



City of Seattle
URM Building
Policy Committee

October 31, 2008

**Seattle Fault
Earthquake Scenario**

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Notable Earthquakes


Seattle Fault Earthquake Scenario

NIGHT SPORTS EXTRA
EARTHQUAKE LISTED AS MAJOR;
5 DEAD; DAMAGE IN MILLIONS
Wide Northwest Area Feels Tremor's Force
ROCKS BLANE CUT OFF HARBOR ISLAND WATER

The Seattle Times
Biggest quake in 30 years


QUAKE HITS SEATTLE
City Lists 2 Dead, Damage
Widespread, Mostly Minor

Seattle Post-Intelligencer
6.8 SHOCKER



Scenario Project Overview

- Project First Conceived in 1996
- Project Published Document in 2005
- Builds Upon Previous Work and Current Research
- Multidisciplinary Project Team:
 - Seismologists and Geologists
 - Geotechnical, Civil, and Structural Engineers
 - Land Use Planners
 - Emergency Managers
 - Economists and Social Scientists
- Collaborative Public-Private Effort:
 - SEAW, ASCE, CREW, EERI, USGS, UW
 - Seattle and Bellevue DEM
 - Washington State DEM
- Over 4000 Volunteer Hours!
- Report PDF Available Free at www.eeri.org





Scenario Purpose

- Intent of the Scenario Study is to:
 - Increase awareness of a real threat
 - Start (or continue) a conversation
 - Have some public policy debate
 - Increase our region’s preparedness
- Develop recommendations for effective actions to reduce regional earthquake risk



The Study Area

King, Pierce, Snohomish Counties

- More than half state’s population.
 - Six of the 10 largest cities in state.
- Cornerstone of state’s economy.
 - King County alone has 44 percent all jobs statewide.
 - Employers: Boeing, Microsoft, Starbucks, Alaska Air Group, UW, Military.
 - WA is fifth largest exporter in nation.
 - Ports of Seattle, Tacoma handle \$52 billion waterborne international freight annually.



Key Learned Project Points

- Great Urban Earthquake (similar to Kobe)
- High PGA Near Fault, 4x Nisqually
- Enhanced Damage in Lowland Areas (most of Waterfront, South Seattle, and Kent Valley)
- Renton Lifeline Cluster Near Fault Zone
- Interdependent Transportation Network
- Only 30% King Co. Hospital Beds Available 3-Days After E.Q.
- Scenario Planning => Expanded Thinking
- Order of Magnitude Cost Impacts grow 1949 > 2001 > Scenario E.Q.
- Multi-disciplinary tool to explain regional risk in terms of 3D’s to elected officials and policy makers
- Call to Action Can Guide Future Risk Reduction Efforts



Scenario Earthquake Losses

Magnitude 6.7, 14 mi fault rupture

- Damage, economic loss: \$33 billion.
- Casualties: 1,600 deaths, 24,000 injured.
- Buildings destroyed: 9,700.
- Buildings unsafe to occupy: > 29,000.
- Moderately damaged buildings, use restricted: > 154,500.
- Fires: 130
- Recovery period: Several years.



Earthquake Loss Comparisons

Earthquake	Damages	Economic Losses*
M6.7 Seattle Fault Scenario (Shallow quake, with fault rupture at surface in Bellevue, WA)	1,600 deaths, 24,000 injured, 9,700 buildings destroyed, 29,000 buildings severely damaged, 154,000 buildings moderately damaged, 130 fires.	\$33 billion
M6.8 Nisqually Earthquake (2001, Deep quake at 36 miles depth, NE of Olympia, WA)	One death, 320 injured, 25 red tagged buildings in Seattle, 400 yellow tagged, additional damages in Olympia.	\$2 - \$4 billion
M6.9 Kobe Earthquake (1995, Shallow quake at 8.7 miles depth fault ruptured into downtown Kobe, Japan)	6,300 deaths, 40,000 injured, 300,000 people homeless, 102,000 buildings 300 fires burned 7,000 buildings.	Up to \$200 billion
M6.6 Northridge Earthquake (1994, Shallow quake at 10.3 miles depth, beneath San Fernando Valley, NW of Los Angeles, CA)	57 deaths, 9,000 injured, 22,000 people homeless, 7,000 buildings severely damaged (red tagged), 22,000 moderate damage (yellow tag), 9 hospitals closed.	\$40 billion
M6.9 Loma Prieta Earthquake (1989, Shallow quake at 10.5 miles depth, NW of Santa Cruz, CA)	62 deaths, 3,000 injured, 12,000 people homeless, 18,300 homes and 97 business destroyed, 1-880 collapsed, 27 fires burned.	\$9 - \$15 billion
M6.8 Olympia Earthquake (1949, Deep quake at 33.5 miles depth, NE of Olympia, WA)	8 deaths, state capitol campus badly damaged, 40% of Chehalis damaged.	\$0.2 billion

* Rounded to the nearest billion and adjusted to 2004 dollars.



Public Perceptions

Two post-Nisqually EQ studies:

- Small Business:
 - 20% physical loss, 60% lost productivity.
 - Only 1 in 3 increased preparedness afterward.
- Households:
 - Before – less than half took steps to prepare.
 - 300,000 damaged by EQ.
 - 1 in 4 experienced loss, averaging \$622 to \$1,350.
 - Only 1 in 5 increased preparedness afterward.
- Perceptions:
 - We faced the “big one” and it wasn’t so bad...

Seattle Fault Earthquake Scenario

Seattle Best Design

STRUCTURAL DESIGN AND SEISMIC PERFORMANCE

Experts believe that the Pacific Northwest will likely experience a significant earthquake much sooner than the next 100 years. Seattle buildings will be expected to perform well in the moderate ground shaking that will occur. However, there will be a significant risk of structural failure in some buildings.

STRUCTURAL PROBLEM AREAS

- Soft-story or weak-story design:** Buildings with a soft or weak story are more likely to suffer structural damage during an earthquake.
- Irregular layout or shape:** Buildings with an irregular layout or shape are more likely to suffer structural damage during an earthquake.
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SEISMIC FORCE RESISTANCE

Buildings with a high level of seismic force resistance are more likely to perform well during an earthquake. Buildings with a low level of seismic force resistance are more likely to suffer structural damage during an earthquake.

STEEL FRAME STRUCTURES

Buildings with a steel frame structure are more likely to perform well during an earthquake. Buildings with a non-steel frame structure are more likely to suffer structural damage during an earthquake.

Seattle Fault Earthquake Scenario

Ground Motions and Soil Effects

Seattle Hazard Maps

From 2002 USGS National Seismic Hazard Map

PGA (%g) with 2% Prob. Of Exceedance in 50 Years

USGS



Photo Courtesy Reid Middleton, Inc.

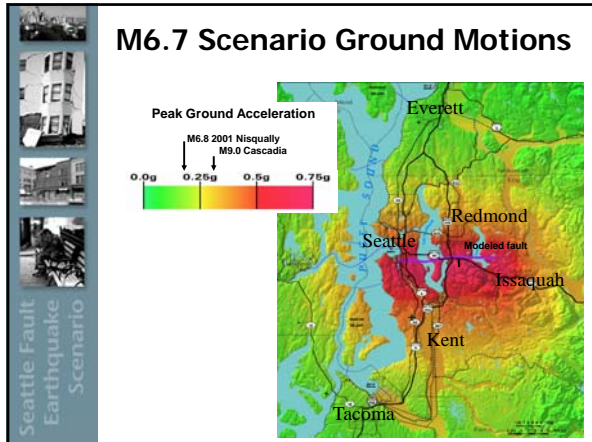


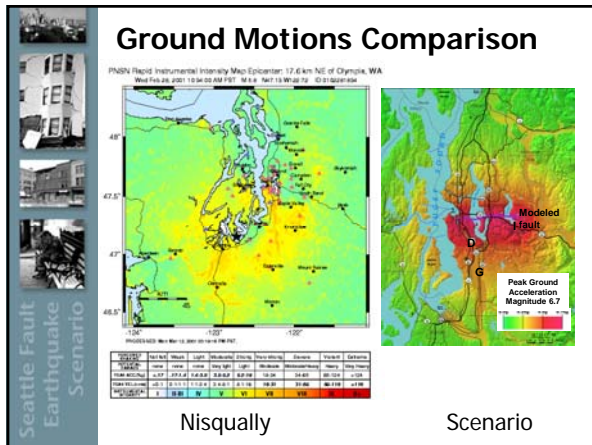
Photo Courtesy Reid Middleton, Inc.

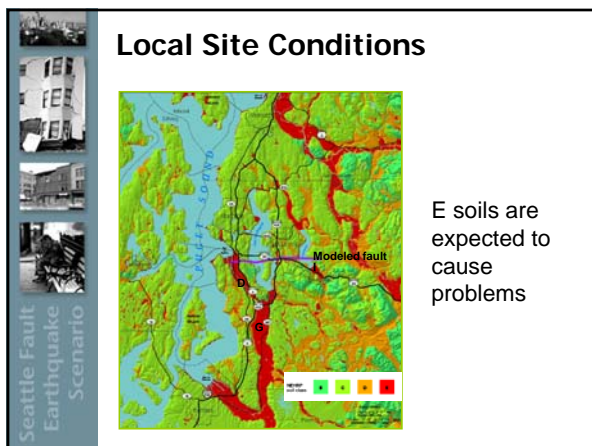
Seattle Fault Earthquake Scenario

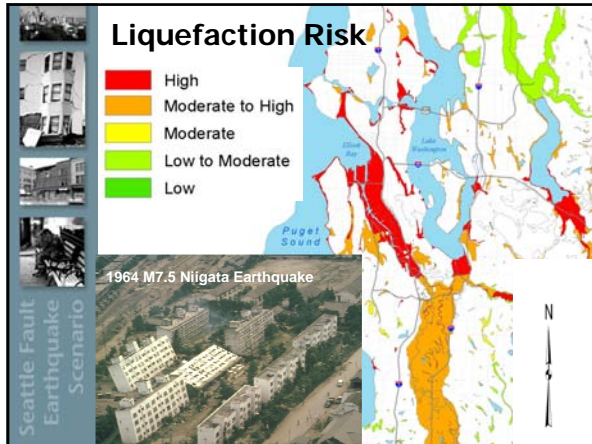
Scenario Earthquake Faulting Parameters

- Magnitude 6.7
- Surface rupture = 6 feet (matches trench)
- Located at frontal fault
- Four segments, about 16 miles length
- 9 miles deep fault
- 45° from surface
- Breaks from depth up









Buildings and Critical Facilities

Seattle Fault Earthquake Scenario

- ## Scenario Damage Estimates
- Very strong ground motions near the fault
 - 4,000 (27%) commercial structures with significant damage:
 - Unreinforced masonry (URM's)
 - Reinforced concrete Tilt-ups
 - Pre 1970-vintage reinforced concrete frame buildings
 - Significant damage to structures founded on poorly consolidated soils
 - 46,000+ households displaced
 - Long-term impact on industry and economy
- Seattle Fault Earthquake Scenario










Seattle Fault Earthquake Scenario

Building Performance Summary

- Scenario ground motions would be significantly greater than in recent local earthquakes.
- Modern structures would survive with varying degrees of damage.
- Many older existing structures would experience significant damage with some collapses.
- Building owners should assess potential risks and make practical improvements.

Seattle Fault Earthquake Scenario

Overview of Schools



- Over 1,200 schools and campuses in region
- Wide range of construction materials and age
- Some level of upgrade completed but not well documented as a region



School Damage Projections

Table 6-3: Expected Damage to Schools

County	Damage (in percent)				
	No Damage	Slight	Moderate	Extensive	Complete
King County	23%	22%	29%	18%	8%
Pierce	64%	18%	12%	5%	1%
Snohomish	64%	14%	9%	3%	10%
Total Region	38%	20%	22%	13%	7%



What Do We Do Now?

- Intent of the Scenario Study is to:
 - Increase awareness of a real threat
 - Start (or continue) a conversation
 - Have some public policy debate
 - Increase our region's preparedness
- 9 Overall Recommendations
 - 4 Priority Recommendations
 - 5 Additional Recommendations



3 - Implement Mandatory Seismic Retrofit of High Risk Buildings

- Develop local and state funding and legislation for mandatory seismic retrofit of high risk buildings.
- Buildings with known seismic hazards are older unreinforced masonry (URM) and tilt-up concrete buildings.
- Over 2200 URM buildings identified in the King, Pierce, and Snohomish County study region.
- Establish long-range plans to improve their seismic safety.
- Similar to URM Loss Reduction Programs in other Cities/States.



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