CORS 911: Continuously Operating Reference Stations for the Bayou Corne Sinkhole

INTRODUCTION

A sinkhole formed in the wetlands near Bayou Corne in Assumption Parish, Louisiana, on August 3, 2012. The sinkhole was centered approximately 1,500 ft. (~460 meters) south of Louisiana Highway 70, a state-maintained route. The highway corridor stretches nearly 10,000 ft. (1.9 miles, or 3.05 kilometers) and includes three bridges that cross relatively narrow bayous. The highway serves as an emergency evacuation route for the surrounding rural communities and businesses; and, if closed, would result in an hour-and-a-half detour around the site.

The event triggered numerous hazards across the affected area, including surface instability, horizontal displacement, subsidence, and seismic events. These hazards directly threatened the safety and well-being of the surrounding communities and businesses (GOHSEP, 2012; LADNR, 2012). For this reason, the Louisiana Department of Transportation and Development (DOTD) immediately commissioned multiple monitoring solutions for the continued and safe use of the portion of highway considered to be vulnerable to the sinkhole.
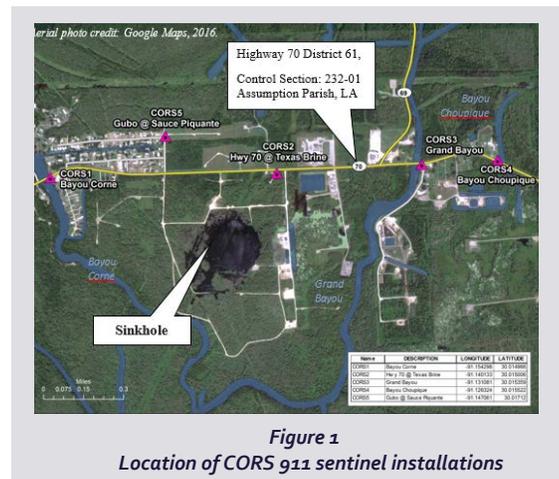

Figure 1
Location of CORS 911 sentinel installations

In order to mitigate any potential damaging effects to the highway and address issues of public safety, DOTD implemented a program of monitoring, decision support, and research to provide continuous, long-term observation and measurements of the surface stability using continuously operating GPS reference stations (CORS).

OBJECTIVE

The goal of this project was to implement a monitoring and reporting solution capable of providing situational awareness of the portion of Highway 70 at risk of damage from the Bayou Corne sinkhole. The system was designed to help mitigate sinkhole related hazards and ensure the continued and safe use of the affected highway. The project required a continuously operating, in-situ monitoring solution that could detect and record any movement of the roadway and bridges within the affected corridor. The proposed solution had to support real-time situational awareness that was capable of notifying key personnel of abnormal activity near the highway infrastructure. Finally, measurements recorded at each site had to provide decision makers with a synoptic understanding of the physical processes acting on the roadway. Accordingly, the following objectives were defined:

1. Design, install, and maintain multiple, continuously operating sensor platforms capable of monitoring and recording surface motions of the Highway 70 roadway and bridges made vulnerable by the sinkhole.
2. Provide real-time access to sensor telemetry for response personnel and decision makers tasked with ensuring the safe use of the roadway.
3. Provide regularly updated reports detailing surface motions recorded at each sensor platform.
4. Provide notification services to alert key personnel should movement exceed a pre-defined threshold.
5. Provide instructional and operational support for designated clients accessing these services.
6. Perform geodetic analysis of the telemetry for long-term subsidence analysis and decision-making.

METHODOLOGY

In April 2013, following consultation among DOTD and response stakeholders, the Center for GeoInformatics (C4G) at Louisiana State University (LSU) was selected to design, deploy, operate, and maintain continuously operating reference stations (CORS) sentinels comprised of GNSS receivers and antennas.

Once integrated within the C4G Real Time Network (RTN), the horizontal and vertical motions detected by the sites would be measured relative to a constrained reference point beyond the influence of the sinkhole's subsidence zone (e.g., the North American continent).

The C4G executed this project following a work plan composed of 7 tasks. Tasks one through four were completed at the beginning of the project. These included (1) site assessments, (2) CORS fabrication, (3) deployment, and (4) implementation. The remaining tasks [(5) utilization and client support, (6) administration, and (7) maintenance and reporting] have been ongoing.

DISCUSSION OF RESULTS

The project identified locations along the portion of Highway 70 corridor at risk of potentially hazardous consequences attributable to the Bayou Corne sinkhole. CORS sites were designated according to their ability to provide a useful indicator of surface motion for the road and bridges near the sinkhole. Five CORS911 sentinels were installed in the vicinity of the sinkhole to measure the horizontal and vertical displacements of each site relative to each other and a fixed location outside the study area. On April 10, 2013, the C4G deployed CORS1 at Bayou Corne. CORS3 at Grand Bayou was installed on April 11, 2013, and CORS4 at Bayou Choupique was installed on April 13, 2013. CORS 2 was installed on July 16, 2013, along Highway 70 at Texas Brine property. Finally, CORS5 was installed on December 11, 2015, at the intersection of Gumbo Street and Sauce Piquante Lane. CORS 2 and CORS 5 required resolution of servitude to access the property. Photos of each CORS sentinel are presented in Figure 2. Installation of the CORS was coordinated with the DOTD Emergency Operations Center and District 61 personnel.

Stations were networked together using cellular modems and software maintained by the C4G. Differential motions measured by integrity monitoring software are automatically summarized within a report and uploaded to an FTP server on a daily basis. Station positions measured to millimeter precision were monitored and recorded 24 hours per day. An email system was also implemented to notify decision makers of anomalous movements measured by the CORS911 sentinels.

CONCLUSIONS

The project received funding and was initiated in April 2013. LSU C4G developed, deployed, operated, and maintained the CORS911 sentinel system to provide continuous monitoring of the horizontal and vertical positions of the sentinels.

The CORS 911 system has been operational since April 2013. Five CORS 911 sentinels have been operating at select locations within the Highway 70 corridor. Email notification service, report generation was functional, and GNSS analysis has been performed. To date, the CORS have not detected movement that can be directly attributed to sinkhole activity. The system is sensitive enough to see movement continuously, and seasonal or weather-related changes were observed but tended to be within a non-alarming range. No email notices indicating the threshold values were issued. Over 5,600 reports have been generated (to 9/30/2018) and are available online. Remote access to real-time results is available for authorized users.

This monitoring solution was used to establish situational awareness of surface stability, which was necessary for ensuring the safe and continued utilization of Highway 70. The project was extended additional years, to ensure continued safety to Highway 70, with an end date of September 2018.

RECOMMENDATIONS

The purpose of erecting and operating the CORS 911 sentinels was to observe and report to DOTD. It is our opinion that this operation worked as desired. It was reasonable for DOTD to continue monitoring concerns about the proximity of the sinkholes in relationship to the roadway. With little movement experienced, that cause seems to have diminished, and so the project is concluded successfully. DOTD reduced the threat level from emergency to monitoring, and then to closed this project at the end of September 2018. The CORS stations employed will be recommissioned to other areas of the state by DOTD.

Figure 2
CORS 1-5 installations, in order from left to right