FEMA Hazus-MH

Catastrophic Planning – NLE 2011

Scenario Modeling for the New Madrid Seismic Zone

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NMSZ Scenario Modeling Timeline

- **2005:** Hazus scenario modeling with CUSEC
- **2006-2008**: Catastrophic Planning Project, Phase I
  - Funded by FEMA. Partnership between FEMA, CUSEC, IEM, GWU, VT, Sandia and the MAE Center
- **2008-2009**: Catastrophic Planning Project, Phase II
  - Funded by FEMA. Partnership between FEMA, CUSEC, IEM, GWU, VT, Argonne and the MAE Center
  - Analysis used new hazard and soil info, improved inventory, and latest analytical fragilities
- **2010-2011**: NLE 2011
  - Based on the Phase II Hazus Study Regions, ground truthing based on SW segment scenario
- **2012**: EERI Scenario Project

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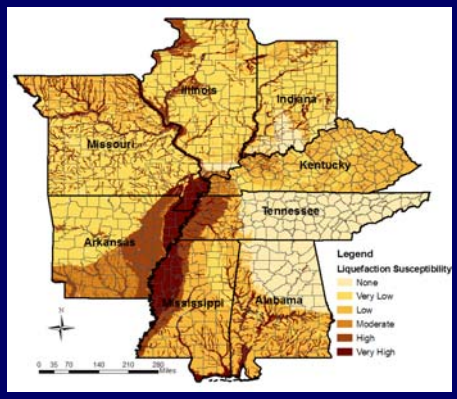
Hazard Improvements

- **Ground Shaking**
  - Comprehensive soil class maps were developed by the CUSEC State Geologists
  - New soil amplification data for entire region developed based on systematic procedure
- **Ground Deformation**
  - New liquefaction susceptibility map for entire region
  - Developed with consistent procedure the 8 State Geologists

Liquefaction Map



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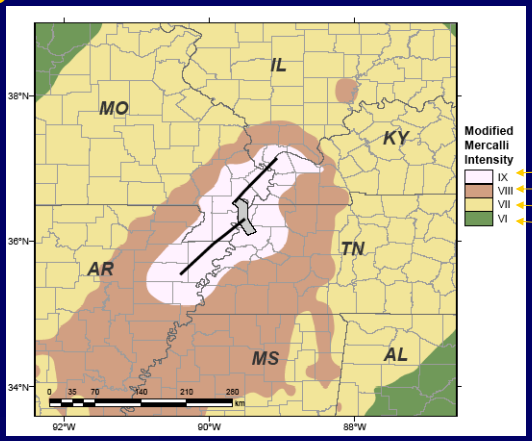
Cat Plan Scenario: Assume one M 7.7; everywhere gets shaking as if closest segment broke



- Heavy damage
- Mod/Heavy damage
- Moderate damage
- Light damage

Represents several months of historic ground motion
Modeling limitation for aftershocks or triggered events

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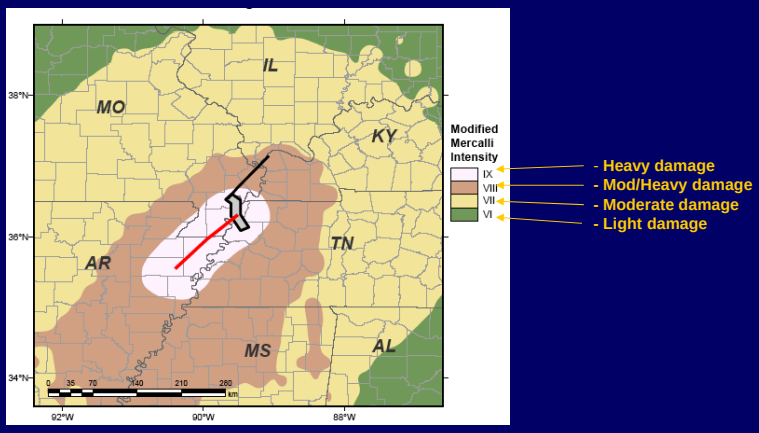
NLE 2011 Scenario-72 Hours



Scenario Intensity Map: M 7.7 Southwest Segment

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Inventory Additions -1

- Baseline data provided by HAZUS Program
- Additional sources of inventory
  - HSIP 2007 upgraded to 2008
  - POLIS Center (Indiana only)
  - National Bridge Inventory (NBI) 2008
  - MAE Center Project (Illinois essential facilities only)
  - MAE Center independent search of various sources - Major River Crossings
  - US Army Corp. - Levees

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Inventory Additions -2

- Total inventory for 8 states:
  - Default: 185,000 facilities
  - Updated: 604,000 facilities
- Additional 419,000 facilities when all updated inventory is incorporated
- Significant specific improvements to facilities:
  - Communication: +142,600
  - Oil: +89,500
  - Natural Gas: +33,900
  - Highway Bridges: +61,700
  - Waste Water: +43,900
  - Hazmat: +19,800
  - Electric Power: +10,300

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Infrastructure Category	MR2 Default Inventory Total	Regional Modeling Inventory Total	Additional Infrastructure from Default Case
Essential Facilities			
Hospitals	1,074	2,825	1,751
Schools	18,455	20,291	1,836
Fire Stations	5,032	10,346	5,314
Police Stations	3,982	4,480	498
Emergency Operation Centers	353	1,182	829
Essential Facilties Total	**28,896**	**39,124**	**10,228**
Transportation Facilities			
Highway Bridges	104,048	165,771	61,723
Highway Tunnels	11	11	0
Railway Bridges	1,663	1,888	225
Railway Facilities	990	1,118	128
Railway Tunnel	2	72	70
Bus Facilities	310	405	95
Port Facilities	1,738	1,904	166
Ferry Facilities	6	52	46
Airports	2,435	3,773	1,338
Light Rail Facilities	0	537	537
Light Rail Bridges	38	38	0
Transportation Facilities Total	**111,241**	**175,569**	**64,328**
Utility Facilities			
Communication Facilities	3,160	145,722	142,562
Electric Power Facilities	554	10,893	10,339
Natural Gas Facilities	464	34,339	33,875
Oil Facilities	138	89,621	89,483
Potable Water Facilities	918	1,195	277
Waste Water Facilities	4,518	48,430	43,912
Utility Facilities Total	**9,752**	**330,200**	**320,448**
High Potential-Loss Facilities			
Dams	15,098	17,573	2,475
Hazardous Materials Facilities	20,153	39,939	19,786
Levees	0	1,326	1,326
Nuclear Power Facilities	15	25	10
High Potential-Loss Facilities Total	**35,266**	**58,863**	**23,597**
Total Number of Facilities	**185,155**	**603,756**	**418,601**

Fragility Improvements -1

- **New building fragilities**
  - **HAZUS-Compatible**
  - **Uses the earthquake records generated by Rix and co at Georgia Tech for the region**
- **New bridge fragilities**
  - **Bridge types common to the CEUS**
  - **Based on detailed analytical simulation**
  - **Accepted as US standard and used in REDARS, FHWA impact software**

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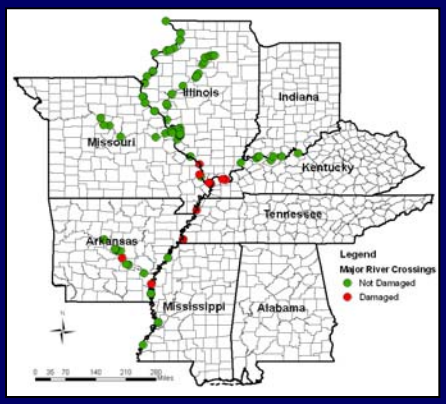
Fragility Improvements -2

- New Pass-Fail values
  - Dams
  - Levees
  - 127 Major river crossings
  - Hazmat Facilities
- Developed via literature search
- Designed to provide likely levels of damage

Damage Level	Slight	Moderate	Extensive	Complete
Cable Stayed	-	0.15g	-	-
MSC Steel Truss	0.18g	0.31g	0.39g	0.50g
MSSS Concrete Girder	0.28g	0.61g	0.73g	1.00g



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General Buildings

- Building damage based on construction materials
  - Over 80% of regions buildings are wood
  - 15% unreinforced masonry (450,000, >70% of severe casualties)

State	Total Buildings	Buildings Damaged	URM Damage	Wood Damage
Alabama	1,758,300	15,400	400	3,000
Arkansas	1,325,400	162,200	29,100	68,800
Illinois	3,655,800	44,500	10,100	17,700
Indiana	2,202,000	14,200	2,600	4,800
Kentucky	1,543,900	68,400	9,400	36,100
Mississippi	1,064,000	57,400	5,000	19,900
Missouri	2,101,800	86,800	26,800	40,200
Tennessee	2,126,600	264,200	48,900	163,600
Total	15,777,800	713,100	132,300	354,100

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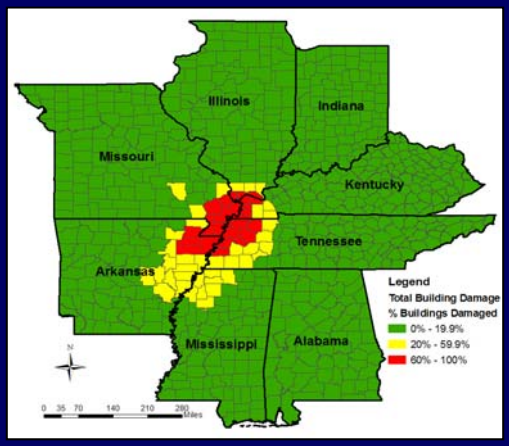
General Buildings

- Roughly 25 counties are catastrophically damaged, meaning more than 60% of all buildings are damaged (colored red)
- Additionally, almost 40 counties incur substantial damage with 20% to 60% of all buildings damaged (colored yellow)



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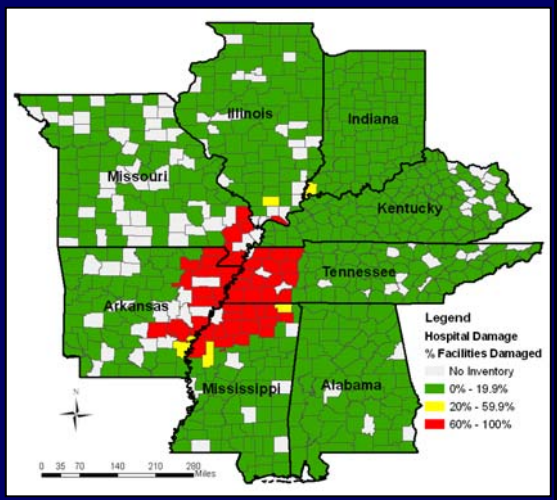
Essential Facilities

Hospitals	Total	Damaged
Alabama	210	0
Arkansas	125	24
Illinois	413	7
Indiana	1,285	5
Kentucky	189	9
Mississippi	163	23
Missouri	208	7
Tennessee	232	54
TOTAL	2,825	129

Schools	Total	Damaged
Alabama	1,903	0
Arkansas	1,328	219
Illinois	5,795	114
Indiana	2,874	6
Kentucky	1,871	99
Mississippi	1,297	140
Missouri	2,871	136
Tennessee	2,352	608
TOTAL	20,291	1,322

Fire Stations	Total	Damaged
Alabama	1,388	0
Arkansas	1,330	179
Illinois	1,822	60
Indiana	1,247	4
Kentucky	1,066	71
Mississippi	984	104
Missouri	1,399	69
Tennessee	1,110	242
TOTAL	10,346	729

Police Stations	Total	Damaged
Alabama	496	0
Arkansas	515	107
Illinois	1,082	34
Indiana	537	2
Kentucky	407	22
Mississippi	365	42
Missouri	654	53
Tennessee	424	119
TOTAL	4,480	379



[1] NOTE: In this analysis 'Hospitals' include hospitals as well as urgent care facilities, but do not include long-term care facilities such as nursing homes

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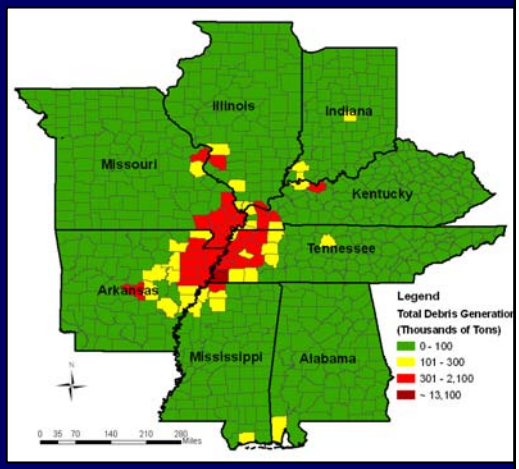
Debris Generation

	Brick, Wood, Other	Steel & Concrete	Total Debris
Alabama	256,000	303,000	559,000
Arkansas	4,096,000	5,295,000	9,391,000
Illinois	1,308,000	1,454,000	2,762,000
Indiana	488,000	561,000	1,049,000
Kentucky	2,058,000	2,760,000	4,818,000
Mississippi	1,489,000	1,919,000	3,408,000
Missouri	2,943,000	3,507,000	6,450,000
Tennessee	9,305,000	12,314,000	21,619,000
TOTAL	21,943,000	28,113,000	50,056,000

- Over 50 million tons of debris generated
- Largest amount of debris generated in Shelby County, TN, roughly 13 million tons in Memphis area
- Several counties Missouri, Kentucky, and Arkansas generate over 1 million tons of debris
- Over 2 million truckloads required to remove all debris



NOTE: Debris truckloads required are based on the use of a 25-ton truck to remove all debris generated during the earthquake event.

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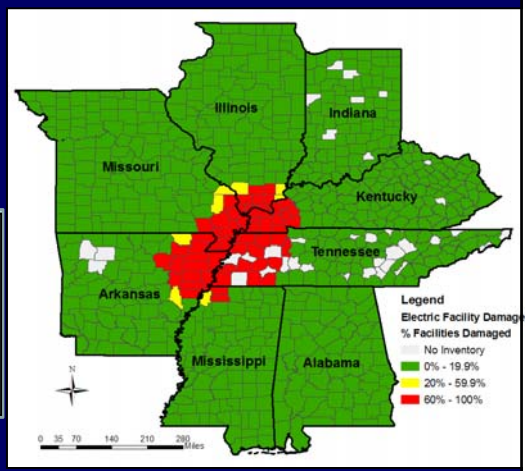
4/25/2012

Utility Lifelines - Facilities

Electric Facilities	Total	Damaged
Alabama	1,629	0
Arkansas	800	147
Illinois	2,231	75
Indiana	975	0
Kentucky	1,976	202
Mississippi	853	36
Missouri	1,855	117
Tennessee	574	96
TOTAL	10,893	673

Natural Gas Facilities	Total	Damaged
Alabama	458	0
Arkansas	422	47
Illinois	3,778	150
Indiana	3,556	0
Kentucky	22,146	77
Mississippi	3,442	19
Missouri	354	64
Tennessee	183	61
TOTAL	34,339	418

Oil Facilities	Total	Damaged
Alabama	425	0
Arkansas	96	14
Illinois	41,105	755
Indiana	5,771	0
Kentucky	34,492	175
Mississippi	7,405	4
Missouri	167	7
Tennessee	160	43
TOTAL	89,621	998



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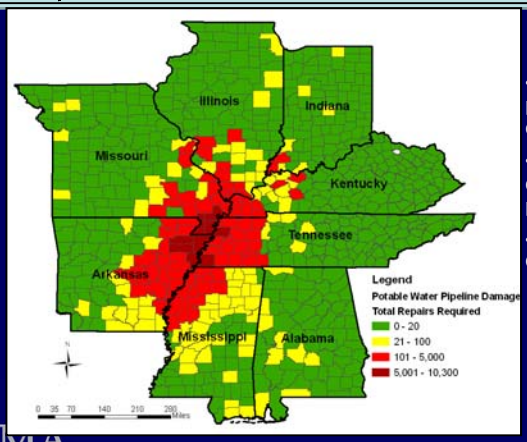
Utility Lifelines - Pipelines

Total Pipeline Repairs	AL	AR	IL	IN	KY	MS	MO	TN	TOTAL
Potable Water	752	47,181	9,763	1,807	11,406	10,735	36,588	39,309	157,541
Waste Water	595	37,316	7,732	1,429	9,022	8,490	28,940	31,089	124,613
Natural Gas	652	41,321	9,493	1,561	9,930	9,831	31,872	34,817	139,477
Oil	7	276	148	130	142	89	228	305	1,325



- Potable & Waste water pipelines – local distribution ONLY;
- Natural Gas – both local distribution and interstate pipelines;
- Oil – interstates pipelines ONLY

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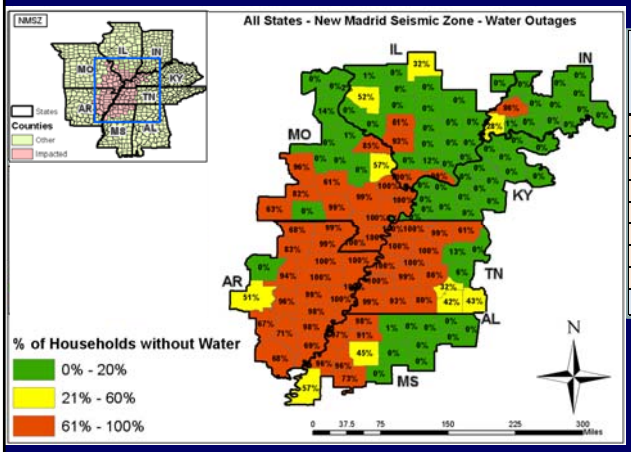
Households without Water



Impacted Counties (IC)	Households w/o Water (Day 1)	Total Households (IC)
Alabama	-	-
Arkansas	174,743	213,587
Illinois	94,626	425,860
Indiana	14,577	210,873
Kentucky	76,169	197,823
Mississippi	80,068	200,674
Missouri	123,719	898,507
Tennessee	507,346	566,153
Total IC	1,071,248	2,713,477

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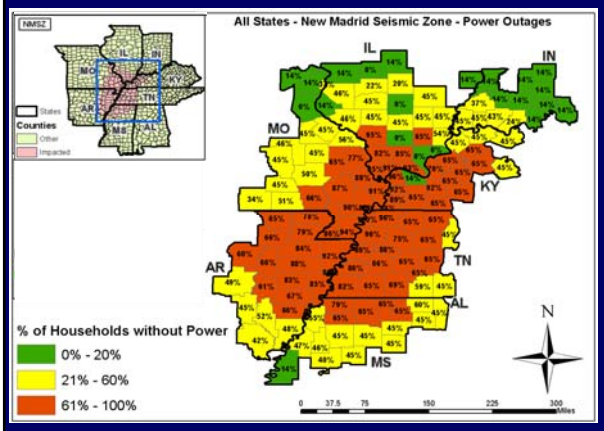
Households without Power



Impacted Counties (IC)	Households w/o Power (Day 1)	Total Households (IC)
Alabama	-	-
Arkansas	151,259	213,587
Illinois	140,402	425,860
Indiana	63,028	210,873
Kentucky	124,895	197,823
Mississippi	104,936	200,674
Missouri	243,763	898,507
Tennessee	440,194	566,153
Total IC	1,268,477	2,713,477

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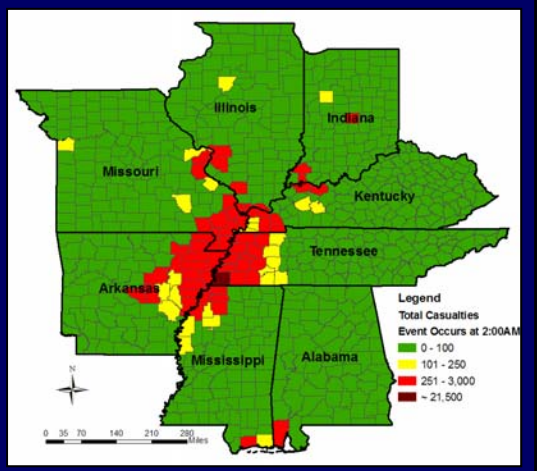
Casualties

2:00AM Event	Fatalities	Total Casualties
Alabama	28	948
Arkansas	641	15,307
Illinois	271	6,284
Indiana	80	1,976
Kentucky	287	6,840
Mississippi	183	6,057
Missouri	687	14,125
Tennessee	1,319	34,233
TOTAL	3,496	85,770

- The largest number of total casualties occurs Tennessee, mostly western Tennessee. Nearly 40% of all fatalities and total casualties occur in Tennessee
- Shelby County, TN, alone incurs nearly 21,500 total casualties and 825 fatalities. This means 25% of all casualties occur in the Memphis, TN, area.
- Northeast Arkansas and southeast Missouri also incurs substantial casualties. Nearly 20% of all fatalities and total casualties occur in each state



- Casualties refer to both injuries and deaths
- The event occurs at 2 am

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Other Critical Infrastructure

- Dams, Levees, and Hazardous Materials facilities are the only forms of additional infrastructure considered
- All damage to these types of infrastructure occur in northeast AR, southern IL, western KY, southeast MO, an western TN
- Flooding due to dam/levee failure is most likely in areas of most sever shaking and substantial displacement from liquefaction

Dams	Total	Damaged
Alabama	2,233	0
Arkansas	1,228	55
Illinois	1,562	31
Indiana	1,187	0
Kentucky	1,196	53
Mississippi	3,544	0
Missouri	5,408	55
Tennessee	1,215	133
TOTAL	17,573	327

Levees	Total	Damaged
Alabama	5	0
Arkansas	124	20
Illinois	576	34
Indiana	101	0
Kentucky	90	10
Mississippi	50	0
Missouri	369	25
Tennessee	11	7
TOTAL	1,326	96

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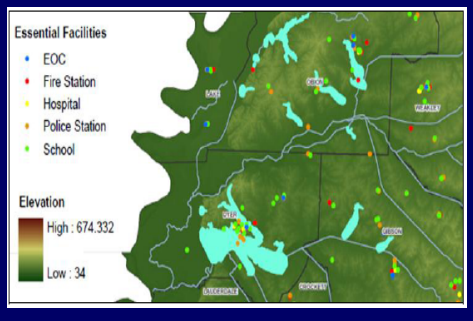
Flood Risk Analysis

- Simplistic approach to estimate flood potential due to dam damage only
- At risk inventory is identified
- 5 states affected
  - Arkansas
    - Poinsett
  - Illinois
    - Massac, Pope, and Pulaski
  - Kentucky
    - Ballard, Carlisle, and Hickman
  - Missouri
    - Scott County
  - Tennessee: Dyer, Gibson, and Obion



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Flood Risk Analysis

Inventory Category	Facility Type	Number of Potentially Flooded Facilities					Total by Facility Type
		AR	IL	KY	MO	TN	
Essential Facilities	EOC	0	0	0	0	2	**2**
	Fire Stations	2	1	1	0	7	**11**
	Hospitals	0	0	0	0	1	**1**
	Police Stations	0	0	0	0	7	**7**
	Schools	0	1	0	1	8	**10**
Transportation	Airports	0	0	0	0	2	**2**
	Bus Facilities	0	0	0	0	1	**1**
	Highway Bridges	25	2	23	2	132	**184**
	Ports	0	0	0	0	0	**0**
	Railway Bridges	0	0	0	0	0	**0**
	Railway Facilities	0	0	0	0	0	**0**
Utilities	Communication Facilities	0	0	4	1	59	**64**
	Electric Power Facilities	0	0	0	0	1	**1**
	Natural Gas Facilities	0	0	0	2	1	**3**
	Oil Facilities	0	0	0	0	1	**1**
	Potable Water Facilities	0	0	0	0	2	**2**
	Waste Water Facilities	0	2	3	0	15	**20**
Total Facilities by State		**27**	**6**	**31**	**6**	**239**	**309**

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Mitigation Opportunities
Unreinforced Masonry Related Casualties
- NE Scenario (~450K URMs)

Time of Day	**Nighttime**	**Daytime**	**Commute**
Severity 2, 3 & 4 Casualties w/out URMs	1,750	3,750	5,500
Severity 2, 3 & 4 Casualties w/URMs	16,500	16,550	17,300
% Casualties Caused by URMs	89%	77%	68%

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County-by-County Results: Capabilities Requirements

Search and Rescue Requirements

US&R Type I Teams:	**Clear rate is estimated as 2 buildings per 12 hours.** Approximately 70 members trained & equipped for light frame, heavy wall, heavy floor and concrete-steel construction (heavy reinforced concrete.
US&R Type II Teams:	**Clear rate is estimated as 4 buildings per 12 hours.** Approximately 32 members trained & equipped for light frame, heavy wall, heavy floor and concrete-steel construction.
Collapse Type III Teams	**Clear rate is estimated as 8 buildings per 12 hours.** Approximately 22 members trained & equipped for light frame construction.
Collapse Type IV Teams	**Clear rate is estimated as 16 buildings per 12 hours.** Approximately 6 members trained & equipped for light frame construction.)

	Type 1	Type 2	Type 3	Type 4
Collapsed Buildings	1	-	16	32
Time Required by Team (hours)	6	-	24	24

Factor	Classification	
Poverty	HIGH	19.1 % of the population is living in poverty
English Proficiency	LOW	.58 % of the population speaks English less than well. Spanish: 90 Asian: 8 European: 34 Other: 0
Disability	MODERATE	26.21 % of the population is disabled
Age	HIGH	23.84 % of the population is younger than 5 or older than 65 6.65 % is under 5 (1,703 children) 17.19 % is 65 or older (4,400 adults)

Sheltering Requirements (Day 3)

# of Shelters	Space		Staffing		
200 person	Sleeping (sq. ft.)	Total (sq. ft.)	Operations	Feeding	Distribution
21	256,140	2,049,120	213	85	170

Chronic Illnesses

Populations	Cancer	Diabetes	Heart Disease	Hyper-tension	Stroke	Mental Disorders	Pulmonary Conditions	Total Cases
Pre-Disaster	1,084	1,454	1,922	3,697	246	2,637	4,930	18,194
"At Risk"	645	865	1,144	2,200	146	1,569	2,933	9,504
Shelter	187	251	332	640	42	456	853	2,766

Cat Plan Loss Summary

State	No. Damaged Buildings	No. Damaged Bridges	Power Outages*	Casualties	Total Direct Economic Loss
Alabama	15,400	0	235,000	1,000	$14 billion
Arkansas	162,000	1,100	330,000	15,300	$40 billion
Illinois	45,000	160	237,000	6,300	$44 billion
Indiana	14,000	0	222,000	2,000	$12 billion
Kentucky	68,400	250	329,000	6,900	$53 billion
Mississippi	57,500	10	233,000	6,100	$17 billion
Missouri	87,000	1,000	313,000	14,100	$49 billion
Tennessee	265,000	1,050	709,000	34,200	$69 billion

- **Estimated regional impacts for sequential rupture scenario:**
  - **715,000 damaged buildings**
  - **Over 2.6 million people without electric power at Day 1**
  - **More than 85,000 casualties** (injuries and fatalities)
  - **$300 billion in DIRECT economic losses**
  - **50 million tons of debris**

* Represents the number of households without electric power at Day 1.

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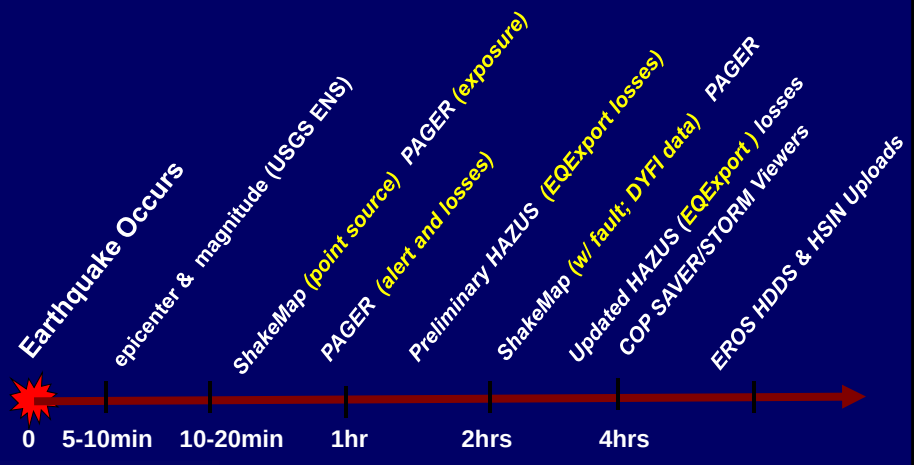
USGS science for a changing world

Earthquake Information Timeline
(NLE2011)



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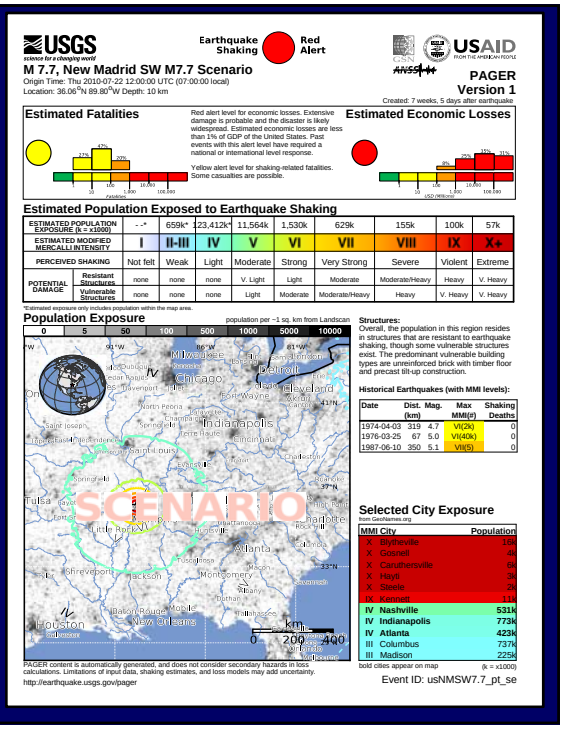
USGS science for a changing world

M7.7 New Madrid PAGER

- Point Source
- Loss Estimates



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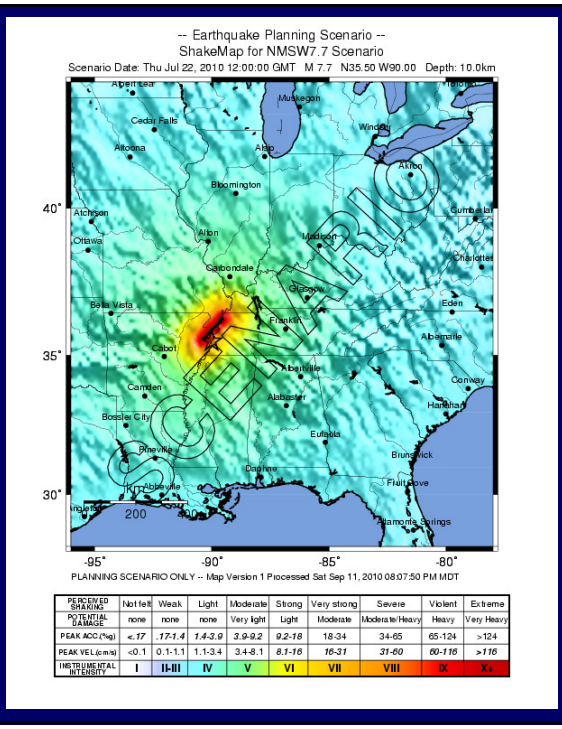
ShakeMap M7.7 New Madrid

- Finite Fault Added



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	*8.1-16*	*16-31*	*31-60*	*60-116*	*>116*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

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1.5 – 2.5 hrs: Preliminary FEMA HAZUS Losses

- FEMA running MAEC study regions with point source ShakeMaps
- Automated loss data feeds for FlexViewer
- Automated map template produces

Table 2: Estimated Extent of Damage to Buildings and Collapsed Building

County	Building Count by Expected Damage: None	Slight	Moderate Extensive	Complete	Total Building Collapsed
Kentucky					
Ballard	1,401	1,240	1,013	96	5
Calloway	7,226	4,758	2,456	54	4
Carlisle	774	966	675	54	3
Fulton	377	1,722	927	300	31
Graves	6,145	5,489	3,823	268	19
Hickman	379	1,104	777	113	7
Marshall	8,308	3,620	2,314	77	5
McCracken	11,728	8,395	6,219	606	45
Kentucky	36,338	27,295	18,204	1,570	119
Grand Total:	36,338	27,295	18,204	1,570	119

Table 3: Urban Search and Rescue Teams and Personnel Needed by County

	USAR Type I Task Forces: Number Collapsed Buildings	Number Task Forces	Number Trained Personnel	USAR Type II Task Forces: Number Collapsed Buildings	Number Task Forces	Number Trained Personnel	USAR Type III Task Forces: Number Collapsed Buildings	Number Task Forces	Number Trained Personnel	USAR Type IV Task Forces: Number Collapsed Buildings	Number Task Forces	Number Trained Personnel
Counties of Kentucky												
Ballard	-	-	-	-	-	-	3	1	22	2	1	6
Calloway	-	-	-	-	-	-	2	1	22	1	1	6
Carlisle	-	-	-	-	-	-	2	1	22	1	1	6
Fulton	-	-	-	2	1	32	26	2	44	3	1	6
Graves	-	-	-	1	1	32	13	1	22	5	1	6
Hickman	-	-	-	-	-	-	5	1	22	2	1	6
Marshall	-	-	-	-	-	-	4	1	22	2	1	6
McCracken	-	-	-	3	1	32	30	2	44	11	1	6
Kentucky	-	-	-	6	3	96	89	10	220	27	8	48
Grand Total:	-	-	-	6	3	96	89	10	220	27	8	48

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3.0 – 4.0 hrs: Updated FEMA HAZUS Losses

- FEMA running MAEC study regions with updated finite source ShakeMaps
- Automated loss data feeds for FlexViewer
- Regional and State-level assessments
- Automated map templates produces

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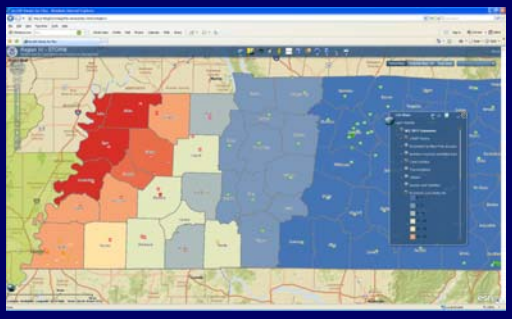
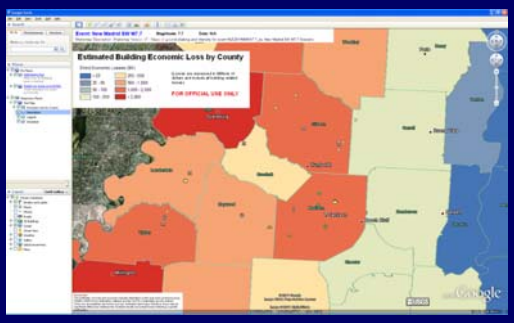
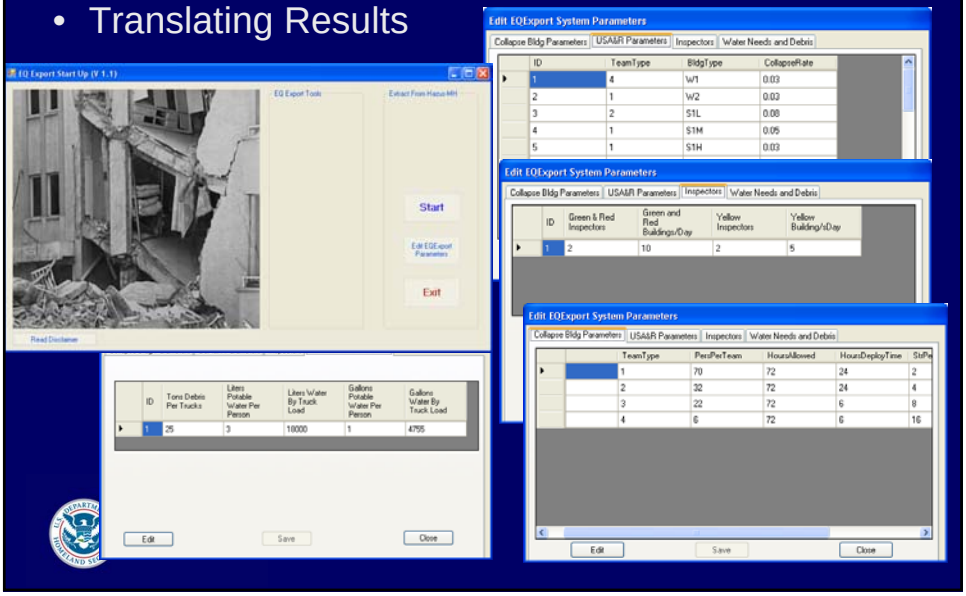




Automation EQExport

- Translating Results



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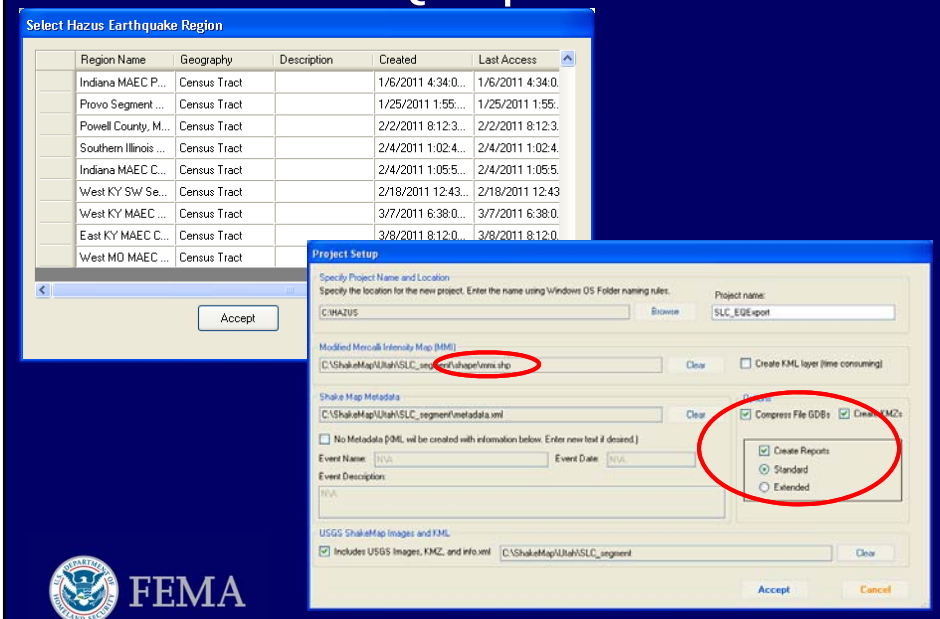
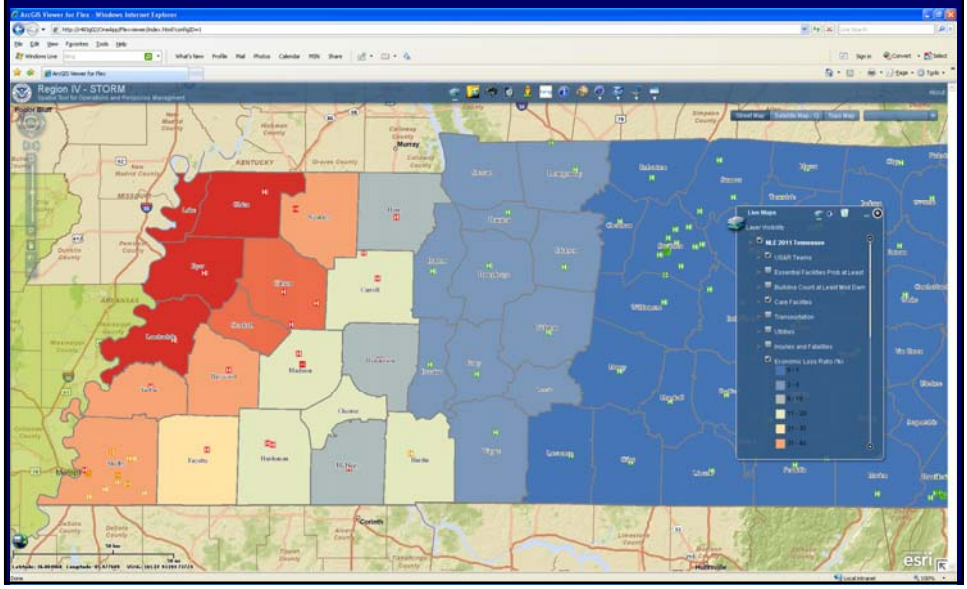
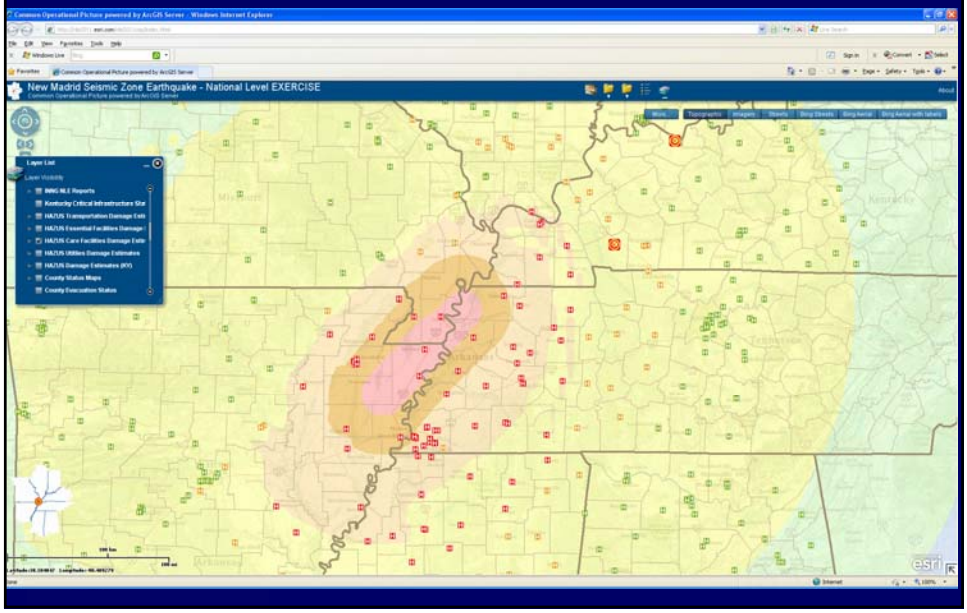


EQExport

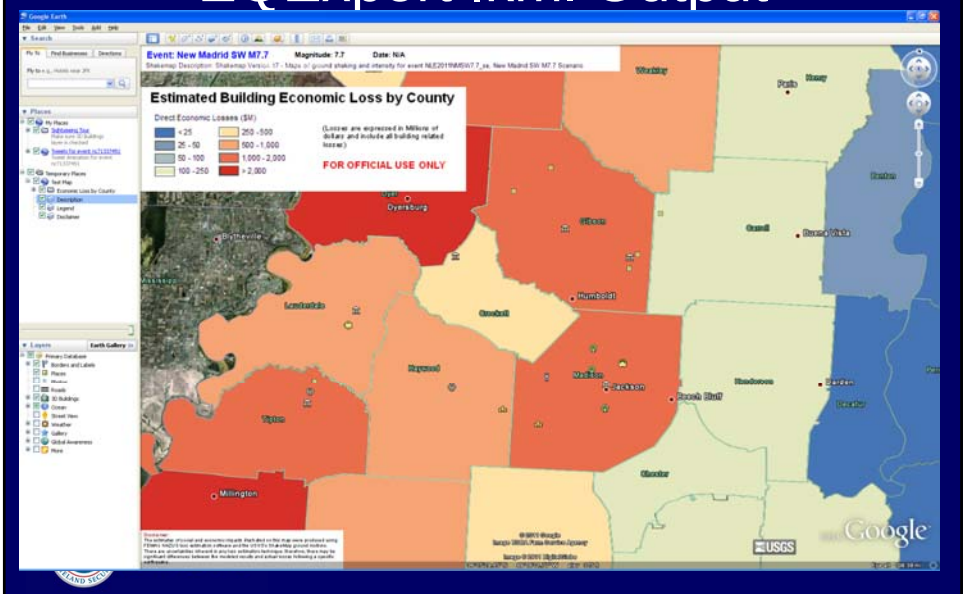
Flex Viewers-
FEMA SAVER^2, STORM, ERUPT



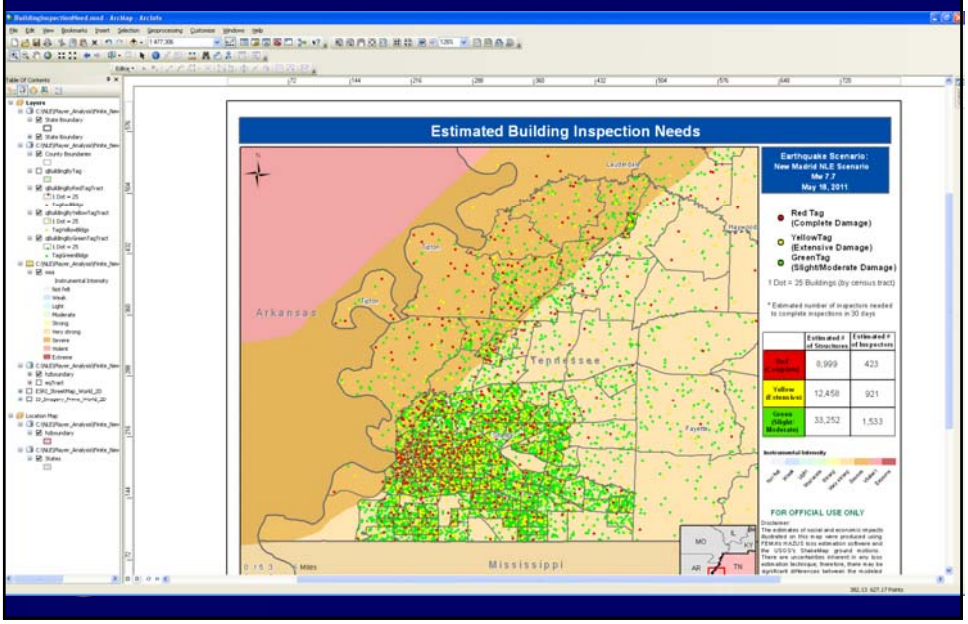
ESRI NLE COP-ShakeMap Feed



EQExport .kml Output



Suite of .mxds (30)



EQExport Report Output

Table 5: Demographic Summary by County and Intensity Level (Feel)

State	County	Feel	Population	Households	Population in Group Quarters	Population Over 65-yrs	Population Less 16-yrs	HH annual income 20K or less
			4,077	1,692	57	575	789	519
			4,209	1,703	103	724	857	455
			8,286	**3,395**	**160**	**1,299**	**1,646**	**974**
			30,053	12,172	2,996	4,505	4,748	3,835
			30,053	**12,172**	**2,996**	**4,505**	**4,748**	**3,835**
			1,626	606	59	272	355	112
			3,725	1,602	0	686	709	510
			5,351	**2,208**	**59**	**958**	**1,064**	**622**

Table 2: Estimated Extent of Damage to Buildings and Collapsed Building

County	Building Count by Expected Damage: None	Slight	Moderate	Extensive	Complete	Total Building Collapsed
Kentucky						
Ballard	1,401	1,240	1,013		96	5
Calloway	7,226	4,758	2,456		54	4
Carlisle	774	966	675		54	3
Fulton	377	1,722	927		300	31
Graves	6,145	5,489	3,823		268	19
Hickman	379	1,104	777		113	7
Marshall	8,308	3,620	2,314		77	5
McCracken	11,728	8,395	6,219		608	45
Kentucky						
Grand Total:						

Table 3: Urban Search and Rescue Teams and Personnel Needed by County

	USAR Type I Task Forces: Number Collapsed Buildings	Number Task Forces	Number Trained Personnel	USAR Type II Task Forces: Number Collapsed Buildings	Number Task Forces	Number Trained Personnel	USAR Type III Task Forces: Number Collapsed Buildings	Number Task Forces	Number Trained Personnel	USAR Type IV Task Forces: Number Collapsed Buildings	Number Task Forces	Number Trained Personnel
Counties of Kentucky												
Ballard	-	-	-	-	-	-	3	1	22	2	1	6
Calloway	-	-	-	-	-	-	2	1	22	1	1	6
Carlisle	-	-	-	-	-	-	2	1	22	1	1	6
Fulton	-	-	-	2	1	32	26	2	44	3	1	6
Graves	-	-	-	1	1	32	13	1	22	5	1	6
Hickman	-	-	-	-	-	-	5	1	22	2	1	6
Marshall	-	-	-	-	-	-	4	1	22	2	1	6
McCracken	-	-	-	3	1	32	30	2	44	11	1	6
Kentucky	**-**	**-**	**-**	**6**	**3**	**96**	**85**	**10**	**220**	**27**	**8**	**48**
Grand Total:	**-**	**-**	**-**	**6**	**3**	**96**	**85**	**10**	**220**	**27**	**8**	**48**

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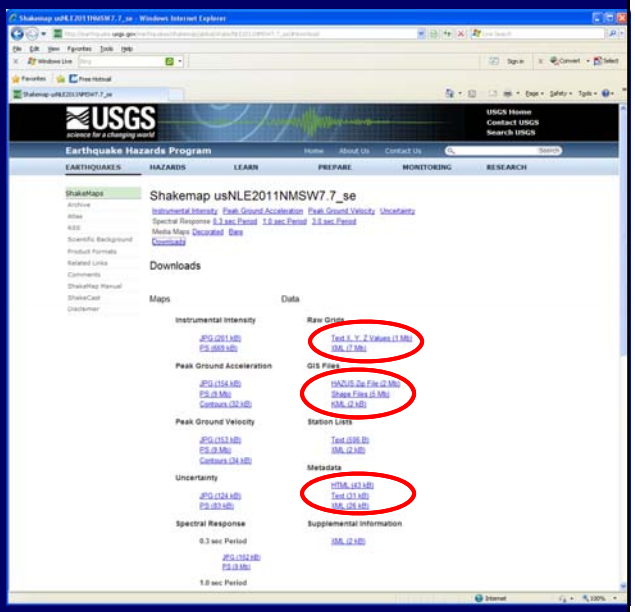
USGS science for a changing world

ShakeMap Post NLE Enhancements

- .prj WGS84 added
- FGDC metadata integrated in .zip
- .lyr file integrated
- USGS NHSS Published Feed
- New ShakeMap2Hazus utility



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Summary

Products identify potential mitigation strategies:

1. URMs result in Catastrophic Impacts
2. Mobility issues, resource gaps (beds, inspectors, etc.)
3. Opportunity to Exercise ShakeMap/Hazus Data Flow for NLE

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