



NATURAL HAZARDS MISSION AREA



SAFRR Project: Science Application for Risk Reduction

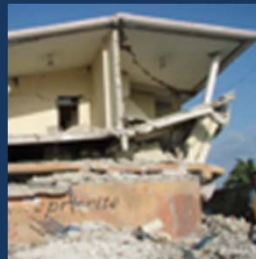
# ARkStorm, the Role of Atmospheric Rivers and Implications for Sacramento

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U. S. Geological Survey

Science Application for Risk Reduction (SAFRR) Project



Natural Hazards: Earthquake • Volcanic Eruption • Landslide • Flood • Geomagnetic Storm • Wildfire • Tsunami • Coastal Erosion

# USGS Mission



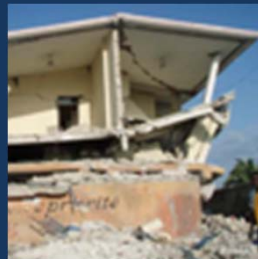
The USGS serves the Nation by providing reliable scientific information to describe and understand the Earth; **minimize loss of life and property from natural disasters**; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life.



Natural Hazards: Earthquake • Volcanic Eruption • Landslide • Flood • Geomagnetic Storm • Wildfire • Tsunami • Coastal Erosion

## SAFRR: Science Application for Risk Reduction

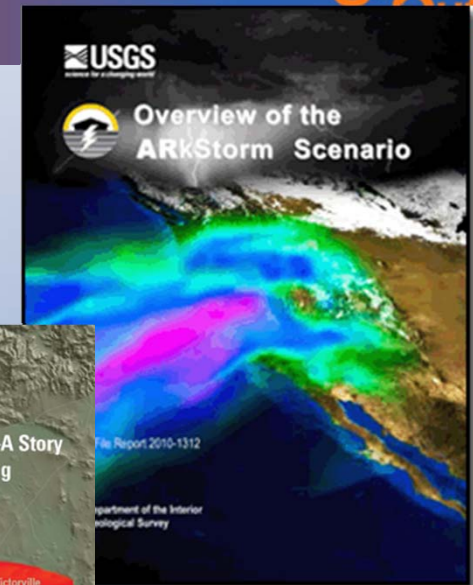
The mission of SAFRR is to **innovate the application of hazard science** for the safety, security, and economic well-being of the nation.



# Principles of a Scenario

1. A single, large but plausible event (realistic but not worst case)
2. An event we need to be ready for
3. Integrate across many disciplines
4. Consensus among leading experts
5. Create study together with community partners
6. Results presented in products that fit the user, not the scientist

...A tool to help visualize, plan, & prepare.





# The SAFRR Scenarios

Shake  
Out

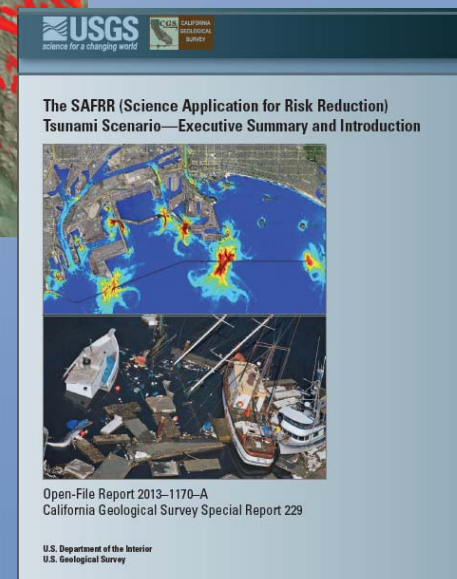
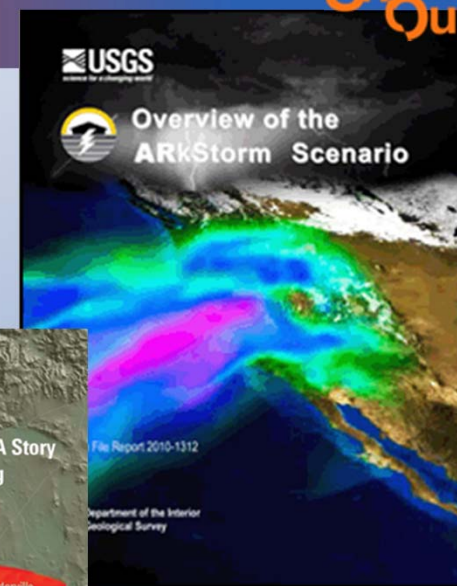
**ShakeOut:** San Andreas fault (southern California) earthquake scenario (2008)

**ARkStorm:** winter storm scenario impacting U.S. West Coast (2010)

**Tsunami Scenario:** tsunami generated by an Alaskan earthquake and impacting the U.S. West Coast (2013)

**HayWired:** Hayward fault (northern California) earthquake scenario (in progress)

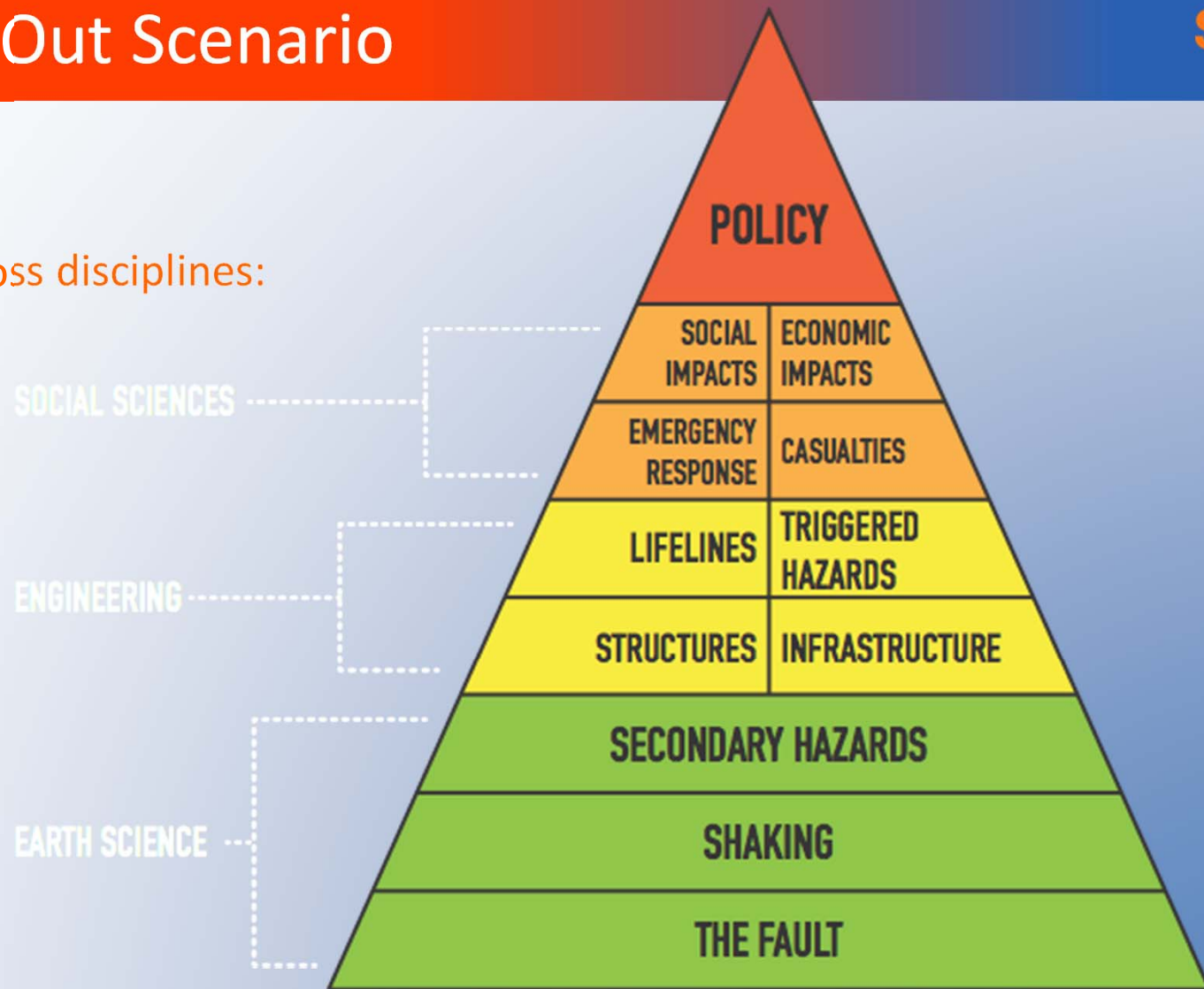
**Hawaii Tsunami Scenario:** tsunami scenario affecting Hawaii, Pacific islands, and the U.S. mainland (in initiation stage)



# The ShakeOut Scenario



Integrating across disciplines:

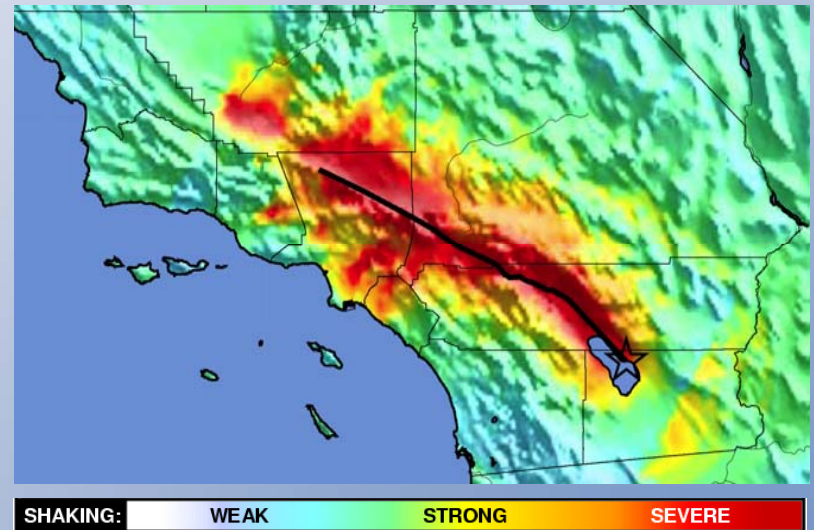


Building the ShakeOut Scenario

# The ShakeOut Scenario



- The possible “Big One:” an earthquake on the southernmost section of the San Andreas Fault
- SAFRR led a group of scientists, engineers, and others to create a realistic scenario of what could happen.
- 180 mile rupture
- Magnitude 7.8
- 100 seconds of fault rupture
- Shaking for over 2 minutes in many places



Full Report details

<http://pubs.usgs.gov/of/2008/1150/>

Resources: [www.shakeout.org](http://www.shakeout.org)



# ShakeOut Simulation: Los Angeles

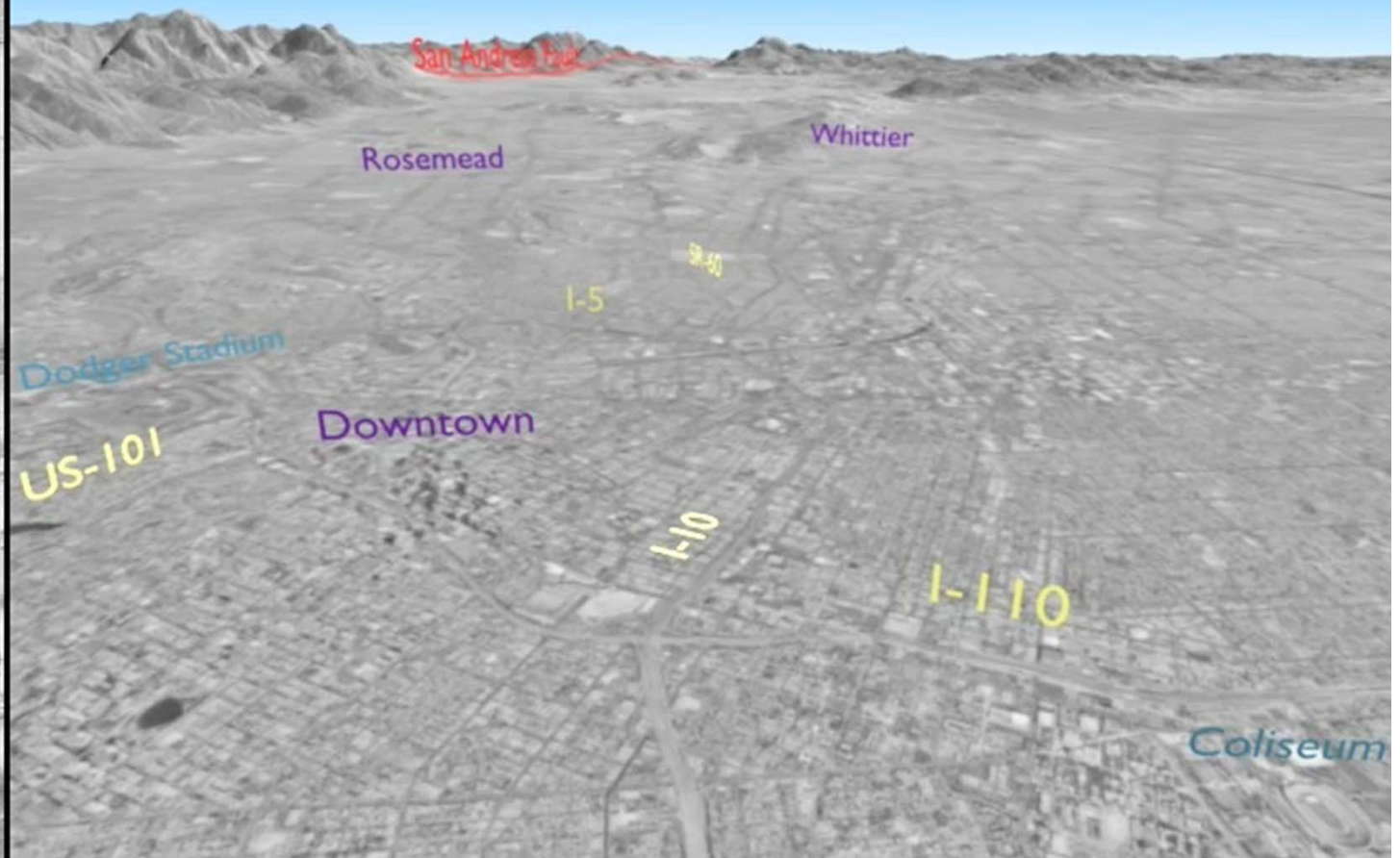
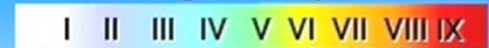


## M7.8 Scenario Earthquake

1000x exaggeration

Time = 000.0 s  
Los Angeles

Shaking Intensity (MMI)

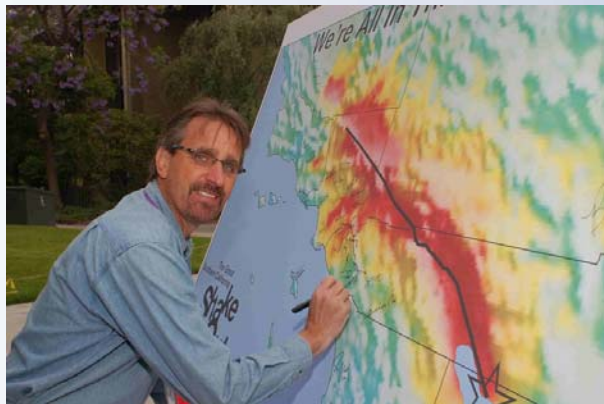




# “The Great ShakeOut”



- 45 million people worldwide participate in the ShakeOut Drill (see: <http://www.shakeout.org> )
- School, Business, & Community Organization recruitment efforts help “spread the word” and promote participation in the ShakeOut



- Helps shift the culture in southern California toward improved earthquake awareness:
  - We must all take greater responsibility for readiness
  - We all need to talk about earthquakes and preparedness more often
- Significant increase in earthquake readiness at all levels

# The ARkStorm Scenario

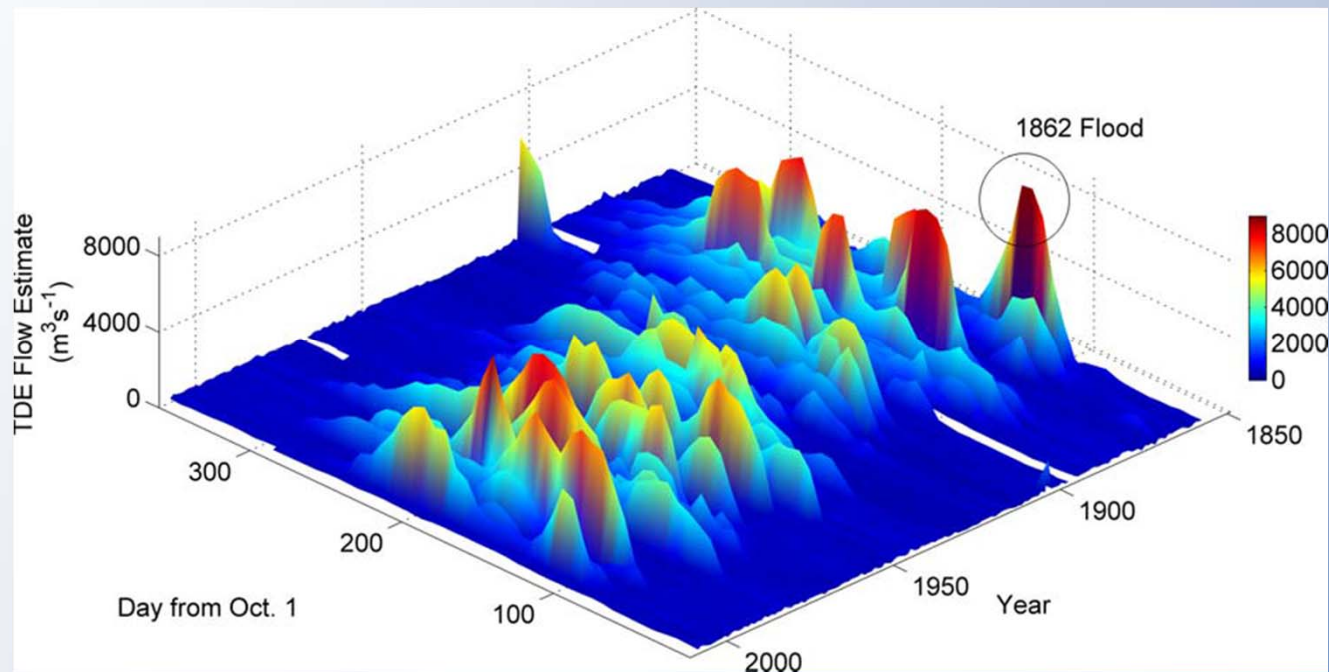
## Historical Floods: 1861 – 1862

- **Central Valley: flooding over about 300 miles long, 12 – 60 miles wide**
- **LA Basin: reported as “generally inundated”**
- **San Gabriel & San Diego Rivers: cut new paths to sea**
- **Agua Mansa: the largest community between Los Angeles and New Mexico – obliterated.**
- **Two Storms: 12 days separated the flood crest in Sacramento from the crest in Los Angeles.**



# The ARkStorm Scenario

## Historical Floods: 1861 – 1862



**The 1862 flood is the largest flow event of the last 150 years....about 25% larger than the 1997 flood.**

*Moftakhari, H. R., D. A. Jay, S. A. Talke, T. Kukulka, and P. D. Bromirski (2013), A novel approach to flow estimation in tidal rivers, Water Resour. Res., 49, 4817–4832, doi:10.1002/wrcr.20363.*



# The ARkStorm Scenario



## Prehistoric Megafloods

**Revised dating of the laminated sediment in the Santa Barbara Basin (SBB) by Arndt Schimmelman et al. (2013) indicates the occurrence of megafloods around BC 107, AD 53, AD 263, AD 735, AD 1269 and AD 1532.**

**“Exceptionally large regional flood events in the SBB area have occurred every few hundred years in prehistoric times.”**

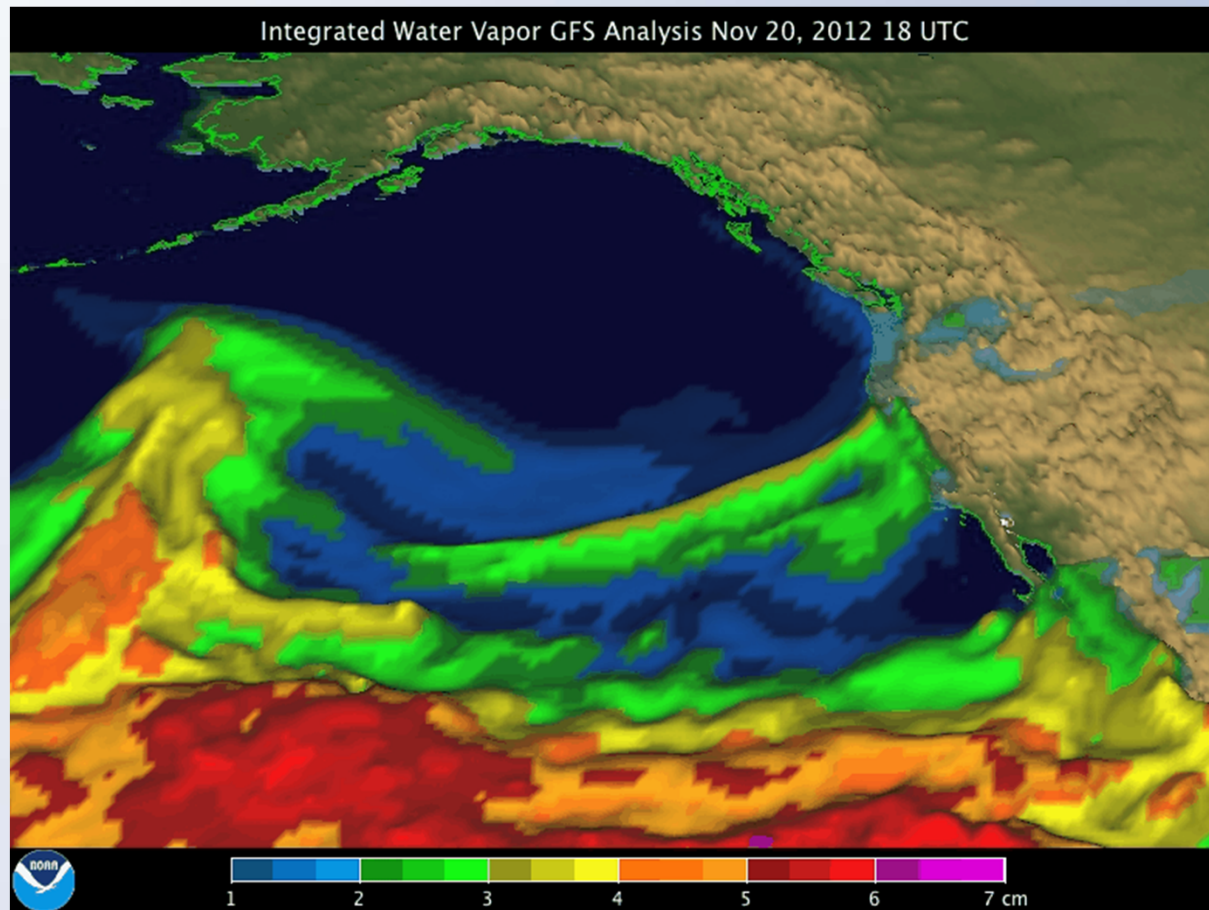
**“The past rate of recurrence makes severe flooding in the future a likely possibility, especially in a warming global climate.”**

**Schimmelman, A., Hendy, I.L., Dunn, L., Pak, D.K. & Lange, C.B., 2013: Revised , ~2000-year chronostratigraphy of partially varved marine sediment in Santa Barbara Basin, California. GFF, 2013**



# The ARkStorm Scenario

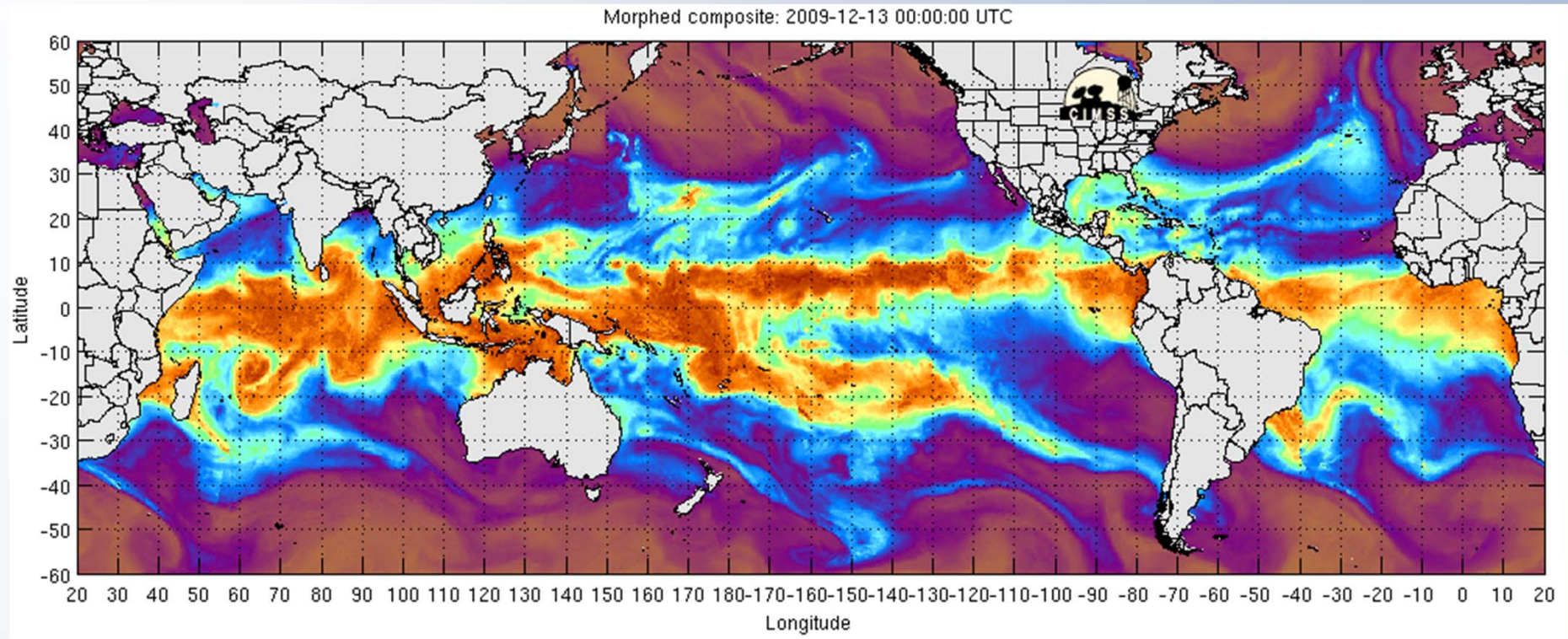
Atmospheric River = AR



ARkStorm = Atmospheric River (AR) 1,000 (k)

# The ARkStorm Scenario

Atmospheric River = AR



ARkStorm = Atmospheric River (AR) 1,000 (k)



# The ARkStorm Scenario

**October 1968**

S	M	T	W	T	F	S
		1	2	3	4	5

**November 1968**

S	M	T	W	T	F	S
6						
13						
20					1	2

**December 1968**

S	M	T	W	T	F	S
3						
10						
17	1	2	3	4	5	6
24	7					

**January 1969**

S	M	T	W	T	F	S
8						
15			1	2	3	4
22						
29	5	6	7	8	9	10
	11	12	13	14	15	16
	17	18	19	20	21	22
	23	24	25	26	27	28
	29	30	31			

**January 1969**

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

+ Extra 25

*Southern California Phase*

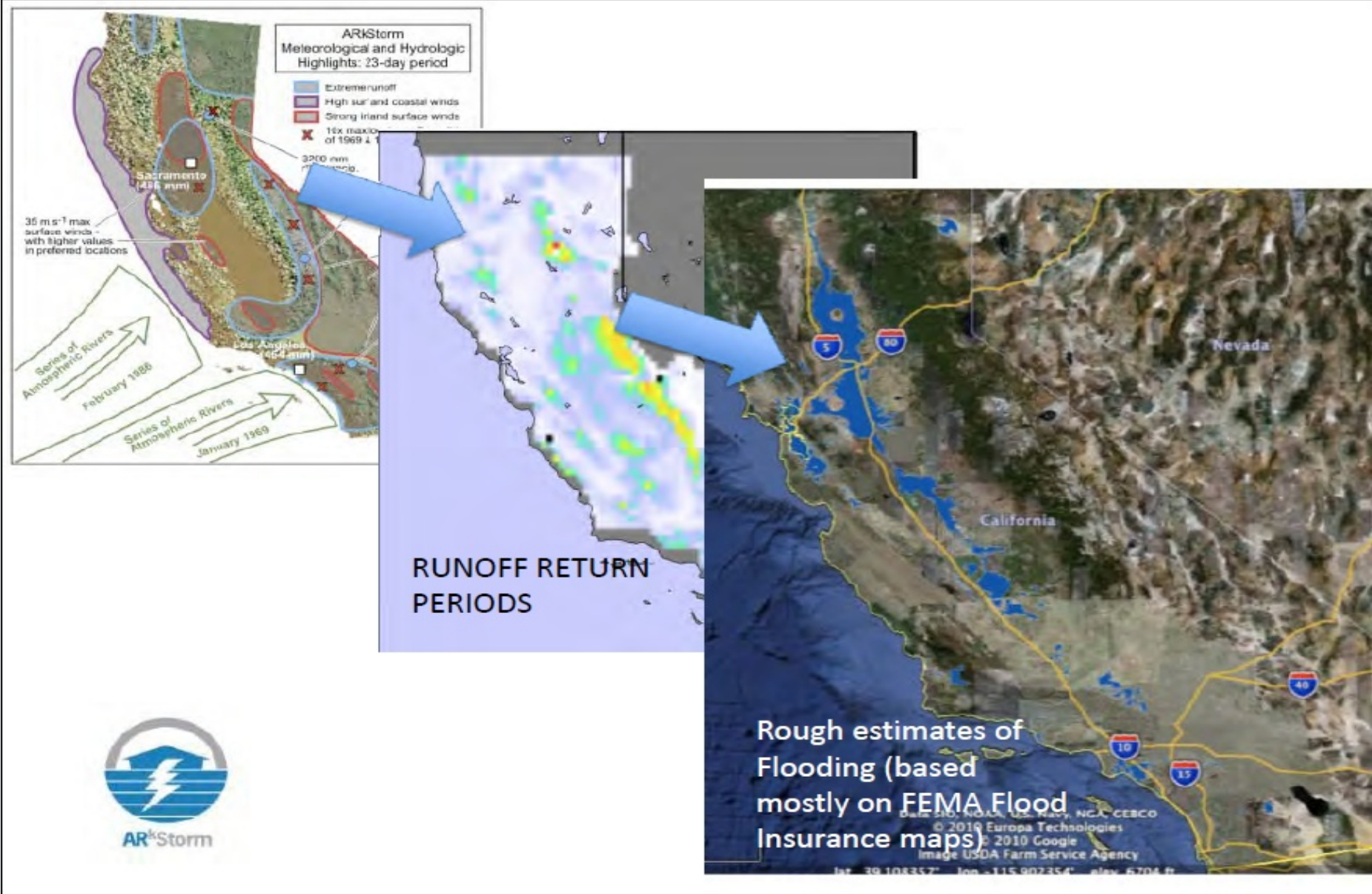
**February 1986**

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	

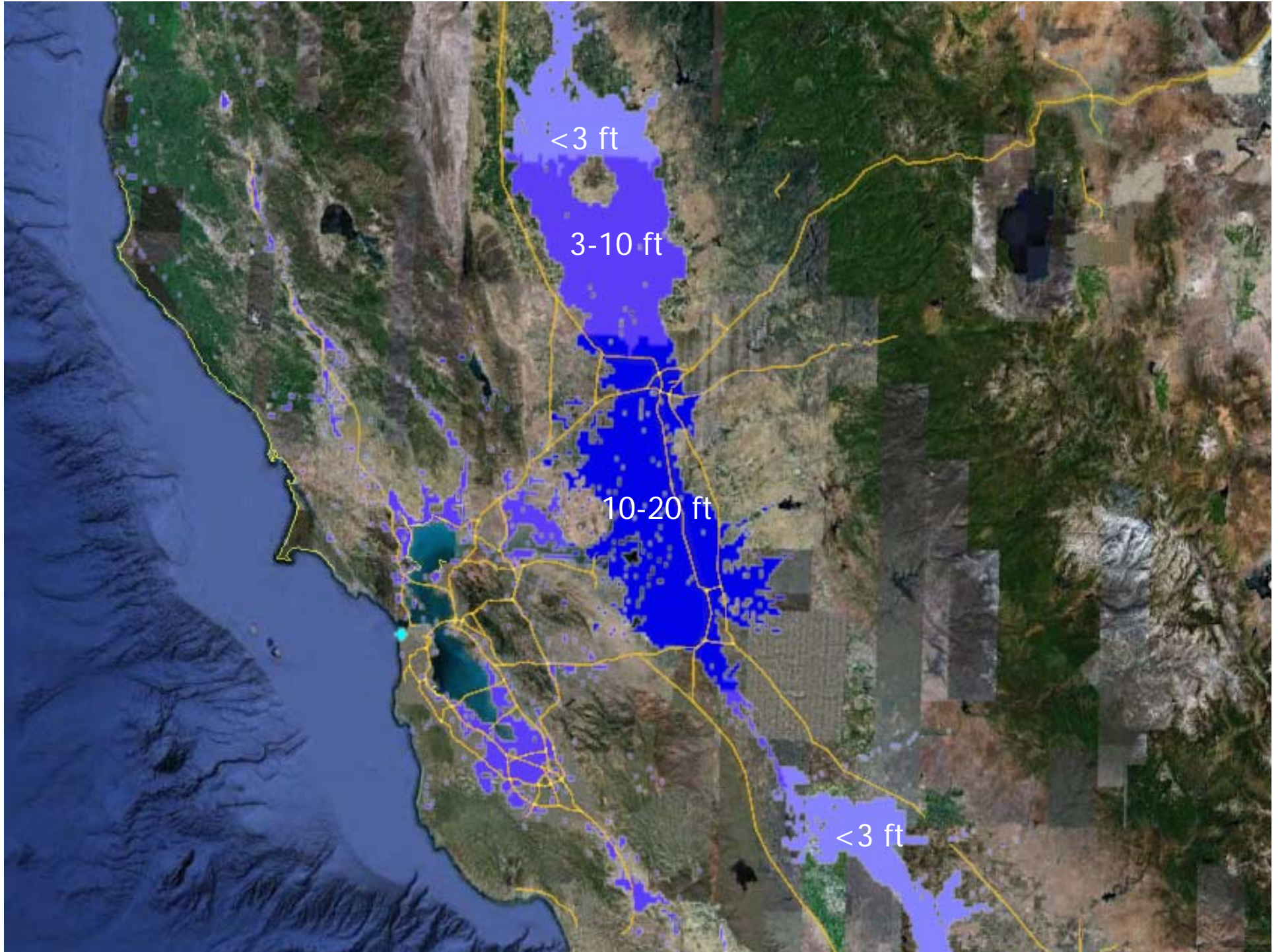
*Northern California Phase*



# The ARkStorm Scenario

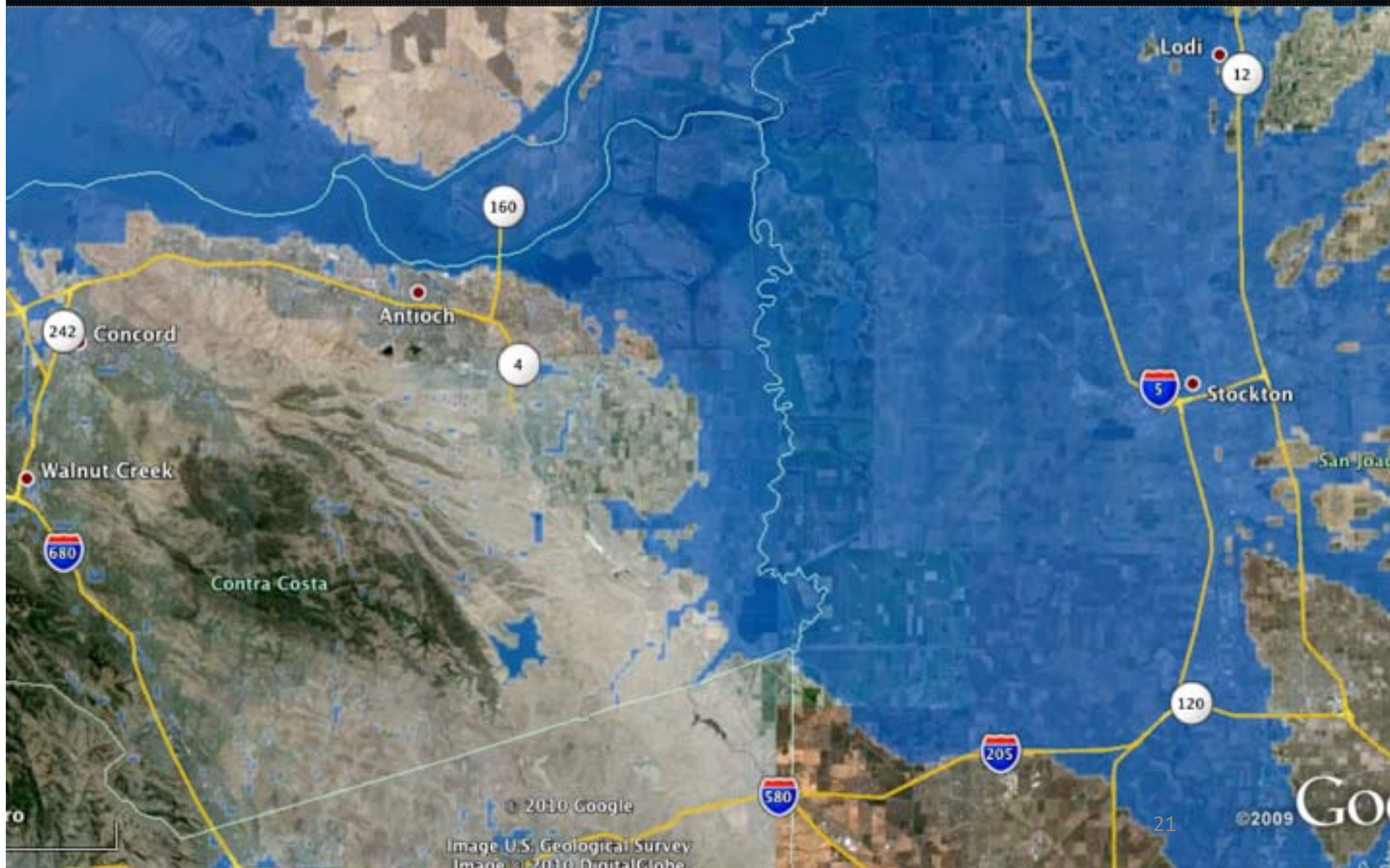








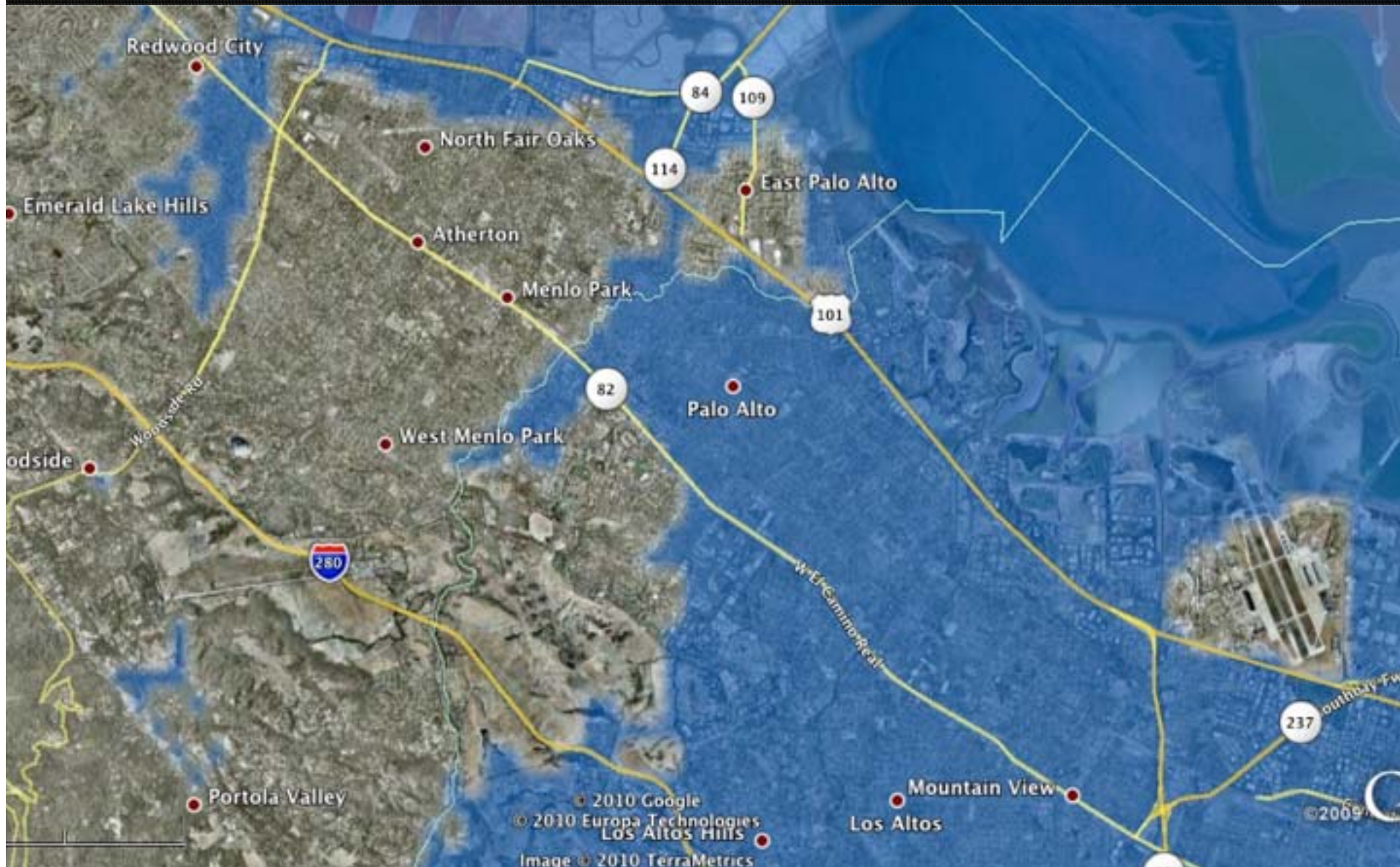
# EXERCISE FLOOD MAP: DELTA





Greco Island

# EXERCISE FLOOD MAP: SOUTH BAY





# EXERCISE FLOOD MAP: SACRAMENTO



‘I don't have enough boats,’ Marc Bentovoja,  
Battalion Chief, Sacramento Urban Search and  
Rescue



# The ARkStorm Scenario

**Flood Protection System:** Extensive flooding overwhelms the state's flood-protection system, designed to resist 100- to 200-year runoffs.

**Flooding:** The Central Valley experiences hypothetical flooding 300 miles long and 20 or more miles wide. Depths in some areas could reach 10-20 feet.

**Wind:** Wind speeds in some places reach 125 miles per hour, hurricane-force winds. Across wider areas of the state, winds reach 60 miles per hour.

**Landslides:** Hundreds of landslides damage roads, highways, and homes.



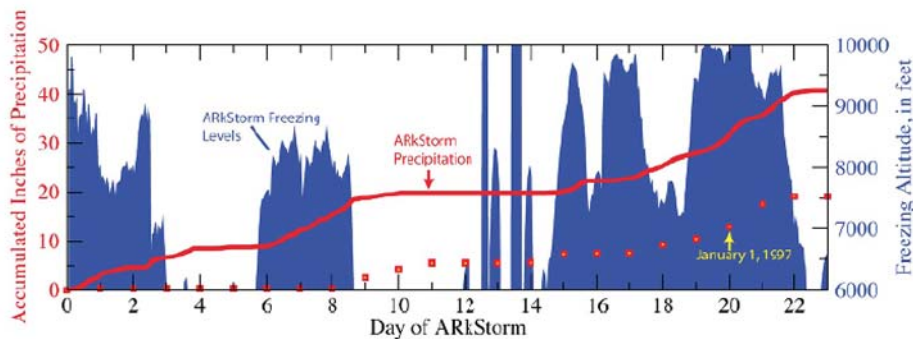
Figure 8. Blue areas indicate ARkStorm flooding as projected by models used in the scenario.

# The ARkStorm Scenario



- **Property Damage:** Exceeds \$300 billion, most from flooding.
- **Demand Surge:** Labor rates and repair costs could increase property losses by 20 percent.
- **Damage and Losses:** Agricultural losses and costs to repair lifelines, drain flooded islands, and repair damage from landslides brings total to \$400 billion.
- **Lifeline Damage:** Power, water, sewer, and other lifelines experience damage that takes weeks or months to restore.
- **Business Interruption:** Costs reach \$325 billion in addition to the earlier \$400 billion.
- **Total:** ARkStorm could cost on the order of \$725 billion, which is nearly three times the loss deemed to be realistic by the ShakeOut authors.

# Getting Local with Scenarios



## ARkStorm@Tahoe

Stakeholder perspectives on vulnerabilities and preparedness for an extreme storm event in the greater Lake Tahoe, Reno and Carson City region

- Christine M. Albano, University of California, Davis
- Dale A. Cox, Science Application for Risk Reduction, U.S. Geological Survey
- Michael D. Dettinger, National Research Program, U.S. Geological Survey and Scripps Institution of Oceanography
- Kevin D. Schaller, University of Nevada, Reno
- Toby L. Welborn, Nevada Water Science Center, U.S. Geological Survey
- Maureen I. McCarthy, Tahoe Science Consortium and University of Nevada, Reno



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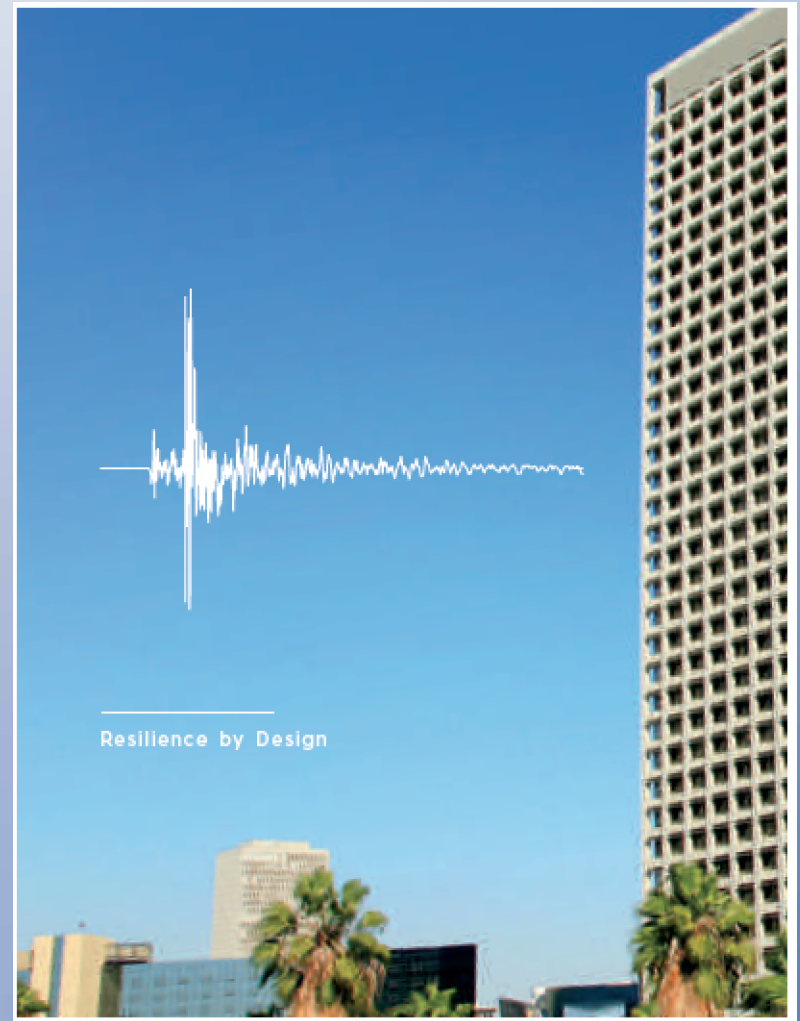
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A partnership of Nevada counties; University of Nevada, Reno; and U.S. Department of Agriculture



# Getting Local with Scenarios

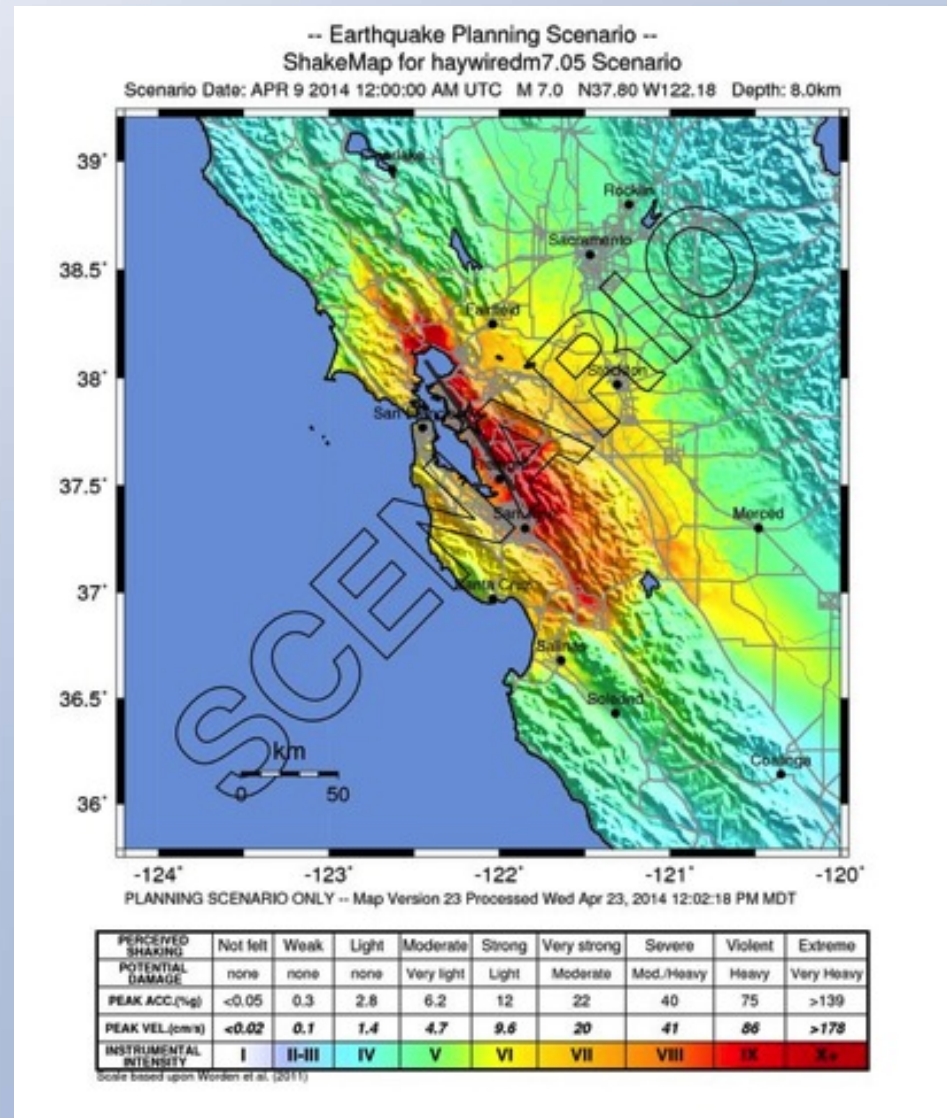
- The Los Angeles Mayoral Seismic Task Force used ShakeOut to evaluate and address four areas of seismic vulnerability, namely:
  - Pre-1980 “non-ductile reinforced concrete” buildings
  - Pre-1980 “soft-first-story” buildings
  - Water system infrastructure (including impact on firefighting capability)
  - Telecommunication infrastructure



# HayWired Scenario (In Progress)



- M7.05 on Hayward Fault
- Parallel with FEMA/CalOES Planning
- Examination of vulnerable lifeline interactions
  - Water
  - Electric
  - Gas
  - Telecommunications
  - Roads
  - Special Focus: Internet and Internet Economy, Outmigration



# Southwest Climate Extremes Scenario

- Create scientifically plausible meteorological and hydrological drought scenarios to examine how water supply is stressed in the Southwest.
- Assess how cascading impacts, like forest fires, landslides, and more extreme storms, might play out in non-water-supply sectors.
- Assess how they could effect resilience to other natural hazards like earthquakes.
- Inform federal, state and local climate adaptation strategies, plans and exercises.





# Questions?



The poster is titled "ARstorm" and features a circular logo with a lightning bolt and a grid pattern. It is divided into three main sections: "WHAT TO GET", "WHAT TO DO", and "WHERE TO GO". The "WHAT TO GET" section lists three items: 1. One gallon of water per person per day, for at least 7 days, for drinking and sanitation. 2. At least a seven-day supply of non-perishable food. 3. Fuel for an air conditioner. The "WHAT TO DO" section lists three actions: 1. Listen to radio warnings and news officials. 2. Follow all shutdown signs and orders. 3. Check information for services. The "WHERE TO GO" section includes a map of a city area with a red box highlighting a "Mandatory evacuation area".

**ARstorm**

**WHAT TO GET**

- 1 One gallon of water per person per day, for at least 7 days, for drinking and sanitation.
- 2 At least a seven-day supply of non-perishable food.
- 3 Fuel for an air conditioner.

**WHAT TO DO**

- 1 Listen to radio warnings and news officials.
- 2 Follow all shutdown signs and orders.
- 3 Check information for services.

**WHERE TO GO**

Mandatory evacuation area

For more information visit us at: [www.usgs.gov](http://www.usgs.gov)

Dale A. Cox, [dacox@usgs.gov](mailto:dacox@usgs.gov)

# Questions?



- Resources (scenarios, videos, reports):  
[http://www.usgs.gov/natural\\_hazards/safrr/](http://www.usgs.gov/natural_hazards/safrr/)
- Contact: [safrr@usgs.gov](mailto:safrr@usgs.gov)



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Change  
Core Science Systems  
Ecosystems



## SAFRR - Science Application for Risk Reduction

Modern Americans are more at risk from natural hazards today than at any other time in our nation's history, due especially to our increasing reliance on technology and communications and the strong interdependencies of both. Expected losses from Natural Hazards in the US exceed \$3 billion per year. These losses are most

### SAFRR News



[SAFRR Newsletter -  
Spring/Summer 2014](#)