Continuous Methane Emission Monitoring with RMLD-REM

Alberta Methane Field Challenge

Heath Consultants Final Report

Recipient Agreement 19-AMFC-05

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1. Purpose and Objectives

This project addresses Oil & Gas (O&G) industry objectives to develop, demonstrate, evaluate, and ultimately implement methods of monitoring natural gas pipelines and infrastructure to reduce fugitive emissions of greenhouse gases, enhance public safety by reducing potential explosion hazards, and improving system reliability. Continuous monitoring can provide early warning of abnormal gas concentrations that may indicate a leak as a precursor to a catastrophic pipeline, valve, or storage vessel containment failure. Early warning provides the operator an opportunity to mitigate the leak. A continuous monitor that detects sudden and potentially explosive increases in gas concentration can activate alarms to warn the population and automatically shut off gas supplies.

To this end, Heath Consultants is developing laser-based long-path sensor technology for continuously monitoring of natural gas at production, transmission, processing, and storage sites. The technology rapidly detects and reports natural gas leaks and other excess emissions to the atmosphere. It is based on our widely-deployed handheld Remote Methane Leak Detector (RMLD®). Since its introduction in 2005, over 4000 RMLDs® deployed worldwide have transformed the practice of distribution pipeline compliance leak surveys. The fixed-location continuous monitor version demonstrated in this project is named "Remote Methane Leak Detector – Remote Emission Monitor (RMLD-REM)". Since 2015, advanced prototype REM units have been installed at multiple O&G production sites, underground gas storage facilities, and along high consequence pipeline corridors.

Current practices for leak detection at REM installation sites generally follow US EPA and similar state, Environment Canada, and provincial regulations specifying scheduled periodic walking, driving, or aerial surveys using measurement tools such as Optical Gas imaging (OGI) or Method 21. However, as demonstrated repeatedly by our early REM installations and further validated by data presented in this report, these intermittent short-lived survey practices are insufficient for rapidly detecting failures that could potentially create explosive conditions. They are unlikely to detect many, indeed most, small fugitive emission events. Since most events themselves are intermittent and short-lived, the probability of temporal overlap between a leak event and a scheduled inspection is small, thus rendering the costly inspection process largely ineffective at reducing emissions. Continuous emission monitoring provides rapid detection and user notification of leak events, providing quantitative data that enable operator mitigation decision and actions. Furthermore, continuous monitoring can help identify trends that may indicate that operational emission levels are increasing over time, thereby allowing for improved preventative maintenance scheduling.

To perform the intended safety function, continuous monitoring of the natural gas content above and around protected areas in both time and space is needed. For continuous measurement in time the gas monitor must be: field-worthy, automated and autonomous, rugged, reliable, fast, specifically sensitive to natural gas with no cross-sensitivity. For continuous measurement in space the gas monitor must: either sample at many closely spaced intervals, or interrogate along continuous lines-of-sight along and around the pipeline. RMLD-REM is designed with intention to meet these needs.

The Alberta Methane Field Challenge (AMFC) project described herein provided further field validation of RMLD-REM performance during its 6 month installation. The project Objectives were to demonstrate:

1) RMLD-REM's real time detection capabilities, long-term stability, robustness, and reliability
2) RMLD-REM exceeds OGI in leak detection performance and efficiency at lower cost.
3) Value of continuous monitoring for reducing emissions compared to periodic surveys.

2. Technology Description

The RMLD-REM is based on open path Tunable Diode Laser Absorption Spectroscopy (TDLAS), the same technology as RMLD®, Heath's well-established commercial laser-based handheld pipeline leak survey product. In the open-path REM sensor architecture Illustrated by Heath product literature attached as Appendix A, a laser light beam emanating from a transceiver head illuminates a remote surface. The transceiver detects light reflected back from the illuminated surface. The laser beam carries a signal that is processed by the unit to deduce the amount of methane in the path the beam traverses. It quantifies the methane in units of part per million – meter (ppm-m).

Appendix B provides more technical detail describing RMLD-REM and its capabilities. RMLD-REM has previously been shown to detect leaks as small as 0.5 scfh, comparable to the gas flow rate of a pilot light. Power is typically provided by renewable sources (solar, wind). The remote illuminated surface can be located as far as 1000 ft or more from the laser source. Being an open path laser, a site can be monitored from a single, downwind side.

RMLD-REM continually transmits routine sensor data, including ppm-m, wind vector, and diagnostic system health information to a cloud-based portal for emission detection, event notification, analytics, and storage. Section 5 below provides more description of the portal data product. When the system detects a potentially dangerous gas leak, it transmits an immediate alert via text or e-mail to the facility operator. For smaller, non-emergency leaks, the system transmits alerts hourly. Repetitive small leak alerts indicate a need for further operator investigation and repair. RMLD-REM's leak detection algorithms are protected by US Patent 9797798.

3. AMFC Participation

This AFMC project provided a site for installing and demonstrating a REM unit for a six-month period beginning 12 June 2019. Heath personnel installed the unit and retrieved it upon project completion. Via the web portal, Heath and AFMC researchers had real-time and subsequent access to the sensor data. Data examples are presented in Section 5 below.

Figure 1 pictures the REM unit. The laser pathlength is 45 m. The site location was in Red Deer County AB (52° 15' 41.6664'' N, 114° 22' 43.8492'' W, Figure 2). Figure 3 is a satellite view of the site with the laser path illustrated. The path is southeast of a storage tank battery. A gas transfer spigot is at the southwest corner of the tank battery. Gas from storage tanks is periodically transferred to trucks parked on the west side road.

Figure 1 -Pictures of RMLD-REM installed at project test site.
Left: Transmitter and receiver station with control box. Solar and Wind powered.
Right: Transmitter and receiver are combined in one unit.
Reflective target not shown.

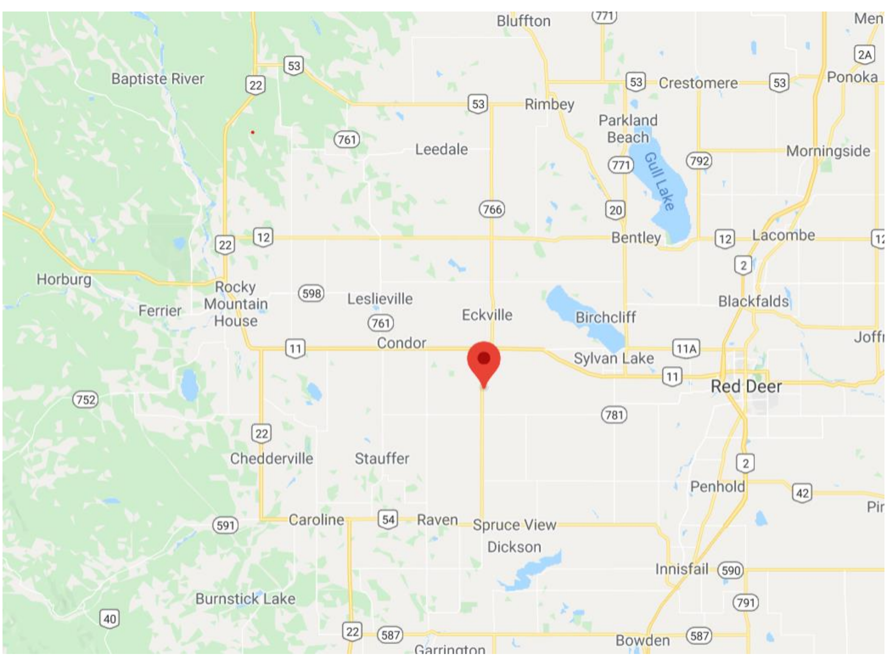

Figure 2 – Test site location in Red Deer County (Google Maps)

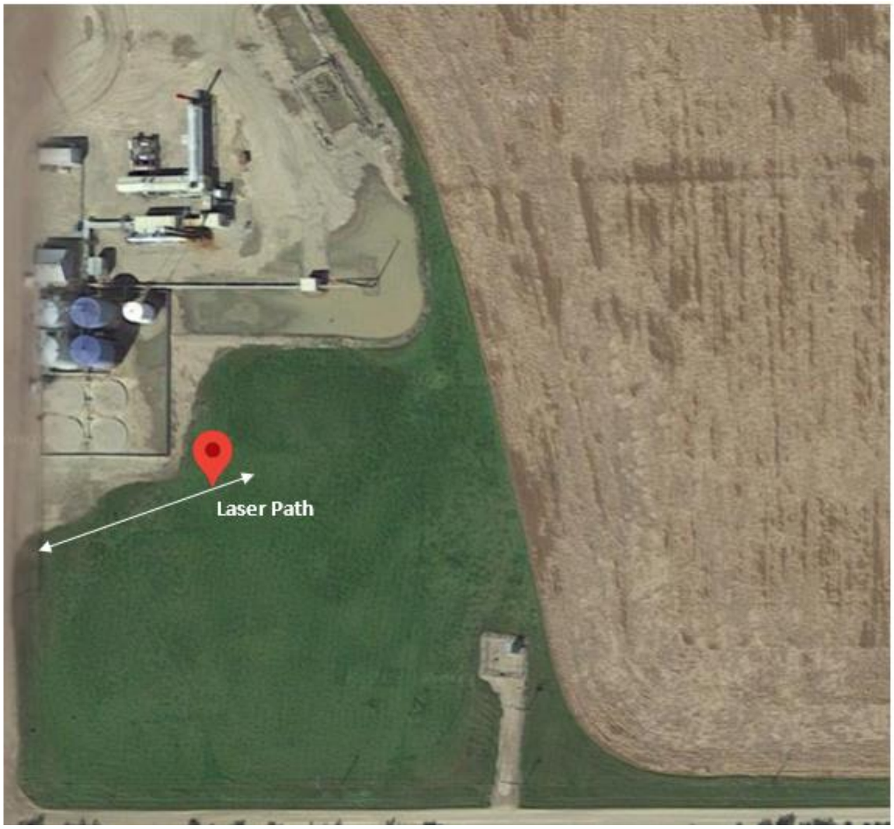

Figure 3 – Satellite View of Test Site (Google Maps). Laser path is 45 m.

4. Learnings and Areas of Improvement

This project successfully achieved all objectives. As illustrated by the data presented in Section 5 below, the RMLD-REM continuous monitoring operated stably and reliably without any maintenance during its six-month installation. It detected short-lived leaks of various magnitudes that would not have been known to periodic leak survey tools such as OGI. Indeed, even permanently installed OGI would likely not have detected these leaks, as the OGI would need to be aimed at the leak source. Though we have presumed the leak source to be the truck transfer spigot, this has not been confirmed. Correlation to site activity such as offloading would have been beneficial. An on-site alarm, notifying a truck operator of a leak, would aid mitigation and reduce lost gas. In the event that the REM detects a leak of this magnitude that persists, a follow-up survey with OGI or RMLD® to identify the leak source would be warranted

Areas of improvement underscored by this project relate to ease of installation and use.

a) Installation currently requires a trained Heath technician to travel to the installation site and perform the instrument setup. The cost of technician time and travel to remote sites can be comparable to the cost of the REM itself. A significant improvement would be to package the sensor and its accessories for simple operator installation with remote service support.
Easier navigation the web-based portal would simplify the user experience and reduce cost of processing and analyzing REM data.

5. Data Product Examples

The RMLD-REM system generates real time ppm-m reading, system diagnostics and wind information. Data, recorded every six seconds, is transmitted to the cloud-based portal. Users have access to the real time data through the portal and can download stored data for any user-selected time frame. Appendix B presents some portal screenshot images.

Figures 4-7 present example data acquired via download and processed using Excel. The data show the expected continuous background methane of approximately 100 ppm-m, consistent with an ambient concentration of ~2ppm uniformly distributed along the 45m laser pathlength. Superimposed on the background are occasional methane “spikes”. These are short-lived leak events as described in the figure captions. The sources of these events are not identified but are believed to be predominantly due to gas transfers to trucks at the spigot located northwest of the laser path.

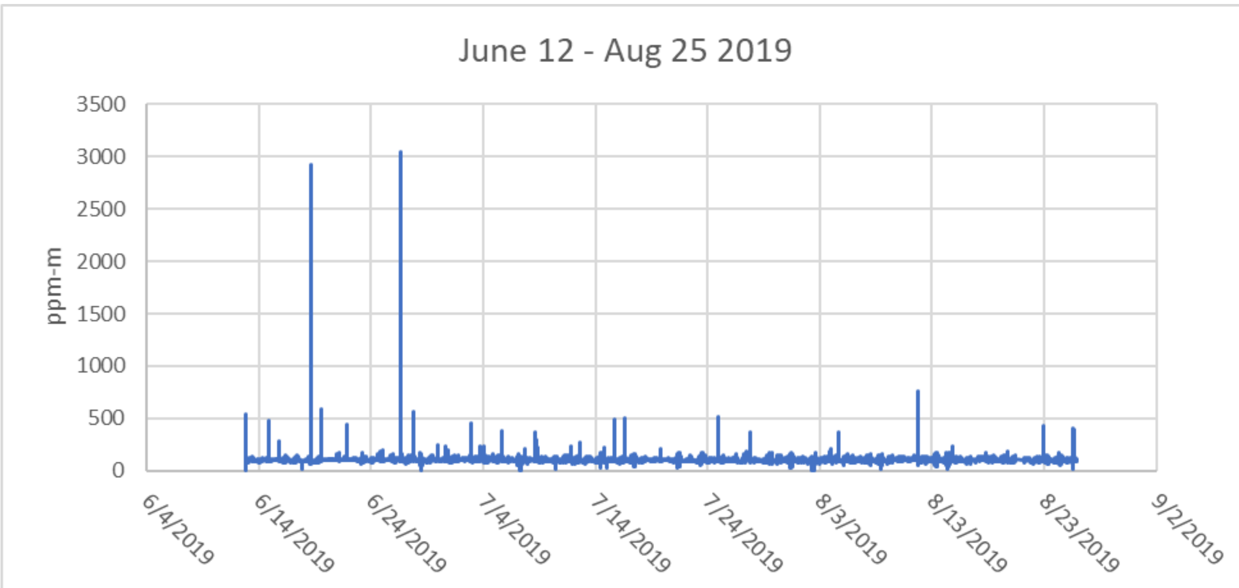

Figure 4 – RMLD-REM methane data for 74 days, illustrating continuous background methane with occasional leak “spikes”

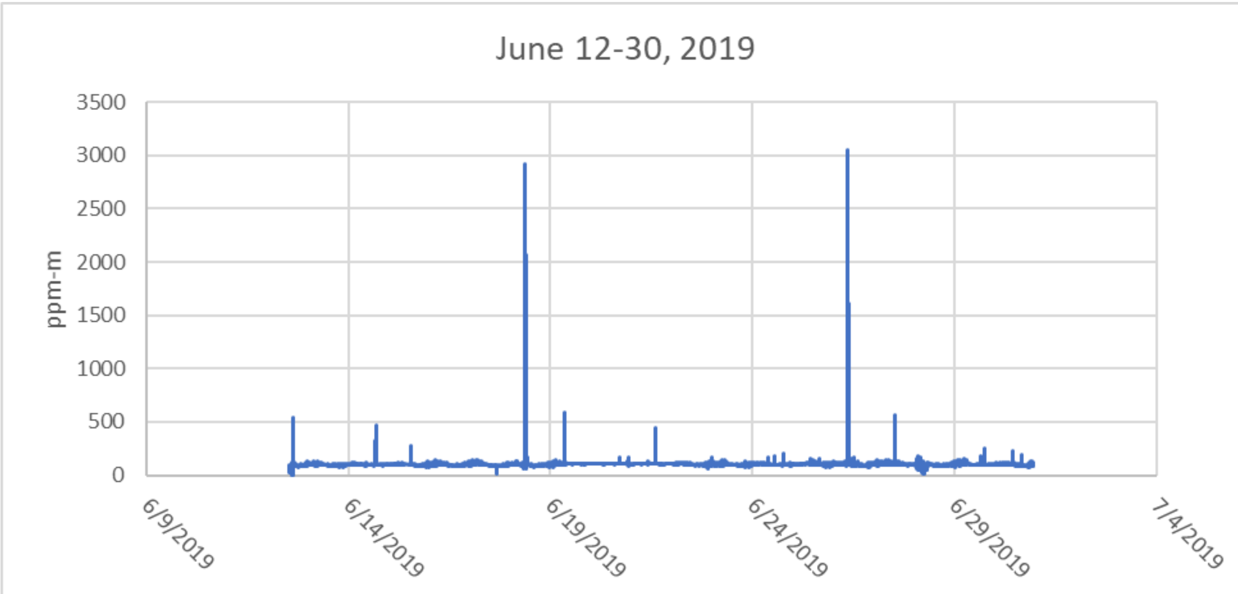

Figure 5 – Data from Figure 5 expanded to highlight the spikes detected in June.

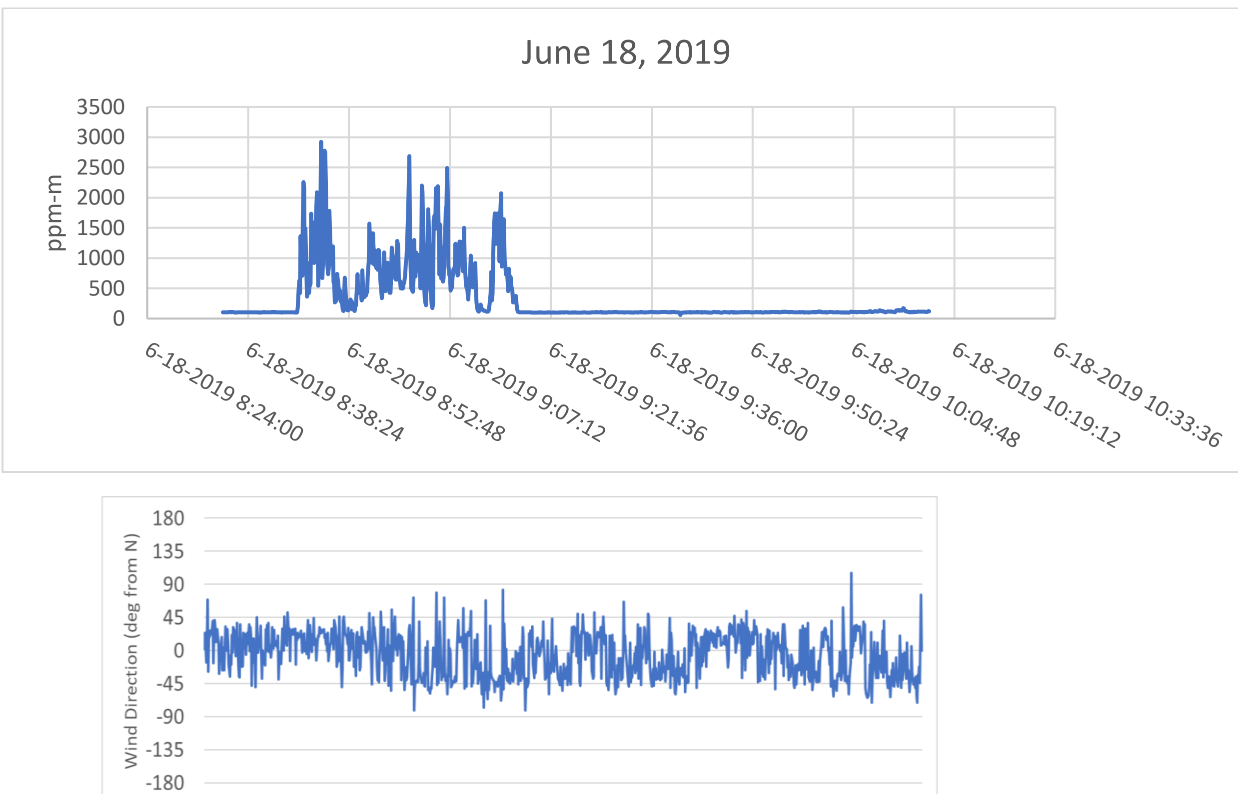

Figure 6 – Expanded view of the leak detected on June 18 and wind direction. The data represent a leak located generally north of the laser path with a duration of less than one hour. This illustrates the value of continuous monitoring covering a broad area for detecting this event.

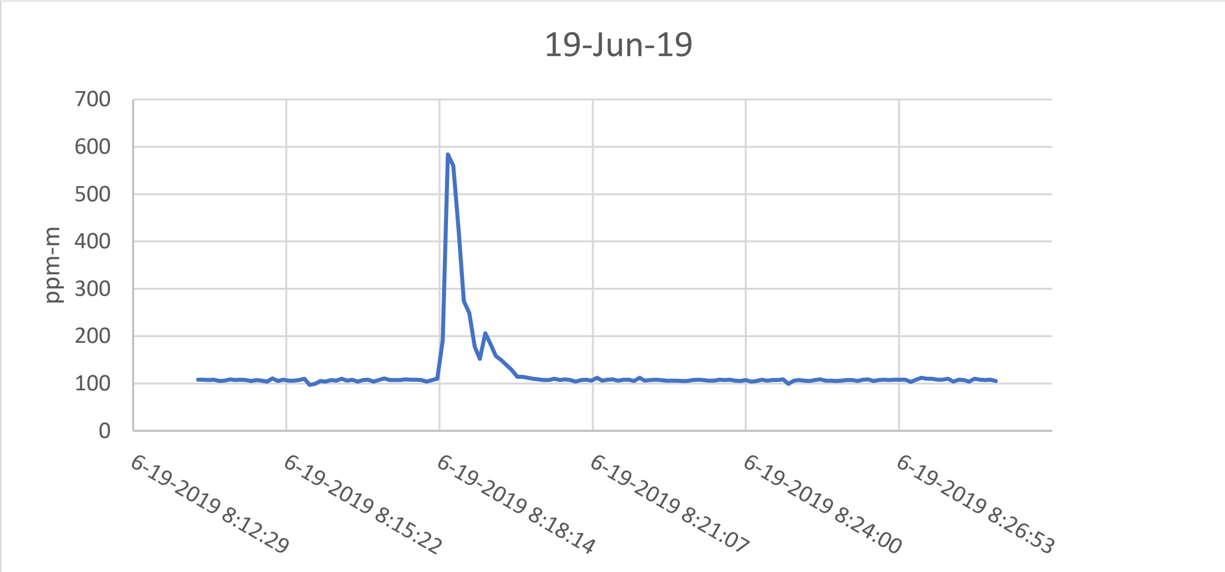

Figure 7 – Expanded view of the relatively small leak detected on June 19 showing a duration of only a few minutes, illustrating the value of fast sensitive detection.

6. Performance and Cost Implications

This project demonstrated that the continuously operating long-open path laser-based RMLD-REM reliably detects, records, and reports intermittent and short-lived natural gas leak events. These leaks likely would have gone undetected by traditional periodic scheduled surveying techniques or permanently installed optical gas imagers that may not be aimed to view the leak source during the leak duration.

In 2014, ICF International analyzed the cost benefits of Optical Gas Imaging (OGI) for methane leak inspections at well pads, gathering, processing, transmission, and local distribution sites.[1] The study assumed OGI camera and support equipment cost of $142k, an hourly labor rate of $77.79, 2.7 hours for each inspection at each well, 8 hours at all other sites, and training of 80 hours per year. Table 1 presents the annual cost of OGI inspection at various sites, assuming semi-annual inspections at well pads, and quarterly inspections at all other sites. And, as described previously in this report, these periodic inspections are highly unlikely to detect the intermittent leaks that are most prevalent at these sites, therefore the inspection cost provides little value to the operator. *In contrast, amortized over a 10 year lifetime, the cost of RMLD-REM, including installation and operation, is less than the cost of OGI inspections and provides the operator with the valuable real-time information that enables rapid leak mitigation, enhancing safety, minimizing harm to the environment, and reducing the cost of lost gas.*

[1] "Economic Analysis of Methane Emission Reduction Opportunities in the U.S. Onshore Oil and Natural Gas Industries," ICF International, March 2014.

Table 1. Annual OGI Inspection Costs

Annual Cost of Inspections (per site)					
Method	**Well Pads**	**Gathering**	**Processing**	**Transmission**	**LDC**
OGI	$550	$3250	$3250	$3250	$800