Field-Based Quantification of Methane Emissions from Natural Gas Infrastructure

RIC Methane Emissions Quantification Program

Virtual Project Review Meeting - October 28, 2020

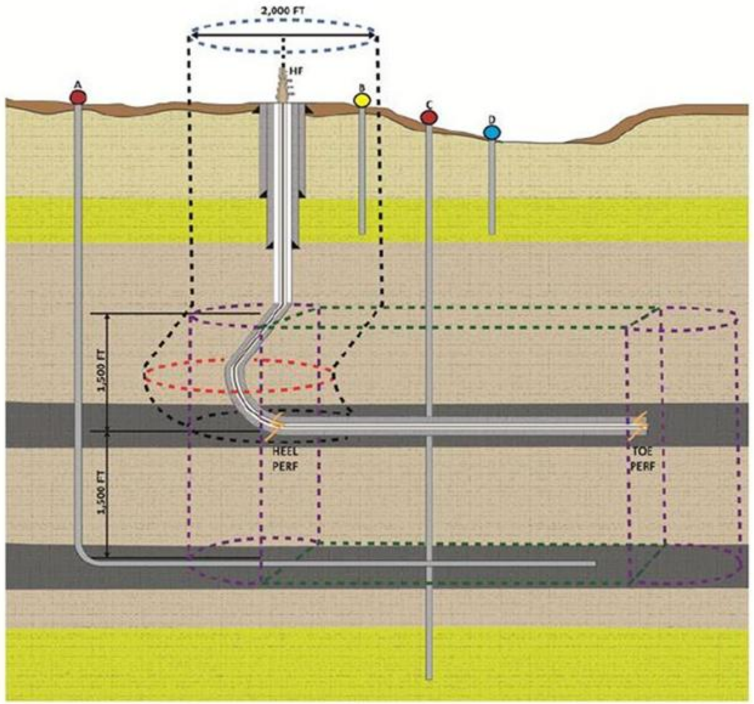
Natalie Pekney, PhD
Geo-Analysis and Monitoring Team, NETL

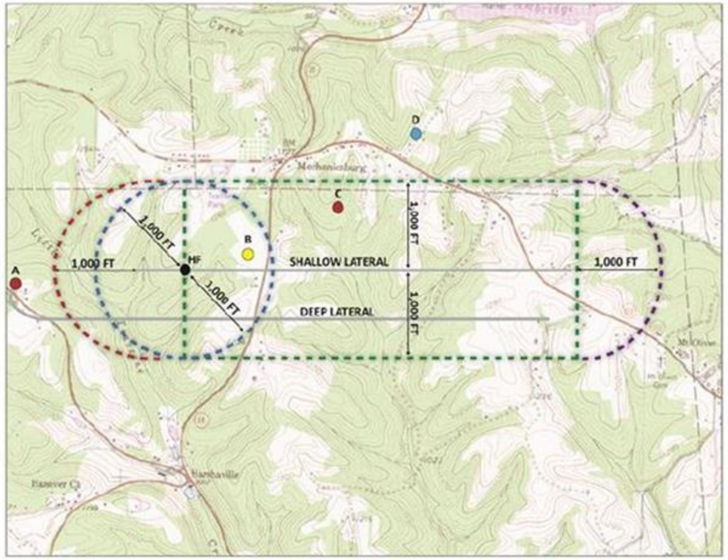
NETL Research and Innovation Center's Methane Emissions Quantification Program

- **OBJECTIVE**
  - Characterization/quantification of emissions from natural gas infrastructure
- **APPROACH**
  - Obtain a comprehensive data set for selected natural gas components/facilities
  - Research and field efforts concentrated on characterizing:
    - Abandoned and orphaned gas wells
    - Gathering system pipelines
    - Industrial and commercial metering stations
    - Ambient air quality impacts from unconventional natural gas development
    - Mapping buried steel flowlines using geophysical sensors mounted on drone aircraft

Methane Emissions from Abandoned Oil & Gas Wells

- Contribute measurable emissions of methane, a potent greenhouse gas
- Environmental, safety, and economic concerns
- Pennsylvania regulations now require land developers and oil and gas drilling operations to identify and properly seal wells within a 1000 foot buffer of the perimeter



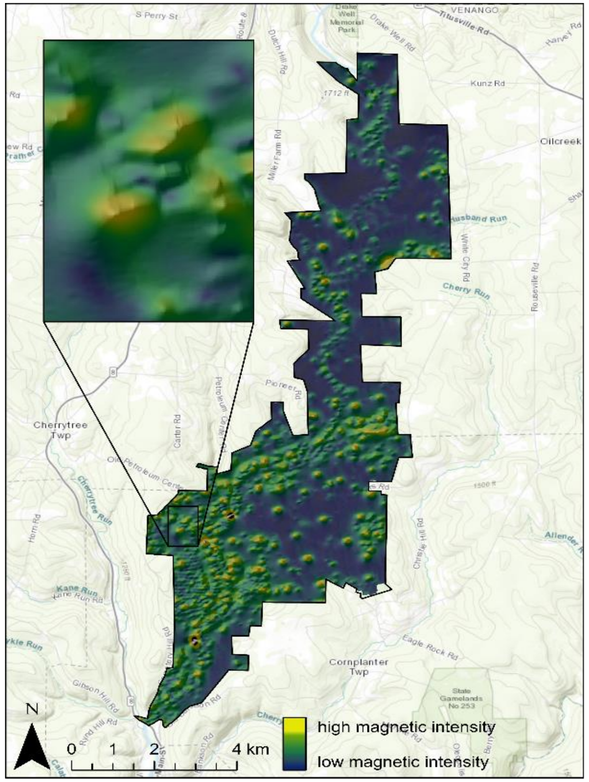


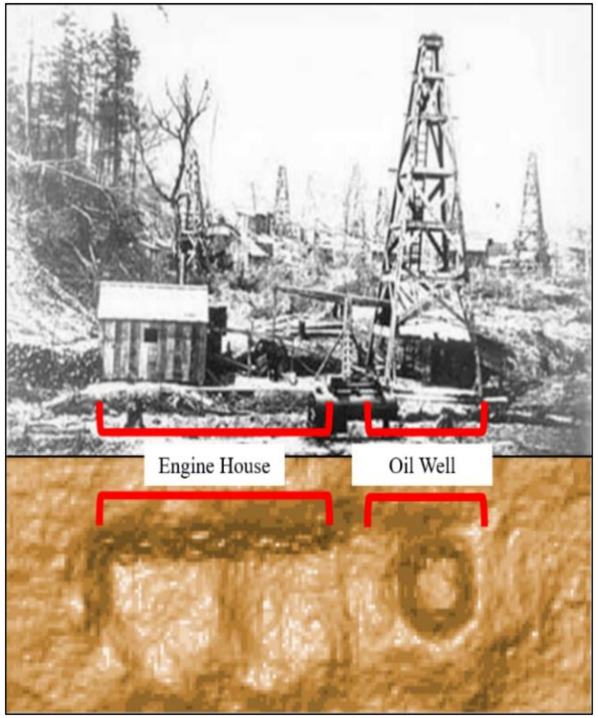
Notes: Yellow (identify); Red (identify and visually monitor); and Blue (no requirements); HF (well that is subject of area of review that will be *hydraulically fractured*)

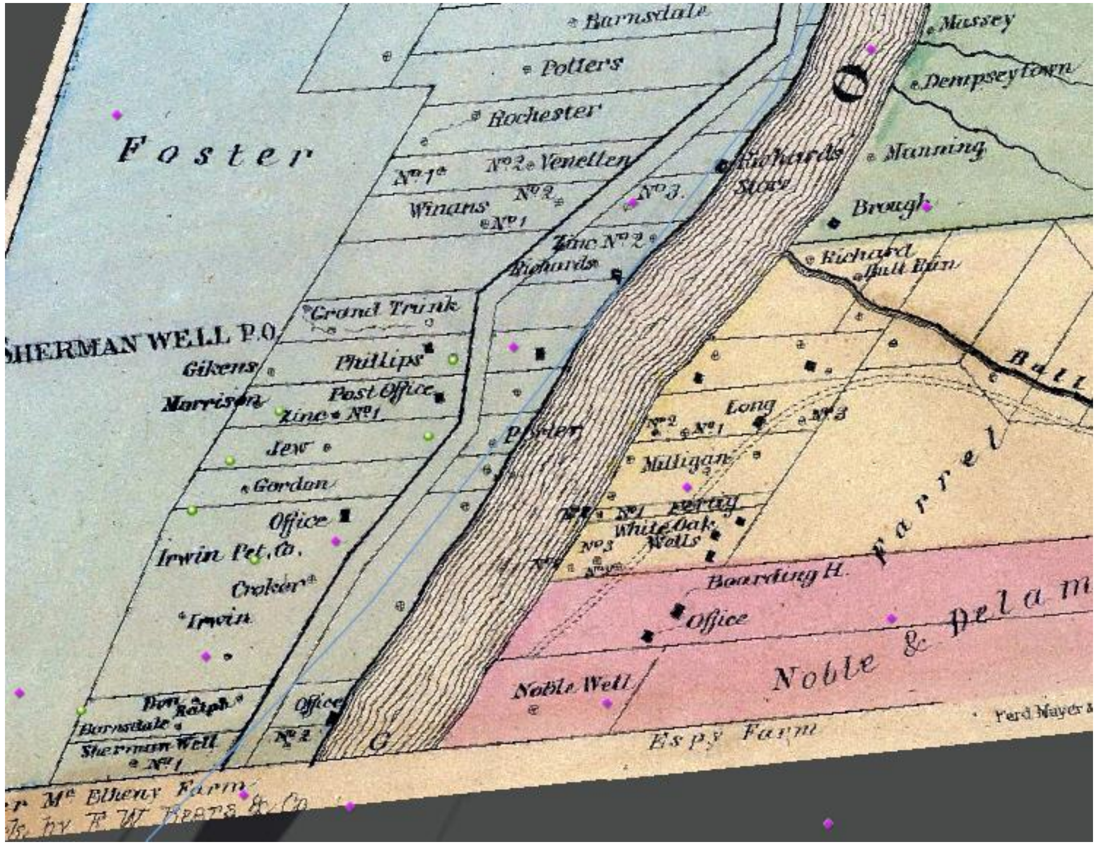
Wellfinding Methods

Determining possible abandoned well locations prior to fieldwork

- Historical Survey: Database records, Farmline maps, Historical maps, Aerial photographs
- Remote Sensing: LiDAR, Aeromagnetics







1952 Photo of Winganon, OK

Methane Emissions Measurements

Oklahoma – Summary of Results

- 179 wells measured

	Mean ± SD	Minimum	Maximum	Median	Coverage (%)	ρ to Observed Emissions
Distance to nearest earthquake (m)	5394 ±1139	3995	11123	5028	100	0.2851
Distance to nearest injection well (m)	1736 ±469	250	3097	1788	100	0.2004
Well depth (m)	142 ±16	63	170	148	63	-0.4266
Age (y)	52 ±28	12	105	50	83	-0.0250
Length of inactivity (y)	21 ±13	8	64	19	30	-0.0681

- Submitted to AGU Geophysical Research Letters

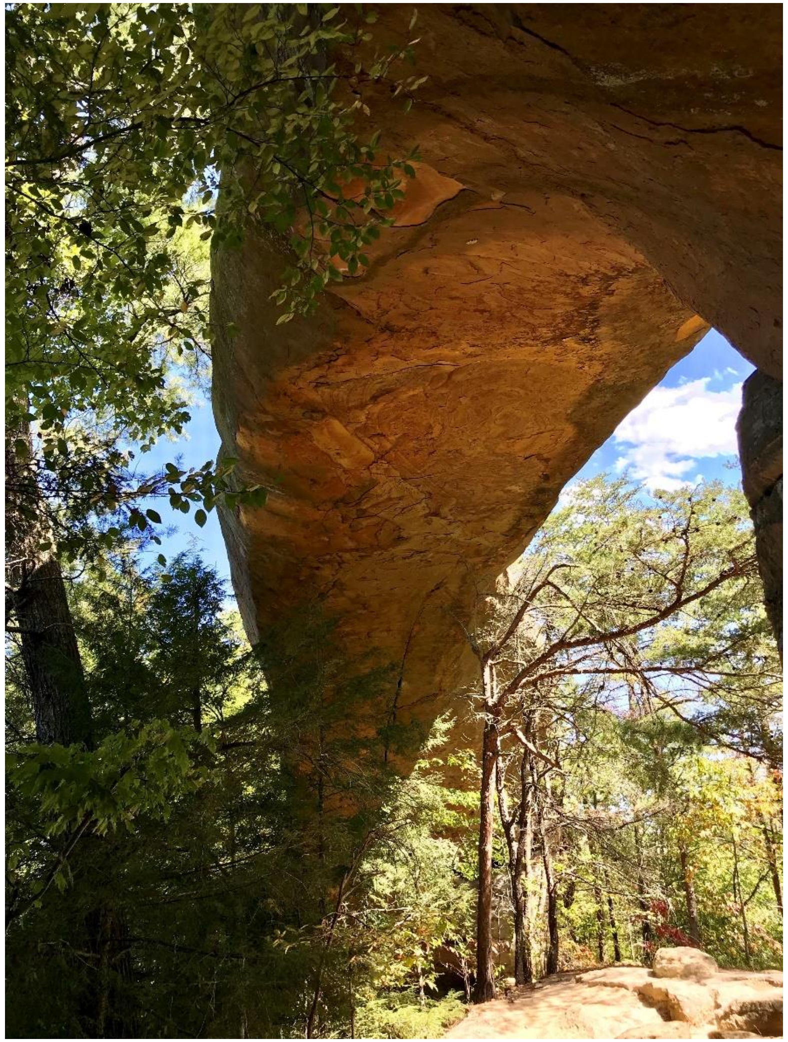
Methane Emissions Measurements

Kentucky – Preliminary Results

- 54 wells

	Methane EF (g/h/well)	
	This study	EPA GHGI
Plugged	0.0 (n=1)	0.036 (29)
Unplugged	1.1 (53)	30.57 (42)

- Return trip
- Older wells



Databases are not reliable in the field

Determining possible abandoned well locations prior to fieldwork

- Magnetic surveys identify 46 - 59% more wells than recorded in state and national databases

Location	Size (km^2)	No. Magnetic Well Locations	Magnetic Well Density ($wells/km^2$)	No. State Database Well Locations	% Error Magnetic & State Database	No. DI Database Well Locations	% Error Magnetic & DI Database
HSP	15.71	165	11	33	80.0%	1	99.4%
MCC	0.57	100	175	9	91.0%	6	94.0%
OBSP	1.56	66	42	54	18.2%	10	84.8%
OCSP	28.97	931	32	1163	24.9%	955	2.6%
SCOF	88.22	5154	58	4231	17.9%	3703	28.2%
TDOF	39.36	2333	59	1369	41.3%	1356	41.9%
Mean ±Standard Deviation	29.07 ±29.87	1458 ±1833	63 ±53	1143 ±1489	45.6% ±29.5%	1005 ±1317	58.5% ±36.4%

Table 3. Comparison of number of well locations calculated from aeromagnetic surveys compared to state and DrillingInfo (DI) databases.

Natural Gas Gathering Pipelines Leakage Rate Estimation

Assessment of Gathering Natural Gas Pipelines in Colorado/Utah/Ohio/New Mexico

- Objectives
  - Refine methods to improve quantification of methane emissions from natural gas pipelines
  - Conduct field-based campaigns to collect measurements from a variety of gathering pipelines systems
  - Use emissions measurements collected to calculate improved emission factors and compare them to the current GHGI factor
- Data Sources

Zimmerle et al. 2019
Colorado State University-led field campaign conducted during year 2017 to characterize emissions from G&B stations across the U.S.

+

Subpart W Data
Greenhouse Gas Reporting Program (GHGRP)

Field Campaign

Study Approach

VEHICLE-BASED SURVEY

Ground Speed: 5 mph with hazard lights/ strobe

Wind Conditions: < 10 mph

Survey method: Two passes per segment

Capturing plume: (> 0.5 ppm CH4 above background)

Vehicle- Mounted Equipment	*Function*	*Sensitivity*
Ultraportable Methane/ Acetylene Cavity Ring Down Spectrometer (CRDS)	methane measurements	2 ppb / 0.6 ppb
Ultrasonic Weather Station	wind, pressure, temperature data	0 m/s to 5 m/s - 0.5 m/s + 10% of reading
R2 GNSS Receiver	GPS unit	
Power Inverter	DC to AC	-
Power Center	GPS, weather station power	-
DC Power Pack for CRDS	CRDS power	-
Laptop Computer	datalogger	-

Figure 5: Sample representation of vehicle used for ground-based methane survey

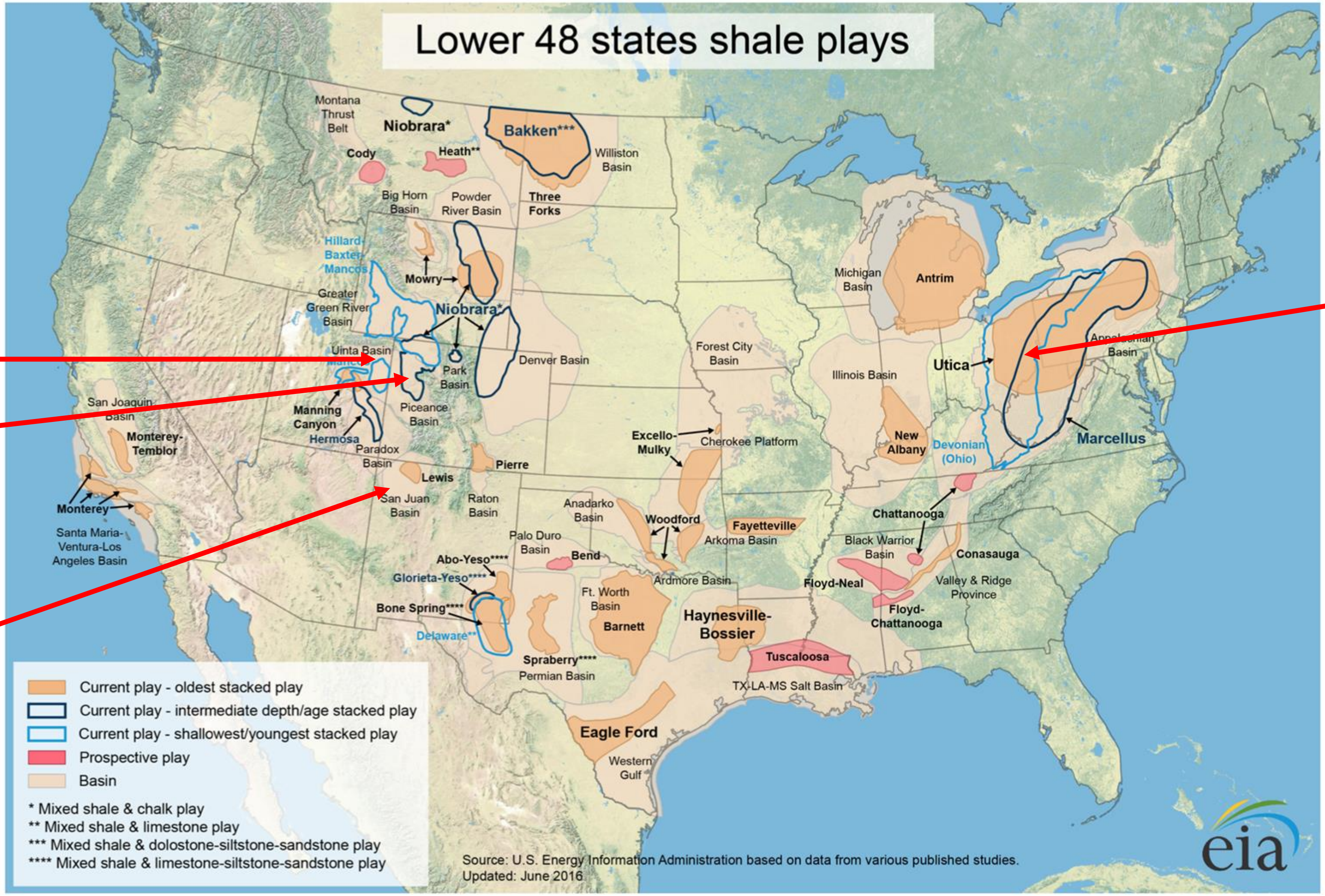
Figure 6: A Hi-Flow Sampler will be used to quantify the leak rate once a leak is identified.

Total mileage surveyed ~230 mi

Utah, 50 mi
Feb. 2020

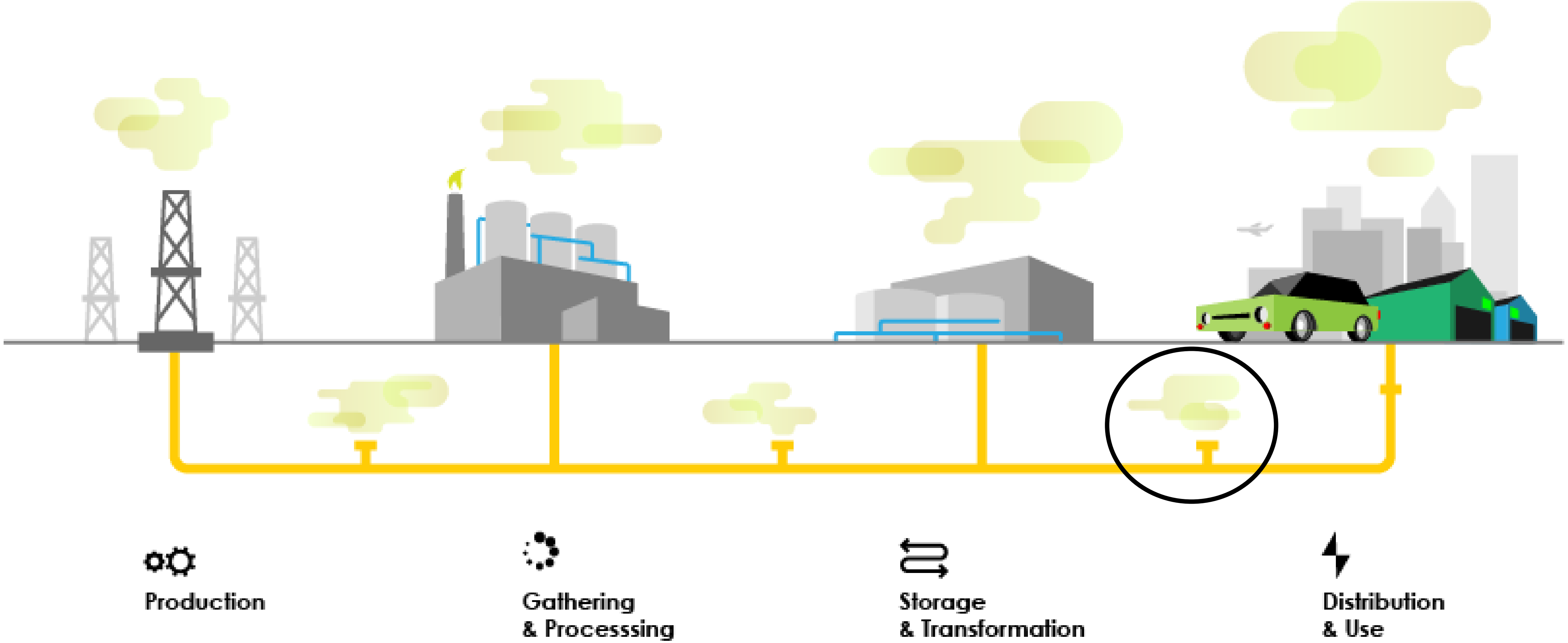
Colorado, 20 mi
Sep. 2019
Feb. 2020

New Mexico, 116 mi
Sep. 2019



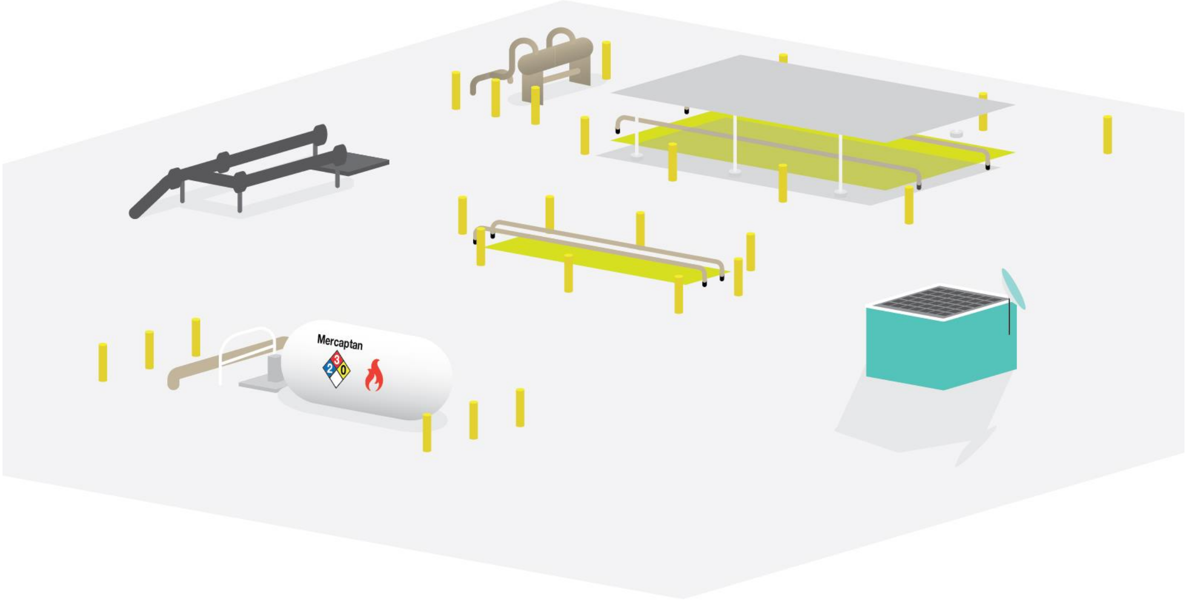
Ohio, 46 mi
Mar. 2019

Quantifying Methane Emissions From Natural Gas Metering & Regulating (M&R) Stations



Credit: NETL Multimedia

M&R Stations



Credit: NETL Multimedia

M&R Stations as Categorized in EPA GHGI

Category	Sample	Activity	Category	Sample	Activity
M&R (>300psi)	56	4,008	Regulators (40-100psi)	14	39,780
M&R (100-300psi)	10	14,627	Regulators (<40psi)	1	16,868
M&R (<100psi)	0	7,818	R-Vaults (>300psi)	8	3,602
Regulators (>300psi)	42	4,382	R-Vaults (100-300psi)	7	11,164
Regulators (100-300psi)	50	13,256	R-Vaults (40-100psi)	8	8,364

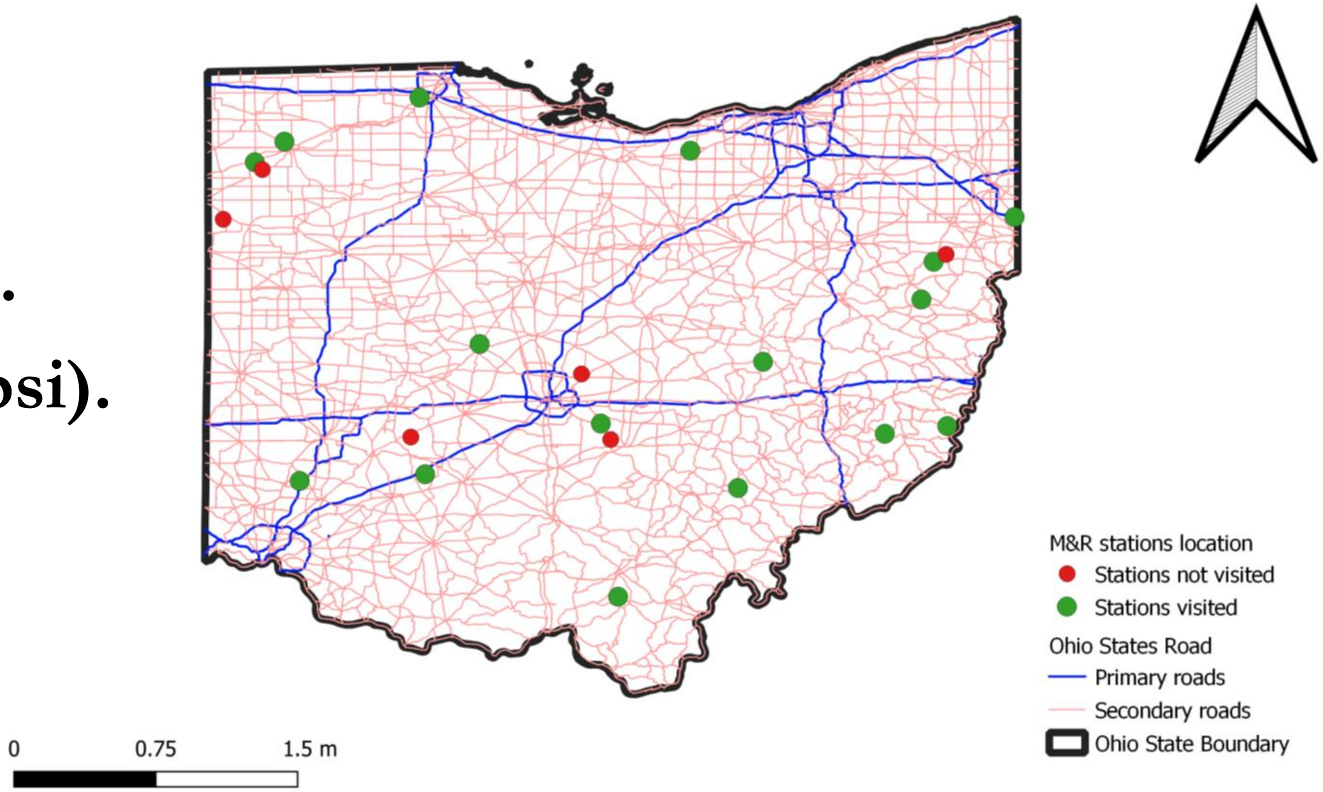
Source: Lamb et. al. (2015), EPA GHGI

Field Campaign in Ohio

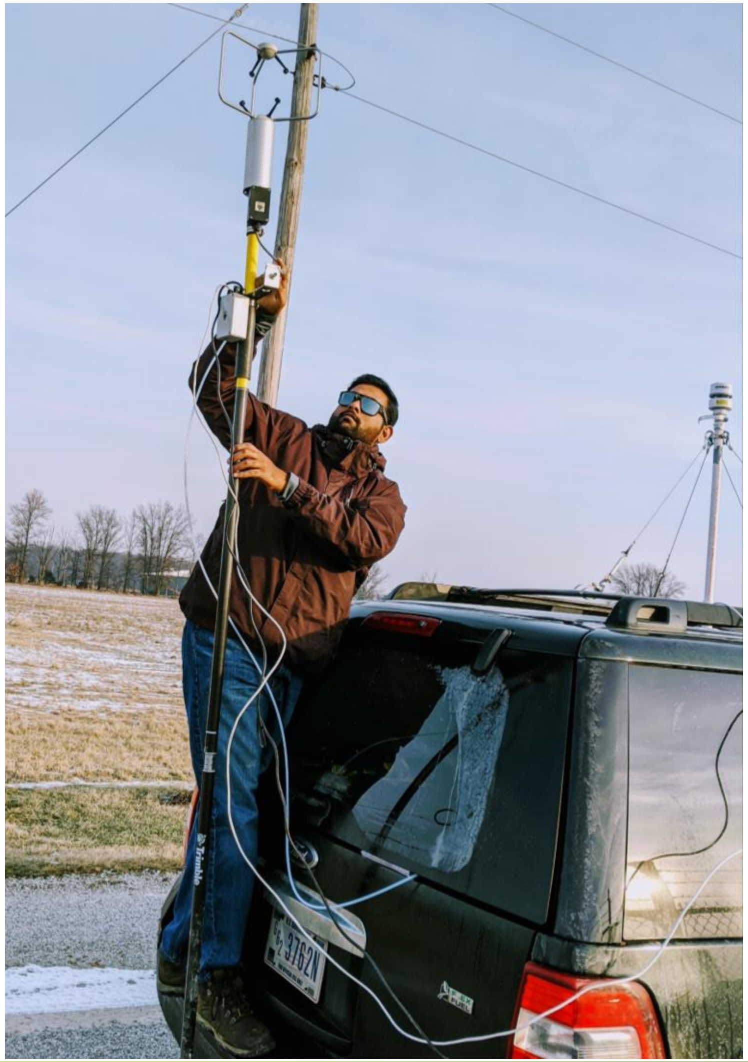
Identified 22 M&R Stations in Ohio.

No prior information about the sites.

Assumption is they are M&R (>300psi).



GMAP Vehicle



Field Campaign: Preliminary Results

- Higher emission rates from the sites visited.
- Rest of the campaign impacted by COVID-19 pandemic.
- Lamb, 2015 study was done in Summer and there was an implication.
- Methane emissions high in Winter?

Comparison	Lamb, 2015 (EPA GHGI)	This Study
Sample Size, n	59	11
Emission Rate (g/min)	**4.06**	**12.47**
Standard Deviation (g/min)	14.15	6.36
95% UCL (g/min)	7.67	16.23

Mapping buried steel flowlines using geophysical sensors mounted on drone aircraft

Geophysical Sensors: Field-testing of state-of-the-art sensor technology

Magnetic

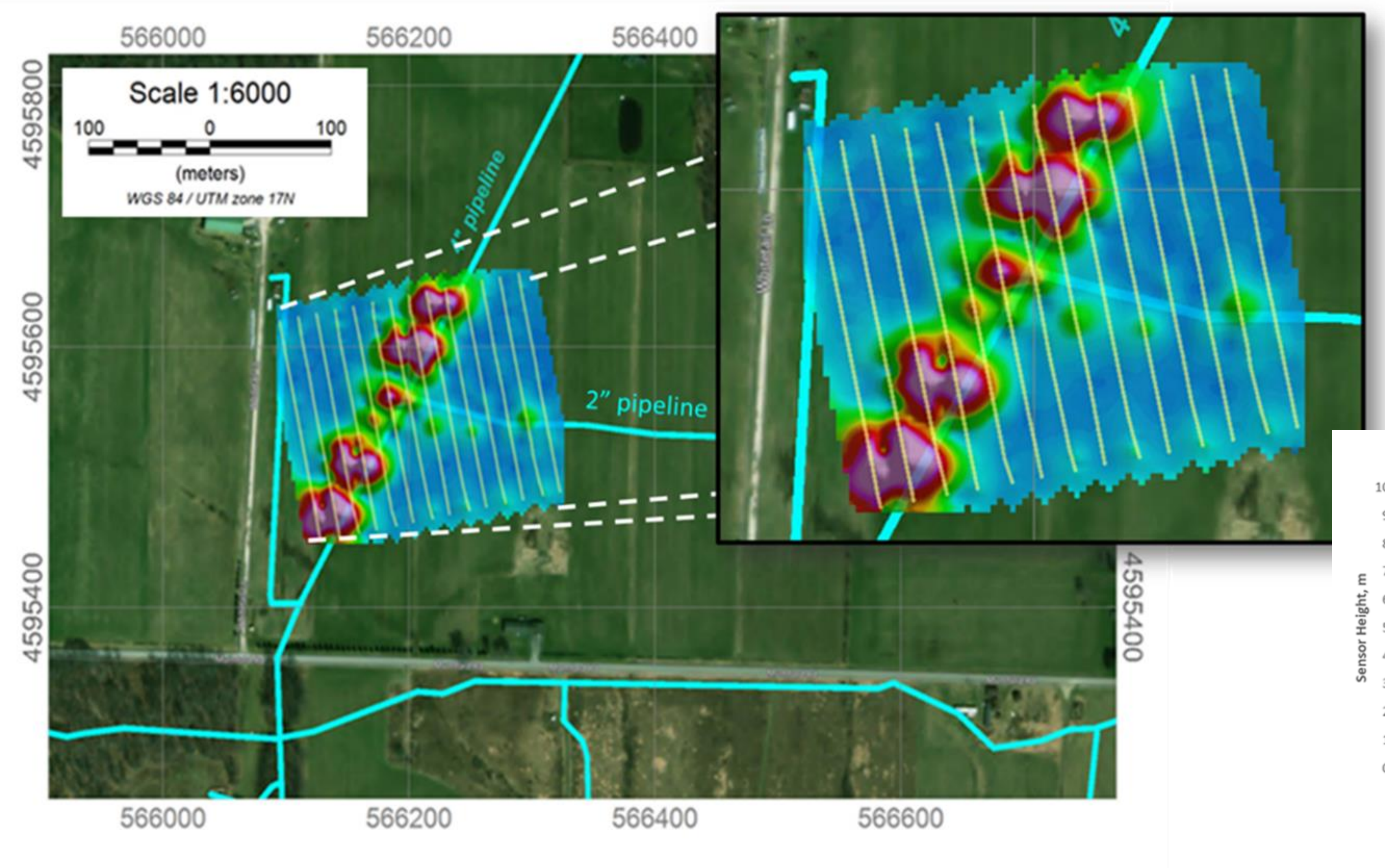
Sensor- Total Field Magnetometer
Manufacturer – QuSpin
Atomic Magnetometer – Rubidium
UAS- DJI M600
Operator- DiGioia Gray

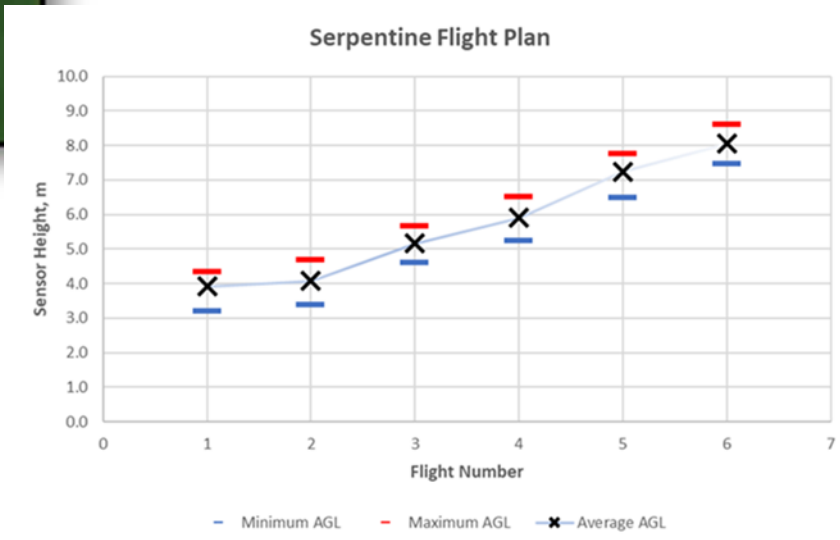
Sensor- Total Field Magnetometer
Manufacturer – Geometrics (MagArrow)
Atomic Magnetometer – Cesium
UAS- DJI M600
Operator- Juniper Unmanned

ElectroMagnetic

Sensor- Electromagnetic (EM)
Manufacturer – Geophex (GEM2 UAV)
Multifrequency EM transmitter/receiver
UAS- Custom Heavy Lift Hexarotor
Operator-UAV Exploration

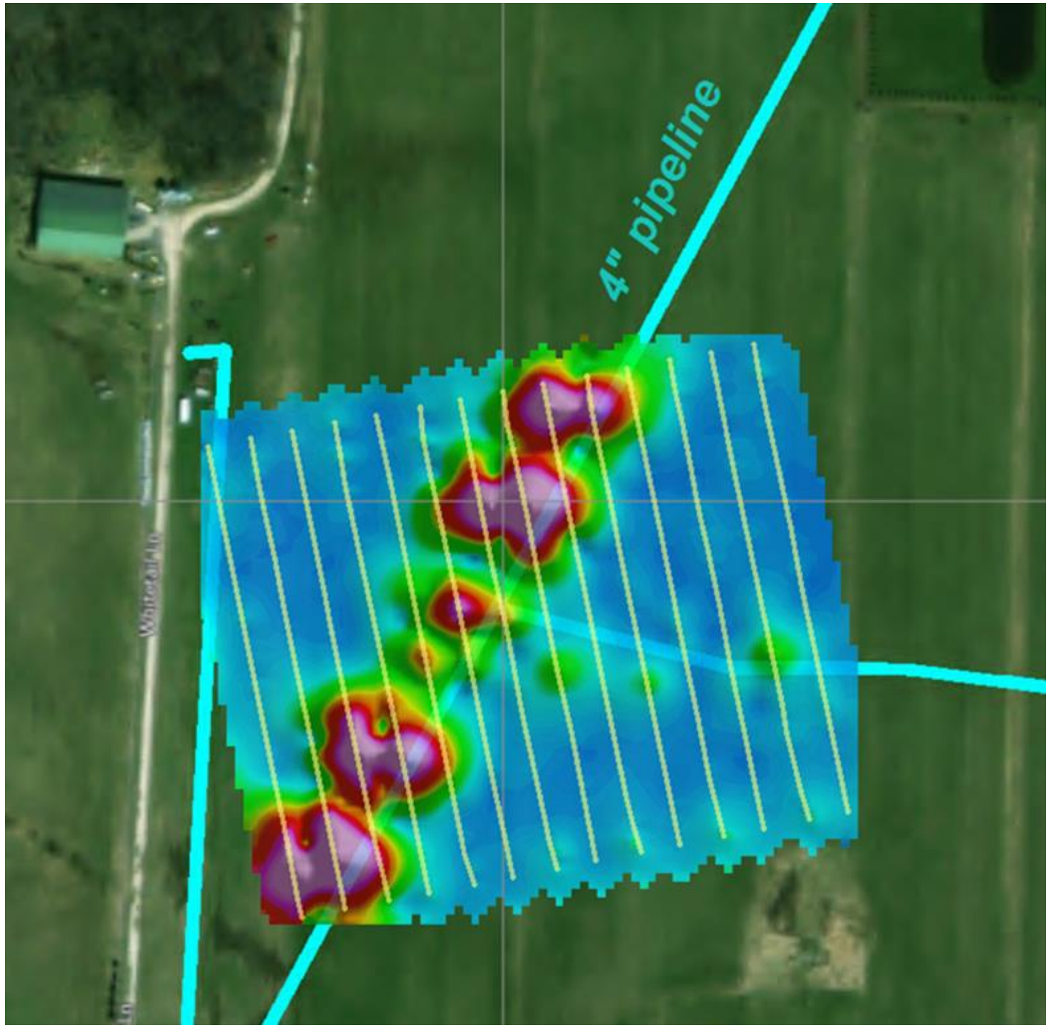
Pennsylvania Test Site

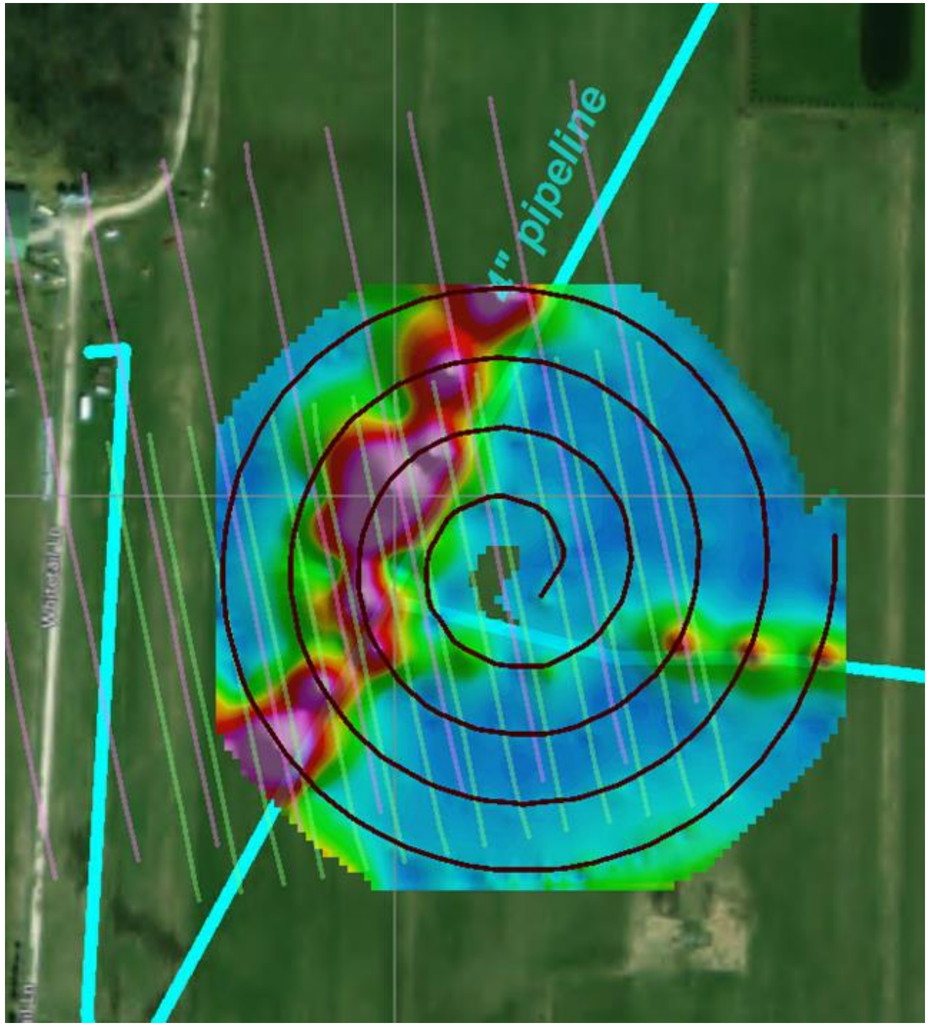




Pennsylvania Test Site – Sensor Height = 8 m

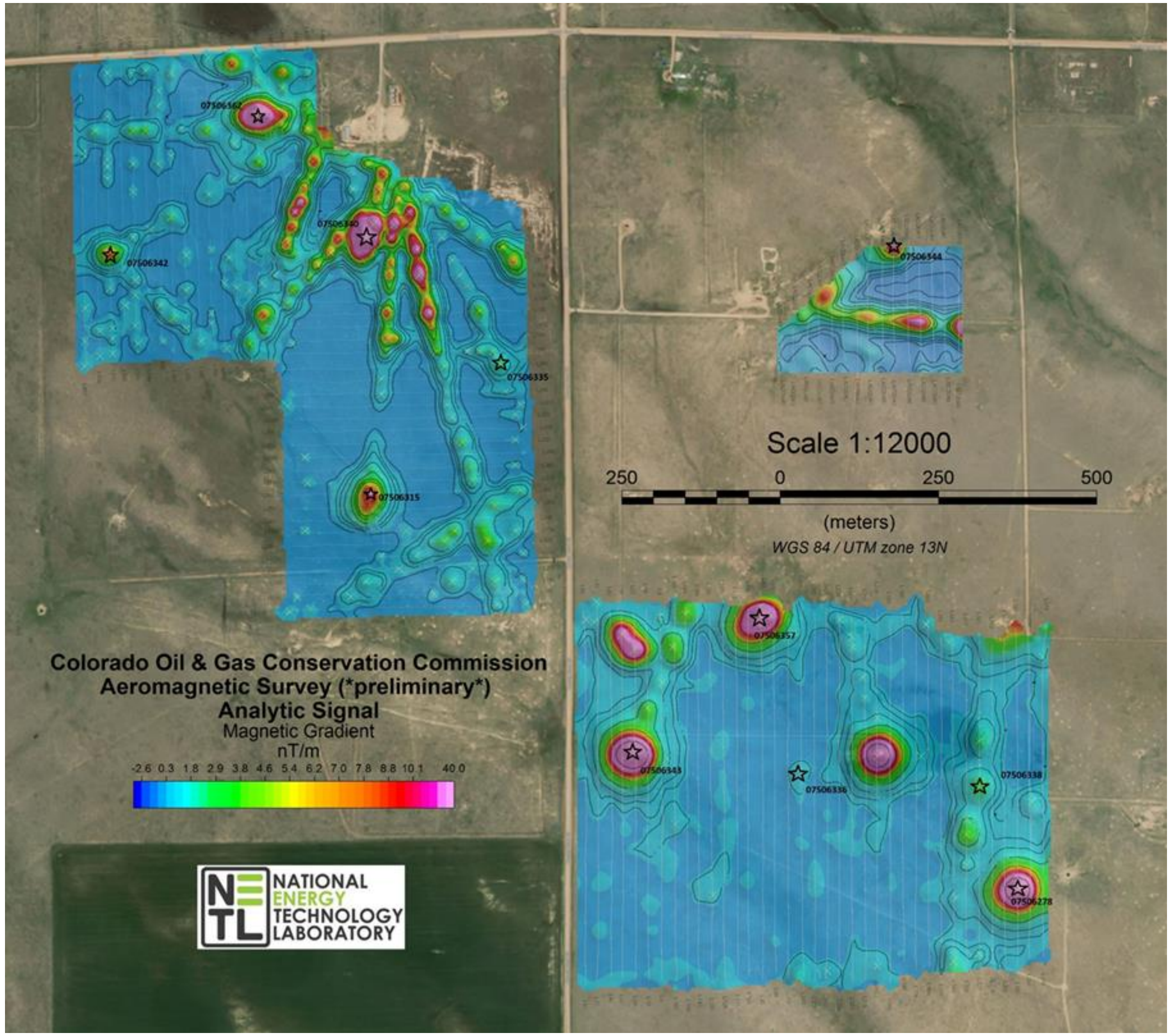
NATIONAL ENERGY TECHNOLOGY LABORATORY

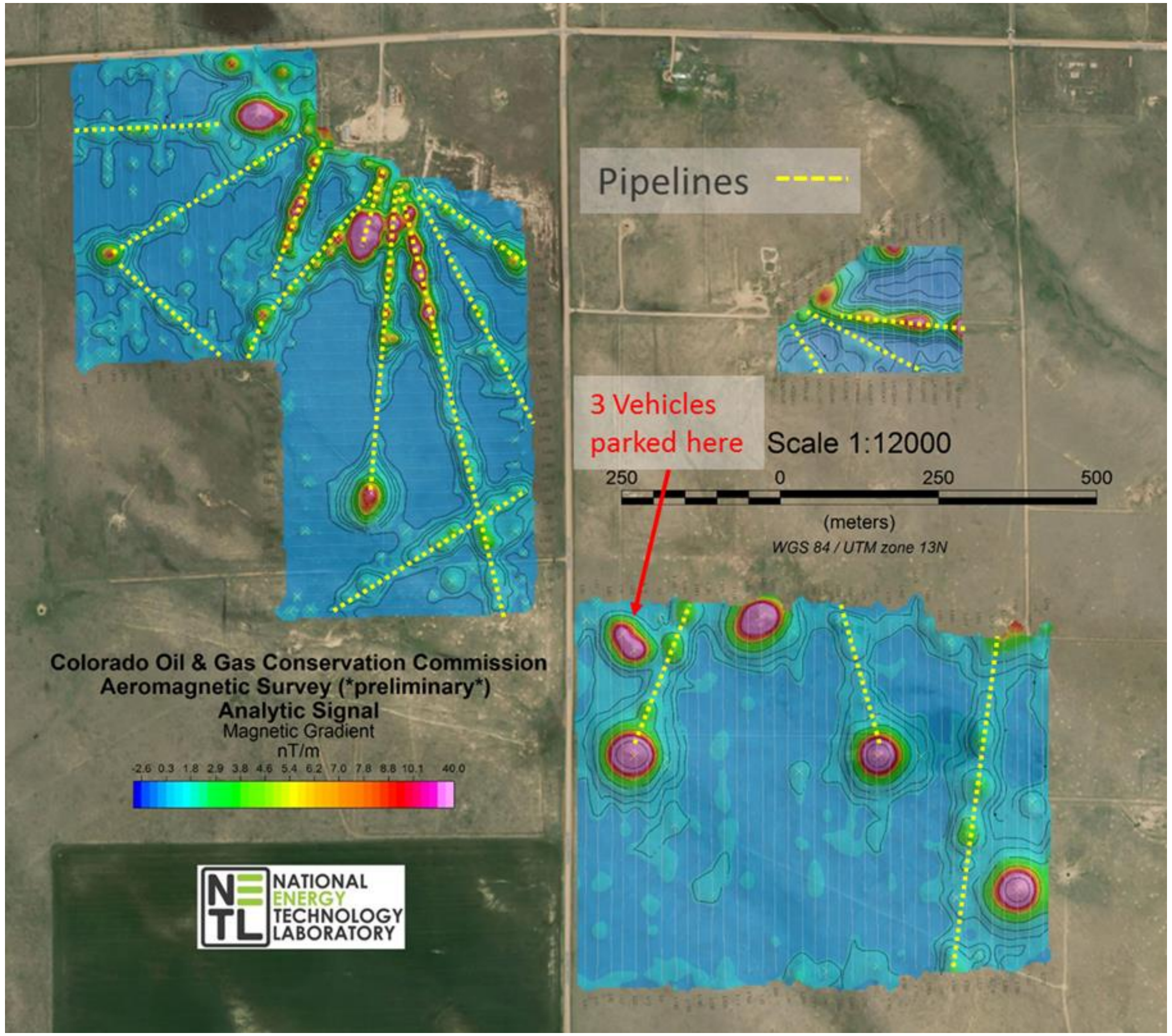




Colorado Test Site

Collaboration with Colorado Oil & Gas Conservation Commission





Results/Preliminary Conclusions

- 2-inch steel pipelines can be mapped using **magnetic sensors** at 8-m AGL and below.
- 4-inch steel pipelines can be mapped using **electromagnetic sensors** at 4-m AGL and below.
- Magnetic pipeline anomalies are discontinuous; electromagnetic pipeline anomalies are continuous
- Spiral magnetic surveys are more sensitive to pipelines and more time efficient
- Observed Problems:
  - Altitude too low for obstacle clearance
  - Pipeline anomalies are too broad:
  - COGCC requires +/- 1 meter
  - US DOE requires +/- 10 cm
  - Drone surveys less than 4m AGL have poor altitude control