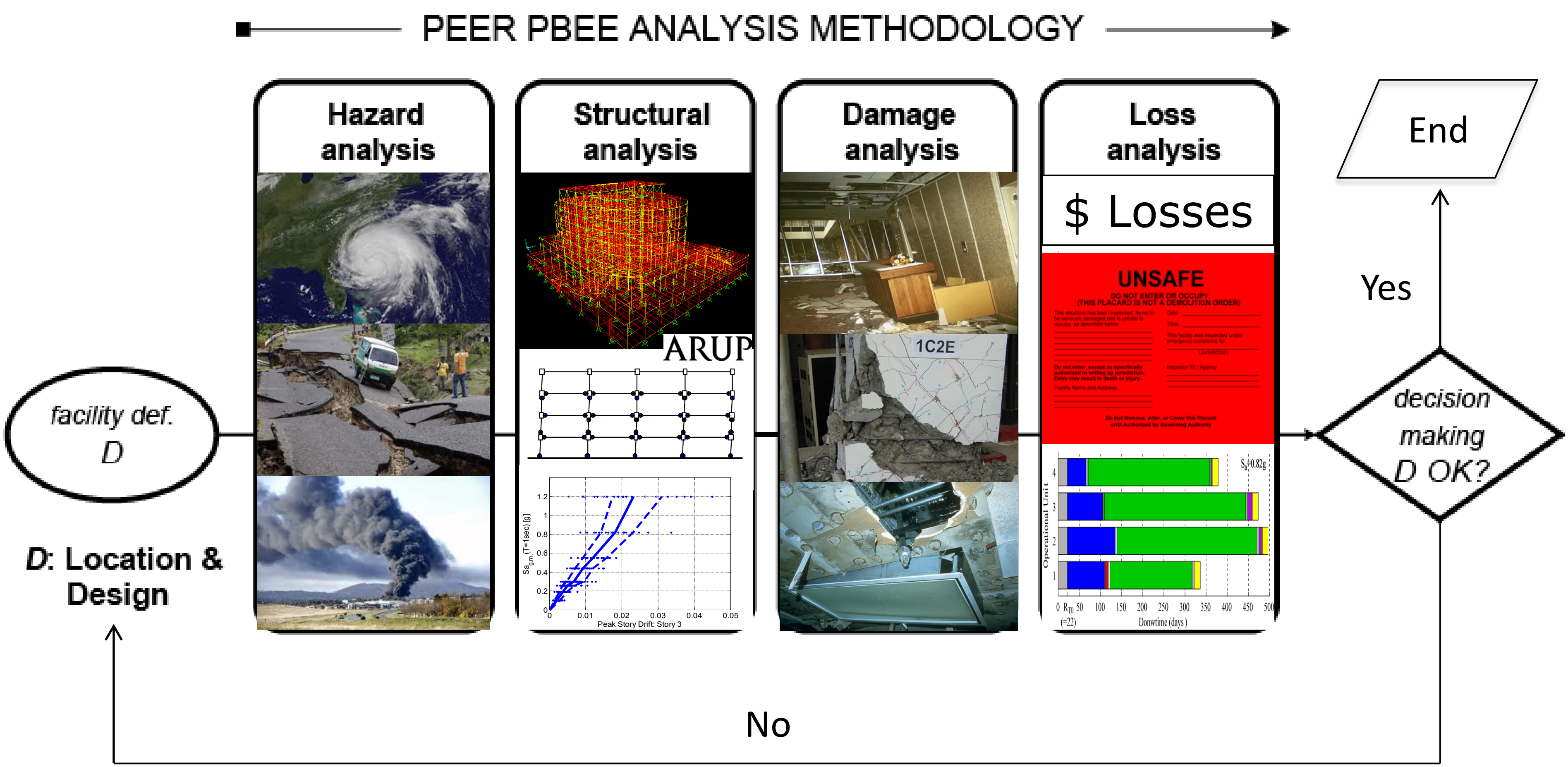
Mr. Stever's previous Emergency Management employment experiences include service as Deputy Director of Emergency Services and Director of Public Affairs at the county level.

Mr. Stever has a Bachelor of Science degree from Weber State University. Before pursuing advanced education, Mr. Stever proudly served in the United States Army Special Forces. Major Stever retired from active reserve military duty as a company commander for the 19th Special Forces Group of the Utah National Guard.

UTAH RESILIENCY WORKSHOP

Judith Mitrani-Reiser, Ph.D.

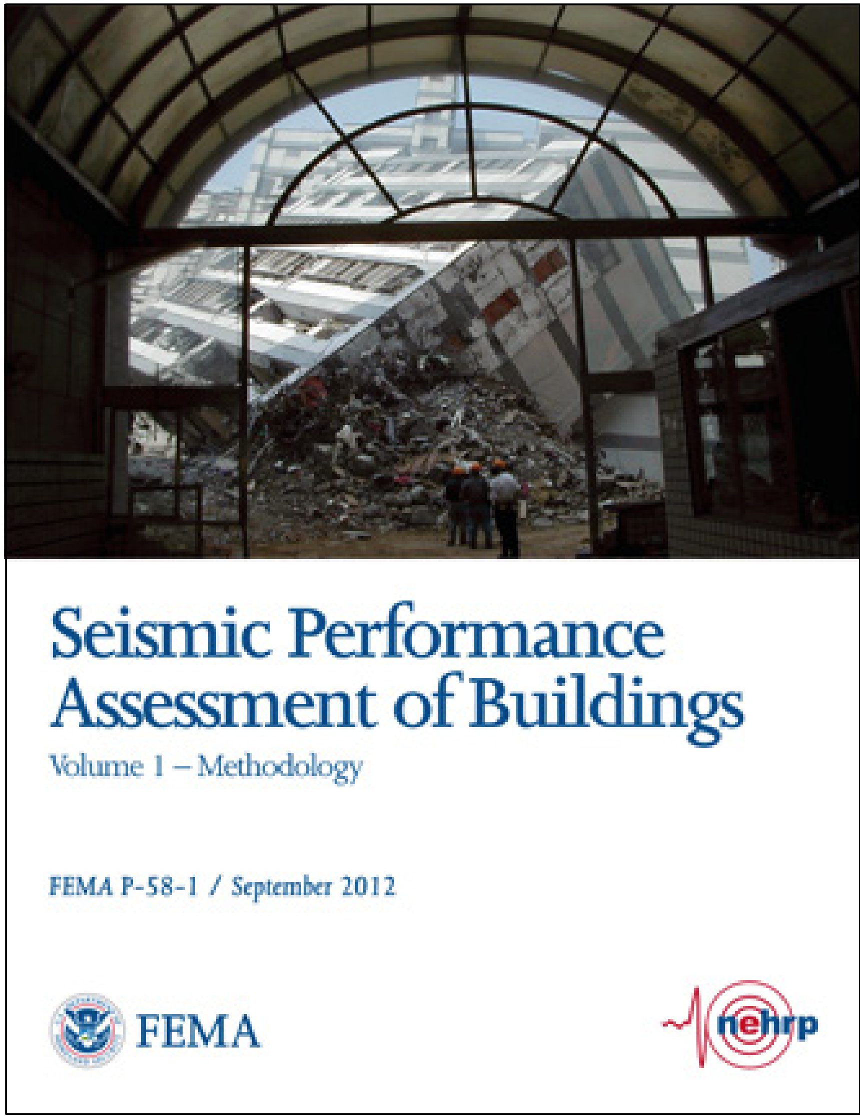
Performance-Based Design: Buildings



Performance-Based Design: Downtime in Buildings

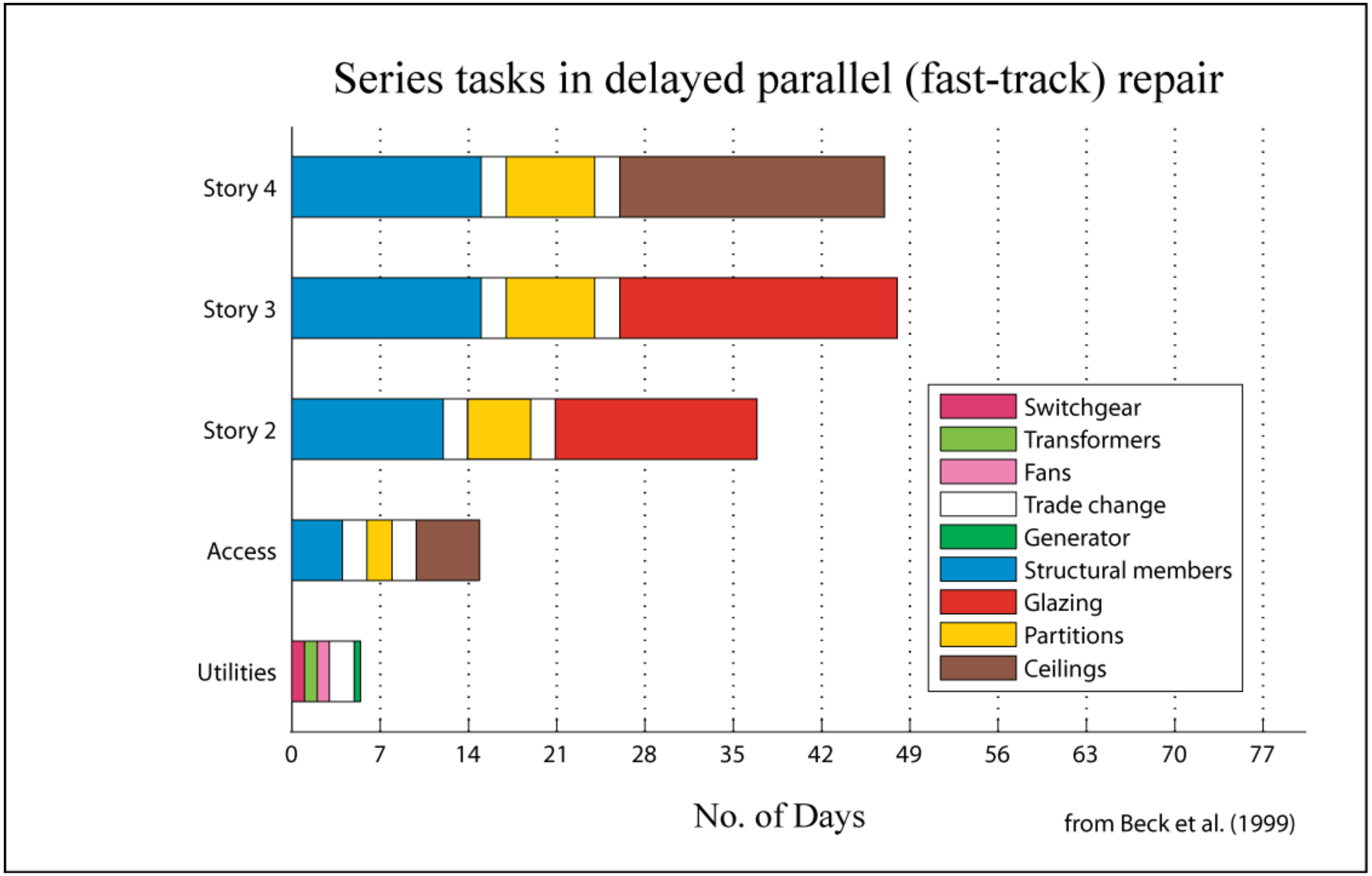
ATC-58 procedures (Mitrani-Reiser) provide the following measures of occupancy interruption:

- **The length of time necessary to conduct repairs,**
- **The need to procure items with long lead-times,**
- **The probability that the building will be placarded as unsafe for occupancy.**



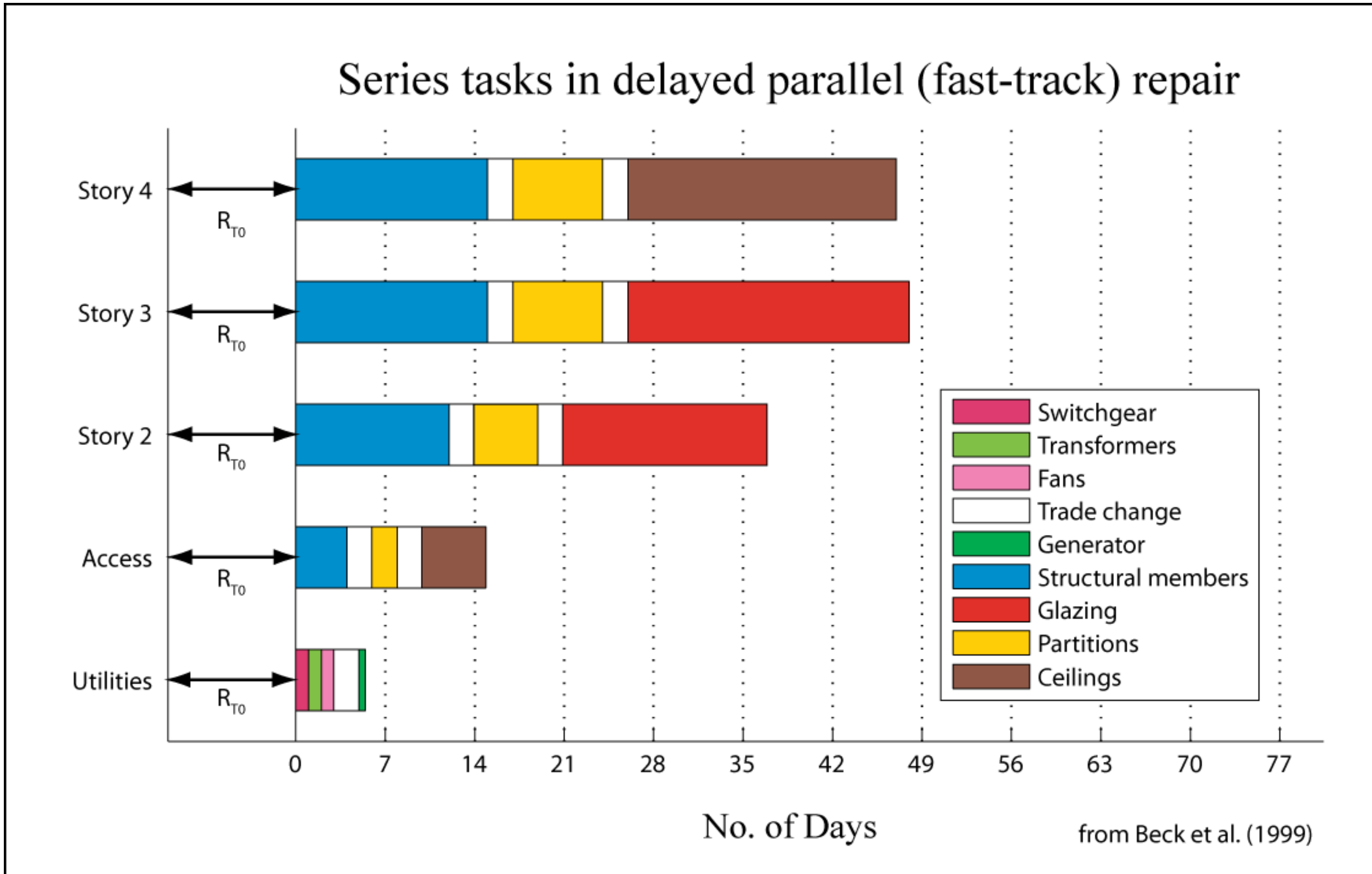
Performance-Based Design: Downtime in Buildings

Repair time is the time needed to repair the earthquake damage and return the building to its pre-earthquake condition.



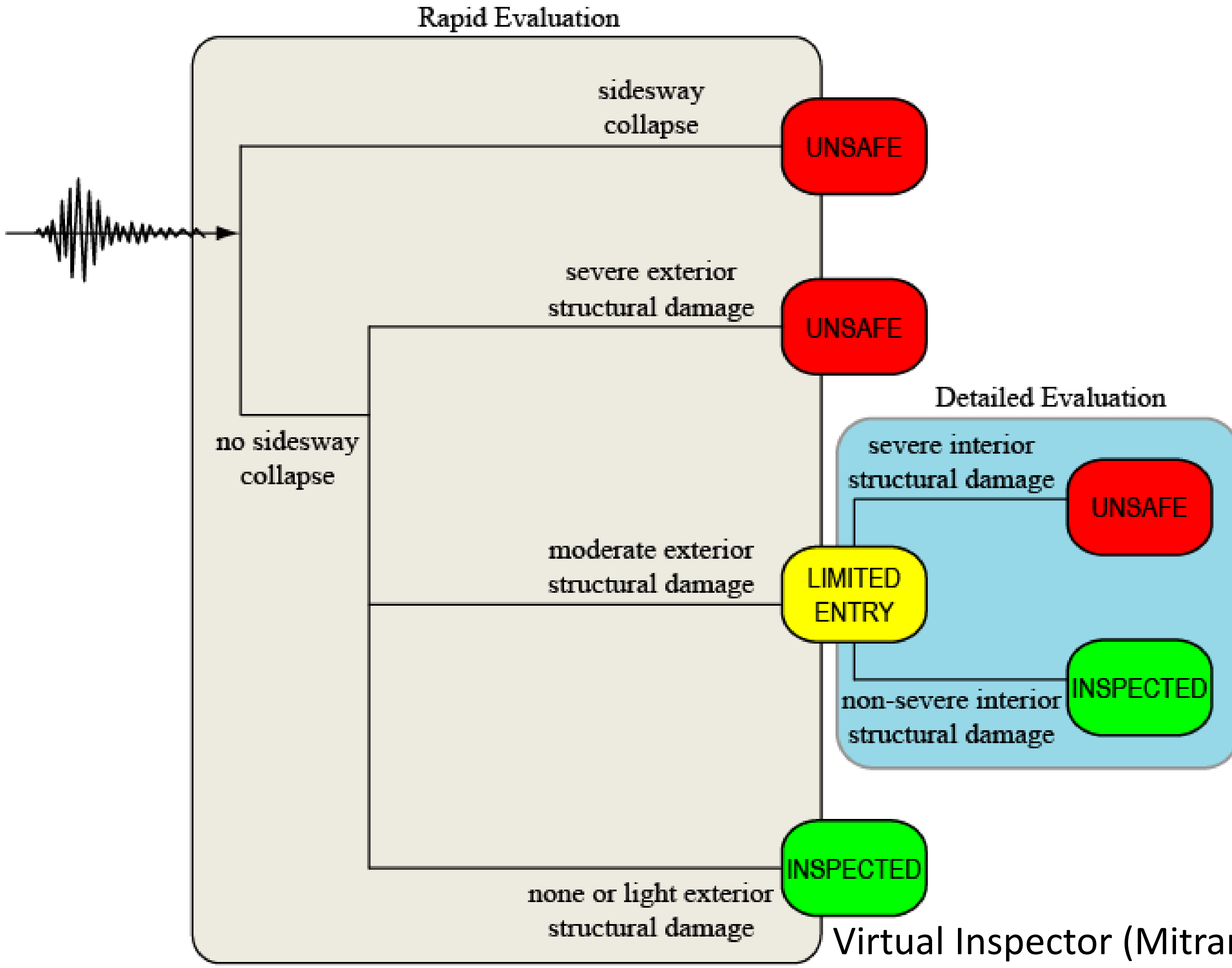
Performance-Based Design: Downtime in Buildings

Mobilization Time is the delay before construction begins needed to assess damage and inspect building, time to consult with professional engineers, time for bidding process, time for clean-up, time to acquire items with long lead times.



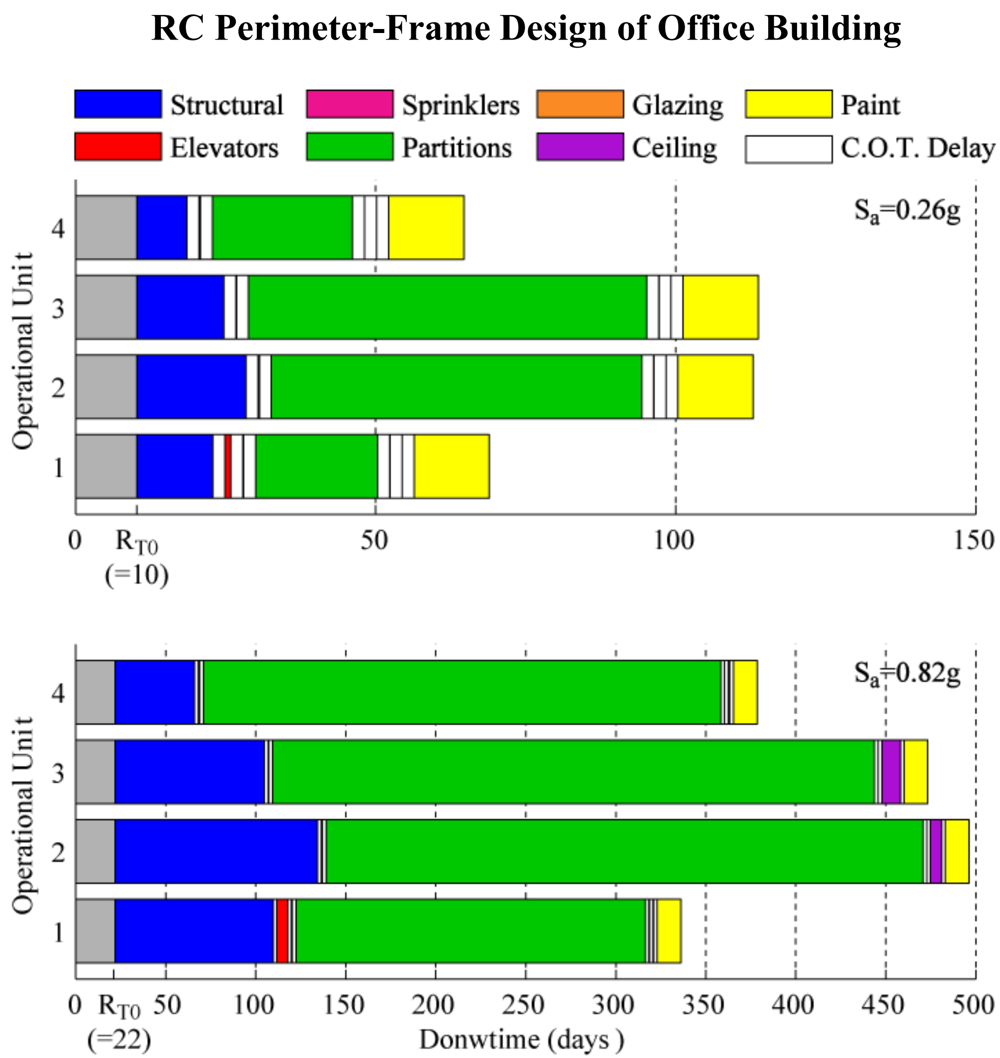
from Beck et al. (1999)

Performance-Based Design: Downtime in Buildings



Virtual Inspector (Mitrani-Reiser 2007)

Performance-Based Design: Downtime in Buildings



10%-in-5yr

DT ~ 4 months

2%-in-50yr

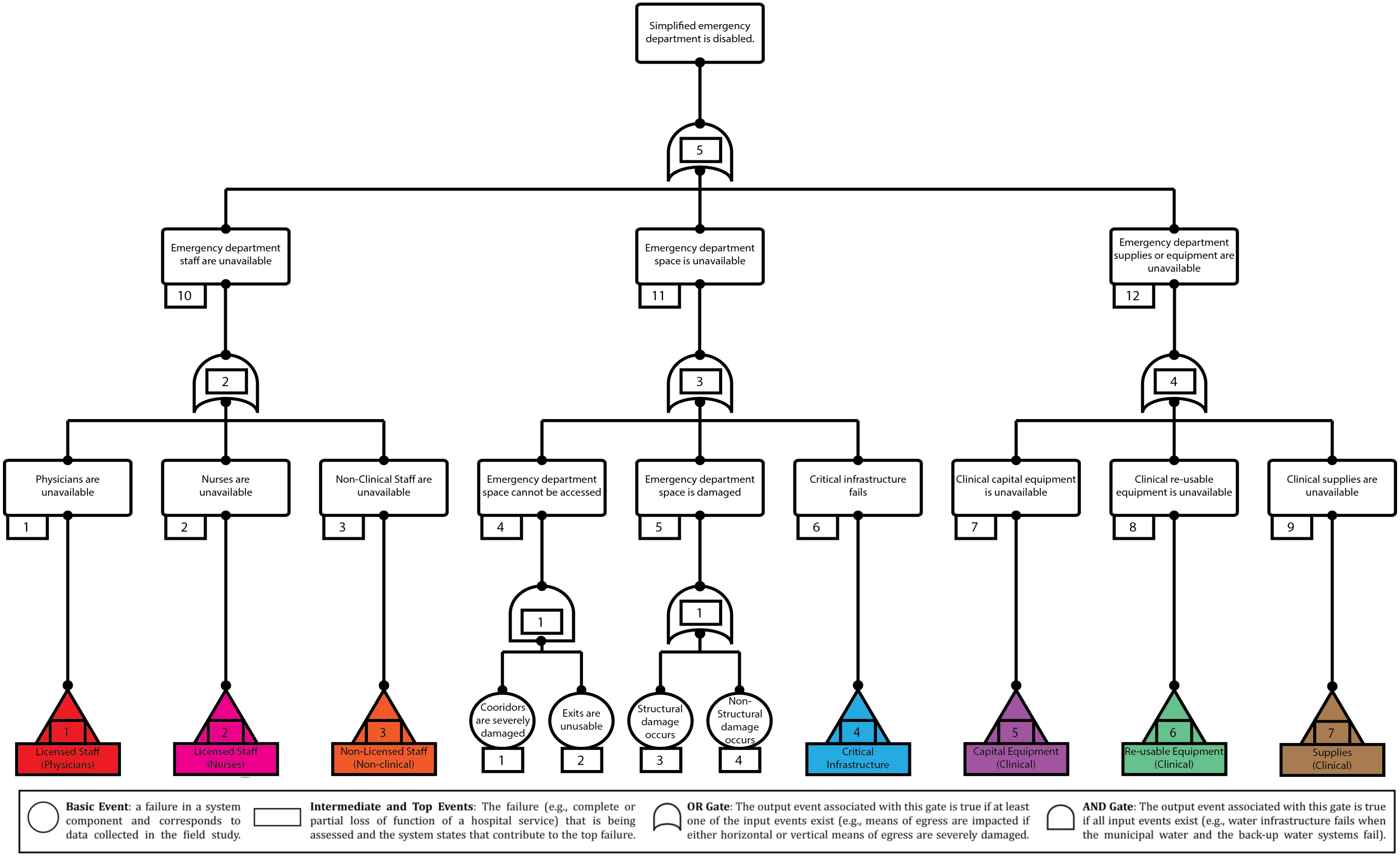
DT ~ 17 months

Performance-Based Design: Summary

For some building occupancies (i.e., hospitals), the above procedures will not suffice in capturing the loss of important services:

- **Need models that include infrastructure failures outside the building.**
- **Need occupancy-specific models that incorporate human infrastructure.**
- **Need systematic procedures for capturing building damage and loss of function over time in the field (eq reconnaissance).**

Building Impacts: beyond physical damage

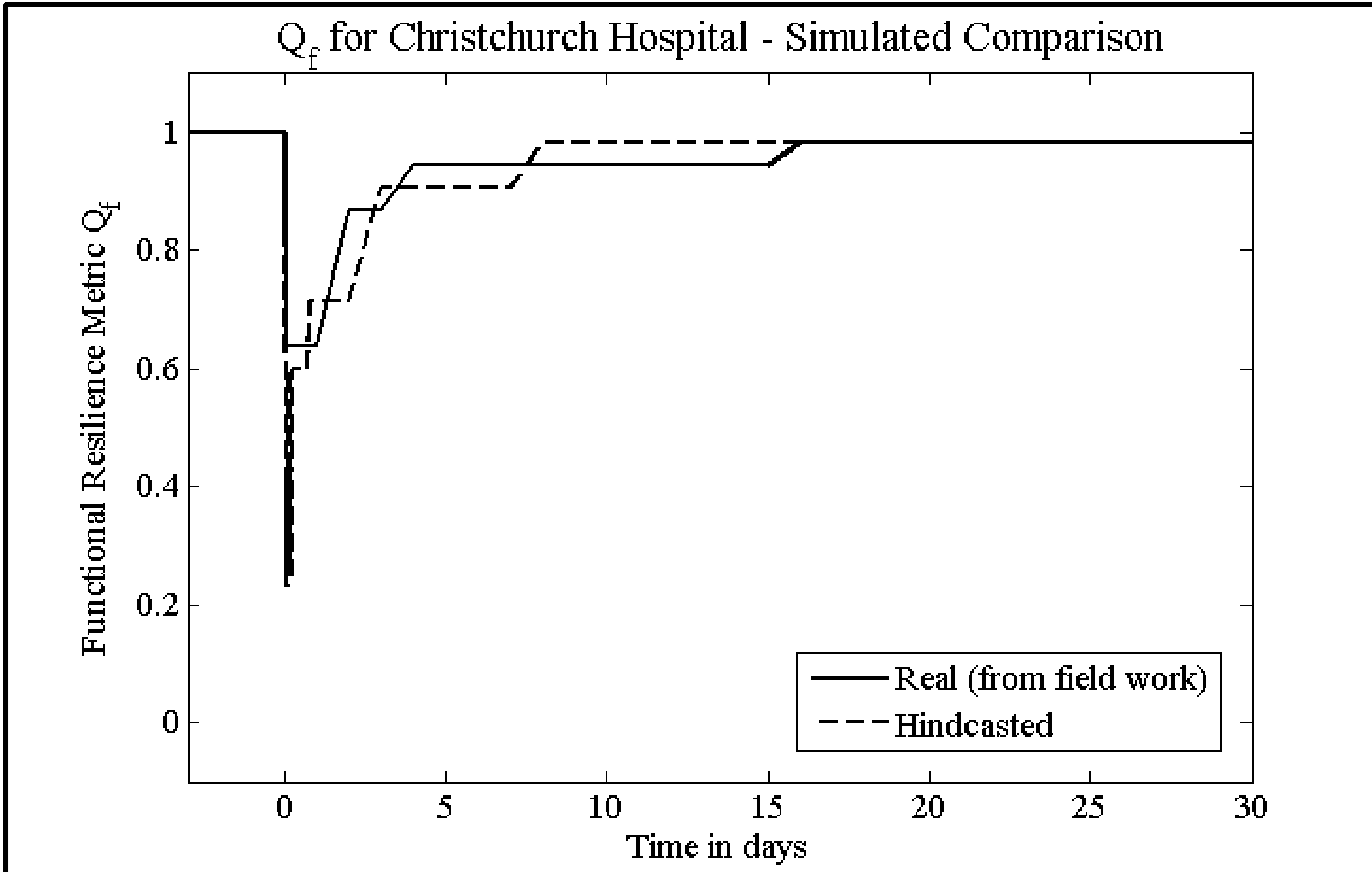


Resilience: functioning over time

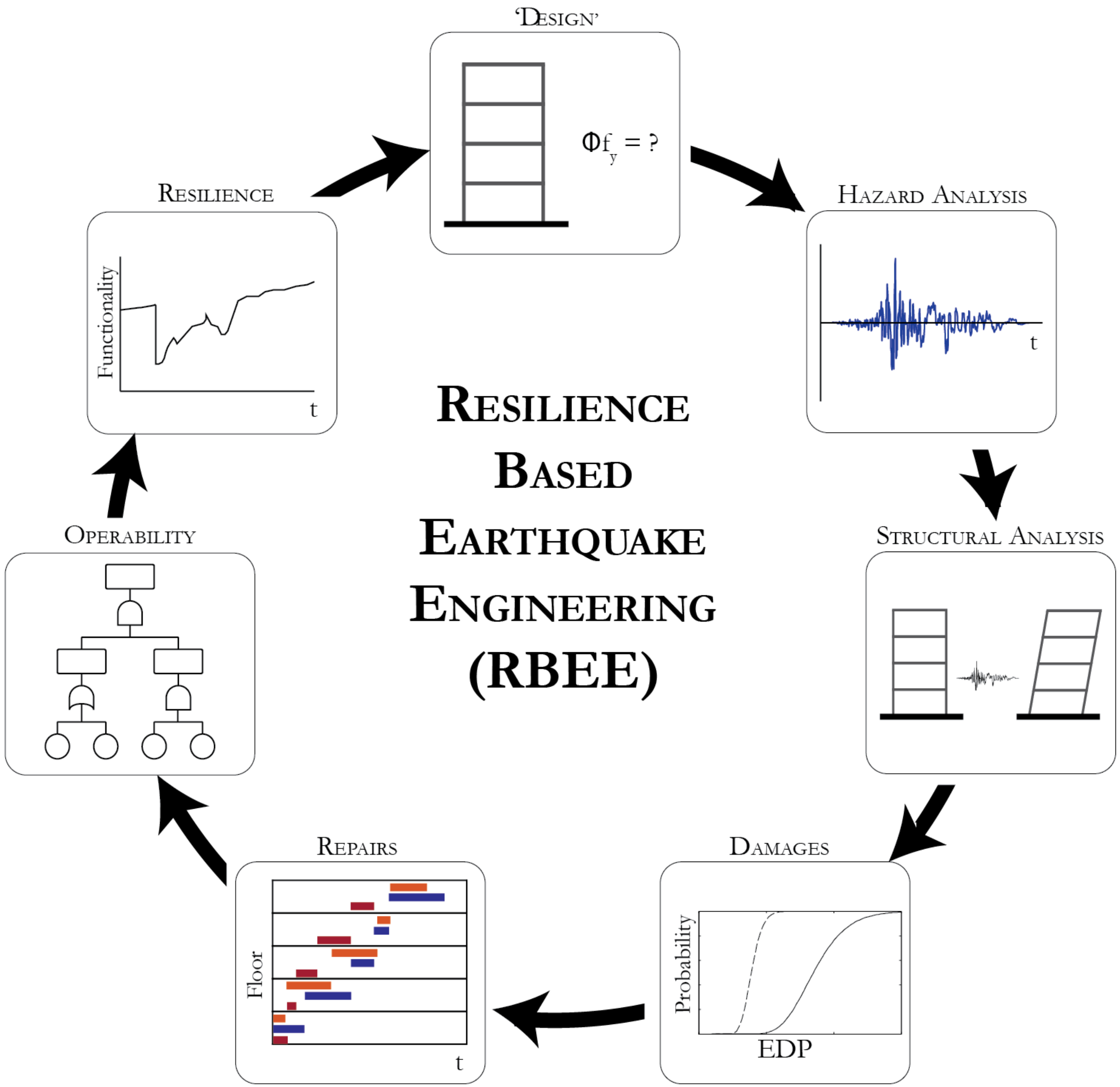
$$Q_f(t) = \frac{\sum_n w_i \left(1 - \left(1 - R_i(t)\right) L_i(t)\right)}{\sum_n w_i}$$

Variable	Definition
i	Total number of functions
w_i	Weight term, importance of the function
$L_i(t)$	Loss of function, range 0-1 (no loss to total loss)
$R_i(t)$	Redistribution of function, range 0-1 (no redistribution to complete redistribution)

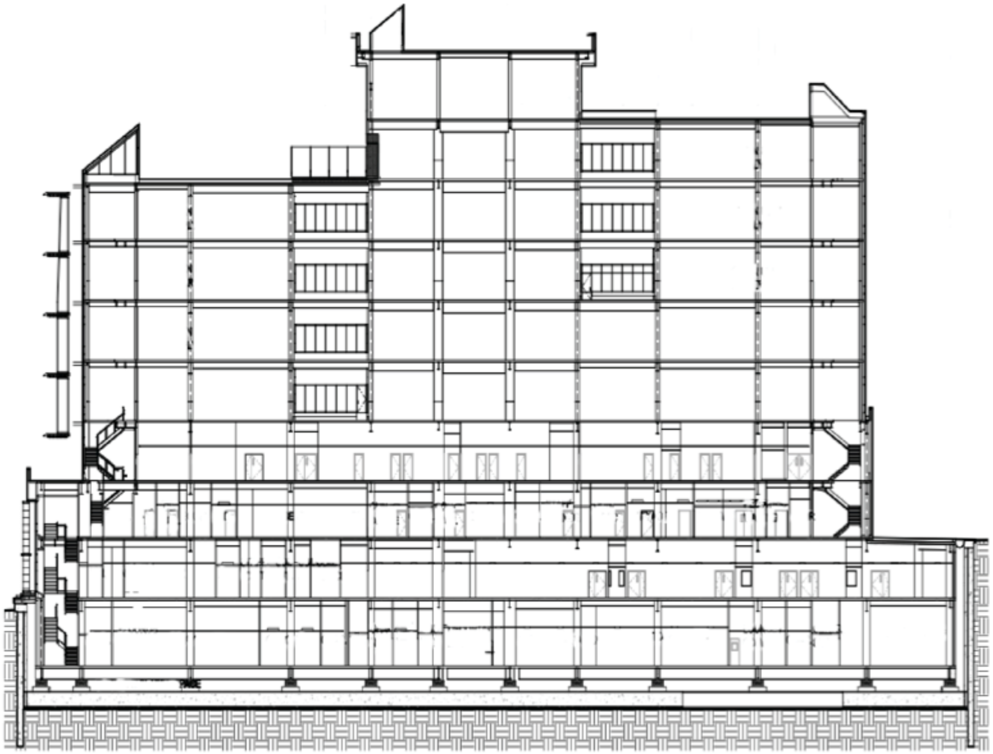
Resilience: functioning over time



Resilience-Based Design: Hospitals



Resilience-Based Design: Hospitals



Services by Floor

Mechanical Floor

Level 7: Medical/Surgical, Acute Care for Elderly
Palliative Care, Roof Garden

Level 6: Medical/Surgical

Level 5: Medical/Surgical Unit, Forensic Unit

Level 4: Step Down Medical/Surgical,
Step Down ICU, Dialysis

Level 3: Intensice Care Units (ICU)

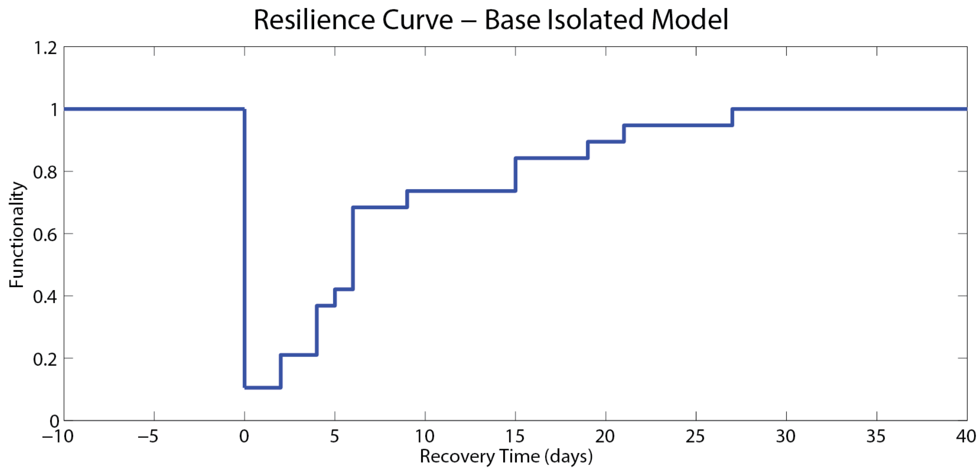
Level 2: Labor and Delivery, Postpartum, Pediatrics,
Neonatal Intensive Care

Level 1: Emergency Department and Trauma Center

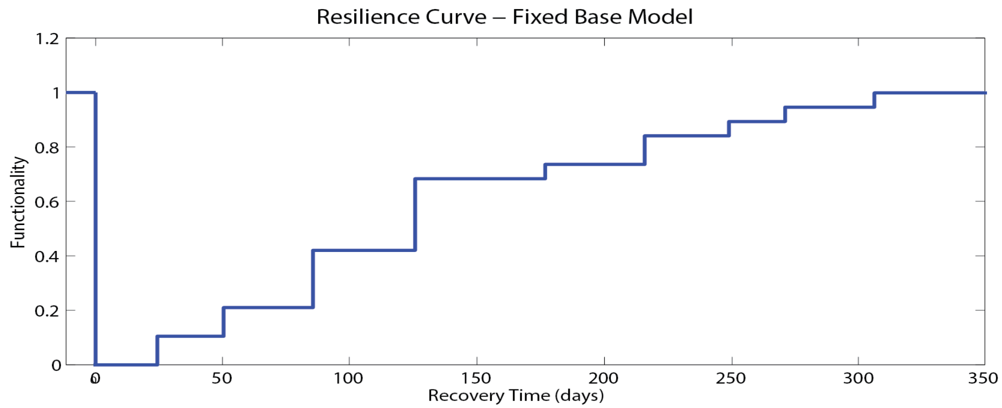
Basement 1: Operating Rooms, Pre-op, Post Op,
Endoscopy, Blood Bank

Basement 2: Dietary. Pharmacy, Cardiologloy,
Pulmonary, Diagnostic Imaging (Xray),
Sterile Processing

Resilience-Based Design: Hospitals



26 days until all hospital services are functional



~300 days until all hospital services are functional

Resilience-Based Design: Summary

The above procedures, while helpful for individual buildings (nodes), will not suffice in capturing disaster impacts on important community institutions:

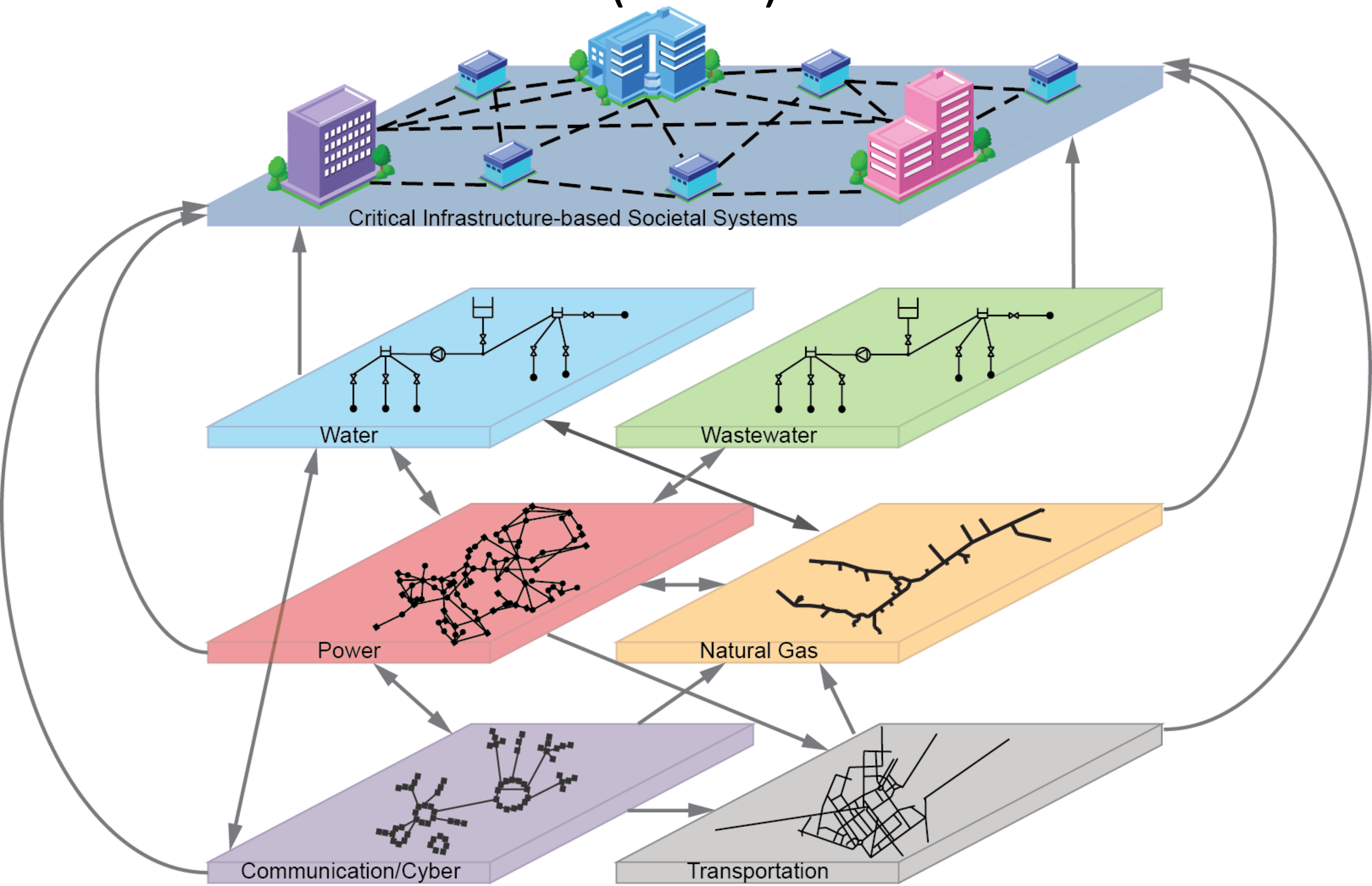
- **Need models that include interdependent critical lifelines and supply chains.**
- **Need to capture the 'networked' system of buildings that provides specific community services.**
- **Need performance metrics that are relevant to the entire system and to the stakeholders managing these institutions.**

Community Functioning Domains

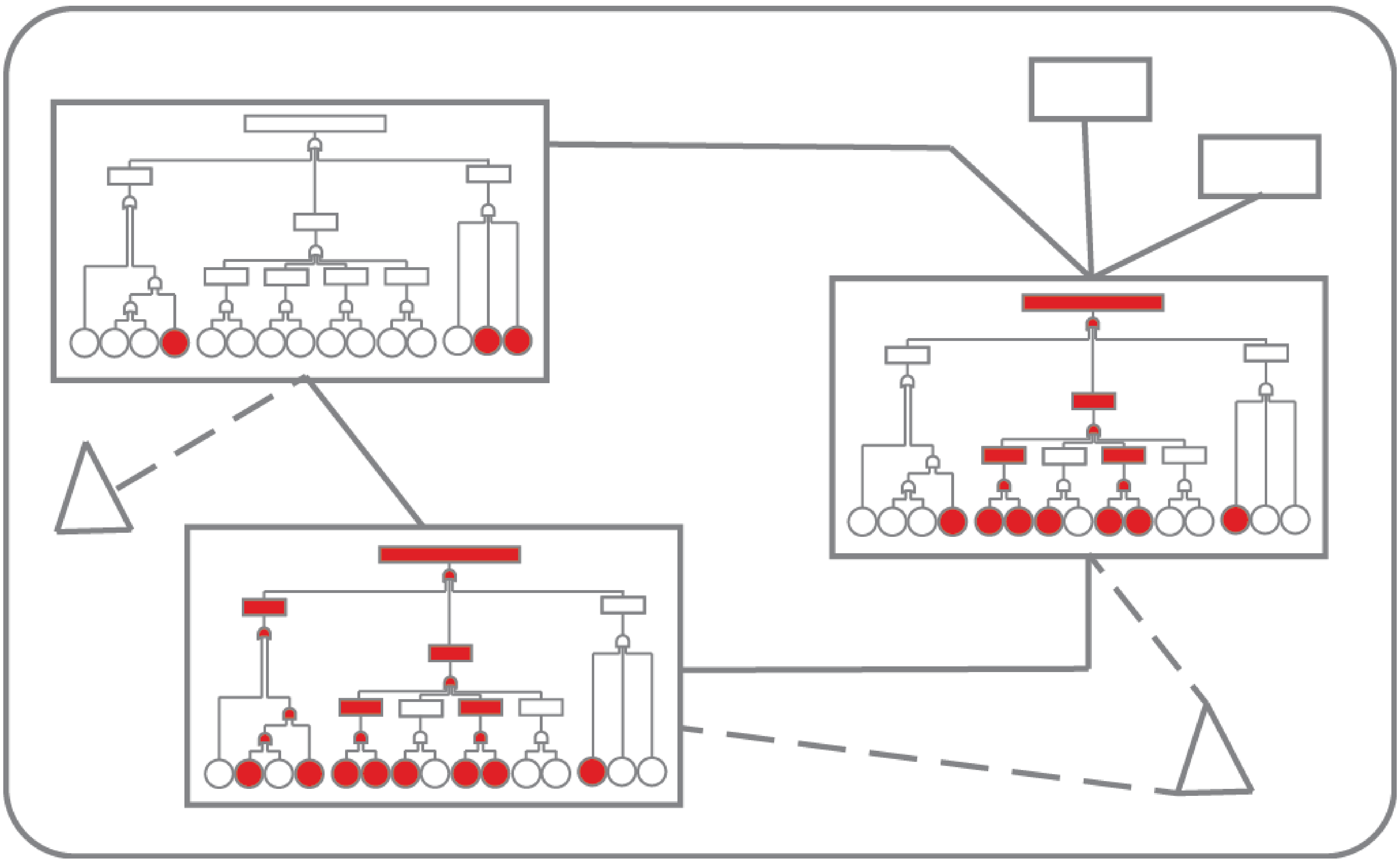
Disaster sociologists explain that not all community institutions mitigate disasters, and offer a short list of disaster-relevant institutions (Aguirre et al., 2005):

- Family
- Religion
- Politics
- Economy
- Medicine & Health
- Education
- Scientific Research
- Law & Courts
- Emergency Responders
- Communication
- Transportation
- Energy
- Food
- Water
- Entertainment
- Construction & Built Environment
- Land Use

Critical infrastructure-Based Societal Systems (CIbSS)



Resilience of the entire CIbSS

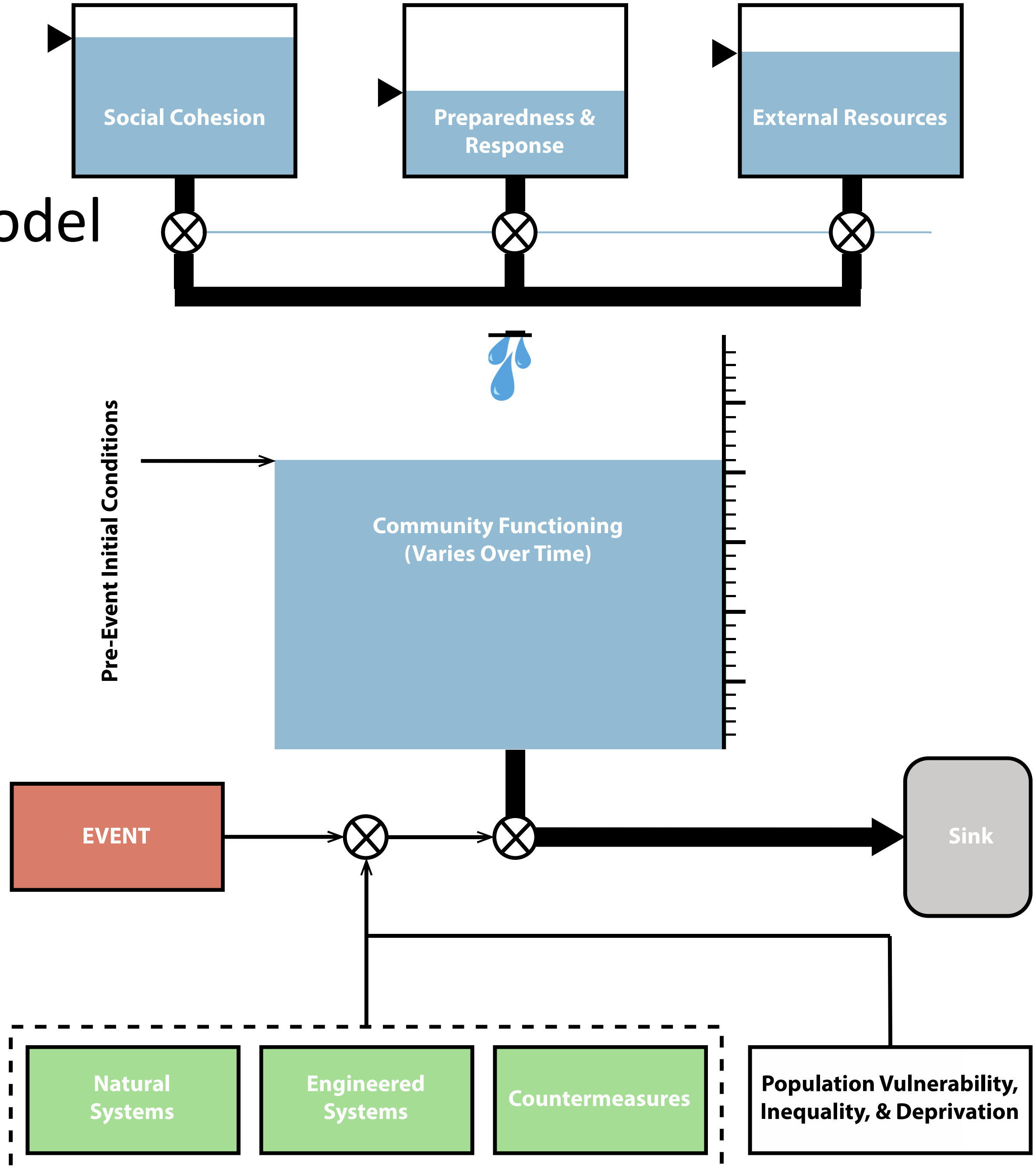


Community Functioning Summary

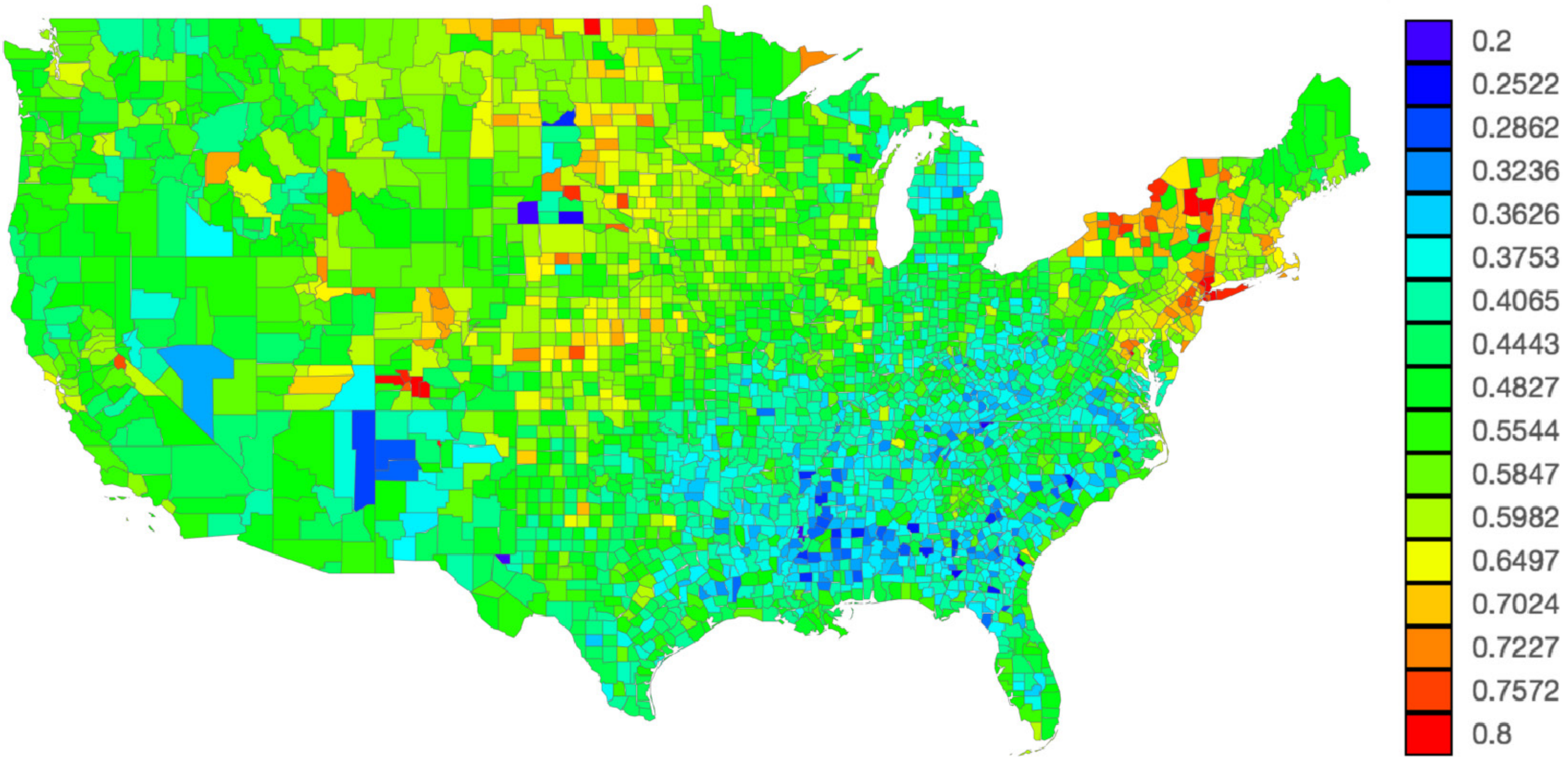
We're starting to scratch the surface of modeling the resilience of one CIbSS, but:

- **Need holistic approach to capture community functioning over time.**
- **Need models that interface multiple scales (building – institution – community).**
- **Need to effectively use data that is collected over a wide range of time scales (e.g., census, tax assessors, reconnaissance, etc.).**
- **Need models that capture the complex interactions of many community institutions.**

Community Functioning: CoPE-Well SD Model



Community Functioning: CoPE-Well SD Model

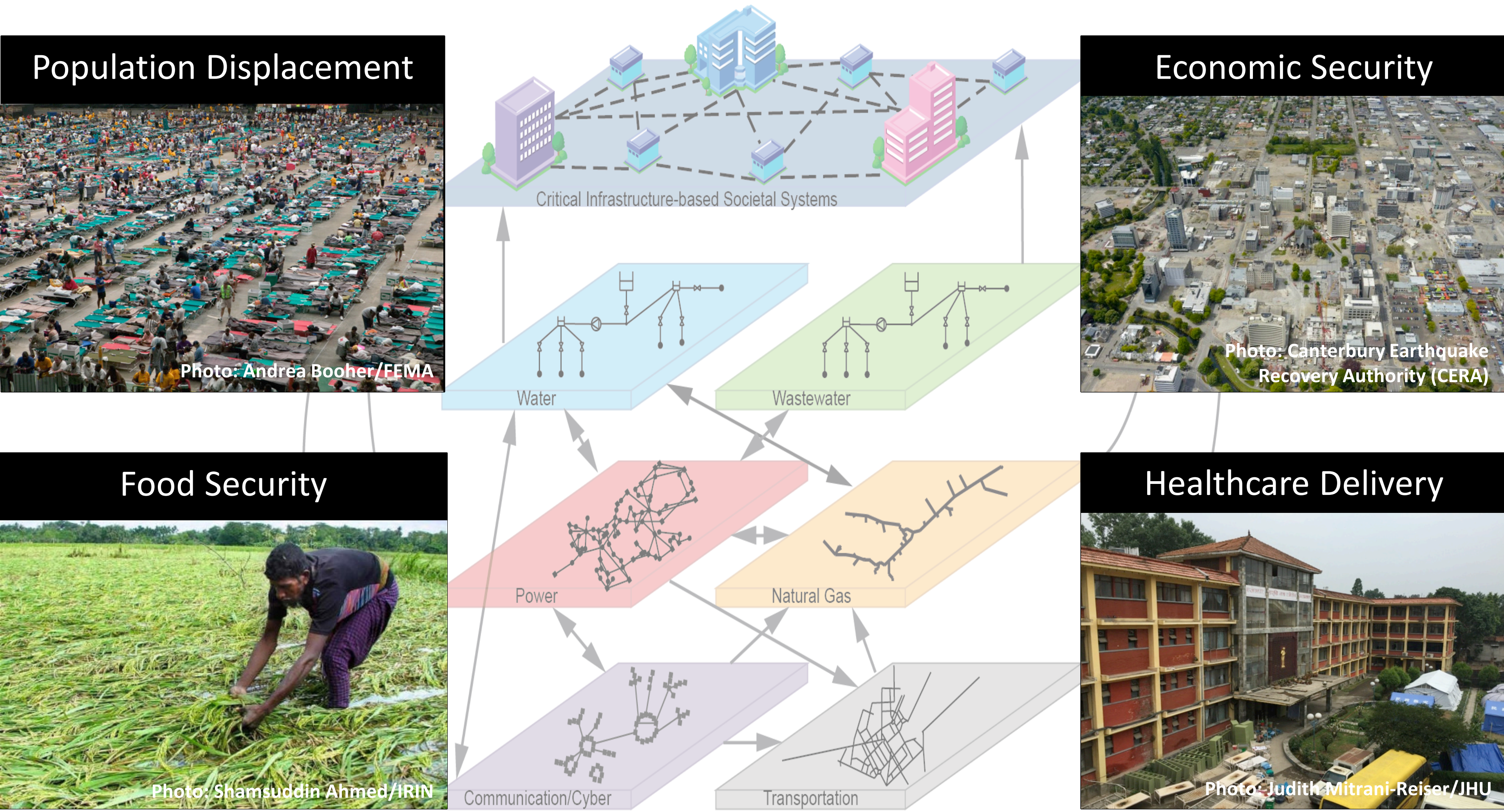


STIRM Research Summary

My research is focused on using engineering tools to answer important questions at the interface of physical and societal systems:

- **Adapting PBEE methods to other hazards (e.g., FPHLPM)**
- **Designing RBEE tools to assess functionality of infrastructure that's critical to communities**
- **Modeling human interaction with compromised infrastructure (building evacuations; patient transfers)**
- **Disaster field studies (acute and longitudinal)**
- **Creating tools that are useful to practitioners (e.g., States of Oregon, Utah, and California; Ministries/Departments of Health; USGS; Arup; CIGIDEN)**

STIRM Research Summary




S.T.I.R.M.
Sensor Technology and Infrastructure risk Mitigation
Team #3
GREEN
Team #2
GREEN
Team #1
YELLOW
YELLOW

Acknowledgements

STATE OF CALIFORNIA Seismic Safety Commission SSC

TVF&R Tualatin Valley Fire & Rescue

NATIONAL SOCIETY FOR EARTHQUAKE TECHNOLOGY-NEPAL NSET-NEPAL 1994 NSET

Canterbury District Health Board Te Poari Hauora ō Waitaha

JOHNS HOPKINS MEDICINE

UTAH DEPARTMENT OF HEALTH

Baltimore Office of Sustainability People·Planet·Prosperity

CDC CENTERS FOR DISEASE CONTROL AND PREVENTION

U.S. DEPARTMENT OF HOMELAND SECURITY

FEMA

JUST WHAT THE DOCTOR ORDERED!

ESF-8 HEALTH AND MEDICAL

Catastrophic Earthquake Resiliency

A PRESCRIPTION IN FOUR DOSES

The Great Disclaimers

- The overall topic is too huge to allow in-depth examination.
- Most of the presentation will consist of BFO's (Blinding Flashes of the Obvious)
- There are exceptions to every rule

UTAH DEPARTMENT OF HEALTH

EMS (866-364-8824)

EPI (888-374-8824)

℞

NAME: Utah Emergency Managers

ADDRESS: Anywhere, Utah, USA

1. It Only Rains At The Local Level
2. ESF – 8 Overview
3. What Keeps Us Up at night
4. Work to be done

Refill As Needed --- Double Dosage In Time Of Disaster

It Only Rains At The Local Level

- All disasters start local
- The role of the next higher level of government is to support

It Only Rains At The Local Level

- Utah Department of Health (UDOH) is your/our link to Public Health response and resources


The Usual Suspects
EMS TEAMS
Health Care Facilities
Rick's
Café Americain
Local Health Emergency Response Coordinators
Long Term Care
Local – State – Federal Teams

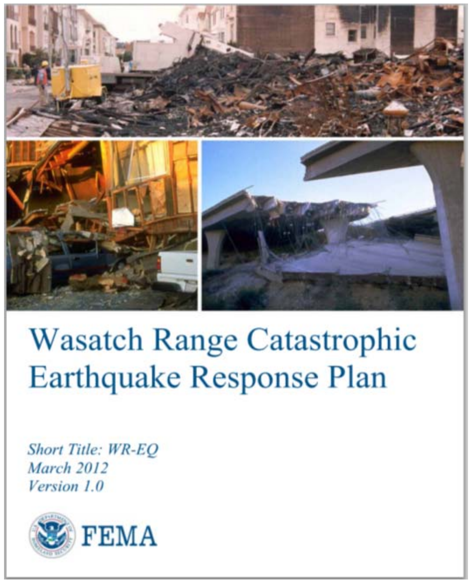
ESF- 8 Team
Department of Health

- Dept. of Agriculture
- Dept. of Corrections
- Dept. of Environmental Quality
- Dept. of Human Resources
- Dept. of Public Safety
- Division of Homeland Security
- Utah National Guard
- (Dept. of Human Services)

- Endless Variables (Myth and Rumor)
- Funding
- Consistency and Coordination at all levels
- Planning and Resiliency (COOP, Pandemic, EOP)
- Training and Exercise

Resiliency Overview

- **Mission**
  - Develop a stake-holder reviewed public health and medical (ESF 8) plan for a catastrophic earthquake
- **Strategy**
  - Mission prioritization and scare resource allocation in support of ESF 8 priorities
- **Focus**
  - 5 days post-earthquake



STATE DEPARTMENT OF HEALTH

NAME: UDOH Employees

ADDRESS: Anywhere, Utah, USA

What Do We Really Face Here in Utah?

Refill As Needed --- Double Dosage In Time Of Disaster

ESF 8 Priorities

1. Support Life-Saving Operations
2. Support Life-Sustaining Operations
3. Support Mass Fatality Operations

Planning Steps

- **Form planning teams**
- **Develop Work Plan**
- Understand current capabilities / gaps
- Understand scenario impacts
- Develop courses of action
- Write Draft Plan
- Final Plan produced

Workshop Highlights

- Invitee’s broad cross section of ESF-8 stakeholders who are directly and indirectly impacted
- Team approved work plan with minor adjustments
- Fine tuned priorities and objectives
- Plans to incorporate Emergency Managers at all levels
- Developed Planning Workgroups, identified membership and identified some chairs
- Revised time line
- Determined 0-5 day planning period and integrated local, state, and federal approach.

Planning Overview

- **Personnel**
  - Integrated local, state and federal approach
- **Timeline**

1. **June 2014** – Advisory approval of Draft Work Plan
2. **September 2014** – Initial Workshop with ESF 8 Partners; establish workgroups
3. **Sept - June 2015** – Workgroup meetings, initial deliverables
4. **Summer 2015** – Mid-term Planning Meeting for all Workgroups
5. **December 2015** – Final Workgroup deliverables collected
6. **Jan - June 2016** – Plan compilation & refinement by Core Planning Team
7. **Summer 2016** – Draft Plan Review by all ESF 8 Partners
8. **Winter 2016** – Final ESF 8 Plan Produced

Planning Workgroups

1. Healthcare System Surge
2. Pre-Hospital & Patient Movement
3. Medical Logistics
4. Routine / Chronic Care
5. Behavioral Health
6. Public & Environmental Health
7. Mass Fatality

Ongoing Concerns

- Scope of Work
  - Staffing
  - Length of time and amount of time


FINI

TAB 6

Public Works

TAB #6

Public Works & Lifelines: Understanding the Interdependencies

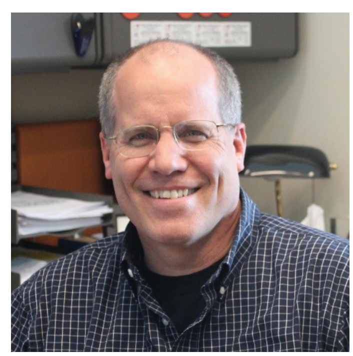
PANELISTS
Jeff King
Peter W. McDonough, PE
Tim Peters
John Leonard, PE

MODERATOR
M. Leon Berrett, PE

Panelists will help attendees understand the fragility of various utility and infrastructure entities and the interdependency between them.

Through their discussion, the audience will gain a better understanding of the need to prepare to be without utilities for a period of time.



PUBLIC WORKS & LIFELINES: UNDERSTANDING THE INTERDEPENDENCIES

JEFF KING
Security & Emergency Response Coordinator, Jordan Valley Water Conservancy District

As the Security and Emergency Response Coordinator, Jeff serves as a liaison with state and county emergency management, local emergency managers and county stakeholders. He is also responsible for training District personnel in security and emergency response procedures.

He administers the District's security systems and Jordan Valley Water Conservancy District Emergency Response Plan (EPR).

Jeff has a number of licenses and certifications including:

- Utah Grade IV Water Treatment and Grade IV Water Distribution
- ICS Train the Trainer #L449
- IS 700 ICS Overview
- IS 800 National Response Framework
- ICS 100, 200, 300, 400

His committee involvement includes the Private Sector Emergency Management Coordinating Council Steering Committee, Private Sector Preparedness Council, UT-WARN Steering Committee Member representing Large Wholesale Water Suppliers, Lifeline Infrastructure Resilience Council, Salt Lake Valley Homeland Security Grants Council, Salt Lake County Local Emergency Planning Committee and Envision Utah Committee Representing Drinking Water.

After 22 years, Jeff retired from the Utah Army National Guard, 142nd Military Intelligence Linguist Battalion.

PETER W. MCDONOUGH, PE
Civil Engineer
Questar Gas

Mr. McDonough has 45 years of engineering design, project management and supervisory experience, primarily relating to natural gas systems and critical infrastructure. He has a strong background in lifeline earthquake engineering and risk management, extending back to 1979.

He has written or contributed to 17 papers and books on the topic of lifeline earthquake engineering. He has presented papers at ten national and international conferences on earthquake engineering.

Peter holds a BS degree in Civil and Environmental Engineering from Clarkson College of Technology and a MS degree in Civil Engineering from the Polytechnic Institute of New York. He is a Licensed Professional Civil Engineer in Utah and Wyoming.

He is a past Executive Committee Chair of the American Society of Civil Engineers' Technical Council on Lifeline Earthquake Engineering (ASCE/TCLEE) and is current chair of ASCE's Infrastructure Resilience Division's Gas and Liquid Fuels Subcommittee.

Peter is a past (four term) chair of the Utah Seismic Safety Commission and currently represents ASCE on the Commission. He is a Fellow of the American Society of Civil Engineers and serves on the Board of Directors of The Western States Seismic Policy Council. Since 2012 he has been a member of the Utah Uniform Building Code Commission's Structural Advisory Committee. He was the 2013 President of the Utah Chapter of the Earthquake Engineering Research Institute.

PUBLIC WORKS & LIFELINES: UNDERSTANDING THE INTERDEPENDENCIES

TIM PETERS
Public Services Manager
Public Works Department
City of West Jordan

As West Jordan's Public Services Manager, Tim is responsible for the following divisions in the Department:

- Streets Maintenance – responsible for 855-lane miles of roadways, pothole repair, concrete repairs & maintenance and snow plowing
- Street Construction – responsible for the implementation of the City's pavement management program including crack-sealing, overlays in the City using the City's lay-down machine.
- Streets Operations – responsible for all graffiti removal in the City, solid waste collection for 23,000 customers through a waste hauler contract, 5,000 street lights, and proper street signage including street & traffic signs

Tim has approximately 29 years of public works related experience including working for the cities of Palo Alto, Belmont and Mountain View in California; Utah Department of Transportation; and, City of West Jordan.

He has had seven articles published in Public Works Magazine. Tim has also been active in APWA having served on the Emergency Preparedness Committee for the Utah Section and has made a number of presentations at multiple conferences. He is also been very active in the organization Engineers Without Borders" and traveled to Africa and the Navajo Nation in Arizona with the organization.

M. LEON BERRETT, PE
Operations Associate Director
Salt Lake County Public Works
Operations Division

Leon has been with Salt Lake County Public Works, Operations Division for over 13 years. One of his duties includes emergency management for Salt Lake County Public Works Operations. He has received extensive training in emergency management from attending training courses at the Emergency Management Institute in Emmitsburg, MD, to numerous training opportunities within Utah. He has also presented many presentations on the role of Public Works during a disaster.

Prior to Salt Lake County he served as the Riverton City Engineer for four years. His professional experience includes civil, structural and environmental engineering. Previous to Riverton City he had gained 14 years of professional engineering experience (seven years in private industry, seven in consulting). He has been project manager and/or engineer on a wide variety of projects with budgets ranging between thousands of dollars to over 20 million dollars.

His educational background includes BS and MS degrees in Civil Engineering from Brigham Young University. He is a Professional Engineer registered in Utah (active), Idaho (active), Nevada and Wyoming.

He currently is the Chair of the APWA (American Public Works Association) Utah Chapter Emergency Management Committee, Member of the APWA National Emergency Management Committee and Chair of the Utah Seismic Safety Commission. His second language is Spanish.

Public Works and Lifelines:

Understanding the Interdependencies

Public Works ~~and~~ IS Lifelines:

Understanding the Interdependencies

PUBLIC WORKS – BIG UMBRELLA

- Streets and Roads
- Traffic
- Stormwater
- Culinary and Waste Water
- Solid Waste
- Natural Gas
- Electrical Power
- Fleet
- Telecommunications
- Animal Services
- Planning & Development
- Building Department
- And More!!

Panelists:

Jeff King – Jordan Valley Water Conservancy District

Pete McDonough, P.E. – Questar

Tim Peters – West Jordan City

John Leonard, P.E. – UDOT

Moderator:

M. Leon Berrett, P.E. – Salt Lake County Public Works

Jordan Valley Water Conservancy District

Jordan Valley Water Conservancy District is a political subdivision of the State of Utah. It was created in 1951 under the Water Conservancy Act and was called the Salt Lake County Water Conservancy District. On June 4, 1999, Jordan Valley's name was changed from Salt Lake County Water Conservancy District to Jordan Valley Water Conservancy District to eliminate confusion with Salt Lake County governments and to better reflect Jordan Valley's service area, which includes most of Salt Lake County outside of Salt Lake City and Sandy and a small portion of northern Utah County.

Jordan Valley is governed by a board of nine trustees who represent eight geographical divisions. They are nominated by either the Salt Lake County Council or a city council, depending upon the division they represent. Each trustee is appointed by the Governor for a four-year term.

Jordan Valley is primarily a wholesaler of water to cities and improvement districts within Salt Lake County. It also has a retail service area in unincorporated areas of the county. Jordan Valley is now the largest municipal water district in Utah, with 90 percent of its municipal water delivered on a wholesale basis to cities and water districts and 10 percent on a retail basis to unincorporated areas of Salt Lake County. In addition, Jordan Valley treats and delivers water to Metropolitan Water District of Salt Lake & Sandy for delivery to Salt Lake City and Sandy City, even though neither city is within Jordan Valley's service boundaries. Jordan Valley also delivers untreated water to irrigators in Salt Lake and Utah Counties to meet commitments under irrigation exchanges.

	**Administration Headquarters:** Constructed in 1989 with seismic upgrading in 2013.
	**Jordan Valley Water Treatment Plant (JVWTP):** Constructed in 1972 with expansions in 1979, 1986, and seismic upgrading in 2008. CUWCD transferred ownership to JVWCD and MWDSLS in 2007; JVWCD operates the plant on behalf of itself and Metropolitan Water District of Salt Lake/Sandy. The rated capacity is 180 million gallons per day (mgd).
	**Southeast Regional Water Treatment Plant (SERWTP):** Constructed in 1985 with a major process enhancement from a direct filtration process to a micro-sand ballasted clarification process (ACTIFLO) in 2000. JVWCD owns and operates this facility with a high-rate clarification technology. The rated capacity is 20 mgd.
	**Southwest Groundwater Treatment Plant (SWGWTP):** Constructed in 2012 and reverse osmosis technology is used to treat contaminated groundwater. The rated capacity is 7 mgd.

	**Jordan Narrows Pump Station (JNPS):** Constructed in 1989, this pump station draws Utah Lake water from the Jordan River and pumps it in to the Provo Reservoir Canal siphon for conveyance of irrigation water to the Welby and Jacob Canals. The pump station delivers up to 140 cubic feet per second (cfs) (90 mgd) to meet requirements of the Welby-Jacob Exchange Agreement.
	**Wells:** JVWCD owns and operates 45 wells throughout the Salt Lake Valley with pumping capacities ranging from 0.7 to 9.5 cfs and a total capacity of 148 cfs (95 mgd).
	**Pump Stations:** JVWCD owns and operates 14 pump stations throughout the Salt Lake Valley with pumping capacities ranging from 4 to 49 cfs and an average capacity of 27.5 cfs.
	**Reservoirs:** JVWCD owns and operates 30 reservoirs throughout the Salt Lake Valley with a total storage capacity of 170 million gallons (MG).
	**Pipelines:** More than 280 miles of water transmission pipelines that allow JVWCD to deliver approximately 43 billion gallons of drinking water annually throughout Salt Lake County and northern Utah County.

Questar Gas serves the entire state of Utah as natural gas provider. Over 90 percent of our population depends on natural gas for heating. Many industrial and commercial firms also rely on natural gas for their operations and processes. As a critical part of the state's infrastructure Questar realizes the need to provide safe, reliable service at all times.

Since the 1970's Questar has been studying earthquake hazards and the associated risks to it's facilities and operations. Seismic hazards are identified as part of all new pipeline projects and suitable mitigation work is incorporated in design. Most recently this has included extensive use of geofoam as a light weight backfill material at fault crossings.

Extensive use of valving to isolate distribution grids and the use of highly ductile medium density polyethylene for pipelines operating below 60 psig further reduces risk to the system.

TAB 7

Government

TAB #7

Role of Government: Mitigation Efforts & Recovery Expectations

PANELISTS
Kate Bowman
Dr. Divya Chandrasekhar
Cory Lyman
Lani Egertsen-Goff

MODERATOR
Brad Bartholomew

How do we bring older buildings up to current code performance levels?

And what are the benefits achieved for individual building owners and for the public? Panelists will explore how codes and standards can help speed up the rate of recovery.

ROLE OF GOVERNMENT: MITIGATION EFFORTS & RECOVERY EXPECTATIONS

KATE BOWMAN
Solar Project Coordinator
Utah Clean Energy

Kate is the Solar Project Coordinator for Utah Clean Energy, a non-profit, non-partisan organization in Salt Lake City whose mission is to lead and accelerate the clean energy transformation with vision and expertise.

She works to generate solutions that overcome barriers to solar market growth through successful partnerships with decision makers and leaders, including local governments, utilities and businesses.

Through the U.S. Department of Energy's Solar Market Pathways Initiative, Utah Clean Energy and Salt Lake City are partnering to explore the potential for solar energy combined with storage to increase community resiliency and emergency preparedness.

Kate's work on innovative programs designed to jump-start the clean energy economy create opportunities for businesses and builders who see the connection between clean energy and a sustainable future.

In April 2014, Kate Bowman was recognized by the White House as a "Champion of Change" for her efforts to promote and expand solar deployment.

Dr. DIVYA CHANDRASEKHAR
Assistant Professor, Dept. of City & Metropolitan Planning
University of Utah

Divya is a faculty member in the City & Metropolitan Planning program within the College of Architecture + Planning and also affiliated with the department's Ecological Planning Center. Her research focuses on community and household recovery from catastrophic disasters, with an emphasis on disaster policy and planning practice.

Over the course of her career, Divya has examined recovery and reconstruction planning processes after disasters, community participation in recovery planning, the emergence of new institutions and coordination structures after disasters, post-disaster displacement, and household and business capacity to recover from major disasters. She specializes in case study research in domestic and international contexts, and in mixed method studies that combine survey and qualitative inquiry approaches.

Divya's research has been funded by the National Science Foundation, the Natural Hazards Center at Boulder, and the Mid-America Earthquake Center, and her work has been published in national and international journals.

She has also previously been a National PERISHIP Fellow with the Natural Hazards Center. Prior to joining the University of Utah, Divya was an Assistant Professor at Texas Southern University, Houston TX.

ROLE OF GOVERNMENT: MITIGATION EFFORTS & RECOVERY EXPECTATIONS

CORY LYMAN
Director of Emergency Management
Salt Lake City

Cory has been the Director of Emergency Management for Salt Lake City since October 2008. He is responsible for design, development and implementation of the City's emergency operations plans and preparedness programs.

Current preparedness programs include Fix the Bricks (Un-Reinforced Masonry (URM) building seismic mitigation and Building Occupancy Resumption Program (BORP). He works with all city departments, government agencies, as well as private partners and volunteer groups to ensure the success of the city's goals. In his time as director, Cory has revitalized the department with his progressive vision and enthusiasm.

Cory brings a wealth of knowledge and experience to Salt Lake City. He served as Police Chief for Ketchum, Idaho, for five years. During which time there were several major events, including wild land fires and flooding that required significant evacuation of residents. Cory attributes part of the evacuation success to the use of media and volunteers.

Prior to that, Cory was a member of the Salt Lake City Police Department for 21 years functioning in many capacities including being part of the 2002 Olympics Communications Committee. During the Elizabeth Smart investigation Cory demonstrated his crisis leadership skills as commander of the task force. His extensive management experience in multiple areas and his ability to carry out missions successfully in times of crisis made him the ideal choice for his current position.

LANI EGERTSEN-GOFF
Construction Program Manager & Project Liaison, Engineering Division of Salt Lake City

Lani is a AICP planner working in the Engineering Division as a Construction Program Manager and Project Liaison. Her work encompasses civic engagement, public information, environmental permitting and project management.

She has also worked in the private sector while living in Utah -- in Transportation and NEPA consulting; in the public sector at the Kenai Peninsula Borough, City of Homer, and the State of Alaska Division of Parks and Outdoor Recreation while living in Alaska for over 13 years.

She attended Alaska Pacific University for her Master of Environmental Science degree, and Utah State University for a Liberal Arts degree.

Lani serves as the President of the Utah APA Chapter and enjoys interacting with many of the over 500 members of the chapter. She is the mother of a 12-year old son and has a busy husband who also works in the public sector. She enjoys walking her dog, Luna, and doing yoga as often as possible.

ROLE OF GOVERNMENT: MITIGATION EFFORTS & RECOVERY EXPECTATIONS

BRAD BARTHOLOMEW
Mitigation & Recover Manager,
Div. of Emergency Management
State of Utah

Brad is the Mitigation and Recovery Manager for the Division of Emergency Management. His work encompasses managing pre- and post-disaster mitigation projects, hazard mitigation plans through out the state and offering local assistance in responding to and recovery from disasters.

Brad has worked for the DEM for over 10 years after earning his Urban Planning degree from the University of Utah where he also received his Master in Public Policy.

He spends his free time with his young and busy family and working in his Rose Park community. He likes to take pictures of conference carpets.

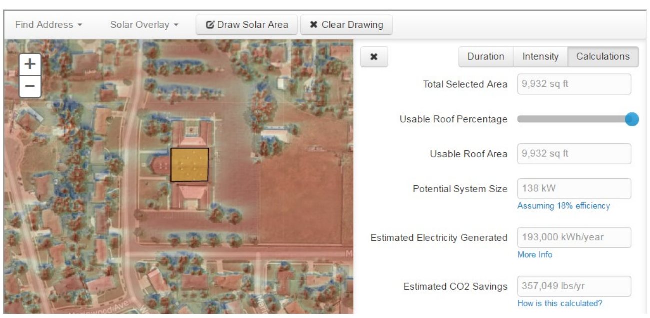
SOLAR SIMPLIFIED

UTAH'S ONE-STOP-SHOP FOR SOLAR INFORMATION

Solar energy is here to stay: more U.S. consumers and businesses are investing in solar energy than ever before. The US has **over 22,700 MW** of cumulative installed solar electric capacity, which is enough to power **more than 4.6 million** average American homes!

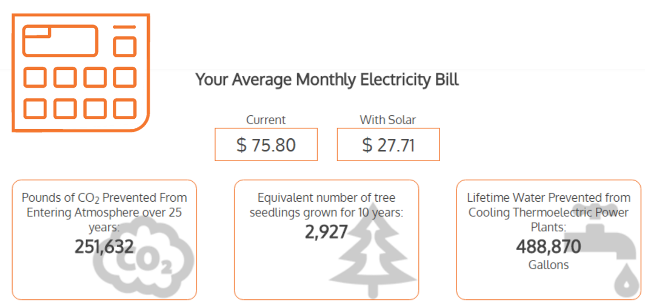
SolarSimplified.org provides comprehensive solar information and tools for **homeowners, businesses, contractors, local governments, and utilities** to help expand Utah's solar market and streamline the solar installation process.

SALT LAKE SOLAR MAP



Use the Solar Map to review your roof's solar potential

RETURN ON INVESTMENT CALCULATOR



Estimate your return on investment with solar

SOLAR-FRIENDLY ZONING TOOLBOX

SOLAR ZONING GUIDELINES

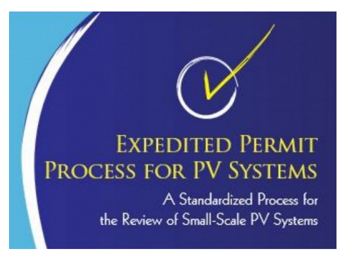
SOLAR-READY DEVELOPMENT

MODEL ZONING ORDINANCE

RESOURCES FOR ZONING OFFICIALS

Review best practices for solar zoning and planning

STREAMLINED PERMITTING TOOLBOX



Save time and money with the model expedited solar permit for Utah

Solar Simplified was made possible with support from the U.S. Department of Energy SunShot Initiative's Rooftop Solar Challenge and the Wasatch Solar Challenge - a partnership of Utah Clean Energy, Salt Lake City Corporation, Salt Lake County, West Valley City, Midvale, Summit County, and Park City. Utah Clean Energy developed all website content and the solar mapping analysis was conducted by GIS Analysts at Salt Lake City's Information Management Services Division and the Utah Automated Geographic Reference Center (AGRC), with support from Salt Lake County's GIS division. Partners would like to give a special thanks to all of the involved partners and organizations for their support and contributions to the development of the website.

Powered by SunShot U.S. Department of Energy | Wasatch Solar Challenge | Salt Lake City | Salt Lake County | Utah Clean Energy | Utah AGRC Automated Geographic Reference Center

SOLAR AND STORAGE FOR ENERGY AND RESILIENCY

A guide for consideration

Utah Clean Energy

With support from:
U.S. Department of Energy SunShot Initiative

SOLAR AND STORAGE FOR ENERGY AND RESILIENCY:
A guide for consideration

Utah Clean Energy, March 2016

Table of Contents

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Cover Photo Source: Salt Lake City Public Safety Building, Utah Adventure Journal, November 2015 <*http://utahadvjournal.com/index.php/is-it-getting-hot-in-here*>.

INTRODUCTION

The growing frequency of extreme weather events and the very real threat of a significant earthquake in Utah drives the need for resilient backup power systems. A self-generation power system comprised of solar photovoltaics coupled with battery storage not only provides robust backup power in the event of an emergency but also helps manage day-to-day energy usage. The versatility and scalability of solar and storage and the ability to combine a solar and storage system with traditional backup generators makes solar and storage an ideal solution for critical facilities that require uninterrupted power supply such as hospitals, communication centers, radio stations, and community emergency shelters.

A 330 kilowatt solar installation at the Natural History Museum of Utah. Utah's solar capacity has grown rapidly in recent years. Retrofitting existing solar installations with battery storage can provide resilient backup power in the event of a grid outage.[1]

The cost to install solar has fallen about 75% since 2006,[2] and solar installations are an increasingly popular way to save money on utility bills. Battery storage costs have undergone similar price declines, falling by more than 50% since 2010, making solar with storage an increasingly viable solution for energy management in addition to emergency power.[3] Future cost declines are expected to make commercial and industrial use of batteries for energy storage a cost-effective choice in certain markets within 3-5 years, amplifying the advantages of solar energy and making solar and storage systems an attractive economic offering in these markets.[4]

As the solar market continues to grow in Utah, planning for storage by building storage-ready projects opens the door for future cost savings. Understanding best practices for solar and storage systems will prepare facilities to incorporate solar and storage into new construction, scheduled renovations, or even retrofits as storage costs continue to fall and technology improves.

As you consider solar for your facility, this guide will help you understand how you can incorporate storage into your project or make your project 'storage-ready' such that storage can be incorporated cost-effectively in the future.

[1] Utah Natural History Museum, <https://newsdesk.nhmu.utah.edu/?q=media/572>.
[2] GTM Research & Solar Energy Industries Association, *U.S. Solar Market Insight 2015 Year-in-Review*, March 2016. <http://www.seia.org/research-resources/solar-industry-data>.
[3] Moody's Investor Service, "Declining battery prices could lead to commercial and industrial customer adoption in 3-5 years," Sept 2015 <https://www.moodys.com/research/Moodys-Declining-battery-prices-could-lead-to-commercial-and-industrial--PR_335274>.
[4] *Ibid.*

CONSIDERATIONS FOR SOLAR AND STORAGE OR STORAGE-READY SYSTEMS

1. **Determine your backup power goals:**

   Solar and storage systems can be used to provide backup power for key critical loads, to provide power to an entire facility, or to provide supplementary power to extend the life of a backup generator. Decisions about battery technologies will be guided by your backup power goals

2. **Isolate critical loads on the same circuit:**

   In order for solar and storage to provide power to critical loads in the event of a grid failure, those critical loads must be isolated on the same circuit. Isolating critical loads during construction or renovation will prepare your facility to add solar and storage at a later date.

3. **When installing solar, choose a battery-ready solar inverter**

   Existing solar installations can be retrofitted with battery storage more easily if they include inverters that have the additional functionalities required to integrate battery storage. For more information, refer to the Technical Options section below.

4. **Identify a location for the batteries which is of sufficient size and well ventilated**

   Batteries must be located onsite and must be directly connected to the solar installation. The size of the batteries will depend on the battery technology and the anticipated power needs of the building. Electrical code requirements for batteries address safety concerns and require batteries to be kept on appropriate racking in a well ventilated location.[5] Anticipate the location of battery storage and make accommodations during construction or renovations to prepare for the addition of storage.

5. **Refer to Clean Energy Group's "Solar+ Storage Project Checklist,"** which is designed to help building owners and developers assess whether solar and storage battery systems make sense for their buildings.[6]

[5] National Fire Protection Association National Electric Code 70, Article 480 Storage Batteries <http://www.nfpa.org/codes-and-standards/document-information-pages?mode=code&code=70>.
[6] Clean Energy Group, "Solar + Storage Project Checklist," <http://www.cleanegroup.org/ceg-resources/resource/solar-storage-project-checklist/>.

TECHNICAL OPTIONS

Solar Panels

Solar panels provide power for a solar and storage system. Solar panels generate direct current (DC) power which must be converted to alternating current (AC) power to provide usable power for a building. Solar panels can be located on rooftops, carports, other structures, or even stand alone in open areas.

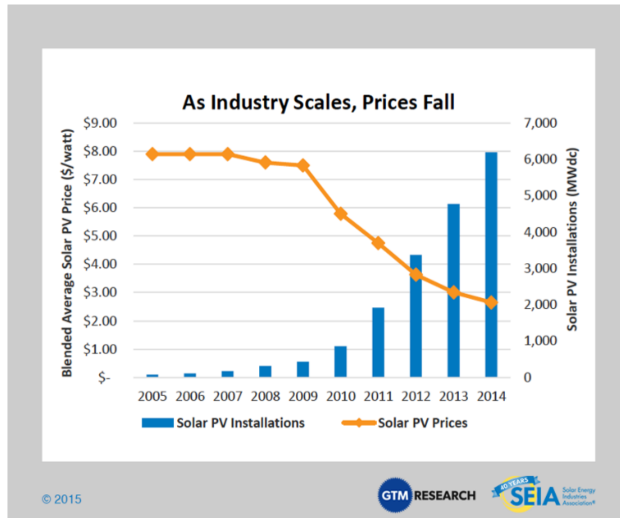

Figure 1: The cost of solar energy has fallen more than 75% since 2006.[7]

Batteries

There are several factors to consider when selecting a battery for a solar and storage system, including cost, energy density, expected lifespan, and safety. All batteries store DC power.

- **Lead acid batteries** are the oldest rechargeable battery technology and are commonly found in automobile engines. Whereas car batteries are designed to remain near full charge, lead acid batteries designed for storage are able to be discharged to 45% - 75% of their rated capacity so that they can withstand repeated charging and discharging. They have a low energy density, thus occupying more space, and have a shorter lifespan than lithium ion batteries.
- **Lithium ion batteries** are commonly used in laptops and electric vehicles. They have a high energy density thus making them lighter and smaller. There are several types of lithium ion batteries currently on the market, each made from a different lithium compound. Lithium ion batteries have a longer lifespan than lead acid batteries because they can be charged and discharged more frequently. Proper installation, maintenance, and use of lithium ion batteries is important to avoid overheating, which can create a fire hazard.

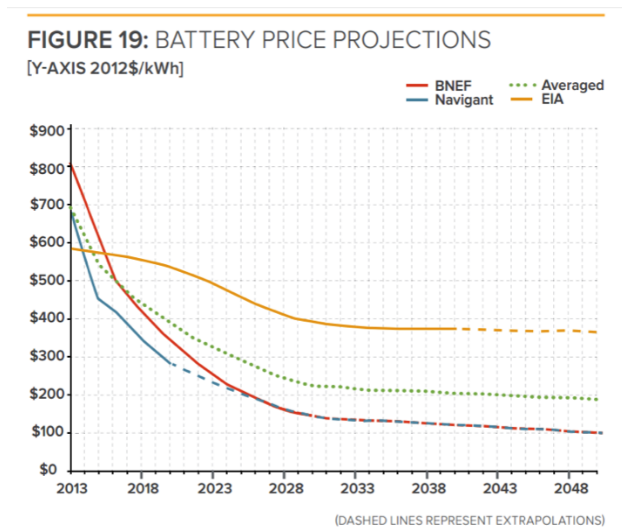

Figure 2: The cost of lithium ion batteries is expected to decline rapidly.[8]

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[7] *Solar Energy Industries Association Q2 2015 Solar Market Insight Fact Sheet*, <http://www.seia.org/research-resources/solar-industry-data>.
[8] *Rocky Mountain Institute, The Economics of Grid Defection*, <http://www.rmi.org/electricity_grid_defection>.

- **Flow Batteries** are a new type of rechargeable battery. Flow batteries consist of two liquid electrolyte compounds which are pumped across a membrane in one direction to produce electricity and in the opposite direction to charge the battery. Flow batteries are very safe because the electrolytes are stored in separate tanks. They can be cycled 10,000 or more times, making them superior to lead acid and li-ion batteries. However, at this time, their relatively high cost, low efficiency and low energy density is still a disadvantage.

Advances in battery technology have brought down the cost and the size of batteries.[9]

Recycling batteries

Some of the batteries used for storage contain toxic metals, and proper recycling is important to prevent pollution and avoid environmental impacts.

- **Lead acid batteries** are recycled more than any other consumer product in the country. Disposal of lead acid batteries into landfills is illegal in most states.[10] During the recycling process, lead can be easily extracted and reused multiple times. Recycling centers must first remove combustible material using a gas-fired thermal oxidizer and must mitigate pollution created by the process of burning using scrubbers.[11]
- **Lithium ion batteries** do not pose as significant an environmental concern but there are benefits to recycling them. Lithium ion batteries are composed of metals that have little or no recycling value such a cobalt, nickel, and manganese, so the economics of recycling these batteries isn't favorable.[12] However, as increasing numbers of lithium ion batteries enter the market, recycling of lithium ion batteries is expected to be one of the main sources of future lithium supply.

Charge Controllers

A battery charge controller regulates the DC power produced by the solar array to prevent overcharging the batteries. If the power input to the battery is not controlled it can result in damage to the batteries and poses a safety hazard.

Inverters

Solar inverters are used to convert DC power produced by solar panels (or the DC power that is stored in batteries) to AC power. A grid-connected solar and storage system must have a specific kind of inverter if it is to provide backup power in the event of a grid failure. A standard solar inverter is designed only for converting DC power to AC power, and it will shut off in the event of a grid failure to protect lineman working on the power lines.

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[9] PV Magazine, "Strong potential growth for storage, distributed generation and microgrids," November 28 2012, <http://www.pv-magazine.com/news/details/beitrag/strong-potential-growth-for-storage--distributed-generation-and-microgrids_100009373/#ixzz44M7zdxJ8>.
[10] Waste Management World, "The Lithium Battery Recycling Challenge," https://waste-management-world.com/a/1-the-lithium-battery-recycling-challenge
[11] Battery University, "How to Recycle Batteries," <http://batteryuniversity.com/learn/article/recycling_batteries>
[12] Waste Management World Op. Cit.

In order for a solar and storage project to function both on and off the grid, the inverter must be able to provide several functions. It must be able to monitor and communicate grid status, convert DC electricity produced by solar panels to AC electricity, provide DC electricity to charge the battery, convert DC electricity stored in the battery to AC electricity for onsite use, and curtail power production from the solar panels as needed to prevent damaging the battery

- **Dual inverters** are used in a DC-coupled solar and storage system and can accomplish all these functions with a single inverter. A DC-coupled battery stores the DC power produced by solar panels without conversion and can also convert the power to AC for use in a building. Some dual inverters, known as **Grid Forming Inverters**, can also regulate voltage and frequency when the solar and storage system is isolated from the grid. When installing a solar project, choosing a Dual Inverter or Grid Forming Inverter for the solar installation will allow for the future addition of storage at a lower cost. See Figure 3, below.
- **Grid-tied inverters** are used for grid-tied solar systems, and cannot provide islanding or backup functionality. Grid-tied inverters can be used to convert DC battery power to AC power for use in homes or buildings as long as they remain grid connected.

- **Stand-alone inverters** are used for off-grid applications. These convert the DC power from the solar panels and battery to AC power for use in homes or buildings that are not connected to the grid.

An existing solar installation that does not have a Dual Inverter must be retrofitted to accommodate storage by either replacing the existing inverter with a Dual Inverter or adding AC-coupled batteries. AC-coupled batteries store power after it has been converted to AC power by a standard solar inverter. A second battery inverter is required to convert the AC power back to DC in order to charge the battery, and to reverse the conversion when the battery power is needed to charge the building.

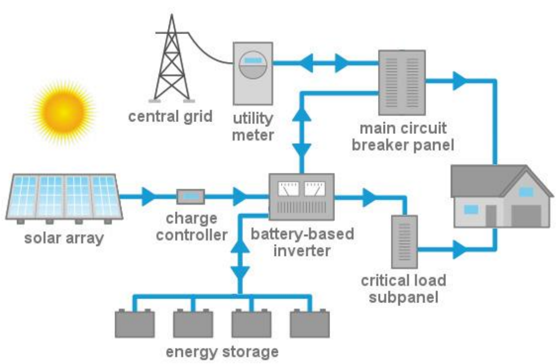

Figure 3: *DC-Coupled Solar and Storage System*
A single battery inverter converts energy to charge batteries and power the building.[13]

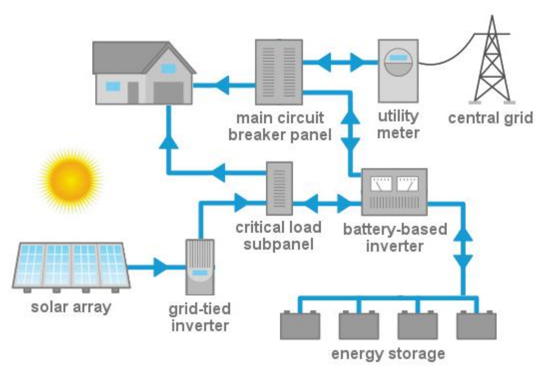

Figure 4: *AC-Coupled Solar and Storage System*
A grid-tied inverter converts DC energy to AC energy. A second battery inverter converts AC power to DC to charge the battery.[13]

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[13] *Source: Clean Energy Group, Solar + Storage 101: An Introductory Guide to Resilient Solar Power Systems"*
<http://www.cleanegroup.org/ceg-resources/resource/solar-storage-101-an-introductory-guide-to-resilient-solar-power-systems/>.

While this configuration is necessary to retrofit a grid-tied inverter with storage, an AC-coupled system is less efficient than a DC-coupled system. For this reason, it is recommended that all inverter options are evaluated when installing solar. If battery storage capability is desired in the future then a storage-ready Dual Inverter is likely more cost effective in the long term.

SOLAR, STORAGE AND MICROGRIDS

If protecting a facility from grid outages is a priority and an objective, then having a system that can isolate from the grid and operate autonomously is critical. A microgrid is an energy system of interconnected loads that consists of one or more form of distributed generation and may also include energy storage that can function while connected to the grid and can also function during grid outages by providing resiliency benefits/emergency power.[14] Microgrids can be utilized to power critical loads on a single circuit, in a single building, or across an entire campus. A microgrid can act as a single controllable entity and can operate in either grid-connected or islanded mode.[15]

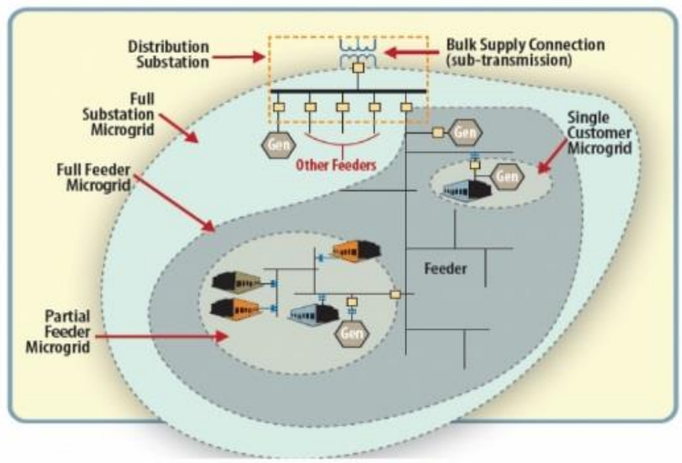


Figure 5: *A microgrid is scalable to serve a single customer or a larger section of the distribution system.[16]*

Solar and storage can be integrated with generators to extend the life of existing backup power sources. In this case, to maintain generator reliability during a grid outage and to control system voltage and frequency, at least one generator must run at all times, at a minimum of 30% of its rated capacity.[17] Additional generators can be ramped up or down in accordance with changes in load and solar energy output.

Additional information about resilient solar hardware components and systems can be found in the NY Solar Smart DG Hub Hardware Factsheet.[18]

[14] CUNY, NY Solar Smart DG Hub, "Glossary," <http://www.cuny.edu/about/resources/sustainability/SmartDGHubEmergencyPower/DG_Hub_Glossary.pdf>.
[15] U.S. Department of Energy Office of Electricity Delivery & Energy Reliability <http://energy.gov/oe/services/technology-development/smart-grid/role-microgrids-helping-advance-nation-s-energy-system>.
[16] *Ibid.*
[17] CUNY, NY Solar Smart DG Hub, "Hardware Fact Sheet." <http://www.cuny.edu/about/resources/sustainability/SmartDGHubEmergencyPower/DecHardwareFactSheet.pdf>.
[18] *Ibid.*

IMPLEMENTATION MODELS

Solar energy systems are an increasingly popular choice for electricity customers who want to reduce their monthly utility bill and generate clean energy on site. When paired with battery storage, the benefits of solar are multiplied. Solar and storage systems can provide a variety of services, from resiliency benefits like emergency power to economic benefits like utility bill savings. The design of a solar and storage system will depend on the intended function (or functions) of the system. Solar and storage systems can be broadly grouped into those designed to provide off-grid power and those designed to provide grid-connected power. Grid-connected solar and storage installations can access a wide variety of resiliency and economic benefits.

OFF-GRID
Solar and Storage System

RESILIENCY BENEFITS: Provide standalone power where grid access is unavailable.

GRID-CONNECTED
Solar and Storage System

RESILIENCY BENEFITS: Provide backup power for a grid-connected building.

ECONOMIC BENEFITS: Manage energy consumption to reduce utility bill payments.

Energy charge reduction: Reduce total number of kilowatt-hours used in a month.

Demand charge reduction: Demand charges are based on the 15 minute period of peak usage each month.

Ancillary services: Some customers are compensated for services which improve grid functionality, including voltage and frequency control. (Not currently available in Utah).

	Resiliency	Energy charge reduction	Demand charge reduction	Ancillary services
SOLAR BENEFITS:	Provides limited standalone power when the sun is shining if paired with an inverter that features an emergency power outlet.	Solar panels are used to offset energy purchases from the utility while the sun is shining. Excess energy is sent to the grid in exchange for credits which are used to offset future energy purchases.	To the extent that this peak occurs during the day, solar may be able to reduce peak demand (and therefore demand charges), however solar cannot be discharged reliably for this purpose.	Some companies are developing advanced solar “smart inverters” which will be able to perform grid-balancing functions that ease the integration of large amounts of solar.
	+	+	+	+
STORAGE BENEFITS:	Can both produce and store energy in order to provide enough power to supply a specific load with power indefinitely.	Batteries store energy and discharge during times when the cost of purchasing energy from the utility is highest, achieving additional savings on energy costs.	Batteries store energy onsite and discharge energy during times of predicted peak usage to reduce demand charges.	Some utilities allow solar and storage systems to bid into a market to provide ancillary services and receive compensation.

CASE STUDIES

OFF-GRID SOLAR AND STORAGE:

The City of Houston purchased 17 solar powered shipping containers that can be dispatched as needed in the event of an emergency, such as a hurricane, that disrupts the power grid. The containers function as mobile microgrids that can be used to provide emergency power for charging critical devices or keeping medications cool. During non-emergency times, the containers will be used to provide mobile power for the Houston Parks Department or for special events.[19]

GRID-CONNECTED SOLAR AND STORAGE:

Florida's SunSmart Emergency Shelter program equipped more than 100 public schools with solar + storage microgrid systems that can power lighting and electrical outlets at the schools if the grid is disrupted by a storm. Each school can provide emergency shelter for 100 – 500 people. During normal operations, the schools are able to use the solar panels to offset daily electricity usage and save $1,500 - $1,600 annually.[20]

[19] *Source: Houston Public Media, "Houston Gets Emergency Solar-Powered Generation Units," April 18, 2011 <http://www.houstonpublicmedia.org/articles/news/2011/04/18/27049/houston-gets-emergency-solar-powered-generation-units/>.*
Photo: Examiner.com, "Woodrow Wilson Montessori School is into solar-powered energy," September 3 2012, < http://www.examiner.com/article/woodrow-wilson-montessori-school-is-into-solar-powered-energy>.
[20] *Source: Clean Energy Group, "SunSmart Emergency Shelters Program," <http://www.cleanegroup.org/ceg-projects/resilient-power-project/featured-installations/sunsmart-emergency-shelters-program/>*
Photo: Florida Solar Energy Center <http://www.fsec.ucf.edu/En/education/sunsmart/index.html>.

BARRIERS TO IMPLEMENTATION

Although solar and storage systems offer significant resiliency benefits, barriers remain that limit implementation of solar and storage systems.

1. **Cost of storage:**
   Although the cost of storage has fallen rapidly, solar and storage systems still entail a long payback period in Utah. Projections indicate that the cost of solar and storage installations will continue to fall and solar systems with storage will be cost-competitive with grid power in some locations by 2020.[21] Facility managers who consider best practices for installing solar and storage (or building solar and storage-ready) will be prepared to take advantage of the benefits of solar and storage when the technologies are cost-competitive.

2. **A value for ancillary benefits:**
   Currently, Utah utilities do not offer payment for ancillary services that solar and storage could provide to the utility. Potential ancillary services include demand response and frequency regulation services that reduce could reduce utility costs and create a more responsive and resilient grid. Although Utah customers are not currently compensated for these services, new rate structures could create additional value for solar and storage installations while also reducing utility costs for all customers.

3. **Lack of clarity in Federal Investment Tax Credit**
   The IRS does not explicitly list energy storage as an approved technology that is eligible for the Federal renewable energy tax credit. The IRS has requested feedback regarding the ITC and its applicability to storage and is projected to issue proposed regulations in spring 2017 and issue final regulations in fall 2018.[22]

4. **Low cost of electricity in Utah**
   Without compensation for ancillary services, the economic benefit of battery storage comes from energy and demand charge reductions. The relatively low cost of electricity in Utah creates a long payback period for solar and storage installations in Utah. As the cost of battery technologies continues to fall, the value proposition for solar and storage systems will improve.

[21] Rocky Mountain Institute, *op. cit.*, P7
[22] Deloitte, “Financing Energy Storage with Tax Credits,” September 28, 2015 <http://www2.deloitte.com/us/en/misc/search.html#qr=investment%20tax%20credit>.

APPENDIX A – Battery Types and Specifications

This table is adapted from the CUNY NY Solar Smart DG Hub, Resilient Photovoltaic (PV) Systems Hardware Factsheet, available at
http://www.cuny.edu/about/resources/sustainability/SmartDGHubEmergencyPower/DecHardwareFactSheet.pdf

Specifications	**Battery Types**						
	Lead Acid	***Lithium Ion***					***Flow Batteries***
	Valve Regulated	*Lithium iron phosphate*	*Lithium nickel manganese cobalt oxide*	*Lithium nickel cobalt aluminum oxide*	*Lithium titanate*	*Lithium manganese oxide*	*Redox*
Usage	Resiliency, Grid Support, Peak load shifting, Intermittent energy smoothing, UPS	Resiliency, Grid Support, Peak load shifting, Intermittent energy smoothing, UPS					Resiliency, Grid Support, Peak load shifting, Intermittent energy smoothing, UPS, Bulk power management
Energy Density (Wh/kg)	30-50	90-120	150-220	200-260	70-80	100-150	10-20
Lifetime cycles (80% depth of discharge)	200-300[23]	1000-2000	1000-2000	500	3000-7000	300-700	10000+
Efficiency (%)	80-90%	90-95%					65-85%
Charge Rate	8-16hrs	2-4hrs	2-4hrs	2-4hrs	1-2hrs	1-2hrs	Depends on size of the tank and cell stack
Cost	$150-300/kWh	$400/kWh	$428-750/kWh	$240-380/kWh	$2000/kWh	$250-300/kWh	$680-800/kWh
Thermal Runaway Temp and Stability[24]	Considered thermally safe	270°C Among the safest type of li-ion battery	210°C Less stable than lithium iron phosphate	150°C Least stable	Among the safest type of li-ion battery	250°C Medium stability	Very safe since storage of electrolyte is separate from power generation unit
Advantages	Well-known, reliable technology, can withstand deep discharges, relatively low cost, ease of manufacturing	High energy density, able to withstand deep discharges, and long cycle lives					Well suited for bulk storage, long cycle life, and easy to scale up the amount of energy stored by simply making the tanks larger
Disadvantages	Relatively low number of life cycles and lower energy density	More expensive than lead acid systems and may become thermally unstable. Overheating or short circuits in Li-ion cells may cause thermal run-away—a phenomenon where the internal heat generation in a battery increases faster than it can dissipate. This heat can damage or destroy the cells and is a potential source for fires. Electronic protection circuits are added to the battery pack to prevent thermal run-away					Relatively high cost, low efficiency and low energy density; high maintenance with pumps that often leak and precipitate out

---

[23] Managing the depth of discharge for lead acid batteries increases the lifespan of these batteries

[24] Battery University, "Types of Lithium Ion," <http://batteryuniversity.com/learn/article/types_of_lithium_ion>, accessed on 15 March 2016. *Note that the battery technology is rapidly changing with their growth in the market.*

ADDITIONAL RESOURCES

1. Clean Energy Group. *Solar+Storage Project Checklist*. January 2016. http://www.cleanegroup.org/wp-content/uploads/Solar-Storage-Checklist.pdf

2. Clean Energy Group. *Solar+Storage 101: An Introductory Guide to Resilient Power Systems*. March 2015. http://www.cleanegroup.org/wp-content/uploads/Energy-Storage-101.pdf

3. The City University of New York, Smart Distributed Generation Hub – Resilient Solar Project. *Hardware Factsheet*. October 2015. http://www.cuny.edu/about/resources/sustainability/SmartDGHubEmergencyPower/DecHardwareFactSheet.pdf

4. The City University of New York, Smart Distributed Generation Hub – Resilient Solar Project. *Finance Factsheet – Economics and Finance of Solar+Storage*. September 2015. http://www.cuny.edu/about/resources/sustainability/SmartDGHubEmergencyPower/DecFinanceFactSheet.pdf

5. Houston Public Media, *Houston gets Emergency Solar-powered Generation Units.* April 2011. http://www.houstonpublicmedia.org/articles/news/2011/04/18/27049/houston-gets-emergency-solar-powered-generation-units/

6. Clean Energy Group, *SunSmart Emergency Shelters Program*. http://www.cleanegroup.org/ceg-projects/resilient-power-project/featured-installations/sunsmart-emergency-shelters-program/

7. Clean Energy Group, *Stafford Hills Solar Farm and Microgrid.* http://www.cleanegroup.org/ceg-projects/resilient-power-project/featured-installations/stafford-hill/

8. Green Mountain Power, *Green Mountain Power to Offer Tesla Home Battery.* May 2015. http://news.greenmountainpower.com/manual-releases/Green-Mountain-Power-to-Offer-Tesla-Home-Battery?feed=d51ec270-a483-4f6c-a55e-8e5fbe2238c2

About Utah Clean Energy: Utah Clean Energy is a non-profit, non-partisan public interest organization partnering to build the clean energy economy. We are committed to creating a future that ensures healthy, thriving communities for all, empowered and sustained by clean energy.

About the SunShot Initiative: The U.S. Department of Energy SunShot Initiative is a collaborative national effort that aggressively drives innovation to make solar energy fully cost-competitive with traditional energy sources before the end of the decade. Through SunShot, the Energy Department supports efforts by private companies, universities, and national laboratories to drive down the cost of solar electricity to $0.06 per kilowatt-hour. Learn more at energy.gov/sunshot

For questions about this document contact:

solar@utahcleanenergy.org | www.utahcleanenergy.org | www.solarsimplified.org

TAB 8

Kent Yu

Closing Speaker

DR. KENT YU, SE

Dr. Yu is Principal of SEFT Consulting Group located in Portland, Oregon. A licensed structural engineer and an earthquake/tsunami policy advocate, Dr. Yu conducted numerous post-earthquake reconnaissance to study performance of buildings and infrastructure systems.

Since 2011, he has led or contributed to seismic resilience planning projects at national, state and local levels.

As the Chair of Oregon Seismic Safety Policy Advisory Commission from 2011 to 2013, he led a team of 169 expert volunteers to develop the Oregon Resilience Plan to better prepare Oregon for next Cascadia earthquake and tsunami.

In 2015 Dr. Yu led a team to develop a resilience plan for the Beaverton School District, the third largest in Oregon. He also assisted National Institute of Standards and Technology (NIST) to develop Community Resilience Planning Guide for Buildings and Infrastructure Systems from 2014 to 2015.

Currently, he is involved in the development of Water System Resiliency Plan for Gresham, Oregon.

Overview of The Oregon Resilience Plan and Implementation Update

for

Utah Earthquake Resilience Workshop

Kent Yu, PhD, SE

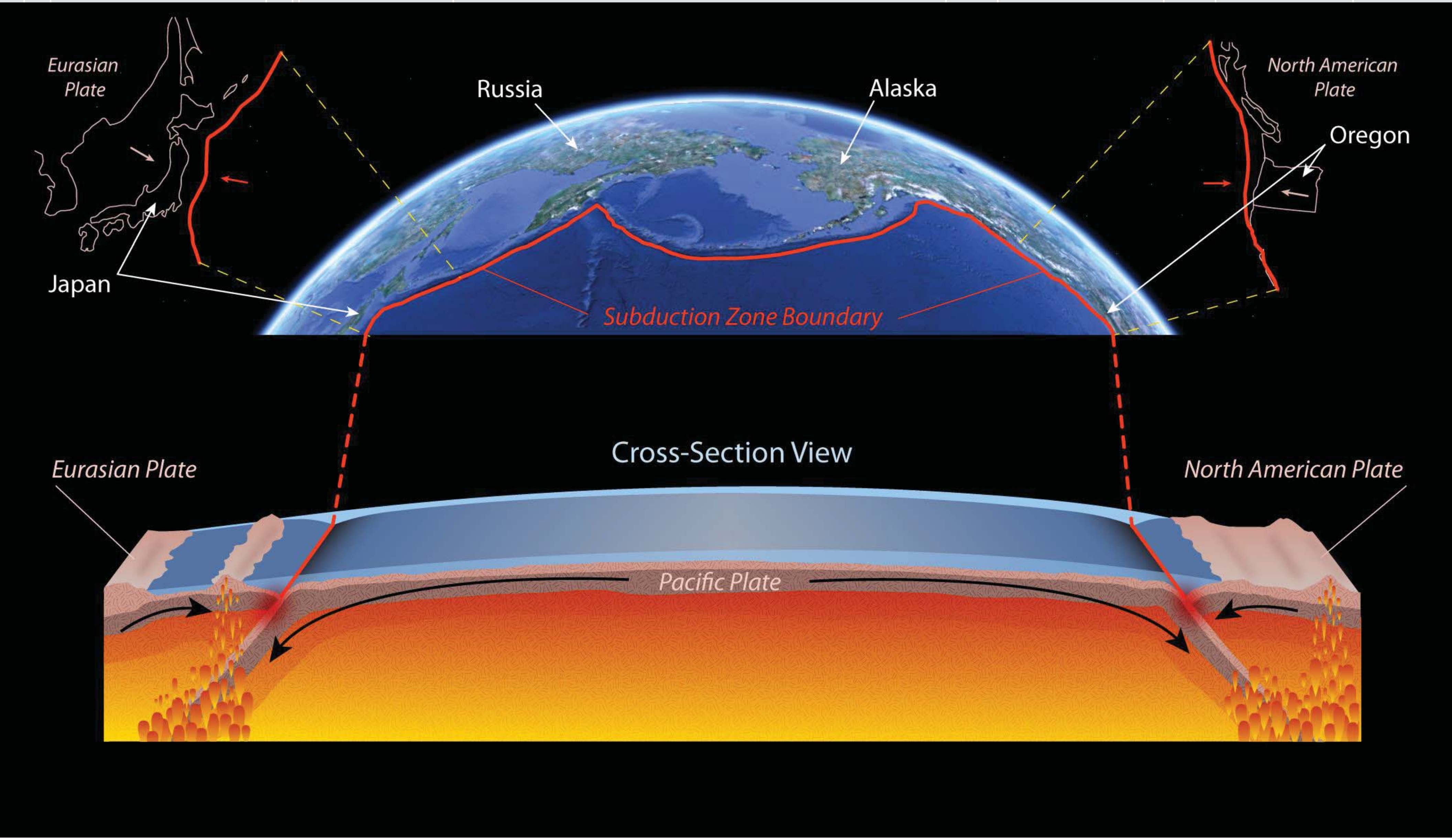
Principal, SEFT Consulting Group LLC

West Jordan, Utah

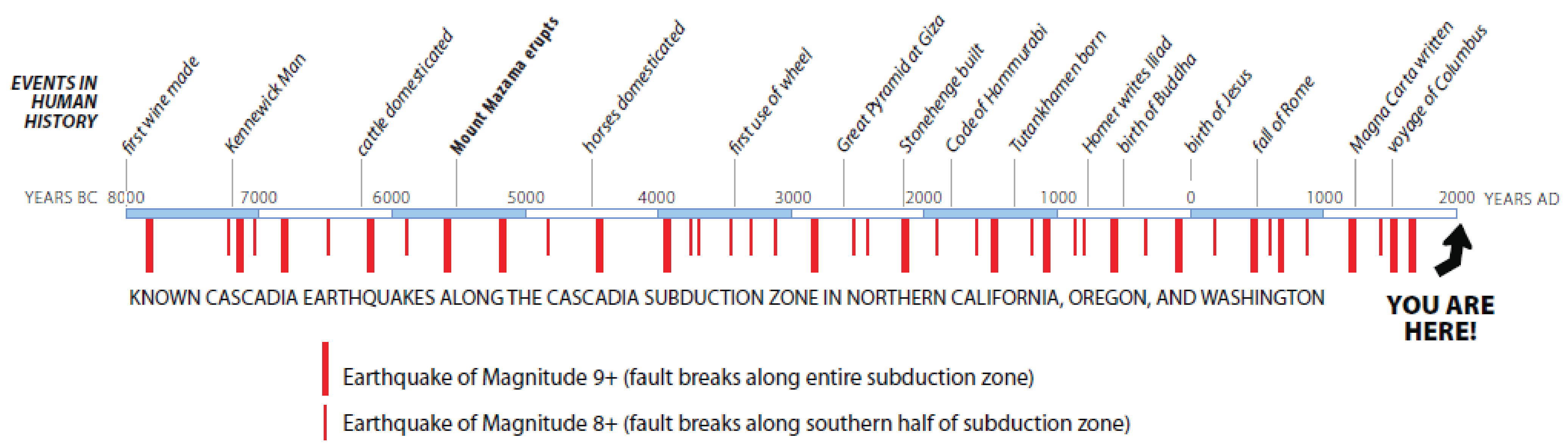
April 27, 2016

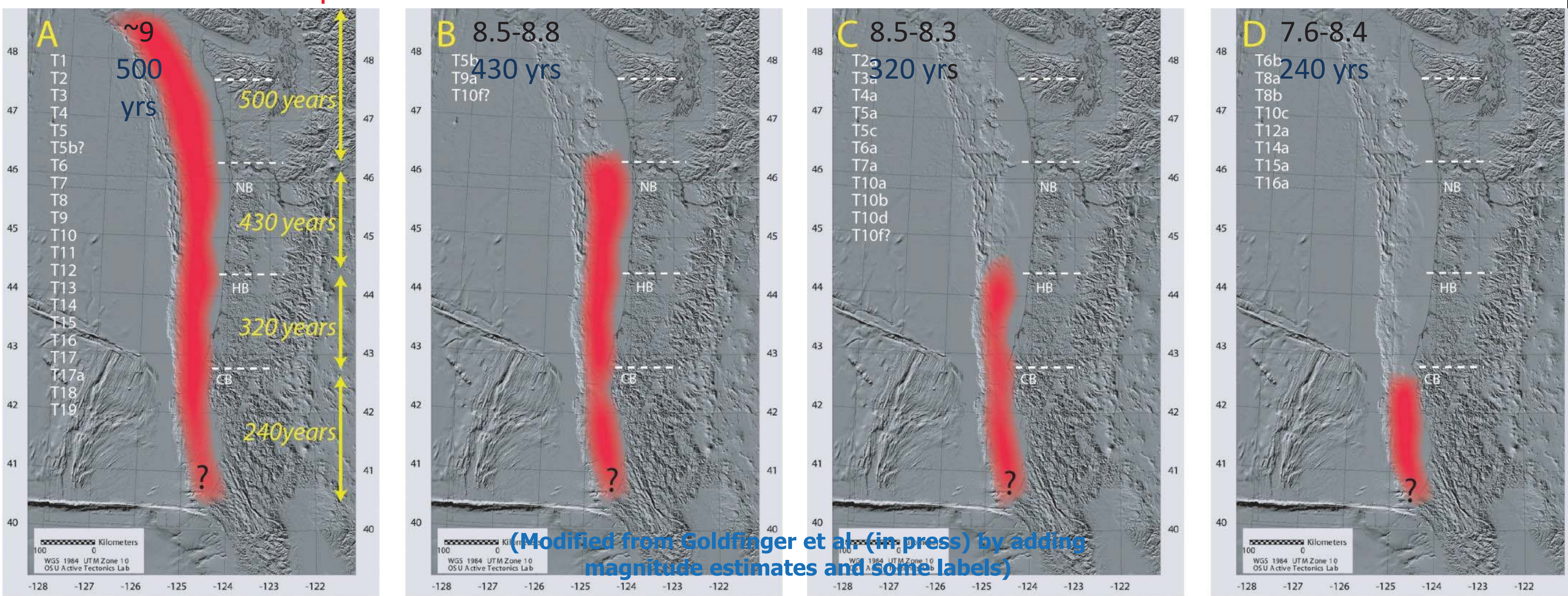
To Keep Communities Functional, We Need Infrastructure

Cascadia Subduction Earthquake



Cascadia Subduction Zone Earthquakes

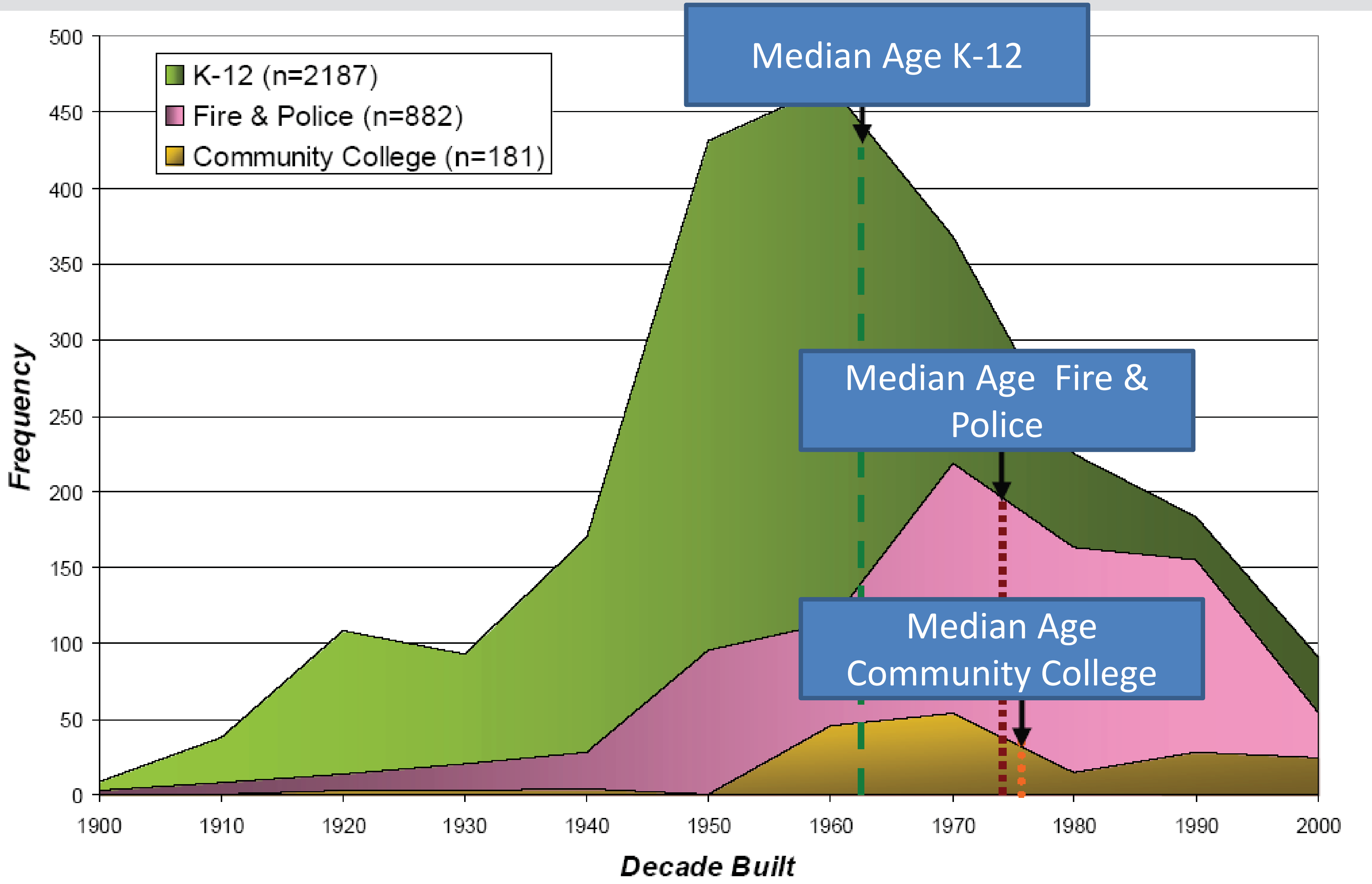




(Modified from Goldfinger et al. (in press) by adding magnitude estimates and some labels)

Cascadia Earthquake Hazards and Risk

Oregon Education & Emergency Facilities



March 25,1993 Scotts Mills Spring Break Earthquake

The Seattle Times
Winner of Nine Pulitzer Prizes

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Thursday, March 25, 1993 - Page updated at 12:00 AM

E-mail article Print

Quake Cracks Oregon Capitol -- Temblor Registers 5.4, Causes Minor Injuries

AP: Times Staff

PORTLAND - An earthquake centered in the Cascade foothills east of Silverton rattled northwest Oregon and parts of Western Washington early today, cracking the rotunda of the Oregon Capitol in Salem and causing minor injuries.

The quake, focused about 12 miles deep and about 30 miles southeast of Portland, registered 5.4 on the Richter scale of ground motion at 5:34 a.m. and lasted about 45 seconds.

"It felt like I was on a boat going down rapids. It woke me right up," said Bill Holder, a cook at Rod's Lafayette Restaurant in Lafayette, near the epicenter.

The original wing of the state Capitol in Salem was closed after serious cracks were found in the rotunda, House Speaker Larry Campbell said. A newer wing remained open. Engineers were considering removing the gold-plated pioneer statue on top of the Capitol.

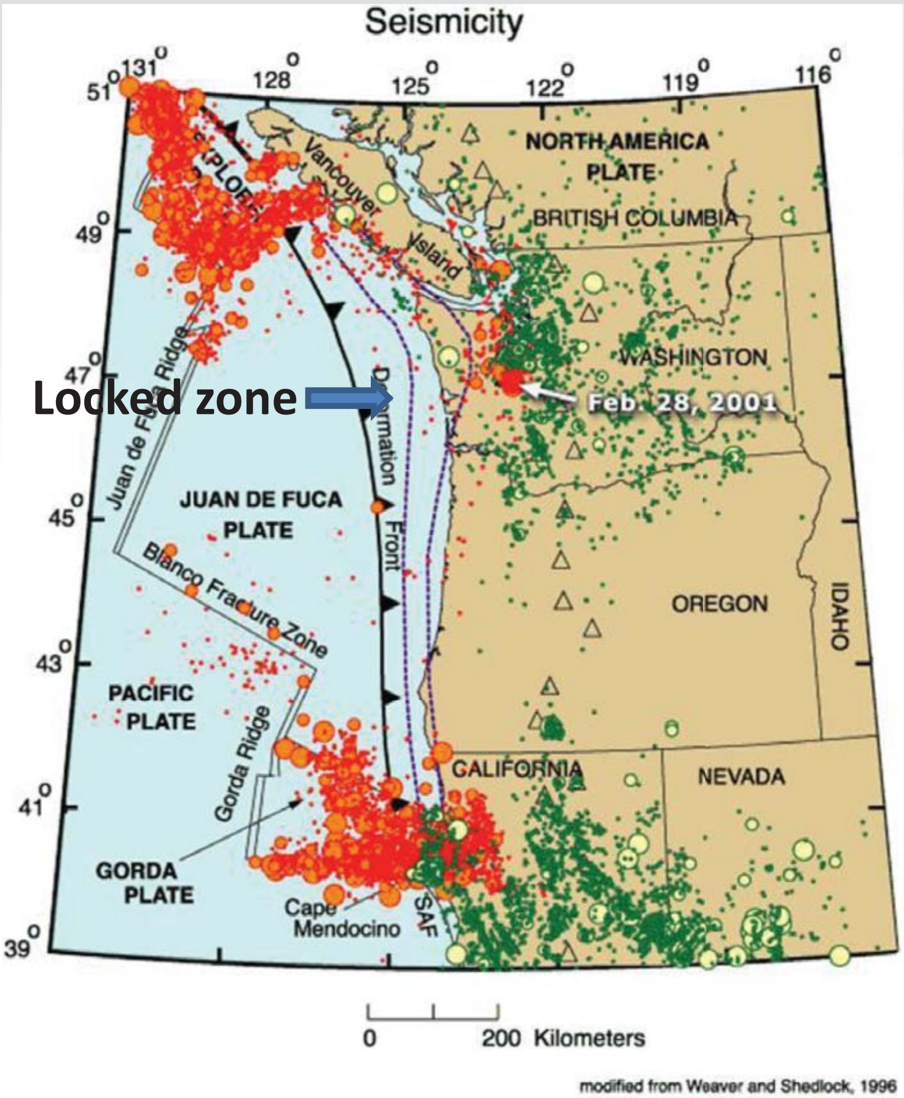
Two people came to the emergency room at Salem Hospital with minor cuts from falling glass.

In Molalla, 27 miles southeast of Portland, two walls at the high school partially collapsed. Bricks and a chimney fell from the school, which was built in 1925.

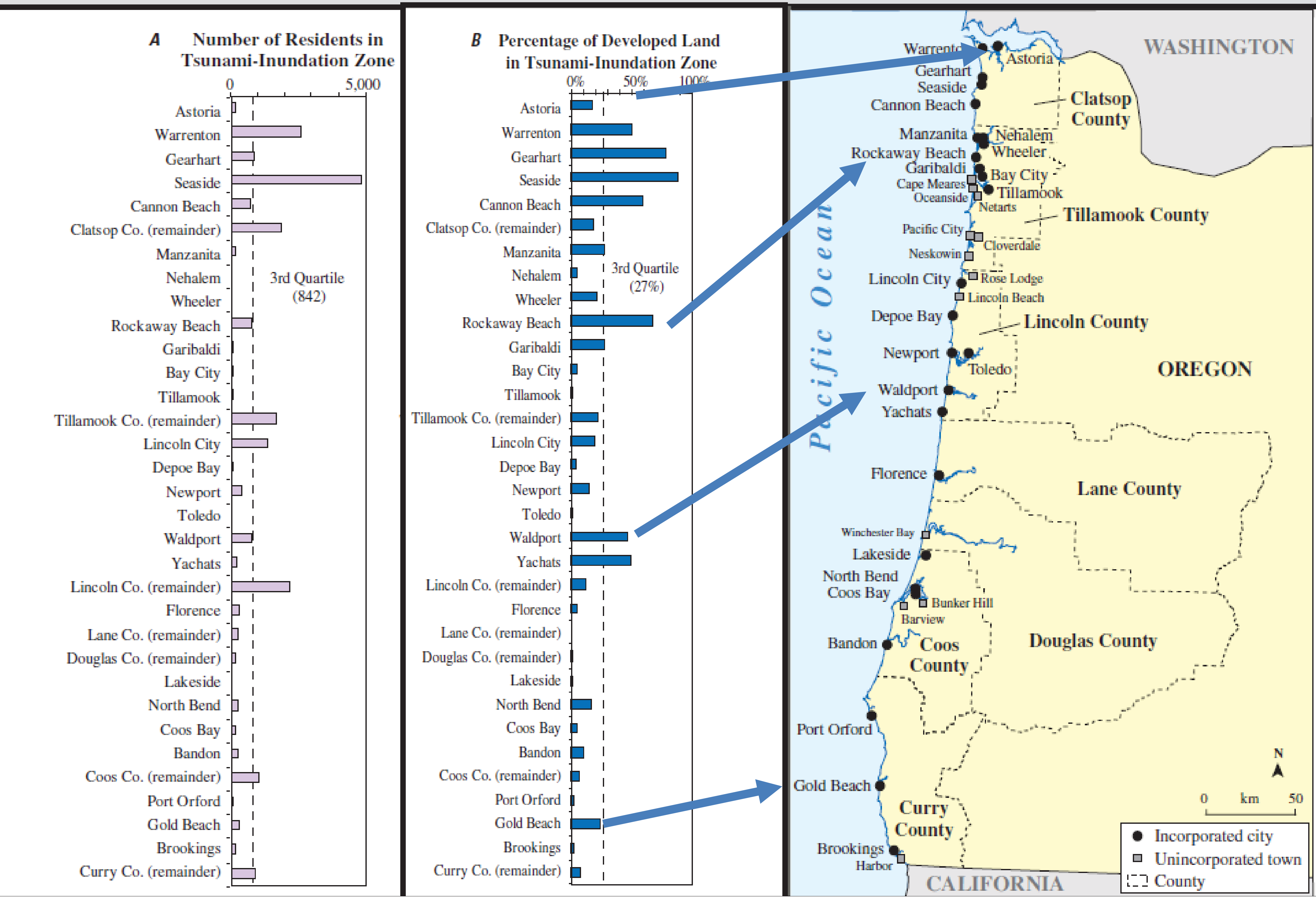
Brick planters and windows also were broken at some homes and businesses in the town of 3,800, and goods were knocked off grocery store shelves.

Cascadia Subduction Earthquake

- Strong Ground Shaking (M9 w/ 2 - 4 min shaking)
- Tsunami within 15 to 25 minutes



Tsunami Life Safety



Capacity for Response and Recovery?

FAILURE

Sometimes you can see it coming around the bend

Lifeline Interdependencies

Interdependencies will make disaster recovery much more difficult. The earthquake will damage all systems at the same time.

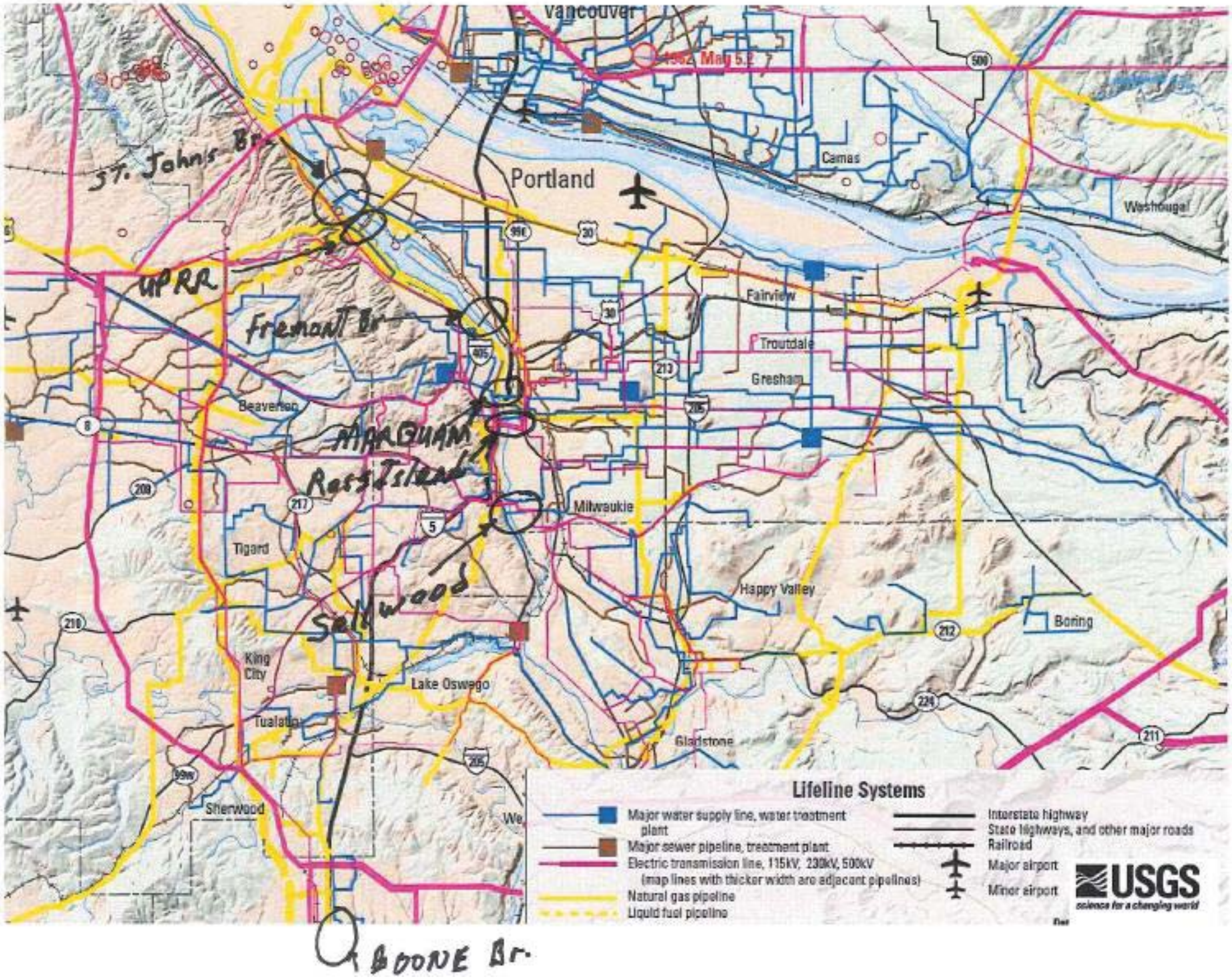
To restore electric service, you need to reopen roads

To restore water service, you need electricity

To restore fuel supplies you need electricity

To reopen roads, you need to restore fuel supplies

Lifeline Co-location



House Resolution 3

THE OREGONIAN'S READERS ON ISSUES

10-YEAR PLAN

State should make itself resilient for a big quake

YUMEI WANG JAY RASKIN EDWARD WOLF

IN OUR OPINION

One year ago this Wednesday, a powerful earthquake devastated Haiti, collapsing homes, schools and businesses and killing at least 230,000 people.

Burdened by poverty, most Haitians had given little thought to earthquakes. After all, none had struck western Haiti since 1842. Though Haiti's agony may seem a world apart from our lives in the Pacific Northwest, Oregon is vulnerable to even stronger earthquakes and the tsunamis they generate.

Our situation is in some respects eerily similar to Haiti's. The most recent quake on the Cascadia fault just off our coast, a huge event about 1,000 times more powerful than the Haitian temblor, struck Jan. 26, 1700. No Oregonian alive today has experienced anything comparable.

Like Haiti, we're not ready for the next big one. Unlike Haiti, we cannot blame poverty for our failure to prepare.

It's time for Oregon to face the risk of earthquakes and tsunamis and build capacity to withstand Cascadia's next mega-quake.

We propose a 10-year, $1.5 billion Plan for Resilience to strengthen Oregon's schools, bridges and coastal towns. Addressing these priorities now will save lives and keep commerce flowing in the aftermath of a quake and tsunami, ensuring that an inevitable disaster does not also become an unparalleled catastrophe. Here's how:

First, make 1,000 Oregon schools quake-safe. A high proportion of Oregon's 1,306 K-12 schools were built decades before the state's first seismic building code, and many are at high risk of collapse in a strong quake. Each year that we fix 100 schools (at a cost of $75 million), we will protect 40,000 more children from collapse-prone classrooms.

Second, reinforce 250 critical bridges. An estimated 1,000 bridges on Oregon's highways may fail in a powerful earthquake, disrupting both emergency response and normal commerce. Strengthening the most vulnerable while reducing imminent risks from landslides and other hazards, at an annual cost of $70 million, will ensure a minimal transportation backbone in the immediate aftermath of the disaster, and provide a framework for recovery.

Third, construct 10 tsunami evacuation buildings in at-risk coastal towns. Roughly 10 Oregon towns lie within tsunami inundation zones, and some neighborhoods in these communities have no easy route to safe high ground. We can build one new evacuation building—an accessible, elevated platform strengthened to withstand wave forces—each year for $5 million. Each such well-sited building can potentially save hundreds of residents and visitors in these towns.

Can Oregon afford to invest $150 million per year in resilience, while we're still struggling in recession? Our answer is yes, if the state's business and philanthropic communities step up as partners with Oregon taxpayers. These critical investments are steppingstones on the path past the state's shortfalls. It's a matter of priorities.

Consider Chile, a nation whose $165 billion economy matches Oregon's in size. Oregon's income per person of $40,000 is almost three times Chile's. Yet that country has advanced building codes, a well-maintained infrastructure and a population highly attuned to earthquake risks.

From a modest base, Chile has invested carefully in seismic resilience. Although last year's massive magnitude 8.8 earthquake there caused at least $30 billion in economic losses, fewer than 500 Chileans died. A comparable quake and tsunami here could cost $100 billion or more and kill thousands of Oregonians. Investing in resilience now will save both lives and money.

Our 10-year plan for Oregon's schools, bridges and coastal towns would yield other benefits, too, including good jobs in most school districts, as well as expertise that the state could export to other quake- and tsunami-prone regions, much as we now trade on the state's reputation as a leader in sustainability and clean energy.

Implementing this Plan for Resilience would show Oregon at its best, tackling a risk with imagination and resourcefulness while sharing the knowledge gained. The next Cascadia quake will not wait for us. Let's begin this year.

•

Yumei Wang, an earthquake risk engineer for the state of Oregon, is featured in the Nova documentary "Deadliest Earthquakes," scheduled for broadcast on OPB on Wednesday. Jay Raskin is an architect and the former mayor of Cannon Beach. Edward Wolf is a Portland writer and school safety advocate.

House Resolution 3

76th OREGON LEGISLATIVE ASSEMBLY--2011 Regular Session

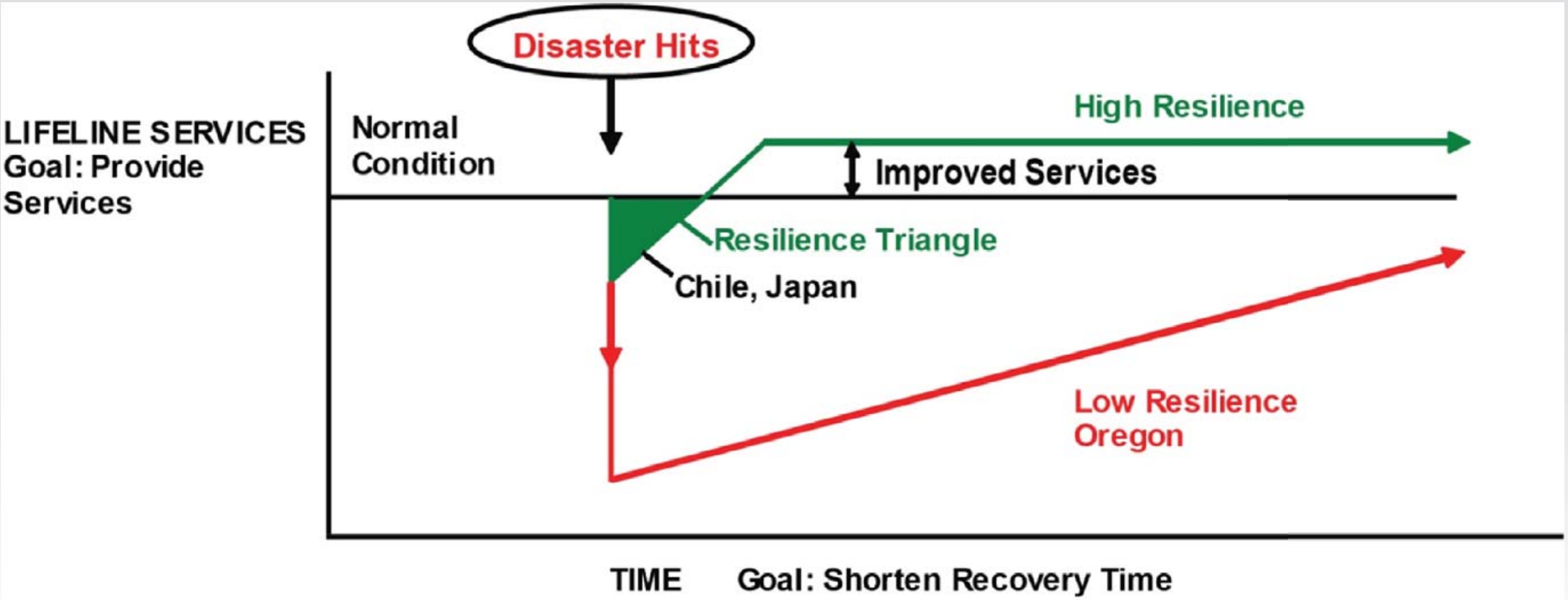
Enrolled

House Resolution 3

Sponsored by Representative BOONE; Representatives COWAN, KRIEGER, ROBLAN, WITT, Senators COURTNEY, JOHNSON, KRUSE, VERGER, WHITSETT

- Directs Oregon Seismic Safety Policy Advisory Commission (OSSPAC) to "lead and coordinate preparation of an Oregon Resilience Plan that . . . makes recommendations on policy direction to protect lives and keep commerce flowing during and after a Cascadia (megathrust) earthquake and tsunami."
- Focuses on physical infrastructure

Shift From Life-Safety to Resilience



(Yumei Wang)

- **Resilience:** Save lives, Reduce Losses, Speed Recovery, & Rebuild Better
- Direct Damage vs Indirect Economic Loss
- Sustainability without **Resilience** is NOT sustainable!
- Resilience enhances sustainability

Key Endorsement

NATIONAL SECURITY STAFF
WASHINGTON, D.C. 20504

December 7, 2011

Kent Yu, PhD
Chairman, Oregon Seismic Safety Policy Advisory Commission
P.O.Box 14370
Salem, OR
97309 5062

Dr. Yu:

On Tuesday, November 8, 2011 I had the pleasure of spending time with the working session of the National Earthquake Hazard Reduction Program (NHERP) Advisory Committee. There, I was honored to meet Deborah Boone, Oregon State Representative and sponsor of Oregon House Resolution 3, which directs the creation of an Oregon Resilience Plan to prepare for the statewide impacts of a Cascadia earthquake and tsunami. I would like to wholeheartedly applaud Representative Boone, yourself, and the rest of the Oregon Seismic Safety Policy Advisory Commission on this initiative..

President Obama's top priority is the safety and security of the American people. I thank you for your leadership and your ongoing contribution to our Nation's resilience.

Sincerely,

Richard Reed
Special Assistant to the President for
National Security Affairs and
Senior Director for Resilience

From White House

JOHN A. KITZHABER, MD
Governor

January 4, 2012

Kent Yu, Ph.D, Chair
Oregon Seismic Safety Policy Advisory Commission
P.O. Box 14370
Salem, OR 97309

Dear Dr. Yu,

The Oregon Seismic Safety Policy Advisory Commission (OSSPAC) has a challenging mission to educate the public about our seismic risks and inform diverse policy decisions. Through OSSPAC's dedicated efforts, though, the State of Oregon and its citizens have become increasingly aware that we live in an earthquake-prone region.

This month will mark the 312th anniversary of the last major earthquake and resulting tsunami from the Cascadia Subduction Zone that sits off Oregon's coast. Throughout this year, OSSPAC will be drafting an Oregon Resilience Plan to help us better prepare for the next major earthquake and tsunami.

A focused resiliency effort can better prepare us for catastrophic disasters as well as help us weather our more common emergencies like storms, floods and fires. OSSPAC has had wide participation from state agencies, local governments, businesses and non-profits and I encourage their continued engagement on this critical effort.

Thank you for all of OSSPAC's efforts to date and for continuing to be a powerful voice for a more prepared and resilient Oregon.

Sincerely,

John A. Kitzhaber, M.D.
Governor

JAK/CS/ap

From Governor of Oregon

254 STATE CAPITOL, SALEM OR 97301-4047 (503) 373-3111 FAX (503) 378-4863
WWW.OREGON.GOV

Broad Participation

- Governor's office
- (1) Indian Tribe: Coquille Tribe
- (3) Ports: Port of Portland, Port of Astoria, Port of Coos Bay
- (4) Federal Agencies: BPA, USGS, US Army Corps, USCG
- (4) State Legislators: Beyer, Boone, Courtney, Kruse
- (5) Universities (UO, OSU, PSU, UP, UTA)
- (6) Private utilities providers
- (10+) Local Government (Astoria to Brookings, Pendleton to Cannon Beach)
- (11) Public utilities providers
- (11) State Agencies/(2)Commissions/(2)Boards
- Earthquake professionals: SEAO, ASCE, EERI, CREW
- Oregon businesses: High tech, healthcare, insurance, food retail, construction…
- Professional associations, NGOs, citizens,…

Eight Task Groups

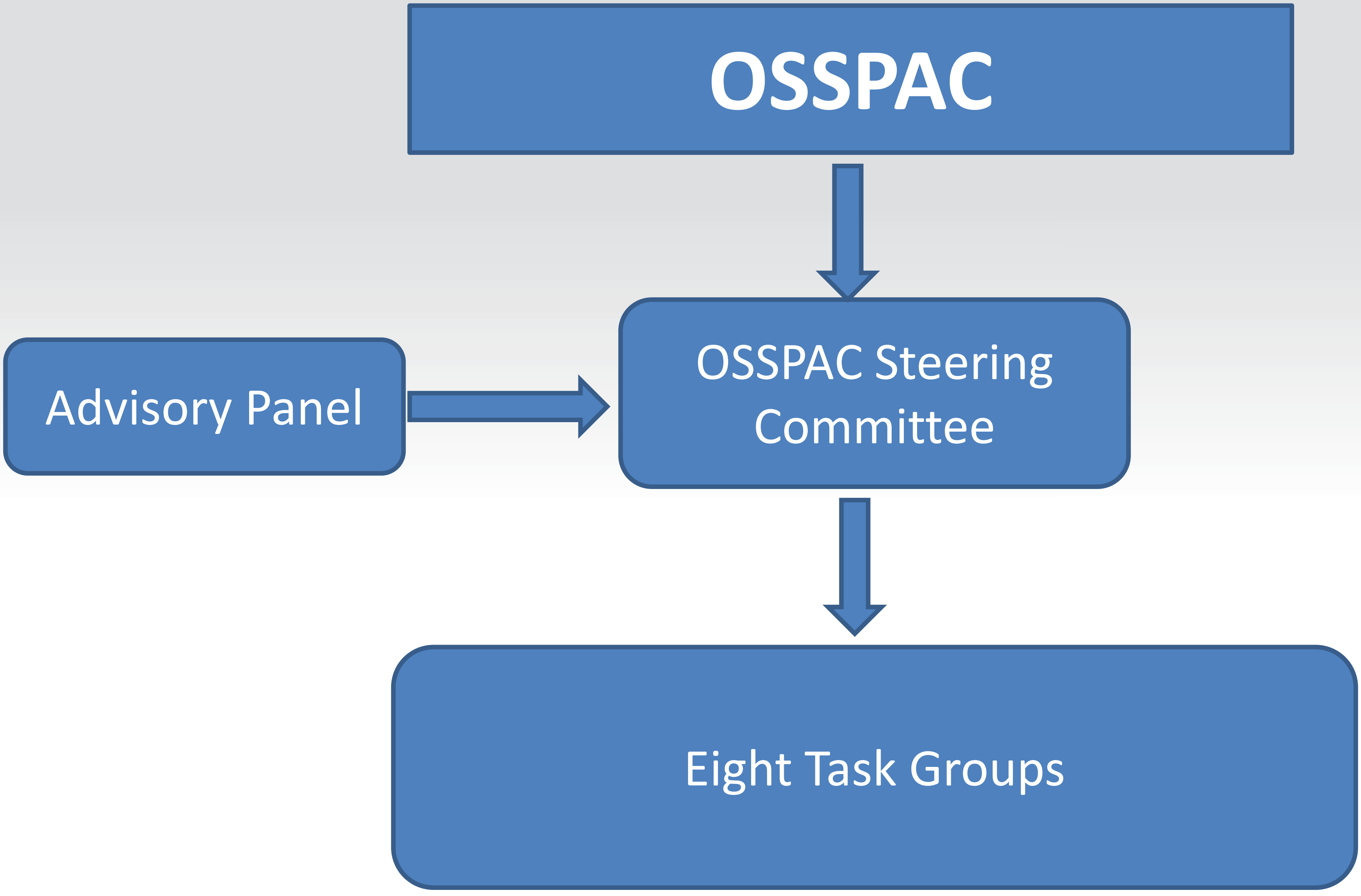
Business and Work Force Continuity

Coastal Communities

- Critical/Essential Buildings
- Energy
- Information and Communications
- Transportation
- Water and Waste Water

Magnitude 9.0 Earthquake/Tsunami Scenario

Organizational Structure



Team Building - Advisory Panel

- Prof. Scott Ashford (Oregon State Univ.)
- Sen. Lee Beyer (Legislature)
- Sen. Peter Courtney (Legislature)
- Ed Dennis (formerly Dept. of Education)
- JR Gonzalez (formerly Oregon PUC)
- Prof. Chris Goldfinger (Oregon State Univ.)
- Dave Harlan (Business Oregon/Ports)
- Onno Husing (formerly OCZMA)
- Bruce Johnson (ODOT)
- Dr. Leon Kempner, Jr. (BPA)
- Prof. Andre LeDuc (Univ. of Oregon)
- Dr. Vicki McConnell (DOGAMI/WSSPC)
- Jean O'Connor (Oregon Health Authority)
- Cameron Smith (Governor's office)
- Jeff Soulages (Intel)
- Yumei Wang (DOGAMI/NEHRP)
- Edward Wolf (Oregon citizen)
- Dr. Nate Wood (USGS)

Earthquake/Tsunami Group

- Led by Ian Madin (DOGAMI)
- Magnitude 9.0 Earthquake/Tsunami Scenario Group will develop:
  1) Ground shaking intensity maps
  2) Tsunami Inundation maps
  3) Landslide and liquefaction maps



Business/Workforce Continuity Group

- Led by Susan Stewart (BOMA) and Gerry Williams (OSSPAC)
- Goals:
  - Raise Earthquake/Tsunami Awareness
  - Gauge Earthquake/Tsunami Preparedness
  - Gather input/ideas from Business for other workgroups to define resilience targets and improve resilience plan

Coastal Community Resilience Group

- Led by Jay Wilson/Jay Raskin (OSSPAC)
- Tsunami Risk Mitigation Group will address the following:
  - Tsunami evacuation
  - Zoning and Land use policy
  - Critical facilities
  - Re-building community
  - Debris management

Critical Building Group

- Led by by Ed Quesenberry and Trent Nagele (SEAO)
- The Critical Building Task Group will address the buildings listed below:

  Emergency Operations Centers

  Healthcare facilities (Hospitals and MOBs)

  Police and Fire Stations

  Critical government administration/services facilities

  Emergency sheltering facilities

  Education facilities (K-12, College and University);

  Community retail centers

  Financial/banking Buildings

  Residential Housing

  Special buildings (URM and non-ductile RC buildings)

Energy Group

- Led by Stan Watters (OSSPAC/Port of Portland) and JR Gonzalez (formerly OPUC)
- The Energy Task Group will address the systems listed below:

  Electricity

  Natural Gas

  Liquid Fuel

  Dams

Transportation Group

- Led by Bruce Johnson (ODOT)
- The Transportation Task Group will address the systems listed below:

  Bridges (owned by ODOT, Counties or Cities)

  Airports and Seaports

  Railroads

  Mass Transit (Trimet)

  Columbia River

Information and Communications Group

- Led by Mike Mumaw (OSSPAC/Beaverton)

- The Information and Communications Task Group will address the systems listed below:

  Communication Network and Database

  Telecommunication Infrastructure

Water and Waste Water Group

- Led by Mike Stuhr (PWB) and Mark Knudson (TVWD)
- The Water and Wastewater Task Group will address the systems listed below:

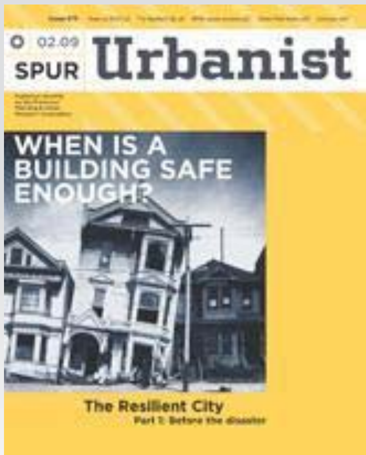
  Water storage, transmission, and distribution systems (including Dams)

  Wastewater collection systems and treatment plants



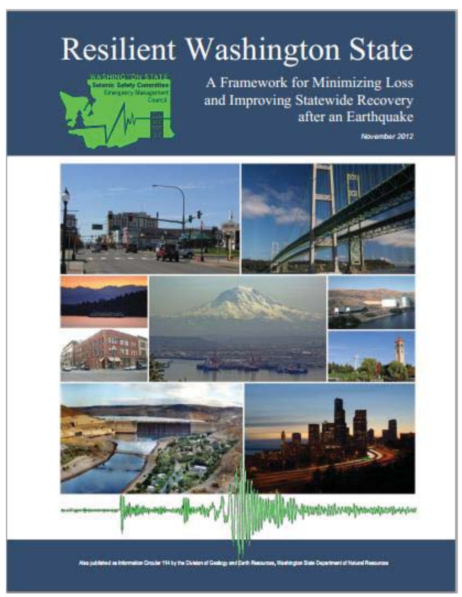
Resilience Inspiration from Other States

- Resilient City by SPUR – Led by Chris Poland

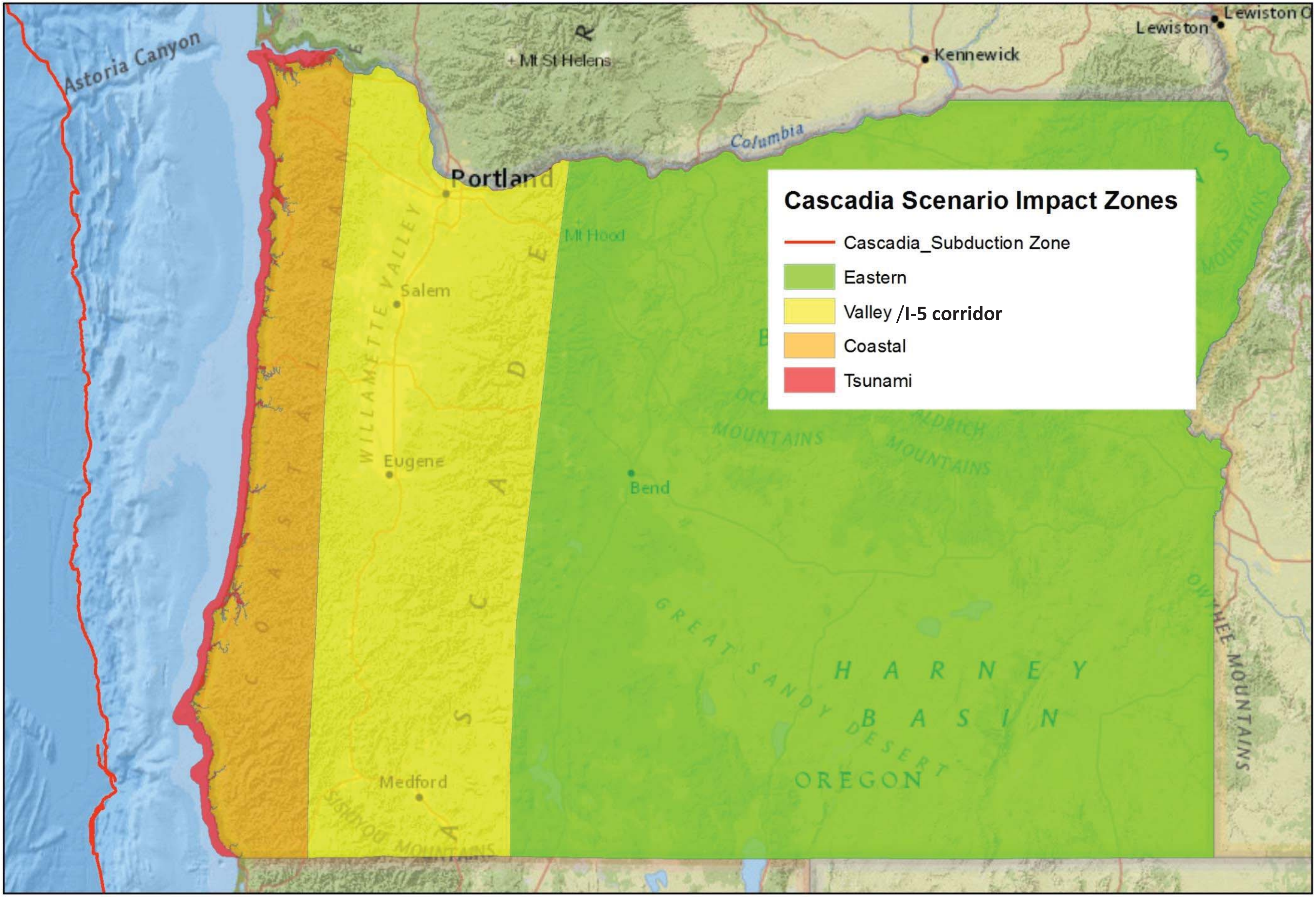


SPUR IDEAS AND ACTION FOR A BETTER CITY
a member-supported nonprofit organization

- Resilient Washington Initiative – Led by Stacy Bartoletti



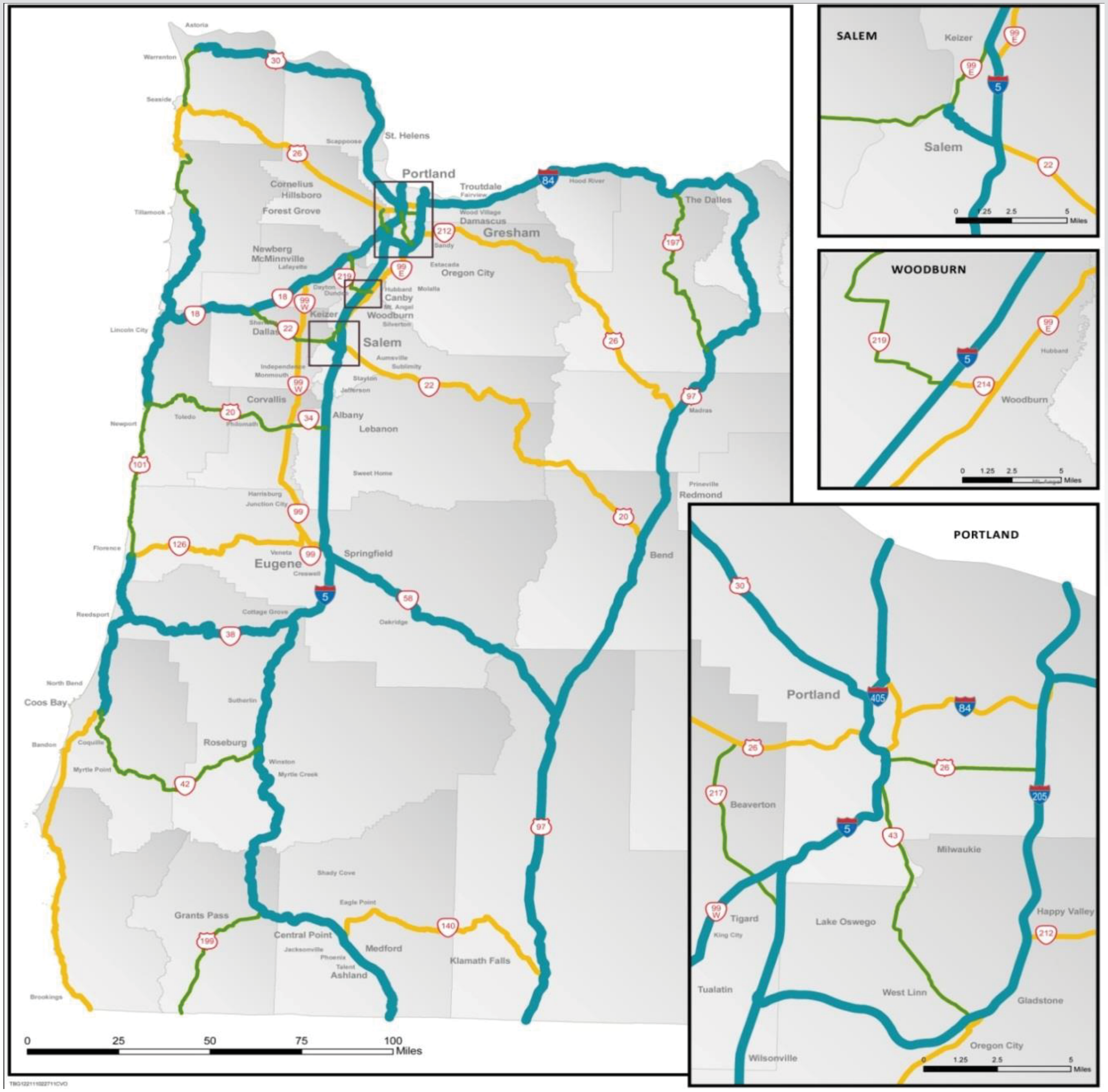
Four Zones



Cascadia Scenario Impact Zones
Cascadia_Subduction Zone
Eastern
Valley /I-5 corridor
Coastal
Tsunami
Astoria Canyon
Mt St Helens
Kennewick
Lewiston
Columbia
Portland
Mt Hood
Salem
WILLAMETTE VALLEY
Eugene
Bend
Medford
HARNEY BASIN
GREAT SANDY DESERT
OREGON
OWYHEE MOUNTAINS

State Response/Recover Strategy

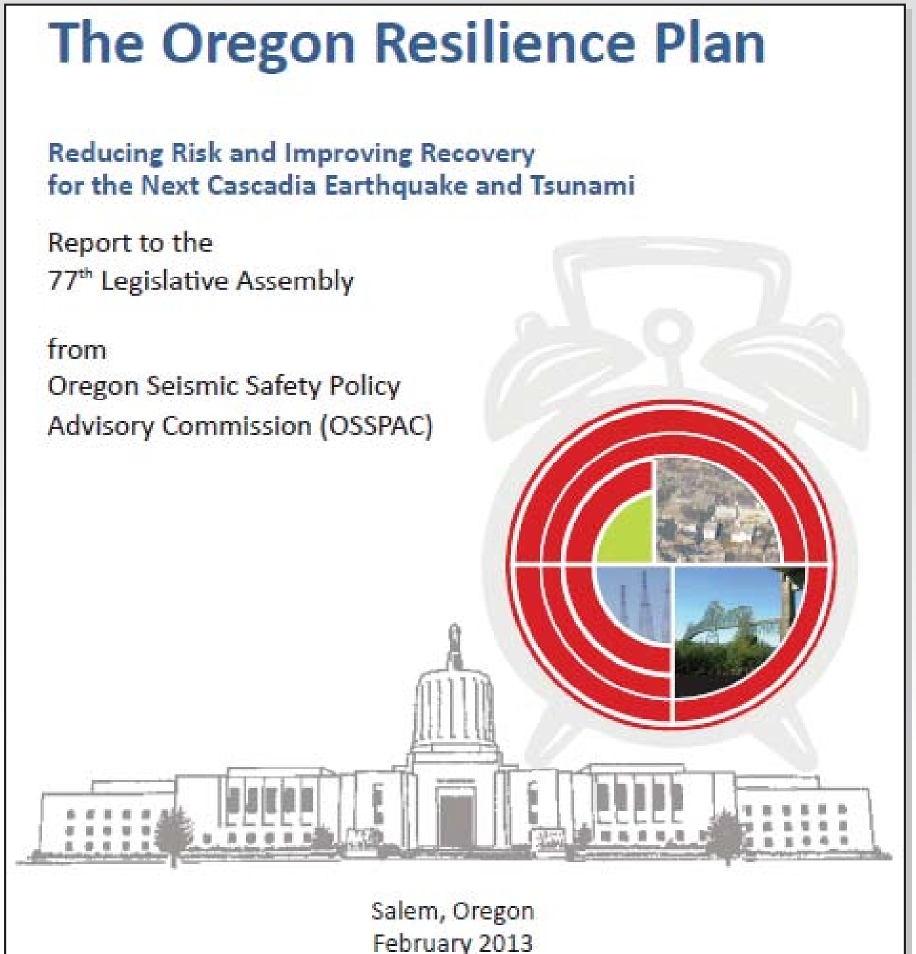
1st tier
2nd tier
3rd tier



Oregon Resilience Planning Steps

- Assess **performance** of existing critical facilities and lifeline systems, and estimate timeframes required to restore functions at present conditions;
- Develop resilience goals based on business and community needs for each zone;
- Define acceptable target timeframes to restore functions to meet resilience goals; and
- Prepare **recommendations** for statewide policies and actions to achieve the desired performance targets.

The Oregon Resilience Plan



50-year Comprehensive Plan

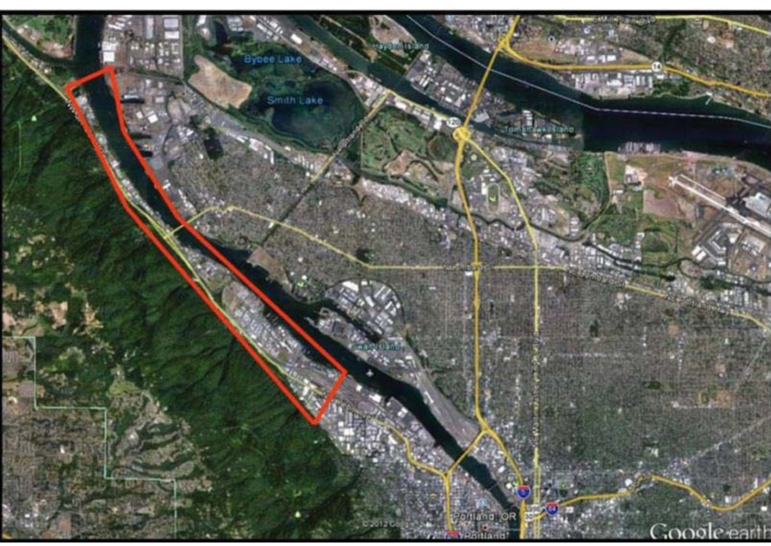
- ❑ **Cascadia Earthquake Scenario**
- ❑ **Business/Workforce Continuity**
- ❑ **Coastal Communities**
- ❑ **Critical & Essential Buildings**
- ❑ **Transportation**
- ❑ **Energy**
- ❑ **Information and Communication**
- ❑ **Water & Wastewater**

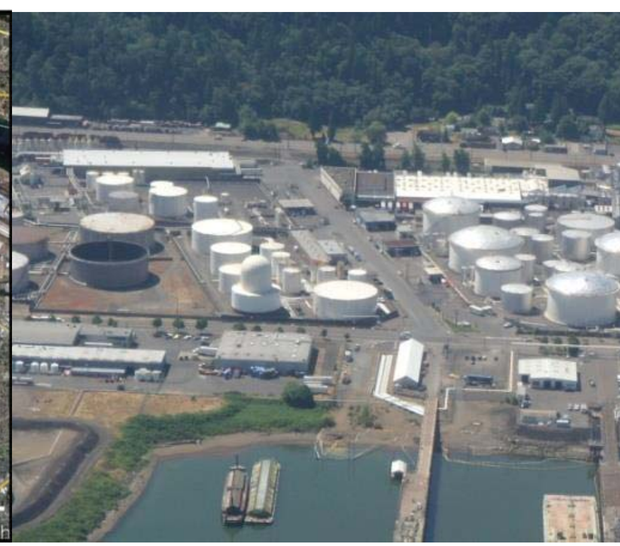
- ❑ Save Lives, protect our economy, and preserve our communities;
- ❑ 169 Expert Volunteers;
- ❑ $ Millions in donation of professional services over a year

Key Findings

- Oregon is far from resilient to the impact of a great Cascadia earthquake today
  - Casualties (a few thousand to more than 10,000)
  - Economic Loss (at least 20% state GDP)
  - More than one million truck loads of debris

- Liquid Fuel vulnerability





Current Resilience Gap

- Business can only tolerate two to four weeks of disruption of essential services

Critical Service	Zone	Estimated Time to Restore Service
Electricity	Valley	1 to 3 months
Electricity	Coast	3 to 6 months
Police and fire stations	Valley	2 to 4 months
Drinking water and sewer	Valley	1 month to 1 year
Drinking water and sewer	Coast	1 to 3 years
Top-priority highways (partial restoration)	Valley	6 to 12 months
Healthcare facilities	Valley	18 months
Healthcare facilities	Coast	3 years

Expected Building Performance

- Falls short in almost every category
- Business can tolerate 2 to 4 week recovery

Critical Building Category	Zone	Estimated Average Recovery Time
Healthcare Facilities	Valley	18 months
Police and Fire Stations	Valley	2 to 4 months
Emergency Operations Centers	Valley	4 months
Schools	Valley	18 months
Housing	Valley	3 days**
Emergency Shelter	Valley	18 month
Retail and Banking	Valley	1 month

** Underestimates recovery for older construction

Can we achieve resilience for M9?

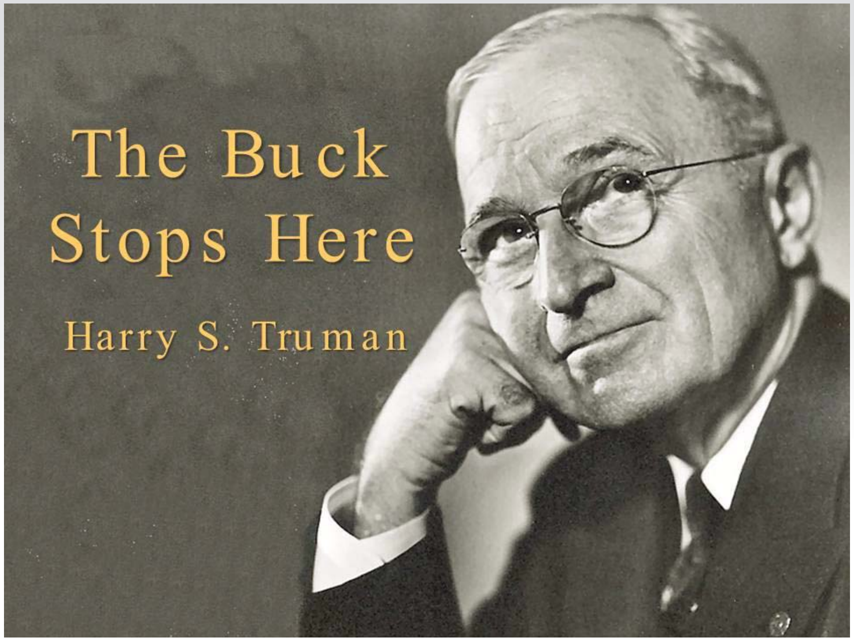
- YES

- Chile (2010 M8.8 Maule Earthquake)
  - 90% communication services within two weeks
  - 95% power supply within two weeks
  - Re-start commercial flights in ten days

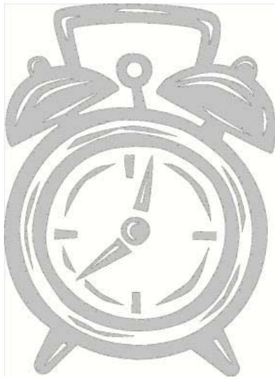
- Japan (2011 M9.0 Tohoku Earthquake)
  - 90% power supply in ten days
  - 90% telephone lines in two weeks

Overarching Recommendations

- Establish a State Resilience Office to provide leadership, resources, advocacy, and expertise in implementing statewide resilience plans



- Undertake comprehensive seismic assessments of the key structures and systems that underpin Oregon’s economy;

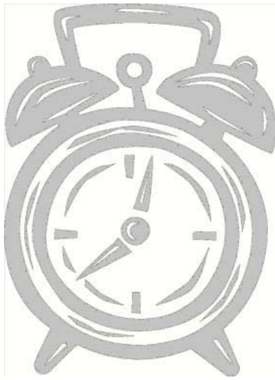


Overarching Recommendations

- Launch a sustained program of capital improvement in Oregon’s public structures;

- Craft a package of incentives to engage Oregon’s private sector to advance seismic resilience;

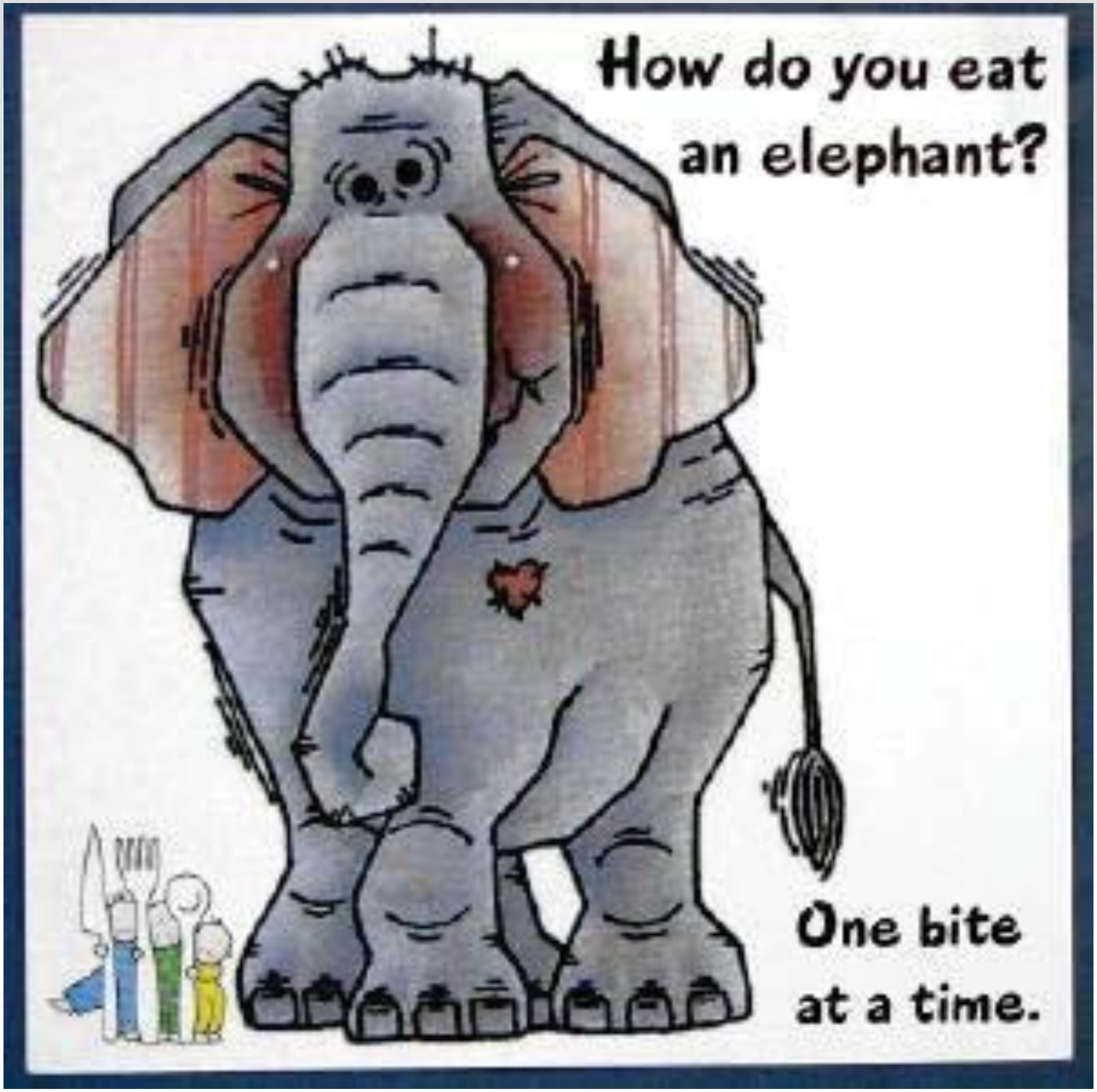
- Update Oregon’s public policies



Looking Ahead

- **Propose to work with Oregon's Legislative Assembly to keep the 50-year goal in view**
- **Community-level Planning**
- **Joint regional planning with Washington State**
- **Civic infrastructure**
- **Human Resilience**

How to Implement it?



Media Attention

Oregon Live

Science on NBC NEWS

CFAX 1070

ASCE

DAILY NEWS
NYDailyNews.com / U.S

The Washington Times

Civil Engineering
THE MAGAZINE OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

San Francisco Chronicle

The Seattle Times

YAHOO! NEWS

KOIN.COM

LIVE SCIENCE

EERI

KHQ Q6 HD
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the Portland MERCURY

FOX 12 OREGON

KVAL NEWS

OPB

NWCN.COM

DJC oregon
DAILY JOURNAL OF COMMERCE - THE BUSINESS OF BUILDING

reddit

NISEE
Pacific Earthquake Engineering Research (PEER) Center
University of California, Berkeley

KGW NewsChannel 8

KATU news

DEMOTIX

The Daily Astorian

77th OREGON LEGISLATIVE ASSEMBLY--2013 Regular Session

B-Engrossed
Senate Bill 33

Ordered by the House June 17
Including House Amendments dated May 31 and June 17

SUMMARY

The following summary is not prepared by the sponsors of the measure and is not a part of the body thereof subject to consideration by the Legislative Assembly. It is an editor's brief statement of the essential features of the measure.

Modifies list of state agencies required to designate liaison for emergency preparedness and response. Requires that liaison be individual with authority during emergency to allocate agency resources and assets.

Establishes task force to facilitate implementation of Oregon Resilience Plan.

Declares emergency, effective on passage.

---

(3) The task force shall facilitate a comprehensive and robust plan to implement the strategic vision and roadmap of the Oregon Resilience Plan for responding to the consequences of naturally occurring seismic events associated with geologic shift along the Cascadia subduction zone by making recommendations about:

(a) Education and training of community leaders in emergency management and resilience practices, including:

(b) Coordination of investments in equipment, facilities and systems critical for enhanced resilience and survivability in the near, intermediate and far terms, including:

SB 33 Task Force on ORP Implementation

- ❖ Oversight
  - Resilience Policy Advisor to the Governor
  - Long term, statewide resilience oversight
- ❖ Transportation
  - Retrofit backbone routes identified in ODOT's Seismic Options
  - Thorough inventory and assessment of transit, air/marine port, and rail assets
- ❖ Land Use (Coastal Community)
  - Adopt the "L" line from most recent tsunami hazard maps
  - $5M for coastal communities for tsunami resilience planning
  - Recovery planning prior to a tsunami
- ❖ Energy
  - OPUC require seismic assessment of its regulated facilities
  - State establish PPP to mitigate/evaluate diversification of locations for storing liquid fuel, and ID new liquid fuel corridors

SB 33 Task Force on ORP Implementation

- Critical Facilities and Seismic Rehabilitation Grant Program (SRGP)
  - $200 Million every biennium for critical facilities (schools/fire station/EOC/hospitals)
  - $20 Million for DOGAMI to update statewide inventory and preliminary evaluation of critical facilities
- Water/Wastewater
  - Water/wastewater providers complete seismic risk assessment and mitigation plan
  - Firefighting agencies, water providers, and EM agencies to establish joint standards for use in planning the firefighting response to seismic event
- Training and Education
  - Fund OEM to support education and training for public/private/not-for-profit
  - Fund Dept. of Education to support K-12 education on our state's hazard
  - Business Oregon encourages continuity assessment & planning for all businesses
- Research
  - Establish $1M research initiative annually for improving OR resilience

2015 Resilience Legislation

- HB 2270 State Resilience Officer
- HB 5005 SRGP $177 M for schools and $30M for essential facilities
- SB 775A Vulnerability assessment ≠ negligence

Resilience In Action

1. Resilience Planning at local levels
    - Port of Portland
    - Portland Water Bureau
    - Tualatin Valley Water District (TVWD)
    - Eugene Water & Electric Board
    - City of Gresham (Water System)
    - Beaverton School District

2. Metro regional resilience planning

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Tenth U.S. National Conference on Earthquake Engineering
Frontiers of Earthquake Engineering
July 21-25, 2014
Anchorage, Alaska

OVERVIEW OF THE OREGON RESILIENCE PLAN FOR NEXT CASCADIA EARTHQUAKE AND TSUNAMI

Q.-S. Yu[1], J. Wilson[2], and Y. Wang[3]

ABSTRACT

Following the March 11, 2011 Tohoku earthquake and tsunami in Japan, Oregon's House of Representatives unanimously adopted House Resolution 3 directing Oregon Seismic Safety Policy Advisory Commission (OSSPAC) to develop a comprehensive resilience plan to prepare the state to withstand and recover from a Cascadia subduction zone earthquake and tsunami. OSSPAC recruited an advisory panel and eight task groups comprising nearly 170 volunteers from earthquake professional organizations, universities, government agencies, and private sectors to describe the scenario earthquake, examine potential impacts to the state's critical buildings, transportation system, and utilities, explore the special challenges facing coastal communities, and anticipate the disruption of business continuity that could jeopardize disaster recovery. The report titled "*the Oregon Resilience Plan: Reducing Risk and Improving Recovery for the Next Cascadia Earthquake and Tsunami*" was delivered by OSSPAC to the 77th Oregon Legislative Assembly on February 28, 2013. The plan reveals significant resilience gaps between expected performance of infrastructure sectors based on their current conditions and the desirable performance levels based on the community needs and economic recovery. All five critical infrastructure sectors are very vulnerable, and the lengthy projected times to return basic infrastructure services to communities greatly exceed the amount of time most small businesses can remain financially viable without infrastructure services. Based on the findings in the *Oregon Resilience Plan*, OSSPAC outlines steps that can be taken over the next 50 years to bring the state closer to resilient performance through a systematic program of vulnerability assessments, capital investments in public infrastructure, new incentives to engage the private sector, and policy changes that reflect current understanding of the Cascadia threat. The highest priority recommendation is to establish a Resilience Office in the Governor's office to provide leadership, resource, advocacy, and expertise in implementing statewide resilience plans.

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[3]Principal Engineer, Sustainable Living Solutions LLC, Portland, OR 97214

Yu Q.-S., Wilson J., and Wang Y. Overview of the Oregon Resilience Plan for Next Cascadia Earthquake and Tsunami. *Proceedings of the 10th National Conference in Earthquake Engineering*, Earthquake Engineering Research Institute, Anchorage, AK, 2014.

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Overview of the Oregon Resilience Plan for Next Cascadia Earthquake and Tsunami

Q.-S. Yu[1], J. Wilson[2], and Y. Wang[3]

ABSTRACT

Following the March 11, 2011 Tohoku earthquake and tsunami in Japan, Oregon's House of Representatives unanimously adopted House Resolution 3 directing Oregon Seismic Safety Policy Advisory Commission (OSSPAC) to develop a comprehensive resilience plan to prepare the state to withstand and recover from a Cascadia subduction zone earthquake and tsunami. OSSPAC recruited an advisory panel and eight task groups comprising nearly 170 volunteers from earthquake professional organizations, universities, government agencies, and private sectors to describe the scenario earthquake, examine potential impacts to the state's critical buildings, transportation system, and utilities, explore the special challenges facing coastal communities, and anticipate the disruption of business continuity that could jeopardize disaster recovery. The report titled "*the Oregon Resilience Plan: Reducing Risk and Improving Recovery for the Next Cascadia Earthquake and Tsunami*" was delivered by OSSPAC to the 77th Oregon Legislative Assembly on February 28, 2013. The plan reveals significant resilience gaps between expected performance of infrastructure sectors based on their current conditions and the desirable performance levels based on the community needs and economic recovery. All five critical infrastructure sectors, including critical buildings, energy, transportation, water and waste water, and communications, are very vulnerable, and the lengthy projected times to return basic infrastructure services to communities greatly exceed the amount of time most small businesses can remain financially viable without infrastructure services. Based on the findings in the *Oregon Resilience Plan*, OSSPAC outlines steps that can be taken over the next 50 years to bring the state closer to resilient performance through a systematic program of vulnerability assessments, capital investments in public infrastructure, new incentives to engage the private sector, and policy changes that reflect current understanding of the Cascadia threat. The highest priority recommendation is to establish a Resilience Office in the Governor's office to provide leadership, resource, advocacy, and expertise in implementing statewide resilience plans.

Introduction

For more than 300 years, Cascadia subduction zone off America's northwest coast has lain dormant. Not until the 1980s did scientists recognize it as an active fault that poses a major geological hazard to Oregon as well as northern California and Washington. In 1993, the

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building codes in Oregon were updated to address this newly revealed earthquake threat to the built environment. Since then, geologists have discovered that over 40 great earthquakes of magnitude 8 and larger have struck Western Oregon during the past 10,000 years (see Fig. 1). The most recent event occurred on January 26, 1700 AD, and was a great earthquake with a magnitude of 9.0. The time interval between previous earthquakes has varied from a few decades to many centuries, but most of the past intervals have been shorter than the 313 years since the last event. The current calculated odds that a Cascadia earthquake will occur in the next 50 years range from 7-15 percent for a great earthquake affecting the entire Pacific Northwest to about 37 percent for a very large earthquake affecting southern Oregon and northern California. Many state and local officials have been concerned about potential widespread vulnerability of the buildings and lifeline infrastructure in Oregon.

In 1999, the Oregon Department of Geology and Mineral Industries (DOGAMI) published a preliminary statewide damage and loss study identifying the dire consequences of a Cascadia earthquake and tsunami for Oregon's infrastructure and for public safety. In the following ten years, the Oregon legislature passed several bills that directed the state to launch a statewide assessment of public schools and emergency response facilities and established a state grant program to help fund seismic upgrades to hazardous schools and other critical emergency response facilities. Meanwhile, the state and local transportation agencies and some forward thinking utility providers have taken voluntary steps to assess seismic vulnerability of their systems and conduct limited seismic rehabilitation. However, the systems in different infrastructure sectors were assessed and/or rehabilitated by their public operators and private owners without coordination and without consistent understanding of their interdependencies on other systems let alone the consequences of their systems' failure on the overall pace of the community recovery. There has been growing desire to break down the "silo" mentality and take a holistic look at comprehensive steps to mitigate the Cascadia earthquake risk to our economy and to our businesses, homes, and communities.

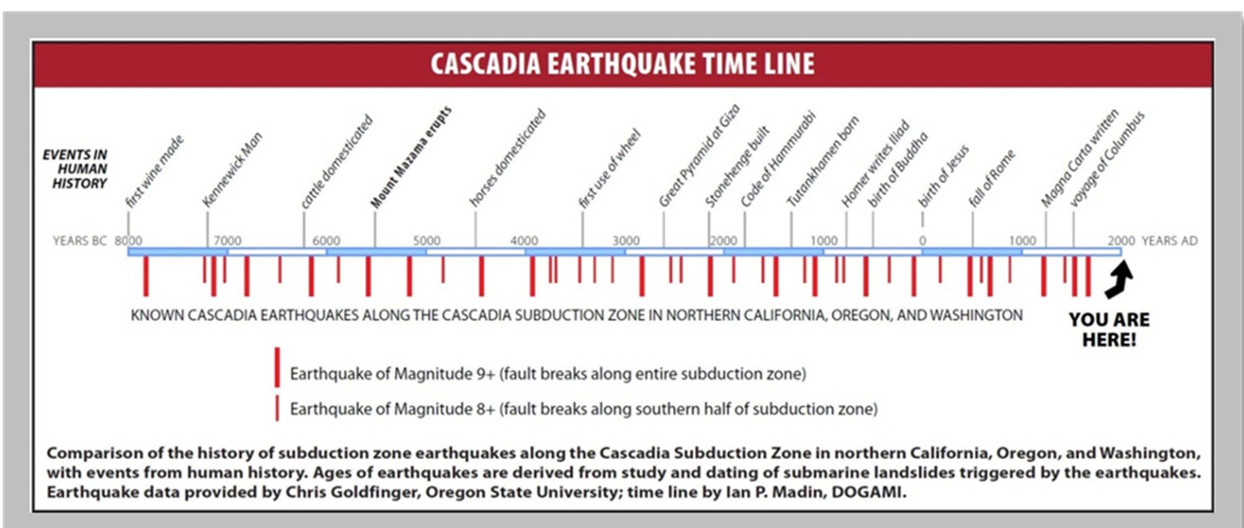

Figure 1. The 10,000-Year History of Cascadia Subduction Zone Earthquakes

In January 2011, three Oregon earthquake safety advocates suggested in the pages of the *Oregonian* [1] that Oregon should take new steps to make itself resilient to a big earthquake. The March 11, 2011 Tohoku Japan earthquake and tsunami provided the occasion for Oregon's House Representative Deborah Boone to introduce House Resolution 3 that was unanimously adopted by the state legislature in April 2011. The House Resolution 3 (HR 3) directed Oregon Seismic Safety Policy Advisory Commission (OSSPAC) to "lead and coordinate preparation of an Oregon Resilience Plan that reviews policy options, summarizes relevant reports and studies by state agencies and makes recommendations on policy direction to protect lives and keep commerce flowing during and after a Cascadia earthquake and tsunami". The focus of the HR 3 is on the state's physical infrastructure. The plan and recommendations were scheduled to be delivered to the 77th Oregon Legislative Assembly by February 28, 2013. As the goal of the *Oregon Resilience Plan* is consistent with the aim of President Obama's Presidential Policy Directive / PPD-8: *National Preparedness* issued on March 30, 2011, Richard Reed, President Obama's Senior Director for Resilience Policy, Oregon Governor John Kitzhaber, and Cascadia Region Earthquake Workgroup (CREW) acknowledged the resilience planning efforts and provided their endorsement prior to the kickoff of the project.

Resilience Definition and Expected Earthquake Scenario

Resilience as defined in the HR 3 means that Oregon citizens will not only be protected from life-threatening physical harm, but because of risk reduction measures and pre-disaster planning, communities will recover more quickly and with less continuing vulnerability following a Cascadia subduction zone earthquake and tsunami. For the *Oregon Resilience Plan*, OSSPAC defines the Cascadia earthquake (as mentioned in the HR 3) to be a Magnitude 9.0 Cascadia subduction earthquake with an average recurrence of once every 550 years. We believe that a Magnitude 9.0 earthquake is a very real possibility that would affect all of Oregon and is directly comparable to the 2011 Tohoku earthquake and tsunami, the effects of which are all too well known.

To achieve the goal of rapid recovery, we need arrangements in place for government continuity, resilient physical infrastructure, and business and workforce continuity. Resilient physical infrastructure is the foundation, and will help the state enhance its sustainability and other aspects of community resilience such as social, environmental, and economic resilience.

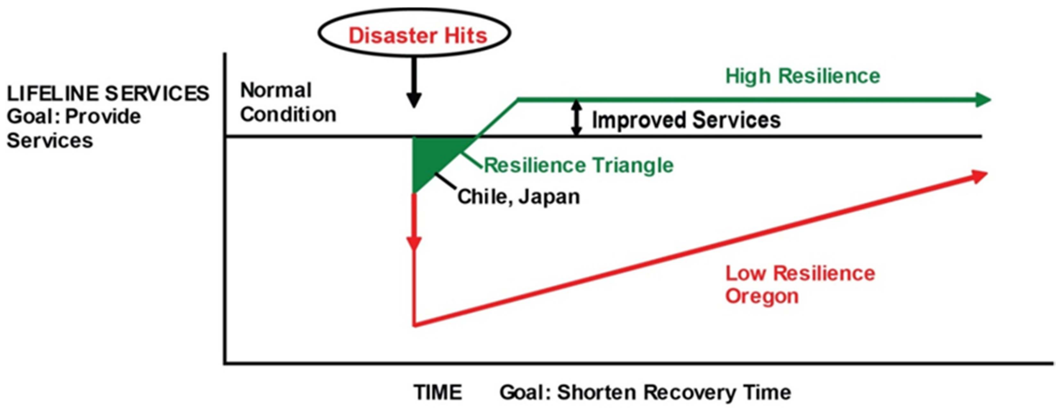

Figure 2. Resilience Triangle [2]

The definition of (physical) resilience can be better illustrated with the resilience triangle diagram as shown in Fig. 2. Higher resilience is characterized with minimal reductions in critical lifeline services after a disaster, speedy recovery of those services, and an overall improved service level as a result of rebuilding damaged systems and implementing better systems. The resilience triangle diagram indicates that Chile and Japan have high levels of earthquake resilience. At the current stage, Oregon's infrastructure has low resilience and is expected to have significant loss of sector services and an excessively long recovery time [2]. This is partly due to the sheer size and power of a magnitude 9.0 earthquake, but it is also the result of the inherent vulnerability of our buildings and lifeline systems. Another major factor that amplifies the effects of a Cascadia earthquake and delays the pace of recovery is the co-location and interdependencies of various lifeline infrastructure systems, coupled with the wide geographic spread of a Cascadia disaster as virtually all of the resources required for the recovery of lifeline systems would have to come from outside the affected states.

Resilience Planning Methodology and State Response/Recovery Strategy

OSSPAC identified existing earthquake resilience planning from San Francisco, California by the San Francisco Planning and Urban Research Association (SPUR) [3] as a good model to follow. The SPUR developed a method that (1) defines performance metrics for buildings and lifeline infrastructure based on what a community needs in the context of response and recovery stages and (2) helps the community identify where the resilience gaps are. The SPUR method focuses on the speed of infrastructure recovery, which is critical for Oregon’s economy as 50-60% of our state work forces are employed by small businesses which do not have sufficient financial resources to survive lengthy business disruption.

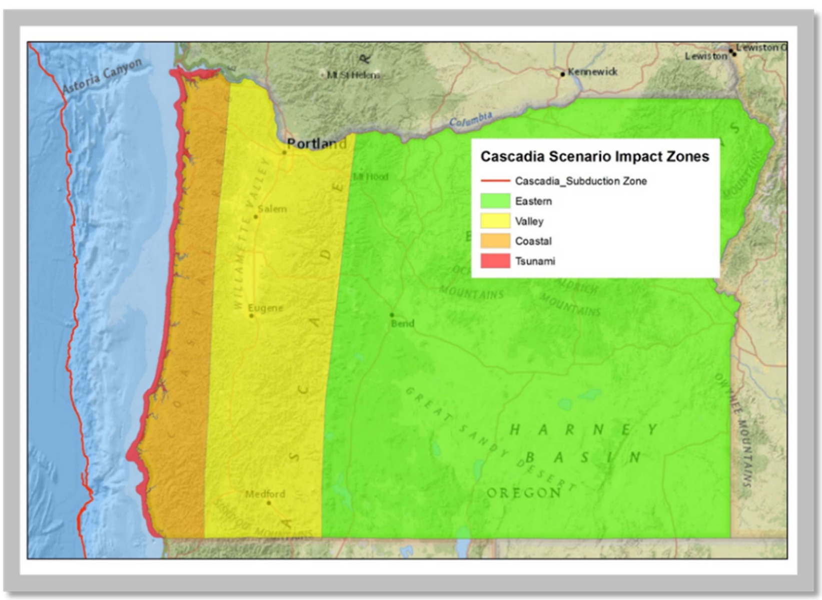

Figure 3. Four Impact Zones for the Magnitude 9.0 Cascadia Earthquake Scenario

To apply the SPUR method to a state level, OSSPAC decided to divide the state into four distinct zones based on expected pattern of damage in combination with Oregon’s mountainous geography: (1) Tsunami Zone; (2) Coastal Zone (outside the Tsunami affected area); (3) Interstate 5/Valley Zone; and (4) Central/Eastern Zone (see Fig. 3 for these four impact zones). In addition, this would allow the state to implement the statewide response and recovery effectively and efficiently.

In the Tsunami Zone, we anticipate that severe shaking and tsunami inundation would cause near total damage of buildings and lifeline infrastructure, and threaten the lives of thousands of residents and tourists. Thus, our focus is simply to save lives.

In the Coastal Zone, severe shaking and landslides that will cause damage to transportation systems would severely disrupt and isolate communities. Thousands of people displaced from the Tsunami Zone are expected to evacuate here. Thus, in the Coastal Zone, keeping the population sheltered, fed and healthy is critical to avoid humanity crises.

In the I-5/Valley Zone where we have majority of the state population and businesses, widespread moderate damage would severely disrupt daily life and commerce. It is clear that restoring services to businesses and residents will be the main priority.

The Central/Eastern Zone, light damage would allow rapid restoration of services and functions, and communities would become critical hubs for the movement of response, recovery and restoration personnel and materials for the rest of the state. This requires the state to develop an efficient and cost-effective multimodal transportation system to maintain statewide connectivity and provide the highest level of mobility to the largest area and the highest population centers. This multimodal transportation system involves a lifeline backbone highway system supplemented with air transportation and marine ports. The backbone highway system (after strengthened) will move goods and people from the Central/Eastern Zone to the Valley to the Coastal Zone. In addition, we believe that the Redmond Municipal Airport in the Central/Eastern Zone could be hardened to remain fully operational without much investment. From there, goods and people would be easily distributed to commercial airports in the Valley via fixed-wing aircrafts. Then, goods and people would access coastal areas by helicopters. An alternative redundant transportation system would serve Oregon from the west from ships. Goods and people would have access to the ships either through selected ports shortly after the event or helicopters.

Advisory Panel and Eight Task Groups

To complete the plan without funding and on a fourteen-month schedule, OSSPAC decided to lead and coordinate the preparation through its Resilient Oregon Steering Committee and chose to tap into volunteer expertise from Oregon's academic, professional, governmental and public communities. Almost one hundred seventy volunteer experts drawn from a broad section of Oregon society were organized into one Advisory Panel and eight work groups to complete this planning task. The eight task groups include (1) Earthquake/Tsunami Scenario, (2) Business and Workforce Continuity, (3) Coastal Communities, (4) Critical/Essential Buildings, (5) Transportation, (6) Energy, (7) Information and Communications, and (8) Water and Waste Water.

The Advisory Panel consisted of representatives from the state and federal government, the state legislature, universities, and local businesses. It augmented OSSPAC's overall capability and capacity, and provided strategic advice to the OSSPAC's Resilient Oregon Steering Committee on an as-needed basis throughout the development of the Resilience Plan. Through its interaction with the Advisory Panel, OSSPAC was able to keep the state government, legislature, and businesses informed of overall statewide earthquake risk and necessary steps to mitigate it.

The OSSPAC's Resilient Oregon Steering Committee provided leadership and direction to the eight task groups and helped coordinate the planning efforts among different groups to address interdependencies of various lifeline infrastructure sectors. Each task group was charged with three primary tasks for four affected zones (Tsunami, Coastal, I-5/Valley, and Central/Eastern Zones):

(1) Determine the likely impact of the scenario earthquake on the assigned sector and estimate the time required to restore functions in that sector if the earthquake were to happen under current conditions;
(2) Define performance targets for the sector. The targets represent the desired timeframes for restoring functions in a future Cascadia earthquake — in other words, the timeframes within which functions must be restored if Oregon is to be resilient;
(3) Provide a series of recommendations to OSSPAC for changes in practice and policy that, if implemented, would ensure that Oregon reaches the desired resilience targets over the next 50 years.

The products from the various task groups were reviewed by the Advisory Panel to ensure that the material was accurate, complete, and up-to-date. OSSPAC then reviewed the recommendations and selected and endorsed those that the commission felt offered the most effective way to achieve resilience to a great Cascadia disaster.

The Oregon Resilience Plan

After fourteen months of extensive planning, coordination, and meetings, OSSPAC assembled eight chapters that make up the plan titled *The Oregon Resilience Plan: Reducing Risk and Improving Recovery for the Next Cascadia Earthquake and Tsunami* [4] (See Fig. 4 for the report cover), and delivered it to the Oregon's 77th Legislative Assembly on February 28, 2013. Below lists a brief summary of what each task group produced for the plan.

The <u>Cascadia Earthquake Scenario Task Group</u> (Chapter One) reviewed current scientific research to develop a detailed description of the likely physical effects of a great (magnitude 9.0) Cascadia subduction zone earthquake and tsunami, providing a scenario that other task groups used to assess impacts on their respective sectors.

The <u>Business and Workforce Continuity Task Group</u> (Chapter Two) sought to assess the workplace integrity, workforce mobility, and building/infrastructure systems performance – along with customer viability – needed to allow Oregon's businesses to remain in operation following a Cascadia earthquake and tsunami and to drive a self-sustaining economic recovery. Resilience is primarily about the timely re-occupancy of residents as employees and businesses.

The Coastal Communities Task Group (Chapter Three) addressed the unique risks faced by Oregon's coast, the region of the state that will experience a devastating combination of tsunami inundation and physical damage from extreme ground shaking due to proximity to the subduction zone fault.

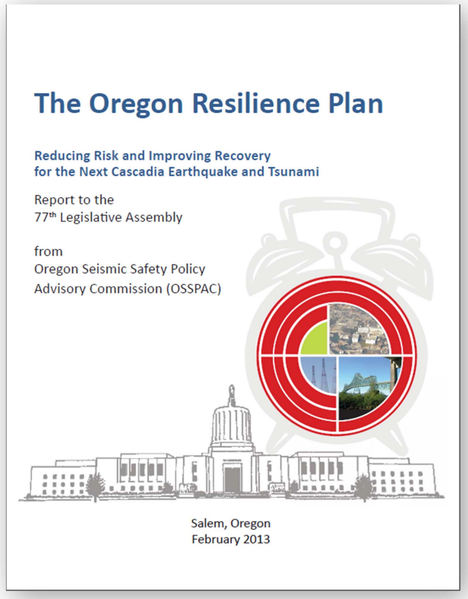

Figure 4. Cover Page of the Oregon Resilience Plan

The Critical and Essential Buildings Task Group (Chapter Four) examined the main classes of public and private structures considered critical to resilience in the event of a scenario earthquake, and sought to characterize the gap between expected seismic performance (current state) and desired seismic resilience (target state). The group also assessed buildings deemed vital to community resilience, and addressed the special challenges posed by unreinforced masonry (URM) and non-ductile concrete structures.

The Transportation Task Group (Chapter Five) assessed the seismic integrity of Oregon's multi-modal transportation system, including bridges and highways, rail, airports, water ports, and public transit systems, examined the special considerations pertaining to the Columbia and Willamette River navigation channels, and characterized the work deemed necessary to restore and maintain transportation lifelines after a Cascadia earthquake and tsunami. The group's scope included interdependence of transportation networks with other lifeline systems.

The Energy Task Group (Chapter Six) investigated the seismic deficiencies of Oregon's energy storage and transmission infrastructure, with a special emphasis on the vulnerability of the state's critical energy infrastructure (CEI) hub, a six-mile stretch of the lower Willamette River where key liquid fuel and natural gas storage and transmission facilities and electricity transmission facilities are concentrated.

The Information and Communications Task Group (Chapter Seven) examined the inherent vulnerabilities of Oregon's information and communications systems and the consequences of service disruptions for the resilience of other sectors and systems. The group explored the implications of co-location of communications infrastructure with other vulnerable physical infrastructure (*e.g.,* bridges), and specified the conditions needed to accomplish phased restoration of service following a Cascadia earthquake and tsunami.

The Water and Wastewater Task Group (Chapter Eight) reviewed vulnerabilities of the pipelines, treatment plants, and pump stations that make up Oregon's water and wastewater systems, discussed the interventions needed to increase the resilience of under-engineered and antiquated infrastructure at potential failure points, and developed strategies to address fire following the earthquake to minimize secondary damage to buildings. The group proposed a phased approach to restoration of water services after a Cascadia earthquake and tsunami, beginning with a backbone water and wastewater system capable of supplying critical community needs.

Major Findings of the Oregon Resilience Plan

Oregon is far from resilient to the impacts of a great Cascadia earthquake and tsunami today. The scenario Cascadia earthquake would be an unprecedented catastrophe for Oregon and for the United States. It would impact every aspect of life for all Oregonians and for the residents of northern California, Washington, and British Columbia. The effects of a Cascadia subduction earthquake will be greatest on the coast, which is right next to the subduction zone fault, and will diminish as one goes inland. This, in combination with Oregon's mountainous geography, divides the state into four impact zones: within the Tsunami Zone, damage will be nearly complete. In the Coastal Zone, shaking will be severe, liquefaction and landsliding will be widespread and severe, and damage will be severe. In the I-5/Valley Zone, shaking will be strong, liquefaction and landslide will be common but less severe, and moderate damage will be widespread. In the Central/Eastern Zone, shaking will be mild, landslides and liquefaction sporadic, and damage generally light.

Fatalities and Economic Loss

Available studies estimate fatalities ranging from 1,250 to more than 10,000 due to the combined effects of earthquake and tsunami, tens of thousands of buildings destroyed or damaged so extensively that they will require months to years of repair, tens of thousands of displaced households, at least $30 billion in direct economic losses (close to one-fifth of Oregon's gross state product), and more than one million dump truck loads of debris.

Extreme Vulnerability of Liquid Fuel Supply

A particular vulnerability is Oregon's liquid fuel supply. Oregon depends on liquid fuels transported into the state from Washington State, which is also vulnerable to a Cascadia earthquake and tsunami. Once here, fuels are stored temporarily at Oregon's critical energy infrastructure (CEI) hub, a six-mile stretch of the lower Willamette River where industrial facilities occupy liquefiable riverside soils. Disrupting the transportation, storage, and distribution of liquid fuels would rapidly disrupt most, if not all, sectors of the economy critical to emergency response and economic recovery.

Large Resilience Gaps Business Communities Can't Afford

Business continuity planning typically assumes a period of two weeks to be the longest disruption of essential services (i.e., utilities, communications, etc.) that a business can withstand, and service disruptions lasting for one month or longer can be enough to force a business to close, relocate, or leave the state entirely. Analysis in the *Oregon Resilience Plan* reveals the following timeframes for service recovery under present conditions as shown in Table 1. As shown on Table 1, row 1, basic electricity services are expected to be down for over three to six months in the Coast Zone and between one and three months in the Valley Zone, and so on.

Resilience gaps of this magnitude reveal a harsh truth: a policy of business as usual implies a post-earthquake future that could consist of decades of economic and population decline – in effect, a "lost generation" that will devastate our state and ripple beyond Oregon to affect the regional and national economy.

Table 1. Estimated Timeframe to Restore Critical Infrastructure.

Critical Service	Valley	Coast
Electricity	1 to 3 months	3 to 6 months
Drinking water and sewer	1 month to 1 year	1 to 3 years
Schools	18 months	18 months
Police and fire stations	2 to 4 months	3 years
Healthcare facilities	18 months	3 years
Top-priority highways (partial restoration)	6 to 12 months	1 to 3 years
Telecommunications	6 to 12 months	6 to 12 months
Liquid fuel	Extreme Vulnerable	Extreme Vulnerable

Recommendations

Based on the findings in the *Oregon Resilience Plan*, OSSPAC recommends that Oregon start now on a sustained program to reduce our vulnerability and shorten our recovery time to achieve resilience before the next Cascadia earthquake inevitably strikes our state.

OSSPAC urges systematic efforts to assess Oregon's buildings, lifelines, and social systems, and to develop a sustained program of replacement, retrofit, and redesign to make Oregon resilient. Sector-by-sector findings and detailed recommendations are presented in each chapter of the *Oregon Resilience Plan*. Overarching priorities, illustrated with examples selected from the chapters, include new efforts to:

1. Establish a State Resilience Office to provide leadership, resources, advocacy, and expertise in implementing statewide resilience plans;
2. Undertake comprehensive assessments of the key building structures and critical infrastructure systems that underpin Oregon's economy;
3. Launch a sustained program of capital investment in Oregon's public school buildings, emergency response facilities, and lifeline transportation routes;
4. Craft a package of incentives to engage Oregon's private sector in efforts to advance seismic resilience;
5. Update Oregon's public policies, including (a) revising individual preparedness communications to specify preparation from the old standard of 72 hours to a minimum of two weeks, and possibly more; (b) developing a policy and standards for installation of temporary bridges following earthquake disruption; and (c) adopting a two-tiered ratings system that indicates the number of hours/days that a citizen in a community can expect to wait before major relief arrives, and the number of days/months that a citizen can expect to wait before the community itself achieves 90 percent restoration of roads and municipal services.

Acknowledgments

We would like to acknowledge our fellow OSSPAC Commissioners for their support, participation and contribution to the *Oregon Resilience Plan*. We are very grateful to members of the project Steering Committee and our Advisory Panel, who have offered their advice, counsel, and support at every stage of our work. We owe the creation of the *Oregon Resilience Plan* to diligent efforts by our eight Task Groups comprising of more than 150 professionals and the capable leadership and project management performed by our Task Group leaders: Ian Madin, Susan Steward, Gerry Williams, Jay Wilson, Jay Raskin, Ed Quesenberry, Trent Nagele, Bruce Johnson, JR Gonzalez, Stan Watters, Mike Mumaw, Mike Stuhr, and Mark Knudson. Finally, we want to express our gratitude to many other organizations and individuals for their support, including Degenkolb Engineers, the Port of Portland, and Cascadia Region Earthquake Workgroup (CREW).

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TAB 9

Final Discussion and Planning

TAB #9

Discussion and Planning

PANELISTS
Many

MODERATORS
Matt Francis, PE
Chris Poland, PE
Dr. Kent Yu, PE
Dr. Judith Mitrani-Reiser

The final panel consisting of many of the days panelists in addition to leaders from various professional organizations and from government will do more than just discuss the material covered during the day.

The panelists for this discussion were chosen because of their position within their organizations to lead change and help drive the resiliency efforts within the State of Utah.

The moderators for this panel are experts in the field of resiliency and their experience will help guide the panel to set goals and form alliances which will form a foundation upon which communities in the State can build.

FINAL DISCUSSION AND PLANNING

Mathew Francis, PE
Infrastructure Resilience Manager
AECOM

Mr. Francis manages the AECOM Southwest Area Water/Wastewater Department and Infrastructure Resilience Business Development, with 22 years' experience doing disaster risk reduction in over 20 nations focused on geotechnical design & construction of lifeline infrastructure and critical facilities, natural hazards risk assessments & climate adaptations. Expertise includes:

- Post-disaster investigations, geo-hazards characterization, Hazus loss modeling and exercises.
- Recovery planning guidance, policy development and building code performance evaluations
- Technology transfer of US hazards expertise and lifeline infrastructure resilience.
- Co-author of >30 publications including UN, USAID and FEMA funded recovery guidance for the Indian Ocean Tsunami, the Japan Tohoku Earthquake & Tsunami and Superstorm Sandy.

For USAID he is AECOM's program manager coordinating two global contracts Water Development IDIQ (WADI) and Making Cities Work (MCW). For FEMA he previously managed the $37M Technical Assistance Research Contract (TARC), leading Hurricane Sandy mitigation assessment studies and several flood insurance reform studies for Congress. Mr. Francis also managed two transportation research programs in freight and urban planning for infrastructure supply chain risk, resumption of trade and sustainable return on investment (SROI). Mathew chairs the Critical Facilities subcommittee of the ASCE Infrastructure Resilience Division and is a member of ISSMGE Asian Technical Committee-1 developing climate resilience for geo-disasters. He has BS and MS Degrees in Civil Engineering from BYU.

Final Discussion and Planning

Please use this page to write down your thoughts and commitments of what you can and will do to help make your home, family, neighborhood, city, county, and the State of Utah more resilient.

Earthquake Engineering Research Institute - Utah Chapter

Dedicated to reducing earthquake risk

utah.eeri.org

Earthquake Engineering Research Institute (EERI) is a national, nonprofit, technical society of engineers, geoscientists, architects, planners, public officials, and social scientists. EERI members include researchers, practicing professionals, educators, government officials, and building code regulators.

Our objective is to reduce earthquake risk by:

ADVANCING the science and practice of earthquake engineering,

IMPROVING understanding of the impact of earthquakes on the physical, social, economic, political, and cultural environment,

ADVOCATING comprehensive and realistic measures for reducing the harmful effects of earthquakes.

Our members are dedicated to reducing earthquake risk by promoting EERI's objectives locally and by serving as advocates for seismic safety through:

- Partnering with other organizations and agencies involved with seismic-risk issues
- Advocating for seismic safety at state & local government levels
- Promoting student chapters and activities
- Involving members through participation in committee work
- Increasing awareness through education & lecture opportunities
- Disseminating relevant seismic information through the *EERI Utah Chapter Newsletter*

Join the EERI Utah Chapter

Together, we can reduce the harmful effects of earthquakes in Utah.
We need your help. To join, go to http://utah.eeri.org
Register as a Regional Chapter Member only.
Our modest $25 dues are used to support our chapter meetings and other chapter activities.