Using Thermal/IR and Multispectral Sensors on Drones to Find the Origin of and Extent of Contamination from Saltwater Spills from Producing Wells*

Susan Nash¹

Search and Discovery Article #80650 (2018)**
Posted September 4, 2018

*Adapted from oral presentation given at 2018 AAPG Annual Convention and Exhibition, Salt Lake City, Utah, May 20-23, 2018
**Datapages © 2018 Serial rights given by author. For all other rights contact author directly. DOI:10.1306/80650Nash2018
¹AAPG, Tulsa, OK, United States (snash@aapg.org)

Abstract

This presentation discusses how new drone-based technologies using thermal / infrared and multispectral sensors can help quickly and efficiently locate the source of a saltwater spill as well as the extent of contamination. We review the workflow, which includes identifying the first indication of a spill, collecting the necessary data to plan the mission, identifying the proper types of drones and sensors, and planning the mission. We discuss the types of sensors and software needed to capture and analyze the data. In addition to reviewing several case studies, we will look in-depth at the case of Black Bear Creek in Pawnee, Oklahoma, and also at Bird Creek in Osage County, Oklahoma, to discuss how drones complemented existing efforts to solve the problem of contamination coming from an unidentified source, and how the combined analytics provided more insight not only of the health of the ecosystem, but also in finding wells and suggesting new ways optimize EOR efforts in a mature field.

Websites Cited


Using Thermal / IR and Multispectral Sensors on Drones to Find the Origin of and Extent of Contamination from Saltwater Spills from Producing Wells

Susan Nash, Ph.D.
AAPG
Problem: Bird Creek Contamination

August 2016:
Oily sheen on water, accompanied by dead fish and turtles

In a pool of the upper creek tributary on the Chapman Ranch, just west of the Tall Grass Prairie Preserve, Osage County

(source: Tulsa World)

Location: Osage County, on Osage Tribal Land
The Bird Creek Watershed

Environmentally sensitive area: watershed to Catoosa and also in the Tallgrass Prairie
History of Oil in Osage County

1920
Marland Oil drilled its discovery well, Bertha Hickman #1

Burbank Sand
2,900 ft

Burbank Field

Location: Osage County, on Osage Tribal Land
And subject to many overlapping agency jurisdictions

Continuously developed since then
Contamination? Who’s to blame?

The EPA blames the operators.
The operators disagree.

File suit to fight EPA order to shut in 7 producing oil wells in the upper tributary of Bird Creek (January 2018)

---Jireh Resources, LLC
---Warren American Oil, LLC
---Novy Oil and Gas
Conflict #1

• EPA claims ongoing contamination and increasing salinity. Operators and independent environmental testing agents say it is decreasing.

• **Drone solution:** Use sensors to do drone-based aerial surveys to determine salinity over time. Hyperspectral sensors.
Conflict #2

• Solution: Run a log to test the surface casing integrity. Look at regional structures for possible conduit (fault).

• **Drone solution:** Look for evidence of salt water spill in the topsoil. Are there distressed plants? Thermal infrared sensors can be used; also hyperspectral.
DJI Phantom MAPIR for Precision Farming

Normalized Difference Vegetation Index

--Most common index used in remote sensing
--Quantifies vegetation by measuring the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs)
--NDVI ranges from -1 to +1
\[
\text{NDVI} = \frac{(\text{NIR} - \text{Red})}{(\text{NIR} + \text{Red})}
\]
NDVI for vegetation health determination

Near Infrared channel on the sensor

--High NDVI: healthy
--Low NDVI: less or no vegetation
NDVI Example: Agriculture

True color: looks for red, green, and blue

NIR band as red: we get color infrared (in the red channel) – bright red means “water me!”

Apply the formula: bright green means high NDVI
Hyperspectral Drone for Environmental and Littoral Observations

The onboard flight control system is composed of a GNSS and an autopilot. Ground station software is used to control the UAV flight parameters during the survey. The flight control is run by DJI® iOSD® software. Although Hyper-DRELIO is able to perform an autonomous flight, take-off and landing are manually controlled. [http://www.mdpi.com/2072-4292/10/2/204/html](http://www.mdpi.com/2072-4292/10/2/204/html)
Typical Thermal Inspection Specifications

<table>
<thead>
<tr>
<th>Model</th>
<th>FLIR Aerial Home Inspection Kit</th>
<th>FLIR Aerial Building Inspection Kit</th>
<th>FLIR Aerial Building Inspection Kit R (30 Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Camera</td>
<td>DJI Zenmuse XT Thermal Camera &amp; Stabilized Gimbal</td>
<td>DJI Zenmuse XT Thermal Camera &amp; Stabilized Gimbal</td>
<td></td>
</tr>
<tr>
<td>Thermal Camera Configuration</td>
<td>6.8 mm lens (45° × 35°), 336 × 256 resolution</td>
<td>13 mm lens (45° × 37°), 640 × 512 resolution</td>
<td>Radiometric 13 mm lens (45° × 37°), 640 × 512 resolution</td>
</tr>
<tr>
<td>Aircraft Type</td>
<td>DJI Inspire 1 (V 2.0)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Can be used for tank batteries, compressors, gas gathering monitoring as well
Hyperspectral sensors

BaySpec Hyperspectral Camera (OCI-UAV-1000) Imaging

**NDVI and ENDVI Vegetation Indexes Generation and Analysis** - Normalized Difference Vegetation Index (NDVI).
FLIR Camera with DJI Zenmuse
Infrared / Thermal Camera

Introducing FLIR VUE

The world’s first affordable, easy to integrate thermal camera for sUAS.
Environmental Vegetation Imaging

OCI-UAV-1000 Flight Data Example (processed with pseudo-RGB color and material color based on spectral characteristics)
Low-Cost Solution

DJI Phantom plus Pix4D – 3D models, Point Clouds, orthomosaics
Conclusions and Recommendations

- Fight finger-pointing with facts
- Use remote sensing for new insights
- Plan ahead and maintain a regular schedule of drone surveys
- Integrate your information
- Calibrate with “ground truth”
- Apply your findings to other locations
- Review “precision farming” and other agricultural applications for up-to-date software
- Low-cost solutions can work
August 2016: An oily sheen, dead fish and turtles are reported on a northern tributary of Bird Creek on the Chapman Ranch in Osage County. Osage Nation, Bureau of Indian Affairs and Environmental Protection Agency officials respond. Initially, it is assumed that production water was dumped from the roadside.

October 2016: After heavy rains swell the creek and the contamination remains and investigators find water temperatures near 100 degrees and salinity levels above 80,000 parts per million, far above the EPA acceptable level of 1,000 ppm. Out of "an abundance of caution" the City of Pawhuska switches its water supply to a source far removed from Bird Creek.

December 2016 and January 2017: Newspaper reports surface of residents complaining about inaction on the part of regulators.

May 2017: EPA Administrator Scott Pruitt visits the site. Close monitoring of the stream begins and producers are told they may be asked to do periodic shut downs of injection wells.

July 2017: The EPA announces it has found the source of contamination in Bird Creek, due to over-pressurized reservoirs below related to seven nearby wells. The wells will be asked to shut down and it is said a wider area may be examined in relation to the saltwater contamination.

August 2017: The EPA issues a formal request to shut down the wells. Some initially comply, but then resume pumping as their own experts doubt the EPA's conclusions.

October 2017: A public hearing is held in Tulsa for all parties to air their positions on the proposed shut-down order. Producers forward a plan to pump the heaviest saltwater concentrations out of the creek.

December 2017: Producers and Chapman Ranch owners take a first shot at pumping saltwater out of the creek and taking readings. On Dec. 20 the EPA finalizes its shutdown order.

January 2018: Producers file suit in federal court to fight the shutdown order. Negotiations to pump out the saltwater and monitor the creek continue.