

COMBINATION LAND AND UNDERWATER SEISMIC REFRACTION SURVEY BEDROCK CHARACTERIZATION FOR BRIDGE CONSTRUCTION

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ABSTRACT

Geotechnology provided geotechnical exploration and design services for a proposed six-span, concrete girder replacement bridge across the Big River approximately 70 miles south-southwest of St. Louis, Missouri. The river is approximately 170 feet wide and two of the structural supports (bents) for the bridge will be located within the river. Obtaining subsurface data over the river by drilling from a barge is costly. As an alternative, Geotechnology conducted a seismic refraction survey along the alignment of the proposed bridge. The survey was conducted by using geophones on land and hydrophones in water. A 24-channel EG&G Geometrics Strataview seismograph was used to record the data. Geophones and hydrophones were spaced 15 feet apart and a hammer source was used. The data were interpreted using the time-delay method.

Based on the results of the refraction survey and confirmation coring on the riverbank, it was determined that the bedrock is a hard dolomite. The seismic velocity of the bedrock ranged between 9,600 and 13,125 feet per second (fps). Depth to bedrock calculated from the seismic data ranged between 10 and 23 feet and was verified by drill data. Geotechnology used the results of the seismic refraction survey in conjunction with other exploration services, including reconnaissance, drilling and sampling, and laboratory testing, to develop recommendations for geotechnical aspects of the design and construction of the project.

INTRODUCTION

A replacement bridge is planned for a bridge located on Upper Blackwell Road over the Big River, located approximately 70 miles south-southwest of St. Louis, Missouri. As shown on Figure 1, the new alignment is approximately 50 to 70 feet north of the existing bridge. The proposed bridge will be a two-lane concrete girder bridge with six spans varying in length from 57 to 100 feet. Two interior bents will be located in the river. An approach embankment is planned for approximately 300 feet between the west end of the bridge and the connection to the existing road.

The proposed bridge will span the Big River over a pool that, at the time of this exploration, is approximately 170 feet wide, with a maximum water depth of approximately 8 feet. The slopes of the river banks are approximately 1 vertical to 2 horizontal. The banks of the river are moderately wooded.

The purpose of our services was to develop recommendations for geotechnical aspects of the design and construction of the proposed bridge. As for most geotechnical explorations, activities included drilling, sampling, conducting laboratory tests and engineering analyses. However, obtaining subsurface data over the river by drilling from a barge is expensive. Therefore, a seismic refraction survey was conducted along the alignment of the proposed bridge to determine depth to bedrock and seismic velocity of bedrock between boring locations, particularly across the river.

SEISMIC REFRACTION SURVEY

Data Acquisition

Seismic refraction data were recorded along an approximately 435-foot survey line as shown in Figure 1. The detectors were placed at 15-foot intervals along the survey line and consisted of 40-hertz Geospace geophones on land and 10-hertz Mark Products hydrophones (Model P44) under water. A sledgehammer was used to generate the seismic energy by striking a metal plate on the ground surface at various locations along the line. Generally, 15 successive hammer strikes were made on the metal plate at each shotpoint to increase the signal-to-noise ratio. The recording instrument used for this survey was a 24-channel EG&G Geometrics StrataView exploration seismograph. This seismograph has

a 32-bit floating point, digital signal processing chip with digital filters. Filters applied during recording included a 250-hertz lo-pass and 60-hertz notch. Data were recorded on hard disk and subsequently transferred to a PC.

The hydrophones used for this survey were attached to a bay cable that is commonly used for shallow water surveys. The cable and hydrophones rested on the water bottom during recording. The hydrophone cable was deployed using a small boat that was maintained on the proposed bridge alignment using a guide line tied off at each bank.

Shot locations included end shots, off-end shots, and various within-line shots. Shots were included at or near each river bank to attempt to ascertain velocities of the shallow soils and underwater sediments.

Data Reduction and Interpretation

The data were interpreted using the "time-delay" method (Redpath, 1973). The interpreted top of bedrock and seismic velocities are presented in Figure 2. Based on direct arrival data, near surface materials exhibit seismic velocities ranging between 1,350 and 1,600 fps. Establishing correct near surface velocities, particularly when large variations may exist, is necessary for making reliable depth-to-bedrock calculations. Based on the time-delay calculations, the depth to bedrock along the seismic refraction line ranges between 10 and 23 feet. Bedrock velocities range from 9,600 feet per second between Stations 100 and 265, to 13,125 fps between Stations 280 and 535.

DRILLING

Five borings, designated as Borings B-1 through -5, were drilled at the locations shown in Figure 1. Borings B-3, -4, and -5 were drilled at accessible locations along the refraction line. Borings were drilled using an all terrain vehicle-mounted CME 750 rotary drill rig and 3-3/4-inch hollow stem augers. Standard Penetration Tests (SPT's) were performed using an automatic hammer. Split spoon and Shelby tube samples were obtained. Rock was cored to a depth of 10 feet in Borings B-2 through -4 using NX rock coring methods. Laboratory testing was performed to evaluate pertinent engineering and index properties of the soil. Moisture contents were determined for cohesive samples, and Atterberg limits tests were determined on selected samples. Unconfined compression tests were performed on selected Shelby tube and rock samples.

The surface stratum to the west of the river generally consists of 8 to 13 feet of medium stiff to soft, brown and gray silty clay, except in Boring B-4. The surface stratum in Boring B-4 consists of loose to medium dense, fine to coarse-grained sand with gravel. The sand was also encountered in Boring B-3 beneath the silty clay stratum. Generally, the sand extends to the top of rock. In Boring B-5, which was drilled at the proposed east abutment, a single stratum of very stiff, reddish brown clay was encountered.

The bedrock surface was encountered at depths of 20 and 21 feet (EI 561 and 560) in Borings B-3 and -4, respectively, which were drilled along the seismic line on the west side of the river. At the east abutment, rock was encountered at a depth of 10 feet in Boring B-5. The rock generally consists of hard, brown and gray, medium to finely crystalline, moderate to highly weathered dolomite with high-angle fractures.

CONCLUSIONS

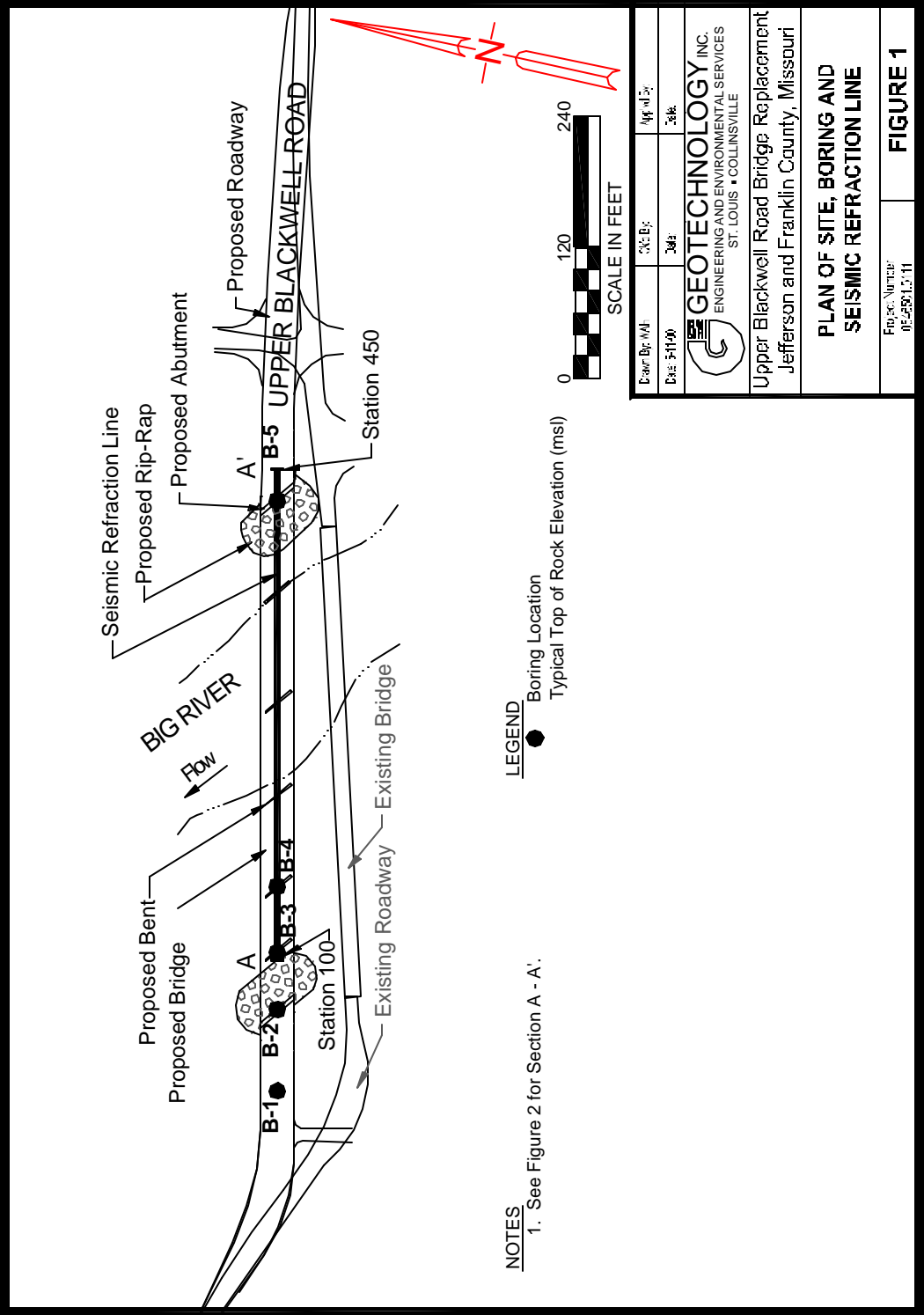
As indicated on the profile in Figure 2, the seismic refraction data ties reasonably well with the drill data (within 10 percent of depth to top of bedrock observations). The increased bedrock seismic velocities observed over the river and to the east suggests that the dolomite between Stations 280 and 535 is less weathered than the dolomite to the west of the river. The presence of highly weathered bedrock was observed in Borings B-3 and -4 to the west, however, comparable core data for Boring B-5 to the east was not obtained. Therefore, at present, a direct comparison of variations in bedrock velocity with logged cores cannot be made.

Even though drill data were not acquired over the river, the general depth to bedrock and competency of bedrock are known along the bridge alignment based on the seismic refraction survey. Based on the results

of the exploration, we are able to recommend that the bridge may be supported by straight shaft drilled piers bearing on rock. Pilot holes are recommended to determine rock soundness criteria at each drilled pier location.

REFERENCES

Seismic Refraction Exploration for Engineering Site Investigations; Bruce B. Redpath, Explosive Excavation Research Laboratory, Livermore, California, AD-768-710, May 1973.



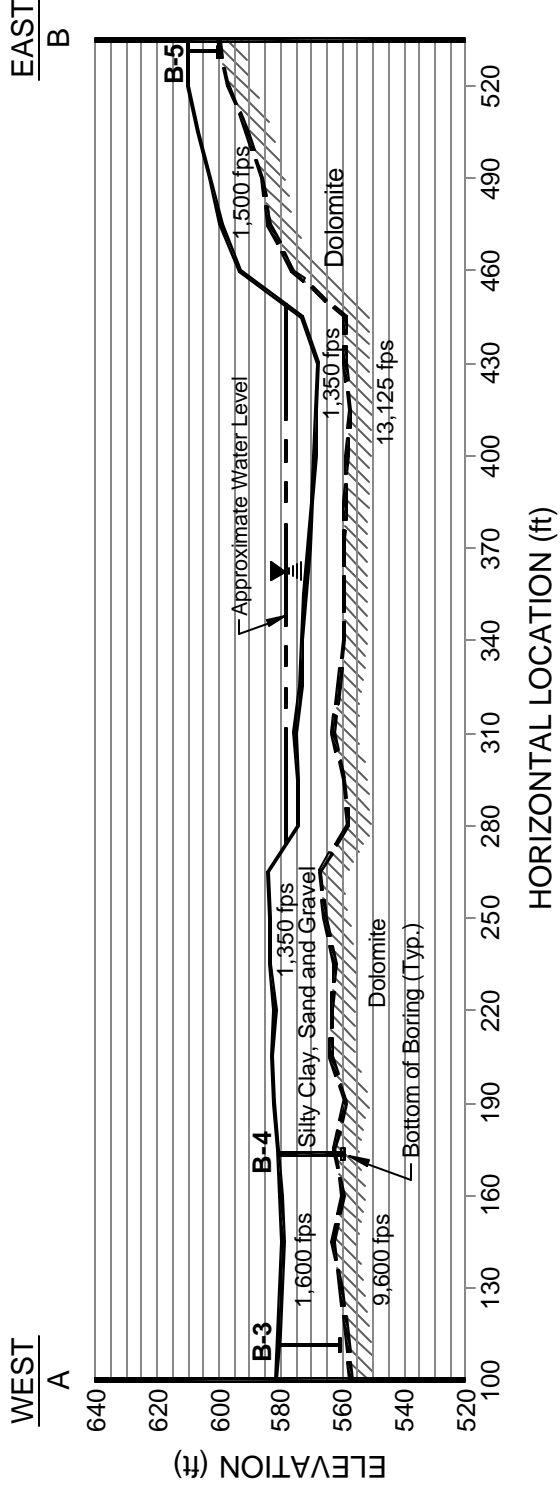
NOTES

1. See Figure 2 for Section A - A'.

LEGEND


- Boring Location
- Typical Top of Rock Elevation (msl)

Drawn By: MJD	Scale: 1"=100'	App. No. 20
Checked By: JMS	Scale: 1"=100'	Date: 10/11/11
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Upper Blackwell Road Bridge Replacement Jefferson and Franklin County, Missouri		
PLAN OF SITE, BORING AND SEISMIC REFRACTION LINE		FIGURE 1
Project Number: 05-2501.1-11		



NOTES

1. Refer to Figure 1 for location of Section A - A'.
2. Ground surface topography based on observation at geophone locations and is approximate only.
3. Depth of water in Big River determined by sounding on April 10, 2000.
4. Seismic velocities are indicated in feet per second (fps).

Drawn By: Jana Giddis	Checked By: Jana	Approved By: Jana
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Upper Blackwell Road Bridge Replacement Jefferson and Franklin County, Missouri		
GENERALIZED GEOLOGIC PROFILE SECTION A - A'		
Project Number 05465311-11		FIGURE 2