From:	Methanestrategy, NM, NMENV
To:	Spillers, Robert, NMENV
Subject:	Fw: [EXT] Kairos Aerospace Comments on NMED Draft Methane Rule
Date:	Thursday, September 17, 2020 9:33:24 AM
Attachments:	Kairos Aerospace NMED Ozone Precursor Rule Comments 200916 signed.pdf

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From: Ryan Streams <ryan@kairosaerospace.com>
Sent: Wednesday, September 16, 2020 12:34 PM
To: NMOAI, NMENV; Methanestrategy, NM, NMENV; Kuehn, Elizabeth, NMENV
Subject: [EXT] Kairos Aerospace Comments on NMED Draft Methane Rule

Hello,

Please find attached comments on behalf of Kairos Aerospace. If you have any questions or concerns, please feel free to contact me.

Sincerely,
Ryan Streams

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Ryan Streams
Business Development Manager
Kairos Aerospace

Denver, CO
Direct: (435) 503-5392
ryan@kairosaerospace.com

KAIROS AEROSPACE

September 16, 2020

New Mexico Environment Department
Attn: Liz Bisbey-Kuehn
1190 St. Francis Dr.
Santa Fe, NM 87505

RE: 20.2.50 Proposed Oil and Natural Gas Regulation for Ozone Precursors Rule

Dear Ms. Bisbey-Kuehn:

Kairos Aerospace appreciates the opportunity to comment on the draft rules for the venting and flaring of natural gas and operation of gas gathering systems by the New Mexico Environment Department ("NMED"). As an alternative methane monitoring technology vendor, Kairos Aerospace is on the front lines of innovation. Since 2013, Kairos Aerospace has provided a range of aerial solutions to oil and gas industry clients and stakeholders to better understand emissions and operational efficiency. Using the latest aircraft-based methane spectrometry, thermal infrared, and optical imaging technologies, Kairos' proprietary data service identifies actionable opportunities for our customers to reduce emissions and improve field performance. Kairos currently operates full-time aerial surveys in Hobbs, New Mexico and Midland, Texas. To date, Kairos has helped oil and gas operators reduce more than 7 billion cubic feet of methane emissions from oil and gas infrastructure in the United States and Canada.

Executive Summary

Kairos has been actively engaged in the State of New Mexico's deliberative process to regulate methane emissions from the oil and gas sector. In our comments to the Methane Advisory Panel, submitted February 20, 2020, we identified the opportunities for cost-effective methane reductions that exist in southeast New Mexico based on peer-reviewed science and Kairos' measurements of tens of thousands of oil and gas facilities. Those comments are attached to this letter as Appendix A.

In our careful review of the proposed rules by NMED, we identified several areas where we believe the proposed rules can be strengthened without sacrificing the state's desired environmental outcomes. Our comments specifically focus on the approval and use of alternative monitoring technologies.

Stripper Well Applicability

In 2019, Kairos Aerospace conducted a large methane survey of the Permian Basin in southeast New Mexico to identify large sources of emissions. In total, Kairos surveyed over 30,000 active oil and gas wells in southeast New Mexico--93% of all active sites in the region. The 2019 Permian survey gives Kairos the ability to evaluate the emissions of many different types of emission sources, including marginal (or stripper) wells. We have analyzed the results from our survey and can offer several insights into the relative emission intensity of marginal vs. non-marginal wells. The full analysis is presented in Appendix B, which we will summarize here.

For this analysis, a marginal well is defined as an oil well that produces 10 or fewer barrels of oil or a gas well that produces 60 MCF or fewer of gas per day. Kairos data reveal several noteworthy trends for marginal wells. First and foremost, Kairos analysis finds that marginal wells tend to emit less frequently than non-marginal wells, and when they do emit, the measured emissions are typically lower than non-marginal well emissions. This trend holds true for both marginal oil and gas wells. Kairos also found that although there are more marginal wells than non-marginal wells in southeast New Mexico, non-marginal wells are responsible for most of the upstream emissions. In total, non-marginal wells represent 86% of upstream oil and gas methane emissions, while marginal wells represent 14%. Marginal well emissions are dominated by oil wells when compared to gas wells in southeast New Mexico. Marginal oil wells are responsible for 12% of upstream methane emissions, while marginal gas wells are responsible for 2%. However, marginal oil wells greatly outnumber gas wells in the southeast, 14,724 to 4,230.

Marginal oil and gas wells do differ in a few significant ways. Our analysis finds that marginal gas wells are more likely to have emissions than marginal oil wells, but that marginal oil well emissions are typically larger than what we observe from gas wells. Overall, marginal gas wells have slightly smaller average emissions despite having more frequent detectable emissions. Notably, we find the lowest producing marginal wells--oil wells that produce less than 5 barrels of oil or 30 MCF of gas per day--have lower emissions than marginal wells with higher production.

Kairos is not in a position to comment on what the right threshold is for regulation--that is a policy decision. What we can say with high confidence, however, is that marginal wells do contribute methane emissions in southeast New Mexico, but at a much lower frequency and total rate than non-marginal wells.

Rule Applicability

We understand that the proposed rule applies to "natural gas production, processing, transmission, and storage includes the well and extends to, but does not include, the local distribution company custody transfer station." We request clarification whether transmission includes low-pressure and low diameter rural gas gathering lines, and whether the processing, transmission, and storage segments are subject to monitoring requirements for above-ground equipment only, or whether below ground pipelines are also subject to the rule.

Monitoring Requirements

We appreciate that NMED is seeking comment on alternative monitoring provisions within the rule. We believe that as currently drafted, the alternative monitoring requirements will likely limit the deployment of new advanced monitoring techniques in the state. We strongly recommend the state make a number of changes in order to make alternative monitoring more accessible and useful to industry in New Mexico.

First, the requirement that only facility operators themselves must submit an alternative compliance plan is flawed. While we agree that alternative monitoring plans should be equivalent, effective, and enforceable, facility operators may not necessarily be the best qualified applicants to make those kinds of demonstrations.

For example, Kairos Aerospace surveyed 40,000 sites in the Permian Basin in 2019, and will survey more than 130,000 in 2020. We are far and away the most qualified subject matter experts to discuss the strengths and limitations of our system, particularly regarding the technical details like detection limit, quantification accuracy, false positive rates, and other key metrics NMED will need to evaluate to determine equivalency. While some large operators may have in-house personnel who are experts in emissions monitoring, none will have more expertise regarding Kairos technology than our own technical experts. Moreover, many small and mid-sized operators may not have *any* in-house personnel with subject matter expertise. The requirement that any company must develop and submit a compliance plan will make alternative monitoring effectively unobtainable for them.

Small operators will certainly be disadvantaged under this approach, and it is unclear what benefit the state derives from only operators being able to submit alternative compliance plans. The state could easily accept applications from operators, while also allowing vendors and industry organizations like trade associations, or others with a vested interest and credible expertise, to also apply for alternative monitoring approval.

Under this approach, a vendor or other interested party could outline the technical requirements for successfully operating an alternative monitoring program. A facility operator could then reference this information in an application, but it would be very difficult for an operator to define an alternative monitoring program without substantive input from a vendor or other monitoring technology expert.

Second, limiting approval of alternative technologies on an operator-by-operator basis will again severely limit the speed at which new technology can be implemented while creating substantial and duplicative workloads for NMED staff. By way of illustration, oil and gas assets are regularly sold and operated by different companies. Under the current rule structure, it is plausible that after an acquisition, the same wellpad that had approval under one company monitoring plan would need to re-apply to use the same technology and same plan under a new company. Applications for alternative monitoring can be tailored such that once approved, they can be applicable on a much broader basis. We recommend statewide approval under defined criteria (i.e. daytime operations, operations under certain environmental conditions, operations at certain kinds of facilities, etc.) regardless of which company happens to be operating a particular site at a given time. Much in the same way that an OGI camera is capable of identifying emission in the hands of a qualified thermographer regardless of site ownership, a Kairos spectrometer is capable of detecting emissions with the same efficacy regardless of site ownership.

This would also serve to eliminate a largely duplicative paperwork exercise for NMED. There are hundreds of companies operating oil and gas wells in New Mexico and reviewing alternative monitoring applications for the same technology (or technologies) from each of them would create a significant burden on State resources without commensurate environmental benefit.

Third, we suggest the State reconsider the requirement to maintain records of who operates the equipment, as it does not fit with collaborative workflows and may not necessarily provide the state with much value. As an example, Kairos instruments are flown on light aircraft which are crewed by a pilot and an observer. Both play important roles in our data collection process. The pilot needs to maintain proper flight conditions to ensure data quality; the observer conducts instrument checks to ensure our pod system is functioning properly. Once on the ground, the data is uploaded and processed, where it is then reviewed by a multidisciplinary team of Kairos scientists. As a part of our standard QA/QC of all data, our suspected detections are reviewed by a hardware expert, a R&D team expert, and an operations expert. Each person brings an important perspective and can provide contextual information that we use to ensure data quality. This team of analysts typically rotates, sometimes multiple times in a day. It is unclear how recording an “operator” name would capture this collaborative workflow that underpins Kairos’ ability to deliver highly accurate data to our clients. Given this, we recommend this reporting requirement be removed from the proposed rule.

Alternative Monitoring Approval Process

The process by which the state evaluates and approves alternatives to OGI and Method 21 technologies for fugitive emissions monitoring will be critical in whether new technology is able to flourish in New Mexico or whether its deployment is stifled as we’ve seen in other jurisdictions. Given the critical importance of this step, we wish to offer our perspective on fundamentally how alternative monitoring should be evaluated.

Equivalency Evaluation

The most important question is how one deems a technology to be equivalent with other methods. When the comparison is between models of handheld OGI cameras, the comparison is relatively straightforward; when the comparison is between a handheld camera, a fixed monitor, and a satellite, things become much more complicated. Establishing the standards by which alternative technologies can be judged equivalent is perhaps one of the most complex elements of this entire rulemaking; the state must consider both alternative technologies in the marketplace today while also providing room for new and even better solutions to emerge.

Alternative technologies by their very nature will take fundamentally different approaches to identifying emissions. Device sensitivity must be balanced with speed of deployment. A device’s ability to quantify, its false positive (and false negative) rates must be considered as well. Fundamentally, good policy will focus on equivalent *outcomes* rather than equivalent *processes*. In other words, a technology doesn’t need to be able to identify the same leaks in the same way but rather must reduce an equivalent amount of total emissions.

Some stakeholders have been advocating for specific thresholds that appear to benefit their preferred technology over others based on self-interest. Some have argued, without evidence, that a 1 kg/hr rate of methane detection is the optimal threshold by which alternative technologies should be judged. At best, this misunderstands the alternative monitoring evaluation process. At worst, it's an attempt to obfuscate the issue in order to game a regulatory process for personal benefit.

Fundamentally, New Mexico cannot establish one single detection limit which alternative technologies need to meet, because that would both fail to consider other important considerations like survey frequency, and would potentially limit new technologies from penetrating the market. For example, a 1 kg/hr detection limit would essentially ban the use of any current or future satellite technology in New Mexico for the purpose of leak detection. Such a prescriptive limit would severely restrict the State's ability to encourage new technology, which would be out of step with its stated desired outcomes.

For an aerial screening tool like the one deployed by Kairos Aerospace, we sacrifice instrument sensitivity for greatly increased speed. This means we can survey many sites in the time that a ground-based crew could survey a relative handful. It also means that we can survey more frequently for the same or lower cost than a more expensive ground-based technique.

Under the proposed rule, New Mexico has selected varying inspection frequencies based on the potential to emit (PTE) of a particular site. For a technology like the one used by Kairos, we must conduct wide area surveys in order to achieve the economy of scale needed to make our product competitive. It would make little sense to deploy an airplane to inspect five sites, for example. Where this becomes problematic is if there are many sites that have varying inspection calendars and revisit times. One can envision a scenario in which to make up for the reduced sensitivity of aerial monitoring, it would take two flyovers of a site to be equivalent to one OGI inspection. If an operator has 10 sites with >25 tpy PTE and 100 sites with 3 tpy PTE, they would need to fly 10 sites eight times per year, and 90 sites twice per year. For multiple operators and multiple tiers of sites, this quickly becomes untenable from a cost and logistical perspective. If Kairos were to fly a handful of sites 8 times per year, we would almost certainly cover many others in the course of our flight plans, but an operator would have no way to claim credit for those extra flights (and the emission reductions they produce).

What we suggest NMED consider is an aggregated, program-level equivalency demonstration. What this means is that instead of flying 10 sites eight times, and 90 sites twice, the operator could fly (as an example) all 100 sites four times provided that leads to equivalent emission reductions as the traditional monitoring approach. By revisiting some sites more frequently than required, an operator would further reduce emissions from those facilities. Using a sufficiently frequent revisit schedule, this could offset less frequent visits of other sites. It would also greatly increase flexibility for operators in how inspections can be performed, and using sufficiently robust criteria to assess equivalency, would still provide the desired emission reduction benefits. Taking an aggregated view of emissions also comports with EPA's logic in its Source Determination (or Source Aggregation) Rule. That rule stipulates conditions that a collection of facilities may be treated as a single source for permitting and compliance purposes. In this rule, EPA recognized that there are certain conditions for which it can make sense to look at emissions from oil and gas production facilities (which are often interconnected) in concert.

Without a program-level equivalency demonstration, alternative monitoring programs will be much more complicated to administer and will lack a mechanism to claim credit for more frequent inspections at certain sites. This in turn would greatly limit the utility of screening tools despite the clear emission reduction benefit they provide.

At the heart of this kind of equivalency evaluation is understanding the relative magnitude of emissions originating from the largest leaks. As documented in the scientific literature and confirmed by Kairos, the largest 5% leaks are responsible for the majority of oil and gas emissions. Our MAP comments provide extensive documentation of this principle. But to put into context for equivalency, consider how the emission reduction from catching a single large leak sooner compares to other emission reduction opportunities.

A typical leak measured by Kairos in the Permian Basin emits 88 MCF/day, but some sources can emit far more than that. A typical gathering line leak is 268 MCF/day, and unlit flares can be as large as 17,000 MCF/day. Retrofitting a single pneumatic controller only saves 0.7 MCF/day at a cost of $1,850 per device.[1] In two weeks, eliminating one 88 MCF/day leak saves as much gas as a pneumatic controller replacement would over *five years*. Meanwhile, fixing one 268 MCF/day gathering line leak reduces emissions at the same rate as spending $700,000 to replace 382 pneumatic controllers. And eliminating an unlit flare, which can emit millions of cubic feet of gas per day, reduces a similar amount of gas in just two days as switching a compressor station from wet seals to dry seals saves in an entire year--while costing hundreds of thousands of dollars less.[2]

Some groups may argue that all emission monitoring technologies need to deliver site-level reductions rather than taking a programmatic view. Such a policy, however, would bias regulations against screening technologies. By allowing aggregated, program-level equivalency demonstrations, the State does not preclude site-level determinations from being considered as well. Fundamentally, the aggregated approach offers more choice and more cost-effective tools to reach the desired policy outcome: reduced emissions from the oil and gas sector. We urge the state to view arguments against allowing the option of aggregated equivalency demonstrations with appropriate caution.

Supporting Evidence for Equivalency Determinations

In addition to determining how alternative monitoring technology equivalency will be judged from an emission reduction standpoint, the state must also consider the evidence it will need in order to assess the validity of claims about a particular technology's capabilities. In order to accurately assess how well a particular alternative technology will perform we recommend the state require the following:

Independently validated controlled release data - Technology performance should be assessed by a credible and qualified third party that has no commercial interest in the success of a technology. The independent validation should examine detection limit, location accuracy, quantification accuracy,

[1] https://www.epa.gov/sites/production/files/2016-06/documents/ll_pneumatics.pdf

[2] https://www.epa.gov/sites/production/files/2016-06/documents/ll_wetseals.pdf

false positive rate, and performance under differing environmental conditions. A technology should in turn only be approved for use under the environmental conditions required for good data quality. As an example, Kairos' reflected sunlight spectroscopy system should not be approved for night use or in heavy clouds, which limit available sunlight.

Demonstrated field use - Technology performance at the bench-scale or even in controlled release situations is valuable but incomplete. Real-world experience with detecting emissions from active facilities is essential in evaluating the technology's capabilities. Onshore applications, ideally in New Mexico or states with similar operating environments and climates, are extremely important. Many factors like topography, temperatures, humidity, latitude, etc. can play a role in an instrument's performance.

Modeled equivalency data - In order to determine equivalency, an alternative monitoring technique should be compared to baseline requirements and evaluated for emission reduction capabilities. Models like the Fugitive Emissions Abatement Simulation Testbed (FEAST) model can be useful for making these comparisons, particularly across a wide number for sources. As much as possible, models should use transparent parameters and yield reproducible results.

Conclusion

We appreciate the opportunity to provide feedback to NMED on the draft rule. We appreciate the thoughtful, data-based approach the State has taken to its methane rulemakings. We believe that with the changes suggested in this letter, the State's strong start can be built into a robust program that also effectively leverages the many benefits which alternative methane monitoring technologies can provide.

At Kairos Aerospace, we are excited to use our innovative methane monitoring technology to work with industry and the Agencies to reduce methane emissions faster and at a lower cost than traditional monitoring technologies. We've identified and mitigated billions of cubic feet of emitted natural gas through aerial monitoring. We've also eliminated thousands of hours of vehicle trips and improved safety in the field for operations personnel. This has all been done on a voluntary basis and we believe that with industry able to use aerial monitoring as a regulatory compliance tool, the benefits will be even greater. We look forward to being able to use our technology nationwide to help the oil and gas industry quickly and safely reduce methane emissions.

Sincerely,

Steve Deiker
CEO

Appendix A
Kairos Aerospace Comments to the Methane Advisory Panel

February 20, 2020

New Mexico Environment Department
New Mexico Energy, Minerals, and Natural Resources Department
Attn: Sandra Ely
1190 St. Francis Dr.
Santa Fe, NM 87505

RE: New Mexico Methane Advisory Panel draft technical report

Dear Director Ely:

Kairos Aerospace appreciates the opportunity to comment on the draft Methane Advisory Panel technical report ("the Report") produced by the stakeholder group convened by the New Mexico Environment Department and the New Mexico Energy Minerals and Natural Resources Department ("the Agencies"). As an alternative methane monitoring technology vendor, Kairos Aerospace is on the front lines of innovation. Since 2013, Kairos Aerospace has provided a range of aerial solutions to oil and gas industry clients and stakeholders to better understand emissions and operational efficiency. Using the latest aircraft-based methane spectrometry, thermal infrared, and optical imaging technologies, Kairos' proprietary data service identifies actionable opportunities for our customers to reduce emissions and improve field performance. To date, Kairos helped oil and gas operators reduce more than 4 billion cubic feet of methane emissions from oil and gas infrastructure in the United States and Canada.

Executive Summary

As MAP panelists detail in the Report, traditional ground-based leak detection and repair (LDAR) techniques can impose significant costs on oil and gas facility operators. However, panelists also correctly identify that fugitive emissions from oil and gas facilities can be significant and are worthy targets of emission reduction efforts. It's clear that what's needed is a low-cost leak detection technique that can reduce emissions without imposing significant additional operating costs.

Kairos' airborne monitoring system achieves greater emission reductions than optical gas imaging (OGI) by finding large leaks earlier and at a fraction of the cost. With a single aircraft, Kairos surveys up to 2,000 oil and gas facilities per day, compared to approximately 4-6 per day for a ground-based OGI operator. However, without sufficiently flexible regulations that foster the use of new technologies, many oil and gas companies will default to OGI and forego the environmental benefits of airborne monitoring.

We encourage the Agencies to adopt flexible regulations that address methane emissions and provide ample pathways for alternative technologies that can demonstrate effectiveness as emission reduction techniques. The Agencies must recognize the importance of super-emitters and the ability of new monitoring methods to find them. A small number of large leaks cause the majority of fugitive emissions. This is often called a “fat-tail” or “super emitter” leak distribution. Finding and repairing a single super emitter accomplishes more, in terms of emission reductions and cost savings, than repairing a host of small leaks. While OGI and Method 21 are limited in their ability to find super-emitters due to their relatively long inspection times, the technologies being developed today find large releases quickly by inspecting multiple facilities across large geographic areas, more frequently, and at lower cost.

Rather than focusing on detection equivalence with traditional OGI and Method 21 technologies, we urge the agencies to evaluate methane mitigation strategies based on mitigation equivalence. Detection equivalence at an individual site is an outdated metric that sheds little light on whether new monitoring technologies achieve emission reductions that are equivalent to OGI. The Agencies should instead evaluate whether the overall emission reductions achieved across many facilities are equivalent to those of OGI.

Fugitive Emissions Are Significant and Worthy of Regulatory Oversight
The Report correctly identifies that fugitive emissions can contribute significant methane emissions, particularly from sites commonly referred to as super emitters. Based on Kairos’ extensive experience in surveying approximately 30,000 oil and gas production facilities in southeast New Mexico, our data support the conclusion that a small number of facilities represent the majority of total methane emissions.

In the course of surveying southeast New Mexico for methane emissions, Kairos identified 1,056 emission sources out of the 30,000+ active wells and 10,000+ miles of gathering lines in the region. The median emission size Kairos identified was 88 MCF per day, with a 90th percentile rate of 441 MCF per day. In other words, Kairos found approximately 100 sources of emissions across the entire that were emitting more than 441 MCF per day, which indicates a relative handful of sites are strongly skewing the total emissions for the basin.

Our survey results reflect the broader consensus in the scientific community, which is referenced in the Report: a small number of sites are responsible for significant emissions and those sites appear to have an element of randomness to them.

That points to two important conclusions. First, there are sites in New Mexico today that are contributing significant methane emissions. Second, those sites are relatively uncommon but identifying them quickly can lead to very rapid emission reductions. In other words, it would take many, many equipment retrofits to achieve the same level of emission reductions that would be achieved by strategically identifying and eliminating all 100 sources that are emitting greater than 441 MCF per day.

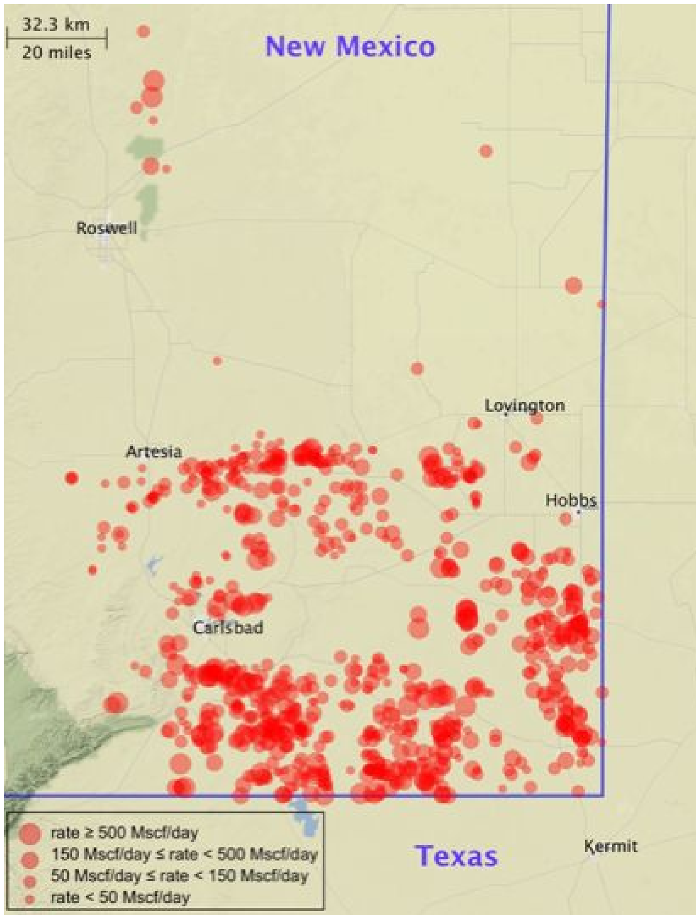

Fig. 1: Kairos 2019 survey results from the New Mexico Permian Basin

The Report also references several scientific studies that point to the outsized impact super-emitters play in total emissions.[3] Kairos has conducted similar comparisons to expected emissions based on

[3] Papers cited include: Rella, Chris W., et al, (2015), "Measuring Emissions from Oil and Natural Gas Well Pads Using the Mobile Flux Plane Technique," Environ. Sci. Technol., 2015, 49 (7), available at http://pubs.acs.org/doi/abs/10.1021/acs.est.5b00099, See, e.g., Allen, D.T., et al., "Measurements of methane emissions at natural gas production sites in the United States," Proc. Natl. Acad., 110 (44) pp. 17768–17773 ("Allen (2013)"), available at http://www.pnas.org/content/110/44/17768.full; ERG and Sage Environmental Consulting, LP, "City of Fort Worth Natural Gas Air Quality Study, Final Report" ("Fort Worth Study") (July 13, 2011), available at http://fortworthtexas.gov/gaswells/default.aspx?id=87074 (finding that the highest 20 percent of emitting sites account for 60–80 percent of total emissions from all sites; the lowest 50 percent of sites account for only 3–10 percent of total emissions); Zavala-Araiza, et al., (2015) "Toward a Functional Definition of Methane Super-Emitters: Application to Natural Gas Production Sites," Environ. Sci. Technol., 49, at 8167−8174 ("Zavala-Araiza (2015)"), available at http://pubs.acs.org/doi/pdfplus/10.1021/acs.est.5b00133 (finding that "functional super-emitter" sites represented approximately 15% of sites within each of several different "cohorts" based on production, but accounted for approximately 58 to 80% of emissions within each production cohort); Zavala-Araiza et al., (2015) "Reconciling divergent estimates of oil and gas methane emissions," Proceedings of the National Academy of Sciences, vol. 112, no. 51, 15597 at 15600 (finding that "at any one time, 2% of facilities in the Barnett region are responsible for 90% of emissions, and 10% are responsible for 90% of emissions.") ("Barnett Synthesis")

component-level emission measurements, and found that isolated large sources of emissions are likely responsible for the majority of methane being emitted in southeast New Mexico.

For example, Kairos conducted a comparison with the University of Texas (UT) and Environmental Defense Fund's (EDF) study of site-level emissions at 150 sites.[4] Kairos compared the measured number of leaks and emissions from those leaks in that study to the actual number of sites that Kairos found to be emitting in New Mexico, and the emission rates measured by Kairos. Their study examined 489 wells at 150 sites, identifying 769 sources of emissions. Scaled basin-wide in New Mexico, that would translate to over 47,000 leaks from New Mexico's 30,000 active wells. The study also calculated emission rates from its observed leaks.

Kairos evaluated its own survey data and determined that approximately 2% of leaks (based on UT-EDF study leak frequency) are responsible for 73.5% of basin-wide methane emissions (based on UT-EDF study emission measurements.) In other words, Kairos data both confirms the existence of the fat-tail distribution of methane as well as provides an operational tool to find and address these very same sites.

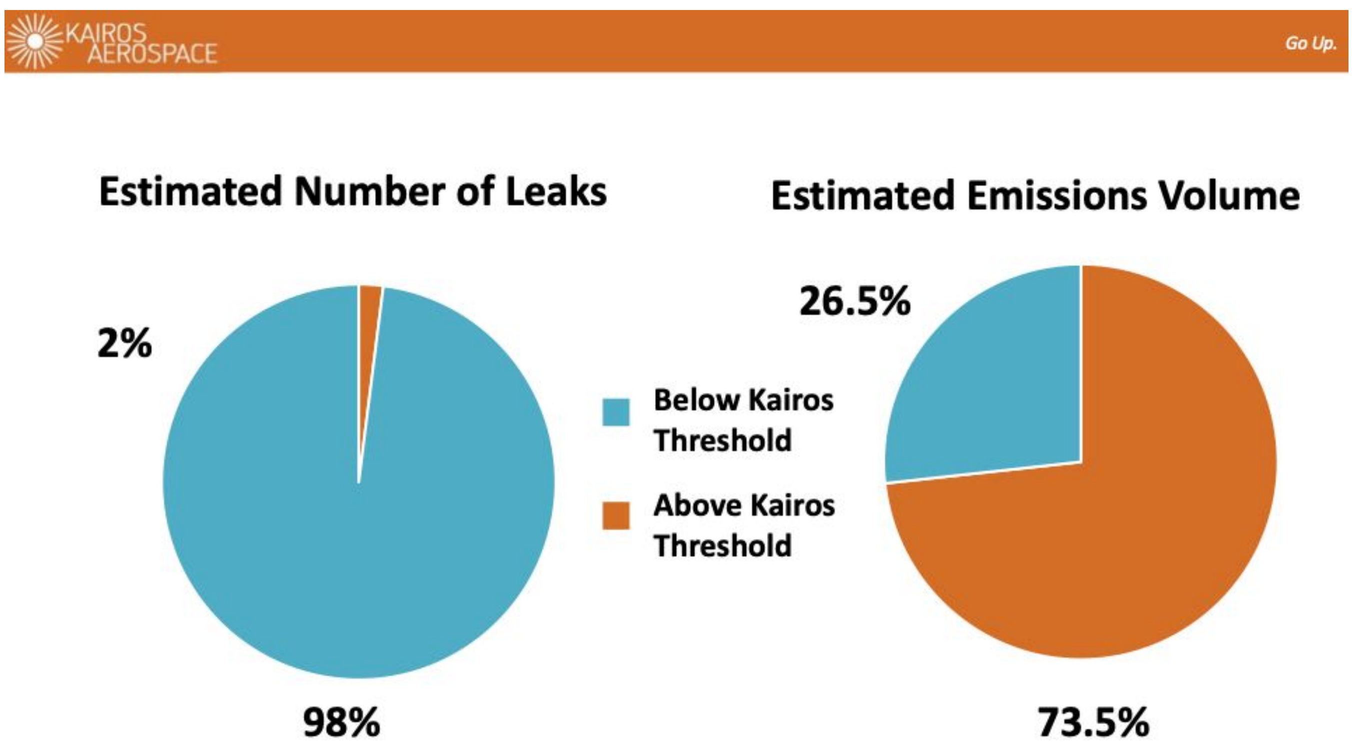

Fig. 2: Count of emissions detected by Kairos vs. estimated overall emission contribution from those detections

[4] Adam, David, et al. " Measurements of methane emissions at natural gas production sites in the United States." PNAS October 29, 2013 110 (44) 17768-17773 https://www.pnas.org/content/110/44/17768

Current Fugitive Emissions Monitoring Techniques Can Be Improved Upon

As further support for the need for a technology like Kairos' in the market, the authors of a 2016 paper [5] analyzed ~15,000 measurements from 18 prior studies and showed that "all available natural gas leakage datasets are statistically heavy-tailed, and that gas leaks are more extremely distributed than other natural and social phenomena. A unifying result is that **the largest 5% of leaks typically contribute over 50% of the total leakage volume**. (emphasis added)"[6] The study authors concluded that "performance targets for novel detection technologies can be informed by the emission distributions synthesized here…[which] could possibly allow more efficient solutions to the problem (i.e., avoid 'over-engineering' of detector technologies.)"[7] Rather than over-engineering an expensive, sensitive instrument, we have built a technologically innovative solution that prioritizes efficiency by identifying these super-emitters quickly.

As MAP panelists identified in the Report, traditional ground-based inspection techniques can be expensive and come with operating and capital expenses that need to be taken into account. While estimates vary, the cost of an OGI camera alone can be $85,000 to $120,000. Moreover, the time and expense involved with site inspections is a factor to consider. As one commenter noted, "Though pricing can fluctuate, a 2014 study determined that average cost of hiring an external service provider to conduct OGI LDAR surveys was estimated to be $2,300 for a compressor station, $5,000 for a gas plant, $1,200 for a multi-well battery, $600 for a single well battery, and $400 for a well site." Rapid aerial screening can cover more sites and therefore achieve economies of scale that may not be possible with reliance on more labor-intensive ground based techniques.

However, many existing methane regulation schemes are geared toward using these traditional ground-based techniques, despite their cost and other limitations. Many alternative methods are therefore compared to a ground-based OGI program, which is an understandable but ultimately flawed way of thinking. If an alternative monitoring standard focuses on an instrument being able to detect the exact same emissions in the same way as an OGI camera, then that analysis undervalues other very important considerations like speed and cost. For example, lower cost surveys can be conducted more frequently, and therefore may catch super-emitters faster, which the data show to be an important path to reducing emissions. Similarly, technologies that are able to rapidly inspect may shorten overall inspection times and deliver results faster. Sensitivity is not the only measure by which a technology should be evaluated. Traditional methods like OGI cameras also have technical weaknesses. For example, OGI camera quantification algorithms are in the early stages of development and are not yet reliable. Many emerging technologies, including LeakSurveyor, have more accurate quantification than current industry standard practices. Encouraging the use of new technologies will capture benefits beyond simply better resolution, faster surveying, and lower program costs.

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[5] Brandt, Adam, et al. "Methane Leaks from Natural Gas Systems Follow Extreme Distributions." *Environ. Sci. Technol.* Oct. 14, 2016. URL: http://pubs.acs.org/doi/pdf/ 10.1021/acs.est.6b04303.

[6] Id.

[7] Id.

The key difference in what we suggest the Agencies consider in future rulemakings is between **detection equivalence** and **mitigation equivalence**. Conducting more frequent surveys would identify any potential fat-tail emission sources faster than a ground-based method, even if the detection sensitivity is lower. Cheaper, faster monitoring will provide mitigation equivalence or superior performance by more frequent targeting of super-emitters.

New technologies like Kairos' aerial methane imaging can find super-emitters much more efficiently than OGI. We urge the Agencies to orient any leak detection programs they develop away from narrow inspections of individual facilities and toward broad inspections of many facilities. Any future rules should incorporate a mitigation equivalence determination rather than focusing on site-by-site detection equivalence. There is ample scientific evidence, as referenced above, showing the relative emission contribution of super-emitters. Developing a regulatory program that provides flexible pathways to efficiently identify and mitigate those sources will yield better outcomes for the Agencies, operators, and the environment.

The Technology to Improve Fugitive Emissions Monitoring Programs Exists Today

Our technology also fills technical needs in the marketplace. At the most basic level, we are filling a gap between handheld gas imaging devices (which are sensitive but time-consuming and costly to use) and aerial air-sampling devices (which are better suited to scientific research than leak detection), creating an entirely new category class of detection technology: aerial methane imaging. Our technology is designed to efficiently and cost-effectively target super-emitters, which have been increasingly shown to be responsible for most of the volume of fugitive methane emissions.

Kairos has demonstrated that new technology isn't simply a promise on the horizon; it is being implemented with success by operators today. In 2019, Kairos surveyed 40,000 oil and gas wells along with thousands of miles of pipelines. The results of our work with industry speak for themselves. Kairos customers eliminated 3.9 billion cubic feet of methane in 2019. This is not simply promising research that needs to be studied; Kairos and others have developed operational tools that already operate at scale. We urge the Agencies to provide a pathway for such technologies to be rigorously reviewed and implemented in the field as soon as possible.

With the proper framework in place, New Mexico can enact methane reduction strategies while minimizing the operational and financial impact to operators. We encourage the Agencies to think about these new tools as part of an overall strategy, not simply as a substitute of OGI or any other kind of emissions monitoring technology.

Conclusion

We appreciate the opportunity to provide feedback to the Agencies and we support many of the arguments laid out in the Report.

- Based on the available scientific research and Karios' own work, super emitters have an outsized impact on total methane emissions.
- We believe that new technologies like Kairos that focus on rapid screening can complement the slower, more detailed ground-based techniques to improve upon the current state of leak detection programs. This can be done by focusing on mitigation equivalence over detection equivalence in leak detection regulatory schemes.
- The technology to make the necessary changes we outlined exists today. Kairos and others have developed proven tools that are ready for field-wide deployment now.

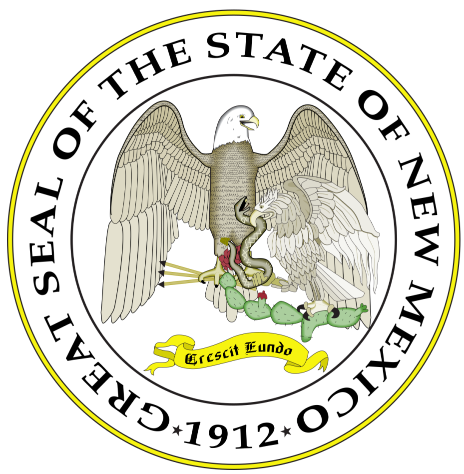
At Kairos Aerospace, we are excited to use our innovative methane monitoring technology to work with industry and the Agencies to reduce methane emissions faster and at a lower cost than traditional monitoring technologies. We've identified and mitigated billions of cubic feet of emitted natural gas through aerial monitoring. We've also eliminated thousands of hours of vehicle trips and improved safety in the field for operations personnel. This has all been done on a voluntary basis and we believe that if industry were able to use aerial monitoring as a regulatory compliance tool, the benefits would be even greater. We look forward to being able to use our technology nationwide to help the oil and gas industry quickly and safely reduce methane emissions.

Sincerely,

Steve Deiker
CEO

Appendix B
Kairos Aerospace Stripper Well Emissions Analysis

Southeast New Mexico Marginal Well Emissions Analysis



Prepared For:
State of New Mexico

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Executive Summary

Since 2013, Kairos Aerospace has provided a range of aerial solutions to oil and gas industry clients and stakeholders to better understand emissions and support operational efficiency. Using the latest aircraft-based methane spectroscopy, thermal infrared, and optical imaging technologies, Kairos' proprietary data service identifies actionable opportunities for our customers to reduce emissions and improve field performance. To date, we estimate that Kairos has helped oil and gas operators reduce at least 6 billion cubic feet of methane emissions from oil and gas infrastructure in the United States and Canada.

In 2019, Kairos Aerospace conducted a large methane survey of the Permian Basin in southeast New Mexico to identify large sources of emissions. In total, Kairos surveyed over 30,000 active oil and gas wells in southeast New Mexico--93% of all active sites in the region. The 2019 Permian survey gives Kairos the ability to evaluate the emissions of many different types of emission sources, including marginal wells. In this report, Kairos Aerospace provides summary statistics from our 2019 survey campaign for marginal wells. The purpose of this statistical analysis is to provide policymakers with empirical data about methane emissions from marginal wells to support and inform data-driven policy.

For this analysis, a marginal well is defined as an oil well that produces 10 or fewer barrels of oil or a gas well that produces 60 MCF or fewer of gas per day. These wells are extremely sensitive to changing economics, including commodity prices and operating costs. As the State of New Mexico contemplates new methane regulations for the upstream oil and gas sector, it is interested in understanding the relative emissions contribution of marginal wells compared to other sources. By understanding the relative emission contribution of marginal wells, the State can balance further regulations of this source category with the environmental and economic costs and benefits.

Kairos has evaluated our database of detected methane emissions from our 2019 New Mexico Permian Basin survey and is providing the State of New Mexico with a summary of marginal well emissions data. Kairos does not provide facility-specific information to entities other than the facility owners. Given that policy, this report contains no facility-specific data. All emissions data included in this report has been aggregated and anonymized. Also note that this report does not include any confidential customer feedback on which emission sources have been repaired. We do know that a number of emissions we detected in 2019 have already been addressed by operators.

Analysis Results

In this section, we provide the results of our marginal well analysis, including the statistics specifically requested by the state of New Mexico.

Kairos covered over 90% of both marginal and non-marginal wells in the Permian Basin. Although marginal gas well coverage was slightly lower by percentage, Kairos still covered most of these sources. For coverage details, refer to Table 1.

Table 1: Kairos 2019 New Mexico Permian Survey Coverage			
Sector	Total Wells	Number Covered	Percent Covered
Upstream (all)	32,584	30,300	93%
Upstream (all marginal wells)	18,954	17,406	92%
Upstream (marginal oil wells only)	14,724	13,975	95%
Upstream (marginal gas wells only)	4,320	3,431	81%

Kairos identified 605 upstream sites that were emitting methane during the 2019 survey. Of those 605, 143 were in the vicinity of marginal wells. Kairos found that both marginal oil and gas wells emit less per emitting facility and that marginal wells emit less frequently than non-marginal wells. Kairos did identify one marginal well with very high methane emissions, 3,553 MCF/day. Although this seems very unlikely, we are including this detection in our summary statistics because we are highly confident in the detected methane volume and we could not identify any other plausible nearby source for methane, including midstream sources. Later in this document, we detail the impact of including or excluding this one large outlier.

For several marginal wells, we detected emissions that we believe are plausibly associated with the marginal well but are in very close proximity to other equipment or facilities that may be responsible for some or all of the detected emissions. For example, some marginal wellheads are located directly adjacent to tank batteries that appear to be central collection points for several wells. It was not always clear to us which equipment within a site is directly responsible for emissions, so we are providing data on complex vs. simple detections. We define a “simple” detection as a case where emissions are clearly coming from a well pad containing only a marginal wellhead (possibly with tanks or processing equipment likely to be associated only with that well). We define a “complex” detection as a case where emissions are coming from a well pad containing a marginal well but where the well pad also contains significant additional equipment, such as a large central tank battery, that is likely to be the source of the detected emissions rather than the marginal well itself.

Our combined simple and complex detections represent a likely upper bound on the emissions Kairos found from marginal wells, since in some cases the emissions from complex detections may be originating from equipment other than the marginal well. Simple detections alone likely represent a lower bound -- only detections clearly associated with the marginal well are classified as simple.

An example of a “simple” marginal well detection is illustrated in Figure 1 below. Note that there are no other nearby sources that are potentially emitting.

Figure 1: An example (not in New Mexico) of a simple detection

Figure 2 illustrates a “complex” detection. Note the presence of extensive equipment that may or may not be associated with the marginal well.

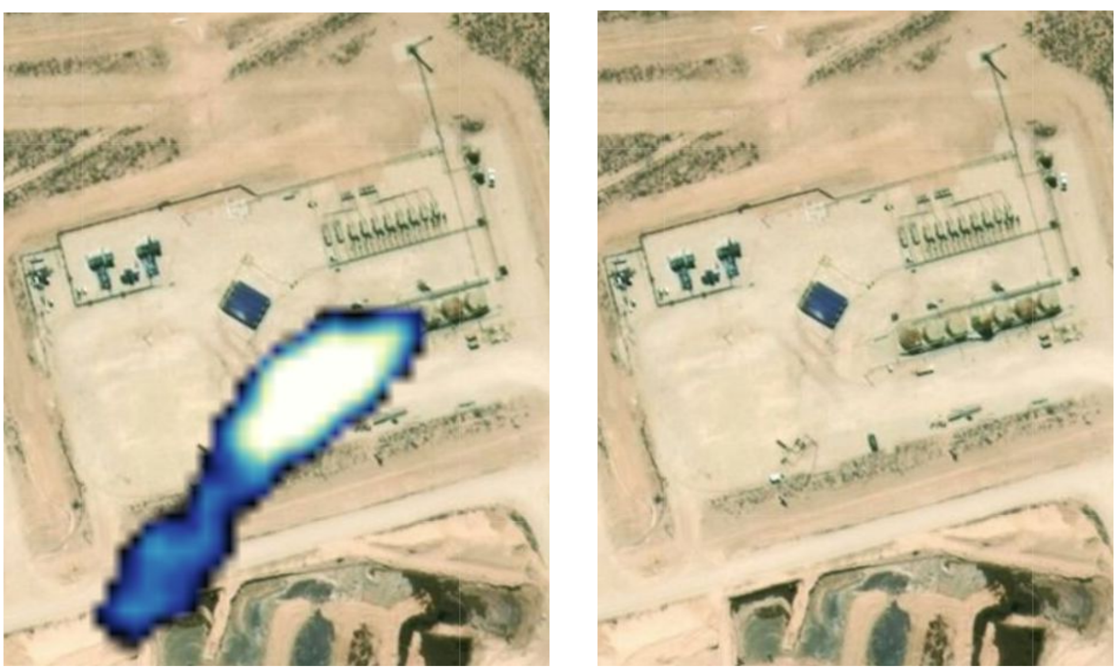

Figure 2: Example (not in New Mexico) of a complex detection. The pictured facility contains a marginal well, but it also contains extensive processing equipment that may not be associated with the marginal well.

Table 2 contains a detailed overview of detected emissions from the Kairos survey. Note that this table and subsequent tables in this document will contain two numbers, one for combined simple and complex detections and the other for simple detections only denoted by *(S)*.

Table 2: Detected Emissions						
Sector	Number of emission detections	Average emission rate per source*	Median emission rate per source*	Average emission rate per well*	Emission sources per 100 wells	Percent of total upstream emissions
Upstream (all)	605	229	88	4.6	2.0	-
Upstream (all marginal wells)	143 *64 (S)***	133 *129*	58 *49*	1.1 *0.5*	0.8 *0.4*	14% *6%*
Upstream (marginal oil wells only)	105 *38 (S)*	151 *175*	59 *57*	1.1 *0.5*	0.8 *0.3*	12% *5%*
Upstream (marginal gas wells only)	38 *26 (S)*	83 *63*	50 *46*	0.9 *0.5*	1.1 *0.8*	2% *1%*

**MCF/day*
***(S) represents only simple detections*

For a detailed breakdown of simple vs. complex detections, see Table 3 below. Our analysis indicates that more than half of the locations where emissions were detected in the vicinity of marginal wells were "complex" cases.

Table 3: Marginal Well Detection Breakdown				
Sector	Number of emission detections	Percentage of marginal well emissions	Average emission rate per source*	Median emission rate per source*
All Marginal Wells	143	-	133	58
Simple Detections	64	44%	129	49
Complex Detections	79	56%	135	59

**MCF/day*

At the State of New Mexico's request, we have also evaluated emissions from wells on the basis of production type and production volume. Table 4 depicts oil well detections and Table 5 depicts gas well detections. For both oil and gas wells, higher producing marginal wells emit more frequently and have larger emissions per emitting facility.

Table 4: Marginal Oil Well Detection Breakdown

Type	Number of wells	Number of emission detections	Average emission rate per source*	Average emission rate per well*	Emission sources per 100 wells
All Marginal Oil Wells	14,724	105 *38 (S)*	151 *175*	1.1 *0.5*	0.8 *0.3*
Wells 5-10 bbl/day	2,874	33 *8 (S)*	162 *105*	1.9 *0.3*	1.2 *0.3*
Wells <5 bbl/day	11,850	72 *30 (S)*	146 *193*	0.9 *0.5*	0.6 *0.3*
All Marginal Oil Wells Excluding Outlier	14,724	104 *37 (S)*	118 *83*	0.9 *0.2*	0.7 *0.3*
Wells <5 bbl/day Excluding Outlier	11,850	71 *29 (S)*	98 *78*	0.6 *0.2*	0.6 *0.3*

**MCF/day*

Table 5: Marginal Gas Well Detection Breakdown

Type	Number of wells	Number of emission detections	Average emission rate per source*	Average emission rate per well*	Emission sources per 100 wells
All Marginal Gas Wells	4,230	38 *26 (S)*	83 *63*	0.9 *0.5*	1.1 *0.8*
Wells 30-60 MCF/day	1,001	16 *10 (S)*	116 *66*	2.2 *0.8*	1.9 *1.2*

Wells <30 MCF/day	3,229	16 *10 (S)*	82 *99*	0.5 *0.4*	0.6 *0.4*

***MCF/day*

Lastly, we provide a comparison of how marginal well emissions compare when the single large outlier of 3,553 MCF/day is excluded. In our analysis of this particular emission, we carefully considered how to treat it since a leak of that size vastly outweighs the production from a marginal well. However, we are highly confident in the accuracy of our detection, and based on multiple sources of asset data, we cannot identify another plausible alternative source of methane in the vicinity. Recognizing, however, that such a large event is difficult to explain we are providing alternative analysis that excludes this single large outlier event.

Table 7: Marginal Well Emissions, With vs. Without Outlier		
Type	With Outlier	Without Outlier
Marginal well share of upstream emissions	14% *6% (S)*	11% *3%*
Average rate per emission source (MCF/day)	133 *129 (S)*	118 *83*
Emissions rate per marginal oil well (MCF/day)	1.1 *0.5 (S)*	0.9 *0.2*

Conclusions

Kairos data reveal several noteworthy trends for marginal wells. First and foremost, Kairos analysis finds that marginal wells tend to emit less frequently than non-marginal wells, and when they do emit, the measured emissions are typically lower than non-marginal well emissions. This trend holds true for both marginal oil and gas wells. Kairos also found that although there are more marginal wells than non-marginal wells in southeast New Mexico, non-marginal wells are responsible for most of the upstream emissions. In total, non-marginal wells represent 86% of upstream oil and gas methane emissions, while marginal wells represent 14%. Marginal well emissions are dominated by oil wells when compared to gas wells. Marginal oil wells are responsible for 12% of upstream methane, while marginal gas wells are responsible for 2%. However, marginal oil wells greatly outnumber gas wells in southeast New Mexico, 14,724 to 4,230.

Marginal oil and gas wells do differ in a few significant ways. Our analysis finds that marginal gas wells are more likely to have emissions than marginal oil wells, but that marginal oil well emissions are typically larger than what we observe from gas wells. Overall, marginal gas wells have slightly smaller average emissions despite having more frequent detectable emissions. Notably, we find the lowest producing marginal wells--oil wells that produce less than 5 barrels of oil or 30 MCF of gas per day--have lower emissions than marginal wells with higher production.

One of the challenges with our analysis is the uncertainty associated with what we classify as “complex” detections. Complex detections, or detections where emissions may be associated with either a marginal or non-marginal facility, have a significant impact on emissions attributed to marginal wells. However, regardless of whether you include or exclude complex detections the overall trend for marginal wells remains the same: marginal wells can emit significant volumes of methane, but tend to do so less frequently and typically at smaller volumes than non-marginal wells.