

Quantifying & Locating Methane Emissions Using Autonomous UAVs

Dr. Peter Barber

Global Director of RNG Business Development

SeekOps Inc

EPA's Landfill Measurement Meeting

Agenda

Introduction of Technology

- From Oil and Gas to Biogas Operations
- Modeling & Uncertainties

Questions



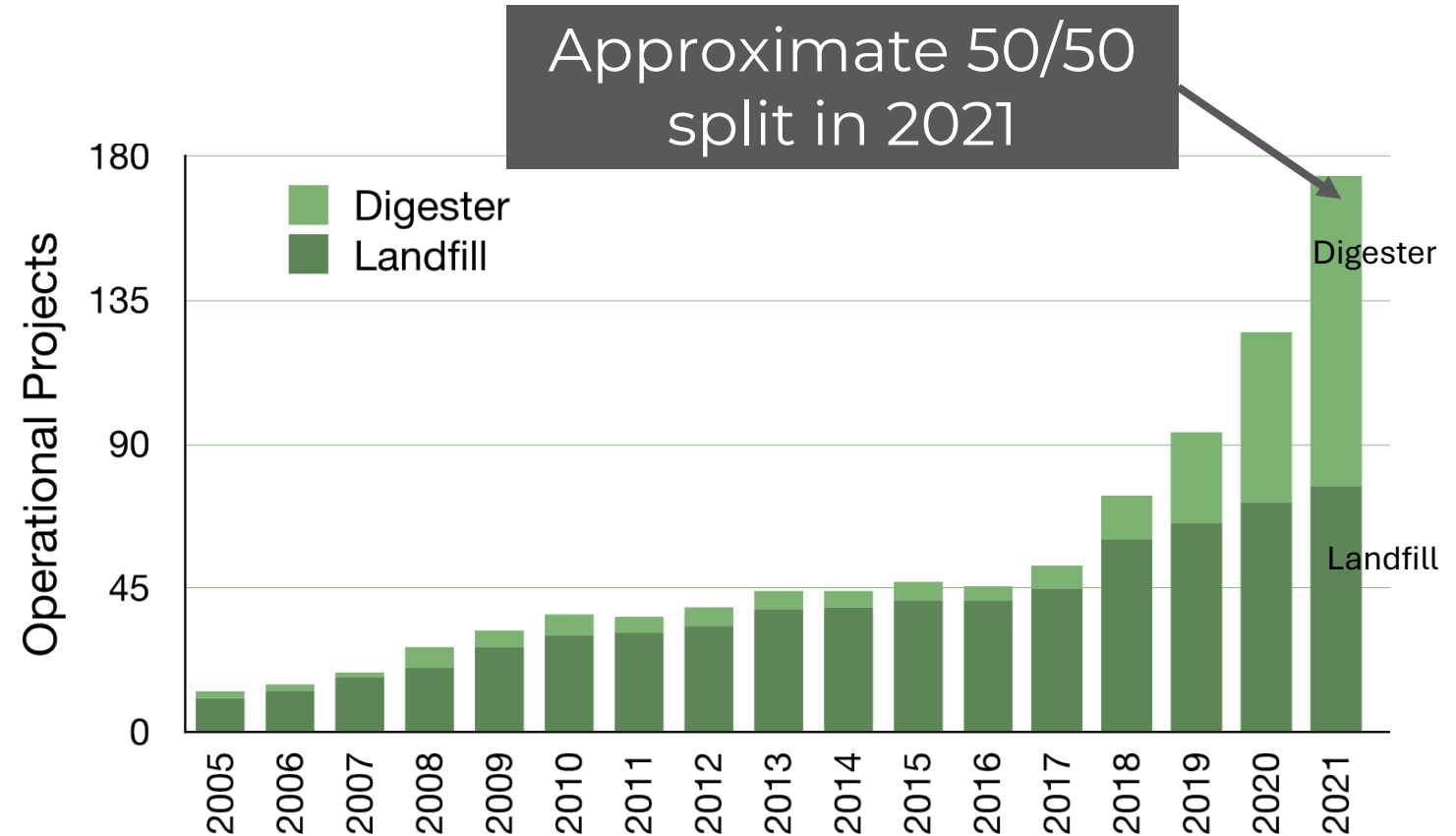
Landfill Case Study

- How landfill operators utilize our technology=

EPA identified 50/50 split in Ag Digester and Landfill RNG Projects

RNG is poised to bring about benefits like:

- Promoting Fuel Diversity
- Enhanced Economic Benefits
- **IMPROVED LOCAL AIR QUALITY**
- **REDUCED GHG POTENTIAL**



Adapted from US EPA: <https://www.epa.gov/lmop/renewable-natural-gas>

SeekOps Identified Methane Emissions from RNG Exceed O&G

Metric	Units	O&G Q2	RNG Q2	YTD 2022	Full Year 2021
Emissions identified by SeekOps technology	t CH ₄ / yr	42,307	75,341	121,084	34,399
Max leak	t CH ₄ / yr	4,582	11,094	16,445	6,620
Total area surveyed	km ²	8.75	9.35	18.42	20.6
Number of observations	#	1,226	341	1,635	469

- RNG emissions (biogas and landfill gas) exceed those from traditional oil and gas (~2x)

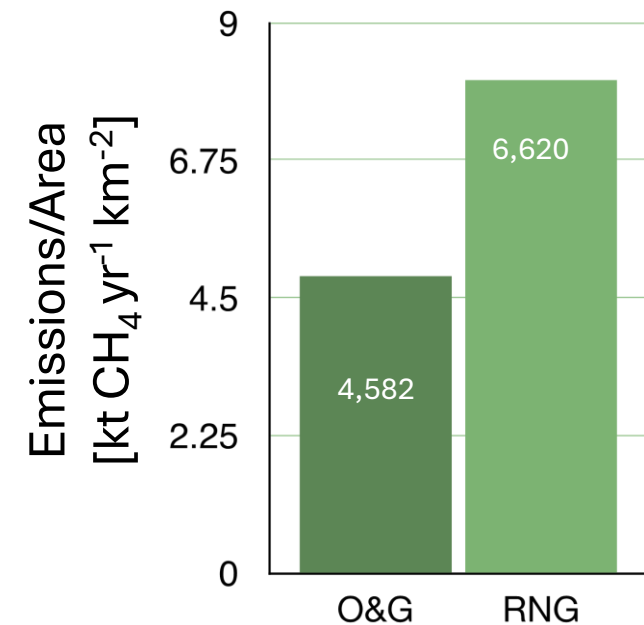


Figure: Emissions surveyed by SeekOps, normalized by area

Landfill Gas

Landfill Gas > Biogas in...



Area

Average 600 acres (~10x the size of a digester)

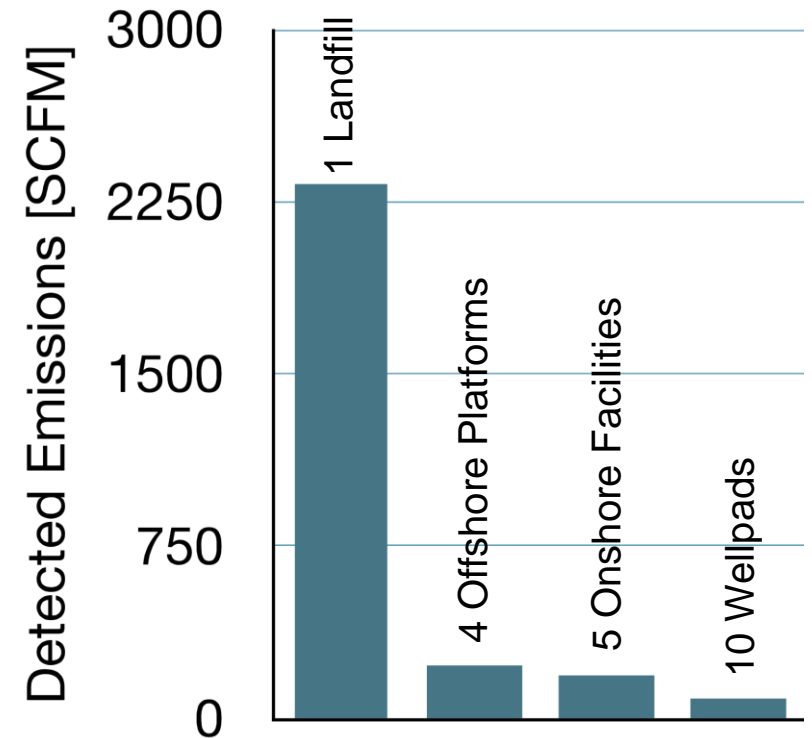
Our drone-agnostic technology can efficiently survey these sites autonomously



Emissions

Large emissions have been observed from landfills that have ~60 times more methane emissions

Our SeekIR has the dynamic range required for detection



SeekOps LDAQ Technology

Patented Technology

LDAQ™

1. Detection

Sensor can be deployed through our complete aerial solution or on the ground to detect CH₄ enhancements

2. Quantification

At emission detection, algorithms combine real-time wind measurements to provide a quantification of leak rate

3. Localization

After aerial emission quantification, our software estimates the locations of the leaks to inform repair activities



SeekOps Technology Provides Leak Detection and Quantification (LDAQ™). More on our technology can be seen at the link:

<https://www.youtube.com/watch?v=jtAVJHbRpPk>

SeekOps LDAQ Technology

Specs Summary

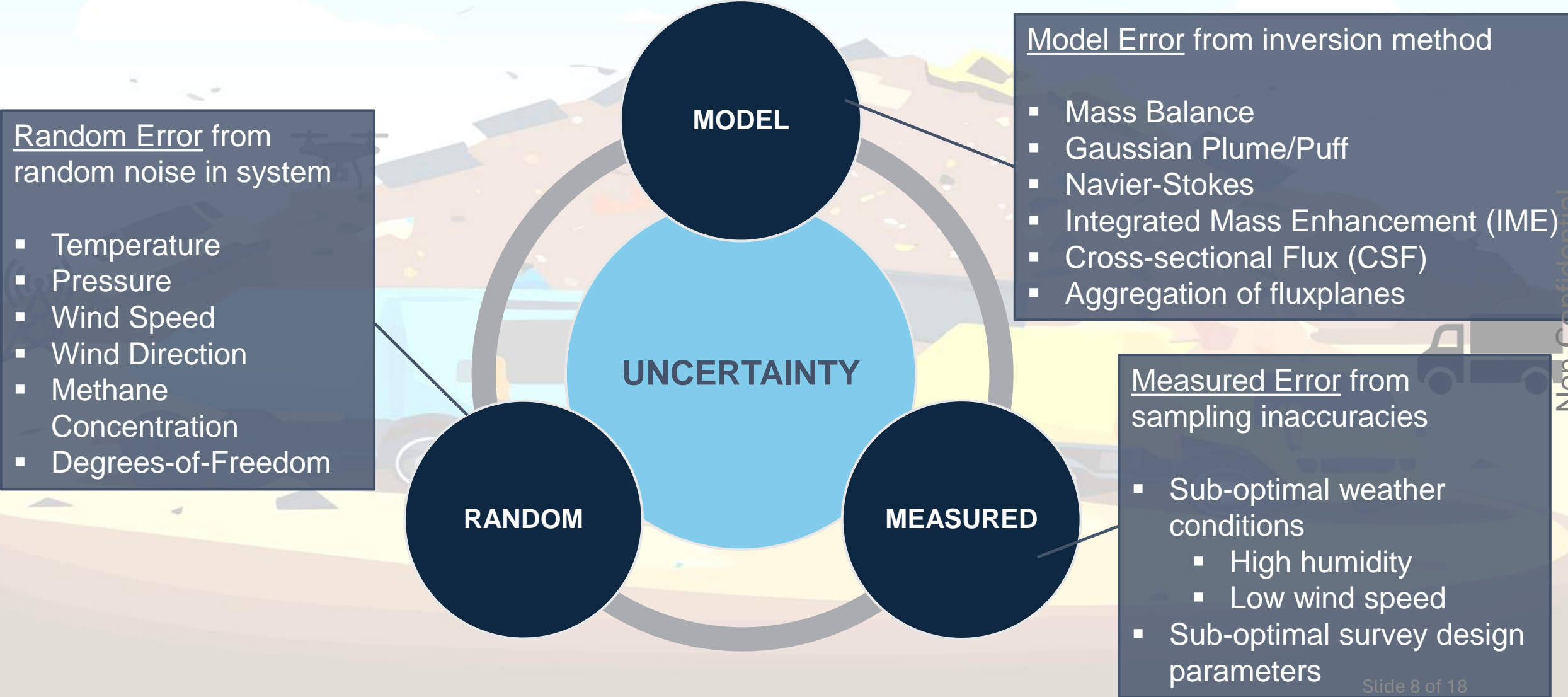
- SeekIR® Laser Absorption Spectrometer (LAS):
designed for industrial applications
- Tunable Diode LAS; Open Cavity
- High Sensitivity PPB
- Onshore detection limit = 0.02 kg hr^{-1}
- Lightweight < 600g
- Self-Contained Power/Communications
- Low Power (< 2W)
- Field-Proven, Repeatable & Consistent Workflows
- Actionable Reporting
- Automation



SeekOps Technology Provides Leak Detection and Quantification (LDAQ™). More on our technology can be seen at the link:
<https://www.youtube.com/watch?v=jtAVJHbRpPk>

Current Methane Quantification **Uncertainty** Landscape

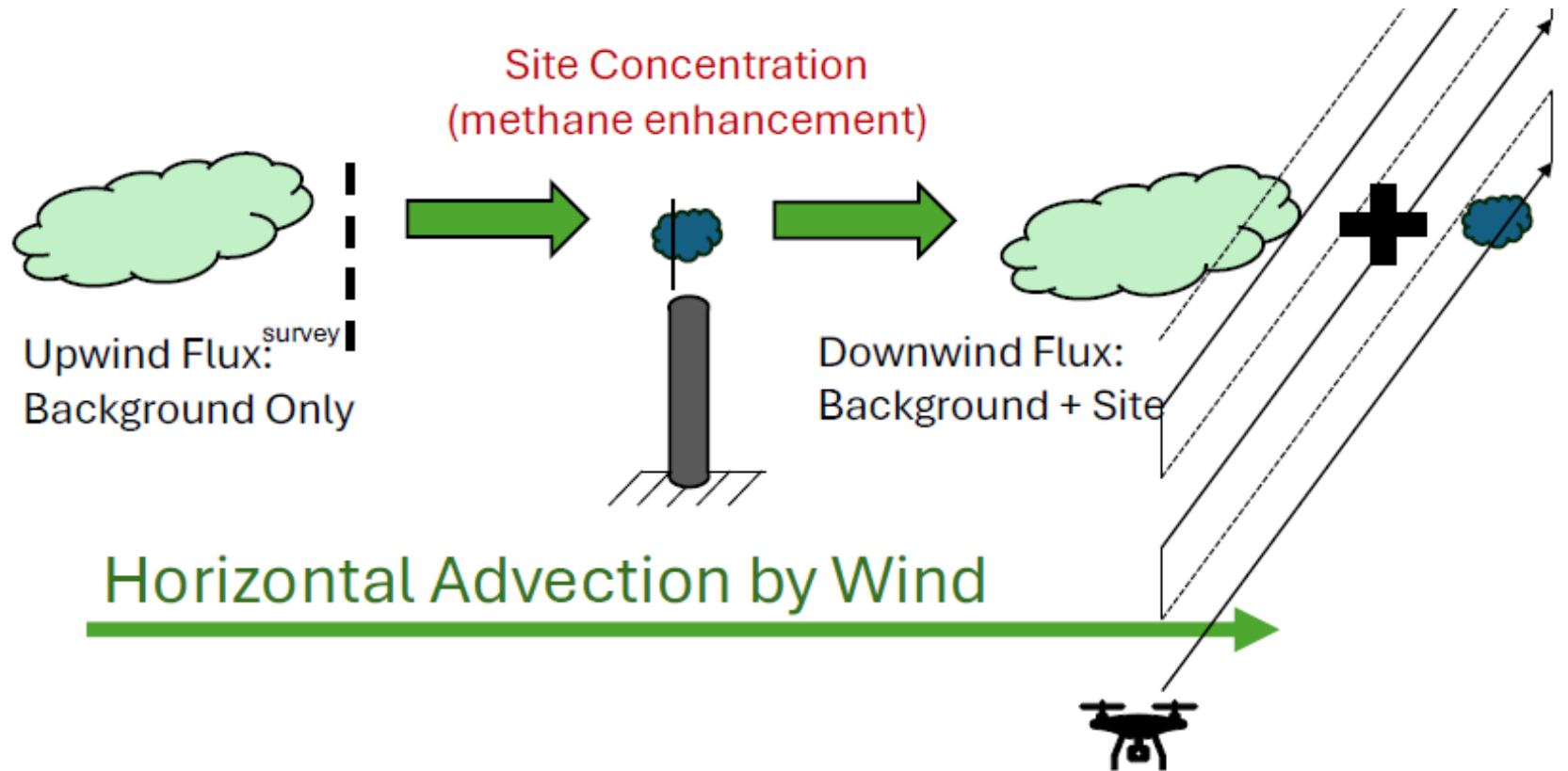
Spectrometers detect (measure) concentration (at different scales). Quantification requires knowledge (or assumptions) about the atmospheric state (i.e., $Q \sim f(T, P, \vec{V}, \chi)$) which introduces additional uncertainty.



Non-Confidential

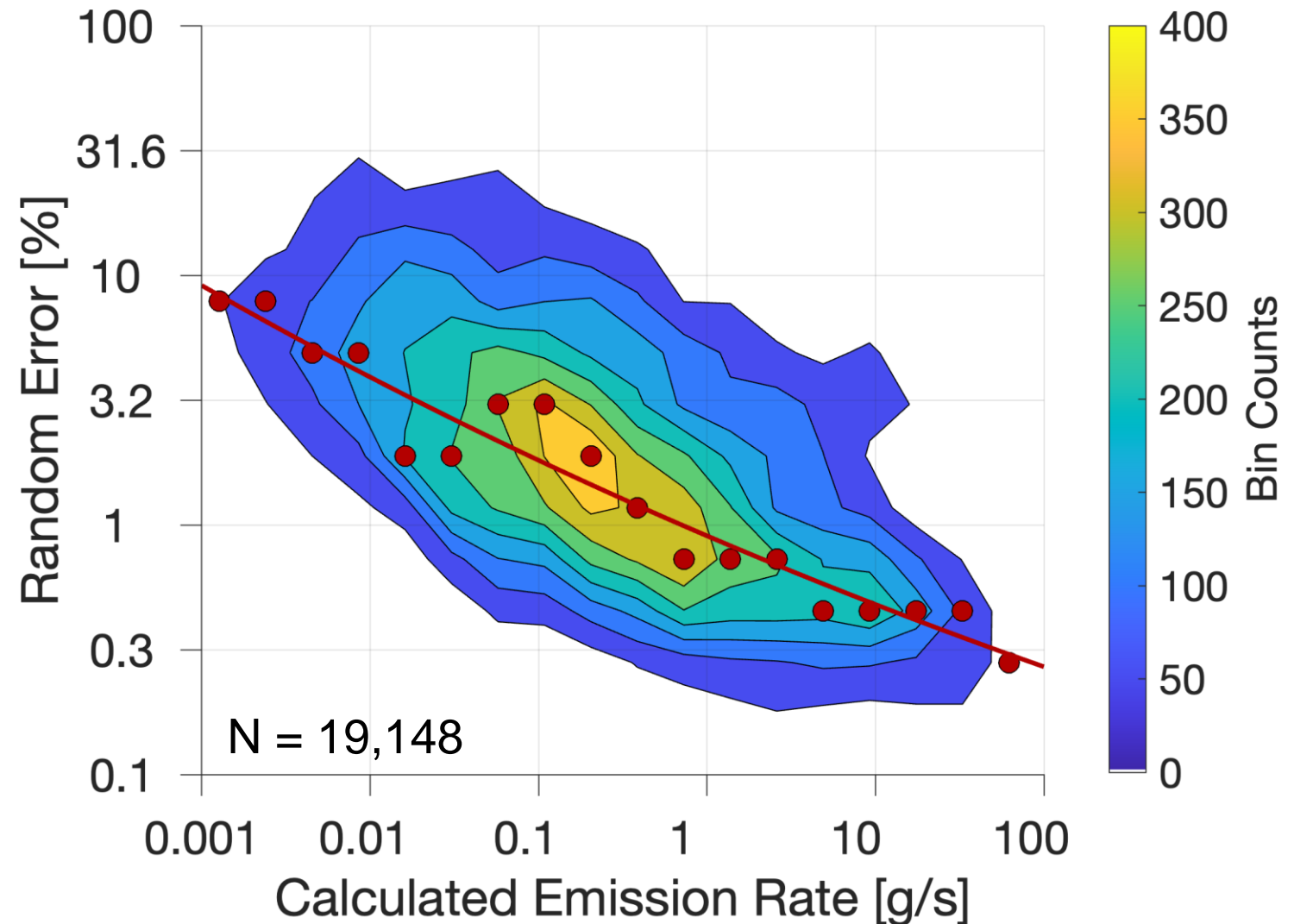
Methane Emissions Quantification is Achieved by Mass Conservation Principles

Site/Source Concentration determined based on Conservation of Mass Principle



**Distribution of SeekOps-
Calculated Random
Errors show majority
within 1-10%.**

Strong correlation between
random error vs emission
rate:
Higher emission rate, lower
random error



Non-Confidential

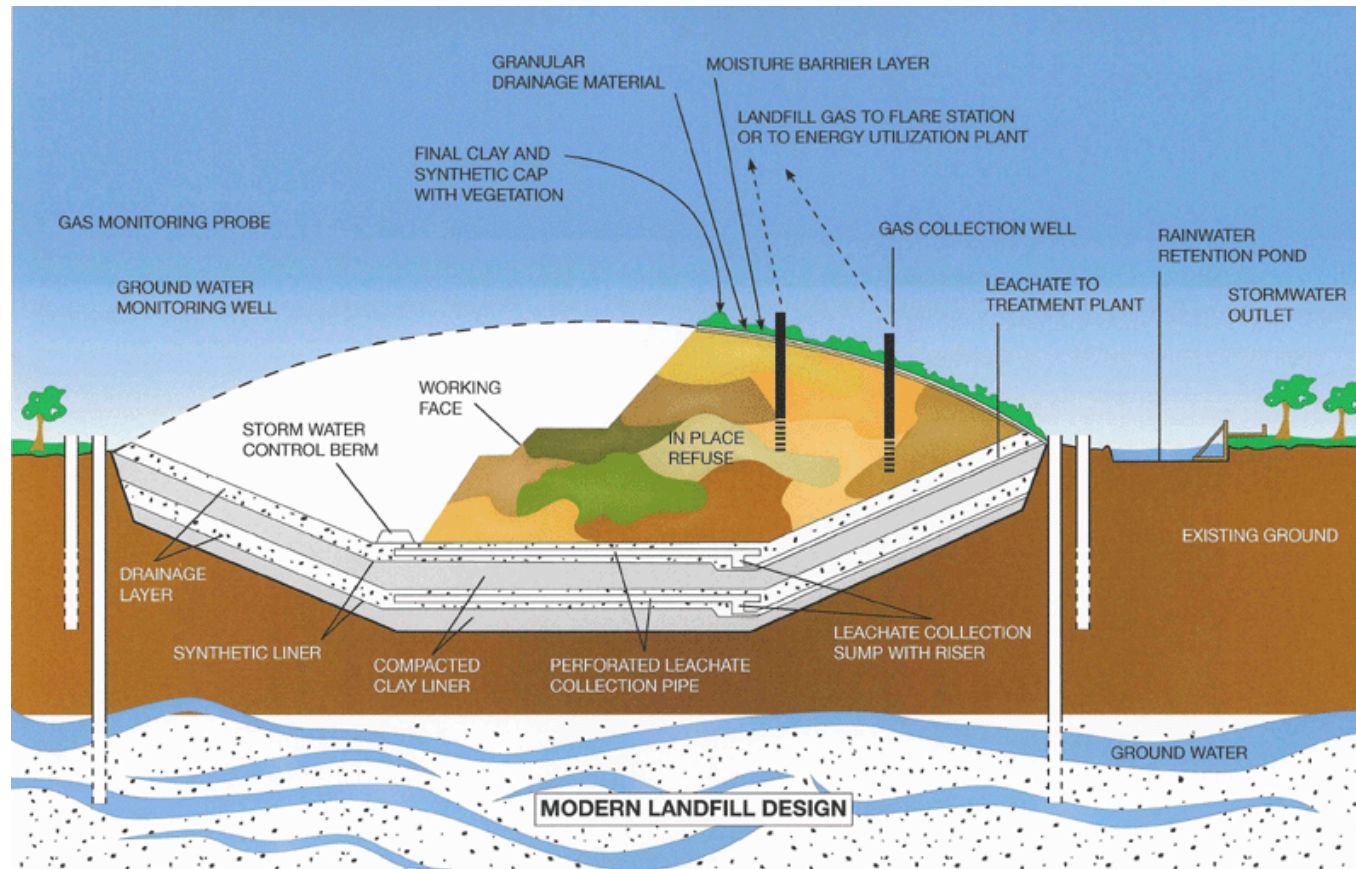
Current Methane Quantification Landscape



Non-Confidential

Landfill

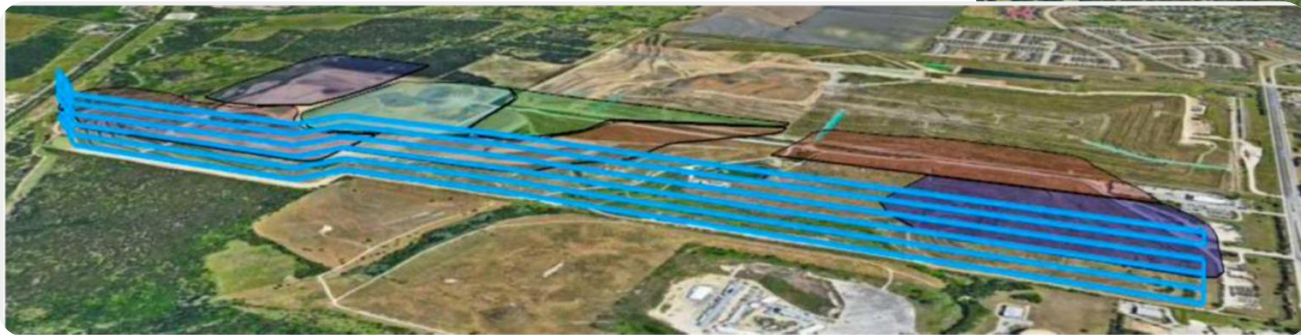
Typical Modern Landfill Schematic



- Many gas collection wells on the waste-in-place sections
- Some locations use the gas for local heat and power
- Active burial region has an ever-changing topology
- Some sites have constant burial from dawn to dusk
- Unobtrusive operations are essential

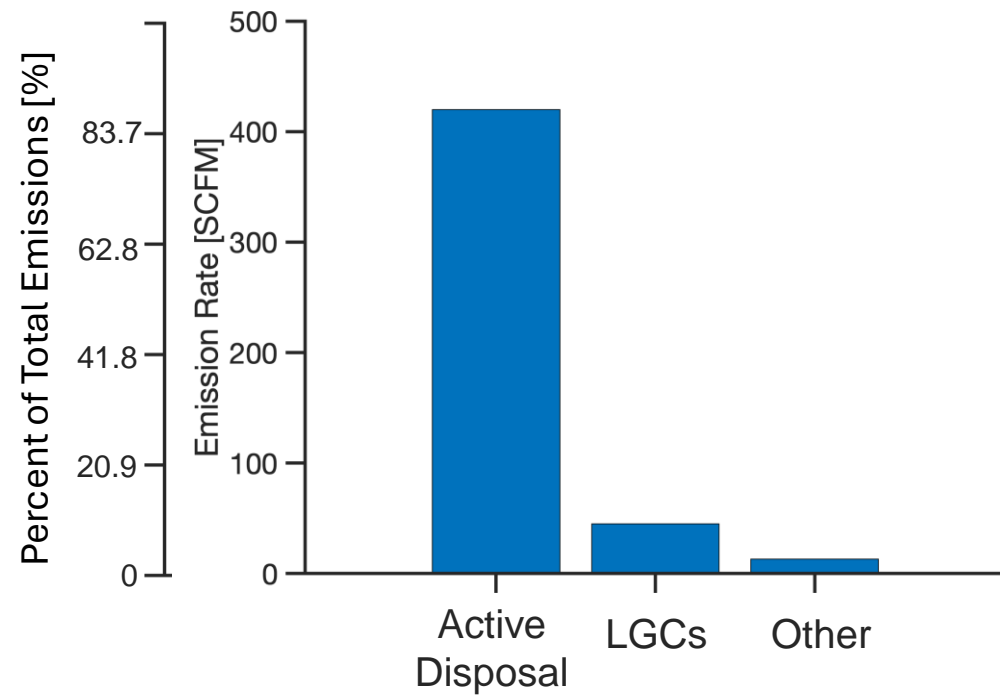
SeekIR and Landfill Gas

- Sector-Based or Whole-Site Quantification
- Drone flights can aggregate sectors to reach site-wide aggregates
- Alternatively, drone flights can fly the entirety of the site
- Emission rates compare within 2%
- Individual well-heads
- Gas collection and processing

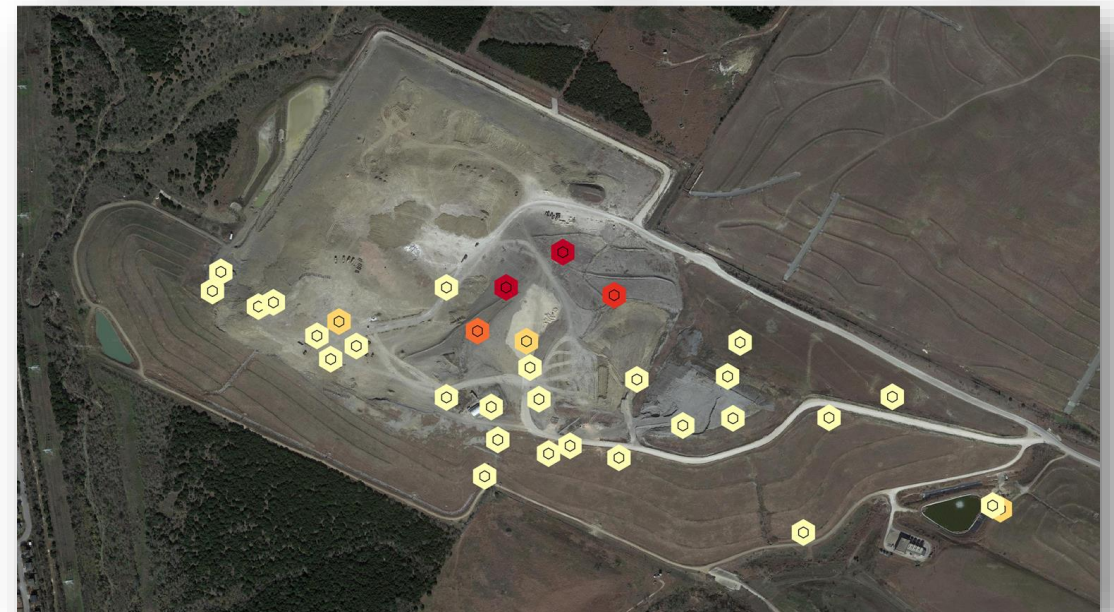


Landfill Gas

Sector Quantification

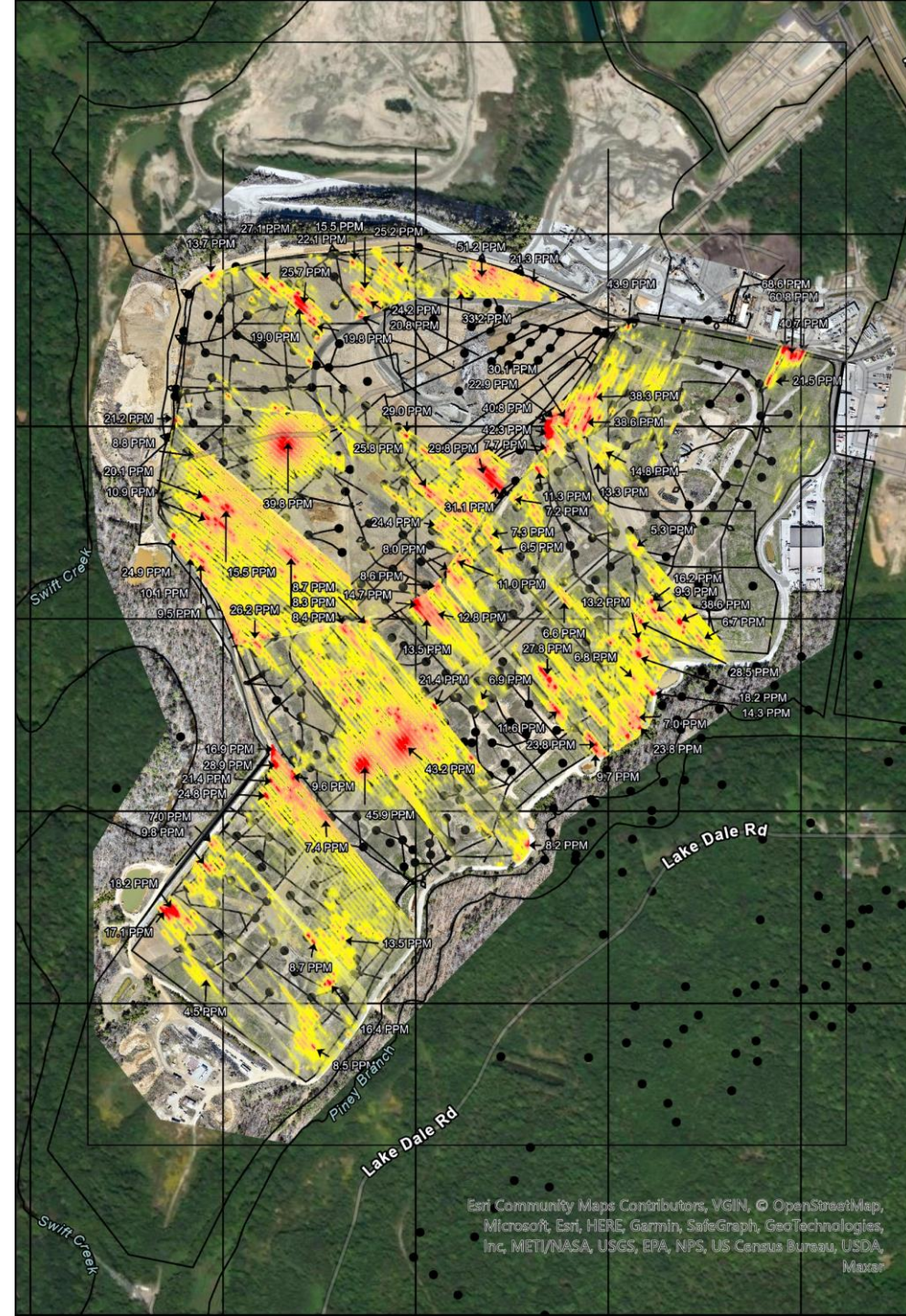


Emissions [SCFM]



- **Prioritize closest monitoring of active disposal areas and Landfill Gas Collectors (LGCs)**

Surface Emissions



Conclusions

SeekOps have the experience in identifying, quantifying, and locating methane emissions.

- **Extensive work within Oil & Gas and Biogas sectors**

Landfill operators currently employ our methane services.

- **for our higher precision and accuracy of measurement**
- **Incorporated to verify other measurement techniques**
- **Well-head optimal placement and optimized LFG collection**

This makes our technology a key enhancement to EPA's Method 21!

- **As well as NSPS and EGs**