

SIMFLEX Controlled Release – Landfill

Experimental Protocol V2

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Executive Summary (Participant Guide)

This document is an operational protocol, not a conceptual overview. Participants should read it as a **testing contract** that defines exactly how performance will be evaluated, what must be reported, and how results will be interpreted. Missing or misunderstanding specific requirements can materially affect how a system performs in the final analysis, regardless of technical capability.

How the document is organized (and how to read it)

The protocol is long, but it is highly structured. Participants should not read it linearly; instead, focus on the sections most relevant to your system type and reporting role.

High-priority sections for all participants:

- **Section 5 – Test Method:** This is the core of the protocol. It defines what you must do before, during, and after testing.
- **Section 5.3 – Reporting:** This is the most frequently missed and most consequential section.
- **Section 6 – Performance Metrics:** This explains how your reported results will be scored.
- **Section 8 – Final Report:** This clarifies what will ultimately be made public and how your data will appear.

Reference sections:

- **Sections 1–4** provide context and definitions. They are important for interpretation but will not affect scoring directly.
- **Appendix A** summarizes changes from the previous version and should be reviewed by returning participants.

What participants must be aware of (critical points)

1. You are being evaluated at the *system* level

Performance reflects the **entire survey solution**. Results apply only to the configuration you document in your questionnaire, including hardware, field workflow, and analysis.

➤ **Read carefully: [Section 5.1 \(Documentation of System Under Test\)](#)**

2. Documentation is mandatory and binding

Your submitted documentation defines what is being tested. The deployed system must match the documented configuration, and undocumented changes are not permitted. Returning participants must explicitly state whether *anything* has changed since prior participation.

- **Do not skim: Section 5.1.1**
- **Especially important for R&D systems: allowances for post-survey documentation are limited and conditional.**

3. Facility boundaries and localization rules matter

Detection and localization are scored only within the defined Facility and according to the allowed localization basis:

- Some systems are scored at the point-source level.
- Others (especially continuous or fixed remote sensors) are scored at the sector level only.

Reporting outside the permitted localization mode (e.g., blobs, polygons, probability surfaces) is not allowed and will generally not be scored without prior agreement.

- **Read carefully:**
 - **Section 5.2.1 (Facility definition)**
 - **Section 5.2.2 (Facility Localization Sector)**

4. Controlled releases are single-blind and variable

Participants will not know:

- which emission points are active,
- how many releases are active,
- or the emission rates.

Release magnitudes intentionally span above and below expected detection limits. Zero-release experiments may be included and count toward false positive statistics.

Background landfill emissions are also part of the test environment.

- **Important for interpreting results: Section 5.2.6 (Emission rates and blinding)**

5. Survey time limits are enforced

Each Experimental Design Point has a maximum allowed survey time, based on information you provide. If your survey is not completed within this window:

- the survey stops,

- missed detections count as false negatives,
- and incomplete reporting may count as omissions.

➤ ***Do not overlook: Section 5.2.11 (Maximum Survey Time)***

6. Reporting: The most common failure point

Everything Must Be Reported (Including Non-Detects). Participants may not selectively report:

- non-detections,
- poor results,
- missed intervals,
- or failed attempts.

Missing reports are tracked explicitly as omissions and are reported alongside accuracy metrics.

➤ ***This is important: Section 5.3.5 (Non-detects, omissions, and reporting completeness)***

7. Reporting frequency must be declared and followed

If you declare a 15-minute or hourly reporting interval:

- every interval must be reported,
- even if no emission is detected.

Reporting frequency directly affects how quantification and omission statistics are calculated. Make sure your intake questionnaire is up to date.

➤ ***Read together:***

- ***Section 5.3.2 (Reporting Interval)***
- ***Section 5.3.3 (Replicates)***

8. Use the exact reporting templates

Detection, localization, and quantification must be submitted in strict CSV formats with exact field names. Non-compliant submissions may be returned or excluded from analysis.

➤ ***Essential reading:***

- ***Section 5.3.9 (Quantification Report)***
- ***Section 5.3.10 (Detection and Localization Report)***

How your performance will actually be scored

1. Detection and localization are binary and rule-based

Detections are classified as True Positive, False Positive, False Negative, or True Negative, using strict spatial and sector-based rules. Multiple detections near one source do not improve your score.

➤ *Do not assume intuitive scoring: Section 6.2.2*

2. POD curves and MDLs are derived post-hoc

Minimum Detection Limits (e.g., 90-percent POD MDL) are not declared by participants. They are derived by the Test Center using pooled detection outcomes and logistic fitting. This means that missed low-rate detections matter, false negatives affect your curve shape, and consistency matters more than occasional high performance.

➤ *Important for expectations: Section 6.2.4*

What will be public (and what will not)

- Individual Performer results reports are confidential by default.
- Public synthesis reporting focuses on performance by measurement principle, not commercial branding.
- R&D participants are protected from public release unless explicitly agreed.
- If you are amenable to public release, we can work together on sharing and publishing outcomes.

➤ *Clarified in: Section 7 and Section 8*

Final advice to participants

- **Read Section 5.3** before the campaign starts, not after.
- Ensure your reporting workflow is automated and complete.
- Align your survey strategy with Facility size and time limits.
- Do not assume oil-and-gas testing norms apply directly to landfills.
- Treat this protocol as both a technical standard and an audit document.

If followed carefully, the protocol provides a fair, rigorous, and defensible evaluation. Most poor outcomes in past campaigns have arisen not from sensor limitations, but from misalignment with reporting, timing, or localization rules.

1. Purpose

This protocol defines testing designed to assess the performance of Emission Detection Systems conducting leak detection and quantification (LDAQ) under Single-Blind Controlled Release (CR) conditions at a landfill. Testing is conducted at the system level and evaluates performance metrics including Probability of Detection (POD) and, where applicable, the accuracy of Localization and Quantification estimates.

The protocol is intended to support consistent, side-by-side evaluation of multiple technologies under comparable test conditions and to enable interpretation of performance relative to known emission release rates and locations. Testing is designed to reflect landfill-specific emission characteristics, including spatially distributed and heterogeneous emission sources.

2. History

This protocol is adapted from the methane detection testing methodology originally developed for oil and gas applications by the Methane Emissions Technology Evaluation Center (METEC) at Colorado State University. METEC's Controlled Test Protocol: Survey Emission Detection and Quantification (Revision 0.0, July 5, 2020) forms the methodological foundation for this work.

While the METEC protocol was designed for relatively compact oil and gas facilities characterized by discrete component-level point sources, landfill environments differ substantially. Landfills exhibit complex topography, heterogeneous surface conditions, and a combination of point-source and area-source emissions that may be spatially separated over distances exceeding one kilometre. Emissions are often diffuse and spatially variable rather than concentrated at engineered components.

Because of these differences, the METEC protocol required adaptation to support Controlled Release testing under landfill conditions. Earlier landfill measurement intercomparison efforts, including an EREF-facilitated controlled-release study conducted in 2010, demonstrated the value of side-by-side evaluation but were limited in scope relative to the diversity of technologies now available.

Since that time, advances in landfill methane measurement technologies have expanded substantially, including mobile and remote sensing approaches. This protocol formalizes a controlled-release

framework tailored to landfill environments, enabling systematic, side-by-side evaluation of contemporary Emission Detection Systems while maintaining alignment with the core principles of the METEC methodology.

3. Definitions and abbreviations

Table 1: Definitions

Controlled Release	A Controlled Release (CR) is an experiment in which Emissions are intentionally generated to evaluate Emission Detection and/or Quantification systems. During a CR, the emission rate and release location are known by the Test Center within well-defined measurement accuracy.
Area-Source Emission	An Area-Source Emission is an Emission of methane or natural gas distributed across a surface area rather than a single point. It is produced using one or more legs of CR tubing placed on the surface, buried, or elevated. Each tubing leg may be up to 50 m in length and contains multiple perforations that release methane or natural gas along its length.
Background Emission Points	Background Emission Points are releases of methane or natural gas originating outside the defined CR area, including emissions from the landfill surface or other natural or anthropogenic sources. Because testing is conducted on a closed landfill, such Background Emission Points may be present and will be identified and characterized by the Test Center on an ongoing basis using walking surveys or other approved techniques. These pre-existing Emission Points will not be labeled, and their locations and emission rates will not be disclosed to Performers.
Detection	A Detection is a formal alert generated by an Emission Detection System indicating that an Emission is present. Elevated gas concentration measurements alone do not

	constitute a Detection; they must be supported by analytics that attribute the observed concentration to an Emission originating within the Facility. This attribution must meet the System’s confidence requirement before a Detection alert is issued to the Facility operator.
Emission	An Emission is a release of methane or natural gas from any system or source into the surrounding environment.
Emission Detection System	An Emission Detection System is an integrated system consisting of sensor(s), deployment platform, auxiliary equipment, and analytics capable of detecting Emissions and attributing them, at minimum, to the Facility. An Emission Detection System may also include analytics to estimate the emission rate and/or the location of the Emission source.
Emission Point	An Emission Point is a location where the Test Center releases an Area-Source Emission or Point-Source Emission using the Emission System. Because constructed Emission Points may be visible on the ground due to surface disturbance or infrastructure, they will be shown on maps provided to Performers as approximate areas rather than exact coordinates.
Emission Survey	An Emission Survey is an inspection conducted within the Facility using an Emission Detection System for the Detection, Localization, and/or Quantification of Emissions during the survey period.
Emission System	The Emission System is the collection of all Emission Points, including both point and area-source configurations, that are constructed and operated by the Test Center for CR experiments.
Experimental Design (a test matrix)	An Experimental Design is the set of Experimental Design Points arranged to evaluate Emission Detection System

	performance across different combinations of Emission rates and environmental conditions.
Experimental Design Point (an experiment)	An Experimental Design Point is a single combination of settings for the independent variables of a CR experiment. Independent variables include the Emission rate(s) of the CR(s) and the environmental conditions present during the experiment.
Facility	The Facility is the defined area within which Emission Surveys are conducted and where Emission Points are located. Facility boundaries are established by the Test Center and may encompass a designated test area within the landfill or, when applicable, the entire landfill.
Facility Localization Sector	A Facility Localization Sector is a predefined sub-area within the Facility used for zone-based localization scoring. Sector boundaries are established by the Test Center for the campaign and remain fixed for the duration of that campaign, but may be revised between campaigns to reflect different test objectives or landfill analog conditions (for example, active working face, closed cell, or intermediate cover). Performers report the Sector associated with a Detection rather than an exact source coordinate.
False Negative (FN)	A False Negative is a CR that occurs within the Facility but is not detected by the Performer's Emission Detection System.
False Negative Fraction (FNF)	The False Negative Fraction is the number of False Negative CRs relative to the total number of Experimental Design Points in which the Performer's Emission Detection System participated.
False Positive (FP)	A False Positive is a Detection reported by a Performer that cannot be attributed to a CR.

False Positive Fraction (FPF)	The False Positive Fraction is the number of False Positive Detections relative to the total number of Detections reported by the Performer's Emission Detection System.
Final Report	A report issued by St. Francis Xavier University FluxLab, NRCan, and EREF following the conclusion of testing that documents the experimental design, test conditions, and the evaluated performance of participating Emission Detection Systems.
Localization	Localization is the process by which an Emission Detection System determines the spatial origin of an Emission within the Facility. Localization requires analytics that interpret concentration measurements together with meteorological and platform-specific data to identify the most probable source location or area. Localization is achieved only when the System's confidence requirement for source attribution is met.
Localization Accuracy (LA)	Localization Accuracy is a distance-based metric that quantifies the horizontal (2D) separation between the Emission location estimated by a Performer and the known location of the CR. Localization Accuracy is calculated using a single latitude–longitude coordinate pair reported by the Performer for each Detection.
Non-Detect	A Non-Detect is a mandatory reported outcome in which an Emission Detection System indicates that no Emission meeting the System's Detection criteria was identified during a Reporting Interval or Emission Survey.
Performer	A Performer is a single participant in the testing, including the personnel and the Emission Detection System(s) deployed by that participant.
Point-Source Emission	A Point-Source Emission is an Emission originating from a localized orifice or opening on or near the ground that

	<p>produces elevated gas concentrations in the air over meter-scale distances. Point-Source Emissions are intended to mimic concentrated ground-level sources such as a membrane tear, separation between a collection well casing and surface membrane, a leak in gas-collection system pipework, or a damaged well vacuum draw connection.</p>
<p>Probability of Detection (POD)</p>	<p>Probability of Detection is the fraction of Experimental Design Points in which a CR occurred that were reported as Detections by the Performer's Emission Detection System. Probability of Detection may vary as a function of survey protocol independent variables, such as emission rate and meteorological conditions, and is commonly represented as a Probability of Detection curve; in some cases, multiple variables may be evaluated jointly.</p>
<p>Quantification</p>	<p>Quantification is the process by which an Emission Detection System estimates the emission rate of an Emission within the Facility. Quantification requires analytics that interpret concentration measurements together with meteorological and platform-specific data to generate an emission-rate estimate. Quantification is achieved only when the System's confidence requirement for emission-rate estimation is met.</p>
<p>Quantification Accuracy (QA)</p>	<p>Quantification Accuracy is a metric that quantifies the absolute or percentage difference between the emission rate estimated by a Performer and the metered emission rate of a CR.</p>
<p>Reporting Interval</p>	<p>A Reporting Interval is the fixed time period declared by a Performer at which their Emission Detection System generates and reports emission estimates or Detection status.</p>
<p>Single-Blind</p>	<p>An experimental procedure in which the Test Center knows the location and emission rate of all CRs, while Performers do not.</p>

Survey Solution	A Survey Solution is the combination of an Emission Detection System, associated personnel, and methodology used by a Performer to conduct an Emission Survey.
Survey Time	Survey Time is the duration required by a Performer to complete an Emission Survey, measured as the difference between the time of arrival at the Facility and the time of departure from the Facility.
Test Center	The Test Center is the entity responsible for conducting testing under this protocol, including the physical facilities where testing is performed, the personnel performing the evaluation, and any supporting software or analysis.
True Negative (TN)	A True Negative is an Experimental Design Point in which no Controlled Release occurred within the Facility and no Detection was reported by the Performer.
True Positive (TP)	A True Positive is a Detection reported by a Performer that can be attributed to a Controlled Release.

Table 2: The variables used in equations throughout the protocol are listed

Variable	Description
FN	False Negative Detection(s)
FP	False Positive Detection(s)
N	Total number across all experiments
n	Total number of evaluated outcomes within a specified subset of Experimental Design Points, as defined by the analysis context (for example, within a quantile bin of Controlled Release emission rates)
TN	True Negative Detection(s)
TP	True Positive Detection(s)

Table 3: The abbreviations used in equations throughout the protocol

Abbreviation	Description
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CR	Controlled Release(s)
FN	False Negative Detection(s)
FNF	False Negative Fraction
FP	False Positive Detection(s)
FPF	False Positive Fraction
LA	Localization Accuracy
MDL	Minimum Detection Limits
POD	Probability of Detection
QE	Quantification Error
R&D	Research and Development
TCM	Tracer Correlation Method
TNR	True Negative Rate
TP	True Positive Detection(s)

4. Site

Controlled Release testing will take place at a closed municipal solid waste landfill in Petrolia, Southern Ontario, Canada (Figure 1). The site is located at 4052 Oil Heritage Road, Petrolia, ON, N0N 1R0 (42.871952° N, -82.121258° W) and is operated by Waste Management. The landfill was historically equipped with an active landfill gas collection and utilization system, which was shut down in 2025.

Background Emission Points may be present at the site due to residual landfill emissions and other natural or anthropogenic sources. These emissions are not part of the Controlled Release Emission System and may contribute to observed methane concentrations during Emission Surveys. Background methane emissions at the site have been characterized in multiple prior studies. Environment and Climate Change Canada (ECCC) estimated background emissions of 18.75 kg/h in 2021 using a Mobile Gaussian Inversion approach, while FluxLab reported emission rates of approximately 20 kg/h in 2022 using the same method. Using the tracer correlation method (TCM), background emissions were estimated at 24.44 kg/h in 2023 and 8.89 ± 2.03 kg/h in 2025.

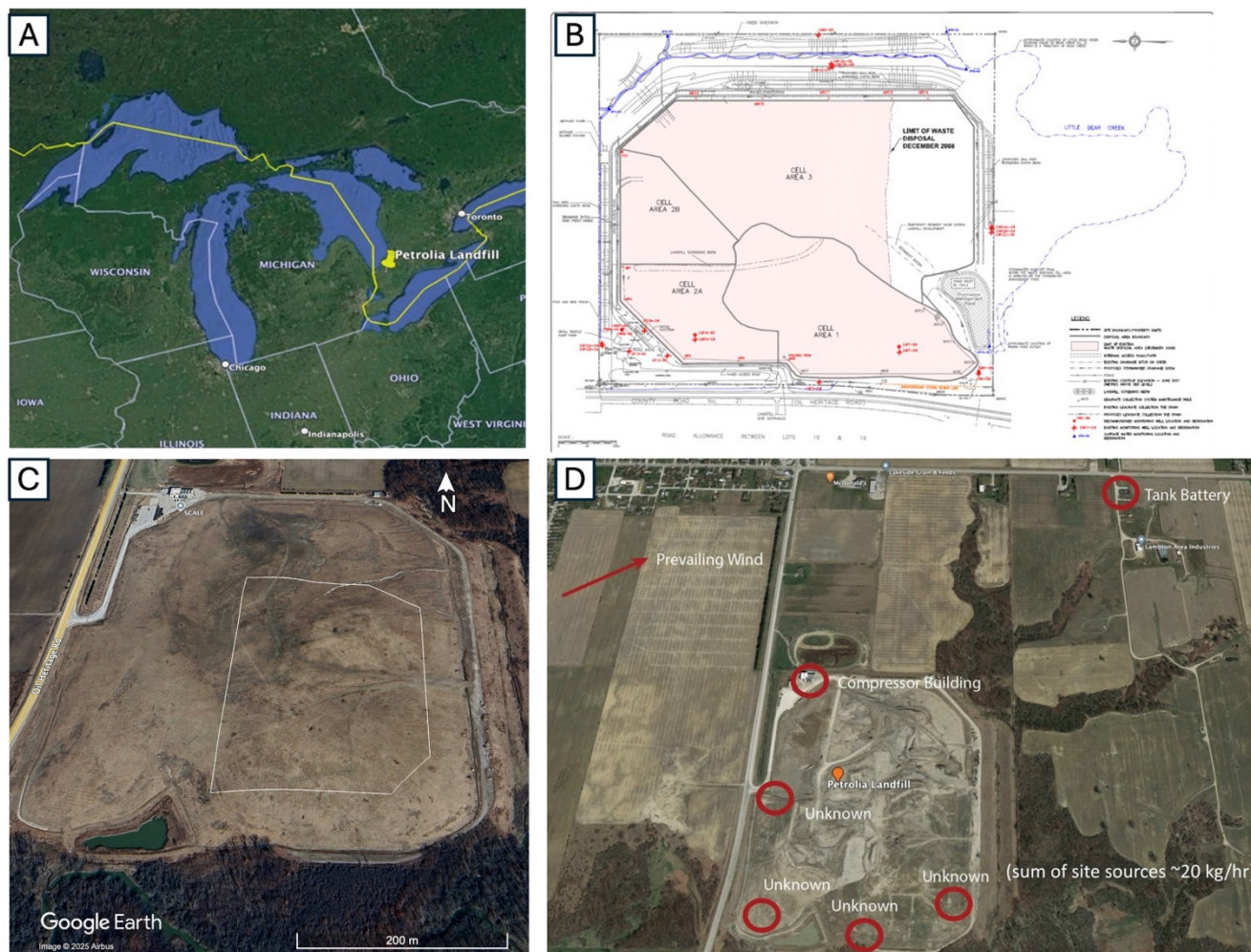


Figure 1. (a) Regional location of the Petrolia Landfill in Ontario, Canada. (b) Engineering site plan of the Petrolia Landfill prior to closure, showing waste cells and infrastructure. (c) Aerial view of the landfill showing the Facility boundary defined by the Test Center (white polygon), representing the designated test area used for emission surveys. Depending on the experiment, the Facility may comprise a subset of the landfill or the entire landfill footprint. (d) Aerial view illustrating identified background and non-landfill emission points surrounding the site, including nearby infrastructure and unknown sources, with prevailing wind direction indicated.

5. Test Method

Testing consists of three activities:

1. Documentation of System Under Test,
2. Emission Surveys, and

3. Reporting.

5.1 Documentation of System Under Test

The Performer shall document and submit the configuration and operational methodology of the Survey Solution under test. Documentation shall be sufficiently detailed to allow an independent reviewer to identify the tested configuration, understand how the Survey Solution was operated during testing, and interpret reported performance outcomes.

5.1.1 Documentation Requirements

Required documentation elements include, at a minimum:

- Emission Detection System configuration and deployment,
- Survey methodology and operating parameters,
- Post-processing and data analysis approach,
- Reporting basis and confidence level,
- Operational, safety, and environmental constraints,
- Personnel requirements and logistics.

Detailed documentation requirements are specified in the Participant Questionnaire provided on the Test Center website. Performers shall complete the questionnaire in full and provide all required information prior to the start of the survey period.

Returning Performers shall include a clear statement describing any changes in sensors, system configuration, analytics, or methodology relative to prior participation. If no changes have been made, the Performer shall explicitly state this.

Documentation that is incomplete or insufficient for interpretation may be returned to the Performer for revision prior to participation.

For research and development (R&D) Performers, documentation of post-processing and data analysis methods may be submitted after the survey period when pre-survey-period disclosure is not feasible, as permitted by the Test Center.

Documentation shall be limited to publicly available information and shall not include proprietary or confidential details (for example, algorithmic source code, internal decision logic, or non-public sensor performance specifications). Supporting public documentation may be appended where applicable.

The documented Survey Solution configuration shall match the configuration deployed during testing and shall remain unchanged for the duration of the survey period unless explicitly approved by the Test Center.

5.1.2 Testing Cautions

Results produced under this protocol are applicable only to the specific Survey Solution configuration that is tested and documented. Reviewers of test results may consider whether systems proposed for field deployment employ comparable sensor quality, deployment platforms, analytics, and operational practices. Use of atypical sensor densities, unusually high-performance sensors, additional analytics, or levels of human intervention that are not representative of intended field deployments may limit the applicability of test results to future field deployments, regulatory applications, or other uses.

5.2 Emission Surveys

Performers shall conduct Emission Surveys at the Test Center using the documented Survey Solution configuration. Performer personnel shall be present at the Test Center during their scheduled Survey Time unless otherwise approved by the Test Center (for example, for systems designed to operate without on-site personnel).

5.2.1 Facility definition

For localization experiments, the Facility shall be defined as a bounding box not exceeding approximately 20 acres. For quantification experiments, the Facility may be defined as the landfill perimeter road or another clearly defined boundary. Facility boundaries may correspond to physical infrastructure (for example, a fence line) or administrative boundaries (for example, a property line, right of way, or easement). Consecutive Experimental Design Points may be conducted within the same Facility or within different Facilities.

Some Survey Solutions may be designed to measure emissions across the entire landfill rather than within a bounded Facility.

The Test Center shall provide Facility boundary files (for example, KMZ or KML formats) to Performers prior to the start of the campaign.

5.2.2 Facility Localization Sector

For continuous or fixed-position remote sensor Survey Solutions, localization performance shall be evaluated using Sector-based (zone-based) localization within the Facility. These Survey Solutions shall report the Facility Sector from which emissions are inferred to originate, according to Sector definitions provided by the Test Center. Continuous remote sensor Survey Solutions shall not be scored on identification of the exact Emission Point location.

Sector definitions shall be established by the Test Center for the campaign and shall be provided to Performers in advance of testing (for example, as KMZ or KML files). Performers shall configure and position sensors consistent with the Sector-based localization basis.

For Survey Solutions capable of resolving individual source locations (for example, drone-based Survey Solutions), localization performance shall be evaluated at the resolution supported by the Survey Solution, which may be Emission Point level.

The Test Center may revise Sector definitions between campaigns to reflect campaign objectives and Facility layout; Sector definitions shall remain fixed within a campaign unless otherwise specified by the Test Center.

5.2.3 Experimental Design and scheduling

The Test Center shall prepare the Experimental Design prior to the start of the survey period after the list of Performers is finalized. The Experimental Design shall consider the Survey Solutions participating in each Experimental Design Point and shall be scheduled to maximize overlap among Performers when safe and practicable.

An Experimental Design Point shall be established by the Test Center and shall specify the designated Facility and the number of Controlled Releases. An Experimental Design Point may include zero Controlled Releases, or one or more simultaneous Controlled Releases from a combination of Emission Points. When Controlled Releases are present, the set of active Emission Points shall remain constant

within an Experimental Design Point, except as allowed under Section 5.2.5 for gas conservation, and may vary between Experimental Design Points.

Where feasible, the Experimental Design may include repeat Experimental Design Points conducted under different environmental conditions (for example, different wind or temperature conditions) to support evaluation of performance variability.

The Test Center shall provide real-time operational updates to Performers during the survey period, including (as applicable) daily start-of-day announcements, Experimental Design Point identifiers, safety or access notices, and the start and end times of each Experimental Design Point and Controlled Release window. Unless otherwise specified by the Test Center, these announcements shall be communicated through a designated group messaging channel (for example, a Telegram channel) established prior to the survey period. Time-stamped messages posted in the designated channel shall serve as the primary reference for operational timing, except where superseded by the Test Center's official experiment logs.

5.2.4 Selection of Experimental Design Points

Performers shall participate in Experimental Design Points consistent with the capabilities declared in their submitted documentation. For scheduling and Experimental Design purposes, the Test Center may group Survey Solutions into two categories: (1) Survey Solutions intended to quantify emissions and (2) Survey Solutions intended to detect and localize emissions.

Survey Solutions intended to quantify emissions may be scheduled in Experimental Design Points that include repetitions at multiple release magnitudes, which may include zero-release Experimental Design Points and small, medium, and large Controlled Releases from a combination of Emission Points.

Survey Solutions intended to detect and localize emissions may be scheduled in Experimental Design Points emphasizing lower release magnitudes (for example, 0–20 kg/h per release location), with the number of active Emission Points and their locations varying between Experimental Design Points. Because surveying the full Facility may require extended time for some Survey Solutions, the Test Center may schedule a limited number of Experimental Design Points per day when such Survey Solutions are participating. Since each release location within an Experimental Design Point can be treated as a separate binary detection experiment, Test Center can achieve good statistical power even with a small number of Experimental Design Points each day.

5.2.5 Controlled Release configuration and measurement trials

Controlled Release testing shall be performed by discharging methane at known rates from the Test Center Emission System within the Facility. To support transparency, the Test Center may designate observers to verify that experiments are conducted without bias.

Controlled Releases within an Experimental Design Point may be operated as steady releases or as time-varying releases, as specified by the Test Center in the Experimental Design to support campaign objectives and landfill-relevant testing conditions. The Test Center reserves the right to deactivate Emission Points that have already been surveyed by the Performer to conserve gas, provided it is unlikely to affect measurement of Emission Points not yet covered.

Measurement trials shall be conducted according to the test schedule established by the Test Center. Replicate measurements may be performed within an Experimental Design Point when required by a Survey Solution methodology or when time allows. Replicate submissions are encouraged because they support interpretation of Survey Time and improve the robustness of performance statistics. The number of replicate measurement reports submitted within a single Experimental Design Point may vary substantially by Survey Solution type (for example, aircraft may require multiple passes, drone-based flux curtain approaches may require multiple passes, and mobile spectroscopy may require one pass per trial). Due to differences in platform speed and operating practice, aircraft Survey Solutions may report substantially more replicate measurement reports within a single Experimental Design Point than slower Survey Solutions.

Any ground-based activities intended to support interpretation of drone-based measurements shall be conducted only following consultation with, and approval by, the Test Center. Where supporting information is required, a simulated ground-verification approach may be deployed to aid interpretation of aerial measurements. Because active Controlled Release points may be readily identifiable at close range due to audible gas flow and odorant, direct ground-based verification at active release locations may compromise experimental integrity or inadvertently reveal release locations and may therefore be restricted or prohibited during measurement trials. All ground-based activities shall be designed to minimize bias and shall not interfere with other Performers, Controlled Release operations, or the Experimental Design.

5.2.6 Emission rates and blinding

The Test Center shall schedule sufficient Experimental Design Points across emission rates of interest to support evaluation of a POD relationship. For each Experimental Design Point, emission rates shall

be selected by the Test Center to span above and below the expected operating range of the Survey Solution(s) participating at the time of testing, subject to Test Center system constraints and operational safety.

Controlled Release emission rates shall be selected to be distinguishable above expected background conditions where feasible and to remain within the range appropriate for landfill emission testing under the Test Center constraints. Background Emission Points may be present and may influence observed concentrations.

The Test Center shall provide to Performers, in advance of testing, the applicable lower and upper limits of Controlled Release emission rates and an estimate of background emission rates for each Facility used during the campaign.

Controlled Release emission rates shall be single-blind with respect to release rate, and release rates shall not be disclosed to Performers during testing. In limited cases, and only with prior approval from the Test Center, release rates may be disclosed to specific Performers conducting method development or research-and-development testing where knowledge of the release rate is necessary to evaluate predefined scenarios. Any such disclosure shall be documented by the Test Center.

The Test Center shall track the number of Experimental Design Points conducted within each emission-rate bin in a design matrix (Table 4). A testing schedule shall be provided to Performers in advance of the survey period.

Table 4: Example Experimental Design matrix for Emission Detection testing.

		Emission Rate			
		Zero	Low	Med	High
Number of experiments					

For each Controlled Release, the Test Center shall record the location, timing, gas composition, metered emission rate, the 95% confidence limit for the metered emission rate, and the calibration records for the flowmeters used in the experiments.

The Test Center has final authority over emission rates and experiment execution, considering system design and operational safety.

5.2.7 Controlled Release duration and initialization

Methane release duration shall be sufficient to allow atmospheric mixing and measurement, which will dictate the volume of methane required for testing. The duration of any initialization period prior to measurement shall be approximated by the Test Center based on site conditions and estimated dispersion time.

5.2.8 Gas composition

Gas composition may vary between Experimental Design Points and between survey scopes, for example between Controlled Release experiments conducted within a defined Facility and full-landfill surveys intended to quantify emissions across the entire landfill footprint. The Test Center shall provide the expected gas composition range for each Facility once it is available from the gas supplier.

5.2.9 Environmental conditions

The Test Center shall record wind speed and wind direction with time stamps in UTC using an ultrasonic anemometer network. Meteorological data may be shared with Performers after submission of their first report (more details in section 5.3). Performers may request to update reports using provided meteorological data, provided updates are submitted within a timeframe specified by the Test Center. Discrepancies between original and revised submissions may be discussed in synthesis reporting to assess dependence on externally provided meteorological data.

5.2.10 Background measurements

Prior to initiating Controlled Releases, ambient methane concentrations may be measured by participating Survey Solutions when feasible to provide background context for interpreting Controlled Release results. The Test Center shall also collect background measurements during the survey period and may provide these data to Performers.

5.2.11 Maximum Survey Time and survey completion

The Test Center shall establish a maximum Survey Time for each Experimental Design Point based on typical survey duration for the participating Survey Solution(s). The maximum Survey Time shall be informed by Performer-submitted expected survey times, with an added margin determined by the Test Center.

For Survey Solutions that require specific environmental conditions, Performers may assess conditions continuously and indicate readiness to conduct the survey, subject to Test Center coordination and scheduling constraints.

An Experimental Design Point shall conclude when either: (1) the Performer completes the survey and notifies the Test Center, or (2) the maximum Survey Time elapses.

If a Performer completes the survey before the maximum Survey Time has elapsed, the Performer shall cease survey operations and notify the Test Center, or may conduct replicate measurement trials when required by the Survey Solution methodology or when time allows.

If the maximum Survey Time elapses before completion, the Performer shall cease all survey operations when the time expires.

Upon conclusion, the Test Center shall provide instructions for the next Experimental Design Point, if ready, or designate a location for the Performer to wait until the next Experimental Design Point is ready.

Performers shall record and report actual Survey Time. Performance metrics shall be calculated using the Detection reports (including start and end times) submitted by the Performer, independent of whether the survey ended due to completion or the maximum time elapsing.

5.3 Reporting

Experimental results shall be reported as described in this section. Performers are encouraged to submit experiment and Detection reports to the Test Center daily during the testing period, when available.

5.3.1 Initial submission requirements and deadlines

Performers shall submit their initial results **no later than three (3) weeks** after the end of the testing period. The initial submission shall be recorded by the Test Center and used in primary results analysis.

Some Survey Solutions require submission of ancillary data in addition to Detection reports. For satellite-based Survey Solutions, Detection reports shall be accompanied by the corresponding satellite imagery required to interpret and validate the reported methane detections. The integration of methane

concentration information with high-resolution satellite imagery supports verification of emission sources, assessment of confounding factors (for example, cloud cover or surface reflectance), and contextualization of observed methane plumes within the broader environmental landscape. This requirement supports traceability and improves the reliability of reported detections.

A template for quantification and localization report submission is provided in Section 5.3.9 and 5.3.10.

5.3.2 Reporting Interval

Performers shall declare their Reporting Interval (for example, every 15 minutes or every hour) and shall report at that declared frequency. Reporting is not limited to one value per Experimental Design Point. A Performer may submit multiple reported values within an Experimental Design Point based on their stated Reporting Interval. Each reported value shall include the start time and end time of the Reporting Interval and the reported emission estimate for that interval. Where multiple values are reported within an Experimental Design Point, the Test Center may compute an average reported emission rate for comparison with the total Controlled Release emission rate during that Experimental Design Point.

5.3.3 Replicates in compiled results

Replicate measurement trials are not required to be reported as separate entries in compiled result templates (section 5.3.9). If replicate measurement trials are combined into a single reported value for an Experimental Design Point or Reporting Interval, the Performer shall document the aggregation method (for example, mean or median) and the number of replicate measurement trials contributing to the reported value. All underlying data collected during replicate measurement trials shall be included in the uncompiled data submission for each measurement trial, as specified in Section 5.3.11.

5.3.4 Reporting categories for remote sensors

For remote-sensing Survey Solutions, reporting may be evaluated within the following categories:

- **Localization by Sector (mandatory):** Performers shall report the Facility Sector from which emissions are inferred to originate, consistent with the Facility Localization Sector framework defined in Section 5.2.2.
- **Total-site quantification (mandatory):** Performers shall report an overall emission rate estimate for the Facility. Where reporting is conducted at a declared reporting frequency (Section 5.3.2),

Performers may report multiple emission rate estimates within an Experimental Design Point, consistent with that reporting frequency.

- **Quantification by Sector (optional):** Performers may report Sector-resolved emission rate estimates (one estimate per Sector). This reporting category is optional; however, when provided, it may be included as a scored category for participating Performers.

5.3.5 Non-detects, omissions, and reporting completeness

Performers shall submit results for all measurements conducted during the study. Performers shall not skip Experimental Design Points, omit runs, or selectively exclude results, including outcomes associated with non-detections or poor performance. Missed or unreported Reporting Intervals relative to a Performer's declared reporting frequency shall be treated as omissions and included in omission statistics. Omission statistics may be reported as totals and percentages overall, and may also be stratified by emission magnitude (for example, low, medium, high) and by emission duration to assess systematic patterns in reporting completeness. This requirement ensures that all measurements and Reporting Intervals are explicitly accounted for and prevents unreported exclusion of data.

5.3.6 Spatial precision reporting for point-source detections

For Survey Solutions that report point-source detections, the Performer shall define and report the spatial precision associated with detected emission locations. Spatial precision may be reported as an expected location uncertainty, for example expressed as a radius (e.g., 15 m) around the reported latitude and longitude. This information shall be sufficient for the Test Center to interpret reported detections relative to the applicable localization scoring basis.

5.3.7 Test Center release of site-specific supporting data

After all Performers have submitted their initial reports, the Test Center shall provide site-specific data that may support refinement of Performer analyses. These data may include:

- **Informed release summary data:** The Test Center may provide an "informed release" dataset that subdivides the Facility 20-acre bounding box into sections and provides the summed release rate for each section. This dataset is distinct from the Facility Localization Sector framework and is provided to support Performer data-quality checks and interpretation.

- **Meteorological data:** The Test Center shall provide wind data from the on-site weather station network (seven stations).

5.3.8 Resubmission following release of supporting data

If a Performer elects to revise results following review of Test Center-provided site-specific data, revised results shall be submitted in a timely fashion and **no later than one (1) week** after the date on which the Test Center releases those data.

Where revised results are submitted, both the initial and revised estimates submitted by the Performer shall be retained and may be used in Final Report analysis.

5.3.9 Quantification Report

Performers participating in Quantification studies shall submit a single comma-separated values (CSV) file containing the quantification results, using the field names specified below exactly as listed in Table 5 (example in Table 6). Field names shall match the specified column headings without modification.

Submissions that do not conform to the required format, contain missing mandatory fields, or use incorrect field names may be returned to the Performer for correction. Delays in providing a compliant submission may extend reporting timelines and, if not resolved within the required submission period, may result in exclusion of the affected results from the Final Report.

Table 5: Quantification estimate data field template.

Field	Description	Acceptable Values / Format	Mandatory or Optional
release_ID	Experimental Design Point identifier	Integer (e.g., 1, 2, 3, ...)	Mandatory
reporting_interval_ID	Unique identifier for each Reporting Interval within a release_ID	Integer or character (e.g., 1, 2, 3... or UUID)	Mandatory for continuous remote sensors; optional for other Survey Solutions
interval_start_utc	Start time of Reporting Interval (UTC)	YYYY-MM-DD HH:MM:SS	Mandatory for continuous remote sensors; optional for other Survey Solutions
interval_end_utc	End time of Reporting Interval (UTC)	YYYY-MM-DD HH:MM:SS	Mandatory for continuous remote sensors; optional

			for other Survey Solutions
emission_rate	Estimated emission rate for the Reporting Interval, or total Facility emission rate for the Experimental Design Point (whichever applicable)	Numeric (kg/h)	Mandatory
emission_rate_lower	Lower bound of emission rate uncertainty	Numeric (kg/h)	Mandatory
emission_rate_upper	Upper bound of emission rate uncertainty	Numeric (kg/h)	Mandatory
sector_ID	Facility Sector identifier, if quantification is reported on a Sector basis	Integer corresponding to Facility Sector definitions (e.g., 1, 2, 3); NA if not applicable	Optional
n_replicates	Number of replicate measurement trials aggregated to produce the reported value	Positive integer (≥ 1); required when aggregation is used, otherwise NA	Optional

Table 6: Example Quantification report template.

release_ID	reporting_interval_ID	interval_start_utc	interval_end_utc	emission_rate	emission_rate_upper	emission_rate_lower	sector_ID	n_replicates
12	1	2026-01-15 14:00:00	2026-01-15 14:15:00	34.62	41.90	28.10	2	3
12	2	2026-01-15 14:15:00	2026-01-15 14:30:00	36.05	43.80	29.40	2	3

5.3.10 Detection and Localization Report

Performers participating in Detection and Localization studies shall submit a single comma-separated values (CSV) file, using the field names specified below exactly as listed in Table 7 (example in Table 8). Each row in the table shall correspond to a single reported detection, expressed either as a point-based source location or as a sector-based attribution, depending on the Survey Solution type reported within a measurement repetition. Field names shall match the specified column headings without modification.

Due to the design of the Controlled Release Facility, which includes multiple active Emission Points, Performers may report multiple detected source locations within a single Experimental Design Point. Additional detected source locations may also be reported outside the defined Facility boundary as a result of atmospheric dispersion or background landfill emissions.

Detection and localization results shall be reported using one of the following mutually exclusive reporting modes, as applicable to the Survey Solution:

- **Point-based reporting:** Localization results shall be reported as point-source locations, expressed as a single latitude and longitude coordinate per detected source.
- **Sector-based reporting:** Localization results shall be reported as Facility Sector identifiers corresponding to the sector in which emissions are attributed. Point-source coordinates shall not be reported for sector-based Survey Solutions.

Reporting of bounding boxes, polygons, probability surfaces, circular “blobs,” or other area-based localization representations is not permitted in the Detection and Localization report.

For point-based reporting, the spatial precision associated with reported point-source locations shall be provided as a single numeric value and shall be constant for all detections reported within a single submission. If spatial precision varies between detections, the Performer shall either (a) report the most conservative (largest) applicable spatial precision value, or (b) document the variation in spatial precision in accompanying metadata. Spatial precision shall be reported as NA for Sector-based reporting.

Submissions that do not conform to the required format, contain missing mandatory fields, or use incorrect field names may be returned to the Performer for correction. Delays in providing a compliant submission may extend reporting timelines and, if not resolved within the required submission period, may result in exclusion of the affected results from the Final Report.

Table 7: Detection and Localization estimate data field template.

Field	Description	Acceptable Values / Format	Mandatory or Optional
release_ID	Experimental Design Point identifier	Integer (e.g., 1, 2, 3, ...)	Mandatory (all Survey Solutions)
sector_ID	Facility Sector identifier (if applicable)	Integer or character; NA if not used	Mandatory for Sector-based (continuous remote) Survey

			Solutions; NA for point-based Survey Solutions
latitude	Latitude of detected source (if point-based)	Decimal degrees, WGS84 (EPSG:4326); NA if not applicable	Mandatory for point-based Survey Solutions; NA for Sector-based Survey Solutions
longitude	Longitude of detected source (if point-based)	Decimal degrees, WGS84 (EPSG:4326); NA if not applicable	Mandatory for point-based Survey Solutions; NA for Sector-based Survey Solutions
spatial_precision_m	Spatial precision associated with reported point-source locations. This value is usually constant for all detections reported within a single submission.	Numeric (meters); NA if not applicable	Mandatory for point-based Survey Solutions; NA for Sector-based Survey Solutions

Table 8: Example point-based Detection and Localization report. Sector-based reports will populate the sector_ID field and report latitude, longitude, and spatial precision as NA.

release_ID	sector_ID	latitude	longitude	spatial_precision_m
81	2	42.87057397	-82.11965742	15
81	2	42.87110831	-82.11965610	15
81	2	42.87166770	-82.11893535	15
85	1	42.86996069	-82.12073468	15

5.3.11 Data submission and use in performance analysis

Performers shall submit Detection, Localization, and Quantification reports in the formats specified in Sections 5.3.9 and 5.3.10. These compiled reports shall be used by the Test Center to generate performance matrices in accordance with this protocol.

In addition to the compiled reports, participating technology companies shall submit uncompiled (raw) data collected for each measurement trial to St. Francis Xavier University. Uncompiled data shall include all measurements underlying the reported results, including data associated with replicate measurement trials, regardless of whether replicates are reported separately or aggregated in the compiled report templates.

If acquired data are modified in ways that are typical and necessary to compute final reported values, such modification is permitted, provided that the Performer supplies a detailed explanation describing the processing steps and justifying the need for such modification. Performers are expected to conduct quality assurance on collected data prior to submission. Data submitted to the Test Center shall be considered final.

The Test Center shall record the date and time at which Performer reports and uncompiled data are received and shall store submitted materials for results analysis, verification, and audit purposes.

5.3.12 Data compilation and reporting deliverables

The Test Center shall compile the data received in accordance with this protocol and shall conduct a comparative analysis relative to the known Controlled Release emission rates. The Test Center shall prepare tables, figures, and a summarized discussion of results to be shared as preliminary findings with the project stakeholder groups and any designated third parties for advance review.

The Test Center shall provide the Funder with an outline for the final report, including the testing data used to generate the report. Review comments pertaining to the findings and report outline shall be compiled and used in preparation of a final report, which shall be released by the Funder.

As appropriate, a manuscript may be prepared for submission to a peer-reviewed journal. Additionally, excerpted or summarized information from the effort may be disseminated through data summaries, presentations, and articles (for example, Waste360 and MSW Management).

This section concludes the Performer-specific protocols for the experiment. The following sections describe the Test Center methodologies used to analyze detection, localization, and quantification performance metrics.

6. Performance Metrics

Performance metrics described in Sections 6.1 and 6.2 shall be calculated by the Test Center after completion of all Experimental Design Points and after either (a) Detection and Quantification reports have been submitted by the Performer for all experiments in which they participated, or (b) two months have elapsed since the final experiment, whichever occurs first. Performance metrics shall be calculated using data aggregated across the full duration of the testing program.

6.1 Quantification

Quantification performance shall be evaluated by comparing Performer-reported emission rate estimates, submitted in accordance with Section 5.3, to the metered Controlled Release emission rates recorded by the Test Center for each Experimental Design Point or Reporting Interval (as described in Section 5.3.2). For each quantification report, the Test Center shall compute statistical measures including but not limited to the following:

- **Percent Quantification Error (QE%)**, defined as

$$QE\% = 100 \times \frac{\hat{Q} - Q_{\text{true}}}{Q_{\text{true}}} \quad \text{Eq. 1}$$

where \hat{Q} is the Performer-reported emission rate (kg/h) and Q_{true} is the metered Controlled Release emission rate (kg/h).

- **Factor-of-accuracy performance**, defined as the fraction of reported emission rate estimates that satisfy:

$$\frac{2}{3} \leq \frac{\hat{Q}}{Q_{\text{true}}} \leq \frac{3}{2} \quad \text{Eq. 2}$$

- **Rate-dependent error structure**, evaluated as a function of true emission rate to assess whether quantification performance varies systematically with emission magnitude. Rate-dependent error analysis may include stratification of results into emission rate bins (for example, low, medium, and high).
- **Sample size and confidence assessment**, where applicable, to estimate the number of Experimental Design Points or Reporting Intervals required to achieve a specified confidence level or margin of error based on observed variability.

In addition to accuracy-based metrics, quantification reporting completeness shall be evaluated using **omission statistics**. These statistics are evaluated separately from quantification accuracy metrics and are used to characterize coverage and reliability of quantification performance, and shall include:

- The total number and percentage of omitted Reporting Intervals relative to the expected number based on declared reporting frequency and participation in Experimental Design Points.
- Omission rates stratified by emission magnitude and emission duration to identify systematic patterns in reporting completeness.

Sector-based quantification (optional): Some Survey Solutions may optionally report emission-rate estimates resolved by Facility Sector. When provided, Sector-level quantification performance shall be evaluated by comparing Performer-reported Sector emission rates to the metered sum of active Controlled Release rates within the corresponding Sector for each Experimental Design Point. Sector-level quantification metrics shall be reported separately from total-Facility quantification metrics and shall not be required for scoring. Survey Solutions that do not report Sector-level emission rates shall be evaluated solely on total-Facility quantification performance.

6.2 Detection and Localization

Detection and localization performance shall be evaluated by classifying Performer-reported detections relative to the Controlled Release configuration for each Experimental Design Point, either at the Emission Point level (point-based reporting) or at the Facility Sector level (sector-based reporting), as defined by the Test Center.

For each Experimental Design Point, the Test Center shall classify reported detections and Controlled Release configuration (Emission Points or Sectors, as applicable) as true positives, false positives, true negatives, and false negatives, and shall compute performance metrics for all Survey Solutions under test.

Performance metrics and the operational and environmental conditions observed during the testing period shall be reported in the Final Report (see Section 8). Performance metrics are applicable only under the conditions tested, and caution shall be exercised when extrapolating results to operational or environmental conditions not encountered during the testing period.

6.2.1 Sector-based evaluation

For Survey Solutions that report emissions by Facility Sector rather than by point location, detection and localization performance shall be evaluated at the sector level. An active Sector is any sector

containing one or more active Controlled Release Emission Points for that Experimental Design Point. A Sector-level True Positive occurs when the Performer reports a detection in the same sector as an active sector. A Sector-level False Positive occurs when a sector is reported as emitting when no active release occurred in that sector. A Sector-level False Negative occurs when an active sector is present but no detection is reported for that sector. A Sector-level True Negative occurs when a sector contains no active release and no detection is reported for that sector. Per Experimental Design Point, Performers may report one or more Facility Sectors as emitting.

6.2.2 Detection rules and evaluation for point-based reporting

For each Experimental Design Point, the Test Center shall classify Performer-reported detections using the procedure illustrated in Figure 2. This procedure applies to point-based reporting.

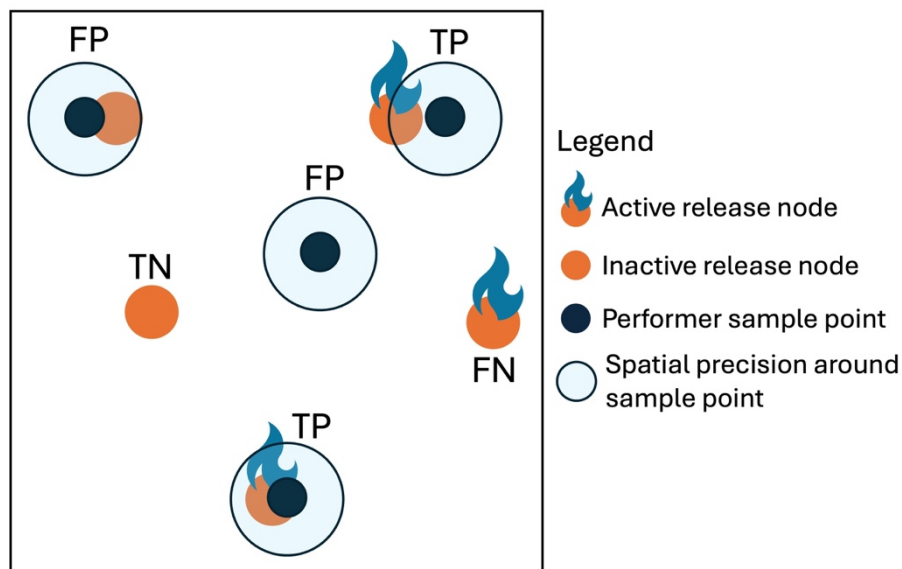


Figure 2. Performer-reported detection evaluation protocol. Dark circles represent reported detections. The light ring represents the Performer-declared spatial precision associated with the reported detection. Blue/orange Flame icons denote active Emission Points; orange dots denote inactive Emission Points.

Each Performer-reported detection shall be classified into one of the following categories:

- **True Positive (TP):** The spatial precision region associated with a reported detection overlaps an active Emission Point.
- **False Positive (FP):** A reported detection is not attributable to an active Emission Point. False positives include either:

- (a) the spatial precision region overlaps an inactive Emission Point, or
 - (b) the spatial precision region does not overlap any Emission Point.
- **False Negative (FN):** An active Emission Point is present, but no reported detection spatial precision region overlaps that active Emission Point.
 - **True Negative (TN):** An inactive Emission Point for which no reported detection spatial precision region overlaps that Emission Point.

Where multiple reported detections are associated with the same Emission Point, the Test Center shall apply a one-to-one matching rule to prevent double-counting. Specifically, each active Emission Point may contribute at most one TP per measurement repetition, and each inactive Emission Point may contribute at most one FP per measurement repetition, regardless of the number of reported detections overlapping that Emission Point. Where multiple reported detections overlap the same Emission Point, the Test Center shall retain the nearest reported detection (based on distance between reported detection location and Emission Point location) and shall disregard additional overlapping detections for counting purposes.

6.2.3 Performance metrics (Point-based and Sector-based reporting)

Using the classification outcomes defined in Sections 6.2.1 (Sector-based) and 6.2.2 (Point-based), the Test Center shall compute the following performance metrics to evaluate detection and localization performance. Metrics shall be computed using the applicable unit of analysis: Emission Points for point-based reporting and Sectors for sector-based reporting.

- **Localization Accuracy (LA):** Measures the fraction of reported detections that correctly identify an active unit (active Emission Point or active Sector).

$$LA = \frac{N_{TP}}{N_{TP} + N_{FP}} \quad \text{Eq. 3}$$

- **False Positive Fraction (FPF):** Quantifies the frequency of incorrect detections.

$$FPF = \frac{N_{FP}}{N_{TP} + N_{FP}} \quad \text{Eq. 4}$$

- **False negative fraction (FNF):** Represents the proportion of active units not detected.

$$FNF = \frac{N_{FN}}{N_{active}} \quad \text{Eq. 5}$$

where N_{active} is the total number of active Emission Points (point-based reporting) or active Sectors (sector-based reporting) present across the Experimental Design Points in which the Performer participated.

6.2.4 POD curves and 90 %-POD MDLs for point-based reporting

Probability of Detection (POD) curves and associated Minimum Detection Limits (MDLs) are defined for point-based detection outcomes, are not calculated for Sector-only reporting, and shall be derived using a standardized framework consistent with published approaches (for example, Ilonze et al., 2024). For each Survey Solution the Test Center shall estimate POD as a function of true Controlled Release emission rate and shall derive the emission rate corresponding to a 90% probability of detection (90%-POD MDL, in kg/h). The procedure consists of four steps:

1. **Link detection outcomes to true release rates:** True positive (TP) and false negative (FN) outcomes shall be pooled across Experimental Design Points and linked to the corresponding metered Controlled Release emission rates (kg/h) for the associated active Emission Points using the node-based matching rules defined in Section 6.2.2 (point-based reporting).
2. **Quantile binning and bin-level POD calculation:** Release rates shall be grouped into equal-count (quantile) bins to avoid empty or sparsely populated categories. For each bin, the Test Center shall compute (i) the mean release rate and (ii) the bin-level POD, defined as:

$$POD = \frac{n_{TP}}{n_{TP} + n_{FN}} \quad \text{Eq. 6}$$

where n_{TP} is the number of true positives and n_{FN} is the number of false negatives within that bin. This produces a set of empirical POD–rate points for each test configuration.

3. **Logistic curve fitting and uncertainty estimation:** A logistic model of the form:

$$\text{POD}(r) = \frac{1}{1 + \exp[-k(r - r_0)]} \quad \text{Eq. 7}$$

shall be fitted to the binned POD–rate points, where r is the Controlled Release emission rate (kg/h), k is the slope parameter, and r_0 is the inflection-point rate. Nonparametric bootstrapping (1,000 resamples) shall be applied to generate confidence intervals around the fitted curve.

4. **Derivation of 90%-POD MDL:** Using the fitted logistic model, the Test Center shall solve for the emission rate r at which $\text{POD}(r) = 0.90$. This emission rate shall be reported as the 90%-POD MDL (kg/h) for the corresponding Survey Solution.

7. Reporting to Performers

The Test Center shall provide a results report to each Performer. The Performer’s results report shall not be distributed to third parties without the Performer’s written consent. Upon request, and subject to Performer consent, the Test Center may provide a copy of the results report to other parties.

Research and Development Performers shall receive data generated during testing to support improvement and refinement of their technologies. R&D Performer results shall not be included in public reporting unless (a) the Test Center determines that inclusion is appropriate for broader dissemination and (b) the R&D Performer provides express written consent for public release. This requirement is intended to preserve confidentiality of preliminary findings unless mutually agreed upon for disclosure.

8. Final Report

The Final Report shall include, at minimum, the information described in this section.

8.1 Experiment summary

The Final Report shall summarize the testing period, including the date range during which experiments were performed, the total number of Experimental Design Points completed, and the total number of Controlled Releases conducted.

Experimental conditions shall be summarized at an aggregate level, including ranges and distributions of Controlled Release emission rates (with lower and upper 95% confidence limits), release durations, and the types and locations of Emission Points utilized during testing.

Environmental conditions observed during the testing period shall also be summarized, including meteorological conditions recorded by the Test Center during Controlled Release experiments.

8.2 Performance metrics

The Final Report shall include the primary performance metrics described in Section 6, including quantification metrics (Section 6.1) and detection and localization metrics (Section 6.2), as applicable to each Survey Solution.

8.3 Performer-reported data

For each reported outcome included in the Final Report, the following information shall be provided:

- Performer-reported data fields, submitted in accordance with the required report templates in Tables 5 and 7.
- Detection classification, assigned by the Test Center as True Positive, False Positive, or False Negative, consistent with the definitions in Section 6.2.

8.4 Documentation of the System Under Test

The Final Report shall include the Performer-provided documentation of the System Under Test submitted in accordance with Section 5.1.

8.5 Documentation of the test protocol

The Final Report shall include a copy of the test protocol used during the experiments, including any version identifiers applicable to the testing period.

8.6 Synthesis report and dissemination

The Test Center may prepare a high-level synthesis report summarizing performance metrics and describing strengths and limitations across Survey Solution types, recognizing that systems are often designed for different operational roles in landfill methane management.

Landfill Leak Detection and Quantification Testing Protocol V2 (Dec 2025)

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As appropriate, the synthesis report may be prepared for submission to a peer-reviewed journal in the months following the experiments. In such publications, participants may be identified by principle of measurement rather than by commercial name.

Draft and final versions of the Final Report and any synthesis report, including testing data used to generate reported results, shall be provided to the Funder for review. Review comments pertaining to findings and report outlines shall be compiled and used in preparation of a final synthesis report, which shall be released by the Funder. Additionally, excerpted or summarized information from the effort may be disseminated through data summaries, presentations, and articles (for example, Waste360 and Waste Management).

Reference

Ilonze C, Emerson E, Duggan A, Zimmerle D. 2024. Assessing the progress of the performance of continuous monitoring solutions under a single-blind controlled testing protocol. *Environmental Science & Technology*. 58(21):10941–10955. DOI: <https://doi.org/10.1021/acs.est.3c08511>.

Appendix A – Changes from Previous Version 1.8 (rev Mar 19, 2025)

General

- Major reorganization of Sections 5–8 for improved clarity and internal consistency.
- Clarified separation between experimental design, reporting requirements, performance metrics, and final reporting deliverables.

Section 5.2.2 – Facility Localization

- Introduced Sector-based (zone-based) localization for continuous or fixed-position remote sensor Survey Solutions.
- Retained point-based localization for Survey Solutions capable of resolving individual source locations.

Section 5.3 – Reporting

- Added requirement for Performers to declare and adhere to a reporting frequency, enabling interval-based reporting.
- Added requirement that all measurements be reported, with formal treatment of non-detects and omissions (no selective exclusion of data).

Section 5.3 – Reporting Templates

- Updated and expanded detection, localization, and quantification report templates.
- Added requirements for point-source localization reporting and declaration of spatial precision.

Section 6 – Performance Metrics

- Expanded definitions of quantification, detection, and localization performance metrics, including POD curves and 90%-POD MDLs.