

FINAL TECHNICAL REPORT

External Grant Ward Number G10AC00042

Title:

Arkansas Seismic Observatory

Principal Investigators:

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2801 South University Avenue
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Term

December 2009 through December 2013

March, 2014

Arkansas Seismic Observatory

G10AC00042

Haydar Al-Shukri and Hanan Mahdi, University of Arkansas, Little Rock, Arkansas

Abstract

The award calls for the adoption of six of the EarthScope/USArray Transportable that were installed in Arkansas during the period 2010 and 2013 for the purpose of enhancing the capability of earthquake monitoring in the central United States in general, and the state of Arkansas, in particular. A six-component strong ground motion station was also installed within the seismically active part of the New Madrid fault system. Other benefits of this project are to assist in hazard mitigation and early warning, provide public education and community outreach, provide state-of-the-art data to the scientific community to better understand seismicity and its risk in the region, and provide real-time information on seismic activity to allow for rapid response by responsible government agencies such as the United States Geological Survey, the Arkansas Geological Survey, and the Arkansas Department of Emergency Management.

For the last several years, state government officials in Arkansas have expressed a strong desire to support the infrastructure for earthquake monitoring in our state and surrounding regions, culminating with the Governor instructing the Arkansas Geological Survey to use a special \$300,000 fund to install six broadband seismic stations. The federal government Omnibus bill earmarked funding to install, integrate, and operate a number of state-of-the-art broadband seismic stations in the state. The Arkansas Earthquake Center at the University of Arkansas at Little Rock was tasked to perform this duty. The research team, in consultation with experts from the USGS, St Louis University, the Center for Earthquake Research and Information, and IRIS, considered several options to optimize use of the allocated funds of this award. The team also worked closely with the Arkansas Geological Survey to make sure that this project and theirs are complimentary without overlapping. The IRIS/EarthScope installation of the Transportable Array (TA) stations within Arkansas was scheduled to start in 2010 and continue through 2013. We found this timing ideal to adopt six of these stations and continue to operate them. The main advantage of this is to have a fully operational state-of-the-art broadband network with only the cost of (or possibly less than) the price of the hardware. It also fulfilled the requirement of integrating this network with the Advance National Seismic System. Real-time network improved earthquake detectability, and the high-quality data increased our knowledge about the seismicity of the central United States.

Report

Project Description

Introduction

Earthquake monitoring in the central United States using regional permanent seismic networks started in the early 70s and since then has gone through multiple revisions, upgrades, and improvements. St. Louis University (SLU) and the University of Memphis/Center for Earthquake Research and Information (CERI) are the main two institutions that design, install, manage, and operate these networks. Several other institutions and local agencies operate local networks or single stations, in most cases, standalone and not an integral part of the monitoring system in the central United States. The principal task of the SLU/CERI networks is to monitor the earthquake activity of the New Madrid seismic zone (NMSZ) and the surrounding regions. Our knowledge and understanding of the seismicity of the central United States in general, and the NMSZ, in particular, is profoundly increased through the study and analysis of the data collected and archived by the SLU/CERI Cooperative Network. This network consists of weak motion (short-period and broadband) and strong-motion stations. Before this ward completed, the furthest of these stations to the south of the NMSZ is the UALR broadband station installed at the University of Arkansas System Administration in Little Rock, Arkansas. The Mount Ida, Arkansas, station (ANSS) is the furthest to the west in Arkansas. According to the USGS website, the earthquake detection capability in the region is no less than M2.5; however, it is about M1.5 for the NMSZ. The addition of more state-of-the-art monitoring stations reduced the detection threshold and improved our understanding of the seismicity of the region to better assess seismic risk.

Arkansas Seismic Observatory

The Arkansas Earthquake Center (AEC) was established at the University of Arkansas at Little Rock in 1980 with a mission to conduct public education and community outreach activities throughout the state. The Federal Emergency Management Agency (FEMA), the Arkansas Department of Emergency Management (ADEM), and UALR supported the center. In 2000, the center's mission was revised to include scientific research and earthquake monitoring. The concept of the Arkansas Seismic Observatory (ASO) was established when ADEM and UALR jointly funded a project to install and operate two broadband seismic stations. The first was installed at the Enola Elementary School, Enola, Arkansas, and the second was at the University of Arkansas Community College at Batesville, Arkansas. Both were installed in 2004 and are still in operation.

For the last several years ADEM, UALR, the Arkansas Geological Survey (AGS), and the Arkansas Governor's Earthquake Advisory Council have coordinated efforts to enhance the capabilities of AEC in research activities, public education, and earthquake monitoring. These efforts resulted into two sources of funding. In 2008, the Governor allocated \$300,000 to install and operate a number of broadband stations. The second funding was through the federal Omnibus bill, which allocated \$500,000 to support the activities of AEC and ASO. This bill translated into the current award for this project. The research team of this project coordinated with AGS to insure that the proposed objectives of these two projects are complementary, with no overlaps or duplications. An ad hoc advisory committee was formed from a number of principal investigators of seismic station installation projects in the central United States. Leading the efforts of this

committee were Dr Robert Herrmann of St Louis University, Dr Mitch Withers of CERI, and Dr. William Leith of the USGS. The research team coordinated with this committee to insure that the benefits of this project are maximized for Arkansas, the region, and the nation. Our principal objective in this project was to build a strong capability of earthquake monitoring at the AEC to be used for scientific research, public education, and risk assessment. It was our goal to have this capability integrated with the regional and national monitoring system. To insure the success of this project, the research team closely coordinated with AGS, SLU, CERI, IRIS, and the USGS. We also worked in coordination with ANSS CEUS regional working group and liaise with the ANSS regional advisory committee.

Implemented Plan

Introduction

This research project built on the tremendous efforts made by many researchers and Principal Investigators for over four decades on earthquake monitoring in the central United States. These efforts produced an outstanding state-of-the-art seismic network that is part of the national monitoring system. The primary goals of this award were to:

- 1- adopt six new broadband seismic stations of the Transportable Array that were installed in the last three years in Arkansas as part of the EarthScope project
- 2- install a six-component strong motion station within the active fault system of the NMSZ
- 3- upgrade the communication system of the existing two broadband stations and integrate them with the network
- 4- build capability at the AEC for data communication and analysis
- 5- work with the AGS to integrate the state's project with the proposed one to build the capability for an advanced monitoring system in the region
- 6- coordinate with the USGS, IRIS, AGS, SLU, and CERI to manage the real-time data flow to the USGS/National Earthquake Information Center, and CERI for immediate data analysis
- 7- integrate this system with ANSS and the regional monitoring system
- 8- reduce the earthquake detection threshold to less than M2.0 in the region, and
- 9- make sure that the data produced by the system is available to the scientific community and public officials.

Conceptual Framework

Through the achievement of the above goals, new seismological knowledge and earthquake detection capabilities was developed in the central United States from analyzing the high-quality data to be collected by the seismic network, advancing immediate and future opportunities for scientists to study and refine the crustal and upper mantle structure, seismotectonic settings, wave propagation and attenuation, and site-specific conditions. The project will assist in validating seismic risk assessment in the central United States. Another main advantage of the project was the improvement of the earthquake detection capability in areas away from the NMSZ to the west, south, and southwest.

In coordination with the AGS, we now able to integrate their stations (6), the UALR existing stations (2), and the adopted stations for this project (6) to provide the framework of the ASO.

With careful selection of station locations, the ASO network now covers an area with an aperture of about 400 kilometers. A principal goal of the research team is to make sure that the earthquake monitoring project in Arkansas is complimentary to current and future monitoring activities in the central United States. Integrating this network with the ANSS provided outstanding improvement in earthquake detection and risk assessment in the region.

EarthScope and the Transportable Array

EarthScope is a national science initiative to explore the structure and evolution of the North American continent and the physical processes controlling earthquakes and volcanoes. This initiative takes interdisciplinary approach to study the active nucleation zone of earthquakes, individual faults and volcanoes, deformation along plate boundaries, continental geodynamics and plate tectonic motion, fluids in the crust, and volcanic and seismic hazard (IRIS TA Operation Manual, VOL I, 2007). The USArray consists of a Transportable Array of 400 broadband seismic stations to be sequentially deployed at 2000 sites in 70 kilometer spacing across the United States. Thirty-one stations of the TA were deployed in Arkansas. This deployment took place between 2011 and 2013 and their removal was planned after 24 months of the deployment (Figure 1). These stations have the most advanced state-of-the-art technology in earthquake monitoring. TA stations provide continuous real-time monitoring of ground motion. The locations of the Arkansas and north Louisiana installation are shown in Table 1 and Figure 2 (both provided by IRIS).



Figure 1. Current and planned installations for the Transportable Array (IRIS Website).

Table 1: Sites in Arkansas and Northern Louisiana

	Site	State	Location	Latitude	Longitude	Site
1	U38A	AR	Bentonville	36.4089	-94.3228	U38A
2	U39A	AR	Berryville	36.4089	-93.5406	U39A
3	U40A	AR	Peel	36.4089	-92.7583	U40A
4	U41A	AR	Viola	36.4089	-91.9761	U41A
5	U42A	AR	Pocahontas	36.4089	-91.1938	U42A
6	U43A	AR	Mc Dougal	36.4089	-90.4116	U43A
7	V38A	AR	Evansville	35.7794	-94.4539	V38A
8	V39A	AR	Pettigrew	35.7794	-93.6779	V39A
9	V40A	AR	Witts Springs	35.7794	-92.9019	V40A
10	V41A	AR	Mountain View	35.7794	-92.1259	V41A
11	V42A	AR	Cord	35.7794	-91.3499	V42A
12	V43A	AR	Bay	35.7794	-90.5739	V43A
13	V44A	AR	Mississippi	35.7794	-89.7979	V44A
14	W39A	AR	Magazine	35.1498	-93.811	W39A
15	W40A	AR	Pottsville	35.1498	-93.041	W40A
16	W41A	AR	Conway	35.1498	-92.2711	W41A
17	W42A	AR	Searcy	35.1498	-91.5011	W42A
18	W43A	AR	Wynne	35.1498	-90.7312	W43A
19	X39A	AR	Mena	34.5203	-93.94	X39A
20	X40A	AR	Hot Springs National Park	34.5203	-93.1759	X40A
21	X41A	AR	Bauxite	34.5203	-92.4118	X41A
22	X42A	AR	Ulm	34.5203	-91.6478	X42A
23	X43A	AR	Marvell	34.5203	-90.8837	X43A
24	Y39A	AR	Lockesburg	33.8907	-94.0651	Y39A
25	Y40A	AR	Prescott	33.8907	-93.3067	Y40A
26	Y41A	AR	Fordyce	33.8907	-92.5483	Y41A
27	Y42A	AR	Star City	33.8907	-91.7899	Y42A
28	Z40A	AR	Buckner	33.2612	-93.4335	Z40A
29	Z41A	AR	El Dorado	33.2612	-92.6806	Z41A
30	Z42A	AR	Crossett	33.2612	-91.9277	Z42A
31	Z43A	AR	Lake Village	33.2612	-91.1748	Z43A
32	140A	LA	Haughton	32.6316	-93.5563	140A
33	141A	LA	Dubach	32.6316	-92.8088	141A
34	142A	LA	Monroe	32.6316	-92.0612	142A
35	143A	LA	Sondheimer	32.6316	-91.3137	143A
36	240A	LA	Mansfield	32.0021	-93.6754	240A

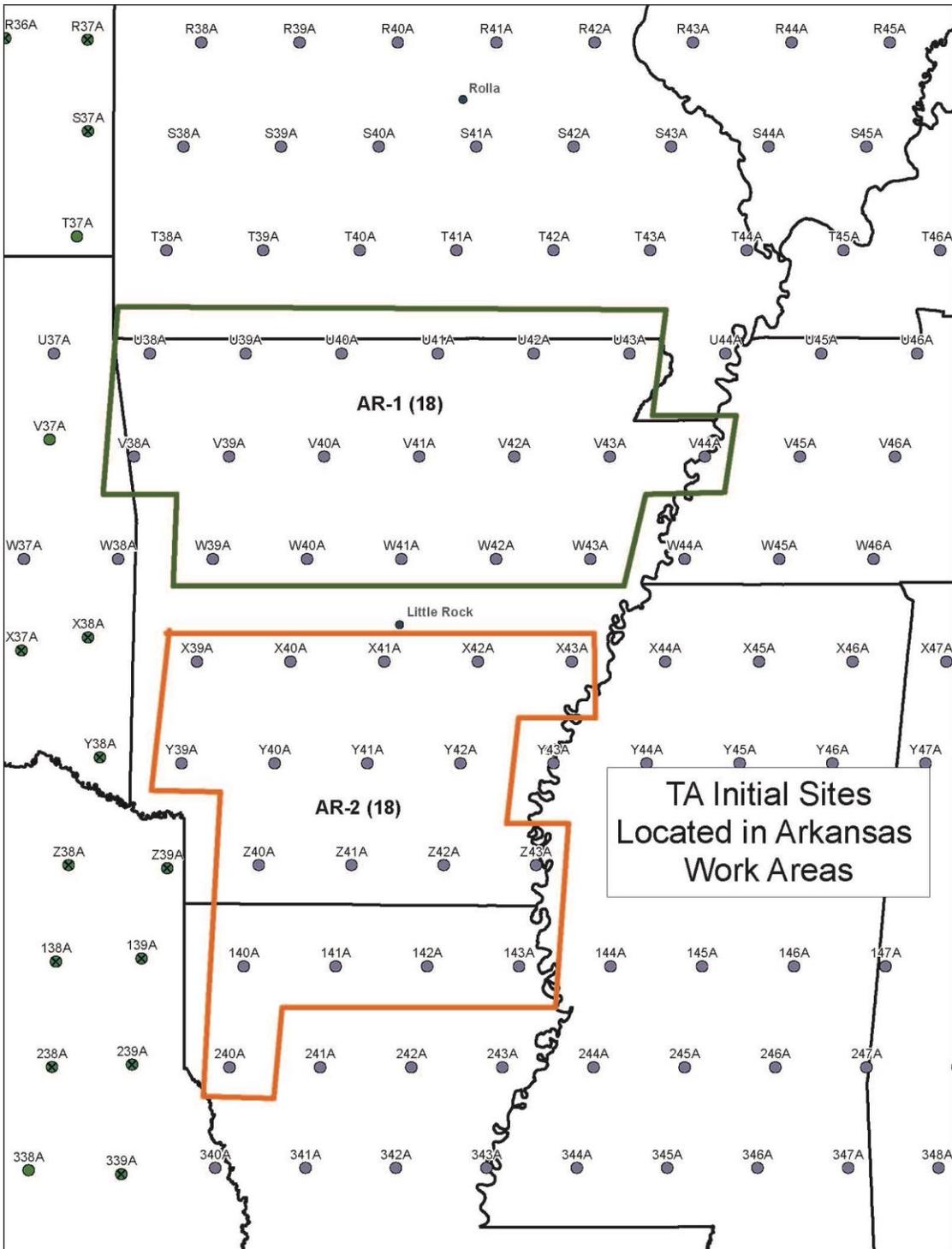


Figure 2: Locations (small dots within polygon) in Arkansas and Northern Louisiana for Transportable Array Stations.

The USArray, in cooperation with the National Science Foundation, the agency that funds the EarthScope project, developed a concept of cooperative research and educational seismic stations which include the transition of TA installations into permanent regional network stations. This concept provides a unique opportunity for educational institutions, local government, and other entities to acquire state-of-the-art, fully operating seismic station(s) for the cost of the hardware. The transition process is administered by IRIS which indicates that *organizations can develop a high-quality, proven, installed earthquake recording station for less than the total cost of vault construction and equipment to:*

- *use as an educational resource*
- *record ground motion from local, regional, and global events*
- *supplement an existing seismic network or start a new network*
- *expand U.S. seismic recording capability.*

IRIS also lists a number of advantages to adopting a TA station:

- A proven, installed station is obtained for less than the cost of the equipment alone.
- Permitting, construction, and installation costs are borne by USArray.
- One-time costs are clearly defined.
- First-time operators are provided with an established operational structure.
- Transportable Array station design has demonstrated scientific value and technical feasibility.
- Individual station performance is available for review prior to adoption.
- Operations and maintenance support of stations over the long term can benefit from access to Transportable Array volume-pricing contracts for equipment and engineered solutions, and engineering support services.
- The station can contribute data to the Advanced National Seismic System, a nationwide network of earthquake sensor systems that continuously monitor earthquakes and other seismic disturbances throughout the United States and provide real-time information for emergency response personnel.

TA Station Sitting in Arkansas

An IRIS common practice is to award a contract to an IRIS member institution or local entity to help with the station sitting within a particular region or state. IRIS contracted UALR for this award. The Co-PI of this project was also the PI for the IRIS station sitting award at UALR. She and three graduate students along with one undergraduate participated in this project and its fieldwork. This helped refine the station locations that we adopted. Their work started in spring 2009 and ended in the fall. They sited 31 stations in Arkansas and 5 in Louisiana. Given such a dense, regularly spaced grid, we had a major advantage in adopting the selected 6 stations. The data about each station (geology, site description, internet access, cell phone coverage, contact person, and willingness for a long term hosting of the station) was available to the research team that were used in the final selection process of the stations.

Broadband Station Description

IRIS/EarthScope transition procedure provides the flexibility to select the station components from a number of options that are available before the installation. These options include the type of

sensor, type of data acquisition system, and type of communication system. After consultation with our advisory committee and the IRIS TA management team, the broadband station configuration was as follows:

- Streckeisen STS-2 broadband sensor. This sensor is a high-performance, portable, very-broadband triaxial seismometer having corner frequencies of 120 seconds to 50 Hz. STS-2 is suitable for teleseismic and regional monitoring. Figure 3 shows the velocity response curve for the STS-2.

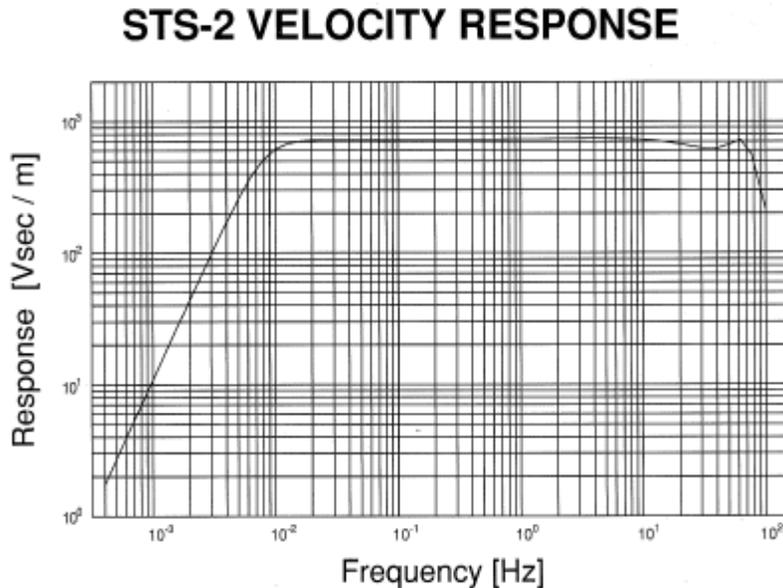


Figure 3. STS-2 Response curve.

- The Data Acquisition System is the Quanterra Q330. The Q330 is an advanced, low-cost, IP network-aware, very low-power 6 channel remote broadband seismic system. The Q330 supports real-time data telemetry to a central site or connection via hard-wire or radio with burst or continuous transmission to a local recording system.
- The Communication System is cell modem. The coverage map of the telecommunications company used by IRIS indicates that the entire state is well covered. We required that all stations be equipped with cell modem.

In summary, each broadband station was equipped with STS-2, 6-channel Q330, and cell modem for communication. Figure 4 shows photographs of different steps of the TA station installation.

The installation of the TA stations shown in Figure 2 started 2011 and end in 2013. IRIS continued operating these stations for about 24 months from the time of the installation. EARN Service was subcontracted to IRIS to service the adopted stations for an additional year. This insured full service operation until the end of 2013. An item was added to the budget as a subcontract for this service.



Figure 4. Photographs of different stages of TA station construction (from IRIS website).

Strong Motion Station Description

Dr. Herrmann (personal communication) indicated that his nearest broadband station to the April 18, 2008, M5.2 Illinois earthquake was clipped on one of its component. Accordingly, the strong motion station configuration was as follow:

Q330HR Ultra-High Resolution Network-Aware Seismic Data Acquisition System (6-ch) includes:

- 3- channel HR26-bit and 3-channel standard 24-bit A/D Converter
- 8 Mbyte RAM
- 2 x 4Gbyte removable USB Memory Rated for -40C to +70C
- GPS antenna

Episensor (2 units) ES-T110301-18-PL Surface Triaxial Force balance Accelerometer with single +12VDC input power

Power System: Battery Box with one 92AH Gel-Cell Battery, 110 AC and Solar Panel Charger, 80 W Dual Panel.

This configuration allowed the 2 Episensors to operate at $\pm 0.5g$ Episensor in Channels 1-3 and the $\pm 2g$ Episensor on Channels 4-6.

The station was installed within the active southern segment of the NMSZ at the Osceola High School, Osceola, Arkansas. The station code is OSAR and it has been reporting real-time data since summer of 2011.

Existing UALR Broadband Stations

In 2004, UALR installed two broadband seismic stations using joint ADEM and UALR funding. By then, these two stations operated as standalone and were not integrated into the regional or national system. The first was installed in Enola, Arkansas, and the second in Batesville, Arkansas (BTAR). Both are equipped with a Guralp CMG-ESPD broadband seismometer and a Guralp 24-bit digitizer. In summer 2013, the Enola station was moved to De Queen, Arkansas (DQAR). The move of the station was due to the closeness of one of the TA adopted stations to Enola. Figure 5 shows the locations of these two stations.

Currently, both BTAR and DQAR are integrated into the regional monitoring system and reporting real time data.

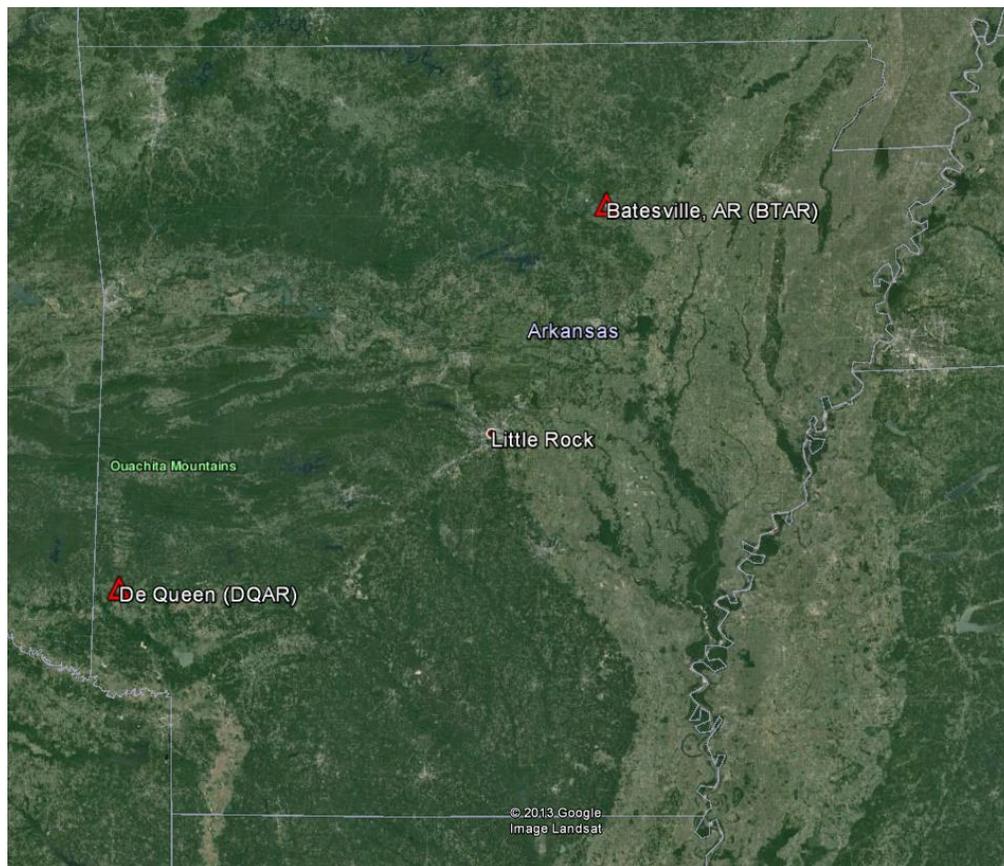


Figure 5. Google map showing the two broadband seismic stations operated by UALR. DQAR is the De Queen station and BTAR is the Batesville station.

ASN

The AGS, in collaboration with CERI, installed six broadband seismic stations using funding that was allocated by the Governor of Arkansas. Figure 6 shows the locations of these stations. These stations are three-component broadband stations that was later upgraded to six components. The research team regularly meets with Bekki White, AGS Director, and Scott Ausbrooks, the Earthquake Program Manager, to combine efforts and make sure that the ASO programs are coordinated.

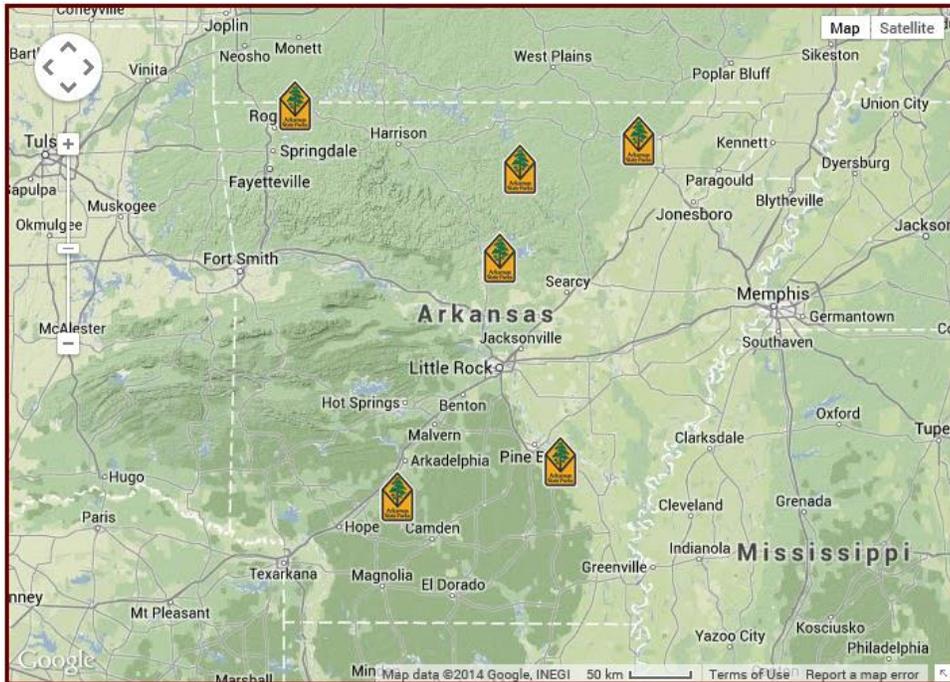


Figure 6. Station locations of the ASN of the AGS.

Scott Ausbrooks (personal communication) provided the below information about the ASN locations:

- 1) Woolly Hollow State Park –near N35.290 W92.288.
- 2) Hobbs State Park –near N36.283 W93.939.
- 3) Cane Creek State Park - near N33.916 W91.772.
- 4) Ozark Folk Center - N35.889 W92.124.
- 5) White Oak Lake State Park - N33.687 W93.112.
- 6) Lake Charles- N36.070 W91.153

ASO Station Selection

The TA installation of 31 stations in Arkansas (Figure 2) provided a unique opportunity for the AGS and UALR teams to select the stations that satisfy the expectations of our sponsors as well as the scientific goals and objectives stated earlier. The selection process was optimized by the collaborative efforts of the teams in continuous consultation with the advisory committee, USGS/ANSS regional advisory committee, AGS, CERI, and SLU. Because the TA stations'

operation continued in the state for an extended period of time, we had the opportunity for data analysis, performance evaluation, and long-term site accessibility. This helped us eliminate the low performance stations and those with the least impact on accomplishing the stated goals and objectives, such as earthquake detectability and source characteristics. In addition to station performance as a selection criterion, we coordinated with AGS to make sure that the installations are complimentary such that gaps are minimized and detectability is maximized. Figure 7 shows the locations of the TA stations that were adopted by UALR. The figure also shows the locations of the ASN and other stations in the area. Table 2 lists the adopted station information and Table 3 provided information about the station sites and the current landowner contacts. The landowner agreement to operate the stations on permanent bases are attached at the end of the report.

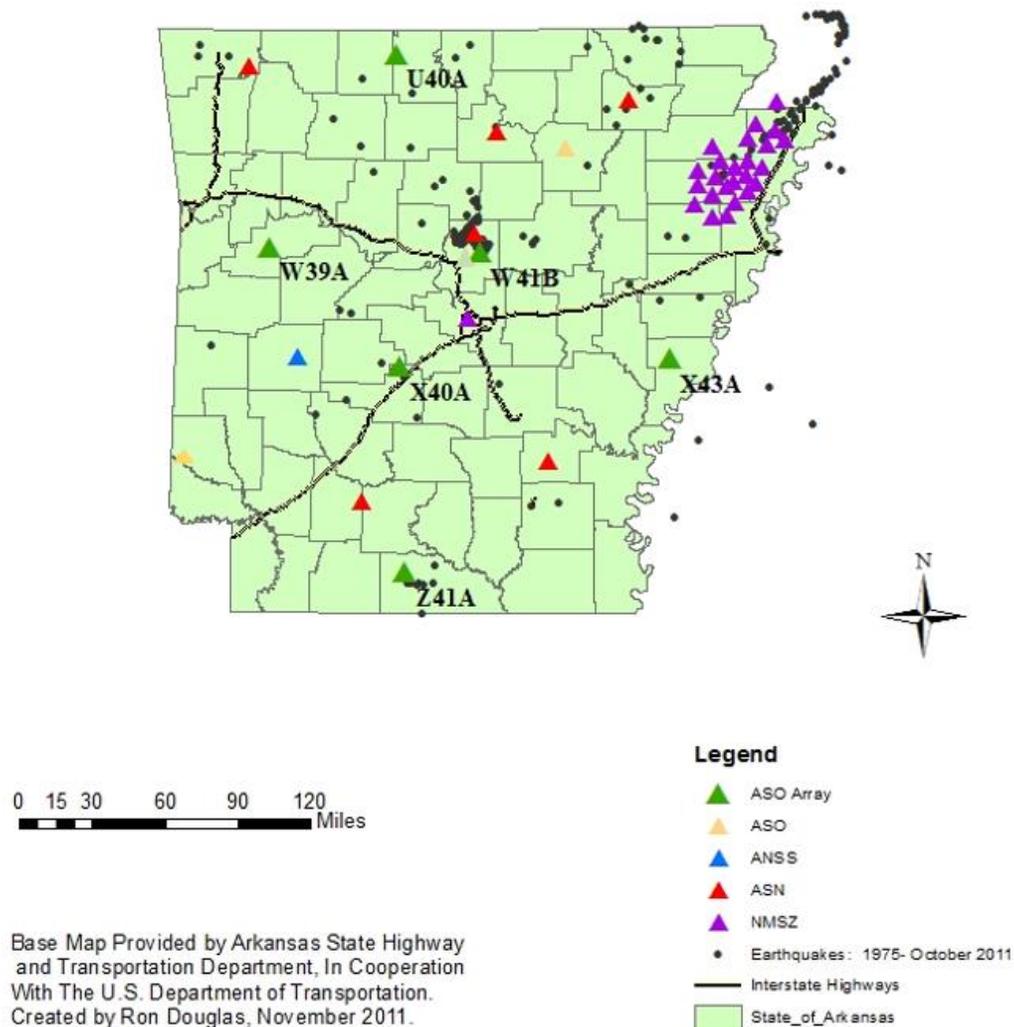


Figure 7. The Adopted TA stations and other stations in Arkansas.

Table 2. Adopted station information.

Station	U40A : Yellville, AR, USA : USArray Transportable Array
Latitude	36.36
Longitude	-92.85
Elevation	374
Start	2011/01/27 (027) 00:00:00

Station	W39A : Magazine, AR, USA : USArray Transportable Array
Latitude	35.20
Longitude	-93.78
Elevation	162
Start	2011/01/29 (029) 00:00:00

Station	X40A : Basin Creek Farm, Marlvern, AR, USA : USArray Transportable Array
Latitude	34.49
Longitude	-92.83
Elevation	158
Start	2011/01/26 (026) 00:00:00

Station	W41B : Gary Mavity, Velonia, AR, USA : USArray Transportable Array
Latitude	35.17
Longitude	-92.25
Elevation	95
Start	2011/04/07 (097) 00:00:00

Station	X43A : Marvell, AR, USA : USArray Transportable Array
Latitude	34.52
Longitude	-90.88
Elevation	53
Start	2011/05/18 (138) 00:00:00

Station	Z41A : Richland Creek Farm, El Dorado, AR, USA : USArray Transportable Array
Latitude	33.26
Longitude	-92.80
Elevation	62
Start	2011/03/10 (069) 00:00:00

Table 3. Information about the adopted station sites and the current landowner contacts.

Site: W41B

Landowner:

Name: Mr. Wade Mavity
MAIL Address: 160 Sawmill Rd., Velonia, AR 72173
Phone: (501) 849-2287
SITE Address: Same as mailing
T6N R12W Sec 11

Contact:

Landowner, Mr. Wade Mavity

Site: X40A

Landowner:

Name: Nettie J. Jackson
Mail Address: 2804 Gourdneck Road, Malvern, AR 72104
Phone: (501) 332-2131
Cell: (501) 844-7167
Site Address: Same as mailing
Malvern, AR 72104

Contact:

Landowner, Nettie J. Jackson

Site: X43A

Landowner:

Name: Winston Foster
MAIL Address: PO Box 865, Marvell, AR 72366
Phone: (870) 829-3267
Cell: (870) 338-0595
E-Mail: winstonfoster15@yahoo.com
SITE Address: T2S R2E S15
Phillips Rd 116
Marvell, AR 72366

Contact:

Landowner, Winston Foster

Site: Z41A

Landowner:

Name: Mr. J. K. (Ken) Rudder, Jr.
Mail Address: 320 Union 757, El Dorado, AR 71730
Phone: (870) 875-1078
Cell: 870-918-5766

Contact:

Landowner, Mr. J. K. (Ken) Rudder, Jr.

Site: W39A

Landowner:

Name: Larry Beaver

MAIL Address: 1814 Chigger Valley Rd., Magazine, Ark 72943

Phone: (479) 969-2268

Cell: (479) 675-6487

SITE Address: Same as mailing
Magazine, Ark 72943

Contact:

Landowner, Larry Beaver

Site: U40A

Landowner:

Name: Mr. Jim McCracken

MAIL Address: 3891 MC3005, Yellville, Arkansas 72687

Phone: (870) 436-5322

SITE Address: T20N R18W S26

Contact:

Landowner, Mr. Jim McCracken

**Revocable Permit and Land Use Agreement
for Seismic Recording System**



Effective Date: May 1, 2012

Permitter: Larry Beaver
Address: 1814 Chigger Valley Road, Magazine, Arkansas, 72943

Permittee: The Board of Trustees of the University of Arkansas acting for and on behalf of the University of Arkansas at Little Rock (UALR)
Address: 2801 South University Avenue, Little Rock, Arkansas, 72204

Site: (TA-W39A) 1814 Chigger Valley Road, Magazine, Arkansas, 72943

WHEREAS, UALR desires to undertake scientific study for the public good as a part of a U.S. geological Survey; and

WHEREAS, the Permitter desires to support UALR's scientific study.

This permit is given by Permitter to UALR without charge in consideration of the above and the following:

1. Permitter understands that the Equipment (defined below), which was installed under an agreement between Permitter and Incorporated Research Institutions in Seismology ("IRIS") shall be adopted by UALR.
2. Permitter hereby grants permission to install, operate, maintain, service, and remove (as required) a Seismic Recording System ("Equipment") to UALR, as listed on Exhibit A to this Agreement, as part of a U.S. Geological Survey (USGA) project ("Project") at the Site.
3. This permit is for the period beginning on the Effective Date and continuing for thirty-six (36) months. Either party may terminate this Agreement at any time upon thirty (30) days written notice.
4. A representative from UALR will notify the Permitter prior to entry for any maintenance visits if required.
5. UALR accepts the premise "as is" condition and upon completion of the permit, agrees to restore the premises as nearly as possible to the condition at the start of the permit.
6. Permitter will not be held responsible for loss of or damage to Equipment on the property.
7. UALR agrees that the maintenance and removal of the Equipment on the lands of the Permitter on which they are installed shall be effected with reasonable diligence to avoid damage to the land.
8. UALR DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE
9. UALR shall perform the Project hereunder only as an independent contractor, and this Agreement shall not constitute, create or in any way be interpreted as a joint venture, partnership or formal business organization of any kind.
10. When fully executed, this Agreement shall supersede any and all prior and existing agreements, either oral or in writing. This Agreement contains the entire agreement between the parties with respect to the subject matter hereof. This Agreement shall not be altered, amended, changed, or otherwise modified except in writing signed by all parties to this Agreement. If a court holds any part, term or provision of this Agreement to be unenforceable, the validity of the remaining portions shall not be affected, and the rights and obligations of the parties shall be construed and enforced as if this Agreement did not contain the objectionable part, term or provision.
11. This Agreement shall be governed and interpreted in accordance with the substantive laws of the State of Arkansas, and with applicable laws of the United States of America.

The parties have executed this Agreement effective as of the date set forth above.

FOR UNIVERSITY	FOR PERMITTER
By: <i>Robert H. Adams</i> Robert H. Adams Vice Chancellor Finance and Administration Date: <i>7-10-12</i>	By: <i>Larry Beaver</i> Name: <i>Larry Beaver</i> Date: <i>6-8-12</i>

**Revocable Permit and Land Use Agreement
for Seismic Recording System**



Effective Date: May 1, 2012

Permitter: Jim McCracken
Address: 3891 Mc 3005, Yellville, Arkansas, 72687

Permittee: The Board of Trustees of the University of Arkansas acting for and on behalf of the University of Arkansas at Little Rock (UALR)
Address: 2801 South University Avenue, Little Rock, Arkansas, 72204

Site: (TA-U40A) T20N R18W S26; within 100 meters of 36.35629, -92.85349

WHEREAS, UALR desires to undertake scientific study for the public good as a part of a U.S. geological Survey; and

WHEREAS, the Permitter desires to support UALR's scientific study.

This permit is given by Permitter to UALR without charge in consideration of the above and the following:

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7. UALR agrees that the maintenance and removal of the Equipment on the lands of the Permitter on which they are installed shall be effected with reasonable diligence to avoid damage to the land.
8. UALR DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE
9. UALR shall perform the Project hereunder only as an independent contractor, and this Agreement shall not constitute, create or in any way be interpreted as a joint venture, partnership or formal business organization of any kind.
10. When fully executed, this Agreement shall supersede any and all prior and existing agreements, either oral or in writing. This Agreement contains the entire agreement between the parties with respect to the subject matter hereof. This Agreement shall not be altered, amended, changed, or otherwise modified except in writing signed by all parties to this Agreement. If a court holds any part, term or provision of this Agreement to be unenforceable, the validity of the remaining portions shall not be affected, and the rights and obligations of the parties shall be construed and enforced as if this Agreement did not contain the objectionable part, term or provision.
11. This Agreement shall be governed and interpreted in accordance with the substantive laws of the State of Arkansas, and with applicable laws of the United States of America.

The parties have executed this Agreement effective as of the date set forth above.

FOR UNIVERSITY	FOR PERMITTER
By: <i>Robert H. Adams</i> Robert H. Adams Vice Chancellor Finance and Administration Date: <i>7-10-12</i>	By: <i>Jim McCracken</i> Name: <i>Jim McCracken</i> Date: <i>6-26-12</i>

**Revocable Permit and Land Use Agreement
for Seismic Recording System**



Effective Date: May 1, 2012

Permitter: Wade Mavity
Address: 106 Sawmill Road, Velonia, Arkansas, 72173

Permittee: The Board of Trustees of the University of Arkansas acting for and on behalf of the University of Arkansas at Little Rock (UALR)
Address: 2801 South University Avenue, Little Rock, Arkansas, 72204

Site: (W41B) On the property located at: 106 Sawmill Road, Velonia, Arkansas 72173, T6N R12W Sec 11 (Site is within 100 meters of: 35.17368, -92.24784)

WHEREAS, UALR desires to undertake scientific study for the public good as a part of a U.S. geological Survey; and

WHEREAS, the Permitter desires to support UALR's scientific study.

This permit is given by Permitter to UALR without charge in consideration of the above and the following:

1. Permitter understands that the Equipment (defined below), which was installed under an agreement between Permitter and Incorporated Research Institutions in Seismology ("IRIS") shall be adopted by UALR.
2. Permitter hereby grants permission to install, operate, maintain, service, and remove (as required) a Seismic Recording System ("Equipment") to UALR, as listed on Exhibit A to this Agreement, as part of a U.S. Geological Survey (USGA) project ("Project") at the Site.
3. This permit is for the period beginning on the Effective Date and continuing for thirty-six (36) months. Either party may terminate this Agreement at any time upon thirty (30) days written notice.
4. A representative from UALR will notify the Permitter prior to entry for any maintenance visits if required.
5. UALR accepts the premise "as is" condition and upon completion of the permit, agrees to restore the premises as nearly as possible to the condition at the start of the permit.
6. Permitter will not be held responsible for loss of or damage to Equipment on the property.
7. UALR agrees that the maintenance and removal of the Equipment on the lands of the Permitter on which they are installed shall be effected with reasonable diligence to avoid damage to the land.
8. UALR DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE
9. UALR shall perform the Project hereunder only as an independent contractor, and this Agreement shall not constitute, create or in any way be interpreted as a joint venture, partnership or formal business organization of any kind.
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11. This Agreement shall be governed and interpreted in accordance with the substantive laws of the State of Arkansas, and with applicable laws of the United States of America.

The parties have executed this Agreement effective as of the date set forth above.

FOR UNIVERSITY	FOR PERMITTER
By: <i>Robert H. Adams</i> Robert H. Adams Vice Chancellor Finance and Administration Date: 7-10-12	By: <i>Wade H. Mavity</i> Name: Wade Mavity Date: 5-11-2012

**Revocable Permit and Land Use Agreement
for Seismic Recording System**



Effective Date: May 1, 2012

Permitter: Ken Rudder
Address: 320 Union 757, El Dorado, Arkansas, 71730

Permittee: The Board of Trustees of the University of Arkansas acting for and on behalf of the University of Arkansas at Little Rock (UALR)
Address: 2801 South University Avenue, Little Rock, Arkansas, 72204

Site: (TA-Z41A) On the property located at: 320 Union 757, El Dorado, Arkansas, 71730, (Site is within 100 meters of: 33.25773, -92.80299)

WHEREAS, UALR desires to undertake scientific study for the public good as a part of a U.S. geological Survey; and

WHEREAS, the Permitter desires to support UALR's scientific study.

This permit is given by Permitter to UALR without charge in consideration of the above and the following:

1. Permitter understands that the Equipment (defined below), which was installed under an agreement between Permitter and Incorporated Research Institutions in Seismology ("IRIS") shall be adopted by UALR.
2. Permitter hereby grants permission to install, operate, maintain, service, and remove (as required) a Seismic Recording System ("Equipment") to UALR, as listed on Exhibit A to this Agreement, as part of a U.S. Geological Survey (USGA) project ("Project") at the Site.
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11. This Agreement shall be governed and interpreted in accordance with the substantive laws of the State of Arkansas, and with applicable laws of the United States of America.

The parties have executed this Agreement effective as of the date set forth above.

FOR UNIVERSITY	FOR PERMITTER
By: <i>Robert H. Adams</i> Robert H. Adams Vice Chancellor Finance and Administration	By: <i>J.K. Rudder, Jr</i> Name: <i>J.K. RUDDER, Jr</i>
Date: <i>7-10-12</i>	Date: <i>5/15/12</i>

**Revocable Permit and Land Use Agreement
for Seismic Recording System**



Effective Date: May 1, 2012

Permitter: Nettie J. Jackson
Address: 2804 Gourneck Road, Malvern, Arkansas, 72104

Permittee: The Board of Trustees of the University of Arkansas acting for and on behalf of the University of Arkansas at Little Rock (UALR)
Address: 2801 South University Avenue, Little Rock, Arkansas, 72204

Site: (TZ-X40A) On the property located at: 2804 Gourneck Road, Malvern, Arkansas, 72104, (Site is within 100 meters of: 34.48736, -92.83420)

WHEREAS, UALR desires to undertake scientific study for the public good as a part of a U.S. geological Survey; and

WHEREAS, the Permitter desires to support UALR's scientific study.

This permit is given by Permitter to UALR without charge in consideration of the above and the following:

1. Permitter understands that the Equipment (defined below), which was installed under an agreement between Permitter and Incorporated Research Institutions in Seismology ("IRIS") shall be adopted by UALR.
2. Permitter hereby grants permission to install, operate, maintain, service, and remove (as required) a Seismic Recording System ("Equipment") to UALR, as listed on Exhibit A to this Agreement, as part of a U.S. Geological Survey (USGA) project ("Project") at the Site.
3. This permit is for the period beginning on the Effective Date and continuing for thirty-six (36) months. Either party may terminate this Agreement at any time upon thirty (30) days written notice.
4. A representative from UALR will notify the Permitter prior to entry for any maintenance visits if required.
5. UALR accepts the premise "as is" condition and upon completion of the permit, agrees to restore the premises as nearly as possible to the condition at the start of the permit.
6. Permitter will not be held responsible for loss of or damage to Equipment on the property.
7. UALR agrees that the maintenance and removal of the Equipment on the lands of the Permitter on which they are installed shall be effected with reasonable diligence to avoid damage to the land.
8. UALR DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE
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11. This Agreement shall be governed and interpreted in accordance with the substantive laws of the State of Arkansas, and with applicable laws of the United States of America.

The parties have executed this Agreement effective as of the date set forth above.

FOR UNIVERSITY	FOR PERMITTER
By: <i>Robert H. Adams</i> Robert H. Adams Vice Chancellor Finance and Administration Date: <i>7-10-12</i>	By: <i>NETTIE J. JACKSON</i> Name: <i>Nettie J. Jackson</i> Date: <i>5-25-2012</i>

**Revocable Permit and Land Use Agreement
for Seismic Recording System**



Effective Date: May 1, 2012

Permitter: Winston Foster
Address: P.O. Box 865, Marvell, Arkansas, 72366

Permittee: The Board of Trustees of the University of Arkansas acting for and on behalf of the University of Arkansas at Little Rock (UALR)
Address: 2801 South University Avenue, Little Rock, Arkansas, 72204

Site: (TA-X43A) On the property located at: P.O. Box 865, Marvell, Arkansas, 72366, (Site is within 100 meters of: 34.51799, -90.884122, T2S R2E S15)

WHEREAS, UALR desires to undertake scientific study for the public good as a part of a U.S. geological Survey; and

WHEREAS, the Permitter desires to support UALR's scientific study.

This permit is given by Permitter to UALR without charge in consideration of the above and the following:

1. Permitter understands that the Equipment (defined below), which was installed under an agreement between Permitter and Incorporated Research Institutions in Seismology ("IRIS") shall be adopted by UALR.
2. Permitter hereby grants permission to install, operate, maintain, service, and remove (as required) a Seismic Recording System ("Equipment") to UALR, as listed on Exhibit A to this Agreement, as part of a U.S. Geological Survey (USGA) project ("Project") at the Site.
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10. When fully executed, this Agreement shall supersede any and all prior and existing agreements, either oral or in writing. This Agreement contains the entire agreement between the parties with respect to the subject matter hereof. This Agreement shall not be altered, amended, changed, or otherwise modified except in writing signed by all parties to this Agreement. If a court holds any part, term or provision of this Agreement to be unenforceable, the validity of the remaining portions shall not be affected, and the rights and obligations of the parties shall be construed and enforced as if this Agreement did not contain the objectionable part, term or provision.
11. This Agreement shall be governed and interpreted in accordance with the substantive laws of the State of Arkansas, and with applicable laws of the United States of America.

The parties have executed this Agreement effective as of the date set forth above.

FOR UNIVERSITY	FOR PERMITTER
By: <i>Robert H. Adams</i> Robert H. Adams Vice Chancellor Finance and Administration Date: <i>7-10-12</i>	By: <i>Winston Foster</i> Name: <i>Winston Foster</i> Date: <i>5/1/12</i>