Evaluation of TTS Air Contaminants Sensor Package for Remote, Drive-By Detection of Methane Release from Oil/Gas Infrastracture

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1. Background

Current methods of remotely detecting (i.e., without direct, immediate access to valves, tanks, etc.) trace amounts of methane (the primary component of natural gas) released inadvertently from oil and/or natural gas facilities requires use of sophisticated, expensive and relatively complex instruments. The goal here is to test whether a small, inexpensive sensor package could be used to provide detection capabilities that could augment such sophisticated devices.

1.1 The TTS Sensor Package

Timberline Technologies and Services, LLC (TTS) has developed a prototype sensor package with a unit cost of about $200 to $300 (depending on options) that, in theory, should have the ability to detect trace natural gas amounts at the sub 10 ppm level. The package (referred to below as the TTS sensor) is small (approx. 14cm x 3cm x 4cm), portable, and equipped with data logging and a global positioning system (GPS) for position and speed. It can be operated either from within a vehicle (via 12V power adapter) with no special vehicle modifications needed, or as a hand-carried package via battery power.

2. Questions

This phase of assessment addresses the following two main questions. These questions define fundamentally whether the TTS sensor might be useful and practical for natural gas leak detection from oil/gas facilities:

Question 1: Can the TTS sensor detect the presence of trace (<10 ppm) amounts of natural gas (predominantly methane) while carried in a vehicle driving at normal speeds along public roads, in the vicinity of oil/gas facilities?

Question 2: Given that the TTS sensor package responds to more types of trace gases than methane alone, as well as to changes in temperature and humidity, is the TTS sensor sufficiently discriminatory in its detections such that its data would help in narrowing down the number of potential natural gas leak locations that would warrant inspection visits? In other words, if the TTS sensor detects gases at too many locations that appear unrelated to significant oil/gas release (or to release of other contaminants of concern), then the sensor might have little practical value for field use as a natural gas leak detector. It is worth noting though that the other gases to which it is sensitive (including carbon monoxide, ethanol, hydrogen, ammonia, hydrogen sulfide, toluene) are potentially significant air contaminants in their own right, with a subset of these gases sometimes associated with oil/gas operations.

3. Approach

To attempt to answer Questions 1 and 2, the TTS sensor package was deployed in a vehicle (Subaru Legacy sedan) driven along roads in Weld County, Colorado in concert with a vehicle-mounted Picarro system operated by a University of Colorado laboratory. This experiment involved the Subaru driving typically within a few cars' lengths behind the Picarro. The TTS instrument's sensor head extended approximate 1 m above the Subaru's roof. Both vehicles were driven at normal speeds, on publicly accessible roads. The experiment took place on 5 August 2014, with a total drive time was approximately 5 hours, covering about 120 km of roads. Distances of the vehicles from oil/gas site equipment during the drive-bys ranged roughly from 5 m to 50 m. Wind speeds were relatively light.

3.1 Data Processing

The TTS sensor includes real-time data processing that results in a stored version of the analyzed data (referred to as v.1 data) along with a variety of additional raw data fields from the sensors and GPS. For the analysis presented here, an additional post-processing step with less restrictive filtering was applied to the stored, raw data (referred to as v.2 data).

Data from the Picarro was provided by the CU laboratory staff, with no subsequent processing applied. The Picarro-measured parameter used for comparison with the TTS observations was methane.

4. Results

Question 1 (Detection Capability): Can the TTS sensor detect trace natural gas (again, assumed to be predominantly methane) in an off-site mode that could be used to find potential leaks by driving along publicly-accessible roads and property (i.e., in a "fenceline survey" mode)?

Analysis of the Picarro data collected during the 5 August 2014 drive show that the Picarro found 10 locations with methane > 3 ppm (Figure 1). All of these locations were either adjacent to or within the vicinity of oil/gas infrastructure based on in-situ observation and subsequent comparison using Google Earth imagery. At 3 of these 10 locations, Picarro-measured methane concentration was > 5 ppm (Figure 2). At one location, the concentration was greater than 50 ppm. (The presence of this leak was confirmed on-site using a thermal imaging system.)

The TTS v.1 data showed elevated air contaminants (methane and/or other gases) at 5 of the 10 locations with > 3 ppm methane as measured by the Picarro. The TTS sensor showed elevated readings at all 3 of the Picarro methane > 5 ppm locations. With the TTS v.2 data-processing approach (the less restrictive processing), the TTS sensor found elevated readings in 8 of the 10 locations where Picarro recorded > 3 ppm CH4.

5. Conclusions

Question 1 (Detection Capability): Detection capability is supported by these results. Under the experiment conditions encountered, the TTS instrument is able to detect sub 10 ppm levels of natural gas concentrations when operated in a drive-by, remote sensing approach on public roads.

Question 2 (Usefulness): Is the TTS sensor a practical option for finding possible CH4 leaks; in particular, does the instrument provide too many false positives?

The TTS v.1 processing yielded about 18 locations with elevated air contaminants along the drive route (the locations with red circles in Figures 1 and 2). Given that 5 of these locations (28%) corresponded to locations flagged by the Picarro, then there were 13 other TTS v.1 locations that, according to the Picarro system, did not have elevated CH4 amounts. Based on Google Earth imagery, 5 of these 13 non-coincident locations coincide with oil/gas structures. The remaining 8 appear associated with farms, feedlots, water bodies/riparian areas, and urban areas that have particular potential to influence the TTS sensor (Figures 7 and 8). If the TTS locations were pre-screened for relevance (by viewing the data plotted in Google Earth, for example), it would be possible to reduce the "target locations associated with oil/gas facilities to 10. In this case, 5 of the 10 TTS locations would correspond to locations with elevated Picarro readings.

As noted earlier, the TTS sensor responds to several other types of gases that are considered air contaminants; several of which are sometimes associated with oil/gas production. Given that 10 of the 18 high-reading TTS locations were close to oil/gas facilities, then it is possible that 56% of these locations may have been associated with oil/gas-related air contaminant release, even if the contaminants measured did not include methane. For example, upon revisiting the oil/gas facility location in the upper left panel in Figure 8 on 25 November 2014, quite high readings were again observed with the TTS sensor, and there was a distinct "chemical" smell in the air.

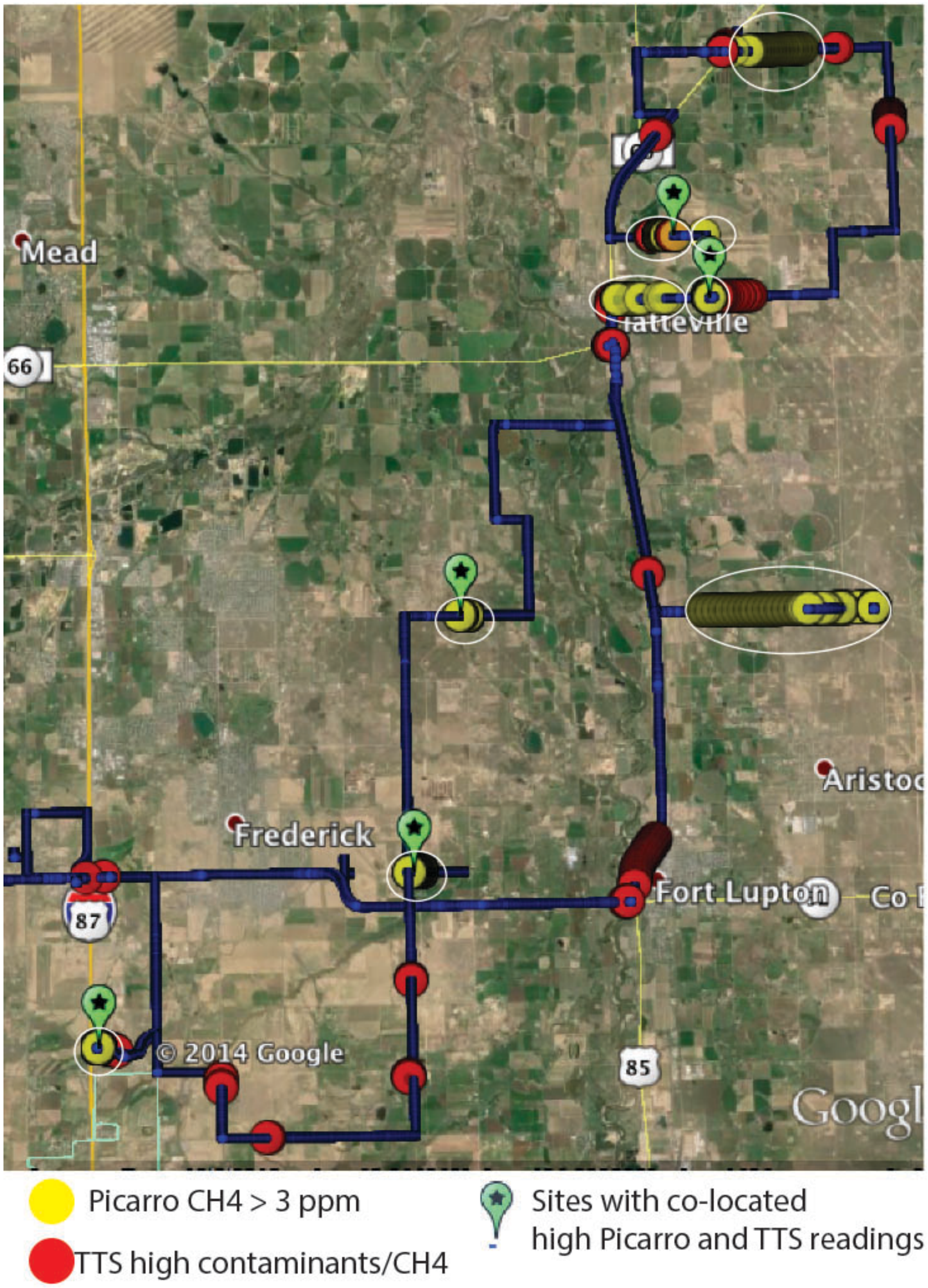

Figure 1. Comparison of Picarro and TTS results for 5 August 2014. Areas circled in white are areas where the Picarro found CH_4 > 3 ppm. Locations with the green flags are locations where coincident high readings were found by both the Picarro and the TTS sensor.

The less-restrictive TTS v.2 processing, which resulted in high readings at 8 of the 10 Picarro locations, yielded about 40 locations with elevated air contaminant readings. Therefore, while this processing method flagged 80% of the Picarro locations with elevated CH_4 amounts, it also produced more "non-CH_4" hits (i.e., locations not coincident with Picarro elevated CH_4 locations). As noted above, most (but not all) of these hits correspond to non-oil/gas structures, and it is possible that the TTS sensor was responding to other contaminants at these locations.

In conclusion, these results suggest that the TTS instrument is useful for certain applications. It seems likely that if the TTS sensor can detect roughly 30% of the elevated-CH4 locations found by the Picarro (or 50%, with some visual screening using GE) while yielding a manageable number of "false hits", then the TTS instrument has value as a reconnaissance sensor for natural gas leak detection. Use of less restrictive filtering results in high readings at 8 of 10 Picarro general sites, but this also yielded about 40 locations of interest along the drive. So, if there is less concern about non-relevant sites, then the likelihood of finding more sites with natural gas release could be increased to perhaps about 80% based on these data. (It is important to note though, that with enough false hits, the chances of randomly overlapping true high-reading locations increases.)

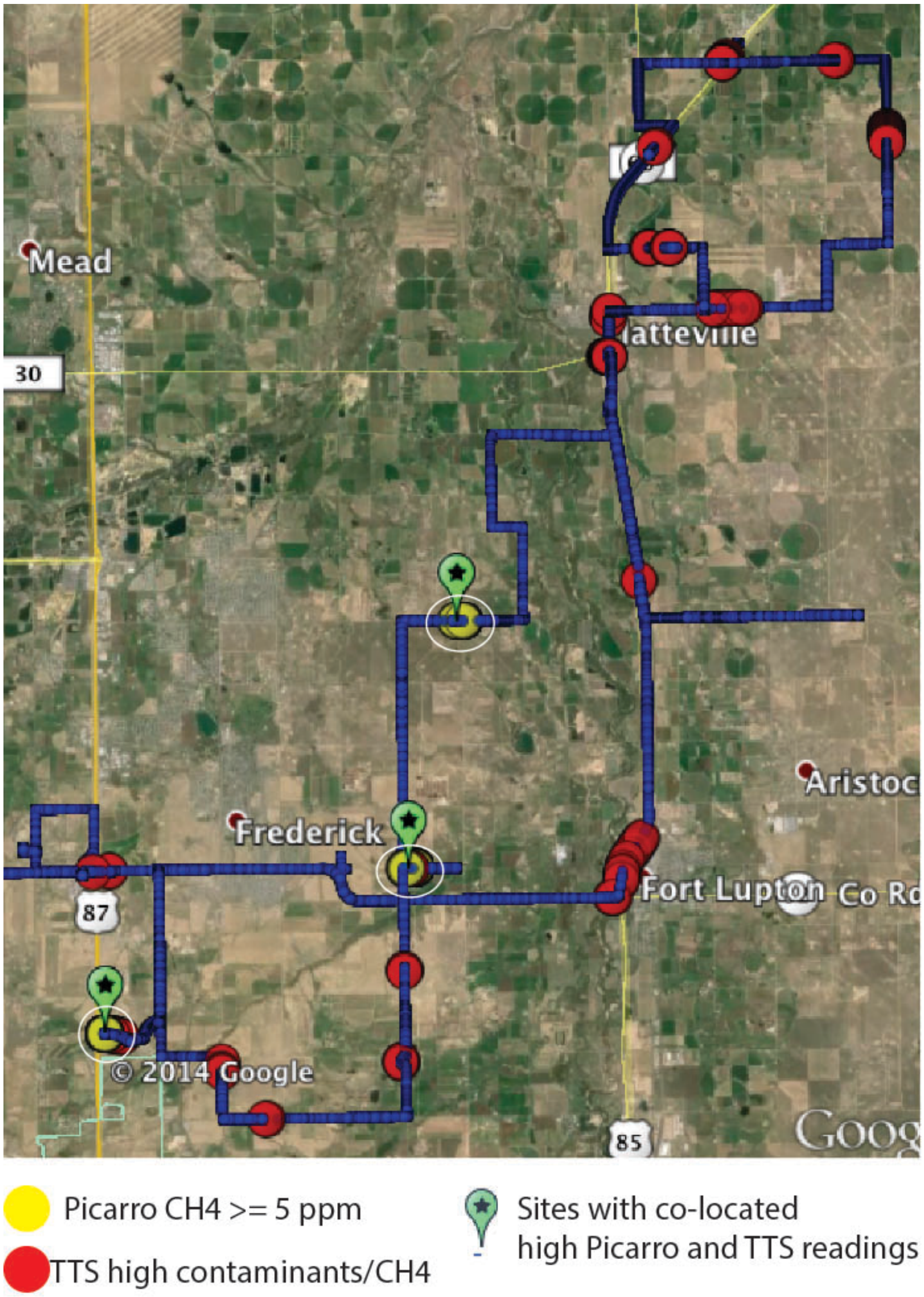

Figure 2. Comparison of Picarro and TTS results for 5 August 2014. Areas circled in white are areas where the Picarro found methane concentrations > 5 ppm. Locations with the green flags are locations where coincident high readings were found by both the Picarro and the TTS sensor.

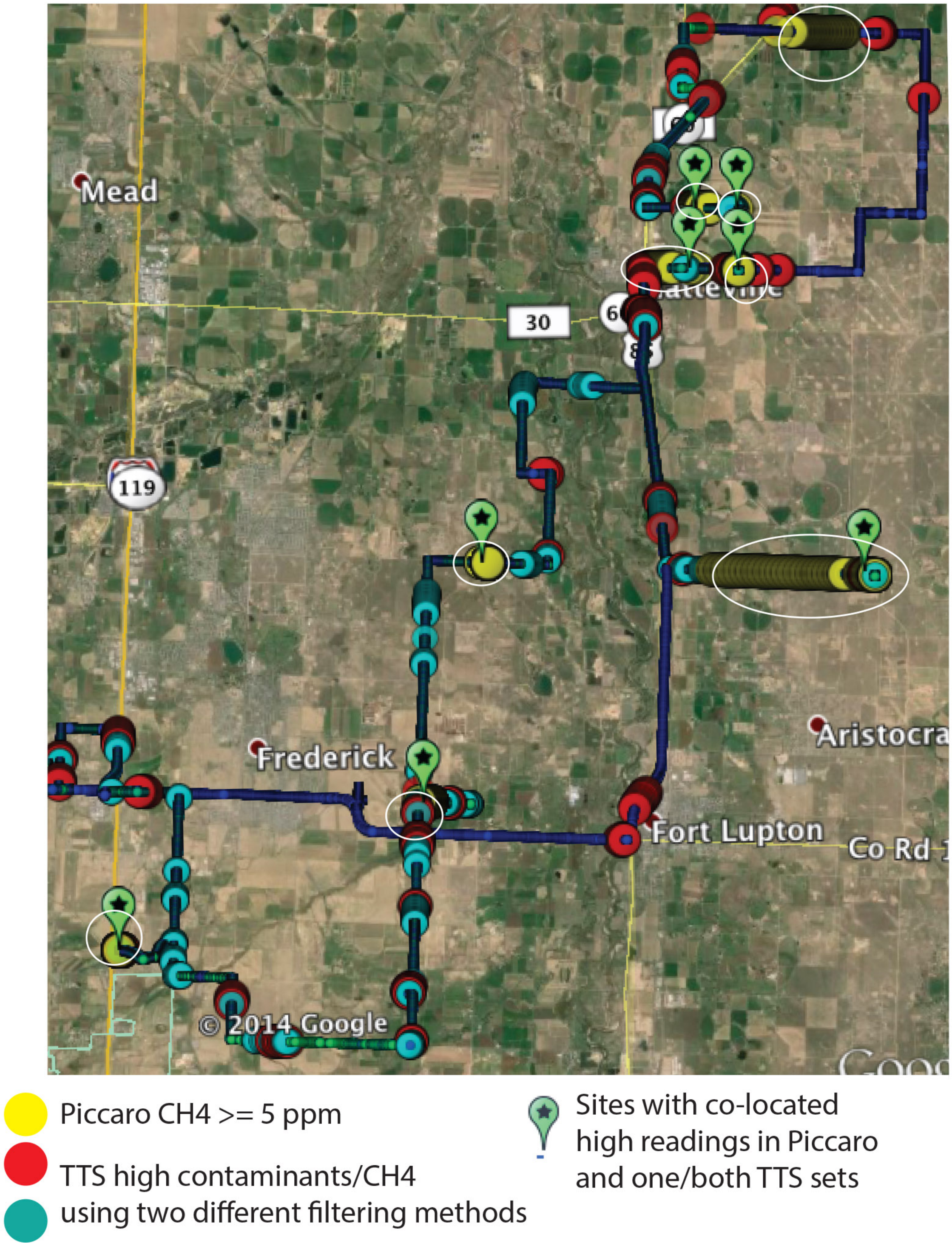

Figure 3. Comparison of Picarro and TTS results for 5 August 2014, showing results for the two levels of TTS data processing, with the more restrictive version (v.1) indicated by red circles and the less restrictive version (v.2) in light blue.

Figure 4. Locations along the drive route where Picarro readings were >= 5 ppm methane (indicated by the larger yellow circles). High readings in the TTS data are indicated by the red (v.1 filtering) and/or blue (v.2 filtering) circles. The site in the top panel of the above three panels was the location with Picarro methane readings > 50 ppm.

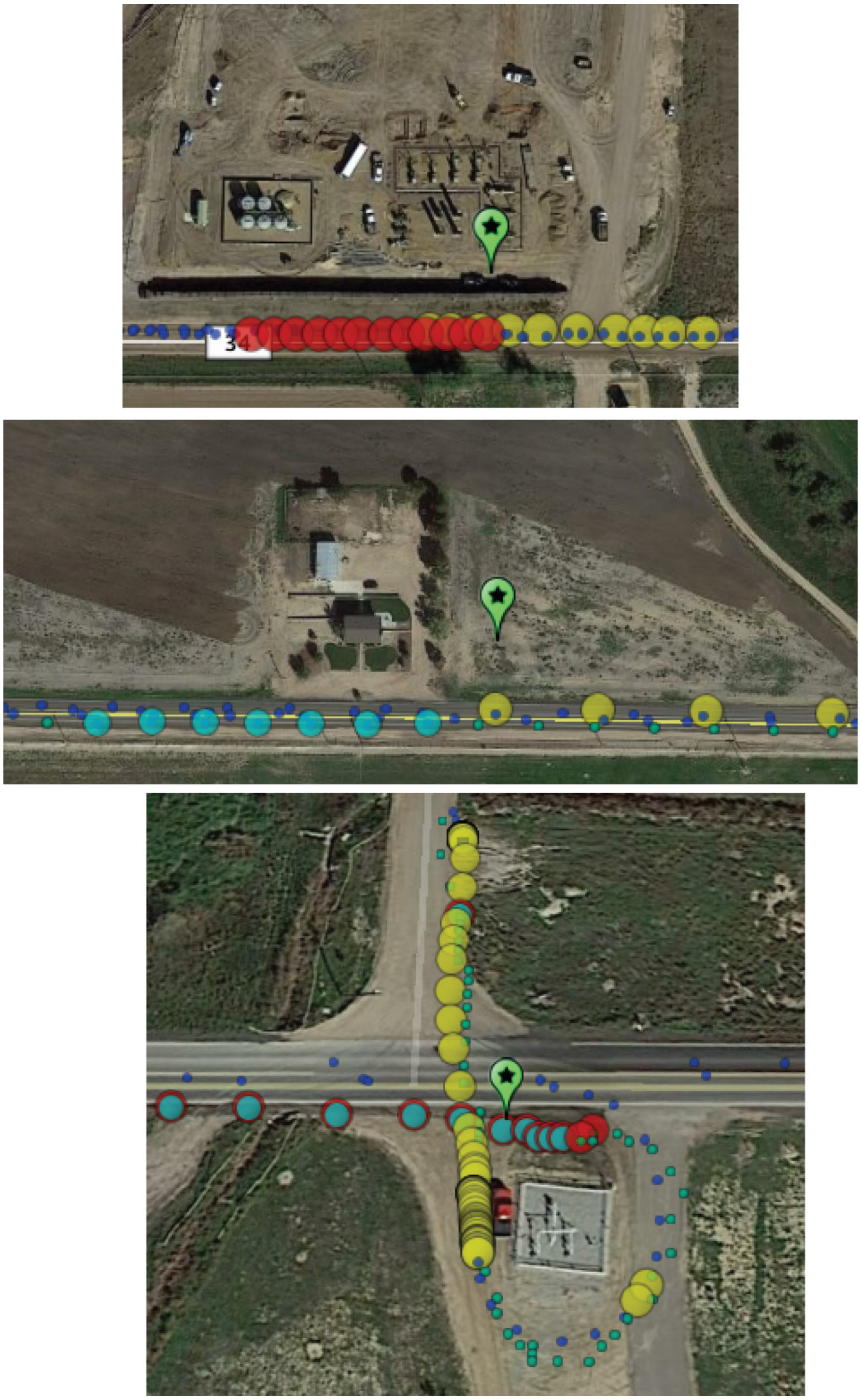

Figure 5. Locations along drive route where Picarro readings were >= 3 ppm methane (indicated by the larger yellow circles). High readings in the TTS data are indicated by the red (v.1 filtering) and/or blue (v.2 filtering) circles.

Figure 6. Locations along drive route where Picarro readings were >= 3 ppm methane (indicated by the larger yellow circles). High readings in the TTS data are indicated by the red (v.1 filtering) and/or blue (v.2 filtering) circles.

Figure 7. Locations along drive route where high readings in the TTS data were found (red [v.1 filtering] and/or blue [v.2 filtering] circles), but not co-located with high Picarro readings.

Figure 8. Locations along drive route where high readings in the TTS data were found (red [v.1 filtering] and/or blue [v.2 filtering] circles), but not co-located with high Picarro readings.