Field Report for Airborne Data Collected In Support of US EPA Region 6 South 4 Group Fire 1 December 2019

Background

On 27 November 2019 an explosion and subsequent fire was reported at the South 4 Group facility located near Port Neches, TX. Local information indicated that at approximately 0100 (central) a large explosion rocked the area. The explosion subsequently caused a massive fire at the facility in a short amount of time. Local officials ordered an initial evacuation of 0.5 miles on 27 November 2019 which was extended to 4 miles around 1430 (central). The evacuation order was lifted at 1000 (central) on 29 November 2019. Reported onsite products include various olefins, butadiene, and isobutylene. The geographical coordinates of the facility are 29.9222N, 95.0547W (figure 1).

The US EPA Region 6 requested that the ASPECT system be deployed to provide monitoring support beginning on 27 November 2019. This report summarizes findings observed during the two missions flown on 1 December 2019.

Figure 1: South 4 Group Facility, Port Neches, TX

ASPECT response to this Mission/Incident was in support of:
US EPA Region 6. OSC: Adam Adams

On 27 November 2019 ASPECT was dispatched to collect aerial remote sensing data over the South 4 Group facility located near Port Neches, TX and conducted three data collection missions. An explosion and fire involving a production unit and subsequent tank farms resulted in a black plume moving toward the south. Reports from the air crew indicated that significant lofting was occurring with smoke reaching 4000 feet above ground. Collected spectral data from both the IRLS and FTIR did not show any chemical detections. Data analysis from the second and third mission showed consistency to that of the first with the presence of a large thermal signature with the absence of detected compounds.

Due to poor weather and very low ceilings, ASPECT was only able to collect a few oblique images on 28 November 2019 and did not fly at all due to poor weather on 29 November 2019. On 30 November 2019 ASPECT collected aerial remote sensing data over the South 4 Group facility located near Port Neches, TX. Analysis of FTIR data did not show any chemical detections. IR image analysis showed the presence of elevated temperatures within the reactor complex, but the magnitude was substantially reduced from prior missions. Visible imagery showed only a light grey plume being generated at the facility with no active fires immediately visible. Damage to the facility and nearby spherical tanks was clearly evident in the aerial and obliques images.

Region 6 requested that ASPECT conduct a morning and afternoon set of data collections downwind and up the wind axis over the facility and also along a drainage channel leading to the Neches River. This report details results and information from those missions.

ASPECT System

The US EPA ASPECT system collects airborne infrared (IR) images and chemical screening data from a safe distance over the site (about 3,000 ft AGL). The system consists of an airborne high-speed Fourier transform infrared spectrometer (FTIR) coupled with a wide-area IR line scanner (IRLS). The ASPECT IR systems can detect compounds in both the 8 to 12-micron (800 to 1200 cm-1) and 3 to 5 micron (2000 to 3200 cm-1) regions. The 8 to 12-micron region is typically known as the atmospheric window region since the band is reasonably void of water and carbon dioxide influence. Spectrally, this region is used to detect carbon - non-carbon bonded compounds. The 3 to 5-micron region is also free of water and carbon dioxide but typically does not have enough energy for use. This band does show use in high-energy environments such as fires. The carbon - hydrogen stretch is very common in this region.

A digital Nikon DX2 camera (12.4 mega pixel CMOS 3:5 aspect ratio, 28 mm wide-angle lens) collects visible aerial imagery as part of the core data product package. The camera timing system is connected to the primary IR sensors and provides concurrent image collection when other sensors are triggered. All imagery is geo-rectified using both aircraft attitude correction (pitch, yaw, and roll) and GPS positional information. Imagery

can be processed while in flight or approximately 600 frames per hour can be processed once the data are downloaded from the aircraft.

An Imperx mapping camera (29 mega pixels; mapping focal plane array) provides a similar aspect ratio and aerial coverage. Like the Nikon DX2, it is connected to the primary IR sensors and provides concurrent image collection when other sensors are triggered. These images are often digitally processed in lower resolution, so they can be transmitted via satellite communication. The high-resolution images (>20 MB each) are pulled from the ASPECT after the sortie and are available later.

All high resolution digital aerial photographic images collected by the ASPECT system are ortho-rectified and geospatially validated by the reach back team. In general, this consists of conducting geo-registration using a Digital Elevation Model (DEM) which promotes superior pixel computation and lessens topographic distortion. The image is then check by a team member (using a Google Earth base map) for proper location and rotation

Data is processed using automated algorithms onboard the aircraft with preliminary results being sent using a satellite system to the ASPECT reach back team for QA/QC analysis. Upon landing preliminary data results are examined and validated by the reach back team.

Flight Results for Flight 8, 1 December 2019

Weather Conditions and Crew Report

Weather for the morning mission are given in table 1.

Table 1. South 4 Group Mission Weather

Parameter	Surface (0900)	Surface (1000)	Surface (1100)
Wind direction	245 degrees	235 degrees	245 degrees
Wind speed	5.8 m/s (13 mph)	5.8 m/s (13 mph)	6.2 m/s (14 mph)
Temperature	16.7°C	18.3°C	18.9°C
Humidity	36%	33%	28%
Dew Point	1.7°C	1.7°C	0°C
Pressure	1019 mb	1019	1019
Ceiling	Clear	Clear	Clear

During the morning flight, the crew reported that winds at altitude (2800 ft) were at about 30 kts (15.5 m/s) from the northwest. There was no visible plume leaving the site. At the beginning of the flight, there was one fire cannon which was increased to 4 cannons at the end.

Flight Status

The order to launch flight 6 was given at 0845 central on 01 December 2019 with the aircraft reporting wheels up at 0906. The initial data collection run over the site was at 0926(central). The aircraft made a total of 7 data collection passes; flight information is summarized in Appendix Flight #8 and Figure 2.

Data Results

General Data Quality Objective

The following general data quality objectives are employed in conducting emergency response data collection with ASPECT:

1. To support overall situational analysis of the incident including aerial photography and IR imagery
2. To screen the incident for the presence of selected chemicals
3. To estimate the location and concentration of plumes being generated by the incident.

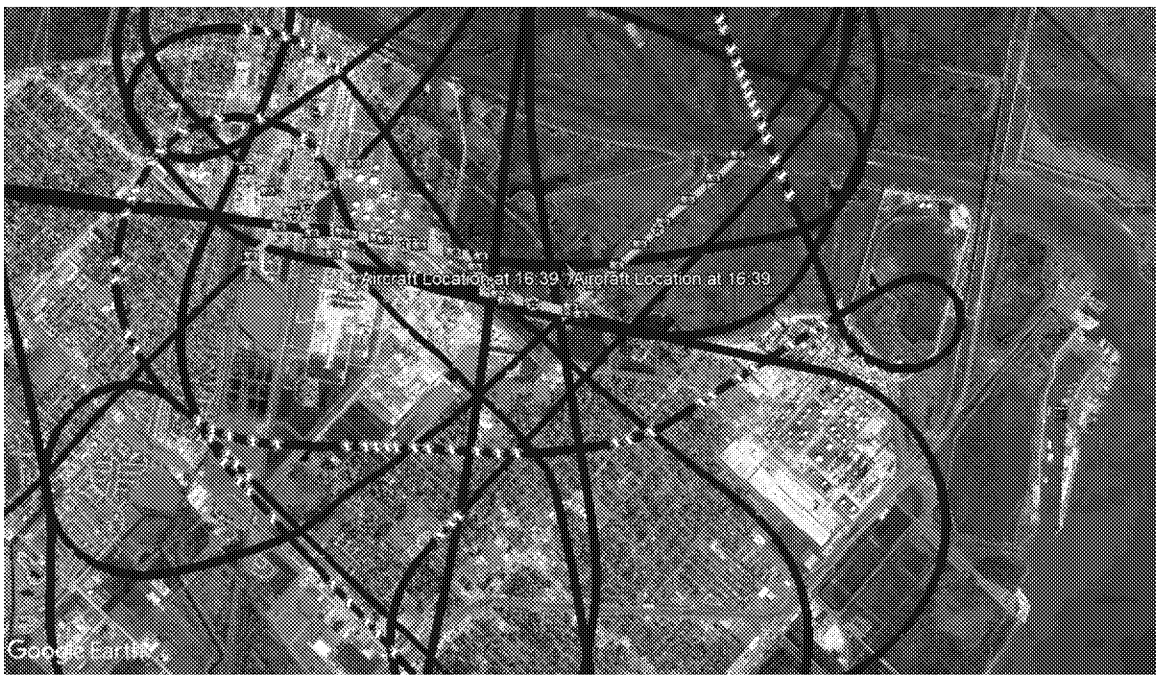

Figure 2: Data collection passes, Flight 8, South 4 Group Fire, Port Neches, TX. The blue lines represent the ASPECT flight path, green lines represent when the FTIR was actively collecting data, the yellow icons with star is the centroid of the line scanner image, and the camera icons represent when a photo was taken.

Line Scanner Data Results

A total of 2 test and 7 data collection passes were made in the proximity of the fire and an infrared line scanner image was generated for each pass. Figure 3 shows a typical 3-band infrared image obtained from data collected for Run 4. The image was obtained by flying directly into the wind to provide the best possible image quality. In a similar fashion as to flight 7, the overall thermal content of the image is low with only isolated higher than background (white) locations. Figure 4 shows a close-up thermal analysis of the production facility.

Figure 4 shows a close-up of the facility. The white content of the image shows the hottest targets which corresponds to reactors, piping, and tanks within the production unit. Close examination of the image does show the presence of water streams directed into the unit. There does not appear to be any plumes leaving the site.

To check for possible oil migration from the site, ASPECT was flown along a waterway leading from the east side of the facility to the Naches River. Figure 5 show an IR image of the waterway flowing into the River. No sheen can be seen in the image.

FTIR Data Results

FTIR Spectral data at a resolution of 16 wavenumbers was collected for each pass. ASPECT uses an automated detection algorithm to permit compounds to be analyzed while the aircraft is in flight. 72 compounds are included in this algorithm and the list is given in Table 2. In addition, collected data are also manually analyzed by comparing any detected spectral signatures to a collection of published library spectra.

A low level detection of isobutylene was made downwind of the facility along the waterway east of the facility near the Orchard Ave bridge. The location of the detection is given in figure 6. Figure 7 shows a spectrum of the detection with the characteristic isobutylene peak at 890 wave number. The detection was very weak with an estimated concentration of 1 ppm. A summary of data of the data collection is given in table 3.

Aerial Photography Results

A full set of high resolution aerial digital photography were collected as part of the flight. Figure 8 shows a representative image collected as part of each pass. As reported by the crew, light grey smoke continues to be evolved from the site which is shown moving toward the southeast. The confirms finding from IR thermal analysis that elevated temperature regions continue to generate emissions. Light grey smoke can be seen leaving the site. The oblique image in Figure 9 shows the presence of at least two small fires and the continued presence of water cannon.

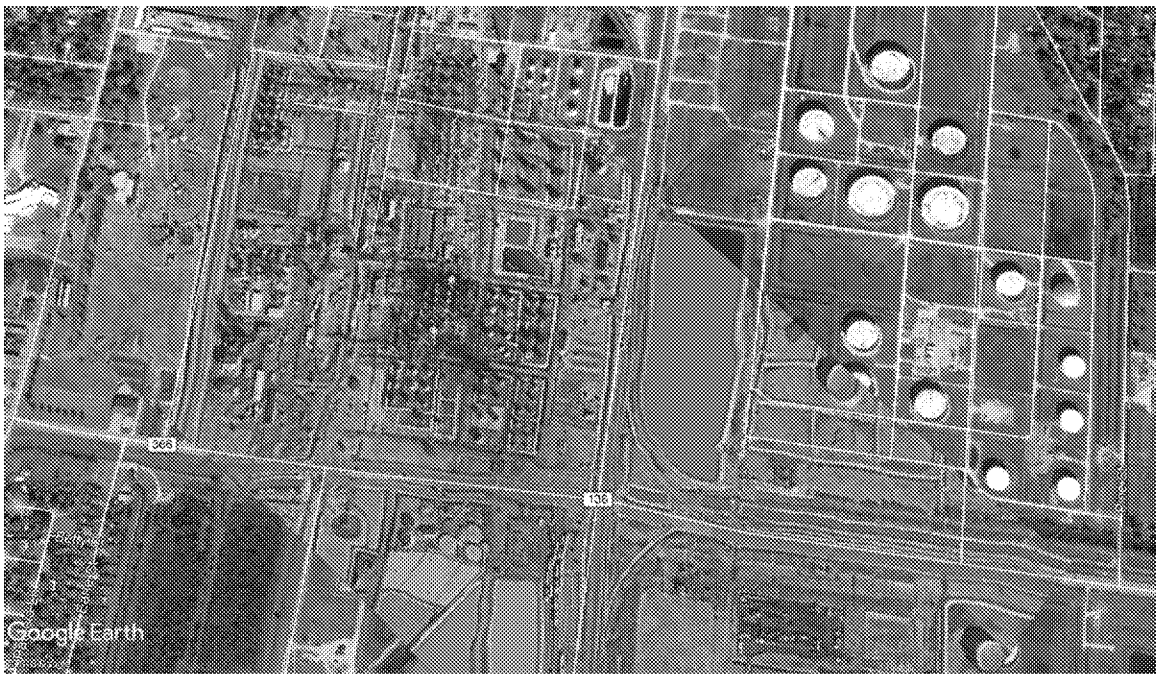

Figure 3: – 3 band IR image, Run 8, South 4 Group Fire

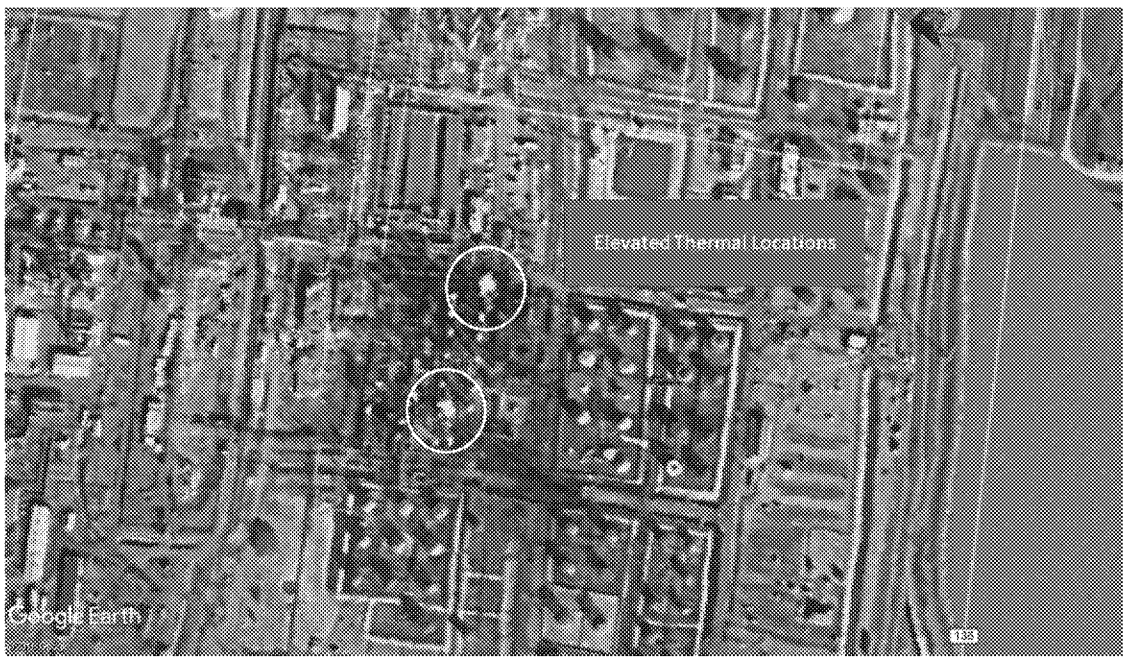

Figure 4: -- 3 band IR Image, Run 8, South 4 Group Thermal Image

Figure 5: -- 3 band IR Image, Flight 8, Run 8, Waterway Image, South 4 Group Fire

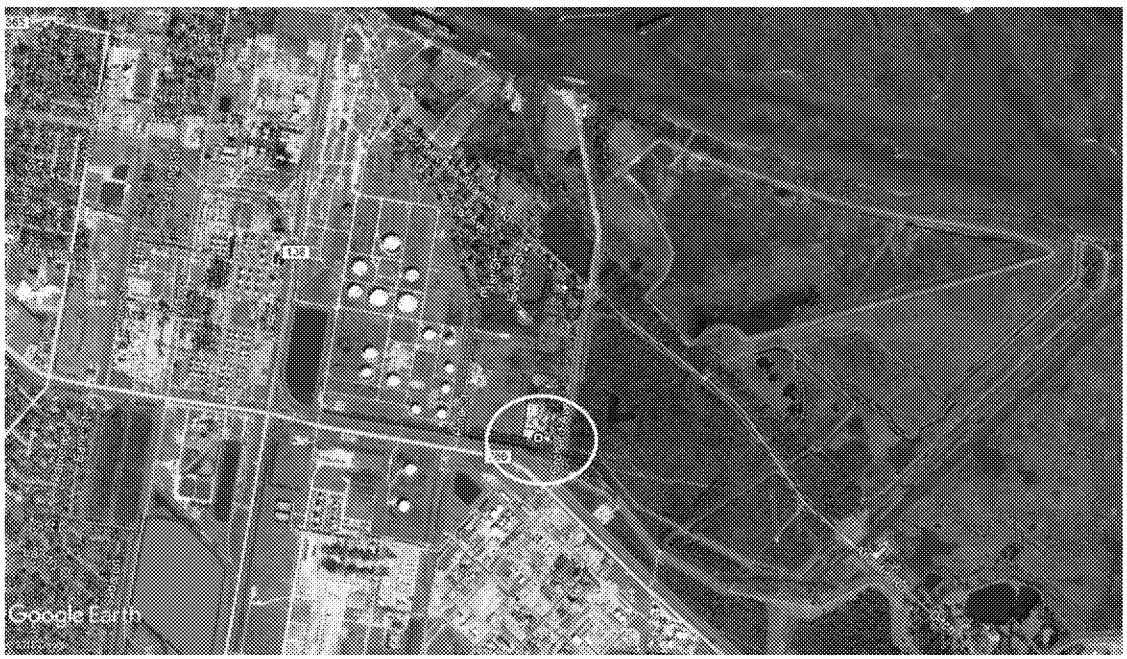

Figure 6: -- Isobutylene Detection, Flight 8, Pass 4, South 4 Group Fire

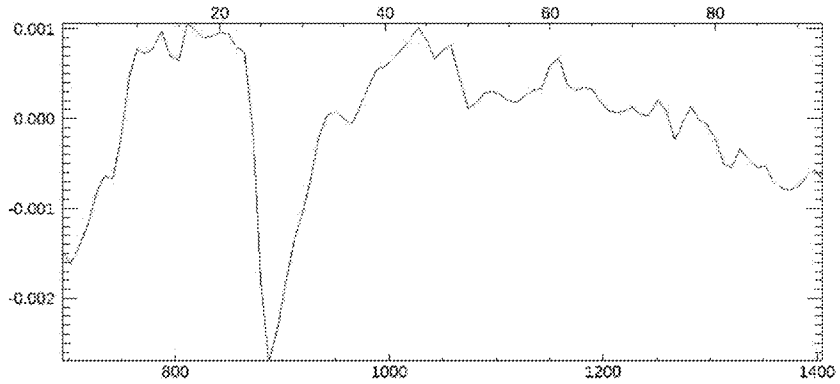

Figure 7: -- Isobutylene Spectrum, Flight 8, Pass 4, South 4 Group Fire

TABLE 2 - Chemicals Included in the ASPECT Auto-Processing Library

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

Table 3. Chemical Results Summary

Run	Date	Time (UTC)	Chemical	Max Concentration ppm
1	1 Dec 2019	0920	Test	Test
2		0922	Test	Test
3		0933	ND	None
4		0941	Isobutylene	1 ppm
5		0946	ND	None
6		0952	ND	None
7		1001	ND	None
8		1009	ND	None
9		1038	ND	None
Note: ND = No Detections				

Conclusions – Flight 8

Analysis of IR imagery collected during the morning flight on 1 December 2019 indicated that isolated elevated thermal locations still exist within the production unit. Visible imagery confirmed that crew reports of light gray smoke was being emitted from the facility and was moving in an easterly direction. FTIR data collected in the vicinity of the facility showed one detection of isobutylene near the Orchard Ave bridge. The estimated concentration was about 1 ppm. Finally, analysis IR imagery of the junction of the waterway east of the facility which intersects with the Naches River showed no evidence of oil sheen.

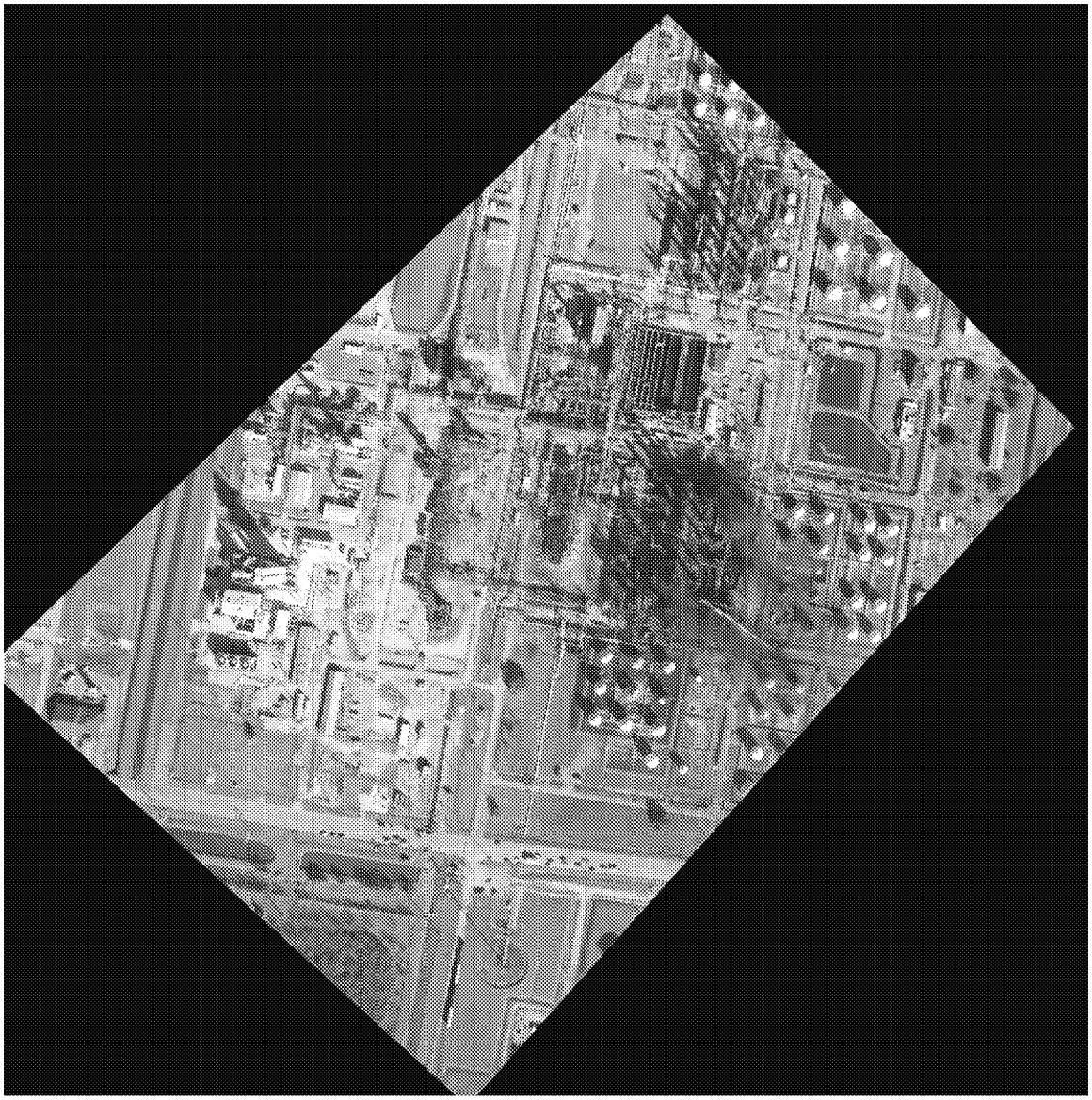

Figure 8: Aerial Image of the South 4 Group Fire, Flight 8, Run 4.

Figure 9: Oblique Image of the South 4 Group Fire

Appendix Flight #8

Abbreviations:

DEM – Digital elevation model
Alt – Altitude (in feet)
MSL – Mean sea level altitude (in feet)
Digital – Digital photography file from the Nikon D2X camera
MSIC – Digital photography file from the Imperx mapping camera
FTIR – Spectral IR data collected with a Fourier Transform Infrared Spectrometer
IRLS – Infrared Line Scanner
Jpg – JPEG image format
UTC – Universal Time Coordinated
img – Spectral data format based on Grams format

Mission: 2019-12-01 South 4 Group - Flight 8

Date: 12/1/2019

Time UTC: 15:13

Aircraft Number: N9738B

Pilot: Todd Seale

Copilot: James Glaviano

Operator: James Crisp

Aft Operator: Gerry Broyles

Ground Controller: Ahmed Hafez

DEM: Using elevation from DEM Database

Run: 1 Time: 15:20:03 UTC

Alt: 2777 ft MSL Elev: 0 ft Elevation from DEM Database

Vel: 135 knots Heading: 276

Digitals: None

MSIC: 3

20191201152009309.jpg

20191201152015659.jpg

20191201152022008.jpg

FTIR: 1

20191201_152010_A.igm

IRLS: 1

2019_12_01_15_20_08_R_01 TA=13.0;TB=32.9;Gain=3

Gamma Runs: None

Run: 2 Time: 15:22:34 UTC

Alt: 2757 ft MSL Elev: 6 ft Elevation from DEM Database

Vel: 134 knots Heading: 283

Digitals: None

MSIC: 3

20191201152240029.jpg

20191201152246378.jpg

20191201152252728.jpg

FTIR: 1

20191201_152236_A.igm

IRLS: 1

2019_12_01_15_22_38_R_02 TA=7.2;TB=25.3;Gain=3

Gamma Runs: None

Run: 3 Time: 15:33:44 UTC

Alt: 2760 ft MSL Elev: 7 ft Elevation from DEM Database

Vel: 105 knots Heading: 31

Digitals: None

MSIC: 5

20191201153350085.jpg

20191201153357355.jpg

20191201153403705.jpg

20191201153410054.jpg

20191201153416419.jpg

FTIR: 1

20191201_153348_A.igm

IRLS: 1

2019_12_01_15_33_49_R_03 TA=6.3;TB=26.3;Gain=3

Gamma Runs: None

Run: 4 Time: 15:41:06 UTC

Alt: 2829 ft MSL Elev: 8 ft Elevation from DEM Database

Vel: 97 knots Heading: 314

Digitals: None

MSIC: 6

20191201154112255.jpg

20191201154119509.jpg

20191201154125875.jpg

20191201154132224.jpg

20191201154138589.jpg

20191201154144938.jpg

FTIR: 1

20191201_154110_A.igm

IRLS: 1

2019_12_01_15_41_11_R_04 TA=9.7;TB=29.7;Gain=3

Gamma Runs: None

Run: 5 Time: 15:46:40 UTC

Alt: 2668 ft MSL Elev: 9 ft Elevation from DEM Database

Vel: 112 knots Heading: 88

Digitals: None

MSIC: 5

20191201154646374.jpg

20191201154652724.jpg

20191201154659089.jpg

20191201154706343.jpg

20191201154711803.jpg

FTIR: 1

20191201_154644_A.igm

IRLS: 1

2019_12_01_15_46_45_R_05 TA=10.8;TB=30.9;Gain=3

Gamma Runs: None

Run: 6 Time: 15:52:25 UTC

Alt: 2603 ft MSL Elev: 8 ft Elevation from DEM Database

Vel: 127 knots Heading: 126

Digitals: None

MSIC: 2

20191201155231396.jpg

20191201155238650.jpg

FTIR: 1

20191201_155229_A.igm

IRLS: 1

2019_12_01_15_52_30_R_06 TA=11.1;TB=31.1;Gain=3

Gamma Runs: None

Run: 7 Time: 16:01:53 UTC

Alt: 2813 ft MSL Elev: 4 ft Elevation from DEM Database

Vel: 111 knots Heading: 92

Digitals: None

MSIC: 4

20191201160159750.jpg

20191201160206115.jpg

20191201160213369.jpg

20191201160215194.jpg

FTIR: 1

20191201_160156_A.igm

IRLS: 1

2019_12_01_16_01_58_R_07 TA=10.5;TB=30.5;Gain=3

Gamma Runs: None

Run: 8 Time: 16:09:11 UTC

Alt: 2846 ft MSL Elev: 1 ft Elevation from DEM Database

Vel: 103 knots Heading: 32

Digitals: None

MSIC: 8

20191201160917375.jpg

20191201160923740.jpg

20191201160930089.jpg

20191201160936438.jpg

20191201160942803.jpg

20191201160949153.jpg

20191201160955518.jpg

20191201161001867.jpg

FTIR: 2

20191201_160915_A.igm

20191201_160954_A.igm

IRLS: 1

2019_12_01_16_09_16_R_08 TA=9.6;TB=29.6;Gain=3

Gamma Runs: None

Run: 9 Time: 16:38:33 UTC

Alt: 2861 ft MSL Elev: 9 ft Elevation from DEM Database

Vel: 111 knots Heading: 84

Digitals: None

MSIC: 4

20191201163839659.jpg

20191201163846008.jpg

20191201163852373.jpg

20191201163858722.jpg

FTIR: 1

20191201_163837_A.igm

IRLS: 1

2019_12_01_16_38_38_R_09 TA=10.8;TB=30.8;Gain=3

Gamma Runs: None

Mission Complete: 16:51 (UTC)

Flight Results for Flight 9, 1 December 2019

Weather Conditions and Crew Report

Weather for the mission is given in table 4.

Table 4. South 4 Group Mission Weather

Parameter	Surface (1500)	Surface (1600)
Wind direction	350 degrees	320 degrees
Wind speed	6.7 m/s (15 mph)	6.2 m/s (14 mph)
Temperature	20°C	18.8°C
Humidity	26%	28%
Dew Point	0°C	0°C
Pressure	1017 mb	1017
Ceiling	Clear	Clear

The crew reported that winds at altitude (2500 ft) were at about 17 kts (8.7 m/s) from the 300 degrees. Light gray smoke was observed from the site.

Flight Status

The aircraft was airborne at 1455 (central) was over the site at 1532 (central). A total of 1 test and 8 data collection passes were completed. Flight information is summarized in Appendix Flight #9 and Figure 10.

Data Results

General Data Quality Objective

The following general data quality objectives are employed in conducting emergency response data collection with ASPECT:

1. To support overall situational analysis of the incident including aerial photography and IR imagery
2. To screen the incident for the presence of selected chemicals
3. To estimate the location and concentration of plumes being generated by the incident.

Figure 10: Data collection passes, South 4 Group Fire, Port Neches, TX. The blue lines represent the ASPECT flight path, green lines represent when the FTIR was actively collecting data, the yellow icons with star is the centroid of the line scanner image, and the camera icons represent when a photo was taken.

Line Scanner Data Results

A total of 1 test and 9 data collection passes were made in the proximity of the fire and an infrared line scanner image was generated for each pass. Figure 11 shows a typical 3-band infrared image obtained from data collected for Run 9. This image is distorted due a turbulence but continues to show a lowered thermal environment in the process unit. Close examination shows that four water cannons are being used to cool the unit. No chemical plume can be observed being emitted from the facility. The intersection of the facility waterway and the Naches River is shown in figure 12. The pattern in the river is typical of silt entry into the water as are the dark areas on each bank that correspond to sediment/sand bars. No oil sheen was observed in the water on this flight.

FTIR Data Results

FTIR Spectral data at a resolution of 16 wavenumbers was collected for each pass. ASPECT uses an automated detection algorithm to permit compounds to be analyzed while the aircraft is in flight. 72 compounds are included in this algorithm and the list is given in Table 5. In addition, collected data are also manually analyzed by comparing any detected spectral signatures to a collection of published library spectra.

Signatures corresponding to isobutylene were detected almost due south of the facility. Figure 13 shows the locations of the detections near a wastewater treatment plant with detections made on two separate passes. Processed FTIR data indicated that these detections showed a maximum concentration of 1.7 ppm. An example of representative spectra is given in figure 14 showing the characteristic peak at 890 wave number. A summary of data of the data collection is given in table 6.

Figure 11: – 3 band IR image, Flight 9, Run 4, South 4 Group Fire

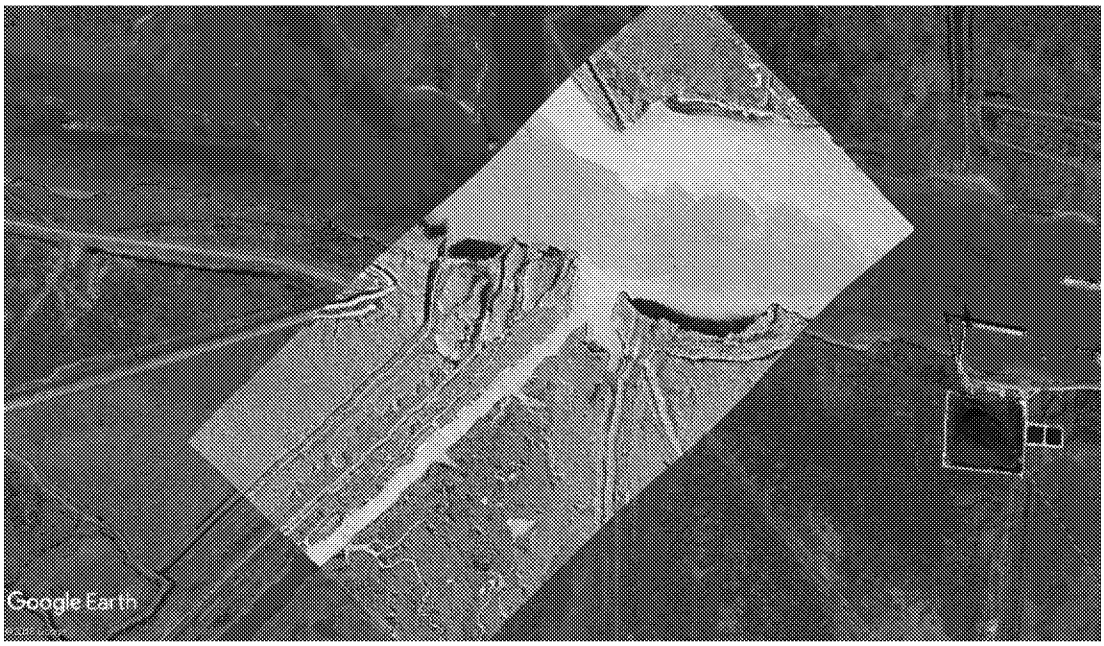

Figure 12: -- 3 band IR image, Flight 9, Run 8, Waterway, South 4 Group Fire

Figure 13: -- Isobutylene Detection, Flight 9, South 4 Group Fire

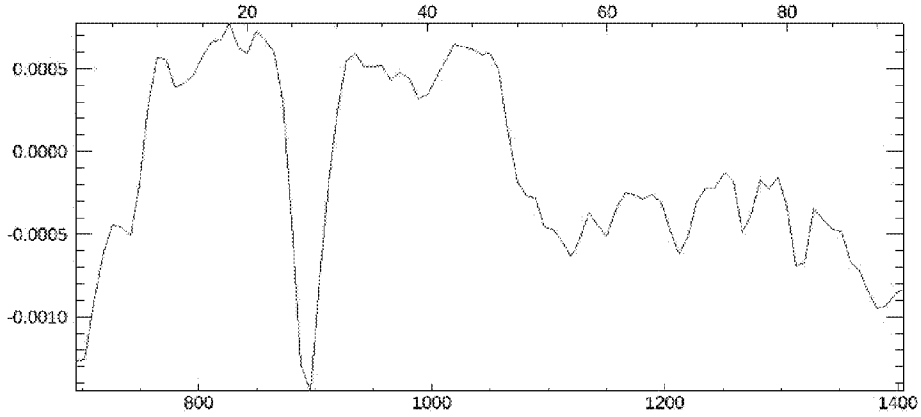

Figure 14: -- Isobutylene Spectrum, Flight 9, Pass 5, South 4 Group Fire

TABLE 5 - Chemicals Included in the ASPECT Auto-Processing Library

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

Table 6. Chemical Results Summary

Run	Date	Time (UTC)	Chemical	Max Concentration ppm
1	1 Dec 2019	1523	Test	Test
2		1532	Test	Test
3		1537	Isobutylene	1.7
4		1542	ND	None
5		1547	ND	None
6		1552	ND	None
7		1605	ND	None
8		1611	ND	None
9		1621	Isobutylene	1.7
Note: ND = No Detections				

Aerial Photography Results

A full set of high resolution aerial digital photography were collected as part of the flight. Figure 10 shows a representative image collected as part of each pass. In a similar fashion as the morning flight, the image shows a weak plume being emitted from the facility. At the time of collection, three water cannons were in operation. An oblique image collection as part of the mission is given in figure 16. Water cannons are visible with minimal smoke leaving the site.

Conclusions – Flight 9

The second flight on 1 December 2019 showed a low thermal environment within the process unit and minimal smoke being emitted from the site. The analysis of imagery showed that four water cannons were being employed at the facility. IR imagery did not show any oil sheen presence on the Neches River. Analysis of FTIR data showed detections of isobutylene south of the facility near the wastewater treatment plant. These detections were approximately 1.7 ppm on two separate passes.

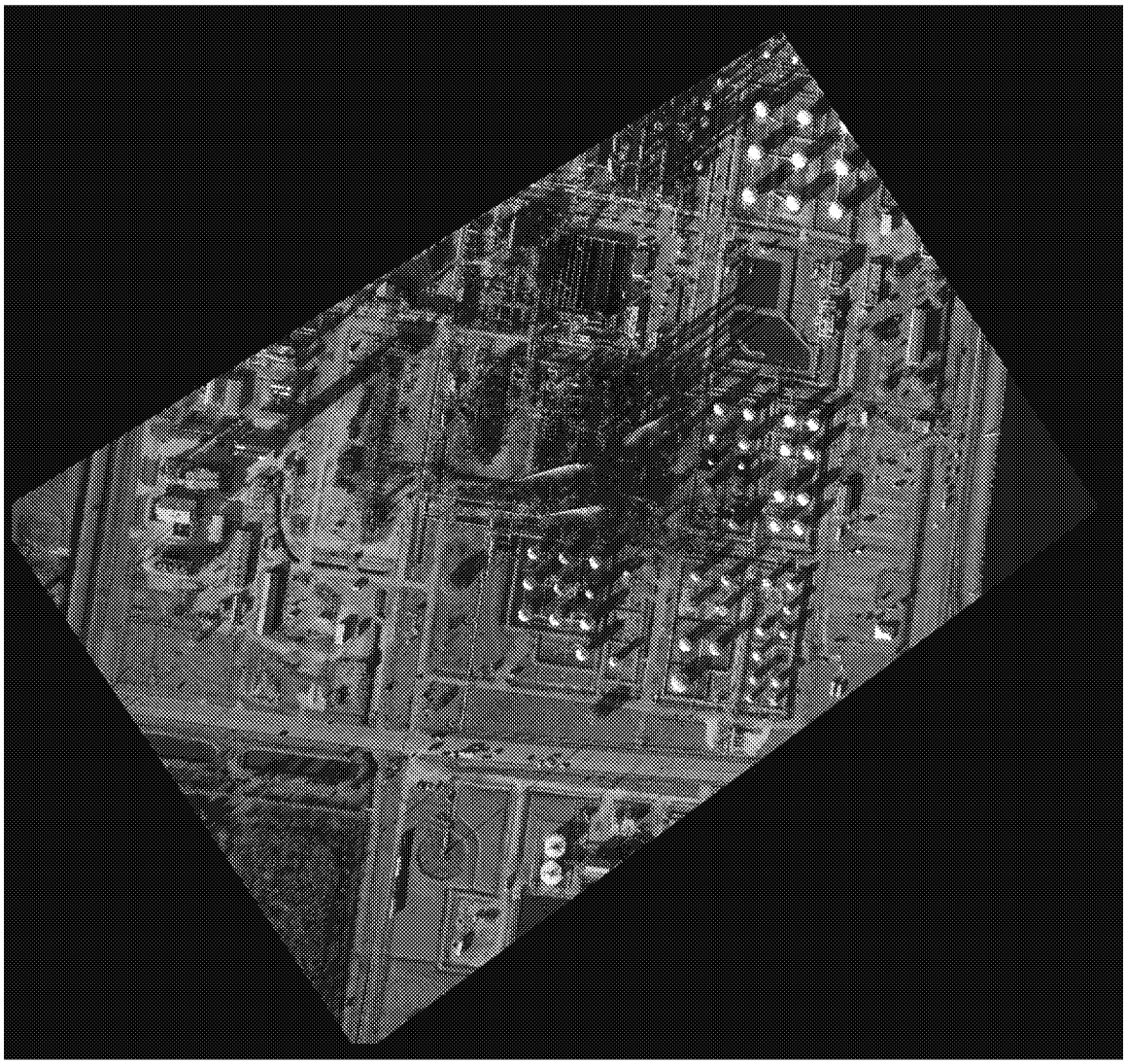

Figure 15: Aerial Image of the South 4Group Fire

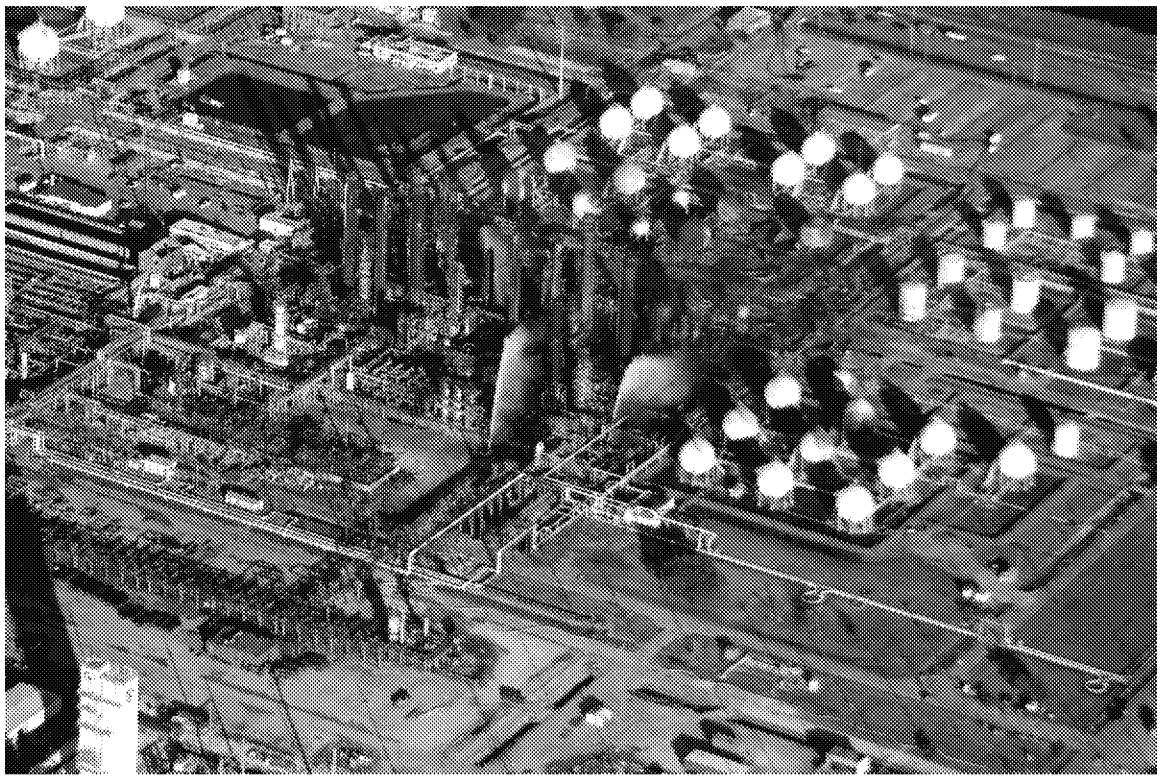

Figure 16: Aerial Image of the South 4Group Fire

Appendix Flight #9

Abbreviations:

DEM – Digital elevation model
Alt – Altitude (in feet)
MSL – Mean sea level altitude (in feet)
Digital – Digital photography file from the Nikon D2X camera
MSIC – Digital photography file from the Imperx mapping camera
FTIR – Spectral IR data collected with a Fourier Transform Infrared Spectrometer
IRLS – Infrared Line Scanner
Jpg – JPEG image format
UTC – Universal Time Coordinated
img – Spectral data format based on Grams format

```
Mission:   2019-12-01 Port Neches 2

Date:      12/1/2019
Time UTC: 21:24

Aircraft Number: N9738B
Pilot: Todd Seale
Copilot: James Glaviano
Operator: James Crisp
Aft Operator: Gerry Broyles
Ground Controller: Ahmed Hafez

DEM: Using elevation from DEM Database
-------------------------------------------------------------------

Run: 1 Time: 21:23:43 UTC
        Alt: 2811 ft MSL  Elev: 6 ft  Elevation from DEM Database
        Vel: 133 knots  Heading: 277

Digitals:  None
MSIC: 3
        20191201212349283.jpg
        20191201212355648.jpg
        20191201212401998.jpg
FTIR: 1
        20191201_212351_A.igm
IRLS: 1
        2019_12_01_21_23_47_R_01 TA=17.0;TB=37.0;Gain=3
Gamma Runs:  None

-------------------------------------------------------------------

Run: 2 Time: 21:32:30 UTC
        Alt: 2830 ft MSL  Elev: 7 ft  Elevation from DEM Database
```

```
        Vel: 110 knots  Heading: 45

Digitals:  None
MSIC: 4
        20191201213236805.jpg
        20191201213243170.jpg
        20191201213249520.jpg
        20191201213255869.jpg
FTIR: 1
        20191201_213234_A.igm
IRLS: 1
        2019_12_01_21_32_35_R_02 TA=10.1;TB=30.1;Gain=3
Gamma Runs:  None

---------------------------------------------------------------------

Run: 3 Time: 21:37:32 UTC
        Alt: 2798 ft MSL  Elev: 7 ft  Elevation from DEM Database
        Vel: 111 knots  Heading: 243

Digitals:  None
MSIC: 4
        20191201213738243.jpg
        20191201213745513.jpg
        20191201213751862.jpg
        20191201213758227.jpg
FTIR: 1
        20191201_213737_A.igm
IRLS: 1
        2019_12_01_21_37_37_R_03 TA=10.8;TB=30.8;Gain=3
Gamma Runs:  None

---------------------------------------------------------------------

Run: 4 Time: 21:42:16 UTC
        Alt: 2770 ft MSL  Elev: 6 ft  Elevation from DEM Database
        Vel: 107 knots  Heading: 42

Digitals:  None
MSIC: 4
        20191201214223347.jpg
        20191201214229696.jpg
        20191201214236046.jpg
        20191201214242411.jpg
FTIR: 1
        20191201_214220_A.igm
IRLS: 1
        2019_12_01_21_42_21_R_04 TA=10.8;TB=30.8;Gain=3
Gamma Runs:  None

---------------------------------------------------------------------

Run: 5 Time: 21:47:08 UTC
        Alt: 2858 ft MSL  Elev: 7 ft  Elevation from DEM Database
```

```
        Vel: 102 knots  Heading: 322

Digitals:  None
MSIC: 4
        20191201214714800.jpg
        20191201214721149.jpg
        20191201214727499.jpg
        20191201214733864.jpg
FTIR: 1
        20191201_214713_A.igm
IRLS: 1
        2019_12_01_21_47_13_R_05 TA=10.4;TB=30.4;Gain=3
Gamma Runs:  None

---------------------------------------------------------------------

Run: 6 Time: 21:52:13 UTC
        Alt: 2757 ft MSL  Elev: 8 ft  Elevation from DEM Database
        Vel: 109 knots  Heading: 43

Digitals:  None
MSIC: 4
        20191201215218950.jpg
        20191201215225316.jpg
        20191201215232571.jpg
        20191201215238920.jpg
FTIR: 1
        20191201_215216_A.igm
IRLS: 1
        2019_12_01_21_52_17_R_06 TA=10.6;TB=30.6;Gain=3
Gamma Runs:  None

---------------------------------------------------------------------

Run: 7 Time: 22:05:32 UTC
        Alt: 2752 ft MSL  Elev: 9 ft  Elevation from DEM Database
        Vel: 109 knots  Heading: 86

Digitals:  None
MSIC: 5
        20191201220538843.jpg
        20191201220545208.jpg
        20191201220551557.jpg
        20191201220557907.jpg
        20191201220604273.jpg
FTIR: 1
        20191201_220537_A.igm
IRLS: 1
        2019_12_01_22_05_37_R_07 TA=10.5;TB=30.5;Gain=3
Gamma Runs:  None

---------------------------------------------------------------------

Run: 8 Time: 22:11:41 UTC
```

```
        Alt: 2821 ft MSL  Elev: 0 ft  Elevation from DEM Database
        Vel: 104 knots  Heading: 36

Digitals:  None
MSIC: 6
        20191201221147470.jpg
        20191201221153820.jpg
        20191201221200185.jpg
        20191201221207439.jpg
        20191201221213804.jpg
        20191201221220153.jpg
FTIR: 1
        20191201_221144_A.igm
IRLS: 1
        2019_12_01_22_11_46_R_08 TA=9.1;TB=29.1;Gain=3
Gamma Runs:  None

---------------------------------------------------------------------

Run: 9 Time: 22:21:41 UTC
        Alt: 2850 ft MSL  Elev: 7 ft  Elevation from DEM Database
        Vel: 109 knots  Heading: 247

Digitals:  None
MSIC: 4
        20191201222147608.jpg
        20191201222153973.jpg
        20191201222200322.jpg
        20191201222206672.jpg
FTIR: 1
        20191201_222144_A.igm
IRLS: 1
        2019_12_01_22_21_46_R_09 TA=9.2;TB=29.2;Gain=3
Gamma Runs:  None


Mission Complete: 22:30 (UTC)
```