

**Seismic Hazard Assessment for Western Kentucky,
Northeastern Kentucky and Southeastern Ohio**

Prepared by
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Prepared for
United States Department of Energy Portsmouth/Paducah Project Office
Acknowledgment: This material is based upon work supported by the Department of Energy under
Award Number DE-FG05-03OR23032.



July 2002

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July 2002

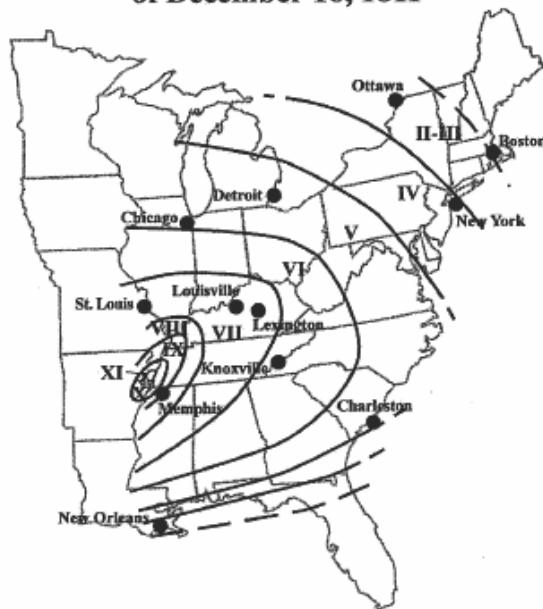
Executive Summary

1. **“As Western Kentucky and Ohio vie to become home to a new \$1 billion uranium plant, the threat of an earthquake near Paducah may be the deciding factor” –the Courier-Journal of Paducah, Kentucky.**
2. **Earthquakes pose seismic hazards and risk to the Commonwealth of Kentucky. Furthermore, the seismic hazards and risk vary throughout the Commonwealth.**
3. **The U.S. Nuclear Regulatory Commission uses the seismic hazard maps developed by the U.S. Geological Survey for seismic safety regulation for nuclear facilities. Under current U.S. Geological Survey’s seismic hazard assessment it is economically unfeasible to build a new uranium plant near Paducah relative to the Portsmouth, Ohio site. This is not to say that the facility cannot be safely engineered to withstand the present seismic load, but enormously expensive to do so.**
4. **More than 20 years observation and research at UK have shown that the U.S. Geological Survey has overestimated seismic hazards in western Kentucky, particularly in the Jackson Purchase area that includes Paducah. Furthermore, our research indicates underestimated seismic hazards in northeastern Kentucky and southeastern Ohio. Such overestimation and underestimation could jeopardize possible site selection of PGDP for the new uranium plant.**
5. **The existing database, research experience, and expertise in UK’s Kentucky Geological Survey and Department of Geological Sciences put this institution in a unique position to conduct a comprehensive seismic hazard evaluation.**

Introduction

Earthquakes from several seismic zones in and around the state affect Kentucky. The most important one is the New Madrid Seismic Zone, in which at least three great earthquakes, each estimated to have been greater than magnitude 7.5, occurred from December 1811 to February 1812. Although the state was sparsely settled, these great earthquakes affected the entire Commonwealth of Kentucky, as well as, the majority of eastern United States. Fig. 1 shows isoseismal map of the first of the 1811-1812 New Madrid Earthquakes. An earthquake measuring 5.2 on the Richter scale that occurred in 1980 near Sharpsburg, in Bath County, and caused an estimated \$3 million in damage; 269 homes and 37 businesses in nearby Maysville were damaged. Thus, earthquakes pose seismic hazards and risk to Kentucky. The seismic hazards and risk vary throughout the Commonwealth.

Isoseismal Map for the Arkansas Earthquake of December 16, 1811



Modified Mercalli Intensity Scale		
INTENSITY	EFFECTS	AVE. PEAK ACCELERATION
VI	Strong 0.98-0.07g	Felt by all. Damage slight.
VII	Very Strong 0.10-0.15g	Everybody runs outdoors. Considerable damage to poorly designed buildings.
VIII	Destructive 0.25-0.30g	Considerable damage to ordinary buildings.
IX	Furious 0.50-0.65g	Great damage to ordinary buildings.
X	Disastrous >0.60g	Many buildings destroyed.
XI	Disastrous	Few, if any, structures remain standing.

(Simplified from Bolt, 1961)



Figure 1. Isoseismal maps of the 1811-1812 New Madrid Earthquakes.

The Federal Regulation

"Seismic area means any area where the probability of a horizontal acceleration in rock of more than 0.3 times the acceleration of gravity in 250 years is greater than 10 percent, as designated by the U.S. Geological Survey." (U.S. Nuclear Regulatory Commission [NRC] Regulation 10 CFR 36.2). The horizontal acceleration with 10 percent probability in 250 years is equivalent to the peak acceleration with 2% probability of exceedance (PE) in 50 years. The current USGS hazard map (Fig. 2) shows that the horizontal acceleration with 10 percent probability in 250 years is approximately 1.0g near Paducah, KY and 0.1g near Portsmouth, Oh. Under the current USGS seismic hazard assessment, Portsmouth is not in a seismic area. However, Paducah is not only in a seismic area, but is also subject to extremely high ground accelerations. Currently in the State of California, 0.4g is the highest building design acceleration. Although structures can be designed for these high accelerations (1.0g) near Paducah, the cost could be very high. At 1.0g ground acceleration, stringent seismic regulations will also be applied to all non-structural components. Therefore, it is economically unfeasible, relative to Portsmouth, to build the new uranium plant near Paducah based on the USGS hazard maps.

The use of the USGS hazard map (Fig. 2) has already resulted in several adverse consequences in western Kentucky. The map (Fig. 2) was used in the 2000 International Residential Code (IRC-2000) to regulate seismic safety for one- and two-story single-family dwelling. IRC-2000 put six counties in the Jackson Purchase area in the seismic design category of E. An E category mandates 1) site-specific investigation and 2) formal engineering design for all single-family houses. These requirements will make it very difficult, if not impossible, for the ordinary family to construct a home in those counties. The ground acceleration value at Paducah Gaseous Diffusion Plant (PGDP) is approximately 1.0g based on the USGS maps (Fig. 2). This ground acceleration has also made it difficult for DOE to obtain a permit from the Kentucky Natural Resource Cabinet to construct a new landfill at PGDP.

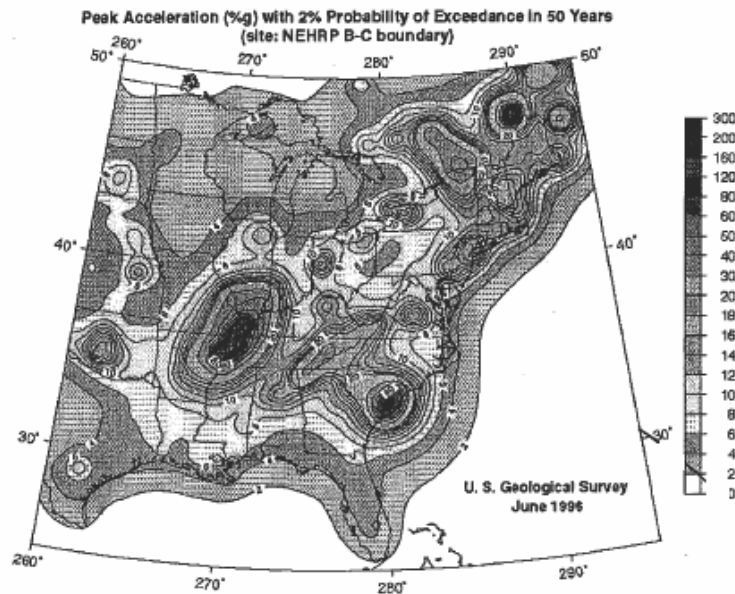


Figure 2. Peak ground acceleration with 2% probability of exceedance in 50 years (USGS, 1996).

Studies at UK

The Kentucky Geological Survey (KGS) and Department of Geological Sciences at the University of Kentucky have operated a seismic and strong motion network and conducted research on earthquake and seismic hazard and risk since 1980. Currently, the network consists of 10 seismic stations and 8 strong motion stations (Fig. 3). The seismic stations are designated for monitoring earthquakes occurring in and around Kentucky. The strong motion stations are designated for recording strong ground motions that have engineering significance. The Kentucky Seismic Network is the third largest east of the Rocky Mountains. The Kentucky Strong Motion Network is the largest east of the Rocky Mountains. The strong-motion database recorded by the Kentucky Strong Motion Network is also the only comprehensive state-of-the-art network east of the Rocky Mountains.

Kentucky Seismic and Strong-Motion Network

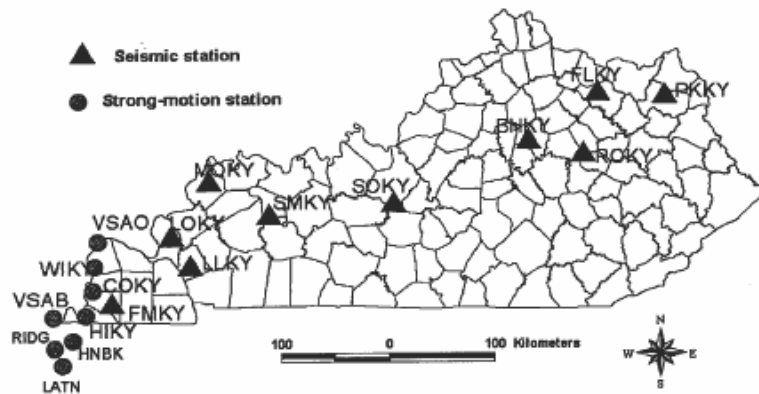


Figure 3. Kentucky Seismic and Strong Motion Network.

More than 20 years of observation and research at UK have shown that the USGS has overestimated seismic hazards in western Kentucky, especially in Jackson Purchase area that includes Paducah. The research also suggests that the seismic hazard in northeastern Kentucky has been underestimated. The study by Street and others (Kentucky Transportation Center Research Report, KTC-96-4) showed a peak ground acceleration of approximately 0.4g near Paducah and 0.2g in northeastern Kentucky near Portsmouth, OH (Fig. 4). A recent study by Wang and others (2002) showed the earthquake deficit and source variation in the central US contributes to an overestimation of the seismic hazard in western Kentucky and an underestimation in northeastern Kentucky (also see UK Press Release, April 18, 2002).

KGS staff and faculty in the Department of Geological Sciences have worked with the federal and state agencies to resolve the overestimation of seismic hazard in western Kentucky by the USGS. Based on the USGS hazard map (Fig. 2), IRC-2000 placed many western Kentucky counties in higher seismic categories, in particular the six counties in the Jackson Purchase area. These counties were designated by seismic design category E (Fig. 5). Even in California, the areas with E category are strictly limited to several active faults such as San Andres fault. KGS recommended that the Kentucky Department of Housing, Buildings and Construction use the ground acceleration with 5% PE in 50 years (Fig. 6) for

western Kentucky with regard to the 2002 Kentucky Residential Code (KRC-2002). KRC-2002 has been adopted with the KGS recommendation. KGS staff and faculty in the Department of Geological Sciences have provided technical advice to the Kentucky Division of Waste Management and Cabinet for Health Services regarding seismic issues for the PGDP landfill projects. A panel led by KGS staff and faculty in the Department of Geological Sciences is currently reviewing the design ground motion for the PGDP landfill submitted by DOE.

Peak Ground Acceleration at the Top of Rock That Will Probably Occur in the Next 500 Years in Kentucky

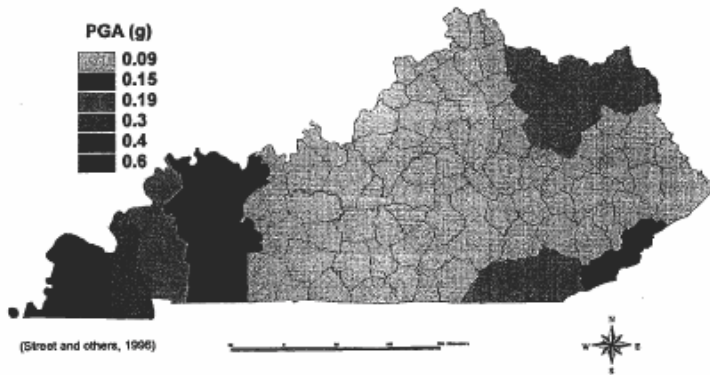


Figure 4. Peak ground acceleration that will probably occur in the next 500 years in Kentucky.

2000 IRC Seismic Category for Kentucky

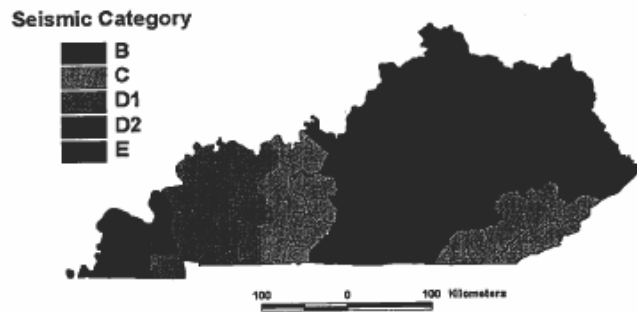


Figure 5. IRC-2000 seismic category for Kentucky.

5% in 50 years (1000 Y Return Period)

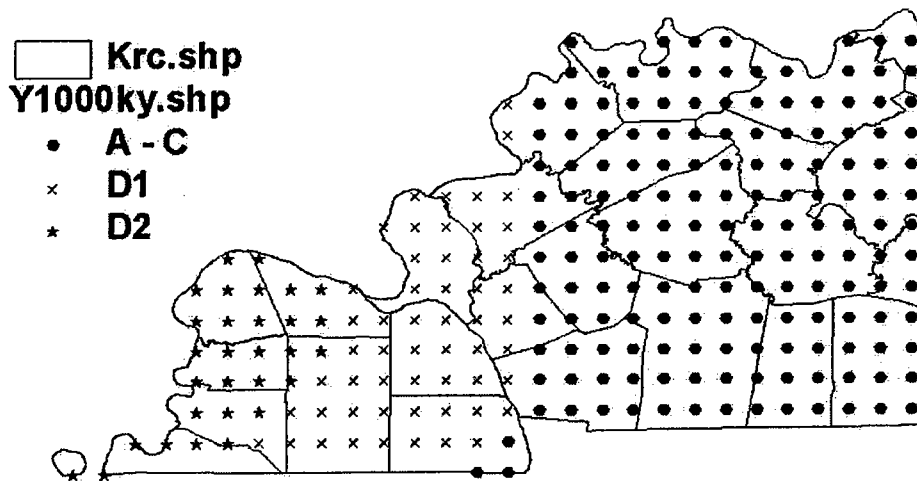


Figure 6. Recommended seismic categories for western Kentucky.

Proposal

Overestimation of the seismic hazard in western Kentucky and an underestimation in northeastern Kentucky and southeastern Ohio by USGS could jeopardize the possible selection of PGDP for the new uranium plant. We propose to conduct a comprehensive study (2 years) to assess seismic hazard and risk near Paducah in western Kentucky and Portsmouth in northeastern Kentucky and southeastern Ohio. The study will include:

- Task 1. Micro-seismicity observation in western Kentucky and northeastern Kentucky and southeastern Ohio.* We propose to deploy ten new seismic stations, five in western Kentucky and five in northeastern Kentucky. These new seismic stations, combined with the existing seismic stations, will capture microseismicity in those areas. The micro-seismic data is the best information because of the lack of geologic data and infrequency of strong earthquakes. The new microseismicity data will allow researchers to accurately characterize seismogenic depths and responsible geologic structures. The current lack of a dense array precludes any definitive answer to these fundamental questions of regional hazard.
- Task 2. Thorough literature review.* There are many new developments in seismic hazard assessment methodology, geology, and seismology regionally, nationally, and internationally. The literature review will ensure the use of the best hazard analysis methodology and available geologic and seismologic data.
- Task 3. Seismic source characterization.* Based on the information derived from Tasks 1 and 2, the seismic sources in and around Kentucky and their characteristics will be defined using the governing NRC regulatory guidelines for nuclear facilities.
- Task 4. Probabilistic seismic hazard analysis (PSHA).* PSHA will be performed based on the seismic source data from Task 3 and following the NRC regulatory guideline RG 1.165. The results will be compared with DSHA (Task 5).
- Task 5. Deterministic seismic hazard analysis (DSHA).* DSHA will be performed based on the seismic source data from Task 3, and will also follow NRC guidelines. The results will be compared with PSHA (Task 4).
- Task 6. Preliminary report.*
- Task 7. Panel review.* A 5-member review panel consisted by national and international experts will be formed to review the preliminary report.
- Task 8. Final report.*