

Research Report
UKTRP-88-X

EARTHQUAKE PRIORITY ROUTES FOR MCLEAN COUNTY, KENTUCKY

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INTRODUCTION

In 1811-1812, three of the most severe earthquakes in American history shook the country. The location of these quakes was not on the infamous San Andreas fault nor anywhere along the well-known fault laden Pacific coast but was near a small town on the Mississippi River where the state of Kentucky and Missouri share a border. It is this river town, New Madrid, Missouri, that is the namesake of a region now regarded by seismologists and disaster response planners as the most hazardous earthquake zone east of the Rocky Mountains -- the New Madrid seismic zone.

In addition to previous occurrences of these great earthquakes, there are several other well documented factors demonstrating the susceptibility of this region to the recurrence of major quakes. Through a decade of extensive research, an ancient crustal rift has been found to underlie the relatively shallow sediments comprising the region's surface. This type of geologic structure, in general, is prone to seismic activity. The New Madrid rift, in particular, has been identified as being of sufficient size to generate major quakes. Further evidence of the area's seismicity is the record of over 2,000 earthquakes detected in the zone since 1974. Though most have been of a magnitude below the threshold of human perception, their existence clearly indicates the high level of seismic activity occurring in the zone even today.

Seismologists have calculated the probabilities of recurrence of sizeable quakes in the New Madrid rift zone. The probability of a 6.3 quake (Richter scale) within 50 years is from 86 to 97 percent. The probability (1) of that same quake occurring within the next 15 years is from 40 to 63 percent. The probability of a 7.6 quake occurring within 50 years is from 19 to 29 percent. The probabilities for this size

quake occurring within 15 years drop quickly to a range of 5.4 to 8.7 percent.

These observations -- prior great earthquakes, an identified geologic structure, and continuing activity -- have created an awareness of the high hazard potential of the New Madrid zone. The very real threat of another significant earthquake coupled with the existence of a number of large population centers and vital facilities in or near the zone have made the formulation of a comprehensive policy for dealing with the effects of an earthquake of utmost importance. A number of steps have already been taken in response to this need.

In 1981, the Federal Emergency Management Agency (FEMA) initiated the Central United States Earthquake Preparedness Project (CUSEPP) to help state governments increase their capability to respond to damaging earthquakes, to promote mitigation activities, and to encourage cooperation between states in the area of emergency planning.

In 1982, the Governor's Task Force on Earthquake Hazards and Safety was created to evaluate Kentucky's earthquake risk and to make recommendations for responding to those risks. This task force recommended increased public awareness and education programs, improved emergency response planning and training, improved building codes and seismic restraint designs, evaluation of other mitigation measures, and participation in national and regional earthquake forums and funding programs.

In 1983, seven states surrounding the New Madrid rift zone joined to form the Central United States Earthquake Consortium (CUSEC), resulting in increased public awareness and closer cooperation among participating states.

In 1984, Governor Collins created the Governor's Earthquake Hazards and Safety Technical Advisory Panel (GEHSTAP) to analyze scientific and

engineering data regarding seismic risks in Kentucky and to make specific recommendations on mitigation, public awareness, response planning, and policy development for public health and safety.

The state's dependence on transportation systems for interstate and intrastate activities and the possible adverse effects a major quake could have on these systems led to the formation of the Earth Stability and Transportation Subcommittee (ESTS) of GEHSTAP. ESTS has made a number of recommendations concerning formulation and implementation of a seismic mitigation policy -- among them the creation of an interagency task force of affected agencies to implement a proposed action plan. The ESTS action plan is synopsisized as follows:

- 1) Establish high priority routes that are vital to the movement of goods and services with special consideration being given to those transportation facilities located in areas of high earthquake probability.
- 2) Compile seismic risk maps of all natural and man-made features susceptible to earthquake damage that could jeopardize those priority transportation routes.
- 3) Educate and train key personnel in the Transportation Cabinet in seismic safety; this includes but is not limited to bridge inspectors, district engineers, construction inspectors, designers, and maintenance personnel.
- 4) Review mitigation planning and establish a program for implementation.
- 5) Use relevant seismic code provisions for all new construction, repair, and maintenance.

This report documents the priority routes that have been established for McLean County, KY. In Appendix A is a detailed list of seismically significant features that have been logged by their milepoints on KY 136

in McLean County. This report also contains a list of retrofitting concepts for various features, a strip map showing the features that were logged (Figure 1), Seismic Performance Categories (SPC) for the bridges in this county (Table 1), and a alluvium map for McLean County (Figure 2).

RETROFITTING CONCEPTS FOR MCLEAN COUNTY, KY., KY 136.

The state maintenance garage is located at the milepost 13.0 on KY 136. The garage should be stocked with various supplies (DGA, steel ramps, chain saws, etc.) in the event of an earthquake. Each individual garage should have an emergency action plan for response during an earthquake.

The bridge/culvert located at milepost 13.1 should have rock berms placed on the toe of both fills approaching the culvert. Several culverts were observed to have settlement problems in their surrounding approaches. Culverts were not logged in our study because they are not seismically prone to failure. But, the fills surrounding the culverts might present a problem. Rock berms should be place at the toe of the fills approaching the culverts.

A rock berm could be placed at milepost 13.2 along the north side of the road adjacent to the swampy area. The rock berm should help hold the road in place if liquifaction occurs in the underlying subgrade. This is probably low priority since the adjacent parking lot will allow for a alternate detour.

At milepost 13.6 two crude oil storage tanks are surrounded by a severely eroded containment dike. The dike should be rebuilt and covered with 57 stone to help prevent erosion. A diversion trench should

also be dug between the dike and KY 136.

A clay core dike should be placed around the tanks at milepost 15.5.

At milepost 16.4 the grain elevator should be tied with restraining cables in the opposite direction of the road.

At milepost 16.45 a large farm pond with a earth dam faces KY 136. The toe of the dam should be reinforced with a rock berm.

The bridge approaches at milepost 17.1 should be reinforced with rock berms.

The crude oil tanks at milepost 18.4 should be relocated if they are still in service.

The bridge at milepost 19.2 should be retrofitted with cable restraints. Cable restraints should be used at the abutment to keep the main span in contact with the abutment. Restraints should also be used to tie the box beams to each other and to the pier. The current open abutments are allowing the soil to migrate through the abutment piers. The abutments should be lined with a heavy shot rock. Rock berms should also be place around the toe of the approach fills.

A gasline crosses under the road at milepost 19.45. A shut off valve is located approximately 300-feet south of the road. County officals should contact the Webster KY. Gas Corporation and correlate an emergency response plan.

At milepost 19.7 a farm pond with a earth empoundment structure lies uphill from the road. A rock berm should be place around the base of the dam.

The bridge at milepost 20.9 should be retrofitted with cable

restraints. Cable restraints should be used at the abutments. Cable restraints should also be used to tie the box beams to each other and to the pier.

Three electrical lines cross Ky 136 at milepost 24.30. The utility which owns the lines should be contacted and a emergency response plan should be corredinated.

A farm pond dam at milepost 24.35 needs a rock berm placed at the toe of the dam. road.

BRIDGES

There are four bridges located on KY 136. To determine if these bridges need retrofiting, their Seismic Performance Categories (SPC) were defined. The SPC permit variation in the retrofiting requirements and analysis methods in accordance with the seismic risk associated with a particular bridge location. According to the Applied Technology Concil's publication entitle "Seismic Retrofitting Guidelines for Highway Bridges" (ATC-6-2), bridges classified as SPC A are designed for the lowest level of Seismic activity and those classified as SPC D are designed for the highest level of seismic activity. The SPC are determined from the importance classification (IC) and the acceleration coefficient (A). The bridges under consideration in this county were classified as essential bridges and were assigned IC values of one. The acceleration coefficient map recommended by ATC-6-2, gives a value of 0.05 for McClean County. Using the described values of IC and A as inputs for the computer program written for this study, the SPC for the bridges in this county were defined. A copy of the program output is shown in Table 1. Important information about the bridges in this

county such as locations, number of spans, types (steel or concrete), beam types, length, and width are also summarized in the program output. All of the bridges classified as SPC A. The retrofiting guidelines recommended by ATC-6-2, indicate that bridges in SPC A generally are not considered for seismic retrofiting. However the areal extent of alluvium that is present in Western Kentucky could change the SPC ratings to a B or possibly even a C.

Conclusions

It is recommended the bridges in McLean County be retrofitted with cable restraints, cover the embankment slopes under the bridge with large stone, and surround the bridge approaches with rock berms.

Oil tanks should be surrounded with clay core dikes, and diversion trenches where needed.

The local or county utility companys that have major water, gas, or electrical lines that cross under or over the road should be contacted and a emergency response plan should be established.

Large farm ponds with dams should be retrofitted with rock berms.

Approximately 15 fills were logged on Ky 136. Rock berms should be placed at the toe of fills. Fills built over or near swampy terrain is a major concern. The bottom of fills if saturated with water could liquify during seismic activity and collapse the entire structure.

Additional problems involving fills could occur at bridge and culvert approach fills. Rock berms should also be placed at the toe of these fills.

There appears to be a large amount of alluvium present in McClean County (Figure 2). Special care should be taken in the areas built on

alluvium, because of the possibility of liquefaction occurring in these areas, especially where high water tables may be present.

There have been eight geologic faults logged in the data base for Ky 136 in McLean County. These faults are seismically since a large earthquake could trigger additional movement along one or more of those old slip planes.

APPENDIX A
SEISMICALLY SIGNIFICANT FEATURES

REPORT BY ROAD AND MILEPOINT
 FOR MCLEAN COUNTY - KENTUCKY
 KY 136

MILEPOINT	FEATURE	DATA
12.90	OTHER	JCT US 81 HEADING NE ROAD SURFACE TYPE - FLEXIBLE
12.90	OTHER	CITY OF CALHOUN ROAD SURFACE TYPE - FLEXIBLE
12.90	OTHER	BEGIN KY 136 EARTHQUAKE STUDY ROAD SURFACE TYPE - FLEXIBLE
13.05	FILL	MATERIAL TYPE - SOIL HEIGHT 8 LENGTH 200 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE
13.15	FILL	MATERIAL TYPE - SOIL HEIGHT 8 LENGTH 200 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE
13.20	OTHER	SWAMPY AREA ROAD SURFACE TYPE - FLEXIBLE
13.30	PIPELINE	PIPELINE TYPE - GAS SIZE 1 IN DEPTH 10 FT PIPELINE NUMBER 1 ROAD SURFACE TYPE - FLEXIBLE
13.35	FAULT	FAULT ROAD SURFACE TYPE - FLEXIBLE
13.60	TANK	OIL TANK NUMBER OF TANKS 2 TOTAL CAPACITY UNKNOWN DISTANCE FROM ROAD 20 ROAD SURFACE TYPE - FLEXIBLE
14.80	OTHER	JCT KY 250 HEADING NORTH ROAD SURFACE TYPE - FLEXIBLE
15.50	TANK	GASOLINE TANK NUMBER OF TANKS 2 TOTAL CAPACITY UNKNOWN DISTANCE FROM ROAD 20 ROAD SURFACE TYPE - FLEXIBLE
15.50	TREES	NUMBER OF TREES 10 HEIGHT 45 DIAMETER 28 IN ENDING MILEPOINT 15.55 DISTANCE FROM ROAD 15 ROAD SURFACE TYPE - FLEXIBLE
15.52	FAULT	FAULT ROAD SURFACE TYPE - FLEXIBLE
16.30	TREES	NUMBER OF TREES 10 HEIGHT 45 DIAMETER 28 IN ENDING MILEPOINT 16.31 DISTANCE FROM ROAD 15 ROAD SURFACE TYPE - FLEXIBLE

REPORT BY COUNTY AND MILEPOINT
 FOR MCLEAN COUNTY - KENTUCKY
 KY 136

CONTINUED

MILEPOINT	FEATURE	DATA
16.40	OTHER	GRAIN SILO ROAD SURFACE TYPE - FLEXIBLE
16.41	FAULT	FAULT ROAD SURFACE TYPE - FLEXIBLE
16.45	OTHER	POND: 42' FROM ROAD, (400 x 200)' ROAD SURFACE TYPE - FLEXIBLE
17.05	FILL	MATERIAL TYPE - SOIL HEIGHT 10 LENGTH 500 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE
17.11	FAULT	FAULT ROAD SURFACE TYPE - FLEXIBLE
17.13	BRIDGE	NUMBER OF SPANS 1 OVER STREAM CONCRETE T-BEAM END 1 FIXED END 2 FIXED DECK TYPE - CONCRETE LENGTH 43 WIDTH 19 SURFACE TYPE - FLEXIBLE SFC A NO RETROFIT EXPANSION TYPE - OTHER END 1 SUBSTRUCTURE - STUB END 2 SUBSTRUCTURE - STUB PIER TYPE - SOLID FOUNDATION TYPE - UNKNOWN
17.15	FILL	MATERIAL TYPE - SOIL HEIGHT 10 LENGTH 1000 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE
18.20	TREES	NUMBER OF TREES 5 HEIGHT 40 DIAMETER 20 IN ENDING MILEPOINT 18.21 DISTANCE FROM ROAD 15 ROAD SURFACE TYPE - FLEXIBLE
18.45	TANK	GASOLINE TANK NUMBER OF TANKS 3 TOTAL CAPACITY UNKNOWN DISTANCE FROM ROAD 10 ROAD SURFACE TYPE - FLEXIBLE
18.74	FAULT	FAULT ROAD SURFACE TYPE - FLEXIBLE
19.15	FILL	MATERIAL TYPE - SOIL HEIGHT 10 LENGTH 200 SIDESLOPE 3:2 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE

REPORT BY COUNTY AND MILEPOINT
 FOR MCLEAN COUNTY - KENTUCKY
 KY 136

Continued

MILEPOINT	FEATURE	DATA
19.17	BRIDGE	NUMBER OF SPANS 3 OVER STREAM CONCRETE -BOX BEAM END 1 FIXED PIER 1 FIXED PIER 2 FIXED END 2 FIXED DECK TYPE - CONCRETE LENGTH 119' WIDTH 19 SURFACE TYPE - FLEXIBLE SPC A NO RETROFIT EXPANSION TYPE - OTHER END 1 SUBSTRUCTURE - STUB END 2 SUBSTRUCTURE - STUB PIER TYPE - SOLID FOUNDATION TYPE - UNKNOWN
19.25	FILL	MATERIAL TYPE - SOIL HEIGHT 10 LENGTH 800 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE
19.31	TREES	NUMBER OF TREES 200 HEIGHT 30 DIAMETER 18 IN ENDING MILEPOINT 19.70 DISTANCE FROM ROAD 15 ROAD SURFACE TYPE - FLEXIBLE
19.45	PIPELINE	PIPELINE TYPE - GAS SIZE 10 IN DEPTH 10 FT PIPELINE NUMBER 1 ROAD SURFACE TYPE - FLEXIBLE
19.45	OTHER	GAS SHUTOFF VALVE 300' SOUTH OF ROAD ROAD SURFACE TYPE - FLEXIBLE
19.70	OTHER	POND: 25' FROM ROAD, (150 x 200)' ROAD SURFACE TYPE - FLEXIBLE
19.72	FAULT	FAULT ROAD SURFACE TYPE - FLEXIBLE
19.90	FILL	MATERIAL TYPE - SOIL HEIGHT 15 LENGTH 70 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE
20.10	OTHER	CAVED MINE ADITS ROAD SURFACE TYPE - FLEXIBLE
20.63	FAULT	FAULT ROAD SURFACE TYPE - FLEXIBLE
20.85	FILL	MATERIAL TYPE - SOIL HEIGHT 15 LENGTH 200 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE

REPORT BY COUNTY AND MILEPOINT
 FOR MCLEAN COUNTY - KENTUCKY
 KY 136

Continued

MILEPOINT	FEATURE	DATA
20.88	BRIDGE	NUMBER OF SPANS 7 OVER STREAM CONCRETE T-BEAM END 1 FIXED PIER 1 FIXED PIER 2 FIXED PIER 3 FIXED PIER 4 FIXED PIER 5 FIXED PIER 6 FIXED END 2 FIXED DECK TYPE - CONCRETE LENGTH 153 WIDTH 19 SURFACE TYPE - FLEXIBLE SPC A NO RETROFIT EXPANSION TYPE - OTHER END 1 SUBSTRUCTURE - STUB END 2 SUBSTRUCTURE - STUB PIER TYPE - SOLID FOUNDATION TYPE - UNKNOWN
20.95	FILL	MATERIAL TYPE - SOIL HEIGHT 15 LENGTH 200 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE
20.96	FAULT	FAULT ROAD SURFACE TYPE - FLEXIBLE
21.50	TREES	NUMBER OF TREES 50 HEIGHT 25 DIAMETER 18 IN ENDING MILEPOINT 21.70 DISTANCE FROM ROAD 15 ROAD SURFACE TYPE - FLEXIBLE
21.70	OTHER	CITY OF LIVERMORE ROAD SURFACE TYPE - FLEXIBLE
21.70	FILL	MATERIAL TYPE - SOIL HEIGHT 10 LENGTH 100 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE
22.40	TREES	NUMBER OF TREES 100 HEIGHT 50 DIAMETER 24 IN ENDING MILEPOINT 23.10 DISTANCE FROM ROAD 15 ROAD SURFACE TYPE - FLEXIBLE
22.50	OTHER	JCT US 431 HEADING N-S ROAD SURFACE TYPE - FLEXIBLE
23.40	OTHER	TANK ROAD SURFACE TYPE - FLEXIBLE
23.60	PIPELINE	PIPELINE TYPE - GAS SIZE 1 IN DEPTH 10 FT PIPELINE NUMBER 1 ROAD SURFACE TYPE - FLEXIBLE
23.80	FILL	MATERIAL TYPE - SOIL HEIGHT 15 LENGTH 100 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE
24.10	FILL	MATERIAL TYPE - SOIL HEIGHT 15 LENGTH 100 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE

REPORT BY COUNTY AND MILEPOINT
 FOR MCLEAN COUNTY - KENTUCKY
 KY 136

Continued

MILEPOINT	FEATURE	DATA
24.20	TREES	NUMBER OF TREES 100 HEIGHT 35 DIAMETER 18 IN ENDING MILEPOINT 23.90 DISTANCE FROM ROAD 20 ROAD SURFACE TYPE - FLEXIBLE
24.30	POWER LINE	ELECTRICAL POWERLINE 3 LINES HEIGHT 30 WOOD SUPPORT STRUCTURE UNKNOWN VOLTS ROAD SURFACE TYPE - FLEXIBLE
24.35	OTHER	POND: 60' FROM ROAD, (100 x 100) ROAD SURFACE TYPE - FLEXIBLE
24.90	FILL	MATERIAL TYPE - SOIL HEIGHT 10 LENGTH 100 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE
25.00	CUT SLOPE	CUT SLOPE TYPE - SOIL HEIGHT 15 LENGTH 75 ROAD SURFACE TYPE - FLEXIBLE BACKSLOPE 2:1
25.10	FILL	MATERIAL TYPE - SOIL HEIGHT 15 LENGTH 100 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE
25.40	FILL	MATERIAL TYPE - SOIL HEIGHT 15 LENGTH 100 SIDESLOPE 2:1 CREST 25 TYPE FILL - OTHER ROAD SURFACE TYPE - FLEXIBLE
25.70	TREES	NUMBER OF TREES 50 HEIGHT 40 DIAMETER 24 IN ENDING MILEPOINT 25.80 DISTANCE FROM ROAD 20 ROAD SURFACE TYPE - FLEXIBLE
25.80	OTHER	JCT KY 1080 HEADING WEST ROAD SURFACE TYPE - FLEXIBLE
25.80	OTHER	MCLEAN CO--OHIO CO BOUNDARY ROAD SURFACE TYPE - FLEXIBLE

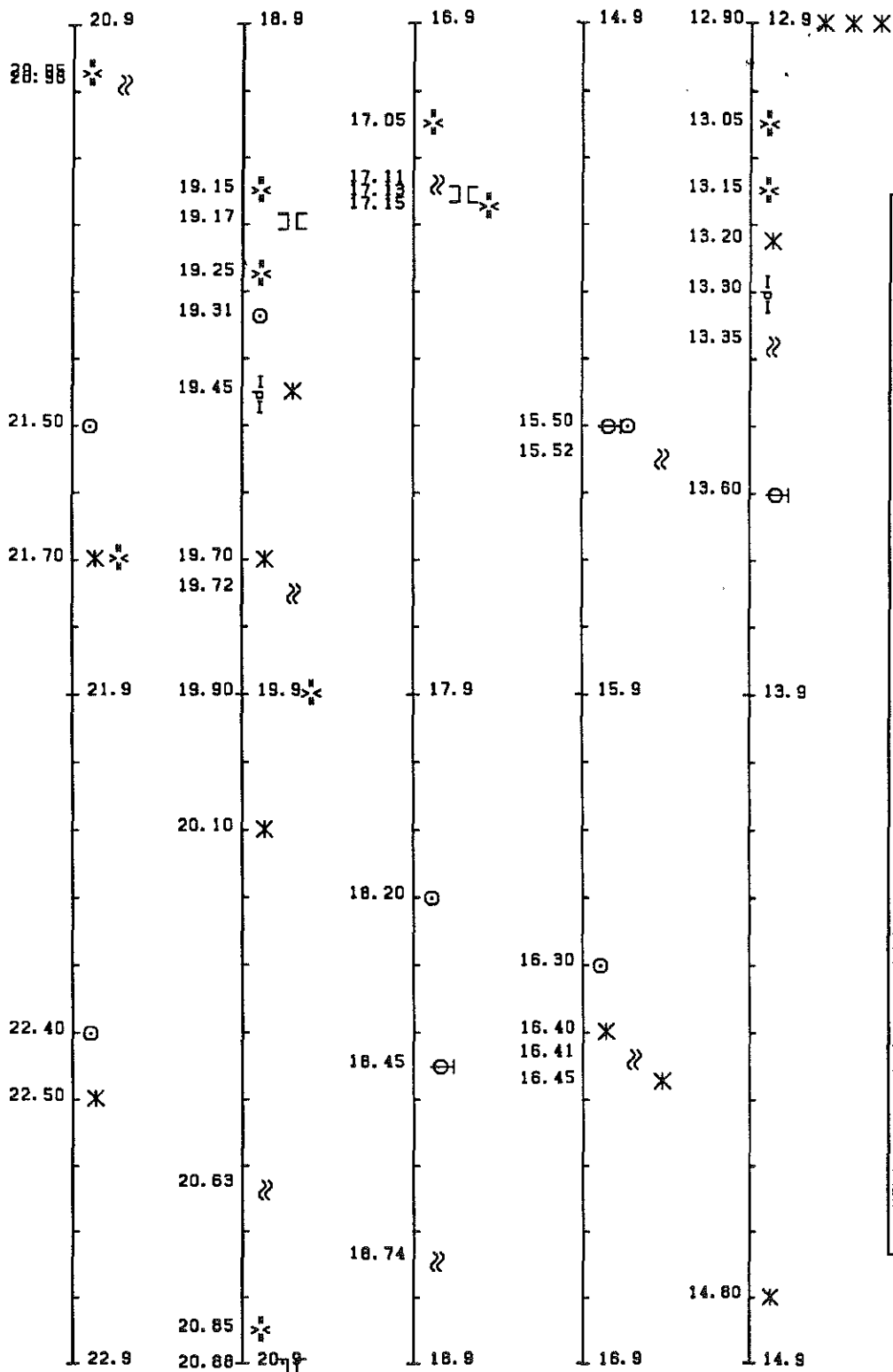
TABLE 1.

SEISMIC PERFORMANCE CATEGORIES (SPC)
FOR THE BRIDGES IN MCLEAN COUNTY

COUNTY NAME	ROAD NAME	MILE NUMBER POST	T OF SPAN	B Y P E M	LENGTH IN FEET	WIDTH IN FEET	ACC. COEFF.	IMP. COEFF.	SPC
MCLEAN	KY136	13.20	2	C B	36.0	19.0	0.05	1	A
MCLEAN	KY136	17.10	1	C T	43.0	19.0	0.05	1	A
MCLEAN	KY136	19.20	3	C B	119.0	19.0	0.05	1	A
MCLEAN	KY136	20.90	7	C T	253.0	19.0	0.05	1	A

FIGURE 1. STRIP MAP FOR MCLEAN COUNTY

KY 136 MCLEAN CO.



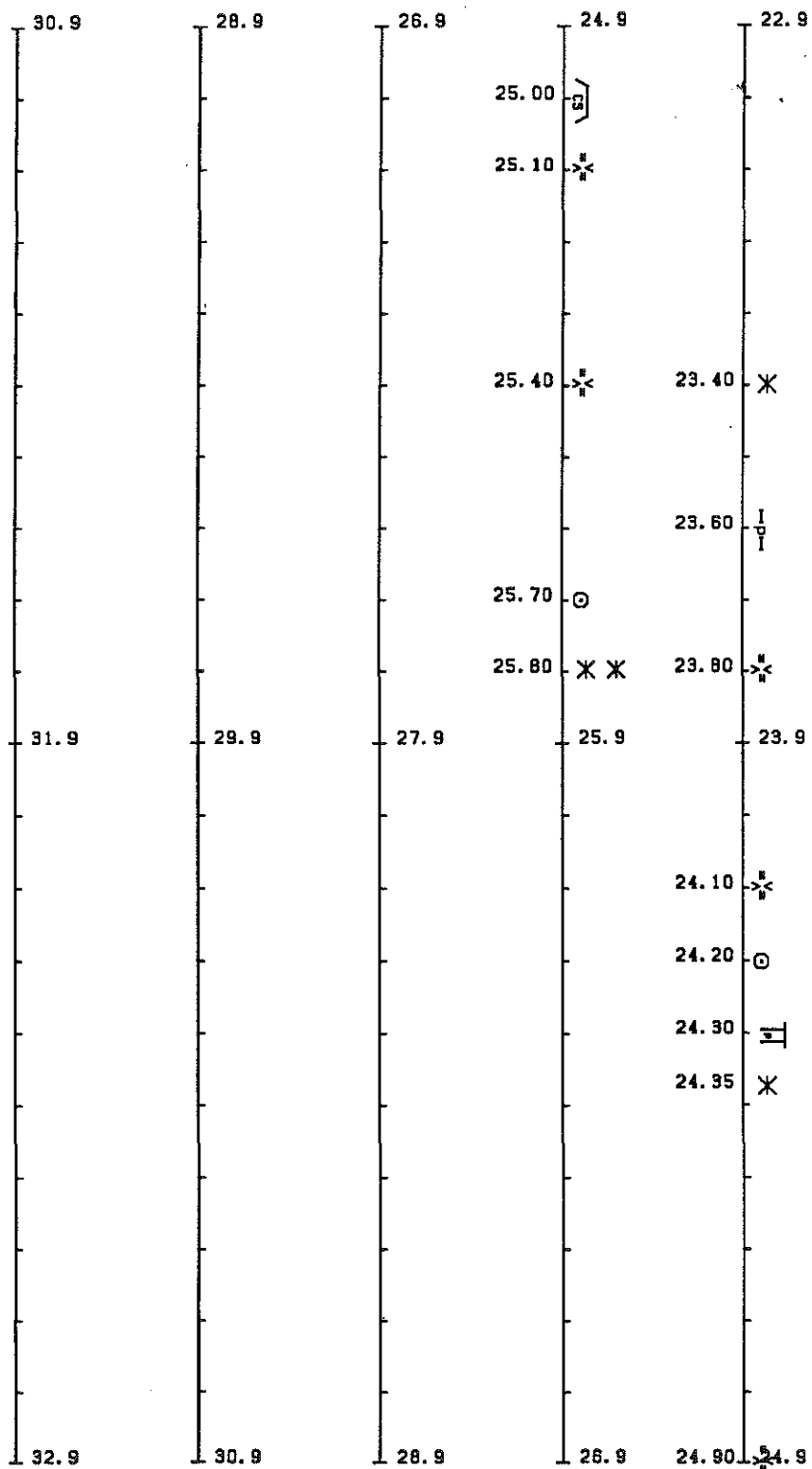
LEGEND OF FEATURES

⊖	BRIDGE	△	BUILDING	*	FILL
⊙	TREE	⊠	SIGN	≈	FAULT
— —	PIPELINE	⊞	TANK	II	DAM
⊞	CUT SLOPE	⊠	POWER LINE	≈	OTHER
⊞	MINE				

SEE REPORT FOR DESCRIPTIONS OF OTHER

FIGURE 1. (Continued)

KY136 MCLEARN CO.



LEGEND OF FEATURES

	BRIDGE		CUT SLOPE		BUILDING		FILL		OTHER
	TREE		POWER LINE		SIGN		FAULT		
	PIPELINE		MINE		TANK		DAM		

SEE REPORT FOR DESCRIPTIONS OF OTHER

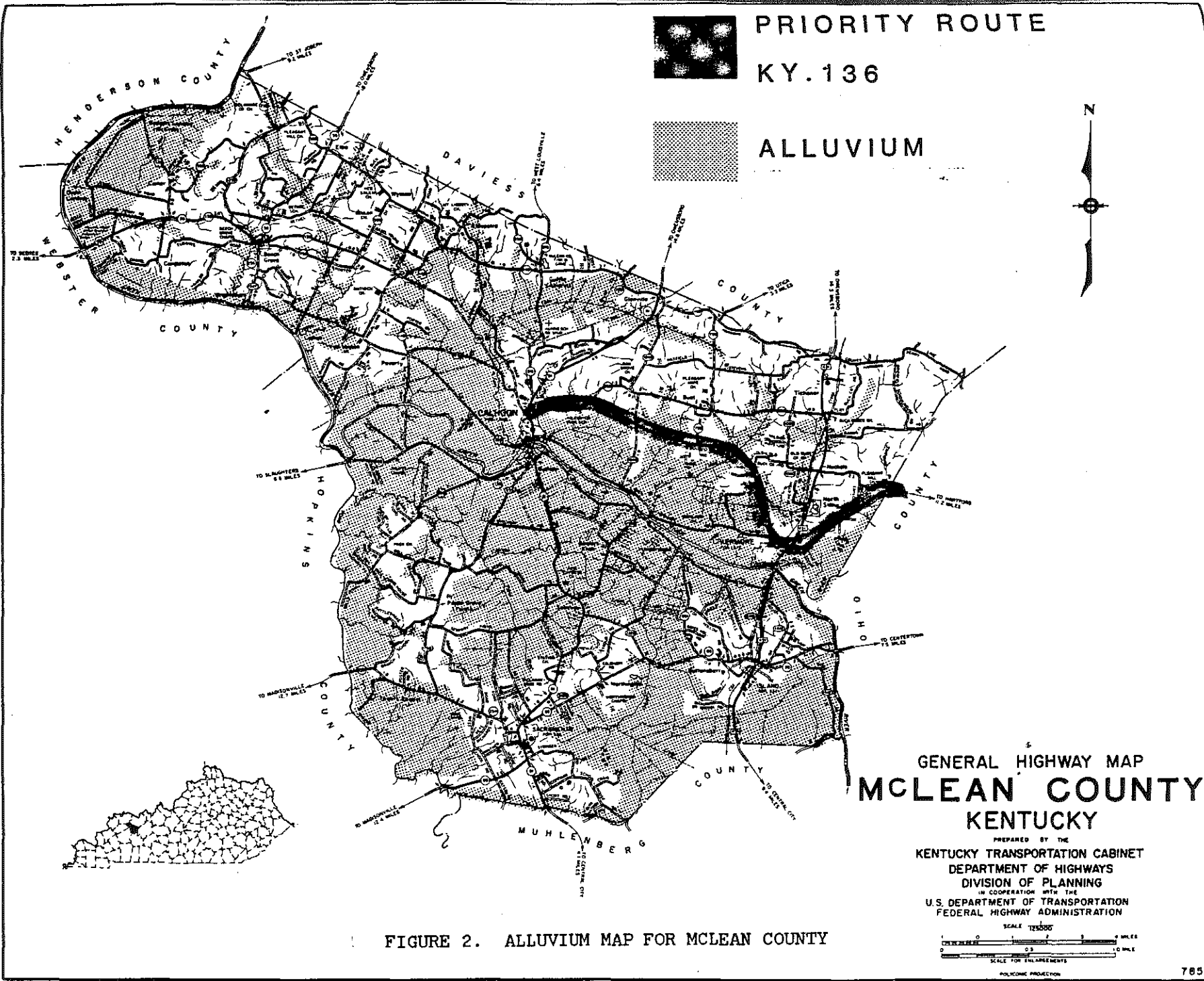


FIGURE 2. ALLUVIUM MAP FOR MCLEAN COUNTY