June 19, 2023

RE: "Public Workshop on Potential Improvements to the Landfill Methane Regulation" Comments

Thank you to California Air Resources Board (CARB) staff for developing and sharing preliminary concepts for potential improvements to the Landfill Methane Regulation (LMR).

We commend California's efforts to drive methane reductions in the waste sector through both organics diversion (SB 1383) to keep methane-generating waste out of the landfill and strong landfill controls (LMR) to mitigate emissions from waste in place. As the Board highlighted, methane monitoring and mitigation have advanced significantly since the 2010 LMR rulemaking, and we encourage CARB to set ambitious new standards that incorporate the latest technologies and best practices in landfill design and operations. Improvements to LMR can achieve major methane emission reductions in California and serve as a model for other state and federal standards.

RMI is an independent nonprofit organization working to secure a clean, prosperous, zero-carbon future for all. RMI develops analytical tools and engages with public and private sector partners to reduce methane emissions across the oil and gas and municipal solid waste sectors.

We support the recommendations in comments jointly submitted by Californians Against Waste, Coalition for Clean Air, Environmental Integrity Project, RMI, and Sierra Club California. Below, we provide additional input, primarily on the opportunity to incorporate advanced monitoring technologies into the LMR.

We appreciate the opportunity to provide feedback on preliminary concepts, and we look forward to engaging throughout this rulemaking process. Please do not hesitate to reach out with questions.

Kind regards,

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Advancements in methane monitoring technologies – from aerial monitoring (satellites, aircraft) to near-ground approaches (drones, rovers) to continuous emissions monitoring systems (towers, tripods) – are transforming landfill operators' ability to detect, geolocate, quantify, and mitigate methane emissions. Relative to conventional surface emissions monitoring, these technologies provide operators with more *frequent* and *comprehensive* data to drive emissions reductions. Operators can leverage advanced monitoring technologies for rapid leak detection and repair and also to inform proactive design and operational decisions that minimize fugitive methane emissions across the landfill.

Near-ground monitoring methods, such as drone surveys and continuous sensors, are generally low-cost, and some landfills are adopting them voluntarily to improve operations. There are also funding opportunities that can expand access to monitoring technologies. For example, the Inflation Reduction Act allocates $20 million for methane monitoring, which EPA plans to use to procure methane measurement equipment that can be loaned to states, local governments, and Tribes.[1]

We are encouraged by CARB's steps to formally incorporate next-generation emissions monitoring technologies into its landfill methane regulation. Our recommendations below build on the agency's preliminary concepts:

1. **We Support Requirements for Follow-up When a Leak Has Been Detected Using Technologies Such as Satellites**

CARB's operator outreach following the 2020-21 overflights drove effective mitigation of large methane plumes detected at landfills across the state. The overflights called attention to leaks that might have otherwise gone undetected for months and prompted successful operator repairs to the gas collection system and landfill cover. A similar outreach program conducted by the Pennsylvania Department of Environment (DEP), in collaboration with Carbon Mapper and the U.S. Climate Alliance, prompted the repair of several landfill methane leaks and development of new best practices to reduce emissions. In Pennsylvania, landfill operators successfully reduced emissions from MSW landfills by over 1,300 kg/hr, or about 37%.[2]

These two examples show how aerial surveys can drive quantifiable methane reductions. However, participation rates are a limiting factor in voluntary programs. Of the 45 incidences CARB sent to operators, 22 (49%) were successfully stopped or repaired.[3] CARB plans to scale up remote sensing efforts through its Carbon Mapper partnership and $100 million in satellite funding, and we strongly

[1] "Inflation Reduction Act Tackling Climate Pollution: Methane Emissions Monitoring - $20 Million," U.S. Environmental Protection Agency, May 25, 2023, https://www.epa.gov/inflation-reduction-act/tackling-climate-pollution.

[2] "Methane Overflight Study Overview," Pennsylvania Department of Environment Air Quality Technical Advisory Committee, March 9, 2023, https://files.dep.state.pa.us/Air/AirQuality/AQPortalFiles/Advisory%20Committees/Air%20Quality%20Technical%20Advisory%20Committee/2023/3-9-23/AIRBORNE%20METHANE%20AQTAC%20MEETING%20230309.pdf

[3] Dr. Jason Schroeder, Landfill Methane Research Workshop: Methane Remote Sensing for Leak Identification and Mitigation, *The California Air Resources Board*, December 5, 2022, https://ww2.arb.ca.gov/sites/default/files/2022-12/Methane%20Remote%20Sensing.pdf.

support the Board's suggestion to make operator follow-up mandatory. Requiring ground monitoring and mitigation can maximize the emissions reductions of these remote sensing investments.

2. We Support Proposed Improvements to Surface Emissions Monitoring and Encourage Adoption of Advanced Monitoring Alternatives to Improve Coverage and Frequency

CARB proposed several potential changes to surface emissions monitoring (SEM) requirements. First, the Board is evaluating whether a lower threshold for mitigation (200 ppm) is feasible and warranted. We support CARB lowering the threshold, as this would drive mitigation of additional methane exceedances without creating undue burden on operators who are already required to monitor and record 200 ppm exceedances. We strongly support CARB's proposal to develop procedures for determining the full extent of the methane leak when an exceedance occurs and ensure the entire affected area is promptly mitigated. We also encourage CARB to expand SEM reporting and require disclosure of all measured SEM values; this can help CARB identify and develop additional measures to reduce methane emissions over time.

In addition to these proposed changes, we encourage the Board to: (1) expand approval and adoption of advanced monitoring alternatives that improve SEM coverage and frequency, and (2) update SEM requirements to account for the enhanced capabilities of these technologies.

Current surface emissions monitoring procedures allow exemptions for areas of the landfill with difficult or dangerous walking terrain, such as steep slopes, construction areas, and the active working face. Aerial surveys have shown exempt areas, in particular the active working face, can be a significant source of fugitive methane emissions.[4] Drones equipped with methane detectors (e.g., tunable diode laser absorption spectroscopy, non-dispersive infrared absorption, or flame ionization) can safely measure methane concentration across the entire landfill surface. They are a viable alternative to traditional walking SEM with several additional benefits:

- *Safety and coverage*: Drone monitoring can protect against the safety risks of walking SEMs and easily survey currently exempt areas. Drones can fly tight patterns that cover more of the landfill's surface.
- *Frequency*: Drone monitoring surveys are faster and less labor-intensive, which has prompted some operators conduct them more frequently than current quarterly requirements.
- *Actionable data*: Drone surveys provide operators with detailed reports that map measured methane concentration to specific GPS location. Landfill operators can leverage these maps to inform quick repairs and also to guide operational decisions about gas collection system expansion and cover practices.

The U.S. Environmental Protection Agency recently approved a drone alternative to surface emissions monitoring (OTM-51). Field studies conducted for the EPA approval process found the drone-based SEM approach often detected more methane exceedances than traditional walking SEM, yielding results that

[4] Eduardo P. Olaguer et al., "Landfill Emissions of Methane Inferred from Unmanned Aerial Vehicle and Mobile Ground Measurements," *Atmosphere*, Vol 13, Iss 6 (2022): 983. https://doi.org/10.3390/atmos13060983; Daniel H. Cusworth et al., "Using remote sensing to detect, validate, and quantify methane emissions from California solid waste operations," *Environmental Research Letters*, 15 (2020): 054012, https://iopscience.iop.org/article/10.1088/1748-9326/ab7b99/pdf.

are "typically no less stringent and often more conservative."[5] Environment and Climate Change Canada (ECCC)'s proposed regulatory framework for reducing landfill methane emissions takes this a step further and requires triannual drone monitoring at covered landfills. ECCC determined drone-based monitoring is "less labor intensive, safer, and offers the ability to more comprehensively measure the landfill surface."[6]

CARB should build on this progress and encourage adoption of approved drone technologies as an alternative to traditional surface emissions monitoring. CARB should also consider how other sensor types and deployment methods, such as continuous emissions monitoring systems, can improve surface emissions monitoring coverage and frequency. We encourage CARB to develop a process to continually evaluate and approve alternative monitoring technologies and develop standardized procedures for landfill operators.

CARB should also update SEM requirements to account for the expanded capabilities of these technologies. Specifically, we encourage CARB to require monitoring across the *entire landfill*, including the working face, steep slopes, and construction areas, as drone technologies can safely monitor previously exempt areas and support tighter flight patterns.[7] We also encourage CARB to evaluate the benefits of more frequent surface monitoring requirements than quarterly. ECCC's proposal would require *monthly* inspection of the landfill surface to identify cover leaks, which could include drone-based inspection. More frequent monitoring surveys could increase leak detection and repair without placing undue burden on operators, given these technologies are less labor-intensive.

3. We Support Proposed Improvements to Component Leak Monitoring and Encourage Adoption of Advanced Monitoring Alternatives to Improve Coverage and Frequency

We encourage CARB to develop more prescriptive procedures for component leak monitoring and expand monitoring to all components containing landfill gas. This will ensure prompt and thorough mitigation of fugitive emissions. We also support plans to clarify third-party and offsite devices are subject to monitoring and reporting requirements.

As with the SEM recommendations above, we also encourage CARB to: (1) expand approval and adoption of advanced monitoring alternatives that can improve component leak monitoring coverage and frequency, and (2) update component leak monitoring requirements to account for the enhanced capabilities of these technologies.

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[5] "Approval to Use Unmanned Aerial System Application as an Alternative to Method 21 for Surface Emission Monitoring of Landfills," U.S. Environmental Protection Agency, December 15, 2022, https://www.epa.gov/system/files/documents/2022-12/Barron%20Sniffer%20Alt%20with%20OTM%2051%20attached_signed.pdf

[6] "Reducing Canada's landfill methane emissions: Proposed regulatory framework," Environment and Climate Change Canada (ECCC), April 18, 2023, https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/publications/reducing-landfill-methane-emissions.html

[7] "Reducing Canada's landfill methane emissions: Proposed regulatory framework," Environment and Climate Change Canada (ECCC), April 18, 2023, https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/publications/reducing-landfill-methane-emissions.html

CARB should continually evaluate and approve alternative technologies for component leak monitoring, such as drones or continuous emissions monitoring systems. The Board should also consider the benefits of more frequent inspection than quarterly. For example, ECCC's proposal requires *monthly* or *continuous* monitoring of all landfill gas components under positive pressure using a portable methane detector or continuous monitoring system.[8]

4. **CARB Should Develop Alternative Compliance Options (ACOs) for Site-Wide Landfill Methane Monitoring and Continually Update Pathways to Accommodate Technology Advancement**

Above, we outlined how advanced technologies can be leveraged to improve upon existing monitoring frameworks, such as using drone monitoring for SEMs or continuous sensors for component leak detection. In addition, we encourage CARB to continually evaluate, approve, and incorporate other sensor types and deployment platforms that may be even more effective.

Today, researchers and operators are evaluating "stack and rack" monitoring approaches that combine multiple sensor types and deployment methods (e.g., drones, rovers, overflights, continuous monitors) with potential to detect *site-wide* methane emissions on a *continuous* basis. While still in the research phase, this framework has potential to accomplish the goals of SEM and component leak detection simultaneously. As these methods progress and once their detection capabilities are thoroughly validated, we encourage CARB to develop Alternative Compliance Options that set appropriate corrective action thresholds for *continuous, site-wide monitoring*. Such advancements would unlock the potential for *performance-based standards,* and we encourage CARB to take the lead in their research and development.

5. **Additional Recommendations**

We support the recommendations submitted by Californians Against Waste et al. on remote sensing, SEM, cover improvements (and adoption of biocover), gas control system design, and reporting requirements.

We also encourage the Board to pursue additional concepts it raised at the public workshop, including: minimizing gas collection system downtime, promoting adoption of automated collection systems, and minimizing area and duration of daily cover. We encourage CARB to address these items in design plans and/or work practice standards.

- *Minimizing GCCS downtime:* Robust GCCS design planning procedures and work practice standards can reduce the risk of downtime. Recommended design practices include: using gabion cubes on bottom liner, incorporating the GCCS with the leachate system, installing horizontal collectors, and installing well boot seals. Recommended operational best practices include: continually upgrading the GCCS, frequent to automated methane monitoring, frequent to automated wellhead tuning, and active management of liquid levels.[9]

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[8] "Reducing Canada's landfill methane emissions: Proposed regulatory framework," Environment and Climate Change Canada (ECCC), April 18, 2023, https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/publications/reducing-landfill-methane-emissions.html

[9] Ebun Ayandele et al., Key Strategies for Mitigating Methane Emissions from Municipal Solid Waste, RMI, 2022, https://rmi.org/insight/mitigating-methane-emissions-frommunicipal-solid-waste

- *Automated well tuning:* Automated well tuning can optimize gas collection by taking continuous measurements of gas composition and adjusting the vacuum-control valve. Operators can track data continuously via a remote dashboard and are alerted of any anomalous activity, such as intrusion of oxygen or nitrogen, prompting rapid mitigation of wellhead issues and fugitive methane emissions. A third-party study recorded a 13-24% increase in gas capture for landfills with an automated tuning system installed, thanks to improved uptime and optimized collection.[10] While the system has a relatively high upfront cost, it can pay for itself over time at landfills with energy projects as higher gas capture rates increase revenue.
- *Minimizing area and duration of daily cover:* Minimizing the exposed surface area of the daily uncovered working face (i.e., where there is no daily cover) can impede the emissions of LFG from underlying trash to the surface and atmosphere.[11] Installing intermediate and final cover on an ongoing basis can also improve methane control.

Finally, we encourage CARB to leverage its in-house research capabilities to support this rulemaking. The Board should build from existing expertise in methane monitoring, as exemplified at its December 2022 Landfill Emissions Workshop, to evaluate the efficacy and methane reduction potential of specific design and operational practices, such as automated well tuning, well design and spacing, and different cover materials (e.g., biocovers) and practices.

We also encourage CARB to consider collecting data on waste composition at landfills through LMR, or potentially in collaboration with CalReycle and SB 1383 compliance efforts, to track the efficacy of organics diversion efforts and their impact on landfill methane generation and emissions at different sites. Finally, we encourage CARB to evaluate the cost, efficacy, and methane reduction potential of organics sorting and extrusion technologies that could be deployed at the landfill to divert organics that are not successfully diverted through source-separation efforts to avoid locking in future methane generation.

[10] Joe Gillard, "Q&A: Can We Greatly Improve Methane Measure and Capture?," *MSW Management*, Feb. 27, 2023, https://www.mswmanagement.com/the-intelligentsia/article/53026295/qa-with-peter-quigley-ceo-and-chairman-of-loci-controls.

[11] Ebun Ayandele et al., Key Strategies for Mitigating Methane Emissions from Municipal Solid Waste, RMI, 2022, https://rmi.org/insight/mitigating-methane-emissions-frommunicipal-solid-waste