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16. Abstract

This project measured and assessed the surface stability of the portion of LA Highway 70 that is potentially vulnerable to the Assumption Parish sinkhole. Using Global Positioning Systems (GPS) enhanced by a real-time network (RTN) of continuously operating reference stations (CORS), the Center for GeoInformatics (C4G) at Louisiana State University (LSU) has collected the horizontal and vertical positions for control points located along the Highway 70 corridor between Bayou Corne (in the west) and Bayou Choupique (in the east). Measurements were collected between September 2012 and June 2013. Data has been processed and made available to LA Dept. of Transportation & Development (DOTD) via an Internet FTP site maintained by C4G. During the report's measurement period, no movement attributable to the sinkhole has been detected on Highway 70. The GPS measurements did exhibit variability typically associated with random and systematic error. In order to capture more accurate, precise, and consistent positions, a permanent monitoring solution is recommended.

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Each research project will have an advisory committee appointed by the LTRC Director. The Project Review Committee is responsible for assisting the LTRC Administrator or Manager in the development of acceptable research problem statements, requests for proposals, review of research proposals, oversight of approved research projects, and implementation of findings.

LTRC appreciates the dedication of the following Project Review Committee Members in guiding this research study to fruition.

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Bayou Corne Sinkhole: Control Measurements of State Highway 70 in Assumption Parish, Louisiana

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LTRC Project No. 13-8GT
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Louisiana Department of Transportation and Development
Louisiana Transportation Research Center

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ABSTRACT

This project measures and assesses the surface stability of the portion of LA Highway 70 that is potentially vulnerable to the Assumption Parish sinkhole. Using Global Positioning Systems (GPS) enhanced by a real-time network (RTN) of continuously operating reference stations (CORS), the Center for GeoInformatics (C4G) at Louisiana State University (LSU) has collected the horizontal and vertical positions for control points located along the Highway 70 corridor between Bayou Corne (in the west) and Bayou Choupique (in the east). Measurements were collected between September 2012 and June 2013. Data has been processed and made available to the Louisiana Department of Transportation & Development (DOTD) via an Internet FTP site maintained by C4G. During the report's measurement period, no movement attributable to the sinkhole has been detected on Highway 70. The GPS measurements did exhibit variability typically associated with random and systematic error. In order to capture more accurate, precise, and consistent positions, a permanent monitoring solution is recommended.

ACKNOWLEDGMENTS

Many people contributed to the successful completion of this project. Field operations and data collection would not be possible without the professionalism of Larry Dunaway (C4G). C4G also acknowledges the support from project manager Joey Tureau (DOTD District 61) for his assistance in coordinating our field measurements. Researchers also received valuable feedback and surveying support provided by Huntington Hodges and Eric Lanier from DOTD Location & Survey. Finally, the researchers acknowledge the contributions and suggestions provided by Gavin Gautreau (LTRC) and James Mitchell (DOTD-GIS).

IMPLEMENTATION STATEMENT

This report summarizes the findings from field operations performed in response to the sinkhole event along Highway 70, near Bayou Corne. These measurements will be used as baseline measurements should any movement occur along LA Hwy 70.

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INTRODUCTION

The sinkhole located in Assumption Parish, Louisiana, threatens the stability of Highway 70, a state maintained route. In order to mitigate the potential damaging effects of the sinkhole on this infrastructure, DOTD has requested accurate and precise measurements of control points along the affected portion of the highway. To that end, C4G at LSU was contracted to measure and collect horizontal and vertical positions at various locations along the highway using GPS enhanced by a real-time network of CORS maintained by C4G.

Figure 1
Sinkhole in Assumption Parish, LA. Located approximately 1200 feet south of Hwy 70: control section 232-01 in District 61

OBJECTIVE

The fundamental objective for this project has been to measure and assess the surface stability of the portion of Highway 70 that is potentially vulnerable to the sinkhole. Using GPS enhanced by an RTN maintained by C4G, both horizontal and vertical positions have been measured and collected for 20 control point locations along the north shoulder of the highway and 8 locations on the bridges over Bayou Corne (west of the sinkhole) and Grand Bayou (east of the sinkhole). An overview of the study area and the control point locations are provided in Figure 1.

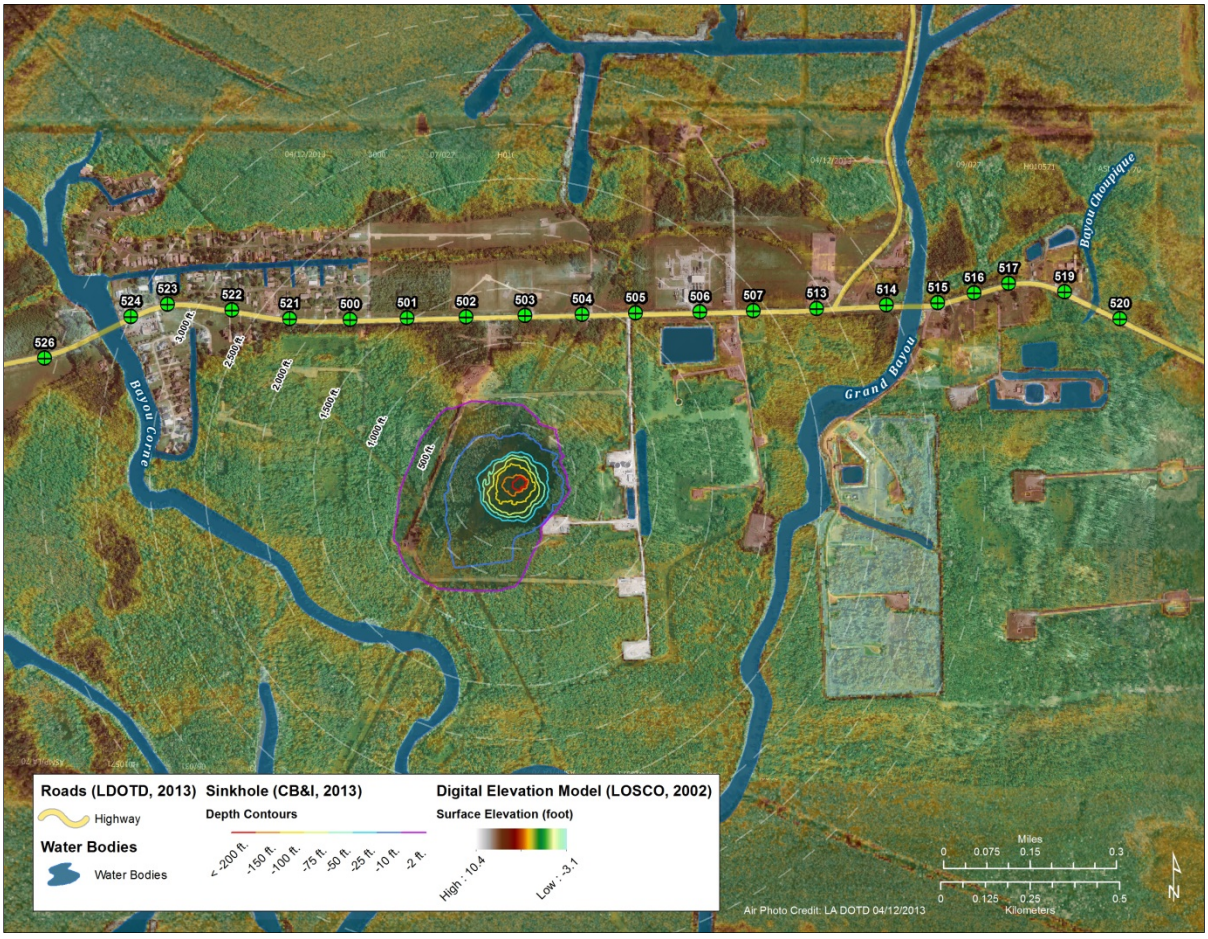

Figure 2
Project area along the north shoulder of Hwy 70, between bayous Corne (west) and Choupique (east)

SCOPE

The original project scope identified 21 road surface control points chosen for GPS measurements along Highway 70. The GPS measurements included the horizontal and vertical positions of the control points along the highway corridor bounded by Bayou Corne in the west and Bayou Choupique in the east.

As per best practices for maximizing accuracy and precision, field observations initially included two separate control measurements per session. This workflow produced two unique GPS datasets that were combined to provide a single weighted solution for each control point.

Following a request by DOTD to modify the data collection tasks, acquisition of weighted positions were abandoned in November 2012 in order to support an additional day of measurements at eight control point locations on the bridges over Bayou Corne and Grand Bayou. Furthermore, a control point was dropped from the workflow due to poor positional accuracy resulting from nearby tree canopy. The project review committee supported this revised workflow.

Twenty-eight points were regularly measured over the study period:

- 20 locations along Hwy 70,
- 4 positions on the Bayou Corne bridge, and
- 4 positions on the Grand Bayou bridge.

In fulfillment of the requirements provided by the DOTD Location and Survey section, all GPS data are transformed into horizontal, State Plane Coordinate Systems (SPCS), Louisiana South, North American Datum of 1983 (NAD83), in survey foot units. Elevations are provided relative to the North American Vertical Datum of 1988 (NAVD88), using geoid model 2009. Furthermore, data are converted and distributed as point feature classes for use in a geographic information system (GIS). Accordingly, point features are saved as ESRI shapefile format (*.shp). Finally, a Microsoft Excel (*.xls) worksheet used for tallying the horizontal and vertical positions of each control point measurement has also been provided and distributed by C4G. All data collected for this project have been made available online via an file transfer protocol (FTP) service maintained by C4G.

METHODOLOGY

The methods employed for this study were organized into three complementary tasks: *field measurements*, *data processing*, and *data distribution*. These tasks, including *data backup strategies*, are described in the following text.

Field Measurements

Field measurement tasks were organized into three distinct observation periods. The methods employed for measuring data points are discussed.

Observation Periods

Table 1 illustrates the time period of each of the field observations. For the first three weeks of the project, September (09/2012) through October (10/2012), measurements were collected twice per week by C4G field personnel. By November (11/2012), positions were measured weekly for three weeks through December (12/2012). Monthly observations began in January (01/2013) and continued through June (06/2013).

Table 1
Time period of field observations

Twice per week	September 2012 – October 2012 (26 points originally selected—narrowed to 21)
Twice per week	October 2012 – November 2012 (21 points minus 1 hwy point, plus 8 bridge points—equalled 28 total)
Weekly	November 2012 – December 2012
Monthly	January 2013 – June 2013

During the 10 month period between September 2012 and June 2013, the highway control points were observed a total of 23 times. The bridge control points were observed and data were collected 13 times between November 2012 and June 2013.

Measurement Techniques

In order to avoid measurements potentially influenced by the sinkhole, all field observations were collected using GPS equipment (e.g., data collectors, antennas, and cellular modems) maintained by C4G and augmented by the C4Gnet RTN. Measurements at each control point were comprised of occupations lasting three-hundred (300) one-second epochs (i.e., 5 minutes).

As per best practice techniques for minimizing the effects of atmospheric instability and mitigating unfavorable satellite geometries, measurements were initially collected at separate

times during each day in the field (i.e., session). Positional solutions were computed using a weighted average technique that emphasized accuracy by minimizing positional dilution of precision (PDOP) and root-mean square error (RMSE) values quantified by the equipment. This technique produced a single weighted solution for each position.

In November 2012, weighted positional measurements were abandoned in order to support a request by DOTD to add the measurements at control points on the Bayou Corne and Grand Bayou bridges. The project review committee members supported this decision. Accordingly, 28 points were regularly measured: 20 locations along Hwy 70, 4 positions on the Bayou Corne bridge, and 4 positions on the Grand Bayou bridge.

Figure 3
GPS equipment installed at a control point (#513) along the west-bound shoulder of Hwy 70

Figure 4
C4G field operations director, Larry Dunaway, monitoring the data collector along Hwy 70

Data Processing

Data collected in the field were extracted from the GPS data collectors and uploaded to C4G computers for processing. Data were converted and saved in the ESRI shapefile format (*.shp). Point features were transformed into SPCS, Louisiana South, NAD83 (NSRS2007), and provided in units of survey feet.

To accommodate rudimentary analysis, field observations were stored within an MS Excel spreadsheet (*.xls) designed to compare positional changes since the first observation collected in September. These tables are provided in the appendix of this document.

Additional analysis was performed to compute the RMSE values for each control point. The formula for calculating the RMSE of a given control point, *i*, at a session date, *t*, is:

$$RMSE_i = \sqrt{\frac{\sum_{t=1}^{n} d_t^2}{n-1}} \quad (1)$$

Where, d_t is the distance between the observed position and the mean of all the observations at the control point, and n is the total number of observations collected. The results of this analysis are provided in the discussion section of this document.

Data Distribution

Data processed by the C4G have been made available via Internet downloads. Select observations have been mapped and distributed via an Internet accessible map gallery.

Data Downloads

C4G has established and maintains an FTP server to distribute the shapefile and Excel worksheet data products produced for this study. Datasets remain accessible via the FTP site through the extent of the project.[1]

Map Gallery

Datasets have also been made accessible via Web-based mapping applications hosted by C4G.[2] As depicted in Figure 2, these data include the point features and brief descriptions for each of the control points measured. Air photos collected by DOTD and other response agencies are also presented.

Data Backups

To ensure fault tolerant data storage, all datasets follow a back-up routine on redundant storage units. In March 2013, the C4G responded to a data recovery request from the DOTD Photogrammetry unit, which suffered data loss due to hard drive failure.[3] A mosaic of the sinkhole imagery was provided.

[1] C4G anonymous FTP server: ftp://mimir.lsu.edu|anonymous:user@mimir.lsu.edu:2123
[2] C4G Public Map Gallery: http://mimir.lsu.edu
[3] DOTD Photogrammetry – Request by Brenda Browning

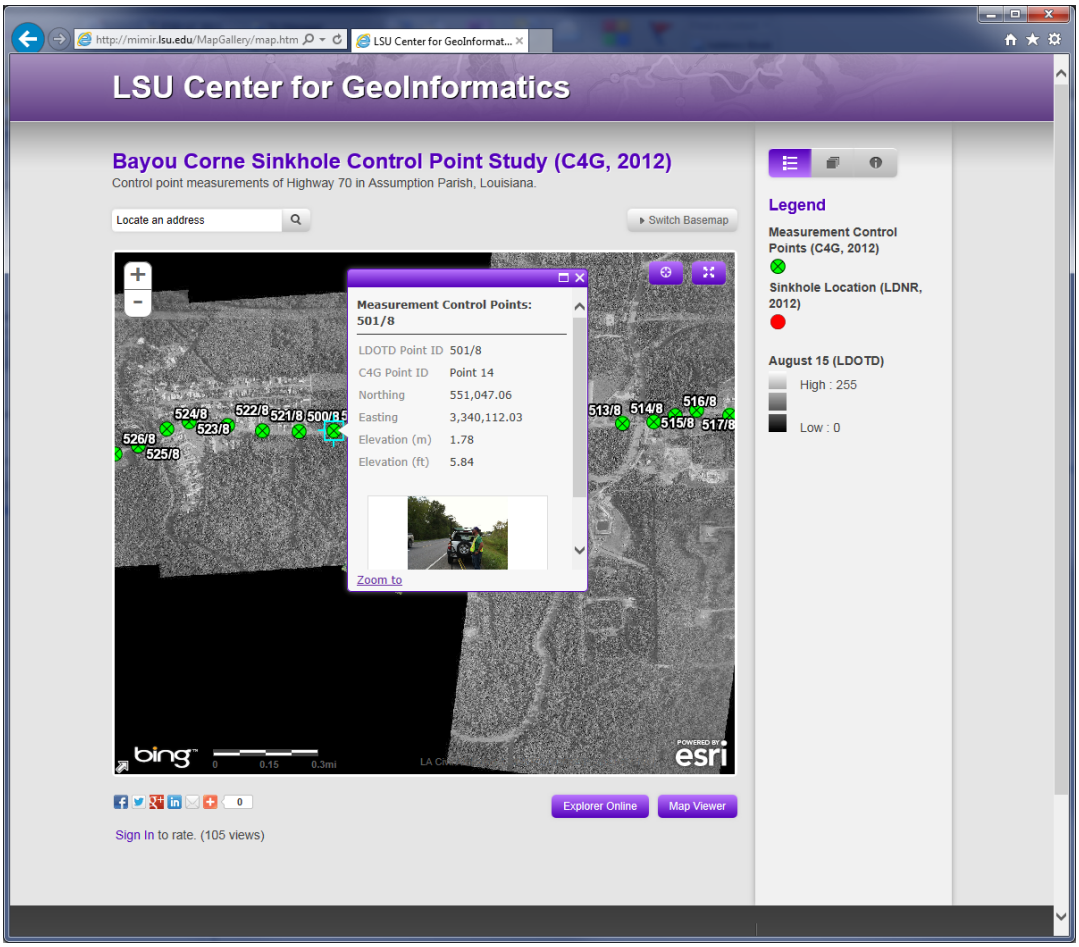

Figure 5
C4G public map gallery depicting the Bayou Corne sinkhole study

DISCUSSION OF RESULTS

Results of this study are organized according to the highway and bridge control point measurements. To summarize the findings, no discernible movement of Highway 70 has been detected relative to the sinkhole during the report period. Measurements collected in the field demonstrated susceptibility to random and systematic errors typically associated with static GPS observations. When left unconstrained, such errors impact detailed analysis. Solutions presented in the recommendations section identify strategies for improving the positional accuracy, precision, and consistency.

Measurement Results

Highway 70 Road Control Points

Field observations were captured using the C4Gnet RTN. This methodology ensured that all measurements were referenced to the State-wide network of CORS sites maintained by LSU, which is part of the National Spatial Reference System (NSRS) for the United States. The rationale for this approach was predicated on the potential influence of the sinkhole on local marks. Thus, all measurements were guaranteed to be independent of the sinkhole's subsidence zone.

Table 2 summarizes the results of the Highway 70 control point measurements. The table covers the 23 field measurements (i.e., sessions) that occurred between September 2012 and June 2013. Figure 2 (above) depicts the locations of the control points along Highway 70. The table provides the average horizontal and vertical values, average positional differences, and the RMSE of the observations.

The RMSE values provide a statistical measure of a given observation's positional error relative to the expected location of the control point (i.e., the mean). The advantage of using this estimator is that the results are provided in the same units of measure as the data. Accordingly, the minimum horizontal RMSE observed for all control point 0.039 ft. (~0.46 in.) and maximum of 0.147 ft. (~1.76 in.). Vertical values had a minimum RMSE of 0.027 ft. (~0.32 in.) and maximum of 0.115 ft. (~1.4 in.).

Table 2
Results of the Hwy 70 control point measurements (9/2012 – 6/2013)

POINT ID	μ NORTHING	μ EASTING	μ VERTICAL	μ ΔDistance² HORIZONTAL	μ ΔDistance² VERTICAL	RMSE HORIZONTAL	RMSE VERTICAL
500	551035.480	3339588.975	6.049	6.049	0.0067	0.0053	0.0838
501	551047.081	3340112.040	5.811	5.811	0.0090	0.0035	0.0968
502	551058.928	3340650.735	5.788	5.788	0.0096	0.0057	0.1003
503	551071.933	3341190.961	5.896	5.896	0.0104	0.0052	0.1042
504	551082.225	3341713.393	5.823	5.823	0.0104	0.0032	0.1041
505	551093.060	3342204.069	5.424	5.424	0.0100	0.0043	0.1024
506	551105.579	3342793.099	5.659	5.659	0.0096	0.0035	0.1001
507	551115.288	3343286.016	5.457	5.457	0.0104	0.0032	0.1042
513	551133.357	3343865.840	5.137	5.137	0.0089	0.0055	0.0963
514	551166.445	3344504.274	5.511	5.511	0.0099	0.0034	0.1020
515	551187.527	3344974.064	4.821	4.821	0.0075	0.0041	0.0884
516	551277.448	3345309.612	5.043	5.043	0.0076	0.0043	0.0890
517	551365.253	3345625.072	6.406	6.406	0.0206	0.0126	0.1467
519	551289.209	3346138.261	6.634	6.634	0.0130	0.0025	0.1165
520	551042.560	3346644.944	5.468	5.468	0.0087	0.0015	0.0951
521	551041.672	3339033.362	6.282	6.282	0.0102	0.0047	0.1031
522	551121.467	3338505.526	6.252	6.252	0.0104	0.0054	0.1045
523	551173.720	3337915.262	8.524	8.524	0.0090	0.0039	0.0970
524	551062.079	3337576.529	6.644	6.644	0.0076	0.0037	0.0894
526	550682.564	3336788.934	7.693	6.609	0.0067	0.0021	0.0875

The chart provided in Figure 5 depicts the horizontal variability for the 20 control points along the portion of Highway 70 potentially vulnerable to the sinkhole. The plot covers 24 field measurements (i.e., field-days) captured between September 2012 and June 2013. The graphics illustrate the 25th, 50th (median), and 75th quartiles (boxes) for all observed positions. Whiskers illustrate the minimum and maximum values (outliers) measured at the locations.

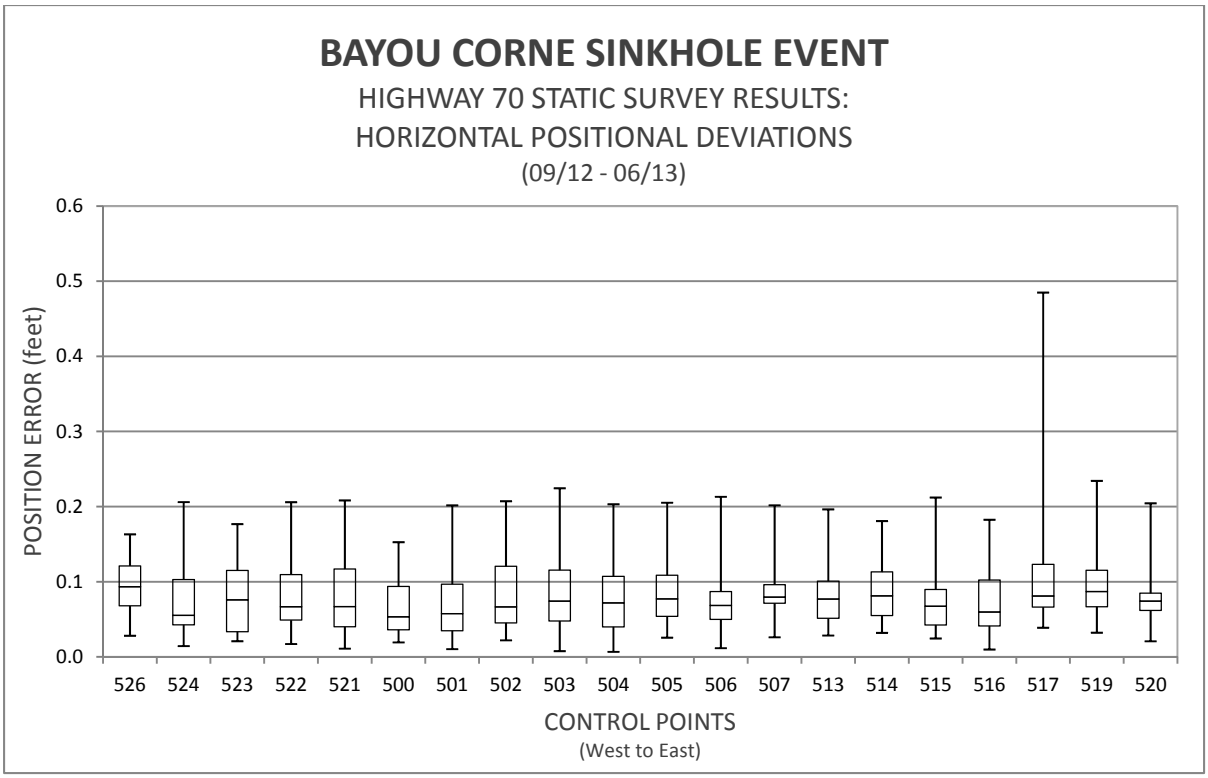

Figure 6
Horizontal deviations from the expected location of the Hwy 70 control points

Figure 6 depicts the elevations measured for the 20 control points along the portion of Highway 70 potentially vulnerable to the sinkhole. The box-whisker plot illustrates the median elevation (bar in box), the 25th and 75th percentile (boxes), and minimum and maximum values (whiskers) for the point location. For each field measurement, the control points were found to have a minimum vertical error of -0.21 ft. (2.58 in.) and a maximum of 0.45 ft. (5.45 in.). Because fewer than 30 observations were collected, significance derived from these findings is limited (i.e., central limit theorem for statistical analysis).

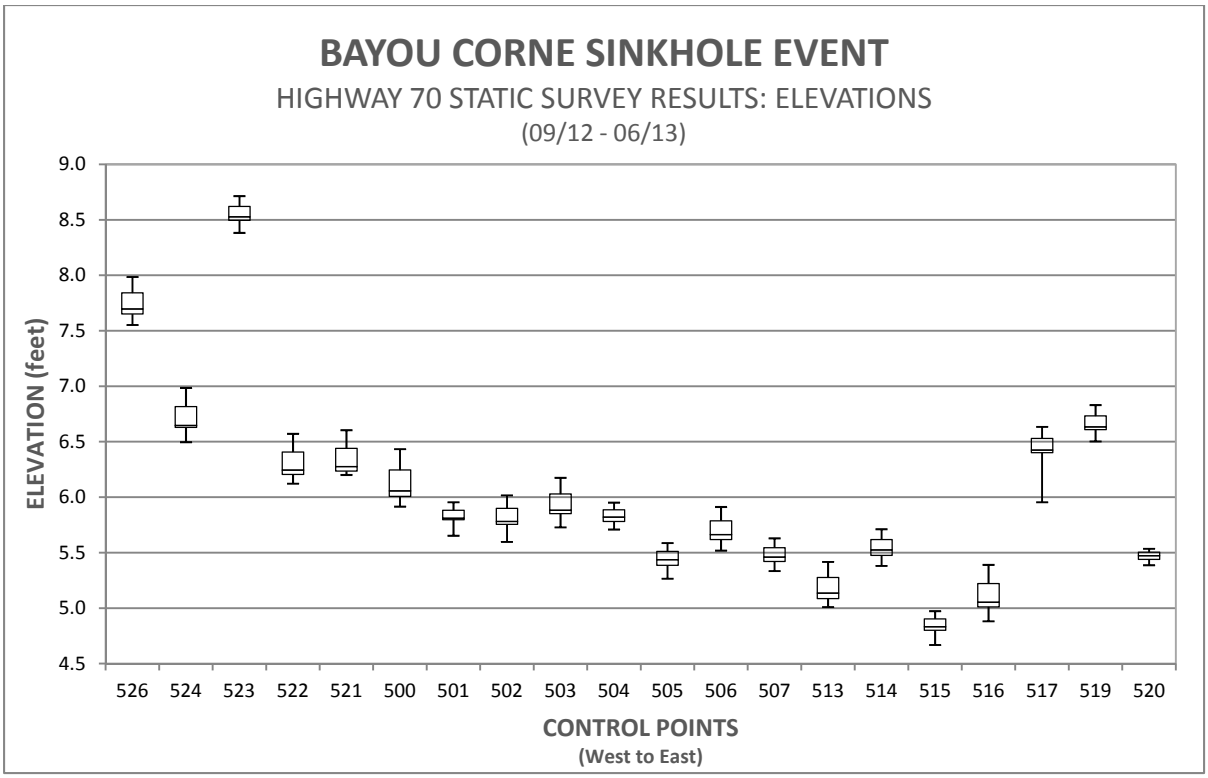

Figure 7
Vertical positions of the Hwy 70 control points and the estimated deviation from the expected value

As these data reveal, the majority of measurements were within 0.17 ft. (~2.1 in.) and 0.25 ft. (7.7 in.) of the expected (i.e., mean) horizontal and vertical values, respectively. There were, however, a number of outlier measurements, most notably at control point #517.

The anomalous outliers and variability observed over the study period demonstrates is not too uncommon for static GPS observations. These uncertainties can be partially attributed to the truncated occupation strategy that was initiated in November 2012, (i.e., single vs. weighted average of two occupations). Other exogenous factors include random error and signal interference, which commonly plague GPS measurements (e.g., Grewal, Weill, & Andrews, 2007). Sources of error typically include satellite orbit errors, atmospheric instability, signal drift/delay, multi-path signal reflections and noise, and more. Other factors can include human and technological error, electro-magnetic interference (EMI), as well as systematic biases attributable to the local environment.

Bridge Control Points

Figures 8 and 9 depict the location of the vertical positions measured. Both images depict three observations on the bridge: two on the south and one on the north. A fourth observation is located on the southeastern side of the bridge on solid ground.

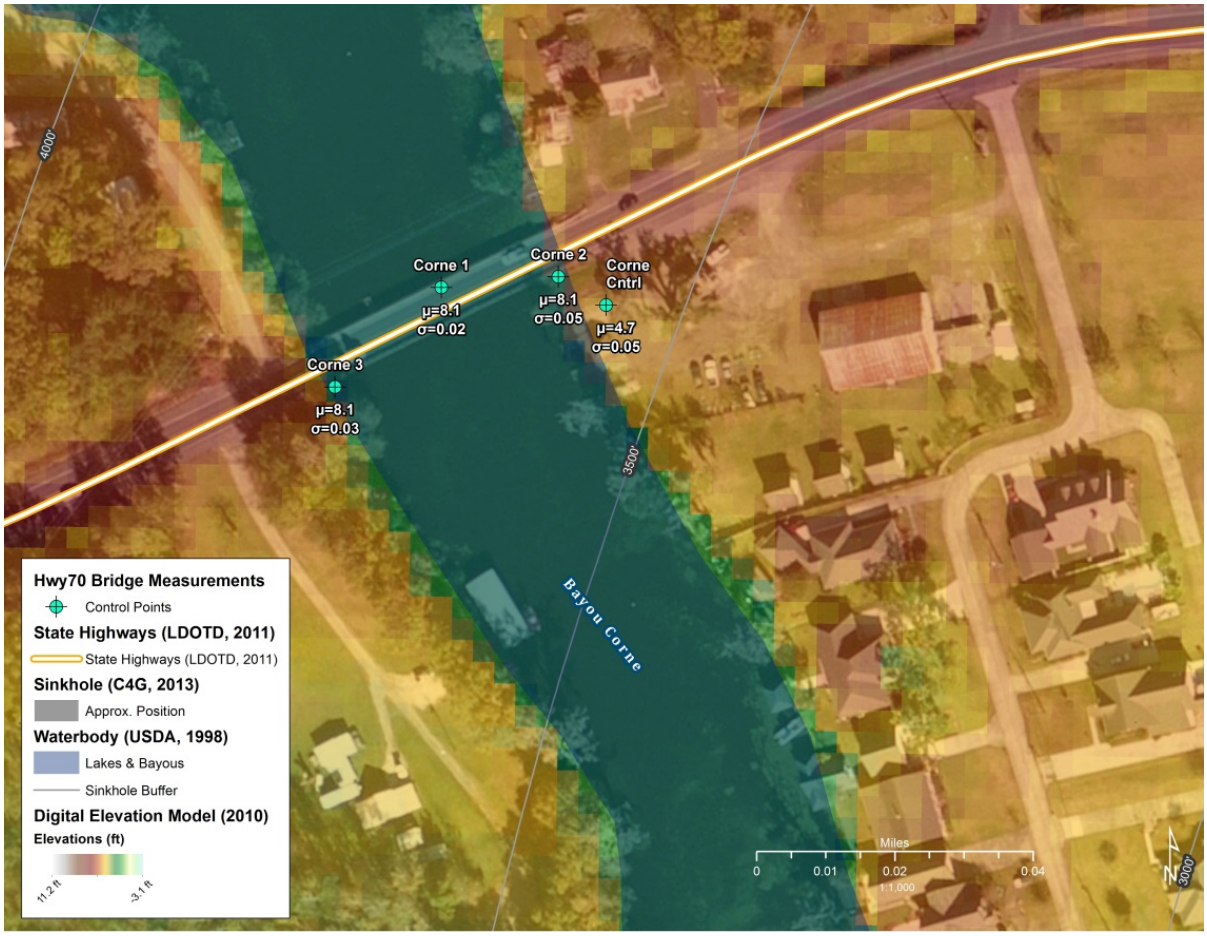

Figure 8
Elevation measurements for control points on the Bayou Corne bridge, LA Hwy 70

Table 3 summarizes the results for the eight control point measurements on the Bayou Corne and Grand Bayou bridges that are potentially vulnerable to the sinkhole. The data values cover measurements obtained over 13 observation sessions captured between November 2012 and June 2013. The minimum horizontal RMSE observed for all bridge locations is 0.039 ft. (~0.47 in.), while the maximum error was computed to be 0.118 ft. (~1.4 in.). Similarly, the minimum and maximum vertical RMSE of 0.03 ft. (0.36 in.) and 0.08 ft. (0.96 in.), respectively, were computed.

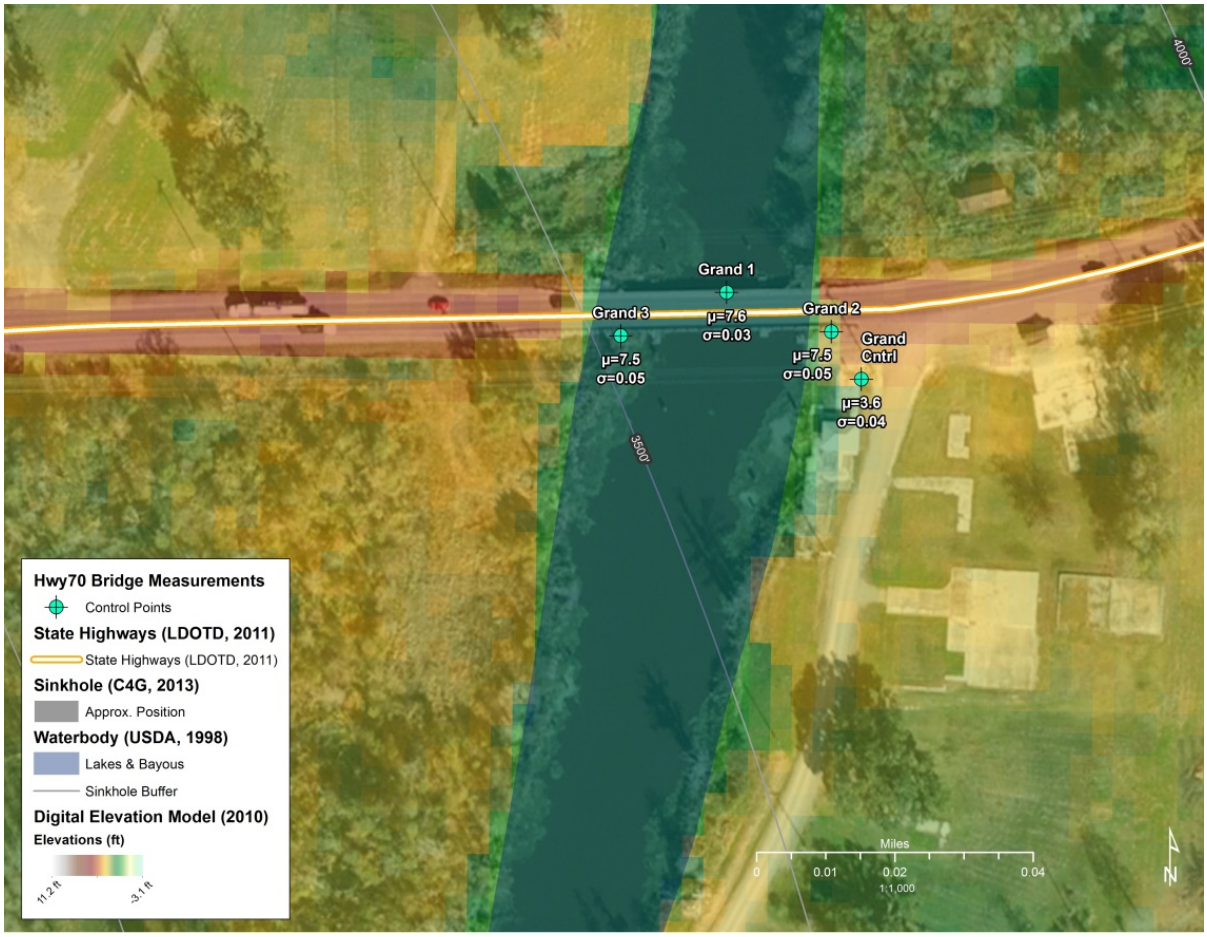

Figure 9
Elevation measurements for control points on the Grand Bayou bridge, LA Hwy 70

Table 3
Results of the Hwy 70 bridge control point measurements (11/2012 – 6/2013)

POINT ID	μ NORTHING	μ EASTING	μ VERTICAL	μ ΔDistance² HORIZONTAL	μ ΔDistance² VERTICAL	RMSE HORIZONTAL	RMSE VERTICAL
Corne1	550968.523	3337384.985	8.1541	0.0044	0.0007	0.0689	0.0277
Corne2	550976.789	3337474.447	8.1733	0.0014	0.0019	0.0390	0.0454
Corne3	550892.626	3337303.655	8.1400	0.0019	0.0025	0.0456	0.0515
Grand1	551170.881	3344760.479	7.6605	0.0019	0.0014	0.0455	0.0395
Grand2	551141.067	3344840.481	7.5058	0.0022	0.0033	0.0487	0.0602
Grand3	551137.876	3344679.616	7.5242	0.0016	0.0023	0.0412	0.0499
Corne Ctrl	550955.138	3337510.809	4.7959	0.0129	0.0056	0.1182	0.0776
Grand Ctrl	551104.810	3344863.339	3.6732	0.0115	0.0015	0.1117	0.0398

The chart provided in Figure 10 depicts the horizontal variability for the eight control points located on the Highway 70 bridges that are potentially vulnerable to the sinkhole. The plot covers 13 field measurements (i.e., field-days) captured between November 2012 and June 2013. The graphics illustrate the 25th, 50th (median), and 75th quartiles (boxes) for all observed positions. Whiskers illustrate the minimum and maximum values (outliers) measured at the locations.

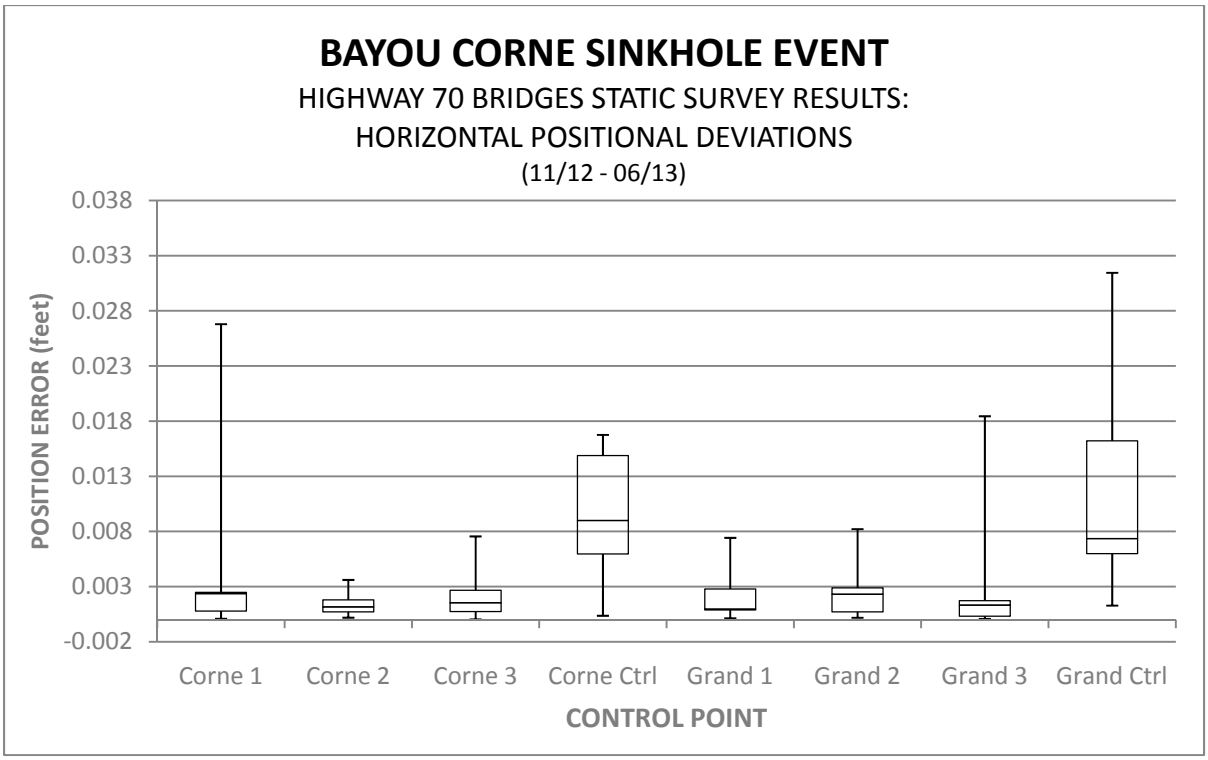

Figure 10
Horizontal deviations from the expected location of the Hwy 70 control points

The box-whisker plot in Figure 11 illustrates the 25th, 50th, and 75th quartiles (boxes), as well as the minimum and maximum outliers (whiskers) for the point locations on the bridges. As these data reveal, the majority of measurements were within 0.15 ft. (~1.8 in.) and 0.16 ft. (~1.9 in.) of the expected horizontal and vertical values, respectively.

The paucity of bridge observations prohibits meaningful interpretations. It is clear, however, that the bridge data exhibits very little variability when compared to those collected along the highway. The most significant contributor this observation is the longer occupation time for the static surveys: 10 minutes (600 epochs), compared to the 5-minute occupations along the highway. Furthermore, as there are fewer than 20 bridge observations in total, it is insufficient for the same interpretation.

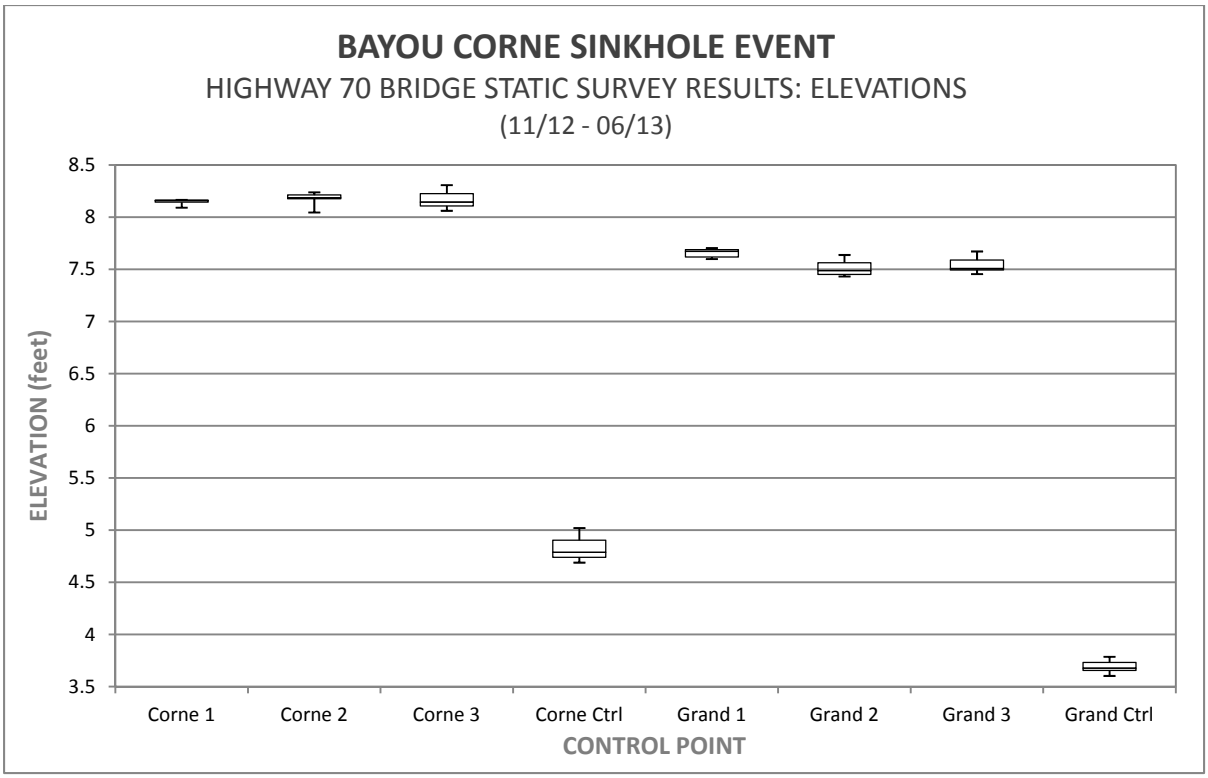

Figure 11
Vertical positions of the Hwy 70 bridge control points and the estimated deviation from the expected value

Trends Analysis

Analysis of the individual records were performed to identify horizontal and vertical positional change over time for the observations along the highway and bridges. The results of this assessment are presented here. The points were split into four groups of five, thus facilitating clarity.

The charts depicted in Figures 12 – 15 illustrate the horizontal position deviations in the northing direction from the mean (y-axis) measured at each highway control point during the project time period (x-axis).

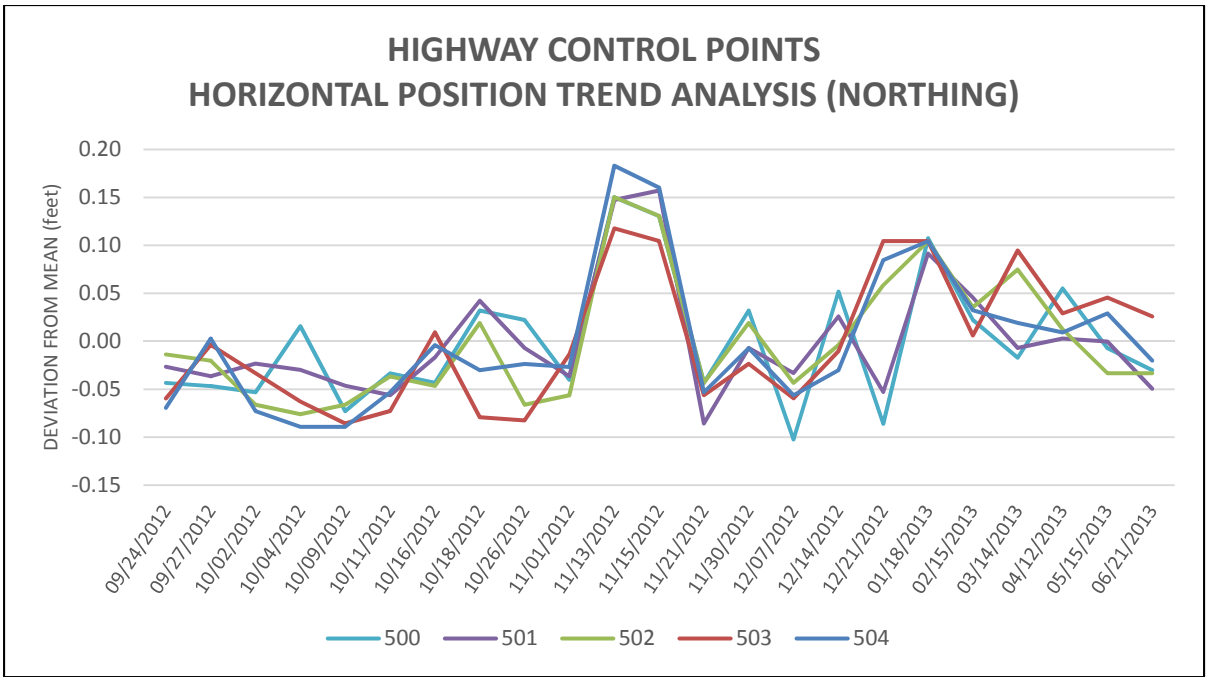

Figure 12
Horizontal positions (northing) of the Hwy 70 control points #500 - #504 and the deviation from the expected value

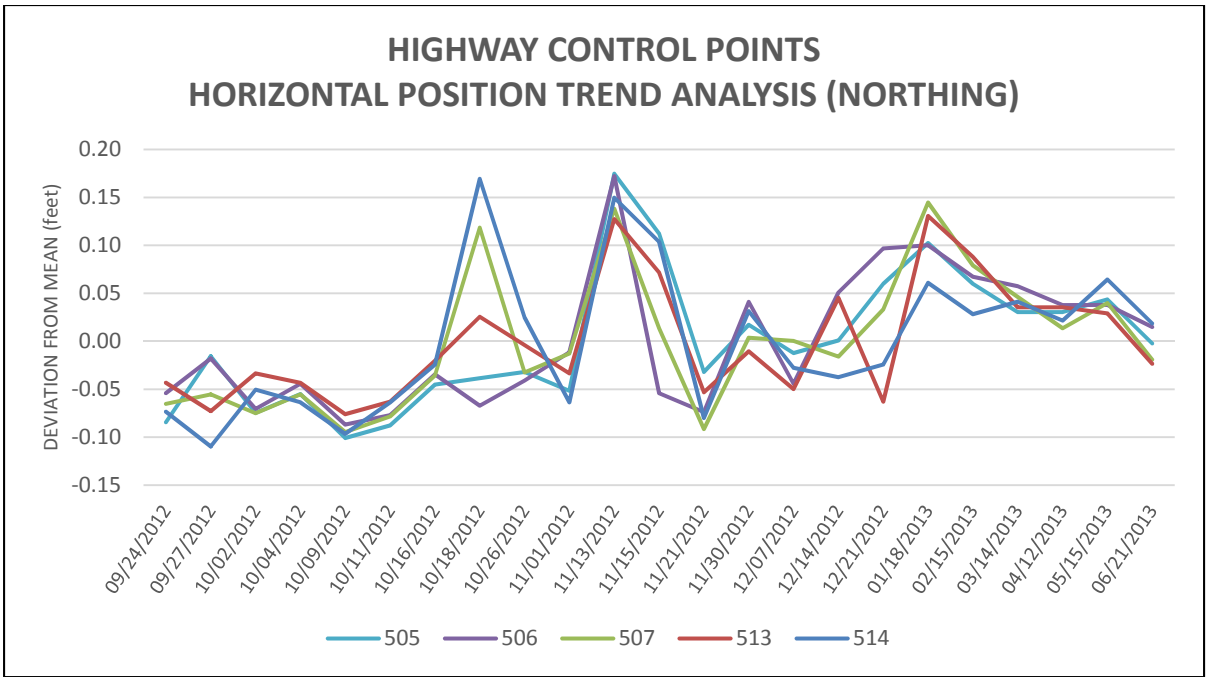

Figure 13
Horizontal positions (northing) of the Hwy 70 control points #505 - #514 and the deviation from the expected value

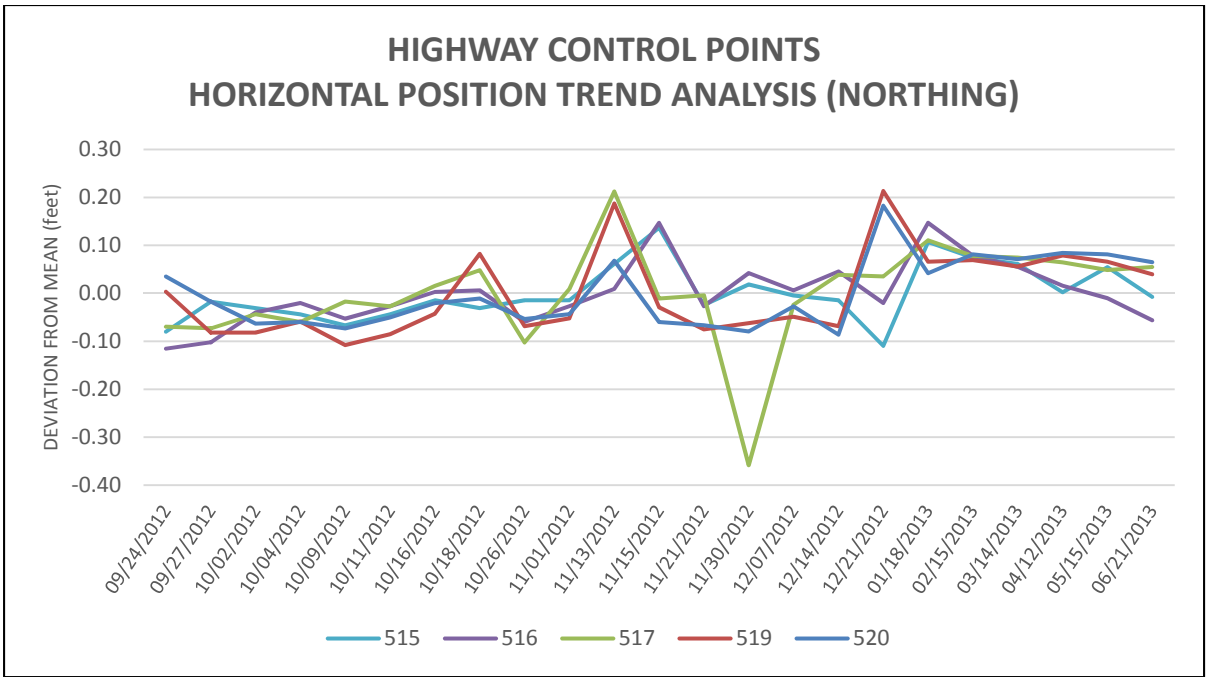

Figure 14
Horizontal positions (northing) of the Hwy 70 control points #515 - #520 and the deviation from the expected value

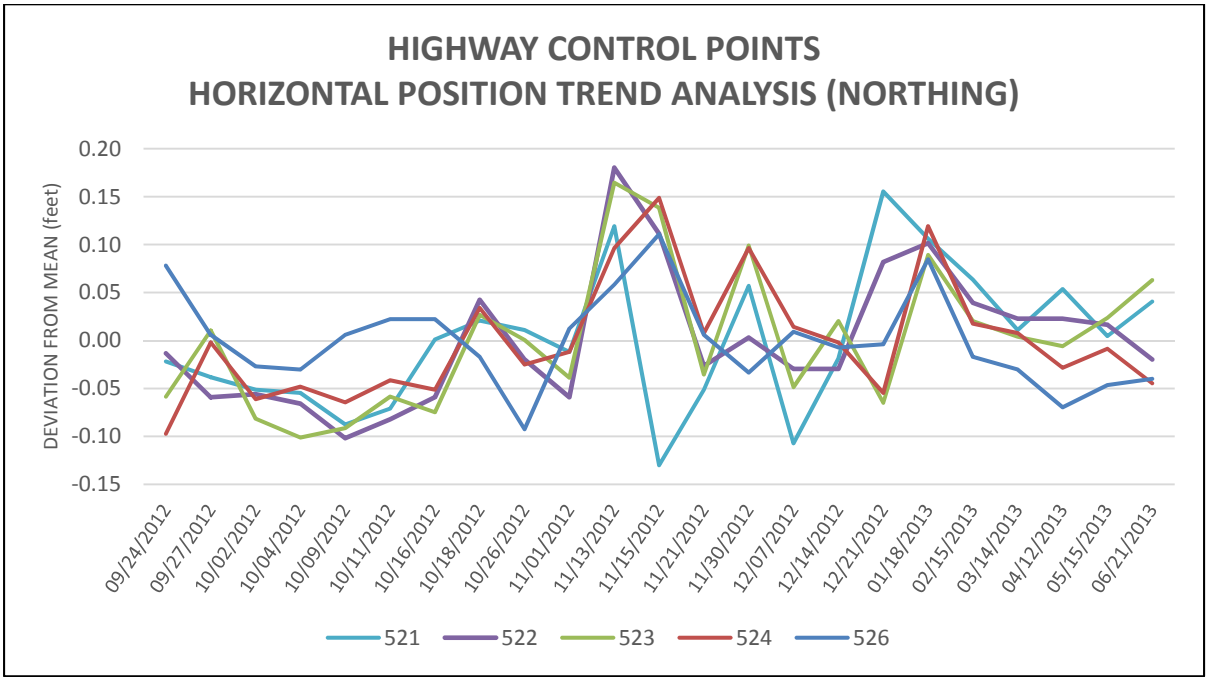

Figure 15
Horizontal positions (northing) of the Hwy 70 control points #521 - #526 and the deviation from the expected value

Figures 16 – 19 illustrate the horizontal position deviations in the easting direction from the mean measured at each control point during the project time period.

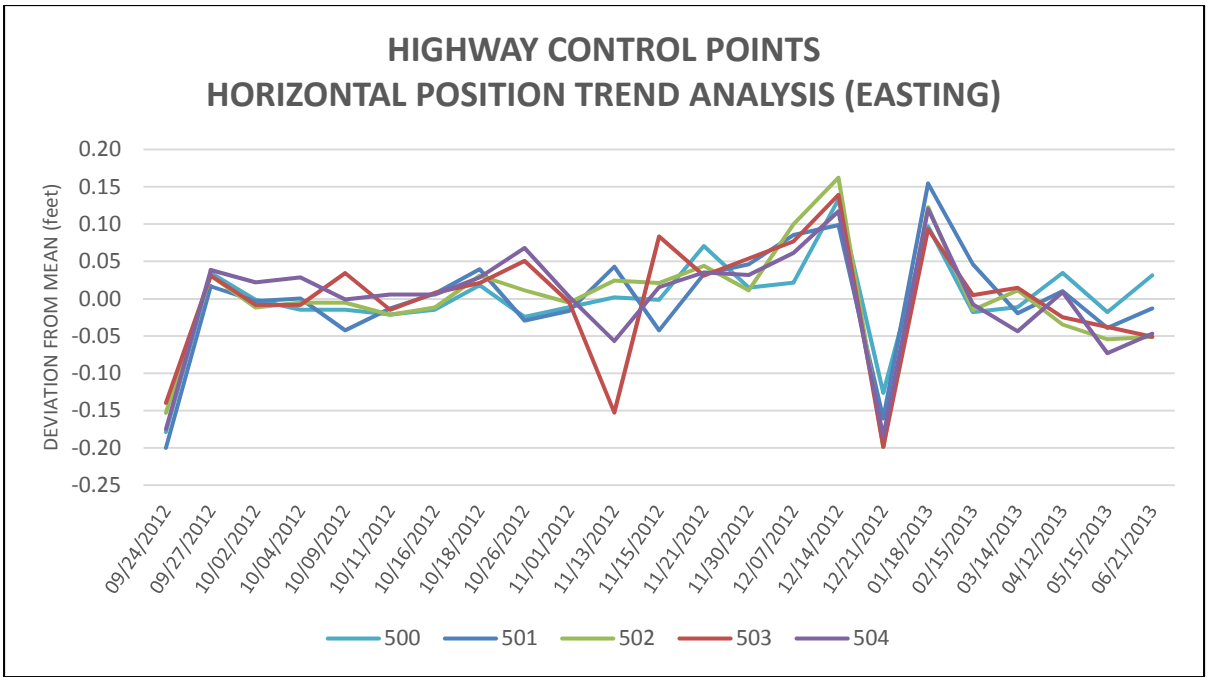

Figure 16
Horizontal positions (easting) of the Hwy 70 control points #500 - #504 and the deviation from the expected value

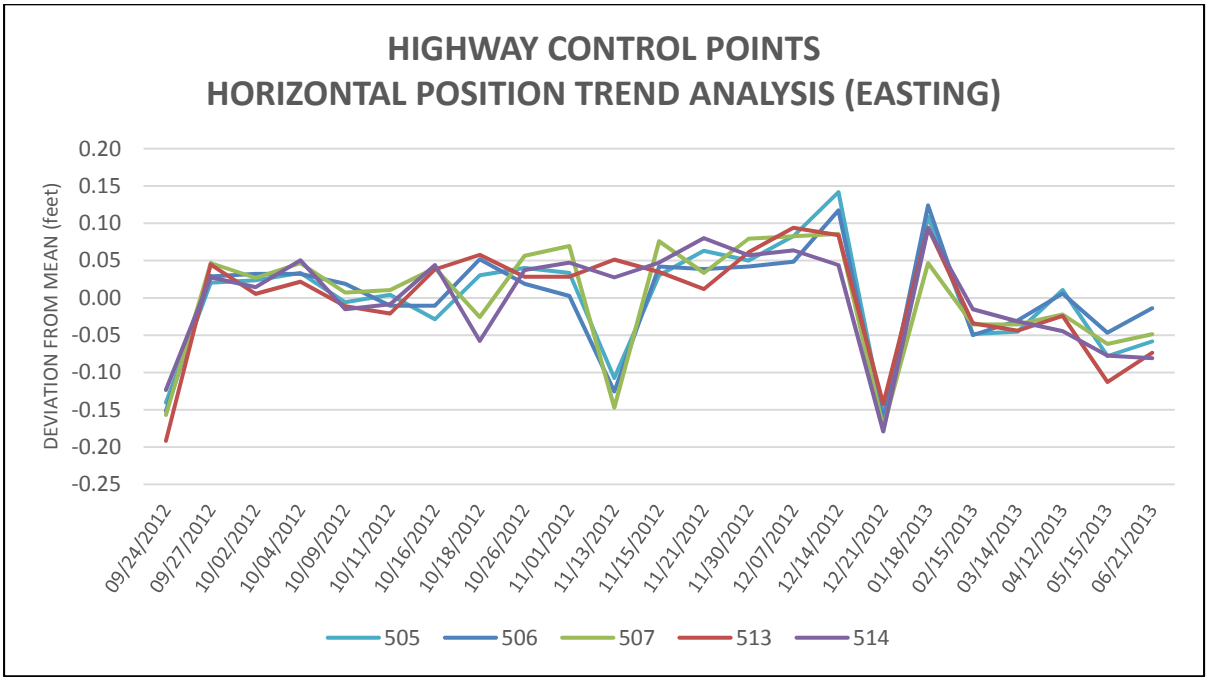

Figure 17
Horizontal positions (easting) of the Hwy 70 control points #505 - #514 and the deviation from the expected value

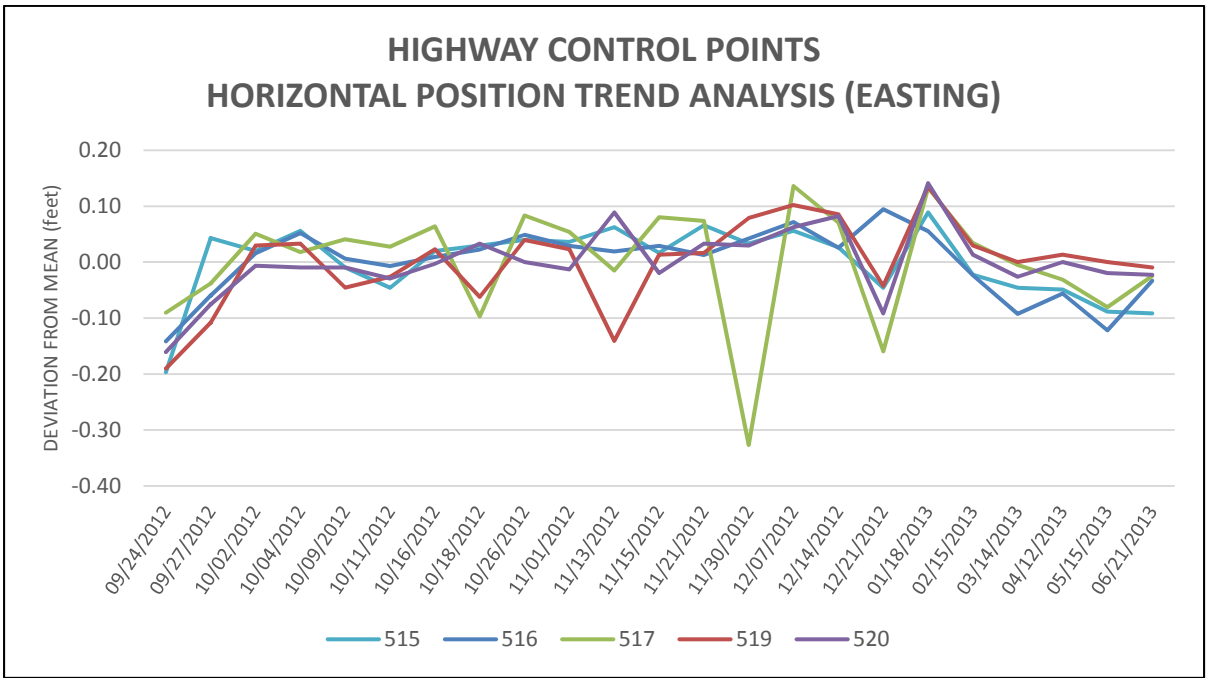

Figure 18
Horizontal positions (easting) of the Hwy 70 control points #515 - #520 and the deviation from the expected value

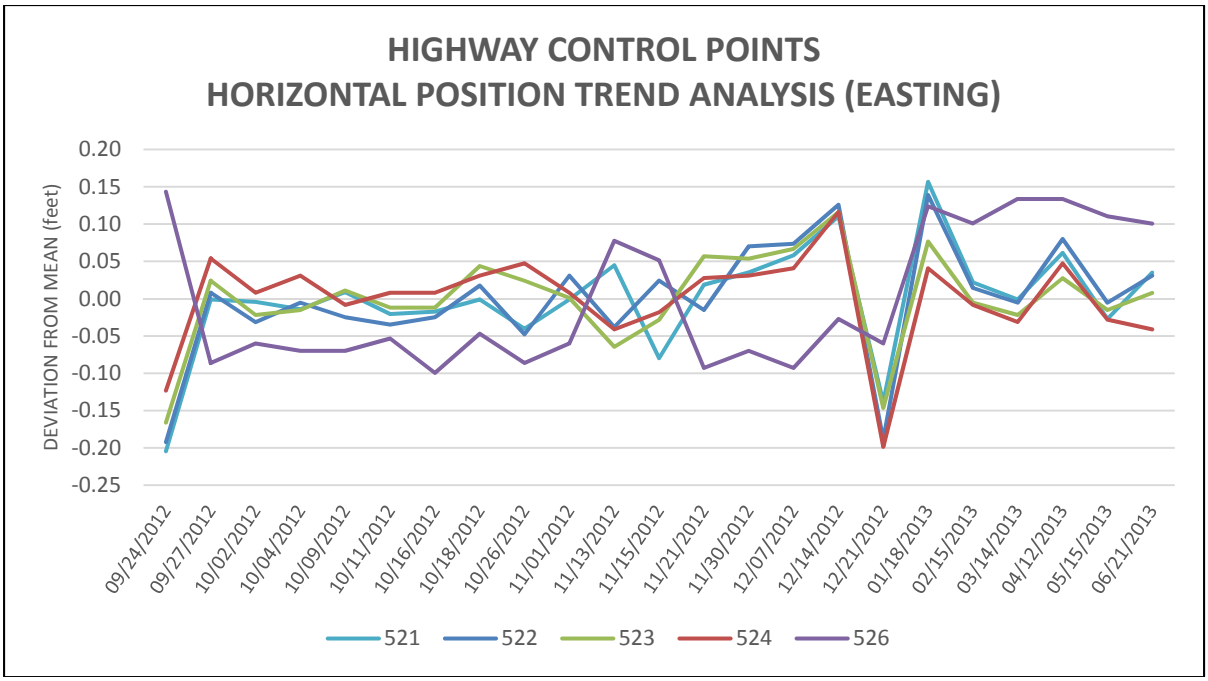

Figure 19
Horizontal positions (easting) of the Hwy 70 control points #521 - #526 and the deviation from the expected value

Figures 20 – 23 illustrate the vertical position deviations from the mean measured at each control point during the project time period.

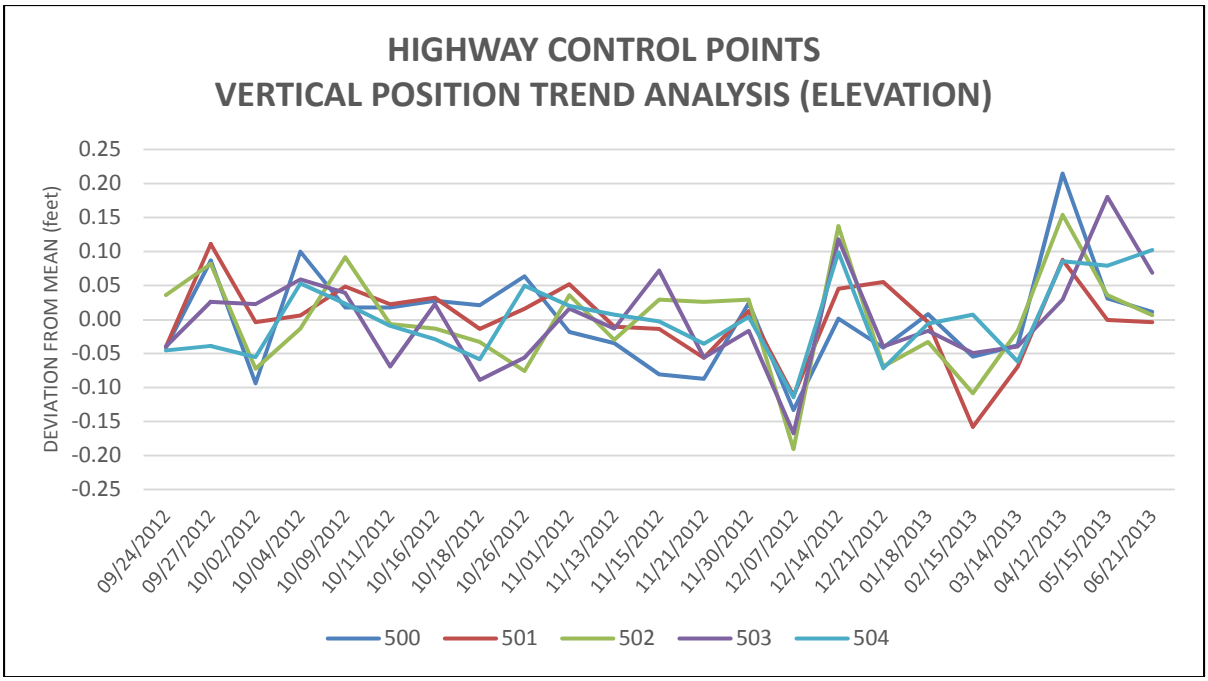

Figure 20
Vertical positions of the Hwy 70 control points #500 - #504 and the deviation from the expected value

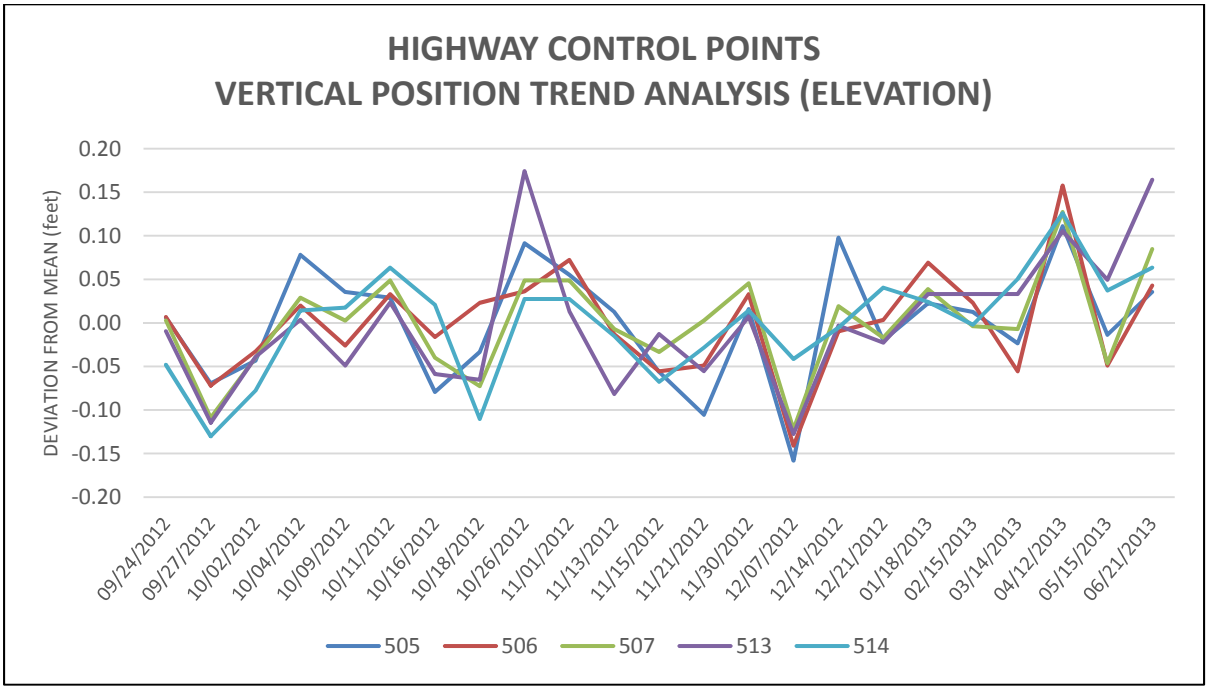

Figure 21
Vertical positions of the Hwy 70 control points #505 - #507, #513, #514, and the deviation from the expected value

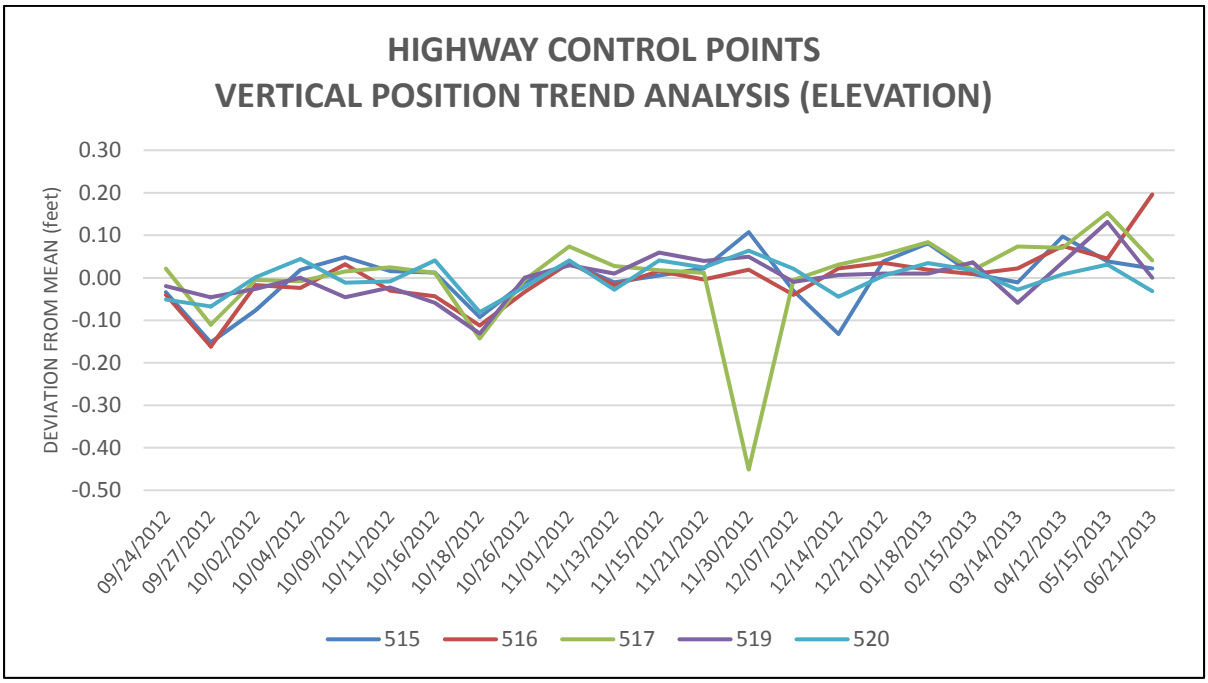

Figure 22
Vertical positions of the Hwy 70 control points #515 - #520 and the deviation from the expected value

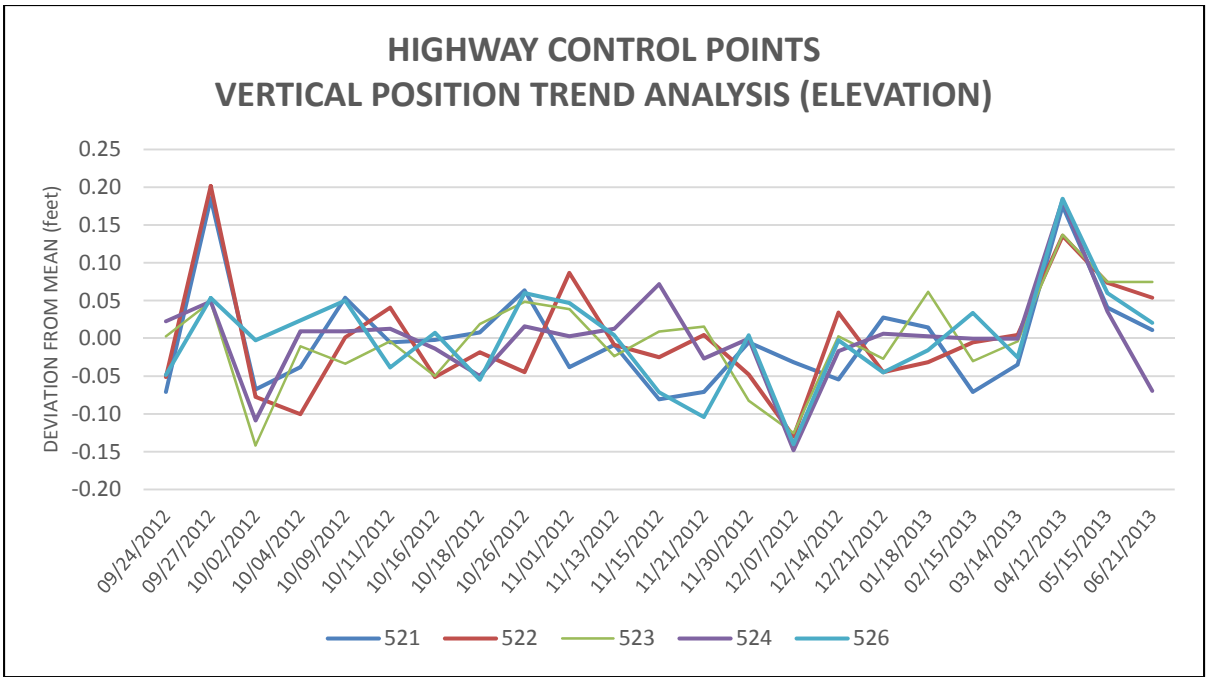

Figure 23
Vertical positions of the Hwy 70 control points #521 - #526 and the deviation from the expected value

Figures 24 – 25 illustrate the horizontal position deviations in the northing direction from the mean (y-axis) measured at each bridge control point during the project time period (x-axis).

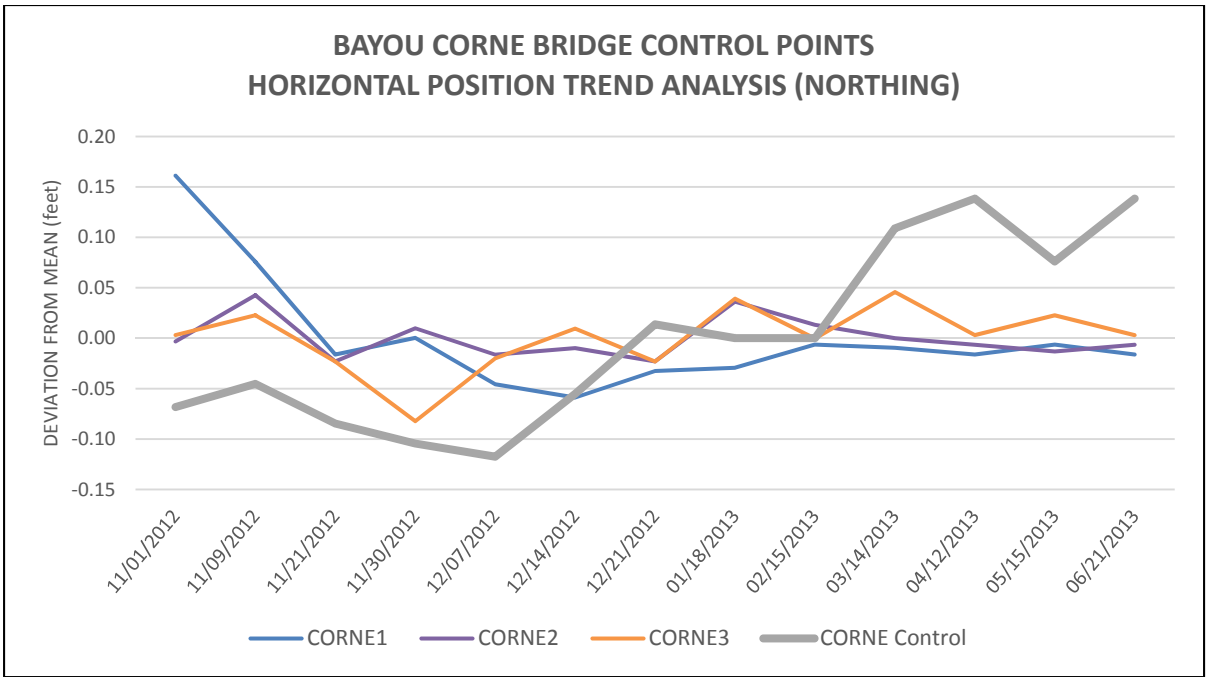

Figure 24
Horizontal positions (northing) of the Bayou Corne Bridge control points and the deviation from the expected value

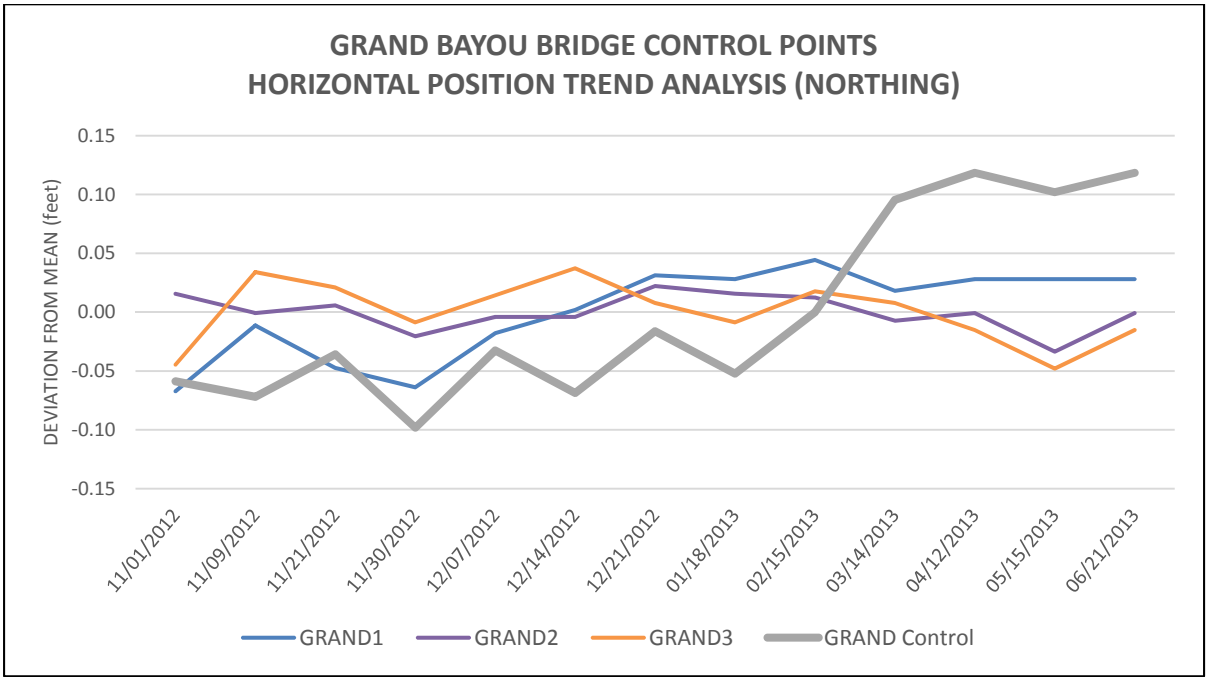

Figure 25
Horizontal positions (northing) of the Grand Bayou Bridge control points and the deviation from the expected value

Figures 26 – 27 illustrate the horizontal position deviations in the easting direction from the mean (y-axis) measured at each bridge control point during the project time period (x-axis).

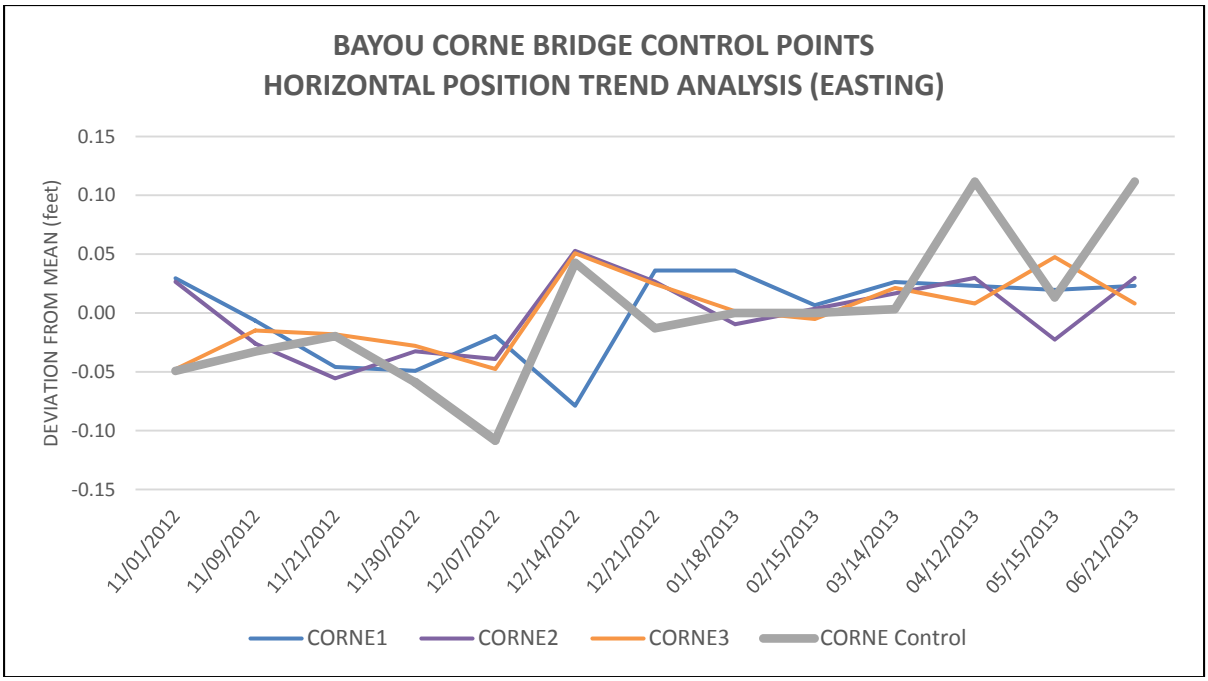

Figure 26
Horizontal positions (easting) of the Bayou Corne Bridge control points and the deviation from the expected value

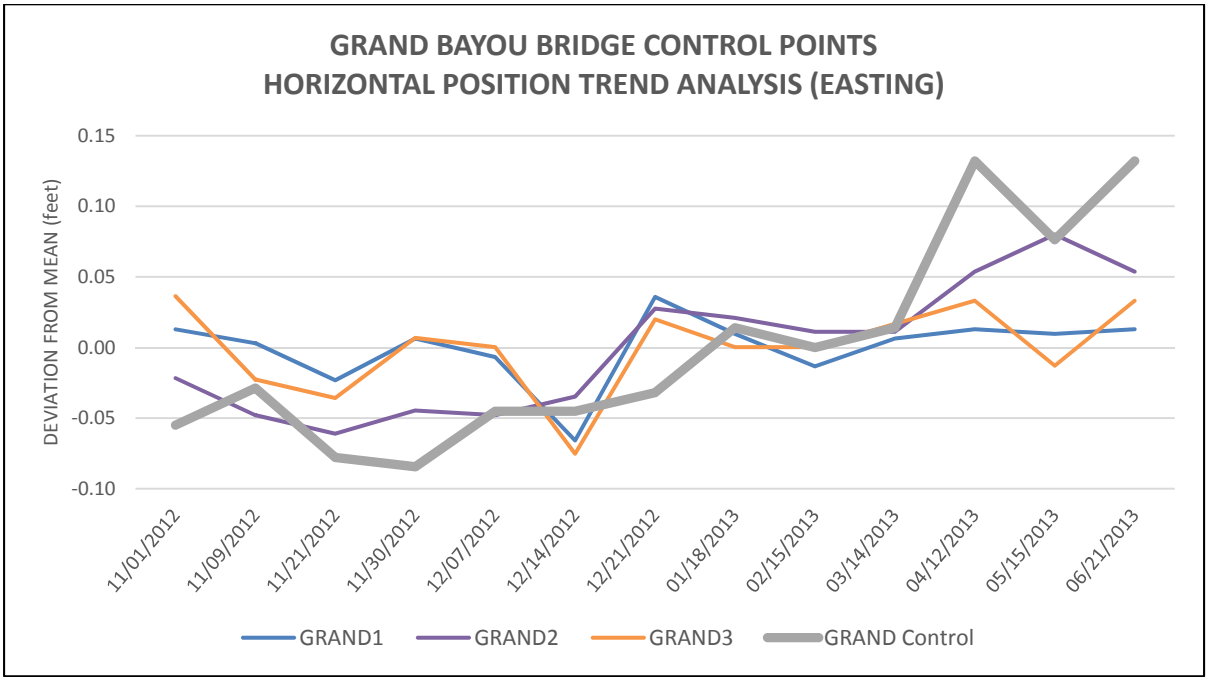

Figure 27
Horizontal positions (easting) of the Grand Bayou Bridge control points and the deviation from the expected value

Figures 28 – 29 illustrate the vertical position deviations from the mean (y-axis) measured at each bridge control point during the project time period (x-axis).

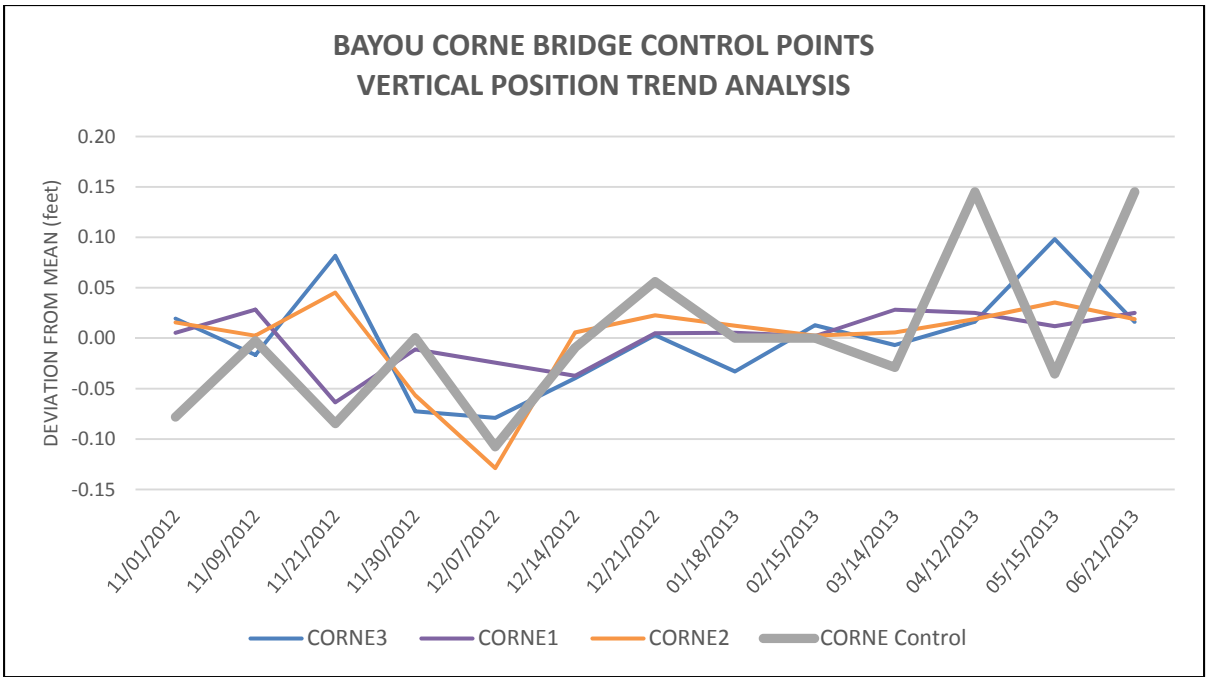

Figure 28
Vertical positions of the Bayou Corne Bridge control points and the deviation from the expected value

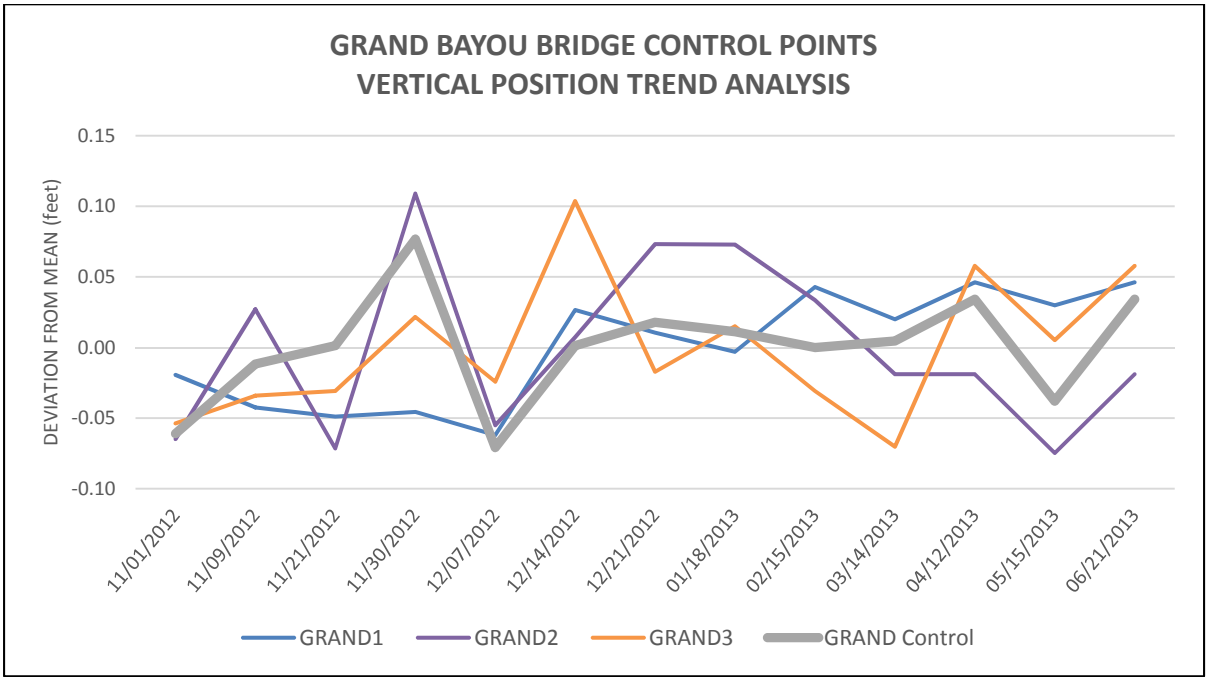

Figure 29
Vertical positions of the Grand Bayou Bridge control points and the deviation from the expected value

CONCLUSIONS

No discernible movement of Highway 70 or the bridges over Bayou Corne, Grand Bayou, and Bayou Choupique have been detected relative to the sinkhole during the report's measurement period. Sporadic measurements collected in the field demonstrate random and systematic errors that confound detailed analysis for determining significant trends. A more effective strategy would employ long-term occupations that can better account for both random and systematic errors.

Despite the biases, the average range of horizontal error observed for the highway control points was 0.19 ft. (5.8 cm), which included a minimum error of 0.007 ft. (0.21 cm) and a maximum of 0.48 ft. (14.6 cm). The average range of vertical error observed along the highway was 0.3 ft. (9.14 cm), with a minimum value of 0.001 ft. (0.3 cm) and a maximum of 0.45 ft. (13.7 cm). For the bridge control point observations, the average range of horizontal error was 0.098 ft. (3 cm), with a minimum of 0.005 ft. (0.15 cm) and a maximum of 0.18 ft. (5.5 cm). The average range of vertical error observed for the bridges was 0.16 ft. (4.9 cm), with a minimum of 0.0 ft. (0 cm) and a maximum of 0.14 ft. (4.3 cm).

Sporadic vs. Long-term Occupation

As depicted in the results, static, ad hoc occupations of control points are susceptible to random and systematic errors. Random errors refer to measurement variability caused by unknown and ***unpredictable*** changes in environmental conditions that can vary in magnitude and direction (Grewal, Weill, & Andrews, 2007). Examples include, but are not limited to: erroneous orbital information of GPS satellites (e.g., relativistic effects of gravity), atmospheric instability in the lower (e.g., troposphere) and upper (e.g., ionosphere) atmosphere, and signal interference due to multi-path reflections. Systematic errors are typically caused by ***predictable*** changes in the environmental conditions and/or processes. Examples include, but are not limited to: user and instrument error (e.g., clock synchronization, software malfunctions); unfavorable satellite geometry; signal interference due to tree canopy cover; and finally, the hydrographic heave and shrink on the local soils (related to the swamp and near-by bayous).

Long-term occupations are less susceptible to both random and systematic error by reducing their influence on the measurement solutions. For instance, random error can be reduced by occupying a location for a long period of time. Doing so provides a more reliable measurement of surface conditions by averaging, or smoothing, outlier values over time. The predictable, systematic errors can be constrained by following best practices when performing static occupations and using models to remove the unwanted sources of

interference. For instance, known sources of multipath interference can be excluded (e.g., masked) from the positional solutions, user error can be mitigated, and EMI can be isolated. Errors expected for a fixed CORS station can be reduced to estimated precisions between 0.8 in. – 1.18 in. (2-3 cm) horizontal and 1.96 in. – 2.75 in. (5-7 cm) vertical (orthometric) (Armstrong, 2013).

It is important to note that systematic error that cannot be constrained may be indicative of movement associated with regional subsidence, or even the sinkhole itself.

RECOMMENDATIONS

C4G recommends deploying continuously operating GPS reference stations (CORS) as a cost effective monitoring strategy for improving the accuracy, precision, and consistency of the surface stability. The variability associated with short-term, static GPS observations makes identifying specific trends difficult due to the myriad of random and systematic error associated with the techniques. While these biases can be reduced, they cannot be eliminated. Utilization of a network of CORS will permit second-by-second monitoring of the surface that, when correlated with the C4Gnet RTN, can minimize biases that plague the sporadic occupations of the current project. Additionally, utilization of a CORS will better detect trends and movement of the road surface, which decision makers and emergency managers require for establishing situational awareness and ensuring public safety. Therefore, nominal observation precision can be constrained to within 1.18 in. (3 cm) horizontal and 3.1 in. (8 cm) vertical under ideal conditions.

Improve Monitoring of Highway Stability Using CORS Technology

Installing multiple CORS along the highway will provide consistent, accurate, and reliable telemetry of surface conditions. Additionally, the CORS network can be correlated with the C4Gnet RTN, a network of 70 CORS sites distributed across the state. In doing so, positional accuracy and precision will be improved by mitigating various sources of random error (e.g., atmospheric and satellite geometry).

Positional Telemetry

Furthermore, C4G maintains a license for software traditionally utilized by geologists to detect tectonic movement in earthquake and volcano prone locations. This software utilizes a handful of tools that may be applicable to monitoring the surface near the sinkhole.

Coordinate Monitoring tools provides a real-time instrument for measuring a CORS position relative to the North American continent.

Rapid Motion Detection tools can measure instantaneous changes in the antenna's position. Such information may be useful for eliminating, or masking, the effects of aerodynamic drag from vehicles passing by the CORS site at high speeds.

Differential Motion Detection tools monitor the short and long term positional changes relative to other CORS installations, as well as CORS sites maintained at other locations in the state.

Network Motion Detection tools track the long-term changes to the basic geometry of the CORS sites.

Real-Time and Web-based Monitoring

The software maintained by C4G can also be configured to support real-time monitoring via Web browsers. Users can be assigned credentials for logging into the system, monitor coordinates, generate time-series reports, and set thresholds for alerts.

ACRONYMS, ABBREVIATIONS, AND SYMBOLS

C4G	Center for GeoInformatics
cm	centimeter(s)
CORS	continuously operating reference station(s)
EMI	electro-magnetic interference
ft.	foot (feet)
FTP	file transfer protocol
GIS	geographic information system
GPS	global positioning system(s)
in.	inch(es)
DOTD	Department of Transportation and Development
LSU	Louisiana State University
LTRC	Louisiana Transportation Research Center
lb.	pound(s)
m	meter(s)
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NSRC	National Spatial Reference System
NGS	National Geodetic Survey
PDOP	dilution of precision
RMSE	root-mean square error
RTN	real-time network
SPCS	State Plane Coordinate Systems

REFERENCES

1. Grewal, M., Weill, L., and Andrews, A., Global Positioning Systems, Inertial Navigation, and Integration. John Wiley & Sons. Hoboken, New Jersey, 2007. ISBN 10 0-470-04190-0

2. Armstrong, M., RTK Precision Vs. Accuracy and Occupation Time. Presentation for the NGS Best Practices for Real Time GNSS Network Administration. July 31, 2013. Silver Spring, MD., USA. Last accessed on August 10, 2013. URL: http://www.ngs.noaa.gov/web/science_edu/presentations_library/files/rtn_precision_vs_accuracy_armstrong.ppt

APPENDIX

The following tables represent a compilation of data collected to date. Tables have been organized into two general categories: highway and bridge measurements. Both categories are further organized into three tables each: northing (y-axis), easting (x-axis), and elevation (z-axis). The first two tables are the computed averages (and standard deviations) of all observations collected during the project.

Table 4
Field observations for 9/24/2012

PROJECT NUMBER: 30000920			
PROJECT NAME: Napoleonville Salt dome			
ROUTE: La 70			
PARISH: Assumption			
ORIGINAL POINT DATA DATE: 09-24-12			
Pt No.	Northing	Easting	Elevation
500	551035.437	3339588.797	6.007
501	551047.054	3340111.840	5.771
502	551058.914	3340650.582	5.823
503	551071.874	3341190.821	5.856
504	551082.156	3341713.218	5.778
505	551092.976	3342203.929	5.430
506	551105.525	3342792.947	5.666
507	551115.223	3343285.859	5.459
513	551133.314	3343865.648	5.128
514	551166.371	3344504.151	5.463
515	551187.447	3344973.868	4.787
516	551277.332	3345309.471	5.003
517	551365.183	3345624.982	6.427
519	551289.212	3346138.071	6.614
520	551042.595	3346644.783	5.417
521	551041.651	3339033.158	6.211
522	551121.454	3338505.334	6.201
523	551173.661	3337915.096	8.527
524	551061.982	3337576.406	6.667
526	550682.642	3336789.078	7.644

Table 5
Field observations for 9/27/2012

PROJECT NUMBER: 30000920
PROJECT NAME: Napoleonville Salt dome
ROUTE: La 70
PARISH: Assumption
ORIGINAL POINT DATA DATE: 09-27-12

PT No.	Northing	Easting	Elevation	PT No. check	North difference (comp. - orig.)	East difference (comp. - orig.)	Elev. Difference (comp. - orig.)
500	551035.433	3339589.010	6.135	CHECK	-0.0033	0.2133	0.128
501	551047.044	3340112.057	5.922	CHECK	-0.0098	0.2165	0.151
502	551058.908	3340650.766	5.869	CHECK	-0.0066	0.1837	0.046
503	551071.929	3341190.991	5.922	CHECK	0.0558	0.1706	0.066
504	551082.228	3341713.431	5.784	CHECK	0.0722	0.2133	0.007
505	551093.045	3342204.090	5.354	CHECK	0.0689	0.1608	-0.075
506	551105.561	3342793.127	5.587	CHECK	0.0361	0.1804	-0.079
507	551115.233	3343286.063	5.348	CHECK	0.0098	0.2034	-0.112
513	551133.284	3343865.884	5.023	CHECK	-0.0295	0.2362	-0.105
514	551166.335	3344504.302	5.381	CHECK	-0.0361	0.1509	-0.082
515	551187.510	3344974.107	4.669	CHECK	0.0623	0.2395	-0.118
516	551277.346	3345309.553	4.882	CHECK	0.0131	0.0820	-0.121
517	551365.180	3345625.034	6.296	CHECK	-0.0033	0.0525	-0.131
519	551289.127	3346138.154	6.588	CHECK	-0.0853	0.0820	-0.026
520	551042.543	3346644.868	5.400	CHECK	-0.0525	0.0853	-0.016
521	551041.634	3339033.361	6.467	CHECK	-0.0164	0.2034	0.256
522	551121.408	3338505.534	6.453	CHECK	-0.0459	0.2001	0.253
523	551173.730	3337915.286	8.573	CHECK	0.0689	0.1903	0.046
524	551062.077	3337576.583	6.693	CHECK	0.0951	0.1772	0.026
526	550682.570	3336788.848	7.746	CHECK	-0.0722	-0.2297	0.102

Table 6
Field observations for 10/02/2012

PROJECT NUMBER: 30000920							
PROJECT NAME: Napoleonville Salt dome							
ROUTE: La 70							
PARISH: Assumption							
ROAD POINT DATA DATE: 10-02-12 (C4G)							
PT No.	Northing	Easting	Elevation	PT No. check	North difference (comp. - orig.)	East difference (comp. - orig.)	Elev. Difference (comp. - orig.)
500	551035.427	3339588.974	5.955	CHECK	-0.0466	0.0180	-0.084
501	551047.057	3340112.037	5.807	CHECK	-0.0216	0.0164	-0.008
502	551058.862	3340650.724	5.715	CHECK	-0.0656	0.0052	-0.073
503	551071.900	3341190.952	5.919	CHECK	-0.0284	0.0077	0.032
504	551082.152	3341713.415	5.768	CHECK	-0.0716	0.0344	-0.046
505	551092.986	3342204.093	5.381	CHECK	-0.0658	0.0382	-0.043
506	551105.509	3342793.131	5.627	CHECK	-0.0556	0.0494	-0.026
507	551115.213	3343286.043	5.417	CHECK	-0.0646	0.0369	-0.031
513	551133.324	3343865.845	5.098	CHECK	-0.0263	0.0139	-0.032
514	551166.394	3344504.289	5.433	CHECK	-0.0440	0.0203	-0.072
515	551187.497	3344974.084	4.744	CHECK	-0.0216	0.0214	-0.071
516	551277.408	3345309.628	5.026	CHECK	-0.0295	0.0184	-0.002
517	551365.210	3345625.123	6.401	CHECK	-0.0511	0.0454	-0.014
519	551289.127	3346138.291	6.608	CHECK	-0.0822	0.0529	-0.015
520	551042.497	3346644.937	5.469	CHECK	-0.0635	0.0098	0.006
521	551041.621	3339033.358	6.214	CHECK	-0.0448	0.0243	-0.045
522	551121.411	3338505.495	6.175	CHECK	-0.0556	0.0033	-0.058
523	551173.638	3337915.240	8.383	CHECK	-0.0664	-0.0010	-0.133
524	551062.018	3337576.537	6.535	CHECK	-0.0555	0.0223	-0.117
526	550682.537	3336788.874	7.690	CHECK	-0.0334	-0.0426	0.005

Table 7
Field observations for 10/04/2012

PROJECT NUMBER: 30000920
PROJECT NAME: Napoleonville Salt dome
ROUTE: La 70
PARISH: Assumption
ROAD POINT DATA DATE: 10-04-12 (C4G)

PT No.	Northing	Easting	Elevation	PT No. check	North difference (comp. - orig.)	East difference (comp. - orig.)	Elev. Difference (comp. - orig.)
500	551035.496	3339588.961	6.148	CHECK	0.0223	0.0049	0.110
501	551047.051	3340112.040	5.817	CHECK	-0.0282	0.0197	0.002
502	551058.852	3340650.730	5.774	CHECK	-0.0755	0.0118	-0.014
503	551071.870	3341190.952	5.955	CHECK	-0.0579	0.0077	0.069
504	551082.136	3341713.422	5.876	CHECK	-0.0880	0.0409	0.063
505	551093.005	3342204.103	5.502	CHECK	-0.0461	0.0481	0.078
506	551105.535	3342793.131	5.679	CHECK	-0.0293	0.0494	0.026
507	551115.233	3343286.063	5.486	CHECK	-0.0449	0.0566	0.038
513	551133.314	3343865.861	5.141	CHECK	-0.0361	0.0303	0.011
514	551166.381	3344504.325	5.525	CHECK	-0.0571	0.0564	0.020
515	551187.484	3344974.120	4.839	CHECK	-0.0347	0.0575	0.024
516	551277.428	3345309.664	5.020	CHECK	-0.0098	0.0544	-0.009
517	551365.193	3345625.090	6.398	CHECK	-0.0675	0.0126	-0.017
519	551289.150	3346138.295	6.634	CHECK	-0.0593	0.0561	0.011
520	551042.500	3346644.934	5.512	CHECK	-0.0602	0.0065	0.048
521	551041.618	3339033.348	6.243	CHECK	-0.0481	0.0145	-0.016
522	551121.401	3338505.521	6.152	CHECK	-0.0654	0.0295	-0.081
523	551173.619	3337915.247	8.514	CHECK	-0.0861	0.0055	-0.002
524	551062.031	3337576.560	6.654	CHECK	-0.0424	0.0453	0.001
526	550682.534	3336788.864	7.717	CHECK	-0.0367	-0.0525	0.031

Table 8
Field observations for 10/09/2012

PROJECT NUMBER: 30000920							
PROJECT NAME: Napoleonville Salt dome							
ROUTE: La 70							
PARISH: Assumption							
ROAD POINT DATA DATE: 10-09-12 (C4G)							
PT No.	Northing	Easting	Elevation	PT No. check	North difference (comp. - orig.)	East difference (comp. - orig.)	Elev. Difference (comp. - orig.)
500	551035.407	3339588.961	6.066	CHECK	-0.0662	0.0049	0.027
501	551047.034	3340111.998	5.860	CHECK	-0.0446	-0.0230	0.045
502	551058.862	3340650.730	5.879	CHECK	-0.0656	0.0118	0.091
503	551071.847	3341190.995	5.935	CHECK	-0.0809	0.0504	0.049
504	551082.136	3341713.392	5.846	CHECK	-0.0880	0.0114	0.033
505	551092.959	3342204.064	5.459	CHECK	-0.0921	0.0087	0.036
506	551105.492	3342793.118	5.633	CHECK	-0.0720	0.0363	-0.020
507	551115.194	3343286.023	5.459	CHECK	-0.0843	0.0172	0.012
513	551133.281	3343865.829	5.089	CHECK	-0.0689	-0.0025	-0.042
514	551166.348	3344504.259	5.528	CHECK	-0.0899	-0.0092	0.023
515	551187.461	3344974.055	4.869	CHECK	-0.0577	-0.0081	0.053
516	551277.395	3345309.618	5.075	CHECK	-0.0426	0.0085	0.047
517	551365.236	3345625.113	6.421	CHECK	-0.0249	0.0355	0.006
519	551289.101	3346138.216	6.588	CHECK	-0.1085	-0.0226	-0.035
520	551042.487	3346644.934	5.456	CHECK	-0.0734	0.0065	-0.007
521	551041.585	3339033.371	6.335	CHECK	-0.0809	0.0374	0.076
522	551121.365	3338505.501	6.253	CHECK	-0.1015	0.0099	0.021
523	551173.629	3337915.273	8.491	CHECK	-0.0763	0.0318	-0.025
524	551062.015	3337576.520	6.654	CHECK	-0.0588	0.0059	0.001
526	550682.570	3336788.864	7.743	CHECK	-0.0006	-0.0525	0.057

Table 9
Field observations for 10/11/2012

PROJECT NUMBER: 30000920
PROJECT NAME: Napoleonville Salt dome
ROUTE: La 70
PARISH: Assumption
ROAD POINT DATA DATE: 10-11-12 (C4G)

PT No.	Northing	Easting	Elevation	PT No. check	North difference (comp. - orig.)	East difference (comp. - orig.)	Elev. Difference (comp. - orig.)
500	551035.446	3339588.954	6.066	CHECK	-0.0269	-0.0016	0.027
501	551047.025	3340112.027	5.833	CHECK	-0.0544	0.0066	0.019
502	551058.891	3340650.714	5.781	CHECK	-0.0361	-0.0046	-0.008
503	551071.860	3341190.946	5.827	CHECK	-0.0678	0.0012	-0.059
504	551082.172	3341713.399	5.814	CHECK	-0.0519	0.0180	0.000
505	551092.973	3342204.073	5.453	CHECK	-0.0790	0.0185	0.029
506	551105.502	3342793.088	5.692	CHECK	-0.0621	0.0068	0.039
507	551115.210	3343286.027	5.505	CHECK	-0.0679	0.0205	0.058
513	551133.294	3343865.819	5.161	CHECK	-0.0558	-0.0123	0.030
514	551166.381	3344504.266	5.574	CHECK	-0.0571	-0.0027	0.069
515	551187.484	3344974.019	4.836	CHECK	-0.0347	-0.0442	0.020
516	551277.421	3345309.605	5.013	CHECK	-0.0164	-0.0046	-0.015
517	551365.226	3345625.100	6.430	CHECK	-0.0347	0.0224	0.016
519	551289.124	3346138.236	6.611	CHECK	-0.0855	-0.0029	-0.012
520	551042.510	3346644.914	5.459	CHECK	-0.0504	-0.0131	-0.004
521	551041.601	3339033.342	6.276	CHECK	-0.0645	0.0079	0.017
522	551121.385	3338505.492	6.293	CHECK	-0.0818	0.0000	0.060
523	551173.661	3337915.250	8.520	CHECK	-0.0435	0.0088	0.005
524	551062.038	3337576.537	6.657	CHECK	-0.0359	0.0223	0.005
526	550682.586	3336788.881	7.654	CHECK	0.0158	-0.0361	-0.032

Table 10
Field observations for 10/16/2012

PROJECT NUMBER: 30000920
PROJECT NAME: Napoleonville Salt dome
ROUTE: La 70
PARISH: Assumption
ROAD POINT DATA DATE: 10-16-12 (C4G)

PT No.	Northing	Easting	Elevation	PT No. check	North difference (comp. - orig.)	East difference (comp. - orig.)	Elev. Difference (comp. -- orig.)
500	551035.437	3339588.961	6.076	CHECK	-0.0367	0.0049	0.037
501	551047.064	3340112.047	5.843	CHECK	-0.0150	0.0262	0.028
502	551058.881	3340650.724	5.774	CHECK	-0.0460	0.0052	-0.014
503	551071.942	3341190.969	5.919	CHECK	0.0143	0.0241	0.032
504	551082.221	3341713.399	5.794	CHECK	-0.0027	0.0180	-0.019
505	551093.015	3342204.041	5.344	CHECK	-0.0363	-0.0143	-0.079
506	551105.545	3342793.088	5.643	CHECK	-0.0195	0.0068	-0.010
507	551115.253	3343286.056	5.417	CHECK	-0.0252	0.0500	-0.031
513	551133.337	3343865.878	5.079	CHECK	-0.0131	0.0467	-0.052
514	551166.421	3344504.318	5.531	CHECK	-0.0177	0.0498	0.026
515	551187.513	3344974.084	4.833	CHECK	-0.0052	0.0214	0.017
516	551277.451	3345309.622	5.000	CHECK	0.0131	0.0118	-0.028
517	551365.269	3345625.136	6.417	CHECK	0.0079	0.0585	0.003
519	551289.166	3346138.285	6.575	CHECK	-0.0429	0.0463	-0.048
520	551042.540	3346644.941	5.509	CHECK	-0.0209	0.0131	0.045
521	551041.674	3339033.345	6.280	CHECK	0.0077	0.0112	0.020
522	551121.408	3338505.501	6.201	CHECK	-0.0589	0.0099	-0.032
523	551173.645	3337915.250	8.474	CHECK	-0.0599	0.0088	-0.041
524	551062.028	3337576.537	6.631	CHECK	-0.0457	0.0223	-0.022
526	550682.586	3336788.835	7.700	CHECK	0.0158	-0.0820	0.014

Table 11
Field observations for 10/18/2012

PROJECT NUMBER: 30000920
PROJECT NAME: Napoleonville Salt dome
ROUTE: La 70
PARISH: Assumption
ROAD POINT DATA DATE: 10-18-12 (C4G)

PT No.	Northing	Easting	Elevation	PT No. check	North difference (comp. - orig.)	East difference (comp. - orig.)	Elev. Difference (comp. - orig.)
500	551035.512	3339588.993	6.070	CHECK	0.0387	0.0377	0.031
501	551047.123	3340112.080	5.797	CHECK	0.0440	0.0590	-0.018
502	551058.947	3340650.766	5.755	CHECK	0.0197	0.0479	-0.034
503	551071.854	3341190.982	5.807	CHECK	-0.0743	0.0373	-0.079
504	551082.195	3341713.422	5.764	CHECK	-0.0289	0.0409	-0.049
505	551093.022	3342204.100	5.390	CHECK	-0.0297	0.0448	-0.033
506	551105.512	3342793.150	5.682	CHECK	-0.0523	0.0691	0.030
507	551115.407	3343285.991	5.384	CHECK	0.1290	-0.0156	-0.064
513	551133.383	3343865.898	5.072	CHECK	0.0328	0.0664	-0.058
514	551166.614	3344504.216	5.400	CHECK	0.1758	-0.0519	-0.105
515	551187.497	3344974.094	4.728	CHECK	-0.0216	0.0312	-0.088
516	551277.454	3345309.635	4.931	CHECK	0.0164	0.0249	-0.097
517	551365.301	3345624.975	6.263	CHECK	0.0407	-0.1023	-0.152
519	551289.291	3346138.199	6.503	CHECK	0.0818	-0.0390	-0.120
520	551042.549	3346644.977	5.387	CHECK	-0.0110	0.0492	-0.076
521	551041.693	3339033.361	6.289	CHECK	0.0274	0.0276	0.030
522	551121.509	3338505.544	6.234	CHECK	0.0428	0.0525	0.001
523	551173.747	3337915.306	8.543	CHECK	0.0418	0.0646	0.028
524	551062.113	3337576.560	6.594	CHECK	0.0396	0.0453	-0.058
526	550682.547	3336788.887	7.638	CHECK	-0.0236	-0.0295	-0.048

Table 12
Field observations for 10/26/2012

PROJECT NUMBER: 30000920							
PROJECT NAME: Napoleonville Salt dome							
ROUTE: La 70							
PARISH: Assumption							
ROAD POINT DATA DATE: 10-26-12 (C4G)							
PT No.	Northing	Easting	Elevation	PT No. check	North difference (comp. - orig.)	East difference (comp. - orig.)	Elev. Difference (comp. - orig.)
500	551035.502	3339588.951	6.112	CHECK	0.0289	-0.0049	0.073
501	551047.074	3340112.011	5.827	CHECK	-0.0052	-0.0099	0.012
502	551058.862	3340650.747	5.712	CHECK	-0.0656	0.0282	-0.077
503	551071.851	3341191.011	5.840	CHECK	-0.0776	0.0668	-0.046
504	551082.202	3341713.461	5.873	CHECK	-0.0224	0.0803	0.059
505	551093.028	3342204.110	5.515	CHECK	-0.0232	0.0546	0.091
506	551105.538	3342793.118	5.696	CHECK	-0.0261	0.0363	0.043
507	551115.256	3343286.073	5.505	CHECK	-0.0220	0.0664	0.058
513	551133.353	3343865.868	5.312	CHECK	0.0033	0.0369	0.181
514	551166.470	3344504.312	5.538	CHECK	0.0315	0.0433	0.033
515	551187.513	3344974.104	4.810	CHECK	-0.0052	0.0411	-0.006
516	551277.388	3345309.661	5.010	CHECK	-0.0492	0.0512	-0.018
517	551365.151	3345625.156	6.401	CHECK	-0.1102	0.0782	-0.014
519	551289.140	3346138.301	6.634	CHECK	-0.0691	0.0627	0.011
520	551042.507	3346644.944	5.446	CHECK	-0.0537	0.0164	-0.017
521	551041.683	3339033.322	6.345	CHECK	0.0175	-0.0118	0.086
522	551121.447	3338505.478	6.207	CHECK	-0.0195	-0.0131	-0.025
523	551173.720	3337915.286	8.573	CHECK	0.0156	0.0449	0.057
524	551062.054	3337576.576	6.660	CHECK	-0.0195	0.0617	0.008
526	550682.471	3336788.848	7.753	CHECK	-0.0990	-0.0689	0.067

Table 13
Field observations for 11/01/2012

PROJECT NUMBER: 30000920							
PROJECT NAME: Napoleonville Salt dome							
ROUTE: La 70							
PARISH: Assumption							
ROAD POINT DATA DATE: 11-01-12 (C4G)							
PT No.	Northing	Easting	Elevation	PT No. check	North difference (comp. - orig.)	East difference (comp. - orig.)	Elev. Difference (comp. - orig.)
500	551,035.4400	3,339,588.9640	6.030	CHECK	-0.0334	0.0083	-0.009
501	551,047.0440	3,340,112.0240	5.863	CHECK	-0.0350	0.0034	0.048
502	551,058.8720	3,340,650.7300	5.823	CHECK	-0.0554	0.0117	0.034
503	551,071.9200	3,341,190.9550	5.912	CHECK	-0.0082	0.0106	0.026
504	551,082.1980	3,341,713.3950	5.843	CHECK	-0.0260	0.0144	0.030
505	551,093.0090	3,342,204.1030	5.479	CHECK	-0.0426	0.0481	0.055
506	551,105.5680	3,342,793.1010	5.732	CHECK	0.0037	0.0198	0.079
507	551,115.2760	3,343,286.0860	5.505	CHECK	-0.0020	0.0798	0.058
513	551,133.3240	3,343,865.8680	5.151	CHECK	-0.0259	0.0368	0.021
514	551,166.3810	3,344,504.3210	5.538	CHECK	-0.0574	0.0526	0.033
515	551,187.5130	3,344,974.1010	4.856	CHECK	-0.0053	0.0381	0.040
516	551,277.4210	3,345,309.6410	5.079	CHECK	-0.0165	0.0311	0.051
517	551,365.2620	3,345,625.1260	6.480	CHECK	0.0013	0.0483	0.065
519	551,289.1570	3,346,138.2850	6.663	CHECK	-0.0523	0.0466	0.040
520	551,042.5170	3,346,644.9310	5.509	CHECK	-0.0435	0.0036	0.046
521	551,041.6600	3,339,033.3610	6.243	CHECK	-0.0058	0.0273	-0.016
522	551,121.4080	3,338,505.5570	6.339	CHECK	-0.0585	0.0654	0.106
523	551,173.6810	3,337,915.2630	8.563	CHECK	-0.0239	0.0218	0.048
524	551,062.0670	3,337,576.5370	6.647	CHECK	-0.0065	0.0225	-0.005
526	550,682.5760	3,336,788.8740	7.739	CHECK	0.0055	-0.0429	0.053

Table 14
Field observations for 11/13/2012

PROJECT NUMBER: 30000920							
PROJECT NAME: Napoleonville Salt dome							
ROUTE: La 70							
PARISH: Assumption							
ROAD POINT DATA DATE: 11-13-12 (C4G)							
PT No.	Northing	Easting	Elevation	PT No. check	North difference (comp. - orig.)	East difference (comp. - orig.)	Elev. Difference (comp. - orig.)
500	551035.630210	3339588.976977	6.013768	CHECK	0.1569	0.0213	-0.025
501	551047.227956	3340112.082886	5.800513	CHECK	0.1490	0.0623	-0.014
502	551059.078326	3340650.759630	5.757862	CHECK	0.1509	0.0413	-0.031
503	551072.050741	3341190.807762	5.882534	CHECK	0.1225	-0.1366	-0.004
504	551082.408332	3341713.336245	5.830041	CHECK	0.1843	-0.0444	0.017
505	551093.235082	3342203.961904	5.436341	CHECK	0.1835	-0.0930	0.013
506	551105.751461	3342792.973193	5.646314	CHECK	0.1872	-0.1081	-0.007
507	551115.426638	3343285.869189	5.449464	CHECK	0.1486	-0.1370	0.002
513	551133.484345	3343865.890995	5.055764	CHECK	0.1345	0.0598	-0.074
514	551166.594515	3344504.301792	5.495396	CHECK	0.1561	0.0334	-0.010
515	551187.588567	3344974.126968	4.809702	CHECK	0.0703	0.0641	-0.006
516	551277.457154	3345309.631546	5.026237	CHECK	0.0197	0.0216	-0.002
517	551365.465508	3345625.057424	6.433714	CHECK	0.2048	-0.0202	0.019
519	551289.396107	3346138.120702	6.643688	CHECK	0.1868	-0.1177	0.021
520	551042.628228	3346645.032418	5.439622	CHECK	0.0677	0.1050	-0.024
521	551041.791615	3339033.407222	6.272953	CHECK	0.1258	0.0735	0.014
522	551121.647098	3338505.488330	6.243426	CHECK	0.1806	-0.0033	0.011
523	551173.884527	3337915.197516	8.500639	CHECK	0.1796	-0.0437	-0.015
524	551062.175432	3337576.487563	6.656811	CHECK	0.1019	-0.0269	0.005
526	550682.622386	3336789.012104	7.696835	CHECK	0.0519	0.0952	0.011

Table 15
Field observations for 11/15/2012

PROJECT NUMBER: 30000920							
PROJECT NAME: Napoleonville Salt dome							
ROUTE: La 70							
PARISH: Assumption							
ROAD POINT DATA DATE: 11-15-12 (C4G)							
PT No.	Northing	Easting	Elevation	PT No. check	North difference (comp. - orig.)	East difference (comp. - orig.)	Elev. Difference (comp. - orig.)
500	551035.611	3339588.974	5.968	CHECK	0.1372	0.0180	-0.071
501	551047.238	3340111.998	5.797	CHECK	0.1588	-0.0230	-0.018
502	551059.059	3340650.756	5.817	CHECK	0.1312	0.0380	0.028
503	551072.038	3341191.044	5.968	CHECK	0.1094	0.0996	0.082
504	551082.385	3341713.408	5.820	CHECK	0.1614	0.0278	0.007
505	551093.173	3342204.100	5.367	CHECK	0.1212	0.0448	-0.056
506	551105.525	3342793.141	5.604	CHECK	-0.0392	0.0593	-0.049
507	551115.302	3343286.092	5.423	CHECK	0.0240	0.0861	-0.024
513	551133.429	3343865.875	5.125	CHECK	0.0787	0.0434	-0.006
514	551166.549	3344504.321	5.443	CHECK	0.1102	0.0531	-0.062
515	551187.664	3344974.081	4.826	CHECK	0.1457	0.0181	0.011
516	551277.595	3345309.641	5.059	CHECK	0.1575	0.0315	0.031
517	551365.242	3345625.153	6.424	CHECK	-0.0183	0.0749	0.009
519	551289.180	3346138.275	6.693	CHECK	-0.0297	0.0365	0.070
520	551042.500	3346644.924	5.509	CHECK	-0.0602	-0.0033	0.045
521	551041.542	3339033.283	6.201	CHECK	-0.1236	-0.0512	-0.058
522	551121.578	3338505.551	6.227	CHECK	0.1117	0.0591	-0.006
523	551173.858	3337915.234	8.533	CHECK	0.1534	-0.0076	0.018
524	551062.228	3337576.511	6.716	CHECK	0.1544	-0.0040	0.064
526	550682.675	3336788.986	7.621	CHECK	0.1044	0.0689	-0.064

Table 16
Field observations for 11/21/2012

PROJECT NUMBER: 30000920							
PROJECT NAME: Napoleonville Salt dome							
ROUTE: La 70							
PARISH: Assumption							
ROAD POINT DATA DATE: 11-21-12 (C4G)							
PT No.	Northing	Easting	Elevation	PT No. check	North difference (comp. - orig.)	East difference (comp. - orig.)	Elev. Difference (comp. - orig.)
500	551035.4366	3339589.0459	5.9613	CHECK	-0.0367	0.0902	-0.077
501	551046.9950	3340112.0730	5.7546	CHECK	-0.0839	0.0525	-0.060
502	551058.8848	3340650.7793	5.8136	CHECK	-0.0427	0.0610	0.025
503	551071.8769	3341190.9915	5.8399	CHECK	-0.0514	0.0471	-0.046
504	551082.1721	3341713.4281	5.7874	CHECK	-0.0519	0.0475	-0.026
505	551093.0284	3342204.1325	5.3182	CHECK	-0.0232	0.0776	-0.106
506	551105.5054	3342793.1372	5.6102	CHECK	-0.0589	0.0560	-0.043
507	551115.1970	3343286.0496	5.4593	CHECK	-0.0810	0.0435	0.012
513	551133.3039	3343865.8516	5.0820	CHECK	-0.0460	0.0205	-0.048
514	551166.3649	3344504.3543	5.4823	CHECK	-0.0735	0.0859	-0.023
515	551187.5033	3344974.1302	4.8425	CHECK	-0.0150	0.0673	0.027
516	551277.4211	3345309.6250	5.0394	CHECK	-0.0164	0.0151	0.011
517	551365.2490	3345625.1460	6.4173	CHECK	-0.0118	0.0683	0.003
519	551289.1336	3346138.2782	6.6732	CHECK	-0.0757	0.0397	0.051
520	551042.4937	3346644.9766	5.4921	CHECK	-0.0668	0.0492	0.029
521	551041.6210	3339033.3810	6.2106	CHECK	-0.0448	0.0473	-0.049
522	551121.4404	3338505.5113	6.2565	CHECK	-0.0261	0.0197	0.024
523	551173.6844	3337915.3189	8.5400	CHECK	-0.0205	0.0777	0.025
524	551062.0869	3337576.5565	6.6174	CHECK	0.0134	0.0420	-0.035
526	550682.5699	3336788.8415	7.5886	CHECK	-0.0006	-0.0754	-0.097

Table 17
Field observations for 11/30/2012

PROJECT NUMBER: 30000920
PROJECT NAME: Napoleonville Salt dome
ROUTE: La 70
PARISH: Assumption
COMPARISON POINT DATA DATE: 11-30-12

PT No.	Northing	Easting	Elevation	PT No. check	North difference (comp. - orig.)	East difference (comp. - orig.)	Elev. Difference (comp. - orig.)
500	551035.5121	3339588.9901	6.0728	CHECK	0.0755	0.1936	0.066
501	551047.0738	3340112.0862	5.8235	CHECK	0.0197	0.2461	0.052
502	551058.9471	3340650.7465	5.8169	CHECK	0.0328	0.1640	-0.007
503	551071.9097	3341191.0145	5.8793	CHECK	0.0361	0.1936	0.023
504	551082.2180	3341713.4248	5.8268	CHECK	0.0623	0.2067	0.049
505	551093.0776	3342204.1194	5.4396	CHECK	0.1017	0.1903	0.010
506	551105.6202	3342793.1405	5.6922	CHECK	0.0951	0.1936	0.026
507	551115.2921	3343286.0956	5.5020	CHECK	0.0689	0.2362	0.043
513	551133.3466	3343865.9008	5.1443	CHECK	0.0328	0.2526	0.016
514	551166.4764	3344504.3313	5.5249	CHECK	0.1050	0.1804	0.062
515	551187.5459	3344974.0974	4.9278	CHECK	0.0984	0.2297	0.141
516	551277.4900	3345309.6545	5.0623	CHECK	0.1575	0.1837	0.059
517	551364.8946	3345624.7457	5.9547	CHECK	-0.2887	-0.2362	-0.472
519	551289.1468	3346138.3405	6.6831	CHECK	-0.0656	0.2690	0.069
520	551042.4806	3346644.9734	5.5315	CHECK	-0.1148	0.1903	0.115
521	551041.7293	3339033.3974	6.2762	CHECK	0.0787	0.2395	0.066
522	551121.4699	3338505.5966	6.2041	CHECK	0.0164	0.2625	0.003
523	551173.8189	3337915.3156	8.4416	CHECK	0.1575	0.2198	-0.085
524	551062.1754	3337576.5597	6.6437	CHECK	0.1936	0.1542	-0.023
526	550682.5305	3336788.8645	7.6968	CHECK	-0.1115	-0.2133	0.052

Table 18
Field observations for 12/07/2012

PROJECT NUMBER: 30000920

PROJECT NAME: Napoleonville Salt dome

ROUTE: La 70

PARISH: Assumption

COMPARISON POINT DATA DATE: 12-07-12

PT No.	Northing	Easting	Elevation	PT No. check	North difference (comp. - orig.)	East difference (comp. - orig.)	Elev. Difference (comp. - orig.)
500	551035.3776	3339588.9967	5.9153	CHECK	-0.0591	0.2001	-0.092
501	551047.0475	3340112.1255	5.6988	CHECK	-0.0066	0.2854	-0.072
502	551058.8848	3340650.8351	5.5971	CHECK	-0.0295	0.2526	-0.226
503	551071.8736	3341191.0374	5.7283	CHECK	0.0000	0.2165	-0.128
504	551082.1688	3341713.4544	5.7087	CHECK	0.0131	0.2362	-0.069
505	551093.0481	3342204.1522	5.2657	CHECK	0.0722	0.2231	-0.164
506	551105.5349	3342793.1471	5.5184	CHECK	0.0098	0.2001	-0.148
507	551115.2888	3343286.0989	5.3346	CHECK	0.0656	0.2395	-0.125
513	551133.3072	3343865.9337	5.0098	CHECK	-0.0066	0.2854	-0.118
514	551166.4174	3344504.3379	5.4691	CHECK	0.0459	0.1870	0.007
515	551187.5230	3344974.1204	4.7900	CHECK	0.0755	0.2526	0.003
516	551277.4539	3345309.6840	5.0033	CHECK	0.1214	0.2133	0.000
517	551365.2293	3345625.2083	6.4009	CHECK	0.0459	0.2264	-0.026
519	551289.1599	3346138.3635	6.6240	CHECK	-0.0525	0.2920	0.010
520	551042.5331	3346645.0062	5.4888	CHECK	-0.0623	0.2231	0.072
521	551041.5652	3339033.4204	6.2500	CHECK	-0.0853	0.2625	0.039
522	551121.4371	3338505.5999	6.1220	CHECK	-0.0164	0.2658	-0.079
523	551173.6713	3337915.3288	8.3989	CHECK	0.0098	0.2329	-0.128
524	551062.0934	3337576.5696	6.4961	CHECK	0.1115	0.1640	-0.171
526	550682.5732	3336788.8415	7.5525	CHECK	-0.0689	-0.2362	-0.092

Table 19
Field observations for 12/14/2012

PROJECT NUMBER: 30000920							
PROJECT NAME: Napoleonville Salt dome							
ROUTE: La 70							
PARISH: Assumption							
COMPARISON POINT DATA DATE: 12-14-12							
PT No.	Northing	Easting	Elevation	PT No. check	North difference (comp. - orig.)	East difference (comp. - orig.)	Elev. Difference (comp. - orig.)
500	551035.531785	3339589.108210	6.049857	CHECK	0.0951	0.3117	0.043
501	551047.106565	3340112.138660	5.856287	CHECK	0.0525	0.2986	0.085
502	551058.924127	3340650.897425	5.925185	CHECK	0.0098	0.3150	0.102
503	551071.922788	3341191.099757	6.013768	CHECK	0.0492	0.2789	0.157
504	551082.195077	3341713.510129	5.921904	CHECK	0.0394	0.2920	0.144
505	551093.061198	3342204.211248	5.521643	CHECK	0.0853	0.2821	0.092
506	551105.630070	3342793.215975	5.649595	CHECK	0.1050	0.2690	-0.016
507	551115.272439	3343286.102128	5.475711	CHECK	0.0492	0.2428	0.016
513	551133.402324	3343865.923803	5.134504	CHECK	0.0886	0.2756	0.007
514	551166.407508	3344504.318196	5.505238	CHECK	0.0361	0.1673	0.043
515	551187.513108	3344974.090878	4.688311	CHECK	0.0656	0.2231	-0.098
516	551277.493243	3345309.638108	5.065607	CHECK	0.1608	0.1673	0.062
517	551365.291624	3345625.142726	6.436995	CHECK	0.1083	0.1608	0.010
519	551289.140202	3346138.347080	6.640407	CHECK	-0.0722	0.2756	0.026
520	551042.474028	3346645.025857	5.423218	CHECK	-0.1214	0.2428	0.007
521	551041.653820	3339033.472838	6.227022	CHECK	0.0033	0.3150	0.016
522	551121.437125	3338505.652372	6.286077	CHECK	-0.0164	0.3182	0.085
523	551173.740170	3337915.377962	8.526886	CHECK	0.0787	0.2822	0.000
524	551062.077007	3337576.645043	6.627283	CHECK	0.0951	0.2395	-0.039
526	550682.556769	3336788.907118	7.690273	CHECK	-0.0853	-0.1706	0.046

Table 20
Field observations for 12/21/2012

PROJECT NUMBER: 30000920							
PROJECT NAME: Napoleonville Salt dome							
ROUTE: La 70							
PARISH: Assumption							
COMPARISON POINT DATA DATE: 12-21-12							
PT No.	Northing	Easting	Elevation	PT No. check	North difference (comp. - orig.)	East difference (comp. - orig.)	Elev. Difference (comp. - orig.)
500	551035.393990	3339588.849024	6.007206	CHECK	-0.0427	0.0525	0.000
501	551047.027825	3340111.879474	5.866130	CHECK	-0.0262	0.0394	0.095
502	551058.986463	3340650.536533	5.718493	CHECK	0.0722	-0.0459	-0.105
503	551072.037617	3341190.761831	5.856287	CHECK	0.1640	-0.0591	0.000
504	551082.309907	3341713.208292	5.751301	CHECK	0.1542	-0.0098	-0.026
505	551093.120252	3342203.909411	5.403533	CHECK	0.1444	-0.0197	-0.026
506	551105.676002	3342792.933823	5.662718	CHECK	0.1509	-0.0131	-0.003
507	551115.321652	3343285.842943	5.439622	CHECK	0.0984	-0.0164	-0.020
513	551133.294057	3343865.697426	5.114819	CHECK	-0.0197	0.0492	-0.013
514	551166.420631	3344504.095099	5.551170	CHECK	0.0492	-0.0558	0.089
515	551187.417964	3344974.018700	4.858914	CHECK	-0.0295	0.1509	0.072
516	551277.427627	3345309.707005	5.078730	CHECK	0.0951	0.2362	0.075
517	551365.288343	3345624.913067	6.459961	CHECK	0.1050	-0.0689	0.033
519	551289.422353	3346138.219128	6.643688	CHECK	0.2100	0.1476	0.030
520	551042.743057	3346644.851972	5.472430	CHECK	0.1476	0.0689	0.056
521	551041.827704	3339033.223495	6.309043	CHECK	0.1772	0.0656	0.098
522	551121.548673	3338505.337412	6.207337	CHECK	0.0951	0.0033	0.007
523	551173.654868	3337915.115495	8.497358	CHECK	-0.0066	0.0197	-0.030
524	551062.024514	3337576.330083	6.650249	CHECK	0.0427	-0.0755	-0.016
526	550682.560050	3336788.874309	7.647623	CHECK	-0.0820	-0.2034	0.003

Table 21
Field observations for 01/18/2013

PROJECT NUMBER: 30000920							
PROJECT NAME: Napoleonville Salt dome							
ROUTE: La 70							
PARISH: Assumption							
COMPARISON POINT DATA DATE: 01-18-13							
PT No.	Northing	Easting	Elevation	PT No. check	North difference (comp. - orig.)	East difference (comp. - orig.)	Elev. Difference (comp. - orig.)
500	551035.587559	3339589.072121	6.056418	CHECK	0.1509	0.2756	0.049
501	551047.172182	3340112.194434	5.807075	CHECK	0.1181	0.3543	0.036
502	551059.032394	3340650.858055	5.754582	CHECK	0.1181	0.2756	-0.069
503	551072.037618	3341191.053825	5.879253	CHECK	0.1640	0.2329	0.023
504	551082.329592	3341713.513410	5.816917	CHECK	0.1739	0.2953	0.039
505	551093.162903	3342204.178439	5.446183	CHECK	0.1870	0.2493	0.016
506	551105.679282	3342793.222537	5.728335	CHECK	0.1542	0.2756	0.062
507	551115.433200	3343286.062758	5.495396	CHECK	0.2100	0.2034	0.036
513	551133.487626	3343865.933646	5.170593	CHECK	0.1739	0.2854	0.043
514	551166.505932	3344504.367408	5.534766	CHECK	0.1345	0.2165	0.072
515	551187.634499	3344974.153214	4.901565	CHECK	0.1870	0.2854	0.115
516	551277.594949	3345309.667635	5.062326	CHECK	0.2625	0.1969	0.059
517	551365.363802	3345625.205062	6.489488	CHECK	0.1804	0.2231	0.062
519	551289.274716	3346138.396293	6.643688	CHECK	0.0623	0.3248	0.030
520	551042.601981	3346645.084912	5.501958	CHECK	0.0066	0.3018	0.085
521	551041.778492	3339033.518770	6.295919	CHECK	0.1280	0.3609	0.085
522	551121.568358	3338505.665495	6.220460	CHECK	0.1148	0.3314	0.020
523	551173.809067	3337915.338592	8.585941	CHECK	0.1476	0.2428	0.059
524	551062.198398	3337576.569584	6.646968	CHECK	0.2165	0.1640	-0.020
526	550682.648632	3336789.058036	7.677150	CHECK	0.0066	-0.0197	0.033

Table 22
Field observations for 02/01/2013

PROJECT NUMBER: 30000920							
PROJECT NAME: Napoleonville Salt dome							
ROUTE: La 70							
PARISH: Assumption							
COMPARISON POINT DATA DATE: 02-01-13							
PT No.	Northing	Easting	Elevation	PT No. check	North difference (comp. - orig.)	East difference (comp. - orig.)	Elev. Difference (comp. - orig.)
500	551035.584278	3339589.078682	6.043295	CHECK	0.1476	0.2822	0.036
501	551047.185305	3340112.151783	5.797232	CHECK	0.1312	0.3117	0.026
502	551058.983182	3340650.858055	5.800513	CHECK	0.0689	0.2756	-0.023
503	551072.047460	3341191.060387	5.853007	CHECK	0.1739	0.2395	-0.003
504	551082.329592	3341713.503568	5.853007	CHECK	0.1739	0.2854	0.075
505	551093.195712	3342204.142350	5.446183	CHECK	0.2198	0.2133	0.016
506	551105.721933	3342793.199571	5.669280	CHECK	0.1969	0.2526	0.003
507	551115.400392	3343286.134937	5.475711	CHECK	0.1772	0.2756	0.016
513	551133.474503	3343865.913961	5.137785	CHECK	0.1608	0.2658	0.010
514	551166.578111	3344504.364127	5.567574	CHECK	0.2067	0.2133	0.105
515	551187.690273	3344974.130248	4.839229	CHECK	0.2428	0.2625	0.052
516	551277.611353	3345309.657792	5.032798	CHECK	0.2789	0.1870	0.030
517	551365.435981	3345625.139445	6.476365	CHECK	0.2526	0.1575	0.049
519	551289.294401	3346138.415977	6.660092	CHECK	0.0820	0.3445	0.046
520	551042.565892	3346645.038980	5.508519	CHECK	-0.0295	0.2559	0.092
521	551041.808019	3339033.489242	6.200775	CHECK	0.1575	0.3314	-0.010
522	551121.561797	3338505.652372	6.227022	CHECK	0.1083	0.3182	0.026
523	551173.828753	3337915.351715	8.553133	CHECK	0.1673	0.2559	0.026
524	551062.224645	3337576.556461	6.650249	CHECK	0.2428	0.1509	-0.016
526	550682.674879	3336789.048193	7.696835	CHECK	0.0328	-0.0295	0.052

Table 23
Field observations for 02/15/2013

PROJECT NUMBER: 30000920							
PROJECT NAME: Napoleonville Salt dome							
ROUTE: La 70							
PARISH: Assumption							
COMPARISON POINT DATA DATE: 02-15-13							
PT No.	Northing	Easting	Elevation	PT No. check	North difference (comp. - orig.)	East difference (comp. - orig.)	Elev. Difference (comp. - orig.)
500	551035.502258	3339588.957292	5.994083	CHECK	0.0656	0.1608	-0.013
501	551047.126250	3340112.086167	5.652876	CHECK	0.0722	0.2461	-0.118
502	551058.963497	3340650.720260	5.679123	CHECK	0.0492	0.1378	-0.144
503	551071.939192	3341190.965243	5.846445	CHECK	0.0656	0.1444	-0.010
504	551082.257413	3341713.385457	5.830041	CHECK	0.1017	0.1673	0.052
505	551093.120253	3342204.020959	5.436341	CHECK	0.1444	0.0919	0.007
506	551105.646474	3342793.048653	5.682403	CHECK	0.1214	0.1017	0.016
507	551115.367583	3343285.980738	5.452745	CHECK	0.1444	0.1214	-0.007
513	551133.444975	3343865.805693	5.170593	CHECK	0.1312	0.1575	0.043
514	551166.473124	3344504.259141	5.508519	CHECK	0.1017	0.1083	0.046
515	551187.601691	3344974.041666	4.829387	CHECK	0.1542	0.1739	0.043
516	551277.526052	3345309.588895	5.052483	CHECK	0.1936	0.1181	0.049
517	551365.330994	3345625.106637	6.423872	CHECK	0.1476	0.1247	-0.003
519	551289.277997	3346138.291306	6.669934	CHECK	0.0656	0.2198	0.056
520	551042.641351	3346644.956959	5.485553	CHECK	0.0459	0.1739	0.069
521	551041.735841	3339033.384256	6.210618	CHECK	0.0853	0.2264	0.000
522	551121.506023	3338505.540823	6.246707	CHECK	0.0525	0.2067	0.046
523	551173.740170	3337915.256571	8.494077	CHECK	0.0787	0.1608	-0.033
524	551062.096692	3337576.520372	6.643688	CHECK	0.1148	0.1148	-0.023
526	550682.546927	3336789.035070	7.726363	CHECK	-0.0951	-0.0426	0.082

Table 24
Field observations for 03/14/2013

PROJECT NUMBER: 30000920
PROJECT NAME: Napoleonville Salt dome
ROUTE: La 70
PARISH: Assumption
COMPARISON POINT DATA DATE: 03-14-13

PT No.	Northing	Easting	Elevation	PT No. check	North difference (comp. - orig.)	East difference (comp. - orig.)	Elev. Difference (comp. - orig.)
500	551035.4629	3339588.9639	6.0105	CHECK	0.0262	0.1673	0.0033
501	551047.0738	3340112.0206	5.7415	CHECK	0.0197	0.1804	-0.0295
502	551059.0029	3340650.7465	5.7710	CHECK	0.0886	0.1640	-0.0525
503	551072.0278	3341190.9751	5.8563	CHECK	0.1542	0.1542	0.0000
504	551082.2443	3341713.3494	5.7611	CHECK	0.0886	0.1312	-0.0164
505	551093.0907	3342204.0242	5.4003	CHECK	0.1148	0.0951	-0.0295
506	551105.6366	3342793.0683	5.6037	CHECK	0.1115	0.1214	-0.0623
507	551115.3348	3343285.9807	5.4495	CHECK	0.1115	0.1214	-0.0098
513	551133.3925	3343865.7959	5.1706	CHECK	0.0787	0.1476	0.0427
514	551166.4862	3344504.2427	5.5610	CHECK	0.1148	0.0919	0.0984
515	551187.5886	3344974.0187	4.8097	CHECK	0.1411	0.1509	0.0230
516	551277.5031	3345309.5200	5.0656	CHECK	0.1706	0.0492	0.0623
517	551365.3277	3345625.0673	6.4796	CHECK	0.1444	0.0853	0.0525
519	551289.2649	3346138.2618	6.5748	CHECK	0.0525	0.1903	-0.0394
520	551042.6315	3346644.9176	5.4396	CHECK	0.0361	0.1345	0.0230
521	551041.6833	3339033.3613	6.2467	CHECK	0.0328	0.2034	0.0361
522	551121.4896	3338505.5211	6.2565	CHECK	0.0361	0.1870	0.0558
523	551173.7238	3337915.2402	8.5203	CHECK	0.0623	0.1444	-0.0066
524	551062.0869	3337576.4974	6.6437	CHECK	0.1050	0.0919	-0.0230
526	550682.5338	3336789.0679	7.6673	CHECK	-0.1083	-0.0098	0.0230

Table 25
Field observations for 04/12/2013

PROJECT NUMBER: 30000920
PROJECT NAME: Napoleonville Salt dome
ROUTE: La 70
PARISH: Assumption
COMPARISON POINT DATA DATE: 04-12-13

PT No.	Northing	Easting	Elevation	PT No. check	North difference (comp. - orig.)	East difference (comp. - orig.)	Elev. Difference (comp. - orig.)
500	551035.5351	3339589.0098	6.2631	CHECK	0.0984	0.2133	0.2559
501	551047.0836	3340112.0501	5.8989	CHECK	0.0295	0.2100	0.1280
502	551058.9405	3340650.7006	5.9416	CHECK	0.0262	0.1181	0.1181
503	551071.9622	3341190.9357	5.9252	CHECK	0.0886	0.1148	0.0689
504	551082.2344	3341713.4019	5.9088	CHECK	0.0787	0.1837	0.1312
505	551093.0907	3342204.0800	5.5348	CHECK	0.1148	0.1509	0.1050
506	551105.6169	3342793.1044	5.8169	CHECK	0.0919	0.1575	0.1509
507	551115.3020	3343285.9939	5.5840	CHECK	0.0787	0.1345	0.1247
513	551133.3925	3343865.8155	5.2428	CHECK	0.0787	0.1673	0.1148
514	551166.4666	3344504.2296	5.6365	CHECK	0.0951	0.0787	0.1739
515	551187.5295	3344974.0154	4.9180	CHECK	0.0820	0.1476	0.1312
516	551277.4637	3345309.5561	5.1181	CHECK	0.1312	0.0853	0.1148
517	551365.3179	3345625.0410	6.4764	CHECK	0.1345	0.0591	0.0492
519	551289.2878	3346138.2749	6.6699	CHECK	0.0755	0.2034	0.0558
520	551042.6446	3346644.9438	5.4757	CHECK	0.0492	0.1608	0.0591
521	551041.7260	3339033.4236	6.4567	CHECK	0.0755	0.2657	0.2461
522	551121.4896	3338505.6064	6.3878	CHECK	0.0361	0.2723	0.1870
523	551173.7139	3337915.2894	8.6614	CHECK	0.0525	0.1936	0.1345
524	551062.0508	3337576.5761	6.8274	CHECK	0.0689	0.1706	0.1608
526	550682.4944	3336789.0679	7.8773	CHECK	-0.1476	-0.0098	0.2329

Table 26
Field observations for 05/15/2013

PROJECT NUMBER: 30000920							
PROJECT NAME: Napoleonville Salt dome							
ROUTE: La 70							
PARISH: Assumption							
COMPARISON POINT DATA DATE: 05-15-13							
PT No.	Northing	Easting	Elevation	PT No. check	North difference (comp. - orig.)	East difference (comp. - orig.)	Elev. Difference (comp. - orig.)
500	551035.4728	3339588.9573	6.0794	CHECK	0.0362	0.1607	0.0722
501	551047.0804	3340112.0008	5.8104	CHECK	0.0264	0.1607	0.0394
502	551058.8947	3340650.6809	5.8235	CHECK	-0.0196	0.0984	0.0000
503	551071.9787	3341190.9226	6.0761	CHECK	0.1051	0.1017	0.2198
504	551082.2543	3341713.3198	5.9022	CHECK	0.0985	0.1017	0.1247
505	551093.1040	3342203.9914	5.4101	CHECK	0.1281	0.0623	-0.0197
506	551105.6171	3342793.0519	5.6102	CHECK	0.0920	0.1050	-0.0558
507	551115.3283	3343285.9545	5.4101	CHECK	0.1051	0.0951	-0.0492
513	551133.3860	3343865.7269	5.1870	CHECK	0.0723	0.0787	0.0591
514	551166.5093	3344504.1968	5.5479	CHECK	0.1379	0.0459	0.0853
515	551187.5821	3344973.9760	4.8589	CHECK	0.1346	0.1082	0.0722
516	551277.4376	3345309.4904	5.0886	CHECK	0.1051	0.0197	0.0853
517	551365.3016	3345624.9918	6.5584	CHECK	0.1182	0.0098	0.1312
519	551289.2748	3346138.2618	6.7651	CHECK	0.0625	0.1903	0.1509
520	551042.6415	3346644.9241	5.4987	CHECK	0.0460	0.1410	0.0820
521	551041.6769	3339033.3350	6.3222	CHECK	0.0264	0.1771	0.1115
522	551121.4832	3338505.5211	6.3254	CHECK	0.0296	0.1870	0.1247
523	551173.7436	3337915.2467	8.5991	CHECK	0.0821	0.1509	0.0722
524	551062.0706	3337576.5007	6.6798	CHECK	0.0887	0.0951	0.0131
526	550682.5175	3336789.0449	7.7526	CHECK	-0.1246	-0.0328	0.1083

Table 27
Field observations for 06/21/2013

PROJECT NUMBER: 30000920
PROJECT NAME: Napoleonville Salt dome
ROUTE: La 70
PARISH: Assumption
COMPARISON POINT DATA DATE: 06-21-13

PT No.	Northing	Easting	Elevation	PT No. check	North difference (comp. - orig.)	East difference (comp. - orig.)	Elev. Difference (comp. - orig.)
500	551035.4499	3339589.0065	6.0597	CHECK	0.0132	0.2100	0.0525
501	551047.0312	3340112.0271	5.8071	CHECK	-0.0228	0.1870	0.0361
502	551058.8947	3340650.6841	5.7940	CHECK	-0.0196	0.1017	-0.0295
503	551071.9590	3341190.9094	5.9646	CHECK	0.0854	0.0886	0.1083
504	551082.2050	3341713.3461	5.9252	CHECK	0.0493	0.1279	0.1476
505	551093.0580	3342204.0111	5.4593	CHECK	0.0821	0.0820	0.0295
506	551105.5941	3342793.0847	5.7021	CHECK	0.0690	0.1378	0.0361
507	551115.2693	3343285.9676	5.5413	CHECK	0.0460	0.1082	0.0820
513	551133.3335	3343865.7663	5.3018	CHECK	0.0198	0.1181	0.1739
514	551166.4634	3344504.1935	5.5741	CHECK	0.0920	0.0426	0.1115
515	551187.5198	3344973.9727	4.8425	CHECK	0.0723	0.1050	0.0558
516	551277.3917	3345309.5790	5.2395	CHECK	0.0592	0.1083	0.2362
517	551365.3081	3345625.0476	6.4468	CHECK	0.1248	0.0656	0.0197
519	551289.2486	3346138.2519	6.6338	CHECK	0.0362	0.1804	0.0197
520	551042.6251	3346644.9208	5.4363	CHECK	0.0296	0.1378	0.0197
521	551041.7130	3339033.3974	6.2926	CHECK	0.0625	0.2395	0.0820
522	551121.4471	3338505.5572	6.3058	CHECK	-0.0064	0.2231	0.1050
523	551173.7829	3337915.2697	8.5991	CHECK	0.1215	0.1739	0.0722
524	551062.0345	3337576.4875	6.5748	CHECK	0.0526	0.0820	-0.0919
526	550682.5241	3336789.035	7.7132	CHECK	-0.1180	-0.0427	0.0689