SEARCH FOR AND STUDY OF SAND BLOWS AT DISTANT SITES RESULTING FROM PREHISTORIC AND HISTORIC NEW MADRID EARTHQUAKES:
Collaborative Research, M. Tuttle & Associates and Central Region Hazards Team, U.S. Geological Survey

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Martitia P. Tuttle
M. Tuttle & Associates
128 Tibbetts Lane
Georgetown, ME 04548
Tel: 207-371-2007
E-mail: mptuttle@earthlink.net
URL: http://www.mptuttle.com

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Martitia P. Tuttle
M. Tuttle & Associates
128 Tibbetts Lane
Georgetown, ME 04548
Tel: 207-371-2007
E-mail: mptuttle@earthlink.net

Abstract

Earthquake-induced liquefaction features, including 34 sand blows, were discovered, documented, and measured at 100 new sites along the Castor River in southeastern Missouri, the Little River in northeastern Arkansas, Mayfield Creek in western Kentucky, and the Hatchie, Loosahatchie, and Wolf Rivers in western Tennessee. The weathering characteristics of the liquefaction features as well as radiocarbon and optically stimulated luminescence dating were used to interpret the ages of most of the liquefaction features. An especially significant findings is a weathered 5.5 kyr old sand blow northwest of Marked Tree, Arkansas that probably formed during a **M** >7 earthquake centered in the Marianna area. It suggests that a record of paleoearthquakes is available in the Late Wisconsin deposits of the western portion of the St. Francis Basin that would help to shed light on the long-term behavior of the NMSZ and other earthquake sources in the region. Many of the other documented liquefaction features also are thought to be prehistoric in age. Additional effort to constrain the age estimates of the features may help to reduce uncertainties related to recurrence times of New Madrid earthquakes and to identify earthquake sources outside the NMSZ. Our findings enlarge the liquefaction fields for the A.D. 1811-1812 and A.D. 1450 New Madrid earthquakes. Compound sand blows, composed of 2 to 4 depositional units, on the Hatchie and Little Rivers formed during the A.D. 1811-1812 and 1450, and possibly earlier New Madrid earthquake sequences, will help to further define liquefaction fields and thus the source areas and magnitudes of earthquakes within each sequence. Evaluation of scenario earthquakes suggests that liquefaction features along the Black, Cache, Current, and White Rivers in the Western Lowlands, the Cross County Ditch in the St. Francis Basin, and the Hatchie River in western Tennessee could be explained by earthquakes similar in locations and magnitudes (**M** >7) to the 1811-1812 New Madrid mainshocks.

Introduction

Paleoseismological studies have begun to decipher the Holocene earthquake history of the New Madrid seismic zone (NMSZ) and have changed the perception of the hazard it poses. 1811-1812-type earthquake sequences, or New Madrid events, in A.D. 900 ± 100 yr and A.D. 1450 ± 150 yr and possibly in 2350 ± 200 yr B.C., were recognized largely through the study of earthquake-induced liquefaction features across the New Madrid region (Figure 1; e.g., Tuttle et al., 2002, and 2005). From these paleoseismic data, a mean recurrence time of 500 years was

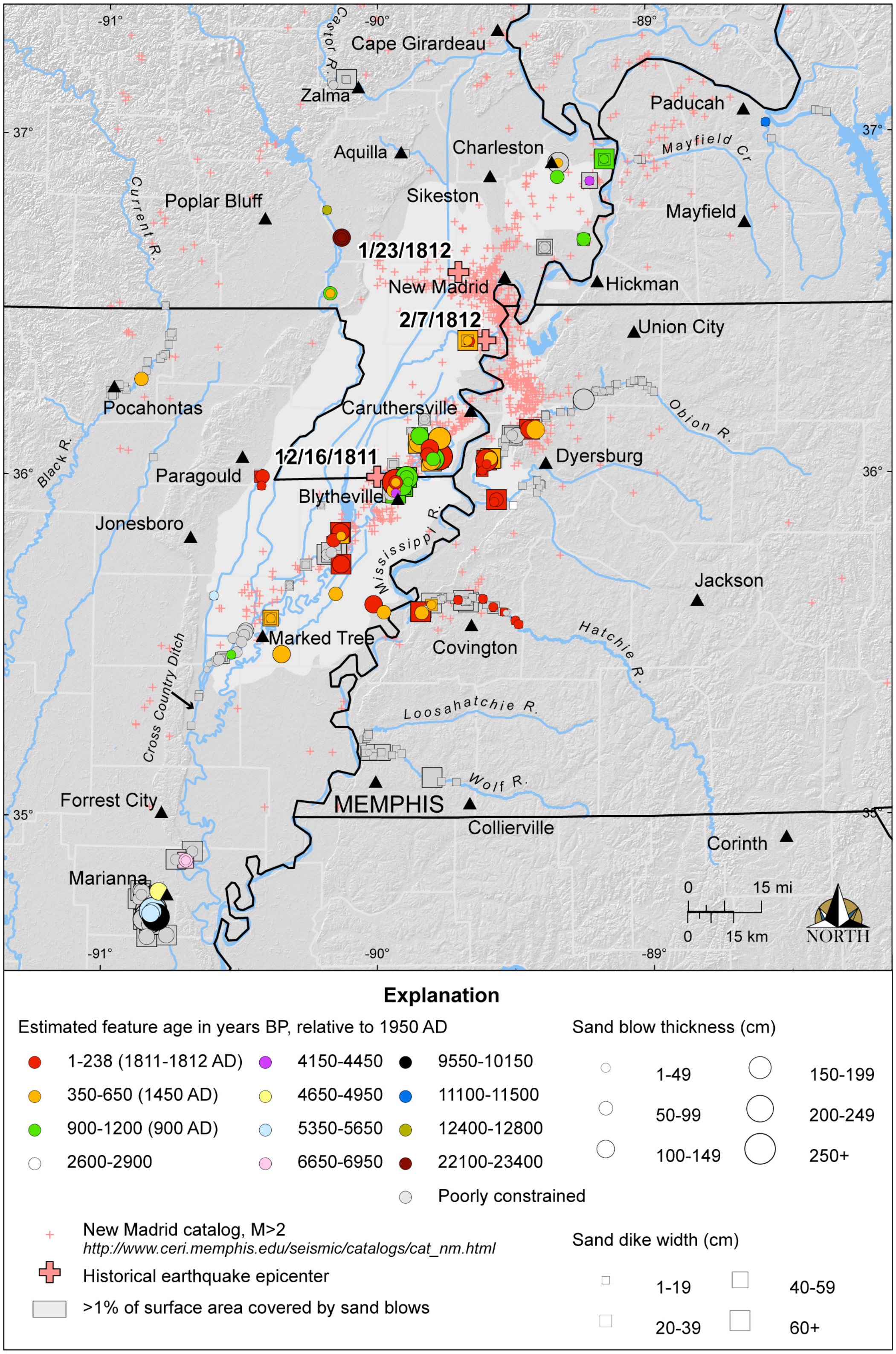

Figure 1. Map of NMSZ showing ages and sizes of earthquake-induced liquefaction features, including sand blows and sand dikes, that were found during this and previous studies in greater New Madrid region (modified from Tuttle et al., 2005).

estimated for New Madrid events. Although it is based on only two earthquake cycles, the 500-year recurrence time has changed assessments of the regional earthquake hazard and has been incorporated into the National Probabilistic Seismic Hazard Map (Frankel et al, 2002; Petersen et al., 2008).

Recently, large New Madrid-size sand blows have been found near Marianna, Arkansas, and the southern end of the Reelfoot Rift, where few modern or historic earthquakes have been centered (Figure 1; Al-Shukri et al., 2006; Tuttle et al., 2006). The sand blows are Middle Holocene in age and are thought to be result of very large (**M** > 7) earthquakes centered in the Marianna area. This discovery suggests that seismicity migrates along the Reelfoot Rift, and therefore, that currently aseismic portions of the rift may produce large damaging earthquakes in the future. A more accurate, more complete, and longer history of paleoearthquakes in northeastern Arkansas, southeastern Missouri, and western Kentucky and Tennessee would help to reduce the uncertainty in the mean recurrence time of New Madrid events and to improve the understanding of the long-term behavior of the New Madrid fault zone and other faults in the Reelfoot Rift system.

This study builds on previous findings and aims to reduce uncertainties regarding locations, magnitudes, and recurrence times of very large New Madrid earthquakes. The specific goals of this study are (1) to find, measure, date, and correlate sand blows beyond their currently known distributions, (2) to identify distal sites of liquefaction related to major New Madrid earthquakes, (3) to employ liquefaction potential analysis to help constrain locations and magnitudes of New Madrid earthquakes, and (4) to determine if mapped faults outside the currently active NMSZ have generated large earthquakes during the Holocene and Late Wisconsin. To accomplish these goals, we conducted reconnaissance for and study of earthquake-induced liquefaction features along the Castor River in southeastern Missouri, the Little River in northeastern Arkansas, Mayfield Creek in western Kentucky, and the Hatchie, Loosahatchie, and Wolf Rivers in western Tennessee. We also compiled geotechnical data for fluvial deposits along the Black, Cache, Current, Hatchie, and White Rivers and Cross County Ditch and evaluated scenario earthquakes using liquefaction potential analysis.

This research was conducted in collaboration with Eugene Schweig of the U.S. Geological Survey. D. Bellan, S. Kroupa, L. Mayrose, N. McCallister, C. Prentice, and H. Schroeder assisted with reconnaissance, K. Dyer-Williams compiled and analyzed geotechnical data, and K. Tucker updated the regional map of liquefaction sites. Beta Analytic, Inc. performed radiocarbon dating and S. Mahan of the U.S. Geological Survey conducted OSL dating for this project.

Reconnaissance for Earthquake-Induced Liquefaction Features

During this project, we searched for earthquake-induced liquefaction features along 50 km of the Castor River in southeastern Missouri, 17 km of the Little River in northeastern Arkansas, 8 km of Mayfield Creek in western Kentucky, as well as 46 km of the Hatchie River, 5 km of the Loosahatchie River, and 18 km of the Wolf River in western Tennessee. We found and documented earthquake-induced liquefaction features, including 34 sand blows, at more than 100 sites and collected organic and sediment samples for dating purposes (Figure 1 and Table 1).

Radiocarbon and optically stimulated luminescence (OSL) dating was carried out on selected samples from some of the liquefaction sites (Tables 2 and 3). The results of dating were used to estimate the ages of the liquefaction features.

<u>Castor River</u>

We surveyed three sections of the Castor River, a 34-km section in the vicinity of Zalma and Greenbrier, a 2-km section near Sturdivant, and a 13-km section near Aquilla. Near Zalma, the Castor River cuts through the southeastern edge of the Ozark Plateau. At Greenbrier, the river discharges into the Advance Lowlands of the Mississippi River Valley (Saucier, 1994). Along the Zalma-Greenbrier section of the river, there are many excellent exposures of what appears to be Holocene fluvial deposits. The river section near Sturdivant was ponded due to diversion of stream flow along the Castor River Diversion Channel. Thus, the cutbanks were low and exposure poor. The section of the river near Aquilla cuts through Crowleys Ridge. Here, there are many good exposures of Holocene fluvial deposits. About 3 km downstream from Aquilla, however, the cutbanks are protected with riprap and exposure becomes poor.

Along the Zalma-Greenbrier section of the Castor River, we documented sand dikes and a possible sand blow at three sites (Figure 1 and Table 1). Sand dikes ranged up to 80 cm wide and a possible sand blow was 20 cm thick. Some of the features are loose and unweathered and therefore are interpreted to be historic in age. They probably formed during the 1811-1812 New Madrid earthquakes. Other features are iron-stained and cemented and therefore are interpreted to be prehistoric in age. This applies to the sand dike and possible sand blow at site 4 (Table 1). Radiocarbon dating of charred material collected from the deposit cut by the dike and below the possible sand blow indicates that these features formed during the past 3 kyr. Near Aquilla, we found three sand dikes at site 1 (Table 1). The dikes range up to 4 cm wide. Two of the dikes are deeply bioturbated suggesting that they are also prehistoric in age. Currently, many of the age estimates of the liquefaction features along the Castor River are poorly constrained. Site investigations are needed to collect and date additional samples in order to better constrain the ages of the liquefaction features.

<u>Hatchie River</u>

We have surveyed 46 km of the Hatchie River downstream from the Rt. 54 crossing east of Covington (Figure 1). To date, we have not yet found the eastern limit of earthquake-induced liquefaction along the Hatchie River. There are many excellent exposures along the river that has not been channelized unlike many of the rivers in the region. Mostly Holocene deposits are exposed along the western portion of the river; whereas, Holocene and Late Wisconsin deposits are exposed along the eastern portion of the river.

Along the Hatchie River, we documented liquefaction features, including 24 sand blows, at 71 sites (Table 1). The sand blows range up to 65 cm thick and the sand dikes range up to 95 cm wide. In general, sand blow thickness and sand dike width decrease with distance from the NMSZ (Figure 1). There are at least two generations of liquefaction features along the Hatchie River. The age of many of the features are poorly constrained but most features can be separated into historic and prehistoric categories on the basis of weathering characteristics, including

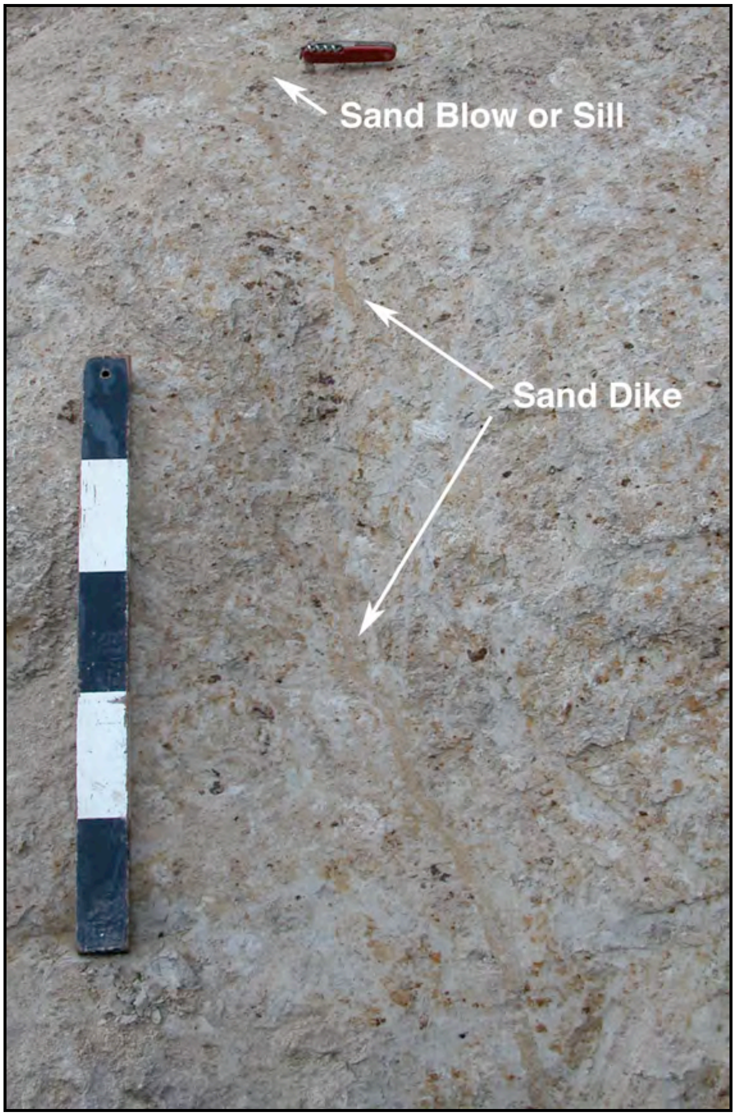

Figure 2. Small liquefaction features, including 1.5-cm-wide sand dike and possible 0.5-cm-thick sand blow or sill at site 38 along Hatchie River. Silt coatings on sand grains and manganese nodules within sand dike suggest that liquefaction features could be thousands of years old. On scale, black and white intervals represent 10 cm.

degree and depth of bioturbation, fines accumulation, iron staining, and formation of iron and manganese nodules (Figure 2). In addition, radiocarbon and OSL dating of samples collected at several sites allow for more precise age estimates (Tables 1, 2, and 3). Accordingly, five of the sand blows probably formed during the 1811-1812 earthquakes, while two other sand blows probably formed during the A.D. 1450 event (Figure 3). Seven of the sand blows are compound in nature, indicating multiple large shocks in an earthquake sequence (Table 1). Two of the sand blows that formed in 1811-1812 are composed of two depositional units, and one of the sand blows that formed in A.D. 1450 is composed of three depositional units (Figure 4). The other four compound sand blows that are thought to be prehistoric in age. Three of them are composed of two depositional units and the fourth prehistoric sand blow is composed of three units.

Figure 3. Mottled and iron-stained sand blow and feeder dike at site 105 along Hatchie River probably formed during A.D. 1450 event. OSL dating of sample of contact between sand blow and buried soil or event horizon provides close maximum age constraint of 532 ± 14.9 yr B.P.

As mentioned above, many of the liquefaction features along the Hatchie River are thought to be prehistoric in age. Weathering characteristics of some of these features suggest that they could be thousands of years old. With additional work at selected sites, it may be possible to better constrain the age estimates of older liquefaction features and to determine if they formed during other New Madrid paleoearthquakes (e.g., A.D. 900 and 2350 B.C.) or during paleoearthquakes outside the New Madrid seismic zone.

Little River

We surveyed a total of 17 km of drainage ditches (#3, #81, and the relief ditch) that follow the Right-Hand Chute of the Little River downstream from Big Lake (Figure 1). The Little River and now the drainage ditches flow along the escarpment of Late Wisconsin braided-stream deposits (Saucier, 1994). The ditches provide almost continuous exposure of Holocene and Late Wisconsin fluvial deposits.

Along the Little River ditches, we documented liquefaction features, including 8 sand blows, at 11 sites (Table 1). Sand dikes range up to 184 cm wide and the sand blows range up to 130 cm thick. The liquefaction features in this area are fairly large but not as large as those in the Blytheville-Caruthersville area (Figure 1). There are at least two generations of liquefaction features along the Little River including those that formed in A.D. 1811-1812 and A.D. 1450.

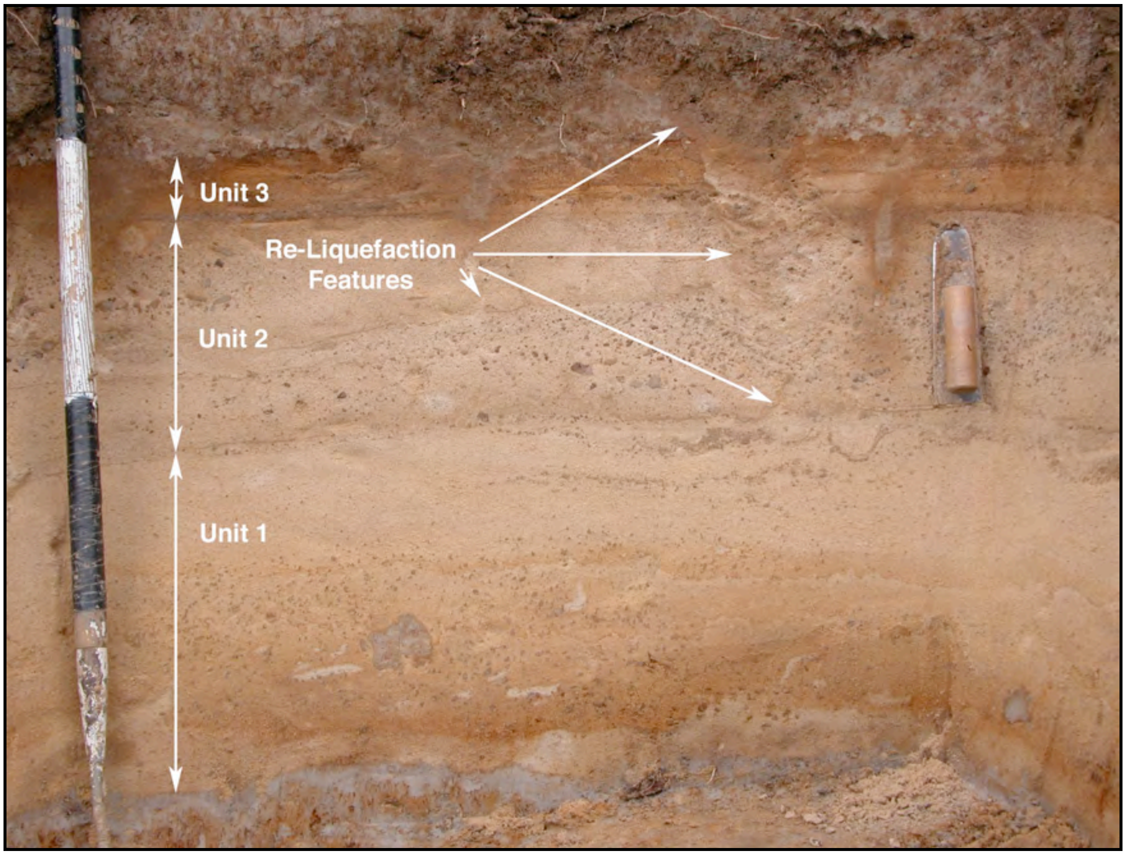

Figure 4. Iron-stained compound sand blow at site 31 along Hatchie River probably formed during A.D. 1450 earthquake sequence. Sand blow is 65-cm-thick and composed of three major sedimentary units thought to have formed during three large earthquakes in sequence. Upper 8 cm of sand blow is especially iron-stained and bioturbated and overlain by mottled silt suggesting it is prehistoric in age. Radiocarbon dating of charred material collected 7 cm below sand blow provides close maximum age constraint of A.D. 1280-1410 or 670-540 yr B.P. Load casts and sand diapirs (one of which extends into overlying mottled silt) within sand blow indicate that sand blow deposit reliquefied during later earthquake, probably in A.D. 1811-1812.

Two, possibly three, of the eight sand blows probably formed during the 1811-1812 earthquakes, two other sand blows probably formed during the A.D. 1450 event, and yet another sand blow formed sometime between A.D. 800 and 1650 (Table 1). Three of the sand blows are compound in nature. The compound sand blow that formed in A.D. 1811-1812 is composed of 2 depositional units and the one that probably formed in A.D. 1450 is composed of 4 depositional units. The third compound sand blow is prehistoric in age and is composed of 3 depositional units.

Our findings along the Little River help to fill the spatial gap in the regional distribution of historic and prehistoric liquefaction features and are consistent with previous findings in northeastern Arkansas and southeastern Missouri (e.g., Tuttle et al., 2002 and 2005; Wolf et al., 2006).

Promised Land

The Promised Land site is located about 20 km northwest of Marked Tree, Arkansas (Figure 1). At this site, we found a weathered sand blow and related feeder dike exposed in a drainage ditch (Figure 1).

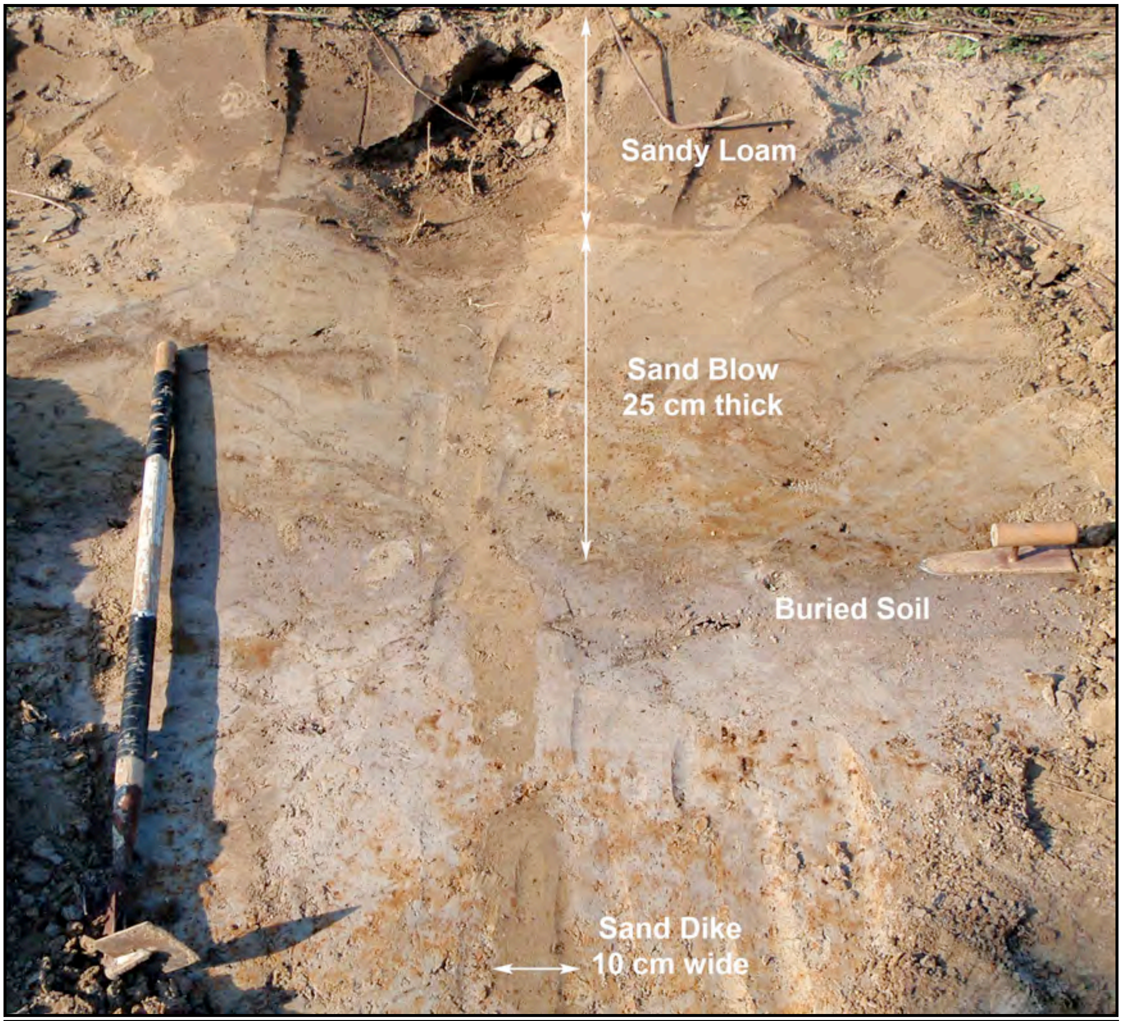

Figure 5. Weathered sand blow and feeder dike at Promised Land site northwest of Marked Tree probably formed during 5.5 kyr event thought to have been centered near Marianna, Arkansas. Radiocarbon dating of sample collected from buried soil provides close maximum age constraint of 5580 yr B.P.

The sand blow is 25 cm thick and 70 m long. A 10-cm wide feeder dike was clearly exposed. A second much wider dike was mostly covered by thick vegetation in the ditch. A thick sand loam has developed in the top of the sand blow, but the soil has been disturbed by agricultural practises. Radiocarbon dating of charred material collected from the buried soil within 1.5 cm of the base of the sand blow yielded a 2-sigma calibrated date of 5580-5440 and 5420-5320 yr B.P. (Table 1). The date provides close maximum age constraint for the sand blow and suggests that it formed about 5.45 +/- 0.13 ka. This is older than previously recognized New Madrid paleoearthquakes but is similar in age to the very large (2.45 m thick, 70 m wide, and 230 m long) Daytona Beach sand blow found in the Marianna area (Tuttle et al., 2006). The smaller Promised Land sand blow is probably a more distant feature that formed during the **M** >7 Marianna earthquake. Additional searches for Early to Middle Holocene sand blows is warranted in this portion of the St. Francis Basin that is underlain by Late Wisconsin valley train deposits (Saucier, 1994).

Loosahatchie River

We surveyed only 5 km of the Loosahatchie River downriver from the Rt. 388 bridge crossing (Figure 1). Exposure was excellent in river bends. At one site, we found somewhat weathered sand dikes and sills that might be prehistoric in age (Table 3). Unfortunately, we found no organic samples for radiocarbon dating. Additional work is warranted along the Loosahatchie River in order to date liquefaction features and to determine if they are due to earthquakes centered in the NMSZ, near Marianna, Arkansas, or to local earthquakes.

Mayfield Creek

We surveyed 8 km of Mayfield Creek downriver from the Rt. 121 bridge crossing. Even though we spent only one day on Mayfield Creek, we found two new liquefaction sites (Figure 1). Sand dikes at these sites are very weathered and are probably prehistoric in age. Radiocarbon dating of host deposits at one of the sites suggests that the sand dikes formed in the past 6 kyr (Table 2). Additional work is warranted along Mayfield Creek and in western Kentucky where few paleoseismic studies have been conducted.

Wolf River

During a previous study by Broughton et al. (2001), liquefaction features had been found along the Wolf River downstream of Collierville. We resurveyed two sections of the river in order to revisit liquefaction sites to collect samples for dating and to look for and document additional liquefaction features that had been exposed since the previous study.

The two river sections we resurveyed included 8 km between S. Houston Levee Road and Germantown Parkway and 10 km between Covington Pike and N. McLean Blvd. Unfortunately, exposure was very poor along both sections at the time of our survey. This was probably due to unusually dry weather and no flooding during the previous 6 months that permitted vegetation to cover most of the river banks. One of the previously identified liquefaction sites near the Germantown Parkway was exposed at the time of our survey but the liquefaction features had been removed by cutbank erosion immediately downstream from the bridge.

Given the location of the liquefaction features far from the NMSZ and in the vicinity of Memphis, it would be worthwhile to attempt again to relocate the liquefaction sites and collect samples for dating when exposure has been improved by flooding and erosion.

Table 1. Results of reconnaissance and age estimates of liquefaction features.

Site Location and Number	Longitude Degrees W	Latitude Degrees N	Thickness of Sand Blows (cm)	Width of Sand Dikes (cm)	Strike and Dip of Sand Dikes	Preliminary Age Estimate of Features
Black River						
300	91.00151	36.18703		cracks		
301	90.99377	36.20803				Geologic context
Castor River						
1	89.89629	36.94807		4 2 1	N37°E, vertical N2°E, 10°NW N17°E, 76°SE	Probably prehistoric
2	90.11963	37.16592		9	N13°E, 86°SE	Probably historic and prehistoric
3	90.11545	37.16446		80 4	N3°W, 50°SW N17°E, vertical	Probably prehistoric
4	90.17201	37.15759	20, possible	5	N68°W, 85°NE	Prehistoric; < 3 ka
Cross-County Ditch						
1	90.65009	35.36017		10 8	N71°E, 89°NW N62°E, 85°NW	Probably historic
2	90.65232	35.35180		6 3 1	N65°W, 86°NE	Probably prehistoric
3	90.65417	35.34446				Geologic context
4	90.67910	35.26814	covered	2 1 1	N67°W, 82°NE	Probably historic
Current River						
8	90.77130	36.38452	12	4 1	N59°E, 87°NW N89°W, 84°SW	Poorly constrained
9	90.76189	36.40024		slump cracks		
10	90.76366	36.40434				Geologic context
11	90.75991	36.40683		2.5 2.5	N13°E, 80°SE N10°E, 85°SE	Probably prehistoric
12	90.76813	36.41293		2 0.8	N17°W, 86°NE N50°W, 87°NE	Probably prehistoric
13	90.76350	36.41822		3 2 0.2	N41°E, 83°NW N85°E, 78°SE N79°W, 83°SW	Probably historic
14	90.75857	36.42184		2.5	N45°E, 87°SE	Poorly constrained
15	90.78394	36.49895	possible silt blow	3 1.5	N45°E, vertical N51°W, 75°NE	Prehistoric; < 5.3 ka
16	90.79211	36.49479				Geologic context
Hatchie River						
1	89.6150	35.6393		2	N77°E, vertical	Poorly constrained
2	89.6138	35.6389	10	11	N88°W, 87°SW	Probably prehistoric
3	89.6138	35.6402	14 - 2 units	11, 1.5, 1	N73°W, vertical	AD 1811-1812
4	89.6215	35.6444		10, 6	N2°E, 88°W	Poorly constrained
5	89.6312	35.6429		5, 2	N6°W, 88°NE N9°W, 66°SW	Prehistoric

Table 1 Cont'd. Results of reconnaissance and age estimates of liquefaction features.

Site Location and Number	Longitude Degrees W	Latitude Degrees N	Thickness of Sand Blows (cm)	Width of Sand Dikes (cm)	Strike and Dip of Sand Dikes	Preliminary Age Estimate of Features
Hatchie River						
6	89.6415	35.6434		15, 4	N47°E, 76°SE N36°E, 85°SE	Poorly constrained
7	89.6515	35.6462		3, 3, 1.5	N18°E, 85°SE N81°E, 87°SE	Poorly constrained; 2 generations
8	89.6616	35.6295				Geologic context
9	89.6674	35.6335	7	18	N43°W, vertical	Poorly constrained
10	89.6667	35.6314	18	96		Prehistoric
11	89.6753	35.6351	14 - 2 units	14	N41°W, vertical	Prehistoric
12	89.6787	35.6337	12	4, 1.2, 0.5	N14°W, 67°NE	Probably prehistoric
13	89.6796	35.6337		4, 3, 3	N21°W, vertical N13°E, 69°NW	Poorly constrained
14	89.6818	35.6360		10.5	N44°E, vertical	Poorly constrained
15	89.6856	35.6365	19 - 3 units	75, 14, 6, 2.5	N24°E, 67°NW N18°W, 83°NE	Probably prehistoric
16	89.6950	35.6436				Geologic context
17	89.7092	35.6385		10	N64°E, 85°NW	Probably historic
18	89.7060	35.6375	21 - 2 units	8	N64°E, 85°NW	1811-1812
20	89.8251	35.6045	18 - 1 unit	20	N28°E, 80°NW	Prehistoric
21	89.8258	35.6088		12, 6, 4, 3, 2	N13°W, vertical N59°E, 77°SE	Poorly constrained
22	89.8269	35.6118	7	10, 10	N24°E, vertical N74°E, vertical	Poorly constrained
23	89.8236	35.6130		4	N26°W, vertical	Poorly constrained
24	89.8238	35.6126		15, 4.5, 2.5, 2, 1.5, 1		Poorly constrained
25	89.82757	35.6021		15 10	N71°W, vertical	Poorly constrained
26	89.8295	35.6026		3	N6°W, vertical	Poorly constrained
27	89.8347	35.6021	10	17	N56°E, 84°NW	Probably prehistoric
28	89.8340	35.6020	7	35	N12°E, 87°SE	Prehistoric
29	89.8378	35.6006	11	32	N32°W, 81°NE	Poorly constrained
30	89.8376	35.6033		42 24, 9, 8, 6, 3	N37°W, 87°SW	Probably prehistoric
31	89.8383	35.6006	65 - 3 units	12 2.5, 2, 2, 1.2	N14°E, vertical	AD 1450
32	89.8395	35.6045				Geologic context
33	89.8430	35.6032		80 5 2.5	N39°E, 82°SE N10°E, vertical N46°E, 85°NW	Probably AD 1811-1812
34	89.60301	35.6239		4 3	N28°W, 80°SW N57°W, 84°SW	Historic
35	89.5754	35.6153		22 5	N82°E, 88°NW N74°E, 68°NW	Poorly constrained
36	89.5760	35.6168	6	1	N88°W, 76°SW	AD 1811-1812
37	89.4950	35.5767	16	11	N88°W, 67°SW	AD 1811-1812
38	89.5290	35.5985	0.5, possible	1.5	N54°E, vertical	Prehistoric

Table 1 Cont'd. Results of reconnaissance and age estimates of liquefaction features.

Site Location and Number	Longitude Degrees W	Latitude Degrees N	Thickness of Sand Blows (cm)	Width of Sand Dikes (cm)	Strike and Dip of Sand Dikes	Preliminary Age Estimate of Features
Hatchie River						
39	89.5336	35.6028		5	N32°W, 88°NE	Historic
40	89.5363	35.6029		9.5 1	N48°W, 86°SW N3°W, 85°NE	AD 1811-1812
41	89.5428	35.6032		3	N67°E, 81°NW	Poorly constrained
44	89.4831	35.5655	15	12 9	N21°W, 82°SW N43°W, 78°SW	AD 1811-1812
45	89.4828	35.5649	Covered	3 2	N10°E, 72°NW	Historic
100	89.8259	35.6049		2	N20°W, 89°SW	Probably prehistoric
101	89.8239	35.6122	17.5 – 2 units	30 10 6 5	N45°W, 86°NE N11°W, 75°NE N32°E, 56°NW N22°E, 84°SE	Probably prehistoric
102	89.8219	35.6167		2.5	N70°E, 89°NW	Probably historic
103	89.8194	35.6163		1.5	N20°E, 77°SE	Probably prehistoric
104	89.8089	35.6201		6 1	N84°W, 86°SW N40°W, 89°SW	Probably prehistoric
105	89.8033	35.6235	8	23	N60°E, 90°	AD 1450
106	89.8060	35.6239		10 10	N15°W, 86°SW N10°W, 82°NE	Probably prehistoric
107	89.8072	35.6242		5 4 3	N24°E, 80°NW N15°E, 70°NW	1811-1812
108	89.8033	35.6281	10	95	N55°E, 86°NW	Probably prehistoric
109	89.8029	35.6285	15	14	N34°E, 84°NW	Probably prehistoric
110	89.7891	35.6347		5	N54°E, 88°SE	Probably prehistoric
111	89.7679	35.6400		2	N50°E, 83°SE	Probably prehistoric
112	89.8386	35.6043		4 4 1	N5°W, 87°SW N2°W, 90° N81°E, 83°N	Probably historic
113	89.8460	35.6040		7.5 7.5	N85°W, 85°NE N50°E, 78°NW	Probably prehistoric
114	89.7797	35.6349		7	N2°E, 84°SE	Probably historic
115	89.7666	35.6408		11	N68°W, 88°SW	Probably prehistoric
116	89.7600	35.6419	20 – 2 units	12 4 3	N36°E, 90° N, 83°W N15°E, 84°SE	Probably prehistoric
200	89.7094	35.6403		2	Not measured	Poorly constrained
201	89.7123	35.6409		1.5	N25°W, 48°SW	Probably prehistoric
202	89.7185	35.6387		3 2.5 1.5	N60°E, 90° N73°E, 85°SE N62°E, 70°NW	Probably prehistoric; two generations

Table 1 Cont'd. Results of reconnaissance and age estimates of liquefaction features.

Site Location and Number	Longitude Degrees W	Latitude Degrees N	Thickness of Sand Blows (cm)	Width of Sand Dikes (cm)	Strike and Dip of Sand Dikes	Preliminary Age Estimate of Features
Hatchie River						
203	89.7331	35.6476		1.5	N85°W, 90°	Poorly constrained
204	89.7353	35.6454		16	N55°E, 80°NW	Probably historic
205	89.7427	35.6462		2	N20°E, 88°NW	Probably prehistoric
206	89.7525	35.6473		8	N85°W, 88°N	Probably historic
207	89.8443	35.5991		21 14	N74°E, 82°NW N40°E, 86°NW	Probably historic
208	89.8427	35.5974	15	52 3 2	N25°E, 78°SE	Probably prehistoric
Little River						
6	90.12933	35.84353	42	10	N87°E, 84°NW	Poorly constrained (prehistoric)
7	90.13745	35.83794	Covered	50	N77°E, 88°NW	1811-1812
8	90.13936	35.83952	34	50 5 2 1.5	N55°W, vertical N6°E, 82°NW N79°W, 81°NE N72°E, 76°NW	1811-1812
9	90.13371	35.82483	11	44	N18°W, 76°NE	AD 1450
10	90.13480	35.83595		184	N58°W, vertical	AD 1811-1812
11	90.1428	35.8146	70	4 2	N65°E, 82°NW N45°E, 77°NW	AD 800-1650
12	90.1499	35.7960		110 7 4	N5°E, 90°	Probably historic
13	90.1566	35.7918	130 – 2 units	12 4 3	N40°E, 90°	AD 1811-1812
14	90.1842	35.7714	80	70 5 4	N12°E, 87°NW	Probably prehistoric And historic
15	90.1637	35.7809	120 – 4 units	45 12 2.5	N36°E, 85°NW N60°W, 43°SW N52°E, 85°NW	Probably AD 1450
16	90.1691	35.7778	80 – 3 units	60	N16°W, 90°	Probably prehistoric
Loosahatchie River						
6	90.0340	35.2493		5	Not measured	Probably prehistoric
Mayfield Creek						
1	89.0169	36.9248		5	N60°E, 85°SE	Probably prehistoric
2	89.0305	36.9271		2	N46°E, 85°NW	Probably prehistoric
Promised Land						
1	90.5982	35.6570	25	10	N15°W, 86°NE	5.45 +/- 0.13 ka
Wolf River						
12	89.9858	35.1918		10	Not measured	Poorly constrained

Table 2. Results of radiocarbon dating.

Sample # Lab #	$^{13}C/^{12}C$ Ratio	Radiocarbon Age Yr B.P.[1]	Calibrated Radiocarbon Age Yr B.P.[2]	Calibrated Calendar Date A.D./B.C.[2]	Sample Description
Castor River					
Cst4-C2	-27.0	2830 ± 40	3050-2850	1100-900 BC	Charred material 10 cm below possible sand blow
Current River					
CR15-C3	-27.7	4530 ± 40	5310-5040	3360-3090 BC	Charred material from deposit cut by dikes
Hatchie River					
HR3-C1 Beta-152015	-26.2	90 ± 40	270-180 150-10 0-0	AD 1680-1770 AD 1800-1940 AD 1950-1960	Charred material 7 cm above sand blow
HR10-C1 Beta-152016	-27.7	270 ± 70	490-260 220-140 30-0	AD 1460-1690 AD 1730-1810 AD 1920-1950	Charred material 5 cm above sand blow
HR10-C3 Beta-275671	-24.4	2470 ± 40	2730-2360	780-410 BC	Charred material 5 cm above sand blow
HR10-C4 Beta-152017	-24.6	6730 ± 80	7700-7450	5740-5500 BC	Charred material 2.5 cm below sand blow
HR10-W1 Beta-275672	-27.4	152.8 ± 0.6 pMC	Modern	Modern	Wood from buried soil; 7.5 cm below sand blow
HR28-C5 Beta-189964	-25.2	180 ± 40	300-240 230-70 40-0	AD 1650-1710 AD 1730-1810 AD 1920-1950	Charred material 2 cm above sand blow
HR31-C102 Beta-214186	-26.1	640 ± 40	670-540	AD 1280-1410	Charred material 7 cm below sand blow
HR33-C2 Beta-190508	-27.6	340 ± 40	500-300	AD 1450-1650	Organic material 15 cm below dike tip
HR36-C1 Beta-189966	-26.4	150 ± 40	290-0	AD 1660-1950	Charred sample 5 cm below sand blow
HR37-C1 Beta-189967	-27.3	210 ± 40	310-260 220-140 30-0	AD 1640-1690 AD 1730-1810 AD 1920-1950	Charred sample just above sand blow
HR40-C3 Beta-277831	-23.2	1320 ± 40	1300-1180	AD 650-770	Charred material 3 cm below dike tip
HR44-C3 Beta-189968	-25.8	170 ± 40	300-60 40-0	AD 1650-1890 AD 1910-1950	Charred material 2.5 cm below sand blow
HR105-C6 Beta-214189	-26.9	1890 ± 60	1690-1700	10 BC-AD 250	Charred material from host below sand blow
HR105-C8 Beta-214190	-26.8	3340 ± 40	3670-3470	1720-1520 BC	Charred material from root cast; 18 cm below sand blow

[1] Conventional radiocarbon ages in years B.P. or before present (1950) determined by Beta Analytic, Inc. Errors represent 1 standard deviation statistics or 68% probability.
[2] Calibrated age ranges as determined by Beta Analytic, Inc., using the Pretoria procedure (Talma and Vogel, 1993; Vogel et al., 1993). Ranges represent 2 standard deviation statistics or 95% probability.

Table 2 Cont'd. Results of radiocarbon dating.

Sample # Lab #	$^{13}C/^{12}C$ Ratio	Radiocarbon Age Yr B.P.[1]	Calibrated Radiocarbon Age Yr B.P.[2]	Calibrated Calendar Date A.D./B.C.[2]	Sample Description
Little River					
LR3-C2 Beta-275676	-27.6	171.7 ± 0.7 pMC	Modern	Modern	Charred material, angular, from soil developed in sand blow
LR3-W1 Beta-275677	-25.6	107.4 ± 0.4 pMC	Modern	Modern	Wood from buried soil below sand blow
LR9-C11 Beta-190510	-26.2	230 ± 40	420-400 320-270 210-140 20-0	AD 1530-1550 AD 1630-1680 AD 1740-1810 AD 1930-1950	Charred material from soil developed in sand blow
LR10-C4 Beta-190512	-24.5	1290 ± 40	1290-1160	AD 660-790	Charred material from silty clay; 5 cm above sand blow
LR10-C2 Beta-190511	-25.3	1270 ± 40	1280-1080	AD 670-870	Charred material from host; 25 cm below sand blow
LR11-C2 Beta-198024	-22.2	1400 ± 40	1350-1270	AD 600-680	Organic sediment from Native American midden; 1 cm below sand blow
LR13-C1 Beta-198026	-25.8	170 ± 40	300-60 40-0	AD 1650-1890 AD 1910-1950	Charred material in soil developed in sand blow
LR15a-C1 Beta-198027	-26.5	970 ± 40	950-780	AD 1000-1170	Charred material from buried soil with Mississippian artifacts; 10 cm below sand blow
LR16-C1 Beta-198028	-27.1	160 ± 40	290-0	AD 1660-1950	Charred material 2 cm above sand blow
Mayfield Creek					
MFC1-C2 Beta-275679	-29.0	4980 ± 40	5880-5820 5760-5610	3930-3870 BC 3810-3660 BC	Charcoal, angular, from host; 3 cm above dike tip
MFC1-C3 Beta-277832	-28.2	5640 ± 40	6490-6320	4540-4360 BC	Charred material from host; 50 cm below dike tip
Promised Land					
PL1-C1+C2	-26.6	4720 ± 40	5580-5440 5420-5320	3630-3490 BC 3470-3370 BC	Charred material from buried soil; 1.5 cm below sand blow

[1] Conventional radiocarbon ages in years B.P. or before present (1950) determined by Beta Analytic, Inc. Errors represent 1 standard deviation statistics or 68% probability.
[2] Calibrated age ranges as determined by Beta Analytic, Inc., using the Pretoria procedure (Talma and Vogel, 1993; Vogel et al., 1993). Ranges represent 2 standard deviation statistics or 95% probability.

Table 3. Results of optically stimulated luminescence dating.

Sample #	Cosmic Dose Rate (Gy/ka)[1]	Total Dose Rate (Gy/ka)[2]	Equivalent Dose (Gy)[3]	Age (Yr)[4]	Sample Description
HR31-1	0.17 ± 0.02	1.81 ± 0.02	0.29 ± 0.01	159 ± 5.45	Upper contact of sand blow
HR31-2	0.17 ± 0.02	0.74 ± 0.01	1.05 ± 0.05	1425 ± 68.5	Lower contact of sand blow
HR105-1	0.17 ± 0.02	2.27 ± 0.02	0.38 ± 0.01	165 ± 5.23	Upper contact of sand blow
HR105-2	0.17 ± 0.02	2.05 ± 0.02	1.09 ± 0.03	532 ± 14.9	Lower contact of sand blow

Evaluation of Scenario Earthquakes

We acquired borehole logs from the Arkansas, Missouri, and Tennessee Departments of Transportation for bridge crossings of the Black, Cache, Current, Hatchie, and White Rivers, and Cross County Ditch in the areas where we had found liquefaction features (Figure 1). We reviewed the logs, selected representative sandy layers that occur below the water table, and compiled data for liquefaction potential analysis (Appendix: Tables A-1 to A-8). Using these data and the revised simplified procedure of Seed and Idriss (1982) and Youd and Idriss (1997), we evaluated whether or not several scenario earthquakes would be likely to induce liquefaction in fluvial sediments along the rivers and ditches and compared these results to field observations (Tables 4 and 5; Appendix: Tables A-1 to A-8). It would be preferable to use geotechnical data collected at liquefaction sites along these rivers, but these data are not currently available.

Similarities in the size and distribution of historic and prehistoric liquefaction features across the New Madrid region suggest that prehistoric earthquakes were similar to the three largest earthquakes in the 1811-1812 New Madrid sequence (Tuttle et al., 2002). Therefore, the scenario earthquakes we evaluated include the December 16, 1811, January 23, 1812, and February 7, 1812 mainshocks. For these earthquakes, we used the estimated magnitudes from three different studies (**M** 8.1, 7.8, and 8.0 from Johnston, 1996; **M** 7.2, 7.0, and 7.4 from Hough et al., 2000; and **M** 7.6, 7.5, and 7.8 from Bakun and Hopper, 2004). The December 16, January 23, and February 7 earthquakes are thought to have been centered near Blytheville, Arkansas, New Madrid, Missouri, and Caruthersville, Missouri, respectively (Figure 1; Johnston and Schweig, 1996). Distances were measured between inferred epicenters of the historic earthquakes and the bridge crossings. In addition, we evaluated smaller magnitude earthquakes, such as the January 5, 1843 shock (**M** 6.3-6.5) thought to be centered near Marked Tree, Arkansas, and also local earthquakes in close proximity to the liquefaction sites. For the local events, we assume a distance of 10 km and evaluate several magnitudes (e.g., **M** 5.25, 5.5, and 6.0). Peak ground accelerations for the earthquakes were derived from ground-motion relations developed for the central United States (Toro et al., 1997).

[1] Cosmic doses and attenuation with depth calculated using the methods of Prescott and Hutton (1994).
[2] Total dose rate is measured from 20-25% water content.
[3] Reported to one sigma, fit to an exponential plus linear regression, and calculated as a weighted mean.
[4] Analysis performed on fine sand grain (150-125 micron size).

Western Lowlands and St. Francis Basin

Results of the liquefaction potential analysis suggest that the December 16, 1811 earthquake, if it were of **M** 7.2, would induce liquefaction in the Western Lowlands along the Cache and Current Rivers and possibly along the Black River at Jacksonport, Arkansas, but not along the Black River at Elgin Ferry, the White River, or along Cross County Ditch in the St. Francis Basin (Table 4; Appendix). If the December 16 earthquake were of **M** 8.1, it probably would induce liquefaction along all of the rivers studied. The analysis also suggests that the January 23, 1812 earthquake, if it were of **M** 7.0, probably would not induce liquefaction along any of the rivers (Table 4). Neither of the last two scenarios would account for field observations of liquefaction features. The February 7, 1812 event, if it were of **M** 7.5, would induce liquefaction along the Cache and Current Rivers, possibly along the White River, but probably not along the Black River or Cross County Ditch (Table 4). Except for Cross County Ditch where liquefaction features have been found, the results for the **M** 7.2 December 16 and **M** 7.5 February 7 events closely matches field observations. An earthquake like the January 5, 1843 earthquake, if it were of **M** 6.5, could produce liquefaction along Cross County Ditch (Table 4).

Table 4. Summary of field observations and results of liquefaction potential analysis for sites in the Western Lowlands and St. Francis Basin.

Borehole Location (River/Town)	**Field Observations**	**December 16, 1811**		**January 23, 1812**	**February 7, 1812**	**January 5, 1843**	
		M 7.2	**M 8.1**	**M 7.0**	**M 7.5**	**M 6.3**	**M 6.5**
Black River/ Elgin	N	N	L	N	N	NA	NA
Black River/ Jacksonport	N	M	L	N	N	NA	NA
Cache River/ Light	L	L	L	N	L	NA	NA
Cross County Ditch/ Birdseye	L	N	L	N	N	N	L
Current River/ Reyno	L	L	L	N	L	NA	NA
White River/ Jacksonport	N	N	L	N	M	NA	NA

L-Liquefaction; M-Marginal liquefaction; N-No liquefaction; NA-analysis not performed.

Liquefaction analysis performed for sites in the Western Lowlands and in the St. Francis Basin suggests that the field observations in these areas could be explained by earthquakes similar to the December 16, 1811, February 7, 1812, and January 5, 1843 earthquakes, if they were of **M** 7.2, 7.5, and 6.5, respectively. We have not yet evaluated if the field observations could be explained by earthquakes like the December 16 and February 7 mainshocks alone if they were of **M** 7.6 and 7.8, respectively.

Hatchie River

We also evaluated whether or not several scenario earthquakes would be likely to induce liquefaction in fluvial sediments along the Hatchie River where we found both historic and prehistoric liquefaction features. The analysis was performed using borehole data from the Route 51 bridge crossing of the Hatchie River north of Covington. The liquefaction analysis suggests that the December 16, 1811 earthquake, if it were of **M** 7.2, would induce liquefaction in about half of the layers of sediment we considered (Table 5; Appendix). If the earthquake were of **M** 7.6, however, almost all the layers would liquefy. Therefore, the December 16th mainshock is much more likely to have produced liquefaction features in the area if it were on the order of **M** 7.6. The analysis also suggests that the January 23, 1812 mainshock, whether of **M** 7.0, 7.5, or 7.8, was located too far away to induce liquefaction along the Hatchie River (Table 5). The February 7, 1812 earthquake probably would not have induced liquefaction unless it were on the order of **M** 7.8. In addition, the analysis suggests that a hypothetical local earthquake would have to be at least **M** 5.5 to induce liquefaction at the Route 51 bridge crossing of the Hatchie River (Table 5).

Table 5. Summary of field observations and results of liquefaction potential analysis for Hatchie River in western Tennessee.

Borehole Location (River/Town)	Field Observations	December 16, 1811		January 23, 1812	February 7, 1812	Hypothetical Local Event
		M 7.2	M 7.6	M 7.0, 7.5, 7.8	M 7.8	M 5.5
Hatchie River/ N. Covington	L	L/N	L	N	L	L

L-Liquefaction; M-Marginal liquefaction; N-No liquefaction..

Liquefaction analysis performed for the Route 51 bridge crossing of the Hatchie River suggests that field observations could be explained by earthquakes similar to the December 16, 1811 and February 7, 1812, mainshocks if they were of **M** 7.6 and 7.8, respectively. The analysis also suggests that earthquakes similar to the January 23, 1812 mainshock would have been located too far away to induce liquefaction in this area, even if it were of **M** 7.8.

A compound sand blow thought to have formed during the 1811-1812 earthquake sequence occurs at site 3 located less than 1 km from the Route 51 bridge crossing. The compound sand blow is composed of two sedimentary units suggesting that it formed as the result of liquefaction induced by two large earthquakes in a sequence. This is consistent with liquefaction potential analysis that predicts the formation of the compound sand blow during the December 16 and February 7 earthquakes if they were on the order of **M** 7.6 and 7.8, respectively. Another 1811-1812 sand blow at site 18, downstream from site 3, is also composed of two sedimentary units.

Conclusions

During the course of this study, earthquake-induced liquefaction features were discovered, documented, measured, and their ages estimated with varying degrees of uncertainty along the Castor River in southeastern Missouri, the Little River in northeastern Arkansas, Mayfield Creek in western Kentucky, and the Hatchie, Loosahatchie, and Wolf Rivers in western Tennessee.

The search for liquefaction features involved reconnaissance along 144 km of river length and resulted in the discovery of liquefaction features, including 34 sand blows, at more than 100 new sites.

Although the limit of liquefaction has not yet been delineated, the liquefaction features we found along the Castor and Hatchie Rivers and Mayfield Creek enlarge the liquefaction fields for the A.D. 1811-1812 and A.D. 1450 New Madrid earthquakes. Many of the liquefaction features are thought to be prehistoric in age and warrant additional study to better constrain their age estimates. By doing so, it may be possible to extend the chronology of New Madrid earthquakes farther back in time and to develop earthquake chronologies for sources outside the NMSZ such as the Marianna source in east-central Arkansas and the Eastern Reelfoot Rift Margin fault in western Tennessee.

Compound sand blows on the Hatchie and Little Rivers, including up to 4 depositional units, formed during the A.D. 1811-1812 and 1450, and possibly earlier New Madrid earthquake sequences. The locations, ages, and number of depositional units of these compound sand blows will help to further define liquefaction fields and thus the source areas and magnitudes of earthquakes within each sequence.

Liquefaction potential analysis was conducted for sites along the Black, Cache, Current, and White Rivers in the Western Lowlands, the Cross County Ditch in the St. Francis Basin, and the Hatchie River in western Tennessee. Although the analysis was performed for a limited area, results suggest that liquefaction features along these rivers can be explained by earthquakes similar in locations and magnitudes (M >7) to the 1811-1812 New Madrid mainshocks.

The weathered ~5.5 ka sand blow at the Promised Land site northwest of Marked Tree, Arkansas is a significant discovery and probably formed during a **M** >7 earthquake centered near Marianna, Arkansas about 80 km to the south. It suggests that the liquefaction field produced by the 5.5 kyr B.P. Marianna earthquake is quite large which it should be if it were produced by a very large earthquake. It also suggests that a record of paleoearthquakes is available in the Late Wisconsin deposits of the western portion of the St. Francis Basin and could shed light on the long-term behavior of the NMSZ and other earthquake sources in the region.

In the future, we hope to improve age estimates of liquefaction features particularly at sites outside the NMSZ proper, to evaluate additional earthquake scenarios incorporating new attenuation relations in our liquefaction potential analysis, and to use the results to better constrain locations and magnitudes of earthquakes generated by the NMSZ and sources outside the NMSZ.

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Contact Information and Data Availability

Dr. Martitia P. Tuttle, Telephone: 207-371-2007, Email: mptuttle@earthlink.net.

Appendix

Evaluation of Scenario Earthquakes Using Liquefaction Potential Analysis

Table A-1a. Results of liquefaction potential analysis for December 16, 1811 earthquake of M 7.2.

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
Black River @ Elgin Ferry/1 /6	7.2@118	0.070	20	Wet, medium dense, gray sand	13	0.042	N
	7.2@118	0.070	25	Wet, medium dense, gray sand	11	0.044	N
	7.2@118	0.070	10	Wet, loose brown fine sand	8	0.042	N
	7.2@118	0.070	15	Wet, medium dense, gray and brown silty sand	7	0.048	N
	7.2@118	0.070	20	Wet, medium dense, gray and brown silty sand with scattered organic matter	10	0.051	N
	7.2@118	0.070	25	Wet, medium dense, gray and brown silty sand with scattered organic matter	9	0.053	N
	7.2@118	0.070	50	Wet, medium dense, gray sand and gravel with organic material	9	0.047	N
/7	7.2@118	0.070	10	Wet, medium dense, gray silty sand and gravel with some organic material (wood)	3	0.042	N
	7.2@118	0.070	15	Wet, medium dense, gray silty sand and gravel with some organic material (wood)	5	0.048	N
	7.2@118	0.070	20	Wet, medium dense, gray silty sand and gravel with some organic material (wood)	13	0.051	N
	7.2@118	0.070	30	Wet, medium dense, gray silty sand and gravel	12	0.053	N
	7.2@118	0.070	40	Wet, medium dense, gray silty sand and gravel with organic material	14	0.051	N
/9	7.2@118	0.070	15	Wet, loose, gray silty sand	4	0.048	N
	7.2@118	0.070	25	Wet, loose, gray and brown sand silty sand	5	0.053	N
	7.2@118	0.070	35	Wet, medium dense, gray sand and gravel	11	0.052	N
	7.2@118	0.070	45	Wet, medium dense, gray sand and gravel	9	0.049	N
Black River Jacksonport@SH69 /1	7.2@120	0.070	15	Wet loose, brown silty sand	5	0.071	N
	7.2@120	0.070	20	Wet, loose, brown silty sand	3	0.070	L

Table A-1a. Con't

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
Black River	7.2@120	0.070	25	Wet, loose, brown silty sand	10	0.068	N
Jacksonport@SH69	7.2@120	0.070	30	Wet, medium dense, gray sand and gravel	14	0.066	N
	7.2@120	0.070	35	Wet, medium dense, gray sand and gravel	10	0.063	N
	7.2@120	0.070	45	Wet, medium dense, gray sand	13	0.057	N
/4	7.2@120	0.070	30	Wet, loose, gray sand with some organic matter	6	0.066	N
	7.2@120	0.070	40	Wet, medium dense, gray sand	6	0.060	N
/5	7.2@120	0.070	15	Wet, loose, brown silty sand	8	0.071	N
	7.2@120	0.070	20	Wet, loose, brown silty sand	10	0.070	N
	7.2@120	0.070	30	Wet, medium dense, gray sand	13	0.066	N
	7.2@120	0.070	40	Wet, medium dense, gray sand and gravel	13	0.060	N
/6	7.2@120	0.070	18	Wet, very loose, gray sand	2	0.071	L
	7.2@120	0.070	25	Wet, medium dense, gray sand	4	0.068	M/N
Cache River @	7.2@75	0.130	15	Wet, very loose, gray sand	3	0.075	L
US 412/1	7.2@75	0.130	20	Wet, medium dense, gray sand with traces of pea gravel	8	0.082	N
	7.2@75	0.130	25	Wet, medium dense, gray sand	9	0.085	N
	7.2@75	0.130	30	Wet, medium dense, gray sand	13	0.087	N
	7.2@75	0.130	35	Wet, medium dense, gray sand	8	0.087	N
	7.2@75	0.130	40	Wet, medium dense, gray sand	14	0.085	N
	7.2@75	0.130	45	Wet, medium dense, gray sand with traces of clay and gravel	7	0.083	N
/2	7.2@75	0.130	15	Wet, loose, gray sand	5	0.092	L
	7.2@75	0.130	20	Wet, loose, gray sand	12	0.097	N
	7.2@75	0.130	25	Wet, medium dense, gray sand	17	0.099	N
	7.2@75	0.130	30	Wet, medium dense, gray sand with some gravel	8	0.099	L
	7.2@75	0.130	35	Wet, medium dense, gray sand with traces of gravel	12	0.097	N
	7.2@75	0.130	40	Wet, loose, gray sand and gravel	6	0.095	L

TableA-1a. Con't

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
Cache River	7.2@75	0.130	45	Wet, medium dense, gray sand with traces of gravel	10	0.092	N
/3	7.2@75	0.130	15	Wet, loose, gray sand with some organic matter	8	0.098	N
	7.2@75	0.130	20	Wet, very loose, gray sand with traces of clay and organic matter	3	0.102	L
	7.2@75	0.130	25	Wet, medium dense, gray sand with traces of lignite	10	0.104	N
	7.2@75	0.130	30	Wet, medium dense, gray sand with traces of lignite	5	0.103	L
	7.2@75	0.130	35	Wet, loose, gray sand with traces of clay	8	0.101	M/N
	7.2@75	0.130	40	Wet, medium dense, gray sand with clay seams	9	0.098	N
	7.2@75	0.130	45	Wet, medium dense, gray sand with traces of lignite and gravel	10	0.094	N
/4	7.2@75	0.130	19	Wet, loose, brown sand	4	0.095	L
	7.2@75	0.130	15	Wet medium dense, gray sand	15	0.090	N
	7.2@75	0.130	20	Wet, medium dense, gray sand with traces of gravel	12	0.095	N
	7.2@75	0.130	25	Wet, loose, gray sand with traces of lignite	7	0.098	L
	7.2@75	0.130	30	Wet, medium dense, gray sand with traces of pea gravel and lignite	14	0.098	N
	7.2@75	0.130	35	Wet, loose to medium dense, sand with some lignite	4	0.096	L
	7.2@75	0.130	45	Wet, loose, gray sand with traces of lignite	6	0.091	L
Cross Country	7.2@93	0.100	15	Fine, brown sand, wet	17	0.066	N
Ditch @ SH 42	7.2@93	0.100	20	Fine, gray sand	15	0.071	N
/5222	7.2@93	0.100	25	Fine, gray, water bearing sand, medium compaction	19	0.073	N
/5223-1	7.2@93	0.100	15	Fine, gray sand, wet	15	0.560	N
	7.2@93	0.100	20	Fine, gray, water bearing sand, medium compaction	15	0.063	N
/5223-4	7.2@93	0.100	26	Fine, gray sand, wet	9	0.052	N
	7.2@93	0.100	30	Fine, gray, water bearing sand, medium compaction	7	0.054	N
Current River @	7.2@80	0.122	25	Wet, medium dense, gray sand	15	0.097	N
SH 328/1	7.2@80	0.122	30	Wet, medium dense, gray sand	11	0.097	N

Table A-1a. Con't

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
Current River @	7.2@80	0.122	35	Wet, medium dense, gray gravelly sand with organic matter	12	0.095	N
SH 328/1	7.2@80	0.122	45	Wet, medium dense, gray gravelly sand with organic matter	11	0.089	N
/2	7.2@80	0.122	15	Wet, loose, brown fine sand	9	0.098	N
	7.2@80	0.122	20	Wet, medium dense, brown sand	12	0.102	N
	7.2@80	0.122	25	Wet, medium dense, brown sand	18	0.102	N
	7.2@80	0.122	30	Wet, medium dense, brown to gray sand with organic matter	13	0.101	N
	7.2@80	0.122	35	Wet, medium dense, brown to gray sand with organic matter	9	0.098	N
	7.2@80	0.122	45	Wet, medium dense, gray sand and gravel	10	0.091	N
/3	7.2@80	0.122	10	Wet, loose, gray fine sand	7	0.970	L
	7.2@80	0.122	20	Wet, loose, gray fine sand	9	0.107	M/N
	7.2@80	0.122	25	Wet, medium dense, gray sand	13	0.107	N
	7.2@80	0.122	30	Wet, medium dense, gray sand	10	0.105	N
	7.2@80	0.122	35	Wet, medium dense, brown and gray gravelly sand	11	0.102	N
/4	7.2@80	0.122	10	Wet, loose, brown sand	10	0.097	N
	7.2@80	0.122	20	Wet, loose, brown sand	7	0.107	L
	7.2@80	0.122	25	Wet, medium dense, brown and gray sand	9	0.107	N
	7.2@80	0.122	30	Wet, medium dense, brown and gray gravelly sand with organic matter	16	0.105	N
	7.2@80	0.122	35	Wet, medium dense, brown and gray gravely sand with organic matter	11	0.102	N
	7.2@80	0.122	45	Wet, medium dense, brown and gray sand and gravel	10	0.094	N
/8	7.2@80	0.122	15	Wet, medium dense, gray sand	8	0.090	N
	7.2@80	0.122	20	Wet, medium dense, gray sand	8	0.061	N
/10	7.2@80	0.122	15	Wet, medium dense to loose, brown fine sand	7	0.105	L
	7.2@80	0.122	20	Wet, medium dense to loose, brown fine sand	8	0.107	L
	7.2@80	0.122	25	Wet, medium dense, gray gravelly sand	16	0.107	N

Table A-1a. Con't

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
Current River @	7.2@80	0.122	35	Wet, medium dense, gray gravelly sand	13	0.102	N
SH 328/10	7.2@80	0.122	40	Wet, medium dense, gray gravelly sand	13	0.098	N
	7.2@80	0.122	45	Wet, medium dense, gray gravelly sand	13	0.094	N
White River @	7.2@120	0.070	35	Wet, medium dense, gray fine sand	4	0.057	N
SH 67/1	7.2@120	0.070	40	Wet, medium dense, fine sand	9	0.055	N
	7.2@120	0.070	50	Wet, medium dense, brown sand and gravel	7	0.050	N
/4	7.2@120	0.070	10	Wet, loose, brown silty sand	7	0.052	N
	7.2@120	0.070	25	Wet, loose, brown clayey sand	3	0.059	M/N

L- liquefaction M- marginal liquefaction N- liquefaction not likely

Table A-1b. Results of liquefaction potential analysis for December 16, 1811 earthquake of M 8.1.

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
Black River @	8.1@118	0.144	20	Wet, medium dense, gray sand	13	0.086	N
Elgin Ferry/1	8.1@118	0.144	25	Wet, medium dense, gray sand	11	0.090	N
/6	8.1@118	0.144	10	Wet, loose brown fine sand	8	0.086	L
	8.1@118	0.144	15	Wet, medium dense, gray and brown silty sand	7	0.099	L
	8.1@118	0.144	20	Wet, medium dense, gray and brown silty sand with scattered organic matter	10	0.105	L
	8.1@118	0.144	25	Wet, medium dense, gray and brown silty sand with scattered organic matter	9	0.108	L
	8.1@118	0.144	50	Wet, medium dense, gray sand and gravel with organic material	9	0.096	L
/7	8.1@118	0.144	10	Wet, medium dense, gray silty sand and gravel with some organic material (wood)	3	0.086	L
	8.1@118	0.144	15	Wet, medium dense, gray silty sand and gravel with some organic material (wood)	5	0.099	L
	8.1@118	0.144	20	Wet, medium dense, gray silty sand and gravel with some organic material (wood)	13	0.105	N
	8.1@118	0.144	30	Wet, medium dense, gray silty sand and gravel	12	0.108	L
	8.1@118	0.144	40	Wet, medium dense, gray silty sand and gravel with organic material	14	0.104	N
/9	8.1@118	0.144	15	Wet, loose, gray silty sand	4	0.099	L
	8.1@118	0.144	25	Wet, loose, gray and brown sand silty sand	5	0.108	L
	8.1@118	0.144	35	Wet, medium dense, gray sand and gravel	11	0.106	L
	8.1@118	0.144	45	Wet, medium dense, gray sand and gravel	9	0.100	L
Black River	8.1@120	0.140	15	Wet loose, brown silty sand	5	0.142	L
Jacksonport@SH69	8.1@120	0.140	20	Wet, loose, brown silty sand	3	0.140	L
/1							

Table A-1b. Con't

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
Black River	8.1@120	0.140	25	Wet, loose, brown silty sand	10	0.136	L
Jacksonport@SH69	8.1@120	0.140	30	Wet, medium dense, gray sand and gravel	14	0.132	L
	8.1@120	0.140	35	Wet, medium dense, gray sand and gravel	10	0.126	L
	8.1@120	0.140	45	Wet, medium dense, gray sand	13	0.114	L
/4	8.1@120	0.140	30	Wet, loose, gray sand with some organic matter	6	0.132	L
	8.1@120	0.140	40	Wet, medium dense, gray sand	6	0.120	L
/5	8.1@120	0.140	15	Wet, loose, brown silty sand	8	0.142	L
	8.1@120	0.140	20	Wet, loose, brown silty sand	10	0.140	L
	8.1@120	0.140	30	Wet, medium dense, gray sand	13	0.132	L
	8.1@120	0.140	40	Wet, medium dense, gray sand and gravel	13	0.120	L
/6	8.1@120	0.140	18	Wet, very loose, gray sand	2	0.141	L
	8.1@120	0.140	25	Wet, medium dense, gray sand	4	0.136	L
Cache River @	8.1@75	0.278	15	Wet, very loose, gray sand	3	0.160	L
US 412/1	8.1@75	0.278	20	Wet, medium dense, gray sand with traces of pea gravel	8	0.175	L
	8.1@75	0.278	25	Wet, medium dense, gray sand	9	0.183	L
	8.1@75	0.278	30	Wet, medium dense, gray sand	13	0.186	L
	8.1@75	0.278	35	Wet, medium dense, gray sand	8	0.185	L
	8.1@75	0.278	40	Wet, medium dense, gray sand	14	0.182	L
	8.1@75	0.278	45	Wet, medium dense, gray sand with traces of clay and gravel	7	0.178	L
/2	8.1@75	0.278	15	Wet, loose, gray sand	5	0.196	L
	8.1@75	0.278	20	Wet, loose, gray sand	12	0.207	L
	8.1@75	0.278	25	Wet, medium dense, gray sand	17	0.212	L
	8.1@75	0.278	30	Wet, medium dense, gray sand with some gravel	8	0.211	L
	8.1@75	0.278	35	Wet, medium dense, gray sand with traces of gravel	12	0.208	L
	8.1@75	0.278	40	Wet, loose, gray sand and gravel	6	0.203	L

Table A-1b. Con't

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
Cache River	8.1@75	0.278	45	Wet, medium dense, gray sand with traces of gravel	10	0.196	L
/3	8.1@75	0.278	15	Wet, loose, gray sand with some organic matter	8	0.209	L
	8.1@75	0.278	20	Wet, very loose, gray sand with traces of clay and organic matter	3	0.219	L
	8.1@75	0.278	25	Wet, medium dense, gray sand with traces of lignite	10	0.221	L
	8.1@75	0.278	30	Wet, medium dense, gray sand with traces of lignite	5	0.220	L
	8.1@75	0.278	35	Wet, loose, gray sand with traces of clay	8	0.215	L
	8.1@75	0.278	40	Wet, medium dense, gray sand with clay seams	9	0.209	L
	8.1@75	0.278	45	Wet, medium dense, gray sand with traces of lignite and gravel	10	0.201	L
/4	8.1@75	0.278	19	Wet, loose, brown sand	4	0.202	L
	8.1@75	0.278	15	Wet medium dense, gray sand	15	0.192	L
	8.1@75	0.278	20	Wet, medium dense, gray sand with traces of gravel	12	0.204	L
	8.1@75	0.278	25	Wet, loose, gray sand with traces of lignite	7	0.209	L
	8.1@75	0.278	30	Wet, medium dense, gray sand with traces of pea gravel and lignite	14	0.209	L
	8.1@75	0.278	35	Wet, loose to medium dense, sand with some lignite	4	0.206	L
	8.1@75	0.278	45	Wet, loose, gray sand with traces of lignite	6	0.194	L
Cross Country	8.1@93	0.204	15	Fine, brown sand, wet	17	0.136	M/N
Ditch @ SH 42	8.1@93	0.204	20	Fine, gray sand	15	0.145	L
/5222	8.1@93	0.204	25	Fine, gray, water bearing sand, medium compaction	19	0.149	N
/5223-1	8.1@93	0.204	15	Fine, gray sand, wet	15	0.118	N
	8.1@93	0.204	20	Fine, gray, water bearing sand, medium compaction	15	0.129	M/N
/5223-4	8.1@93	0.204	26	Fine, gray sand, wet	9	0.106	L
	8.1@93	0.204	30	Fine, gray, water bearing sand, medium compaction	7	0.110	L
Current River @ SH 328/1	8.1@80	0.254	25	Wet, medium dense, gray sand	15	0.202	L

Table A-1b. Con't

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
Current River @ SH 328/1	8.1@80	0.254	30	Wet, medium dense, gray sand	11	0.201	L
	8.1@80	0.254	35	Wet, medium dense, gray gravelly sand with organic matter	12	0.197	L
	8.1@80	0.254	45	Wet, medium dense, gray gravelly sand with organic matter	11	0.184	L
/2	8.1@80	0.254	15	Wet, loose, brown fine sand	9	0.204	L
	8.1@80	0.254	20	Wet, medium dense, brown sand	12	0.211	L
	8.1@80	0.254	25	Wet, medium dense, brown sand	18	0.212	L
	8.1@80	0.254	30	Wet, medium dense, brown to gray sand with organic matter	13	0.209	L
	8.1@80	0.254	35	Wet, medium dense, brown to gray sand with organic matter	9	0.204	L
	8.1@80	0.254	45	Wet, medium dense, gray sand and gravel	10	0.189	L
/3	8.1@80	0.254	10	Wet, loose, gray fine sand	7	0.202	L
	8.1@80	0.254	20	Wet, loose, gray fine sand	9	0.223	L
	8.1@80	0.254	25	Wet, medium dense, gray sand	13	0.221	L
	8.1@80	0.254	30	Wet, medium dense, gray sand	10	0.217	L
	8.1@80	0.254	35	Wet, medium dense, brown and gray gravelly sand	11	0.211	L
/4	8.1@80	0.254	10	Wet, loose, brown sand	10	0.202	L
	8.1@80	0.254	20	Wet, loose, brown sand	7	0.223	L
	8.1@80	0.254	25	Wet, medium dense, brown and gray sand	9	0.221	L
	8.1@80	0.254	30	Wet, medium dense, brown and gray gravelly sand with organic matter	16	0.217	L
	8.1@80	0.254	35	Wet, medium dense, brown and gray gravely sand with organic matter	11	0.211	L
	8.1@80	0.254	45	Wet, medium dense, brown and gray sand and gravel	10	0.194	L
/8	8.1@80	0.254	15	Wet, medium dense, gray sand	8	0.175	L
	8.1@80	0.254	20	Wet, medium dense, gray sand	8	0.186	L
/10	8.1@80	0.254	15	Wet, medium dense to loose, brown fine sand	7	0.218	L

Table A-1b. Con't

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
Current River @	8.1@80	0.254	20	Wet, medium dense to loose, brown fine sand	8	0.223	L
SH 328/10	8.1@80	0.254	25	Wet, medium dense, gray gravelly sand	16	0.221	L
	8.1@80	0.254	35	Wet, medium dense, gray gravelly sand	13	0.211	L
	8.1@80	0.254	40	Wet, medium dense, gray gravelly sand	13	0.203	L
	8.1@80	0.254	45	Wet, medium dense, gray gravelly sand	13	0.194	L
White River @	8.1@120	0.140	35	Wet, medium dense, gray fine sand	4	0.114	L
SH 67/1	8.1@120	0.140	40	Wet, medium dense, fine sand	9	0.110	L
	8.1@120	0.140	50	Wet, medium dense, brown sand and gravel	7	0.100	L
/4	8.1@120	0.140	10	Wet, loose, brown silty sand	7	0.105	L
	8.1@120	0.140	25	Wet, loose, brown clayey sand	3	0.119	L

L- liquefaction M- marginal liquefaction N- liquefaction not likely

Table A-2. Results of liquefaction potential analysis for January 23, 1812 earthquake.

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
Black River @	7.0 @ 173	0.030	20	Wet, medium dense, gray sand	13	0.018	N
Elgin Ferry /1	7.0 @ 173	0.030	25	Wet, medium dense, gray sand	11	0.019	N
/6	7.0 @ 173	0.030	10	Wet, loose brown fine sand	8	0.018	N
	7.0 @ 173	0.030	15	Wet, medium dense, gray and brown silty sand	7	0.021	N
	7.0 @ 173	0.030	20	Wet, medium dense, gray and brown silty sand with scattered organic matter	10	0.022	N
	7.0@173	0.030	25	Wet, medium dense, gray and brown silty sand with scattered organic matter	9	0.023	N
	7.0@173	0.030	50	Wet, medium dense, gray sand and gravel with organic material	9	0.020	N
/7	7.0@173	0.030	10	Wet, medium dense, gray silty sand and gravel with some organic material (wood)	3	0.018	N
	7.0@173	0.030	15	Wet, medium dense, gray silty sand and gravel with some organic material (wood)	5	0.021	N
	7.0@173	0.030	20	Wet, medium dense, gray silty sand and gravel with some organic material (wood)	13	0.022	N
	7.0@173	0.030	30	Wet, medium dense, gray silty sand and gravel	12	0.023	N
	7.0@173	0.030	40	Wet, medium dense, gray silty sand and gravel with organic material	14	0.022	N
/9	7.0 @ 173	0.030	15	Wet, loose, gray silty sand	4	0.021	N
	7.0 @ 173	0.030	25	Wet, loose, gray and brown sand silty sand	5	0.023	N
	7.0 @ 173	0.030	35	Wet, medium dense, gray sand and gravel	11	0.022	N
	7.0 @ 173	0.030	45	Wet, medium dense, gray sand and gravel	9	0.021	N
Black River	7.0 @ 178	0.030	15	Wet loose, brown silty sand	5	0.030	N
Jacksonport@SH69 /1	7.0 @ 178	0.030	20	Wet, loose, brown silty sand	3	0.030	N

Table A-2. Con't

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
Black River	7.0 @ 178	0.030	25	Wet, loose, brown silty sand	10	0.029	N
Jacksonport@SH69	7.0 @ 178	0.030	30	Wet, medium dense, gray sand and gravel	14	0.028	N
	7.0 @ 178	0.030	35	Wet, medium dense, gray sand and gravel	10	0.027	N
	7.0 @ 178	0.030	45	Wet, medium dense, gray sand	13	0.024	N
/4	7.0 @ 178	0.030	30	Wet, loose, gray sand with some organic matter	6	0.028	N
	7.0 @ 178	0.030	40	Wet, medium dense, gray sand	6	0.026	N
/5	7.0 @ 178	0.030	15	Wet, loose, brown silty sand	8	0.030	N
	7.0 @ 178	0.030	20	Wet, loose, brown silty sand	10	0.030	N
	7.0 @ 178	0.030	30	Wet, medium dense, gray sand	13	0.028	N
	7.0 @ 178	0.030	40	Wet, medium dense, gray sand and gravel	13	0.026	N
/6	7.0 @ 178	0.030	18	Wet, very loose, gray sand	2	0.030	N
	7.0 @ 178	0.030	25	Wet, medium dense, gray sand	4	0.029	N
Cache River @	7.0 @ 120	0.060	15	Wet, very loose, gray sand	3	0.035	N
US 412/1	7.0 @ 120	0.060	20	Wet, medium dense, gray sand with traces of pea gravel	8	0.038	N
	7.0 @ 120	0.060	25	Wet, medium dense, gray sand	9	0.039	N
	7.0 @ 120	0.060	30	Wet, medium dense, gray sand	13	0.040	N
	7.0 @ 120	0.060	35	Wet, medium dense, gray sand	8	0.040	N
	7.0 @ 120	0.060	40	Wet, medium dense, gray sand	14	0.039	N
	7.0 @ 120	0.060	45	Wet, medium dense, gray sand with traces of clay and gravel	7	0.038	N
/2	7.0 @ 120	0.060	15	Wet, loose, gray sand	5	0.042	N
	7.0 @ 120	0.060	20	Wet, loose, gray sand	12	0.045	N
	7.0 @ 120	0.060	25	Wet, medium dense, gray sand	17	0.046	N
	7.0 @ 120	0.060	30	Wet, medium dense, gray sand with some gravel	8	0.046	N
	7.0 @ 120	0.060	35	Wet, medium dense, gray sand with traces of gravel	12	0.045	N
	7.0 @ 120	0.060	40	Wet, loose, gray sand and gravel	6	0.044	N

Table A-2. Con't

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
Cache River	7.0 @ 120	0.060	45	Wet, medium dense, gray sand with traces of gravel	10	0.042	N
/3	7.0 @ 120	0.060	15	Wet, loose, gray sand with some organic matter	8	0.045	N
	7.0 @ 120	0.060	20	Wet, very loose, gray sand with traces of clay and organic matter	3	0.047	N
	7.0 @ 120	0.060	25	Wet, medium dense, gray sand with traces of lignite	10	0.048	N
	7.0 @ 120	0.060	30	Wet, medium dense, gray sand with traces of lignite	5	0.047	N
	7.0 @ 120	0.060	35	Wet, loose, gray sand with traces of clay	8	0.046	N
	7.0 @ 120	0.060	40	Wet, medium dense, gray sand with clay seams	9	0.045	N
	7.0 @ 120	0.060	45	Wet, medium dense, gray sand with traces of lignite and gravel	10	0.043	N
/4	7.0 @ 120	0.060	19	Wet, loose, brown sand	4	0.044	
	7.0 @ 120	0.060	15	Wet medium dense, gray sand	15	0.041	N
	7.0 @ 120	0.060	20	Wet, medium dense, gray sand with traces of gravel	12	0.044	N
	7.0 @ 120	0.060	25	Wet, loose, gray sand with traces of lignite	7	0.045	N
	7.0 @ 120	0.060	30	Wet, medium dense, gray sand with traces of pea gravel and lignite	14	0.045	N
	7.0 @ 120	0.060	35	Wet, loose to medium dense, sand with some lignite	4	0.044	N
	7.0 @ 120	0.060	45	Wet, loose, gray sand with traces of lignite	6	0.042	N
Cross Country	7.0 @ 158	0.040	15	Fine, brown sand, wet	17	0.027	N
Ditch @ SH/42	7.0 @ 158	0.040	20	Fine, gray sand	15	0.028	N
/5222	7.0 @ 158	0.040	25	Fine, gray, water bearing sand, medium compaction	19	0.029	N
/5223-1	7.0 @ 158	0.040	15	Fine, gray sand, wet	15	0.023	N
	7.0 @ 158	0.040	20	Fine, gray, water bearing sand, medium compaction	15	0.025	N
/5223-4	7.0 @ 158	0.040	26	Fine, gray sand, wet	9	0.036	N
	7.0 @ 158	0.040	30	Fine, gray, water bearing sand, medium compaction	7	0.038	N
/5222	7.5@158	0.056	15	Fine, brown sand, wet	17	0.037	N

Table A-2. Con't

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
Cross Country	7.5@158	0.056	20	Fine, gray sand	15	0.040	N
Ditch/ /5222	7.5@158	0.056	25	Fine, gray, water bearing sand, medium compaction	19	0.041	N
/5223-1	7.5@158	0.056	15	Fine, gray sand, wet	15	0.032	N
	7.5@158	0.056	20	Fine, gray, water bearing sand, medium compaction	15	0.035	N
/5223-4	7.5@158	0.056	26	Fine, gray sand, wet	9	0.029	N
	7.5@158	0.056	30	Fine, gray, water bearing sand, medium compaction	7	0.030	N
/5222	7.8@158	0.084	15	Fine, brown sand, wet	17	0.048	N
	7.8@158	0.084	20	Fine, gray sand	15	0.051	N
	7.8@158	0.084	25	Fine, gray, water bearing sand, medium compaction	19	0.052	N
/5223-1	7.8@158	0.084	15	Fine, gray sand, wet	15	0.041	N
	7.8@158	0.084	20	Fine, gray, water bearing sand, medium compaction	15	0.045	N
/5223-4	7.8@158	0.084	26	Fine, gray sand, wet	9	0.037	N
	7.8@158	0.084	30	Fine, gray, water bearing sand, medium compaction	7	0.038	N
Current River @	M7.0@105	0.070	25	Wet, medium dense, gray sand	15	0.056	N
SH 328/1	M7.0@105	0.070	30	Wet, medium dense, gray sand	11	0.055	N
	M7.0@105	0.070	35	Wet, medium dense, gray gravelly sand with organic matter	12	0.054	N
	M7.0@105	0.070	45	Wet, medium dense, gray gravelly sand with organic matter	11	0.051	N
/2	M7.0@105	0.070	15	Wet, loose, brown fine sand	9	0.056	N
	M7.0@105	0.070	20	Wet, medium dense, brown sand	12	0.058	N
	M7.0@105	0.070	25	Wet, medium dense, brown sand	18	0.059	N
	M7.0@105	0.070	30	Wet, medium dense, brown to gray sand with organic matter	13	0.058	N
	M7.0@105	0.070	35	Wet, medium dense, brown to gray sand with organic matter	9	0.056	N
	M7.0@105	0.070	45	Wet, medium dense, gray sand and gravel	10	0.052	N
/3	M7.0@105	0.070	10	Wet, loose, gray fine sand	7	0.056	N
	M7.0@105	0.070	20	Wet, loose, gray fine sand	9	0.062	N
	M7.0@105	0.070	25	Wet, medium dense, gray sand	13	0.061	N

Table A-2. Con't

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
Current River @	M7.0@105	0.070	30	Wet, medium dense, gray sand	10	0.060	N
SH 328/3	M7.0@105	0.070	35	Wet, medium dense, brown and gray gravelly sand	11	0.058	N
/4	M7.0@105	0.070	10	Wet, loose, brown sand	10	0.056	N
	M7.0@105	0.070	20	Wet, loose, brown sand	7	0.062	N
	M7.0@105	0.070	25	Wet, medium dense, brown and gray sand	9	0.061	N
	M7.0@105	0.070	30	Wet, medium dense, brown and gray gravelly sand with organic matter	16	0.060	N
	M7.0@105	0.070	35	Wet, medium dense, brown and gray gravely sand with organic matter	11	0.058	N
	M7.0@105	0.070	45	Wet, medium dense, brown and gray sand and gravel	10	0.054	N
/8	M7.0@105	0.070	15	Wet, medium dense, gray sand	8	0.048	N
	M7.0@105	0.070	20	Wet, medium dense, gray sand	8	0.051	N
/10	M7.0@105	0.070	15	Wet, medium dense to loose, brown fine sand	7	0.060	N
	M7.0@105	0.070	20	Wet, medium dense to loose, brown fine sand	8	0.061	N
	M7.0@105	0.070	25	Wet, medium dense, gray gravelly sand	16	0.061	N
	M7.0@105	0.070	35	Wet, medium dense, gray gravelly sand	13	0.058	N
	M7.0@105	0.070	40	Wet, medium dense, gray gravelly sand	13	0.056	N
	M7.0@105	0.070	45	Wet, medium dense, gray gravelly sand	13	0.054	N
White River @	M7.0@178	0.030	35	Wet, medium dense, gray fine sand	4	0.024	N
SH 67/1	M7.0@178	0.030	40	Wet, medium dense, fine sand	9	0.024	N
	M7.0@178	0.030	50	Wet, medium dense, brown sand and gravel	7	0.022	N
/4	M7.0@178	0.030	10	Wet, loose, brown silty sand	7	0.023	N
	M7.0@178	0.030	25	Wet, loose, brown clayey sand	3	0.025	N

[1]L - liquefaction; M- marginal liquefaction; N - liquefaction not likely

Table A-3. Results of liquefaction potential analysis for February 7, 1812 earthquake.

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
Black River @	7.5@160	0.050	20	Wet, medium dense, gray sand	13	0.030	N
Elgin Ferry/1	7.5@160	0.050	25	Wet, medium dense, gray sand	11	0.031	N
/6	7.5@160	0.050	10	Wet, loose brown fine sand	8	0.030	N
	7.5@160	0.050	15	Wet, medium dense, gray and brown silty sand	7	0.035	N
	7.5@160	0.050	20	Wet, medium dense, gray and brown silty sand with scattered organic matter	10	0.037	N
	7.5@160	0.050	25	Wet, medium dense, gray and brown silty sand with scattered organic matter	9	0.038	N
	7.5@160	0.050	50	Wet, medium dense, gray sand and gravel with organic material	9	0.033	N
/7	7.5@160	0.050	10	Wet, medium dense, gray silty sand and gravel with some organic material (wood)	3	0.030	N
	7.5@160	0.050	15	Wet, medium dense, gray silty sand and gravel with some organic material (wood)	5	0.035	N
	7.5@160	0.050	20	Wet, medium dense, gray silty sand and gravel with some organic material (wood)	13	0.037	N
	7.5@160	0.050	30	Wet, medium dense, gray silty sand and gravel	12	0.038	N
	7.5@160	0.050	40	Wet, medium dense, gray silty sand and gravel with organic material	14	0.036	N
/9	7.5@160	0.050	15	Wet, loose, gray silty sand	4	0.035	N
	7.5@160	0.050	25	Wet, loose, gray and brown sand silty sand	5	0.038	N
	7.5@160	0.050	35	Wet, medium dense, gray sand and gravel	11	0.037	N
	7.5@160	0.050	45	Wet, medium dense, gray sand and gravel	9	0.035	N
Black River	7.5@163	0.040	15	Wet loose, brown silty sand	5	0.041	N
Jacksonport@SH69 /1	7.5@163	0.040	20	Wet, loose, brown silty sand	3	0.040	N

Table A-3. Con't

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
Black River	7.5@163	0.040	25	Wet, loose, brown silty sand	10	0.039	N
Jacksonport@SH69	7.5@163	0.040	30	Wet, medium dense, gray sand and gravel	14	0.038	N
	7.5@163	0.040	35	Wet, medium dense, gray sand and gravel	10	0.036	N
	7.5@163	0.040	45	Wet, medium dense, gray sand	13	0.033	N
/4	7.5@163	0.040	30	Wet, loose, gray sand with some organic matter	6	0.038	N
	7.5@163	0.040	40	Wet, medium dense, gray sand	6	0.034	N
/5	7.5@163	0.040	15	Wet, loose, brown silty sand	8	0.041	N
	7.5@163	0.040	20	Wet, loose, brown silty sand	10	0.040	N
	7.5@163	0.040	30	Wet, medium dense, gray sand	13	0.038	N
	7.5@163	0.040	40	Wet, medium dense, gray sand and gravel	13	0.034	N
/6	7.5@163	0.040	18	Wet, very loose, gray sand	2	0.040	N
	7.5@163	0.040	25	Wet, medium dense, gray sand	4	0.039	N
Cache River @	7.5@110	0.100	15	Wet, very loose, gray sand	3	0.058	L
US 412/1	7.5@110	0.100	20	Wet, medium dense, gray sand with traces of pea gravel	8	0.063	N
	7.5@110	0.100	25	Wet, medium dense, gray sand	9	0.066	N
	7.5@110	0.100	30	Wet, medium dense, gray sand	13	0.067	N
	7.5@110	0.100	35	Wet, medium dense, gray sand	8	0.067	N
	7.5@110	0.100	40	Wet, medium dense, gray sand	14	0.066	N
	7.5@110	0.100	45	Wet, medium dense, gray sand with traces of clay and gravel	7	0.064	N
/2	7.5@110	0.100	15	Wet, loose, gray sand	5	0.070	L
	7.5@110	0.100	20	Wet, loose, gray sand	12	0.075	N
	7.5@110	0.100	25	Wet, medium dense, gray sand	17	0.076	N
	7.5@110	0.100	30	Wet, medium dense, gray sand with some gravel	8	0.076	N
	7.5@110	0.100	35	Wet, medium dense, gray sand with traces of gravel	12	0.075	N
	7.5@110	0.100	40	Wet, loose, gray sand and gravel	6	0.073	N

Table A-3. Con't

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
Cache River	7.5@110	0.100	45	Wet, medium dense, gray sand with traces of gravel	10	0.070	N
/3	7.5@110	0.100	15	Wet, loose, gray sand with some organic matter	8	0.075	N
	7.5@110	0.100	20	Wet, very loose, gray sand with traces of clay and organic matter	3	0.079	L
	7.5@110	0.100	25	Wet, medium dense, gray sand with traces of lignite	10	0.080	N
	7.5@110	0.100	30	Wet, medium dense, gray sand with traces of lignite	5	0.079	L
	7.5@110	0.100	35	Wet, loose, gray sand with traces of clay	8	0.077	N
	7.5@110	0.100	40	Wet, medium dense, gray sand with clay seams	9	0.075	N
	7.5@110	0.100	45	Wet, medium dense, gray sand with traces of lignite and gravel	10	0.072	N
/4	7.5@110	0.100	19	Wet, loose, brown sand	4	0.073	L
	7.5@110	0.100	15	Wet medium dense, gray sand	15	0.069	N
	7.5@110	0.100	20	Wet, medium dense, gray sand with traces of gravel	12	0.073	N
	7.5@110	0.100	25	Wet, loose, gray sand with traces of lignite	7	0.075	N
	7.5@110	0.100	30	Wet, medium dense, gray sand with traces of pea gravel and lignite	14	0.075	N
	7.5@110	0.100	35	Wet, loose to medium dense, sand with some lignite	4	0.074	L
	7.5@110	0.100	45	Wet, loose, gray sand with traces of lignite	6	0.070	M/N
Cross Country	7.5@138	0.070	15	Fine, brown sand, wet	17	0.046	N
Ditch @ SH 42	7.5@138	0.070	20	Fine, gray sand	15	0.050	N
/5222	7.5@138	0.070	25	Fine, gray, water bearing sand, medium compaction	19	0.051	N
/5223-1	7.5@138	0.070	15	Fine, gray sand, wet	15	0.040	N
	7.5@138	0.070	20	Fine, gray, water bearing sand, medium compaction	15	0.044	N
/5223-4	7.5@138	0.070	26	Fine, gray sand, wet	9	0.052	N
	7.5@138	0.070	30	Fine, gray, water bearing sand, medium compaction	7	0.054	N
/5222	8.0@138	0.084	15	Fine, brown sand, wet	17	0.069	N
	8.0@138	0.084	20	Fine, gray sand	15	0.074	N

Table A-3. Con't

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
/5222	8.0@138	0.084	25	Fine, gray, water bearing sand, medium compaction	19	0.076	N
/5223-1	8.0@138	0.084	15	Fine, gray sand, wet	15	0.060	N
	8.0@138	0.084	20	Fine, gray, water bearing sand, medium compaction	15	0.066	N
/5223-4	8.0@138	0.084	26	Fine, gray sand, wet	9	0.054	N
	8.0@138	0.084	30	Fine, gray, water bearing sand, medium compaction	7	0.056	N
Current River @ SH 328/1	7.5@103	0.089	25	Wet, medium dense, gray sand	15	0.071	N
	7.5@103	0.089	30	Wet, medium dense, gray sand	11	0.070	N
	7.5@103	0.089	35	Wet, medium dense, gray gravelly sand with organic matter	12	0.069	N
	7.5@103	0.089	45	Wet, medium dense, gray gravelly sand with organic matter	11	0.064	N
/2	7.5@103	0.089	15	Wet, loose, brown fine sand	9	0.071	N
	7.5@103	0.089	20	Wet, medium dense, brown sand	12	0.074	N
	7.5@103	0.089	25	Wet, medium dense, brown sand	18	0.074	N
	7.5@103	0.089	30	Wet, medium dense, brown to gray sand with organic matter	13	0.073	N
	7.5@103	0.089	35	Wet, medium dense, brown to gray sand with organic matter	9	0.071	N
	7.5@103	0.089	45	Wet, medium dense, gray sand and gravel	10	0.066	N
/3	7.5@103	0.089	10	Wet, loose, gray fine sand	7	0.070	L
	7.5@103	0.089	20	Wet, loose, gray fine sand	9	0.078	L
	7.5@103	0.089	25	Wet, medium dense, gray sand	13	0.077	N
	7.5@103	0.089	30	Wet, medium dense, gray sand	10	0.076	N
	7.5@103	0.089	35	Wet, medium dense, brown and gray gravelly sand	11	0.074	N
/4	7.5@103	0.089	10	Wet, loose, brown sand	10	0.070	L
	7.5@103	0.089	20	Wet, loose, brown sand	7	0.078	L
	7.5@103	0.089	25	Wet, medium dense, brown and gray sand	9	0.077	N
	7.5@103	0.089	30	Wet, medium dense, brown and gray gravelly sand with organic matter	16	0.076	N

Table A-3. Con't

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
Current River @ SH 328/4	7.5@103	0.089	35	Wet, medium dense, brown and gray gravely sand with organic matter	11	0.074	N
	7.5@103	0.089	45	Wet, medium dense, brown and gray sand and gravel	10	0.068	N
/8	7.5@103	0.089	15	Wet, medium dense, gray sand	8	0.061	N
	7.5@103	0.089	20	Wet, medium dense, gray sand	8	0.065	N
/10	7.5@103	0.089	15	Wet, medium dense to loose, brown fine sand	7	0.076	L
	7.5@103	0.089	20	Wet, medium dense to loose, brown fine sand	8	0.078	L
	7.5@103	0.089	25	Wet, medium dense, gray gravelly sand	16	0.077	N
	7.5@103	0.089	35	Wet, medium dense, gray gravelly sand	13	0.074	N
	7.5@103	0.089	40	Wet, medium dense, gray gravelly sand	13	0.071	N
	7.5@103	0.089	45	Wet, medium dense, gray gravelly sand	13	0.068	N
White River @ SH 67/1	7.5@163	0.070	35	Wet, medium dense, gray fine sand	4	0.057	M/N
	7.5@163	0.070	40	Wet, medium dense, fine sand	9	0.055	N
	7.5@163	0.070	50	Wet, medium dense, brown sand and gravel	7	0.050	N
/4	7.5@163	0.070	10	Wet, loose, brown silty sand	7	0.053	N
	7.5@163	0.070	25	Wet, loose, brown clayey sand	3	0.059	L

[1]L - liquefaction   M- margial liquefaction   N - liquefaction not likely

Table A-4. Results of liquefaction potential analysis for January 5, 1843 earthquake.

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
Cross Country	6.3@30	0.216	15	Fine, brown sand, wet	17	0.144	N
Ditch @ SH 42	6.3@30	0.216	20	Fine, gray sand	15	0.154	N
/5222-1	6.3@30	0.216	25	Fine, gray, water bearing sand, medium compaction	19	0.158	N
/5223-1	6.3@30	0.216	15	Fine, gray sand, wet	15	0.125	N
	6.3@30	0.216	20	Fine, gray, water bearing sand, medium compaction	15	0.136	N
/5223-4	6.3@30	0.216	26	Fine, gray sand, wet	9	0.113	N
	6.3@30	0.216	30	Fine, gray, water bearing sand, medium compaction	7	0.116	N
Cross Country	6.5@30	0.254	15	Fine, brown sand, wet	17	0.169	N
Ditch @ SH 42	6.5@30	0.254	20	Fine, gray sand	15	0.181	N
/5222-1	6.5@30	0.254	25	Fine, gray, water bearing sand, medium compaction	19	0.186	N
/52223-1	6.5@30	0.254	15	Fine, gray sand, wet	15	0.146	N
	6.5@30	0.254	20	Fine, gray, water bearing sand, medium compaction	15	0.160	N
/5223-4	6.5@30	0.254	26	Fine, gray sand, wet	9	0.132	M/N
	6.5@30	0.254	30	Fine, gray, water bearing sand, medium compaction	7	0.137	L

[1]L - liquefaction; M- marginal liquefaction; N - liquefaction not likely

Table A-5. Results of liquefaction potential analysis for December 16, 1811 earthquake (M 7.2, 7.6, 8.1).

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
Hatchie	7.2@55	0.241	20	gray, medium sand	20	0.266	L
Rt 51	7.2@55	0.241	19	fine gray sand	17	0.268	L
	7.2@55	0.241	29	fine gray sand	20	0.244	L
	7.2@55	0.241	14	fine gray sand	23	0.280	N
	7.2@55	0.241	24	medium gray sand	18	0.256	L
	7.2@55	0.241	14	fine brown and gray sand	23	0.280	N
	7.2@55	0.241	24	medium gray sand	27	0.256	N
	7.2@55	0.241	19	fine gray sand	25	0.268	N
	7.2@55	0.241	29	coarse gray sand	18	0.244	L
Hatchie	7.6@55	0.277	20	gray, medium sand	20	0.305	L
Rt 51	7.6@55	0.277	19	fine gray sand	17	0.307	L
	7.6@55	0.277	29	fine gray sand	20	0.280	L
	7.6@55	0.277	14	fine gray sand	23	0.321	L
	7.6@55	0.277	24	medium gray sand	18	0.294	L
	7.6@55	0.277	14	fine brown and gray sand	23	0.321	L
	7.6@55	0.277	24	medium gray sand	27	0.294	N
	7.6@55	0.277	19	fine gray sand	25	0.307	L
	7.6@55	0.277	29	coarse gray sand	18	0.280	L
Hatchie	8.1@55	0.311	20	gray, medium sand	20	0.342	L
Rt 51	8.1@55	0.311	19	fine gray sand	17	0.345	L
	8.1@55	0.311	29	fine gray sand	20	0.314	L
	8.1@55	0.311	14	fine gray sand	23	0.361	L
	8.1@55	0.311	24	medium gray sand	18	0.330	L
	8.1@55	0.311	14	fine brown and gray sand	23	0.361	L
	8.1@55	0.311	24	medium gray sand	27	0.330	L
	8.1@55	0.311	19	fine gray sand	25	0.345	L
	8.1@55	0.311	29	coarse gray sand	18	0.314	L

[1]L = liquefaction likely; N = liquefaction not likely.

Table A-6. Results of liquefaction potential analysis for Janurary 23, 1812 earthquake (M 7.0, 7.5, 7.8).

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
Hatchie	7.0@100	0.106	20	gray, medium sand	20	0.117	N
Rt 51	7.0@100	0.106	19	fine gray sand	17	0.118	N
	7.0@100	0.106	29	fine gray sand	20	0.107	N
	7.0@100	0.106	14	fine gray sand	23	0.123	N
	7.0@100	0.106	24	medium gray sand	18	0.113	N
	7.0@100	0.106	14	fine brown and gray sand	23	0.123	N
	7.0@100	0.106	24	medium gray sand	27	0.113	N
	7.0@100	0.106	19	fine gray sand	25	0.118	N
	7.0@100	0.106	29	coarse gray sand	18	0.107	N
Hatchie	7.5@100	0.128	20	gray, medium sand	20	0.141	N
Rt 51	7.5@100	0.128	19	fine gray sand	17	0.143	N
	7.5@100	0.128	29	fine gray sand	20	0.130	N
	7.5@100	0.128	14	fine gray sand	23	0.149	N
	7.5@100	0.128	24	medium gray sand	18	0.136	N
	7.5@100	0.128	14	fine brown and gray sand	23	0.149	N
	7.5@100	0.128	24	medium gray sand	27	0.136	N
	7.5@100	0.128	19	fine gray sand	25	0.143	N
	7.5@100	0.128	29	coarse gray sand	18	0.130	N
Hatchie	7.8@100	0.140	20	gray, medium sand	20	0.154	N
Rt 51	7.8@100	0.140	19	fine gray sand	17	0.155	N
	7.8@100	0.140	29	fine gray sand	20	0.141	N
	7.8@100	0.140	14	fine gray sand	23	0.162	N
	7.8@100	0.140	24	medium gray sand	18	0.148	N
	7.8@100	0.140	14	fine brown and gray sand	23	0.162	N
	7.8@100	0.140	24	medium gray sand	27	0.148	N
	7.8@100	0.140	19	fine gray sand	25	0.155	N
	7.8@100	0.140	29	coarse gray sand	18	0.141	N

[1]L = liquefaction likely;   N = liquefaction not likely.

Table A-7. Results of liquefaction potential analysis for February 7, 1812 earthquake (M 7.4, 7.8, 8.0).

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
Hatchie	7.4@75	0.179	20	gray, medium sand	20	0.197	N
Rt 51	7.4@75	0.179	19	fine gray sand	17	0.199	L
	7.4@75	0.179	29	fine gray sand	20	0.181	N
	7.4@75	0.179	14	fine gray sand	23	0.208	N
	7.4@75	0.179	24	medium gray sand	18	0.190	N
	7.4@75	0.179	14	fine brown and gray sand	23	0.208	N
	7.4@75	0.179	24	medium gray sand	27	0.190	N
	7.4@75	0.179	19	fine gray sand	25	0.199	N
	7.4@75	0.179	29	coarse gray sand	18	0.295	N
Hatchie	7.8@75	0.201	20	gray, medium sand	20	0.222	L
Rt 51	7.8@75	0.201	19	fine gray sand	17	0.224	L
	7.8@75	0.201	29	fine gray sand	20	0.204	L
	7.8@75	0.201	14	fine gray sand	23	0.234	L
	7.8@75	0.201	24	medium gray sand	18	0.214	L
	7.8@75	0.201	14	fine brown and gray sand	23	0.234	L
	7.8@75	0.201	24	medium gray sand	27	0.214	N
	7.8@75	0.201	19	fine gray sand	25	0.224	N
	7.8@75	0.201	29	coarse gray sand	18	0.204	L
Hatchie	8.0@75	0.210	20	gray, medium sand	20	0.231	L
Rt 51	8.0@75	0.210	19	fine gray sand	17	0.234	L
	8.0@75	0.210	29	fine gray sand	20	0.213	L
	8.0@75	0.210	14	fine gray sand	23	0.244	L
	8.0@75	0.210	24	medium gray sand	18	0.223	L
	8.0@75	0.210	14	fine brown and gray sand	23	0.244	L
	8.0@75	0.210	24	medium gray sand	27	0.223	N
	8.0@75	0.210	19	fine gray sand	25	0.234	N
	8.0@75	0.210	29	coarse gray sand	18	0.213	L

[1]L = liquefaction likely; N = liquefaction not likely.

Table A-8. Results of liquefaction potential analysis for hypothetical local earthquake (M 6.0, 5.5, 5.25).

Site/ Borehole	Magnitude @ Distance (km)	amax	Depth to Susceptible Sediment (ft)	Description of Susceptible Sediment	Blow Count $N_{1(60)}$	Cyclic Stress Ratio	Results[1]
Hatchie	6@10	0.800	20	gray, medium sand	20	0.881	L
Rt 51	6@10	0.800	19	fine gray sand	17	0.889	L
	6@10	0.800	29	fine gray sand	20	0.810	L
	6@10	0.800	14	fine gray sand	23	0.929	L
	6@10	0.800	24	medium gray sand	18	0.849	L
	6@10	0.800	14	fine brown and gray sand	23	0.929	L
	6@10	0.800	24	medium gray sand	27	0.849	L
	6@10	0.800	19	fine gray sand	25	0.889	L
	6@10	0.800	29	coarse gray sand	18	0.810	L
Hatchie	5.5@10	0.551	20	gray, medium sand	20	0.606	L
Rt 51	5.5@10	0.551	19	fine gray sand	17	0.612	L
	5.5@10	0.551	29	fine gray sand	20	0.557	L
	5.5@10	0.551	14	fine gray sand	23	0.639	L
	5.5@10	0.551	24	medium gray sand	18	0.585	L
	5.5@10	0.551	14	fine brown and gray sand	23	0.639	L
	5.5@10	0.551	24	medium gray sand	27	0.585	N
	5.5@10	0.551	19	fine gray sand	25	0.612	N
	5.5@10	0.551	29	coarse gray sand	18	0.557	L
Hatchie	5.25@10	0.446	20	gray, medium sand	20	0.492	N
Rt 51	5.25@10	0.446	19	fine gray sand	17	0.496	L
	5.25@10	0.446	29	fine gray sand	20	0.452	N
	5.25@10	0.446	14	fine gray sand	23	0.518	N
	5.25@10	0.446	24	medium gray sand	18	0.474	L
	5.25@10	0.446	14	fine brown and gray sand	23	0.518	N
	5.25@10	0.446	24	medium gray sand	27	0.474	N
	5.25@10	0.446	19	fine gray sand	25	0.496	N
	5.25@10	0.446	29	coarse gray sand	18	0.452	N

[1]L = liquefaction likely; N = liquefaction not likely.