United State Environmental Protection Agency

Office of Emergency Management
CBRN Consequence Management Assistance Team
Erlanger, Kentucky 41018

August 25, 2012

Aerial Chemical Survey
Bayou Corne Sinkhole Survey
Assumption Parish, La.

ASPECT CMAT Team Members

Mark J. Thomas
Tim J. Curry
John Cardarelli
Paul Kudarauskas

Dynamac Contract Support:

Jeff Stapleton

Airborne ASPECT Prime Contractor:

Sam Fritcher

ARRAE, Inc. Contract Support:

Paul Fletcher
Beorn Leger
Rich Rousseau
Mike Scarborough
Robert Kroutil

Response Summary

The United States Environmental Protection Agency (EPA), Office of Emergency Management (OEM), CBRN Consequence Management Assistance Team (CMAT) manages the Airborne Spectrophotometric Environmental Collection Technology (ASPECT) Program. The ASPECT remote sensing system provides emergency response support to chemical and radiological release incidents and generates and transmits products within minutes to decision makers in the field.

On August 23, 2012, EPA Region 6 requested the ASPECT Program conduct chemical and radiological surveys over the site of a salt dome sink hole in Bayou Corne, Assumption Parish, La. The site is located southwest of the intersection of State Highways 70 and 69. The sinkhole began forming August 3^{rd}, 2012 and continued to grow over time. The sinkhole is assumed to be the result of a collapse of a former solution mine salt cavern abandoned in 2011. In addition to the collapse of the surface there have been multiple gas boils occurring in the area of the sinkhole. There are a number of gas storage caverns and transmission lines associated within the salt dome structure. The gas releases prompted the local authorities to order an evacuation of local residents due to the threat of a potentially larger release from these facilities. Air monitoring conducted to date has not identified a significant threat from the gas seeps. The gas stored in the closest caverns was moved and transmission lines have been shut down. The gas seeps have continued. At one time in the past there was about 20 ft^3 of pipe scale including naturally occurring radioactive material (NORM) pumped down the well. This prompted the response team to conduct monitoring for elevated gamma activity but to date nothing significant has been found. All these previous monitoring attempts have all been ground based and the swampy terrain is not amenable to wide area monitoring coverage. The purpose of the ASPECT surveys is to provide the specific type of wide area coverage that would take extensive time and costs with the available ground based resources.

Chemical

The chemical survey, consisting of six data collection passes, was conducted between approximately 13:30 and 16:00 local time on August 25, 2012. The area covered in the survey includes a large amount of the ground and swamp overlying the salt dome structure (Figures 1, 10 and 11). No chemical detections were observed in the survey area when reviewed both by the onboard screening library and by manual examination of the collected spectra.

Radiological

The radiological survey consisted of 17 data collection lines covering the same region as examined with the chemical survey. Flight lines used for the survey are given in Figure 6. Data was processed to provide both total gamma count and excess uranium analysis. Results indicated that total gamma count showed slightly elevated but normal levels along state highway 70 and in farmland on the eastern portion of the survey area. Levels over and around the sinkhole were normal. The excess uranium sigma analysis showed isolated elevated values in the farmland on the eastern area of the survey. These elevated sigma values are most likely due to fertilizer usage. All sigma values over and around the sinkhole were normal.

Photography

About 130 aerial and 50 oblique photographs were taken over the area during the chemical screening survey. These were processed for geospatial referencing and are available for viewing through the Google Earth display application using the link provided under separate transmittal or through ESRI by downloading the imagery through the Secure FTP site (access available upon request).

1.0 Introduction

The EPA initiated the Airborne Spectral Photometric Environmental Collection Technology (ASPECT) Program shortly after 9/11. Its primary focus was the detection of chemicals using an infrared line scanner coupled with a Fourier transform infrared spectrometer mounted within an Aero Commander 680 twin-engine aircraft. High-resolution digital photography, video and GPS technology combined with navigation data produces a picture of the contaminated area or cloud dispersion that can be wirelessly transmitted to the EPA On-Scene Coordinator (OSC) or decision makers. Since 2001, ASPECT has assisted the environmental and emergency response communities in over 110 incidents ranging from ammonia releases, Special Event Assessment Rating (SEAR) and National Significant Security Events (NSSE) pre-deployments, to the recent BP Oil Spill and Las Conchas NM wildfires. A three-member crew, two pilots and one technician operate the aircraft. A scientific support staff provides additional assessment and product development commensurate with the site specific needs.

The ASPECT Gamma Emergency Mapper (GEM) project began in March 2008 to improve the airborne gamma-screening and mapping capability of ground contamination following a radiological dispersal device or improvised nuclear device attack. The agency purchased state-of-the-art detection technology, described in Section 4, and actively collaborates with the Department of Energy, National Nuclear Security Administration to ensure that the survey products are scientifically valid and technically defensible.

On August 23, 2012, EPA Region 6 requested the ASPECT Program conduct a chemical, and radiologic screening survey over the Bayou Corne Sinkhole site in Assumption Parrish, La. Infrared images, infrared spectrometer data sets, aerial photos and oblique photos were taken over the site during the survey and later processed for chemical signature evaluation and for standard computer monitor display.

The purpose of the chemical survey was to assess the scene for chemical vapor emissions from the gas boils present to assess their potential threat to the responders and nearby populations. While the primary chemical of concern within the salt dome structure is expected to be natural gas, a low toxicity compound, it presents threats of flammability and if sufficiently concentrated as an asphyxiant by atmospheric displacement. Straight chain hydrocarbons typically have a weak infrared signature but at the concentrations of concern would be detectable by the system. The data sets will be screened for the standard compounds in the data processing library but none are known to be used or stored in the area near the site.

The purpose of the radiological survey was to monitor for any ground-based gamma radiation. At one point the well was used as storage for pipe scaling that contained naturally occurring radioactive material (NORM). As the sinkhole expands, there was a concern for potential radiation exposure in the area. The survey will provide the responders working in the area information on the exposure rates and total counts of any gamma radiation at the surface.

2.0 Survey Area Description and Threat

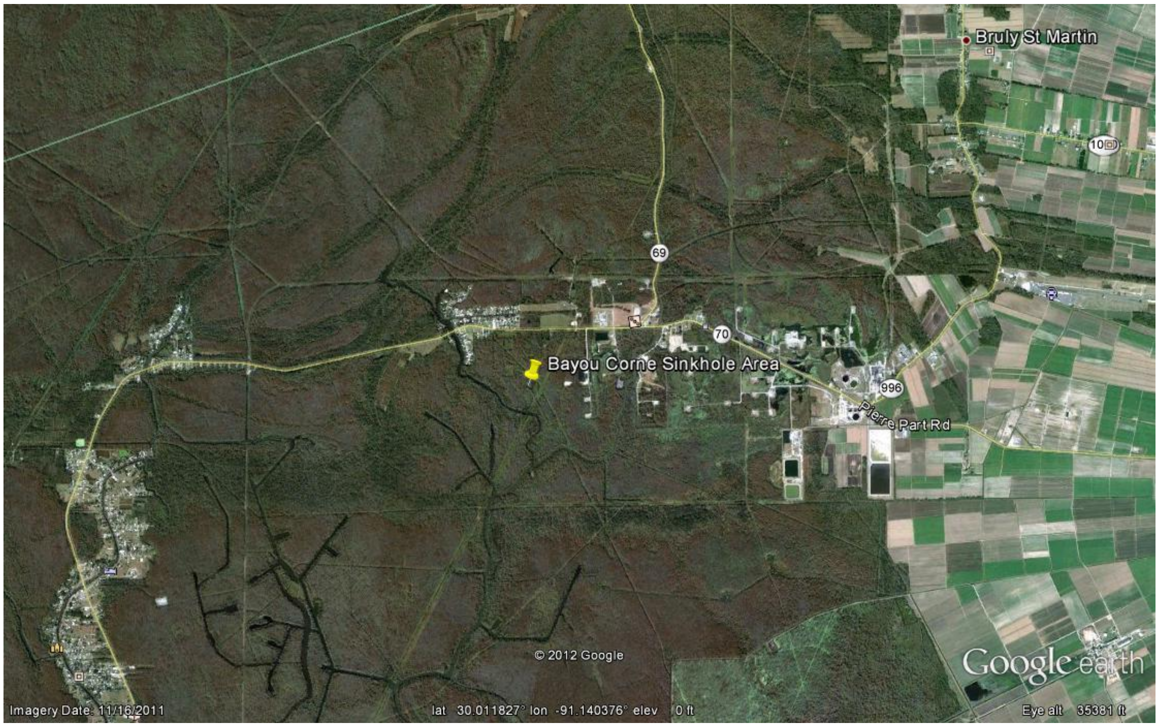


Figure 1: Target area for the Bayou Corne Sinkhole survey

2.1 Site Background

The Bayou Corne sinkhole collapse occurred in the area of a former solution mined salt cavern (Figure 1). Salt caverns are frequently used to store materials such as natural gas. There are a number of salt caverns and gas storage facilities within the subsurface salt dome. The sinkhole is suspected to have formed from the collapse of an abandoned salt cavern. There have been numerous gas boils that are suspected to be associated with the collapse and the State and local authorities have established an incident command structure to manage the response efforts. A website including response updates has been established and situational updates can be found at the following link: http://www.assumptionla.com/bayoucorne

2.2 Chemical Threat

The primary potential for harm from vapors in the target area comes from the flammability of the hydrocarbon gases being transmitted and stored in the salt dome. The toxicity of these types of gases is low, but in sufficient concentration they can displace the atmosphere in a localized area. The volume of gas being released is unknown but the responders have directed the nearest stored gas caverns to transfer contents away from the sinkhole area or move to market. All transmission lines in the immediate area of the sinkhole are reported to be shut down. Gas boils are still ongoing at this time.

3.0 Survey Instrumentation and Flight Parameters

Figure 2: ASPECT Aircraft

The ASPECT aircraft is a twin engine, high wing AeroCommander 680FL capable of cruising speeds ranging from about 100 knots (115 mph) to 200 knots (230 mph) (figure 2). It is based in Waxahachie, Texas and operated by two pilots and one technician. A suite of chemical, radiological, and photographic detection technology is mounted within the airframe making it the only aircraft in the nation with remote chemical and radiological detection capabilities.

3.1 Radiation Detectors

The radiological detection technology consisted of two Radiation Solutions Inc. (RSI) RSX-4 Units (Figure 3). Each unit was equipped with four 2”x4”x16” thallium-activated sodium iodide (NaI[Tl]) scintillation crystals for a total of 8 NaI[Tl] (16.8 L) crystals.

Detector packs for airborne spectroscopy typically consist of clusters of NaI[Tl] crystals because they are relatively inexpensive compared to other scintillation crystals. In addition, NaI crystals have high sensitivity with acceptable spectral resolution (approximately seven percent full width at half maximum (FWHM)[*] at 662 keV), and are easy to maintain.

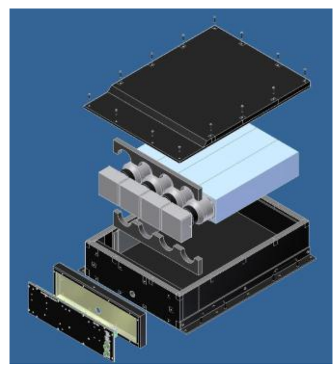


Figure 3: RSX-4 unit showing four detector locations. The ASPECT was equipped with 6 NaI[Tl] and 2 $LaBr_3$:Ce scintillating detectors

The RSI RSX-4 unit was specifically designed for airborne detection and measurement of low-level gamma radiation from both naturally occurring and man-made sources. It uses advanced digital signal processing and software techniques to produce spectral data equivalent to laboratory quality. The unit is a fully integrated system that includes an individual high resolution (1,024 channels) advanced digital spectrometer for each detector. A high level of self diagnostics and performance verification routines such as auto gain stabilization are implemented with an automatic error notification capability, assuring that the resulting maps and products are of high quality and accuracy.

The ASPECT Program calibrates it radiological instrumentation according to the International Atomic Energy Agency specifications.

---

[*] The full width of the peak at half the maximum amplitude (FHWM), expressed as a percentage of the photopeak energy, is used as the measure of resolution.

3.2 Chemical Sensors

Figure 4: View of chemical sensors: high speed infrared spectrometer, lower left corner; infrared line scanner is out of view behind the line scanner

The chemical sensors installed in the aircraft detect the difference in infrared spectral absorption or emission of a chemical vapor. The first sensor is a model RS-800, multi-spectral IR-Line Scanner (Raytheon TI Systems, McKinney, TX) (Figure 4). It is a multi-spectral high spatial resolution infrared imager that provides two-dimensional images. Data analysis methods allow the operator to process the images containing various spectral wavelengths into images that indicate the presence of a particular chemical species.
The second sensor is a modified model MR254/AB (ABB, Quebec, Quebec City, Canada). It is a high throughput Fourier Transform Infrared Spectrometer (FT-IR) that collects higher spectral resolution of the infrared signature from a specific plume location. The instrument is capable of collecting spectral signatures with a resolution selectable between 0.5 to 32 wave-numbers.

The principle of measurement involves the detection, identification, and quantification of a chemical vapor species using passive infrared spectroscopy. Most vapor compounds have unique absorption spectral bands at specific frequencies in the infrared spectral region. Careful monitoring of the change in total infrared radiance levels leads to concentration estimations for a particular vapor species.

The Infrared (IR) sensors used on the ASPECT system are sensitive in two broad IR regions consisting of the mid-wave region which extends from 3 micrometers (microns) to 5 microns and the long-wave region which extends from 7.5 microns to 14 microns. The 3-5 micron band is typically used to detect straight chain hydrocarbons which are elevated in temperature. The long-wave band is often called the IR atmospheric window due to low interference from water vapor and carbon dioxide over most of the band. Compounds having strong IR signatures in this region include the alkenes, ozone, and the alcohols. The aromatic compounds such as benzene and ethyl benzene have very strong absorption signatures at the edges of the long wave region but can often be masked by water vapor and carbon dioxide interference.

3.3 Camera

The ASPECT aircraft uses a high resolution digital camera to collect visible aerial images. The camera consists of a Nikon D2X SLR camera body with a fixed focus (infinity) 24mm F1.2 Nikor lens. The camera sensor has 12.5 million pixels (12.2 Mpixels viewable) giving a pixel count of 4288 x 2848 in a 3:2 image ratio. An effective ground coverage area of 885 x 590 meters is obtained when operated from the standard altitude of 850 meters.

Image ortho-rectification, which corrects for optical distortion and geometric distortion due to the three dimensional differences in the image, is accomplished using an inertial navigation unit (pitch, roll, and heading) coupled with a dedicated 5 Hz global positioning system (GPS). Aircraft altitude above ground is computed using the difference between the indicated GPS altitude and a 30 meter digital elevation model (DEM). Full ortho-rectification is computed using a camera model (lens and focal plane geometric model) and pixel specific elevation geometry derived from the digital elevation model to minimize edge and elevation distortion. Documented geo-location accuracy is better than 49 meters.

3.4 Flight Parameters

The ASPECT aircraft used the following flight procedures for data collection on August 25th, 2012:

Altitude above the ground (AGL):	300 feet for radiological survey 2,800 feet for chemical 2,800 feet for wide area photography
Target Speed:	100 knots (115 mph)
Line Spacing:	600 feet for radiological survey 1,500 feet for chemical and photographic survey
Data collection frequency:	1 samples per second (1 Hz) for the radiological survey 70 samples per second (70 Hz) for the chemical survey

Flight planning lines for the chemical and radiological surveys are illustrated in Figures 5 and 6, respectively.

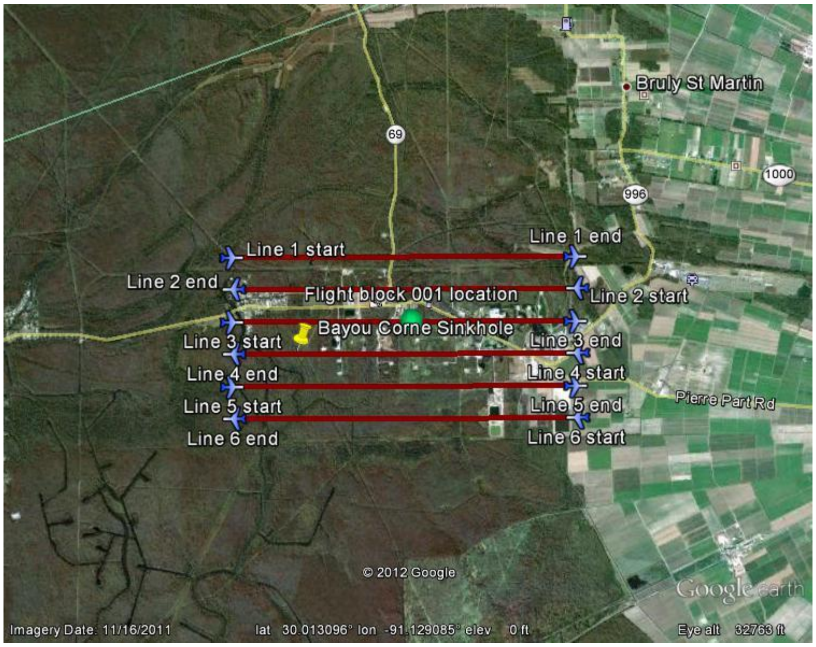


Figure 5: Flight planning lines for the chemical survey over Bayou Corne Sinkhole site

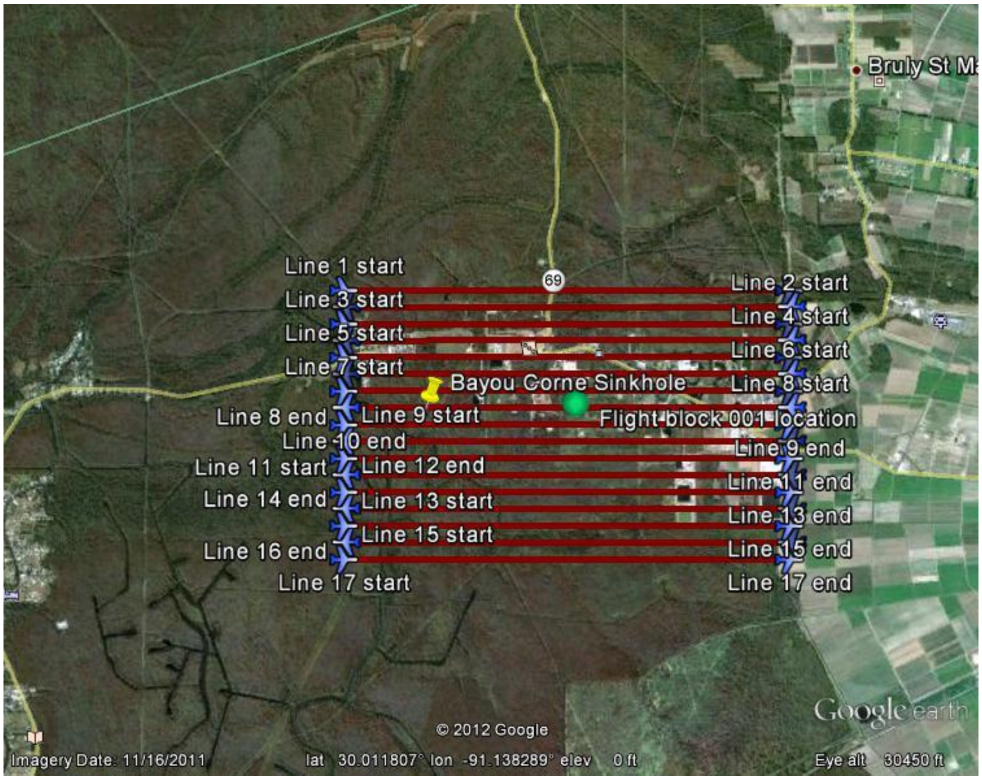


Figure 6: Flight planning lines for the radiation survey lines for the Bayou Corne Sinkhole site

4.0 Data Analysis Procedures

A unique feature of the ASPECT chemical and radiological technologies includes the ability to process spectral data automatically in the aircraft with a full reach back link to the program QA/QC program. As data is generated in the aircraft using the pattern recognition software, a support data package is extracted by the reach back team through the satellite communications and independently reviewed as a confirmation to data generated on the aircraft. For this incident response the urgency of the data needs falls between an emergency and a planned survey.

4.1 Chemical Data

Spectral data processing (signal processing) from the ASPECT MR-254AB spectrometer is processed using background suppression, pattern recognition algorithms. Processing spectral data from a moving airborne platform requires unique methods to balance weak signal detection sensitivity, false alarm minimization, and processing speed. The background suppression, pattern recognition methods associated with the ASPECT Program have been documented in over 100 open literature publications.

One of the principle weaknesses of airborne Fourier transform spectral (FTS) data is the ability to reference each collected spectra to a suitable background for subsequent spectra subtraction. While methods have been devised to accomplish this procedure, typical airborne spectra show changes between successive scan of several orders of magnitude due to changing radiometric scene conditions. These scan-to-scan changes render traditional background subtraction methods unusable for weak signal detection. The background suppression method used by ASPECT circumvents this problem by using a digital filtering process to remove the background component from the raw interferometry data. This approach is analogous to using the tuning section of a radio receiver to preselect the portion of the signal for subsequent processing. The resulting filtered intermediate data maintains the weak signal components necessary for subsequent analysis.

An additional weakness of traditional FTS processing involves the need to provide a resolution high enough to permit compounds exhibiting narrow spectra features to be matched with published library spectra. This method is initiated using the Fast Fourier Transform (FFT). While the FFT algorithm is very robust, mathematically certain data collection requirements must be met to permit the transform to be valid. In order to provide high spectral resolution spectra, the length of the interferogram must be matched to the desired resolution for the transform to work properly. This requirement forces a long collection period for each interferogram and since the aircraft is moving, it is probable that the radiometric scene being viewed by the spectrometer will change during the collection of the interferogram. The changing scene causes the FFT to generate spectral artifacts in the resulting spectral information. These artifacts are phantom signals that confuse and complicate subsequent compound identification.

The standard matched filter compound discrimination method likewise exhibits weak signal performance and often generating false alarms due to common atmospheric interference. ASPECT solves these problems by using a combination of digital band pass filtering followed by a multi-dimensional pattern recognition algorithm. The digital filters and pattern recognition coefficients are developed using a combination of laboratory, field, and library data and folded into a training set that is run against unknown data. Digital filters can be readily constructed which take into account both spectrometer line shapes and adjacent interferents greatly improving the weak signal system gain. The pattern recognition algorithm processes the filter output in a multi-space fashion and enhances the selectivity of the detection. These methods are very similar to a superheterodyne receiver that uses band pass adjustable intermediate filters followed by a DSP detector/discriminator such as in a modern radar system. Since the methods use relatively simple computational operations, signal processing can be accomplished in a few seconds. Finally, as data is processed, the position of the detection is referenced to onboard GPS data providing a GIS ready data output. Table 1 provides a list of compounds that are currently installed in the airborne library using the digital filtering/pattern recognition method.

4.2 Radiological Data Processing

All radiological data is processed automatically using airborne algorithms. Normally, a specifically designed survey flight path is flow by the aircraft and once complete, a spectrum of radiological products is generated from the collected data. Since radiological sources are universally present from the earth and from cosmic sources, all radiological data must be corrected to establish a baseline measurement. Cosmic estimates are established by flying the aircraft 3000 feet AGL while collecting gamma spectral data. At altitudes of 3000 feet and greater all radiological inputs are either from the cosmic sources or the aircraft (which is a constant). Quantified cosmic contributions are stripped out (subtracted) from all subsequent data. Depending on the length of the radiological survey, cosmic backgrounds may be collected at the beginning and end of the survey. In a fashion similar to the cosmic correction, the natural radiological background for the survey area is also established. This process normally calls for collecting a limited amount of data (a test line) at the survey altitude (300 – 500 Ft AGL) in an area of similar geology/land use but outside of the region of survey interest. By subtracting the test line data from the survey data, a corrected radiation map for the survey area is generated.

Several data products are generated automatically by the system including total counts, a sigma map, and an exposure map. The total count product is generated by mapping the corrected total gamma count data (approximately 30 – 3000 KeV) from the spectrometers using the integrated GPS data as the geographic datum. Maps are normally contoured at regular intervals in micro-Roentgens (µR).

A second radiological product includes an array of isotope specific sigma plots or maps. These plots are useful to help highlight specific data points that may warrant further ground investigation. This procedure consist of a two-step method with the first being a windowing for selected isotope energies followed by a statistical treatment of the data. Isotope specific data is generated by windowing the gamma spectrum at energy levels corresponding to the isotopes of interest. As part of this analysis, higher energy contributions from uranium and thorium are removed using a stripping coefficient. A statistical average and standard deviation is next computed for the entire survey area using the isotope windowed data. Since the standard deviation provides a measure of the variance of the data set, data values showing several standard deviations (sigma) indicate that these values are statistically different from the majority of the population. ASPECT uses a graded scale in which 0 to 4 sigma are considered normal and greater than 4 sigma highlights data very different from the population. Greater than 6 sigma indicates that the data is extremely different and warrants additional investigation. By using different isotope windows, a number of sigma maps can be generated for a given survey

Table 1: 72 Chemicals built into the ASPECT automated detection algorithms			
Acetic Acid	1,1-Dichloroethene	Methyl Acetate	Nitrogen Mustard
Acetone	Dichloromethane	Methyl Ethyl Ketone	Phosgene
Acrolein	Dichlorodifluoromethane	Methanol	Phosphine
Acrylonitrile	Difluoroethane	Methylbromide	Tetrachloroethylene
Acrylic Acid	Difluoromethane	Methylene Chloride	1,1,1-Trichloroethane
Allyl Alcohol	Ethanol	Methyl Methacrylate	Trichloroethylene
Ammonia	Ethyl Acetate	MTEB	Trichloromethane
Arsine	Ethyl Formate	Napthalene	Triethylamine
Bis-Chloroethyl Ether	Ethylene	n-Butyl Acetate	Triethylphosphate
Boron Tribromide	Formic Acid	n-Butyl Alcohol	Trimethylamine
Boron Trifluoride	Freon 134a	Nitric Acid	Trimethyl Phosphite
1,3-Butadiene	GA (Tabun)	Nitrogen Trifluoride	Vinyl Acetate
1-Butene	GB (Sarin)	Phosphorus Oxychloride	
2-Butene	Germane	Propyl Acetate	
Carbon Tetrachloride	Hexafluoroacetone	Propylene	
Carbonyl Chloride	Isobutylene	Propylene Oxide	
Carbon Tetrafluoride	Isoprene	Silicon Tetrafluouride	
Chlorodifluoromethane	Isopropanol	Sulfur Dioxide	
Cumene	Isopropyl Acetate	Sulfur Hexafluoride	
Diborane	MAPP	Sulfur Mustard	

5.0 Results

ASPECT collected chemical, radiological and photographic information over the site on August 25, 2012 at approximately 14:00 to 16:00 local time. Chemical detection deliverables included scanning reports for the screening library (Table 1), and sixteen infrared images (Image 10). About 170 high resolution digital photographs were taken over the entire survey area (130 aerial and 50 obliques). These photographs and images have been geo- and/or ortho-rectified for geospatial applications and are available to view within Google Earth or downloaded via the secure FTP site.

Access to the electronic data can be provided by contacting:

Greg Fife,
OSC Region 6
fife.greg@epa.gov

5.1 Chemical Survey Data Collection Summary

Six data collection passes were conducted for chemical screening surveys on August 25th. A summary of the collection lines and associated data set is contained in Table 2. The approximate area covered in both surveys was about three square miles, focused over the sink hole and a significant portion of the area overlying the salt dome. All data was screened while in flight using the 72 automated pattern recognition filters for chemical compounds from the library listed in Table 1. In addition the data was manually analyzed using various spectral analysis tools. Sample locations processed using the in-flight method are shown in Figure 7. Over 100,000 interferograms were collected and none of the spectra collected showed signatures for chemical vapors. A representative output from the in-flight screening library is given in Table 3. Cumulative screening results for the entire survey are provided in Table 4.

Table 2: Infrared Collection – 25 August 2012

Run (Log Run #)	Time (GMT)	Altitude (MSL Ft)	Heading (Deg)	L/S File (2012_08_25 …)	FTIR File	Comments
1	1824	---	---	---	---	System Test All OK
2A	1840	2800	090	18_40_13_R02	H25J1218.40A H25J1218.40B	16 cm Resolution
2B	1841	2800	090	18_41_06_R03	H25J1218.41A H25J1218.41B	14 Photos (2A and 2B), 16 cm resolution
3A	1843	2800	270	18_43_456_R04	H25J1218.43A H25J1218.43B	16 cm Resolution
3B	1844	2800	270	18_44_23_R05	H25J1218.44A H25J1218.44B	16 cm resolution
3C	1845	2800	270	---	H25J1218.45A H25J1218.45B	15 Photos (3A-3C), 16 cm resolution
4A	1847	2800	090	18_47_03_R06	H25J1218.47A H25J1218.47B	16 cm resolution
4B	1848	2800	090	18_47_39_R07	H25J1218.48A H25J1218.48B	12 Photos (4A and 4B), 16 cm resolution
5A	1850	2800	270	18_50_29_R08	H25J1218.50A H25J1218.50B	16 cm resolution
5B	1851	2800	270	18_50_57_R09	H25J1218.51A H25J1218.51B	16 cm resolution
5C	1852	2800	270	18_51_30_R10	H25J1218.52A H25J1218.52B	11 Photos (5A-5B), 16 cm resolution
6A	1853	2800	090	18_53_43_R11	H25J1218.53A H25J1218.53B	16 cm resolution
6B	1854	2800	090	18_54_19_R12	H25J1218.54A H25J1218.54B	16 cm resolution
6C	1855	2800	090	18_54_43_R13	H25J1218.55A H25J1218.55B	12 Photos (6A-6C), 16 cm resolution
7A	1857	2800	270	18_57_05_R14	H25J1218.57A H25J1218.57B	16 cm resolution
7B	1858	2800	270	18_57_44_R15	H25J1218.58A H25J1218.58B	11 Photos (7A-7B), 16 cm resolution
8A	1900	2800	090	19_00_24_R16	F25J1219.00A F25J1219.00B	4 cm resolution

8B	1901	2800	090	19_01_11_R17	---	12 Photos (8A-8B), 4 cm resolution
9	1904	2800	270	---	F25J1219.04A F25J1219.04B	12 Photos, 4 cm resolution
10	1907	2800	090	---	F25J1219.07A F25J1219.07B	13 Photos, 4 cm resolution
11	1911	2800	270	---	F25J1219.11A F25J1219.11B	11 Photos, 4 cm resolution
12	1914	2800	090	---	F25J1219.14A F25J1219.14B	12 Photos, 4 cm resolution
13	1918	2800	270	---	F25J1219.18A F25J1219.18B	11 Photos, 4 cm resolution
14	1924	2800	090	---	Run1_A017 Run1_B017	1 cm resolution
15	1929	2800	270	---	Run3_A017 Run3_B017	1 cm resolution
16	1932	2800	090	---	Run5_A018 Run5_B018	1 cm resolution

Figure 7: FTIR sample locations scanned using in-flight data processing

Table 3: Screening Output for File H25J1218.40A

Interferogram File: C:\ASPECT\1 Mission\Flight Data\FTIR\H25J1218.40A
GPS File: Active GPL File
Total Number of Interferograms Processed : 3000

Filter	Hits	
vinyl_acetate	0	
trimethylamine	0	
triethylamine	0	
triethyl_phosphite	0	
trichloromethane	0	
tetrachloroethylene	0	
TEP	0	
TCE	0	
sulfuryl_fluoride	0	
sulfur_mustard	0	
sulfur_hexafluoride	0	
SO2	0	
silicon_tetrafluoride	0	
propylene_oxide	0	
propylene	0	
propylacetate	0	
phosphorous_oxychloride	0	
phosphine	0	
phosgene	0	
nitrogen_trifluoride	0	
nitrogen_mustard_(HN3)	0	
nitric_acid	0	
nbutyl_acetate	0	
napthalene	0	
n-butyl_alcohol	0	
MTBE	0	
methylmethacrylate	0	
methylene_chloride	0	
methylbromide	0	
methylacrylate	0	
methylacetate	0	
methanol	0	
MEK	0	
MAPP	0	
isopropylacetate	0	
isopropanol	0	
isoprene	0	
isobutylene	0	
hexafluoroacetone	0	
germane	0	
GB_(Sarin)	0	
GA_(Tabun)	0	
freon134	0	
formic_acid	0	
ethylformate	0	
ethylene	0	
ethylacrylate	0	
ethylacetate	0	
ethanol	0	
difluoromethane	0	
difluoroethane	0	
dichloromethane	0	
dichlorodifluoromethane	0	
diborane	0	
cumene	0	
chloromethane	0	
chlorodifluoromethate	0	
CF4	0	
carbonyl_fluoride	0	
carbon_tetrachloride	0	
butadiene	0	
boron_trifluoride	0	
boron_tribromide	0	
bis-chloroethylether	0	
arsine	0	
ammonia	0	
allyl_alcohol	0	
acrylonitrile	0	
acrylic_acid	0	
acrolein	0	
acetone	0	
acetic_acid	0	
2-butene	0	
1-butene	0	
1,1-dichloroethene	0	
1,1,1-trichloroethane	0	
Outliers	0	
Background	3000	C:\ASPECT\1 Mission\Current Mission\Processed FTIR\H25J1218_40A%bkg.shp

Table 4: FTIR data set and detection notations

Run	Compounds	
	Automated Detection	Manual Detection
1 (System Test)	---	---
2A	ND	ND
2B	ND	ND
3A	ND	ND
3B	ND	ND
3C	ND	ND
4A	ND	ND
4B	ND	ND
5A	ND	ND
5B	ND	ND
5C	ND	ND
6A	ND	ND
6B	ND	ND
6C	ND	ND
7A	ND	ND
7B	ND	ND
8A	ND	ND
8B	ND	ND
9	ND	ND
10	ND	ND
11	ND	ND
12	ND	ND
13	ND	ND
14	ND	ND
15	ND	ND
16	ND	ND

5.2 Radiological Survey Collection Summary

A total of 17 radiological survey lines were flown and analyzed for both total gamma count and excess uranium. A summary of the collection lines are given in Table 5. The processing method for generating the total gamma count is given in section 4.2. Figure 8 shows the total count plot for the sinkhole and surrounding area.

Table 5: Radiological Collection – 25 August 2012

Run (Log Run #)	Survey Line #	Time (GMT)	Altitude (MSL Ft)	Heading (Deg)	Comments
17		1935	3000	---	System Test All OK
18	Cosmic (L1)	1937	3000	090	
19	Test Line (L1)	1943	300	090	
20	L1	1945	300	270	
21	L2	1949	300	090	
22	L3	1952	300	270	
23	L4	1955	300	090	
24	L5	1958	300	270	
25	L6	2001	300	090	
26	L7	2004	300	270	
27	L8	2007	300	090	
28	L9	2010	300	270	
29	L10	2013	300	090	
30	L11	2016	300	270	
31	L12	2018	300	090	Line Moved due to Tower
32	L13	2021	300	270	Rain on West End
33	L14	2024	300	090	Rain on West End
34	L15	2027	300	270	Rain on West End
35	L16	2030	300	090	Rain on West End
36	L17	2032	300	270	Rain on West End

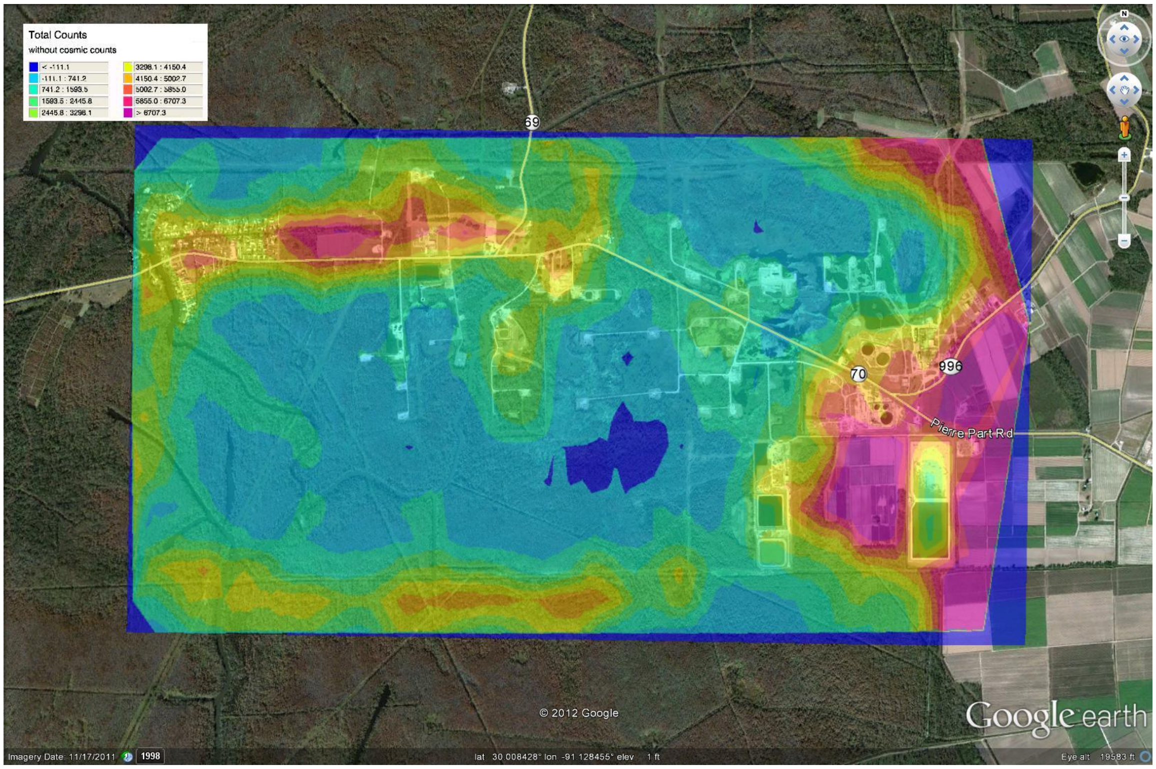


Figure 8: Total Gamma Count Corne Bayou

Examination of total gamma count plot shows that the total gamma count environment is slightly higher over the developed area along state highway 70 and near the intersection of highway 70 and 69. The count levels contained in the survey area are within normal ranges. The colors of the plot are used to show the contrast between data contours and *do not* represent health based levels. No elevated readings were detected in the area near the sinkhole.

An analysis for excess uranium is given in Figure 9. This sigma plot provides an analysis tool that helps to highlight excess uranium from that of the normally occurring proportion seen typical crustal rock. Since uranium decays to a number of daughter isotopes, this method uses bismuth 214 as an indicator since as a uranium daughter isotope and is easily detected using NaI detectors. Excess uranium was also selected for analysis since reports indicate that NORM waste consisting of pipe scale may have been disposed of in the salt domes caverns. Pipe scale often has elevated levels of radium. An analysis of the plot shows that the majority of data points are within 4 sigma units from the mean of the survey. Isolated points on the eastern portion of the survey area do show elevated deviations greater than 4 sigma. The most likely cause for these elevated points is fertilizer usage in the associated farm fields. All points analyzed over the sink area are within the mean of the survey.

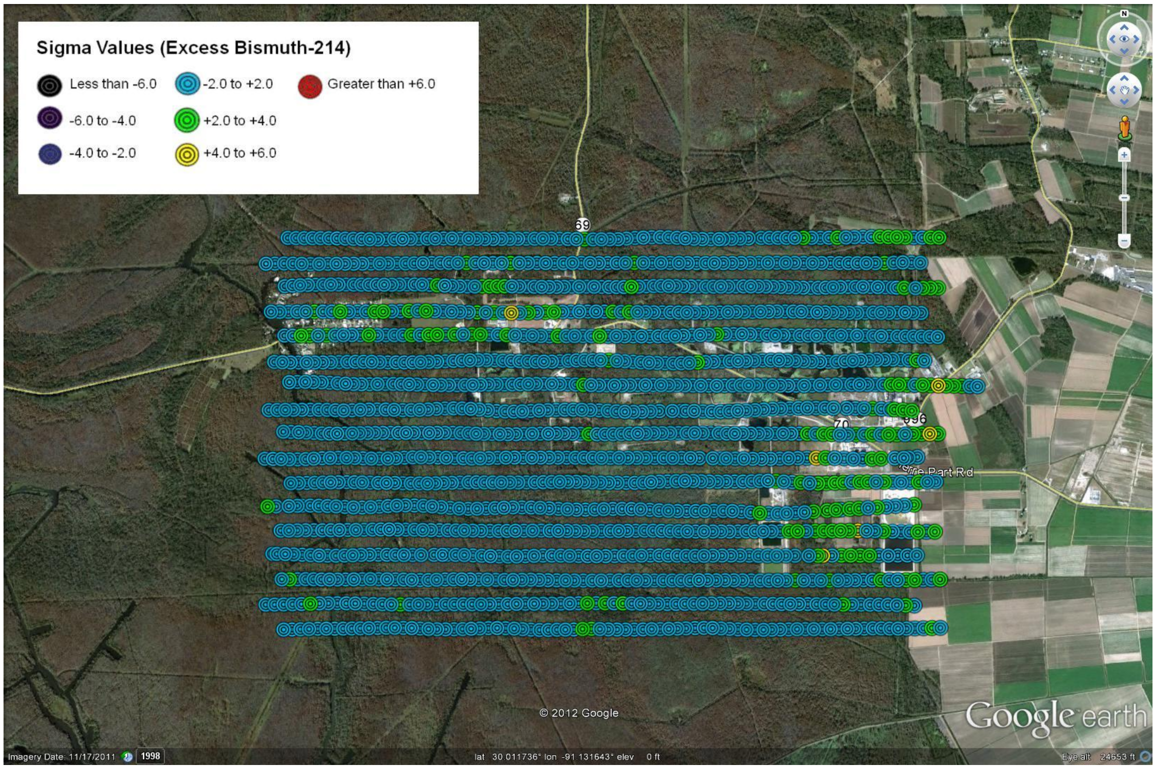


Figure 9: Excess Uranium Sigma Analysis, Corne Bayou

5.3 Infrared Imagery

Sixteen infrared images were taken over the survey areas. Figure 10 shows a representative infrared image over the sinkhole. This image does not show any chemical vapor signatures but does show the heat signature in the sinkhole area to be significantly different from other open water. This is likely due to the reported diesel fuel floating at the surface. Petroleum products in a thin layer on water will absorb more solar energy increasing overall temperature quicker than a deeper water column. These images are geo-rectified and processed for display and incorporation into Google Earth software application. Additional processing techniques can be utilized to highlight thermal differences.

Figure 10: Example of an Infrared Image Bayou Corne Survey August 2012

5.4 Digital Photography

There were several aerial photos and oblique photos collected during this mission. An example of a Georectified digital aerial image is given in Figures 11. An oblique image is given in Figure 12. These have not been geo-located for incorporation into Google Earth but will be when the deliverables are finalized. Oblique photographs were taken out the right side of the plane at an angle consistent with the direction of the white arrows shown in the Google Earth display tool. Aerial photos are collected concurrent with the chemical data collection to provide a reference for the data reviewers.

Figure 11: Digital Aerial Photo

Figure 12: Digital Aerial Photo

6.0 Conclusions

ASPECT was dispatched to conduct a chemical, radiological and photographic survey over and surrounding the Corne Bayou sinkhole and arrived on scene at 1350 on August 25, 2012. A total of 16 FTIR data collection passes were conducted over the area with none showing detectable concentrations of natural gas (methane) or other compounds contained in the ASPECT library.

A 17 line radiological survey was likewise conducted over the same region and was analyzed for both total gamma count and excess uranium due to possible NORM disposal in the salt dome caverns. Results of the total count analysis showed slightly elevated levels on the north and east side of the survey area but well within normal sedimentary rock levels. An excess uranium analysis showed isolated elevated sigma values on the eastern portion of the survey due most likely to fertilizer usage. Total count and excess levels over and near the sinkhole were within in normal levels.

16 infrared images were collected over the survey area and did not show any chemical signatures or plumes being emitted from the sinkhole. It was noted that the infrared character of the water surface over the sinkhole is different than the surrounding water in the swamp suggesting that a petroleum film is present on top of the water in the sinkhole.

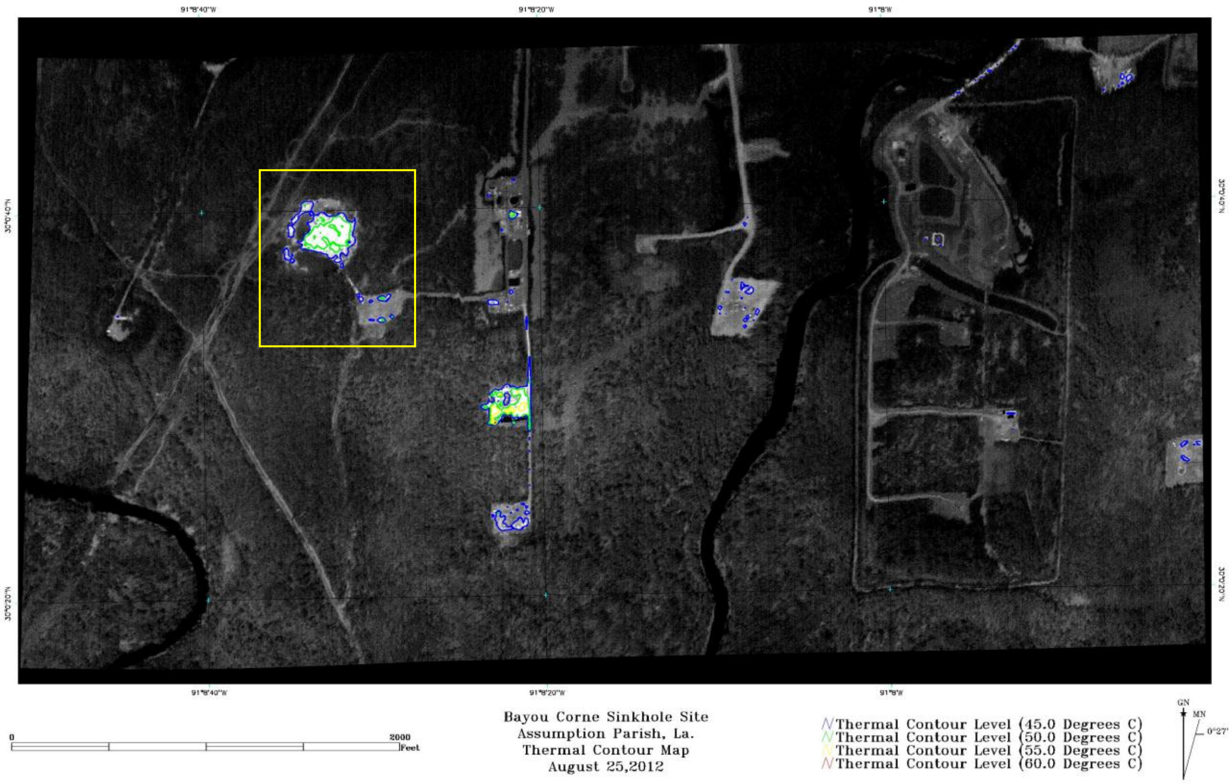
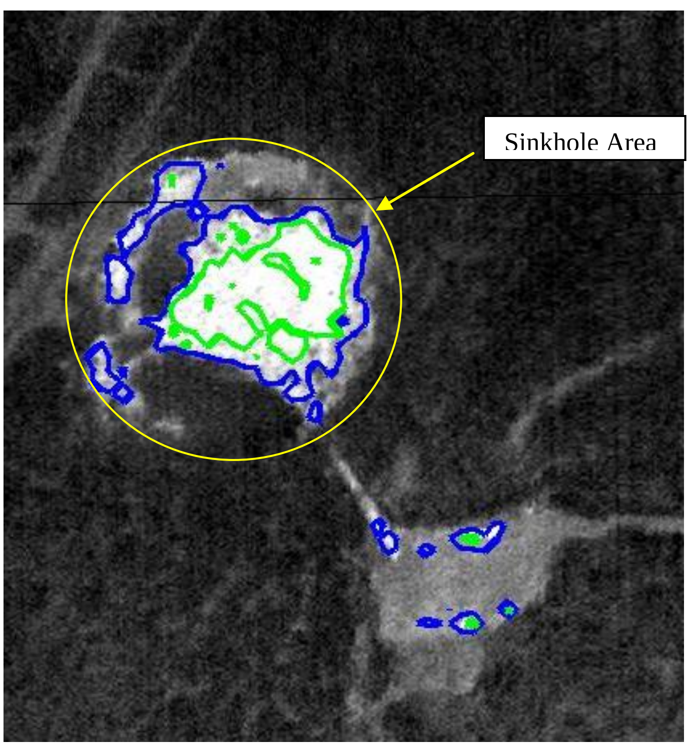


Figure 13. Thermal Contour Map of Infrared Image including the sinkhole area. The outlined portion is included as a zoomed image below.



These thermal contouring levels were selected to begin at temperatures that are above the ambient levels found within the field of view, increasing in five degree increments to the maximum of 60°C. The thermal contrast is greatest where the surface materials are significantly different. The highest contour level (60°C) consists of a very small percentage of the scene and appears to be associated directly to some type of operating mechanical equipment. Those levels over 55°C are still a low percentage and occur where some activity at an operating facility is contributing thermal energy to the nearby surrounding materials. The contour levels over 45°C (blue and green) are consistent with surface materials that differ significantly from naturally occurring materials, such as manmade equipment, structures or construction materials. The sinkhole area has a thermal profile that indicates either man made materials, such as a petroleum product at the surface, or some externally heated naturally occurring material, such as upwelling deep subsurface brine. The booms present in the sink hole area appear to be performing their intended role of separating materials at the surface. Upwelling hot brine would quickly transfer heat to all fluids in the sinkhole regardless of their separation by surface booms.