ANNEX DD
EARTHQUAKE

## I. SITUATION AND ASSUMPTIONS

### A. SITUATION

1. An earthquake is the shaking or trembling of the earth's crust caused by underground volcanic forces or the interaction of continental plates or other geologic phenomenon more commonly referred to as tectonic forces. It is estimated that approximately one million earthquakes occur annually worldwide, which equals an average of one tremor every thirty-two seconds. Fortunately, the majority of these occurrences are of very low intensity with only two thousand to six thousand of the total number being powerful enough, (magnitude 5.0 to 5.9), to cause damage to manmade structures. About one hundred and twenty of the total number are devastating enough, (magnitude 6.0 to 6.9), to cause major structural damage, and around eighteen of the total number could destroy a major city, ( magnitude 7.0 to 7.9), if they were to occur near one. Approximately every three years, one of the most powerful earthquakes, ( magnitude 8.0 and above) occur. Each of the examples listed above represent the threshold of the typical or expected damages for a given magnitude. Each increase in magnitude encompasses all of those damages incurred at lower listed magnitudes, in addition to those threshold damage levels listed. Appendix DD-5 lists average magnitudes, intensities, and annual occurrences for earthquakes worldwide.

2. While scientists are often able to measure the amount of energy that is building beneath the earth's surface, no means has been developed that will permit reliable prediction of when an earthquake will take place. Therefore, earthquakes are unpredictable and can strike without warning. They may range in intensity from slight tremors, below the threshold of unaided observation to human beings, to great shocks that can cause tremendous loss of life and damage to property, and may last from a few seconds to over five minutes. Earthquakes can occur individually or in a series over several days. However, the events of higher intensity

are almost always accompanied by aftershocks, which can be almost as damaging as the quakes they follow.

3. The actual movement of the ground in an earthquake is seldom the direct cause of casualties. Most injuries and deaths result from the falling of objects and debris as a result of the shocks transmitted in various wave forms initiated by the earthquakes occurrence. Further damage and loss of life may result from the disruption of transportation systems, communications and utilities, landslides, soil liquefaction, and the potential of flooding from direct or indirect sources.

4. There are several known fault areas which are in or near enough to Kentucky to be damaging to life or property if a damaging earthquake were to occur within one. The major known fault zones located within the state include: the Mississippi Valley fault system,(commonly referred to as the New Madrid fault zone) located near the Kentucky/Missouri border; the Rough Creek fault system, located in the Northwest area of the state; the Pennyrile fault system, located in the Southwest part of the state; the Kentucky River fault system, located near Sharpsburg Kentucky; the Irvine-Paint Creek fault system, located in the Central to Eastern portion of the state; and the Pine Mountain fault zone, located near Pineville Kentucky.

5. Fault zones that lie outside the boundaries of Kentucky which have a known potential for affecting the state include: the Giles County fault zone located in Giles County, Virginia; the Charleston fault located near Charleston South Carolina; and the Wabash Valley fault zone, located near the Illinois - Indiana border, approximately 25 miles North of Henderson County, Kentucky. See Appendix DD-6 for locations of major fault zones in Kentucky, seismicity map of Kentucky, and epicenter points surrounding Kentucky, with generalized isoseismal zones in the state.

6. In order to accurately and consistently describe the occurrence and effects of earthquakes and the damages or potential for damages they produce, scientists have developed

numerous methods for displaying the energy released and damages observed from their occurrence. The two methods most widely used are the Richter scale and the Modified Mercalli scale.

a. The Richter Scale is a numeric representation of the amount of energy released (amptitude) of an earthquake at its moment of creation. It is obtained from seismic records produced by a seismograph.

b. The Richter scale is logarithmic in nature, which means that each increase of one magnitude, as it is measured on the Richter scale, corresponds to a 10 fold increase in vibrational amptitude. Appendix DD-3 shows the Richter scale. In addition, each increase of one magnitude level, as measured on the Richter scale, corresponds to a 31.5 fold increase in energy released by an earthquake. The approximate energy released by the various Richter scale measurements is depicted in Appendix DD-4.

c. The degree of damages observed in the event of a damaging earthquake is measured using the Modified Mercalli intensity scale of 1931 (MM scale). The MM scale is subjective in that it measures the degree of ground shaking at a given location. The relationship of the MM scale to the Richter scale is non linear, being affected by factors such as depth of occurrence, soil type, etc. Appendix DD-2 shows the Modified Mercalli scale.

d. The relationship between the Richter scale and the Mercalli scale is shown in Appendix DD-5. This illustrated relationship will, due to the nature of the two scales being used, change with the distance from the occurrence of the earthquake. For example, an earthquake that measures 3.9 on the Richter scale (energy released) will typically correspond with a Mercalli measurement (damage observed) of between II and III near the occurrence. The same event of 3.9 on the Richter scale may be reduced to a measurement of I, or less, on the Mercalli scale within a few miles of the occurrence. Stated another way, The Richter scale measures the energy released at the location of the earthquake and the Mercalli scale measures the damages observed as a

result of that earthquake at whatever location the observer wishes to consider.

7. Injuries and deaths resulting from a catastrophic earthquake are expected to be caused principally due to the failure of man-made structures, particularly older multi-story and unreinforced masonry buildings constructed prior to the adoption of building codes that contain seismic provisions.

8. Congregate/mass care and area evacuation may be necessary, due either from direct or secondary events arising from the occurrence of an earthquake.

9. Normal food and medical supply lines may become inoperative, requiring supplemental food and medical supply deliveries from outside sources by available and obtainable ground or air transport. See Annex S (Food Management) and Annex M (Medical) of the state EOP.

10. A catastrophic earthquake affecting any region within the state would require the implementation of major relief efforts from both the state and federal level, as outlined in the state and federal disaster plans. Initial disaster response teams will be mobilized within hours after the incident. However, local government officials must rely on available resources for as much as seventy-two (72) hours before additional supplies, equipment, and manpower will become available.

B. ASSUMPTIONS

1. General

a. The Commonwealth of Kentucky is vulnerable to significant damage by earthquakes from several areas. The threat includes injuries and deaths to residents, as well as, widespread property and economic losses. Although public knowledge and attention has historically been focused on the western portion of the state, there are several other regions, within the state and in nearby states, that have exhibited measurable earthquake activity. There is also the possibility that some of the known, or those not yet discovered, faults that have not had recent recordeable seis-

mic activity will resume activity. Therefore, no location in Kentucky can be considered free from the threat of earthquakes.

2. Medical

   a. A major earthquake would create extraordinary requirements for emergency medical services. This need would be further magnified because many health care facilities are located in areas of high damage potential, the probability of major utility and transportation interruptions, non-availability of critical supplies, and the probability that some of the affected health care professionals will be among the casualties.

   b. Injuries requiring hospitalization are estimated to be four times as great as fatalities in the event of a catastrophic earthquake.

   c. The number of casualties (injuries or deaths) resulting from occurrence of a catastrophic earthquake would depend on the time of day in which it occurred. At night, most of the population would be found in relatively safe wood joist wall bearing construction, which is the typical construction method employed in residential dwellings. In contrast, during a typical weekday the majority of the population moves to buildings which are much more vulnerable to severe structural damage or collapse. A substantial portion of the daytime casualties may occur among school children. Total daytime deaths in a catastrophic event could easily exceed several thousand persons.

   d. In the event of a catastrophic earthquake, local and state supported medical assistance, as outlined in Annex M (Health and Medical),of the state EOP, will be augmented by the appropriate emergency support function of the Federal Disaster Response Plan.

3. Economic

   a. The regional economy may be severely af-

fected due to loss of employment caused by damage to workplaces, loss of transportation or supply lines, or other factors.

b. The state or national economy may be affected due to the interruption of vital supplies or services which may be routed through or affected by the damaged area. An example of this would include the gas and crude oil transmission lines located throughout Kentucky and the various coal fields in both Western and Eastern Kentucky, as well as the interruption of rail, air, waterway, and roadway transportation routes, located throughout the region, that are vital for the delivery of goods and services.

c. Economic damage to the affected area may be intensified by the failure of finance, insurance, or monetary systems which use electronic funds transfer and data processing equipment. In the event that these services become unavailable, either due to lack of electrical or telephone services, damage to equipment, or to the facility in which the services are located, the operations of the affected services will be crucially impaired. A stricken community could be paralyzed without the availability of cash and minimal credit, and could further be threatened by economic chaos. The restoration of financial and insurance systems is crucial to the effective recovery of individuals, families, neighborhoods, and commerce.

d. Insurance companies may be unable to adequately respond to the financial burden placed upon their resources in the event of a catastrophic earthquake. This may create the possibility of insolvency which could leave many claims unsettled.

4. Public Information

a. Emergency public information, in the period following a catastrophic earthquake, will be vital to the dissemination of information concerning emergency measures to be taken by the stricken population, both for their individual safety, as well as to ensure notification of orders issued by

authorities to speed the response efforts.

b. A tremendous need will exist for a variety of information immediately following an event. Disaster victims will need to know where to take the injured, where to go for food and shelter, evacuation routes, and countless other items of essential interest.

c. Basic informational guidelines provided in Annex E (Public Information) of the state EOP.

4. Relief Efforts

a. Search and rescue personnel may be required to extricate and transport earthquake victims, as well as render aid to those casualties suffered as a result of secondary effects of the disaster, as outlined in Annex L (Rescue Services) of the state EOP.

b. Jurisdictions in the affected area possessing resources in excess of their own needs may be requested to assist those jurisdictions requiring assistance.

c. Congregate/mass care may be required for victims of the disaster. Care may include shelter, food preparation, and distribution of food. Annex F (Reception and Care) of the state EOP details this operation.

d. Evacuation of the affected population may be required as a result of either the initial earthquake damages or secondary occurrences such as fires, lack of utilities, or other emergencies. This requirement may be complicated due to limited usable transportation, fuel shortages, debris, etc. Additional information concerning this operation is covered in Annex EE (Evacuation) of the state EOP.

e. Additional complications to rescue, relief, and firefighting efforts may arise due to the fact that many of the structures in which these services are located may be among those damaged in the event, thus, possibly removing the affected vehicles from service. Local plans should include

provisions for moving these vehicles from such buildings immediately after a damaging event, even if the building has sustained no major damage, in anticipation of aftershocks which may further damage the possibly weakened structure(s).

5. Structural Damage

   a. Injuries and deaths are expected to be caused primarily due to the failure of man-made structures, particularly older, multi-story and unreinforced brick masonry buildings built before the adoption of building codes that contain seismic provisions. Appendix DD-7 is a graphic representation of the worldwide fatalities suffered from earthquake damages from 1950-1989, and indicates the portion of the total losses in which unreinforced masonry construction was a contributing factor.

   b. Buildings, or specific areas within buildings, that have been determined to be unsafe for habitation or use following an earthquake shall be inspected and re-certified as safe in accordance with the SOP's of the appropriate agency. Appendix DD-8 provides a summary of both the criteria and techniques involved in the inspection and posting of the affected area and structures.

   c. Buildings of special concern such as healthcare facilities, schools, those with longspan roofs, multi-story construction with weak lower stories, and those with non-symmetrical construction (torsionally imbalanced) are particularly vulnerable to earthquake damage. Examples of types of construction most susceptible to earthquake damages are displayed in Appendix DD-9.

6. Geotechnical Hazards

   In the event of a damaging earthquake, seismological and geological scientists, and engineers will assist in evaluating areas concerning present and projected damages. Among the areas anticipated to be most critical are:

   a. Assessment of earthquake intensities and computation of probable aftershock

intensities;

b. Production of maps delineating the geographic boundaries of earthquake magnitudes (isoseismal maps);

c. Inspection of ground movement and areas of potential future movement; and

d. Inspection of dams and levees for signs of damage, etc.

7. Utilities

a. A catastrophic earthquake in any region of the state would severely affect commercial communications in the damaged area. This may be the result of downed power lines, collapsed transmission towers, or similar events. Emergency communications may be limited to two way radios, the KEWS radios, and assistance by the Amateur Radio Relay League (ARRL). Commercial radio transmissions may be limited to those stations that have generator backup to their systems. Additional information is available in Annex B (Communications) of the state EOP.

b. Electrical power, being particularly vulnerable to damage from an earthquake due to the high probability of damaged power lines, transmission towers, broken underground conduits, etc., may not be available for an extended period of time. Annex P (Energy Supply) details energy response operations.

c. Residential and commercial gas and water distribution systems may suffer from ruptured transmission lines and the loss of electrical power often required for pump stations, etc. Details of specific actions to be implemented in this instance are also covered in Annex P (Energy Supply).

d. Sewage systems may be inoperative, requiring implementation of portions of Annex M (Health and Medical), as well as, Annex R (Public Works).

e. Interstate gas and crude oil transmission

lines may be ruptured, causing widespread loss of utilities, as well as secondary dangers of fire, toxic leaks, etc. Annex Q (Hazardous Materials) details appropriate actions in this event.

8. Transportation

   a. Damage to transportation systems may severely hamper recovery efforts following an earthquake. The loss or impairment of major rail and highway links serving the area may significantly increase the difficulty of rescue and relief efforts, and may also have long term effects on the regional and national economy.

   b. River traffic in the affected area may be interrupted due to damaged ports and lock facilities. Further difficulties may arise from debris in the rivers.

   c. Partial or limited availability of airport facilities is expected following an earthquake. Equipment that relies on electrical power such as runway lights or navigational aids may be non-operational and severely limit the usefulness of the airport. However, it is anticipated that airports will be at least partially usable in even severely damaged areas. Suitability of a facility for an intended purpose will be established by the proper authority before use.

   d. Inspection and certification of transportation facilities, such as bridges and bridge approaches, roadways, overpasses, etc. will be carried out under Annex H (Transportation) of the state EOP.

   e. Transportation needs not within the scope of, or exceeding the capabilities of the local and state emergency response plans, will be covered under the appropriate Emergency Support Functions of the Federal Disaster Response Plan.

9. Secondary Effects

   a. In addition to the initially recognized damages, a catastrophic earthquake may cause a variety of secondary events such as

release of hazardous materials from factories, ground or river transport, or other methods of transmission, storage, or transportation.

b. Fires due to ruptured gas lines, electrical power sources, or the upsetting of fixed ignition sources (such as boilers, fireplaces, etc.) may occur and could be complicated due to damaged roads or lack of water to fight them.

c. Earthen dams are not expected to rupture in the event of an earthquake. However, if high water exist at the time of an earthquake levees protecting low lying areas may fail, allowing flooding of those areas.

d. Roadways made impassable due to the earthquake may complicate normal and expedient rescue, relief, and firefighting efforts.

e. Landslides may result in damage to roadways, rail and river transport, or the endangerment of residential or other types of buildings.

II. MISSION

The mission of the earthquake annex is to establish basic policies, establish concepts of operation, and direction and control authority in order to provide emergency operations in the event of a damaging or catastrophic earthquake.

III. DIRECTION AND CONTROL

A. Direction and control for earthquake operations relief shall be exercised by the local Chief Executive Officer in accordance with the basic plan of the local EOP. State resources, when required to supplement the local efforts, will be directed in accordance with the basic plan (and annexes), of the state EOP. In the event of a catastrophic earthquake, and upon the issuance of a Presidential declaration of disaster, at the request of the Governor, the Federal Emergency Management Agency (FEMA) will implement the appropriate portions of the Federal Response Plan under authority of public law 93-288, as amended. This plan will assist local and state efforts in response to and recovery from

catastrophic natural disasters by providing a wide variety of services and resources as outlined within the various emergency support functions (ESFs) of that plan.

B. If necessary, a forward disaster field office (DFO) will be established as close to the disaster area as possible. That facility will be staffed by local, state, and federal personnel, as well as the appropriate volunteer and private disaster relief organizations in order to provide relief, process requests for assistance, and coordinate the efforts of those involved in the disaster relief effort.

C. A forward personnel and equipment staging area, if required, will be established in close proximity to the disaster area in order to expedite assistance to those involved in the relief effort.

## IV. CONCEPT OF OPERATIONS

A. Emergency operations functions and responsibilities assigned to state agencies for earthquake response will be the same as for any other disaster relief operation as provided under the concepts of the Integrated Emergency Management System (IEMS).

B. In the event of a damaging earthquake, local authorities within the damaged area(s) will be expected to rely on local resources to provide emergency services. If local resources are not adequate to meet the need, state DES, at the direction of the Governor, shall coordinate state efforts and resources to the affected area in accordance with the appropriate annexes of the state EOP. In the event of a catastrophic event in which the President of the United States issues a National Disaster Declaration, federal assistance shall be provided through FEMA in accordance with the appropriate ESF(s) of the Federal Response Plan. These ESFs, initiated in accordance with the basic plan of the Federal Response Plan, will provide a variety of services as outlined in Annex A (Direction and Control).

C. Emergency operations under the response and recovery phase of the Earthquake Annex will begin upon the occurrence of a damaging earthquake and will continue until those operations are no longer required. The forward disaster field office (DFO) concept of operation will be implemented in accordance with the appropriate sections of the local,

state, and federal plans.

D. Operations and missions required as a result of a damaging earthquake will be carried out in accordance with the Basic Plan of the state EOP. These phases include Preparedness, Response, and Recovery.

1. Preparedness Phase

a. The preparedness phase occurs prior to and in anticipation of a catastrophic earthquake. This phase includes, but is not limited to, the following:

1) Public information efforts and other program development for increased public awareness of the potential emergency. This may include community and school emergency drills, distributing lists of essential emergency supplies for self help in an emergency situation to the public, and other related programs for increased public preparedness. Appendix DD-10 provides a representative listing of personal readiness guidelines appropriate for individual and community preparedness.

2) Updating and modernizing operational plans and procedures, formulating mutual aid agreements with nearby jurisdictions, developing equipment and resource inventories, and other similar tasks.

3) Hazards vulnerability analyses for the determination of areas of particular danger or concern.

4) Stockpiling of essential disaster relief supplies.

5) Updating and enforcement of building codes in earthquake prone areas.

6) Research and practical experience by scientists and engineers, aimed at the development of mitigative measures for buildings within areas exhibiting a high probability for seismic activity, have increased dramatically within the past several years. An increased under-

standing of the method by which seismic waves affect various soil types and methods of construction has aided the development of building designs with a high degree of earthquake resistance. Appendix DD-11 details several methods currently employed in new construction, in order to increase public safety and reduce damages resulting from an earthquake.

7) Conducting exercises and training programs.

2. Response Phase

a. The response phase is initialized upon the occurrence of a damaging earthquake and continues until lifeline facilities and public safety is restored to adequate levels. Agencies participating in the response and the degree of that participation will be determined by the degree of damage sustained and the need which exist as outlined in the basic plan. During the response phase, assuming a catastrophic earthquake, the federal government provides disaster relief upon Presidential declaration. Functions during this phase include federal relief under P.L. 93-288, as amended, for public and individual assistance, establishment of disaster assistance centers (DACs), establishment of temporary housing facilities, and federal disaster loans and grants. Examples of items included under this heading include, but are not limited to:

1) Render lifesaving aid and search and rescue operations. The efforts implemented within this area of concern may include a wide variety of medical and rescue services, hospital care, ground and air ambulance support, and other services intended to assist the affected population.

2) Provide public information services aimed at providing accurate and timely emergency instructions to the public, media and other agencies or organizations involved or interested in the ongoing operation.

3) Provide firefighting efforts to minimize damages to the affected area.

4) Provide security to the affected population and properties in order to protect life and property.

5) Provide necessary evacuation and congregate/mass care for the affected population.

6) Inspect and make necessary repairs to transportation and utility infrastructures in order to expedite the relief operations.

7) Establish public assistance centers for administering to the needs of the affected population.

8) Restore banking, insurance, telecommunications, and medical computer capabilities, and other areas of essential public services to the public.

3. Recovery Phase

a. The Recovery Phase usually overlaps the Response Phase. It begins a few days after the earthquake and can last as long as the need exist. Operations carried out within this phase of the plan include, but are not limited to:

1) Provide public information services to inform the public, media , and affected agencies with recovery related information.

2) Restoration of utility services such as gas and electricity to the affected area.

3) Inspection and demolition of damaged buildings, and repair of those capable of being utilized after an earthquake, in order to protect the public.

4) Return of evacuees to their residences.

5) Inspection and cleanup of congregate/mass care facilities.

6) Notification of diminishing need for services to agencies involved in the relief effort.

7) Compilation of payment and expenses documentation for disaster finance records.

8) Assessment of relief and recovery effort in order to implement necessary changes to SOPs and regulations.

V. ADMINISTRATIVE SUPPORT

a. Each state agency is responsible for developing internal staff and procedures for administrative support.

b. The annexes to this plan explain how state resources will be used for operational and administrative support.

c. The appropriate ESF's of the Federal Response Plan explain how federal resources and administrative support will be used to support this plan.

IV. GUIDANCE DOCUMENTS

1. Earthquake Prediction
Harcourt, Brace, and Jovanovich
Toyko, 1985

2. Earthquakes, Volcanoes, and Tsunamis,
Skandia American Group, N.Y. 1982

3. The Trembling Earth,
Charles Scribner's Sons, N.Y 1983

4. The New Madrid Earthquakes,
University of Missouri Press,
Columbia and London, 1981

5. The Next New Madrid Earthquake
Southern Illinois University Press,
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6. Federal Response Plan

7. Investigation of the New Madrid,
Missouri, Earthquake Region,
USGS, Professional Paper 1236, 1983

8. Earthquake History of the
United States,

USGS, Publication 41-1, 1980

VII. APPENDICES

DD-1 Glossary

DD-2 Modified Mercalli Intensity Scale

DD-3 Richter Scale

DD-4 Earthquake Magnitude and Energy

DD-5 Annual Worldwide Incidence of Earthquakes

DD-6 Major Fault Zones in Kentucky, Seismicity Map of Kentucky, and Epicenter Points Surrounding Kentucky With Generalized Isoseismal Zones in the State.

DD-7 Contributing factors in Earthquake Fatalities 1950-1989.

DD-8 Post Earthquake Building Inspection.

DD-9 Building Vulnerability to Earthquake Damage.

DD-10 Home and Community Earthquake Preparedness.

DD-11 Earthquake Resistant Construction.