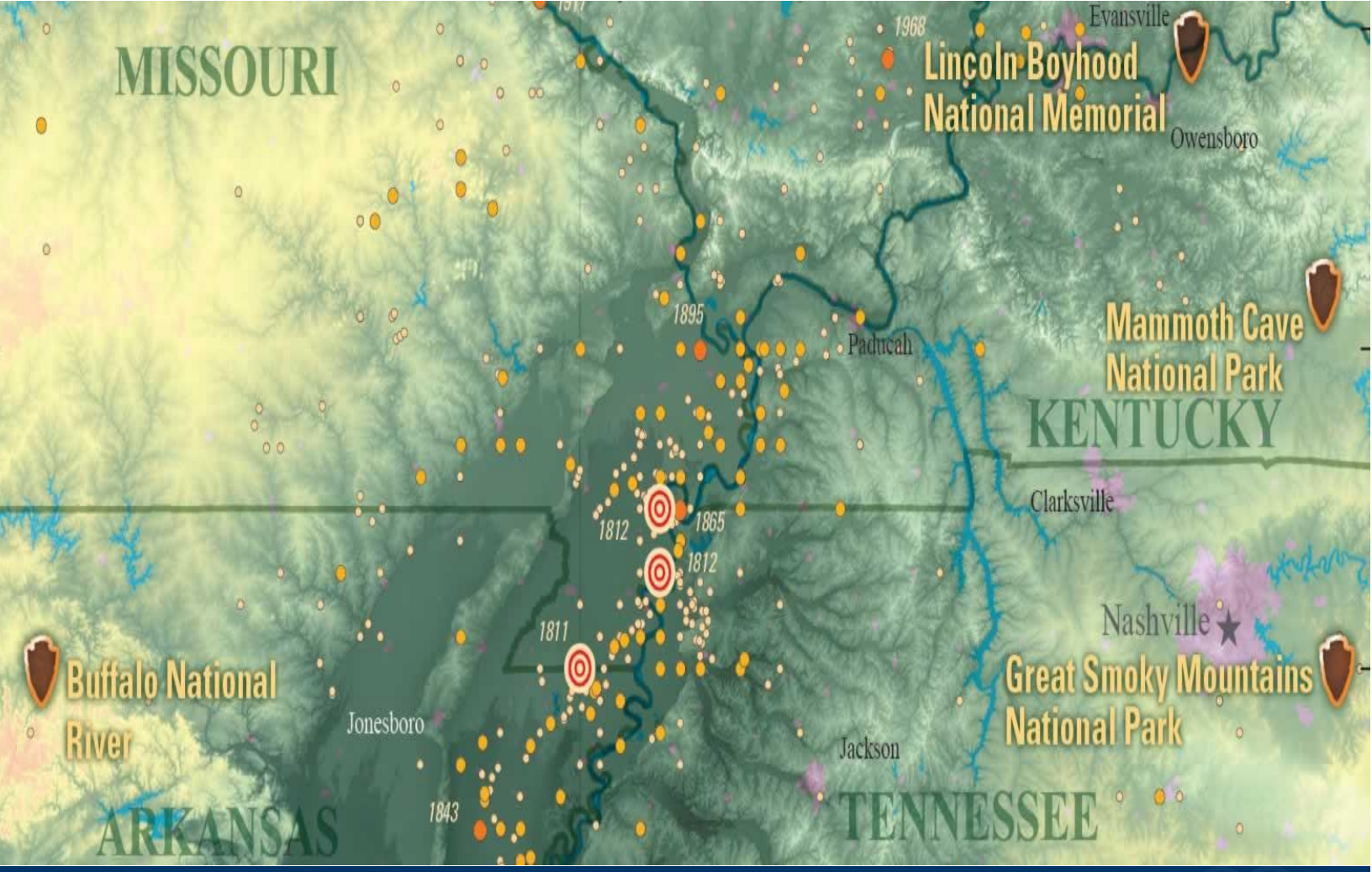

Central United States Earthquake Consortium
New Madrid Seismic Zone

Earthquake Tabletop Exercise

February 6, 2019

Scenario Ground Truth Supplemental Document

NATIONAL EXERCISE PROGRAM

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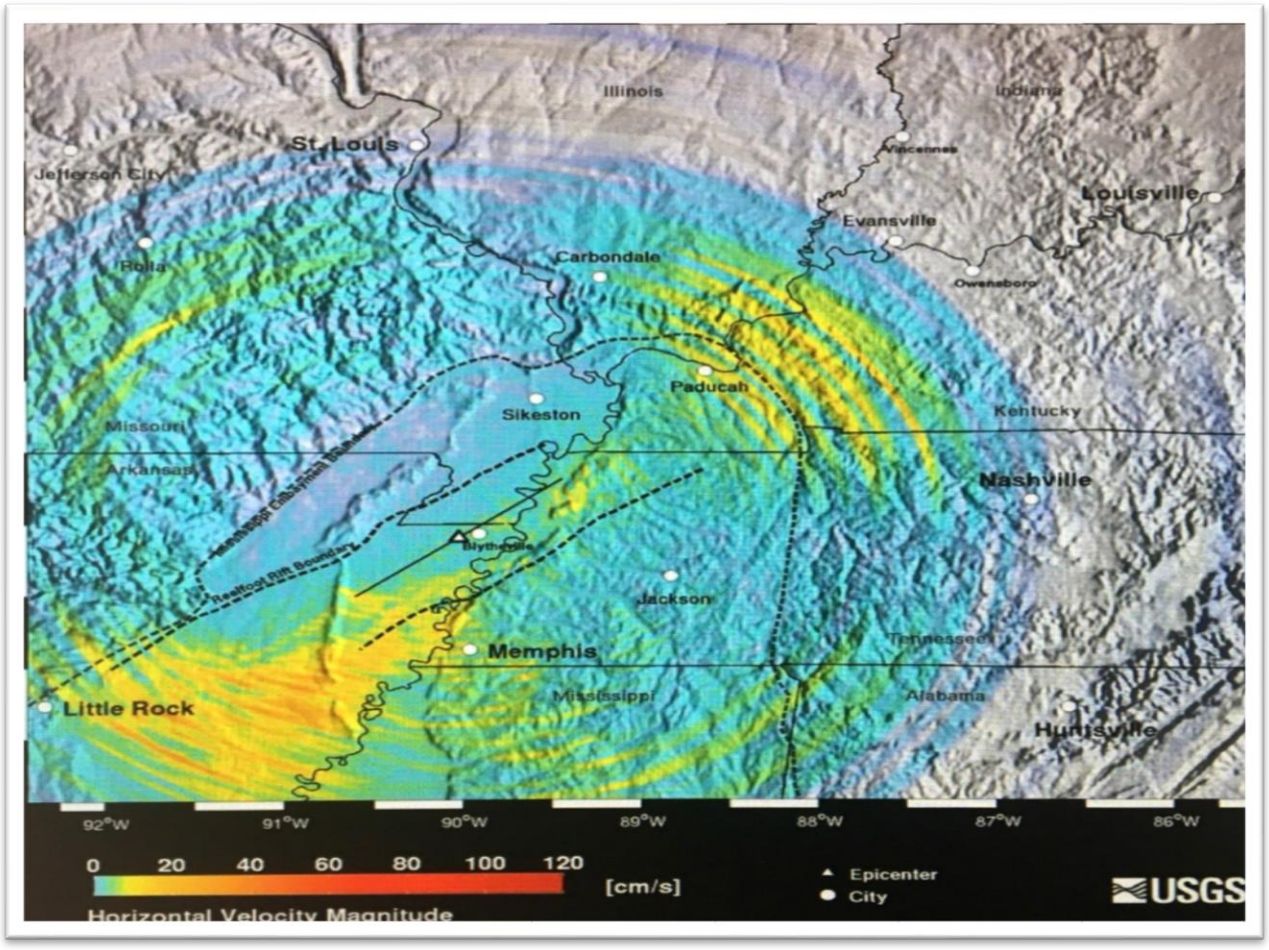
EXERCISE OBJECTIVES

1. Test **information sharing and information integration** as well as agreements and relationships established to address **energy/fuel prioritization, main supply route command and control, evacuation routes, and state geologist resources**.
    - Core Capability – Intelligence and Information Sharing
    - Core Capability – Operational Coordination
2. Discuss **operational reporting, tracking, and management of deployed INDOT resources**.
    - Core Capability – Operational Coordination

Scenario Overview

Magnitude 7.7 Earthquake Occur in New Madrid Seismic Zone

At **0700 a.m. (CST)** on February 6, a magnitude 7.7 earthquake was recorded in the central U.S. region near the southern arm of the New Madrid Seismic Zone. The United States Geological Survey is reporting the epicenter appeared to be just southwest of Blytheville, Arkansas and seismic waves traveled outward in all directions. This earthquake produced successive waves of strong ground shaking that began moving along the Reelfoot rift and appeared to be focused northeast toward Paducah, Kentucky and southwest toward Little Rock, Arkansas. The USGS has also reported the earthquake produced long-period shaking that lasted up to 45 seconds in some areas, including Memphis, Little Rock, and Paducah.



Situational Assessment

Be aware that the exercise scenario will include assumptions and artificialities to create conditions to drive decision making, planning, and exercise participation

Table 1: Initial Estimated Impact and Damage

State	No. of Damaged Buildings	No. of Damaged Bridges	Power Outages	Casualties
Alabama	15,400	0	235,000	1,000
Arkansas	162,000	1,100	333,000	15,300
Illinois	45,000	160	237,000	6,300
Indiana	14,000	0	222,000	2,000
Kentucky	68,400	250	329,000	6,900
Mississippi	57,500	10	233,00	6,100
Missouri	87,000	1,000	313,000	14,100
Tennessee	714,300	3,570	2,611,000	85,900

Figure 2: Estimated Impact and Damage following the Magnitude 7.7 Earthquake, USGS

Damage to Transportation Sector

1. **Major Highways and Bridges**

- **Interstate 55 North and South** in Missouri sustained heavy damage and is impassable from Hayti, Missouri to just south of Osceola, Arkansas. Most roadways within a 35 mile radius northeast and southwest of Blytheville, Arkansas have sustained moderate to severe damage.
- The **Memphis-Arkansas Memorial Bridge**, that carries Interstate 55 across the Mississippi River between West Memphis, Arkansas and Memphis, Tennessee was heavily damaged and has collapsed. Vehicle traffic carrying morning commuters plunged into the Mississippi River during the earthquake. The bridge also carries U.S. Highways 61, 64, 70 and 79 from Memphis to West Memphis.
- The **Harahan Bridge** that carries two rail lines and a pedestrian bridge across the Mississippi River between West Memphis, Arkansas and Memphis, Tennessee experienced a catastrophic fail and collapsed into the Mississippi River. The bridge is owned by Union Pacific Railroad. A 42-car train was approaching the bridge when the earthquake began and 21 cars plunged into the river.
- The adjacent **Frisco Bridge** also collapsed but was closed and not open to vehicle or pedestrian traffic.
- The **Caruthersville Bridge** on Interstate 155 and Route 412 that spans the Mississippi and

connects Dyersburg, Tennessee to the east with Caruthersville and Hayti, Missouri to the west has sustained significant damage to pylon support. State highway crews have closed the bridge and are conducting further inspections and earthquake damage assessments.

- The **Martin Luther King Bridge** in St. Louis, Missouri connecting St. Louis with East St. Louis, Illinois across the Mississippi River sustained moderate damage. The bridge serves as traffic relief connecting the concurrent freeways of Interstate 55, Interstate 64, and U.S. Route 40 with the downtown streets of St. Louis.

2. **Airports**

- **Arkansas-International Airport (Blytheville, AR) Closed –** Significant infrastructure and runway damage
- **Jonesboro Municipal Airport (Nettleton Township, AR) Closed** – Significant infrastructure and runway damage
- **Manila Municipal Airport (Manila, AR) Closed** – Significant infrastructure and runway damage
- **Covington Municipal Airport (Covington, TN) Closed** – Significant infrastructure and runway damage
- **Fayette County Airport (Somerville, TN) Closed** – Significant infrastructure and runway damage
- **Memphis International Airport (Memphis, TN) Closed** – Significant infrastructure and runway damage
- **Charles W. Baker Airport (Memphis, TN) Closed** – Significant infrastructure and runway damage
- **West Memphis Municipal Airport (West Memphis Township, Mississippi Township, AR) Closed** – Significant Infrastructure and runway damage
- **Tunica Airport (Tunica, MS) Open** – Minor damage, full operations
- **University Oxford Airport (Oxford, MS) Limited Operations** – Mild infrastructure damage, no damage to runway. Open to disaster response flight operations only
- **Bill and Hillary Clinton National Airport (Big Rock Township, AR) Limited Operations** – Mild to moderate infrastructure damage, one runway no damage and operational to disaster response operations only
- **Conway Municipal Airport at Cantrell Field (Cadron Township, AR) Limited Operations** – Mild infrastructure damage, no runway damage
- **Malden Regional Airport (Cotton Hill Township, MO) Closed** – Significant infrastructure and runway damage
- **Mississippi County Airport (Trywappity Township, MO) Closed** – Significant infrastructure and runway damage
- **Mountain View Airport (Goldsberry Township, MO) Limited Operations** – Moderate infrastructure damage, no damage to runway

- **Branson Airport (Oliver Township, MO) Open** – Minor infrastructure damage, no damage to runway
- **Dyersburg Regional Airport (Dyersburg, TN) Closed** - Significant infrastructure and runway damage
- **Millington-Memphis Airport (Millington, TN) Closed** – Significant infrastructure and runway damage
- **Walnut Ridge Regional Airport (Campbell Township, AR) Closed** – Significant infrastructure and runway damage
- **McKeller-Spies Regional Airport (Jackson, TN) Closed** – Significant infrastructure and runway damage
- **Kirk Field Airport (Spring Grove Township, AR) Closed** – Significant infrastructure and runway damage

Damage to Energy Sector

1. Electric

- Electricity infrastructure systems appear to have been impacted well beyond the NMSZ Region. The impacts have affected 100-150 million people, especially those in the states nearest the epicenter experiencing the majority of the power outages.

- Many areas within the Eastern Interconnection could potentially face downtimes ranging from a minimum of **14 hours to as much as up to 5 days**. Areas farther away from the epicenter may experience considerably less downtime. The equipment with the longest lead time is transformers with an 8-12 month timeframe.

Voltage Category (kV)	No. of Transmission Lines	No. of Substations
230	40	37
345	20	18
500	28	19
Sub-total	**88**	**74**

Figure 3: Estimated Impact to Electric Grid within the New Madrid Area, Argonne National Lab

2. Petroleum

- The most important components of petroleum infrastructure within the area of severe damage are four major transmission pipelines and the Memphis refinery. The Capline and Mid-Valley pipelines carry crude oil to Midwest refineries. The Enterprise/TEPPCO and Marathon Centennial pipelines carry refined products.

- Barge transportation of petroleum on the Mississippi River and a major rail line in eastern Arkansas that currently transports Bakken crude to the Saint James Terminal in Louisiana has been damaged and all transportation halted. Although rail shipments are looking to be re-routed around the NMSZ affected areas, barge transportation do not have alternative routes.
- Disruptions due to destruction of terminals and other shore facilities, and damage to locks on the Mississippi River have all but halted all petroleum transport. Landslides caused by the earthquake have block some river channels and dumped massive amounts of sediment into navigation channels.
- The only refinery that appear to be directly affected is in Memphis, Tennessee; engineers are initially forecasting it could be shut down for approximately one year.
- The Mississippi River is closed to barge traffic from the Ohio River down to Greenville, Arkansas. Army Corp of Engineers are initially forecasting a closure of one year.
- Pipelines that go through the affected areas, which includes segments of the Capline crude pipeline, a Premcor crude pipeline that supplies the Memphis refinery, and the Marathon Centennial refined-product pipeline, could be shut down for up to 100 days.
- Pipelines that go through the affected area, which includes segments of the Mid-Valley crude pipeline and Enterprise/TEPPCO refined-product pipelines, may be shut down for up to 60 days. Barge traffic on the Mississippi River below Greenville is expected to be shut down for up to 60 days also.
- The distribution terminals in the NTFM (National Transportation Fuel Models) that are directly affected by the earthquake are Memphis, Tennessee, and West Memphis, Arkansas (both shut down for approximately 30 days), Helena, Arkansas (shut down for approximately 7 days), and Arkansas City, Arkansas (shut down for approximately 3 days). These outage durations are based on estimates of electric-power restoration times16 and do not include possible extended down times and loss of fuel storage that could be caused by physical damage to storage tanks.
- In addition to the areas directly affected by the earthquake, there are fuel shortages in areas that are supplied by pipelines that transit the earthquake area. In particular, shortages occur in parts of Arkansas, Missouri, Illinois, Indiana, Kentucky, Ohio, and West Virginia because of the disruption of the TEPPCO and Centennial refined-product pipelines. Detailed observations from the simulation include:
- Fuel consumption drops to zero in the directly affected areas, including the areas around Memphis, Tennessee, and Cape Girardeau, Missouri, and around the Arkansas cities of West Memphis, Arkansas City, Helena, and Little Rock. (As a practical matter, fuels are not expected to completely run out because emergency measures likely would be taken: for example, trucking in fuels to mitigate the shortages from disrupted pipelines.)
- The damage to the Memphis refinery will be catastrophic for gasoline, diesel and jet fuel supplies in a 200 mile radius, which even includes Little Rock, AR. Their product loading rack is the largest and busiest in the U.S. This refinery is the major direct supply of jet fuel to the FedEx world terminal in Memphis, currently the 2nd busiest cargo airport in the world. Less known, the refinery supplies diesel just across the Mississippi River to West Memphis, Arkansas, arguably the largest truck stop in the U.S. On any given night, there is an average of 40,000 truckers stopped there.

- The next closest refinery is likely the Delek refinery in El Dorado, Ark., which given its age, location and distance from I-30, may also be impacted by an event. There is another smaller refinery on the Ohio River in Cattlesburg, KY, that would be critical for supplies.
- Thus, Arkansas will have to look south to Texas and west to Oklahoma for product. If accessible, the Memphis region will likely be heavily dependent on barge delivery for all petroleum products for an extended time until the refinery re-opens. For instance, the refinery's major storage tanks were built on top fill right next to the water; thus, until told otherwise, I would expect those to be completely destroyed.
- Areas not directly affected by the earthquake do not run out of fuels immediately, but are able to continue their consumption using local storage. For example, in Little Rock, local storage lasts for almost two weeks before it runs out. Normally there is not enough local storage for that long, but there is extra storage of fuels that would normally be sent to West Memphis and Cape Girardeau but cannot because the pipelines are out.
- Consumption rebounds after 60 days when the Enterprise/TEPPCO pipelines are brought back into service, but lesser fuel shortages remain in some locations until the Marathon Centennial pipeline is back in service after 100 days.
- Normal fuel supplies for Memphis are cut off for a year because the local refinery and barge traffic on the Mississippi River are both assumed to be disrupted for that period. Demand for fuels likely would be lower than normal because of earthquake damage. At the same time, alternative supply methods, such as truck and possibly rail, likely would be used to meet remaining demand.
- Several refineries in Ohio and Kentucky have temporary reductions in output because of the disruption to the Mid-Valley crude pipeline, but they are not severely affected because they also have other supply routes. Of note is that the Chicago area refineries are not affected. Until fairly recently, the Capline pipeline was a major supply artery for the Midwestern refineries, but now they are getting more of their supply from Canada and thus are not as vulnerable to an NMSZ earthquake as in the past.

3. Natural Gas

- Ten interstate pipelines would be at risk of damage due to the events
- All ten pipelines would experience at least one break and several leaks due to PGA, PGV, and liquefaction
- Even with implementation of emergency remedial measures, all FEMA Region V states (except Minnesota) and other nearby states would experience a substantial reduction in delivery, ranging from 2% to 27%
    - Indiana ~ 18%
    - Michigan ~ 18%
    - Illinois ~13%
    - Ohio ~12%
    - Wisconsin ~2%
- Even with emergency remedial actions, the seismic events would impact:
    - 20,000–30,000 households (or 60,000–100,000 people)
    - 50,000–140,000 Industrial and commercial customers or units

- A well-orchestrated implementation of remediation measures would limit impact on natural gas-fired power to insignificant levels (less than 2% of installed capacity)
- In general, all underground storage facilities (except for 2) would not experience any serious damage so as to make them dysfunctional
- Restoring damaged pipelines to full functionality would take about 1–3 months depending on how the pipeline companies subdivide and "phase" the work, the availability of crews, conditions of access roads, and resolved target completion times; restoration for residential and industrial customers would take 2–4 and 4–8 weeks, respectively

Damage to Water and Wastewater Systems Sector

1. Water Treatment

Water and wastewater utilities will be particularly vulnerable because of the extensive network of above and below ground pipelines, pump stations, tanks, administrative and laboratory buildings, reservoirs, chemical storage and treatment facilities.

The Mid-America Earthquake Center (MAE) study indicates approximately 1.1 million households could be without water as a result of thousands of breaks in water pipelines, ruptures in storage and process tanks and the collapse of buildings. This may cause a loss of water system pressure, contamination and drinking water service disruptions.

The wastewater system may also experience infrastructure damage from breaks in the collection system. Sewers and wastewater treatment plants tend may be located on ground which is subject to liquefaction. Damage can lead to sewage backups in homes and potential releases of untreated sewage into the environment.

- There are seven major pipelines crossing the Mississippi River in eastern St. Charles County, Missouri. All seven are buried in loose unconsolidated sediments of the Missouri-Mississippi River flood plain. Spillage has occurred due to multiple fractures in the pipeline system causing contamination to the municipal water supply to the city of St. Louis.

Damage to Healthcare Network

- **Great River Medical Center (Chickasawba Township, Blytheville, AR)** – Significant damage, partial roof collapse, transferring patients
- **SMC Regional Medical Center (Monroe Township, AR)** – Significant damage, transferring patients
- **Lauderdale Community Hospital (Ripley, TN)** – Significant damage, transferring patients
- **Baptist Memorial Hospital (Covington, TN)** – Moderate damage, 60% operational, cannot accept patients
- **Tennova Healthcare – Dyersburg Regional (Dyersburg, TN)** – Significant damage, transferring patients

- **Arkansas Methodist Medical Center (Spring Grove Township, AR)** – Moderate damage, not accepting additional patients
- **Lawrence Memorial Hospital (Campbell Township, AR)** – Minor damage, accepting additional patients
- **NEA Baptist Memorial Hospital (Nettleton Township, AR)** – Moderate damage, not accepting additional patients
- **St. Bernards Medical Center (Nettleton Township, AR)** – Moderate damage, not accepting additional patients
- **Methodist North Hospital (Memphis, TN)** - Moderate damage, not accepting additional patients
- **Methodist University Hospital (Memphis, TN)** - Moderate damage, not accepting additional patients
- **Baptist Memorial Hospital (Memphis, TN)** – Minor damage, accepting additional patients
- **Arkansas Continued Care Hospital (Nettleton Township, AR)** - Moderate damage, not accepting additional patients

Assumptions to Consider

- The magnitude of the earthquake has created geographic competition for resources. Regional mutual aid fire, EMS, and law enforcement resources are limited as other jurisdictions face similar circumstances.
- Federal mobilization of resources may take 24 to 48 hours to arrive in the affected areas, and there may not be enough resources to service all affected areas initially.
- Disrupted communications systems, overwhelmed first responders, and the overall magnitude of the situation may slow the collection and sharing of the initial situation assessment.
- Damage to critical City facilities (EOC, DOCs, and fire stations) may require alternative arrangements to manage response services.
- Damage to water and communications systems may challenge EMS operations.
- The number of people trapped in buildings may initially exceed capacity to respond.
- Local medical facilities are damaged. Surviving hospital capacity may be inadequate to treat casualties and other medical emergencies
- All EOCs have operational communication capability

ADDITIONAL SOURCES TO SUPPORT RESPONSE PLANNING

U.S. Department of Energy maintains an energy waiver library website describing the various regulatory assistance measures states may request during an emergency to enhance the response. https://www.energy.gov/ceser/energy-waiver-library

The University of Memphis Center for Earthquake Research and Information is a Center of Excellence with several geologists and students focused on the New Madrid Seismic Zone and research.

The Diamond Pipeline as a new important crude oil pipeline running under the Mississippi River at Memphis. **The Diamond Pipeline** is a 440-mile, 20 inch pipeline capable of transporting up to 200,000 barrels per day of domestic sweet crude from Cushing, OK, to Memphis, TN. As a result the importance of Capline Pipeline has diminished to less than 50% capacity. Capline is seeking approval to reverse flow to bring refined product from Midwest refineries to the Gulf Coast for export.

U.S. Department of Energy's EAGLE-I software has many helpful GIS layers that show current critical infrastructure – pipelines, major transmissions lines, etc. EAGLE-I can also be used to show major oil refineries and power plants in the NMSZ region. EAGLE-I uses the U.S. DHS funded and managed energy infrastructure GIS layers from here: https://hifld-geoplatform.opendata.arcgis.com/

National Association of State Energy Officials NASEO facilitates peer information exchange among State Energy Officials, serves as a resource for and about State Energy Offices, and advocates the interests of State Energy Offices to Congress and federal agencies. Members are senior officials from State and Territory Energy Offices, as well as affiliates from the private and public sectors. Member State Energy Offices work on a wide range of energy programs and policies https://naseo.org/Data/Sites/1/petroleum-guidance/final-naseo-petroleum-guidance-feb-2018.pdf NASEO also produced guidance documents on petroleum shortage responses. https://naseo.org/petroleum-shortage-response-planning

The National Pipeline Mapping System **(NPMS)** is a dataset containing locations of and information about gas transmission and hazardous liquid pipelines and Liquefied Natural Gas (LNG) plants which are under the jurisdiction of the Pipeline and Hazardous Materials Safety Administration (PHMSA). The NPMS also contain voluntarily submitted breakout tank data. The data is used by PHMSA for emergency response, pipeline inspections, regulatory management and compliance, and analysis purposes. It is used by government officials, pipeline operators, and the general public for a variety of tasks including emergency response, smart growth planning, critical infrastructure protection, and environmental protection.

The Environmental Protection Agency Power Resilience Guide for Water and Wastewater Utilities includes information from water industry professionals on how to increase power resilience in disasters. The purpose is to promote coordination and communication between water sector utilities and their electric utilities; and provide strategies to increase water utilities' resilience to power loss.

The Environmental Protection Agency Earthquake Incident Action Plan for Water pprovides information on preparedness and response actions water utilities can take in an earthquake.

APPENDIX A: REFERENCES AND SOURCES

The scenario for this exercise was developed using simulation and scientific research data collected from the list of referenced sources below. Additional information was submitted by planning team members that cover their roles and areas of responsibility.

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APPENDIX B: EXERCISE PARTICIPANTS

ORGANIZATION	REPRESENTATIVE	ROLE/SECTOR
Alabama Department of Economic and Community Affairs	Emergency Management Coordinator	State Emergency Management
Alabama Power Company	Power Delivery Storm Center Director	Other
American Red Cross	State Emergency Management Liaison	ESF Representative
Arkansas Department of Emergency Management	Response & Recovery Division Director	State Emergency Management
Arkansas Department of Transportation	Staff Maintenance Engineer	ESF Representative
Arkansas Geological Survey	Geology Supervisor	State Geological Survey
CUSEC	Associate Director	Other
CUSEC	Executive Director	Other
Dept. of Energy	ESF12 Region IV Regional Coordinator	Dept. of Energy
DHS	NG Military Advisor	Other
DHS / FEMA	Regional Administrator	FEMA
DHS/FEMA R-IV	Plans Chief	FEMA
DNR/MGS	Division Director	State Geological Survey
DNR/MGS	Chief, Geologic Resources Section	State Geological Survey
Federal Highway Administration	ER Coordinator/Bridge Engineer	ESF Representative
FEMA	National Exercise Division	FEMA

FEMA Exercise Branch	Support	FEMA
FEMA Exercise Branch		FEMA
FEMA Exercise Branch	Lead Support to Shaken Fury 2019	FEMA
FEMA NED	Exercise Program Manager	FEMA
FEMA Region 7	Earthquake Program Manager	FEMA
FEMA Region V	Response Division Director	FEMA
FEMA Region V	Operational Planner	FEMA
FEMA RVII	REO	FEMA
G&H International, Inc.	Support for DHS S&T	Other
IEMA	Exercise Officer	State Emergency Management
IEMA-DOIT	GIS Specialist	State Emergency Management
IL Emergency Management Agency	Manager, Applications Development and GIS	State Emergency Management
Illinois Emergency Management Agency	Exercise Planner	State Emergency Management
Illinois National Guard	Interagency and Intergovernmental Liaison to IEMA	State National Guard
Illinois National Guard	BG, Dir. of Joint Staff	State National Guard
Indiana Geological and Water Survey	Outreach Coordinator	State Geological Survey
INDOT	Dir. Emergency Planning & Response	ESF Representative
Kentucky Emergency Management	Director	State Emergency Management

Kentucky National Guard	Director of Joint Staff	State National Guard
KYEM	Ops & Planning Chief	State Emergency Management
KYEM	Assistant Director of Operations	State Emergency Management
KYEM	Planning Section Supervisor	State Emergency Management
KYEM		State Emergency Management
KYNG	Director of Military Support	State National Guard
MABAS-IL	Operations Branch Chief	Other
MABAS-IL	SEOC LNO	Other
MABAS-Illinois	Deputy Operations Branch Chief	ESF Representative
MABAS-Illinois	Operations Branch Chief	Other
Missouri National Guard	Chief, Plans and Exercises	State National Guard
Mutual Aid Box Alarm System (MABAS)	Operations Branch Chief	Other
Shawnee Preparedness and Response Coalition	President	ESF Representative
South Carolina Emergency Management Division	Operational Planner	State Emergency Management
TEMA	Exercise Specialist	State Emergency Management
TEMA		State Emergency Management
US Army Corps of Engineers, Memphis District	Emergency Management	Other
USASMDC/NGB	DAART Operations	Other

APPENDIX C: ACRONYMS

CUSEC	Central United States Exercise Consortium
NMSZ	New Madrid Seismic Zone
EMAC	Emergency Management Assistance Compact
USGS	United States Geological Survey
TEPPCO	TEPPCO Partners LP
NTFM	National Fuel Transportation Models
PGA	Peak Ground Acceleration
PGV	Peak Ground Velocity
FEMA	Federal Emergency Management Agency
MAE	Mid-America Earthquake Center
NASEO	National Association of State Energy Officials
NPMS	National Pipeline Mapping System
LNG	Liquefied Natural Gas
PHMSA	Pipeline and Hazardous Materials Safety Administration
DOE	Department of Energy
ESF	Essential Support Function
NG	National Guard
DHS	Department of Homeland Security
DNR/MGS	Department of Natural Resources/Missouri Geological Survey
ER	Emergency Response
REO	Regional Exercise Officer
IEMA	Illinois Emergency Management Agency
INDOT	Indiana Department of Transportation
KYEM	Kentucky Emergency Management Agency

KYNG	Kentucky National Guard
MABAS-IL	Mutual Aid Box Alarm System-Illinois
TEMA	Tennessee Emergency Management Agency
USAMDC/NGB	United States Army Space and Missile Defense Command/National Guard Bureau
DART	Domestic All-Hazards Response Team

APPENDIX D: NEW MADRID SEISMIC ZONE MAP