November 27, 2024

Via Electronic Transmission: www.regulations.gov
Vasco Roma
Office of Atmospheric Protection, Climate Change Division
Office of Air and Radiation
U.S. Environmental Protection Agency
roma.vasco@epa.gov

Re: Use of Advanced and Emerging Technologies for Quantification of Annual Facility Methane Emissions under the Greenhouse Gas Reporting Program; Docket ID No. EPA-HQ-OAR-2024-0350

Waste Management ("WM") is pleased to provide the following comments on the U.S. Environmental Protection Agency's ("EPA's" or "the Agency's") *Request for Information for Use of Advanced and Emerging Technologies for Quantification of Annual Facility Emissions Under the Greenhouse Gas Reporting Program;* Docket ID No. EPA-HQ-OAR-2024-0350 (hereinafter, the "RFI") at 89 Fed. Reg. 77,510 (Sept. 23, 2024).

WM is North America's leading provider of comprehensive environmental solutions. Previously known as Waste Management and based in Houston, Texas, WM is driven by commitments to put people first and achieve success with integrity. The company, through its subsidiaries, provides collection, recycling, and disposal services to millions of residential, commercial, industrial, and municipal customers throughout the U.S. and Canada. With innovative infrastructure and capabilities in recycling, organics processing, and renewable energy, WM provides environmental solutions to, and collaborates with, its customers in helping them pursue their sustainability goals. WM has the largest disposal network and collection fleet in North America, is the largest recycler of post-consumer materials, and is the leader in beneficial use of landfill gas, with a growing network of renewable natural gas plants and the most landfill gas-to-electricity plants in North America. WM's fleet includes over 12,000 natural gas trucks — the largest heavy-duty natural gas truck fleet in the industry in North America.

WM was the first U.S.-based company in the solid waste management utilities sector to have near-term Scope 1 and Scope 2 targets validated by the Science-Based Target Initiative, in line with limiting global warming to 1.5 degrees Celsius. As such, we are actively implementing emissions reduction plans to reduce our emissions by 42% by 2031, increase the beneficial use of landfill gas to 65% by 2026, and make continued investments in landfill gas collection and measurement systems.

To support our sustainability goals, we need to measure and manage our emissions. WM is exploring several methods of measuring landfill emissions more accurately and easily, and we have welcomed various stakeholders to work with us to help identify solutions. WM also is working with academics, regulators, non-governmental organizations, and measurement technology providers that provide satellite, aircraft, drone, fixed, and portable sensors and analytics services that support our journey towards having a comprehensive landfill emissions measurement system. Advancing measurement methods leads to more specific data that will enable us to target initiatives to capture landfill gas and reduce emissions.

For example, WM has engaged with several industry stakeholders to improve knowledge and data around landfill emissions measurements. In November of 2023, WM hosted a controlled methane release study at our Petrolia Landfill in Ontario, Canada. The study, which was funded by the Environmental Research & Education Foundation and conducted by researchers from St. Francis Xavier University, assessed a combination of existing and emerging technologies and methodologies for methane detection and quantification in a landfill environment. A number of commercial technology vendors as well as researchers from academia and Environment and Climate Change Canada (ECCC) participated in the study. This work built on past studies including ECCC research staff's deployment of emissions measurement technology at the WM's Petrolia and Twin Creeks Landfills.[1]

Finally, WM has been working cooperatively with the Agency for 15 years on implementation of and revisions and clarifications to the MSW Landfill GHG reporting requirements at 40 C.F.R. Part 98, Subpart HH ("Subpart HH"), of EPA's Greenhouse Gas reporting Program ("GHGRP").[2] Per Subpart HH, WM prepares emission estimates and reports annually for approximately 250 active and closed MSW landfills. WM is a member of the Solid Waste Industry for Climate Solutions ("SWICS"), which intends to publish and publicly share updates to its landfill emissions modeling tool in early 2025. WM looks forward to continuing our dialogue with the Agency around the use of this modeling tool as

[1] A more detailed discussion of the findings from this study can be found in the National Waste & Recycling Association's ("NWRA") comment submittal to this RFI.

[2] EPA recently updated Subpart HH in a final rule entitled, *Revisions and Confidentiality Determinations for Data Elements Under the Greenhouse Gas Reporting Rule,* 89 Fed. Reg. 31802 (April 25, 2024) ("2024 Subpart HH Revisions").

well as our engagement and findings on the use of advanced measurement and remote sensing technologies in detecting and quantifying landfill emissions.

SUMMARY AND BACKGROUND TO WM'S COMMENTS ON THE RFI

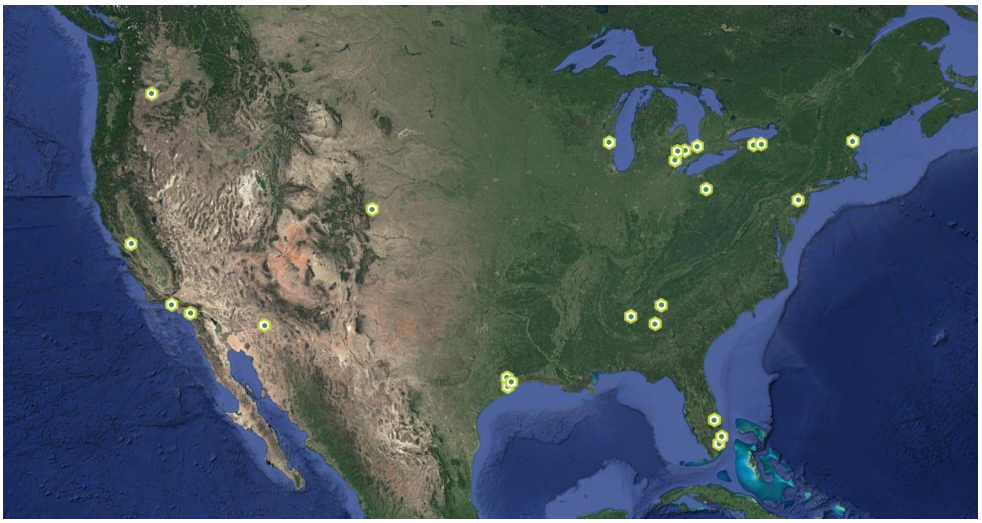
As discussed below, as well as in the comments submitted to this docket on behalf of the National Waste and Recycling Association ("NWRA"), our sector is well positioned to provide input on the use of advanced measurement detection technologies.[3] WM is working with over 20 different technology providers in the methane measurement space—including via drones, aircraft, satellites, fixed sensors, and portable meters—along with entities that provide unique analytical capabilities to assist us with data analysis. Our research and engagement to date, described below, reveals that although technologies are evolving quickly, they often yield inconsistent and inaccurate data based on the unique characteristics of landfill topography and operations. Accordingly, additional research and development is necessary before EPA can justify incorporating the use of advanced measurement technologies for purposes of reporting under the GHGRP or altering the existing modeled approach (*i.e.*, reducing collection efficiency values within Equations HH-7 and HH-8) under the GHGRP.

WM conducted a site-specific Comparative Methane Measurement Study ("Comparative Study") in partnership with an outside consultant and several technology vendors, wherein various types of emerging advanced measurement technologies were applied and compared across numerous WM sites. WM compared satellite measurements to emissions quantified under the pre-2024 GHGRP method, using the collection efficiencies required by the 2024 Subpart HH Revisions, and using SWICS Methodologies. The comparison showed mixed results in terms of correlation, including that some sites would be overreporting, and some underreporting relative to both GHGRP methods. As a general matter however, the 2024 Subpart HH Revisions tended to result in more overreporting than underreporting when compared to data derived from emerging measurement technologies. In addition, of the three methodologies, SWICS was most consistent with data derived from satellite measurements, and is most responsive to real-time operational observations at municipal solid waste landfills. WM believes it would be helpful and responsive to the questions posed by EPA in this RFI to provide details, learnings, and other insights from the Comparative Study.

Description of WM Comparative Methane Measurement Study

The Comparative Study, which began in 2022, analyzed data collected across 25 WM landfill sites of varying geography throughout the United States, as depicted on the map below.

[3] WM contributed to, supports, and incorporates by reference the comment submitted to this RFI on behalf NWRA



Monthly observations were made at sites in different geographic locations, while seven primary sites were observed on a quarterly basis using various contracted and open-source ground and aerial technologies, including:

1. TROPOMI;
2. Commercial Satellite;
3. EMIT;
4. Carbon Mapper;
5. Aerial Mass Balance;
6. Unmanned Aerial Vehicles (also known as Drones);
7. Surface Emissions Monitoring ("SEM") using Method 21;
8. Tracer Correlation technology; and
9. Metal Oxide Fixed Sensors.

These technologies captured the following number of measurements between February 2023 and October 2024:

Sensor	Site coverage	# measurements
TROPOMI	25	15K
Commercial Satellite	25	869
EMIT	8	23
Carbon Mapper Aircraft	9	326
Aerial Mass Balance	8	57
Drone	4	738
SEM	25	1.7M
Tracer Corr	5	88
Metal oxide ground sensor	7	67M

WM aimed to evaluate the relative accuracy, reliability and scalability of technologies for landfill application and build data management aggregation and analytics systems to track emissions and mitigation responses, with the ultimate goal to better correlate measured and modeled data in the long-term. As a result of the Comparative Study, WM gained insights on how to best analyze trends and correlations in aggregated data from both WM-contracted and public sources. These learnings are poised to improve WM's find-and-fix approach to fugitive emissions in the short-term, and to inform research and development of advanced measurement technologies to quantify emissions for purposes of the GHGRP in the long-term.

Objectives of this Comparative Study were to evaluate various remote methane measurement technologies to determine their capabilities, including:

- **Localizing Emissions.** Identifying the physical location of emission sources to facilitate remediation and understand root causes.
- **Quantifying Emissions.** Determining mass emission rates to compare to model and inventory values and gauge emissions mitigation actions.
- **Evaluation and Deployment.** Comparing methods with whole landfill measurements to understand what combination of approaches is accurate and scalable; developing and assessing best practices to operationalize information for mitigation.

Based on WM's intensive deployment and analysis of the various technologies and the resulting outcomes, we speak with experience and understanding of both the opportunities and challenges of applying emerging technologies to the quantification of annual emission estimates. At this time, WM believes there are significant limitations to the use of emerging technologies for the quantification of emissions, based on challenges in detection, attribution and quantification driven in large part by the unique characteristics of municipal solid waste landfills and the lack of standardized methodologies to effectively address those challenges. To be clear, WM is heavily invested in finding technically and economically feasible and scalable solutions. We are collaborating with EPA, state agencies, technology vendors other industry partners and eNGOs through controlled release studies, quantification and localization methods development and technical papers. Although the technologies show promise, there is much work yet to do before measurement can augment or replace current methods for emissions estimation.

GENERAL COMMENTS:

WM's initial learnings from the Comparative Study are as follows:

- **There is no silver bullet, one-size-fits-all approach**. Some combination of measurement approaches that capture temporal variability in emissions and provide reasonably accurate quantitation will be needed.

- **Technologies developed and used for the oil and gas sector are not directly transferrable to landfills.** Fixed sensors and drone flux approaches show promise. However, quantification and localization needs additional development and study.

- **Satellite technologies currently present an irreconcilable level of uncertainty**.
    - Repeat measurements are necessary for accurately identifying emission sources, uncovering opportunity to improve gas collection, and verifying the effectiveness of corrective actions.
    - During a study period in October and November 2024 at the 7 pilot sites, 10 detections were made by a satellite provider. WM worked extensively with operators on site to identify possible ground sources for the emission detections. In one case, the plume location was determined to be an unlikely source of emissions because it was in an excavation area with no waste in place. In another case, the plume had multiple potential sources even though only one was identified by the satellite provider.
    - The uncertainty for satellite-based emission source location detections ranges from tens to hundreds of meters, depending on wind speed.
    - The uncertainty reported by providers for satellite emission quantifications averages 44% based on 551 measurements collected in 2024.

- **Understanding the status of the landfill is key to understanding the potential sources of emissions**. This includes:
    - Landfill gas collection and control system status and construction activity.
    - Cover type and distribution (current, high resolution optical imagery can be very useful in this context).
    - Local meteorological data (wind speed, direction, atmospheric pressure).
    - Reliance on either global or regional wind data as opposed to local wind data can significantly impact the calculated emission rate.
    - Uncertainty and wind speed are correlated.

- **Executing studies combining multiple measurements is complex, expensive and challenging.** We need to find more ways to collaborate and leverage expertise and reduce the cost of this work.

- **2023 EPA reported emissions compared to measured emissions at 25 sites are highly variable.**

- **To inform emission estimates more research still needed on:**

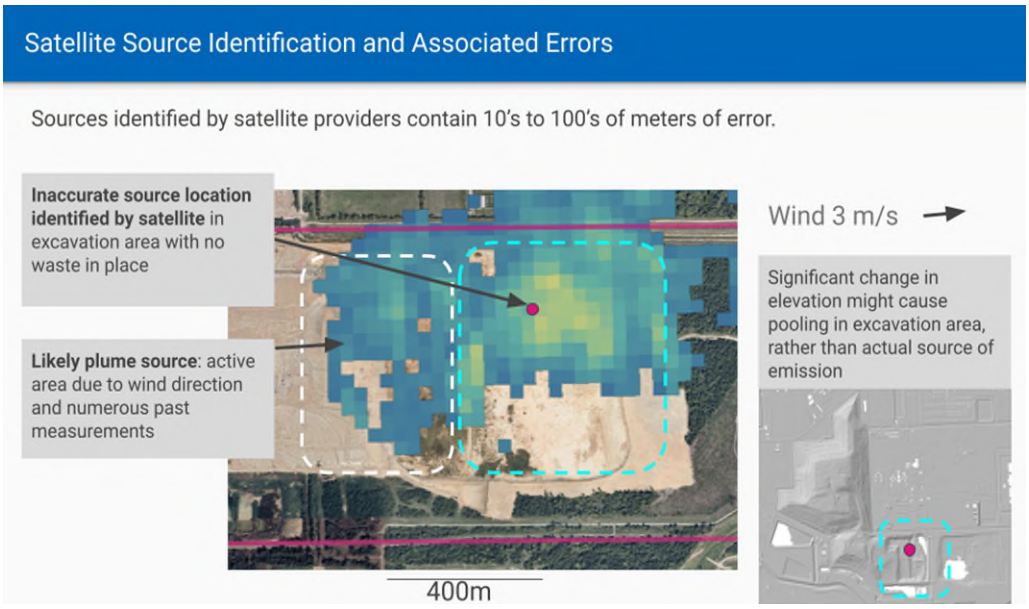
- How to address emissions variation throughout the day/night as most measurements are taken during clear daytime conditions?
- How to weight episodic (construction, maintenance) events?
- How to reconcile differences in measurements of emissions from different technologies?

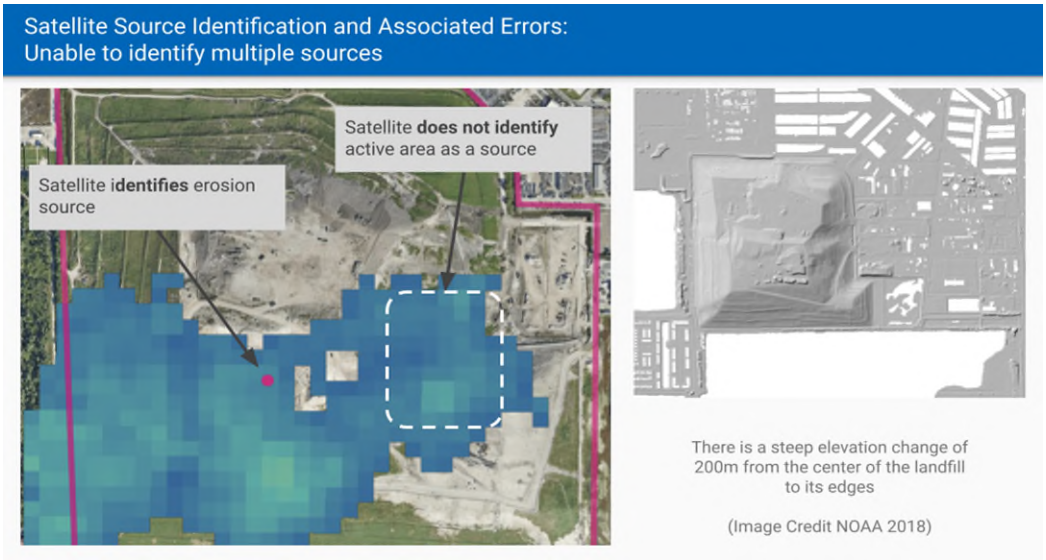
SPECIFIC COMMENTS:

The following comments pertain to more specific learnings from the Comparative Study, all of which are relevant to better understanding the capabilities of advanced measurement technologies, and inform their use in detecting, quantifying, and annualizing emissions for purposes of reporting under the GHGRP.

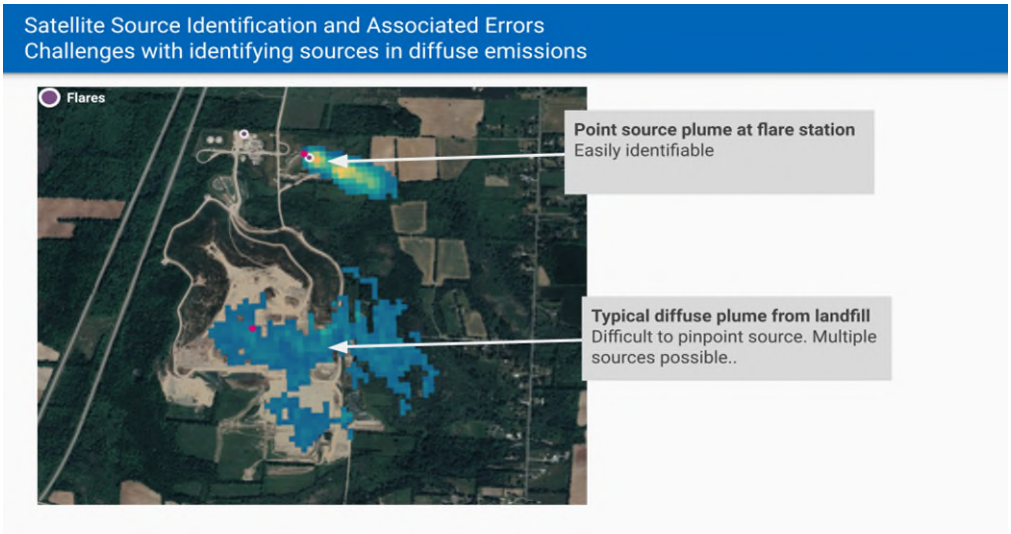
Localization and Attribution

WM is working on the development of an advanced method for pinpointing the physical locations of methane emission sources. The company has also assessed the capabilities of measurement data providers to identify emission sources at landfill sites, focusing not just on detecting emissions but on tracing their specific origins within the complex landfill environment. In doing so, WM has found that vendors have limited ability to provide accurate source locations, likely due to a combination of factors unique to landfills that create uncertainty, such as wind data; landfill gas behavior (*i.e.*, the tendency to pool in low-lying areas), cover type, and complex topography as shown in the figures below.





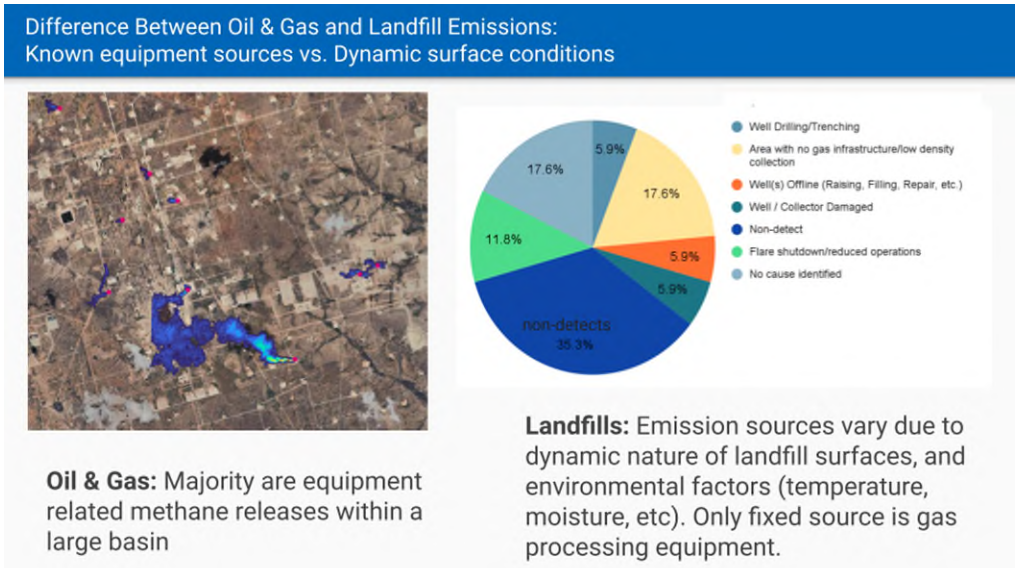
The inability of vendors to accurately localize and attribute sources is due in part to the complexity of landfill emissions. Landfill gas plumes behave sporadically due to the composition of landfill gas, the topography of landfills, the atmospheric and meteorological conditions at the source, the relevant cover type, and other interferences such as physical objects or vegetation. The following figure presents the visual differences between point source and diffuse plumes to illustrate the complexities associated with localizing diffuse plumes from landfills:



Moreover, by the very nature of landfills, emissions sources are difficult to localize due to constant construction. For example, the working face/working area moves to accommodate additional waste tonnage. Satellite or aerial measurements and images captured during the period of time when the working face/working area shifts will not accurately localize emissions from the working face/working area.

Quantification of Emission Rates

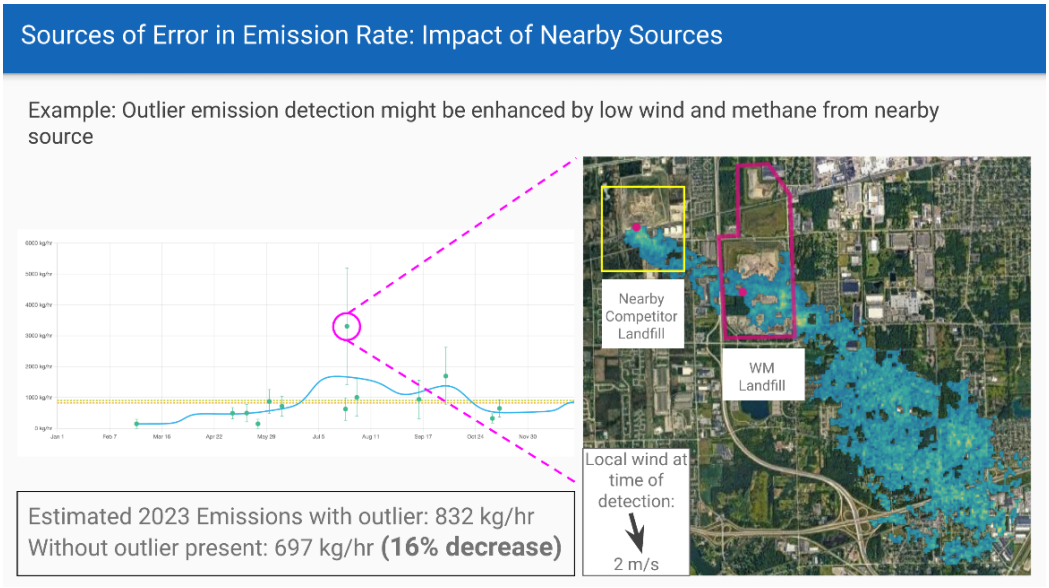
There are numerous complexities associated with detecting and quantifying landfill gas emissions that complicate the application of advanced technologies to sector emissions.[4] Many of these complexities are unique to landfills, and are not applicable in the oil and gas sector. These complexities begin with the composition of landfill gas, which is heavier than air and released at near atmospheric pressure. The behavior of landfill gas plumes is highly influenced by topography, meteorological conditions, atmospheric conditions, and other site-specific conditions, making it unpredictable and therefore challenging to detect and quantify. As a result of dynamic surface conditions, landfill emissions can be attributable to various sources, as identified by WM's own study and shown in the figure below:

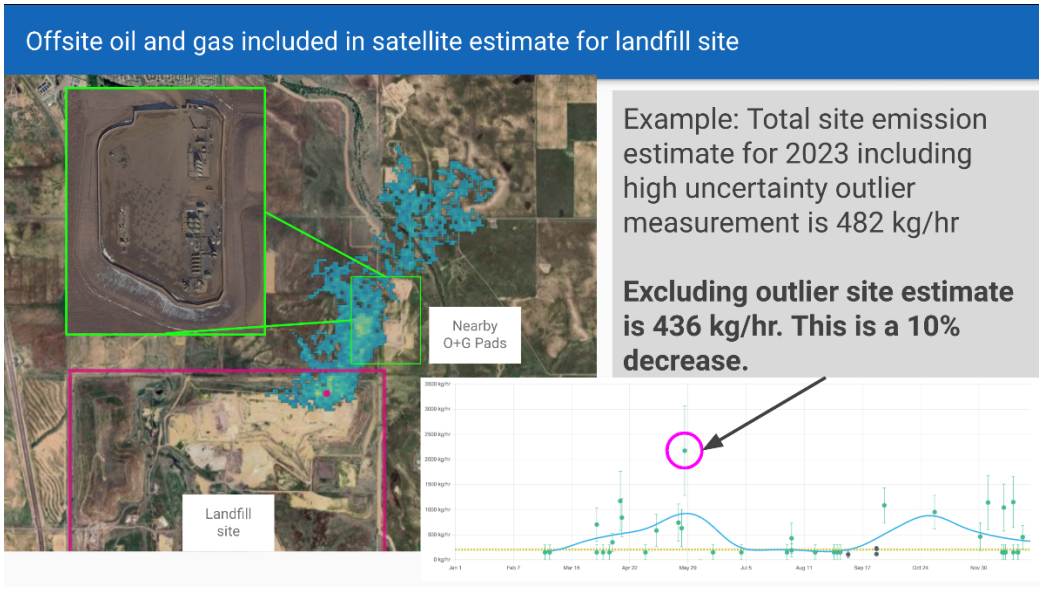


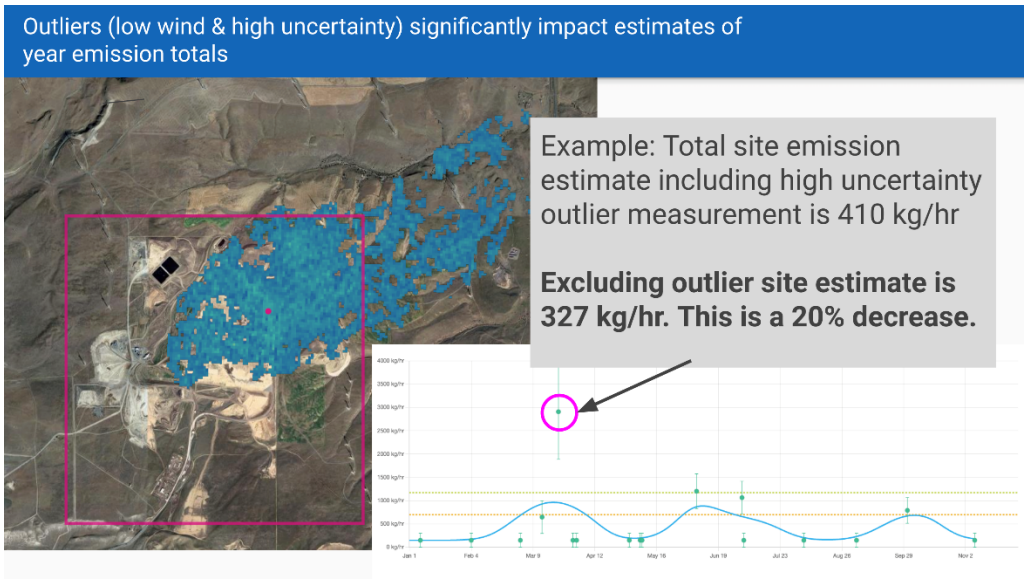
Thus, while flux planes from drones have been proven effective in quantifying emissions from a known point source, the vendors used by WM was unable to effectively separate and quantify the multiple emission sources to produce an accurate and reproducible estimate of the whole site emissions. This is due in part to the aforementioned complexities inherent in the nature and structure of landfills and landfill gas emissions, but exacerbated by the fact that different advanced technology vendors apply unique and often proprietary methodologies and algorithms to their quantification processes and often cannot differentiate between landfill emissions and emissions from nearby sources. As a result, the datasets in the Comparative Study included highly uncertain outliers that significantly influenced the emission rates. In several examples,

[4] The complexities associated with landfill gas emissions are described more thoroughly in NWRA's comment in response to this RFI.

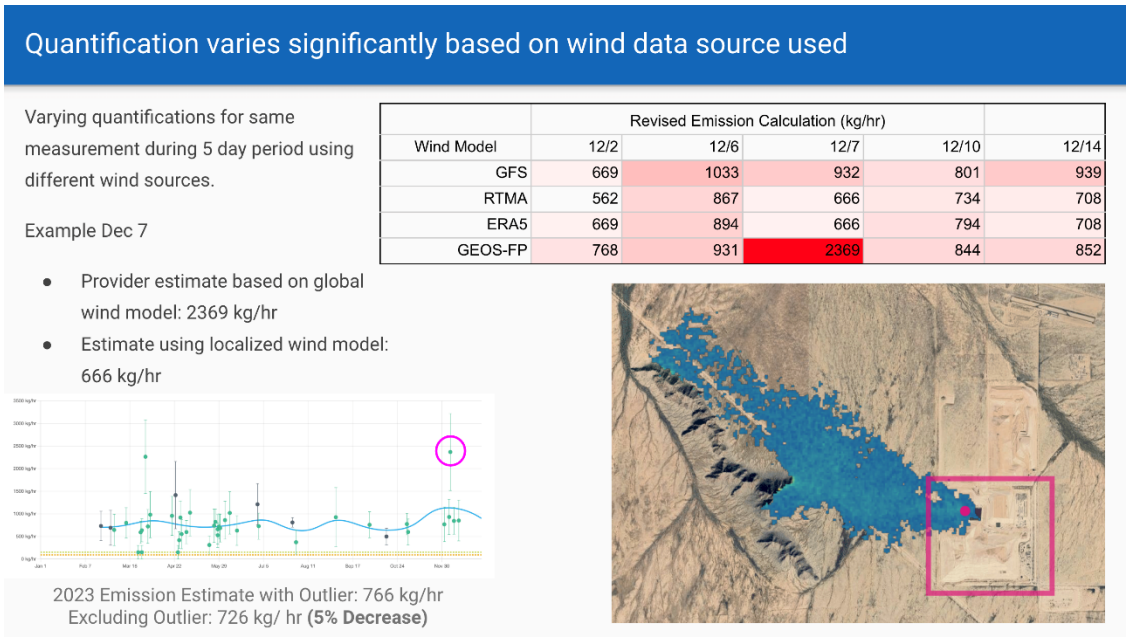
removal of the outlier caused emission estimates for the relevant sites to drop by 10% or more:





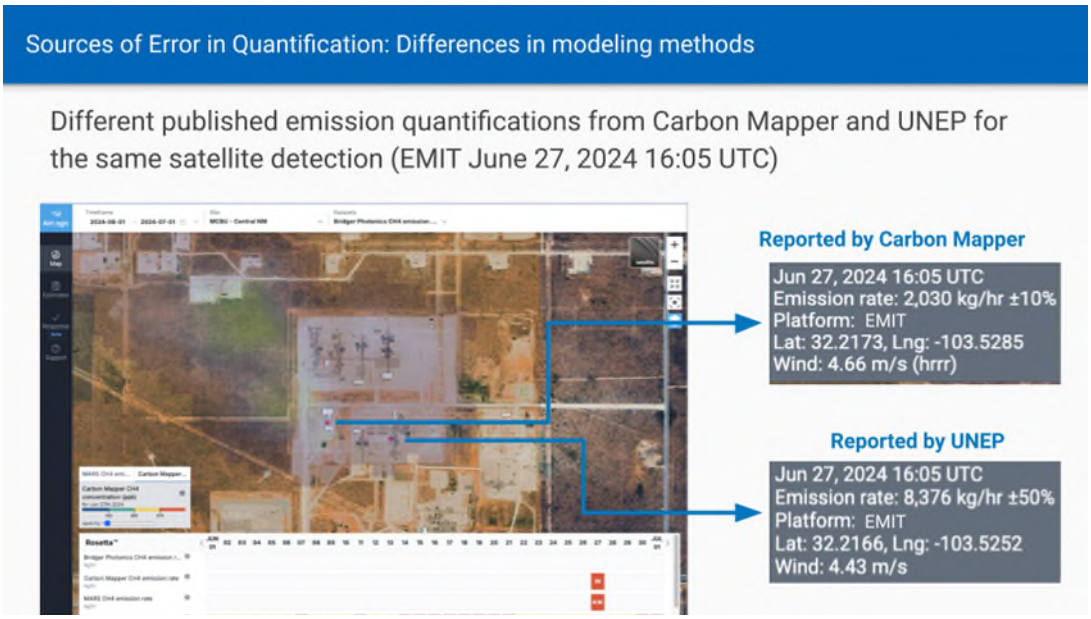


Relatedly, emission rates varied remarkably depending on the wind model integrated into the quantification algorithm.



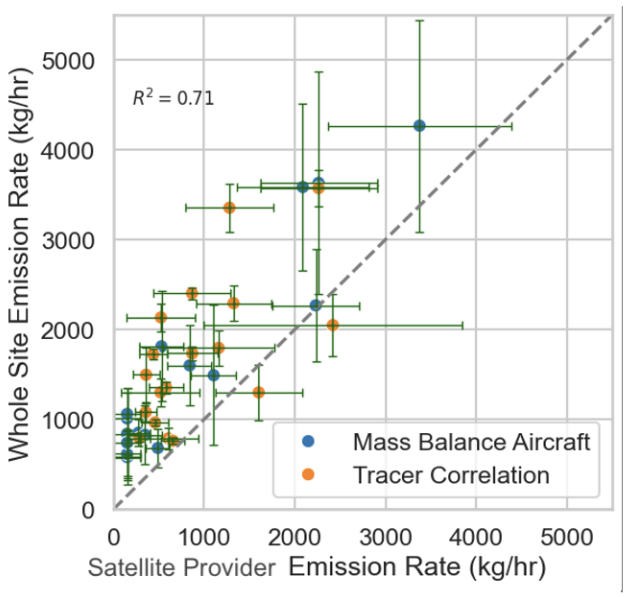
	Revised Emission Calculation (kg/hr)				
Wind Model	12/2	12/6	12/7	12/10	12/14
GFS	669	1033	932	801	939
RTMA	562	867	666	734	708
ERA5	669	894	666	794	708
GEOS-FP	768	931	2369	844	852

In the same respect, where different vendors apply their own quantification methodologies and algorithms, the estimated emission rates naturally differ, evidencing an irreconcilable lack of standardization in the quantification process.



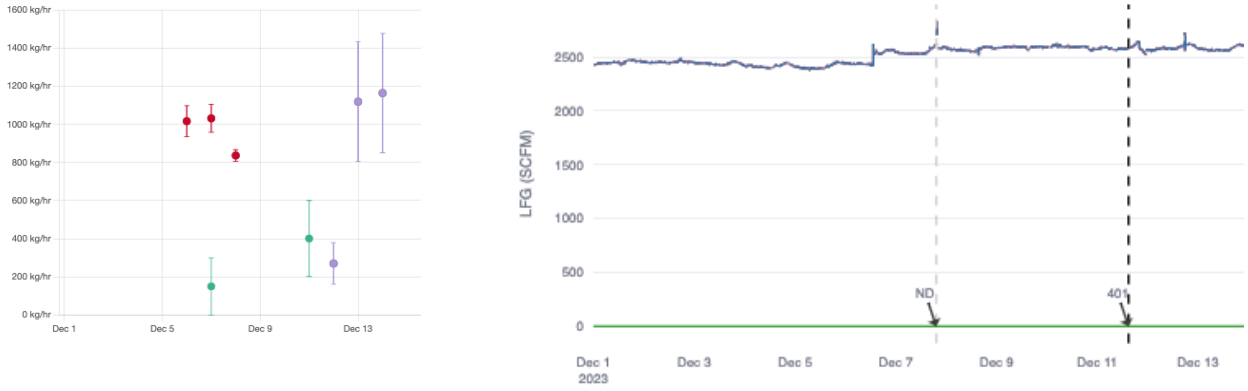
While the above figure provides evidence of an oil and gas facility with drastically different emission rates produced by different vendors, the results of WM's Comparative Study evidence the same issues. Drone flux planes and fixed sensors were unable to produce reproducible whole site emission quantification. In fact, more consistency was observed in the measurements collected using tasked 30-m resolution satellites, tracer correlation, and mass balance aircraft methods. Whole site emission measurements using either aerial mass balance or tracer correlation were made at 9 landfills from June 2023 to Sept 2024.[5] The whole site measurements were found to correlate with emission rates from targeted satellite observations in the same month—although large uncertainties were present in all methods due to both temporal variation in measurements within the same month and the reported method uncertainty. The whole site emission estimates were found to be higher than the emission rates, on average, as shown in the figure below:

[5] WM used the methodologies outlined in Varon et al., *Quantifying methane point sources from fine0scale satellite observations of atmospheric methane plumes*, 11 Atmos. Meas. Tech. 5673–86 (2018).



Despite the correlation when considered in aggregate, results from different technologies at a single landfill varied dramatically from day to day, while the collected volume of landfill gas remained consistent. The dramatic variation in point-in-time measurements within days increases the frequency needed to effectively extrapolate measurements to a reliable annual estimate.

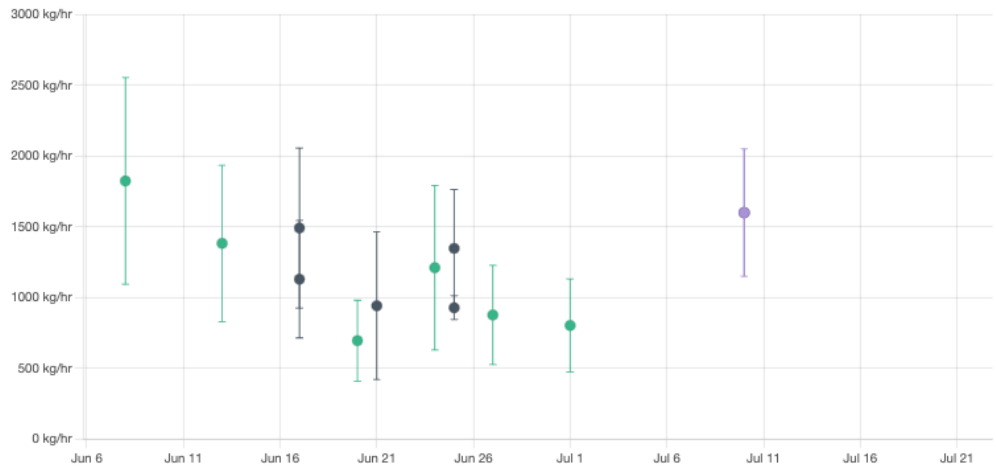
Example Measurement Comparison at Landfill A:



The figure on the left above depicts the measurements using tracer correlation (red), aerial mass balance (purple), and commercial satellite (green).

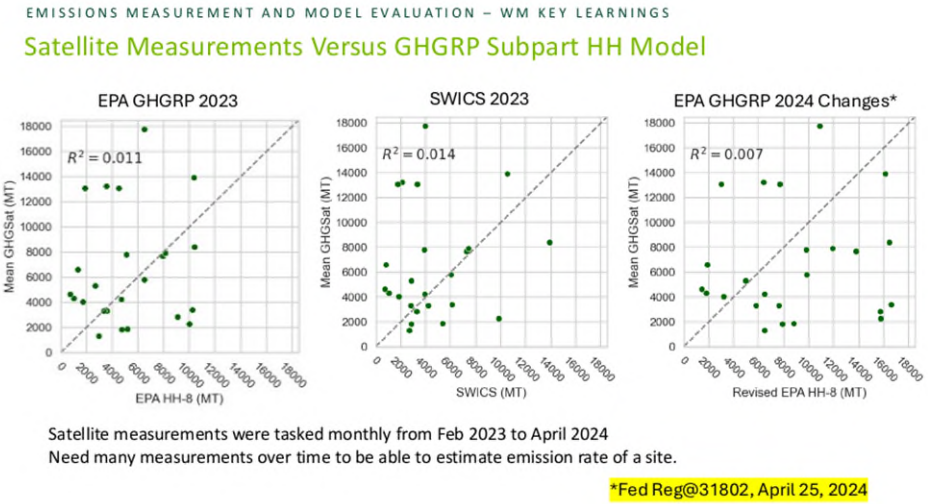
At another landfill, Carbon Mapper emission rate estimates were compared with commercial satellite and aircraft mass balance measurements. The results were more consistent, but uncertainties of 50% were common.

Example Measurement Comparison at Landfill B:



The figure above depicts commercial satellite measurements (green), Carbon Mapper measurements (gray), and aerial mass balance measurements (purple).

As part of the Comparative Study analysis, WM compared quantification based on satellite measurements to reported emissions under the GHGRP. As evidenced in the figure below, limited correlation existed between the satellite measurements and the emissions reported under the GHGRP, indicating that satellite technologies are not yet poised for quantification and calculation of annual emission rates at this point in time. The depiction below shows that the 2024 changes to collection efficiency in Subpart HH of the GHGRP, when compared to quantifications based on satellite measurements, would tend to cause more overreporting using GHGRP methodologies as compared to the GHGRP methodologies applicable prior to the 2024 revisions. The figure also illustrates the strongest correlation between the satellite measurements and the SWICS methodology.



CONCLUSION

The results of WM's Comparative Study illustrate the challenges and current shortcomings of advanced measurement technologies, specifically in localizing and quantifying emissions at landfills. However, the findings highlight the potential for further development of these technologies to better understand landfill gas emissions, and in turn, quantify annual emission rates for the purpose of reporting under the GHGRP. Additional time is needed to research, develop, and standardize the methodologies and algorithms associated with these technologies. WM has partnered with EPA's Office of Research and Development to lead the way on this front. Indeed, based on data gathered from the Comparative Study, WM and ORD have co-authored a collaborative paper that is currently undergoing internal peer review before it will be transmitted for external peer review. The underlying study analyzes nearly 700 observations made using advanced measurement technologies across 60 active WM landfill sites to analyze calculated collection efficiency versus those reported under the GHGRP. WM believes that this comprehensive paper will better inform the current understanding of both landfill gas emissions and advanced measurement technologies, based on data derived from deployment of technologies at active landfills across the United States.

WM very much appreciates the Agency's consideration of these comments. Should you have any questions about this letter, please contact me at abaniste@wm.com.

Very truly yours,

Amy Van Kolken Banister
Senior Director of Air Programs
Environmental Management Group